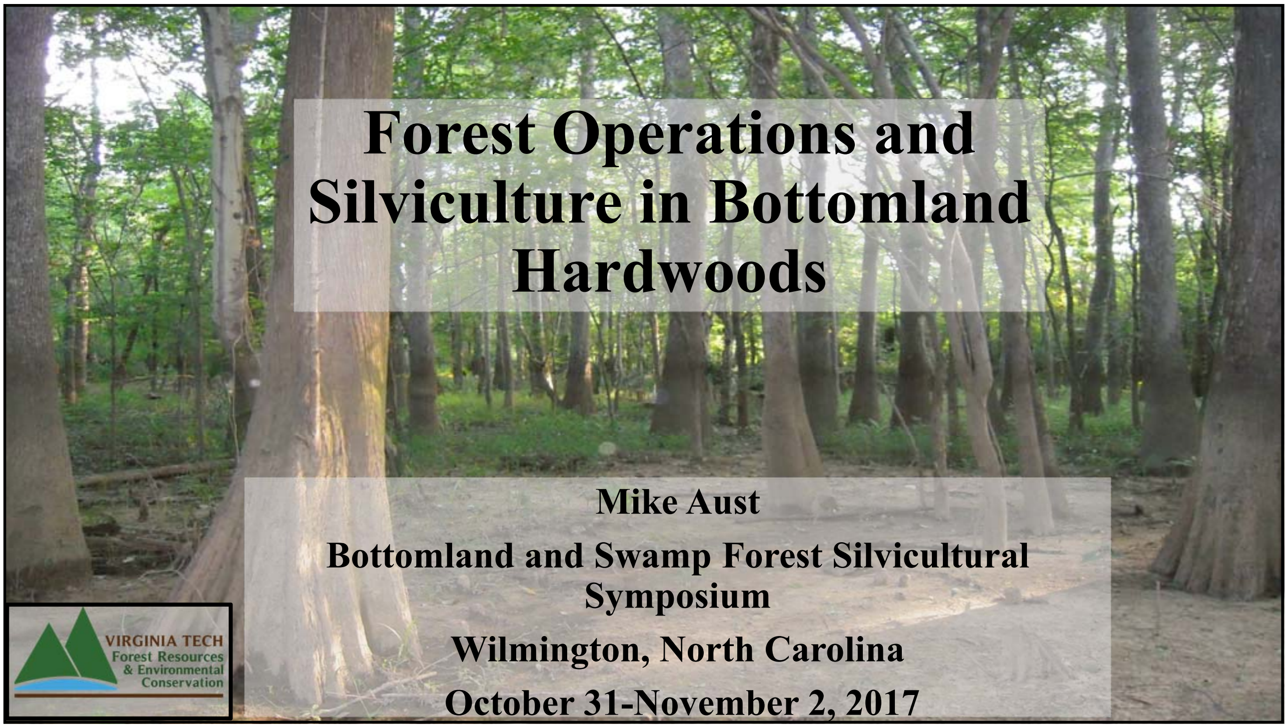


Forest Operations and Silviculture in Bottomland Hardwoods

Mike Aust

Bottomland and Swamp Forest Silvicultural Symposium

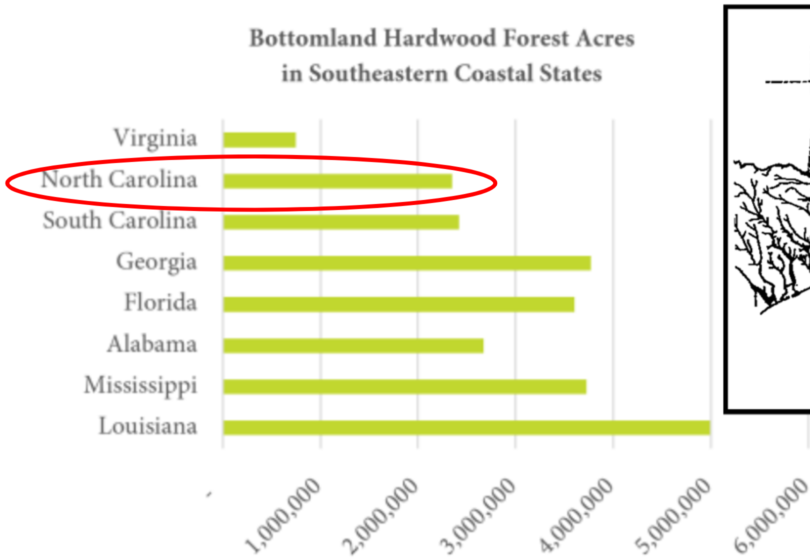
Wilmington, North Carolina

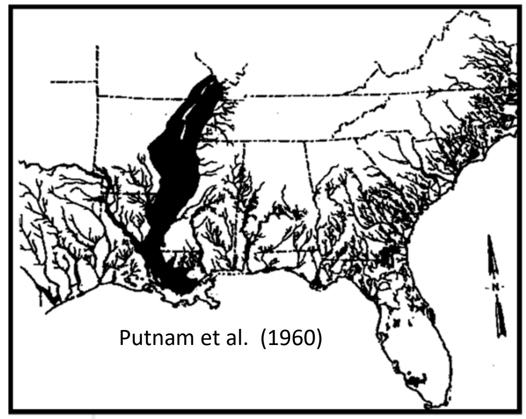
October 31-November 2, 2017

Sponsors during 24 year study

- Kimberly Clark
- McIntire-Stennis Program
- National Council for Air and Stream Improvement
- North Carolina State University
- US Forest Service
- Scott Paper Company
- Virginia Department of Forestry
- Virginia Agricultural Experiment Station
- Virginia Cooperative Extension
- Virginia Tech College of Agriculture & Life Sciences
- Virginia Tech College of Natural Resources & Environment

