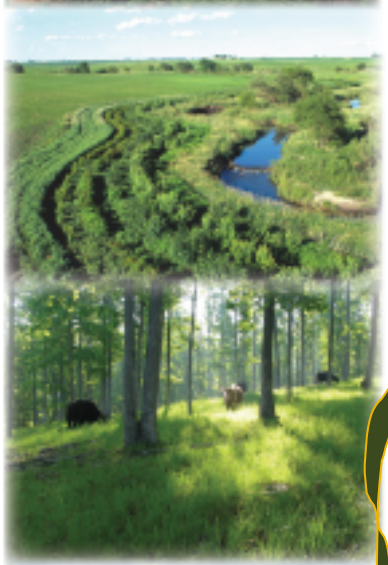

Temperate Agroforestry in the 21st Century: A North American Perspective

Shibu Jose

H.E. Garrett Endowed Professor and Director

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Challenges of the 21st Century

Food
+50%

Energy
+50%

Water
+50%

GHG emission
+37%

Biodiversity Loss
-68% forest loss in SA
-26% in China
-24% in Africa
-20% in EE,AU, NZ

Diseases, invasives
+50%

Food-Energy-Environment Trilemma

Tilman et al. 2009, Science 325

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Challenges of the 21st Century

"We are feeding the world"

Today's American farmer feeds about 155 people worldwide

In 1960, that number was 26

Over 40% of corn produced in the US goes into ethanol

	% Great deal, 2014	% Great deal, 2015
Pollution of drinking water	60	55
Pollution of rivers, lakes and reservoirs	53	47
Air pollution	46	38
Extinction of plant and animal species	41	36
The loss of tropical rain forests	41	33
Global warming or climate change	34	32

The World is Looking for Sustainable Solutions

Food-Energy-Environment Trilemma

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Can Agroforestry Be Part of the Solution?

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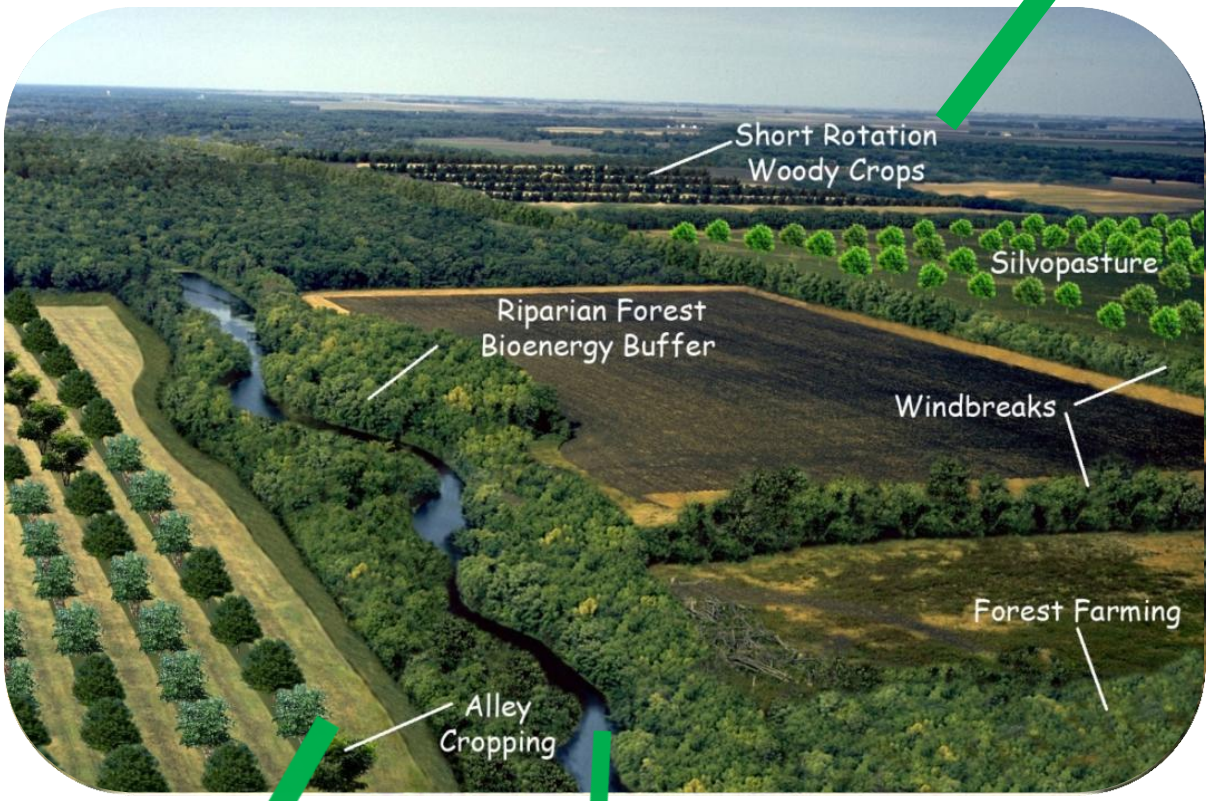
Yes, We Know; Time to Make it Mainstream



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So, Where is Agroforestry Headed?

Top 10 USDA Science Efforts (Office of the Chief Scientist)

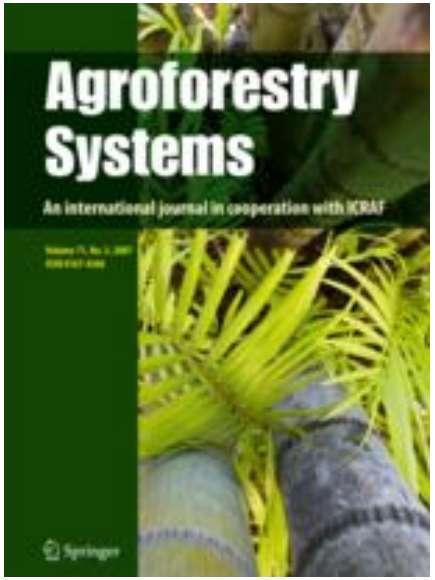
1. Genetics and Genomics
2. Climate Change
3. The Human Microbiome
4. Behavioral Economics
5. Open Data for Agriculture
6. **Agroforestry**
7. Food Safety
8. Bioproducts and Bioenergy
9. Nutrition and Epigenetics
10. Grand Challenges in Biology

Agroforestry as a Science

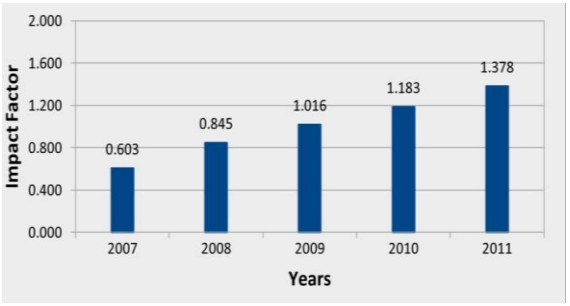
Not an "age-old practice with a new name" anymore!

