

# Landscape planning incorporates bioenergy crops for ecosystems services

Joint FAO-IEA Bioenergy Task 43 Workshop: Sustainable Landscape Management for Bioenergy and the Bioeconomy  
11-12 October 2018

Rome, Italy

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**Acknowledgement:** Kristen Johnson and Jim Spaeth, US DOE Bioenergy Technologies Office.

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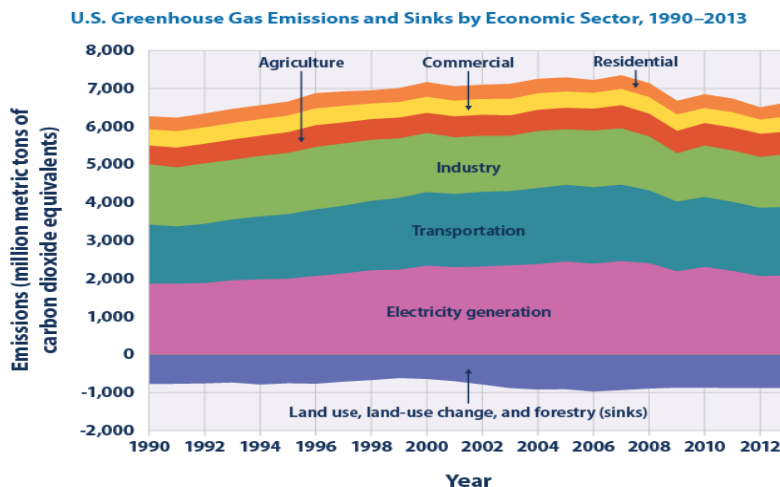
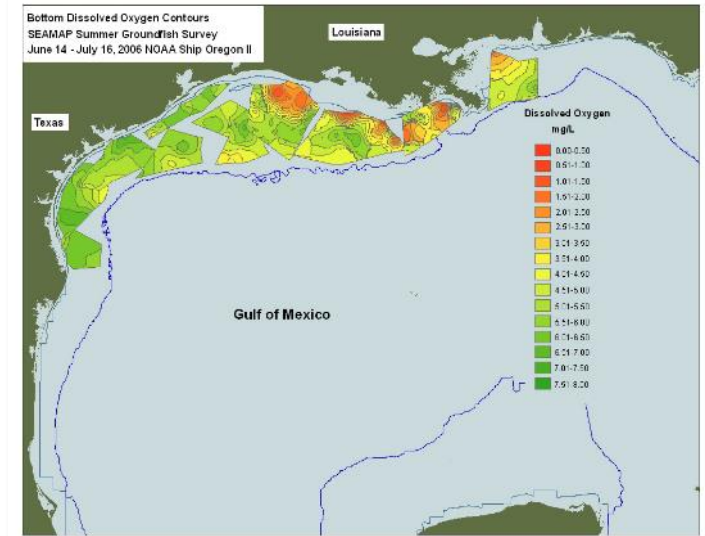
# Key questions

- How can feedstock production systems be located, designed & managed to increase efficiency and environmental benefits?
- How can environmental & economic outcomes be optimized to meet the goals of local stakeholders as well as those of broader society?
- Can analysis & assessment inform participatory processes by
  - Engaging landowners, policy makers, & other stakeholders in further developing?
  - Re-defining goals and plans for landscape management and designs?
- Two case studies in US Midwest (states of Illinois and Iowa)



# Agriculture's sustainability challenge

- Providing food, feed, fiber, & energy for a growing world population, while also:
  - Conserving soil, water & biodiversity
  - Reducing GHG emissions & other drivers of global warming
  - Providing resilience to a changing climate
- Meeting multiple needs of individuals and societies
- Addressing urbanization & losses of nutrients & prime cropland



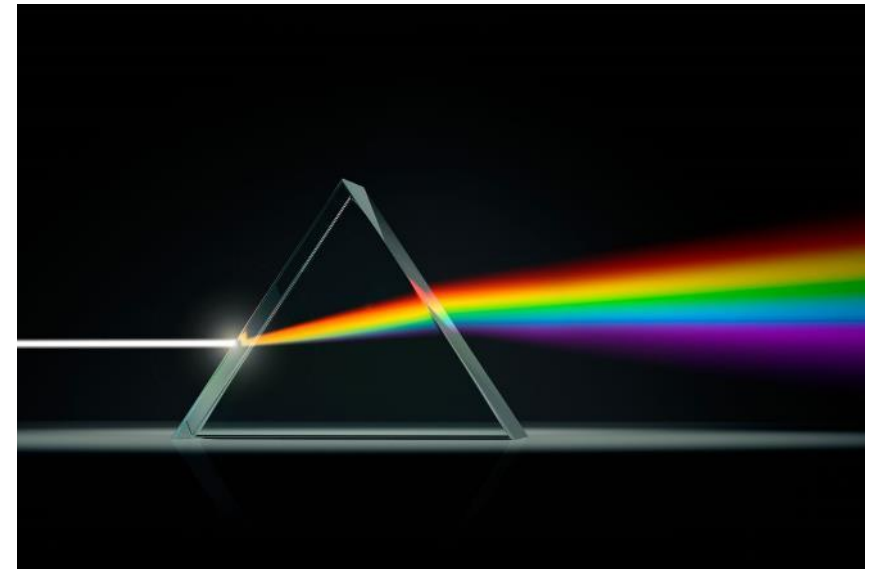
Source: U.S. Global Change Research Program [http://e360.yale.edu/feature/report\\_gives\\_sobering\\_view\\_of\\_warmings\\_impact\\_on\\_us/2166/](http://e360.yale.edu/feature/report_gives_sobering_view_of_warmings_impact_on_us/2166/)

Data source: U.S. EPA (U.S. Environmental Protection Agency). 2015. Inventory of U.S. greenhouse gas emissions and sinks: 1990-2013. EPA 430-R-15-004. [www.epa.gov/climatechange/ghgemissions/usinventoryreport.html](http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html).