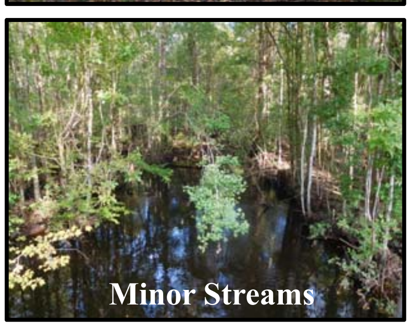
BLH Resource: Wear and Greis (2012) reported 32.6 million acres of forested wetlands. Mahaffey and Evans (2016) reported ≈26 million acres of BLH in 8 coastal states.

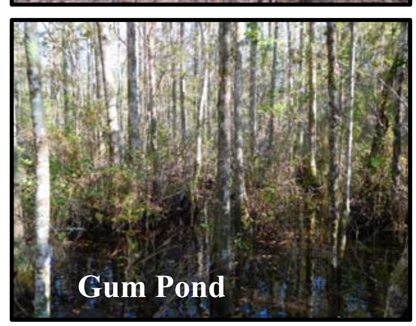


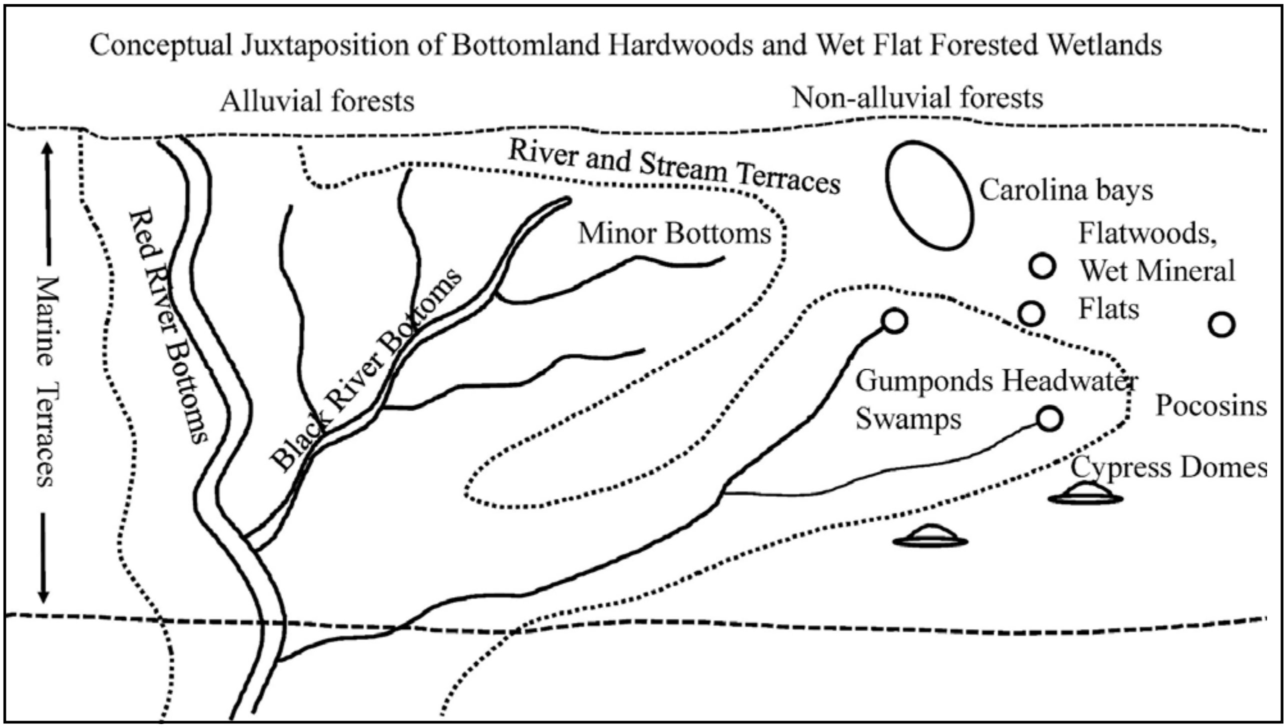


Bottomland Hardwoods (Kellison et al. 1981)

- Muck Swamps
- Red Rivers
- Black Rivers
- Minor Streams
- Intermittent Streams
- Gum pond/cypress domes
- Cypress stringers







Functions and Values of BLH. Moore et al. (2011) as reported by Mahaffey and Evans (2016)

