Impacts on Agriculture: Our Region’s Vital Economic Sector

Encompassing more than 100 million acres of agricultural land in the North American heartland, the Great Lakes region supports one of the largest agricultural economies in the world, estimated at $40 billion (1999). Taken together, the states of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin contain more than 380,000 farms.

The region produces vast stores of rain-fed cash grains such as corn, soybeans, and wheat, and also ranks high nationally in production of fruits and vegetables for the fresh market. Livestock operations in the region bring cattle, hogs, and chickens to market.

The vast majority of scientists are now certain that human activity—primarily land clearing, deforestation, and burning fossil fuels—is changing Earth’s climate. These activities emit gases, principally carbon dioxide (CO₂), that blanket the planet and trap heat.

This fact sheet highlights the potential impact of climate change on the Great Lakes region’s agriculture, which is also affected by changing markets and technological advances. We also suggest ways farmers can help solve the problem by reducing heat-trapping emissions from farms and other sources.

Climate Projections

Farmers in the region are already suffering from wetter spring and fall weather, and the intensity of rainstorms has also increased. These trends will continue and likely strengthen. Later in the century, the region’s climate will grow considerably warmer and probably drier in the summer. By the century’s end, the region’s climate will be quite different than it is today.

- Precipitation. While annual average precipitation may not change much, seasonal precipitation in the region will shift, increasing in winter and spring and decreasing in summer. By the end of the century, the combination of increased summer temperature, evaporation, and runoff from intense rainfall events, accompanied by a decline in summer precipitation, will increase drought frequency, especially over the southern and western part of the region where most agriculture is concentrated.

- Extreme events. The frequency of heavy 24-hour and multi-day rainstorms will continue to increase and may double by 2100. Increased flooding is also expected; even though the climate will likely turn drier, more flooding will occur if a greater proportion of rain falls in extreme storm events.

- Temperature. Average annual air and soil temperatures are increasing while winters are getting shorter. By the end of the century, maximum daily temperatures could rise by 5 to 12°F in winter and 5 to 20°F in summer. This warming is more dramatic than that seen since the last ice age. In addition, the growing season could be four to nine weeks longer by the end of the century, but the number of extremely hot days exceeding 90°F could increase almost as much (four to six weeks).

- Soil moisture. By the end of the century, soil moisture is projected to decline by 30 percent regionally, but may increase by as much as 80 percent in winter at some locales.

Within three decades, Illinois summers will generally resemble those of Oklahoma today in terms of average temperature and rainfall; by the end of the century, the summer climate will

Historical Trends in Extreme Rainfall Events (1931–1996)

The past 30 years were the region’s wettest in the 20th century. Heavy summer downpours have also become more frequent, leading to increased crop losses and higher costs associated with weather extremes.
resemble that of eastern Texas. A summer in Minnesota by century’s end will feel like Kansas does today, while Michigan and Wisconsin summers in 2100 will resemble that of Arkansas. In general, using current climate comparisons, Great Lakes agriculture must prepare for climate conditions marked by extreme summer heat, summer drought, and spring and winter flooding.

**Consequences for Agricultural Products**

Given these climate changes, production patterns are likely to shift in the region. Optimal weather conditions will move north and east, although soils there are relatively thin and infertile. Some projections have suggested that climate trends will not seriously disrupt the region’s agricultural capacity during this century; however, newer research that considers, for example, extreme weather and pest interactions, produces less favorable outcomes for agricultural production.

**Horticultural and Row-Crop Production**

Crop yields are affected by many climate-related factors:

- **Amount and timing of precipitation.** Crop production in the region is already suffering from problems associated with both excess and insufficient moisture, and these problems will only worsen. Too much water at the wrong time leads to waterlogging and delayed planting. On the other hand, four days of ill-timed soil moisture stress can reduce corn yields by 50 percent, and soil moisture stress already limits soybean yields. Responses to moisture surpluses and deficiencies will increase production costs. Wet fall weather, for example, increases the need for crop drying, and mid-summer drought will increase the number of acres requiring irrigation. Such shifts will impose additional costs on farmers and increase tensions over limited resources.

- **Climate variability and extreme events.** Extreme events such as severe storms and floods during the planting season are likely to depress yields. Soybeans seem to be particularly vulnerable to climate variability. Perennial crops such as fruit trees and vineyards are also vulnerable because adjustments cannot be made as flexibly, putting long-term investments at risk. The combination of flooding and high heat is especially lethal to both corn and soybeans.

