

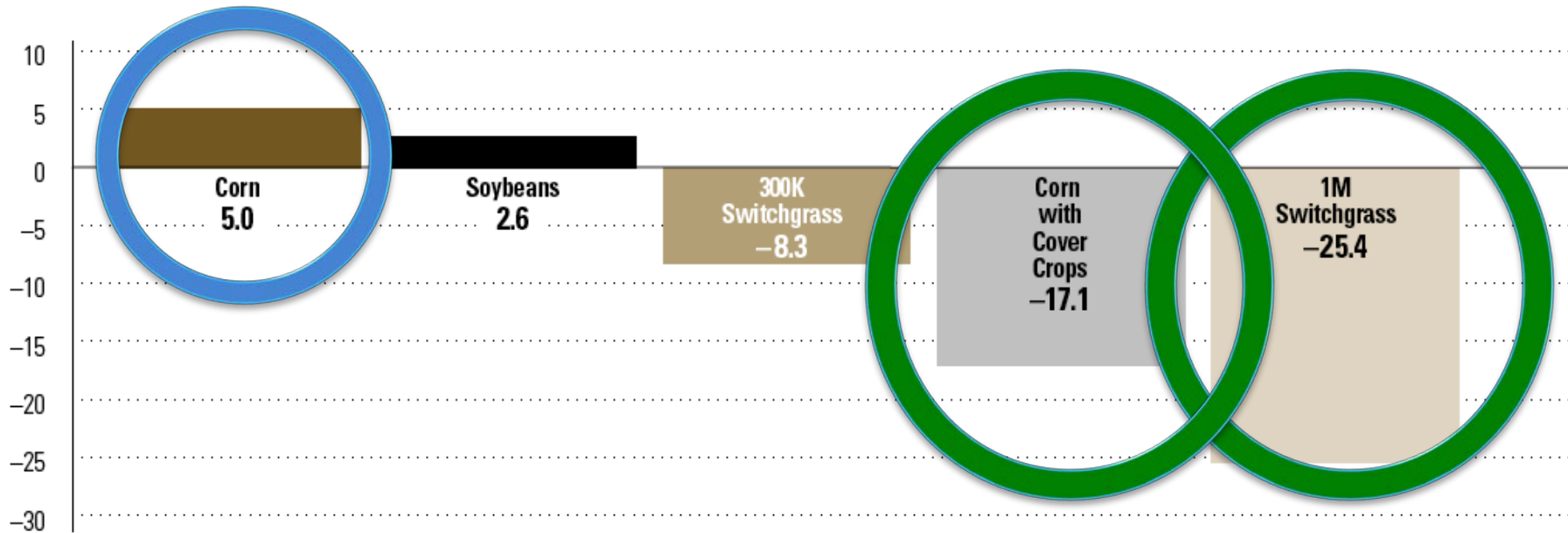
Chesapeake Biomass: Market-based Strategies for Water Quality

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Biofuels and the Bay – From 2008 to Today

Maximum Nitrogen Load Changes for Biofuels

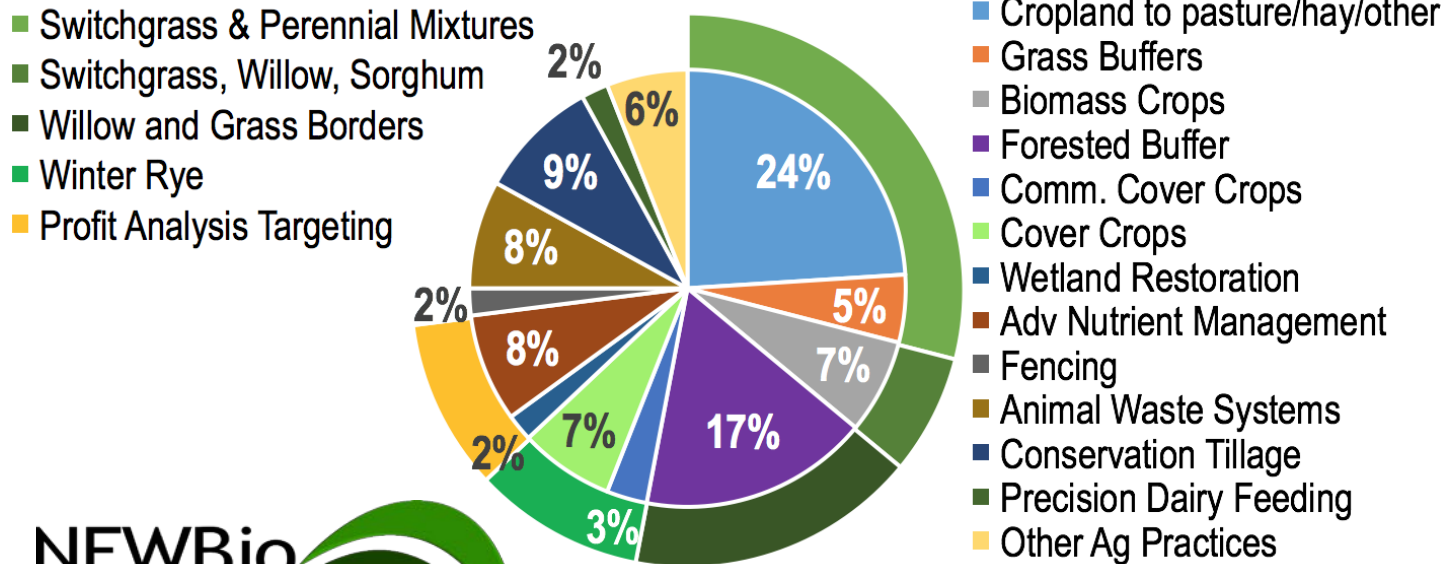
Millions of pounds per year of nitrogen delivered from the Chesapeake Bay watershed to the Bay under five modeling scenarios.



Assumptions for Alternative Scenarios:

- Corn:** 300,000 additional acres of corn with typical levels of management practices
- Soybeans:** 300,000 additional acres of soybeans with typical levels of management practices
- 300K Switchgrass:** 300,000 acres of switchgrass, converted primarily from hay and pastureland, with no fertilization
- Corn with Cover Crops:** Cover crops on all existing and new (additional 300,000) corn acres and one quarter of all other row crops, watershed-wide.
- 1M Switchgrass:** 1 million acres of switchgrass, converted primarily from hay and pastureland, with no fertilization

Mapping Biomass to Water Quality



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Challenges for Conservation Plantings

- * Farmers don't want to give up cropland
- * Planting perennials is expensive
 - * (Current program subsidies not sufficient)
- * Lack of incentives and insurance for perennial crops
- * Cover crops release nitrate in spring
- * Phosphorus becomes more bioavailable in buffers (Dodd and Sharpley 2016)

Working Buffers – by the numbers

- * The Chesapeake Bay Watershed has 181,440 miles of streams and rivers.
- * WIPs require vegetative buffers for 70% of streambanks and shorelines. Currently at 58%. The difference represents 22,000 miles of new buffers.
- * At 900 miles per year, this will take decades
- * Each mile of two-sided 35 foot buffer = 8 acres.
- * This represents 7,200 acres removed from production, and over 175,000 acres eventually – at \$400/acre the lost revenue totals \$70 million/year.
- * In contrast, 100 foot wide market-based buffers could produce 250 million gallons of biofuel, with revenue of >\$1 billion/year for rural communities.



