UNBC Northwest Public Presentation Series

Glaciers, Streams and Salmon:
Will Climate Change Leave the Kitsumkalum River High and Dry?

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KITSUMKALUM, A GALTS'AP OF THE TSIMSHIAN NATION

UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

NORTHWEST COMMUNITY COLLEGE

Indigenous and Northern Affairs Canada

How will climate change impact food security?

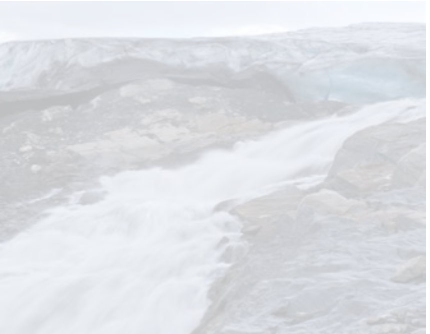
Photo credit: Kitsumkalum

How fast are our glaciers melting and does that matter for salmon?

Will Climate Change Leave the Kitsumkalum River ^ High and Dry?

Salmon

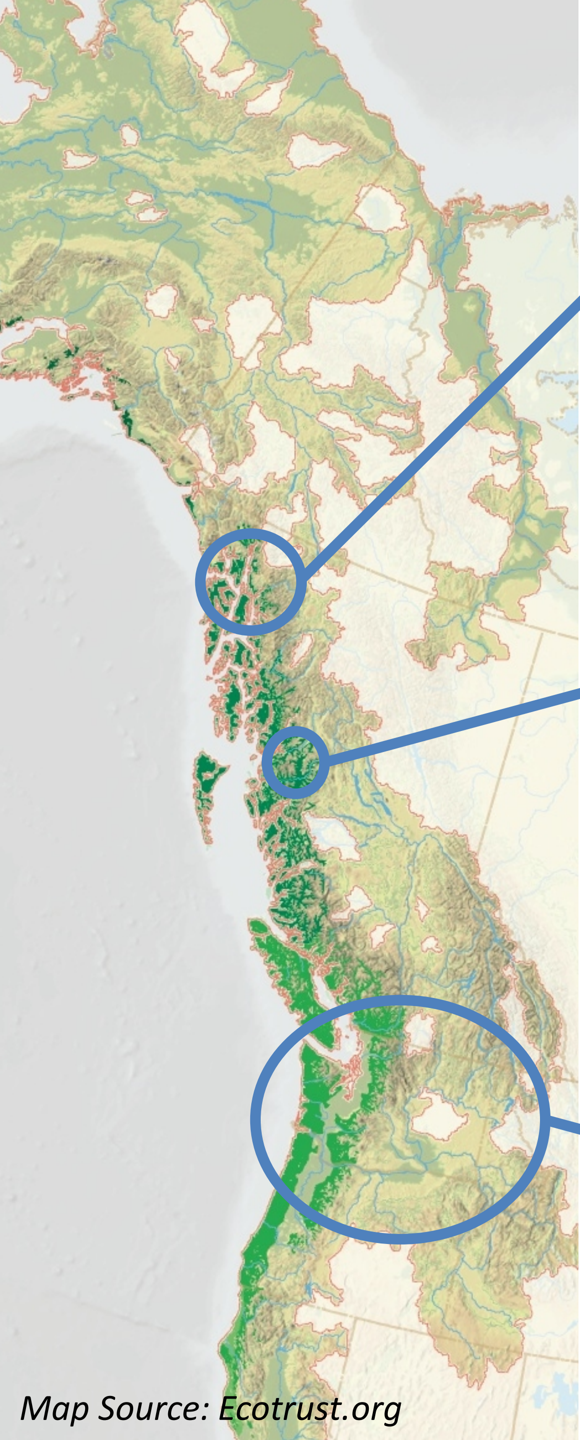
Land Use	Overfishing	Lack of Monitoring	Dams
Hatcheries	Ocean Temperatures	Predators	Mines
Aquaculture	Roads	Ocean Acidification	Bycatch
Disease	Ocean Ranching	Climate Change	Pollution



Potential Impacts of Climate Change

- ***Salmon populations show great resilience*** and should have the capacity to respond to change if magnitudes and rates aren't too great
- ***Increase in thermal stress*** – spawning migrations, spawning, rearing, smolt migration
- Competitive ***advantage to warm water predators*** that consume smolts
- ***Stocks that spend at least one summer in freshwater*** (Sockeye, Coho, Chinook)
  - Greater ***exposure to thermal stress***
  - Increased aquatic ***food-web productivity*** – greater growth response
- ***Reductions in volume of summer/fall low flows*** – access to spawning habitat
- Increase in intensity and frequency of ***winter flooding*** – redd and egg scouring
- Reduced ***availability of slow-water habitats*** – displacement of rearing juveniles
- ***Seaward migration timing*** evolved to match peak snowmelt

Adapted from Mantua et al., 2010, *Climatic Change*



Juneau, Alaska:

"Temperatures in heavily glaciated watersheds were predominantly ***below the optimal thermal range for salmon*** . . . future ***reductions in glacier meltwater*** input may actually ***enhance salmon survival and growth*** . . ."

(Fellman et al., 2014, *Hydrological Processes*)

Kitsumkalum River, BC:

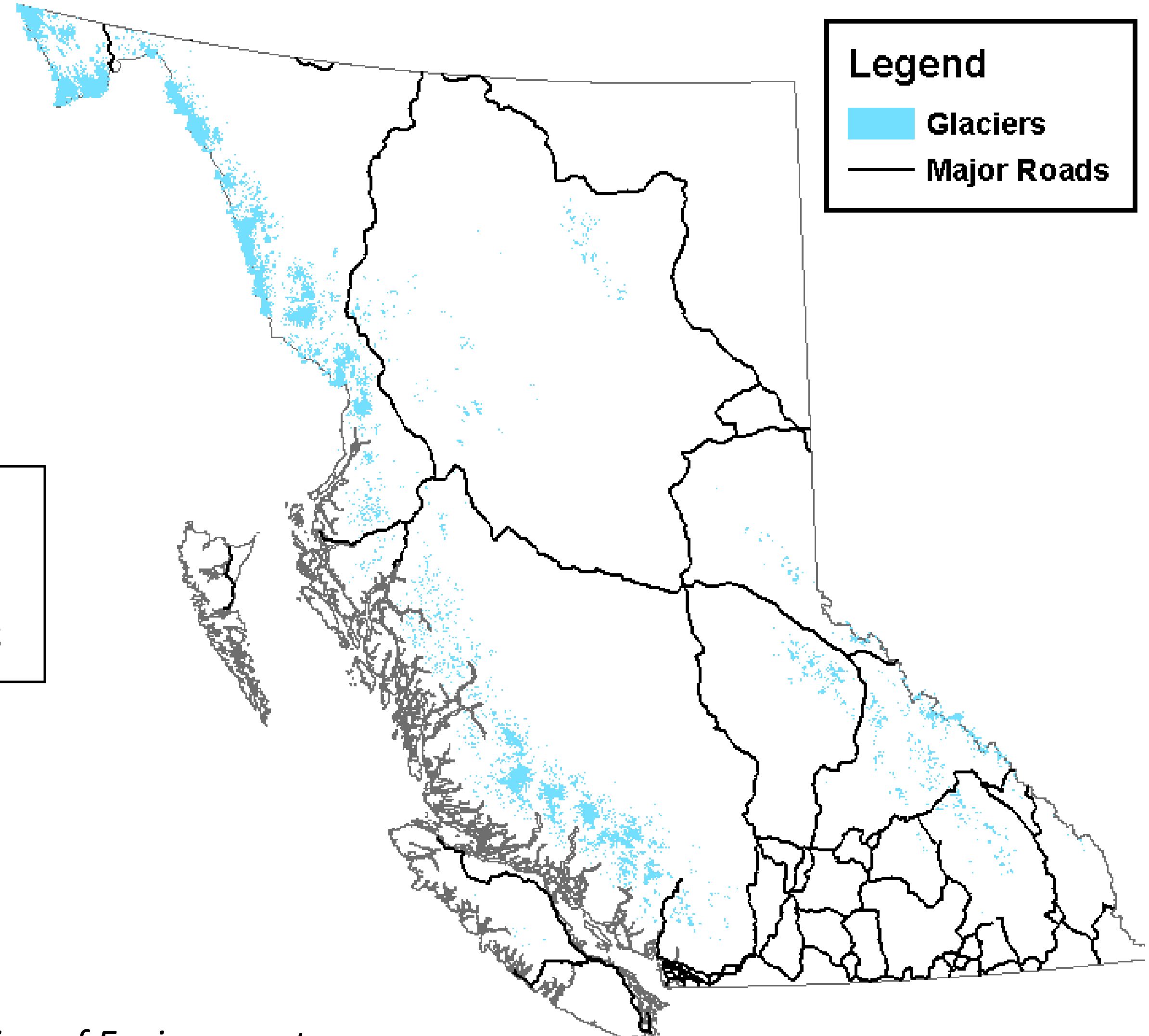
?

Washington State:

"[Many streams] already have periods with ***episodes of extreme thermal stress*** for salmon . . . there will be large increases in the number of stations that are especially unfavorable for salmon in summer (T_w > 21°C)."