A strong scientific foundation has been laid, particularly during the last two decades

Biophysical and Socioeconomic dimensions have been explored in detail



Nearly 400 submissions from 79 countries!
A rejection rate of 70-75% expected for 2015



Ranking (2011):
18/59 FOR
30/89 AGR

For. Sci. 1.047; 27/59

Downloads

Totals	
2009	109,099
2010	134,131
2011	140,207
2012	162,376

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Agroforestry As a Practice

How Can Agroforestry Help Resolve the Food-Energy-Environment Trilemma?

Food-Energy-Environment Trilemma

<u>USA</u>
Forests = 300 million ha
Farmland = 179 million ha
Pasture – 237 million ha
Total = 716 million ha

Agroforestry = 57 million ha (~8%)

Or 3 million ha (~0.42%)
(if you remove grazed forests)

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Can Agroforestry Provide Food Security?

Dust bowl of the 1930s

Food Availability:

86,000 miles of field windbreaks protect about 4 million acres of agricultural land in the Great Plains

Nebraska:

- **15,300 miles of field windbreaks protect 1 million acres of crops**
- **$72 million/year in increased crop yields**

A major effort underway to map crop yield in relation to windbreaks in the Great Plains; Number of papers from USA, Canada, China

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Food Security and Rural Prosperity

Farm Diversification – Global Competitiveness

- Chinese Chestnut - $6000 /acre/year
  beginning 7th yr
  Castanea mollissima
  (Fagaceae)

- Pecan - $3000 /acre/yr
  beginning 8th yr
  Carya illinoensis
  (Juglandaceae)

- Elderberry - $6000 – 12,000 /acre/yr
  Sambucus Spp.
  (Adoxaceae)

Crop/Tree Improvement –Genomics-assisted Selection and Breeding

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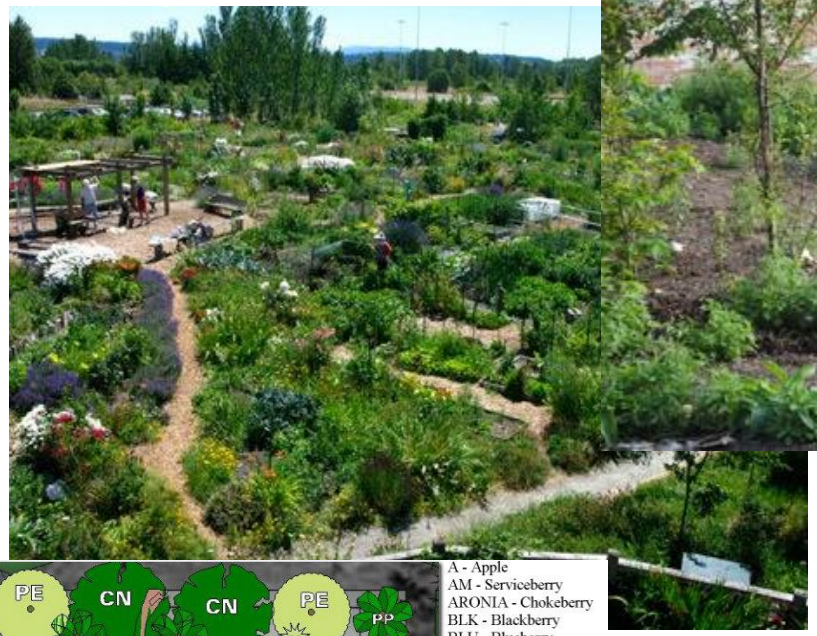
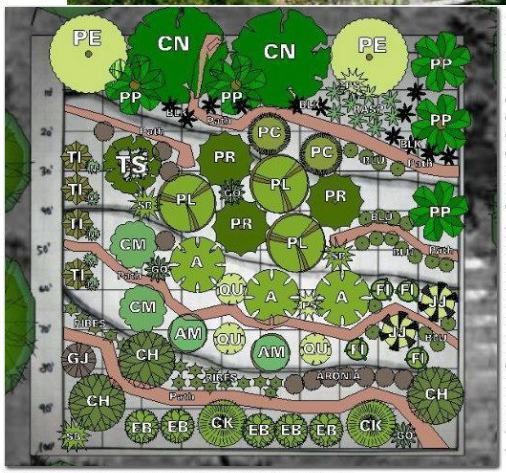
Food Security and Urban Prosperity
Urban Agroforests/Food Forests



Pittsburgh



A - Apple
AM - Serviceberry
ARONIA - Chokeberry
BLK - Blackberry
BLU - Blueberry
CH - Tart Cherry
CK - Cornus Kousa
CM - Cornelian Cherry
CN - Chinese Chestnut
EB - Elderberry
FI - Fig
GO - Goumi
JJ - Jujube
NJ - New Jersey Tea
PC - Peach
PE - Persimmon
PP - Pawpaw
PL - Plum
PR - Pear
PS - Sib. Pea Shrub
QU - Flowering Quince
Rasp - Raspberry
Ribes - Ribes spp.
SB - Sea Buckthorn
TI - Linden (tilia cordata)
TS - Toona Sinensis

The canopy and shurb layers of our planned food forest.

Seattle

Kansas City

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Agroforestry is a Way to "Bullet-Proof" Farms in the Face of Climate Change (Simons, 2010)

More than 130,000 acres of Missouri farmland under water (Birds Point Levee breach, May 2011)

Tree Buffers >500 ft can protect levees

Diversification = Resilient Farmscapes

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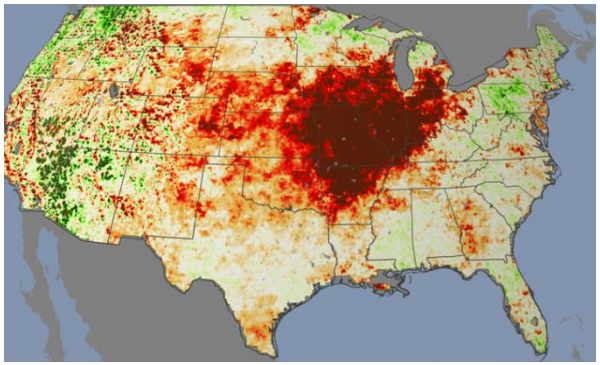
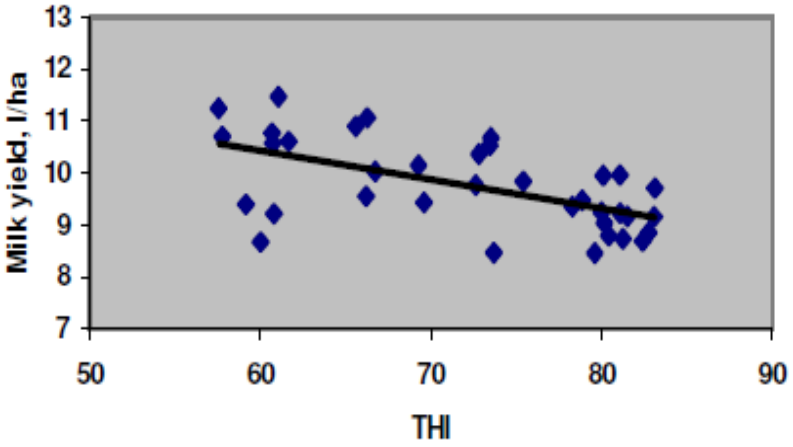
Can Agroforestry Help the Cattle Industry?



