MIDWEST AGRICULTURE & CLIMATE RISK

The upper Midwest economy is dominated by commodity agriculture, with some of the most productive corn and soybean growing in the world. The agricultural industry in this region includes more than 520,000 farms valued at $135.6 billion per year as of 2012, and the Midwest accounts for 65% of national production of corn and soybeans alone.[13] As a result, crop and livestock production is a crucial business whose success or failure also determines basic economic conditions in many rural communities.

The health and productivity of the agricultural sector is inextricably intertwined with climate conditions. Our research focused on two specific climate impacts—changes in heat and precipitation—and their interaction with the three major commodity crops found in the Midwest, as well as their impact on livestock production and the effectiveness of the agricultural labor force. In examining climate-related crop impacts, we also took into account the fertilization that occurs at higher carbon dioxide (CO_2) concentrations in the atmosphere.

As in a classic risk assessment, we did not model potential future adaptation into this analysis—that is, we assumed that growing seasons would be the same as they are now and did not account for specific adaptation measures, such as introducing irrigation in areas that have not traditionally had to rely on this practice. Farmers are generally very quick to adapt to changing climate conditions; however, some adaptive measures may be prohibitively costly or otherwise constrained by other climate change effects that our research did not take into account. For instance, climate change may lead to decreased water supplies in certain regions, limiting the availability of water for irrigation. This type of impact would be especially significant in the Midwest, which relies heavily on rain and consistent ground water supplies for crop irrigation.

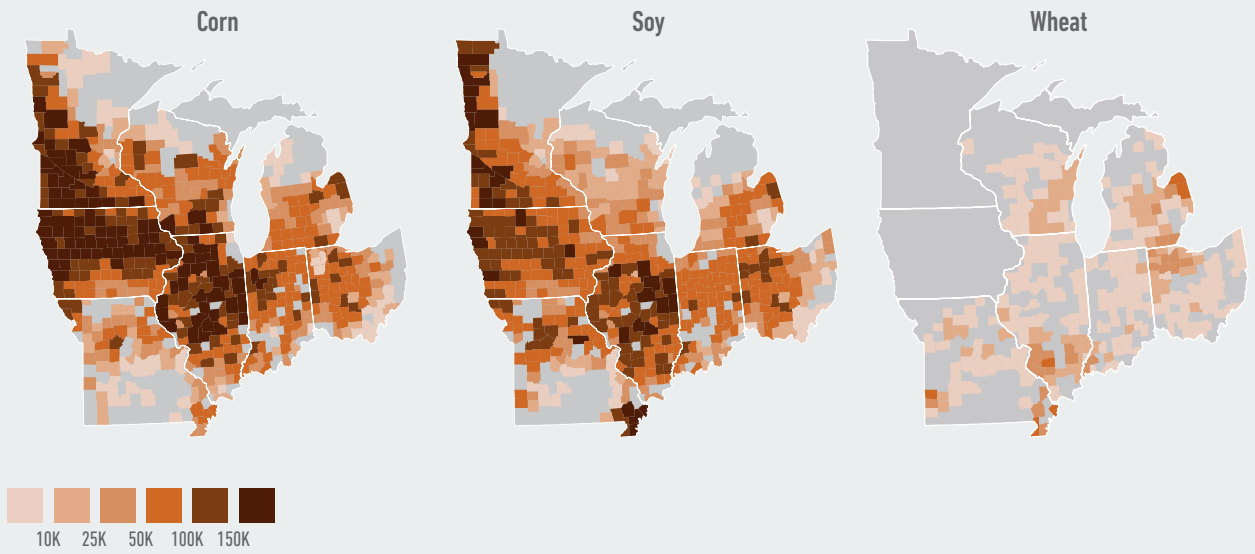
Overall, our research shows that the Midwest region faces significant climate risks to its agricultural sector if we stay on our current greenhouse gas emissions pathway, but that these risks vary markedly by state, county, and even specific crop.

The most direct climate impact on Midwest agriculture is due to the likely increases in heat across the region. Plant growth is highly dependent on temperature: Each crop species has a unique temperature threshold that defines its temperature range for optimal growth, outside of which crop yields can drop dramatically. The current distribution of crops across the nation generally reflects these thresholds, so small increases in temperature can lead to production declines, absent significant crop adaptation.

