The Age and Origin of Scallop Floodplain Benches from Difficult Run, Fairfax County, Virginia

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I. Introduction

Previous studies have looked at the storage of sediment in downstream reaches of Difficult Run in Fairfax county, VA[1] as well as scalloped bank erosional features on rivers geographically similar to Difficult Run[2]. Recent field observations and LiDAR maps have identified sediment deposits accumulating in scalloped eroded banks on the river near Leesberg Pike, the site identified with the highest floodplain and bank deposition rates by Hupp et al. (2012). This study intends to look at the origin and age of sediment deposits within scalloped eroded banks, termed Scallop Floodplain Benches (SFB) by this group, to determine their importance as storage features in the sediment budget of Difficult Run.

II. Field Site

Difficult Run is a 5th order stream in a suburban watershed with a forested riparian zone. Difficult Run near Leesburg Pike (Site 4 on Fig.1) has a sediment load of 7641 tons/year. Annual floodplain deposition is 219 tons/year.

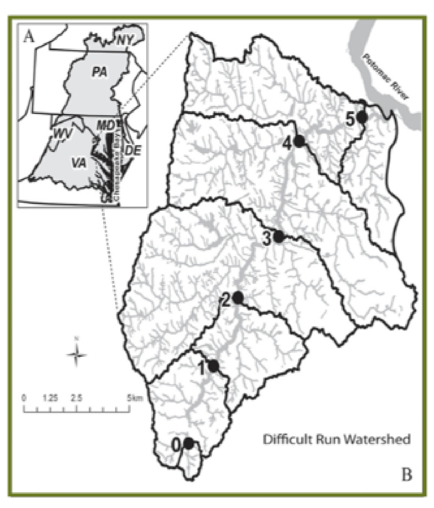

Figure 1: Map of Difficult Run Watershed in Fairfax County, VA[1]

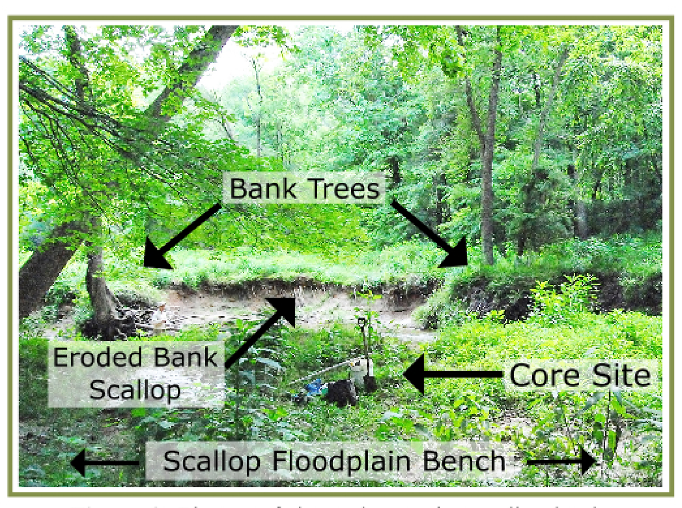

Figure 2: Picture of site and opposite eroding bank,

Scallop Floodplain Benches are deposited in scallop shaped erosional scarps formed between trees on the bank. There are two Scallop Floodplain Benches on Difficult Run near Leesburg Pike and 16 scallop-shaped eroded banks (see Panel V).

Hypothesis: Field observations and the absence of trees on the deposit suggest that the Scallop Floodplain Bench was deposited during the last few decades.

III. Field Methods

Core samples were collected at an interval of 3 cm to 21 cm, 5 cm to 45 cm, and 14 cm to 118 cm from a 45 cm deep soil pit and 118 cm deep core on a Scallop Floodplain Bench near Leesburg Pike on June 24, 2015.

Bulk Density samples were collected from the pit and the bank.

Figure 3: Scallop Floodplain Bench being sampled. The original scalloped eroded bank is highlighted (Also, see Panel V).

Figure 4: Soil Pit and Core

Flood deposits were collected from the surface (3 on the bench and 4 upstream) from a flood event that occurred on June 20th.