2012 August- Heat Stress Index



$2 billion lost annually!!

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Less Stress = $$$$$$

- Dairy cows provided with shade produced 10-19% more milk than non-shaded cows (University of Florida)
- When temperatures exceeded 90°F, milk production decreased by 20 to 30% (Virginia Tech. University)
- Cattle provided with shade had conception rates of 44%, compared to conception rates of 25% without shade (University of Florida)
- Shade increased overall pregnancy rates of cattle by 40% (87.5% with shade compared to 50% without shade)(University of Missouri)

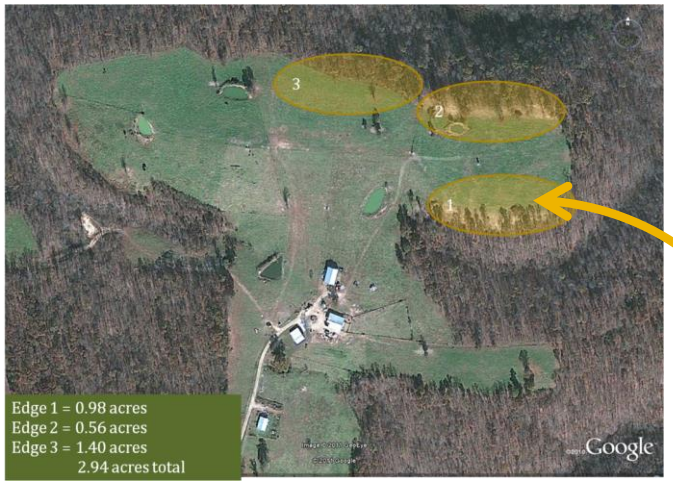
Data from Silvopasture

- Lost approximately 10% less weight over winter
- Had less stress at calving
- Weaned heavier calves

- Overall returns in the *Silvopastoral* system were about **$108.98 per pair** greater than in the *Traditional* pasture

Treatment	Cow BW loss over winter (lbs)	Calving Difficulty (%)	Calf Weaning Weight (lbs)
Traditional	231	17	595
Integrated	205	4	650
p value	0.02	0.04	0.01
$ value	$43.09	-	$65.89

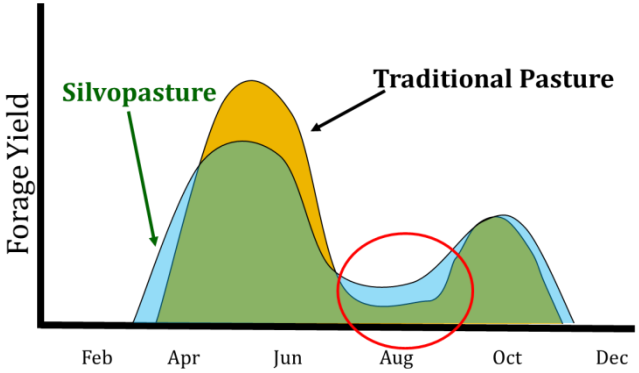
A Success Story!



Thinning + Forage Establishment=$3500 ($1200 per acre; 2.9 acre total for 3 areas)

$10,920 increase in profit from 84 head operation

B/C Ratio = 3.2; $130 more per head over regular pasture!!!!!



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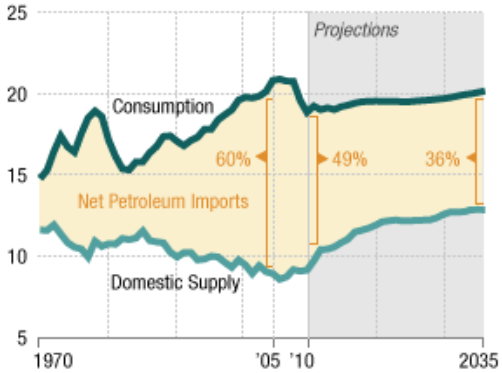
Can Agroforestry Help with Energy Security?

Energy Security is as important for any country as Food Security

In the US, In 2011, 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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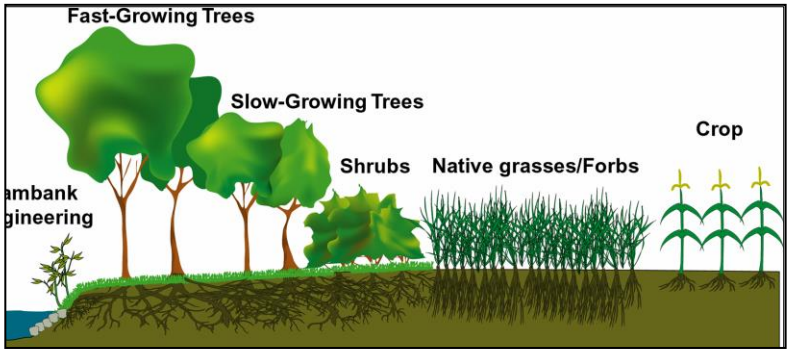
Agroforestry is a Flexible Land Use System that can Accommodate Biomass Production

Short-rotation willow, poplar plantations on farms as monoculture or mixed with herbaceous or woody species

