Paradigm Shift:
Perennial Biomass Crops and Multifunctional Agriculture

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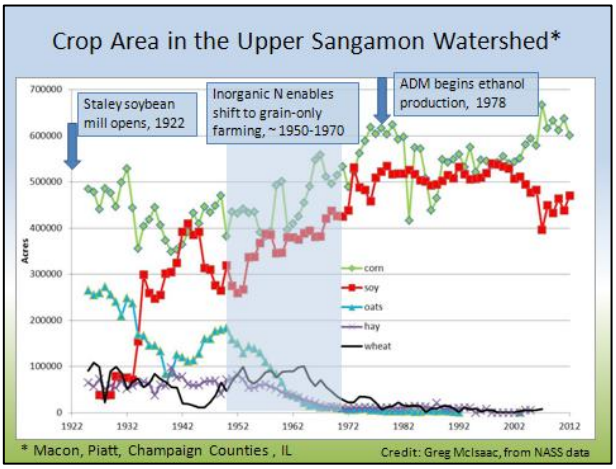
These slides were prepared for meetings with federal agencies and NGOs in April 2014. Text was added to convert that PowerPoint into a discussion paper for wider circulation. Feedback will be appreciated.

Significant change has taken place on the Midwest agricultural landscape over the past century. In thinking about how to address challenges including climate change and Gulf hypoxia in the coming decades, let's look back at factors that helped shape the current agricultural paradigm. This historical perspective can provide insights for achieving more sustainable and resilient agricultural systems with better environmental, economic, and social outcomes. The Decatur, Illinois, area is used as a case study.

Two events in Decatur illustrate the large role of entrepreneurs and corporate decision-makers in shaping the agricultural landscape and economy. A total of 32,000 acres of soybeans were planted in Illinois in 1921, largely as a hay crop and rotational legume. That fall, A. E. Staley, owner of a corn milling company in Decatur, announced plans to build "a plant for grinding and extracting the oil from the soya bean". In 1922, reported Illinois soybean acreage jumped to 135,000, a four-fold increase in a single year. By creating a market for the beans, Staley helped launch a landscape transformation.

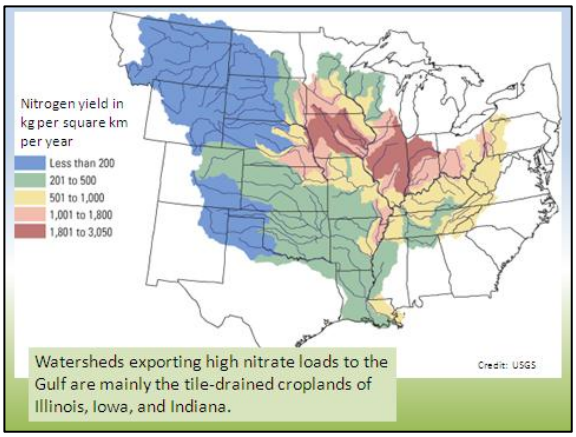


In 1978, the Archer Daniels Midland Company began producing ethanol at its Decatur corn processing facility. By then, corn-soybean rotation had already come to dominate agriculture in Central Illinois and much of the Midwest. Corn-based ethanol has established agriculture as a source of renewable energy, and may account for the increase in corn acres and decrease in soybean acres after 2000.

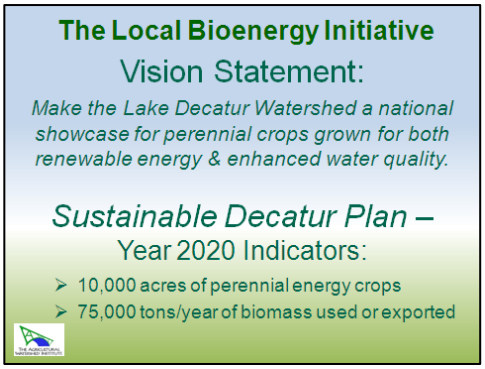
The driver of today's agricultural paradigm I want to focus on is inorganic nitrogen fertilizer. In *The Omnivore's Dilemma*, Michael Pollan wrote: "[A] key turning point in the industrialization of our food can be dated with some precision to the day in 1947 when the huge munitions plant at Muscle Shoals, Alabama, switched over to making chemical fertilizer." In prime crop areas, the period from 1950 to 1970 saw a shift to grain-only farming and a steady decline in hay and pasture acreage. In the Upper Sangamon counties, hay declined from 7 or 8 percent of cropped acres before 1950 to less than 1 percent since 1970. A similar decline occurred in pasture acres, which are not included in annual crop statistics. The pattern of intensive row cropping in some areas and feedlots in others leads to water quality problems and other environmental impacts.

