How Understanding Geomorphic Conditions Can Inform Resiliency Planning

EMILY BROWN, PE & LYDIA WARD, PE
FREESE AND NICHOLS, INC.

INTRODUCTION

Lydia Ward, P.E.

- Environmental Engineer
- Stormwater Management and Ecological Restoration
- 8 Years in industry

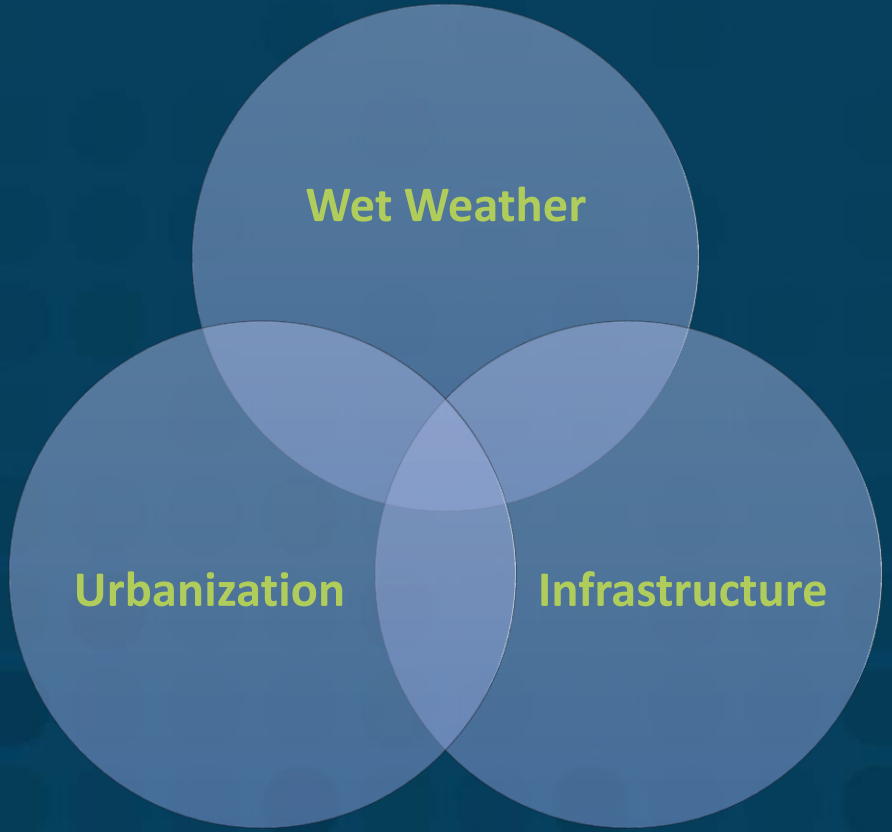
Emily Brown, P.E., CFM

- Ecological Engineer
- Stormwater Management and Ecological Restoration
- 10 Years in industry

OVERVIEW

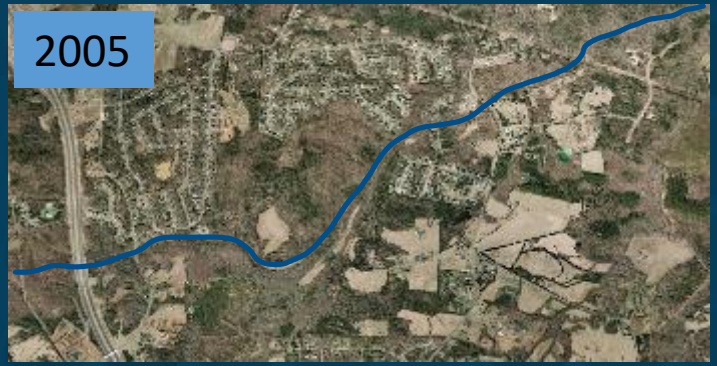
- Drivers and Motivation
- Use of Geomorphology
- Methods of Quantifying Erosion
- Introduction to Dendrogeomorphology
- Data Collection Overview
- Field Characterization
- Data Collection and Analysis
- Practical Applications
- Acknowledgements
- Questions

DRIVERS AND MOTIVATION



DRIVERS AND MOTIVATION

Urbanization (Charlotte – Reedy Creek)



DRIVERS AND MOTIVATION

THREAT TO INFRASTRUCTURE: CHANNEL CROSSINGS

DRIVERS AND MOTIVATION

DRIVERS AND MOTIVATION

DRIVERS AND MOTIVATION

LOSS OF LAND AND CHANNEL CAPACITY

Source: Dick et al. 2018

USE OF GEOMORPHOLOGY

FLUVIAL	GEO	MORPHOLOGY
Flowing Water	Earth	Study of changing shape, form & structure

A Different Approach

- Geomorphological Science
- Slope stability
- GIS-based prioritization efforts

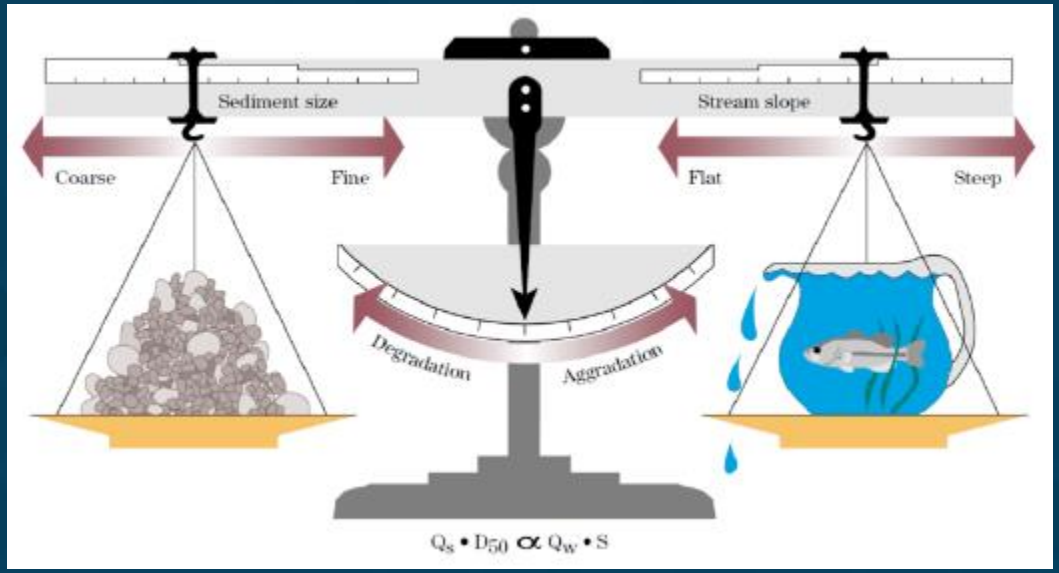
Holistic Thinking

- Sustainable design solutions
- Integrate across City departments
- CIP prioritization
- Without sustainable planning, results can be severe; options are limited and expensive

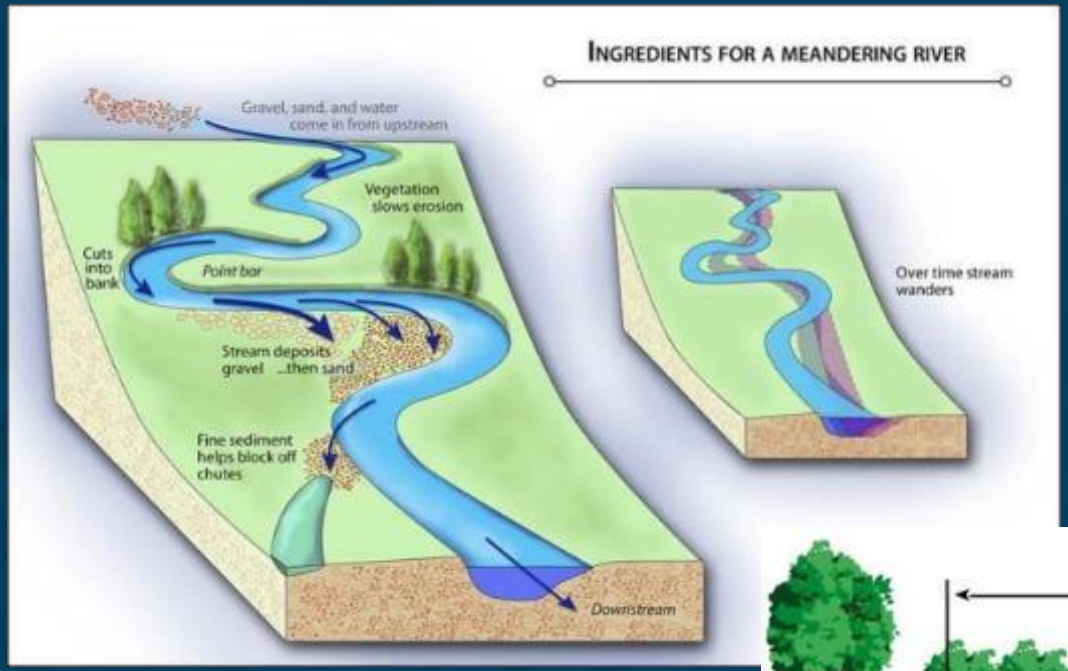
USE OF GEOMORPHOLOGY

LANE'S BALANCE

- **Streams convey water and sediment through a watershed**
- **Key relationships between sediment flux, discharge, slope, and grain size**
- **Channels adjust laterally and vertically such that these variables are in equilibrium**

