

# Salmon Futures:

Stewardship of salmon systems in an era of rapid change

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Salmon Watersheds Lab

# APPROACH

Big Data Analyses

Field Research

Connecting &  
Catalyzing

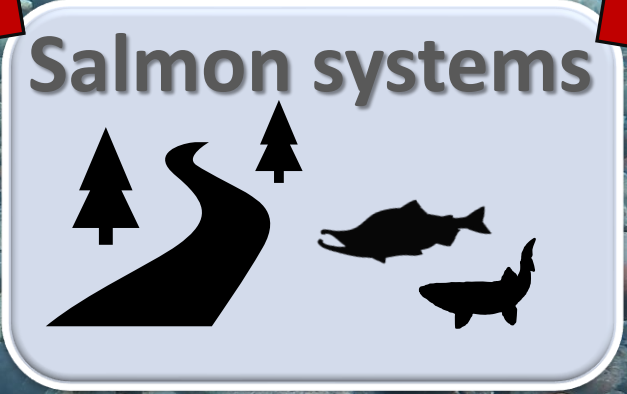
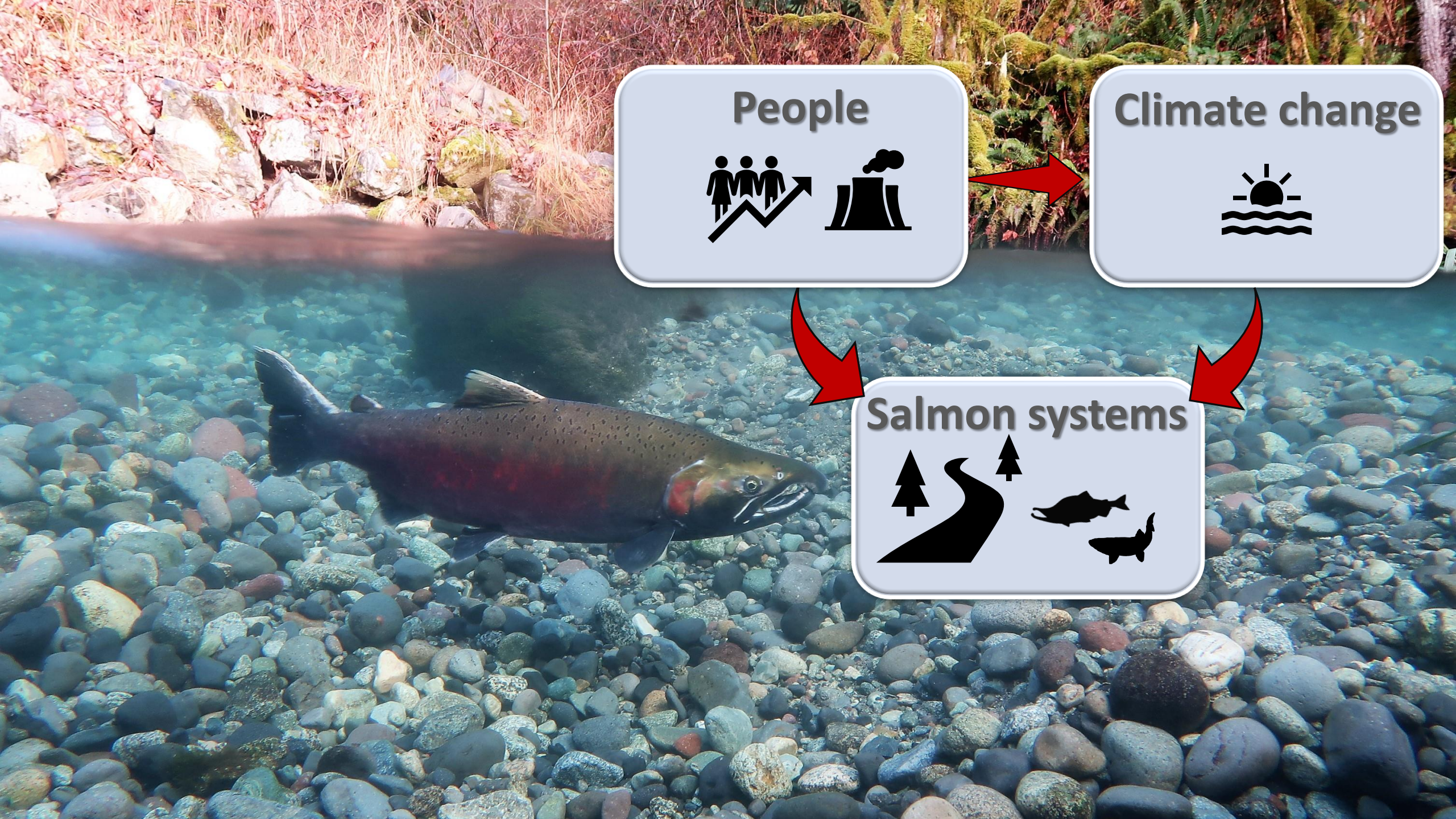




# Collaborators & Support













**How can we best steward salmon watersheds,  
given climate change and multiple stressors?**







## **Fundamental**

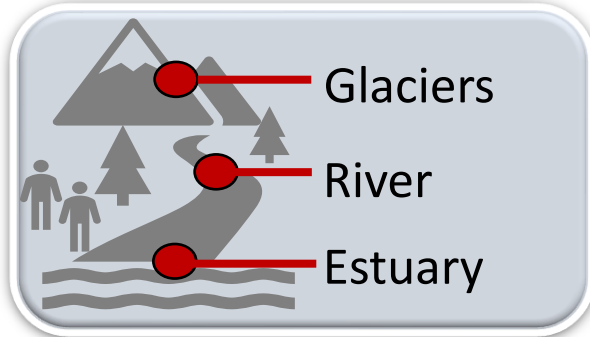
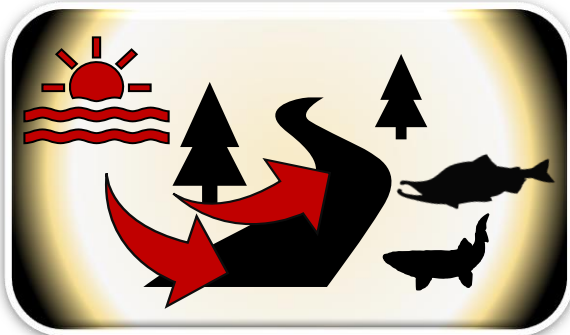
*How do salmon watersheds work? How are they changing?*  
Aquatic ecology

## **Application**

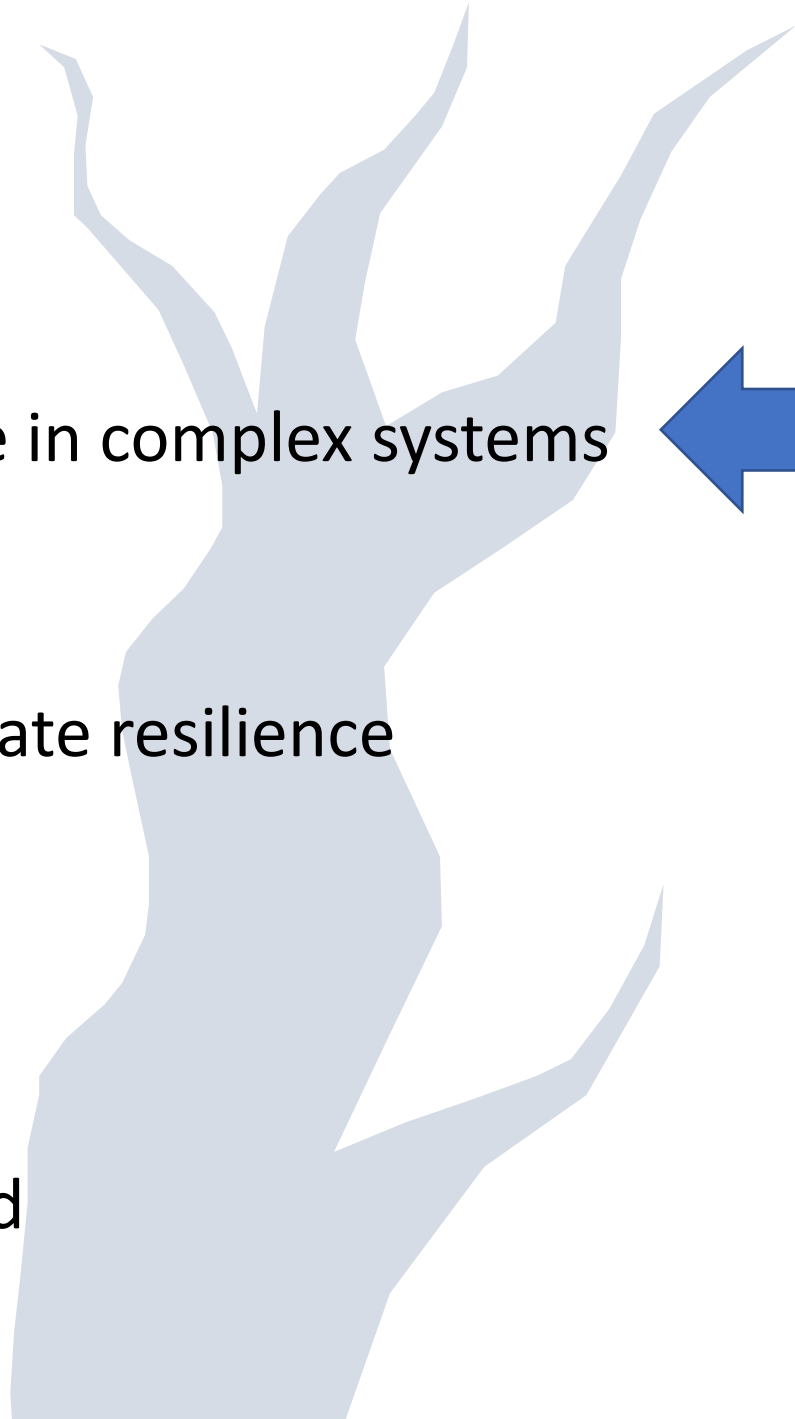
*What to do about it?  
How improve, conserve?*  
Law | Regulation | DM



# FLOW



- Rapid change in complex systems
- Towards climate resilience
  - Estuary
  - River
  - Glacier
- Paths forward