(Mantua et al., 2010, *Climatic Change*)

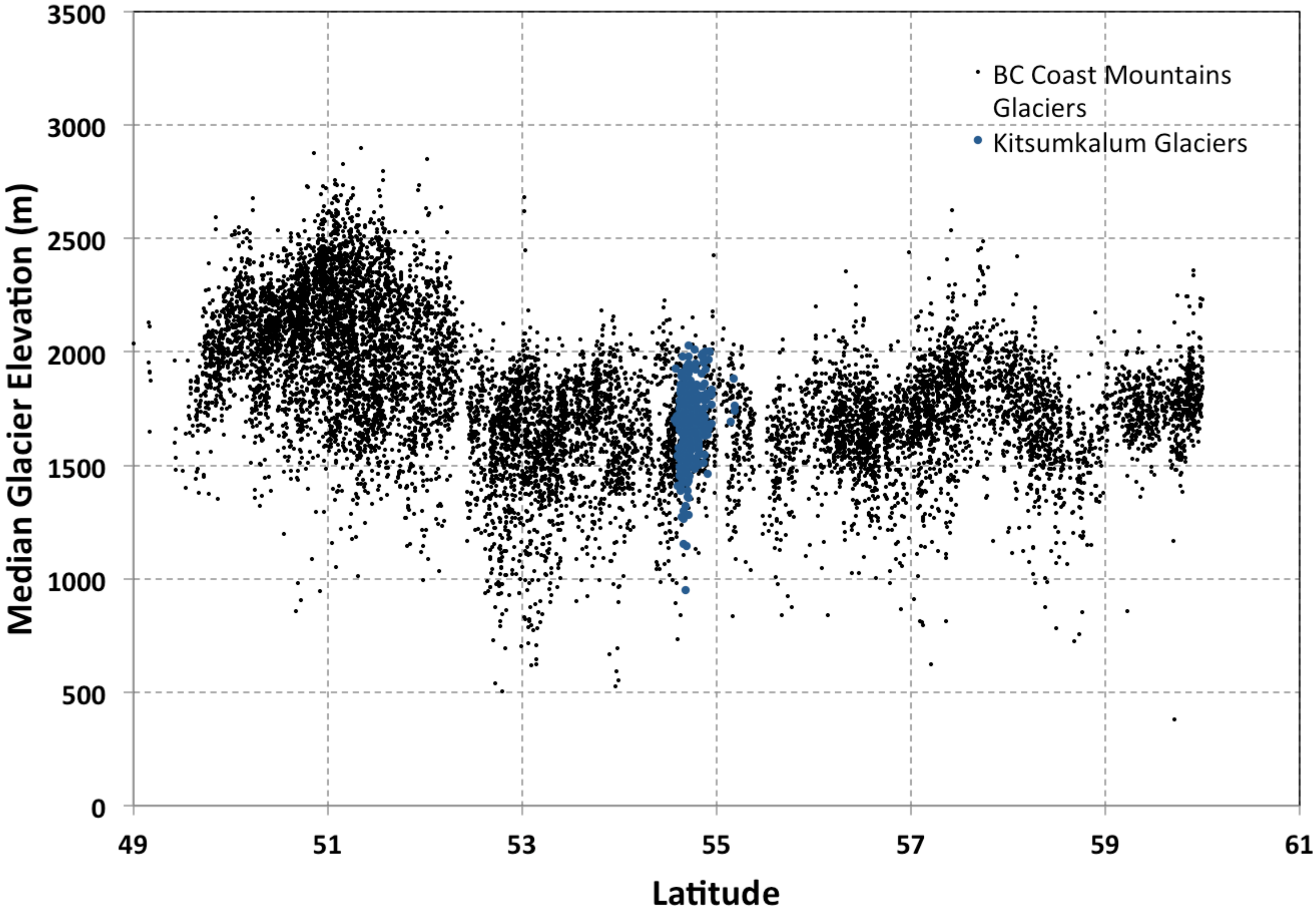
British Columbia Glaciers



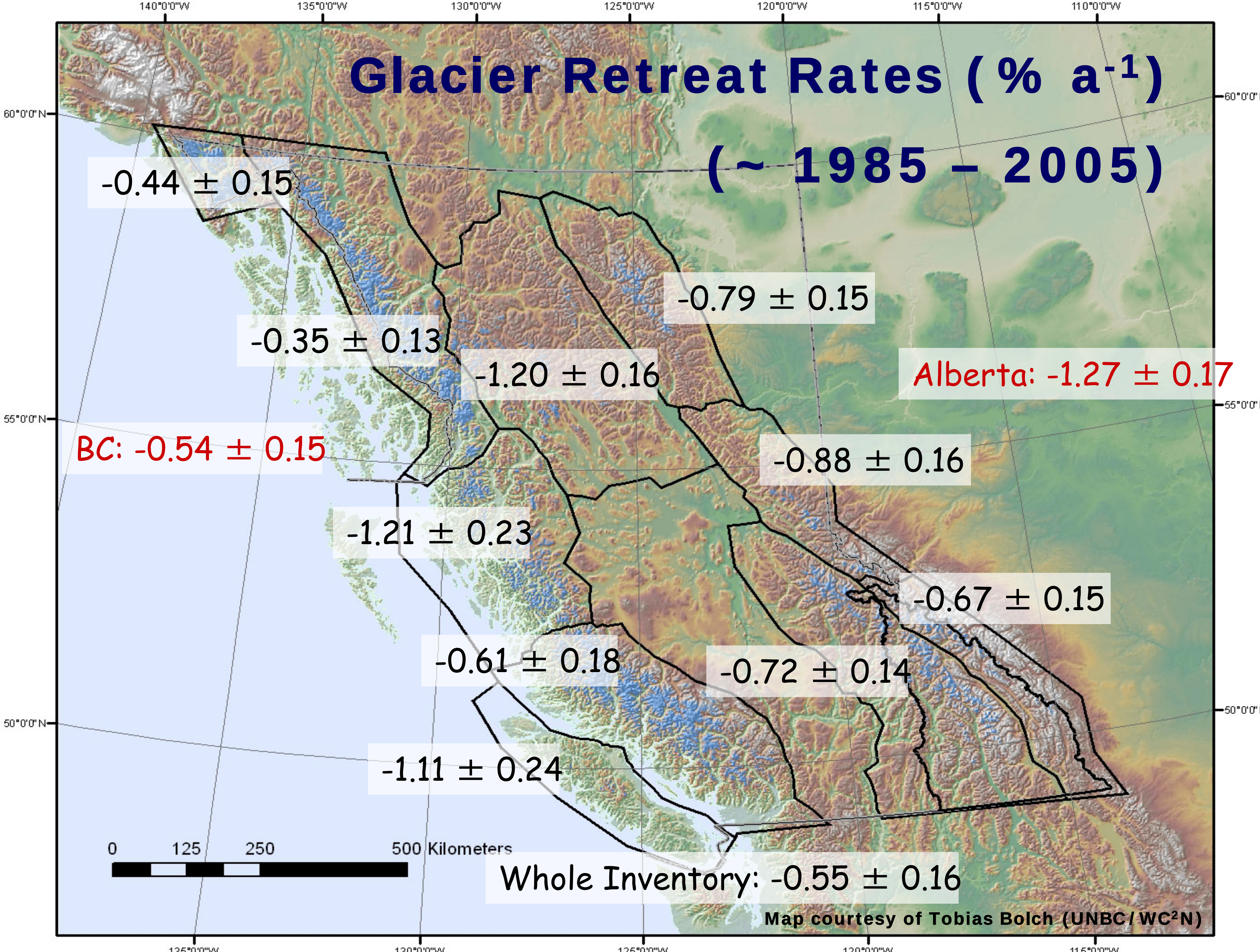
17,000 Glaciers

25,000 km²

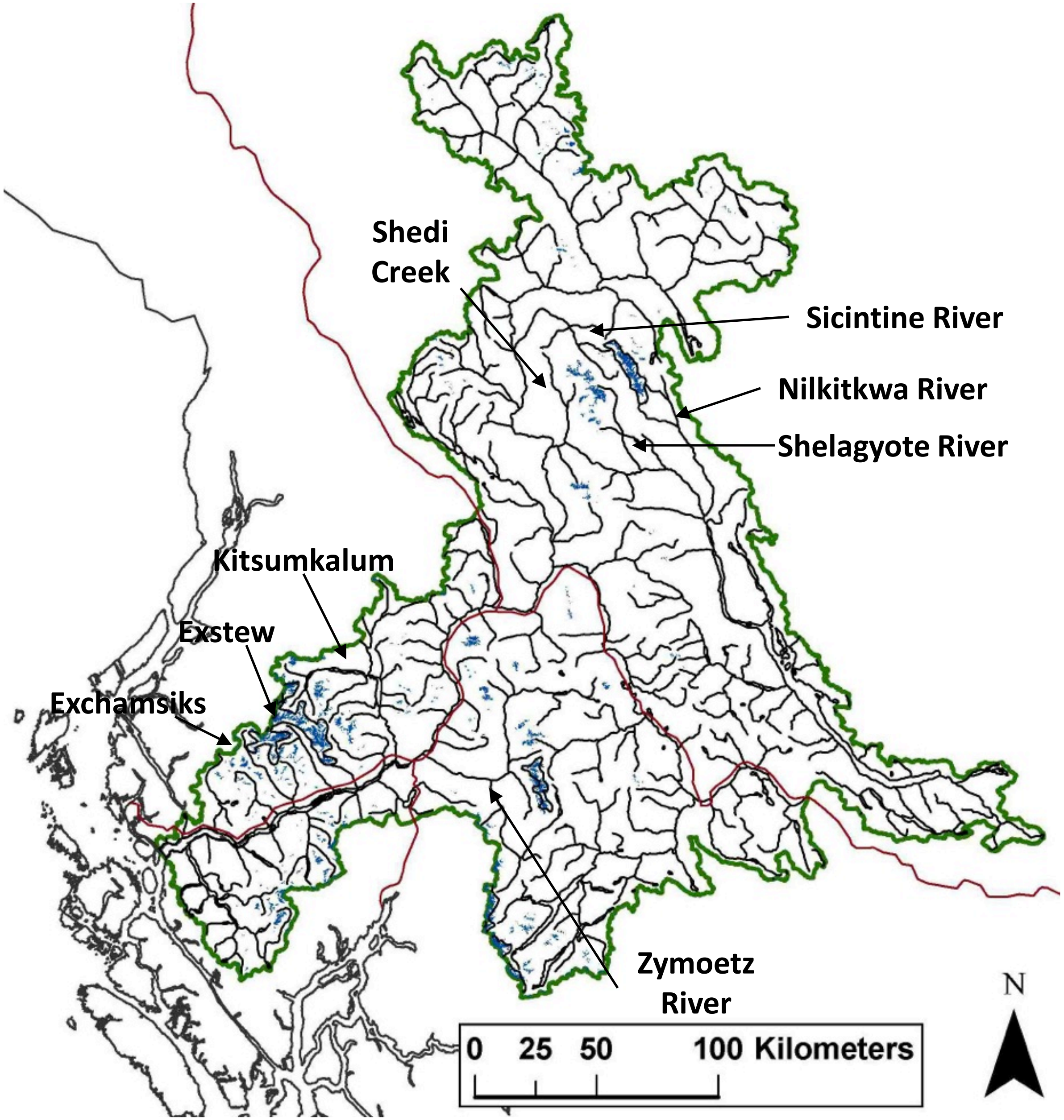
Bolch et al., 2010, *Remote Sensing of Environment*



