Integration of Bioenergy Crops in Agroforestry

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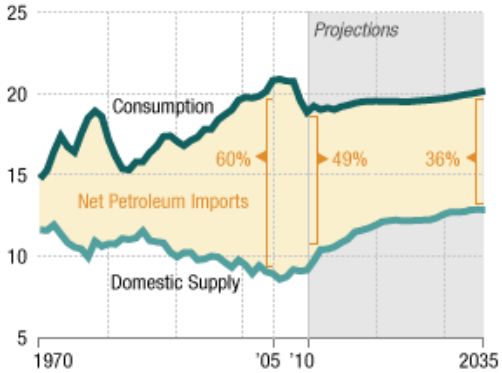
Why Bioenergy Crops?

Energy Security is as important for any country as Food Security

In the US, In 2013, nearly 5 out of 10 g
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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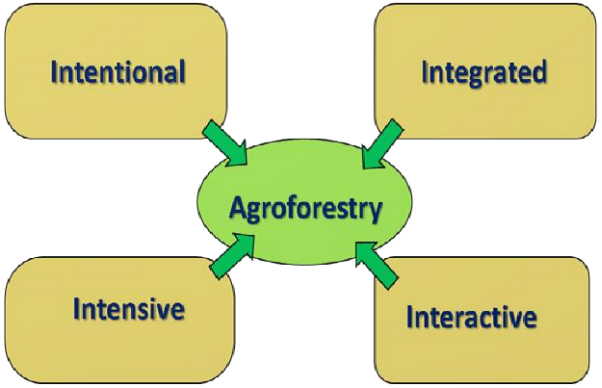
Agroforestry: A Flexible Land Use System to Accommodate Biomass Production

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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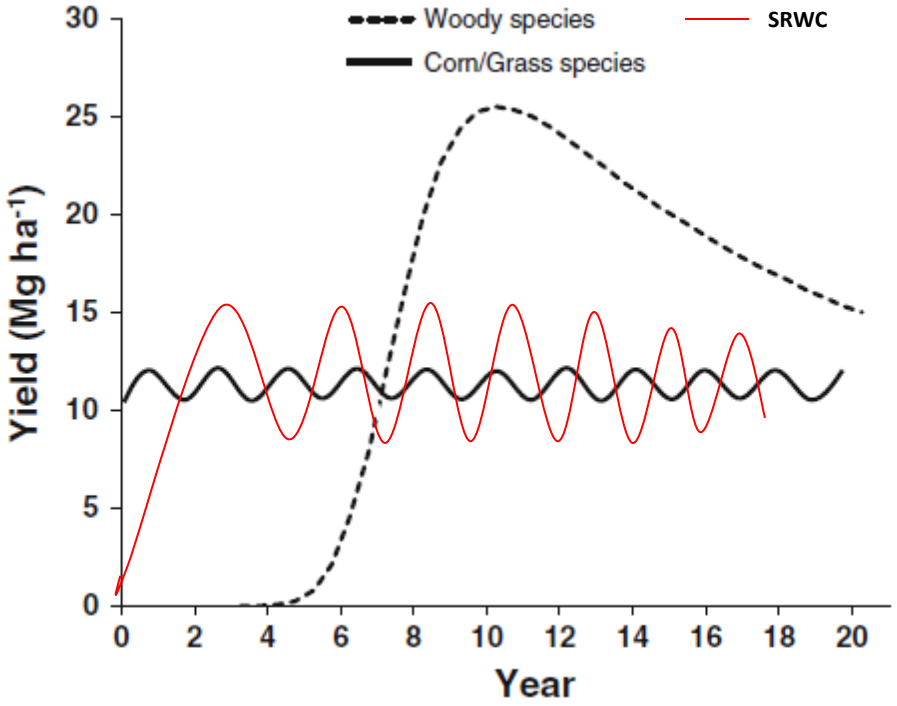
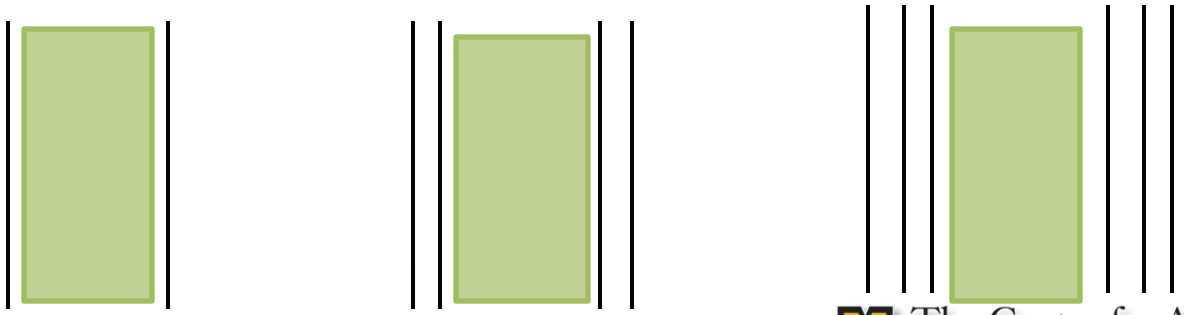
Biomass Production Potential

