RECENT TRENDS IN PEAK FLOWS AND SEDIMENT TRANSPORT IN THE NOOKSACK BASIN

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NATURAL SYSTEMS DESIGN

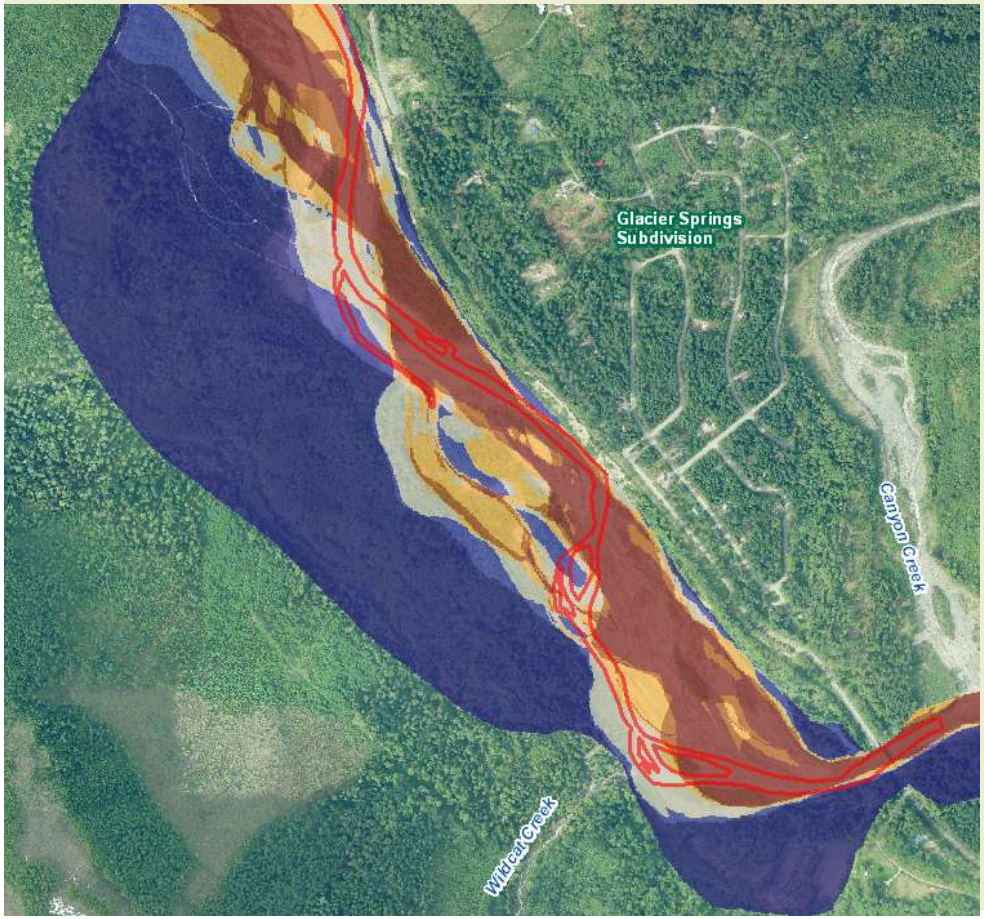
Natural Systems Design

RIVER DYNAMICS

- Rivers will adjust their form to convey the amount of water and sediment delivered to them.
- In the Pacific Northwest
  - Water and sediment load not constant through time. Delivery is more episodic
  - Significant channel change is driven by large sediment and flood events
  - Results: river channels are very dynamic!