Median Glacier Elevation (m)
3500
3000
2500
2000
1500
1000
500
0
49
51
53
55
57
59
61
Latitude
BC Coast Mountains Glaciers
Kitsumkalum Glaciers

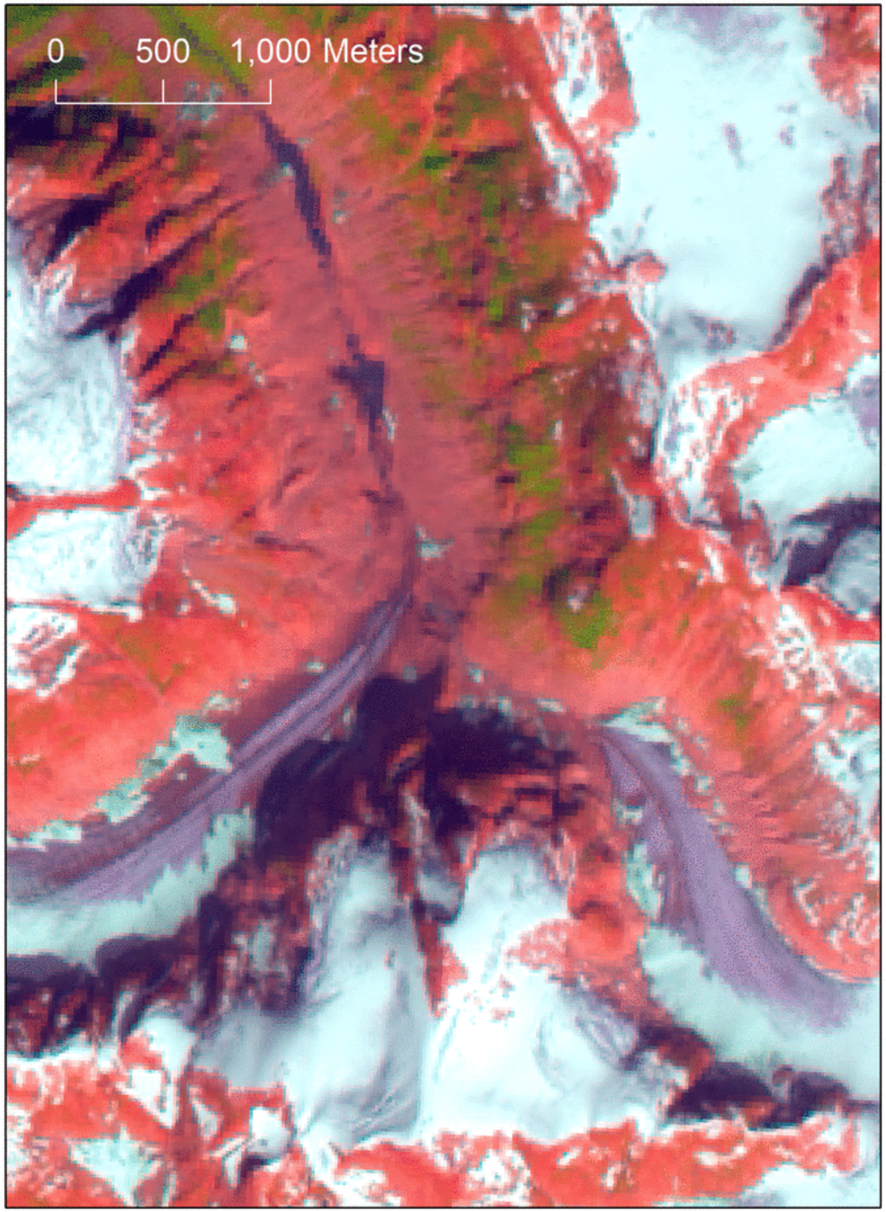

Glacier Retreat Rates (% a-1)
(~ 1985 – 2005)
-0.44 ± 0.15
-0.35 ± 0.13
-1.20 ± 0.16
-0.79 ± 0.15
Alberta: -1.27 ± 0.17
BC: -0.54 ± 0.15
-0.88 ± 0.16
-1.21 ± 0.23
-0.67 ± 0.15
-0.61 ± 0.18
-0.72 ± 0.14
-1.11 ± 0.24
0 125 250 500 Kilometers
Whole Inventory: -0.55 ± 0.16
Map courtesy of Tobias Bolch (UNBC/WC2N)
140°0'0"W
135°0'0"W
130°0'0"W
125°0'0"W
120°0'0"W
115°0'0"W
110°0'0"W
60°0'0"N
55°0'0"N
50°0'0"N

Skeena River Watershed



- 1985: 972 km^2 (1.8%)
- 2005: 825 km^2 (1.5%)
- -147 km^2 (-15%)

- Kalum: 151 km^2
- Zymoetz: 94 km^2
- Exstew: 70 km^2
- Excham.: 39 km^2
- 354 km^2 (43%)

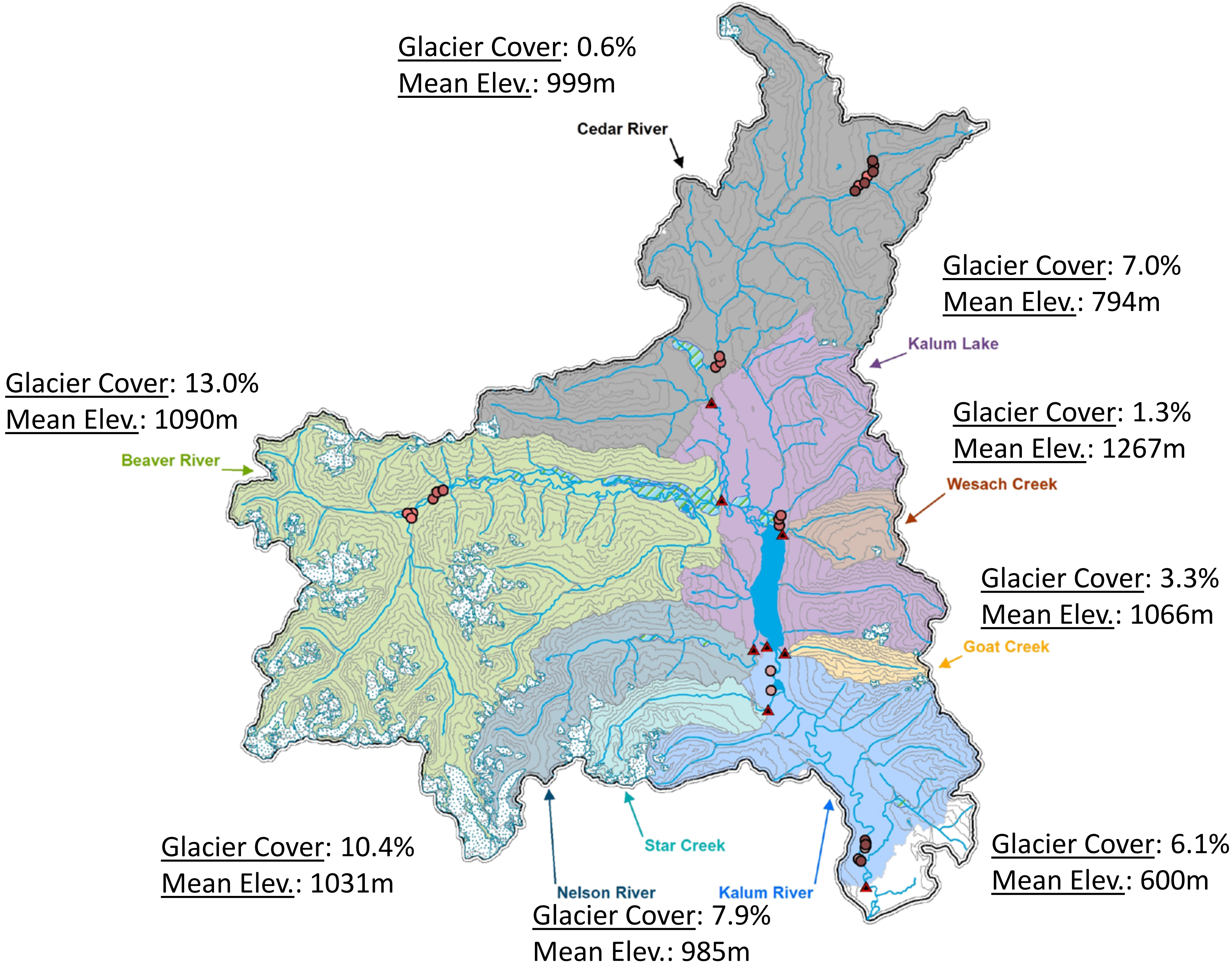


Kitsumkalum Glacier Surface Area

	Surface Area (km^2)	Watershed Coverage (%)
1985	179.2	8.1
2005	145.4	6.6
2017	124.3	5.6

