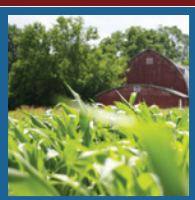


## CHAPTER FIVE

# AGRICULTURE AND



### Agriculture in Wisconsin



### Impacts and Vulnerabilities



### Adaptation Strategies

Photo: Wisconsin Department of Natural Resources





# THE SOIL RESOURCE

**A**griculture is an essential component of Wisconsin's economy, identity and culture. The Dairy State is one of the nation's most diverse agricultural producers, generating more than \$59 billion in economic activity on 36 percent of the land in the state. The combination of a suitable climate and fertile soils allows farming to be one of the mainstays of the Wisconsin economy. With a new focus on producing renewable energy crops, our agricultural land base will become even more valuable.

Climate change is impacting many facets of agriculture in Wisconsin, and future changes are likely to continue. This report is our first assessment of climate change impacts on Wisconsin agriculture, and our analysis is preliminary. Drawing on research available at the time of this report's production, we focus on climate impacts on corn and soybean yields. Climate change also has the potential to degrade the soil resource on which all Wisconsin agriculture is ultimately based. Additionally, agricultural activities can increase the loss of soil and associated nutrients to water resources, with implications for aquatic ecology.

A significant question confronting agriculture concerns the ways in which cropping systems and farmers have responded to recent changes in climate and whether future climate change and increasing levels of carbon dioxide in the atmosphere will significantly increase the risk of failure for agro-ecosystems. Climate change poses real threats to the stability of agro-ecosystems in the long term, potentially jeopardizing food and economic security. Numerous studies have demonstrated the sensitivity of cropping systems to climate; however, no consensus has yet emerged regarding the specific mechanisms responsible for causing such sensitivities or how these play out in specific geographical regions.





# Agriculture in Wisconsin

## Importance of Agriculture to Wisconsin

The economic impact of agriculture in Wisconsin is substantial. Agriculture contributes more than 350,000 jobs to the Wisconsin economy, or 10 percent of total employment. Agriculture provides a diversity of ecosystem goods and services that enhance the economy and improve the quality of life in our state. Our agricultural systems use more than 15 million of the 42 million acres of land in the state (figure 1), although the average size of our 78,000 farms is a modest 194 acres. Approximately two-thirds of the dollars generated by Wisconsin agriculture comes from livestock, dairy and poultry. Crops such as corn and soybeans, vegetables and horticultural crops make up much of the remainder.

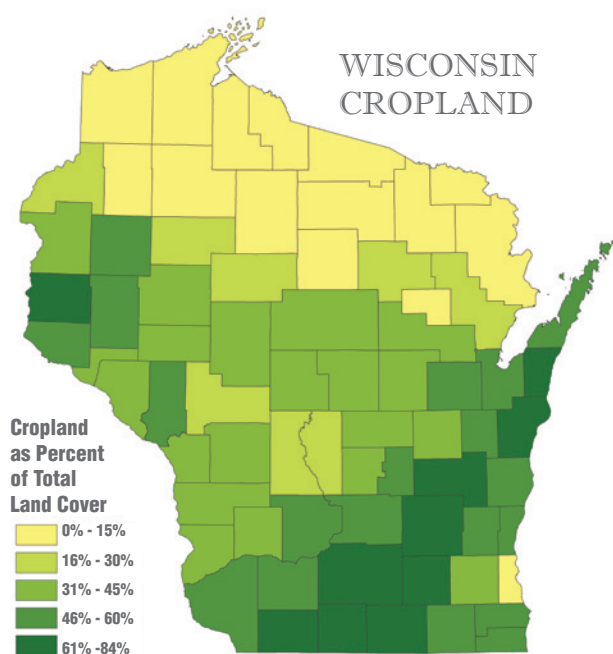


Figure 1. Percent of total land cover in each county classified as cropland.

Source: Map created by Dan McFarlane. Summer 2010. Wisconsin Land Use Megatrends: Agriculture. Center for Land Use Education. Data from U.S. Department of Agriculture, National Agricultural Statistics Service. 2009 Cropland Data Layer.

