Associations Between Conservation Practices and Ecological Responses of Agricultural Streams and Lakes

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Presentation Focus

Synthesize existing ecological assessments of Conservation Practices across CEAP watersheds

Three CEAP Stream Watersheds

- Two midwestern corn belt – IN, OH
- One southern coastal plain – GA

One CEAP Lake Watershed

- One southern coastal plain – MS

Objectives

- Quantify the benefits of Conservation Practices on aquatic ecosystems
- Provide critical knowledge in linking Conservation Practices and aquatic ecological responses
- Examine these relationships at the watershed scale

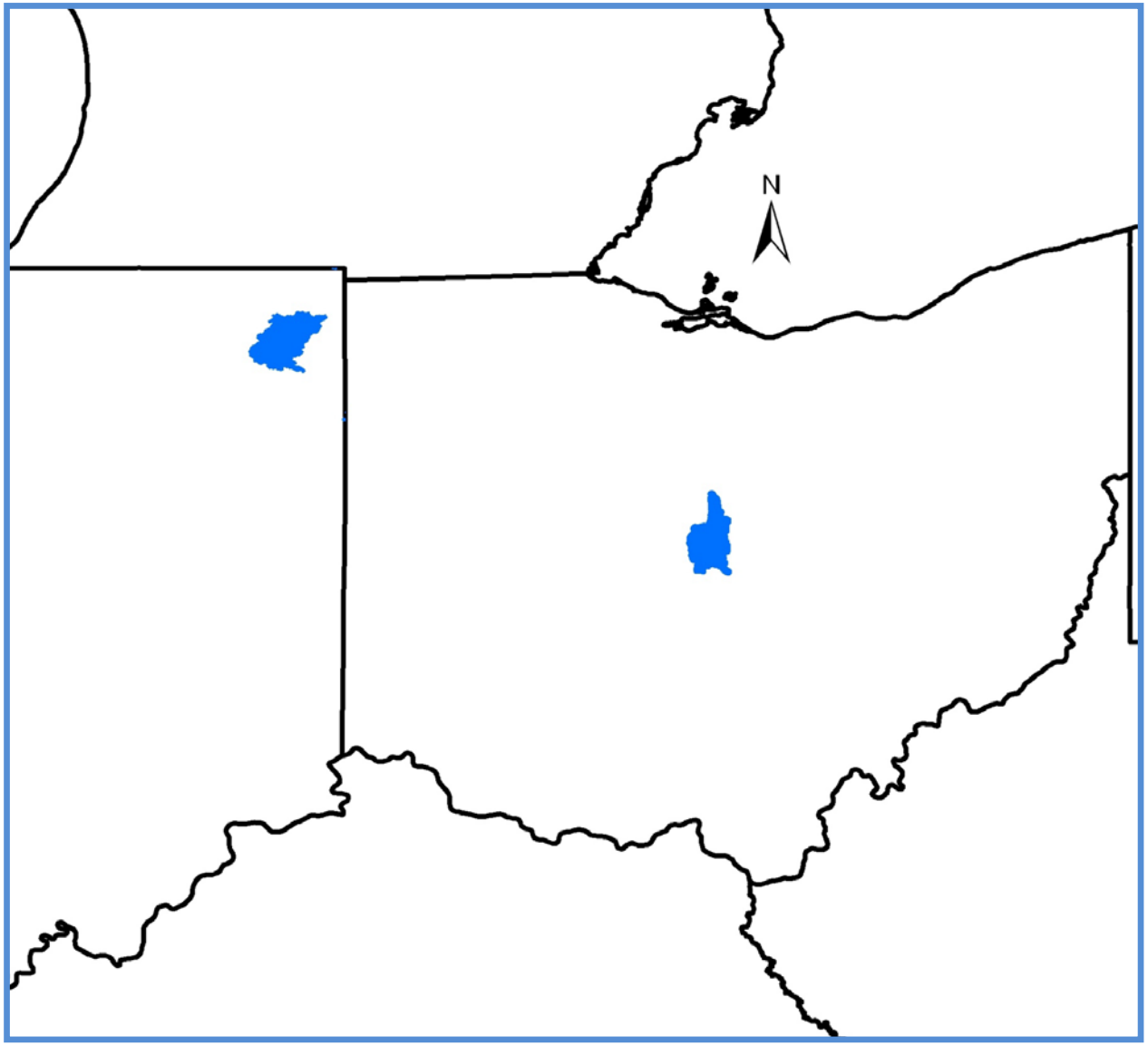
Midwestern Corn Belt CEAP Stream Watersheds

Cedar Creek

- Located in northeast Indiana
- 175,370 acres
- 64% crop, 15% pasture, 10% forest, 11% urban
- Impaired WQ: pesticides, nutrients, sediment
- Impaired physical habitat as result agricultural drainage

Upper Big Walnut Creek

- Located in central Ohio
- 122,000 acres
- 59% crop, 14% forest, 13% urban
- Impaired WQ: pesticides, nutrients, sediment
- Impaired physical habitat as result agricultural drainage



Assessments of fish-habitat relationships within channelized agricultural headwater streams

Conservation Practices

a) Grass Filter Strips
b) Integrated Pest Management

Relationships between water chemistry and fishes in Cedar Creek, IN & Upper Big Walnut Creek, OH

Relative abundance (top 99%) and number of captures of fishes (2005-2007)

Fish	%	# Captures
Creek chub	26.92	6591
Fathead minnow	17.65	4321
Bluntnose minnow	17.24	4221
Johnny darter	10.48	2565
Central stoneroller	7.26	1777
Blacknose dace	5.41	1325
Green sunfish	4.89	1197
Orangethroat darter	2.34	574
Common shiner	1.78	436
Bluegill	1.68	412
White sucker	1.52	372
Mottled sculpin	0.67	164
Largemouth bass	0.49	120
Central mudminnow	0.46	113
Grass pickerel	0.38	94

Multiple regressions showing relationships between water chemistry and fish communities with $R^2 > 0.2$

Fish response variable	Nutrient (slope)	Herbicide (slope)	Physicochemical (slope)	R^2
% Insectivores	NH_4 (-) NO_3 (-)	Metolachlor (+) Simazine (+)	Temp. (-) D.O. (+) pH (+)	0.294
% Headwater fishes	NH_4 (-) NO_3 (-) DOC (-)	Metolachlor (+)	D.O. (+) pH (+) Cond. (+)	0.291
% Creek chub	NH_4 (-) DOC (-) PO_4 (+)	Metolachlor (+)	Temp. (-) pH (+) Cond. (+)	0.283
% Percidae	NH_4 (-) NO_3 (-) TP (-)		D.O. (+) Cond. (+)	0.279
Reproductive guild richness	NH_4 (-) NO_3 (-)	Metolachlor (+)	D.O. (+) pH (+)	0.242
Fish abundance	NH_4 (-) NO_3 (-)	Metolachlor (+)	D.O. (+) pH (+)	0.220

