Impact of Agriculture on Water Quality and Quantity and Land Value: A Case From Southwestern Louisiana

Presented to:

Lambda Alpha International (LAI) Global Land-Water Webinar Series

Agriculture, Water, Land Nexus: Unlocking the Intricacy

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Presented by:

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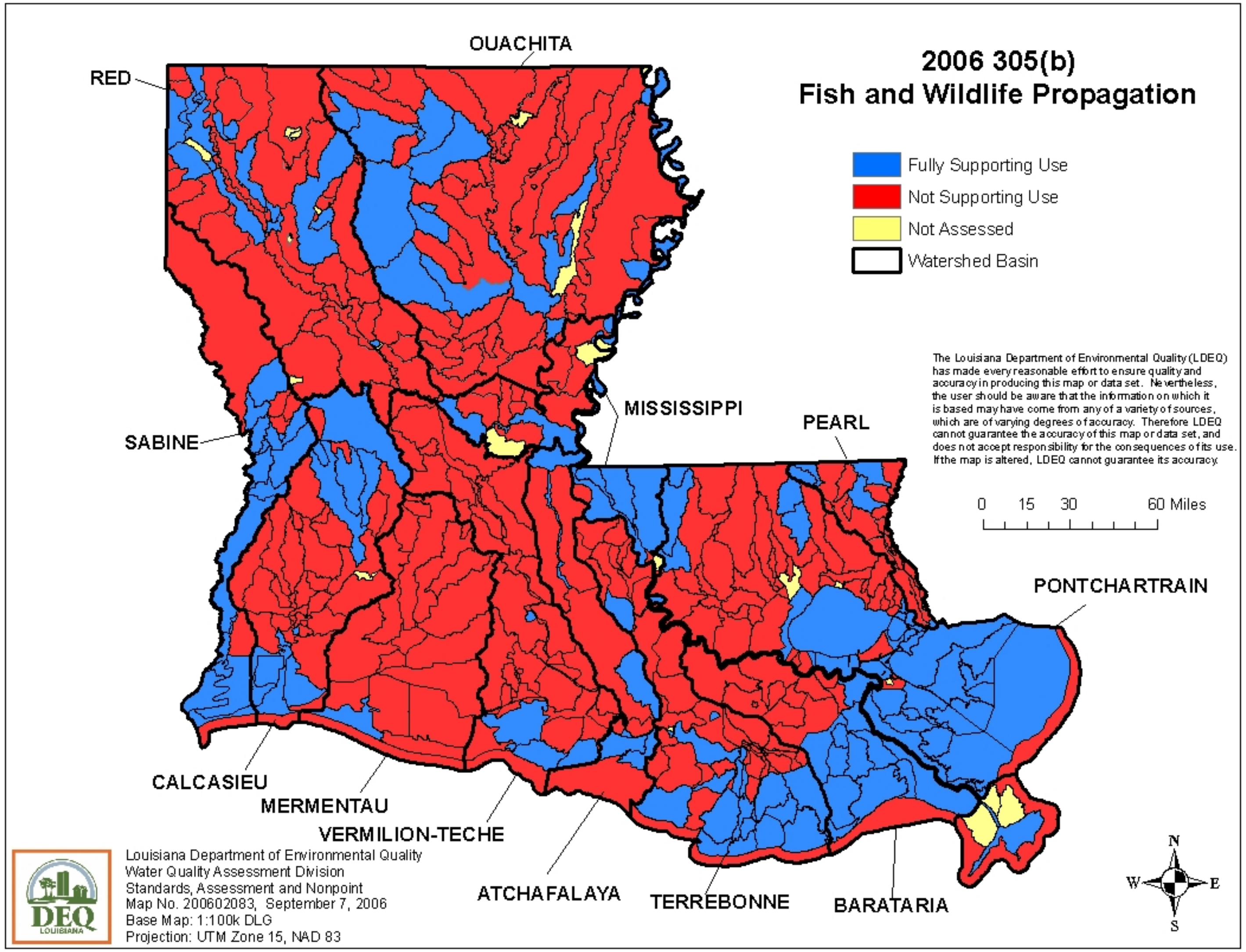
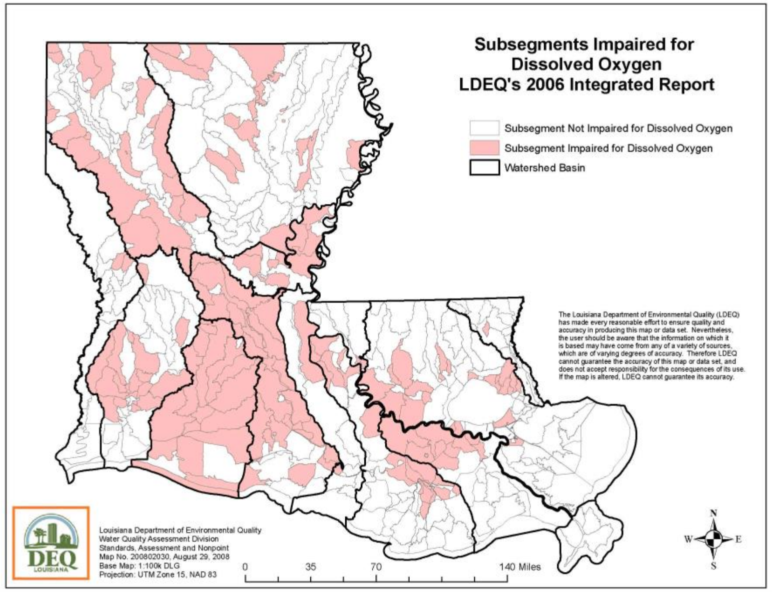
- Surface water pollution in Louisiana
- Water quality monitoring **at the field, microwatershed, watershed, and basin scales**
- Biological integrity of surface water bodies
- Invasive aquatic vegetation
- Conclusions

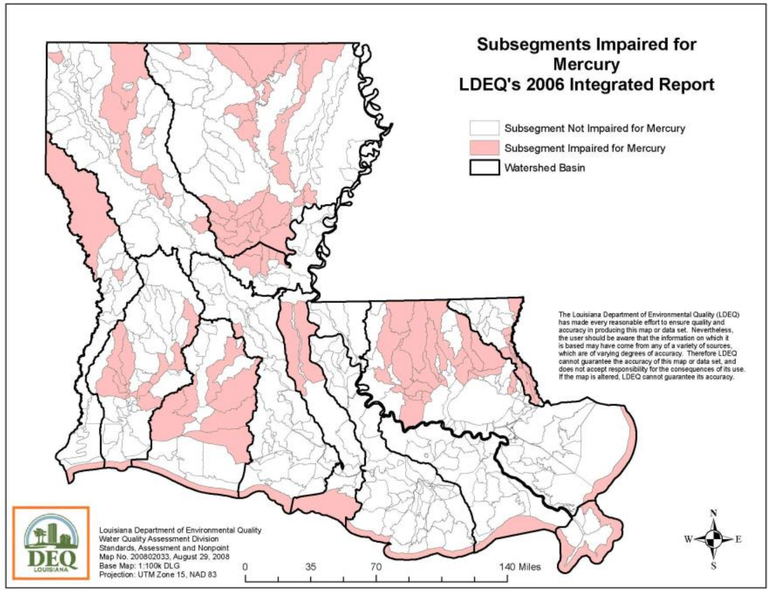
Impairments of surface water bodies in Louisiana

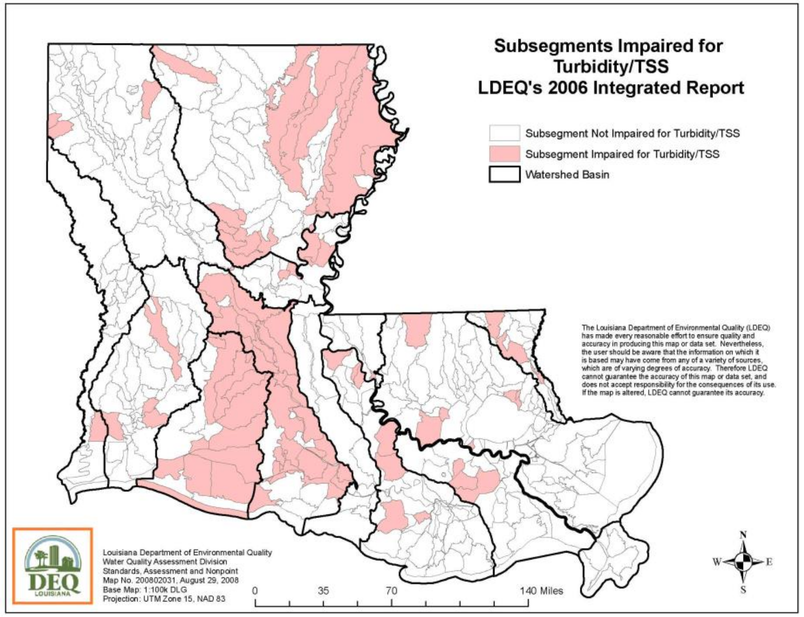


Water Quality Assessment - Louisiana

DO, Mercury, Turbidity, Nitrate-Nitrite-N, Phosphorus, TSS, TDS, Sedimentation/siltation, Sulfates, Chloride, Non-Native Aquatic plants, Carbofuran, low pH, Ammonia, Color, Lead, DDT, Fipronil, Atrazine, PCBs, PAHs, Dioxin, others (LDEQ 2006 305(b) report)

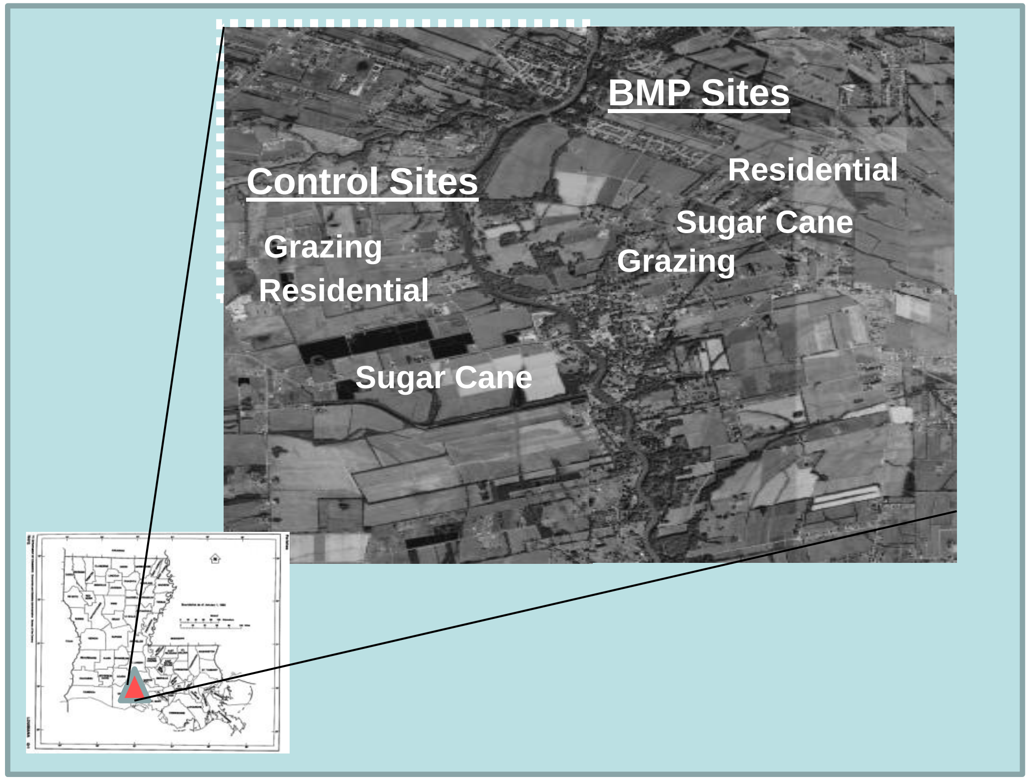






Jan Boydstun, LDEQ

Water quality monitoring- Field-scale
(September 2000 – November 30, 2005)



Field instrumentation

Four sites with Area Velocity (AV) probes
4250 AV Flowmeters
Automated sampler ISCO 6712
20 v solar panels
12 v batteries
Standard rain gauge
Surge protector lightening rods

Two pasture sites with 3230 model Bubler Flowmeters
Automated sampler ISCO 6712
20 v solar panels
12 v batteries
46 cm H-Flumes (86.4 cm wide, 172.7 cm long, and 46 cm high)
Standard rain gauge
Surge protector lighting rods

Water sample collection and analyses

Sampling method

- Flow-paced discrete samples (every 15,142 L) collected from September 2002 to October 2005. Composite samples were prepared by mixing all the flow-interval-based samples in the container and collecting two liters of composite sample for each rain event.

- Comparison of results from flow-paced discrete samples and manual composite samples, October 2002 to October 2003.

Laboratory determination

TSS, TCS, TN, Nitrate-nitrite-N, TP, SRP, BOD_5 , pH, and
Fecal coliform

Average concentrations for TSS, BOD5, TN, TP, NO3/NO2-N, SRP, and pH for surface runoff from sugarcane field, pasturelands, and residential areas

	Sugarcane	**Pastureland**	**Residential**
TSS mg l^{-1}	1,846a	87b	84b
BOD5 mg l^{-1}	7.09a	7.13a	5.05b
TN mg l^{-1}	5.36a	3.69b	2.85b
TP mg l^{-1}	0.40b	1.17a	0.61b
NO3/NO2-N mg l^{-1}	2.41a	1.36b	1.03b
SRP mg l^{-1}	0.23c	0.94a	0.47b
pH	5.79b	5.75b	6.16a

Different letters across a row indicate that the means are significantly different at the 0.05 probability level by the Student-Newman-Keuls test.