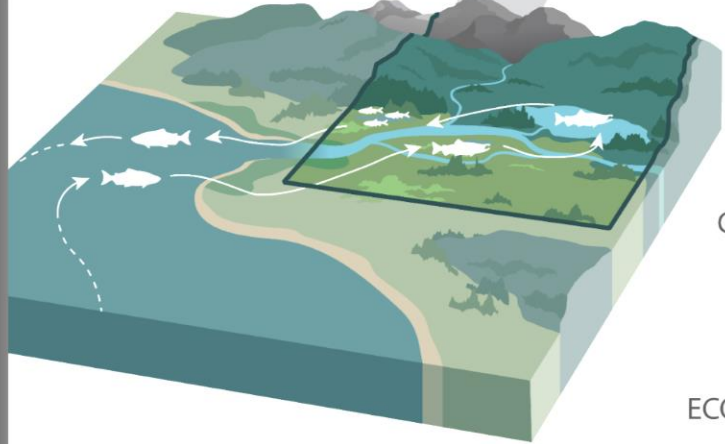


# Rapid change in complex systems

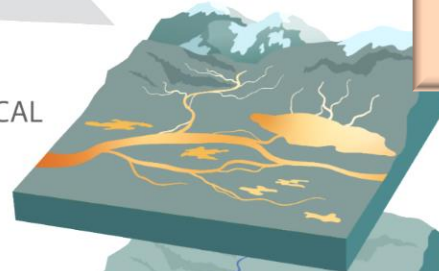




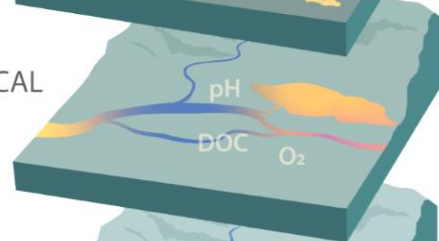
CLIMATE CHANGE



PHYSICAL



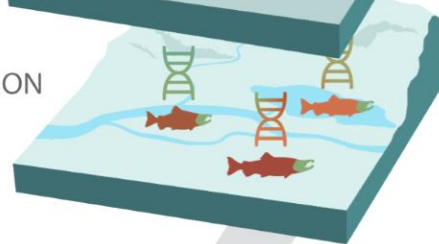
CHEMICAL



ECOLOGICAL



SALMON

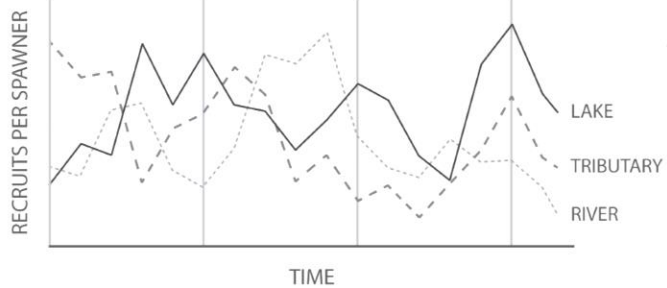


RECRUITS PER SPAWNER

LOW HIGH



YEAR 0 YEAR 5 YEAR 10 YEAR 15



# Shifting habitat mosaics & portfolio effects



Wilson, Moore, Schindler, Westley  
in prep



# Amazing biodiversity of salmon systems

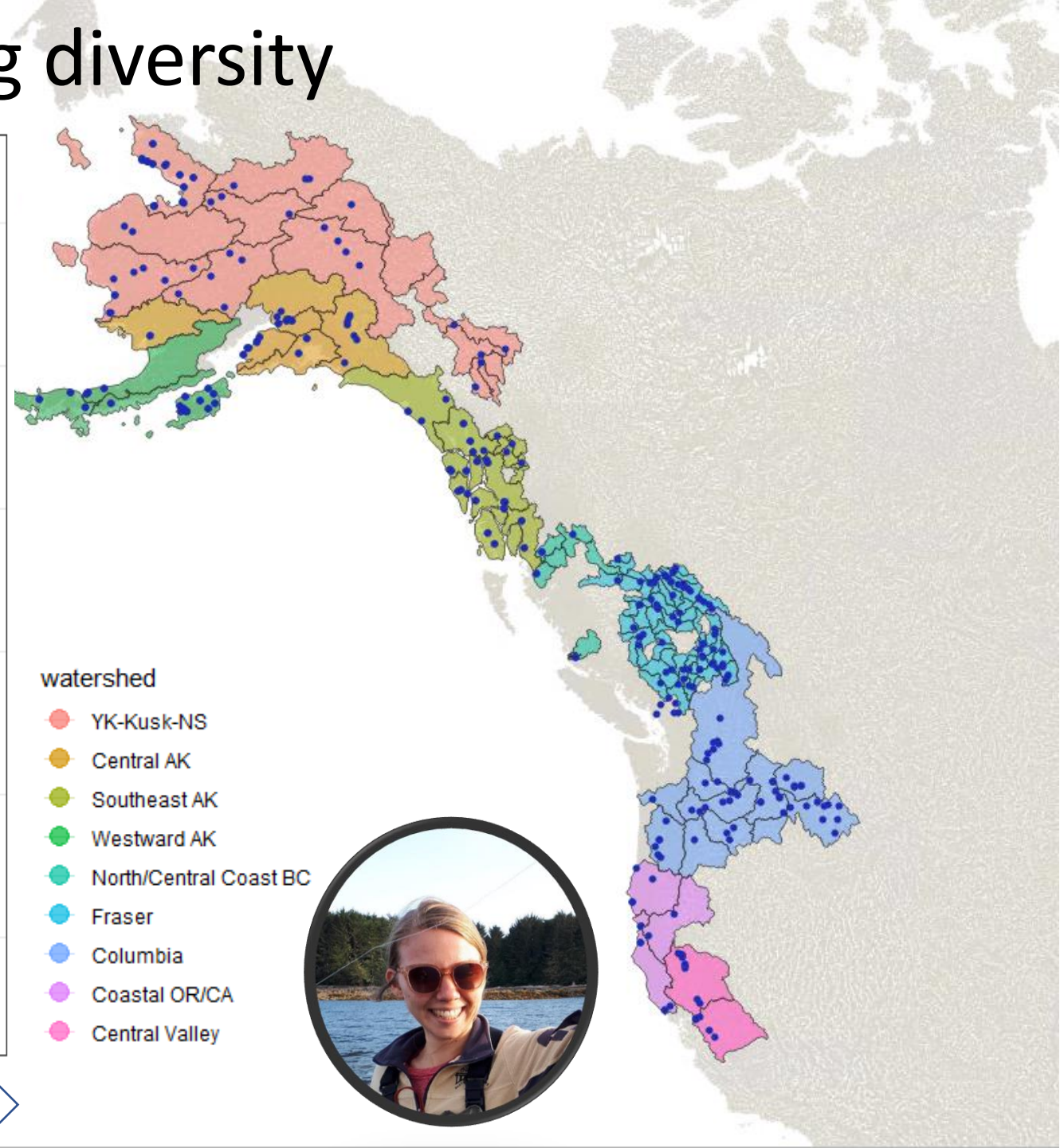
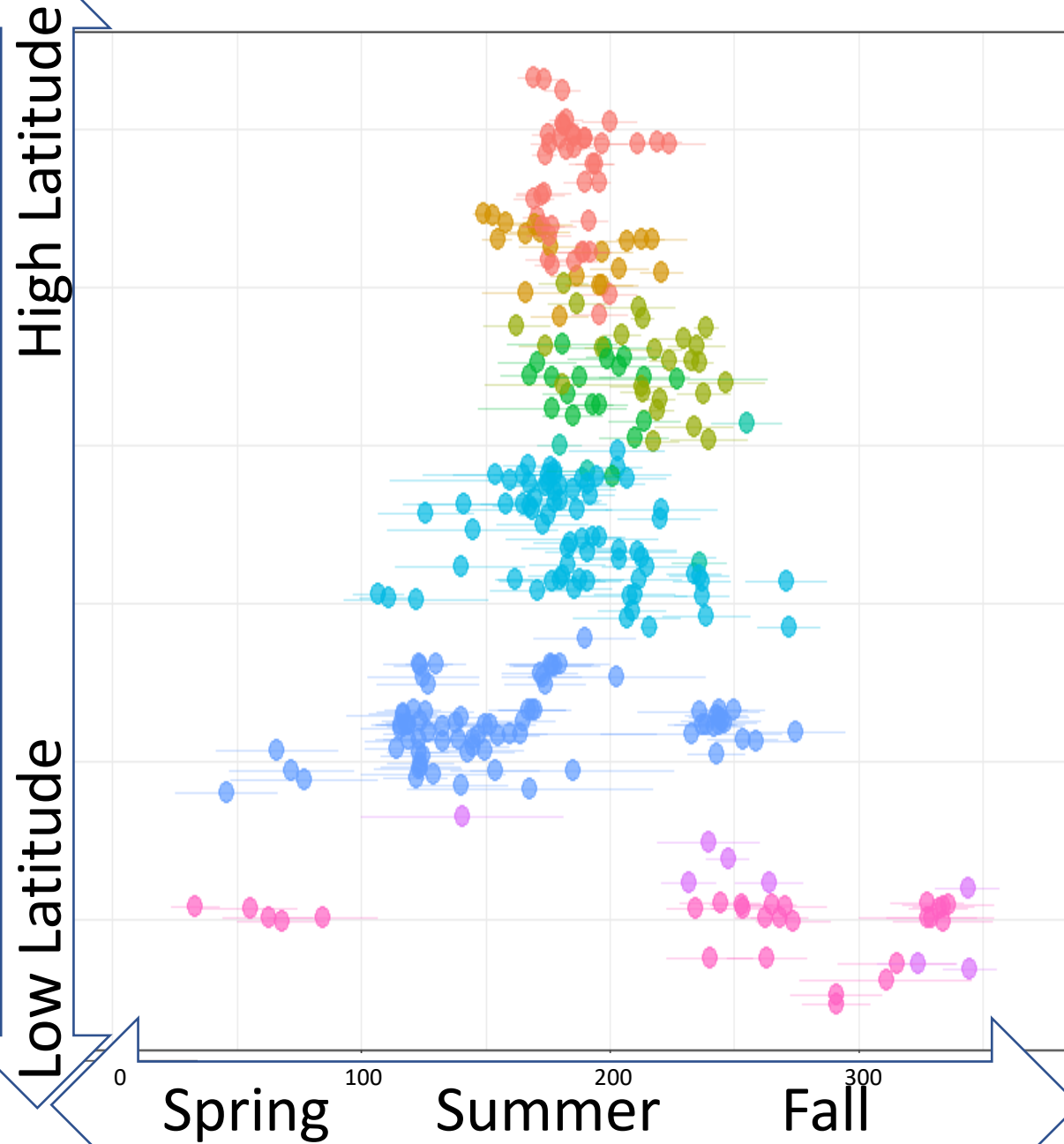






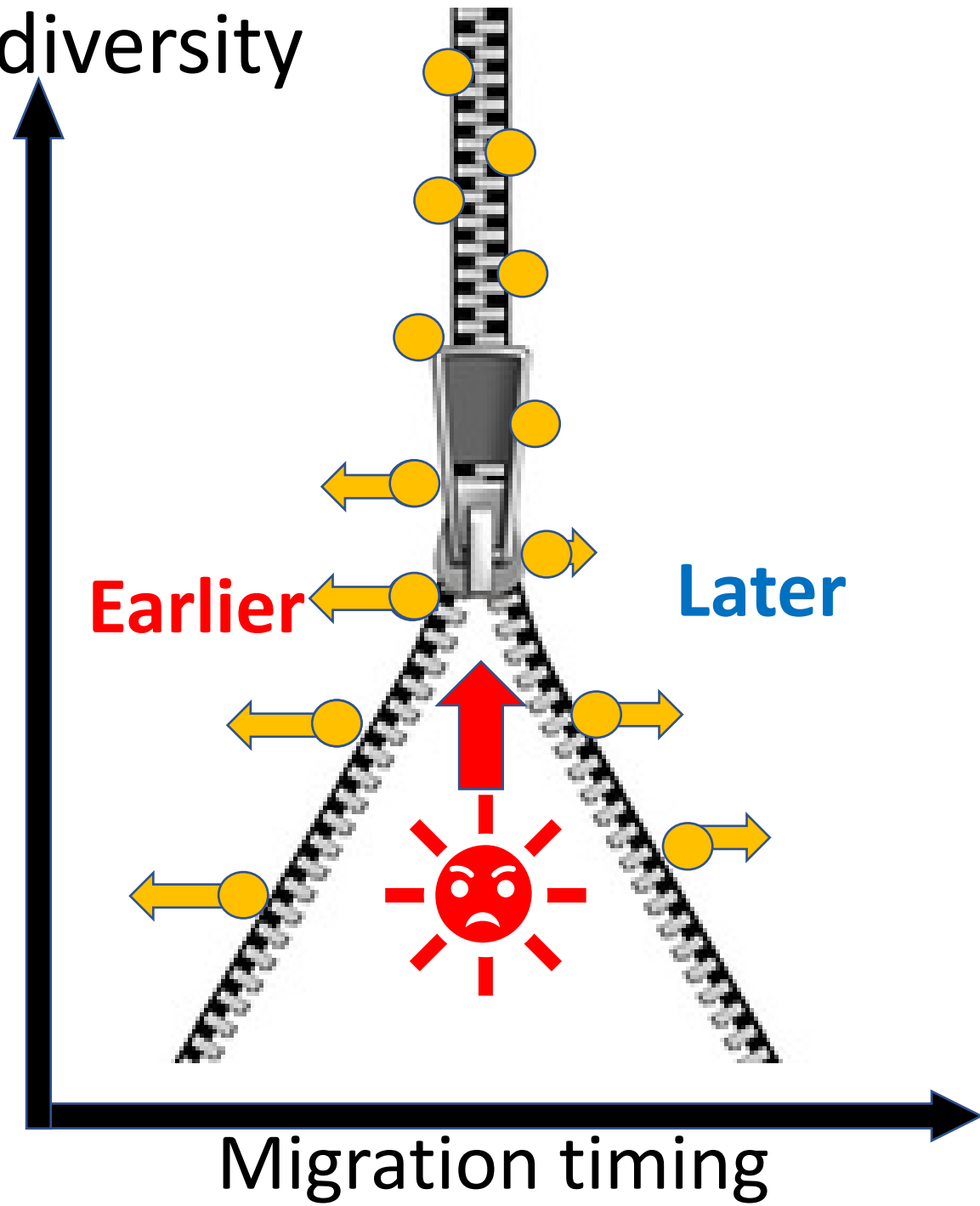
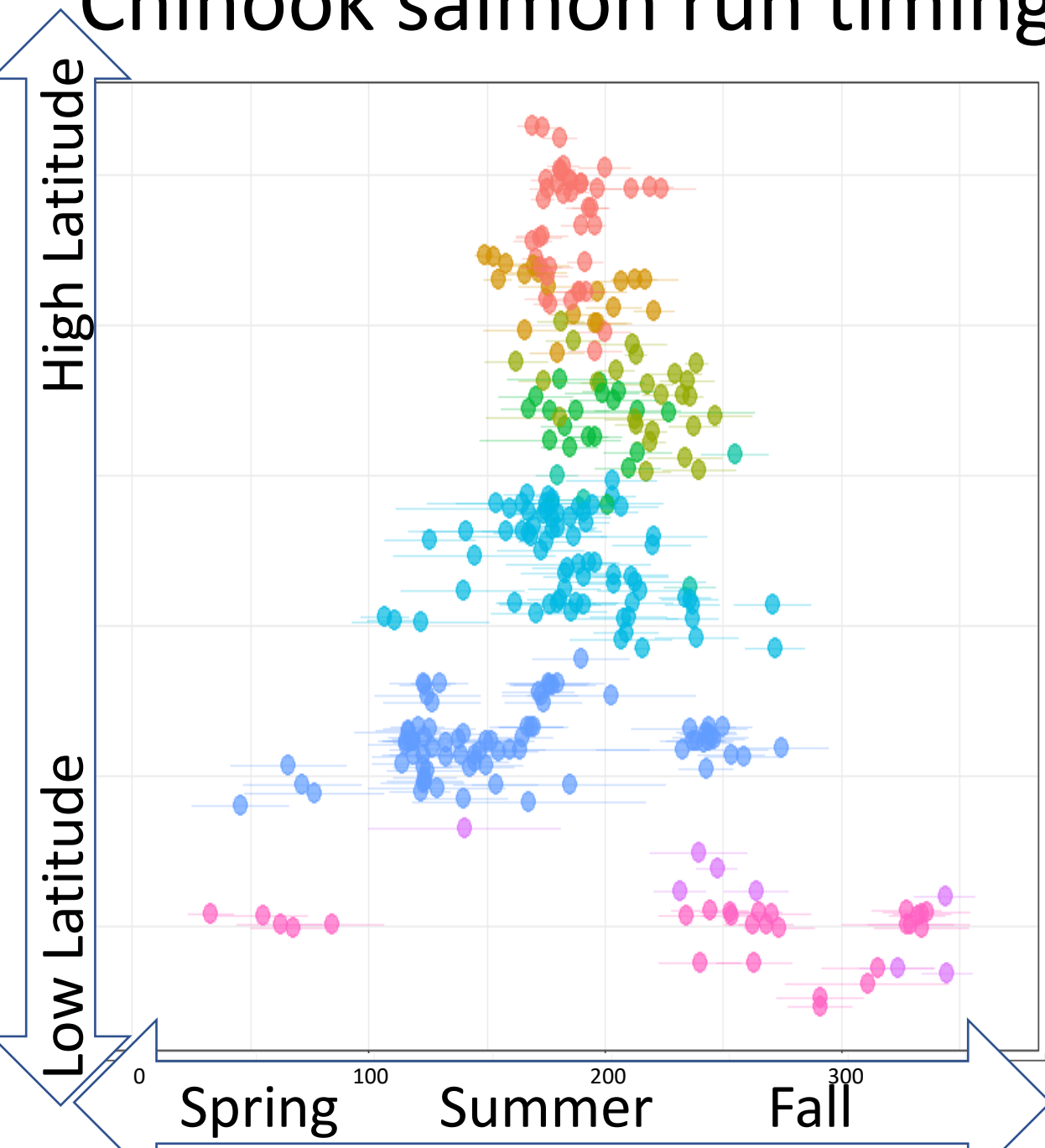