Alley Cropping for Herbaceous Feedstock

Alley Cropping for SRW Biomass Feedstock

Riparian Buffer: Another Agroforestry Practice Suitable for Biomass Production



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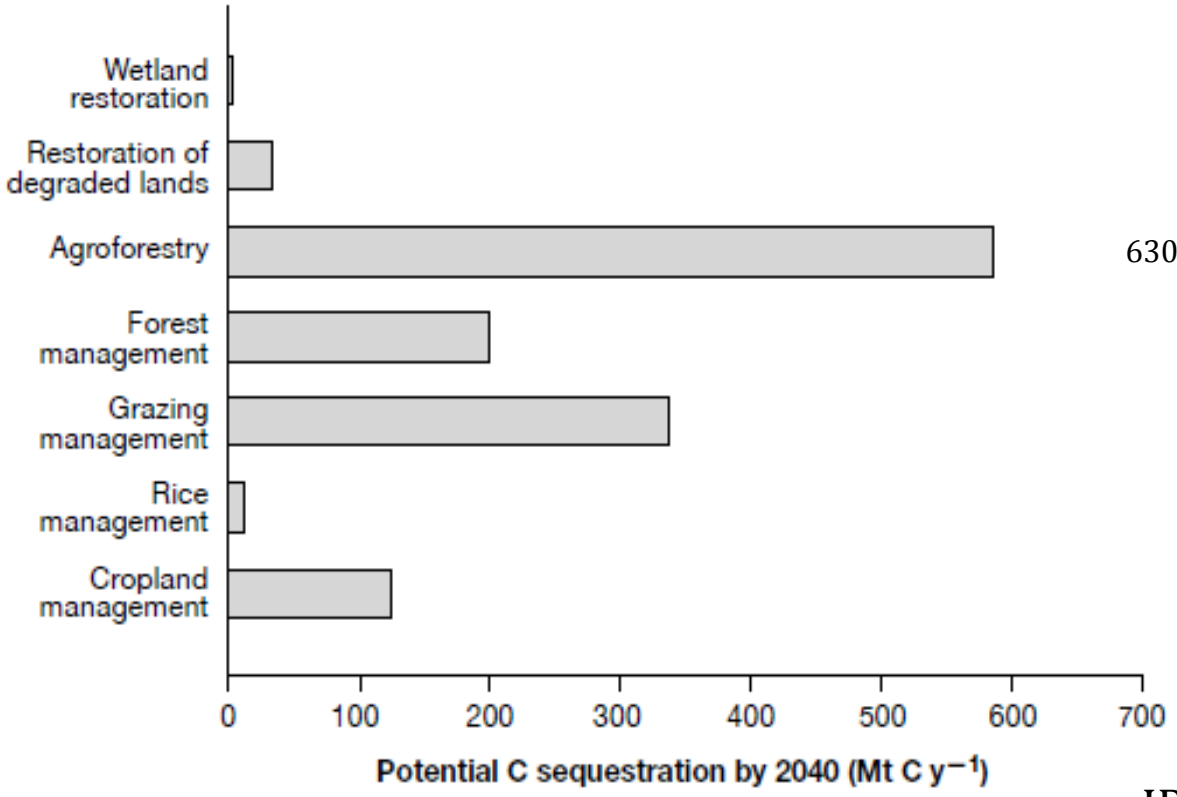
Agroforestry: Helping the Environment



630*10^6 ha

IPCC, 2000

Estimated C sequestration = 1.1-2.2 PgC/yr
(Dixon, 1995)

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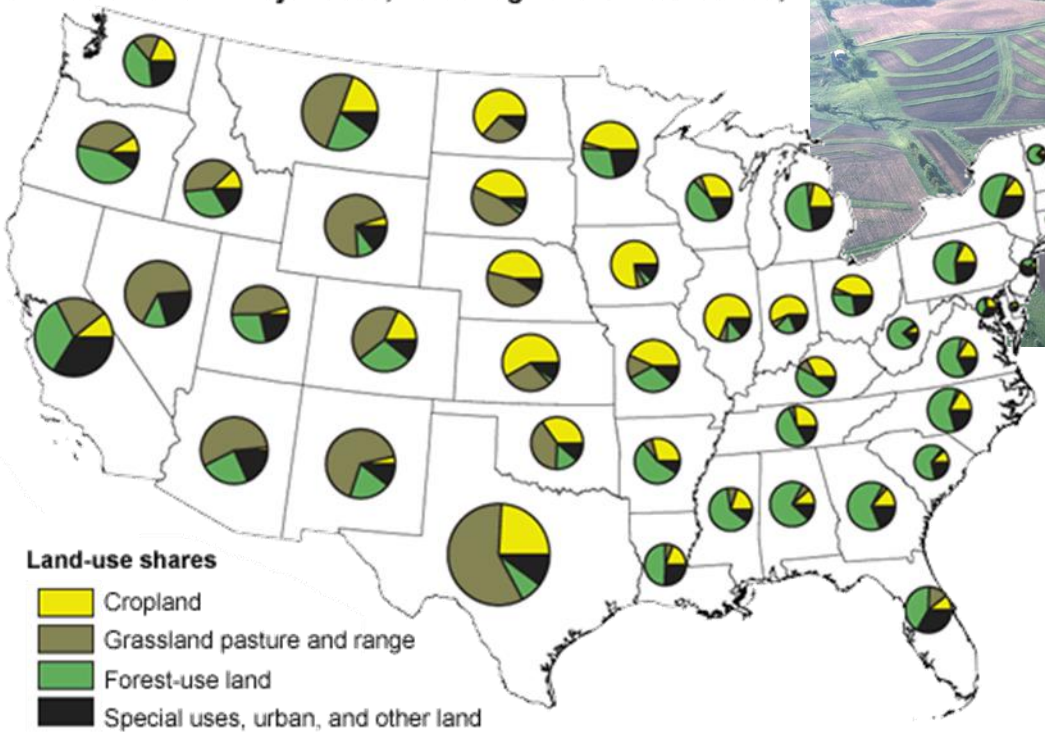
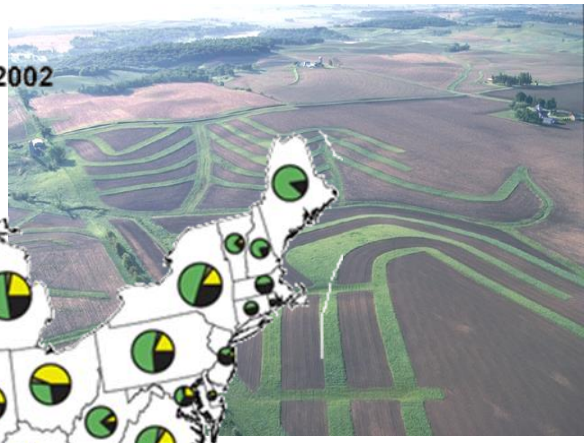
Agroforestry can help increase C Density on 23.7 million marginal pasture and 17.9 million marginal cropland





Estimates of C Seqestration

10% of the pasture land (23.7 million ha); 54 million ha of grazed forestland (18% of the U.S. forestland); 474 Tg C yr^{-1}

10% of the crop land (17.9 million ha); 61 Tg C yr^{-1} (Actual Area =< 0.5 million ha)

5% of cropland (8.95 million ha); Poplar and White Spruce; 20-yr rotation; 9 Tg C $yr^{-1;}$ (Actual Area =1.21 million ha)

30-m wide riparian buffer along both sides of 5% of total river length - 1.69 million ha; 5 Tg C yr^{-1} (Actual Area =1.15 million ha of upland and riparian buffer, NRCS)

- (Udawatta and Jose, 2011)