The Dairy State ranks first nationally in cheese production and second in milk and butter production. Wisconsin is also second in oats, carrots and sweet corn. It remains the national leader in processed snap beans, cranberries, corn for silage, mink pelts and milk goats. It is also among the top five states for commodities such as potatoes, maple syrup, mint oil and cucumbers for pickles. Furthermore, Wisconsin is ninth in trout aquaculture, corn for grain and fresh market cabbage. Other agricultural products, such as cherries, ginseng, Christmas trees and pumpkins, help define rural Wisconsin, as do an increasing number of award-winning craft cheeses and beers.

In addition, agriculture supports a growing bio-economy as part of our quest for more homegrown renewable energy resources. Growth in bioenergy will make it more important that we understand the impacts of climate change on agriculture. Biomass crops can be used to produce ethanol and other fuels, thereby decreasing our dependence on imported fossil fuels. By protecting agricultural resources, we also provide food security for the future by producing nutrition and fiber for humans and animals.

## Geographic and Geological Diversity

The diversity of the social and economic characteristics of Wisconsin agriculture is matched by the diversity of the physical setting in which they occur. The south central part of Wisconsin is characterized by gently sloping ground moraines, lake plains, outwash plains, drumlin fields, end moraines, flood plains, swamps and marshes. The soils are derived from glacial drift and are generally very deep, well-drained and loamy. The majority of this area is in cropland with a large proportion in cash grains.



Immediately to the north are the Central Sands. This area, approximately 3,400 square miles in size, is characterized by outwash till and glacial sand from the most recent period of Wisconsin glaciation. Almost half of the area was once covered by Glacial Lake Wisconsin. Much of this area is now forested and provides both lumber and pulp production, with much of the rest used mainly for cash-grain crops, dairy farms, livestock grazing, irrigated vegetables, Christmas trees or cranberries.

To the west of this region is the Driftless Area. The geology is characterized by both sandstone and dolomite outcrops that create a complex scenic landscape. Most of the land is in agriculture, with woodlots on the steeper slopes and cropland in the valley floors and on ridge tops.

The eastern area of Wisconsin bordering Lake Michigan is characterized by nearly level to rolling till

plains, lake plains and outwash plains mixed with drumlin fields, bedrock-controlled moraines, lake terraces, dunes, swamps and marshes. Much of the area is dominated by land uses dedicated to cash grains and pasture.

Each of these different biophysical and ecological regions of Wisconsin relies on different techniques and management strategies to produce the commodities and products listed earlier. Wisconsin farmers have adjusted their production strategies to the often-unique agro-ecological areas of the state where they farm and to the normal – and often extreme – variability in Wisconsin weather. This long-standing experience with adaptation will assist farmers in formulating responses to climate change; however, uniform statewide strategies are unlikely given the diversity of agricultural systems, geography and other conditions described in this chapter.

## SOIL AND LANDFORM TERMINOLOGY

**Dolomite:** a sedimentary carbonate rock composed of calcium magnesium carbonate; limestone that is partially replaced by dolomite is referred to as dolomitic limestone.

**Drumlin:** an elongated hill formed by glacial ice pushing underlying till into mounds. Its long axis is parallel with the movement of the ice, with the blunter end facing into the glacial movement.

**Flood plain:** flat land adjacent to a stream or river that experiences occasional or periodic flooding, usually during periods of heavy precipitation.

**Glacial drift:** gravel, sand or clay transported and deposited by a glacier or by glacial meltwater.

**Lake plain:** a former lake bottom, usually a featureless surface that formed from the deposition of sediments carried into the lake by streams.

**Lake terrace:** a level plain, usually with a steep front, bordering a lake.

**Loam:** an ideal agricultural soil composed of sand, silt, and clay; typically rich in nutrients, with good water retention and drainage characteristics; relatively easy to till.

**Marsh:** a tract of low, wet, soft land that is temporarily or permanently covered with water, characterized by aquatic, grass-like vegetation.

**Moraine:** any glacially formed accumulation of unconsolidated soil and rock; typically found in areas acted upon by a past ice age.

**Outwash plain:** a broad, outspread flat or gently sloping deposit of material left by the water coming off a melting glacier.

