

Mountain glaciers influence biogeochemical and ecological characteristics of alpine lakes in the Northern Rockies

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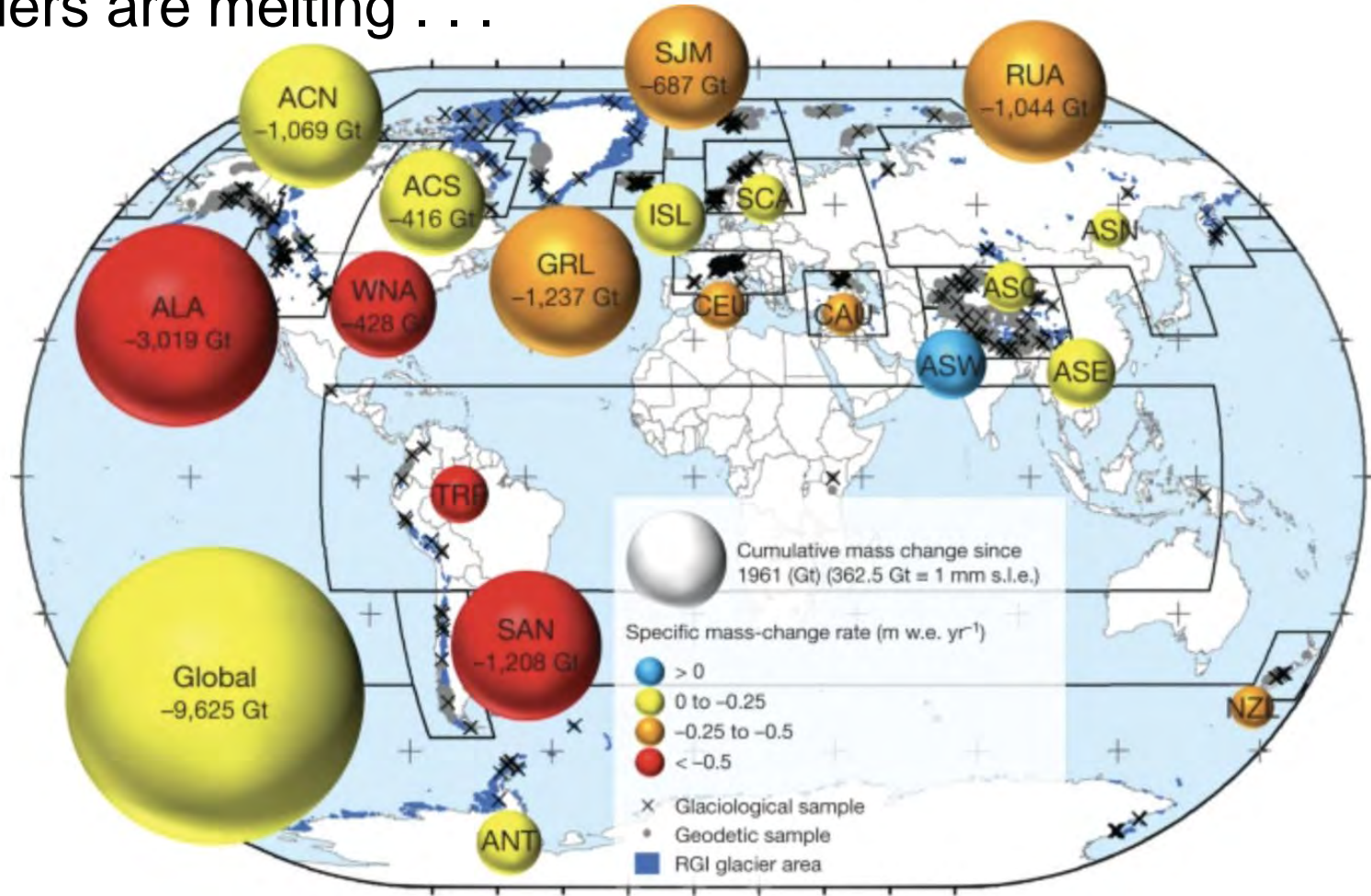
Montana Lakes Conference
Thursday, October 19th 2023