# Chinook salmon run timing diversity



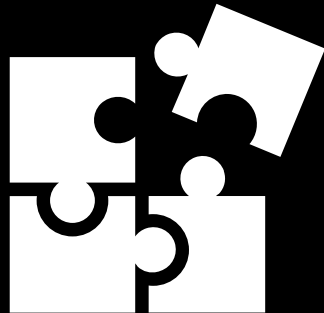


# Chinook salmon run timing diversity



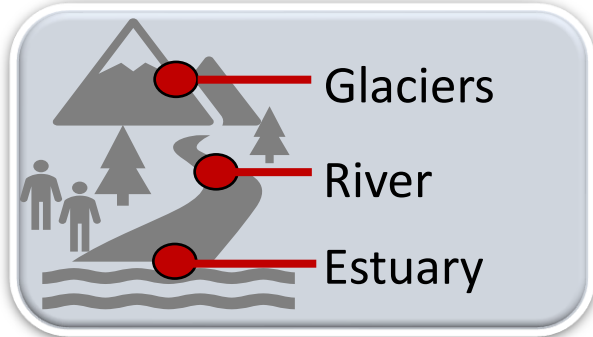


# Diversity and resilience of salmon systems

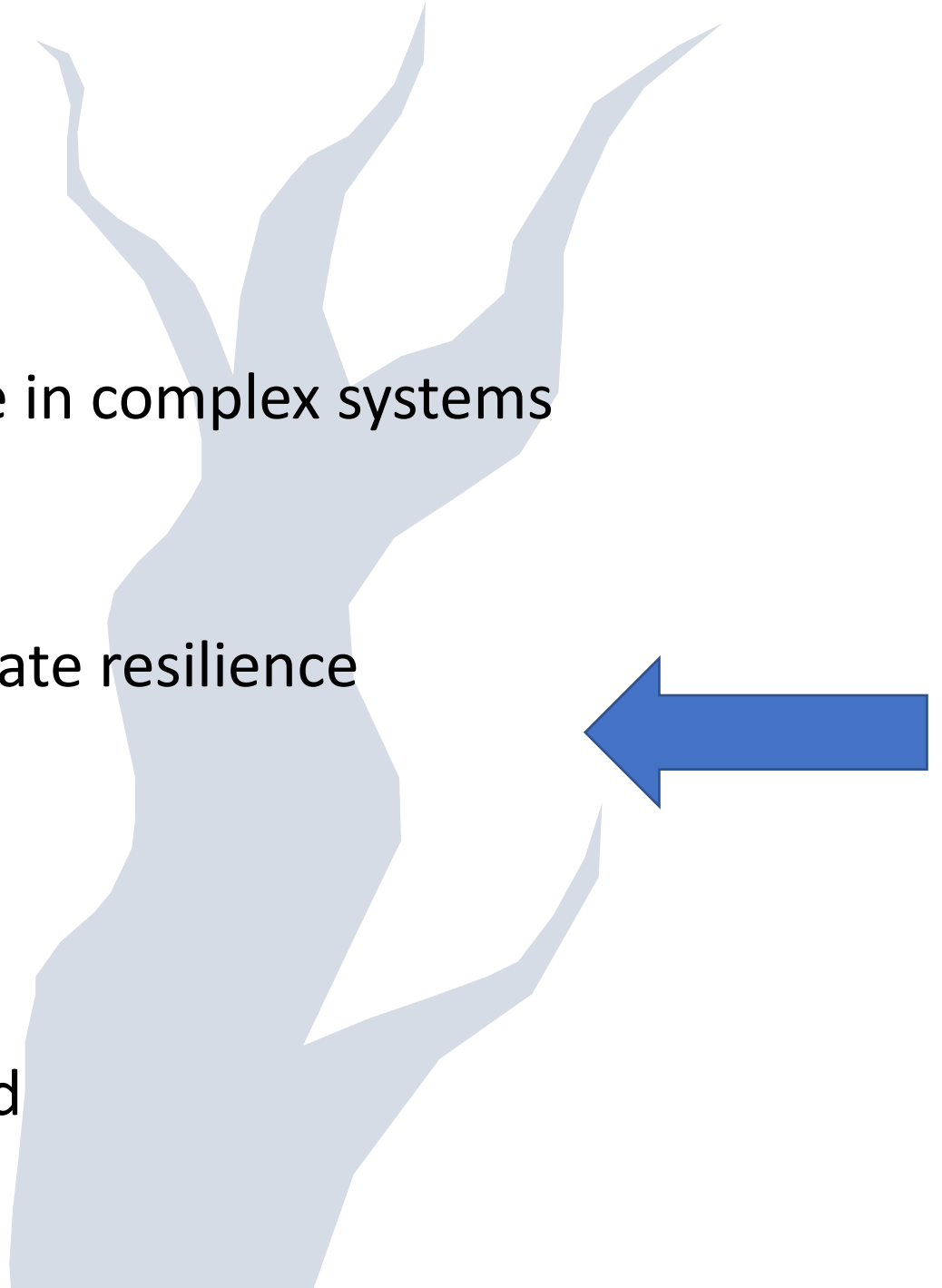




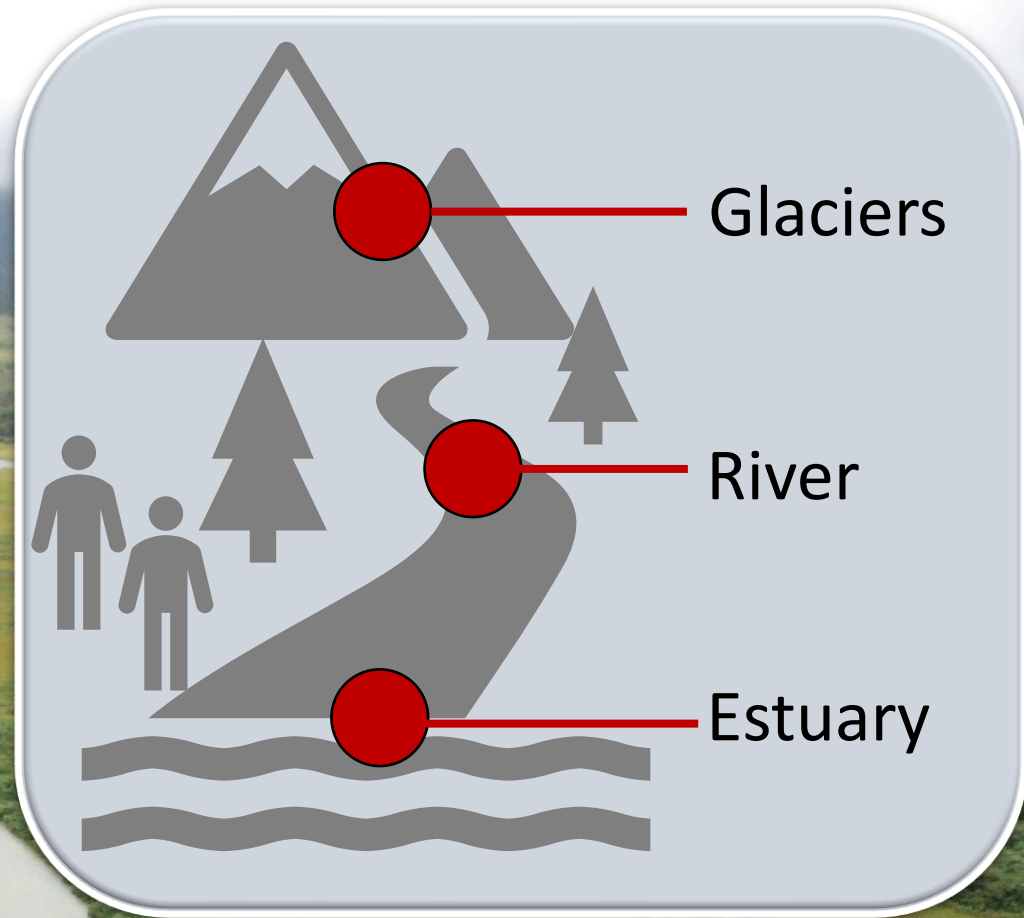
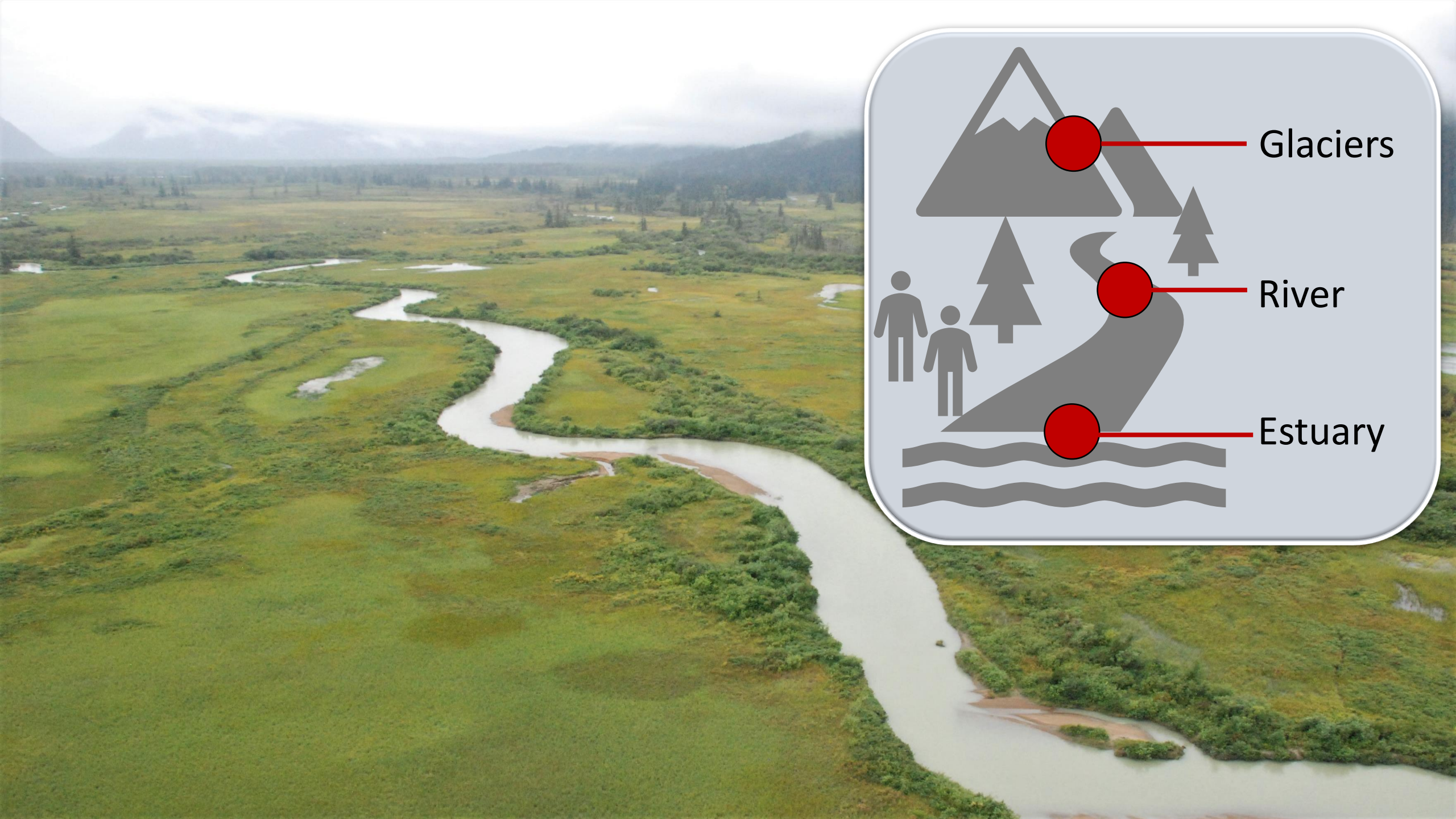
# FLOW



- Rapid change in complex systems
- Towards climate resilience
  - Estuary
  - River
  - Glacier
- Paths forward







