



# The Development and Evaluation of Environmental Flow Prescriptions for Big Cypress Creek: A Tributary to Caddo Lake

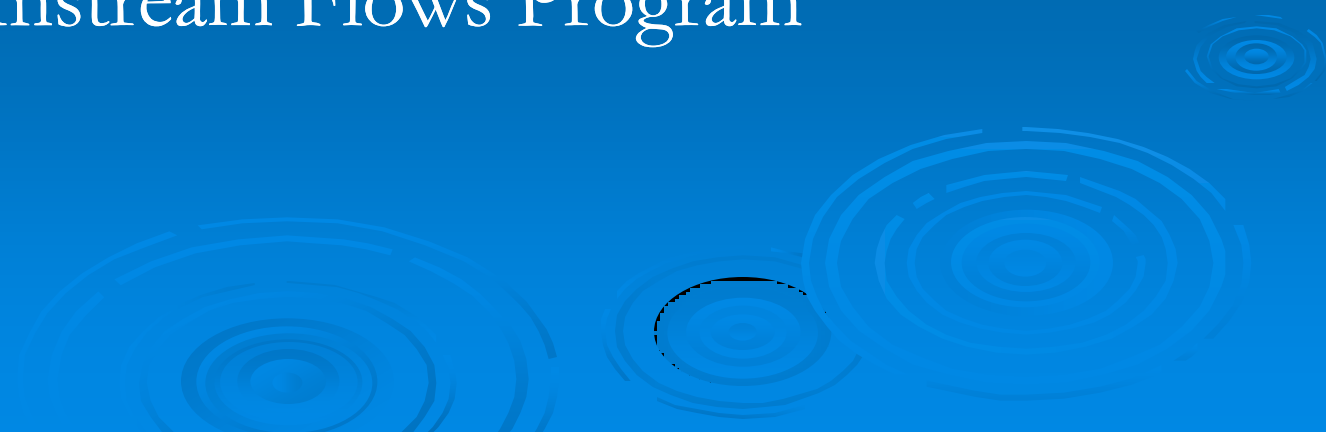
## An Emphasis on Connectivity

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# Acknowledgements First!

- Caddo Lake Institute
  - The Texas Nature Conservancy
  - The U.S. Army Corps of Engineers (Fort Worth District)
  - North East Texas Municipal Water District
  - The Texas Instream Flows Program
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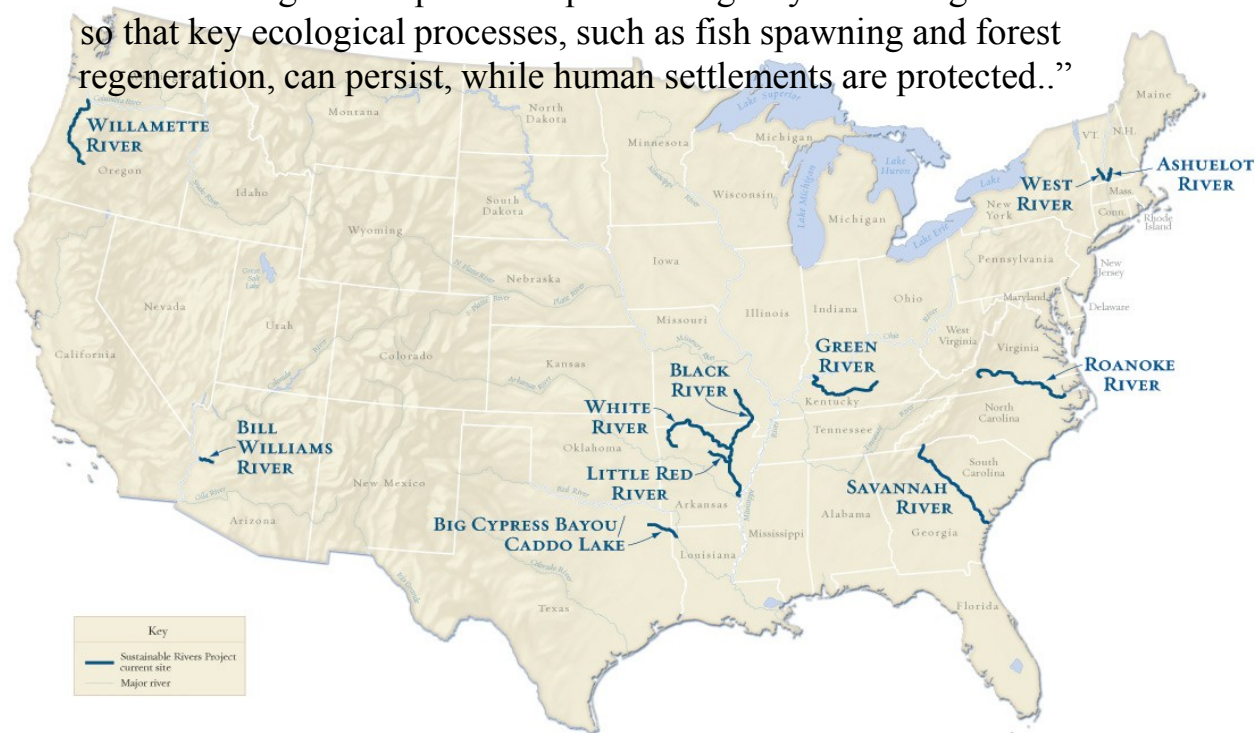
# Returning to a More Natural Flow Regime

- The Nature Conservancy Sustainable Rivers Project under an MOU with U.S. Army Corps of Engineers resulted in the a directive issued 14 December 2000.

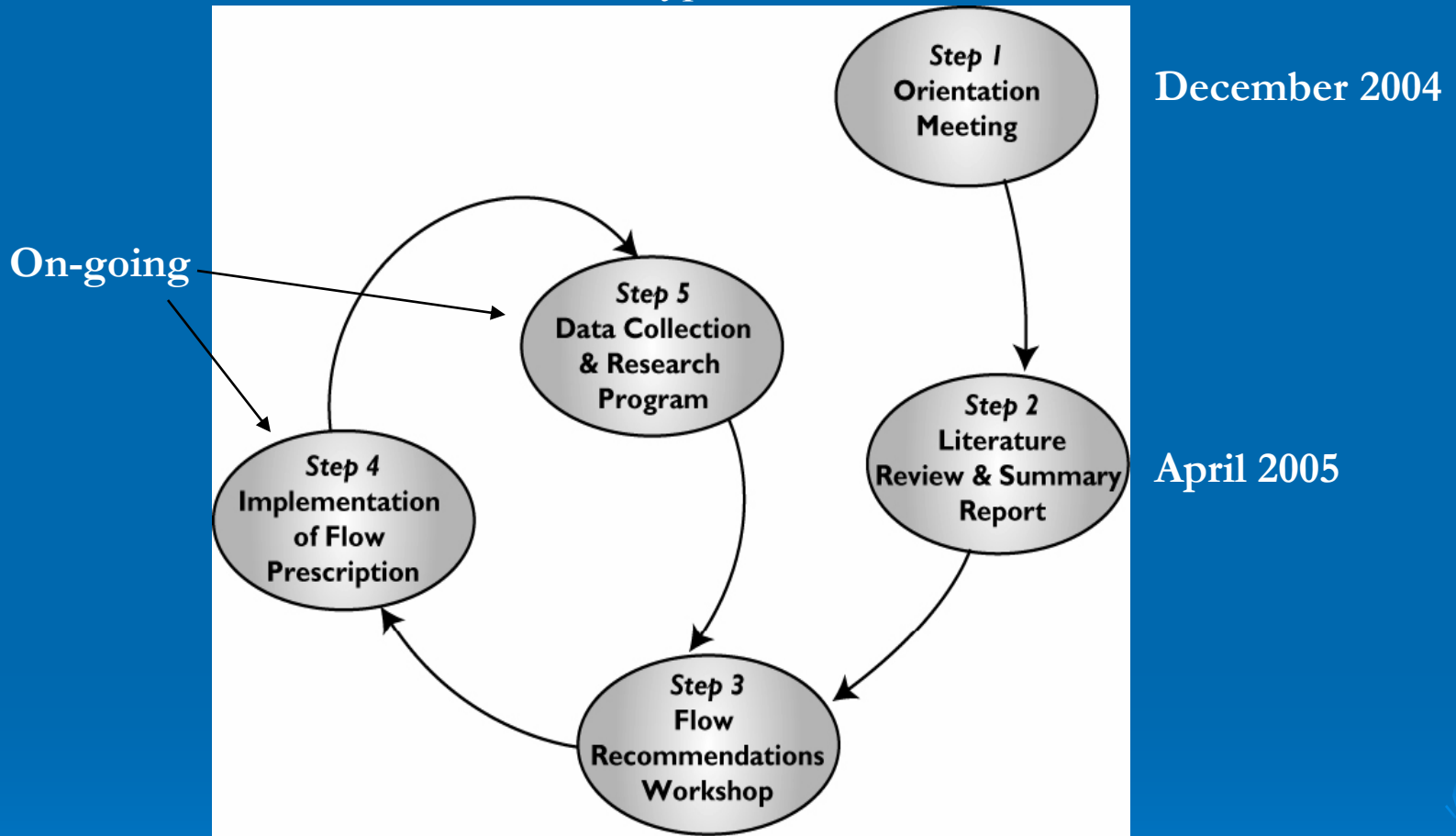
“Integrate environmentally sustainable concepts into the planning, operation, and construction of Corps. of Engineers project”.

-Lt. General Flowers, USACE

“A focal challenge in the partnership is finding ways to manage floods so that key ecological processes, such as fish spawning and forest regeneration, can persist, while human settlements are protected..”



