West Tennessee Floodplain Forests, Sedimentation, and Geomorphology

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SEDIMENTATION IN WEST TENNESSEE

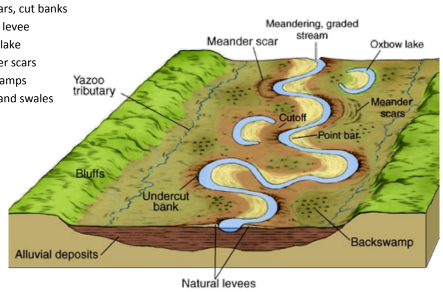
Outline

- Brief overview of Basic River Geomorphology and Floodplain Dynamics
  - Hydrology; Hydroperiod
- West Tennessee geography
- The Issues and their Impacts on West Tennessee floodplains:
  - West Tennessee landuse
  - West Tennessee Soils
  - Sedimentation
    - Normal versus Excessive
  - Channelization
  - Levees
  - Beavers and other natural processes
  - People
- Restoration of a river system: what would it take?
- Current status
- Beyond West Tennessee--A Landscape Perspective
- Recommended Reading (about W. Tennessee and other Fabulous wetland and river-related books that I highly recommend!)

Factors Impacting Floodplain Vegetation

Floodplain Geomorphology (study of the origin and evolution of floodplain landform)

- Main channel meanders
- Point bars, cut banks
- Natural levee
- Oxbow lake
- Meander scars
- Backswamps
- Ridges and swales
- Flats



Factors Impacting Floodplain Vegetation

Floodplain Hydrology (study of the occurrence, movement, distribution, and properties of water in the river and surrounding floodplain)

- Hydroperiod:
  - Frequency (how often flooding occurs)
  - Duration (how long floodwater sticks around)
- Water Depth
- Flow Pattern

Geomorphology + Hydrology = Hydrogeomorpology

Factors Impacting Floodplain Vegetation

Sedimentation in Floodplain Systems

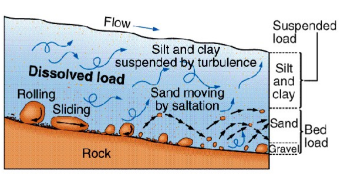
- Nutrient source for floodplain soils
- Builds floodplain topography
- Improves water quality as sediments drop out of the water column
- Surface for new plant colonization

Sedimentation Factors:

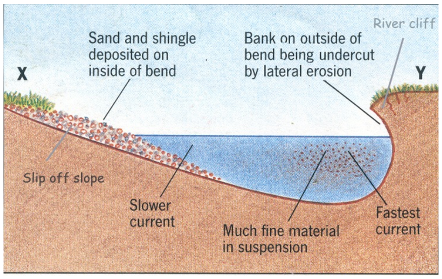
- Source input (bank erosion, nonpoint source – runoff, etc…)
- Grain size (fine-silty, coarse-sandy, etc…)
- Flow velocity (fast, slow)

Factors Impacting Floodplain Vegetation

Contents of a Stream Bed



Factors Impacting Floodplain Vegetation

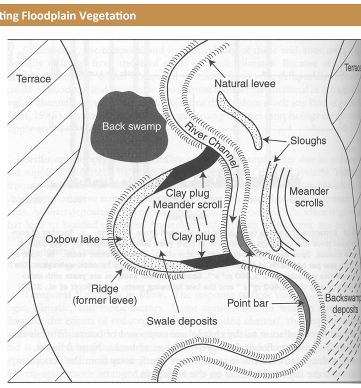


Factors Impacting Floodplain Vegetation

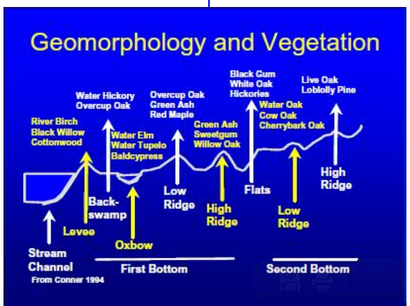
Sedimentation in Floodplain Systems

- Most sedimentation occurs in/adjacent to the main river channel
- Depressions in the floodplain also receive comparatively high sediment rates
- Deposition rates are normally <1 cm/year on the floodplain—and usually consist of FINE/SILTY soils (high nutrient level, high productivity, good surface for seed establishment)