From: Smiley et al. Ecohydrology 2, 294-302 (2009)

Streamside Bioassays at Cedar Creek Sites

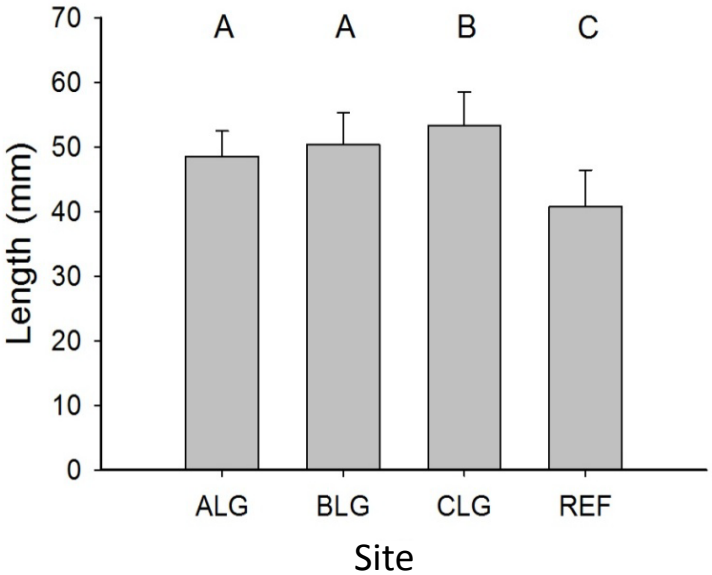
Fathead Minnow Population Responses

- No differences in survivorship, Hepatosomatic Index , or Gonadosomatic Index among streams
- Fish length and weight greater at CLG
- Fish significantly smaller at REF (laboratory conditions)
  - Food quantity/quality, water temperature, artificial light vs natural

- Fathead minnows exposed initially in stream water from three Cedar Creek sites in lab as embryos and larvae and then transferred to streamside bioassays

Water Chemistry Results

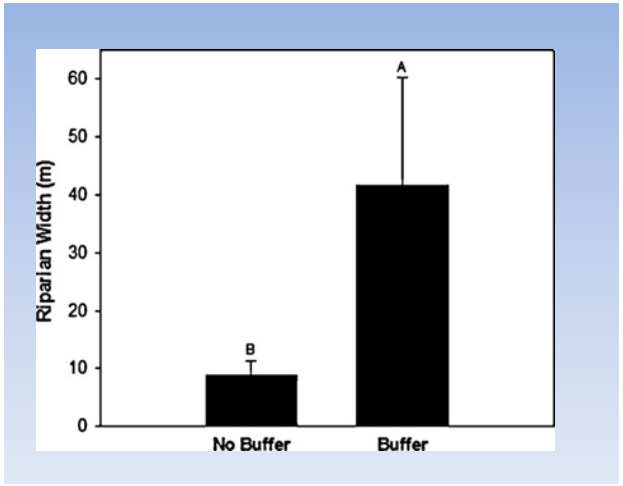
- Total N and Total P exceeded impaired aquatic life benchmark.
- Ammonia, nitrates, and herbicides were below acute or chronic toxicity benchmarks
- Concentrations of TN, TP, Ammonia, Nitrate, Simazine, Atrazine, Metolachlor, and Glyphosate tended to be lower in CLG compared to other stream sites

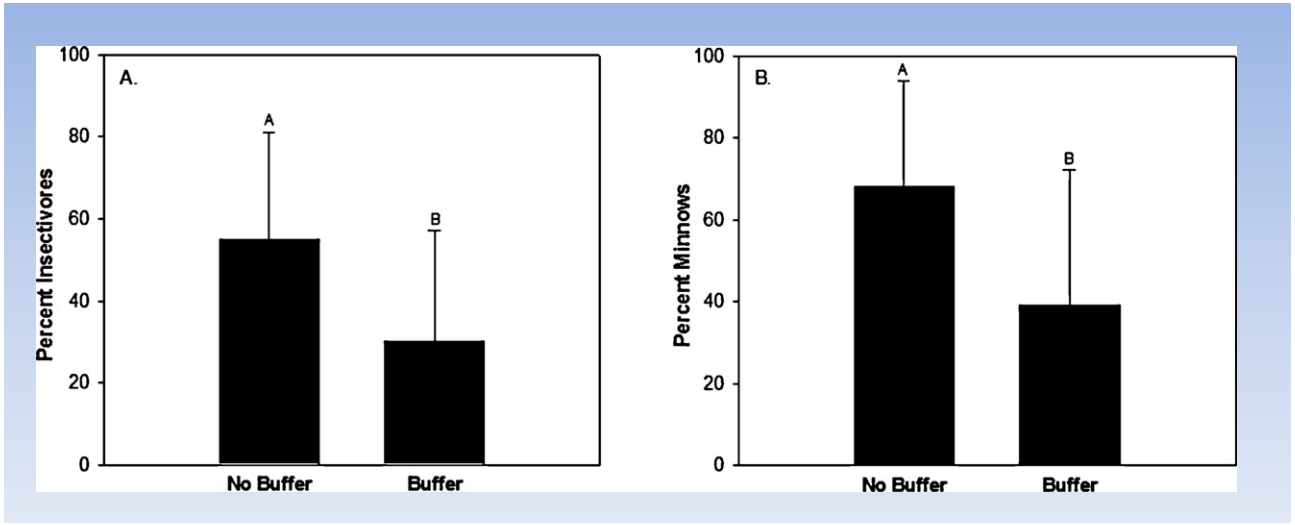


Each treatment tank had 90 fish at the start of bioassay

Influence of herbaceous riparian buffers on fish communities

- Only 2 of 10 fish community response variables differed between buffer types
- **Observed similarity in physical habitat suggests differences in % cyprinids and insectivores is not a result of buffer types**
- Channelized agricultural headwater streams with and without herbaceous riparian buffers are similar physically, chemically, and have similar stream communities

