Living Erosion Pins - Streambank and Hillslope Erosion Rate Assessments using Exposed Tree Roots

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- Traditional assessment methods
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WHY ASSESS STREAM BANK EROSION?

- Threat to infrastructure
WHY ASSESS STREAM BANK EROSION?

- Loss of land and channel capacity
WHY ASSESS UPLAND AND STREAM BANK EROSION?

- Excess sedimentation, nutrient loading, and contamination
WHY ASSESS STREAM BANK EROSION?

- Prioritization of restoration projects: “Best Bang for the Buck”
Methods of Quantifying Riverbank Erosion

**Erosion Pins**
- **Most commonly used method**
- **Accurate but requires annual monitoring**
- **Several years of data needed**

**Historic Aerial Photographs**
- **Gives long-term erosion rates**
- **Not as accurate due to scale**
- **Used for high erosion rates**
Methods of Quantifying Riverbank Erosion

**Bank Surveys**
- Toe Pins
- Scan

**Less Common:**
- Photovoltaic
- Lidar

**Analytical Models**
- RUSLE
- USDA Bank Stability Model
Methods of Quantifying Riverbank Erosion

Empirical Models

- **BA N C S Model:** Uses erosion rate curves which relate bank-specific ratings of erodibility to erosion rates.

Erosion rate curve must be developed from other method.
Methods of Quantifying Hillslope & Riverbank Erosion

New Method: Dendrogeomorphology

Using tree rings to identify dates of changes in land surfaces

- Root anatomy changes when root is exposed to air/elements
- Now mentioned by Chesapeake Expert Panel
- Dick et al., River Research and Applications, 2013
WHAT IS DENDROGEO MORPHOLOGY?

- Dendrogeomorphology - Use of tree growth rings to identify dates of changes in earth surface processes

- Tree rings change in response to environmental factors (e.g. landslide, streambank, and hillslope erosion)
WHAT IS DENDROGEOLOGY?

- Used since the 1960s
- Most research done in Europe
- Most research done on conifers
- Initial studies on fluvial erosion in the U.S. in 2008
WHAT IS DENDROGEOMORPHOLOGY?

- Growth anomalies after exposure to atmosphere (erosion):
  - Ring size and eccentricity
  - Change in vessel and fiber size
  - Scarring from debris
WHAT IS DENDROGEOmorphology?
WHAT IS DENDROGEOGRAPHOMORPHOLOGY?

Distance of exposed root from riverbank ÷ Years of Exposure = Annual Erosion Rate
Macroscopic Indicators of Exposure

Cut disk of elm root (*Ulmus rubra*)

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

**Diffuse-Porous Species**
- Decrease in size and increase in number of cells in post-exposure rings
- Division into earlywood and latewood

**Ring-Porous Species**
- Change from diffuse-porous cell anatomy to ring-porous anatomy (resembling more the stem).

**BEFORE EXPOSURE**

**AFTER EXPOSURE**

Diffuse Porous - Sugar Maple

Ring Porous - Slippery Elm
<table>
<thead>
<tr>
<th>FINDINGS</th>
<th>RING POROUS 40X</th>
<th>RING POROUS 400X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraxinus americana</td>
<td>Buried</td>
<td>Exposed</td>
</tr>
<tr>
<td>Juglans</td>
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<td>Quercus alba</td>
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<tr>
<td>Ulmus rubra</td>
<td>Buried</td>
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</tr>
<tr>
<td>Celtis laevigata</td>
<td>Buried</td>
<td>Exposed</td>
</tr>
</tbody>
</table>
FINDINGS

DIFFUSE POROUS

40X

DIFFUSE POROUS

400X
Pros/Cons of Dendrogeomorphic Method

Time Savings Over Other Methods
- Collection: 20 samples per day;
- Analysis: 20 samples per day (using macroscopic indicators);
- 3-4 samples per day (if using microscopic indicators)

Potential Disadvantages
- 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 growth ring observation (mainly in subtropical geographies)
Case Study: River in Central MI

**All samples:** Indicates that method can be used to predict erosion rates where no direct erosion rate measurements have been obtained, but BEHI has been measured.

**Samples exposed 10 years or less:** Indicates older roots may be indicative of different state of erodibility than current bank.
CASE STUDY: BUFFALO BAYOU, HOUSTON TEXAS

- Develop baseline data for future stream stability projects
  “Prioritization of future projects”
**CASE STUDY: BUFFALO BAYOU, HOUSTON TEXAS**

- **Comparison of erosion rates to BEHI (bank erosion hazard index)**

![Eroding riverbank on Buffalo Bayou](image)

**Erosion Rate vs. BEHI Score for Samples on Buffalo Bayou**

- $y = 3E-06x^{2.9549}$
- $R^2 = 0.8729$

![Graph showing Erosion Rate vs. BEHI Score](image)
DENDRO GEO MORPHOLOGY TAKE-AWAYS

- Upland or channel erosion assessment is equally possible
- Data where none existed prior to the initiation of concern of a particular study area
- Easy to train staff to implement
- Coarse data can be obtained with hand lens
- Quickly get accurate erosion data on variety of time scales
- Most local tree spp can be used
- Cost effective - Long Timeframe of Data – Historical and Predictive
Questions?

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Why do we care about streambank erosion?

- Evaluating threats to infrastructure (e.g. bridges, pipelines, pump-stations, etc.)
- Pre-Restoration: Estimates of riverbank erosion rates provides means of prioritizing efforts
- Post-Restoration: Estimates of riverbank erosion rates provides quantifiable means of determining restoration effectiveness for sediment/nutrient reduction
- Estimate the total annual quantity of sediment being entrained from eroding riverbanks
  - EPA reported excessive sediment as leading cause of impairment of the nation’s waters
  - TMDL for nutrient loading associated with sediment loads
Issues with traditional erosion evaluation methods:

- Erosion pins
  - Most commonly used method
  - Accurate but requires annual monitoring
  - Several years of data needed
- Historic aerial photographs
  - Gives long-term erosion rates
  - Not as accurate due to scale
  - Used for high erosion rates
- Lidar repeated
  - Expensive
- Bank surveys
  - Expensive, time consuming
- Analytical models
  - Requires data to be accurate
Benefits of Using Dendrogeomorphology

- Quantifies extent and magnitude of stream bank erosion
- Most hardwood species respond to exposure in a predictable manner
- Extensive data sets easily gathered
- Erosion rates determined quickly
- Long term erosion trends can be analyzed
- Cost effective
WHAT IS DENDROGEOLOGY?

[Image of a section of a tree showing annual rings and a close-up of the tree bark.]