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Applying Dendrogeomorphic Methods to Determine Site Specific Annual Erosion Rates – A Quick and Cost Effective Alternative to Using Erosion Pins

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Riverbank Erosion

The rate at which streambanks are eroding, and the total annual quantity of sediment being entrained from eroding streambanks are of a primary concern for ecological, water quality, and sedimentation studies.

- Streambank erosion is responsible for upwards of 80% of total sediment yield in some rivers (US EPA, 1990)
- Where contaminants are bound to riverbank sediments, erosion poses a primary means by which contaminated sediments are transported downstream
- Need methods to quickly calculate erosion rates at specific locations
- Some common methods to calculate annual erosion rates include:

Exposed roots on an erosive streambank

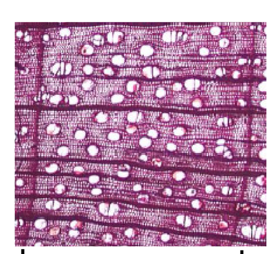
Method	Pro	Con
Direct measurement (e.g, erosion pins, bank surveys, etc.)	• Most commonly used method • Accurate	• Requires annual monitoring • Several years of data needed • No hindcasting
Time trend analysis of historic maps/photos	• Gives long-term erosion rates quickly • Inexpensive	• Not as accurate due to scale • Only used for high erosion rates
Sedimentological/biological monitoring	• Accurate	• Expensive/labor intensive • Complicated data analysis • Requires several years of data
Dendrogeomorphology	• Accurate • Economical • Generate large data sets rapidly • Great for hindcasting erosion rates • Great for forecasting erosion rates	• Need exposed tree roots to sample • Weak annual growth ring formation in sub-tropical trees will require a more advanced skill set to analyze

- **Dendrogeomorphology** provides a quick and cost effective method for calculating annual erosion rates

Using Dendrogeomorphology to Quantify Streambank Erosion

What is Dendrogeomorphology?

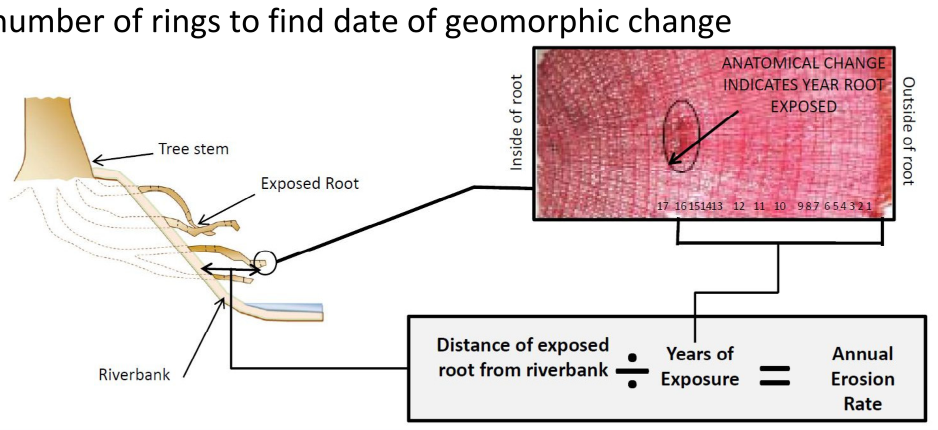
Using tree rings to identify dates of changes in land surface (riverbanks, hillsides, lakeshores)



Annual Growth ring on the cross-section of a tree stem

How does it work?

- Tree anatomy changes in response to environmental factors (e.g., landslide, lakeshore, streambank and hillslope erosion)
- Change reflected in growth rings of tree
- Count number of rings to find date of geomorphic change



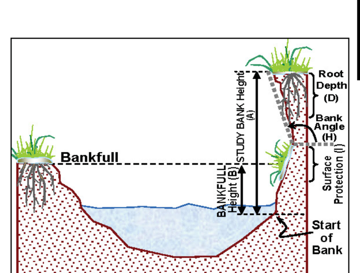
Methods – Root Collection and Sample Preparation

Field Sample Collection

- Select live, healthy, exposed tree roots with a 2" minimum diameter
- Measure distance between root and river bank (1" minimum)
- Cut samples from bank using a handsaw first marking the top of the tree root
- Take multiple samples from each tree along vertical and lateral distribution
- Perform a Bank Erosion Hazard Index (BEHI) analysis on bank as measurement of erodibility

Collecting roots samples from eroding streambank

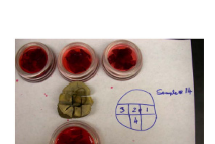
Exposed roots sampled from eroding streambank



Multiple bank variables measured in a BEHI analysis

Root Sample Preparation

- "Disks" cut into small samples (15-90µm thickness)
- Stained with safrannin and mounted on glass slides for microscopic analysis of cellular structure



