Restoring salmon in a changing climate

Tim Beechie, Hiroo Imaki, Jen Greene, George Pess, Phil Roni, Peter Kiffney
NW Fisheries Science Center

Alisa Wade-Wilcox
University of California Santa Barbara

Huan Wu, John Kimball, Jack Stanford
University of Montana

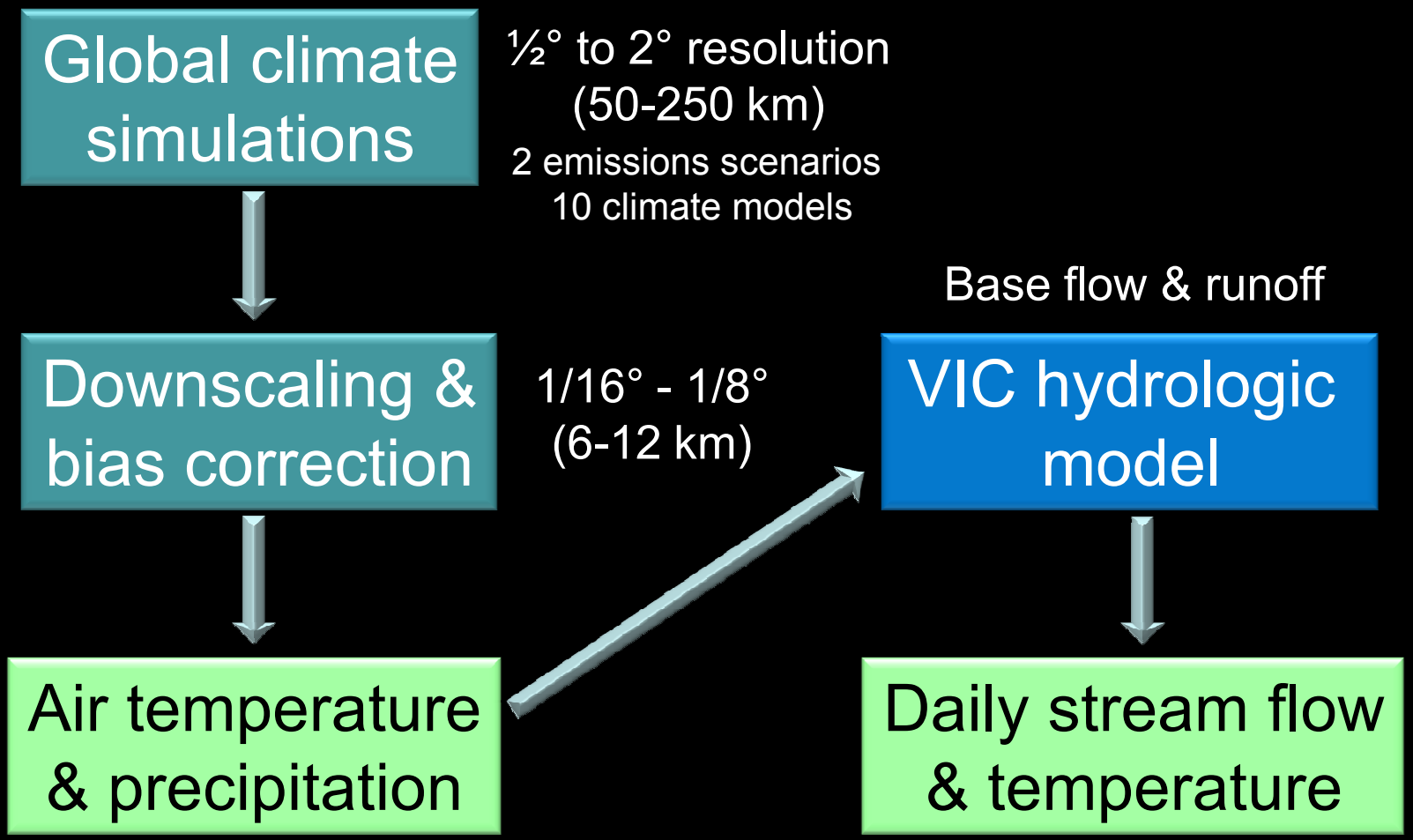
The big question

- Will climate change negate salmon restoration efforts?
  - Recovery plans in place
  - Millions of dollars will be spent
  - Should we alter habitat restoration plans to accommodate climate change?

Outline

- Predicted climate change effects
- Salmon vulnerability
- Restoration actions and climate change
- Adapting restoration plans to accommodate climate change

