Agroforestry Systems for Climate Change Mitigation and Adaptation

Shibu Jose

H.E. Garrett Endowed Professor and Director

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University of Missouri

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Claims Galore!!

Agroforestry promises to create synergies between efforts to mitigate climate change and help vulnerable populations adapt to the negative consequences of climate change (Kandji et al. 2006)

Agroforestry is a way to “bullet-proof” farms in the face of climate change (Simons, IUFRO Congress, 2010)

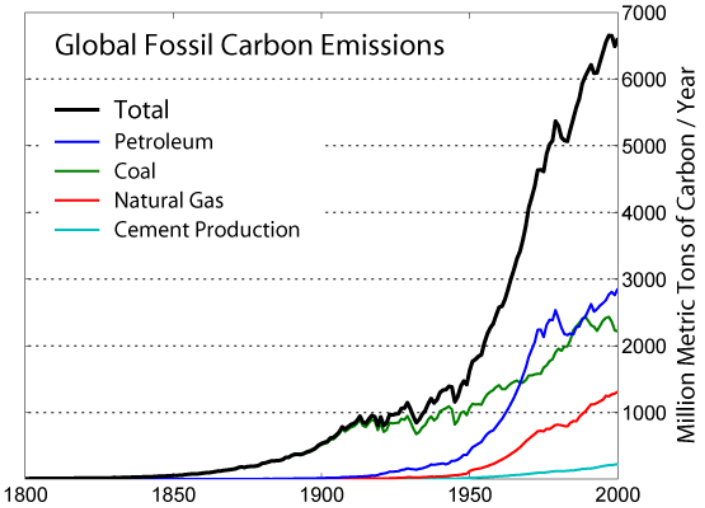
Agroforestry can be developed for: poverty alleviation; attainment of Millennium Development Goals (MDGs); food security; carbon sequestration; combating deforestation and desertification; fodder and fuel-wood supply; and environmental protection (Nair, IUFRO Congress, 2010)

Science is Now Supporting the Claims!

Data to support the claims of ecosystem services and environmental benefits provided by AF

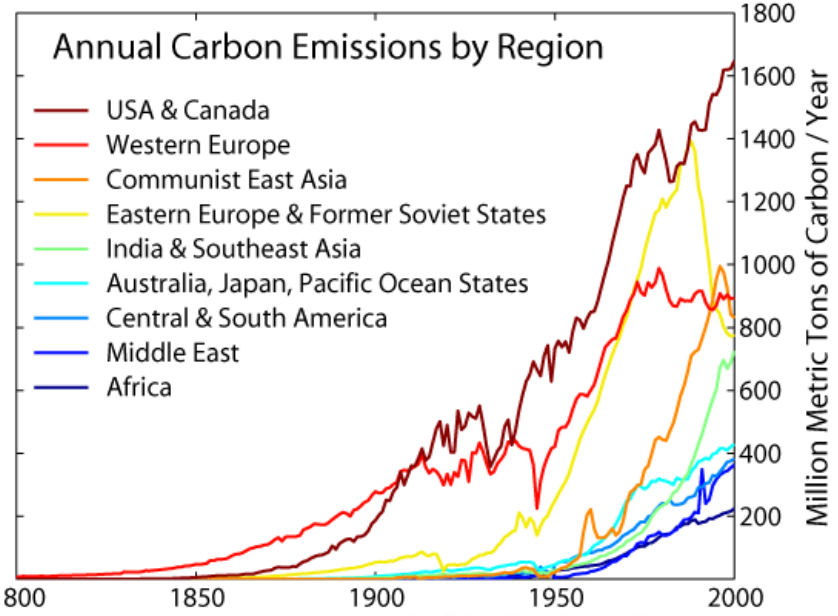
(1) Adaptation
(2) Mitigation

Mitigation: Agroforestry for C Sequestration

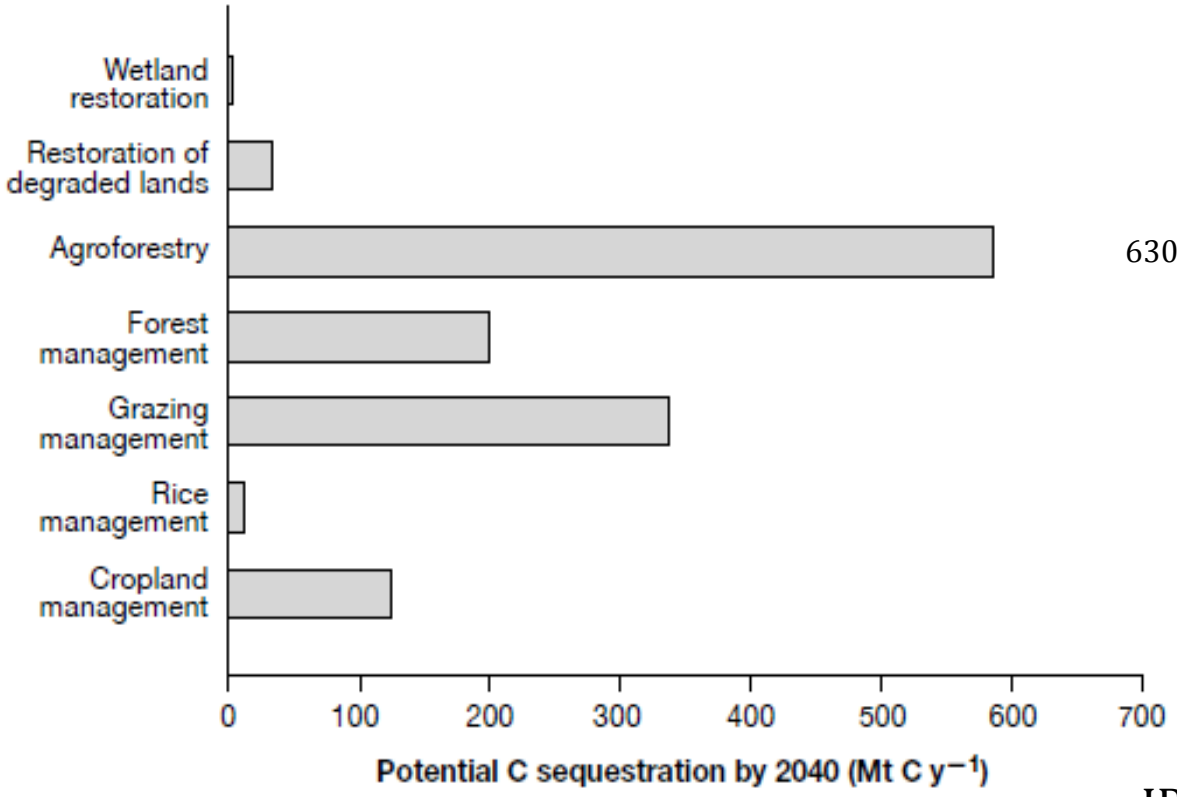


The U.S. produces about 25% of global CO_2 emissions from burning fossil fuels

Data Source:
US DOE, CDIAC



Is Agroforestry a Viable Option for Carbon Sequestration?