Samples Prepared for Microscopy

Methods – Laboratory Analysis

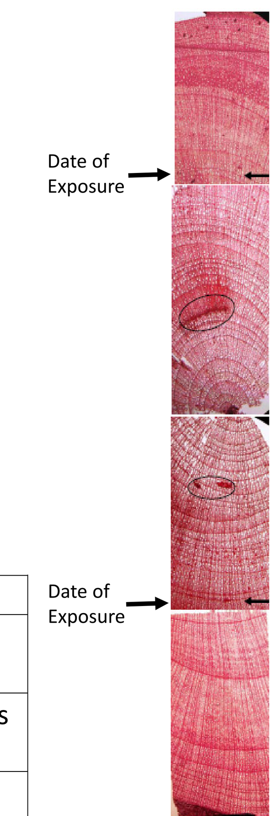
Analysis of Samples

- Date of exposure identified using macroscopic and microscopic indicators

Indications of Root Exposure

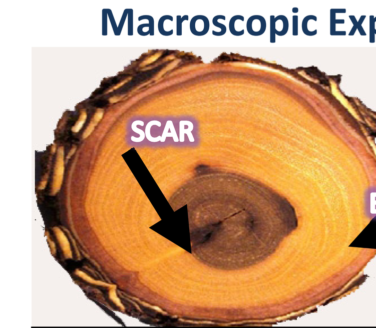
- Hardwood species easiest to detect change
- Looking for visible scarring, root eccentricity, change in vessel size, change in vessel arrangement, change in growth ring width, etc.
- Cellular response differs based on species and type:

Species Type	Response in Tree Anatomy
Diffuse-porous Hardwoods (Maples, Cottonwoods, Dogwoods, Alders, etc)	Vessel size and arrangement clearly takes on earlywood and latewood structure Vessel size decreases while the number of vessels increases in post-exposure rings
Ring-porous Hardwoods (Elms, Hackberry, Ash, Oaks, etc)	Distinct change from diffuse-porous type vessel arrangement to ring-porous structure (resembling tree stem cell anatomy)

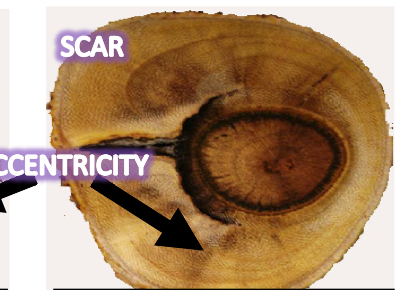


Cross section of root sample

Macroscopic Exposure Indicators

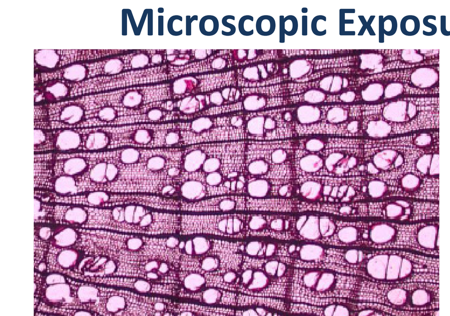


Cut disk of hackberry root (*Celtis spp.*)

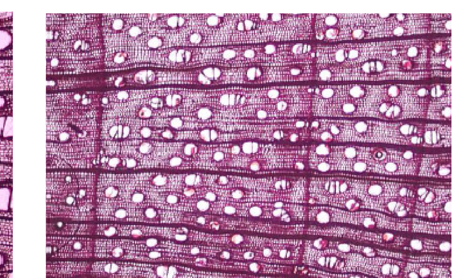


Cut disk of elm root (*Ulmus rubra*)

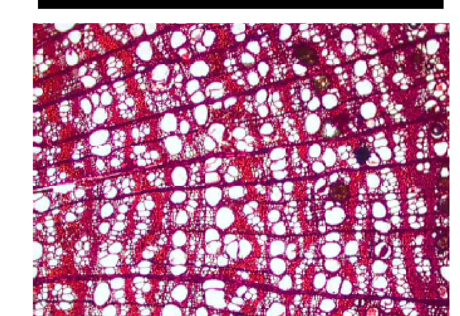
Microscopic Exposure Indicators



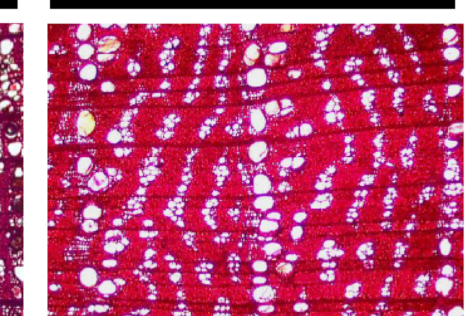
BEFORE EXPOSURE



AFTER EXPOSURE



BEFORE EXPOSURE



AFTER EXPOSURE

Projects and Results

Results

- Dendrogeomorphology has been tested on several projects and has shown high levels of accuracy in predicting annual erosion rates

How was BEHI used?