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at [www.epa.gov/climatechange/indicators](http://www.epa.gov/climatechange/indicators).



# Towards a total economic valuation of landscape management



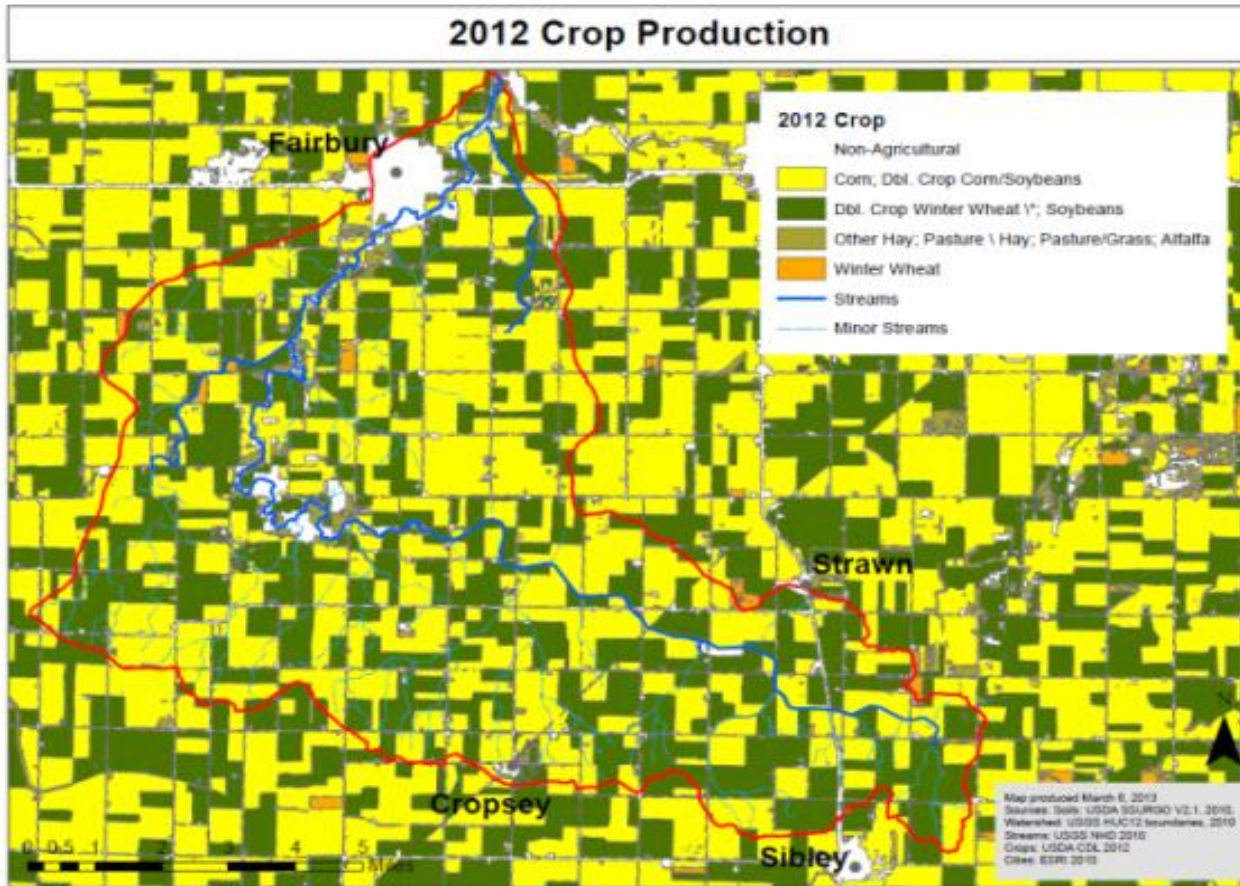
Evaluating  
damage

Preventing  
damage

Enhancing natural capital  
and human wellbeing



# Landscape design vs business as usual - meeting societal goals



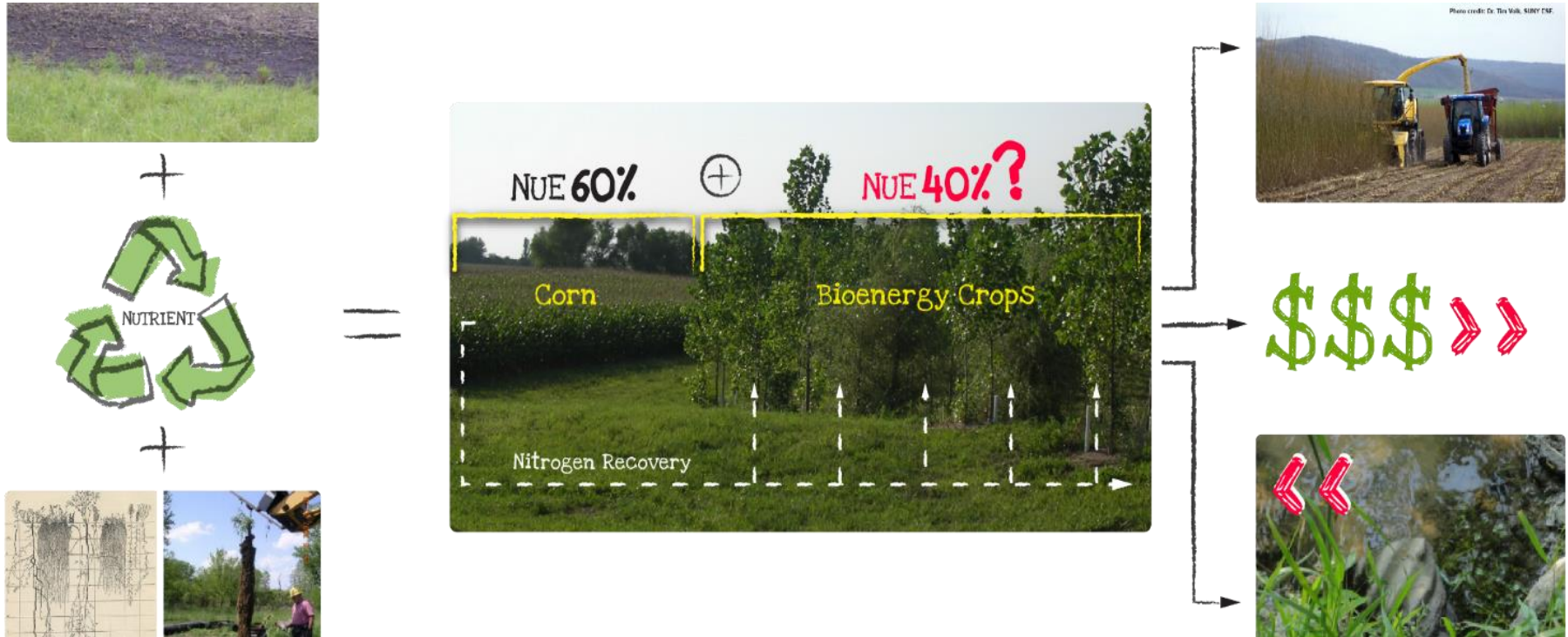
Business as usual  
focused on one  
*provisioning* service:  
yield

*Regulating* services not  
factored in economics -  
most environmental  
services considered  
“externalities”