UNIVERSITY OF
MONTANA

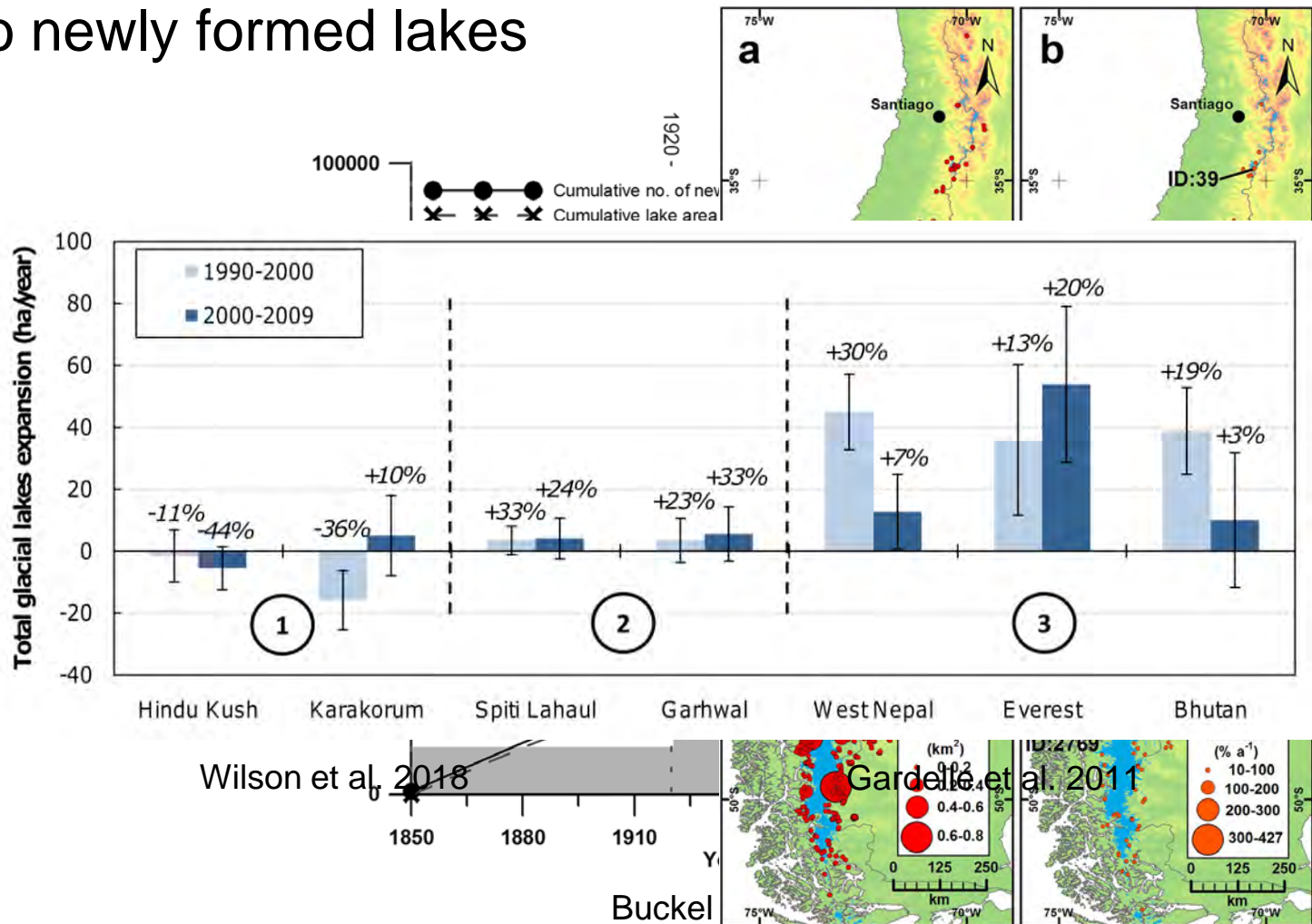


Glaciers are melting . . .



... leading to newly formed lakes

- Himalaya



Grinnell Glacier



Grinnell Glacier 1910 USGS photographic library

1910



Grinnell Glacier 2017 Lisa McKeon, USGS

2017

1913



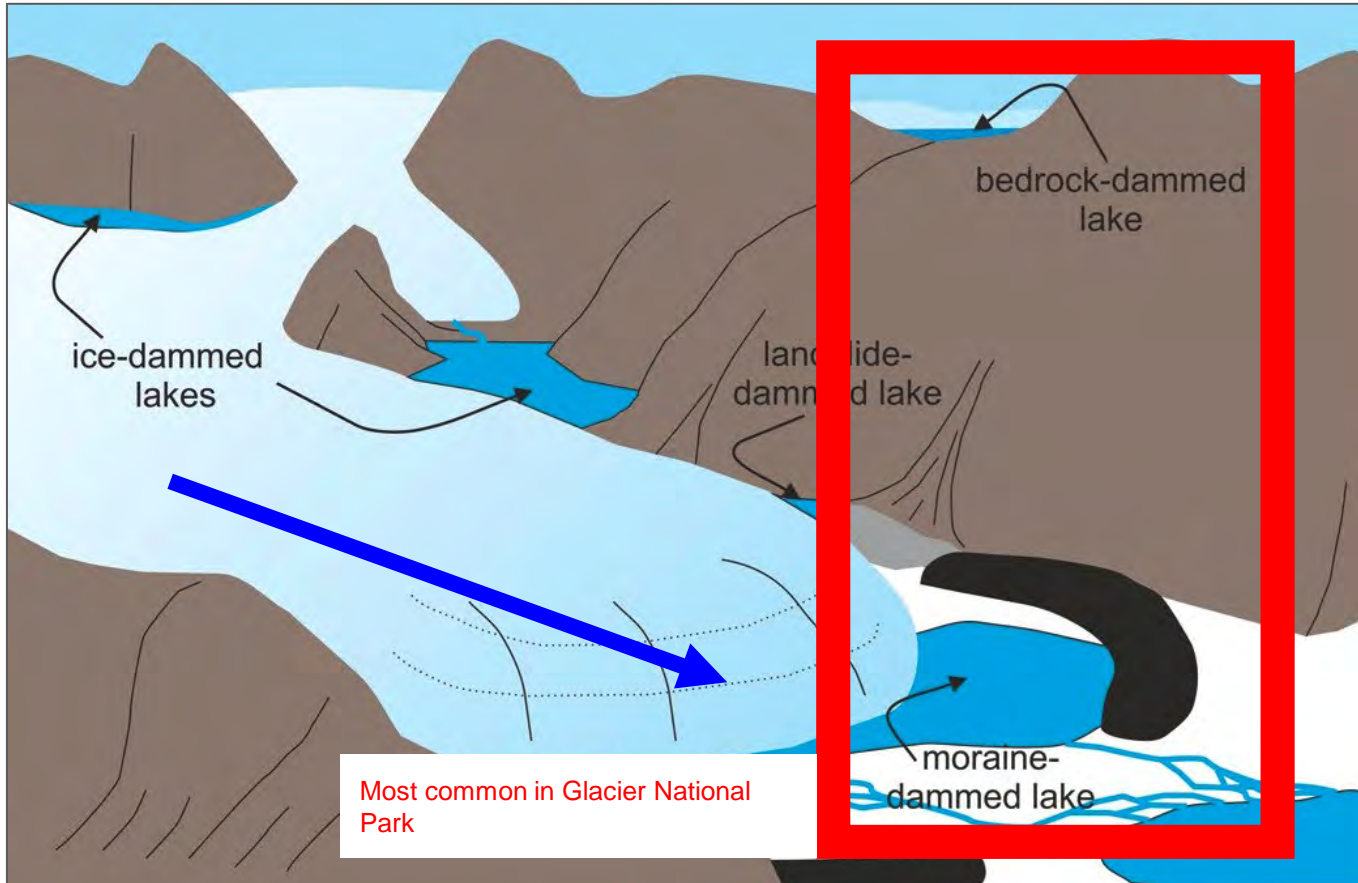
Sperry Glacier, Sept. 15, 1913
WC Alden, USGS Photographic Library