630*10^6 ha

IPCC, 2000

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

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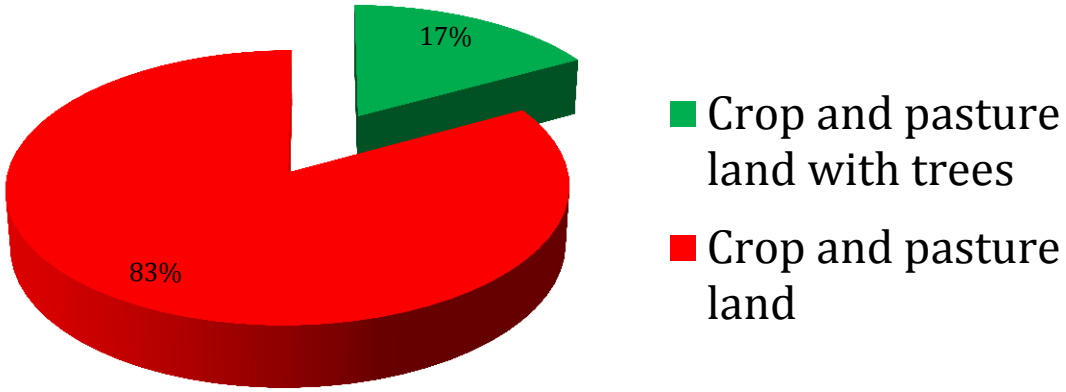
17 % of the World's Arable Land in Agroforestry: What's the U.S. Share?



Dixon, 1995
FAO, 2007
Nair et al., 2009

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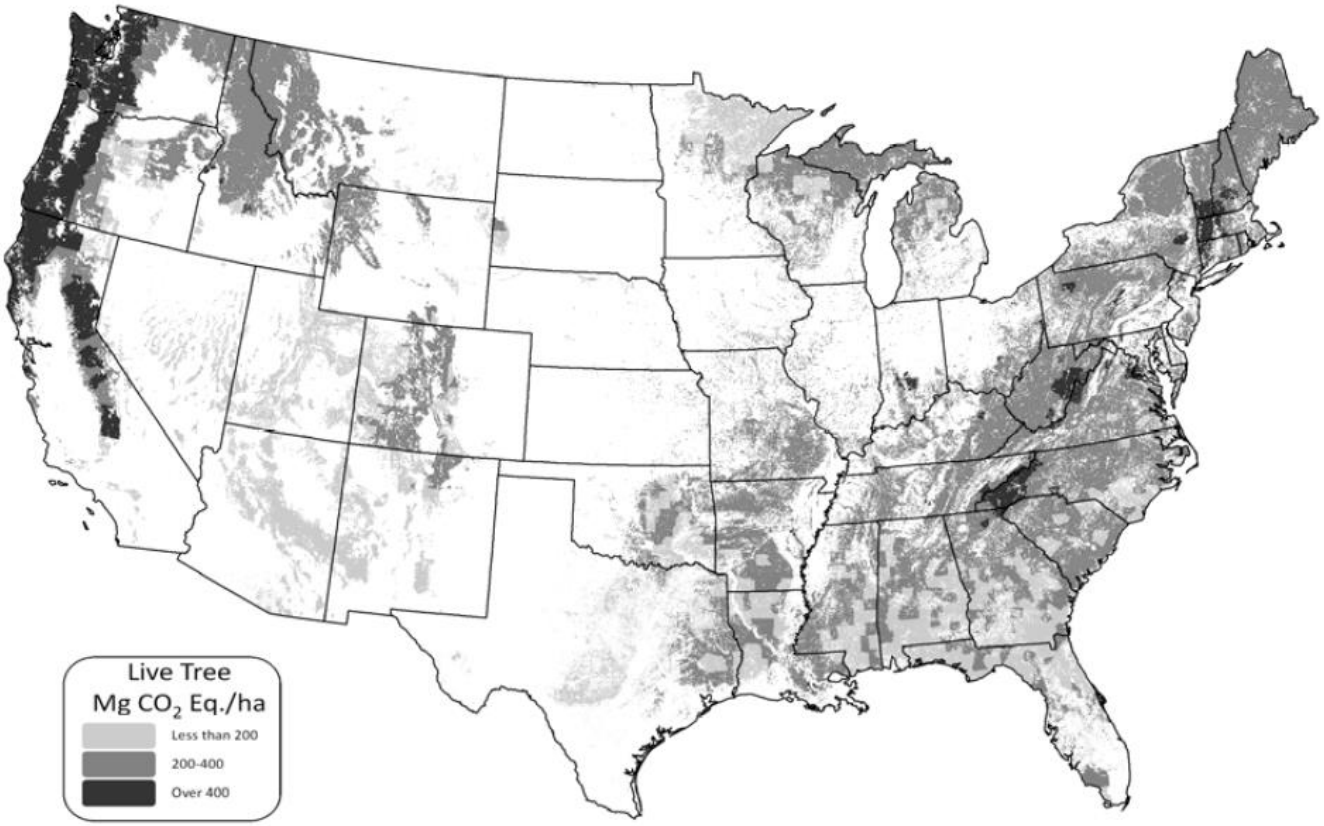
Why Agroforestry Shows Greater Potential?