*Conceptual focus* is  
how to mitigate  
negative impacts  
retroactively



# Landscape design vs business as usual - meeting societal goals



## Landscape design:

*Provisioning services* – optimize yields for multiple bioproducts

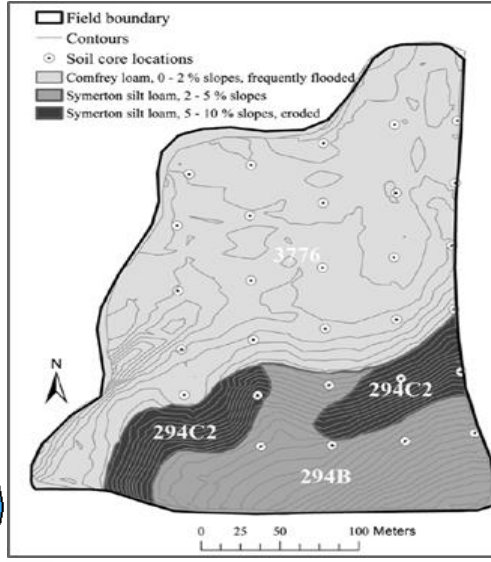
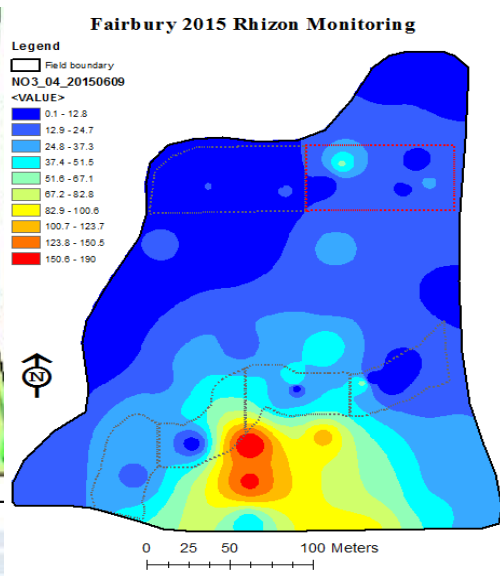