Poudel et al., 2010.

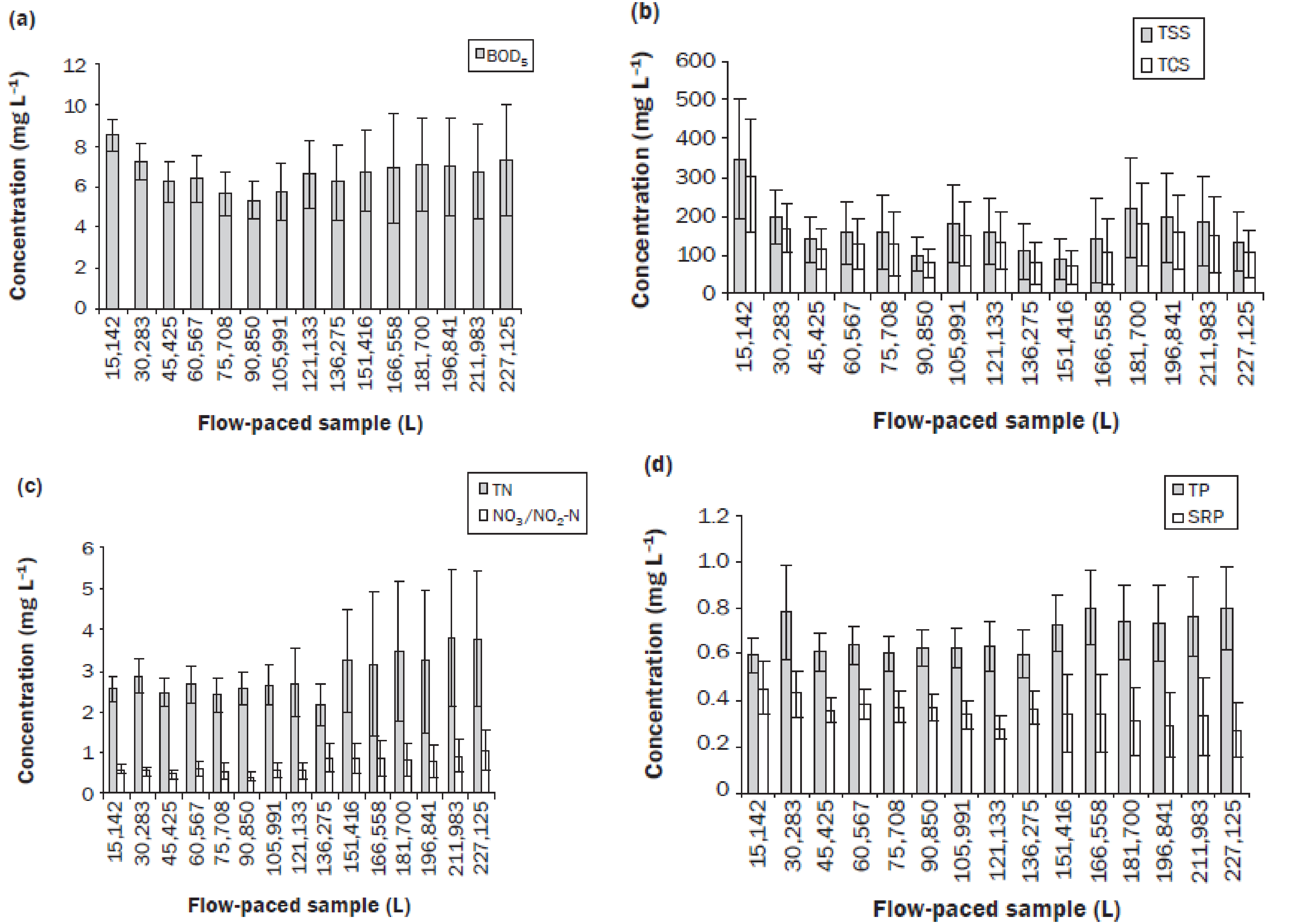
Average concentrations for TSS, BOD5, TN, TP, NO3/NO2-N, SRP, and pH for surface runoff from sugarcane field and pasturelands with and without BMPs

	Sugarcane		Pastureland	
	With BMPs	*Without BMPs*	*With BMPs*	*Without BMPs*
TSS mg l^{-1}	3,566*	780*	39*	133*
BOD5 mg l^{-1}	7.46ns	6.87ns	6.16ns	8.05ns
TN mg l^{-1}	5.96ns	5.01ns	3.22ns	4.09ns
TP mg l^{-1}	0.35ns	0.43ns	1.33ns	1.02ns
NO3/NO2-N mg l^{-1}	2.85ns	2.16ns	1.15ns	1.56ns
SRP mg l^{-1}	0.17*	0.27*	1.09ns	0.79ns
pH	5.67ns	5.87ns	5.56*	5.94*

* Mean between the BMPs and the control for a land use is significantly different at 0.05 probability level by student t-test; ns = not significant at the 0.05 probability level.

Poudel et al., 2010.

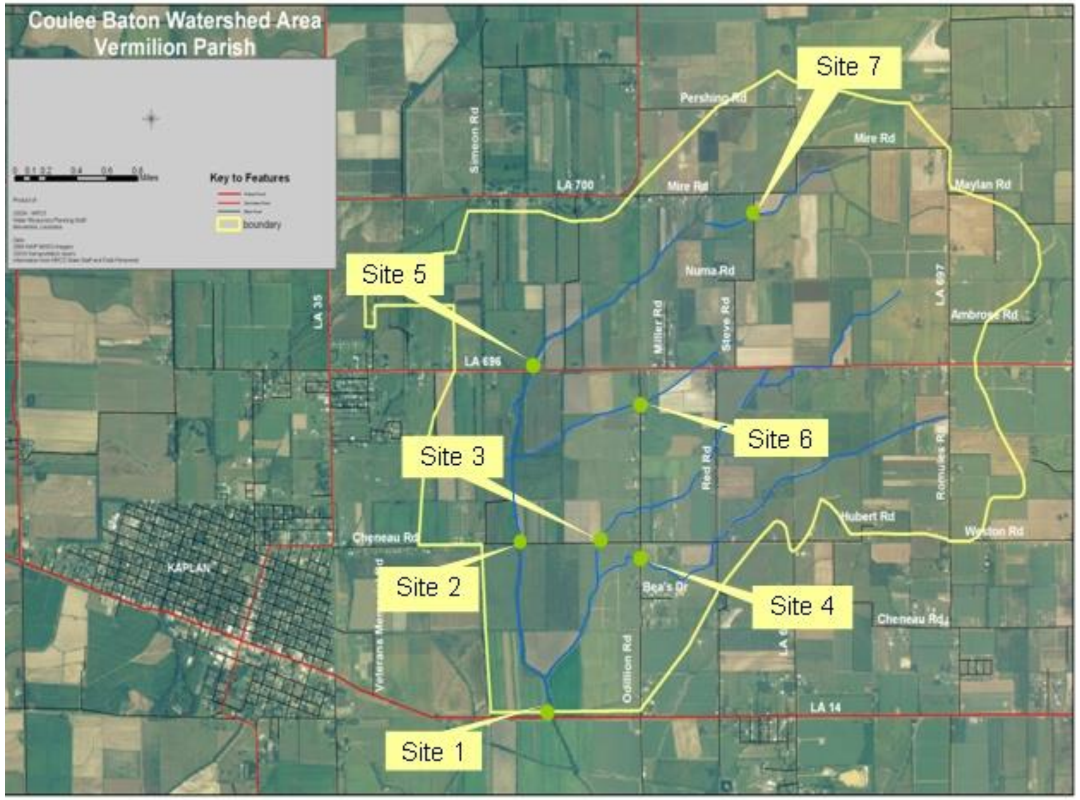
Flow-paced sample and concentrations

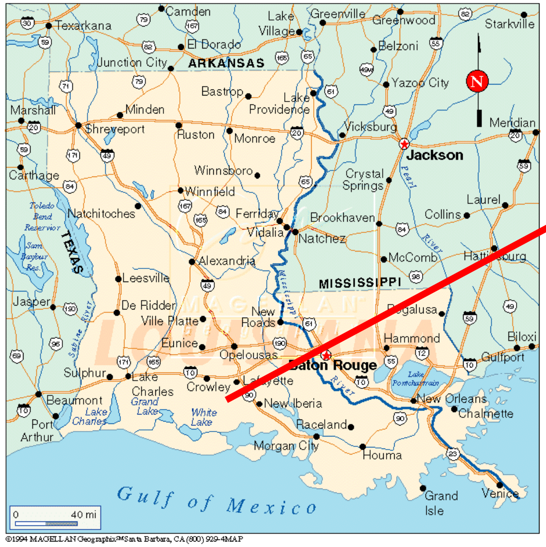


Poudel and Jeong, 2009

Water quality monitoring: Microwatershed-scale
(May 1, 2008 – September 30, 2011)

The Coulee Baton Microwatershed in Southwestern Louisiana





The 6,200 acres of Coulee Baton Microwatershed in Mermentau River Basin drains into the LA-050702 waterbody description of GIWW from the Mermentau River to the Leland Bowman Locks.

Field Installation

Two different techniques for water quality sample collection.
Left: a perforated PVC pipe housing a suction strainer (sieve) with suction hose floated with the help of a styro foam.
Right: a suction strainer, sitting on a metal piece at 6 inch off the bottom of stream, connected to ISCO sampler through a conduit PVC pipe, and a bubble line for Bubler Flowmeter.

Water quality sampling and analyses

- Water samples were collected for 66 rain events from September 24, 2009 to August 9, 2011.

- Laboratory determinations of water samples included TSS, BOD_5, $NO_{3-}N$, NO_2-N, SRP, TP, TKN, Cl, Fl, SO_4, and fecal coliform.

- Field measurements included the determination of temperature, DO, turbidity, conductivity, and pH using YSI Sonde.

Overall surface water quality of Coulee Baton Microwatershed in southwestern Louisiana (September 2009 – August 2011)*.

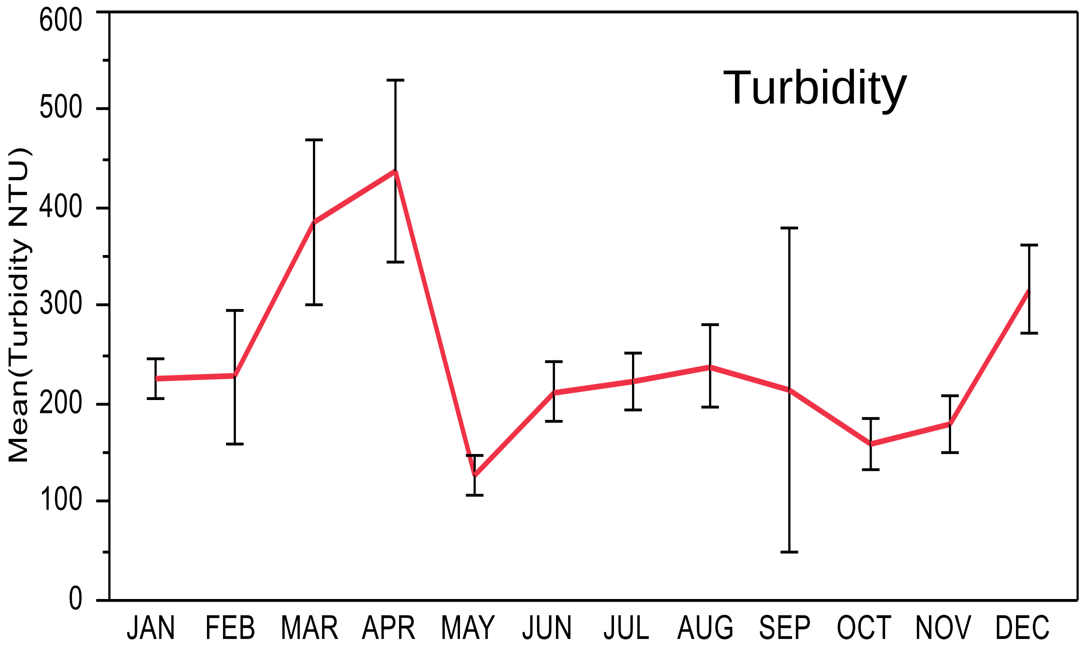
Parameter	n	25^{th} percentile	Median	Mean
Temperature (°C)	443	14.02	19.31	19.16(±0.31)¶
Conductiv ity (mS cm^{-1})	443	0.081	0.174	0.247(±0.01)
pH	443	7.14	7.54	7.50(±0.02)
Turbidity (NTU)	443	81.7	149.2	244.85(±15.23)
DO (mg L^{-1})	441	4.71	6.48	6.89(±0.13)
TSS (mg L^{-1})	446	47.75	81.5	152.33(±10.37)
TDS (mg L^{-1})	446	151	212	274.13(±13.97)
TS (mg L^{-1})	446	243.5	345	426.98(±21.00)
NO_3-N (mg L^{-1})	447	0.07	0.102	0.184(±0.011)
NO_2-N (mg L^{-1})	447	0.37	0.85	1.102(±0.05)
BOD_5 (mg L^{-1})	447	4.76	6.54	8.21(±0.26)
Chloride (mg L^{-1})	447	12.16	18.7	21.56(±0.17)
Fluoride (mg L^{-1})	447	0.04	0.04	0.15(±0.01)
SO_4 (mg L^{-1})	447	0.782	1.54	2.07(±0.11)
SRP (mg L^{-1})	447	0.03	0.04	0.14(±0.01)
TP (mg L^{-1})	447	0.25	0.36	0.45(±0.02)
TKN (mg L^{-1})	447	0.68	1.05	1.27(±0.05)
Fecal coliform (MPN/100 mL)	447	5,000	17,000	231,429(48,844)