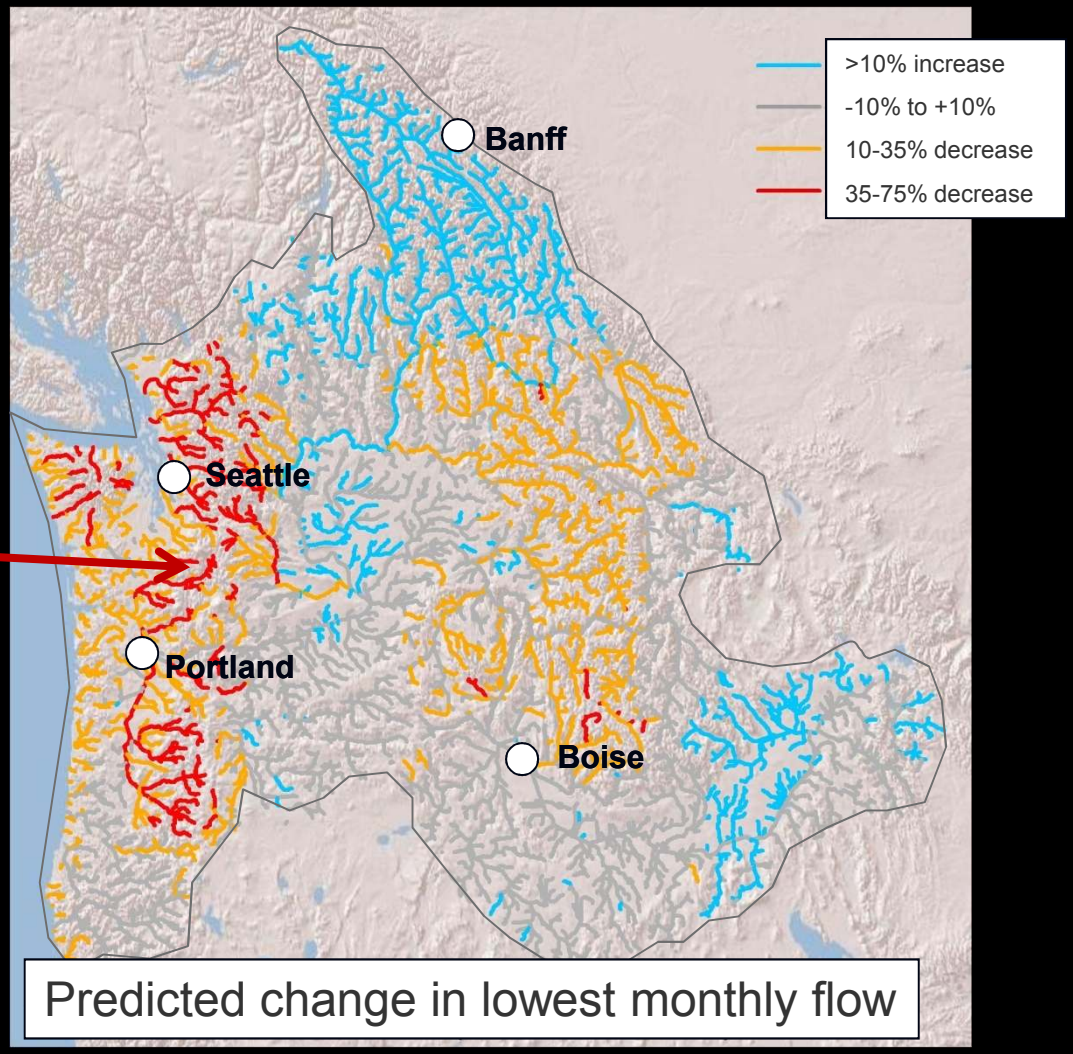
Predicting climate change effects



Predicted change in low flow

- Change in lowest monthly flow between 1980s and 2080s

35-75% Decrease

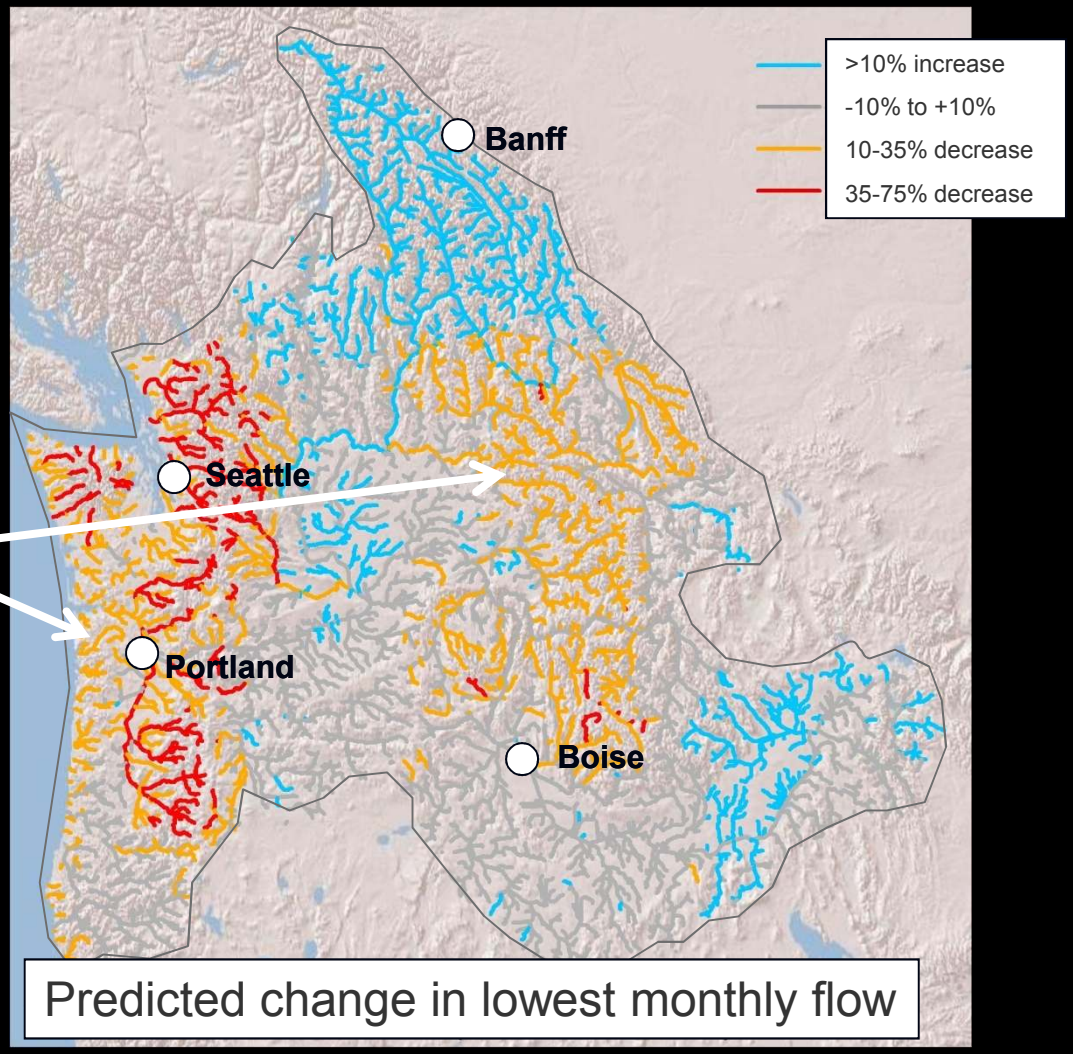


Data source: http://www.hydro.washington.edu/2860/report/

Predicted change in low flow

- Change in lowest monthly flow between 1980s and 2080s

