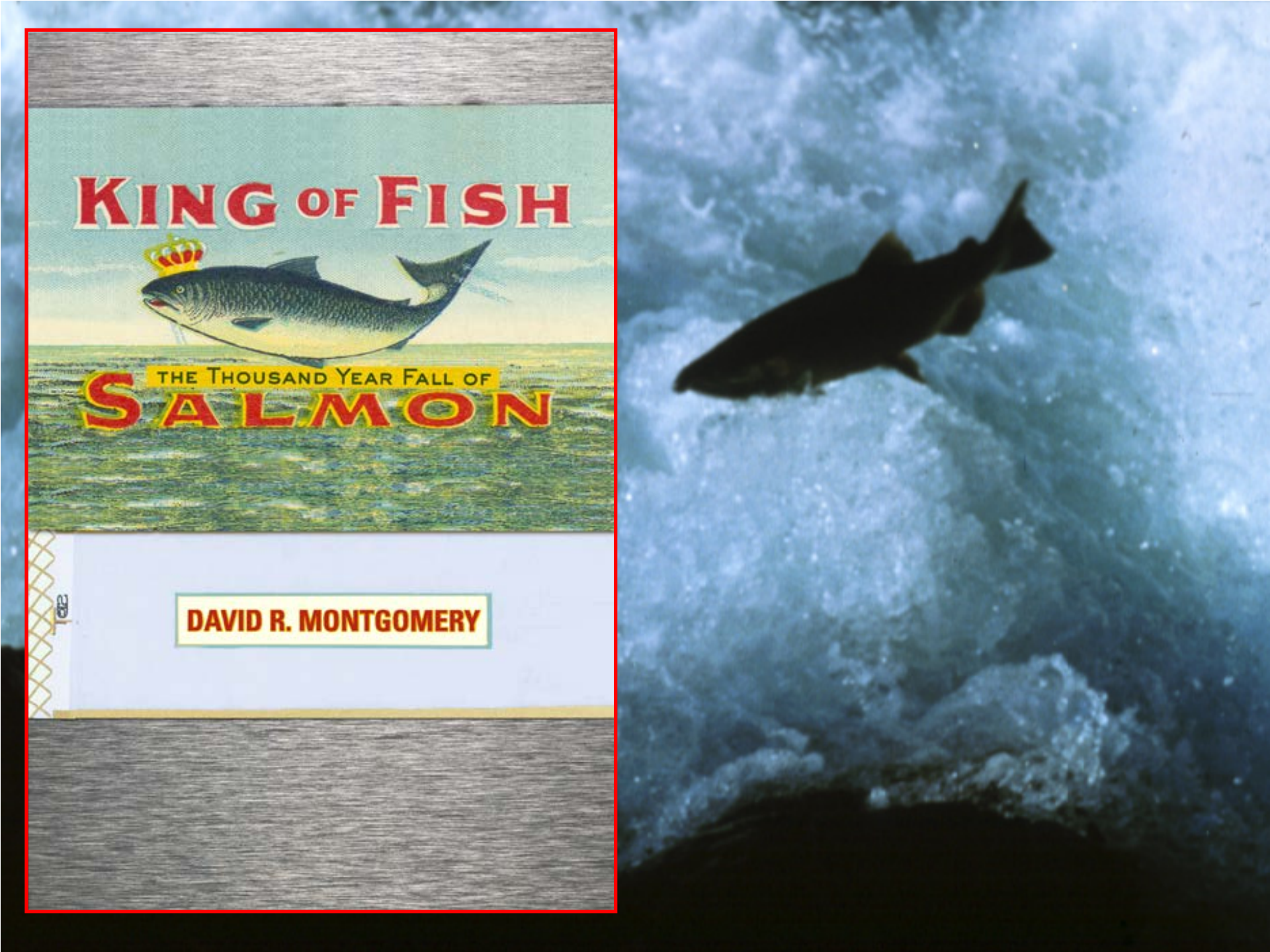

KING OF FISH
THE THOUSAND YEAR FALL OF
SALMON
DAVID R. MONTGOMERY

THE SALMON FAMILY TREE

RAY TROLL 2003

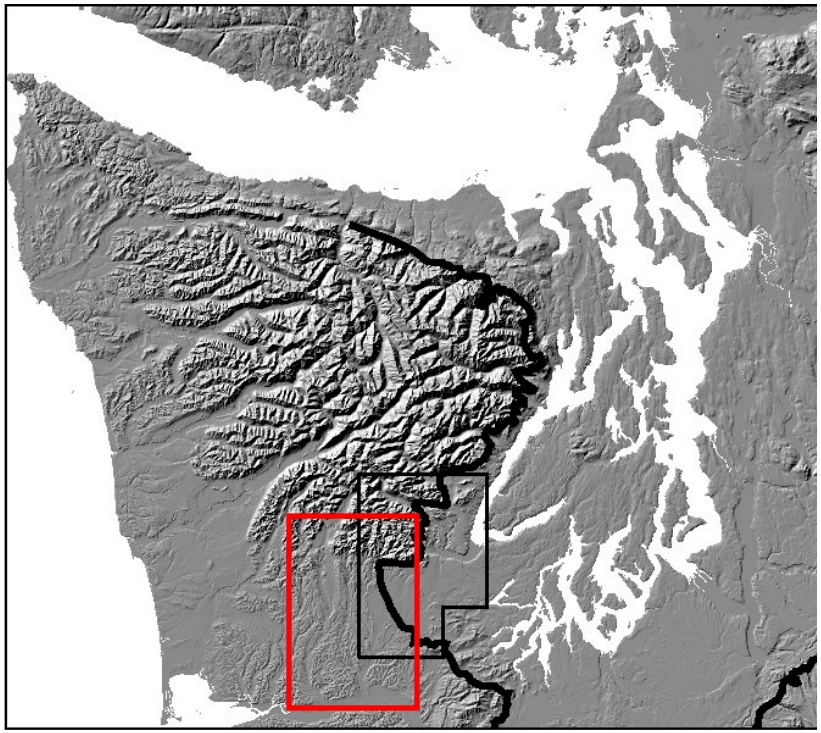
Classical Hypothesis for Pacific Salmon Evolution and Diversification

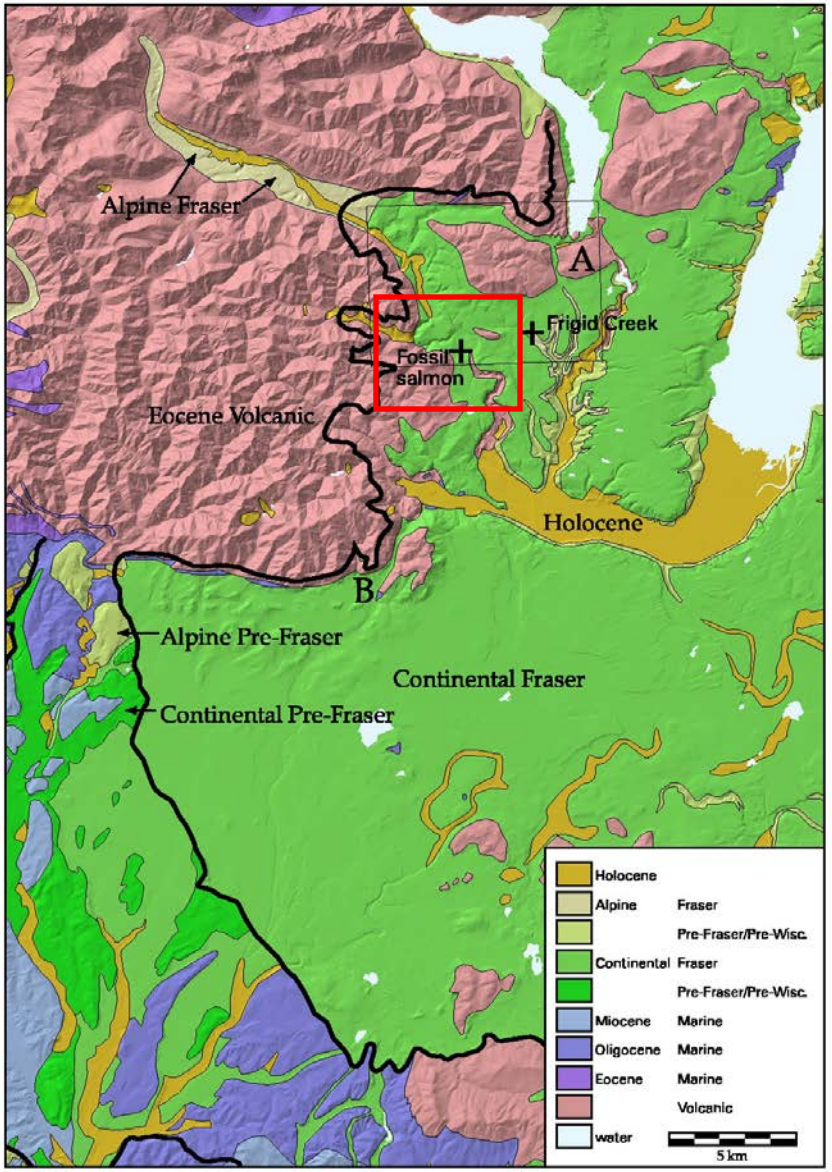
- Isolation during glacial advances
- Problem: Fossil salmon pre-date Pleistocene glaciations!

Evolution of the Pacific Salmon

- Pacific salmon evolved between 20 million and 6 million years ago (Miocene).
- Radiation of Pacific salmon into distinct species coincides with uplift of Pacific Rim topography.

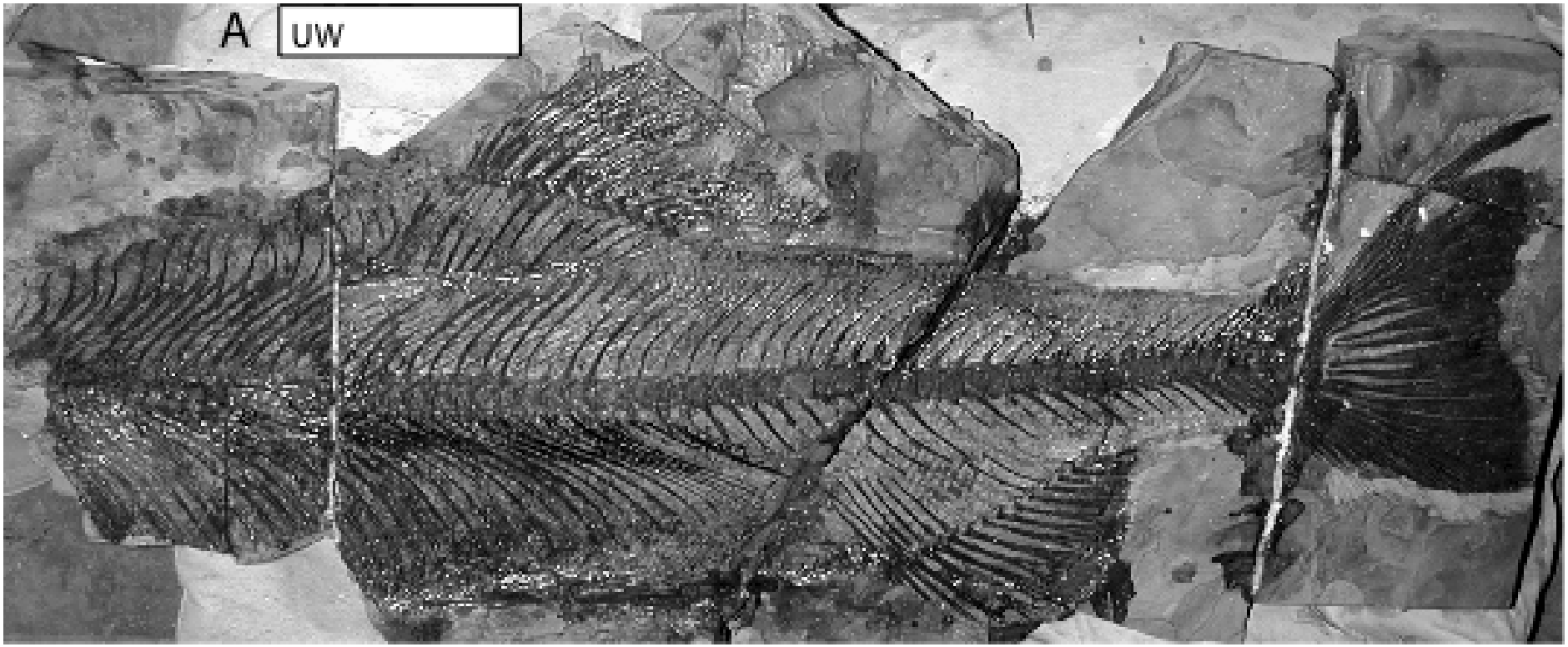
The Skokomish River fossil salmon locality is just upstream of the gorge of the South Fork at the edge of the Puget Lowland.