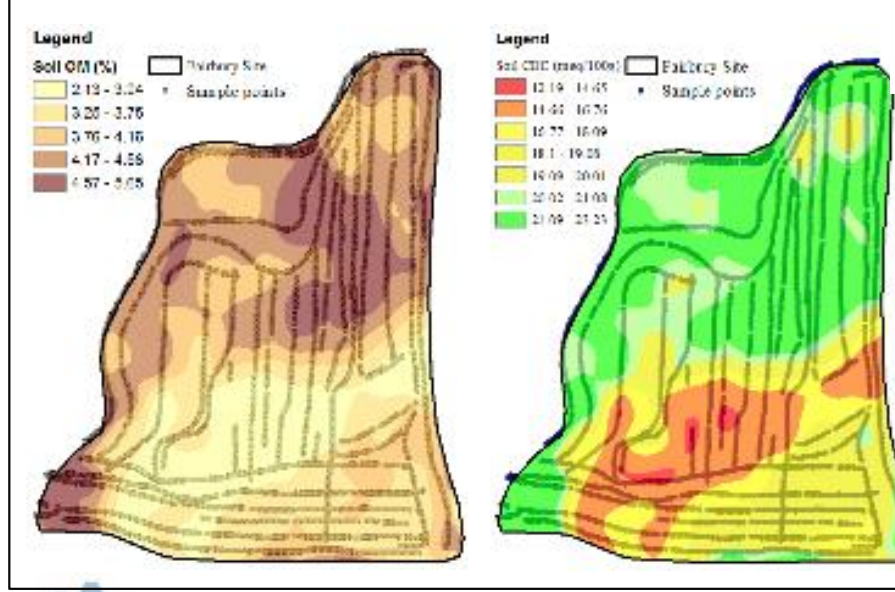
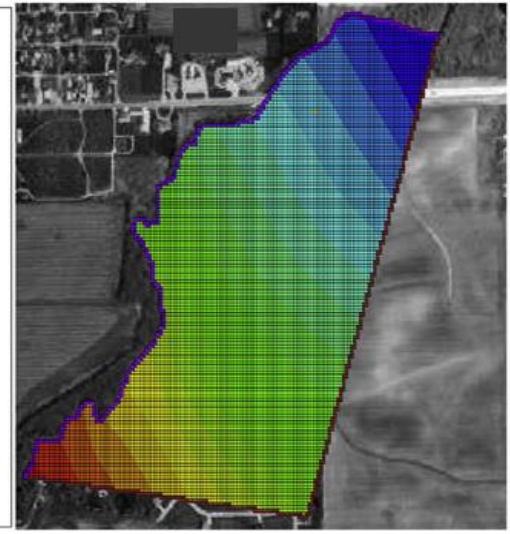
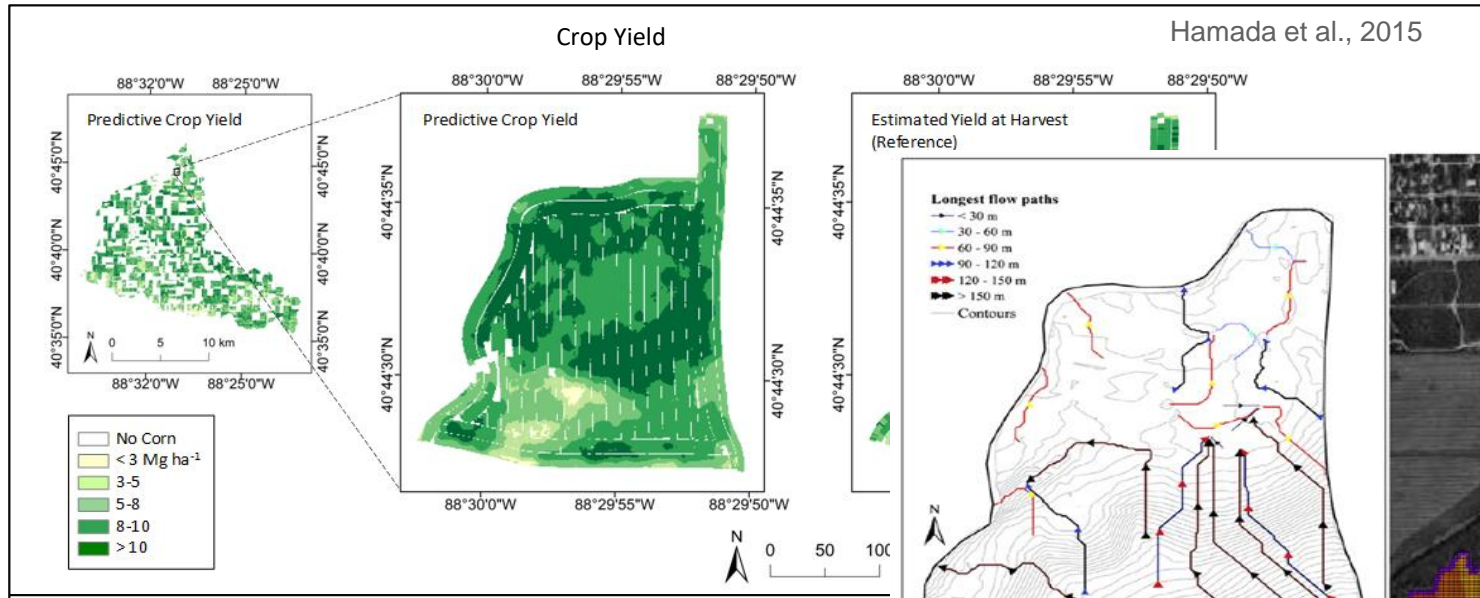
*Regulating services* – water, habitat, C-sequestration, GHG reduction, flood control, etc. (& economic valuation)

*Conceptual focus* – design to optimize provision of multiple services (rather than merely mitigate negative impacts)