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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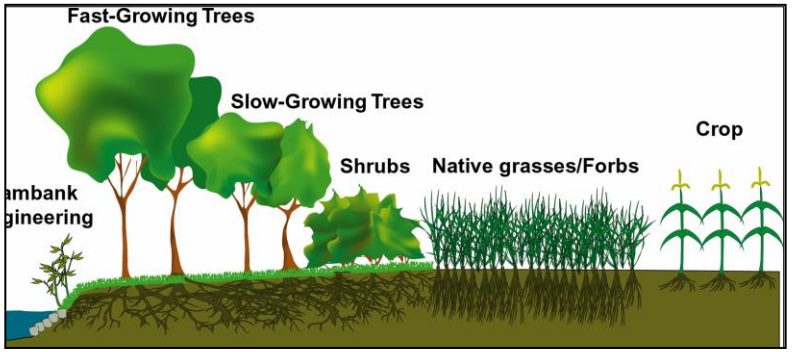
Riparian Buffer: Another Agroforestry Practice Suitable for Biomass Production



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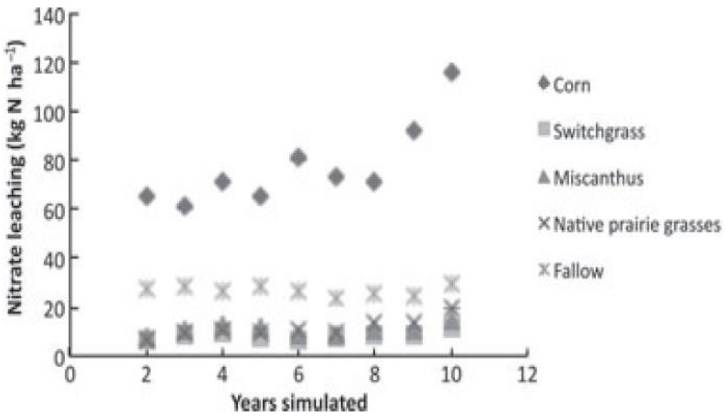
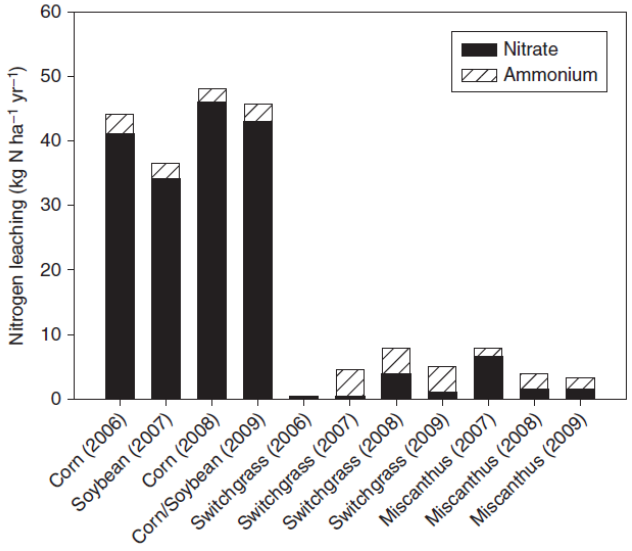
Promising Biomass Feedstock Species



