Union of Concerned Scientists

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Confronting Climate Change in the U.S. Midwest

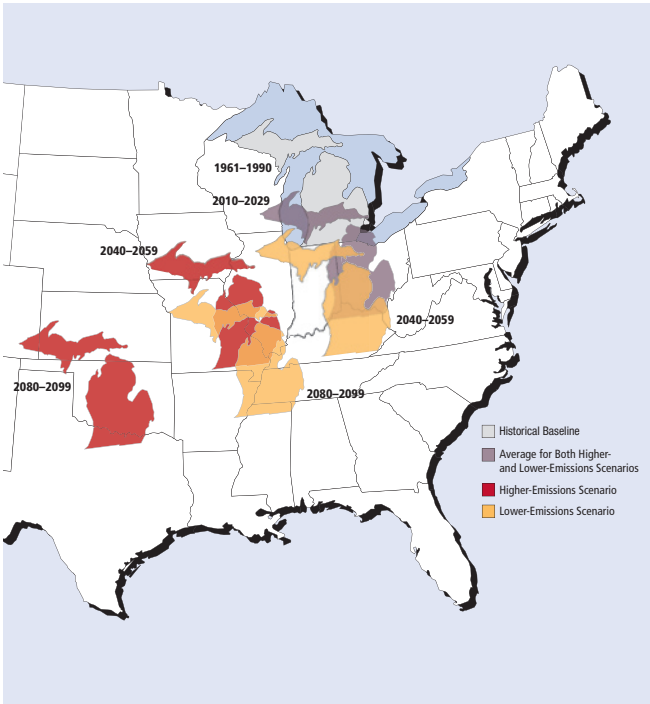
MICHIGAN

From its diverse farmlands and boreal forests to its many inland lakes and thousands of miles of shoreline, Michigan has been strongly shaped by its climate. However, that climate is changing due to global warming, and unless we make deep and swift cuts in our heat-trapping emissions, the changes ahead could be dramatic. This report presents new projections showing some of the potential impacts of global warming on Michigan, including severe summer heat, more dangerous storms and floods, and new threats to agricultural production.

GLOBAL WARMING AND THE MIDWEST

Global warming is caused by an increase of pollutants in the atmosphere, including carbon dioxide produced by human activities such as the burning of fossil fuels and the clearing of forests. Carbon dioxide acts like a blanket that traps heat in our atmosphere and warms our climate; oceans, forests, and land can absorb some of this carbon, but not as fast as we are creating it. As a result, heat-trapping emissions are building up in our atmosphere to levels that could produce severe effects including extreme heat, prolonged droughts, intense storms, corrosive ocean acidification, and dangerous sea-level rise.

The climate of the Midwest has already changed measurably over the last half century (De Gaetano 2002; Kunkel et al. 1999). Average annual temperatures have risen, accompanied by a number of major heat waves in the last few years. There have been fewer cold snaps, and ice and snow are melting sooner in the spring and arriving later in the fall. Heavy rains are occurring about twice as frequently as they did a century ago, increasing the risk of flooding.



Michigan's Climate Migrates South

Changes in average summer "heat index"—a measure of how hot it actually feels based on a specific combination of temperature and humidity—could strongly affect Midwesterners' quality of life in the future. For example, the red outlines track what summers in Michigan could feel like over the course of the century under the higher-emissions scenario; the yellow outlines track what summers could feel like under the lower-emissions scenario.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New Climate Projections for Michigan

New research summarized here projects significant consequences for Michigan as soon as the next few decades, increasing in severity into the middle and end of this century. This report considers these consequences in terms of three time frames: 2010–2039 ("the next few decades"), 2040–2069 ("mid-century"), and 2070–2099 ("toward the end of the century"). We compare these periods with the climate in Michigan during 1961–1990 ("the historical baseline").

Toward the end of the century, if current pollution trends continue, projected effects in the state include:

Far more scorching summers

- Every summer in Michigan would be hotter than 2005—the state's hottest summer of the last half century.
- Detroit would experience almost 65 days per summer with highs over 90 degrees Fahrenheit (°F) and 23 days per summer with highs over 100°F.
- Detroit would face around two heat waves per summer like the one that killed hundreds in Chicago in 1995.
- Air quality would deteriorate, as hotter weather causes more severe smog problems (assuming similar levels of tailpipe and smokestack emissions). This would have serious consequences for public health, including a greater incidence of asthma attacks and other respiratory conditions.

Dangerous storms and flooding

- Heavy rains would become more common throughout the year, leading to a greater incidence of flash flooding.
- Winters and springs, when the flood risk is already high, would become more than 25 percent wetter.

New threats to agriculture

- Crops and livestock would face substantially more heat stress, decreasing crop yields and livestock productivity.
- Warmer winters and a growing season up to six weeks longer would enable pests like the corn earworm to expand their range.
- Crop production would be inhibited by changing rain patterns such as wetter springs (which delay planting and increase flood risk) and almost 10 percent less rain during the increasingly hot summers.

Effective and Affordable Solutions

The most dangerous effects of climate change are likely to occur if the global average temperature rises more than two degrees Celsius above where it stood in 1850. Science shows we still have a chance of keeping temperatures below this level if we cut heat-trapping emissions deeply and quickly—and limit atmospheric levels of carbon dioxide to 450 parts per million (see *www.ucsusa.org/mwclimate* for more details).

Michigan can do its part by implementing its own carbon-reducing state policies and investing in clean energy technologies that can both reduce consumer energy costs and build new growth industries in the state. Michigan can also play a lead role in calling for strong federal legislation that would provide climate-friendly choices for Michigan consumers and businesses and help for resource managers and local governments that must prepare for the effects of climate change that cannot be avoided.