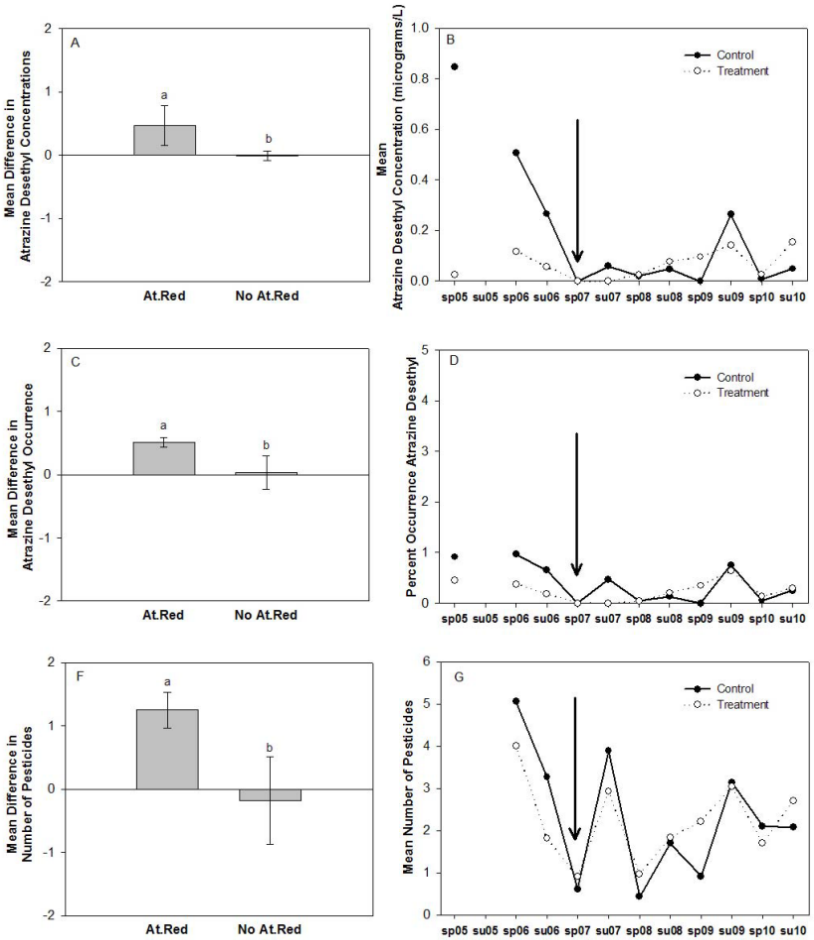


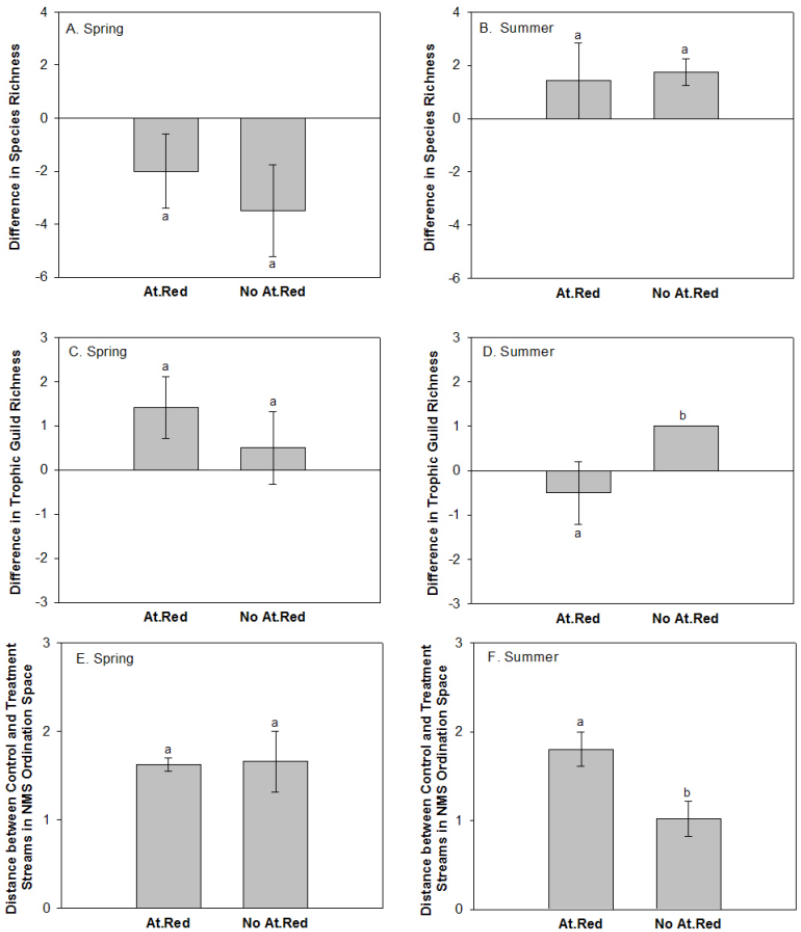


From: Smiley et al. Ecological Engineering 37 (2011) 1314-1323

Influence of Integrated Pest Management Practices (Atrazine Reduction Practices)

From: Smiley et al. Journal of Sustainable Watershed & Science Management 1 (2) 61-75, 2012



