Midwest

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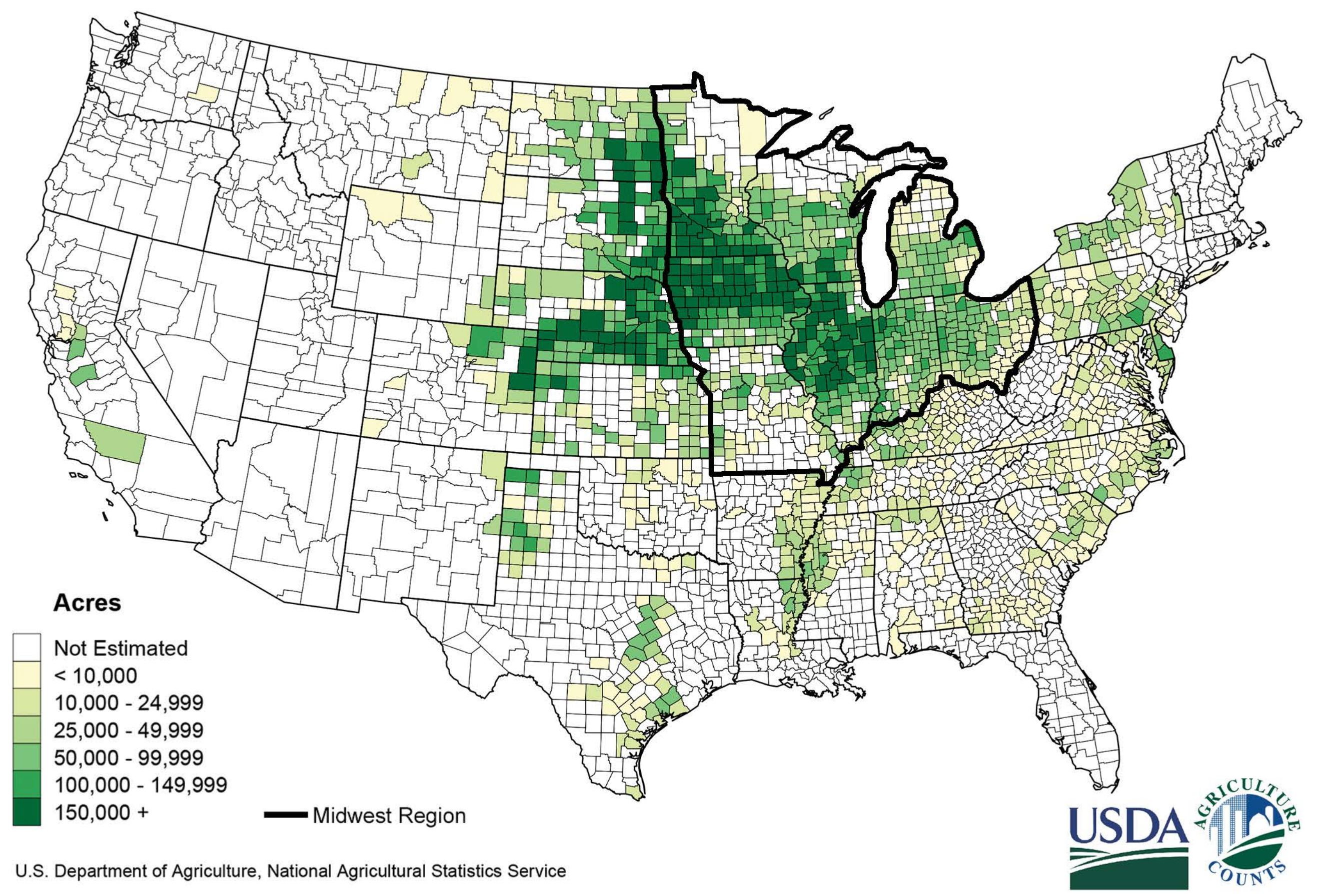
Description of the Region

