Climate Change and Chicago:

Projections and Potential Impacts

CHICAGO CLIMATE ACTION PLAN

Research Summary Report

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This document is a summary of the report entitled *Climate Change and Chicago: Projections and Potential Impacts.* It is the first in a series of reports on climate change and Chicago commissioned by the Chicago Climate Task Force.

The Task Force was created by the City of Chicago, with the mandate of assessing the potential impacts of climate change on Chicago and, based on these impacts, developing a plan for the future. The Task Force includes representatives from local communities, universities, business and labor, and city and state government.

Working together, the members of the Task Force developed the Chicago Climate Action Plan, based on the information provided by this report. In addition to informing the Plan, this summary report also shows the people of Chicago why taking action on climate change is important.

This research would not have been possible without the generous support of Global Philanthropy Partnership, The Joyce Foundation, The Lloyd A. Fry Foundation, and Grand Victoria Foundation.

Other reports in this series evaluate the potential costs of climate change to the city, and explore options to reduce emissions and to adapt to coming changes. The full set of Chicago climate reports is available online at **www.chicagoclimateaction.org.**

This research was commissioned to advise the Chicago Climate Task Force in the development of the Chicago Climate Action Plan. It does not represent official City of Chicago policy.

Figure 1 The City of Chicago

Introduction: Climate Change and the City of Chicago

On June 14, 1876, an article in the Chicago Tribune described Chicago's summer weather as idyllic: "…cool breezes, refreshing rains, green fields, a grateful sun, and balmy air—winds from the north and east tempered by the coolness of the Lake…". Residents and visitors know what to expect from Chicago's **climate**: cold, windy winters followed by green springs; then pleasant, sunny summers that give way to crisp, colorful autumns.

climate: *the average of weather over time, usually at least 30 years*

What other features define Chicago's climate? There is the presence of Lake Michigan, which tempers the hot Chicago summers, and moderates the icy winters. Also, because the land that Chicago is built on is relatively flat, winds blow freely through the city. In the downtown area, tall buildings create tunnels that intensify wind strength, enhancing Chicago's image as the "Windy City."

Chicago's current climate is not merely familiar to its inhabitants; it is the basis for their way of life. When the first snow can be expected, how long winter will last, which flowers to plant in spring, what outdoor activities can be enjoyed in summer—all these aspects of life in Chicago take a stable and predictable climate for granted.

Chicago's climate is already changing, however. Many of the defining characteristics of the city are being altered as a result. If actions are not taken soon to reduce emissions of heat-trapping gases from human activities, Chicago could experience significant effects on its water resources, human health and welfare, natural ecosystems, agriculture, infrastructure, and economy over the coming century.

Even if we act now to reduce our emissions of heat-trapping gases, some degree of change is still expected because of emissions that have already been produced (**Figure 2**). Thus, it is important to assess the changes expected even under reduced emissions. Chicago needs to determine how to prepare for potential future conditions.

What changes should be expected over the coming century for Chicago? How is climate change likely to impact the city and its inhabitants? What difference would it make if we reduced our emissions of heat-trapping gases? Before answering these questions, we need to take a closer look at the concept of climate change. Why is it happening? What we are able to do about it?

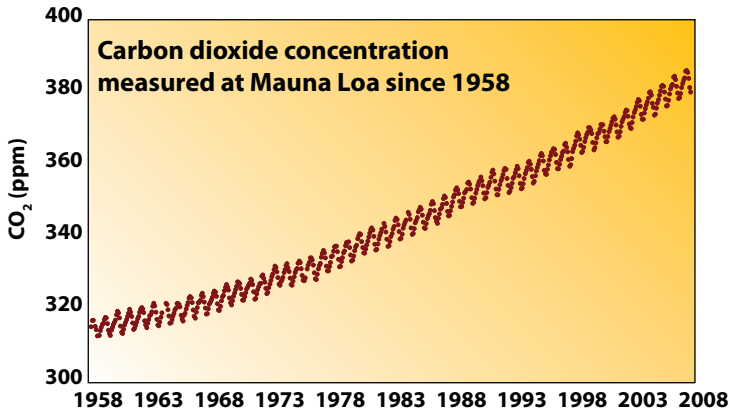


Figure 2 Increases in CO_2 levels since 1958.

Natural Climate Change in the Past

Scientists use records of atmospheric conditions, trapped as air bubbles in polar ice, to track past changes in climate. Over hundreds of thousands of years, ice core records show that the Earth's climate has changed in very slow cycles, from ice ages to warm periods, and back to ice ages again. Each ice age cycle takes about 100,000 years. These cycles are primarily caused by changes in the amount of energy the Earth receives from the Sun, amplified by natural feedbacks within the earth-ocean-atmosphere system.

During the last ice age, for example, small changes in the Earth's orbit reduced the amount of energy received from the Sun, triggering the formation of a massive ice sheet. At its peak, this ice sheet was a mile deep over the Midwest and much of the rest of North America. About 10,000 years ago, this ice age ended and the glaciers retreated. As they retreated, the glaciers carved out lakes from the surrounding rock, revealing the land on which Chicago now stands.

Natural factors, such as variations in the Earth's orbit around the Sun, still affect Earth's climate today—very slowly, over long periods of time.

Over the last century, warming temperatures and other indications of a changing climate have been observed both in Chicago and around the world. These recent changes, however, don't fit the patterns of natural variability.

Heat-Trapping Gases and Climate Change

In the past, most large-scale climate variations in the Chicago area and around the world have been driven by natural factors. Today, however, the story is very different. Scientists studying climate over the last 50 years have now concluded that it is very likely (with a certainty of more than 90%) that most of the observed changes have been caused by emissions of heat-trapping gases from human activities. For the first time in Earth's history, humans are driving a global-scale change in the Earth's climate.

greenhouse gases: *heat-trapping gases in the atmosphere*
greenhouse effect: *a natural process in which the atmosphere traps heat, keeping Earth's temperature warmer than it would otherwise be*

Earth's atmosphere already contains natural levels of heat-trapping gases, also called **greenhouse gases**, such as water vapor (H_2O), carbon dioxide (CO_2), and methane (CH_4). These gases prevent some of the heat produced by the Earth from escaping to space, keeping Earth's temperature stable and much warmer than it would be otherwise. This natural process, called the **greenhouse effect**, is what makes life possible here on Earth (**Figure 3**).

"Climate warming is already occurring in Chicago and across the Midwest."

Ever since the beginning of the Industrial Revolution, however, humans have been producing increasing amounts of carbon dioxide and methane. Two of the main ways these gases are produced are through burning fossil fuels (e.g., coal, oil, and natural gas) and deforestation. Agriculture and waste treatment also contribute. As human emissions have increased, so have the levels of heat-trapping gases in the atmosphere. Methane levels have more than doubled, and carbon dioxide has increased by over 30%. Levels of other heat-trapping gases, including nitrous oxide (N_2O), are also increasing. The evidence is clear: human activities are the major cause of the observed increase in heat-trapping gases over the last century.

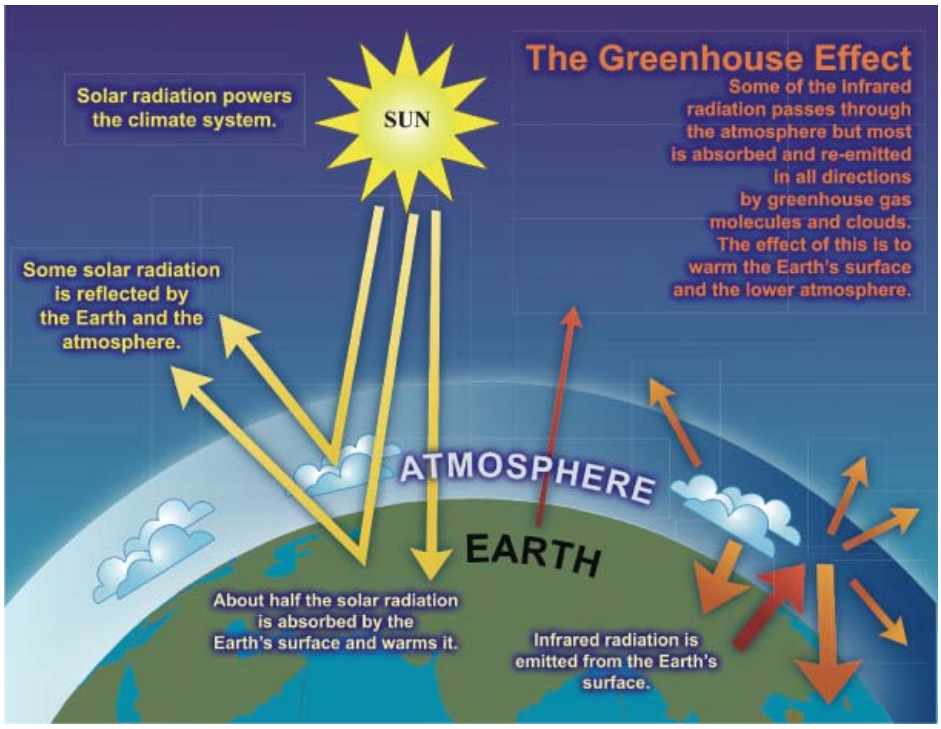


Figure 3 The greenhouse effect. (*diagram courtesy of the IPCC)*

It makes sense that an increase in atmospheric levels of heat-trapping gases would cause an increase in Earth's temperature. And this is exactly what is being observed. Globally, Earth's temperature has slowly increased by 1.4°F over the past 150 years. This may not sound like much. However, even this relatively small change in temperature has already triggered enormous changes around the world, from record lows in Arctic sea ice to record highs in both global and local temperatures.

