Climate Ready Carmel

AUGUST 2023

INDIANA UNIVERSITY
ENVIRONMENTAL RESILIENCE INSTITUTE

GEOS INSTITUTE

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Welcome Letter

August 9, 2023

Dear Community,

Global climate change is a serious and immediate concern for our local environment, as well as our city character and way of life in Carmel. The impacts of climate change can greatly increase potential hazards, such as extreme heat and flooding, and adversely impact our local businesses, industries, health, and more. We must act now to simultaneously reduce future greenhouse gas emissions and prepare for changes that are, in many cases, already underway.

As a city, we are committed to action, working collaboratively across all sectors to build partnerships and develop a roadmap for long-term resilience. This collaborative process has been underway for many months. It is with great pleasure that we introduce *Climate Ready* Carmel, our first climate resilience plan.

This plan describes how climate change is projected to impact Carmel and the vulnerabilities that we need to address. Bold strategies have been developed to protect our residents, infrastructure, economy, community culture, and environment. These strategies were created through extensive stakeholder input by diverse community stakeholders to ensure Carmel maintains its character and quality of life.

This plan is a crucial first step in the process of preparing Carmel for the effects of climate change. The strategies identified here will serve as a launching point for policy adoption and implementation, while also complementing our greenhouse gas reduction and sustainability efforts.

I encourage you to dive into this plan and evaluate how you can contribute to each resilience measure. To create a climate-ready Carmel, we must all reduce our individual and collective carbon footprints and adapt to the cascading effects of a changing climate. Together, we can ensure that Carmel endures as a safe and vibrant community for years to come.

Sincerely,

[Signature]

Mike Hollibaugh, Director of Community Services

Acknowledgements

This report is the product of a 10 week-long process led by the Department of Community Services, a climate resilience Task Force of key stakeholders in the community, the Environmental Resilience Institute at Indiana University, and the Geos Institute's Climate Ready Communities Team. With appreciation and gratitude for their time and expertise, we expressly thank:

Carmel Staff

Alexia Lopez, Planning Administrator
Adrienne Keeling, Planning Administrator
Daniela Castellanos, McKinney Climate Fellow through IUB Environmental Resilience Institute

Special Thanks

Much of the information in this report was developed during a daylong stakeholder workshop, and a community-wide survey, which are described in more detail in Appendix 6: Community and Stakeholder Outreach. Thank you to the following people and organizations who helped make them successful:

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Daren Mindham, Environmental Planner-Community Services
Matt Higginbotham, Street Commissioner-Street Department
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Ron Carter, President-Camel Farmers Market
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Alex Jordan, Storm water Management-Engineering Department
Dr. Tim Hannon- City Council
Mike Hollibaugh, Director-Community Services
Henry Mestesky, Executive Director, Redevelopment Department
Joslyn Kass – Code Enforcement Department – Community Services

Executive Summary

Introduction

Carmel is already experiencing the impacts of climate change with increases in heatwave intensity, flooding, and invasive species; decreases in cold season; and changes in vegetation. The City of Carmel ~~Department of Community Services~~ is stepping up to the challenge by taking concrete action that protects and benefits people today as well as future generations.

Climate Ready Carmel is a strategic plan that prioritizes climate-related risks and vulnerabilities, with a focus on safeguarding both people and nature. The objective is to preserve the essential elements and values that define Carmel's vibrant quality of life, while recognizing how climate change can impact these aspects now and in the future. We aim to protect our most vulnerable residents and foster resilience across all individuals, businesses, and natural resources.

Preparing for climate change is not an easy task — it requires action by every member of the community, as well as government, businesses, organizations, and others. The threat of climate change also presents us with opportunities. Carmel is in position to harness its innovation, compassion, diversity, and strong community networks to make serious and systemic change. By prioritizing food access and security, public health and safety, outdoor enjoyment and leisure, diverse ecological balance, healthy parks and floodways, clean technologies, a more resilient power grid, stable water supply, and social equity and justice, the *Climate Ready Carmel* plan aims to benefit all community members and protect the environment and future generations.

Climate Ready Carmel is the culmination of an intensive and highly participatory, community-driven process. To ensure that *Climate Ready Carmel* is based on local community values and reflects the expertise of residents, we organized a stakeholder workshop and conducted surveys to gather extensive community input and feedback throughout the entire process. By actively engaging with the people who live and work in Carmel, we aim to create a plan that represents the aspirations and concerns of our community, making it a shared vision for a resilient and sustainable future.

Figure 1. Remarks and efforts toward a more resilience City.

Carmel's Changing Climate

Climate change may be a global phenomenon, but the impacts are felt at the local level. The region is expected to experience substantial impacts brought on by climate change. These impacts affect all sectors of our community, including human health, natural resources, infrastructure, emergency

response, the economy, and others. Those who are already vulnerable in our community will be impacted the most.

Climate Trends Snapshot Max and Min – Carmel

	HISTORICAL TRENDS (1976-2005)	MID-CENTURY PROJECTIONS (2035-2064)		LATE-CENTURY PROJECTIONS (2070-2090)	
		Higher emission scenario	Lower emission scenario	*Higher emission scenario*	Lower emission scenario
Annual Maximum temperature	95.3° F	↑ 98.0° F to 107.9° F	↑ 96.2° F to 105.8° F	↑ 100.3° F to 114.7° F	↑ 98° F to 107.9° F
Minimum temperature**	41.6° F	↑ 47° F	↑ 46° F	↑ 50.9° F	↑ 46.8° F
Number of days per year above 95°F	1.8	↑ 6.5 to 64.71	↑ 3.6 to 46.1	↑ 14.9 to 102.7	↑ 5.3 to 68.9
Number of days per year below freezing	32.6	↓ 10.9 to 27.1	↓ 11.5 to 29.5	↓ 1.9 to 20.9	↓ 9.0 to 27.1
Change in annual precipitation (in)	39.6"	↑ 37.7" to 46.5"	↑ 37.1" to 45.9"	↑ 36.9" to 48.7"	↑ 37.0 to 47.5
Days per year with precipitation days	189.1	↓ 164 to 198.9	↓ 169.6 to 199.6	↓ 146.3 to 205.9	↓ 171.6 to 196.1
Changes in vegetation**	Temperate deciduous broadleaf (91.7%) & cool mixed (8.3%)	↓ Temperate deciduous broadleaf (85.1%) & cool mixed (13.7%) ↑ Temperate evergreen needleleaf (1.2%)	↓ Temperate deciduous broadleaf (91.2%) & cool mixed (7.7%) ↑ Temperate evergreen needleleaf (1.2%)	↓ Temperate deciduous (77.7%) ↑ Temperate cool mixed (14.3%) & Temperate evergreen needleleaf (8%)	↓ Temperate deciduous broadleaf (77.7%) ↑ Temperate cool mixed (14.3%) & Temperate evergreen needleleaf (8%)
Days per year with higher chances of Fire danger**	73	↑ 102.7	↑ 89.6	↑ Data Not Available	↑ Data Not Available

Source: Climate Mapping for Resilience and Adaptation tool.
** Source: Climate Toolbox kit. Range period: Historical (1971-2000). Lower and higher emissions RCP 4.5 (2040-2069). Lower and higher emissions RCP 8.5 (2070-2099)

Climate Equity and Our Community

Climate change threatens our people, resources, and overall quality of life, including the features and values that create our vibrant community. Several unique aspects contribute to Carmel's distinctiveness such as its:

Figure 2. Carmel Community Members. Source: DOCS

- Roundabout network used as a traffic management solution
- Urban forestry program with numerous benefits such as carbon sequestration, cooling, pollution absorption and stormwater management
- Robust parks and green spaces with features amenities such as walking trails, bike, path, playgrounds, picnic areas and beautiful landscapes
- Cultural and artistic scene with focus on promoting the arts and fostering creativity
- High quality of life ranking among the top cities in the Unites states to live, work and raise a family.

While climate change affects everyone in the community, it impacts some residents far more than others. Climate change exacerbates many existing stressors related to health, income, and housing quality and availability. The strategies outlined in the *Climate Ready Carmel* plan address climate impacts to the entire community, with a focus on the needs of those on the frontlines.

Figure 3. Carmel Community Members. Source: DOCS

Climate Vulnerabilities

This plan examines the climate vulnerabilities across five community systems: Social (Health and Emergency Services) Systems, Natural Systems, Infrastructure, Business and Economy, and Community Culture. The vulnerabilities identified by the community experts with the highest votes in Carmel include:

- Food access and security or higher prices due to flooding, heat, drought, and shipping disruptions
- Water supply demands
- Threats to urban green infrastructure (trees, forest, gardens, lawns)
- Power outages attributed to extreme weather-related events (thunderstorms, tornadoes, etc.)
- Increased erosion and floodway due to storm event intensity
- Greater health risk for people participating in outdoor activities
- Increased demand for energy due to hotter temperature and more humidity for cooling
- Impacts to year-round outdoor recreational activities (festivals, events, normal day activities)
- Increased mental health challenges due to all climate change impacts
- Property damage and loss
- Increased risk of injury and fatalities due to extreme heatwaves
- Increased pressure from invasive species

Introduction

Carmel is already experiencing the impacts of climate change with changes in storm patterns increasing the overall flood risk, heat waves extending the growing and allergy seasons, frequency and severity of extreme heat increasing the likelihood of heat-related illnesses with warmer winters that create more favorable conditions for some pests and invasive species. The Community Services Department is stepping up to the challenge by taking concrete action that protects and benefits people today as well as future generations.

In response to the rapid climate and natural environment changes, Carmel has developed a climate risk and vulnerability assessment to increase community resilience. This ongoing effort aligns with the public education (PE-2) strategy of the Climate Action Plan. The provided climate trends primer serves as a valuable resource, offering information on the past and future trends and impacts specific to Carmel. Gaining a fundamental and shared understanding of trends already affecting residents and identifying community vulnerabilities allows the building of a more resilient community that can withstand and respond to disruptions. Additionally, it enables the development of resilience strategies that positively address the previously mentioned impacts, helping to protect people, property, and nature.

Recognizing the need for adaptation measures, Carmel has launched *Climate Ready Carmel.* This initiative aims to assess the risk posed by climate change and determine the necessary steps to enhance resilience, as outlined in the plan, encompassing the creation of thriving and resilient neighborhoods, families, business, cultural and faith communities, food systems, infrastructure, and other critical component of the community.

> Climate change is already underway and must be addressed. Carmel is dedicated to investing in a vibrant future for all residents by protecting both people and nature from ongoing and future impacts and reducing emissions.

Preparing for climate change is not an easy task — it requires action by every member of the community, as well as government, businesses, organizations, and others. The threat of climate change also presents us with opportunities. Carmel is in position to harness its innovation, compassion, diversity, and strong community networks to make serious and systemic change. By prioritizing food access and security, public health and safety, outdoor enjoyment and leisure, diverse ecological balance, healthy parks and floodways, clean technologies, a more resilient power grid, stable water supply, and social equity and justice, the *Climate Ready Carmel* plan aims to benefit all community members and protect future generations.

The *Climate Ready Carmel* plan is the culmination of an intensive and highly participatory process. The process included extensive engagement by the community, with local stakeholders representing many different sectors, including health care, neighborhood associations, transportation, business, government, emergency preparedness and response, non-profit organizations, conservation groups, industry, and others.

Purpose of this Climate Resilience Plan

Climate Ready Carmel is more than a planning document. It is also an opportunity for our community to clarify our vision for the future and develop a pathway to realize that vision. The guiding principles and vision statements below are the result of a highly collaborative effort with local government staff, the project Task Force, and community members. These statements represent our best understanding of the challenges and opportunities in our community today, recognizing that they may shift and change over time.

Vision Statement

In the pursuit of a sustainable and resilient future, the Carmel community envisions a model city that passionately commits to ambitious greenhouse gas reduction goals, aligning with the Mayors National Climate Change Agenda and the Paris Agreement. Our aim is to achieve a 45 percent emissions reduction by 2035 and ultimately reach net zero emissions by 2050. We prioritize the vulnerabilities of our communities and resources, implementing proactive measures to enhance resilience. Additionally, we emphasize nurturing green spaces, promoting sustainable transportation, embracing alternative energy sources, and collectively fostering the responsibility to protect the environment for the prosperity of future generations.

Climate action in Carmel promotes:

- → Use of sustainable infrastructure
- → Community outreach
- → Neighborhood networks and support
- → Cross-cultural and interracial understanding
- → Opportunities to be active and healthy
- → Transition to cleaner energy sources, and conservation of waterways, and parks
- → Improved ecosystem health
- → Environmental education and social awareness

Figure 4. Carmel Community Members. Source: DOCS

Figure 5. Carmel Community Members. Source: DOCS

Guiding Principles

These guiding principles reflect the city's commitment to sustainability and reducing GHG emissions, covering a range of areas from building design and transportation to community engagement and education. By adhering to these principles, the City of Carmel aims to create a more sustainable and environmentally friendly community for its residents and visitors.

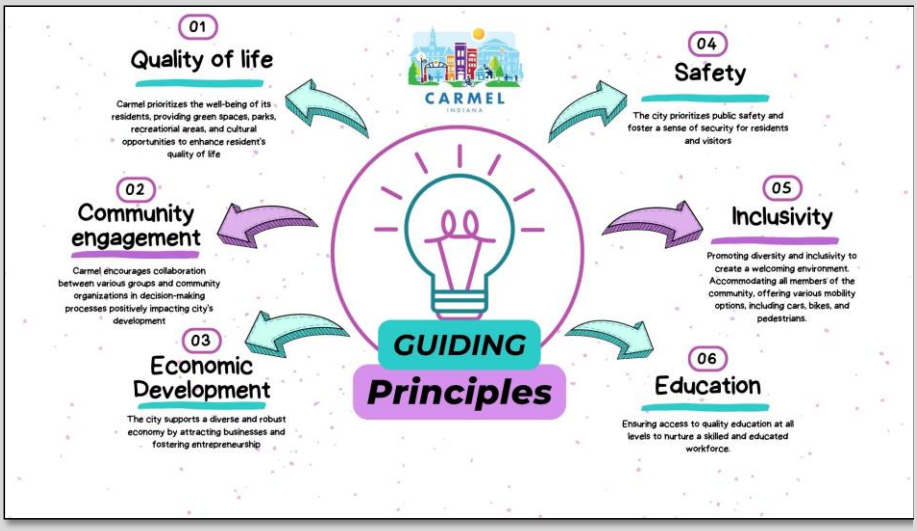

Figure 6. Guiding principle of Carmel, IN based on stakeholders input on Climate Risk and Vulnerability Workshop on July 19th. Source: Canva

Scope of Plan

The scope of *Climate Ready Carmel* encompasses the municipal boundaries of Carmel.

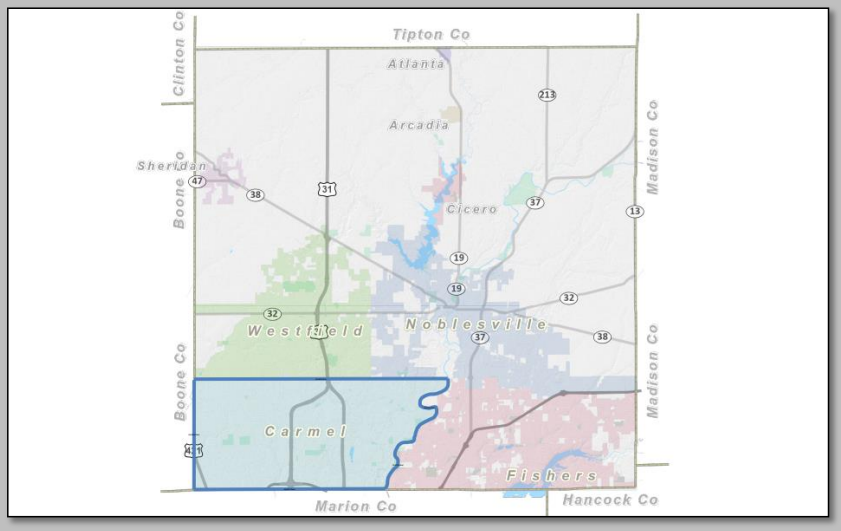

Figure 7. Project boundaries. City of Carmel. Source: Hamilton County general viewer map

Whole Community Resilience

Figure 8. The Whole Community climate resilience planning framework

Climate change affects everyone and everything in our community at the same time. As people start to make changes to adapt to climate change, some of these changes can have unintended consequences. Close coordination and communication are needed to prevent redundancy or conflicting actions. People will need to work together to ensure all sectors and populations of Carmel are protected.

The Planning Process

Climate Ready Carmel is the culmination of an intensive and highly participatory, community-driven process. A Task Force from diverse sectors of the community guided the process and ensured that all risks and vulnerabilities were identified to prioritize community efforts, conserve nature, advance equity, and protect the most vulnerable populations from climate impacts. (See Appendix 6: Community and Stakeholder Outreach)

Figure 9. Timeline of major milestones in the Climate Ready Carmel Planning process

To ensure that *Climate Ready Carmel* is based on local community values and reflects the expertise of residents, a stakeholder workshop and surveys provided community input and feedback throughout the process.

Stakeholder Workshop

Subject matter experts from a diversity of community sectors came together to guide this planning process. In the workshop, participants reviewed future climate change projections and then identified and prioritized climate impacts across the five community systems: Built, Natural, Economic, Cultural, and Social. This information was combined with broad public input collected via surveys and listening sessions to develop the Vulnerability Assessment portion of this plan.

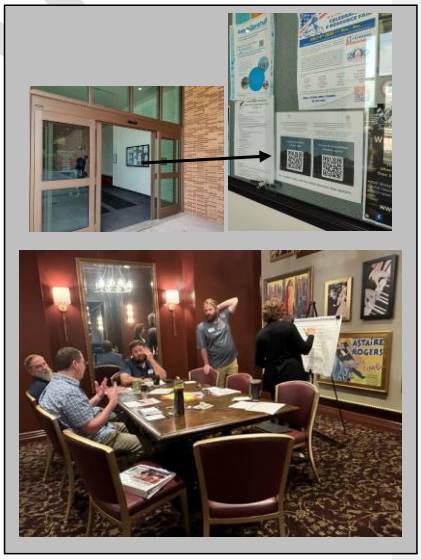

Figure 10. Survey location at Carmel Clay Library and Stakeholder Workshop on July 19th.

Community Surveys

Surveys were distributed in electronic and paper formats, in English and Spanish, to gather community input on climate change. The survey covered basic demographic information and assessed levels of concern and interest in climate change. Key findings from the survey (detailed in Appendix 6: Community and Stakeholder Outreach) include:

- 82% of respondents in Carmel expressed concerned about Climate Change: 64% were extremely concerned and 18% were a bit concerned.
- The top three climate impacts that worry people in Carmel are:

  - Heat, flooding, and drought affecting vegetation, wildfire, and forest (70%).
  - Health impacts including heat-related illnesses, hospitalization, and increased medical costs (52.3%)
  - Food access and security, as well as higher prices due to flooding, heat drought and shipping disruptions. (53.8%)
- 27.7% of respondents are concerned about receiving more people in Carmel who need to escape heat and drought elsewhere.
- 33.8% of respondents are no concerned about losing their jobs or having employment opportunities due to climate chance.
- People perceive milder and shorter winters as the most noticeable change compared to the past.
- Carmel residents are concerned about air quality and loss of vegetation as two significant consequences of climate impacts.

> *"It hardly snows as much in winter as it did when I was a kid. Summers have become significantly warmer. Recently, the air quality in Carmel sunk with wildfires from Canada creeping into the states. With air pollution on the rise and temperatures rising, I'm mostly concerned about its effects on the ecosystem.'" – Carmel Community Resident*

Among respondents who provided demographic information:

- 86.7% of people own their homes
- 62% have a household income above $100,000; 20% fall between $70,000 and $100,000; 15% between $25,000 and $70,000; and 2% below $25,0000
- 83% of respondents identified as white, 7% as Hispanic or Latino, 6% as other (not specified), 3% as Asian and 1% as American Indian or Alaskan native.
- 23% of people who indicated their favorite thing about the Carmel community mentioned green spaces and parks, 18% its sense of community, 17% schools and 12% safety.
- 55% of respondents indicated parks as the area they spend most of their time, followed by 26% enjoying the Monon Center.

> *"…People don't believe this is happening to our environment and won't until it's too late. I hear all the time when it's cold in the winter "oh this is global warming?" Yes! It is part of it. Education is key'" – Carmel Community Resident*

How to Use This Report

This report provides information on the past and future climate trends of Carmel, as well as information about climate vulnerabilities across all sectors of the community: Built, Natural, Economic, Cultural, and Social (Emergency and Food/Housing/Education). The information in this report should be used as a starting point for building climate resilience, with regular updates and revisions over time.

The *Climate Ready Carmel* plan is divided into three primary sections:

1. Climate Trends
2. Community Trends
3. Climate Vulnerabilities

Figure 11. The components that comprise this Climate Ready Carmel Plan

Each section builds on the information from the previous, ensuring that the resulting priority vulnerabilities are based on the best available information. (Figure 11) This identification of vulnerabilities was developed in collaboration with the community, providing clear and prioritized steps to building greater climate resilience.

This report has been designed so that each section acts as a summary and may be used independently, with additional details and supporting information provided in the appendices:

1. Appendix 1: Climate Trends
2. Appendix 2: Community trends
3. Appendix 3: Climate Vulnerabilities
4. Appendix 4: Community and stakeholder outreach

Connecting Past and Present

This *Climate Ready Carmel* plan builds upon our previous efforts and recognizes the importance of considering climate change in all decision-making processes. By doing so, we have the opportunity to plan for climate impacts in a way that promotes equity across different income levels and backgrounds within our community.

As Carmel is expected to face warmer temperatures, changing precipitation patterns, flooding, extended allergy season, shifts in vegetation, and a faster rate of change. It is our responsibility to prepare and build resilience throughout our community, enabling both people and nature to respond and adapt positively to these challenges.

Since adopting a climate resolution plan in 2017, Carmel has made significant strides in sustainability. The city has conducted a Greenhouse Gas Inventory, establishing a baseline for carbon emissions and introduced a comprehensive climate action plan with 42 strategies aimed at reducing emissions.

Carmel has been at the forefront of clean urban development initiatives, including the promotion of alternative fuel vehicles, energy efficiently, recycling practices, and the creation of spaces such as the Monon Greenway for outdoor exercise and recreation[1].

Carmel remains dedicated to maintaining a leadership role in climate action, and preparing for the challenges of climate change, while ensuring the well-being of current and future generation[2]. Strengthening this commitment necessitates conducting a comprehensive Climate Risk and Vulnerabilities Assessment. As an integral strategy of the Climate Action Plan, this assessment will provide valuable insights for informed decision making, cost benefit analysis, and the development of a tailored plan to effectively address specific climate change impacts.

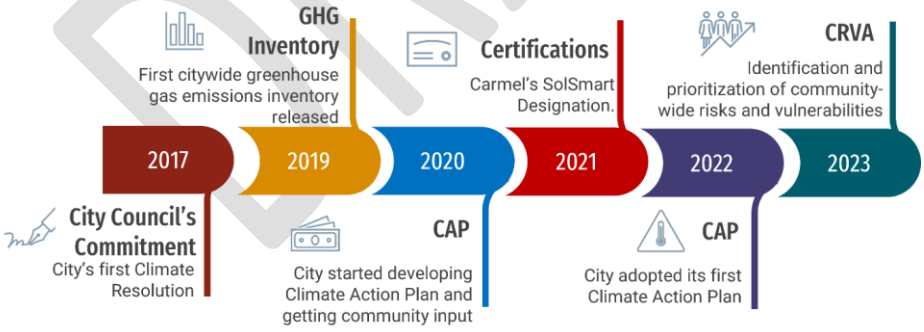

Figure 12. A timeline of Carmel steps and major milestones towards climate resilience

[1] Carmel Green Initiative - promise project 1, 2023

[2] Carmel Green Initiative – promise project 2, 2023

Advancing Climate Equity

Climate change does not affect all residents evenly. Many people experience more severe impacts than others. Those who are most impacted often contributed the least to the problem. Climate inequities stem from the existing unequal distribution of social, political, and economic power.

Preparing Carmel for the impacts of climate change requires significant investment of time and resources across all parts of the community, including businesses, health, schools, infrastructure, community culture, and natural resources. Investments in climate solutions need to support and empower those who are most at risk. Unless climate equity is prioritized from the beginning, and power disparities recognized throughout the process, climate planning will likely default to existing inequitable and exclusionary patterns and approaches and prevent real progress.

What is Climate Equity?

Climate equity is a framework, a goal, and a process. It asks that the diversity of histories, abilities, and needs across community members be accounted for in the design and implementation of climate change solutions. Residents of Carmel have differing levels of ability to protect themselves from impacts. As climate change progresses, important work on social and environmental justice will increasingly need to focus on climate impacts.

Figure 13. Carmel Community Members. Source: DOCS

According to the neighborhoods at risk portal, residents of Carmel are disadvantaged due to disability, insurance status, housing surrounding conditions such as living close to flood zones, areas lacking tree canopy or with extensive impervious surfaces (type of surface that does not allow water to pass through, leading to increased stormwater runoff)[3]. By engaging and empowering disadvantaged residents to take on leadership roles and become the recipients of much of the investment in climate resilience, existing inequities can begin to be corrected. All residents of Carmel benefit when those who are most vulnerable become more resilient and empowered.

More information about those on the frontline of climate change impacts in Carmel is included in the Community Trends section.

[3] Neighborhoods at risk. Carmel, IN. People and Climate exposure variables

Figure 14. Carmel Community Members. Source: DOCS

References

[1]CGI. (2023). *Promise Project 1 Passing the resolution*. Carmel Green Initiative. https://www.carmelgreen.org/advocacy/youth-advocacy/promise-project-1-passing-the-resolution/

[2]CGI. (2023). *Promise Project 2—Advocating for Meaningful Carbon Reductions*. Carmel Green Initiative. https://www.carmelgreen.org/advocacy/youth-advocacy/promise-project-2/

[3]Headwaters Economics. (2023). Neighborhoods at risk Explore Map. Retrieved from https://nar.headwaterseconomics.org/1800010342/explore/map

Climate Change Trends

Climate change may be a global phenomenon, but the impacts are felt at the local level here, and all around the world. These impacts affect all sectors of our communities, including human health, natural resources, infrastructure, emergency response, and the economy. Those who are already vulnerable in our community will be impacted the most.

Carmel's Climate is Already Changing

The average annual temperature in Carmel has already increased 0.9°F[4]. The extreme maximum temperature has increased from 95.3°F to 95.8°F from 1975 to 2015[5] and the extreme minimum temperature has increased from 40.5°F to 43.4°F from 1971 to 2019[6]. The average number of days above 95°F has increased to 9.3 days[5]. The average number of nights below 32°F has declined by 8.9 days[5].

Average precipitation in Carmel has increase 4.3%[5] from 1975 to 2015. In contrast, average snowfall has declined by 8.5% compared to 50 years ago[7]. Despite more total annual precipitation, drought stress has increased due to increasing temperatures and fewer, although larger, precipitation events. For example, Hamilton County has experienced two reported deaths between 1996 and 2023 because of extreme rainfall causing flooding and $35,951,000 of reported property damage during the same period[8].

Figure 15. Morse Reservoir, Noblesville, Indiana. Source: Publicintegrity.org

Figure 16. Flood issue and falling trees happened in Carmel in 2015 after a more than 1' of rain/hour event. Source: DOCS

Future Climate Change in Carmel

Atmospheric scientists created models that help us predict future climate. These Global Climate Models (GCMs) were adjusted to the local scale and help us understand how Carmel will be affected. Carmel's climate is expected to continue to change. If greenhouse gas emissions are reduced, this change is expected to level off mid-century. Table 1 highlights the expected changes for continued business-as-usual emissions and reduced emissions.

[4] Climate mapper - Climate toolbox
[5] Climate mapping fore resilience and adaptation/ extreme heat/annual single highest maximum temperature
[6] Climate Toolbox/Climate/Minimum temperature.
[7] Indiana environmental reporter: Snowfall rates decreased significantly in fall, spring over las 50 years.
[8] Climate and Hazard mitigation planning (CHaMP) Tool/extreme rainfall/hazards/flood.

Table 1. Projected changes in key climate indicators for Carmel. The arrows represent the overall trend, either upwards or downwards.