RIVER DYNAMICS

Channel Occupancy of the North Fork Nooksack within the past 100-years



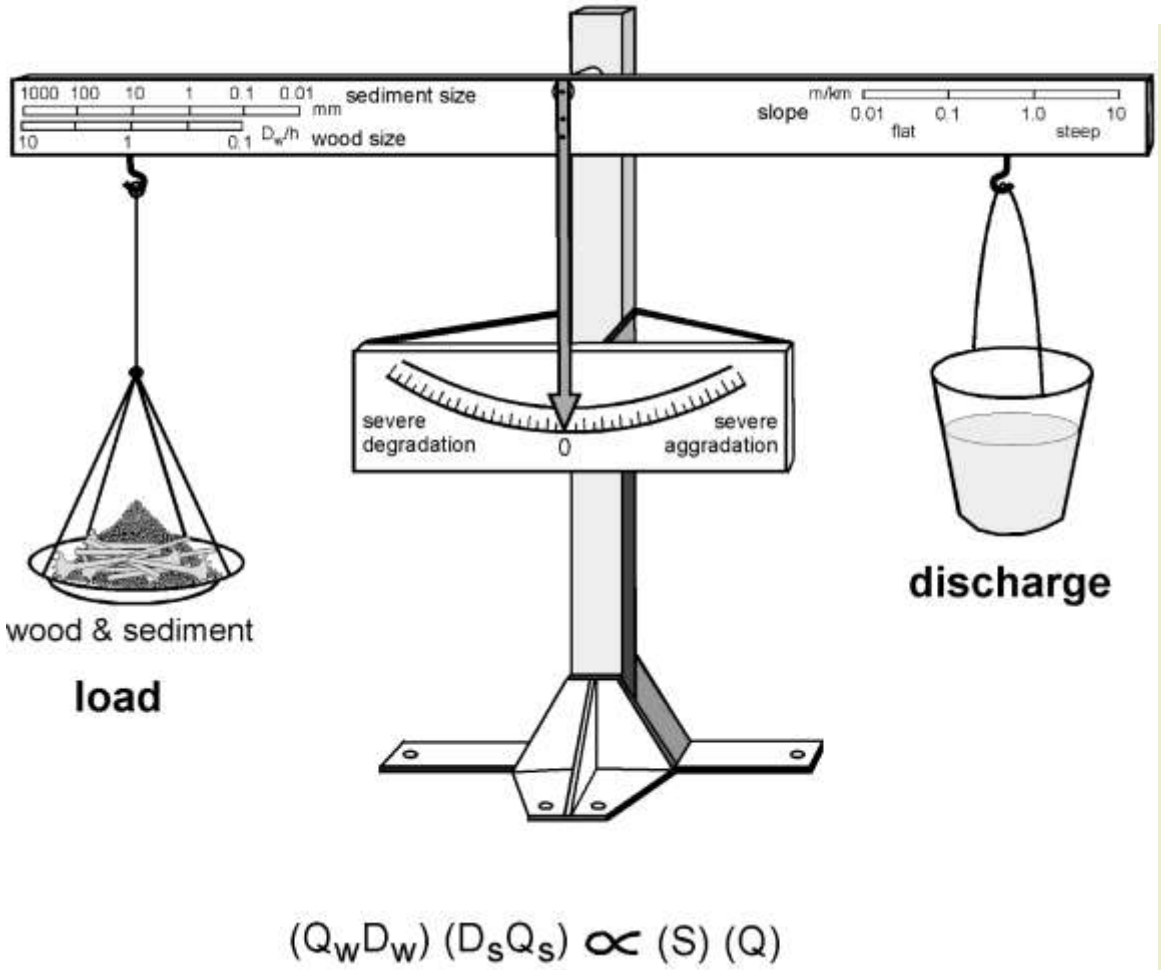
Blue – low percentage of occupancy

Maroon – high percentage of occupancy

Red – 2009 low flow channel location

RIVER DYNAMICS

RIVER RESPONSE



The product of;

Qs – Sediment load

Ds – Sediment size

Qw – Wood load

Qw – Wood size

Is Proportional to;

The product of

Q – Water volume

S – Slope of the channel

Channel morphology = f (Qc, Qs) (Lane 1955)

PNW CLIMATE CHANGE

CURRENT HYPOTHESES: higher peak flows and a larger sediment load in the Puget Sound watersheds will cause increased flooding due to:

- Reduced interannual snowpack, early spring melt causing altered seasonal extent of ground surface exposure and increased frequency of occurrence of landslides and debris flows
- Larger and more frequent winter storm events, greater storm intensity, higher flood flows Receding glaciers producing excess sediment available for transport
- Receding glaciers producing excess sediment available for transport