**Outwash till:** unsorted rock and sediment left by retreating glaciers.

**Swamp:** a seasonally flooded bottomland with more woody plants than a marsh.

**Till:** unstratified soil deposited by a glacier; consists of sand and clay and gravel and boulders mixed together.

**Till plain:** an extensive, relatively flat area overlying a till.

# Impacts and Vulnerabilities

Climate change will likely impact agriculture in a variety of ways, some negative and some positive. For this first assessment of climate impacts on agriculture, we provide three tables (tables 1, 2 and 3) listing potential climate change impacts, followed by an analysis of shifting plant hardiness zones and in-depth discussions

of climate impacts on corn and soybean yields and soil loss.

The impacts of climate change on Wisconsin agriculture will be both direct and indirect. Direct impacts will generally occur as changes in temperature and precipitation impact crop productivity; the timing of those changes within agricultural cycles will deter-

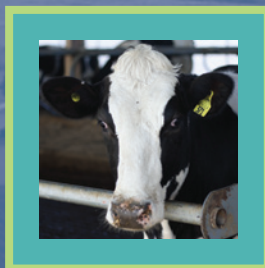
## DIRECT IMPACTS - POSITIVE

ASPECTS OF CLIMATE CHANGE	IMPACT ON AGRICULTURAL PRODUCTION
Longer frost-free periods	Use of higher-yielding genetics
More freeze/thaw cycles in winter	Increased soil tilth and water infiltration
More summer precipitation	Reduced plant stress
More soil moisture	Reduced plant stress
Higher dew point temperatures	Reduced moisture stress
More diffuse light (increased cloudiness)	Reduced plant stress
Higher water-use efficiency	Higher yields
Warmer spring soil temperatures	Use of higher-yielding genetics
Reduced risk of late spring or early fall frosts	Use of higher-yielding genetics
Increased atmospheric CO <sub>2</sub> levels	Increased photosynthesis and yields

Table 1. Positive direct climate change impacts on agricultural productivity.







mine the nature and severity of each impact. Indirect impacts – for example, increasing numbers of weed and pest species due to changing conditions that become more advantageous to them – are harder to predict. These can lead to additional indirect impacts such as the need to use more herbicides and pesticides, followed by environmental impacts of these increased

applications, which may lead to legal or policy responses.

We hope to explore these potential impacts – both positive and negative – in greater detail in subsequent assessment reports.

## DIRECT IMPACTS - NEGATIVE

ASPECTS OF CLIMATE CHANGE	IMPACT ON AGRICULTURAL PRODUCTION
More spring precipitation causes waterlogging of soils	Delayed planting, reduced yields, compaction, change to lower-yielding genetics
Higher humidity promotes disease and fungus	Yield loss, increased remediation costs
Higher nighttime temperatures in summer	Plant stress and yield loss
More intense rain events at beginning of crop cycle	Replanting and field maintenance costs; loss of soil productivity and soil carbon
More droughts	Yield loss, stress on livestock, increase in irrigation costs, increased costs to bring feed and water to livestock
More floods	Replanting costs, loss of soil productivity and soil carbon; damage to transportation infrastructure may reduce delivery to milk processing plants
More over-wintering of pests due to warmer winter low temperatures	Yield loss, increased remediation costs
More vigorous weed growth due to temperature, precipitation and CO <sub>2</sub> changes	Yield loss, increased remediation costs
Summertime heat stress on livestock	Productivity loss, increase in miscarriages, may restrict cows on pasture
Temperature and precipitation effects on pollinators	Losses to cropping (forage, fruits, vegetables) systems
New diseases or the re-emergence of diseases that had been eradicated or under control	Enlarged spread pattern, diffusion range, and amplification of animal diseases

Table 2. Negative direct climate change impacts on agricultural productivity.