- Flood control: $4700/acre
- Water quality: $3479/acre
- Water supply: $1157/acre
- Wildlife habitat: Many species
- Carbon storage: Highly productive
- Timber: Varied, To be discussed

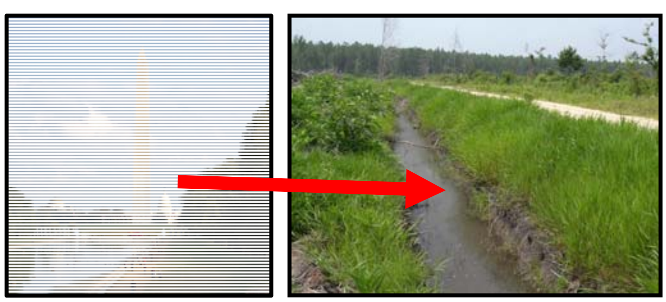
- Issue: Most of these values accrue to society. Difficult for private landowners to receive significant financial rewards for these societal values. Timber management is the major opportunity for most landowners to receive monetary values from BLH.

Scenario based on TimberMart South (2017) values for Virginia

- Landowner with 50 acres of bottomland hardwoods accessible by old woods road. Stand is dominated by mixed bottomland hardwoods, averaging 100 tons/acre of sawtimber and pulp.
- Saw 8000 BF (Doyle)/acre x $236 MBF = $1888/acre
- Pulp 50 tons/acre x $6.53/ton = $326/acre
- Stumpage to landowner (sawtimber and pulp) = $2214/acre
- Total income to landowner = $110,700
- Note that is a market value rather than a nonmarket value.

BLH management is influenced by policy (Lucier and Shepard 1997)
What happens in DC doesn't stay in DC

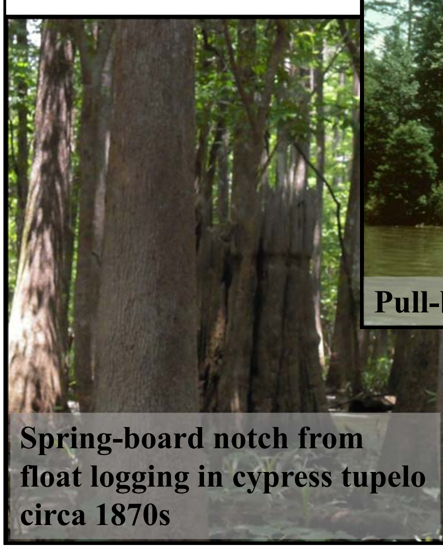
- WOTUS???
- Federal Water Pollution Control Act of 1972 and amendments.
- Endangered Species Act (F&WS consideration of 374 new riparian/aquatic species in SE).
- Rivers and Harbors Act of 1899. (Shovel logging)
- Silvicultural exemption.
- 15 Federal BMPs.
- State BMPs.
  - Roads
  - Skidding
  - Stream Crossings
  - SMZs
  - Shovel logging



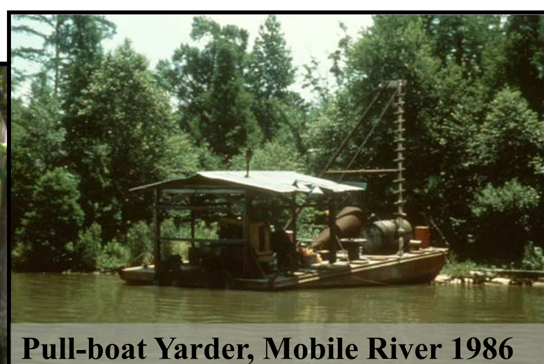
"Silvicultural Exemption"

- Silvicultural operations in wetlands generally fit into a special type of permit that is usually called "The Silvicultural Exemption".
- The silvicultural exemption has 5 specific requirements:
  - Normal silvicultural operation.
  - On-going operations.
  - Do not alter the site hydrology sufficiently to change wetland status.
  - Do not introduce toxins to the wetland.
  - Follow BMPs:
    - 15 Federal BMPs:9 relate to access BMPs, 6 relate to discharge and protected species
    - 6 Site preparation BMPs for pine plantations.
    - State BMPs are implied.

BLH have long histories of repeated timber harvests (Lockaby 2009).

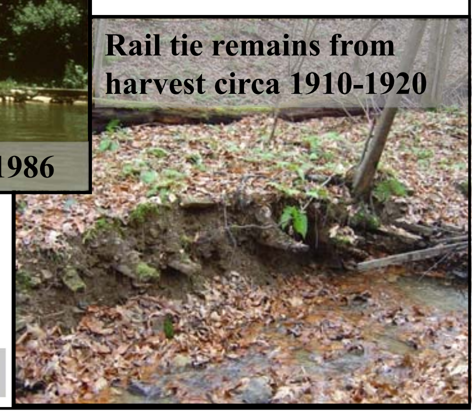


Spring-board notch from float logging in cypress tupelo circa 1870s



Pull-boat Yarder, Mobile River 1986

Pull-boat Run from 1918



Rail tie remains from harvest circa 1910-1920

BLHs can recover from anthropogenic disturbances (Lockaby 2009).