Climate Trends Snapshot Max and Min – Carmel

	HISTORICAL TRENDS (1976-2005)	MID-CENTURY PROJECTIONS (2035-2064)		LATE-CENTURY PROJECTIONS (2070-2090)	
		Higher emission scenario	Lower emission scenario	*Higher emission scenario*	Lower emission scenario
Annual Maximum temperature	95.3 °F	↑ 98.0° F to 107.9° F	↑ 96.2° F to 105.8° F	↑ 100.3° F to 114.7° F	↑ 98° F to 107.9° F
Minimum temperature**	41.6 °F	↑ 47° F	↑ 46° F	↑ 50.9° F	↑ 46.8° F
Number of days per year above 95°F	1.8	↑ 6.5 to 64.71	↑ 3.6 to 46.1	↑ 14.9 to 102.7	↑ 5.3 to 68.9
Number of days per year below freezing	32.6	↓ 10.9 to 27.1	↓ 11.5 to 29.5	↓ 1.9 to 20.9	↓ 9.0 to 27.1
Change in annual precipitation (in)	39.6"	↑ 37.7" to 46.5"	↑ 37.1" to 45.9"	↑ 36.9" to 48.7"	↑ 37.0 to 47.5
Days per year with precipitation days	189.1	↓ 164 to 198.9	↓ 169.6 to 199.6	↓ 146.3 to 205.9	↓ 171.6 to 196.1
Changes in vegetation**	Temperate deciduous broadleaf (91.7%) & cool mixed (8.3%)	↓ Temperate deciduous broadleaf (85.1%) & cool mixed (13.7%) ↑ Temperate evergreen needleleaf (1.2%)	↓ Temperate deciduous broadleaf (91.2%) & cool mixed (7.7%) ↑ Temperate evergreen needleleaf (1.2%)	↓ Temperate deciduous (77.7%) ↑ Temperate cool mixed (14.3%) & Temperate evergreen needleleaf (8%)	↓ Temperate deciduous broadleaf (77.7%) ↑ Temperate cool mixed (14.3%) & Temperate evergreen needleleaf (8%)
Days per year with higher chances of Fire danger**	73	↑ 102.7	↑ 89.6	↑ NA	↑ NA

Source: Climate Mapping for Resilience and Adaptation tool.
** Source: Climate Toolbox kit. Range period: Historical (1971-2000). Lower and higher emissions RCP 4.5 (2040-2069). Lower and higher emissions RCP 8.5 (2070-2099)

More details about the climate change trends and projections for Carmel can be found in Appendix 1: Climate Change Trends Primer.

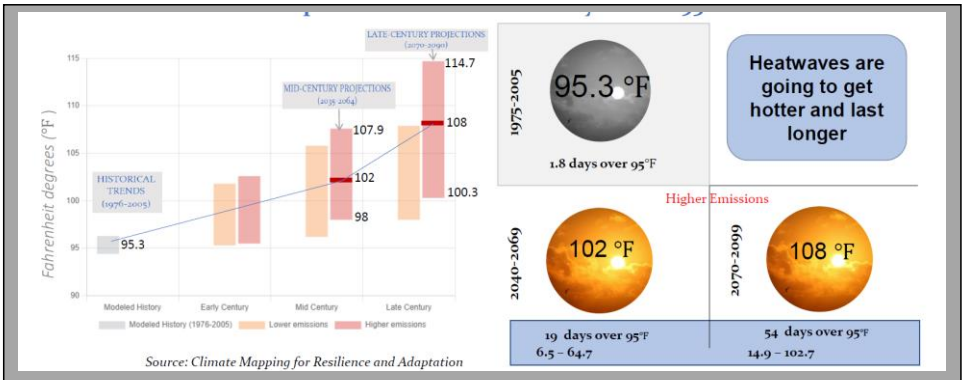

Figure 17. Annual single highest maximum temperature. Source: Adapted from Climate Mapping for resilience and adaptation and retrieved from Leslie Webb's Climate trends presentation on stakeholder workshop on July 19th

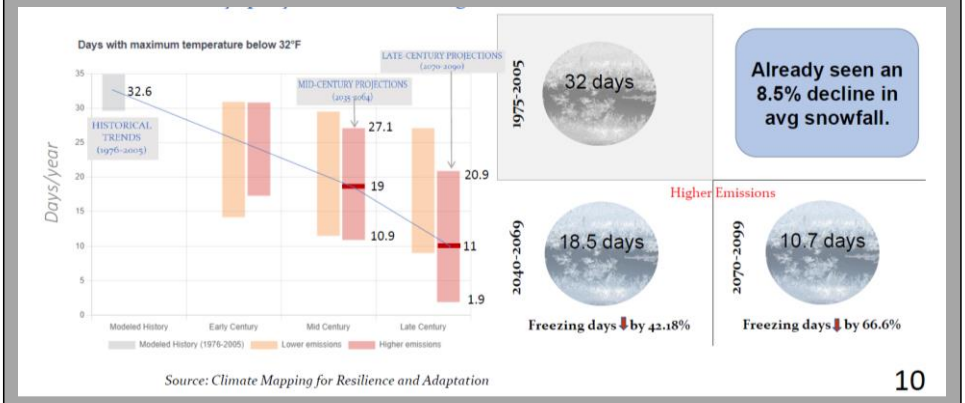

Figure 18. Number of days per year below Freezing. Source: Adapted from Climate Mapping for Resilience and adaptation and retrieved from Leslie Webb's Climate trends presentation on stakeholder workshop on July 19th

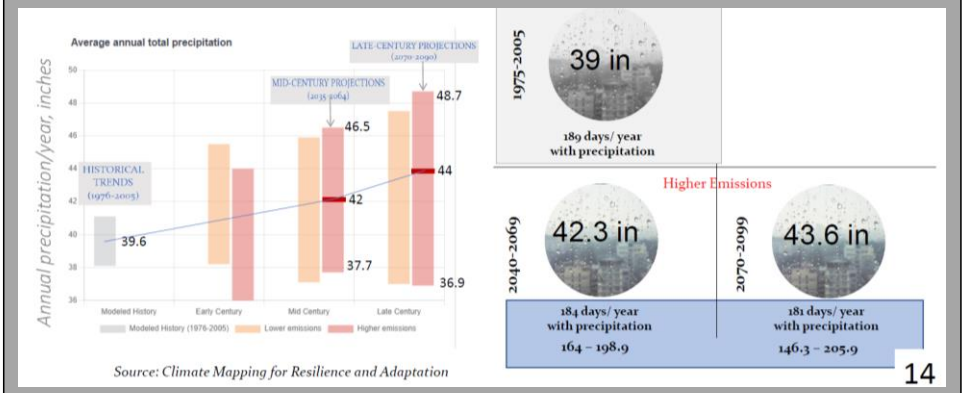

Figure 19. Annual precipitation. Source: Adapted from Climate Mapping for Resilience and adaptation and retrieved from Leslie Webb's Climate trends presentation on stakeholder workshop on July 19th

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Community Trends Summary

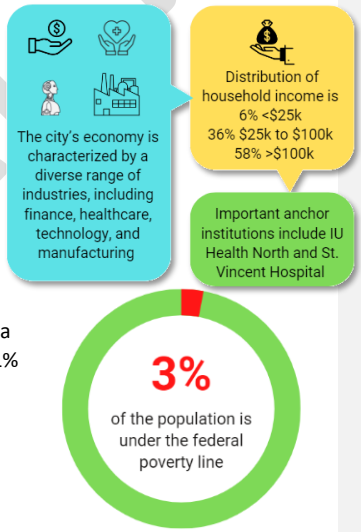
Climate change threatens our people, resources, and overall quality of life. As Carmel works to develop a plan that will ensure long term climate resilience, it is important to identify the features and values that create our vibrant quality of life.

This overview of basic community systems in Carmel provides a snapshot of how the community and its surrounding area function at the time this report is written. It is intended to support the climate change vulnerability assessment workshop process, and lead to robust strategies. More information about these community trends can be found in Appendix 2: Community Trends.

Figure 20. Carmel Community member. Source: DOCS

People and the Economy

- Carmel 's population of 101,964 has grown 88% since 2000[9].
- 80.5% of Carmel residents identify as White alone and 11% identify as Asian and 4.0% as Hispanic or Latino
- The female population is over 56.1%[10].
- The top three sectors are Finance and insurance 11%, retail trade 10% and professional and technical services 10%[11].
- 75,3%[12] of housing units are occupied by their owners, and 24,4%[13] by renters[14].
- Areas of floodway with a 100-year flood stage is 1% and with a 500-yearflood is 0.2%[15], meaning on any given year, there is 1% and 0,2% chance that there will be a flood of that magnitude, respectively.
- Disadvantaged populations in Carmel include people of color and Hispanics, people with disabilities, people without insurance, people living close to flood zones, people living in areas lacking tree canopy, and people living in areas of impervious surfaces.[14]



Nature and the Environment

- Carmel has an urban forestry program promoting and preserving its inventory of 29,235 trees, with red and sugar maple being the most prevalent species[16].

[9] Biggest US cities/Carmel-Indiana
[10] United States Census Bureau
[11] Economic Profile System
[12] Unites States Census Bureau
[13] Economic Profile System
[14] Economic Profile System
[15] Flood insurance study Hamilton County, Indiana, and incorporated areas
[16] Tree management plan. City of Carmel, Indiana. June 2018.

- The White River plays a vital role in Carmel, providing a crucial groundwater supply in the West Fork White River. There are nearby water bodies such as Cool Creek in Westfield, Richey Woods Nature Preserve in Fishers, and Eagle Creek reservoir located in Indianapolis[17].
- Carmel prioritizes green spaces and outdoor recreation, with green areas such as Central Park, Prairie Meadow Park, Flowing Well Park, Founders Park, West Park, and Midtown Plaza[18].
- Air quality in Carmel is typically good [19], however, in 2023, the city has experienced alerts due to poor atmospheric conditions caused by wildfires in Canada[20].
- Carmel has the Monon Greenway, a popular multiuse trail that stretches across the Indianapolis area, including Carmel, and provides some elements of natural landscaping, such as trees and vegetation and access to outdoor recreation and green spaces.

Infrastructure

- The White River plays a vital role in Carmel, providing a crucial groundwater supply in the West Fork White River[21]. Tap water complies with Environmental Protection Agency and Indiana state standards, and in summer, the average family's water use is 320 gallons per day[22].
- Duke Energy Indiana is the state's largest electric supplier and serves about 850,000 homes and businesses in 69 counties including Hamilton County where Carmel is located[23]. Improvements in grid will reduce the number of power outages by 17% and the length of outages by 19%[24].
- Carmel is considered the roundabout capital of the U.S. having 138+ roundabouts. It reduces accidents with injury by 80%, helps drivers save 272 tanker trucks of fuel, and reduces the cost of traffic light maintenance[25].
- Areas of floodway with a 100-year flood stage is 1% and with a 500-yearflood is 0.2%[26], meaning on any given year, there is 1% and 0,2% chance that there will be a flood of that magnitude, respectively
- 171 historical tornado events have been recorded in Carmel between 1950-2010 and the city tornado index is 37[27].
- Carmel is expected to see 157.1% increase in the number of days over 101°F over the next 30 years[28].

[17] White River. Visit Hamilton County Indiana
[18] Carmel, Clay Park & Recreation. Carmel, Indiana government website/parks
[19] IQAir and Air Now portals/ Historic air quality Index (AQI)
[20] Indiana Department of Environmental Management/ Air quality/ Near-real Time Air Quality Maps and Data
[21] City of Carmel/Utilities official website
[22] Water quality report. City of Carmel Utilities, 2019.
[23] Duke Energy/Homepage/Our company. Duke Energy foundation
[24] Duke Energy Indiana files plan to improve reliability and resilience of its statewide electric grid with innovative technology.
[25] City of Carmel/Roundabouts/ official website
[26] Flood insurance study Hamilton County, Indiana, and incorporated areas
[27] The U.S. Tornado and Weather Extremes database of 1950-2010
[28] Risk Factor/Heat factor

Cultural Resources

- The City of Carmel was established in 1837 as Bethlehem and experienced steady growth over its first 50 years as a farming community, attracting Quaker pioneers to settle in the area[29].
- Carmel treasures its historical heritage and has four properties listed in the National Register of Historic Places, showcasing its significance in transportation, architecture, agriculture, commerce, and historic residential suburbs[30].
- Carmel offers a vibrant cultural scene with the Center for the Performing Arts, Carmel Arts & Design Districts, and various music performance venues.
- The city's cultural offerings also include local attractions such as the Monon Museum, Museum of Miniature houses, and the World's Smallest Children's Art Gallery[31].

Figure 21. Carmel Community members. Source: DOCS

[29] Carmel Clay Historical Society. Bethlehem/Carmel since 1837
[30] U.S. National Register of Historic Places
[31] Carmel Indiana official government website/ Design & Style in Carmel

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[24]Duke Energy. (2023). Duke Energy Indiana Files Plan to Improve Reliability and Resilience of Its Statewide Electric Grid with Innovative Technology [Press release]. Retrieved from https://news.duke-energy.com/releases/duke-energy-indiana-files-plan-to-improve-reliability-and-resilience-of-its-statewide-electric-grid-with-innovative-technology

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[28]Risk Factor/Heat factor

[10,12]United States Census Bureau. (2021). QuickFacts. Retrieved from https://www.census.gov/quickfacts

[17]Visit Hamilton County. (2023). White River. Retrieved from https://www.visithamiltoncounty.com/things-to-do/outdoors/white-river/

Climate Change Vulnerabilities

Climate impacts affect every person, structure, business, natural resource, and organization in Carmel. And yet, some will be impacted far more than others. Vulnerability depends on many factors, including ongoing stressors, potential climate impacts, and existing adaptive capacity.

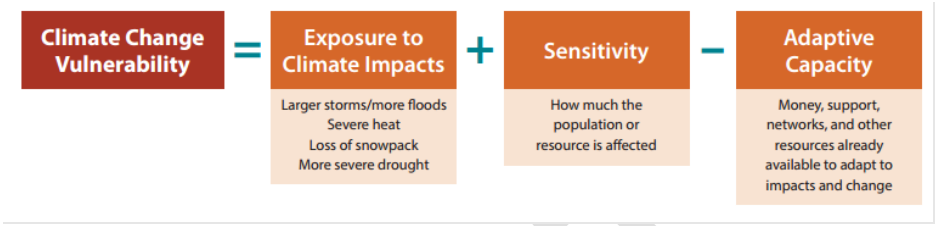


Figure 22. Aspects of Climate Change Vulnerability Assessment.

This plan examines the vulnerabilities across five community systems:

Figure 23. Dry cove at Morse Reservoir in Noblesville, IN. Source: Michael Conroy, Thursday, July 5,2012.

Social (Health, Emergency) Systems – this includes the health care system, education and schools, law enforcement, emergency response services, and under-represented populations such as communities of color, people with disabilities, youth, elders, low-income workers, and those experiencing homelessness.

Natural Systems – this includes all the aquatic and terrestrial ecosystems in the Carmel community. These may be public lands or privately owned, and include urban greenways such as parks, tree lawns, and residential yards.

Built/Infrastructure Systems– this includes all the built elements in the community such as stormwater, wastewater, and drinking water systems; transportation networks like roads and railways; energy production and distribution; communications towers; and homes, businesses, and other buildings.

Business and Economy Systems – this includes the economic drivers of the community such as small businesses, large industry, agriculture, commercial spaces, recreation, and tourism.

Community Culture Systems – this includes all the specific ways that make a community special and feel like home to its residents, such as faith communities, civic organizations, local cultural groups, festivals, and events. This also includes any specific cultural practices or needs of the indigenous people in the community, as well as any immigrant populations.

"Summers are hotter, drier. Winters are milder, less snow. More extreme heat year-round. More severe storms/tornados. More heavy downpours. Blue Spruces are dying. Flowering trees are stressed. More irrigation needed for lawns. Need to turn on AC earlier in the year." - Carmel Community Resident

The main difference is the acknowledgement that it's not just "getting hotter," but that weather patterns are shifting and causing extreme weather events (polar vortex, tornadoes, flooding, etc.). Also, now it is considered not reversible, whereas 30 years ago it was still a "maybe."- Carmel Community Resident

"Warmer, dryer summers are impacting plants. There is too much emphasis on manicured lawns and not enough emphasis on native planting to replace turf grass. Native plants use less water and are more drought tolerant than turf grass. Native plants do not generally require watering, fertilizer, or heavy use of chemicals to control weeds. Native plants do not require weekly mowing with its large expense and carbon emissions. Landscape companies should be encouraged to plant native plants to replace turf grass and shift their business models to managing native plantings rather than mowing turf grass." – Carmel Community Resident

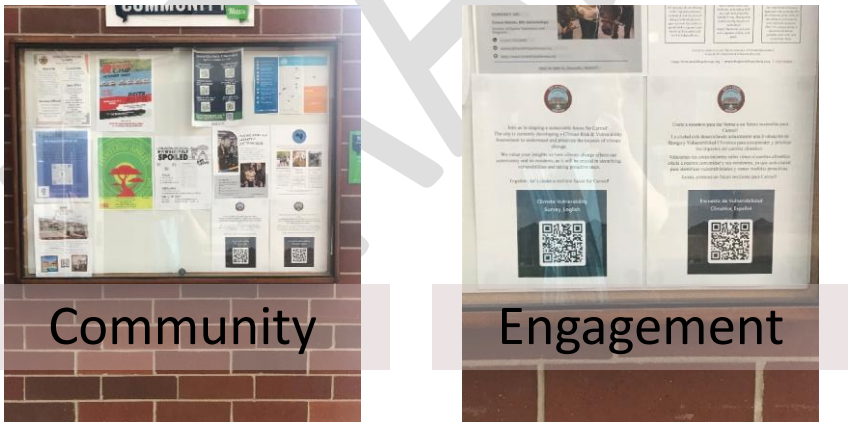


Figure 24. Hard copies of Climate Community Survey up at the Monon Community Center

Climate Change Vulnerabilities in Carmel

Local experts from diverse sectors of the community created the list of vulnerabilities and prioritized them across all five systems. For more information and details on this process, see Appendix 3: Climate Vulnerability Assessment.

Climate hazards - The specific climate trend or projection that is already causing or is expected to cause the impact.

Severe Heat – There could be 15-102 more days/year above 95°F[32]

Larger Storms - The amount of precipitation in the largest storms could increase by 5-23%, resulting in risk of potential flooding[33].

Drought - Drought stress could change vegetation type and increase fire danger days up to 41%[34]

Flooding – There could be fewer days per year below freezing point[35], with an average decrease of 8.5% in snowfall[36].

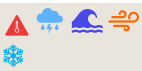
Components of Climate Vulnerabilities – Some of the criteria involved during the Climate Risk and Vulnerability Assessment.

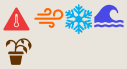
Timeframe	Sensitivity	Adaptive Capacity
When the impact is expected to occur *Near-term = current to 2030s* *Mid-term = 2035s to 2064s* *Long-term = 2070s to 2090s and beyond*	How much of a response or how great of an impact is expected (e.g. how disruptive it is, how serious the consequences are, and how much overall change is expected) *High, Medium, or Low*	Whether there are already existing resources, programs, or policies in place to protect people or to respond to the changes with little disruption *High, Medium,or Low*

Table 2. Vulnerabilities Assessment

Rank	Sector(s)	Vulnerability	Climate Hazard(s)	Time frame	Sensitivity	Adaptive Capacity
1	Cultural/ Economic	Food access and security or higher prices		Near term	High	Low
2	Cultural/ Natural	Impacts to year-round outdoor recreational activities		Near term	High	Low
3	Social	Health impacts from heat (heat stroke, more hospitalizations, and medical costs)		Near term	High	Low

[32] Climate Mapping for Resilience and Adaptation tool/ days above 95°F
[33] Climate Mapping for Resilience and Adaptation tool/ Change in annual precipitation
[34] Climate Toolbox kit. Fire danger
[35] Climate Mapping for Resilience and Adaptation tool/ days per year below freezing point
[36] Indiana environmental reporter: Snowfall rates decreased significantly in fall, spring over las 50 years

4	Cultural	Disruption of cultural practices, rituals, and ceremonies		Near term	High	Low
5	Social	Increased mental health challenges due to all climate change hazards		Near term	High	Med
6	Built	Water supply demands		Near term	High	Med
7	Social/Built	Increased risk to housing infrastructure/ Property damage and loss		Near term	High	Med
8	Cultural	Weather events affecting disadvantaged population, exacerbating existing inequalities		Near term	High	Med
9	Social	Decreased air quality due to windblown dust particles caused by droughts and wildfires causing smoke		Near term	Med	Low
10	Built	Solar and EV battery fire control risk		Near term	Med	Low
11	Economic	Increased weed, pest and disease risk in green areas		Near term	Med	Low
12	Social	Increased risk of injury and fatalities due to extreme heatwaves		Near term	Med	Med
13	Built	Increased demand for energy		Near term	Med	Med
14	Economic	Increased risk of early flowering and frost damage		Near term	Med	Med
15	Economic	Health risk to outdoor worker-lower productivity & increased worker compensation		Near term	Med	Med
16	Natural	Threats to urban green infrastructure (trees, forest, gardens, lawns)		Near term	Med	Med
17	Natural	Increased pressure from invasive species		Near term	Med	Med
18	Natural	Restricted participation in outdoor activities		Near term	Med	Med

		events and recreational opportunities				
19	Economic	Increased cost associated with reconstruction		Near term	High	High
20	Natural	Increased erosion and floodway due to storm event intensity		Mid term	Med	Low
21	Cultural	Impacts to outdoor festivals and events		Mid term	High	Med
22	Built	Power outages		Mid term	High	Med
23	Social	Increased mosquitoes, ticks, and vector-borne illnesses		Mid term	High	Low
24	Social	Greater health risks for people participating in outdoor activities		Mid term	High	High
25	Built	Impacts to power generation and disruptions		Mid term	High	High

References

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Glossary

100-year Flood Zone – the land that is expected to be flooded due to a flood event that has a 1 in 100 chance of being equaled or exceeded in any given year.

Carbon Sequestration – The removal of carbon (CO2) from the atmosphere to be stored elsewhere, especially in natural systems, such as trees, soils, and wetlands.

Clean Energy – Energy used by people and businesses that doesn't cause pollution. Includes electricity, transportation, buildings, and food systems.

Climate Change Adaptation – Actions that protect people or nature from, or prepare them for, the current and future impacts of climate change.

Climate Change Mitigation – Actions that reduce greenhouse gas emissions (primarily from fossil fuels combustion) or increase the storage of carbon (primarily in soils, forests, and other natural systems).

Climate Equity – Removing or addressing obstacles to climate resilience such as discrimination, poverty, and their consequences.

Contaminant/toxin/pollutant – a substance that makes something less pure or makes it poisonous (contaminant); any substance poisonous to an organism (toxin); any substance, as certain chemicals, or waste products, that renders the air, soil, water, or other natural resource harmful or unsuitable for a specific purpose (pollutant).

Ecosystem Services – Represent the many and varied benefits of a healthy natural environment. They include the production of food and water, the control of climate and disease, nutrient cycles and oxygen production, and spiritual and recreational benefits.

Energy Efficiency – The reduction of the amount of energy required to provide the same level of products and services.

Equity – Achieving the same level of opportunity based on variable levels of support and assistance depending on the difference in historical disparity and current need. Some types of equity of concern include racial, economic, social, and intergenerational.

Food Insecurity – An economic or social condition of limited or uncertain access to adequate food supply.

Fossil Fuels – Energy sources that were formed when ancient plants and organisms were subject to intense heat and pressure over millions of years. There are three major types of fossil fuels: coal, oil, and natural gas.

Green infrastructure – The use of natural and engineered ecological systems to provide specific services to the community, often in relation to stormwater management, but also including cooling, pollination, and filtration.

Greenhouse Gas (GHG) – A gas that absorbs infrared radiation (heat) in the atmosphere and contributes to climate change. Greenhouse gases include carbon dioxide, methane, water vapor, nitrous oxide, and others.

Impervious surfaces – Land surfaces that repel rainwater and do not permit it to infiltrate (soak into) the ground. Impervious surfaces are mainly artificial structures—such as pavements that are covered by water-resistant materials such as asphalt, concrete, brick, stone—and rooftops. Soils compacted by urban development are also highly impervious. (Also see "Pervious surfaces").

Infrastructure – The built environment such as buildings, energy generation and distribution systems, water delivery, storm- and wastewater, floodwalls, roads and highways, bridges, culverts, and many other basic structures.

Resilience – the ability of people and their communities to anticipate, accommodate and positively adapt to or thrive amidst changing climate conditions and hazard events.

Renewable energy – Energy produced from sources that do not deplete or can be replenished within a human's lifetime. The most common examples include wind, solar, geothermal, biomass, and hydropower.

Sustainability – A broad concept that refers to meeting the needs of the present without compromising the ability of future generations to meet their needs.

Vectors – An insect that transmits a disease is known as a vector, and the disease is referred to as a vector-borne disease (for example, Lyme disease transmitted by a deer tick).

Appendix 1: Climate Change Trends Primer

People around the world are experiencing changing conditions that affect their daily lives. Many changes are due to human-caused climate change, resulting from combustion of fossil fuels and deforestation. Climate change is a global problem, yet the impacts and opportunities for action are local. As climate change accelerates with continued greenhouse gas emissions, local communities will need to be prepared for impacts and take action to protect people and the natural resources they depend on. Like other parts of the U.S., Carmel is experiencing rapid change in climate, and people are seeking strategies to increase safety, wellness, and resilience.

In Carmel residents report changes in rising temperatures that are reducing the intensity of cold waves and intensifying heat waves. The severity and frequency of large storms have increased, leading to more flooding incidents despite a decrease in precipitation days. There is less snowfall during the cold season, bringing milder winters that may appear desirable, but bring extended allergy seasons and heightened disease risks. These shifts also affect local vegetation, potentially altering traditional fall and winter seasons. All these changes can affect peoples' health, culture, and livelihoods. Local infrastructure such as roads and bridges are also at risk from severe heat, storms, and flooding. Many changes are already occurring, and many more are expected to occur in the future.

If global action to greatly reduce greenhouse gas emissions is taken quickly, the long-term severity of climate change will be reduced, and local strategies to adapt will be more successful. In the near term, because of long-lasting greenhouse gases already emitted, drastic change will continue over the next few decades. Local action and planning to reduce the impacts of climate change are needed.

This climate change primer provides information on the expected trends and impacts specific to Carmel (Figure 25). Understanding climate change trends and impacts is the first step in identifying climate related risks and vulnerabilities. The next step will be to develop strategies that build overall resilience for both the people and natural resources of the region.

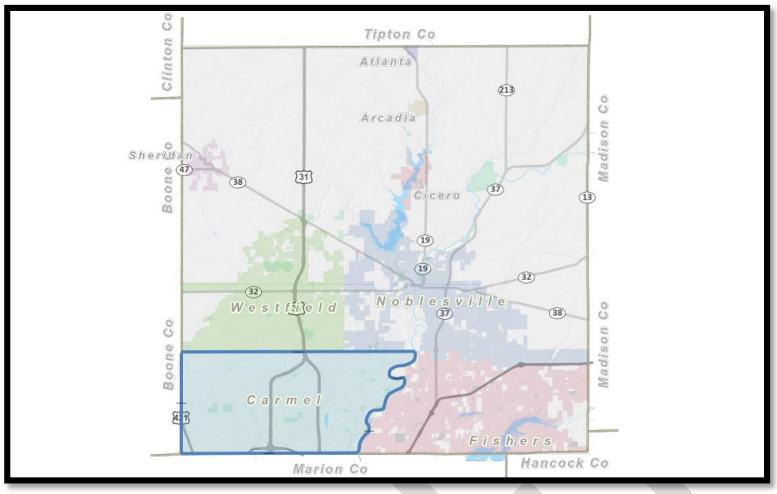

Figure 25. Map of project boundaries. Sources: Hamilton County Viewer Map

Table 3. Carmel trends and projections snapshot - Average

Higher emission: scenario in which humans continue increasing emissions of heat-trapping gases from fossil fuels through 2100.

Lower emission: scenario in which humans reduce their use of fossil fuels and reduce global emissions of heat-trapping gases to zero by 2040.

Historical Trends (1976-2005)	Mid-century projections (2035-2064)	Mid-century projections (2035-2064)	Late-century projections (2070-2099)	Late-century projections (2070-2099)
• Maximum Temperature 95.3°F • Minimum Temperature 41.6°F • 1.8 additional days/year above 95°F • 32 days below freezing • Average precipitation 39.6 in/year • 189.1 days with precipitation • 73 days of 'high' fire danger and 11 days of 'extreme' fire danger.	• Maximim Temp 101.9°F • Minimum Temperature 47°F • 22.2 additional days/year above 95°F • 18.5 days below freezing • Average precipitation 42.3 in/year • 184.4 days with precipitation • 102.7 days of 'high' fire danger and 24.1 days more of 'extreme' fire danger.	• Maximim Temp 100.5°F • Minimum Temperature 46°F • 15.5 additional days/year above 95°F • 20.4 days below freezing • Average precipitation 41.7 in/year • 185.9 days with precipitation • 89.6 days more of 'high' fire danger and 16.1 days more of 'extreme' fire danger	• Maximim Temp 107.1°F • Minimum Temperature 50.9°F • 53.6 additional days/year above 95°F • 10.7 days below freezing. • Average precipitation 43.6 in/year • 181.3 days with precipitation	• Maximum temp 101.8°F • Minimum Temperature 46.8°F • 22.7 additional days/year above 95°F • 17.7 days below freezing. • Average precipitation 41.8 in/year • 184.8 ldays with precipitation

The previous table displays the mean values, representing the average conditions over a 30-year period, including both historical observations and future projections based on climate models and scenarios.

The following table presents the maximum and minimum values, indicating the extreme ends of the projected data. These values represent the highest and lowest estimated values for specific climate variables, offering insights into the potential range of variability within the climate system.

