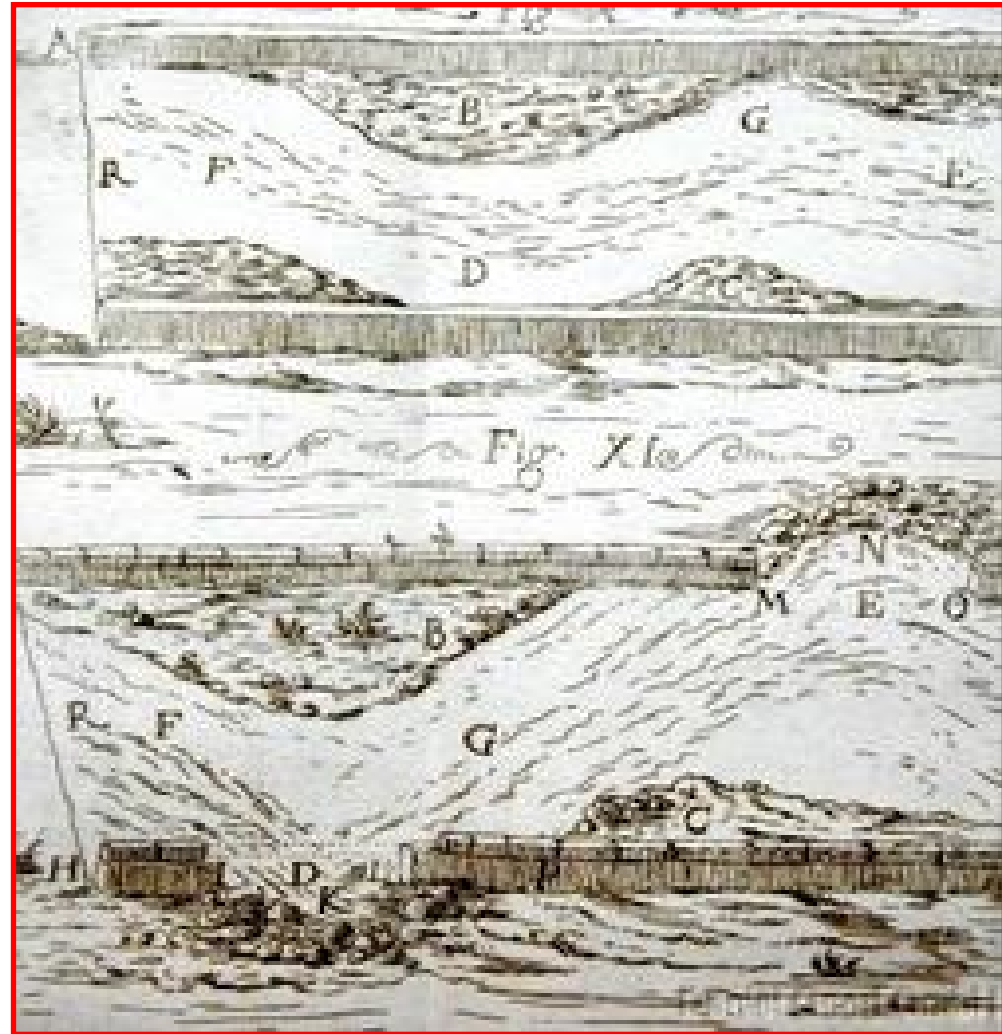


# River Restoration



# River Engineering: Flood Control...

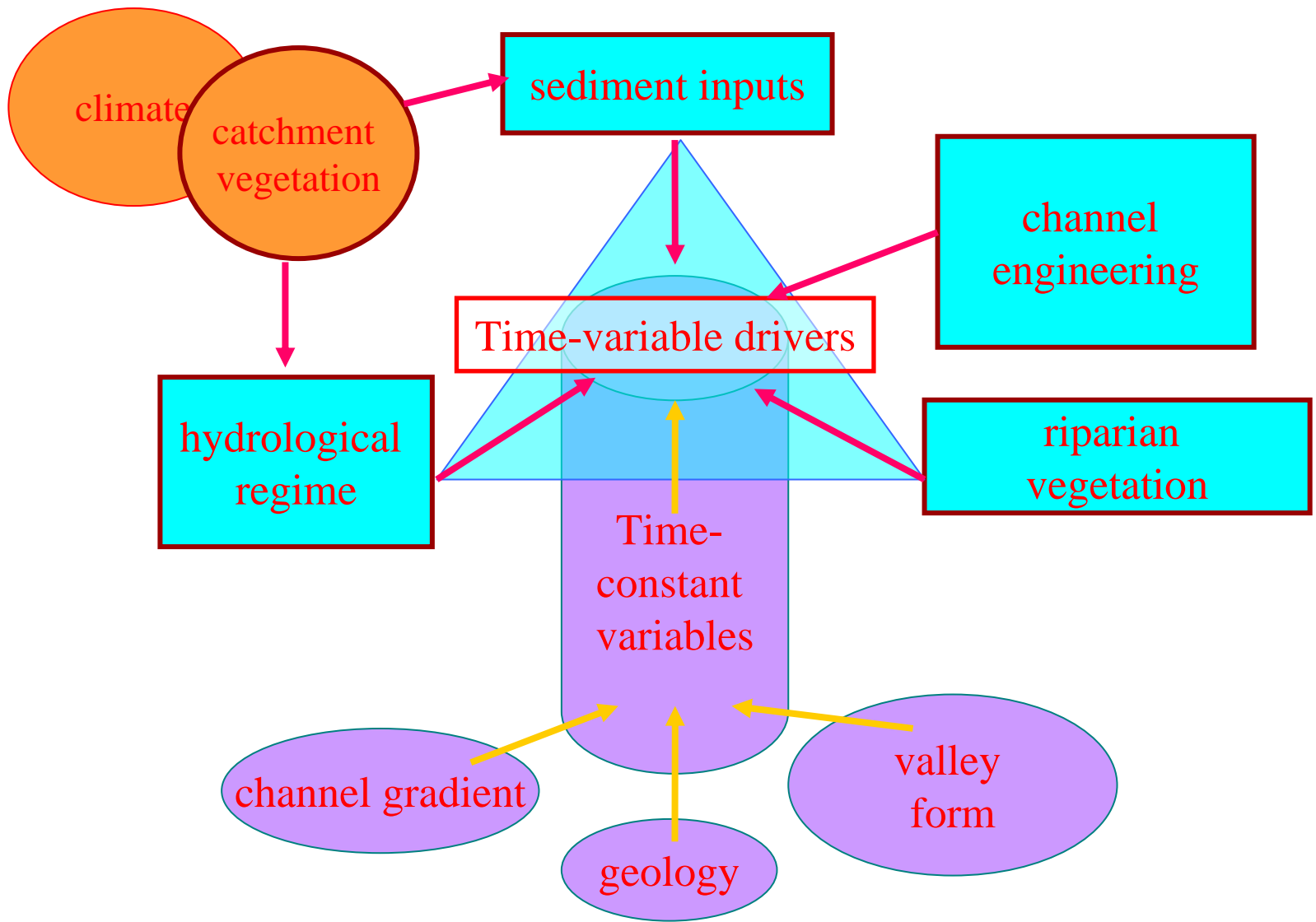




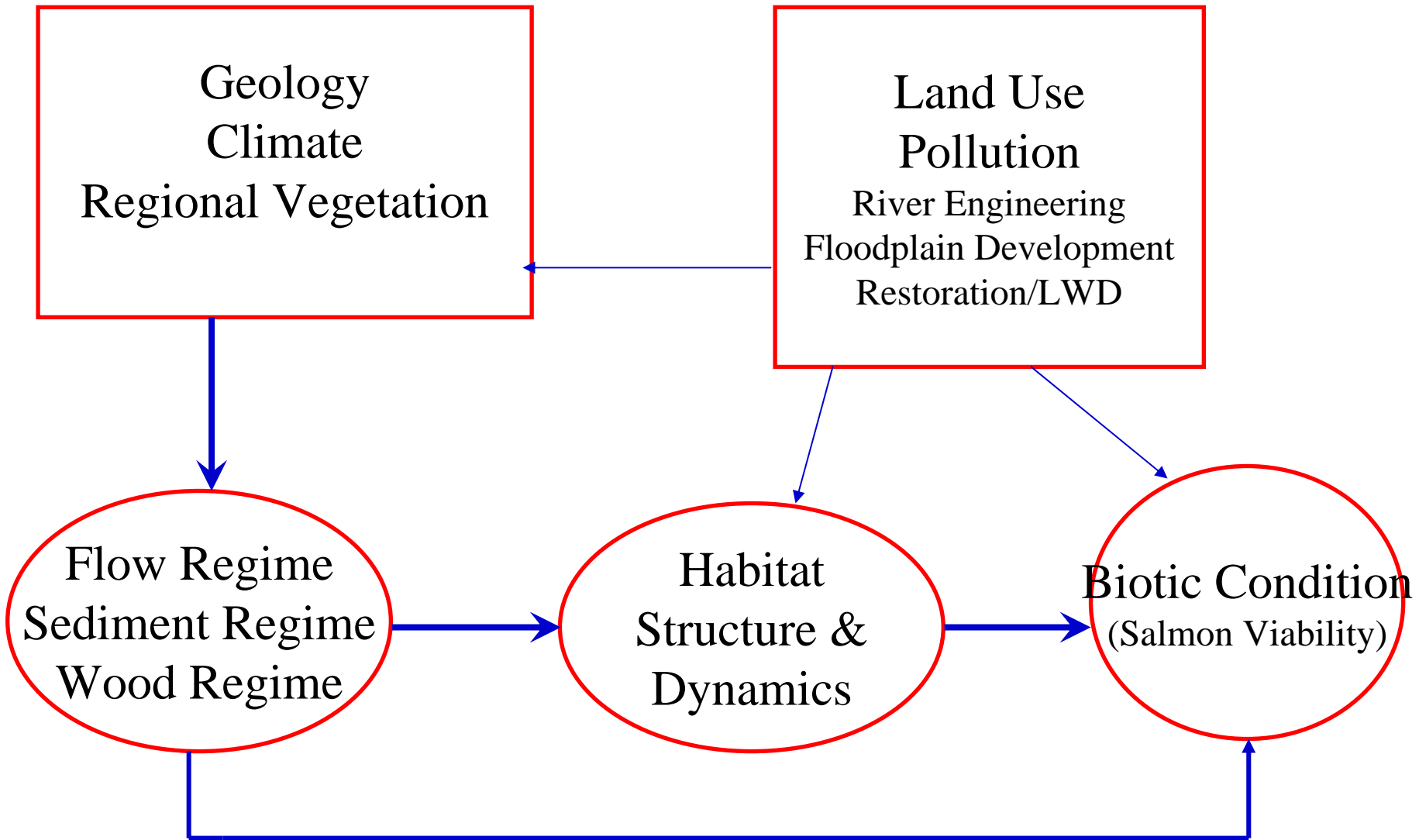
# River Restoration: Habitat Improvement

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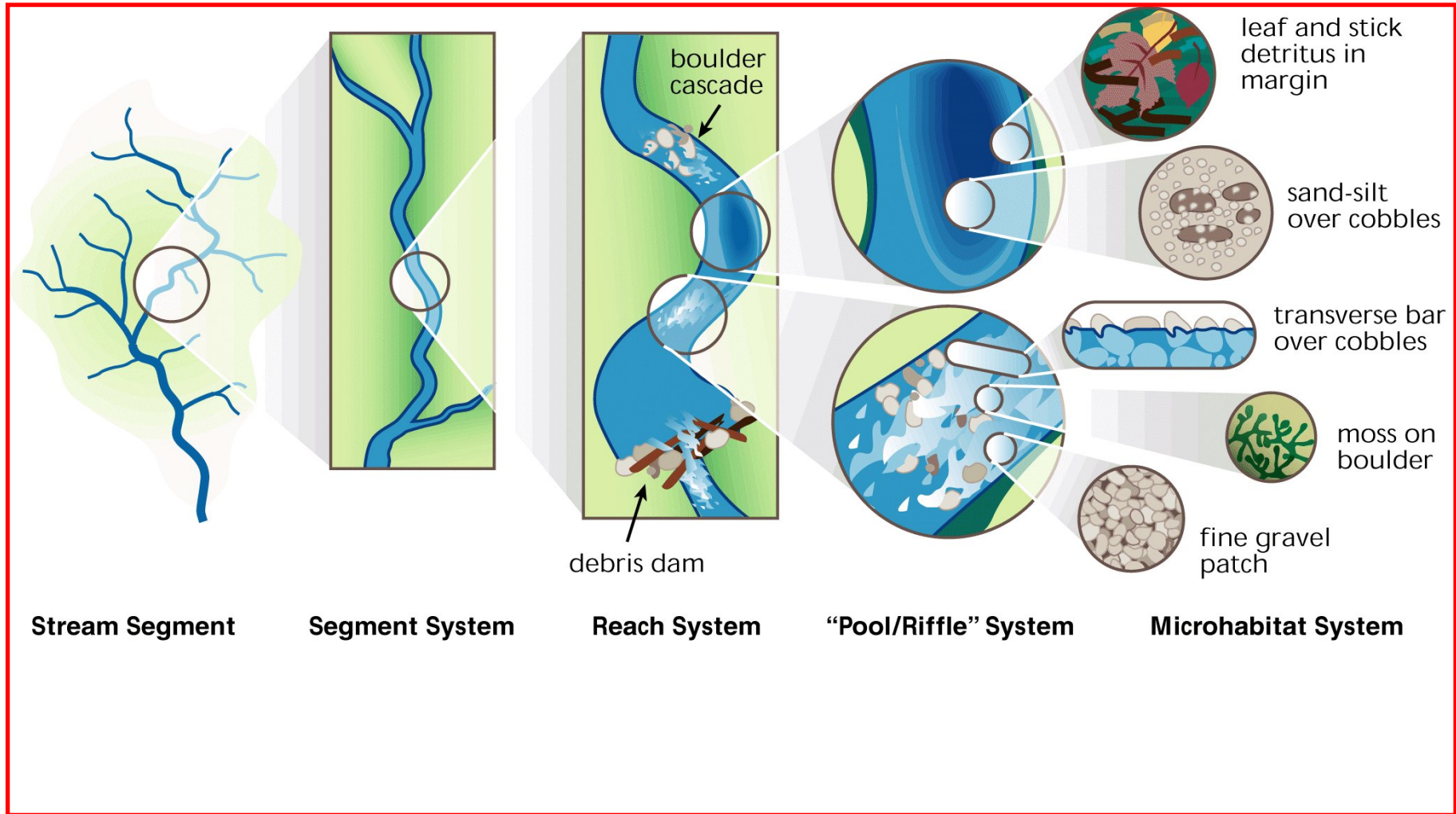




