The Ultimate Hydrologic Sponge:

how the plumbing system of the Cascades controls streamflow and response to climate change in the Willamette (and Clackamas) Basins

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- Clackamas River hydrology: where does the water come from?
- How will climate change affect streamflow in the Clackamas and beyond?
- Implications for water management…

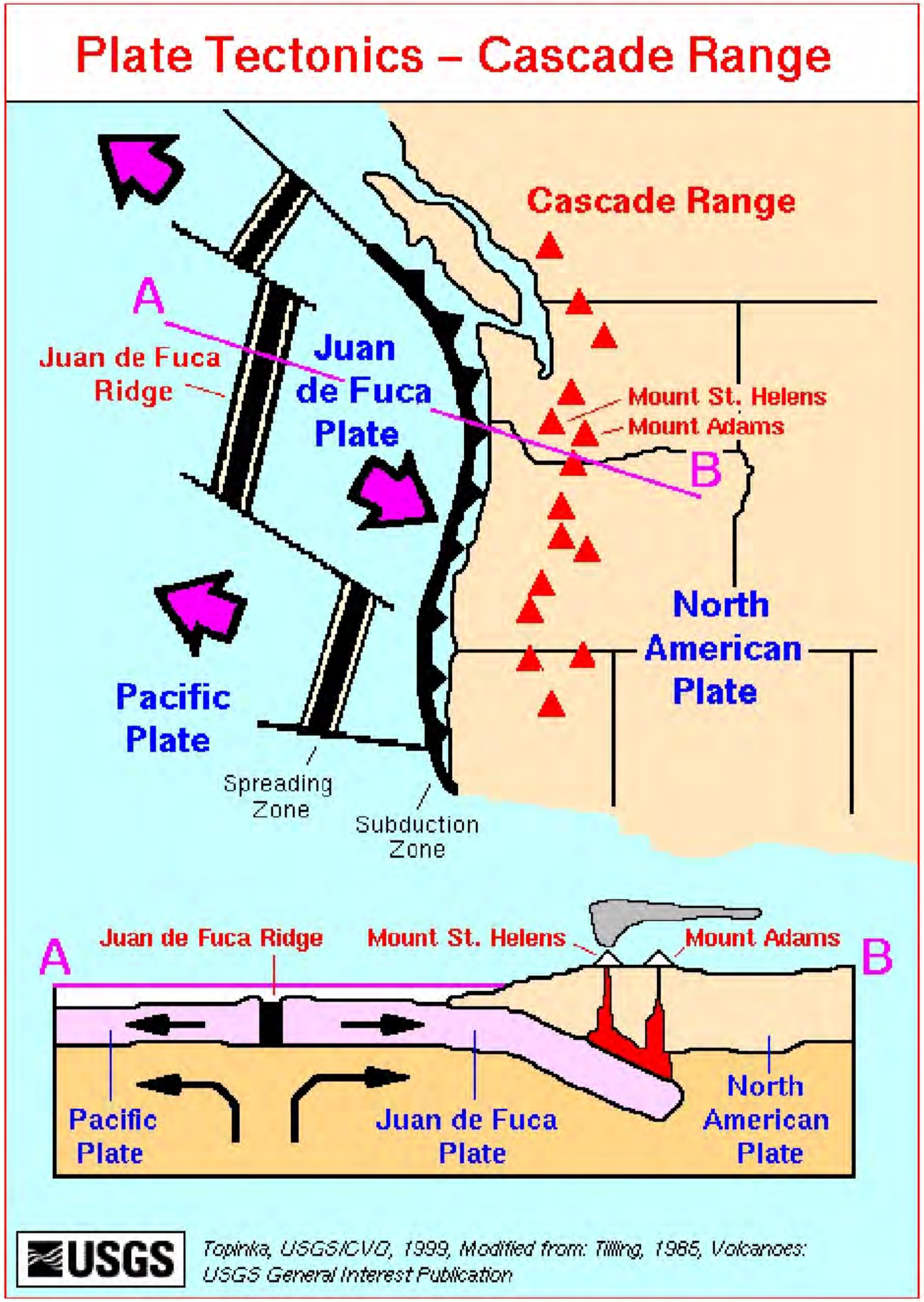
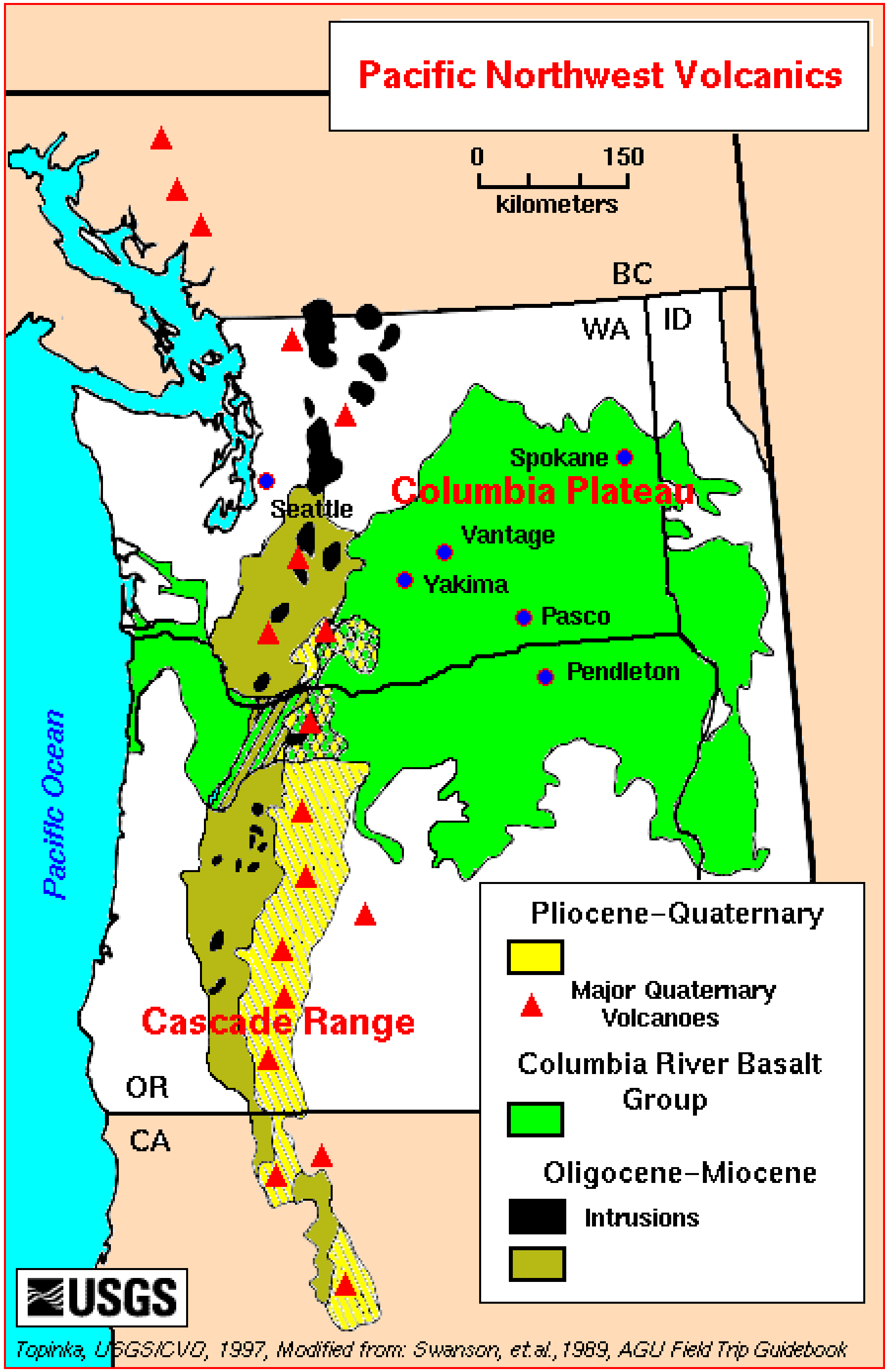
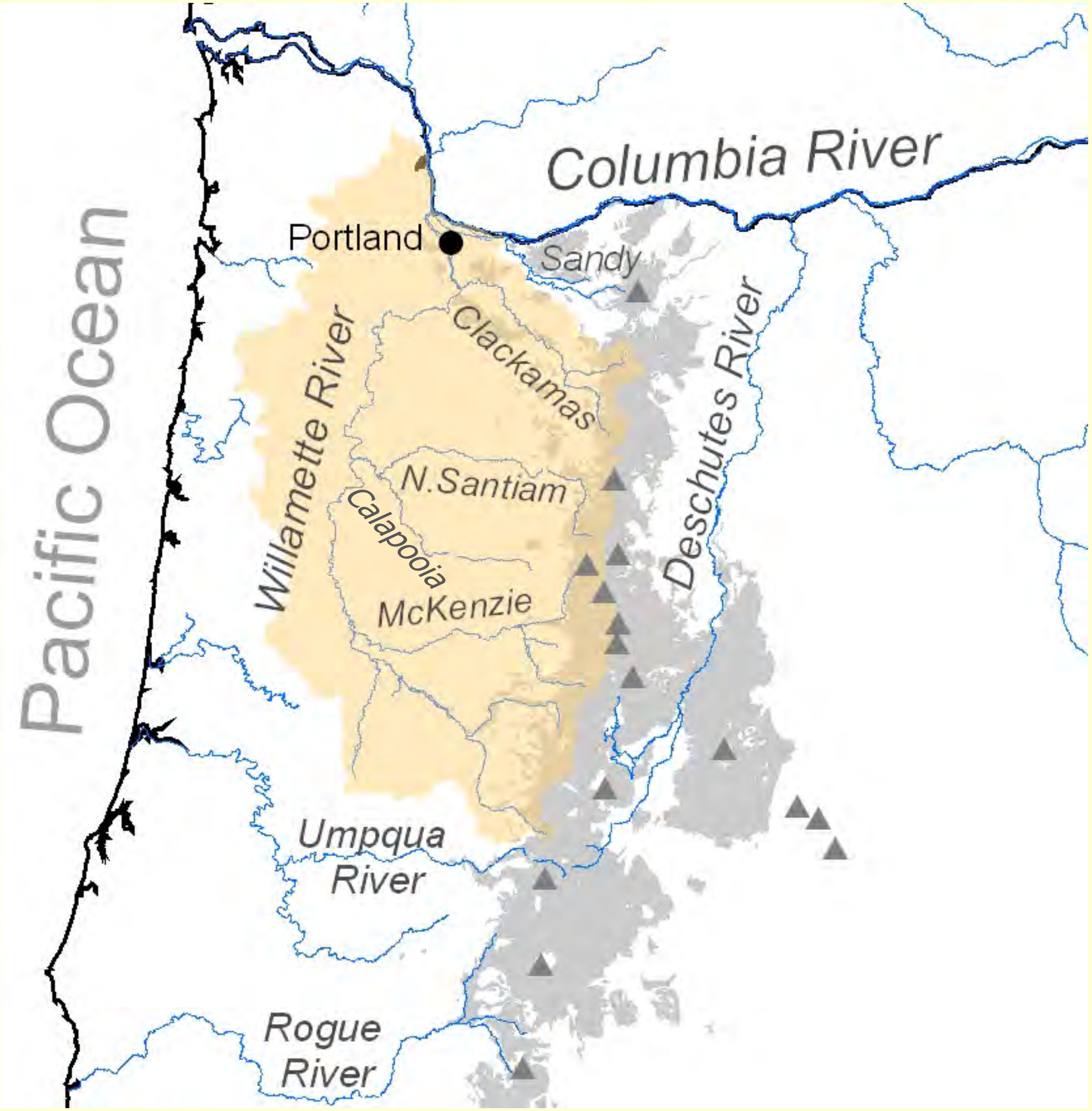


