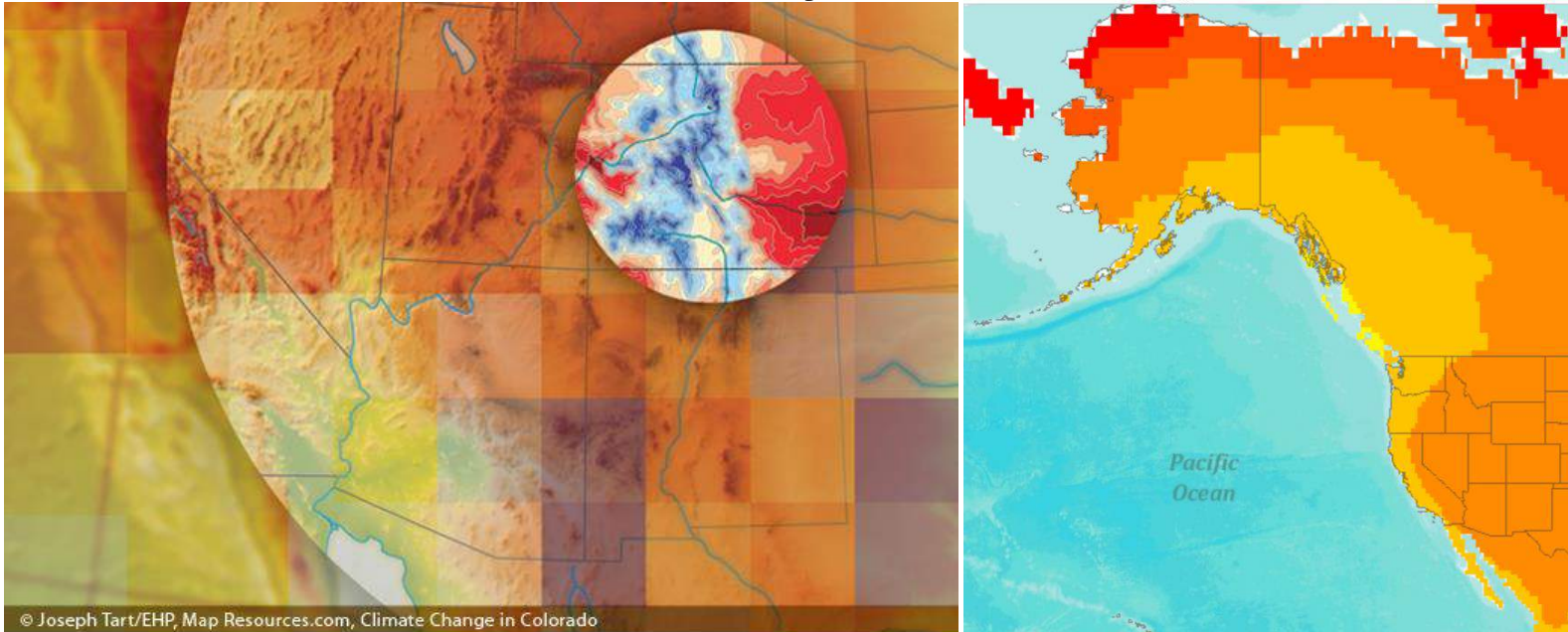


The importance of hydrologic variation to the spawning phenology of salmon and species they support in river systems.



Peter Lisi, Daniel Schindler, Jonny Armstrong, Kale Bentley, KathiJo Jankowski, Laura Payne, George Pess

Implication of climate change for ecosystems.



- Can we get away with coarse scale projections (10,000 to 2500km²) or do we need a finer scale understanding (2km²) of climate?

- How much thermal variation do we see at finer spatial scales?
- What are the controls on this variation?



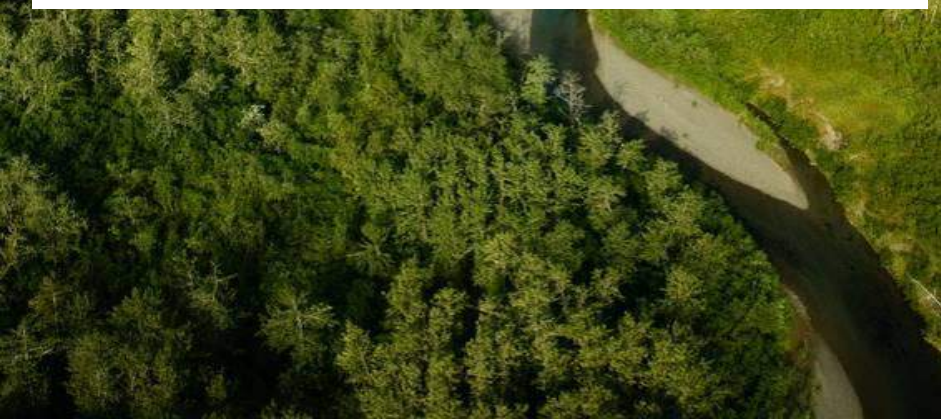
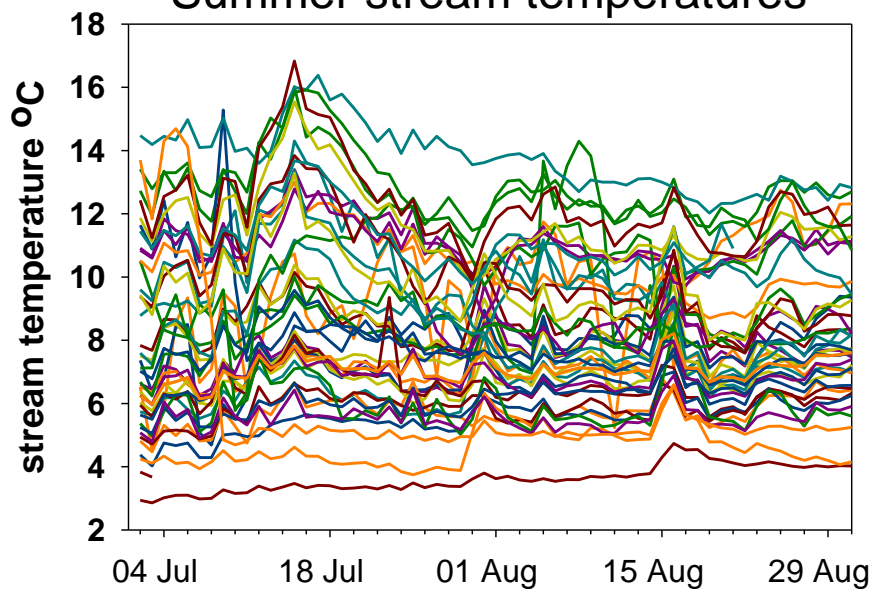
- Is this variation important to wildlife?



Photos – Jonny Armstrong

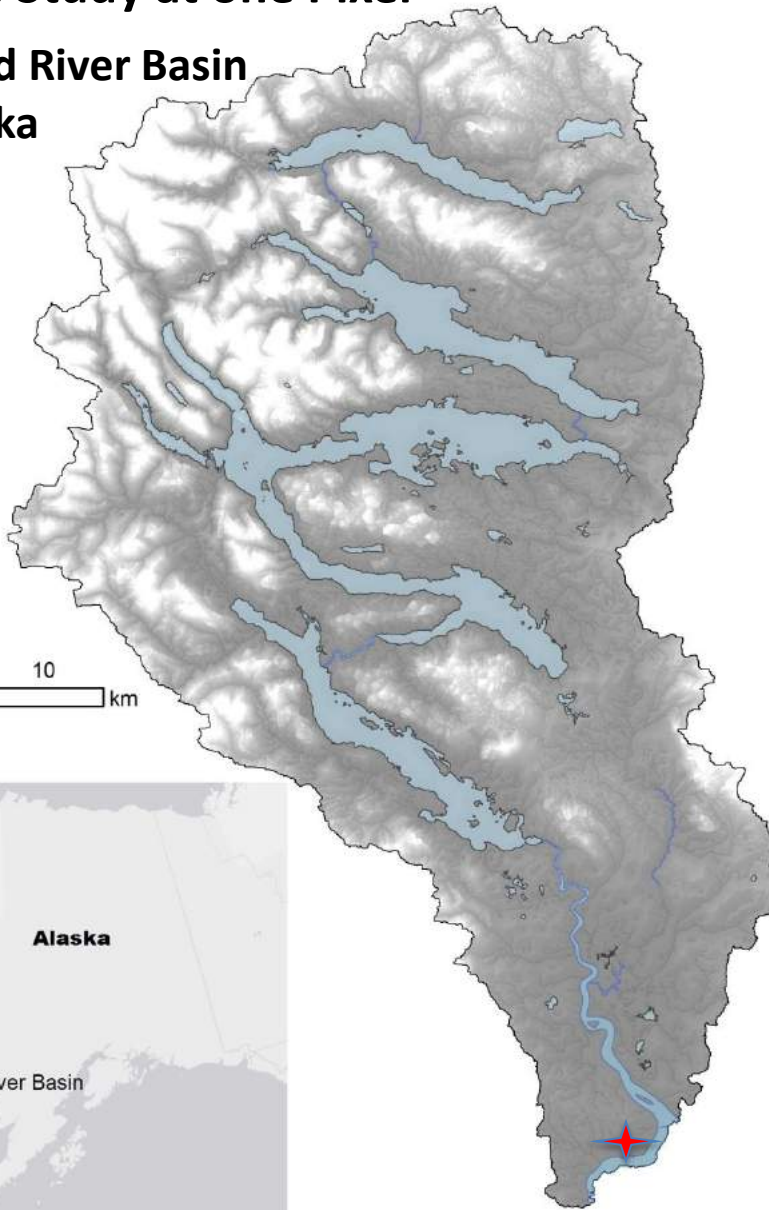
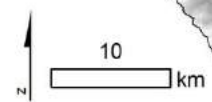