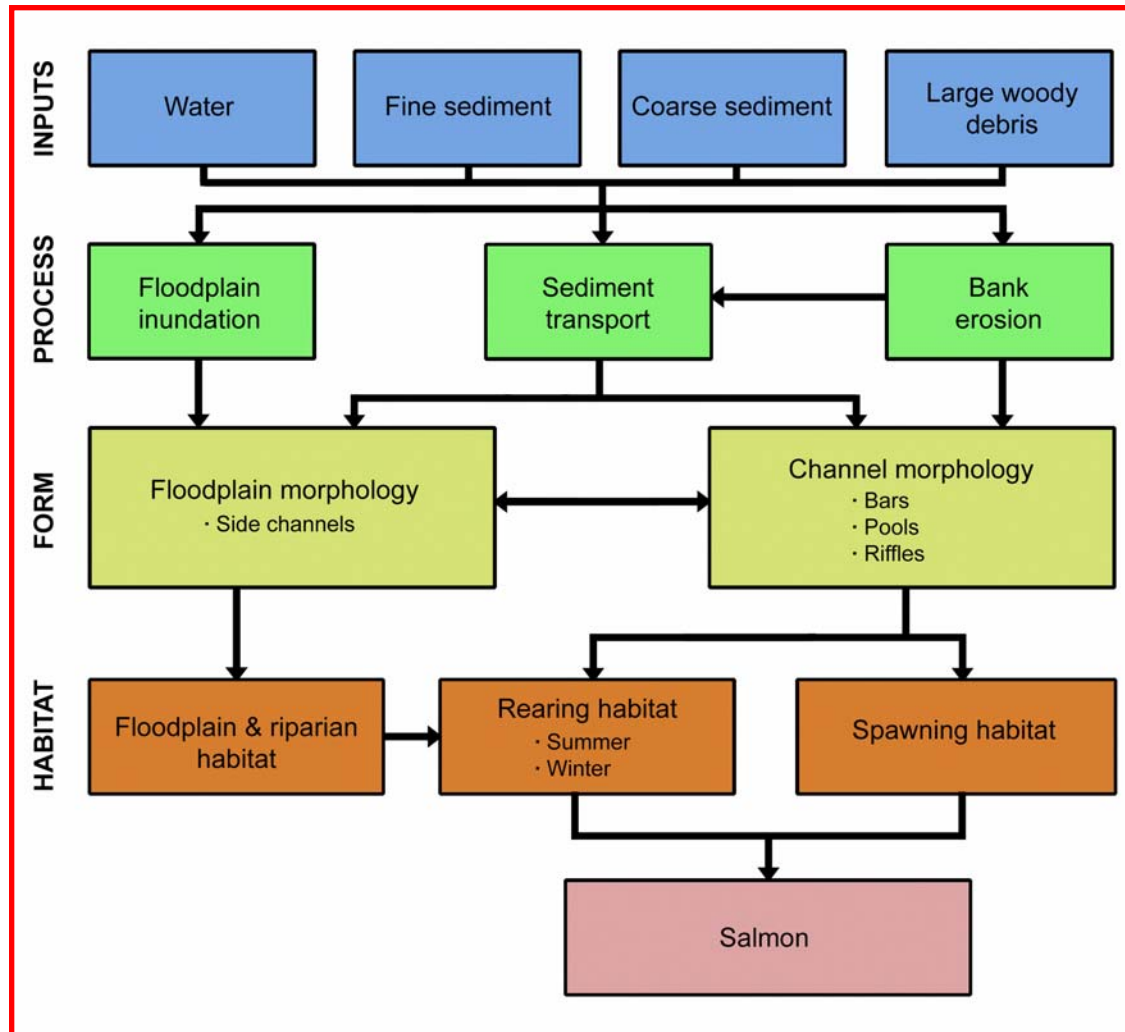




# Habitat Scales

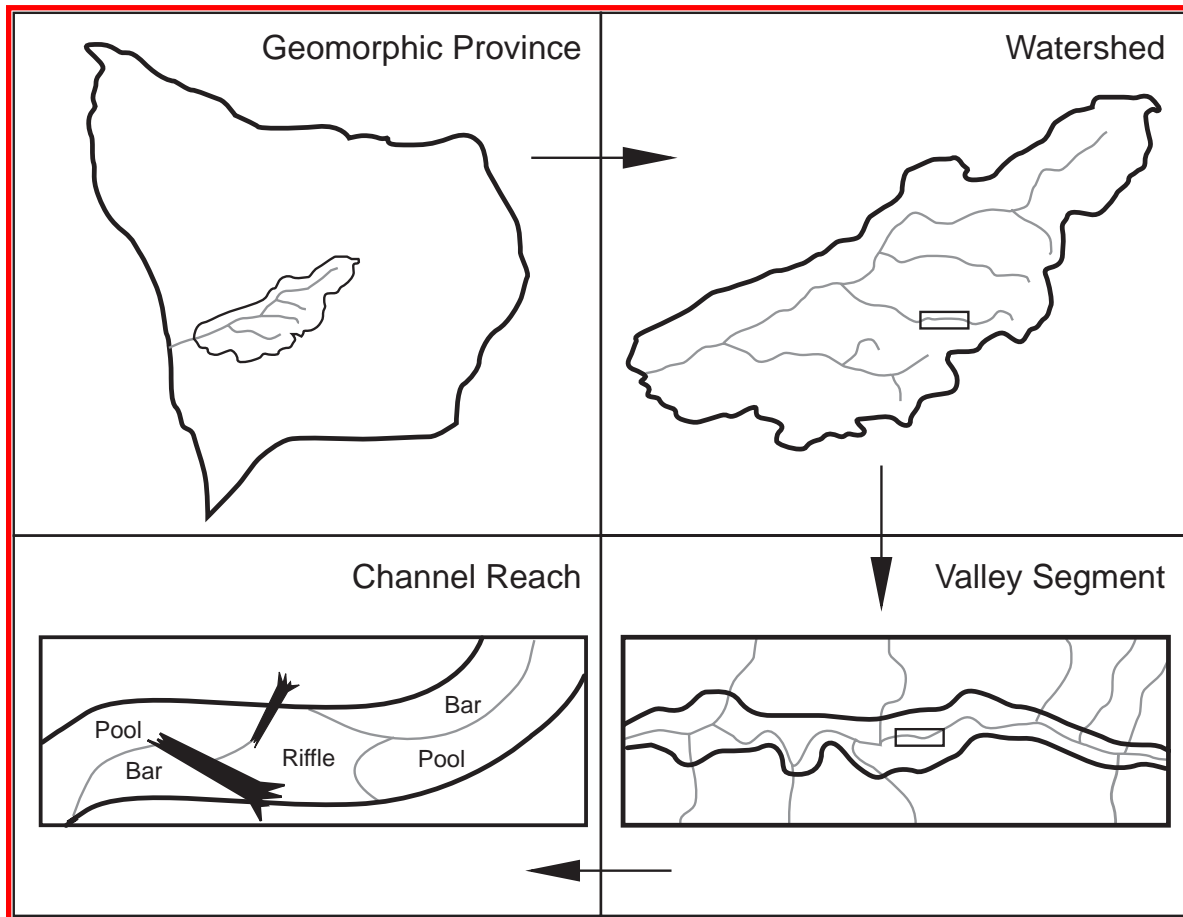


# The supply and transport of water, sediment, and wood interact to structure salmon habitat.



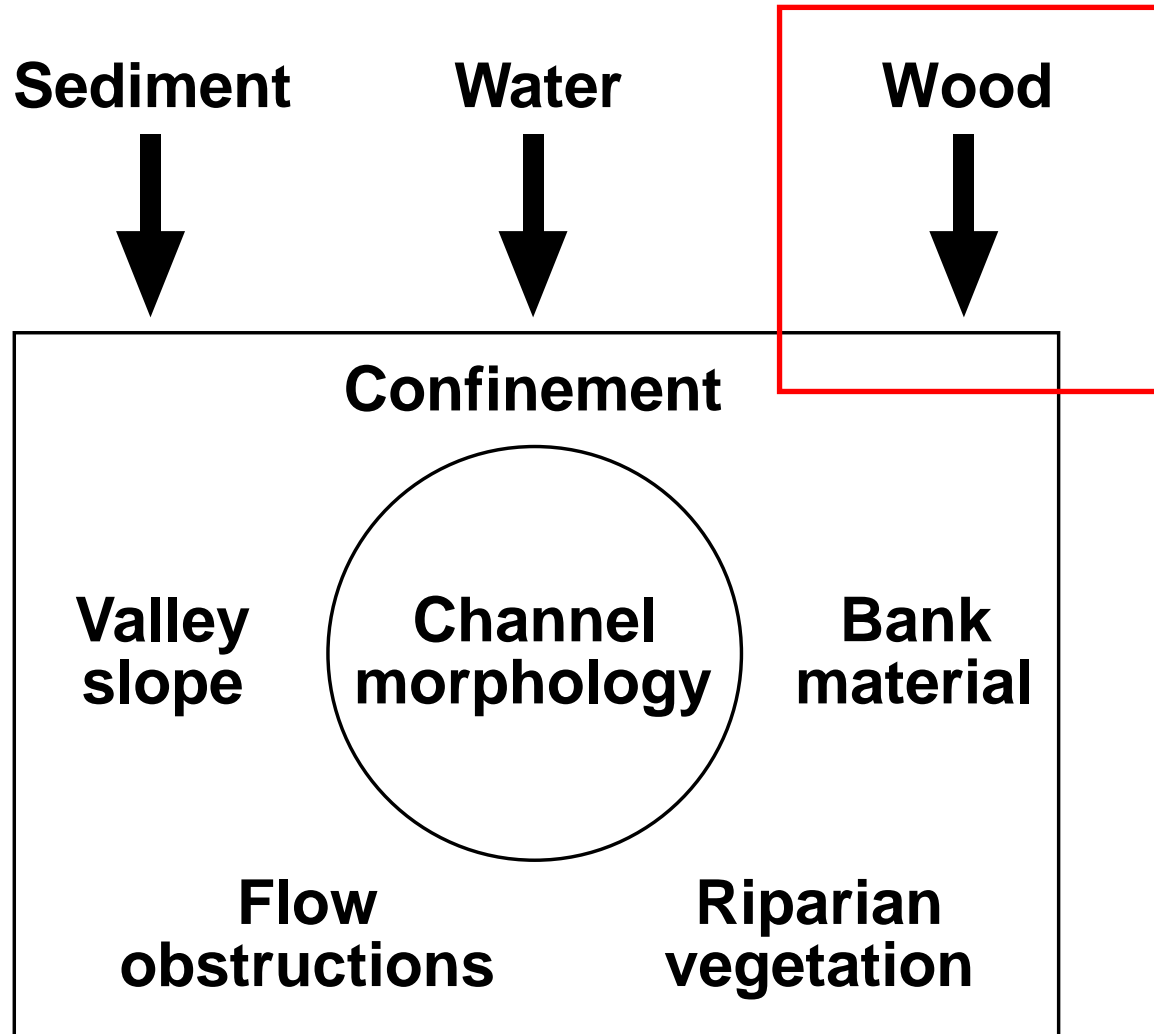


# Over what range of scales does LWD influence channels?



# River Restoration

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# River Restoration

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Application of general principles to the context of a particular site.

1. Assessment / diagnosis
2. Design
3. Implementation
4. Monitoring



# 10 Commandments of River Restoration

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- I. Do no harm
- II. Look beyond the channel to assess it in context
- III. Use native materials
- IV. Emulate natural analogs
- V. Let the channel do the work
- VI. Let the channel use its floodplain
- VII. Manage inputs to the system so that the river can fix itself
- VIII. Use direct manipulation of the channel only as a last resort
- IX. Allow for changes authored by the river
- X. Use appropriate personnel to scope and design restoration efforts.

# River Restoration

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## Context, Context, Context

Spatial: What kind of stream is it?

Temporal: What is its disturbance history?

# River Restoration

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What kind of stream is it?

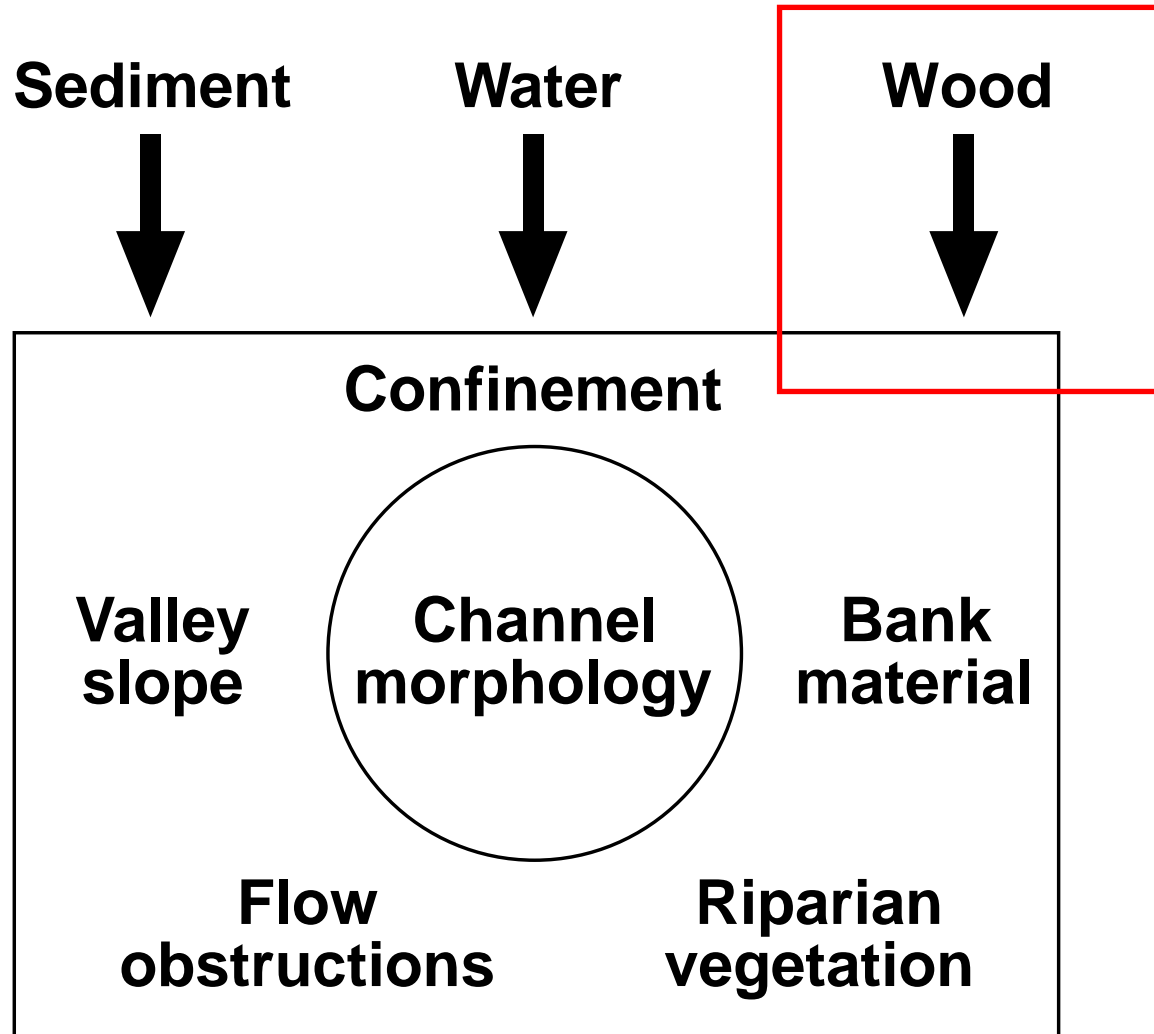
Braided, meandering, straight?

