

Living Erosion Pins- Streambank Erosion Rate Assessment Using Exposed Tree Roots

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CONTENTS

- Why assess streambank erosion?
- Traditional assessment methods
- What is dendrogeomorphology?
- Case studies
- Dendrogeomorphology take-aways

WHY ASSESS STREAMBANK EROSION?



- Threat to infrastructure

WHY ASSESS STREAMBANK EROSION?



- Loss of land and channel capacity

WHY ASSESS UPLAND AND STREAMBANK EROSION?



- Excess sedimentation, nutrient loading, and contamination

WHY ASSESS STREAMBANK 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

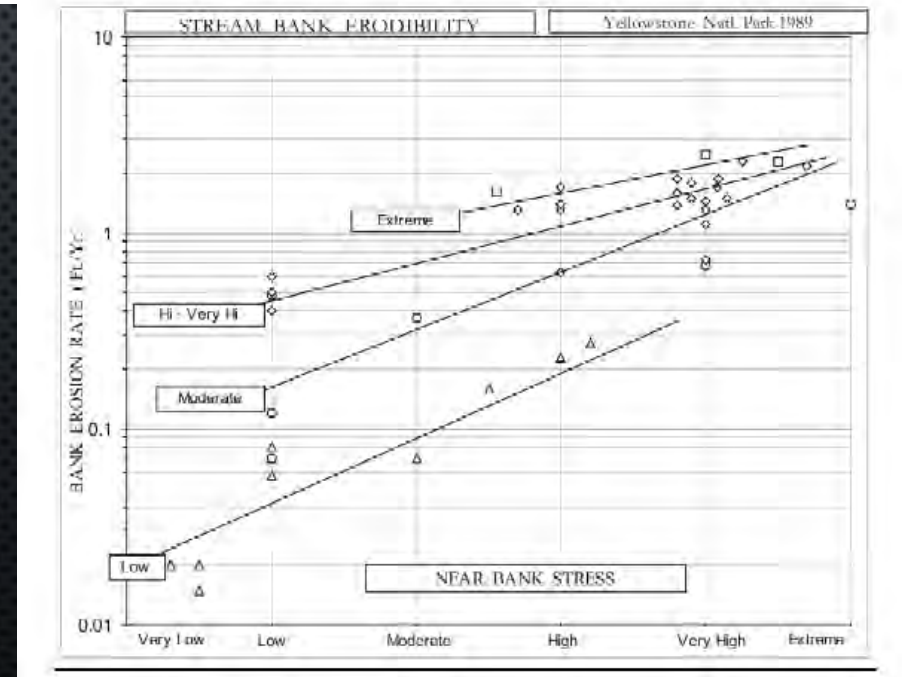
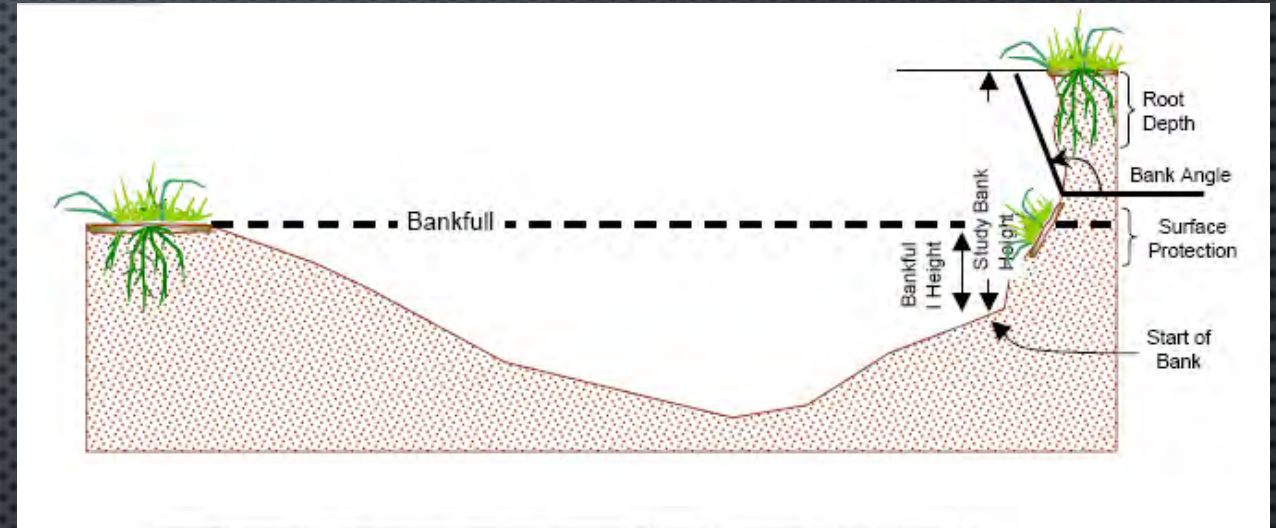


Methods of Quantifying Riverbank Erosion

EMPIRICAL MODELS

- BANCS 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 DENDROGEOMORPHOLOGY?

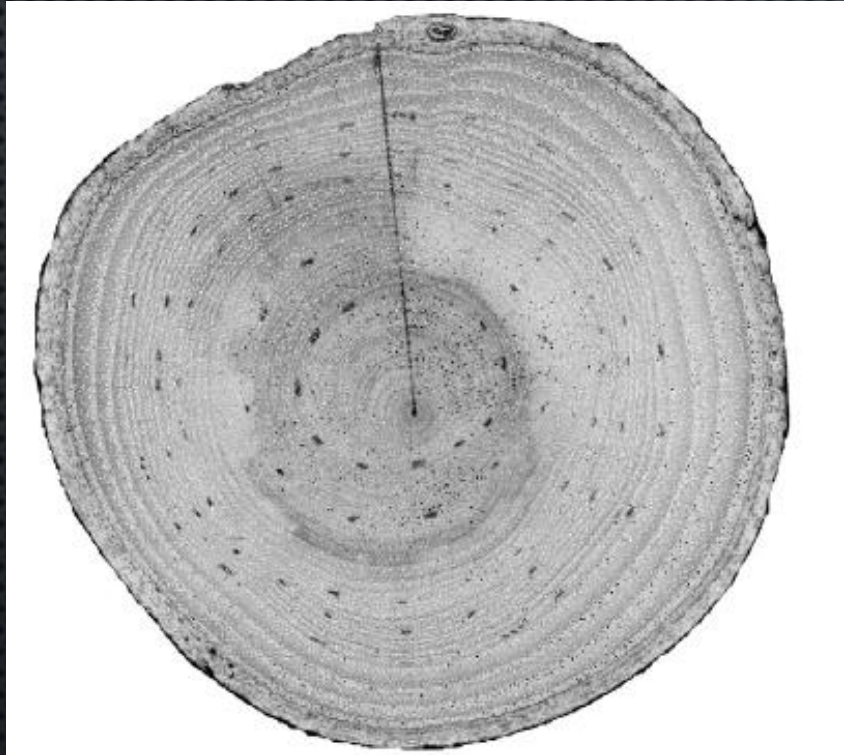


- Dendrogeomorphology - Use of tree growth rings to identify dates of changes in earth surface processes



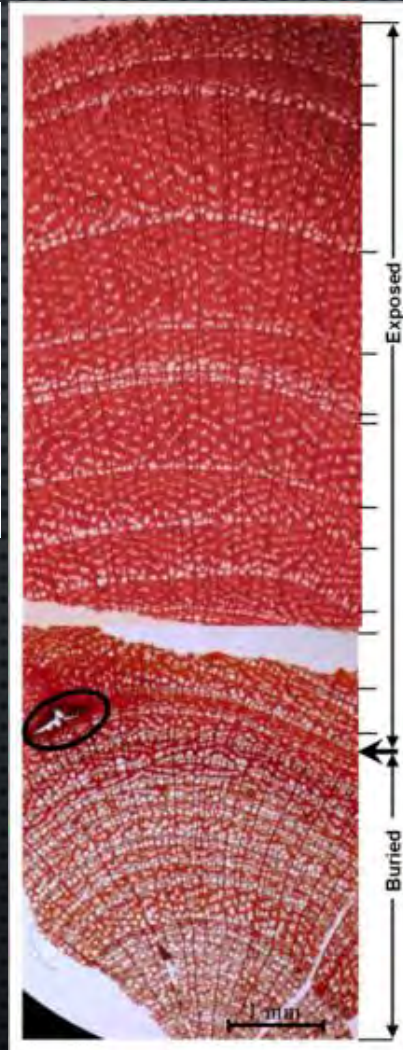
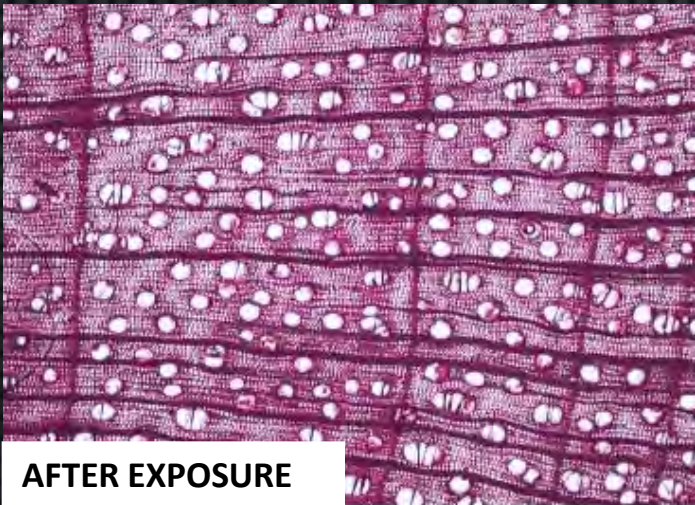
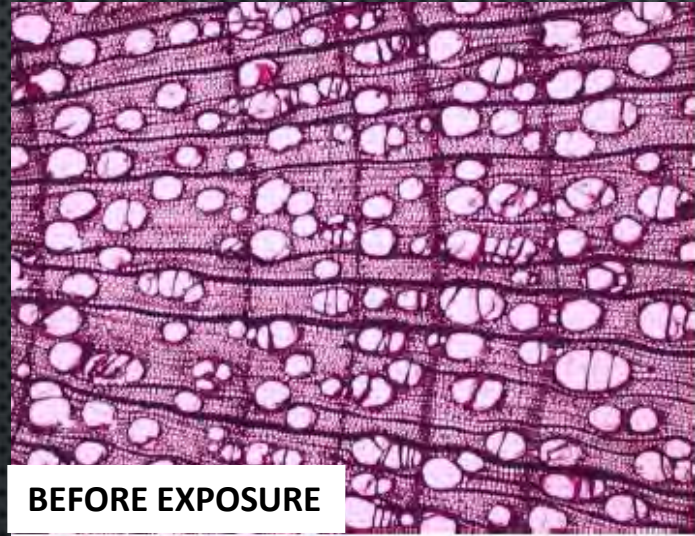
- Tree rings change in response to environmental factors (e.g. landslide, streambank, and hillslope erosion)

WHAT IS DENDROGEOMORPHOLOGY?



- 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?

