Non-point source pesticide pollution in CEAP watersheds - controlling factors and mitigation strategies

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Presentation overview

Highlights of pesticide environmental fate research in 3 ARS-CEAP watersheds

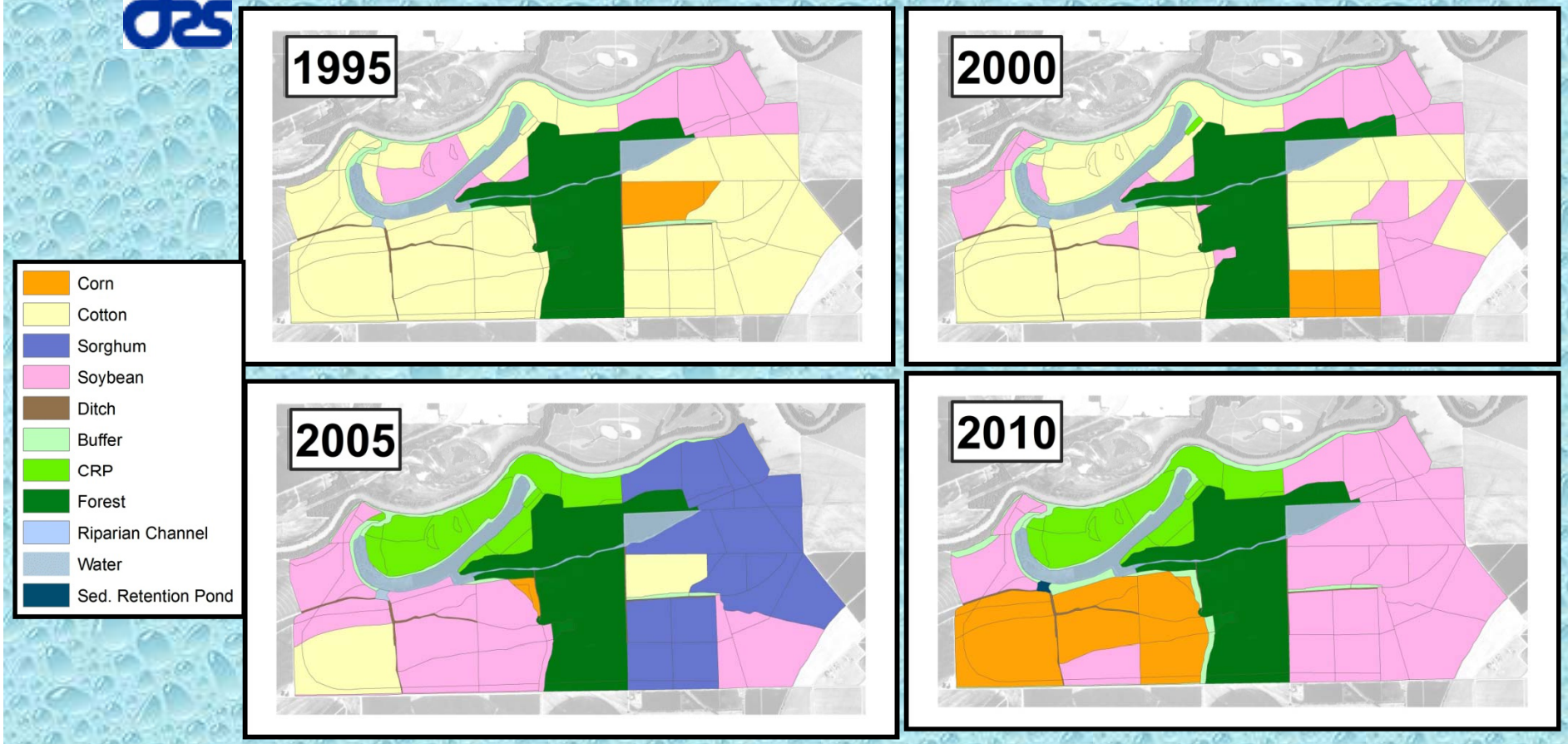
- Beasley Lake, MS
- Goodwater Creek, MO
- Little River, GA

Beasley Lake Watershed, MS

- **Lower <u>Mississippi Delta</u> (Sunflower County, MS)**
- Small (915-ha) watershed with 135 ha of riparian forest and a 25-ha oxbow lake - common landscape feature.
- Water quality monitoring (sediment, nutrients, pesticides) 1995 to present.
- Historical and current research focuses on monitoring lake limnology, evaluating conservation practice effects on edge-of-field runoff, quantifying changes associated with the Conservation Reserve Program, and modeling watershed responses.

MA Locke et al. 2008. Environmental quality research in the Beasley Lake watershed, 1995 to 2007: Succession from conventional to conservation practices. JSWC 63:430-442.

Land Use in Beasley Lake Watershed, 1995-2010



about **70 % OF WATERSHED** in crop production; in 1995 cotton was widely grown (80% of cropland); by 2010 land in cotton production was converted to to corn (31%) and soybean (69%) .