# TNC's Adaptive Management Approach to Implementation Process for the Cypress Basin

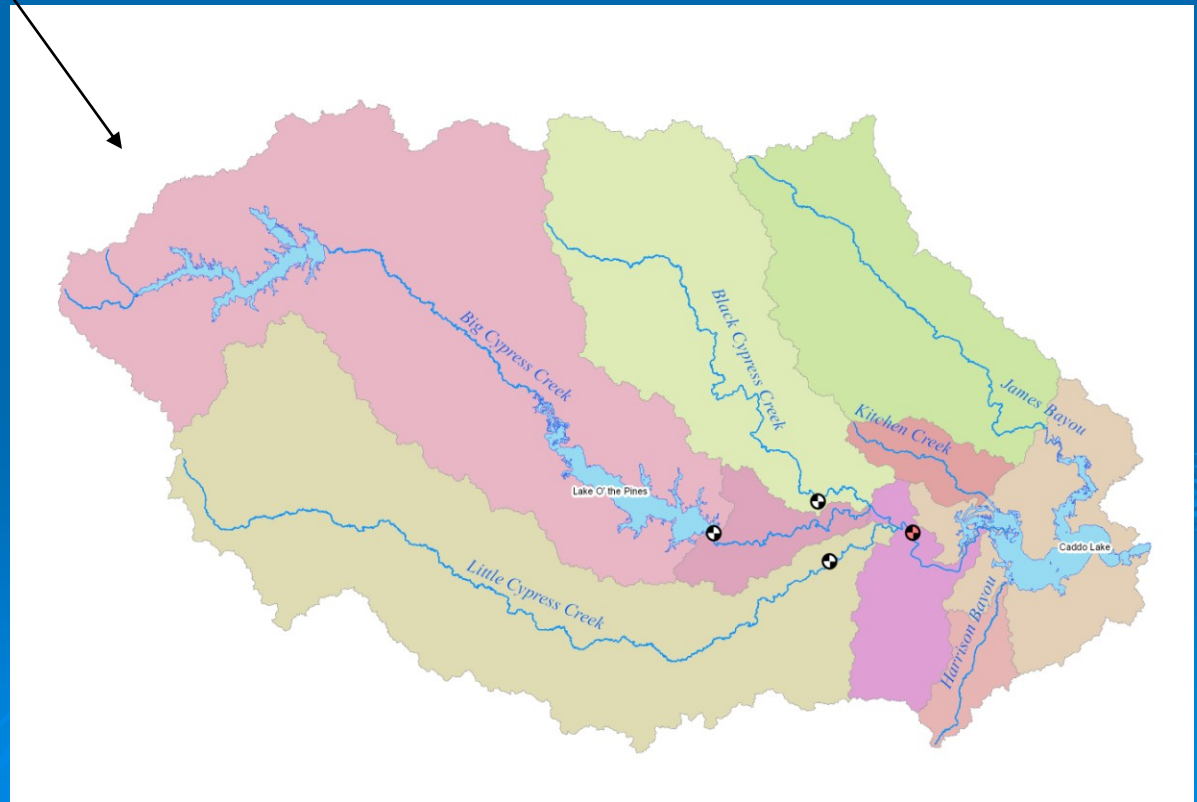
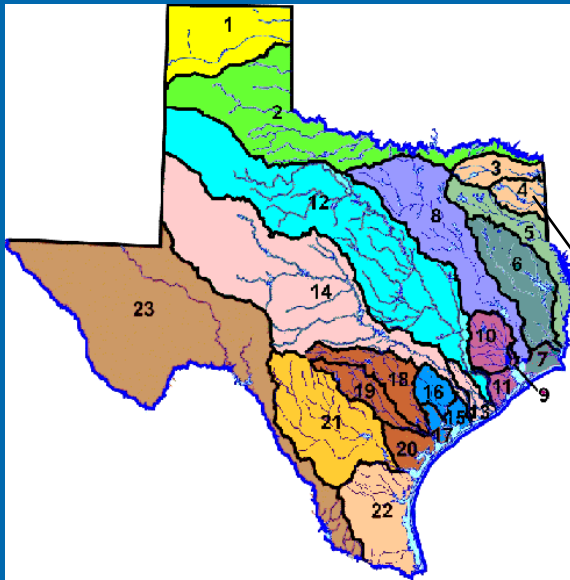


May 2005 & October 2006  
and planned for Dec 2008

# Cypress Watershed

## Big Cypress Creek

- 887 mi<sup>2</sup>
- More agricultural and urban development than in adjacent Black Cypress Bayou or Little Cypress Creek
- Two reservoirs



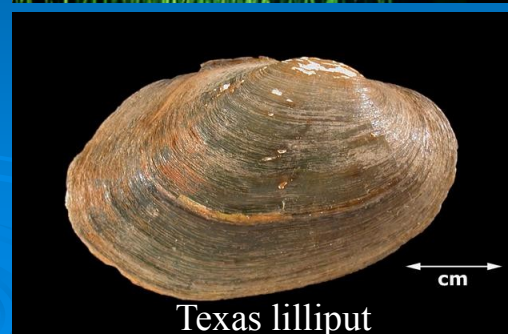
# Ecological Setting of Big Cypress Creek



- South Central Plains Ecoregion
- Tertiary uplands to the W grading to floodplains and low terraces to the E.
- Perched wetlands dominated by bald cypress and tupelo.
- Black-water streams dominated by cypress “knees” and snags.

-80 species of fish documented.  
-Paddlefish and bluehead shiner listed as “threatened” by State of Texas.

-26 species of FW mussels.  
-2 mussel species listed as “critically imperiled” by the State of Texas.



# USGS Efforts on Big Cypress Creek

## ➤ Overall goals

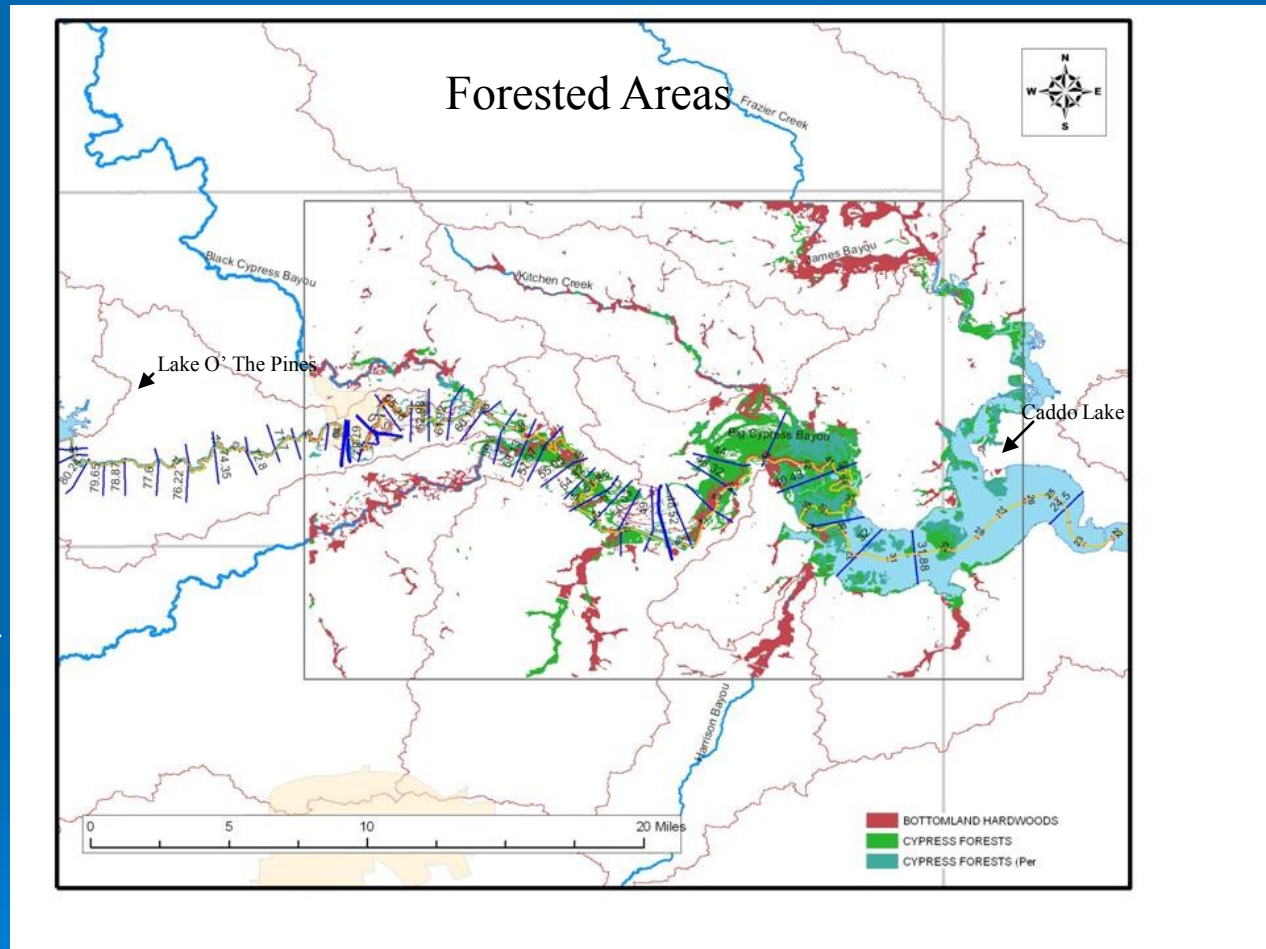
- Evaluate the accuracy and refine as needed selected flow “prescriptions” adopted during the May 2005 Flows Workshop in Jefferson, Texas
- Complete baseline surveys of the fish assemblage and the freshwater mussel community at selected sites.
- Assess current channel morphology, sediment, and aquatic habitat features.



Big Cypress Creek near Jefferson, Texas

# What are the flow-related ecological concerns for Big Cypress Creek?

- Encroachment by upland vegetation into wetlands.
- Sediment and nutrient transport to backwater habitat.
- Use of backwater habitat by fishes during higher flows.
- Spring pulses for spawning by paddlefish and other fishes.
- Loss of native fishes and freshwater mussels because of regulated flows.



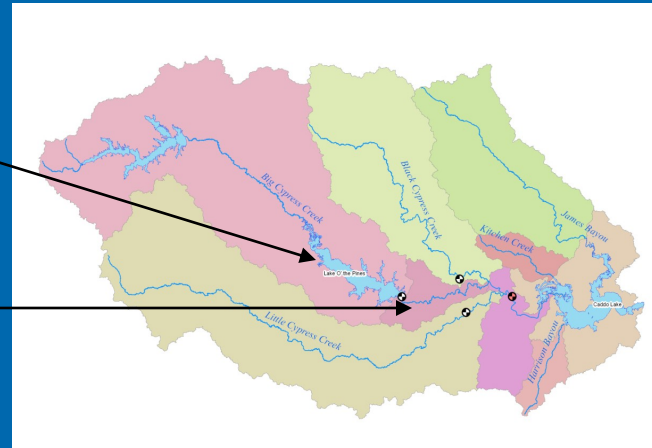


# Steps in Re-Constructing a Natural Flow Regime

1. Evaluate if sufficient flow record ( $\geq 50$  years) exists at one or more relevant locations!

Lake O' The Pines  
completed in 1959

Suitable gauging station  
1927-current



2. Use Index of Hydrologic Alteration (IHA) software to evaluate flow record and basis for development of flow prescriptions.

<http://www.nature.org/initiatives/freshwater/conservationtools/>

- Calculates timing and maximum flow of each year's floods and low flows.
- Summary statistics of floods, high flow pulses, and low flows over period of interest.
- Analysis of how flow patterns have changed after regulation.
- Use to derive flow "building blocks" and associated "flow prescriptions" for ecological services.

