

The Watershed System

A Holistic Approach to Forest Management in Watersheds

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About me – Watershed Geoscientist

- P.Geo PhD
 - BSc Geology
 - MSc Geology
 - PhD Forest Res. Mngmt
 - Watershed response to forest disturbance
- Studying watersheds for 30 years
- Hundred(s) of watershed assessment across western Canada
- Consulting geoscientist – Apex Geoscience Consultants Ltd since 1997
- Researcher – Selkirk Innovates (2018 - 2026)
- Forest hydrologist MoF (1993 – 1997)
- Geoscientist for BC Geological Survey 1986 - 1993

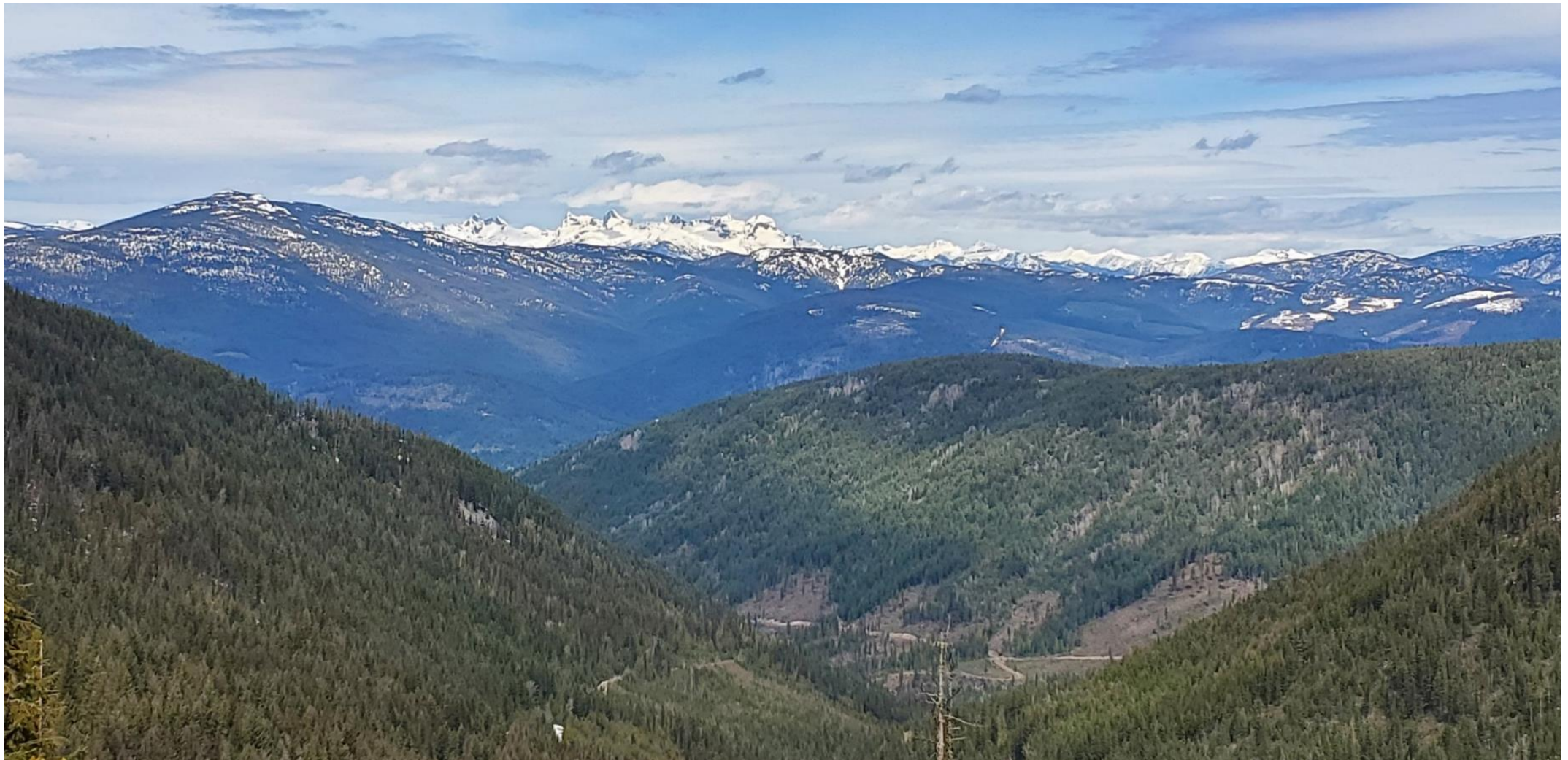
“a bad day in waders is better than any day not in waders”



Watersheds are Earth's conveyor belts

- Water and sediment and nutrients moves through watersheds from high elevations to low elevations
- from mountains to lakes and oceans





Watersheds are...

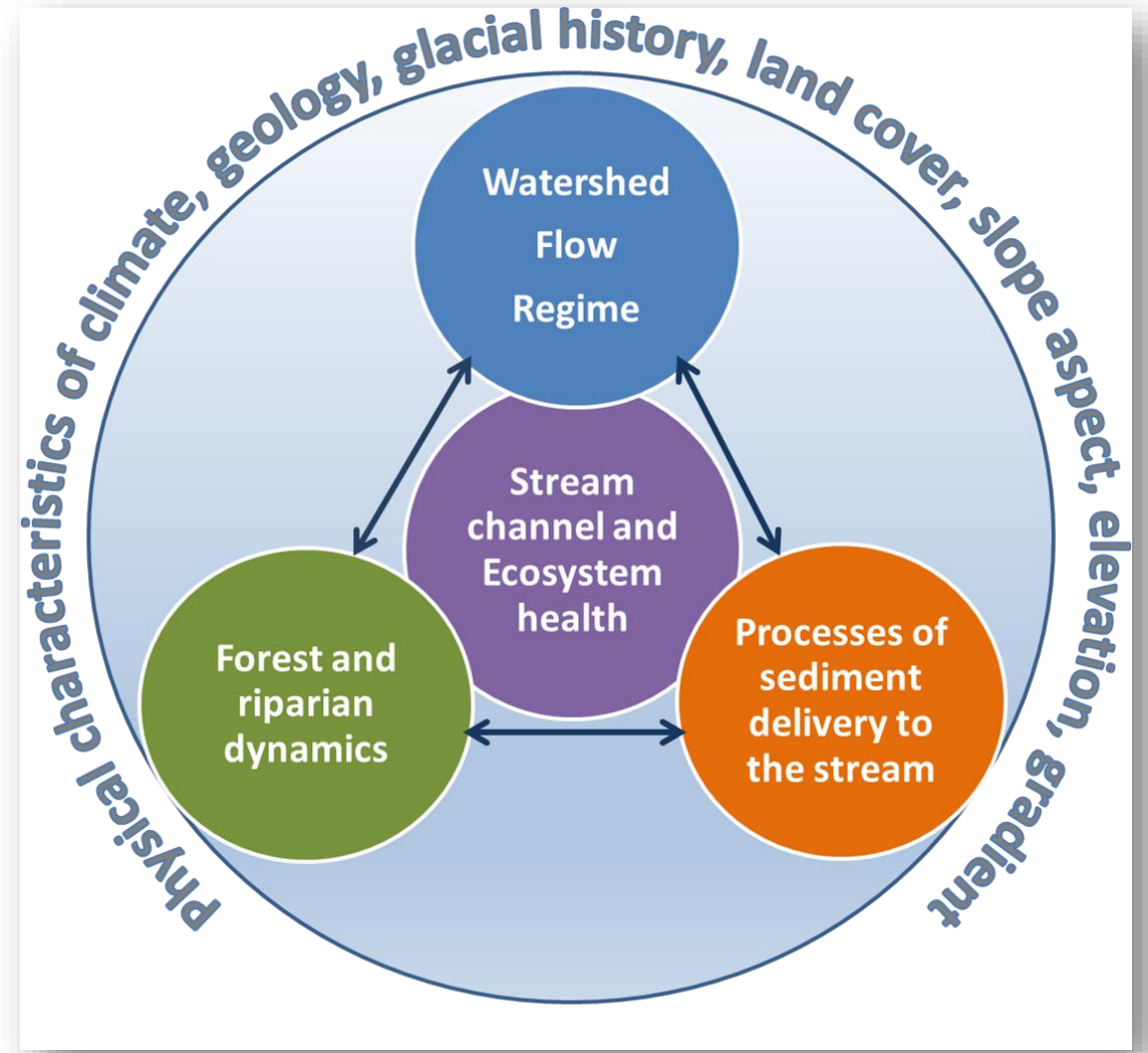
Areas in which land and water are connected; shaped over 10's of thousands of years and still changing.