IV. Laboratory Methods

Figure 5: Canberra HPGe Detector

Activities for $^{210}Pb_{ex}$, ^{137}Cs, and ^{7}Be were measured on Canberra High Purity Germanium Detectors (Model: GL2020R)

Grain Size samples were analyzed on a Coulter Counter at the USGS in Reston, VA.

V. Mapping and Stratigraphy

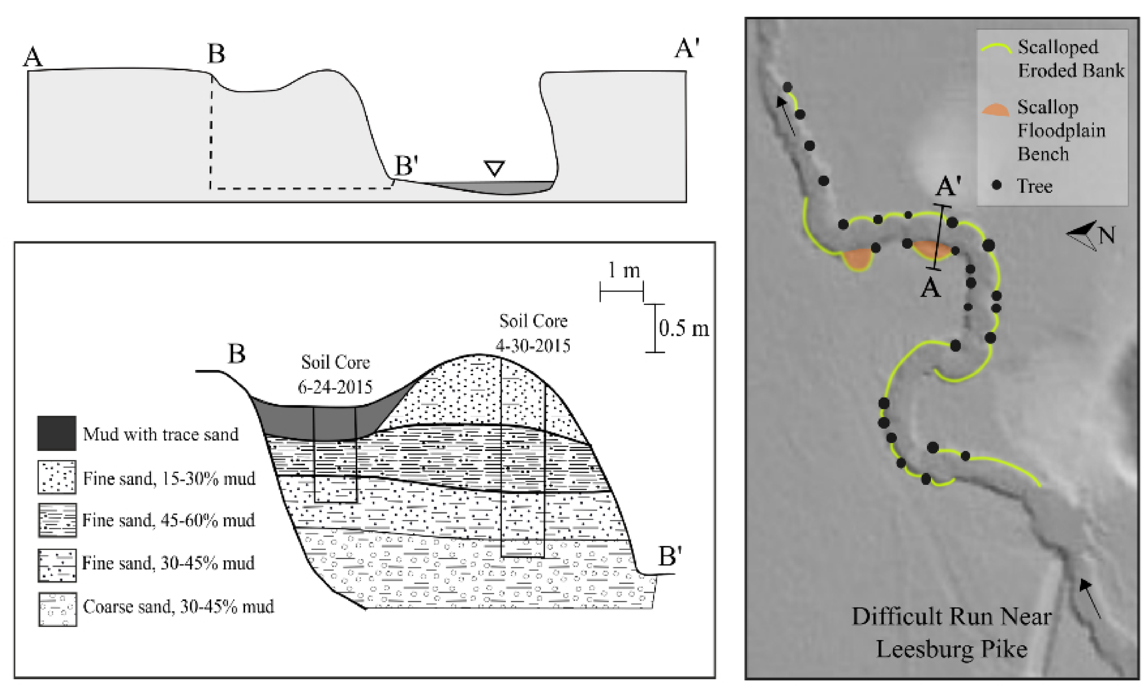

Figure 6: Cross section and location of Scallop Floodplain Bench on Difficult Run

VI. Development

A 6 stage conceptual model of the Scallop Floodplain Bench was constructed from the stratigraphy (Figure 6), grain size data and field observations.