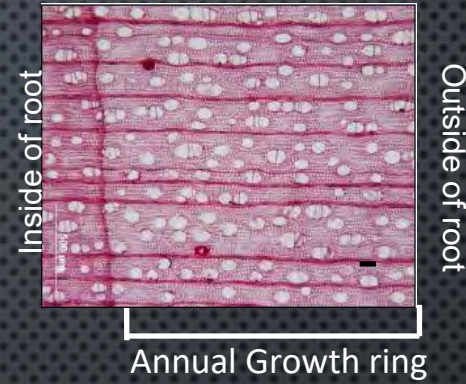
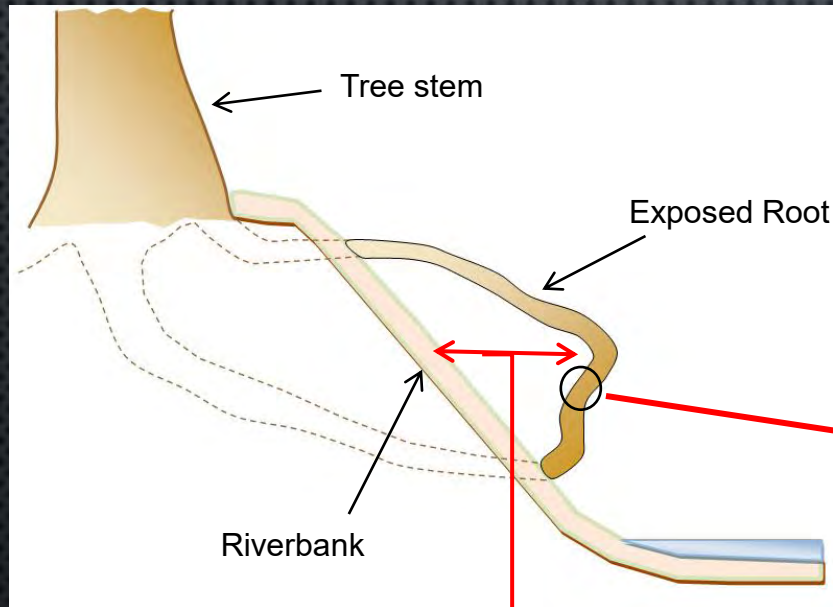


- Growth anomalies after exposure to atmosphere (erosion):
 - Ring size and eccentricity
 - Change in vessel and fiber size
 - Scarring from debris

WHAT IS DENDROGEOMORPHOLOGY?

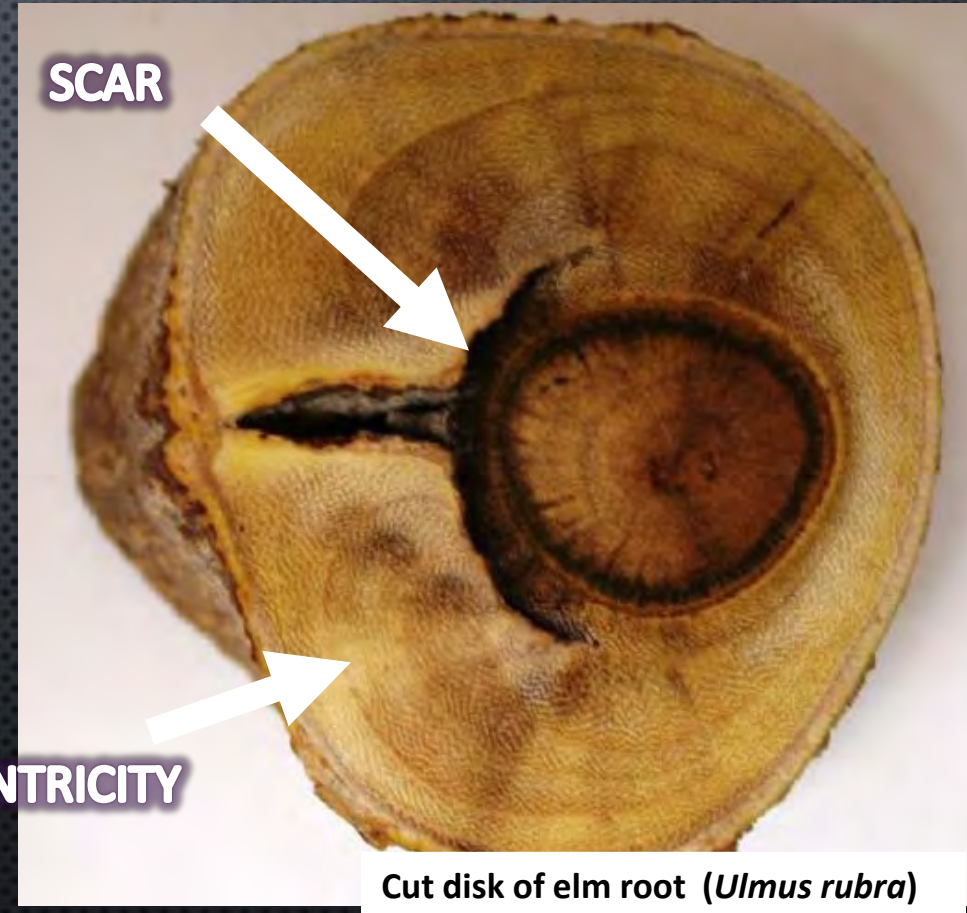


WHAT IS DENDROGEOMORPHOLOGY?



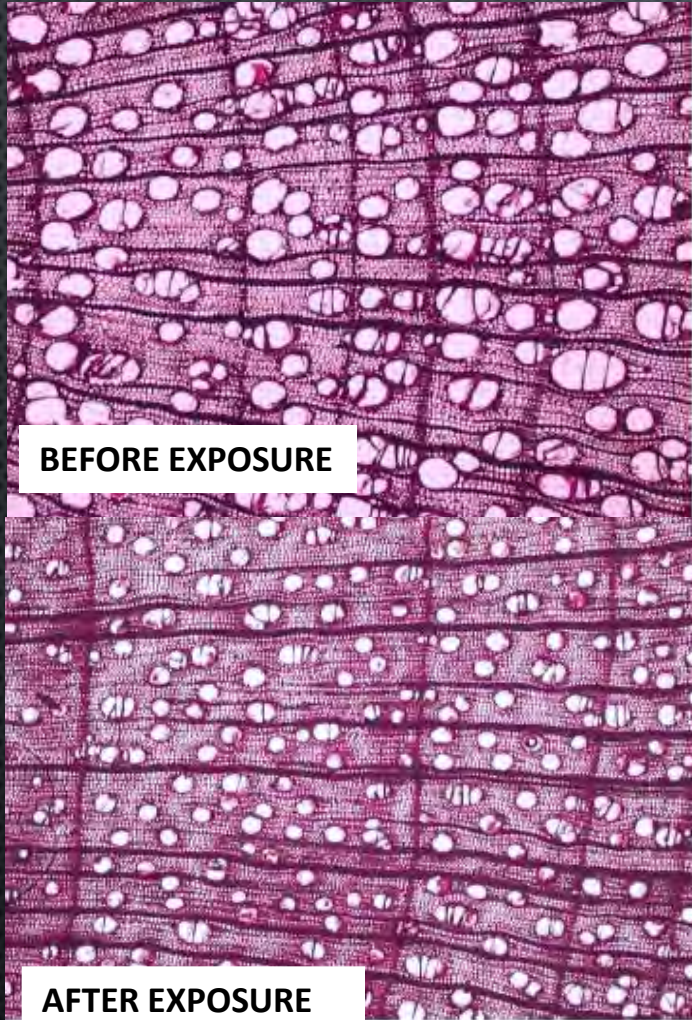
$$\frac{\text{Distance of exposed root from riverbank}}{\text{Years of Exposure}} = \text{Annual Erosion Rate}$$

Macroscopic Indicators of Exposure



MICROSCOPIC INDICATORS

Diffuse Porous-Sugar Maple



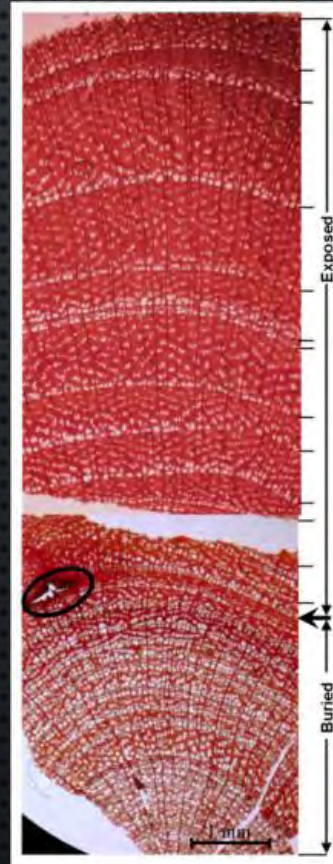
Ring Porous- Slippery Elm



- 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).

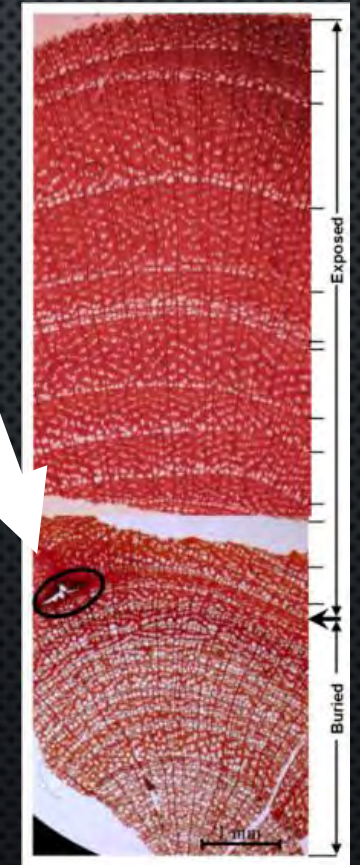
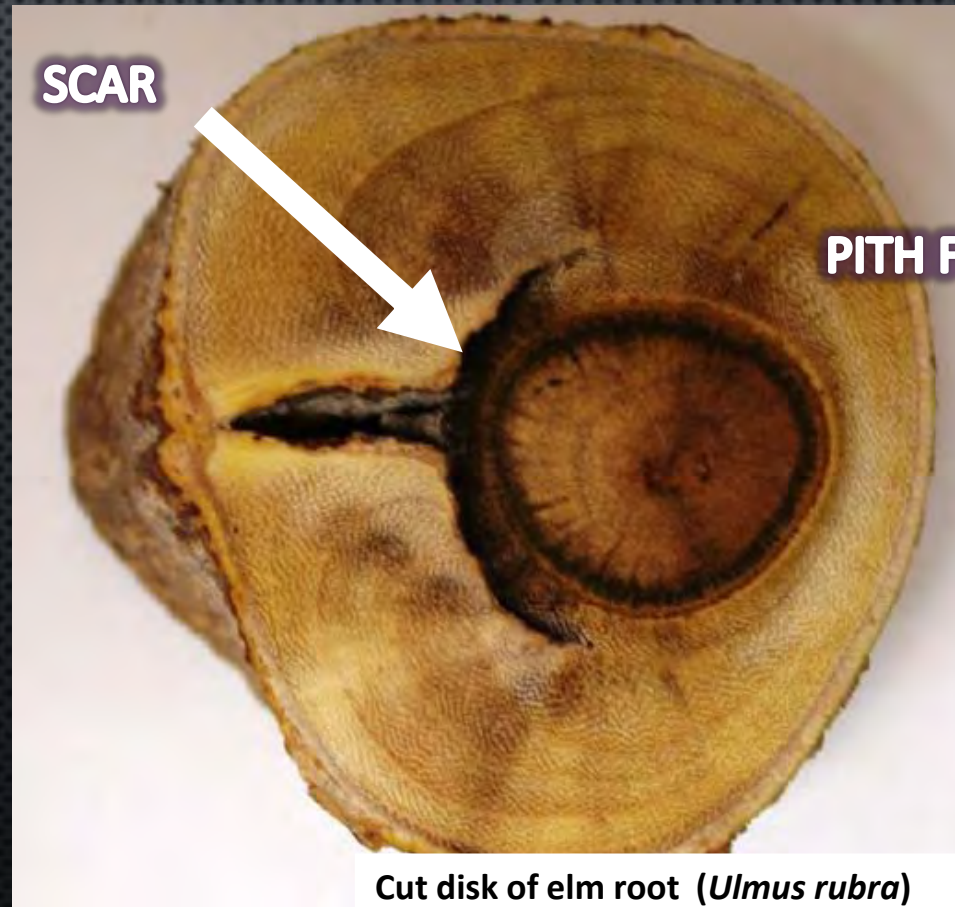
GROWTH RING ANATOMY

