Rising Riverbeds and the Future of Mount Rainier

A Masters of Disasters Production ©

Overview of Presentation

- Storm damage 2006 at Mount Rainier;
- Valley filling and flooding;
- Climate change effects; and
- Management implications.

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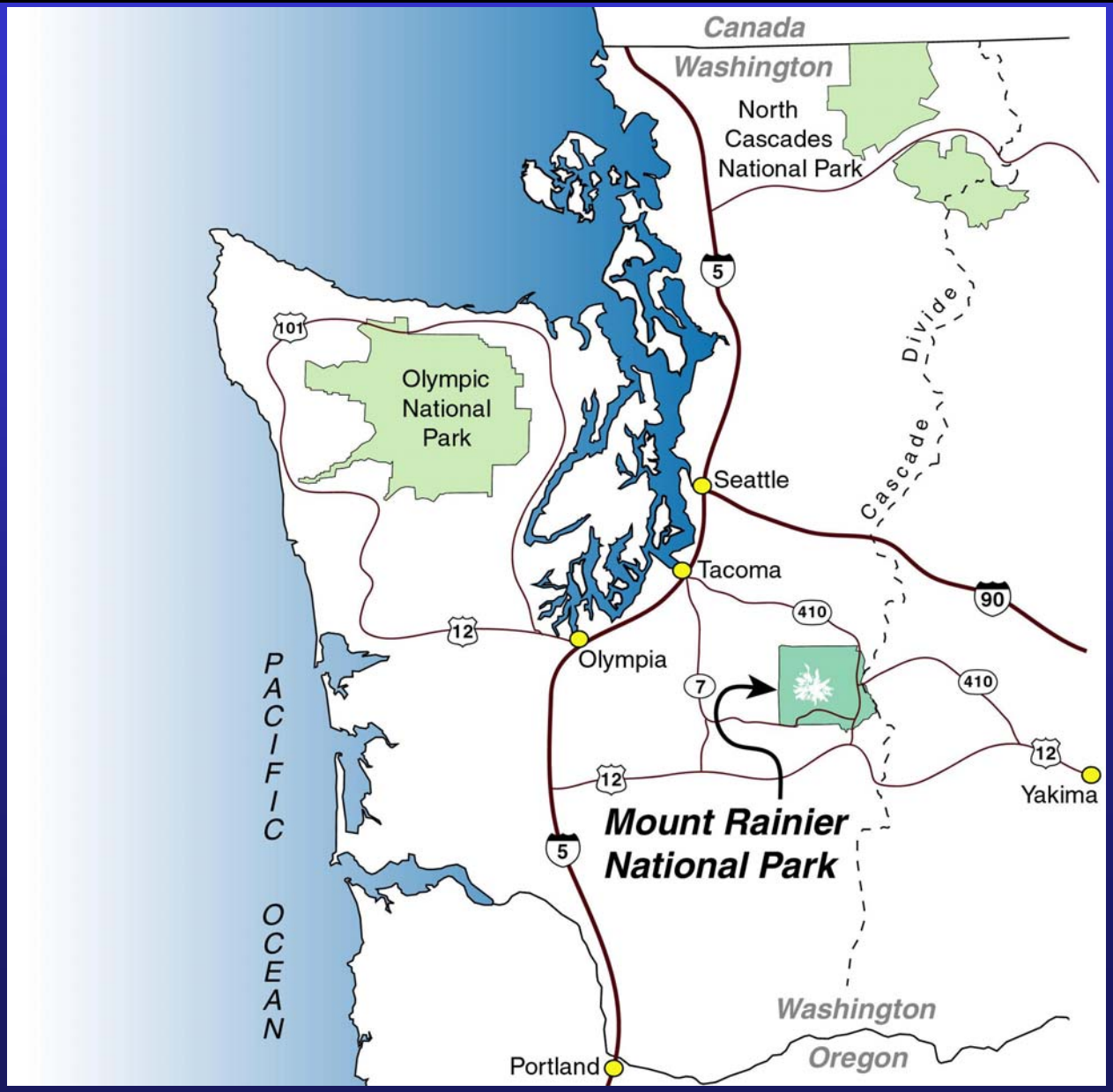
Mount Rainier National Park and Vicinity

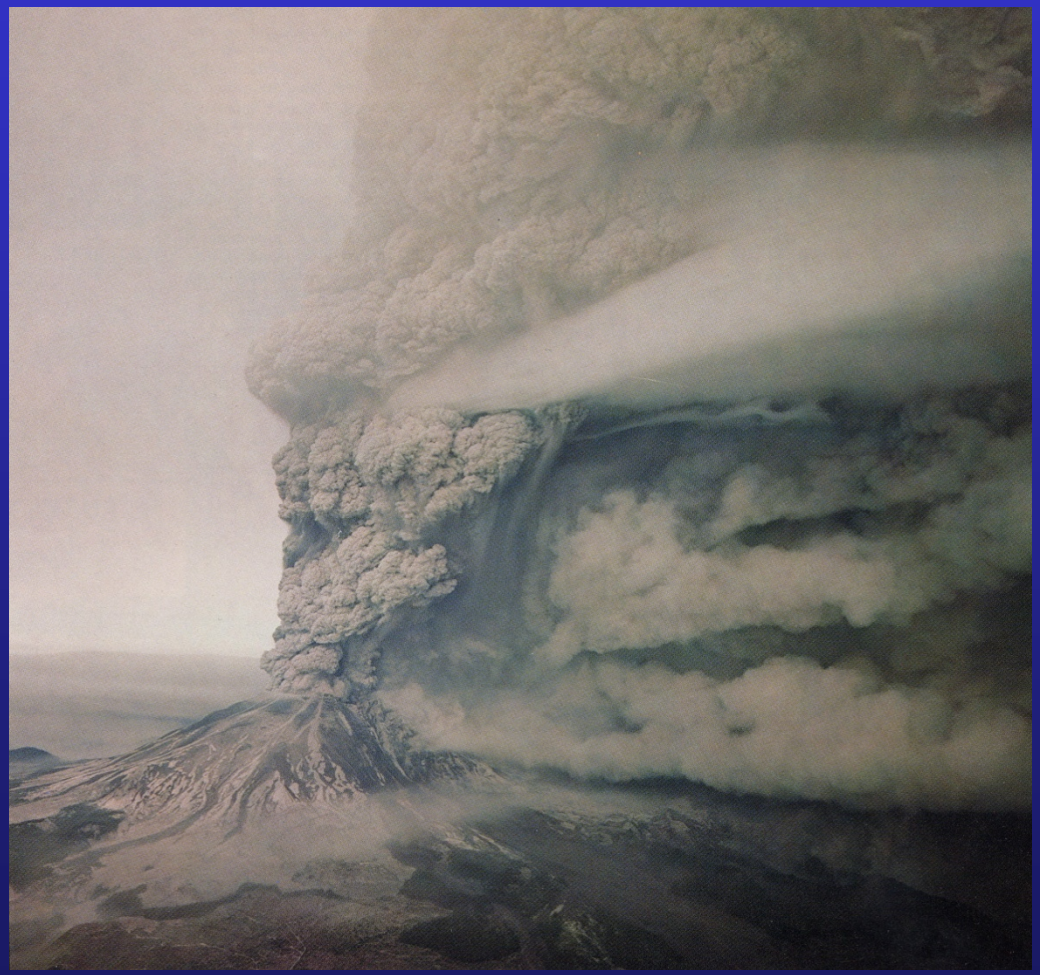


Mount Rainier National Park

Mount Rainier is a volcano

“Most dangerous mountain in the United States…”

While volcanos are not without peril…



…we are going to focus on other, more common “geo”-hazards

Floods and Debris Flows

Mount Rainier National Park

The Great Flood of November 2006

Starting Nov. 6, 18 inches of rain fell in 36 hours, immediately flooding many roads.

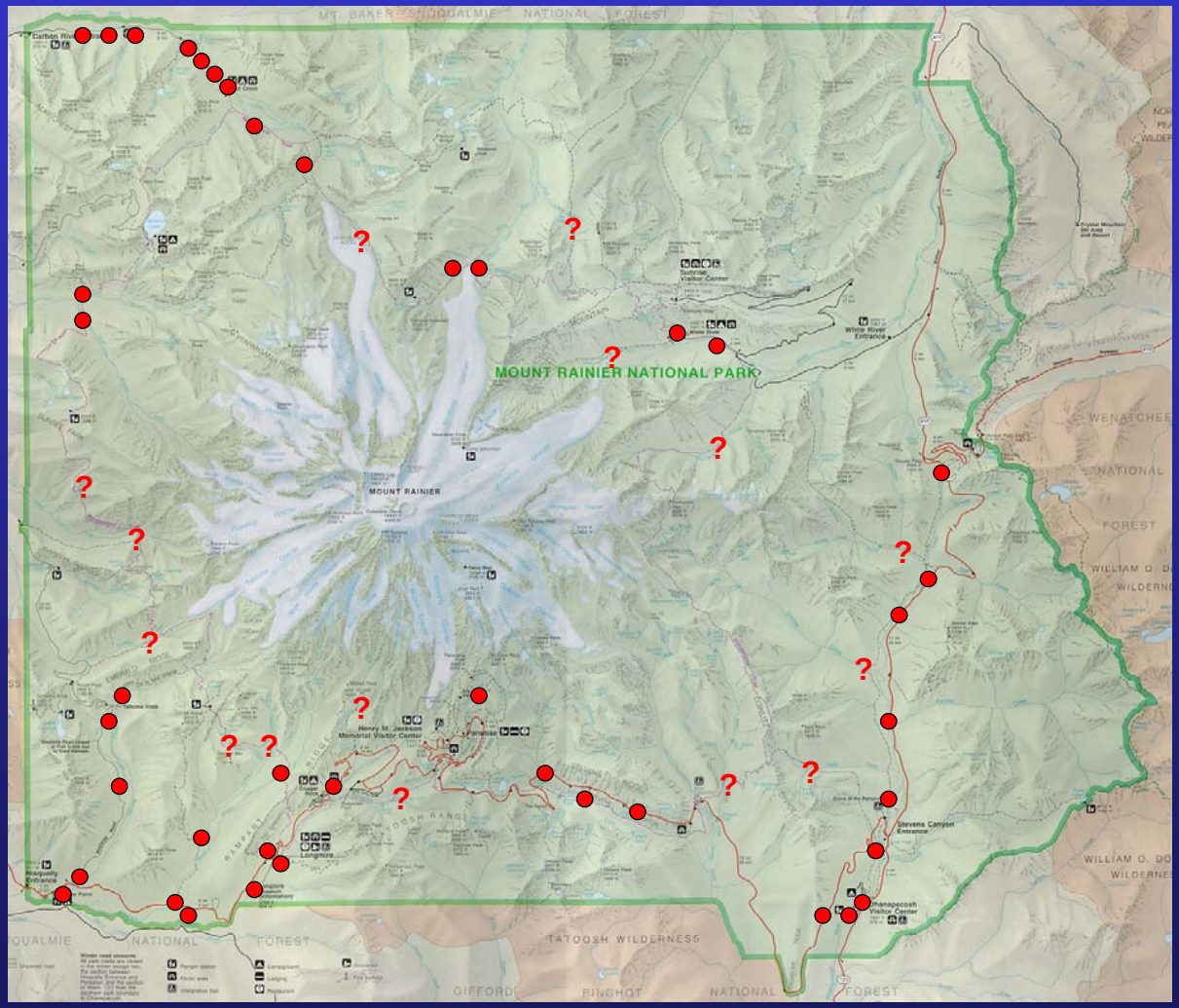
Park rivers responded immediately, with record flows

Mount Rainier National Park

The Great Flood of November 2006

Aerial surveys confirmed that rivers had left their banks all over the park.

Park-wide Locations of Damage



KEY

● **Known damage**

? **Probable damage**

Mount Rainier National Park

The Great Flood of November 2006

Helicopter flights revealed many washouts through out the park.

Mount Rainier National Park

November 2006 Flood Damage

This washout, cuts across both lanes to a depth of 70 feet.

Mount Rainier National Park

The Great Flood of November 2006

The bottom of one of the landslides is visible across the river from the Ohanapecosh Campgrou

Mount Rainier National Park

The Great Flood of November 2006

The Carbon River Road, in NW of park, was damaged or destroyed in numerous places.

Mount Rainier National Park

The Great Flood of November 2006

© John Chao

In all, about two miles of road were destroyed.

Mount Rainier National Park

The Great Flood of November 2006

The historic Ipsut Creek Patrol Cabin was undermined, but fortunately did not wash away.

Mount Rainier National Park

The Great Flood of November 2006

At Longmire, the park's primary worker and visitor center, most of the protective lev
was washed away.

Mount Rainier National Park

The Great Flood of November 2006

The park's Emergency Operations Center was undermined by the river.