The Midwest Region encompasses the States of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin and includes about 20 percent of the U.S. population (61 million), which primarily lives within its cities. Agriculture is the dominant land use in the Midwest, with more than two-thirds of the land designated as farmland, and plays a major role in the regional and national economy (fig. A.11). Midwestern States traditionally are considered to be the Corn Belt, because corn (*Zea mays*) and soybean (*Glycine max*) constitute 85 percent of the crop receipts. Agricultural exports from the Midwest accounted for more than $86 billion in 2009, which amounted to nearly 87 percent of the national agricultural export. A diversity of production systems, however, ranges from corn, oats, soybean, and wheat to fruits, nuts, vegetables, and livestock. The Midwest is also home to some of the most valuable timber species in the United States that include the central hardwood, northern hardwood, and Lake States coniferous regions.

The Midwest Region enjoys a continental climate, with warm summers and cold winters. The frequency and intensity of extreme weather events, such as droughts and floods, have increased during the past few decades, threatening agriculture in the region (Andresen et al. 2012). The rate of warming has also accelerated, resulting in warmer nights and milder winters. For example, the average Midwest air temperature increased 0.11 °F per decade between 1900 and 2010. The average temperature increased twice as rapidly (0.22 °F per decade)

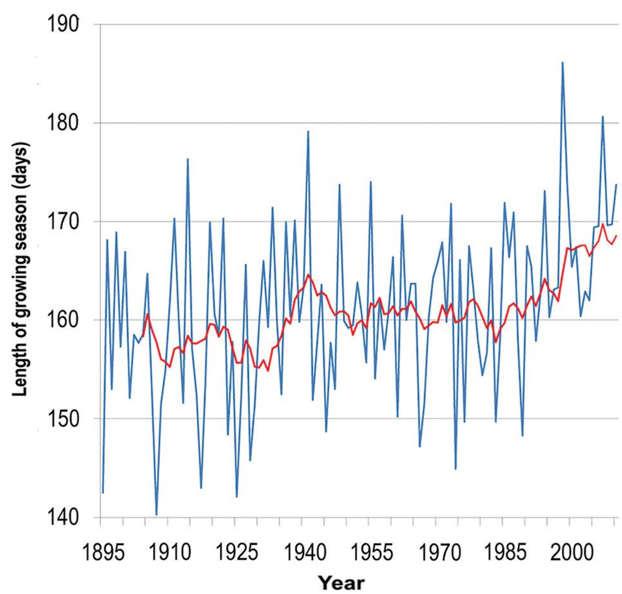
Figure A.11. Corn acres planted for all purposes, by county, 2015. (Map by USDA National Agricultural Statistics Service).



during the past 60 years and four times as rapidly (0.47 °F per decade) during the past 30 years compared with the increase from 1900 to 2010 (Kunkel et al. 2013). The Midwest has also experienced a lengthening of the growing season by 1 to 2 weeks since 1950 (Robeson 2002, Skaggs and Baker 1985). Fig. A.12 shows that the growing season averaged about 155 days before the 1930s and has been approaching 170 days in recent years (Andresen et al. 2012).

Positive and negative impacts are predicted for the Midwest as a result of climate change. Although a longer growing season and increased levels of carbon dioxide (CO_2) in the atmosphere may benefit agriculture, those benefits may be offset by the impacts of unusual heat waves, spring freezes, extreme droughts, and floods of greater intensity. Farm diversification and intensification through agroforestry may help offset some of the negative effects of climate change. The following sections describe some of the threats and challenges that Midwest agriculture faces as a result of climate change and identify potential mitigating effects that agroforestry practices provide.