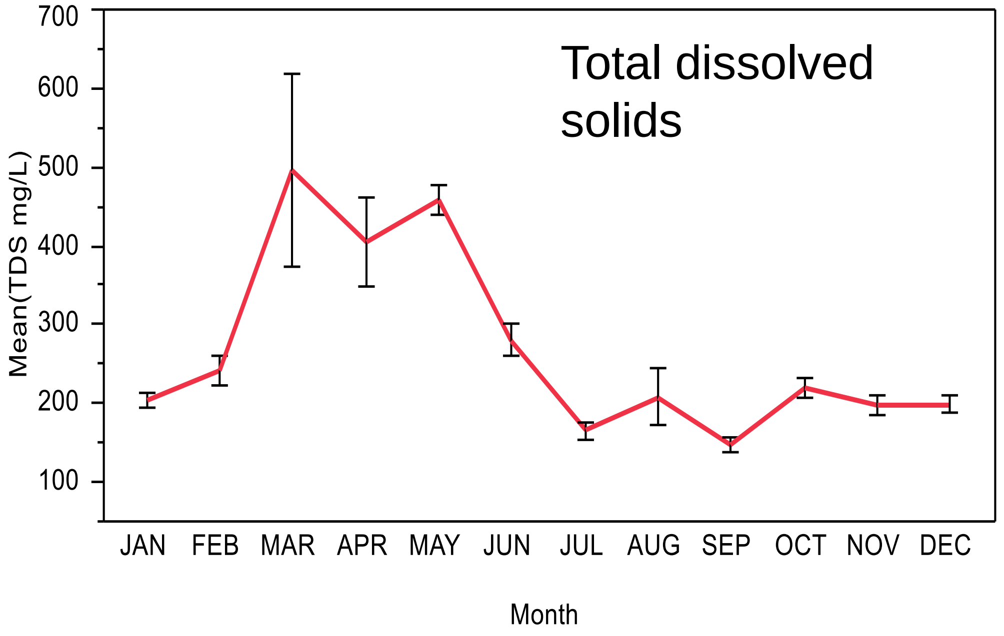
* Criteria for the downstream water body of 050702 from LDEQ include: Chloride 250 mg/L, Sulfate 75 mg/L, DO 5 mg/L, pH 6-9, temperature 32°C, and TDS 400 mg/L (LDEQ,2014). Similarly, LDEQ has established turbidity 25-150 for rivers and streams in Louisiana. USEPA criteria for Aggregate Ecoregion X which includes Texas-Louisiana coastal and Mississippi alluvial plain rivers and streams as: TP 128 µg/L, TN 0.76 mg/L, Chl-a 2.10 µg/L, and turbidity 17.5 FTU/NTU (USEPA,2001)

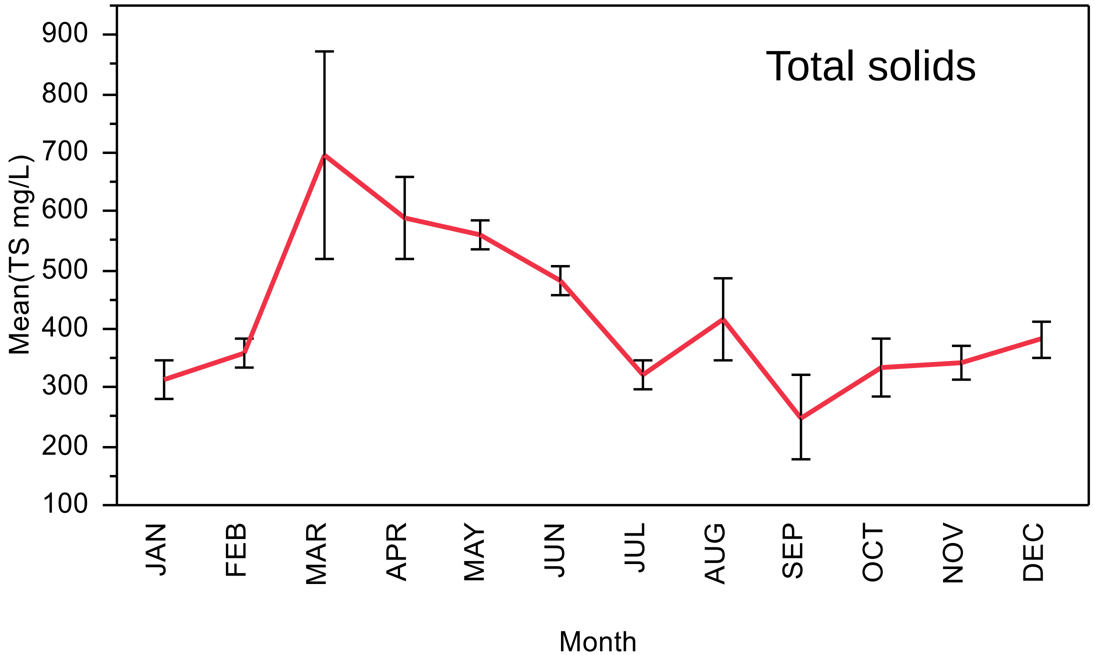
¶ ± standard error of mean.

Poudel, 2016.

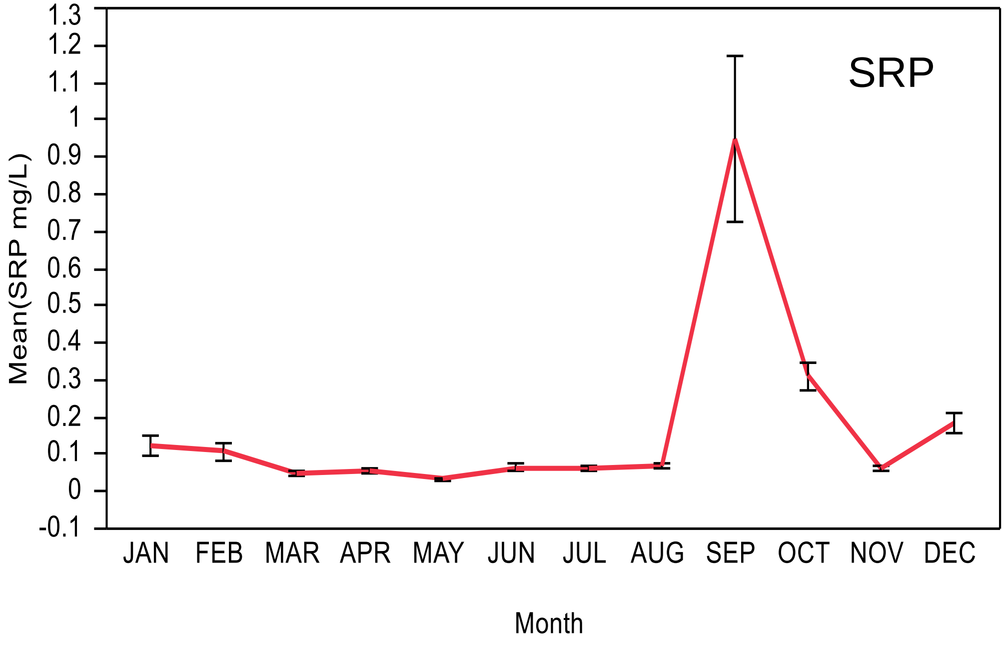
Turbidity, Total Dissolved Solids, and Total Solids of Coulee Baton water body, Louisiana

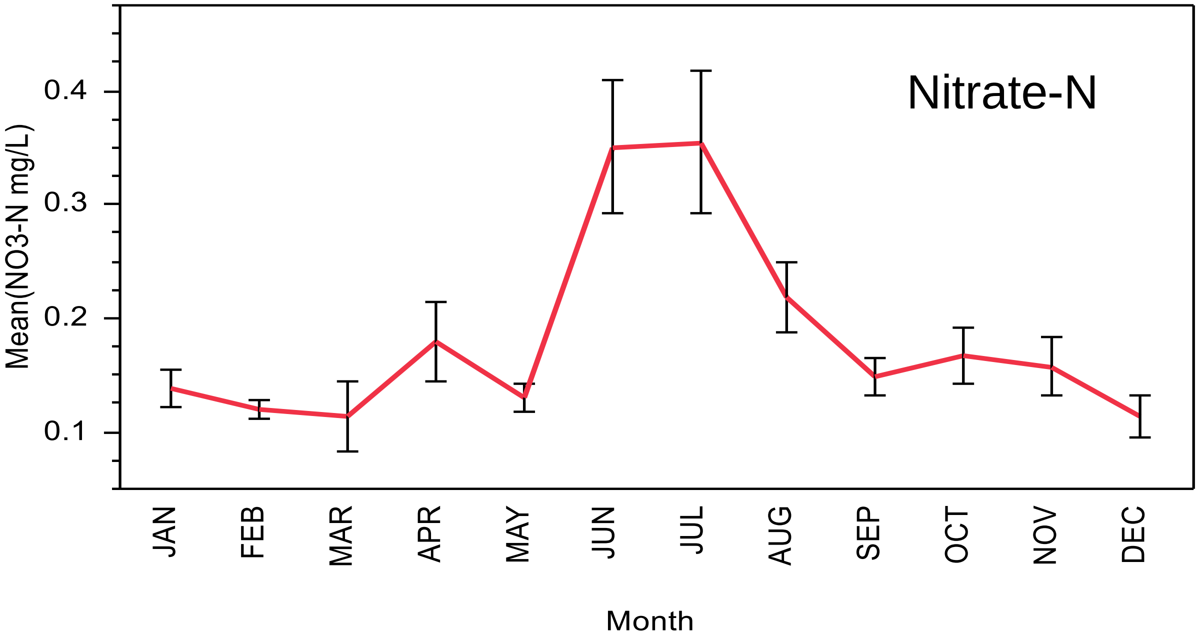


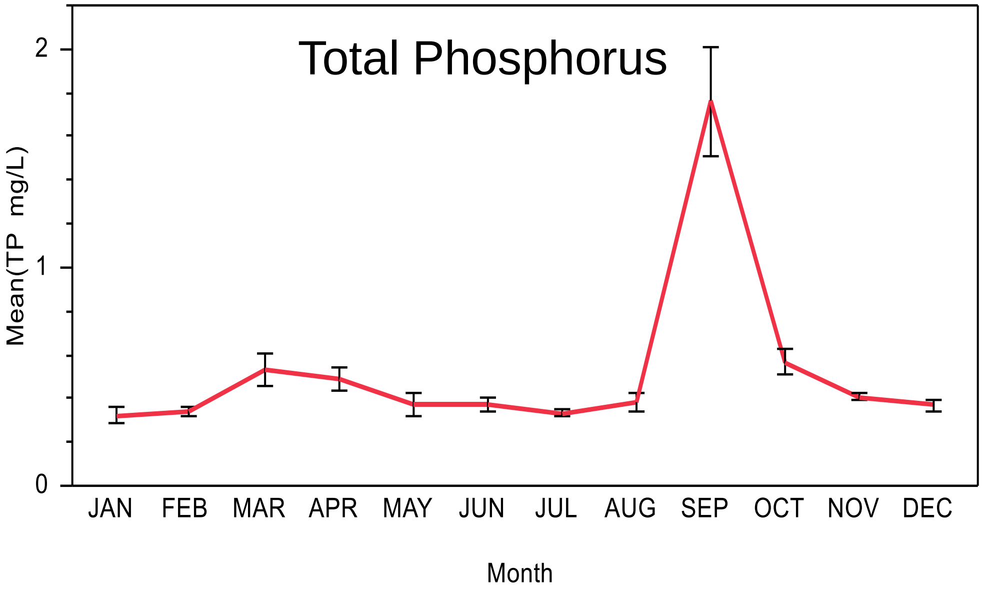


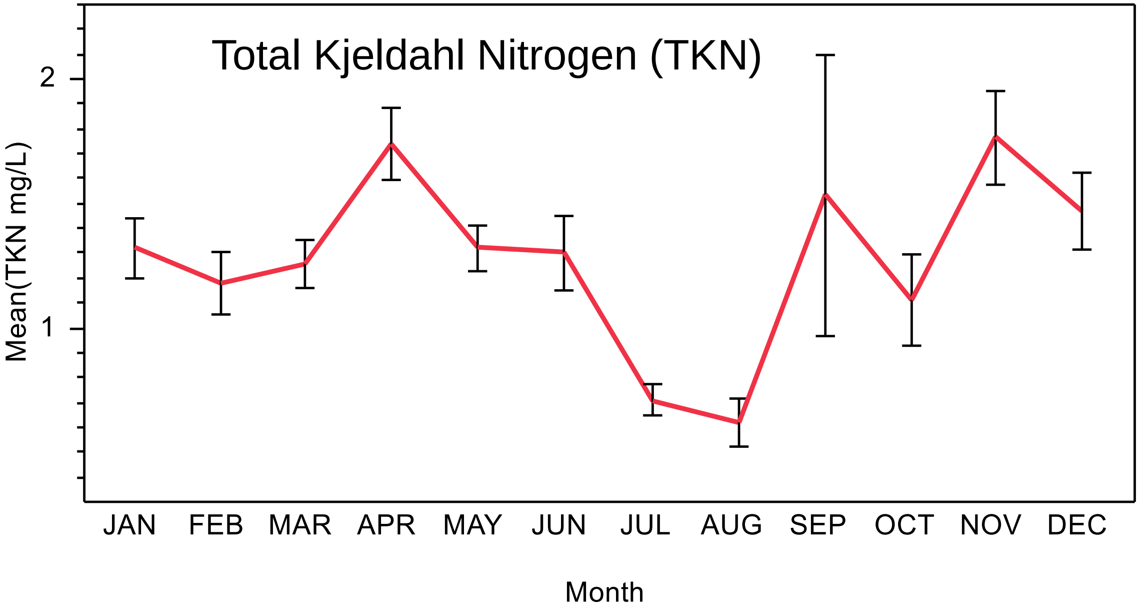


Turbidity, Total Dissolved Solids, and Total Solids of Coulee Baton water body, Louisiana