Chesapeake Biomass Initiative

Key questions:

- * Why would farmers plant biomass crops?
 - * Is it more profitable than existing crops?
 - * Is it easy to manage and market?
- * Why would businesses buy biomass?
 - * Is it less expensive than current feedstocks?
 - * Are there logistics or scale advantages?
- * What are the water quality benefits if they do?
 - * Are there ways to monetize those benefits?
- * Can a market-based solution succeed?

Existing Regional Markets

Fiber

- * Mushroom Compost – 250,000 tons/year current demand
- * Poultry Bedding
- * Stormwater erosion control

Energy:

- * Pellet Mills: Ernst Conservation Seeds
- * Biomass Boilers: St. Mary's
- * Fuels to Schools: Hughesville, Penns Valley
- * Biomass Power Plants – ReEnergy, Lockheed Martin in Owego NY, Evergreen Power in Reading, PA

Future Regional Opportunities

Aviation and Military Biofuels:

- * Renmatix, global headquarters in King of Prussia, PA, partnering with Amyris Biotechnologies and Total to make jet fuel from cellulosic biomass.
- * Delta, operating a former Conoco-Phillips refinery in Trainer, PA. Capacity: 3 billion gallons/year
- * The Navy's Great Green Fleet
- * Naval Station Norfolk
- * BWI, Dulles, Philadelphia Airports



Other:

- * Applied Biorefinery Sciences, CoolPlanet, Enchi, AgriTech
- * Tranlin, building a \$2 billion pulp mill in Chesterfield, VA
- * American Refining Group – biolubes in Bradford, PA



Conservation Feedstock: Shrub Willow



Conservation Feedstock: Perennial Grasses



~~Perennial~~ Annual Biomass Crops

Winter Rye

- * High uptake of N
- * Highly digestible
- * No conflict with food production



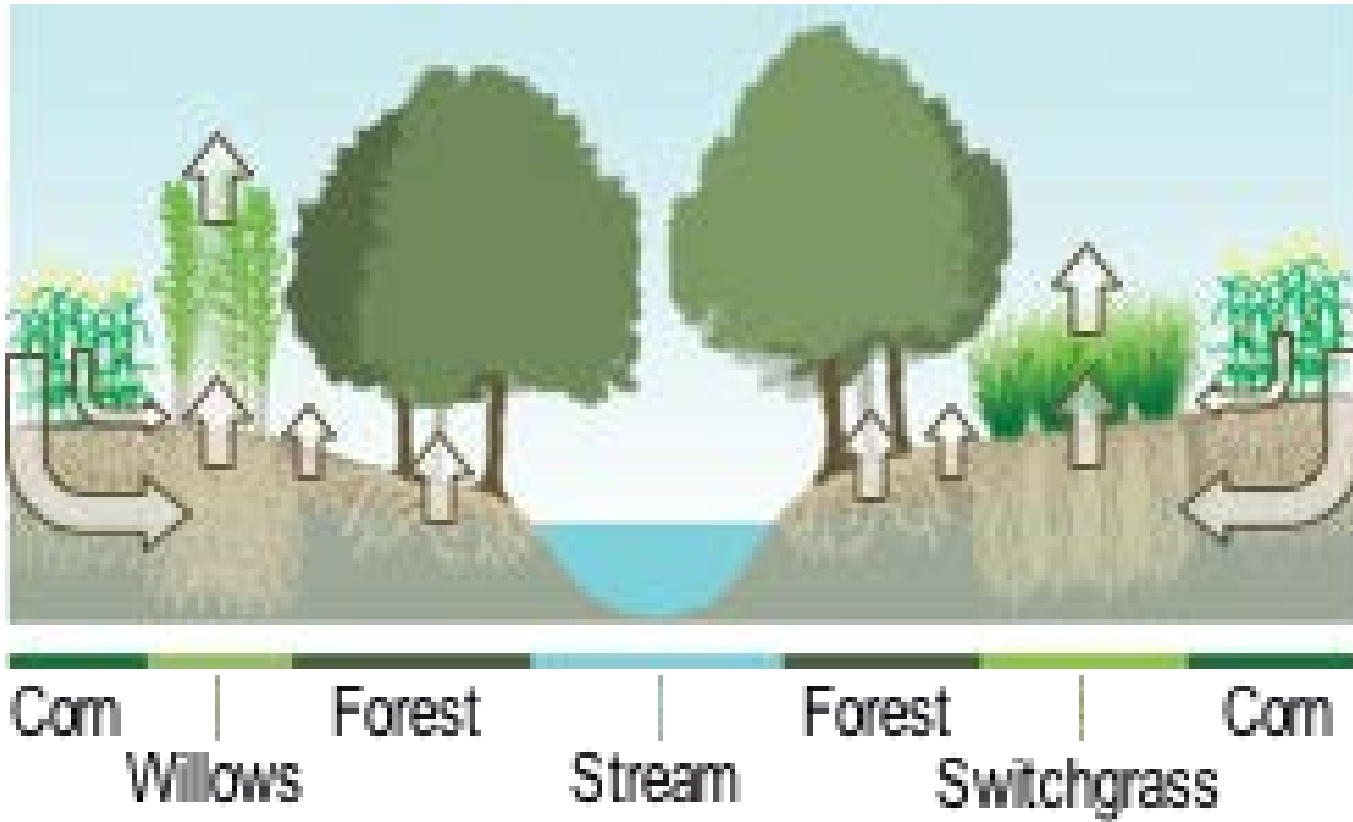
Biomass Sorghum

- * High uptake of P
- * Rotate with other summer annuals
- * Use as bedding before producing energy



- * Both also with multiple bioenergy/biofuel/biomaterial projects!