Summer stream temperatures



Case Study at one Pixel

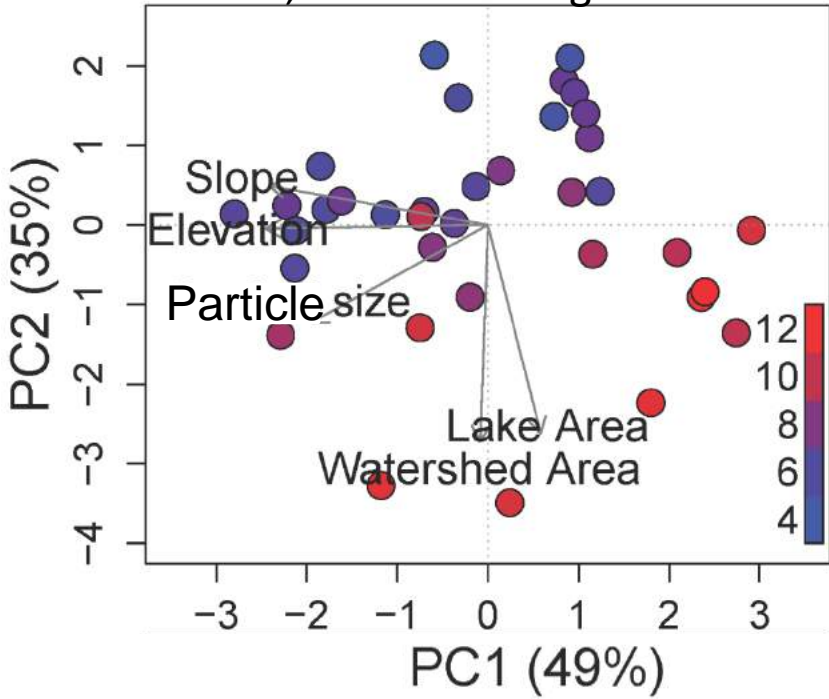
Wood River Basin
Alaska

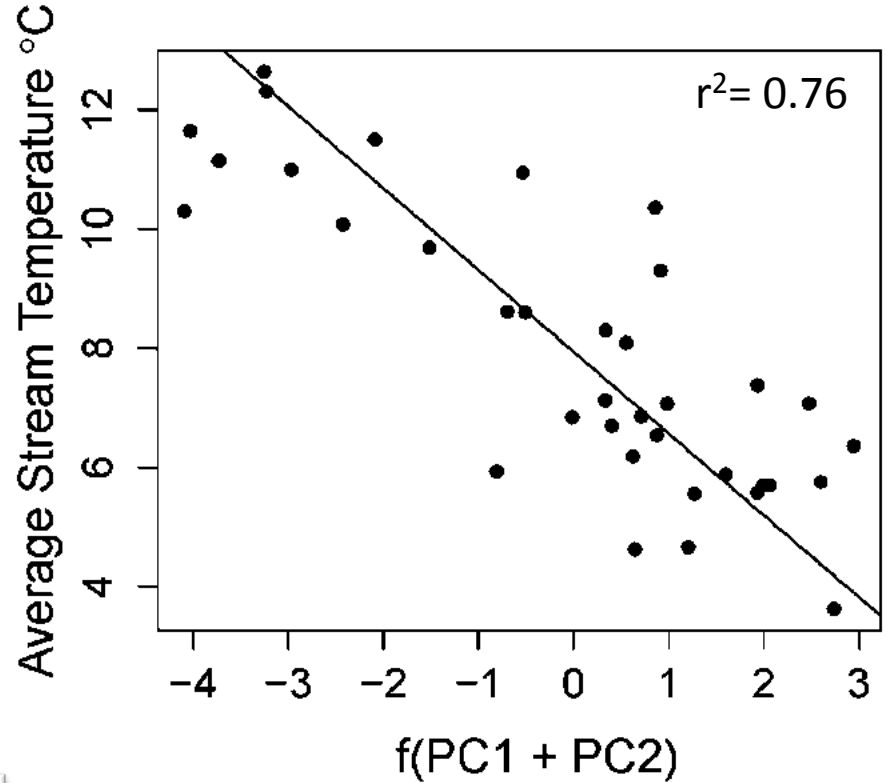
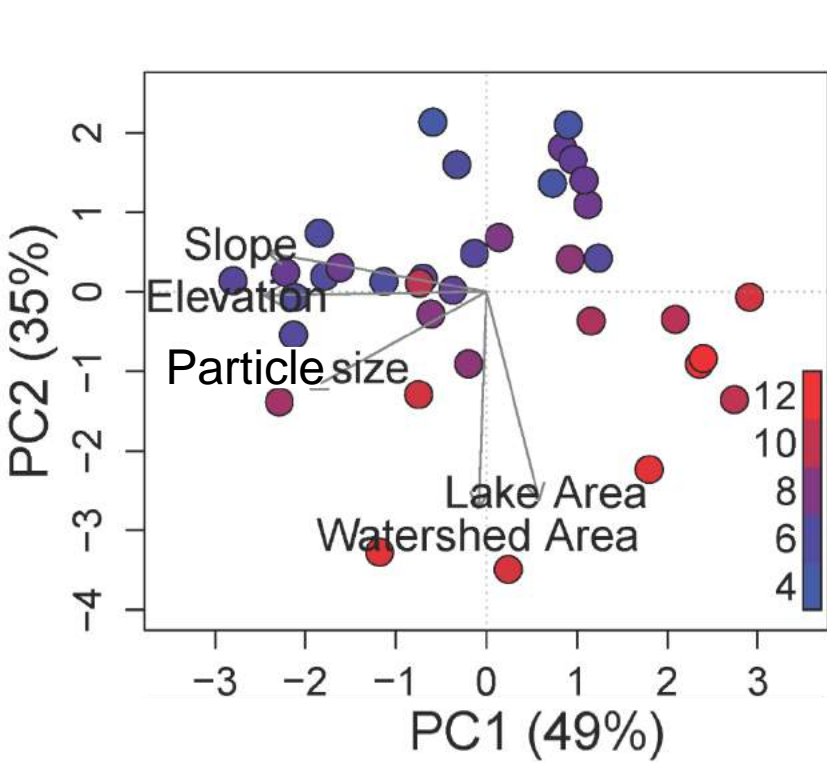


Dillingham



36 streams; Color = Average summer temperature





Sub watersheds set the thermal template in this landscape

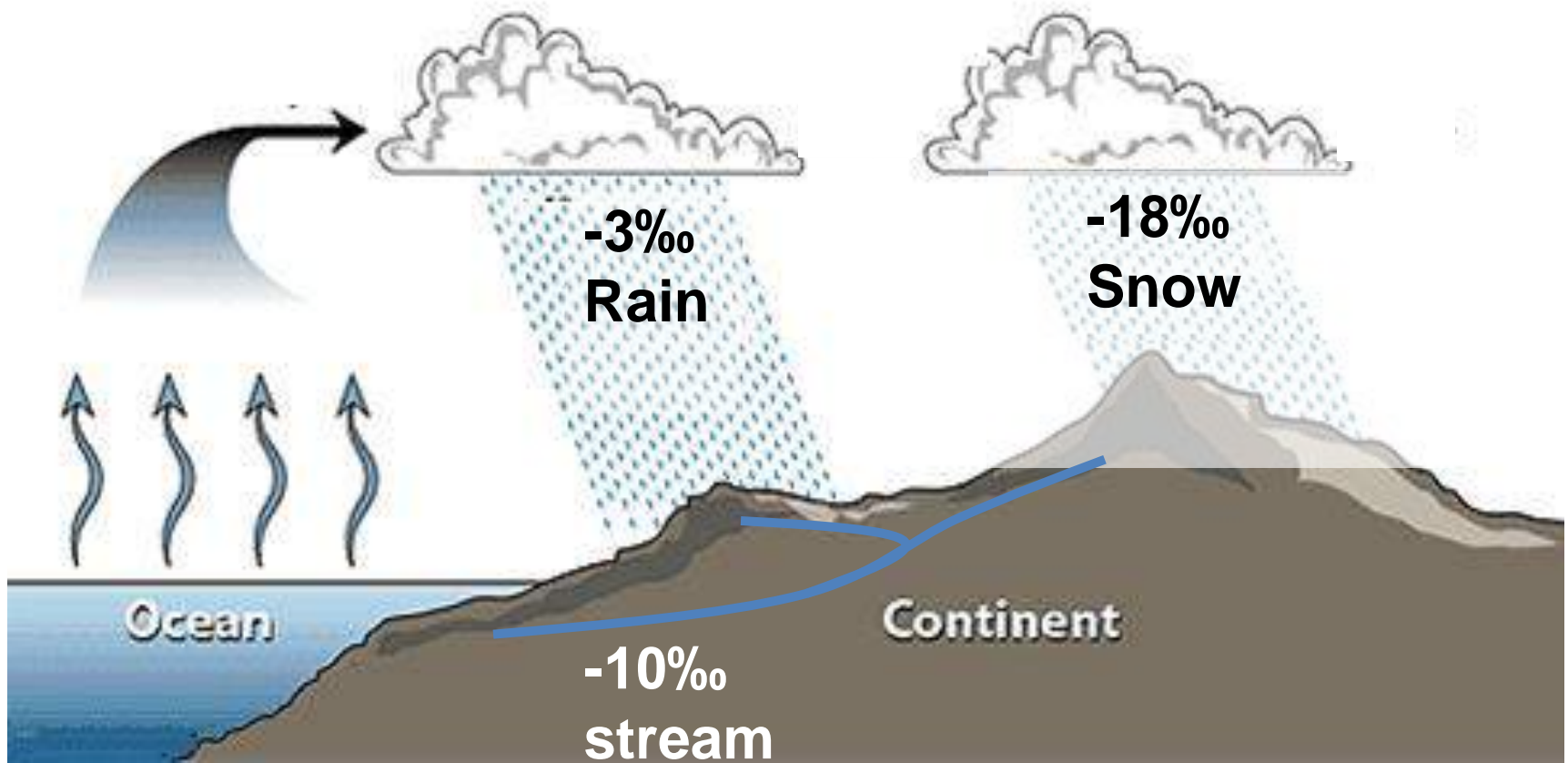
Lisi et al. *Geomorphology* 2013

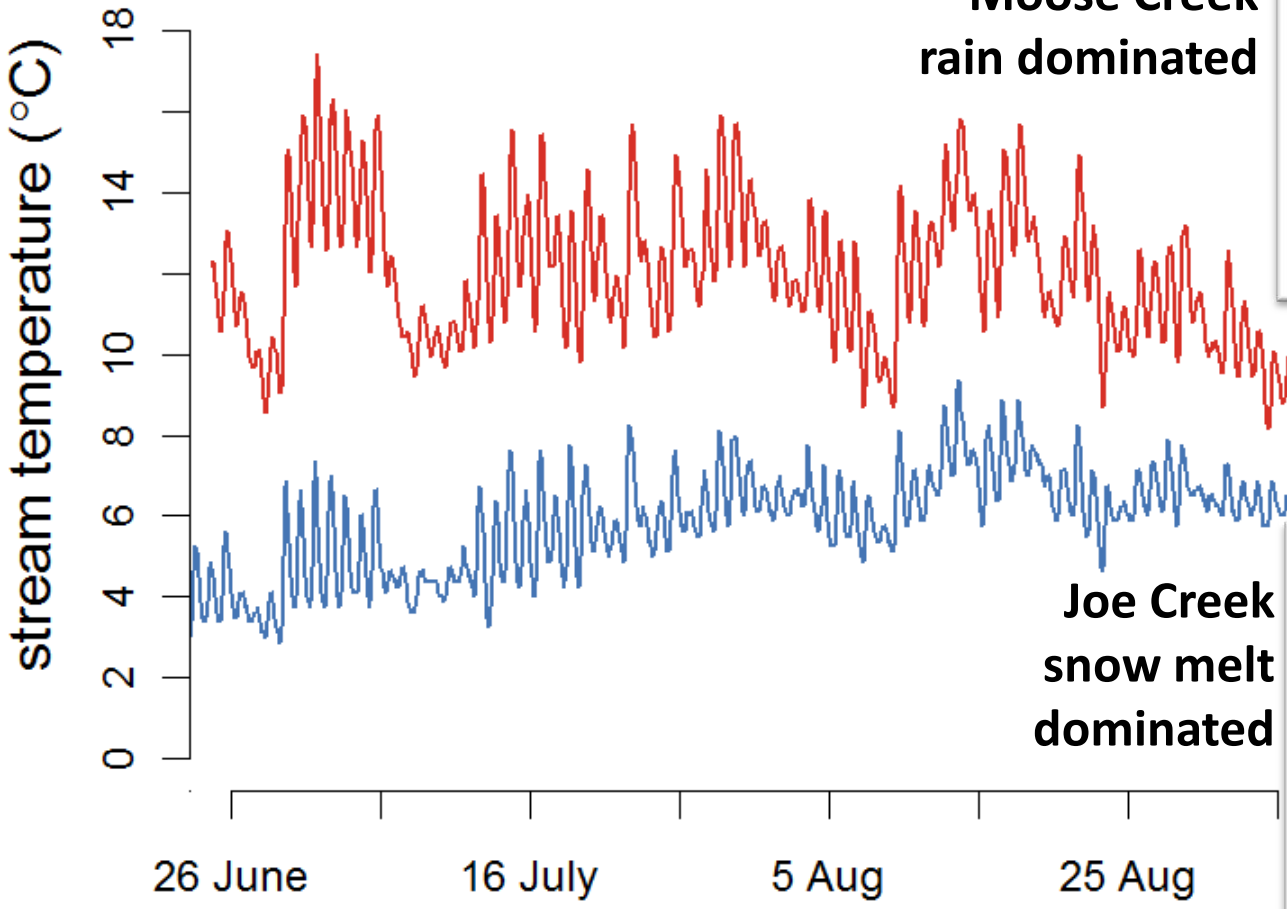


How does topography influence water source (Rain or Snow) and stream temperature?