Sperry Glacier, Sept. 17, 2008
Lisa McKeon, USGS

2008

Glacial lake formation





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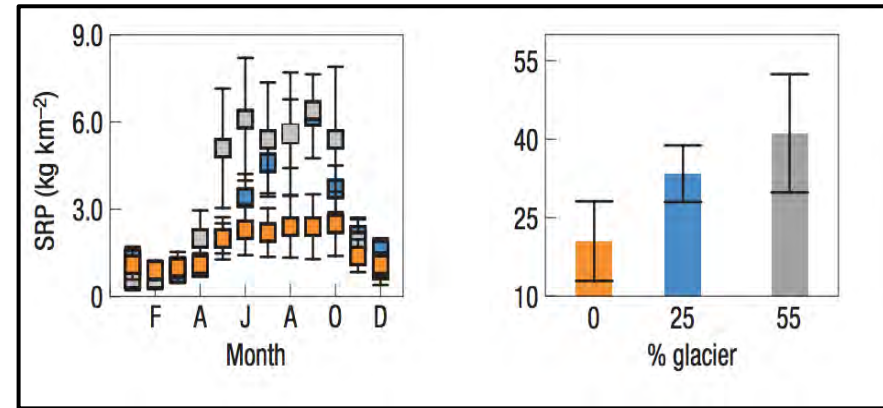
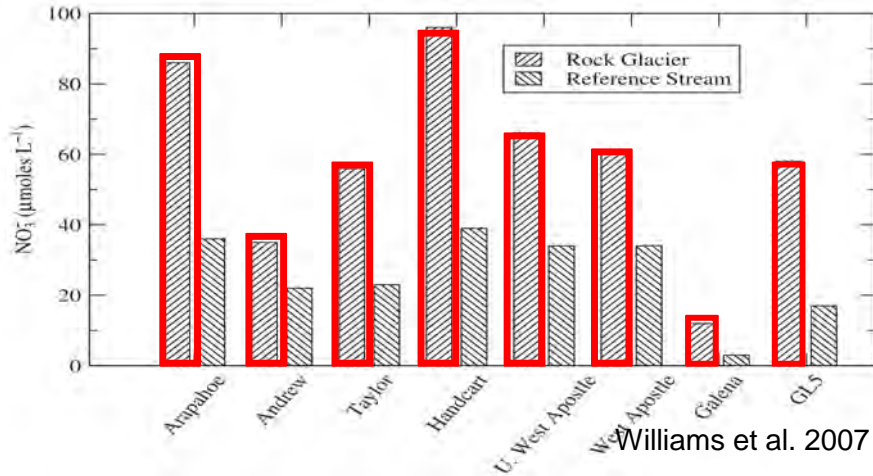
Glacial meltwater is nutrient rich

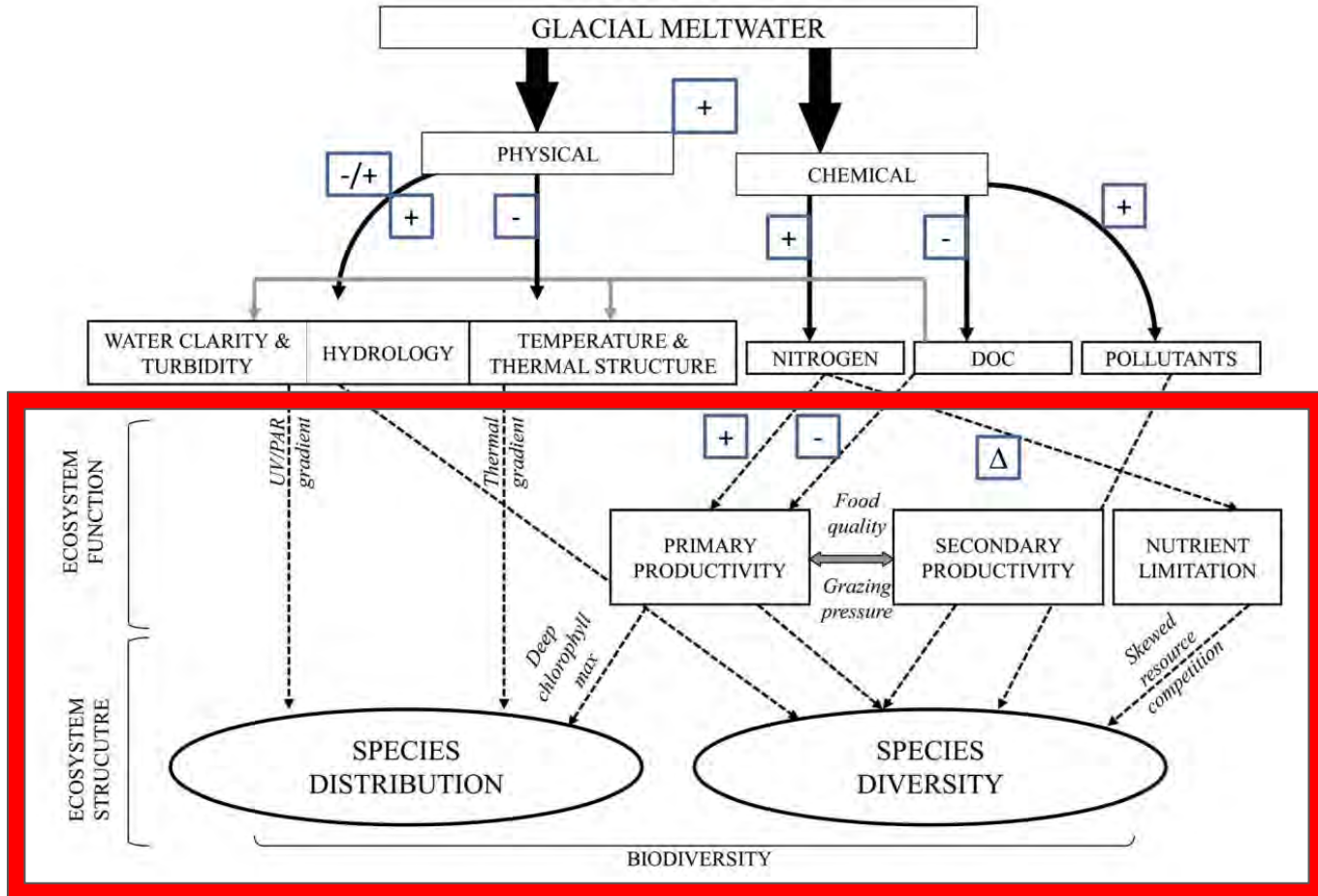
Table 2

The number of molecular formulas identified, the % containing the heteroatoms N, P, and S, and their average molecular weight as revealed by FTICR-MS for DOM samples isolated from the waters of the Tibetan Plateau.