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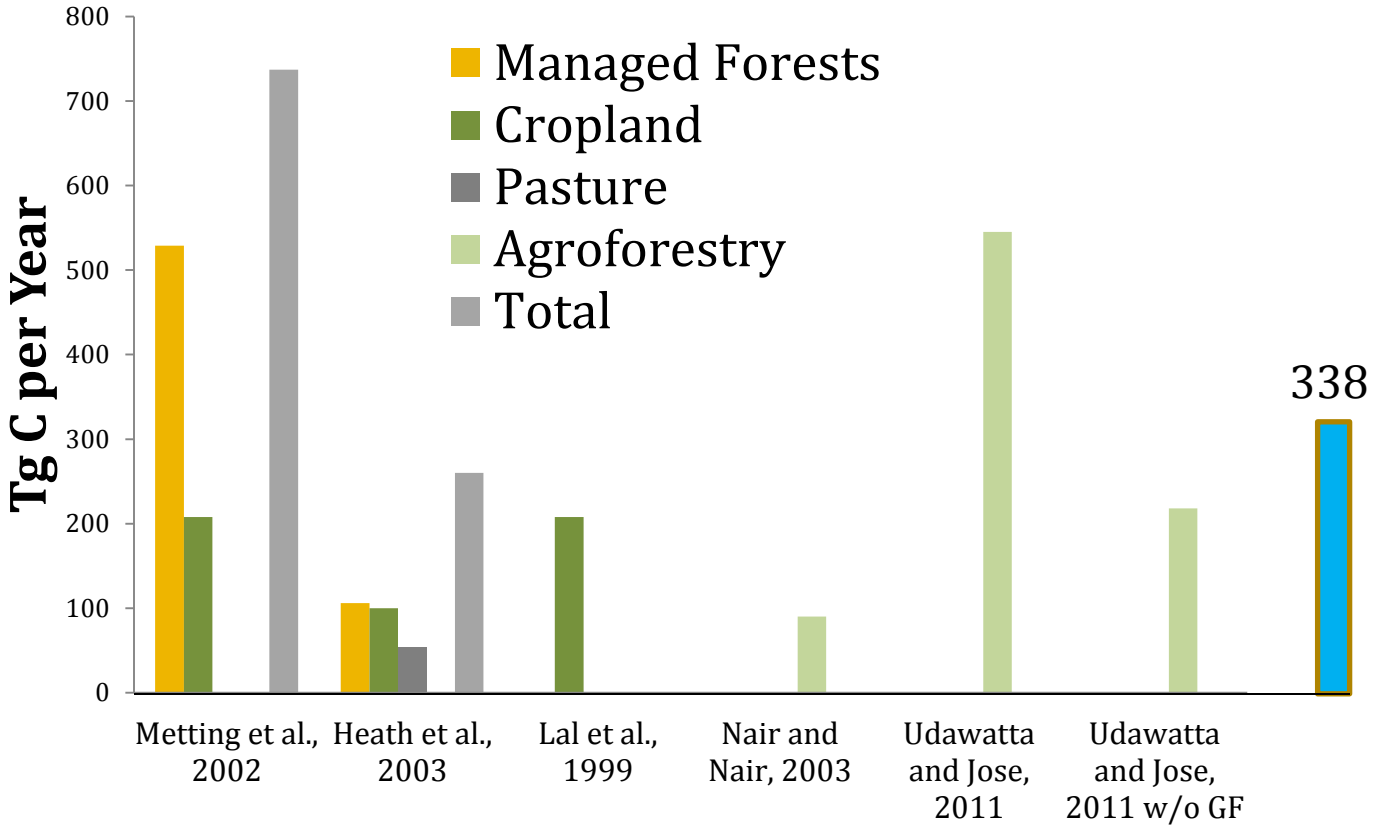
Agroforestry Could Offset Current C Emission Rate by 13 - 34%



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Agroforestry for Water Quality

Water Body	Total size	Assessed (% of total)	Impaired (% of assessed)
Rivers	3,533,205 miles	19%	**39%**
Lakes	41.7 million acres	43%	**45%**
Estuaries	87,791 square miles	36%	**51%**

EPA, 2012

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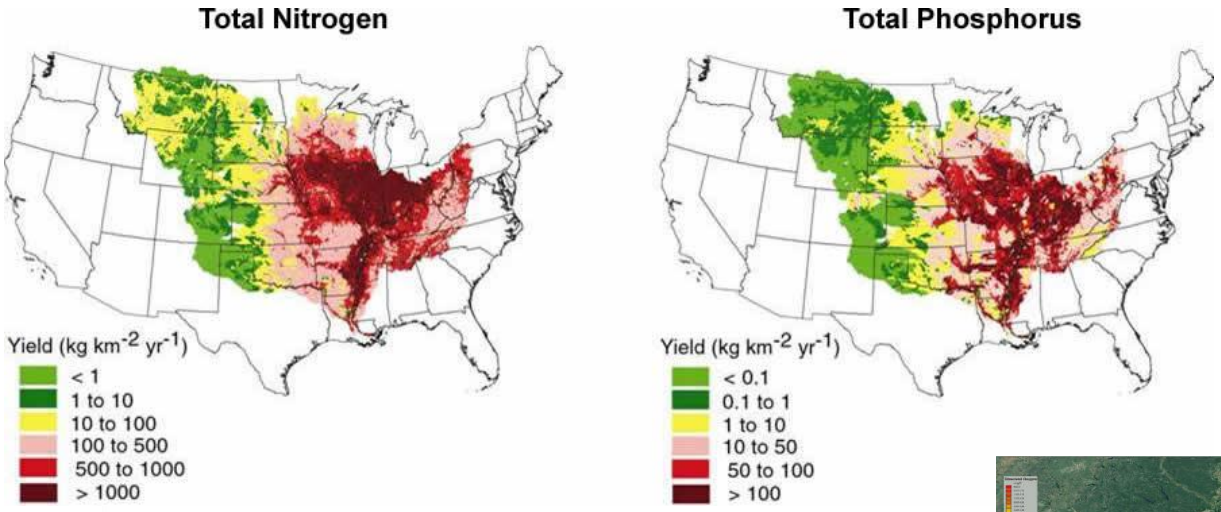
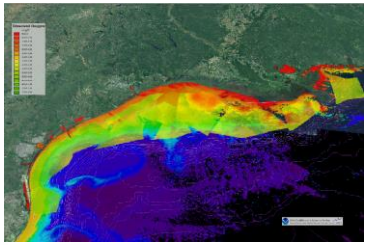
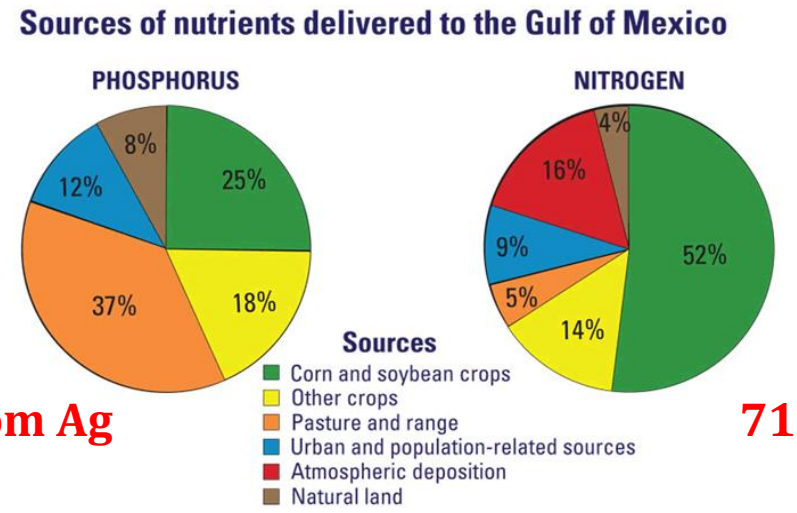
Agroforestry for Water Quality