MIDWEST AGRICULTURE & CLIMATE RISK

Figure 5: Current Crop Distribution: Corn, Soybeans & Wheat

Planted acres by county (2013)



Data Source: U.S. Department of Agriculture, National Agricultural Statistics Service

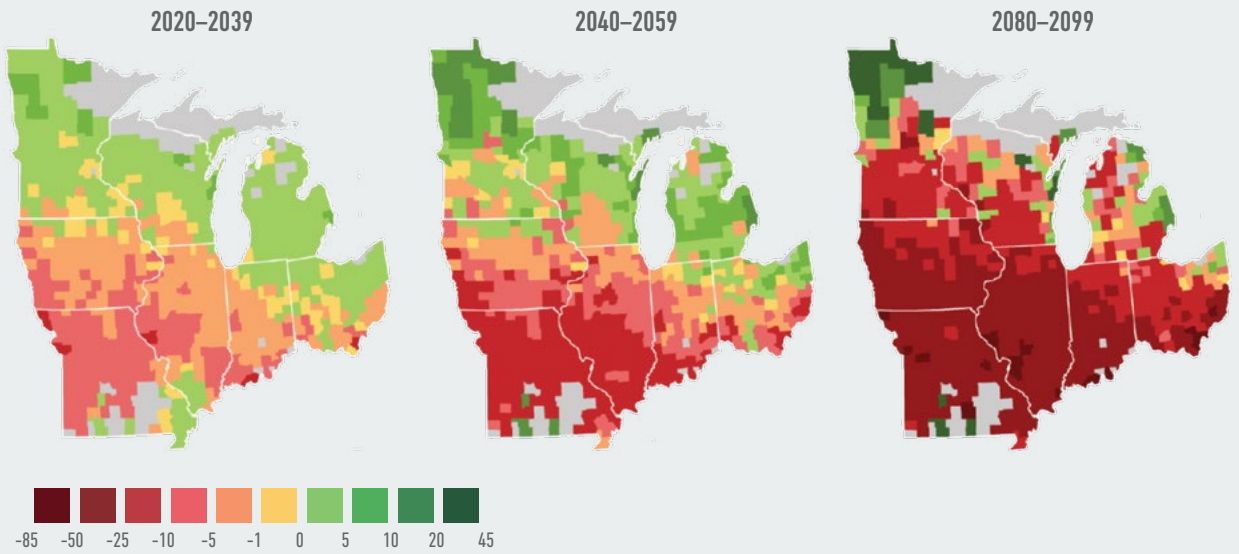
Take corn, for example: The corn crop is strongly heat sensitive and responds less to the beneficial impacts of carbon fertilization than do wheat or soybeans. As a result, the lower half of the Midwest region—the states of Missouri, Illinois, Indiana, and Iowa—will likely suffer significant corn yield losses by mid-century absent adaptation. The upper Midwest states face mixed outcomes: Both increases and decreases are within the range of likely possibilities, and even these states face a 1-in-20 possibility of significant corn yield declines (for example, more than 30% losses in Minnesota by mid-century).

The region's wheat crop, on the other hand, seems more resistant to the heat, perhaps because the majority is winter wheat, grown in the cooler months.[14] Of all the crops we analyzed, wheat seems the most resistant to major yield declines as a result of rising temperatures from climate change. However, of all the commodity crops we analyzed, wheat is currently grown the least intensively in the Midwest region as we have defined it (See Figure 5).

MIDWEST AGRICULTURE & CLIMATE RISK

Figure 6: Projected Change in Corn, Soybeans, and Wheat Yields

Median percent change in yield of corn, soybeans, and wheat relative to current production without significant adaptation



Data Source: American Climate Prospectus

As a result of these variations in crop resistance to extreme heat, as well as in the levels of extreme heat likely to affect different parts of the Midwest region, there is no single story to tell about the impact of climate change on Midwest agriculture. In general, the Midwest states with the greatest increases in extremely hot days will likely also see the greatest declines in crop yields, with the most significant impacts on the corn crop. Missouri, the southernmost state in this region, will be the hardest hit with likely annual losses in corn yields of up to 24% over the next 5 to 25 years on average and likely losses of 37% to 90% by the end of the century. Illinois is a close second, with likely losses in corn yields up to 20% in the short term.

