Evaluation of the Effects of Hydrologic and Geomorphic Processes and Bottomland Hardwood Plant Communities of the Lower White River Basin: An integrated approach

Sammy L. King[1], Richard Keim[2], and Cliff R. Hupp[3]

[1]Louisiana Cooperative Fish and Wildlife Research Unit, USGS, 124 School of Renewable Natural Resources, LSU

[2]School of Renewable Natural Resources, LSU Agricultural Center

[3]USGS, 430 National Center, Reston, VA

Impacts to White River

- Base-level lowering of the Mississippi River (Biedenharn and Watson 1997)
- Hydroelectric dams
- Navigational lock at its confluence with the Mississippi River
- Navigation channel along much of its course
- Irrigation pump that diverts surface water from the river

Rivers as Process-Response Systems

- Rivers are process-response systems that fluctuate around an “endpoint” of dynamic equilibrium
- Changes in sediment load, channel depth, and discharge, among other parameters, can result in rapid changes in the river and associated floodplain

Geomorphic Impacts of Dams

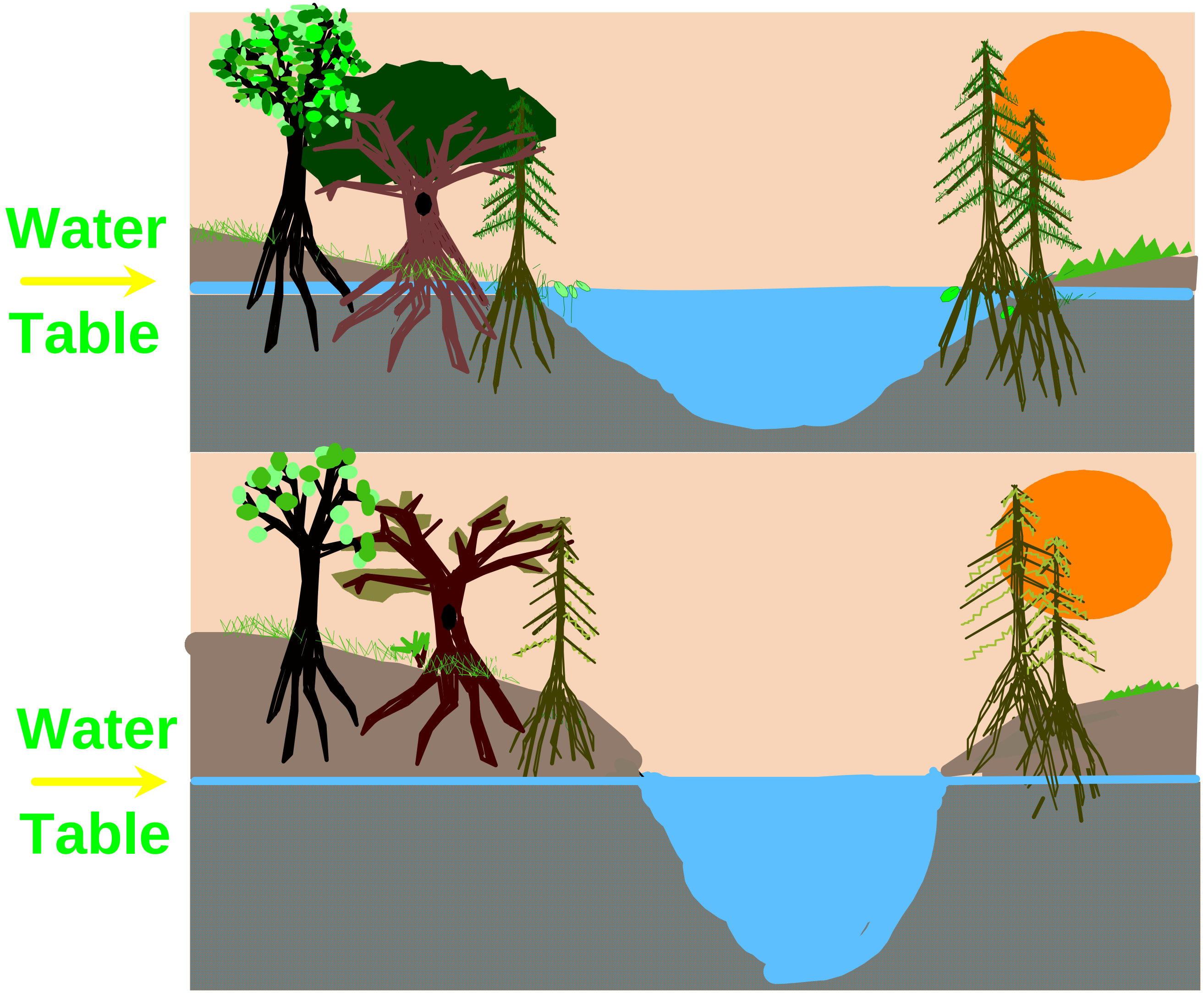
Incised Channel

Lower Floodplain

Headcutting

Photos courtesy of USFWS

Impacts of Channel Entrenchment



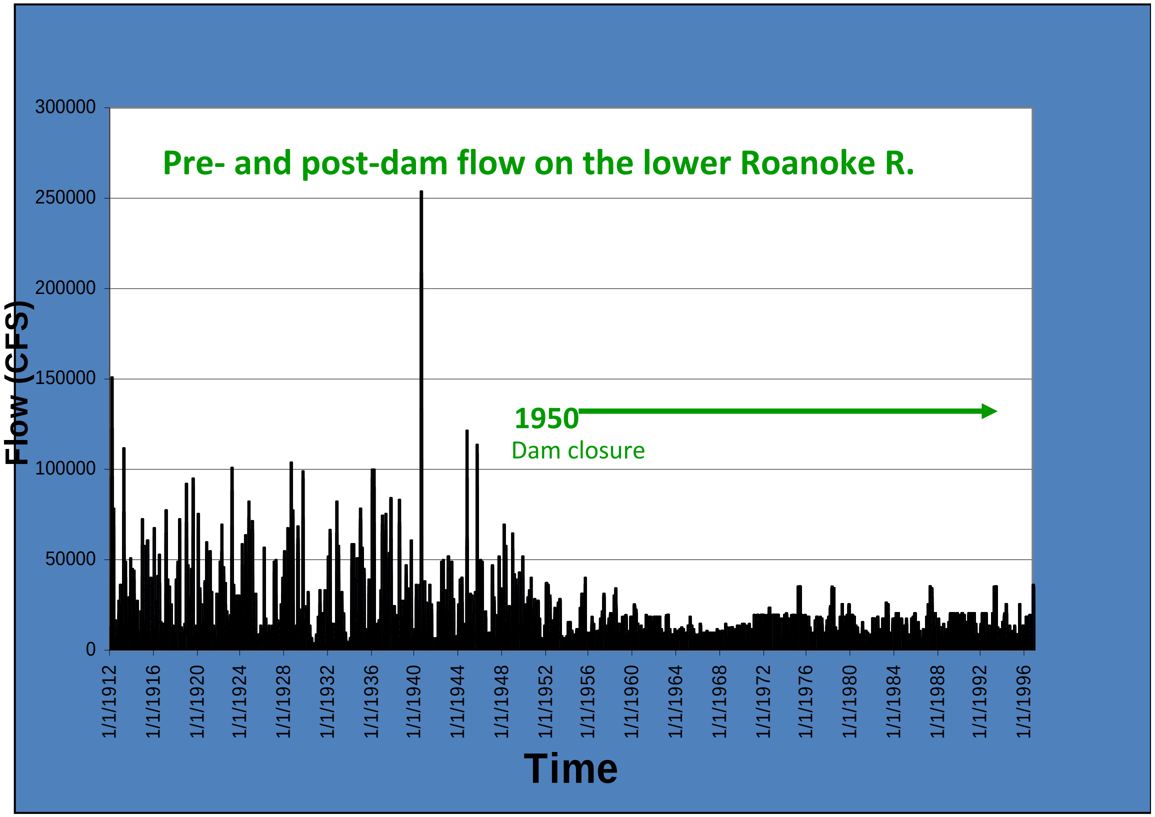
Objectives

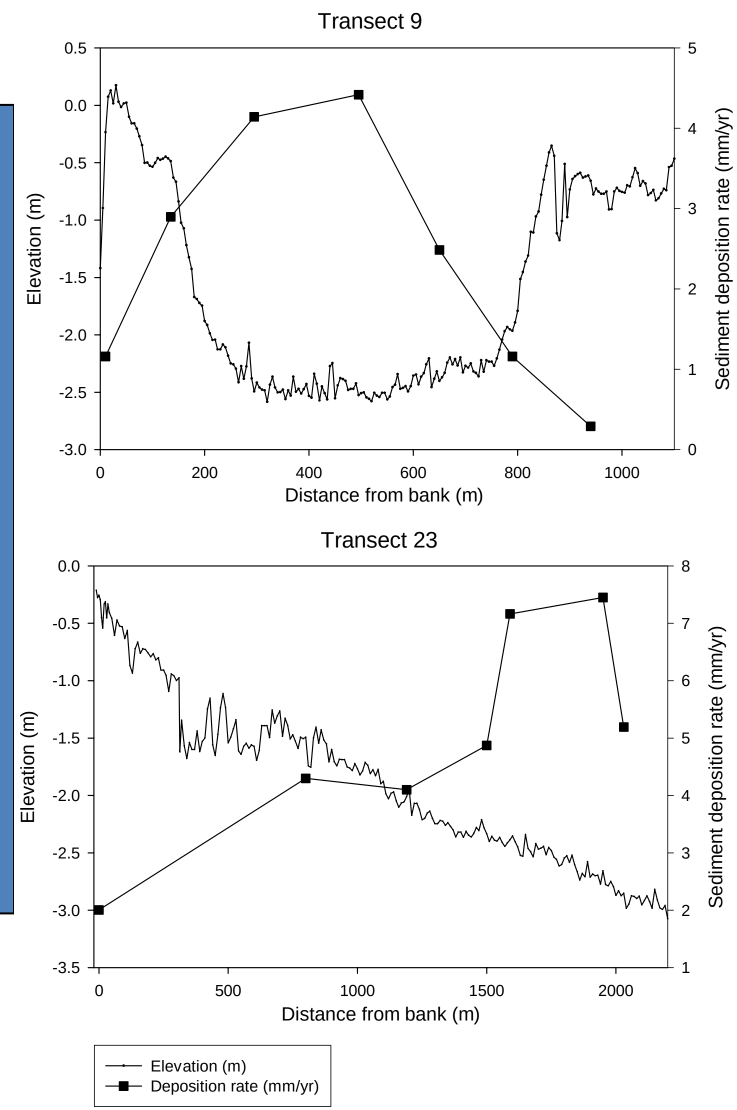
1) Conduct a rapid assessment of bank stability/failure at selected points from the mouth of the river to Newport
2) Determine annual (or more frequent) bank erosion and sedimentation rates along selected reaches of the floodplain
3) Expand the validation of the COE HEC-GeoRAS model to include the floodplain as well as the channel
4) Determine the effects of river stage (and the potential effects of entrenchment) on groundwater dynamics in different geomorphic settings
5) Develop a process-based model that will allow us to predict groundwater dynamics at specific locations within the floodplain based on reach- and site-specific characteristics, including local watershed inputs, geomorphic surfaces, soils, and riverine connectivity
6) Determine growth rates and stand establishment of bottomland hardwoods within selected plant communities /geomorphic surfaces
7) Develop an integrated, spatially-explicit, multi-scale simulation model to determine the effects of current and potential hydrologic processes on the distribution of bottomland hardwood plant communities on the floodplain of the White River