Integrated with Forest Buffers



Integrated with Annual Crops



Biomass
Sorghum

Corn

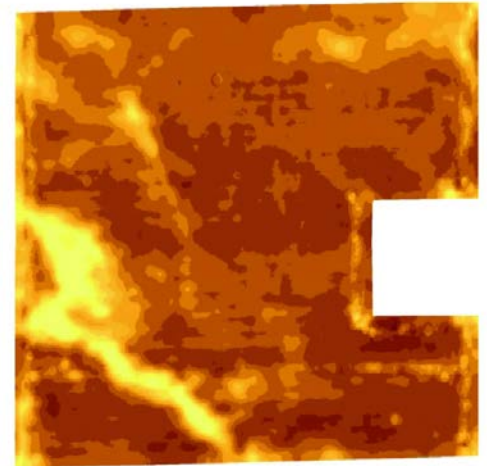
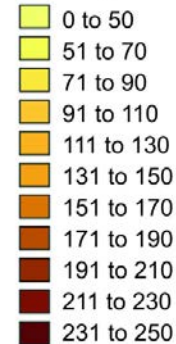
Corn
Stubble

Winter Rye
Stream

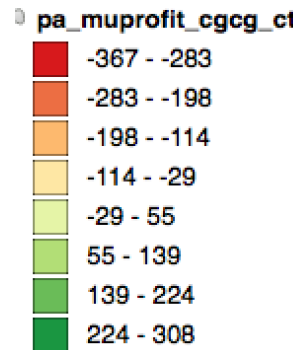
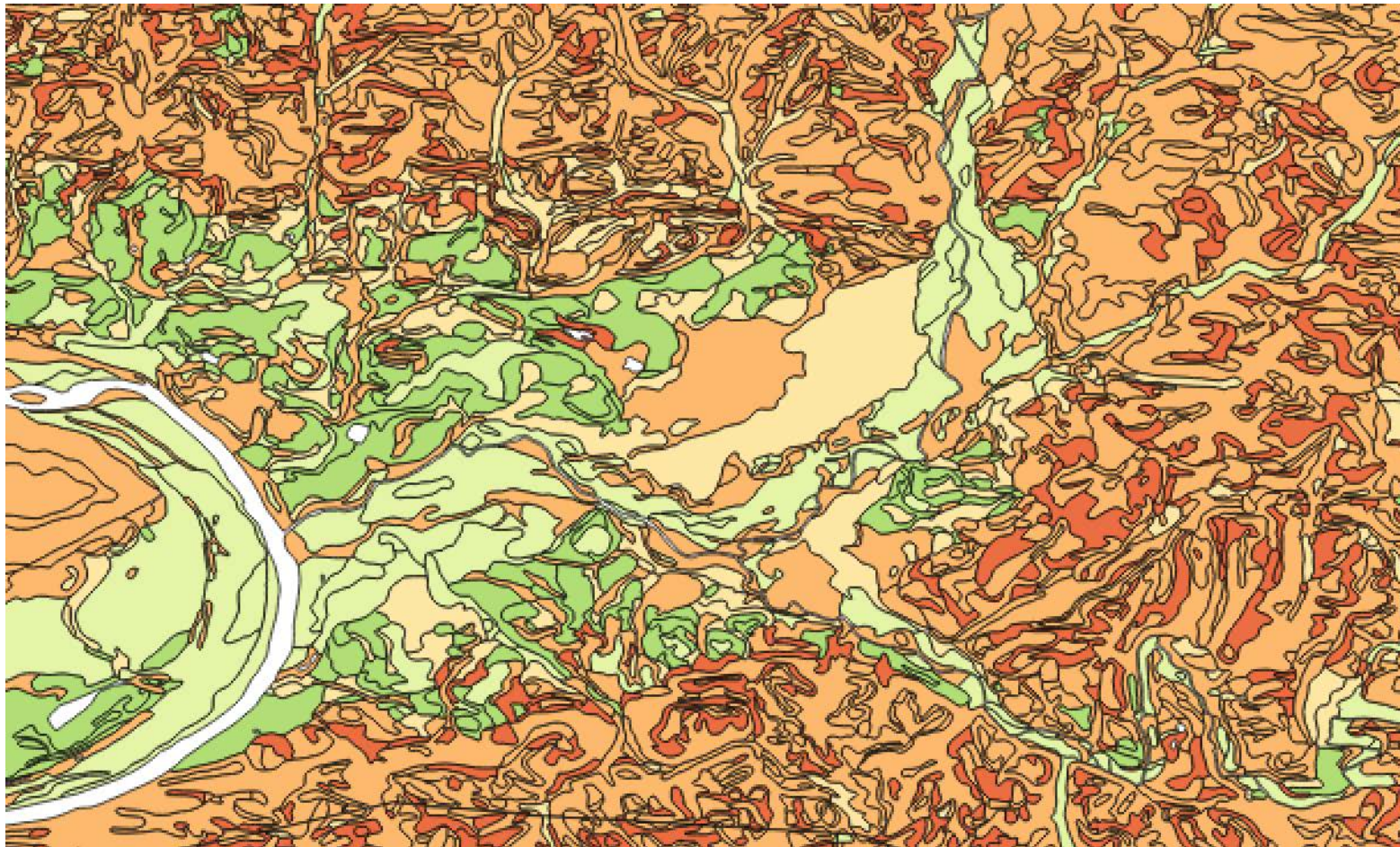
Yeoman Farmer meets The Internet of Things: Sub field economic analysis

- * Since the dawn of agriculture, farmers have managed the landscape as fields. These fields were once small, but now are large. And they are far from uniform.
- * Farmers have traditionally assessed profitability on the basis of a whole field. Precision agricultural tools allow much higher resolution. That knowledge now allows sub-field profit management.
- * Key question: To what extent do economically marginal regions of fields overlap with environmentally sensitive parts of the landscape?