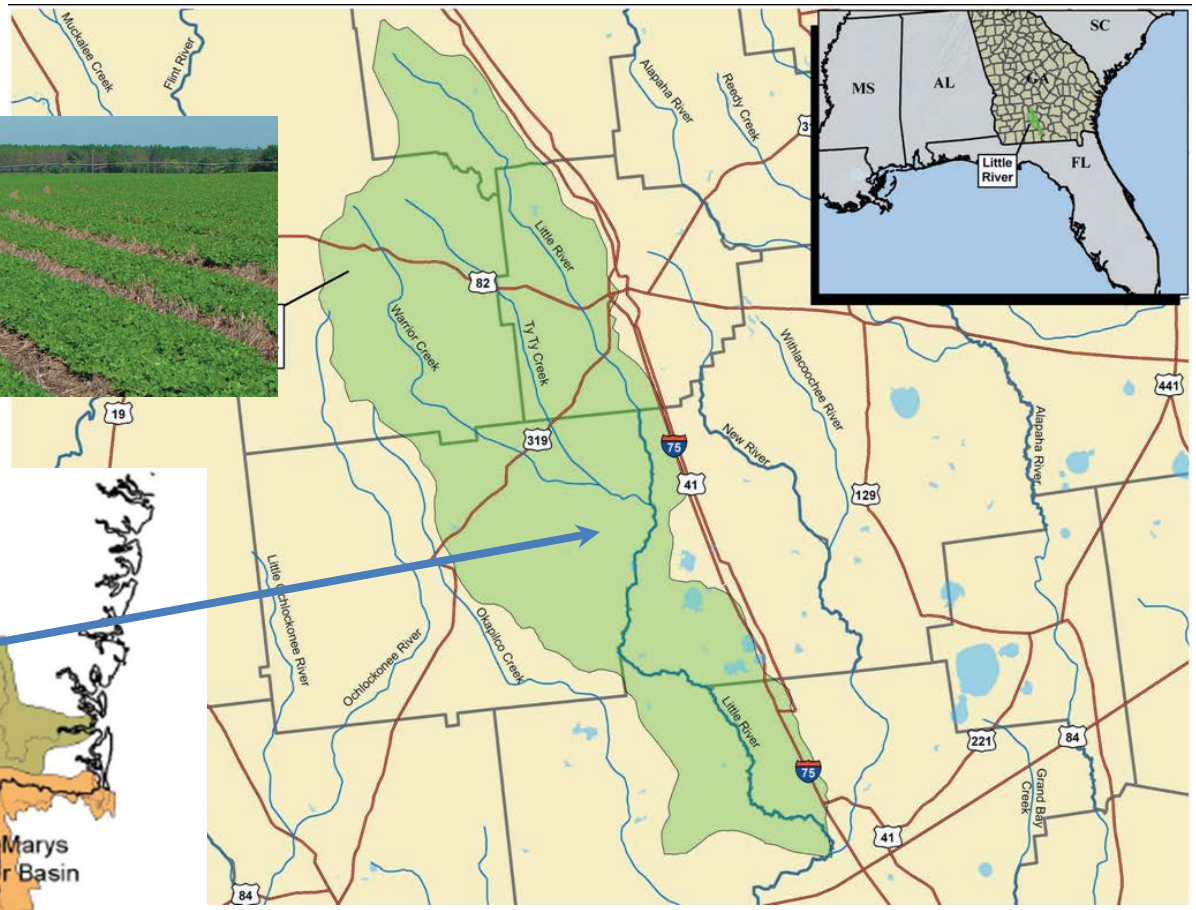


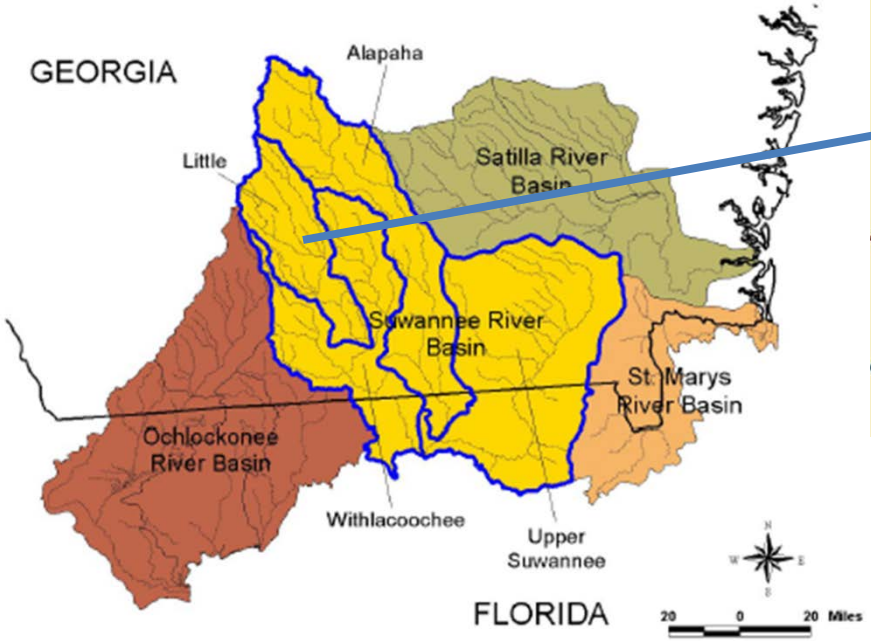
- Only 3 of 15 pesticide variables differed as result of watershed scale atrazine reduction practices

- Only 2 of 14 fish differed as result of watershed scale atrazine reduction practices
- **Lack of pesticides response indicates no effect on fishes**

Southern Coastal Plain CEAP Stream Watershed

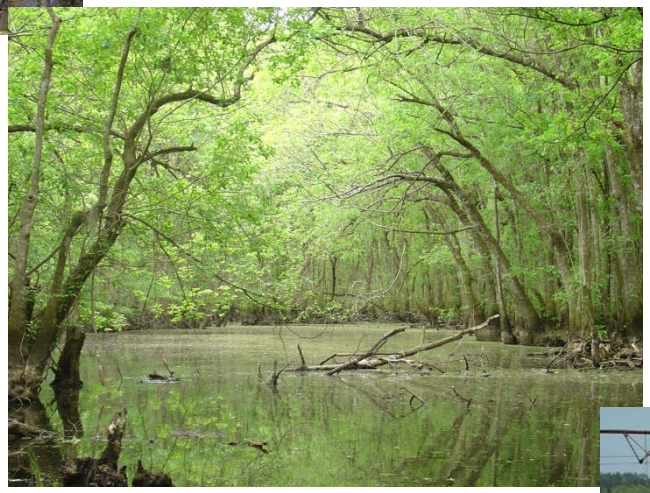
Little River Watershed, GA





82,560 ac
36% crop, 18% pasture, 40% forest
Impaired WQ: pesticides, nutrients, sediment, low dissolved oxygen

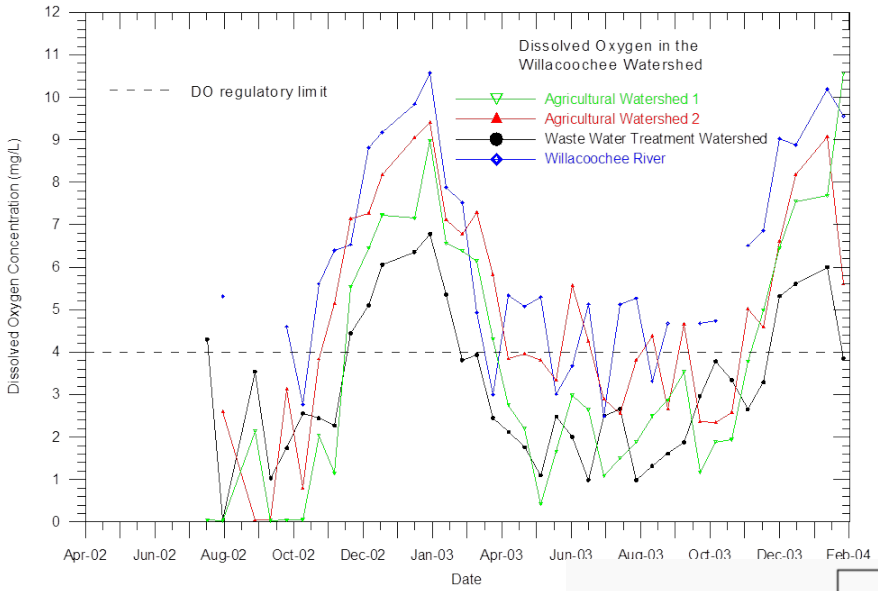
Assessments of ecological and hydrological processes governing dissolved oxygen dynamics in agricultural coastal plain streams