Cascade, Step-Pool, Plane-Bed, Pool-Riffle?



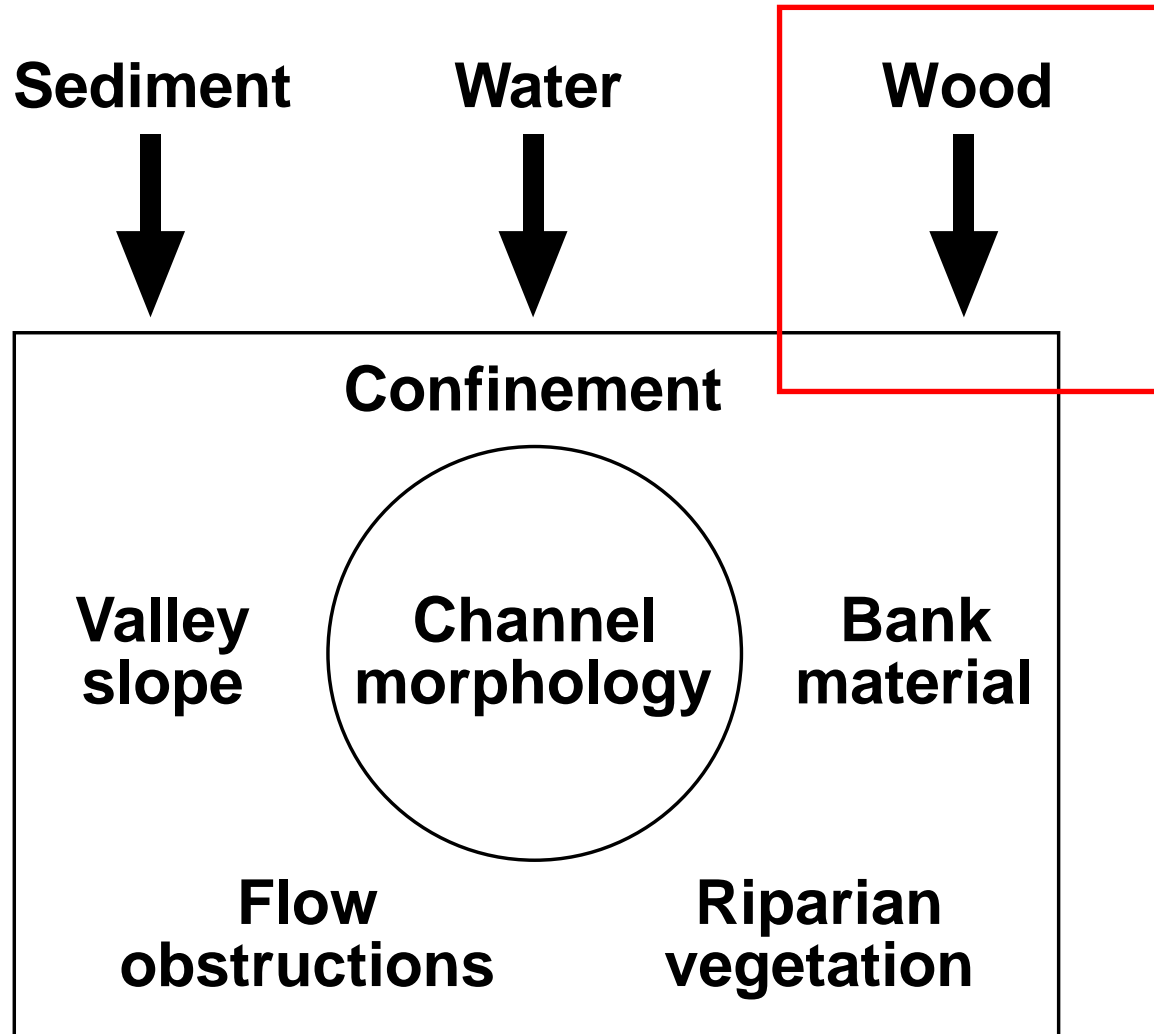
# River Restoration

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# River Restoration

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# Wood in rivers

Wood acts as an impediment to flow that can cause flow to converge and scour out pools that provide important habitat



# Extent of global forests

Forests have covered about one-third of the Earth's land surface during the Holocene.

But the extent of forest cover has changed substantially ...



Oregon

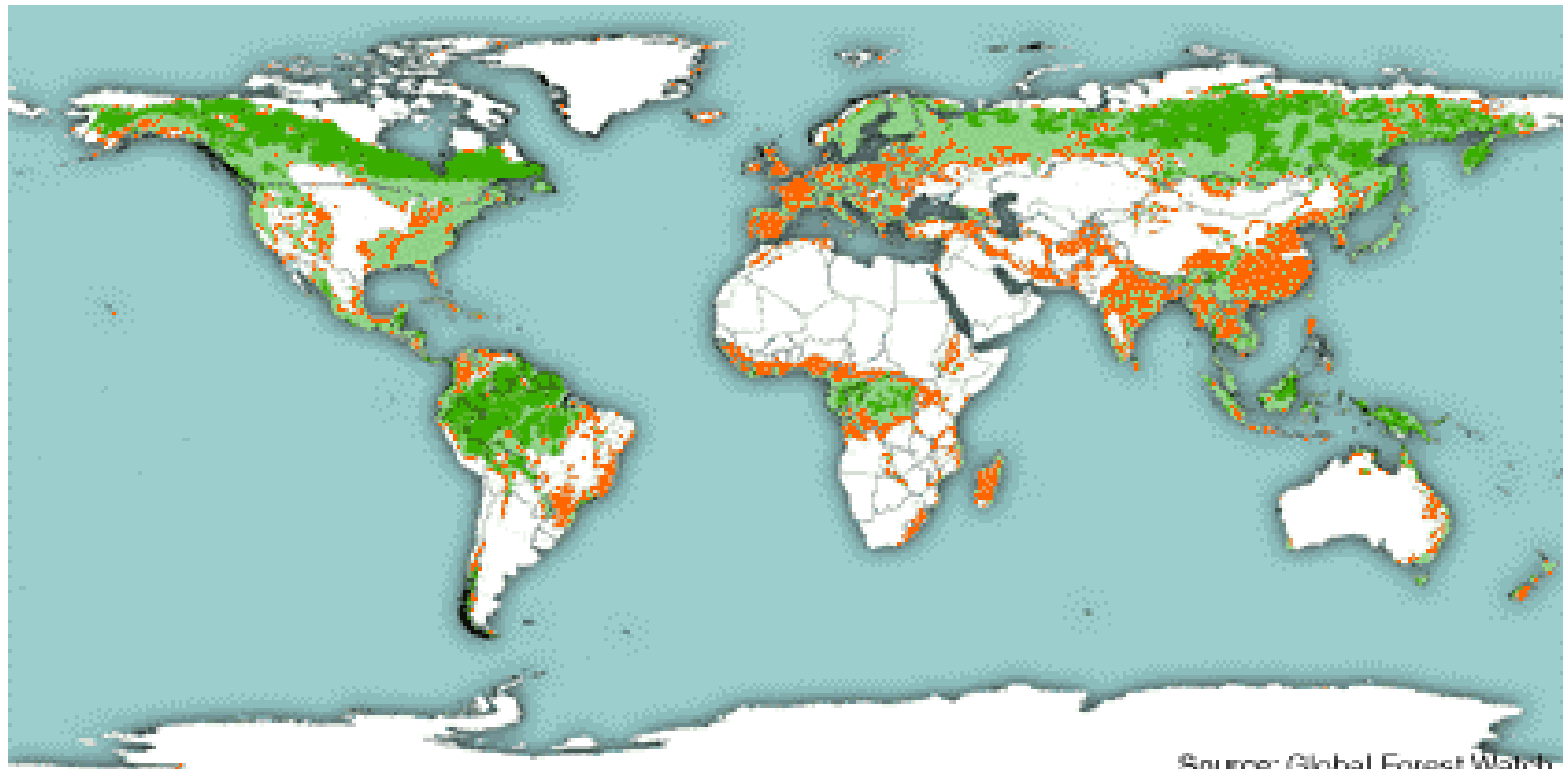


Amazon



Cameroon

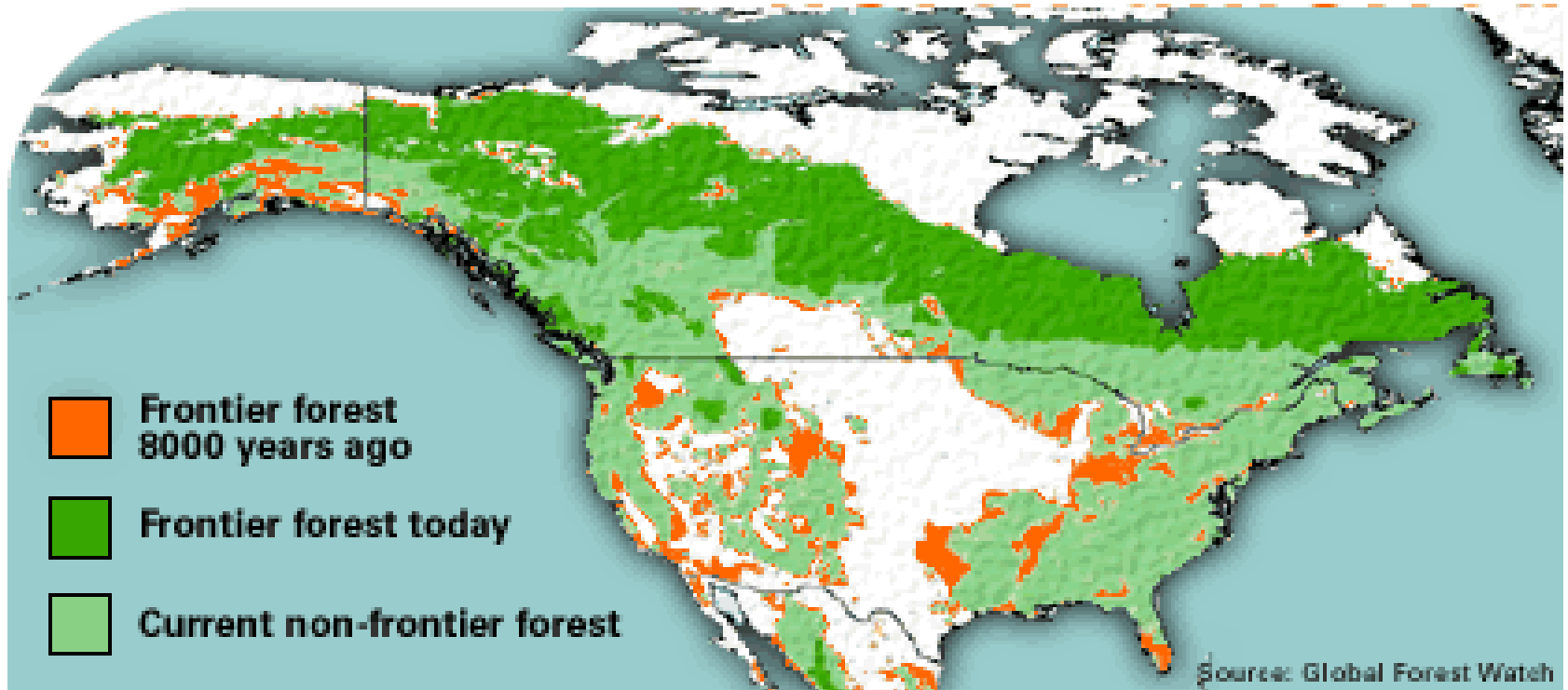
# Few of the worlds forests retain "frontier" conditions



■ Frontier forest 8,000 years ago    ■ Frontier forest today    ■ Current non-frontier forest



Much of our understanding of river systems was developed in areas that either lacked large wood or that had been cleared of wood debris.



To what degree are our perceptions of the role of wood in rivers due to such historic legacies?

