

# Definitions, Examples and Geographic Extent of Legacy Sediment

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*Chesapeake Bay Program, Scientific and Technical  
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# Introduction

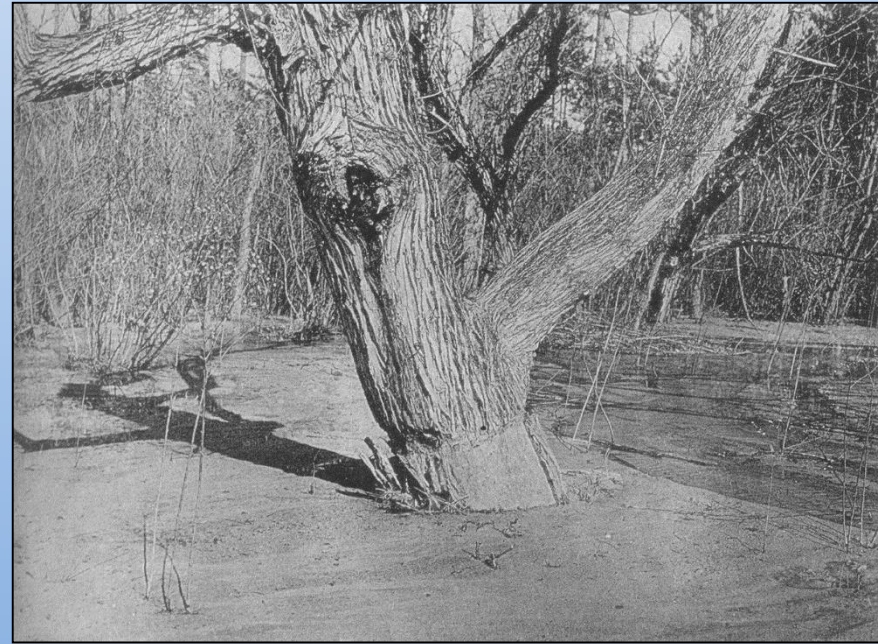
- Definitions of Legacy sediment (LS) have varied
  - Early workers on LS (Gilbert, Happ, Knox, Costa, Jacobson) did not call it that.
  - Early specific definitions giving way to broader definitions.
- Objectives
  - Broadly define legacy sediment (LS)
  - Present broad typology of LS

LS over aquent  
Contact  
(gleyed floodplain soil).  
Clarks Fork, South Carolina