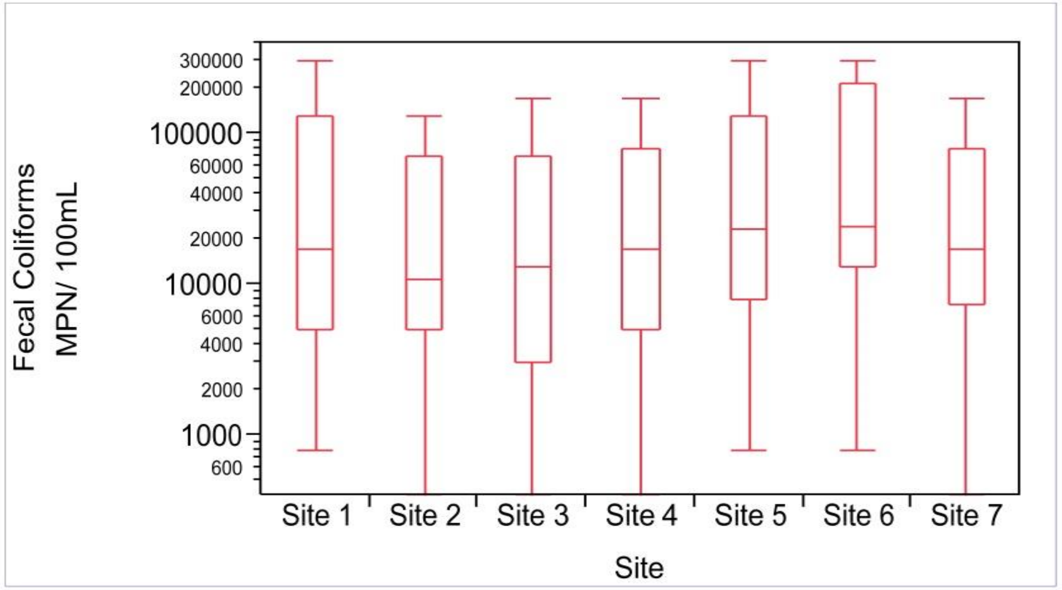








Fecal coliform count of the Coulee Baton water body, Louisiana



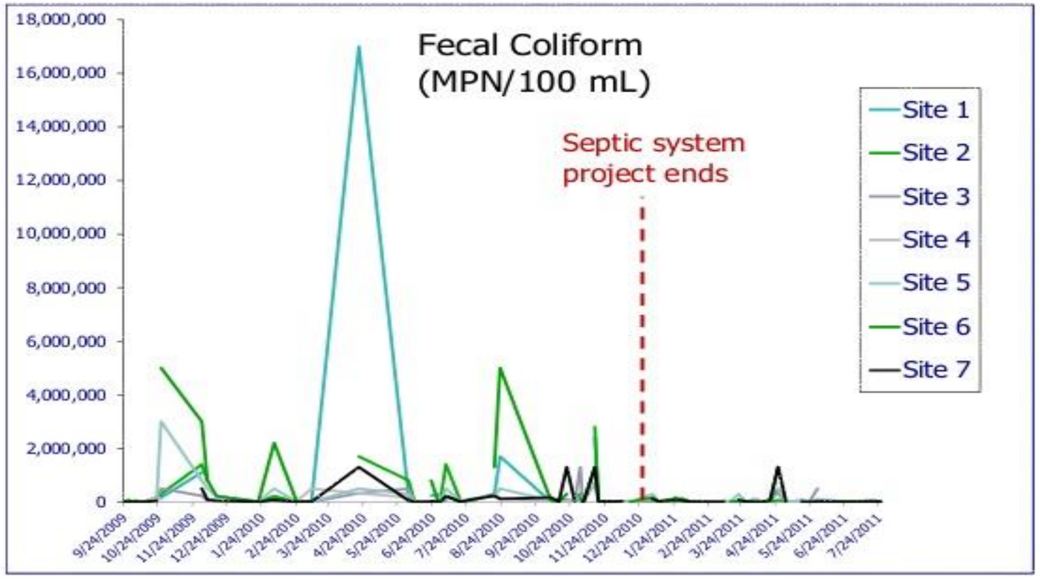
Septic systems replacement cost-share program

VSWCD together with Acadiana RC&D Council and LDEQ through cost-share program

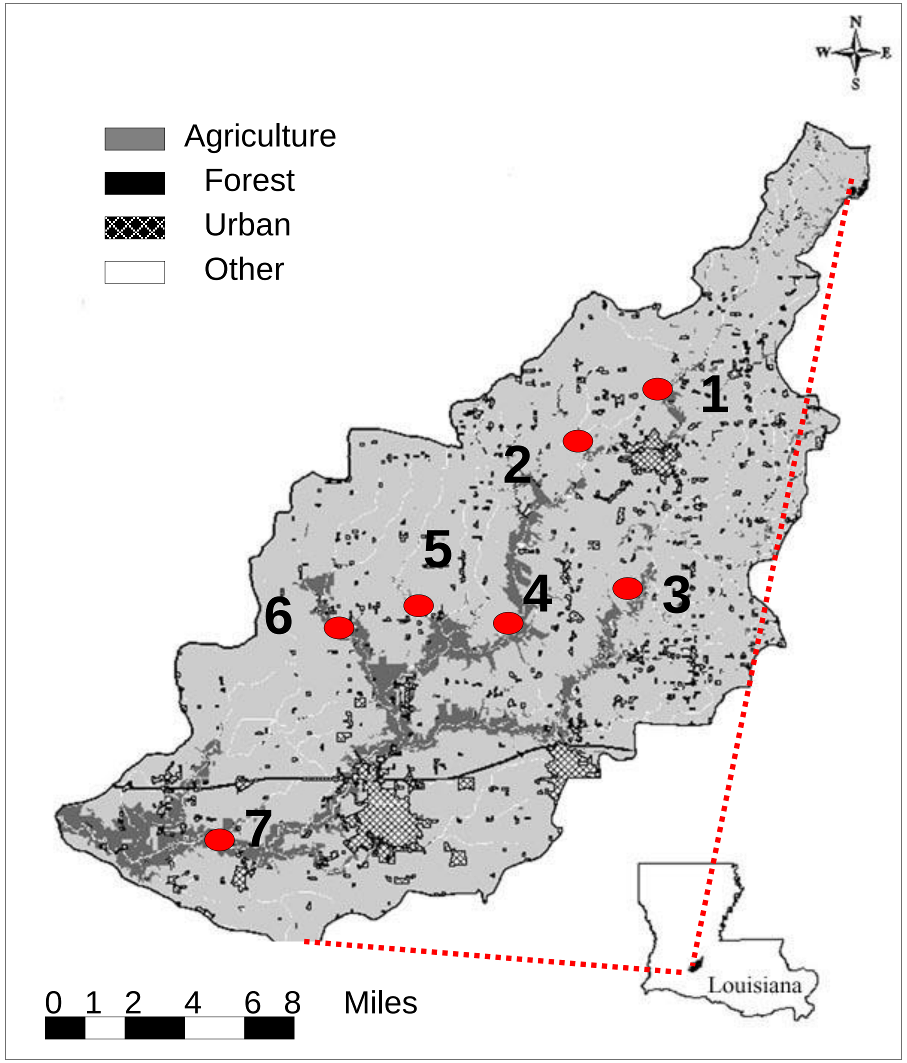
Repair or replacement of failing or aging home septic systems (80 systems installed out of 230 homes) in the microwatershed

Homeowner education, field day, and demonstration of three ER systems:

- Spray Irrigation System
- Rock Plant Filter System, and
- Gravel Field line



Water quality monitoring: Watershed-scale
(April 2001- June 2009)



1998 303(d) list due to not meeting EPA standards for designated uses of contact recreational uses and wildlife propagation.

The suspected causes of impairment were organic enrichment/low dissolved oxygen, and nutrients. Priority rank 1.

TMDLs for DO, fecal coliform, mercury, nutrients, TSS, and TDS were developed in in Dec. 1999 and approved by EPA in Feb. 2000.

Water quality sampling and analyses

- Water samples were collected every two weeks from March 2002 to February 2008. One background sample and one after-rain-event sample.

- Laboratory determinations of water samples included TSS, BOD5, TN, NO3/NO2-N, TP, and SRP

- Field measurements included the determination of temperature, DO, turbidity, conductivity, and pH using YSI Sonde.

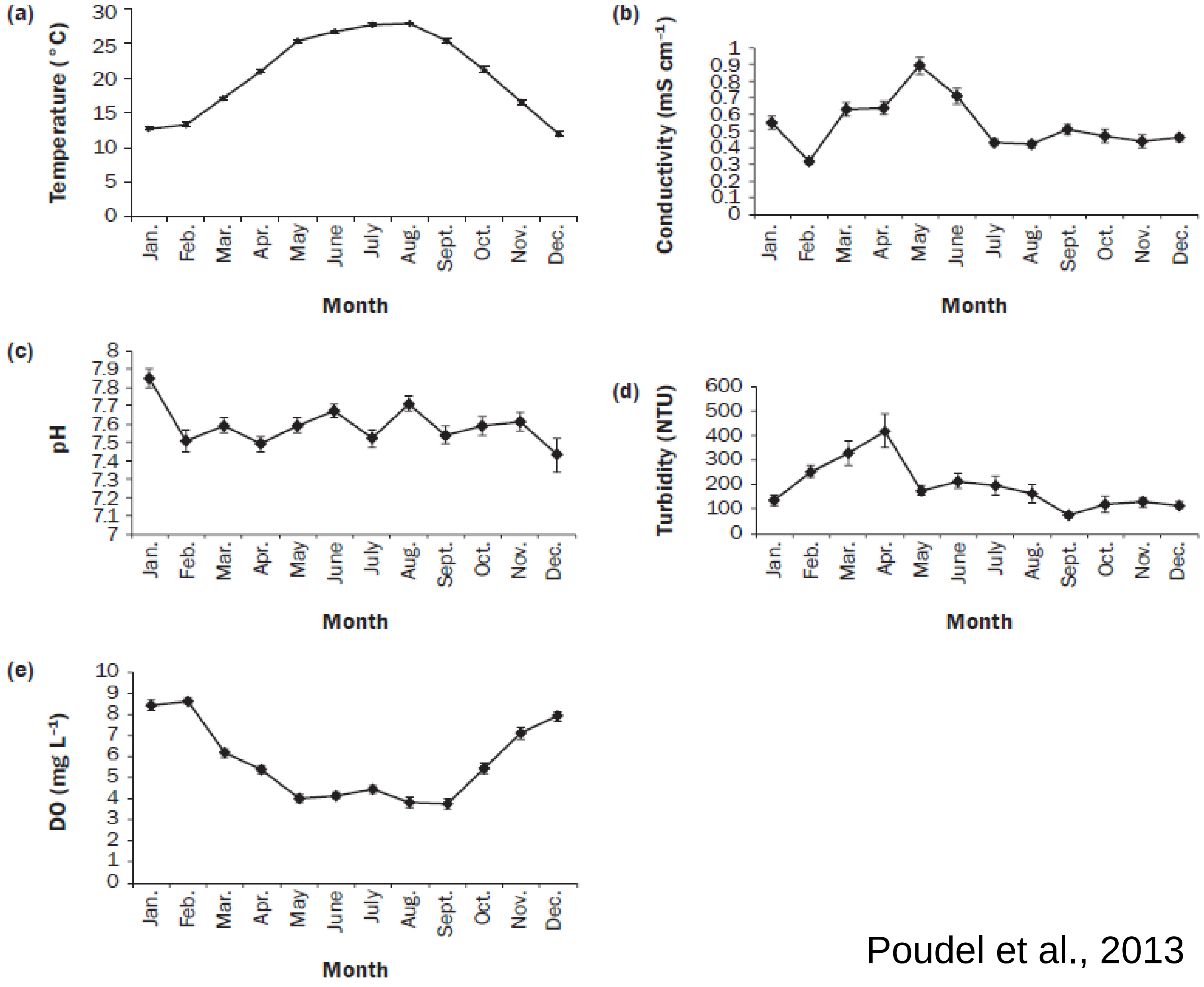
Water quality sampling

➢Lowering a plastic bucket from the bridge and collecting a composite sample at 80% from the surface of the water. Each composite sample filled 2 L glass or plastic bottle.

➢Field parameters measured in the field with a multiprobe YSI Sonde (YSI Sonde Model 6820 with 650MDS) at 20%, 60% and 80% depth.