Plate Tectonics – Cascade Range
Cascade Range
A
Juan de Fuca Ridge
Juan de Fuca Plate
Mount St. Helens
Mount Adams
B
North American Plate
Pacific Plate
Spreading Zone
Subduction Zone
A
Juan de Fuca Ridge
Mount St. Helens
Mount Adams
B
Pacific Plate
Juan de Fuca Plate
North American Plate
USGS
Topinka, USGS/CVO, 1999, Modified from: Tilling, 1985, Volcanoes: USGS General Interest Publication



Pacific Northwest Volcanics
0
150
kilometers
BC
WA
ID
Spokane
Columbia Plateau
Seattle
Vantage
Yakima
Pasco
Pendleton
Pacific Ocean
Cascade Range
OR
CA
Pliocene–Quaternary
Major Quaternary Volcanoes
Columbia River Basalt Group
Oligocene–Miocene
Intrusions
USGS
Topinka, USGS/CVO, 1997, Modified from: Swanson, et.al., 1989, AGU Field Trip Guidebook

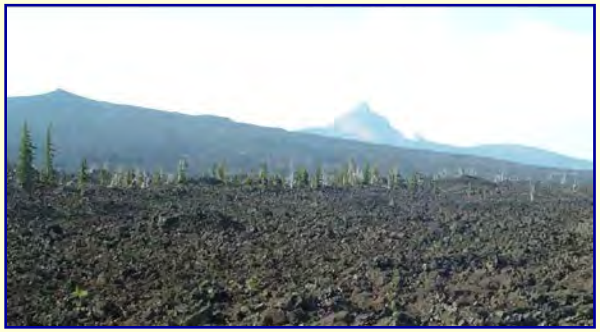
The Willamette: the Big Picture



- Drains an **uplifted, young volcanic arc**,
- squarely in the path of **westerly prevailing winds**,
- at a **temperate latitude**,
- near a **source of marine moisture**.

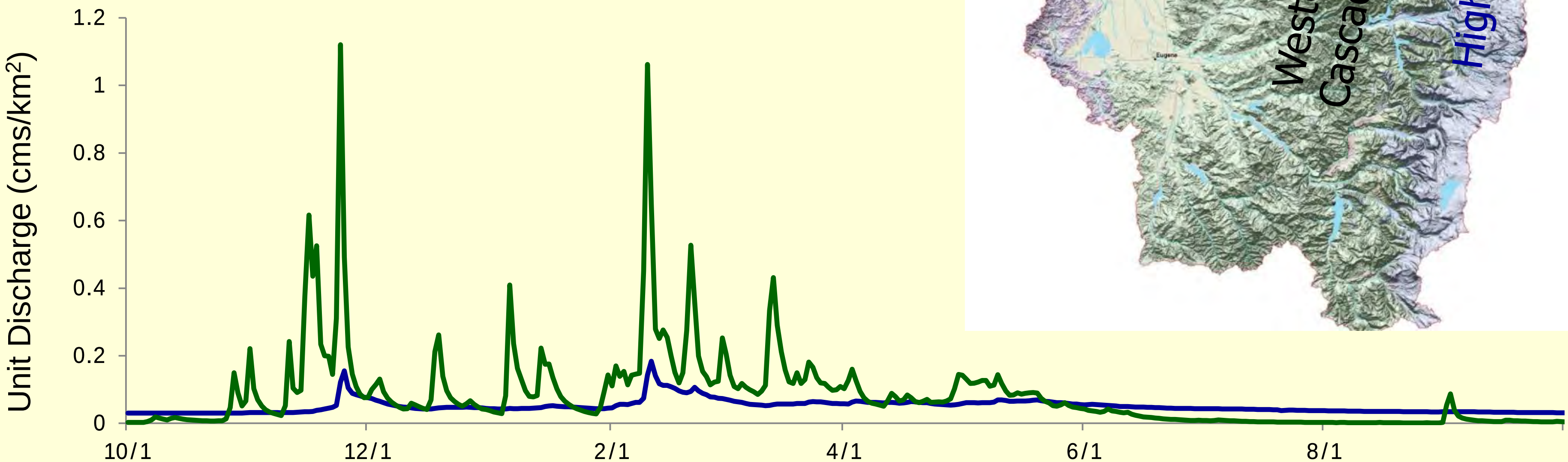
Western Cascades (surface flow)

Precipitation and snowmelt run off hillslopes directly and rapidly to stream channels.



High Cascades (spring-fed)

Precipitation infiltrates into young lava flows and emerges much later at large springs.



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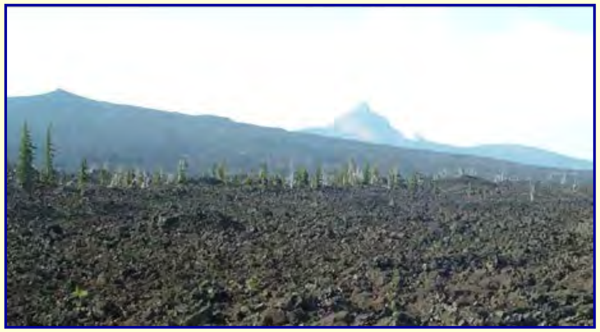

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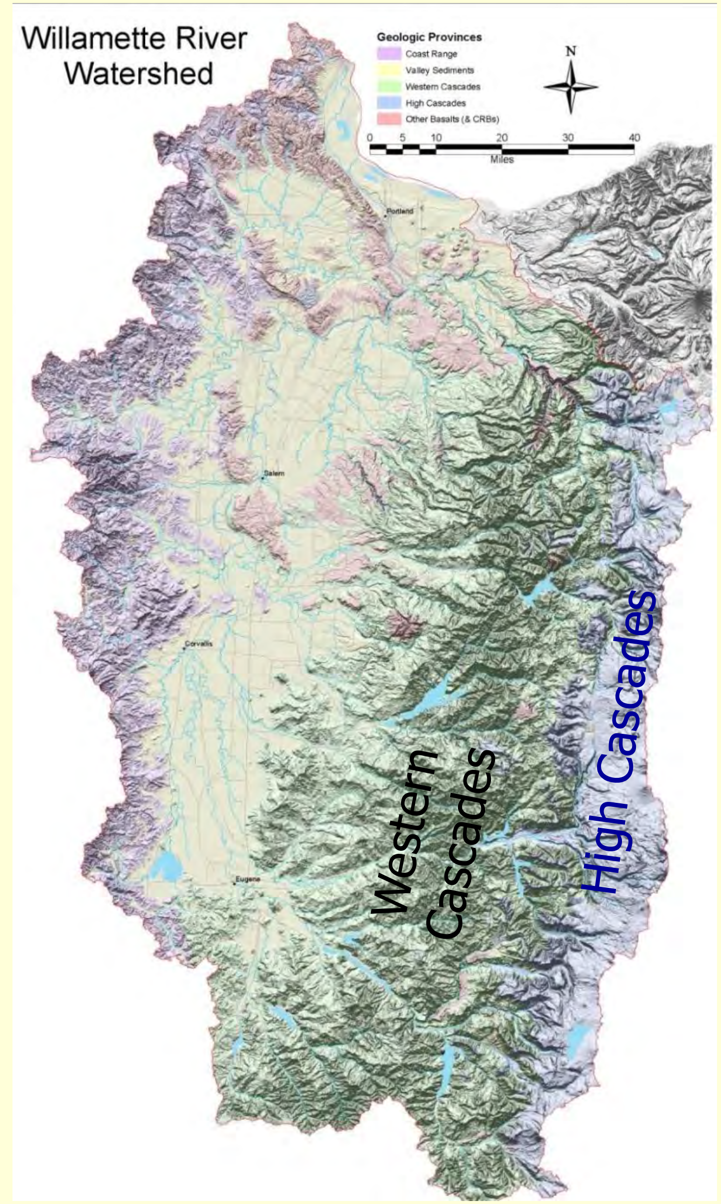
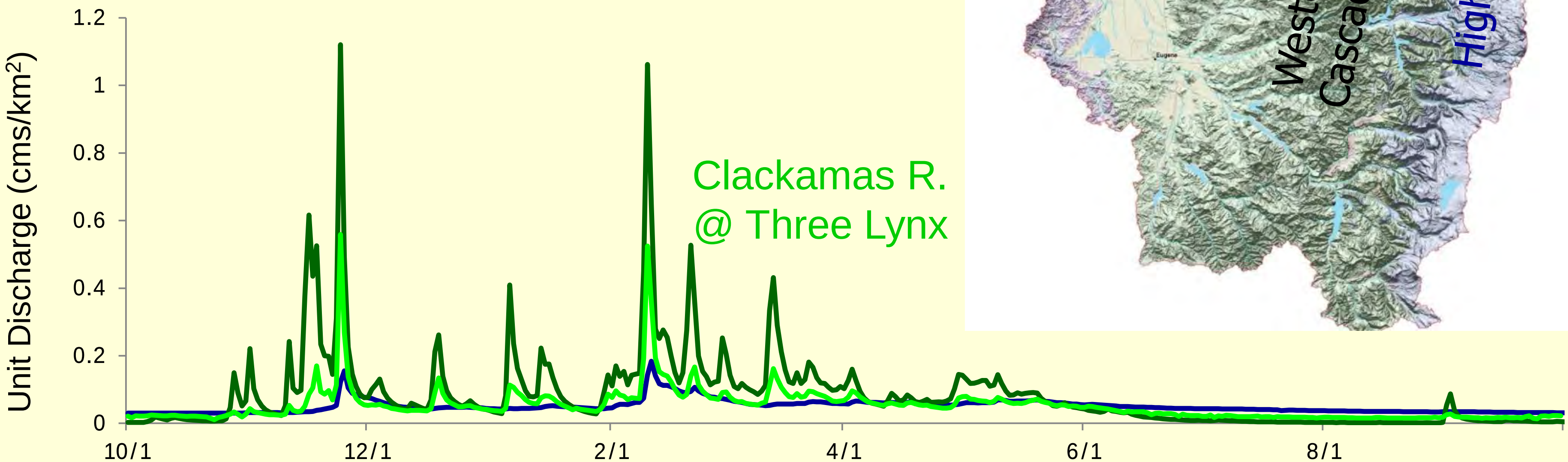
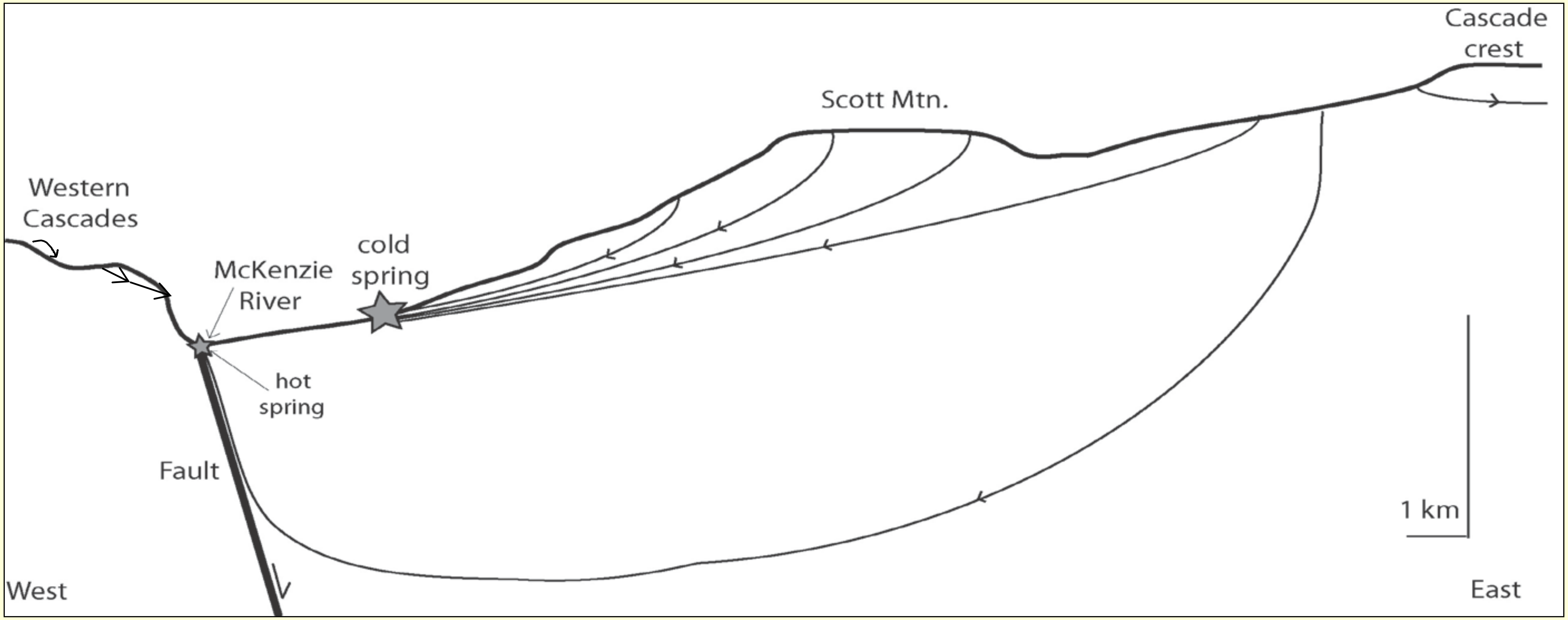