Pesticide Use in Beasley Lake Watershed, 1995-2010

	year			
	1995	2000	2005	2010
	----------Total applied (ha)----------			
Atrazine	29	69	278	361
2,4-D	0	103	129	325
Fluometuron (cotton only)	918	234	0	0
Glyphosate	**129**	**1370**	**1084**	**1696**
Metolachlor	487	33	278	361
Herbicides (non glyphosate)	5053	2903	868	1047
Total herbicides	5182	4273	1952	2742
Total insecticides	4714	2754	772	643

Pesticide Detections in Beasley Lake, 1998-2010

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
atrazine (H)	+ **(2)**	+ **(6)**	+ **(8)**	+ **(3)**	+ **(6)**	+ **(5)**	+ **(1)**	+ **(1)**	+	+	+	+	+
metolachlor (H)	+ **(1)**	+ **(7)**	+ **(6)**	+ **(1)**			+ **(3)**			+		+	+
cyanazine (H)	+	+	+	+									
fluometuron (H)	+	+	+	+	+	+							
bifenthrin (I)										+			
cyhalothrin (I)					+								
esfenvalerate (I)	+												
methyl parathion (I)									+				

I=insecticide; H = herbicide; + indicates at least one detection; number in parenthesis is # of detections 1998-2005.

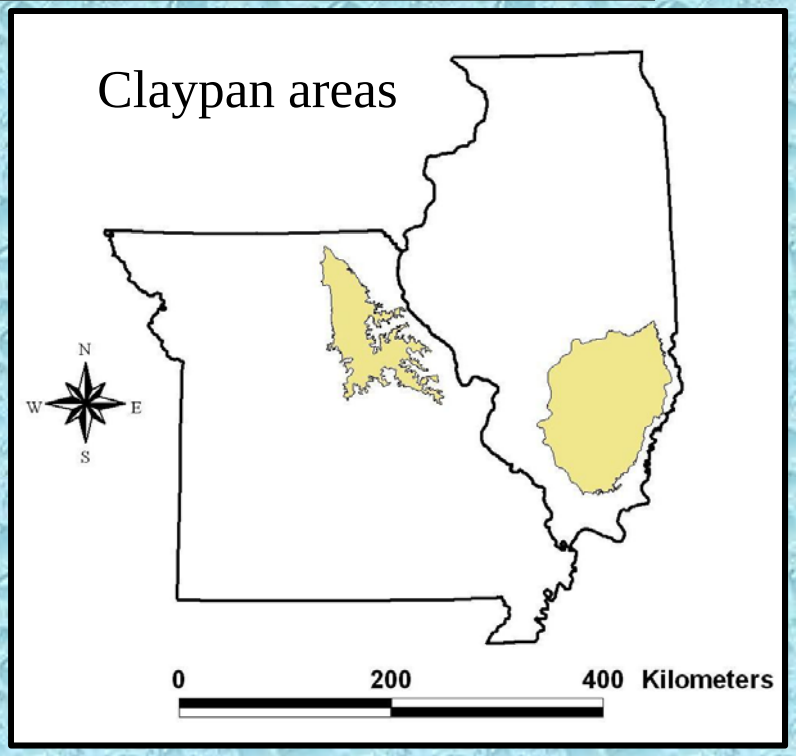
Goodwater Creek, MO

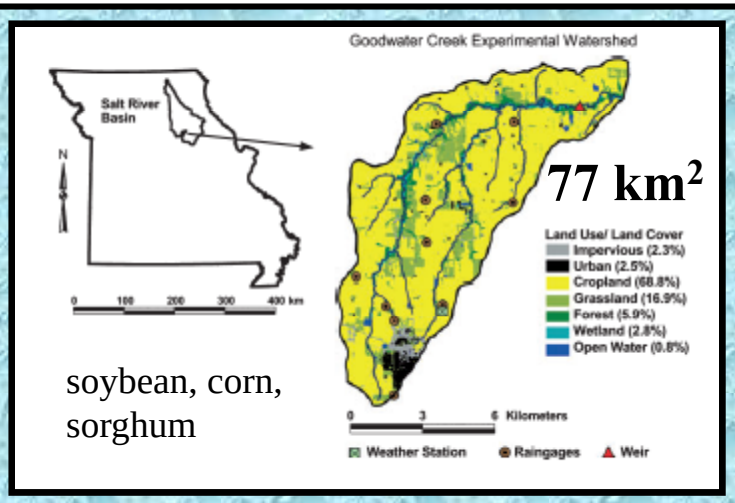
Central Claypan Soil Areas

- 33,000 km^2 in MO and IL
- Claypan is an extreme form of an argillic horizon

Vulnerable to contaminant transport in surface runoff

- **Sediment** and atrazine are persistent water quality problems in watershed.
- To control sediment no-till and other practices implemented.
- No trends in atrazine loads 1992-2006. *(Lerch et al., 2011. JAWRA 47:209-23).*





