Assessment of Soil Creep Sediment Generation for Total Maximum Daily Load Development in a Northern Coastal California Watershed

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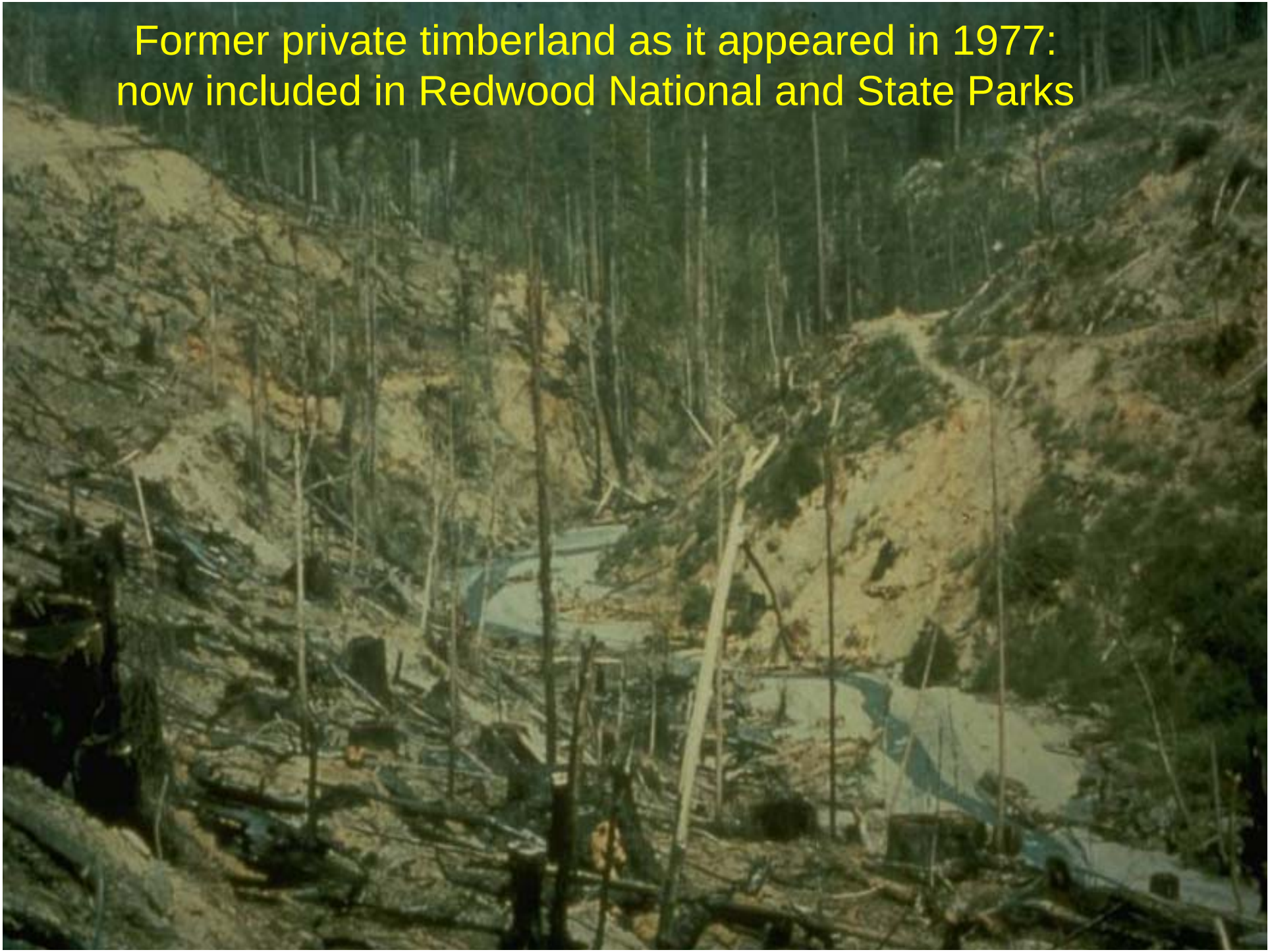
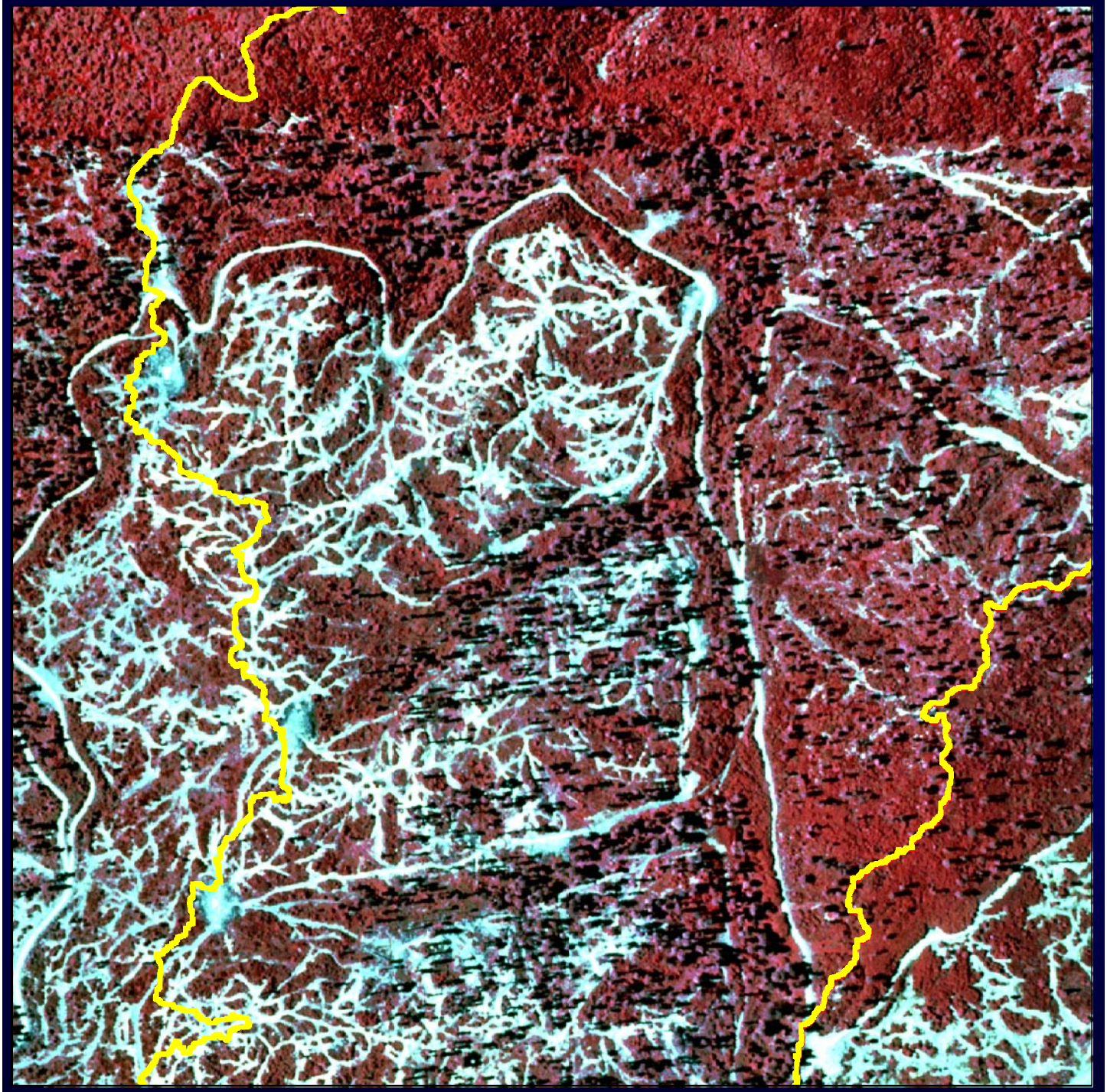
Presentation Outline