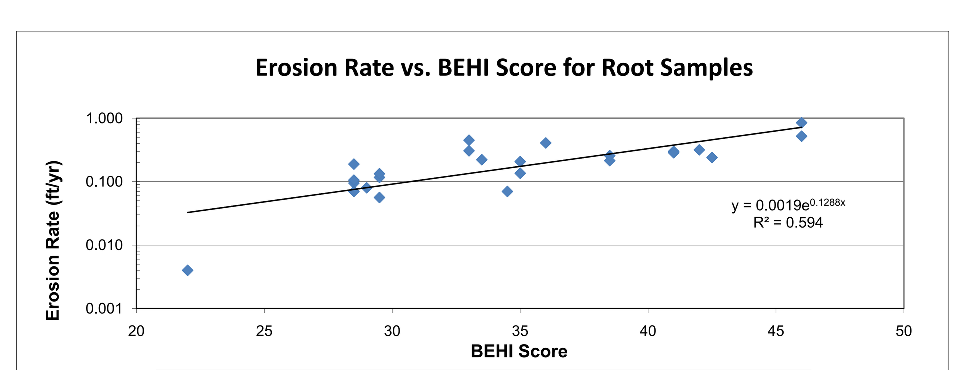
- To assess/test the accuracy of the dendrogeomorphology erosion rate prediction method
- Allow the ability to predict erosion rates (from erosion rate curve)

Confidential Site – Midwestern U.S.

- River had several highly erosive streambanks
- Erosion causing sediments to become mobile within the water system
- Client needed a quick/effective way to quantify erosion rates at specific locations of banks to track and quantify sediment flux

Exposed roots on a section of the River

Eroding streambank on the River



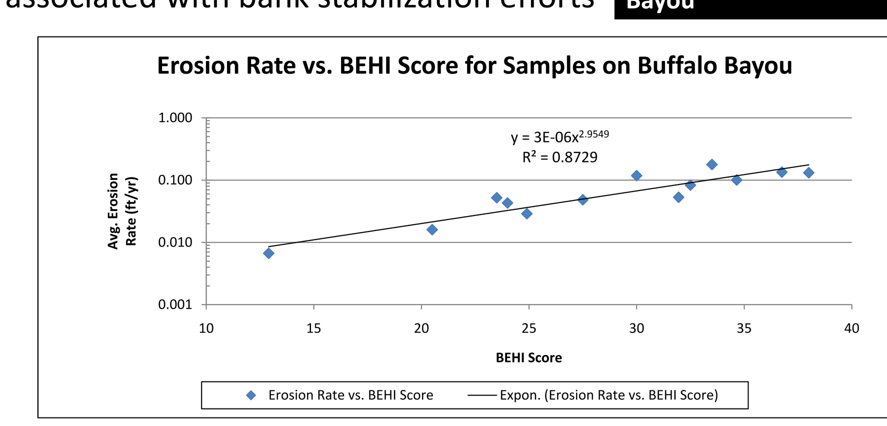
Results suggest:

- Erosion rate can be estimated from BEHI score where no direct erosion rate measurements had previously been made
- Strong ability to predict erosion rates (indicated by high R^2 values)

Buffalo Bayou – Houston, TX

- Unstable channel is causing threats to infrastructure and increased flood damage potentials
- Client needs stream specific erosion rate to provide sediment reduction numbers associated with bank stabilization efforts

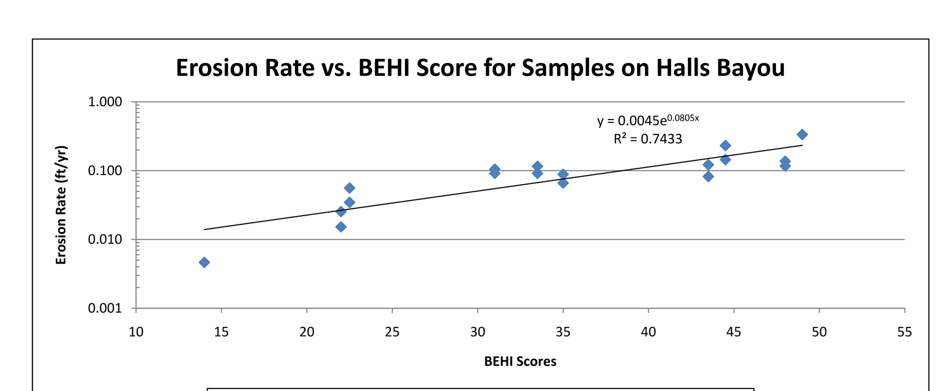
Eroding streambank on Buffalo Bayou



Halls Bayou – Houston, TX

- Client needed to establish an erosion rate curve to use for prediction of entrainment at any point along the study reach of Halls Bayou