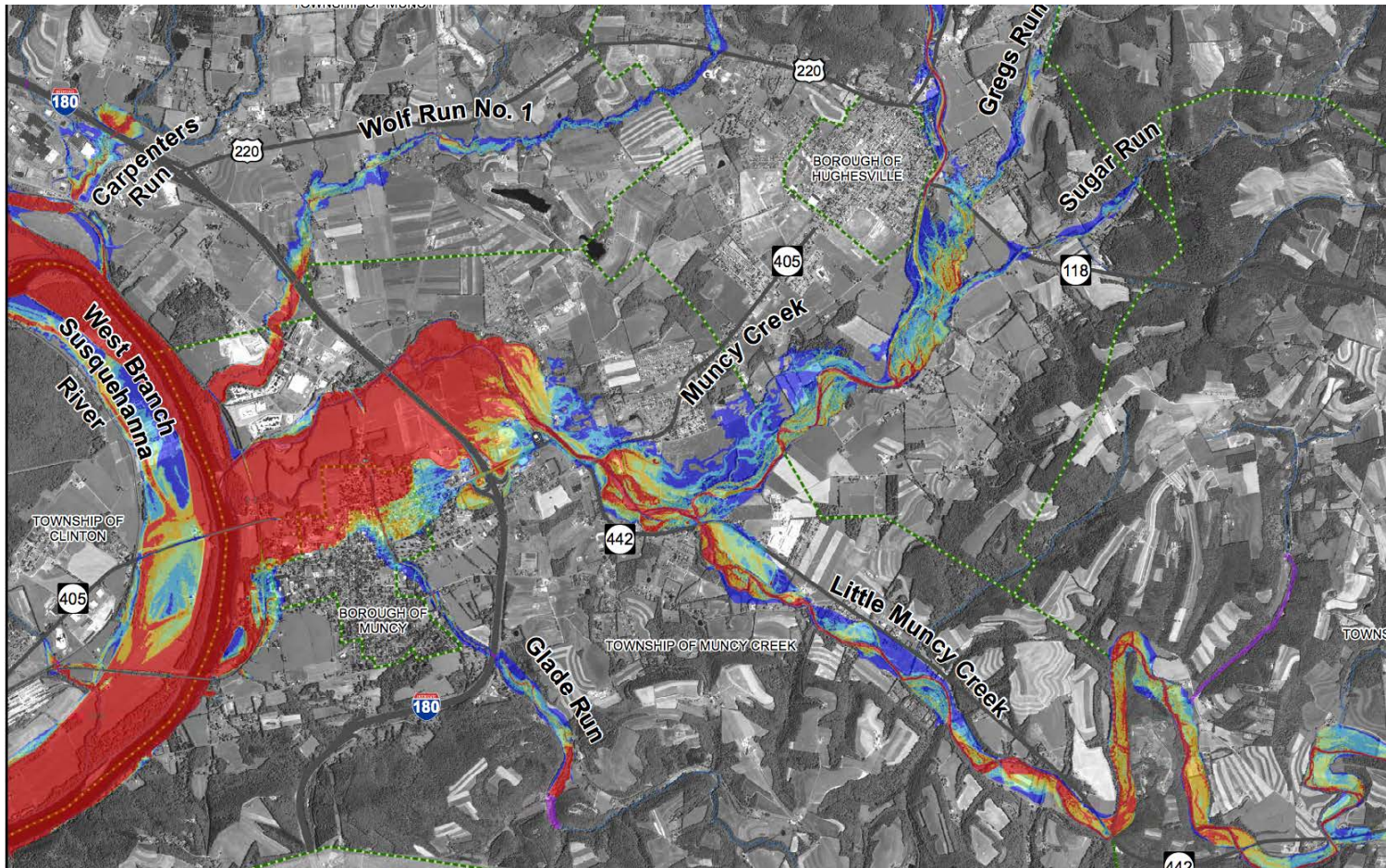
Grain yield
(bu ac⁻¹)



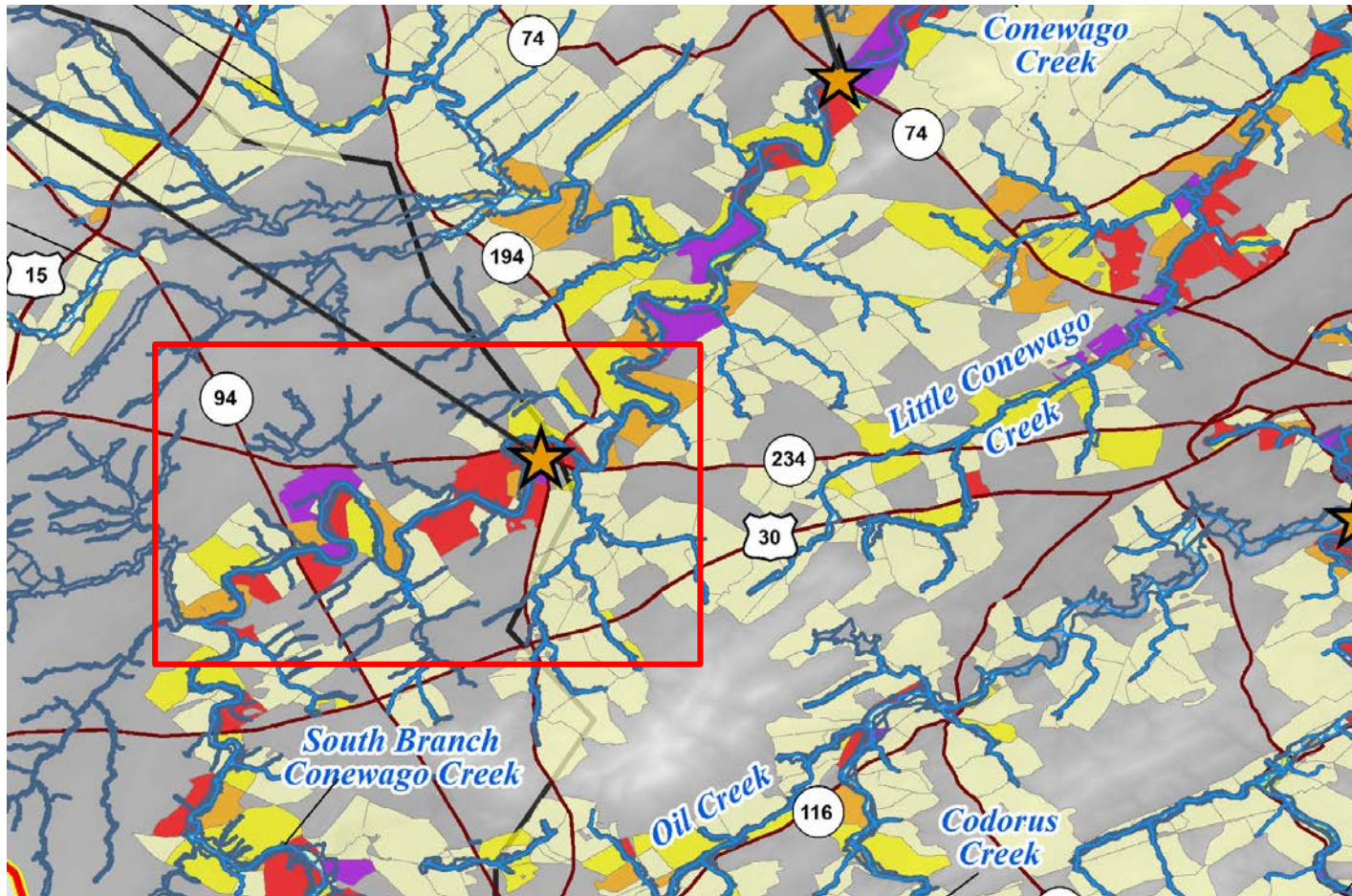
Sub-field profitability based on soils...