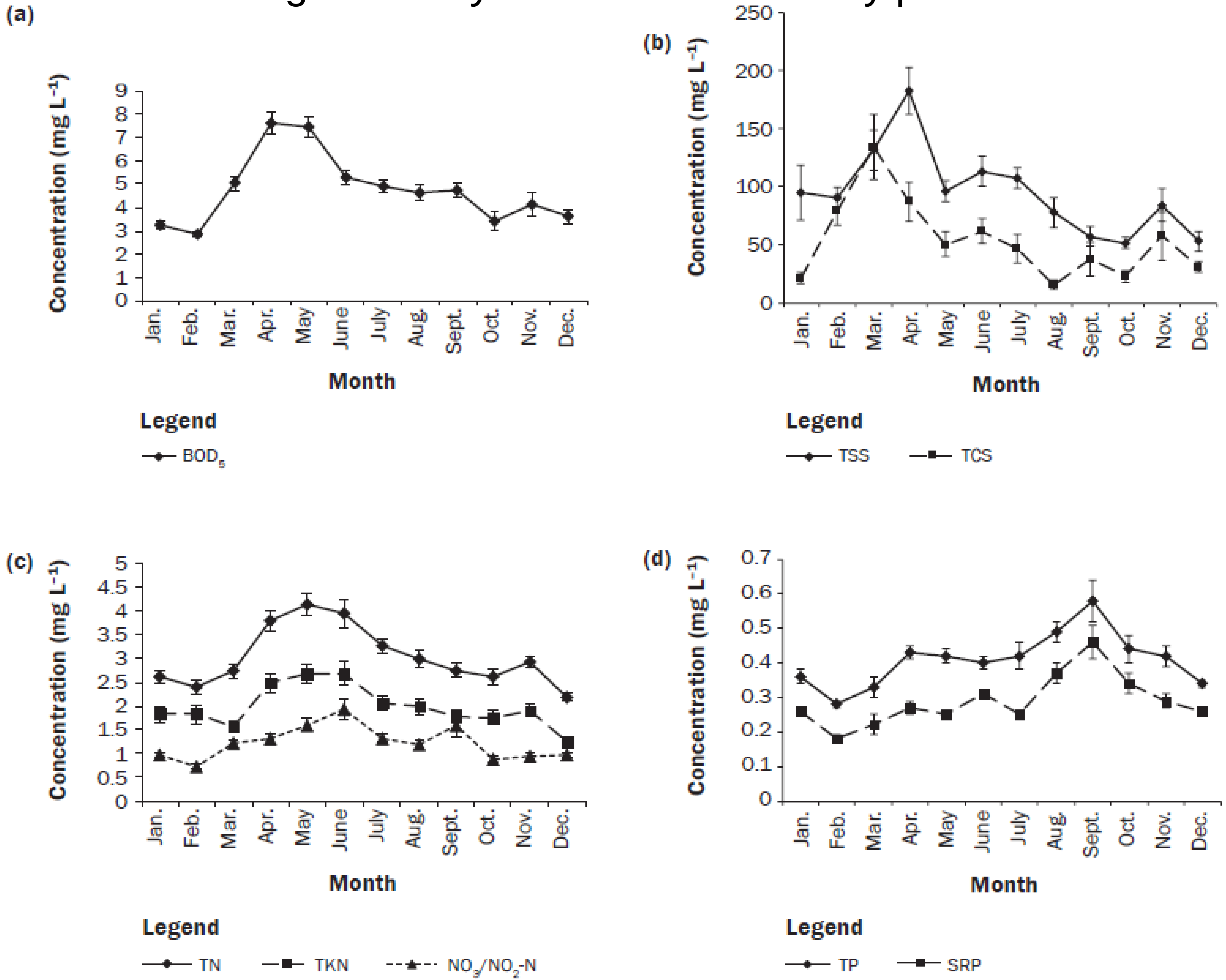
Discharge measurement

Average monthly values for the field parameters



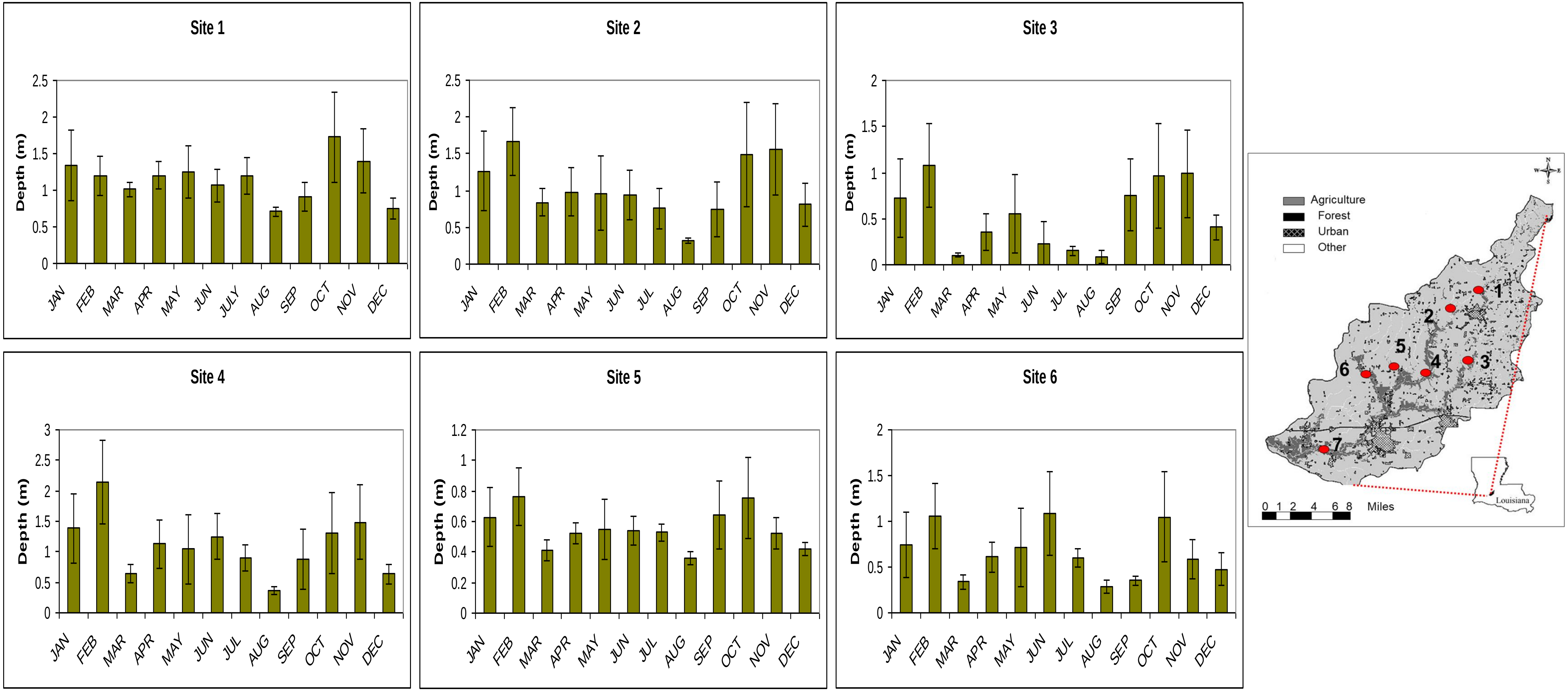
Poudel et al., 2013

Average monthly values for laboratory parameters



Poudel et al., 2013

Bayou Plaquemine Brule is drying upstreams: Monthly Average Water Depth



Poudel et al., 2013

Low flow conditions of the upstream sites

"A centuries-old law gives Louisiana landowners "ultimate dominion" over the groundwater beneath their property. That means farmers, manufacturers and homeowners can take as much as they want, when they want it — no fees required.

But this hands-off approach to groundwater management is creating big problems in southwestern Louisiana, where the state's largest and most important aquifer is losing water fast. More than 661 million gallons of water are being pumped every day from the Chicot Aquifer System, while only about 313 million gallons are being returned through rain or natural drainage.

The aquifer is being overdrawn by 348 million gallons each day — well beyond a sustainable measure."

Source: Coastal Desk
Louisiana's Biggest Source Of Groundwater Is Losing Water Fast
WWNO - NEW ORLEANS PUBLIC RADIO | BY TEGAN WENDLAND
Published March 9, 2021 at 6:00 AM CST. Available at https://www.wwno.org/coastal-desk/2021-03-09/louisianas-biggest-source-of-groundwater-is-losing-water-fast

Principal Component and Factor analyses

Principal component (Yi)	Eigenvalue (λi)	Cumulative proportion of variability	Parameters with higher loadings on the rotated factors	Factor identified
Y_1	3.46	26.59	TCS, TSS, Turbidity	Sediment
Y_2	2.43	45.26	SRP, TP	Phosphorus
Y_3	1.60	57.57	TKN, TN	Nitrogen
Y_4	1.34	67.84	Temperature, DO	Temperature
Y_5	1.11	76.41	NO_3/NO_2-N, Conductivity	Dissolved solids
Y_6	1.00	84.14	pH	Acidity/alkalinity

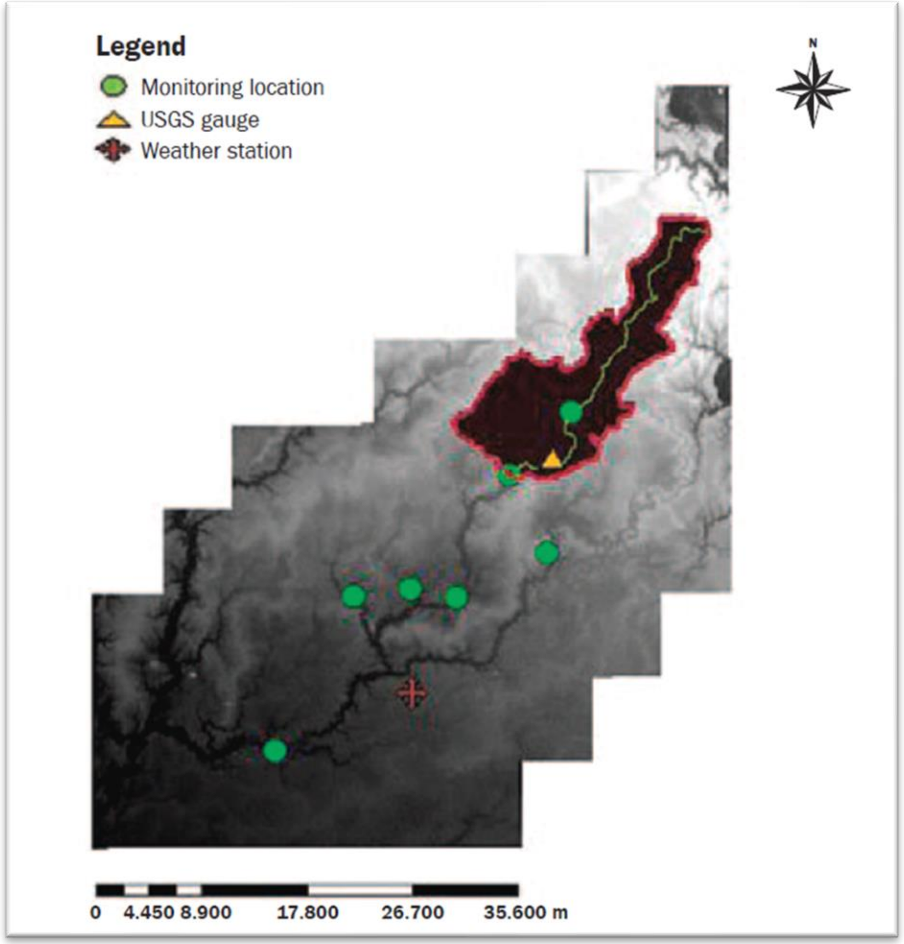
Poudel et al., 2013

Identifying Sediments, Phosphorus and Nitrogen pollution hotspots in Bayou Plaquemine Brule watershed by applying the Soil and Water Assessment Tool (SWAT) Model (ArcSWAT Version 2.3.3, ArcGIS 9.3 SP1)

- Digital Elevation Model (DEM), LiDAR Data –
- 5 m DEM (http://atlas.lsu.edu/LiDAR)
- Landuse map (LDEQ – Landsat TM, 1998)
- Soils data (STATSGO 1:250,000 scale)
- Weather data (Rice Research Station, Crowley, Louisiana, 1980 to 2008)
- Daily discharge data for flow calibration and validation (http://ida.water.USGS.gov/ida/available_records.cfm?sn=08010200), June 2002 to November 2005),