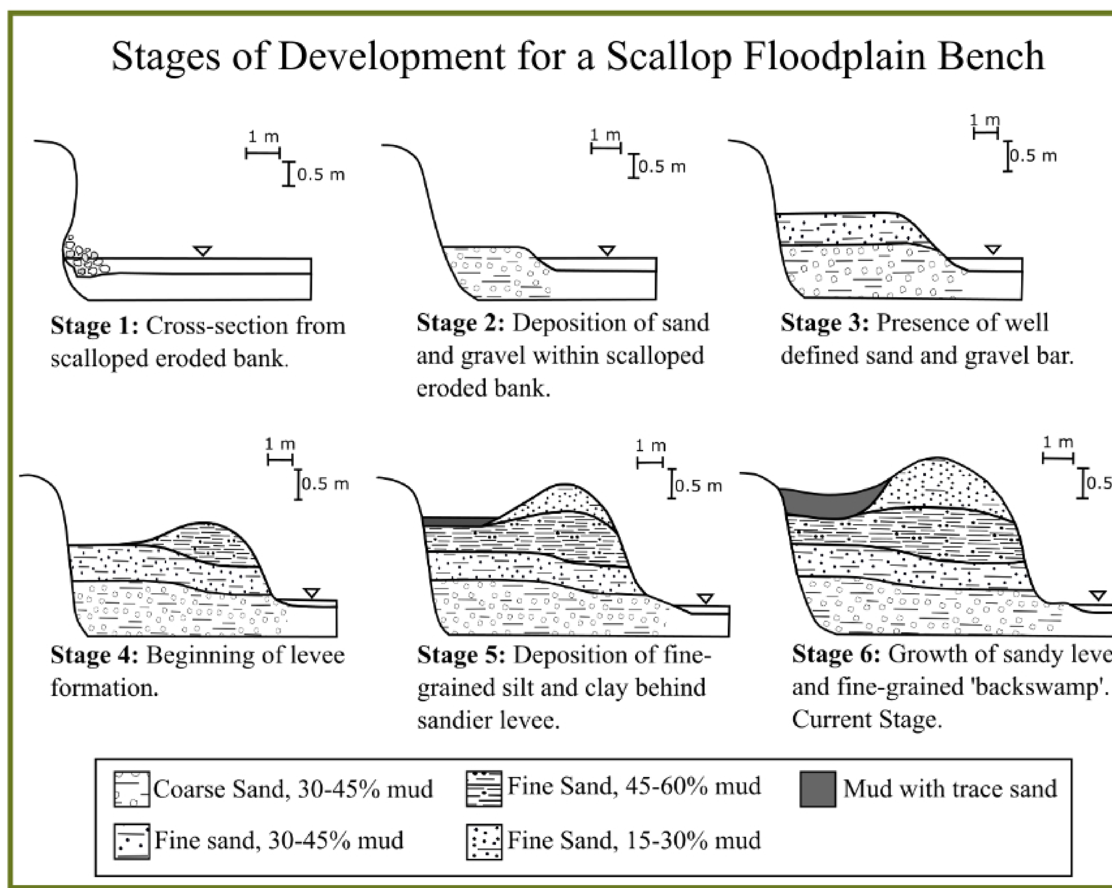

Figure 7: Developmental stages of a Scallop Floodplain Bench in cross-section.

Current Stage is stage 6 for the studied Scallop Floodplain Bench. The current surface area is 85.3 m^2 and the current volume is 300 m^3.

VII. Nuclide Activities

^{7}Be activity (not graphed below) was absent below the surface and in the 4 recent flood deposits sampled upstream of the study site. The bench flood deposits have ^{7}Be activities of 64 Bq/kg, 39 Bq/kg, and 28 Bq/kg.