Skokomish River, Sockeye Salmon

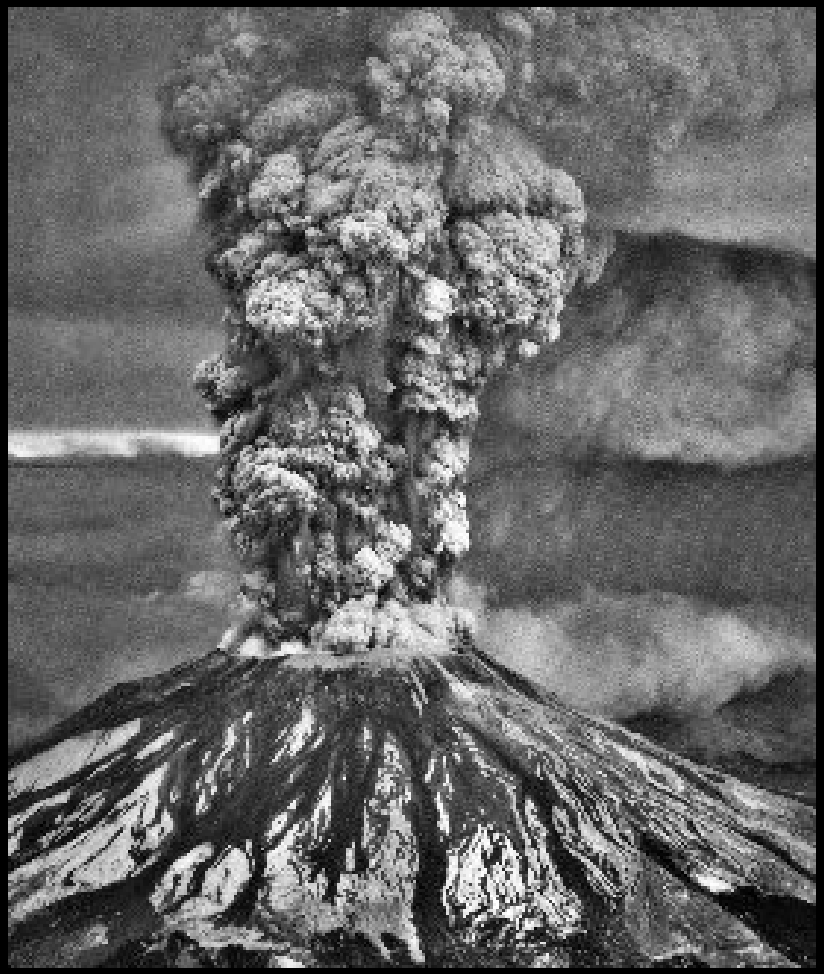
4 year old, spawning population



Major life history traits established by 1 million years ago

Salmon & Natural Disturbances

For millions of years salmon thrived in a landscape shaped by floods, volcanic eruptions and natural disturbances.

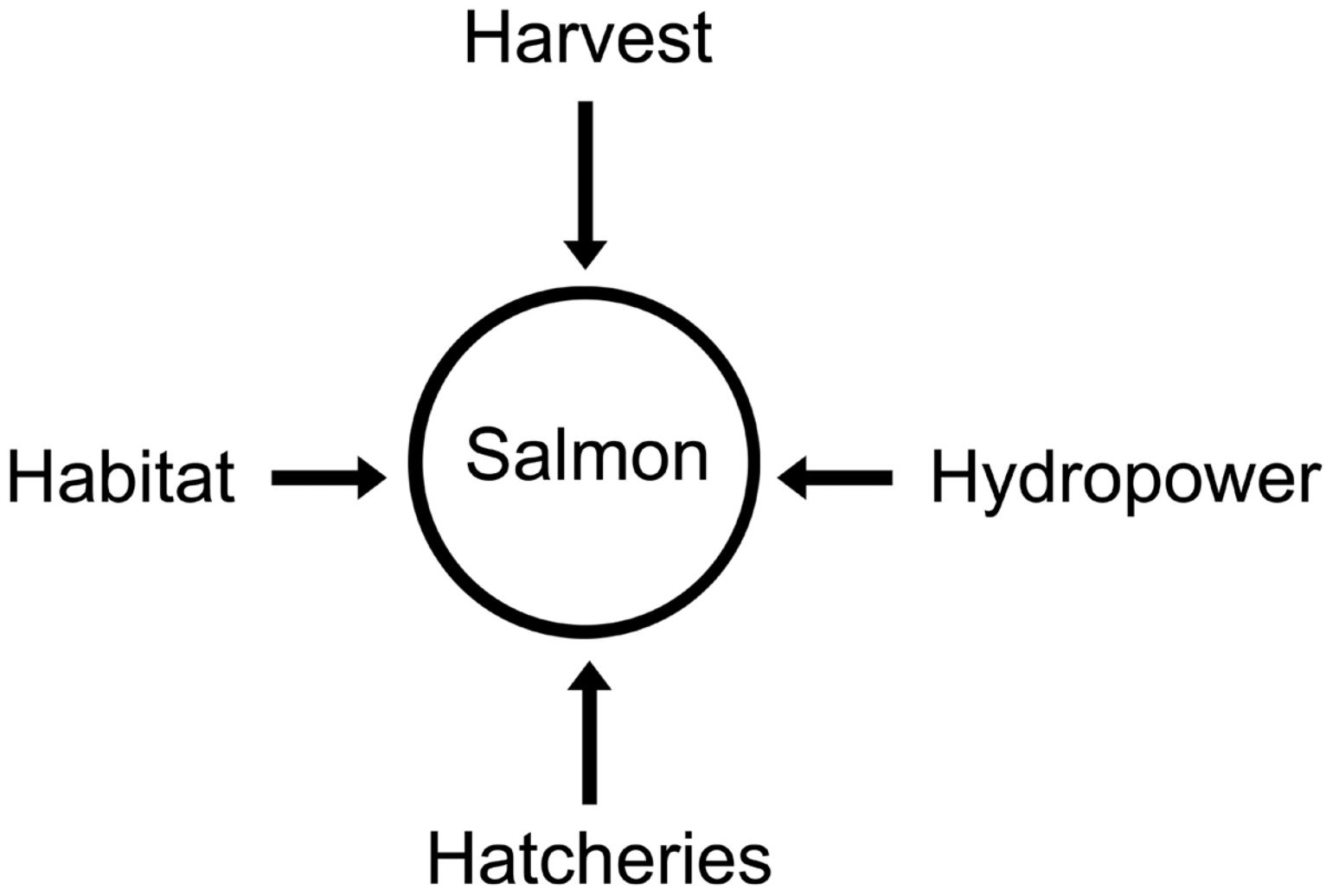


Archaeological excavations along the Columbia River confirm extensive salmon fishing for >9300 years...

Butler and O'Connor, Quaternary Research, v 62, p 1-8, 2004

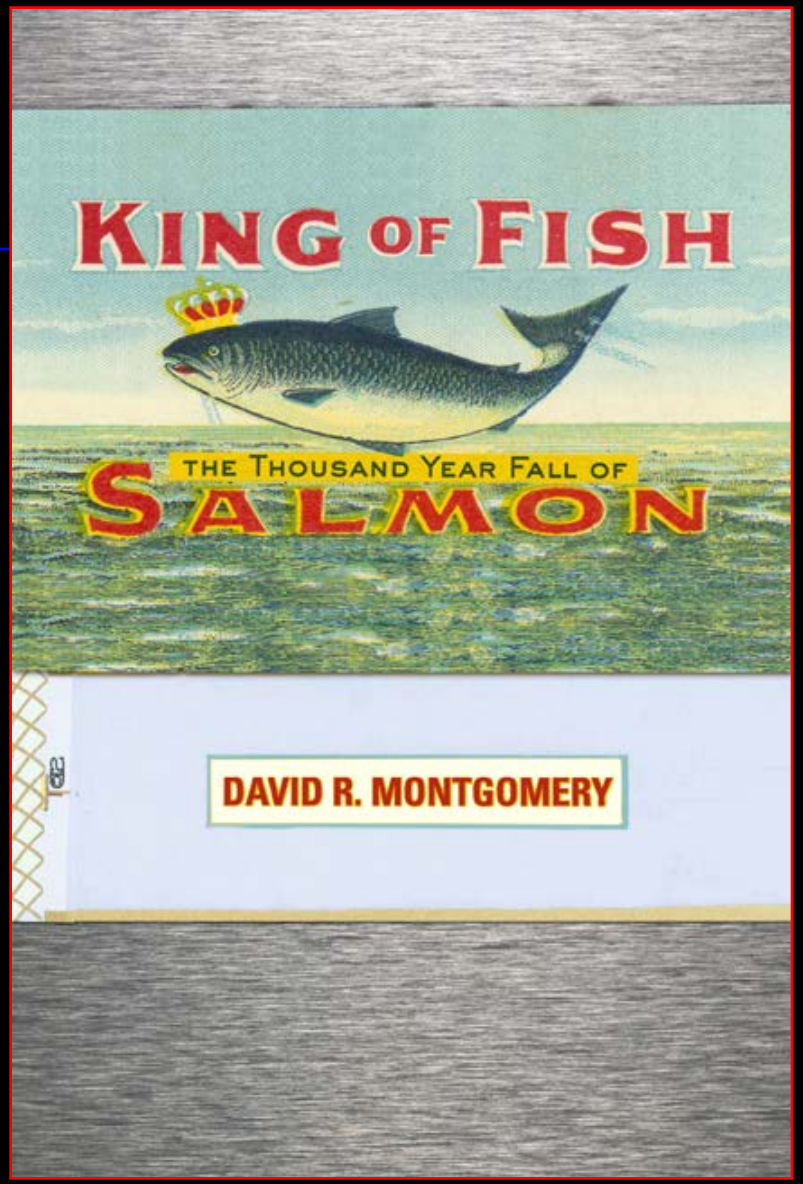
Status of Salmon Populations Today

Region	Percent of Historical Run Size
• Alaska	106
• British Columbia	36
• Puget Sound	8
• Washington	<2
• Columbia Basin	<2
• Oregon	7
• California	5
• California, Oregon, Washington, Idaho	5


Harvest
Habitat
Salmon
Hydropower
Hatcheries

History, The 5th H

Strikingly similar pattern of changes to river systems and salmon crises in Great Britain, New England and now the Pacific Northwest.



Harvest

The earliest recorded salmon-fishing legislation was an edict issued by King Malcolm II of Scotland in 1030 that established a closed season for taking "old salmon."

Habitat

A statute dating from the reign of Richard the Lionheart declared that rivers must be kept free of obstructions so as to permit a well-fed three-year-old pig, standing sideways in the stream, not to touch either side.

Hydro (dams)

An act passed in the reign of King Robert the First, in 1318, forbade the erection of fixtures of any size or dimensions that would prevent the progress of salmon up and down a river.

George I Tries to Save the Salmon

In 1714, George I enacted a law to prevent blocking salmon from their spawning grounds in 17 English rivers.

By 1868, all 17 rivers protected by George I were either blocked or poisoned by pollution. [habitat and hydro]

Alexander Fraser proposed steps to increase the number of salmon in Scottish rivers (1833):

(1) don't block the ability of salmon to migrate up or down stream [hydro];

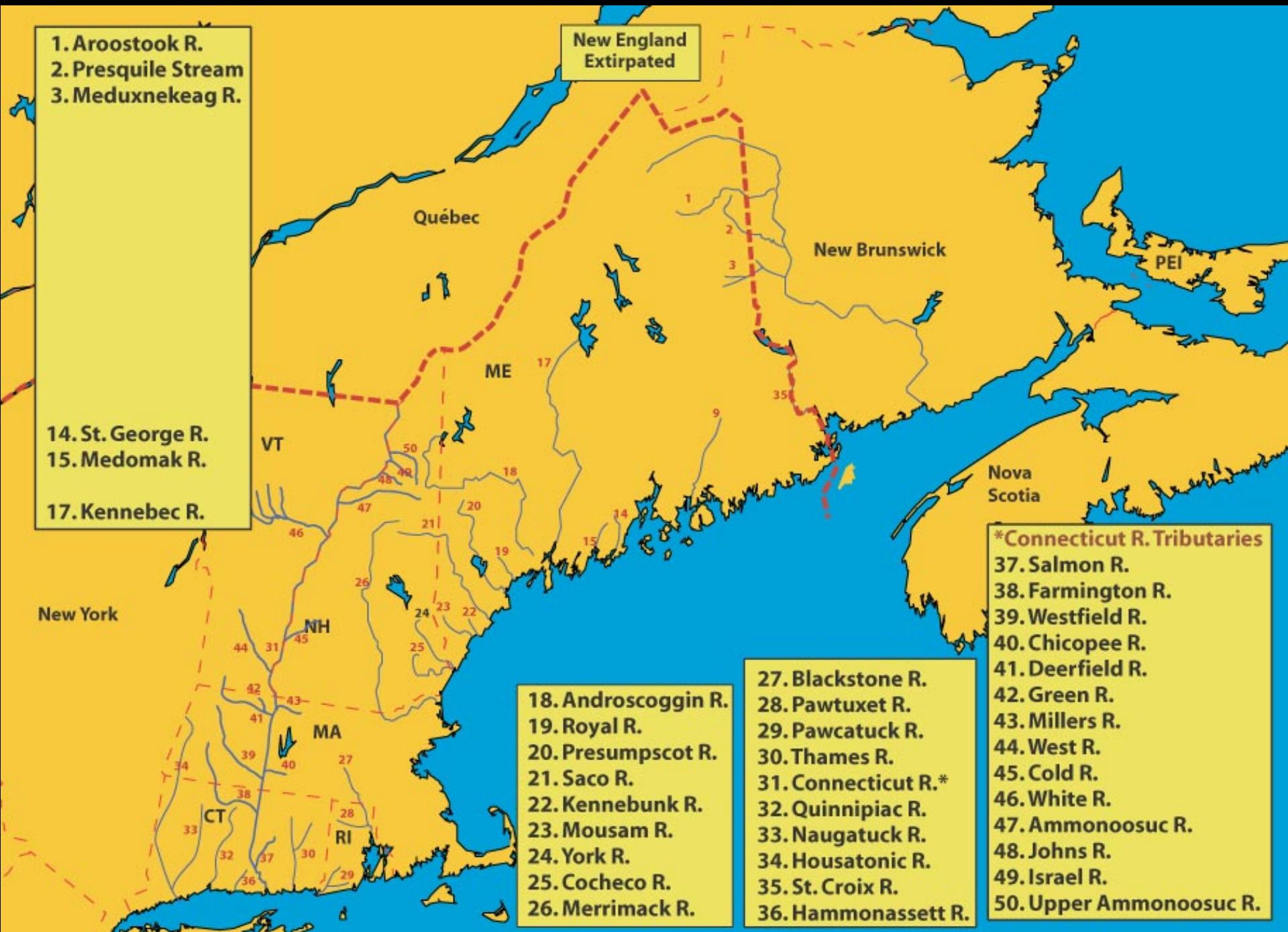
(2) limit fishing intensity so as to not take the majority of the spawners [harvest];

(3) prevent habitat degradation that could damage the fishery [habitat].