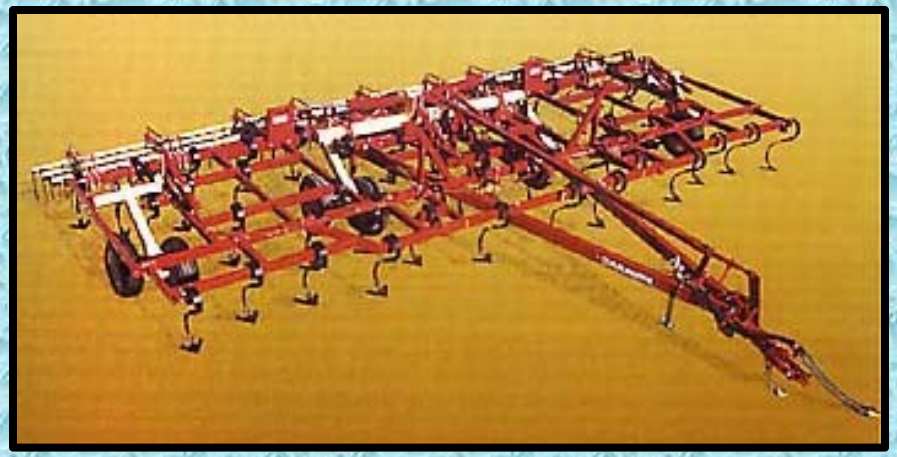
Atrazine Incorporation and Soil Erosion – Balancing Competing Water Quality Concerns for Claypan and Restrictive Layer Soils

R. N. Lerch, C. M. Harbourt, R. R. Broz, and T. J. Thevary

USDA Agricultural Research Service

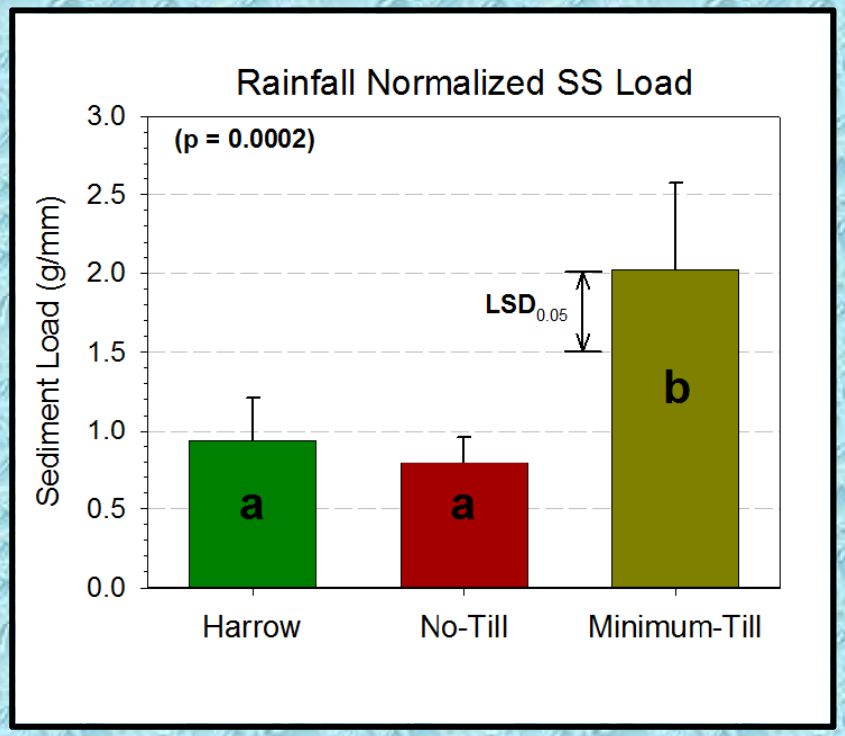
Atrazine incorporation TREATMENTS

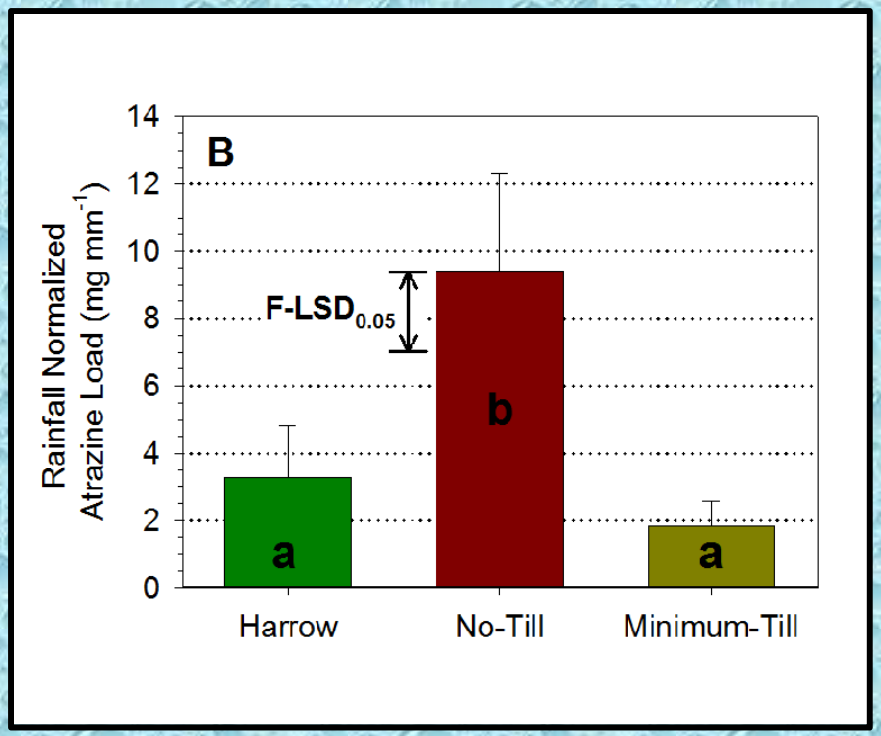
Phillips Harrow



Field Cultivator
(minimum till)

