Midwest Food and Agriculture Indicators: Status and Needs for Monitoring Land Use, Soils, Water, and Human Health

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Background: Agriculture in the Midwestern United States is dominated by commodity crops, mostly feed grains, and livestock fed those crops. The U.S. grain industry was built up in this region where favorable climate and good soils support rain fed production. The Great Lakes hold about 20% of the world's fresh surface water supply found in liquid form, although the Great Lakes watershed accounts for much less land area in the region than the Mississippi. The central Corn Belt (IL, IA, MI, OH, IN, IA) contains over 50 million hectares of agricultural land and supports over 400,000 farms. Farm numbers have declined, however, by nearly 20 percent during the past decade. In addition to notable corn, soybean, wheat, and livestock sectors, the region ranks high nationally in production of horticultural crops, as well as fresh market fruits and vegetables. In general, livestock has been more important in the northern and western reaches, with row crops dominating the south and horticultural crops being most important in the northeastern sector.

Land Use: The conversion of large areas of land to agricultural production and large scale drainage projects during the 19th century transformed the Midwest landscape. Forests and wetlands were lost to the extent that hydrology and even climate were changed. Yields climbed notably between the 1940s and 2000 with rising levels of fertilizer and pesticide inputs. Significant research resources are being devoted to efforts to increase the yield potentials of major grain crops. **The amount and condition of land in the region with respect to agricultural production might be argued to be the most important metric for sustainability;** however, the benefits and environmental services of alternate land use should not be overlooked. Agriculture competes well with relatively unmanaged seminatural and natural land use because it is highly measured and monetized with benefits easily captured by individuals while external costs are socialized. Yield data are quantified and reported intensively in the media and ultimately traded on the stock exchange. Even though current estimates in the academic literature cite a benefit-to-cost ratio at a 100:1 for wild lands such as forests and wetlands, handy metrics of the environmental services they provide are not readily available. Indicators that track the multiple benefits of wild or natural land uses are needed to design sustainable land use. The Conservation Reserve and Conservation Reserve Enhancement Programs have allowed private land owners to protect environmentally sensitive lands. As of April 30, 2008, there was a total of 14 million hectares enrolled in the CRP/CREP programs nationally, which is down from 15 million hectares in 2007. Non-cultivated acreage accounts for about 15% of arable land. Agriculture does not compete well with residential and commercial uses of land. Based on the National Resources Inventory, approximately 14 million hectares have been lost to development since 1982. Nationwide, losses were the least dramatic in the western and central portions of the heartland, with notable losses to urbanization

occurring in WI and the Ohio Valley. Loss of prime agricultural land adjacent to urban centers is a particular threat to food-security. Approximately half of all US agricultural production comes from counties on the edge of cities.

Soils: Soil's productive potential, which determines the extent to which plants efficiently use water, energy and nutrients, is another key indicator, yet there is no standard approach for measurement. **Soil organic matter levels are probably one of the most widely accepted proxies for inherent productivity.** Interest in use of soil carbon sequestration as one strategy to help mitigate climate change has put a spotlight on associated data sets. Most models and summaries of trends reported by federal agencies suggest that soil organic matter reserves in North America are increasing where above ground productivity and conservation practices are applied. Using the soil conditioning index, the Natural Resources Conservation Service estimates practices are increasing organic matter in the surface depth on 46% of croplands. Mid-term and long-term projections that consider warming and shifts in precipitation suggest that both accelerated erosion and increased rates of decay may reduce soil's productive potential. Fertilization practices in the Midwest have been designed to replace nutrients removed through crop harvest. Trends in soil test values and for fertilizer sales are available. Individual research projects report accumulation of antibiotic resistance genes in soils amended with livestock wastes. No coherent system for tracking accumulating risk exists. Information about chemical contamination is needed, particularly for urban soils, where heavy metals and organic wastes are of greatest concern. Methodological constraints and cost are cited as barriers to data collection. Where available, data on soil pollution are distributed, incomplete and difficult to access.

Water: **Water metrics will become of increasing importance**. Conversion of large tracts of land from perennial to annual plant cover fundamentally altered the region's hydrologic cycle. About 70% of the wetlands have been lost from the lower Great Lakes and lower St. Lawrence River valley of Canada; wetland loss rates of nearly 100% have occurred in the central Corn Belt in states like Iowa. Loss has been greatest in the southern portion of the region where agriculture is most intense. Tile drainage in agricultural fields, draining of wetlands, water diversion, and floodplain development combined to increase the frequency of flash flooding. Development in urban areas tends to result in even greater reduction of natural drainage patterns that increase runoff and reduce percolation and recharge of aquifers. These alterations are likely to exacerbate climate change effects on stream flow, by increasing the frequency and height of flood events, and increasing drought potential through loss of groundwater recharge. Future increases in precipitation intensity will increase the erosive power of rainfall and will disproportionately impact wetlands, which are predominately small, isolated water bodies, and ephemeral wetlands. Establishment of perennial bioenergy crops could alter the hydrologic cycle by reducing spring time flooding and erosion and having a drying effect on the landscape, reducing late summer and early autumn stream flow significantly. Trends in water quality and quantity are well documented and point to significant contamination of surface and ground waters by agricultural chemicals. Declines in amphibian populations and increasing sexual abnormalities have emerged as key indicators of agricultural pollution of the landscape. Limited surveys of wells in the Midwest suggest that pesticide metabolites are abundant and that greater data and improved methods for quantification are needed to

understand the environmental fate and risk of pesticides. Systematic collection of data on chemical risk factors is needed, especially concerning the effects of exposures to multiple compounds and their metabolites.