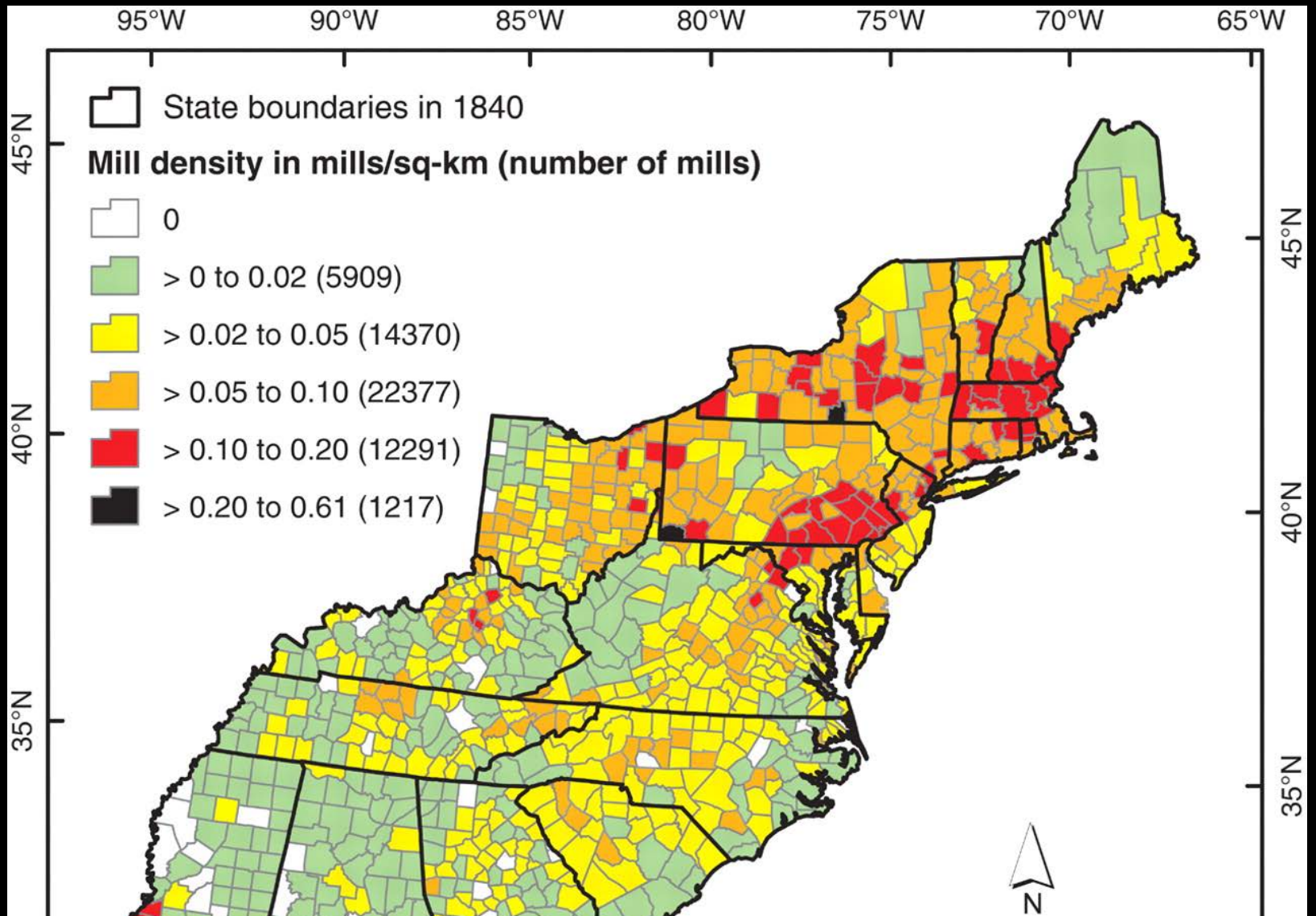
New World Salmon

"If the Pigeons plagued us by their abundance, the Salmon gave us even more trouble. So large a quantity of them enters into this river that at night one is unable to sleep, so great is the noise they make in falling upon the water after having thrown or darted themselves in to the air."

— N. Denys (1672 , p. 199).


1. Aroostook R.
2. Presquile Stream
3. Meduxnekeag R.
14. St. George R.
15. Medomak R.
17. Kennebec R.
New England Extirpated
Québec
New Brunswick
PEI
Nova Scotia
ME
VT
NH
MA
CT
RI
New York
18. Androscoggin R.
19. Royal R.
20. Presumpscot R.
21. Saco R.
22. Kennebunk R.
23. Mousam R.
24. York R.
25. Cocheco R.
26. Merrimack R.
27. Blackstone R.
28. Pawtuxet R.
29. Pawcatuck R.
30. Thames R.
31. Connecticut R.*
32. Quinnipiac R.
33. Naugatuck R.
34. Housatonic R.
35. St. Croix R.
36. Hammonassett R.
*Connecticut R. Tributaries
37. Salmon R.
38. Farmington R.
39. Westfield R.
40. Chicopee R.
41. Deerfield R.
42. Green R.
43. Millers R.
44. West R.
45. Cold R.
46. White R.
47. Ammonoosuc R.
48. Johns R.
49. Israel R.
50. Upper Ammonoosuc R.

The proliferation of small dams gradually blocked salmon from New England's rivers.



First laws outlawing salmon-blocking dams date from 1709.

Between 1820 and 1880, the State of Maine passed more than 150 fishery laws relating to salmon.

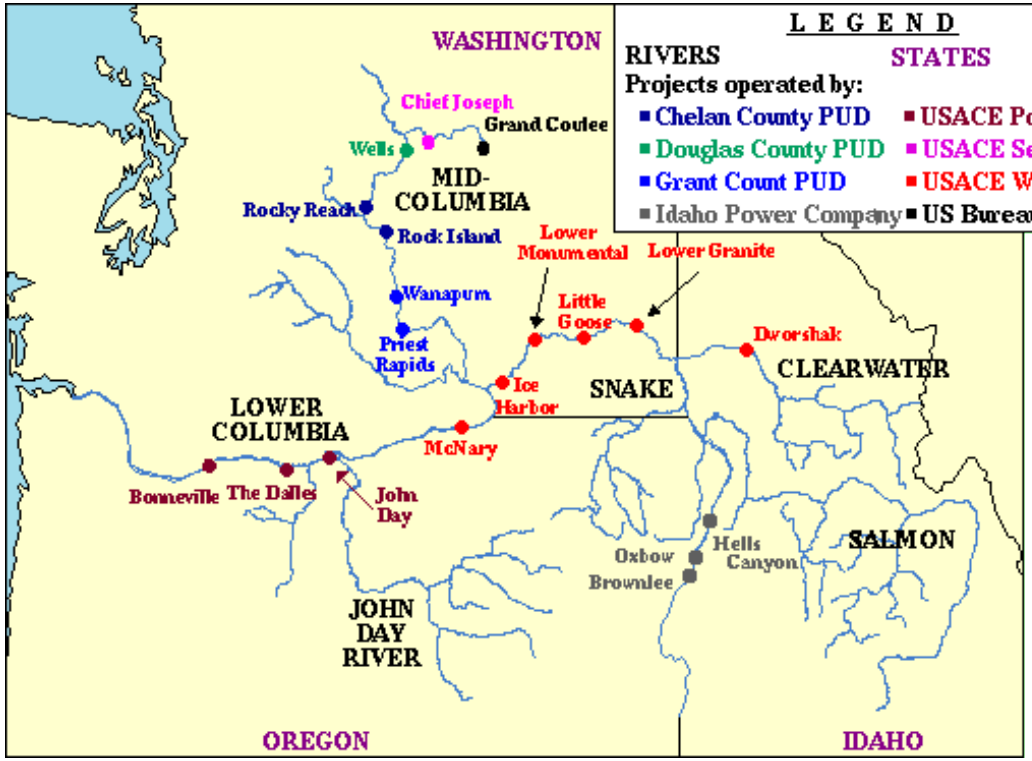
Enforcement, provided for at the local level, was virtually nonexistent.

Key factors in British and New England salmon declines

- Local control and lax enforcement
- Gradual accumulation of many individual habitat impacts
- Over-reliance on hatcheries at the expense of habitat
- Lack of long-term planning and understanding of habitat-fish linkages…

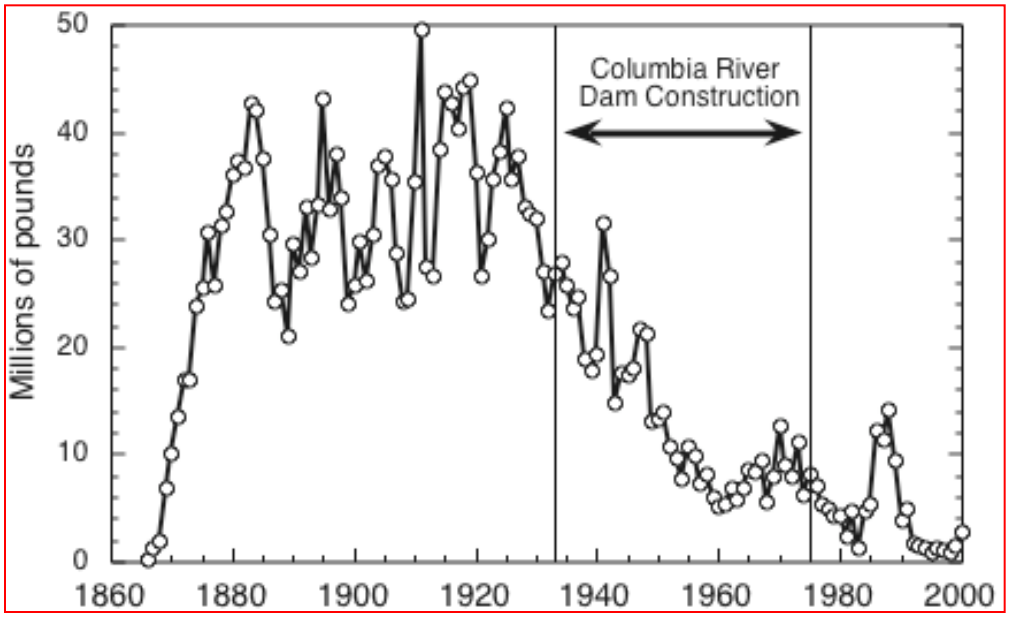
Have we learned any of these lessons?
Are we really doing anything any different in the Pacific Northwest?