Mount Rainier National Park

November 2006 Flood Damage

At Sunshine Point, the Nisqually River now flows where there once was a campgroun

Mount Rainier National Park

November 2006 Flood Damage

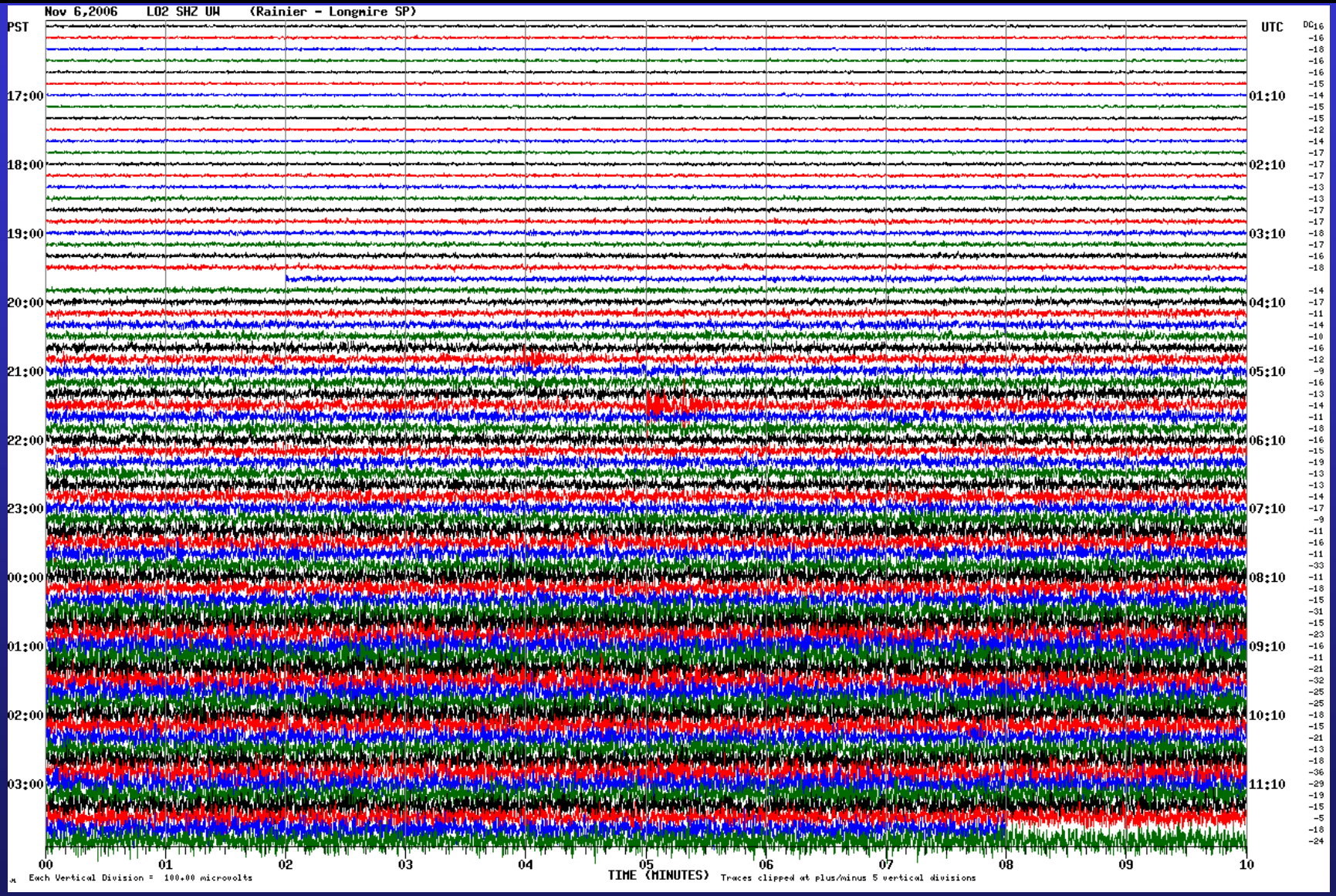
Over half the campground, more than 5 acres of land in all, were washed away. The
winter road into the park was destroyed.

Mount Rainier National Park

The Great Flood of November 2006

In addition to roads, trails were damaged all over the park.

Pacific West Region - Mount Rainier National Park

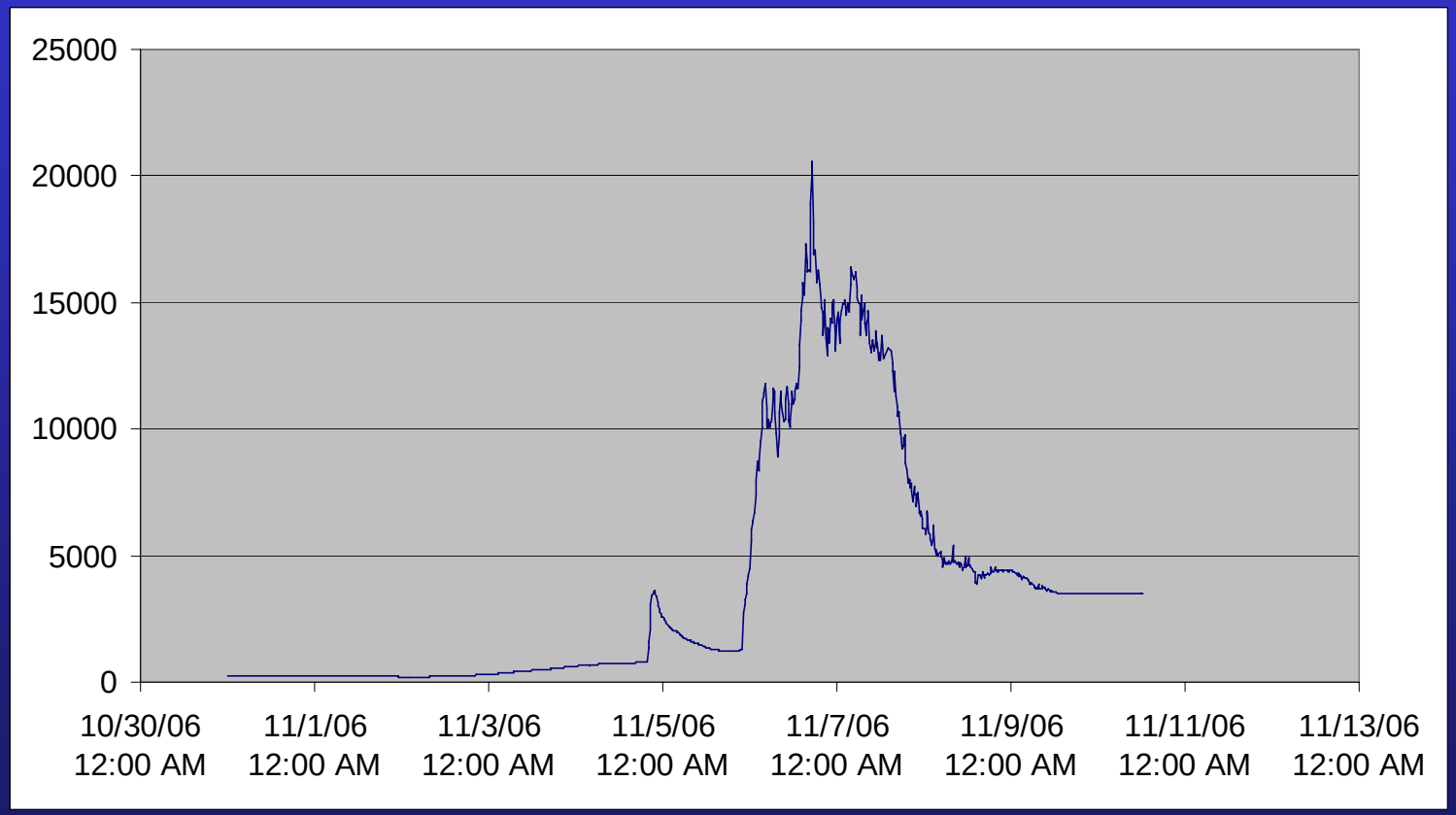


Seismometers pick up vibrations from rolling boulders in the rivers…

Pacific West Region - Mount Rainier National Park

- Park closed for over 6 months;
- Over $36 million dollars damage;
- Park still not fully recovered…

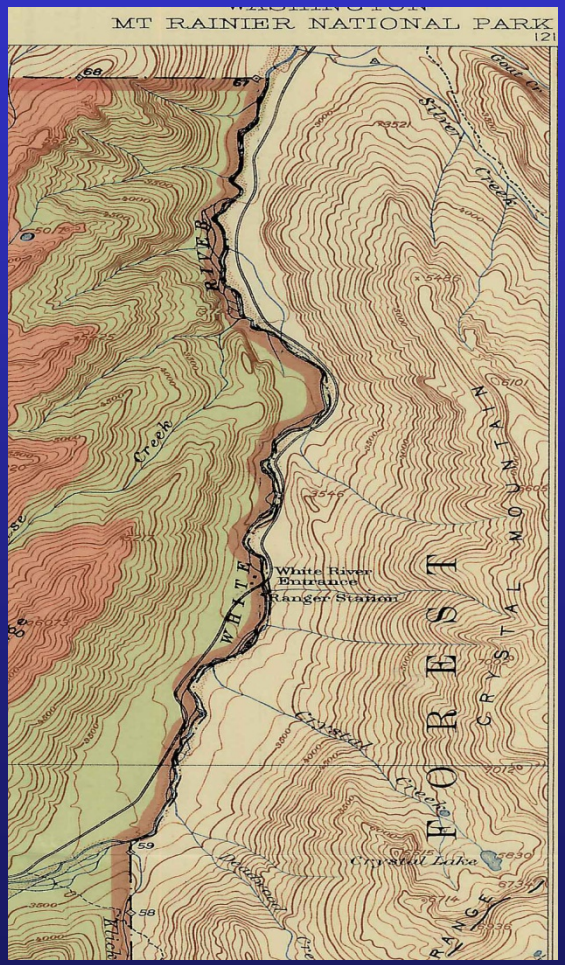
Why was the Flood so bad?



Record rain and flood, but…

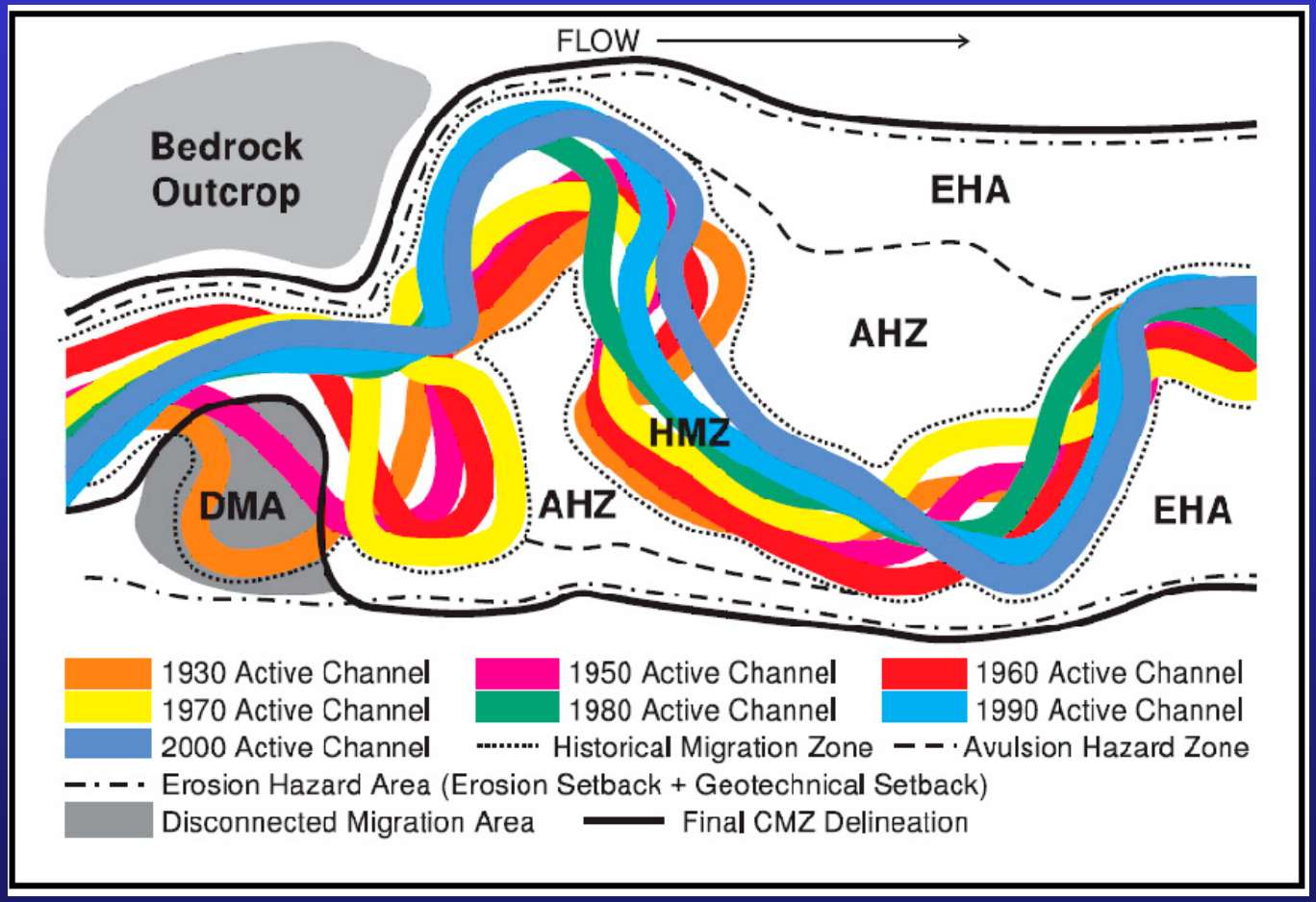
The last flood was exceptional – however, other, recent damage to the park was great in much smaller storms…

- The park was dealt a "bad hand" – back in the day, roads were often built in rivers….