Results





<u>CONCLUSION</u>: Roller harrow achieved the needed balance by controlling both erosion and atrazine losses

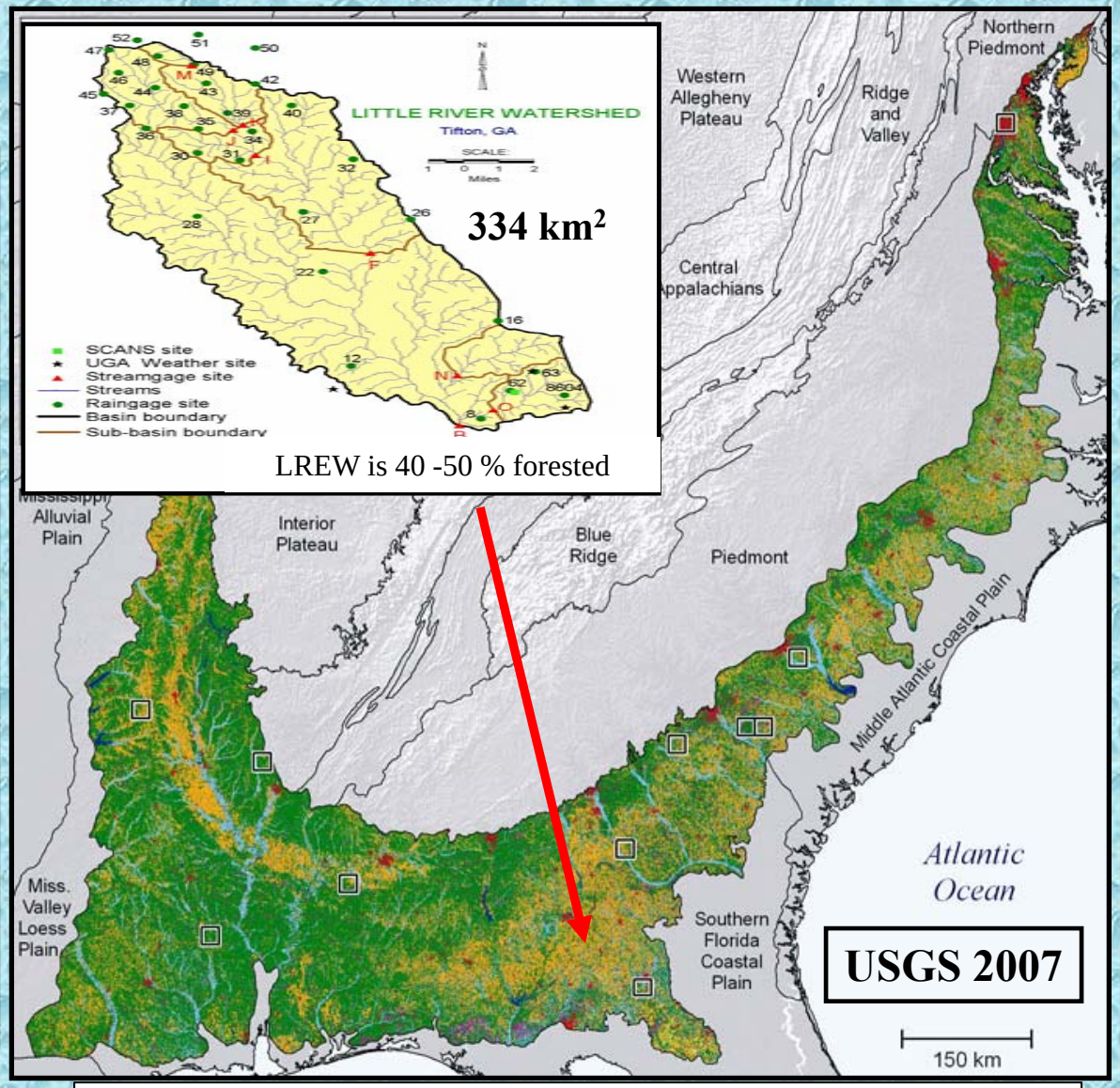
Little River Watershed, GA

≈ 336,000 km² *in Eastern USA from Maryland to Mississippi*

Uplands intensively cropped (≈20%); Lowlands forested wetlands (≈10 %).

Predominant soil order: <u>Ultisols</u>. Sandy surface horizons (80 to 90 % sand) dense clay rich subsoil and plinthite promote <u>lateral subsurface flow</u>

Both surface runoff (sediment, nutrients, pesticides) and lateral subsurface flow (nitrate and soluble pesticides) are significant contaminant pathways.