Sample site	Formulas assigned	CHO-only (%)	Contains N (%)	Contains S (%)	Contains P (%)	Mean mass
Mount Nyainqentanglha Glacier	4399	1848 (42%)	2035 (46%)	371 (8%)	195 (4%)	390
Karola Glacier	4351	1761 (40%)	2078 (48%)	279 (6%)	289 (7%)	404
Mount Nyainqentanglha Stream	4416	1739 (39%)	2158 (49%)	363 (8%)	229 (5%)	398
Karola Glacier Stream	4520	1758 (39%)	2189 (48%)	402 (9%)	261 (6%)	395
Namtso Lake	2301	953 (41%)	997 (43%)	355 (15%)	40 (2%)	402
Yamdruk Lake	2399	972 (41%)	1032 (43%)	409 (17%)	42 (2%)	413

Spencer et al. 2014



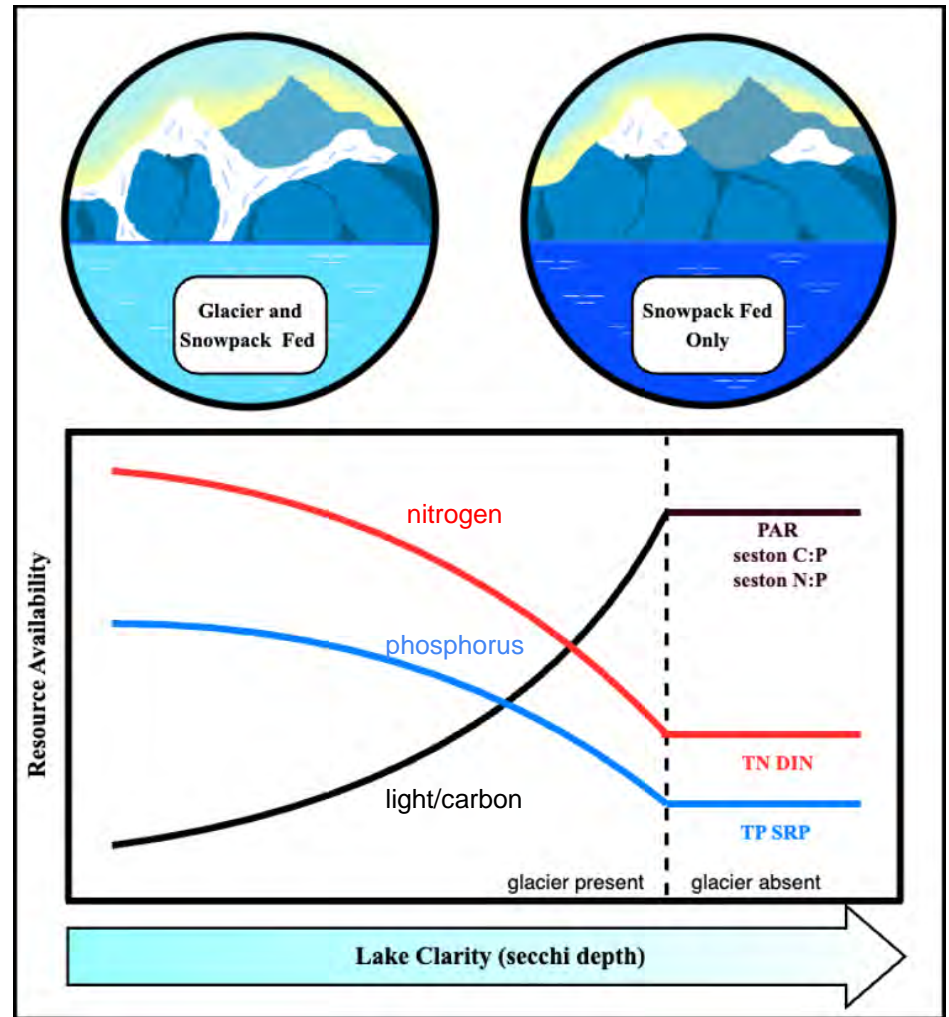


How do lake nutrient concentrations change along a gradient of glacial influence?

Does the relative supply of nitrogen and phosphorus change as well?

How do phytoplankton nutrient ratios change across glacial influence?

Are physical or chemical drivers more important in structuring glacial lake zooplankton assemblages?



Glacier National Park - a perfect natural experiment

- Well documented glacial retreat: many lakes ~ 100 yrs old
- Both glacial and non-glacial lakes at similar elevations
- Some basins have their own turbidity gradient!



Lake X

Ghost Lake

View of Sperry Basin - from glacier

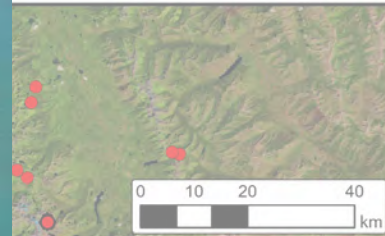
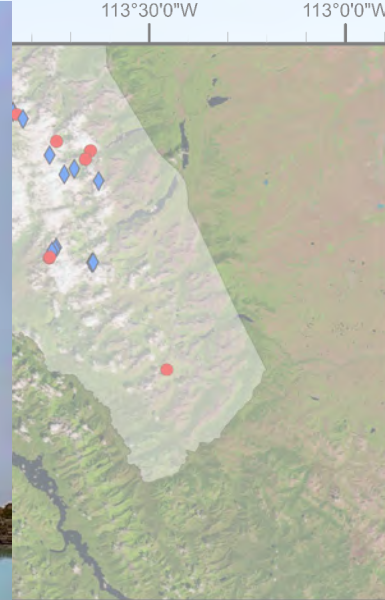