Old Storbo Mine Road – 1915 map

River Channel Migration Zones



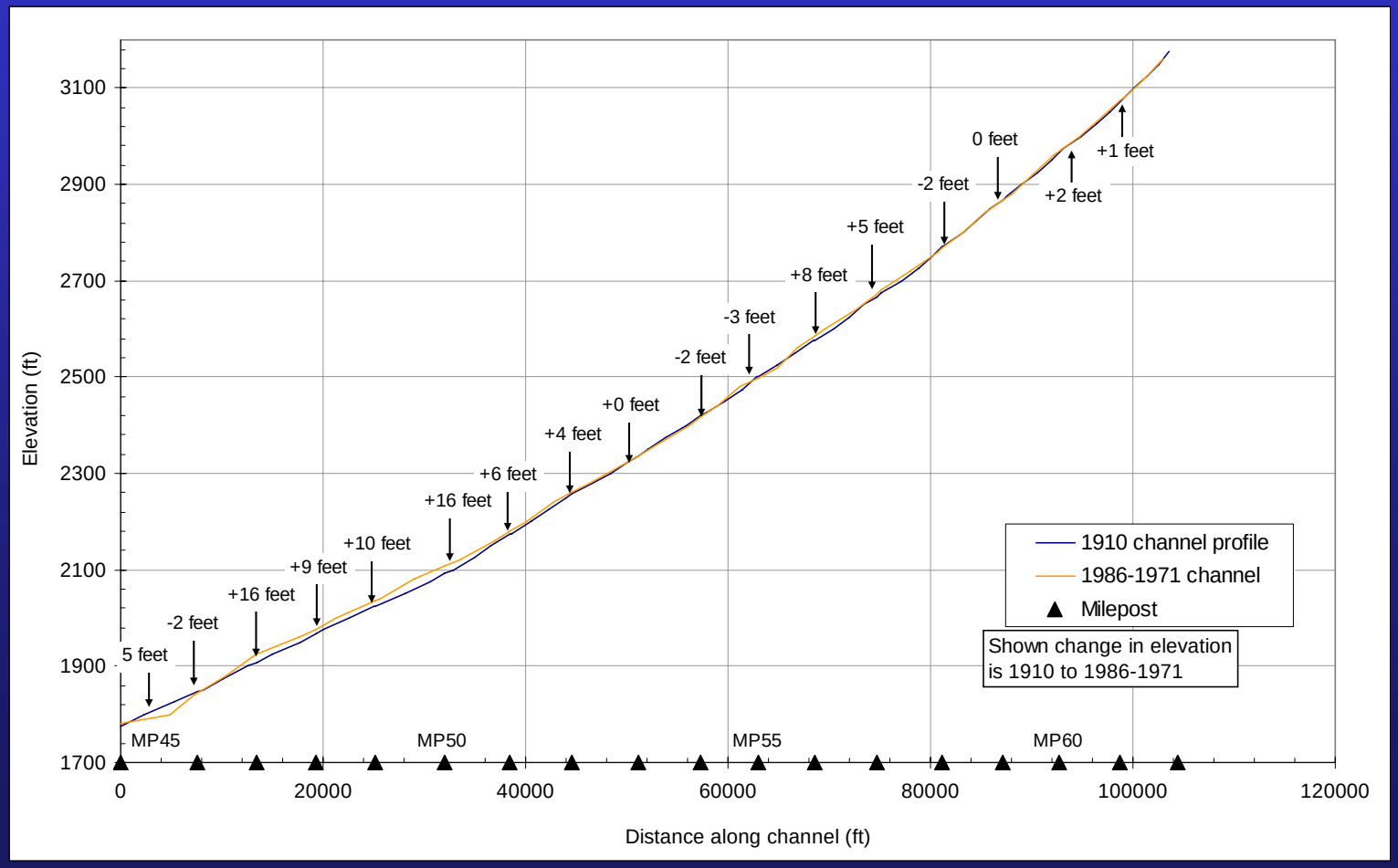
- Rivers are dynamic, and move across valley bottom.

Mount Rainier National Park

The Great Flood of November 2006

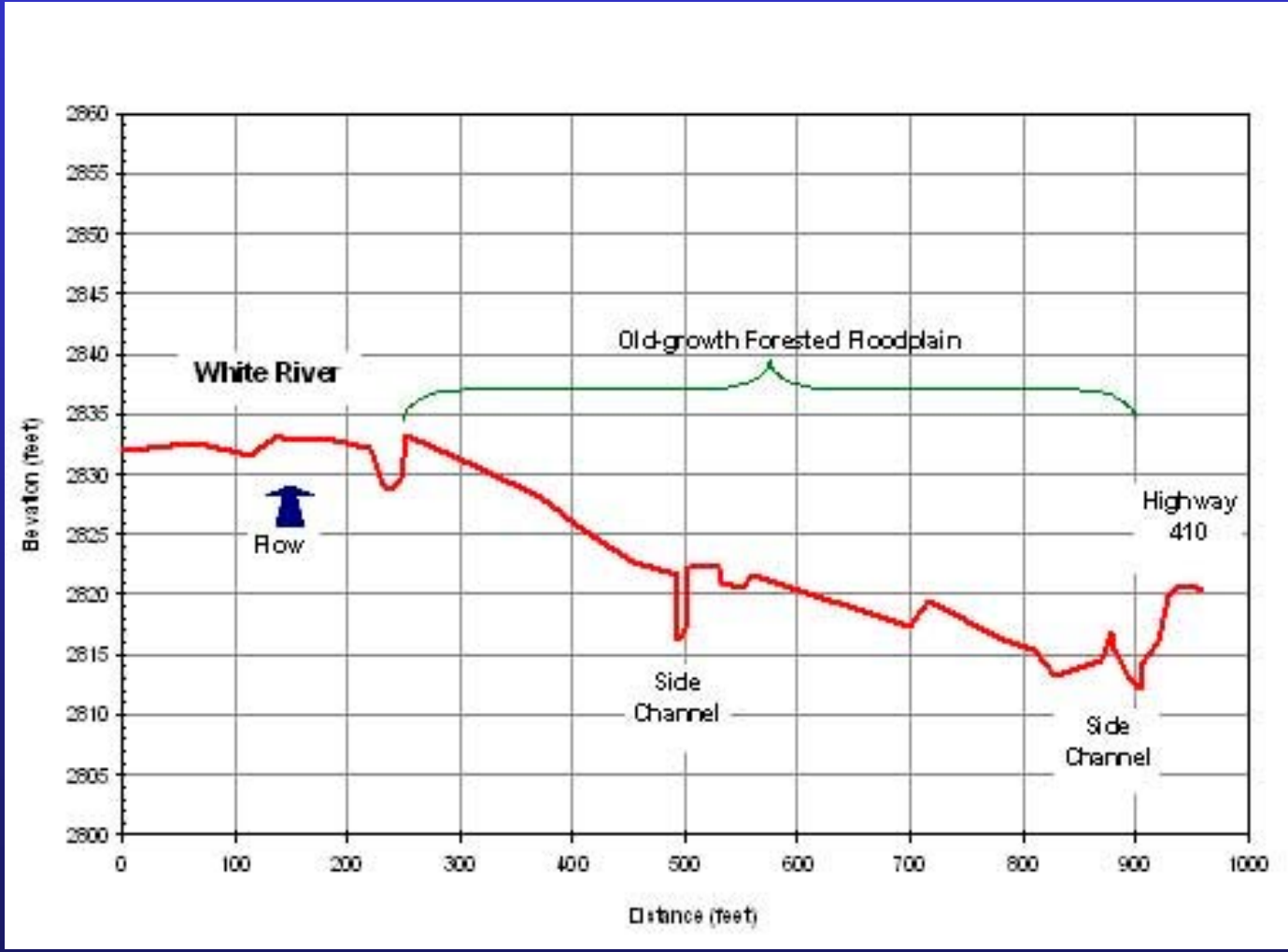
The riverbed under the Tahoma Creek Bridge rose more than four feet during the flo

River valley-filling (aggradation) – White River



White River – flow above road surface in summer

Road Problem at White River



Road is up to 16 feet below river *bed*!

The Environmental Implications of Aggradation on Major Braided River Channels

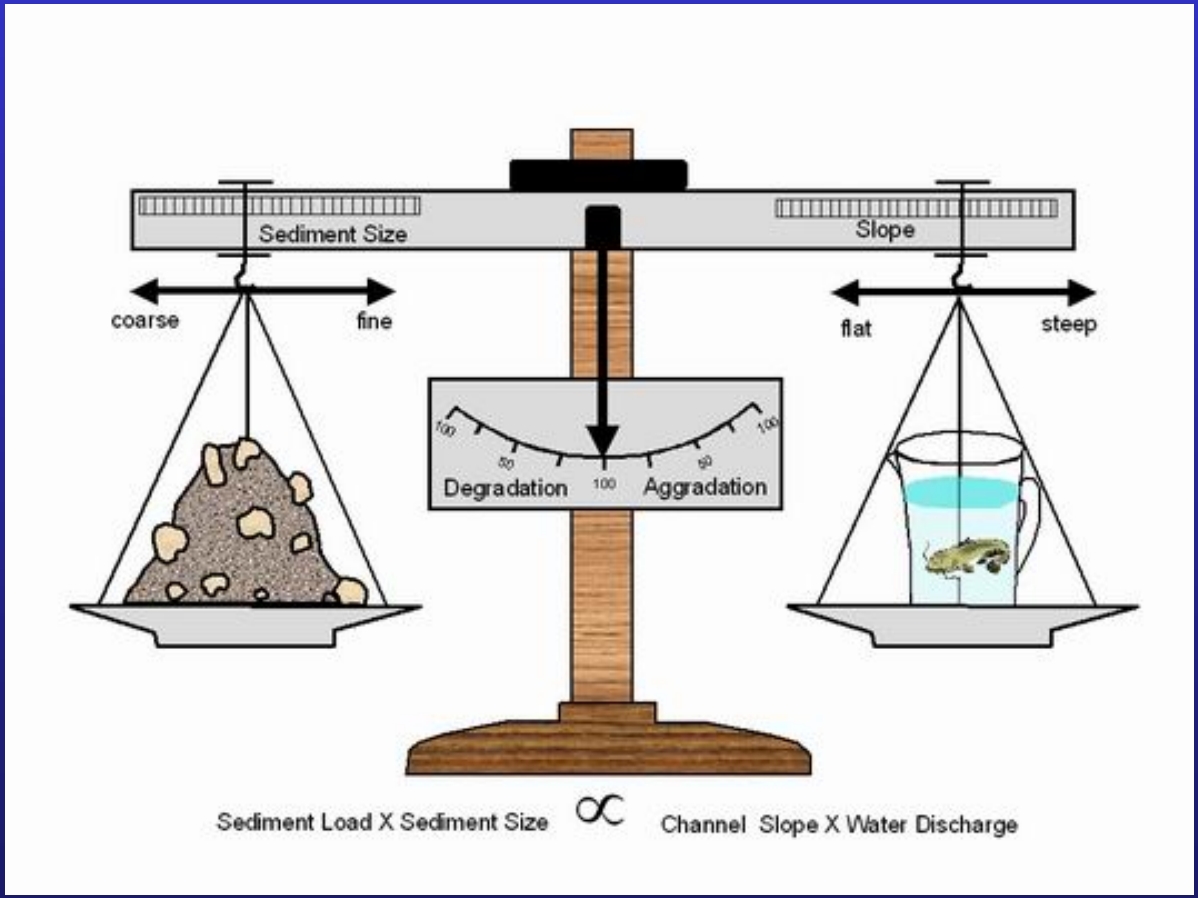
Team X-Stream (post-flood cross sections)