National Hydrologic Assessment Tool (NATHAT): **Another tool!**

<http://www.fort.usgs.gov/Products/Software/NATHAT/>

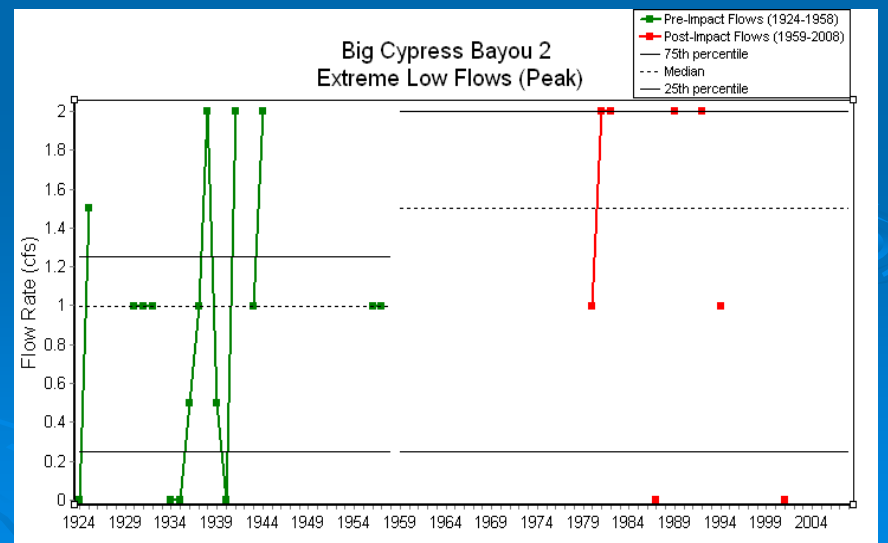
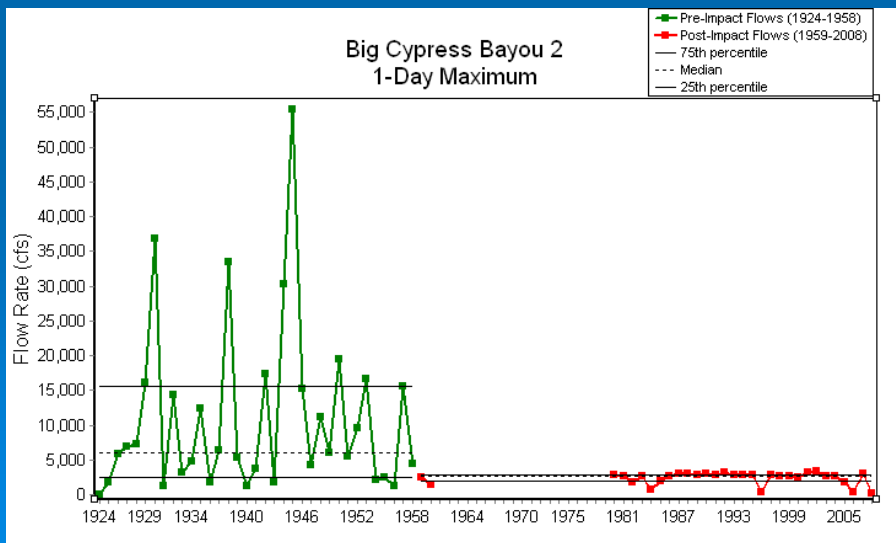
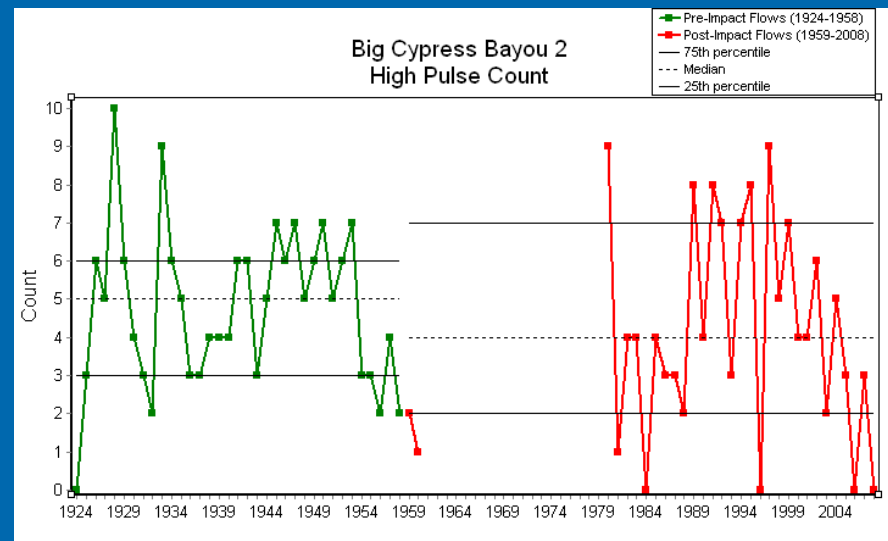
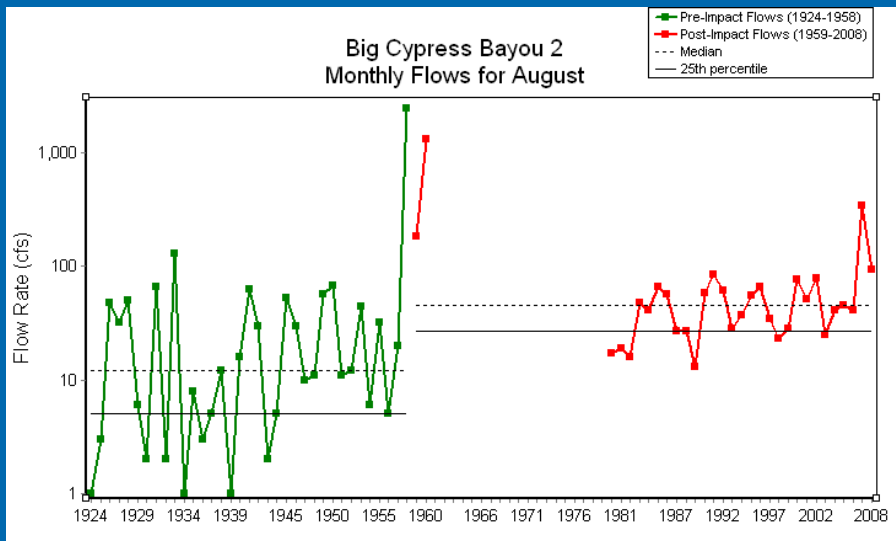
# IHA Table : Monthly Flow (cfs) Percentiles Pre-Dam and Post-Dam

	Pre-Dam			Post-Dam		
	25%	50%	75%	25%	50%	75%
Parameter Group #1						
October	4.5	23.5	53	26	49	135.3
November	24	74	180.9	40.25	96	319.9
December	98.25	238	649.3	49.25	363.5	755.5
January	261	572	1303	46.25	465	1713
February	378.1	628.5	1284	372.3	912	1984
March	519	884	1410	314.8	693	1855
April	462.8	733	1259	141.9	310.3	1604
May	305.5	715	1518	48	121.5	1260
June	52.88	152.3	452	50.38	119.8	1318
July	14.5	49.5	118	30.75	65.5	170.3
August	3	11.5	48.5	27	43	66
September	3	13	37.25	30.88	40.25	69.13

# IHA Table : Frequency, Magnitude, and Duration of Selected Flows (Pre- and Post-Dam)

	Pre-Dam			Post-Dam		
	25%	50%	75%	25%	50%	75%
Parameter Group #4						
Low pulse count	2	3	4	1.75	2.5	4
Low pulse duration	5.5	14	25	5.5	9	16
High pulse count	4	5	6.25	2	4	7
High pulse duration	8.5	13	18.5	9.875	15.25	21.25
Extreme low peak	0	0.5	1	0	0.5	1
Large flood peak	33500	36800	55400			
Large flood duration	21	30	80			
Large flood timing	26	92	141			
Large flood freq.	0	0	0	0	0	0
Large flood rise rate	1272	2603	8275			
Large flood fall rate	-2149	-1832	-1451			

# IHA Graphic Output: Selected graphs of pre-dam and post-dam flows



# Flow Building Blocks and Flow Prescriptions for Big Cypress Creek

## Floods

6,000-10,000 cfs for 2-3 days  
 Every 3-5 years  
 \*Maintain aquatic habitat in floodplain  
 \* Riparian seed dispersal  
 \* Inhibition of upland vegetation for both creek & lake  
 \*Seed dispersal  
 \* Vegetation removal  
20,000 cfs for 2-3 days  
 Every 10 years  
 \*For channel migration

## High Flow Pulses

6,000 cfs for 2-3 days  
 Every 2 years  
 \* For channel maintenance

1,500 cfs for 2-3 days  
 3-5X a year every year  
 \* 1 occurring in March for Paddlefish  
 \* Sediment transport, oxbow connectivity  
 •Waterfowl habitat flushing  
 (Includes December)

Targeted flows largely based on pre-dam IHA output

IHA output, previous studies, and best professional judgement.

## Low Flows

40 – 536 cfs  
 Maintain biodiversity and connectivity (backwater & oxbows)

268-347 cfs  
 Pre-dam median

390 - 79 cfs  
 Benthic drift & dispersal, fish spawning

35 - 40 cfs  
 Fish habitat

40 - 117 cfs  
 Pre-dam median

90 cfs  
 Fish habitat

218 – 49 cfs  
 Spawning habitat

13 - 6 cfs  
 Maintain aquatic diversity

40 - 90 cfs  
 Fish habitat

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

**Key**

- Wet Year
- Avg Year
- Dry Year

# Evaluating Selected Flow Prescriptions

## Instream Flow Building Blocks Big Cypress Creek/ Caddo Lake

Floods

20,000 cfs for 2-3 days  
Every 10 years  
\*For channel migration

6,000-10,000 cfs for 2-3 days  
Every 3-5 years  
\*Maintain aquatic habitat in floodplain  
\* Riparian seed dispersal  
\* Inhibition of upland vegetation for both creek & lake  
\*Seed dispersal  
\* Vegetation removal

High Flow Pulses

6,000 cfs for 2-3 days  
Every 2 years  
\*For channel maintenance and floodplain connectivity

1,500 cfs for 2-3 days  
3-5X a year every year  
\* 1 occurring in March for Paddlefish  
\* Sediment transport, oxbow connectivity  
•Waterfowl habitat flushing (Includes December)

3000 cfs limit on release from Lake O' The Pines

Low Flows

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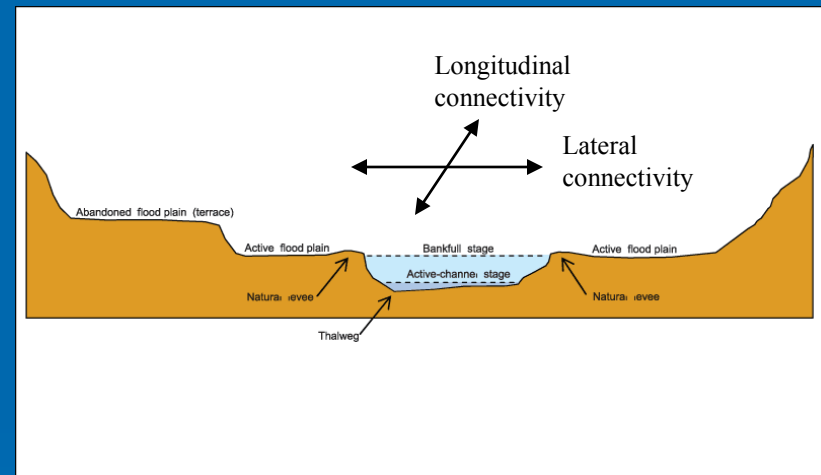
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**Key**

- Wet Year
- Avg Year
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# Evaluation of Flow Prescriptions With an Emphasis on Connectivity!