A recent analysis by the Union of Concerned Scientists (UCS), *Climate 2030: A National Blueprint for a Clean Energy Economy* (Cleetus, Clemmer, and Friedman 2009), demonstrates that the United States can cut heat-trapping emissions deeply and swiftly enough to avoid the most dangerous consequences of climate change. A comprehensive climate and energy approach—combining a cap on emissions with policies that encourage renewable electricity, energy efficiency, and cleaner transportation choices—can reduce emissions 26 percent below 2005 levels by 2020 and 56 percent below 2005 levels by 2030 while saving consumers and businesses money.

Our Analysis

Our analysis considers two different possible futures: one with a lower level of global warming pollution and one with a higher level (see *www.ucsusa.org/mwclimate*). These futures represent the best and worst cases of the emissions scenarios described by the international scientific community in 2000 and which have been used for scientific analysis ever since. However, they by no means encompass the full range of futures that could plausibly unfold.

Climate protection policies, if implemented quickly, could reduce emissions significantly below the lower-emissions scenario considered here. On the other hand, up until 2008, global emissions have been higher than the higher-emissions scenario being considered.

HOW WILL EMISSIONS CHOICES AFFECT MICHIGAN'S FUTURE?

Dangerously Hot Summers Ahead

Our new research projects dramatically hotter summers for Michigan. This is true under both the lower- and higher-emissions scenarios, but the prevalence of extreme heat is much greater under the higher-emissions scenario. The conditions that constitute "extreme" heat were measured in two ways: counting the expected number of days above 90°F and 100°F per summer, and projecting the likelihood of extreme heat waves similar to the one that hit Chicago in 1995 (see the text box on p. 4). By both measures, summers in Michigan will become dangerously hot.

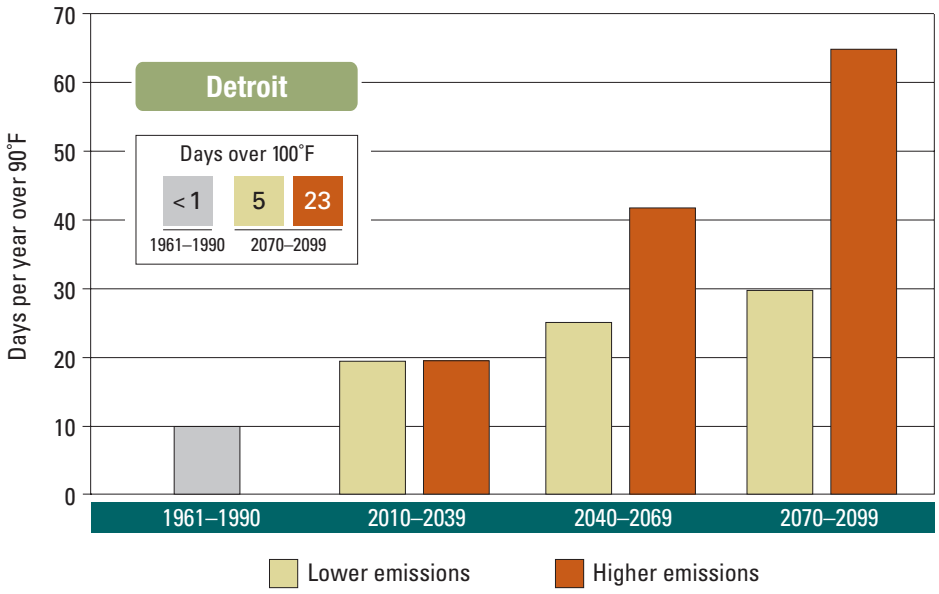
More days over 90°F and 100°F

Because heat waves are especially lethal in cities, where urban landscapes absorb more heat during the day and are less effective at releasing it at night (the "heat island" effect), our analysis focused on the extreme heat projected for the state's largest city, Detroit, and the number of days each year likely to exceed 90°F and 100°F. During the historical baseline Detroit averaged only 10 days per summer with highs over 90°F. That number rises substantially in the next few decades, and toward the end of the century under the higher-emissions scenario, the city is projected to experience almost 65 days above 90°F—more than two months of the summer. Under the lower-emissions scenario that number would be cut by half.

As for the more dangerous days over 100°F, Detroit averaged less than one such day each summer during the historical baseline. But toward the end of the century under the higher-emissions scenario, the city is projected to face 23 such days—more than three weeks. That number would be reduced to five under the lower-emissions scenario. Other Michigan cities such as Ann Arbor, Flint, Grand Rapids, Lansing, and Warren will face conditions similar to Detroit.

The severe heat projected for Michigan poses serious health risks for residents. Heat waves already kill more people in the United States each year than hurricanes, tornadoes, floods, and lightning combined (CDC 2006), and the average annual death toll of nearly 700 may well be an underestimate, since there are no uniform reporting requirements and many deaths are probably misclassified (Luber and McGeehin 2008). Studies show that deaths from many causes, including cardiovascular and respiratory disease, increase during heat waves.

The health costs associated with heat waves are not limited to deaths; many other people become sick enough to be hospitalized. In 2005, medical costs related to extreme heat and cold totaled $1.5 billion nationwide, or more than $16,000 per patient. The Chicago heat wave of 1995 increased admissions to Cook County hospitals 11 percent (more than 1,000 patients) during the peak week (Semenza et al. 1999). Many heat-related deaths and illnesses can



Extreme Heat Becomes More Frequent

Under the higher-emissions scenario, Detroit could experience almost 65 days per summer with highs above 90°F toward the end of the century. Under the lower-emissions scenario, the number of such days would be halved. Dangerously hot days over 100°F (shown in the inset box) are also projected to increase dramatically, with more than three weeks of such days expected under the higher-emissions scenario.