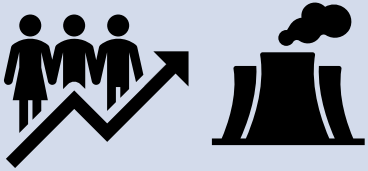
Glaciers

River

Estuary



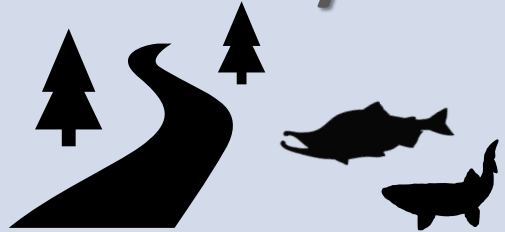
People



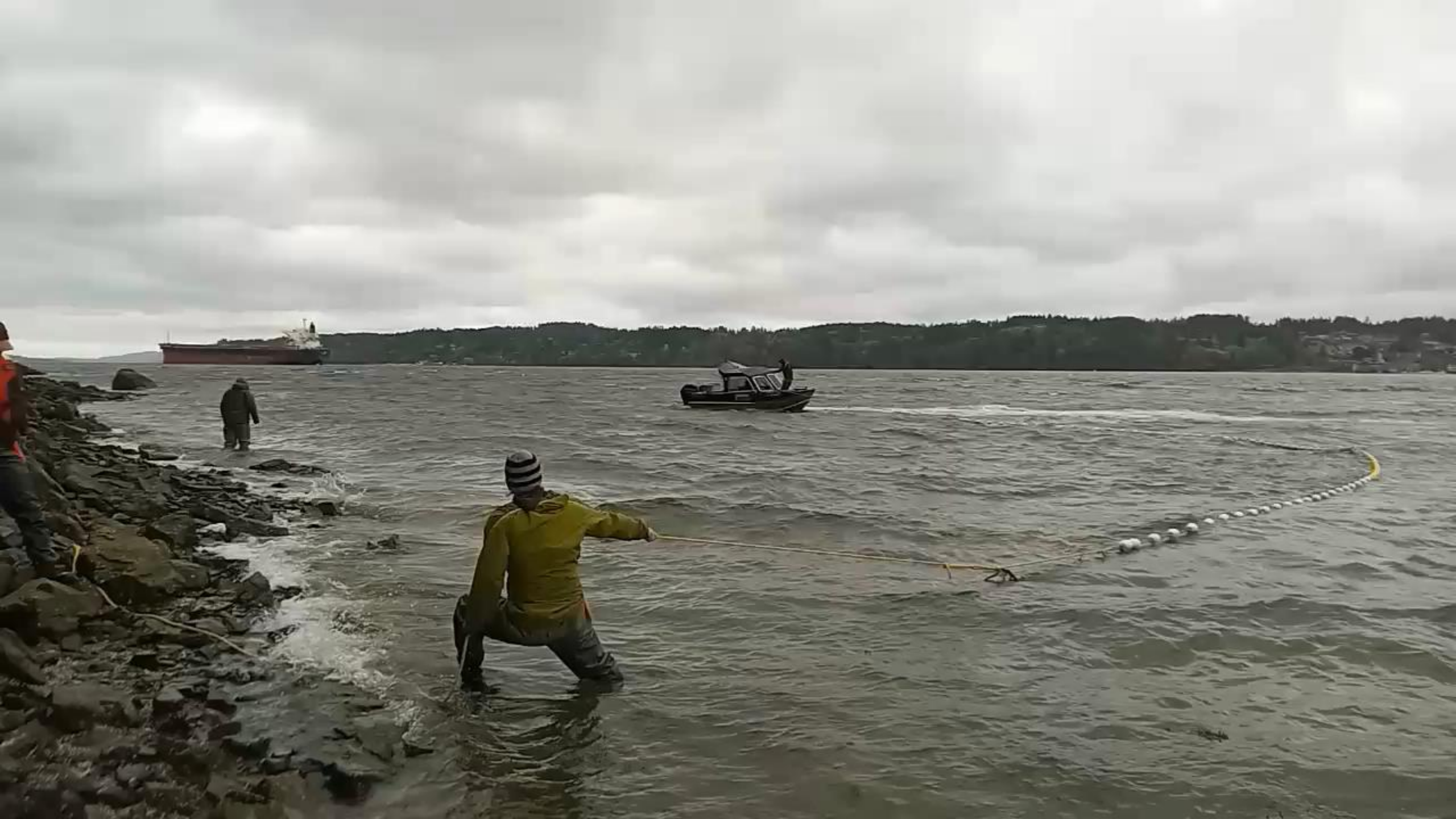
Climate change



Salmon systems





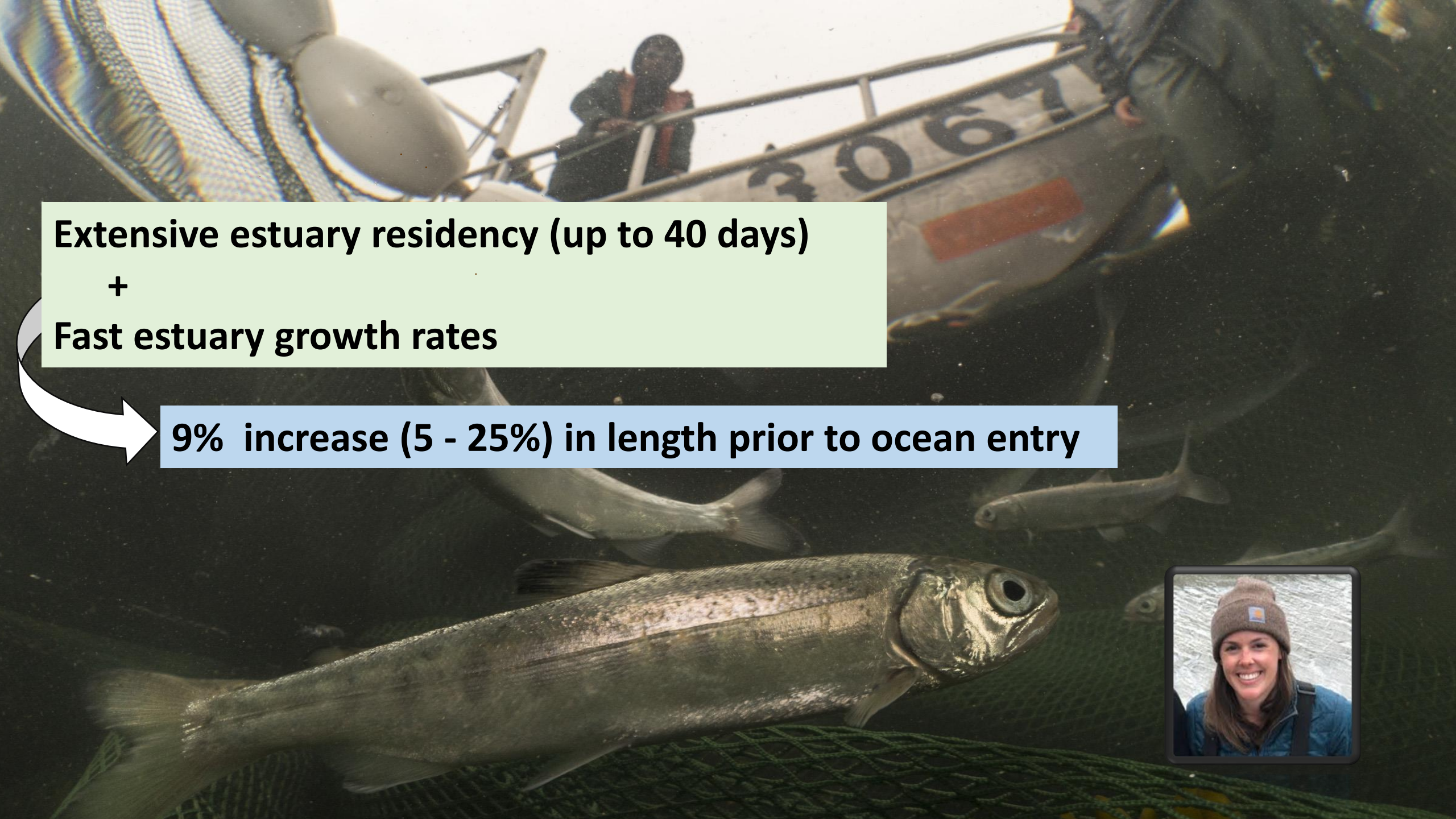






**I am not a juvenile salmon**





**Extensive estuary residency (up to 40 days)**

**+**

**Fast estuary growth rates**

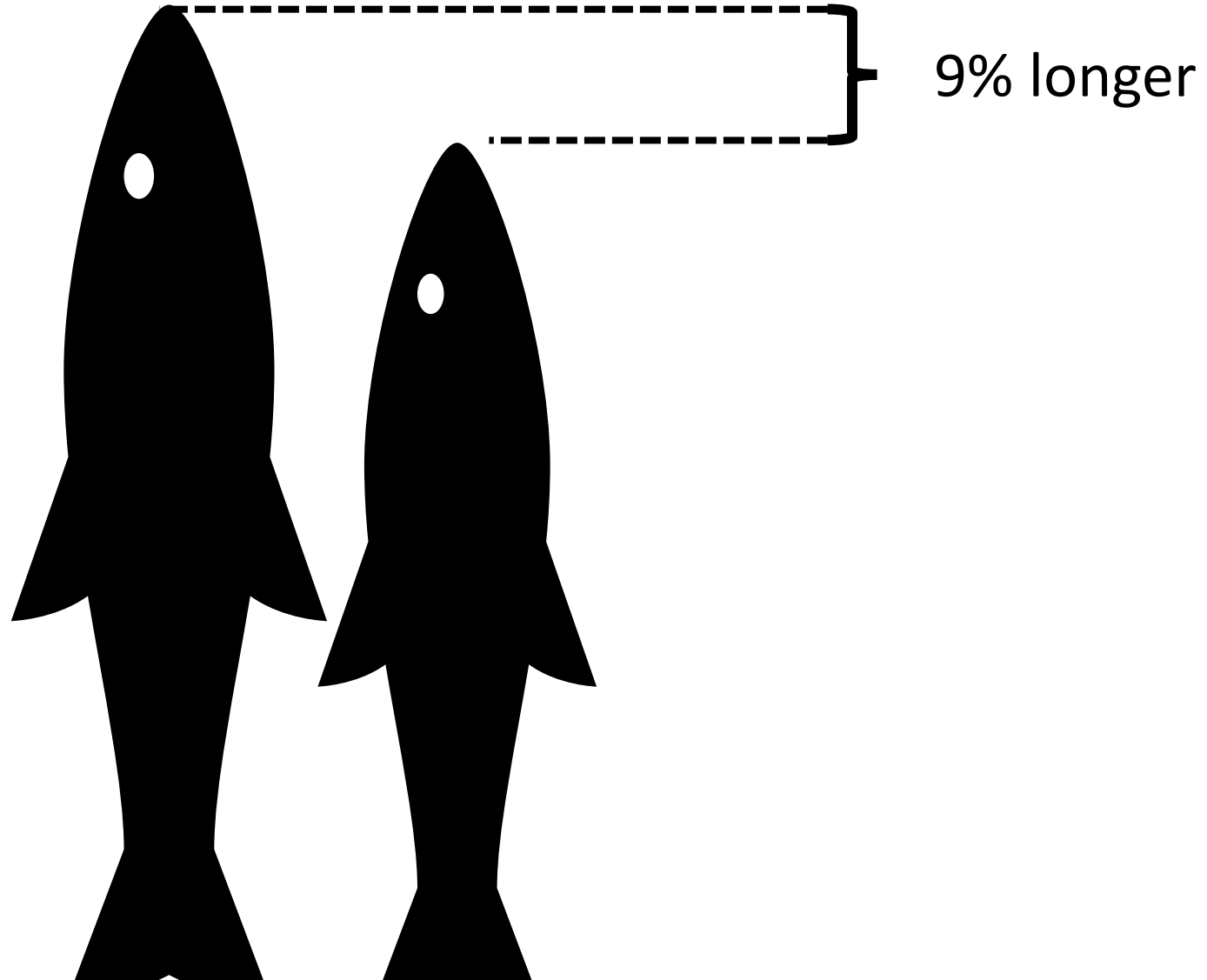


**9% increase (5 - 25%) in length prior to ocean entry**





# Growth benefits of estuary nursery habitat





# Growth benefits of estuary nursery habitat

Lebron James: 6' 7"

Luka Doncic = 6' 6"

Jon Moore = 6' 1" (on a tall day)

8.2% taller







**Extensive estuary residency (up to 40 days)**

**+**

**Fast estuary growth rates**

**9% increase (5 - 25%) in length prior to ocean entry**

**~35% increase in marine survival!**

**I am basically LeBron James!**



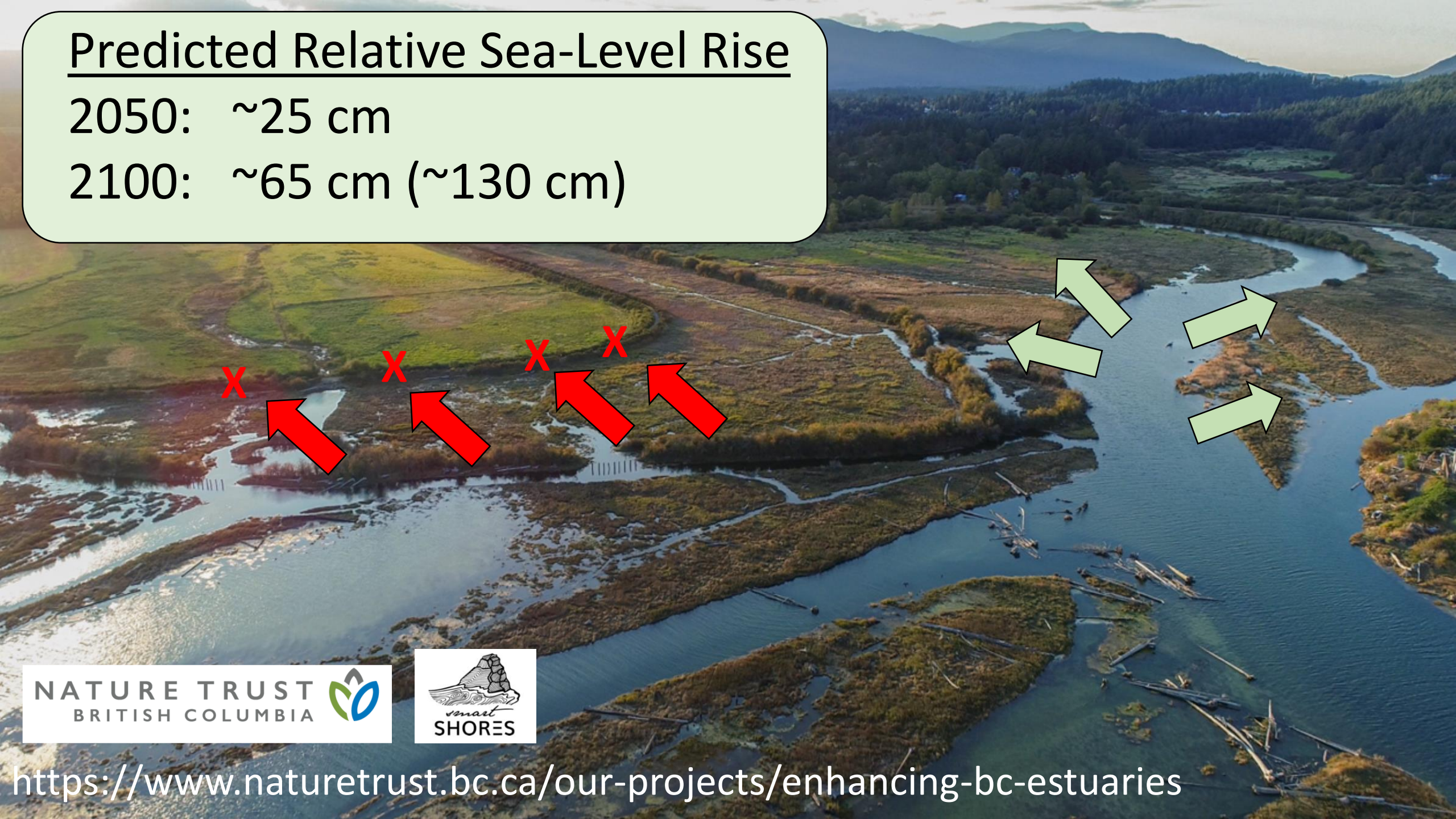




# Predicted Relative Sea-Level Rise

2050: ~25 cm

2100: ~65 cm (~130 cm)



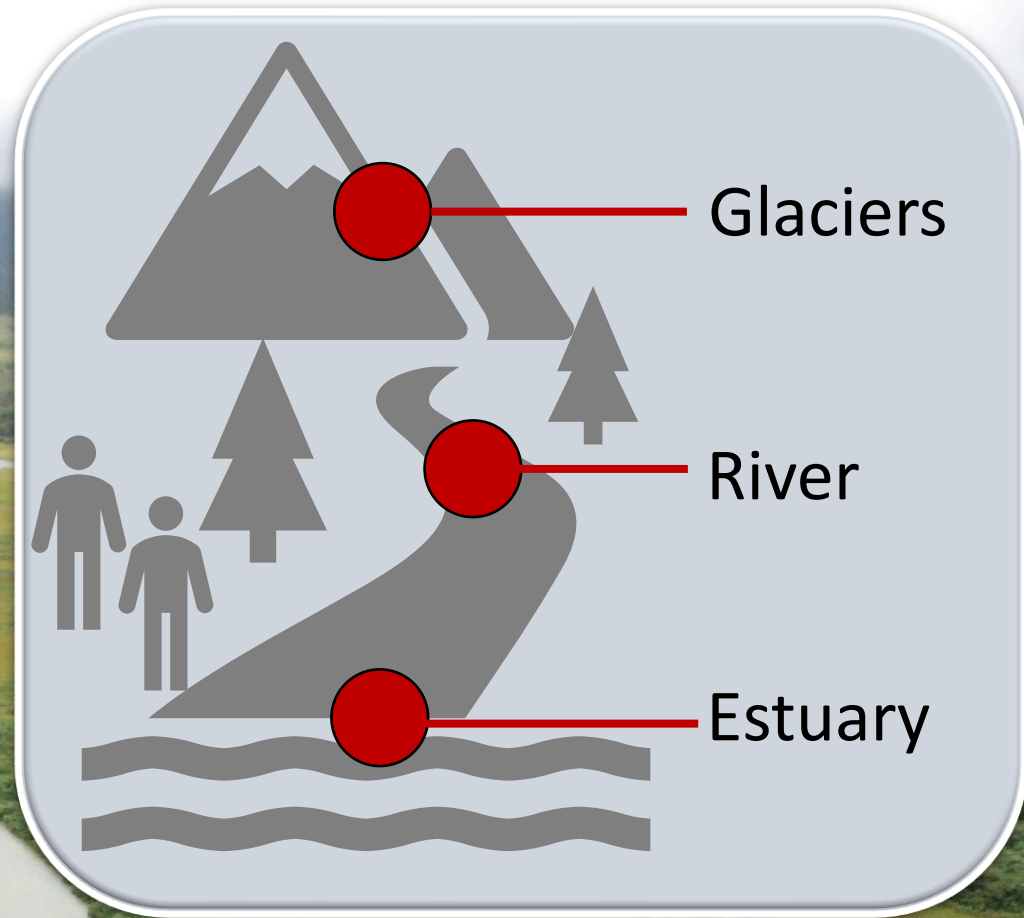
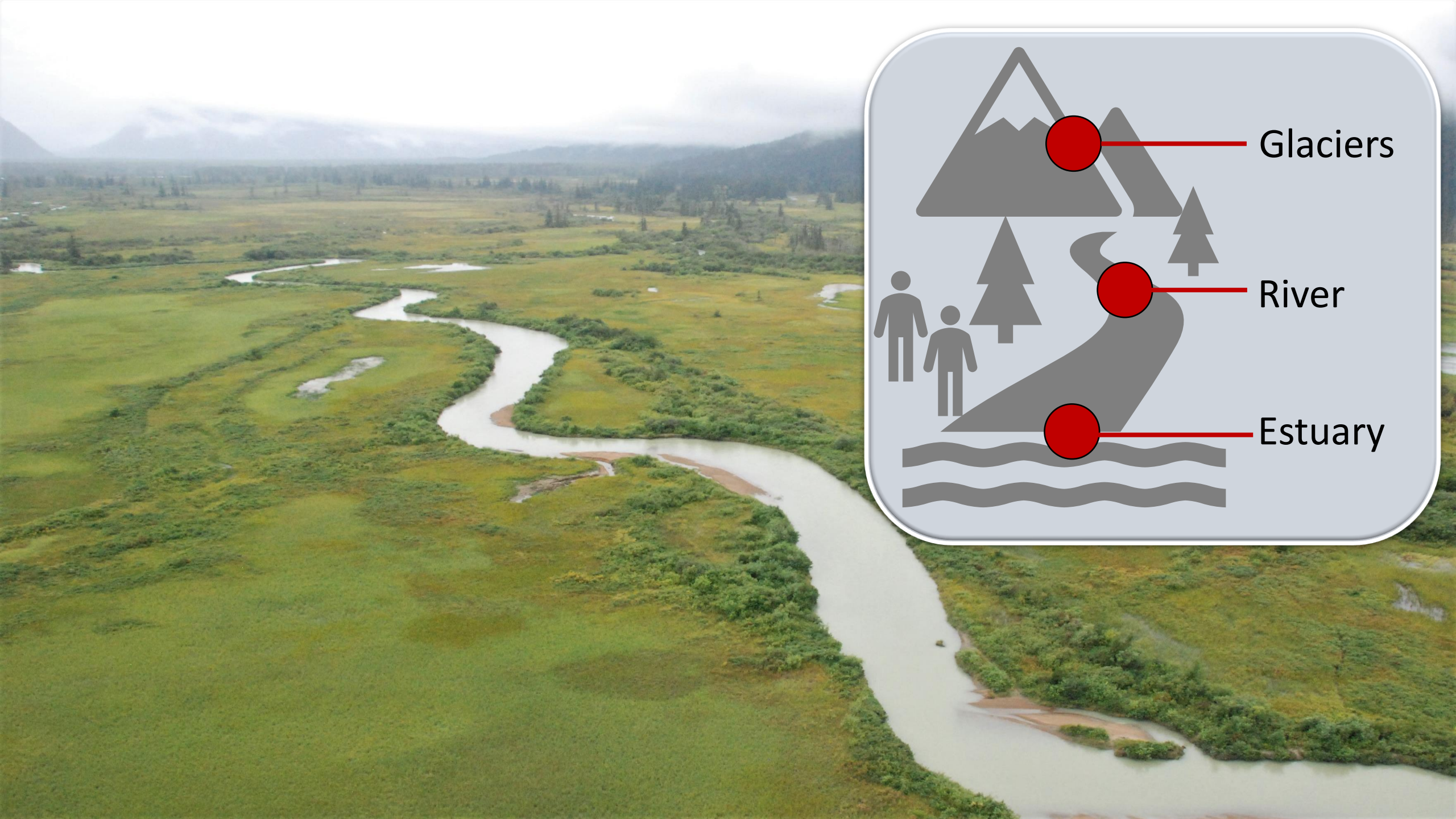


# Estuary resilience



<https://www.naturetrust.bc.ca/our-projects/enhancing-bc-estuaries>





Glaciers

River

Estuary





# Multiple stressors

An aerial satellite view of a forest landscape in interior British Columbia, Canada. The image shows a complex pattern of forest fragmentation, with large, irregularly shaped clear-cut areas interspersed among remaining forest patches. The clear-cuts appear as lighter, more uniform brown and tan areas, while the remaining forest is darker green and brown. The overall appearance is one of a heavily managed and fragmented forest landscape.