Geomorphic Study

IMPACT

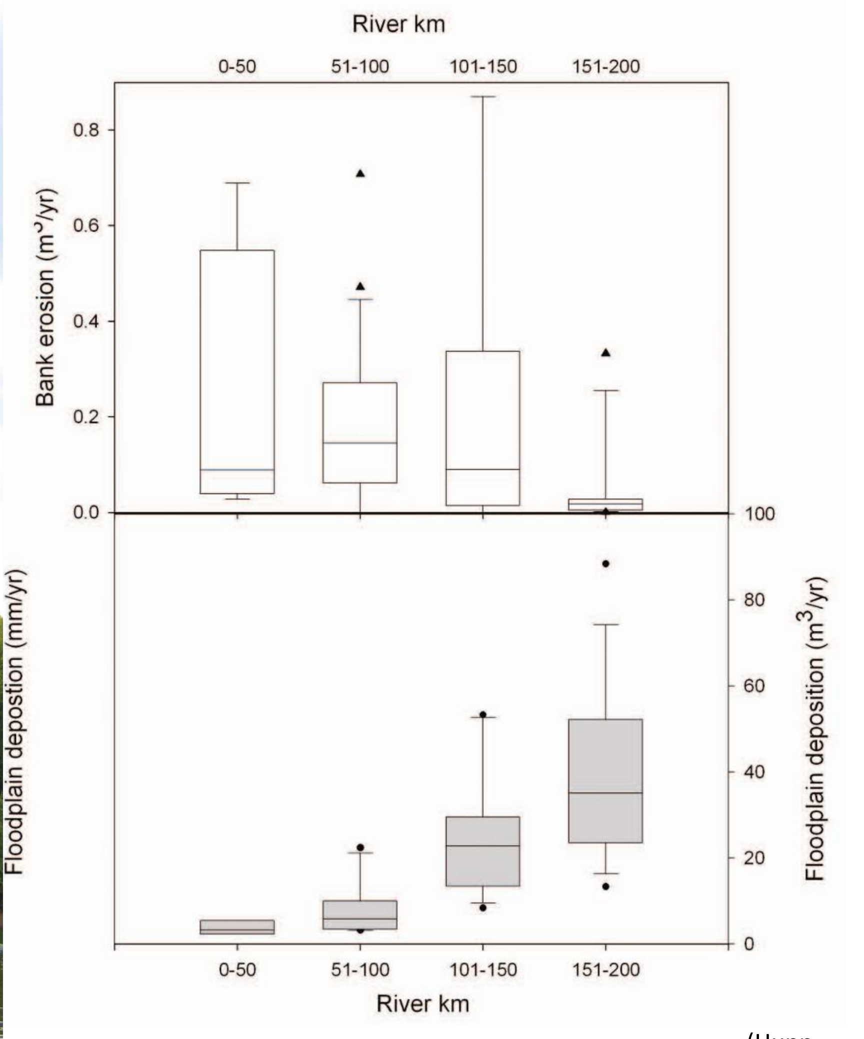
FLOW REGULATION



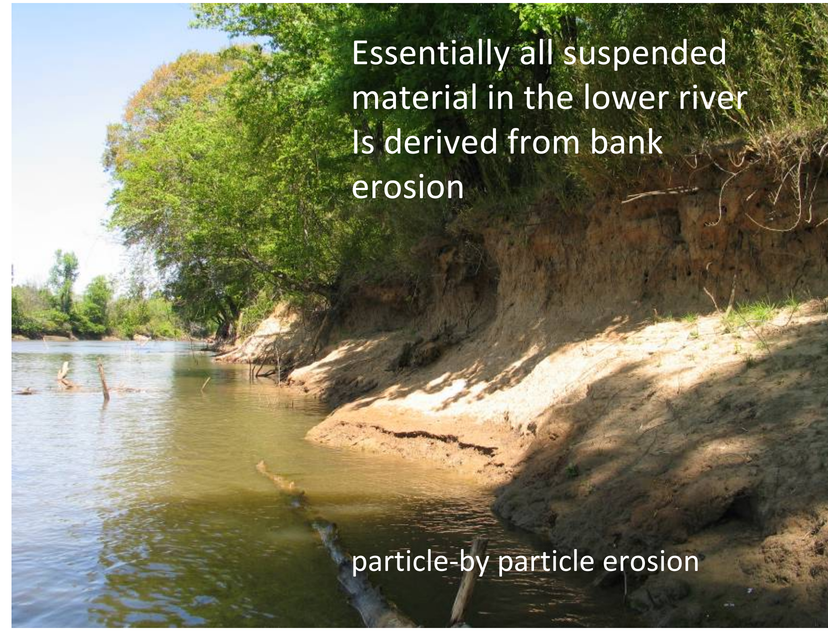


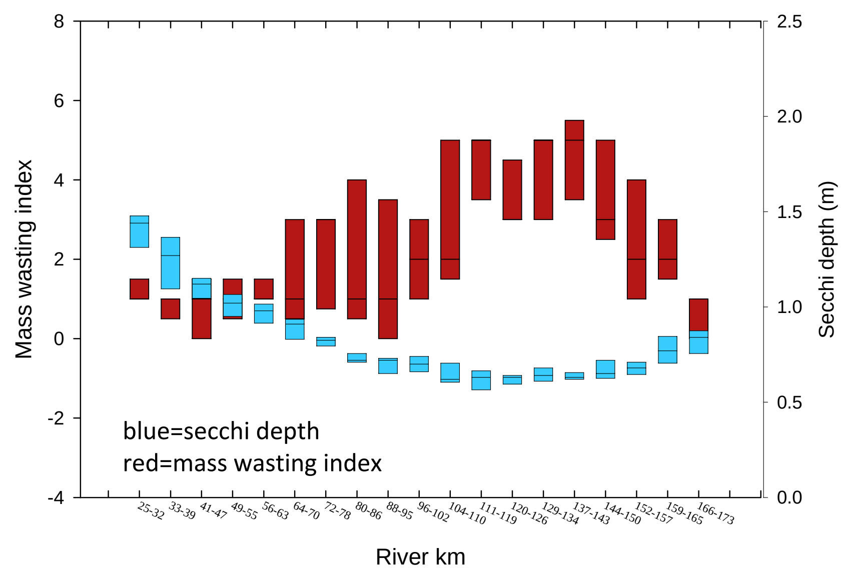
