Integration of Bioenergy Crops in Agroforestry for Water Quality Benefits

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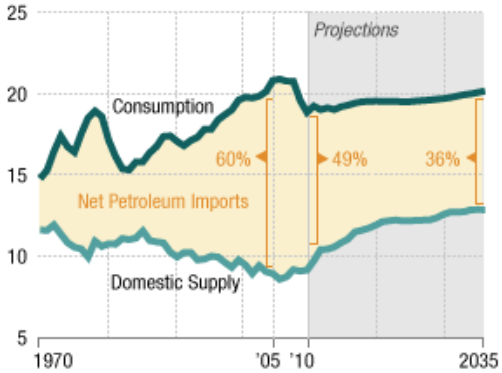
Why Bioenergy Crops?

Energy Security is as important for any country as Food Security

In the US, In 2010, 5 out of 10 gallons we pumped in our cars came from a foreign country



EISA of 2007 mandates the use 36 billion gallon of biofuels by 2022 (1/4th of the petroleum consumption in 2009); 21 billion from cellulosic biofuels

Sustainable production of biomass feedstock is one of the major bottlenecks

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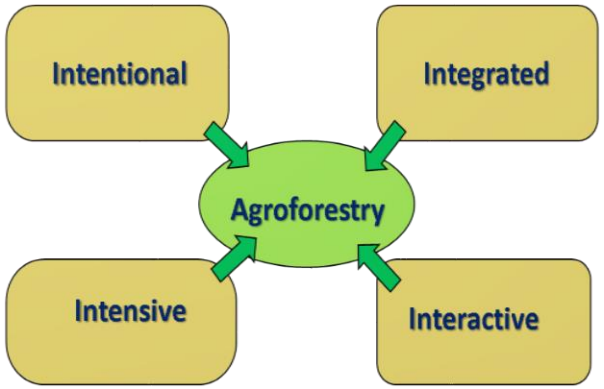
Agroforestry: A Flexible Land Use System to Accommodate Biomass Production

Intentional integration of trees and crops/livestock where interactions are intensively managed




Alley Cropping for Herbaceous Feedstock


Alley Cropping for SRW Biomass Feedstock

Commercial Scale Example

Catchlight Energy™
A Chevron | Weyerhaeuser Joint Venture

LSU

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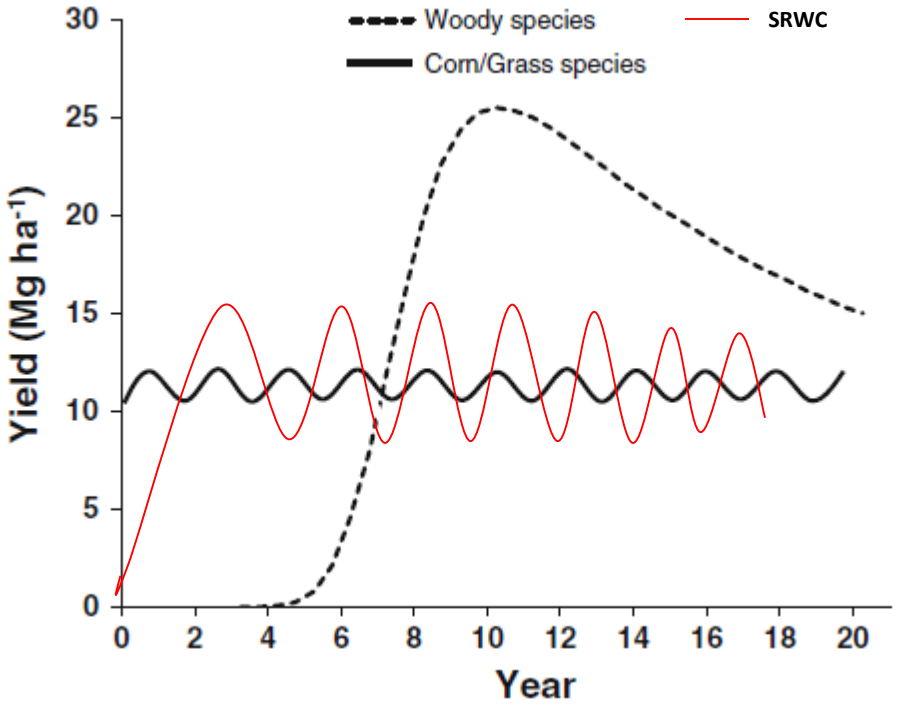
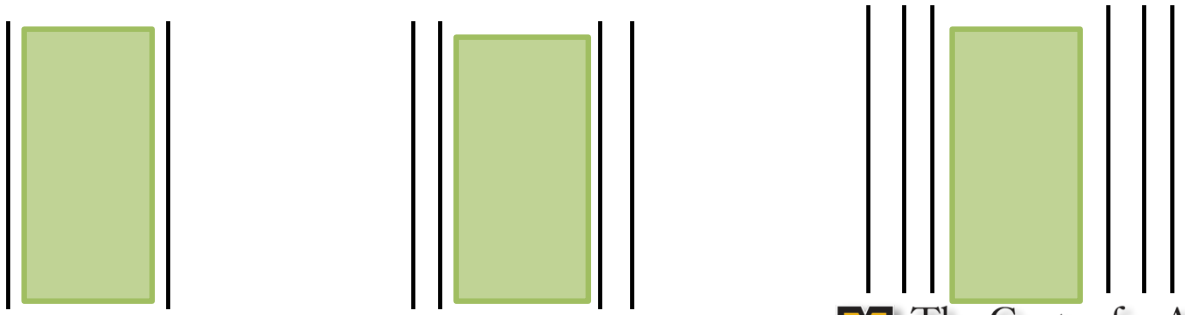
Biomass Production Potential