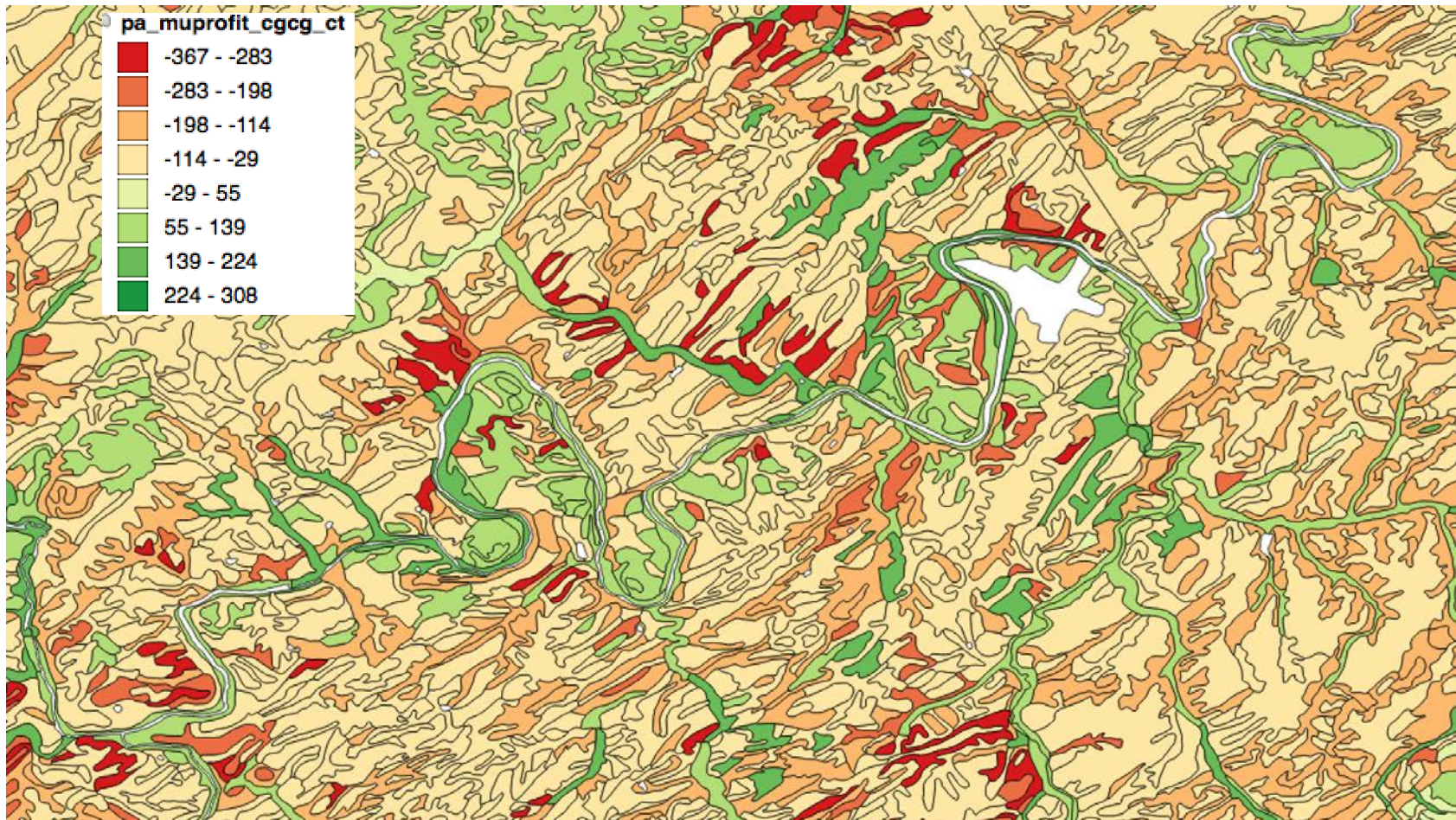
Flood risk vulnerability increasing



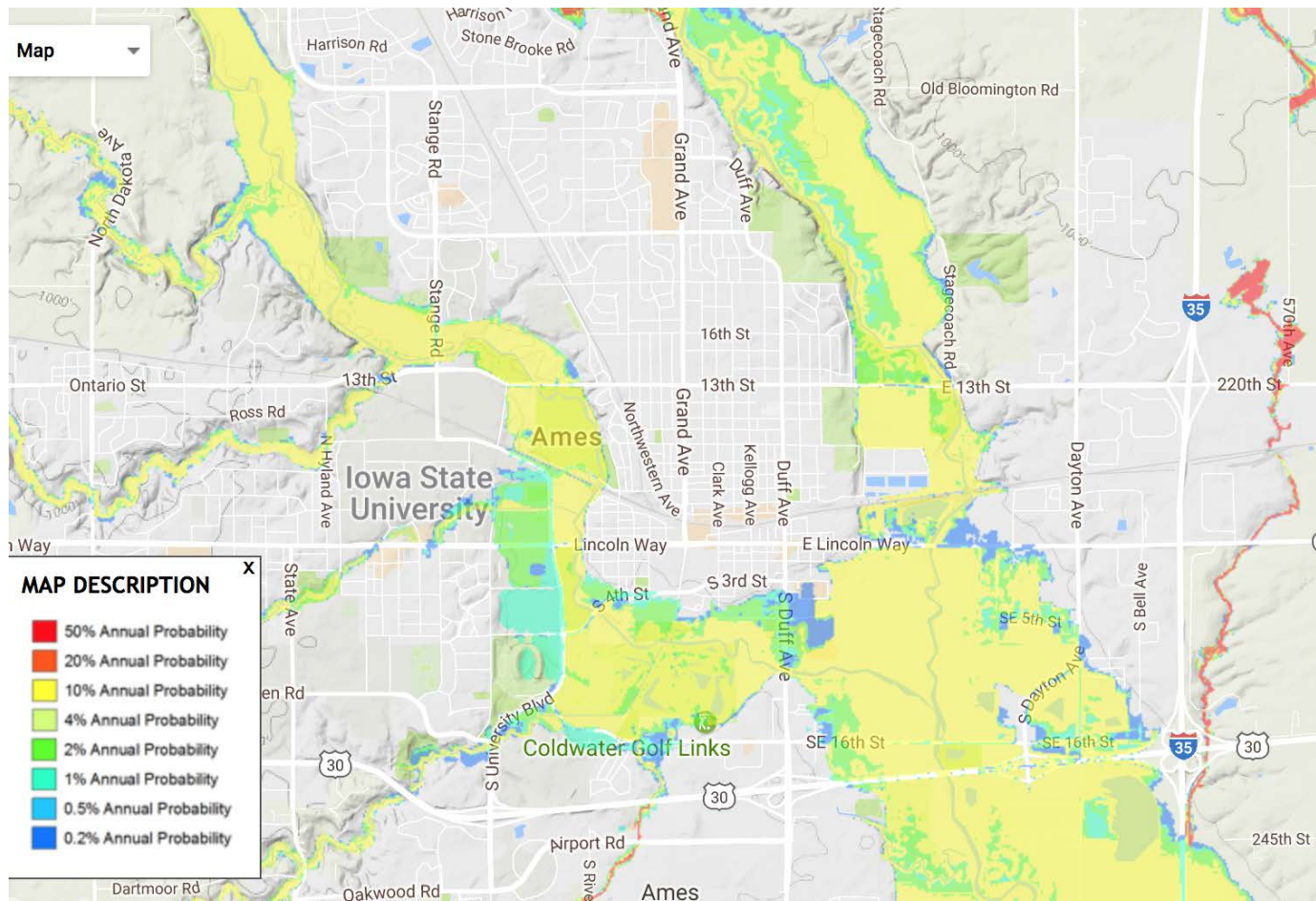
Losses!?! Tropical Storm Lee – 9/8/2011



Sub-Field Profitability needs Soils plus... hydrology, risk and resilience

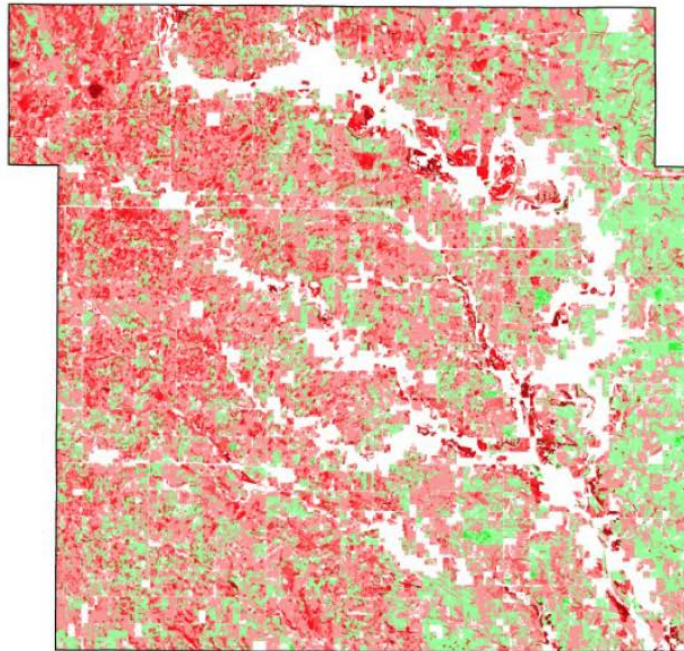


Predicting Flood Probabilities