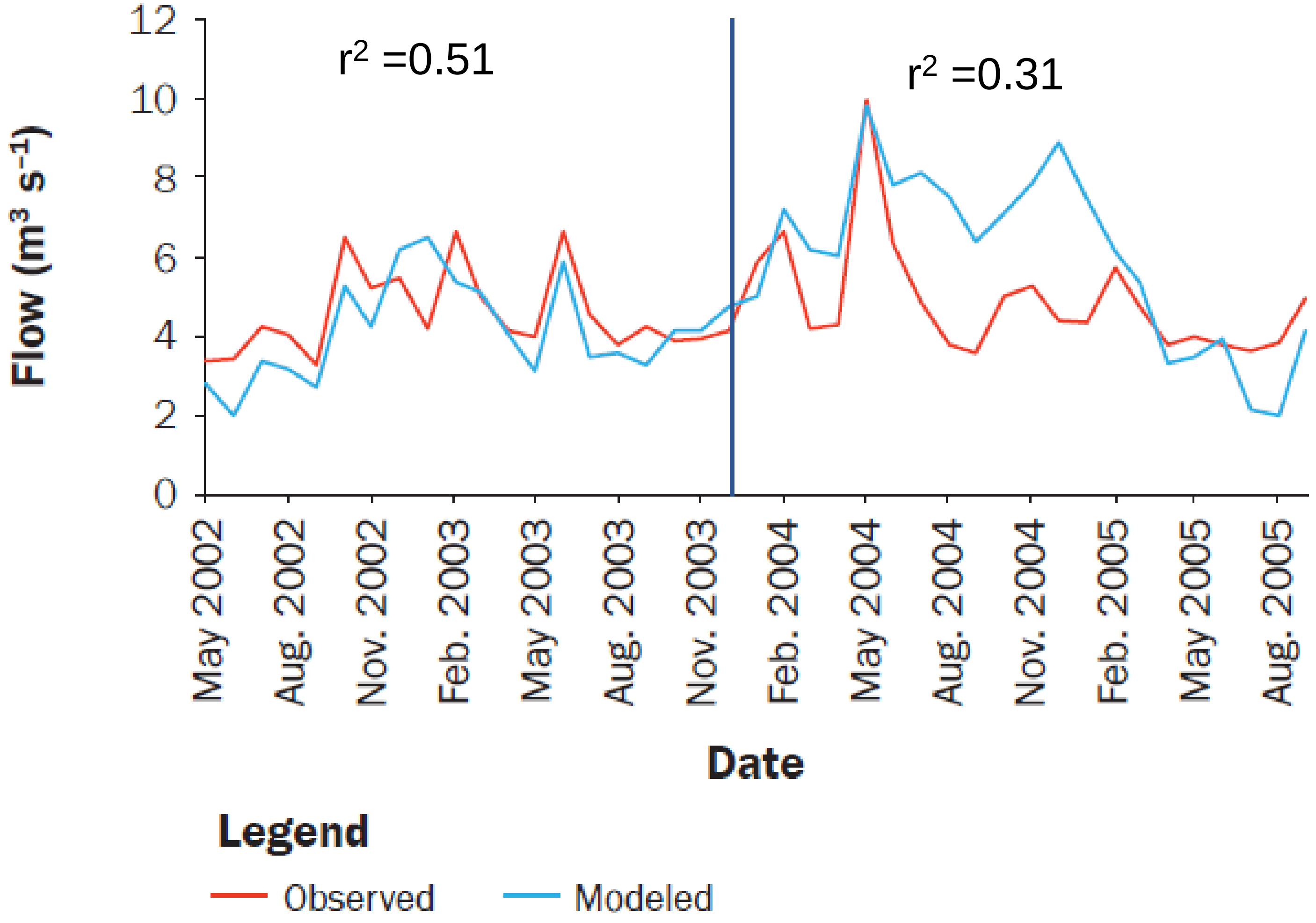
USGS 08010200 BYU PLAQUEMINE BRULE at CHURCH POINT, LA

Pilot basin for flow calibration and validation



Poudel et al., 2013

Model calibration and validation



Poudel et al., 2013

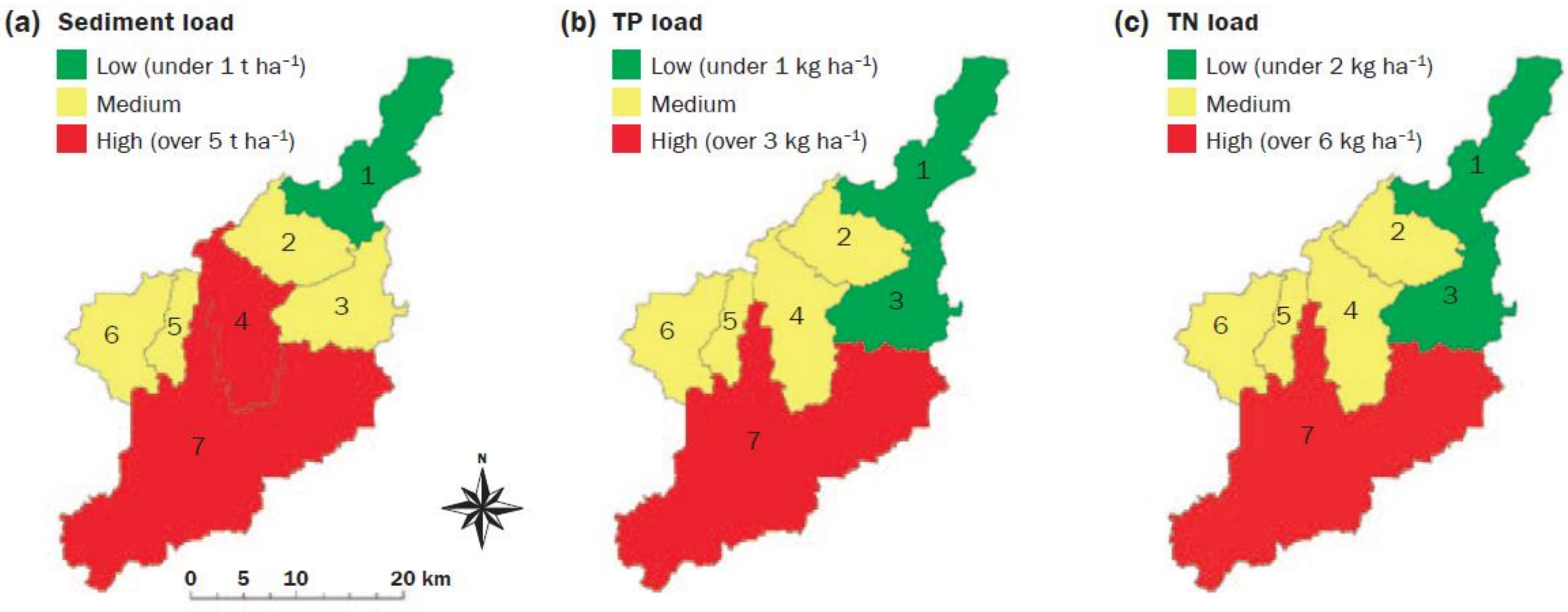
Total mass and average load observed and modeled

(May 1, 2002, to Sept. 30, 2005)	Sediment (t)		TN (kg)		TP (kg)	
	Observed	Modeled	Observed	Modeled	Observed	Modeled
Total mass	88.2	88.4	3,160.0	4,458.1	519.6	397.7
Average	1.1	1.1	45.8	64.6	7.5	5.8

Notes: TN = total nitrogen. TP = total phosphorous.

Poudel et al., 2013

Critical areas for sediment and nutrient loads

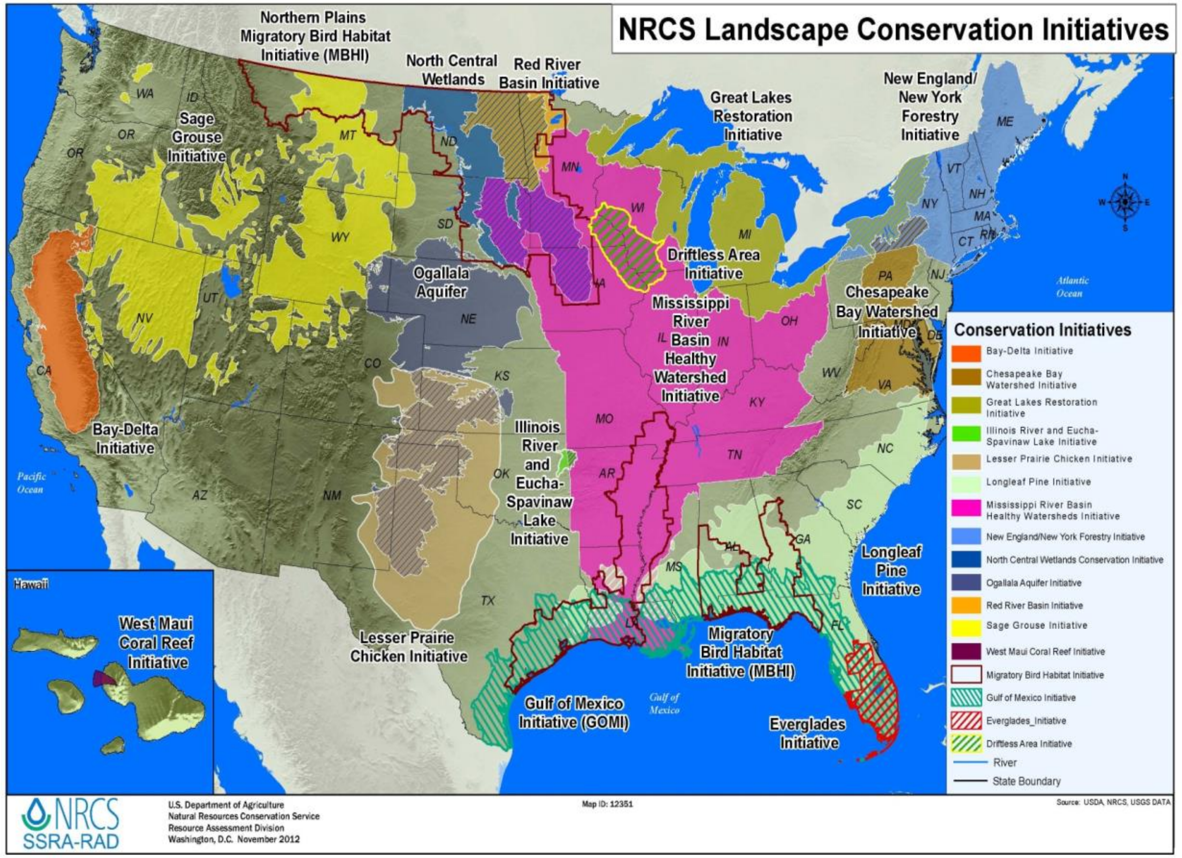


Poudel et al., 2013

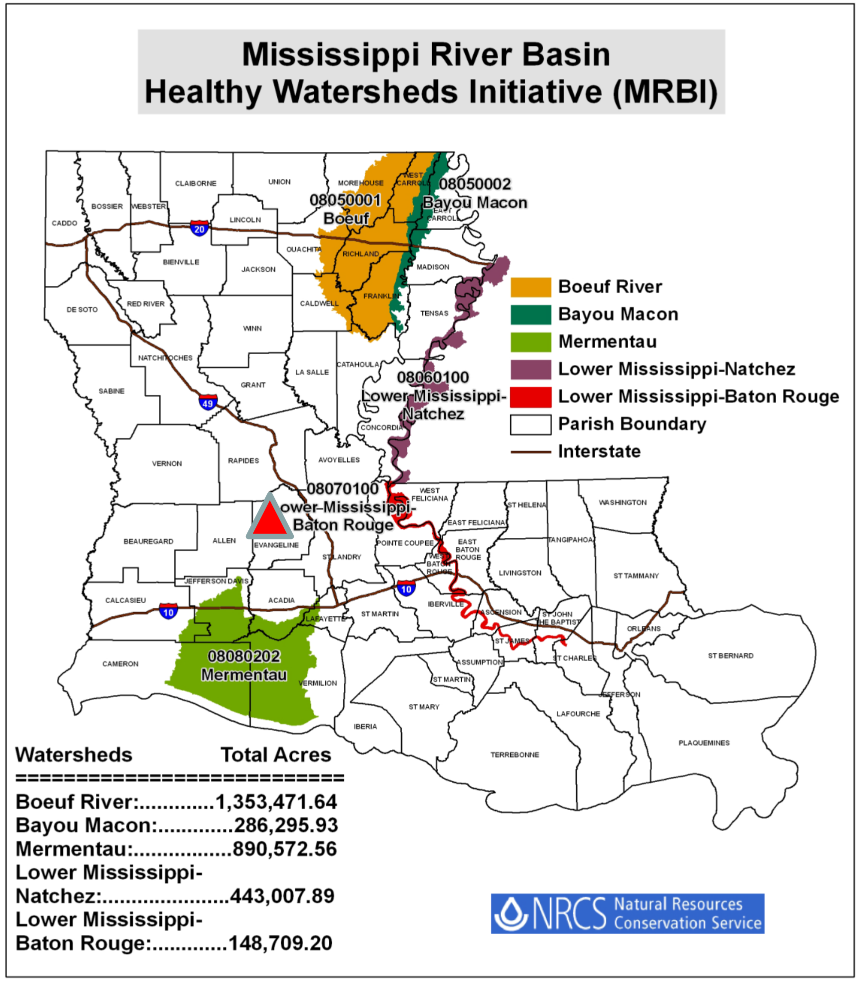
Water quality monitoring: Basin scale

The Mississippi River Basin Initiative (MRBI) Watershed Water Quality Monitoring in Bayou Chene and Lacassine Bayou Project (April 2012-June 2017)

Mississippi River Basin Healthy Watersheds Initiative (MRBI)
(2008 NRCS Farm Bill Conservation Programs, the conservation provisions in the Food, Conservation, and Energy Act of 2008)



http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/initiatives/



Sources:NRCS,Louisiana.http://www.nrcs.usda.gov/wps/portal/nrcs/detail/la/programs/financial/ccpi/?cid=stelprdb1097321. Triangles are added by the presenter.

Figure 1
Bayou Chene and Lacassine Bayou subwatersheds in Bayou Lacassine watershed (BLW), Louisiana, and the 15 water quality sampling sites in this study.