Features of the Corn Belt agricultural paradigm since 1960s:

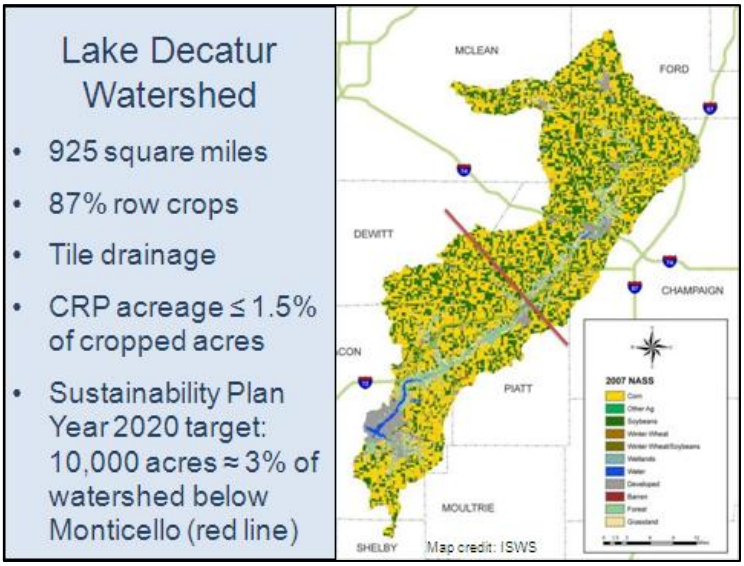
- Grain-only farming in areas well-suited to corn & soybeans – Inorganic N fertilizer replaces manure
- Grassland for hay & pasture makes up a tiny percentage of total farmed acreage, mainly on HEL in these areas
- Livestock production concentrated in areas less suited to row crops
- Drainage ditches & tiles needed for row cropping in prime prairie soils of IL, IA, IN
- BMPs promoted to mitigate water quality impacts of intensive annual cropping & tile drainage



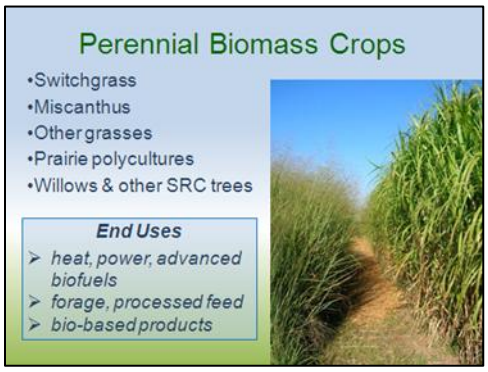
For example, nutrients from cropland in the Upper Midwest contribute significantly to the hypoxia problem in the Gulf of Mexico. Subsurface drainage tiles are a pathway by which nitrate and dissolved phosphorus move from fields to surface waters. This is a particularly difficult challenge since buffers and grassed waterways do not remove pollutants in tile flow. AWI and other organizations are working to develop and demonstrate cropping systems that can help to address water quality issues locally and throughout the Corn Belt. Our interest in perennial biomass crops is linked to that broad objective.



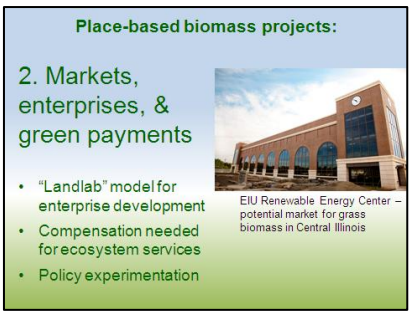
AWI's Local Bioenergy Initiative is intended to advance both environmental and economic goals included in the *Sustainable Decatur* plan adopted by the City Council. Financial support for this Initiative is provided by the City of Decatur and the Walton Family Foundation.