Logging in interior BC over 30+ years. Derived from Google Earth Engine by Joanne Hammond





# Logging



~2 - 6°C

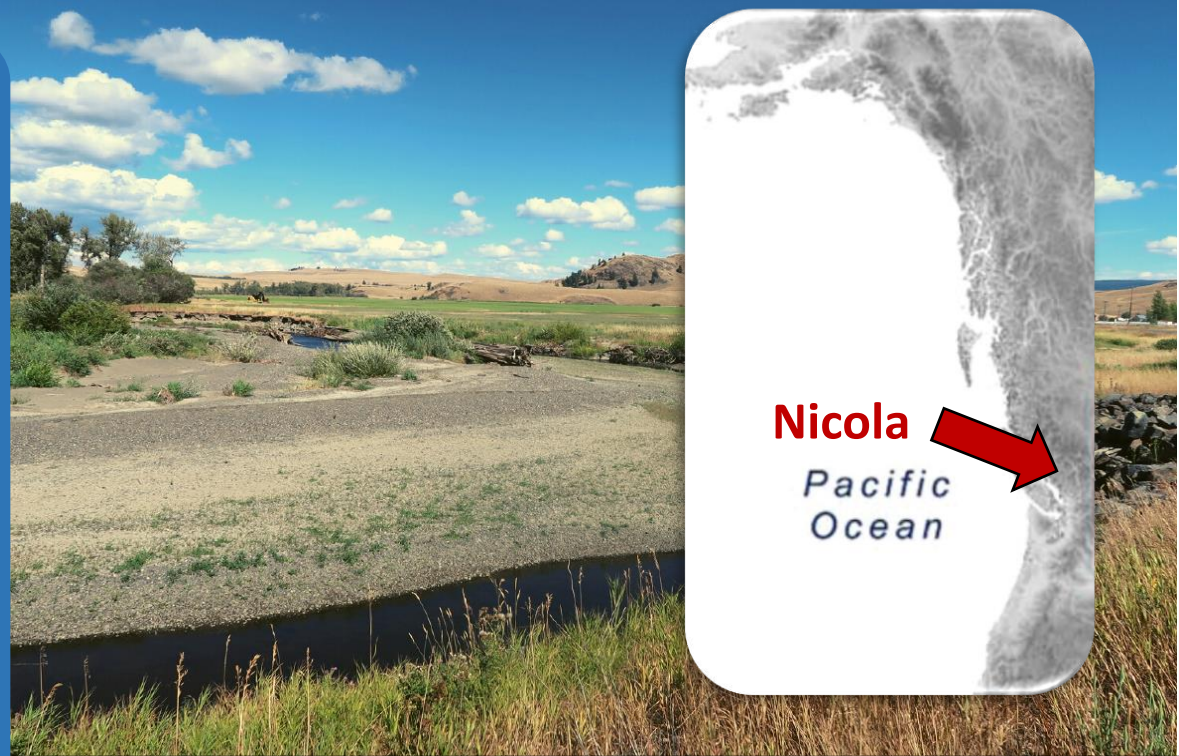
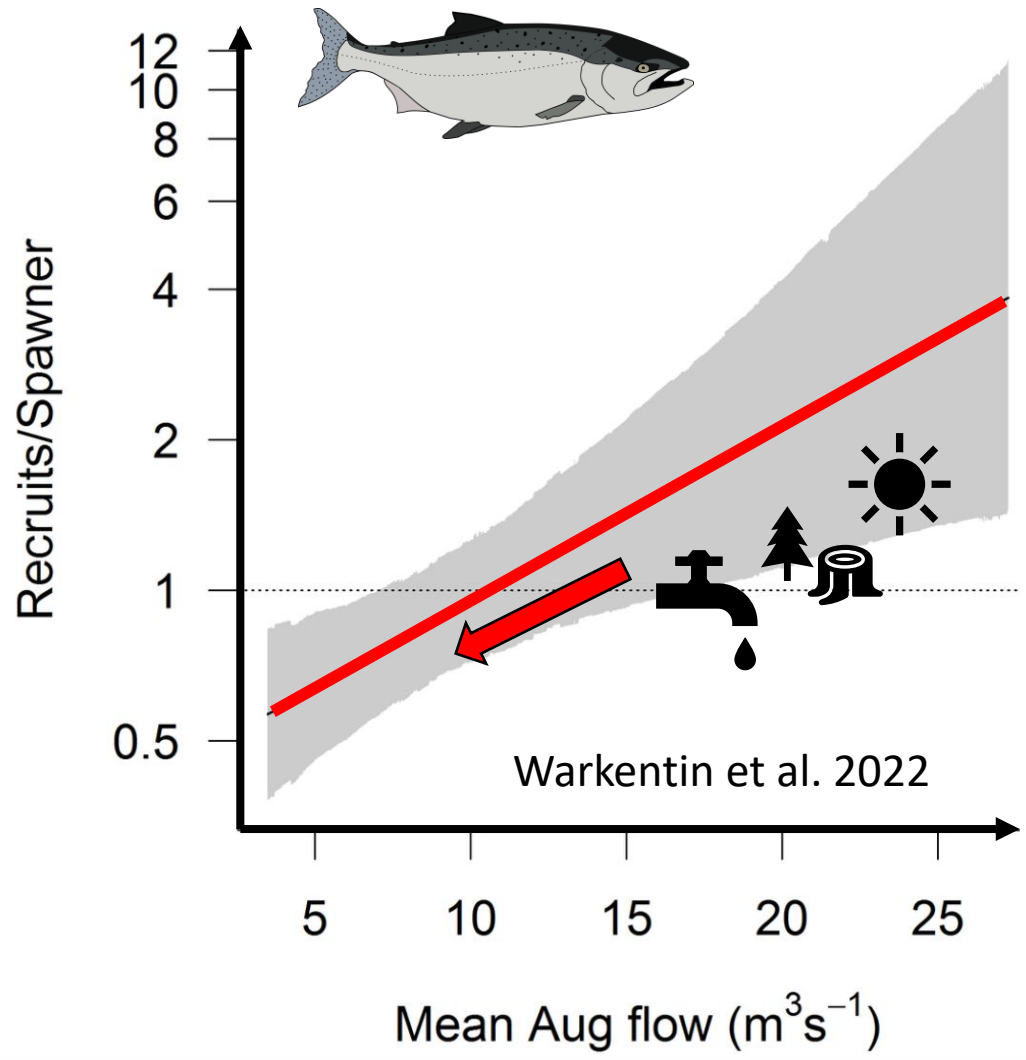
Wondzell et al 2019; etc.



~ 25%

Gronsdalh et al. 2019; etc.





DOI: 10.1002/2688-8319.12124

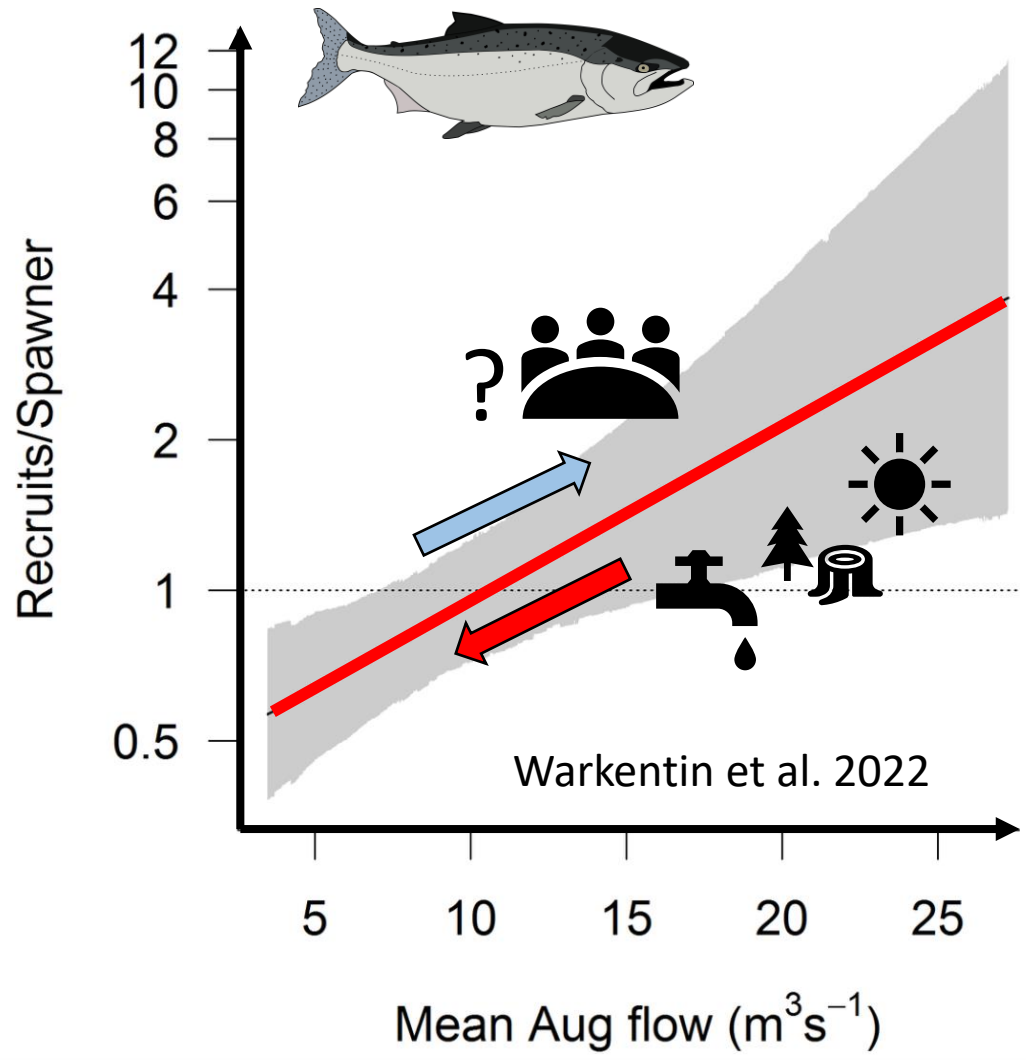
RESEARCH ARTICLE



## Low summer river flows associated with low productivity of Chinook salmon in a watershed with shifting hydrology

Luke Warkentin<sup>1</sup> | Charles K. Parken<sup>2</sup> | Richard Bailey<sup>2,3</sup> | Jonathan W. Moore<sup>1</sup>