*Snags on the Missouri* Karl Bodmer, circa 1850





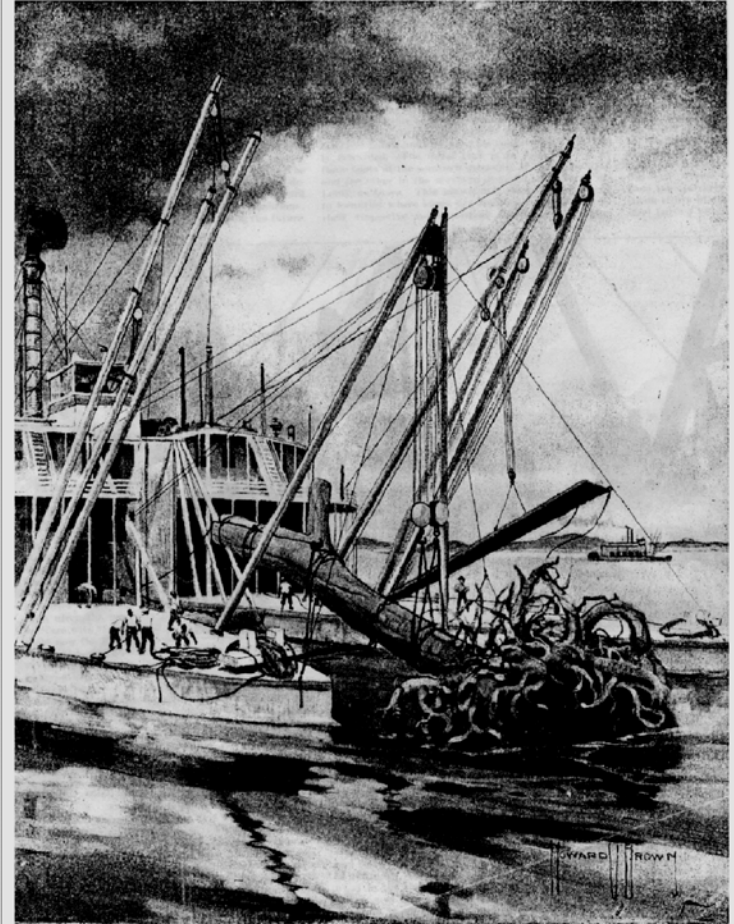
Log jams were significant obstacles to navigation and land development in the western U.S.



# SCIENTIFIC AMERICAN

*A Weekly Review of Progress in*

INDUSTRY • SCIENCE • INVENTION • MECHANICS



PULLING THE MISSISSIPPI'S TEETH: HAULING A HEAVY SNAG ABOARD. -[See page 60]

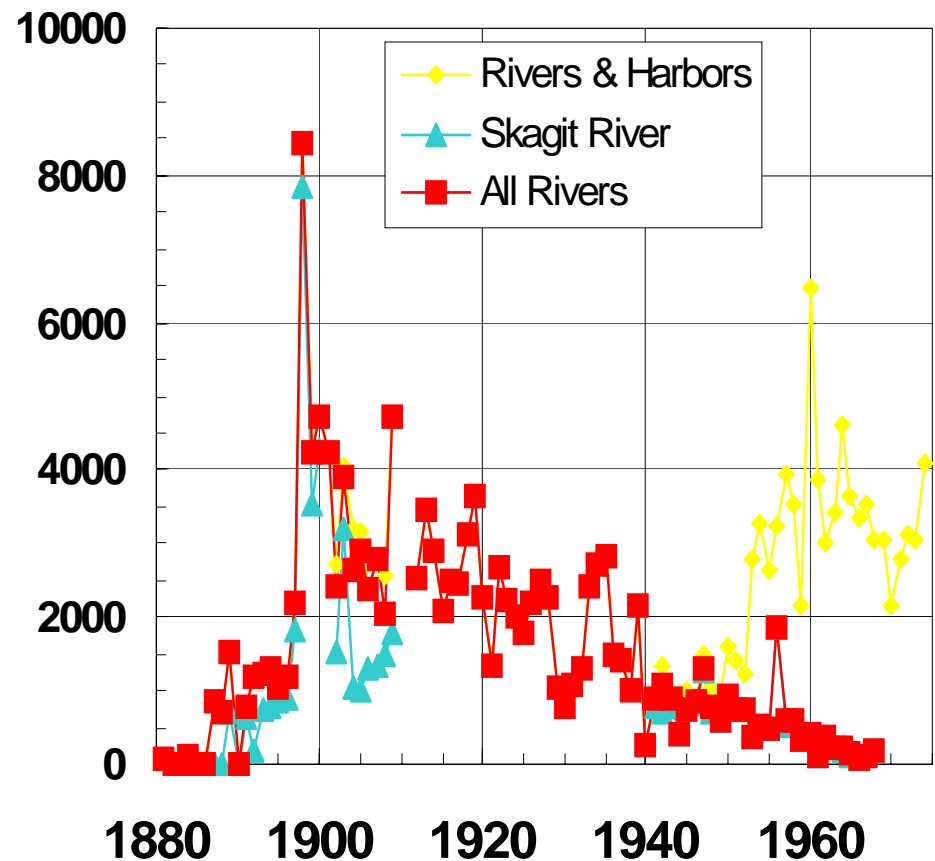
Vol. CXXV, No. 4  
July 23, 1921

Published Weekly by  
Scientific American Publishing Co.  
Mupp & Co., New York, N.Y.

Price 15 Cents  
20 cents in Canada

# Army Corps of Engineers aggressively "de-snagged" American Rivers

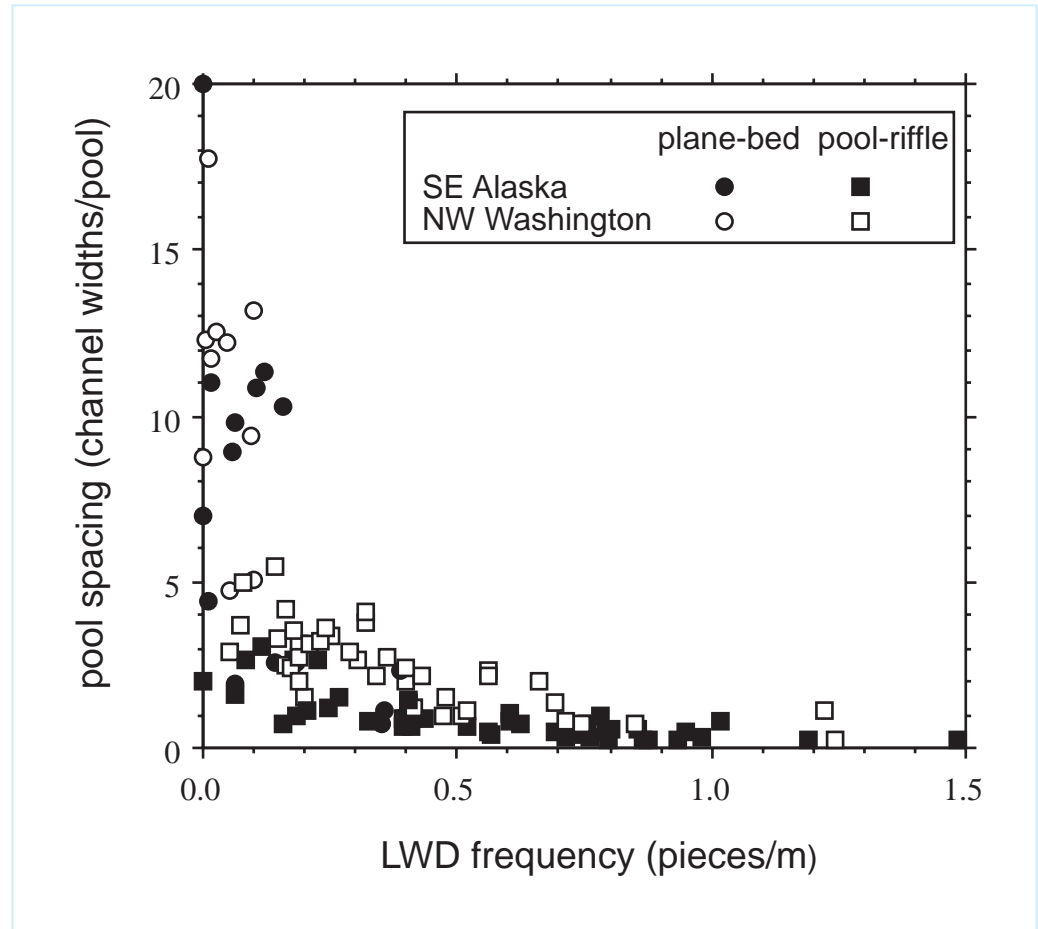
Thousands of snags were removed from Puget Sound rivers between 1880 and the mid-20th Century



# Channel Unit Scale

Greater wood loading  
leads to more pools

For channels we've  
surveyed in Alaska  
and Washington, a  
plane-bed  
morphology occurs  
only at low LWD  
loading





# Reach Scale

LWD can control the formation of pools and bars, and thereby channel reach morphology



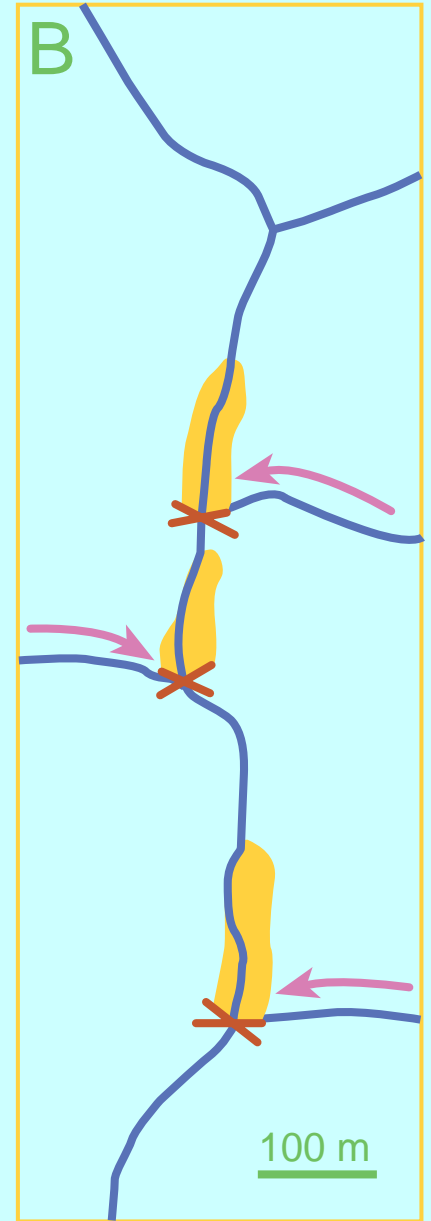
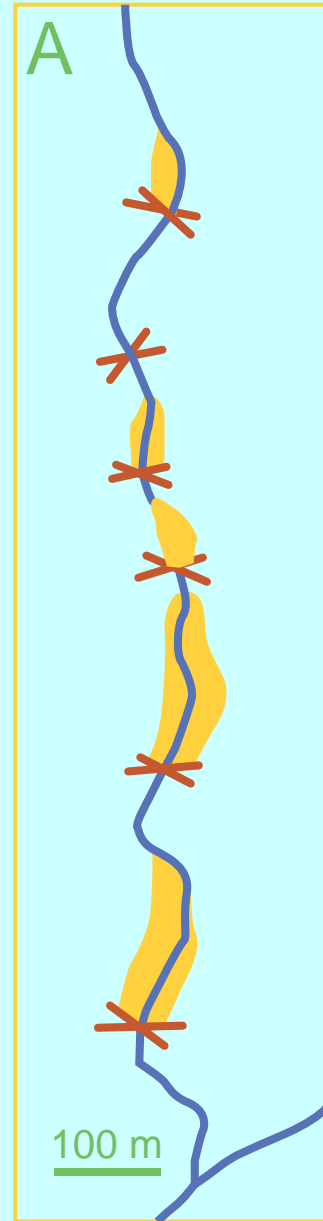
# Valley Segment Scale

Log jams trap  
copious amounts of  
sediment and  
aggrade entire  
reaches of channel.



# Valley Segment Scale

Both locally recruited trees and log jams delivered by debris flows can create alluvial valley bottoms in confined mountain streams.

