Introduction

Science of Climate Change

Climate change is one of the most serious threats confronting society. Characterized by changes in temperature and precipitation, climate change is a threat multiplier to challenges already facing the world including crop production, food security, and water quality. As stated in the ***U.S. Fourth National Climate Assessment: Climate Science Special Report***, "it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence."[1, 2] The human influence is the direct increase in greenhouse gases (GHGs), so called for their innate ability to absorb and maintain heat in Earth's atmosphere. While an optimal range of GHGs (e.g., water vapor, carbon dioxide, methane) are vital for keeping the planet's temperatures stable and habitable, human activities, such as the burning of fossil fuels, increasing deforestation, and development have resulted in accumulation of GHGs in the atmosphere at rates unprecedented since human settlements began (Fig. 1). These higher levels of GHGs have increased temperatures and led to major climate impacts that are altering our world's natural and human-constructed systems.

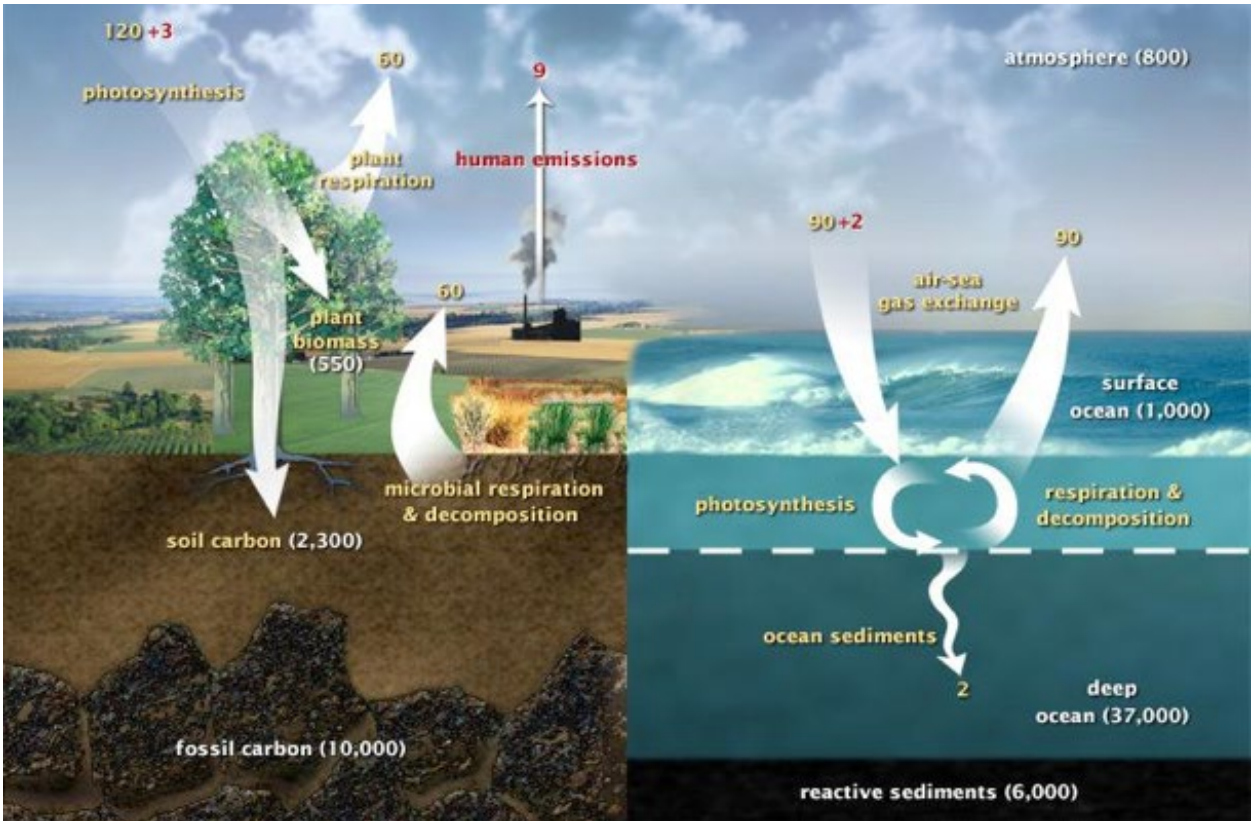

Figure 1. *Diagram of the fast carbon cycle shows the movement of carbon between land, atmosphere, and oceans. Yellow numbers are natural fluxes, and red numbers are human contributions in gigatons of carbon per year. White numbers indicate stored carbon. (Diagram adapted from U.S. DOE, Biological and Environmental Research Information System).*[6]