- Background – Sediment Impairment
  - Clean Water Act
  - Sediment budgets
- Soil Creep
  - Creep rates and depth
- Stream Density
- Soil Creep Sediment Delivery
- Checks –
  - Bank erosion and suspended sediment loads
- Conclusions & Recommendations

LUNCH TIME - GUMMA WOODS
ABOUT 1905. SKIDDING & LOGGING
CREW - NOTE LOG SKID ROAD IN


Former private timberland as it appeared in 1977:
now included in Redwood National and State Parks



spawning adult chinook salmon
juvenile coho salmon

Clean Water Act

- Section 303(d) of the federal Clean Water Act requires states to identify waterbodies that are impaired, and to develop a pollution control plan in order to attain and maintain water quality standards

What is a TMDL?

- A Total Maximum Daily Load (TMDL) is a water quality attainment strategy and provides a framework for
  - assessing watershed condition
  - evaluating the sources contributing to water quality problems in the waterbody
  - developing a water quality restoration plan for landuses and ownerships across the watershed

TMDLs Nationwide and in California

- > 40,000 impairments nation-wide
- 1,500 impairments across California
- North Coast Region
  - 61% of the region's area drains to sediment impaired water bodies

Sediment Budgets

Methods to determine sediment sources

- Aerial photo analysis and interpretation
- Computer modeling
- Literature review
  - especially information from nearby watersheds
- Field surveys

Sediment Sources

- Best estimates of loading
  - Range from reasonably accurate estimates to gross allotments
- Margin of safety is <u>required</u> for TMDLs
  - Implicit: make conservative assumptions in the development of the sediment loadings
  - Explicit: reserve a portion of the load allocation

Completed TMDLs

- 20 sediment TMDLs have been completed for the north coast
  - Current loading
    - average = 228% (over background)
    - median = 177%
  - Loading capacity
    - average = 134% (over background)
    - median = 125%

Accuracy for Completed TMDLS

- Turbidity Levels
  - Turbidity levels suggest managed watersheds are currently 717% over background (Klein et al., 2008)
- Suspended Sediment Loads
  - Comparing managed and unmanaged watersheds suggest > 1,000% over background (Manka, 2005)