Groundwater flowpaths and geology

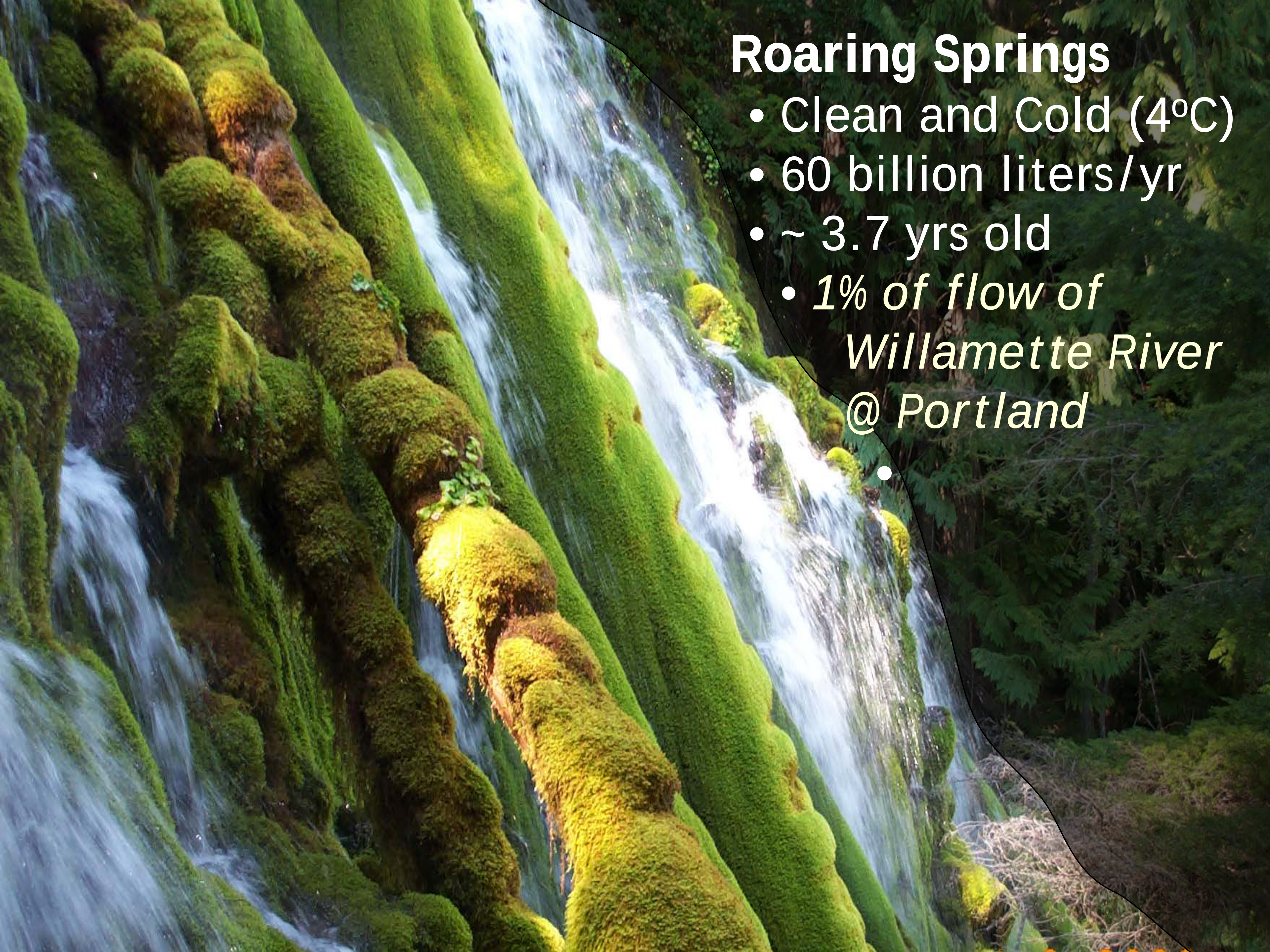


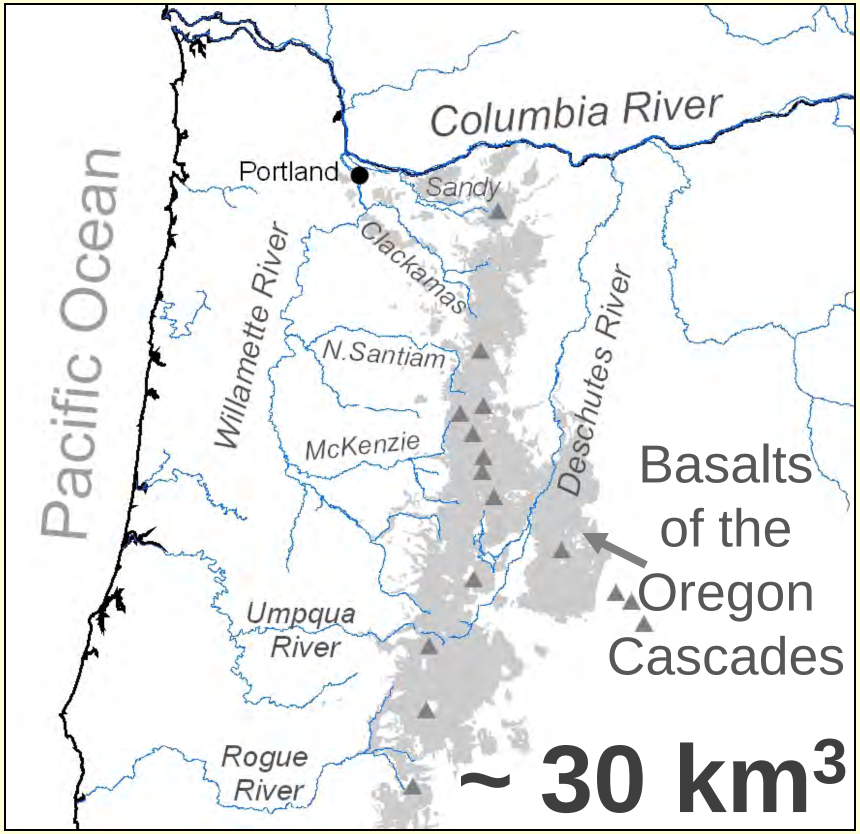
(Jefferson et al., 2006)

Cascade Springs

Roaring Springs

- Clean and Cold (4ºC)
- 60 billion liters/yr
- ~ 3.7 yrs old
  - *1% of flow of Willamette River @ Portland*

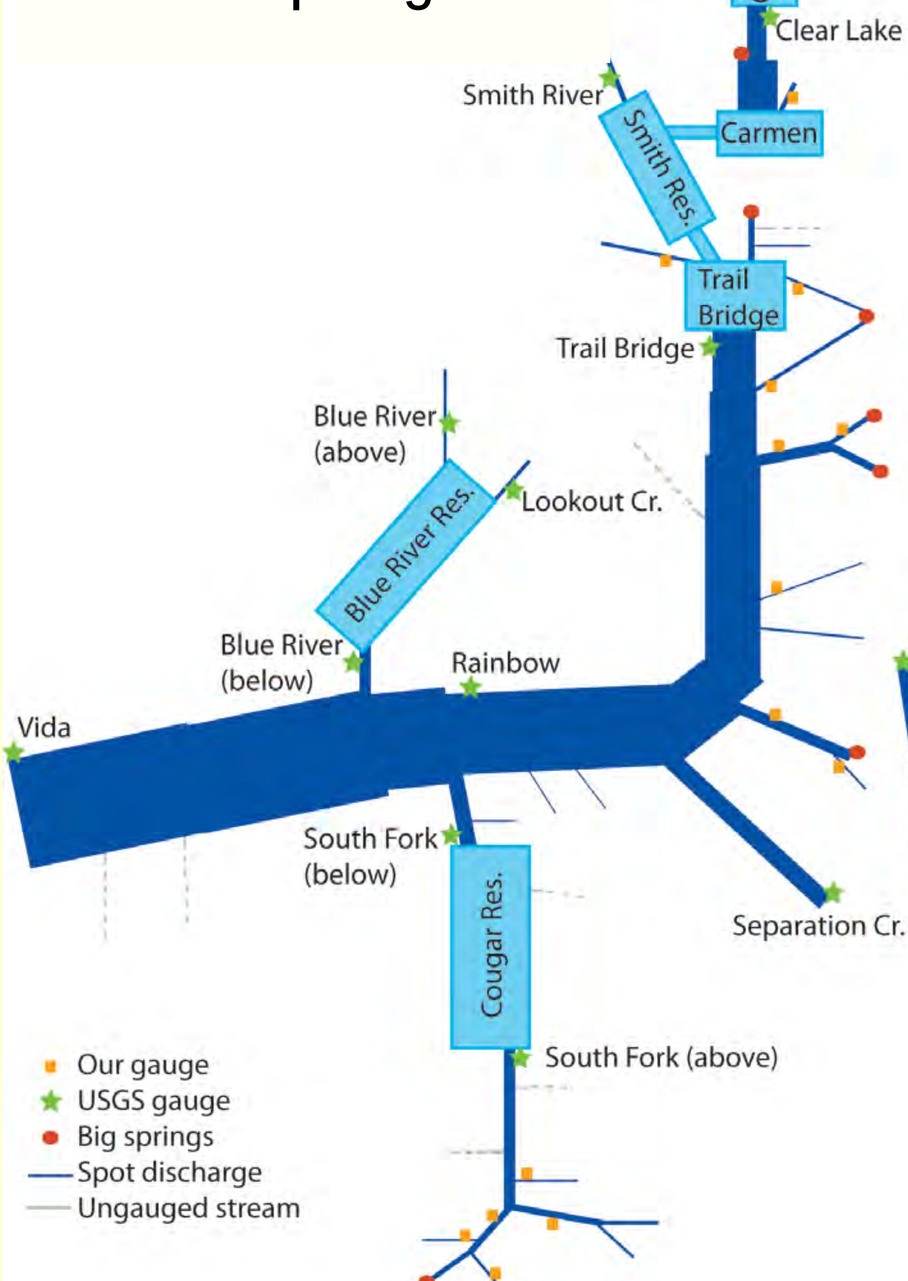



Columbia River
Pacific Ocean
Portland
Sandy
Clackamas
Willamette River
N.Santiam
McKenzie
Deschutes River
Basalts of the Oregon Cascades
Umpqua River
Rogue River
~ 30 km3