- Root eccentricity
- Growth Ring Thickness
- Often presents much more apparent growth ring boundary



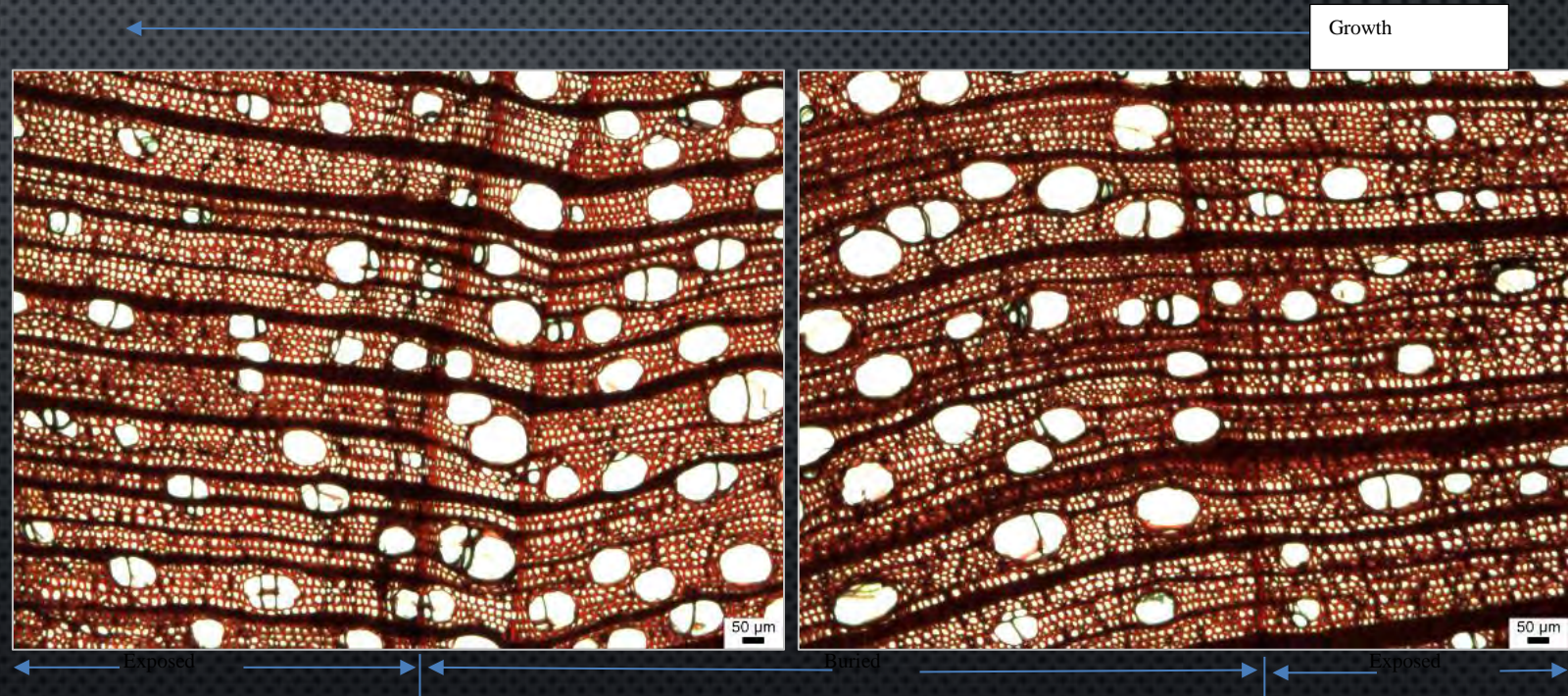
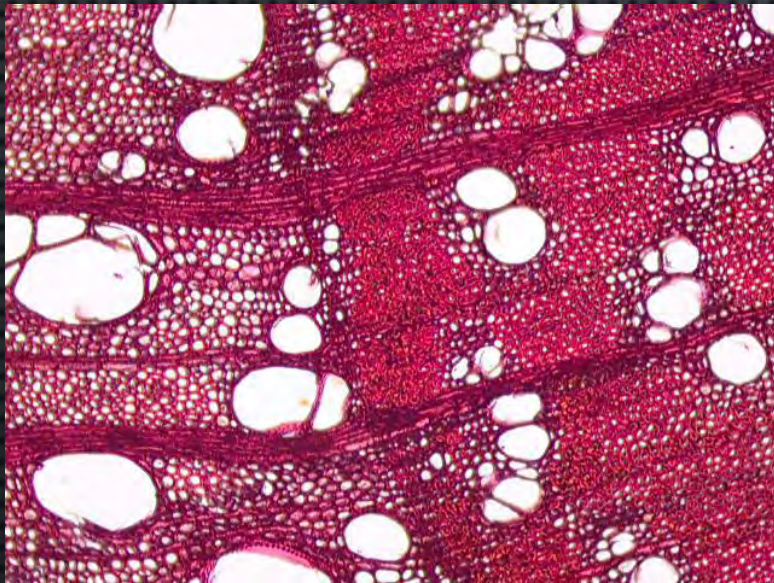
SCARS AND PITH FLECKS

- May or may not be present
- Serve to validate other indicators
- “Multiple lines of evidence approach”

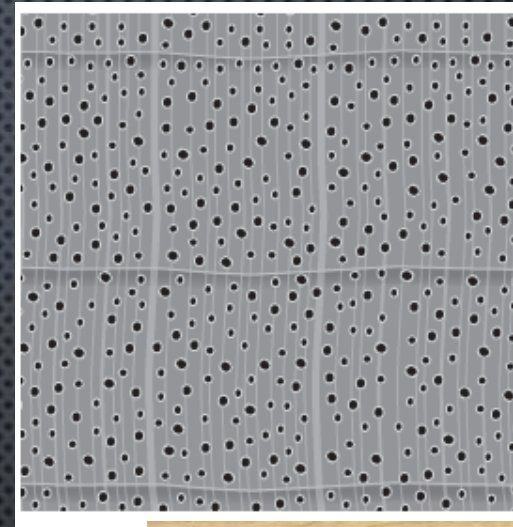
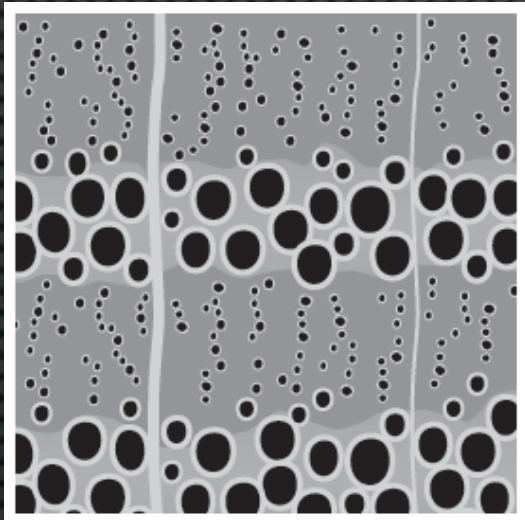


RAY DIRECTION

- Ray bending often occurs in first year of exposure
- And again in re-burial

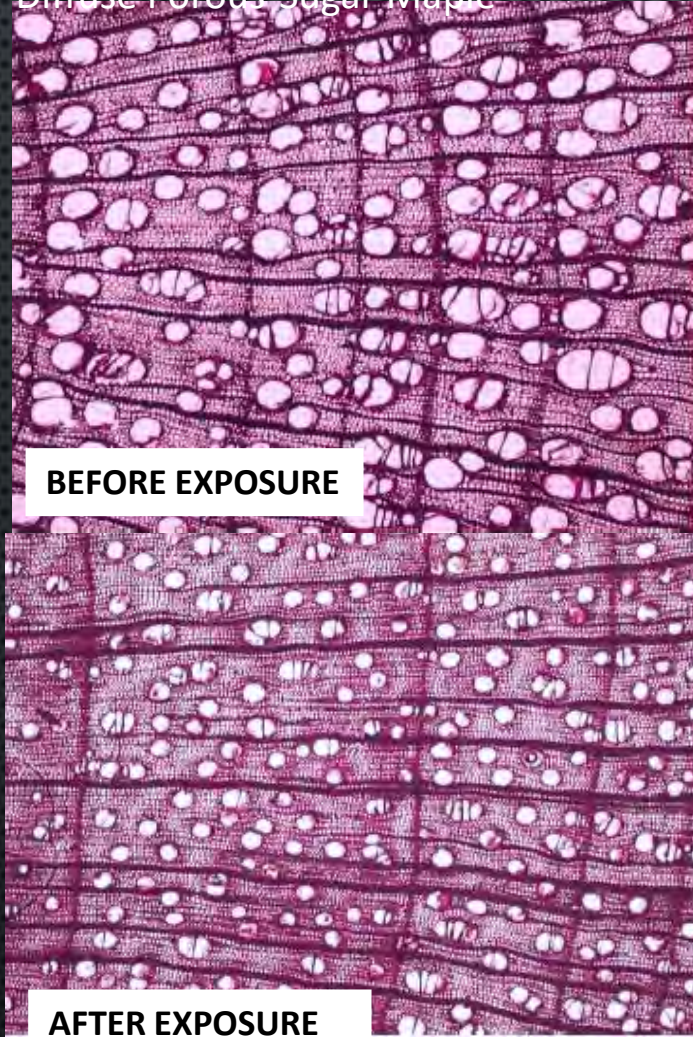


RING POROUS VS DIFFUSE POROUS



VESSEL DIAMETER

Diffuse Porous-Sugar Maple



- Vessels primarily transport water and nutrients
- The “pipes” of the tree tissue
- Roots main function is to transport water
- Stem main function → strength
- Exposure forces root wood development towards strength = STEM-LIKE
- **A PRIMARY INDICATOR FOR DIFFUSE POROUS SPECIES**