# Understanding site conditions - opportunities and constraints



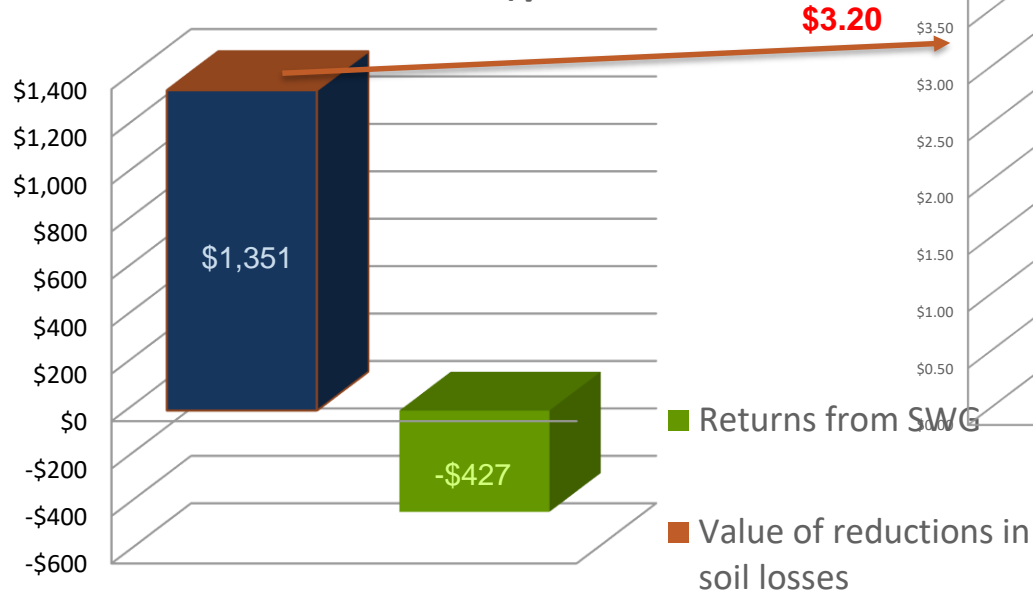
VERIS® soil mapping and image provided by Farm Map Solutions, LLC.



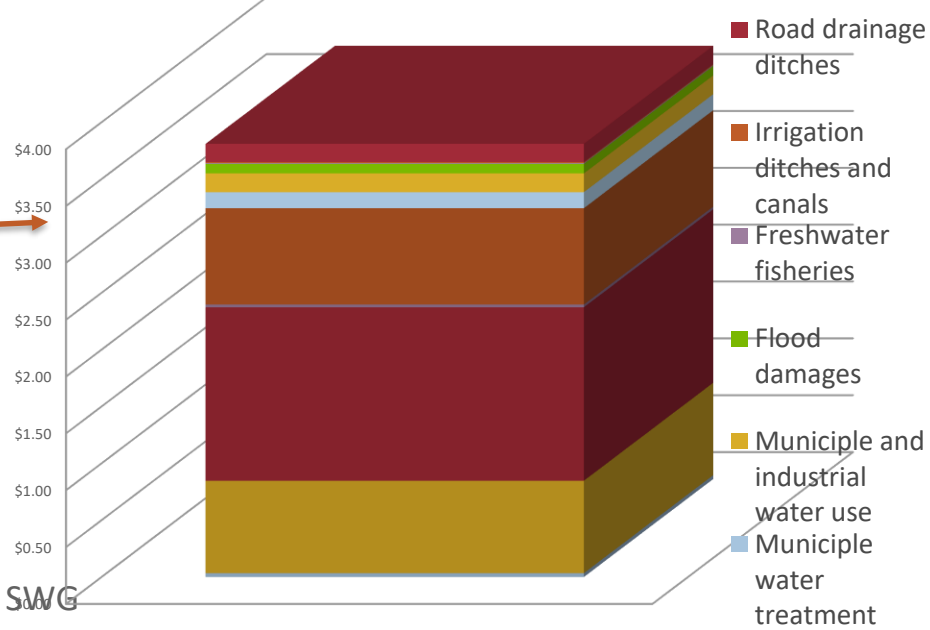


# Case study - landscape design for water quality and biomass production

Value of ES from reductions in nitrogen and soil losses \$/ha



Value of ES benefits from reductions in soil losses



Per hectare, losses from switchgrass production could be more than compensated by the value of the ecosystem services provided.