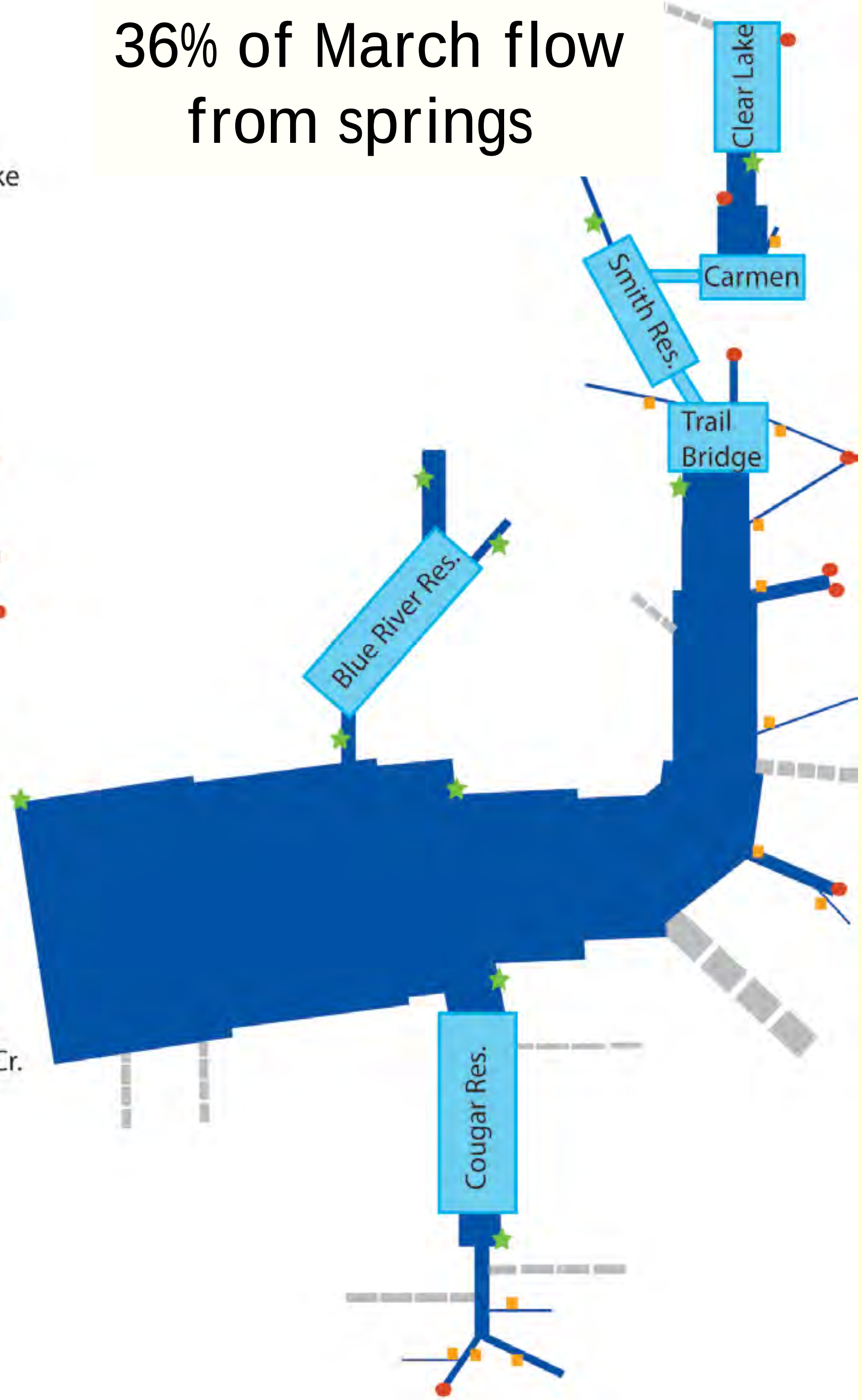

Crater Lake = 17km3
USGS
USGS Photo by Lyn Topinka, September 1982


Lake Mead = 35 km3

82% of August flow from springs

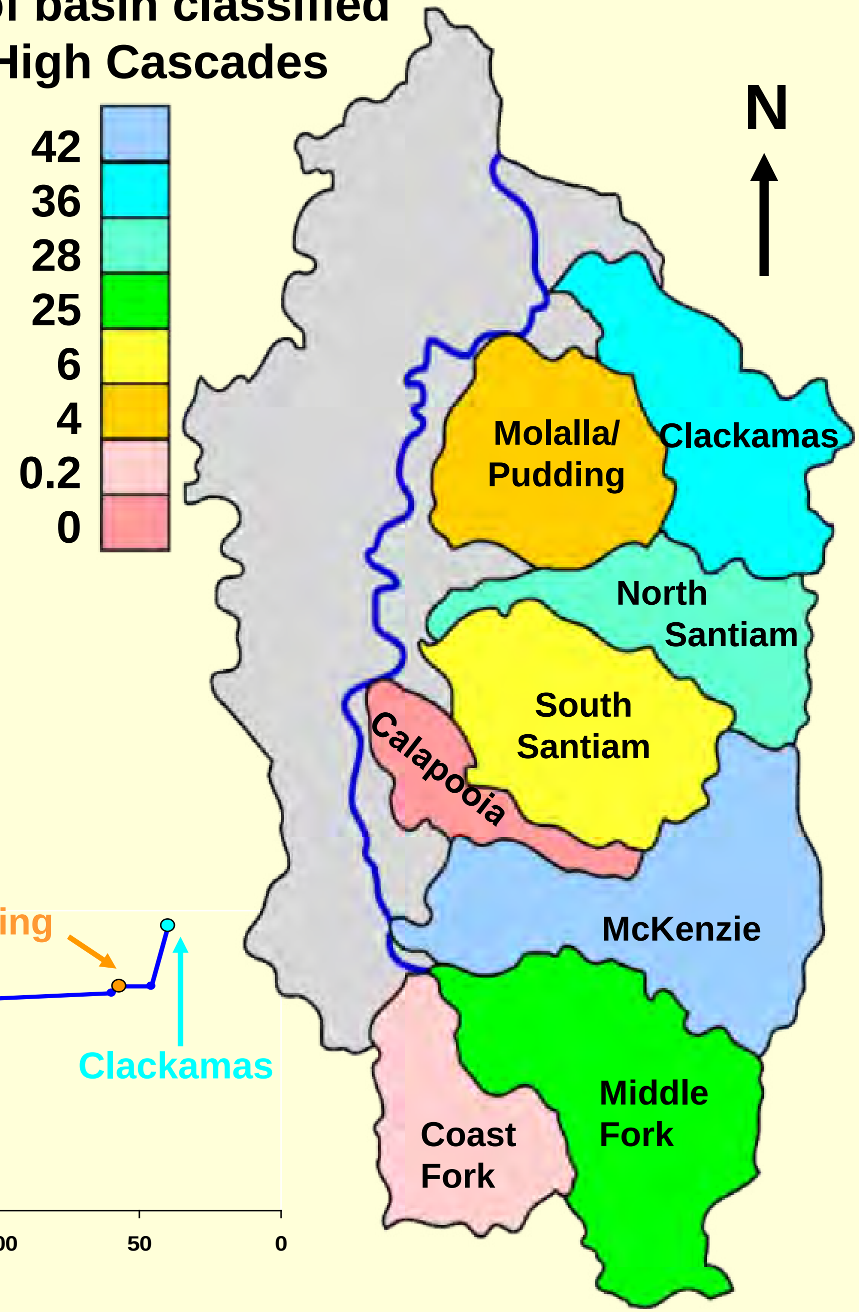


36% of March flow from springs

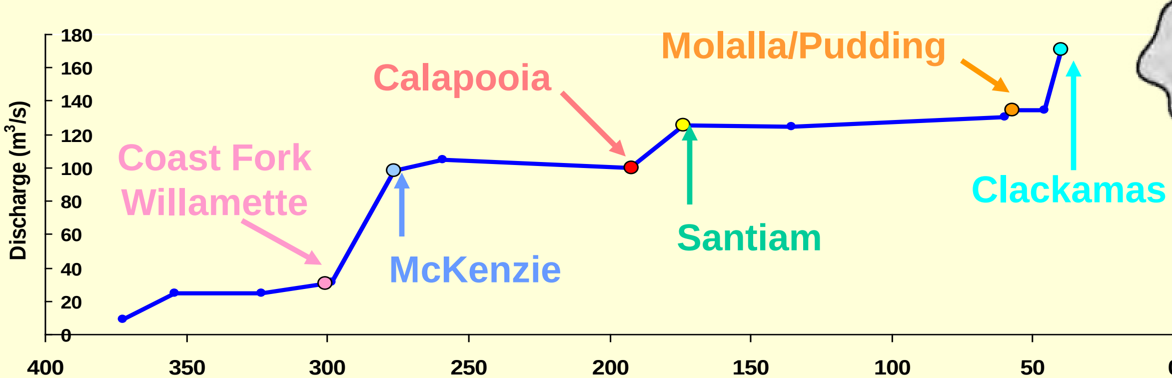


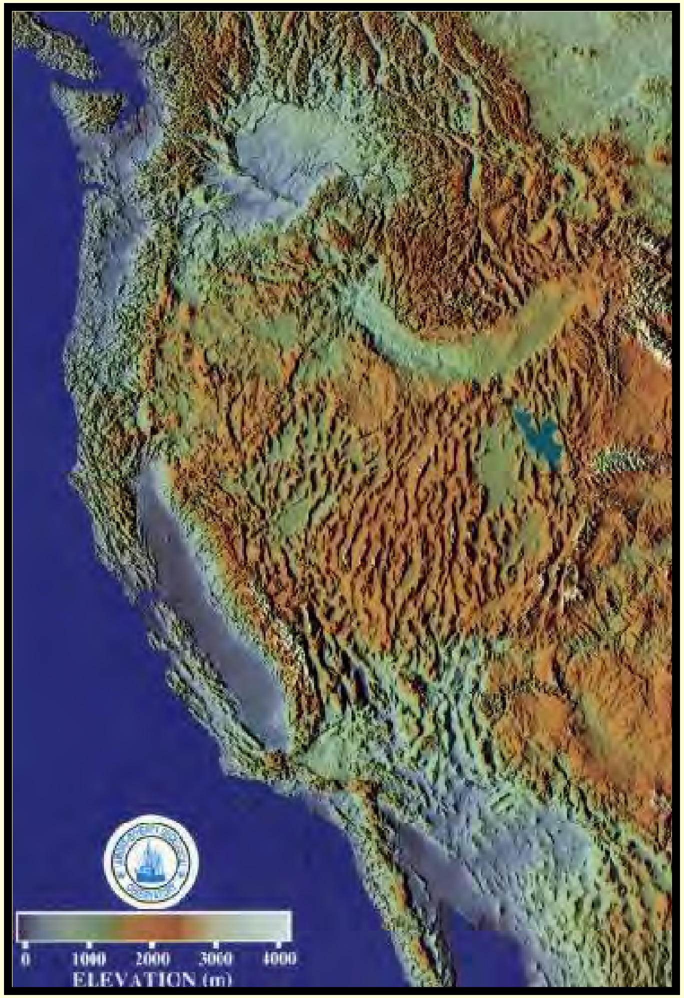
Willamette River at Portland