Species	Annual yield (Mg ha^{-1})	Rotation	Location	Citation
Agricultural crop				
Maize (*Zea mays*) grain	7–9	Annual	Illinois	Tollenaar and Lee (2002)
Maize grain	9.7	Annual	United States	USDA (2010a, b)
Sorghum (*Sorghum bicolor*) grain	4.5	Annual	United States	USDA (2010a, b)
Tree species				
Black locust (*Robinia pseudoacacia*)	7.3	Annual	Kansas	Geyer (2006)
Cottonwood (*Populus deltoides*)	5.4	Annual	Kansas	Geyer (2006)
Honey locust (*Gleditsia triacanthos*)	6.1	Annual	Kansas	Geyer (2006)
Poplar (*Populus*) clones				
7300501	16.8	5 years	Iowa	Riemenschneider et al. (2001)
80X00601	17.2	5 years	Wisconsin	Riemenschneider et al. (2001)
D121	6.8	5 years	Minnesota	Riemenschneider et al. (2001)
Eugenii	17.0	10 years	Iowa	Goerndt and Mize (2008)
Eugenii	5.4	7 years	Iowa	Tufekcioglu et al. (2003)
Crandon	30.0	10 years	Iowa	Goerndt and Mize (2008)
Silver maple (*Acer saccharinum*)	5.7	Annual	Kansas	Geyer (2006)
Silver maple	18.0	10 years	Iowa	Goerndt and Mize (2008)
Silver maple	8.4	4 years	Iowa	Schultz et al. (1995)
Willow (*Salix*) clones				
SX67	18.3	2 years	Minnesota	Thelemann et al. (2010)
9882-41	12.5	2 years	Minnesota	Thelemann et al. (2010)
Grass				
Miscanthus (*Miscanthus* × *giganteus*)	29.6	Annual	Illinois	Heaton et al. (2008)
Switchgrass (*Panicum virgatum*)	10.4	Annual	Illinois	Heaton et al. (2008)
Switchgrass	9.4	Annual	Illinois	Khanna et al. (2008)
Switchgrass	13.1–19.9	Annual	Iowa	Tufekcioglu et al. (2003)
Giant cane (*Arundinaria gigantea*)	6.8	5 years	Illinois	Schoonover, personal communication

Alley Cropping Design





Modified from Holzmueller and Jose, 2012

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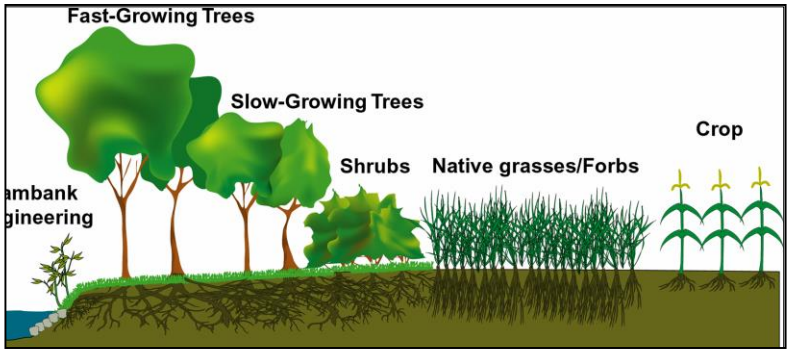
Riparian Buffer: Another Agroforestry Practice Suitable for Biomass Production



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Can Agroforestry Biomass Production Systems Help Water Quality?

We support agroforestry as a land management approach because it helps landowners achieve certain natural resource goals, such as clean water and productive soils…America's economic success is directly linked to a continuous and abundant supply of clean water (Sec. Vilsack, April 17, 2012)

Science is Now Supporting the Claims!