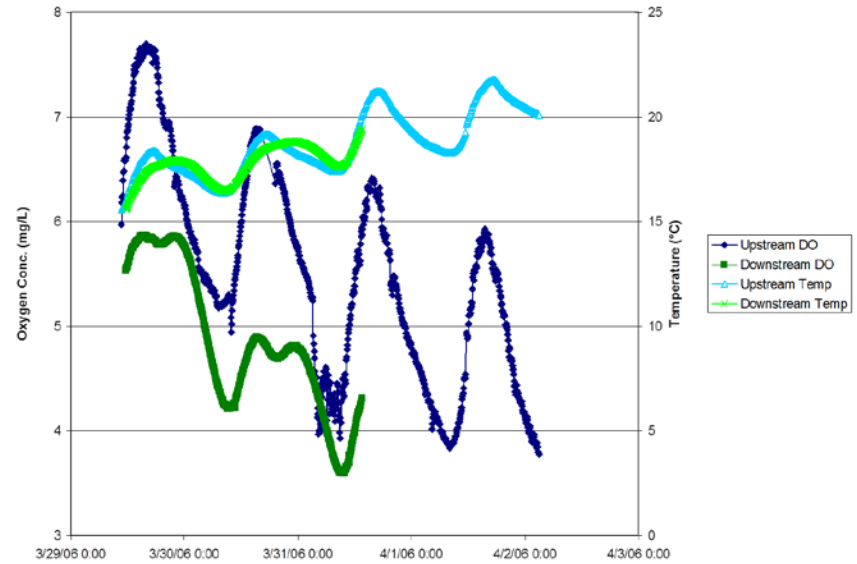


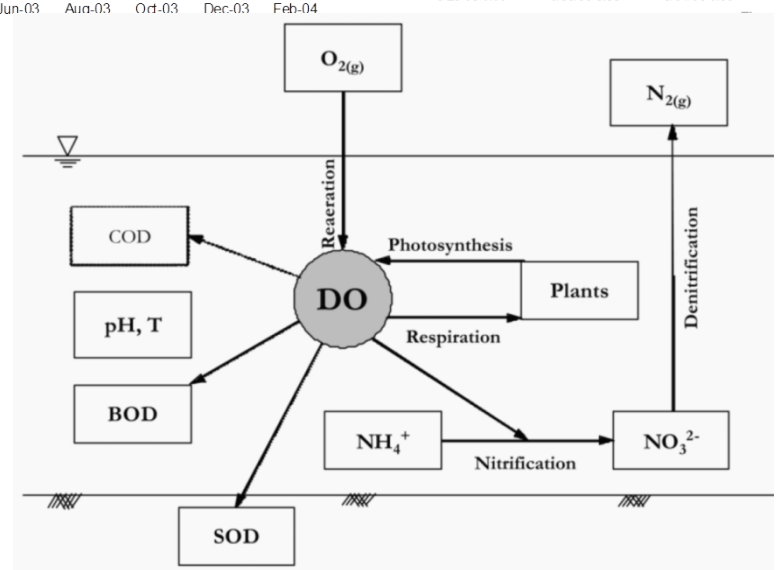
Conservation Practices

a) Erosion control practices (e.g. CRP)
b) Water quality control practices

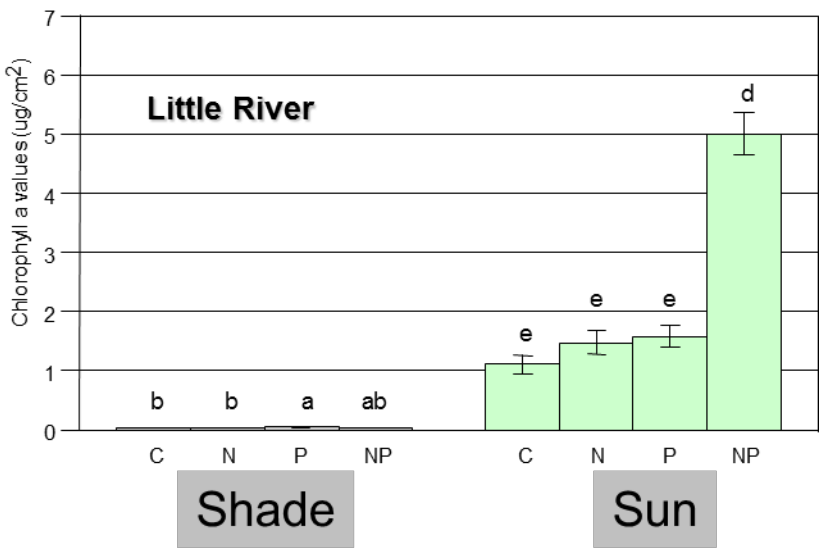
- Assess effects of in-stream nutrients on primary production that may lead to low stream DO
- Assess the effects of sediment oxygen demand on stream DO
- Determine the integrated effects of swamps and riparian zones (floodplains) on stream DO