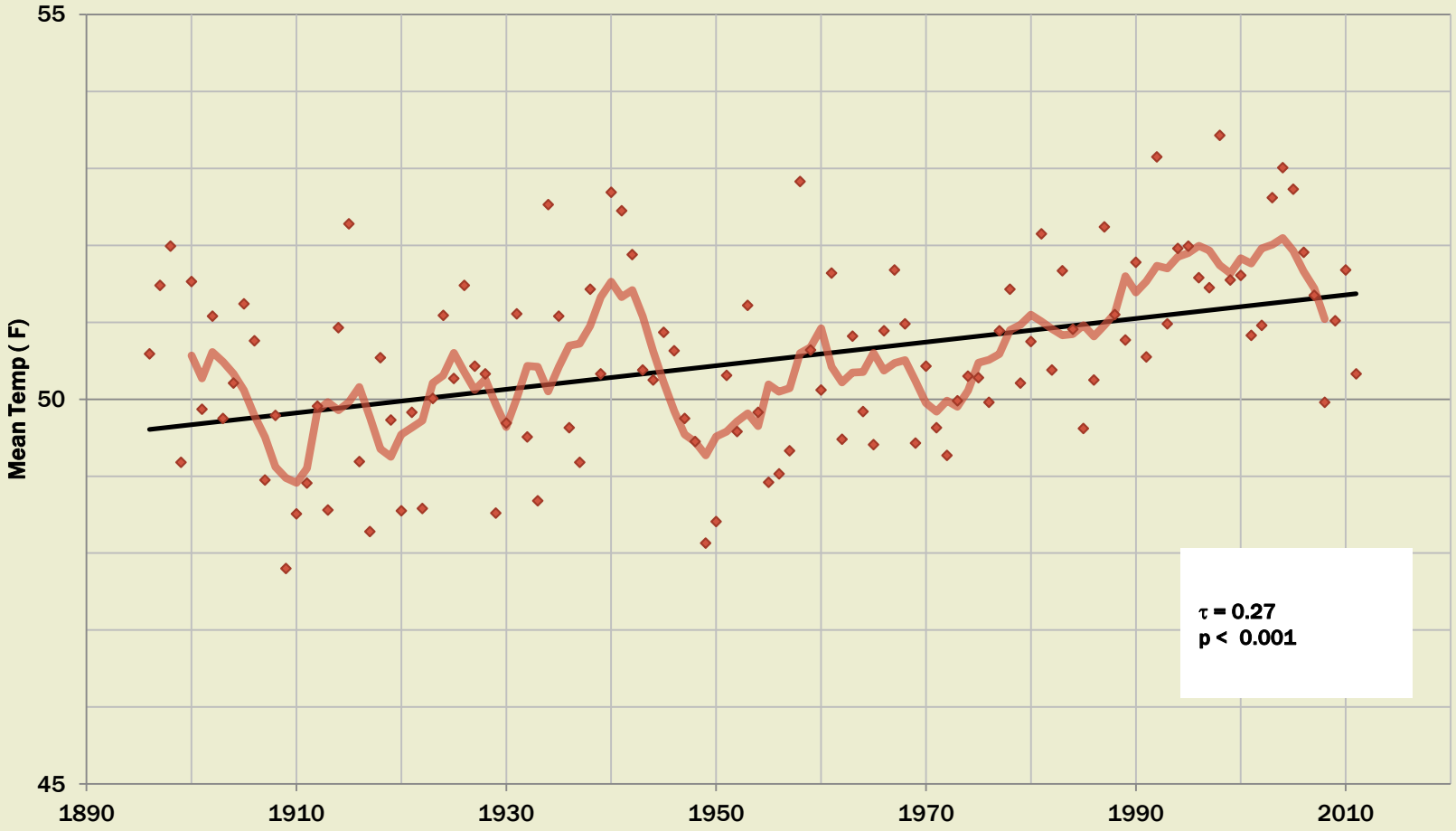
CLIMATE CHANGE EFFECTS

WHAT WILL CAUSE FLOODING TO INCREASE?

Increased Air Temperatures:

- Increased glacial melt, fewer glaciers
- Bigger storms due to warmer marine temperatures; increased magnitude, (pineapple express)
- Average freezing elevations rise; more precipitation falls as rain in the winter, less storage as snow