(Hupp et al. 2009)

Bank Erosion and Floodplain Sedimentation, Volume



(Hupp et al.





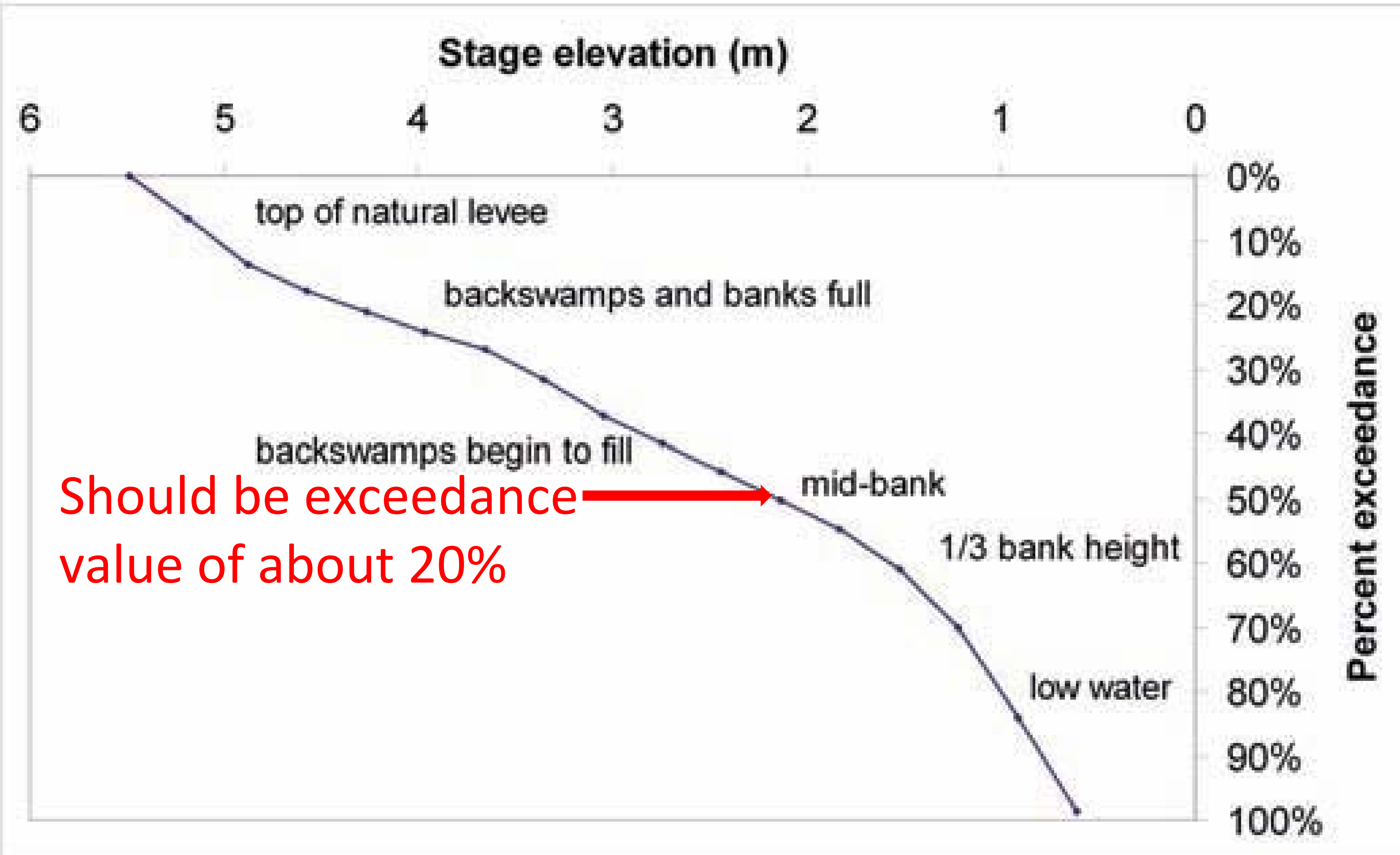
(Hupp et al. 2009)