Harvest


WASHINGTON
LEGEND
RIVERS
STATES
Projects operated by:
Chelan County PUD
Douglas County PUD
Grant Count PUD
Idaho Power Company
USACE Portland District
USACE Seattle District
USACE Walla Walla District
US Bureau of Reclamation
Chief Joseph
Grand Coulee
Wells
MID-COLUMBIA
Rocky Reach
Rock Island
Lower Monumental
Lower Granite
Wanapum
Little Goose
Priest Rapids
Dworshak
CLEARWATER
Ice Harbor
SNAKE
LOWER COLUMBIA
McNary
Bonneville
The Dalles
John Day
Oxbow
Hells Canyon
Brownlee
SALMON
JOHN DAY RIVER
OREGON
IDAHO


TO-4847
500'
10-17-56

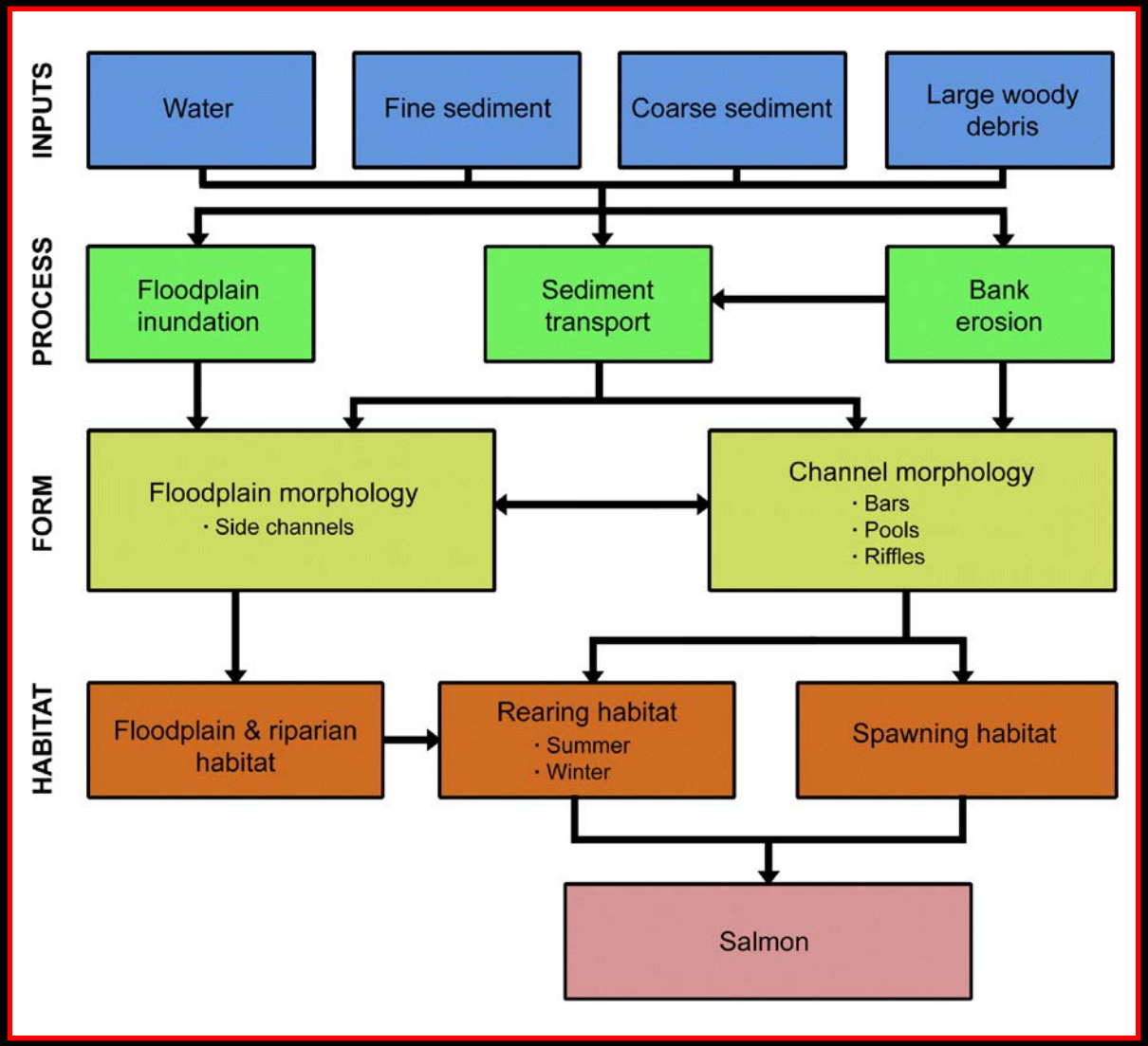
Hydro


Millions of pounds
50
40
30
20
10
0
1860
1880
1900
1920
1940
1960
1980
2000
Columbia River Dam Construction

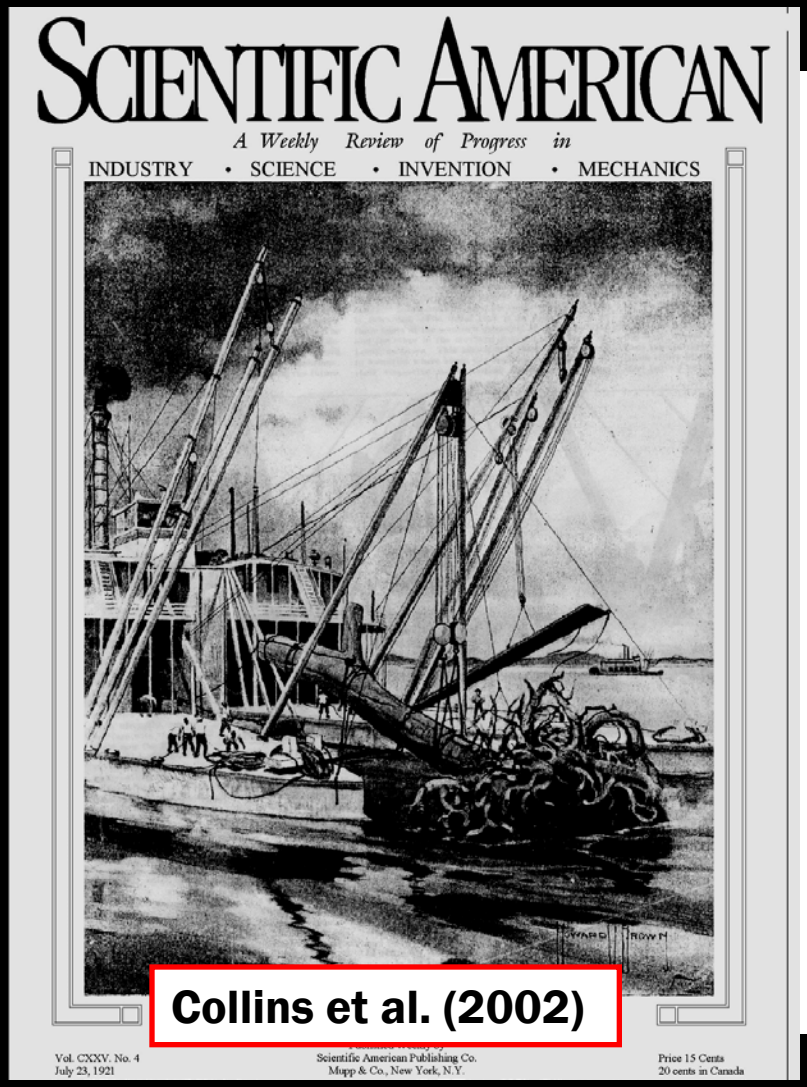

OPERATION FISH RUN II
CORPS OF ENGINEERS

Habitat

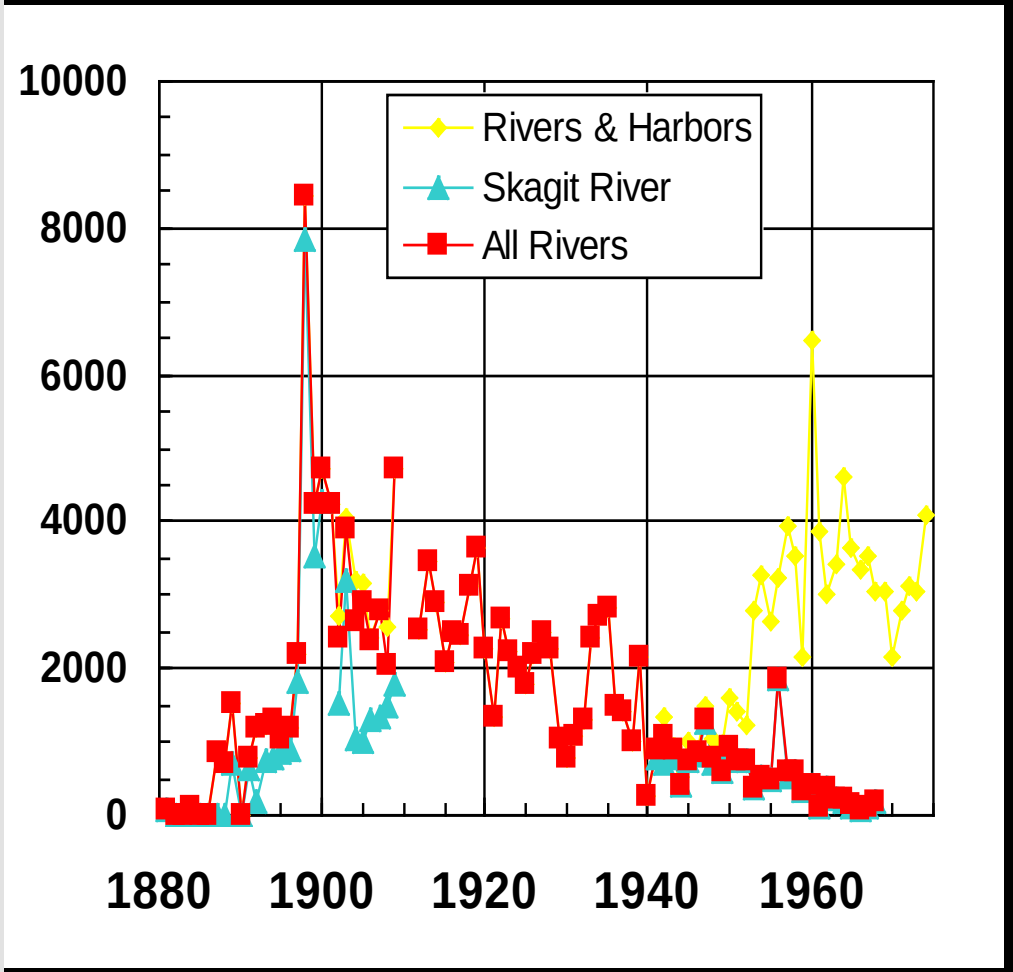
The supply and transport of water, sediment and wood interact to structure salmon habitat.



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



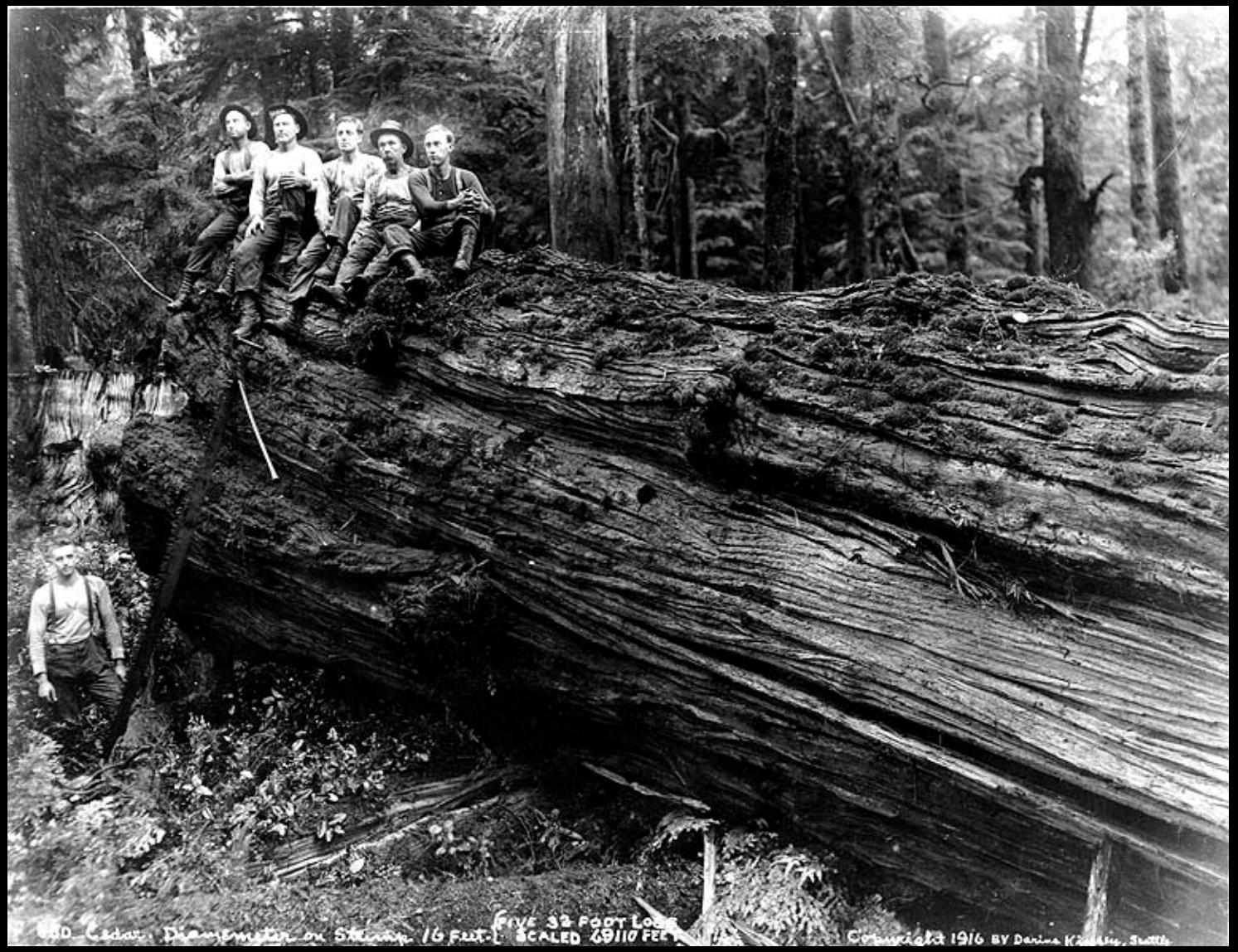
Collins et al. (2002)