- How accurate are the flow prescriptions for lateral and longitudinal connectivity?
  - Lateral connection to over-bank and below bankfull backwaters habitats.
  - Longitudinal connects of mesohabitats (e.g., riffles, runs, and pools and important structural components for biota)



- Should the flow prescriptions be prescribed differently depending on location in the receiving waters of interest?





# Tools in the Field



Pressure transducer installed at each site for continuous monitoring of stage and water temperature

- Base of transducer sensor surveyed in to benchmark of known datum.
- Continuous (hourly beginning in March 06 to August 07) recording of stage and water temperature.
- Transducer data downloaded and units calibrated every 3-4 weeks.

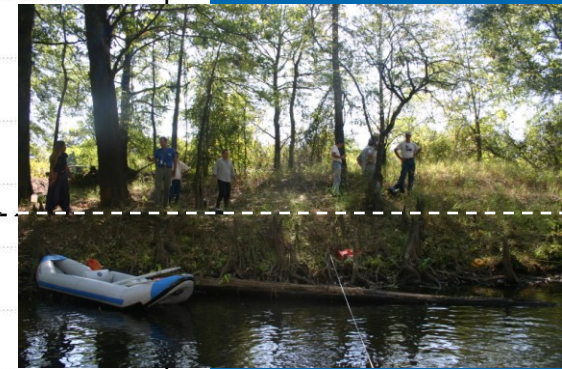
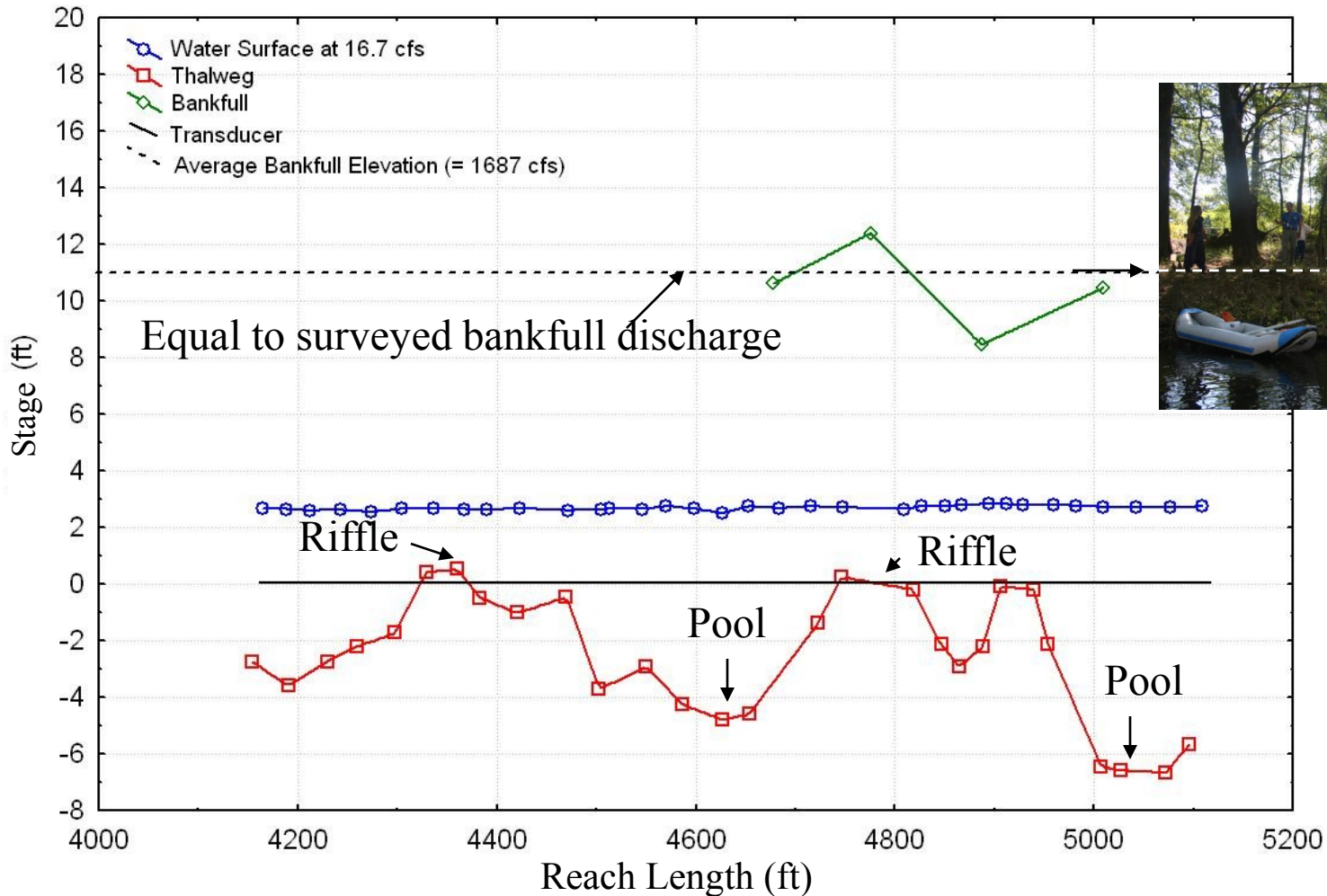


Surveyed channel features into pressure transducer and temporary Benchmark.

# USGS Field Studies: Evaluating the Flow Prescriptions

Bankfull discharge ( $\bar{X} = 1687$  cfs) in upstream reach is much less than “every 2 years” discharge (6,000 cfs) prescription from Building Blocks

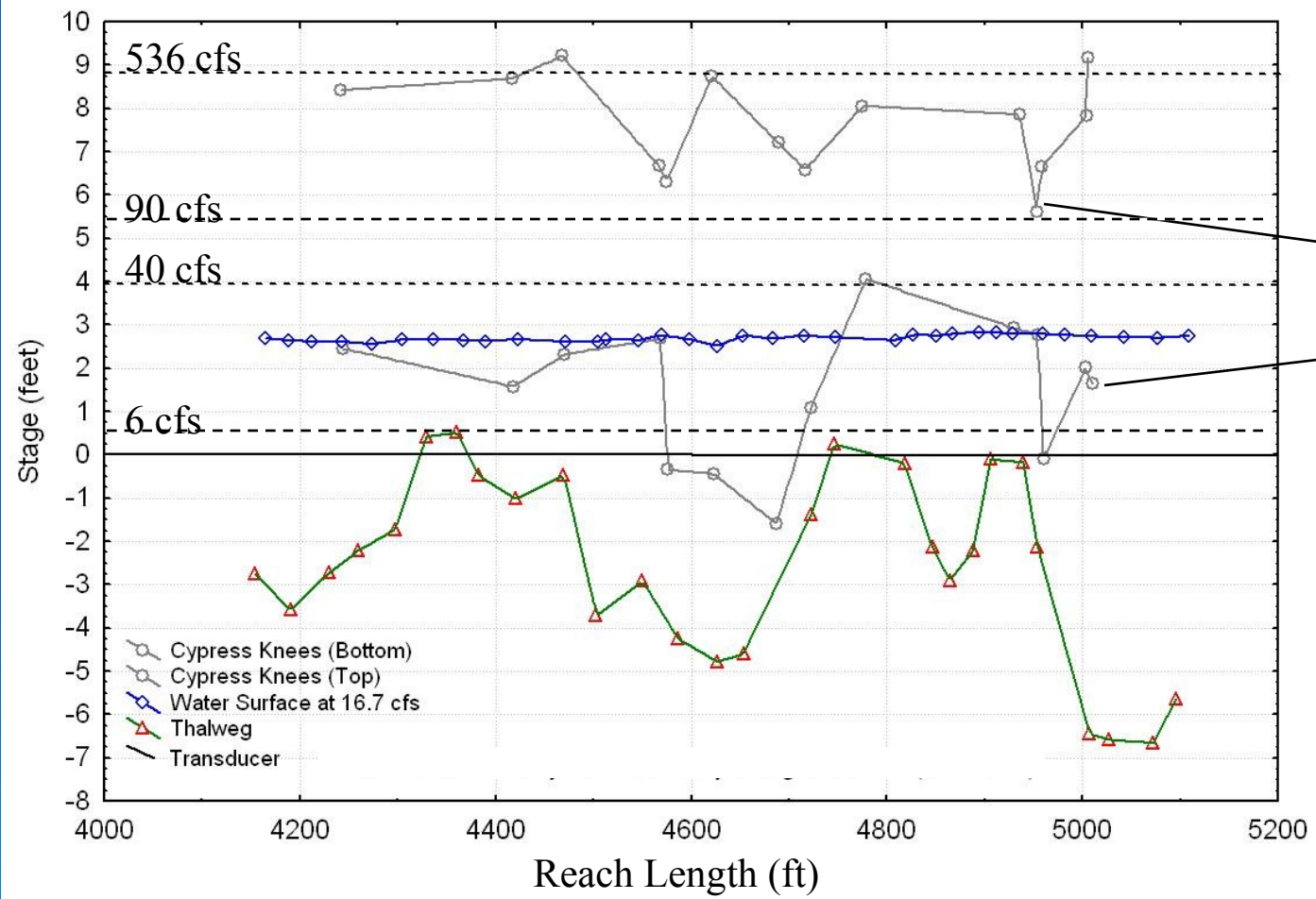
Big Cypress Creek at Thomas Camp (BC03)  
Estimated Bankfull Discharge



# USGS Field Studies: Evaluating the Flow Prescriptions, cont.

Good agreement between surveyed channel features and the flow prescriptions chosen to maintain longitudinal **connectivity** from dry (6 - 90 cfs) through wet year (40 – 536 cfs)

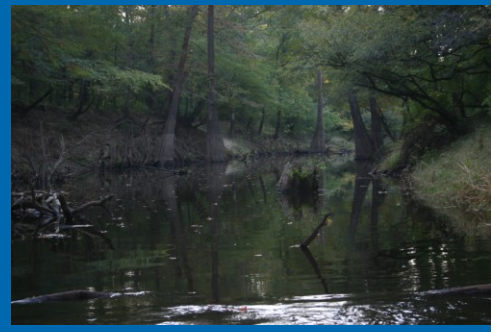
Big Cypress Creek at Thomas Camp (BC03)  
 Maintain Biodiversity and Connectivity During a Wet Year