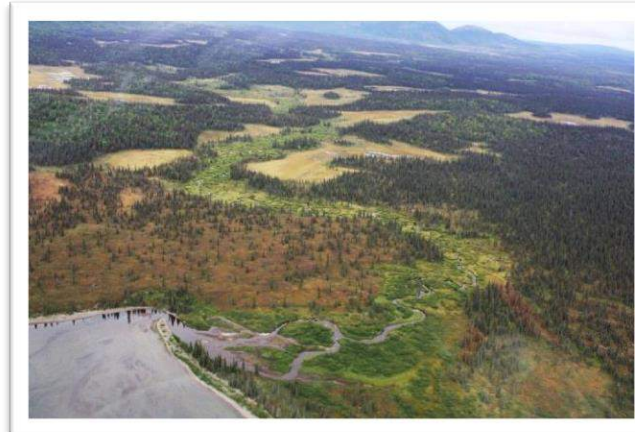


Stable isotopes in water ^{18}O and ^2H can help determine water source in streams.





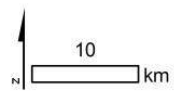
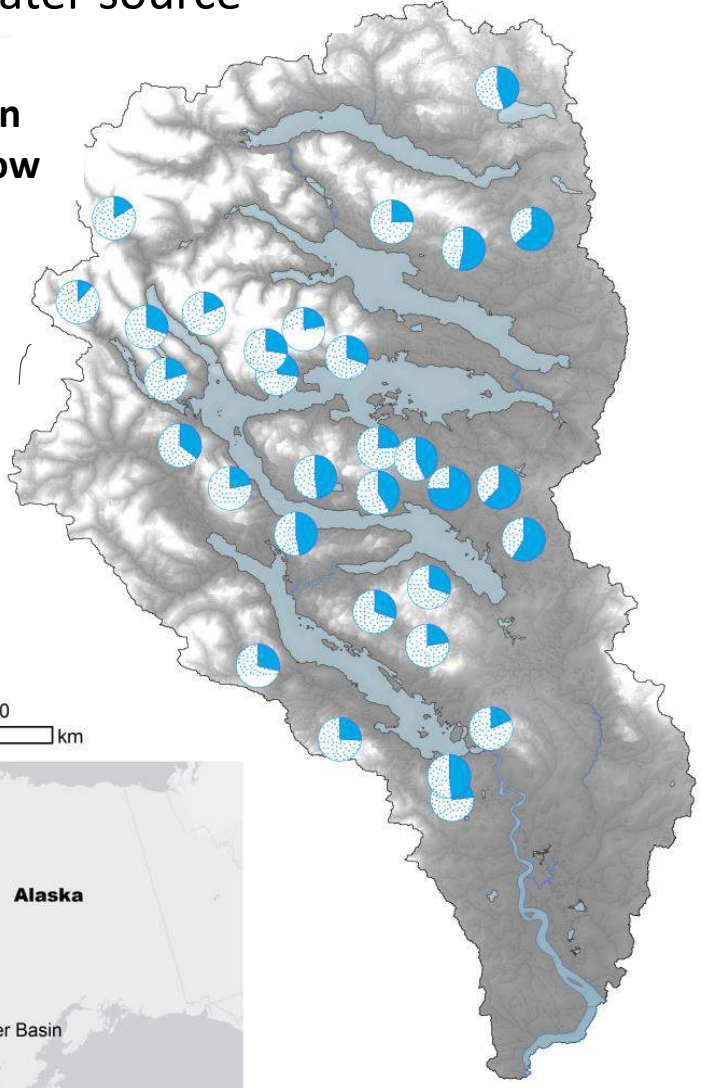
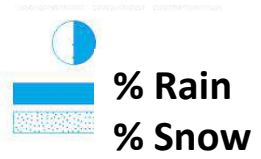
**Moose Creek
rain dominated**



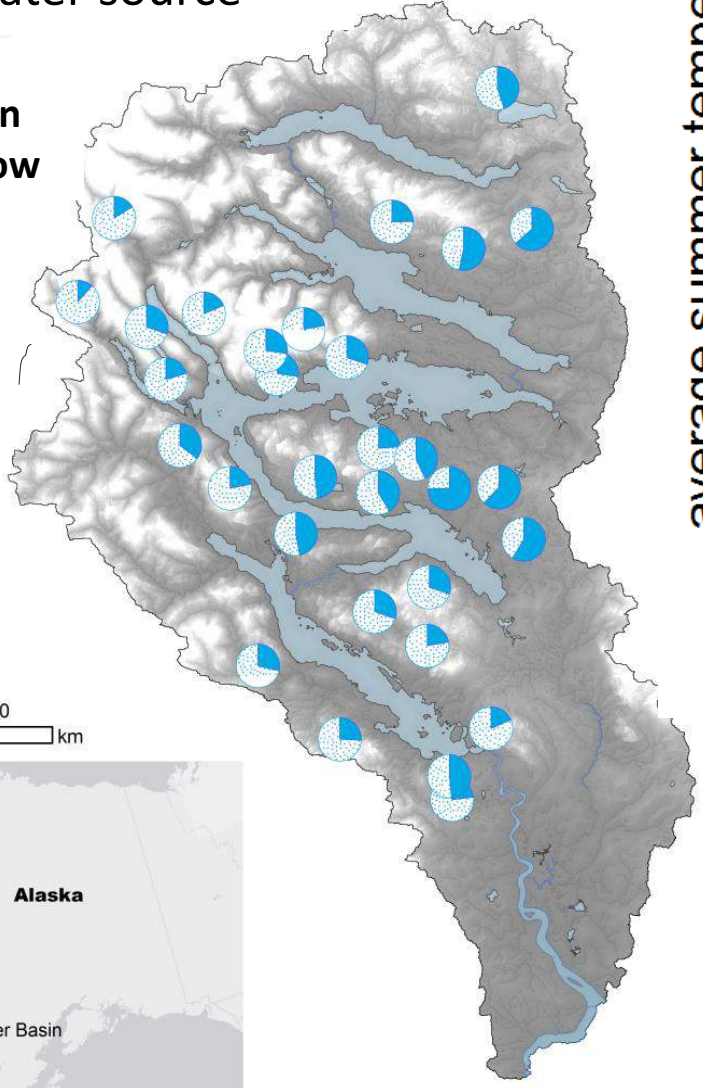
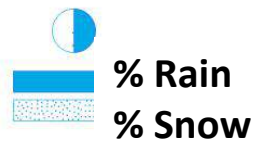
**Joe Creek
snow melt
dominated**