Climate Change in Chicago

Climate warming is already occurring in Chicago and across the Midwest. Since 1980, the average temperature has risen by about 2.6°F. Trees and plants flower earlier in the spring and frosts occur later in the fall. There have been several major heat waves in recent years, and the amount of winter ice on Lake Michigan is decreasing. Heavy rainstorms are also increasing in frequency.

"Chicago's future climate depends on global choices that are made today and in the years to come."

Along with the rest of our planet, we expect the climate of Chicago to continue to warm. But by how much? The answer depends on current global levels of heat-trapping gas emissions, and also on future changes in those emissions.

Chicago Takes Action

More than 35 million metric tons of CO_2-equivalent heat-trapping gases are emitted each year in Chicago. (*CO_2-equivalent* is a way of comparing other heat-trapping gases to carbon dioxide.)

Mayor Richard Daley is leading a campaign for Chicago to become "the most environmentally friendly city in America." To this end, the city has already begun to reduce its greenhouse gas emissions and to adapt to changes in climate. The city also intends to increase its renewable energy usage from 2.5% in 2006 to 20% in 2008. Chicago is already a center for environmental design, and currently ranks 4th in the U.S. in "urban sustainability"—in other words, the city has a strong foundation for adaptation to changes caused by global warming.

Two Different Scenarios for Chicago's Future Climate

Chicago's future climate depends on global emission choices made today and in the years to come. Because we don't yet know what these choices will be, it is difficult to predict future change. For that reason, this report covers two possible scenarios:

Scenario A: Chicago and the rest of the world continue to depend on fossil fuels as their primary energy source, although with rapid introduction of new and more efficient technologies. As a result, CO_2 levels rise from today's 385 parts per million (ppm) to almost 1000 ppm by the end of the century.

Scenario B: Chicago and the rest of the world shifts to clean and resource-efficient technologies, with a global focus on environmental sustainability. As a result, CO_2 levels only rise to about 550 ppm by the end of the century.

Scenarios A and B are not the "worst case" and "best case" scenarios. If we continue to depend on fossil fuels without improvements in efficiency, our CO_2 levels could end up being higher than in Scenario A. If we take aggressive action to reduce our heat-trapping gas emissions, we could limit the increase in CO_2 to even lower levels than suggested by Scenario B.

Predicting Changes in Climate

It is relatively straightforward to detect changes in climate that have already happened. There are many National Weather Service weather stations in the Chicago region. These weather stations keep records of temperature, precipitation, humidity, snowfall, and other weather variables. By analyzing these records, we can identify trends in temperature, precipitation, and the occurrence of extreme events that have happened over time. For example, we can see whether temperature has been increasing. We can see if there are more or less heat or cold waves today than in past decades.

As you can imagine, it is far more difficult to predict changes in climate and the resulting impacts that may occur in the future. Earth's **climate system** is made up of complex cycles that involve the Sun, the atmosphere, land, salt and fresh water, ice caps, and glaciers. To understand past changes and produce projections of the future, scientists use **climate models**. These models are complex computer programs that simulate the many processes at work in the Earth's climate system. They are based on what we know about how the Earth's systems work. By changing one factor (e.g., CO_2 in the atmosphere), a climate model shows what could happen to the rest of the climate system over time. Sector-specific impact models then use the results from climate models to examine the effects of climate change on specific aspects of the Earth's climate system, such as agriculture, water resources, or human health.

climate system: *the connected processes that determine climate on Earth; includes the atmosphere, land, water cycle, and ice, along with the Sun*
climate models: *complex computer programs that simulate the many processes at work in the Earth's climate system*

Scientific Uncertainty

It is scientifically impossible to state that something *will* happen, no matter what. The actual amount of change that we will see in the coming years, and how that change will affect the city, is uncertain for two reasons:

Social and Economic Uncertainty:
We don't know what choices people will make. For example, what will future emissions be? How will the population of Chicago adapt to change?

Scientific Uncertainty:
It is impossible to know for sure how the Earth system will respond to change. For example, how do urban centers with tall buildings influence local climate change? Exactly how will the atmosphere, water systems, and living things respond to increasing levels of heat-trapping gases?

In this report, researchers addressed the scientific source of uncertainty by using several different climate models. They addressed the social and economic uncertainty by examining the changes expected under a higher and lower emission scenario.

The climate models used to collect data for this report cover the accepted range of how the climate system is likely to respond. These three models were chosen because of their ability to represent the past climate, particularly over the United States and the Midwest.

To test the usefulness of climate models in projecting future conditions, scientists use them to "predict" the climate over past years. Next, they compare the model's predictions to what actually happened. In places where the model's result is different from reality, scientists try to learn more about the physical processes that may be causing the discrepancy. Then they incorporate that improved understanding into the model.

Climate models look at the "big picture," so researchers used advanced statistical and scientific techniques to scale down the results and make them more specific to the Chicago region.

This Report

This report begins by discussing probable changes in temperature and precipitation in the Chicago area. Next, it outlines possible effects on Chicago's water resources, health system, ecosystems, agriculture, infrastructure, and economy.

More information on the scientific basis for the climate change projections, and on the way researchers expect these changes to affect our environment in the future, is available in the full climate change impacts report, *Climate Change and Chicago: Projections and Potential Impacts*, provided online at: **www.chicagoclimateaction.org.**

Part 1: Changes in Temperature

"Chicago's annual temperature has warmed up by more than 2°F in the past 60 years."

Chicago has four main seasons. In the winter, freezing air from the Arctic moves south into the region. January is the coldest month, with an average high of 31°F and an average low of 16°F. There are frequent storms in the winter, with cloudy skies, wind, and snow or rain. On average, Chicago receives 38 inches of snow each winter.

Summers are hot and humid, with an average high of 84°F during the day, and an average low of 66°F at night. On average, about 2 days each summer are hotter than 100°F. Summer also tends to be the rainiest season.

During all seasons, Chicago's temperatures are moderated by the presence of Lake Michigan (**Figure 4**).

Chicago Weather Records

Coldest temperature:	–27°F with a wind chill of –83°F on January 20, 1985
Most snow in a year:	114.2 inches of snow during the winter of 1929–30
Highest temperature:	105°F at Midway Airport on July 17, 1995
Most rain in a day:	6.49 inches on August 14, 1987

Figure 4 Large bodies of water like Lake Michigan lose and gain heat more slowly than land. As a result, the lake has a warming effect on the land during fall and early winter, and a cooling effect during spring and early summer.

Current Changes in Chicago's Climate

To examine changes in Chicago's climate that have already started to happen, researchers analyzed observations from 14 different weather stations in Chicago and surrounding areas, taken over the past 80 years. For example, **Figure 5** shows temperature data taken from the Midway Airport weather station from 1945 to 2006.

Weather station records show that Chicago's annual temperature has warmed up by more than 2°F since 1945. Since the mid-1980s, most years have seen above-average temperatures. A larger increase in temperature is seen during winter months.

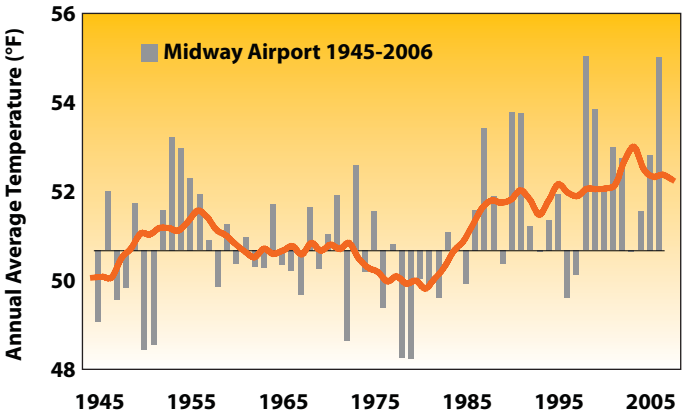


Figure 5 Annual average observed temperature at Midway Airport from 1945 to 2005.

Other temperature-related changes have also been noticed, including the following:

- There have been fewer cold waves during the 1990s than in the previous decades.
- Growing seasons are getting longer. In Illinois, the length of the growing season has become about one week longer over the last hundred years.
- Ice on Lake Michigan forms later in the year and lasts for shorter periods of time. In some years, there is almost no lake ice at all.
- The risk of potato late blight, gypsy moths, and other pests has increased because of a warmer and wetter growing season in the upper Great Lakes.
- A number of major heat waves have occurred in the last few decades.

Changes over the Coming Century

Using the climate models, the researchers estimated what types of changes Scenario A (higher emissions) and Scenario B (lower emissions) would bring to Chicago's climate. Both scenarios showed warmer temperatures, more extreme heat events, and more extreme precipitation events for the Chicago area. Changes were much more severe in the higher emissions Scenario A. **Figure 6** shows the projected changes in temperature for Chicago. In the graph, you can see that even the lower emissions scenario results in an increase in temperature. This is because even a low emissions scenario involves some emissions of heat-trapping gases. However, the lower emissions scenario results in a much smaller temperature increase than the higher emissions scenario.