10-35% Decrease



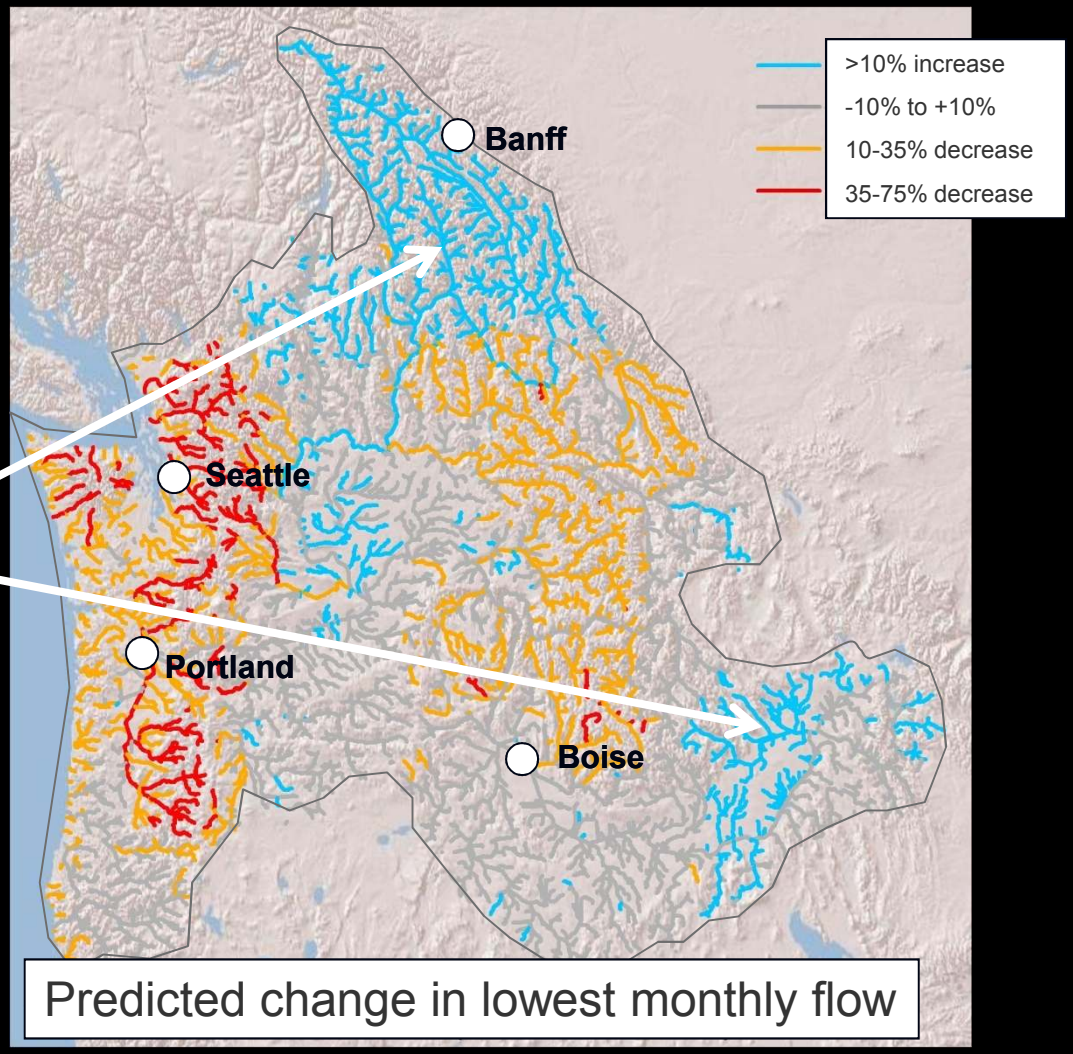
Predicted change in lowest monthly flow

Data source: http://www.hydro.washington.edu/2860/report/

Predicted change in low flow

- Change in lowest monthly flow between 1980s and 2080s

>10% Increase

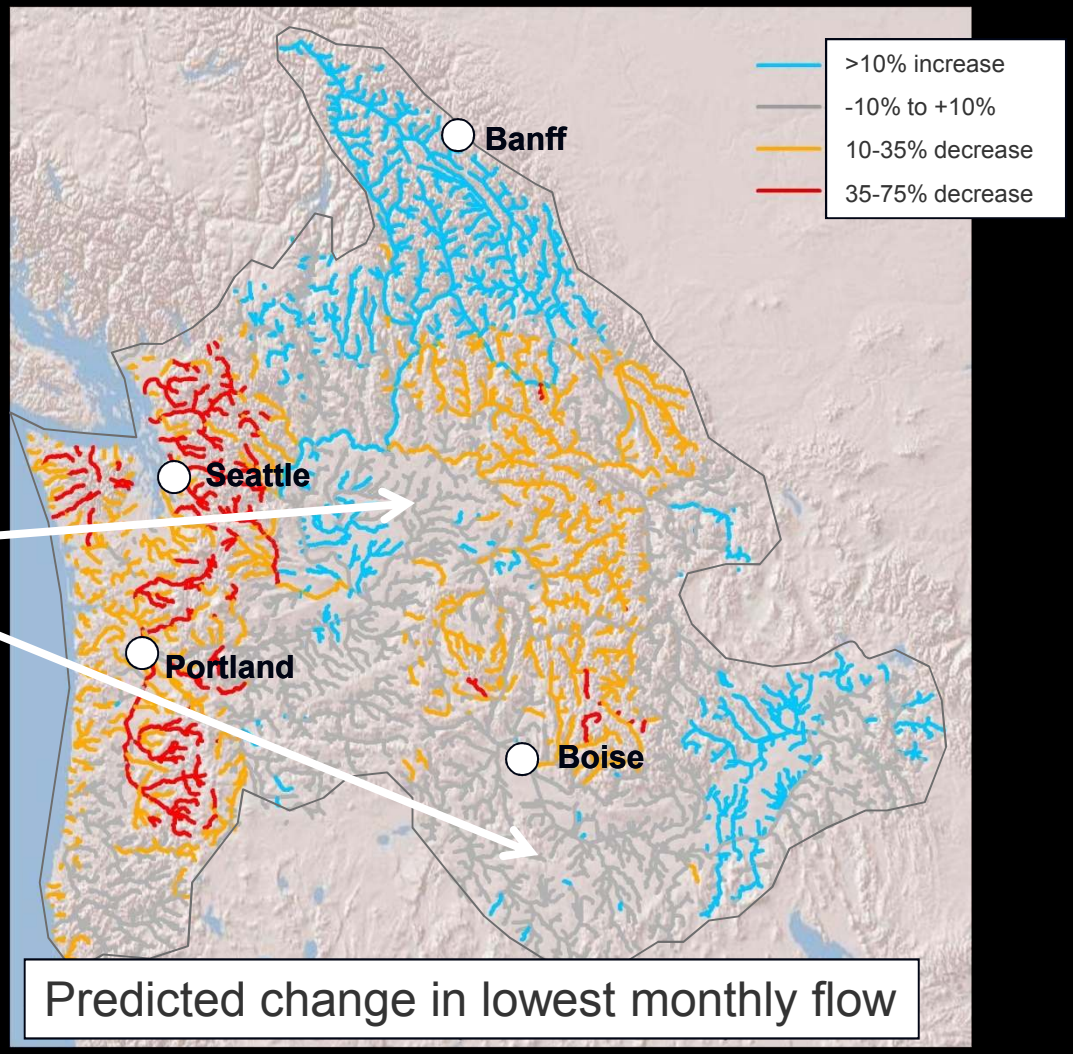


Data source: http://www.hydro.washington.edu/2860/report/