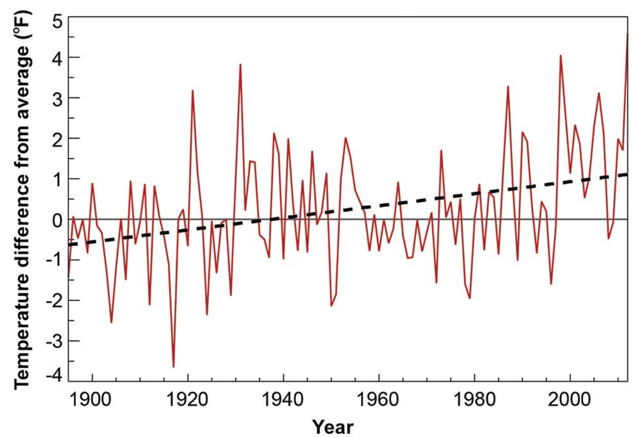
Figure A.12. Length of growing season in the Midwest. The red line is a 10-year moving average. (Andresen et al. 2012).



Threats and Challenges to Agricultural Production and Other Ecosystem Services

The Midwest is projected to experience a continuing rise in average annual temperature (fig. A.13). This rise will lead to increased heat stress and associated yield decline in many crops, despite the CO_2 fertilization effect. Trees modify site microclimate in terms of temperature, water vapor content or partial pressure, and wind speed, among other factors. Trees can also improve water recharge in the soil and reduce

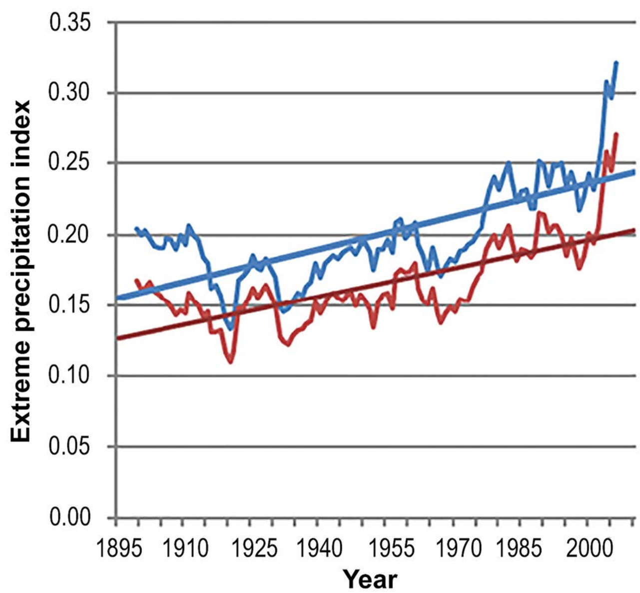
Figure A.13. Average annual temperature (red line) across the Midwest shows a trend toward increasing temperature. The trend (heavy dashed black line), calculated during the period 1895 to 2012, is equal to an increase of 1.5 °F. (http://nca2014.globalchange.gov/report/regions/midwest).



evaporative water loss from exposed soil surfaces. For example, windbreaks slow the movement of air and thus, in general, reduce evaporative stress. Windbreaks are known to improve soil moisture availability, improve the distribution and utilization of irrigation water, reduce evapotranspiration, and improve crop water use efficiency (Davis and Norman 1988). Temperature reductions from tree shade can help reduce heat stress of crops and animals in agroforestry systems. A study in Nebraska showed earlier germination, accelerated growth, and increased yields of tomatoes (*Lycopersicon esculentum*) and snap beans (*Phaseolus vulgaris*) under simulated narrow alleys compared with wider alleys (Bagley 1964).

Extreme rainfall events result in more frequent flooding, more erosion, declining water quality, and difficulty in crop establishment in the spring. The frequency of heavy precipitation events has been increasing in the Midwest in recent decades (Changnon and Kunkel 2006). Andresen et al. (2012) showed that the number of 24-hour, once-in-5-years storms increased about 4 percent per decade since the beginning of the 20th century (fig. A.14). This trend of increasing frequency of heavy rainfall has exacerbated the intensity and frequency of flooding events in the region. Frequent flooding and the resulting loss of agricultural production have caused large-scale economic loss and hardship in the Midwest in recent years. The introduction of trees into agricultural fields as riparian forest buffers or alley cropping along the contour as an upland buffer has been shown to take up large quantities of water and lower the water table, particularly when there is excess water (Anderson et al. 2009). Planting fast-growing trees such as poplar (*Populus* spp.), sycamore (*Platanus occidentalis*), and willow (*Salix* spp.) in combination with shrubs and warm-season grasses in multispecies riparian forest buffers or in alley cropping configurations can help lower the water table in marginal land that experiences