Watersheds are systems

- A watershed is a collection of processes that function to move material and energy from high to low elevations

Watersheds are systems comprised three primary processes

These processes are governed by the physical characteristics of the watershed



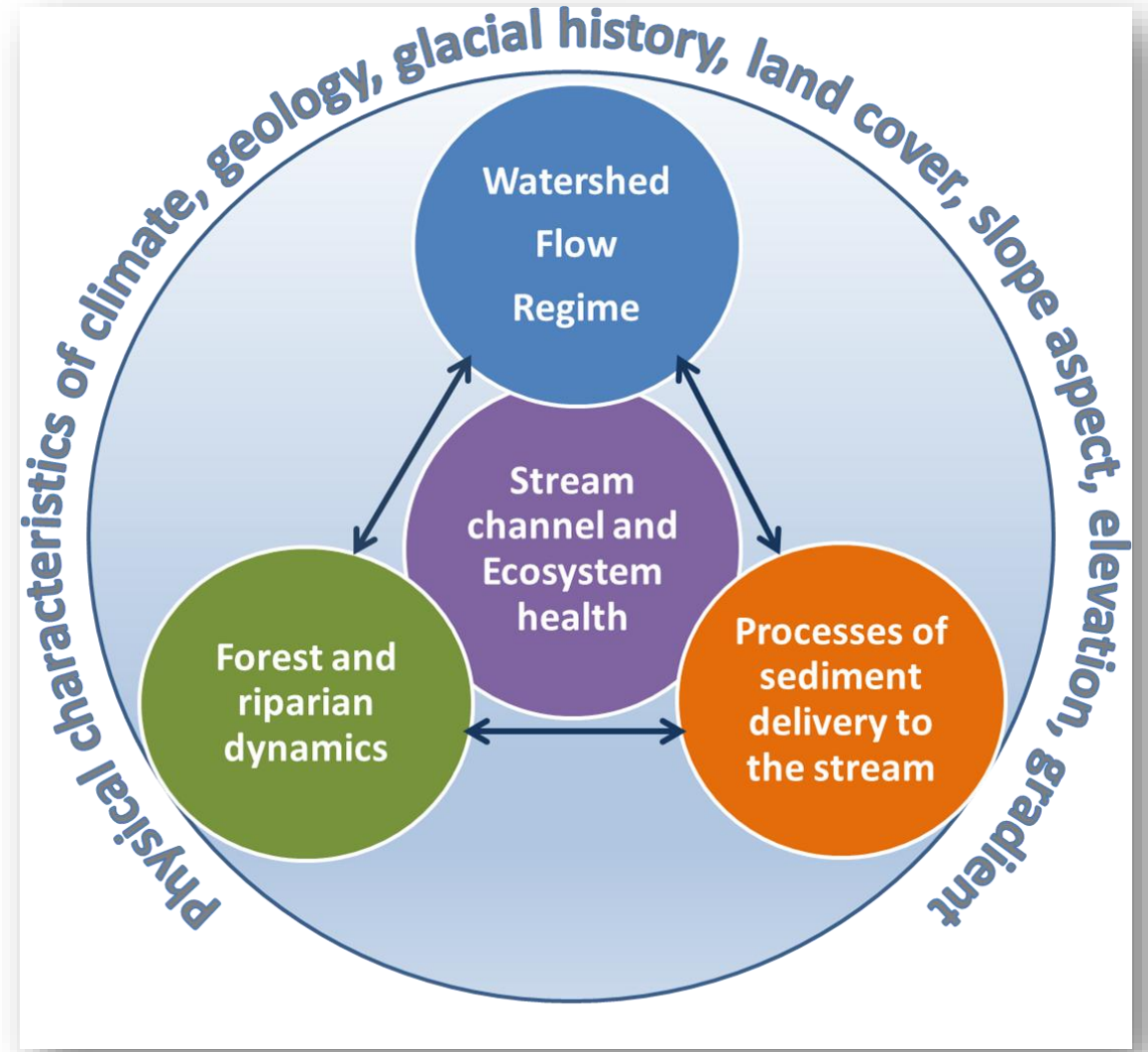
Watershed systems

First order controls on these processes are the external characteristics of

- geology,
- glacial history,
- climate,
- topography
- landcover,

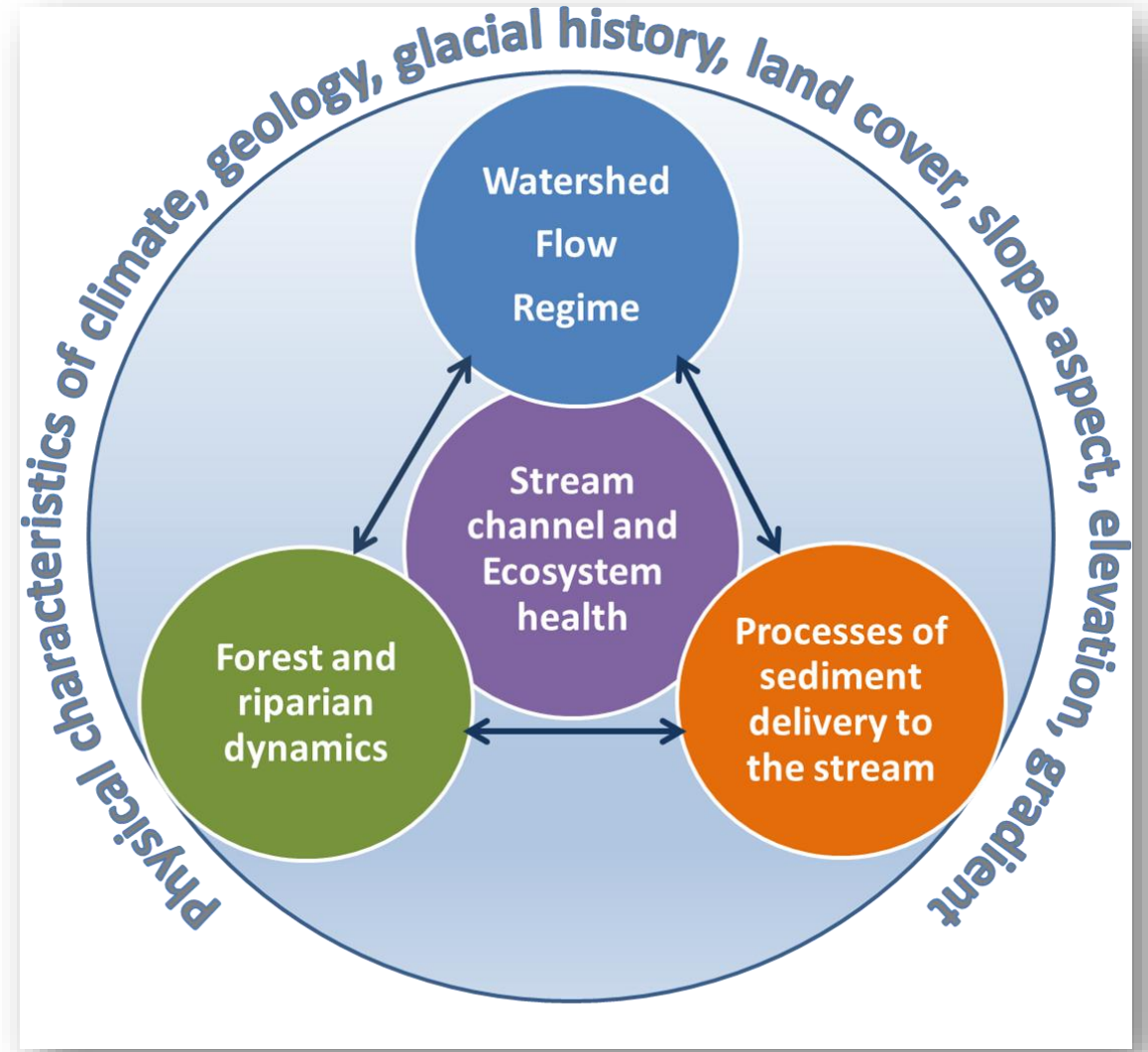
These physical characteristics determine the responsiveness of the watershed – its capacity to change.