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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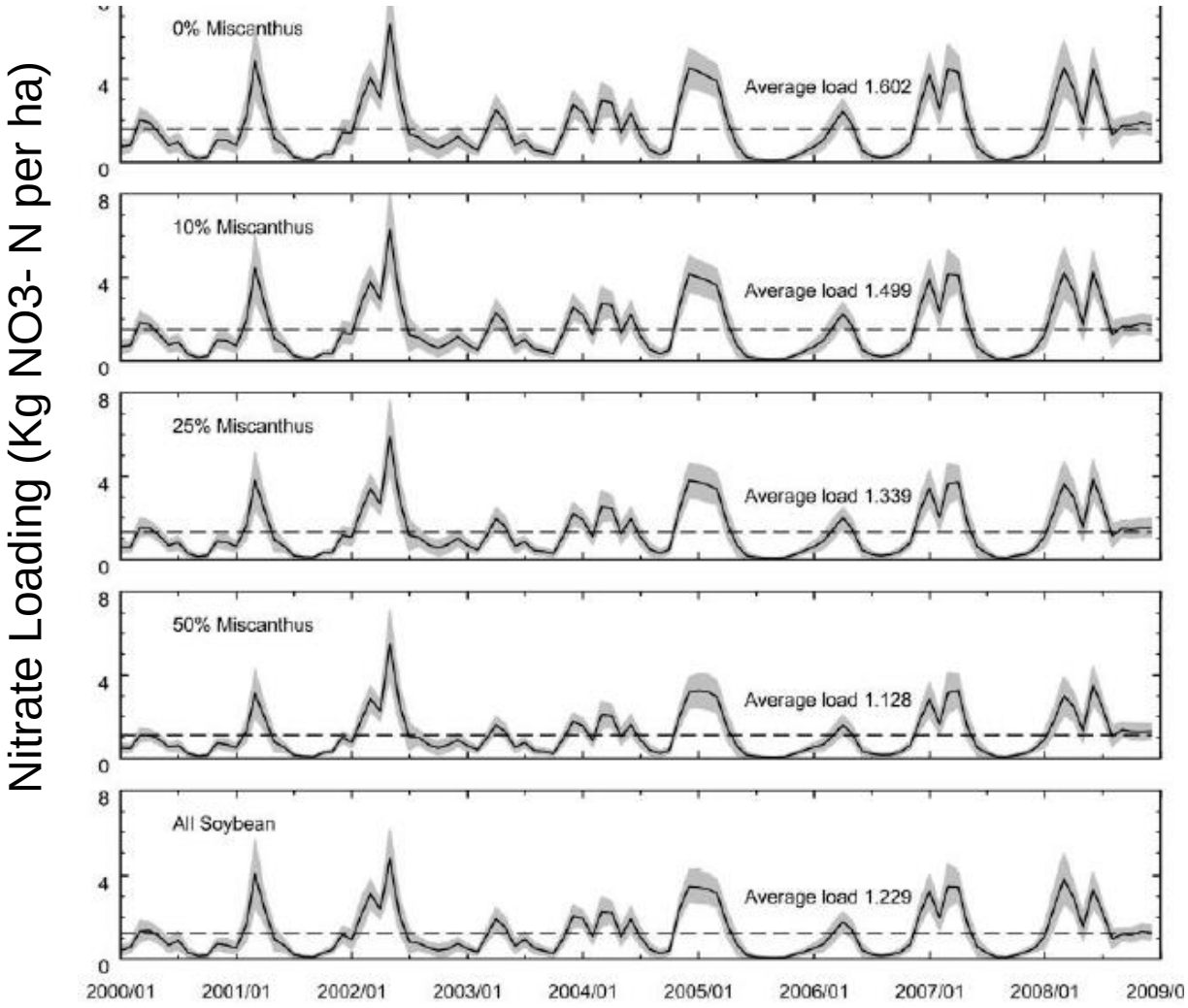
What Does it Mean at the Farm Scale?



