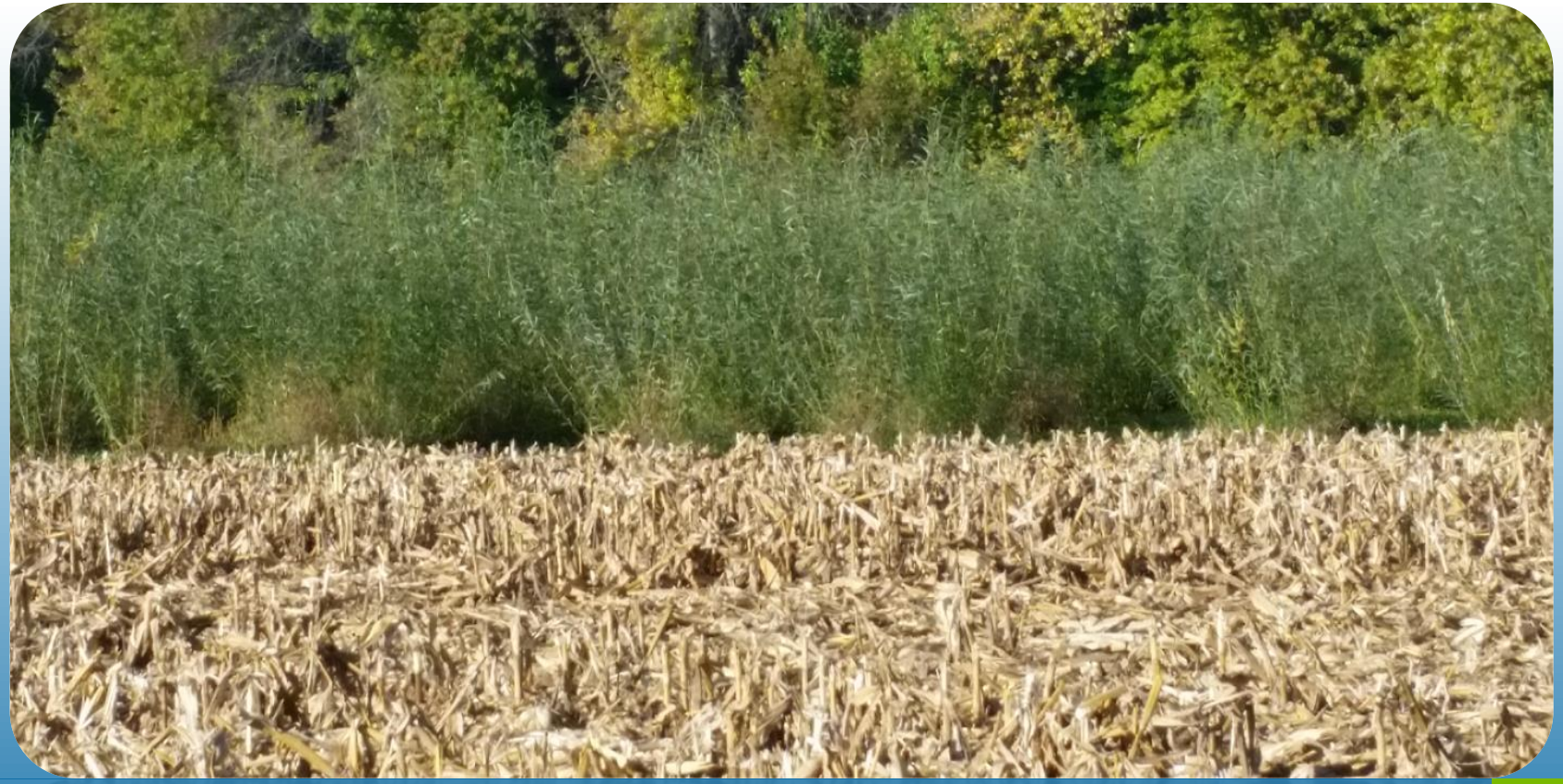
BIOFUELS FOR THE ENVIRONMENT AND COMMUNITIES



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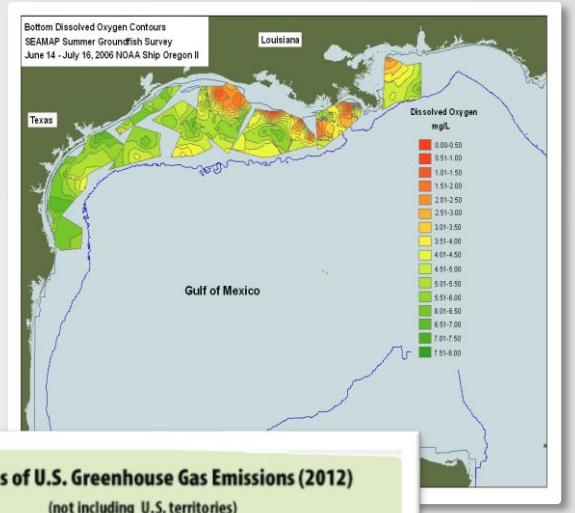
Argonne National Laboratory
BETO Webinar | April 22, 2015

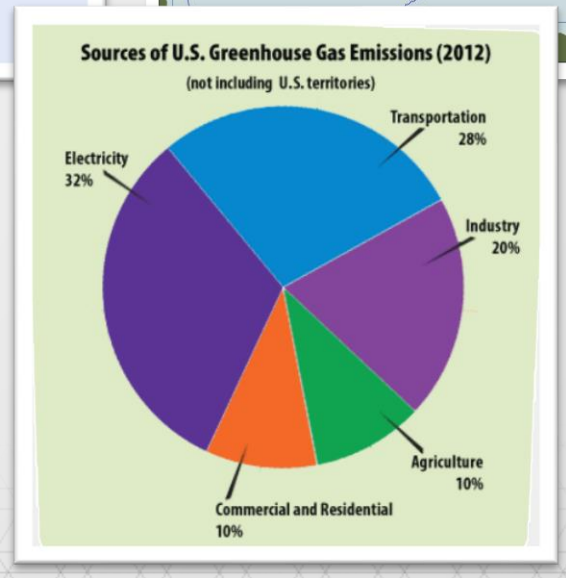
AGRICULTURE'S SUSTAINABILITY CHALLENGE

- Providing food, feed, fiber, energy for a growing world population
- Conserving soil, water and biodiversity, and decreasing greenhouse gases
- Providing resilience to a changing climate

E. Detaille, Charge of the 4th Hussars at the battle of Friedland, 14 June 1807 - http://upload.wikimedia.org/wikipedia/commons/1/10 Detaille_4th_French_hussar_at_Friedland.jpg

Source: U.S. Global Change Research Program http://e360.yale.edu/feature report_gives_sobering_view_of_warmings_impact_on_us/2166/



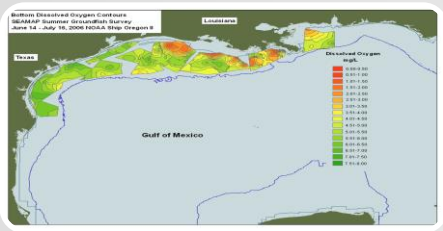


Questions for bioenergy development

- Is there sufficient land?
- Is land for food and conservation impacted?
- Do we have the right crops?
- What are the impacts to water quality and quantity?
- Is there a better way to plan for our resources?