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Water Quality: Major National Issue

Water Body	Total size	Assessed (% of total)	Impaired (% of assessed)
Rivers	3,533,205 miles	16%	**44%**
Lakes	41.7 million acres	39%	**64%**
Estuaries	87,791 square miles	29%	**30%**

EPA, 2009

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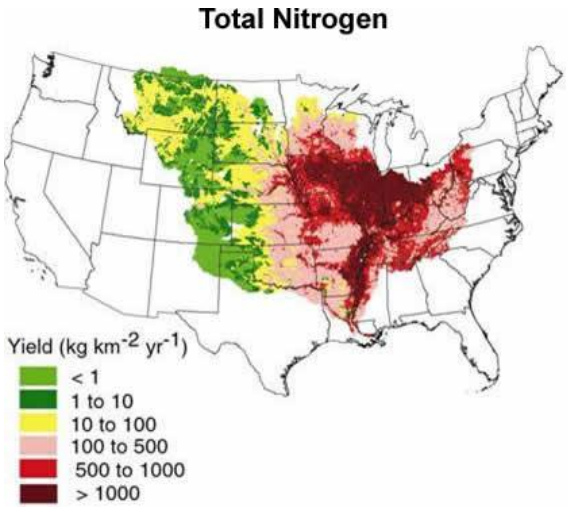
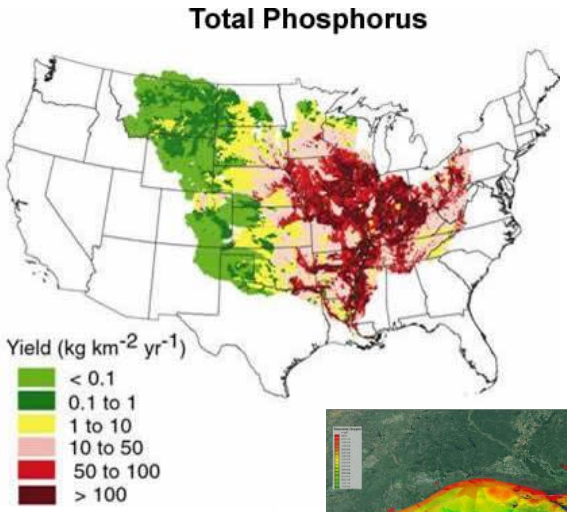
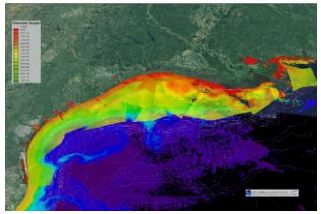
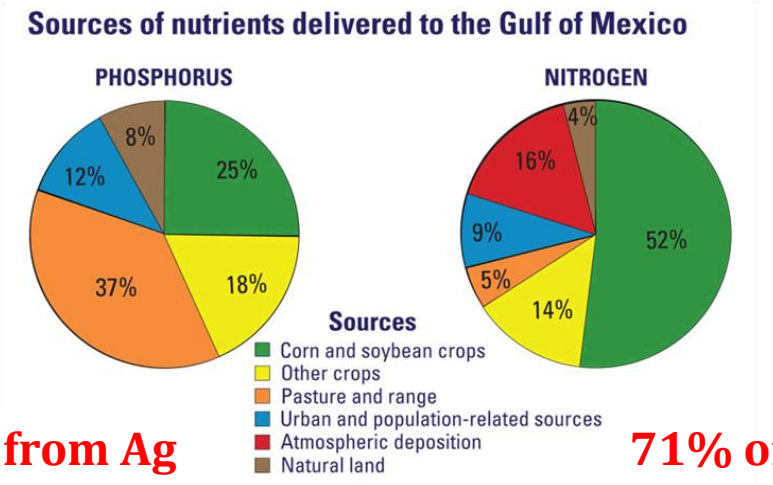
What does It Mean?









One of 405 hypoxic zones identified around the world (2012)
Only 162 zones in 1980!