  Climate variability will likely pose a greater risk for smaller farms, thus reinforcing the trend toward increasing farm size and agricultural industrialization. These changes will affect local farming communities and change the character of rural landscapes across the region.

- **Nutrient availability, heat, and air pollution.** Increased atmospheric CO\textsubscript{2} could boost the yields of some crops such as soybeans and wheat that are not as efficient at photosynthesis as corn. Projections for soybeans, which are generally positive and attributed to both the CO\textsubscript{2} fertilization effect and earlier planting dates, suggest increases in yield in the central and northern portions of the region but losses in southern areas. Soybean yield variability, however, is also expected to increase. Enhanced wheat yields of approximately 20 percent could result from these combined factors, but wheat production is likely to be limited by competition for land from other crops, including soybeans.

  As temperatures rise, the CO\textsubscript{2} fertilization effect may be offset or negated by rising ozone concentrations that result from human activities such as the application of nitrogen fertilizers and burning fossil fuels. Ozone is particularly damaging to soybeans and horticultural crops, and soybean yields in the region are already reduced approximately 25 percent by ozone damage. High heat and associated heat stress will reduce corn yields in the south and western parts of the region.

- **Pests and pathogens.** Leaf-chewing insects and aphids are stimulated by elevated CO\textsubscript{2}. Higher temperatures, particularly in spring and summer, accelerate the number of generations of harmful multi-generational pests such as soybean and corn leaf aphids, potato leafhoppers, and two-spotted spider mites. Ranges for many pests, including bean leaf beetles and corn borer, have already expanded northward.

*Projected increases in rainfall and runoff in the spring, followed by a drier growing season and more rainfall during harvest times, will be challenging for Great Lakes farmers.*

Courtesy of the University of Minnesota
Milder winters enhance survival for some pests such as bean leaf and corn flea beetles. A hot, dry summer may exacerbate yield losses from corn rootworm larvae. Excess moisture and humidity can increase the frequency of gray leaf spot, crazy top, and smut in corn; later in the century, drought will likely increase the damage inflicted by soybean cyst nematodes.

On the other hand, extremes in temperatures and precipitation at important insect growth stages may reduce the threat of some pests such as western corn rootworm or European corn borer. The interactions of extreme weather events and insect reproduction, survival, and success are complex and must be evaluated on a species by species basis.

**Livestock Production**
Climate change will also affect livestock production in a number of ways.

- **Animal well-being.** In general, warmer summer temperatures will suppress appetite and decrease weight gain in livestock, and extreme heat decreases milk productivity. Extreme weather events such as heat waves, droughts, floods, and blizzards have severe consequences for livestock.

Higher temperatures may necessitate reduced stocking rates or investments in improved ventilation or cooling equipment, making livestock production more expensive. Intensively managed systems, however, may be affected less by these problems because controlled facilities are better able to adjust to extreme events.

- **Animal food sources.** Increasing temperatures will potentially increase temperate grassland production but reduce warm-season grasslands. Warmer winters and less snow cover are likely to reduce the quantity and quality of spring forage and, thus, milk quality. Additionally, reduced protection by snow cover will increase weather-related damage to forage crops.

The negative effects of a changing winter climate may be disproportionately borne by producers in the northern portion of the region, where warmer fall temperatures will reduce fall hardening of forage crops and may cause loss of hardiness during the winter. Changes in forage species may be required due to moisture or nutrient limitations, especially in grass production for winter-feeding.

**Water Supply and Pollution**
Agriculture’s impact on the region’s water resources—due to chemical contamination of ground and surface waters—is already a concern and will intensify as the climate changes. More intensive production in the region’s northern areas may require chemicals and nutrients to increase soil fertility, and more pests may drive farmers to increase pesticide use.

Increased flooding and more frequent and intense runoff pulses from extreme rainfall events will worsen soil erosion and introduce more agricultural chemicals and animal waste into the water supply. Farmers’ costs to maintain soil fertility and municipalities’ costs to preserve or restore safe drinking water are likely to increase. Concerns over water quality and costs may increase scrutiny of current rates of fertilizer use on corn and the expansion of soybean cultivation, both of which have already contributed to nutrient inputs into the Mississippi River.

Tile drainage in agricultural fields, draining of wetlands, water diversion, and floodplain development all increase the frequency of flash flooding. These alterations are likely to exacerbate the effects of climate change on stream flow by increasing the frequency and height of flood events. In addition, they will likely increase drought potential through loss of groundwater recharge.

Eroded sediments and water runoff degrade streams and wetlands, reducing food and habitat for migratory birds and waterfowl. That, in turn, affects bird-watching and hunting activities.