Factors Impacting Floodplain Vegetation



Floodplain Forest Composition on intact, naturally-functioning West Tennessee Rivers (i.e. the Hatchie River)



Borrowed from Pierce

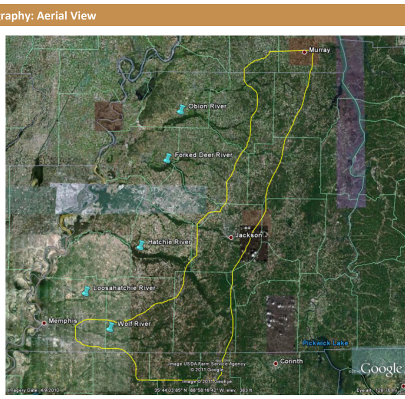
Geography: Rivers in West Tennessee

•5 Major Tributaries to the Mississippi (North to South):

- Obion River (North, Middle, South, and Rutherford forks)
- Forked Deer River (North, Middle, South forks)
- Hatchie River
- Loosahatchie River ("Loosahatchie Canal")
- Wolf River

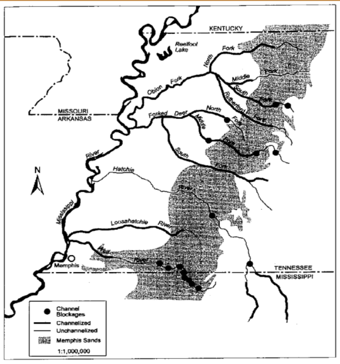
SEDIMENTATION IN WEST TENNESSEE

Geography: Aerial View



SEDIMENTATION IN WEST TENNESSEE

Rivers in West Tennessee and the Memphis Sands



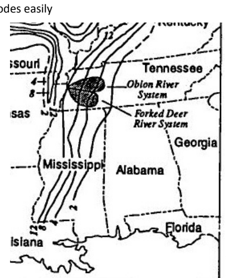
SEDIMENTATION IN WEST TENNESSEE

Soil Composition in West Tennessee (This is very important!)

West Tennessee encompasses several ecoregions, including the Mississippi Alluvial Plain and the Loess Bluffs and Loess Plains

- Loess is very fine, windblown material that was originally alluvium
- Loess is easily eroded when vegetative cover is removed—very fragile soil
- Underneath the loess is a very deep layer of unconsolidated sand, which is part of the Memphis Sands aquifer—this sand erodes easily

Loess Thickness (feet)



Land use: Pre-settlement

•River systems were unaltered

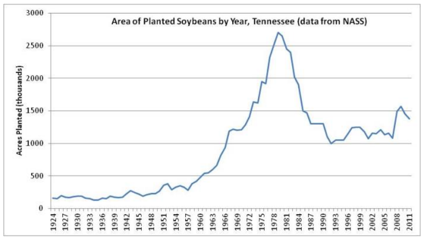
•Native Americans (general Chickasaw Indians in W. Tennessee) were nomadic, so when floods occurred they moved up to the surrounding bluffs—thus, floodwaters replenished nutrients, fish populations, etc…

•Wildlife were plentiful

- In 1827 Davy Crockett wrote about hunting the Obion River system—he describes plentiful populations of fish, ducks and other birds, panthers, elk, beaver, bears and "every wildlife but buffalo." He also describes killing 105 bears in one season—a testament to the richness of the ecosystem.

Land use: Rich, productive soils = Prime Farmland

- State boundaries established 1818; Memphis settled around 1819; Dyersburg around 1850
- Widespread clearing in the loess bluffs and floodplain (exploit and move west was the mindset—ambition with little thought to the future)
- Timber and agriculture prevailed—then the big soybean boom of the 1960s and 70s
- Dyer County is #1 soybean producing county in the state



Land use: Rich, productive soils = Prime Farmland

West Tennessee's Fragile Soils Meet Civilization….