Only climate and land cover are alterable in the short term



Watershed systems

- Three primary 'apex' processes shape the stream channel and directly impact the aquatic ecosystem
 - Flow Regime
 - Sediment regime
 - Riparian function
- The apex processes are shaped by external physical factors but also influence each other (inter-dependant)



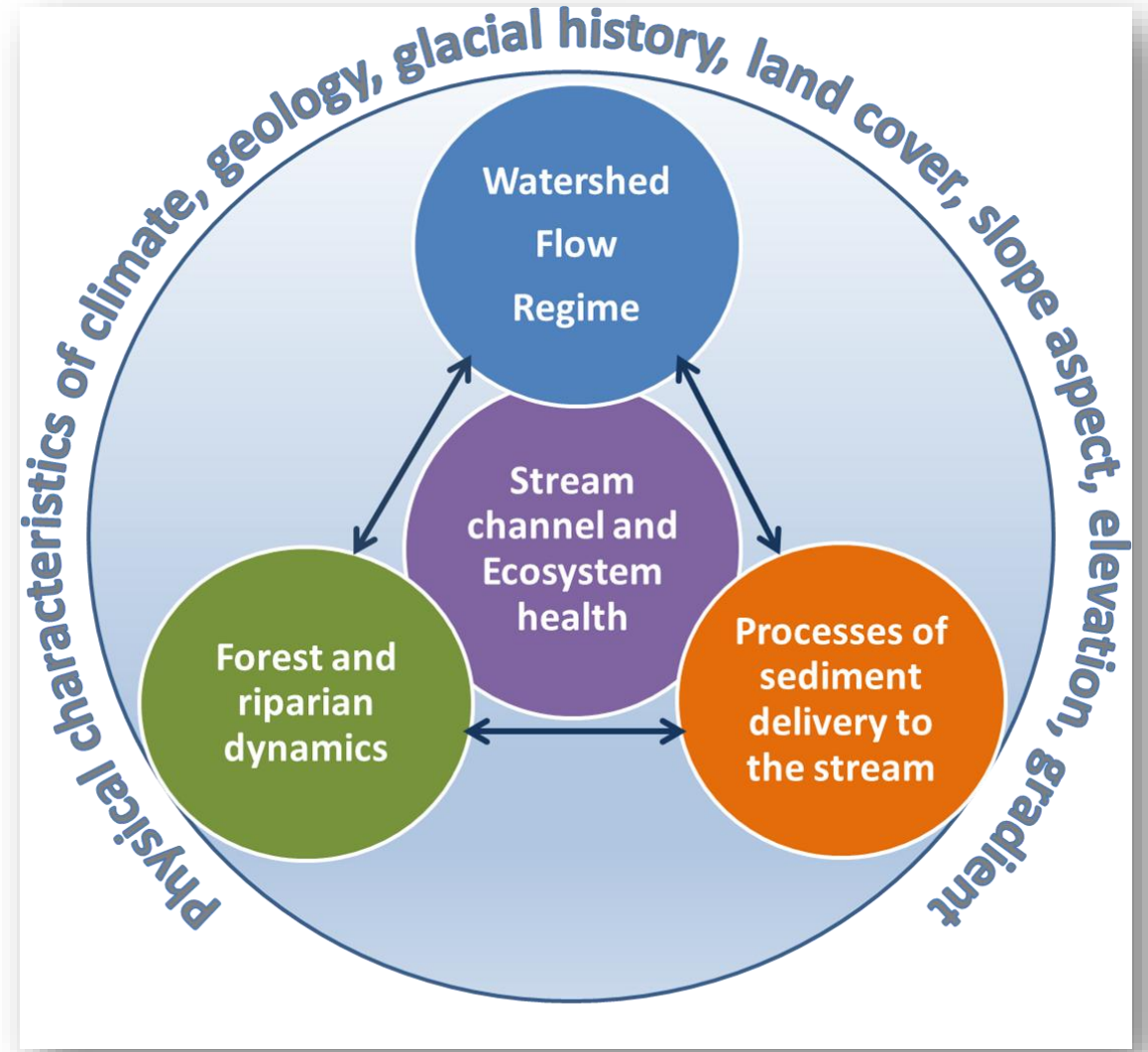
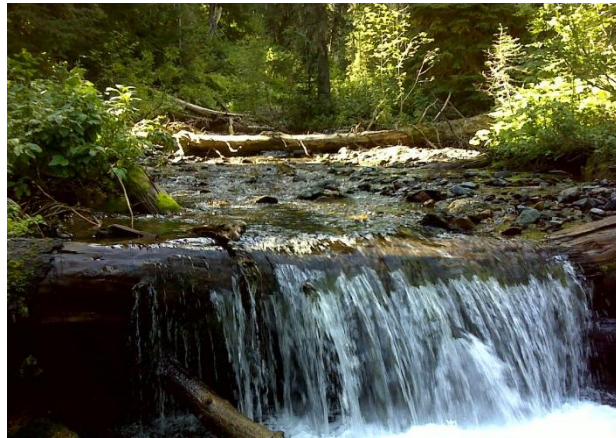
Watershed systems