% of basin classified as High Cascades

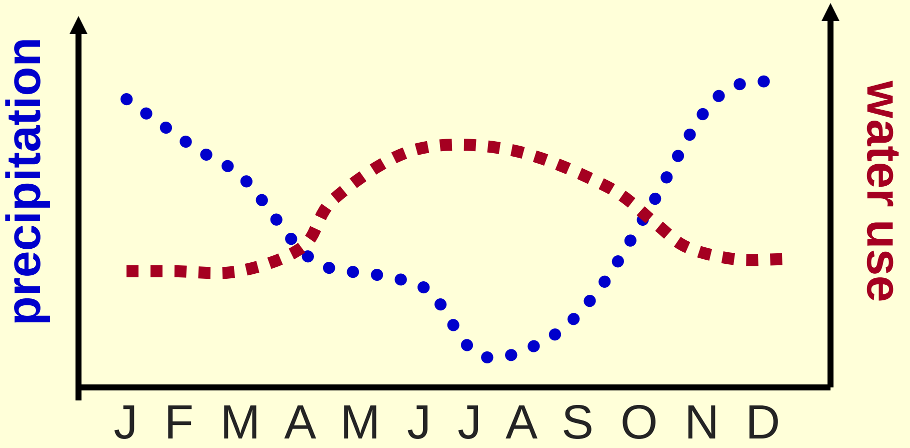


1950 Low Flow

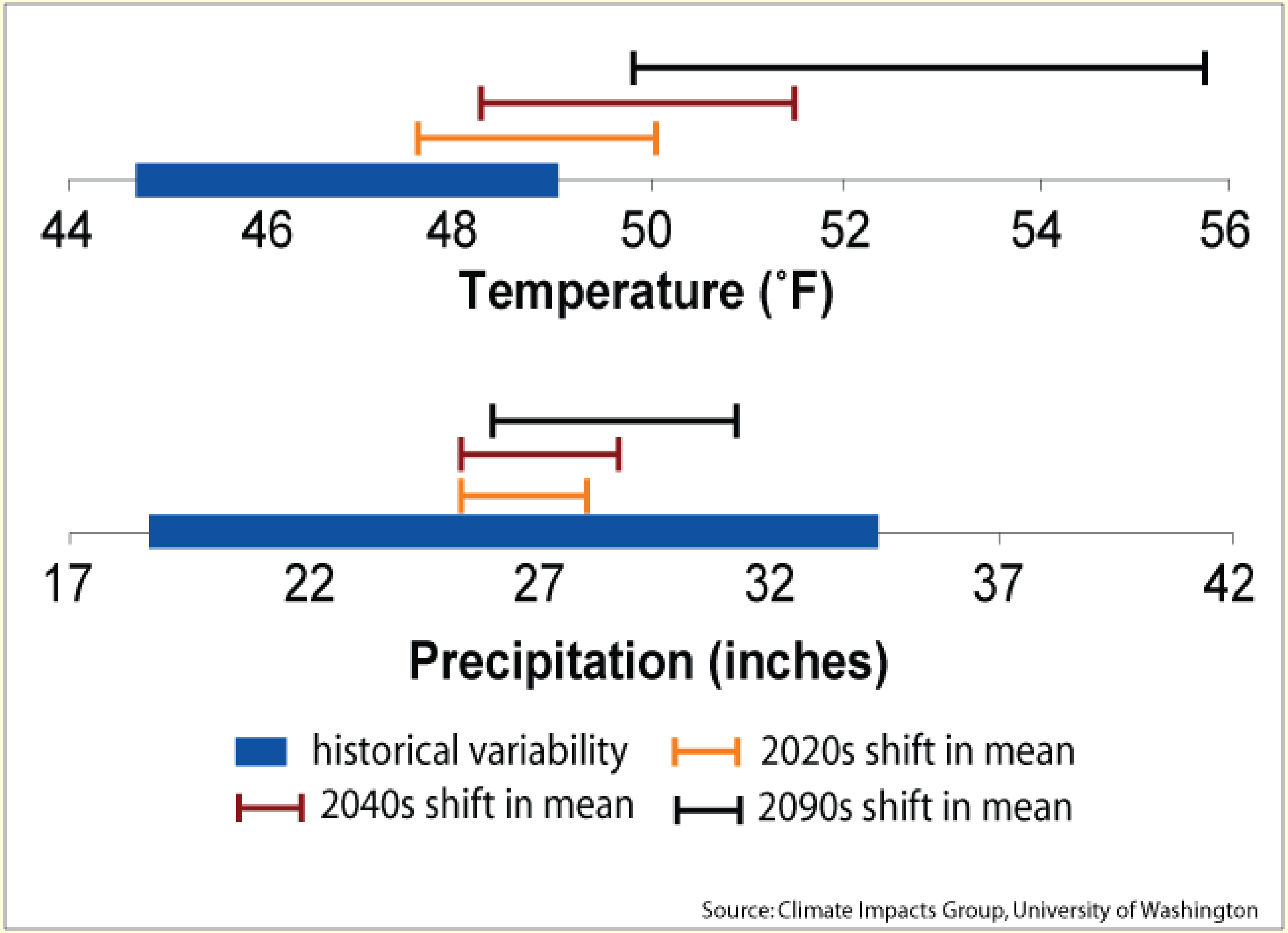




The Paradox of Water in the West…

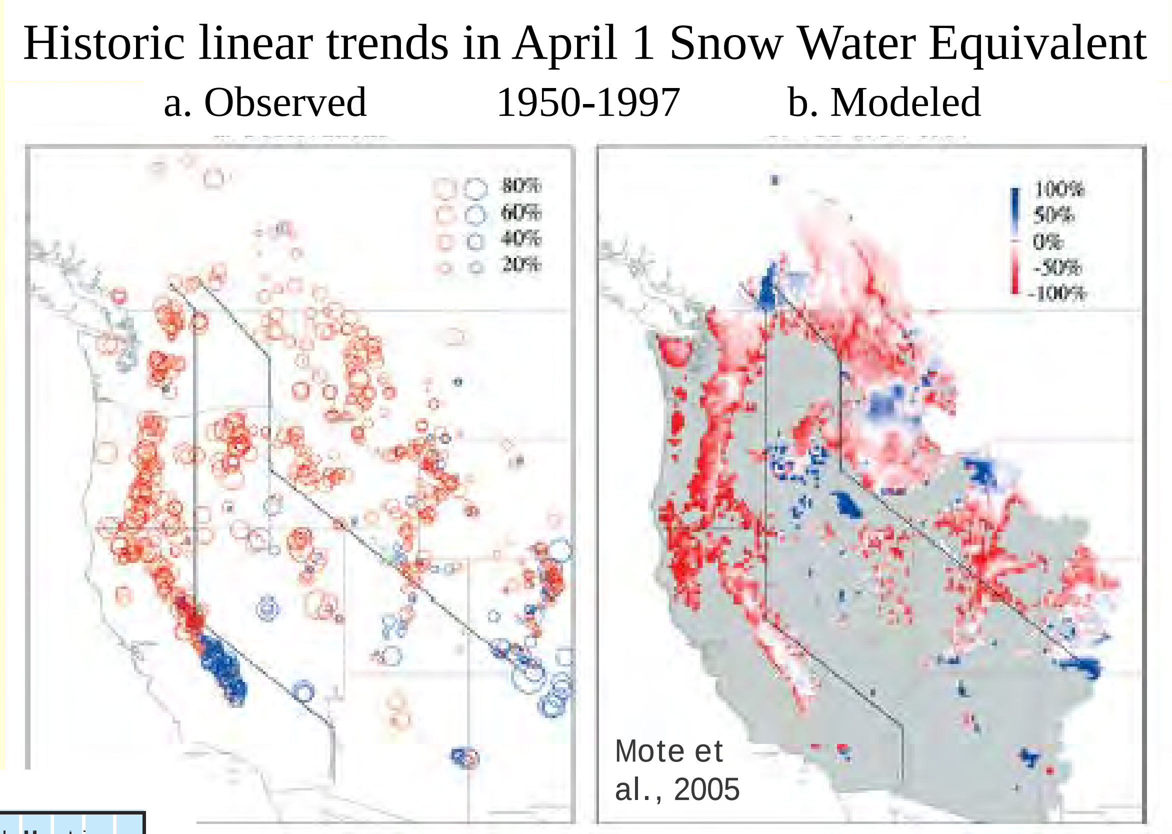


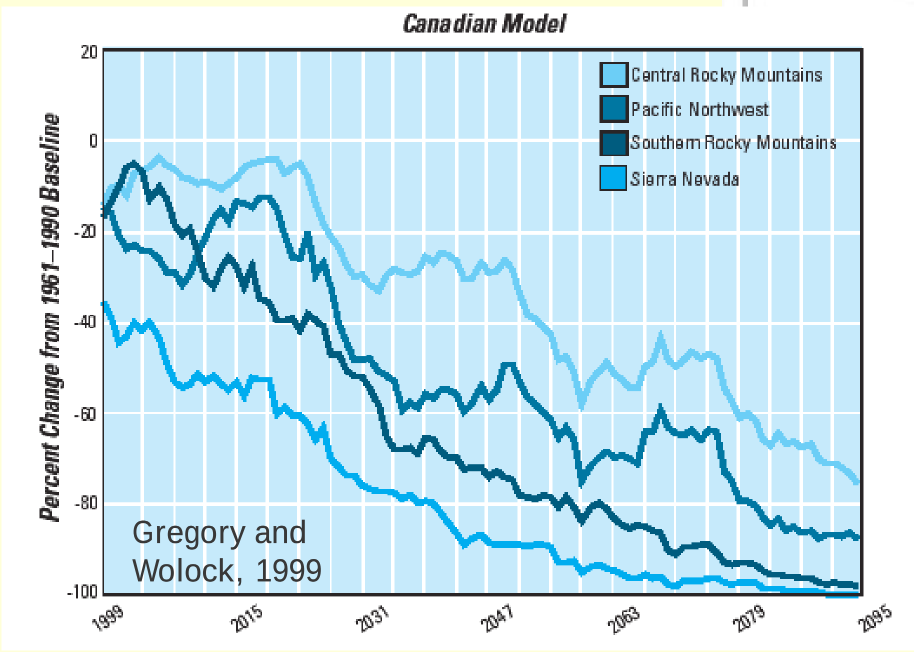
"The solution to our water problems is more rain" *Mark Twain*