Silvicultural regeneration systems in BLH (Kellison and Young 1997; Meadows and Hodges 1997; Mahaffey and Evans 2016)

- **Clearcutting with Natural Regeneration**
- Patch Clearcutting with Natural Regeneration
- Irregular Shelterwood
- Shelterwood
- Old Fields, Mitigation sites: Plantations

Highgrading/"Selective Harvesting"***
Not a silvicultural regeneration system

Intensive silvicultural operations in BLH

- Usually, much less intensive than pine management.
- Some potential for mechanical, chemical site prep on old field plantations.
- Fertilization is rare.
- Thinnings can be conducted, but effect of epicormics sprouting is a major consideration for some species (Meadows 1998).

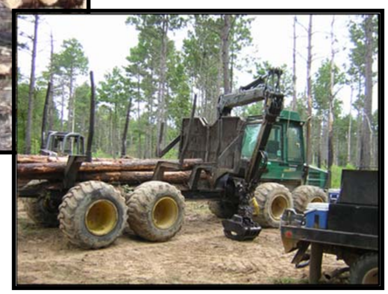
A common issue for managing BLH is access due to standing water and/or low soil strength (Rummer 2002)

- Roads
- Skid trails
- Stream crossings
- Low soil strength

Equipment modifications for low soil strength

- Dual tires
- Wide tires
- Wide tracks
- Forwarders





Reinforcement options for low soil strength

- Corduroy
- Mats
- Panels
- Geosynthetics
- Portable Bridges




Current harvest systems in BLH (Stokes and Schilling 1997; Rummer 2002)

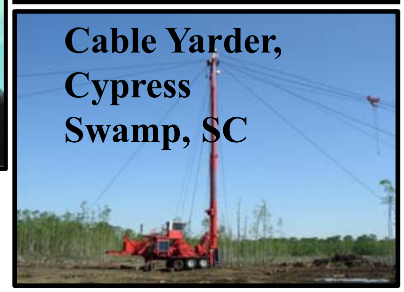
- Conventional
    - Feller bunchers
    - Grappled skidders
- Shovel Logging/Mat Logging
    - Conventional plus shovel, corduroy

Shovel Logging (Egan et al. 2002; Florida Forest Service 2008)

- Mats < 20 feet wide (40 in areas of passage)
- Trail > 200 feet apart is possible, < 25% of area
- Timber laid down in direction of travel
- Minimize depth of mats (1 layer if possible)
- Remove merchantable material from mat

Less frequent harvest operations in BLH (Stokes and Schilling 1997; Willingham 1989)

- Cut to length systems
- Helicopter
- Cable Yarder



Selected BMP implementation scores in SE US (Cristan et al. 2017)

SE State	Overall BMP	Roads	Skid Trails	Stream Crossings	Wetlands	SMZs
Alabama	96.9	93	.	96	.	97
Arkansas	87.4	85	.	84	.	86
Florida	99.4	99	100	98	98	98
Georgia	96.5	94	95	93	97	95
Louisiana	96.0	96	96	96	96	96
Mississippi	90.5	84	84	92	95	94
North Carolina	**84.6**	**84**	**82**	**72**	**.**	**91**
South Carolina	91.1	98	.	81	.	92
Tennessee	84.2	88	85	82	70	88
Virginia	89.9	85	90	92	92	92
Average	**91.7**	**90.6**	**90.3**	**88.6**	**91.3**	**92.9**

Previous Research Reviews

- Lockaby et al. (1997) reviewed effects of silvicultural activity in BLH.
  - "*no evidence that harvesting followed by natural regeneration represents a threat to ground or surface water quality on floodplain forests as long as Best Management Practices are followed*"
  - "*Vegetation productivity is maintained at levels similar to those observed prior to harvests*"
  - "*amphibian populations seem to rebound rapidly following harvests*"

Previous Research Reviews

- Hutchens et al. (2004) reviewed 25 published research projects that examined the effects of silvicultural activities on biota in wetlands.
  - "*Most dramatic impact of timber harvest on wetlands is the associated change in plant communities*".
  - "*Wet soils in wetlands are vulnerable to compaction and rutting*".
  - Sediment export is unlikely to occur in flat wetlands.
  - **Concluded that permanent biotic changes can be avoided if wetlands forests successfully regenerate.**
  - **BMPs** that promote regeneration of natural wetland forests should minimize long term impacts.
  - Efficient regeneration of BLH should result in recovery of most other wetland plants and animals.
  - **Effects of silviculture in BLH should be evaluated over longer time frames than are typically done.**

Concerns regarding wet site harvesting soil disturbance are not water quality related, rather the concerns are regarding hydrology, stand site regeneration, and site productivity.

- Traffic Disturbances (compaction, rutting or churning/puddling).
- Soil Physical Properties (strength, porosity, aeration).
- Hydrologic Response (Reduced ET, higher water table, reduced soil drainage).