No two watersheds are the same



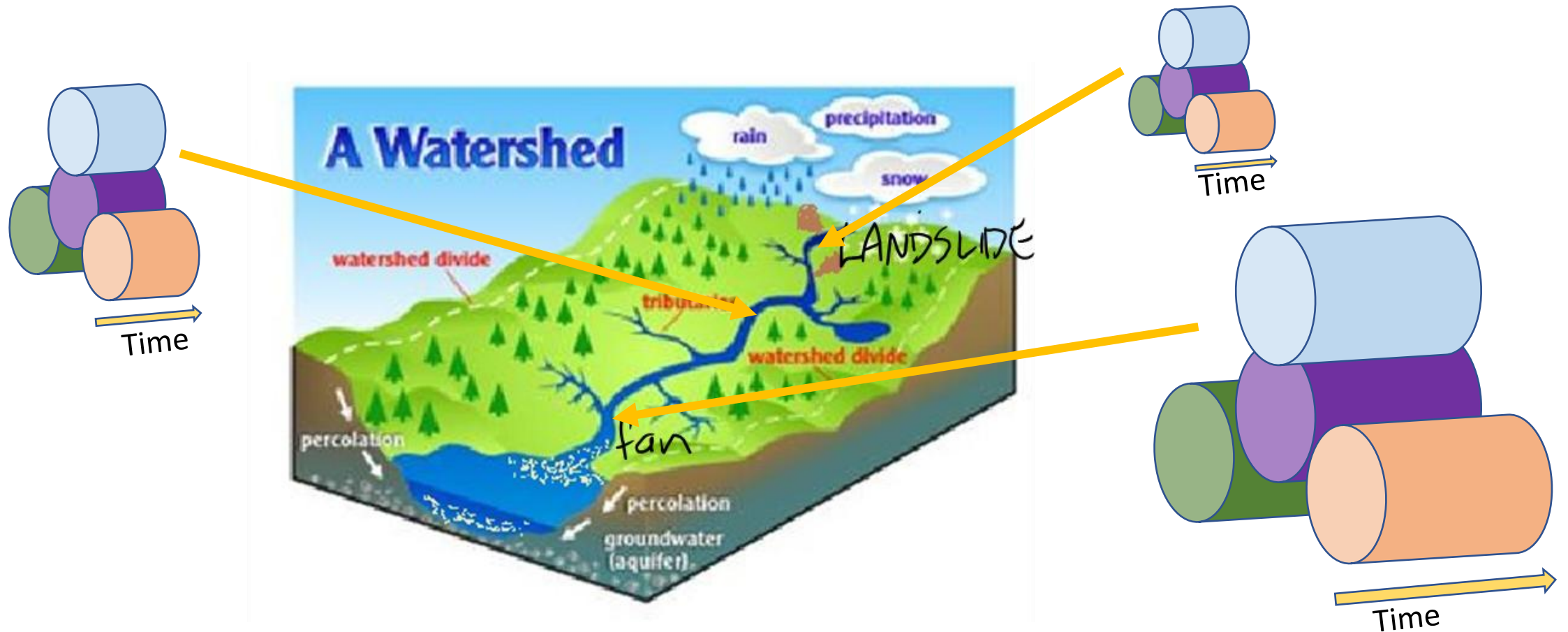
Differences in geology, climate, land cover and topography lead to differences in the 3 'apex' processes.

Contribute to differences in channel morphology and aquatic ecosystems



Watershed systems are dynamic in 4-dimensions

- Within a watershed the three interrelated 'apex' processes and the aquatic ecosystem they control change with (1) increasing scale and (2) over time in response to disturbances



Questions to guide forest management

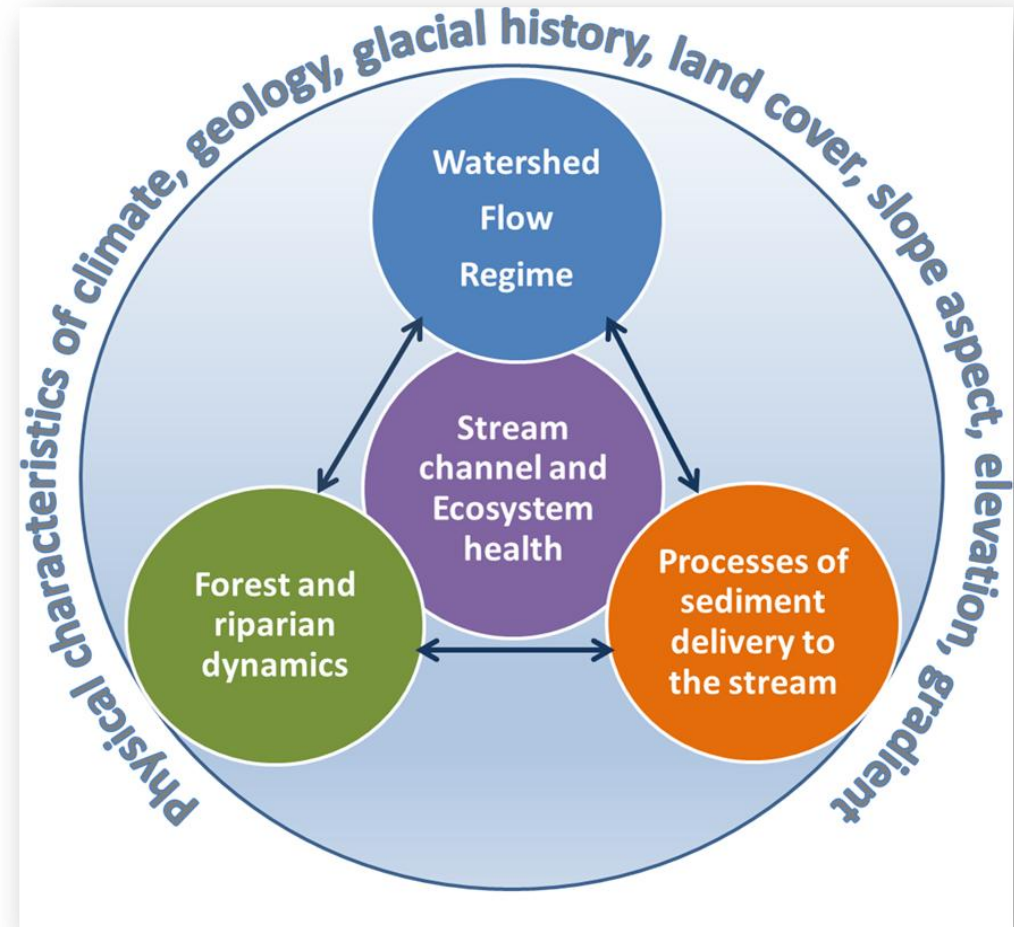
How has/will the processes of water, sediment and riparian function respond to changing landcover and climate?

- Is the watershed experiencing disturbance? Is it recovering from disturbance? Does it display a 'healthy' aquatic ecosystem?
 - What does a healthy aquatic ecosystem look like in a watershed?
- Gaining a process understanding of the watershed provides a holistic understanding of watershed sensitivity to landcover and climate disturbance



BC's Watershed Systems

- External controls



Landcover Controls



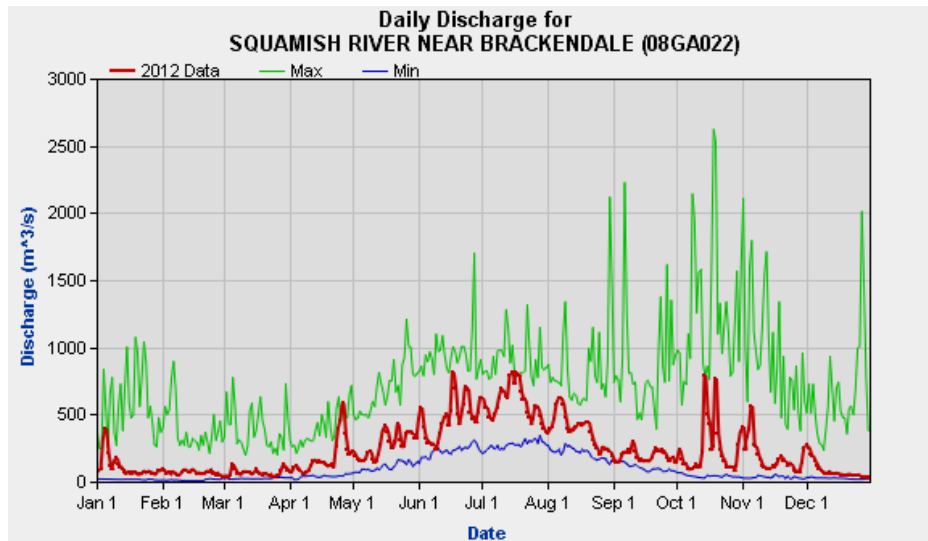
- Landcover intercepts precipitation and slows snowmelt in snowy regions
- Tree species vary in their capacity to intercept precipitation/snow and shade snowpack