average annual for Pacific Northwest

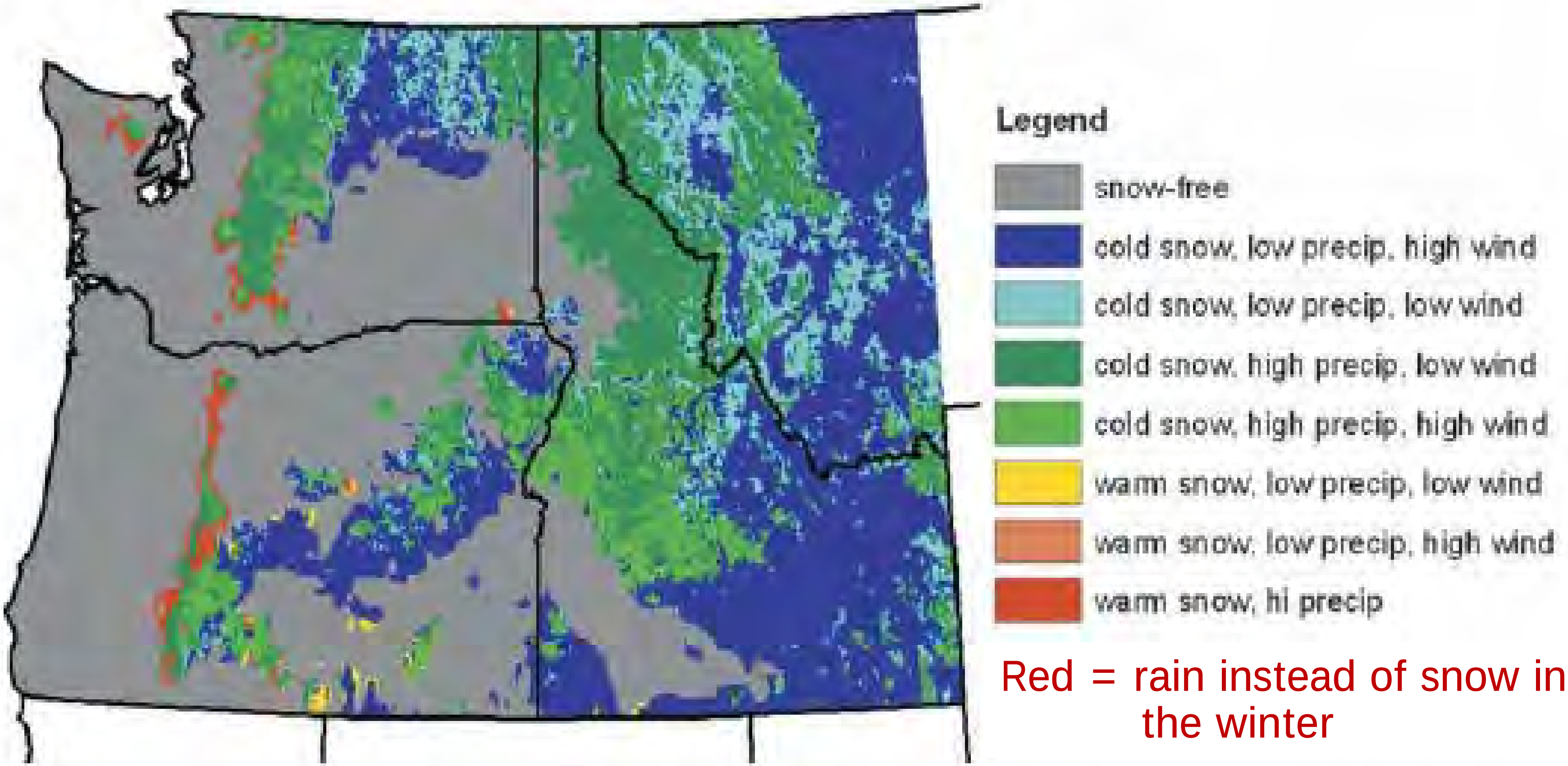
Snowpacks have gotten smaller, are melting earlier…





…and are projected to continue to diminish.

Snow at risk in a warming climate

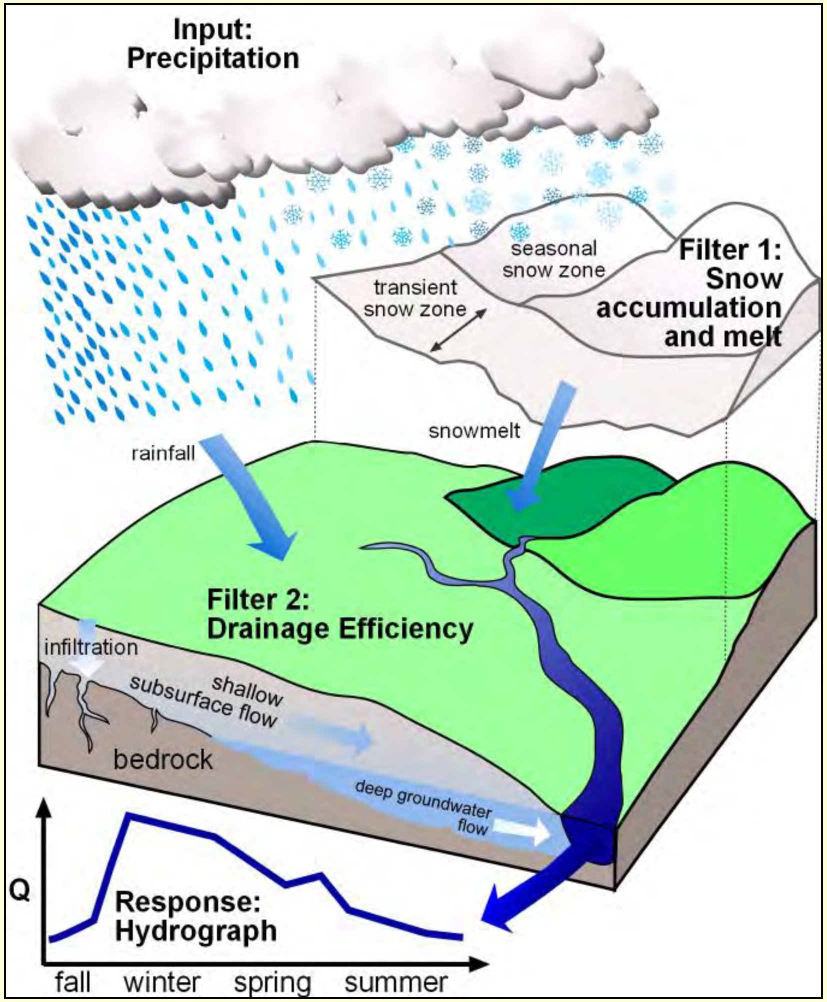


Red = rain instead of snow in the winter

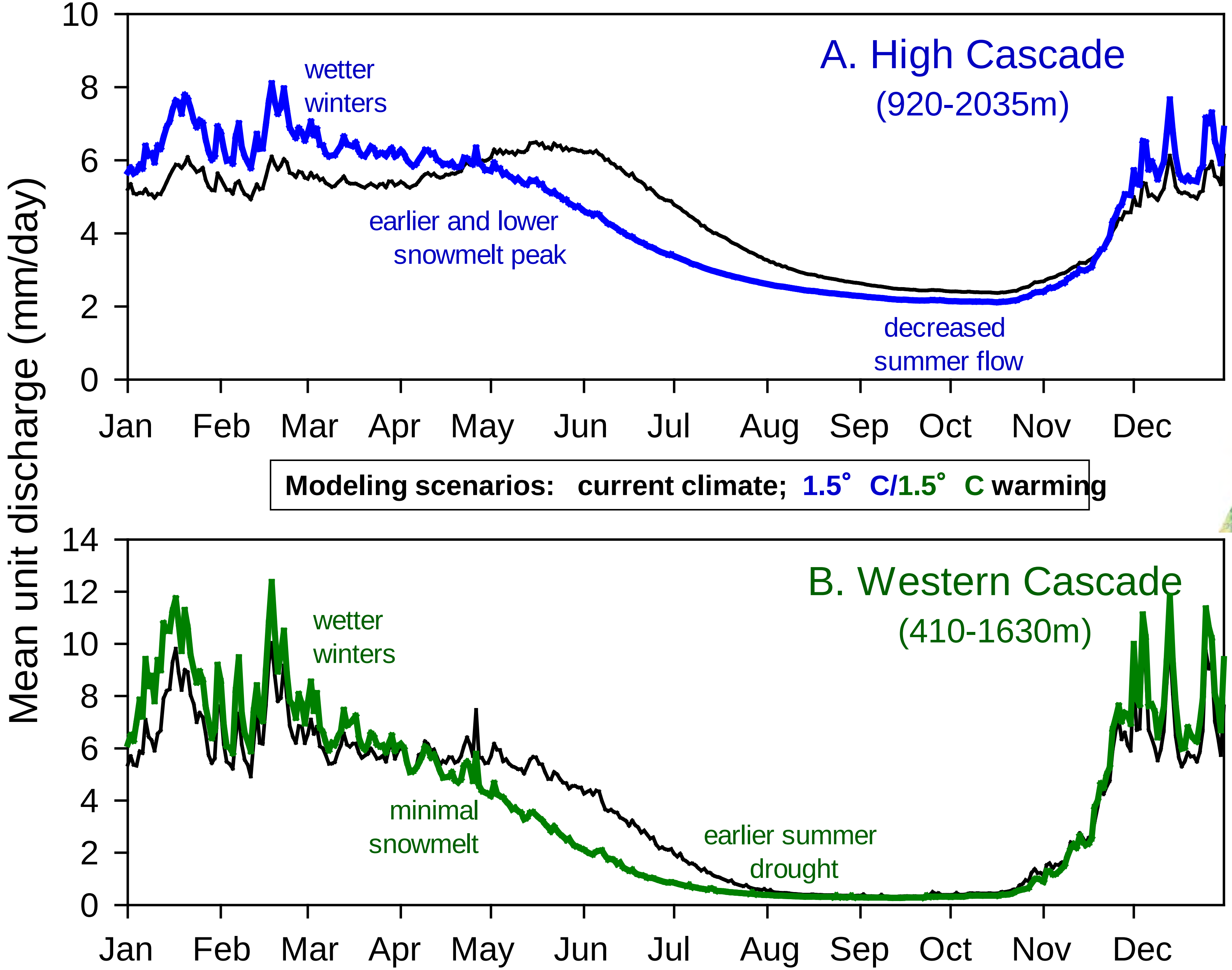
FIG. 3. Snow cover classification using a rain–snow threshold of 0°C. At-risk snow is shown in red.

22%	Oregon Cascades
12%	Washington Cascades
61%	Olympic Range
<3%	Pacific Northwest study area

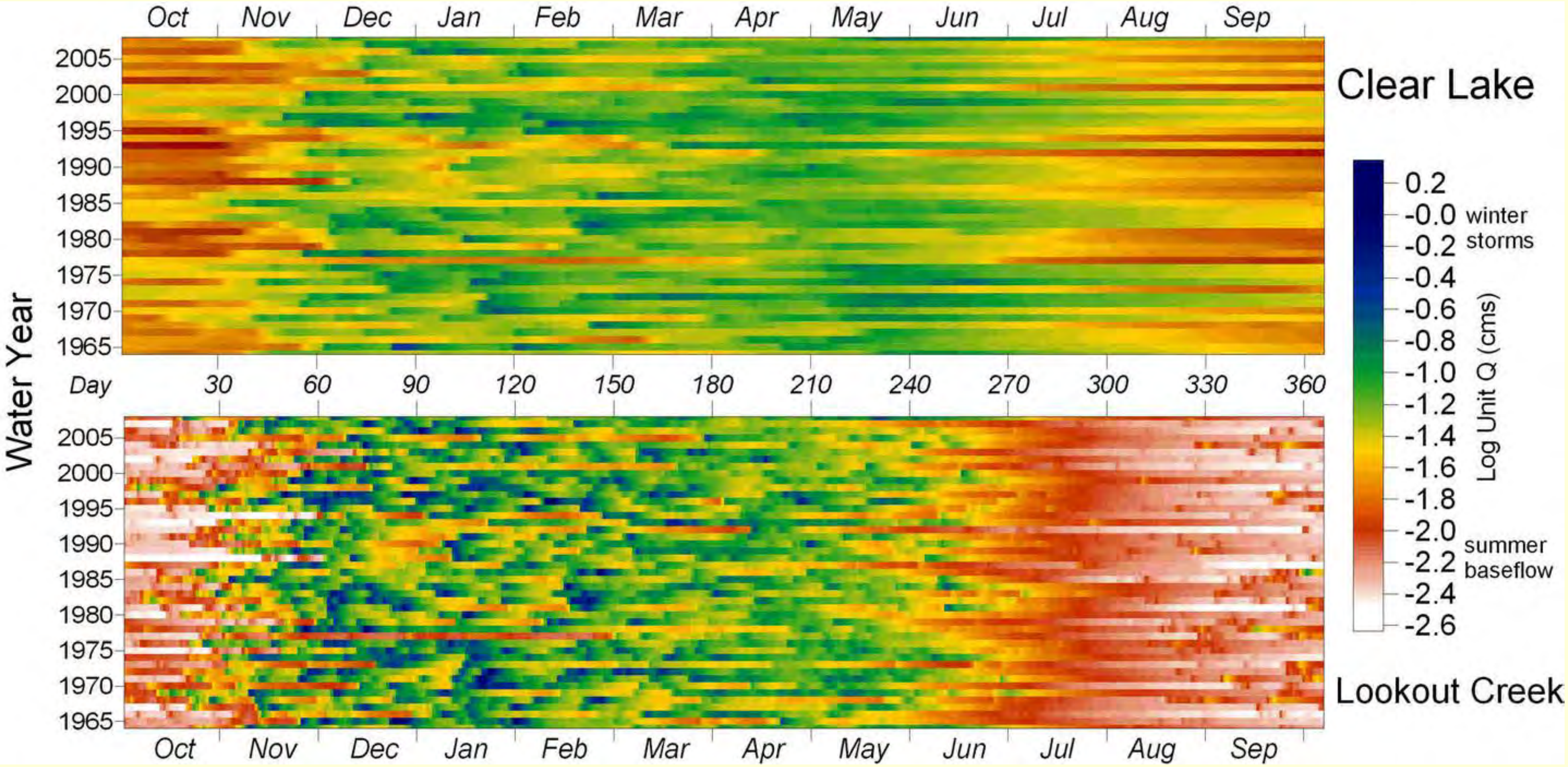
(Nolin and Daly, 2006)