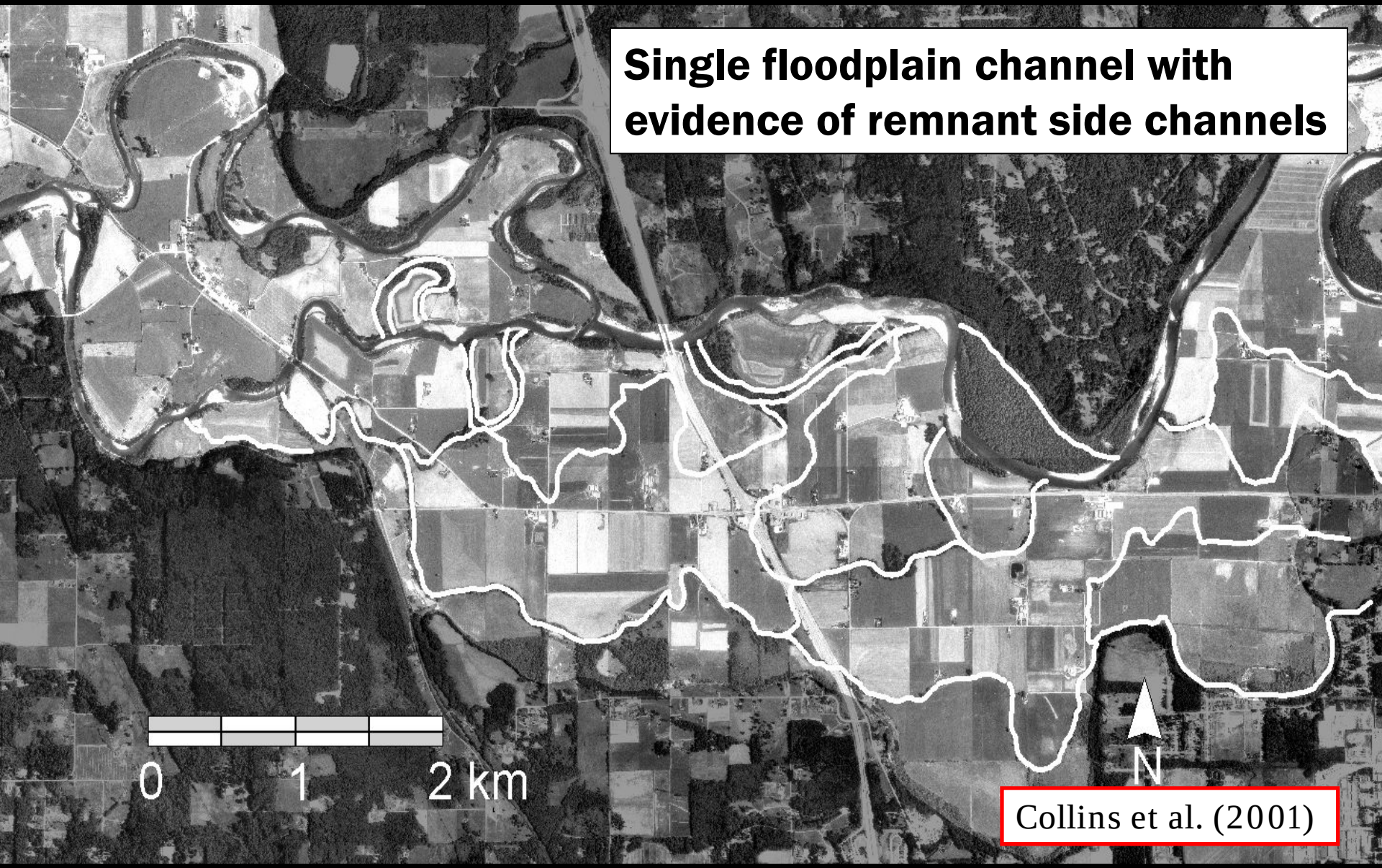
Nisqually River Floodplain

Collins et al. (2001)