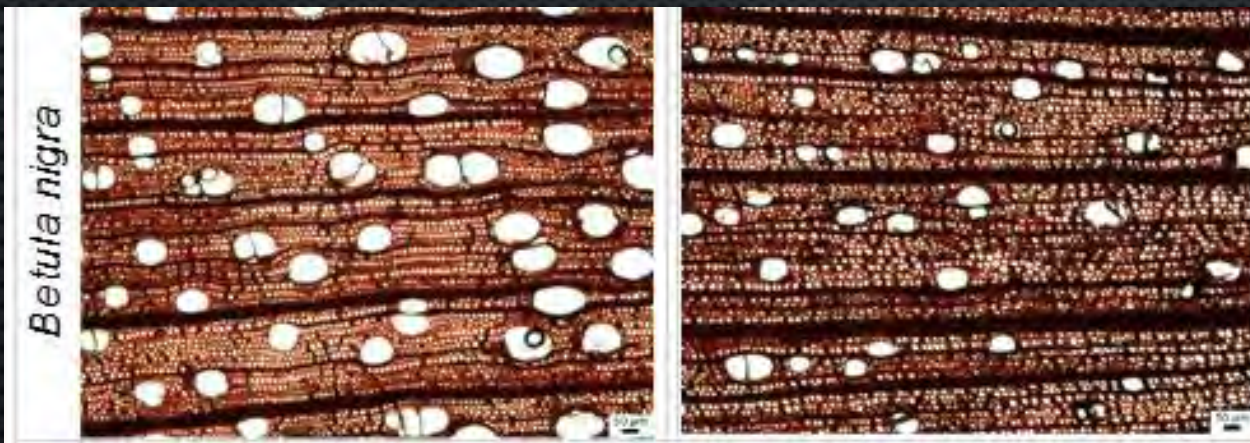
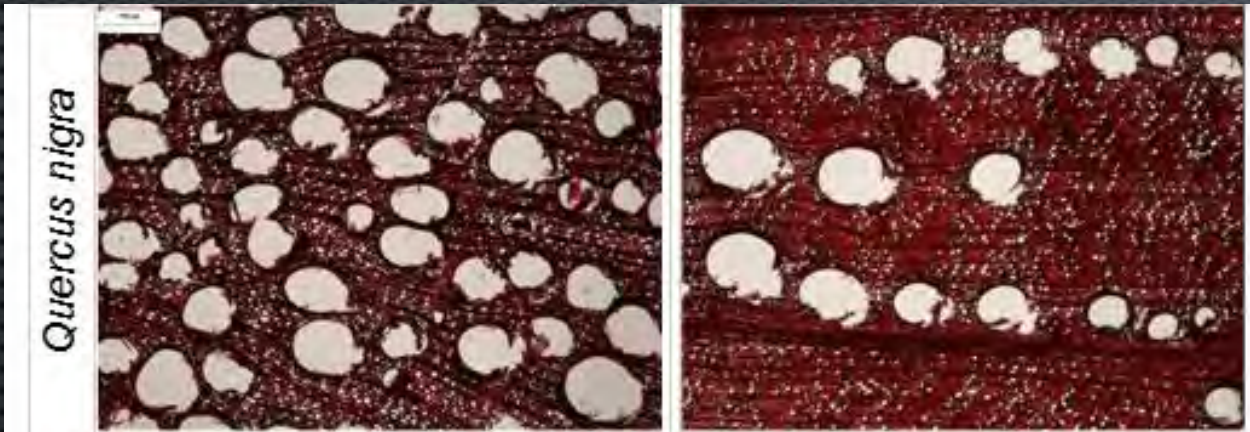
VESSEL ARRANGEMENT

Ring Porous- Slippery Elm



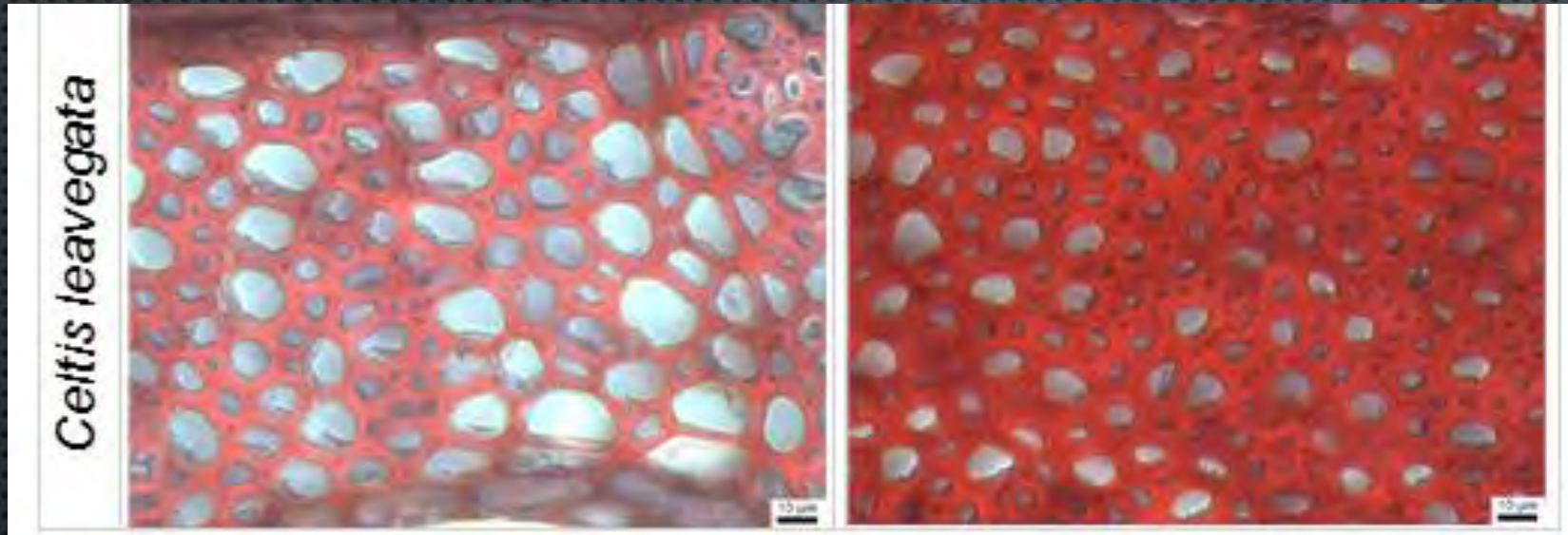
- Stem-like arrangement of vessels
- Reference material documents stem wood anatomy of most species globally
- **A PRIMARY INDICATOR FOR RING POROUS SPECIES**

VESSEL FREQUENCY AND AREA

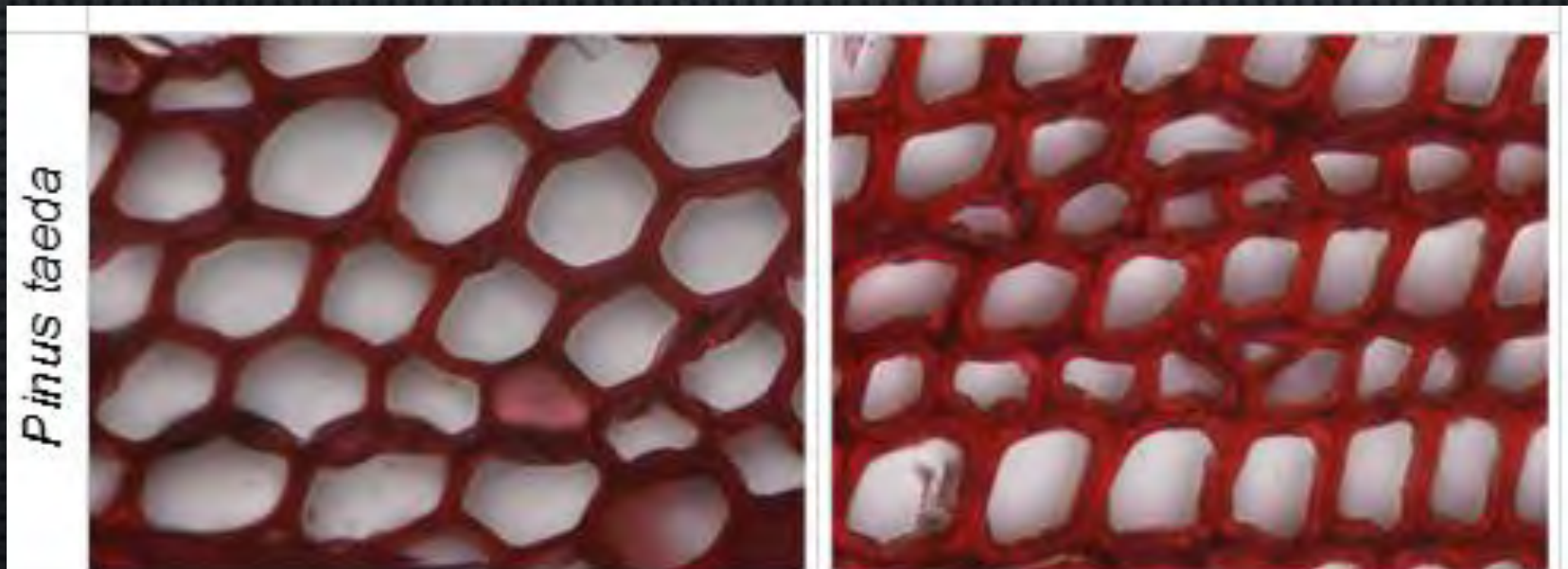


- Decrease in vessel frequency is highly apparent in some species
- Statistical significance in most species with laboratory image analysis