Aggradation Trends

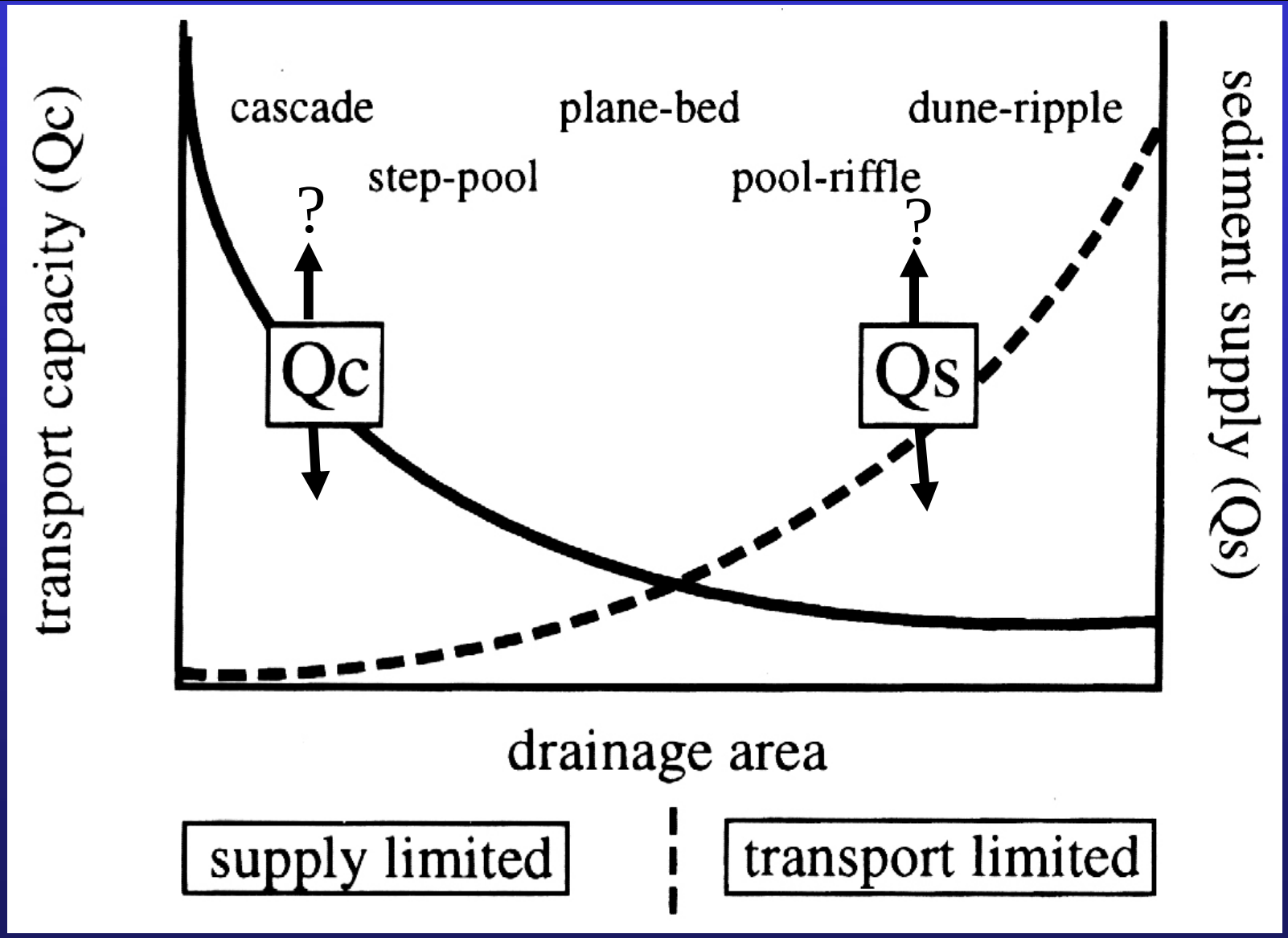
- "Historical" Park-wide Rate: < 3"/decade;
- Rate in the last 10 years: 6-14"/decade;
- Debris flows: 5.6 feet of material in 1 event;
- 2006 flooding: >3 feet in 1 event;
  - (~2 decades of material in 2 days!)
  - Floods *should* erode river channels…
    - » …no evidence of that!

- So…. Why an **increase?**

Lane's Balance

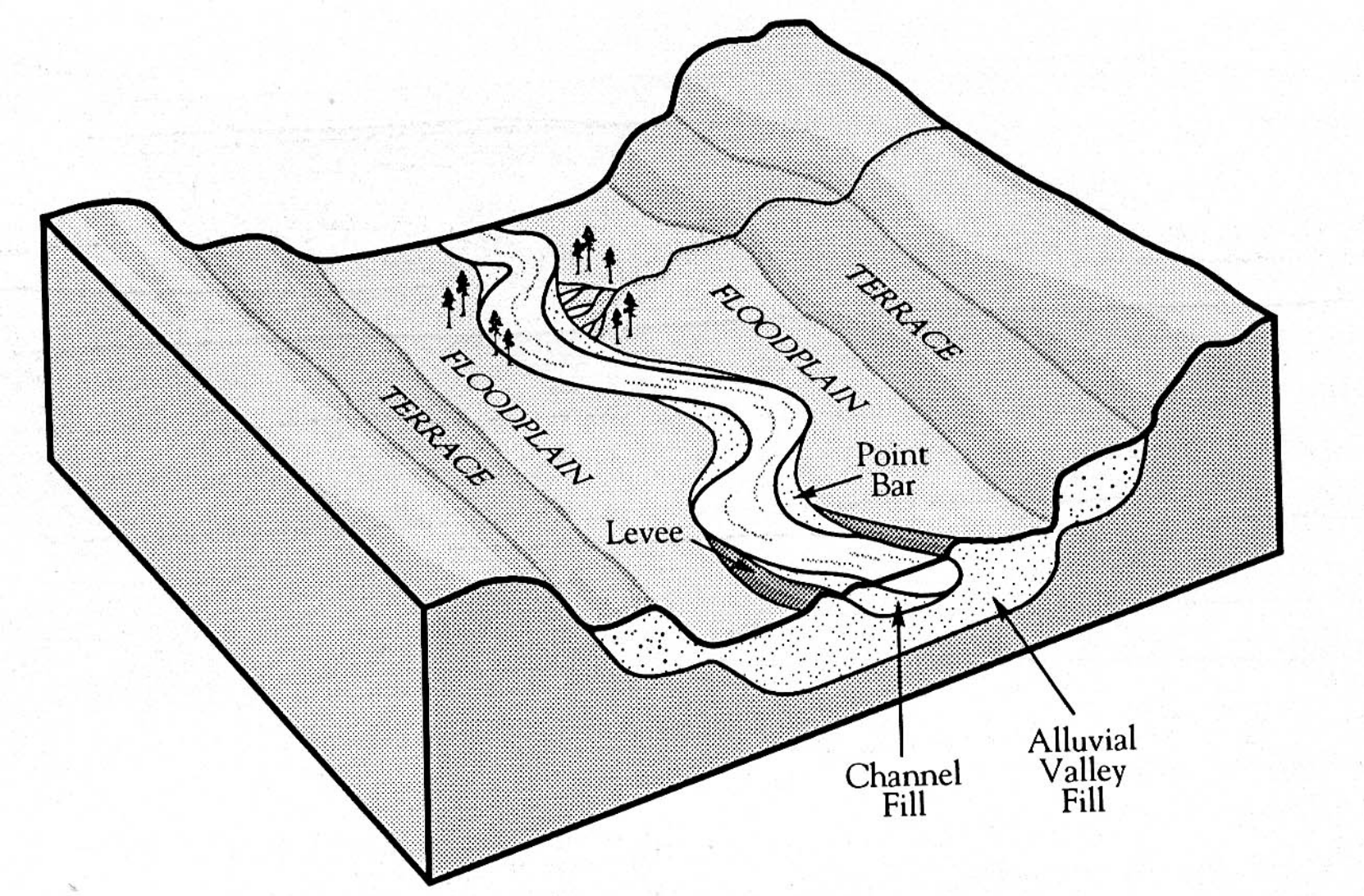


Now we look at how rivers respond to changes in *river flow* and *sediment* supply.



Montgomery and Buffington 1997

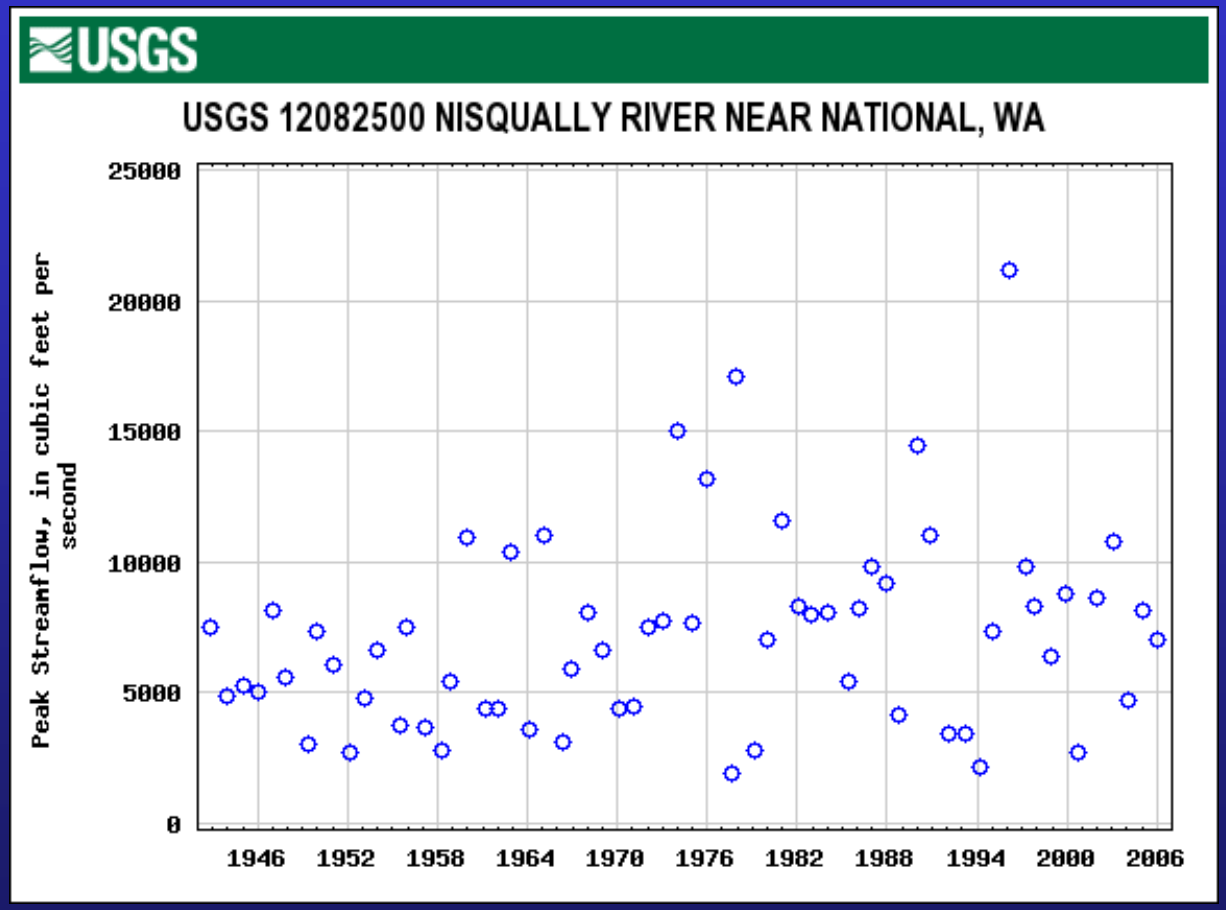
Channel Adjustment: *f* (Qc, Qs)



Flow Changes:

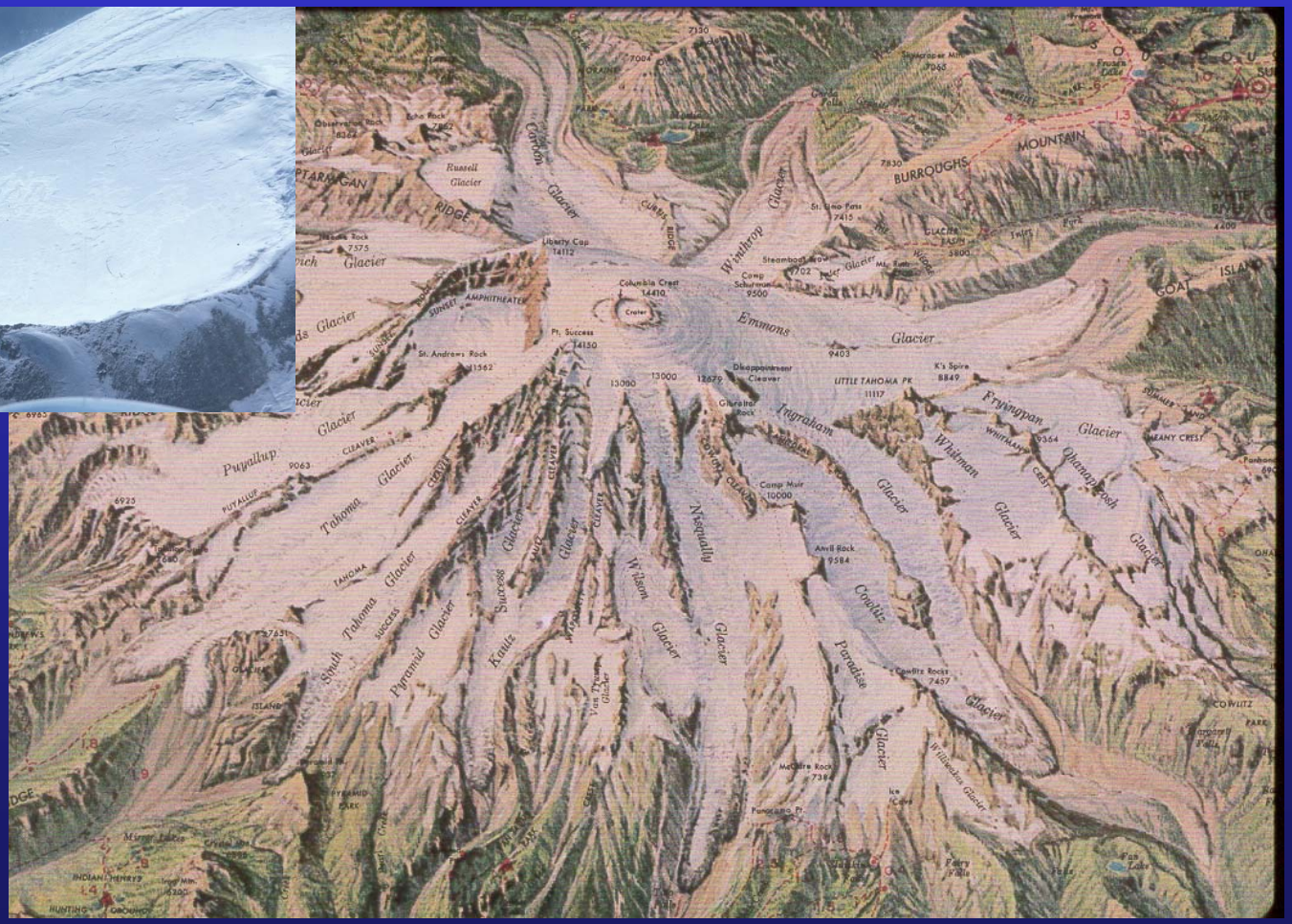
- Peak flows appear increasing with time (not include 2006 flood);
- Large floods should cause incision, or river lowering;
- Instead we got ~2 decades of material in 2 days!