Nutrient Enrichment / Primary Production

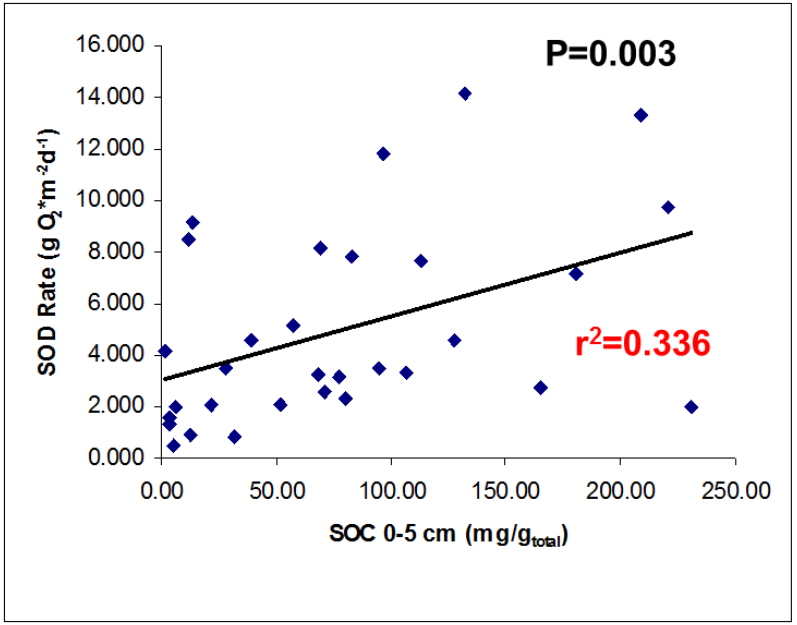


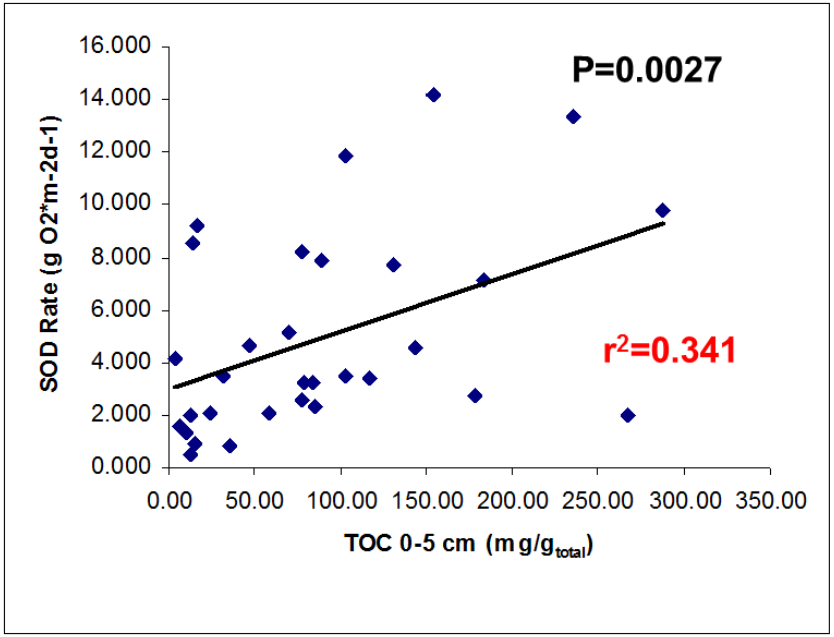
- Shading greatly inhibits algal growth
- Excess algal growth unlikely to be cause of low DO, because of shading and no general trend for nutrient response

Sediment Oxygen Demand - SOD

- The rate at which DO is removed from the water column due to the decomposition of organic matter on the bottom and within the bottom sediments

- SOD a combination of two processes:
  - biological respiration of benthic organisms residing on the bottom or in the sediment
  - chemical oxidation of reduced substances found within the sediment matrix