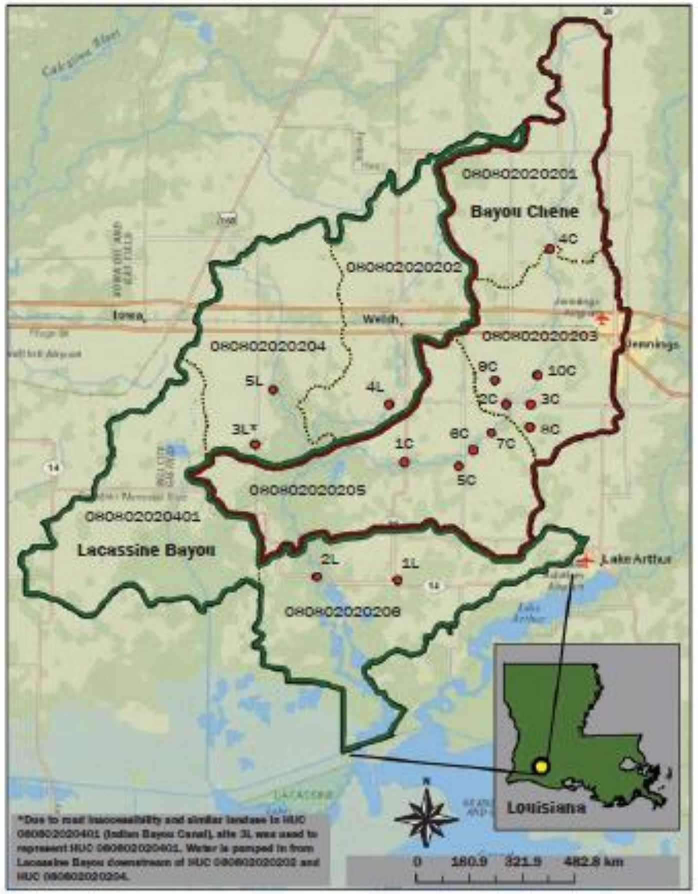


Table 1
Key characteristics of Bayou Chene and Lacassine Bayou subwatersheds of Bayou Lacassine watershed in Louisiana.

Characteristic	Bayou Chene	Lacassine Bayou
Total area (catchment size; ha)	45,672	63,699
Percentage of total area under*		
Cropland (%)	69.5	59.0
Aquaculture (%)	7.5	2.0
Pastureland (%)	6.2	13.9
Developed (%)	7.8	6.0
Wetlands (%)	8.8	17.3
Others (%)	0.3	1.8
Year of inclusion on 303(d) list	1999	1999
Suspected causes of water quality impairment	Organic enrichment, low dissolved oxygen	Phosphorus, nitrogen, turbidity, TSS, TDS, lead, organic enrichment, low dissolved oxygen
Louisiana Department of Environmental Quality water quality subsegment	LA050603	LA050601

*Land use area developed from the 2013 NASS cropland data layer of USDA National Agricultural Statistics Service database (USDA NASS 2013).

Materials and Methods

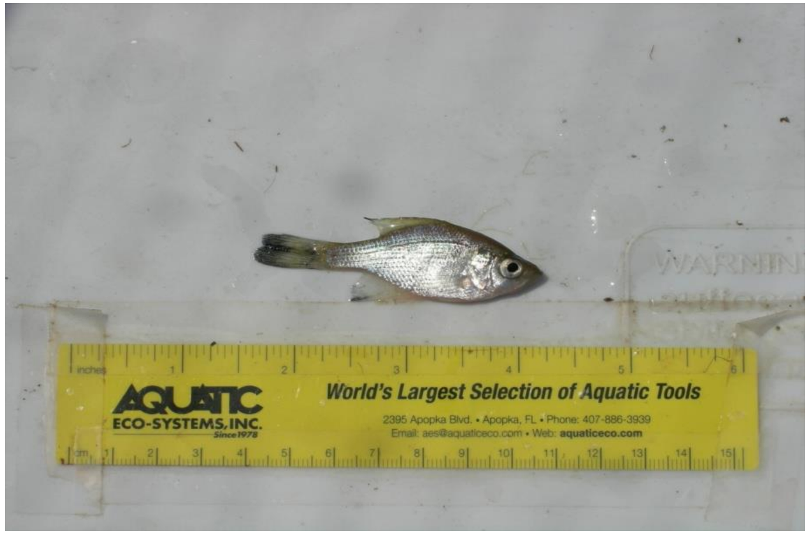
Weekly field measurements and sampling:
Water depth, DO, temp. pH, turb., cond.
(Started in June 2012)

Laboratory determination:

TSS, TDS, TS, Nitrite, Nitrate, TKN, TP, SRP, Cl, Fl, SO4, BOD5

(Started in June 2012)

Fish and macroinvertibrates sampling



Petite Ponar Grab sampler

> 500 µm fraction to be preserved in 10% formalin with Rose Bengal stain.

"***Spatial Patterns***. In Bayou Chene, average values for TSS, TDS, TS, NO3/NO2-N, TKN, TP, F–, SO4, and conductivity were lower at the most downstream site (1C) than at the most upstream site (4C), by 18.7% to 60.3%.

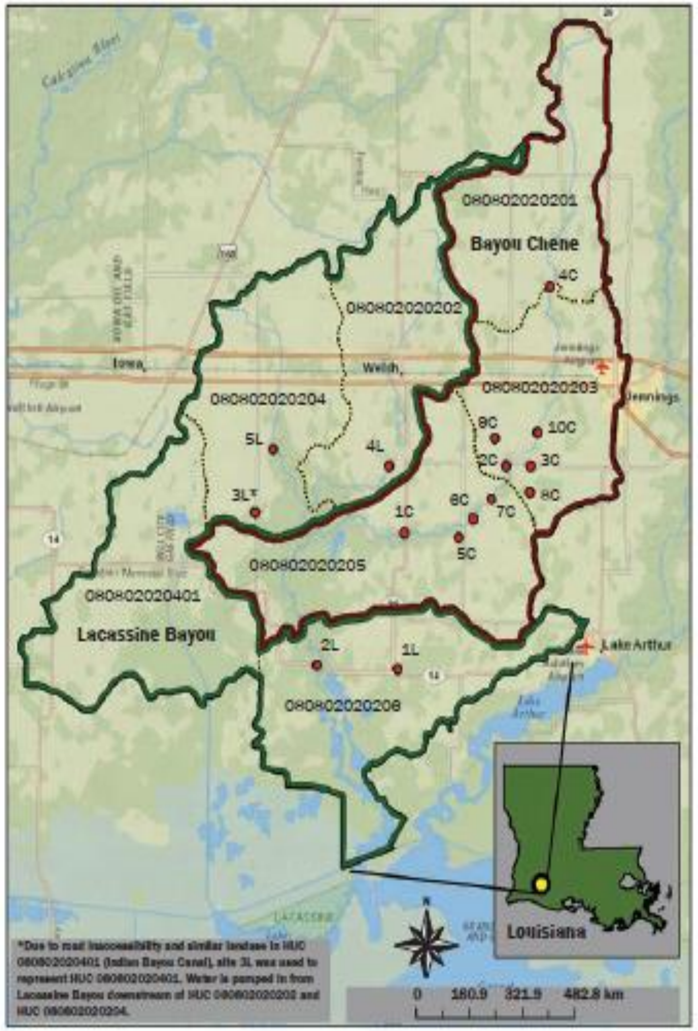
The same pattern was observed for Lacassine Bayou, where average values for turbidity, TSS, TDS, TS, NO3/NO2-N, TKN, TP, BOD5, F–, and conductivity at downstream site 2L were lower by 23.0% to 50.7% compared to upstream site 4L.

A similar spatial pattern, with water quality improving with distance away from the more-developed upstream areas, has been observed for enteric bacteria (Mallin et al. 2000) and BOD (Yoon et al. 2015).

The present study's data are indicative of better water quality downstream. Potential reasons for the poorer water quality upstream include the upstream presence of concentrated agricultural activities, the downstream presence of riparian buffers and wetlands that improve surface water quality by enhancing nutrient uptake, sediment retention, litter decomposition (Whigham et al. 1988; Johnston 1991), and the dilution effect due to increased volume of water downstream."

Figure 1

Bayou Chene and Lacassine Bayou subwatersheds in Bayou Lacassine watershed (BLW), Louisiana, and the 15 water quality sampling sites in this study.



Poudel et al., 2020

Figure 3

Temporal variation in the benthic invertebrate community in Bayou Chene and Lacassine Bayou. (a) Average values for the invertebrate density, (b) their diversity index H', and (c) the number of taxonomic orders were regressed on the sampling month. The solid line is for Lacassine Bayou and the broken line is for Bayou Chene.

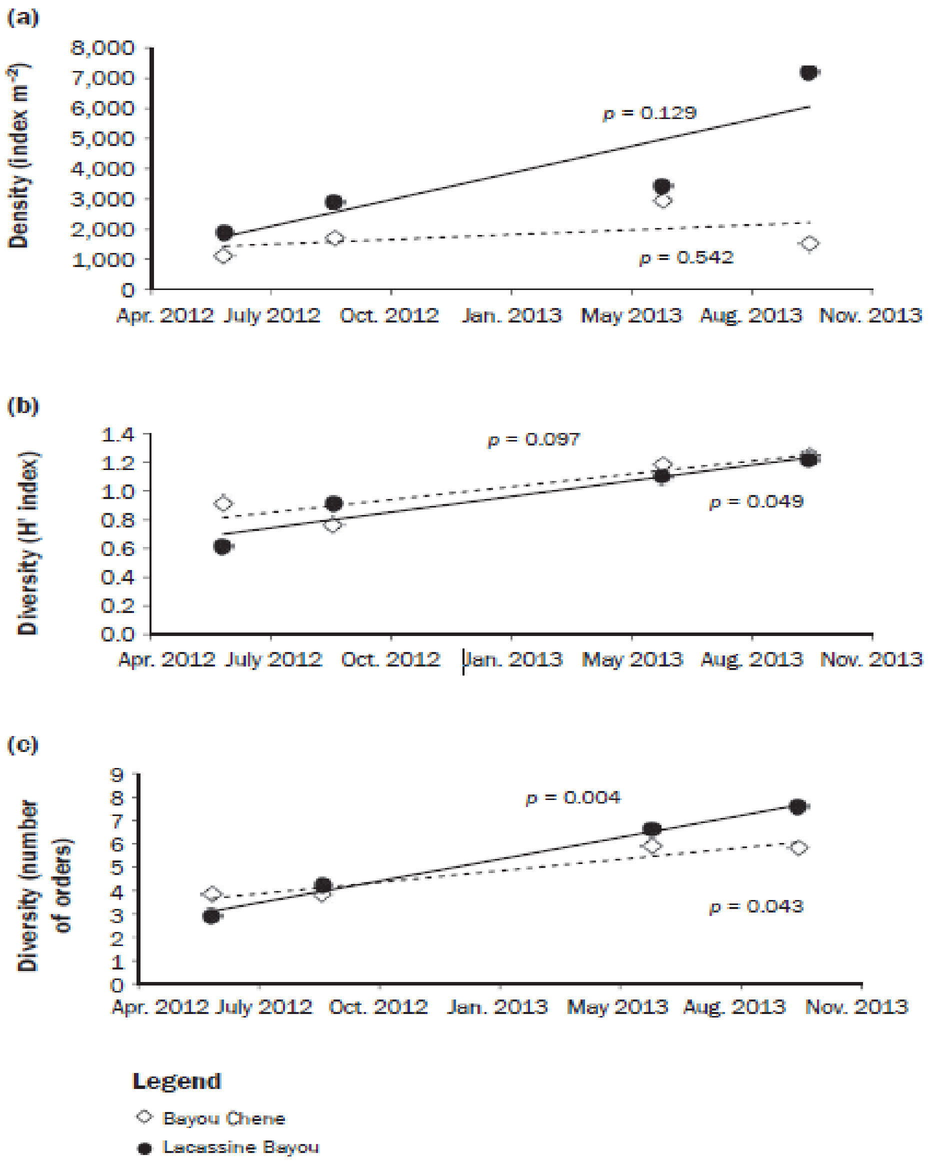
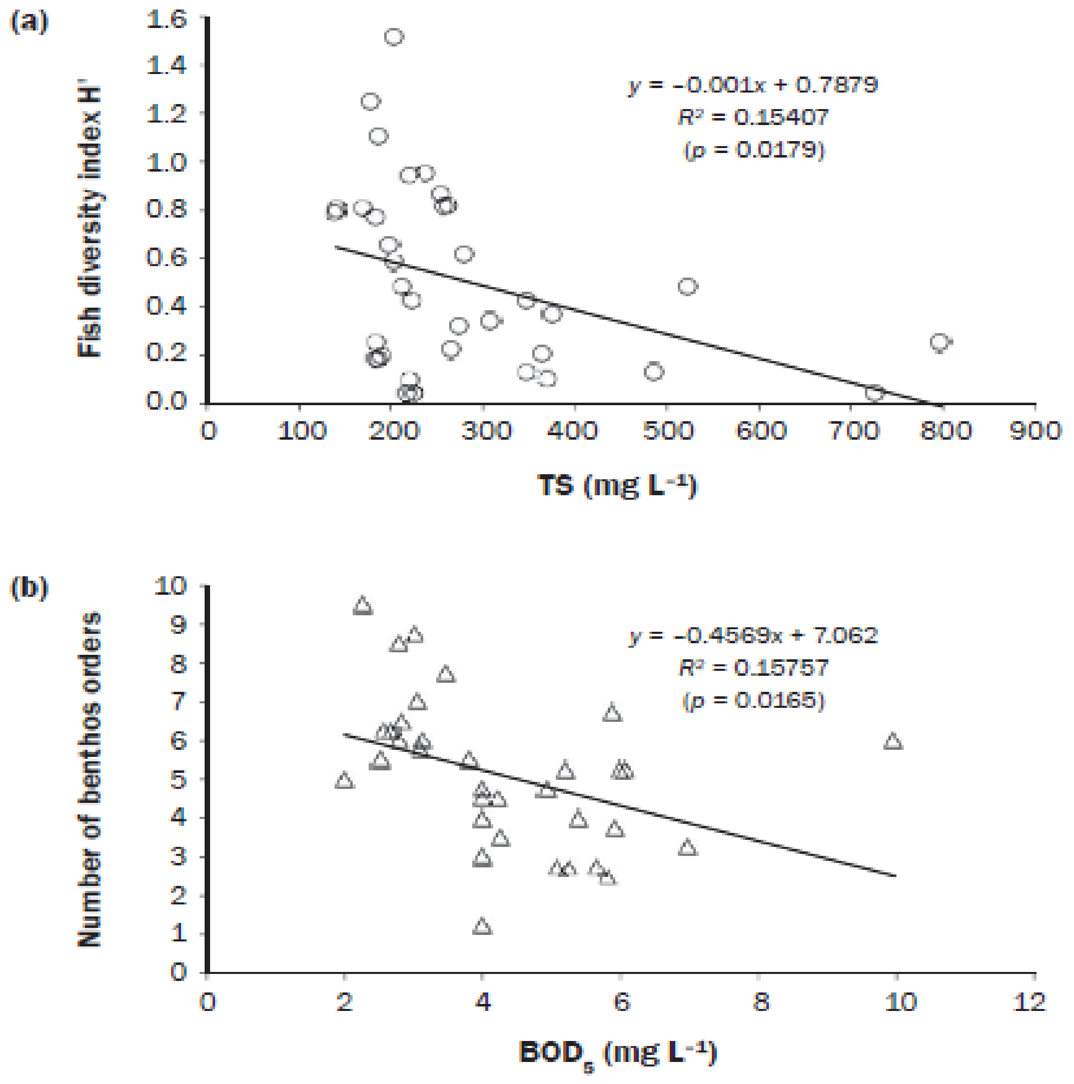