Expected mineral soil response to traffic (Greacen and Sands 1980)

(Modifying factors: soil water, soil texture, soil mineralogy, restricting horizons, organic matter, equipment, number of passes, site flooding, site preparation)

Traffic

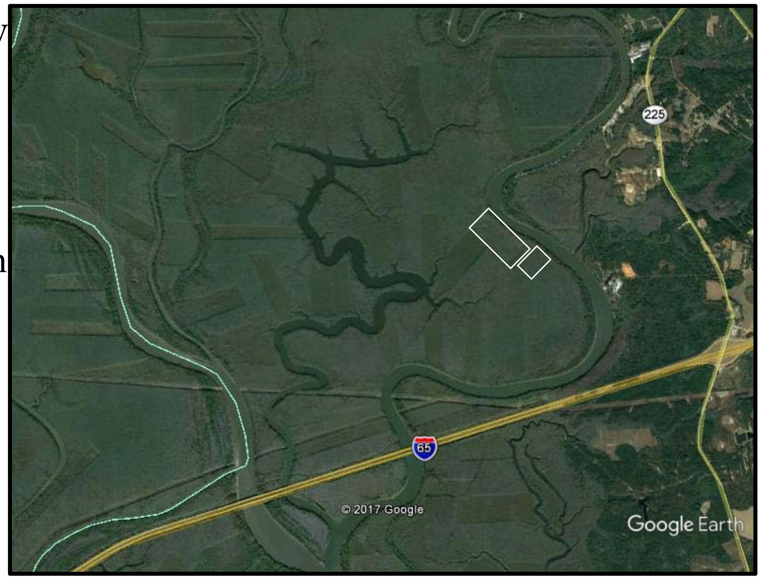
Dry
↓
Minimal response
(Dependent on weight and passes)
↓
Soil conditions similar to preharvest.
Increased short term soil moisture due to reduced ET.
Similar site productivity.

Moist
(Plastic Limit)
↓
Compaction
↓
Bulk density increased.
Decreased porosity.
Root penetration limited.
Site productivity?

Saturated
(Liquid Limit)
↓
Puddling
↓
Bulk density may be increased.
Macroporosity decreased.
Hydraulic conductivity reduced.
Soil air/water altered
Site drainage altered.
Species/Site productivity??

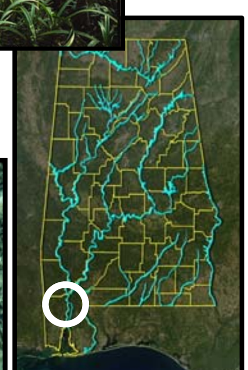
Long-term BLH study

- Summarize the results from a long-term study that evaluated the effects of harvest disturbances in BLH
  - Mobile Tensaw River in Alabama



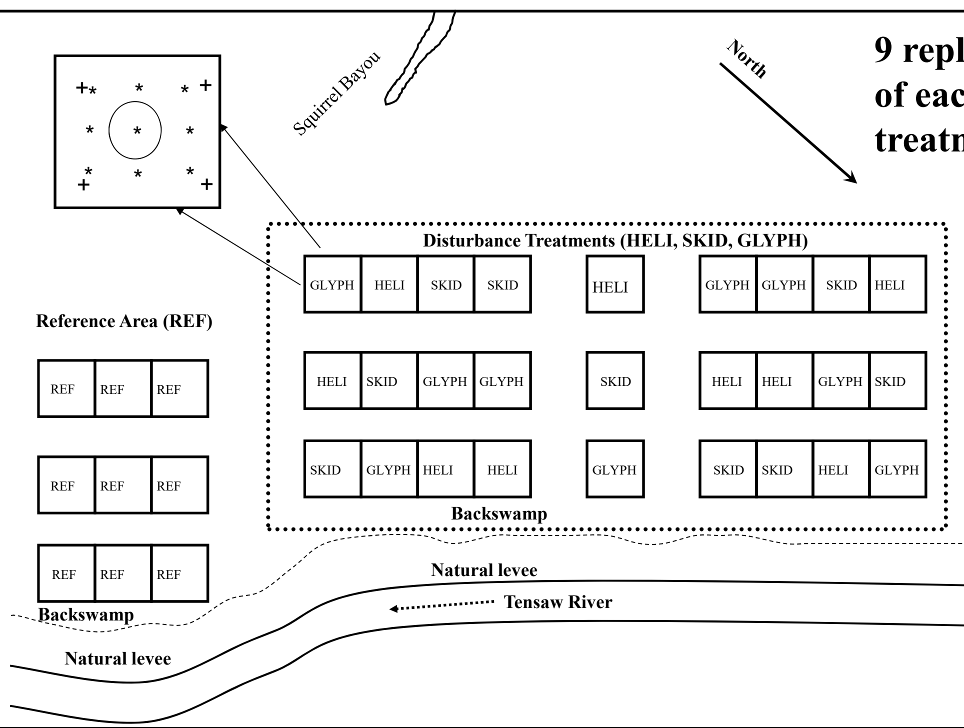
Mobile-Tensaw BLH Study: Long-term research (24 years) regarding helicopter and skidder harvests in tupelo-cypress

- Study began in 1986
- 70+ year old Tupelo-Cypress in 1986
- 4 harvests - late 1700's, 1860's, 1918, 1986
- Remeasured repeatedly, most recently in 2010-2011 (24 growing seasons)
- Periodic measurement of:
  - Vegetation
  - Soils
  - Hydrology
  - Sediment