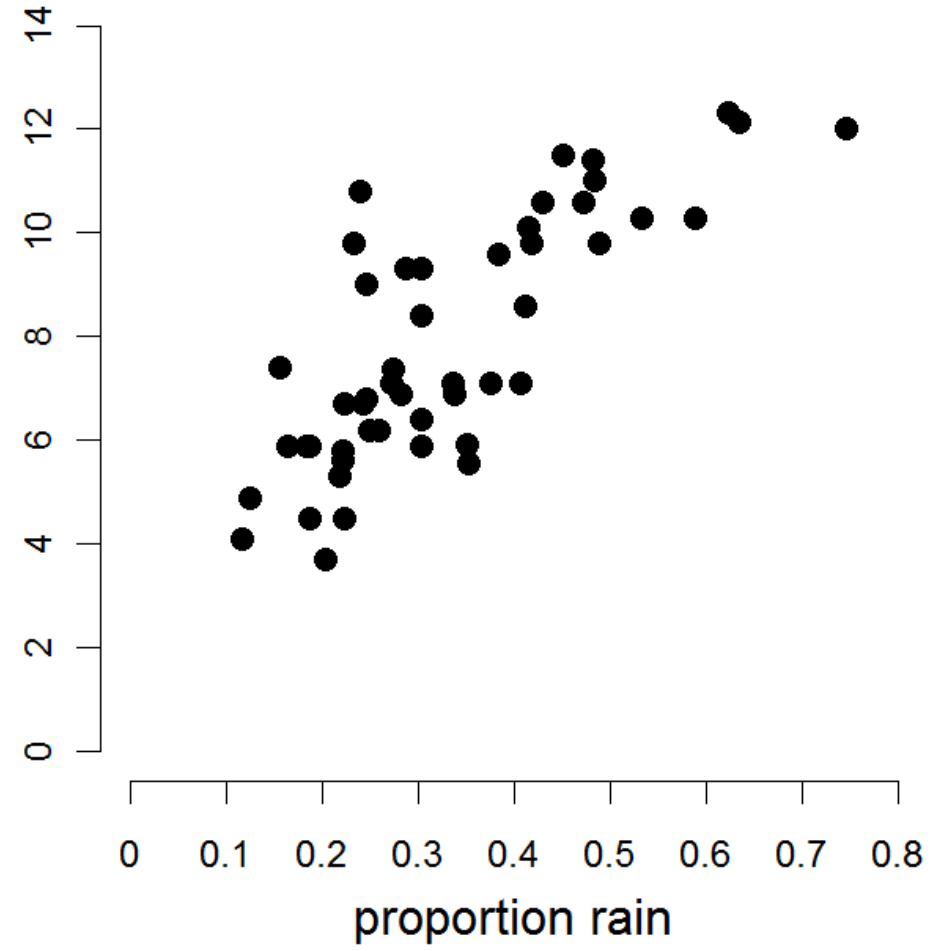
stream water source



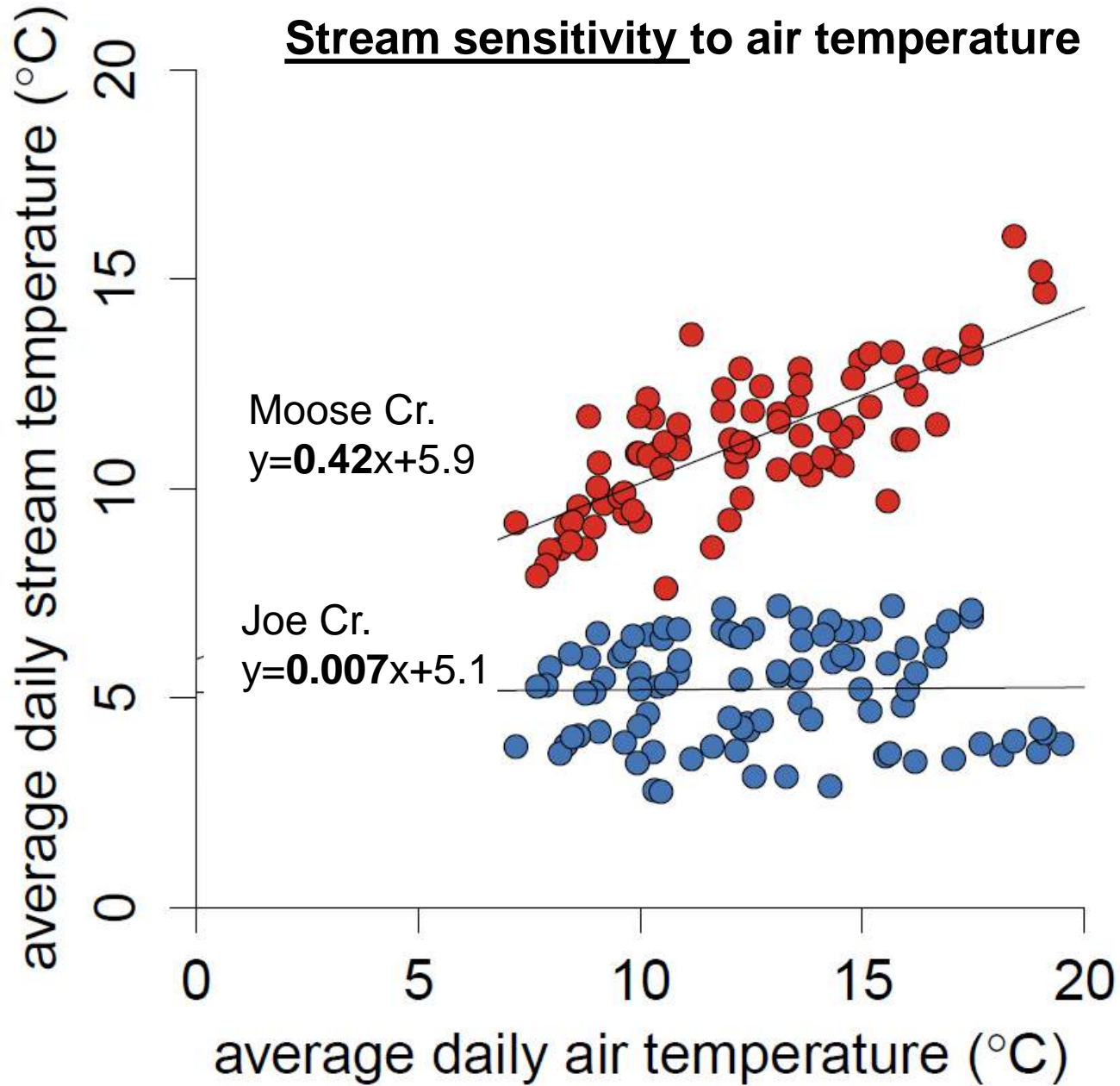
stream water source

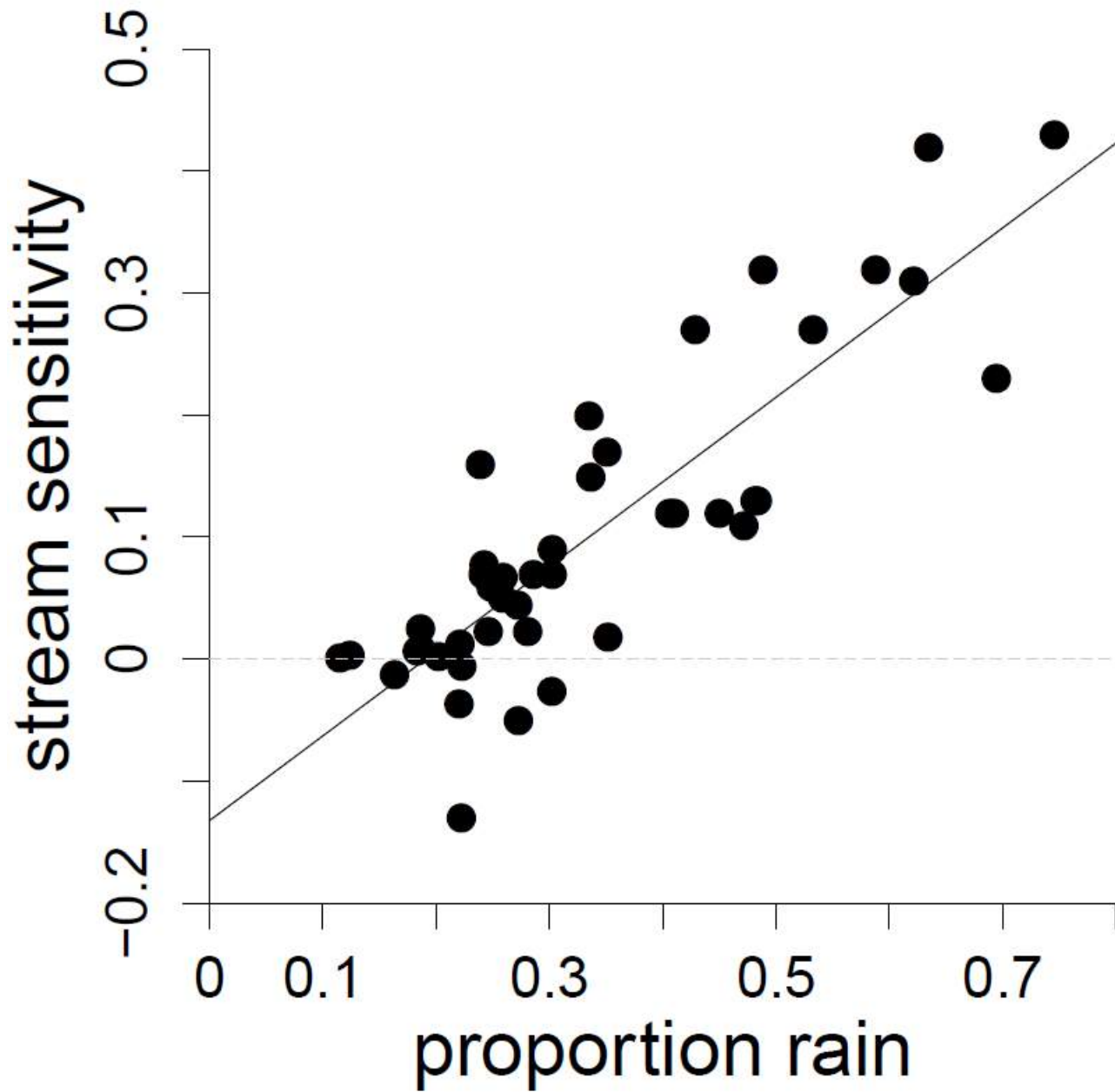


average summer temperature (°C)



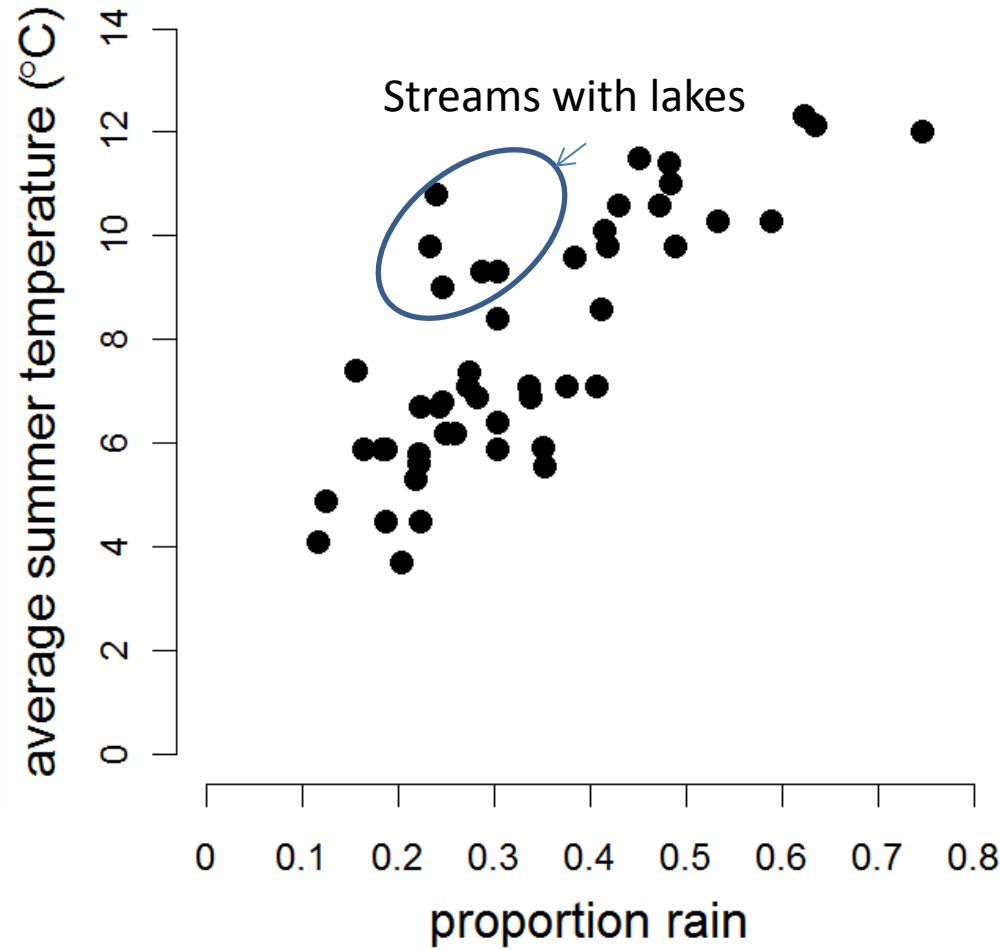
Stream sensitivity to air temperature





$r^2 = 0.73$

Lakes and thermal regimes at river outlets.





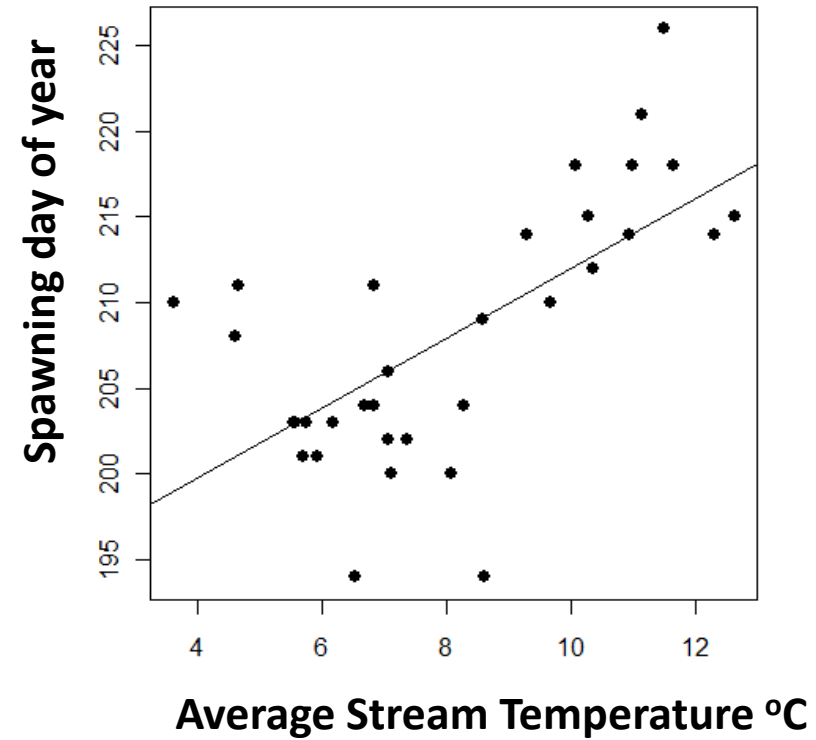
Summary:

- Topography influences stream temperature through a variety of controls on residence time and water source conditions.