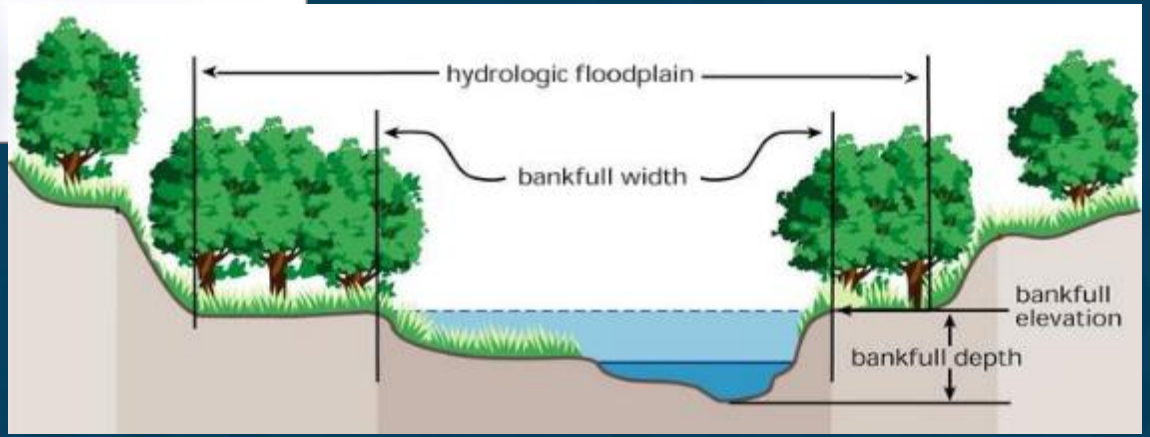


USE OF GEOMORPHOLOGY

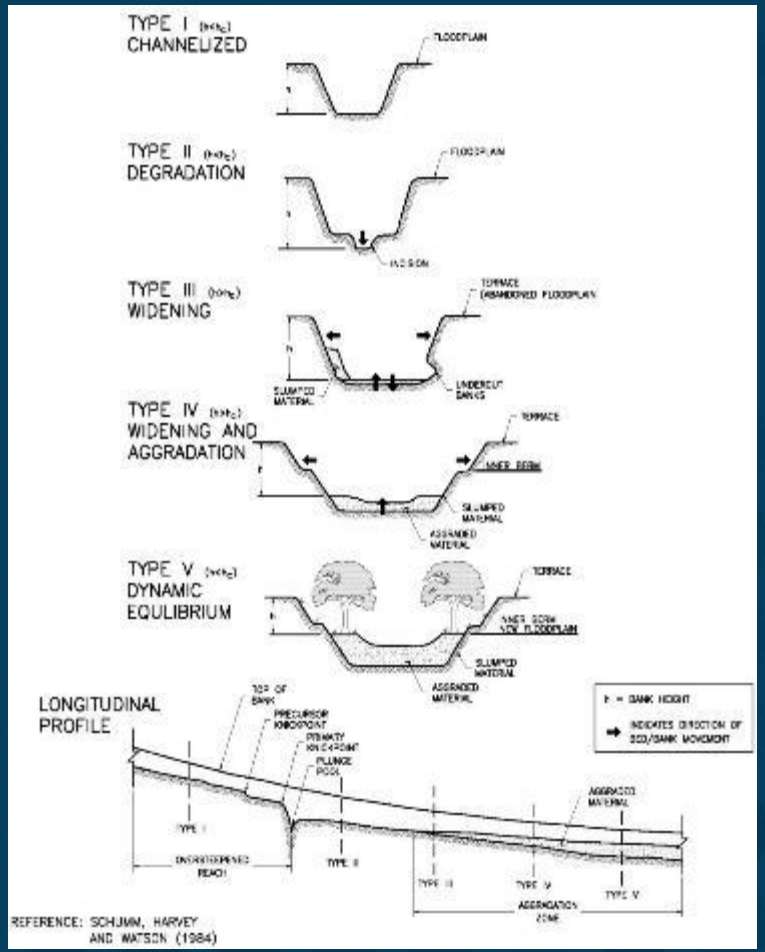


STABLE CHANNEL

- **Maintains dimension, pattern and profile**
- **Transports the flow and sediment**
- **Neither aggrades nor degrades.**



USE OF GEOMORPHOLOGY



METHODS OF QUANTIFYING EROSION

Erosion pins
- Most common 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

Less common:
- Photovoltaic
- LIDAR

Bank Surveys
- Toe Pins
- Scan

Analytical Models
- RUSLE
- USDA Bank Stability Model

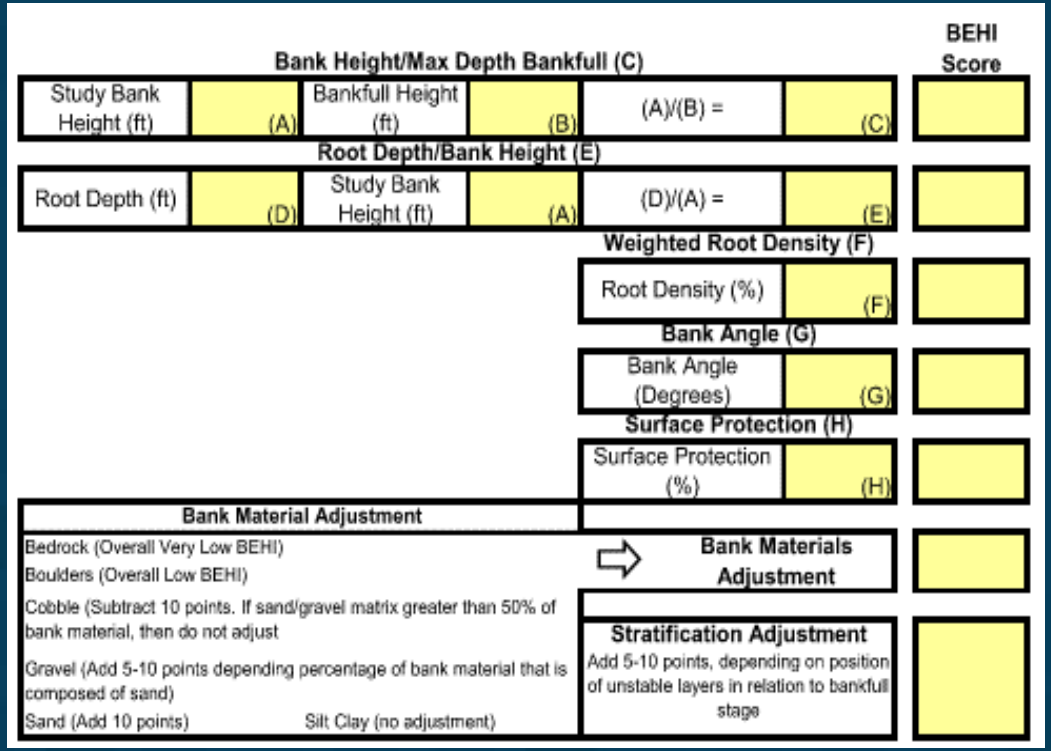
METHODS OF QUANTIFYING EROSION

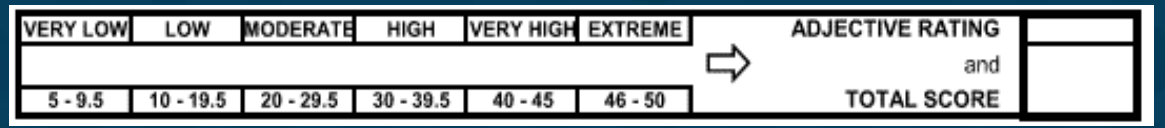
What are we evaluating?
Streambank erosion potential

Evaluate 5 related variables that influence bank erodibility:

- **Bank Height Ratio (BHR)**
- **Rooting Depth Ratio**
- **Root Density**
- **Bank Angle**
- **Surface Protection**

Also consider bank material and stratification





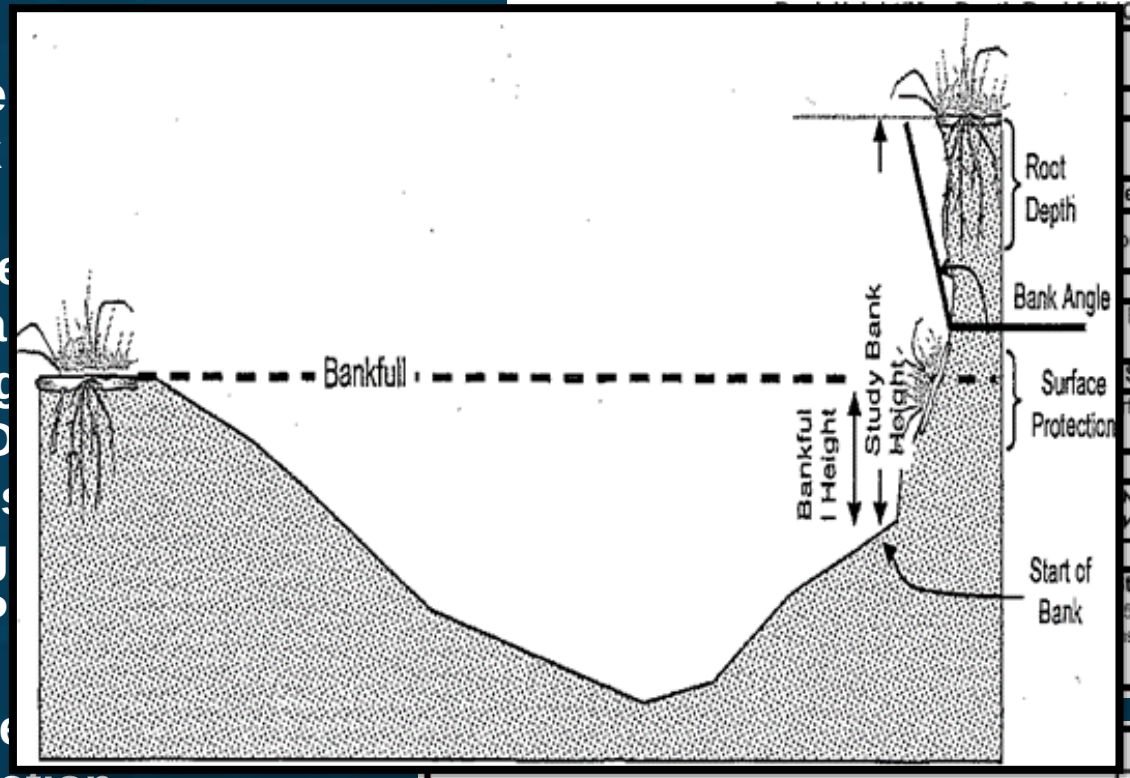
METHODS OF QUANTIFYING EROSION

What are we
Streambank

Evaluate 5 re
influence ba

- **Bank Heig**
- **Rooting D**
- **Root Dens**
- **Bank Ang**
- **Surface P**

Also conside
and stratification



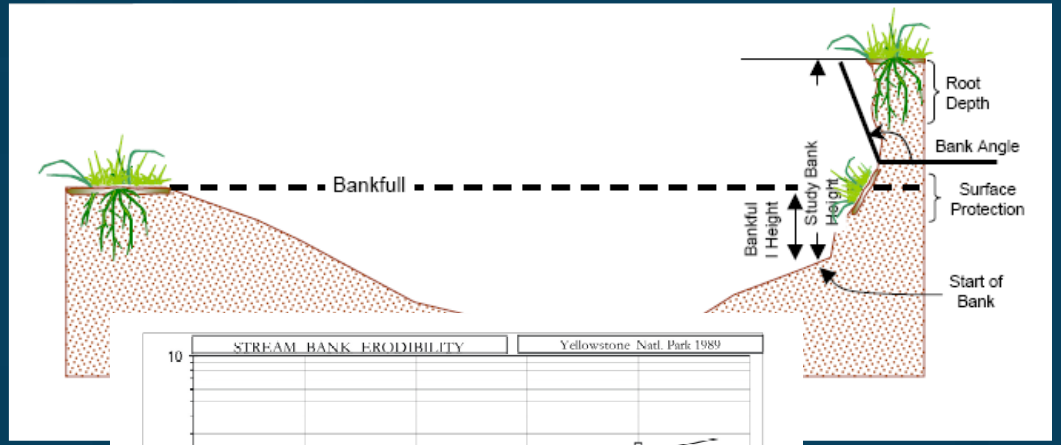
METHODS OF QUANTIFYING EROSION

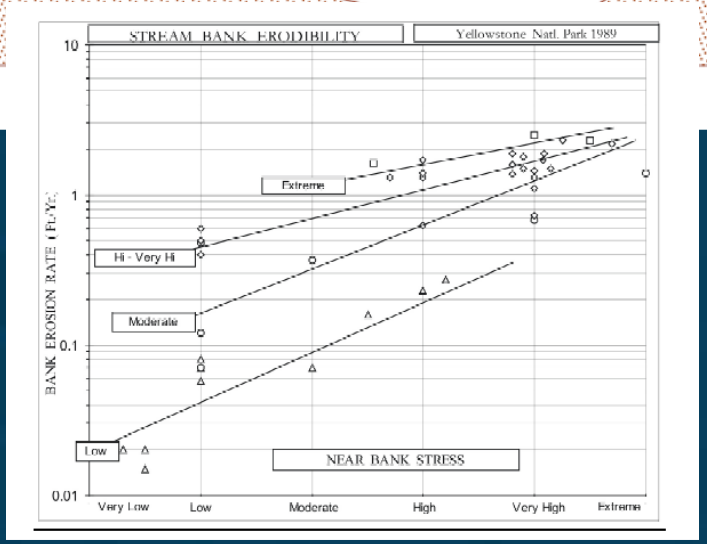
EMPIRICAL MODELS

BANCS model:

- **Uses erosion rate curves which relate bank-specific ratings of erodibility to erosion rates.**

- **Near Bank Stress (NBS) and Bank Erosion Hazard Index (BEHI) are used as ratings of erodibility**