Table 4. Summary or Carmel trends and Projections expected for Carmel-ranges

Climate Trends Snapshot Max and Min – Carmel, Indiana					
	HISTORICAL TRENDS (1976-2005)	MID-CENTURY PROJECTIONS (2035-2064)		LATE-CENTURY PROJECTIONS (2070-2090)	
		Higher emission scenario	Lower emission scenario	*Higher emission scenario*	Lower emission scenario
Annual Maximum temperature	95.3° F	↑ 98.0° F to 107.9° F	↑ 96.2° F to 105.8° F	↑ 100.3° F to 114.7° F	↑ 98° F to 107.9° F
Minimum temperature**	41.6° F	↑ 47° F	↑ 46° F	↑ 50.9° F	↑ 46.8° F
Number of days per year above 95° F	1.8	↑ 6.5 to 64.71	↑ 3.6 to 46.1	↑ 14.9 to 102.7	↑ 5.3 to 68.9
Number of days per year below freezing	32.6	↓ 10.9 to 27.1	↓ 11.5 to 29.5	↓ 1.9 to 20.9	↓ 9.0 to 27.1
Change in annual precipitation (in)	39.6″	↑ 37.7″ to 46.5″	↑ 37.1″ to 45.9″	↑ 36.9″ to 48.7″	↑ 37.0 to 47.5
Days per year with precipitation days	189.1	↓ 164 to 198.9	↓ 169.6 to 199.6	↓ 146.3 to 205.9	↓ 171.6 to 196.1
Changes in vegetation**	Temperate deciduous broadleaf (91.7%) & cool mixed (8.3%)	↓ Temperate deciduous broadleaf (85.1%) & cool mixed (13.7%) ↑ Temperate evergreen needleleaf (1.2%)	↓ Temperate deciduous broadleaf (91.2%) & cool mixed (7.7%) ↑ Temperate evergreen needleleaf (1.2%)	↓ Temperate deciduous (77.7%) Temperate cool mixed (14.3%) & Temperate evergreen needleleaf (8%)	↓ Temperate deciduous broadleaf (77.7%) ↑ Temperate cool mixed (14.3%) & Temperate evergreen needleleaf (8%)
Days per year with higher chances of Fire danger**	73	↑ 102.7	↑ 89.6	↑ NA	↑ NA

Source: Climate Mapping for Resilience and Adaptation tool.
** Source: Climate Toolbox kit. Range period: Historical (1971-2000). Lower and higher emissions RCP 4.5 (2040-2069). Lower and higher emissions RCP 8.5 (2070-2099)

Climate change data and models

The Earth's climate is regulated by a layer of gases commonly referred to as greenhouse gases for their role in trapping heat and keeping the earth at a livable temperature. These gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and water vapor (H_2O). CO_2 plays an especially large role due to its long-lasting nature and amount compared to other gases. The atmospheric concentration of

CO_2has risen from 280 to more than 417.06 parts per million (ppm)[37] in the past century, driven largely by the burning of fossil fuel, deforestation, and other human activity.

Information from ice cores allows us a glimpse into CO_2 levels over hundreds of thousands of years. This data shows us that CO_2 has fluctuated between about 175 and 300 ppm over the last 800,000 years and the current level is far above anything detected in that period. As CO_2 levels changed in the past, changes in temperature tracked closely and we can expect this relationship to hold in the future as CO_2 and other greenhouse gases continue to increase.

For over a century, we have known that increases in the concentration of greenhouse gases in the atmosphere result in warmer temperatures. Long-term tracking data from weather stations and other research support this expected trend. Traditional knowledge from indigenous communities around the globe also indicates that there has been substantial change in conditions over time, especially since the end of the last ice age.

In order to look at projected future climate, we use computer models based on our understanding of the Earth's climate. The Intergovernmental Panel on Climate Change (IPCC), which is made up of thousands of leading scientists from around the world, has created a suite of 25+ global climate models (GCMs) from different institutions with which to predict future trends.

The IPCC models were created independently and vary substantially in their output. Yet most of the uncertainty in future conditions comes not from the models themselves, but from estimating how much action will be taken to reduce greenhouse gas emissions in the future. The different possible greenhouse gas concentrations (called Regional Concentration Pathways, or RCPs), depend on whether the international community cooperates on reducing emissions.

In this report, we provide projections based on a lower emissions pathway where emissions are greatly reduced (RCP 4.5) and a higher emissions pathway where emissions are only slightly reduced (RCP 8.5), which is similar to the current global trajectory.

A note about uncertainty

All models have uncertainty because complex processes are simplified, and assumptions are made about how the Earth's processes work. Therefore, different models show different trends in future climate. How much they agree or disagree with each other gives us information about uncertainty. The uncertainty is similar to other types of models that we use every day to make decisions about the future, including economic models, population growth models, and ecological system models.

Much of the data on future trends in this report are compiled from an "ensemble" or average across many GCMs, which have been adjusted or "downscaled" from the global scale (coarse) to local scales (fine) using climatological data that reflects variation across the local landscape. When ensembles are used, it is important to understand the range of variation among the different models, as it can be quite great. In general, precipitation projections are associated with higher uncertainty (more variation among models) while temperature projections are associated with lower uncertainty (more agreement among models). Also, short to medium-term projections have lower uncertainty than long-term projections.

[37] NOAA Climate Change: Atmospheric Carbon Dioxide

Global Trends

Global climate is changing quickly compared to past climate change throughout the Earth's history. Larger storms and severe heat waves increased in both frequency and severity across most of the world[38]

The hottest year on record was 2016 (Figure 26). The average global temperature for 2016 was 1.7° F (about 1° C) above the 20th century average[37]. The last few years have also seen record-breaking, climate-related weather extremes. In the U.S., there were 18 weather- and climate-related events that cost more than $1 billion each in 2022, making it the third largest total on record ($165 billion) since 1980[39].

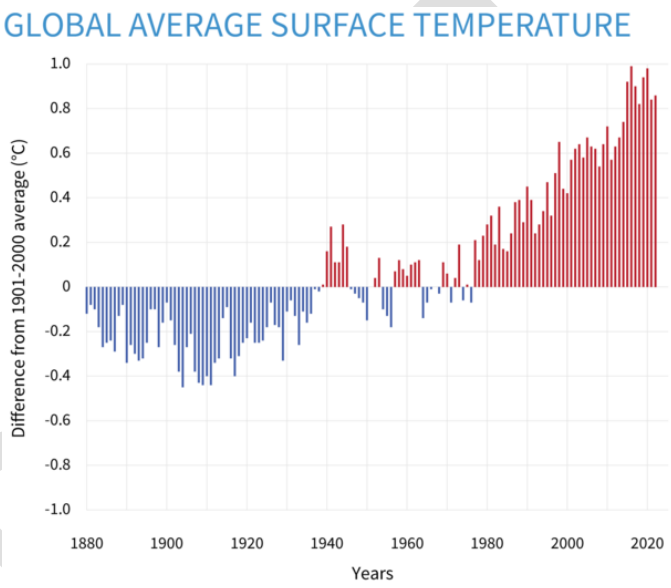

Figure 26. Yearly surface temperature compared to the 20th-century average from 1880–2022. Blue bars indicate cooler-than-average years; red bars show warmer-than-average years (Climate Change: Global Temperature, 2023).

Models project continued average global warming of 5.0° to 10.2° F (2.8° to 5.7° C) by the end of this century and continued warming for the next two centuries if emissions continue to increase (Figure 27)[37] Because higher latitudes (closer to the poles) warm faster than areas closer to the equator, the United States is expected to warm significantly more than the global average.

[38] Climate Science Special Report: Fourth National Climate Assessment, Volume I
[39] National Center for Environmental Information

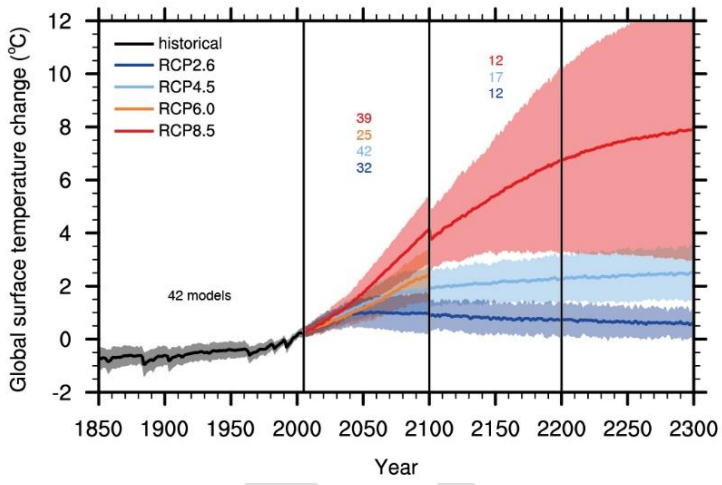

Figure 27. Global average surface temperature projections relative to 1986-2005. In this report, we provide projections based on a lower emissions pathway where emissions are greatly reduced (RCP 4.5) and a higher emissions pathway where emissions level off (RCP) (Schmittner, 2018).

Past and Future Trends in Indiana

Temperature

Since 1895, Indiana has seen an average temperature increase of approximately 1.2°F, or an average of 0.1°F per decade. However, since 1960, the average temperature increase is approximately 0.4°F, showing an increase in climate change's effects over time. By 2050, temperatures are projected to increase between 5-6° F under the medium and high emissions scenarios, respectively. By the end of the century, average temperatures are expected to be 6 to 10° F higher than the historical average[40].

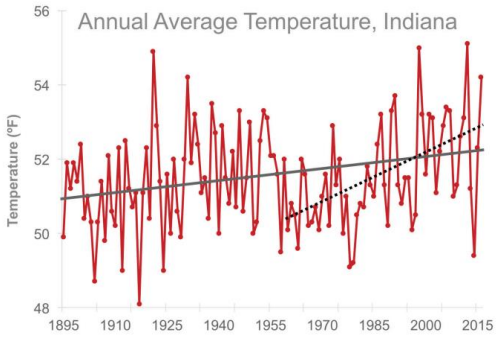

Figure 28. Statewide annual average temperature for Indiana from 1895 to 2016 is shown in red. The black solid line shows the increasing trend in annual temperature (0.1°F/decade) for the period from 1895 to 2016. The black dotted line shows the temperature trend since 1960 (0.4°F/decade). Image from Widhalm et al. (2018).

Similarly, maximum temperatures have increased decade-on-decade as well, with a marked increase from 1960 to present. Maximum temperatures from 1960 to 2016 have increased by an average of 0.3°F per decade; from 1895 to 2016, maximum winter and spring temperatures have increased by an average of 0.1°F per decade.

[40] Indiana's Past and future Climate: A report from the Indiana Climate Change Impacts Assessment.

Extreme cold days (where the minimum temperature was below 5°F) and frost days have decreased from 1960 to 2016 by 8 and 9 days respectively. The northern third of Indiana is expected to experience the most significant decreased in frost days, from an average of 13 days per year to only six days by 2050.

While there has not been an increase in extreme heat days (defined as days where the maximum temperature is over 95° F) from 1960 to 2016, they are projected to increase significantly in the future, from seven per year (present) to between 38 to 51 days per year.

Indiana Temperature Trends (1895 to 2016)

Variable	Winter	Spring	Summer	Fall	Annual
Tmax	0.1ºF	0.1ºF	- 1ºF	0ºF	0ºF
Tavg	0.1ºF	0.2ºF	0ºF	0.1ºF	0.1ºF
Tmin	0.2ºF	0.2ºF	0.1ºF	0.1ºF	0.2ºF

Units = ºF per decade

Indiana Temperature Trends (1960 to 2016)

Variable	Winter	Spring	Summer	Fall	Annual
Tmax	0.5ºF	0.6ºF	0.1ºF	0.2ºF	0.3ºF
Tavg	0.7ºF	0.5ºF	0.3ºF	0.2ºF	0.4ºF
Tmin	0.8ºF	0.5ºF	0.5ºF	0.3ºF	0.5ºF

Units = ºF per decade

Figure 29. Annual and seasonal temperature trends for Indiana from 1985 to 2016(top) and from 1960 to 2016 (bottom). Both tables show maximum temperature (Tmax), average temperature (Tavg), and minimum temperature (Tmin). Image from Widhalm et al. (2018).

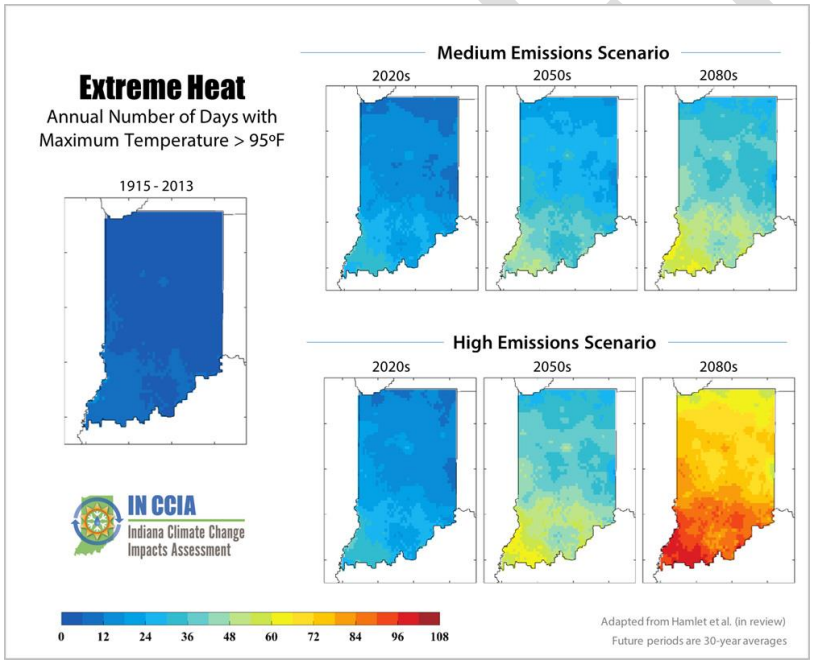

Figure 30. Maps showing the annual number of extreme heat days (maximum temperatures above 95°F) Image from Purdue University (n.d.).

Indiana's frost-free season has increased by nine days since 1895. By the middle of the century, the number of frost-free days is projected to increase by between 3.5 and 4.5 weeks.

Annual precipitation in Indiana has also increased significantly since 1895. Average annual precipitation has increased by 5.6 inches, and different regions of the state have seen different amounts of increase. In the future, rainfall is expected to increase by approximately 6-8%, depending on the emissions scenario. This increase is not expected to fall evenly throughout the year - multiple climate models suggest a high likelihood of more precipitation during the winter and spring months, with less certainty about changes in precipitation during the summer and fall.

Indiana's risk of drought conditions in the future is also worsening. The frequency of drought conditions is expected to increase, particularly during the later parts of the growing season[41].

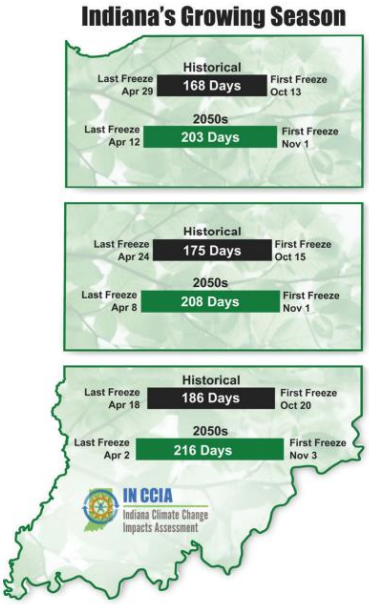

Figure 31. Growing season length and average first/last freeze dates for northern, central, and southern Indiana. 'Historical' is the average for the period 1915 to 2013. For future projections, '2050s' represents the average of the 30-year period from 2041 to 2070 for the high emissions scenario. Imagen from Widhalm et al. (2018).

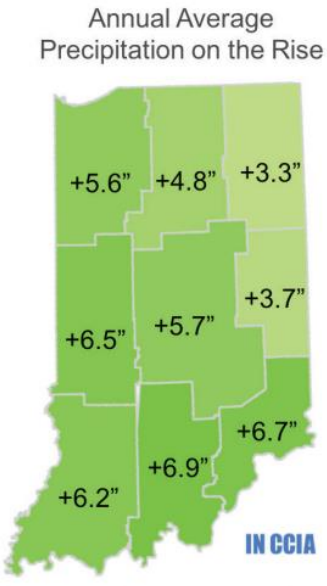

Figure 32. Increase in annual precipitation for Indiana's nince climate divisions, based on a linear trend, from 1985 to 2016. image from Widhalm et al. (2018).

[41] Climate change impacts and strategies for adaptation for water resource management in Indiana.

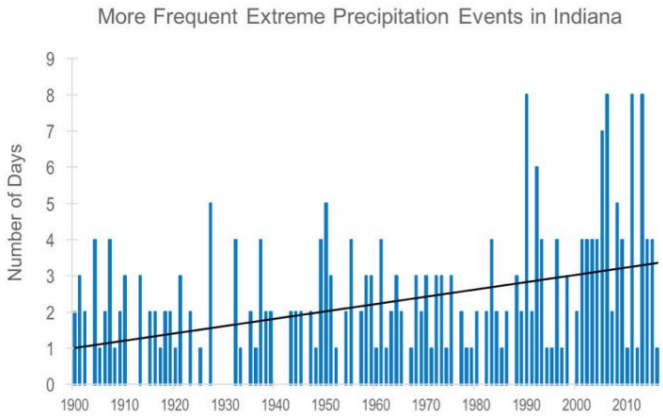

Figure 33. The number of days with precipitation events that exceed the 1900 to 2016 period's 99th percentile for Indiana (statewide average). The black line represents the trend line (0.2 days/decade) for the 1900 to 2016 period. Image from Widhalm et al (2018).

Past and Future Trends in Carmel

Temperature

This section of the report focuses on two types of temperature data: the annual highest maximum temperature and the annual average maximum and minimum temperature. These data points are derived from the models used to analyze climate trends.

The annual highest maximum temperature refers to the hottest temperature recorded in a specific year over a 30-year period, whereas the annual average maximum temperature represents the average of all maximum temperatures recorded throughout the year.

Understanding the difference between these two values helps to gauge how much the highest temperature each year deviates from what is considered normal for a specific period.

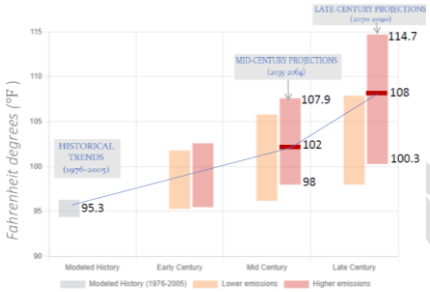

Figure 34. Annual single highest maximum temperature. Source: Adapted from Climate Mapping for Resilience and Adaptation. Retrieved from Leslie Webb's Climate trends presentation.

Historical - The highest temperature in Hamilton County was calculated for a 30-year period 1976-2005. Over this period, the annual single highest maximum temperature was 95.3°F[42] (Figure 34). The annual average maximum temperature for Carmel was 61.8°F.

Examining the seasonal data, the city of Carmel has experienced moderate temperatures historically. The average temperature during winters was 37.2°F, while springs had an average around 62°F. Summers brought average temperatures of 83.7°F, and Falls settled at an average of 64.2°F (Figure 35~~Figure 35~~).

However, in recent times, Carmel has been encountering higher temperatures. The current annual highest temperature has risen to 97.3°F. Additionally, the seasonal data indicates an average increase of 3°F across all four seasons. These changes are particularly notable in winters and summer (Figure 35~~Figure 35~~).

[42] Climate Mapping for resilience and adaptation: Extreme heat. Indicator: annual highest maximum temperature.

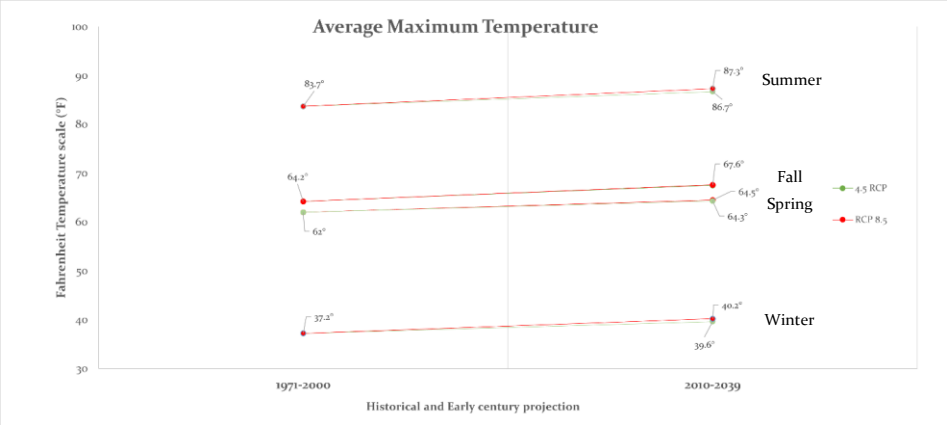

Figure 35. Historical and current data temperatures for n Carmel. Source: Adapted from Hegewisch, K.C., Krosby, M."Future Vegetation" web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on [Jul 2023].

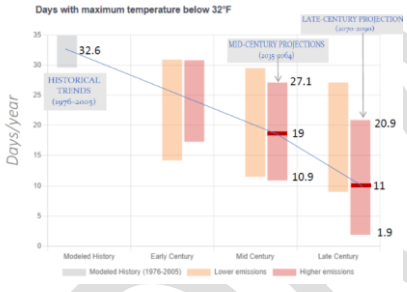

Figure 36. Number of days per year below freezing. Source: Adapted from Climate Mapping for Resilience and Adaptation. Retrieved from Leslie Webb's Climate trends presentation.

Upon analyzing the annual average minimum temperature for Carmel, it was observed to be 41.6°F [43]. Further examination of historical data reveals a noticeable shift in the minimum average temperatures for the city. In the past, Carmel experienced relatively cooler winters, with temperatures averaging around 20.8°F. Springs were milder, with temperatures averaging 40.8°F. Summers brought warmth, reaching an average of 62°F, while fall temperatures averaged around 42.6°F (Figure 37~~Figure 37~~).

Historical records show that in the past, there were approximately 32.6 days per year below freezing. However, with projections into the future, it is expected that this number will decrease significantly. By the midcentury, the average number of days below freezing is predicted to be around 19 days, and by the late century, it could further reduce to just 11 days. These patterns imply a shift towards milder winters, potentially reducing snowfall. Concurrently, across all seasons, an average temperature increases of approximately 3°F underscores warmer springs and falls, and hotter summers. (Figure 36~~Figure 36~~).

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[43] Climate Toolbox. Climate Tracker. Indicator: Average minimum temperature

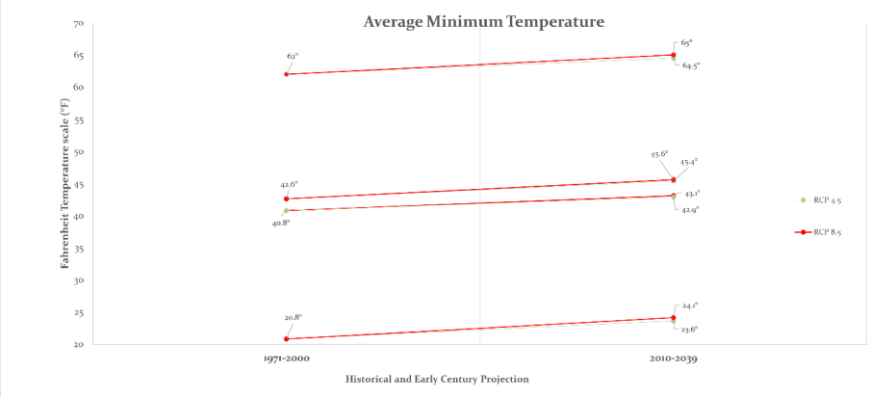

Figure 37. Historical and current data average minimum temperatures in Carmel. Source: Adapted from Hegewisch, K.C., Krosby, M."Future Vegetation" web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on [Jul 2023].

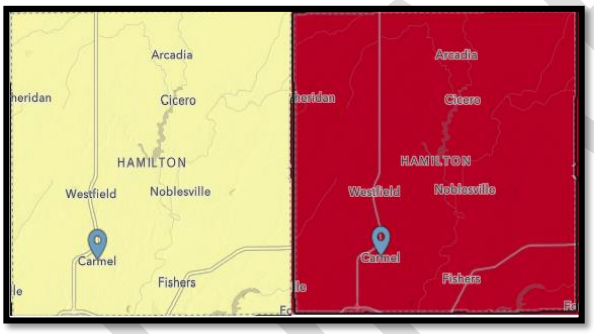

Figure 38. Annual highest temperature shown for two time periods. Historical (1976-2005) (left) and Late-century (2070-99) (right), based on a higher emission pathway. Data ensemble from CMRA.

Projections - The annual single highest temperature in Hamilton County is expected to rise by 0.9°F[44]. Under the lower emissions scenario, this increase in maximum temperature is projected to reach a 100.5°F (+4.8°F) by mid-century. However, under the higher emissions scenario, the increase is expected to be more significant, reaching 101.9°F (+10.1°F). By the late century, assuming continued high greenhouse gas emissions, temperatures are projected to reach 100.5°F (lower scenario) and 107.1°F (higher scenario)[45] (Figure 38).

Looking at the current trends under the RCP 8.5 scenario, Carmel is already witnessing noticeable increases in temperature across all seasons. Winter is becoming warmer with maximum temperature reaching 40.2°F. Spring and summer temperature are reaching 64.3°F and 87.3°F, respectively, while fall temperature peak at 67.6°F. As the city moves towards the mid-century, the changes are expected to be more pronounced. The RCP 8.5 scenario projects maximum temperatures of 43°F, 67.4°F, 91.1°F, and 71°F for winter, spring, summer, and fall, respectively. Meanwhile, under the RCP 4.5 scenario, the projections show slightly lower maximum temperatures: 41.8°F for winter, 66.2°F for spring, 88.9°F for summer, and 69.4°F for fall. Looking further into the late century, the anticipated temperature increases become more significant. Under the RCP 8.5 scenario, maximum temperatures are expected to soar to 46.5°F, 70.5°F, 95.4°F, and 75°F for winter, spring, summer, and fall, respectively. Similarly, the RCP 4.5

[44] Climate mapper - Climate toolbox
[45] Climate Mapping for resilience and adaptation: Extreme heat. Indicator: annual highest maximum temperature.

scenario projects maximum temperatures of 42.5°F, 67.2°F, 90.1°F, and 70.5°F for winter, spring, summer, and fall, respectively (Figure 39~~Figure 39~~). All four seasons will be reaching warmer temperatures compared to historical data.

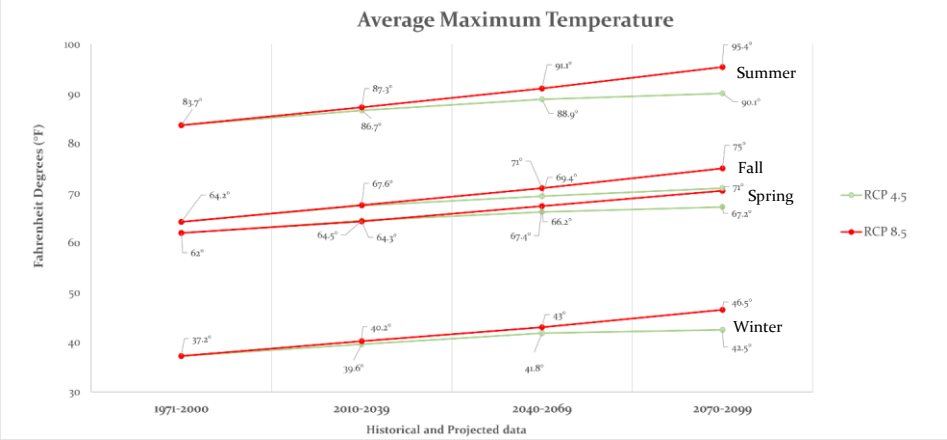

Figure 39. Historical and projected data for average maximum temperatures in Carmel. Source: Adapted from Hegewisch, K.C., Krosby, M. "Future Vegetation" web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on [Jul 2023].

In terms of average minimum temperature, the projections for the mid and late-century periods also indicate further increases. For the 2040-2069 period, the estimated values show and upward trend with minimum temperatures of 25.8°F in winter, 44.7°F in spring, 66.3°F in summer, and 47.1°F in fall. Under the RCP 8.5 scenario, the projections show even higher temperatures, reaching 27°F in winter, 45.9°F in spring, 68.3°F in summer, and 48.5°F in fall.

Moving into the late-century period, the projections continue to show rising temperatures. Under the RCP 8.5 scenario, the estimates are projected to be 27°F in winter, 45.9°F in spring, 68.3°F in summer, and 48.5°F in fall. Meanwhile, under the RCP 4.5 scenario, the anticipated minimum average temperatures are slightly lower, with values of 26.6°F, 45.5°F, 67.3°F, and 48°F for winter, spring, summer, and fall, respectively (Figure 40).

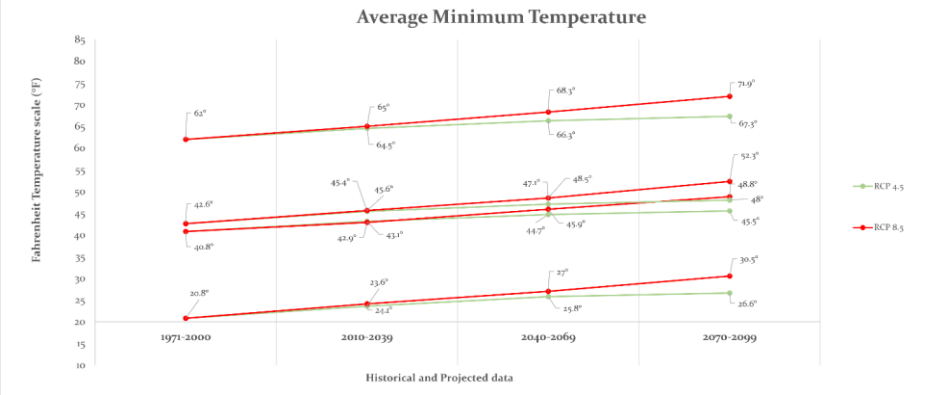

Figure 40. Historical and projected data for average minimum temperatures in Carmel. Source: Adapted from Hegewisch, K.C., Krosby, M. "Future Vegetation" web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on [Jul 2023].