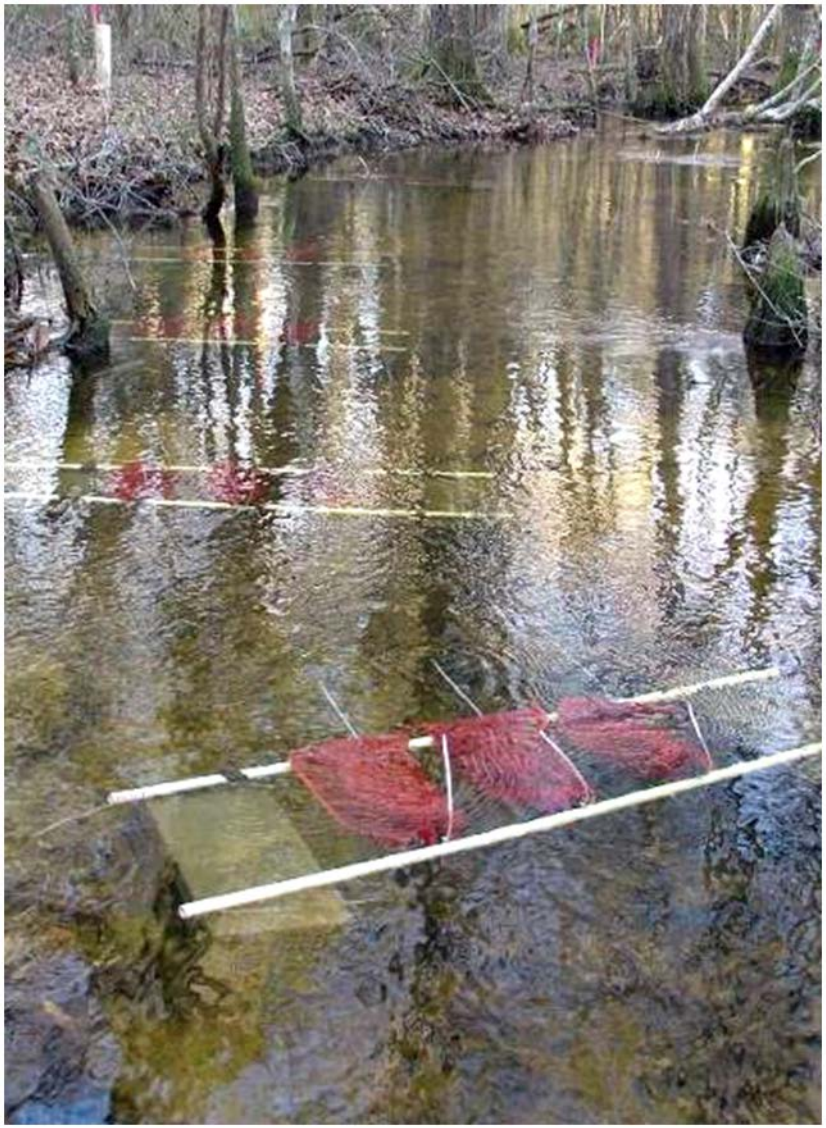




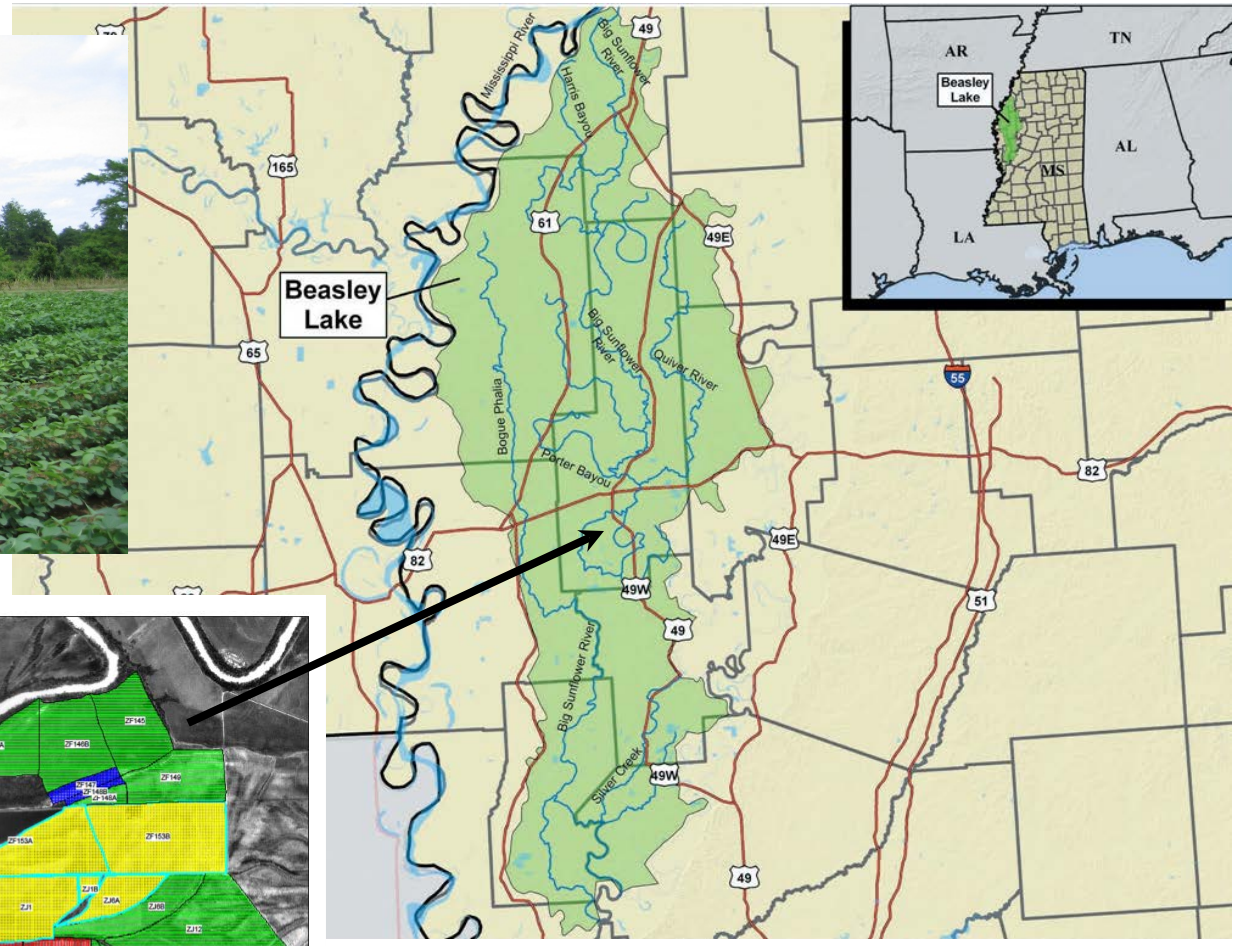
Total Organic Carbon (TOC) (litter + soil) and Sediment Organic Carbon (SOC) were best predictors of Sediment Oxygen Demand

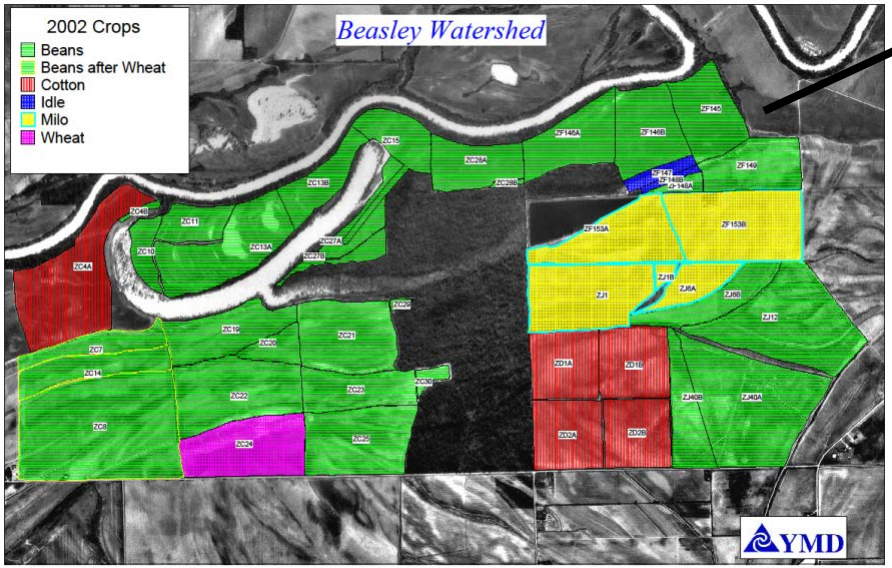
Stream Litter Breakdown and Respiration

- Litterfall respiration: 0.9 – 5.8 g O_2 m^{-2} d^{-1}
- SOD: 1.3 – 14.2 g O_2 m^{-2} d^{-1}
- Litterfall respiration is important component of SOD
- Average SOD rates can completely account for DO depletion – even under cool temperatures
- High retention time
  - **15 - 27** h to flow through 1350 m of swamp



Southern Coastal Plain CEAP Lake Watershed





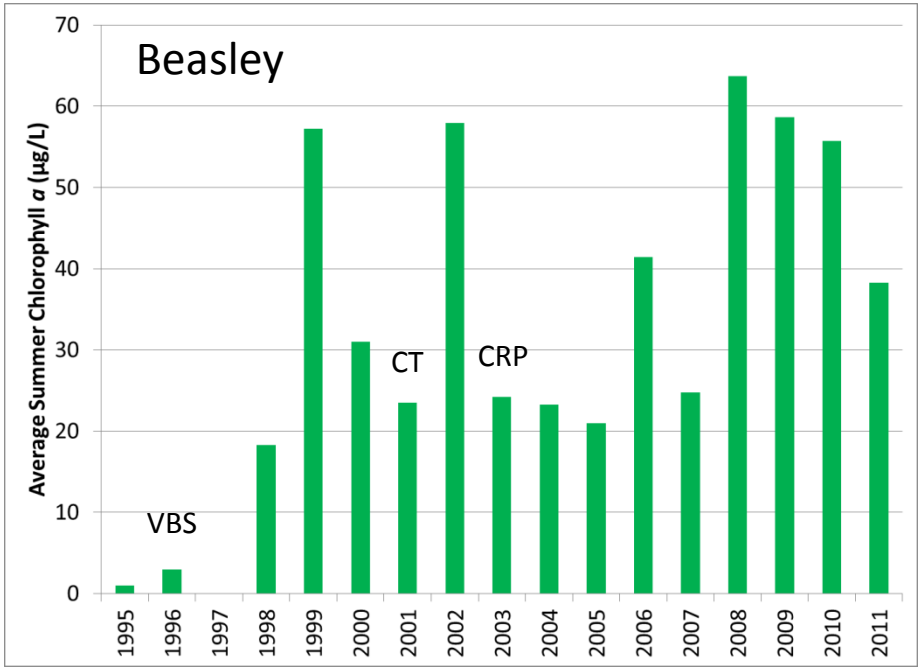
2,2610 ac
77% crop, 16% forest
Impaired WQ: sediments, nutrients, pesticides