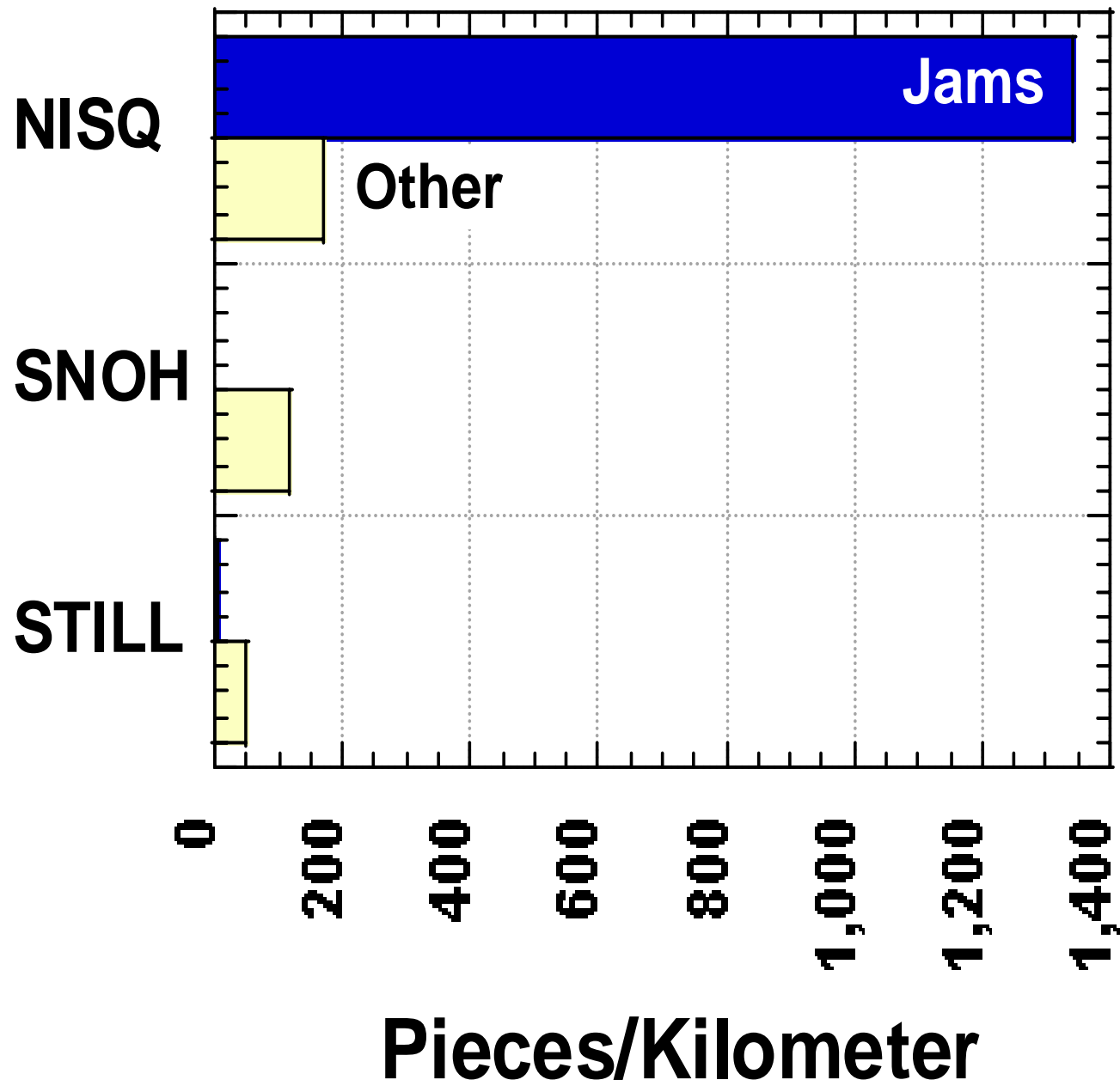




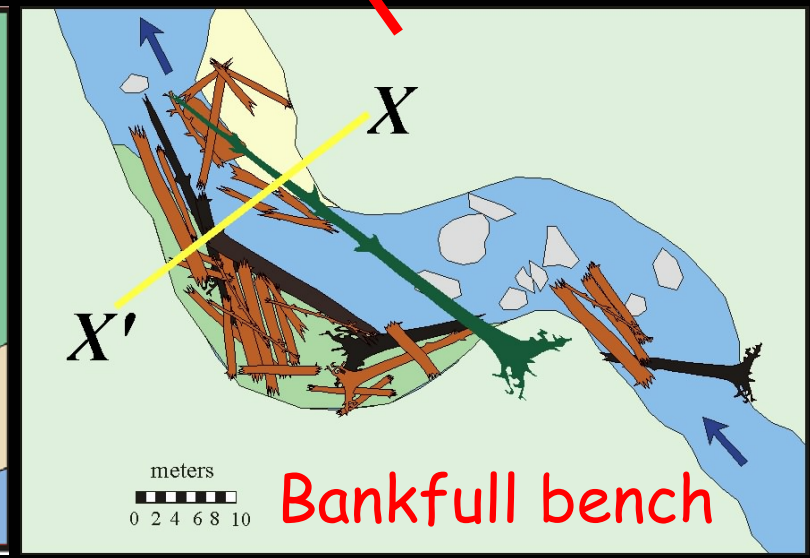
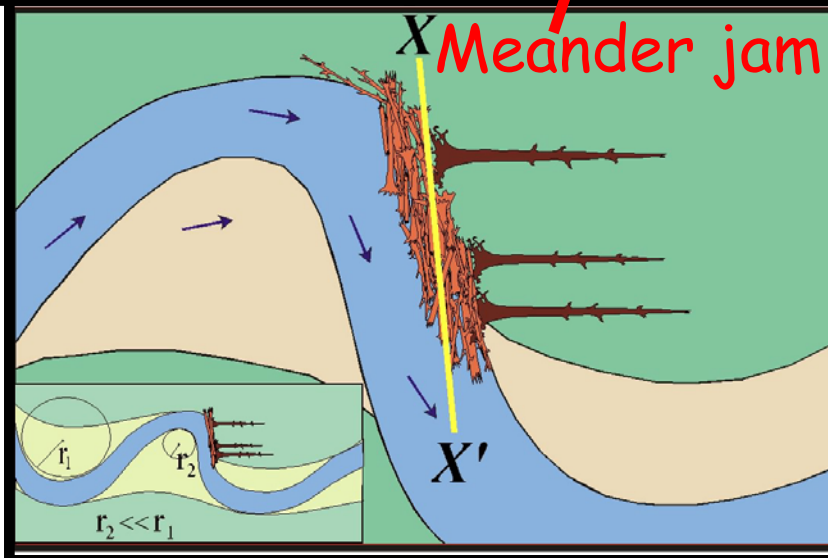
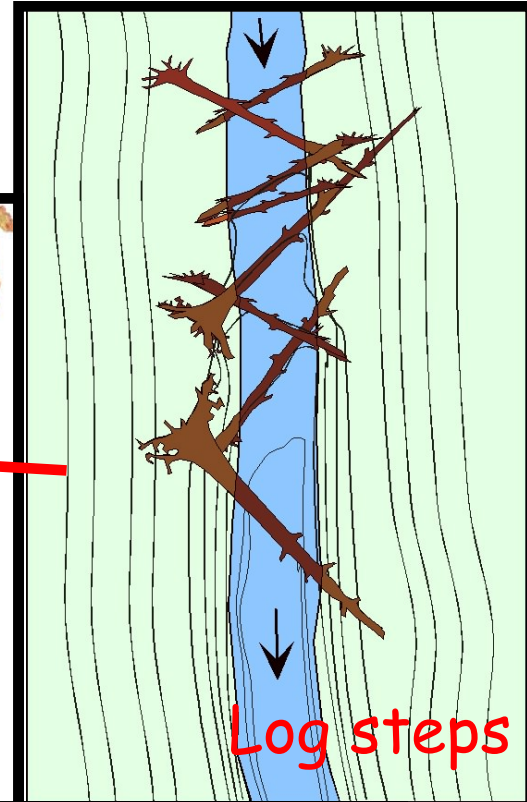
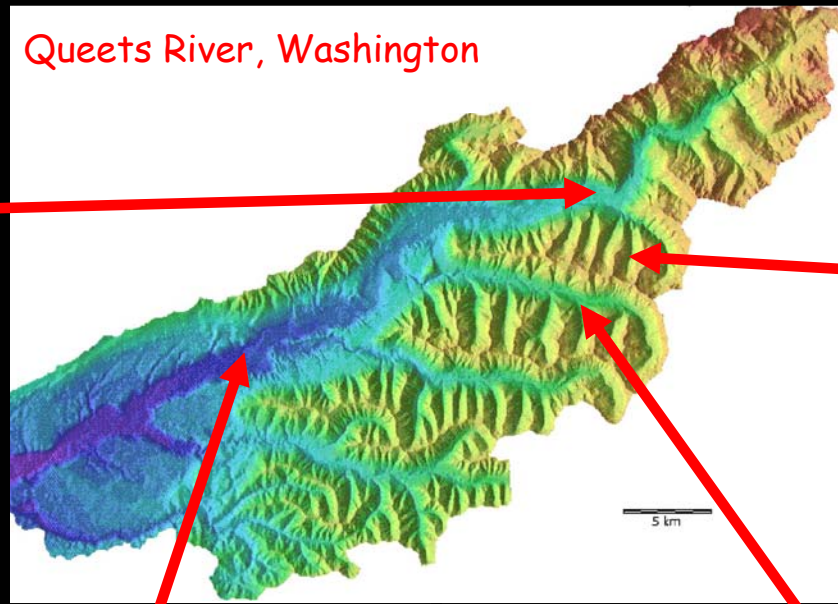
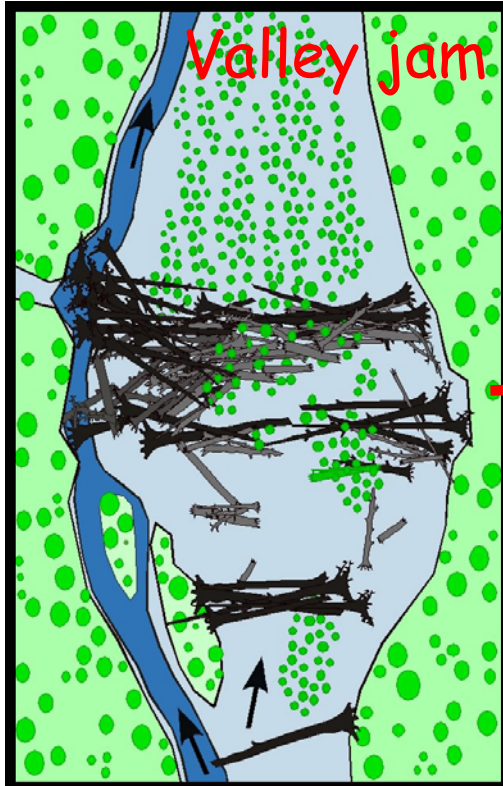
# Log jams can influence even large rivers



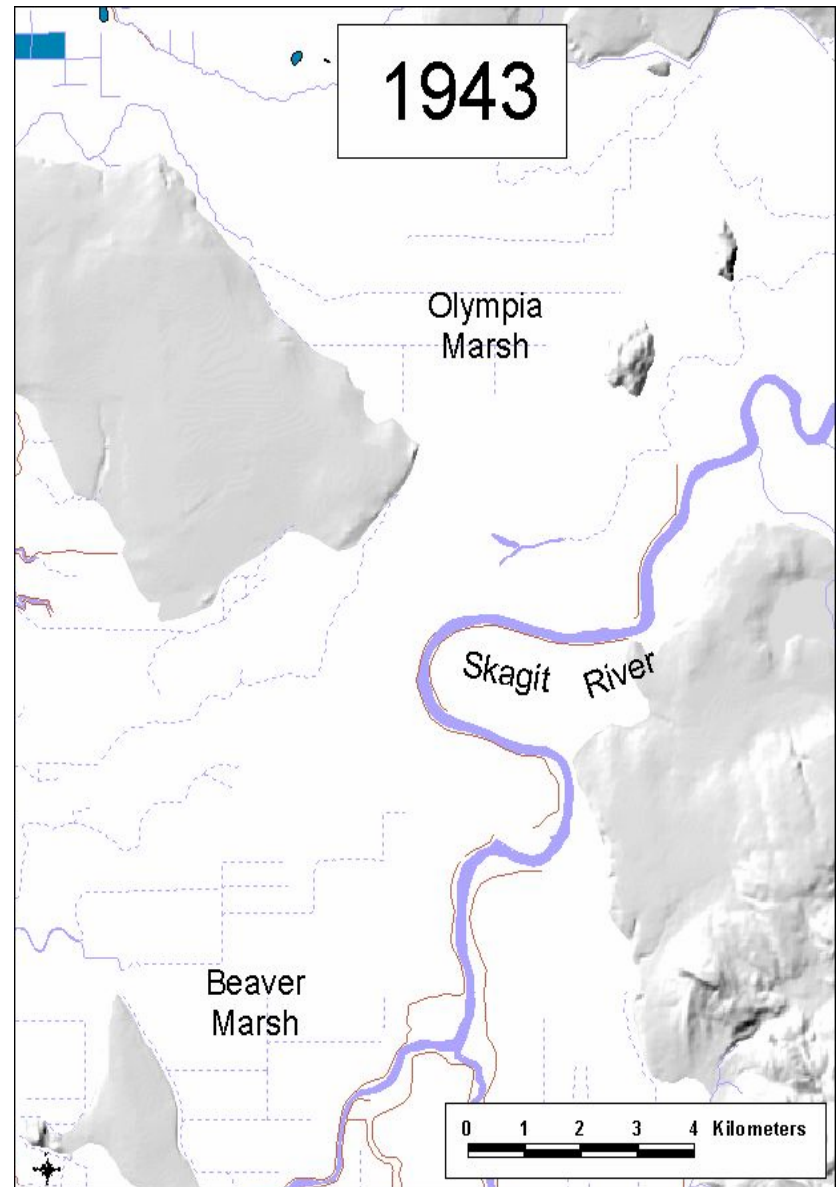
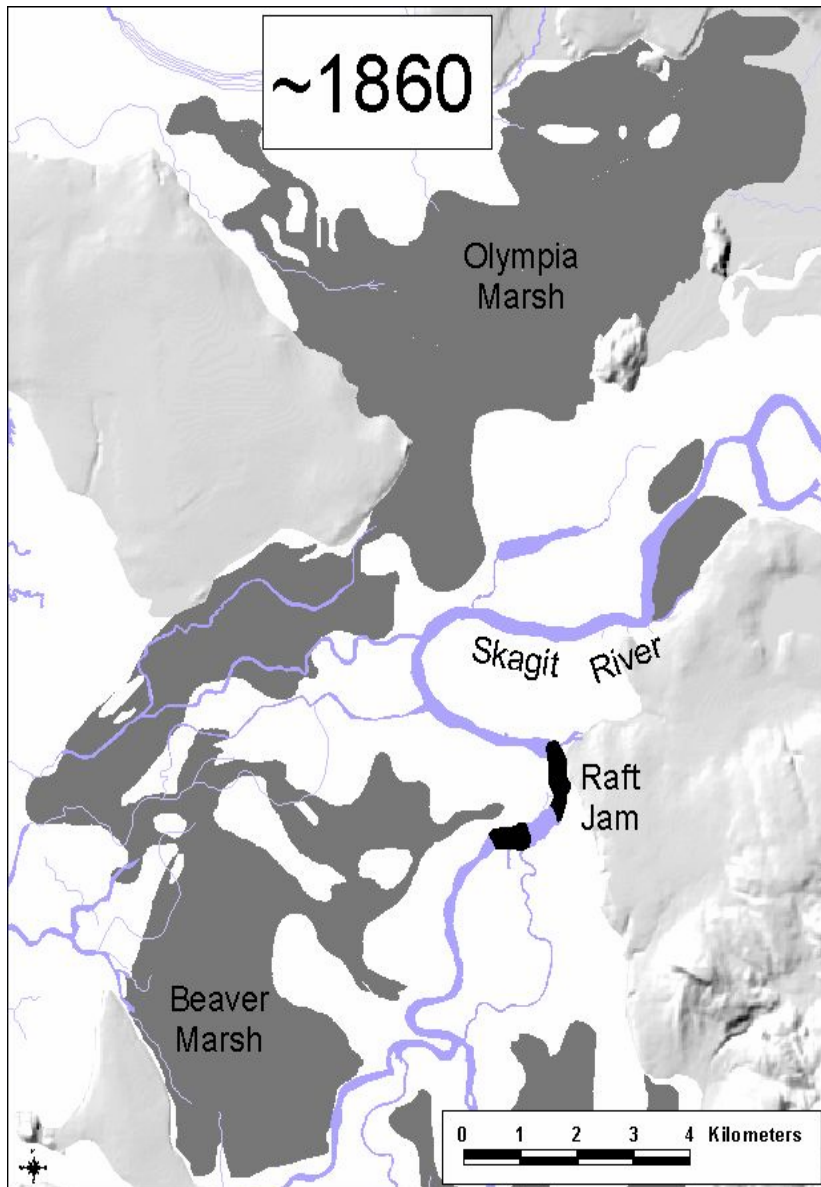