SOUTHEASTERN PLAINS ECOREGION

Riparian wetlands are a common natural feature of the South Georgia landscape that serve to protect water quality

Floodplains are broad and flooded annually—difficult to farm.
Riparian forests are well established and cover large areas .

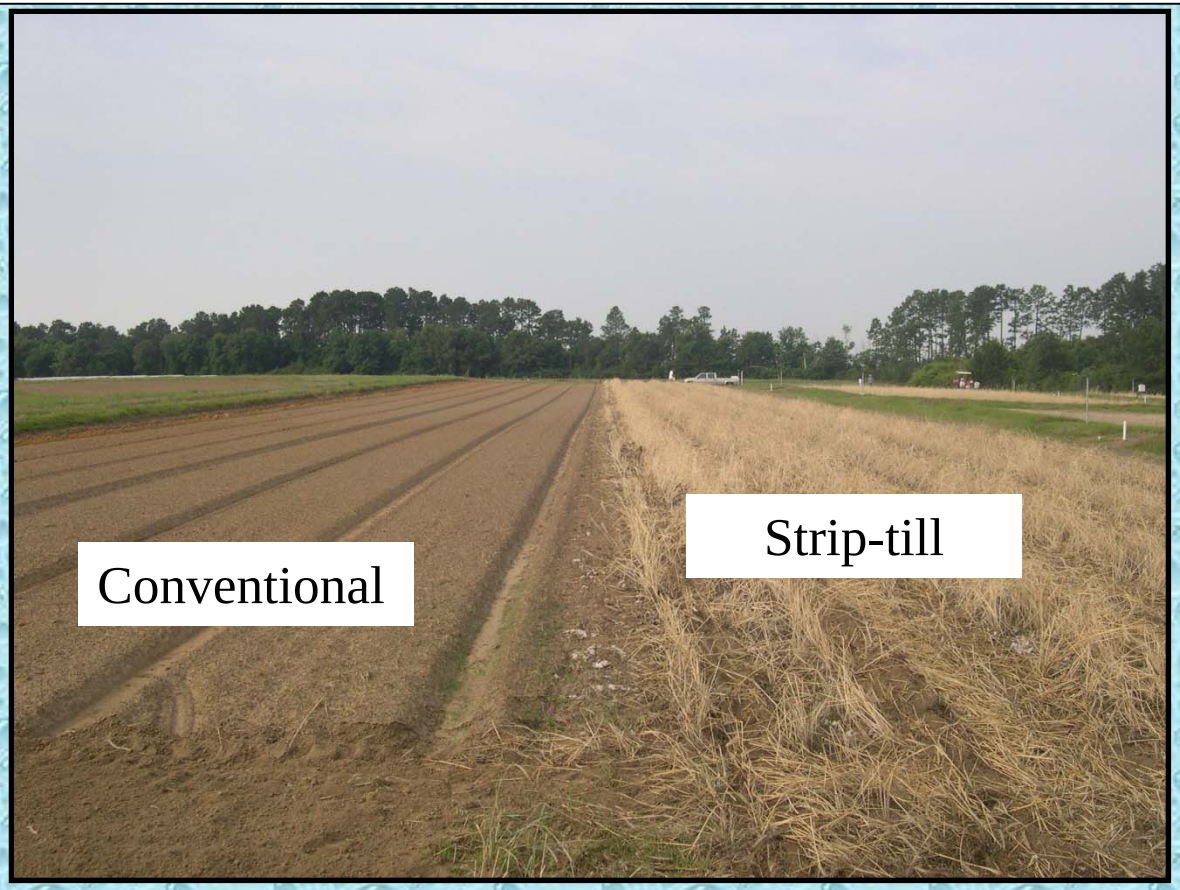
SEWRL conservation-tillage research and demonstration site