Is this variation important to wildlife?

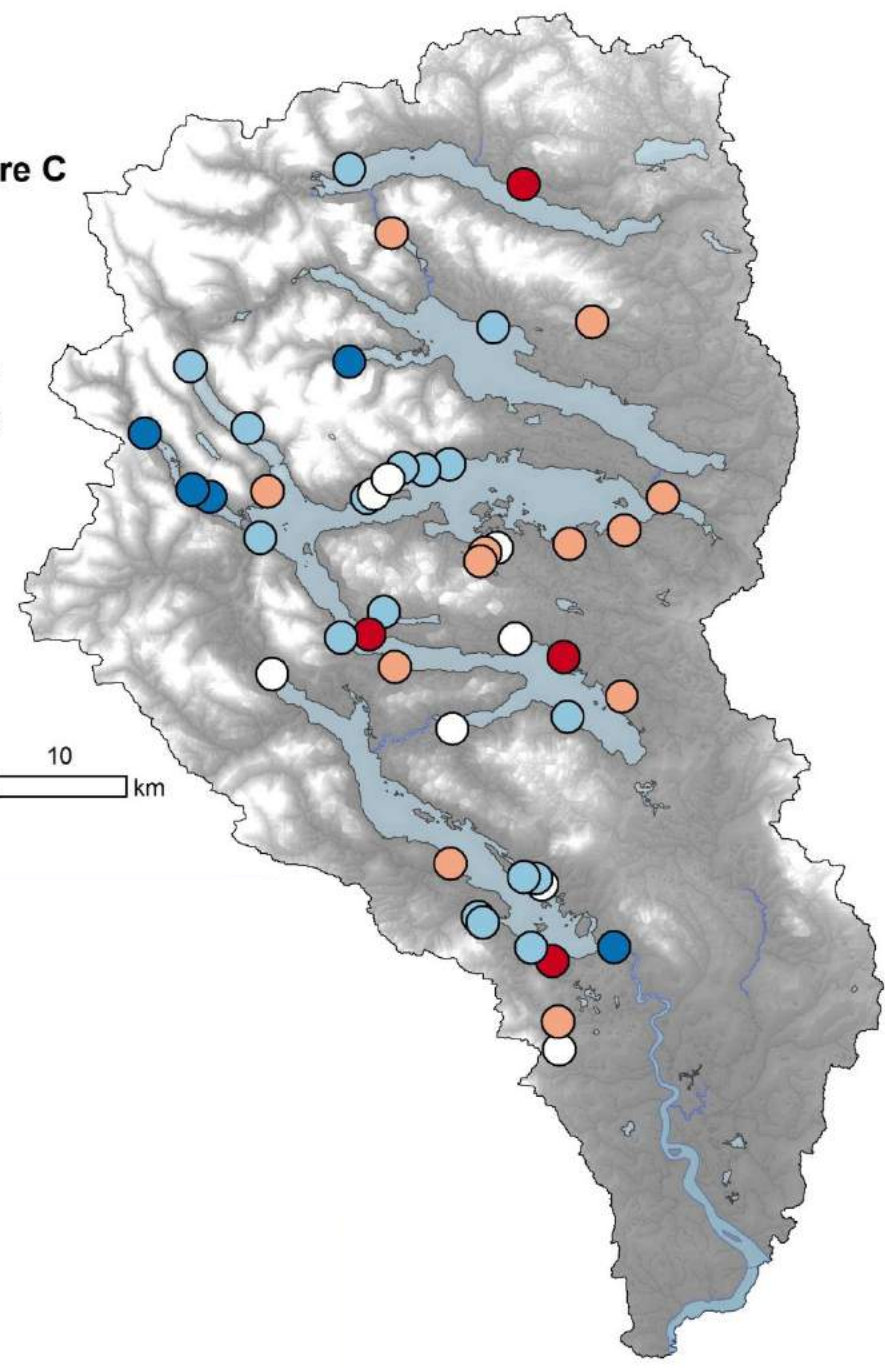
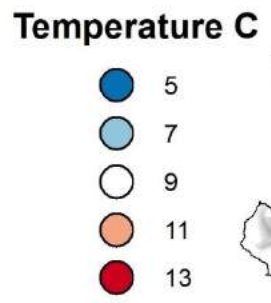
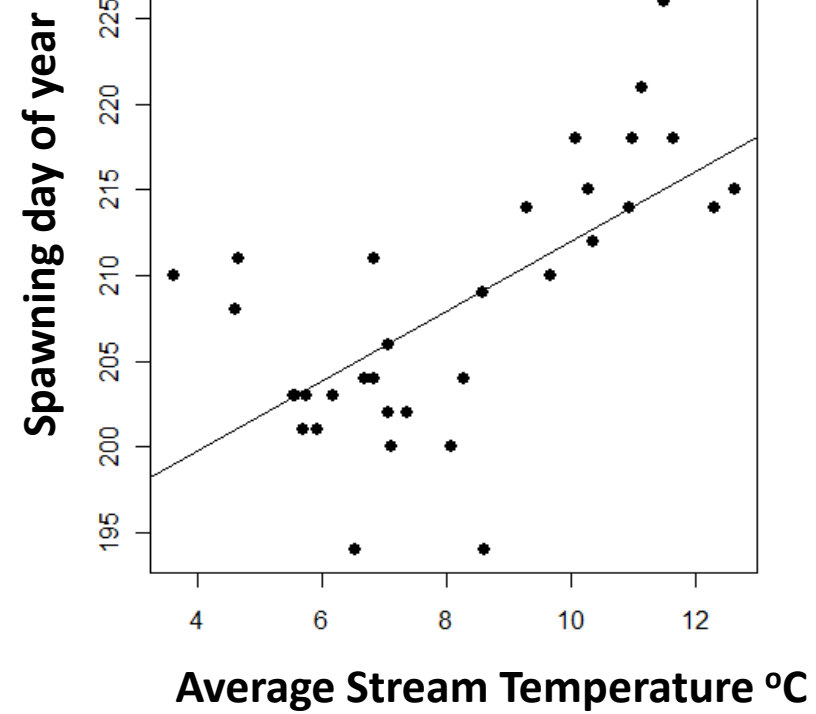




Salmon spawn-timing is linked to stream temperature

Salmon spawn earlier in cool streams and several weeks later in warmer streams.

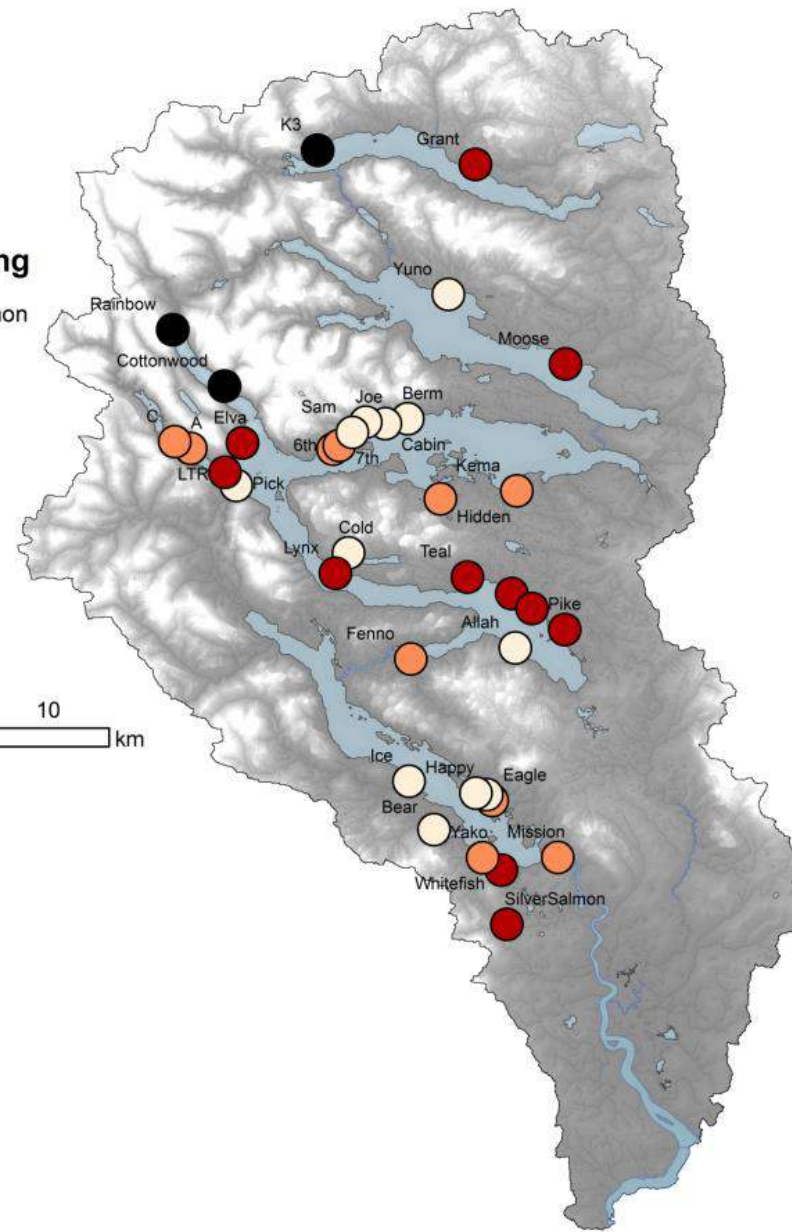
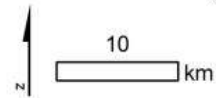
Lisi et al. *Geomorphology* 2013