Average C Density in Live Forest Tree Pool -2009



Source: US EPA, 2011

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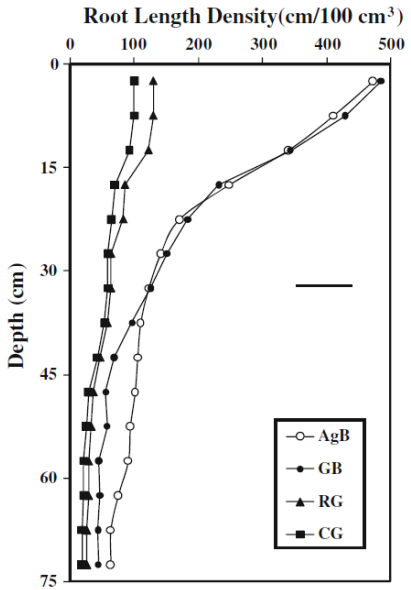
Why Agroforestry Shows Greater Potential?

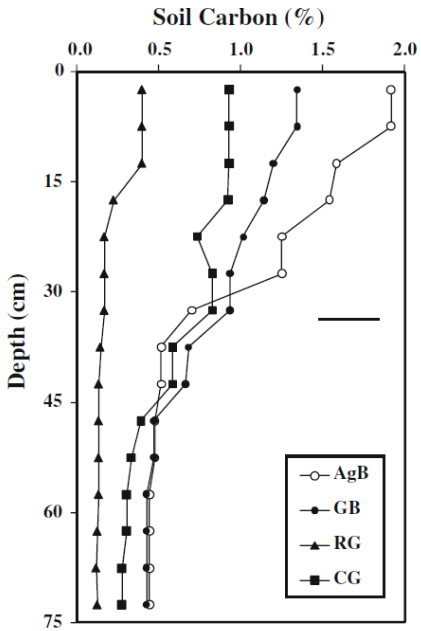
Agroforestry Buffer (AgB)

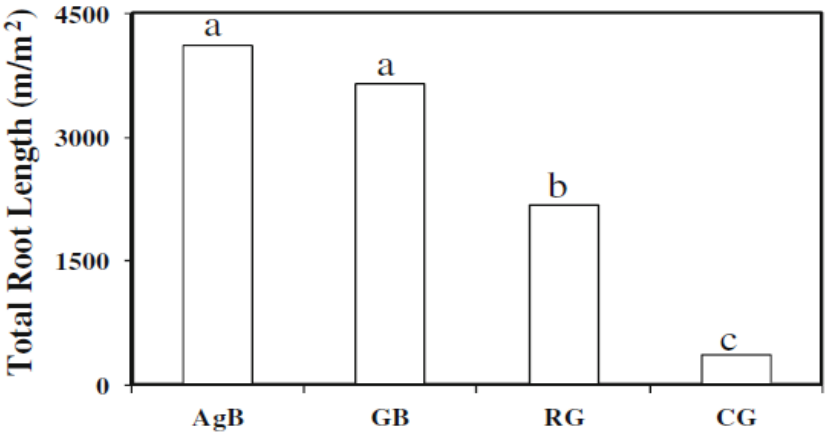
Grass Buffer (GB)

Rotationally Grazed (RG)

Continuously Grazed (CG)