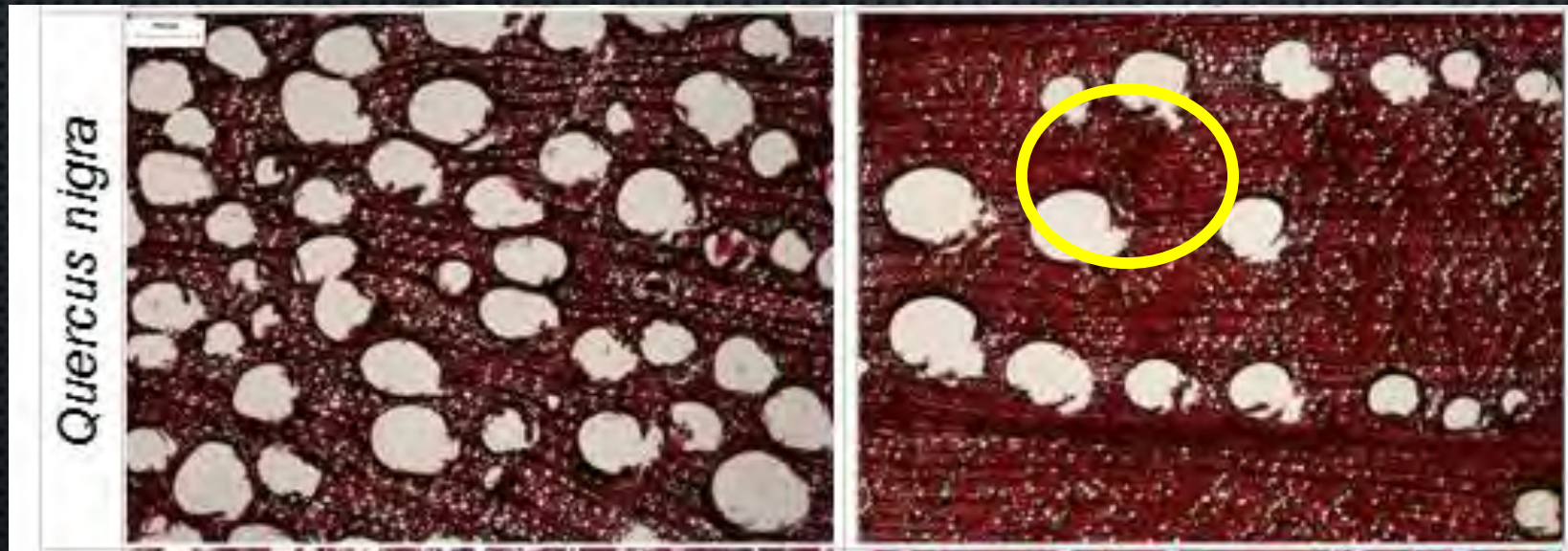
FIBER/TRACHEID LUMEN DIAMETER AND CELL WALL THICKNESS



- Decrease in FLD
- Increase in CWT



REACTION WOOD- GELATINOUS FIBERS

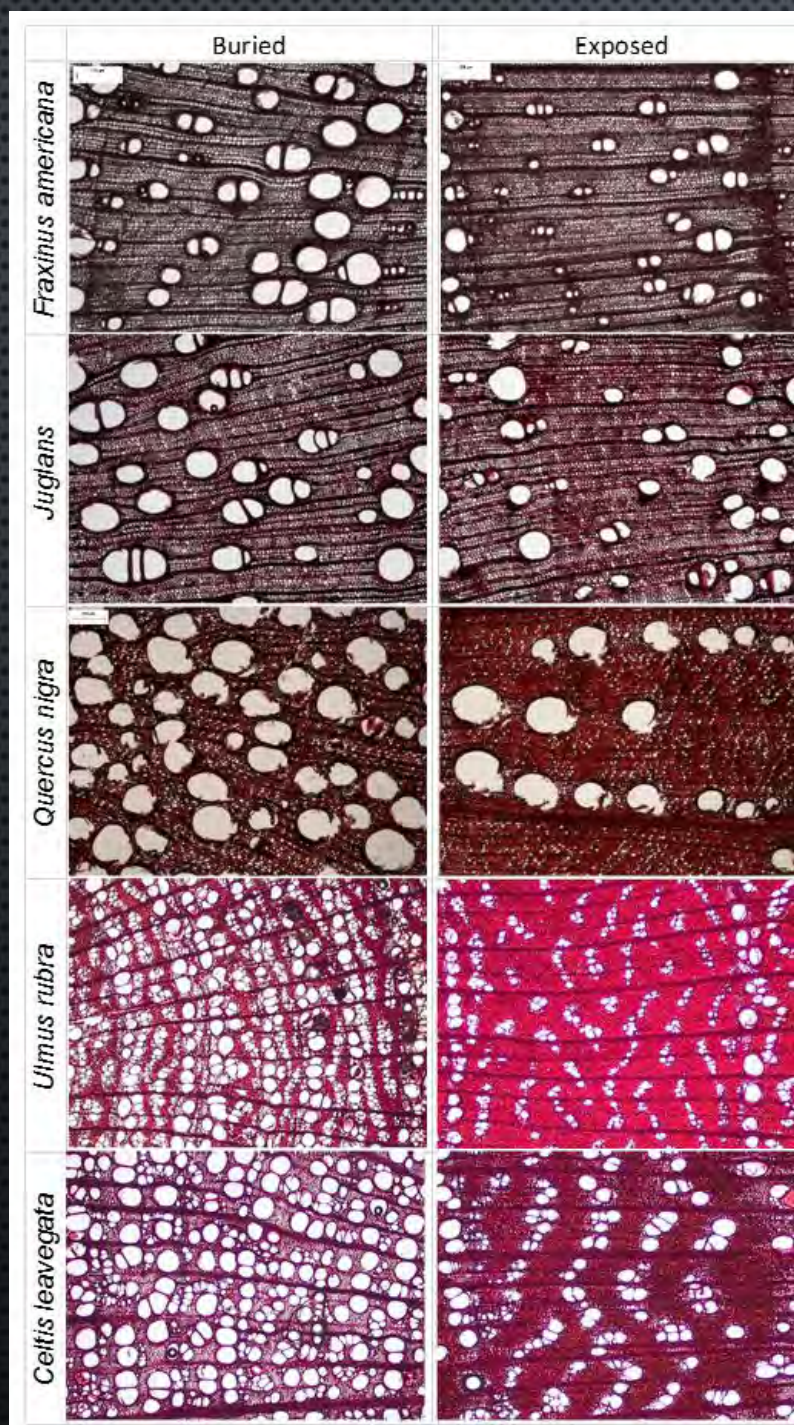


- Reaction wood contains gelatinous fibers (g-fibers)

FINDINGS

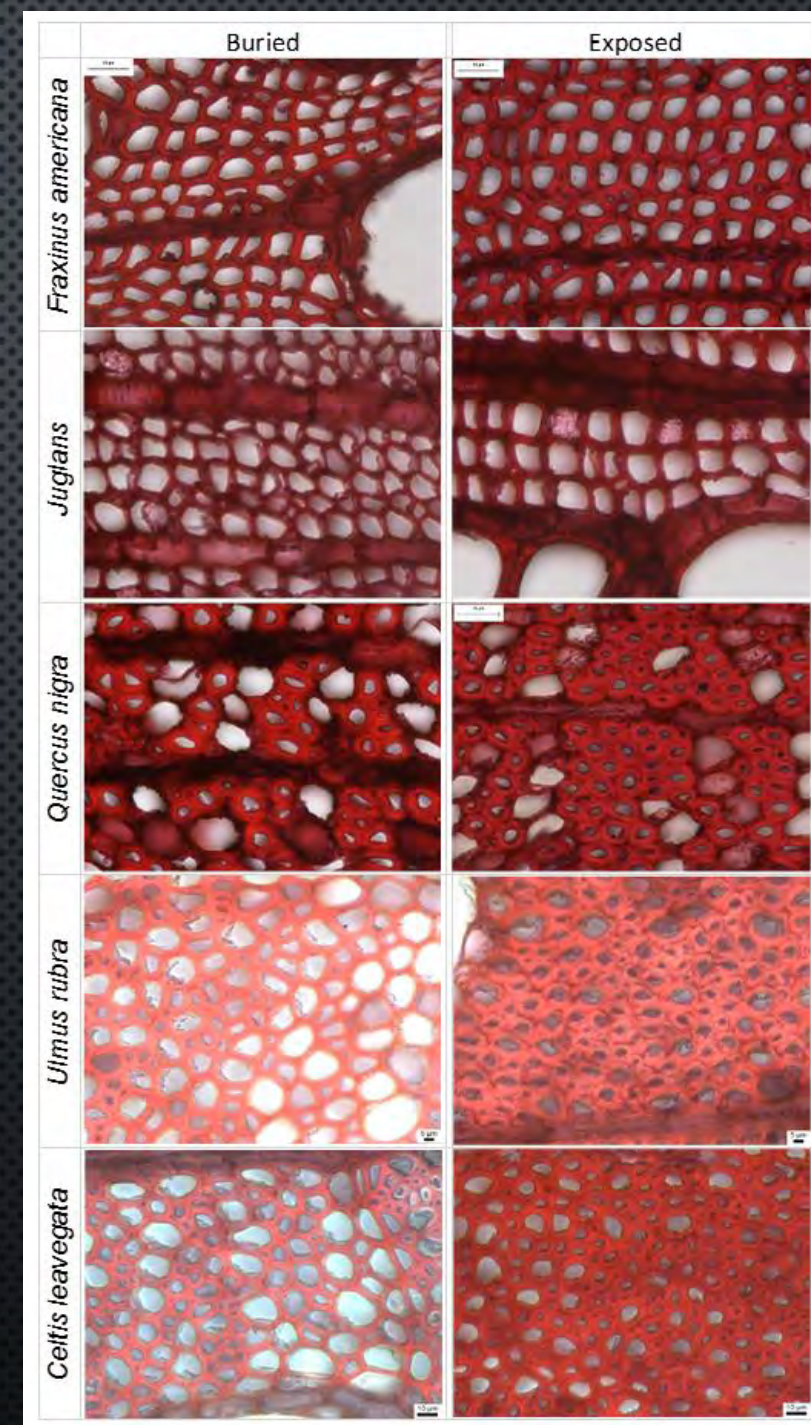
RING
POROUS

40X



RING
POROUS

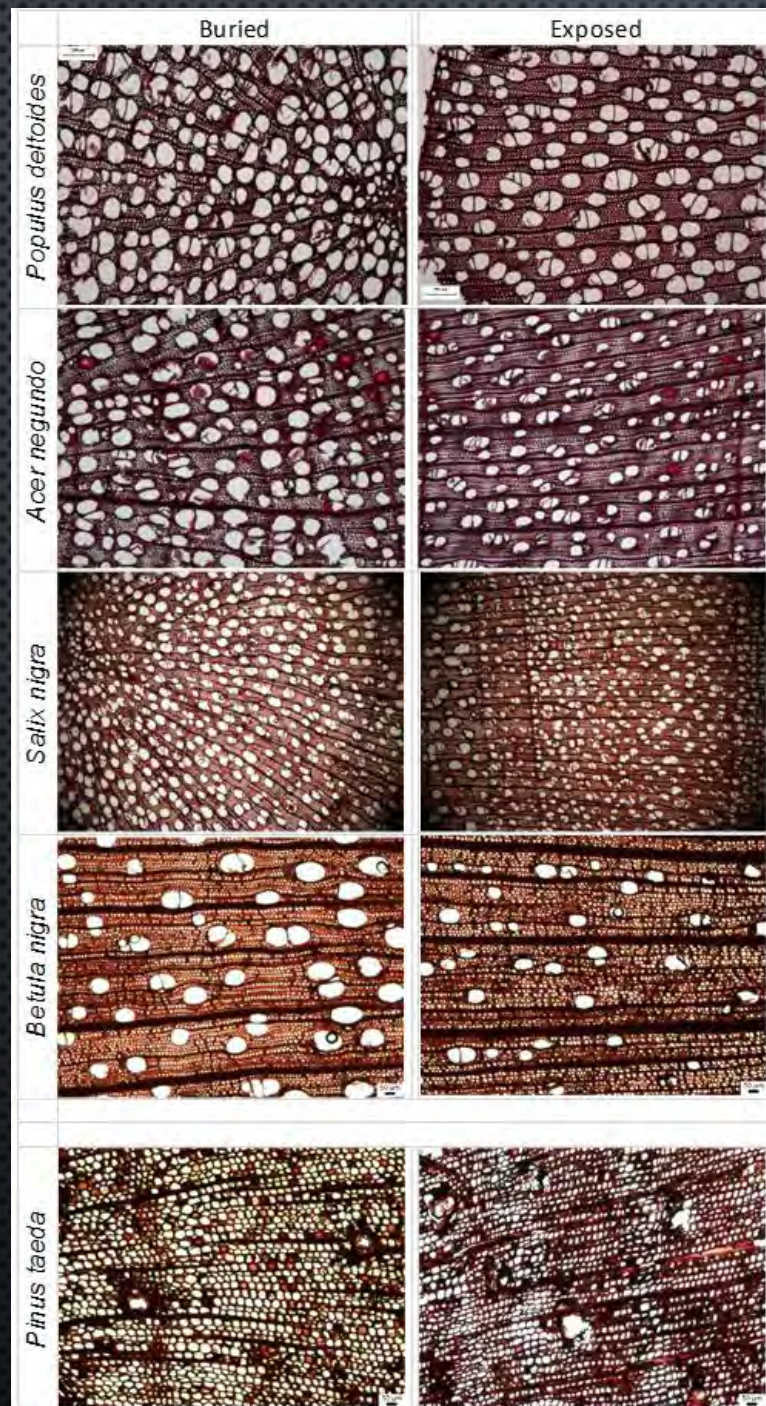
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FINDINGS