Cypress Knees are important structure for aquatic biota

# Should Flow Prescriptions be Adjusted for Variability in the Channel?

## Upper Reach

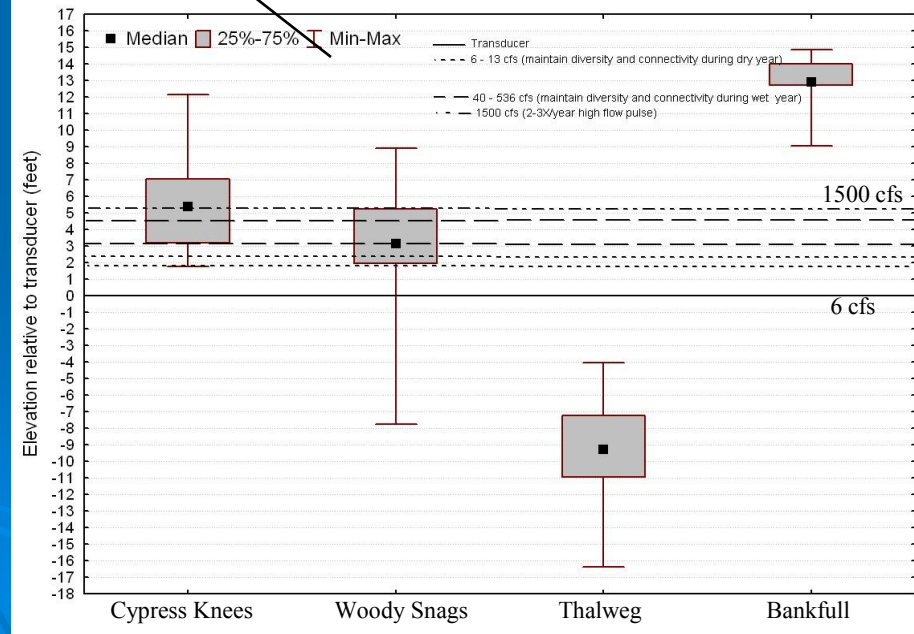
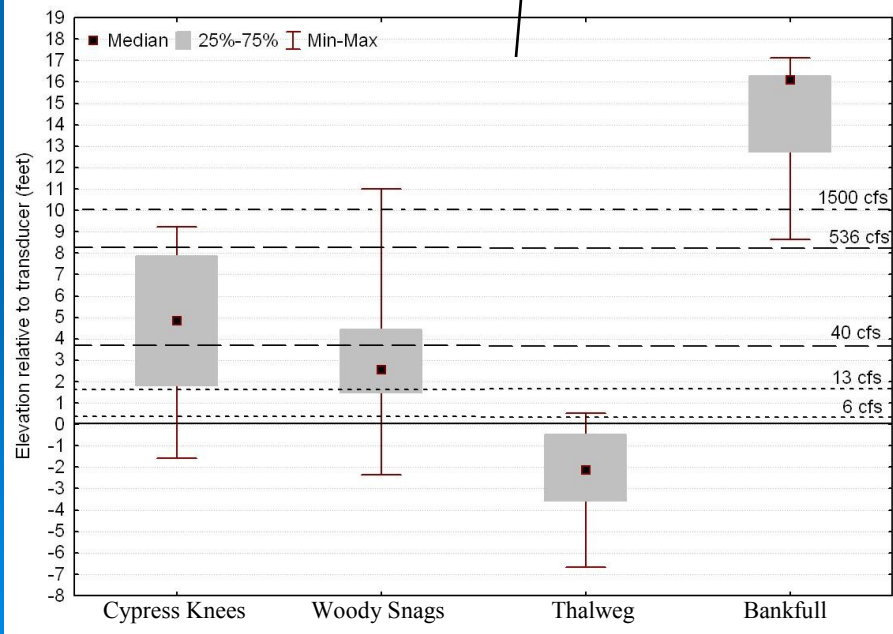
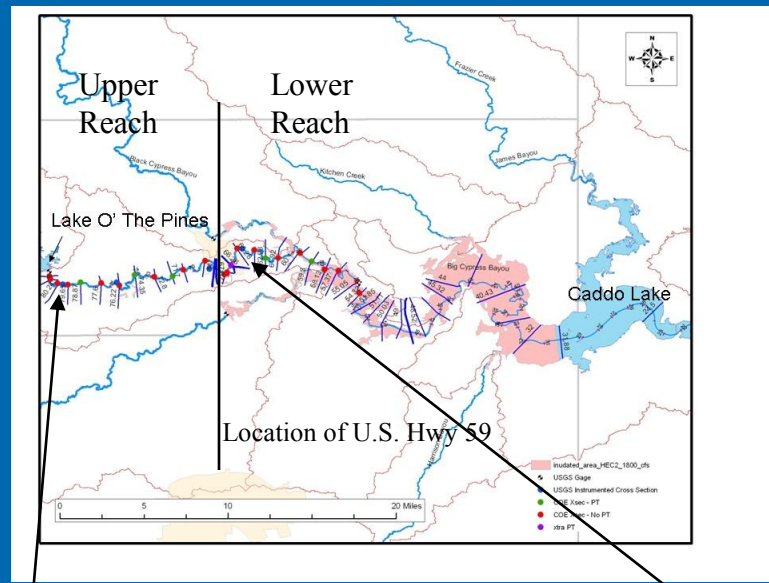


Upstream of U.S. Hwy 59

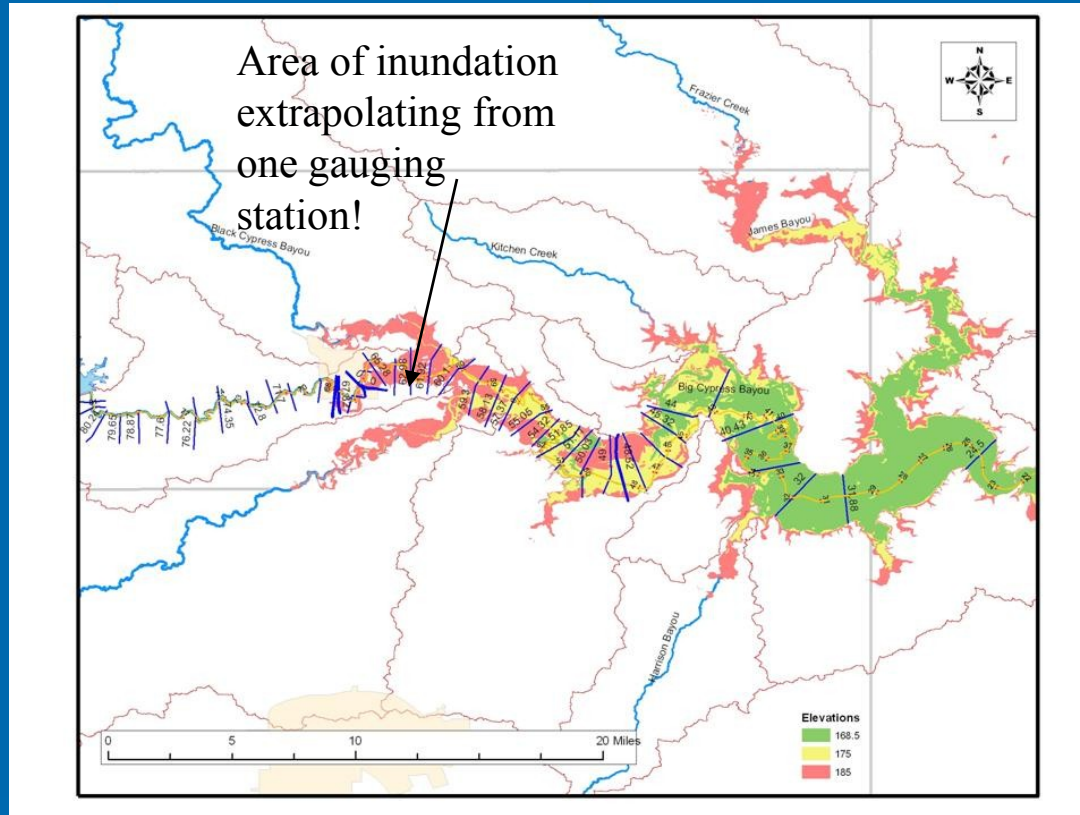
## Lower Reach



Downstream of U.S. Hwy 59



# Evaluating Area of Inundation over Range of Flows



## Refined Approach



Instrument x-sections and record stage over range of releases from Lake O' The Pines

controlled releases



RTK GPS to convert stage to actual elevations



Convert stage to elevations and use in HEC-RAS to model areas of inundation

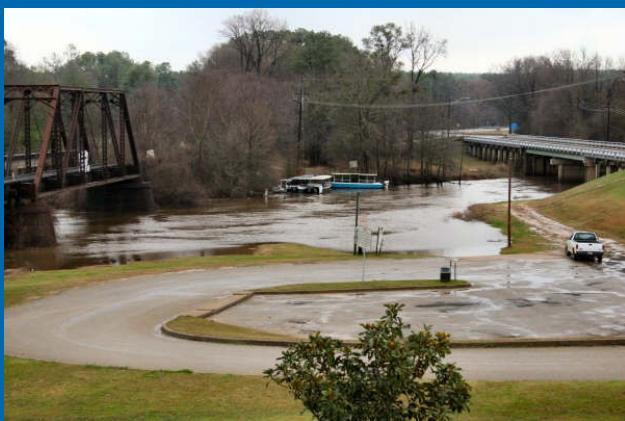


Intersect areas of inundation at varying discharge with woody vegetation.

## Controlled Releases from Lake O' the Pines to Evaluate Flow Prescriptions

### Controlled Releases in 2007

- January 2007 controlled release targeting a revised prescribed bankfull discharge for upper reach (500 – 1800 cfs)