Mostly fluvial (particle) erosion


Large primary mass wasting, probably a rotational slump, with deep bank instability.


Arcuate failure, primary
Slab failure, secondary

Impacts of Low Flows on Potential of Bank Failure



Measuring Floodplain Deposition

Geomorphic Study

- Overall objectives are to determine the geomorphic condition of the river, particular as it relates to current (and future) flow regimes (including the effects of sustained low flows on bank erosion and downstream sedimentation)

Hydrologic Issues

- Unknown accuracy and precision of the COE HEC-GeoRAS model
  - Have always suggested 1-2 ft, but we have no idea if this is correct
  - If incorrect, does it occur in a predictable manner?
  - Improving our understanding of surface and subsurface groundwater dynamics is critical to model vegetation dynamics

Hydrologic Issues

- We know that there is some channel entrenchment, but what are the effects of channel entrenchment on groundwater dynamics? Has it lowered groundwater levels below the root zone?
- If so, what is the effect of various river stages on groundwater levels?
- How do groundwater (and surface water) dynamics vary within and among geomorphic features?
- If we ignore these differences (such as we currently do) will it significantly affect predictions of forest successional change?

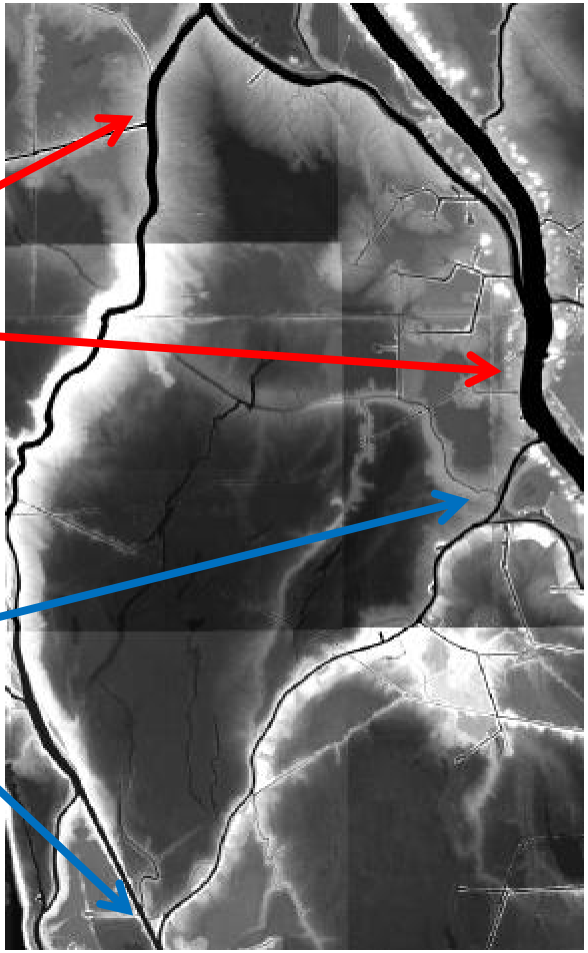
Hydrologic Issues

- Process-based models using soils, geomorphic surface, surface and subsurface riverine connectivity, and local watershed inputs/outputs among other measurable attributes may allow us to extrapolate to similar settings throughout the watershed