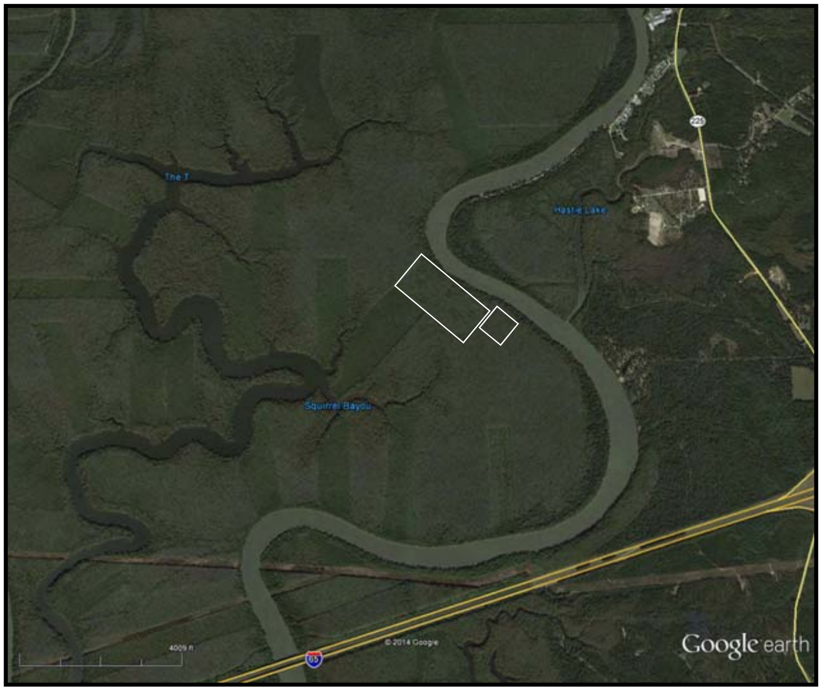


Treatments: Reference and 3 Disturbance (Only 2 disturbances discussed today) (9 reps for each)

- Reference area (70+ year old tupelo cypress in 1986, 101 years old in 2017).
- Helicopter (chainsaw felling).
- Skidder (Helicopter removal followed by skidder simulation. 52% of areas were rutted to 1 foot (30 cm) or deeper.

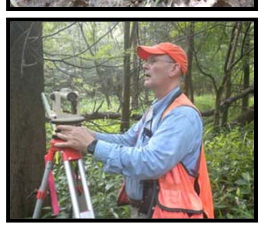


9 replications of each treatment



24-year measurements

- Overstory biomass
- Lowerstory biomass
- Herbaceous layer
- Woody debris
- Soil carbon/roots
- Sediment

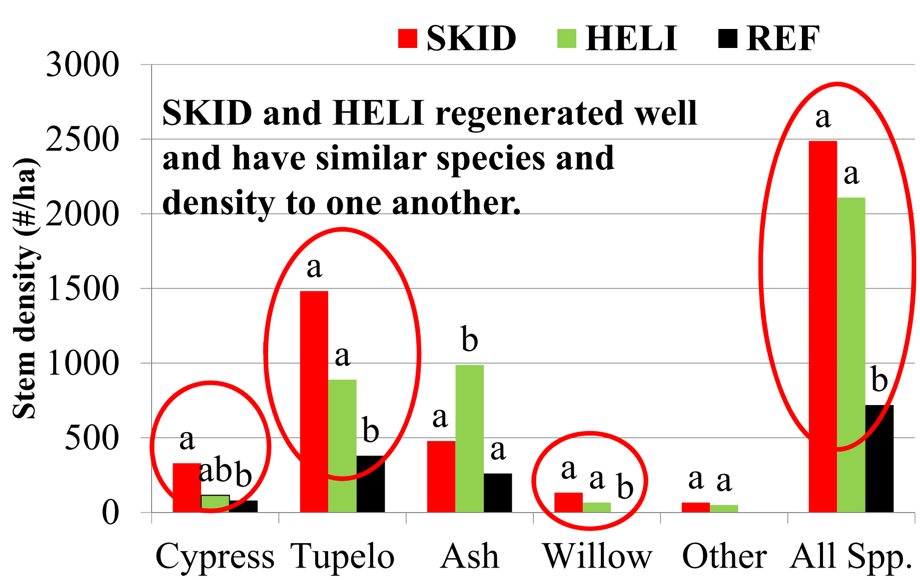


Year 1 BLH harvesting effects on site hydrology and aeration.

1. Harvesting made the site wetter during the growing season.
2. SKID affected soil physical properties and aeration more than HELI. (This effect disappeared by stand age 24 years).

Soil and Water Measurements	REF	HELI	SKID
Water Depth (Growing Season) (cm)	-0.3 a	5.1 b	4.9 b
Saturated Hydraulic Conductivity (cm/hr)	17.7 c	8.5 b	3.3 a
Soil Redox Potential (mV)	250 b	175 ab	125 a

Vegetation effects: Stems/ha by species at 24 years.