80% of P from Ag

71% of N from Ag

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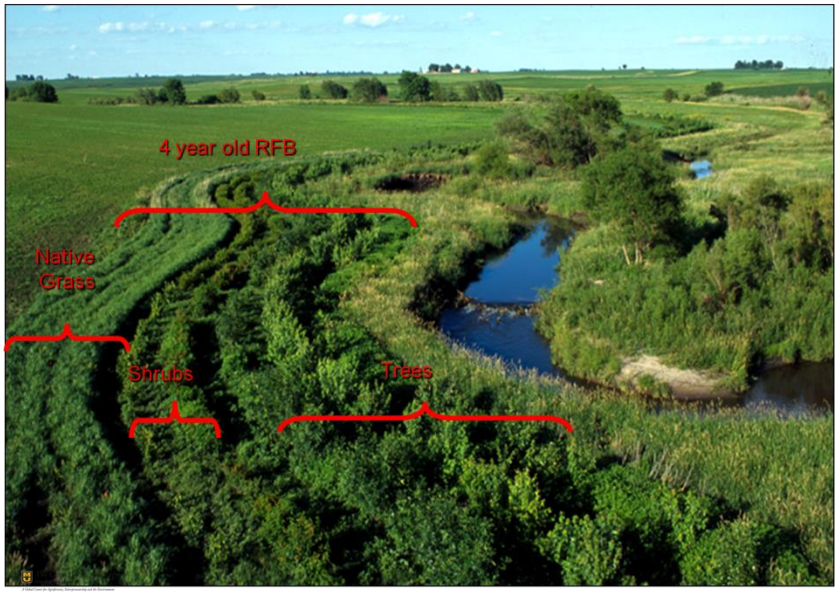
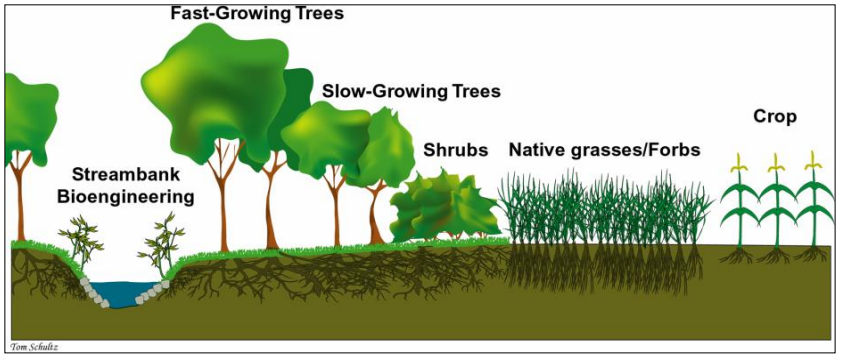
Agroforestry Can Reduce Nutrient Loading!





50 to 80% total N
41 to 92% NO3–N

46 to 93% total P
28 to 85% dissolved P

$320 million MRBI program

Lin et al., 2000; 2003;
Schultz et al., 2009

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AF Can Reduce Veterinary Antibiotics in Surface and Ground Water!

11 to 16 million kg of Veterinary Antibiotics (VA) used annually in U.S. (Levy, 1998; Mellon et al., 2001)

Therapeutic, prophylactic, and growth promotion purposes

30 to 80% of a VA dose passes through the GI tract

VA concentrations in manure range from trace to 200 mg L^{-1} or kg^{-1} (Kumar et al., 2005)

VAs in water resources – Major Water Quality Concern!!

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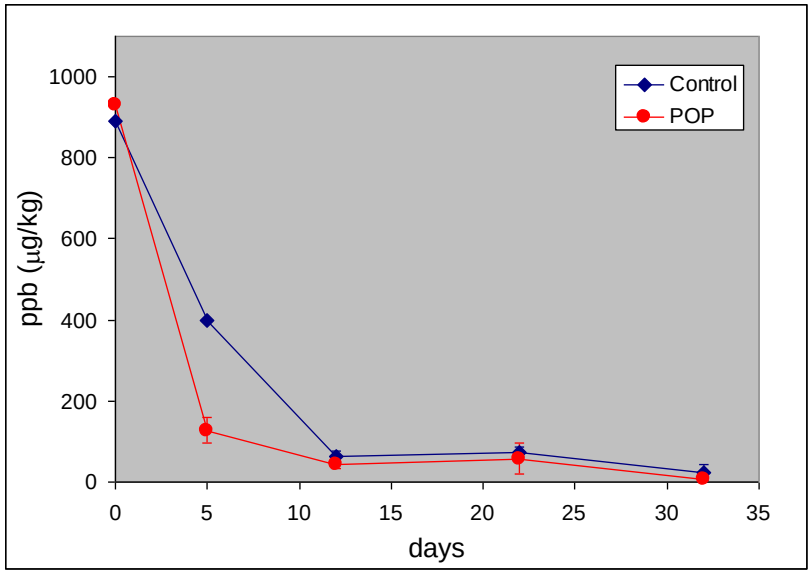
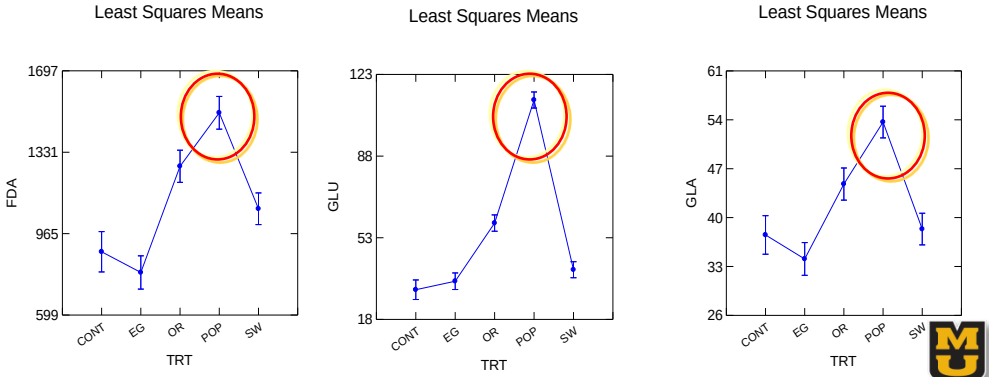
Veterinary Antibiotics – Microbial Degradation