Predicted change in low flow

- Change in lowest monthly flow between 1980s and 2080s

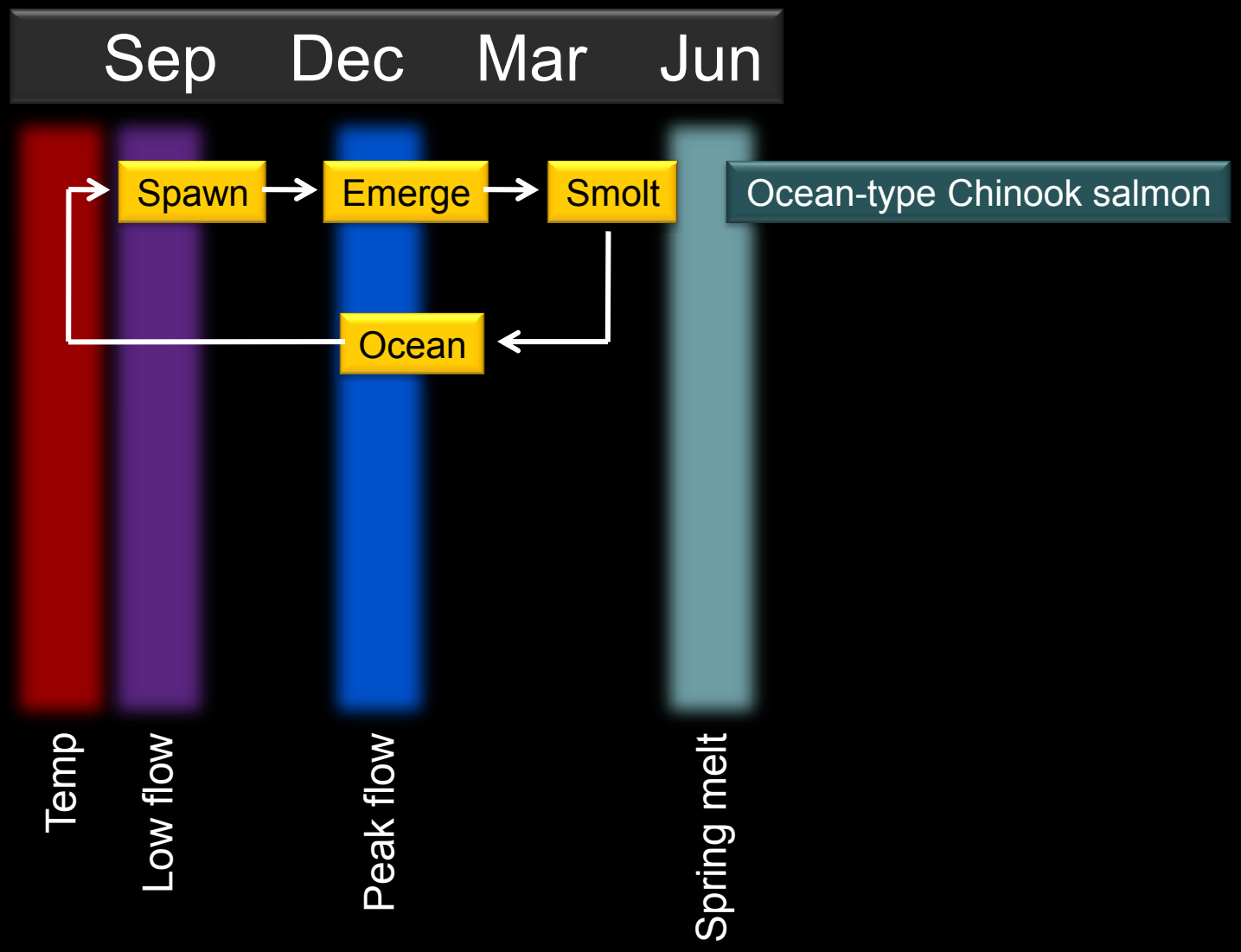
No change



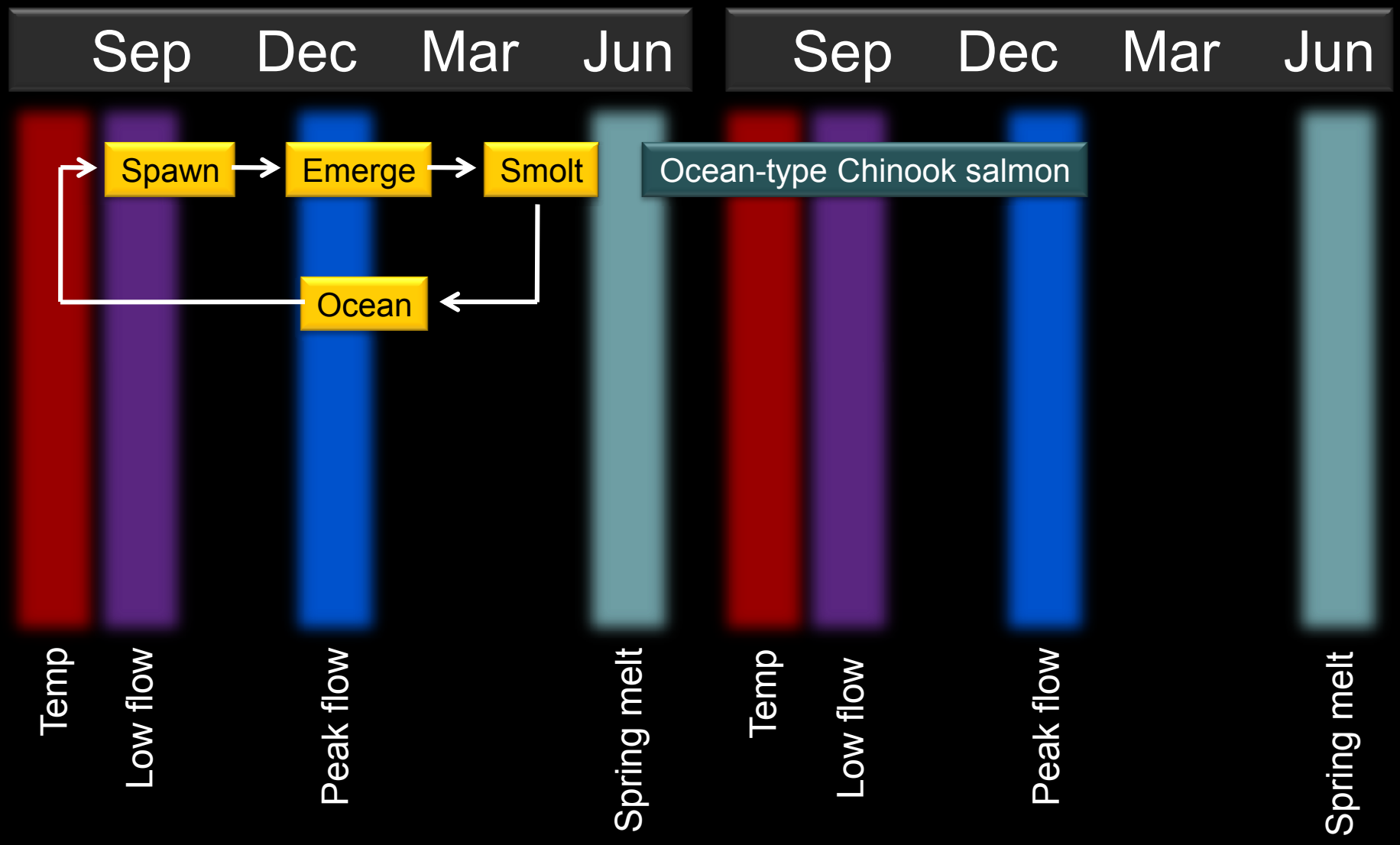
Data source: http://www.hydro.washington.edu/2860/report/

What does that mean for salmon?

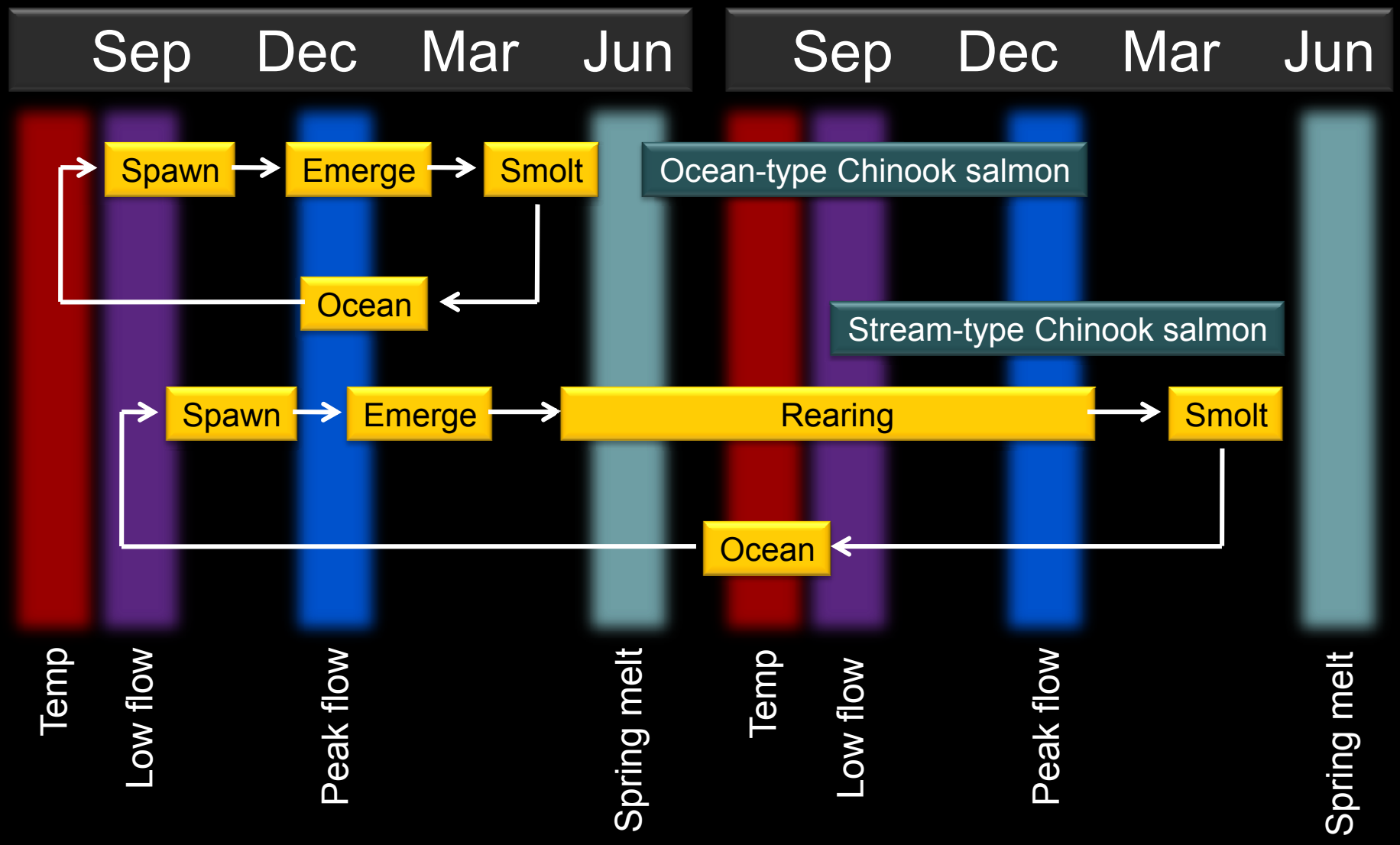
What does that mean for salmon?