Michigan Could Face Heat Waves of Historic Proportions

In July 1995, Chicago experienced its worst weather-related disaster ever. Temperatures reached or exceeded 90°F for seven days in a row and exceeded 100°F on two of those days (Kaiser et al. 2007). Conditions were made worse by high humidity levels, unusually warm night-time temperatures, and the pollution that built up in the stagnant air. Thousands of Chicagoans developed serious heat-related conditions, overwhelming the city's emergency responders and forcing 23 hospitals to close their emergency room doors to new patients. Like the city's hospitals, the county morgue was completely overwhelmed (Klinenberg 2002).

The heat wave was ultimately responsible for between 450 and 700 heat-related deaths in Chicago (Klinenberg 2002; CDC 1995). Hundreds of additional heat-related deaths occurred in other parts of the Midwest and along the East Coast (NOAA 1996).

If our heat-trapping emissions continue unabated, heat waves like this are projected to become routine in Michigan. Under the higher-emissions scenario, for example:

If our heat-trapping emissions continue unabated, heat waves of historic proportions are projected to become routine in Michigan.

- Over the next few decades, Detroit would experience a heat wave as hot as the 1995 Chicago heat wave *once a decade*
- By mid-century Detroit would experience a heat wave as hot as the 1995 Chicago heat wave *every other year*
- Toward the end of the century Detroit would face heat waves as hot as the 1995 Chicago heat wave *twice every summer*

Under the lower-emissions scenario, these projections are greatly reduced, with Detroit experiencing one such heat wave per decade by the end of the century.

Chicago's experience actually pales in comparison to the European heat wave of 2003—the worst of the past 150 years in terms of both duration and intensity. For almost three months daily high temperatures were hotter than normal, with half of those days more than 10°F above normal. Daily low temperatures were also abnormally hot. The death toll was initially estimated around 30,000 (UNEP 2004), but more recent analyses have identified 70,000 heat-related deaths that summer in 16 countries (Robine et al. 2008). Hardest hit was France, where fatalities exceeded 2,000 per day during the heat wave's peak (Pirard et al. 2005).

Projections for Chicago and Minneapolis-St. Paul (cities that are only slightly warmer than Detroit), show that these cities are very likely to suffer a heat wave comparable to the 2003 European heat wave in the next several decades. Under the higher-emissions scenario a heat wave of this magnitude would occur at least every fifth year by mid-century, and every other year toward the end of the century.

be prevented by improving warning systems, access to air conditioning, and year-round medical staffing.

More dangerous air pollution

In areas where there are local sources of fossil fuel emissions, ground-level ozone—a dangerous air pollutant and the main component of smog—increases at temperatures over 90°F (Luber and McGeehin 2008). Since our projections show that, under the higher-emissions scenario, Michigan will experience such temperatures for most of the summer toward the end of the century, the state can expect far more days of unhealthy ozone levels than would occur without global warming.

This is particularly bad news for the nine Michigan counties—the majority of which are in the Detroit-Ann Arbor region—that already experience ozone levels higher than the Environmental Protection Agency's (EPA's) health-based ozone standard (EPA 2008b). During the three-year period from 2005 to 2007, Michigan experienced more than 170 orange ozone alerts and almost 20 red ozone alerts (ALA 2009); orange alerts represent ozone levels dangerous to sensitive groups including children, the elderly, athletes, and people with heart and lung diseases, and red alerts indicate the air is unhealthy for anyone to breathe.

High concentrations of ground-level ozone (not to be confused with ozone in the stratosphere, which provides an important natural shield against solar radiation) diminish lung function, cause a burning sensation in the lungs, and aggravate asthma and other respiratory conditions.

Ozone may also contribute to premature death, especially in people with heart and lung disease (EPA 2008). Studies show that when ozone levels go up, so do hospitalizations for asthma and other lung conditions, and it appears that heat and ozone together increase mortality (Luber and McGeehin 2008). Ozone also damages plant life; the EPA warns that a climate change-induced increase in ozone could damage ecosystems and agriculture as well as human health (EPA 2008).

Another air contaminant of particular concern in Michigan is small particulate pollution (or soot); the five counties surrounding Detroit and Ann Arbor have already been identified as failing to meet federal air quality standards for this pollutant (EPA 2004), and Detroit ranks among the nation's 10 most soot-polluted cities (ALA 2009). Small particulates increase the severity of asthma attacks in children, increase the number of heart attacks and hospitalizations for cardiovascular disease and asthma, and cause early deaths from heart and lung disease (ALA 2009).

The leading source of small particulate air pollution is coal-fired power plants, and as demand for electricity increases in response to rising temperatures, power plants generate more emissions. Therefore, climate change threatens to exacerbate Michigan's particulate air pollution.

In Michigan today, more than 9 percent of the population (more than 170,000 children and more than 520,000 adults) suffers from asthma (ALA 2009). Heart disease caused 577 of every 100,000 deaths among residents 35 and older between 1996 and 2000, compared with 536 nationwide (CDC 2009). The combination of increasing heat, ozone, and small particulate pollution can be especially dangerous for these populations.

Changes in Storm, Flood, and Drought Patterns

In June 2008, 11 counties in Michigan's Lower Peninsula were declared federal disaster areas after enduring their wettest June ever; the record-breaking storms killed at least eight people and blacked out more than 730,000 homes and businesses (AP 2008). In 2009, similar storms—with rainfall amounts once considered likely to happen only once in 100 years—hit Michigan for the second year in a row. As much as eight inches of rain fell overnight in some areas (National Weather Service 2009), causing the Grand River to spill over its banks and flood much of Allegan and Ottawa counties.