Spawn timing

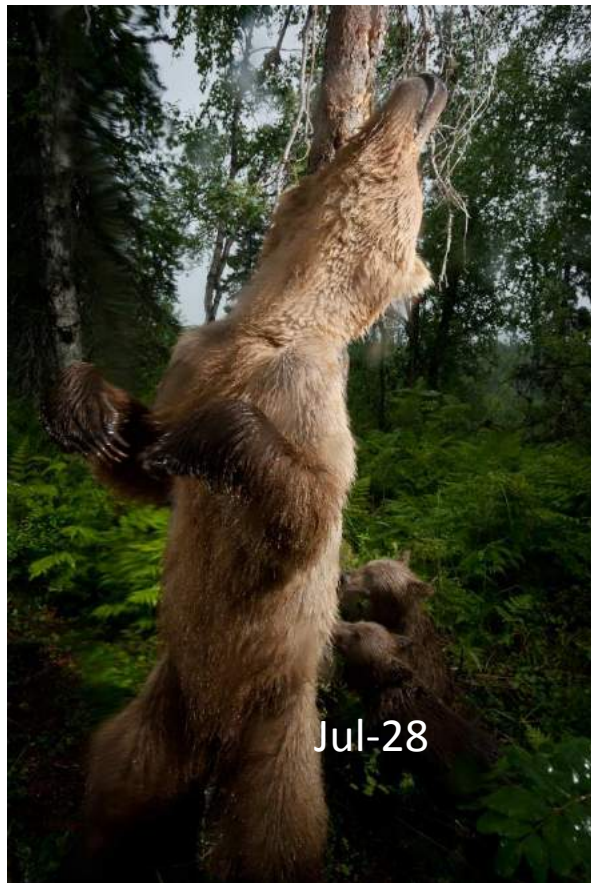
- Non salmon
- Early
- Middle
- Late

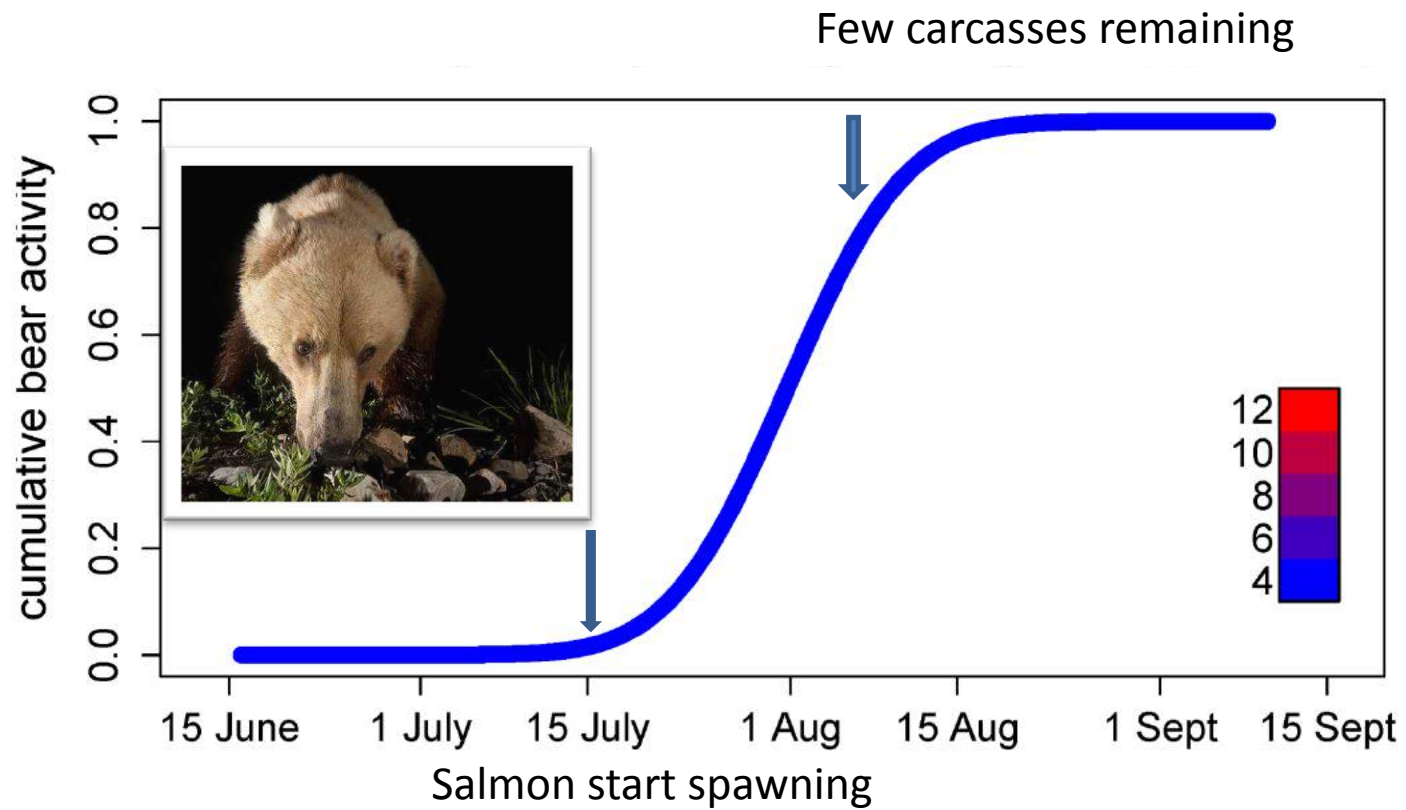


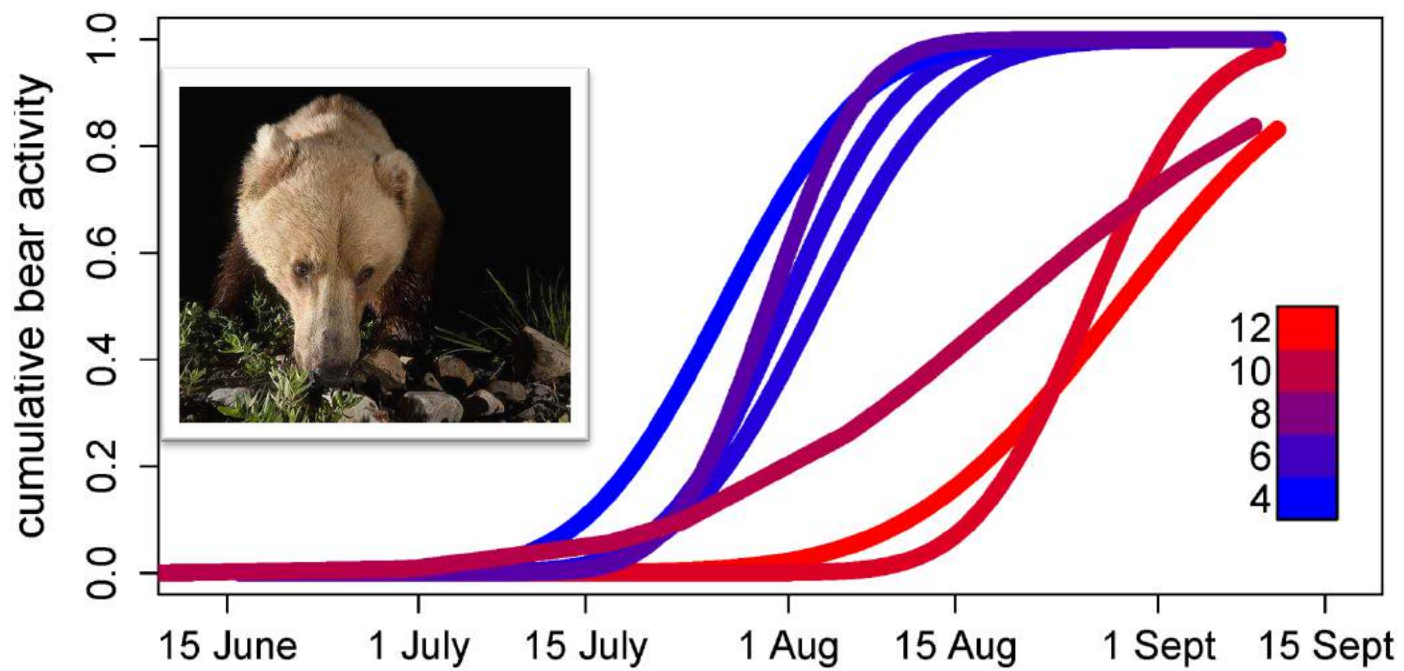
Does wildlife take advantage of the asynchrony in salmon spawn-timing?

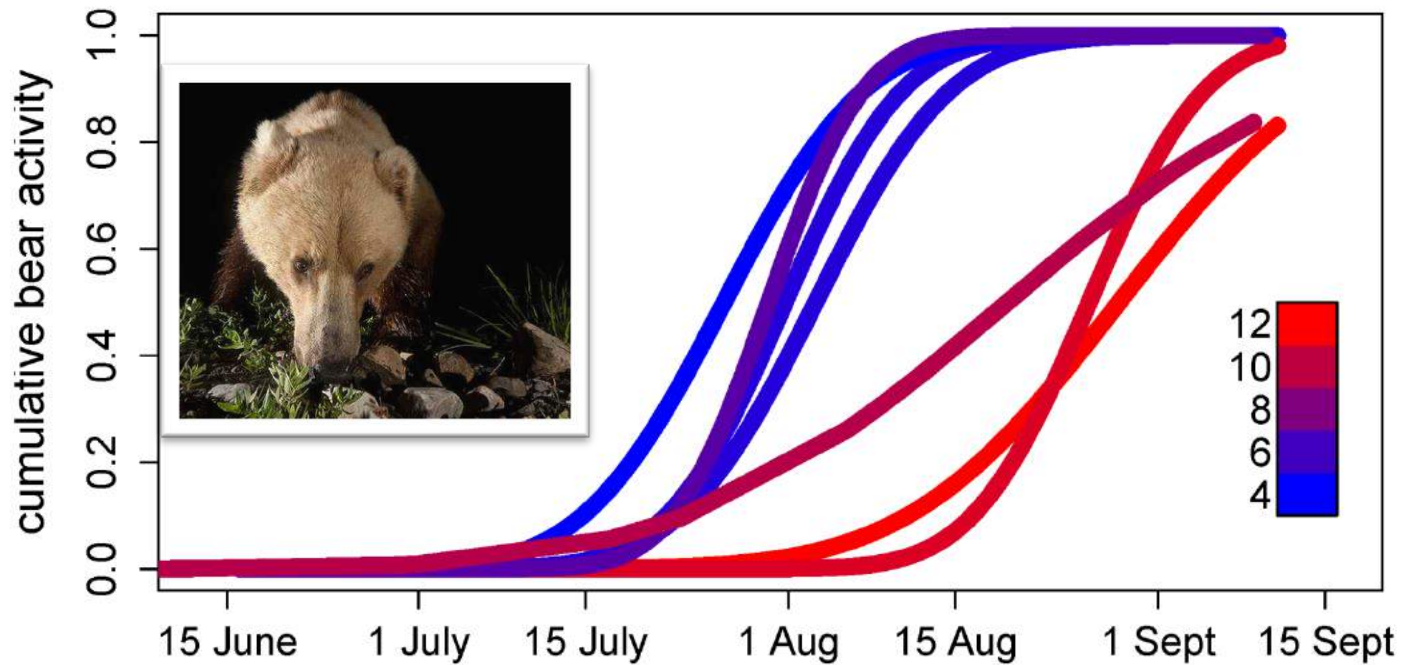
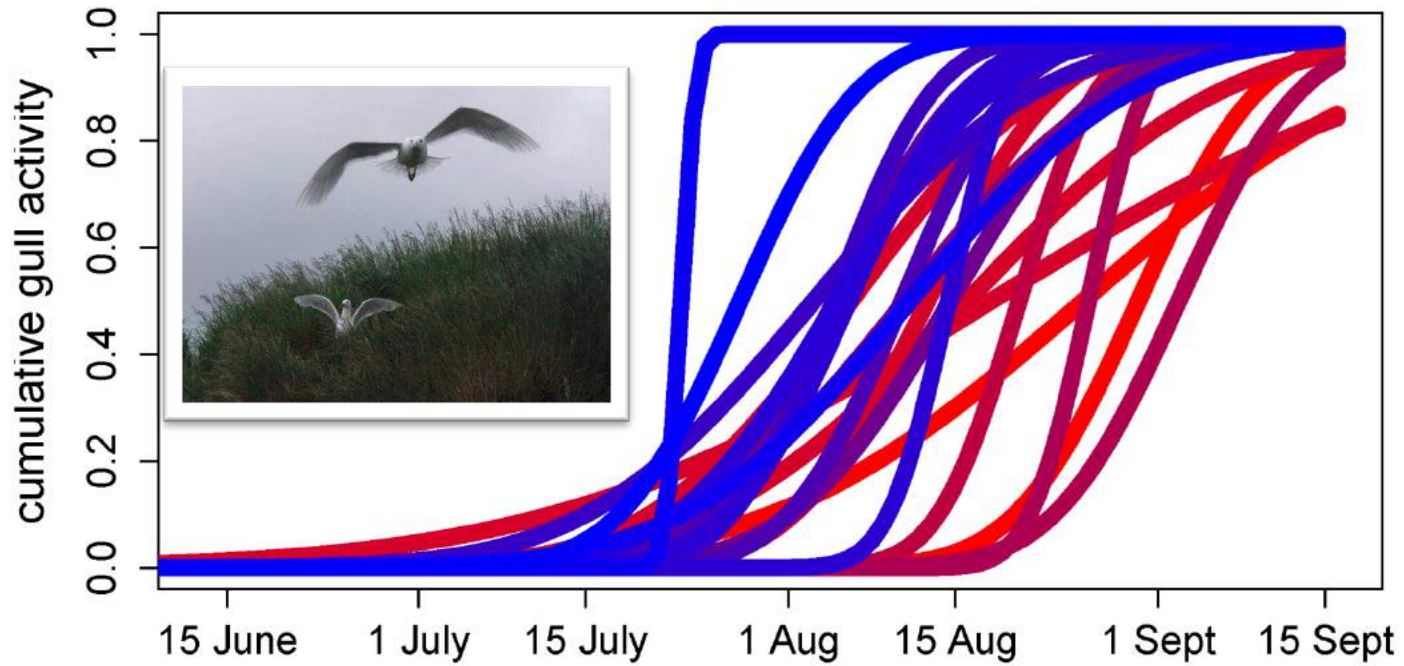


It's important to eat all you can, when you can.