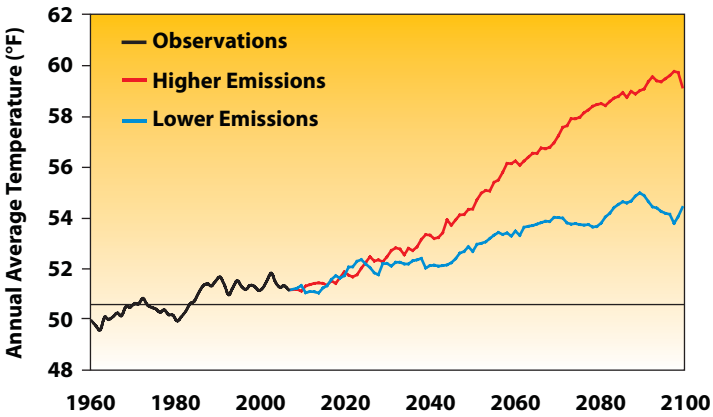


Figure 6 The red and blue lines show projected increases in temperature over the next century. The black line shows observed changes up to the present day.

Specific Changes Expected for the Chicago Region

More specifically, researchers expect the following temperature-related changes:

1. Overall temperature increases: Average temperatures are projected to increase by 1–1.5°F over the next few decades. By the end of the century, a temperature increase of 7–8°F would be expected under higher emissions, and 3-4°F under lower emissions. The greatest increases (up to 10°F) are likely to occur during summer.
Impacts of this change: Both summers and winters would feel warmer. Snow and ice would melt more quickly, and surface water evaporate more rapidly. Plants would flower earlier in the spring, and trees could lose their leaves later in the fall.

2. Changing temperature ranges: In winter, there is likely to be a smaller difference in temperature between warmer and colder days. In summer, there would be a larger difference in temperature between hotter and cooler days.
Impacts of this change: In winter, there would be fewer very cold days *(see point 8)*. In summer, there would be more extremely hot days *(see point 3)*.

3. Hotter summers: There will likely be more very hot summers, and the number of extremely hot days (over 100°F) is likely to increase. Today, there are only about 2 extremely hot days per year. Under the lower emissions scenario, this could increase to 8 days per year. Under the higher emissions scenario, it could increase to more than 30 extremely hot days per year by the end of the century. **Figure 7** shows the possible increase in the number of extremely hot days per year in Chicago.

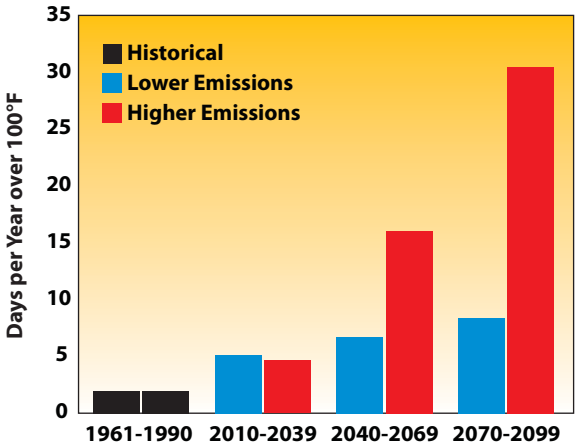


Figure 7 Projected frequency of 100° F days per year in Chicago

"There will likely be more very hot summers. The number of extremely hot days (over 100°F) is likely to increase."

Impacts of this change: Hotter summers would put additional strain on elderly and ill members of the population. They would also lead to an increase in energy use for air conditioning. There would also be an impact on outdoor activities.

4. More heat waves: There will probably be more frequent, longer, and more intense heat waves in Chicago in the future. In 1995, Chicago experienced a record-breaking heat wave. Under the lower emissions scenario, heat waves like this one may occur twice a decade by mid-century, and as frequently as every other year by the end of the century. Under the higher emissions scenario, there could be several such heat waves *each summer* by the end of the century. **Figure 8** shows the increase in heat waves that could occur over the next 80 years.

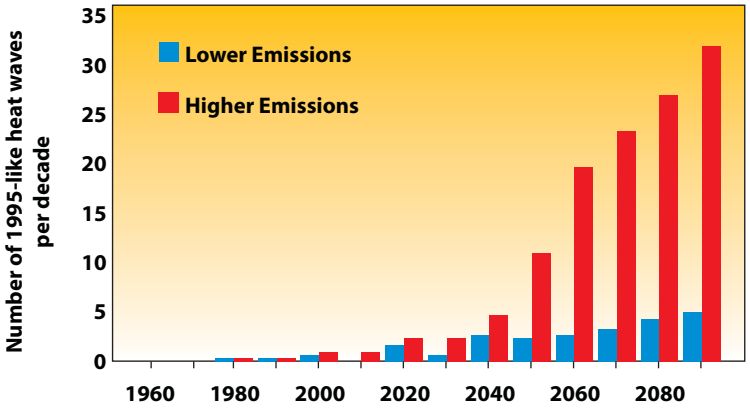


Figure 8 Increases in the number of heat wave events per decade

Impacts of this change: The expected increase in heat waves carries serious implications for health, as discussed in Part 5. We can probably expect more illness due to heat-stress in the future.

5. More humidity: In a warmer climate, the increased evaporation of surface water would result in increased humidity.

Impacts of this change: Hot days would feel even hotter due to the humidity. This would create even more severe heat stress conditions in the future than expected based on increases in air temperature alone.

6. Longer growing season: The length of the frost-free or "growing" season is likely to continue to expand. Under the higher emissions scenario, the last spring frost would occur about 30 days earlier by the end of the century. Under the lower emissions scenario, it would occur about 20 days earlier.

Impacts of this change: Longer growing seasons may have positive implications for agriculture and gardening.

7. Less frost: We can expect fewer frost days per year. *Frost depth* is a measure of the depth to which the soil freezes each winter. It is likely that annual frost depth will decrease.
Impacts of this change: Because frost depth is one of the factors determining the depth of a building's foundations, a change in frost depth would probably affect building codes in the Chicago area. A change in frost depth would also affect the load limits on roads. Changes in frost depth would impact agricultural practices as well.

8. Fewer extremely cold days and cold spells: During this century, there would be fewer and less intense cold days and cold spells. The coldest day of the year could warm by 4 to 6°F through this century. Under the lower emissions scenario, there would be about 30% fewer extremely cold days. Under the higher emissions scenario, there would be about 70% fewer extremely cold days by the end of the century.
Impacts of this change: Winters would feel warmer, and heating costs would likely drop, but average winter snowfall could remain similar to today. It would be harder to maintain ice cover for skating and ice fishing.

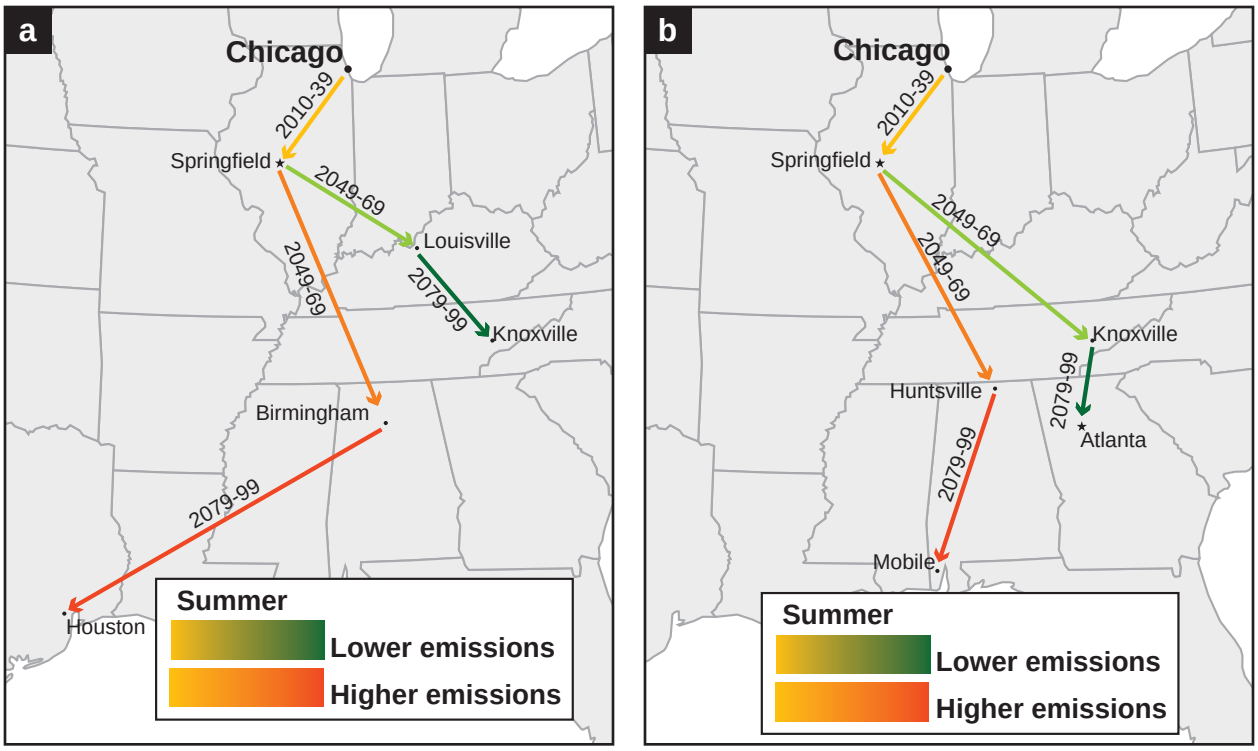
Picturing Chicago's New Climate

To help people understand the potential effects of climate change on the City of Chicago, researchers first determined the projected temperature and precipitation in Chicago for three time periods: over the next few decades (2010–2039); by the middle of the century (2040–2069); and by the end of the century (2070–2099). Next, they compared these projections with the present-day climates of other U.S. cities. In this way, we can imagine how climate change could make it feel as if the city were "migrating" to a different part of the country over time.