80% of P from Ag

71% of N from Ag

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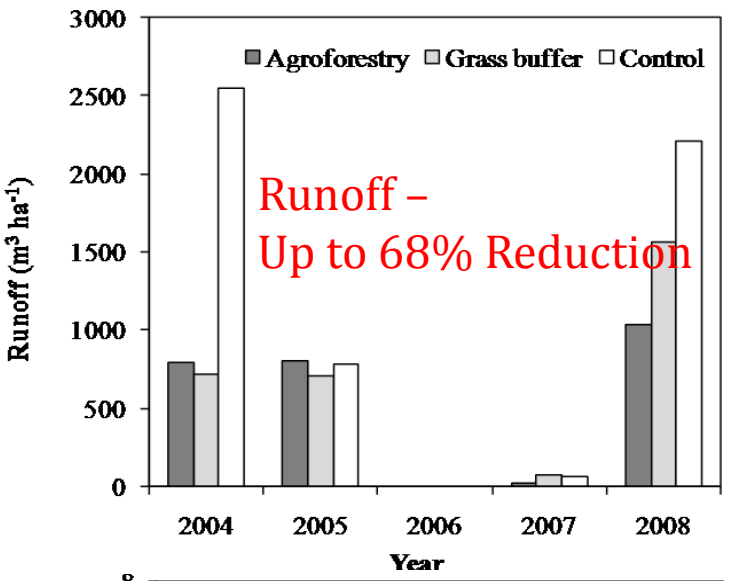
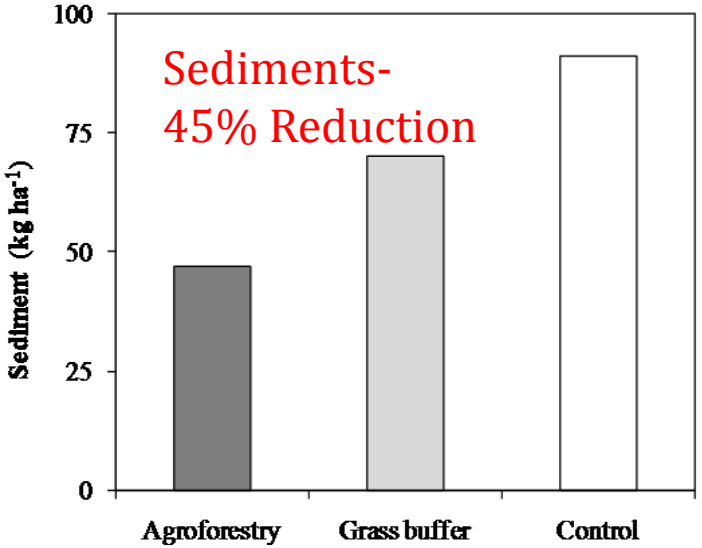
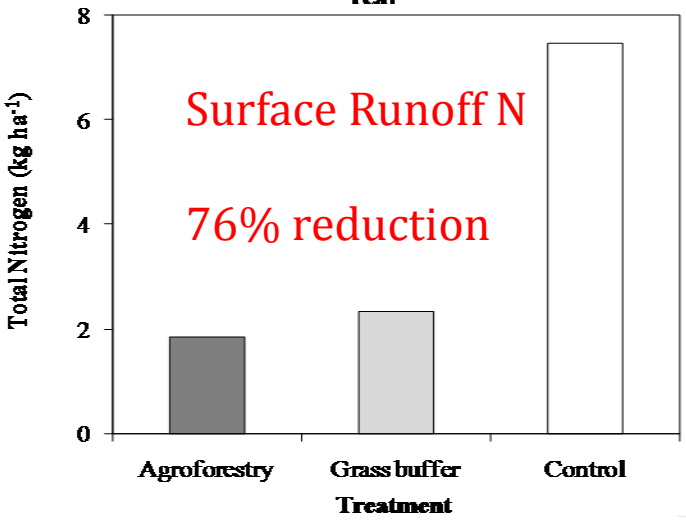
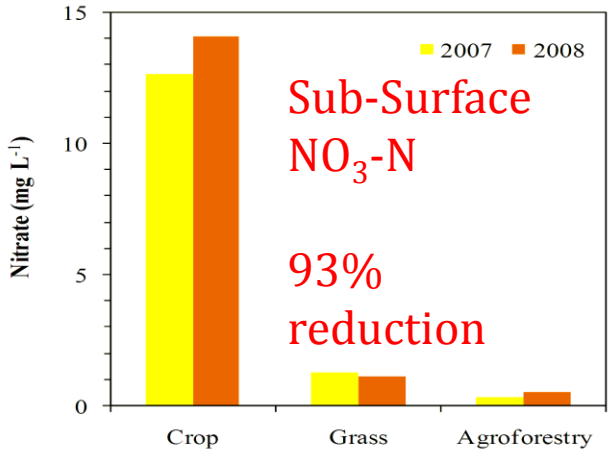
Seeing Is Believing: Crop vs. Grass + Trees