## INDIRECT IMPACTS

SITUATIONAL CHANGE	IMPACT ON WISCONSIN AGRICULTURE
Regulation involving greenhouse gas emissions	Potential increased costs to meet new regulations; opportunities to participate in new carbon markets and increase profits
Litigation from damages due to extreme events or management of carbon markets	Legal costs may increase
New weed and pest species moving into Wisconsin	Control strategies will have to be developed; increased pest management costs and crop losses
Vigorous weed growth results in increased herbicide use	Increase in resistance or reduction in time for development of resistance; regulatory compliance costs or litigation over off-site damages from pesticides
Possibility of increased inter-annual variability of weather patterns	Increased risk in crop rotation, genetic selection, and marketing decisions
Increased global demand for food production due to climate and demographic changes	New markets; increase in intensification of production; increase in absentee ownership
Increased period for forage production	Decreased need for large forage storage across winter for livestock operations
Increased taxes or regulations on energy-dependent inputs to agriculture (for example, nitrogen fertilizer)	Profitability impacts on producers; loss of small-scale farm supply dealers

Table 3. Indirect climate change impacts on agricultural productivity.

### Yields

The direct impacts of climate change on crops are complex and depend on a number of interrelated conditions. In general, research suggests that warming temperatures in spring and fall would help boost agricultural production by extending the growing season across the state; however, increased warming during the core of the growing season – June through August – appears to have a negative impact on row crop production. Increases in precipitation appear to counteract the negative effects of warming temperatures within a narrow range; furthermore, climate change will have varying impacts on yields from crop to crop. In this first assessment, the Agriculture Working Group focused solely on impacts on corn and soybean yields.

Using crop yield information from Wisconsin counties combined with climate data, UW scientists determined

that both corn and soybean yield trends were supported by cooler and wetter conditions during the summer because increases in precipitation seem to counteract the potentially negative impacts of recent warming on crop yield trends. Study results suggest that for every 2° F of warming, corn and soybean yields could potentially decrease by 13 percent and 16 percent, respectively. However, modest increases in precipitation during the summer could help boost yields by 5-10 percent, counteracting the negative effects of increased temperature to a limited extent.

While northern U.S. corn belt regions, including Wisconsin, may benefit from climate and management changes that lengthen the crop-growing period in spring and fall, they may not be immune to decreased productivity caused by warming during summer months if summer precipitation declines or becomes increasingly variable.

Based on historical relationships between county-level climate data and USDA crop yield information across southwestern regions of Wisconsin, corn yield variability has been most influenced by maximum temperatures and precipitation in the month of July, whereas across northeastern Wisconsin, daily high temperatures in September had the greatest impact on corn yield variability. In contrast, soybeans were most affected by precipitation in July and August over the west central and southeast regions of the state and by minimum daytime temperatures during May for northeastern counties close to Lake Michigan.

During some years from 1950 to 2006, above-normal average high temperatures during July and August – which are on the same order of magnitude projected by climate models under future warming scenarios – were correlated with annual yields 10-30 percent lower than the expected averages. Surprisingly, summers during which precipitation exceeded the average by 50-100 percent translated into yield increases of only 3-11 percent. Overall, crop yields were favored by cooler-than-average daytime high temperatures in late summer and above-normal temperatures in September.

Results from research by UW scientists, using historical data gathered across Wisconsin from 1950 to 2006, suggest that any degree of additional warming during

**Overall, crop yields were favored by cooler-than average daytime high temperatures in late summer and above-normal temperatures in September.**

the summer months appears to be correlated with lower-than-expected corn and soybean yields. An increase in monthly average maximum temperatures of 7° F in July and August could lead to corn

yield losses of 22-28 percent and soybean yield losses of 13-24 percent if adaptive measures do not occur and precipitation does not increase. It appears that any degree of future warming during the core of the growing season would have a negative impact on productivity in the absence of adaptation.

The potential responses of Wisconsin agriculture to changing climate, atmospheric composition and land

Photo: William Walker



management contain a great deal of uncertainty. For example, changes in the timing of precipitation paired with increased warming during the growing season may significantly alter the rate of development of corn and soybeans. Furthermore, future increases in atmospheric carbon dioxide could increase soybean production, but the effects may vary under different precipitation scenarios. Environmental changes in the future might make some watersheds more suitable for agriculture while others could be limited by drought and other extreme weather events. In order to cope with future conditions and prevent yield losses, farmers might need to adapt by adjusting the timing of planting or the genetics of the crops they choose to plant.