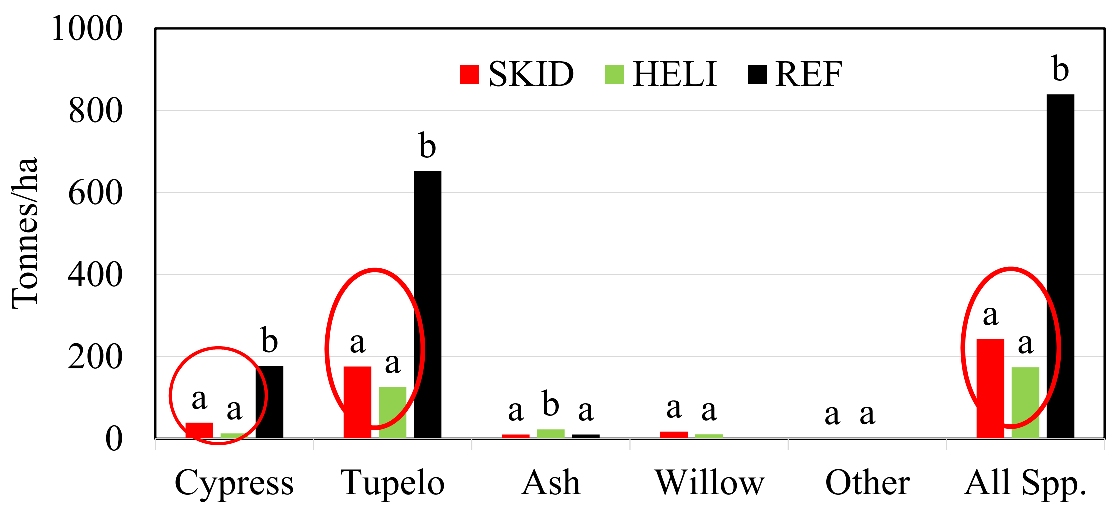


Sources of tupelo and cypress regeneration

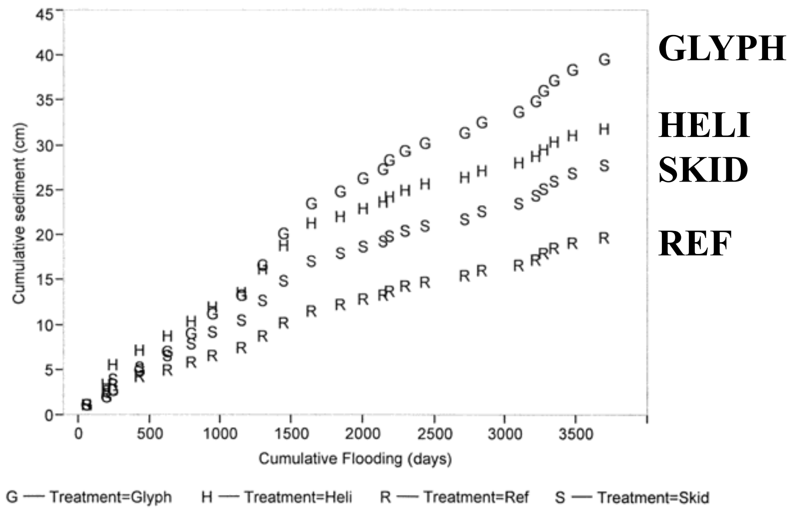
- Initially, seedlings were prevalent, but coppice growth quickly dominated.
- Currently water tupelo > 75% coppice regeneration source.
- Currently baldcypress > 40% coppice.
- Concerns over coppice failures seem overestimated.
- Willow is declining as stand ages.
- Several hurricanes have occurred.

Aboveground biomass (tonnes/hectare) by species at 24 years.

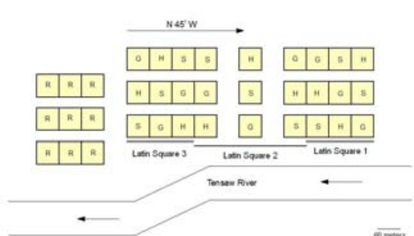
SKID and HELI have similar biomass and ≈ 25% biomass of REF at 25% of age.

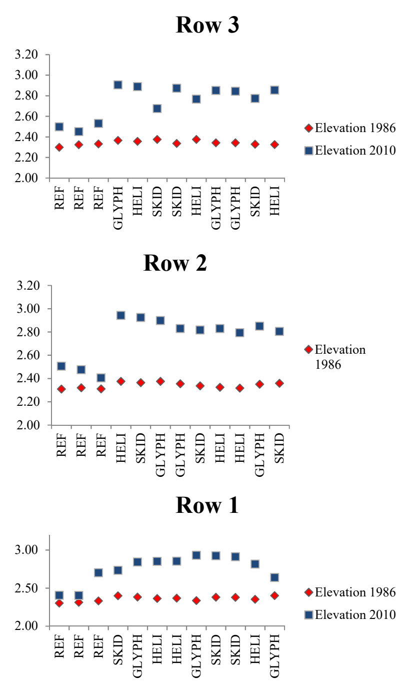


Sediment accretion (23 years) as influenced by cumulative number of flood days.