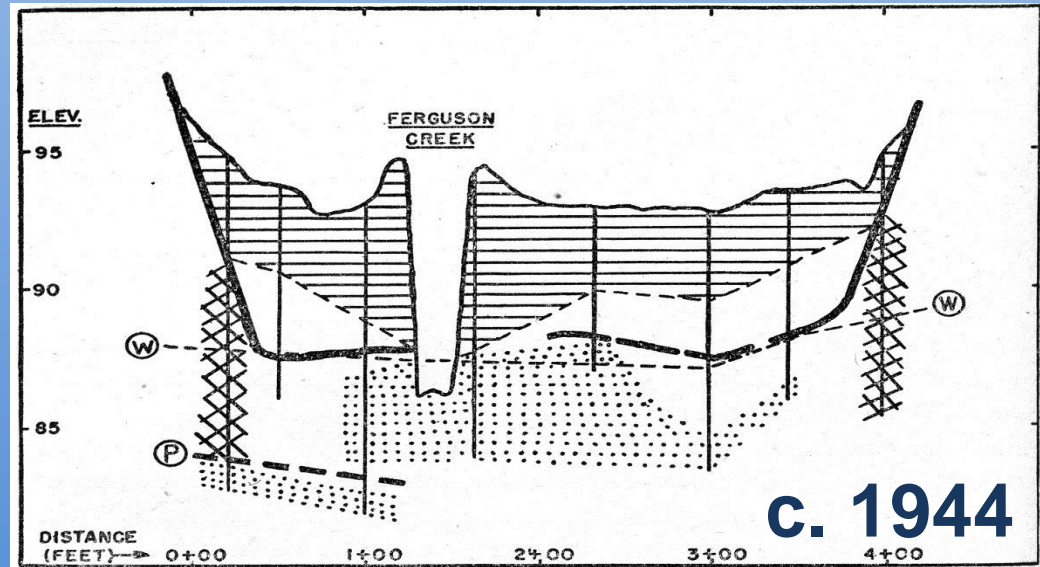


# Ferguson Creek, SC

c. 1944



*Stafford Happ, 1945.  
Amer. Journal Science.*



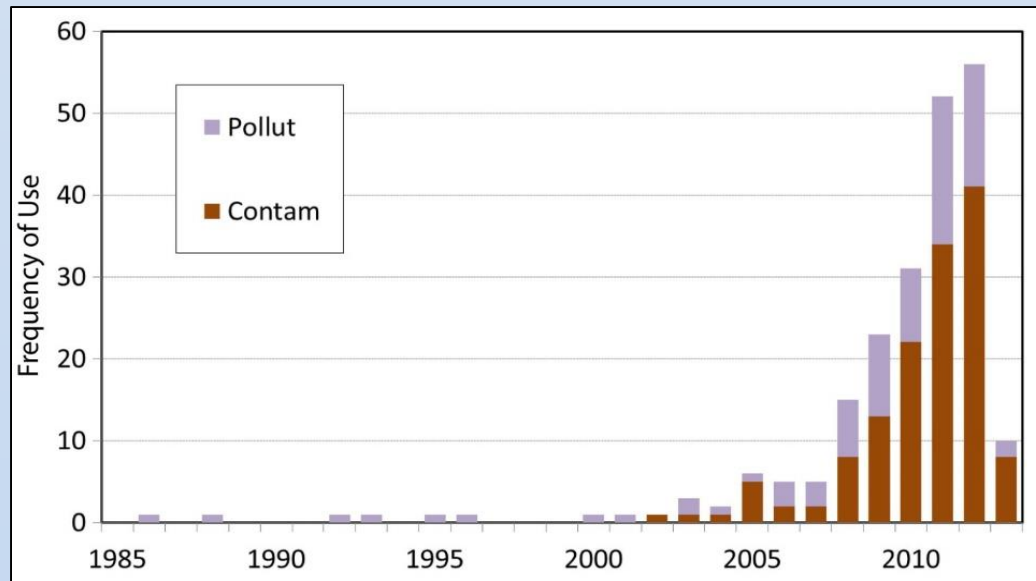
2004

# Semantics of 'legacy'

Merriam Websters dictionary: "...something transmitted by or received from an ancestor or predecessor or from the past...". All sediment is from past, so 'LS' implies something more specific.

- Recent usage of legacy without explanation or modification implies ***anthropogenic origin***.
- Legacy pollution & legacy contamination have earlier history
  - Searches on *Wiley Online & Science Direct* for 'Legacy pollut\*' & 'Legacy contam\*' show increased use of 'legacy' after 2000.

James,  
*Anthropocene*,  
2013



# Early Use of LS in Publications

- Earliest: 2004 concerned with copper contamination from LS on water quality (*Novotny 2004*).
- Use proliferated after 2004 in geomorphology, hydrology, ecology, env. toxicology & planning.
- Increased further with legacy mill-pond surveys in PA (*Walter and Merritts, 2008; Merritts et al., 2011*). Neither paper used 'LS', but the authors used it in abstracts & field trip logs in association with alluvium in legacy mill ponds.

# Early Definitions of LS

- Previous definitions of LS were somewhat narrowly constrained to valley bottom alluvium in the post-colonial era.

*“Sediment that was eroded from upland hill slopes after the arrival of **early Pennsylvania settlers** and during centuries of intensive land uses; that deposited in valley bottoms along stream corridors, burying pre-settlement streams, floodplains, wetlands, and valley bottoms; and that altered and continues to impair the hydrologic, biologic, aquatic, riparian, and water quality functions of pre-settlement and modern environments. Legacy sediment **often accumulated behind ubiquitous low-head mill dams** and in their slackwater environments, resulting in thick accumulations of fine-grained sediment that contain significant amounts of nutrients.”* (Hartranft, Merritts, and Walter, PDEP, 2006)

***Emphasis added.***

Penn. Dept. Env. Prot. (PDEP), Legacy Sed. Workgroup.

## ***A Broader Definition of LS has Emerged***

- Implied by much current use that equates 'LS' with postsettlement alluvium (PSA) and other anthropic deposits (*Hupp et al.*).
- Definition should include (1) colluvium, (2) non-agricultural land uses (mining, deforestation, domestic grazing, etc.), (3) non-North American locations, (4) pre-Columbian aggradation-degradation episodes.
- Definition extends to entire facies:
  - From colluvial aprons, to streams, to floodplains, to fine-grained slack-water deposits.