- So it must be *sediment*…..



River Valley Filling (or Aggradation)

Major Glaciers of Mount Rainier



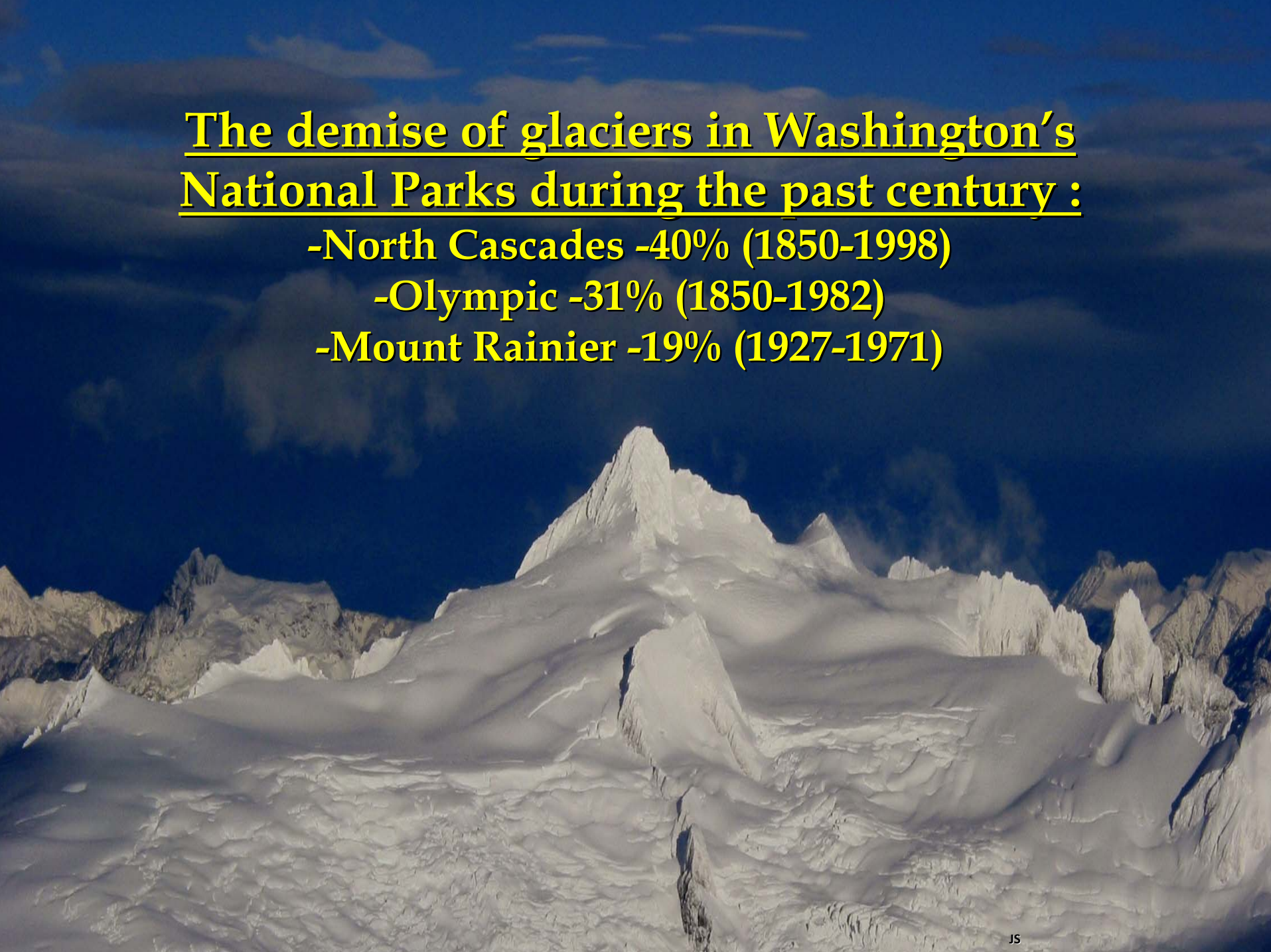
How much perennial snow and ice is there on Mount Rainier?

- Twenty five named glaciers
- 34 square miles
- One cubic mile!
- Enough to fill Safeco Field in Seattle 2,600 times!
- As much perennial snow and ice as on all the other Cascade volcanoes combined.
- Mount Rainier is the largest ice massif in the 48 contiguous states.

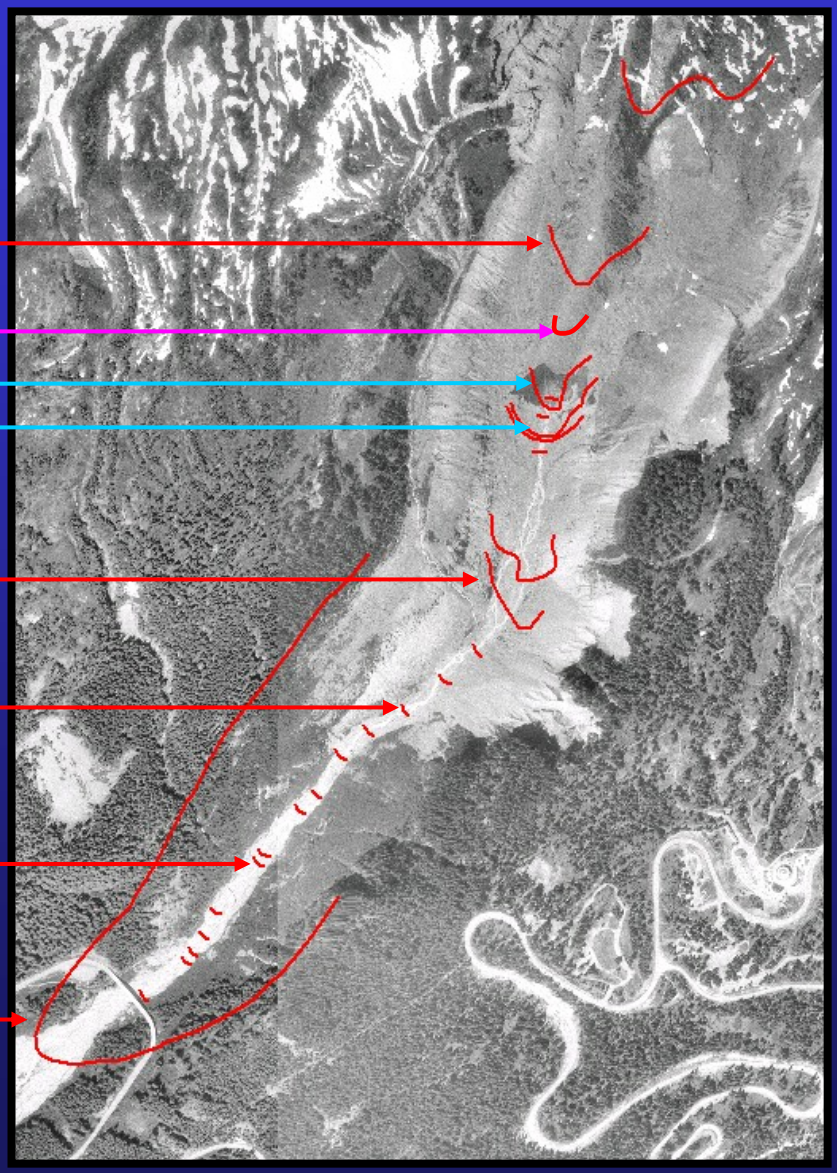
Climate change

"Pacific Northwest temperatures are higher than anytime in the last 1300 years"

**Philip Mote,
Washington State
Climatologist (May, 2007)**


The demise of glaciers in Washington's National Parks during the past century :
-North Cascades -40% (1850-1998)
-Olympic -31% (1850-1982)
-Mount Rainier -19% (1927-1971)
JS

Glacier variations and retreat



Nisqually Glacier
2004
Photo: NPS/Scott Beason

Incision: Qc >> Qs

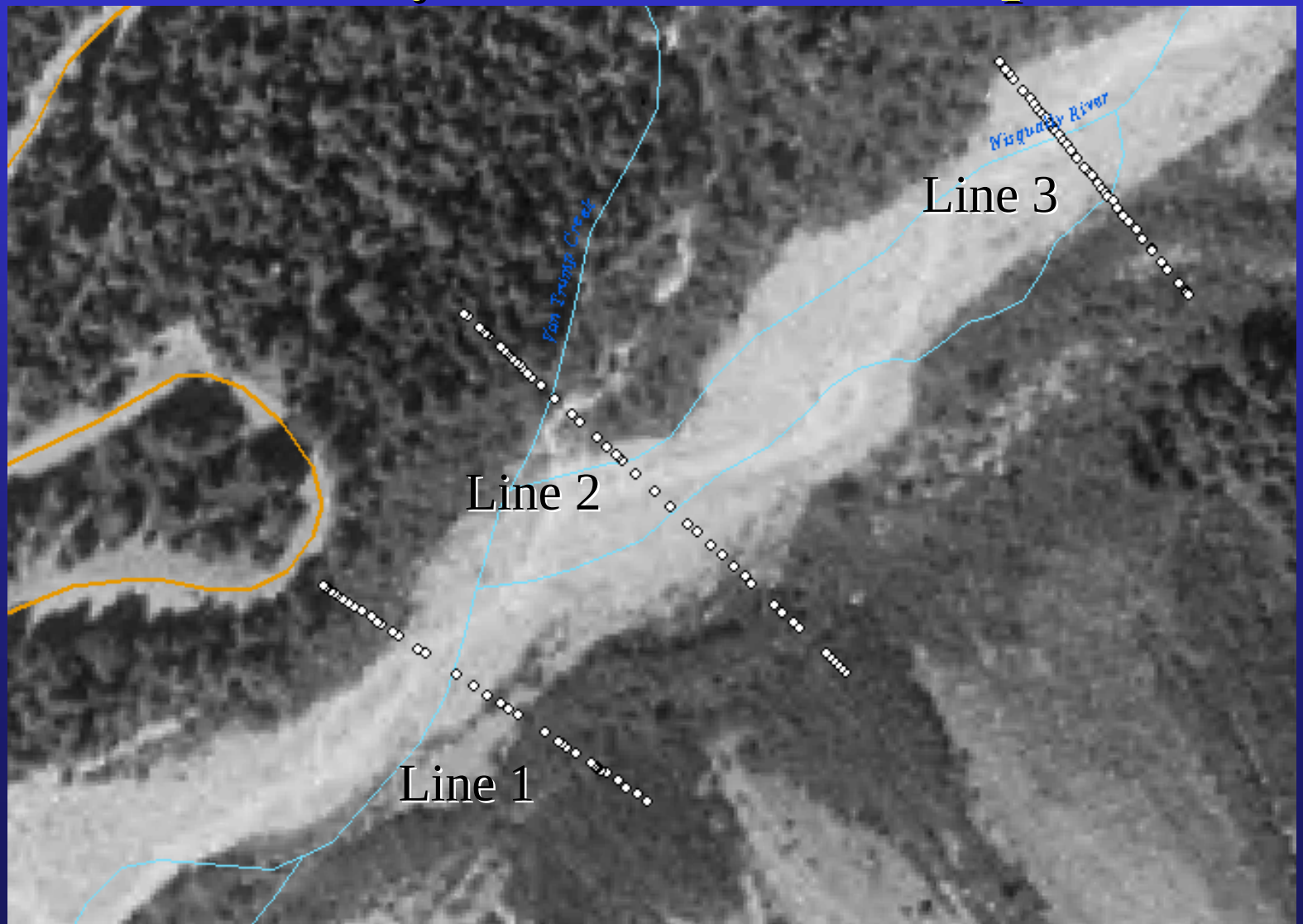
Normal channel response to increase in peak flows (Qc).