**Getting Products to Market**
Greater evaporation and reduced ice cover will accompany a changing climate in the region, thus lowering lake levels. A conservative estimate suggests shipping costs will increase 5 to 40 percent as a result of lower lake levels, although reduced ice cover will likely extend the shipping season.

Siltation and flood-related damage to waterways and locks will add significant costs to agriculture, which accounts for 44 percent of the total shipping traffic through the Upper Mississippi River-Illinois Waterway. Off-site dredging costs will also increase and are already estimated (adjusted to 1998 dollars) at $98 million for the lake states of Michigan, Minnesota, and Wisconsin, and $216 million for the Corn Belt states of Illinois, Indiana, Iowa, Missouri, and Ohio.
Climate Solutions for Agriculture

In 2001, agriculture activities, not including CO₂ emissions from on-farm energy use, were responsible for nearly seven percent of total U.S. heat-trapping emissions—27 percent of methane emissions and 74 percent of nitrous oxide emissions.

The good news is that practical solutions exist today for agriculture to reduce these emissions. Along with helping to address the growing problem of climate change, many of the solutions discussed below would also reduce soil erosion, improve air and water quality, increase biodiversity, and generate economic benefits.

- **Increase funding for energy efficiency and renewable-energy projects.** Over the past two years, the U.S. Department of Agriculture (USDA) has provided $44 million from the Farm Bill to support 280 renewable-energy and energy efficiency projects on American farms. Projects funded in the first year alone will produce enough electricity to supply the annual needs of 30,000 households while creating 1,300 new jobs and reducing CO₂ emissions by more than one million metric tons over the life of these projects. However, the USDA has denied proposals for dozens of projects due largely to insufficient funding. Congress should increase funding levels, and states should offer incentives or tax credits to supplement these funds.

- **Improve soil management practices.** Certain best practices in soil management such as no-till, reduced tillage, and crop diversification (including the use of cover crops) can enhance short-term soil carbon storage. Effectively managed soils could abate an estimated 10 percent of U.S. heat-trapping emissions during the next 30 to 50 years. Additional funding should be made available from the USDA’s Conservation Reserve Program, Natural Resources Conservation Service, and other programs to encourage such practices.

- **Expand programs to reduce nitrogen fertilizer use.** Best practices that achieve this goal can produce significant reductions in heat-trapping emissions while lowering nitrate contamination of water supplies. For example, between 1985 and 1995, Iowa had several projects in place that reduced fertilizer use by more than two million tons, saved farmers $363 million, and reduced heat-trapping emissions by 10 million tons per year without affecting corn yields. Some states have programs to promote the use of nitrification inhibitors that conserve nitrogen in soils while reducing unwanted losses to the environment.

- **Reduce methane and nitrous oxide emissions from livestock and livestock waste.** Several states and the Environmental Protection Agency offer incentives and programs to reduce such emissions. For example, Haubenschuld Farms, a 1,000-acre dairy farm in Minnesota, received state and federal assistance in 1999 to install a manure digester that converts methane into enough electricity to meet the needs of the farm and an additional 75 homes. The 750-head dairy generates nearly $81,000 per year from electricity sales and saves $4,000 per year in heating costs. These savings should recoup the initial $355,000 investment in five years or less.

- **Provide incentives to sequester carbon on marginal lands.** Converting one million acres of marginal lands into native forests and planting 200,000 acres of riparian zone buffer strips with native trees or grasses such as switchgrass could reduce CO₂ emissions by an estimated 7.3 million tons per year. Additional funding should be made available from the USDA’s Conservation Reserve Program, the U.S. Forest Service’s Forest Legacy Program, and other programs.

- **Establish renewable-energy standards for electricity and transportation.** Such standards are a popular and effective means of creating markets for clean energy produced on the farm. Standards requiring electric utilities to supply a portion of their electricity from renewable sources such as wind and bioenergy have already been established in more than a third of U.S. states, including Minnesota, New York, Pennsylvania, and Wisconsin.

A UCS study found that a national standard requiring utilities to provide 20 percent of their electricity from renewable sources by 2020 would create 355,000 new jobs (including 30,000 in agriculture), save consumers $49 billion on their electricity and natural gas bills, and reduce the projected growth in power plant CO₂ emissions by 59 percent. Competition from renewable energy would also lower natural gas prices, thereby lowering fertilizer prices.

While our most urgent task is reducing heat-trapping emissions, immediate steps are also necessary to increase the health and resilience of ecological and economic systems vital to the region. We must also be prepared to manage those future changes that cannot be avoided.