Further north, the states of Minnesota and Wisconsin will likely see warmer summers, fewer extremely cold days, and increased CO_2 in the atmosphere due to the same emissions that cause climate change. As a result, these states will likely experience yield *increases* in some crops—though even they will see yield declines in the "tail risk." For example, Minnesota will see a likely increase of up to 17% in soybean yields by 2040–2059, with a 1-in-20 chance of an 8% decrease. However, our research did not take into account possible negative byproducts of warmer winters, such as the potential for some insect species to live through the winter. Warmer winters will also extend the geographic distribution of weeds northward, exposing farms in northern latitudes

MIDWEST AGRICULTURE & CLIMATE RISK

to new or enhanced threats to productivity. This can increase the cost of weed control, which already has an $11 billion price tag per year in the U.S. alone, mostly for herbicides such as glyphosate (also known as RoundUp™), to which some weeds have demonstrated increased tolerance at higher CO_2 levels.[15] Moreover, many invasive species, both plant and insect, may actually benefit more than crops from the increased CO_2 and temperatures brought about by climate change, though the relative effect of these factors on crop-weed competition is likely to be species-specific.[16]

It is important to note that heat doesn't only affect crop production; it also has a direct influence on livestock productivity. For many livestock species, increased body temperatures of 4°F to 5°F above optimum levels can disrupt performance, production, and fertility, limiting an animal's ability to produce meat, milk, or eggs. Higher temperatures can also increase animal mortality. In addition, climate change can affect the price and availability of water, feed grains, and pasture, and change patterns of animal diseases. Finally, any negative impact on crop productivity, especially for corn and soybeans, will increase feed costs for livestock producers, putting additional pressure on that sector.

Simple crop and livestock impacts don't tell the full story of the impact of climate change on the Midwest agricultural sector. There is also the question of the role that these commodities play in the overall economy of particular states. Iowa has by far the highest percent of its state economy dependent on commodity agriculture of any of the states in this region; as a result, the economic output losses from commodity crop declines in Iowa are high (likely $850 million to $12 billion per year by century's end) even though yield declines aren't as high in this state as in some others. Illinois faces even higher potential economic costs from climate-related yield losses. By 2020–2039, likely impacts to the state economy span gains ($1.1 billion per year) to losses ($2.6 billion per year, with a 1-in-20 chance of more than $3.4 billion in losses) due to the potential for economic gains from increases in yields. However, given that corn and soybeans are the top two crops grown in the state, overall likely losses are larger than gains. In the long term, the likely impacts to the state economy are exclusively losses: Illinois stands to lose $1.5 to $13 billion per year from crop losses by the end of the century.

One risk from climate change that is not often discussed in the agricultural sector is the impact rising temperatures will have on labor productivity. Economists consider agriculture a "high-risk" industry in that many of the workers in this sector are outdoors for long stretches of the day, even with the advent of air-conditioned farm equipment. Other industries closely tied to agriculture, such as transportation and manufacturing (including food processing) are also considered high-risk. As heat rises past human comfort levels, labor productivity falls, and some states in this region will see likely labor productivity declines across all high-risk sectors by as much as 3% by the end of this century. In Missouri, there is a 1-in-20 chance the decline could reach as high as 4.2%—a decline comparable to the decline in absolute labor output during past U.S. recessions.[17]