Figure A.14. Temporal pattern of extreme precipitation index for occurrence of 24-hour, once in 5-year extreme precipitation events in the Midwest. The annual time series and linear trend (straight line) are shown in blue. A time series and linear trend for the months of May through September are shown in red. (Andresen et al. 2012).



frequent flooding or wet conditions (Zaimes et al. 2004, 2008). Research also shows that having a 500-foot buffer of trees situated between major rivers and levees can protect levees from failure, thus protecting crop fields in floodplains (Allen et al. 2003). It is well known that properly designed riparian forest buffers can reduce surface runoff and sediment loss by as much as 90 percent (Udawatta et al. 2005). The same buffers can also act as filters to trap, store, and transform agricultural chemicals, including pesticides and fertilizers, thereby improving water quality in streams and rivers (Lin et al. 2007, Lin et al. 2011).

Stress on the region's agriculture will likely include larger populations of harmful insects. Insect populations are likely to increase as a result of warmer winters, increasing their winter survival, and higher summer temperatures, increasing reproductive rates and favoring multiple generations each year. Diversification by introducing trees into monocultured croplands will increase the number and abundance of birds and beneficial insects that feed on harmful insects. Alley cropping is a potentially useful technology for reducing pest problems because tree-crop combinations provide greater niche diversity and complexity than do annual crops alone (Stamps and Linit 1998). Studies with pecan (*Carya illinoensis*), for example, have looked at the influence of ground covers on arthropod densities in tree-crop systems. Bugg et al. (1991) observed that annual legumes and grasses cover crops sustained lady beetles (Coleoptera: Coccinellidae) and other arthropods that may be useful in the biological control of pests in pecan. Willow show promise for supporting biological control of insect pests in agricultural systems (Dalin et al. 2011). Stamps and Linit (1998) and Stamps et al. (2009) observed similar results in a black walnut (*Juglans nigra*)-based alley cropping system in Missouri. In an alley cropping trial with peas (*Pisum sativum*) and four tree species (*Juglans*, *Platanus*, *Fraxinus*, and *Prunus* spp.). Peng et al. (1993) found an increase in insect diversity and improved natural-enemy abundance compared with monocultured peas. Agroforestry systems also have a greater diversity of birds compared with monoculture agronomic systems and are also likely to provide additional pest reduction to adjacent crops (Berges et al. 2010, Gillespie et al. 1995).

Higher summer temperatures will stress livestock, increasing costs as livestock productivity decreases and ventilation and cooling costs increase. Heat stress has been identified as a major constraint to cattle production. At high temperatures, evaporative cooling is the principal mechanism for heat dissipation in cattle. It is influenced by humidity and wind speed and by physiological factors such as respiration rate and density and activity of sweat glands. Failure to maintain homeostasis at high temperatures may lead to reduced productivity or even death. Providing shade, however, can reduce the energy expended for thermoregulation, which, in turn, can lead to higher feed conversion and weight gain. For example, in a study in Missouri, cattle in a silvopastoral practice gained more weight than in open pasture, translating to nearly $50 more per cow-calf pair (Kallenbach 2009).

Climate change may threaten forests in the Midwest with more frequent droughts and wildfires and larger populations of harmful insects. Forest farming and silvopastoral practices reduce unwanted understory growth, provide added protection from fire, reduce crowding and stress on remaining trees, and improve overall forest health. Moser et al. (2008) estimated that farmers owned nearly one-half of the 11 million acres of all woodlands in three of the Midwestern States (Illinois, Indiana, and Iowa). They showed that active management of those woodlands increased productivity and biodiversity. Actively managing the woodlands using agroforestry can further enhance the value of the forests. For example, periodic thinning is essential in maintaining a woodlot under a forest farming or silvopastoral practice. Thinning also helps to produce valuable sawlogs, and reduce wildfire risks while reducing understory invasives and outbreaks of harmful pests.