As heavy rainfalls become more common, the threat of flooding will rise, as will the value of the property at risk and the costs of emergency response systems and flood control measures such as levees and dams.

More frequent downpours and flooding

Heavy downpours are already twice as frequent in the Midwest as they were a century ago (Kunkel et al. 1999). While scientists cannot attribute any single storm to climate change, more heavy precipitation can be attributed to climate change that has already occurred over the past 50 years (Trenberth et al. 2007).

Our analysis indicates that the warming ahead will make Michigan substantially more vulnerable to the kind of natural disasters it suffered in 2008 and 2009. Two findings stand out from the research:

Warming Climate Leads to Poor Air Quality

The fact that air pollution worsens as temperatures rise should concern residents of Detroit—poor air quality already puts large numbers of people at risk from respiratory illnesses such as asthma, chronic bronchitis, and emphysema. Higher temperatures are also expected to increase the dangers of allergy-related diseases (Ziska et al. 2008).

- **Precipitation is more likely to come in the form of heavy rains.** Under the higher-emissions scenario Midwest cities including Cincinnati and Indianapolis are projected to experience a 30 percent increase in heavy rainfalls (defined as more than two inches of rain in one day) over the next few decades. Toward the end of the century, heavy rainfalls in these cities are projected to occur more than twice as frequently under the higher-emissions scenario and 50 percent more frequently under the lower-emissions scenario. The maximum amount of precipitation falling within a one-, five-, or seven-day period is also projected to rise under both scenarios. Conditions in Detroit may be similar.

- **Winters, springs, and falls will be wetter but summers will be drier.** Winters and springs in Michigan are projected to see more than a 20 percent increase in precipitation toward the end of the century under the higher-emissions scenario, and autumns are projected to see more precipitation as well. Meanwhile, summers will see between 5 and 10 percent less rain. As described above, more of the rain that does fall will be in the form of downpours.

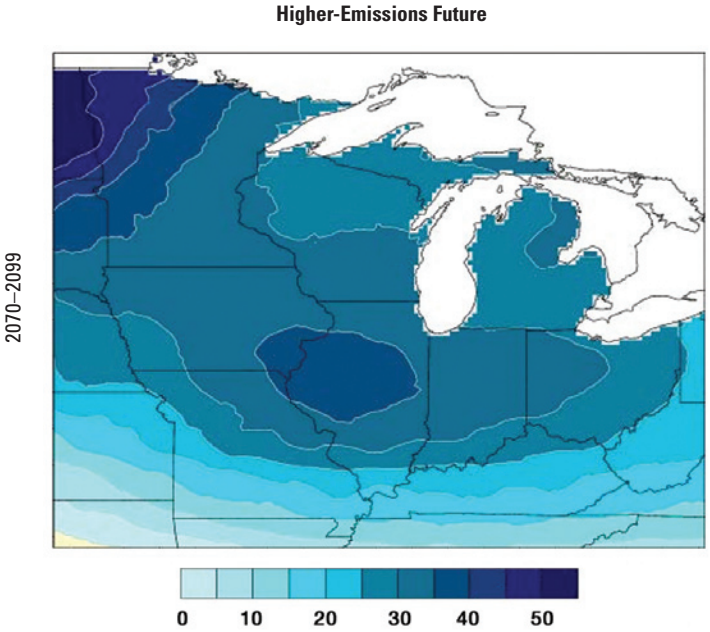
These projections support earlier studies showing a substantially increased risk of flooding in Michigan as the century progresses, especially if emissions are high. While there is likely to be some increase in local summertime flooding due to more frequent downpours, the greatest flooding risk will occur in the winter and spring, when rainfall combines with melting snow and still-frozen soils to increase runoff. In fact, analyses of various rivers in the Midwest (which used a level of emissions somewhat lower than our higher-emissions scenario) projected more than triple the number of high-flow days toward the end of the century (Cherkauer and Sinha 2009; Wuebbles et al. 2008).

More frequent short-term droughts

Paradoxically, Michigan could face not only the risk of greater flooding but also the risk of greater drought, although climate projections are less consistent in this regard. The more temperatures rise, the more water evaporates from the soil and plants, requiring more rainfall just to maintain the same soil moisture levels. However, the Midwest is projected to receive less rain in the summer (when temperatures are hottest), not more. As a result, the likelihood of drought in the region will increase, as overall water levels in rivers, streams, and wetlands are likely to decline. In Michigan, short-term droughts are projected to increase, but long-duration droughts (lasting more than two years) are likely to decline.

Lower water levels in the Great Lakes

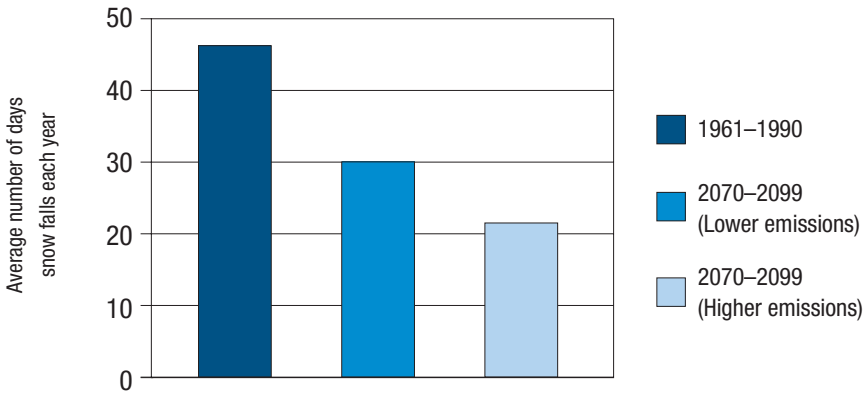
Water levels in the Great Lakes are projected to decline both in summer (due to increased evaporation caused by higher temperatures) and winter (due to a decrease in lake ice) (Angel and Kunkel 2009; Hayhoe et al. 2009). The greatest declines are expected for Lake Huron and Lake