DESIGNING LANDSCAPES TO INCLUDE BIOENERGY

SHIFTING PERSPECTIVE TO ADDRESS ISSUES



NUTRIENT LOADINGS

- Exploit deep rooted perennials to capture runoff and subsurface flow in strips and target areas
- Beneficially reuse nutrients lost from other crops to enhance biomass yields

WATER QUANTITY

- Design planting to match water budget
- Preferentially target marginal water

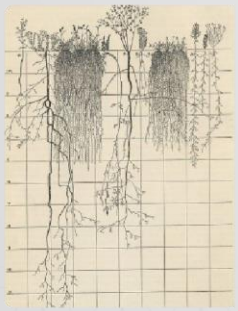
GRASSLAND CONVERSION AND DEFORESTATION

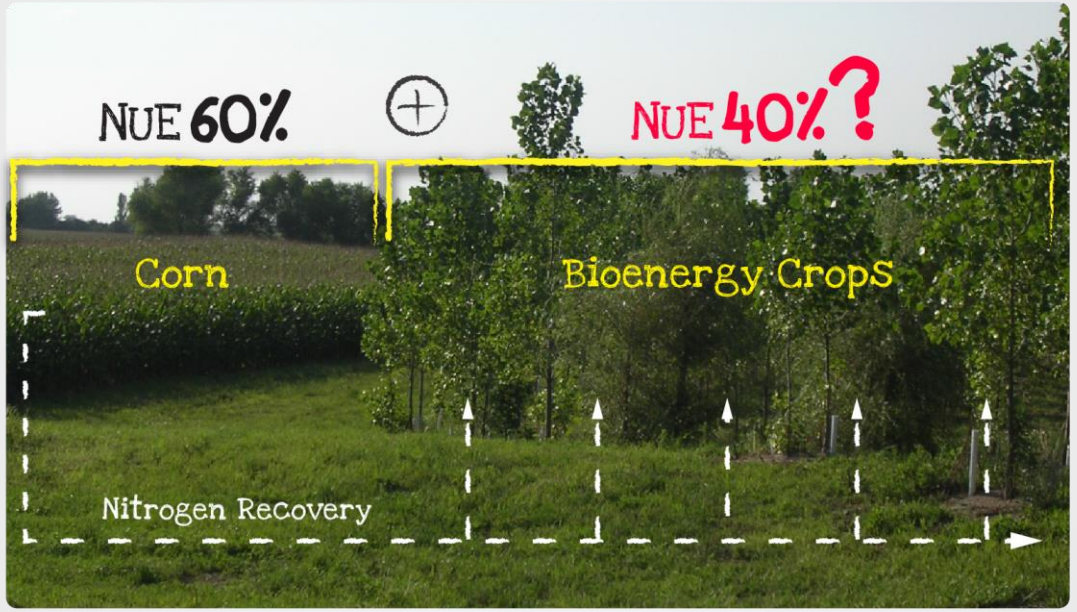
- Sustainably intensify arable land production through resource allocation planning

BIODIVERSITY

- Use bioenergy crops as shelter, connectivity and nesting opportunities to support biodiversity

SUSTAINABLE LAND USE INTENSIFICATION AT THE FARM LEVEL

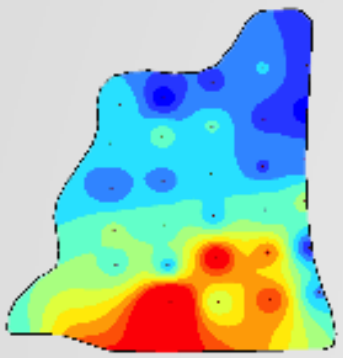


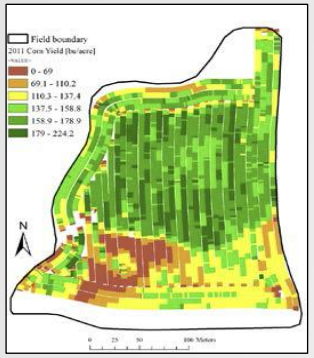


Underproductive land + excess nitrate recycle + deep rooted bioenergy crop = integrated landscape: sustained bioenergy production + environmental services + optimized farm revenue

UNDERPRODUCTIVE OR RISKY LAND- WHAT ARE WE TALKING ABOUT?