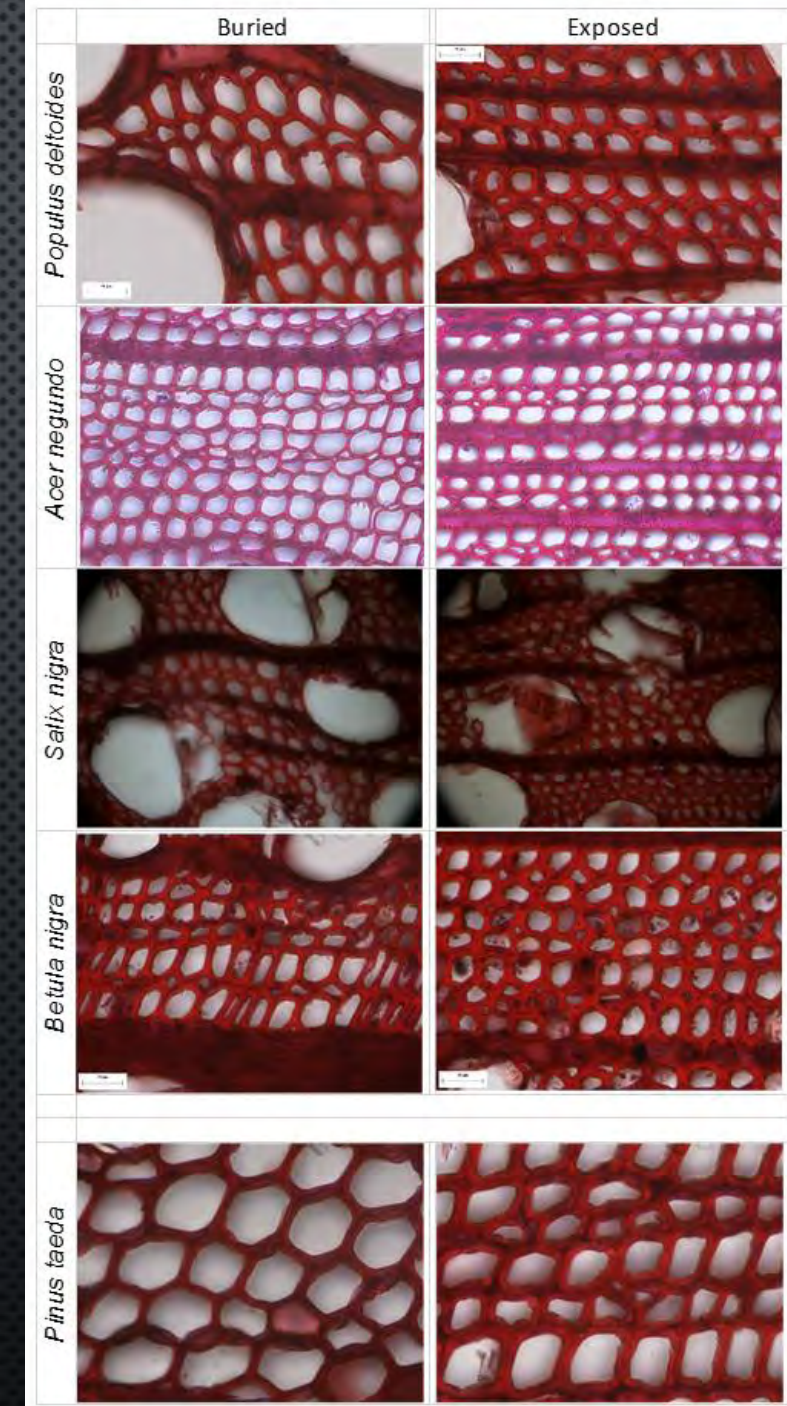
DIFFUSE
POROUS

40X



DIFFUSE
POROUS

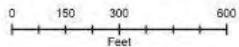
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PUTTING IT TOGETHER



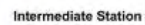
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Legend



Priority Score



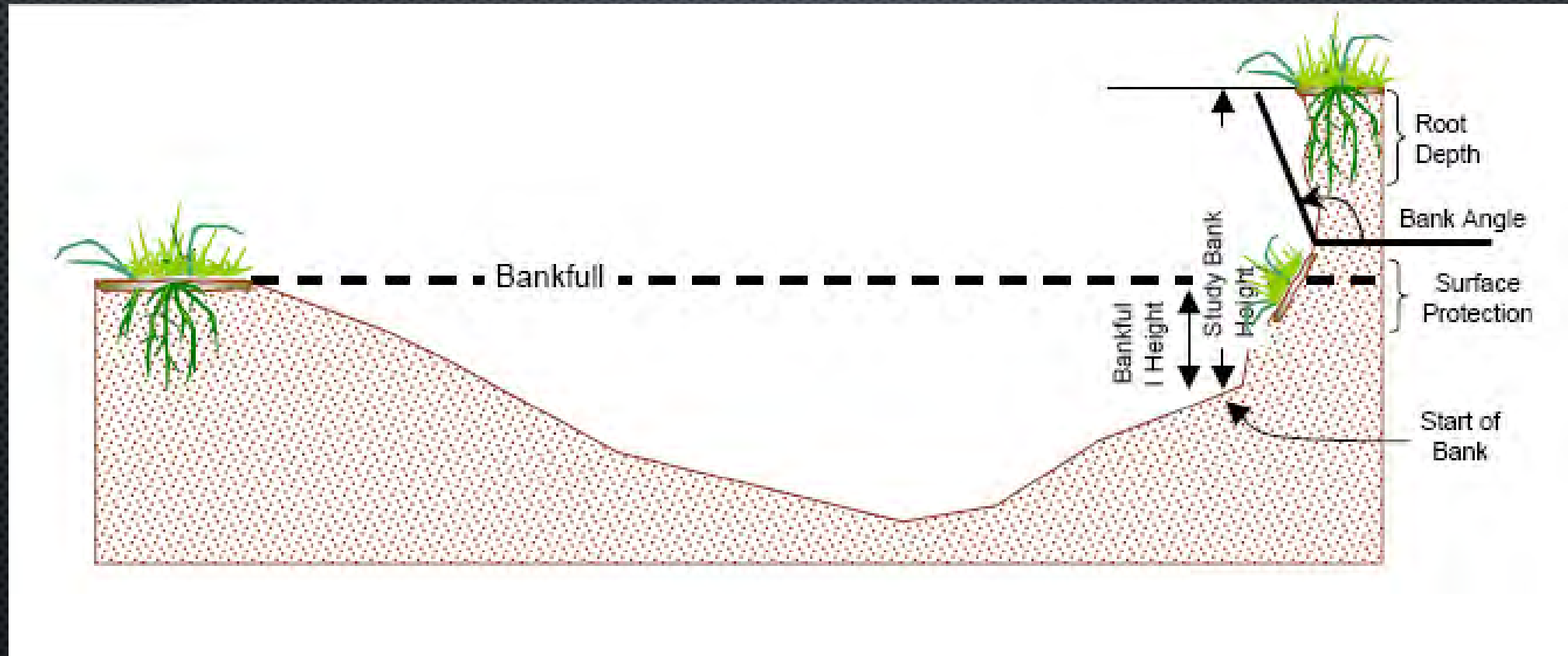
BUFFALO BAYOU PRIORITIZATION OF BANK STABILIZATION SITES

PRIORITIZATION SCORES

Date: January 2012

SHEET07

INTRODUCTION TO BANK EROSION HAZARD INDEX (BEHI)



BEHI EXAMPLES



Location 997+50 Left Bank

BANK EROSION HAZARD INDEX (BEHI) 4 RATING EXAMPLE

CHARACTERISTICS OF A BEHI WITH A 2 RATING

Ratio of **Study Bank Height / Bankfull Height** (8.0 ft/ 4.0 ft) = 2.0

Ratio of **Root Depth / Study Bank Height** (7.0 ft / 8.0 ft) = 0.875

Weighted Root Density =

Root Density % X (Ratio of Root Depth / Study Bank Height)

30.0 X 0.875 = 26.25

Bank Angle 70°

Surface Protection 5%

Bank Material Adjustment (Sand bank adjustment)

SCORE

8.0

9.0

8.0

8.0

9.0

5.0

Total Score

47.0

BEHI EXAMPLES



Location 975+00 Left Bank

BANK EROSION HAZARD INDEX (BEHI) 4 RATING EXAMPLE

CHARACTERISTICS OF A BEHI WITH A 2 RATING

Ratio of Study Bank Height / Bankfull Height (8.0 ft / 4.0 ft) = 2.0

Ratio of Root Depth / Study Bank Height (8.0 ft / 8.0 ft) = 1.0

Weighted Root Density =

Root Density % X (Ratio of Root Depth / Study Bank Height)

20.0 X 1.0 = 20.0

Bank Angle 15°

Surface Protection 10%

Bank Material Adjustment (Sand bank adjustment)