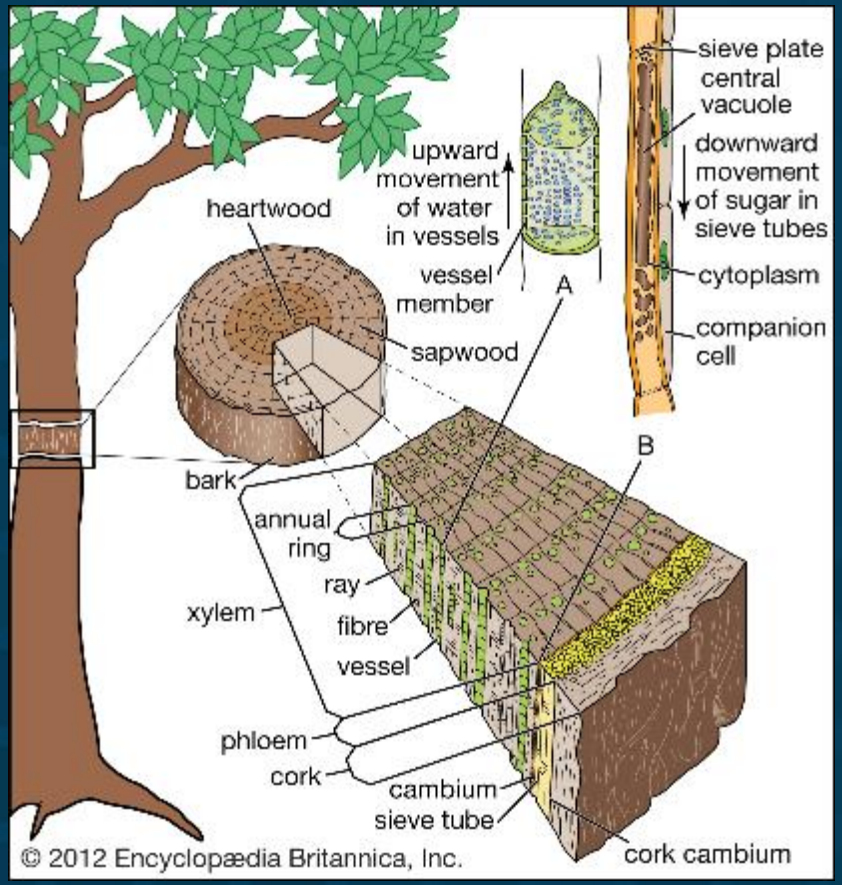


INTRODUCTION TO DENDROGEOMORPHOLOGY

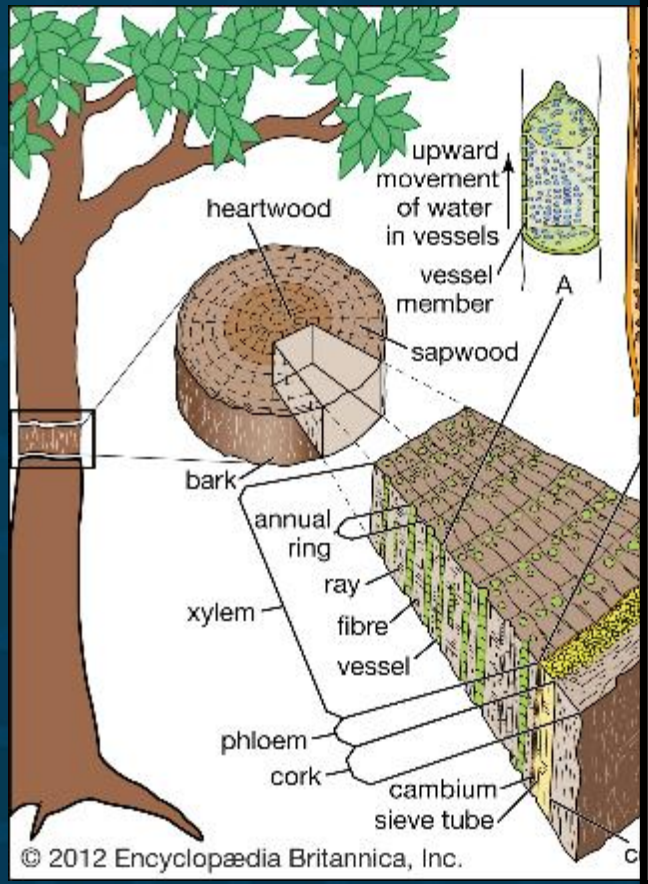
DENDROGEOMORPHOLOGY

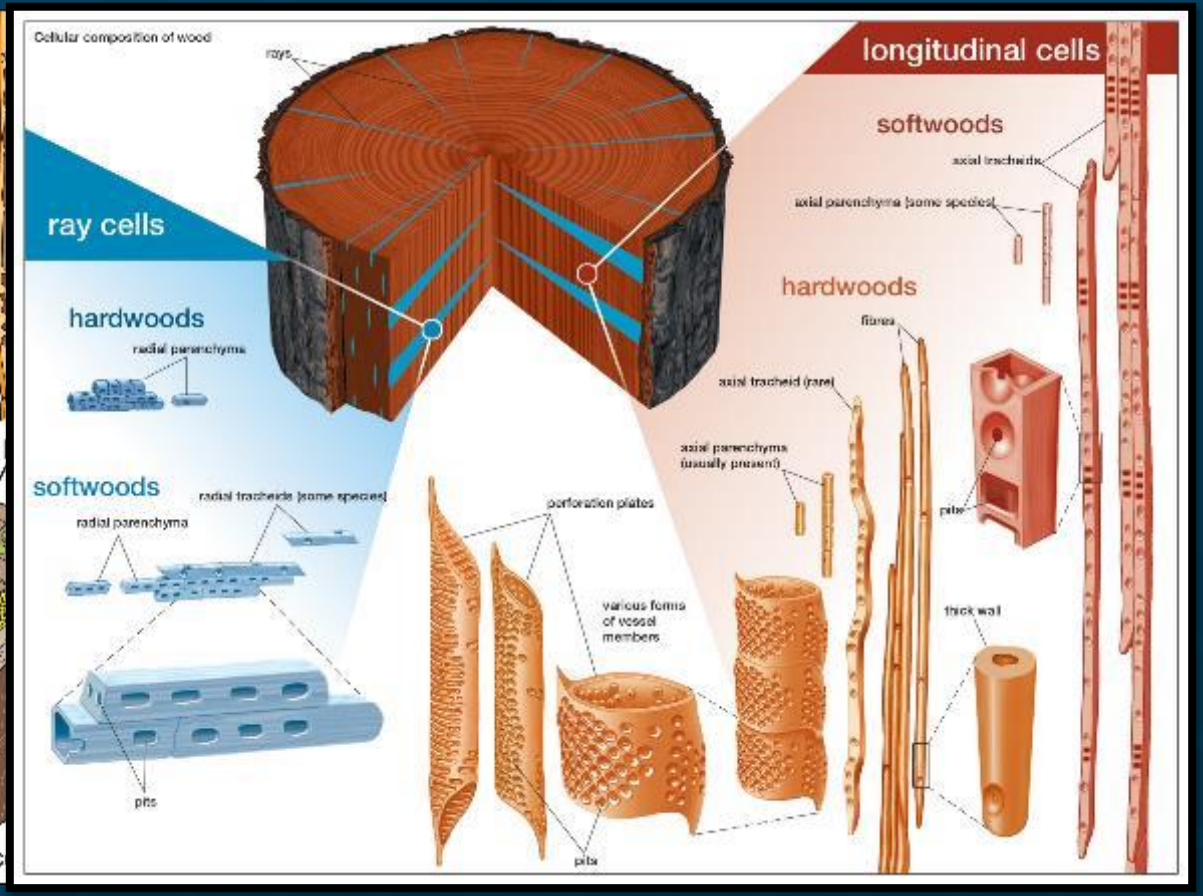
- **Using tree rings to identify dates of changes in land surfaces**
- **Tree anatomy changes in response to environmental factors**
- **Root anatomy changes when root is exposed to air**
- **Dick et al., River Research and Applications, 2013**