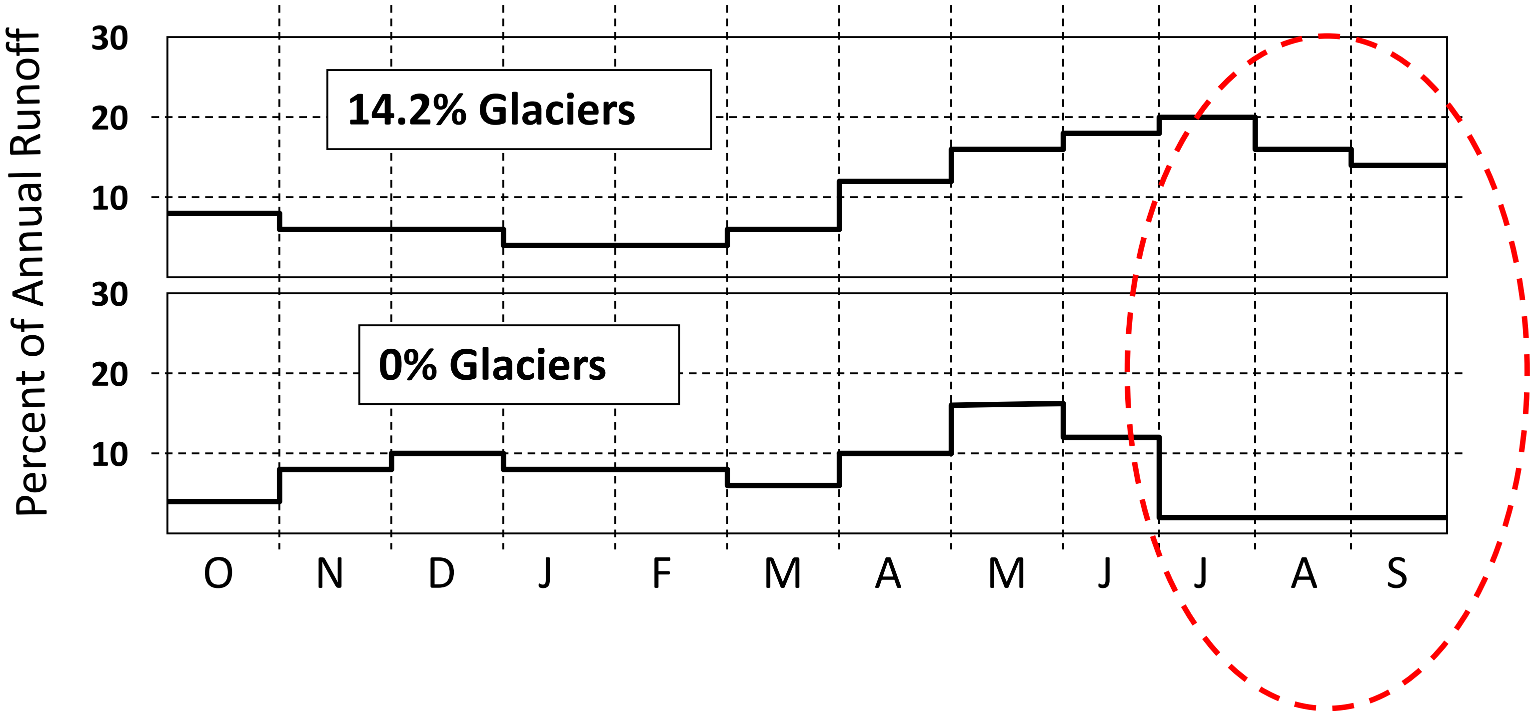
Kitsumkalum Glacier Area Change

	Area Change (km^2)	Area Change (%)	Rate of Change (%/yr)
1985-2005	-33.7 ± 4.5	-18.8 ± 2.5	-0.94 ± 0.13
2005-2017	-21.1 ± 3.2	-14.5 ± 2.2	-1.21 ± 0.18
1985-2017	-54.8 ± 7.6	-30.6 ± 4.2	-0.96 ± 0.13



Glacier Cover: 0.6%
Mean Elev.: 999m
Cedar River
Glacier Cover: 7.0%
Mean Elev.: 794m
Kalum Lake
Glacier Cover: 13.0%
Mean Elev.: 1090m
Beaver River
Glacier Cover: 1.3%
Mean Elev.: 1267m
Wesach Creek
Glacier Cover: 3.3%
Mean Elev.: 1066m
Goat Creek
Glacier Cover: 10.4%
Mean Elev.: 1031m
Star Creek
Nelson River
Kalum River
Glacier Cover: 7.9%
Mean Elev.: 985m
Glacier Cover: 6.1%
Mean Elev.: 600m

Glaciers and Streamflow Variation



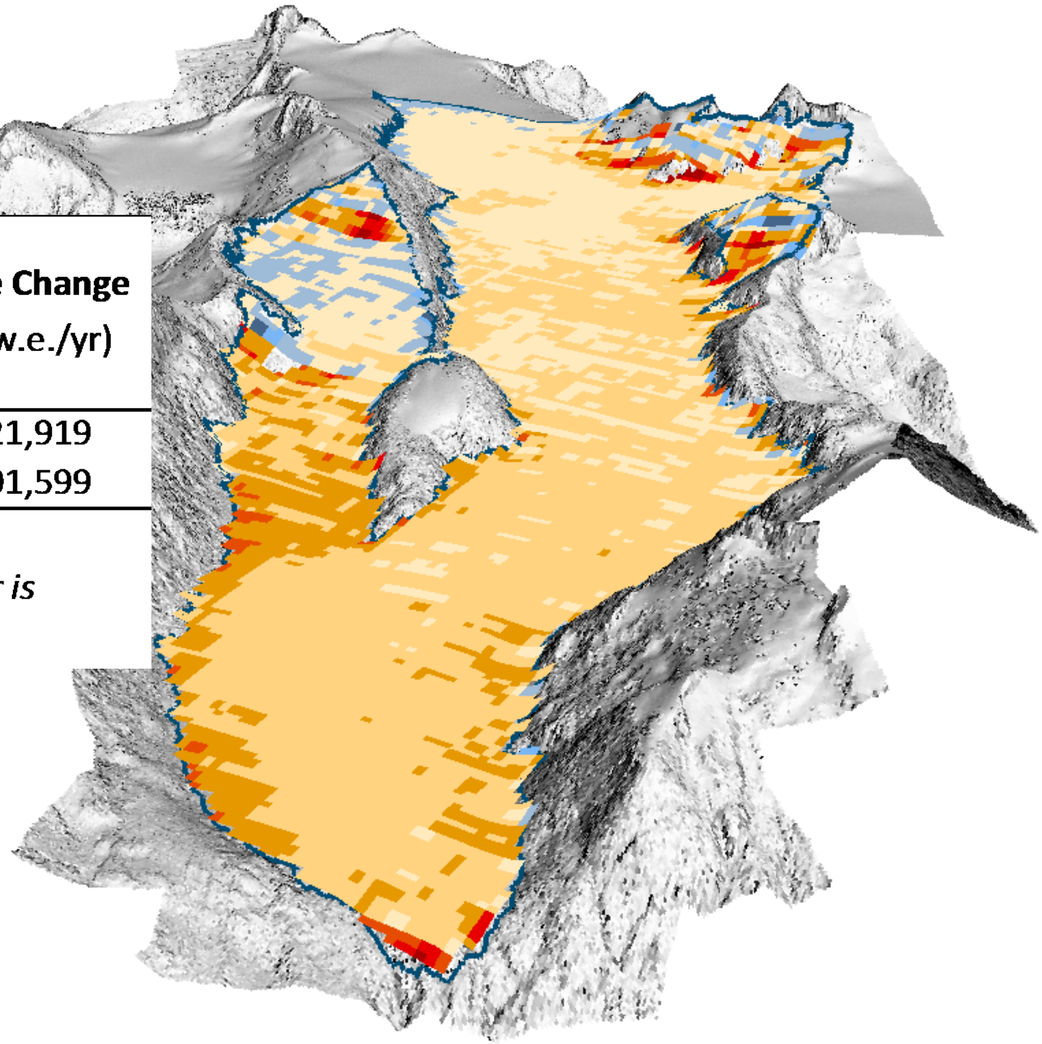
Adapted from: Fountain and Tangborn, 1985

Glacier Surface Elevation and Volume Change

	Surface Elevation Change (m s.w.e.)	Surface Elevation Change (m s.w.e./yr)	Volume Change (m^3 s.w.e./yr)
1988 - 1999	-13.9	-0.6	-9,121,919
1999 - 2017	-9.9	-0.5	-7,601,599

NOTE: Average daily discharge of Kitsumkalum River is

~10 Million m^3/day



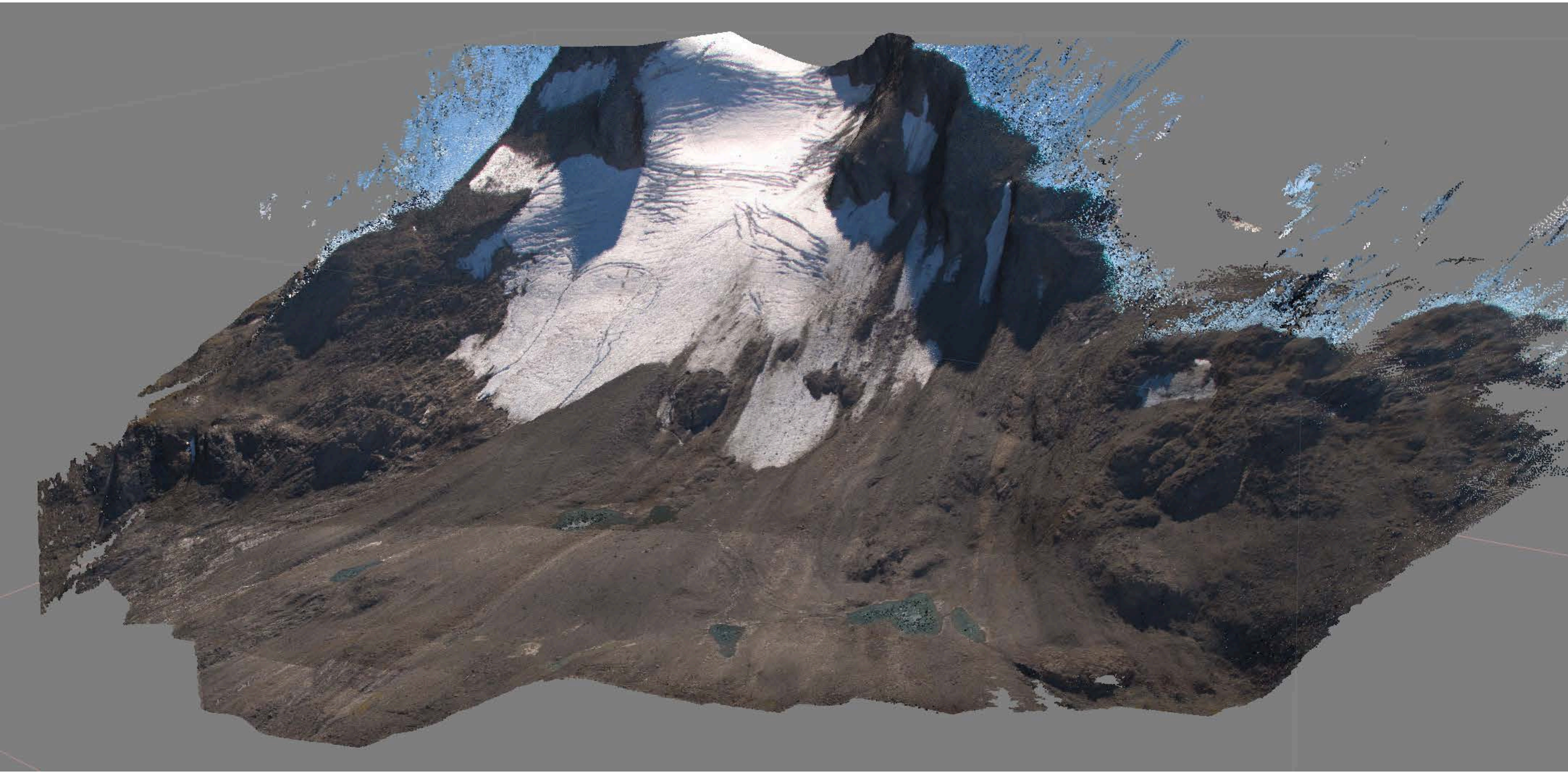
LIDAR surface model (2017) of the glacier at the headwaters of the Beaver River, largest glacier in the Kitsumkalum River watershed.