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Comparing

- Backpack survey
- 29 lakes ranging in size
 - Sampled
- Collected physical and chemical data and zooplankton data



pc Jim Elser

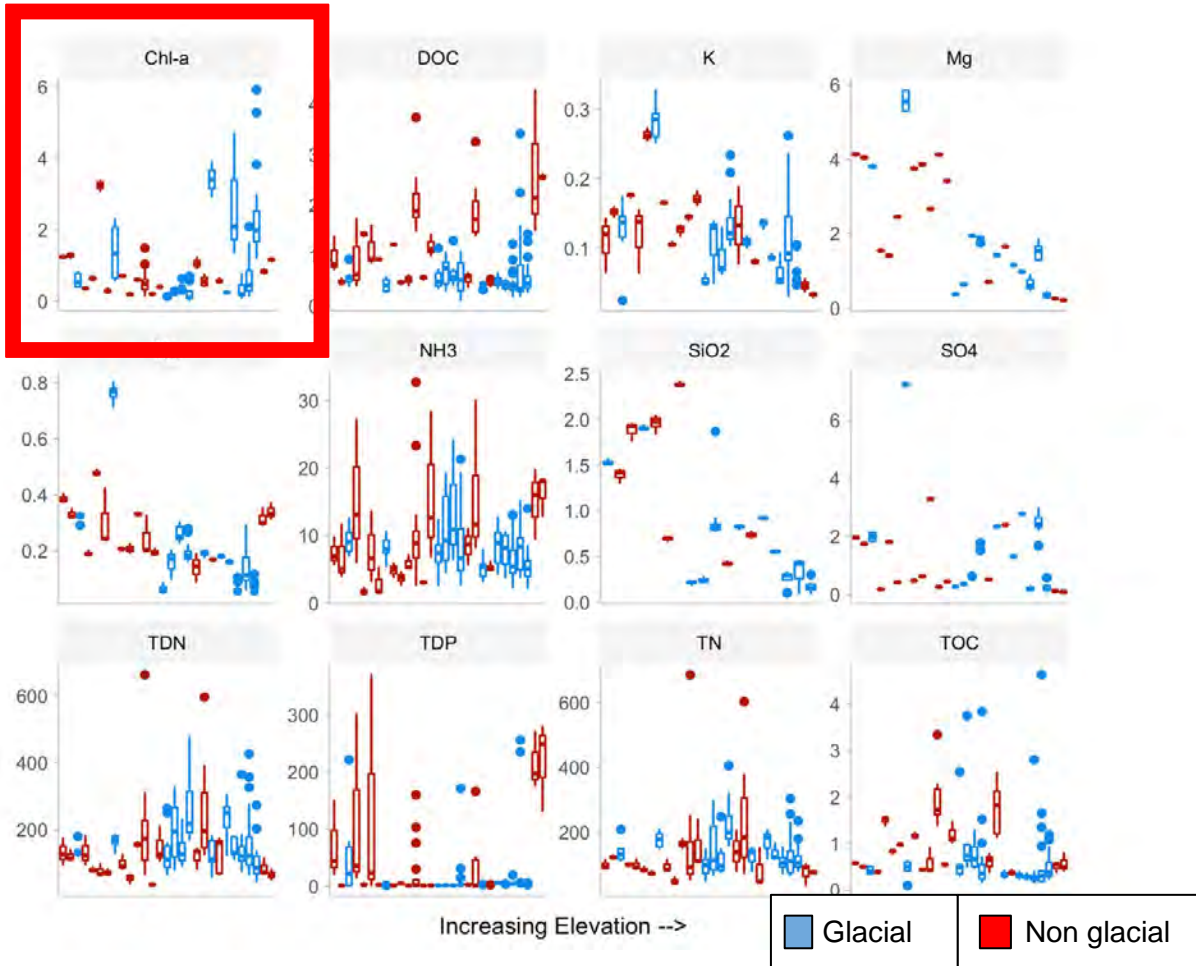
pc Chad Hammer



pc Joe Giersch

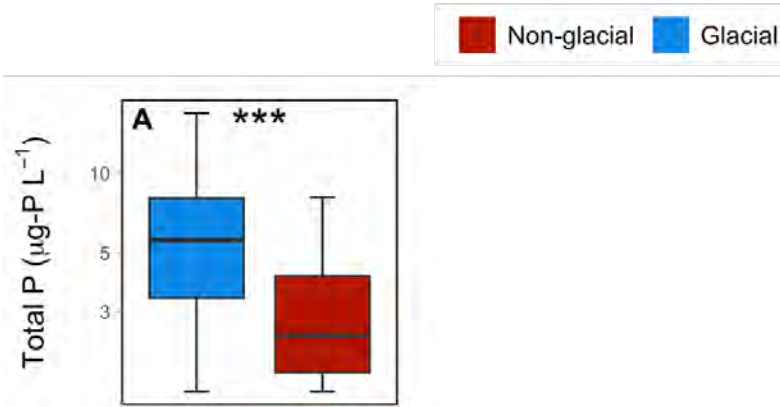
Lake chemistry across elevation

- Most mineral cations and anions decrease with elevation with no difference between lake types
- Chl seems to be high in a few high elevation glacial lakes