Degraded air quality due to human-induced emissions and increased pollen season duration are projected to be amplified with higher temperatures. More than 20 million people in the Midwest experience air quality that fails to meet national ambient air-quality standards. Traditional farming systems are often impacted negatively by high winds. Windbreak systems can easily be integrated into existing farm, horticulture, and animal production systems to minimize impacts of adverse weather caused by climate change. These windbreaks can also reduce dust pollution, thereby enhancing air quality.

Specially designed windbreaks and shelterbelts, known as vegetative environmental buffers, can improve air quality around confined animal feeding operations. Most odor-causing chemicals and compounds are carried as volatile organic compounds (VOCs) (particulates). These buffers can filter airstreams of particulates by removing dust, gas, and microbial constituents (Tyndall and Colletti 2007).

Agroforestry Uses—Opportunities and Challenges

Early settlers in the Midwest historically practiced slash-and-burn agriculture and tended multilayer home gardens. Grazing by livestock such as bison, combined with the intentional use of fire by Native Americans, was a form of management in the oak savanna ecosystem in the region. During the past 30 years, Federal cost-share programs (e.g., Conservation Reserve Program [CRP], Environmental Quality Incentives Program [EQIP]) administered by the USDA Natural Resources Conservation Service have resulted in major increases in riparian forest buffer establishment in the Midwest Region. A recent national assessment revealed that most of the USDA funds spent on agroforestry in fiscal years 2011 and 2012, about $316 million, enabled landowners across the country to install riparian buffers and windbreaks on their land through CRP and other USDA conservation programs (USDA 2013).

Research in the Midwest Region has also concentrated on selecting plants better adapted to the expected climate change. Within in the transition zone from cool-season to warm-season forages, preliminary estimates are available for selecting new forages with tolerance to moderate or heavy shade that can be integrated into alley cropping, silvopastoral, and riparian buffer practices (Van Sambeek et al. 2007). Likewise, if crop options need to change under a changing climate, decision tools exist for selecting new crops with more favorable tree-crop interactions (Van Sambeek and Garrett 2004). Other studies have concentrated on what cultivars are currently adopted and where, to make better decisions as to what cultivars can be moved. For example, Casler et al. (2007) examined the latitudinal and longitudinal adaption of switchgrass populations. Likewise, understanding genetic variation among nut tree cultivars adapted to growing in open conditions rather than closed forest conditions will aid in selecting more productive mast species for use in alley cropping and silvopastoral practices. Results from flood-tolerance screening trials and use of large container-grown planting stock will aid in decisions regarding what hardwood planting stock to include in bottomland restorations in a region dominated by river systems (Dey et al. 2004, Kabrick et al. 2005).

Additional opportunities for agroforestry adoption in the Midwest are presented by new, small landowners willing to use incentive programs and their own funds to try alternative land uses that do not provide immediate financial returns. According to the 2012 USDA Census of Agriculture, the number of small- (1-9 acres) to medium-sized farms that exist in the Midwest represent opportunity for a wide range of agroforestry practices (USDA NASS 2014). Hundreds of thousands of acres in the Midwest are also under orchard and timber production suitable for integrating agronomic and horticultural crops to enhance production and utilization of these lands. Alley cropping can be used to optimize productivity of the land. The growing demand for "nutraceuticals" (supplements designed to optimize nutrient benefits) and specialty crops, such as ethnic vegetables, herbs, fruits, and nuts, may provide candidate crops for production in tree crop alleys. Alley cropping, which is a good option for sustainable farming in hilly lands, reduces soil erosion and helps diversify regional horticulture production. The emerging biobased economy is providing additional opportunities to grow fast-growing, short-rotation woody crops and herbaceous biomass crops (annuals and perennials) in agroforestry configurations in the Midwest. Establishing such mixed-species systems in strategic locations in the Mississippi River watershed will help improve water quality and alleviate the hypoxia issue in the Gulf of Mexico.