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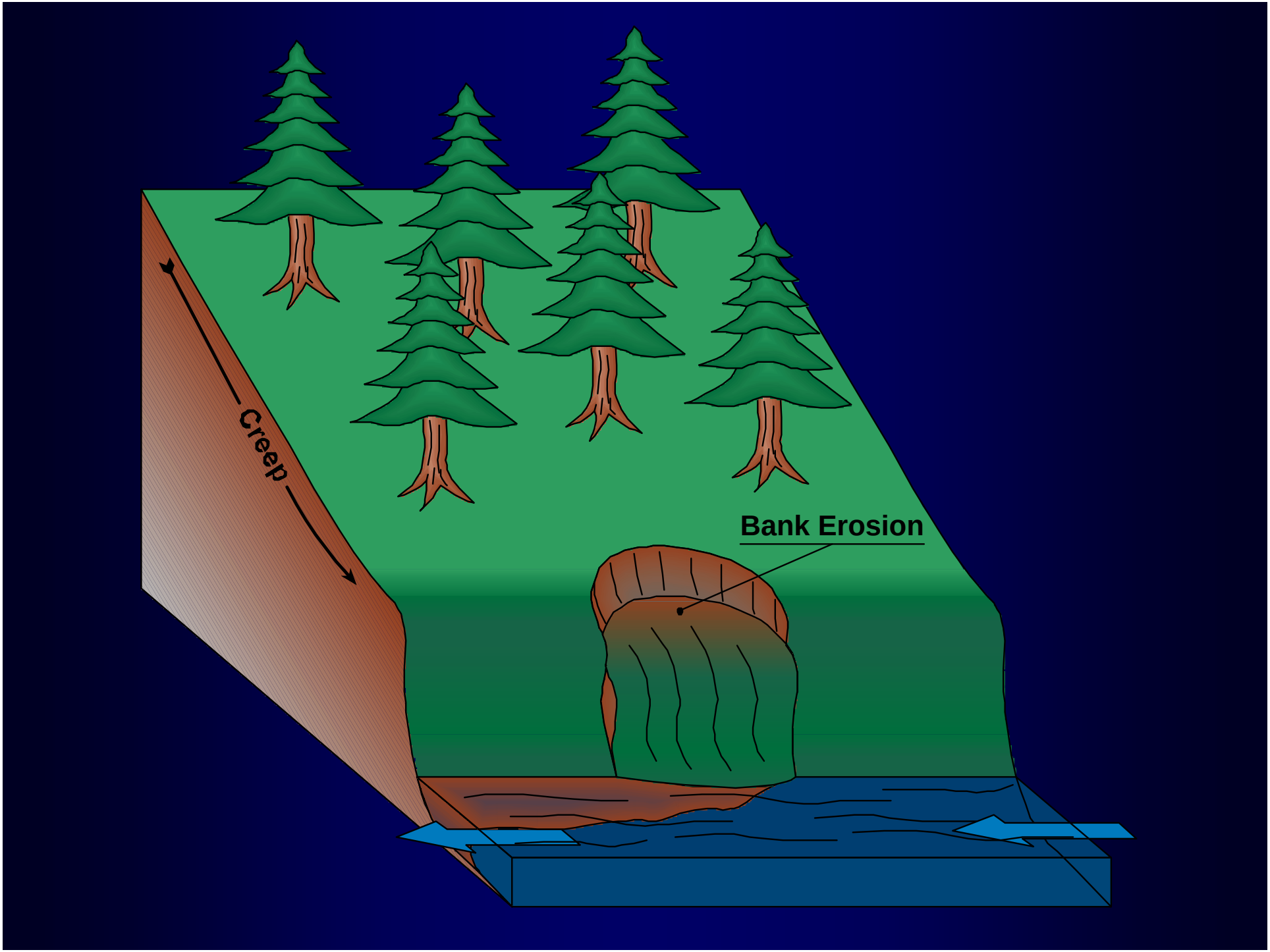
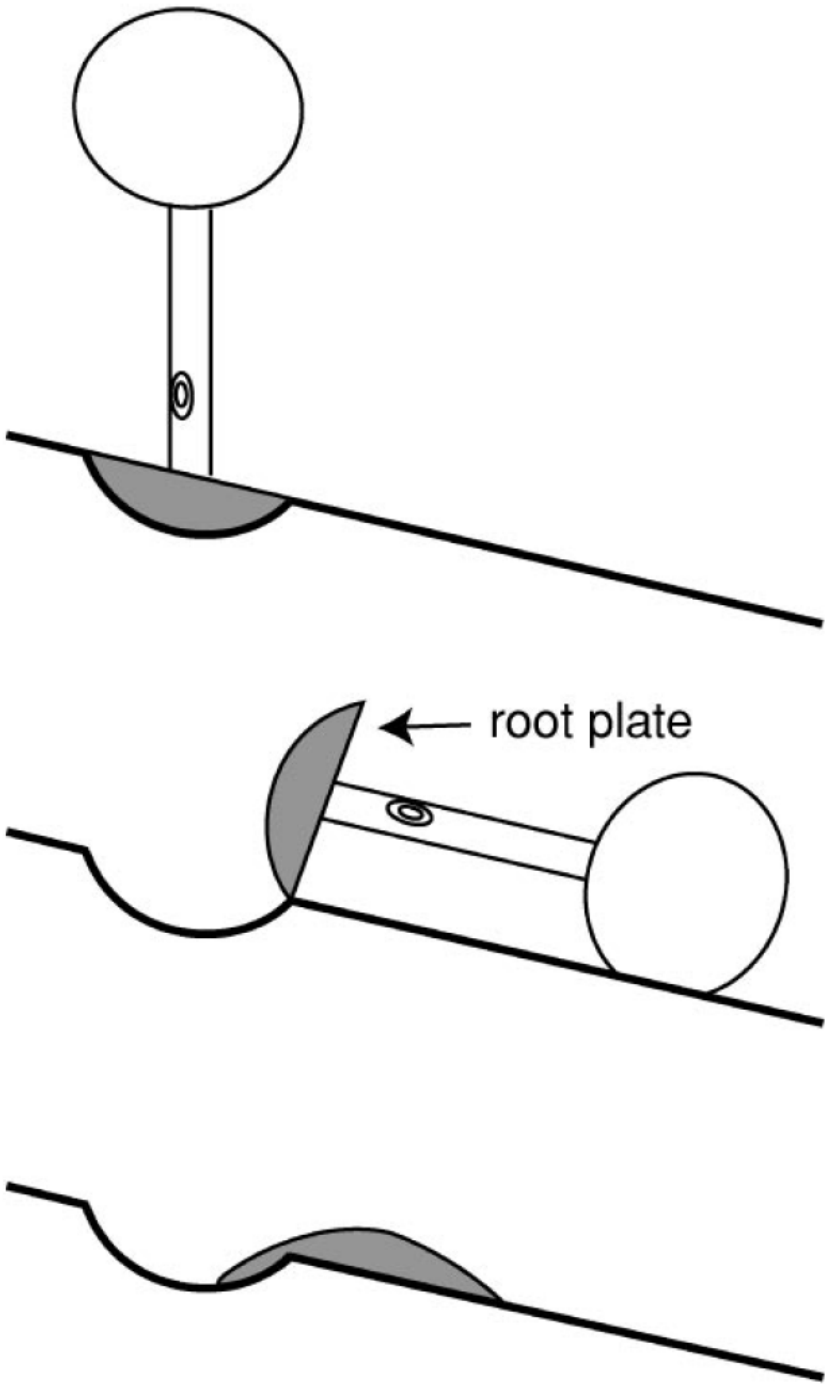
Problem Statement