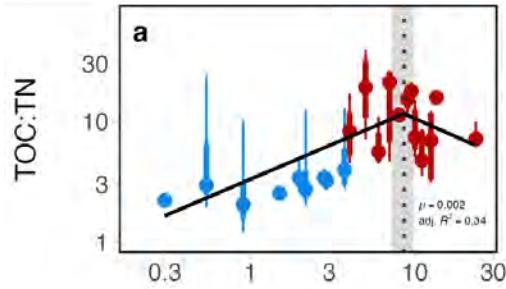
Nutrients and elevation

- Higher phosphorus (2x) and nitrate (3.5x) concentrations in glacial lakes



Nutrient and seston ratios across Secchi depth

- **Segment regression:** independent breakpoint



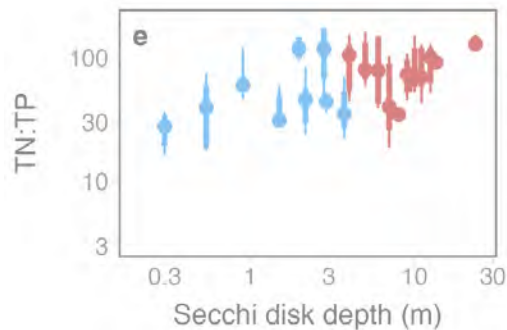
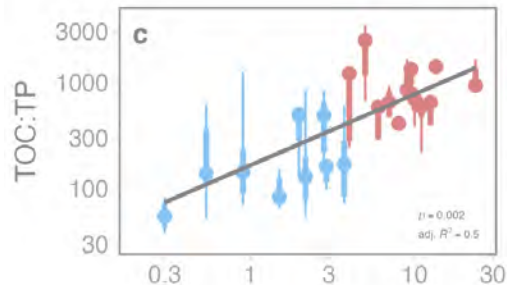
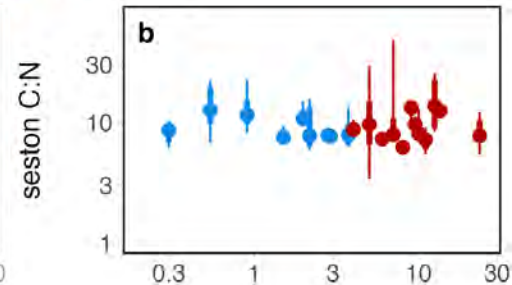
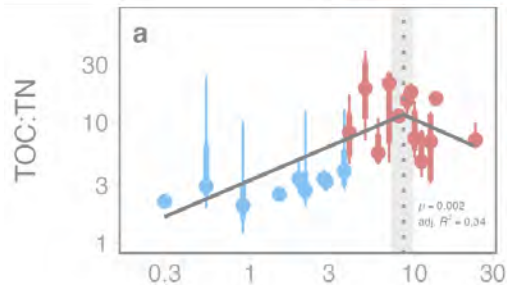
lake nutrients

Glacial Non-glacial

seston nutrients

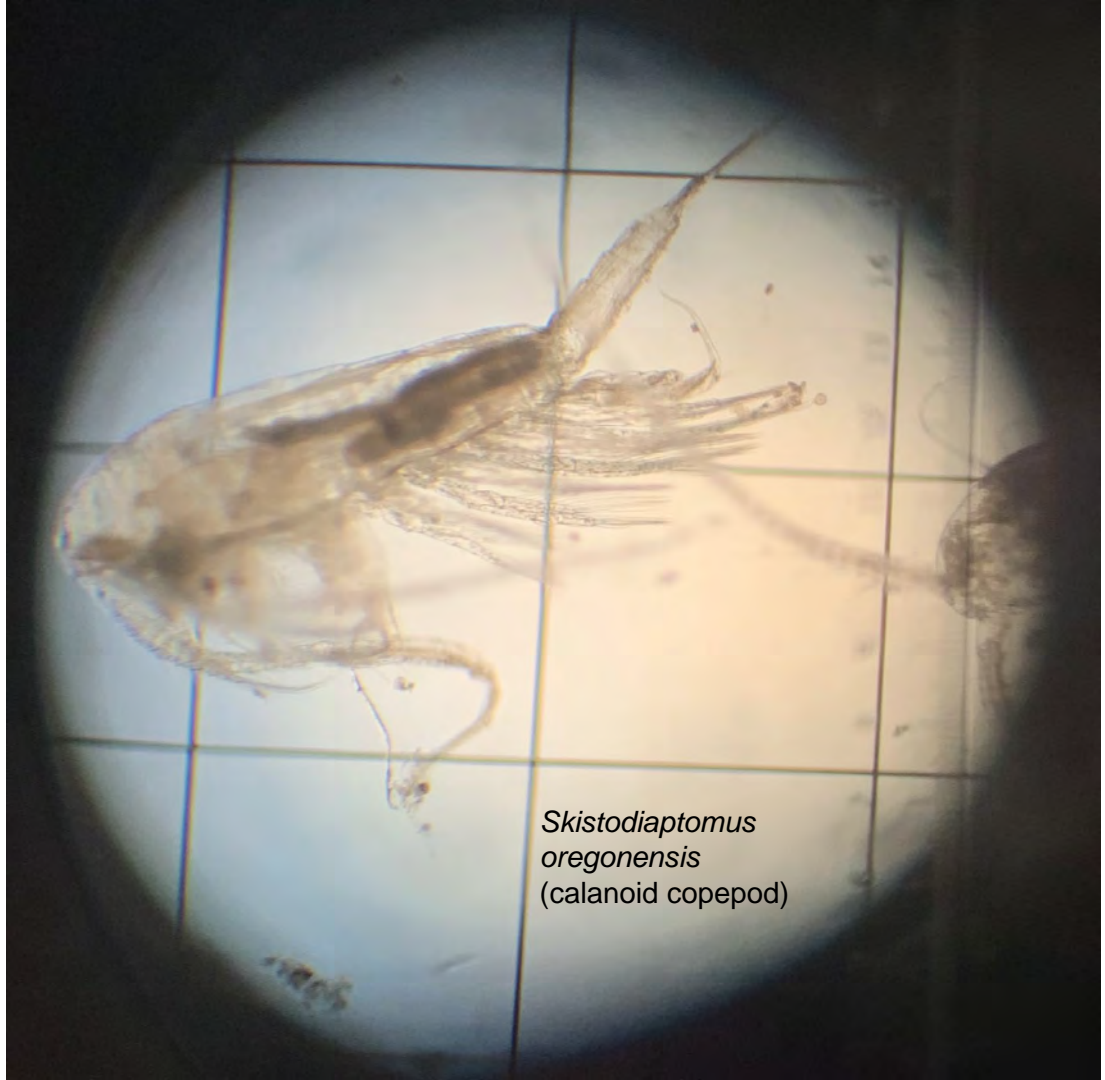
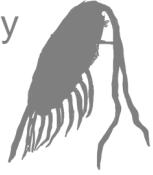
Nutrient and seston ratios across Secchi depth

- **Segment regression:** independent breakpoint
- Nutrient ratios: TOC:TP increased across secchi depth