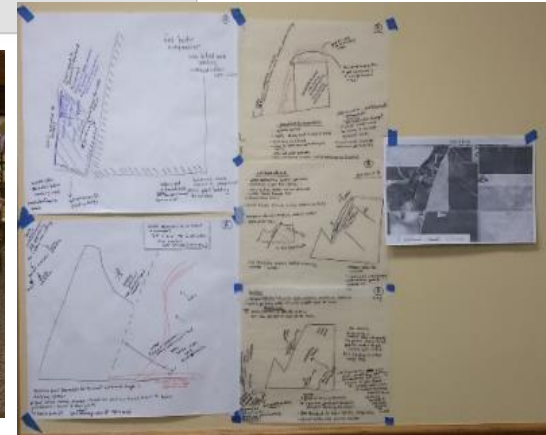
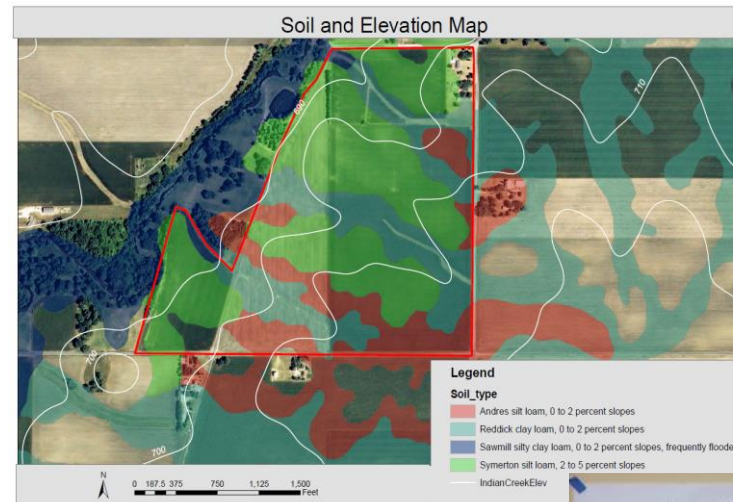
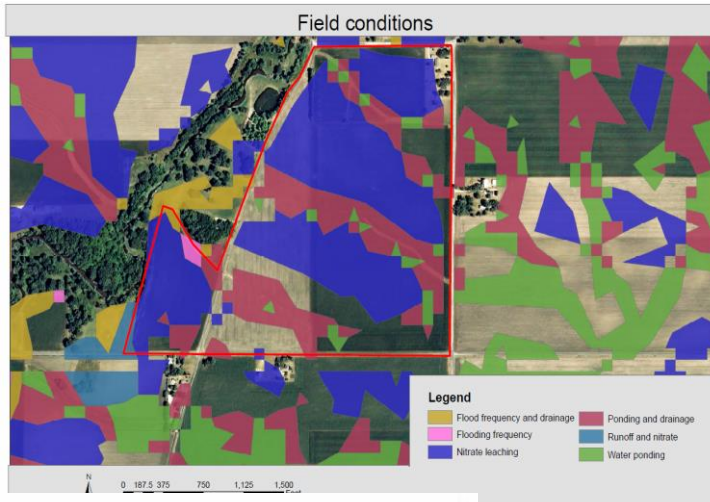


# Stacked Ecosystem Services

	Carbon sequestration	Nutrient Reduction (Cost of N removal)	Reduced GHG emission	Reduced sediment yield	Provide another commodity return	Increases biodiversity	Reduces water yield
Reduced N application							
Control drainage							
Bioreactors							
Wetlands							
Cover crops							
Strip tilling							
No till							
Spring N application							
Crop rotation							
Bioenergy/Forage crop integration							
Prairie STRIPS							



# Stakeholder meetings help identify practical and viable pathways



In collaboration with U. of Michigan, Nassauer Lab



## Case study #2: Challenges to expanding use of bioenergy to offset fossil-based energy using landscape design

- Deploying landscape designs that integrate energy production & other services
- Understanding, quantifying & communicating net benefits
- Public perceptions of “available & suitable” land to sustainably supply biomass for bioenergy



# “Reality is a special case”

- \* Dupont closed its refinery in East Tennessee
- \* Largest US biorefinery using cellulosic feedstock is the POET plant in Iowa
- \* Provides opportunity to iterate on approach



Poet-DSM Project Liberty

# Overview of Approach: working with partners to identify improved practices

Adoption of practices depends on credibility with land owners & managers & their willingness to change

*Quantify effects of integrating cellulosic bioenergy production in commercial production landscape*

Code for checks	
✓	Reviewed
✓	Tested in East TN
✓	Iowa landscape design



# Practical options to identify stakeholder priorities

- Literature reviews
- 3<sup>rd</sup> party surveys
- Legal proceedings
- Focus group meetings
- Local experts
- Interactive posters...