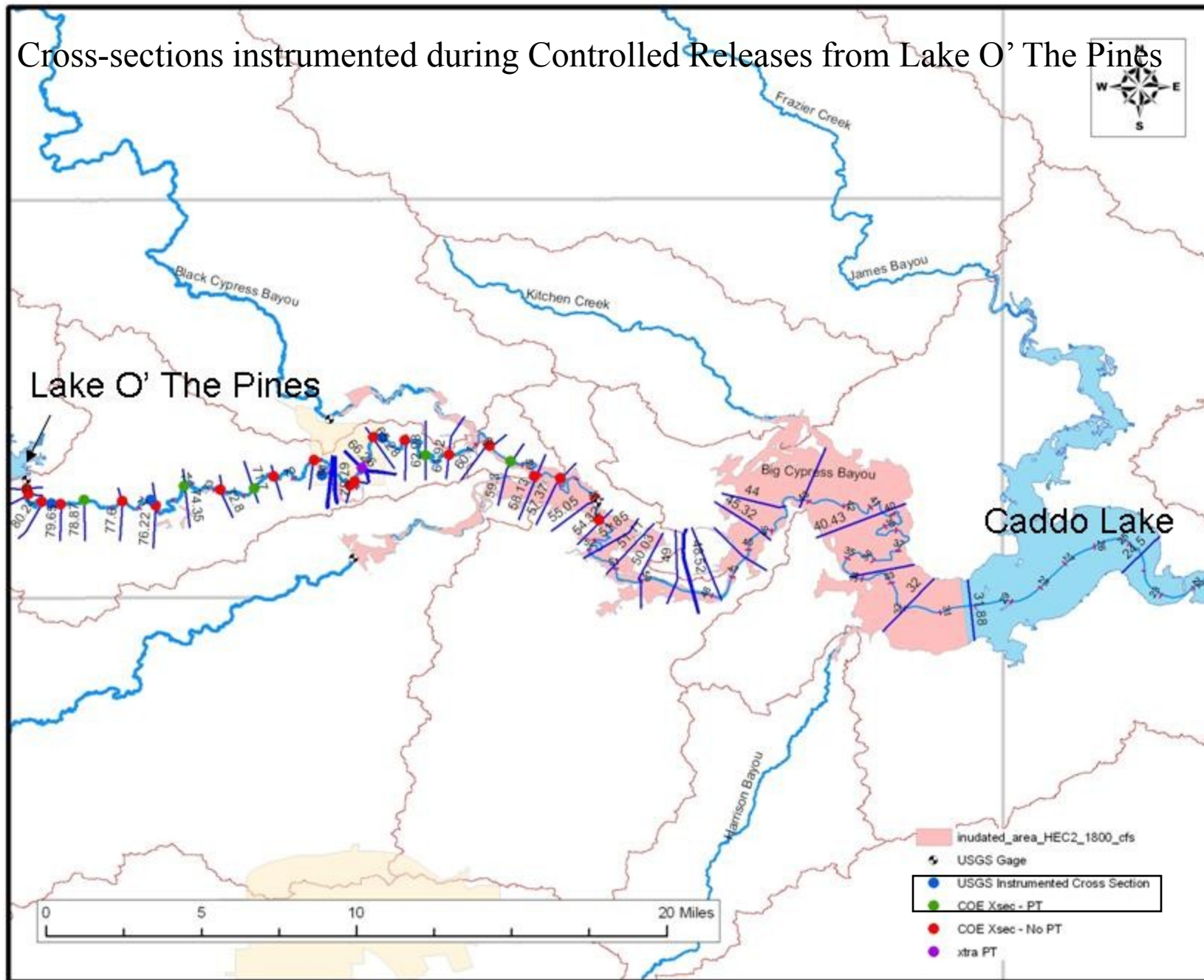
1800 cfs in Jefferson



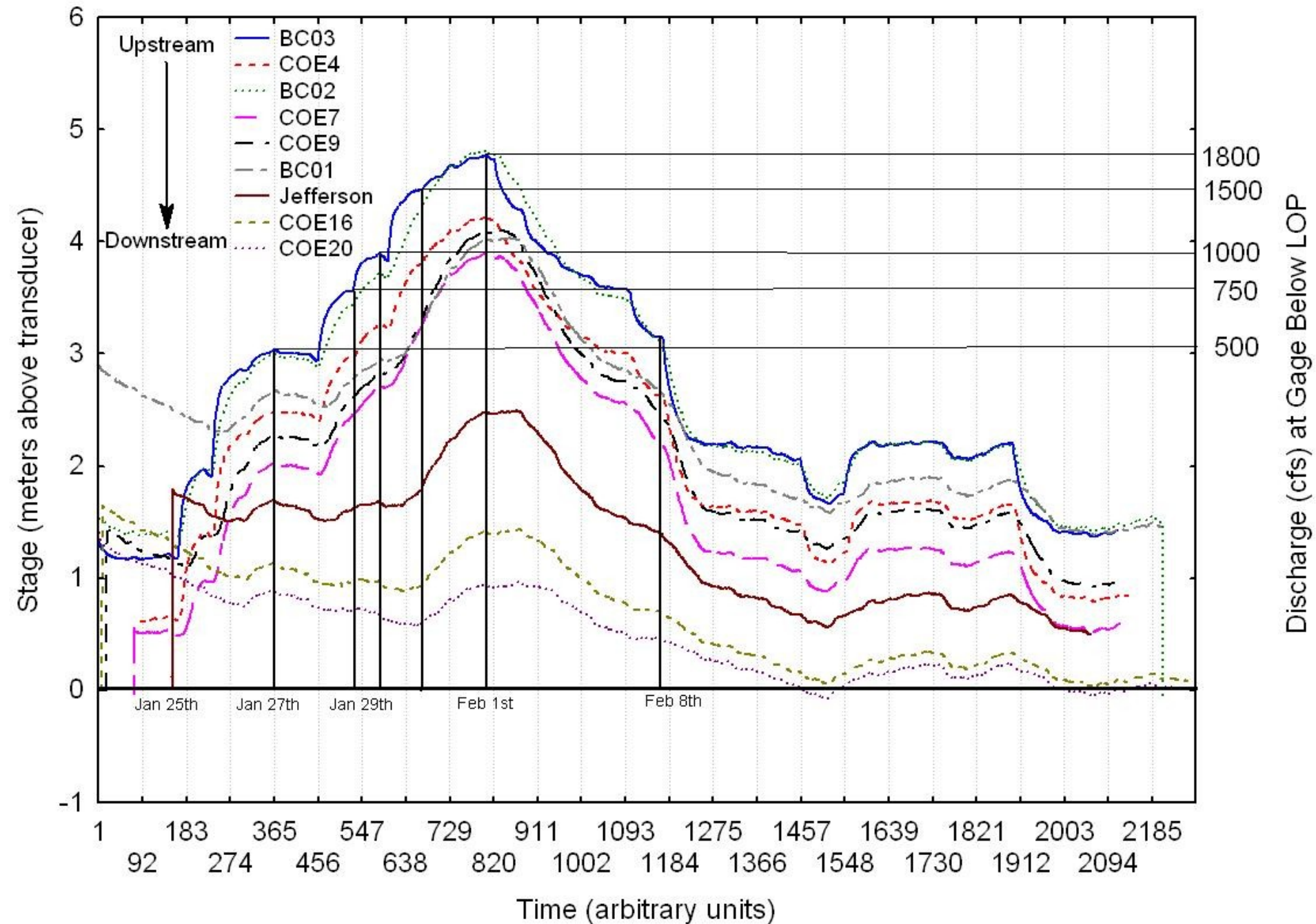
3000 cfs reaching sloughs

- August 2007 release targeting the low-flow prescriptions (500 – 30 cfs)
- July 2007 non-controlled release peaking at 3000 cfs.

# Cross-sections instrumented during Controlled Releases from Lake O' The Pines



Stage over the January 2007 Release from Lake O' The Pines for USGS and USACE Sites

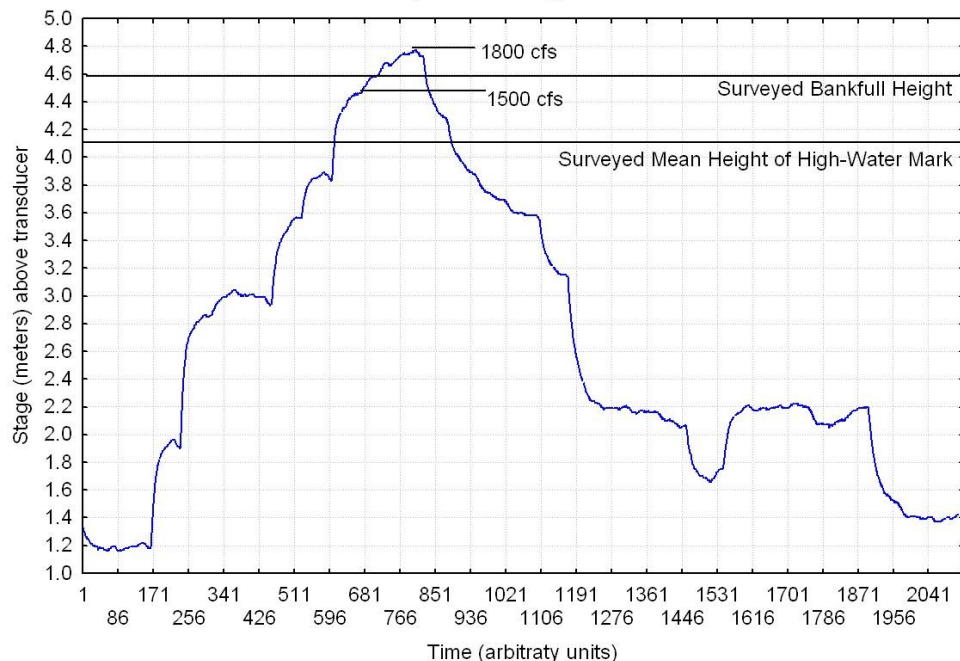




Hydrographs from one site in Upper Reach and one site in Lower Reach during Jan 2007 (500-1800 cfs) controlled release from Lake O' The Pines.

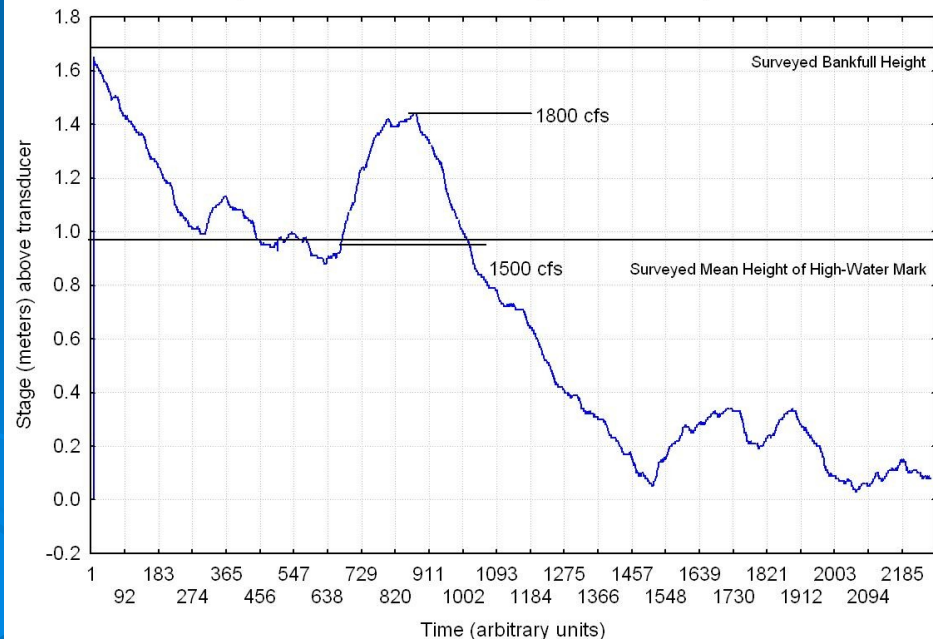
BC03 (USGS site at Thomas Camp about 3 miles below Lake O' The Pines)

Surveyed High-Water and Bankfull Heights at BC03 (Thomas Camp)