When Sediment load exceeds flow capacity to carry the sediment, it is deposited in the stream bed & floodplain

More Examples from West Tennessee

More Examples from West Tennessee

More Examples from West Tennessee

The "Solution" = Channelization

•First instituted using levees and jetties along with "shortcuts" through meanders in the 1860s on the Mississippi River by Andrew Humphreys and James Buchanan Eads (read more about them in "Rising Tide")

•Was "successful" on the Mississippi (at least, it seemed so at the time) at scouring the channel bedload by increasing water velocity—thus deepening the channel for navigation purposes and flood control

• It was only natural that, seeing the successes of Humphreys and Eads in scouring the Mississippi, West Tennesseans would give it a try on the clogged Tennessee streams

•Channelization =

- Straightening and shortening the channel by cutting off meanders
- Deepening the channel through dredging and/or scouring
- Widening the channel

•Initially began by small groups of landowners, local governments

Channelization: What is it?

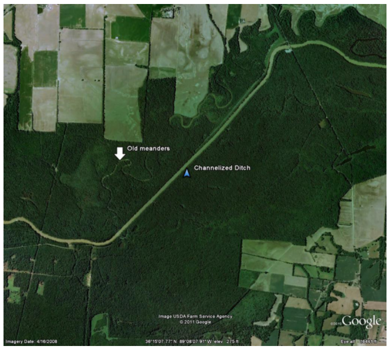
Unchannelized Hatchie River:

Channelization: What is it?

Channelized Forked Deer River:

Channelization: What is it?

Channelized Obion River:

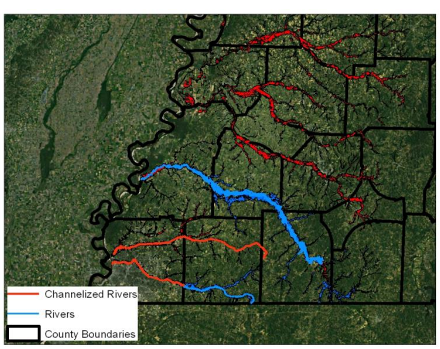


Channelization—The Problems with the "Solution"

- West Tennessee's soils are not stable – unconsolidated material
- Rivers want to meander
- Requires constant maintenance = constant money!
- Upstream draining = downstream flooding
- Levees – intentional and unintentional
- Someone always loses.....and that someone is your neighbor....

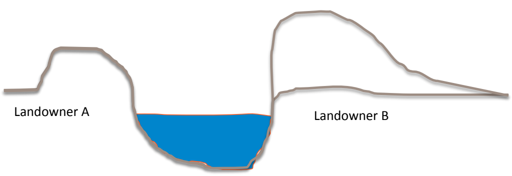
Channelization video

Channelized Rivers in West Tennessee



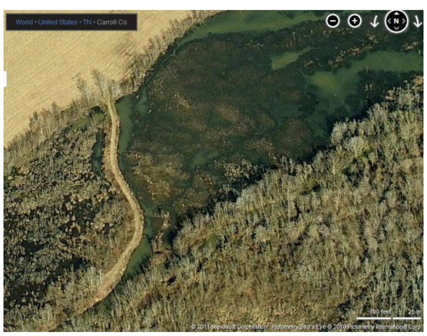
Levees—Adding to the Growing Problem

- The dirt from channel excavation has to go somewhere = Spoil Banks (otherwise known as an unintentional levee)
- Road construction
- Levees built for duck hunting
- What happens when you squeeze the river??
  - Water has to go somewhere
  - Levee wars



Levees: Adding to the problem

Levee on the Middle Fork Forked Deer River, just upstream from a channel blockage

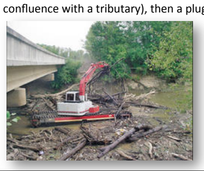


Sedimentation from the River Itself…

The system has no equilibrium

Unconsolidated Sediments + Straight channel + High flow events = Headcutting

- Headcutting and Aggradation
  - Progresses from downstream to upstream
  - Water flow is scouring the channel, carrying sediment downstream
  - Flow slows, and sediment is deposited
  - River widens, flow slows further
  - More sediment is deposited
  - If sediment load is higher than can be transported and/or something blocks or slows the river flow (e.g. beaver or a fallen log, confluence with a tributary), then a plug forms