These comparisons show that in a decade or two, Chicago's average summer temperature and precipitation could be very similar to what is experienced in Springfield, Illinois, today (**Figure 9a** on the next page). By mid-century, Chicago's summer climate could be similar to that of Birmingham, Alabama under higher emissions, and Louisville, Kentucky, under lower emissions. By the end of the century, Chicago's summer climate could be more like Houston, Texas, under higher emissions and Knoxville, Tennessee, under lower emissions.

Average temperature and precipitation is what scientists typically use to characterize the climate of a region. However, how hot a given summer actually "feels" depends more on daytime maximum temperatures and humidity levels than average temperatures and rainfall. The average summer Heat Index value is a key measure of how hot it "feels" during the summer.

Chicago's summer Heat Index value, calculated from typical afternoon high temperatures and humidity, averaged around 83°F for the period 1971–2000. Within a few decades, the average summer Heat Index is projected to be around 90°F. In other words, Chicago could feel like Springfield, Illinois does today (**Figure 9b** on the next page). By mid-century, the Heat Index could reach 98°F under higher emissions. This would feel like a summer in Huntsville, Alabama today. Under lower emissions, it could reach 92°F, and feel more like a summer in Knoxville, Tennessee. By the end of the century, a Chicago summer could feel like Mobile, Alabama under higher emissions, with an aver-



Figures 9a and 9b How Chicago in the summer might be expected to "migrate", based on summer climate, defined by its average summer temperature and precipitation (above left), and how hot it will feel, defined by the average summer Heat Index (above right), as projected under higher emissions (orange/red arrows) and lower emissions (green arrows).

age Heat Index of more than 105°F. Under lower emissions, it could feel like Atlanta, Georgia, with an average Heat Index of more than 93°F. Such intense summer heat would be uncomfortable for residents, and reduce the city's attraction to tourists.

For winter climate, researchers compared projected winter temperatures and snowfall amounts in Chicago with conditions experienced in other U.S. cities today. **Figure 10** shows that although Chicago's winters are likely to be warmer, the increased precipitation in winter (discussed in Part 2) means that average winter snowfall could remain similar to today for much of the century. As a result, Chicago's "migrating" winter climate would feel more like it is moving eastward through Indiana, Ohio, and eventually Pennsylvania, rather than moving south.

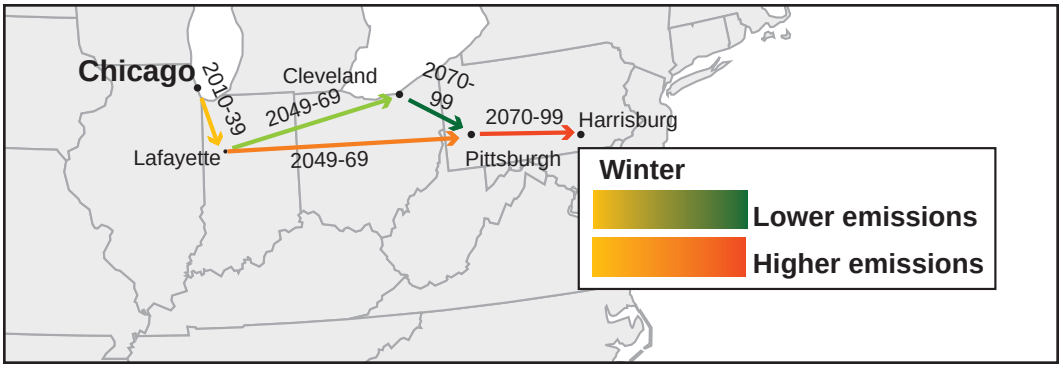


Figure 10 Chicago's "migrating" winter climate under higher emissions (orange/red arrows) and lower emissions (green arrows).

"There are likely to be more heavy rain and snow storms. These increase the risk of flooding and stormwater contamination."

Part 2: Changes in Precipitation

Temperature and **precipitation** are two of the most visible indicators of the climate of a region. As the climate changes, researchers expect to see changes in precipitation patterns over the Chicago region. For example, the frequency of heavy rainfall events is changing. Also, the proportion of precipitation that falls as rain instead of snow is shifting. The following precipitation-related changes have already been noticed in the Chicago area:

precipitation: *rain, snow, hail, and sleet*

- The frequency of heavy rainfall events has doubled since the 1970s.
- More precipitation is falling as rain instead of snow. There is less snow in winter, and the snow melts earlier in the spring.

Figure 11 The number of heavy rainfalls are projected to increase over the coming century.

Changes in Precipitation Patterns

Over the coming decades, researchers expect the following changes in precipitation amounts and types:

1. More precipitation overall per year: Annual precipitation could increase by about 20% over the coming century. Most of this increase is likely to occur in winter and spring, as shown in **Figure 12**, with little change in summer and fall.

Impacts of this change: Little change in summer rain together with increased evaporation because of warmer temperatures means that farmers would have to use more water from wells and springs to water their crops. More rain and snow in winter and spring could mean an increase in flood risk for many areas. Floods cause damage to homes, buildings, roads, and bridges.

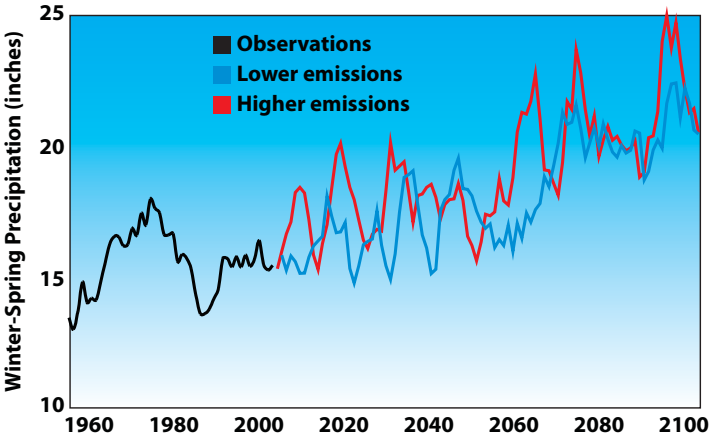


Figure 12 Increases in winter and spring precipitation.

2. More heavy rain storms and dry periods: There could be considerably more heavy precipitation events (e.g., heavy rain and snow storms). These would increase the risk of flooding and stormwater contamination. **Figure 13** shows the expected increase in days with heavy precipitation. A day with heavy precipitation is defined as more than 2.5 inches in 24 hours. During the summer, rain may fall more heavily but at fewer times. As a result, there may be dry periods in between rainfalls.

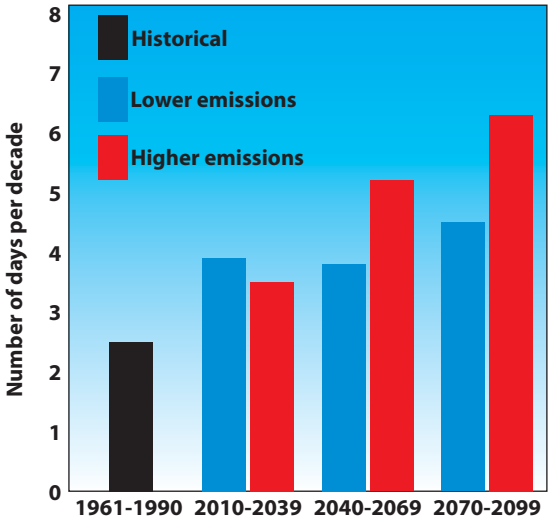


Figure 13 Increases in the number of days per decade with heavy precipitation.

Impacts of this change: Flooding can damage crops and cause soil erosion, contaminate the water supply, promote infectious disease, disrupt transportation, and lead to property damage or loss. In the Chicago region, extremely heavy precipitation events can lead to the pollution of water bodies such as Lake Michigan by contaminated stormwater.

Dry periods cause serious problems, such as water shortage, reduced crop yields, increased livestock deaths, increased stress to wild plants and animals, greater risk of wildfires, reduced hydropower generation, and higher risk of water-borne diseases.

3. Similar snowfall but less snow cover during winter: As winter temperatures increase, more winter precipitation is likely to fall as rain instead of snow. However, because winter precipitation is projected to increase, the total amount of snowfall isn't expected to change much under lower emissions. Under higher emissions, average winter snowfall could be reduced by about 10 inches by the end of the century. Because of warmer temperatures, however, the snow that does fall is likely to melt faster. The number of days with snow on the ground is projected to decrease from an annual average of 40 days to between 13 and 23 days per year, depending on future emissions.
Impacts of this change: Since snow causes traffic problems and requires road clearance, fewer days with snow on the ground could have a positive effect on Chicago's infrastructure. However, fewer snow days will also affect winter activities in the Chicago area.

"Increased peak river flow [in the Illinois River] would increase the risk of flooding and flood damage."

Part 3: Changes in Chicago's Water Systems

Chicago sits on the continental divide between the Great Lakes and the Mississippi River. These two water sources provide an apparently endless supply of fresh water. Over the last two centuries, they also provided easy transportation routes in and out of the area.