# Position in Channel Network

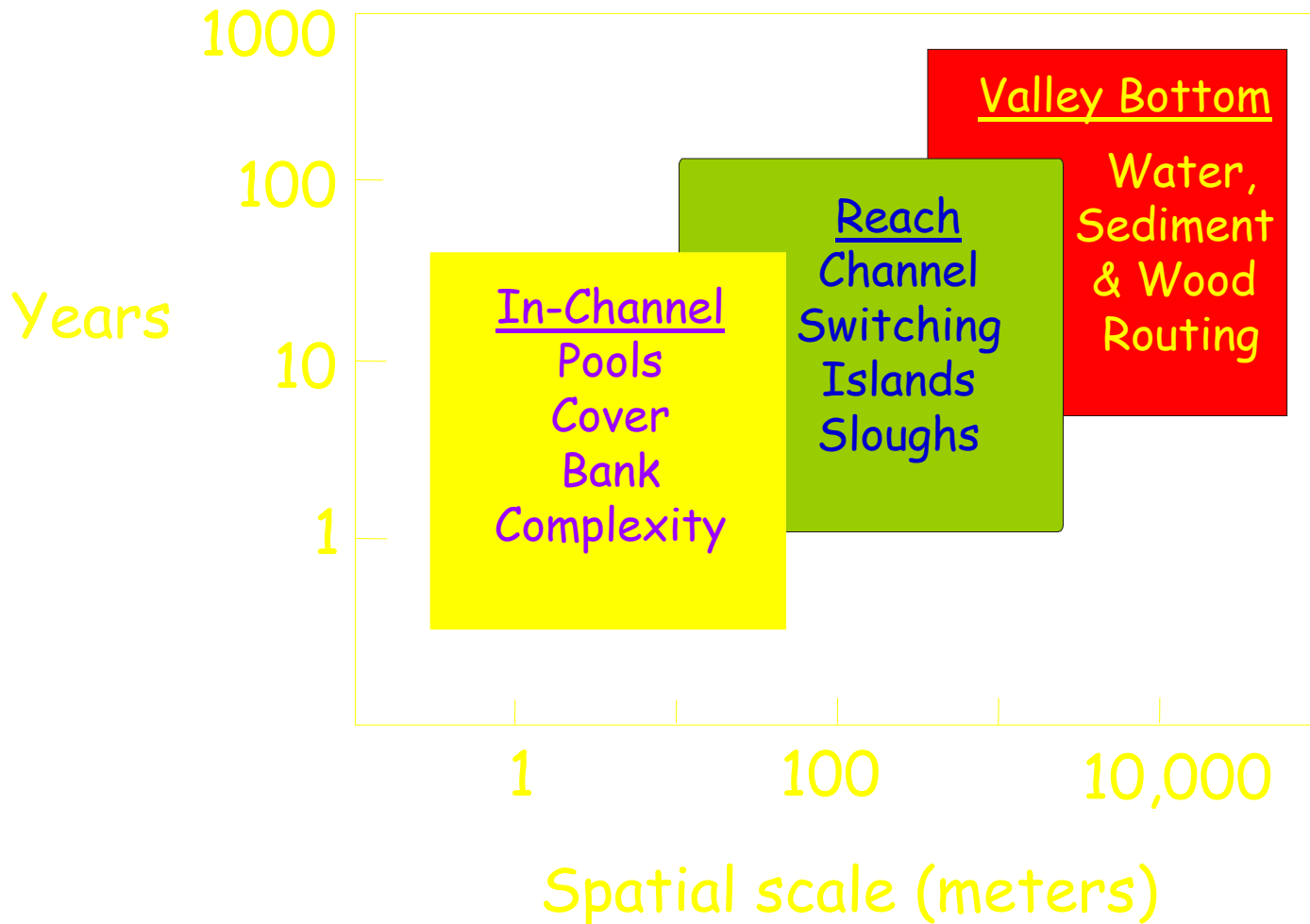


# Watershed Scale



# Effects of Wood in Rivers

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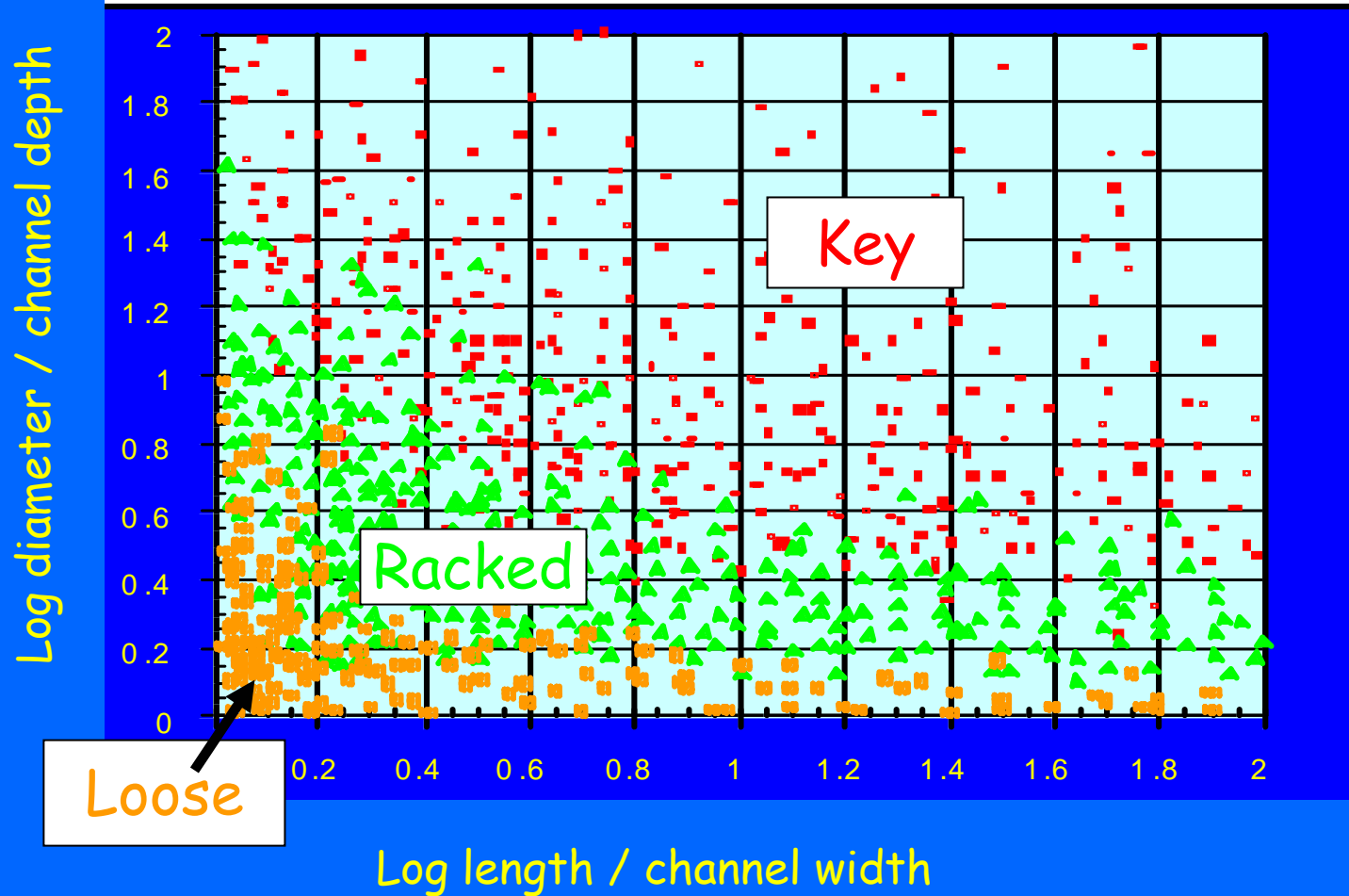




**How big does a log have to be in order to influence a river?**



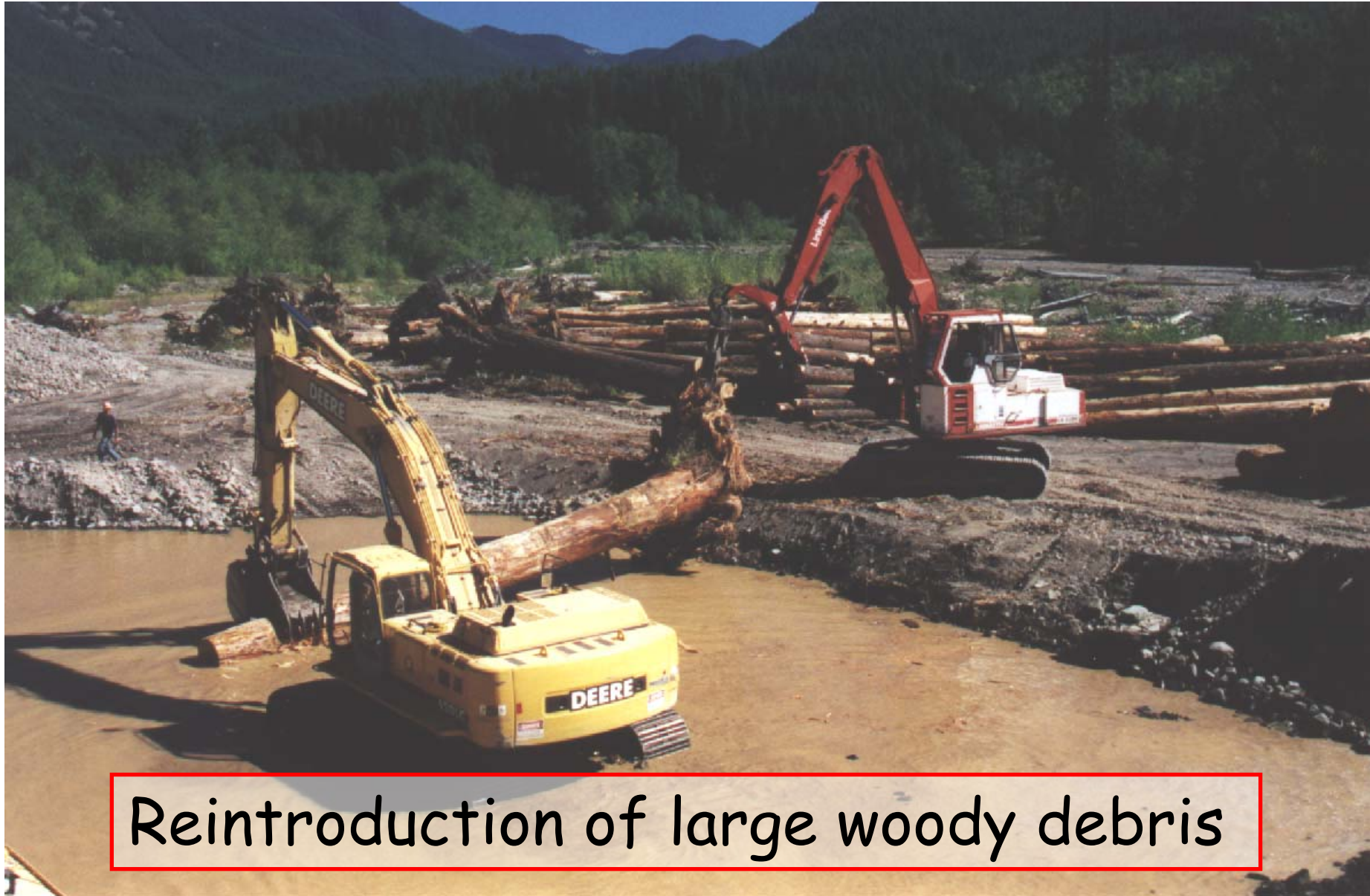
# LWD Size and Channel Size Govern LWD Stability & Influence





# River Restoration

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Reintroduction of large woody debris



Restoration of "natural" wood loading would take centuries because of the time needed to grow large, "key member" logs that can shape aquatic habitat.



# ELJs: Engineered Log Jams

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Engineered log jams are in-stream flow control structures based on the architecture of naturally occurring, stable log jams.