Climate controls

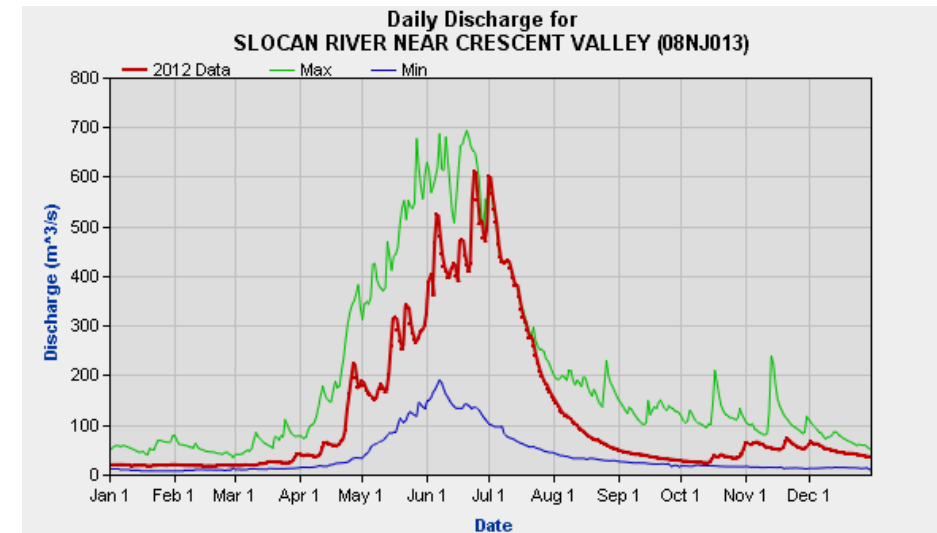
- Climate

- Rain versus snowmelt contributes to different annual hydrograph

- Maritime – rain (ROS)



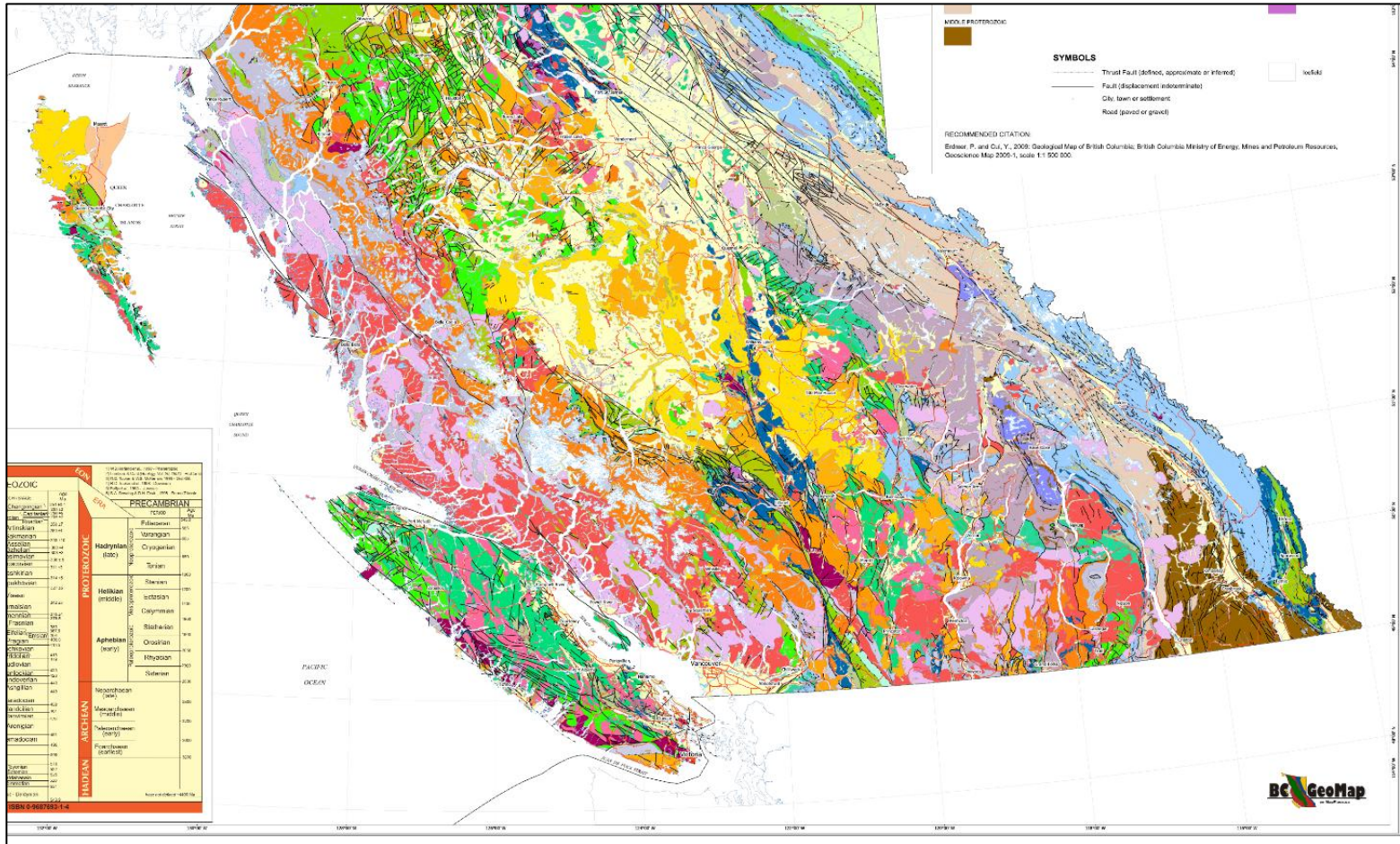
- Interior snowmelt - solar



- Peak flows in maritime hydrograph stem from rain fall intensity/duration and snow melt
- Peak flows in interior are snowmelt driven by solar radiation (and rainfall)

Geology controls

- Geology influences the caliber of sediment and glacial landforms
- Lardeau Gp Meta-sediments