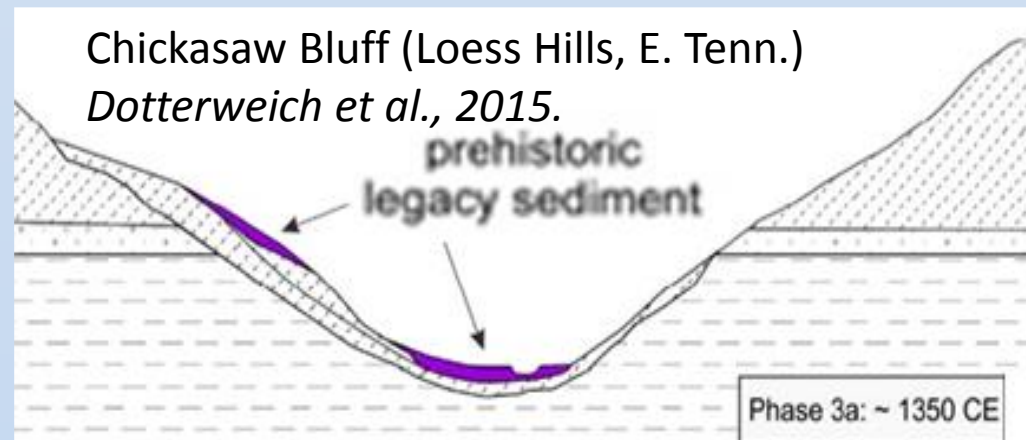
Stratified legacy sediment over pre-settlement soil, Clarks Fork, SC.

*James, Anthropocene, 2013*



# Types of LS Deposits

- **Hillslopes** - colluvial deposits from mass wasting, sheet flow, rills, or gullies
  - \*) **Cascades** (aka) **Midslope drape**: separated pockets near site of hillslope erosion.
  - \*) **Apron**: sediment wedge at base of slope
  - \*) **Fan**: at mouths of gullies, debris flows & tributaries.



Based on European Cascade model (Lang et al., 2003)



# Types of LS Deposits

**Floodplains** – alluvium from lateral & vertical accretion.

\*) **Graded**: continuous floodplain deposits; abundant delivery

\*) **Punctuated**: –LS only at local storage sites; limited delivery.

**Lakes, Wetlands, estuaries & other low-lying areas** – prograding deltas & fine-grained slackwater deposits.

**Beaches** – fluvial sed. delivered to coastal beach-dune complexes.

Hydraulic mining sediment;  
Greenhorn Creek, Calif.