INTRODUCTION TO DENDROGEOMORPHOLOGY



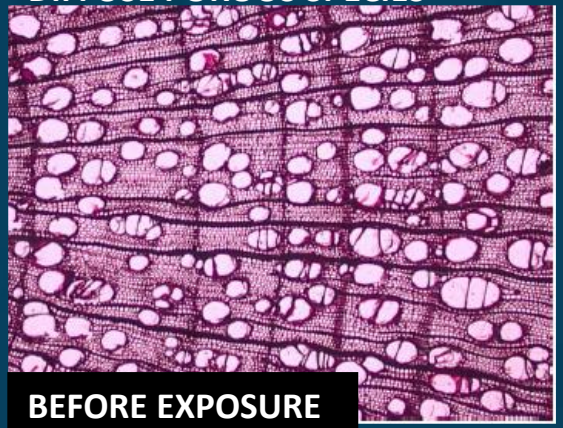
INTRODUCTION TO DENDROGEOMORPHOLOGY



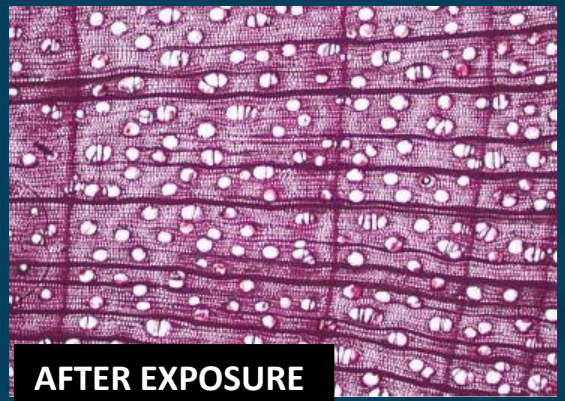


INTRODUCTION TO DENDROGEOMORPHOLOGY

DIFFUSE POROUS SPECIES

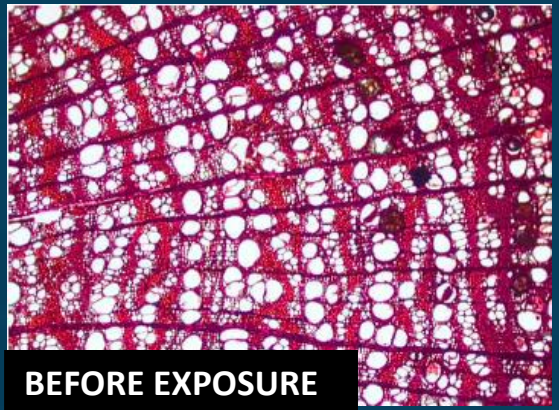


BEFORE EXPOSURE



AFTER EXPOSURE

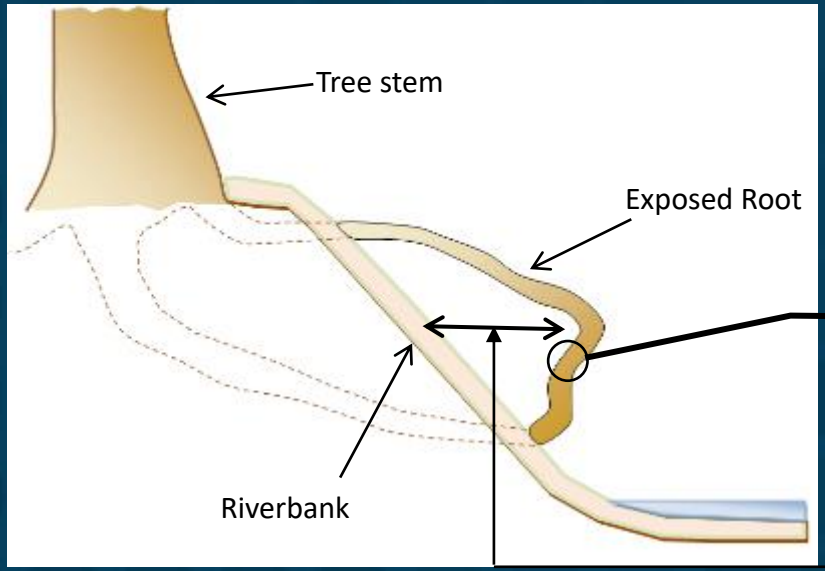
RING POROUS SPECIES



BEFORE EXPOSURE

AFTER EXPOSURE

INTRODUCTION TO DENDROGEOMORPHOLOGY



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

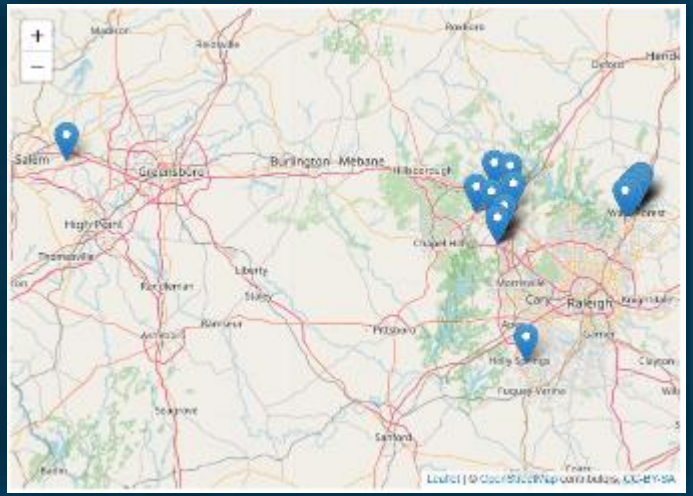
DATA COLLECTION OVERVIEW

- **Management of stream erosion has become increasingly more important for local governments**

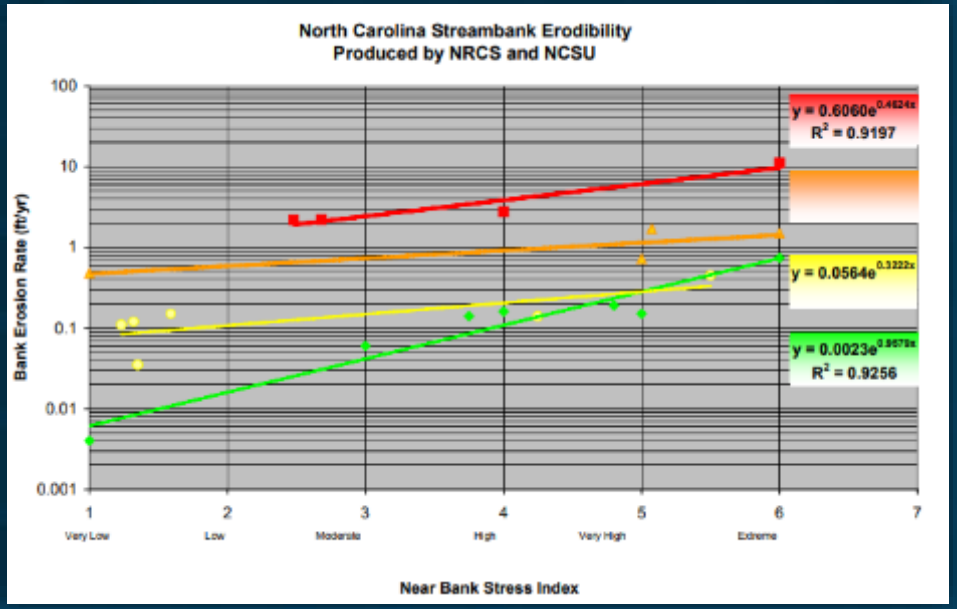
- **Prioritizing projects for funding requires accurate analysis of erosion rates**
  - How soon will this foundation be undermined?
  - How long until a pipe is exposed?

- **Erosion rate determination can be costly and time-consuming (years of monitoring)**

- **Exposed roots allow rapid assessment and estimation of erosion rates**



DATA COLLECTION OVERVIEW



Goals of Analysis

- Can these curves be combined to create an accurate estimate of bank erosion rates?
- Provides an idea of erosion rate variability across streams in the NC Piedmont Region
- Compare with existing erosion rate curves

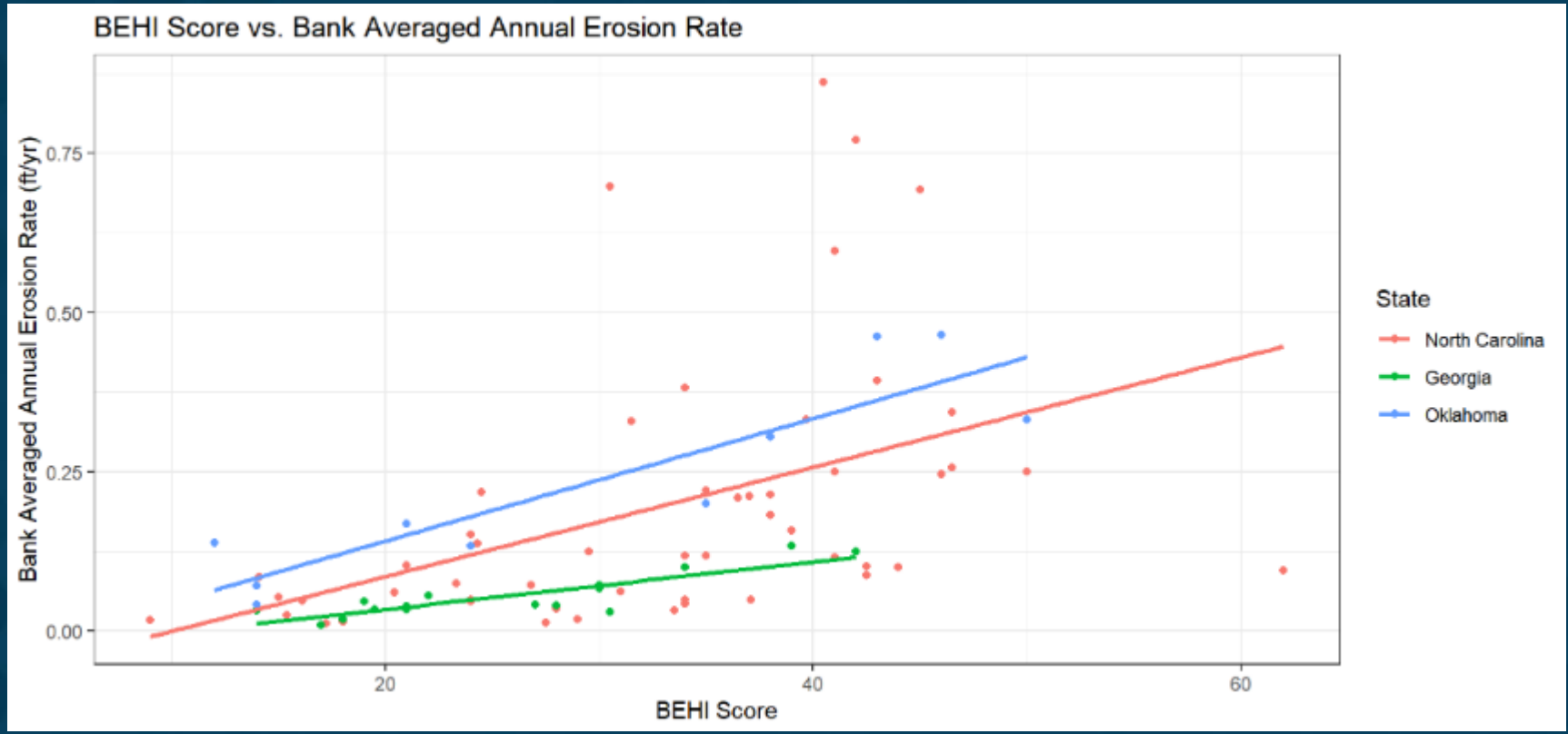
FIELD CHARACTERIZATION

- **Identify root samples to collect in the vicinity of the bank pins**
- **If there are no roots available, collect the sample from a similar location (i.e. similar near bank stress, same BEHI, same erosional forces)**
- **Try to collect roots across the bank (top, middle, and bottom)**