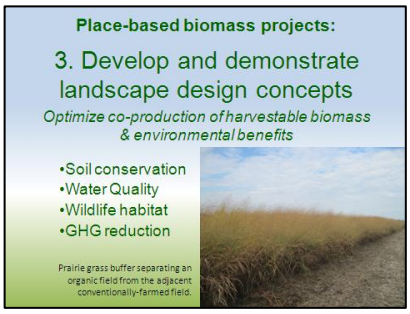


Lake Decatur is an impoundment of the Sangamon River. Dam construction began in 1921, coinciding with the Staley grain mill expansion. The Year 2020 goal of 10,000 acres of perennial biomass crops represents about 3% of the lower half of the Lake Decatur watershed. If achieved, this would be more than twice the acreage enrolled in the Conservation Reserve Program. No long term goal has been adopted but it seems reasonable to set a target in the neighborhood of 15% which would be roughly the area in hay and pasture, combined, in the mixed grain—livestock era before introduction of inorganic fertilizer.



Perennial biomass crops include warm season grasses grown in monocultures or polycultures and short rotation coppice trees that can be planted and harvested like an agricultural crop. The slide photo shows small plots of switchgrass (left) and Miscanthus that AWI and University of Illinois jointly manage on the grounds of the Farm Progress Show in Decatur. AWI calls our project the Local Bioenergy Initiative to highlight parallels to Local Food. With no local market yet in place for bioenergy feedstock, we also promote use of prairie grasses as a warm season forage.





AWI and other members of the Green Lands Blue Waters consortium (GLBW) are working at a watershed scale to promote perennial crops and cover crops that provide continuous living cover on the agricultural landscape. While details vary, place-based projects focusing on perennial biomass crops for feed and/or fuel typically include the three broad components listed in the above slides:

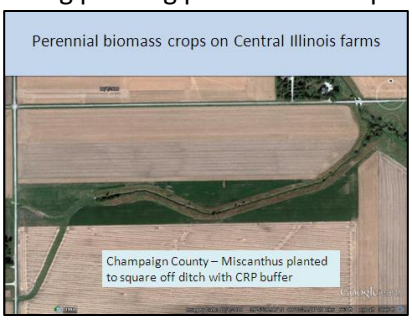
1. **Outreach and stakeholder engagement:** Field days, workshops, financial incentives, and one-on-one technical assistance are widely used to promote established conservation practices including cover crops and are also used by GLBW members to promote perennial crops. For new practices and perennial cultivars not commonly grown as a crop, early adopter producers and receptive landowners may be key participants in on-farm research and demonstrations.

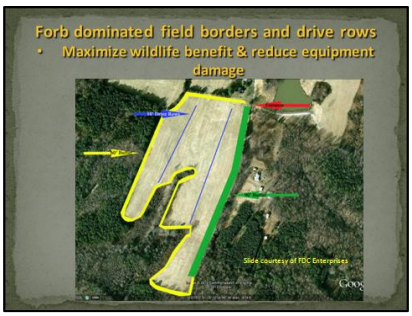
2. **Market and enterprise development:** This has been a core element of GLBW's theory of change since the consortium was formed a decade ago. The Midwest Conservation Biomass Alliance, formed in 2013, focuses on commercial use of prairie biomass. Scientists affiliated with GLBW, MCBA, and CenUSA Bioenergy are demonstrating "landlabs" in which land grant universities and local stakeholders collaborate to develop new markets and enterprises. Policy experimentation at a watershed scale is also needed; for economic viability in prime crop areas, bioenergy crops are likely to require payments for ecosystem services in addition to markets for the biomass.

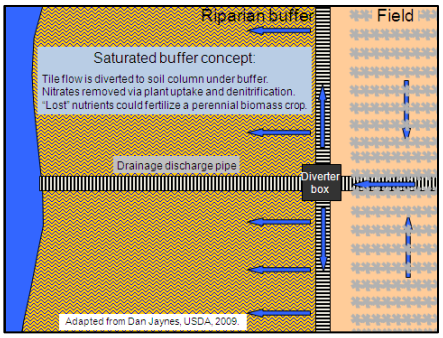
3. **Co-production of agricultural goods and environmental services:** Place-based biomass projects offer a platform for collaboration by researchers, producers, NGOs, public agencies, and agri-business to demonstrate and study synergies and trade-offs among multiple agricultural and environmental objectives of perennial-based cropping systems. Innovator and early-adopter farmers involved in this R&D can be key partners in testing new cropping systems and catalyzing wide adoption of successful innovations.

These slides show a few examples of perennial energy grasses on the landscape, left to right:

- Iowa State researchers study water quality benefits of prairie strips integrated in row crop fields.
- Miscanthus planted to square off a ditch makes for easier field operations on Eric Rund's farm.
- FDC Enterprises is demonstrating planting patterns for co-production of biomass and wildlife.