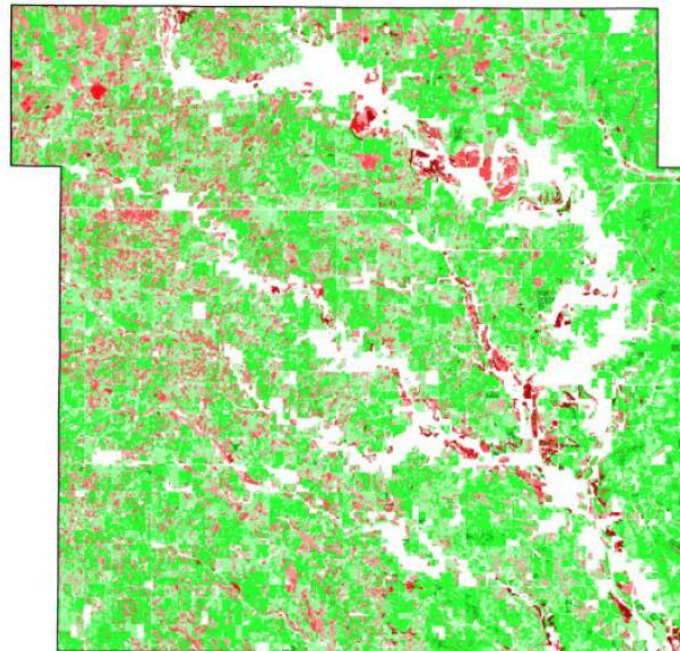


Sub-field Profit Analysis in Iowa

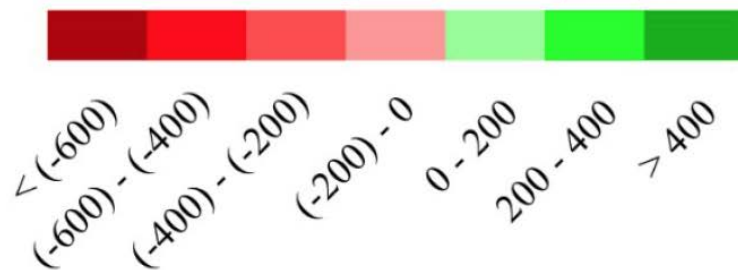
0.18 \$/kg Grain Price



0.20 \$/kg Grain Price



6-Year Average Net Profit (\$/ha)



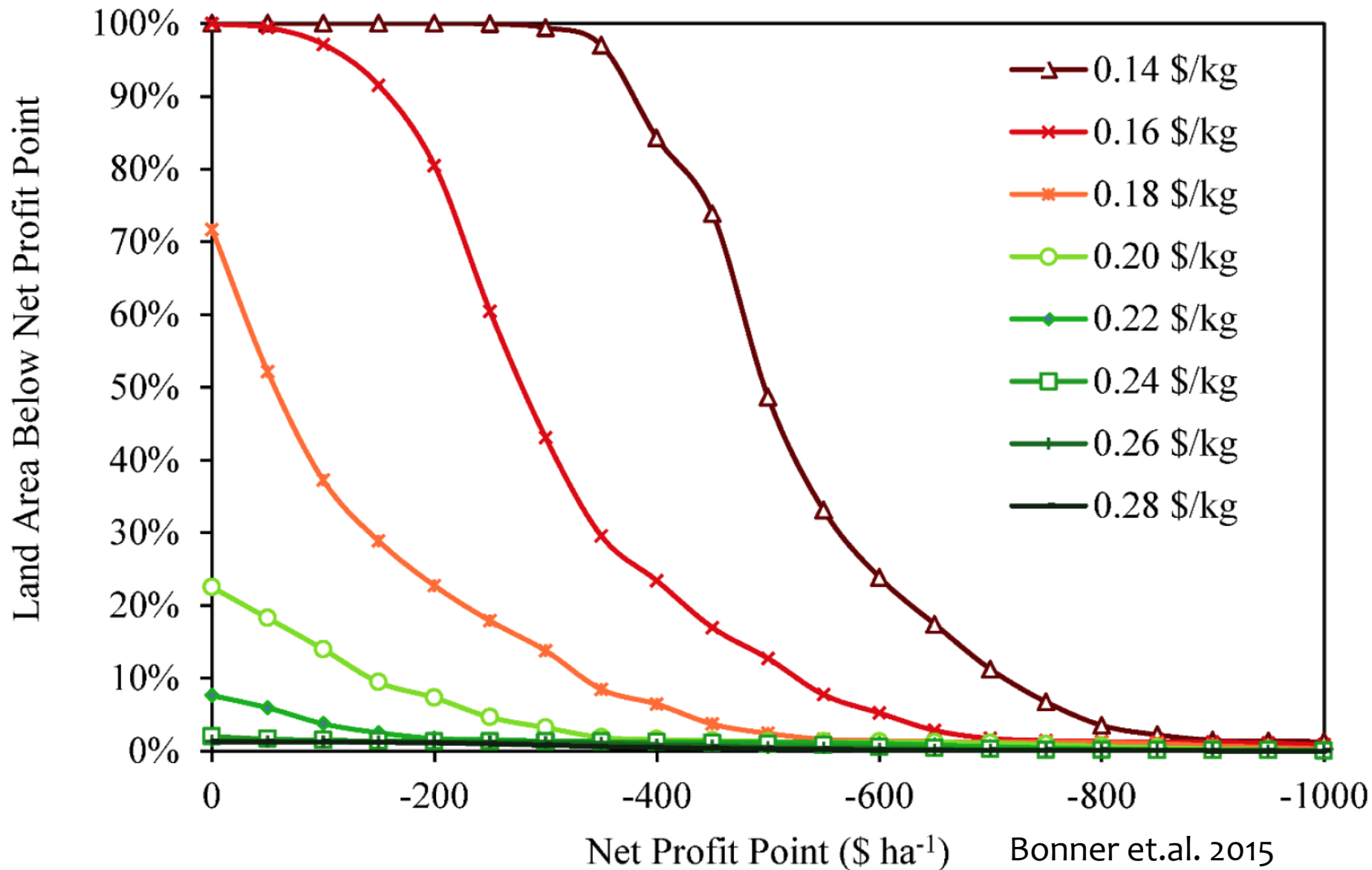
Converting the 0.20 \$/kg red regions from corn to switchgrass nearly doubles biomass tonnage