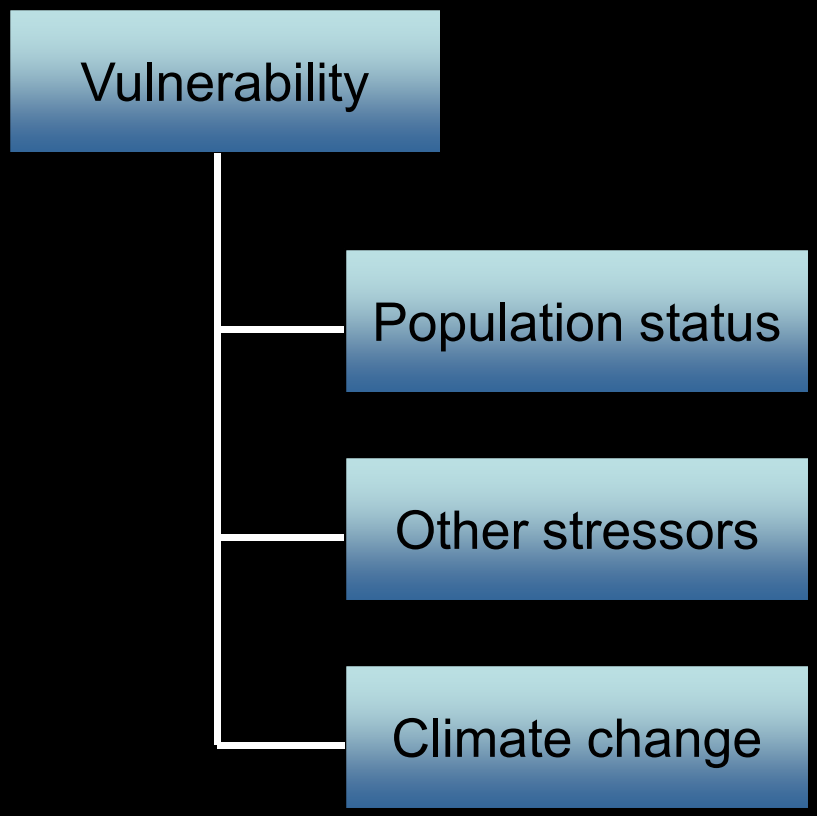
What does that mean for salmon?



What does that mean for salmon?



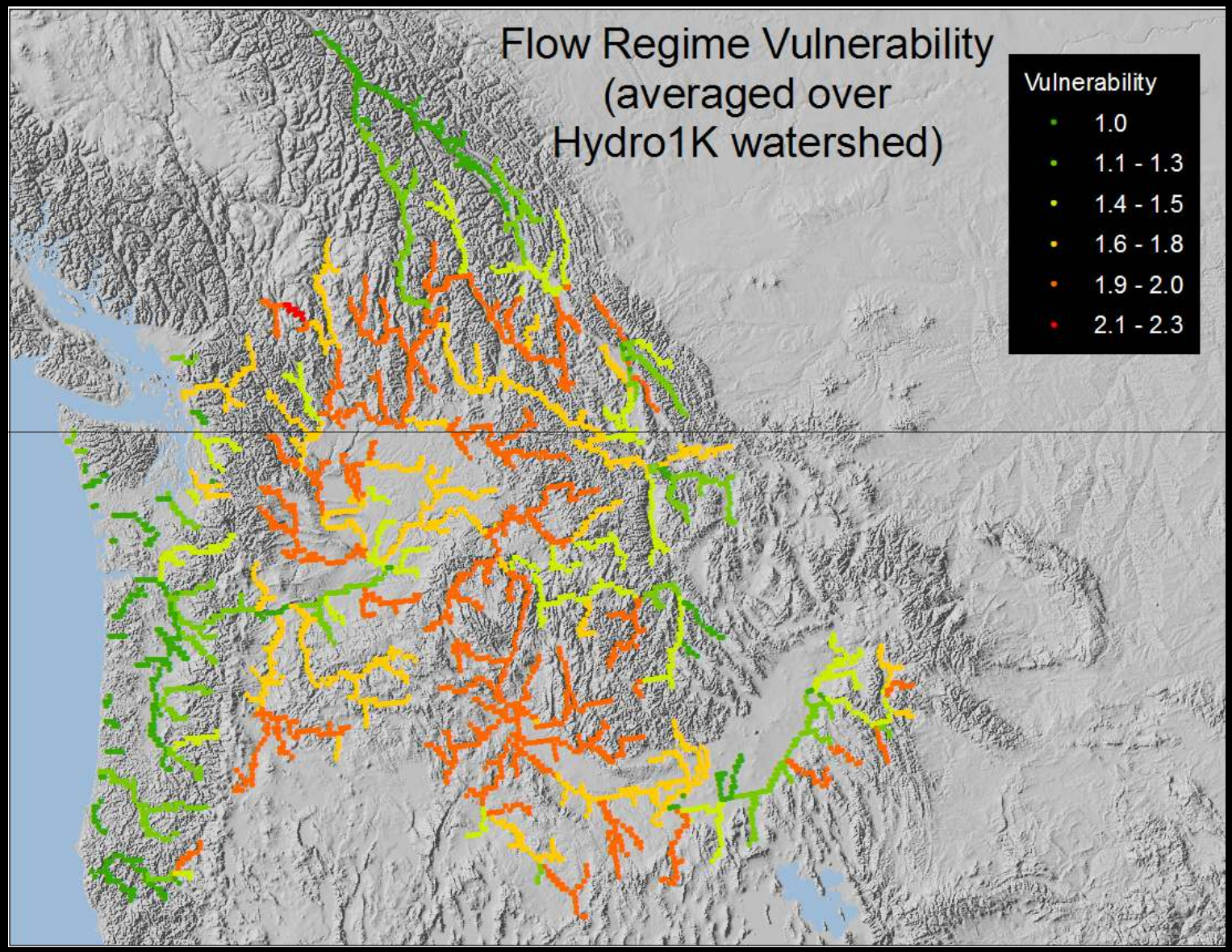
Salmon vulnerability to climate change



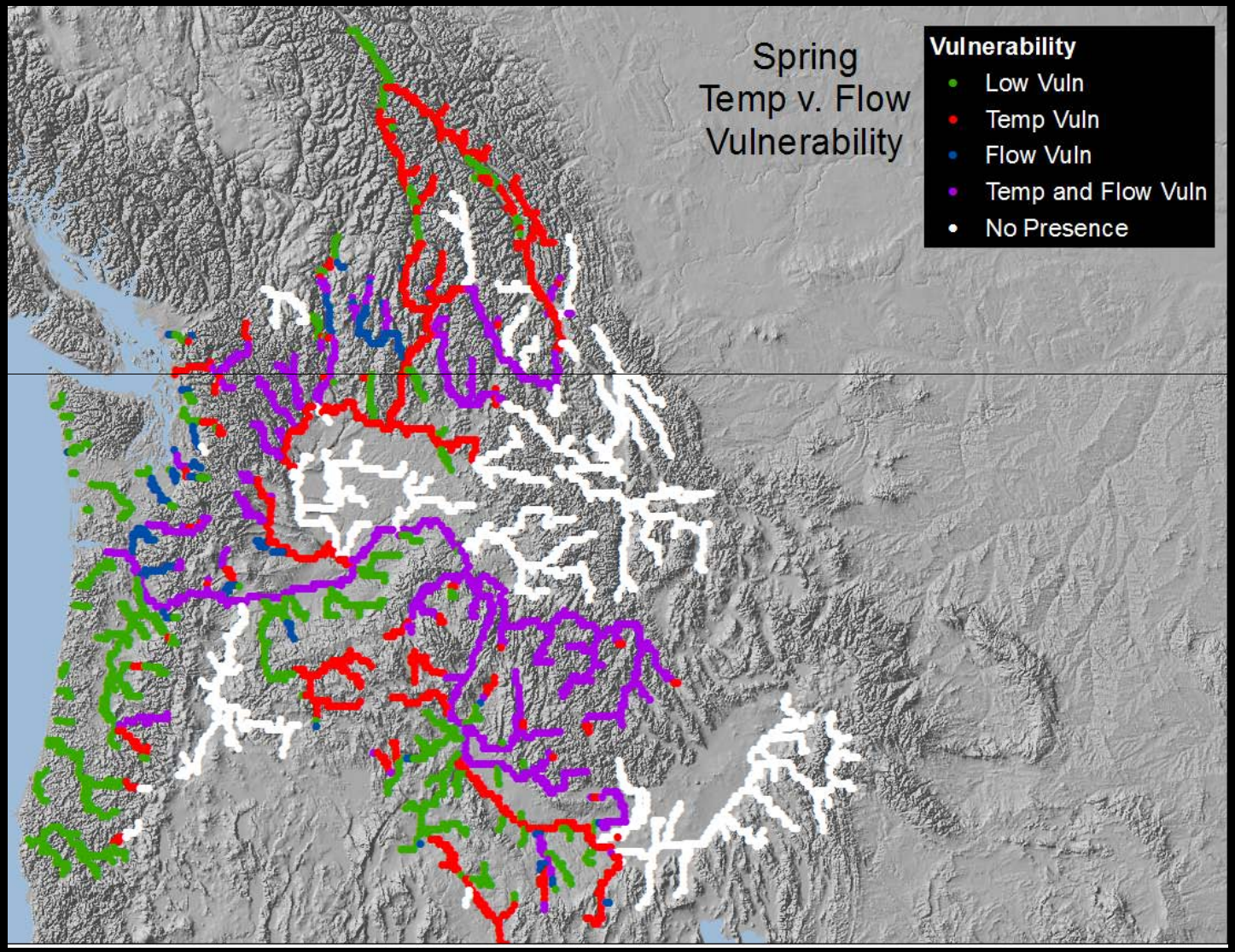
- Conceptual basis:

  Existing stresses reduce salmon's ability to respond to climate change

Flow regime vulnerability



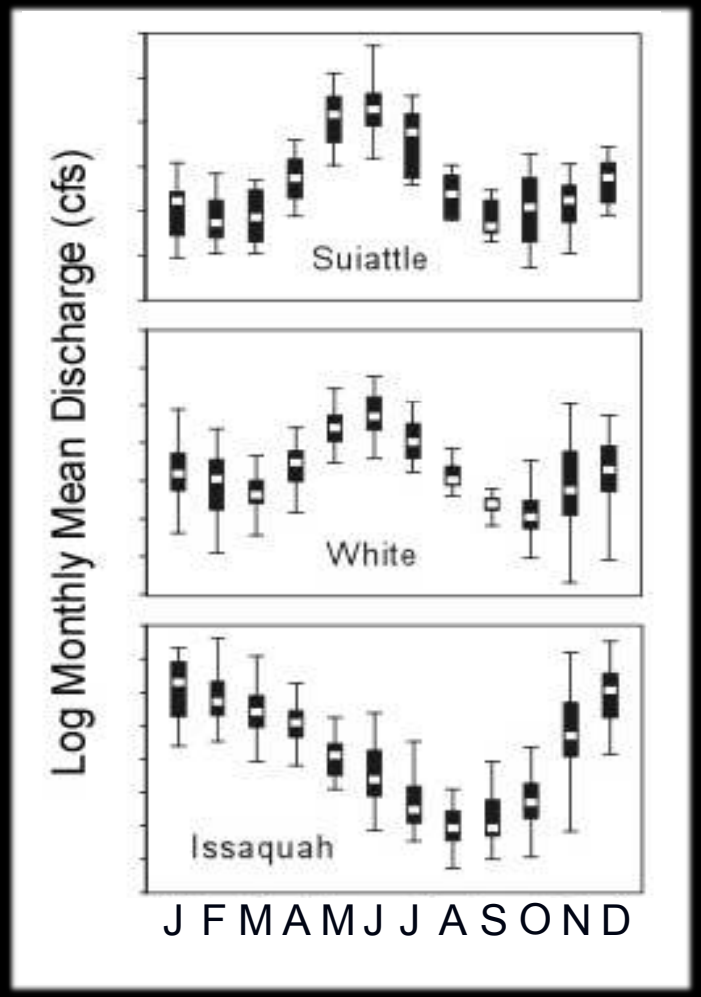
Combined flow and temperature vulnerability