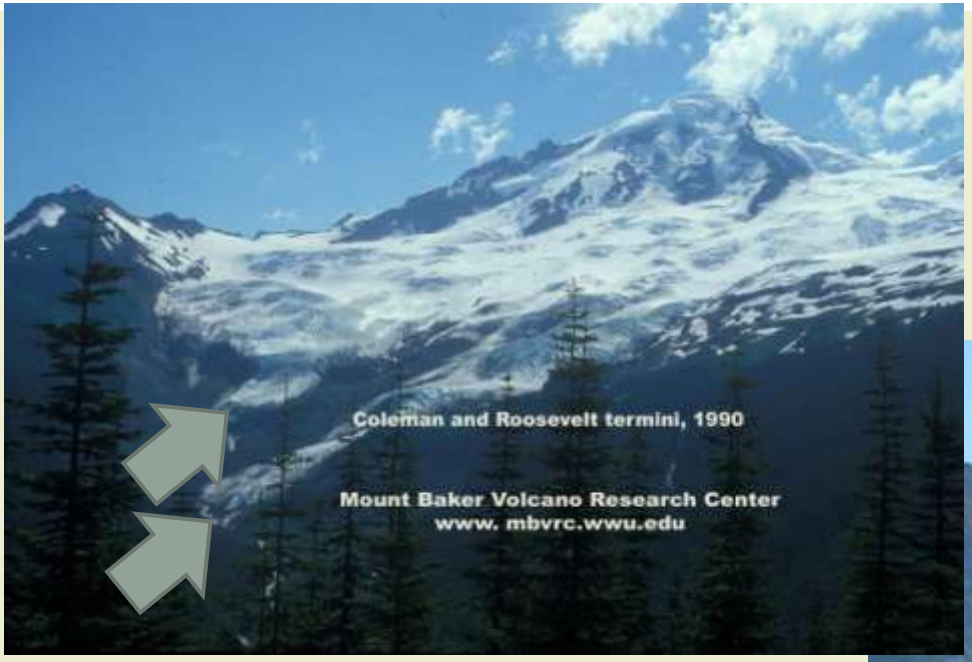
PNW CLIMATE CHANGE

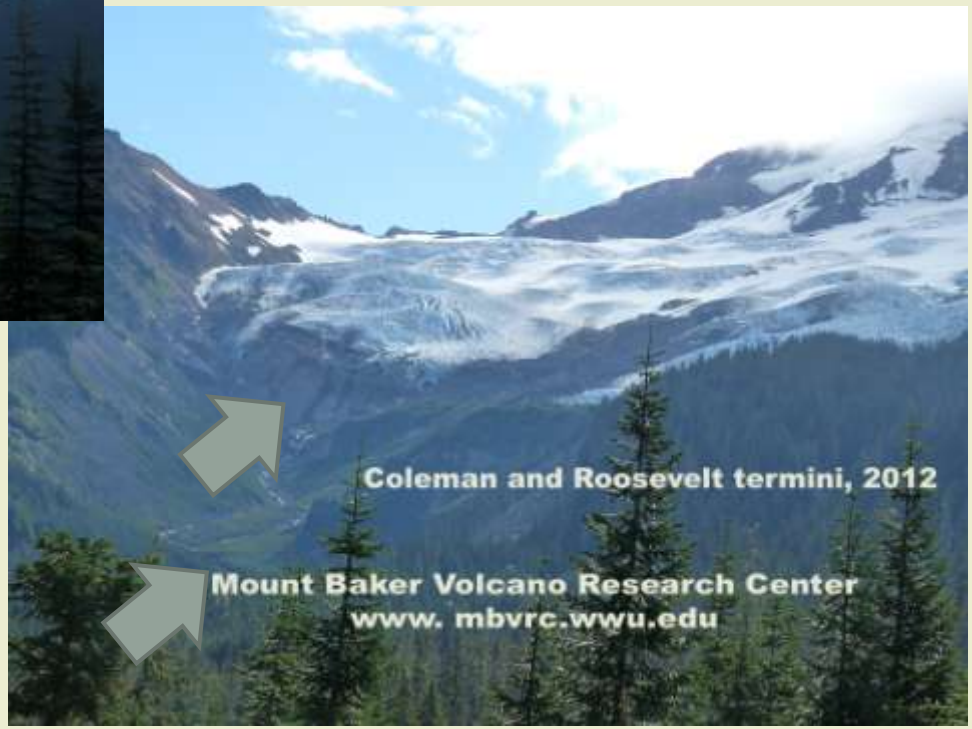


Sedro-Woolley, WA Climate Station 1806-2011

U.S. Historical Climatology Network

PNW CLIMATE CHANGE





Photos from: Dr. Jon Riedel and Bellingham Area Glacial Erratics

PNW CLIMATE CHANGE

Retreat of the South Cascade Glacier

USGS Benchmark glacier in Suiattle Watershed

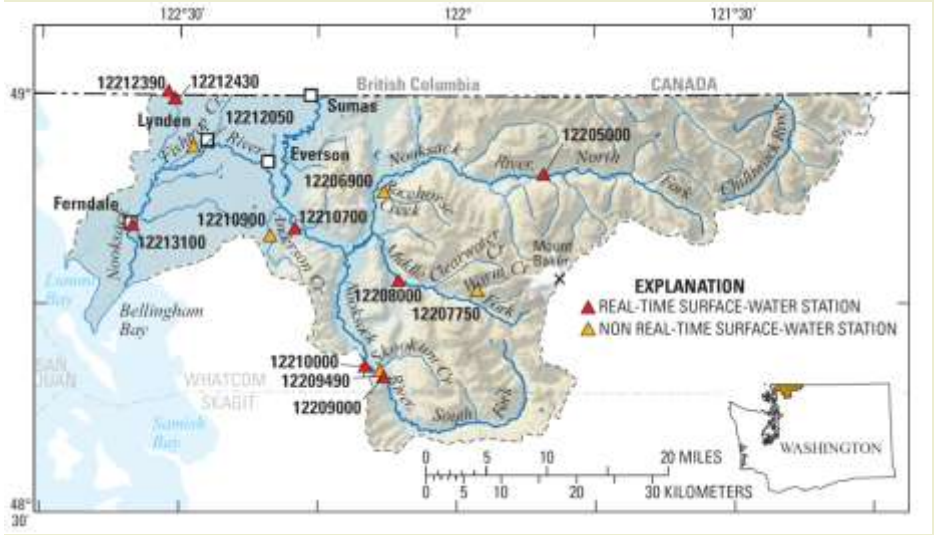
CLIMATE CHANGE EFFECTS

WHAT WILL CAUSE FLOODING TO INCREASE?