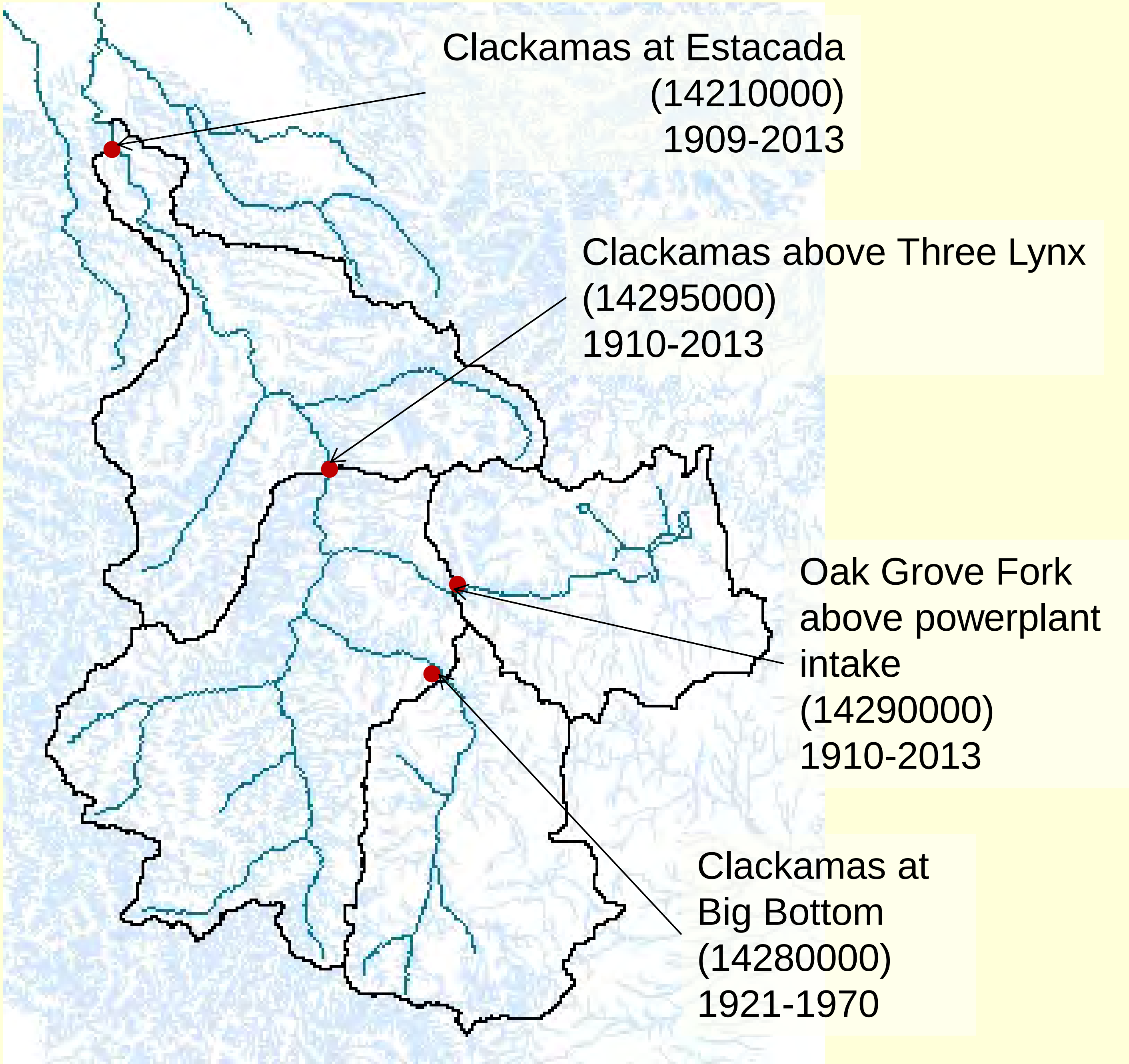


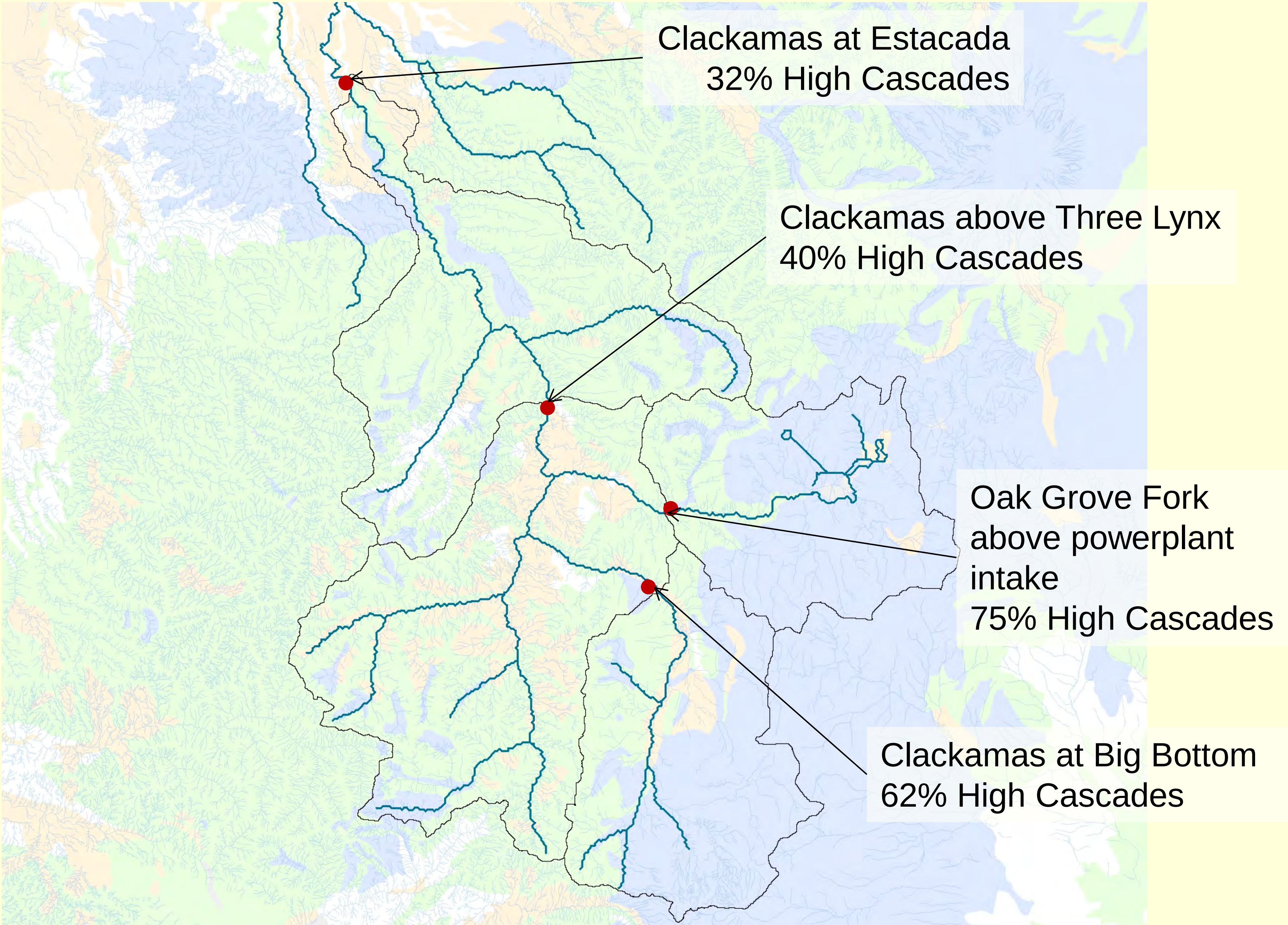
How will the interplay of snowpack dynamics and landscape drainage efficiency affect streamflow regimes under climate warming scenarios?


Mean unit discharge (mm/day)
A. High Cascade
(920-2035m)
wetter
winters
earlier and lower
snowmelt peak
decreased
summer flow
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Modeling scenarios: current climate; 1.5° C/1.5° C warming
B. Western Cascade
(410-1630m)
wetter
winters
minimal
snowmelt
earlier summer
drought
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