Glacier Surface Elevation and Volume Change

Julia Roberts, Warren Bolton, Jim Webb and Mark Biagi learn the ropes of the eBee RTK Surveying Drone from Spatial Technologies engineer John Tong, March 2018.

Mark Biagi prepares to launch the eBee RTK Surveying Drone with instruction from Spatial Technologies sales rep Peter Willis, March 2018.

Glacier Surface Elevation and Volume Change



Structure-from-Motion surface model (2016) of small north facing glacier on Maroon Mountain .

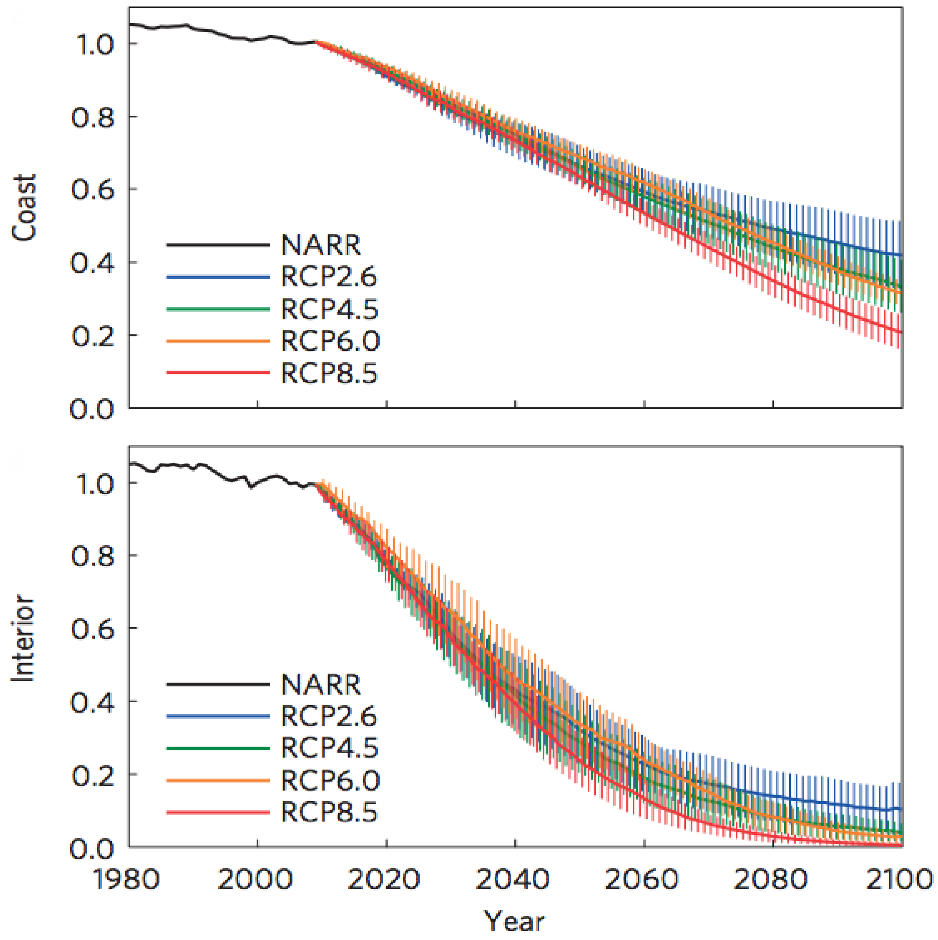
How much does glacier melt contribute to discharge?

NWCC GEOG 207 (Hydrology) students measure the discharge of Shames River, January 2018.

Estimated % of Total July, August, September Discharge

	1985	*2017*
	Discharge from Glacier Melt (%)	**Discharge from Glacier Melt (%)**
Goat Creek	3.1	2.4
Wesach Creek	1.2	0.9
Star Creek	7.5	5.7
Nelson River	9.7	7.5
Cedar River	0.6	0.4
Beaver River	12.2	9.4
Kalum Lake	6.6	5.1
Kalum River	5.7	4.4

Projected Deglaciation of Western Canada's Glaciers



Clarke et al., 2015, *Nature Geoscience*

The Role of Snow Melt

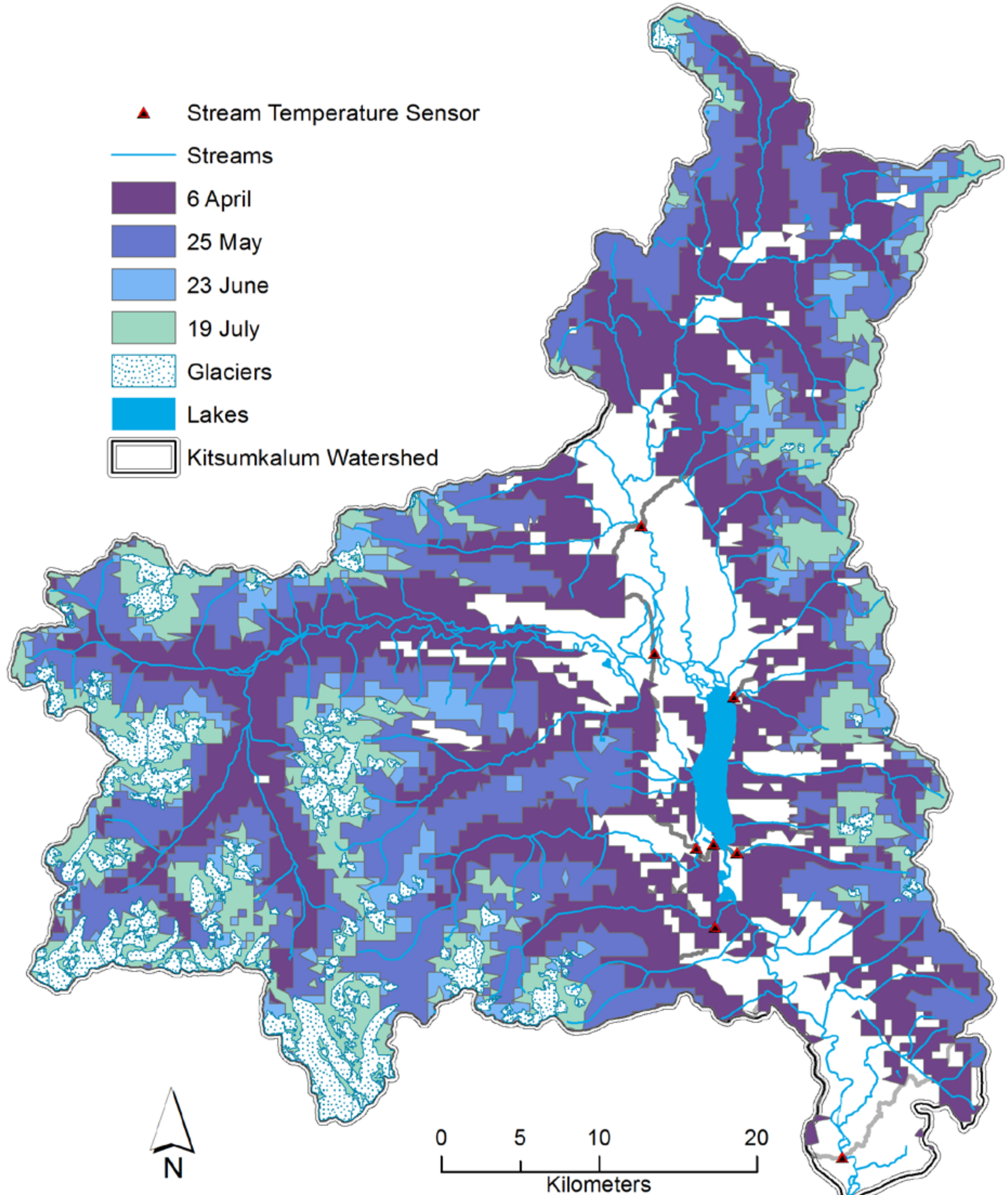
NWCC student and Kitsumkalum Glacier studies intern Julia Roberts measures snow water equivalent of the snow pack in the of Shames River watershed, February 2018.