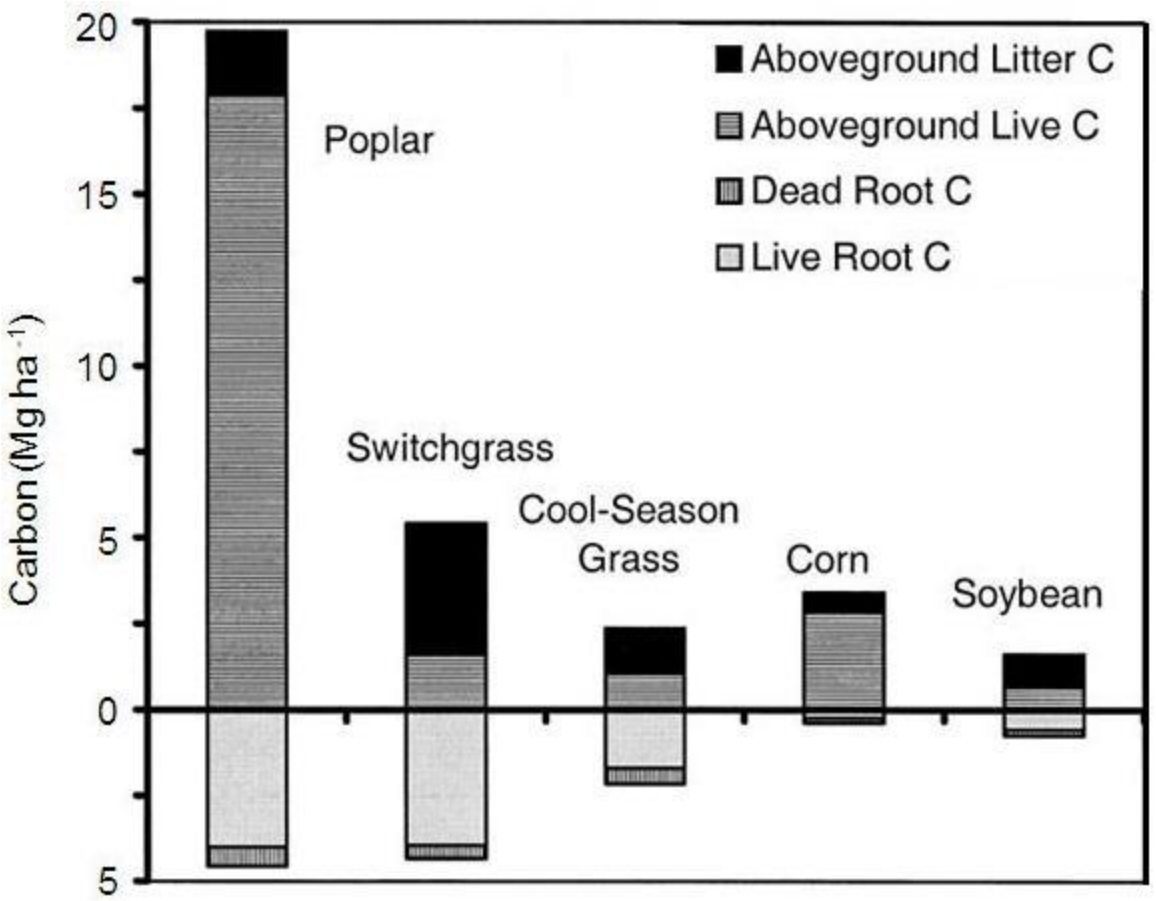






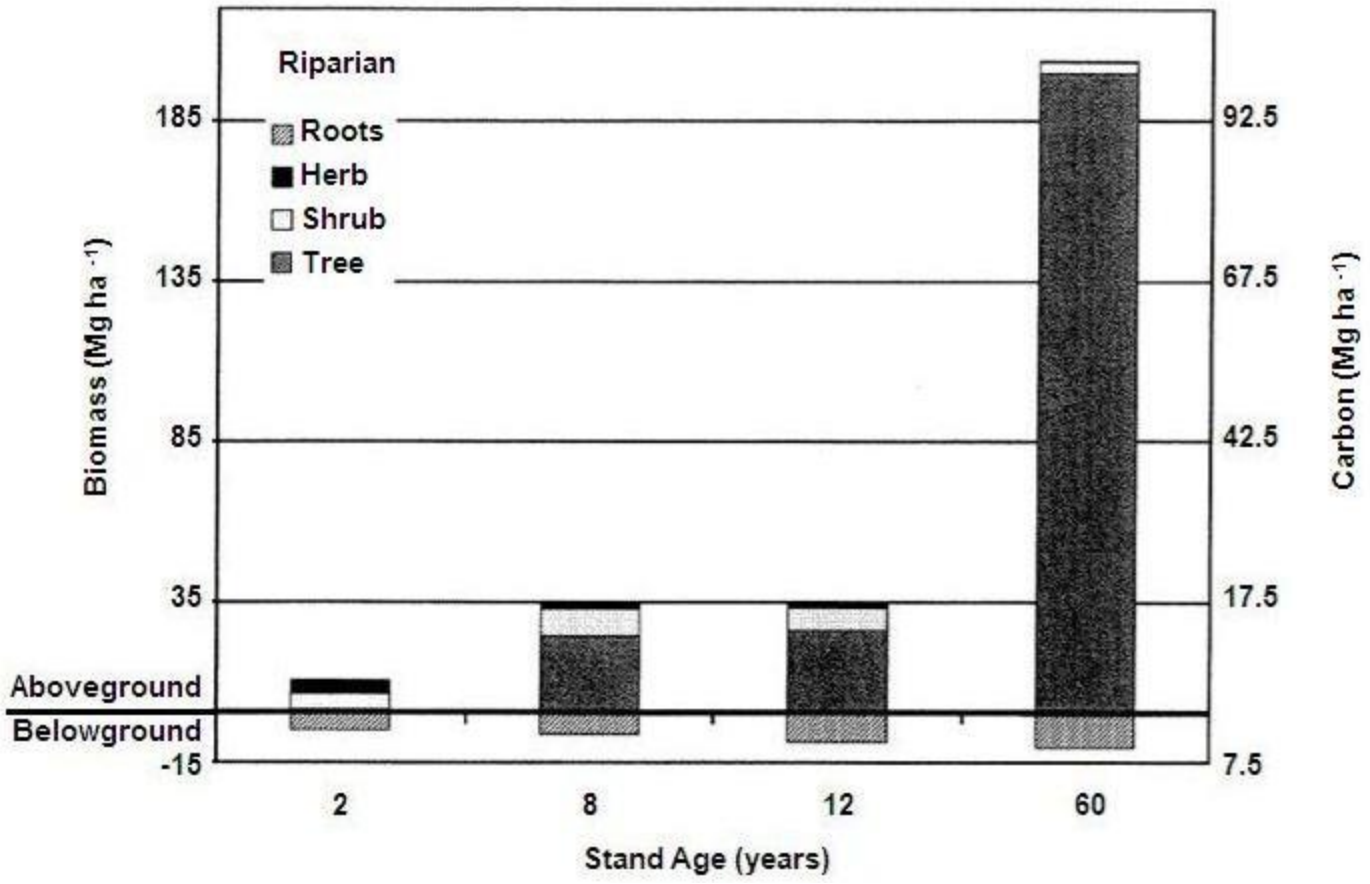
Kumar, Udawatta and Anderson, 2010

Above and Belowground C Addition



Tufekcioglu et al., 2003

Long-term Storage of C



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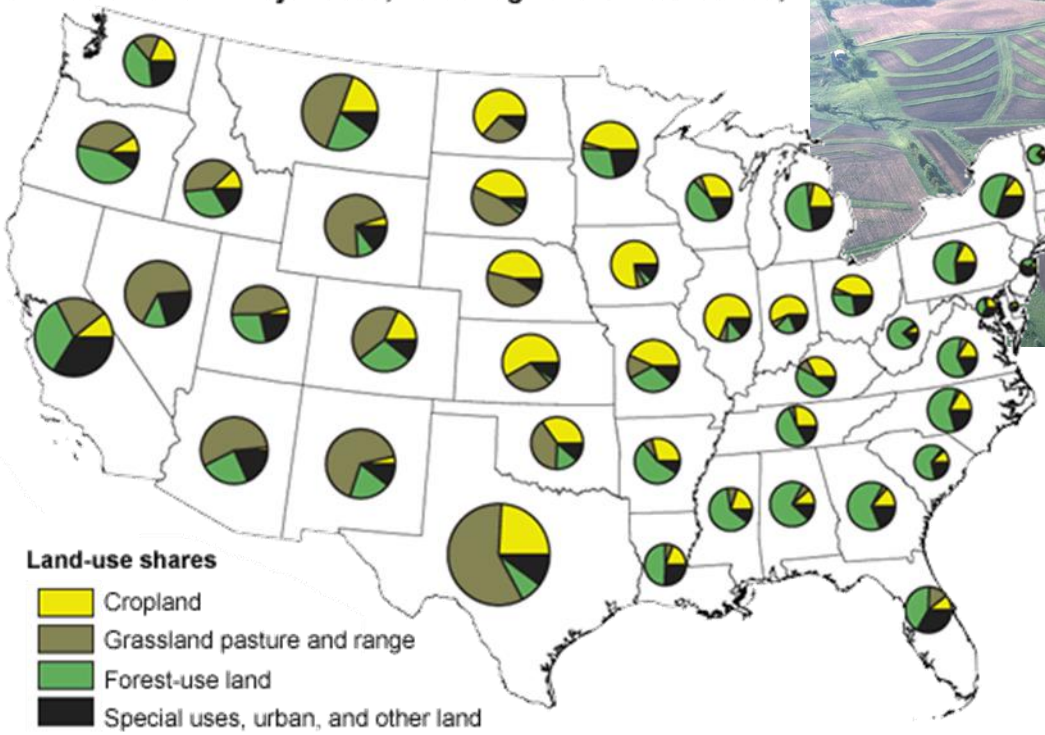
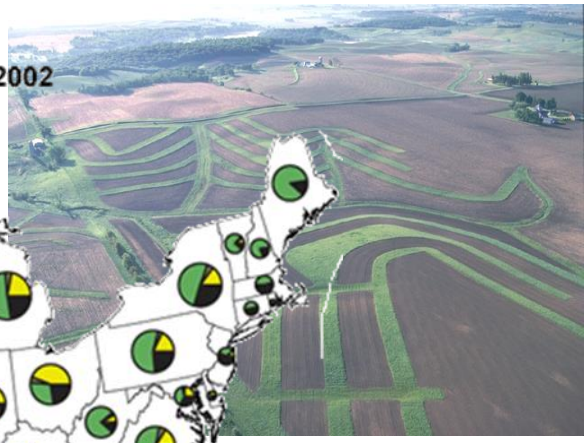
Agroforestry can help increase C Density on 23.7 million marginal pasture and 17.9 million marginal cropland