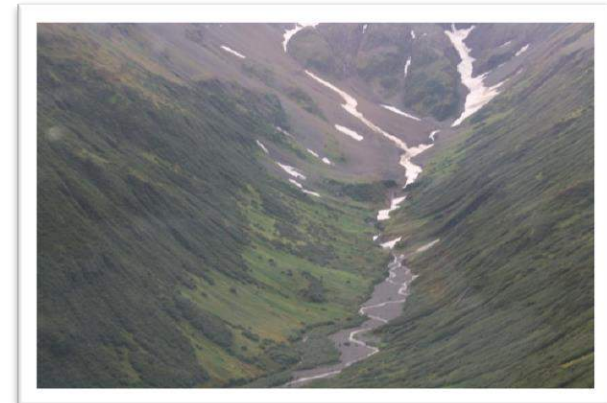






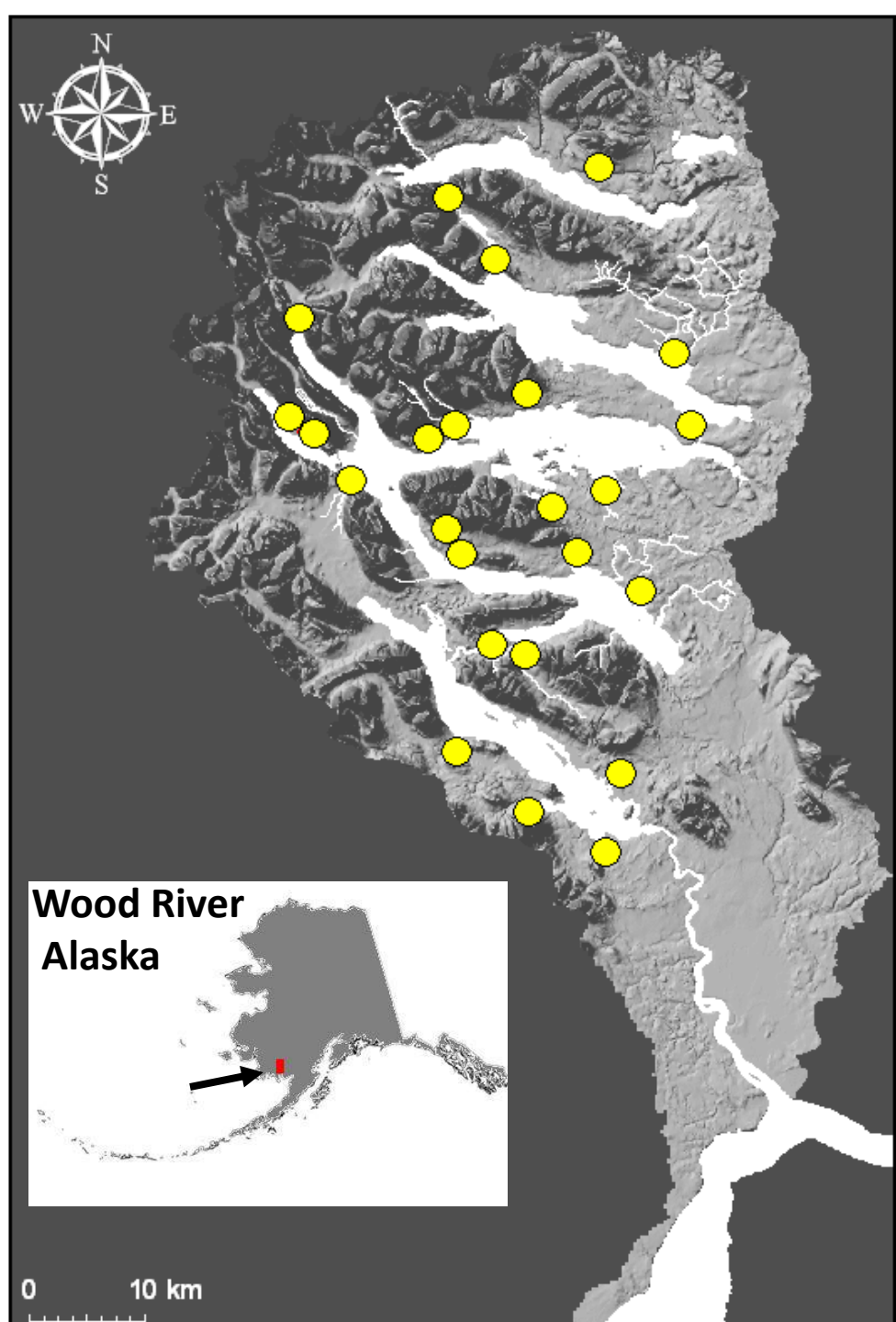
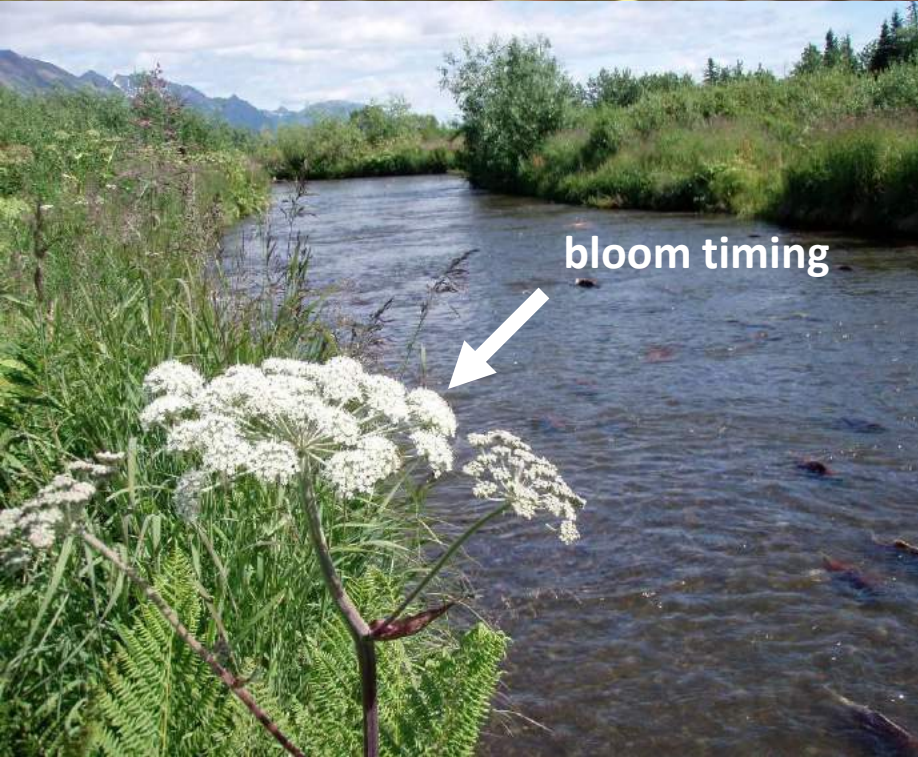


- Local adaptation to hydrologic regimes produce population diversity that can triple the time that consumers can eat salmon.