Today, Lake Michigan and its waterways support a wide variety of commercial and recreational uses (**Figure 14**). Visitors to Chicago marvel at the beauty and accessibility of the lakefront. The city's waterways also contain a large number of important plant and animal species.

In order to understand the impacts of climate change on the Chicago region, it is essential to understand the effects of climate change on these water systems.

Figure 14 The Chicago River meeting Lake Michigan

Changes in Water Systems

How will changes in precipitation affect the water systems in the Chicago area? The researchers examined changes to river flow, lake levels, ice cover, water quality, and aquatic ecosystems in the Chicago area, and found that the following changes could occur:

1. Increased peak river flow: Under the higher emissions scenario, a major increase in peak river flow in the Illinois River is projected over the next century (**Figure 15**). Under the lower emissions scenario, only a slight increase in peak river flow is projected. Specific impacts were not researched for the Chicago River. Because the Chicago River is highly managed, it is difficult to separate the potential effects of climate change from those due to human intervention.

Figure 15 Flooding near the Illinois River during the Midwest flood of 2007

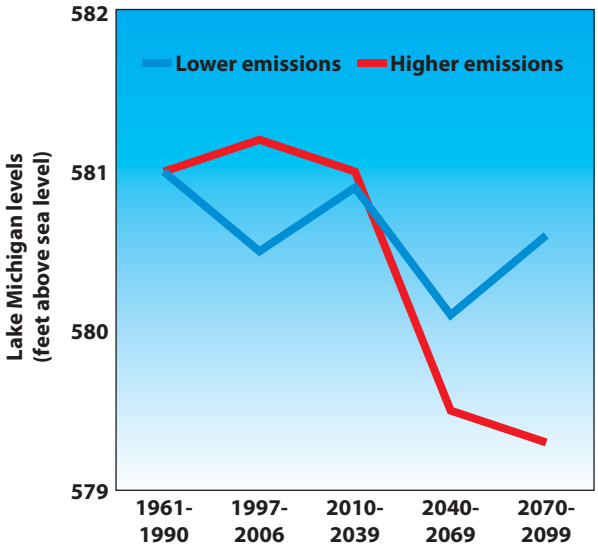


Figure 16 Changes in the level of Lake Michigan under both scenarios. The red and blue lines show the average of a range of possible lake levels.

Impacts of this change: Increased peak river flow would increase the risk of flooding and flood damage in the Illinois River basin.

2. Decreased lake levels: Lake levels vary naturally from year to year. Under the higher emissions scenario, however, the average level of Lake Michigan could decrease by up to 1.5 ft. by the end of this century. This drop would be caused by warmer temperatures and decreased ice cover, leading to more evaporation. For the lower emissions scenario, little change is projected in Lake Michigan levels, as the effects of warming temperatures are offset by increased precipitation. **Figure 16** shows expected changes to lake levels under both scenarios. The blue line shows possible lake levels under the lower emissions scenario. The red line shows possible lake levels under the higher emissions scenario.

"Under higher emissions, the average level of Lake Michigan could decrease by up to 1.5 ft by the end of this century."

Impacts of this change: On the positive side, lower lake levels would lead to beach expansion. On the negative side, lower lake levels may require dredging of shallow channels, with implications for both commercial shipping and recreational boating. If the level of Lake Michigan drops enough, the Chicago River could reverse its direction and start flowing into the lake. The resulting pollution of the lake could create additional water quality issues for Chicago.

3. Decreased ice cover: Lake temperatures are likely to increase, due to warming air temperatures. During the winter, ice cover on Lake Michigan is projected to continue to decrease. This change has already been observed, as shown in **Figure 17**.

Impacts of this change: The impacts of decreased ice cover can be both positive and negative. Less ice cover in the winter means increased evaporation, which could lead to even lower lake levels. Reduced ice cover would extend the sport-fishing season, although it would limit ice fishing on inland lakes. Ice formation protects wetlands and aquatic ecosystems, so

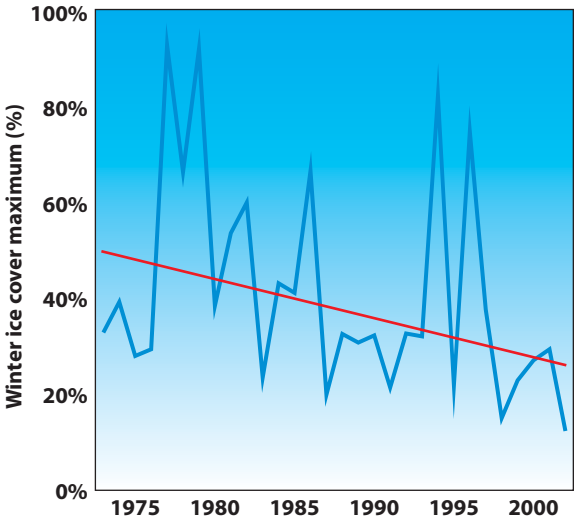


Figure 17 Decreases in winter ice cover on Lake Michigan *(Source: Assel, 2003).* The red line represents the average.

"Lake temperatures will likely increase and ice cover on Lake Michigan will decrease."

less ice cover could harm ecosystems. On the positive side, less ice cover in the winter would open more of the Great Lakes to shipping and recreational boating.

4. Decrease in water quality: Heavy rainfall and runoff, caused by climate change, can affect water quality in complex ways. As heavy precipitation events become more common, Chicago's drainage systems may be unable to contain the excess water. Overflowing stormwater can cause combined sewer overflows and can pollute nearby lakes and rivers (**Figure 18**).

Figure 18 Stormwater can overflow drainage systems and pollute nearby lakes and rivers.

Impacts of this change: Cryptosporidiosis is one of the most prevalent diarrhea-causing diseases in the world. During a 1993 cryptosporidiosis outbreak in Milwaukee, 403,000 cases were reported, and 54 people died. This outbreak was preceded by the heaviest rainfall in fifty years in the area. If more heavy precipitation events occur, outbreaks like this one would happen more often.

In addition, beaches could be contaminated more often over the coming century. Chicago beach closures tend to happen after heavy rainfall events, during warmer lake temperatures, and/or during drops in lake level. Because researchers expect all of these events to increase in frequency, there are likely to be more beach closures in the future than there are now.

5. Damage to aquatic ecosystems: Warmer lake surface temperatures could inhibit the mixing between the oxygen-rich surface waters and the nutrient-rich deep waters. Reduced mixing would affect plankton living in the surface waters, limiting the amount of nutrients available to support their growth. It would also reduce oxygen levels in the deep waters, affecting many fish species and other bottom-dwelling organisms. Since plankton are the basis of the aquatic food chain, they are essential for the survival of many species of fish.

Cold-water stream habitats will be altered by a warming climate, affecting cold-water fish. In Lake Michigan, as the lake level declines, coastal wetlands will be less accessible. Also, as the lake warms, invasive species currently limited to the warmer regions of the lake may be able to migrate further north.

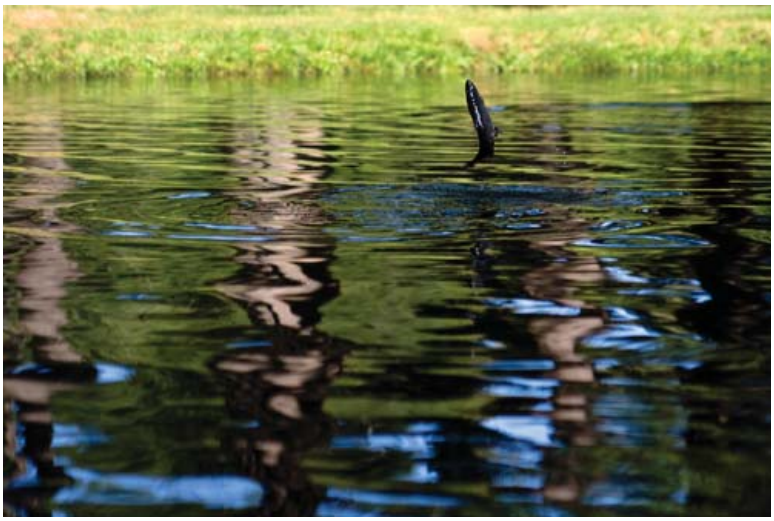


Figure 19 Trout and other fish could be harmed.

Impacts of this change: Warmer waters may reduce numbers of sport fish, and affect fishing in the Chicago area. Altered habitats would affect species such as walleye and trout (**Figure 19**). These and other desirable cold-water species may migrate to deeper and more northerly waters.

Changes to coastal wetlands would affect the breeding habits of many species of fish. There may also be unpleasant algae blooms, making drinking water smell and taste "fishy," and increasing water treatment costs. Increased algae growth may also result in more frequent beach closures.

"As the climate continues to change, some plant and animal species could move out of the region, and new species could move in."

Figure 20 Ecosystems in the Chicago area

Part 4: Changes to Ecosystems and Agriculture

Before the City of Chicago existed, the area was covered by forest, savanna, grassland, and wetland **ecosystems** (**Figure 20**). These ecosystems still remain in the area, although they have been changed by housing, industry and agriculture. New ecosystems have also developed in farms and gardens throughout the area.

ecosystem: *a connected system of plants, animals, and their habitats in an area*

Today, many plants and animals characteristic of the original ecosystems are still found in the area. Native plants exist in forest preserves, parks, natural areas, and residential lots. Many native plants, such as red oaks, are valued for aesthetic reasons.