More Precipitation

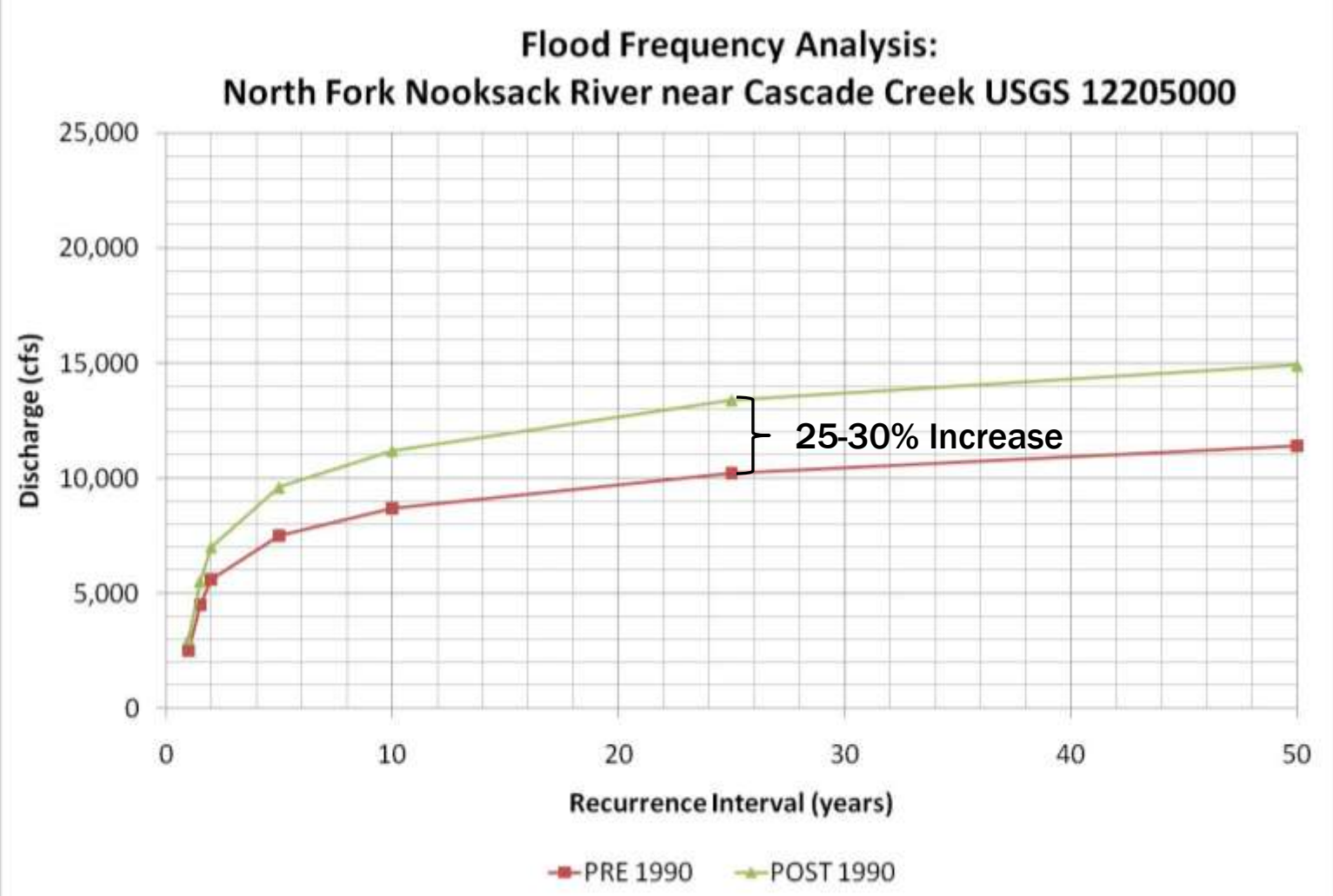
- Bigger storms (known as atmospheric rivers, pineapple express)
- Average freezing elevations rise; more winter precipitation falls as rain (increase in runoff at each storm event)
- No average increase in precipitation annually; related to specific storms