- Nelson Batholith Granodiorite



Glacial Geology controls



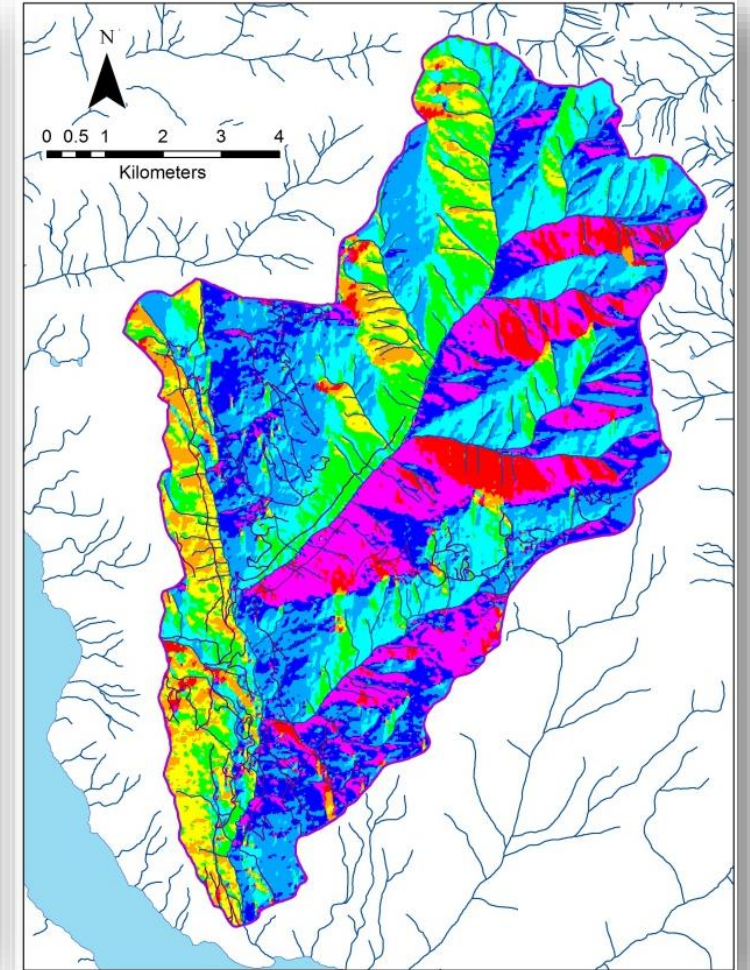
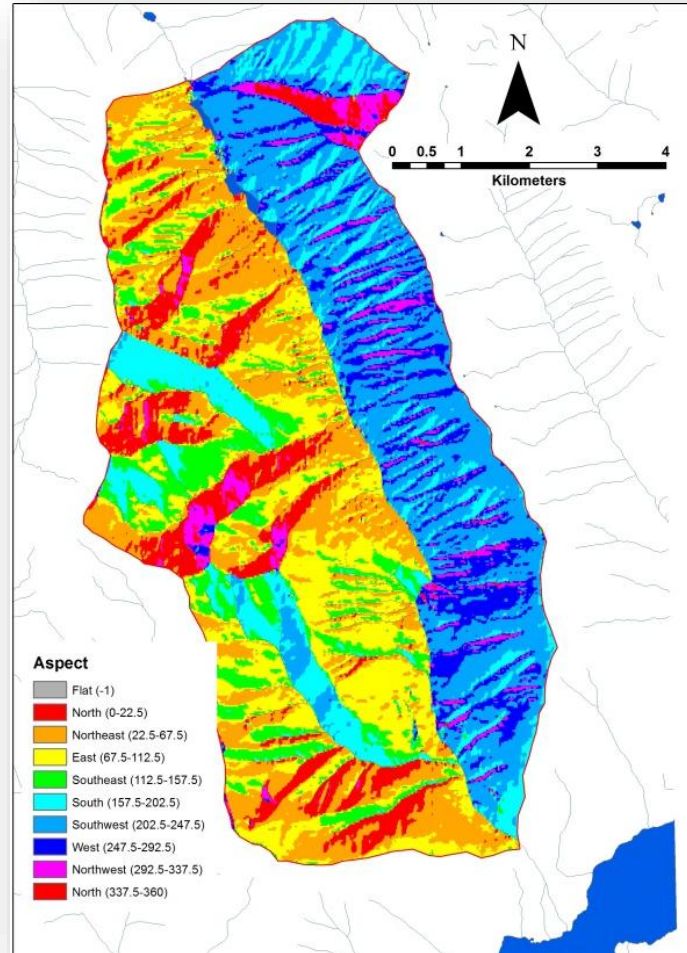
- Glacial 'entanglement' in fluvial processes and channel morphology
- These are not alluvial systems

Kame terrace – sediment deposited along the side of a valley glacier

Lag boulders in the stream from the kame terrace (not moved much in 10,000 years!)

Aspect controls

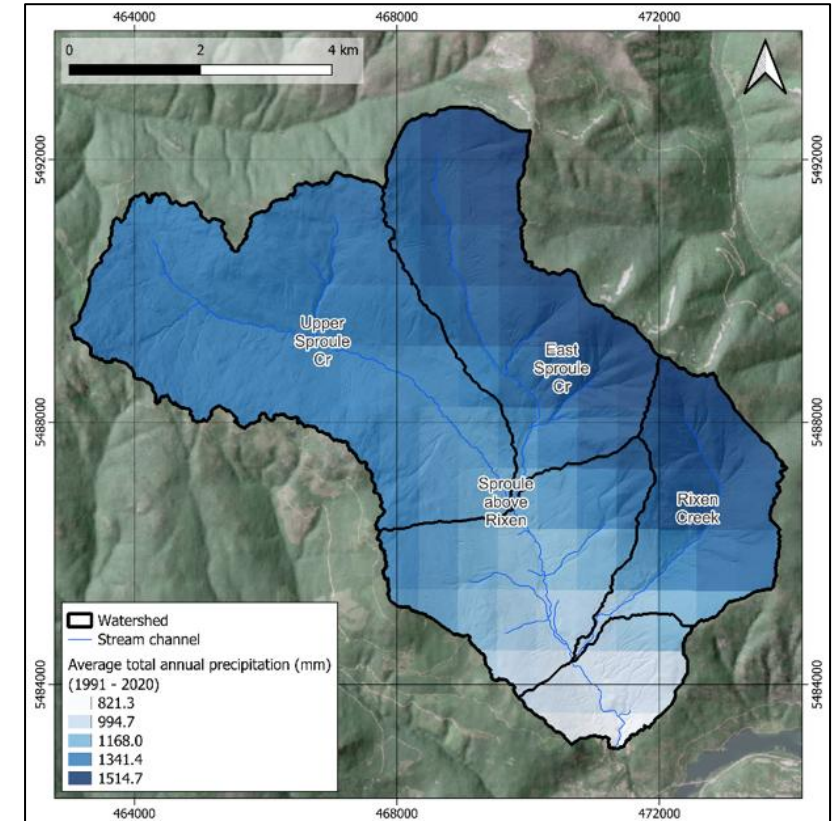
- Aspect distribution
 - Influences solar radiation in snowmelt and ROS regimes – which are reflected in the hydrograph
 - Influences wind and precipitation intensity in coastal regimes – which influences sediment delivery



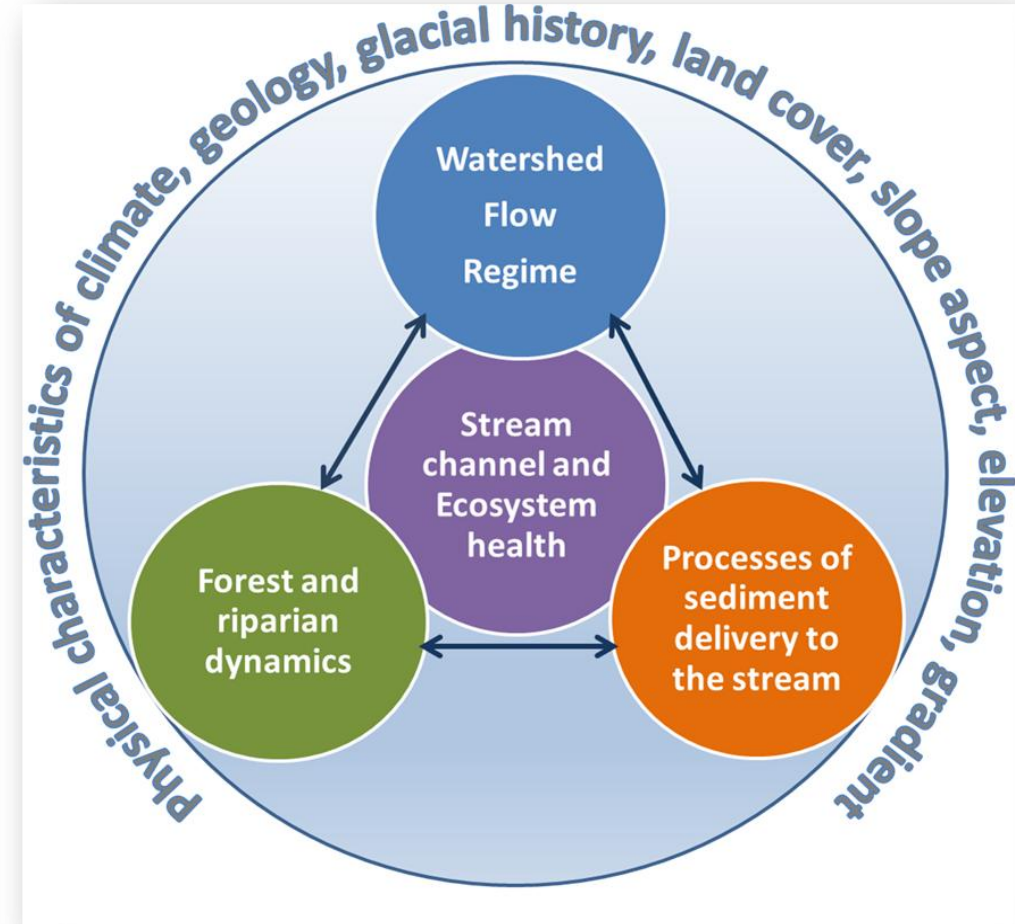
Topographic controls

The slope gradients and elevation range (relief) influences

- the rate and volume of water and sediment moving through a watershed
- the flood processes (debris floods vs clearwater) at work in the watershed.
- The flashiness of the peak flows, duration and volume of low flows