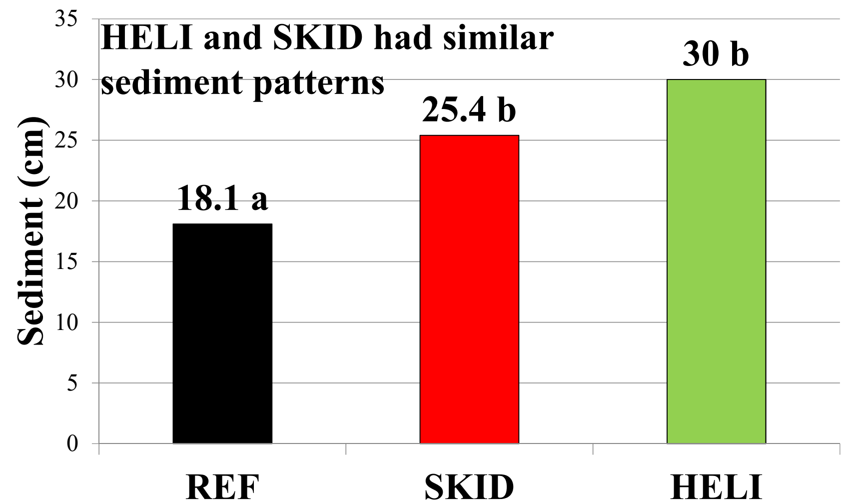


Soil deposition and distance from channel.





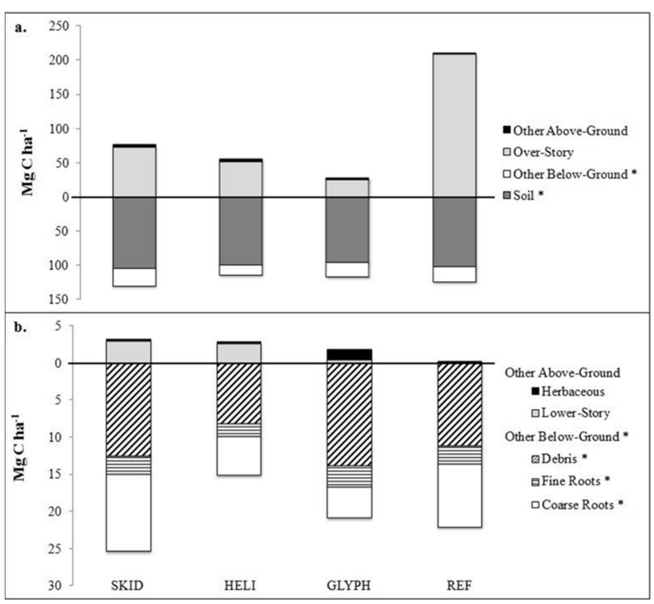
Total sediment accumulations (cm) during 24 years period favored site recovery.



Carbon pools by treatments.
Overstory is driving differences.

Major Components

Minor Components



Conclusions: Forest Productivity.

- Both HELI & SKID resulted in fully stocked, productive stands.
- Primary long term source of regeneration for tupelo was coppice although seed regeneration filled holes.
- Overall productivity: SKID treatments ≥ than HELI due to:
  species, microsite, sediment, organic matter.
- Species diversity: HELI ≥ SKID, favored some less flood tolerant species (Carolina ash, pumpkin ash, red maple).
- Disturbances increased sediment deposition by increasing herbaceous component. Has implications for SMZ management.

Conclusions: Carbon Pools.

- The soil is the largest carbon pool and disturbance treatments did not alter soil carbon during 24 years.
- Overstory biomass carbon pools were affected by disturbance, but are recovering.
- SKID treatments are storing the most carbon of all disturbance treatments.
- Biomass carbon pools in SKID and HELI are about ¼ the size of those in REF at ¼ the age.
- Buried woody debris on the site may be allowing much more carbon storage on the site than anticipated.

Conclusions: Disturbance & Recovery

- Traffic negatively affected soil physical properties, yet soils and vegetation recovered due to:
  - sediment deposition,
  - shrink swell soils,
  - organic matter incorporation,
  - microtopography (ruts).
- ET/Hydrology recovered rapidly due to rapid growth of coppice regeneration.
- HELI & SKID resulted in fully stocked, productive stands similar to REF species.

1986 2010

REF

HELI

SKID

Broader Implications of 24 Year Study

- Soils recovered after deliberate, drastic disturbances.
- No sediment or nutrient concerns were detected.
- Hydrology recovered rapidly as stand regenerated.
- All original overstory species are present in similar ratios.
- Net Primary Productivity is becoming similar.
- Stands are young forests with recovering structure, strata, and woody debris.
- Implications are that wildlife habitats are similar.
- All soil, water, and vegetation parameters indicate that harvesting is compatible with long term sustainability of the forest.

Results From Mobile-Tensaw Published in Peer Reviewed Journals

McKee et al. 2013. Biomass & Bioenergy 55:130-140.

Sain et al. 2012. Forest Ecol. & Manage. 280:2-8.

Aust et al. 2012. Wetlands 32:871-884.

McKee et al. 2012. Forest Ecol. & Manage. 265:172-180.

Aust et al. 2006. Forest Ecol. & Manage. 226: 72-79.

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Aust et al. 1991. Water Resources Bull. 27(1):111-116.

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Aust et al. 1990. Forest Ecol. & Manage. 33/34:215-225.