Percent increase in spring rainfall compared with average from 1961–1990

Spring Rains Increase

Heavy downpours are now twice as frequent in the Midwest as they were a century ago. Under the higher-emissions scenario, Michigan's spring rainfall is projected to increase almost 10 percent over the next several decades and more than 30 percent toward the end of the century. This may lead to more flooding, delays in the planting of spring crops, and declining water quality in rivers, streams, and storage reservoirs.



Fewer Days of Snow Falling

The traditional Michigan winter may become shorter as the state's climate warms, and higher winter and spring temperatures will likely bring more precipitation in the form of rain rather than snow. If our heat-trapping emissions continue to increase at current rates, toward the end of the century Michigan is expected to have half the number of days every year when snow falls compared with the historical baseline (1961–1990).

Michigan. Under the lower-emissions scenario, water levels are projected to fall less than one foot toward the end of the century; under the higher-emissions scenario, levels are projected to fall between one and two feet. A decline of this magnitude can have significant economic, aesthetic, recreational, and environmental impacts, such as significantly lengthening the distance to the lakeshore, affecting beach and coastal ecosystems, exposing toxic contaminants, and impairing recreational boating and commercial shipping.

New Threats to Michigan's Agriculture

Agriculture is Michigan's second largest industry, and the state ranks second among U.S. states in terms of the diversity of crops grown (MDA 2009). Its production of Christmas trees ranks third in the nation; its production of fruits, tree nuts, and berries ranks fifth; and its production of nursery and greenhouse plants, floriculture, and sod ranks sixth. Michigan also produces substantial quantities of other crops including corn and soybeans, and its sales of dairy products ranks seventh in the nation (USDA 2009c). In 2002, more than 13 percent of Michigan's jobs were farm-related (USDA 2005) and, in 2007, agricultural commodities brought nearly $6 billion to the state (USDA 2009a).

The heat and precipitation changes projected for Michigan have potentially profound implications for agricultural production. Toward the end of the century, growing seasons are likely to lengthen by three weeks under the lower-emissions scenario and by six to seven weeks under the higher-emissions scenario. Also, rising CO_2 levels have a fertilizing effect on crops. These changes by themselves would increase crop production, but they will be accompanied by many other changes that threaten production, such as heat stress, increased drought and flood risks, and an expansion of crop pests' range.

More heat stress for crops

The extreme summer heat projected for Michigan, particularly under the higher-emissions scenario, puts the region's crops at significant risk. Corn crops, for example, can fail at 95°F, with the risk increasing the longer the heat lasts. When such hot spells coincide with droughts, as they often do, crop losses can be severe.

More Disastrous Spring Floods Could Be on the Way

While Michigan will likely see some increase in localized summer flooding due to heavier downpours, the greatest flood risk will be in the spring, when seasonal precipitation is expected to increase the most. This would result in catastrophic flooding like that experienced in 2008, which caused damage across much of the state.

Declining Lake Levels Endanger the State's Economy

Under the higher-emissions scenario, water levels in the Great Lakes are projected to fall between one and two feet toward the end of the century. Such a decline represents a threat to the state's lucrative shipping industry.

The United States lost $40 billion from a 1988 heat wave—mostly due to crop losses. Crop yields in Michigan dropped precipitously that year, with corn falling below three-quarters of its average annual yield for the period 1978–1997 (USDA 2009b). Over the next few decades (under both emissions scenarios) most Michigan summers are projected to be hotter than 1988, and by mid-century under the higher-emissions scenario, all Michigan summers are projected to be hotter than 1988.

Our analysis projects the frequency with which Michigan and the Midwest would face three- and seven-day periods of crop-damaging temperatures of 95°F or higher. During the historical baseline such periods of intense heat were extremely rare in the Midwest, with three-day periods occurring about once every 10 years and seven-day periods occurring on average only once every 30 years in the more southern states.

Under the higher-emissions scenario, however, a three-day period with temperatures reaching 95°F or higher is projected to occur every other summer in Michigan by mid-century, and in three of every four summers toward the end of the century. A more destructive seven-day period would occur at least once every five summers by mid-century and every other summer toward the end of the century. Under the lower-emissions scenario, the frequency of such periods would be significantly less toward the end of the century, with a week-long period of extreme heat remaining rare in the state.

The possibility of crop-damaging heat waves becoming more prevalent in Michigan represents a significant threat to the state's economy, which took in more than $845 million from corn alone in 2007 (USDA 2009a). Crops such as wheat and beans that fail at lower temperatures than corn are even more vulnerable.

Recent analysis of the impact that projected temperature and precipitation changes will have on the value of U.S. farmland found that rain-fed (non-irrigated) farmland in the eastern and central United States could decrease in value as much as 25 percent by mid-century, and as much as 69 percent toward the end of the century (Schlenker et al. 2006). Almost all of the loss is due to the increasing number of days above 93°F, a temperature at which most crops start to suffer.