SCORE

8.0

0.0

7.0

1.0

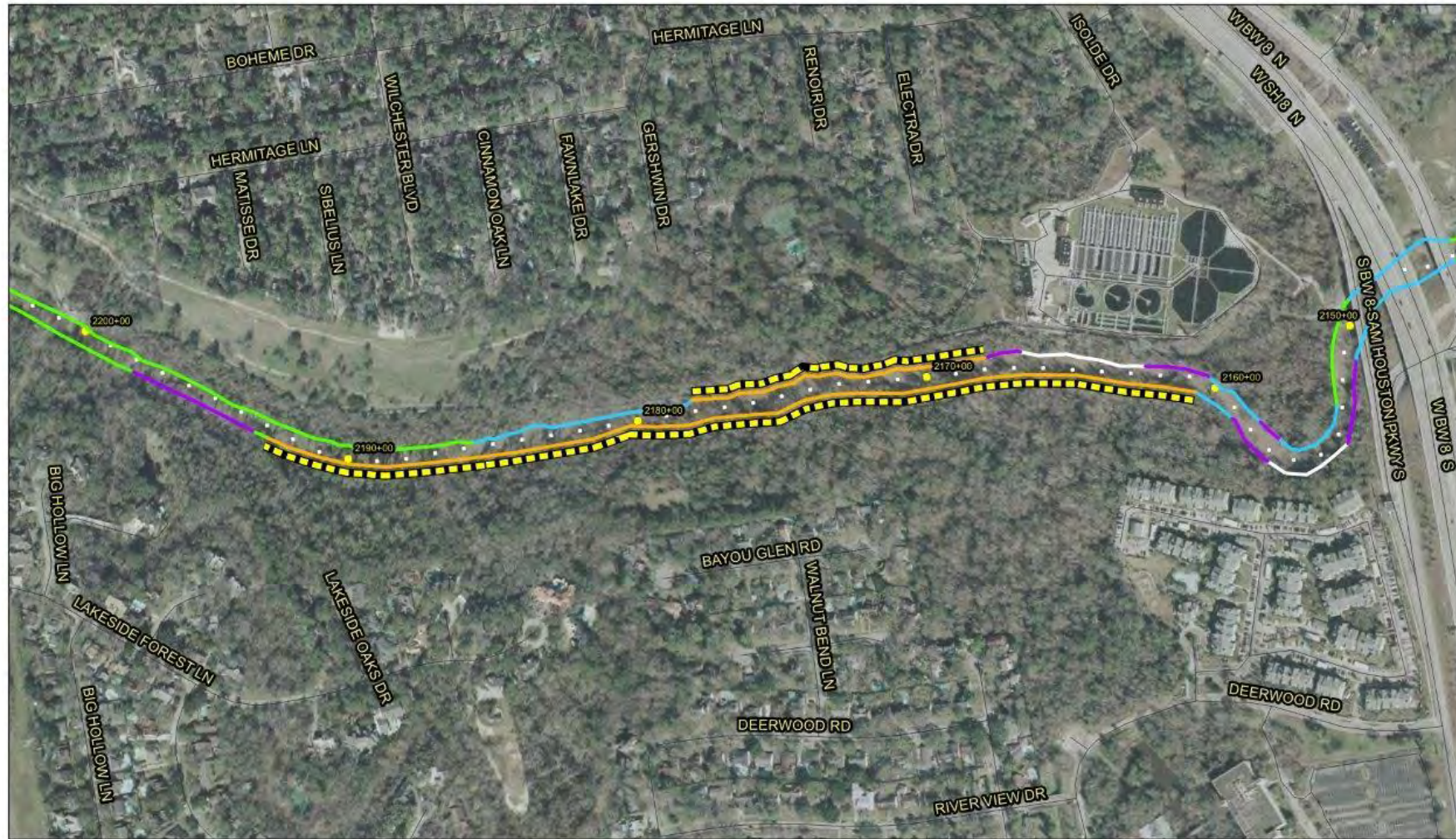
9.0

5.0

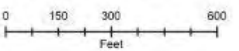
Total Score

30.0

EROSION MAPPING



The roadway data used in this map are derived from the STAR*Map®. STAR*Map is a registered trademark of the Houston-Galveston Area Council and the Geographic Data Committee.



Legend

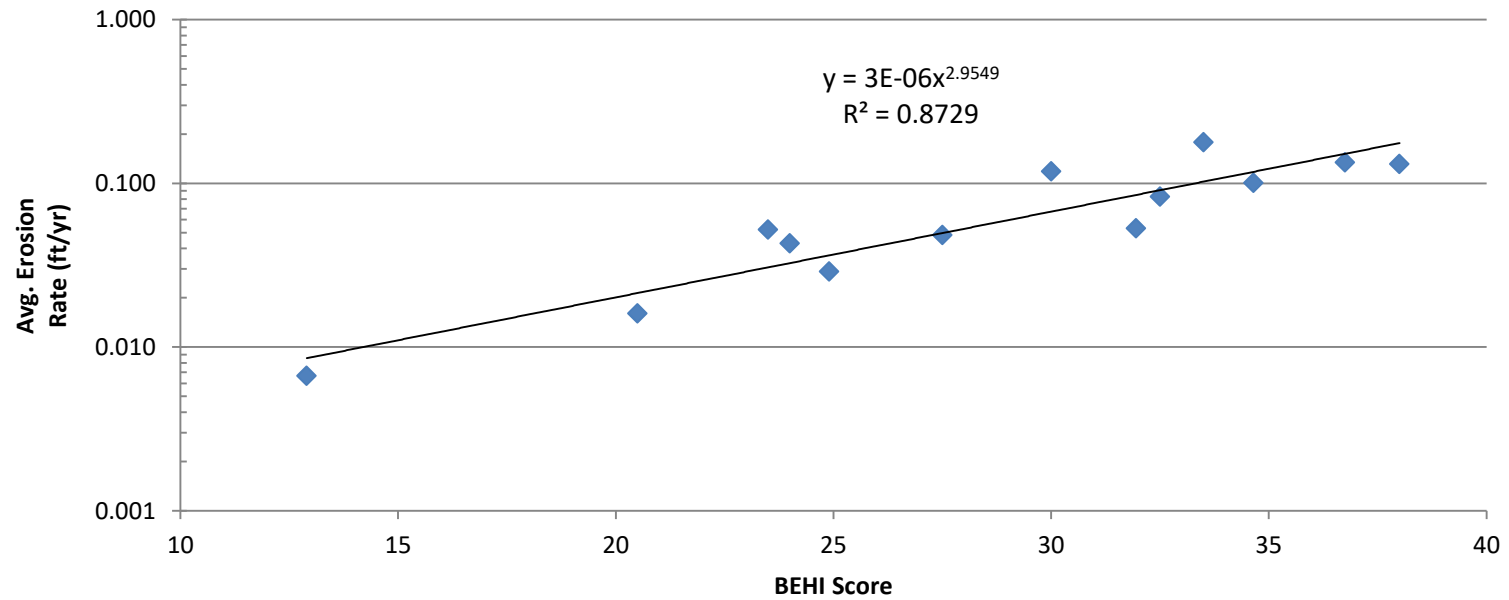
- Top Priority Sites
- Very Low
- Medium
- Very High
- Major Station
- Low
- High
- Extreme
- Intermediate Station

BUFFALO BAYOU PRIORITIZATION OF BANK STABILIZATION SITES

DATE: January 2012
SHEET07

STREAMBANK EROSION RATE CURVE

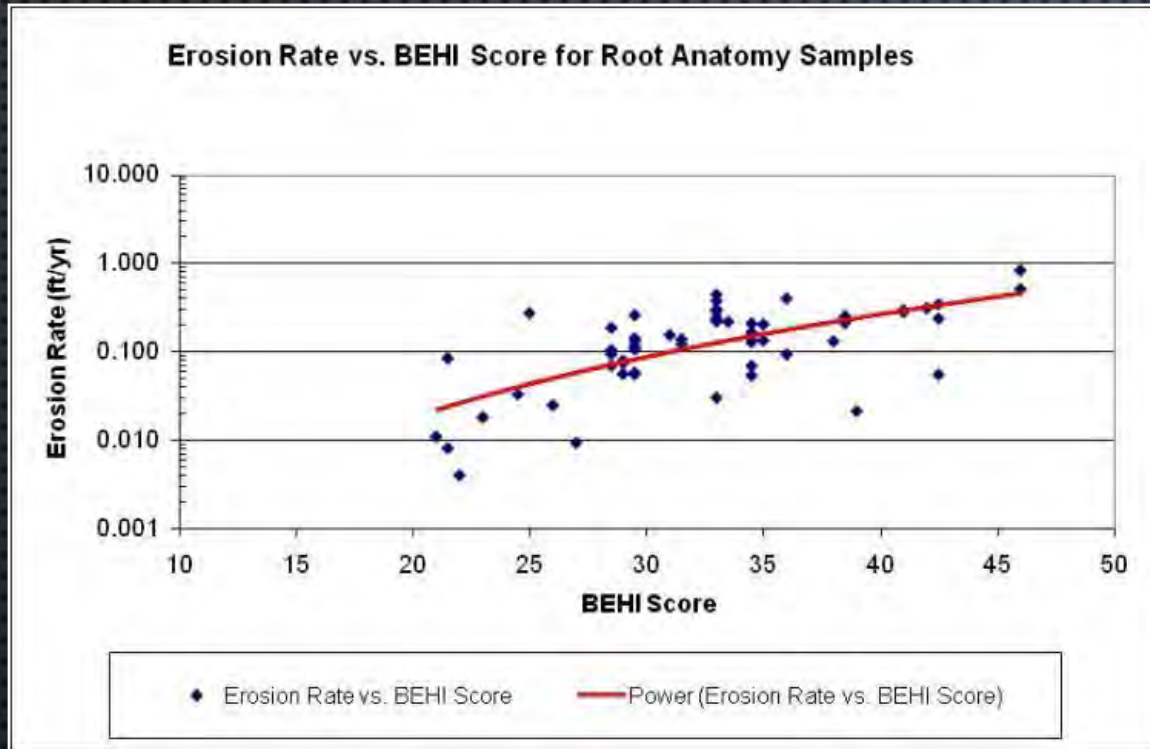
Erosion Rate vs. BEHI Score for Samples on Buffalo Bayou



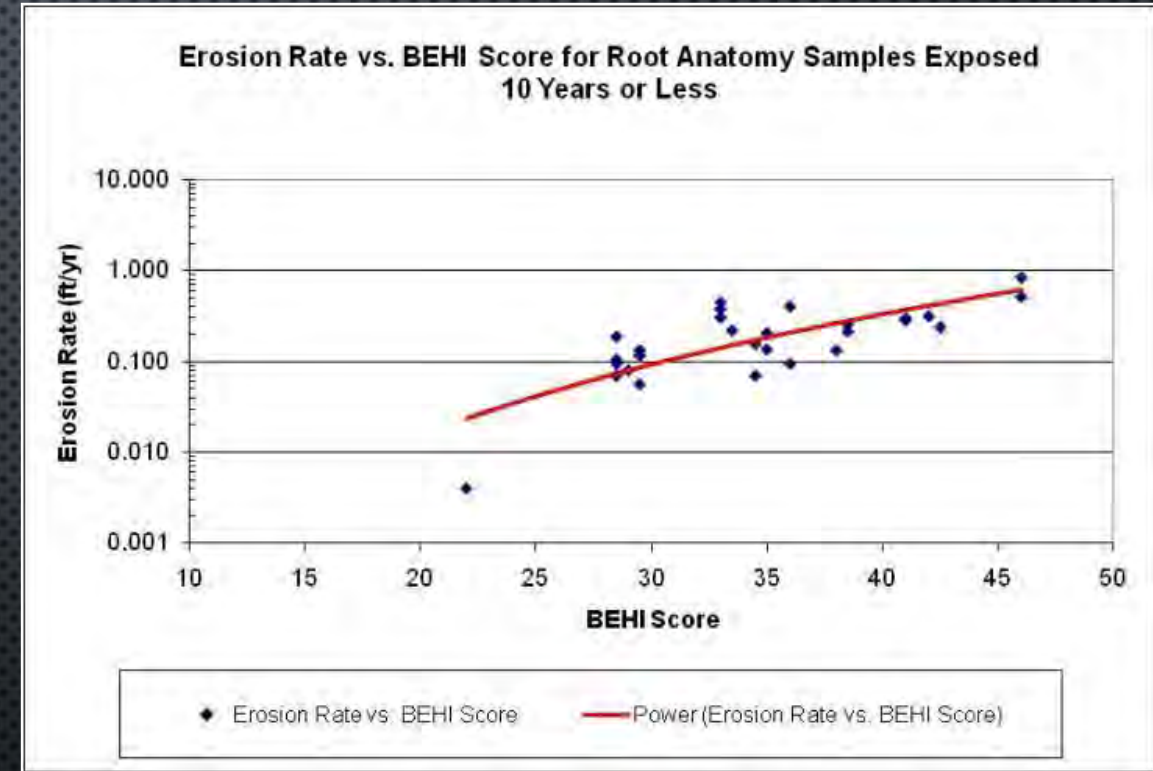
◆ Erosion Rate vs. BEHI Score

— Expon. (Erosion Rate vs. BEHI Score)