Preliminary Estimates of C Seq.

- Based on the literature from US and Canada (Udawatta and Jose, 2011)
- Guesstimates of potential land area under agroforestry
- Only four of the five temperate agroforestry practices included
  - Silvopasture
  - Alley Cropping
  - Riparian Buffers
  - Windbreaks

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Silvopasture

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

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Alley Cropping

- **10% of the crop land (17.9 million ha)**
- **3.4 Mg C ha^{-1} yr^{-1} Sequestration Potential**
- **60.9 Tg C yr^{-1}**

Windbreaks

- **5% of cropland (8.95 million ha)**
- **20-yr rotation**
- **Poplar and White Spruce**
- **8.79 Tg C yr^{-1}**

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Riparian Buffer

- **If a 30-m wide riparian buffer is established along both sides of 5% of total river length in the U.S., it would occupy 1.69 million ha**
- **2.6 Mg C ha^{-1} yr^{-1} potential C sequestration**
- **4.7 Tg C yr^{-1}**

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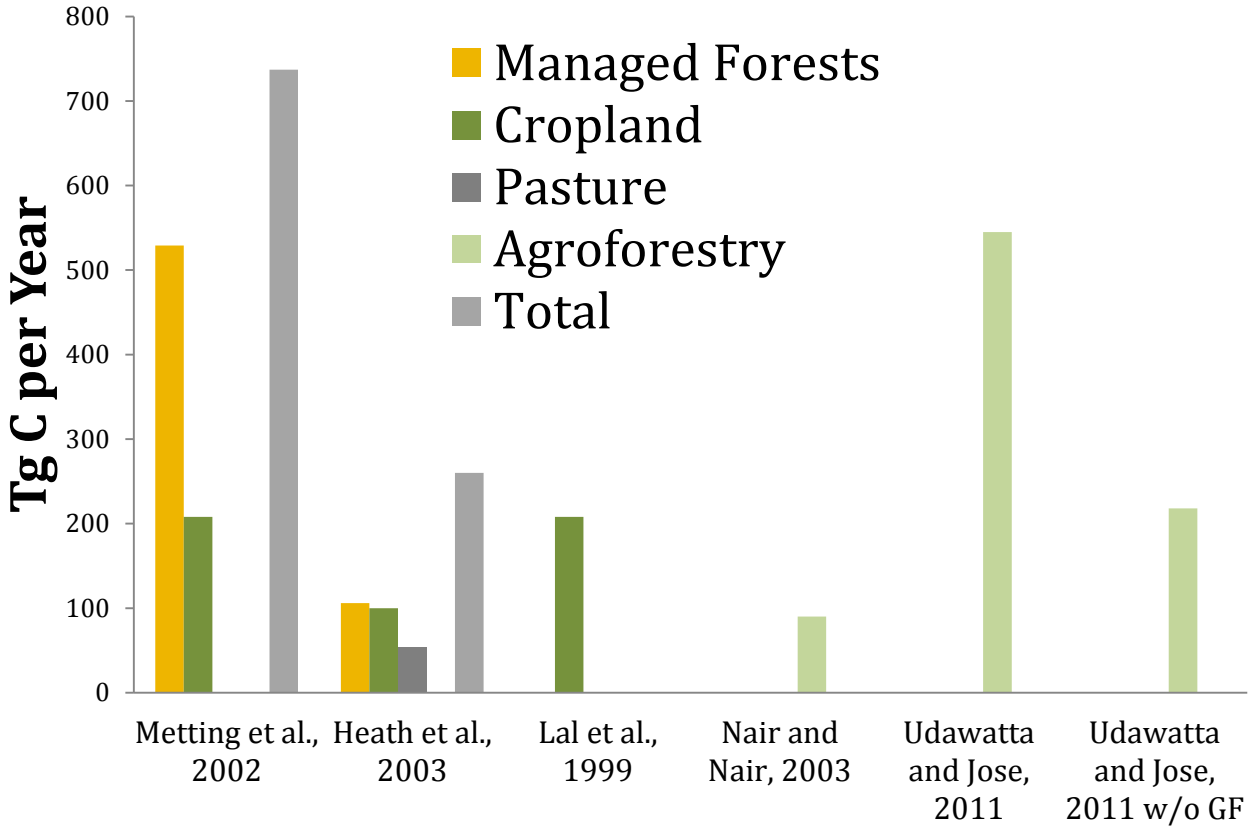
Agroforestry Could Offset Current C Emission Rate by 13 - 34%



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Adaptation: Adding Resiliency

Microclimate parameter	Field average	
	2006	2007
PPFD (μmol m^{-2} s^{-1})[a]		
Agroforestry field	1044[b]	1176[b]
9:00 a.m.	994d	928e
12:00 p.m.	1527b	1628b
3:00 p.m.	1378c	1466c
6:00 p.m.	277f	680f
Control field	1294[b]	1345[b]
9:00 a.m.	1048d	1272d
12:00 p.m.	1753a	1845a
3:00 p.m.	1692a	1594b
6:00 p.m.	687e	730f
Soil temperature (°C)[c]		
Agroforestry field	23.1b	19.0b
Control field	23.5a	21.7a
Soil moisture (%)[c]		
Agroforestry field	26.5a	10.1a
Control field	24.6b	8.7b
Soil nitrogen (%)[c]		
Agroforestry field	n/a	0.34b
Control field	n/a	0.47a
Foliar nitrogen (%)[d]		
Agroforestry field	n/a	2.69a
Control field	n/a	2.69a