- Research and investigate soil creep
  - a category that may be overestimated in sediment budgets
- Soil Creep is a key natural process that leads to sediment delivery
  - Numerous sediment budgets use Washington's Watershed Analysis Methodology to estimate soil creep contributions


Creep
Bank Erosion



(Gabet et al., 2003)

Washington's Watershed Analysis Methodology

$$V = 2 * C * D * L$$

V = annual erosion volume ($m^3\ a^{-1}$)

2 = the number of streambanks

C = creep ($m\ a^{-1}$)

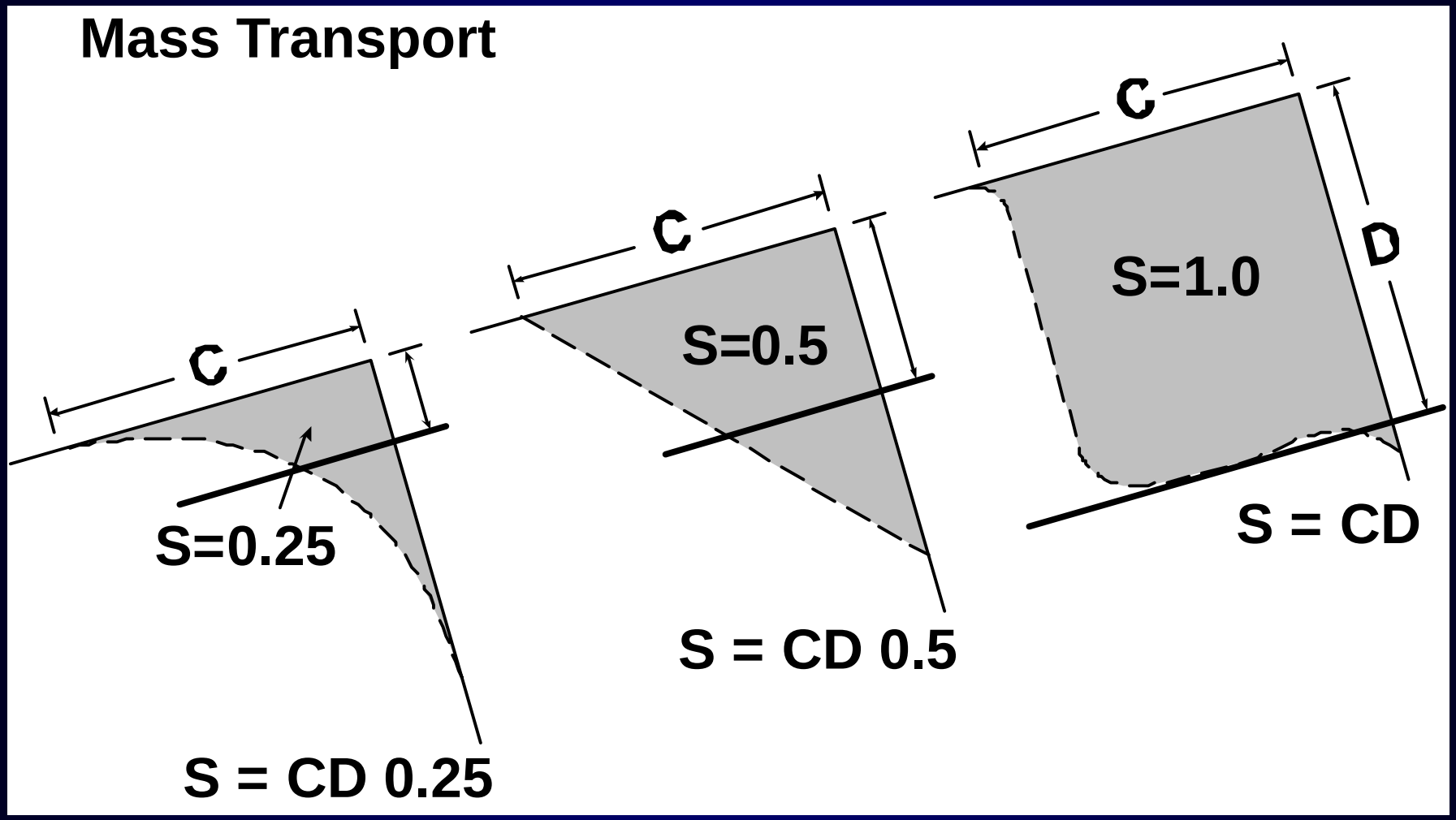
D = soil depth (m)

L = channel length (m)

Creep Rates for Temperate Forests

- Creep is very hard to measure and studies need to be conducted for long periods to overcome initial disturbance
- Surface Creep Rates
  - Range from zero to 5 mm a^{-1}
- Volumetric Creep Rates
  - Range from 0.1 to 3.5 cm^3 cm^{-1} a^{-1}

Variation with Depth



(Adapted from Selby, 1993 and Jahn, 1981)