PEAK FLOWS ON THE NOOKSACK

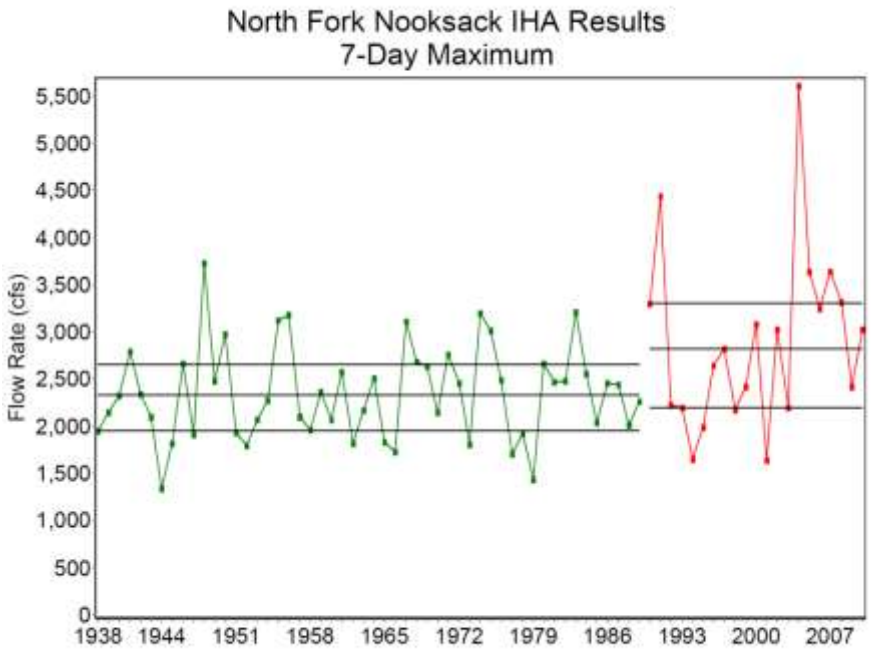


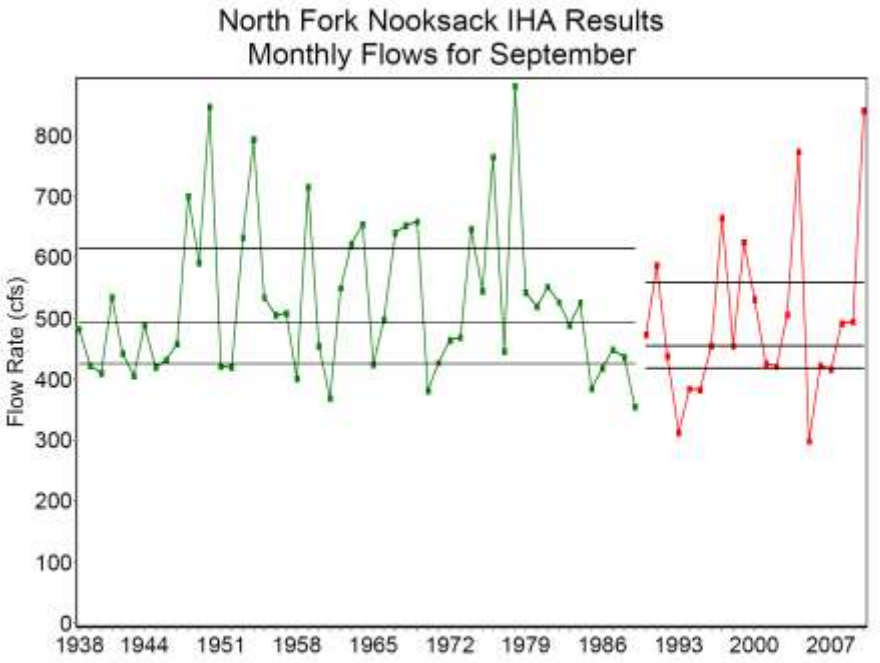
	USGS 12213100		USGS 12205000	
	OOKSACK AT FERNDAL		NF NEAR CASCADE	
	Date	Discharge (cfs)	Date	Discharge (cfs)
1	**11/10/1990**	**57000**	**10/16/2003**	**15200**
2	2/10/1951	55000	**11/6/2006**	**12600**
3	**1/8/2009**	**51700**	11/10/1989	11200
4	11/11/1989	47800	11/26/1949	10300
5	**11/30/1995**	**47200**	1/4/1984	9700
6	12/3/1975	46700	10/21/1963	9680
7	**11/25/2004**	**42300**	10/28/1937	9670
8	10/26/1945	41600	**11/10/1990**	**9540**
9	1/5/1984	41500	**1/7/2002**	**9300**
10	**10/21/2003**	**39900**	**11/11/1999**	**9220**
	61		73	

PEAK FLOWS ON THE NOOKSACK



AVERAGE FLOWS ON THE NOOKSACK





CLIMATE CHANGE EFFECTS

WHAT WILL CAUSE FLOODING TO INCREASE?

More sediment in the main channel:

- Debris flows and post-glacial storage; more sediment available to be moved
- Bigger storms;, channel can do more work transporting larger material, more sediment available from existing storage upstream
- Sediment from headwaters deposited in the river valley downstream; channel bed level rise causes flooding

CLIMATE CHANGE EFFECTS

WHAT WILL CAUSE FLOODING TO INCREASE?

More sediment in the main channel:

Glacier recession exposes large areas of steep bare ground, much of which is unconsolidated easily eroded sediment

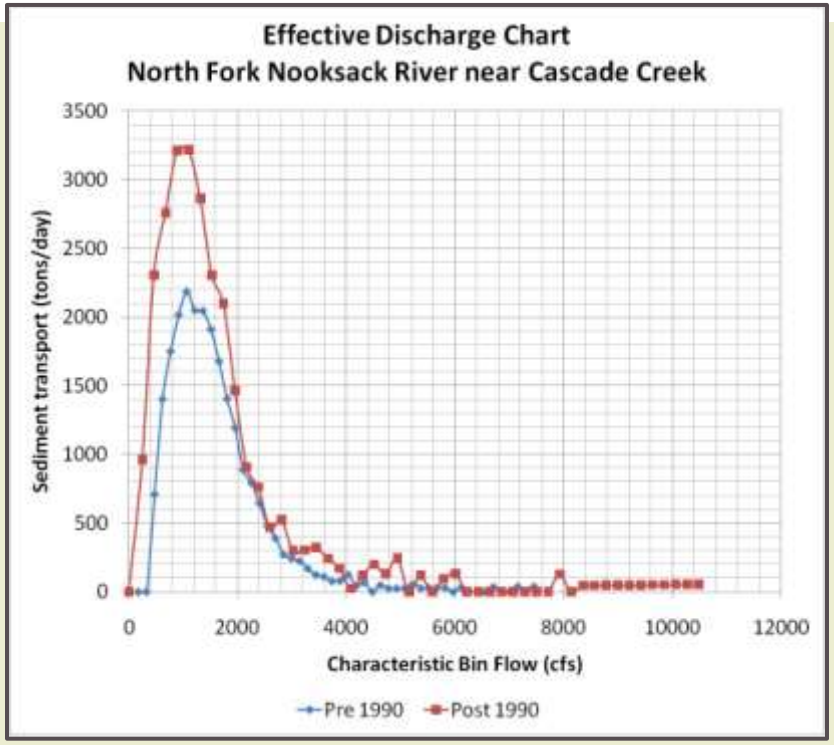
SEDIMENT TRANSPORT

Effective Discharge (Q_{eff}) – Discharge that transports the largest fraction of annual sediment load over a period of years (Andrews, 1980)