More heat stress for livestock

Extreme heat is also projected to cause heat stress for much of Michigan's livestock. Dairy cattle are particularly vulnerable to high temperatures, and milk production can decline when temperatures exceed 75°F to 80°F depending on humidity. During the historical baseline, average summer temperatures and humidity in Michigan did not exceed levels known to cause stress in livestock. Under the higher-emissions scenario, however, dairy cattle and other livestock will endure near-permanent heat stress during the average Michigan summer toward the end of the century unless they are kept cool using costly measures such as air-conditioned barns. This could deal a significant blow to Michigan's economy—dairy products are the state's top agricultural commodity, worth nearly $1.5 billion in 2007.

Wider spread of pests

The warmer winters ahead mean that crop pests and pathogens normally kept in check by cold temperatures are projected to expand their ranges northward. A recent study warned that the expanding ranges of corn pests could have a substantial economic impact in the form of higher

seed and insecticide costs and lower yields (Diffenbaugh et al. 2008). Already, corn pests cost U.S. corn producers more than $1 billion annually; the corn earworm alone is responsible for destroying about 2 percent of the nation's corn crop every year, and it has shown resistance to a wide range of insecticides (Diffenbaugh et al. 2008).

Michigan's valuable corn crop would be at risk if two types of corn rootworm and the European corn borer do indeed move north. During the historical baseline, conditions conducive to these pests occurred rarely. Under the higher-emissions scenario, however, such conditions will occur virtually every year in Michigan toward the end of the century.

Potentially damaging changes in precipitation

Crops under stress from extreme heat need more rain, but Michigan is projected to receive less rain in the summer growing season as the climate warms. Dry conditions will be a particular problem for Michigan's crops because only about 6 percent have access to irrigation (USDA 2009a). In addition, the projected increase in spring rains could interfere with planting and pose a greater risk of floods. Changes in precipitation are therefore likely to limit farmers' ability to take advantage of the longer growing seasons expected to accompany future climate change.

There are many uncertainties about the timing and extent of the effects that climate change will have on Michigan's agriculture. Much depends on how quickly and successfully farmers can adapt to changing weather patterns by altering their traditional crop choices, planting times, and other practices. However, as the number of summer days characterized by extreme heat increases over the course of this century, yields of virtually every crop will decrease—and the losses will only get worse as the climate continues to change.

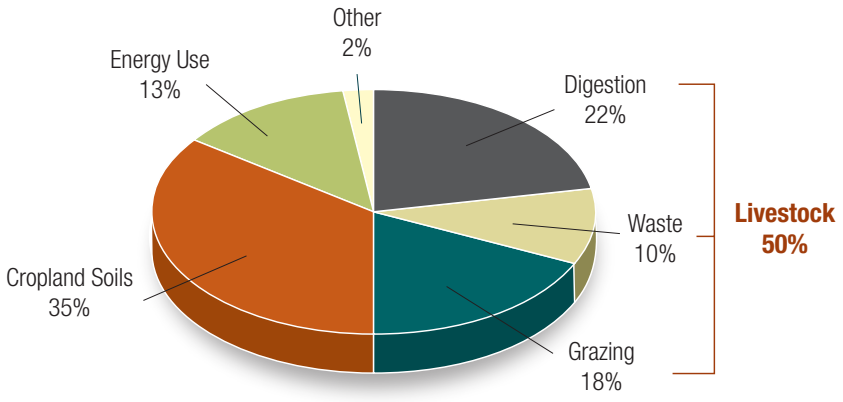
CLIMATE SOLUTIONS FOR MICHIGAN

Michigan is the ninth largest producer of global warming emissions among all the states (EIA 2008a). Electricity generation and transportation account for almost three-quarters of the state's total fossil fuel emissions, with more than half of Michigan's electricity generated by coal-fired power plants (similar to the national average) (EIA 2007). Agriculture also produces global warming emissions—close to 3 percent of Michigan's total in 2005 (MCAC 2009).

Although Michigan's emissions are high, they would be even higher if not for a number of mitigating factors. For example, below-average economic growth limited the increase in Michigan's global warming emissions between 1990 and 2005 to 12 percent—lower than the national average of 16 percent. In addition, about one-fifth of all the electricity consumed in Michigan is imported from other states, and emissions associated with electricity use are attributed to the state where the electricity was generated. Finally, more than half of Michigan is forested, and forests significantly reduce the state's net carbon dioxide emissions (MCAC 2009).

If Michigan and the world are to avoid the worst consequences of climate change, the state must aggressively reduce its emissions by:

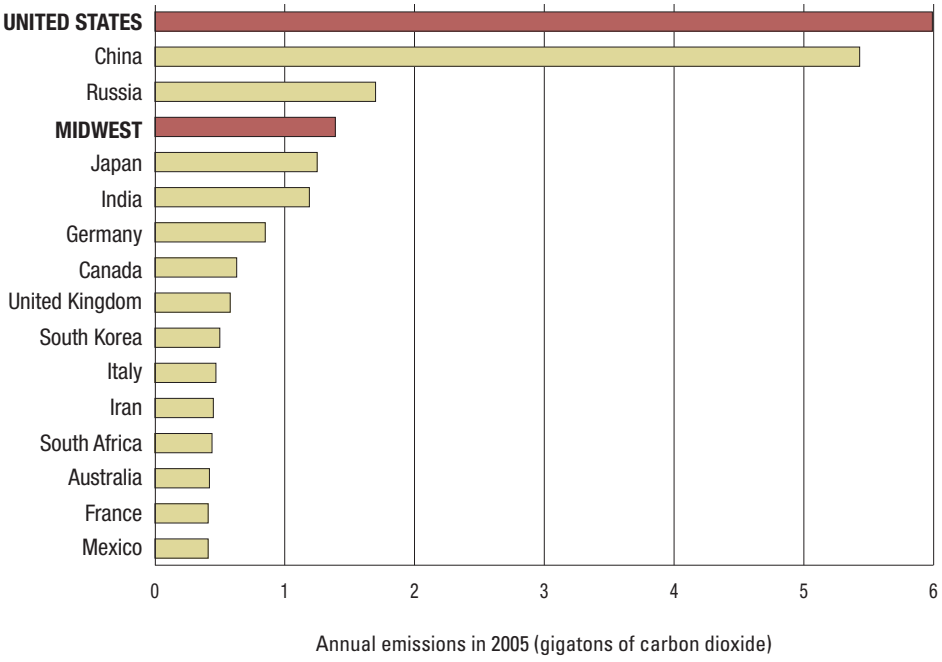
- increasing energy efficiency and conservation in industries and homes;
- boosting the use of renewable energy resources such as wind