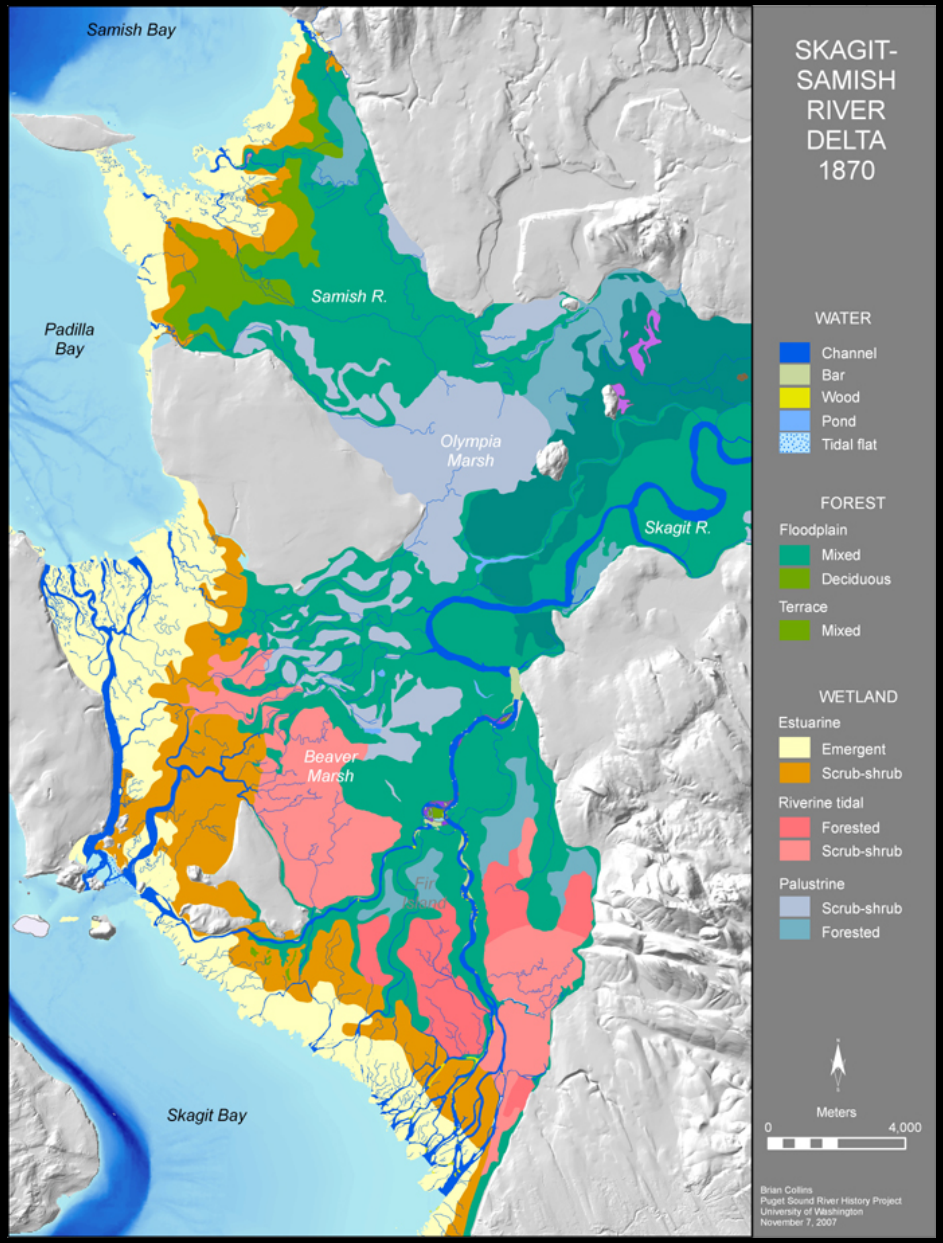
Big Trees Influenced Big Rivers

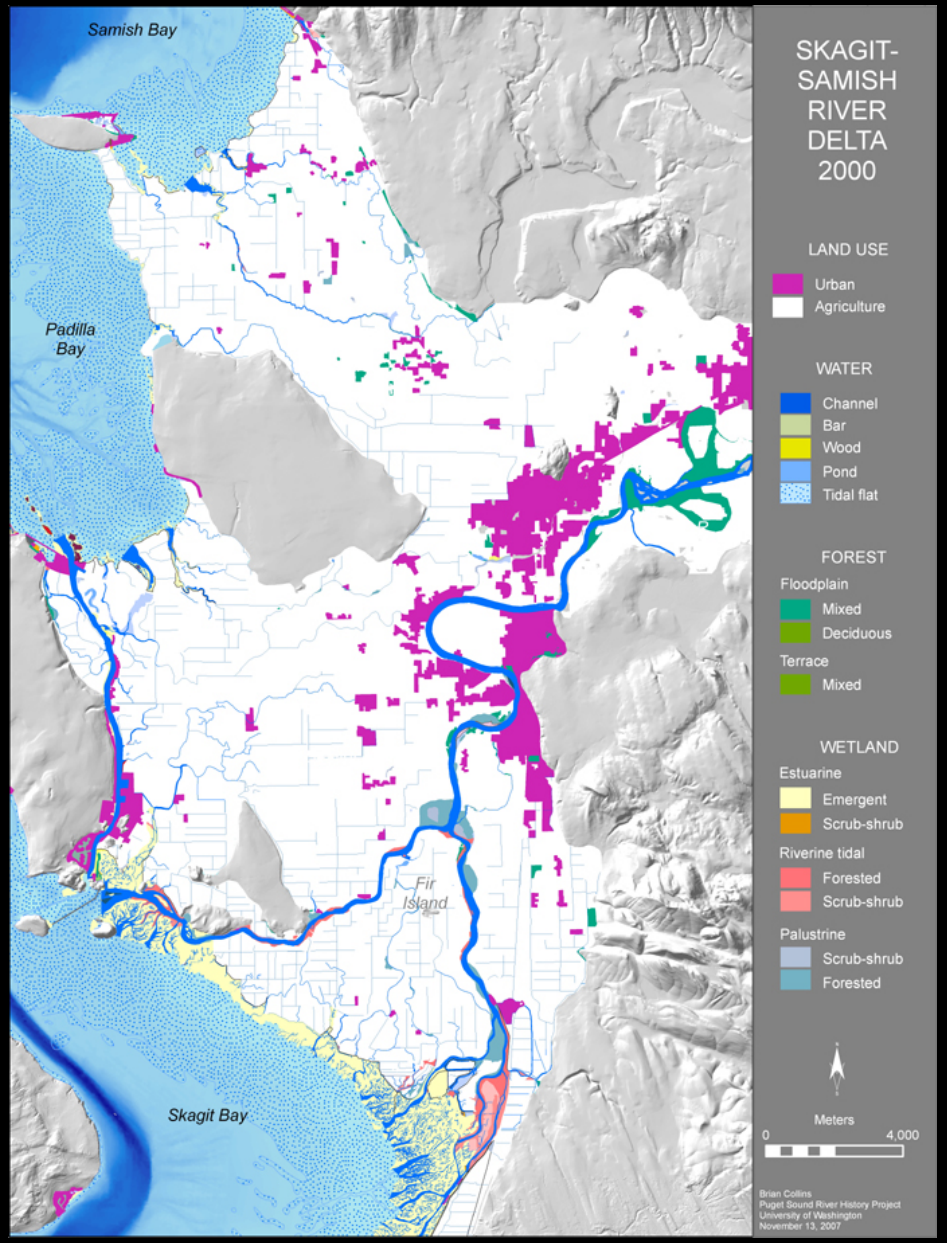


Stillaguamish River, Washington

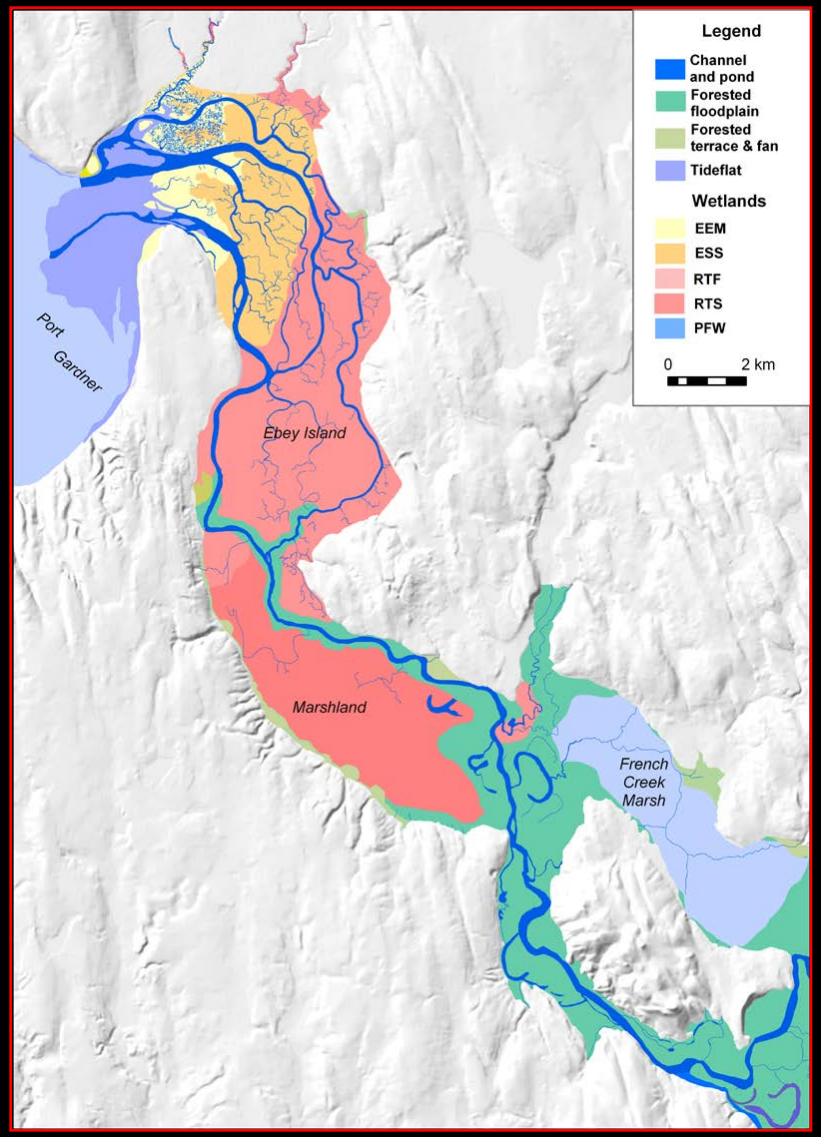


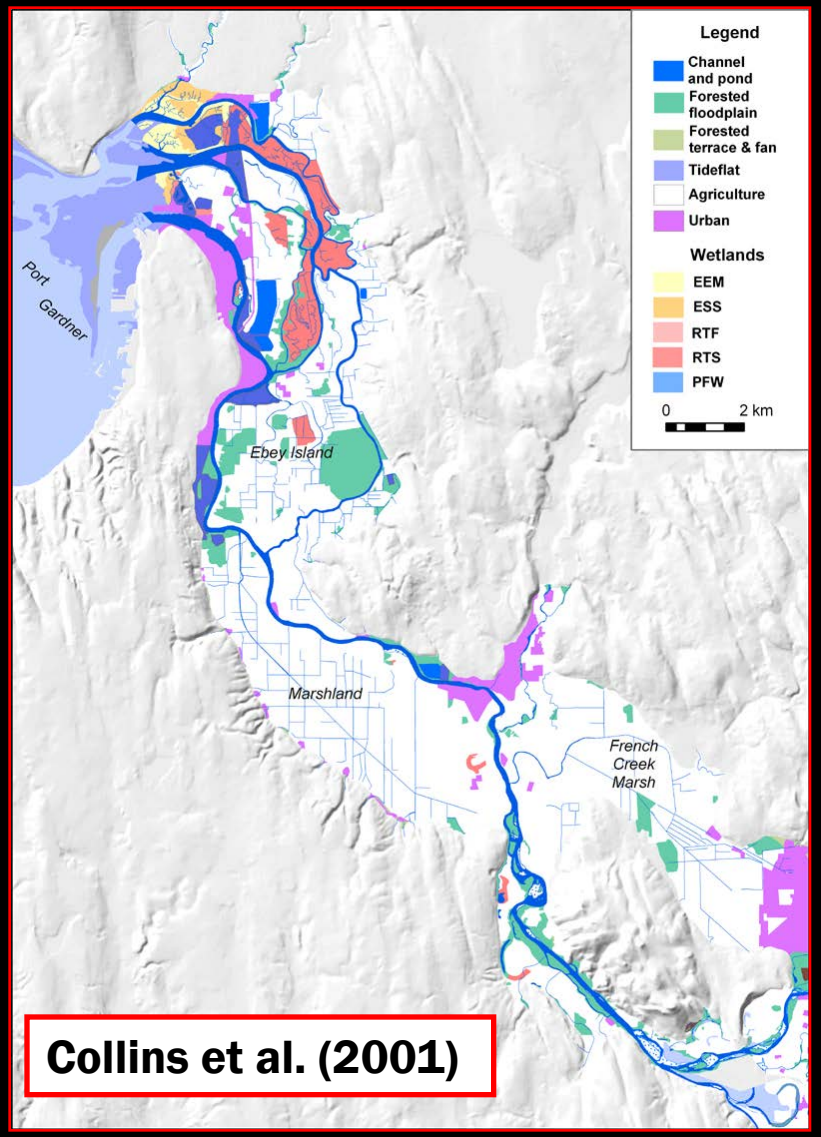
Historical changes in salmon habitat along the Skagit River





Huge losses of side channels and valley bottom wetlands along most major Puget Sound rivers, yet the story for each river is unique.

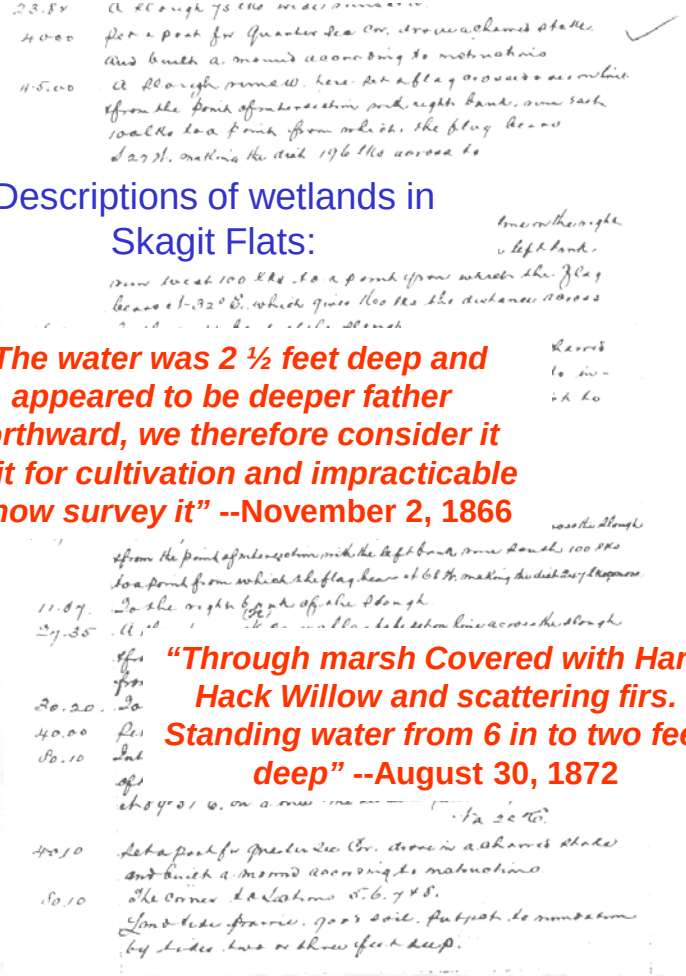




Collins et al. (2001)

Estimating historical aquatic habitat in wetlands:
Historical wetland habitats, Skagit River estuary

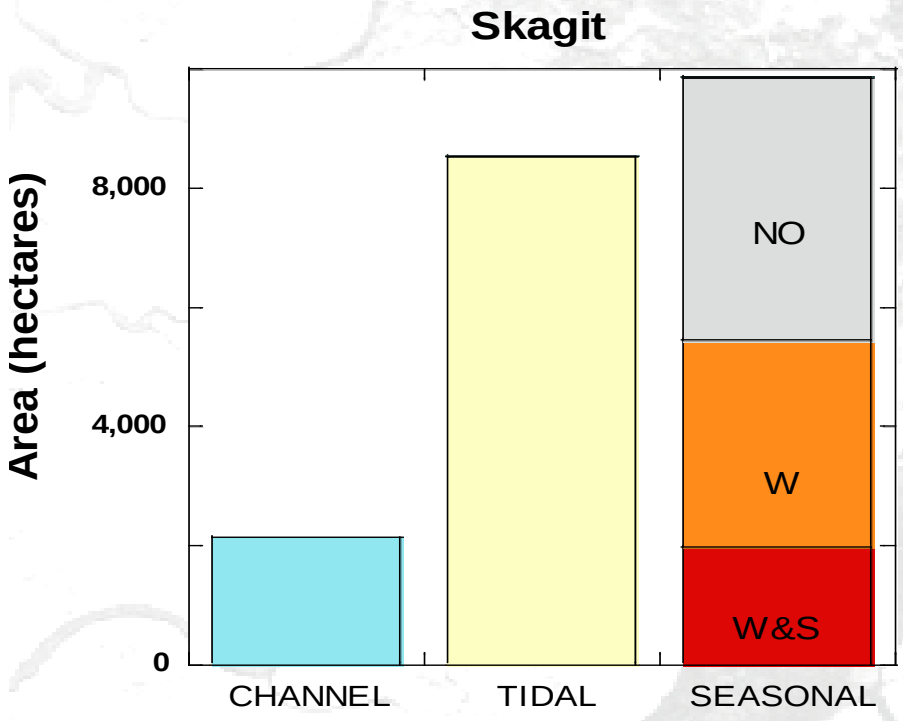
Seasonal water depths from GLO field notes help describe historical wetland habitat



Descriptions of wetlands in Skagit Flats:

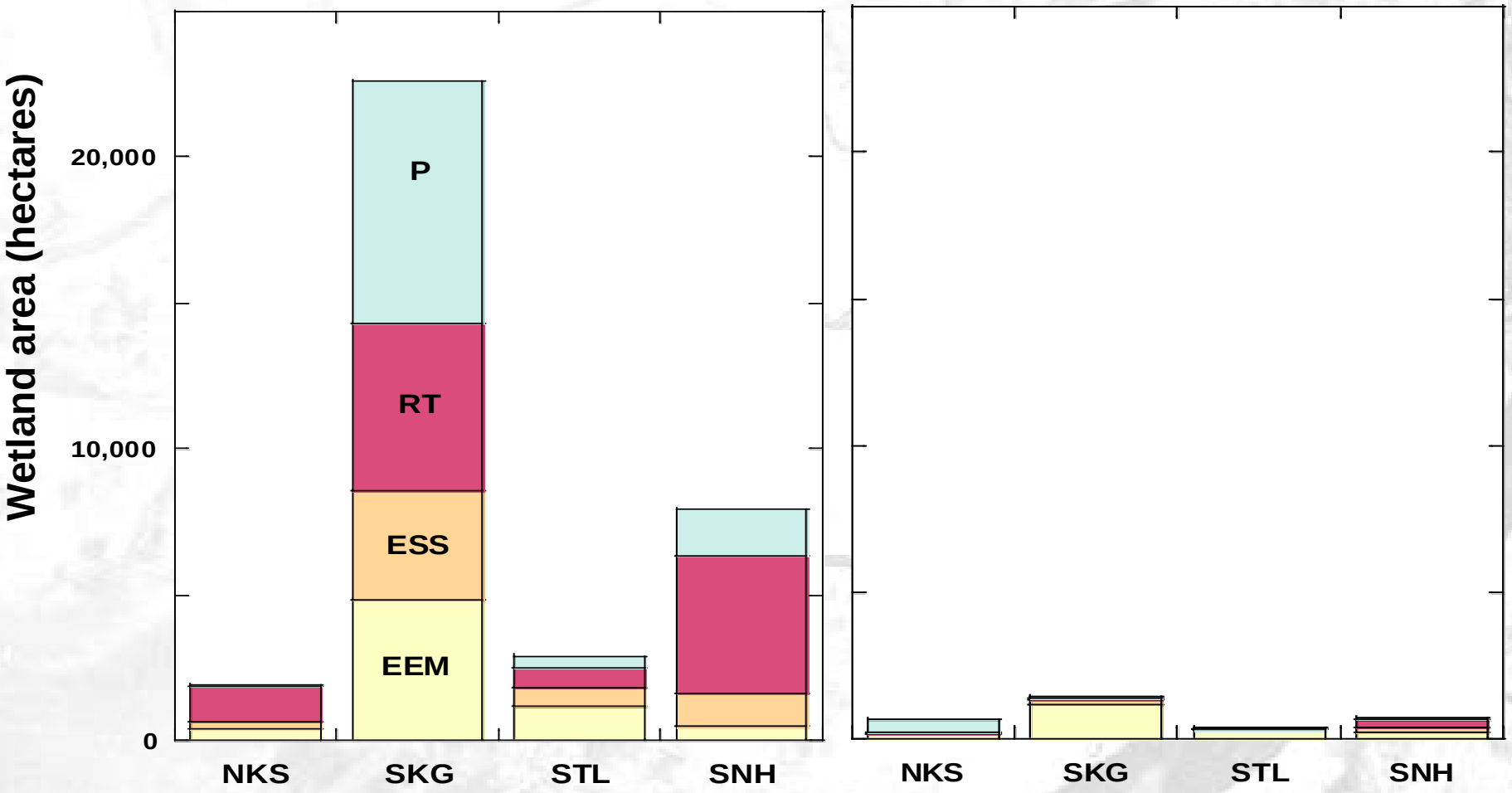
"The water was 2 ½ feet deep and appeared to be deeper father northward, we therefore consider it unfit for cultivation and impracticable to now survey it" **--November 2, 1866**