Case Study: River in Central MI

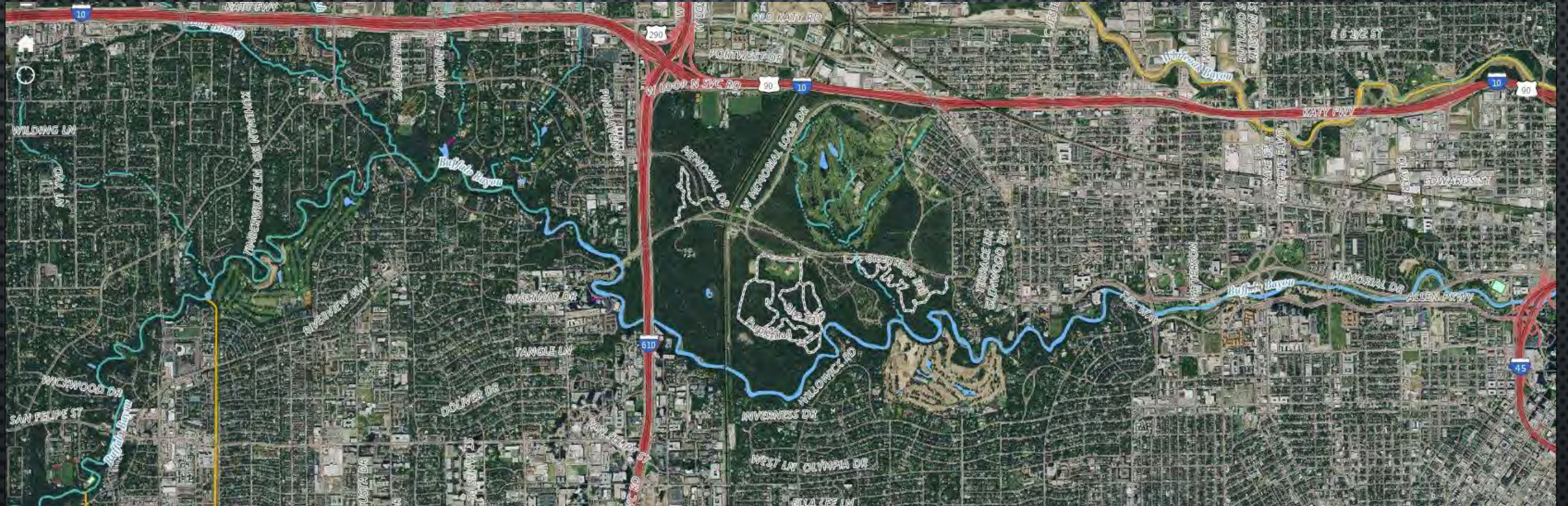


All samples: Indicates that method can be used to predict erosion rates where no direct erosion rate measurements have been obtained, but BEHI has been measured



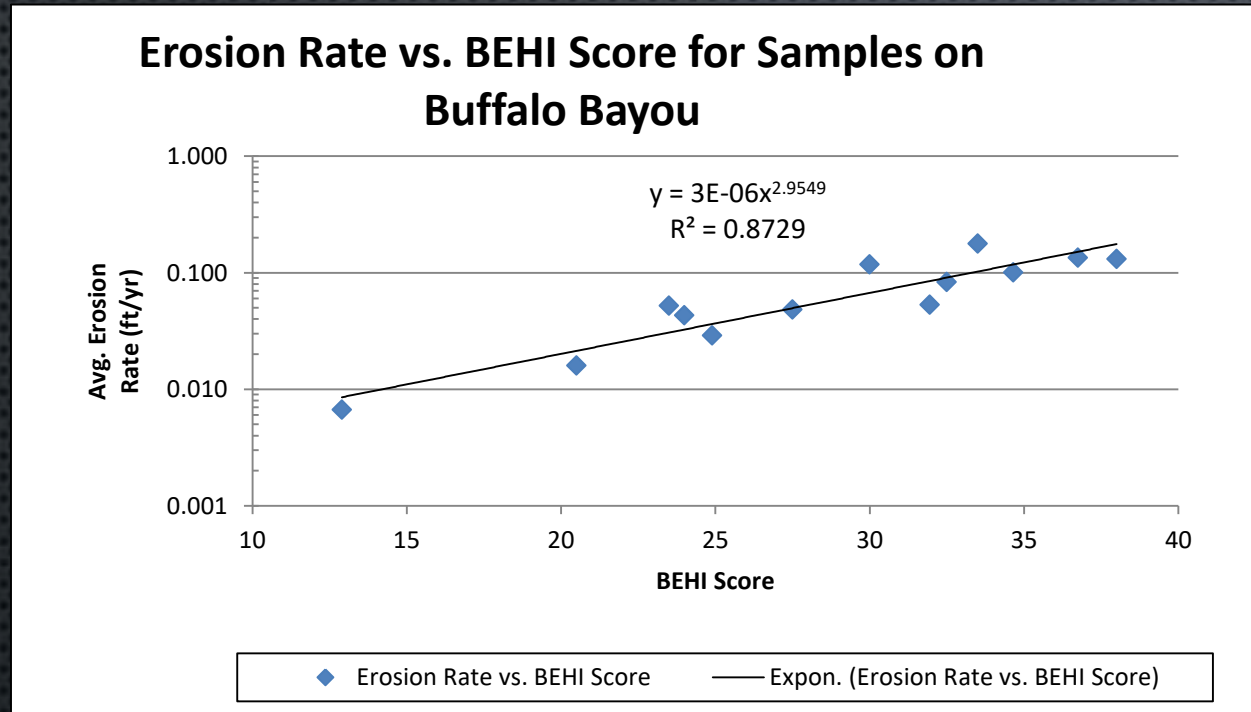
Samples exposed 10 years or less: Indicates older roots may be indicative of different state of erodibility than current bank

CASE STUDY: BUFFALO BAYOU, HOUSTON TEXAS



- Develop baseline data for future stream stability projects
“Prioritization of future projects”

CASE STUDY: BUFFALO BAYOU, HOUSTON TEXAS



Eroding riverbank on Buffalo Bayou

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

SAMPLE PREPARATION AND ORGANIZATION



- Samples can be analyzed at various levels of magnification
- Lowest level is cut disk with cheap microscope
- Greater magnification and preparation increases certainty for difficult samples



ANALYSIS WITH DIFFERENT MAGNIFICATIONS AND BUDGETS



Portable Microscope , Portable LCD GERI Digital Handheld Microscope 8 LED Photo and Video Capture TV Out

by GERI

\$115⁰⁰ ✓prime (4 days)

Only 4 left in stock - order soon.

★★★★☆ 12

Product Features

... 240V, 50/60Hz; Output: 5V, 1A. Microscope OSD languages: English/ ...



Celestron 44347 TetraView LCD Digital Microscope (Black)

by Celestron

<https://www.popularwoodworking.com/techniques/understanding-wood-four-structure-types>

\$259⁹⁵ ✓prime

Only 1 left in stock - order soon.

More Buying Choices

\$259.95 (10 new offers)



VanGuard Brightfield Phase Contrast Clinical Microscope, 1300PHi series, Halogen Illumination

by Vanguard

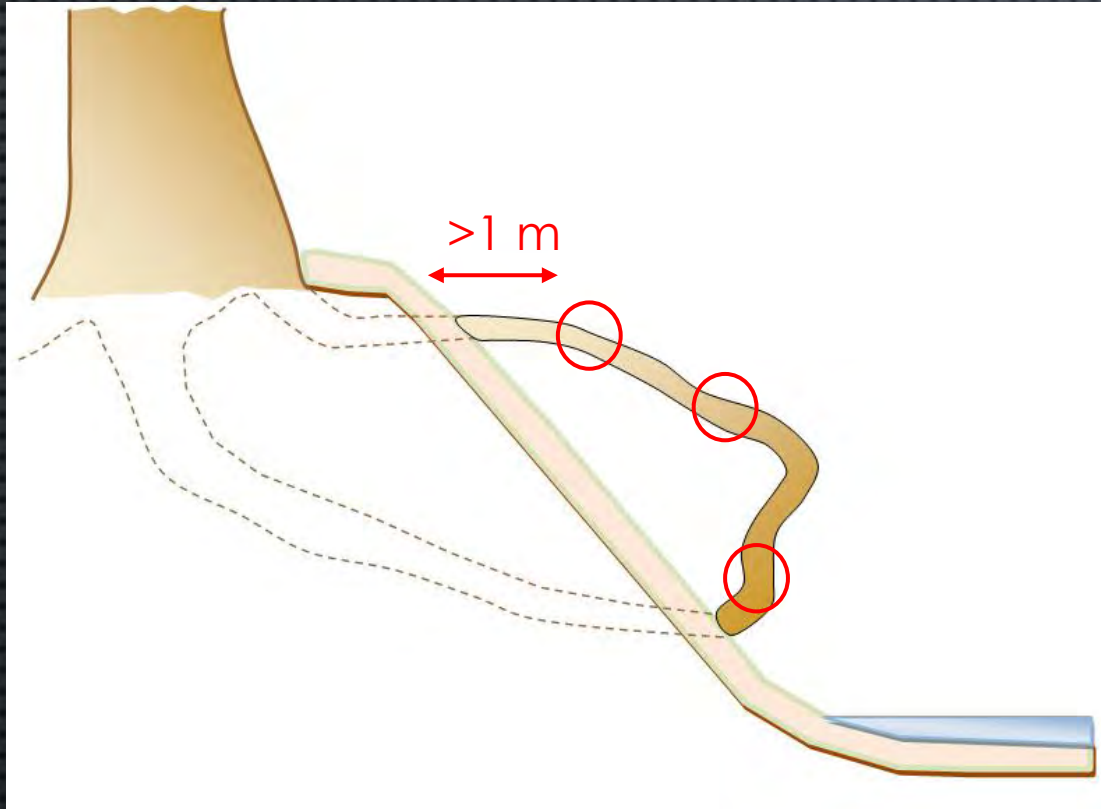
\$1,794³¹ - \$2,050⁰⁰ ✓prime

Some sizes are Prime eligible

More Buying Choices

\$500.00 (1 used offer)

SAMPLING TIPS



- Measure multiple samples up a riverbank to obtain average erosion
- Collect samples at least 1 meter away from riverbank

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)

DENDROGEOMORPHOLOGY 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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