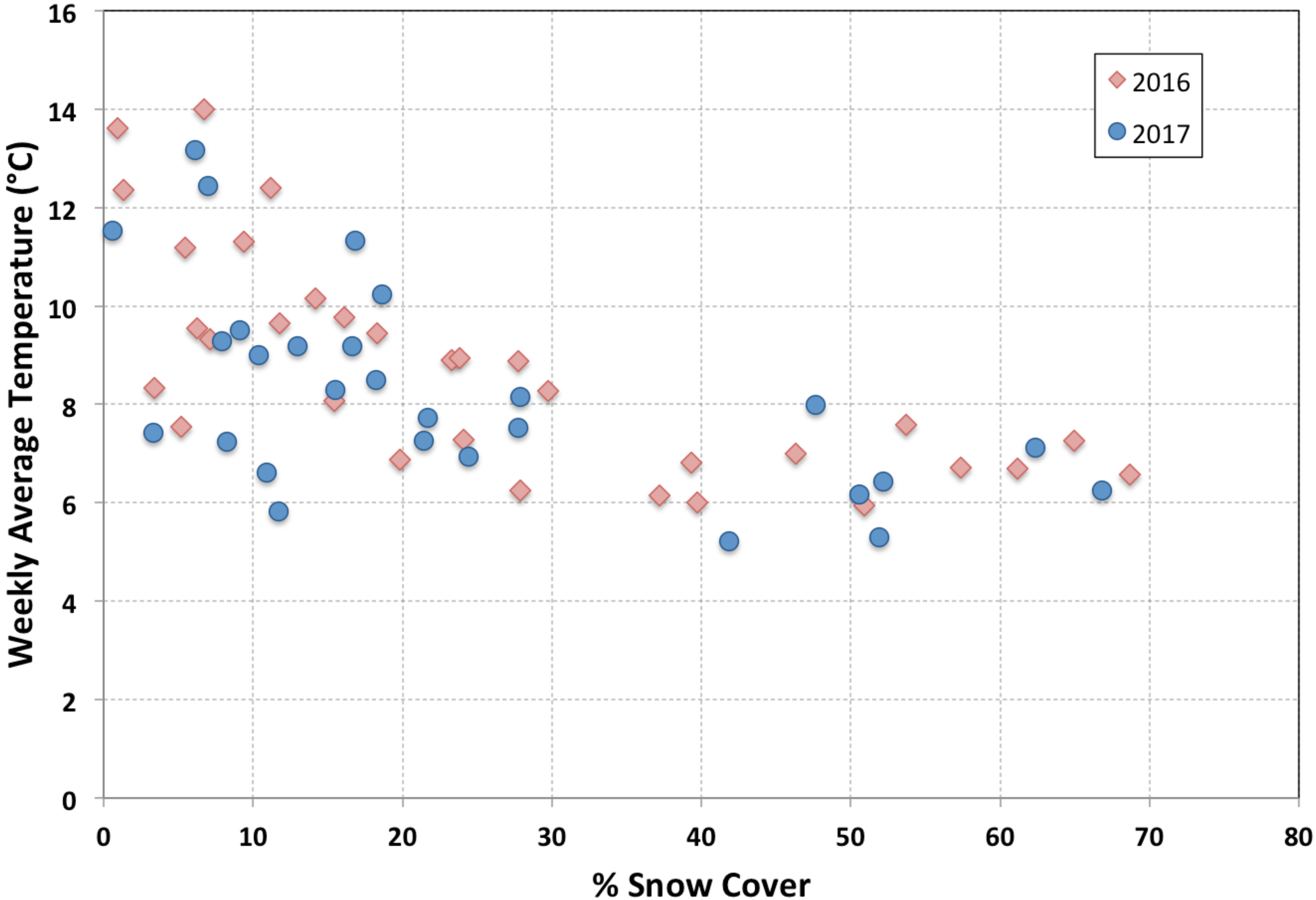
Mapping Snow Cover

- MODIS instrument (NASA's Terra and Aqua satellites)

2016 vs. 2017

- Record setting temp., March 2016
- <u>May 21, 2016</u>: 781 km^2
- <u>May 25, 2017</u>: 1051 km^2




16
14
12
10
8
6
4
2
0
Weekly Average Temperature (°C)
0
10
20
30
40
50
60
70
80
% Snow Cover
2016
2017

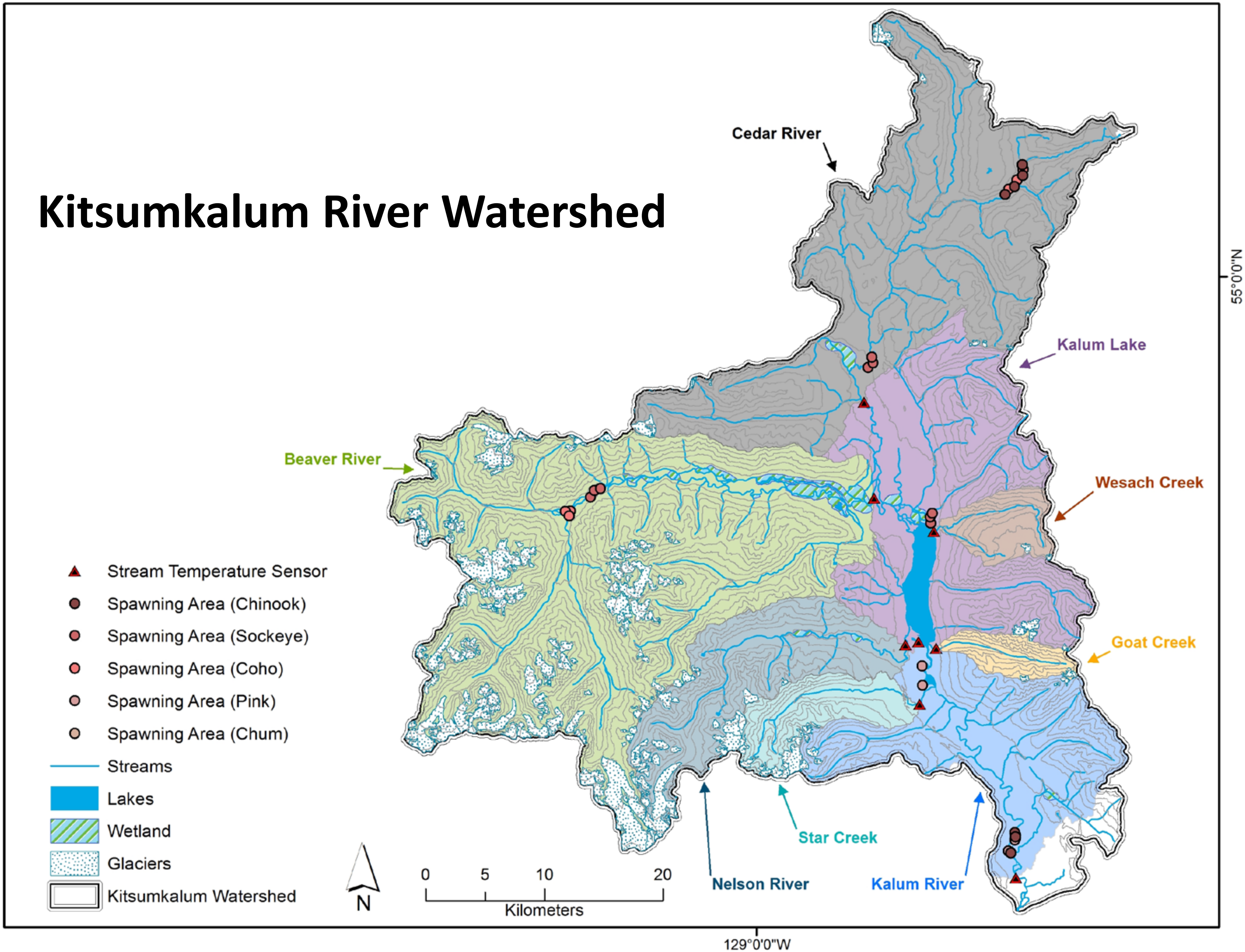
What is the thermal regime of Kitsumkalum River?

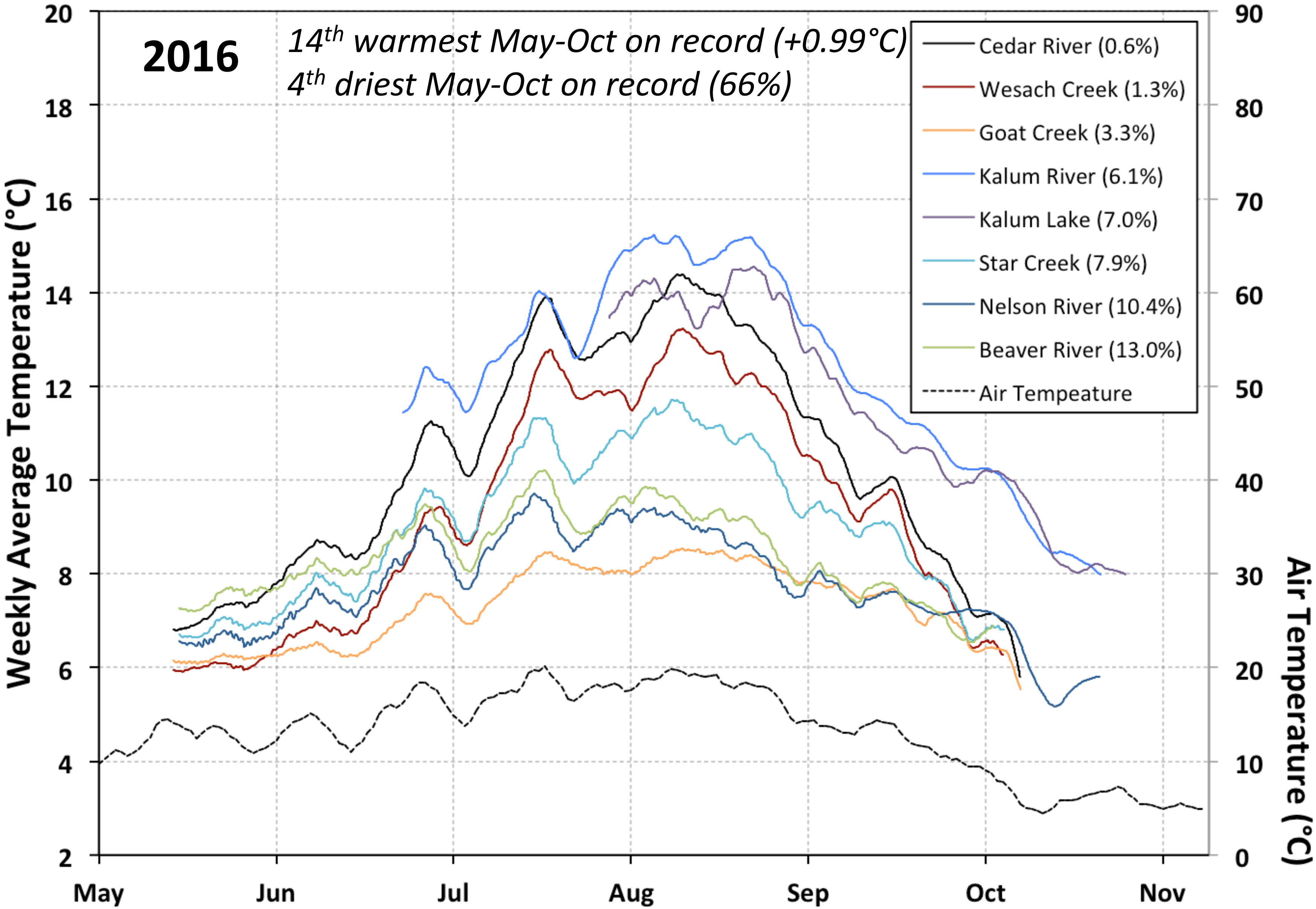
NWCC student Dallas Nikal measures the temperature of Goat Creek, May 2016