Corn/Soybean (100%)

Miscanthus + Corn/Soybean (50% each)

30% Drop in NO3-N

Lin et al., 2010

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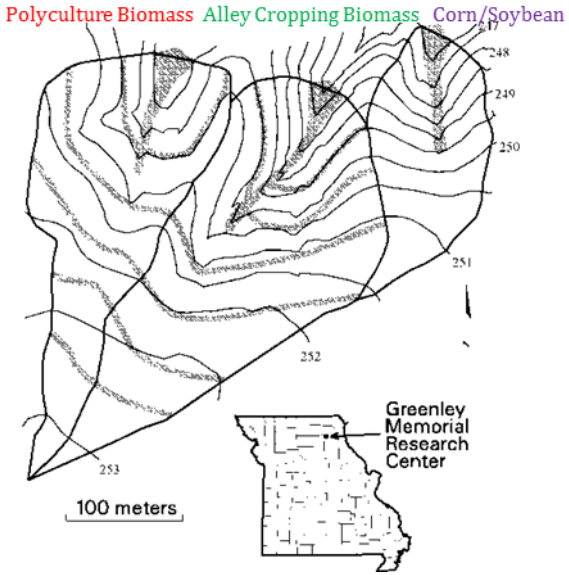
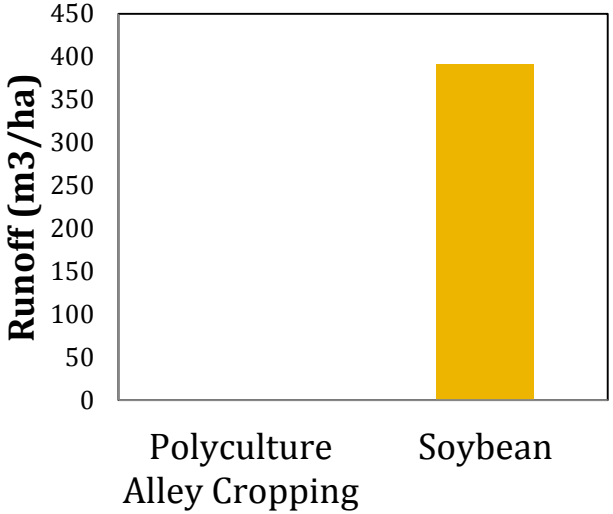
What Does it Mean at the Small Watershed Scale?



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



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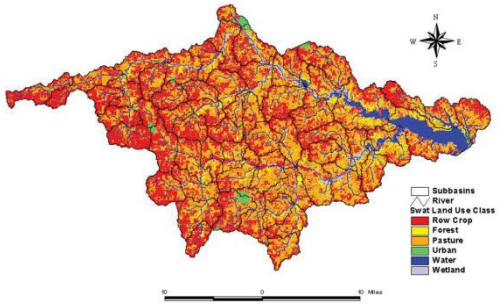
What Does it Mean at the Large Watershed Scale?



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!

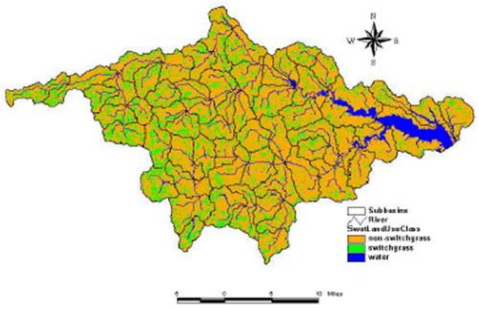


Figure 8 Areas of Agricultural Land Converted to Switchgrass for Biomass Production – Switchgrass Scenario