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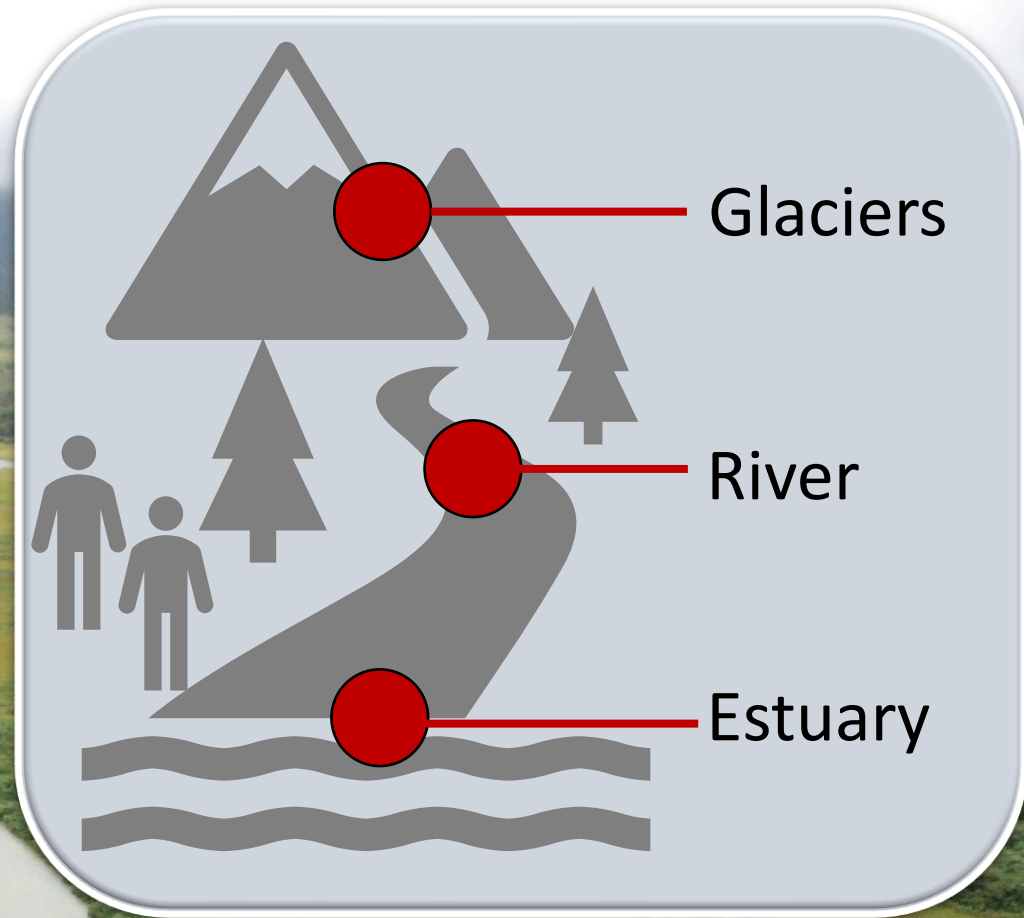
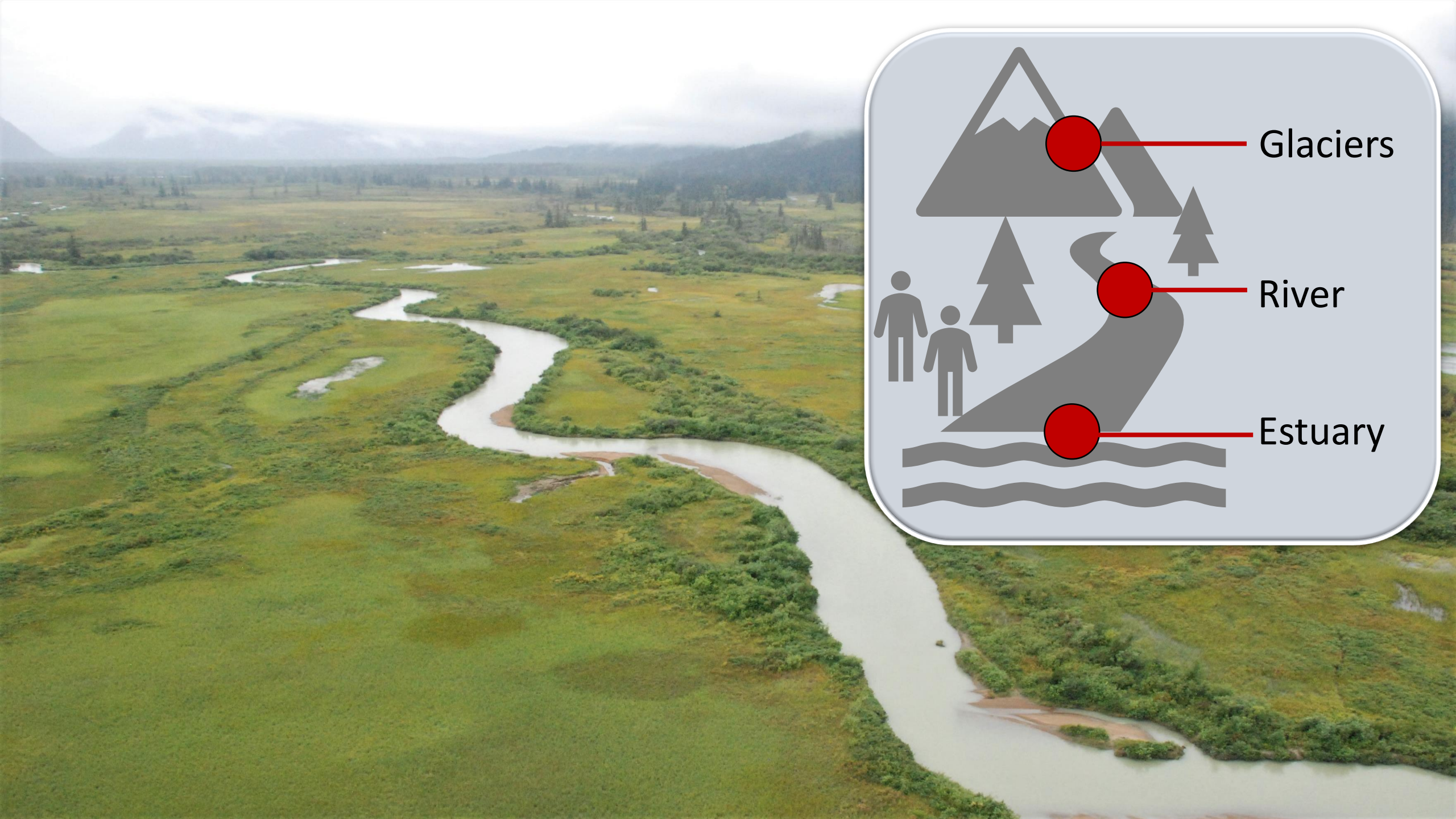
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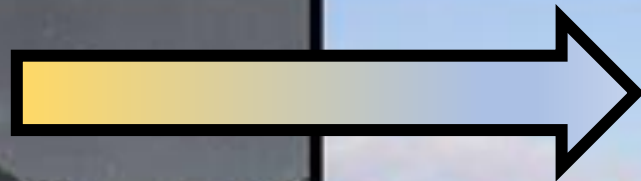
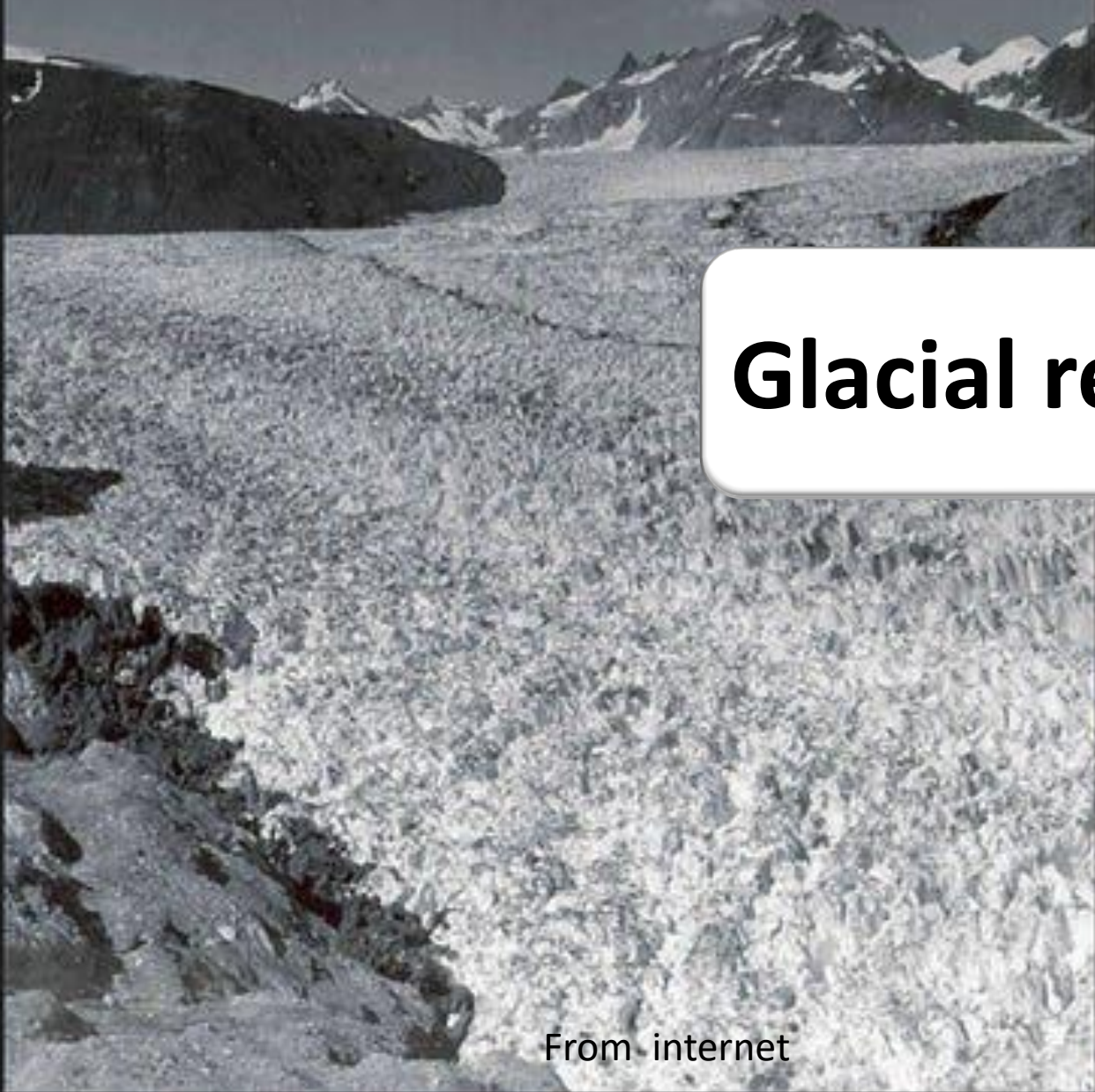
Glaciers

River

Estuary



1941



2004



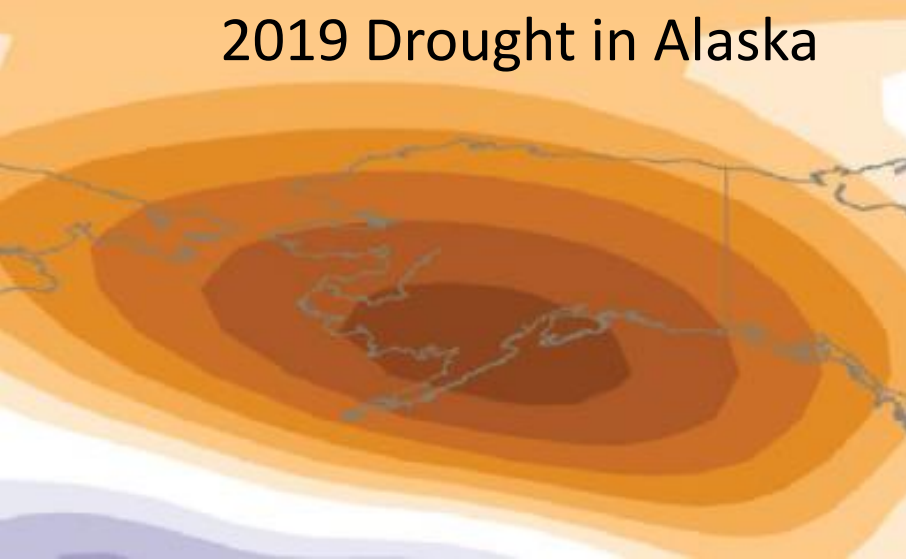
# Glacial retreat

- 80% of glaciers gone in western Canada by 2100 with moderate emissions

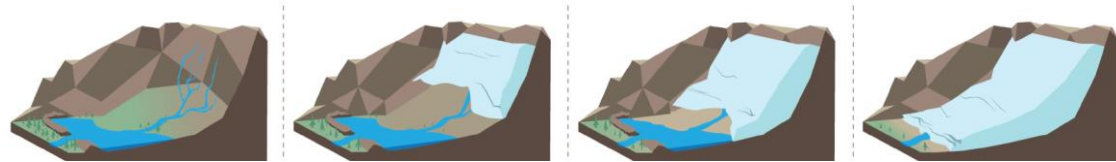
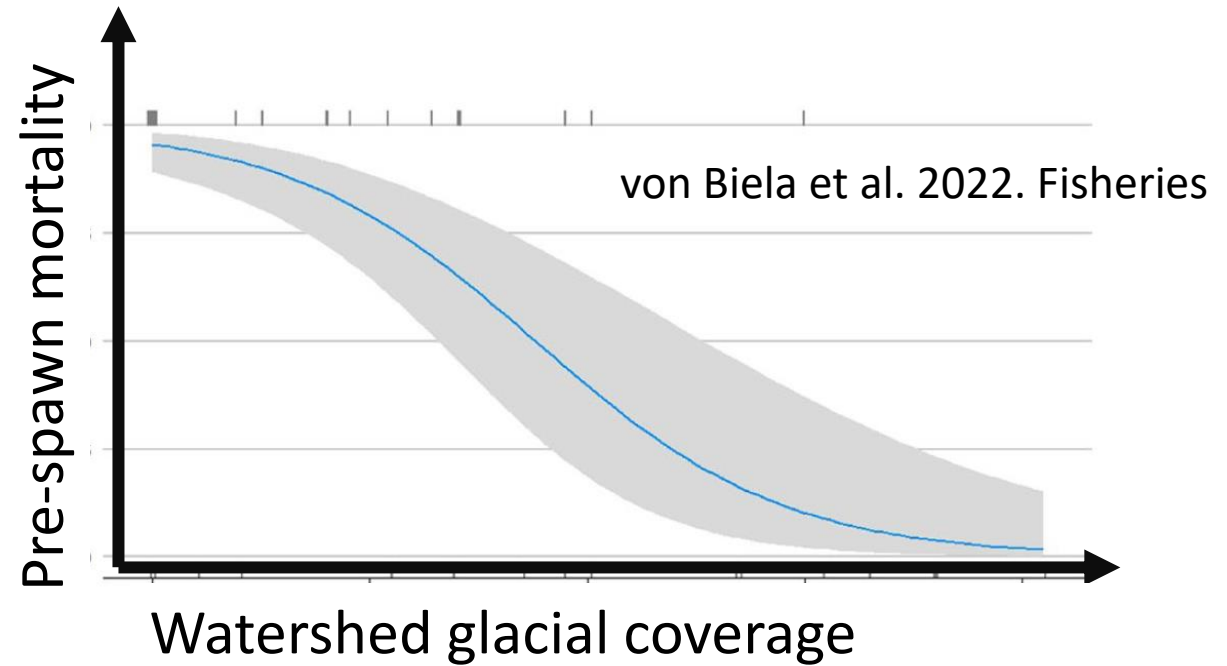
From internet



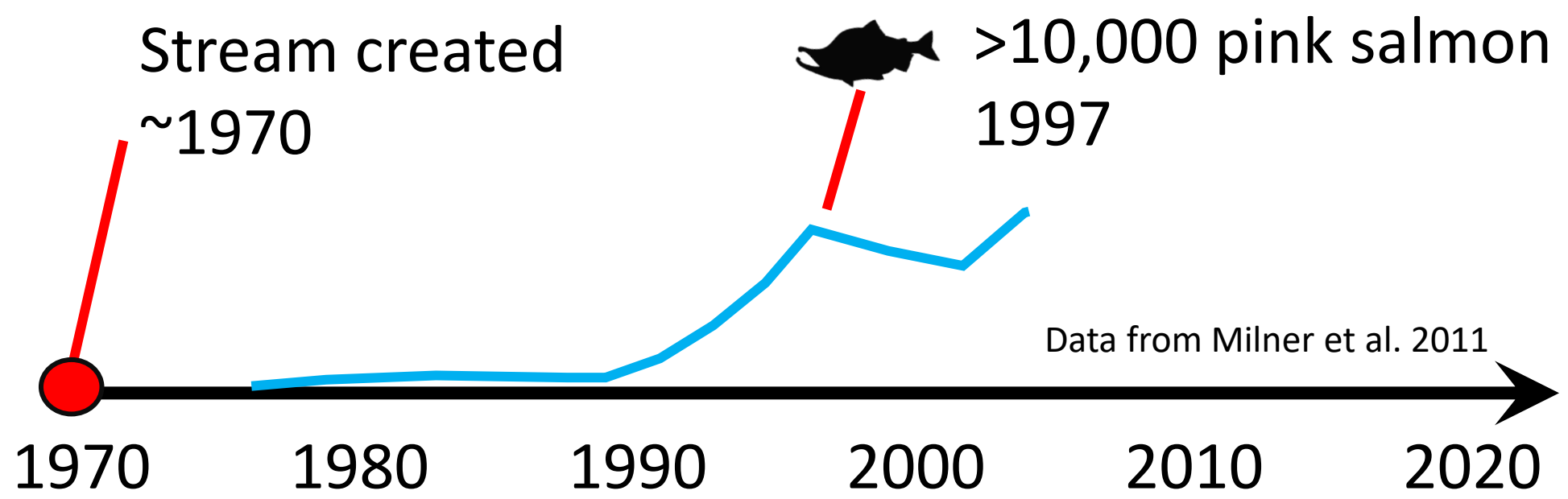
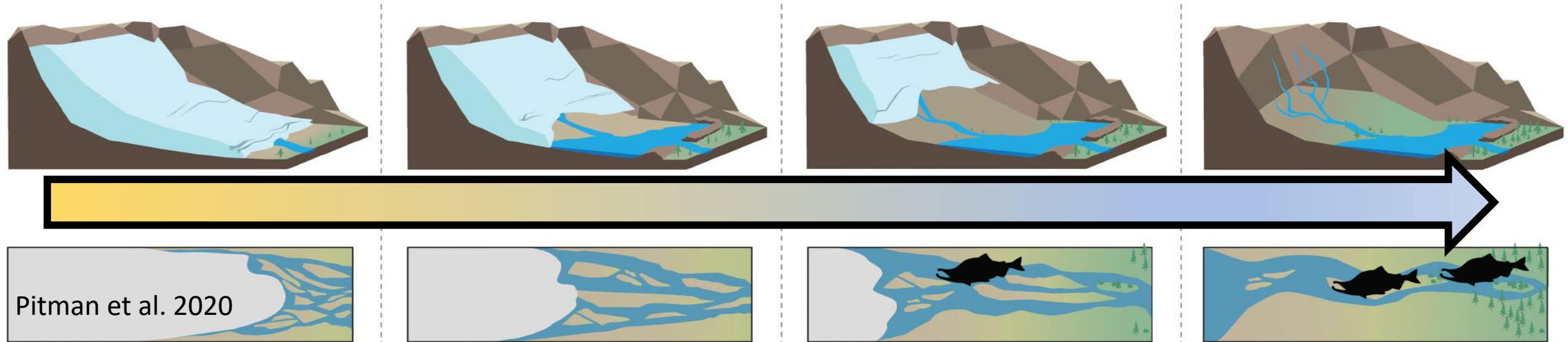
# 2019 Drought in Alaska