Zooplankton - key filter feeders

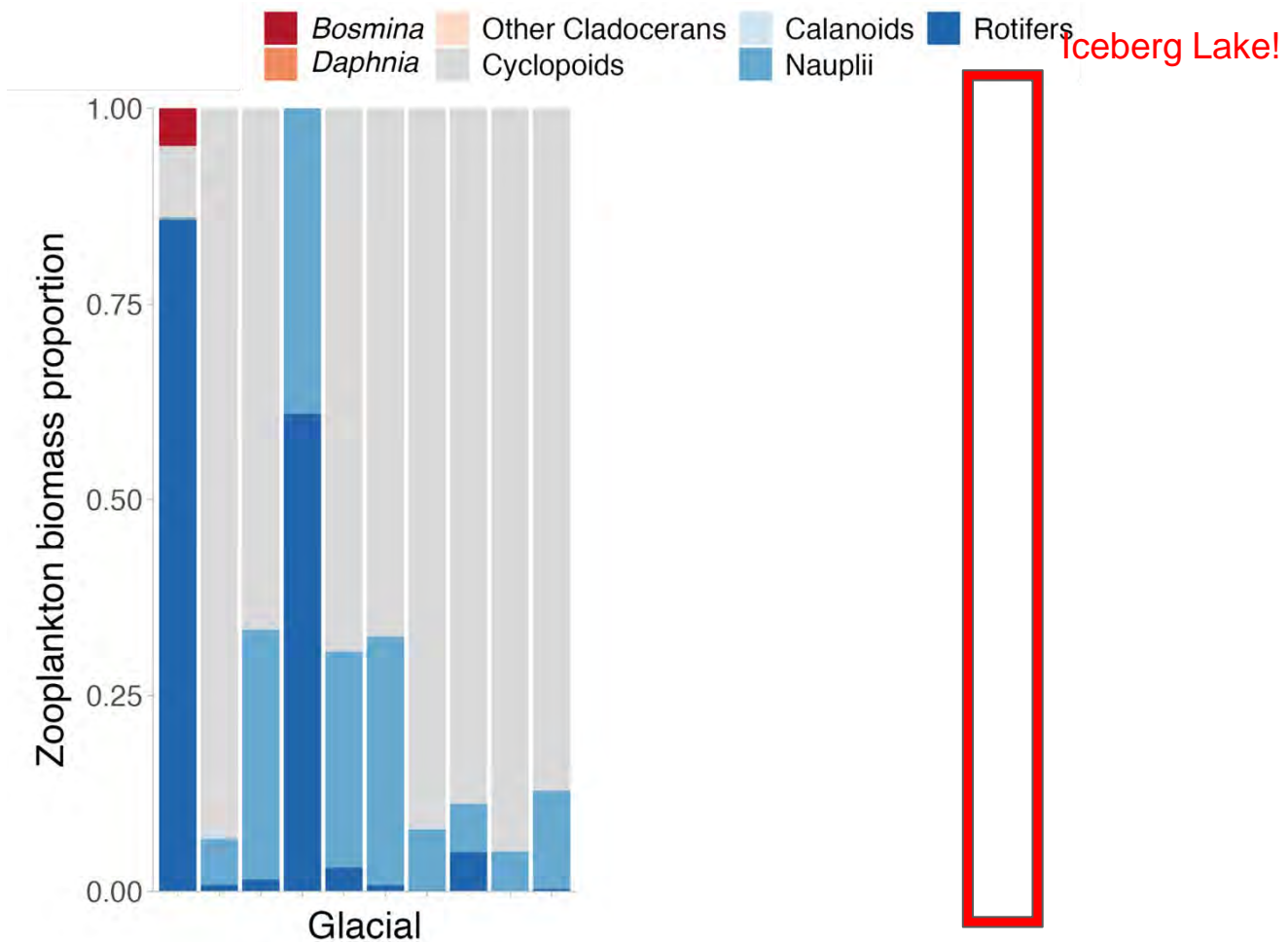
- Calanoid copepods
 - tend to be relatively large
 - Primarily filter feeders (Kleppel 1993)



*Skistodiaptomus
oregonensis*
(calanoid copepod)