Price and Profit Variability



SOURCE: WWW.TRADINGECONOMICS.COM | CBOT

Figure 4. Area within Hardin County, Iowa operating at or below a range of six year average net losses based on varied corn grain price.



Bonner et.al. 2015

Saving Money by Growing Biomass

County Level Statistics	Net Profit Decision Point ($\text{\$}\cdot\text{ha}^{-1}$)						
	0	-100	-200	-300	-400	-600	None
Corn Stover Availability, $\text{Mg}\cdot\text{year}^{-1}$	182,000	193,000	206,000	213,000	217,000	217,000	217,000
Switchgrass Availability, $\text{Mg}\cdot\text{year}^{-1}$	250,000	149,000	73,000	29,000	12,000	9,000	0
Total Biomass Availability, $\text{Mg}\cdot\text{year}^{-1}$	432,000	342,000	278,000	241,000	228,000	226,000	217,000
Mass Fraction Corn Stover	42%	57%	74%	88%	95%	96%	100%
Mass Fraction Switchgrass	58%	43%	26%	12%	5%	4%	0%
Annual Biomass Increase ^a	99%	58%	28%	11%	5%	4%	-
Land Conversion	22%	14%	7%	3%	2%	1%	-
Fields Affected	85%	74%	57%	30%	16%	15%	-
Mean Field Level Area Change ^b	25%	18%	12%	10%	10%	9%	-
Mean Field Level Profit, $\text{\$}\cdot\text{ha}^{-1}$ ^c	198	174	151	134	127	125	113
Field Level Profit Std.Dev, $\text{\$}\cdot\text{ha}^{-1}$	92	127	157	175	183	185	205
Profit Variance Between Fields	49%	39%	36%	37%	38%	38%	41%
Profit Variance Within Fields	51%	61%	64%	63%	62%	62%	59%
Reduction in Total Profit Variance	78%	65%	50%	36%	28%	25%	-

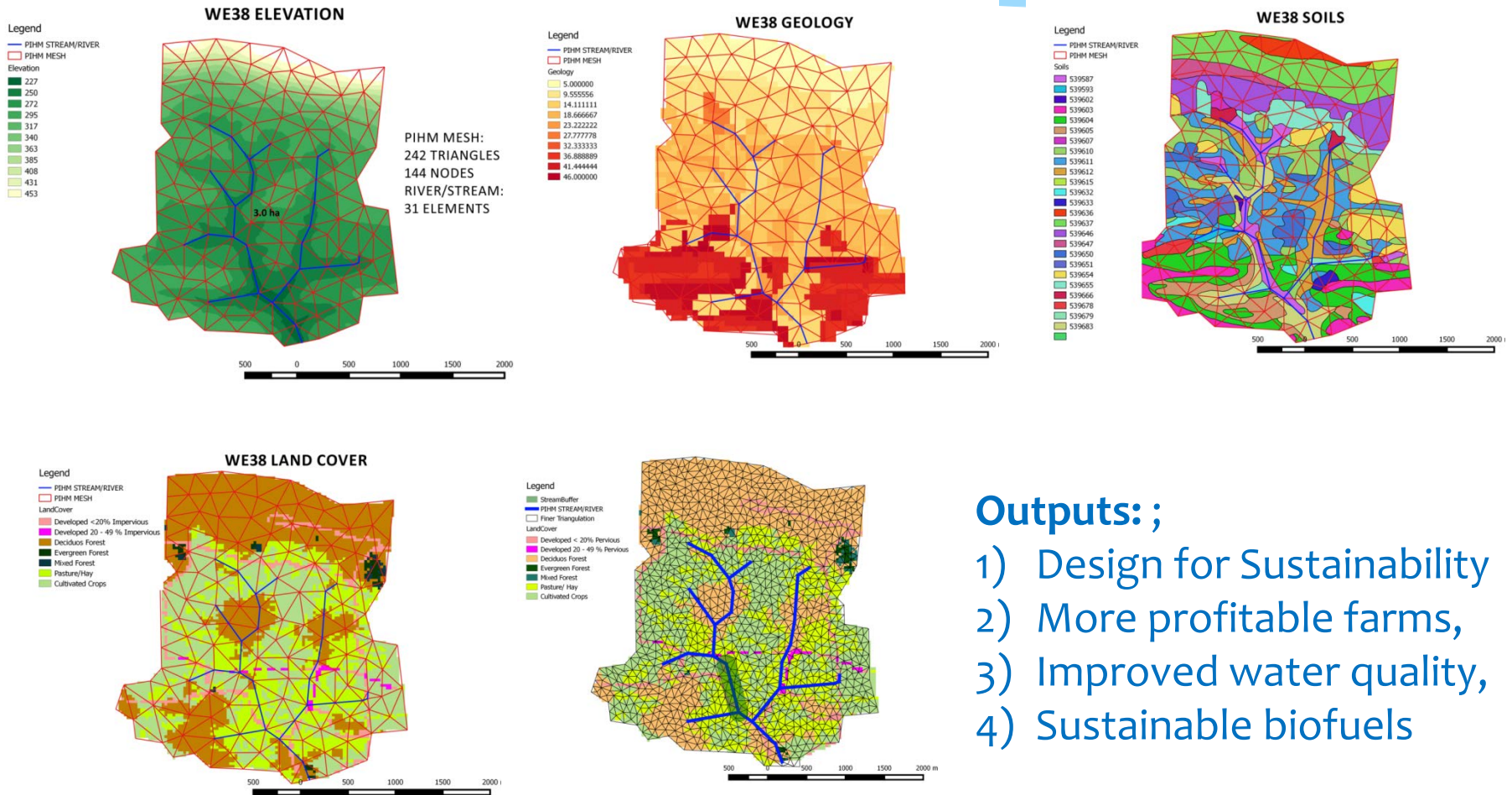
^a Biomass increase relative to sustainable corn stover availability when no landscape integration is considered;

^b Mean change in area of only the fields affected by landscape integration at each respective decision point;

^c All profit calculations are relative to the remaining row crop area of all fields as switchgrass is incorporated.