Extreme events, particularly severe heat, pose a significant health threat that is anticipated to intensify due to climate change. The frequency of days with exceptionally high temperature, exceeding 95 degrees, is expected to escalate further. Historical data indicates a range of 1.8 days annually, while projections indicate an increase to 22.7 days by mid-century and 53.6 days by late century under a higher emissions scenario (RCP 8.5). Alternatively, a lower emissions scenario (RCP 4.5) suggests 15.5 days by mid-century and 22.7 by late century, respectively, showcasing the potential severity of the issue[46].

The occurrence of extreme heat will have multiple consequences. It will adversely affect air quality, prolong the allergy season, and create more favorable conditions for pests and invasive species[47]. Simultaneously, the frequency of cold days is projected to decline. In the historical data, there were approximately 32.6 cold days, but under the higher emissions scenario, this number is expected to decrease to 18.5 days by mid-century and 10.7 days by late-century. Conversely, under a lower emissions scenario, a more optimistic outlook suggests 20.4 days and 17.7 days by mid-century and late century, respectively[48]. It's important to acknowledge that colder weather helps control disease-carrying insects such as mosquitoes. Therefore, warmer winters would enable these species to remain active for longer periods potentially increasing the number of deaths attributed to extremely hot days (Figure 41).

[46] Climate Mapping for resilience and adaptation: Extreme heat. Indicator: annual highest maximum temperature.
[47] Indiana's Past & Future Climate A report from the Indiana Climate Change Impact Assessment p.1
[48] Climate Mapping for resilience and adaptation: Extreme heat. Indicator: annual highest maximum temperature.

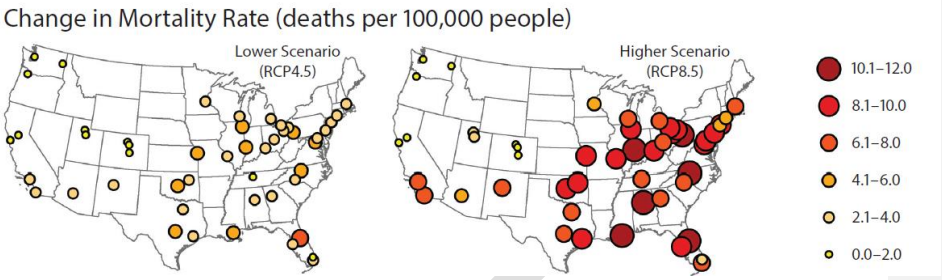

Figure 41. Estimated change in annual net mortality rate due to extremely hot days. Deaths are halved if emissions are reduced (left map). Adapted from: : Climate Trends Primer: Louisville Metro Region, Kentucky.

Precipitation

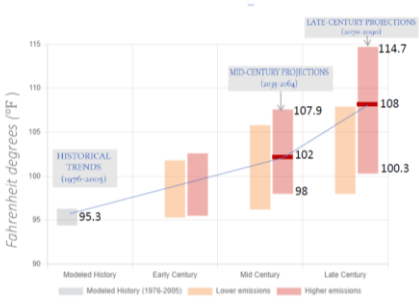

Figure 42. Average annual precipitation historical data and projections. Source: Adapted from Climate Mapping for Resilience and Adaptation. Retrieved from Leslie Webb's Climate trends presentation.

Historical - The average precipitation in Carmel was determined based on a 30-year period spanning from 1976 to 2005. During this timeframe, the annual average precipitation amounted to 39.6 inches [49] (Figure 42). Due to the unavailability of specific snowfall data for Carmel, information regarding snowfall patterns was sourced from the nearby city of Indianapolis. As Carmel and Indianapolis are situated in the same region of Indiana, it is expected that regional changes in snowfall would have a similar impact on both cities. In Indianapolis, over the past 50 years, there has been an observed decline of 8.5% in average snowfall. This reduction translates to 1.5 inches less snowfall during the fall season and 2 inches less during the winter season. These findings suggest a broader regional trend that could potentially affect Carmel as well[50].

Projections - Average annual total precipitation in Carmel will increase in the future. Under a continued higher emissions scenario, it is expected to rise by an average of 7.8% by mid-century and 10.1% by late-century. With a lower emissions scenario, the increase is more modest, projected to be around 5.3% by mid-century and 5.5% by late-century. It is important to note that precipitation projections exhibit a high degree of variation among different models, ranging from drier to wetter outcomes (Figure 42).

The increased precipitation levels will contribute to the accumulation of water from sources such as heavy rainfall events. This, in turn, raises the risk of flooding, which can have significant human and economic consequences. Urban lands are at risk of inundation, while navigation in roads, rivers, and reservoirs near Carmel may be disrupted.

[49] Climate Mapping for resilience and adaptation: Flooding. Indicator: average annual total precipitation
[50] Indiana environmental reporter: Snowfall rates decreased significantly in fall, spring over las 50 years.

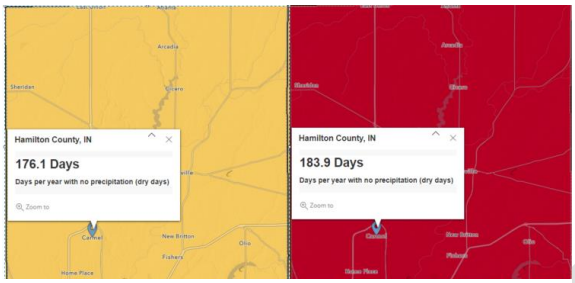

Figure 43. Days per year with no precipitation (dry days). Historical (1976-2005) (left) and Late-century (2070-99) (right), based on a higher emission pathway (RCP8.5). Source: Hegewisch, K.C., Krosby, M."Future Vegetation" web tool. Climate Toolbox (https://clim

Extreme events, particularly drought stress, pose a significant challenge as climate change progresses. The frequency of dry days, characterized by the absence of precipitation, is anticipated to increase. Under a higher emissions scenario, it is projected to rise by 2.3% by mid-century and 4.3% by late-century. However, with a lower emissions scenario, the increase is expected to be more moderate, halving to 1.8% by mid-century and 2.6% by late-century[51] (Figure 43).

As temperatures rise, the subsequent increase in evaporation rates can contribute to drier soils and reduced runoff into rivers and streams. This exacerbates the risk of drought conditions. However, it is important to note that despite the prevalence of drought, there is also a concurrent increase in the frequency and intensity of extreme precipitation events. Consequently, both drought and flooding events may become more common in certain regions.

Dominant Vegetation

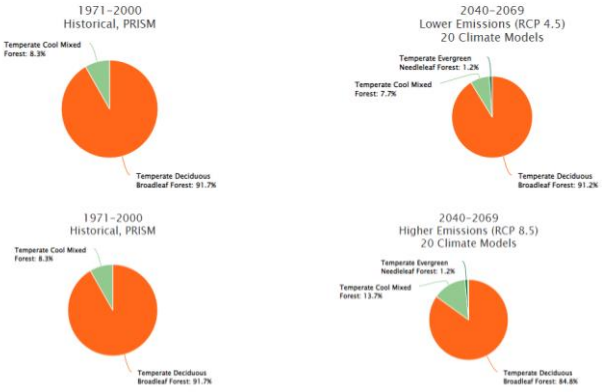

Figure 44. Changes in Modeled Vegetation Type. Carmel, IN. Source: Hegewisch, K.C., Krosby, M."Future Vegetation" web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on [Jun 2023].

Historical - Carmel has been predominantly covered by temperate deciduous broadleaf forest, accounting for 91,7% of the area (Figure 44). This type of tree is well adapted to withstand the variations in temperature associated with the four seasons. During the fall, leaves change color and start to drop in preparation for the winter season. Trees have adapted to withstand the winter by going into a period of sleep. Over spring and summer comes the growing season and trees flower and grow again[52].

Projections - In general, the forest of the city is expected to gradually change in vegetation type due to climate change. This implies that the ecosystem services provided by the forests[53], such as improving air quality, sequestering carbon, conserving energy, and managing stormwater, will also

[51] Climate Mapping for resilience and adaptation: Drought. Indicator: days per year with no precipitation (dry days).
[52] Nasa earth observatory. Temperate deciduous forest
[53] Tree management plan, City of Carmel, Indiana. p3

undergo changes. The forest density is expected to decrease to 84.8% under a higher emissions scenario and to 91.2% under a lower emissions scenario by mid-century (Figure 44), and new vegetation better adapted to a more consistent temperature regime, resembling those found closer to the equator, will begin to establish. These new plants may exhibit different characteristics, such as thin waxy needles instead of broad leaves, and their color may not change significantly with the changing seasons.

Climate change will accelerate this transition, significantly altering local conditions. Some areas that become too wet or warm may no longer support the current common species found in the Carmel forest. Moreover, the frequency and severity of extreme events, such as strong winds, flooding, drought, or tornadoes, may increase because of these climatic shifts.

Wildfire

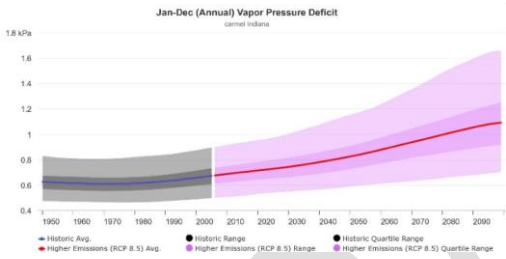

Figure 45. Historic Vapor Pressure deficit value and projected values under higher emissions scenario (RCP 8.5) by mid and late-century. Source: Hegewisch, K.C., Krosby, M."Future Vegetation" web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on [Jun 2023].

Historical - Data was utilized to calculate the average Vapor Pressure Deficit (VPD) over a 30-year period from 1971 to 2000, yielding an average VPD of 0.6kPa[54] (Figure 45). VPD serves as a measure of the moisture content in the air relative to the maximum amount of water vapor that can exist within that air. Lower VPD values indicate air that is closer to saturation, indicating wetter conditions. Conversely, higher VPD values indicate a larger moisture deficit, signaling drier conditions. In Hamilton County, these drier conditions make the region prone to experiencing 73 days of 'high' fire danger and 11 days of 'extreme' fire danger, as indicated by historical patterns.

Projections - Anticipated changes in VPD (Vapor Pressure Deficit) reveal a noticeable pattern. By mid-century, under a lower emissions scenario it is expected to rise to 0.8 kPa. Under a higher emissions scenario, it is projected to reach 0.9 kPa. More worryingly, by late century, the average VPD might reach 1.0 kPa, under the influence of a higher emissions scenario. This larger moisture deficit (Figure 45), will result in drier conditions, leading to increased tree mortality. This effect will be particularly evident in densely packed stands of trees where competition for water becomes pronounced.

Figure 46. Transition in days of 'high' fire danger historical and future projections. Source: Source: Hegewisch, K.C., Krosby, M."Future Vegetation" web tool. Climate Toolbox (https://climatetoolbox.org/) accessed on [Jun 2023].

Consequently, the elevated moisture deficit and drier conditions will significantly escalate the risk of wildfires. Under a lower emissions scenario, the number of days classified as 'high' fire danger is projected to increase to 89.6 days by mid-century, while under a higher emissions scenario, it is expected to reach 102.7 days.

[54] Climate toolbox-climate tracker

Additionally, under a lower emissions scenario, the occurrence of 'extreme' fire danger is expected to increase by 5.2 days compared to historical values, reaching 16.1 days. Under a higher emissions scenario, this increase is projected to be even more significant, with 'extreme' fire danger lasting for 24.1 days (Figure 46).

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Appendix 2: Community Trends

Carmel is ranked as the number one best place to live in Indiana and 18th in the U.S for best suburbs to live[55]. Carmel has a strong sense of community, spectacular views, and diverse outdoor opportunities. This could change, however, as our world changes with climate change, population growth, development, and other stressors. As the City of Carmel works to prioritize its climate vulnerabilities to strengthen long term resilience, it is important to identify the features and values that create Carmel's vibrant quality of life. This primer provides an overview of some major characteristics of how Carmel currently functions. This information will help local community members to assess which people and resources are expected to be most vulnerable to climate change impacts.

Overview of natural systems

The natural environment is important for Carmel. The city has implemented various initiatives to protect natural areas, promote sustainability, and provide residents with opportunities to connect with nature. Since people choose to live, work, and travel to Carmel because of the surroundings and opportunities associated with the landscape, waterways, and urban forest, this section will provide a short overview of current conditions, ongoing stressors, and potential future trends related to the natural environment in Carmel.

Forests – Carmel takes pride in its outstanding urban forestry program, which aims to promote and preserve the urban forest while enhancing the management of public trees[56]. These trees offer numerous physical benefits, including carbon sequestration (2,009 tons), noise reduction, absorption of particulate pollution (17,331 pounds of pollutants removed), provision of cooling and shade areas (943,931 Kilowatt-hours (kWh)), and reduction of storm runoff (37,559,345 gallons)[57]. In April 2018, a comprehensive street tree inventory was conducted in Carmel, documenting a remarkable total of 29,235 trees.

The inventory revealed that red and sugar maple were among the most prevalent species. However, it is important to note that certain tree species, such as maples, may face challenges as forests age due to their poor adaptation to anticipated warmer and drier summer conditions projected by climate models. Consequently, changes in forest composition have the potential to decrease forest productivity and carbon uptake.

Moreover, the 2018 management plan report highlighted the crucial role of planting new trees in Carmel to maintain and expand the canopy cover. This is particularly important as the city faces tree losses due to natural causes and threats like construction and invasive species, which can thrive under changing climatic conditions and pose challenges to the native ecosystem. To offset these losses, increase canopy coverage, and maximize the associated benefits, it is recommended to plant a minimum of 522 trees annually[2], selecting a diverse range of species.

Furthermore, climate change has the potential to amplify the frequency and intensity of extreme weather events such as storms, hurricanes, and wildfires. These events can result in damage to the infrastructure of parks, the vegetation within them, and the habitats of wildlife. Additionally, they may

[55] Niche. (2023).Best Places to Live in Indiana.https://www.niche.com/places-to-live/search/best-places-to live/s/Indiana/
[56] Tree management plan. City of Carmel, Indiana. June 2018.
[57] Tree management plan. City of Carmel, Indiana. June 2018

pose safety risks to both visitors and park staff, requiring appropriate measures to mitigate and address these challenges.

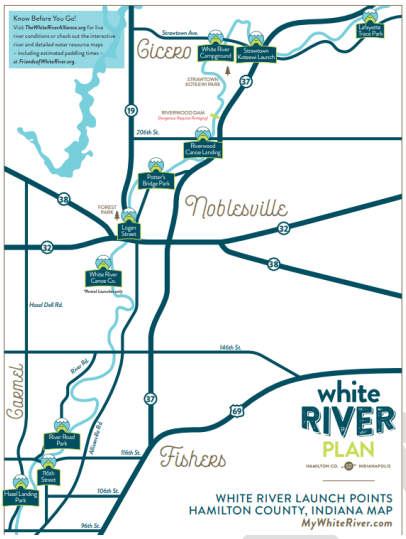


Figure 47. White Rivers access map. Sources: Hamilton White River

Waterways - The city of Carmel is located within the White River watershed (Figure 47). It is major waterway that flows through the region and plays a crucial role in the overall hydrology of Carmel and the surrounding areas offering opportunities for boating, fishing, and other recreational activities[58]. Carmel is a landlocked city, and it does not have any major natural water bodies within its borders. However, there are some lakes and ponds in and around providing recreational opportunities such as Cool Creek in Westfield that runs through the southern part of the city providing scenic beauty and recreational opportunities. Carmel has several reservoirs and lakes near the city, including Morse Reservoir, Geist Reservoir, and Eagle Creek Reservoir. These bodies of water provide opportunities for boating, fishing, and water-based recreation.

Climate change can have several impacts on rivers and waterways such as the White River. With change in rainfall patterns resulting in more frequent or intense rainfall, water levels can overflow, leading to increase flood risk or water availability during different seasons. Warmer conditions can increase streamflow by enhancing evaporation, leading to more moisture in the atmosphere and resulting in increased precipitation. This higher volume of water affects streamflow and can impact water quality[59]. These changes can have implications for the health of the White River ecosystem including water quality for recreation uses.

Parks- The City of Carmel has a strong focus on green spaces and outdoor recreation, offering a wide range of parks and facilities for residents and visitors to enjoy[60]. Central Park is one of the largest (161 acres) and most popular, hosting community events (Figure 48). Prairie Meadow Park (13-acre) showcases natural prairie landscapes. Flowing Well Park is known for its artesian well, where visitors can fill their water containers with natural spring water. Founders Park located in the Carmel's Arts & Design District offers a serene environment with landscaped gardens. West Park is a neighborhood park with a variety of recreational amenities. All these areas provide residents with access to walking trails, bike paths, playgrounds, and picnic areas while preserving the city's natural beauty[61].

Figure 48. Central Park Carmel, Indiana. Source: VisitHamiltoncounty.com

[58] White River. Visit Hamilton County Indiana.
[59] Environmental Resilience Institute. Sustainable water resources in Indiana in a changing world. Predicting water access and sustainability.
[60] Carmel, Clay Park & Recreation. Carmel, Indiana government website/parks
[61] Carmel, Clay Park & Recreation. Carmel, Indiana government website/parks

Changes in Climate change can have impacts on the green areas of the city with increased heat and extreme temperatures altering the comfort and safety of park visitors, particularly in summer. Parks may experience increased flooding risks during heavy rainfall increasing the potential damage to park infrastructure, trails, and amenities. Prolonged drought conditions can result in water scarcity, affecting the health and vitality of park vegetation and waterways such as the White River.

Air Quality - Carmel generally benefits from good air quality [62] (Figure 49~~Figure 49~~). However, in late June and early July 2023, the city experienced several alerts due to the haze caused by wildfires in Canada, which had an impact on central Indiana. The Indiana Department of Environmental Management issued these alerts due to elevated levels of the main pollutant particulate 2.5 and the presence of smoke spreading across the state due. Initial precautions indicates that high levels of fine particle can settle deep into the lungs and can irritate the lungs and cause respiratory issues[63]. The situation highlighted the local repercussions of global issues.

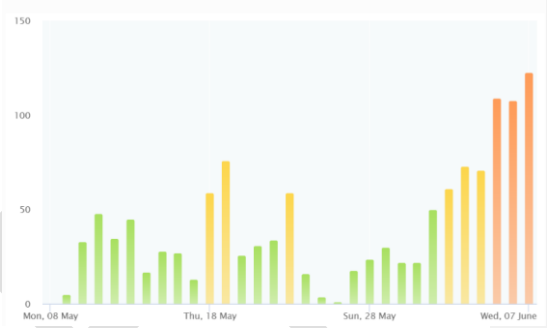


Figure 49. Historic air quality Index (AQI) graph for Carmel, IN. Source: IQAir.

[62] IQAir and Air Now portals/ Historic air quality Index (AQI)
[63] Indiana Department of Environmental Management/ Air quality/ Near-real Time Air Quality Maps and Data.

Overview of Economic systems

Carmel has a robust socioeconomic system that contributes to its status as a desirable place to live, work and raise a family[64]. This section will provide a short overview of current conditions, ongoing stressors, and potential future trends related to the Carmel Community.

1. Demographics

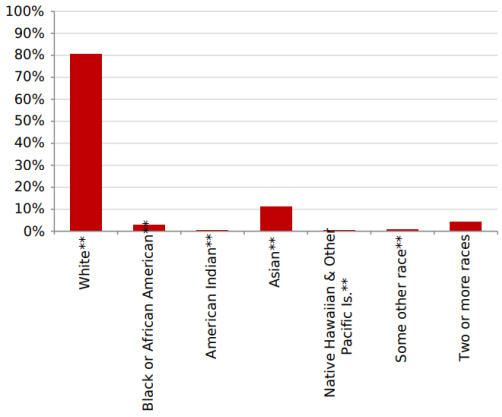


Figure 50. Population by race in Carmel, IN, 2021. Source: Census Bureau, Economic Profile System

Population - Growth is an indication of a healthy economy. Growth can benefit the general population of a place, especially by providing economic opportunities, but it can also stress communities and lead to income stratification. Carmel has a population of 101,954 (2022). From 2000-2021 Carmel has grown 88.1%[65] and is expected to grow to 120,190 by 2030[66]. About 80.5% of the population identifies as white, 11.1% as Asian and 4.0% as Hispanic or Latino. Other race or ethnicities identify as Black or African American (2.8%), two or more races (4.3%) and American Indian (0.5%)[67] (Figure 50~~Figure 50~~).

The sex distribution is 51.9% female persons and 48.6% male. The age distribution is: under 18 years-25.4%, persons 65 years and over-14.1%, persons 80 years and older-1.8% and under 5 years-5.3%[68] (Figure 51). Carmel has a population density of 1,668 people per square mile and it's the 4th largest city in Indiana[69]. This information helps us understand whether policy changes and management actions might affect some age groups more than others, and the different needs, values, and attitudes that community members might have.

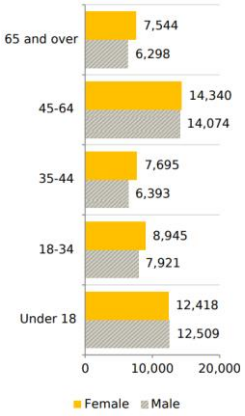


Figure 51. Age and gender distribution. Source. Census bureau and Economic Profile System

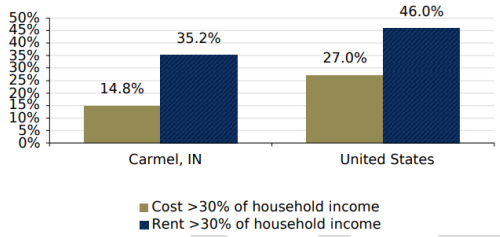
[64] City of Carmel official government website/Living in Carmel
[65] Biggest US cities/Carmel-Indiana
[66] Estimates from the Department of Community Services Staff
[67] United States Census Bureau
[68] United States Census Bureau
[69] Biggest US cities/Carmel-Indiana

Employment and the Economy - The city's economy is characterized by a diverse range of industries, including finance, healthcare, technology, and manufacturing. The top three sectors are Finance and insurance 11% (health, financial services, workforce benefits), retail trade 10% (gasoline stations, clothing and accessories, and miscellaneous stores) and professional and technical services 10%[70] (Figure 52~~Figure 52~~). 71.1% of Carmel residents are among those 16 and older that are in the labor force[71]. Employment rates are 66% full-time, 18% part-time and 16% do not work. The unemployment rate is 2.0% lower than the state[72]. The distribution of household income is 6% <$25k, 36% $25k to $100k and 58% >$100k[55] with a median household income of $119,772[55].

Percent of Total				Percent Change 1990-2000
Total Employment				91.3%
Non-Services Related	39.1%	23.1%	19.5%	61.2%
Farm	10.6%	1.6%	1.0%	18.6%
Agricultural services, forestry, fishing & o	0.5%	1.8%	1.4%	48.6%
Mining (including fossil fuels)	0.4%	0.6%	0.3%	4.7%
Construction	6.8%	9.0%	7.6%	62.6%
Manufacturing (incl. forest products)	20.9%	10.2%	9.2%	72.0%
Services Related	46.2%	67.8%	72.3%	104.1%
Transportation & public utilities	2.9%	5.9%	2.3%	-25.4%
Wholesale trade	4.5%	8.0%	5.9%	40.9%
Retail trade	16.7%	17.2%	18.2%	102.2%
Finance, insurance & real estate	7.4%	12.3%	17.3%	170.1%
Services	14.7%	24.5%	28.7%	124.2%
Government	14.7%	9.1%	8.2%	72.8%

All employment data are reported by *place of work*. Estimates for data that were not disclosed are indicated with tildes (~).

Figure 52. Employment sector for Hamilton County. Source: Economic Profile System.



75.3%[73] of housing units are occupied by their owners, and 24.4%[55] by renters (Figure 53~~Figure 53~~). The median value of owner-occupied housing units is $372,100[58], and the median gross rent is $1,348[58].

Figure 53. Housing costs as a percent of household income. Source: Census Bureau and Economic Profile System

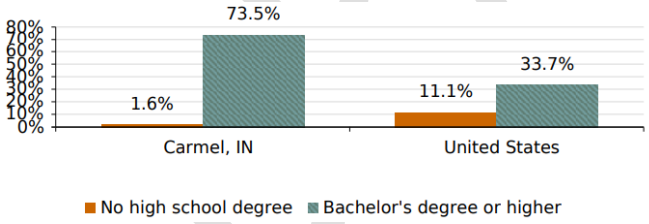


Figure 54. Educational Attainment. Source: Census Bureau and Economic Profile System

The education level: 97.9% of Carmel residents have at least a high school degree or equivalent, 70.6% have a bachelor's degree and 30.2% have a graduate or professional degree[59] (Figure 54~~Figure 54~~).

13.1% of Carmel residents aged 5 and older speak a non-English language at home. Broken down by language: 2.3% of residents speak Spanish at home, 3.3% speak an Indo-European language, and 6.8% speak an Asian language[74].

[70] Economic Profile System
[71] United States Census Bureau
[72] DWD Indiana Department of Workforce development- Hoosier by the numbers
[73] United States Census Bureau
[74] Biggest US cities/Carmel-Indiana

Tourism, Recreation and Quality of life

Figure 55. Jurisdiction & Park Locations. Source: Carmel Clay Parks & Recreations

The City of Carmel provides a visual diversity of arts scene, different local food options and hundreds of miles of walking and biking trail. These cultural attributes make the city one of the best places to live in America, a place people are excited to call home.

Having access to places for physical activity such as parks encourages people to get active and enjoy outdoor activities. Walking and biking to parks can decrease air pollution. 47.9% of people living in Hamilton County live within half a mile of a park[75].

20 parks and greenways are managed and maintained by Carmel (Figure 55~~Figure 55~~). In partnership with Indiana Wildlife Federation, the city park system is certified as wildlife and habitat-friendly[76].

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Health Trends and Vulnerabilities

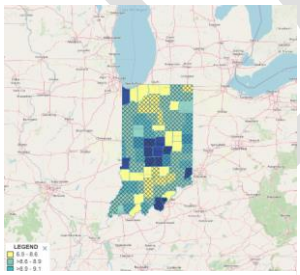

Figure 56. Historical Air Quality PM2.5 annual average concentration in Indiana. Source: CDC National Environmental Public Health Tracking Networks.

Disabled people are less likely to have health insurance and being confined to a bed raises mortality during extreme heat events. In Carmel, people with disabilities represents 6.4% and without health insurance 3.4%[77].

Air pollution is a leading environmental threat to human health. Particles in the air like dust, dirt, and smoke are one kind and can lead to breathing problems, asthma symptoms, some heart conditions and low birth weight[78]. The national standard for annual PM2.5* is 12.0µg/m3. Wherever the levels are above that limit, it means that air quality is likely to affect people's health. For Hamilton County the average concentration is 10.2 µg/m3**. However, monitoring current

[75] National Environmental Public Health ephtracking
[76] Carmel Clay Parks & Recreation website
*Particles that are 2.5 microns or less in diameter (PM2.5)
**Micrograms per cubic meter
[77] United States Census Bureau
[78] Environmental Public Health Tracking- Centers for Disease Control and Prevention- Hamilton County, IN report/ air quality particulate matter.

air quality (airnow.gov) can help residents understand how the air quality changes and whether people should limit the amount of time spent outside (Figure 56~~Figure 56~~).

High levels of air pollution and extreme hot and cold temperatures have been linked to increases in heart disease and deaths from heart attacks. In 2020, there were 62 deaths from heart attacks in Hamilton County[79].

Heat can also pose threats to health and human safety such as fatigue, heat stroke, heat exhaustion, and heat cramps. This year the estimated days above 100 will be 10 days and in 30 years this number will go up to 23 increasing high risk of health issues[80].

Underrepresented Populations

Some populations are more likely to be exposed to environmental contaminants, experience serious impacts during natural disasters, and/or experience discrimination or a lack of opportunity that other groups have. These are considered disadvantaged populations, and these same groups are, unfortunately, likely to experience an inordinate share of impacts associated with climate change. According to the neighborhoods at risk portal (Figure 57~~Figure 57~~), in Carmel, potentially disadvantaged populations included people of color and Hispanics (1%), people with disabilities (3%), people without insurance (2.5%), people living close to flood zones (>2%), people living in areas lacking tree canopy (>78%) and people living in large areas of impervious surface (>29%)[81].

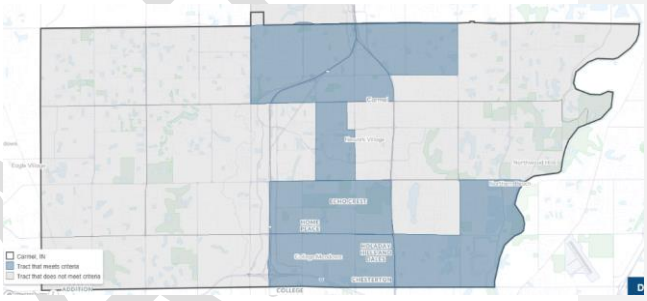

Figure 57. Tracts meeting criteria of underrepresented population. Source: Neighborhoods at risk.