Punctuated



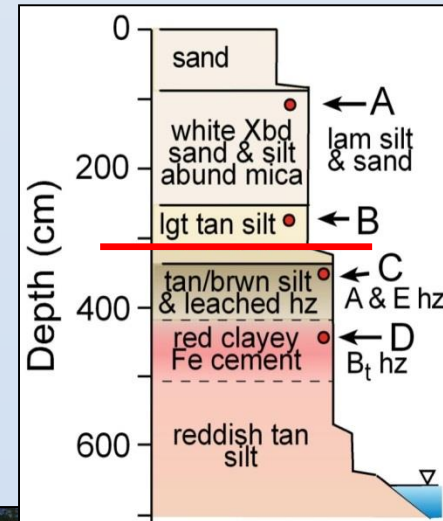
Graded LS



# Hydraulic Mining Sediment 70 km Below Mines

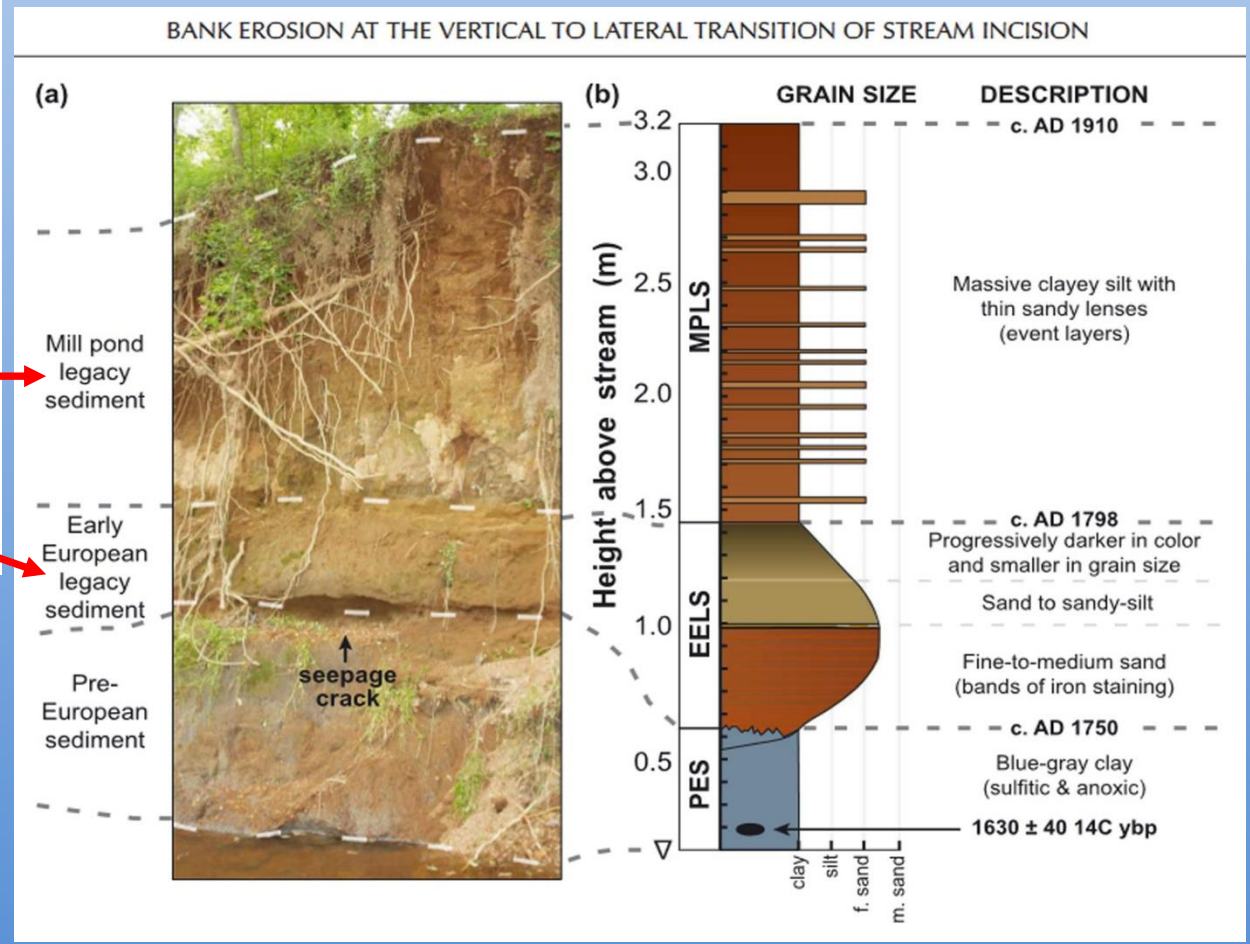
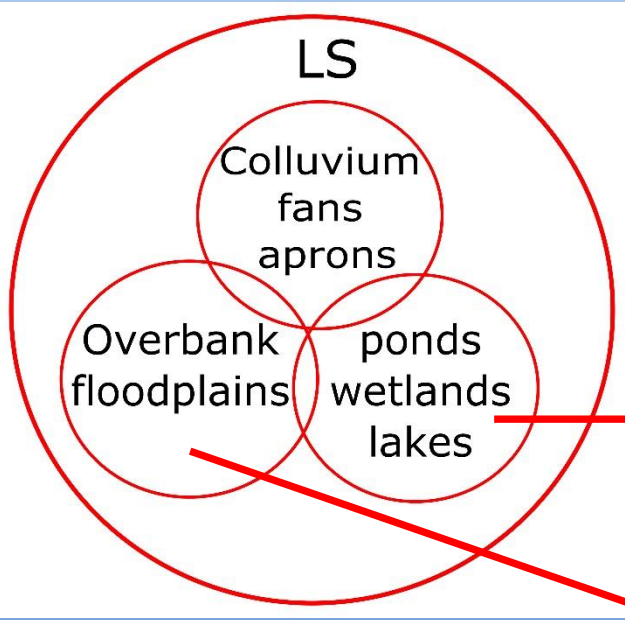
Clear soil stratigraphy: soils buried by 3 m LS with distinctive geochemistry (high AU and Hg).

LS forms distinct lithostratigraphic unit.



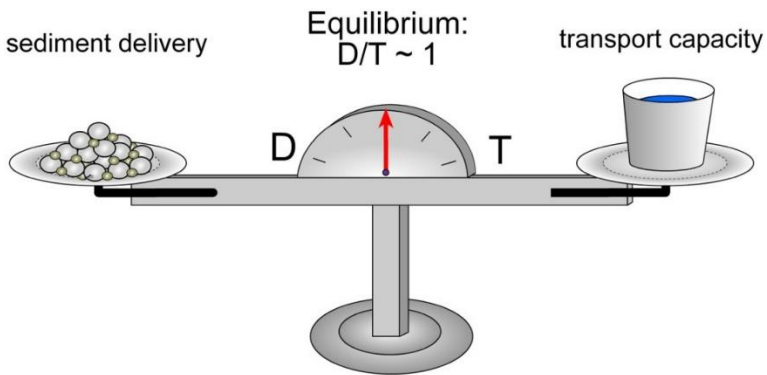
Pre-settlement soil buried by 3 m of hydraulic mine tailings. Feather River, California.