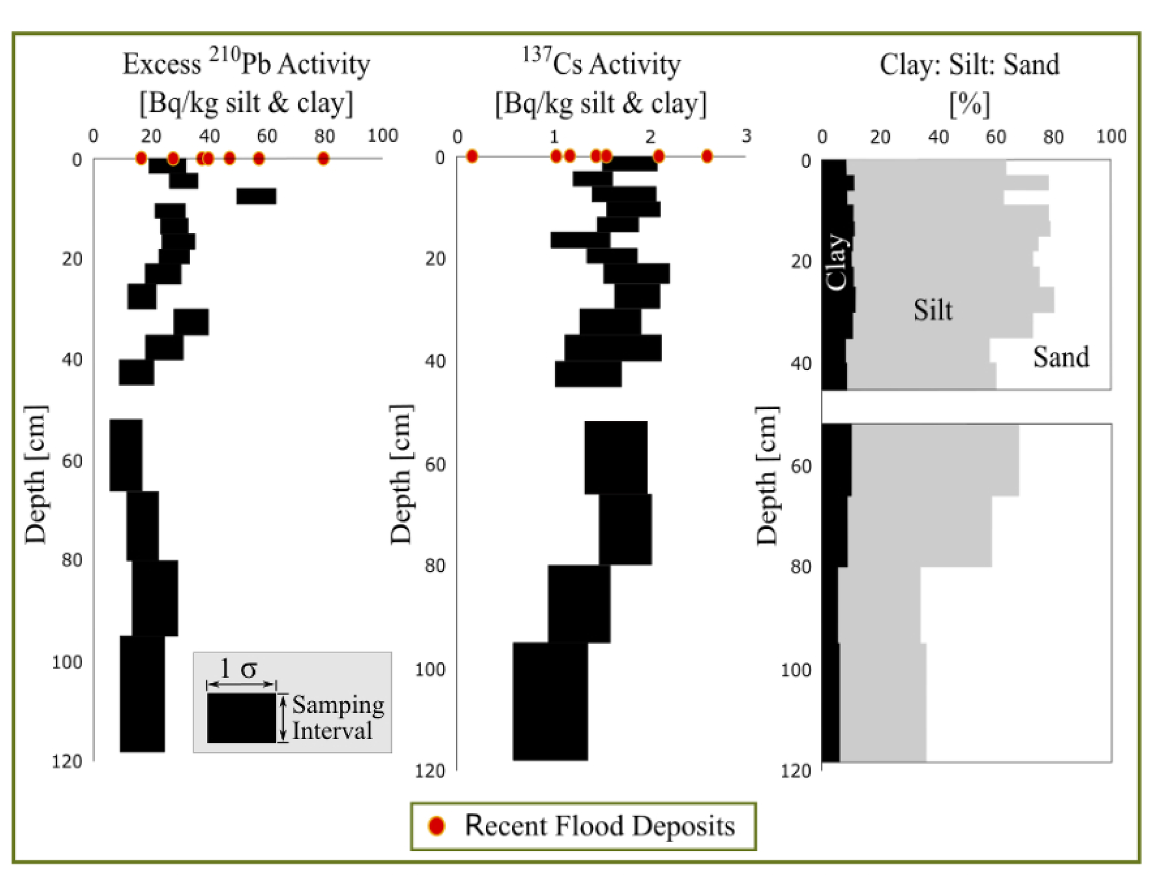

Figure 8: Activities at depth for radionuclides compared to grain size at depth

^{137}Cs activity decreases minimally with depth and has no significant peak. Flood deposit activities vary by an order of magnitude.

^{210}Pb$_{ex}$ activity is relatively constant to depth with a peak value at 6 cm. Flood deposit activities vary by a factor of 4.

VIII. $^{210}Pb_{ex}$ Age Models

Constant Rate of Supply Model uses surface $^{210}Pb_{ex}$ activity (A_0, units: Bq/kg), the decay constant (k, units: 1/year), the deposit depth (d, units: cm), atmospheric ^{210}Pb deposition (P_0, units: Bq/cm^2), and total $^{210}Pb_{ex}$ inventory (N, units: Bq/cm^2) to obtain an age date (t, units: years) .

$$\textbf{CRS Model: } N = \frac{[P_0 + A_0(\frac{d}{t})]}{k}(1 - e^{-kt})$$

The CRS Mode computes an approximate age of 13.5 years for the base of the deposit.

Constant Initial Concentration Model uses $^{210}Pb_{ex}$ activity (A, units: Bq/kg), sedimentation rate (w, units: cm/year) and variables described above to calculate an age.