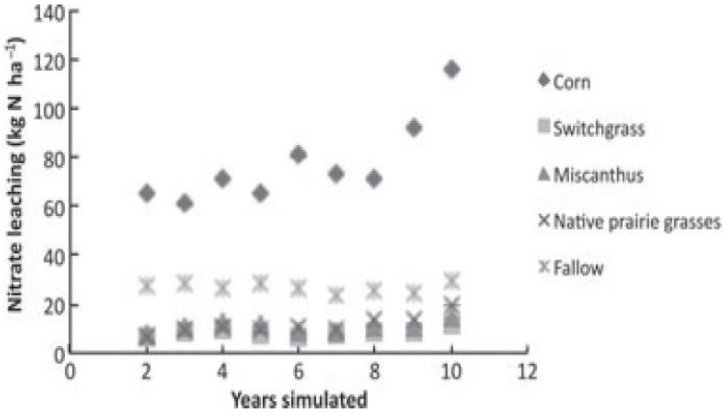




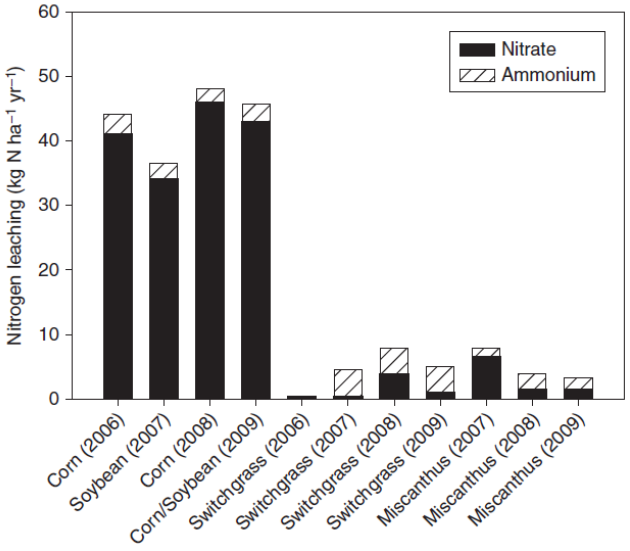


Udawatta et al., 2002; 2007; 2009; 2011

Promising Biomass Feedstock Species



Leaching fluxes of NO3 –N under switchgrass, Native Prairie and Miscanthus in central Illinois, USA. Gopalakrishnan et al., 2012



Annual leaching fluxes of NO3 and NH4 N at 50 cm depth under corn-soybean, switchgrass, and Miscanthus in central Illinois, USA. Heaton et al., 2010

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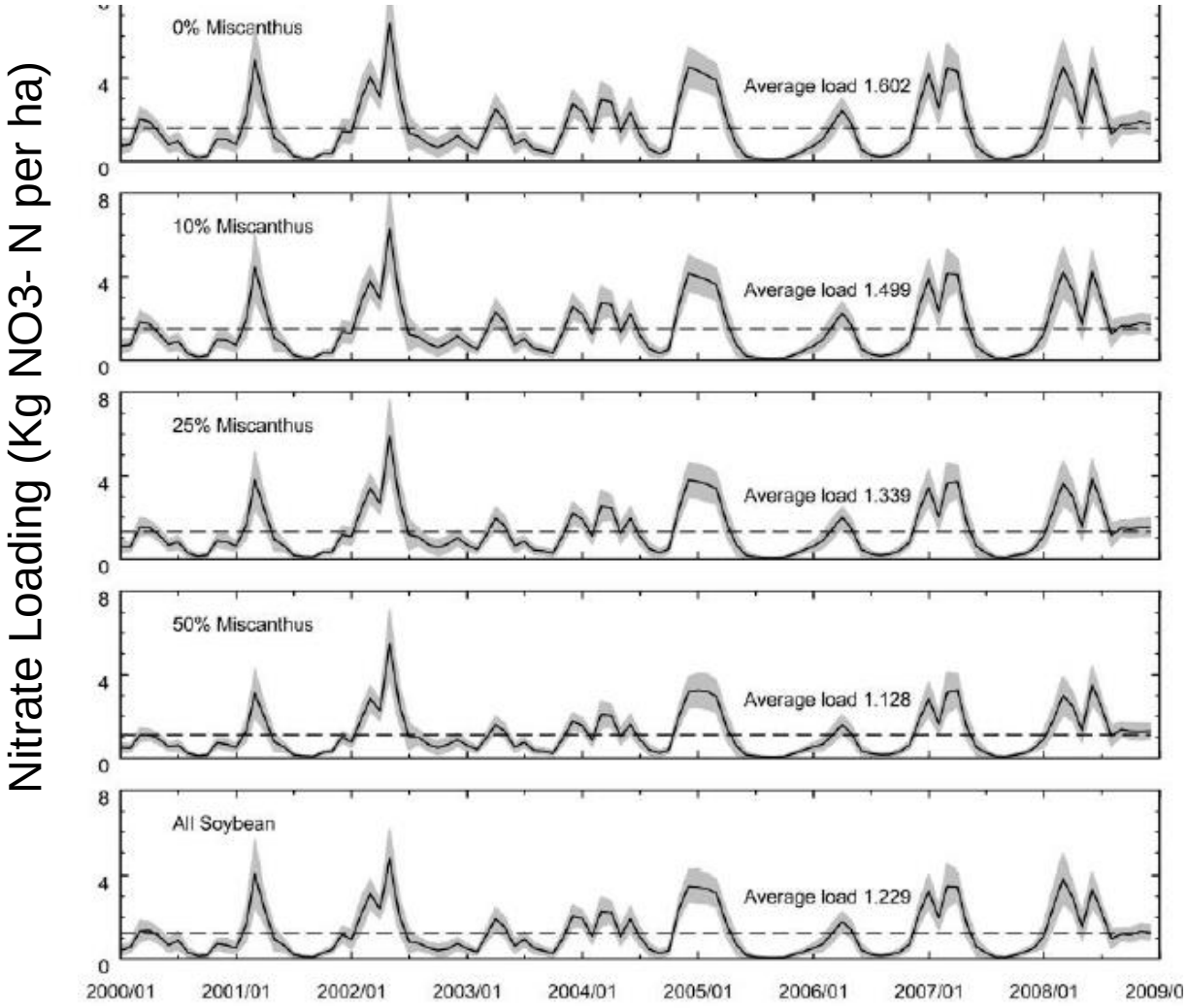
What Does it Mean at the Farm Scale?