Emissions percentages are CO_2-equivalent units

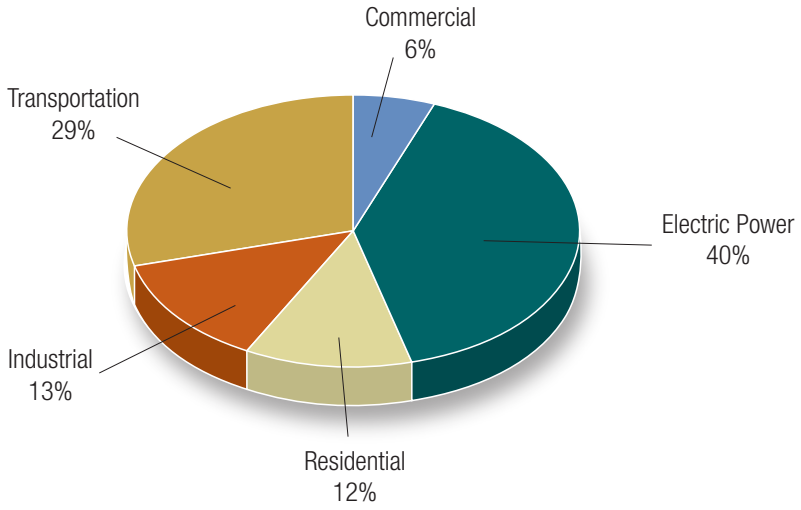
Agriculture Contributes to Warmer Temperatures

Agriculture generates 7 percent of total U.S. heat-trapping emissions, including three potent global warming gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Half of these emissions come from livestock production, one-third from the cultivation and fertilization of cropland (which decreases its ability to absorb carbon), and the rest from energy used for power generation, transportation, and construction (USDA 2008).



The Midwest Burns More Fossil Fuels Than Entire Nations

The total combined emissions from eight states (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin) would make the Midwest the world's fourth largest polluter if it were a nation. The region's emissions are more than double those of the United Kingdom, which has about the same population (EIA 2008b).



Vehicles and Power Plants Are Michigan's Biggest Fossil Fuel Polluters

Transportation and electricity generation—primarily from coal-fired power plants—are the largest sources of heat-trapping emissions in Michigan (EIA 2008a). This chart reflects CO_2 emitted by power plants within the state; it has not been adjusted to reflect power imported to or exported from Michigan.

power, advanced biofuels, and geothermal energy;

- improving vehicle fuel efficiency and reducing the number of miles driven; and
- improving agricultural practices to reduce the release of heat-trapping emissions from soil tilling and fertilizer application.

These actions will also provide benefits such as lower energy costs (after just a few years), new local jobs, and cleaner air and water. A recent analysis by the Union of Concerned Scientists shows that businesses and industries in the Midwest could collectively save $3.8 billion on their electricity bills in 2020 and $11.9 billion in 2030 by instituting these kinds of changes (Cleetus, Clemmer, and Friedman 2009).

Michigan has made strides toward implementing a number of the strategies listed above and deserves credit for its progress on the following initiatives:

- In February 2009, Governor Granholm directed the Department of Environmental Quality to assess the need for new electricity generation technology and to explore "all feasible prudent alternatives" before approving new coal-fired power plants in Michigan. This directive puts seven such plants on hold.
- In 2008 Michigan adopted the Clean, Renewable, and Efficient Energy Act. The bill's key provisions include a renewable energy standard that requires utilities to supply customers with 10 percent renewable electricity by 2015 (EPA 2009). In addition, a requirement that natural gas and electric utilities reduce energy demand through energy efficiency

programs will reduce emissions while saving consumers money and creating local jobs for people who perform energy audits, weatherize homes, and manufacture efficient windows.

Pathways to Real Progress

Michigan can do much more to take advantage of clean energy opportunities and reduce global warming emissions, by pursuing the cost-effective strategies summarized below.

Strengthen the renewable electricity standard (RES)

Michigan's new RES requires 10 percent renewable electricity by 2015. This is a step in the right direction, but Michigan should follow the lead of states such as Illinois and Minnesota, which have a 25 percent by 2025 standard. A strong standard creates jobs and saves consumers money, and Michigan's agricultural and manufacturing sectors are particularly well-positioned to benefit from the state's abundant wind capacity. Michigan should also rescind a provision in the law that allows 20 percent of the RES target to be met with certain non-renewable energy sources including the class of coal-fired power plants known as integrated gas combined-cycle.

Improve building codes

Modern building codes require a minimum level of energy efficiency in the design and construction of new buildings. Michigan's commercial building codes, which have not changed since 1999, are far behind the standards that states such as Illinois have adopted. The Michigan Bureau of Construction Codes should therefore adopt 2009 residential and commercial building standards, and the legislature should pass a law that adopts updated standards automatically. Doing so would save Michigan residents and businesses money, create jobs, and make the state eligible to compete for $3.1 billion in federal stimulus funds available for state energy programs.