Flow regime and Chinook life history

Stream-type Chinook

Ocean-type Chinook



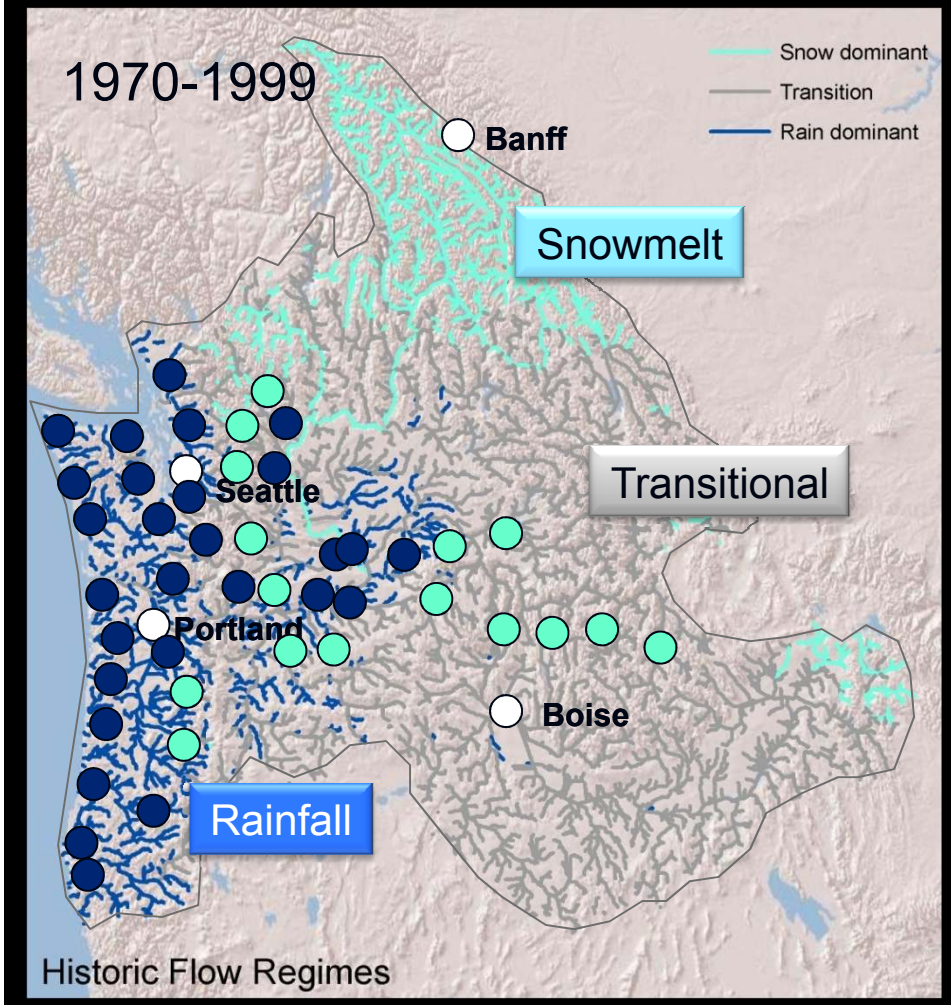
Snowmelt

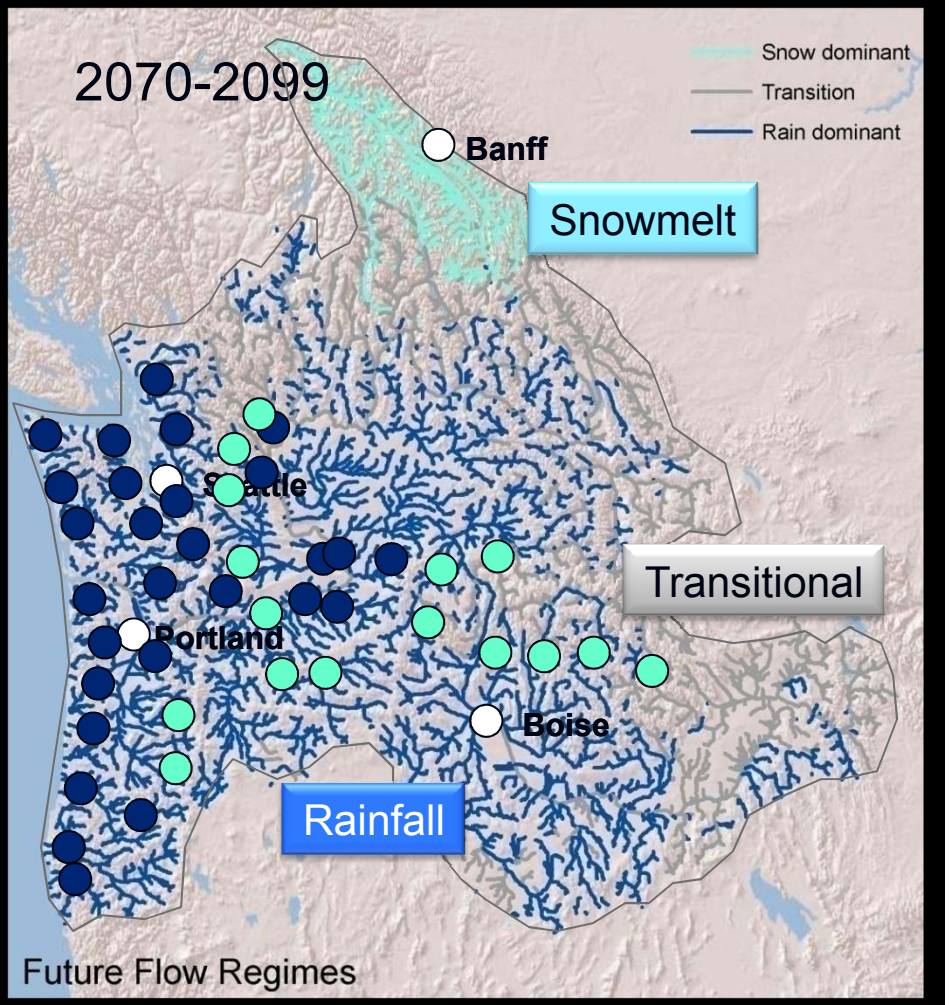
Transitional

Rainfall

Beechie et al. 2006

Flow regime and Chinook life history





Data source: http://www.hydro.washington.edu/2860/report/

Do climate change predictions alter restoration plans?

- What habitat factors limit salmon recovery?
- What are local predicted climate change effects?
- Do proposed restoration actions reduce climate change effects?
- Do proposed restoration actions increase habitat diversity or ecosystem resilience?

Restoration actions and climate change

Category	Common techniques	Ameliorates temperature increase	Ameliorates base flow decrease	Ameliorates peak flow increase	Increases salmon resilience
Longitudinal connectivity (barrier removal)					
	Removal or breaching of dam	●	●	○	●
	Barrier or culvert replacement/removal	○	○	○	●
Lateral connectivity (floodplain reconnection)					
	Levee removal	●	○	●	●
	Reconnection of floodplain features (e.g., channels, ponds)	●	○	●	●
	Creation of new floodplain habitats	●	○	●	●
Vertical connectivity (incised channel restoration)					
	Reintroduce beaver (dams increase sediment storage)	●	●	●	●
	Remove cattle (restored vegetation stores sediment)	●	●	●	○
	Install grade controls	●	●	●	○

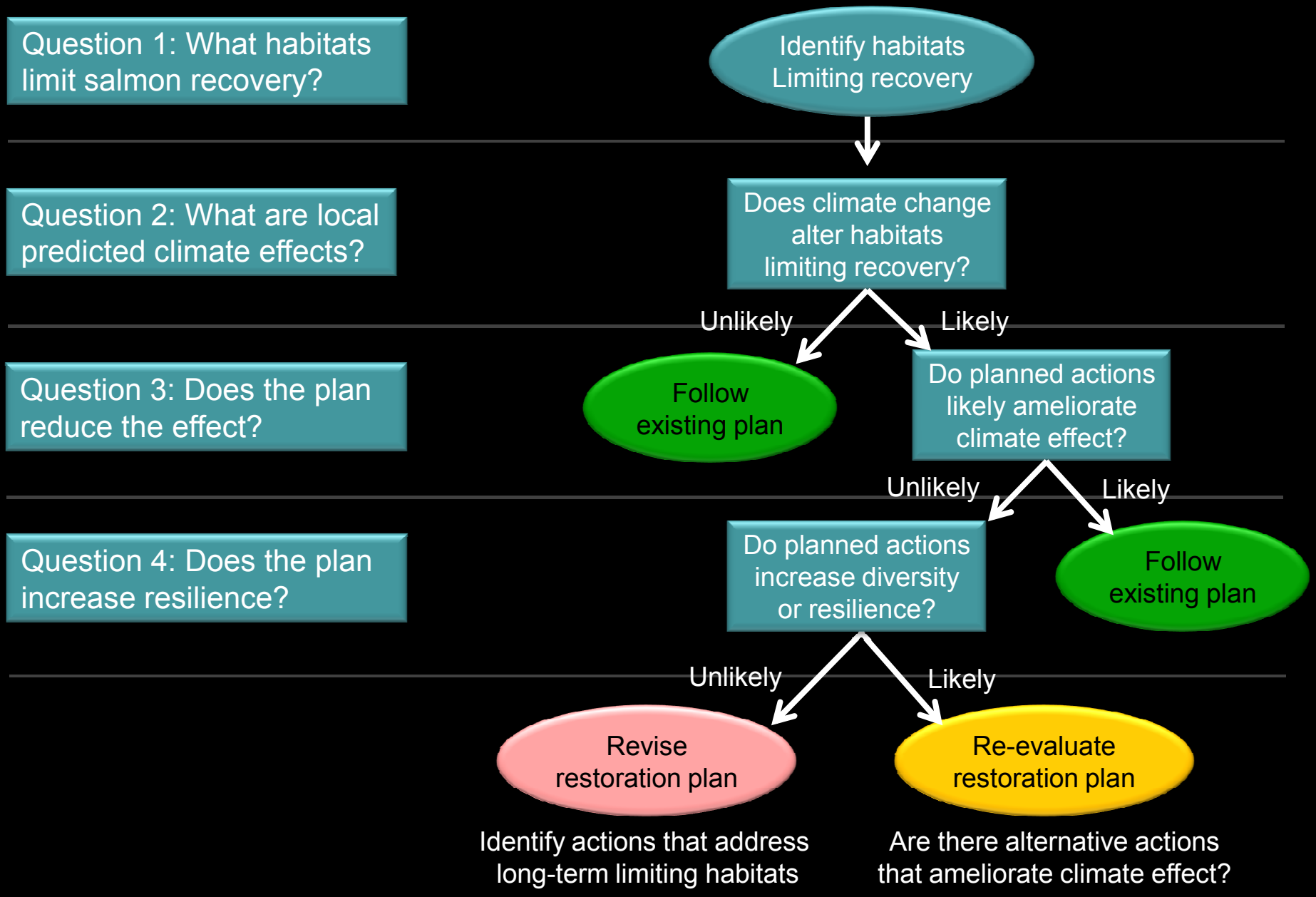
Restoration actions and climate change

Category	Common techniques	Ameliorates temperature increase	Ameliorates base flow decrease	Ameliorates peak flow increase	Increases salmon resilience
Riparian functions					
	Grazing removal, fencing, controlled grazing	●	●	○	○
	Planting (trees, other vegetation)	●	○	○	○
	Thinning or removal of understory	○	○	○	○
Instream rehabilitation					
	Remeandering of straightened stream, channel realignment	◒	○	○	◒
	Addition of log structures, log jams	○	○	○	○
	Boulder weirs and boulders	○	○	○	○
	Brush bundles, cover structures	○	○	○	○
	Gravel addition	○	○	○	○