Aggradation: Qc << Qs

Van Trump Curve -- Debris Flow 2005

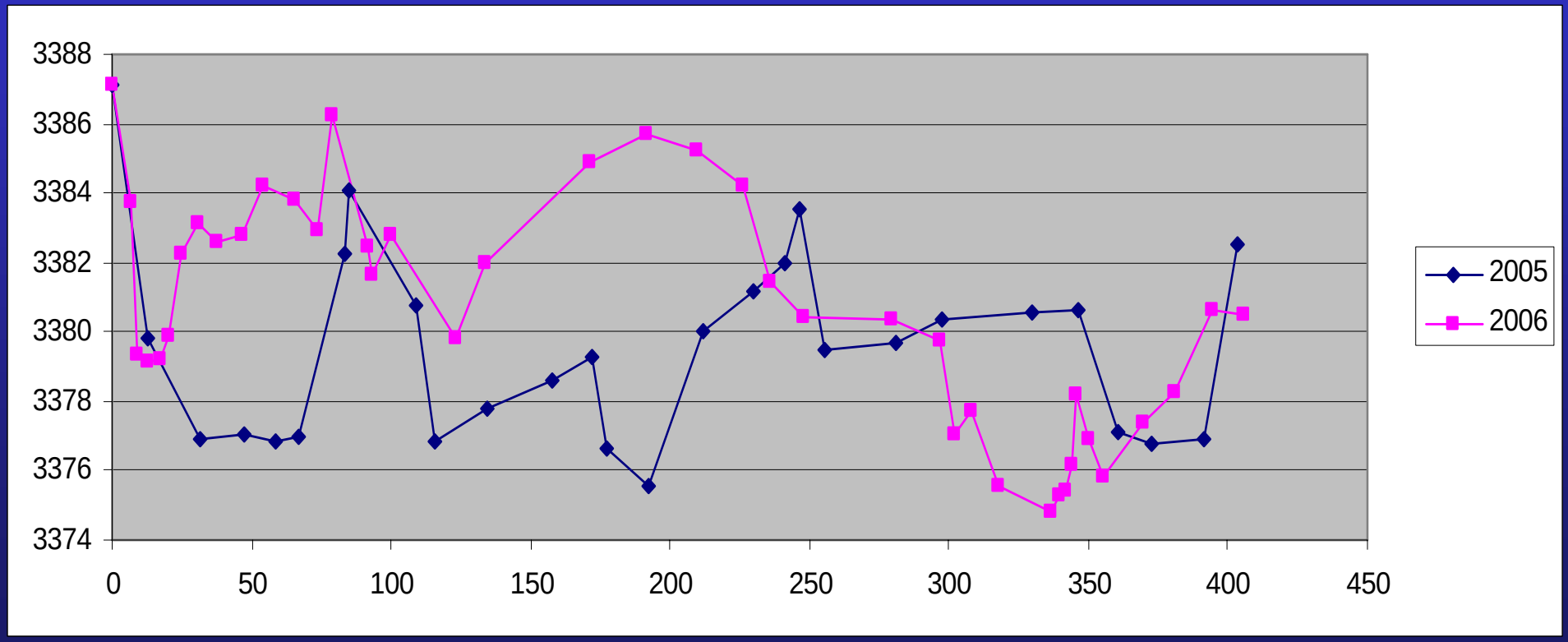
- Nisqually river aggraded over 5 feet in one year, across the 400+ foot wide floodplain, by Van Trump curve, after 1 debris flow.
- Area has aggraded ***38 feet*** since 1910….

Study Area – Van Trump



Results – Van Trump

- XY Graph of elevation ***before flood***:

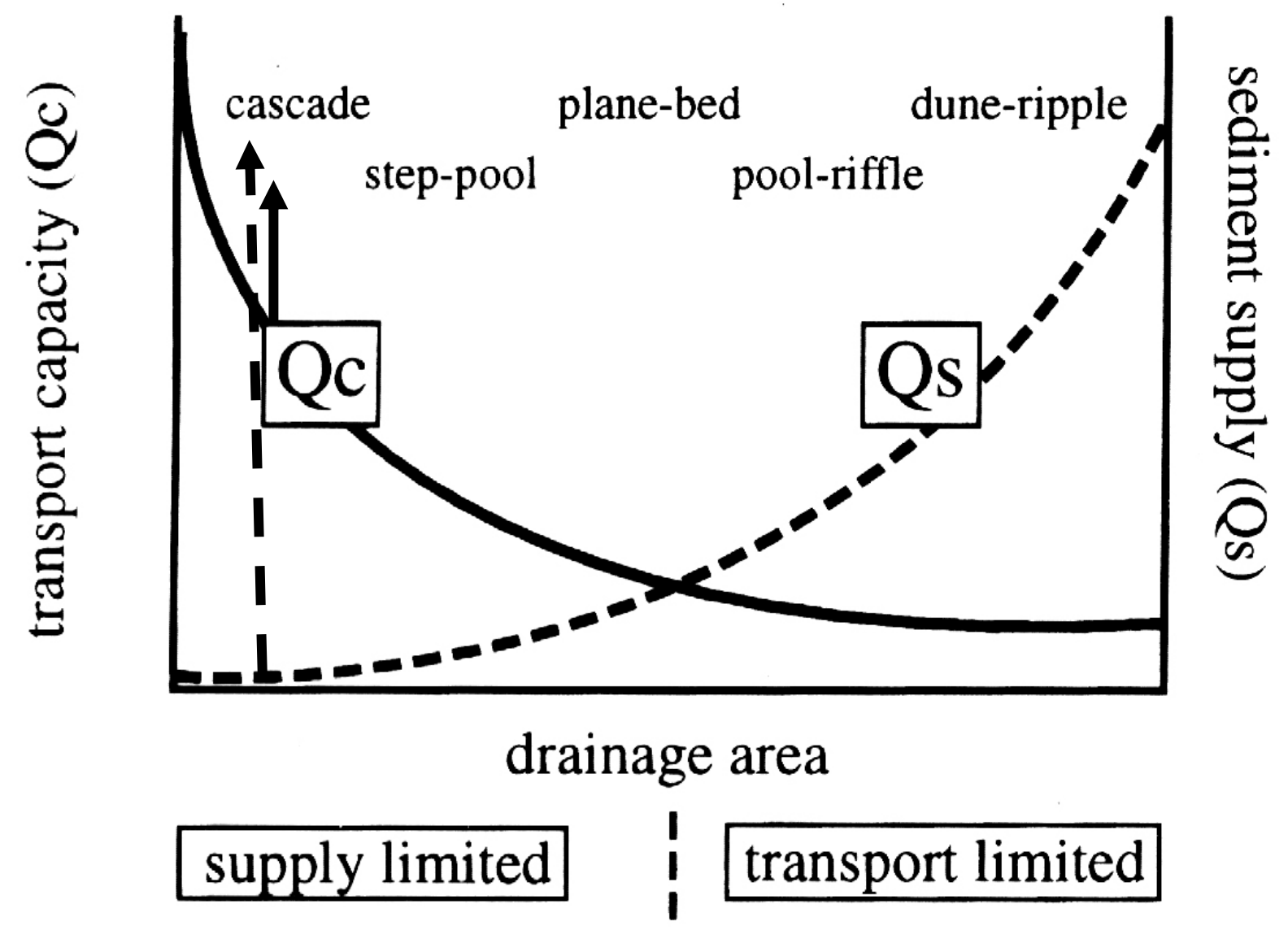


Retreating Glaciers Spawn Debris Flows…..

Debris flows are occurring
supra-annually at Mount Rainier.

Glacier recession and increased debris flows

- As glaciers recede, small outburst floods cause massive moraine failures (see right figure);
- As climate changes, debris flows are increasing;
- The park is hoping to study this phenomena in the future…


transport capacity (Qc)
sediment supply (Qs)
cascade
step-pool
plane-bed
pool-riffle
dune-ripple
Qc
Qs
drainage area
supply limited
transport limited

All the new sediment comes rolling downstream.