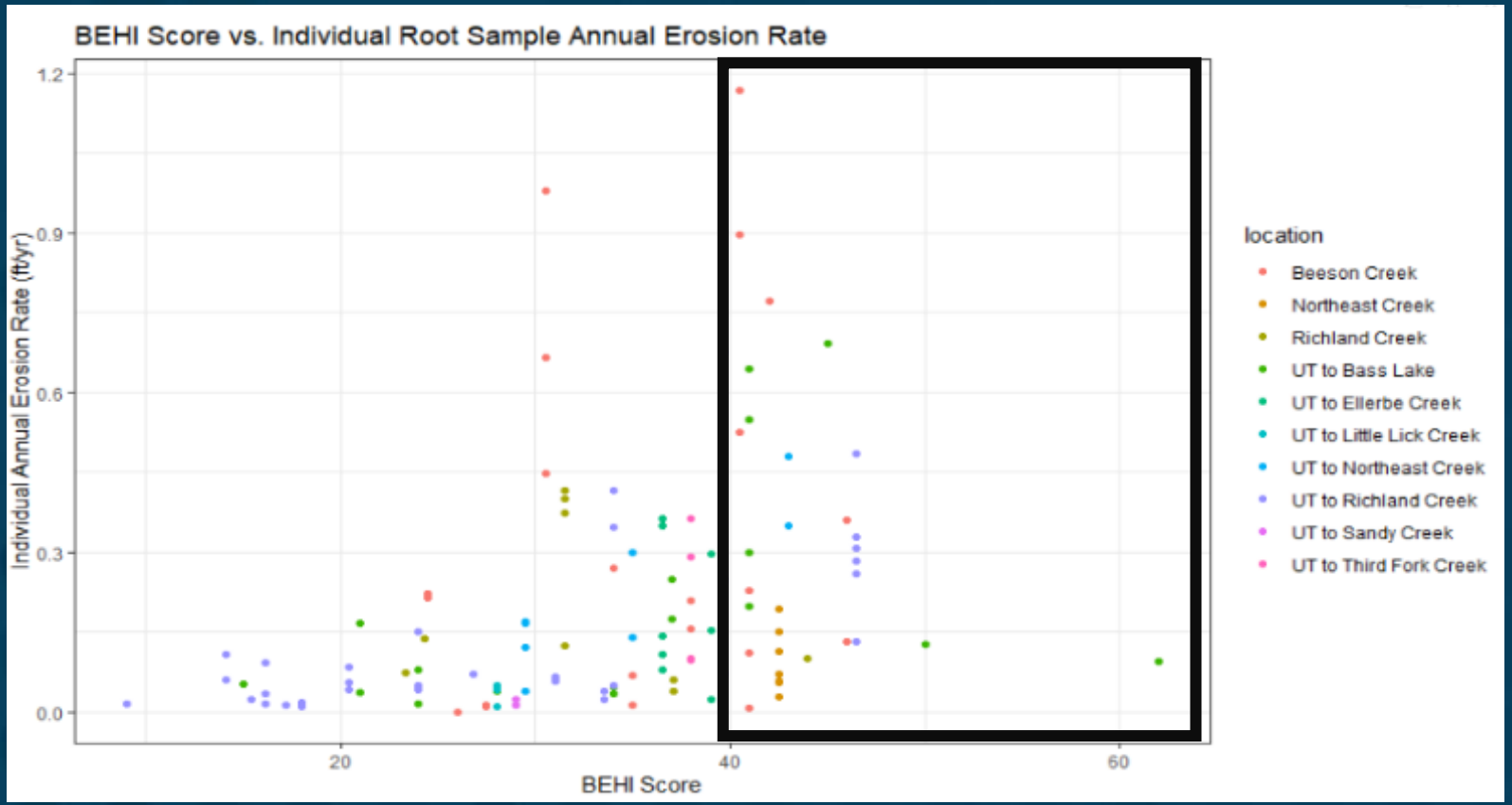
FIELD CHARACTERIZATION

- **Document bank conditions (BEHI measurements, photos, GPS)**
- **Measure the horizontal distance from the mid-point of the root back to the bank and record**
- **Measure the vertical distance from the mid-point of the root down to the toe of slope and record**