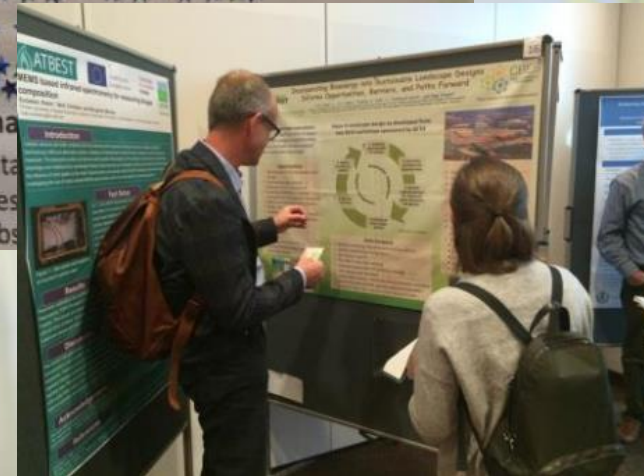
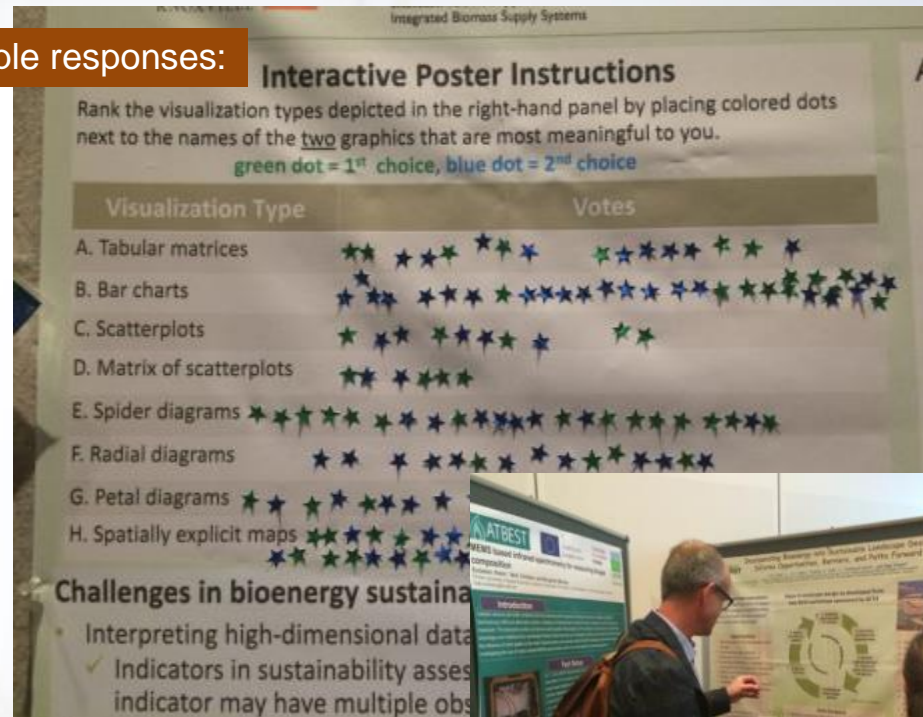


IEA Bioenergy

**Stakeholder consultation is challenging and costly.**

Dale VH, Kline KL. (2017) Interactive Posters: A valuable means for enhancing communication & learning about productive paths toward sustainable bioenergy. *Biofuels, Bioprod. Bioref.*

Example responses:



# Iowa case: information about stakeholders concerns & priorities collected via:

- Literature review
- Survey by Drake University
- Stakeholders meetings
- Project meetings
- Interviews with key stakeholders

Dale, Kline, Richard, Karlen, Belden (2018) Bridging biofuel sustainability indicators and ecosystem services through stakeholder engagement. *Biomass and Bioenergy* 114: 143-156.



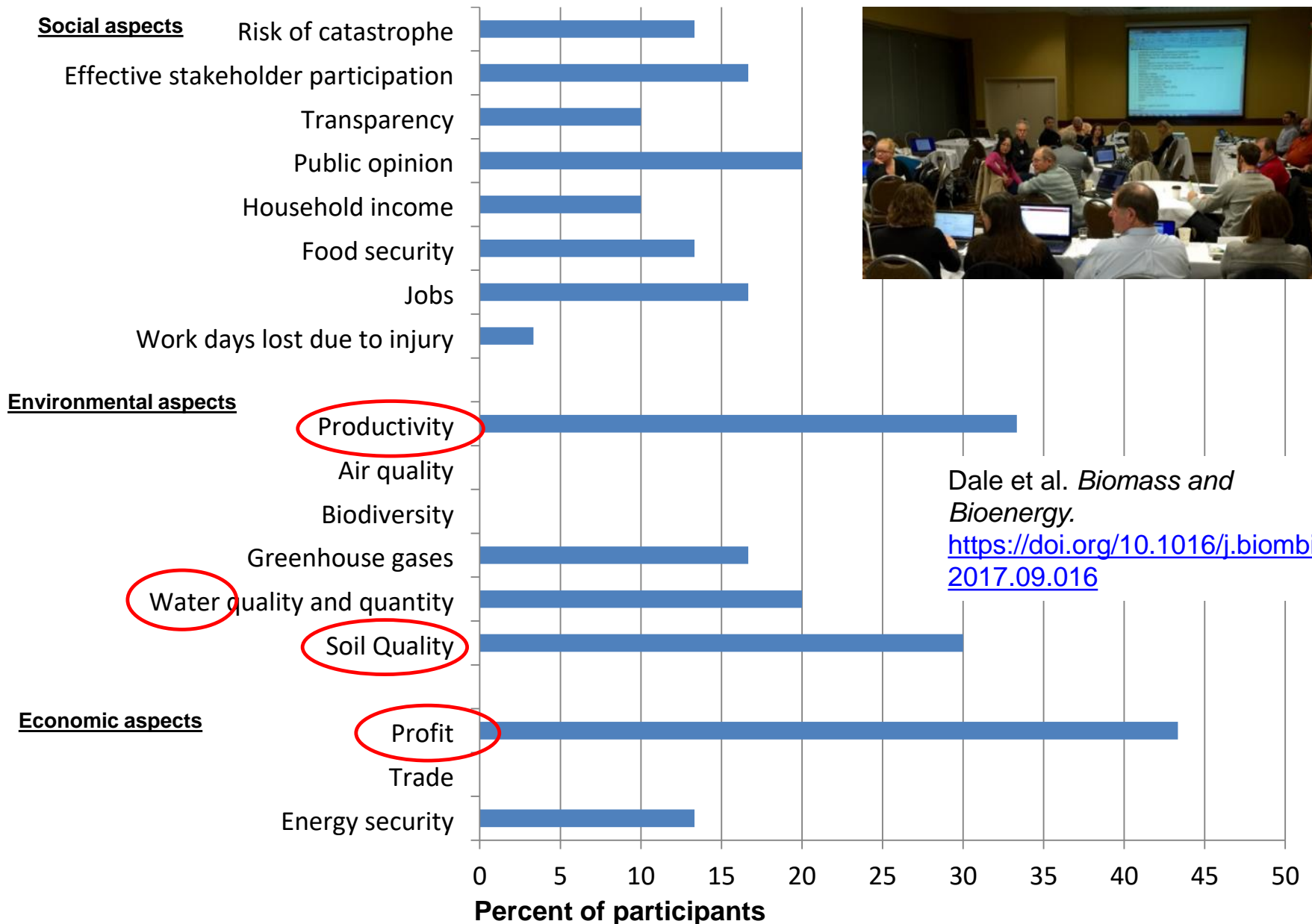
# Landscape Design for Sustainable Bioenergy Systems