SUBFIELD VARIATIONS IN SOIL CONDITIONS DETERMINE DIFFERENT ENVIRONMENTAL IMPACTS AND FARM REVENUES



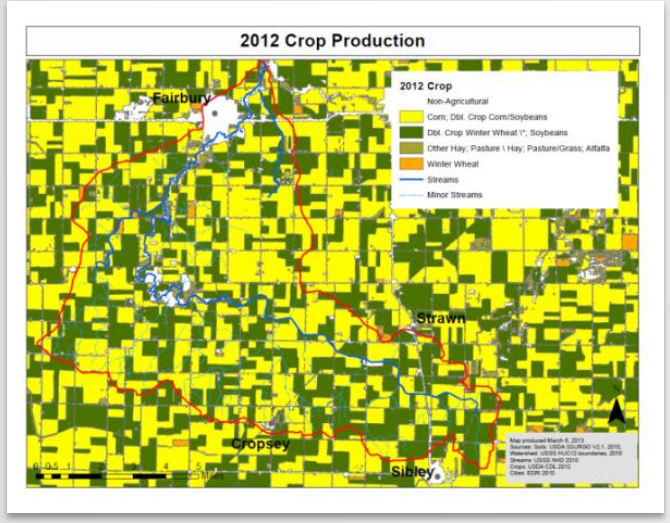


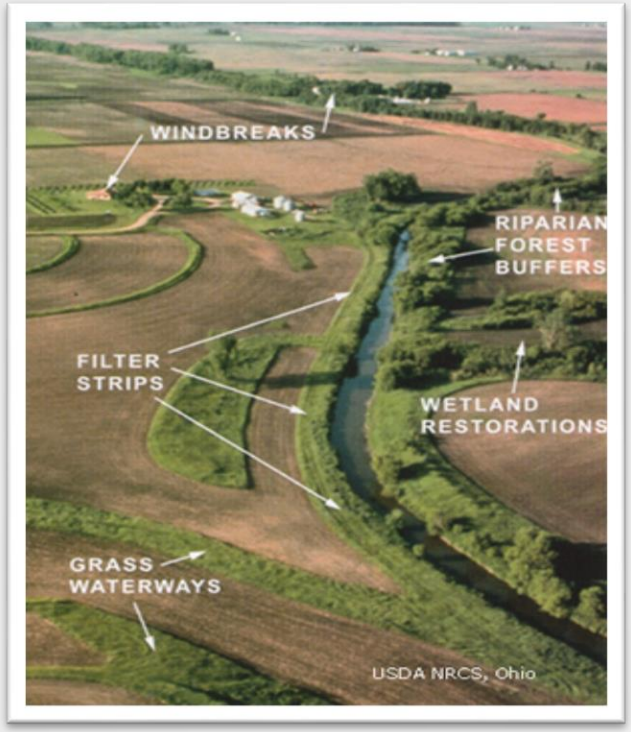
- Not all parts of a field are equally likely to leak nutrients or equally productive
- Areas that are sensitive to grain price and dependent on acceptable loss are candidate to bioenergy production (Bonner et al., 2014)
- Risk reduction (flood, drought) is also an economic consideration

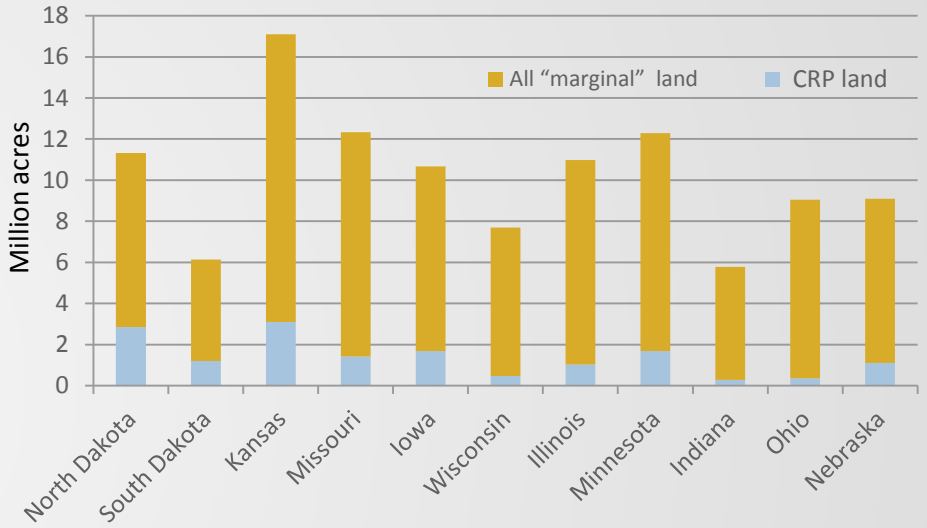
- Finding the sweet spot where it is cost-effective to grow biomass rather than corn/soybean, and where we can target the highest nutrient losses

- Dual-use crops and dual payment: paving the way for ecosystem services valuation for economic sustainability.

IS THERE ENOUGH OF THIS LAND?