[79] Environmental Public Health Tracking- Centers for Disease Control and Prevention- Hamilton County, IN report/heart attacks
[80] Risk Factor/Heat factor
[81] Neighborhoods at risk. Carmel, IN. People and Climate exposure variables.

Emergency Preparedness and Response.

There are 1,311 properties in Carmel that have a greater than 26% chance of being severely affected by flooding in the next 30 years[82]. This number represents approximately 6% of all properties in Carmel that are mainly located nearby White River or tributaries to the White River[83]. According to the FEMA map, the chances of the streams flowing as high as the 100-year flood is 1%, and 0.2% for the 500-yearflood magnitude in any given year (Figure 58~~Figure 58~~).

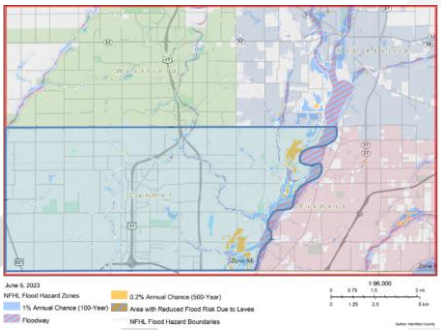

Figure 58. Flood Hazard Boundaries (FEMA). Source: Hamilton County General Viewer.

Severity of flooding can lead to damage and can also result in the disruption of essential services such as utilities, emergency services, and transportation.

Carmel's tornado index is 37[84]. A total of 171 historical tornado events have been recorded of a manifest 2 or above[85]. 108 thunderstorm events have been reported between 1996 and 2023 in Hamilton County.

Carmel is expected to see a 157.1% increase in the number of days over 101 over the next 30 years with the potential of affecting around 36,755 properties. The likelihood of 3+ day heat waves this year is 51% and in 30 years is 80%[86].

2. Infrastructure

Carmel has a well-developed and modern infrastructure that supports the needs of its residents and businesses. Here are some key aspects of the general infrastructure in Carmel:

Water Supply and Flood Control

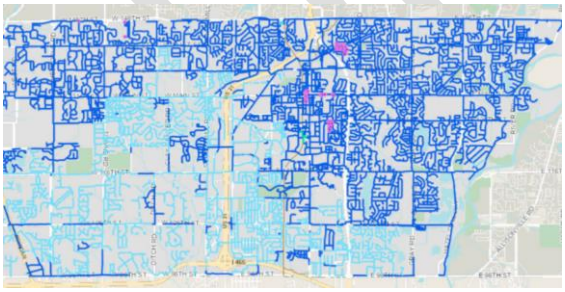

Figure 59. Carmel water pipes. Sources: Carmel GIS water Map viewer.

The Carmel utilities department is a municipal utility that oversees the provision of water, wastewater, and waste management services to residents and business in the city of Carmel[87] (Figure 59~~Figure 59~~). The White River plays a vital role in Carmel, providing a crucial groundwater supply in the West Fork White River basin. 20 wells pump water from the aquifer to four water plants for treatment. The city has some of the purest ground water in the state[88]. Tap water complies with Environmental Protection

[82] Risk Factor/Flood factor
[83] Flood insurance study Hamilton County, Indiana, and incorporated areas.
[84] The U.S. Tornado and Weather Extremes database of 1950-2010
[85] Climate and Hazard mitigation planning (CHaMP) Tool/extreme rainfall/hazards/flood
[86] Risk Factor/Heat factor
[87] City of Carmel/Utilities official website
[88] City of Carmel Utilities/Water

Agency and Indiana state standards[89]. In summer, the average family's water use is 320 gallons per day and as temperatures rises in the summer it can go up to 1,000 gallons per day, some even uses 3000 gallons per day[90].

The Wastewater Treatment Plant is located at 96th Street and Hazel Dell Parkway. Since 2021 it has expanded its capacity from 12 million gallons per day to 14 million gallons per day[91] (Figure 60~~Figure 60~~).

Figure 60. 2021 Wastewater Treatment Plant Expansion/One new final clarifier. Source: City of Carmel Utilities.

The City of Carmel covers approximately 32,050 acres and the Municipal Separate Storm Sewer System (MS4) jurisdictional boundary mirrors the city boundaries[92] (Figure 61~~Figure 61~~). The Municipal Separate Storm Sewer System General permit (MS4GP) requires the city to implement six minimum storm water control measures to minimize the number of pollutants entering the storm water runoff (Figure 62~~Figure 62~~), which typically drains untreated, to the nearest waterway. The residential rate for storm water utility service is $4.95/month to every resident[93].

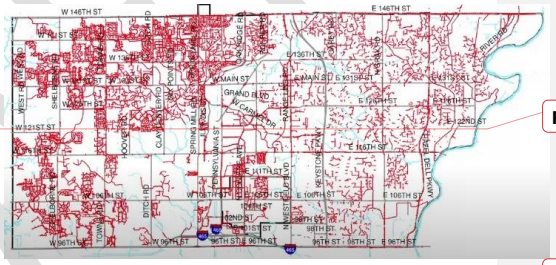

Figure 61. Carmel's stormwater system. Source: City of Carmel Utilities.

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[89] Water quality report. City of Carmel Utilities, 2019.
[90] Water quality report. City of Carmel Utilities, 2019.
[91] City of Carmel Utilities/Wastewater
[92] Storm Water Management City of Carmel Management Plan
[93] City of Carmel Storm Water Utility Video

Public Education and Outreach	• Place city staff to educate community with different events
Public Participation and Involvement	• Offer opportunities to the public to be actively involved in cleaning activities of individual waterways
Illicit Discharge Detection and Elimination	• Map with stormwater system and pass ordinance that prohibit illicit discharges and education of the public on how to recognize illicit discharges and prevent it
Construction Site Runoff Control	• Inspect and permit active constructions site
Post-Construction Site Runoff Control	• New development put in place control and treat storwater runoff
Good Housekeeping for Municipal Operations	• City requires good management practices that eliminates pollution of all city facilities

Figure 62. Stormwater control measurements to minimize pollutants entering storm water runoff. Source: Storm Water Management City of Carmel.

Climate change can affect groundwater uptake through various mechanisms, including higher temperatures leading to increased evaporation rates and water loss from surface and groundwater systems, shifts in precipitation patterns resulting in intense rainfall events or extended dry periods, and unbalanced hydrological cycles that impact the movement of water between surface water bodies, soil, and groundwater. As storms become larger with greater intensity because of climate change, and flooding events probabilities are higher, adjustments to stormwater infrastructure will need to be made.

Energy

Duke Energy plays a significant role in supplying electricity to the community and supporting energy infrastructure in Carmel[94]. Duke Energy Indiana is the state's largest electric supplier and a subsidiary of Duke Energy Corporation, serving about 860,000 homes and businesses in 69 counties including Hamilton County where the city of Carmel is located. The company provides electricity through its power generation facilities, transmission lines and distribution network. The company has been working on grid modernization to improve energy resilience and reliability to reduce the number of power outages by 17% and the length of outages by 19%[95].

Figure 63. Duke Energy workers in Carmel, IN. Source: Duke Energy Plan.

Climate change can have significant impacts on the energy supply in Carmel. Rising temperatures associated with climate change can lead to increased demand for energy, particularly for cooling during heatwaves, which can strain the energy infrastructure. To illustrate, it is worth noting that Carmel's cooling degree days, which provide an estimate of the cooling required to maintain a comfortable temperature, were 904.5°F/days during the 30-year period from 1975 to 2005. However, projections indicate that this value could increase to 2300°F/days in the next 50 years if emissions continue a

[94] Duke Energy/Homepage/Our company. Duke Energy foundation.
[95] Duke Energy Indiana files plan to improve reliability and resilience of its statewide electric grid with innovative technology.

business-as-usual trajectory. Implementing climate-resilient energy strategies becomes crucial in this context, including measures such as diversifying the energy mix and investing in renewable energy. These measures can reduce the cooling degrees days to 1700°F/day[96] promoting a more sustainable and resilient energy future.

Moreover, the occurrence of more frequent and intense extreme weather events, including storms and hurricanes, can damage energy infrastructure and lead to power outages. One concern is that disruptions to electrical production that affect pricing could impact lower income residents and other disadvantaged populations.

Important Roadways

Carmel has a well-connected transportation network, including a system of well-maintained roads, highways, and intersections. Major roads such as US 31, 146 street and Keystone Parkway provide convenient access to and from the city. Carmel is considered the roundabout (Figure 64~~Figure 64~~) capital of the U.S. (>145). In the late 1990's, the city started replacing signalized intersections with roundabouts to move traffic more efficiently and reduce the number of fatalities and serious-injury accidents, which has reduced by about 80% and the number of accidents overall by about 40%[97]. The city also has a large network of bike lanes and trails that promote active transportation and reduce people's dependence on the automobile.

Figure 64. Roundabout in Carmel, Indiana. Source: Carmel Government official website.

Heat-related stress is a significant concern for roadways in Carmel due to rising temperatures associated with climate change. As temperatures increase, road surfaces are subjected to challenges, resulting in the deterioration of pavement and an increased need for maintenance and repairs. Moreover, the intensified heat can pose a risk of warping and buckling of roadway materials, especially if they were not designed to withstand such expected elevated temperatures[98]. Heat waves can also create challenges for drivers, causing discomfort and potentially affecting vehicle performance.

3. Cultural Resources

The City of Carmel, originally known as Bethlehem, was founded in 1837 by pioneer Daniel Warren. Over its first half-century, it grew steadily as a typical agricultural town, attracting a significant number of Quaker pioneers to settle in the area. In 1874, the town was officially incorporated as Carmel, marking a turning point for the community. The arrival of the Monon railroad in 1882 and the development of paved roads and interurban transportation in the early 20th century spurred rapid growth and transformation. Despite facing challenges during the Great Depression and World War II, Carmel persevered and has emerged as a highly desirable residential location with a rich history and a thriving community[99].

[96]Climate Mapping for resilience and adaptation/drought/cooling degree days.
[97] City of Carmel/Roundabouts/ official website.
[98] Indiana Past and future trends/climate change
[99] Carmel Clay Historical Society. Bethlehem/Carmel since 1837

Given its historical significance, Carmel values its heritage and provides opportunities for residents and visitors to explore the city's past. Notably, there are four properties in Carmel listed in the National Register of Historic Places, each representing different areas of significance. The Monon Depot Museum, listed in 2013, showcases the city's transportation history. The John Kinzer House, added in 1975, reflects Carmel's architectural heritage. The Newby-Micah House, added in 1986, speaks to the town's history in agriculture and commerce. Finally, the Thornhurst Addition, listed in 2010, showcases the importance of historic residential suburbs in the United States. These properties are part of a national program that identifies, evaluates, and preserves America's historic and archaeological resources[100], underscoring Carmel's commitment to preserving its cultural legacy

Nowadays, Carmel is a thriving city with rich cultural experiences and abundant entertainment options. Art enthusiasts can immerse themselves in the vibrant Center for the Performing Arts, which comprises the 1,500-seat Palladium concert hall, the 500-seat Tarkington proscenium theater, and the black-box Studio Theater. For those with an appreciation for visual arts, the Carmel Arts & Design District offers an array of galleries, restaurants, bars, and unique shopping experiences. Music lovers can indulge in a variety of performances, including those held at the Cat Theatre, the community-driven Carmel Community Players, and the Carmel Symphony Orchestra. Furthermore, museums are a highlight of the city, with attractions such as the Monon Depot, the Miniatures exhibit, and even the World's Smallest Children's Art Gallery, ensuring a diverse and enriching cultural scenes for all to enjoy.[101]

[100] U.S. National Register of Historic Places
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Appendix 3: Climate Vulnerability Assessment

Cities and counties throughout the nation and world are working to reduce greenhouse gas emissions in efforts to prevent warming more than 1.5°C (2.7° F). This level of warming has been recognized by the international scientific community as an important threshold, below which we can avoid catastrophic and runaway climate change[102]

Figure 65. Carmel Community Members. Source: DOCS

In addition to reducing greenhouse gases, however, communities need to respond to the changes already being felt and plan for those still to come. Because greenhouse gases can remain in the atmosphere for decades after release, we will continue to warm and experience impacts for many decades, even if we reduce emissions today.

While greenhouse gases are measured globally, climate change impacts are experienced locally. Each community feels climate change in a different way, depending on historic conditions and local climatic conditions and patterns of change. As these local impacts and changes worsen over time, we will need to prepare and protect our most vulnerable resources and populations from the impacts.

Carmel has already experienced changes in temperature, rainfall, and extreme weather events. As changes in climate continue, we can expect increasing severity and frequency of extreme heat, larger storms with more precipitation levels, extended allergy season due to more prolonged periods of drought, and changes to the forests and other natural features in and around Carmel. These changes are expected to become increasingly severe over the course of the century.

Figure 66. Carmel Community Members. Source: DOCS

Determining which resources and populations are most vulnerable to ongoing and future impacts of climate change is the first step in developing effective strategies and sound solutions. While this Climate Change Vulnerability Assessment presents sector-specific vulnerabilities to the community, it is important to also look at Carmel in a holistic way. Many of the vulnerabilities identified here cross diverse sectors and affect people of all different walks of life.

Methods

On July 19th, a group of 36 local experts from diverse sectors of the community met for a daylong vulnerability identification workshop. These stakeholders combined their local knowledge and expertise

[102] *Special Report on Impacts of Global Warming of 1.5°C above Pre-industrial Levels*

with information provided about climate science and model projections to identify and prioritize local vulnerabilities in the five primary systems of the community: Health and Emergency Services, Natural Systems, Infrastructure, Business and Economy, and Community Culture.

The workshop participants were provided with a list of community concerns generated from the online survey outreach. They reviewed the scientific information on climate change and identified the impacts that are already underway as well as the potential impacts that are expected in the future. For each identified vulnerability, participants collected the following information:

Participants identifying vulnerabilities at the stakeholder workshop on July 19, 2023. Photo provided by DOCS

Table 5. Criteria to evaluate at the vulnerability assessment

Exposure	The specific climate trend or projection that is already causing or is expected to cause the impact
Timeframe	When the impact is expected to occur in Carmel
At-Risk	The specific neighborhood, population, area, or resource that is expected to be especially affected by the impact
Sensitivity	A relative measure of the degree of severity of the impact, given our understanding of the specific sector or population
Adaptive Capacity	The extent of existing resources, programs, or policies *already in place* to protect people or to respond to the changes with little disruption
Other Stressors	Additional and ongoing stressors to the focal population
Indicators	A quality or trait related to the focal population that can be tracked to indicate the effectiveness or success of actions taken to address this vulnerability

After identifying the specific vulnerabilities within each community system, participants ranked vulnerabilities across all systems to determine their relative priority. Most impacts identified in this vulnerability assessment are important to address, but action on some may be more urgent than on others, which is reflected in the ranking. See

Table 6

~~Table 6~~ at the end of this Appendix for a list of vulnerabilities in priority rank order. Additional populations and resources not specifically mentioned in this report may also be vulnerable.

Social (Health, Emergency) Services

Carmel is not immune to global health risks from climate change. Existing health threats are expected to be exacerbated with climate change, while new and emerging threats also take hold. Extreme events are already occurring more frequently, and emergency services will be increasingly taxed as these events become even more common.

The vulnerability assessment revealed that Carmel's social systems are vulnerable to climate change in the following ways:

Heat-Related Illnesses and Mortality – One of the biggest health threats facing Carmel residents is the increasing incidence, severity, and longevity of heat waves. The number of days per year above 95°F has increased by 45.5%. The year with the highest number of severe heat days was 2012 with 10 days above 95°F (the historical average is 1.8 days per year). Projections indicate that summers in Carmel will be 7.4°F warmer by the middle of this century and 11.7°F[103] warmer towards the end of the century under a higher emissions scenario. Studies showed that Indiana has already warmed 1.2°F since 1895, and temperatures are projected to increase by 5°F to 6°F[104] by mid-century and even more by the end of the century. This rising average temperature will lead to more extreme heat events, affect air quality, extend allergy seasons, and increased the spread of pests and invasive species.

> *"Climate change is among the greatest health risks of the 21st Century. Rising temperatures and more extreme weather events cost lives directly, increase transmission and spread of infectious diseases, and undermine the environmental detriments of health, including clean air and water, and sufficient food."*
> **World Health Organization**

Even more important than daytime highs are nighttime low temperatures. When nighttime temperatures do not cool below 75°F, core body temperature does not cool enough to protect people from the heat, which can lead to increased mortality. People who already suffer from chronic disease are particularly vulnerable.

Many of Central Indiana's residents are already vulnerable to heat waves (Figure 68), and with increasing temperatures, more people will become vulnerable. People in areas with less tree canopy coverage (Figure 67~~Figure 67~~) and less access to air conditioning are highly vulnerable. Lower-income neighborhoods and elderly people are particularly vulnerable to heat, as are infants, people with pre-existing health conditions, and those lacking access to health insurance or no equitable access to medical care that use the emergency department, as their general practitioner[105].

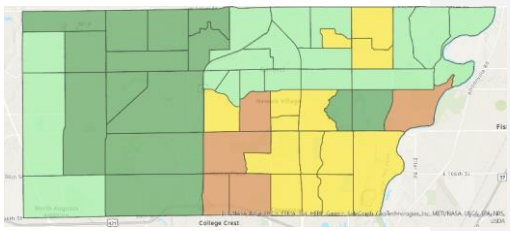

Figure 67. Average temperature in Carmel Indiana, given Tree Score. Ranges: Orange: 74-76.1° F; Yellow: 76.1-78.1° F; vivid green: 78.1-80.1° F, dark green 80.1-82° F. Source: Tree Equity Score, 2023.

[103] Climate Mapping for resilience annual days with maximum temperature >95° F
[104] Indiana's Past & Future Climate A report from the Indiana Climate Change Impact Assessment
[105] Input from stakeholders CRVA workshop on July 19th

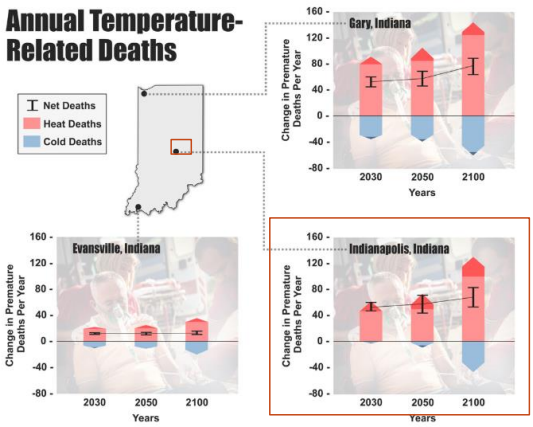

Figure 68. Indiana Climate Change Impacts Assessment. Source: Schwartz et al. (2015)

Flooding – Severe thunderstorms represent a significant source of catastrophic loss, which may be influenced by changes in precipitation patterns (Figure 69). With increased convective potential energy and strong winds associated with climate change, the likelihood of severe thunderstorms is expected to rise. These storms can lead to energy outages and flooding, posing risks to vulnerable populations, especially medically sensitive individuals, and elders. During power outages, exposure to extreme heat or cold and the failure of vital medical equipment can further jeopardize their well-being

Projected Changes in Indiana's Precipitation

Scenario	Period	Winter	Spring	Summer	Fall	Annual
Medium Emissions	2050s	16%	13%	-2%	-2%	6%
	2080s	17%	10%	-3%	-3%	5%
High Emissions	2050s	20%	16%	-3%	-2%	8%
	2080s	32%	17%	-8%	-2%	10%

Figure 69. Projected annual and seasonal percent change in precipitation for Indiana compared to the historical period. Source: Hamlet et al. in Health in a Changing Climate: A report from the Indiana Climate Change Impacts Assessment

Flooding affects many neighborhoods throughout Carmel (Figure 70). Flood waters often become contaminated with hazardous materials that can impact human health and contaminate drinking water. People most vulnerable to flood impacts include those living in high flood risk areas, and especially those with limited mobility, such as elders, homeless, and people without vehicles. Some areas of concern include the northeastern and

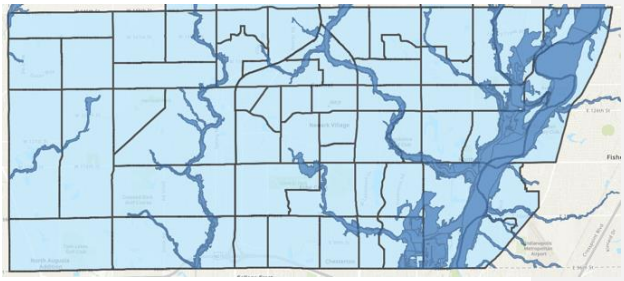

Figure 70. FIRM Flood Hazard Zones, 2023. Source: Indiana Map

southeastern parts of the county, as well as certain sections in the southwest.

Pests and Disease – In the last 13 years, the number of disease cases from mosquito, tick, and flea bites has tripled in the U.S[106]. Many disease-causing organisms and insect pests experience natural control during winter months, when freezing temperatures reduce populations. The number of days below freezing is now 28% lower, on average, than it was historically.

According to model projections, there is expected to be a significant decrease of 42.18% in below-freezing days by the 2050s and a substantial 66.6% decrease by the 2080's. These projections indicate that winters will become warmer and wetter, and diseases carried by vectors, such as mosquito and ticks could become more prevalent (Figure 72). Insect pests and disease organisms from the southern regions may begin to overwinter in northern regions (Figure 71). Many vector-borne diseases seriously affect domestic animals and livestock, so climate change could impact food security as well as human health[107]

State and local health agencies and vector control organizations are responsible for detecting and responding to diseases. Increasing capacity will be needed for continued tracking, diagnosing, and reporting of cases of known and new illnesses.

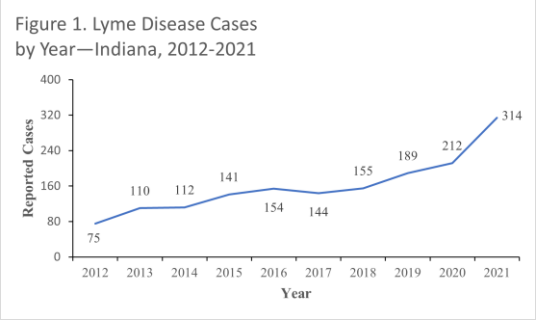

Figure 72. Reported Lyme diseases in Indiana. Incidence rate of 4.6 per 100,000 population. Source: Indiana Department of Health.

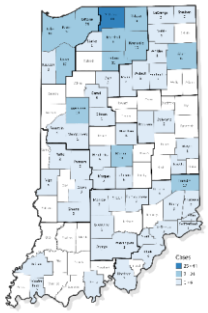

Figure 71.Depicts cases of Lyme disease by county of residence. Source: Indiana Department of Health.

Stress to Public Safety (violence and domestic disputes) during Extreme Heat and Other Events – Rising temperatures have been linked to increase irritability and hostility among individuals, contributing to higher rates of violence and domestic abuse. Furthermore, economic disruption caused by events like wildfires or floods can result in traumatized families and exacerbate mental health issues. The inability to spend time outdoors due to extreme weather conditions can worsen mental health and make adaptation to these change smore challenging.

Overburdened Health Care System – A primary climate change vulnerability identified for Carmel is the potential for an overburdened health care system tasked with responding to outbreaks and extreme events. An influx of climate refugees could exacerbate this issue further. Recurring disasters, such as flooding, disease outbreaks (COVID-19), and heat waves may overwhelm the current capacity, which is

[106] Center for Disease Control and Prevention
[107] Impact of recent and future climate change on vector-borne diseases.

already challenged by a shortage of staff and supplies. Factors such as a stressed supply chain, decline in people entering medical fields, and the lack of specialized skills (e.g., respiratory workers)[108] since the pandemic contribute to the challenge.

Vulnerable populations include elderly residents, people who live in flood-prone areas, non-English speaking populations, people without health insurance, homeless populations, and those with comorbidities.

An existing lack of services, including in-home support services, may also be exacerbated. Extreme conditions and events are expected to lead to declines in overall health and struggles to remain independent. Elderly residents and people with disabilities are especially vulnerable.

Figure 73. Pictures identifying community values. Source: DOCS

Identified Vulnerabilities: Social (Health & Emergency Services) System

The Climate Risk and Vulnerability Assessment (CRVA) identified the following health and emergency services-related vulnerabilities to Carmel.

HIGH

- Health impacts from heat (heat stroke, more hospitalization and medical cost)

MEDIUM-HIGH

- Increased mental health challenges due to all climate change hazards
- Decreased air quality due to windblown dust particles caused by droughts and wildfires causing smoke
- Increased risk of injury and fatalities due to extreme heat events
- Increased vulnerabilities of housing infrastructure to extreme weather events, such as tornadoes, floods, and storms, leading to property damage, and displacement
- Greater health risks for people participating in outdoor activities
- Increased mosquitoes, tick, and vector-borne illnesses such as Lyme disease

Note: Overall vulnerability ranking is determined from the combined scores for time frame, sensitivity, and adaptive capacity.

[108] Input from stakeholders CRVA workshop on July 19th

Infrastructure

Carmel, located in Hamilton County, has undergone significant development and transformation influenced by various factors, including urban sprawl - a phenomenon characterized by the expansion of residential and commercial development, as well as the establishment of highways, and the expansion of railroads in the 19th century. The arrival of Monon Railroad in the 1880s connected Carmel to Indianapolis, prompting economic opportunities and development.

Throughout its history, Carmel has experienced population growth and urbanization, leading to the emergence of new housing developments and businesses. The city's investment in downtown revitalization, parks, recreational areas, and public spaces has played a crucial role in shaping its urban landscape.

Currently, the city is known for its urban planning and smart growth strategies, creating well-planned neighborhoods, excellent schools, and a high quality of life - a quieter and more residential lifestyle, making it an attractive destination for new residents year after year. Carmel has also been proactive in promoting arts and culture, fostering creativity through cultural districts, art galleries, and public art installations.

The city's dedication to balancing development with green spaces and a focus on community engagement has contribute to its status as a model city for sustainable growth and a welcoming place for all[109].

The infrastructure systems covered in this vulnerability assessment for Carmel include communications, electricity, water, wastewater, and storm water and energy utilities, as well as roads, bridges, public buildings, homes, and businesses. Most infrastructure is built based on building codes that take into consideration the range of variation in temperature, precipitation, snowpack, and other climatic factors in the region.

Unfortunately, these codes are based on the historical climate rather than future climate. In many cases, outdated standards will be inadequate to meet the needs for safety and basic functioning under changing climatic conditions.

Some increasingly common infrastructure failures associated with climate change include inadequate stormwater infrastructure leading to road failure and water contamination during extreme precipitation events; dry wells due to drought; schools shut down for lack of air conditioning during extreme heat events; and toxic algae contaminating municipal water supplies, particularly in low water years.

The vulnerability assessment revealed that Carmel's infrastructure systems are vulnerable to climate change in the following ways**:**

Aging Infrastructure and Flooding – One of the major disruptions to infrastructure exacerbated by climate change, is flooding. Flooding is expected to become more severe and frequent with climate change. Urban areas are susceptible to flooding because a high percentage of the surface area is composed of impervious streets, roofs, and parking lots where runoff occurs very rapidly.

[109] History of Carmel, Indiana. Carmel.in.gov/our-city/history

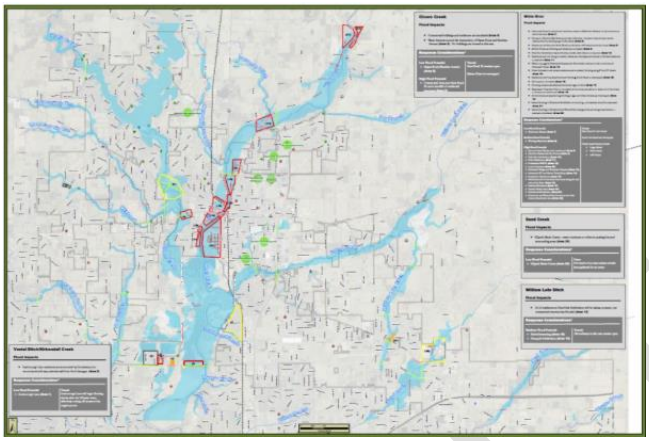

Figure 74. Potential flood areas in Hamilton County, IN. Source: City of Noblesville FRP Flood Impacts Exhibit

The 2019 Multi-Hazard Mitigation Plan of Hamilton County[110] provides a detailed view of the flood potential in the county, categorizing areas into High Flood Potential (red shapes), Medium Flood Potential (orange shapes), and Low Flood Potential (yellow shapes) (Figure 74).

The report also highlights the impact of flood on structures, leading to damages and numerous insurance claims. For instance, in the city of Carmel, 107 claims have been made since 1978, totaling approximately $563,000 in payments. Similarly, the neighboring of Noblesville has experienced 186 paid losses, resulting in around $2.1 million in payments.

Large floods present a serious challenge to sewer systems, resulting in sewage backups and infrastructure collapse. These issues were also identified during the workshop assessment held on July 19th by the built system group, which recognized vulnerabilities like property damage, poor water quality and supply shortages, as well as security concerns, all attributed to aging infrastructure and leaks.