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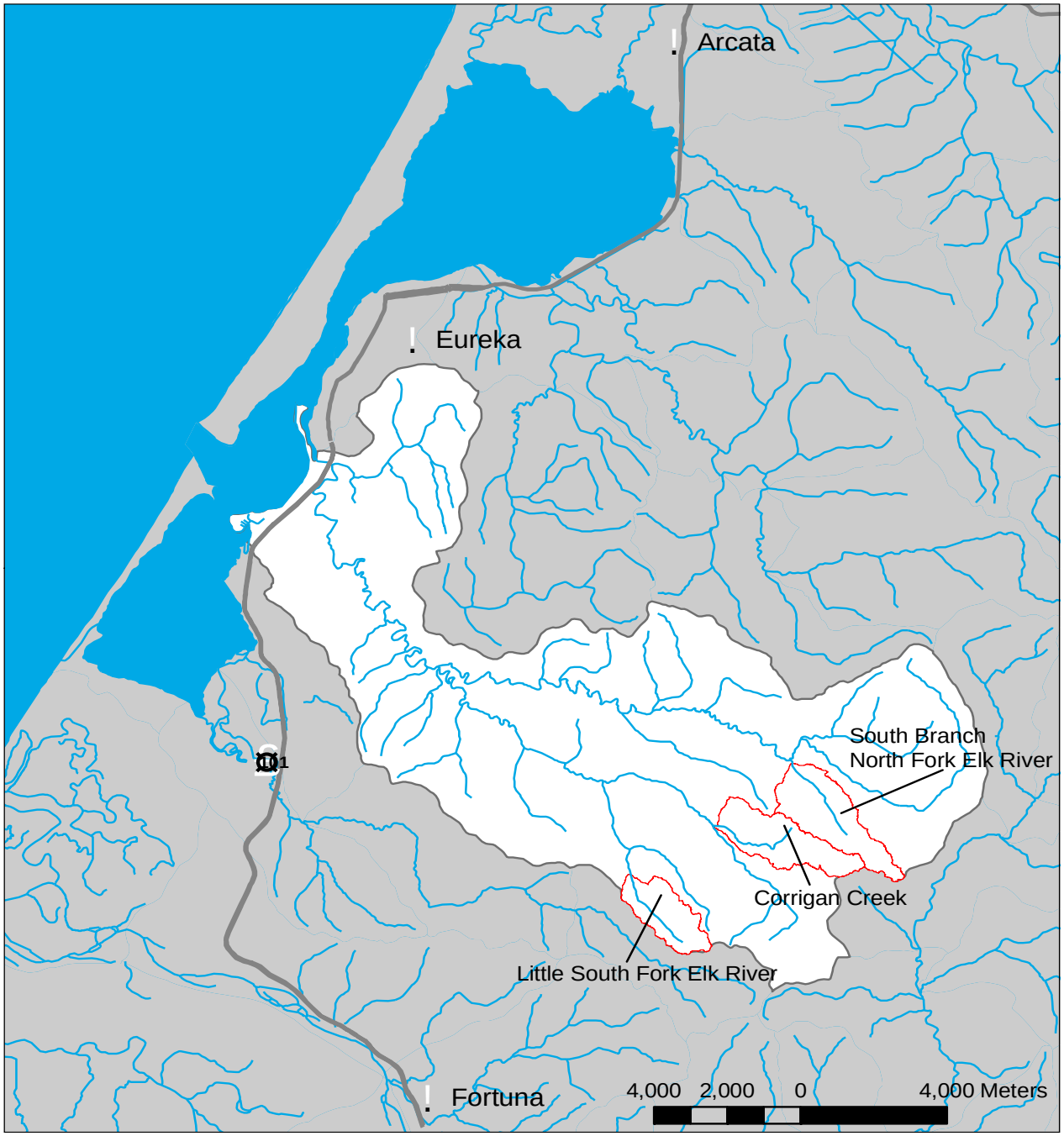
Stream Density

- Aerial photographs underestimates stream density
  - Canopy hides small streams
- Field surveys are recommended
  - Current stream density may have changed due to management activities
- Compare current stream density with pristine watershed
  - Determine if there is a slope/drainage area relationship