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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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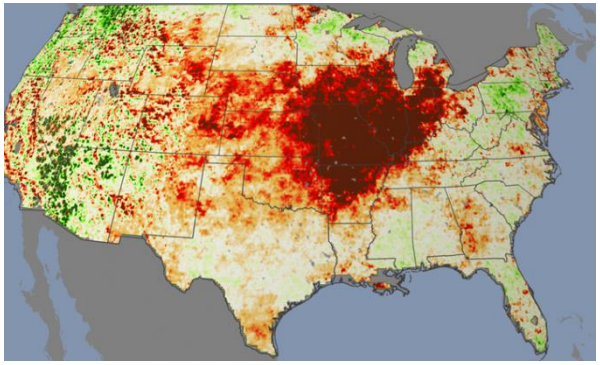
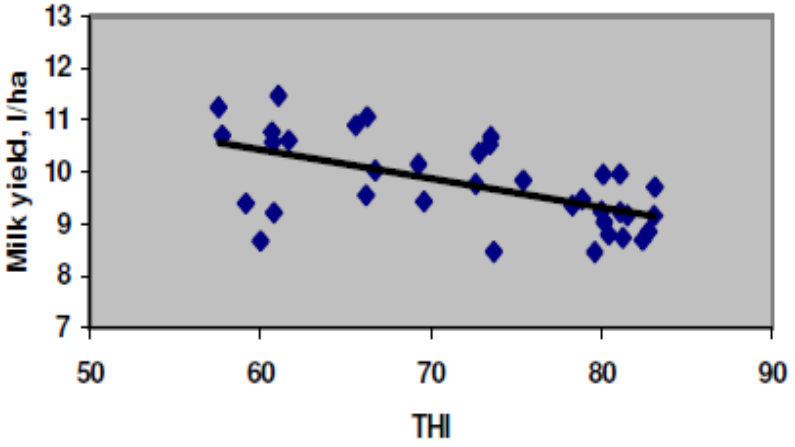
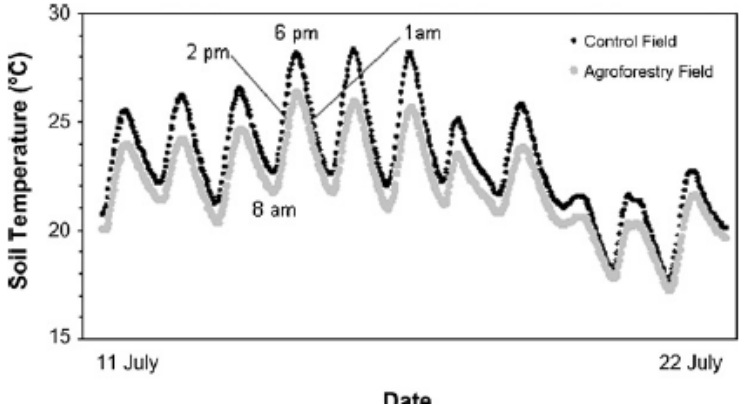
Rising Temperature? Agroforestry Can Help!



2012 August- Heat Stress Index



$2 billion lost annually!!



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)

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Data from Silvopasture

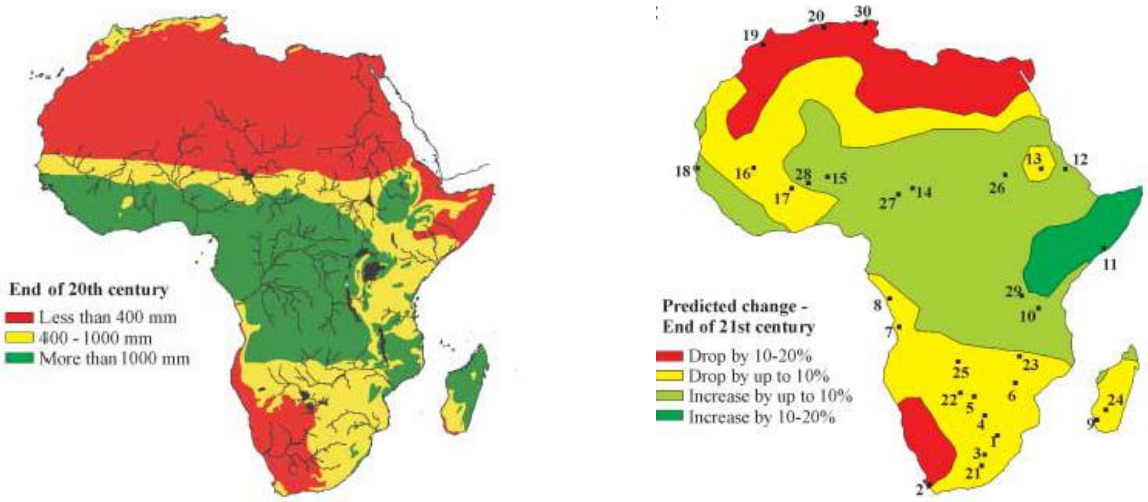
- Lost approximately 10% less weight over winter
- Had less stress at calving
- Weaned heavier calves

- 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

Drought - Climate Change Adaptation

Changes in Available Water



de Wit and Stankiewicz, 2006

Agroforestry helps recharge water better!