- Mill pond LS overlying pre-pond, post settlement LS.  
(Lyons, Wegmann, et al. 2015, ESPL)



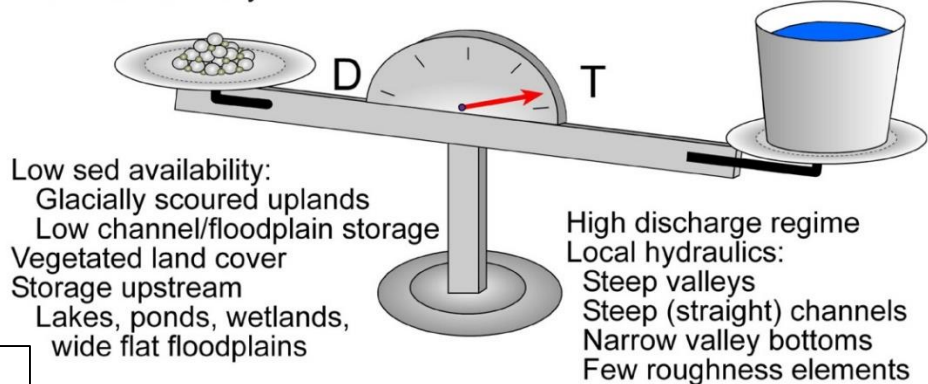
# Why LS here and not there? sed delivery / transport capacity

$D/T \leq 1 \rightarrow$  erosion & degradation



$D/T \sim 1 \rightarrow$  equilibrium  
and graded deposits

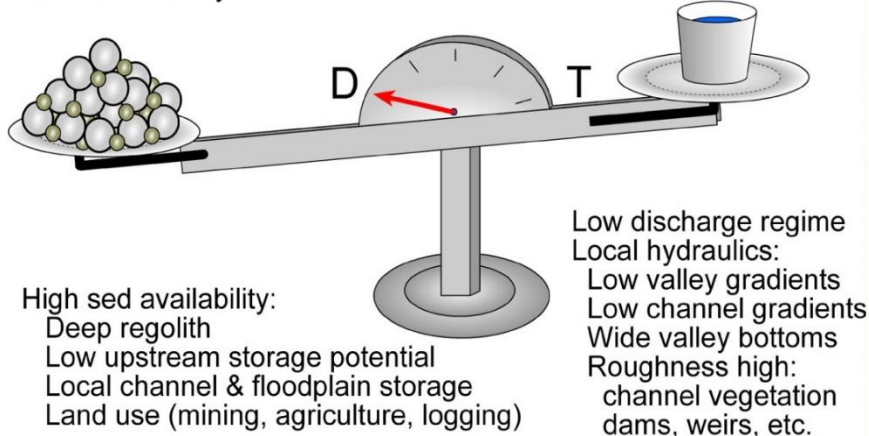
Transport Dominated:  
 $D/T < 1$



$D/T > 1 \rightarrow$  channel deposition  
& aggradation

$D/T \gg 1 \rightarrow$  floodplain deposition  
& aggradation

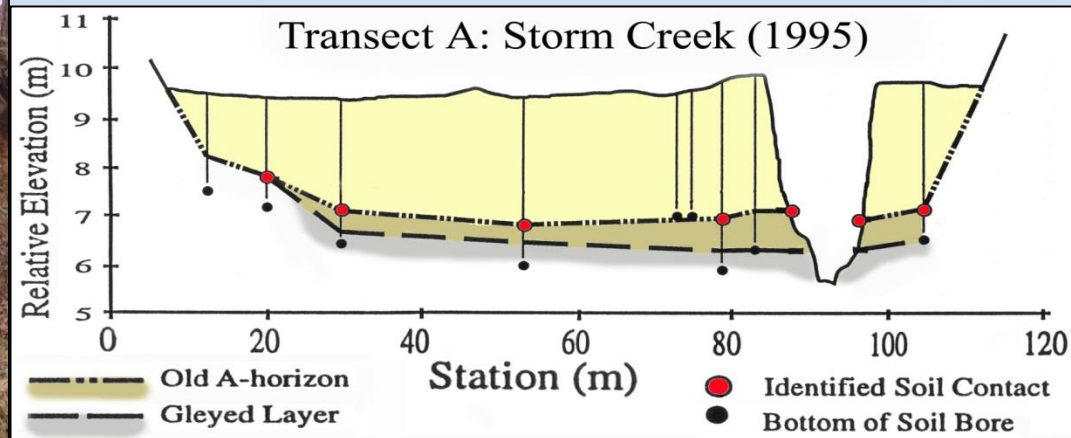
Delivery Dominated:  
 $D/T > 1$



Adopted from Lane

# Conclusions

- LS is episodically produced anthropogenic sediment, regardless of where, when, or how it occurred.
- Includes alluvium, colluvium, lacustrine or deltaic sediment
- Type may shift along facies.
- Sed delivery/transport capacity determines how much LS is stored in channels or on floodplains.