## **WILL MORE CARBON DIOXIDE IN THE AIR BOOST CROP YIELDS?**

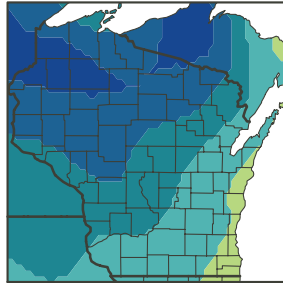
**PROBABLY NOT FOR CORN.** While it is true that plants depend on carbon dioxide for photosynthesis, carbon dioxide levels have been rising dramatically over the last few decades, and new experimental data suggest that corn photosynthesis is already saturated at current levels in the atmosphere. Therefore, any further increases in carbon dioxide will not boost corn productivity.

**MODEST INCREASES FOR SOYBEANS ARE LIKELY.** In the case of soybeans, it appears that increases in yield could still occur as atmospheric carbon dioxide levels rise. But the expected yield increase is modest, and new projections are approximately 50 percent lower than previous research had projected. New studies suggest that if temperature, precipitation and soil resources remain unchanged, soybean yields may increase by approximately 13-15 percent across Wisconsin as atmospheric carbon dioxide levels climb toward 550 parts per million by 2050, compared to today's level of 388 parts per million.

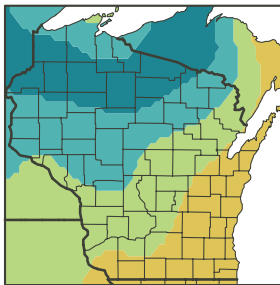


## SHIFTING HARDINESS ZONES

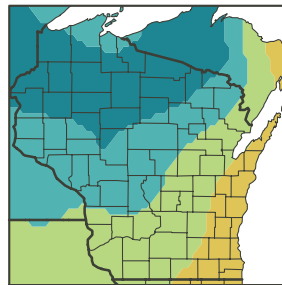
### PLANT HARDINESS ZONES



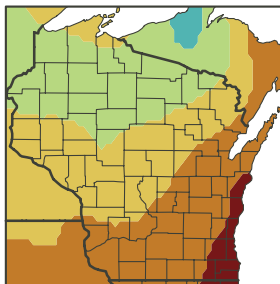
**1990 Modern**



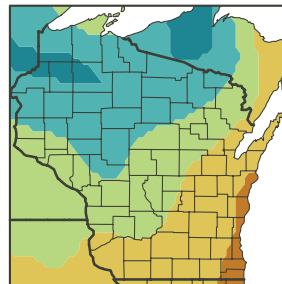
**2050 High Emissions**



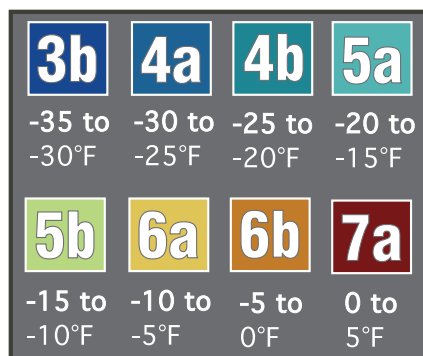
**2050 Low Emissions**



**2090 High Emissions**



**2090 Low Emissions**



WICCI climate scientists have documented a significant expansion of Wisconsin's growing season since 1950. Climate models project an increase in temperatures that will continue to lengthen the growing season and affect crop productivity in Wisconsin. While the extension of the growing season may boost the productivity of some crops, others could see negative effects if temperatures warm too much. To help us understand how climate will influence agriculture, we can look at how plant hardiness zones are shifting with changes in climatic conditions. As these zones shift, so do the types of plants that are able to grow in varying regions of the state.

We have already seen shifts in plant hardiness zones; these will continue to move northward as the climate continues to change. The maps illustrate potentially major changes in climatic conditions that characterize Wisconsin, and by the end of the century we might be able to grow new varieties of fruit crops, but new insects and diseases that impact all of our crops may move into the region, and growers may be challenged by additional management problems that will require adaptive measures. This implies that the growth and maintenance of our state's agricultural crops, particularly the fruit industry, may require new management methods and practices to remain profitable.

Figure 2. Plant hardiness maps.

Source: Michael Notaro, David Lorenz and Daniel Vimont, Nelson Institute Center for Climatic Research, University of Wisconsin-Madison.