"Through marsh Covered with Hard Hack Willow and scattering firs. Standing water from 6 in to two feet deep" **--August 30, 1872**



Seasonal inundation (> 1 ft for most of season):
W: winter W&S: winter & summer

Change to wetland area in four North Sound estuaries/deltas

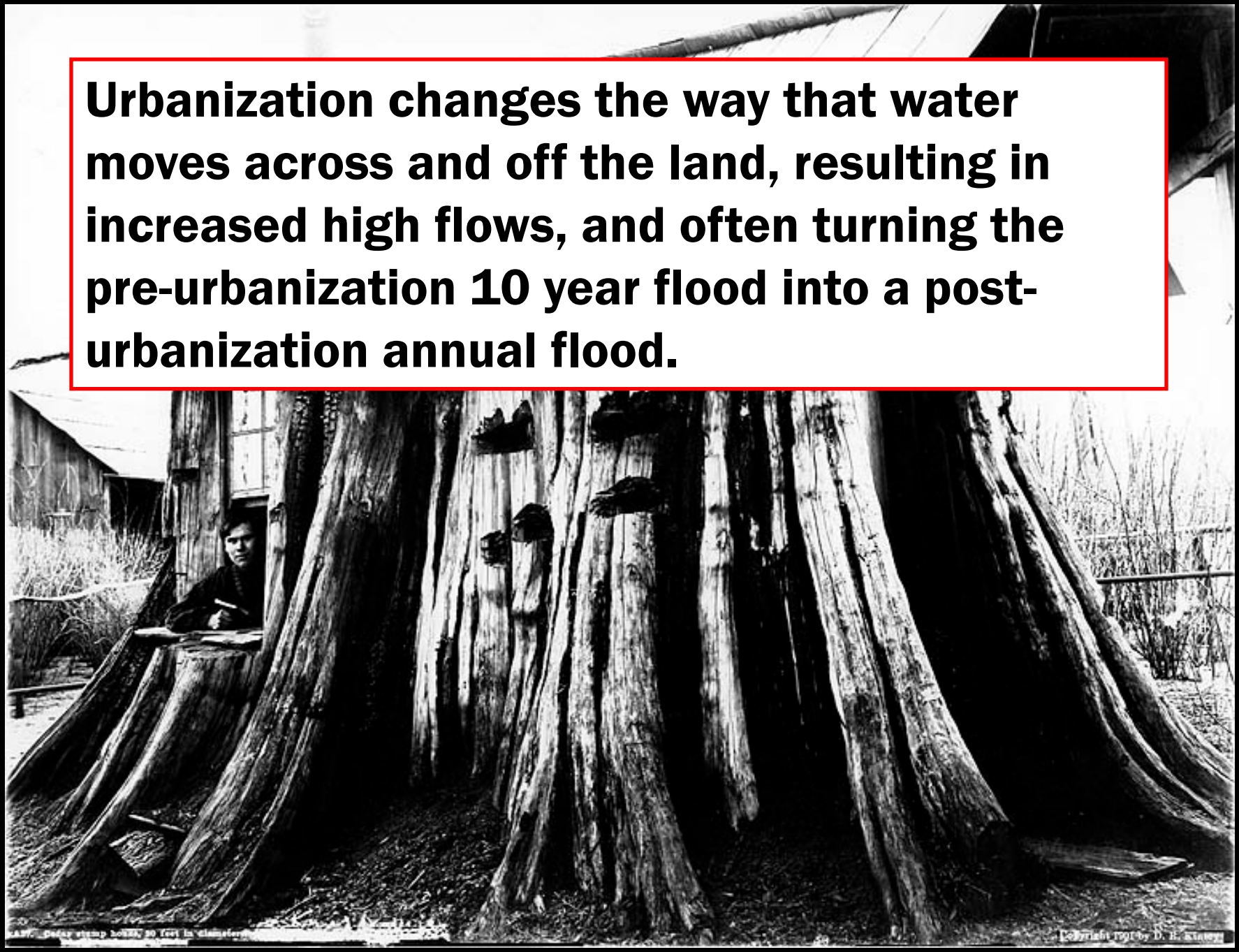


EEM=estuarine emergent; ESS=estuarine scrub-shrub; RT=riverine-tidal; P=palustrine

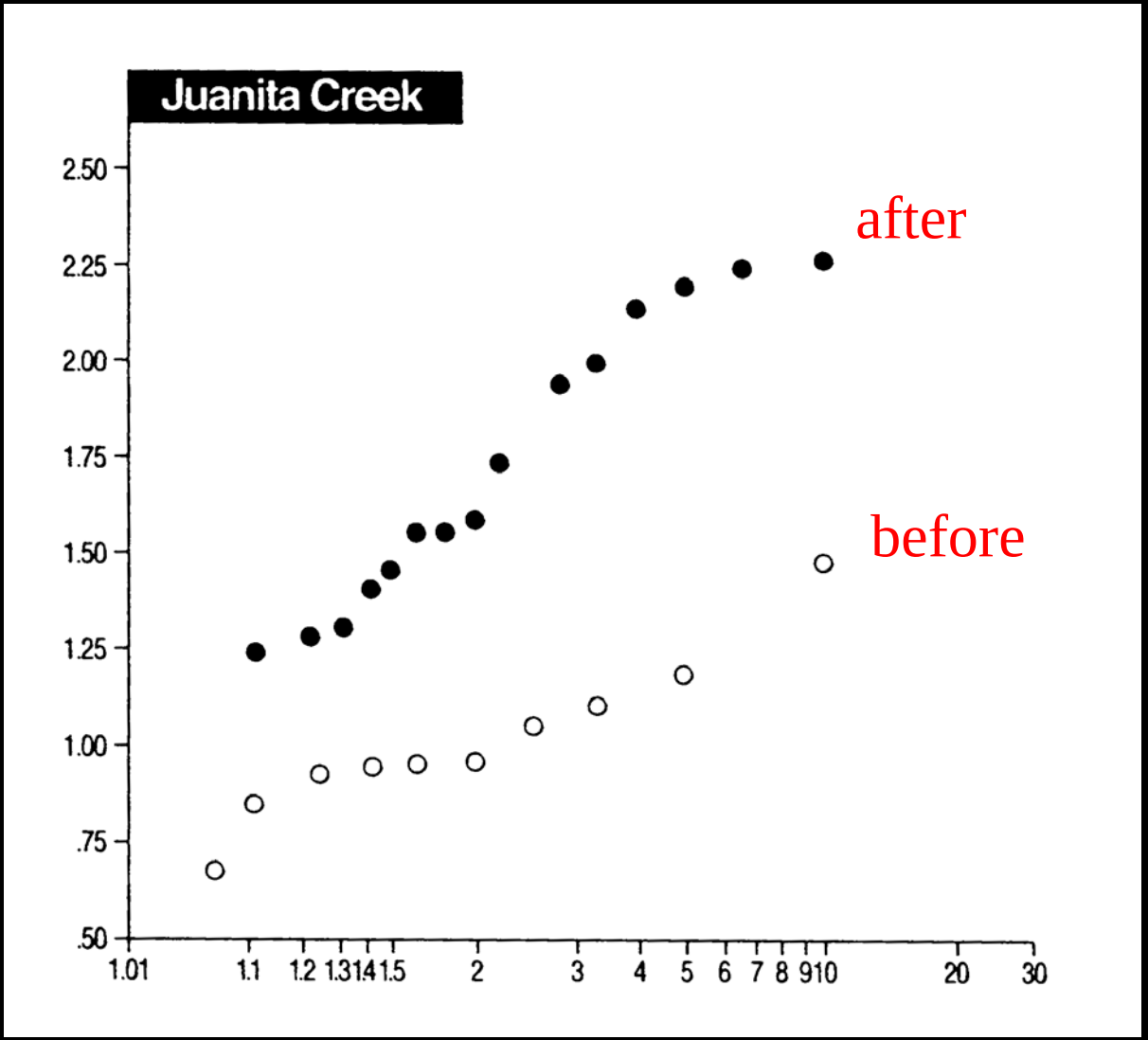
Provide some refuge for the salmon, and provide it quickly, before complications arise which may make it impracticable, or at least very difficult. ... If we procrastinate and put off our rescuing mission too long, it may be too late to do any good. After the rivers are ruined and the salmon gone they cannot be reclaimed ... all the power of the United States cannot restore salmon to the rivers after the work of destruction has been completed.

— Livingston Stone (1892)

One of the few strategies that might work over the long run would be to create a network of Salmon Sanctuaries by restoring forested river corridors along river floodplains.

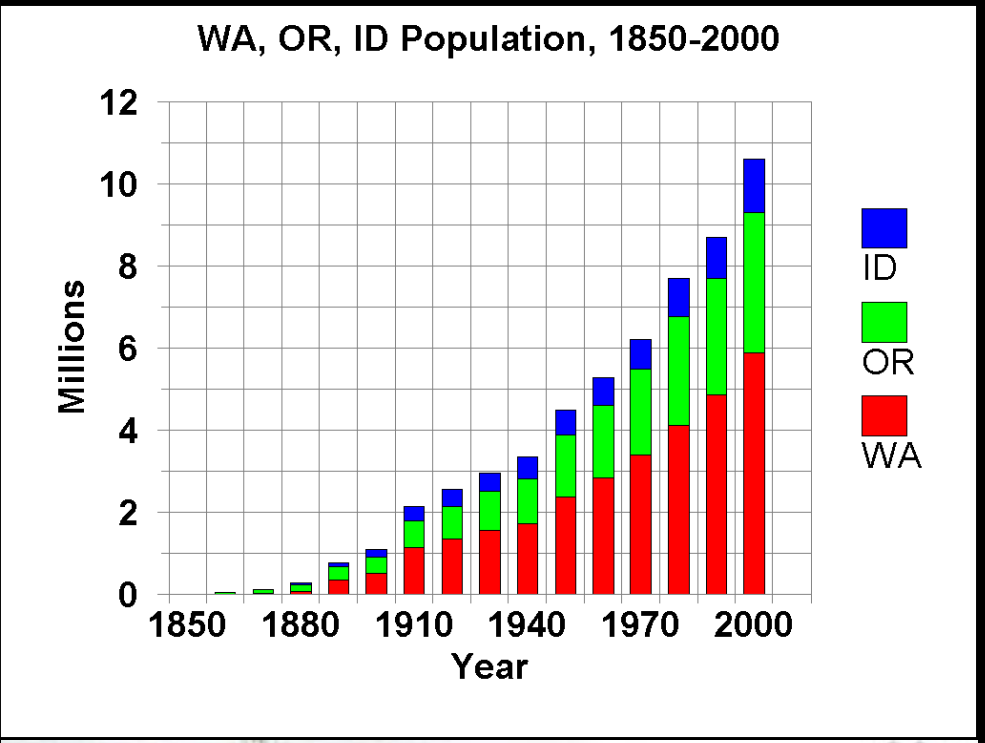

Urbanization changes the way that water moves across and off the land, resulting in increased high flows, and often turning the pre-urbanization 10 year flood into a post-urbanization annual flood.

Discharge (cfs)



Recurrence interval

Moscrip and Montgomery, JAWRA, 1997



Puget Sound Partnership recommendations essentially ignore the adverse impacts likely to occur due to future development.

On October 26, 2006, 14 so-called “experts” sent a letter to the Puget Sound Partnership expressing concern over failure to adequately address management of stormwater runoff from future development.