Food and Health: Last but not least are indicators of health and food-system integrity. Data related to human health is widely available. US food availability (calories in food and waste) increased by 18% or 600 kcal (2.51 MJ) per person in the U.S. in the last two decades and this equals 0.36 hectares (ha) of land and fishing area per capita, 100.6 million ha for the US population, and 3.1% of total US energy. Indicators of food quantity, quality, and waste provide compelling evidence that commodity agriculture has not resulted in human health and optimized nutrition. Estimates suggest food waste accounts for just-under 30% of the caloric value of food stuffs. Over consumption and excess calories from animal fats and sweeteners account for an unprecedented rise in obesity. The percentage overweight and obese has increased across society but is most significant for those who are at a socioeconomic disadvantage and of non-white race and ethnicity. Data from numerous organizations (World Health Organization, USDA) suggest that more fresh fruits and vegetables are needed to improve health. Expanding the capacity of communities to produce fresh food for residents has been proscribed as a remedy but empirical evidence for how localized a foodshed can become and the extent to which local foods will increase human health is lacking. Historical dietary evidence indicates that moving to a locally-grown diet may actually reduce the percentage of the population which meets recommendations for fruit and vegetable consumption. This is, of course, complicated by issues of dietary costs, which are a major factor in food choices. Evidence does suggest that impoverished food environments and limited access and availability of healthy food explain health differences among sectors of society. Numerous kinds of data are needed to evaluate and then design effective and efficient local food systems. Community driven assessments of food supply indicate the Midwest imports the vast majority of its fresh fruits and vegetables from other regions and that demand for local fresh food outstrips supply. Further, state survey data show there is a scarcity of both processors and producers within the region. Food access is another critical part of the food-system story. Requests for food bank assistance have surged in the Midwest during the last quarter. The percentage of children and adults not meeting the US dietary recommendations for fruit and vegetable consumption (tracked by the USDA) and the prevalence of obesity (tracked by the CDC) are both integrative measures that provide insight into food insecurity status. Food relief programs and food banks struggle to provide the calories needed to meet dietary requirements without contributing to health problems associated with high fat and sweetened products. Creative policies and partnerships are often sought as a way to provide fresh foods to the low income community. Innovative health care institutions have responded to this challenge by changing purchasing rules to seek food quality instead of the cheapest price. More information about food quality, food access and health-benefits of food-systems is needed to address the equity component of sustainability.

Summary Statement

Changes in energy supply, demography and climate will all help shape the future of agriculture and foods systems in the Midwest. These 'drivers' of change did not make the 'top four' regional indicators list because they are embedded within the system. The top four indicators for the 'corn belt' include the land base (amount and condition of arable land), soil productivity (soil organic matter), water metrics (quality and quantity) and health (food security and nutritional quality). In general, data is available at reasonably fine resolution for soil characteristics (USDA), land use/land cover (NASS), and some of the social (CDA, USDA) and economic variables (US Census). Some of the data on environmental pollution is held by state agencies (EPA) but is not readily available and so not considered in indicator frameworks. More standardized information about environmental pollutants and risk is needed. There is a very large amount of data relating to agriculture and environmental quality in the region. As a result, we have a fairly good understanding of how land management practices and more specifically farming practices affect environmental quality at the plot and increasingly watershed scale. What we lack is a broadly held understanding of how to change current farming systems to improve environmental quality, which includes biodiversity, and human well being. Nutrition statistics currently provide the best handle we have on human health. However, data relevant to social organization at the level of the individual (e.g. parcel data on land tenure or landholder data on membership in civic organizations), is either unavailable or fractured into many local government jurisdictions (e.g. state and local governments in the US) and institutions (e.g. universities, corporations, citizen groups). Social organization, however, is one of the most important of the variables listed above in terms of its contribution to agricultural ecosystem and food-system health. Therefore, standardized and area-wide datasets describing socioeconomic conditions at parcel scales currently are lacking and represent an important opportunity for monitoring agriculture and food system health is a way that can lead to community and watershed or foodshed scale guidance in management for adaptation to change.

Failure to place observations into indicators that are standardized, adequately valued or routinely monitored has allowed worrisome trends to go unaddressed. Development of indicators that are useful tools is our challenge. To be useful they should inform decisions about land use, soil and water management such that biodiversity and human health and nutrition are preserved and enhanced. Perhaps as important as consistent and comprehensive monitoring of the multiple indicators related to sustainability, however, is combining them to measure progress toward societal goals. The societal goals that are of interest include multiple and often competing objectives such as high crop yield and biodiversity or farm economic stability and food accessibility and affordability (or at least competing under current production systems). Science-based frameworks are needed to assess combinations of indicators measuring progress towards multiple objectives; these frameworks need to be applied at different scales by a variety of users and reveal tradeoffs among choices as well as the uncertainty surrounding prediction.