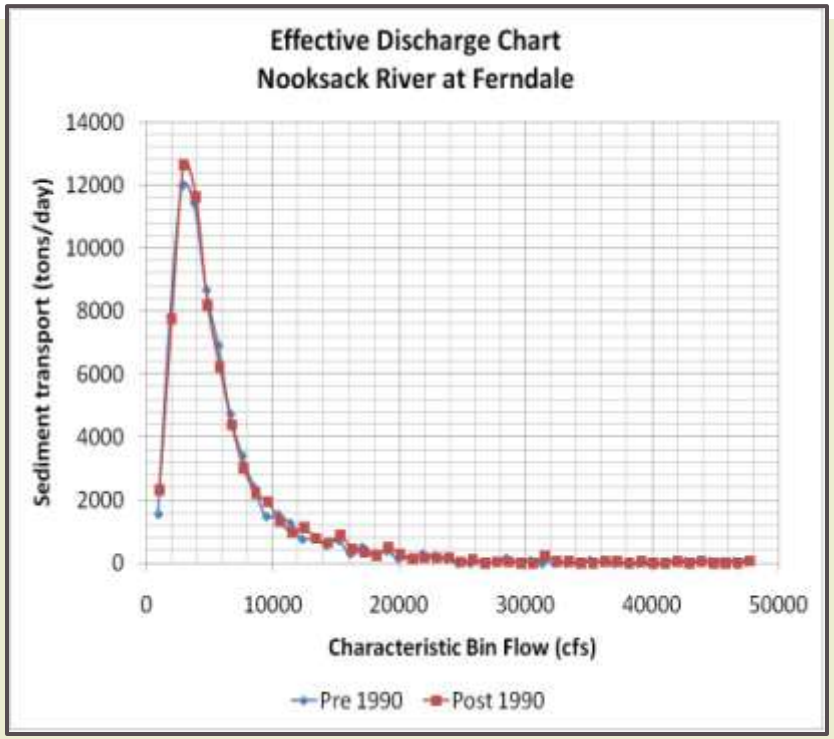
Analysis combines;

- Hydrology
- Hydraulics
- Sediment Transport

SEDIMENT TRANSPORT RESULTS



	Effective Discharge	Peak Bin Sediment Load	Annual Sediment Load
	(cfs)	(tons/day)	(mil tons)
Pre 1990	1060	2200	8.6
Post 1990	1310	3200	9.8
% difference	24%	45%	14%



	Effective Discharge	Peak Bin Sediment Transport	Annual Sediment Load
	(cfs)	(tons/day)	(mil tons)
Pre 1990	2840	11990	25.4
Post 1990	2940	12650	25.3
% difference	4%	6%	0%

SEDIMENT TRANSPORT RESULTS

Sediment availability & transport increasing

Sediment transport constant. Aggradation probable

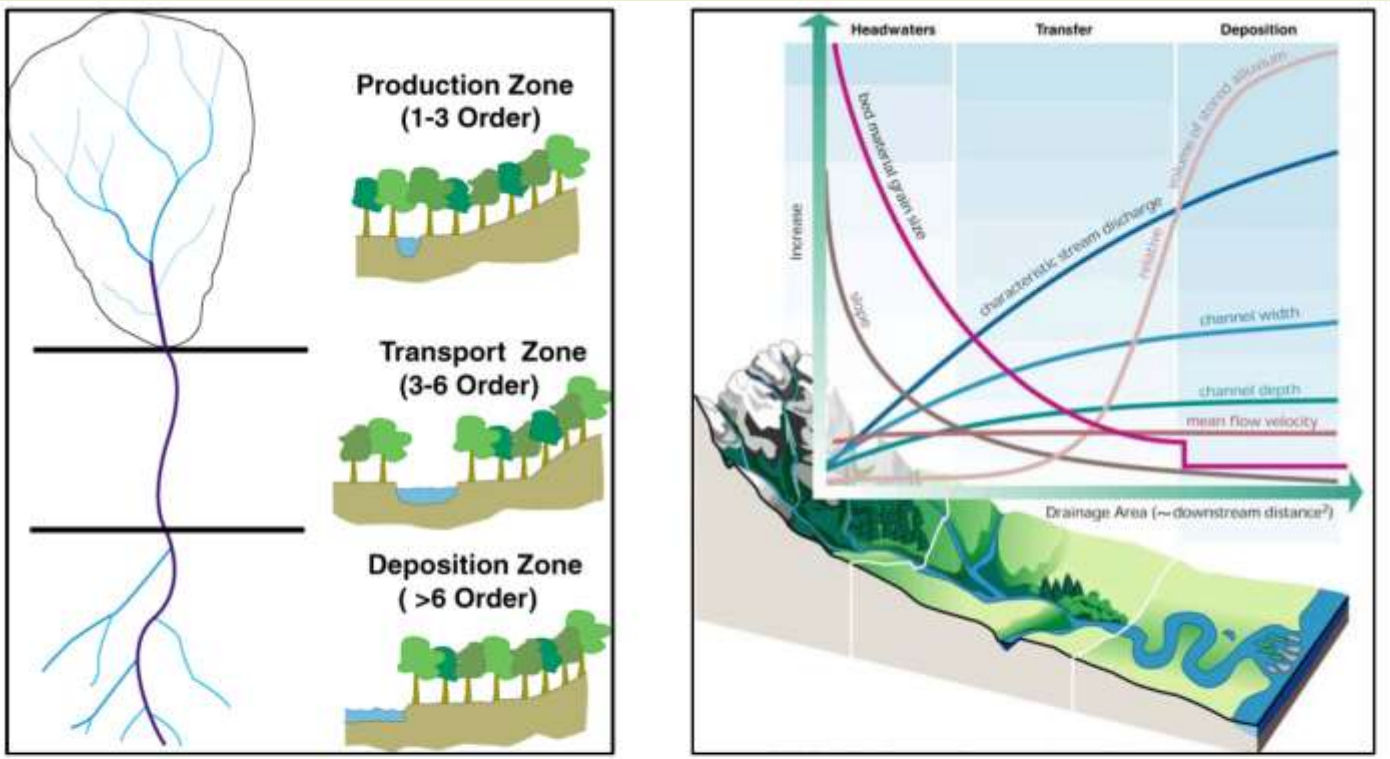


Figure 15. a. (left) The three functional zones of the stream: zone of production, zone of transfer or transportation, and zone of deposition (Schultz et al., 2000). **b. (right)** The hydrologic and geomorphic changes among the three functional zones of the streams [from "Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)].