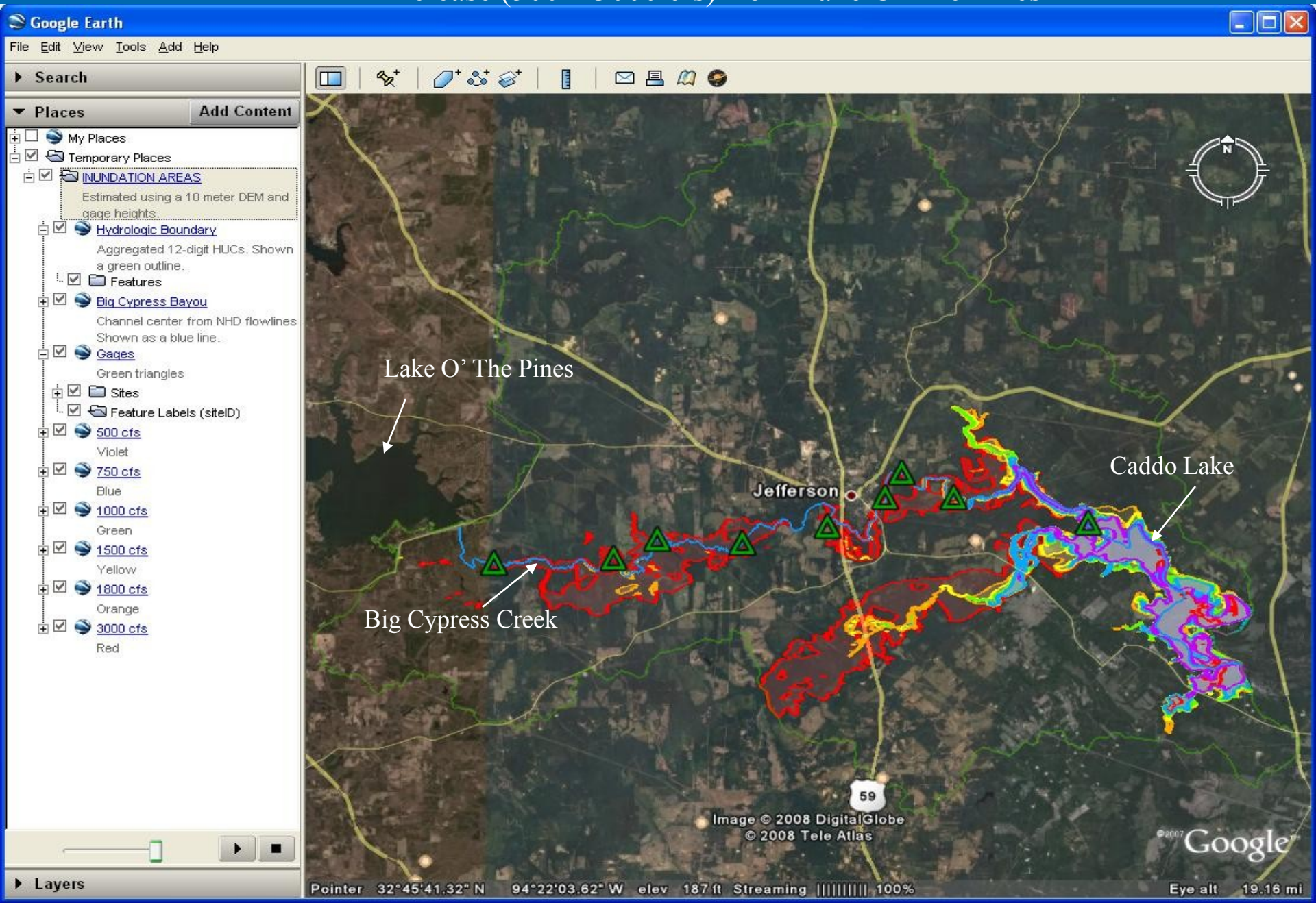


COE16 (USACE X-section below Jefferson and just above confluence of Black Cypress Bayou)

Surveyed High-Water and Bankfull Heights at COE16 (USACE X-Section above Black Cypress Confluence)



# Areas of Inundation Adjacent to Big Cypress Creek During a July 2007 Release (500 – 3000 cfs) from Lake O' The Pines



# Possible Revisions to Flow Prescriptions for Big Cypress Creek

## Floods

~~6,000-10,000 cfs for 2-3 days~~  
 Every 3-5 years  
 \*Maintain aquatic habitat in floodplain  
 \* Riparian seed dispersal  
 \* Inhibition of upland vegetation for both creek & lake  
 \*Seed dispersal  
 \* Vegetation removal  
~~20,000 cfs for 2-3 days~~  
 Every 10 years  
 \*For channel migration

← Limited by infrastructure of Lake O' The Pines Dam

## High Flow Pulses

~~6,000~~ **3000 with 1800 minimum cfs for 2-3 days**  
 Every 2 years  
 \* For channel maintenance

← 3000 cfs during wet years and 1800 cfs during average years

**1,500 with 800 minimum cfs for 2-3 days**  
 3-5X a year every year  
 \* 1 occurring in March for Paddlefish  
 \* Sediment transport, oxbow connectivity  
 •Waterfowl habitat flushing (Includes December)

← 1500 cfs during wet years and 800 cfs during average years

## Low Flows

40 – 536 cfs  
 Maintain biodiversity and connectivity (backwater & oxbows)

268-347 cfs Pre-dam median	390 - 79 cfs Benthic drift & dispersal, fish spawning	35 - 40 cfs Fish habitat	40 - 117 cfs Pre-dam median
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90 cfs Fish habitat	218 – 49 cfs Spawning habitat	13 30 – 20 6.cfs Maintain aquatic diversity	40 - 90 cfs Fish habitat
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JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

**Key**

- Wet Year
- Avg Year
- Dry Year

# Future Efforts?

- Use of MesoHABSIM or similar approach to assess connectivity of mesohabitats over range of low-flows (summer or fall 2008).
- Inventory and acquire elevations of below bankfull points of connection to backwater habitat (summer and fall 2008).



- Produce accurate inundation maps over range of discharge (500 – 3000 cfs) from Lake O' The Pines (fall 2008).
- Develop sediment to discharge ratings and evaluate bed load to better understand sediment transport over range of flows.

## Future Efforts cont. ...

### Freshwater Mussels in Big Cypress Creek

- What is the current mussel assemblage in Big Cypress Creek from Lake O' The Pines to Jefferson, and how has the assemblage changed, particularly pre- and post-dam.
- Locate a series of relatively large mussel beds along the reach of interest for long-term monitoring as flow prescriptions are implemented.
- Compare distribution and composition of mussels to host (if known) fishes present.
- Should flows be prescribed that facilitate mussel reproduction and/or substrate composition and stability.





Questions?



Questions?

# Re-Constructing Biological Reference Condition (Pre-Regulation)

- Historical trends of **fishes** and freshwater mussels.
- Paired-watershed comparison: Black Cypress Bayou



# Historical Museum Surveys

- Josh Perkin: Texas State Grad Student
- Assessing historical fish assemblage to determine relative species abundance in the Cypress Basin

## ➤ Sources:

- Smithsonian National Museum of Natural History
- Texas Natural History Collection (University of Texas)
- Tulane University Museum of Natural History
- University of Kansas Museum of Natural History
- Texas Cooperative Wildlife Collection (Texas A & M)
- Texas Game and Fish Commission
- Texas Parks & Wildlife Department
- Texas Commission for Environmental Quality
- United States Geological Survey

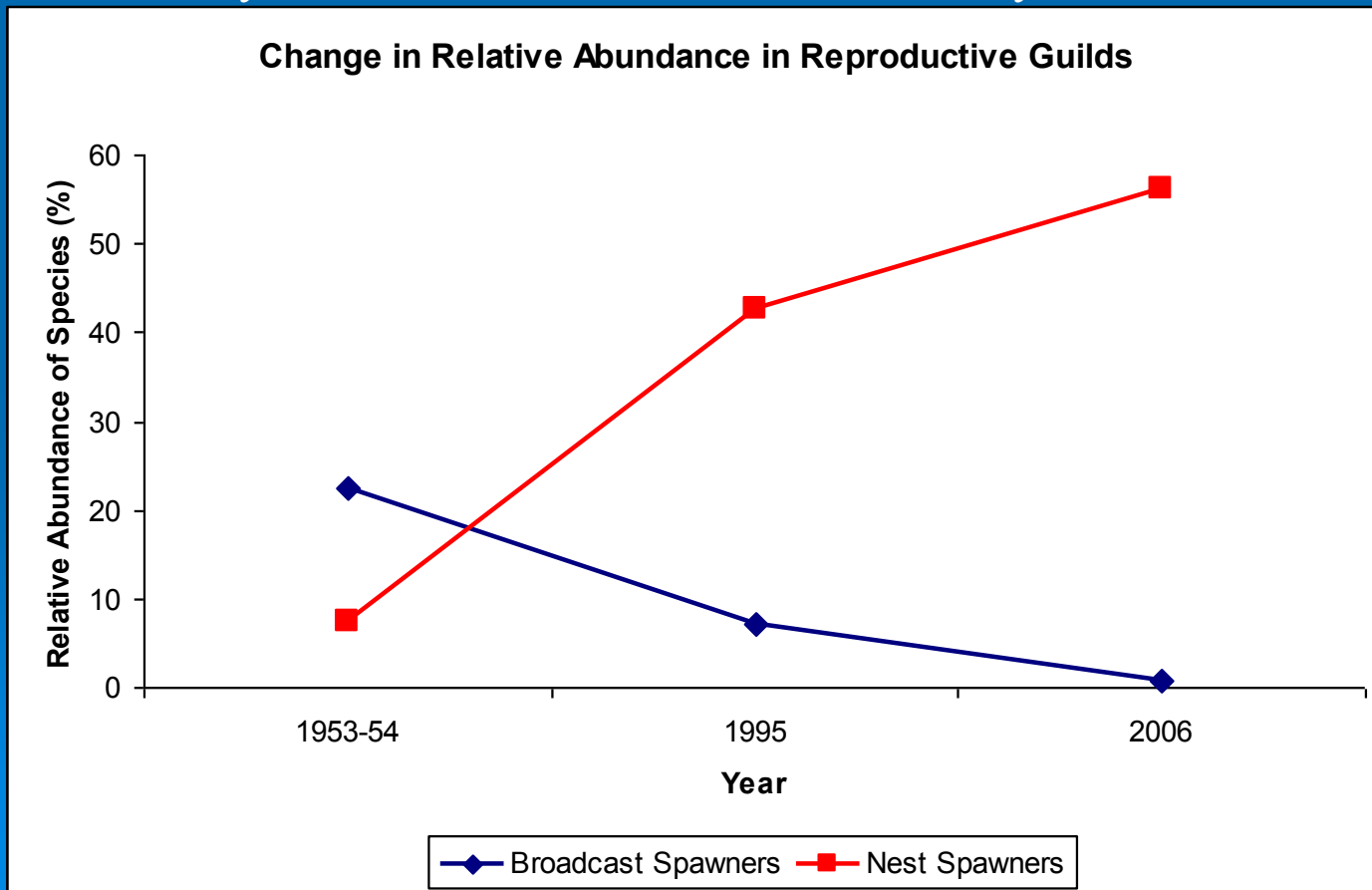


# Historical Survey Findings

➤ Nest Spawners are generally increasing

➤ Broadcast Spawners are generally decreasing

Provided by Josh Perkin with Texas State University



# USGS Field Studies: Establishing Baseline Conditions



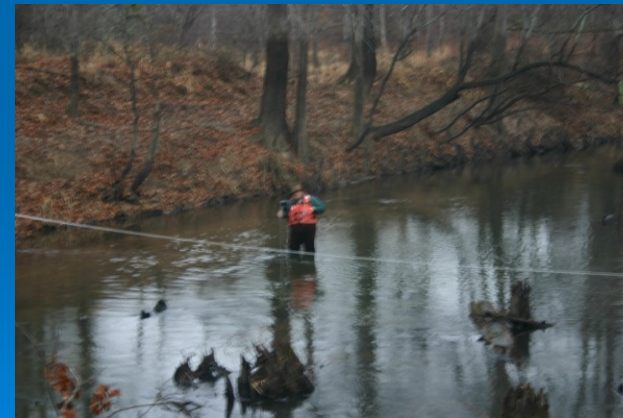
Continuous recording of stage and water temperature.