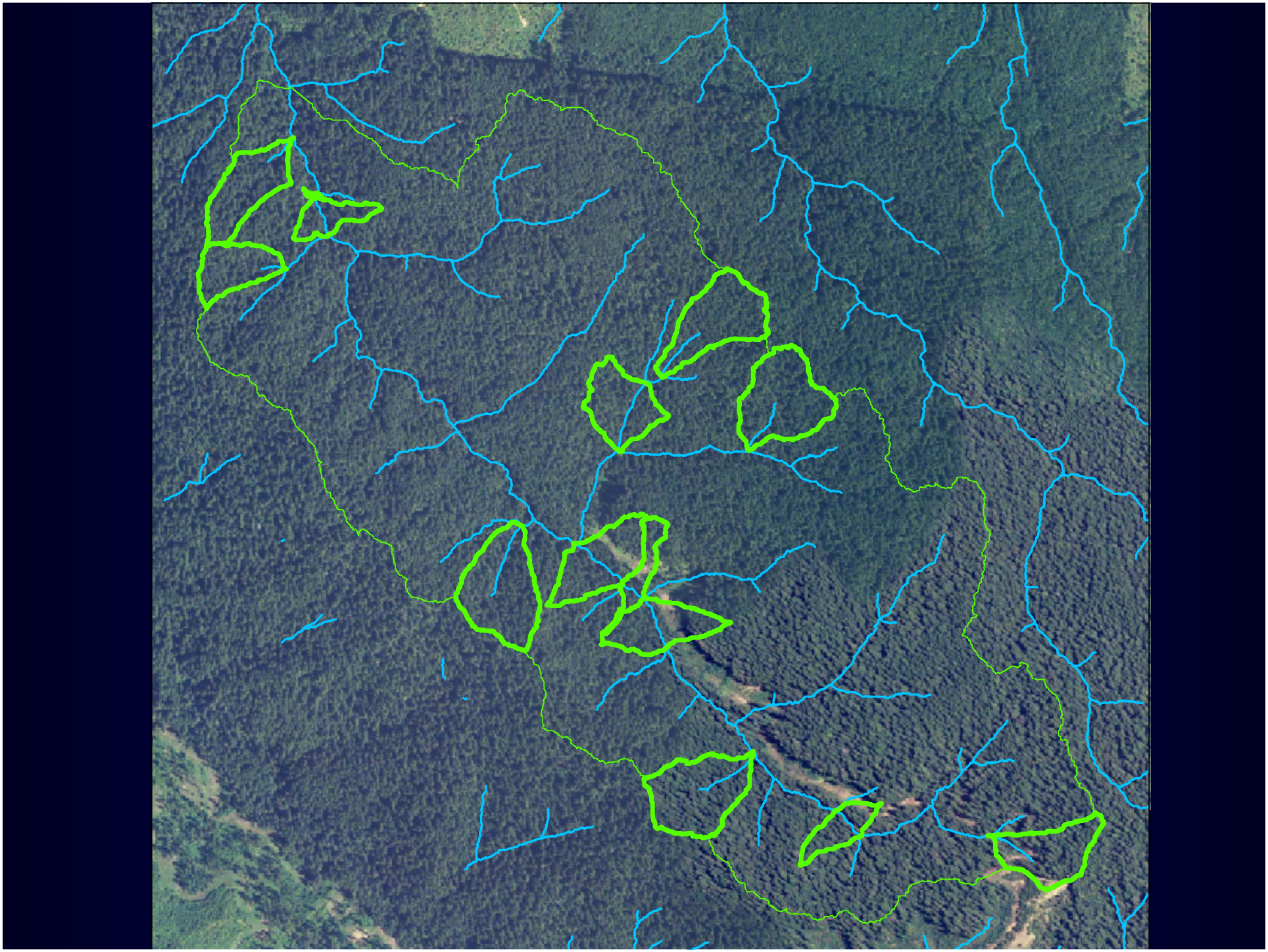
Elk River

- Listed as sediment impaired in 1998
- Mediterranean climate
  - Very little temperature variation
  - 90% of precipitation falls during the winter season


Arcata
Eureka
South Branch
North Fork Elk River
Corrigan Creek
Little South Fork Elk River
Fortuna
4,000 2,000 0 4,000 Meters