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Renewable Energy Presents Opportunity for Growth

Michigan ranks second in the nation in terms of new wind energy installations. Nationwide, the wind power industry employs 85,000 people (AWEA 2009) while generating clean energy that reduces the heat-trapping emissions from coal-fired power plants (the United States' primary contributor to global warming).

Stop investing in polluting coal plants

Michigan should adopt a moratorium on both the construction of new coal-fired power plants and the import of power from proposed coal plants outside the state—unless and until such plants adopt carbon capture and storage (CCS) technology (provided this proves commercially feasible). New financial commitments to coal plants without CCS will lock the state into high emissions for decades, while inhibiting needed investments in clean energy technologies.

Building More Resilient Communities

Because climate change is already upon us and some amount of additional warming is inevitable, Michigan must adapt to higher temperatures and more heavy rains while working to reduce its emissions. Any delay in emissions reductions will make it more difficult and costly to adapt; conversely, aggressive steps to reduce emissions *now* will provide the time ecosystems and societies need to become more resilient. For each adaptation measure considered, Michigan's decision makers must carefully assess the potential barriers, costs, and unintended social and environmental consequences.

A State-Federal Partnership

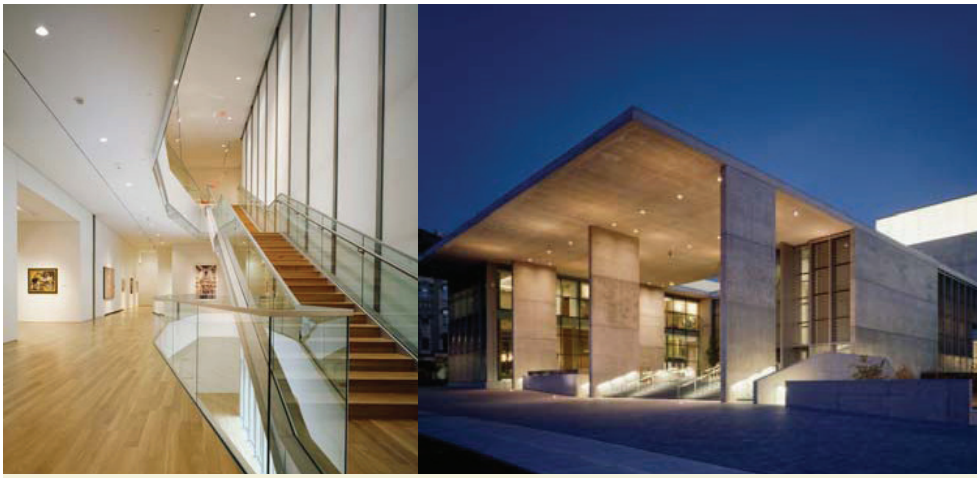
Although Michigan can achieve much with its own policies and resources, the scale of emissions reductions required suggests that individual states will need strong support from the federal government. The United States should therefore enact a comprehensive set of climate and energy policies including standards for renewable electricity, energy efficiency, and transportation that set a tight limit on heat-trapping emissions nationwide. The goal should be to reduce emissions at least 35 percent below current levels by 2020 and at least 80 percent by 2050.

A national renewable electricity standard and strong fuel economy standards for cars and trucks can boost local economies while substantially reducing emissions nationwide. For example, a renewable electricity standard of 20 percent by 2020

would create 4,800 jobs in Michigan and lower residents' electricity and natural gas bills a total of $160 million by 2020 (UCS 2007). A separate UCS analysis showed that if every car and light truck on U.S. roads averaged 35 miles per gallon (mpg) by 2018 (compared with the fleetwide average of 26 mpg today), drivers would save enough in fuel costs to create 11,000 new jobs in Michigan by 2020 (UCS 2007b). The Obama administration is currently pursuing new standards that would achieve an average of 35.5 mpg by 2016.

Another complementary federal strategy known as a "cap-and-trade" program would set a price on emissions and require polluters to obtain government-issued permits in order to continue emitting. By auctioning these permits the government could generate revenue for investment in:

- Energy efficiency and renewable energy solutions
- Assistance for consumers, workers, and communities facing the most difficult transition to a clean energy economy (coal miners and mining towns, for example)
- Conservation of precious natural resources
- Assistance for communities that must adapt to unavoidable consequences of climate change



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Green Building Design Saves Money and Energy

The new "whole-building" approach to architecture attempts to incorporate both energy efficiency and attractive aesthetics into a building's design. One impressive example is the Grand Rapids Art Museum, which meets the gold standard of sustainability criteria established by the U.S. Green Building Council and was named one of *Newsweek*'s Six Most Important Buildings of 2007.

Setting a price on heat-trapping emissions will also stimulate investment in cleaner and more efficient energy technologies such as CCS (if and when this proves commercially feasible) by making them more cost-competitive.

Finally, federal resources devoted to climate monitoring and assessments can provide essential information for states and communities that need to devise and implement adaptation plans. Michigan's U.S. senators and representatives must therefore support strong federal climate and clean energy policies that will help the state reduce emissions, transition to a clean energy economy, and prepare for the climate change that will occur in the interim.

CONCLUSION

Global warming represents an enormous challenge to Michigan's way of life and its residents' livelihoods, but we can meet this challenge if we act swiftly. The emissions choices we make today—in Michigan and throughout the nation—will shape the climate our children and grandchildren inherit. The time to act is now.

The Union of Concerned Scientists is the leading science-based nonprofit working for a healthy environment and a safer world.

For more information on the Midwest's changing climate, along with a list of references for this report, visit:
www.ucsusa.org/mwclimate

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