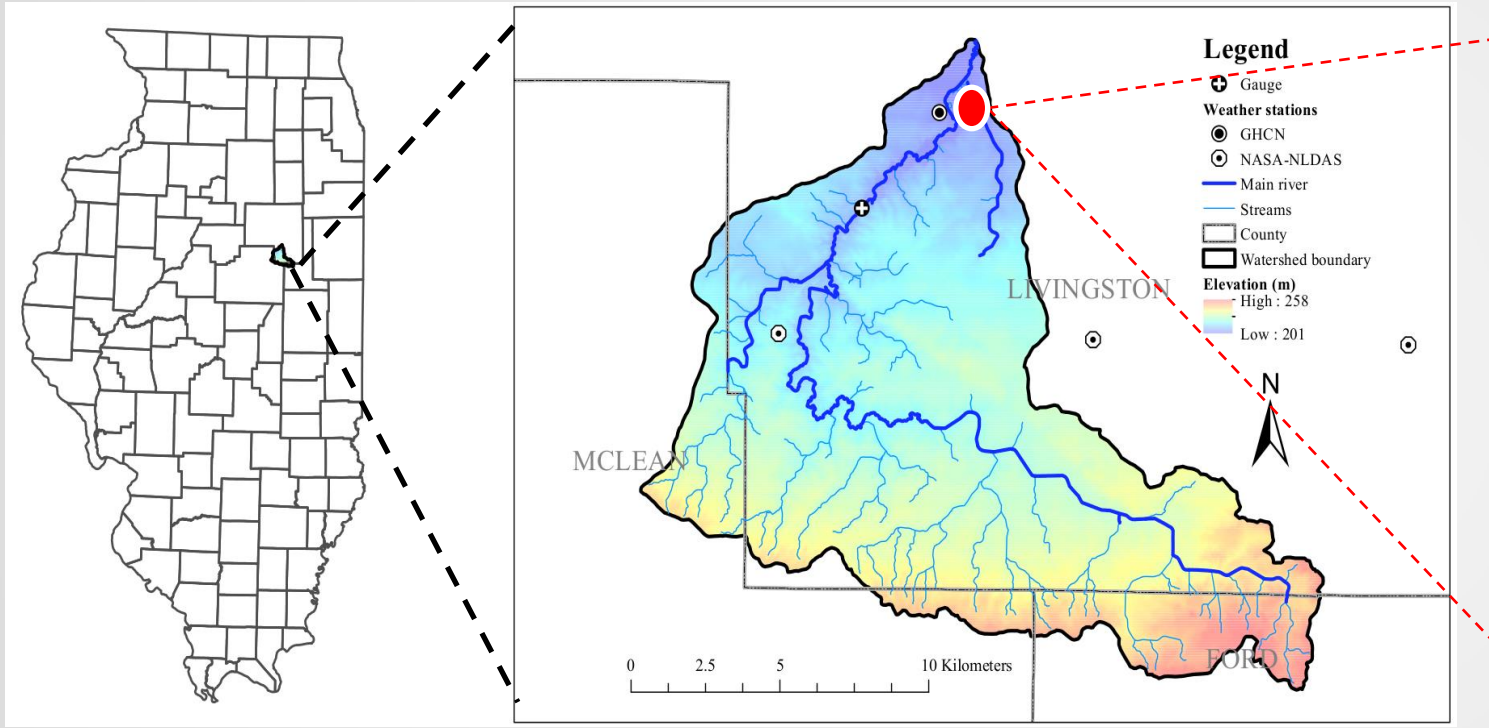




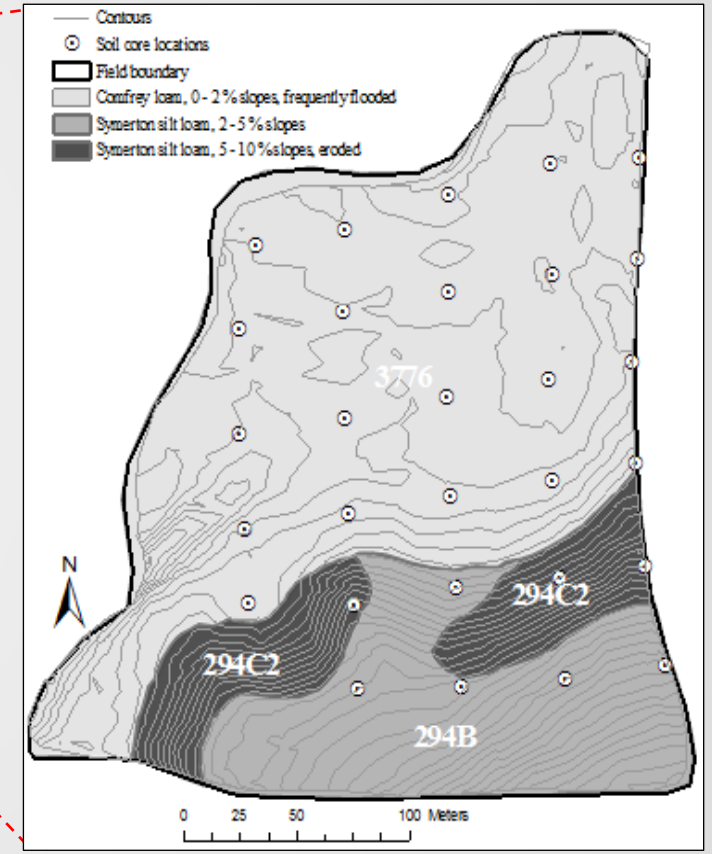
Ethanol production from the above states from buffers = 23 billion gallons (EISA 2007= 36 billion gallons)
Substantial land increase compared to CRP – provide flexibility in keeping most vulnerable CRP land in conservation