Corn/Soybean (100%)

Miscanthus + Corn/Soybean (50% each)

30% Drop in NO3-N

Lin et al., 2010

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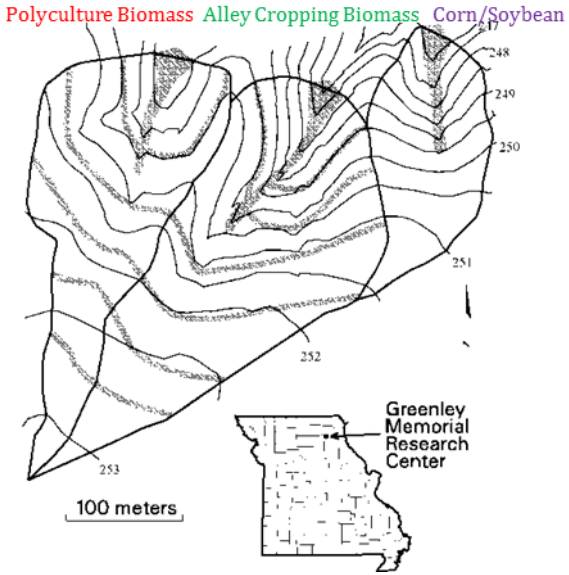
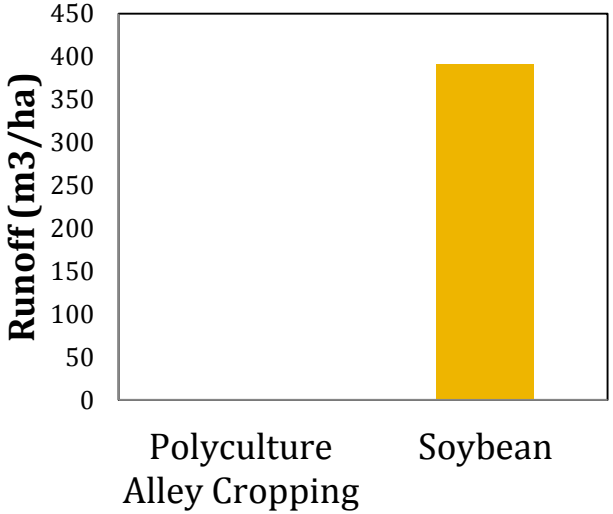
What Does it Mean at the Small Watershed Scale?



Rainfall = 607 mm (34% lower)
30-yr Average = 919 mm



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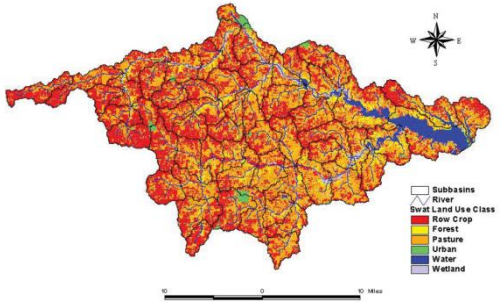
What Does it Mean at the Large Watershed Scale?



142,700 ha

80% Agriculture/Pasture
9% Forest
5% Wetland
4% Water
2% Urban

15% of highly erodible and marginal land converted to switchgrass

SWAT model simulation, Rathbun Lake watershed, Iowa.
Neppel et al. 2001

Substantial Improvement in Water Quality!

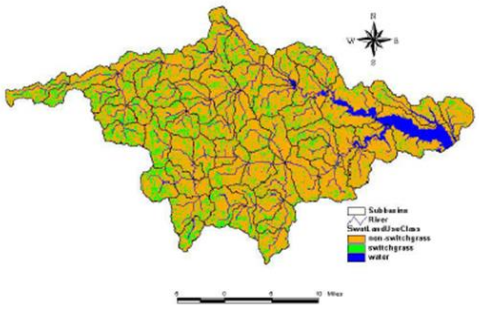


Figure 8 Areas of Agricultural Land Converted to Switchgrass for Biomass Production – Switchgrass Scenario