Climate change worsens the situation as more extreme storms deposit larger amounts of precipitation in shorter periods, putting additional strain on already outdated infrastructure and further endangering public health and safety.

As older infrastructure is updated, prices for housing may increase. Increased mandates for energy efficiency, sewer upgrades, extreme heat resistance, water conservation, natural shading, wildfire risk reduction, and other sustainability measures associated with combating climate change could result in fewer housing opportunities for lower income residents unless efforts are made to specifically address housing affordability.

[110] Hamilton County Multi-Hazard Mitigation Plan

Figure 75. 126th street roundabout in Carmel, IN. Source: DOCS, 2023

Transportation Disruption – Carmel is working towards creating a walkable and accessible community, offering a wide range of amenities for residents who use cars, bikes, or prefer to walk. While public transportation is not available in the city, there are various private transportation options. These include bike sharing and rental services, private taxi companies, and rental vehicle agencies.

Under Mayor Jim Brainard's leadership, Carmel has undergone rapid development, focusing on town designs that prioritize people rather than just cars. A significant feature of this development is the city's roundabout system, with over 150 implemented to address traffic congestion and enhance safety (Figure 75). This approach has resulted in several benefits including improved traffic flow, reduced accidents, and increased pedestrian safety, leading to national recognition as a model city for other municipalities to follow[111].

However, despite these achievements, the city faces challenges due to increasing temperatures and the risk of flooding, which could potentially disrupt transportation networks. Severe heat can cause rail tracks to buckle (sun warping) and derailments[112], while extreme heat may soften and melt asphalt on roadways.

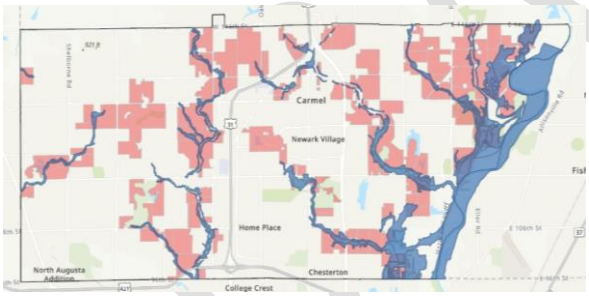

Figure 76. FEMA layers displaying potentially affected areas due to flooding. Source: DOCS GIS layers & FIRM, 2023 flood zones.

Roadways in Carmel, particularly intersections at E 146th St, E Main St, E 116th St, and E 106th St with River Road, along with some patches on Keystone Parkway crossing E Smoky Row, are vulnerable to flooding due to their proximity to the White River floodway and the likelihood of 100 and 500-year floods. Additionally, sections of W Main St and W 116th St and W 106th St may also be affected by Williams Creek. Tributaries that are susceptible to flooding include intersections at E 146th St, E main St, W 126 St, and E 116TH St with River Road intersection. Bike lanes crossing Creekside are also at-risk during flooding events (Figure 76).

Washouts, erosion, and water contamination are some of the potential impacts associated with inadequate stormwater infrastructure. As storms become larger with climate change and rain-on-snow events become more likely, adjustments to stormwater infrastructure will be required. Without upgrades and replacements, damage to roads and increased flooding during extreme events is expected.

[111] Roundabouts. Source: carmel.in.gov/government/departments-services/engineering/roundabouts
[112] Climate Change Impacts on Transportation, EPA.

Extreme temperatures associated with climate change can lead to lower weight limits on air cargo. Because warm air is less dense, planes have a harder time taking off in triple-degree heat, leading to less cargo and weight capacity per flight. More frequent and severe heat waves can increase costs of shipping and disrupt air travel, sometimes grounding all planes until temperatures cool again[113]

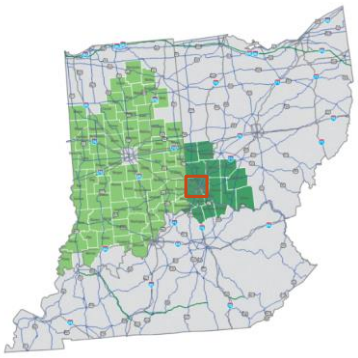

Figure 77. Midwest Service Territory. Source: Duke Energy

Energy Disruption and Pricing –. Duke Energy is a large energy company that provides electric and gas services to various regions in the United States. Figure 77 display a map outlining Duke Energy's service territory in the Midwest region where Hamilton County is served by Duke Energy Ohio and Kentucky. Almost all of Duke Energy's Midwest generation comes from coal, natural gas, or oil. As temperatures rise and extreme weather events occur more frequently, electrical use is expected to rise with increased demand for air conditioning, heating, and smoke filtering. New investments in energy production and distribution will be needed to meet peak demand. Because of the community's heavy reliance on fossil fuel-based energy, replacement of fossil fuels with renewable energy sources (in addition to energy conservation) is necessary to meet Carmel's greenhouse gas emissions targets. These new investments could result in higher prices, depending on the cost of new infrastructure and energy prices. Lower income residents, hospitals, senior housing, schools, water/wastewater, commerce, communications systems[114] could be impacted by increasing energy prices.

Extreme temperatures also reduce the efficiency and reliability of energy production and distribution. In addition, power outages are common during heat waves and extreme cold events, due to overburdening of the power grid. Power outages can put peoples' lives at risk as they leave people vulnerable to soaring temperatures. Older adults, low-income residents, and people with existing health problems are all at risk. If electric prices increase, even more residents will be unable to afford to cool their homes, putting them at risk during periods of severe heat.

During the stakeholder workshop on climate resilience, a concerning issue was identified regarding incidents of solar and electric vehicle (EV) batteries catching fire. For instance, an insurance company in Indiana filed a $1.27 million subrogation claim against a well-known car brand[115], attributing a house fire that caused significant damage in Carmel in 2020 to various factors, primarily related to the design, manufacturing, and assembly of components, battery packs, cells, and related parts of the 2016 model. The claim highlighted potential defects in design or manufacture that could pose risks in using renewable energy technologies and EVs in the city and the unintended consequences of climate change mitigation strategies.

[113] The impacts of rising temperatures on aircraft takeoff performance.
[114] Input from stakeholders CRVA workshop on July 19th
[115] InsideEV's. Source: https://insideevs.com/news/569443/tesla-state-farm-negligence-lawsuit/

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Figure 78. Pictures identifying community values. Source: DOCS

Identified Vulnerabilities: Infrastructure

The vulnerability assessment identified the following infrastructure-related vulnerabilities to Carmel

MEDIUM-HIGH

- Impacts to power generation and distribution
- Power outages attributed to aging infrastructure and extreme weather-related events (thunderstorms, tornadoes, extreme cold, flood events, heat waves)
- Aging infrastructure and inadequate sewer systems cause flooding due to extreme rainfall, damaging homes and businesses.
- Increased Water supply demands due to population growth and urbanization
- Solar & EV battery fire control risk
- Increased demand for energy due to hotter temperatures and more humidity for cooling, charging, affecting local businesses, government, and lower income residents.

Note: Overall vulnerability ranking is determined from the combined scores for time frame, sensitivity, and adaptive capacity

Natural Systems

Carmel, places significant importance on its natural systems and has implemented initiatives to protect and enhance its urban forest and waterways. The city's urban forestry program focuses on preserving public trees, offering benefits such as carbon sequestration, noise reduction, and storm runoff reduction. Carmel's commitment to green spaces is evident in its diverse parks and recreational facilities, providing residents and visitors with outdoor leisure opportunities.

The city is situated within the White River watershed, which plays a crucial role in its hydrology and offers recreational opportunities. While Carmel itself lacks major natural water bodies, nearby lakes and reservoirs provide space for boating, fishing, and other water-based activities.

Climate change can have significant impacts on natural systems, through increases in temperatures, extreme storms, and drought. Increasingly, one of the most important functions of natural systems is to provide a buffer against the impacts of climate change. Intact natural systems can reduce the impacts of extreme events, such as floods, fire, and drought, on local communities. Forest and ecosystem management to maximize natural function is increasingly becoming a priority.

The vulnerability assessment revealed that Carmel's natural systems are vulnerable to climate change in the following ways.

Overall Degradation of the Natural Environment and Loss of Species – Open space is a valued resource, offering a visual and physical connection to the natural environment. The White River plays a vital role in Carmel, providing a crucial groundwater supply in the West Fork White River basin[116]. Beyond, the rive also contributes to the city's well-being and identity by supporting recreational activities, fostering biodiversity, and holding cultural value. However, climate change impacts pose challenges to rivers and waterways such as the White River, altering rainfall patterns, increasing flood risks, and affecting water quality thereby impacting the health of ecosystems and adjacent populations[117].

Natural lands within the city also face climate-related threats, including pests affecting tree canopy species, drought weakening vegetation, and incompatible vegetation due to shifting climate conditions. Increasing heat and extreme temperatures can compromise park comfort and safety, while floods and droughts can disrupt infrastructure, vegetation, and waterways like the White River. Climate change is expected to degrade natural systems, particularly vulnerable species, and habitats, such as wetlands, riparian areas, and high-elevation species like the northern tree species found in Carmel. These ecosystems are struggling to adapt to the ongoing impacts of climate, facing challenges in forest regeneration and tree seedling survival. Additionally, the presence of stressors like invasive species and building construction only exacerbates the situation[118], amplifying the risks for these fragile environments. As climate change progresses, more extreme events like floods, droughts, and heatwaves are anticipated, impacting species and their habitats.

Moreover, the city has also been affected by air quality issues, exacerbated by wildfire haze from Canada, highlighting the global environmental impact on Carmel's local surroundings. Addressing air pollution becomes imperative to preserve the city's natural beauty and ecological balance. Ensuring proper forest management and implementing appropriate measure to safeguard parks from extreme

[116] Ground-water Hydrology. White & West Fork White River Basin. Source: DNR
[117] Input from stakeholders CRVA workshop on July 19th
[118] Input from stakeholders CRVA workshop on July 19th

weather events are essential steps in promoting sustainability and resilience within Carmel's natural systems.

Spread of Pests and Disease – Climate change is also expected to lead to increases in pests and disease, affecting and threating natural areas, urban green infrastructure (trees, forest, parks, gardens, lawns, wetlands), and fish and wildlife. With increase in temperatures, fewer nights below freezing, and stressed native vegetation, invasive species have the potential to devastate urban tree canopies and other vegetation. Moreover, the rise in fungal disease affecting already stressed, vulnerable plants could require additional staffing and labor efforts for effective plant maintenance[119].

Loss of Green Space – The mental health benefits of open spaces, vegetation, parks, and nature are well proven. Access to green space and nature improve mood, ability to concentrate, school test scores, and many other metrics. Unfortunately, the challenges posed by climate change, including extreme heat and poor air quality conditions, threaten to restrict participation in outdoor activities and decrease recreational opportunities. This will particularly affect vulnerable populations such as children, the elderly, and those with allergies, limiting their ability to benefit from these natural spaces[120]

Currently, access to green spaces and parks is often considered a luxury in some communities, especially in higher-income neighborhoods with greater urban tree canopy coverage. Unfortunately, lower-income areas, often with higher percentages of people of color, tend to have fewer natural habitats and limited park facilities. Climate change will exacerbate this disparity, further degrading existing natural areas and reducing biodiversity, leading to increased anxiety, reduced physical activity, fewer opportunities for community connections, and greater social isolation. Addressing these issues is essential to ensure equitable access to the mental health benefits of nature and create inclusive and resilient communities for all residents.

Figure 79. Pictures identifying community values. Source: DOCS

[119] Input from stakeholders CRVA workshop on July 19th
[120] Input from stakeholders CRVA workshop on July 19th

Identified Vulnerabilities: Natural Systems

The vulnerability assessment identified the following natural systems-related vulnerabilities to Carmel

MEDIUM-HIGH

- Degradation of the natural environment, loss of species, and reduced forest regeneration, affecting tree seedling survival.
- Threats to urban green infrastructure (trees, forest, gardens, lawns)
- Increased pressure from invasive species- spreading pests and disease (ticks, plant diseases, etc.) that affect fish and wildlife, natural vegetation, street trees, gardens, and lawns
- Increased erosion and flood way-degrading aquatic systems and leading to loss of wildlife habitat and ecological function.

Note: Overall vulnerability ranking is determined from the combined scores for time frame, sensitivity, and adaptive capacity

Business and Economy

Carmel's economy is built on many different types of businesses and industries, ranging from large industry to small local and diverse businesses. With a population of over 100,000 and an impressive growth rate of 88.1% from 2000 to 2021, Carmel offers a wealth of economic opportunities for its residents. The city's economy spans various industries, including finance, healthcare, technology, and manufacturing, contributing to a median household income of $119,772. Education is highly valued in Carmel, as 97.9% of residents possess at least a high school degree, and more than 70% have attained a bachelor's degree or higher. The presence of numerous parks, greenways, and cultural amenities adds to the city's appeal, offering a high quality of life to its diverse population.

Climate change is expected to affect the local economy in numerous ways. Not only are transportation routes expected to be interrupted more frequently which can affect food shipping distribution since Carmel lack ability to grow its own food and depends on imports[121] (see the infrastructure section). However, the cost of doing business is expected to rise with increased expenditures, higher prices, less outdoor and recreational activities to offer, and increased cost associated with reconstruction which consequently increases insurance costs.

Climate change is expected to affect the local economy in numerous ways. A potential increase in the frequency of interrupted transportation routes could disrupt food shipping and distribution, particularly given the city's reliance on imports due to limited ability to grow its food. Addressing these challenges becomes crucial to ensure the city's economic resilience and sustainability in the face of climate change impacts.

The vulnerability assessment revealed that Carmel's economic systems are vulnerable to climate change in the following ways**:**

Outdoor Workers at Risk – Increasing smoke and heat events may severely disrupt the productivity of outdoor workers in fields such as infrastructure, entertainment, construction, landscaping, forestry, and recreation[122]. These extreme weather conditions can severely disrupt their productivity and pose health hazards, especially for those with existing health challenges. Therefore, employment disruptions are likely to cause financial instability, particular for low-income workers. Businesses may also face higher turnover rates and an increase in worker's compensation claims because of these challenges. That affects the safety and well-being of outdoor workers.

Increased Cost Associate with Reconstruction and Insurance Costs – As the risk of climate-related events, such as flooding, severe storms, drought, and wildfire, rises, insurance premiums also increase. This can lead to some areas becoming uninsurable, shifting the full financial risk to individual property and business owners. Entities situated in floodplains, waterways, underground parking garages, and downtown areas are particularly susceptible to potential risks with climate change impacts. As the frequency and intensity of climate-related events increase, these entities may face the daunting task of funding reconstruction efforts if they are affected, this can lead to higher prices for insurance coverage and an increased financial burden on property and business owners in these areas.

[121] Input from stakeholders CRVA workshop on July 19th
[122] Input from stakeholders CRVA workshop on July 19th

The impact of climate change on local governments goes beyond insurance costs. Credit rating agencies have now incorporated 'resiliency' into their rating criteria for city and state governments. This inclusion affects the ability of local governments to raise bond funds and influences the rates taxpayers pay for those funds. For instance, Standard and Poor regularly publishes extensive research on the climate-related risks to cities[123]. They also evaluate environmental, social, and governance risks as a key part of their ratings methodology.

Food Access and Security or Higher Prices – Extreme weather events such as droughts and floods can disrupt agricultural production, resulting in reduced crop yields and food shortages in the region. As Carmel relies on food imports[124] to meet the population's needs, transportation costs and supply chain disruptions caused by climate-related may further drive up food prices.

Furthermore, changes in weather patterns due to climate change can have effects on the local economy, including impacts on food distribution and related businesses. The availability and quality of certain foods may be affected, leading to fluctuations in prices and limited access to nutritious options. As extreme weather events disrupt shipping reliability, the overall cost and profitability of food distribution could be negatively impacted, affecting farmers' markets, produce farmers, local businesses, and even the landscaping industry. Addressing climate change and building resilience in the food supply chain becomes essential to ensure food access and security for the community and to support the economic sustainability of these vital sectors.

Increase Weed, Pest and Disease-Risk in Green Areas – Climate change is amplifying this issue, demanding increased expenditure for monitoring, removal, and management[125]. The decline in tree canopy not only affects the beauty of natural and planned landscapes but also poses risks to outdoor workers, tourists, and recreation areas. Moreover, it impacts farmers and their produce, creating a domino effect on food security in the city. Additionally, the extension of allergy seasons and the proliferation of disease vectors due to warmer temperature leads to a rise in vector-borne illnesses, resulting in increased hospitalizations and health care expenses. Addressing these climate-induced challenges becomes essential to safeguard public health and the overall well-being of the community.

[123] Climate Risk and Resilience
[124] Input from stakeholders CRVA workshop on July 19th
[125] Input from stakeholders CRVA workshop on July 19th

Figure 80. Pictures identifying community values. Source: DOCS

Identified Vulnerabilities: Business and Economy

The vulnerability assessment identified the following business and economy-related vulnerabilities to Carmel

HIGH

- Food access and security or higher prices due to flooding, heat, drought, and shipping disruptions

MEDIUM-HIGH

- Increased weed, pest, and disease-risk in green areas
- Increased cost associated with reconstruction
- Increased risk of early flowering and frost damage due to warmer winter and spring temperatures which could impact farmer's market and cause a decline in tourism and recreation events
- Health risk to outdoor workers - lower productivity and increased worker compensation

Note: Overall vulnerability ranking is determined from the combined scores for time frame, sensitivity, and adaptive capacity

Community Culture

Carmel's appeal lies in its unique blend of historical charm and modern infrastructure, making it a dynamic community. The city takes pride in its rich heritage, with several properties listed in the National Register of Historic Places, offering opportunities for residents and visitors to explore its past. Alongside its historical significance, Carmel boasts a thriving cultural scene, providing a diverse array of arts and entertainment options. Notably, the Center for the Performing Arts showcases the city's commitment to music and performing arts, while the Carmel Arts & Design District offers experiences with its galleries, restaurants, and shopping.

Carmel is a thriving city that prioritizes sustainability and community well-being. With its focus on green spaces and active transportation, it offers a healthy and natural environment for residents and visitors. The city's dedication to preserving its cultural heritage while embracing progress makes it an attractive place to live and explore. The population is diverse, with White residents making up 80.5%, along with Asian (11.1%) and Hispanic or Latino (4.0%) populations. The city's population is balanced in terms of gender, with 51.9% female and 48.6% male residents. The age distribution highlights a mix of age groups, with 25.4% under 18 years old and 14.1% aged 65 years and over. With a population density of 1,668 people per square mile, Carmel is the 4th largest city in Indiana.

Outdoor Recreational Activities – Year-round outdoor recreational activities, including festivals and events, play a vital role in the vibrant community life of Carmel. The diver offerings, ranging from youth sports and club-organized public sporting events to individuals and families enjoying cycling, walking, running, white river kayaking, creek park fishing, and swimming[126]. Additionally, the hospitality industry and Christmas tree farmers also thrive due to the influx of tourists and visitors attracted by the city's outdoor offerings.

However, climate change has started to impact these activities. Carmel is experiencing rising temperatures and larger storms, posing challenges to the outdoor sports and events that define the city's recreational culture. These changes can lead to health risks, especially among young people, and result in a loss of nature-based recreational values and activities. One of the immediate requirements to address these challenges is the necessity of wearing masks during outdoor events, considering the potential health risks posed by extreme heat and weather events. Furthermore, the high cost can affect the development of new facilities, making it crucial to utilize and improve existing venues effectively.

City planners and policymakers need to strike a balance between maintaining outdoor event spaces while considering the option of migrating events indoors during extreme weather conditions[127]. This will require careful planning to ensure that the city has suitable indoor facilities to host these events without compromising the essence of the activities that make Carmel so unique. As the city continues to grow, preserving its outdoor recreational opportunities becomes paramount. By investing in climate-resilient infrastructure, promoting public health measures, and preserving green spaces, Carmel can safeguard the outdoor lifestyle that brings joy to its residents and visitors alike.

Quality of Life and Sustainable Lifestyles – Carmel's overall quality of life is vulnerable to climate change impacts. Heat and severe storms could keep people indoors, reduce their connection with nature, and negatively impact their mental health. Tourism may decline, resulting in less revenue and

[126] Input from stakeholders CRVA workshop on July 19th
[127] Input from stakeholders CRVA workshop on July 19th

fewer government services. If schools are impacted, families may move away from the area, further exacerbating the issue. Finally, residents that are paying more for housing, energy, and food, may not have the capacity to invest in more sustainable lifestyles, like energy efficient windows, electric cars, and locally produced food.

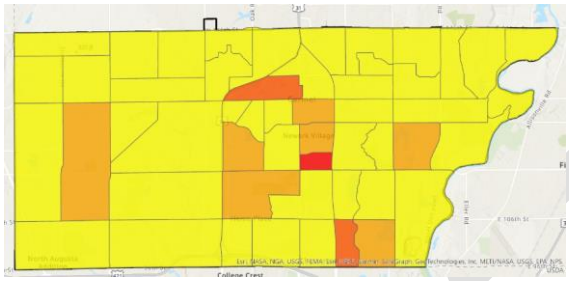

Figure 81. People with income below poverty level. Yellow: 0%-4.75%; Orange: 4.75%-9.5%; Vivid orange: 9.5%-14.25%; Dark Orange: 14.25%-19%. Source: Adapted from Census Bureau

Impact on Disadvantaged Populations - Climate-related events such as higher temperatures leading to increased flooding or drought, and the occurrence of diseases and injuries due to extreme heat or cold events, can worsen existing inequalities and vulnerabilities, especially among disadvantaged populations. This includes individuals and families with lower incomes (Figure 81), those on fixed incomes, and the elderly who rely on well water for their daily needs[128].

Certain neighborhoods in Carmel, such as southwest, Johnson Village, and Newark Village, may face additional challenges as they lack updated infrastructure to effectively cope with and adapt to extreme weather events[129]. Being older neighborhoods, they are highly sensitive to the impacts of climate change and have limited economic resilience, making it difficult for them to manage and adapt to changes effectively.

Disadvantaged populations often struggle to recover from the effects of extreme weather, given their limited financial resources and access to support systems. The lack of adequate infrastructure and resources in these neighborhoods can further compound their vulnerability to climate-related challenges.

Addressing the concerns of disadvantaged communities requires a multifaceted approach. Carmel should consider prioritizing investments in updated infrastructure and climate-resilient systems in these neighborhoods. Additionally, providing support, resources, and assistance to those on fixed incomes, the elderly, and well water users can help enhance their resilience and capacity to adapt to changing climate conditions.

Reduced ability to hold ceremonies and community events – Extreme heat, storms, flooding, and drought in Carmel can have a significant impact on the city's ability to hold culturally important ceremonies and community events, affecting various groups, including those with religious and cultural reasons for utilizing outdoor venues. Visitors to cemeteries, individuals seeking outdoor venues for religious and cultural practices, and East and South Asian religious groups[130], among others, may face challenges due to these weather conditions, especially during the summer months.

[128] Input from stakeholders CRVA workshop on July 19th
[129] Input from stakeholders CRVA workshop on July 19th
[130] Input from stakeholders CRVA workshop on July 19th

While some cultural events can be rescheduled or moved indoors to avoid the adverse effects of weather, certain religious practices and ceremonial afterlife celebrations may require specific outdoor settings, such as cemetery burials. As a result, not all events can be easily adapted or relocated. To address these challenges, Carmel should explore climate-resilient infrastructure and adaptive measures that allow for the preservation of these valued traditions and community gatherings.

Figure 82. Pictures identifying community values. Source: DOCS

Identified Vulnerabilities: Community Culture

The vulnerability assessment identified the following community culture-related vulnerabilities in Carmel

HIGH

- Impacts year-round outdoor recreational activities
- Food access and security or higher prices due to flooding, heat, drought, and shipping disruptions
- Disruption of cultural practices, rituals, and ceremonies

MEDIUM-HIGH

- Climate change disproportionately affecting disadvantaged populations, exacerbating existing inequalities and vulnerabilities
- Impacts to outdoor festivals and events

Note: Overall vulnerability ranking is determined from the combined scores for time frame, sensitivity, and adaptive capacity

Conclusions

Climate change is a global threat with locally unique impacts for communities. Because each region is affected differently, and each community has a unique combination of existing vulnerabilities and assets, it is vital to develop climate change solutions at the local level. Some of the most important vulnerabilities to Carmel include food access and imports security, constrained outdoor recreational activities due to flooding and heat, failure of aging infrastructure causing property damage and loss, power outages, and increased demand for water and energy, particularly for cooling purposes. Health concerns arise also from heat and air quality, amplifying stress on vulnerable communities and resources, and causing damage to essential natural systems.

The international scientific community agrees that keeping average warming at the global level below 1.5°C (2.7° F) is vital to protect young people and future generations from catastrophic and runaway climate change. Emissions reductions are the first and most important step to preventing many of the worst impacts on the community. However, many impacts are already occurring and need to be addressed to protect people and resources throughout the community.

Because climate change affects all sectors and resources, actions must be coordinated to increase overall resilience. Without coordination, actions in one sector or population could shift impacts to other sectors or populations, especially those who are already most vulnerable. Truly co-beneficial solutions to climate change address economic and social inequities, increase ecological health and resilience, and collaborate across diverse groups and resources.

Climate hazards - The specific climate trend or projection that is already causing or is expected to cause the impact.

Severe Heat – There could be 15-102 more days/year above 95° F	**Larger Storms** - The amount of precipitation in the largest storms could increase by 5-23%, resulting in risk of potential flooding.	**Drought** - Drought stress could change vegetation type and increase fire danger days up to 41%	**Flooding** – There could be fewer days per year below freezing point, with an average decrease of 8.5% in snowfall.

Components of Climate Vulnerabilities – Some of the criteria involved during the Climate Risk and Vulnerability Assessment

Timeframe	Sensitivity	Adaptive Capacity
When the impact is expected to occur *Near-term = current to 2030s* *Mid-term = 2035s to 2064s* *Long-term = 2070s to 2090s and beyond*	How much of a response or how great of an impact is expected (e.g. how disruptive it is, how serious the consequences are, and how much overall change is expected) *High, Medium, or Low*	Whether there are already existing resources, programs, or policies in place to protect people or to respond to the changes with little disruption *High, Medium,or Low*

Table 6. List of vulnerabilities in priority rank order

Rank	Sector(s)	Vulnerability	Climate Hazard(s)	Time frame	Sensitivity	Adaptive Capacity
1	Cultural/ Economic	Food access and security or higher prices		Near term	High	Low
2	Cultural/ Natural	Impacts to year-round outdoor recreational activities		Near term	High	Low
3	Social	Health impacts from heat (heat stroke, more hospitalizations, and medical costs)		Near term	High	Low
4	Cultural	Disruption of cultural practices, rituals, and ceremonies		Near term	High	Low
5	Social	Increased mental health challenges due to all climate change hazards		Near term	High	Med
6	Built	Water supply demands		Near term	High	Med
7	Social/Built	Increased risk to housing infrastructure/ Property damage and loss		Near term	High	Med
8	Cultural	Weather events affecting disadvantaged population, exacerbating existing inequalities		Near term	High	Med
9	Social	Decreased air quality due to windblown dust particles caused by droughts and wildfires causing smoke		Near term	Med	Low
10	Built	Solar and EV battery fire control risk		Near term	Med	Low
11	Economic	Increased weed, pest and disease risk in green areas		Near term	Med	Low
12	Social	Increased risk of injury and fatalities due to extreme heatwaves		Near term	Med	Med
13	Built	Increased demand for energy		Near term	Med	Med
14	Economic	Increased risk of early flowering and frost damage		Near term	Med	Med

15	Economic	Health risk to outdoor worker-lower productivity & increased worker compensation		Near term	Med	Med
16	Natural	Threats to urban green infrastructure (trees, forest, gardens, lawns)		Near term	Med	Med
17	Natural	Increased pressure from invasive species		Near term	Med	Med
18	Natural	Restricted participation in outdoor activities events and recreational opportunities		Near term	Med	Med
19	Economic	Increased cost associated with reconstruction		Near term	High	High
20	Natural	Increased erosion and floodway due to storm event intensity		Mid term	Med	Low
21	Cultural	Impacts to outdoor festivals and events		Mid term	High	Med
22	Built	Power outages		Mid term	High	Med
23	Social	Increased mosquitoes, ticks, and vector-borne illnesses		Mid term	High	Low
24	Social	Greater health risks for people participating in outdoor activities		Mid term	High	High
25	Built	Impacts to power generation and disruptions		Mid term	High	High

Risk Matrix

The symbol * indicates highest priority for strategy development

Sensitivity	Adaptive Capacity: Low	Adaptive Capacity: Medium	Adaptive Capacity: High
High	***Food access and security or higher prices** ***Impacts to year-round outdoor recreational activities** Impacts to forest regeneration and tree seedling survival Health impacts from heat (heat stroke, more hospitalizations, and medical costs) Disruption of cultural practices, rituals, and ceremonies.	***Water supply demands** ***Power outages attributed to extreme weather-related events (thunderstorms, tornadoes, etc.)** ***Increased mental health challenges due to all climate change impacts** ***Property damage and loss** Increased mosquitoes, tick, and vector-borne illnesses such as Lyme disease. Weather events affecting disadvantaged population, exacerbating existing inequalities Impacts to outdoor festivals and events	***Greater health risk for people participating in outdoor activities** Increased cost associated with reconstruction. Impacts to power generation + distribution
Medium	***Increased erosion and floodway due to storm event intensity** Solar+EV battery fire control risk Increased weed, pest and disease-risk in green areas Decreased air quality due to windblown dust particles caused by droughts and wildfires causing smoke	***Threats to urban green infrastructure (tress, forest, gardens, lawns)** ***Increased demand for energy due to hotter temperatures and more humidity for cooling** ***Increased risk of injury and fatalities due to extreme heatwaves** ***Increased pressure from invasive species** Health risk to outdoor workers-lower productivity & increased worker compensation Increased risk of early flowering & frost damage due to warmer winter & spring temperatures which could impact farmer's market Restricted participation in outdoor activities, events, and recreational opportunities. Increased risk to housing infrastructure/ Property damage and loss	
Low			

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Appendix 4: Community and Stakeholder Outreach

Figure 83. Social system assessing vulnerabilities on Climate Workshop on July 19th. Source: DOCS

The process of developing the *Climate Ready Carmel* plan was the result of significant time and input from a variety of people in and around the Carmel community. The "Whole Community Resilience" process utilized by Carmel developed a stakeholder workshop to solicit feedback on community priorities. Carmel also promoted an online survey to get additional feedback from the public throughout the process.