Figure 4

Relationships between benthos and fish diversity measures and the physicochemical properties of surface water measured at the same site during the two weeks prior to the biological sampling. Results are shown for (a) the fish diversity index H' over total solids (TS) and (b) benthos diversity (number of orders) over the five-day biological oxygen demand (BOD_5).



Poudel et al., 2020

Invasive aquatic vegetation in Louisiana water bodies


1C upstream 6-27-12.JPG


1L upstream 10-25-12.jpg


1C downstream 6-27-12.JPG


1L downstream 10-25-12.jpg


Hydrilla


Water Lettuce


Water Hyacinth

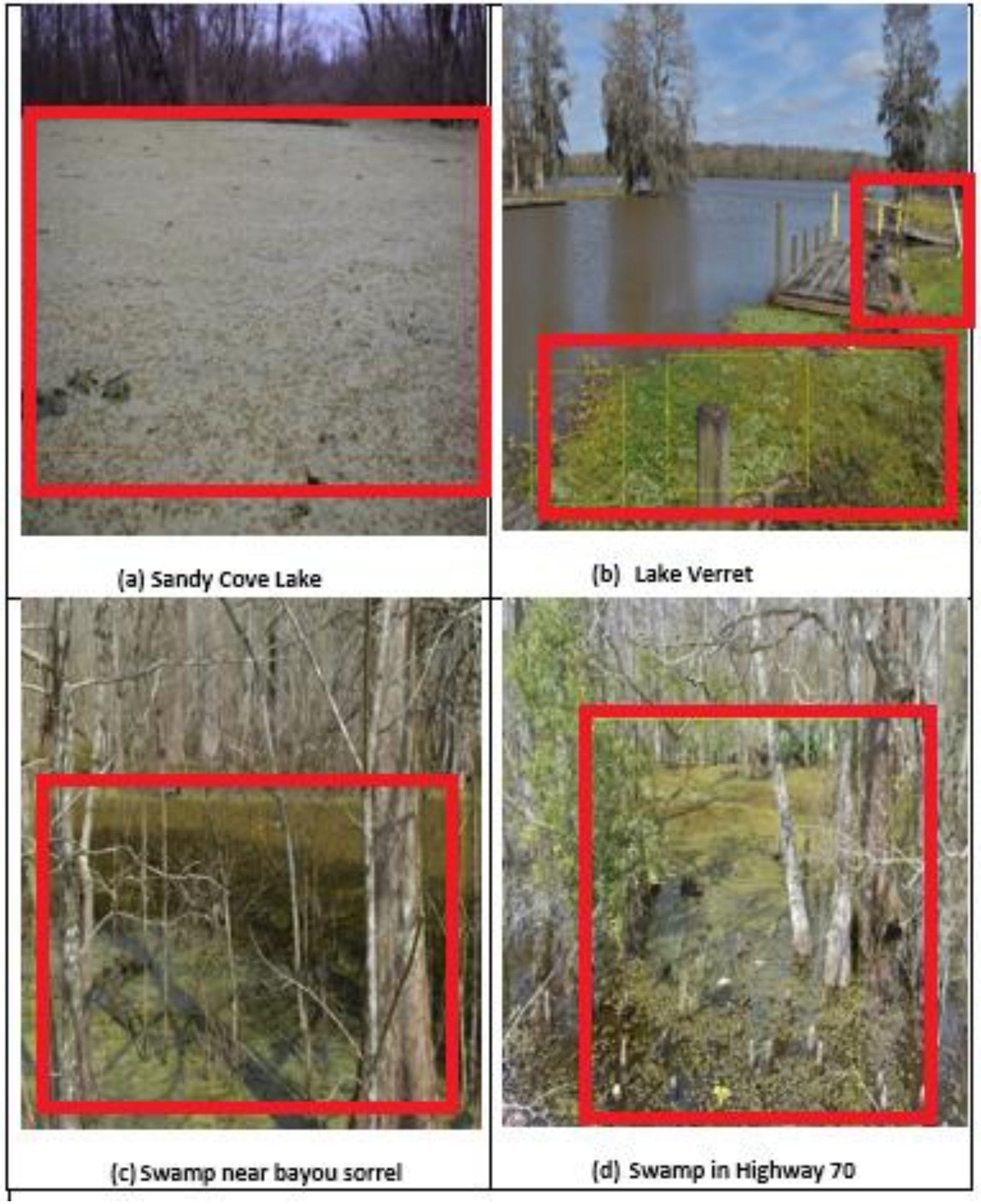

Giant Salvinia

- Giant salvinia (*Salvinia molesta*) is a small free-floating aquatic plant that is native to Brazil and is found in many parts of the United States including Louisiana.

- The presence of giant salvinia in Toledo Bend Reservoir on the Texas-Louisiana border was reported in late 1998. Giant salvinia is easy to identify because the upper leaf surface is covered with rows of tiny hairs that split and then mix at the tip creating an oval shape.

- The tip traps air which makes it easy for the plant to float in the water. As the plant grows into mats, the leaves fold and develop a chain-like appearance which makes the roots suspend in the water with a mass of fine filaments.

- Giant salvinia can cover water surface easily due to its invasive nature. It can stack up upon itself and can extend a couple of inches inside and outside the surface water.



(a) Sandy Cove Lake

(b) Lake Verret

(c) Swamp near bayou sorrel

(d) Swamp in Highway 70


Cyrtobagous salviniae : Giant salvinia's natural control
Length: 1.5-3.1 mm
Width: 1.2-1.6 mm
Live for about 6 months
Egg to adult in 6 weeks
All stages are temperature dependent
Host specific

- Salvinia weevil (Cyrtobagous salviniae) is a small insect native to Brazil and Argentina which has been used for biological control of giant salvinia in many countries.

- Salvinia weevils feed only on giant salvinia species and reduce its growth. After having success in controlling giant salvinia in Australia, salvinia weevils have been released as a biological control agent in other countries.

- Salvinia weevils were first released in the Toledo Bend Reservoir boundary between Louisiana and Texas in 2001 . They feed on giant salvinia plants and reduce the growth of giant salvinia.

- Salvinia weevils do not destroy giant salvinia completely, but this biological method of controlling giant salvinia is highly economical, environmentally friendly, and its impacts are realized for many years without re-introduction of the weevil.

University of Louisiana ponds with salvinia weevil

Conclusions

- Agricultural systems have huge reservoirs of nonpoint source pollutants, and these systems release nonpoint source pollutants to surface water bodies continuously during an extended rain event. Residential areas also contribute to NPS pollution.

- Surface water pollution in an agricultural watershed directly relates to the agricultural activities in the watershed. Often, there are excessive concentrations of fecal coliforms in surface water bodies in agricultural watersheds.

- Sediments and nutrients constitute the major nonpoint source pollutants in agricultural watersheds. The SWAT model is useful in identifying critical areas for NPS pollution in an agricultural watershed.

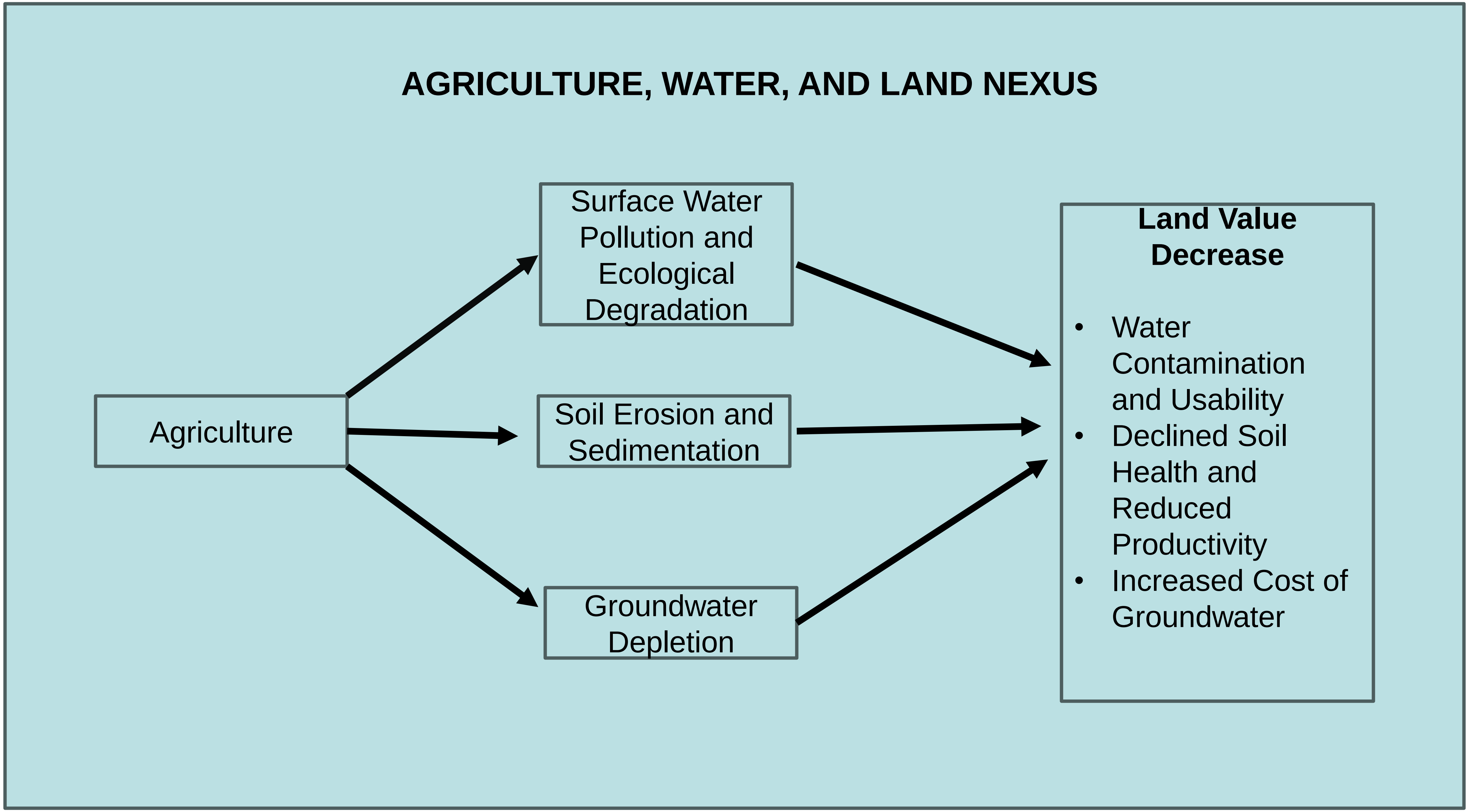
- The implementation of the BMPs improves surface water quality, and surface water quality is poor in areas where agricultural activities are intense. Benthic invertebrate diversity negatively relates to TSS and BOD5.

Conclusions contd..

- Invasive aquatic vegetation degrades the biological integrity of a surface water body, clogs navigation canals, destroys winter habitat for migratory birds, and lowers the land values.

- The impact of agriculture on water quality and quantity and land value occurs in many different ways, including surface water pollution, erosion and sedimentation, ecological degradation, and land degradation.

- These complex processes require an in-depth understanding and careful planning and implementation of Best Management Practices (BMPs) in agriculture for surface water quality improvement, soil and water conservation, and ecological preservation in the region. This will increase land productivity and land value.


AGRICULTURE, WATER, AND LAND NEXUS
Agriculture
Surface Water Pollution and Ecological Degradation
Soil Erosion and Sedimentation
Groundwater Depletion
Land Value Decrease
• Water Contamination and Usability
• Declined Soil Health and Reduced Productivity
• Increased Cost of Groundwater

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Thank you for your attention.

Any questions?