Episodic periods of high commodity row crop prices (e.g., corn and soybeans) encourage continued production by farmers, sometimes without adequately considering environmental implications. During times of high commodity prices, lands enrolled under the CRP may be converted back to intensively managed row-crop systems when CRP contracts expire. This conversion is likely to reestablish the environmental degradation (e.g., loss of soil quality, accelerated erosion causing nonpoint source pollution) evident before enrolling. More than 7.3 million acres of land enrolled in CRP are expiring within the next 5 years (USDA-FSA 2012). Of those acres, more than one-half are located in the Midwest. Alternative and holistic approaches to maintaining these areas in continuous living cover systems that support sustainable production and economic opportunities to farmers and that provide conservation benefits must be developed using agroforestry (NWF 2012, USDA 2013).

With more than 85 percent of the agricultural landscapes under corn/soybean rotational systems, riparian and upland forest buffers or strips (Tyndall et al. 2013) can be used to minimize the environmental impacts of intensive row crops. The use of riparian buffers can also meet an expanding set of landowners' and societal objectives. Government cost-share programs help to promote the establishment and maintenance of buffers through EQIP. State programs, such as the Minnesota Agricultural Water Quality Certification Program, enable farmers and agricultural landowners the opportunity to take the lead in implementing conservation practices that protect our water. Landowners who implement and maintain approved farm management practices will be certified and, in turn, obtain regulatory certainty for a period of 10 years (Minnesota Department of Agriculture 2014).

The Midwest is home to lush hardwood ecosystems, but their long-term productivity is threatened due to unsustainable woodland grazing (Loeffler et al. 2000). The grazed woodlots are often unmanaged for timber, resulting in both low yield of forage and reduced timber production. Even though the conversion of pastures to planned agroforestry systems could have long-term economic benefits for producers, many landowners think that it is economically difficult for them to make the change. Agroforestry practices can provide landowners with needed income from their land during the 10 to 60 years or more necessary to sell marketable forest products. As an integrated management system, silvopasture can offer better woodland management both for economic production and environmental benefits and can address these concerns.

The relevance of small-scale farm and forest landowners in the Midwest continues to increase as consumer demand for food that is locally produced and marketed is gaining popularity throughout the United States. Local food markets typically involve small-scale farmers and woodland owners who sell directly to consumers. A recent study showed that in two regions in Missouri (the Old Trails Region near Kansas City and the Ozarks Region in the south), local foods created approximately 40 to 45 percent more indirect economic activity than conventional food sales (Johnson et al. 2014). A growing number of smaller acreage landowners practice agroforestry, including growing nontimber forest products, such as ginseng (*Panax* sp.), log-grown mushrooms, black cohosh (*Actaea racemosa*), and other cultivated plants under shade. The history of wildcrafting and the use of medicinals, especially within specific cultural groups, provide additional opportunities for development of forest farming in the region (Gold et al. 2004). Likewise, the introduction of nut trees, including walnut, pecan, and chestnut, into agroforestry practices will not only diversity the farmscape but also will enhance the economic viability of the farming enterprise.

Agroforestry adoption among landowners remains a challenge in the Midwest because of the cost to establish these systems, the incompatibility of existing farm equipment, and the long lag time before the benefits of these systems can be realized. The complexity of the practices, lack of information and demonstration sites, and limited extension/outreach personnel are also identified as limitations to large-scale adoption of agroforestry in the Midwestern landscape.

Key Information Needs

- Interactive maps identifying landowners practicing agroforestry and growing specialty crops.
- Trained professionals with agroforestry certification credentials.
- Improved financial information on emerging specialty crops coupled with widely tested improved specialty crop cultivars available to farmers to reduce risks and ensure profitability.

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