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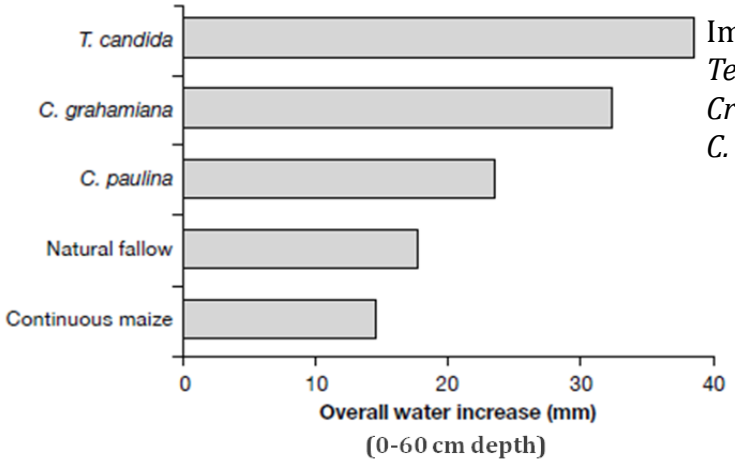
Changes in Soil Water Storage in Western Kenya



Improved Fallows with
Tephrosia candida
Crotalaria grahamia
C. paulina

Low rainfall

↓

Increased soil porosity,
Reduced runoff,
increased water infiltration,
higher storage, greater RUE

↓

Higher Yield

Grain yield (kg/ha) and rainfall use efficiency (RUE, kg/mm) of maize in continuous maize and improved fallow (*Sesbania sesban*), Zambia

	Season 1 (rainfall = 1001 mm)		Season 2 (1017 mm)		Season 3 (551 mm)		Season 4 (962 mm)		Season 5 (522 mm)	
	Maize	IF	Maize	IF	Maize	IF	Maize	IF	Maize	IF
Grain yield	990	1100	1300	2400	600	1850	1100	2300	500	1180
RUE	0.99	1.10	1.28	2.36	1.09	3.36	1.14	2.39	0.96	2.26

97% increase
110% increase

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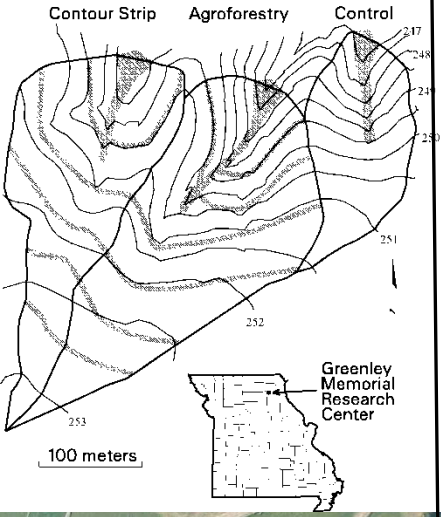
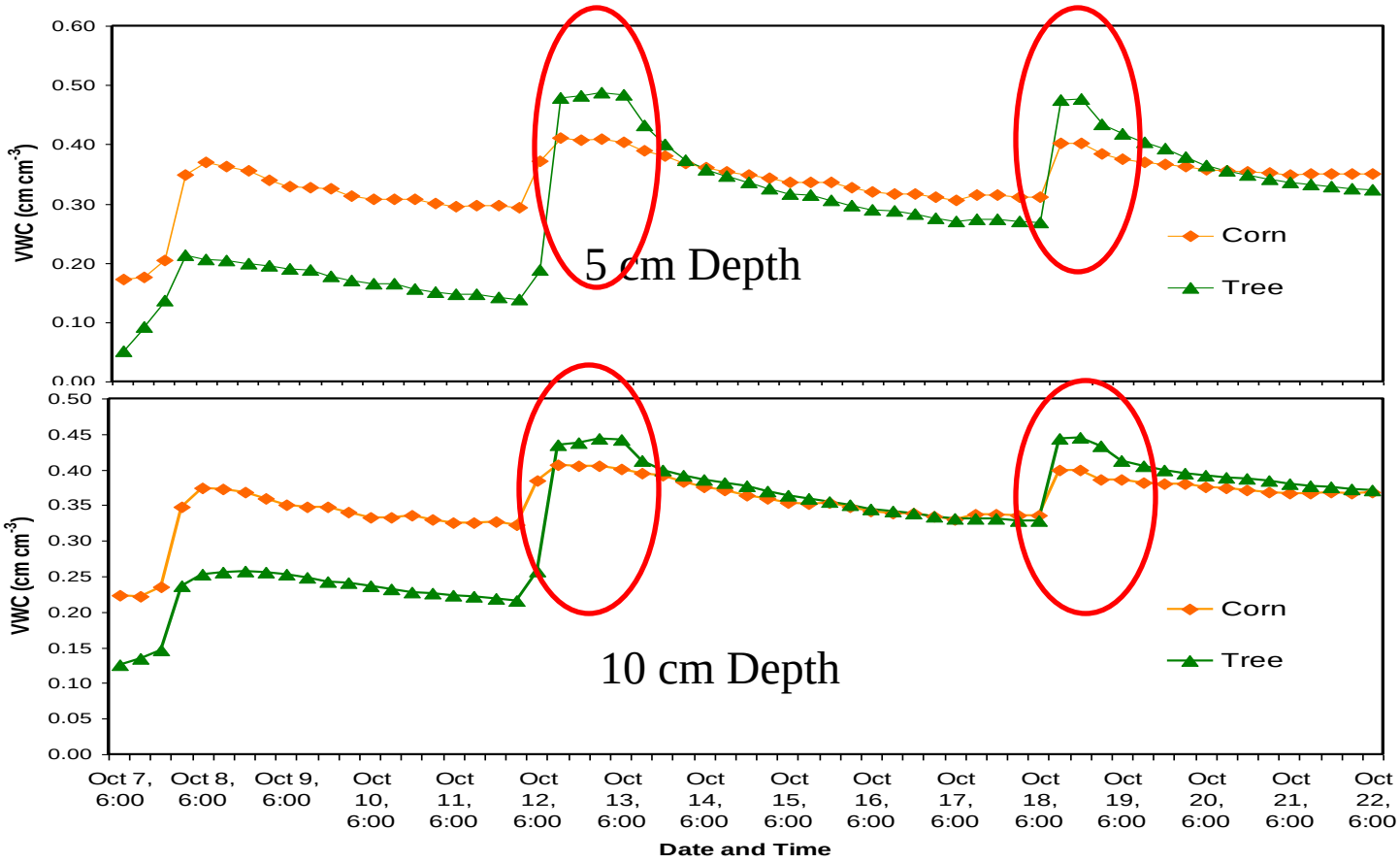
Changes in Soil Water Storage