Stream Temperature Methods

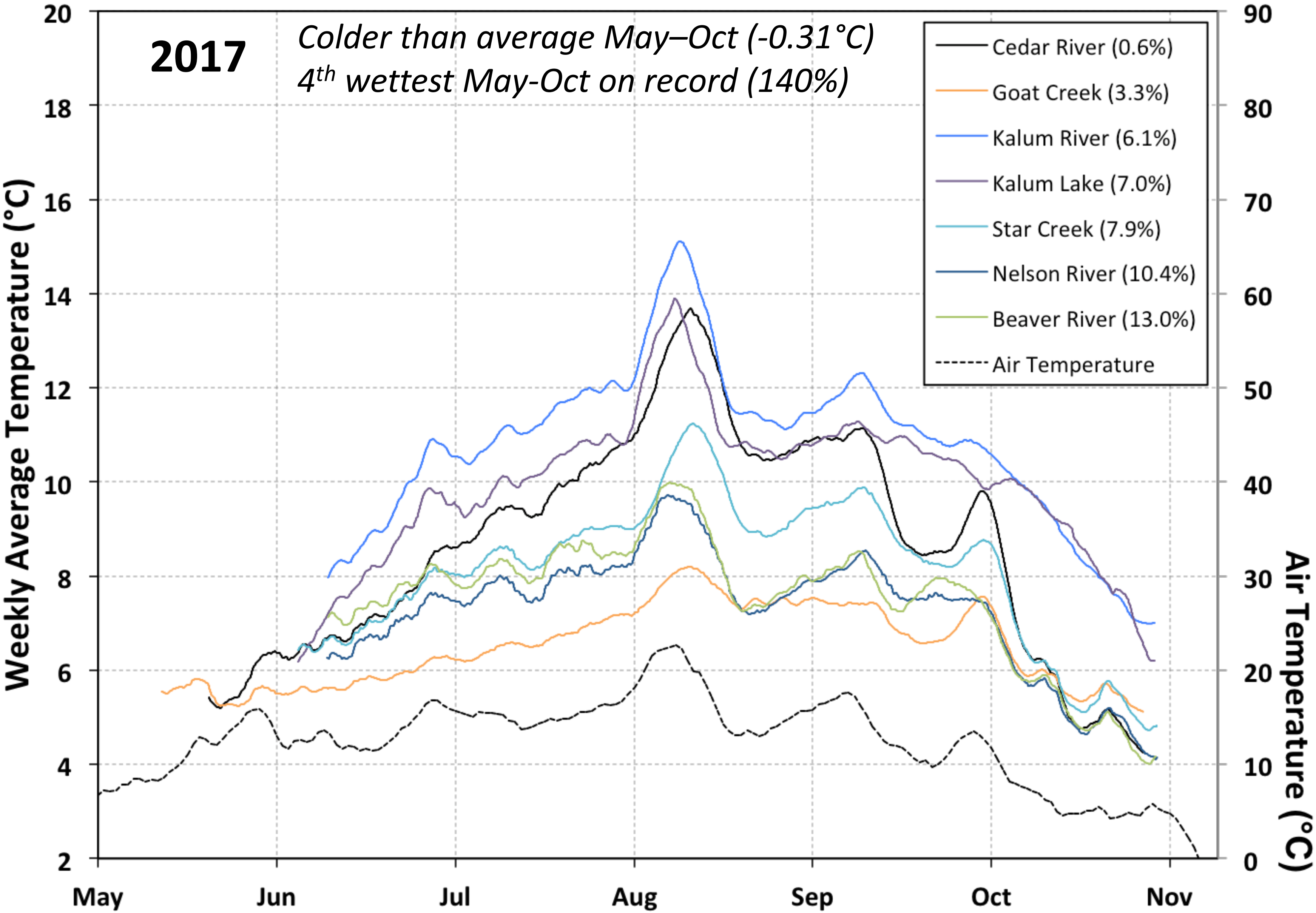
- Adapted from Fellman et al., 2014, *Hydrological Processes*
- Onset HOBO Water Temp Pro v2
- Every 15 minutes
- ~May through October, 2016 and 2017
- Sensor within ~10 cm of stream bed

Kitsumkalum River Watershed





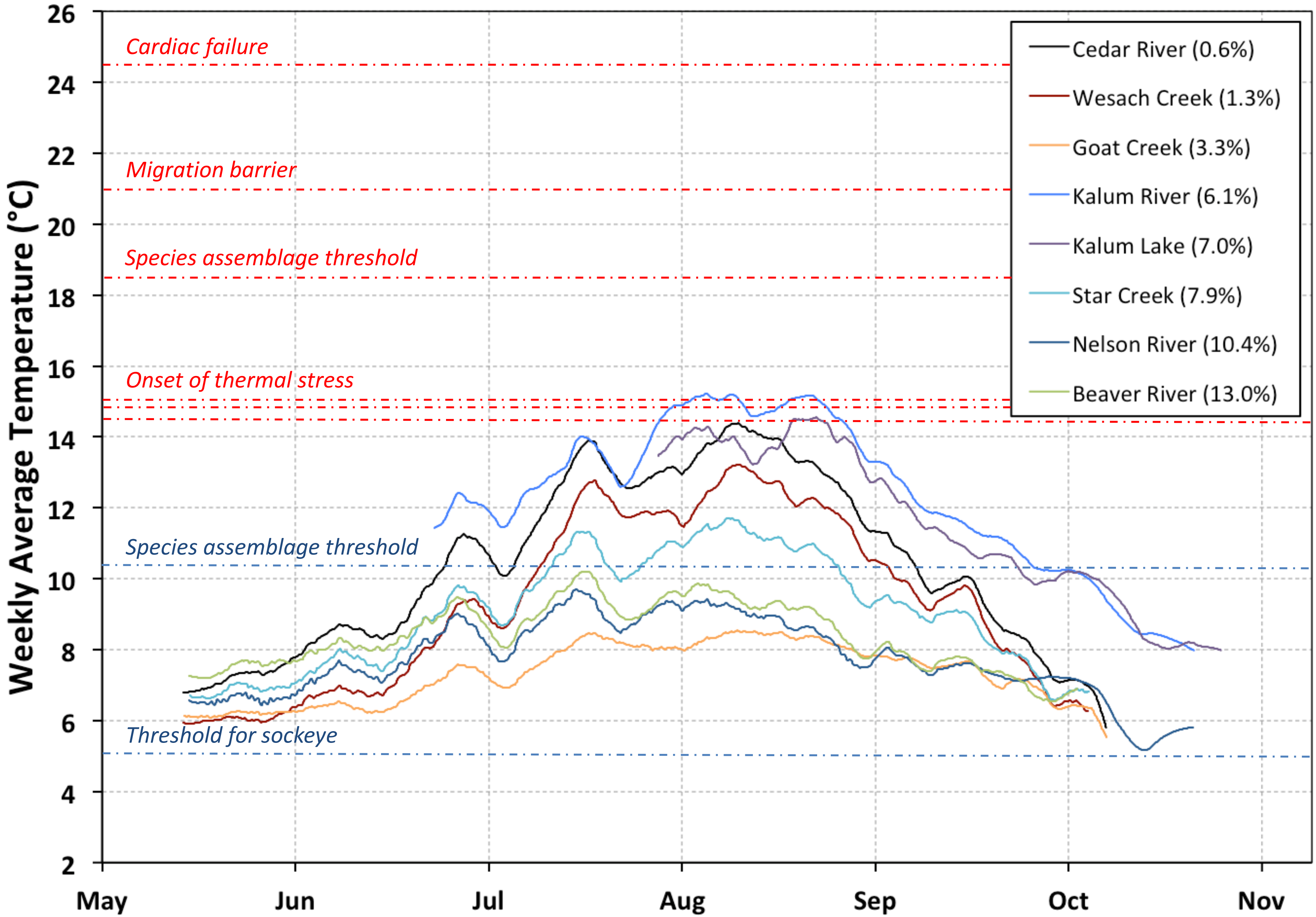
2016
14th warmest May-Oct on record (+0.99°C)
4th driest May-Oct on record (66%)
Cedar River (0.6%)
Wesach Creek (1.3%)
Goat Creek (3.3%)
Kalum River (6.1%)
Kalum Lake (7.0%)
Star Creek (7.9%)
Nelson River (10.4%)
Beaver River (13.0%)
Air Tempeature
Weekly Average Temperature (°C)
Air Temperature (°C)
20
18
16
14
12
10
8
6
4
2
90
80
70
60
50
40
30
20
10
0
May
Jun
Jul
Aug
Sep
Oct
Nov