A CASE STUDY IN LIVINGSTON COUNTY, IL

Indian Creek watershed, IL



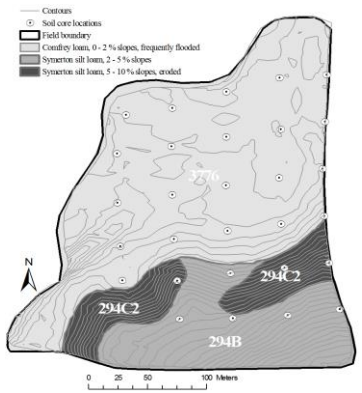
Fairbury site, IL soil map



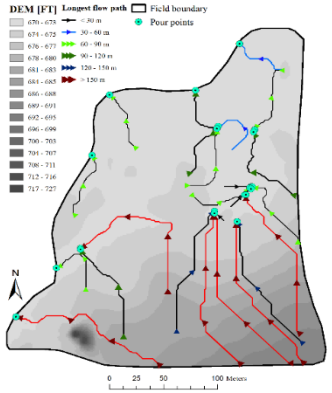
A STUDY AT THE SCALES AT WHICH IMPLEMENTATION DECISIONS ARE MADE

DESIGNING A BIOENERGY BUFFER

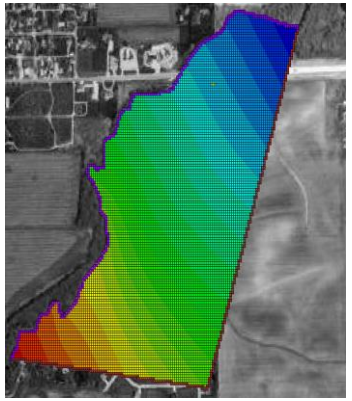
Soil classification



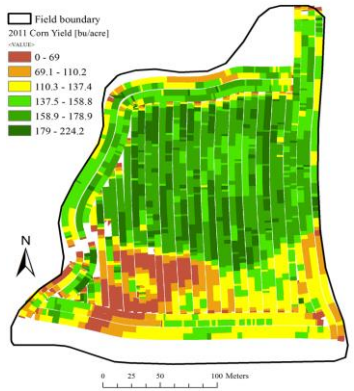
DEM and flow path lengths

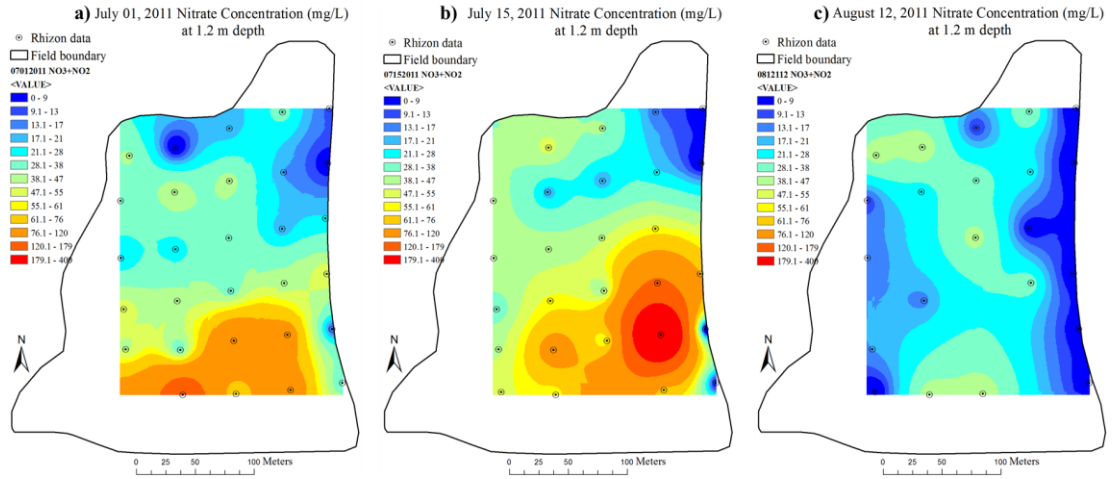


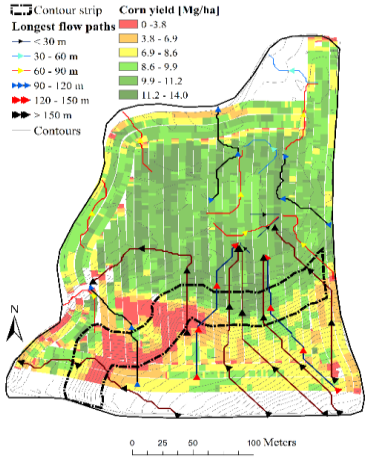
Hydrogeological model



2011 corn yield map

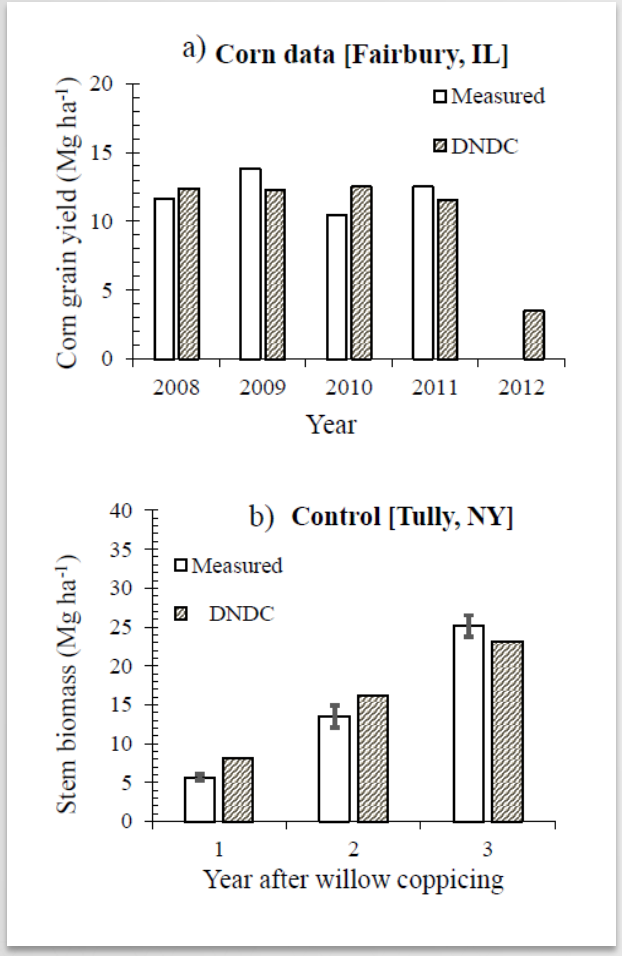






PREDICTED IMPACTS

DNDC MODEL DEVELOPMENT RESULTS: N_2O EMISSIONS, NO_3^- LEACHING AND CROP YIELDS



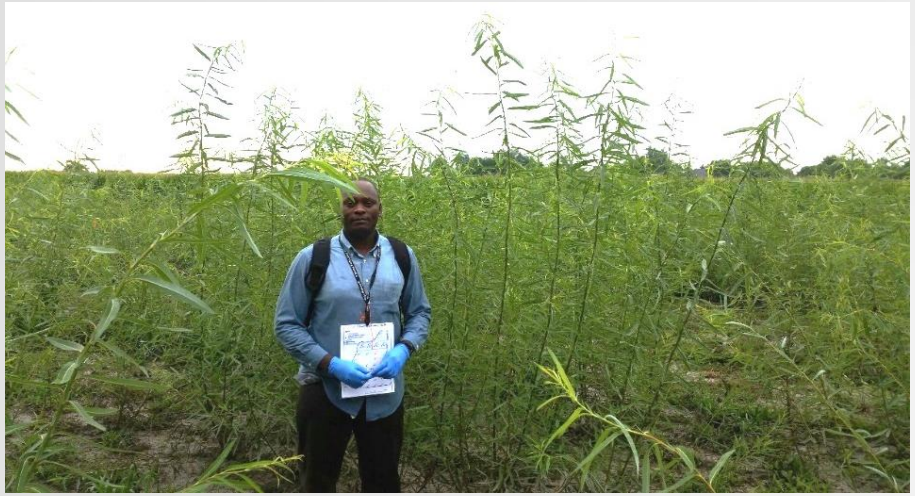
Simulated average (and standard error) annual yields, leached NO_3, and N_2O emissions at the Fairbury site, IL for 2008 to 2012.