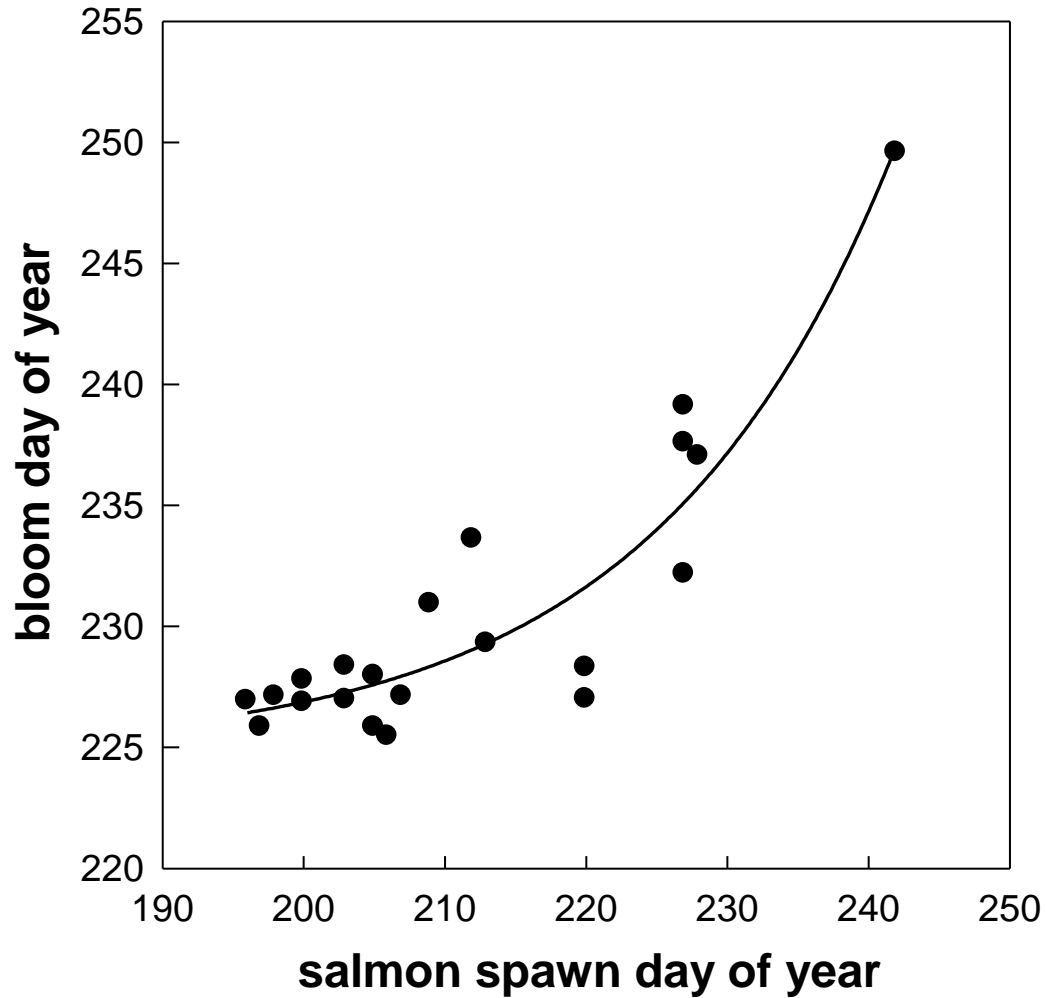


Indirect link between aquatic and riparian biodiversity

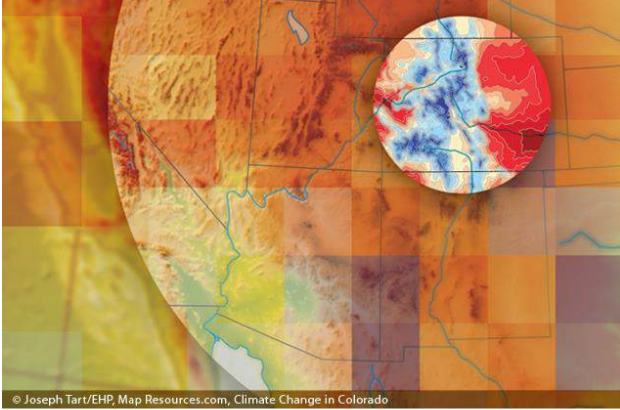




Salmon spawn timing propagates to riparian bloom timing



Local Climate

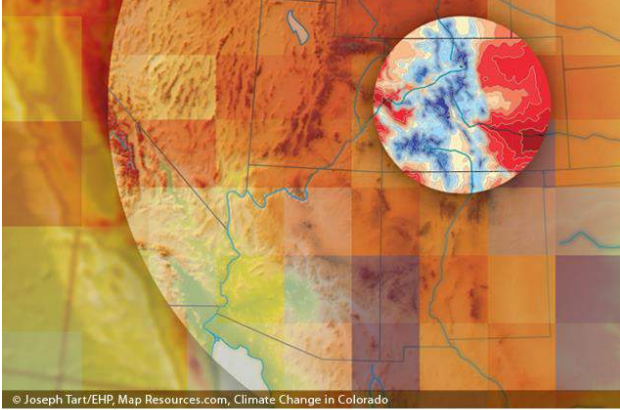


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Heterogeneous landscape

Local Climate



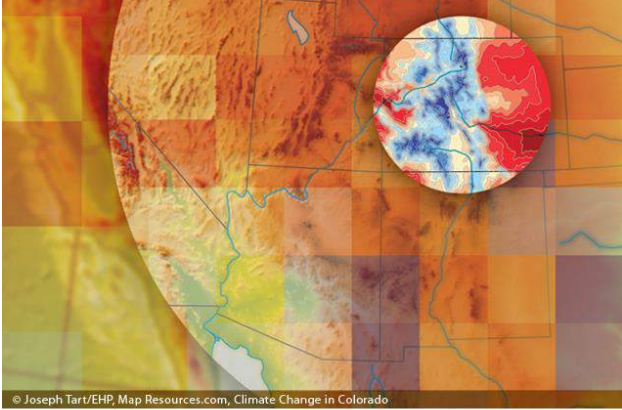
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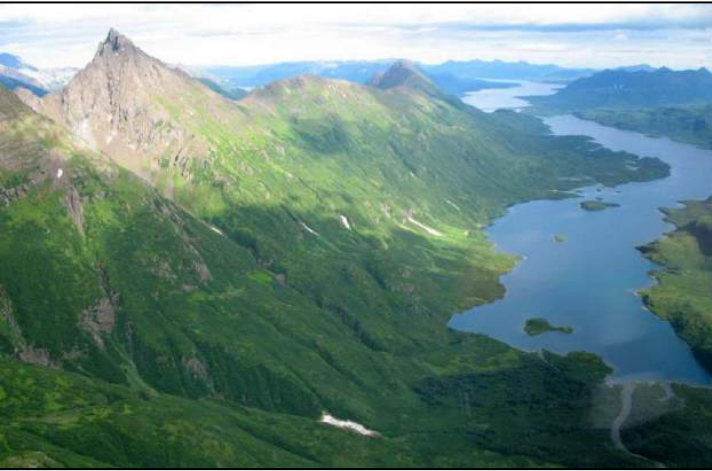
Heterogeneous landscape



salmon



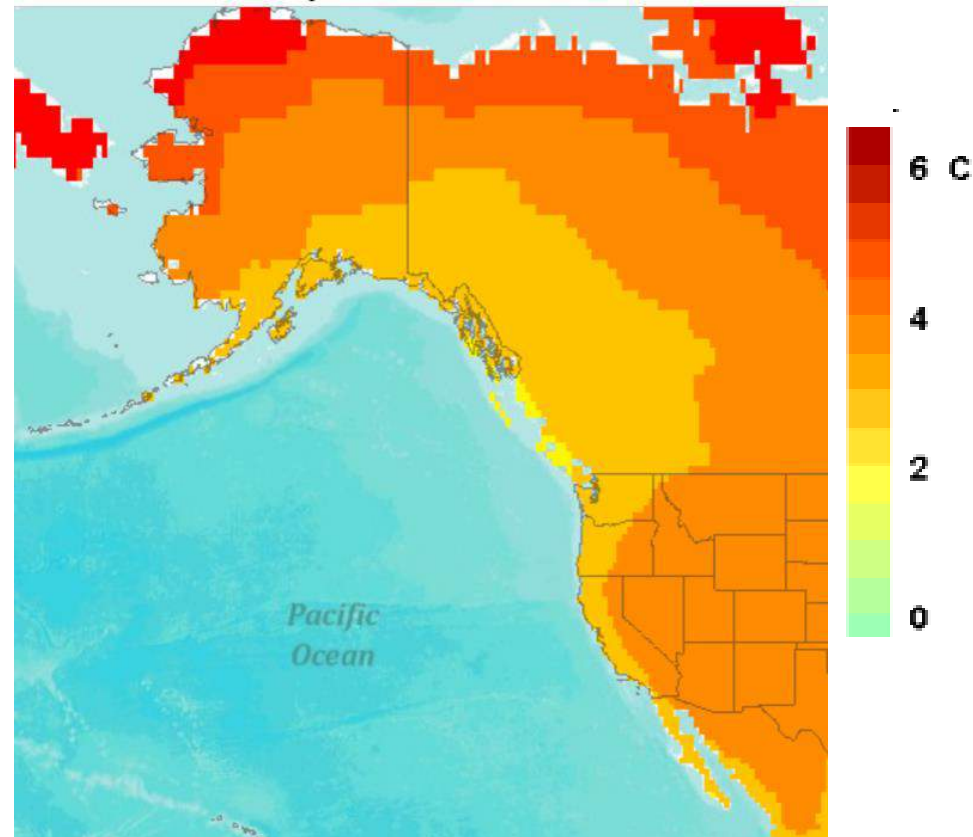
Local Climate



Aquatic/terrestrial connections

Heterogeneous landscape

predicted air temperature departures in 2079-2099

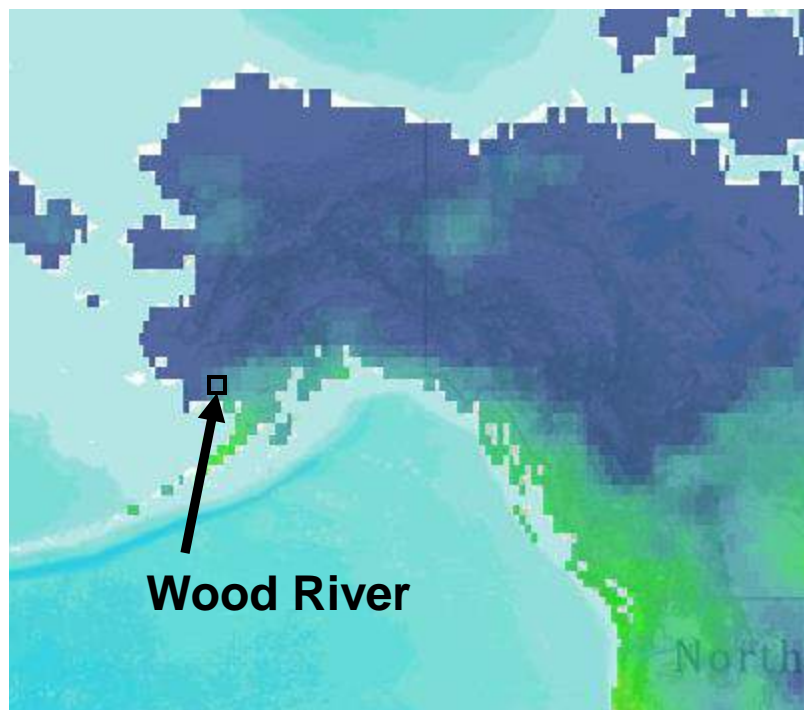


Predictions based on continued rate of anthropogenic CO₂.

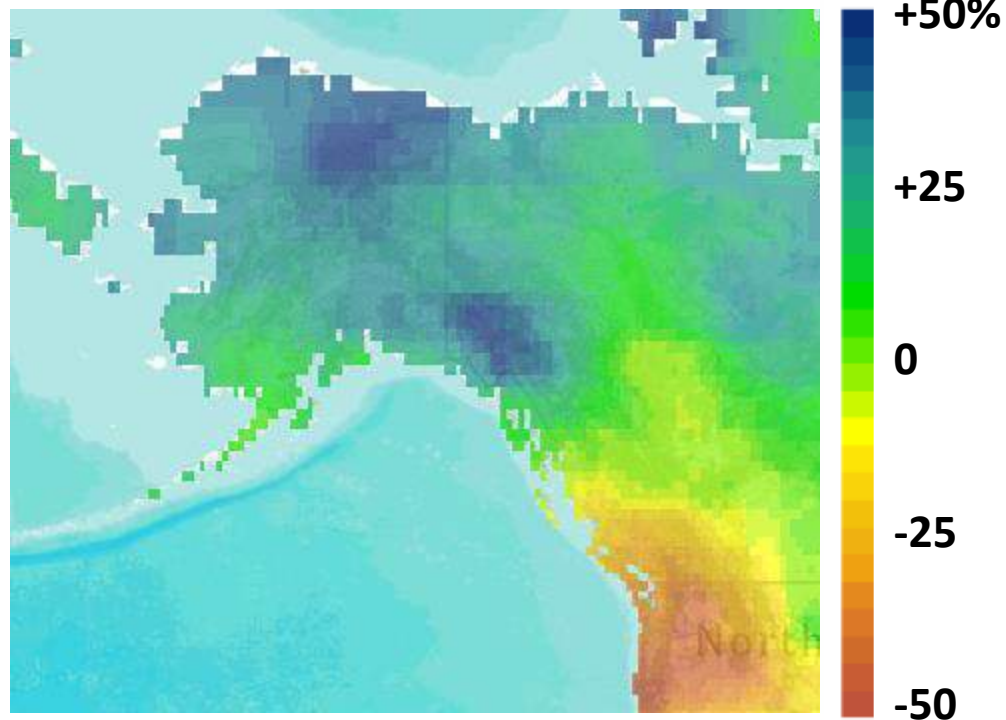
Maurer, et al (2007), Eos Trans. AGU, 88(47), 504

seasonal precipitation departures in 2079-2099

Winter



Summer



Predictions based on continued rate of anthropogenic CO₂.

Maurer, et al (2007), Eos Trans. AGU, 88(47), 504

Landscape diversity can buffer the effects of climate change on aquatic systems.

What can we do?

Protect the processes that create environmental variation

Maintain habitat options for wildlife.



Co Authors:

Daniel Schindler, Jonny Armstrong, Kale Bentley, Kathijo Jankowski, Laura Payne,
University of Washington
George Pess: NOAA

Bear Photography
Jonny Armstrong



Collaborators :

Patrick Walsh and Mark Lisac.
Federal Fish and Wildlife
Bill Berkahn and Claire LeClair.
Wood-Tikchik State Park



Questions and collaborations? pjlisi@uw.edu