2017
Colder than average May–Oct (-0.31°C)
4th wettest May-Oct on record (140%)
Cedar River (0.6%)
Goat Creek (3.3%)
Kalum River (6.1%)
Kalum Lake (7.0%)
Star Creek (7.9%)
Nelson River (10.4%)
Beaver River (13.0%)
Air Temperature
Weekly Average Temperature (°C)
Air Temperature (°C)
20
18
16
14
12
10
8
6
4
2
90
80
70
60
50
40
30
20
10
0
May
Jun
Jul
Aug
Sep
Oct
Nov

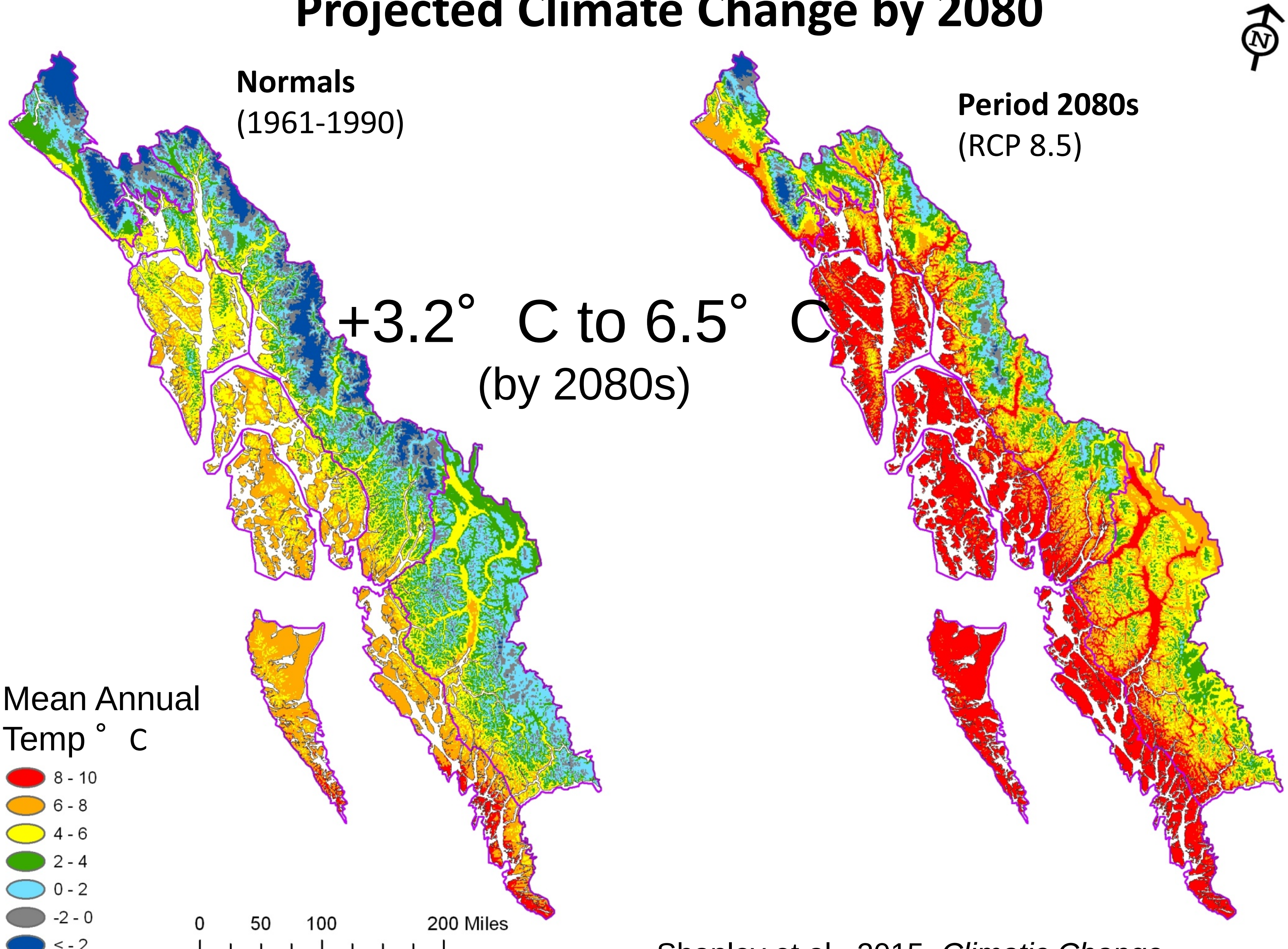
Temperature Thresholds for Salmon

- **5°C**: Lower threshold for sockeye (Fellman et al., 2014)
- **14.5°C**: WA DOE criterion for spawning, rearing and migration (EPA 2017)
- **>15°C**: Increased predation, competitive disadvantages (EPA, 2017)
- **21-22°C**: Can prevent migration (EPA, 2017 and McCullough, 1999)
- **21°C**: Susceptible to disease, Prolonged exposure lethal to juveniles and adults (McCullough, 1999)
- **24.5°C**: Cardiac failure threshold, Chinook (Munoz et al., 2014)
- **12.8 - 14.8°C**: Optimum for salmon growth (Sullivan et al., 2000)
- **10.5 - 18.5°C**: Cold water zone (salmonids) (Parkinson et al., 2016)

Temperature Thresholds for Salmon

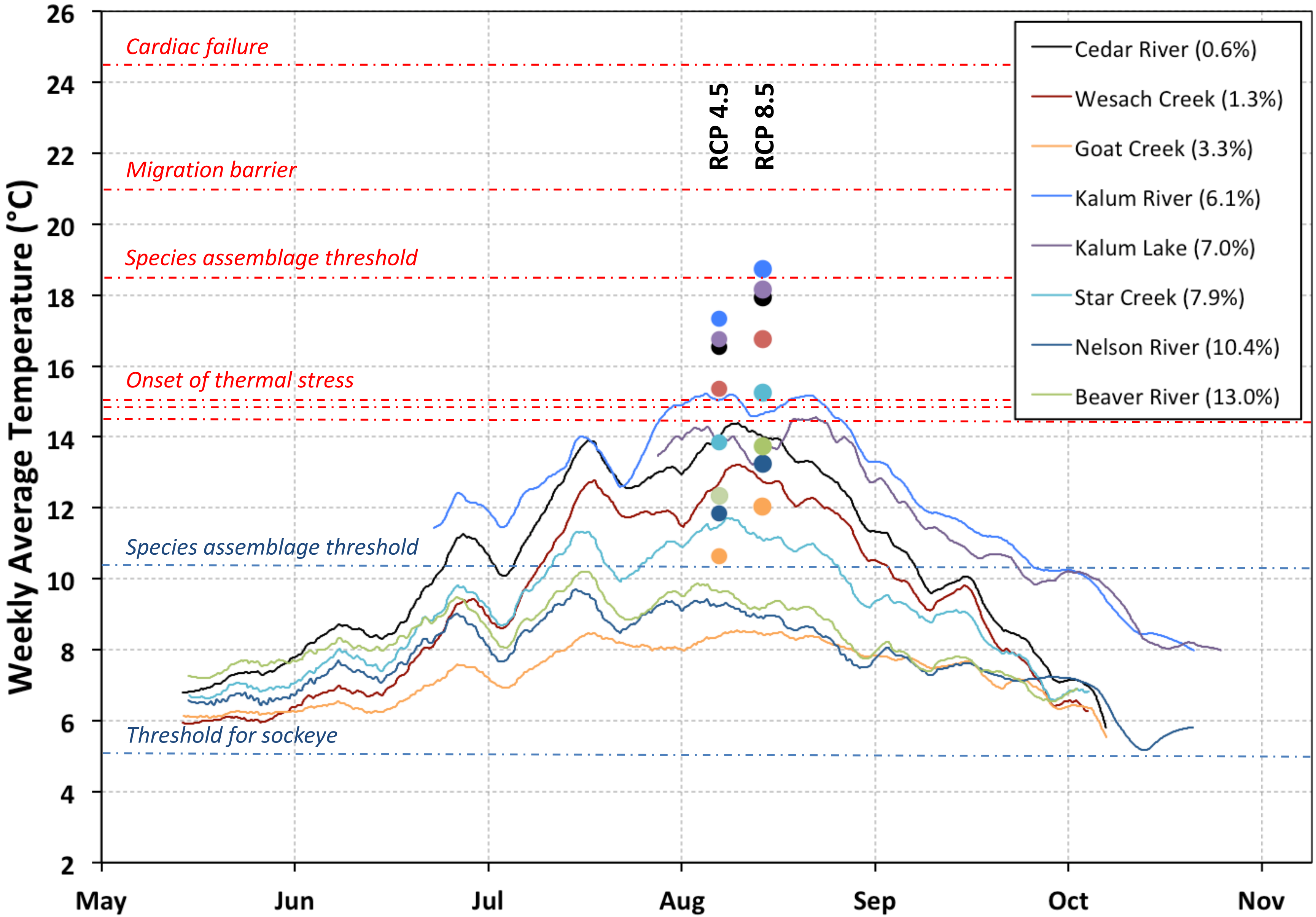


Projected Climate Change by 2080



Shanley et al., 2015, *Climatic Change*

First-order Estimate of 2080 Stream Temperature



Projection based off approach in Moore et al., 2013, *Canadian Water Resources Journal,* and modeled 2080 temperatures from Shanley et al., 2015, *Climatic Change*

Will Climate Change Leave the Kitsumkalum River High and Dry?

- Kitsumkalum watershed conditions likely present little to no thermal stress with present day climate
- Summer water temperatures are likely to increase >2°C by 2080
- Average JAS discharge is likely to decrease by up to 12% by 2080
- Next steps in Kitsumkalum's Glaciers, Streams and Salmon Project:
  - Start seasonal glacier mass balance monitoring
  - Continue and enhance stream monitoring
  - Start meteorological monitoring
  - Train and inspire the leaders of the future