Floodplain channel dug



Log Jam Placement



Log Placement

# Upper Cowlitz River

near Packwood, WA  
River mile 129, 1993

landowners

1993

1993-95 erosion

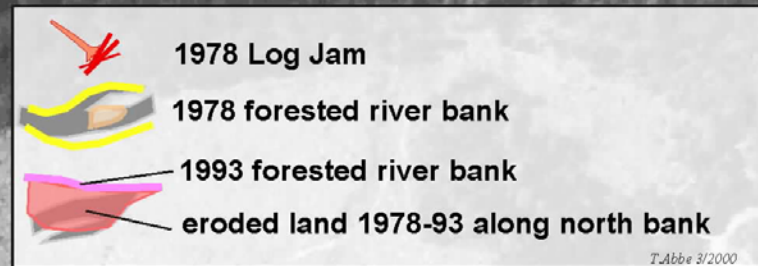
1978

1978 forest edge

flow

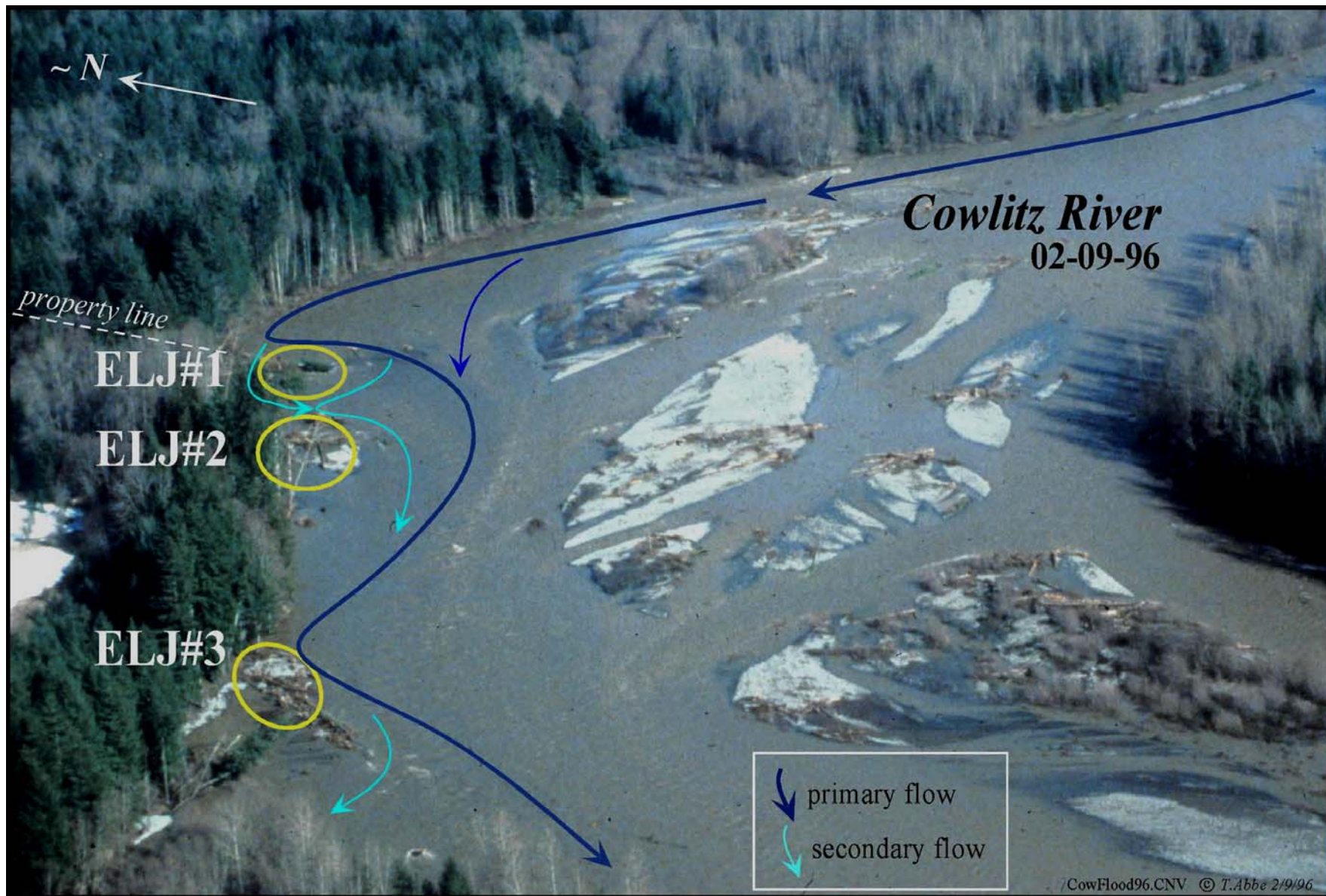
flow

North

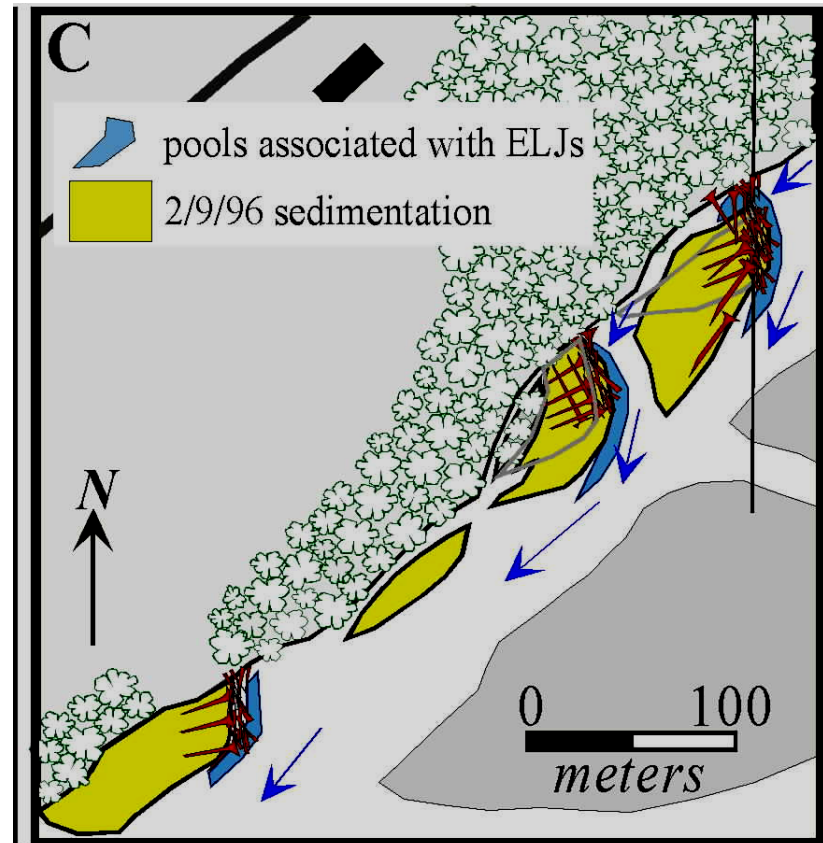
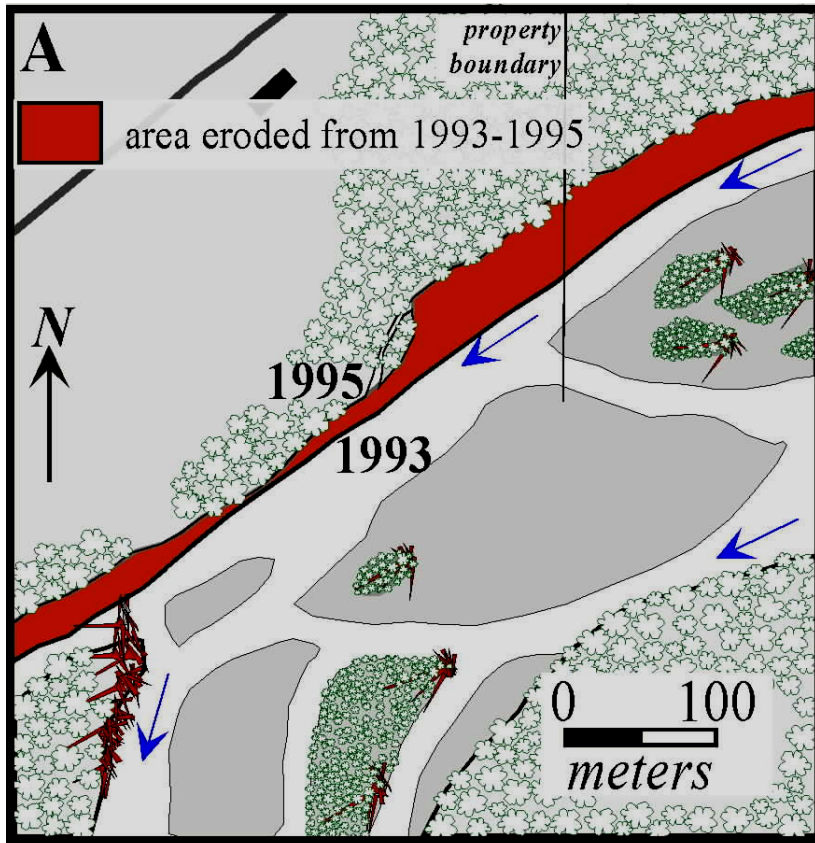




# Cowlitz River Engineered Log Jams, 25 yr flood event 5 weeks after construction

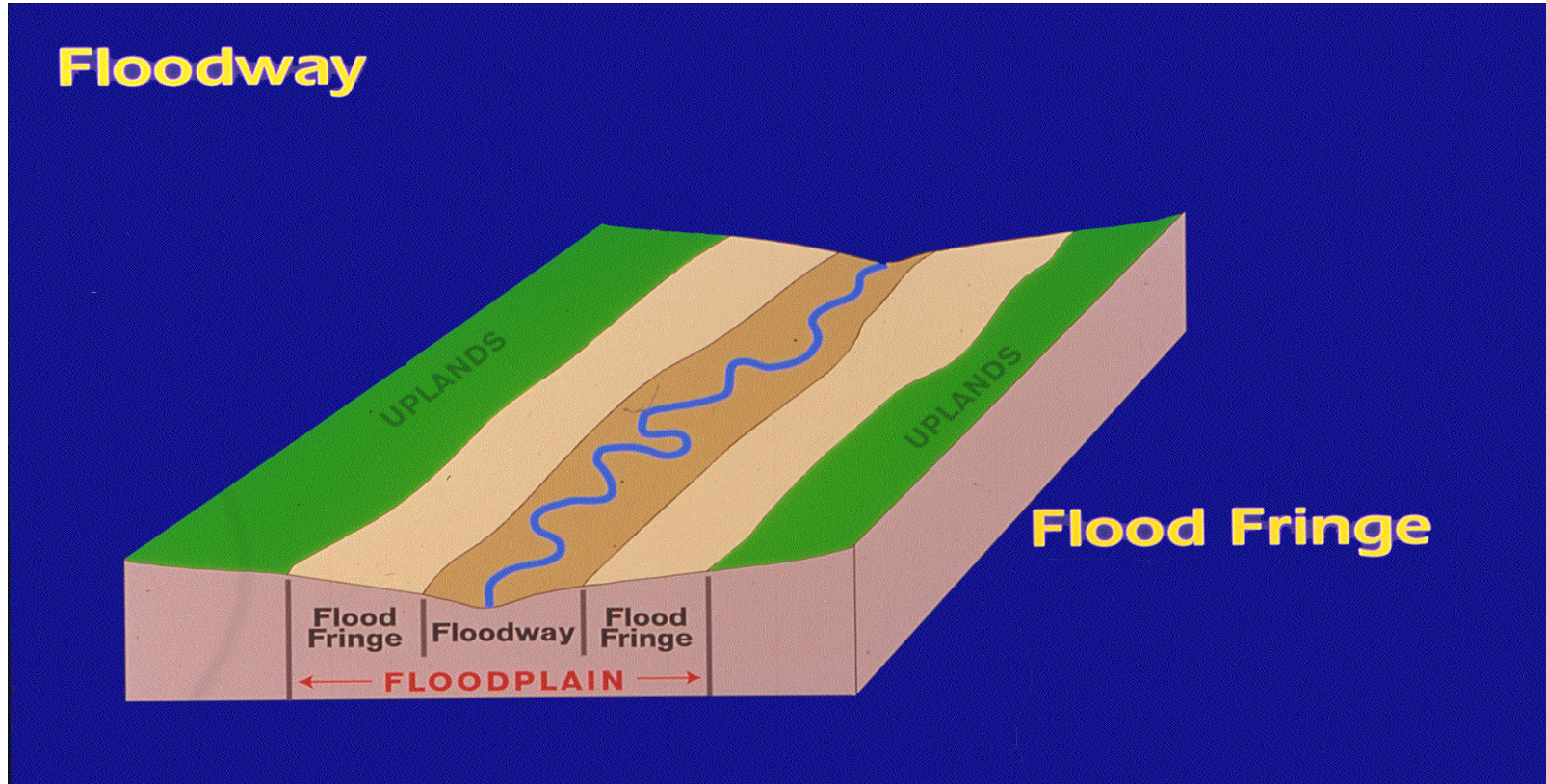


# Changes at the Cowlitz Site: 12/95 to 04/97





# Floodplain setbacks



Levee relocation to allow floodway along rivers becoming increasingly popular as a restoration measure