University of Georgia Gibbs Farm – Tift Cty, GA

Tillage Research Site

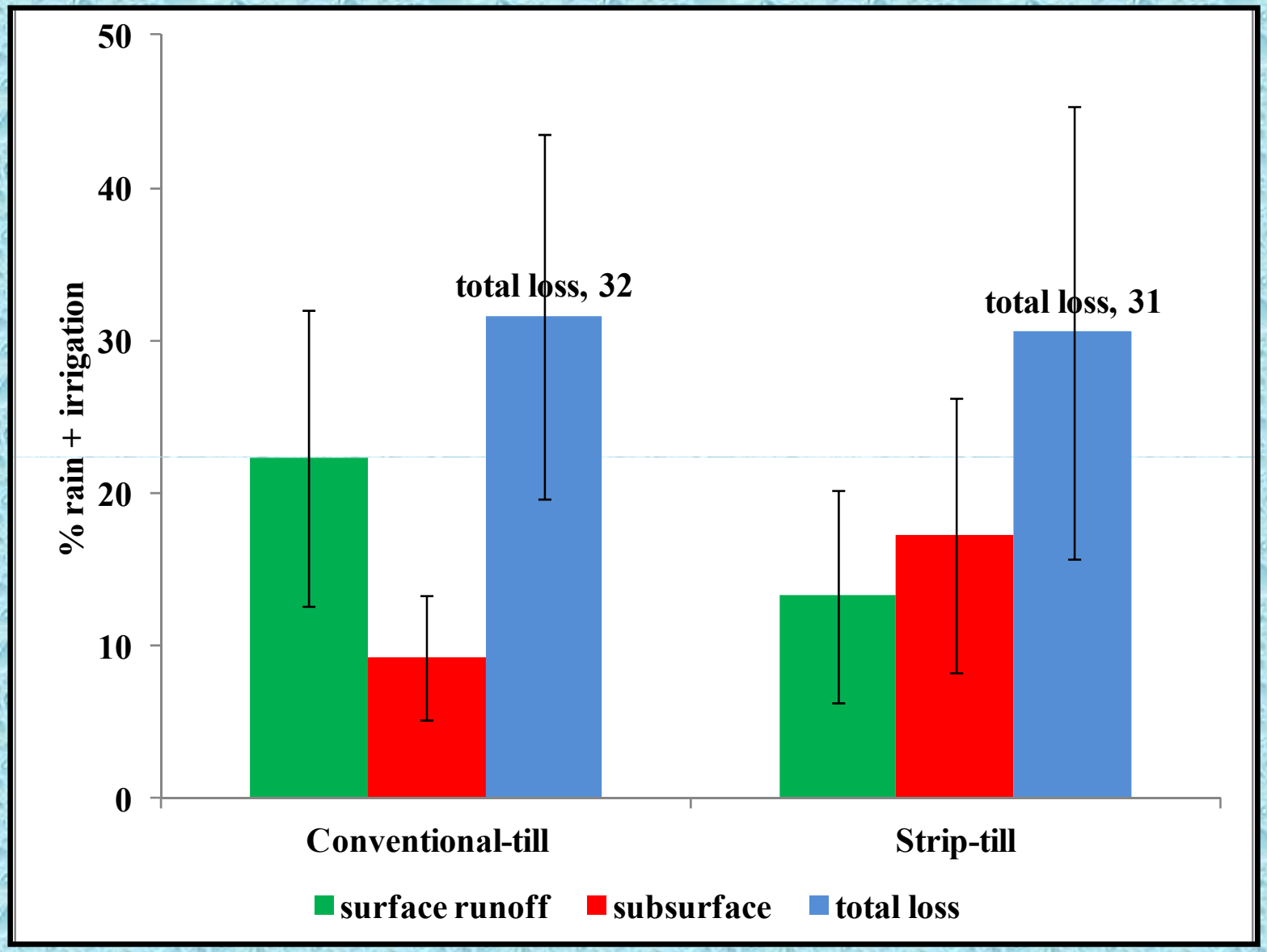
Established 1999 – 14th crop was planted in May 2012

Tillage practices



- *Rye used as winter cover crop; killed with glyphosate in Spring; cotton or peanut planted into 15-cm strips tilled into crop residue mulch (30 to 60% soil cover)*

H-flumes installed to measure surface runoff and lateral subsurface flow and collect water quality samples



Annual water loss on tillage plots 1999-2006

See Bosch et al. 2012. Agr .Wat. Manag. 111: 40-52.

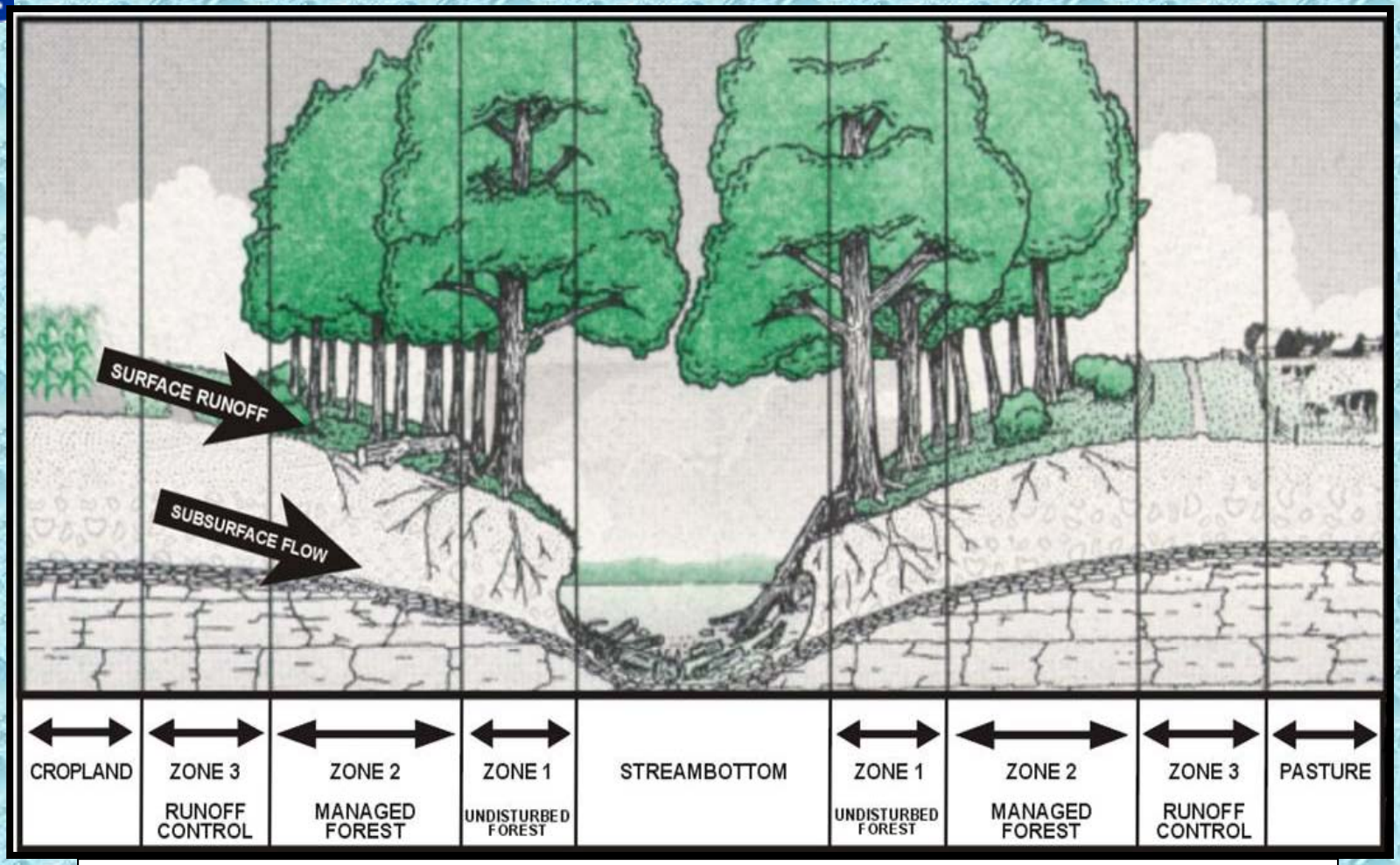
Fluometuron and pendimethalin use and properties