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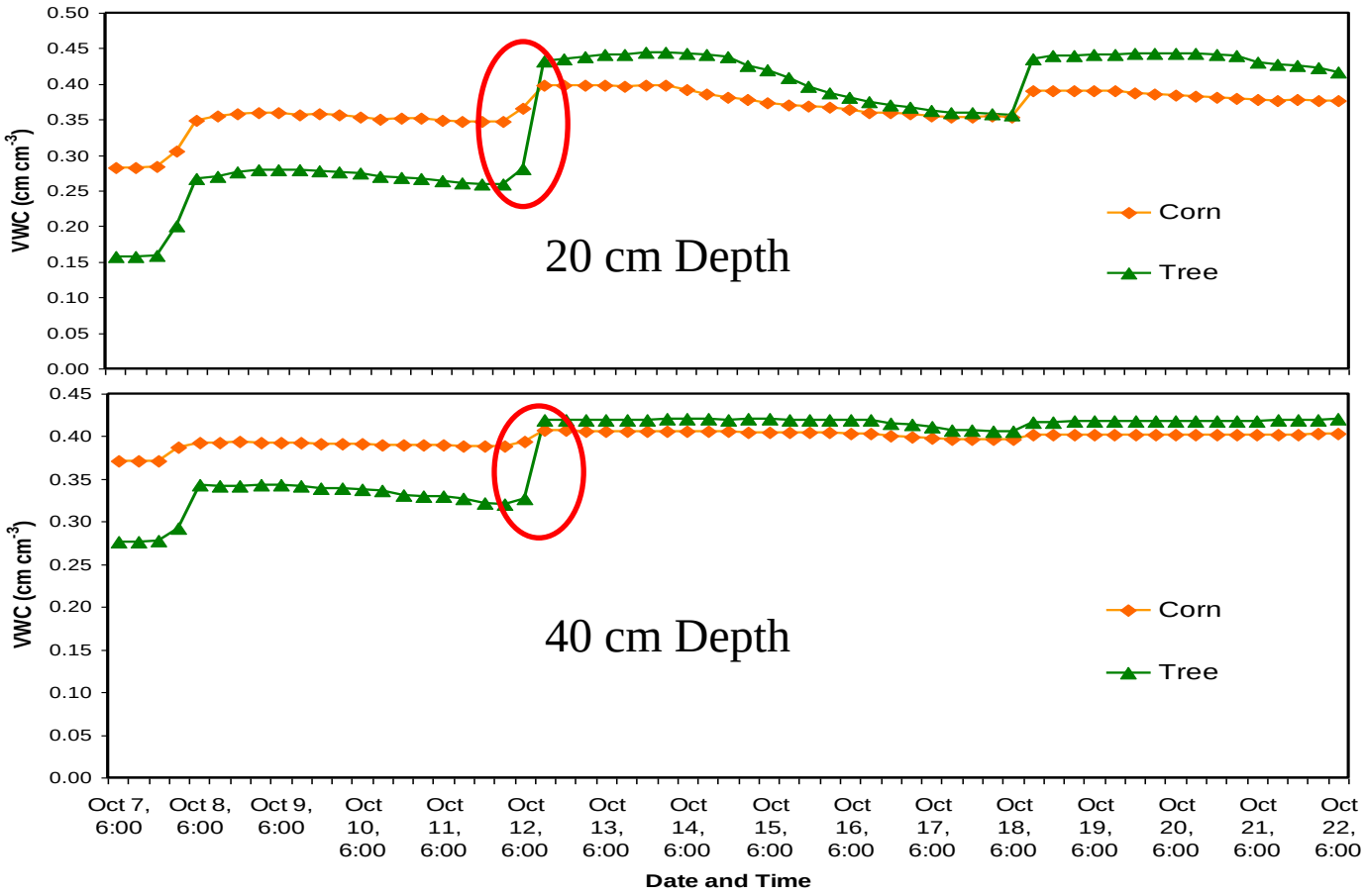
Changes in Soil Water Storage



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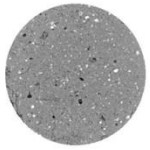
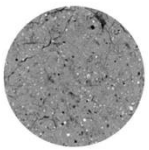
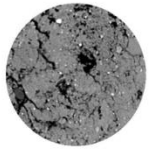
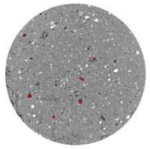
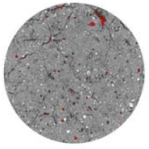
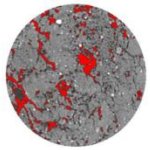
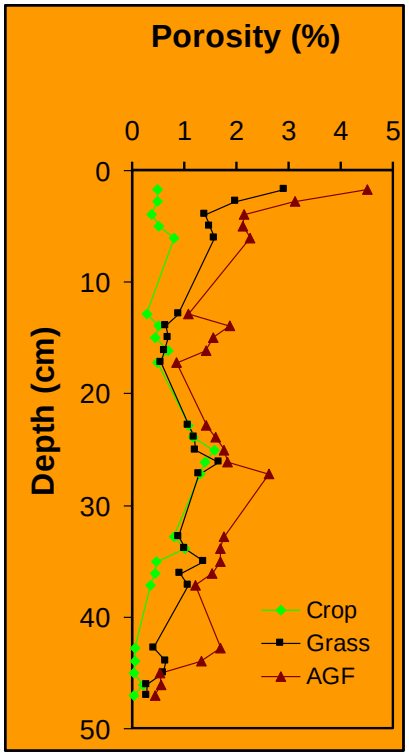
Changes in Soil Water Storage –

Resulting from increased porosity

	Row crop	Grass buffer	Tree
Typical scan images 68 mm diam. area			
After thresholding, air-filled pores are in red			
Isolated pores within the scans			



Udawatta and Anderson, 2009

Udawatta et al., 2006

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Heavy Winds – Erosion – Well, Windbreaks!

Windbreak Benefits

<u>Nebraska</u>:

- **15,300 miles of field windbreaks protect 1 million acres of crops**
- **$72 million/year in increased crop yields**
- **C sequestration**
- **Wildlife habitat**
- **Aesthetics and more…..**

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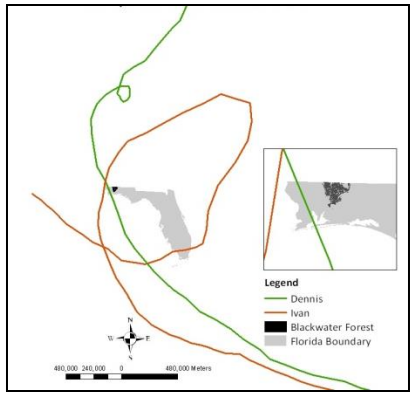
Buffering Against Income Risks

Associated With Climatic Variability and Extreme Weather Events



Paths of Hurricanes Ivan (2004) and Dennis (2005) with Respect to study location

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