LS in Storm Creek, South Carolina Piedmont

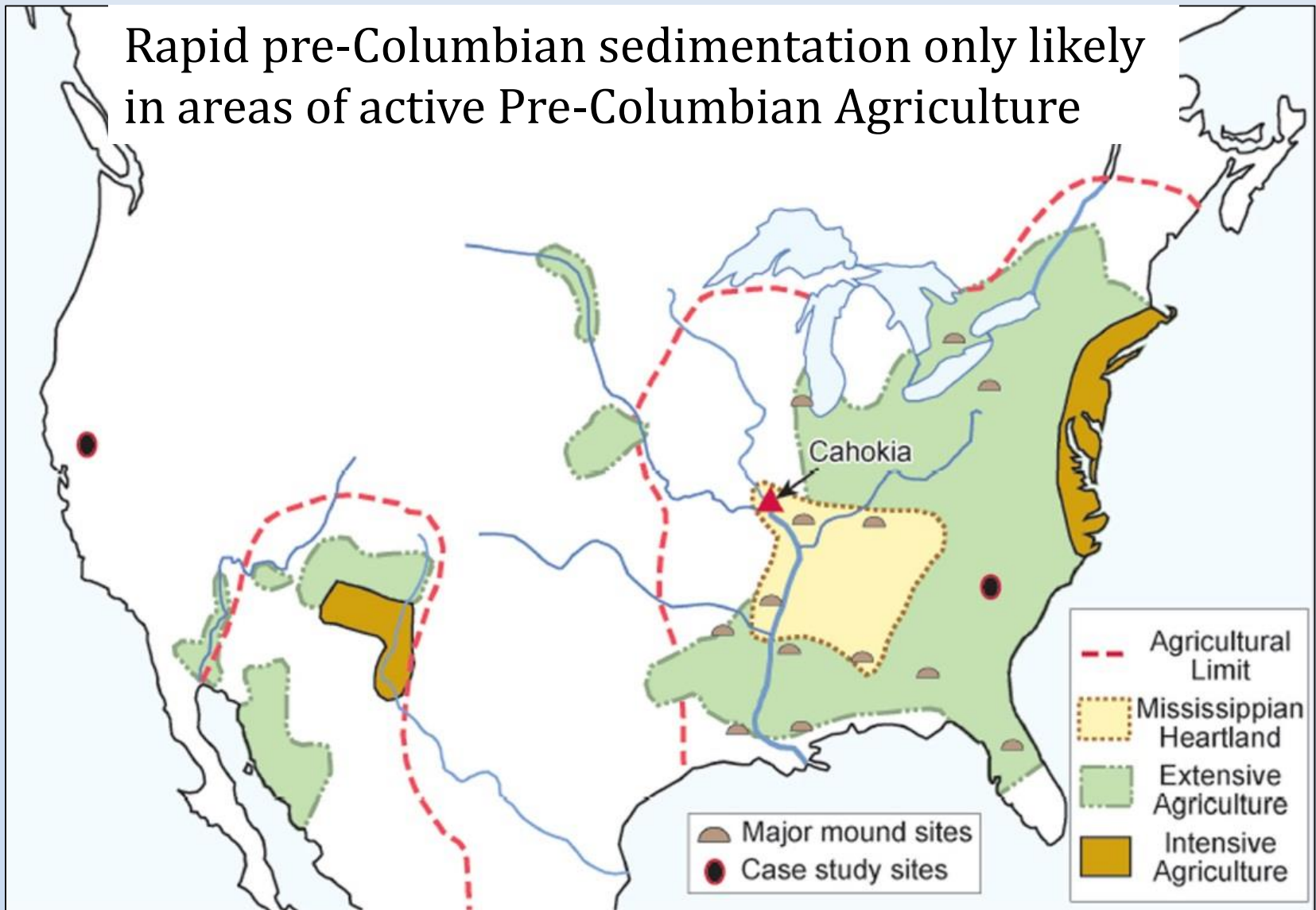
# Pocket Slides

- In the New World most LS is post-Columbian but mid-Atlantic states may have exceptions.
  - High spatial variability of pre- & post-Cola LS has not been mapped.
  - Pre-Cola LS limited in geographic extent but important in some regions (e.g. MesoAmerica).
  - High spatial variability of post-Cola LS.

# Spatial Patterns of Anthropogeomorphic Change at Continental or Regional scale

- LS is well documented in SE & Mid-Atlantic Piedmont; upper Midwest; California mining districts.
- Incomplete mapping in many regions may be due to:
  - Few, thin, or no LS: Myth of colonial devastation (*Butzer*).
  - LS not exposed - remains buried
  - Lack of field mapping & research.
  - Indistinct pre-settlement soils:
    - gleysols,
    - weak floodplain pedogenesis (fluvents),
    - instable surfaces (climate change, geomorphic activity),
    - rapid pre-Columbian sedimentation.