Water

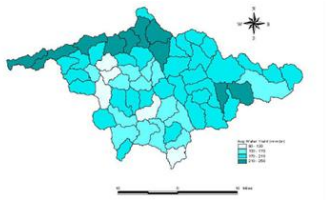


Figure 11 Average Water Yield – Baseline Scenario

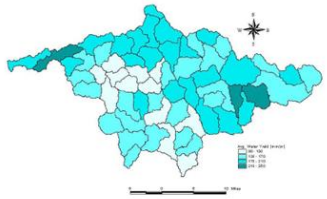


Figure 12 Average Water Yield – Switchgrass Scenario

Runoff 10%

Soluble P 26% & N 38%

P

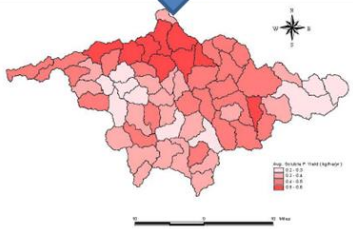


Figure 17 Average Soluble Phosphorus Yield – Baseline Scenario

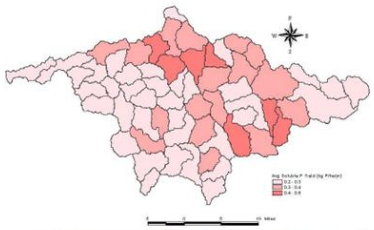


Figure 18 Average Soluble Phosphorus Yield – Switchgrass Scenario

Sediment -bound P 36% & N 39%

Sediment

Figure 13 Average Sediment Yield – Baseline Scenario

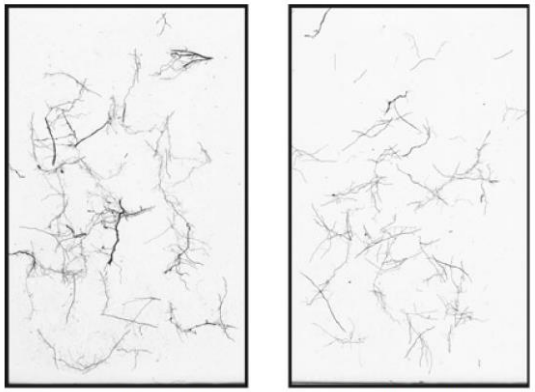
Figure 14 Average Sediment Yield – Switchgrass Scenario

Sediment 55%

Soluble Atrazine 86% and Sediment-bound 83%

Neppel et al. 2001

Why Agroforestry Shows Greater Potential for Reducing Sediments, Nutrients and other Agrochemicals?

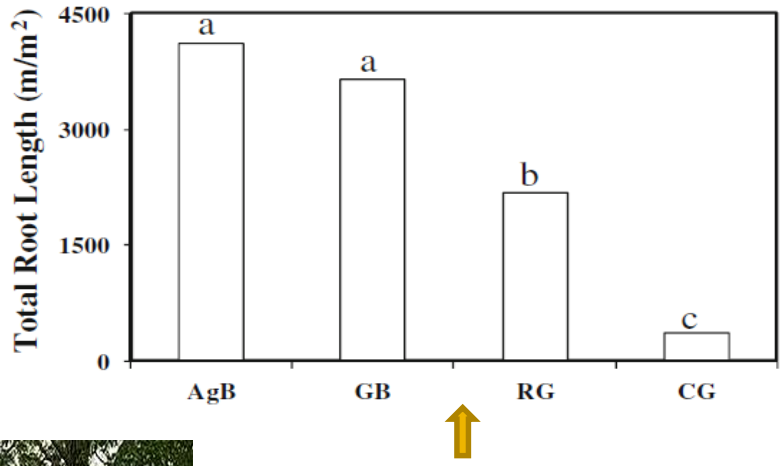


Agroforestry Buffer (AgB)

Grass Buffer (GB)

Rotationally Grazed (RG)

Continuously Grazed (CG)