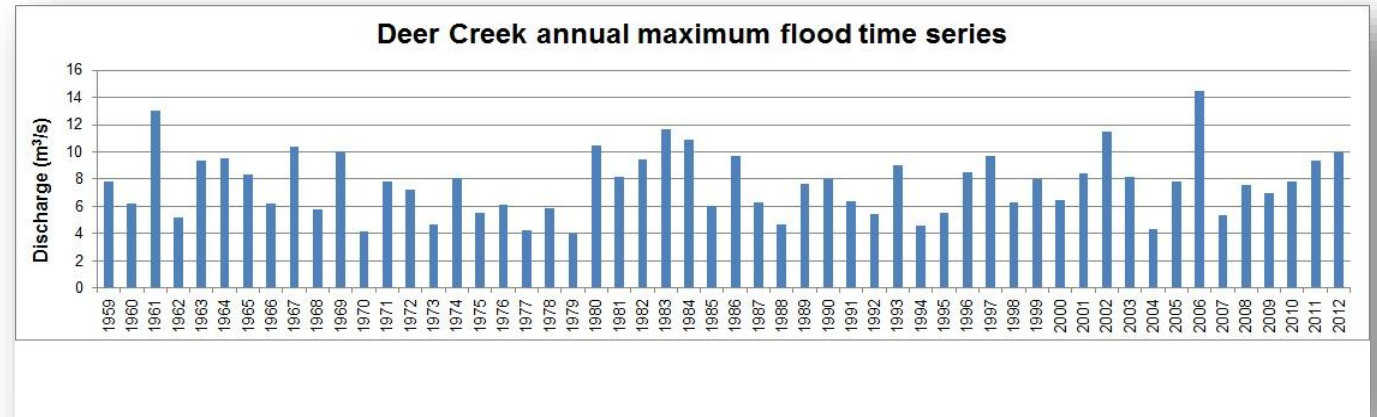
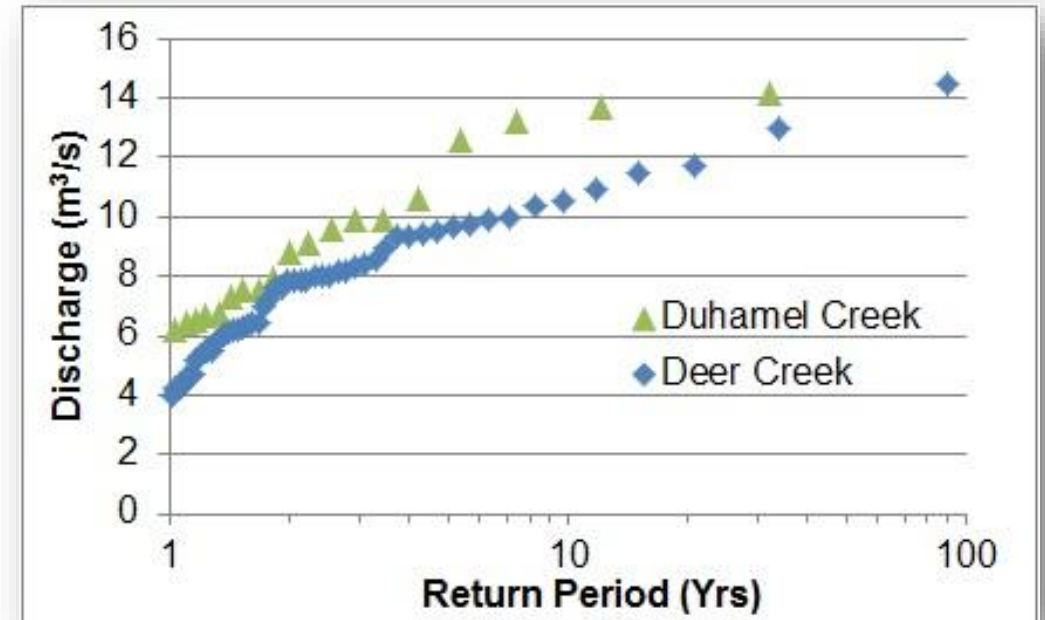
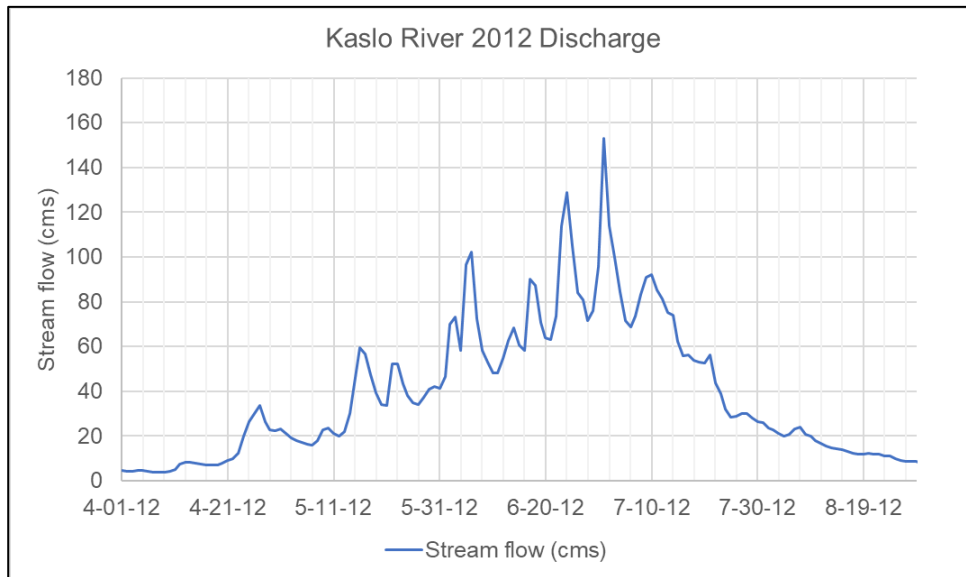