The water quality challenge of reducing nitrates from tile drained cropland was already noted. This schematic shows a saturated buffer designed to remove nitrate mainly through microbial denitrification. The saturated buffers now being tested by the Agricultural Drainage Management Coalition through a USDA Conservation Innovation Grant are installed in CRP buffers.

Linking Biomass Crops and Drainage

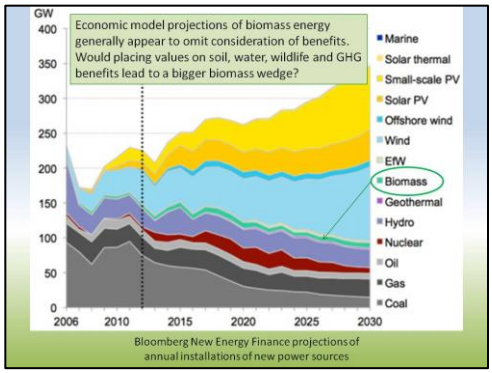
Nitrates in tile flow are a major nonpoint source pollution problem and one of the most difficult challenges to deal with by conventional BMPs.

Perennial biomass crops make it possible to re-think drainage practices designed for annual crops to grow feed & fuel in saturated buffers, contour strips, seasonal wetlands.

Innovative practices for co-production of biomass and clean water may be candidates for **water quality trading** or other eco-payments.

R&D on cropping systems and **policy experimentation** are needed to go **beyond BMPs** toward a new paradigm.

Water-tolerant perennial biomass crops do not require spring field operations or a lowered water table and thus make it possible to re-think drainage practices. Harvestable saturated buffers, strips, or seasonal wetlands could keep nutrients from reaching surface waters and use N and P lost from row crop fields to fertilize biomass crops. Such synergies can go beyond existing BMPs to become part of a new multifunctional agriculture paradigm.



Macro-analyses of agricultural and energy futures often show a fairly small role for biomass as renewable energy feedstock or raise concerns about food—fuel tradeoffs and secondary land use impacts of dedicated energy crops. I posit that, with attention to sound landscape design, perennial crops grown for food, fuel, animal feed, and bio-products can also furnish important ecosystem services. If benefits are factored into economic analyses and new farm policies, these crops can help achieve a sustainable and resilient agricultural future.

Time for a paradigm shift?

Today's Corn Belt paradigm is heavily dependent on fossil fuels and produces severe environmental impacts.

Perennial crops can provide agricultural products AND landscape-scale ecological benefits → clean water, wildlife habitat, GHG reduction, soil health, etc

Climate change, the shift from fossil fuels to renewables, and Gulf hypoxia may be drivers of landscape change comparable to the introduction of inorganic N fertilizer.

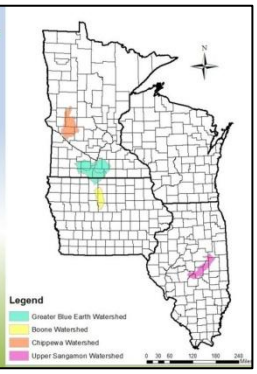
Multifunctional agriculture with perennial crops grown for feed, fuel, & bio-products PLUS ecosystem services can meet human needs and improve environmental outcomes.

The concept of paradigm shift or change was elaborated by Thomas S. Kuhn in his 1962 book *The Structure of Scientific Revolutions.* Anomalies not explainable by the prevailing paradigm are seen as drivers of fundamental change. In the socio-economic realm, adverse impact of current practices combined with technological advances and shifting societal goals can drive transformations. The need to mitigate and adapt to climate change and address impacts such as Gulf hypoxia may drive an agricultural paradigm shift. Perennial and cover crops could be central to an emerging paradigm.

Green Lands Blue Waters Consortium

Implementation Sites for Continuous Living Cover

- Perennial forage
- Perennial biomass
- Perennial grains
- Agroforestry
- Cover crops



GLBW focuses on a spectrum of Continuous Living Cover systems. Watersheds on this map are a few of the growing number of sites where NGOs in the GLBW Watershed Initiative are working. MCBA focuses on native herbaceous polycultures. These place-based projects can be sites to experiment with multifunctional cropping systems. Biomass project sponsors are looking at various energy conversion technologies and end uses to provide markets. Please contact the author for further information, to offer feedback, or explore opportunities for collaboration with GLBW or MCBA.