## Soil Erosion

When soil particles erode from agricultural lands, the loss degrades the quality of the soil resource and contributes to the degradation of rivers and streams. In this section, we focus on climate change impacts on soil quantity and quality; the impact of soil erosion on Wisconsin’s aquatic ecosystems is discussed in detail in Chapter 3: *Water Resources*.

Erosion degrades the soil body by removing material from the surface. The soil material at the surface is the layer most supportive of plant growth; stripping away this topmost layer is a loss of “natural capital.” The creation of soil from parent materials proceeds in large measure from the top down, where plant carbon inputs are greatest and soil microbiological activity benefits from good aeration. Human-added nutrients, such as synthetic fertilizer or livestock manure, are greatest at the surface, as are nitrogen additions from legumes growing in the soil. The formation of soil structure that

facilitates root growth, water infiltration and desirable water-holding capacity is typically most advanced near the surface.

to be increasing. These precipitation trends increase the opportunities for significant soil erosion.

Recent estimates by soil scientists indicate that soil erosion losses are increasing in Wisconsin, most likely because of a combination of cropping system changes, relatively erodible land being returned to cultivation and changing precipitation patterns. These influences interact, and climate change may exacerbate the current threats to soil erosion from cultivation and land use practices. In the absence of appropriate adaptation actions, future precipitation patterns could cause soil erosion in Wisconsin to double by 2050 from 1990 rates.

Although farmers have known which practices are necessary to keep soil in place despite heavy rainfalls (table 4), these practices have been based on past climate scenarios. The boundaries of climate variability are shifting, and soil conservation practices will need to adapt to the precipitation changes we are seeing and expect to see in the future.

At the core of soil conservation is the voluntary adoption of appropriate practices by farmers. These include cropping and tillage practices as well as laying out fields, land shaping, and engineered structures. Federal, state and county governments provide technical assistance and cost-sharing as incentives for farmers to adopt these preferred practices; however, Wisconsin has ample room for improvement when it comes to their implementation.

In the absence of appropriate adaptation actions, future precipitation patterns could cause soil erosion in Wisconsin to double by 2050 from 1990 rates.

### SOIL CONSERVATION PRACTICES

PRACTICE	DESCRIPTION
Crop rotation	Planting a sequence of species through the years to reduce soil loss but meet farm needs
Crop residue management	Tillage practices that leave residue on top of the soil rather than bury it
Contour farming and strip-cropping	Tilling and planting across the slope, following the contours of the land, and planting crops in alternating bands of species that permit more or less erosion
Contour buffer strips	Permanently planted strips along the contoured field
Cover crops	Temporary, fast-growing species that protect the soil between main crops

Table 4. Soil conservation practices.



# Adaptation Strategies

The wide range of factors that contribute to climate impacts on agriculture and soil conservation leads to a wide range of possible strategies for adaptation. In keeping with the organizational framework presented in Chapter 2: *Understanding Adaptation*, we present here several adaptation strategies relevant to Wisconsin's agricultural systems. (Please see the Adaptation and Soil Resources Working Group reports at [www.wicci.wisc.edu](http://www.wicci.wisc.edu) for a more detailed discussion of adaptation strategies.)



Photo: Avery Dorland



## ADAPTATION

### TAKING ACTION

- Expand the adoption of accepted soil-conserving field practices that will reduce erosion and polluted runoff to streams and lakes.

### BUILDING CAPACITY

- Develop a stronger presence for an agro-meteorology (or agro-climatology) program within the University of Wisconsin System, including courses that would train the next generation to understand the connections between agriculture and climate.
- Initiate an ongoing analysis of how bioenergy policies and changing production practices influence the effectiveness of soil conservation programs.
- Provide the resources necessary to facilitate broad adoption of the practices we know can reduce soil erosion and to ensure compliance with existing rules.

### COMMUNICATING

- Communicate what needs to be done within agriculture to adapt to changing climate, using basic research and a new type of framework for integrating these findings into policy decision-making.
- Review public policy surrounding subsidies for soil conservation practices to determine if they meet present and future needs.
- Expand watershed-based educational programming efforts with appropriate targeting of hydrologic units, farms and fields.