Enhanced Rhizodegradation of Antibiotic (Sulfamethazine) by Poplar

Via Increased Microbial Enzyme Activities
(FDA, fluorescein diacetate hydrolytic; GLA, glucosaminidase, GLU, β-glucosidase)



Lin and Goyne, Lin et al. 2010

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Agroforestry for Air Quality

Confined Animal Feeding Operations (CAFO) are increasing in numbers

Odors from CAFOs is a major environmental concern

Vegetative environmental buffers (VEBs) for odor abatement is an option

Significant quantities of compounds known to correlate highly with odor can be removed through the use of windbreak technology

e.g., ammonia 47%;
dust emissions 50%

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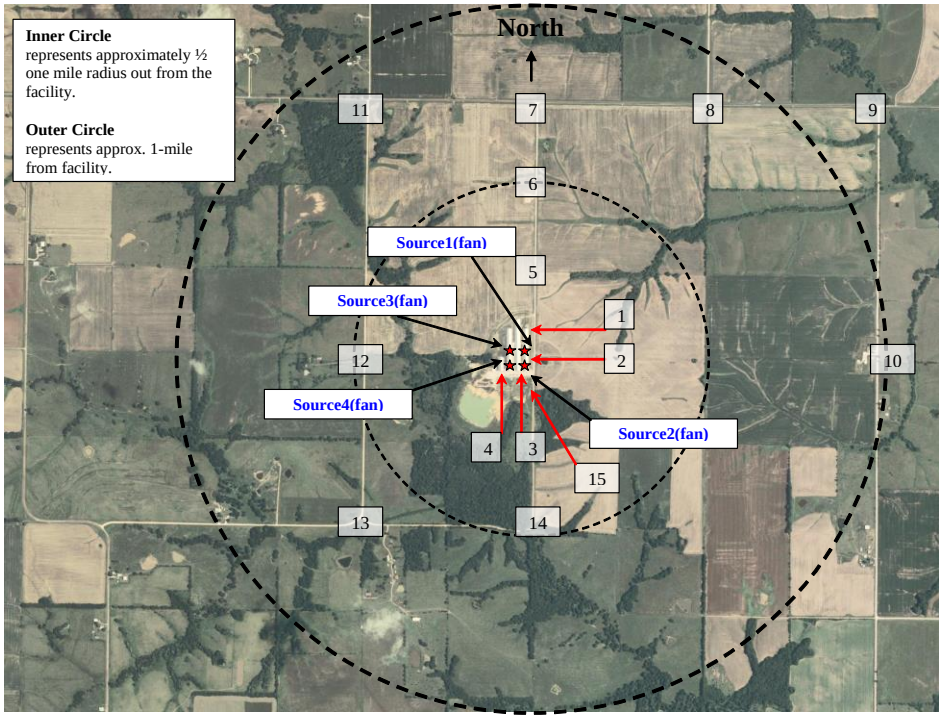
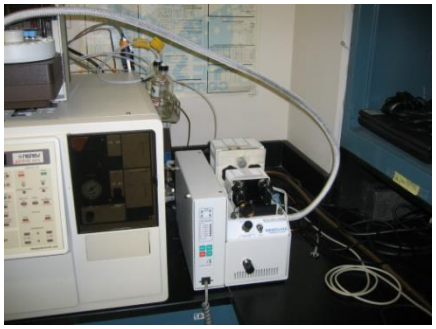
Agroforestry for Air Quality: VEBs





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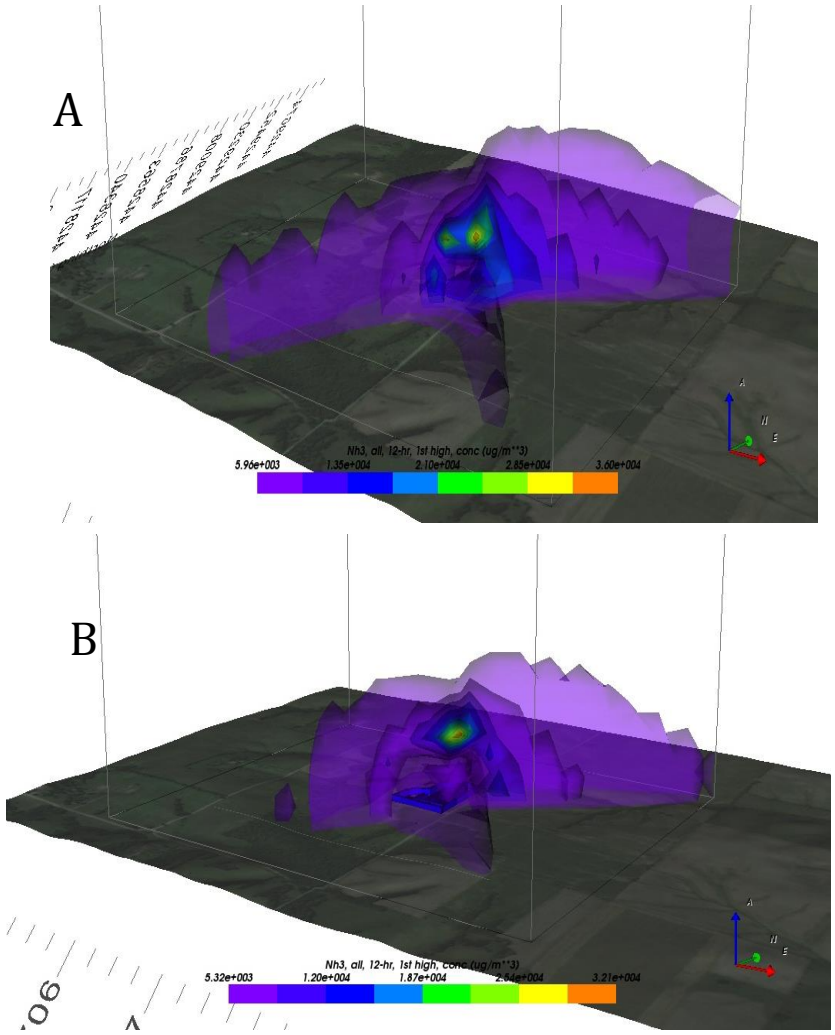
VEB: 27% Reduction in NH_3



12 hr AERMOD model simulation showing 3-D dispersion of NH_3 without VEB (A), and with a fully developed VEB (B) – 27% Reduction