Date applied	Crop	Fluometuron (kg ha^{-1})	Pendimethalin (kg ha^{-1})	Application timing
5/1/00	cotton	1.1	0.93	plant
5/7/01	cotton	1.4	0.93	plant
6/18/01	cotton	1.1		post-directed
5/10/02	peanut		1.1 (ST only)	plant
5/12/03	cotton	1.1	1.1	plant
5/10/04	peanut			
5/23/05	cotton	1.1	1.1	plant
5/16/06	peanut		1.1	plant
<u>Properties</u>				
water solubility (mg L^{-1})		100	0.3	
Koc (mL g^{-1})		100	16000	
transport characteristic		leaching potential	sediment transport	

Loss at tillage study site – 1999-2006

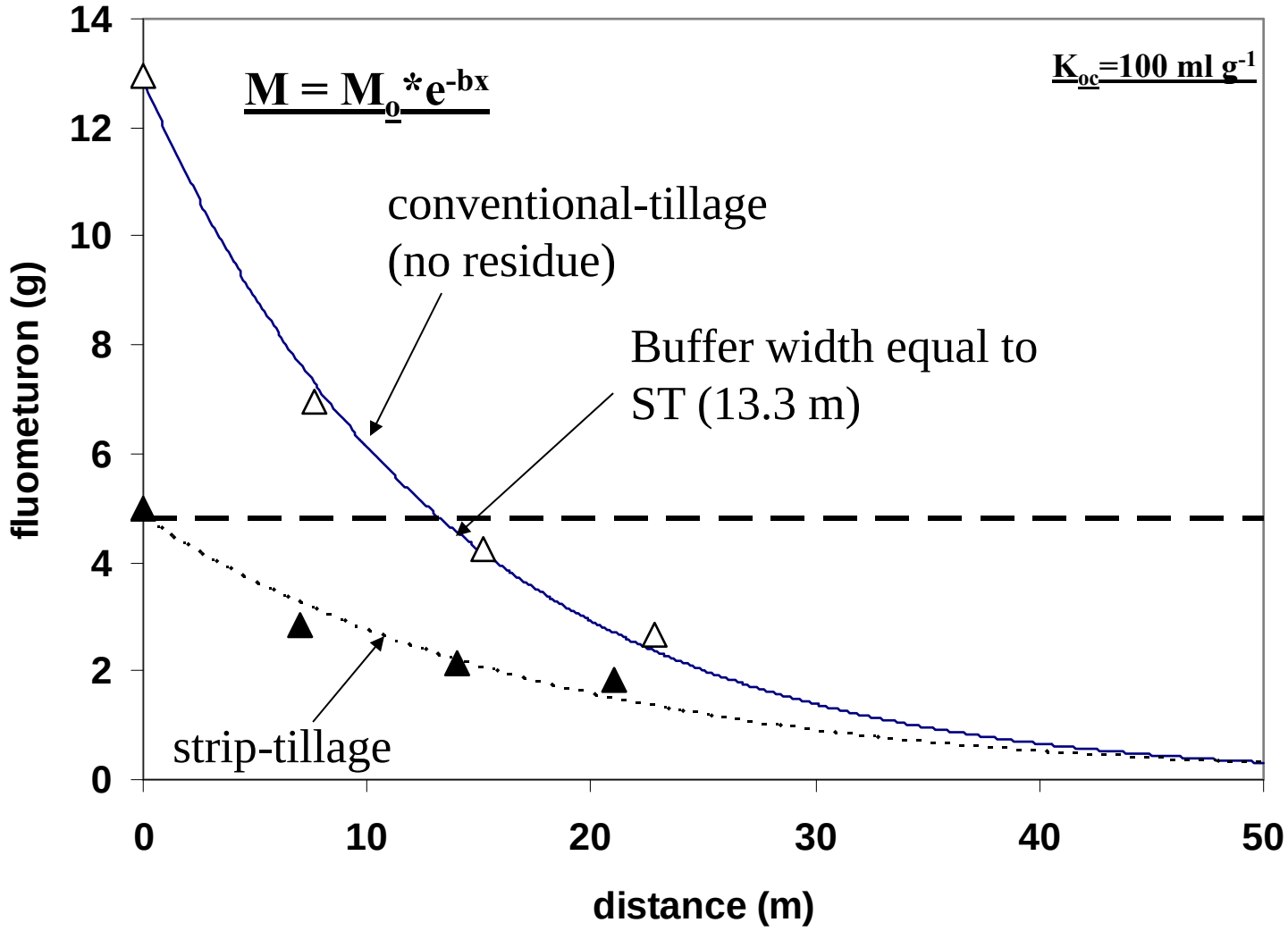
		% of applied	
tillage	runoff	fluometuron (DMF + parent)	pendimethalin
Strip	surface	0.20	0.03
Strip	subsurface	0.20	<0.004
Strip	**total**	**0.40**	**0.03**
Conventional	surface	0.78	0.50
Conventional	subsurface	0.10	<0.002
Conventional	**total**	**0.88**	**0.50**