Native plants are also valued because of their important ecological roles. For example:

- They provide habitats for wildlife.
- They provide shade and windbreaks.
- They help regulate the flow of water, sediment, and nutrients to rivers and lakes.
- They help regulate temperature and humidity and contribute to healthy soils.

Native birds, animals, fish, and insects also have important roles:

- Insect pollinators such as honey bees and wasps help plants reproduce.
- Predators such as beetles keep the number of insects and plants under control.
- Each species in an ecosystem is an essential part of keeping that ecosystem healthy.

Over the past 200 years, local ecosystems have been changed by human land use and by the introductions of new species. Today, changes in temperature and precipitation are further altering plant growing conditions and modifying animal habitats. As the climate continues to change, some plant and animal species could move out of the region, and new species could move in. Some native species may become extinct if they cannot successfully adapt to a changed climate or migrate to more suitable habitats.

Climate Change and Chicago Ecosystems

As the climate changes, researchers expect the following changes to native ecosystems:

1. The types of plants growing in the Chicago area could change. "Plant hardiness zones" are zones where different species of plants can grow. As the climate warms, Chicago's zone will change (**Figure 21**). Under the lower emissions scenario, Chicago's zone would become equivalent to southern Illinois then Missouri by the end of the century. Under the higher emissions scenario, Chicago's zone would become equivalent to western Kentucky by mid-century, and to northern Alabama by the end of the century.

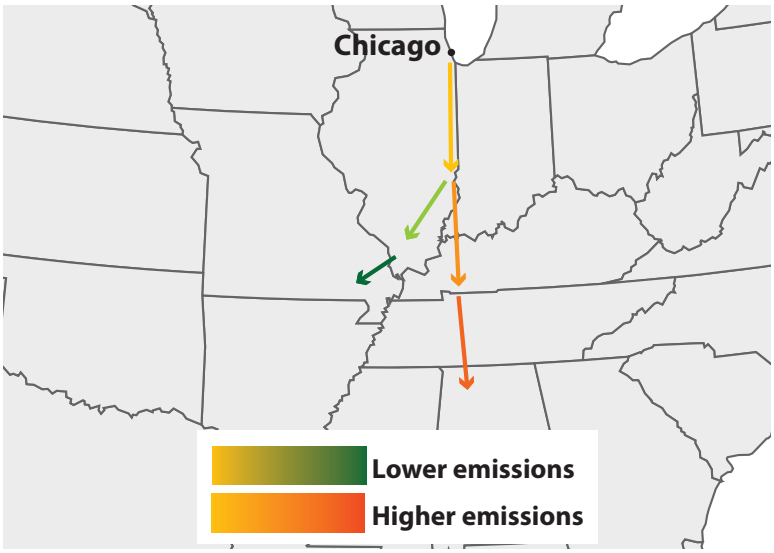


Figure 21 Under lower emissions, Chicago's plant hardiness zone would "migrate" along the path of the yellow arrow (30 years), the light green arrow (50 years), and then the dark green arrow (100 years). Under the higher emissions scenario, Chicago's zone would "migrate" along the path of the yellow arrow (30 years), the orange arrow (50 years), and the dark orange arrow (100 years).

Impacts of this change: Some plant species in the Chicago region would migrate north or decrease in number. For example, there could be fewer numbers of white oak, maples, and northern red oak. Hardwoods that are now less common, such as aspens and paper birch, would become rare. Some evergreen species may disappear altogether. Also, plant species from the south could begin to grow in the region. Gardeners and homeowners may need to replace current trees and shrubs with new species that are less vulnerable to disease and better suited to the new climate.

2. Types of birds, insects, fish, and mammals living in the Chicago region could change. As the climate and the types of plants in the region change, so would the animals living there. Under both scenarios, many native species are projected to decrease in number, such as the American Goldfinch (**Figure 22**), while other southern species increase in number, such as the Summer Tanager (**Figure 23** on the next page). Changes in species would dramatically alter the biological character of the Chicago region. Also, changes in species could disrupt the balance of local ecosystems and alter certain ecosystem services.

Figure 22 American Goldfinch

"As the climate warms, current insect pests would reproduce faster and cause more damage."

Figure 23 Summer Tanager

Impacts of this change: Researchers modeled that 46 bird species (low emissions) to 51 species (high emissions) would lose at least half of their suitable habitat from the Chicago region. Examples include the Hermit Thrush, Black-throated Green Warbler, Winter Wren, and Common Loon. Also, 25 species (low emissions) to 35 species (high emissions) would gain at least twice the suitable habitat. Examples include the Loggerhead Shrike, Blue Grosbeak, Summer Tanager, and Red-shouldered Hawk.

The Chicago area currently contains 115 species of butterfly. About 20 of these species could leave the region, and approximately the same number of new species appear in the region. For example, the Falcate Orangetip may expand into the Chicago region with climate warming, while the Aphrodite Frittilary could disappear.

Climate change will further endanger vulnerable or threatened species in the region. To protect native species, the region will need new or more intensive strategies of ecosystems management and greater efforts at conserving vulnerable species. Recreational activities such as bird watching and gardening will also be affected by the changes in habitats and species.

Another significant problem is known as "landscape fragmentation" due to human settlement. Protected sites for plant and animal species at risk are not often linked to migration pathways. As a result, if plants and species need to migrate to survive climate change, a green pathway must be made for them out of the protected area. Unless the region invests in major green pathways through suburban areas, migration may not be possible for some species.

3. Damage caused by plant and animal pests could increase. As the climate warms, current insect pests are likely to reproduce faster and cause more damage. Also, pests may move from the south into the Chicago region. Plants that are stressed by climate change will be more vulnerable to insect or disease attacks. Many invasive species are more adaptable to changing conditions than the native plant species. We can also expect invasive plants and weeds to grow and spread more quickly under a warmer climate and higher CO_2 levels.

Figure 24 Kudzu

Impacts of this change: Some weeds such as the spotted knapweed and Canada thistle are already a problem in the area, and may become more aggressive in the future. Kudzu, an invasive weed, may spread into the region from the south (**Figures 24 and 25**). The Japanese beetle may cause greater damage to soybean crops and household gardens. The gypsy moth, a major forest pest that harms or destroys trees, is already beginning to move into the Chicago area. Its spread is thought to be aided by warmer winter temperatures. These and other pests would impact gardening and farming in the Chicago area.

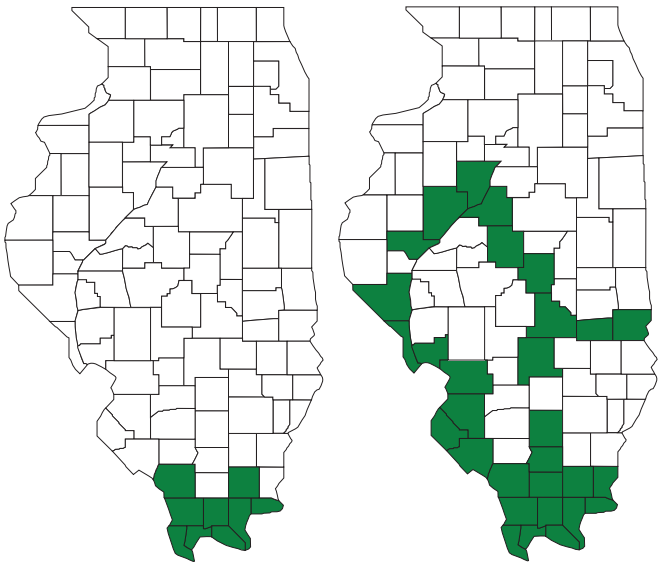


Figure 25 These maps show the spread of kudzu, an invasive weed, across Illinois from 1971 (left) to 2006 (right).

4. Lake and river ecosystems will be affected. As described in Part 3, changes in climate would impact aquatic ecosystems in the Chicago area. As the temperatures of Lake Michigan and smaller inland lakes warm, the amount of mixing between nutrient-rich deep waters and oxygen-rich surface waters could decrease. This would affect fish in deep waters that require oxygen, and plankton at the surface that require nutrients. Since fish depend on plankton as the basis of most aquatic food chains, warming lake waters could severely impact aquatic ecosystems. As the temperature warms, cold water fish may leave the area or decrease, while warm water fish increase in number. Algae levels, particularly blue-green algae (known as 'Cyanobacteria'), may increase, polluting water and beaches. Shoreline erosion may increase due to more seasonal flooding, while water quality near the shore will likely decrease.

"Soybean production could decrease… under the higher emissions scenario, it would mean a 50% decrease [by the year 2100]."

Protecting Our Ecosystems

What can we do to protect these ecosystems? As this report shows, ecosystems would be harmed less under the lower emissions scenario than under the higher one. Reducing our emissions of heat-trapping gases will help protect ecosystems. In addition, we can protect ecosystems by making wise management and land use choices. As discussed in Part 7 of this report, the City of Chicago is looking ahead to protect trees and plants within the city and help them adapt.

Climate Change and Agriculture

The agriculture of Illinois is based primarily on soybean and corn crops (**Figure 26**). Of the state's 9 billion dollar agricultural economy, about 3 billion comes from soybean and 4 billion from corn. Researchers expect the following changes in the agriculture industry in northern Illinois:

Figure 26 Soybean crops are an important part of Illinois agriculture.