Water

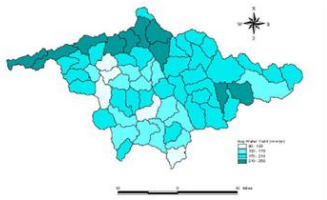


Figure 11 Average Water Yield – Baseline Scenario

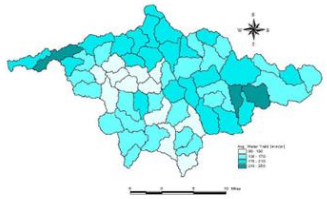


Figure 12 Average Water Yield – Switchgrass Scenario

Runoff 10%

P

Soluble P 26% & N 38%

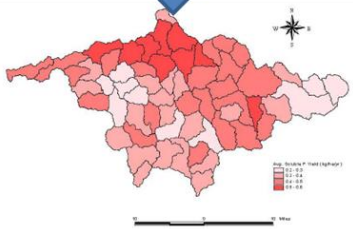


Figure 17 Average Soluble Phosphorus Yield – Baseline Scenario

Sediment

Figure 13 Average Sediment Yield – Baseline Scenario

Sediment -bound P 36% & N 39%

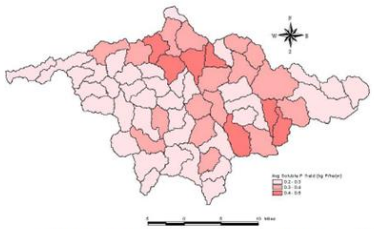


Figure 18 Average Soluble Phosphorus Yield – Switchgrass Scenario

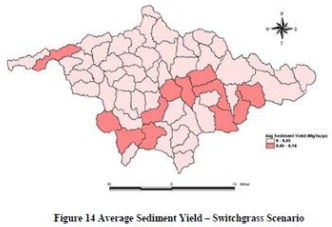


Figure 14 Average Sediment Yield – Switchgrass Scenario

Sediment 55%

Soluble Atrazine 86% and Sediment-bound 83%

Neppel et al. 2001

Yield and Economics!

Higher biomass production in agroforestry compared to open field!!

Field and willow clone	2006[a]		2007[b]	
	Yield[c] (odt ha^{-1})	Percent survival	Yield[c] (odt ha^{-1})	Percent survival
Agroforestry	0.78*	93*	3.00*	89*
SV1	0.56b	90c	3.93a	90a
SX67	0.89a	96a	3.30a	90a
9882-41	0.89a	92b	1.77b	88a
Control	0.54*	86*	1.11*	66*
SV1	0.83a	95a	1.63b	79b
SX67	0.46c	81d	1.03b	63c
9882-41	0.33c	81d	0.68c	57d

Clinch et al. 2009

Yield and Economics!

Land Expectation Value

Scenario	Definition	SG price ($ Mg^{-1})	Stumpage price ($ m^{-3})	
			High LEV ($ ha^{-1})	Medium
Scenario A	No intercropping	n.a	6888.88	4659.3
Scenario B	No decrease in SG or LP productivity	15	6686.9	4457.5
		30	7708.5	5479.0
		44	8662.9	6440.5
		50	9084.6	6862.2
Scenario C	15% decrease in SG productivity	15	6555.7	4326.2
		30	7446.0	5216.5
		44	8277.0	6047.5
		50	8633.1	6410.8
Scenario D	15% decrease in SG and LP productivity	15	5365.2	3418.8
		30	6255.5	4309.2
		44	7086.5	5140.1
		50	7447.8	5505.8
Scenario E	15% decrease in SG and 25% decrease in LP productivity	15	4571.6	2815.6
		30	5461.9	3704.2
		44	6292.8	4535.2
		50	6657.5	4902.5
Scenario F[a]	SG monoculture	15	–427.9	
		30	2891.1	
		44	5988.8	
		50	7316.4	

(1077 trees/ha)

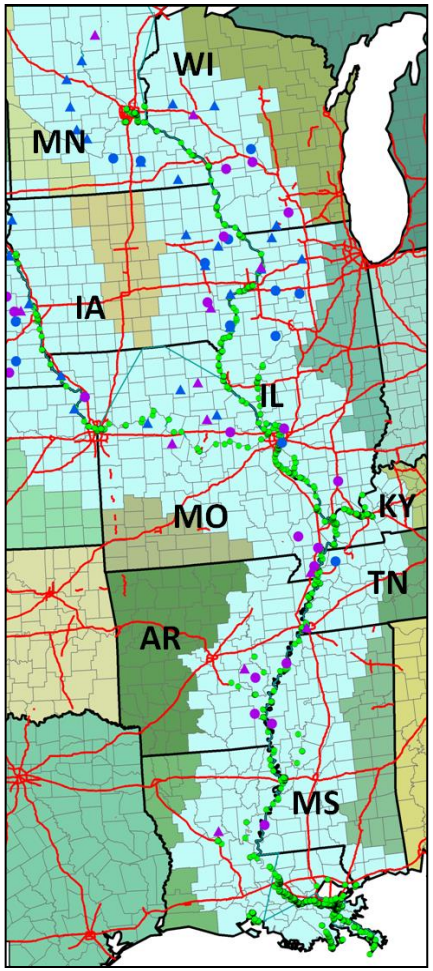
Susaeta et al. 2012

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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