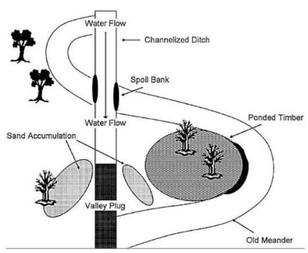


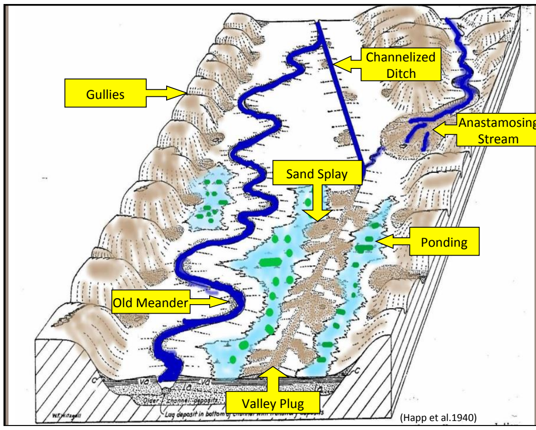
The Culmination of Problems

Sand Deposition in the River Systems

Valley Plug

- •The result of excessive sedimentation
- •Fills in the channel
- •Forces the River onto the surrounding floodplain (increases flooding)
- •Sedimentation on the floodplain surrounding the plug
- •Can stretch for up to a mile as sediments continue to deposit
- •Braiding can occur as the river tries to "escape"

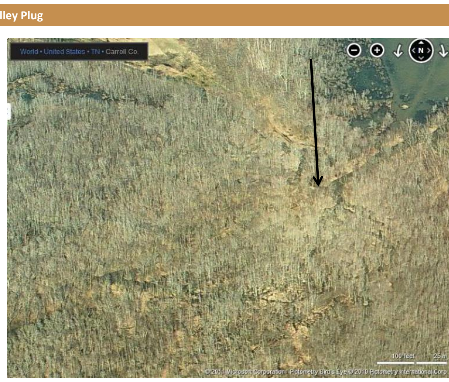




(Happ et al.1940)

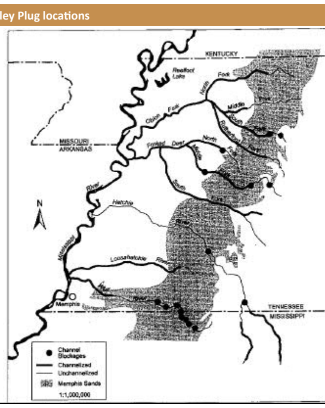
Valley Plug—2 examples on the Forked Deer River

Valley Plug



Valley Plug close-up

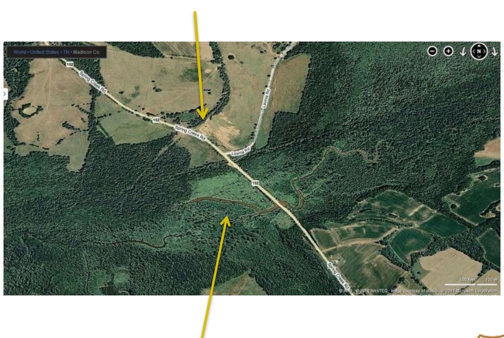
Some Known Valley Plug locations



More Examples

Same plug

Zoomed out – look just south

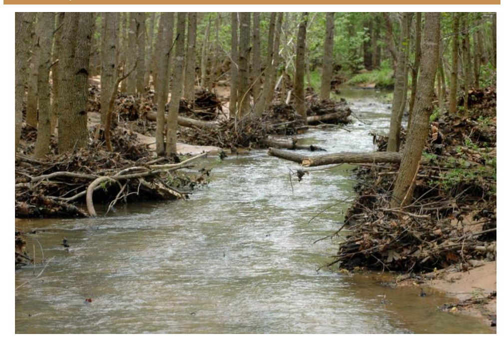


Closeup of Spring Creek Swamp

Close-up of Spring Creek swamp

Beaver are also playing a role in the formation of these swamps throughout West Tennessee, along with highway crossings that constrict the river