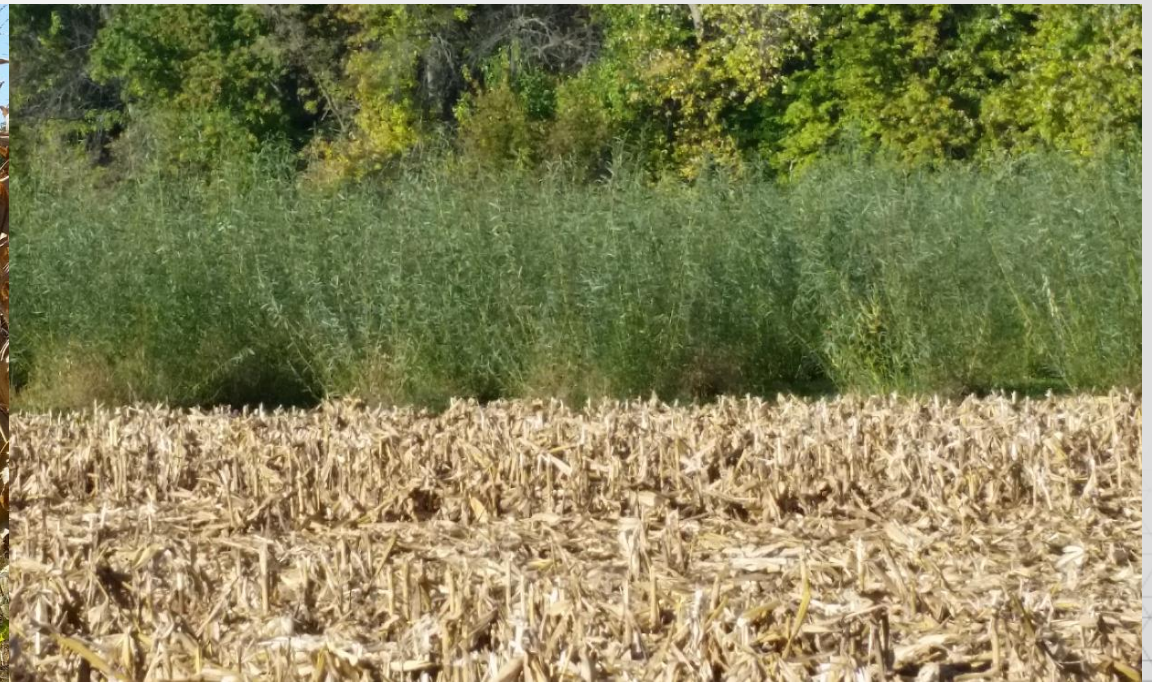
Scenario[a]	Yield	Leached NO_3	N_2O flux
	Mg ha^{-1} yr^{-1}	kgN ha^{-1} yr^{-1}	kgN ha^{-1} yr^{-1}
Corn	10.4 ± 1.7	31.9 ± 4.4	2.2 ± 0.3
Corn / switchgrass	8.7 ± 1.0	11.6 ± 1.6	2.0 ± 0.2
Corn / willow	9.7 ± 0.6	12.5 ± 1.6	1.9 ± 0.2
% reduction[b]	---	61.0 ± 6.2	5.5 ± 3.1
	---	59.3 ± 4.0	10.8 ± 2.6

[a]Corn scenario is the continuous corn while corn/switchgrass and corn/willow scenarios replace only corn in the buffer with one of the energy crops. The yields under scenarios two and three are for the energy crops in the buffer. The NO_3 and N_2O are area weighted values for the entire field and thus include areas still under corn.

[b]Top values are percent reductions when the buffer is under switchgrass and the bottom values under willow