# Rapid pre-Columbian sedimentation only likely in areas of active Pre-Columbian Agriculture

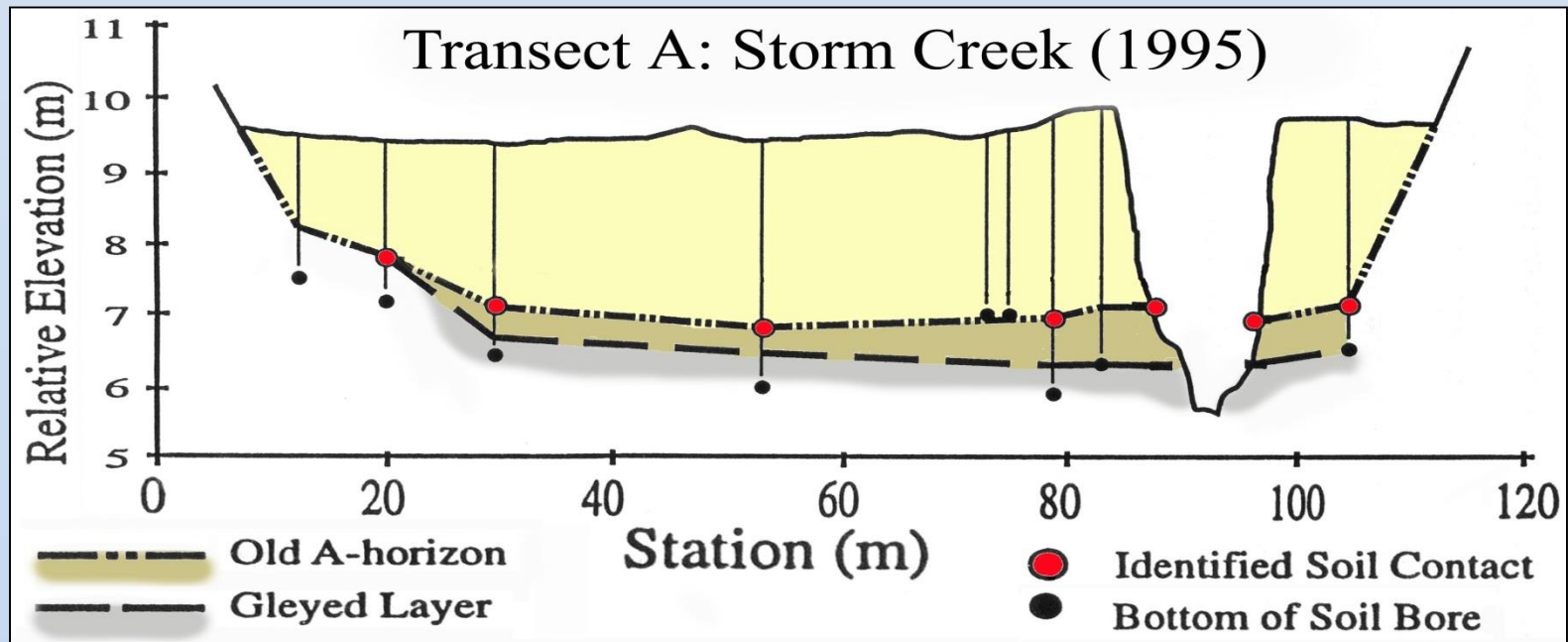


Areas of intensive pre-colonial agriculture; many areas had little or no agriculture. *James, 2011. Sources: Butzer, 1990; Denevan, 1992; Delcourt & Delcourt, 2004.*



- Three transects cored across small floodplain show shallow buried soil.
  - Bedrock exposed in present channel bed.
  - $^{14}\text{C}$  date of tree trunk at base of section is historical.
  - Pre-settlement channel had low banks & shallow fill floodplain.

## Little pre-Columbian Sediment



James,  
2006

Top of pre-settlement soil



Thick legacy sediment (historical) over thin buried channel banks (logs). Channel bed is on bedrock so pre-historic valley bottom had limited sediment storage.