Inter-dependent processes



Watershed flow regime

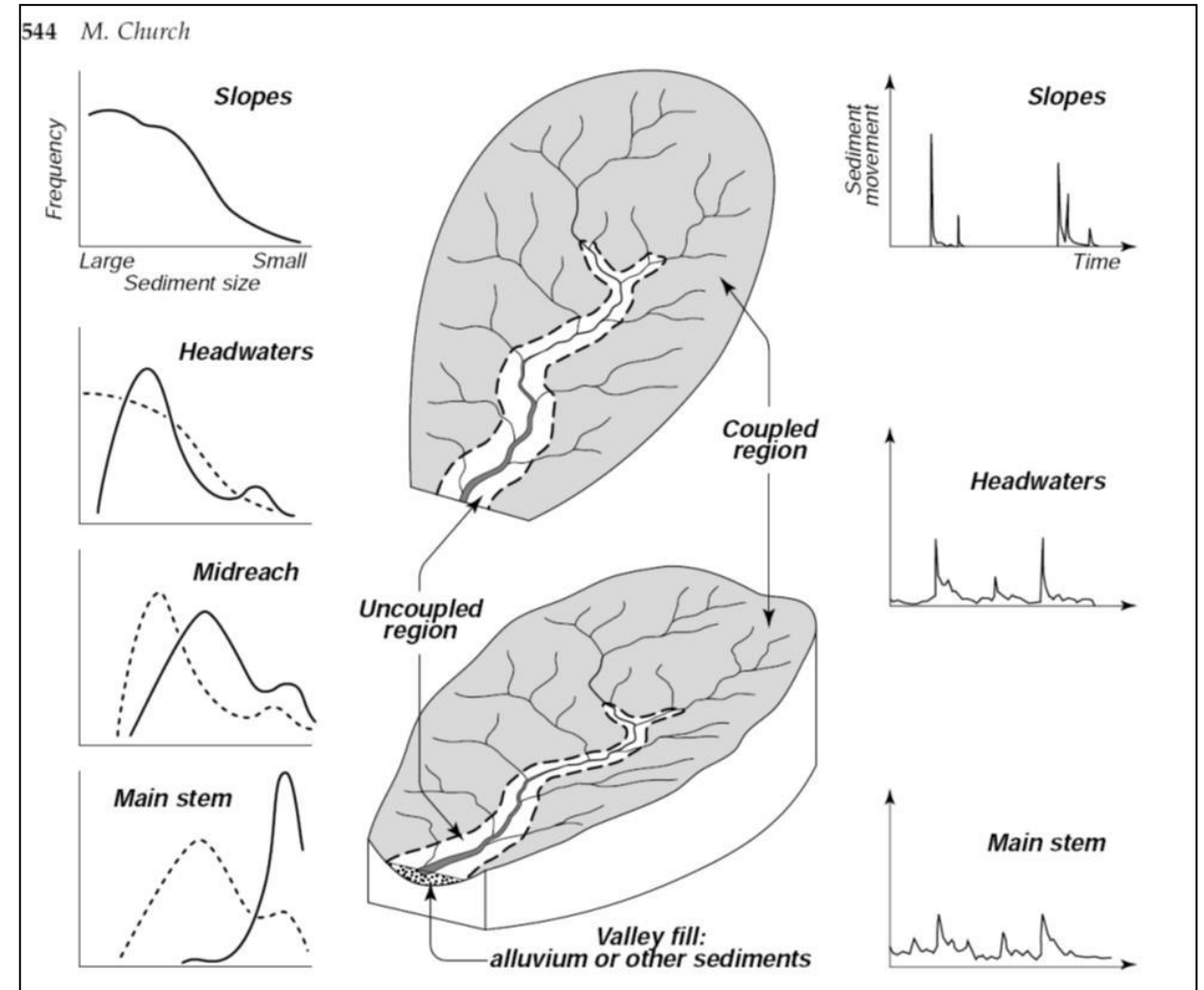
- Flow Regime
 - Flood regime
 - Frequency/magnitude of floods
 - Timing of peak flows
 - Duration of low flows
 - Rate of flow change



Watershed sediment regime

Sediment delivery and transport

- The rate and volume of sediment being delivered and mobilized and frequency of sediment moving events changes with increasing scale through a watershed
- This is because the sediment delivery/mobilizing processes differ between these different domains of the watershed



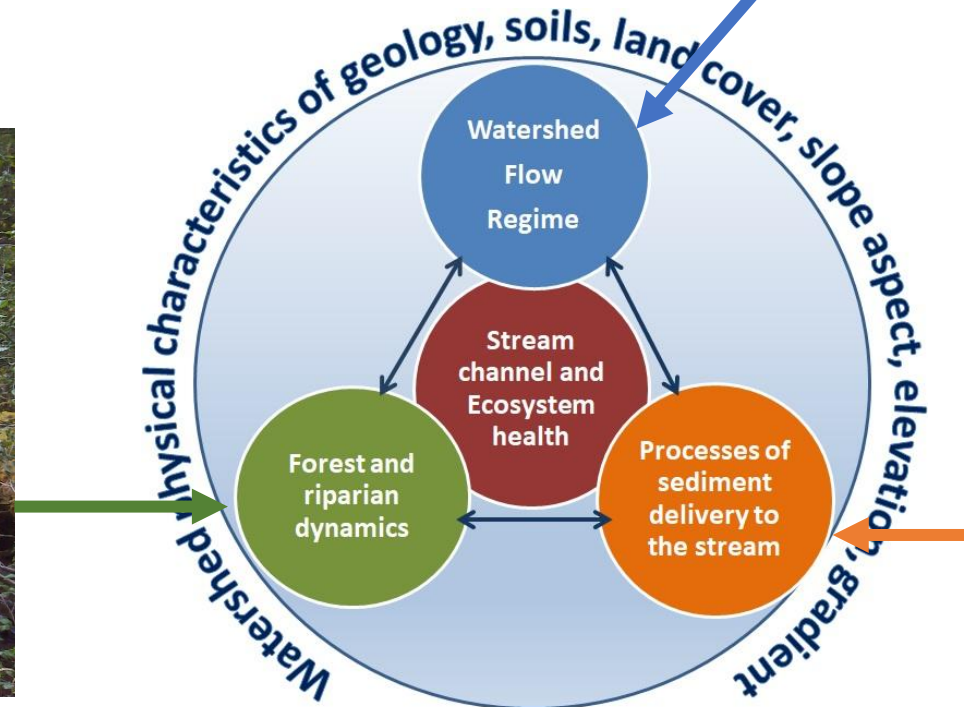
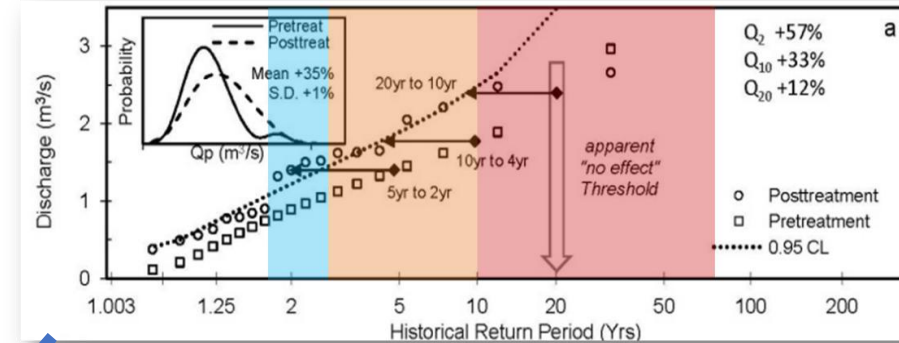
Watershed Riparian Function

- Roots protect channel banks and supply LWD to the channel that create jams.
 - reducing flow velocity ($V=(R^{2/3}*S^{1/2})/n$) and flow discharge ($Q=A*(R^{2/3}*S^{1/2})/n$)
 - reducing the rate of sediment transport (sediment storage sites).
 - Creating complexity (pools and riffles) to the channel bed
 - Where LWD is distributed along channel margins and oriented // to banks – providing armor to banks during bankfull flow
- Shade
- Nutrients
- Habitat for invertebrates and fish



Forest impacts on Watersheds systems

- Forest removal can directly impact each of the apex processes but their inter-dependence means that changes in one process results in changes in the other processes.
- Logging impacts on the **flow regime** and **sediment regime** can impact the channel and aquatic ecosystem system for decades.
- Logging impacts to **Riparian function** can destabilize a channel for centuries



The Harrop Creek Watershed System