## ORNL's focus

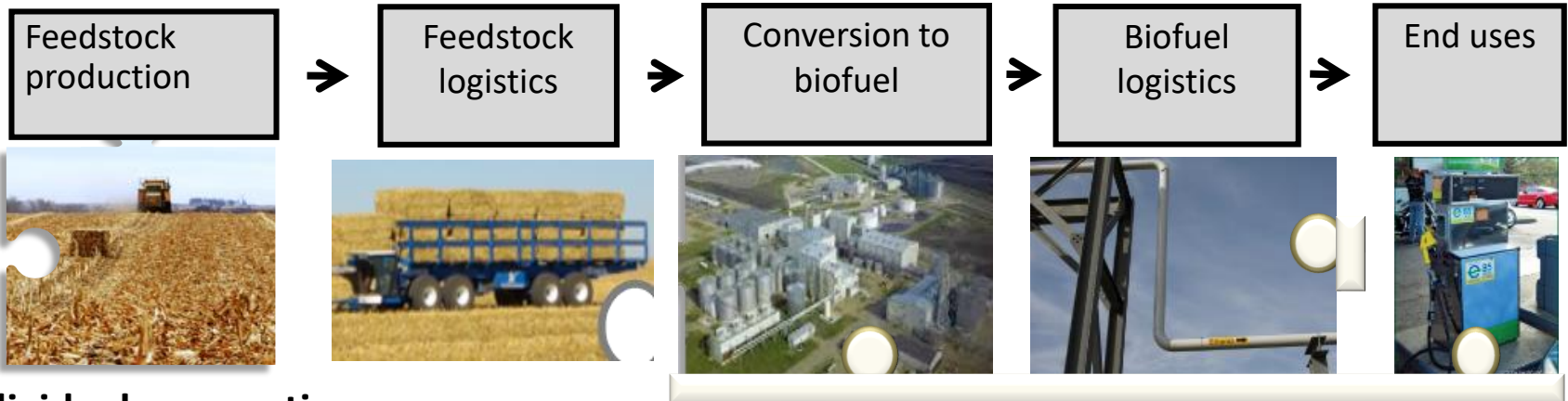
1. Multi-stakeholder landscape design process
2. Assessment of environmental sustainability indicators
3. Assessment of feedstock supply and logistics
4. Building a template for future biorefinery projects.



# Project meeting participants prioritize indicators



# Stakeholders associated with different parts of the agriculture to biofuel supply chain



## Individual perspective:

### Farmer's decisions:

- What to plant?
- Where to plant it?
- How to manage it

### Buyers' decisions-minimize costs:

- How to harvest & collect feedstock?
- How to process?
- How to store?
- How to transport?

### Plant mger's decisions:

- What process to use?
- What fuel type to produce?
- What co-products?

### Fuel logistics decisions:

- Where & how to transport?
- Where & how to store?

### End user decisions:

- What type of vehicle to buy?
- What blend of fuel to use?

## Cumulative perspective:

Land cover & use patterns & practices

Collection, processing, storage & movement of goods across the landscape

Distribution of conversion facilities across the landscape

Transportation & storage of biofuels for a region & the nation

National & regional choices of vehicles & fuels

# Conclusions

- Managing land for bioenergy can generate ecosystem services
- The value of ecosystem services could exceed that of biomass for energy
- Research can identify land-management practices that reduce risks & enhance benefits
- Stakeholders need to be involved & supportive of the process
  - Cooperatively map desirable outcomes
  - Identify practical solutions
  - Monitor results
  - Share in benefits



**Meeting future needs for food, energy, water  
& nature: When & where does land matter?**

**Always and everywhere**

**...focused on land management.**

**Let's discuss opportunities to make a difference**

# Thank you!

# Epilogue for scientists: Do we have the right tools for the job?

*"I used to think the top environmental problems were*

- *Biodiversity loss*
- *Ecosystem collapse*
- *Climate change*

*And thought science could address these problems... I was wrong.*

*The top environmental problems are greed and apathy, and to deal with those we need a cultural, spiritual transformation. Scientists don't know how to do that."*

*– attributed to Gus Speth*

Imagine If Trees Gave Off  
Wifi Signals, We Would  
Be Planting So Many Trees  
And We'd Probably Save  
The Planet Too.



Too Bad They  
Only Produce The  
Oxygen We  
Breathe.

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