Importance of Climate Adaptation

There is no "one-size fits all" solution to climate change adaptation, but sharing best-practices, learning by doing, iterative processes, and stakeholder involvement can support progress. Adaptation actions can fulfill other societal goals and therefore be incorporated into existing decision-making processes for sustainable development and disaster risk reduction. Climate change vulnerability intersects with other stresses such as pollution and poverty, therefore demanding examination of overall threats while weighing tradeoffs between costs, benefits, and risk. Unfortunately, climate change adaptation is still in its infancy with many actions having only recently been initiated, in both the public and private sectors, and comprehensive evaluation metrics do not exist.[9] A list of additional resources discussing the science of climate change, impacts of climate change, and climate adaptation are provided in Table 1. Readers are encouraged to examine at least the executive summary of each resource to learn more.

Since the Industrial Revolution, when humans started emitting significant amounts of GHGs, global temperatures have been on the rise. The 2017 average global temperature across land and ocean surface areas was 1.51°F (0.84°C) above the 20th century average. Sixteen of the 17 warmest years on record have occurred since 2001, and the 6 warmest years have occurred since 2010.[3, 4] These trends are expected to continue through the end of the twenty-first century, with projections ranging from an additional warming of 2.5°F (1.4°C) in best-case scenarios to 10°F (5.5°C) in worst-case scenarios.[5] This warming has resulted in a number of climatic and environmental changes that are challenging communities around the world. Sea-level rise, due to melting land ice and warming ocean temperatures, has led to increasing high tides, greater erosion, and extensive flooding for some coastal communities and low-lying island nations.[7] More severe and frequent precipitation events have caused infrastructure damage and loss of life. Extended droughts and heat waves have created food and water shortages. These types of threats are expected to become more common and more severe as the climate continues to change.[8]

All individuals, businesses, and governments have and will continue to be affected by climate change. However, changes vary from region to region. To adequately prepare our community for climate impacts, it is important to understand the current and projected local effects of climate change, while recognizing how some populations will be disproportionately impacted. For example, children, the elderly, and low-income and socially-isolated populations are expected to be more vulnerable to climate impacts in Central Ohio that include flooding, droughts, extended heat waves, and deteriorated air quality.

Nations, states, and cities throughout the world have started to implement strategies that reduce GHG emissions (mitigation) and limit the damage that is likely to occur to natural and human-

constructed systems (adaptation). While it is vital that the global community takes aggressive action to reduce GHG emissions to avoid the worst climate-change impacts, Earth's climate is already locked-in to a certain amount of warming. Some GHGs (e.g., carbon dioxide) remain in the atmosphere for long periods of time. By acknowledging the changes that Columbus has already experienced and those that are likely to occur, this document aims to prepare our city and its residents for a more climate-resilient future.

Impacts of Climate Change on Columbus

The ***Climate Change in Columbus, Ohio*** report outlines many of the projected climate impacts for our city and region, and it also identifies the primary vulnerabilities that are likely to result from them.[12] Based on local climatological data and input from sector-specific stakeholders, it identifies eight climate impacts and fourteen priority vulnerabilities for Columbus that are expected to arise due to one of the two major climate changes projected for the region: rising temperatures and increasing precipitation.