Figure 84. Economic System assessing vulnerabilities during Climate Workshop on July 19th. Source: DOCS

Stakeholder Workshops

On July 19th, 2023, a group of 36 local experts from diverse sectors of the community met for a daylong vulnerability identification workshop. These stakeholders combined their local knowledge and expertise with climate science and model projections to identify and prioritize local vulnerabilities in all major sectors of the community. This information was used to help develop the Climate Vulnerability Assessment, found in Appendix 3. Carmel deeply appreciates the time, expertise, and knowledge of these workshop participants.

- Alex Jordan - Stormwater Management
- Amy Slade - Green Team Building Rep
- Bob Swanay - Carmel Public Library
- David Littlejohn - Department of Community Services
- Daren Mindham - Community Services
- Dwight Frost - Police Department
- Eric Mehl - Clay Parks & Recreation
- Henry Mestetsky - CRC Department
- JeanMarie Kane - Safety and Emergency Management
- Jenell Fairman - CRC Department
- Joel Heavner - Division Fire Department
- Joslyn Kass - Code Enforcement Department
- Kelly Karn - Duke Energy
- Kelvin Okamoto - Mayor Advisory Commission
- Laura Johns - Hamilton County Tourism Rep.
- Larysa Glaspie - CRC Department
- Leslie Webb - Carmel Green Initiative
- Mark LaBarr - Duke Energy
- Matt Higginbotham - Street Commissioner

- Michael Hendricks - Carmel Utilities
- Michael Klitzing - Clay Parks & Recreation
- Mike Hollibaugh - Community Services
- Mike Lee - CRC Department
- Rabbi Justin Kerber - Carmel Interfaith Alliance
- Rebecca Lee - Carmel Mayor's Youth Council
- Ron Carter - Carmel Farmers Market
- Stephen Sturts - Pedcor Constructors
- Tim Hannon - City Council
- Timothy Renick - Information and Communication System
- Todd Gillian - Urban Forest

Community Surveys

During the development of *Climate Ready Carmel,* a community survey was used to gather information from the broader public, which was then used to develop this report. The survey was distributed across the community via many different networks and channels. In addition to the Carmel newsletters, websites, and social media, Carmel Library and Parks & Recreation members shared the surveys with their local networks using both printed and electronic version with a QR code in English and Spanish languages.

Figure 85. Cloud of cultural values identified by Stakeholders Workshop on July 19th. Source: Menti.

These surveys are not intended to be scientifically rigorously, rather they are designed to inform the resilience building process while also serving as a mechanism to educate residents. Information is provided here to explain how responses were used and facilitate transparency in this process.

Vulnerability Assessment Survey

The community-wide survey was conducted from Jun 30th to July 26th and collected a total of 130 responses. This survey presented information about the changes expected in Carmel, and asked what impacts are already being seen and what, if any, specific concerns exist. Some of the responses collected were used to build the list of vulnerabilities per sector to use in the stakeholder workshop and contributed to this assessment report.

Specific efforts used to collect responses, include:

- Designed a newsletter template, which was shared with the Communications Department of Community Services and began circulation on Friday, June 30th. Additionally, a survey link was displayed on Carmel's social media platforms like Instagram to reach a wider audience. To ensure accessibility, the newsletter provided two links-one in English and the other in Spanish
- We engaged in a collaborative effort with two community organizations, namely, the Carmel Community Library and the Monon Community Center. During this partnership, we supplied them with various materials, including QR codes and hard copies.

- The provided materials were designed to cater to everyone with access to a phone, allowing them to easily scan the survey. Simultaneously, individuals without internet access or the elderly were encouraged to use the hardcopies to share their insights.
- Inclusivity was a priority, and the survey was made available in both English and Spanish considering the demographics of Carmel, where 82% of residents identified themselves as white and 6% as Hispanic or Latino.
- The Carmel Green Initiative, a non-profit organization dedicated to promoting environmental responsibility and addressing climate change challenges, provided support by publishing the survey on their website and social media channels.

List of questions asked, and summary of all responses are below:

The survey began by presenting Climate Change Impacts in Carmel, providing the public with an overview of historical data and projected changes in various variables identified during the elaboration of the Climate Trends Primer in Carmel.

- **There has been a significant increase in our annual highest maximum temperature**, currently reaching 98.9°F. Projections indicate that this trend will continue, with temperatures surpassing 101.9°F in the next 30 years
- **Precipitation days have declined from an average of 189.1 days per year to 185.9 days per year**, with projections indicating a further decline to 181.3 by 2050s.
- While the frequency of precipitation may decrease**, the intensity of extreme rainfall events could increase, potentially causing intense flooding.** This can be attributed to the expected rise in average annual precipitation from 39.6 inches to 43.6 inches in the coming years.
- **The number of days with temperatures exceeding 95°F has significantly risen in recent years.** We used to have an average of 13.7 days (1976-2005), but now it is 36.6 days. Projections indicate a potential increase to 51.8 days by the end of the 2060s.
- **Winters are becoming milder**, with a decrease in cold days from 23.7 to 10.7 over the next 50 years. **While appealing, this has concerning implications, such as an extended allergy season and increased pest activity, which can worsen disease pressures**.
- **Changes in local vegetation may alter future seasons, deviating from traditional fall and winter patterns.** Constantly warm conditions could result in year-round green trees, resembling equatorial countries**. This transformation will significantly impact the local ecosystem.**

Question 1: How concerned are you about climate change for our community? Choose one (required)

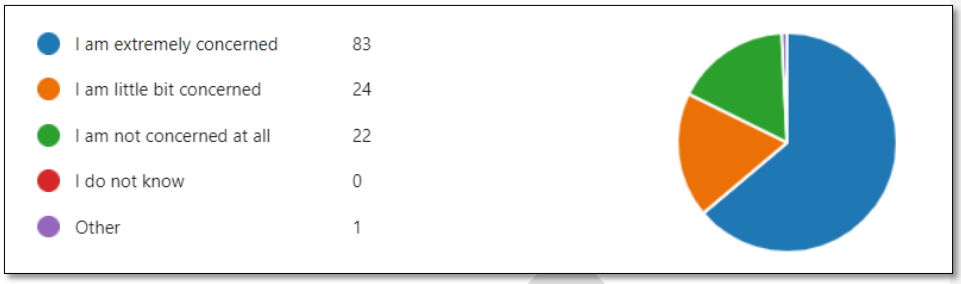

Figure 86. Summary Results from Q1 on Climate Community Survey

A total of 130 people responded to this question. Among them, 82% expressed concern about the issue, with 64% being extremely concerned and 18% having some level of concern. On the other hand, 17% of respondents stated that they were not concerned at all.

Question 2: How much do each of the following potential climate impacts concern you? Select one for each: Not concerned; Some concern, or very concerned (required)

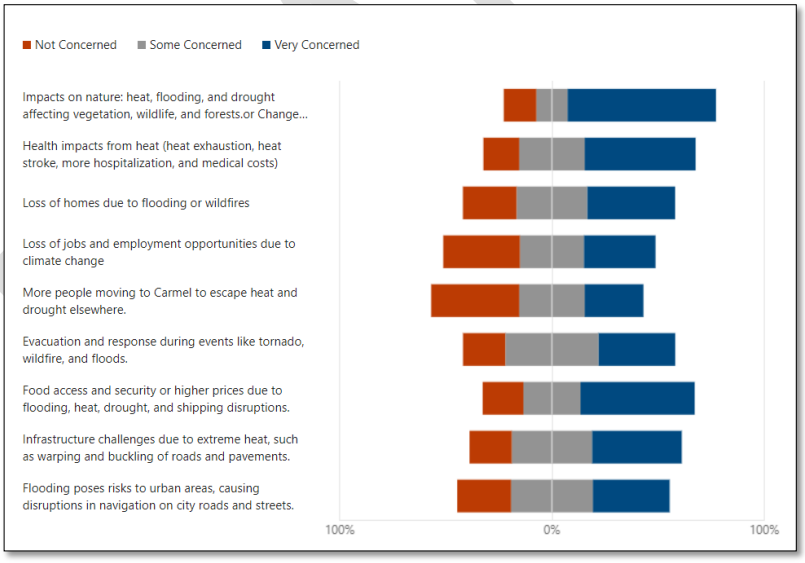

Figure 87. Summary Results from Q2 on Climate Community Survey

A total of 130 people responded to this question and some of the survey results regarding their concerns are:

- Impacts on Nature from heat, flooding, and drought affecting vegetation, wildfire, and forest: 15.4% were not concerned, 14.6% had some concerns, **and 70%** were very concerned.

- Health Impact from Heat such as stroke more hospitalization and medical costs: 16.9% were not concerned, 30.8% had some concerns, and 52.3% were very concerned.
- Loss of Homes due to Flooding or Wildfires: 25.4% were not concerned, 33.1% had some concerns, and 41.5% were very concerned.
- Loss of Jobs and Employment Opportunities due to Climate Change: 36.2% were not concerned, 30% had some concerns, and 33.8% were very concerned.
- More People Moving to Carmel to Escape Heat and Drought Elsewhere: 41.5% were not concerned, 30.8% had some concerns, and 27.7% were very concerned.
- Evacuation and Response during Events like Tornadoes, Wildfires, and Floods: 20% were not concerned, 43.8% had some concerns, and 36.2% were very concerned.
- Food Access and Security or Higher Prices due to Flooding, Heat, Drought, and Shipping Disruptions: 19.2% were not concerned, 26.9% had some concerns, and 53.8% were very concerned.
- Infrastructure Challenges due to Extreme Heat, such as Warping and Buckling of Roads and Pavements: 20% were not concerned, 37.7% had some concerns, and 42.3% were very concerned.
- Flooding Poses Risk to Urban Areas, Causing Disruptions in Navigation on City Roads, and Streets: 25.4% were not concerned, 38.5% had some concerns, and 36.2% were very concerned.

Question 3: What aspects of climate change have you perceived differently compared to your childhood?

A total of 130 respondents provided the following insights (responses marked as 'none' were omitted for presentation quality):

Table 7. Responses to Q3 from Climate Community Survey.

Milder winters, longer summers with hotter days
My childhood was the era when people were telling us we were heading for another ice age because of some unusually cold and snowy winters in the 1970s.
None
A trend toward higher average temperature. There were periods of very high temperatures and violent storms during my childhood too.
We are getting closer and closer to the point of no return and running out of time to make changes that prevent climate catastrophes. It is also becoming clear that corporate greed has a huge impact and they have been trying to place the blame on individuals when corporations are the ones who can truly make a difference.
Since childhood it has become obvious that our dependency on cars has drastically increased climate change. There are so many negative side effects to the way we've built cities around cars.
more intense rain weather events, longer heat waves, more droughts, stronger winds
Warmer, dryer summers are impacting plants. There is too much emphasis on manicured lawns and not enough emphasis on native planting to replace turf grass. Native plants use less water and are more drought tolerant than turf grass. Native plants do not generally require watering, fertilizer, or heavy use of chemicals to control weeds. Native plants do not require weekly mowing with its large expense and carbon emissions. Landscape companies should be encouraged to plant native plants to replace turf grass and shift their business models to managing native plantings rather than mowing turf grass.
Too much debate among scientists. Not sure which set of data to believe.
The wildfire smoke impacts on the entire country. The risk for extreme thunderstorms and tornado activity. Extreme seasonal temperature changes.
Milder winters. More severe weather on a more regular basis
Over the centuries the climate has changed back and forth. Such changes are now being used by politicians for their political gain.

Definitely hotter and sunnier than in the past. Wildfire smoke from the western US and Canada is significant.
Extreme temperatures, high levels of drought, stress on plants and trees, too much pollution, toxic water/waste, most ponds, and grass have so many chemicals it's hurting vulnerable populations, higher levels of anxiety due to climate change in varying populations
Use of this issue in a divisive way
The smog
Climate is always changing-not concerned that it is any different than when I grew up.
not concerned during my childhood. Somewhat concerned now
I was a child in the 1960's. If there were wildfires, they were isolated - as far as I knew. Glaciers were not eroding. Islands were not disappearing. Weather was not as extreme as now. Australia was not burning. Canada was not burning. Antarctic glaciers were not shrinking at alarming rates. Animals were becoming endangered because people were killing them, not because their habitat was drastically changing. The frequency and severity of tornadoes in Indiana has not seemed to change. Winters are generally not as cold, summers not as hot. Smoke from wildfires didn't come to the midwest - because they didn't happen - and affect our air quality and health. I could go on.
Air quality and water quality concerns are greater
Less snowfall and milder winter
The change to winters, decreasing snowfall and higher summer temperatures with less gentle rain showers in Central IN. Decrease in firefly, butterfly, and bee populations
When I was a child, we were told the planet was cooling and climate would get colder. Now the opposite is what we are being told. Doomsday predictions for climate warming didn't come true. I think too much hype is being made of "Climate Change". The elite tell us what we need to do while they fly the globe in private jets and live in expansive mansions. Hypocrites.
Length of seasons
More extreme weather events than previously
less snow and hotter summers
Much more extreme summer heat and more bad storms like "derecho" last week.
Winters were longer Did not hear as much about warmer temps and effect on the ocean and nature habitats
Everything seems more intense. Droughts linger, rains harder, winds mor violent, more flooding, more very hot days.
Climate change is discussed more than when I was a child. There's definitely a sense of urgency to do something. I also feel like weather where I grew up (Southern California) is a little more unpredictable than I remember it being.
Warmer winters and southern species moving northward, droughts, more tornadoes, less snow, ponds not freezing the whole winter,
N/a
Definitely much warmer days, of course when I was a child, we never had a.c.! I would never give that up, God willing!!
Less snow in winter; fewer opportunities for activities such as cross-country skiing.
Seasons are extremely unpredictable, and the cycles are longer (storm systems and rainfall that span a week+ instead of 3 days, extremely hot months instead of weeks, and drought periods that seem more random and severe.)
We have very little snow now. Also, we rarely have a true Spring or a true Fall with pleasant, moderate temperatures.
Lack of green space and more asphalt creating unpleasant, heated microclimates. This requires more AC
Fossil fuels
Hotter summers, milder winters, and less variety of insects, birds, wildlife. Less respect for our environment and taking care of the natural resources and wildlife which remain.
I hear more about it. It was not on anyone's radar.
Increased temperatures, more storms, less snowfall, changes in bird migrations
less snow fall
Never thought about it until Al Gore brought it up in 2000
It appears it is a real concern
The overall effects of climate change to nature and economic

Air quality (fires/heat and burning chemicals); effects on food production/prices
Understanding the effect of eating meat on the environment - have become a vegetarian.
Less snow in the winter, the hot late July/early August days are now all July and August, inconsistent precipitation patterns
I have heard that crop-growing climate zones may be shifting, but I have not seen it for fact.
Direct impact of increasing temperatures on food costs, availability, jobs, etc.
Climate change is getting worse at an accelerated pace
Spending time outside is getting more challenging for extended periods of time due to heat
Excess heat
Lack of snowpack from winter months to support surface water, reduction of the groundwater under the influence of surface water recharge
Air quality
Winters do not seem as cold and less snow fall.
Scientists in my university degree programs enlightened me to facts only: climate change is part of the organic "alive" system that is the universe. Humans did not cause it; humans cannot stop it. We will have highs and lows, another ice age, etc. Climate change is not political, not human-induced, it is natural and will happen no matter what we do.
More storms and they are more severe. Interruptions in travel due to storms. More physical damage to homes and environment due to storms. Stress in animals
More air pollution. More need for trees. Ecosystem complicated interactions.
I am a native Hoosier, born in Indiana. I honestly have seen no noticeable changes since my childhood.
Less snow
Hotter summers with more humidity and warmer winters.
The sun seems brighter, more intense. Summer much warmer as is winter. The four seasons less predictable. Wildfires impacting air quality over long distances. Less snow in winter& less rain in summer.
Hot weather appears earlier in the Spring Hotter temperatures in Summer The four seasons not so clearly defined Storms seem more violent
Incursion of wildlife into urban areas; lowered water levels in bodies of water.
More extreme weather, much hotter summers, and milder winters. Also, climate change is having negative impact on other countries (floods or drought that reduce crops and increase food insecurity; hotter weather that causes human suffering) that will inevitably directly impact us/our country.
Recycling and finding ways to avoid producing waste.
It's not about the weather getting warmer, it's about the climate getting more extreme.
Recycling and learning to live without producing waste
Urgency of it
Hotter all year round, less snowfall, more extreme natural disasters
warmer
Warming planet, air pollution, too much plastic
Not sure I understand but a lot less birds, dry weather
Heat, the scorching sun sizzling your skin.
Hot, natural disasters
Awareness
We now are in a situation of mass extinction
I am not a native of Indiana, so I can't comment
The rains are more intense and spaced farther apart. I am noticing torrential downpours vs. lazy, drizzly rain that lasts a day or two. I have noticed more hot days throughout the summer instead of in August. We should only be seeing 90s and above in August.
On average, much higher temperatures

more intense hurricane seasons, hotter summers, warmer winters, additional tornado threats
Hotter summers, milder winters, drier summers, more severe extremes in Temps, precipitation.
It hardly snows as much in winter as it did when I was a kid. Summers have become significantly warmer. Recently, the air quality in Carmel sunk with wildfires from Canada creeping into the states. With air pollution on the rise and temperatures rising, I'm mostly concerned about its effects on the ecosystem.
Air quality - I never had to think about air quality and playing outside as a child (I am almost 50, a Gen-Xer).
We need to work with nature. We are only a part of it, not the master.
There are regular, weekly climate disasters around the world that are scientifically attributable to a warming planet.
The summers have been warmer and more humid than in past decades.
Higher heat and concerned about water supplies. We cannot survive without water.
Higher temps and shorter winter seasons. Water. We cannot survive without water.
Summer is warmer and drier and winter has much less snow cover.
very little
I think this climate change is a bunch crap...total lies.
Summers are hotter, drier. Winters are milder, less snow. More extreme heat year-round. More severe storms/tornados. More heavy downpours. Blue Spruces are dying. Flowering trees are stressed. More irrigation needed for lawns. Need to turn on AC earlier in the year.
The severe weather has increased significantly since my childhood as well as the heat of the summers. I have seen much more heat related illnesses as an aquatic's worker.
The main difference is the acknowledgement that it's not just "getting hotter," but that weather patterns are shifting and causing extreme weather events (polar vortex, tornadoes, flooding, etc.). Also, now it is considered not reversible, whereas 30 years ago it was still a "maybe."
The extremes of weather, rising use of plastic leading to pollution of water and harmful effects on marine life. I would like Carmel to be in the lead dealing with the climate change risks.
Fewer pollinators and lightning bugs.
I used to think it was how we would experience the heat locally. Now I understand that Climate Change is a global phenomenon that is projected to cause major disruptions to the livelihoods of people everywhere. Scientists now project there will be a Billion climate refugees (10 times what we now have and don't seem able to manage). This will cause wars, authoritarian governments to take hold, and likely global economic collapse. This will impact Hoosiers whether it's hot or rainy in Carmel.
through my 80 years in Indiana, I have seen varying degrees of temperature trends. I can remember that in the late 60s winters were warmer, but that changed. The extreme temperatures (The number of days with temperatures exceeding 95°F has significantly risen in recent years. We used to have an average of 13.7 days (1976-2005), but now it is 36.6 days. Projections indicate a potential increase to 51.8 days by the end of the 2060s.) as stated here is not put into context.
Vegetation changes, huge decrease in animal spiciest (I especially notice it in frogs and birds). The water quality of our lakes and streams including Lake Michigan. Oh, and the invasive species we have to deal with seems larger today.
Hotter summers. More natural disasters.
I think our seasons have shifted some. Warmer in the fall, cooler in the spring. No worries.
See much less direct sunlight all year round and especially in the morning.
Weather patterns
Higher max temps and higher low temps. Higher max temps' impact when I and especially workers can safely work outside. Rain bombs that lead to temporary flooding of creeks in Carmel.
The impact it has on native flora and fauna.
All aspects.
I am only 20 years old, but we have less snow in the winters, summers are considerably hotter, it's harder to enjoy time outside. Especially with such terrible air quality most recently.
Much more invasive flora. Heavier rains. Warmer winters.
Less clean water, much less wildlife butterflies, bees, wildflowers…. forests have been plowed down killing animals and their habitat, hotter summers, extreme fluctuations in weather rain, snow, heat, cold. More wildfires and drought. Water is more polluted; oceans are being destroyed-again marine habitat ruined.

Many aspects including experiencing milder winters, more extreme weather patterns such as severe storms, extreme drought, and warmer ocean temperatures. I also hear more about it today than during my childhood, as I never remember this being discussed in any of my social circles including school, home life, news cycles, or friendships.
Just more awareness, I was a child in the 60's, so didn't hear much about the climate
Flooding seems as bigger issue as natural wetlands have been filled.
Impact of human activity on climate and environmental changes.
My need for snowblower has diminished.
Areas of denser population that are affected quickly
Not much change
More noise about the weather and communications today that make us aware of all-weather events around the world
Severe weather impacts, people moving
More severe weather events in winter, spring, and summer.
None, I think it was hotter then.
I believe it is a made-up thing. There is not enough data to know there is a global warming or "climate issues." The only issues we seem too continually have are man-made.
Wildfires and flooding as well as heat waves and droughts. I don't recall hearing of those very often nor as severe.
I can tell it is much warmer and much less snow in the winter.

Question 4: Are there climate impacts not listed above that you are particularly concerned about? Please share them here. (optional)

A total of 130 respondents provided the following insights (responses marked as 'none', 'N/A', or 'No' were omitted for presentation quality):

Table 8. Responses to Q4 from Climate Community Survey.

Harsher weather, impacts to food, water, and animals
No - climate change is real. However, Carmel does not appear to be exposed to risks in a material way that would justify some climate-specific adaptation strategy.
None
Use of resources to contemplate/worry about climate change. It's good for us to assess and determine what we can affect vs. spending resources on impacts that might not occur or that we can't change.
I think you got most of them
melting ice caps
Heavy development in Carmel has reduced our green spaces and disrupted the soil which, in turn, encourages invasive plant growth. Invasive plants such as Callery / Bradford Pear have not been allowed in development planting plans for years but have nonetheless been planted by builders because of their quick growth and showy flowers. Similarly, burning bush has been used as a landscape plant and is spreading into the few native areas left in Carmel. The loss of native areas has a direct negative impact on valuable insect species (>80% of hatchling birds are fed caterpillars that depend on native plants to feed and reproduce). This, in turn, reduces the numbers and biodiversity of native bird species. Allowing business interests to manage environmental impacts is counter to scientific evidence, is well behind the curve of forward-thinking communities in America and is a conflict of interest.
War on gas stoves, wood burning pizza ovens, solar panels, and windmills. Solar panels and windmill production is virtual all done in China. China also major control over the components for elective batteries. Then there is the issue of how to dispose of these products once their useful life is over. Coal and fossil fuels still will be needed. But these may be eliminated as well by regulation.
School safety due to wildfire smoke.
infrastructure on need for electricity to have to power AC more often or backup generators due to power outages. City's ability to respond quickly to weather related issues.
The bogus expenses for climate change are causing the Nation to go into serious and dangerous debt. The National Debt is now over $32 Trillion.

Air quality issues due to more wildfire smoke and droughts kicking up more airborne dust.
Toxic waste, invasive species taking over, not enough trees planted for carbon capture, not having people recycle, plastic bags and its impact on local wildlife (especially water wildlife), severe droughts, air quality, air quality, air quality. We need more grants for solar panels and better return rates on extra energy given back to the grid. Building security and building sustainability. Carmel is growing so much and there should be more restrictions in place to ensure quality building that can withstand climate change.
Impact of invasive plants and insects
The smog
I think you covered it pretty well.
The impact to the ecology overall
Nope. I'm relieved that global cooling didn't happen as I think that would be far more damaging to the planet than warming.
Air quality
Water toxicity
air quality issues
Yes, impacts on resources for those without much money or many resources. We had partial generator last week for 3.5 days of AES power outage and neighbors who did not have generators suffered more.
Economic impact - can we afford our insurance and upkeep due to weather related issues? Property taxes, insurance premiums, repairs, and updates necessary to prevent or withstand future damage.
Air quality
All of the above issues affect so many people & it seems, sadly, that the people that are the most affected already have issues with trying to survive economically. Very sad, scary world.
Impact on humans' ability to enjoy nature, garden, exercise outdoors, etc.
Water in Carmel is wasted over watering lawns. It doesn't really matter now, but in the near-ish future I can see a problem with water restrictions. The community won't tolerate it; we'll likely push for a pipeline from the Ohio to bring in more water rather than ration what we already have. I don't like that option for lots of reasons I won't expand on here, but in summary I think that would be ecology irresponsible and a bandaid solution. Xeriscaping would be a great trend to preemptively combat that! Especially in areas like roundabouts that currently just have a curated lawn aesthetic.
Impact on our food sources.
Effect on social life - especially for elderly - too warm to go outside, storm fears, etc.
Reluctance of legislators to confront climate change proactively.
Especially concerned about water. Going forward the lack of water and especially clean water, contaminated soil with its runoff of chemicals from farms & pesticides in our water.
Loss of wildlife habitat
Increase impacts on our parks. The weather has affected the vegetation in our parks and the increase population with more people visiting the parks are tearing them up more. Creating more erosion on the trails and adjacent to the trails.
Loss of land due to flooding
Mental Health impact. Scary to have air conditioner break in high temps or have a strain on power supply. Not being able to enjoy outdoor activities and be active during summer months.
Reducing waste - would love to see city-wide composting. More trees - we need more trees on all public spaces. Rooftops as well. Limits to watering yards. Would love to see solar on public buildings.
Increase chance of pests due to longer growing seasons, higher spread of invasive plants due to different growing conditions, water security with increased demand from aquifers and fewer natural areas to help recharge those aquifers
Lack of shade from cutting down trees to build up more developments
I think more than anything extreme weather would be my largest concern. Like, more intense thunderstorms, wind, tornadoes, etc.
Prioritization of 'wealthy communities' not losing value versus poor communities being less able to adapt. I foresee Hamilton County making sure that the people that live near reservoirs or water bodies getting support because a drop in their home values will cause the tax base to come down, yet we will have portions of the community that will see increased morbidity and mortality due to heat related disease or exacerbation of pre-existing conditions. I see government officials making sure

that we have water in the reservoir to allow recreational activities for homeowners before spending money on permanent heat relief shelters, storm shelter s
Air quality
My concern is that working taxpayers will suffer for nonexistent, man-made ideological and political purposes that use "climate change" as a fear tactic for gaining votes.
Less native and natural habitat for animals
Urban development often trumps ecological concerns. This city boasts about planting trees yet destroys a 300-year-old woods. Some tree cities we have.
None come to mind.
Warmer temperatures
I think you covered them.
Drought & air quality.
The cost of doing nothing/not enough to reduce the impacts of climate change will be very high. Future generations will bear the brunt.
Future for my kids
Worsened air quality due to loss of trees
Tornados and severe storms
Water quality killing ocean life
Global impact
Energy and renewables. Desperate need for government response.
A big concern for me is the potential for climate change to contribute to the mass extinctions of species. I think Carmel, Hamilton County and the US in general could plan development so much better, with regards to habitat destruction and using nature to help limit the effects of climate change.
Food security.
Yes. Overbuilding of apartments in Carmel with limited green space, removal of mature tree all affects our environment. Please STOP
Nothing that I can think of.
Air quality. Even now if you travel east on 96th, past Keystone, many days it's smoggy/dusty. This was true before the Canadian wildfires. My son has asthma. I'm concerned about his ability to do outside activities.
Slowness of US and v local governments to respond
I think it's an utterly logical conclusion that if nations don't move to slow climate change right now, we will see war in the next 50 years. Probably in other countries first, but then there will be competition for resources in the US as our own citizens migrate and search for water. I worry about my children's future daily- I'm glad to see that Carmel is starting to prepare.
Concerned about politicians and too many humans stating climate change is a hoax.
Too many politicians and humans think global warming is a hoax. It has become w political issue with majority of republicans believing there isn't global warming.
I am mostly concerned with drought, shifts in agricultural growing zones, and extreme weather events.
The impact of all these things on our quality of life and cost of living. Hotter days means more air conditioning. Climate Anxiety is hurting our kids. Sea Level Rise. Indiana governor and legislators are not doing anything about climate/clean energy, their policies are hurting climate/clean energy.
There are so many ways the climate affects are daily living and community that we can barely comprehend. I worry the most about how we will continue to sustain ourselves when other less affluent communities suffer. Air quality, food access, and overall life quality are all things I am immensely concerned about when it comes to the global climate.
Strain on the energy grid due to increased demand for air conditioning, usage of fossil fuels (coal, natural gas) to provide that energy making the problem even worse
There is a lot of food wastage leading to greenhouse emissions. I recently attended a talk at the Public library and have signed up for Compost pick up through Earth Mama(Composting services) Can Carmel introduce this option for all its citizens on a voluntary basis like other cities have done? Germany is the leading country with its recycling efforts, I hope that we can learn and do better.