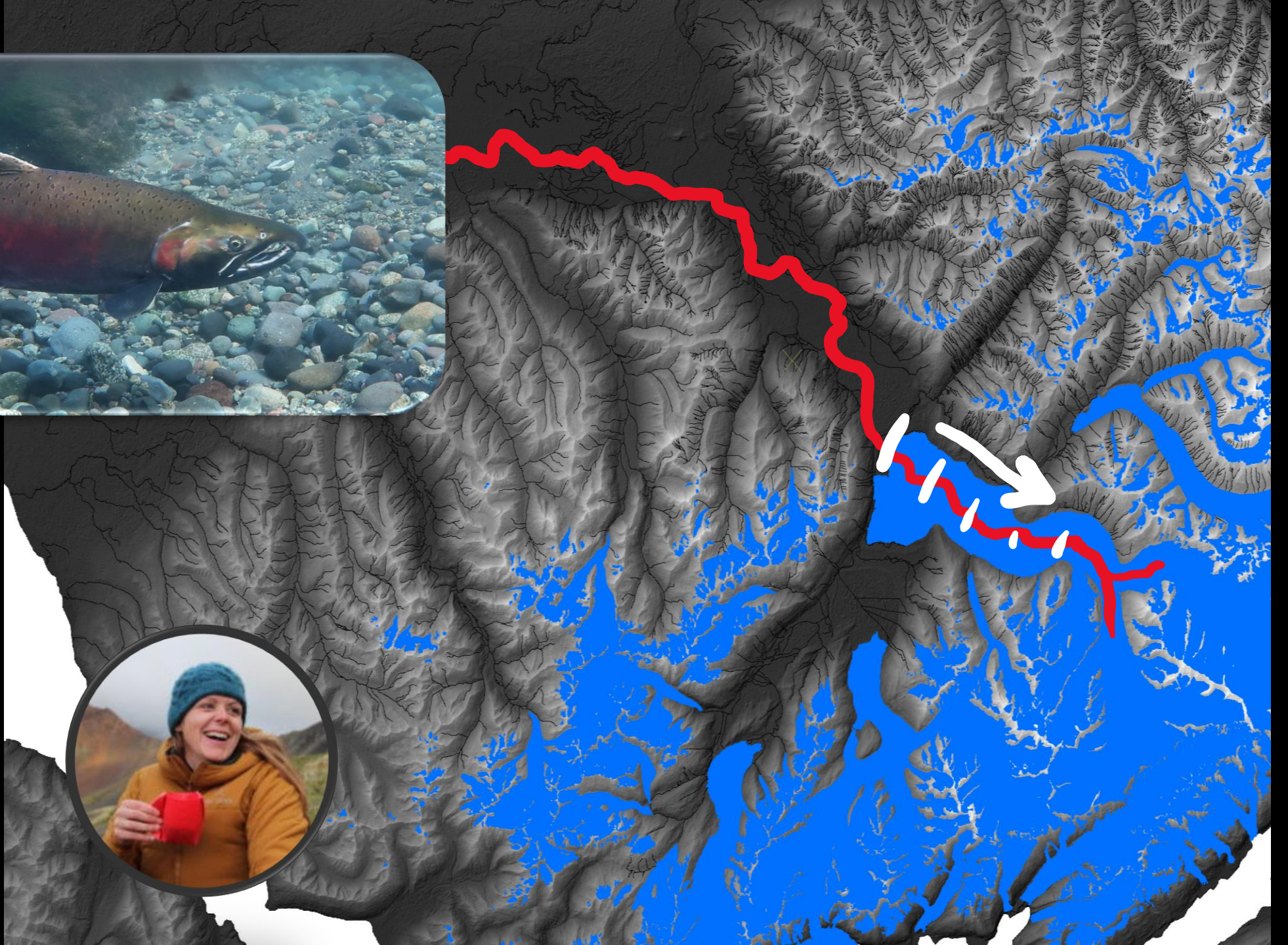
Glaciers provide cool summer water to salmon streams





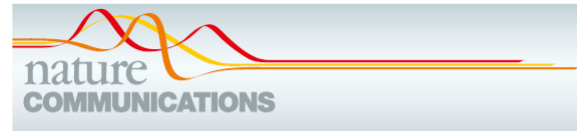
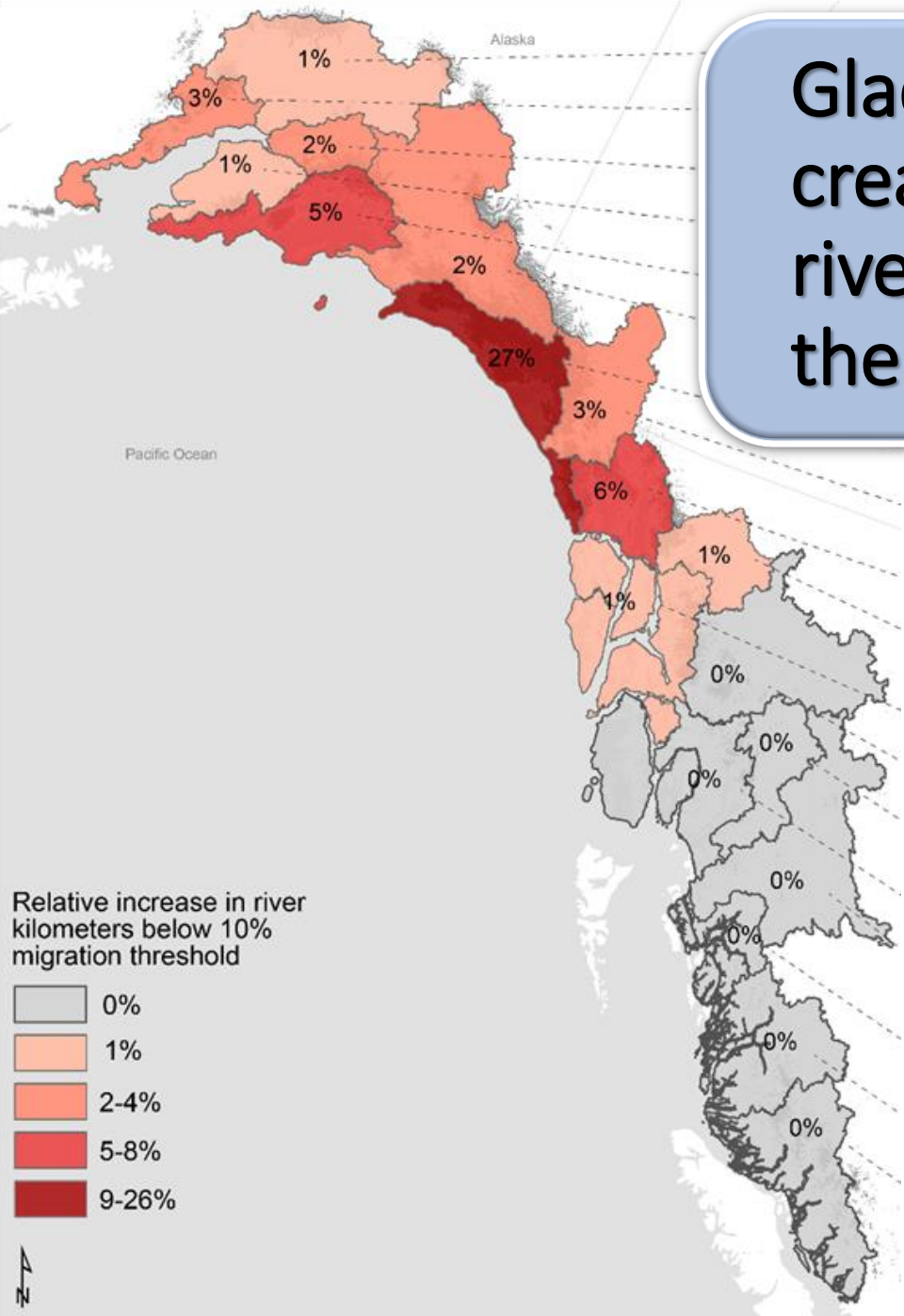








Glacier retreat will create >6000 km of new rivers for salmon over the next 100 years



ARTICLE

<https://doi.org/10.1038/s41467-021-26897-2> OPEN

Check for updates

## Glacier retreat creating new Pacific salmon habitat in western North America

Kara J. Pitman<sup>1</sup>, Jonathan W. Moore<sup>1</sup>, Matthias Huss<sup>2,3,4</sup>, Matthew R. Sloat<sup>5</sup>, Diane C. Whited<sup>6</sup>, Tim J. Beechie<sup>7</sup>, Rich Brenner<sup>8</sup>, Eran W. Hood<sup>9</sup>, Alexander M. Milner<sup>10,11</sup>, George R. Pess<sup>12</sup>, Gordan H. Reeves<sup>13</sup> & Daniel E. Schindler<sup>14</sup>



2007

2019



Pictures: Mark Connor

Chris Sergeant









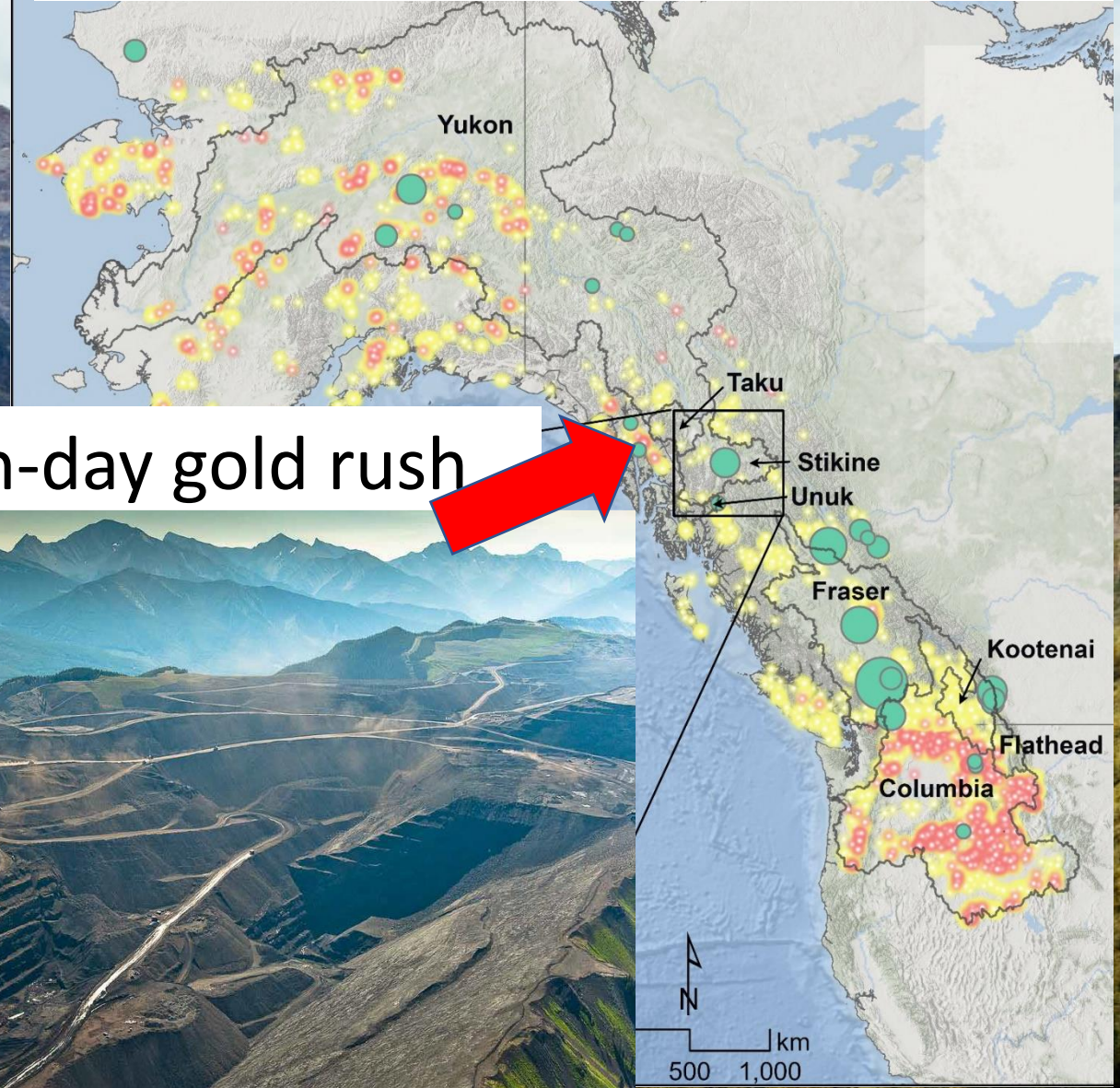
# Glacier retreat— frontiers for salmon & mining

*“In eight years of glacial retreat, at the rate it has been going, there could be an ore body sticking right out of the ground that nobody’s even seen before”*  
<https://www.mining.com/web/a-revival-takes-shape-in-bcs-golden-triangle/>