A more specific ‘technical definition’:

*“Sediment that (1) was eroded from upland slopes during several centuries of intensive land clearing, agriculture, and milling (in the eastern U.S., this occurred from the late 17th to late 19th Centuries); (2) collected along stream corridors and valley bottoms, burying pre-settlement streams, floodplains, wetlands, and dry valleys; and that altered the hydrologic, biologic, aquatic, riparian, and chemical functions of pre-settlement streams and floodplains; (3) **accumulated behind ubiquitous low-head mill dams in slackwater environments**, resulting in thick accumulations of fine-grained sediment, **which distinguishes ‘legacy sediment’ from fluvial deposits associated with meandering streams**; (4) can also accumulate as coarser grained, more poorly sorted colluvial (not associated with stream transport) deposits, usually at valley margins; (5) can contain varying amounts of total phosphorus and nitrogen, which contribute to nutrient loads in downstream waterways from bank erosion processes...”*

**Emphasis added.**

*Hartranft, Merritts & Walter, 2006, PDEP Legacy Sediment Workgroup.*

# Recent Definitions

- *“Legacy sediment is primarily alluvium [and colluvium\*] that was deposited following human disturbances in a watershed. The disturbance may have been in the form of deforestation, plowing agricultural land, mining, or other land-use changes. In North America and Australia, legacy sediments are ubiquitous and represent episodic erosion in response to the colonization of land by European settlers who introduced Old World land-clearance technologies (e.g. steel tools and plows pulled by draft animals) and export economies. In these settings, legacy sediments are often described as post-settlement alluvium (PSA), which may cover entire floodplains and bury the pre-settlement soil with a thick mantle of relatively young stratified sediment (Griffiths 1979; Knox 1972, 1977, 2006).*  
(James, 2010, *Geography Compass*, p.588)

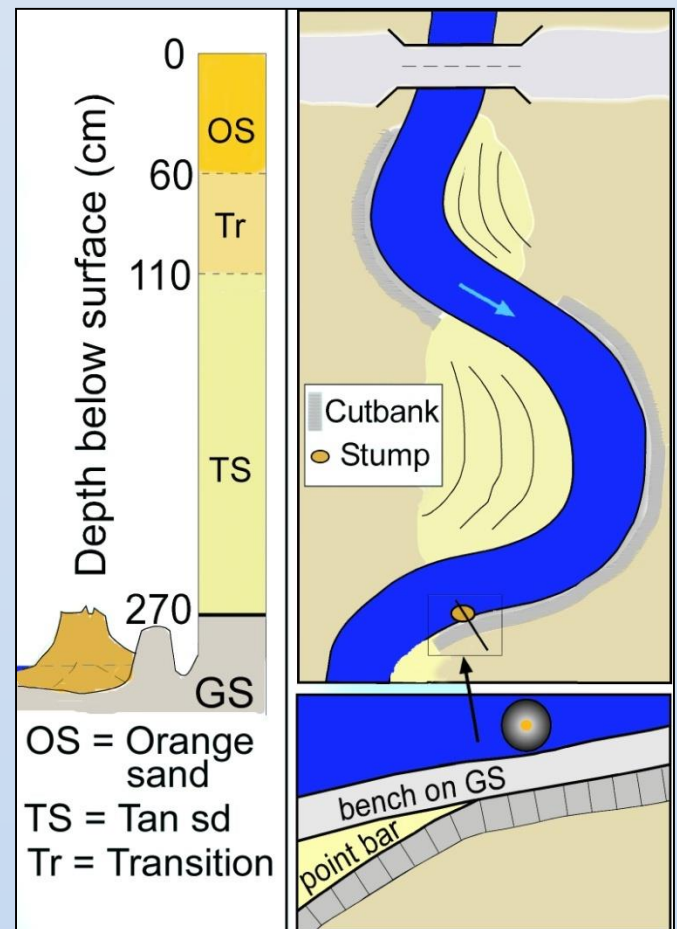
- *“Legacy sediment: Earth materials—primarily alluvium [or colluvium\*]—deposited following human disturbances such as deforestation, agricultural land use, or mining. The phrase is often used to describe post-European floodplain sediment, also known as post settlement alluvium...”*

(James, 2013, *Treatise on Geomorphology*, Glossary)

\* ‘[and colluvium]’ added in definitions listed by James, 2013.

# SE Piedmont Example

- Sedimentation in southern piedmont of South Carolina occurred in valley bottoms with little sediment. (*Happ, 1945; Trimble, 1974; James, 2006*)
- Most stream beds were on bedrock at time of settlement.



# ***LS as a Stratigraphic Unit***

- ***Lithostratigraphic units*** (LSU) - distinct lithic or pedogenic features; conform with Law of Superposition. Mapped by physical properties (*NACSN, 2005; Murphy & Salvador, 1994*).
  - LS conforms w/law of superposition, but lithic/pedogenic features may differ between basins. LS may have distinct soil strat, sed texture/structure, geochem, or fossils that can be used to fingerprint or infer processes & env of formation.
- ***Chronostratigraphic units*** (CSU) - reference material for other sed deposited during same period; consist of materials from same period.
  - LS may be time transgressive & vary in age. Often from a distinct period of LU & settlement and can be traced across a landscape. Thus, LS may document Anthropocene history.

*James, 2013, Anthropocene*