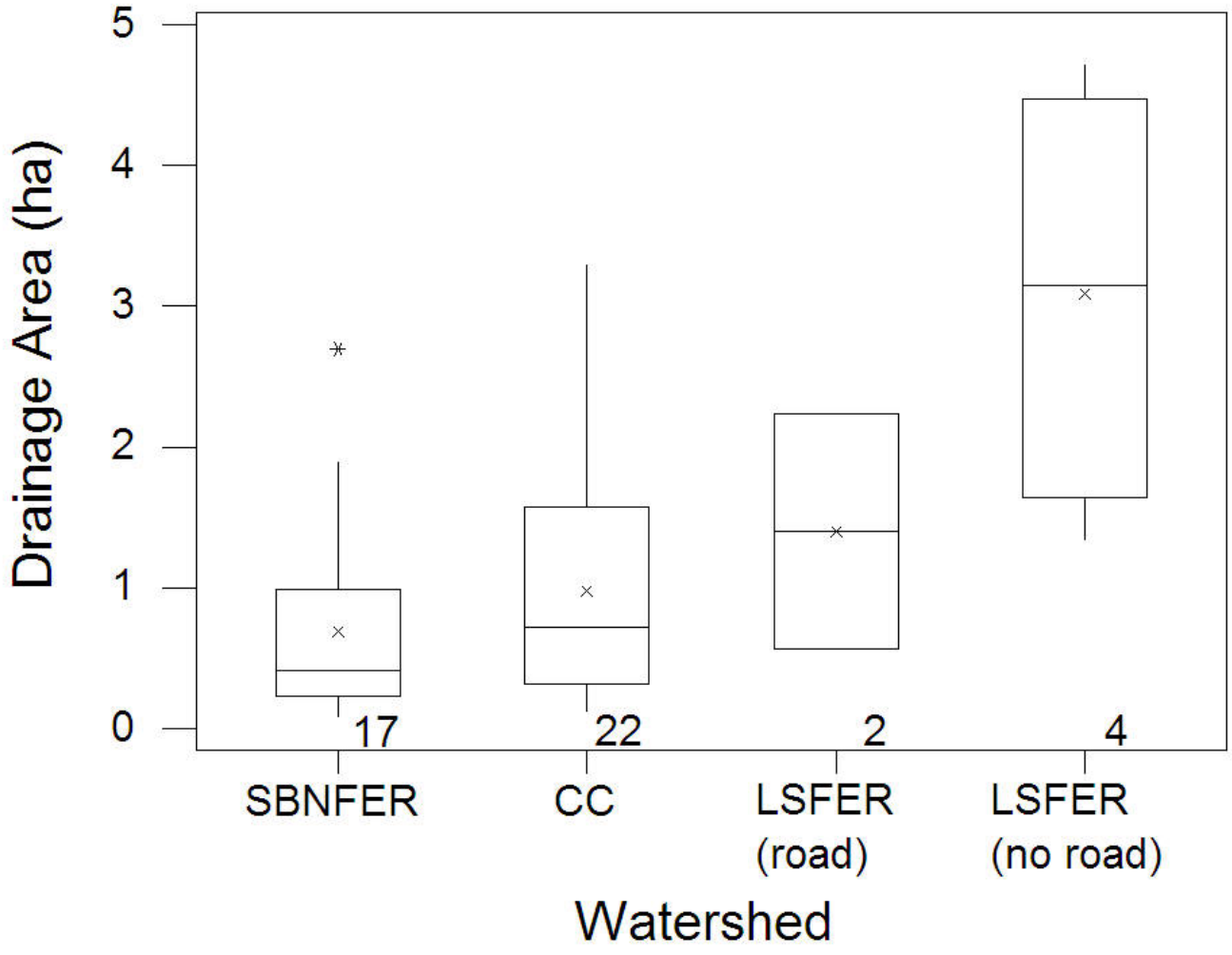
Survey methods

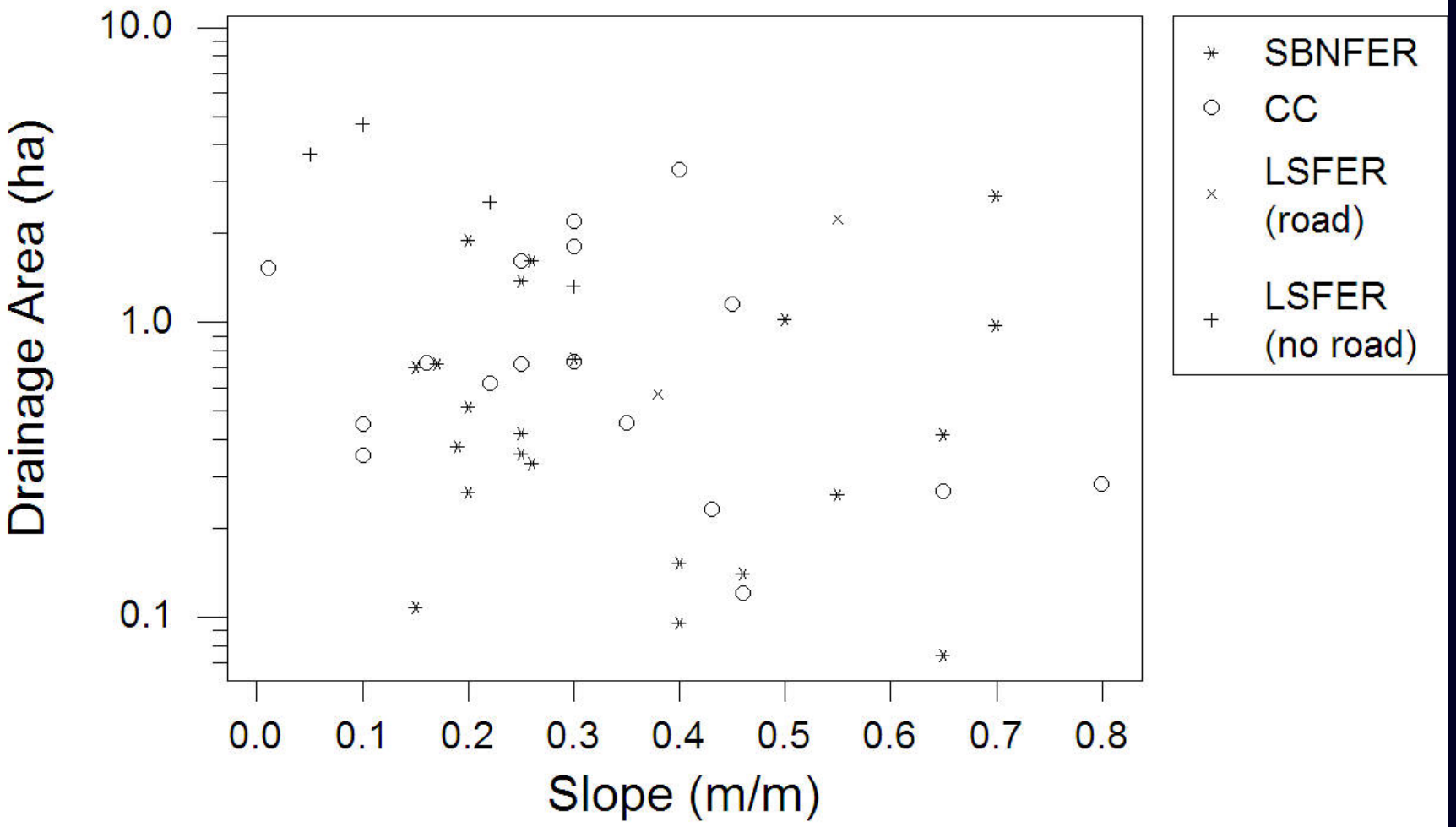
- Divided watershed into “catchments”
- Selected random sample
- Field methods
  - GPS
  - Range finder



Results

- Large differences between managed and unmanaged watershed in drainage area for channel heads
- No slope – area relationship


Drainage Area (ha)
5
4
3
2
1
0
17
22
2
4
SBNFER
CC
LSFER
(road)
LSFER
(no road)
Watershed


10.0
1.0
0.1
Drainage Area (ha)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Slope (m/m)
SBNFER
CC
LSFER (road)
LSFER (no road)

Discussion

- Impacts of logging increased drainage density by 3 times over natural conditions
- Further research needed to determine if current locations are stable or if drainage area can decrease further due to additional harvesting activity

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Estimating Sediment Delivery

- Large variation in creep rates
  - Over an order of magnitude
- Depth
  - Soil depth, creep depth or stream bank height
- Stream density
  - Need field surveys in unmanaged watersheds