# Mines across the salmon coast



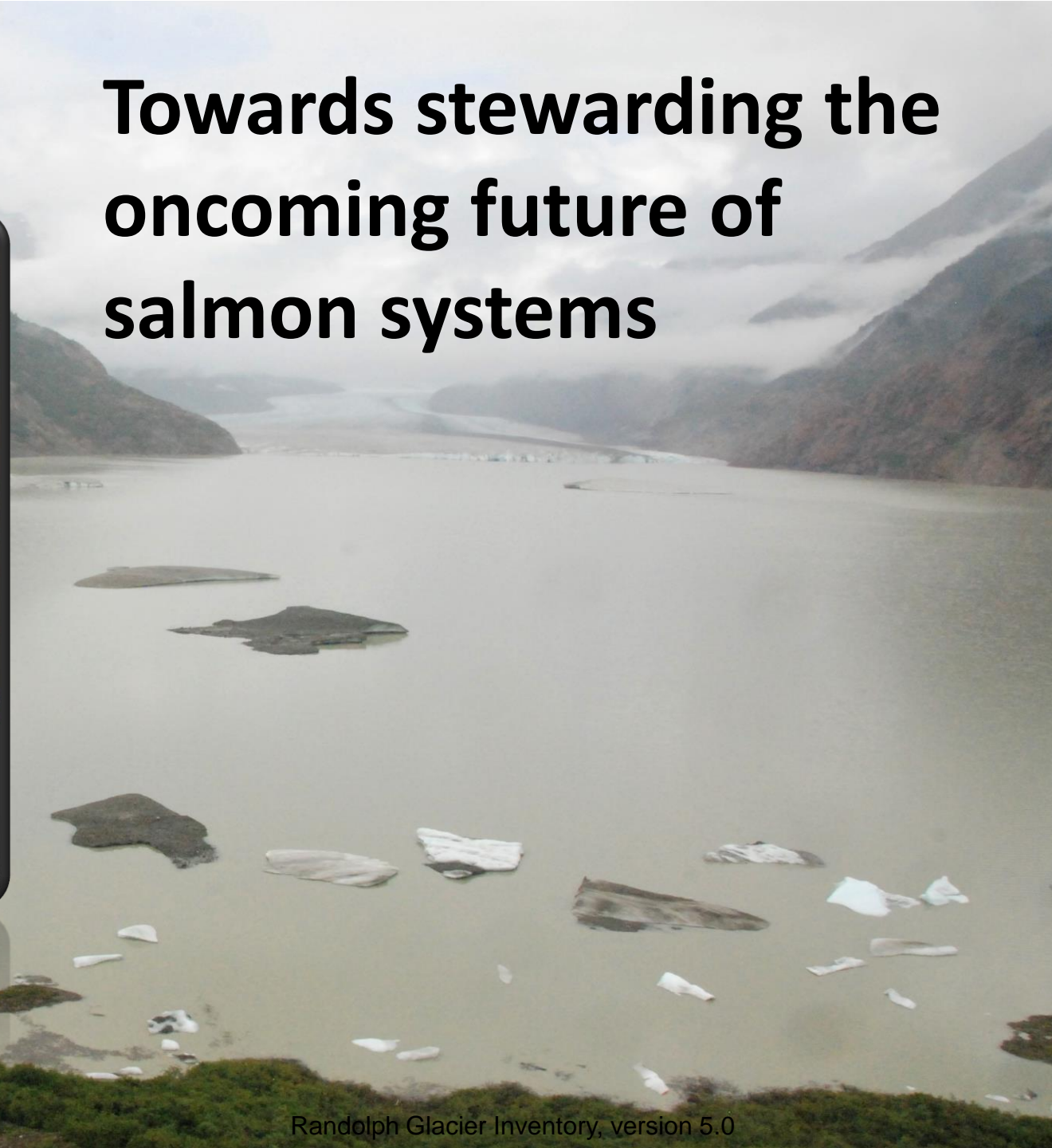
Modern-day gold rush



Sexton et al. 2020. Science.  
Sergeant et al. 2022. Science Advances.



# Towards stewarding the oncoming future of salmon systems

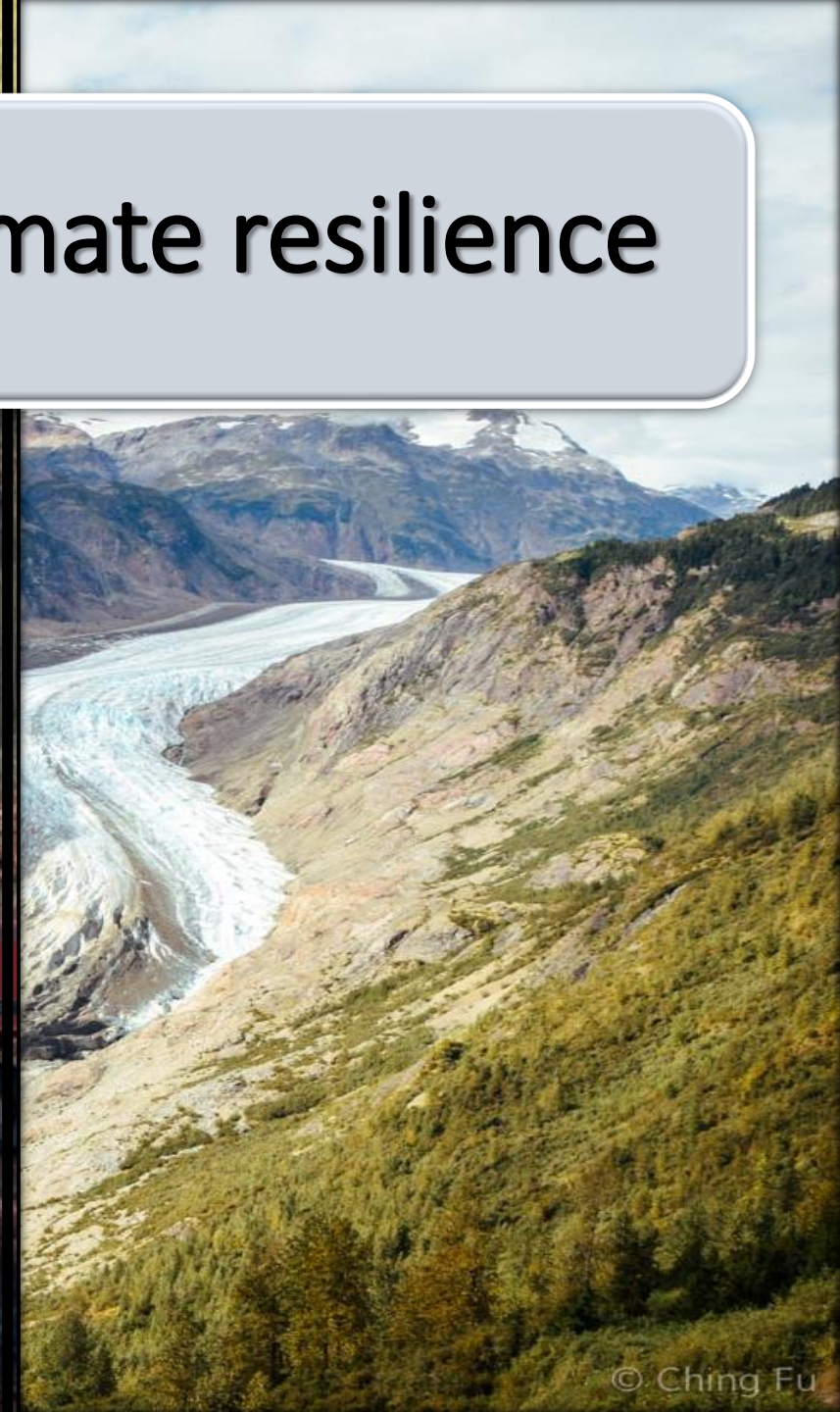




**Stewarding habitat:  
current and future**

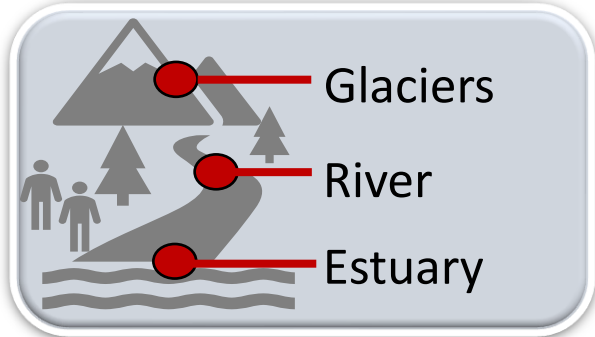


**Climate resilience**

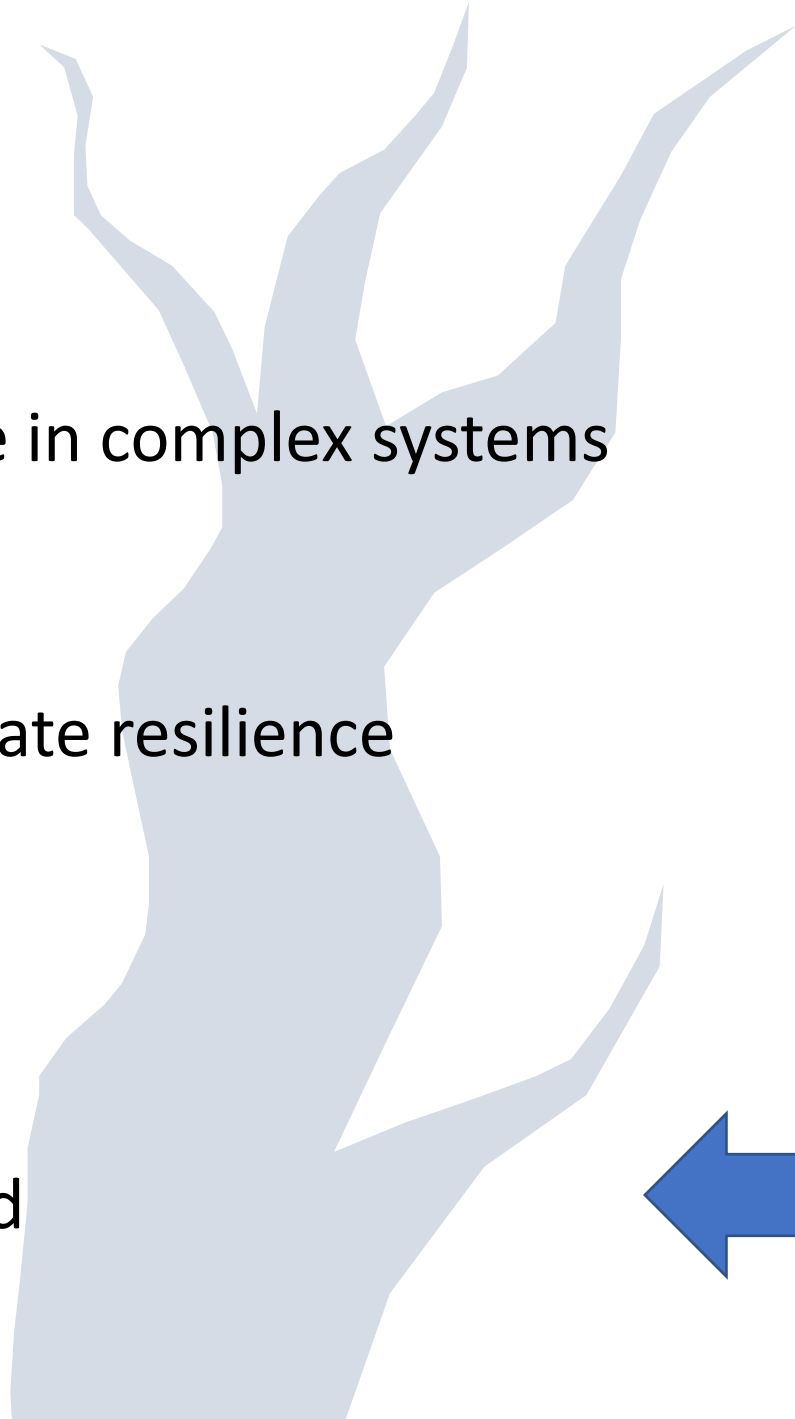




# FLOW

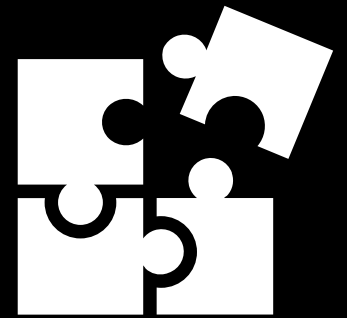


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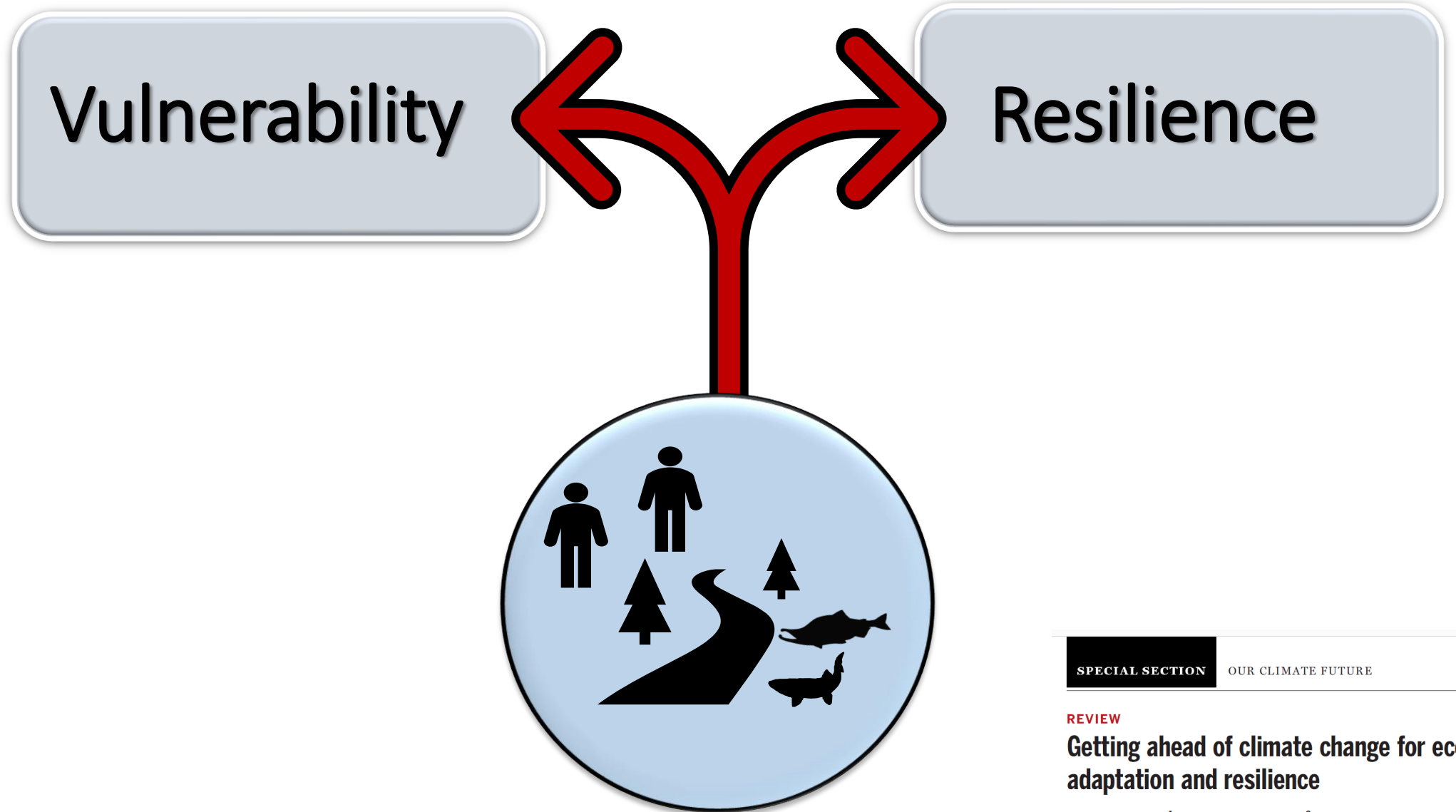


# Biodiversity for resilience





# Crossroads



SPECIAL SECTION OUR CLIMATE FUTURE

REVIEW

**Getting ahead of climate change for ecological adaptation and resilience**

Jonathan W. Moore<sup>1\*</sup> and Daniel E. Schindler<sup>2\*</sup>





**Need for collaborative & forward-looking science, action**



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