HOW WILL THE NOOKSACK RESPOND

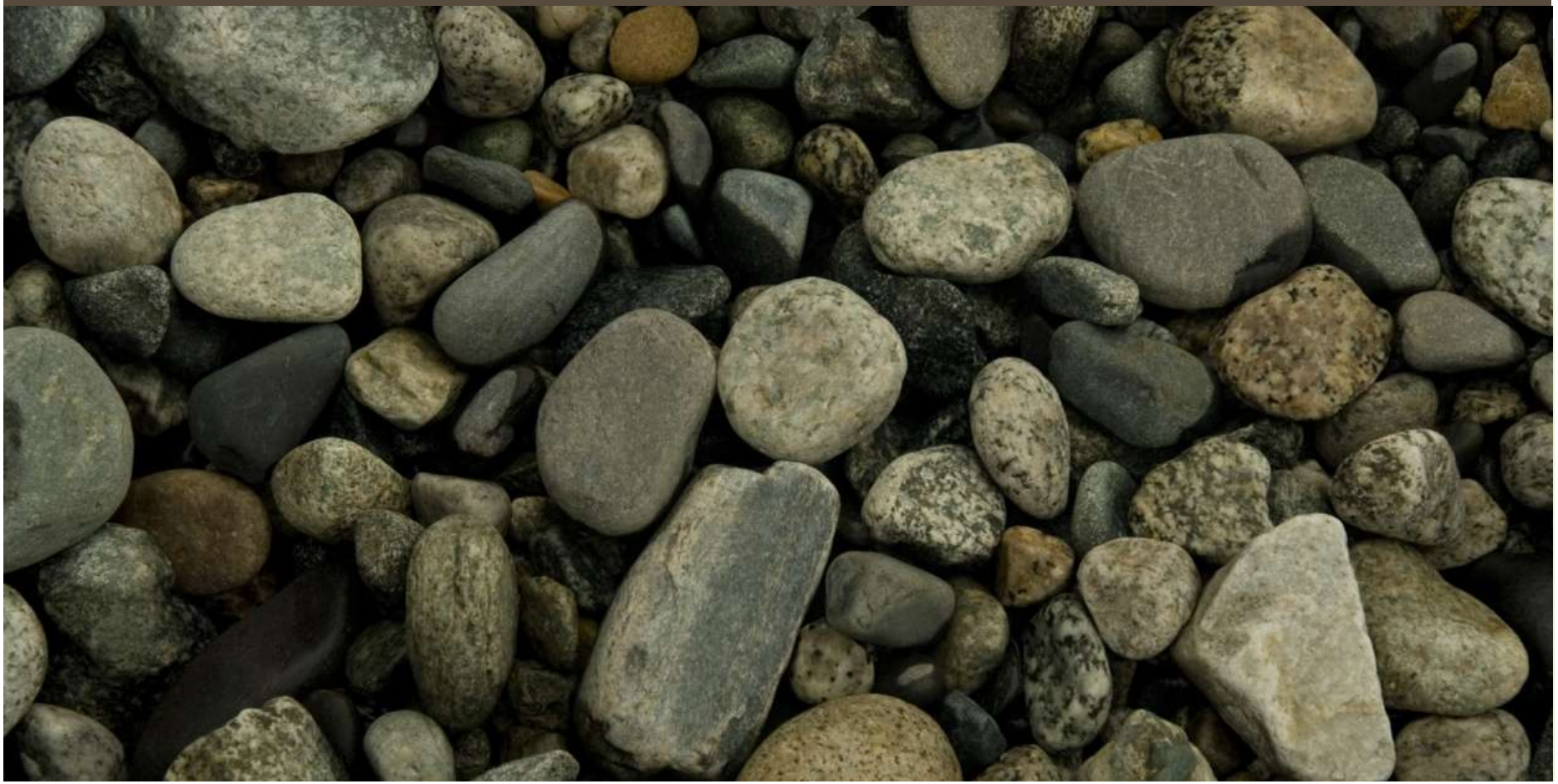
- Response is dependent on location in watershed
  - Peak flows are increasing (Q)
  - Sediment availability is increasing (Q_s)
  - Sediment transport is increasing (Q_s)

- In general, river will be more dynamic
  - Increase in bank erosion and channel migration
  - Increase in flooding due to aggradation and higher flows

HOW CAN WE PLAN FOR RESPONSE

- Pursue opportunities to reduce sediment availability
- Pursue opportunities to increase sediment storage
- Provide and enhance forest/riparian buffers
- Provide additional freeboard for infrastructure
- Limit development and infrastructure within channel migration zone

THANK YOU



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