Doug Beyerlein
Susan Bolton
Derek Booth
Tom Holz
Thom Hooper
Richard Horner
James Karr
DeeAnne Kirkpatrick
John Lombard
Chris May
Gary Minton
David Montgomery
David Somers
Cleve Steward

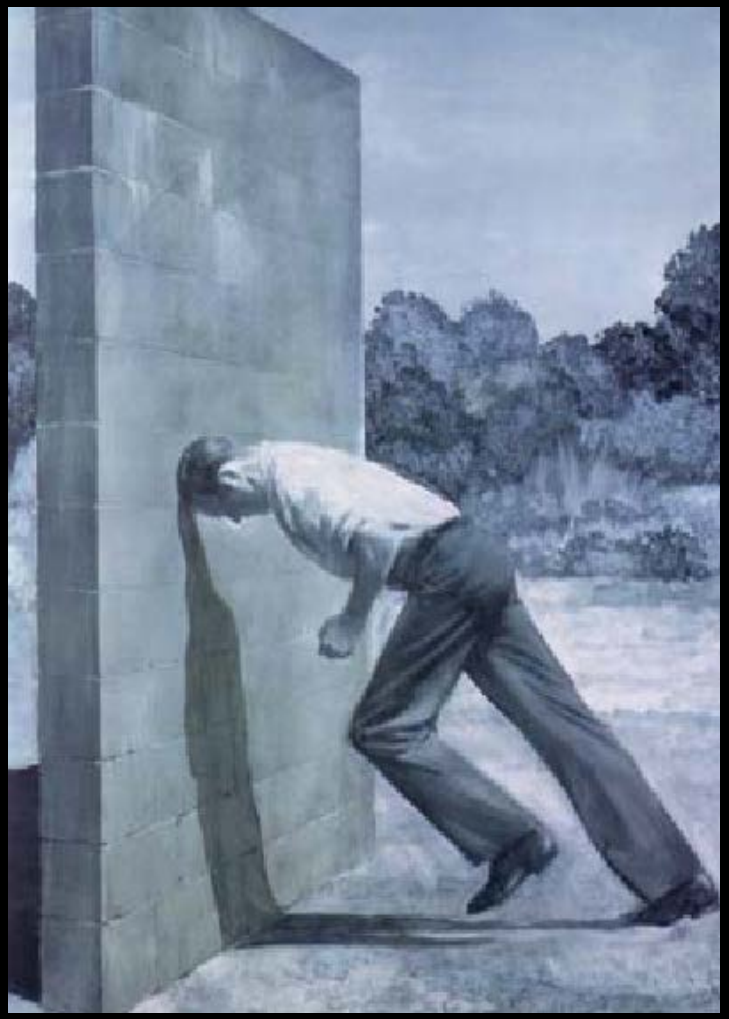
"The strategies listed are not likely to be sufficient to achieve ecosystem goals..."

Puget Sound Parternship, Page 43, Appendix A, report of scientific working group.

NPDES permits only require adherence to the state stormwater manual, which itself states:

“*Land development as practiced today is incompatible with the achievement of sustainable ecosystems*.”

When a key industry group threatened to pull out of the Partnership, the effort to re-examine stormwater runoff recommendations apparently was abandoned, despite the acknowledged failure to adequately address impacts from future development.



“Forest practices had no effect on landsliding”

- WA State DNR

Stillman Creek, Washington

Photo: Seattle Times

Site was inspected and found to have “no potentially unstable slopes.”

- Timber Company Forest practice application

Stillman Creek, Washington

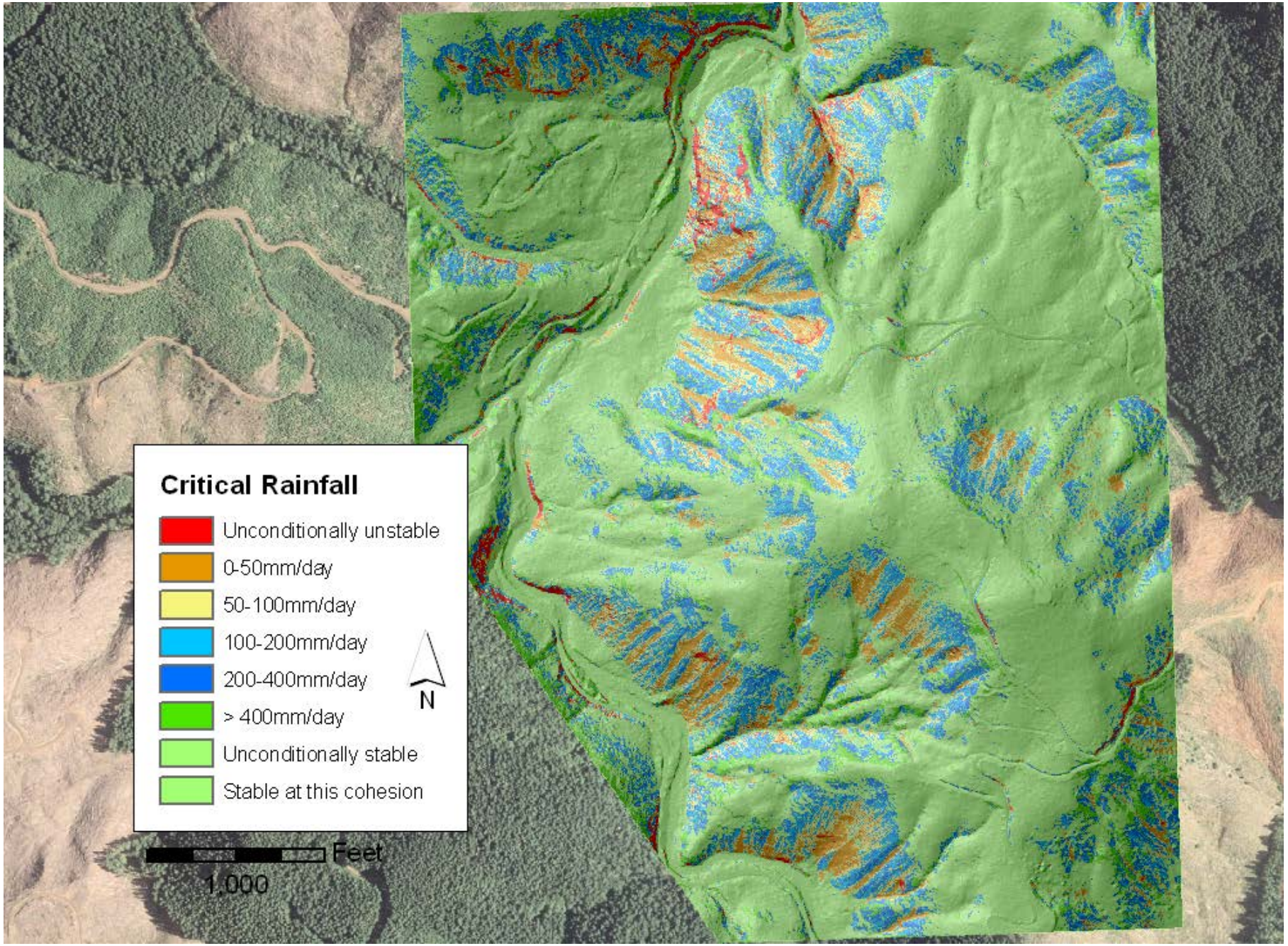
Photo: Seattle Times

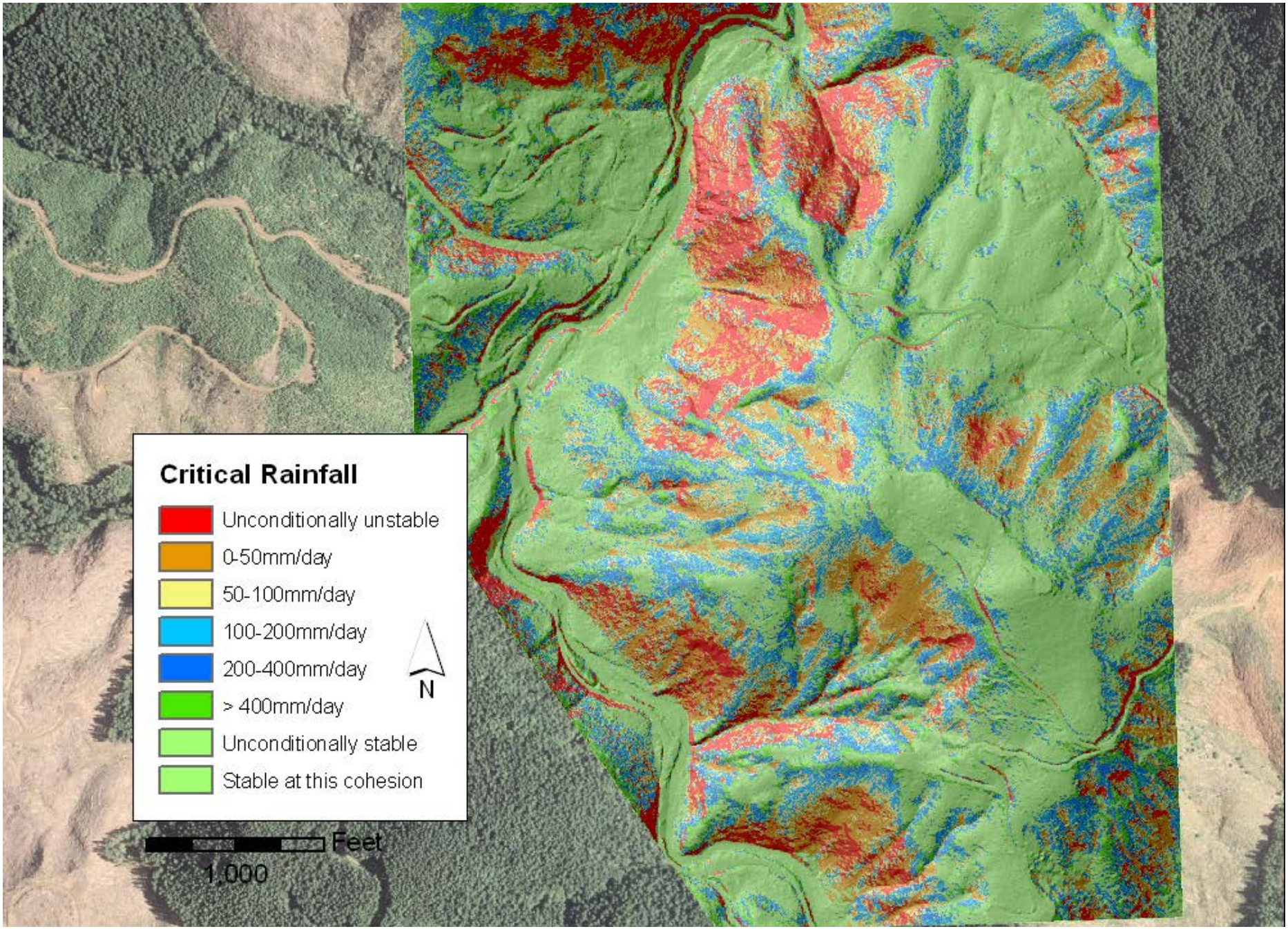
“Who could have predicted it?”

- WA State DNR

Stillman Creek, Washington

Photo: Seattle Times


Critical Rainfall
Unconditionally unstable
0-50mm/day
50-100mm/day
100-200mm/day
200-400mm/day
> 400mm/day
Unconditionally stable
Stable at this cohesion
N
Feet
1,000


Critical Rainfall
Unconditionally unstable
0-50mm/day
50-100mm/day
100-200mm/day
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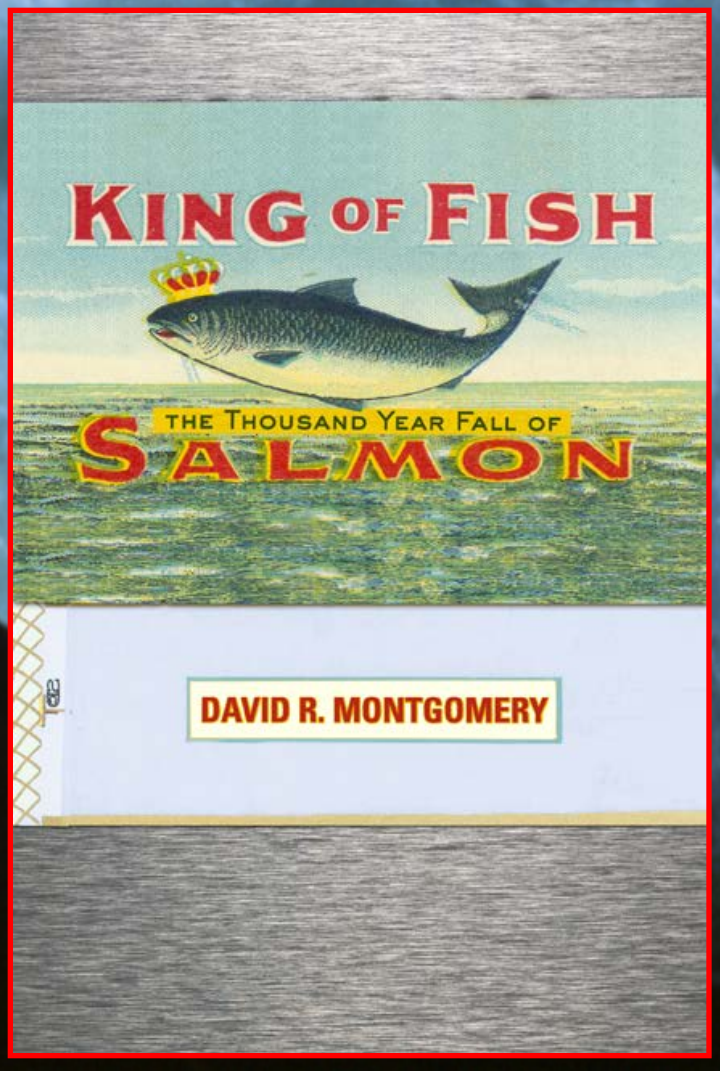
> 400mm/day
Unconditionally stable
Stable at this cohesion
N
Feet
1,000

History



Process