Hydrologic Model Based on Geomorphic Boundaries

Topographic features within the floodplain define surface flow boundaries

A few channelized connections allow surface exchange below flood stages



General Conceptual Model

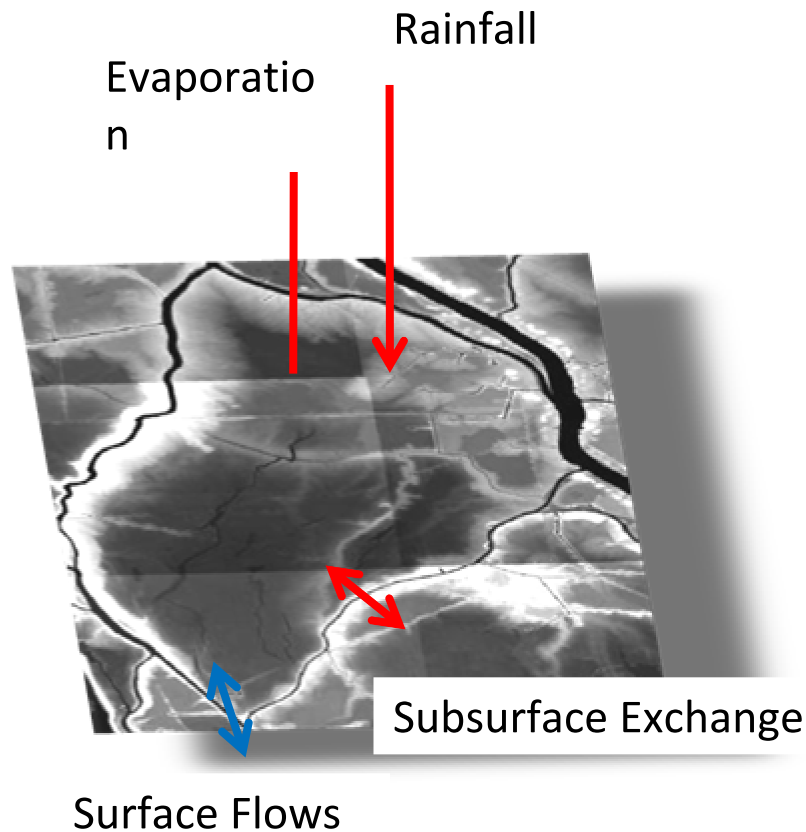
ΔStorage = Rain – Evaporation ± Surface Flows ± Subsurface Exchange

Rainfall: local gauges, radar estimates

Evaporation: model based on current field research in Louisiana

Subsurface Exchange: model based on recent research in Louisiana and groundwater data

Surface Flows: model based on HEC-GeoRAS and measurements of connections



Tree Growth / Stand Development

Tree Growth / Stand Development

- Will be closely linked to hydrology and geomorphology studies; water wells/pressure transducers will be co-located
- Sampling plots will be stratified across geomorphic features and longitudinal distance from the dam/mouth
- A combination of transects and plots will be used to insure adequate coverage of common vegetation communities

Modeling Study

- Ultimately, want to develop a predictive, spatially explicit simulation model of floodplain forest dynamics that will allow for evaluation of the effects of various flow regimes
- This approach necessitates process-based geomorphic and hydrologic models linked to tree growth and establishment
- In the original proposal, the modelling student (that integrates all components) would begin in year 2. However, funding is currently questionable for this student / study component