Lin et al. 2012

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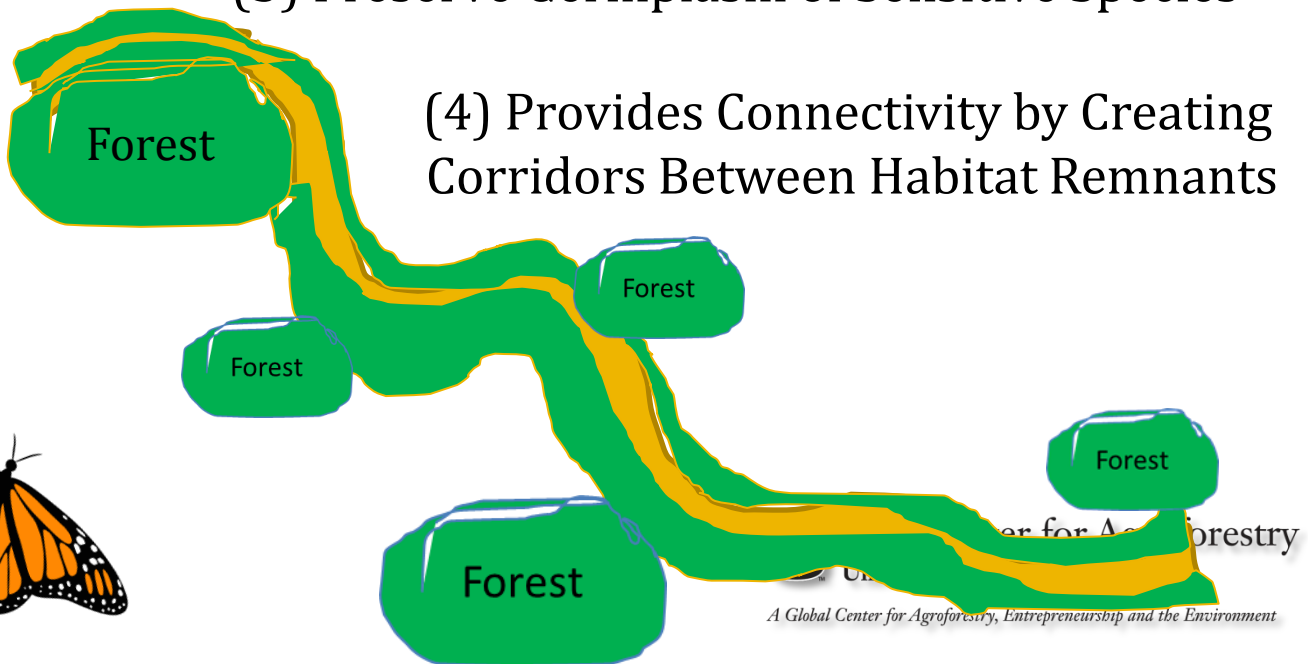
Agroforestry for Biodiversity Conservation: Pollinators Emphasis

(1) Reducing Pressure on Natural Habitats by Providing a More Productive, Sustainable Alternative to Traditional Agriculture

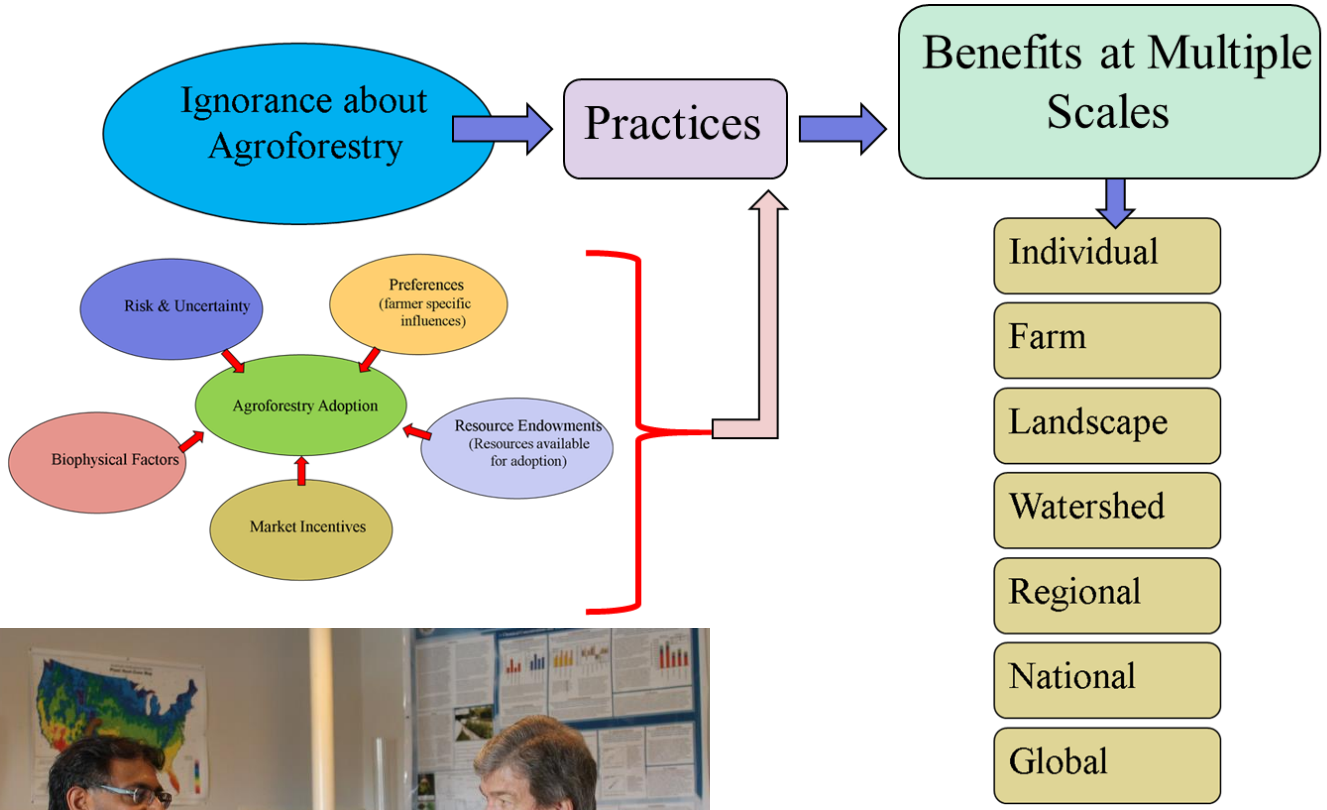
(2) Providing Habitat for Native Plant and Animals that Can Tolerate Certain Level of Disturbance

(3) Preserve Germplasm of Sensitive Species

(4) Provides Connectivity by Creating Corridors Between Habitat Remnants



Well, Where are all the Practitioners?



"Blunt sees agroforestry as important force in curbing world hunger"

Agroforestry is a Market-based Approach to Conservation!

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Well, the Momentum Is Building

- Young farmers are interested in diversifying their farms
- Older farmers are looking for perennial crops so that they don't have to do all the annual disking, planting etc.
- Biomass and bioenergy markets are emerging
- Revival of carbon markets for climate change mitigation
- Agroforestry's role in conservation – pollinators, corridors
- Growing interest in specialty crop production and emphasis on local food, organic food, and urban food forests
- Agroforestry as an economic engine for rural revitalization

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)

…which will lead to economic and environmental prosperity of our nations

Much work still remains……..

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Not only in research…….

….but in making agroforestry a mainstream land use practice, as part of a multifunctional working landscape, for the right reasons

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