Temperatures in Columbus have risen at rates faster than both the national and global averages (2.3°F from 1951-2012), with the greatest warming occurring during the spring and at night.[13] Precipitation has also increased, rising 19.8% from 1951 to 2012, and the largest increase has occurred during the fall.[9] Additionally, extreme-precipitation events have become more frequent. Based on model projections, our temperatures are expected to rise another 3 to 5°F by mid-century, and up to 10°F by the end of the century.[14] While precipitation is most likely to continue to increase during the cooler seasons, it

Resources	Organization	Web Link
Fourth National Climate Assessment (2018)	U.S. Global Change Research Program	***https://www.globalchange.gov/nca4*** [1]
Warming of 1.5°C (2018)	Intergovernmental Panel on Climate Change	***http://www.ipcc.ch/report/sr15*** [8]
Fifth Assessment Report (2014)	Intergovernmental Panel on Climate Change	***http://www.ipcc.ch/report/ar5*** [10]
Climate Change: Evidence and Causes (2014)	U.S. National Academy of Sciences and Royal Society	***http://nas-sites.org/americasclimatechoices/events/a-discussion-on-climate-change-evidence-and-causes*** [11]

Table 1. *Resources for science of climate change, impacts of climate change, and climate adaptation information.*

will likely be most variable during the summer. By the end of the century, our summers are likely to resemble those of Arkansas and Louisiana, while our winters will be more like Virginia and North Carolina (Fig. 2).[15]

As a result of these changes, Columbus is expected to face a number of risks and challenges. For example, warmer temperatures raise the likelihood of extreme-heat events, which lead to more heat-related illnesses, increased water and energy demand, and induce more stress on local vegetation. Warmer temperatures also lead to air-quality issues, especially in the city, due to stagnant air and increased energy demand. This ultimately produces more emissions from our current forms of cooling. Columbus also experiences a severe urban heat island effect - a phenomenon whereby built structures within the city retain heat more than the surrounding rural areas - which will likely intensify. Increased precipitation also poses a major risk. Extreme-precipitation events have the potential to cause flooding, damage infrastructure, and cause transportation issues. Other consequences such as mold buildup, waterborne pathogens, and decreased water quality all negatively affect public health.[12]

The actions proposed in this document are specifically designed to address the risks and vulnerabilities identified in Climate Change in Columbus, Ohio. With Central Ohio expected to experience significant population growth and associated development between now and 2050, individual and collective actions need to immediately consider the information contained in this report.[16] Cities around the world are taking similar steps and beginning to share their initiatives.[17]