Boat electrofishing as part of fish community surveys.



Surveying of channel features



Discharge measurement to develop a stage to discharge rating

# USGS Field Studies: Fish Assemblage Surveys

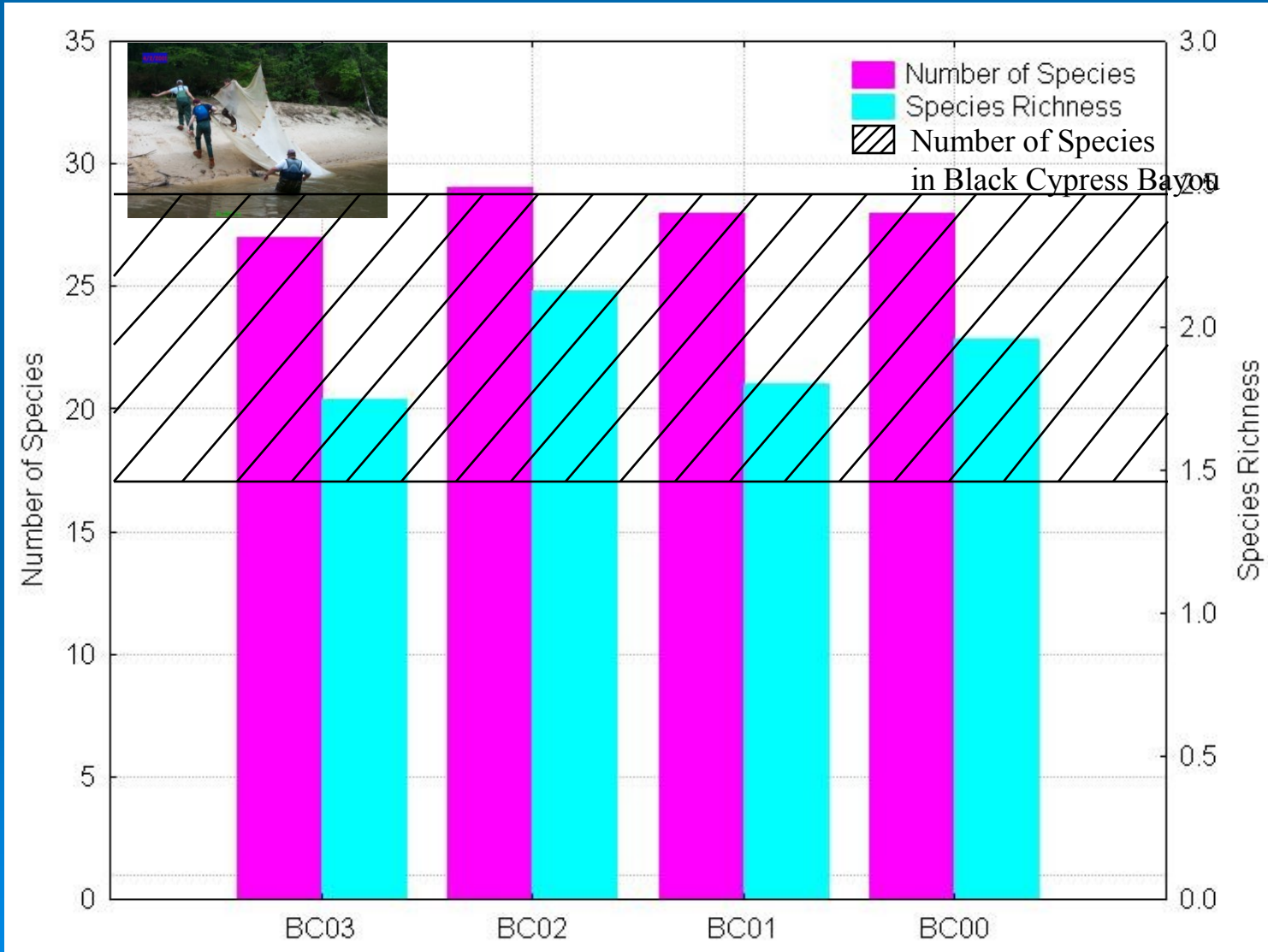
Cumulative total of 43 species collected from four sites

*Bigmouth buffalo, Blackstripe topminnow, Blacktail shiner, Bluegill, **Bluehead shiner**, Bluntnose darter, Bowfin, Brook silverside, Bullhead minnow, Chain pickerel, Channel catfish, Common carp, Dollar sunfish, Dusky darter, Fathead minnow, Flathead catfish, Freckled madtom, Freshwater drum, Gizzard shad, Golden topminnow, Grass pickerel, Green sunfish, Largemouth bass, Logperch, Longear sunfish, Pirate perch, Pugnose minnow, Redfin shiner, Red shiner, Redbreast sunfish, Redear sunfish, Scaly sand darter, Smallmouth buffalo, Spotted bass, Spotted gar, Spotted sucker, Spotted sunfish, Swamp darter, Threadfin shad, Warmouth, Weed shiner, Western mosquitofish, White crappie,*



# USGS Field Studies: Comparing Fish Assemblages

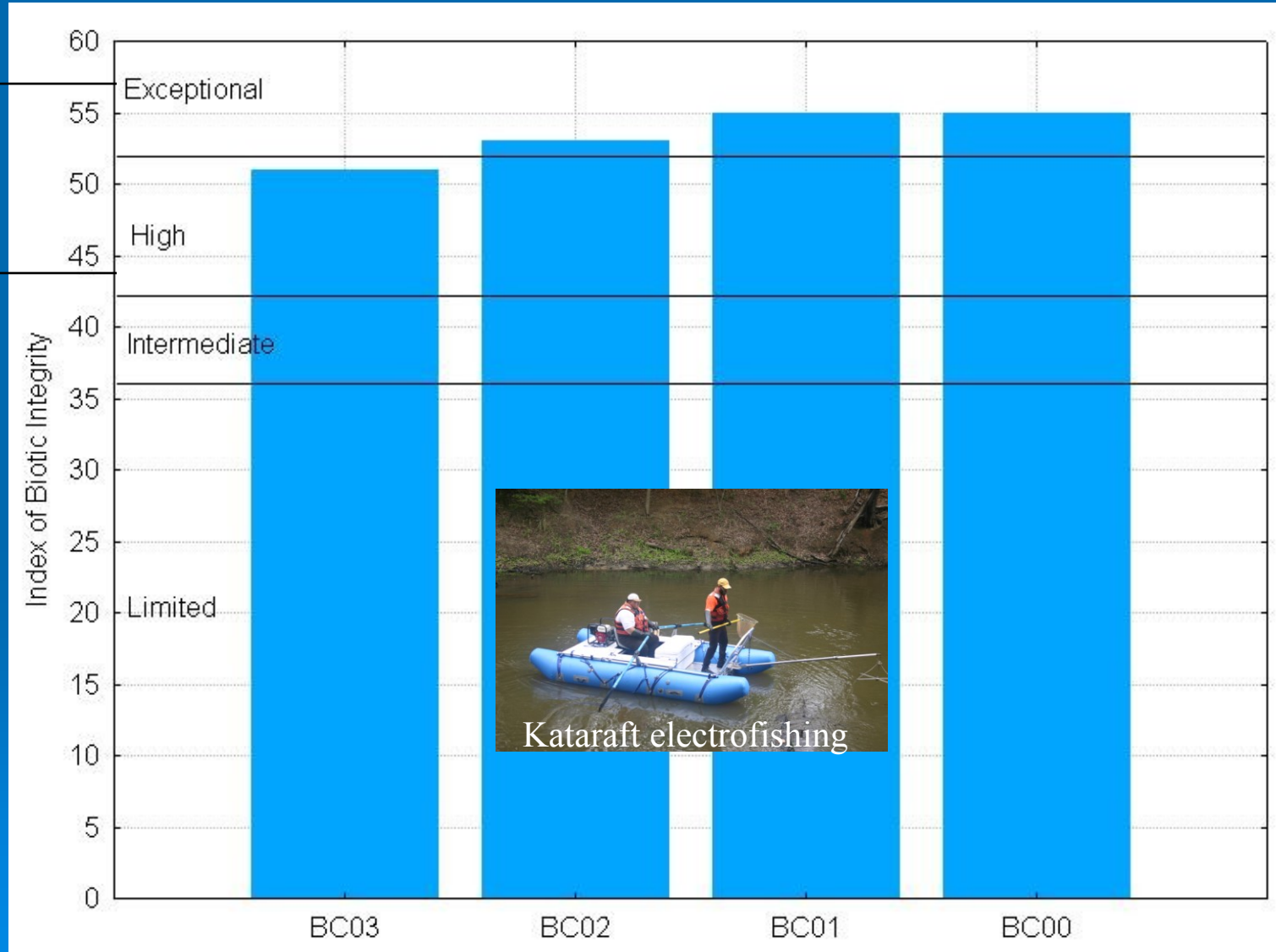
The four sites are very similar



# USGS Field Studies: Comparing Fish Assemblages

Regional Fish Index of Biotic Integrity (IBI) scores are from high to exceptional

Black Cypress  
IBI scores



# Freshwater Mussels in Big Cypress Creek

- 26 species identified since 1913 (Howells, 1996).
- Louisiana pigtoe (*Pleurobema riddellii*) is one of rarest in Texas and has been ranked as “critically imperiled” by State of Texas.
- Sandbank pocketbook (*Lampsilis satura*) listed as critically imperiled, and is thought to occur in Big Cypress watershed.
- Howells (personal comm.) reports dominance of species tolerant of soft-bottom habitats and eutrophication.



Texas lilluput

## Freshwater Mussels in Big Cypress Creek, cont. ...

- What is the current mussel assemblage in Big Cypress Creek from Lake O' The Pines to Jefferson, and how has the assemblage changed, particularly pre- and post-dam.
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