PLANT GROWTH

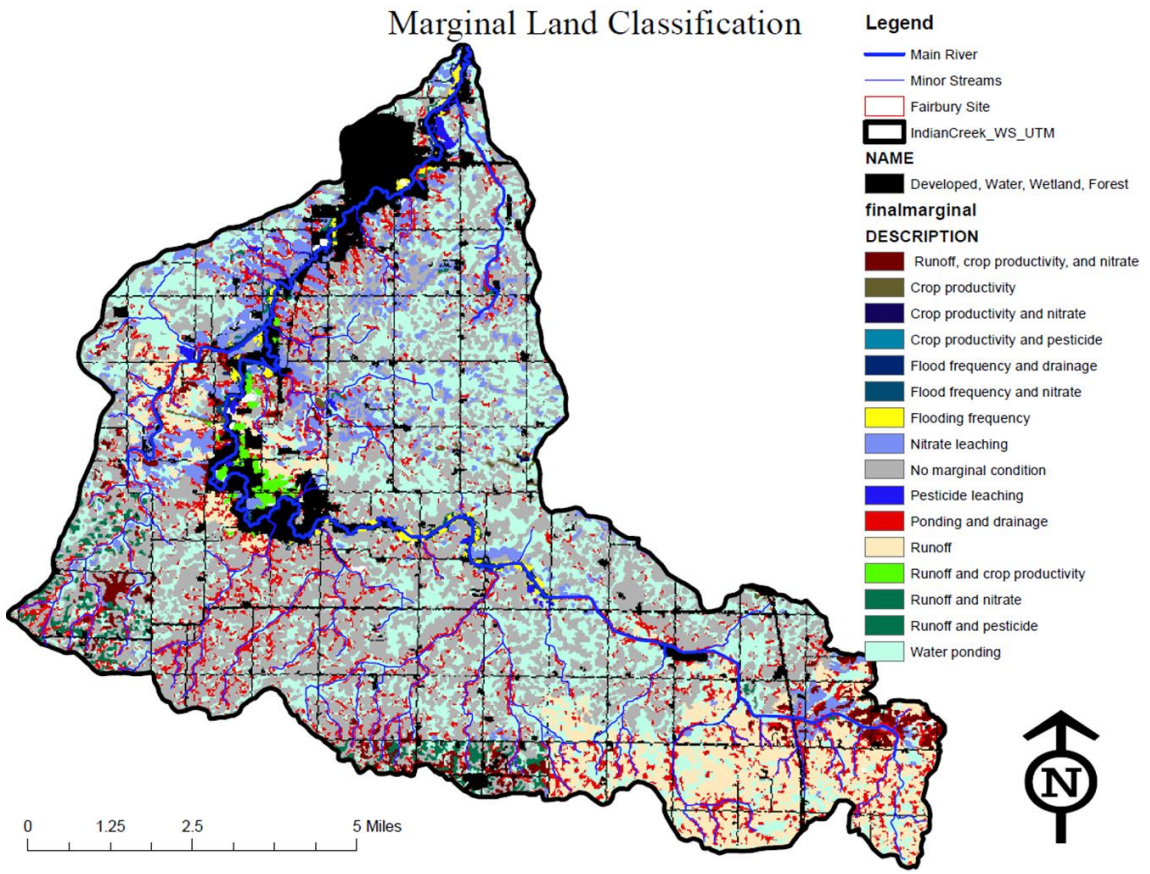


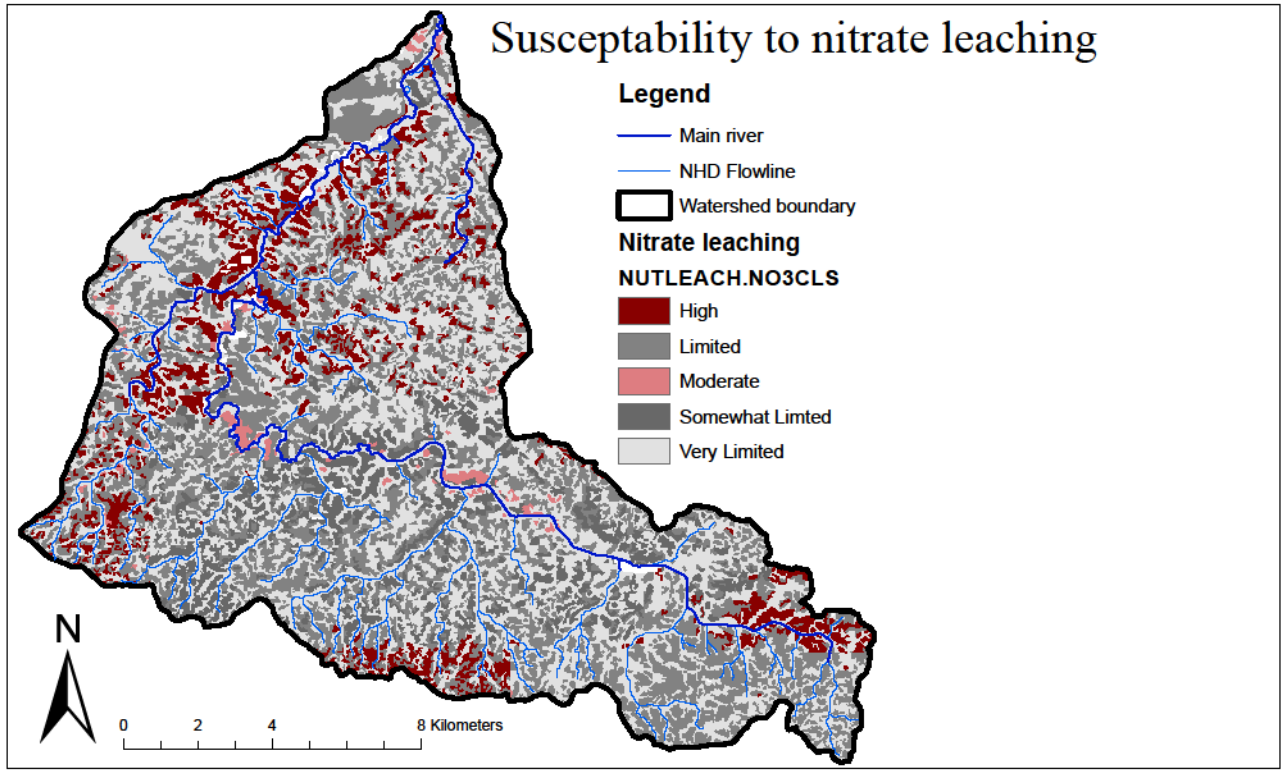


ENVIRONMENTAL MONITORING

SCALE UP TO WATERSHED

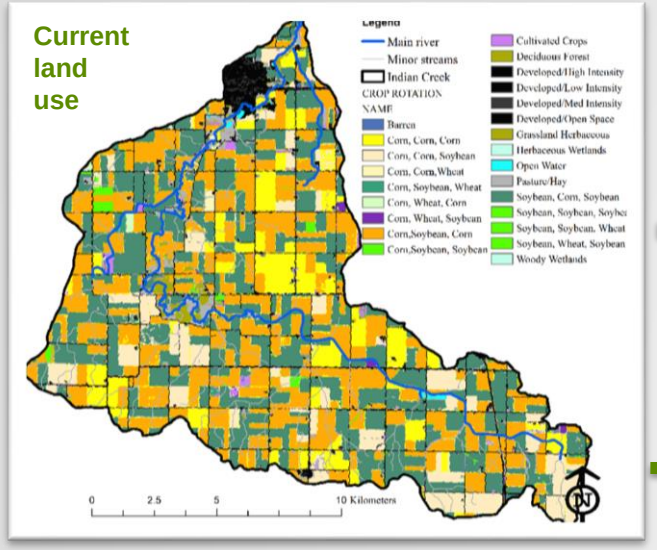
LAND PROPERTIES ARE A BASIS FOR WATERSHED DESIGN



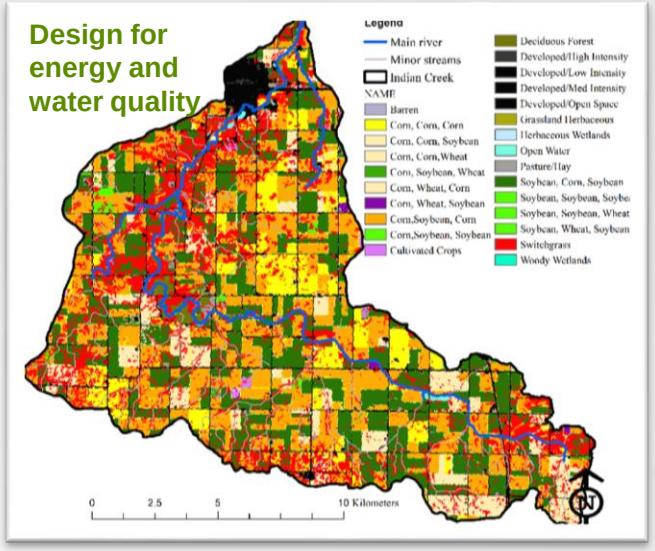


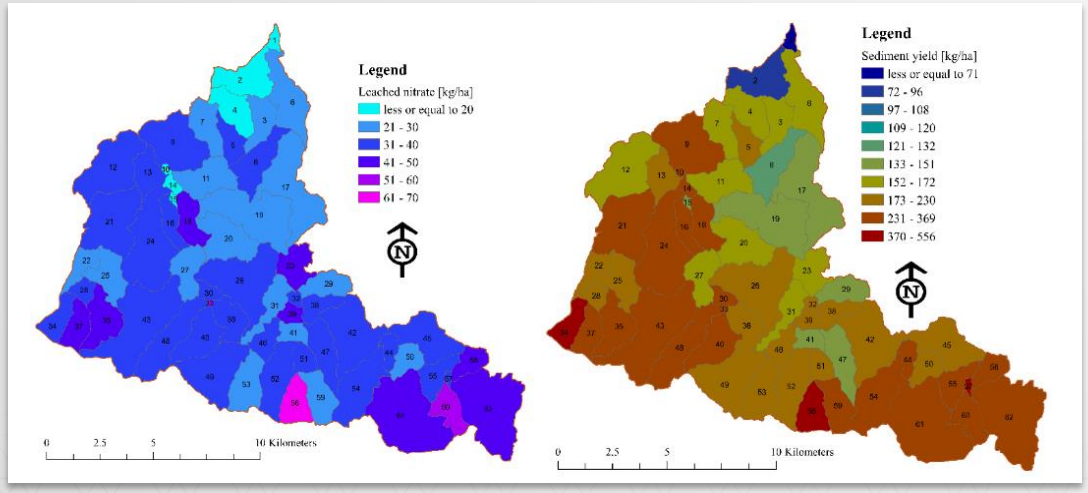
WATERSHED DESIGN

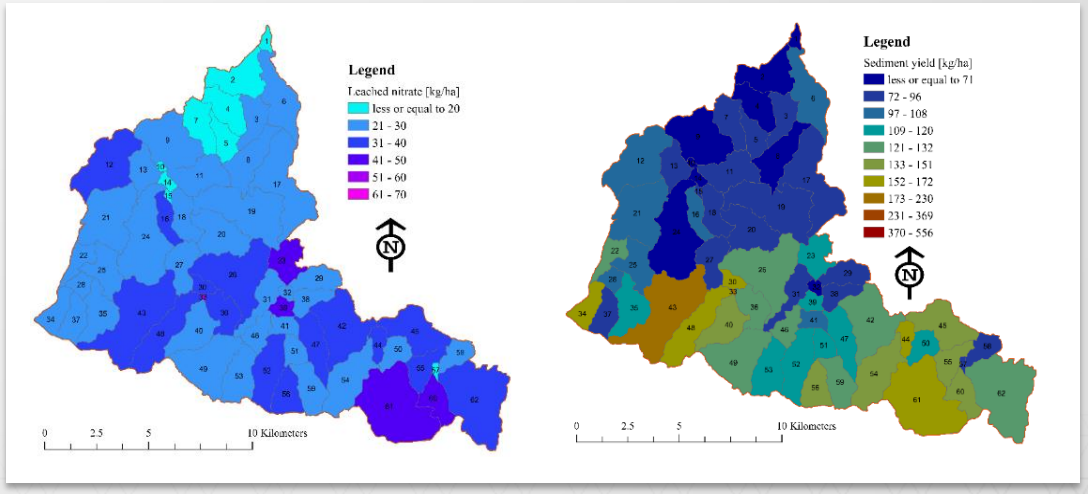
Current land use



Design for energy and water quality

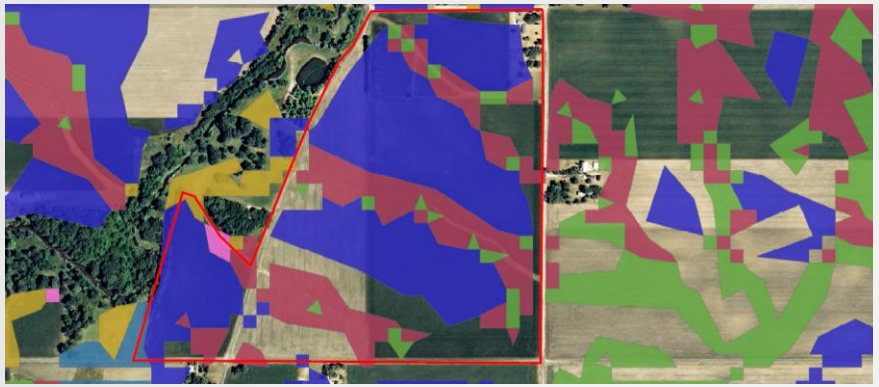


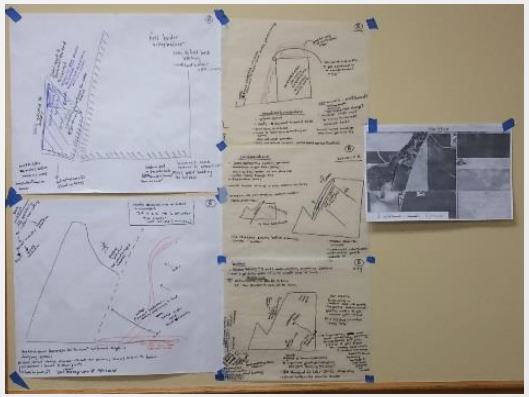




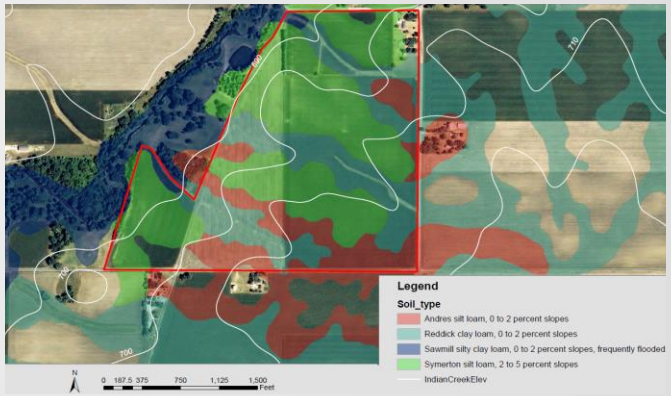
CREATING AN ENGAGED COMMUNITY OF STAKEHOLDERS GENERATES PRACTICAL SOLUTIONS

Field Conditions





Soil and Elevation Map



In collaboration with the University of Michigan

TAKE HOMES FROM A DOE WORKSHOP

POSITIVE OUTCOMES

- Landscape design to include bioenergy crops is a desirable way forward
- There is considerable knowledge from different disciplines that could be brought to fruition in an integrated effort
- Incentive structures may be the best avenue to bring this approach forward

OBSTACLES TO BE ADDRESSED

- Risks associated with growing bioenergy crops and implementing landscape design need to be reduced. Crop insurance for bioenergy crops??
- Market need market for the biomass producers generate.
- Uncertainty about the value of ecosystem services, tools for assessing them, productivity, logistics, and practicality.
- Land ownership issues. Short rental agreements may prevent the establishment of perennial rotations; however, large-scale management may enable some landscape design practices.
- Lack of incentives to minimize planting and/or fertilizing in areas that are risky or underproductive
- Biodiversity issues: unless landscape design could include polycultures, biodiversity will not increase — one monoculture will simply be substituted for another one.

RECOMMENDED ACTIVITIES

- Develop case studies
- Address supply chain obstacles
- Develop know how
- Promote broad partnerships and integrate research with broader stakeholder community

IT'S ABOUT TEAM WORK!

- Michael Barrows, Salman Ali, Samantha Fuchs, Allison Pillar and Irene Zhang
- Paul Kilgus
- Terry Bachtold –Livingston County SWCD
- Eric McTaggart, Livingston County USDA-NRCS
- Conservation Technology Information Center
- Gayathri Gopalakrishnan
- University of Michigan Nassauer Lab, John Graham
- The Indian Creek Watershed Project Leadership and Sponsors
- Eric Rund, Harold Reetz, and many others who provide realistic input.

Project sponsor: U. S. Department of Energy, Bioenergy Technologies Office