1. Olympics

2. Mt. Baker

3. North Cascades

4. Glacier Peak

5. Mt. Rainier

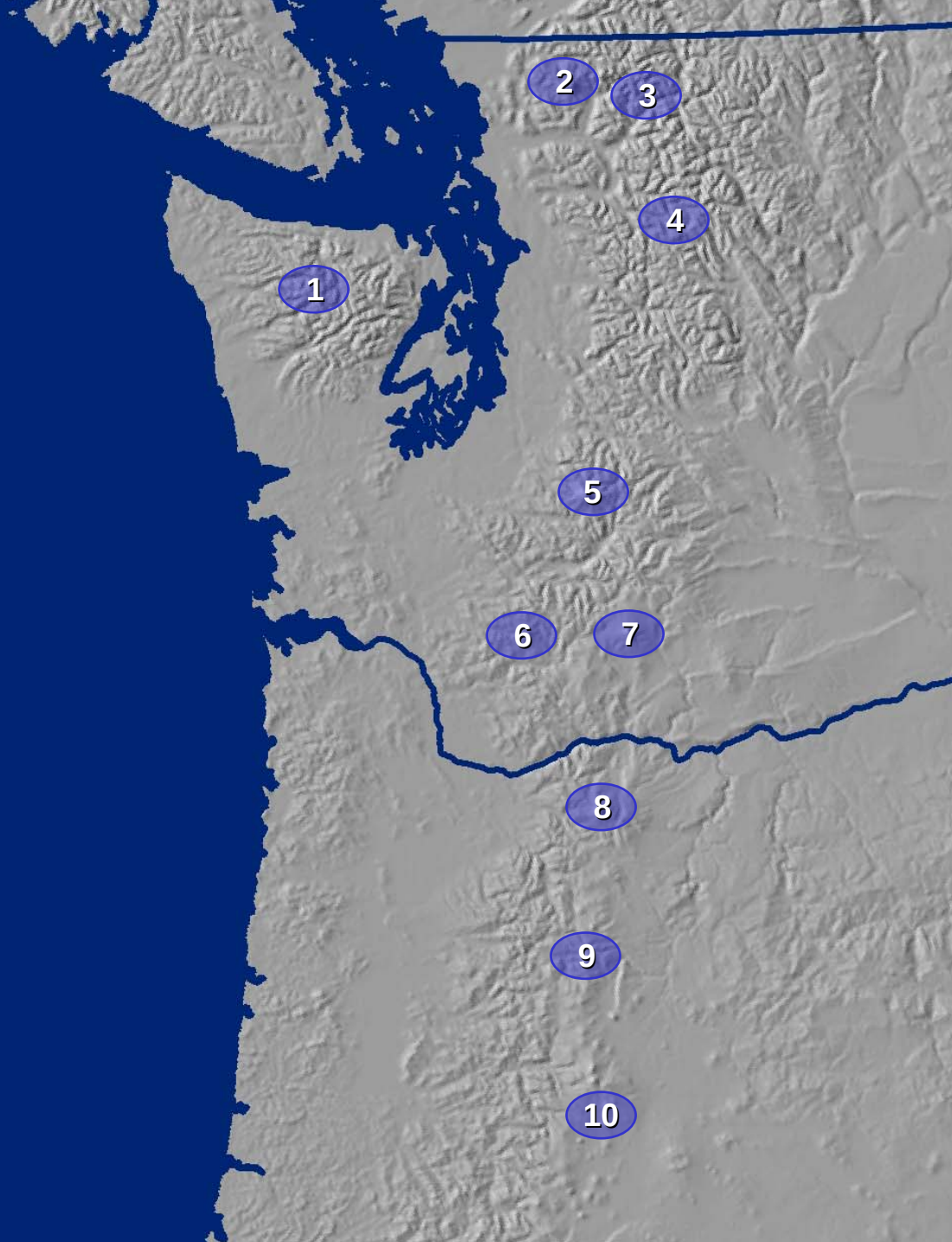
6. Mt. St. Helens

7. Mt. Adams

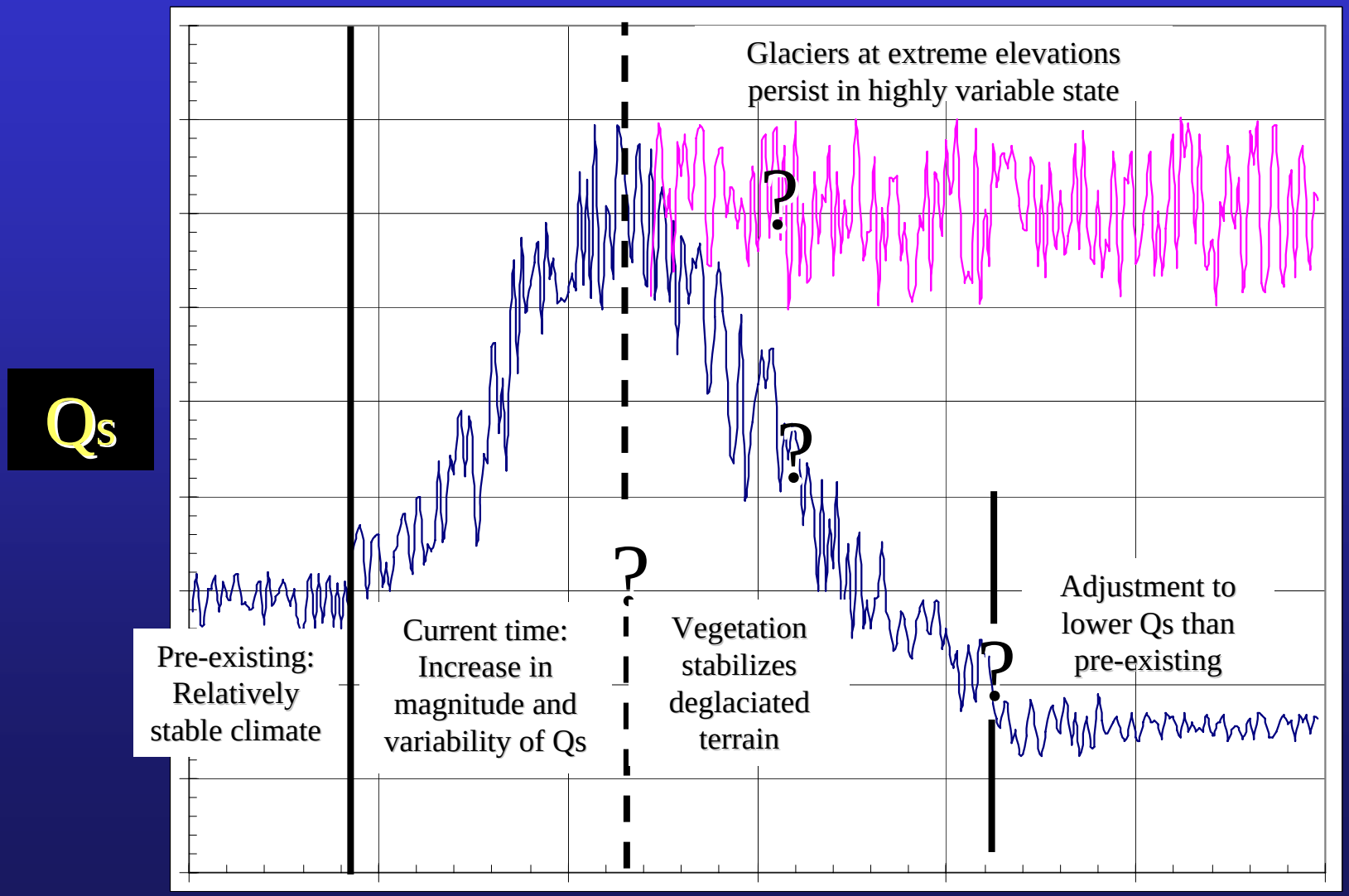
8. Mt. Hood

9. Mt. Jefferson

10. Three Sisters

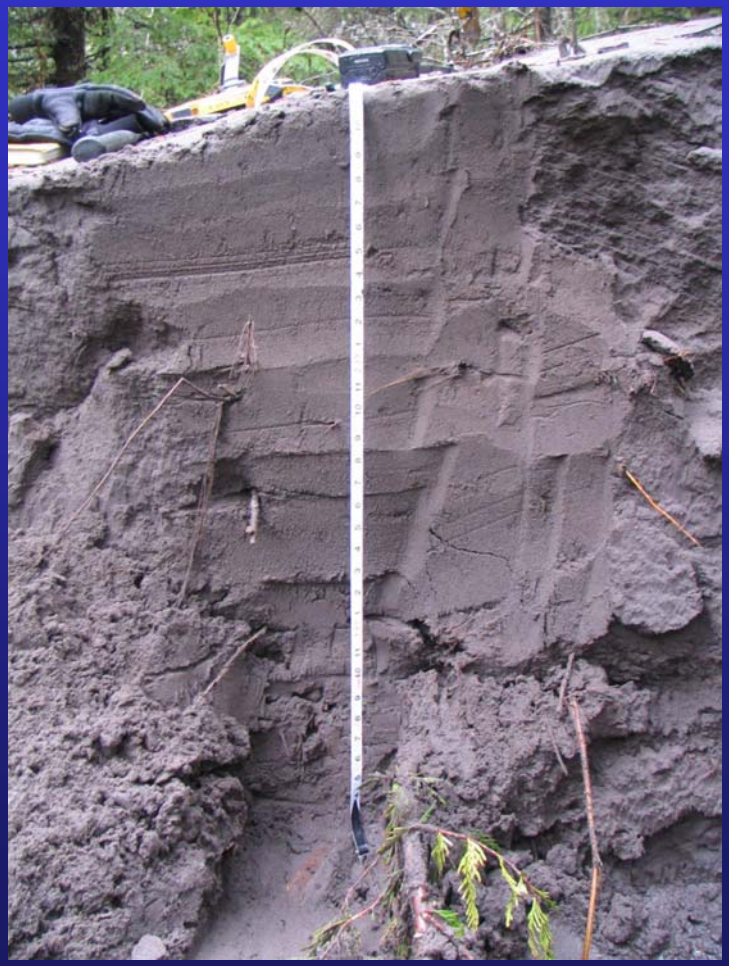


Pacific West Region - Mount Rainier National Park



Management Strategies for Dynamic Systems

1. Understand the factors controlling landscape evolution (Q_c, Q_s);
2. Delineate geomorphic response corridors;
3. Give the system elements that resist adverse impacts and sustain critical habitat; and,
4. Design for vertical and horizontal changes.



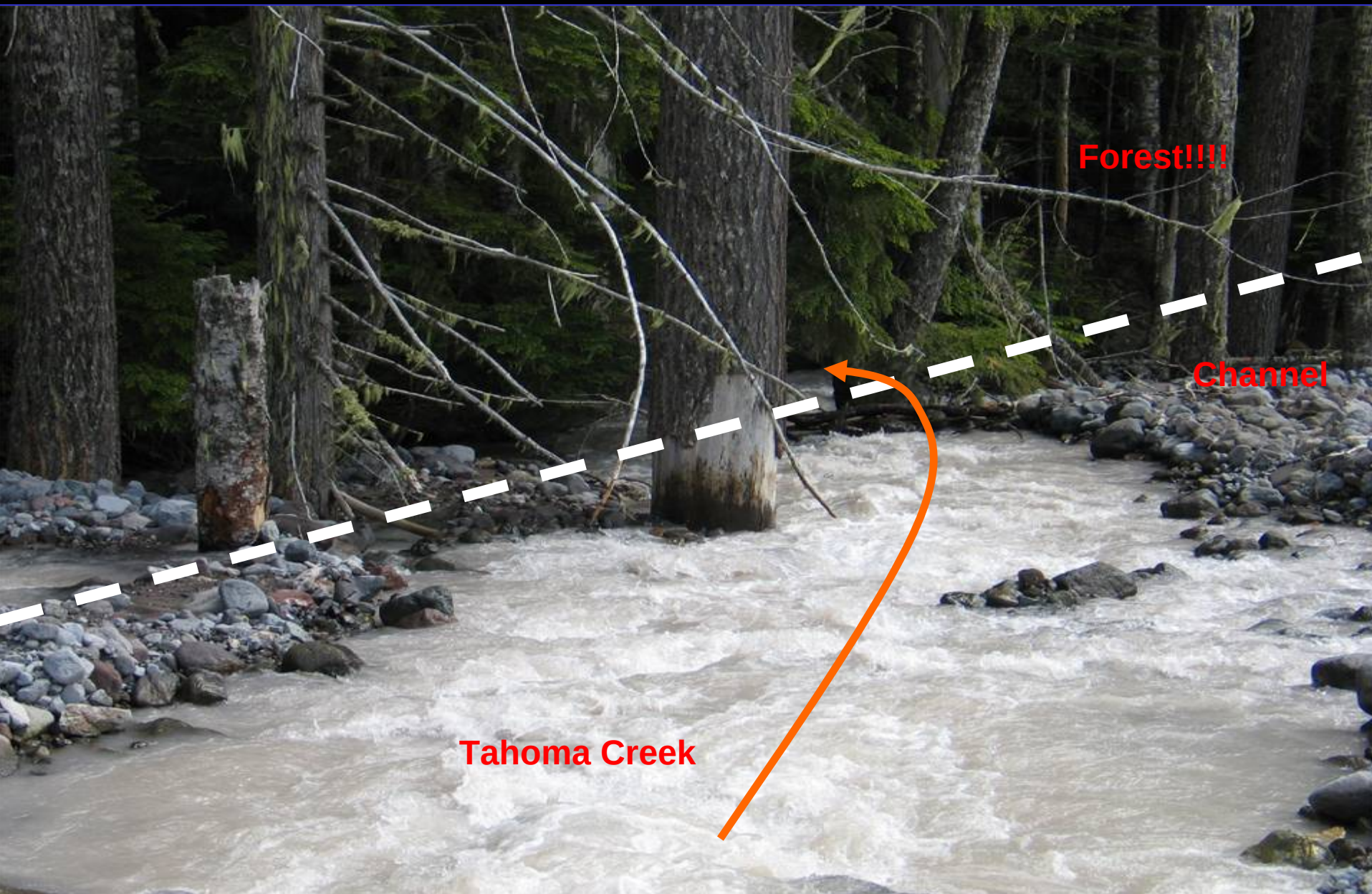
Geomorphic Response Corridors, Dredging, and Manifest Destiny

Dealing with aggradation is going to be one of the most challenging issues facing river restoration and management in the Pacific Northwest.

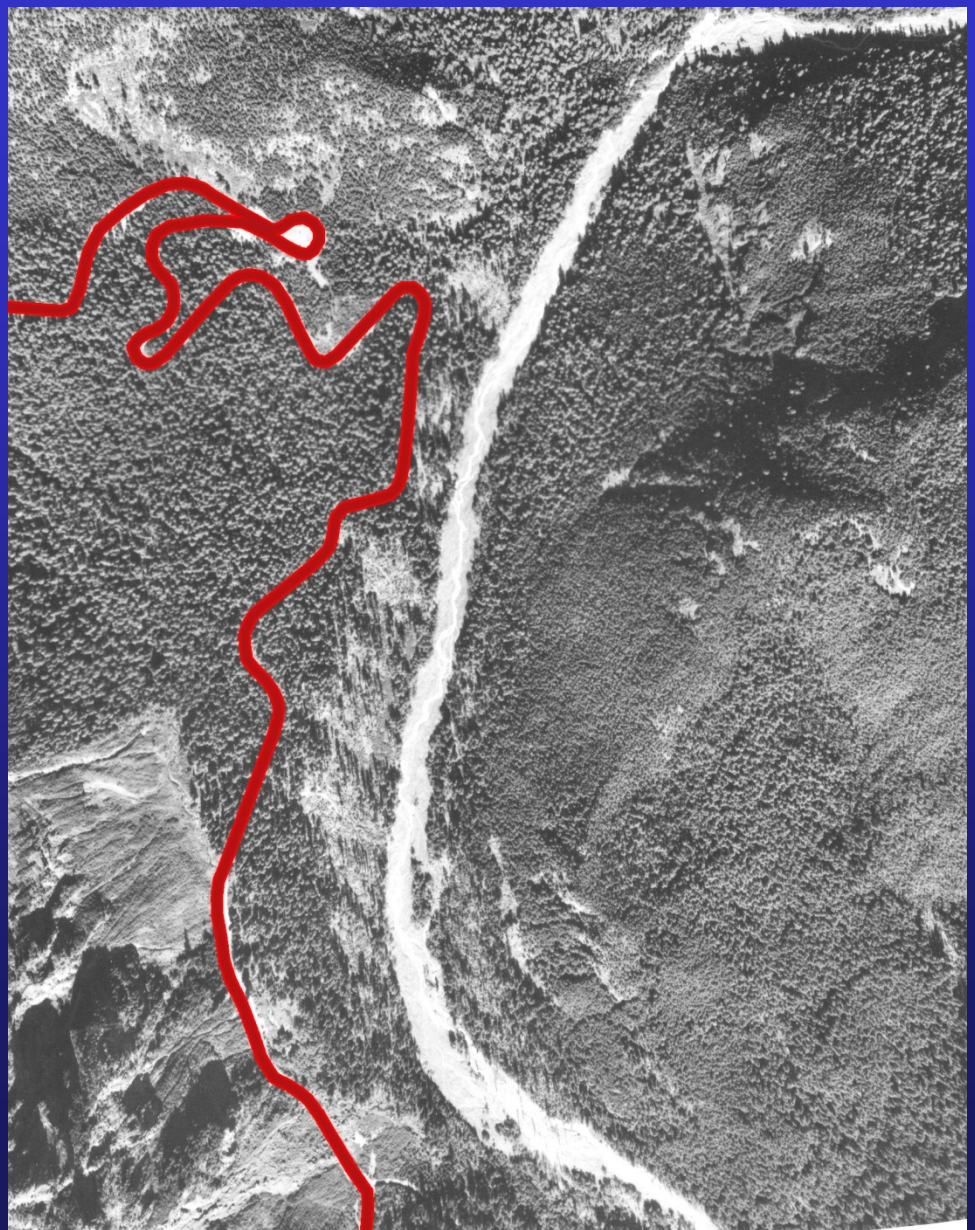
All the more reason for aggressive recognition and delineation of geomorphic response corridors.