DATA COLLECTION & ANALYSIS



DATA COLLECTION & ANALYSIS

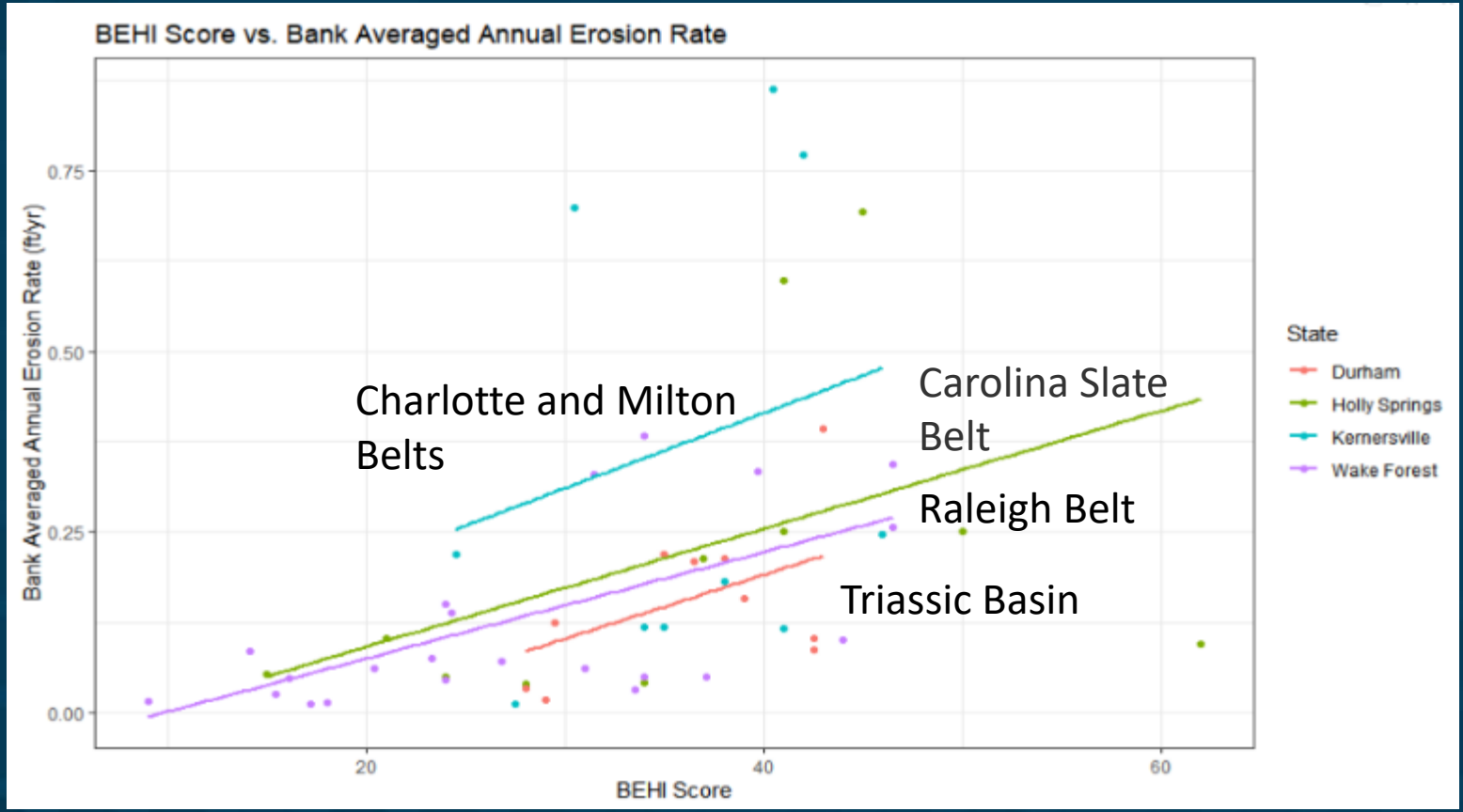


DATA COLLECTION & ANALYSIS

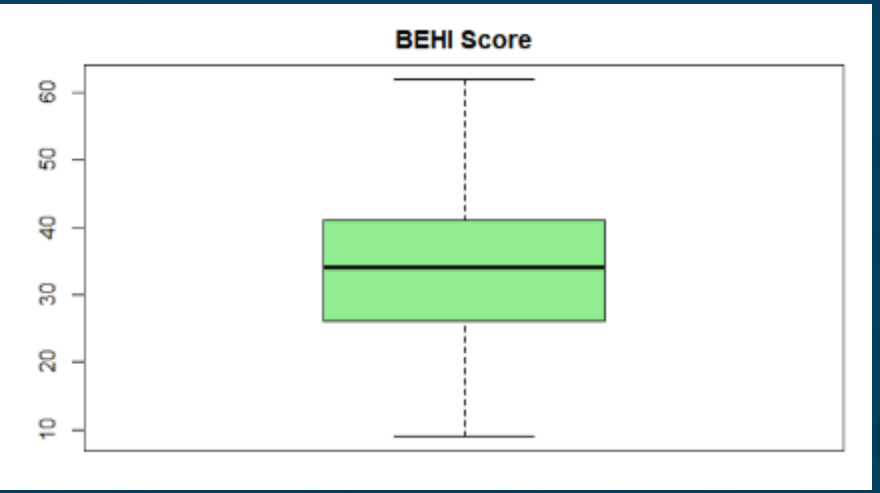
Maximum ER
- **0.86 ft/yr**

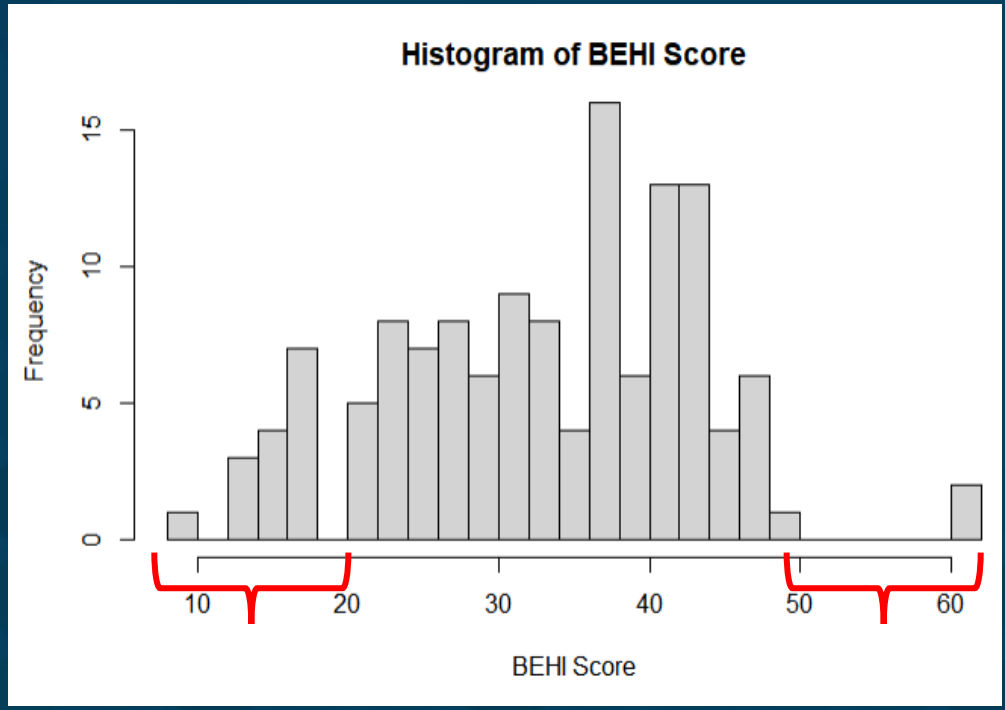
Average ER
- **0.21 ft/yr**

Minimum ER
- **0.013 ft/yr**

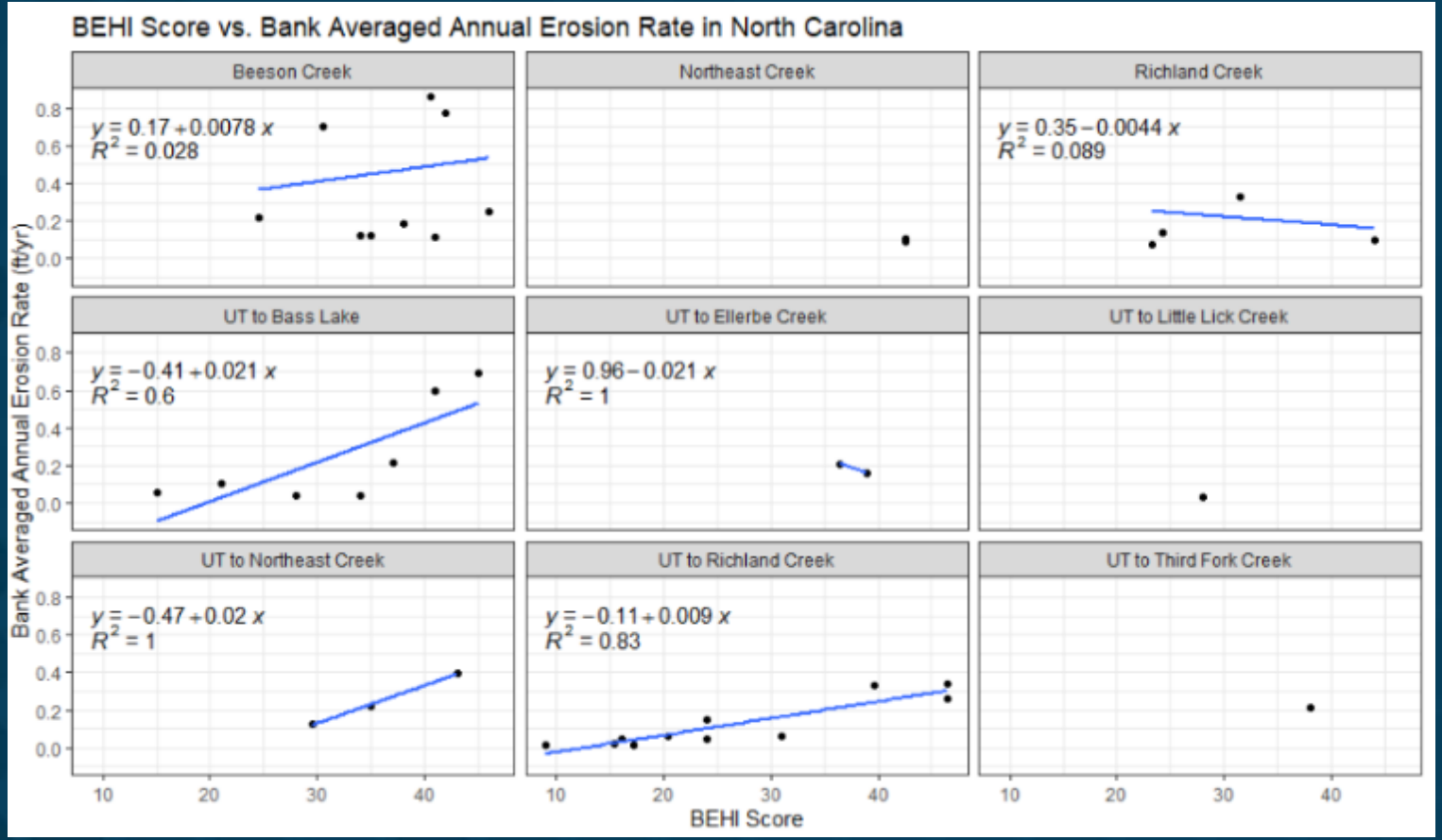


DATA COLLECTION & ANALYSIS

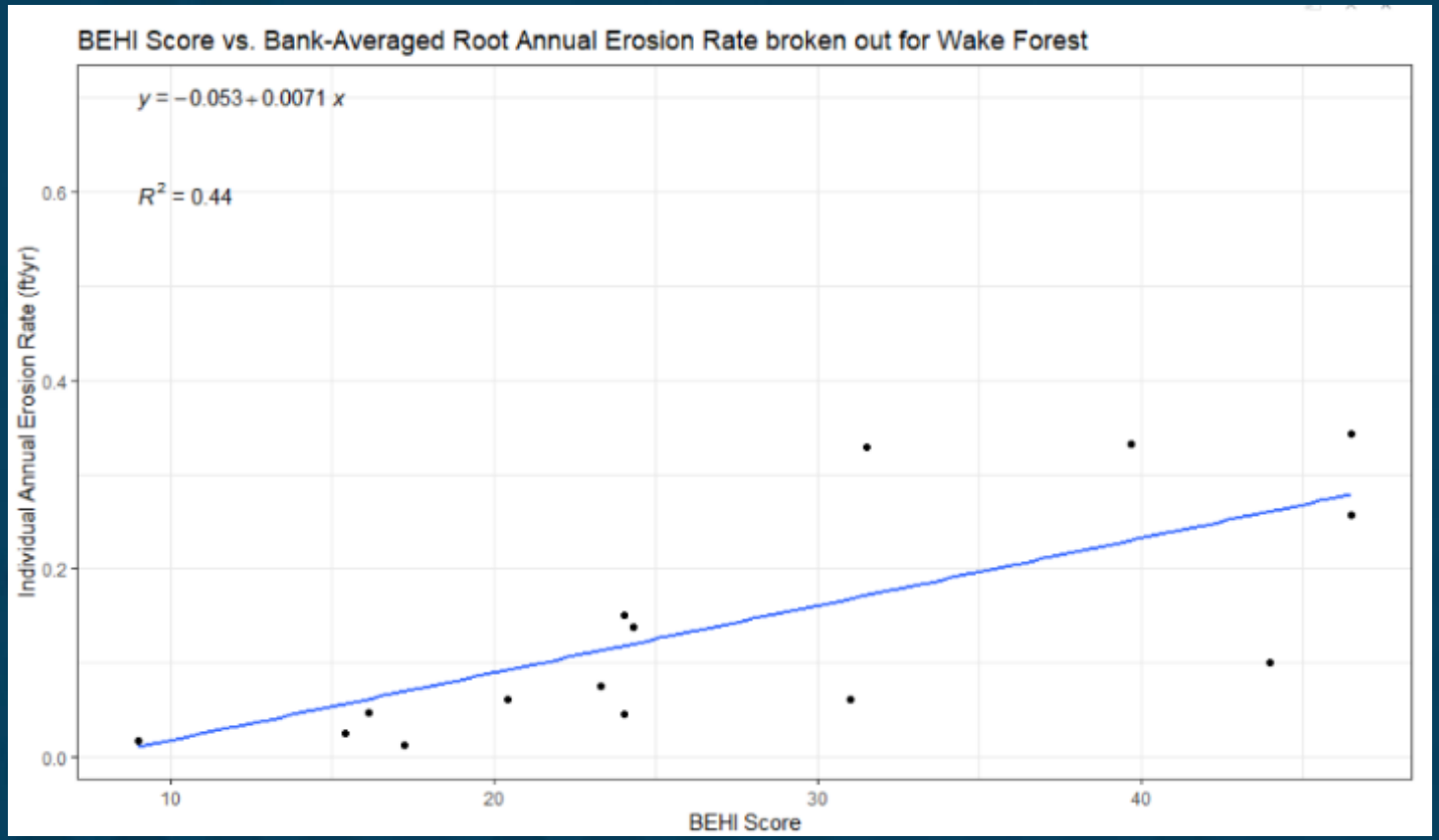




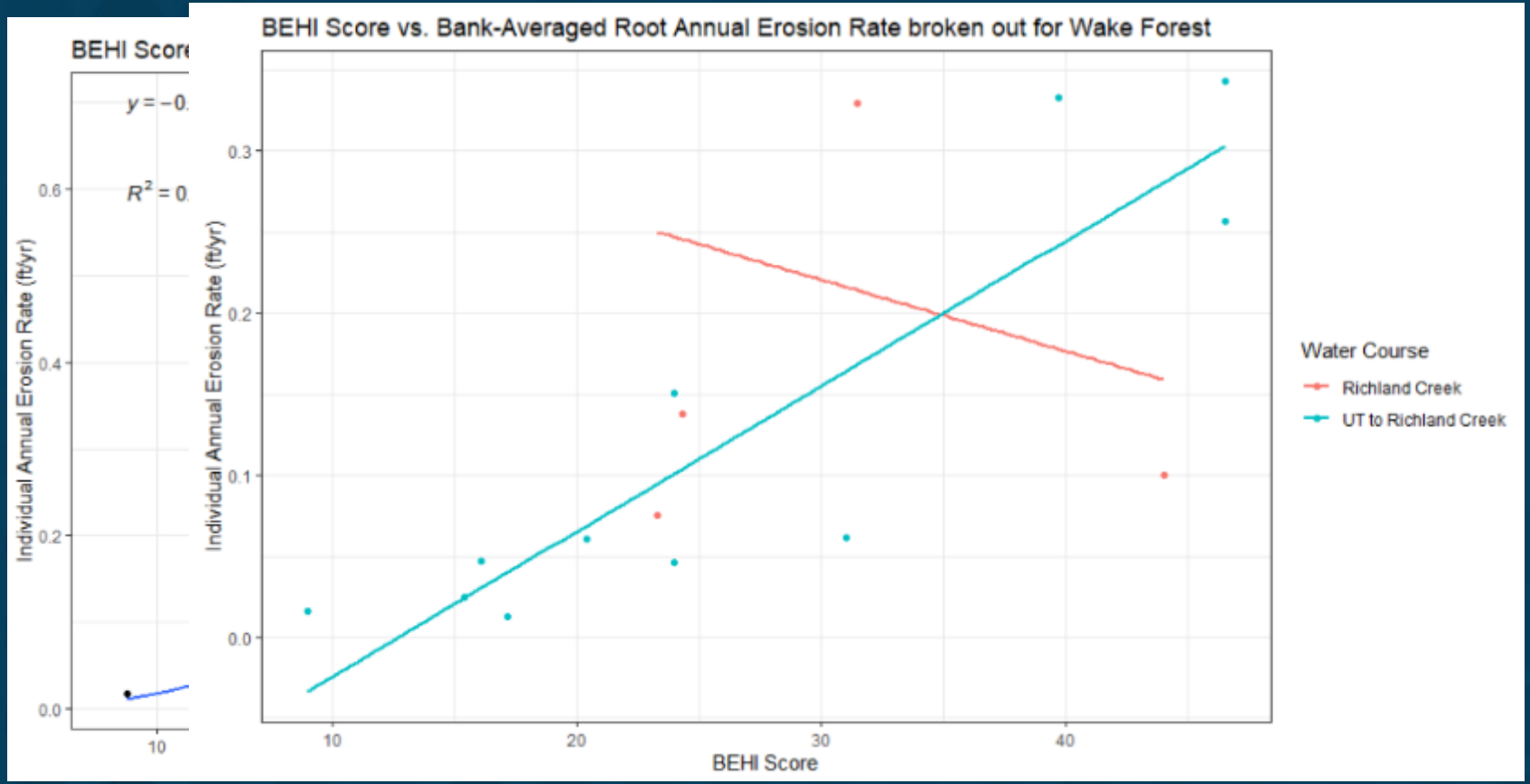
DATA COLLECTION & ANALYSIS



DATA COLLECTION & ANALYSIS



DATA COLLECTION & ANALYSIS



DATA COLLECTION & ANALYSIS

- **Most commonly used NC piedmont curve (NCSU): erosion rate from 0.004 ft/year to 10 ft/year**
- **Curve from Exposed roots: erosion rate from 0.0014 ft/year to 0.86 ft/year**
- **Combined curve has good prediction with medium to lower BEHI scores**
- **Need more data to explain wide variability of higher scores**
- **Variability likely explained due to soil conditions**

PRACTICAL APPLICATION

- **Best value when picking a measuring tool for planning purposes**
  - **Bank Pins take Time & Effort**
  - **Understand your assumptions**
- **Use measurement techniques to quantify water quality improvements**
  - **Nitrogen**
  - **Phosphorous**
- **Should include stream assessment with condition assessment AND should incorporate exposed root study into stream assessment**

- **Justification to Agencies for Streambank Stabilization and Stream Restoration projects**
- **Opportunities for grant funding**

ACKNOWLEDGEMENTS

Periann Russell

Division of Mitigation Services

Dr. Celso Castro-Bolinaga
NCSU Bio & Ag Department

City of Durham

Town of Kernersville

Town of Wake Forest

Town of Holly Springs

Q&A

Lydia Ward, P.E.

Emily Brown, P.E.