1. Soybean production would decrease. Soybean production is sensitive to temperature.

For every 1ºC rise in temperature, there is about a 17% drop in crop yield. Under the lower emissions scenario, this would mean a 30% drop in soybean crops in northern Illinois by the year 2100. Under the higher emissions scenario, it would mean a 50% decrease. Since corn is already adapted to relatively hot, dry conditions, it is less sensitive to temperature.

2. Increases in spring flooding and hot summers may damage farm crops in the Chicago area. Although it is difficult to predict specific changes in rainfall, in general researchers expect more rainfall in the spring, raising flood risk. Little change in summer rain combined with higher evaporation could increase drought risk.

3. Longer growing seasons may increase crop productivity. As the climate changes, increased levels of CO_2 in the air would probably benefit crops and increase productivity. However, these positive changes may not be enough to balance the negative effects of a warmer climate.

4. Increases in pests and disease may damage farm crops. Pests and diseases would be favored in a warmer climate. Also, insects and weeds from the south, such as kudzu, may spread north into Illinois.

Protecting Our Agriculture

Illinois farmers can adapt in a number of ways to the changing climate. Some options include:

- adjusting planting and harvesting dates
- planting more heat-tolerant or genetically-modified varieties better suited to future climate
- switching to warmer season crops (e.g. melons)
- investing more capital in irrigation, crop storage, or livestock facilities

Climate change can also provide opportunities for farmers. For example, farmers could increase their income by growing crops that benefit from increased CO_2 levels. The agricultural industry needs more research to identify strategies and adaptations for Illinois farmers. Research could include studies of heat-tolerant or CO_2-sensitive soybean crops; ongoing and future pest problems; and economic opportunities that benefit both farmers and the environment.

Part 5: Health Impacts in Chicago

"We can expect to see longer, more frequent, and more intense summer heat waves."

In July of 1995, Chicago experienced a heat wave that was unprecedented in the 123-year-old weather records of the city (**Figure 27**). Maximum daily temperatures reached at least 90°F for a full week. For two days during that week, temperatures were greater than 100°F. At night, the high humidity kept the city oppressive and hot.

Figure 27 This picture was taken during the 1995 heat wave in Chicago. (©Gary Braasch)

Heat waves are known to cause higher rates of illness and death. Prolonged heat waves also worsen cardiovascular, respiratory, and other conditions. Children, seniors, and people with pre-existing health conditions are particularly at risk. The 1995 heat wave is estimated to have caused almost 700 deaths that would not have happened otherwise.

Over the coming century, climate change is expected to increase the frequency of heat wave events. Even though the people of Chicago will probably become used to higher temperatures over time, the city needs to consider significant changes to prevent increases in heat-related illnesses and deaths.

Changes in climate also affect our health indirectly. A warming climate may cause disease-carrying insects and animals to change their territory, or to increase in number (**Figure 28**). Plants that cause allergies may also increase in number and in their ability to produce pollen.

Figure 28 Mosquitoes carrying West Nile Virus may increase in number and move farther north as the climate warms.

"…an increase in ground-level ozone is one of the top five global health impacts expected from climate change."

Heat Waves

Over the next century, researchers expect increases in extreme temperatures. We can also expect to see longer, more frequent, and more intense summer heat waves. Without preventative measures, these heat waves could cause significant increases in heat-related illnesses and deaths.

In 2003, the European Heat Wave was responsible for more than 40 thousand deaths across Europe. Using an "analog city" analysis, researchers estimated what would happen in Chicago during a similar heat wave. To create the analog analysis, the meteorological conditions that occurred over Europe in the summer of 2003 were transposed to central North America instead. The way Chicago's population responds to heat, the amount of air conditioning we use, and the types of buildings we live in were included in the analysis as they are today. It is estimated that a heat wave like that one, if it occurred today, would break all high-temperature records in Chicago's written history. With a heat wave of this magnitude, more than 1,000 people in Chicago could die in just a few weeks, severely taxing the health care system.

Climate projections indicate that it is very likely such a heat wave will occur before 2050. **Figure 29** shows the projected increase for Chicago in the number of years per decade with a heat wave similar to the 1995 heat wave. According to the lower emissions scenario, events like this could occur *every other year* by the 2090s. By the end of the century, a heat wave as extreme as the 1995 heat wave could occur *several times* each summer under the higher emissions scenario.

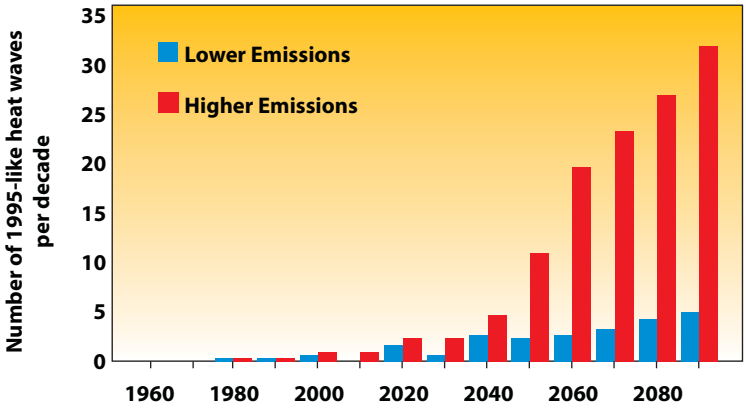


Figure 29 Average number of summers per decade with a Chicago heat wave similar to the 1995 heat wave.

Preventing Heat-Related Illness and Death

Over the coming century, the number of illnesses and deaths caused by heat-affected circulatory and respiratory diseases would probably increase. The risk is greater under the higher emissions scenario.

Many adaptations can help prevent heat-related illness and death. Examples include effective early warning systems, public education, air conditioning, and having "cooling centers" available during heat waves. Part 7 of this report describes specific adaptations listed in the Chicago Climate Action Plan.

Over the coming century, the population of Chicago is expected to increase. The city's demographic profile is also expected to shift, with an increasingly aging population. These changes make it even more urgent that we take measures to protect the population during heat waves. Several U.S. cities are already using heat watch warning systems, along with intervention plans. These systems have been shown to save lives.

Changes in Air Quality

Ground-level ozone gas, O_3, is a major concern for air quality. Climate experts say that an increase in ground-level ozone is one of the top five global health impacts expected from climate change. Ozone is a toxic gas that causes respiratory health problems. In Chicago, summertime ozone levels have significantly decreased since the late 1970s. However, Chicago has never been able to consistently meet the ozone standards set by the Environmental Protection Agency to protect public health.

The production of ground-level ozone is linked to human combustion of fossil fuels. Air quality is measured mainly through ground-level ozone. High ozone levels indicate poor air quality, while low ozone levels indicate acceptable air quality. Ozone production tends to increase as temperatures warm. As a result, air quality in the Chicago area will likely get worse as the climate warms and air circulation patterns change.

Chicago and Cleveland were the first U.S. cities to pass municipal air quality regulation in the 1880s.

Under the lower emissions scenario, summer ozone levels in the city could increase by about 10% by 2100. Under higher emissions conditions, summer ozone levels could increase by as much as 50% by 2100.

This analysis assumes that emissions of pollutants remain the same as they are today. However, it is possible to reduce ozone levels even while the temperature continues to warm. Cutting down on local emissions of nitrogen oxides, volatile organic compounds, and other pollutants could reduce production of ground-level ozone.

Disease Outbreaks

As the climate warms, northern areas of the U.S. could become warm enough for plants and animals that usually live further south. Also, current pests and disease organisms could flourish under the warmer and wetter conditions. Unfortunately, this means that many new disease-carrying insects and other animals would be able to move farther north, while those already present could become more frequent.

Today, animal-borne diseases are an ongoing health concern in the Chicago area. In Illinois, the two most common animal-borne diseases are West Nile Virus (WNV) illness, carried by mosquitoes, and Lyme disease, carried by ticks. Since 2002, the counties of Cook and DuPage have reported almost 1200 cases of human illness from WNV. The bacteria that cause Lyme disease have also been found in the Chicago region.

As the climate warms and precipitation patterns change, researchers expect the following changes:

1. The risk of exposure to West Nile Virus (WNV) could increase rapidly. Warmer summers mean a longer mosquito season, and higher temperatures allow mosquitoes to develop faster. Heat waves increase the risk further. Past outbreaks of WNV have been linked with very warm temperatures and very dry conditions.

2. There may be a change to the risk of Lyme disease. Lyme disease has only recently arrived in the Chicago area. Studies show that the deer ticks carrying the disease may be more active during warmer weather. However, the ticks may decrease in number during dry periods. It is not yet clear how a change in climate could affect the risk of this disease, but it is important to monitor any changes.

"The risk of exposure to West Nile Virus could increase rapidly."

"Road repairs and maintenance are projected to double under the higher emissions scenario."

Part 6: Impacts on Chicago's Infrastructure and Economy

As the climate changes, the frequency of heavy rainfall events, heat waves, and elevated flood risk in the Chicago area would probably increase. These events could impact roads, bridges, highways, rail systems, and buildings.

One of the most significant changes for Chicago's infrastructure will be the change in energy consumption. The United States accounts for 5% of the world's population, but it consumes 25% of the annual energy used worldwide. Over the past 25 years, the use of energy in the U.S. has increased by 25%. Most of this increase is due to additional heating and cooling in homes and offices. As the number of very hot days in Chicago increases, the energy used for air conditioning could also increase. Because most of our energy currently comes from fossil fuel combustion, an increase in energy consumption could worsen the problem of climate change (**Figure 30**).