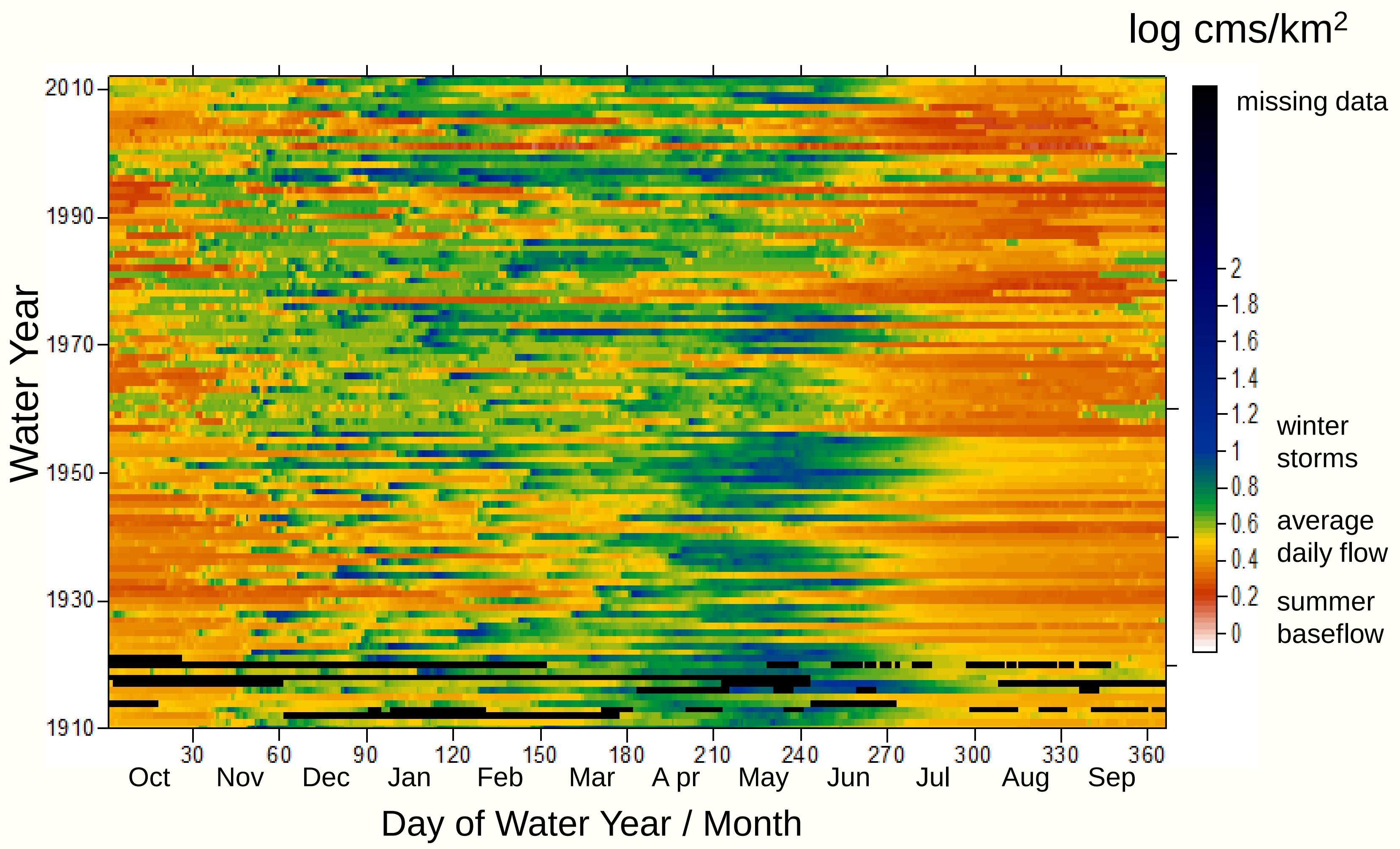
Daily discharge (log unit m^3/s) for 1964-2007

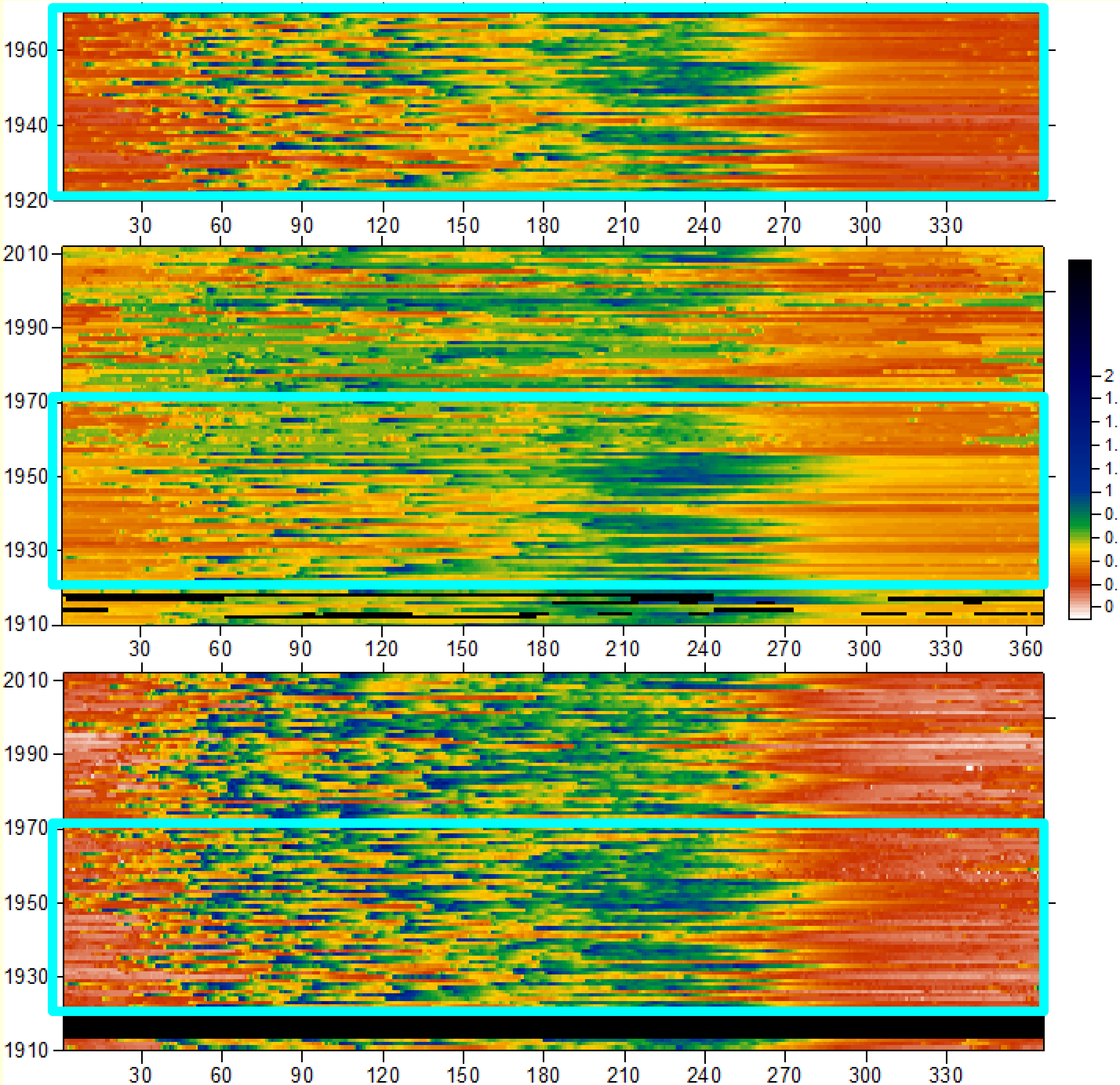



Clackamas at Estacada
(14210000)
1909-2013
Clackamas above Three Lynx
(14295000)
1910-2013
Oak Grove Fork
above powerplant
intake
(14290000)
1910-2013
Clackamas at
Big Bottom
(14280000)
1921-1970


Clackamas at Estacada
32% High Cascades
Clackamas above Three Lynx
40% High Cascades
Oak Grove Fork
above powerplant
intake
75% High Cascades
Clackamas at Big Bottom
62% High Cascades

Daily discharge (log unit m^3/s) 1910-2013
Oak Grove Fork abv powerplant intake (14209000)

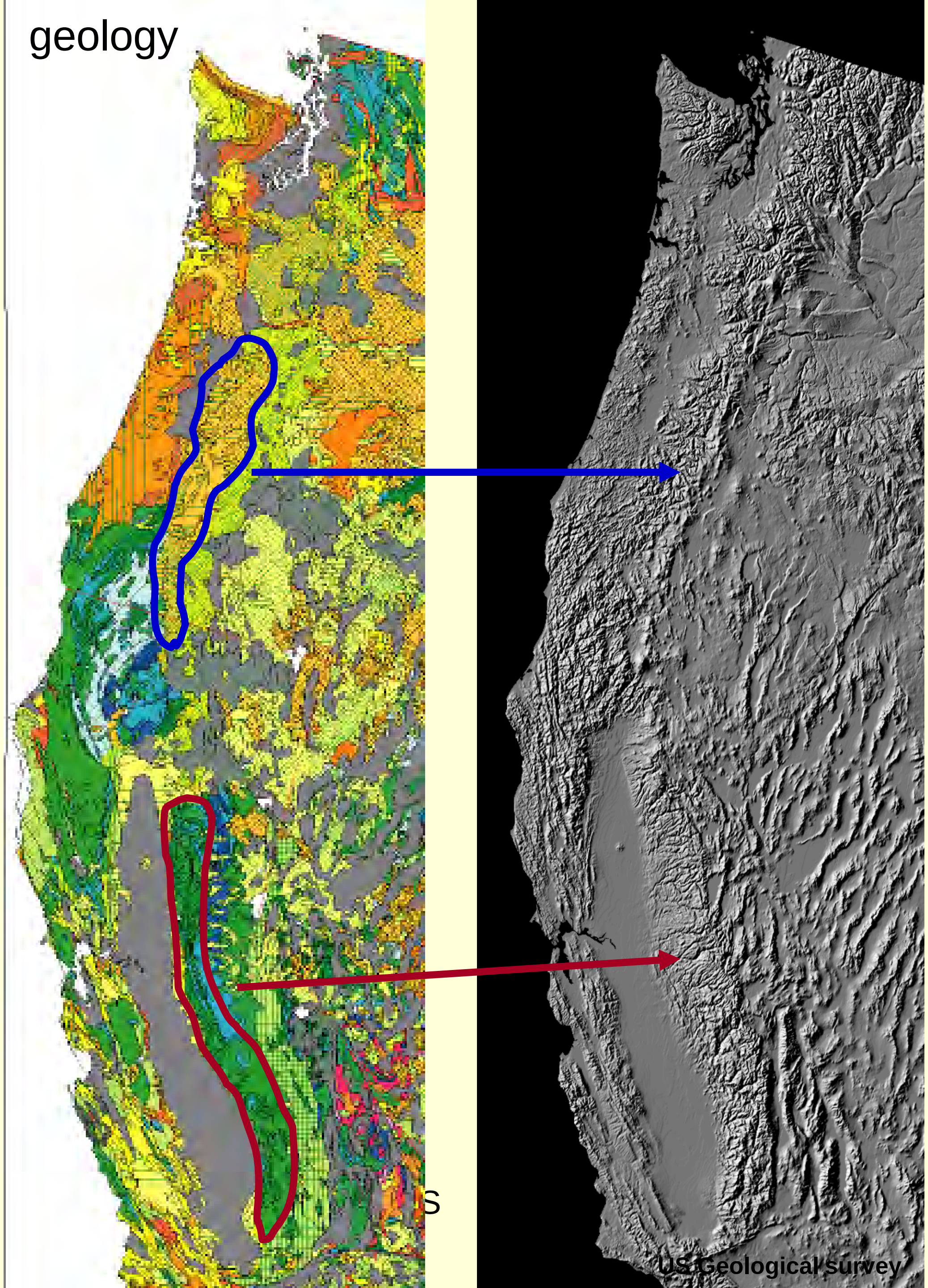




14208000
(1921-1970)
Clackamas at
Big Bottom

14209000
(1910-2013)
Oak Grove Fork
abv Powerplant
Intake

14209500
(1910-2013)
Clackamas abv
Three Lynx Creek



Oregon Cascades

Young volcanic rocks =
Large groundwater system

Water stored in:

- groundwater
- snowpacks
- reservoirs

Sierra Nevada

Old granitic rocks =
Surface-flow dominated

Water stored in:

- snowpacks
- reservoirs

We are beneficiaries of a geologic gift

- The good news:
  - There will be water in the Willamette in the future even as other regions experience water shortages
  - Late season streamflow in Western Cascade rivers, including parts of the Clackamas basin, will be similar to today (no big loss)
- The bad news:
  - Groundwater dominated rivers such as the Willamette and upper Clackamas are likely to experience greater loss of streamflow in the future
  - Low flows on rivers like the Clackamas will occur earlier in the year; stream temperatures also likely to increase

We are beneficiaries of a geologic gift

- The context:
  - Population demands, land use patterns, cycles of climate variability may trump climate change are drivers of water availability and scarcity
  - How we manage dams and reservoirs in the future may be the single most important thing we can do to mitigate climate changes on hydrology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