Near Future Milestones

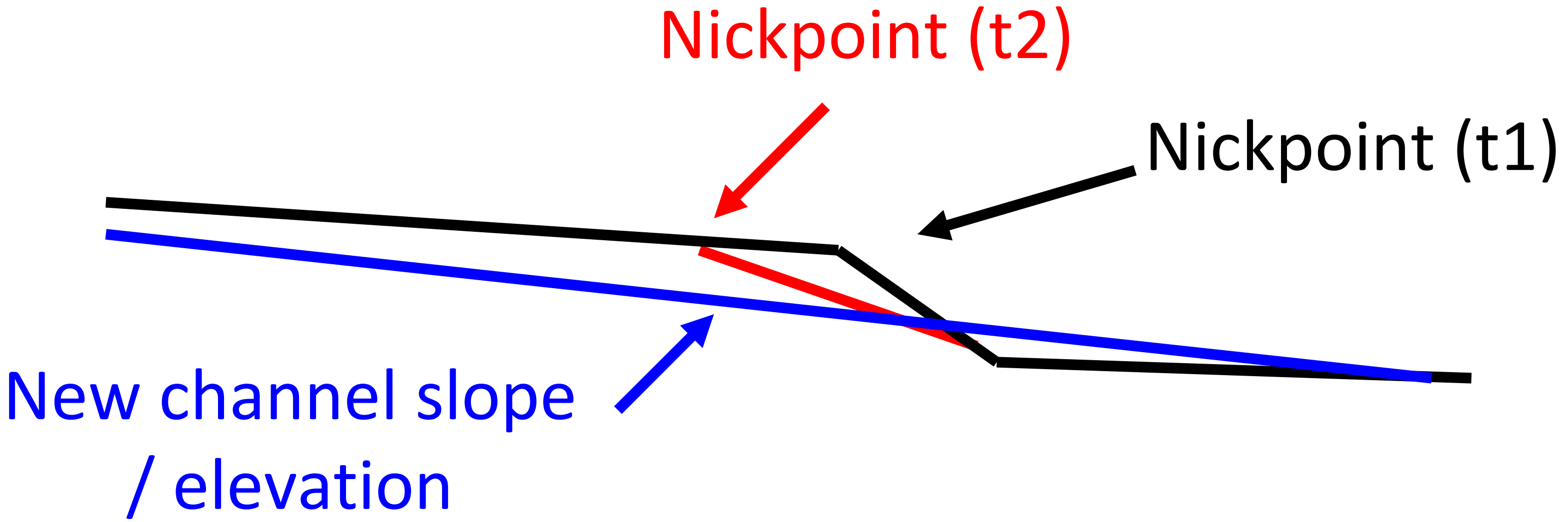
- In the next 30 days, we will begin efforts to identify and compile relevant datasets for this project
- In the next 60 days, we will initiate selection of study sites. We hope to complete selection of most sites during this timeframe
- The Ph.D. student will attend training for rapid geomorphic assessment
- Provided water levels are appropriate, the rapid assessment and bank erosion study will be initiated
- In the next 90 days, we hope to begin deploying pressure transducers and begin collecting vegetation data


WORK VEST
ONLY


- Very little point bar formation; it is not in equilibrium
- Go to photos of Little Red to see a bank in equilibrium
- Fig 6 is not a bank; midbanks flooded 50% of time; should be flooded 20% of time. This is showing impact of high sustained low flows.
- Measure toe slope by tying pins in laterally and vertically. Tie off boat to one of pins above water; have boat pulled into river so that nose is near edge of bank. Walk from bow of boat to stern and measure at intervals and drop measuring rod at specified distances and measure water depth.

- Cliff and them put in pins; at 1 m or break in slope. Then go back and measure how much of pin has been exposed. If pin completely gone because of mass wasting. You would put a benchmark in tree at some distance from bank; this will allow you to get measurements if entire bank erodes.
- Having done the work on Roanoke will make things a lot easier on White River

Channelization/ Channel Shortening



- ✓ Nickpoint migrates upstream causing bed lowering upstream of nickpoint
- ✓ Can reduce flood frequency and lower floodplain water table