Figure 30 Burning fossil fuels increases the problem of climate change.

Stress from Summer Energy Consumption

In particular, researchers expect the following changes in energy use over the coming century:

1. Increased need for air conditioning: By the end of the century, the number of days per year requiring air conditioning could double under the lower emissions scenario and triple under the higher emissions scenario.

2. Decreased need for heating: The number of days per year requiring heating is likely to decrease by a similar amount.

3. More energy use in summer and less in winter: As a result, there would be a decreased demand for natural gas in the winter, and an increased demand for electricity during the summer.

4. More brown-outs or black-outs: More frequent, severe, and longer heat waves could increase the likelihood of electricity shortages, leading to brown-outs or black-outs.

Other Impacts on Chicago's Infrastructure

In addition to changes in energy use, we can expect the following impacts on the infrastructure of Chicago:

"Individuals in the City of Chicago would also face increased costs."

1. Higher cost maintenance for roads and transit: Road repairs and maintenance are projected to double under the higher emissions scenario, due to changes in planting and maintenance costs, road replacement, and repair related to heat and rain. Costs would also rise for maintaining parking lots to manage flooding. In addition, vehicle costs would rise. Maintenance costs for public buses could increase because of heat-related stress to vehicles, increased use of air-conditioned buses during heat waves, and increased numbers of absentee workers due to extreme heat stress. Emergency vehicles—fire engines, police cars, and ambulances—would need to be replaced more often due to heavier usage and more wear.

2. Higher building capital and maintenance costs: Costs for cooling buildings and roof and façade repairs are expected to rise under both the lower and higher emissions scenarios. Research based on city buildings suggests that costs under the higher emissions scenario could be ten times higher than under the lower emissions scenario. All non-cooled facilities would need retrofits so they can continue to be used in extreme heat. Roofs would have higher repair costs due to the sun breaking down petroleum-based roofing materials. Facades may also need more maintenance and repairs. Building losses due to storm damage could be a much larger expense. After the storm on August 23 and 24 of 2007, for example, the City of Chicago spent $6.6 million on overtime and cleanup.

3. Higher landscaping costs: Landscaping costs related to maintenance of trees, plants, and flowers would increase as temperatures warm. This is due both to a longer blooming season and more required maintenance and replacement. Trees could have a shorter lifespan because of increased stress due to higher temperatures. These costs are projected to be five times higher for the Chicago Park District under the higher emissions scenario as compared to the lower.

4. A more stressed police, fire, and medical response system: Researchers estimate that a doubling in number of very hot days would result in 5–10% more fires in the Chicago area. There would be more emergency response calls as a result of increases in fires, power outages, well-being checks, and transportation to cooling facilities.

Since the numbers of heat-related illnesses increase during heat waves, the medical response system would become more stressed. Hospitals could be overwhelmed during heat waves, and reject ambulances, sending them to non-local hospitals. These changes will raise costs.

Police costs could also rise with the heat. An increase in police emergencies generally occurs when Chicago hits the "heat trigger" of 98 or 99°F. Calls include electrical outages, loss of air conditioning in high-rise buildings and subsequent evacuations, and other heat-related problems. Police also see more calls during extended heat waves. In addition, the Police Department strains its resources during extreme rainfall events, which are projected to be more frequent in the future. Diverting police from crime fighting to weather emergencies could hurt crime deterrence.

5. Higher harbor dredging costs: The Chicago Park District could see harbor dredging costs that are twice as high under the higher emissions scenario as the lower emissions scenario. It also could experience higher costs for algae treatment due to increased temperatures.

6. Higher business costs due to staff absences: People who work outside in summer would be under increasing stress as temperatures warm. Workers would be vulnerable to increasing heat stress and exacerbation of respiratory diseases.

7. Higher property insurance costs: With gradual increases in temperature and precipitation, as well as extreme heat and rainfall events, we expect to see increasing insurance premiums for coverage applicable to weather-related events; potential exclusions for certain losses such as flooding, hail damage, or business disruption; and increased deductibles or risk sharing.

8. Less tourism: Chicago may have a longer summer season, but under the higher emissions scenario, it would be a much hotter and more humid summer too. An increase in average temperatures will create a more uncomfortable climate. This could lead to a decrease in the number of outdoor entertainment events held in Chicago, because it would be harder to attract non-resident attendees.

Reducing Our Energy Use

Most of our energy is produced from burning fossil fuels. As our energy consumption increases, we can't just produce more energy in the same way. Burning more fossil fuels produces more heat-trapping gases, which just increases the original problem of climate change.

Instead, we need to reduce our use of energy. For example, if we use fans and better ventilation for more efficient cooling, the amount of energy required for air conditioning could decrease significantly. In addition to reducing our energy use through conservation and higher efficiency, we need to switch to alternative sources of energy, such as nuclear, wind, and solar electricity generation. By using alternative energy sources, we can meet the need for cooling, without increasing our emissions of heat-trapping gases.

Avoiding Negative Impacts on the Chicago Economy

Research shows that there is a compelling economic advantage to pursuing activities that lead to a lower emissions scenario. As temperatures and extreme precipitation rise, so will the economic costs. These costs can only be partly offset by savings due to warmer winters. This report presents only cost estimates for city government. Individuals in the City of Chicago could also face increased costs. For city government alone, costs are 3.7 times higher under the higher emissions scenario than they are under the lower emissions scenario. The magnitude of this difference in impacts clearly shows the advantage of pursuing activities that lead to a lower emissions scenario. Even partial success in minimizing climate effects will help reduce the negative impacts of climate change for everyone in Chicago.

Part 7: Mitigation and Adaptation Strategies for Chicago

"Chicago has committed to reduce its heat-trapping gas emissions to 25% below 1990 levels by 2020, and 80% below 1990 levels by 2050."

The City of Chicago is considering climate change in all aspects of city planning and investment. This ensures the city will be able to make the best decisions in the face of rapid change.

Chicago has committed to reduce its heat-trapping gas emissions citywide to 25% below 1990 levels by 2020, and 80% below 1990 levels by 2050. If all cities and countries together achieve this reduction, we will be able to reduce the impacts of climate change. However, we will not be able to eliminate them. We still must adapt to some degree of change.

The research that has been done to create the Chicago Climate Action Plan has brought up important questions about how to prepare for unavoidable climate change, such as:

- What needs to be done to protect vulnerable citizens from heat-related illnesses?
- How can we cool our buildings more efficiently?
- What can we do to improve air quality despite higher temperatures?
- How can we prepare for flooding and reduce the damage caused by flooding?
- Should we be planting different species of trees that can survive a changing climate (**Figure 31**)?

Figure 31 The city may need to plant different species of trees that can survive in an altered climate.

These and other questions are addressed by the Chicago Climate Action Plan.

City government, companies, and individuals will have to work together to reduce heat-trapping gas emissions and to adapt to projected changes in climate. Every company should prepare an assessment of potential climate impacts on its business, and come up with steps for adapting to change and reducing emissions. Individuals can also take steps to become better prepared for warmer weather and more frequent heavy rainfall events and increased flood risk. Some steps include:

- installing rain barrels
- installing back-up battery power for sump pumps
- new parkway and yard tree planning
- checking on neighbors during heat waves

Individuals can also take steps to reduce heat-trapping gas emissions, such as:

- walking, bicycling, or taking public transit instead of driving
- insulating windows and homes to reduce energy use during the summer and winter
- reducing energy use at home by turning off appliances such as computers and air conditioners when not needed

Together, the people of Chicago can successfully adapt to the expected changes in climate. In addition, by reducing our emissions, we can help to ensure a safer and more predictable future for our city and the rest of the world.

Conclusions

The climate in the Chicago area has already begun to change. Temperatures have risen by several degrees. Trees and plants flower earlier in the spring and frosts occur later in the fall. There have been several major heat waves in recent years, and the amount of winter ice on Lake Michigan is decreasing. Heavy rainstorms are increasing in frequency.

These changes are not simply natural variations in climate. Most of them are likely being caused by human emissions of heat-trapping gases.

This report outlined the even greater changes in climate that may occur over the coming century. However, scientists can only offer advice on what the future might look like, based on the choices we make that determine our future emissions.

Figure 32 Our decisions can change the future of our city.

Although some future changes are unavoidable, because of past emissions, the worst of the projected changes do not have to happen if we act to reduce our emissions now. Decisions made by individuals, cities, states, and nations are what will determine whether we follow a higher or lower emissions pathway into the future (**Figure 32**).

Reducing Our Emissions and Adapting to Change

People in the Chicago area can do a great deal to prevent the worst of the impacts in this report from happening. Though the lower emissions scenario still results in changes for the region, these changes are much less serious than the changes expected under the higher emissions scenario. This means that our emissions of heat-trapping gases do make a difference! If we immediately start down the path towards reducing our energy use and our heat-trapping gas emissions, we can help protect our communities, economy, and ecosystems. We must also plan intelligently to adapt to climate change and minimize its harmful effects. Doing nothing carries a high cost, and could seriously change the character of the Chicago area. The Chicago Climate Action Plan includes a comprehensive set of strategies for reducing Chicago's emissions of heat-trapping gases. We hope the people of Chicago will rally around these initiatives.

Final Note:

More information on the scientific basis for the climate change projections and the likely impacts these will have on Chicago is available in the full report, *Climate Change and Chicago: Projections and Potential Impacts,* available online at **www.chicagoclimateaction.org.**