Thank you for offering a platform to express thoughts on this vital matter.
Smoke from wildfires making it difficult to breathe.
Mitigating the effects of climate change involves stopping the use of carbon fuels (ASAP), of course, as well as making our infrastructure resilient enough to withstand multiple climate catastrophes. If in fact these can be done. In addition, we must think about the people! Our children are already suffering climate anxiety and depression, and the future will bring many causes for people to have major cares and concerns over Climate Change. People will lose jobs, homes, friends, and family, etc. Carmel needs to be a whole lot more about caring for people - and not be so focused on money. IMHO
The number of mature trees that have been destroyed by apartment and other development in Carmel. Cutting down a tree with a diameter of 2 ft and planting one of 2 inches diameter will not really impact CO2 development.
Water quality - ash pits as well as the animals waste pits created by Caffos. Too much use of water to keep up the lawn - I'd like to see the encouragement more natural plantings in yard as well as clover.
Climate change affects globally. Air quality issues.
I'm most worried about what our government is trying to do to us. Talking about sun blocking and cloud seeding.
Trying to live with perpetual jet lag because we have way too much daylight in the evening and pay way more for air conditioning than for needed lighting in the morning.
Air pollution
There are several global aspects of climate change that might not impact Carmel directly, but are hugely important (e.g., sea level rise, stronger hurricanes, melting glaciers, global warming, increased drought and subsequent forest fires, reduction in crop yields).
Species (flora and fauna) extinction.
With climate change adversely affecting birds and wildlife, I would like consideration on removing lawns and instead planting as a prairie with wildflowers and grasses. There is so much new construction and, therefore, more lawns with the pollution that accompanies them.... exhaust from mowers, fertilizer, etc.
I am incredibly concerned about the disproportionate impacts of climate change that may not directly concern Carmel but can and will impact areas around Carmel.
Hopefully humans can put the brakes on over consumption, live on less, leave areas wild to support creatures for their clean water and food. Creatures can't shop at a store human can. Make safe crossings for animals to migrate. Animals need our help.
The political climate we are in today is preventing real climate change progress; thus, impacting not only how it is being perceived but how it should continue to be addressed. Unfortunately for all of us, this is affecting the entire scope of climate change - thus creating a real concern for causing worsening long-term conditions.
That people don't believe this is happening to our environment and won't until it's too late. I hear all the time when it's cold in the winter "oh this is global warming?" Yes! It is part of it. Education is key
Impact on nature and animals (besides humans).
Heat and air quality this summer have affected my ability to exercise outdoors. I worry that it will worsen beyond a few days to large parts of the summer being too hot
The fact that they move forward without having the science to back it up much like the electric vehicles without consideration to the electrical grid battery science is not there yet and still there is very small amount invested
Yes, I'm concerned about this overhyped on the weather affect having on young people
I am greatly concerned that those who have less economic resources will be disproportionately impacted by the effects of climate change.
I am not concerned about a climate issue. There are things we can do to conserve resources and not be wasteful, but there is no climate issue.
Climate and nuclear/bioterrorism shelters. With the Ukrainian war going on, I look and realize subways and old bunkers were used as shelter; however, here in Carmel there are no subways or underground emergency shelters nor a known plan with the City of Carmel, I just like to be prepared in case of emergencies especially protect any vulnerabilities. In addition, is there an emergency plan for catastrophic flooding? I was living in Carmel/ Fishers for the floods in 2000's. However, with extreme weather comes more dangers to be prepared for. So, I'm asking if there's a plan in place for any of these, try to make known to us citizens so we won't panic because we have a plan, and a backup plan and a back up to the backup. Plans help mitigate anxiety. Thank you kindly.

Socio-economic aspects in Carmel:

In the second part of the survey, we continue to inquire about the needs and concerns of specific populations within the Carmel Community. This section aims to gather more comprehensive data to address the diverse perspectives and challenges faced by different groups within our community. Some of the questions were optional.

Question 5: What is your housing situation? Select one (optional)

A total of 128 people responded to this question. Among them, 86.7% indicated that they own their own home, 10.93% are renters, and 1.56% live with friends of family.

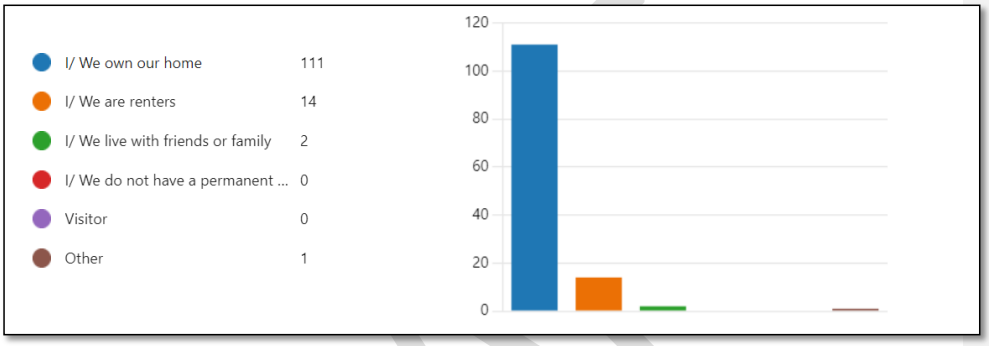

Figure 88. Summary Results from Q5 on Climate Community Survey

Question 6: What is your household income level? (optional)

A total of 114 people responded to these questions, sharing their insights on the following aspects:

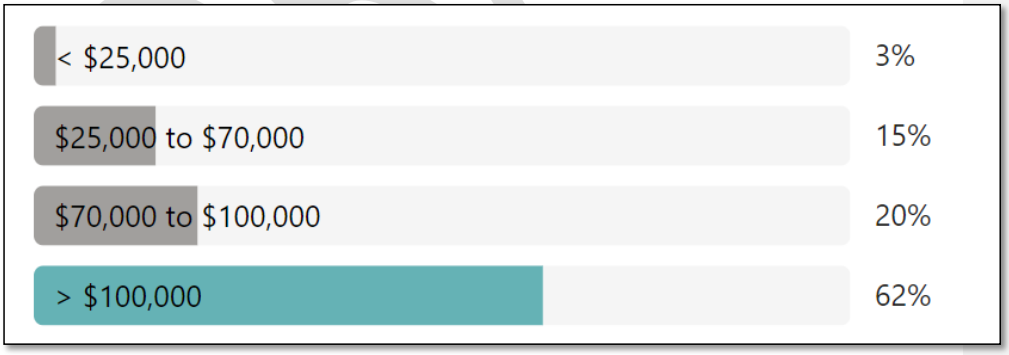

Figure 89. Summary Results from Q6 on Climate Community Survey

Question 7: How do you identify? Select all that apply (optional)

A total of 130 people responded to this question. Among them, 84.6% identified as white, followed by 6.9% as Hispanic or Latino, 6.15% as other (not specified), 3.07% as Asian, and 0.76% as American Indian or Alaska Native.

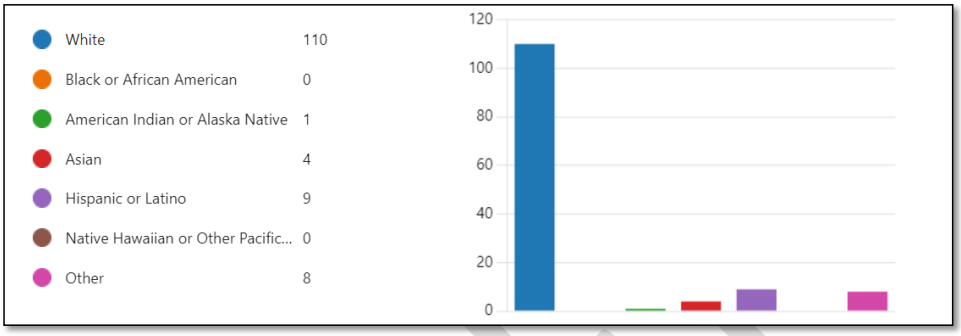

Figure 90. Summary Results from Q7 on Climate Community Survey

Question 8: What is your favorite thing about our community? What do you love the most about living here?

A total of 120 respondents provided the following insights:

Lower crime, good schools, amenities such as trails and parks.
World class infrastructure and high-quality municipal services.
Safety
Schools and parks.
multi-use paths enabling car-light lifestyle
the urban forest & street trees, paths/trails, birds/animals, cleaner air, mixed land uses, and more
Convenient access to the entire city and inclusion of new dining options that are ethnically diverse
Lots of activities.
Bike lanes and pedestrian friendly! More of this please!! Less car traffic in the main core would be amazing!
bike paths, good roads, great police presence, therefore, lower crime. Good schools and community sports programs which set high expectations for our youth.
I am sorry I moved to Carmel in 2005.
Community has all resources, local events, weather, and sensitivity to environmental issues.
Ability to bike places, emphasis on parks and keeping native/natural woods, native plants, community feel
The general courtesy and consideration with which people treat public spaces
The community is kept clean i.e., streets and green spaces. I feel safe here, we have a good police department.
It is safe and affordable. Well maintained
Our neighborhood has not changed a lot since we've lived here, in the same house, over the last 30 years. We generally feel safe as we go about our lives in Carmel and the surrounding areas. There are many opportunities for activities for all age groups. The schools are excellent. The community is becoming more open to diversity. I was inspired by the recent

newsletter from One Zone and their focus on diversity and inclusion. I see a lot of philanthropy and benevolence, and that's inspiring.
Accessible green spaces where my family can give together
Walking and bike trails
The community feel and all the things to do as a family or with friends, the safety, and the lower cost of living
Safe from crime and violence.
Parks and activities
walkability
intelligent governing folks, emphasis on green spaces, safety, kind neighbors
Parks-Library
Parks and whatever is left of greenspace
I love the family-friendliness, the cleanliness, the safety, and investment into the community.
The available trails to avoid using the car
Aquatics accessibility
All of it!!! There is so much to do for all age groups, safe (so far thank God), we are very blessed to live in such a unique, lovely place!!
The parks, trails, and education system.
It's safe.
Parks, Monon Trail, Roundabouts, low crime
Great public schools and an amazing Library, beautiful City Parks, our exceptional Police and Fire Departments, Gazebo concerts, the Palladium, Christkindlmarkt, and other entertainment venues, plus the Carmel Farmers Market. The city also offers great community events year-round (at no or little cost) that add value to living in this city. Something for everyone!
Parks, trails
The parks!
What I once loved about our community is gone. The small-town feel has left a long time ago
The Park District
Forward thinking
Outdoor spaces and activities
The Pint Room!
Roundabouts --> very little time spent in traffic
schools and safety
family friendly, clean, safe, GREAT schools, walkability
This is a focus on making the community livable and enjoyable including protecting our people from the harsh effects of climate change.
The focus on alternate transportation methods such as walking and biking
Community parks, events, and social atmosphere
Safety and cleanliness
Parks, trails, outdoor entertainment, restaurants
Good school but concerned with direction they are headed with DEI currently. Get back to school academics. Safe low crime rate. Love our police and fire folks. Clean city. Concerned with too much concrete and not enough green being left when development of land.
Quality of life, excellent schools, parks, and library.
We love the excellent public services such as police, fire and rescue services, roads, and in the past, we used to be proud of our schools. We love Carmel because our tax dollars show in the aspects of the community such as flowers in the streets, activities and projects that bring our residents together, careful zoning and planning to keep out undesirable aspects, etc.
The people

Safety and school system.
Our support of green spaces, parks, and multi-use trails. BTW. I have concerns that our city center is continuing down the path of becoming a concrete jungle someday. It's a fact that urbanization contributes to hotter temperatures versus suburbs. High concentrations of multi-family housing do also.
Nice people
The activities planned for the citizens to enjoy.
Carmel is trying to meet future needs not just the present. Safety.
Great public services Diversity Low crime rate
I love that the city has leadership willing to act to provide a welcoming environment and the amenities that attract an active, well-educated population.
I love the safe neighborhoods, walking paths, schools, changing seasons, community.
Good infrastructure, paved multi-use paths.
My neighborhood is a walking neighborhood, adjacent to bike paths. We don't use cars as much as other places I have lived.
Lots of community activities and things to do
My neighborhood is a walking neighborhood, adjacent to biking trails Carmel has planned our city so using our cars is reduced.
The quality of living in Carmel is top-notch! The schools are exceptional, crime rates are low, and our parks system is awesome! I've found a particular love of the arts in Carmel! We have multiple state of the art performance venues, and we are lucky for that fact! I also do like the roundabouts and the infrastructure that has been implemented.
Trees
Minimal traffic
The variety and plethora of activities
Safety
I've lived here for 30+ years
Schools Thoughtful urban planning
Safety. Walkways.
I do enjoy all the public amenities and the downtown area.
Walkability or bike ability to everything.
I like the downtown main street area but do not go there often because parking is so limited for senior citizens.
the safety
Cleanliness, great parks, and good bike trails, Monon Center, lots of eating options
I love how involved Carmel's community is. There are plenty of opportunities for engaging with people in the city, especially in the library. It's easy to find some kind of event that suits your interests, and a lot of places to hang out.
Bike ability, Monon community center, roundabouts, public schools, library, overall quality of life
The parks and rec departments approach to building things allowing for better water drainage, using native plants etc.
The fantastic schools
Central Park and Monon Greenway
Low crime rates, beautiful clean city, and our round-a-bouts. Forward thinking in terms of urban planning and the arts. Range of shopping amenities. Low taxes.
Low crime, low taxes, clean and beautiful city. Forward thinking in urban planning. Stricter zoning requirements. Our roundabouts.
Carmel is a friendly community with many amenities.
the roundabouts
The cleanliness of Carmel, and how beautiful and safe the area is

Our school district, the trees & parks, the bike paths, and the fact that solar is growing in Carmel. We have the means to do great things and be a role model for other communities.
I love all of the opportunities available in Carmel, and the parks!!
It's safe, clean, and has a lot of parks and walking paths.
It is a good community with excellent public schools, library, walkability. The city has done well with the current Mayor's leadership.
It's large enough to have public amenities, but small enough to BE a community.
Our pond. The liberal minority is growing.
The Monon Park and the Library.
My grandkids live here. The parks and schools are great, and I love the activities that the city coordinates with local businesses and volunteer groups.
Diversity of neighborhood and city - hoping they both become even more diverse with time.
Festivals, concerts, safety, our fire, and police departments, Monon center.
Vibrant and inclusive.
Outdoor space
bike paths
Parks, convenience, walkability, roundabouts, safe, high quality of life
All things Carmel!
I love the community we have built and the places we get to enjoy
Most of my family is living in this area.
Feeling safe.
The roundabouts and ease of accessibility, the friendliness of our community, all the businesses that are offered, the schools, and our library.
Green spaces, Monon
Strong schools, good community participation in activities.
Good place to raise a family.
The focus on transportation like roundabouts and connected paths
Lived here for 60 years
Not woke
It is safe
Safety, kept up, looks nice
The schools, the quiet, nature
It's safer than Indy.
I love many things about living in Carmel.
I moved to the area in 1994; officially becoming a resident in 1996. I love all the improvements. There's always new roads or improvement to roads. I love the Palladium area and the redo of the old lumberyard mall area. Overall, I love it! However, my one fault is the bikers on the main road like 146th street or even 141st or west roads —west Carmel in particular. It's hazardous for bikers to ride on streets with cars going 45+ mph. Especially with the roundabouts. It's hard to see bikers coming around the roundabout. Can we maybe have some education on the "rules if the road" for bikers. I was under the understanding that bikers must go the speed of the vehicles in order to be in a main road. For instance, if speed limit is 45 mph the biker needs to maintain a speed of 40-45mph. In addition, bikers obey all traffic signals including stop lights and signs. So, can we have an updated "bikers' rules of the road" education PR campaign? We all could use a refresher now that there are roundabouts. Thank you
Diversity. Cleanliness. Water fountains. Walkability.

Question 9. Which community areas do you prefer to spend most of your time when you are not home or working.

A total of 122 respondents provided the following insights:

Meadowlark Parks, monon trails/ Hagan Burke trail and public library.
Downtown Carmel (Old Town through to City Center)
Parks, midtown, Monon Greenway
Parks
Monon Greenway, Main Street, Midtown
Monon Trail, Central Park, Carmel Midtown, Carmel Old Town, and more
Parks
Trails, main street, and midtown
Monon Greenway, library, and Midtown!
greenways and bike paths
On my property.
Parks
Parks, Monon, monon center
West Park, Central Park, Monon and pathways in neighborhoods around us
Palladium is a favorite. Also, like Main Street retail.
Parks, HB trails. greyhound trail
Many parks. Monon Greenway except it's so crowded. The library. Low to mid-priced restaurants. My church (St. Peter's United Church of Christ on Carmel Drive east of Keystone.) Picking up carryout pizza from Bazbeaux, Greek Tony's, Jet's, Donato's, and others. Always on the lookout for places to walk where it's not crowded.
Parks and public library. Then Midtown and downtown
Monon
Parks, Monon, Main Street, Mid Town, walking paths, outdoor spaces
Parks and trails
Monon Trail
monon
Monon Center, Library, parks, home gardening
Parks Library
Parks and greenways
Monon Trail, Monon Community Center and parks, Carmel playgrounds.
Midtown, monon center, parks, Main Street
Parks and swimming
I walk down to Main Street, to Midtown, the Monon, etc. & try to attend as many activities as possible that I can.
Parks and such, contributing to education and experiences of young people, through school gardening, native plant projects, literacy efforts, etc.
Parks 100%, primarily ones with playgrounds and shade such as the natural play area at cool creek. We also like to bike down the white river greenway.
Hagan Burke trail, Monon Greenway trail
Single story, small homes, good neighbors, smallish yard allowing a small garden, near Central Park and the Monon Trail.

Monon Center, Monon Trail, Wednesday Gazebo concerts, midtown, downtown events
Parks, Library, Monon Greenway, Gazebo, Midtown, and downtown Main Street!!
Founders Park, river road trail, inlow park
Parks and monon Greenway, other trails
The parks were once my favorite get away. Fighting the crowds at the parks to get away to relax defeats the purpose.
Monon Center, Midtown, Dining, downtown
Parks, Monon
Monon, parks and Center for Performing Arts
Parks and main street
Parks, Main St, shops near my home (116/keystone)
Monon Greenway, Monon Community center, parks, Main Street/Midtown
main street shops and restaurants
Monon Greenway, Main Street, Midtown and walking through neighborhoods
Main Street, midtown, parks, monon
Monon, midtown, city center and Main Street
Monon greenway, Central Park
Main Street, Monon Greenway, Hamilton County Parks
Main Street, neighborhood, monon greenway
Main St, Carter Green
Main Street, Monon, parks, midtown.
West Park, Coxhall Gardens
We like to spend time biking on the Monon Trail and in the parks.
Parks!!
West Park. Coxhall Gardens.
We are a bike riding and walking family. So, parks and trails are a plus!
Main Street
Library, walking on the Monon trail, the Farmers Market, concerts at the Gazebo and other free concerts with live music, CarmelFest, Christkindlmarkt
Restaurants, Palladium, Saturday market.
ParksMonon
I love the Monon but take advantage of the city's network of multi-use paths to run and bike. I also love the park system and all it offers, from playgrounds to trails.
Midtown or trails
multi-use paths and trails, including Monon, West Park.
Walking paths
Main Street
Walking paths
Main street
Library, Monon Center
Library
Parks and pool
Parks
Midtown
Midtown West Clay parks MononSchools

Gardening. Monon. Library.
I use the Monon for biking on regularly and I enjoy walking round the parks to view the wildlife.
Monon trail, Monon Center, and parks.
parks, monon
Monon Center, parks, midtown, and main street
Downtown Carmel, Midtown, trails along the White River
Library, Monon Community Center
Parks
Monon community center and Waterpark, the Greenway, midtown plaza
Monon Greenway
Midtown, City Center, Monon Greenway
Monon Greenway, Main Street, Midtown, City Center.
Midtown, Main Street, Central Park Dog Park, The Monon Center.
monon greenway, parks, midtown, theatres, and restaurants
Monon, parks, bike paths
Parks and Midtown.
Parks, the library, Main Street
Farmers Market, Parks, Monon Trail, Chriskindlmart, Art Fairs, Local shops on Main Street.
Parks & Main St./Midtown.
Parks, restaurants, hardware stores, library.
Central Park, Monon Center and the Library.
Bike trails and parks, Midtown, the Monon Center.
Parks, Monon, Midtown
Monon center, Arts and Design, my neighborhood.
Unsure. Love living within walking distance of Carmel Green, Midtown, etc.
Monon greenway
Monon Greenway, Midtown
Parks and midtown
Walking on sidewalks, enjoying the wildlife around lakes and ponds, Palladium/Tarkington/Actor's Theater, Christkindlmrkt, Market District, College Park Church, Carmel Clay Library.
I spend time in our own backyard and downtown carmel. I also really enjoy river road park!
1) Working in my flower beds. 2) Removing invasive flora from public areas, as well as from Teter Organic Farm
Parks and library.
Main Street.
Trails, monon greenway,
West Park, monon greenway
Monon Center, various parks, church, food pantry
Multiuse paths, parks
None anymore it's way too congested
Parks and Monon
Main Street
Parks, monon community center, midtown, walking trails
Westpark, Monon, Holliday Park, Cool Creek,

I generally don't have time.
Main Street, various sidewalks for walks
I use West Park quite often. However, I do not like the redesign; grocery shopping is inconvenient and inaccessible for West Carmel area. I clocked a 5+mile drive to any grocery store in addition to 20-25 + minutes' drive to the high school, can there be a grocery store at 146/Towne or 146/ditch or even on 146/ 421. With all the redesign it seems us in West Carmel area spend most of our time in car driving around. I realize the community will never be completely walkable but a nice mini grocery store or a general store (not a specialty store) in West Clay (pettigru drive) area would be nice. So, to answer the topic question I spend most of my time in my car drive driving for basic necessities (now I use a lot of Amazon and Walmart.con but I woukd love to support a local nearby business instead)
Monon. Parks. Coffee shops.

Community engagement:

In the third part of the survey, we gather questions and feedback from community members and ask for their name and email to keep them informed about future Climate Resilience Planning engagement opportunities. This input will help shape effective strategies tailored to Carmel's specific needs.

Question 10. Please share your question:

A total of 54 respondents provided the following insights:

What is Carmel doing to reduce emissions? When will we start composting as a city?
Carmel, along with every city, needs to make drastic improvements to walk and bike-ability in the city center, so that people can reduce their dependency on cars. Carmel has a great core with the Monon Trail, especially in Midtown, but it has a long way to go to making trips to work, school, and groceries safe and convenient. What is the city doing to accelerate building the multi-use path network? Especially towards the destinations I mentioned. We need safer crossings and more east/west connections. The speed at which car infrastructure gets built only serves to extend our dependency on cars and worsen climate change.
Do we even have a chance to turn this around, or are we too late?
I've been told that the reason Carmel does not implement stricter planting rules against invasive species is that it is too difficult to enforce. Why doesn't the city levy fine against developers who plant outside the approved plans and let individual residents report the violations? Can Carmel engage in a multi-year effort to encourage replacement of invasive plants with native alternatives by subsidizing some of the cost? Can developers be required to replace not the number of trees they remove, but the board feet they remove?
Not a question, just a comment. Seniors do not seem to be welcomed at the Monon Community Center.
Will the city be doing more to encourage alternative modes of transportation? Adding public transit and reducing car trips?
Why disregard the historical record regarding changes in the climate?
Seems like the focus is on trendy things like electric cars whereas good old-fashioned things like minimizing light pollution having porous driveways well and septic systems hanging out your laundry to dry, local garden are not given as much encouragement
What will you do with this information? Is this process connected to any political agenda?
I would like to see a greater emphasis on affordable housing (so people who work in Carmel can live in Carmel, reducing commuting and associated pollution. Similarly, I would like increased access to public transportation.
Why so many apartments? We are not the city of roundabouts; we are the city of apartments.
Are we looking to do more for the ecology of our area? I have seen some things Westfield I has been doing but not in Carmel.
How can we contribute?
Is Carmel ready to limit stupid irrigation of stupid green lawns now that water is an issue?
What is Carmel doing yo help prevent the city from becoming a solid concrete jungle?
I do believe there is way too much building in Carmel of hundreds (or more) of condo/business places--Carmel is losing its charm & hopefully the infrastructure can handle all of it.
How is Carmel as a city planning to address climate change when it is a global issue?

Why has the city not dedicated space to a park in the center instead of so many apartments and condos with no green space at all. Will this change?
I am concerned about the recent overbuilding of apartments in our city. Heavy traffic has become an issue lately plus overuse of all areas of the city will be impacted moving forward. We need considerably more Green Space!!
What are we doing to increase use of solar, wind, and batteries for energy storage.
What are we doing to address climate change here?
Carmel water has always been plentiful, so any impact to that would be concerning.
What can be done to improve the quality of life for low-income workers trying to live in our community
How is funding allocated to combat climate change?
What I shared earlier about concrete urbanization, and Carmel's ongoing support of construction of already excessive multi-family housing.
Hope that the city leaders will continue to request citizen input on things that impact the city. For an example, I am concerned about the rapid construction of residential housing and at the cost of giving up green space
Concern over growth. Increase in large apartment complexes & therefore, increase in population.
I encourage Carmel to reduce our carbon footprint as quickly as possible. And reduce the city's waste of resources.
How is the city going to preserve the already scarce wetlands and nature preserves that Carmel has left? / How does the city plan to address the shortage of affordable housing in Carmel?
How do you anticipate handling the density of people as more apt complexes are being built
An awful lot of 5/1's is interfering with the aesthetics of the community along major thoroughfares like Rangeline, Monon Trail, and Main Street. Highly disappointing that in the planning there wasn't more allocation of green space along the edges of those thoroughfares.
What steps is Carmel taking to prevent the negative effects of climate change?
How can we encourage better air quality and air quality awareness, even when we're not getting smoke from Canada? How do we encourage a culture of xeriscaping/carbon sinking vs. "pristine" front lawns/landscaping which releases lots of carbon into the air?
What is Carmel doing to prohibit idling and require recycling and green building.
Please stop the over development of green space in Carmel. I worked in New York City for many years. Carmel will soon have more rental apartments than NYC,
Carmel's Climate Action Plan is a great start. What is the plan for engaging our schools, parks, businesses, and neighborhoods to develop their own carbon reduction plan? How can we share our progress with other communities?
What do we as a community see as our role in the overall climate crisis and how will we address that locally?
Do you compost all the flower arrangements which are arranged on the streets after they are replaced with new ones? They are very pretty to look at, but I think every issue needs to be looked through the eye of preventing further damage to the environment in the name of aesthetics.
The current Carmel Climate Action Plan says the city hopes to reduce CO2 equivalent emissions by 45% by 2035 and that we will not be carbon neutral (net zero carbon) by 2050. These goals are not good enough. The increasing pace of Climate Change effects requires that we get all the way to zero much faster than this. Carmel needs to look at things like making Duke get to Net Zero Carbon quickly or cutting our ties with the utility and buying only electricity generated by renewables from someone else. IMHO, we need a mayor who will take on the Indiana Legislature on this.
How can you justify destroying all the mature trees, which are one of the main natural ways of controlling climate change?
What specifically is Carmel doing to make regional and National impact on climate change?
Recommend more tunnels (or pedestrian bridges) so that bikers and pedestrians don't have to cross busy streets.
What can Carmel improve upon to build a climate resilient community? How can we further reduce our greenhouse gas footprint?
Could you hold an educational session or sessions on 1) what is currently being done, 2) what are the challenges, 3) how those challenges are prioritized to be tackled, 4) and what are our opportunities to help? Are there any committees looking for volunteers to serve? I am interested in helping.
What is the City of Carmel doing to encourage the use of vehicles - both commercial and private -- that use "alternative fuels", particularly electricity.
How can we slow construction and give wildlife a place to live? More green space with all the building going closer and closer to streets it's claustrophobic to drive. Unsafe to ride bike or walk in some places. The trees help clean the air and we need to save the mature trees we have.

None, thank you.
How can we make people understand global warming is real?
I'd like to see more solar, either individuals or community solar. What is Carmel doing to address alternative energy sources for individuals? I'd also like to see a transit option, such as buses. Does Carmel have a plan for
It would seem that moving forward is going in the same direction as when we had the environmental emergency with paper bags, and we replace them with plastic which is 1000 times worse. Why did we not get the answers from science before moving headlong and hoping we're doing something that helps.
Taxes for all the development projects
Concern the number of small homes, decreased parking availability
Do we have adequate shelters in cases of extreme heat, cold, etc.?
Are you trying to become a 15-minute city?