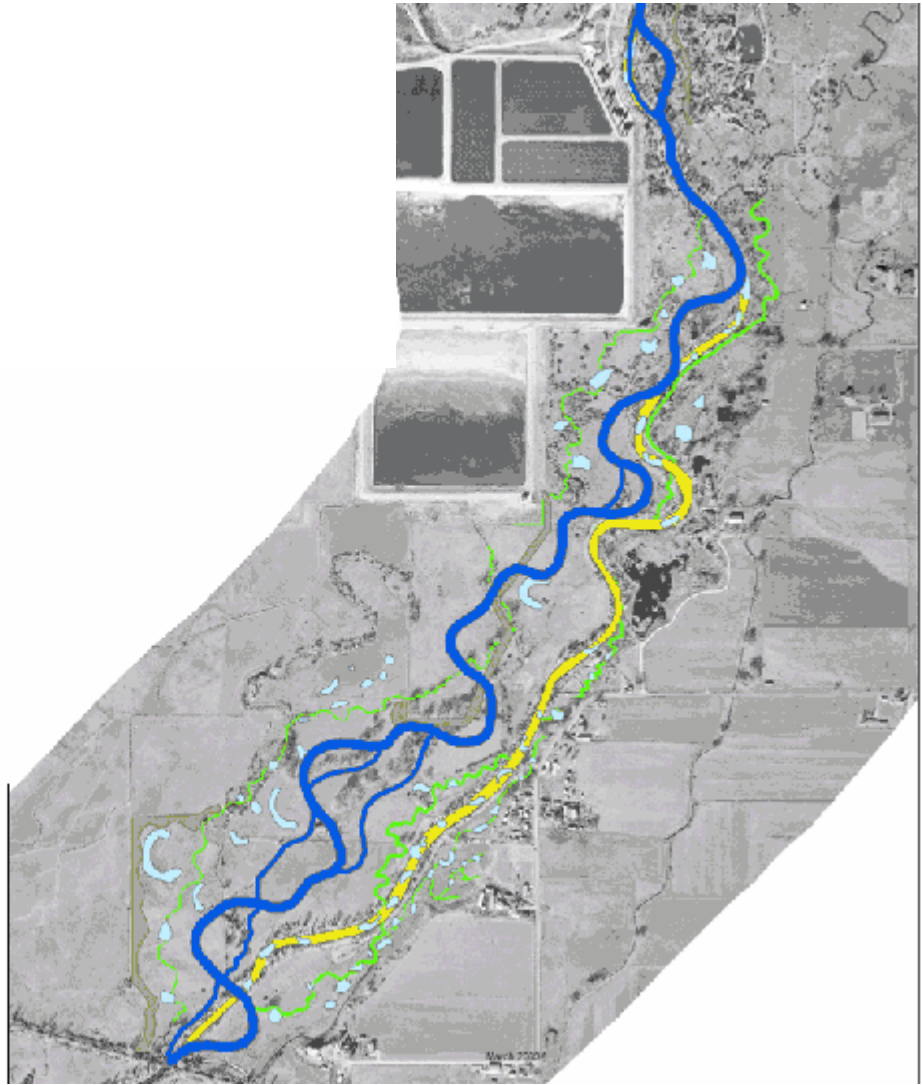
# Re-meandering, Undoing channelization

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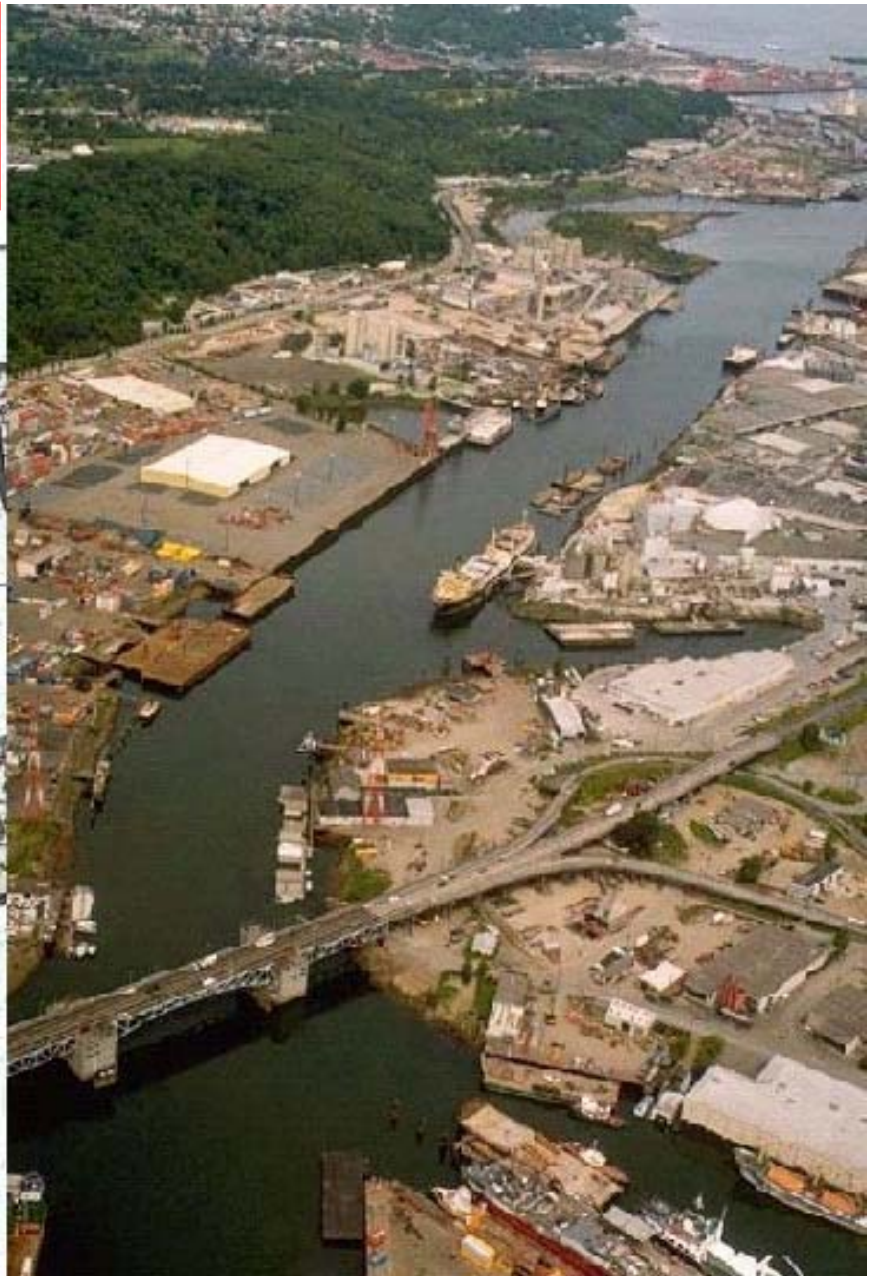


Kissimmee River, Florida

# Provo River, Utah



# Lower Duwamish River, Seattle







Restored reach formerly in a straight culvert, Berkeley, CA

# Uvas Creek, January 1996

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# Uvas Creek, July 1997

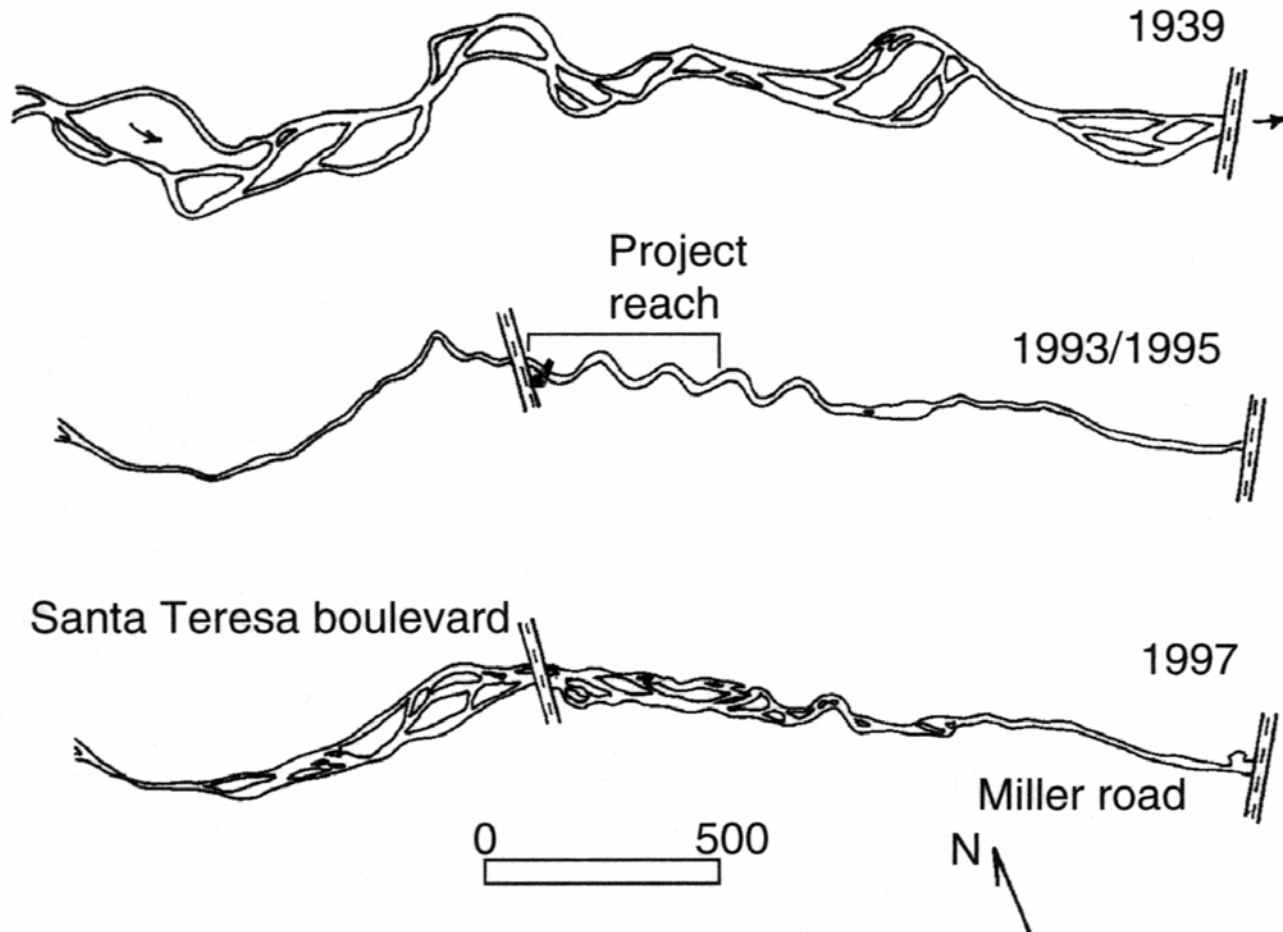
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# Uvas Creek "restoration" project

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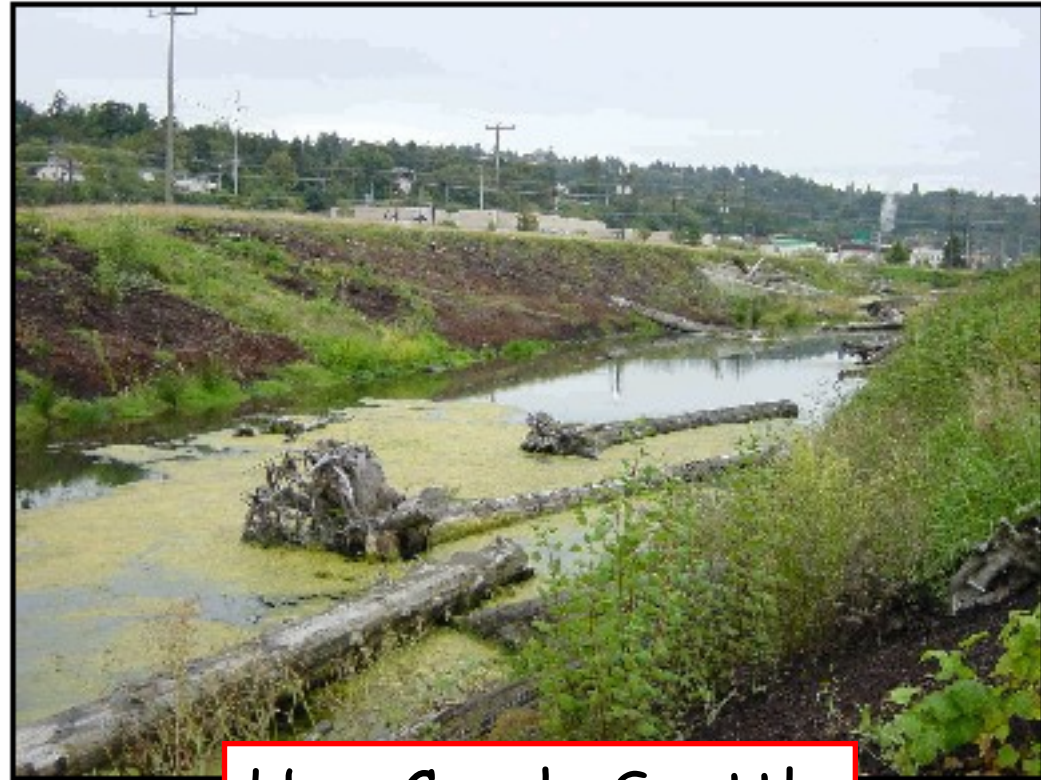
# Urban channels

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Thornton Creek, Seattle



Few opportunities for restoration



Ham Creek, Seattle

# Cuyahoga River, 1952





## Land Use Framework B River Restoration Option

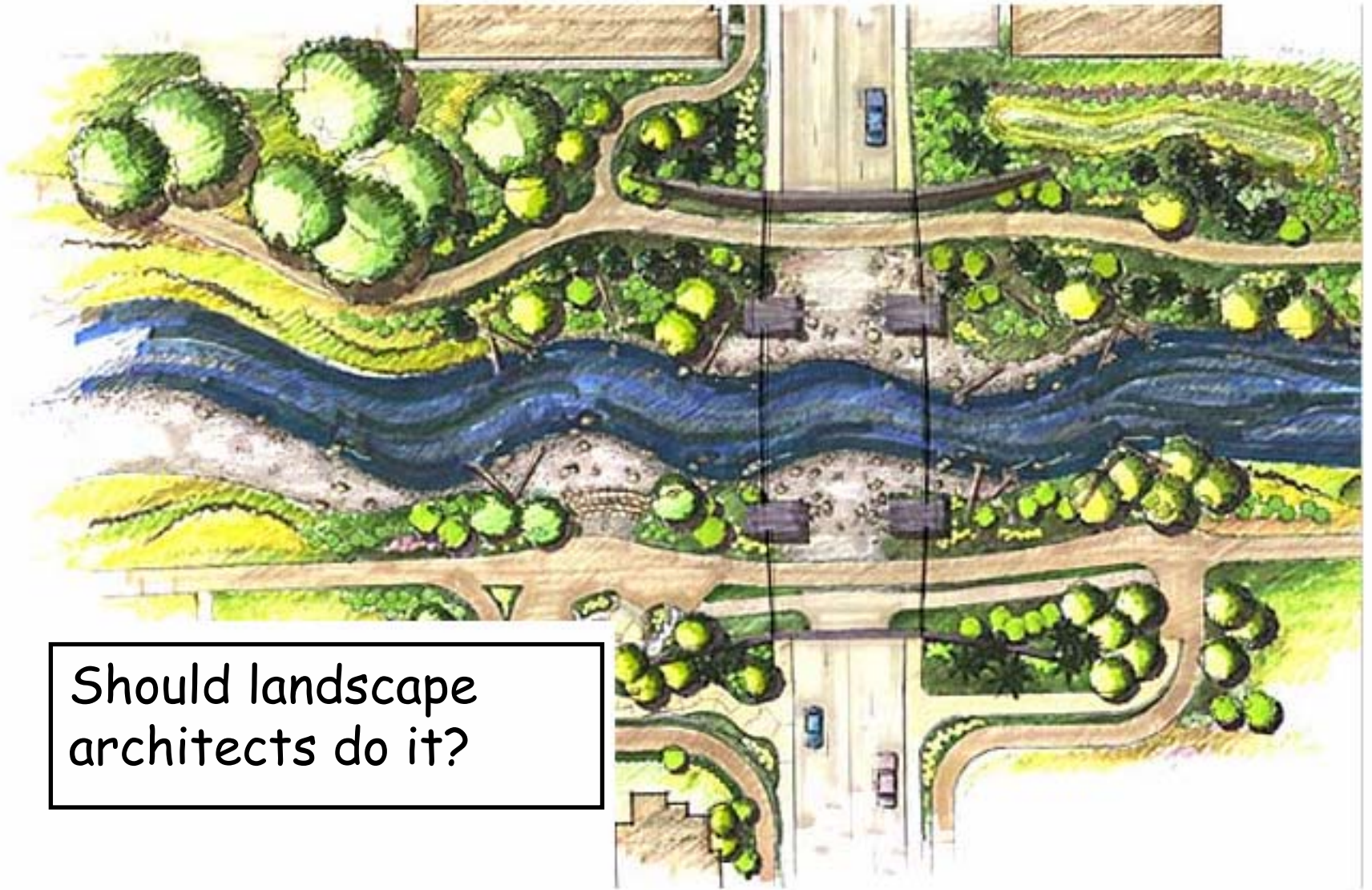


### Land Use Key

 Residential	 Public Facility (Comm. Center, PCC, Aquarium, etc.)	 Parking Garage
 Employment	 Grocery Store	 Public Square
 Residential or Employment	 Required Retail Frontage	 Park or River Greenway
 Existing Land Use	 Hotel	 Riparian Habitat



What does it take to design a restoration project?



Should landscape architects do it?

*[The Grand Canyon] is, of course, altogether valueless. It can be approached only from the south, and after entering it there is nothing to do but leave. Ours has been the first, and will doubtless be the last, to visit this profitless locality. It seems intended by nature that the Colorado River, along the greater portion of its lonely and majestic way, shall be forever unvisited and undisturbed.*

*- Lieutenant Joseph C. Ives, report to Congress  
on the Colorado River, 1861*