More examples



More Examples

More Examples

More Examples

More Examples

Valley Plugs– the bottom line

•Deposition is as much as 10 times greater than where plugs don't exist
•Soil composition is extremely different than on an unaffected floodplain
•Affects vegetation composition and floodplain hydrology
•Impacts wildlife
  • What are the possible impacts on herps? Birds? Mammals? Insects?
•Renders the river virtually unusable by people (it's inaccessible and un-navigable)

Impacts to Vegetation

•Where headcutting is occuring:
  • Floodplain gets drier so competition is more prevalent (not limited by moisture)
  • Less diversity a possibility as micro-topography becomes less important
  • Loss of hydroperiod connectivity—understory vegetation changes dramatically

•Where aggradation is occuring:
  • Flooplain gets wetter so some species are unable to persist
  • Hydroperiod changes dramatically

•On/adjacent to valley plug:
  • Sedimentation buries trees
  • Nutrient content is low, so only a handful of disturbance-related species establish (e.g. red maple, black willow, green ash)
  • Moisture content is lower because sand does not retain moisture as well as silt
  • Water table may be higher, resulting in a change in species composition

•Above the valley plug:
  • Ponding eventually kills the trees, new seedling establishment is impaired

Basically, the whole system has changed

Impacts to Vegetation—examples of various findings

Diehl (2004): Plugs "increase depth and area of seasonal flooding…promoting the development of open water communities, marshes, shrub communities in place of bottomland hardwood swamps…"

Weins (2003): On the Wolf River, headcutting has resulted in drier floodplains, which has translated into abnormal growth rates and an increase in flood-intolerant species

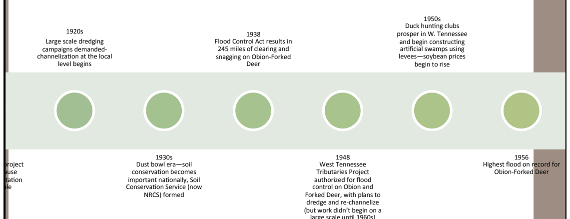
Franklin et al. (2009): Absence or reduction in Baldcypress and tupelo, increase in early successional species, particularly red maple, in channelized systems

Pierce and King: Larger numbers of maple, willow, and sweetgum on valley plugs compared to control sites where baldcypress and oaks were prevalent

Oswalt and King (2005): Larger numbers of maple and willow on valley plugs, dead and dying cypress in associated swamps, bottomland hardwoods with elevated floodplains in areas with head cutting

The People Factor

- The real challenge begins and ends with people
- The majority of land in west Tennessee is privately owned
- Cooperation across multiple ownerships is difficult
- The people along west Tennessee Rivers are a broad cross-section; many of them:
  - Are highly educated
  - Are second or third generation landowners
  - Love the rivers and their land
  - Are absentee
  - Are hunters, fishermen, or farmers
  - Are leery of government and governmental intervention

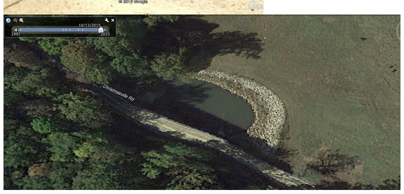


Restoration of a whole river system: What would it take?

- Sedimentation control
  - October 4, 2000—from the National Resources Inventory (Southeast Farm Press = source) : Erosion levels on TN cropland are half as high as 20 years ago (due to no-till systems and CRP) BUT, Tennessee has the highest rate of erosion of cultivated cropland in the United States—it is twice the tolerance level of 2-4 tons/ac every year
  - Revegetation
  - Bank stabilization
  - Sediment fencing/mats
- Upstream to downstream approach
  - Why would starting mid-stream or downstream be problematic?
- Re-establishing hydrology through meanders
  - Landowner concerns about boundary lines, losing property, privacy, security
  - Why won't the river "fix itself" by flowing through the old abandoned meanders?
- Levee breaks
  - Removing levees, including WMA levees, on "first bottoms" immediately adjacent to the river
  - Managing levees in the "second bottoms" not immediately adjacent to the river for hunting purposes
- Leaving valley plugs in place
  - Why does this make sense?