$$\textbf{CIC Model: } A = A_0 e^{-kd/w}$$

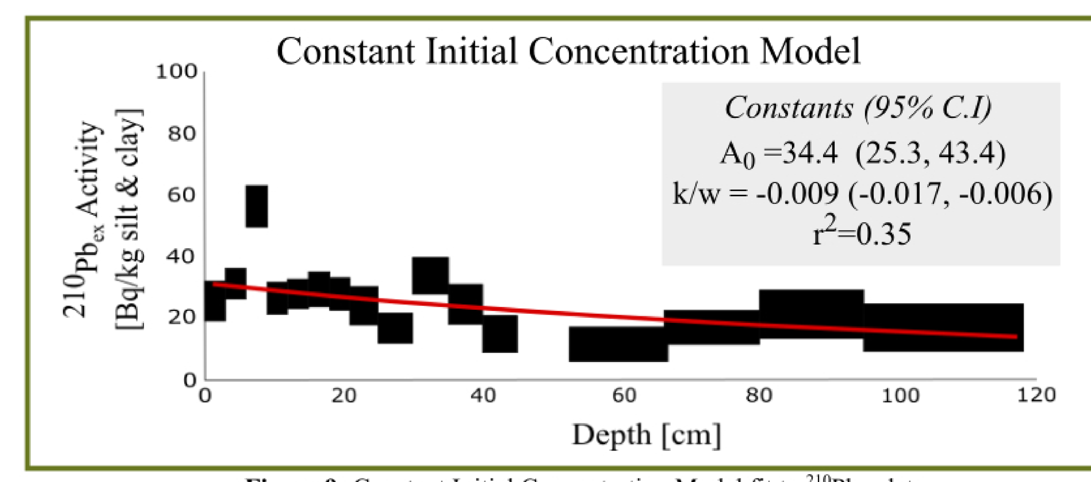

Figure 9: Constant Initial Concentration Model fit to $^{210}Pb_{ex}$ data

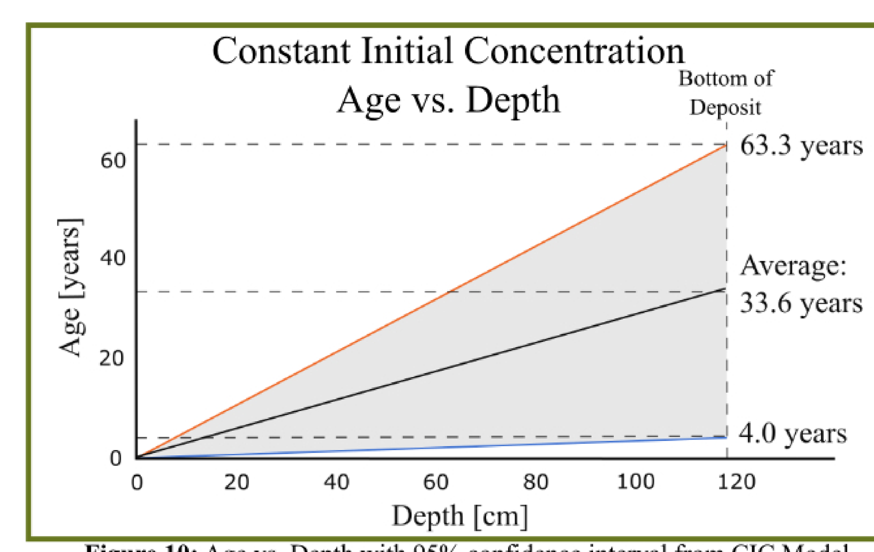

Figure 10: Age vs. Depth with 95% confidence interval from CIC Model

The CIC Model computes a sedimentation rate of 3.5 cm/year, making the base of the deposit 33.6 years old.

IX. Conclusion

Age of the Scallop Floodplain Bench is likely in the lower interval of the C.I.C. Model (4 to 33.6 years) or approximately the age from the C.R.S. Model (13.5 years). The absence of a significant ^{137}Cs peak means the bench was deposited after 1963.

Development started with the deposition of a sand and gravel bar in a scalloped eroded bank. The deposit grew with vertical accretion, eventually developing a sandy levee adjacent to the river and a fine-grained backswamp.

Sediment storage is occurring at a rate of 27 tons/ year at the study site (based on the volume, bulk density, and age of the bench). This is equal to 0.35% of the total sediment load and 12.3% of deposition in Difficult Run near Leesburg Pike.

X. Acknowledgements

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XI. Sources

[1] Hupp, C. et al., Recent and historic sediment dynamics along Difficult Run, a suburban Virginia Piedmont stream, Geomorphology (2012), doi:10.1016/j.geomorph.2012.10.007

[2] Pizzuto, J. et al., On the retreat of forested cohesive riverbanks, Geomorphology (2009), doi:10.1016/j.geomorph.2009.11.008

XII. Contact Information

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