Figure 7: Projected Change in Crop Yields by State and Probability

		All Crops		Corn		Soybeans		Wheat	
		Likely Range	1-in-20	Likely Range	1-in-20	Likely Range	1-in-20	Likely Range	1-in-20
2020–2039	IL	+8.3 to -13.5	-17.3	+4.9 to -20.3	-25.7	+11.5 to -8.5	-12.2	+6.5 to +2.0	+0.2
	IN	+7.8 to -10.3	-14.0	+5.4 to -16.7	-21.8	+10.2 to -6.1	-9.3	+6.1 to +1.9	+0.2
	IA	+8.0 to -11.1	-14.7	+4.5 to -16.5	-22.1	+12.1 to -6.0	-9.0	+6.0 to +1.1	-0.7
	MI	+6.5 to +0.1	-2.6	+4.5 to -4.4	-8.0	+9.5 to +2.9	+0.4	+5.8 to +2.4	+1.2
	MN	+6.3 to -4.2	-7.1	+3.8 to -9.3	-14.3	+9.1 to -0.9	-4.1	+6.0 to +1.5	-0.3
	MO	+8.1 to -13.5	-20.4	+4.7 to -24.4	-31.1	+9.9 to -12.7	-20.2	+6.5 to +1.5	-0.3
	OH	+6.4 to -4.5	-7.1	+5.0 to -10.4	-14.4	+8.1to-2.3	-5.2	+5.9 to +2.2	+0.7
	WI	+5.5 to -3.1	-6.0	+3.4 to -6.4	-10.1	+10.8 to +2.2	-0.4	+5.6 to +2.2	+1.1
2040–2059	IL	+6.5 to -30.2	-42.4	-3.1 to -40.9	-54.2	+14.1 to -23.3	-35.3	+15.0 to +5.5	+1.4
	IN	+8.6 to -21.4	-31.1	+0.0 to -32.5	-43.4	+15.5 to -13.7	-23.7	+14.7 to +5.8	+2.0
	IA	+5.2 to -21.1	-29.1	-2.3 to -31.3	-41.0	+12.9 to -11.7	-18.9	+14.8 to +5.4	+1.2
	MI	+12.5 to -0.7	-5.6	+5.8 to -12.0	-17.6	+19.3 to +6.8	+1.4	+14.5 to +7.3	+4.6
	MN	+10.4 to -8.6	-14.8	+2.6 to -21.5	-29.8	+16.5 to -1.5	-8.1	+14.1 to +6.1	+3.2
	MO	+3.7 to -31.9	-41.1	-9.4 to -49.1	-60.5	+7.3 to -30.4	-39.7	+15.2 to +4.9	+0.1
	OH	+10.1 to -10.7	-17.7	+1.8 to -23.8	-31.3	+15.3 to -5.4	-13.0	+14.6 to +6.6	+3.3
	WI	+10.0 to -7.3	-12.7	+4.8 to -15.2	-21.4	+20.1 to +5.1	-0.2	+14.3 to +7.1	+4.3
2080–2099	IL	-0.5 to -77.2	-87.2	-23.6 to -87.3	-94.4	+17.1to -73.1	-86.5	+44.6 to +16.5	+2.7
	IN	+7.9 to -68.4	-82.1	-16.4 to -82.0	-91.7	+26.2 to -62.2	-78.6	+44.3 to +16.5	+2.6
	IA	+2.9 to -64.8	-80.8	-17.8 to -77.2	-89.2	+22.1 to -53.6	-73.7	+43.8 to +17.6	+3.0
	MI	+24.3 to -35.6	-61.3	+1.8 to -57.8	-80.3	+43.1 to -25.6	-57.9	+43.0 to +21.0	+7.9
	MN	+19.7 to -41.1	-59.8	-5.9 to -66.1	-81.6	+36.2 to -32.8	-56.1	+42.5 to +19.1	+7.1
	MO	-5.7 to -72.8	-81.8	-37.4 to -90.0	-95.8	-0.3 to -75.8	-88.3	+44.6 to +15.8	+2.2
	OH	+17.7 to -51.7	-74.0	-9.1 to -72.1	-88.6	+31.5 to -47.2	-74.9	+43.7 to +18.7	+5.1
	WI	+17.1 to -45.1	-66.5	+1.2 to -59.2	-78.9	+45.0 to -25.2	-55.0	+43.1 to +21.1	+7.2

Percent change in yield of corn, soybeans, and wheat is relative to current production, without adaptation by farmers. "All crops" is the sum of the impacts to corn, soybeans, and wheat in each state weighted by the amount of each crop that is currently grown in that state.

Data Source: American Climate Prospectus

MIDWEST AGRICULTURE & CLIMATE RISK

There is little doubt that the Midwest agricultural industry will face significant and varied risks from climate change through this century, but this sector is also one of the best equipped to manage these risks. Farmers have always adapted to changing weather and climate conditions, with adaptation and flexibility built into their business models. Armed with the right information, Midwest farmers can, and will, mitigate some of these impacts through double-cropping, seed modification, crop switching, and other adaptive practices. In many cases, crop production will likely shift from the Midwest to the Upper Great Plains, Northwest, and Canada, helping to keep the U.S. and global food system well supplied. However, this shift could put individual Midwest farmers and rural communities at risk if production moves to cooler climates.

Luckily, many of the strategies the agricultural sector can use to adapt to climate risk and increase resilience to climate change can actually save producers money in the short term. This is particularly worthwhile to consider at a time when commodity prices are retreating from the record highs experienced in 2010–2013. Conducting energy audits for farms and agribusinesses, for example, provides an inexpensive way for producers to identify energy savings on lighting, HVAC, farm equipment, and processes that both reduce overhead costs and reduce the farm's carbon footprint. Other factors, such as nutrient management to optimize fertilizer use and reduce emissions from excess fertilizer, can also increase the bottom line while taking steps to reverse the impact of climate change.

Food systems are resilient at a regional, national, and global level, and agricultural producers have proven themselves extremely able to adapt to changing climate conditions. But these shifts can carry risks for the individual farming communities most vulnerable to projected climatic changes. As interest grows in strategies to boost climate resiliency, policymakers and agricultural business leaders will need to place a greater emphasis on helping growers put new technology and methods to use that can help maintain current productivity levels while boosting resilience to climate change in the long term.