Eroding streambank on Halls Bayou



Benefits of Using Dendrogeomorphic Methods to Determine Site Specific Erosion Rates

Significant Time and Cost Savings Over Alternative Bank Erosion Measurement Methods

- Root analysis provides erosion rate data quicker and with less cost than other methods

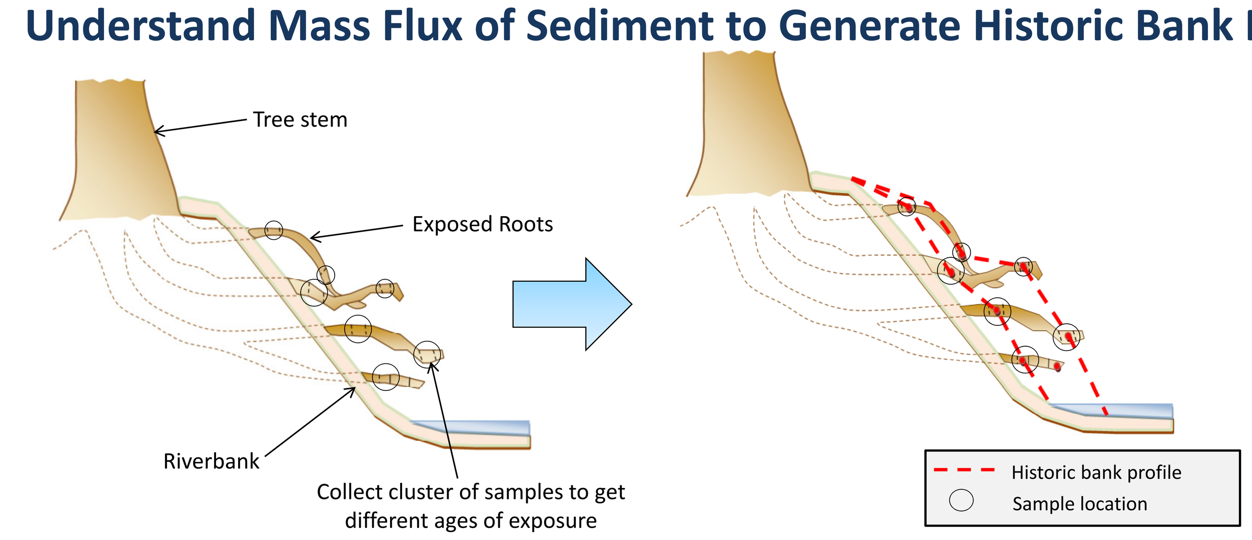
Exposed root sampled from an eroding bank

Analysis Used	Time Investment
Root Analysis	Collection: 20 samples per day; Sample preparation time: 10 samples per day; Analysis of samples: 15 samples per day
Erosion Pins	Install 20 bank pins/day; Minimum yearly monitoring of pins; Need at least 3 years of data to see meaningful trends

Create Site Specific Erosion Rates

- Avoid the reliance on regional erosion rate curves
- Results suggest erosion rate data varies largely on a site to site basis
- More accurate representation of erosion rate than using regional erosion rate curves
- Quick calculations of annual erosion on specific rivers/streams can be extremely critical if contaminated sediments are present (to track the fate and transport of contaminants)
- A great metric for prioritizing sites along the banks of streams
- Create real world numbers to establish baseline data to monitor success of restoration projects

Understand Mass Flux of Sediment to Generate Historic Bank Profiles



- Analyze historic trends of bank erosion through bank profile recreation
- Predict future migration of river and estimate mass flux of sediments

Potential Disadvantages to Method

- Longer-exposed samples may not reflect current susceptibility of bank to erosion
- Difficult to obtain samples on banks with worst and least susceptibility to erosion
- Climactic variations can cause difficulty in analysis, mainly in subtropical geographies

Conclusions

Dendrogeomorphic assessments of tree roots provides an effective means for estimating annual erosion rates on site specific riverbank locations

- Dendrogeomorphic assessment presents the best predictor of erosion rates in the absence of erosion pins or bank profiles
- Assessments proven to be reliable and inexpensive
- Samples can be collected with little time investment and training

References

United States Environmental Protection Agency., 1990. Managing Nonpoint Source Pollution: Final Report to Congress on Section 319 of the Clean Water Act (Washington, D.C.: US EPA).

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