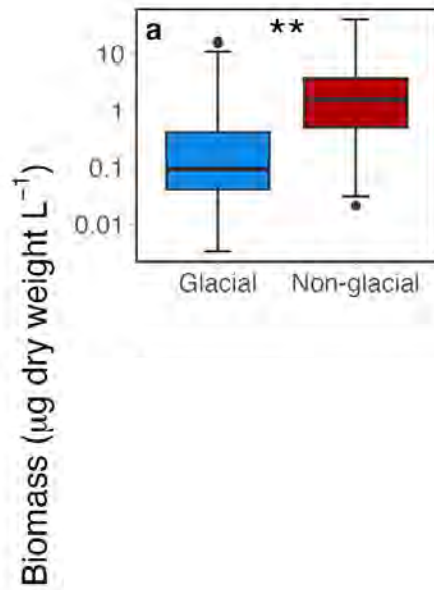
Zooplankton

- **Assemblages:** virtually no *Daphnia* or calanoid copepods in glacial lakes



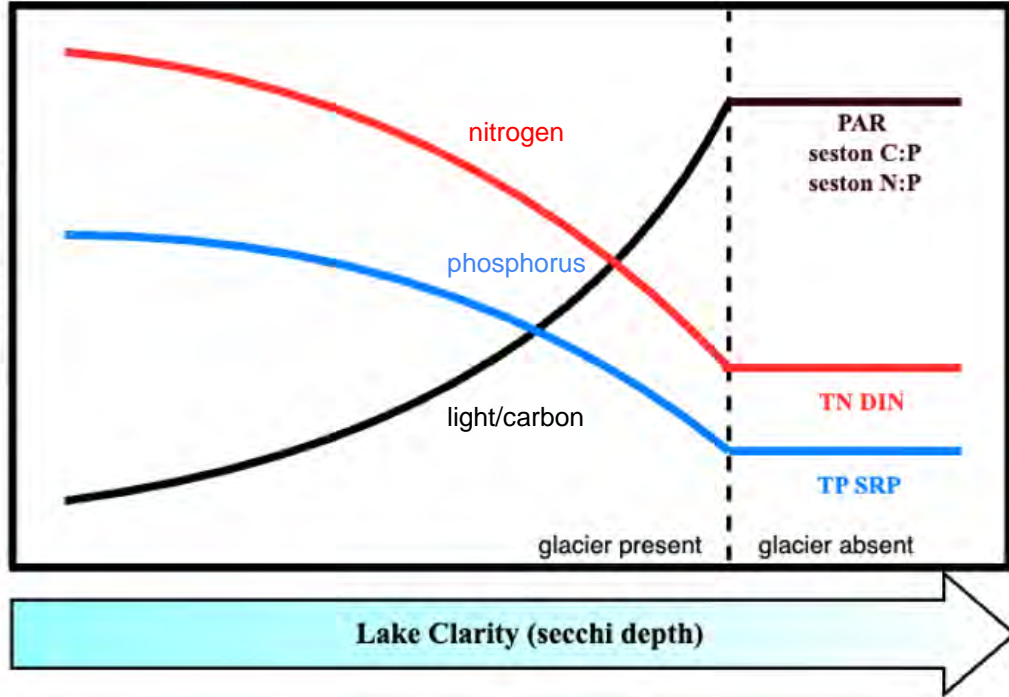
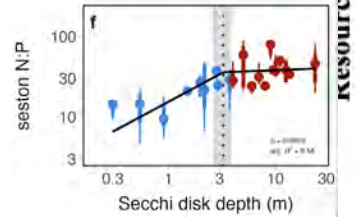
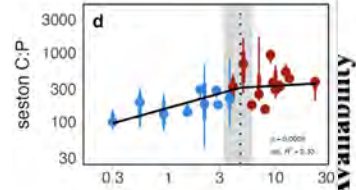
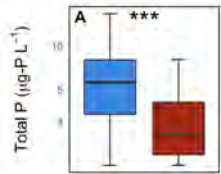
Zooplankton

- **Assemblages:** virtually no *Daphnia* or calanoid copepods in glacial lakes
- **Biomass:** Lower in glacial lakes



How does glacial meltwater structure the ecology of newly formed mountain lakes?

- Higher concentrations of nitrogen and phosphorus in glacial lakes



Why are these lakes important? Why should we care about them?

- Scientifically
 - Opportunity to study how lakes develop directly after formation
 - Habitat refuge
- Non-scientifically
 - Iconic landscape features
 - Stark reminder of changing climate



Lower Grinnell Lake

Acknowledgments

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Questions?



Ghost Lake



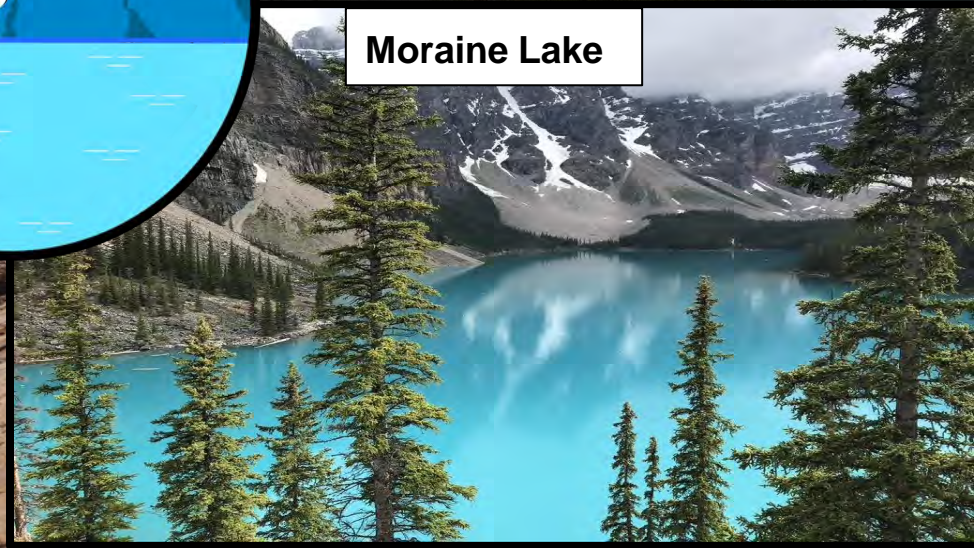
Upper Grinnell Lake



Ghost Lake



Moraine Lake



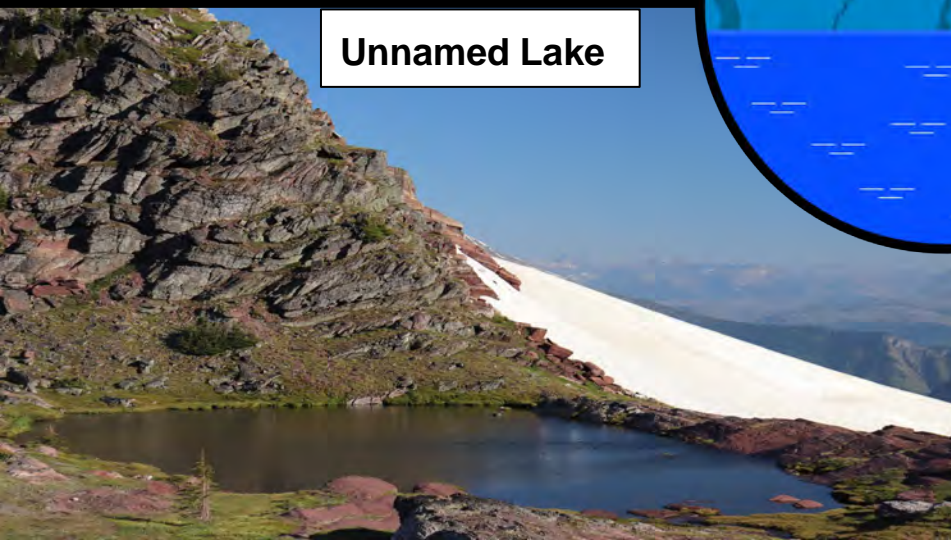
Ptarmigan Lake



Iceberg Lake



Unnamed Lake



Unnamed Lake