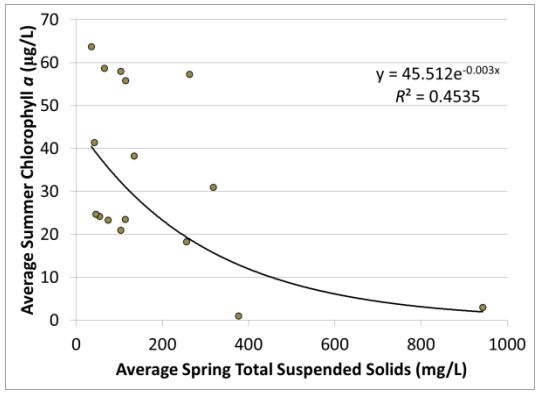
Effects of agricultural BMPs on phytoplankton and fisheries in an agricultural coastal plain lake

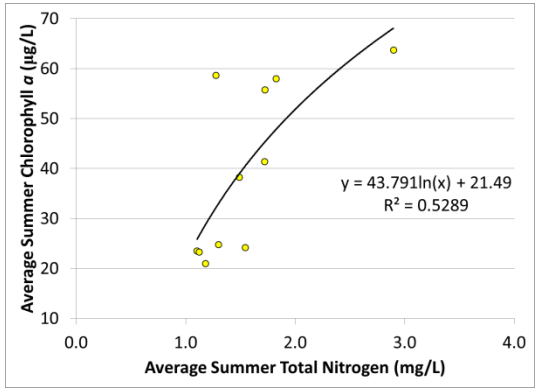
Conservation Practices

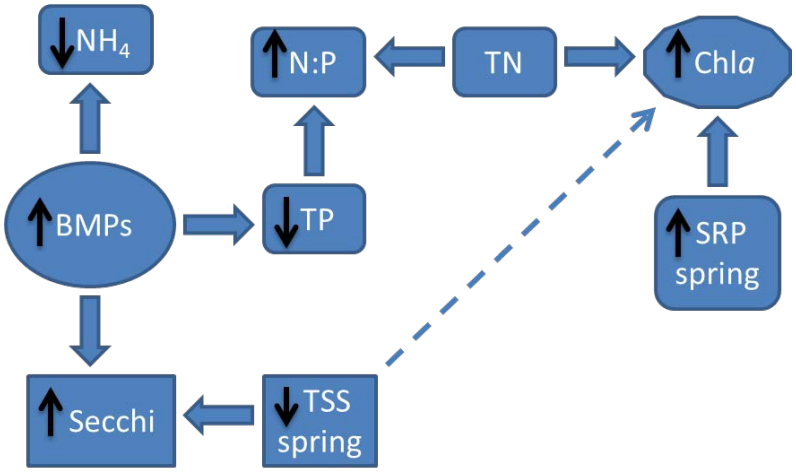
a) Erosion control practices (e.g. CRP, Conservation Tillage)
b) Water quality control practices (e.g. Vegetated Buffer Strips)

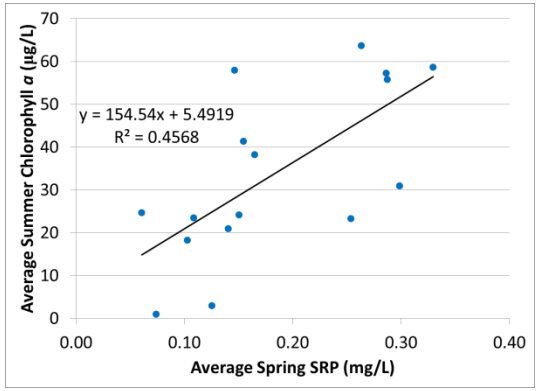
Connection between BMPs and Beasley Lake phytoplankton algae











Changes in Beasley Lake fisheries after BMP implementation

Fish collected in Beasley Lake (1998-2009)

	Catch per unit effort (kg/hr)				
	1998	1999	2004	2006	2009
Bowfin			0.94		3.33
Buffalo	0.36				23.34
Bass/Sunfish	2.50	0.15	17.02	12.65	54.22
Shad	2.35	0.21	4.34	13.88	9.52
Minnow	5.05	0.23	9.90	6.06	10.22
Catfish		0.50	0.40		
Gar	1.23	1.73	1.08	0.41	5.60

Sport Fisheries collected in Beasley Lake (1998-2009)

Parameter		1998	2004	2006	2009
Catch Per Effort Unit		4.7	3.3	33.0	35.3
Percent of catch					
Largemouth bass	**Number**	46.0	21.0	17.7	30.0
	Weight	6.0	46.0	30.3	48.0
Bluegill sunfish	**Number**	12.0	29.0	30.5	16.0
	Weight	19.0	54.0	6.0	1.0

Relationships between water chemistry and fishes in Beasley Lake, MS

Pearson Product Moment correlation coefficients (*r*) showing relationships between water chemistry and fish catch per unit effort in Beasley Lake 1998-2009

Fish	TSS	TDS	TP	SRP	NO_3	NH_4	Secchi	Chlorophyll a
Bass/Sunfish		-0.938[a]			-0.927[a]	-0.883[a]	0.924[b]	
Shad		-0.959[a]	-0.957[a]					
Minnow						-0.929	0.888	

[a]Log_{10} fish; [b]Log_{10} WQ Log_{10} fish

Relationships between conservation practices and fishes in Beasley Lake, MS

Pearson Product Moment correlation coefficients (*r*) showing relationships between conservation practices and fish catch per unit effort in Beasley Lake 1998-2009

Fish	Vegetated Buffer Strips	Conservation Tillage	CRP
Bass/Sunfish		0.952[a]	
Shad		0.916[a]	
Minnow		0.913	

[a]Log_{10} Conservation Practice Log_{10} fish

CONCLUSIONS

Midwestern Corn Belt CEAP Stream Watersheds

- Conservation Practices targeting water quality likely to have minimal effect on fish communities
- Conservation Practices targeting improved physical habitat may be more successful

Southern Coastal Plain CEAP Stream Watershed

- Spring low DO probably related to oxygen demand in swamps and braided channels
- Overall low DO influenced by sediment oxygen demand and microbial respiration
- Excess algal growth is an unlikely cause of low DO
- Conservation Practices targeting nutrient reduction will have minimal effect on low DO.
    - These low DO levels appear to be naturally occurring and thus should not be the focal point of conservation practices

Southern Coastal Plain CEAP Lake Watershed

- Conservation Practices targeting nutrient and sediment reduction indirectly led to increased algal biomass
- Conservation Practices improved fish and sports fisheries biomass
- Conservation Practices will have greatest improvement on ecology in small watersheds