TMDL sediment budget

- Must be conservative
  - Use an implicit margin of safety requires using a low, but reasonable creep rate
- Compared to other sediment sources in managed watersheds
  - Soil Creep < 1% of the sediment budget

Tons km^{-2} a^{-1}	SBNFER	CC	LSFER
Soil Creep	0.5	0.4	0.4
Nat. Landslides	10.6	17.2	23.7

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Bank erosion

- Two rapid methods recently used for North Coast
  - Measure voids
  - Measure wood volume

Survey Methods

- In the three subwatersheds, conduct bank erosion inventory
- Selected a random sample by stream order
  - Used a uniform length for each order

Results

- Void Inventory
  - 175 small and 58 large voids
- Wood Inventory
  - 26 pieces of wood, primarily in the largest streams

Delivery Rates (t km^{-2} a^{-1})

	Void	Wood (> 1st Order)	Wood (large streams)	Suspend sediment loads
SBNFER	44	5307	3390	290
CC	32	748	224	80
LSFER	11	303	211	11

Discussion

- Accuracy of the qualitative age estimates for both methods is not known
- Wood methodology results in unreasonably high estimates
- Management watersheds have higher bank erosion rates

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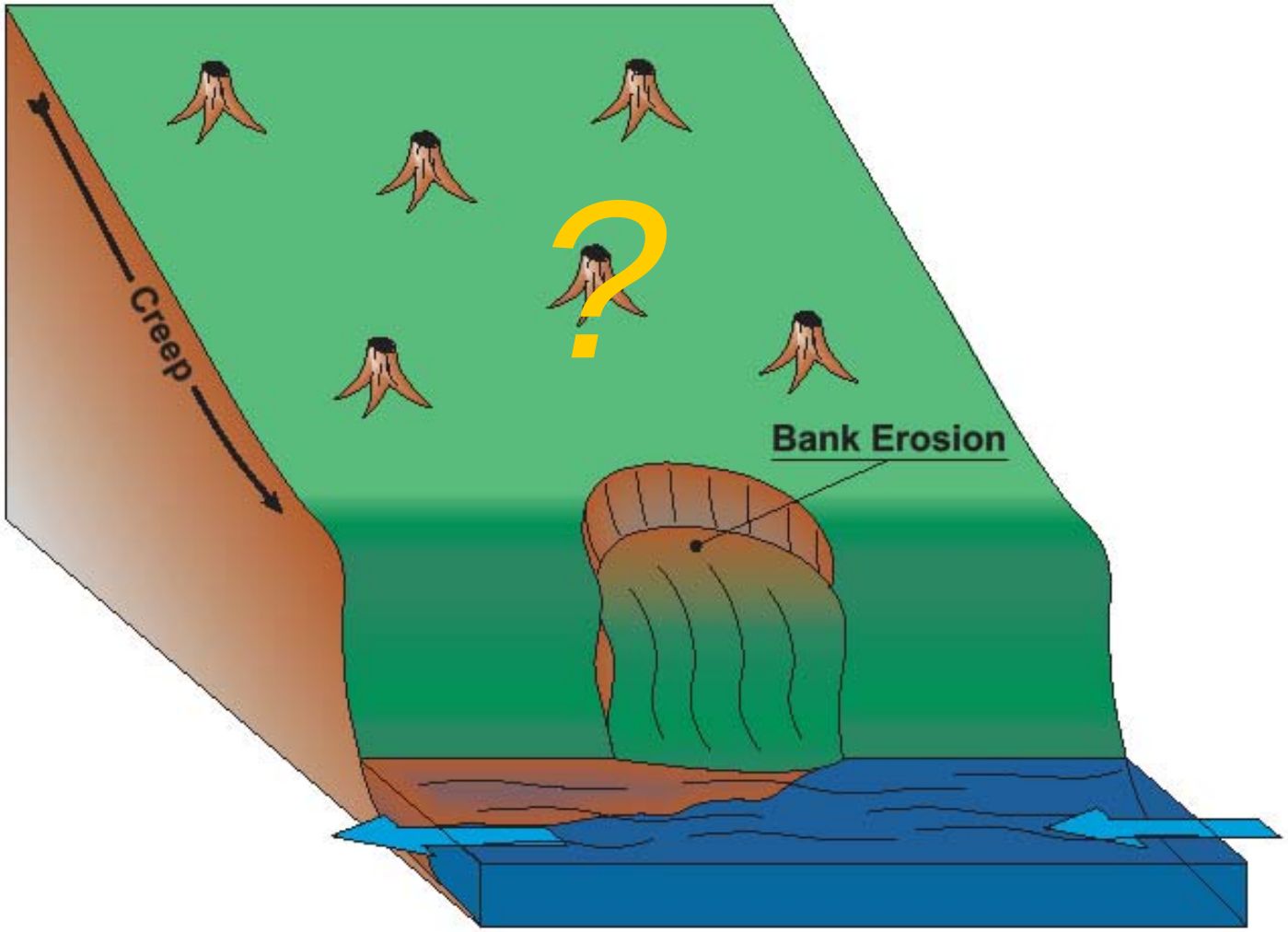
Conclusions

- Previous sediment budgets overestimated soil creep related sediment delivery
  - Stream Length, creep rates, and depth of movement
- Logging increases
  - Drainage density
  - Bank erosion


Creep
?
Bank Erosion

Recommendations

- Suspended Sediment/ Turbidity Gauging Stations
  - Needed to verify sediment budgets and trends
- Bank Erosion & Channel Incision Monitoring
  - Important sources with little information
- Erosion Control Measures
  - Need to minimize sediment delivery from small incised streams

Thank You

Any Questions?