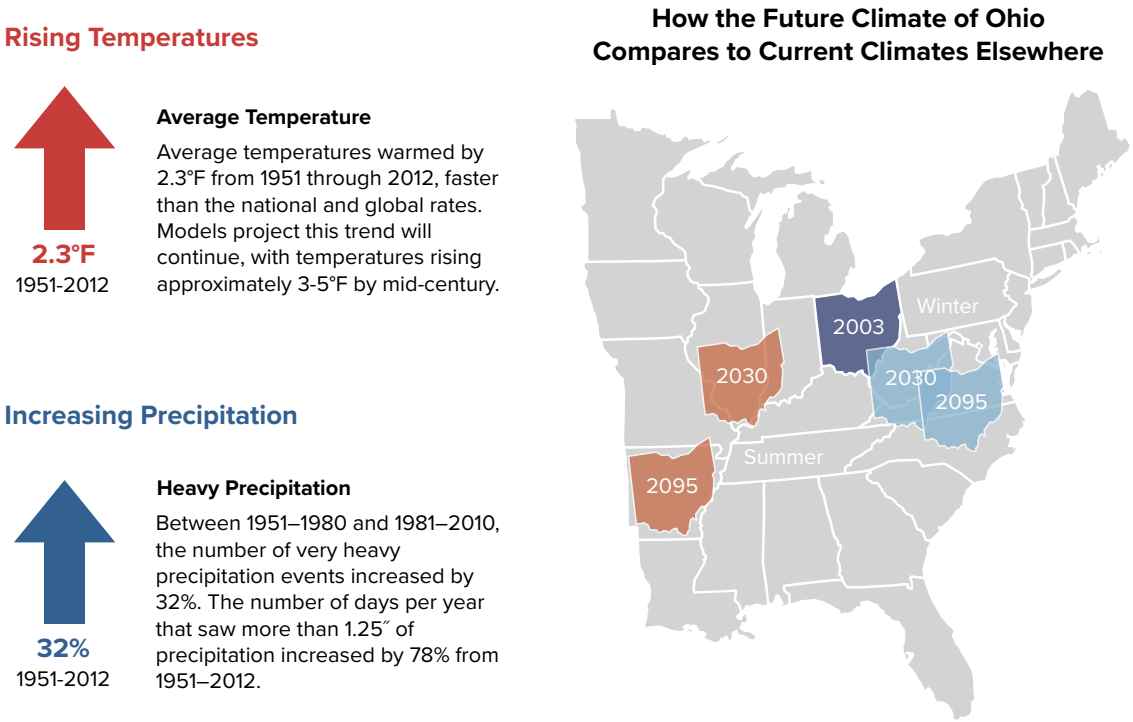

Figure 2. *Observed historical temperature and precipitation changes in Columbus, Ohio and changes likely to occur.*[15]

Efforts to Reduce Emissions in Columbus

While this plan does not directly address climate change mitigation strategies, since 2005 the City of Columbus has implemented programs and taken steps to reduce carbon emissions.[19] Mayor Ginther signed onto the ***Compact of Mayors*** in 2016, which represents a commitment to take inventory of GHG emissions, create reduction targets, establish a system of monitoring and measurement, and develop an action plan.[20] Improvements to the city's transportation system, being developed through the ***Smart Columbus*** initiative, should reduce emissions from the transportation sector.[21] While all of these programs represent positive steps forward, they are insufficient to transition Columbus to a carbon neutral community, and additional actions will need to be taken to mitigate GHG emissions associated with Columbus.

Purpose of the CCAP

In summer 2016, a Task Force, led by the Byrd Polar and Climate Research Center at The Ohio State University and including individuals from the City of Columbus and MORPC, began a two-year effort to develop this Columbus Climate Adaptation Plan (CCAP). The purpose of the CCAP is to provide specific, prioritized actions that the City of Columbus, along with its residents, non-profit organizations, and local businesses, can take to make Columbus a more climate-resilient community.

According to the IPCC's Fifth Assessment Report, climate adaptation is "The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects." Likewise, the IPCC defines climate mitigation as "A human intervention to reduce the sources or enhance the sinks of greenhouse gases."[18] The primary goal of this document is to prepare the city and its residents for the projected changes that will result from climate change (adaptation). The primary goal of this plan is not to reduce Columbus' carbon emissions (mitigation), which is being addressed separately by the City. However, there are mitigation co-benefits (benefits that are not the direct goal of a recommended action but rather a beneficial side effect) resulting from some actions within the plan, all of which are tied to transportation and heating and cooling of buildings.

The prioritized actions of this report are found in eight technical chapters (numbered 2 through 9). Each of these technical chapter represents either a major climate impact (e.g., Extreme Heat, Flooding) or a sector that will be heavily affected by climate change (e.g., Emergency Preparedness, Vulnerable Populations). While each action is only listed once in the document, the Task Force recognizes that some actions could easily be placed in multiple chapters as they result in benefits that fall outside the confines of one climate impact or sector. While actions are meant to be implemented by specific

city departments, with accountability following these departmental assignments, it was outside the scope of work for the Task Force to designate these assignments. Likewise, many of the actions involve educational campaigns that will benefit from shared best practices and central coordination between city departments via Sustainable Columbus. Engaging education-focused organizations that work in both formal and informal learning (e.g., Columbus City Schools, Columbus Parks & Recreation, Columbus and Franklin County Metro Parks, Franklin Park Conservatory, COSI, Franklin County Extension, Franklin County Soil & Water) ensures that key constituencies, including youth, are involved in climate resilience efforts. The Task Force strove to make this document accessible to a broad audience, realizing that all members of the community have something to gain by reading it and actively engaging in the process of building resilience.

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