Quantifying Water Quality Benefits



Outputs: ;

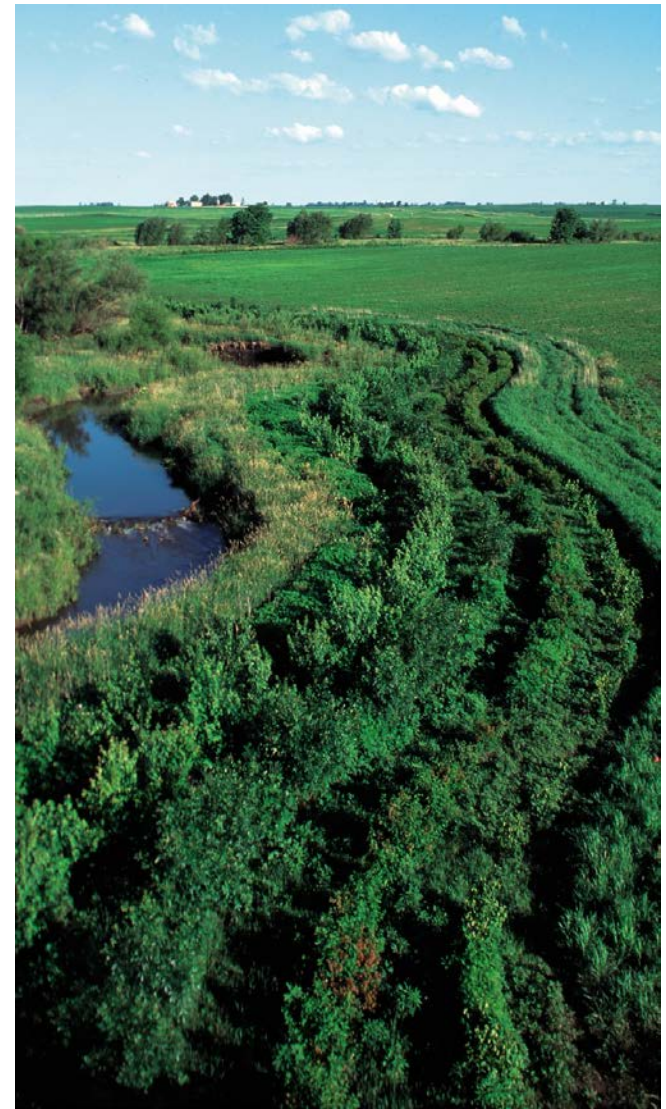
- 1) Design for Sustainability
- 2) More profitable farms,
- 3) Improved water quality,
- 4) Sustainable biofuels

Pilot to Scale-up

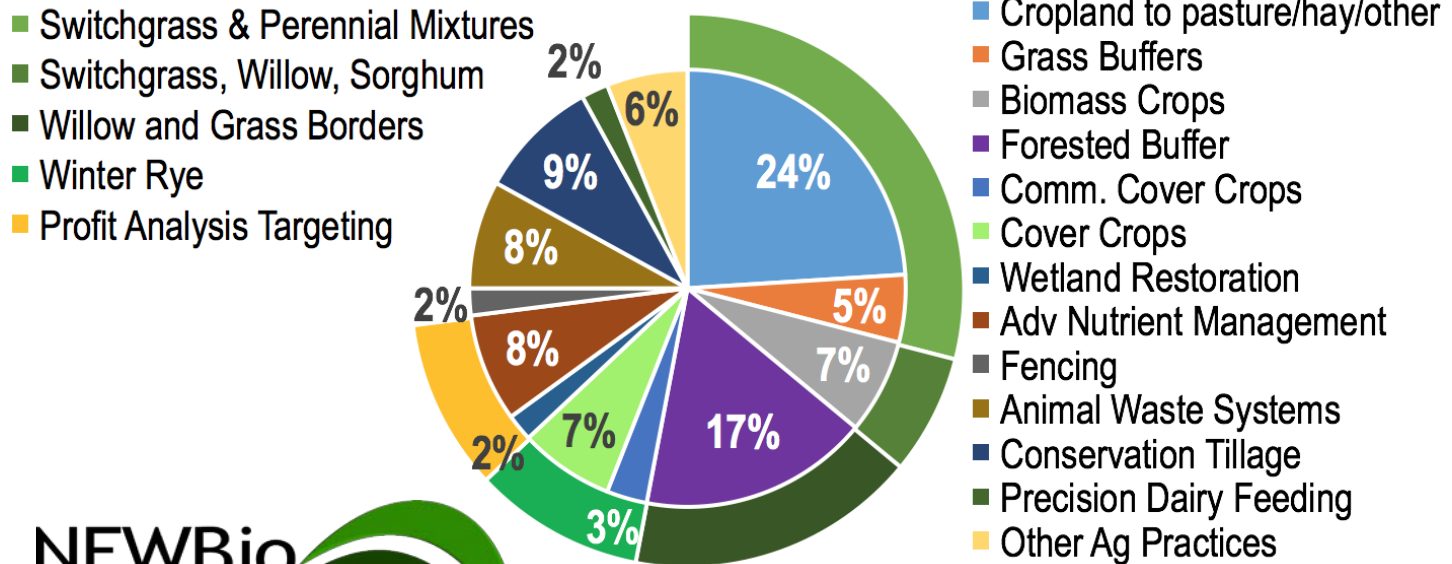
1. Now: NRCS pilots with AgSolver: 10 farms in Pennsylvania this winter
2. “Discovery Farms” instrumented for water quality
3. Additional farm pilots (50? 100?) and commercial demonstrations
4. Beck Ag Farmer-to-Farmer network: 20,000 farmers in the Chesapeake Watershed

Summarizing the Opportunity:

- * Perennials and cover crops are recognized as least-cost strategies for improving water quality. Both can also be biomass feedstocks.
- * Farmers currently **assume** that converting land to perennials and cover crops will **reduce** profits.
- * Sub-field economic analysis suggests strategic planting of perennials can instead **increase** profits.
- * The Bay-State Watershed Implementation Plans include planting hundreds of thousands of acres of cover crops and perennial riparian buffers.
- * Managing those areas for biomass represents an opportunity for not just improving water quality, but improving farm profitability, rural economic activity, and sustainable energy for the region.



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