Biomass Feedstock

Switchgrass

Willow

Kumar, Udawatta and Anderson, 2010

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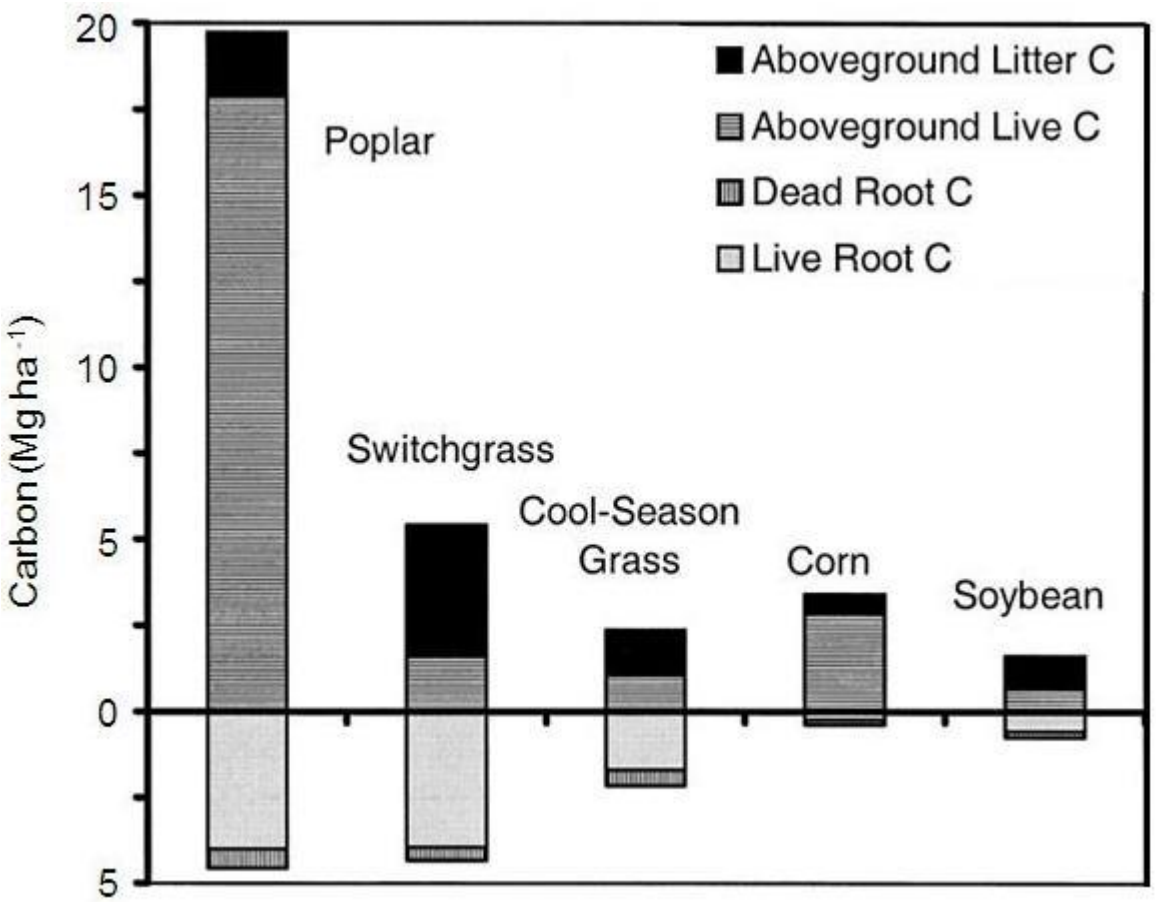
Greater Above and Belowground Biomass Production



Tufekcioglu et al., 2003

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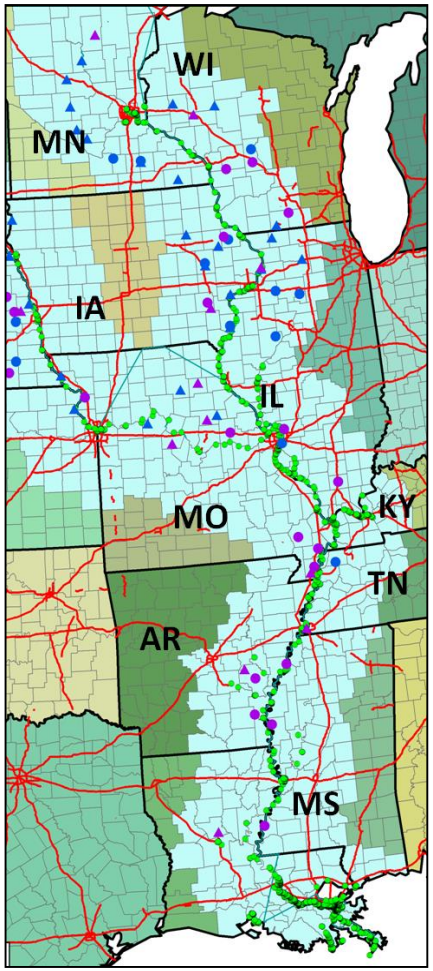
A Blueprint for Bio-based Economy

10% of the marginal land base (`10 million acres) established in biomass feedstock crops– SOLVING A MAJOR BOTTLENECK

8 BGY advanced biofuel (e.g. butanol, green diesel etc.) by 2022 – NATIONAL MODEL FOR ADV. BIOFUEL

$3 to $4.5 billion net economic impact and associated social and environmental benefits, particularly in rural areas along the MS/MO River Corridor in the near-term- JOBS, CLEAN AIR & WATER



MRABC

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In Conclusion……..

We should support agroforestry as a land management approach because it helps landowners achieve certain natural resource goals, such as clean water and productive soils… (Sec. Vilsack, April 17, 2012)

…while providing the much needed biomass feedstock for a bio-based economy

Much work still remains……..

…to make this market-based approach to conservation a reality

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