Morphologic response associated with channel aggradation:

Recent channel evolution of Tahoma Creek

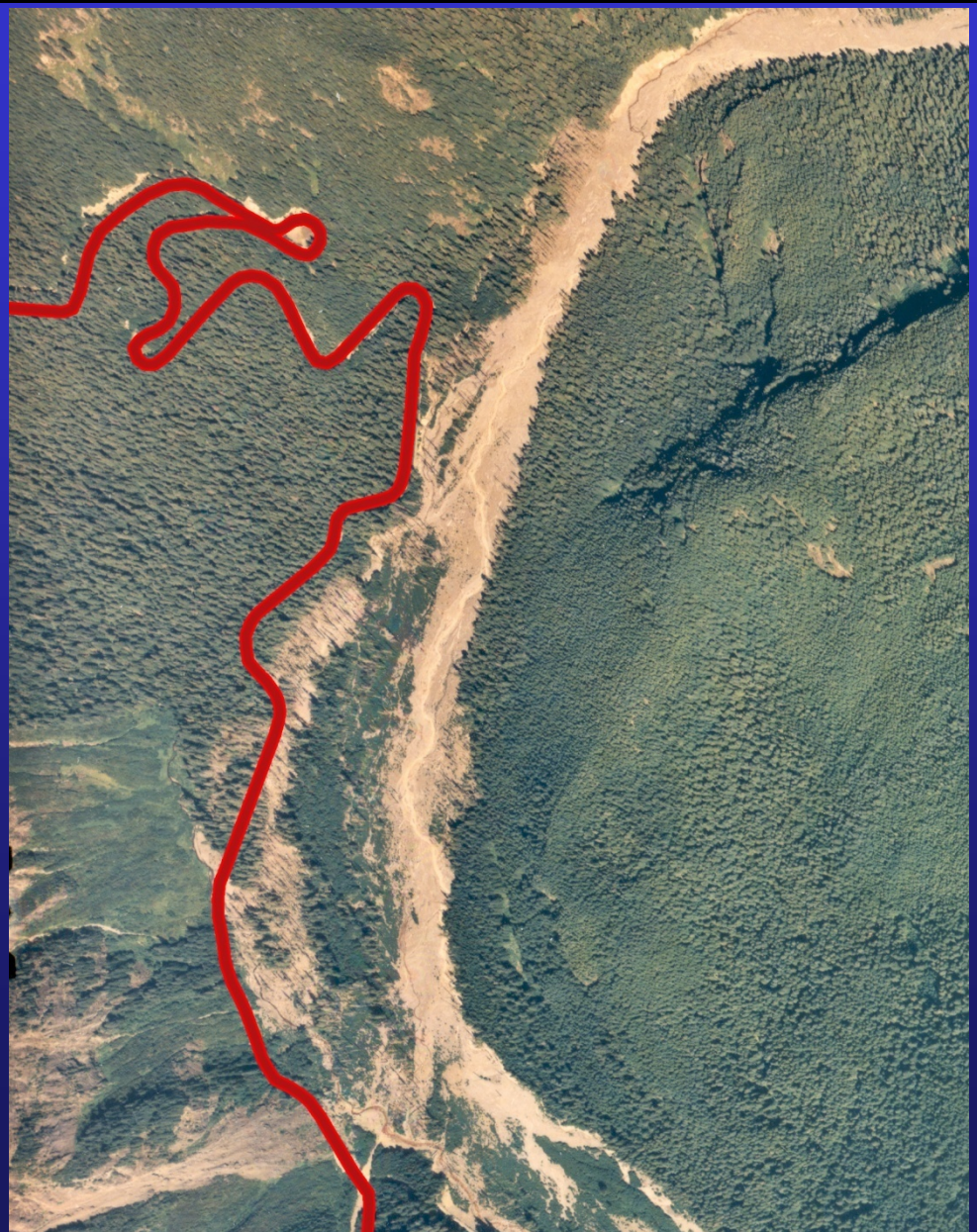

Forest!!!!
Channel
Tahoma Creek

- 1960



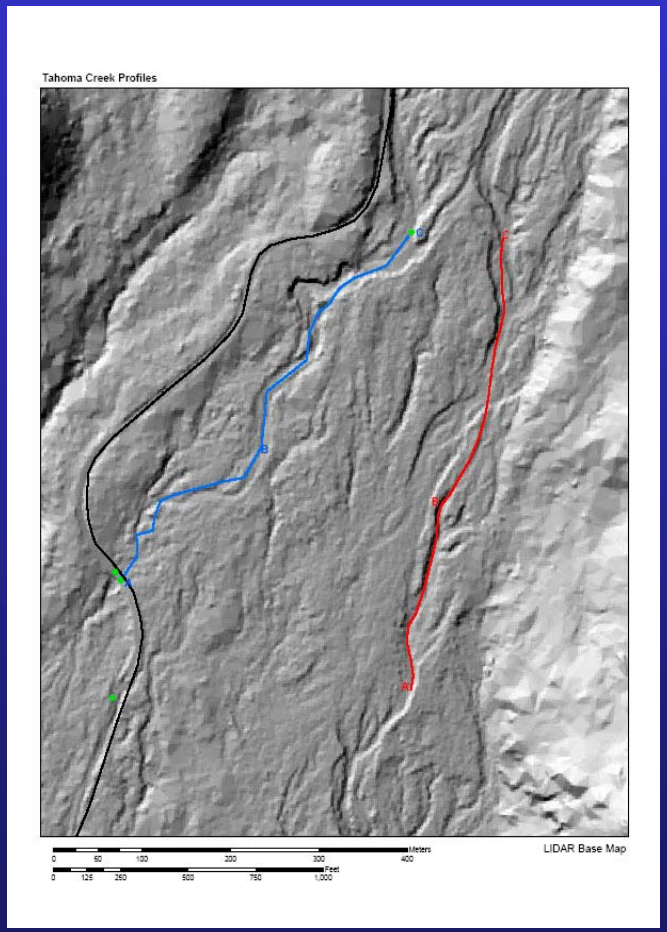
- 1979

- 1996



- 2006

Longitudinal profiles at Tahoma Creek



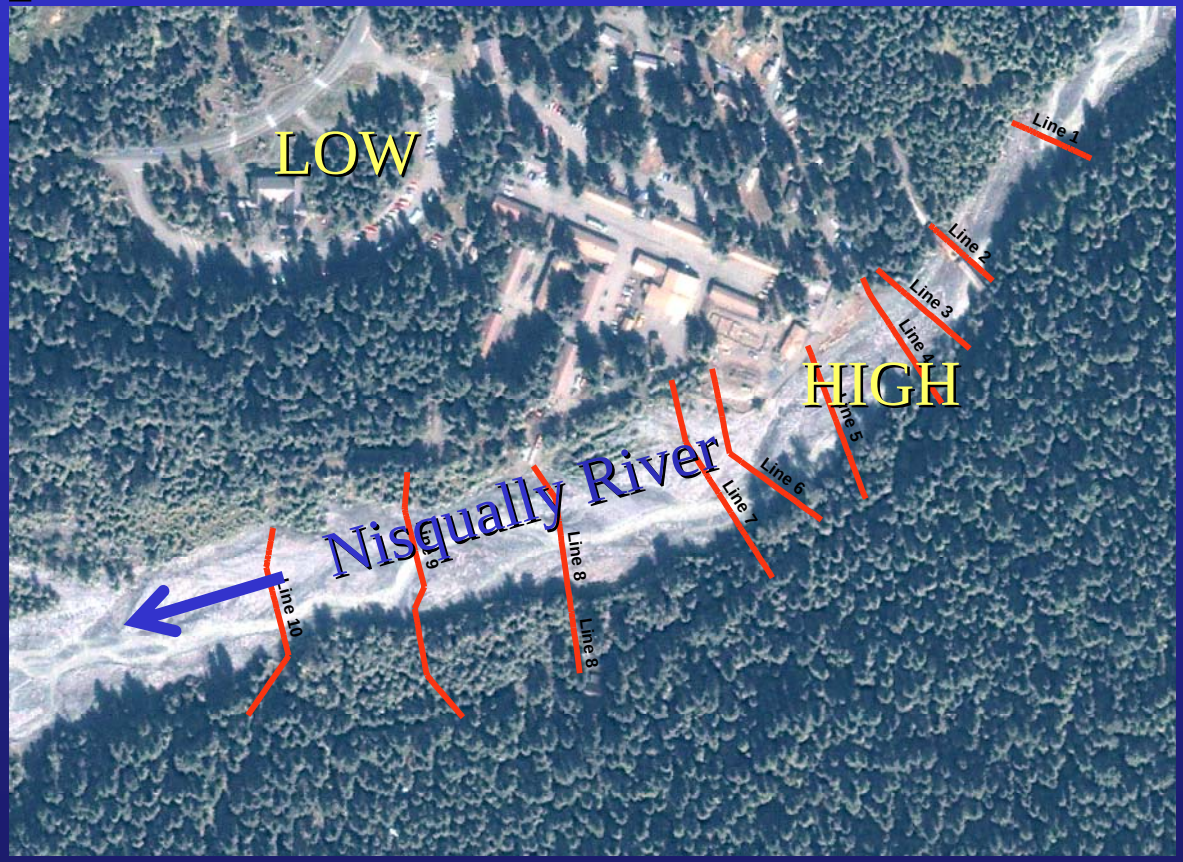
- Aggradation doesn't only mean channels only go up!
- By 2005, the bed of Tahoma Creek was up to 20 feet higher than surrounding terrain.
- This created conditions for major avulsion, sending the main stem into an unnamed tributary, across the valley, where it remains today.

An Intact Geomorphic Response Corridor

- This creek has experienced a change in its flow regime.
- What was once its 100 year flood now occurs twice a year.
- But unlike many other creeks in this area, it remains in excellent condition - why?
- It has lots of **wood** & accommodates vertical & horizontal complexity

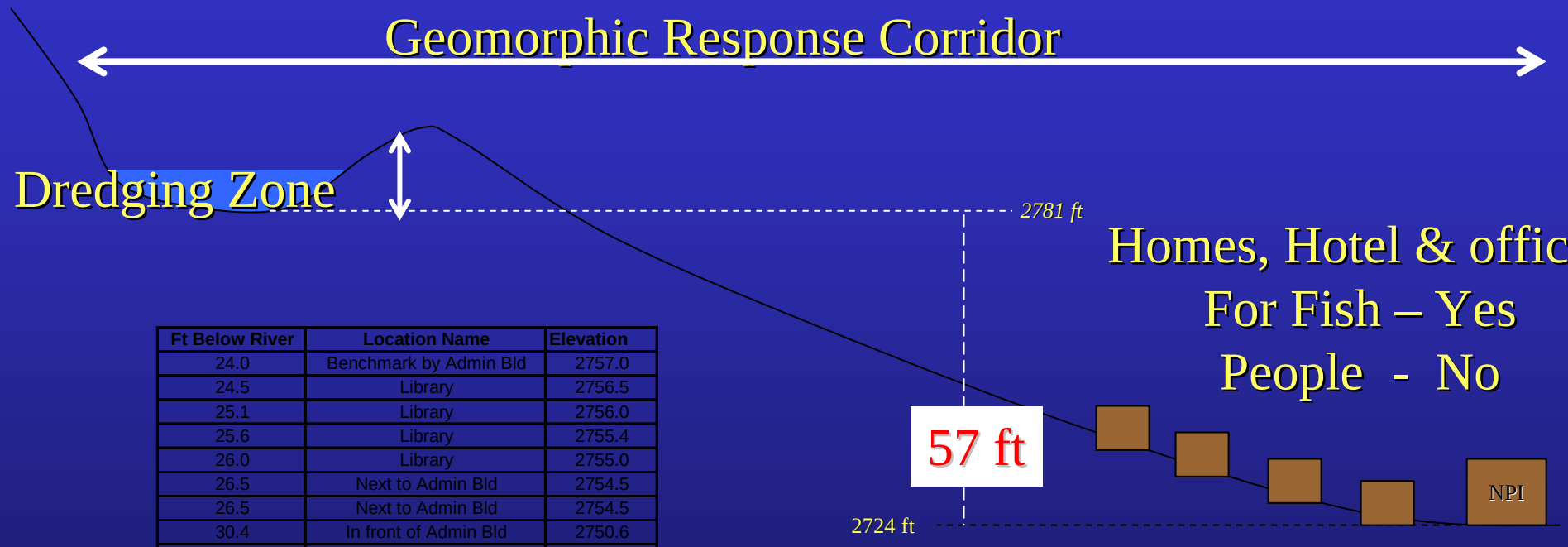
Ironically, Aggradation-Related Tree Mortality Does Not Promote Wood Recruitment to Stream…

Expect vertical and horizontal changes.



Longmire worker and visitor center.

The future is now at Longmire



Homes, Hotel & office
For Fish – Yes
People - No

Ft Below River	Location Name	Elevation
24.0	Benchmark by Admin Bld	2757.0
24.5	Library	2756.5
25.1	Library	2756.0
25.6	Library	2755.4
26.0	Library	2755.0
26.5	Next to Admin Bld	2754.5
26.5	Next to Admin Bld	2754.5
30.4	In front of Admin Bld	2750.6
34.9	Longmire Museum	2746.1
44.4	Trail of shadows Trailhead	2736.6
46.8	North from ToS Trailhead	2734.2
47.0	East side of NPI	2734.0
50.6	South from ToS Trailhead	2730.4
51.0	Western side of NPI	2730.1
51.1	South from ToS Trailhead	2730.0
57.0	Picnic area west of NPI	2724.0
	River Elevation	**2781.0**
	(lowest point of line 3)	

What will it take for us to recognize the inevitable?

Wish to Avoid:

River straightening, and wood removal.

There are solutions that enhance the environment and protect people.