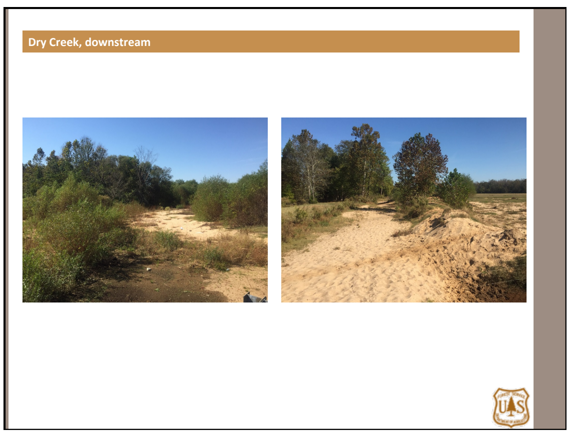
Virtual Field Trip – Where we hold our breath to see if technology fails….

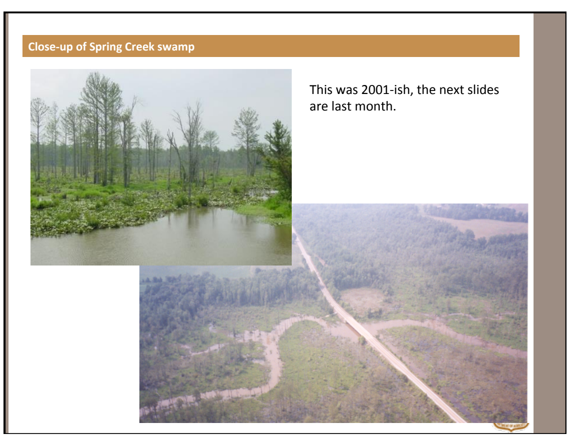
2009



2015


The Middle Fork of the Forked Deer, Today – Dry Creek, Upstream


Dry Creek, downstream


Close-up of Spring Creek swamp
This was 2001-ish, the next slides are last month.

Spring Creek Wetland, Upstream

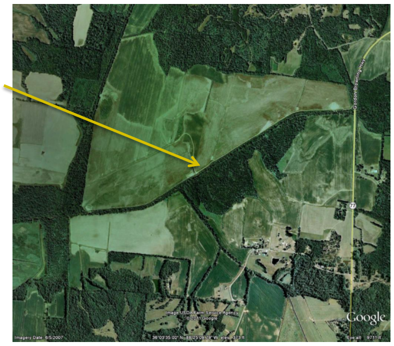
Spring Creek Wetland, downstream

Ongoing restoration projects: Crooked Creek (South Fork Obion Watershed)- completed 2010 WTRBA

Circa 1997:

Ongoing restoration projects: Crooked Creek (South Fork Obion Watershed)

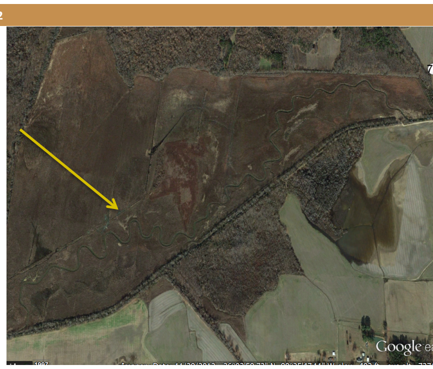
Circa 2007:



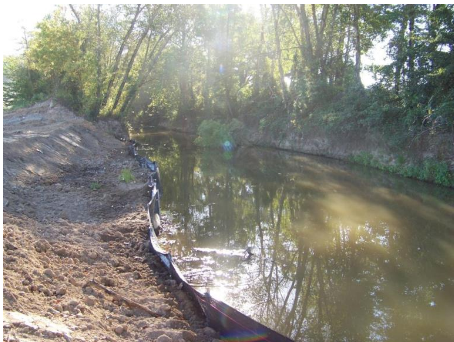
Ongoing restoration projects: Crooked Creek (South Fork Obion Watershed)

Circa 2008:

2012



Canal at restoration segment



New meanders right after construction

Erosion control blankets at the new meandering channel inlet

Inlet and erosion blankets

Flow diversion into the new channel

Crooked Creek restoration segment one year later

Restoration segment 1 year later

•Canal length at restoration segment: 1.5 mi

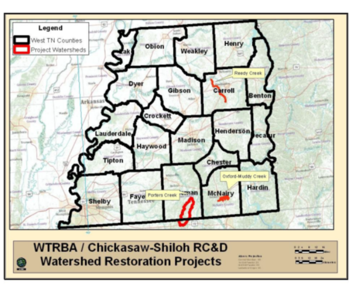
•Restored channel length: 2.3 mi

Old Canal—downstream of restoration—note the bank collapse on both sides that had been occurring.

Examples of Ongoing Restoration projects

Nature Conservancy, WTRBA cooperative: Porters Creek, Reedy Creek, Oxford-Muddy Creek; 5 more channels proposed for restoration

- Grade Stabilization
- Outlet protection
- Streambank Stabilization



Grade stabilization and channel erosion control

Before

After

Sediment retention ponds

Before

After

Revegetation with native warm season grasses

Before

After

Channel stabilization, revegetation, cattle exclusions

Before

After

More Ongoing projects

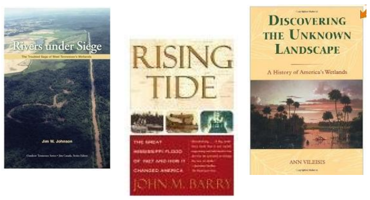
- •USDA Mississippi River Basin Initiative project driving force
  - $320 million desginated in 2009 for conservation in the Mississippi River Basin—designed to improve the heath of the river, wildlife habitat, and reducing hypoxia in the Gulf of Mexico
- •158 projects designated in the Obion and SF Obion watershed
- •20 grade stabillization structures, 18 plantings, 5 access control sites (cattle), 25 sediment control basins, others
- •Pays portions of the restoration costs (costshare)
- •Stokes Creek (some controversy about the goals, steps)
- •Black Swamp (controversial)

Importance beyond Tennessee's borders: Landscape Perspective

- •Mississippi River Basin is a critical ecosystem for people and wildlife
- •Excess sediment = excess nutrient input = contributions to the Gulf of Mexico hypoxic zone
- •Loss of habitat = impacts on the Mississippi Flyway—an extraordinarily important migratory pathway, particularly for waterfowl and shorebirds.
- •Sixty percent of all the bird species in the United States use the Mississippi River as a migration corridor, and 40 percent of all the waterfowl in North America use the river basin during migration. The flyway is considered the most significant flyway in the world.
- •The entire MS alluvial valley in Tennessee is designated as an Important Bird Area by Audubon.

Recommended Reading

- Rivers Under Siege: The Troubled Saga of West Tennessee Wetlands: Jim W. Johnson
- Rising Tide: The Great Mississippi Flood of 1927 and How it Changed America: John M. Barry
- Discovering the Unknown Landscape: A History of America's Wetlands: Ann Vileisis



Thank You for Updates, Photos, Conversations…

- Dr. Sammy King, USGS Louisiana Cooperative Fish and Wildlife Research Unit
- Christopher Bridges, West Tennessee Project Director, The Nature Conservancy
- Dr. Scott Franklin, University of Colorado
- Carl Wirwa, Wildlife Manager II, Tennessee Wildlife Resources Agency
- Dr. Aaron Pierce, Nicholls State University
- Larry Smith, Wolf River Conservancy and Shelby County Government
- David Salyers, West Tennessee River Basin Authority
- Will Pinson, NRCS