REMM: Riparian Ecosystem Management Model



Lowrance, RR et al. 2000. The riparian ecosystem management model. JSWC 55(1):27-36.

REMM predicted fluometuron attenuation in edge-of-field buffer



Pesticide attenuation tillage versus buffer

	CT-load mass (g)	ST-load mass (g)	Buffer width (m) for CT= ST load
fluometuron	13	5.0	13.3
DMF	8.5	4.5	9.4
pendimethalin	5.8	0.2	35.5

See Potter et al., 2012. pp 259-272 in Pesticide Strategies for Surface Water Quality. ACS Symposium Series 1075.

Inputs and simulated output from forested buffer (7 years)

tillage system Input	compound	Input (g ha^{-1})	Output (g ha^{-1})	% attenuation
CT	pendimethalin	5.7	0.9	84
ST	pendimethalin	0.22	0.06	73
CT	fluometuron	13	4	69
ST	fluometuron	5	2	60
CT	DMF	8.5	2.3	73
ST	DMF	4.5	2.1	53

Total strip load to buffer >50% less than from CT.; however relative rate of attenuation lower with inputs from strip-tillage system. More than 50 % of DMF and fluometuron edge-of-field load in subsurface flow.

See Potter et al., 2012. pp 259-272 in Pesticide Strategies for Surface Water Quality. ACS Symposium Series 1075.

Daily edge-of-field inputs and simulated edge-of-buffer outputs and attenuation within the buffer for the two largest "edge-of-field" daily inputs during simulations.

Compound date	DAT† (days)	Input ‡ (g ha-1)	Output‡ (g ha-1)	Attenuation (%)	Rain+Irr (mm)
pendimethalin					
3-Jun-05	11	1.60 (28%)	<0.001	100	43
6-Jun-05	13	0.65 (11%)	0.55 (60%)	9	40
fluometuron					
21-Jun-01	3	2.0 (16%)	1.0 (24%)	52	25
6-Jun-05	13	1.3 (10%)	1.0 (24%)	24	42
DMF					
6-Jun-05	13	0.48 (6%)	0.37 (16%)	23	42
10-Jul-05	48	0.29 (3%)	0.25 (11%)	13	122

† DAT = days after treatment; ‡ value in parenthesis is % of total 7-yr load

A single storm event may account for large fraction of a pesticide moving through the buffer.

CONCLUSIONS

- **"*A conservation practice* such as conservation tillage may have different environmental outcomes in different settings depending on factors such as the pollutant, soil type, or climate *(Osmond et al., 2012)*."**
- ***Water and sediment management practices (conservation-tillage etc) may not target pesticides; field data that quantify performance are needed.***
- ***Combining practices (e.g. reduced tillage and mechanical incorporation) can greatly increase treatment efficacy.***

Osmond, D.L., D.W. Meals, A.N. Sharpley, M L. McFarland, and D.E. Line. **2012**. *Lessons Learned from the NIFA-CEAP: Conservation Practice Implementation and Adoption to Protect Water Quality*. NC State University, Raleigh, NC.

CONCLUSIONS

- ***"No matter how rigorous the water quality monitoring, it will be impossible to link observed changes in water quality to land treatment without equally rigorous land treatment and management monitoring (Osmond et al., 2012)."***
- **The problem is compounded with pesticides; <u>Rarely if ever</u> are "actual" use data in watershed available. Typically NASS survey estimates are used; uncertainties are unknown!**

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