Photo: Elizabeth Kart-Reinders



Photo: Lance Klessig



Photo: William Walker



Photo: Avery Dorland

## STRATEGIES

- Apply state-of-the-art evaluation work related to soil conservation to measure impact and improve programs and practices.

### FILLING GAPS

- Re-establish a network of agro-meteorological stations across the state of Wisconsin to collect climate observations, including estimates of evapotranspiration, to support research and development of agricultural practices.
- Create a program to collect on-farm information, such as fertilizer and pesticide usage, other management practices and yield responses to support researchers and educators across the state.
- Provide support for placed-based research that integrates ecological and social science with field work, numerical modeling, remote sensing and the social sciences to better understand how ecosystem services associated with agricultural systems can be sustained into the future.
- Develop new metrics for the sustainability of soil and water resources.
- Develop strategies to objectively and efficiently identify portions of the landscape that should be maintained in healthy full-cover perennial vegetation, and develop programs to encourage returning these areas to this condition.
- Undertake research to enable more inclusive accounting of the costs and benefits of soil management choices.
- Develop systematic, transparent and accessible monitoring programs for soil conservation and its impacts on water quality.



## ADAPTATION IN ACTION

### **Pecatonica River: Wisconsin Buffer Initiative Pilot Project**

An experiment is taking place in southwest Wisconsin that could improve water quality in streams more efficiently and effectively. One of the challenges facing landowners and managers in Wisconsin and nationwide is keeping sediment and nutrients on the land and out of streams. Is there a way to target efforts to improve water quality so they have the greatest impact at the lowest possible cost? Farmers, University of Wisconsin scientists, public agencies and The Nature Conservancy through the Great Rivers Partnership are working together to answer this question. Known as the Wisconsin Buffer Initiative (WBI), the group hopes to improve water quality by using science to target conservation efforts on those fields and pastures with the greatest potential for contributing nutrients and sediment to streams. WBI is testing this approach in the Pecatonica River watershed. If successful, the partners will look for opportunities to implement it more broadly across the state.

Using research by University of Wisconsin graduate students and Dane County Land and Water Resources Department conservation staff, the partners have identified a handful of farms in one of the watersheds that contribute comparatively large amounts of phosphorus and sediment to the stream. Dane County conservation staff members are working with these farm owners to identify alternative management practices, including different types of tillage, crop rotations and manure handling, that will reduce the amount of sediment and nutrients entering the stream.

The goal is to identify conservation practices that are compatible with a farm's current cropping and livestock system and, where possible, increase or not significantly reduce profitability. Dane County has secured funding to help farmers implement needed changes that aren't financially feasible for them otherwise.

It will take several years for conservation practices to be fully implemented and begin to show results. Ultimately, however, the partners hope to demonstrate that targeting conservation practices where most needed will result in significant water quality improvements and provide the most efficient and effective use of limited resources.

If they are successful, the partners believe their research will create tools that streamline implementation of targeted conservation efforts in other watersheds. Their data will also be valuable to the agricultural community and other decision-makers in reshaping public policy related to water quality management not only in Wisconsin but across the nation.



*Aerial view of Pecatonica River watershed.*

Photo: Wisconsin Department of Natural Resources

Condensed from:

[http://www.nature.org/wherewework/northamerica/states/wisconsin/files/pecatonica\\_river\\_fact\\_sheet.pdf](http://www.nature.org/wherewework/northamerica/states/wisconsin/files/pecatonica_river_fact_sheet.pdf)



## Conclusion

Agriculture is a major force in Wisconsin's economy and culture as well as a source of food security for the people of our state. Farmers need more information on how climate change will affect agriculture in order to safeguard crops and soil resources, make wise market decisions and engage in the best on-the-ground farming practices. Policy-makers will also need access to the best available information in order to craft the most effective policy responses to climate change.

We acknowledge that this is a preliminary assessment of climate change impacts on Wisconsin agriculture. This is the first effort at a statewide analysis; more detailed assessments will follow in the years ahead as climate modeling continues to improve and research on impacts expands in scope.

**Source material for this chapter was drawn from the Agriculture and Soil Resources Working Group reports, available online at [www.wicci.wisc.edu](http://www.wicci.wisc.edu).**



Photo: Avery Dorland