Restoration actions and climate change

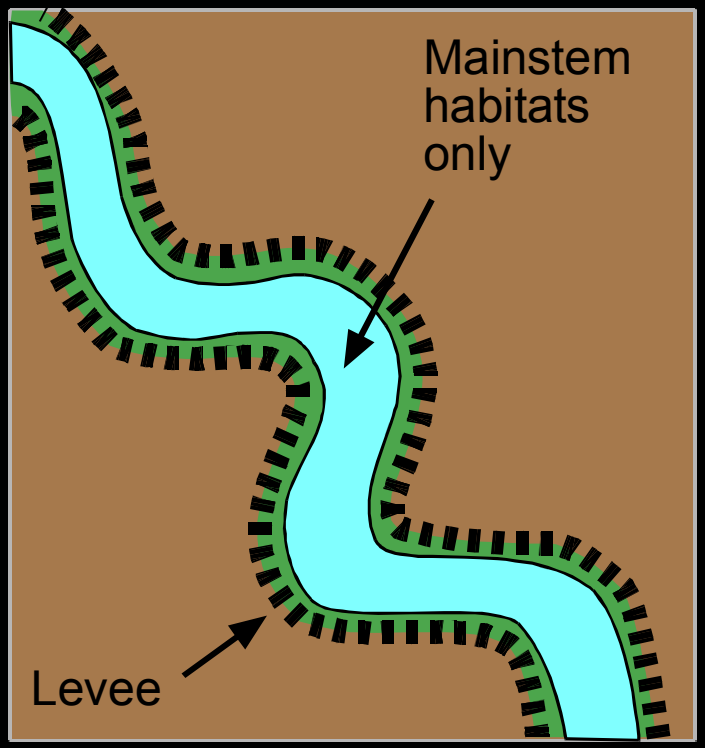
Restoration action	Does action reduce a climate change effect?		
	Temperature increase	Low flow decrease	Peak flow increase
Longitudinal connectivity	Y	Y	Y
Floodplain connectivity	Y	N	Y
Restore incised channel	Y	N	Y
Restore in-stream flow	Y	Y	N
Riparian rehabilitation	Y	N/Y	N
Sediment reduction	N	N	N/Y
In-stream habitat	N	N	N
Nutrient enrichment	N	N	N

Evaluating a restoration plan



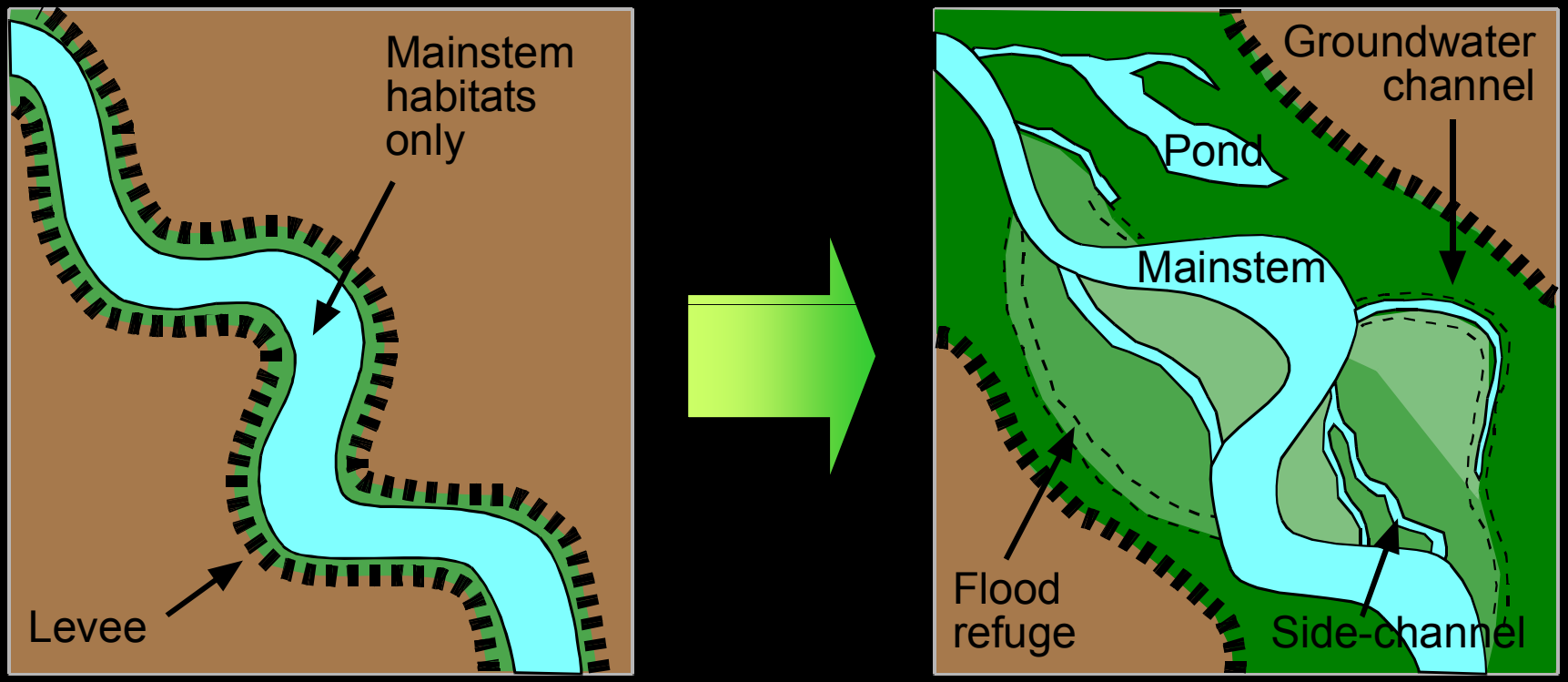
Strategies to increase resilience

Increase habitat diversity



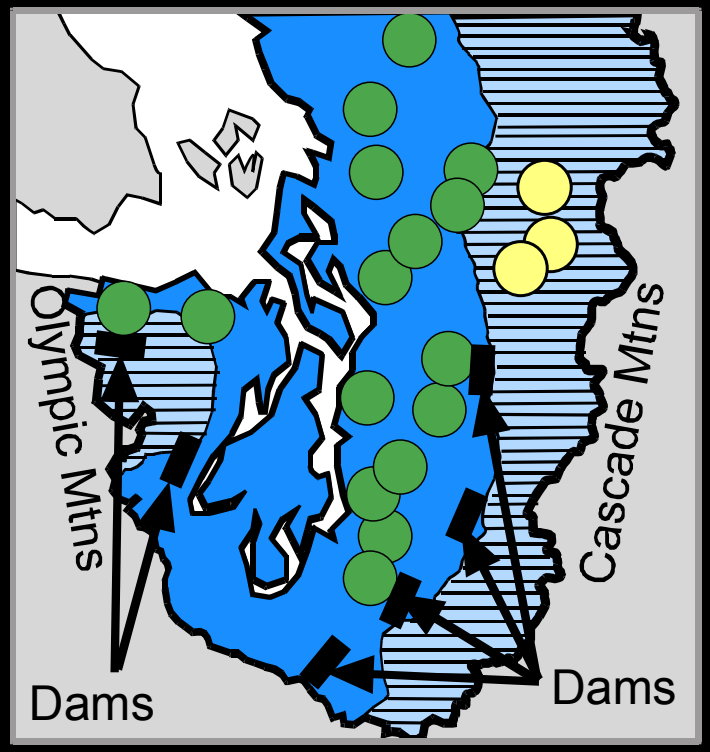
Waples et al. 2008

Increase habitat diversity



Waples et al. 2008

Restore access to diverse habitats



Rainfall/transitional hydrologic regime

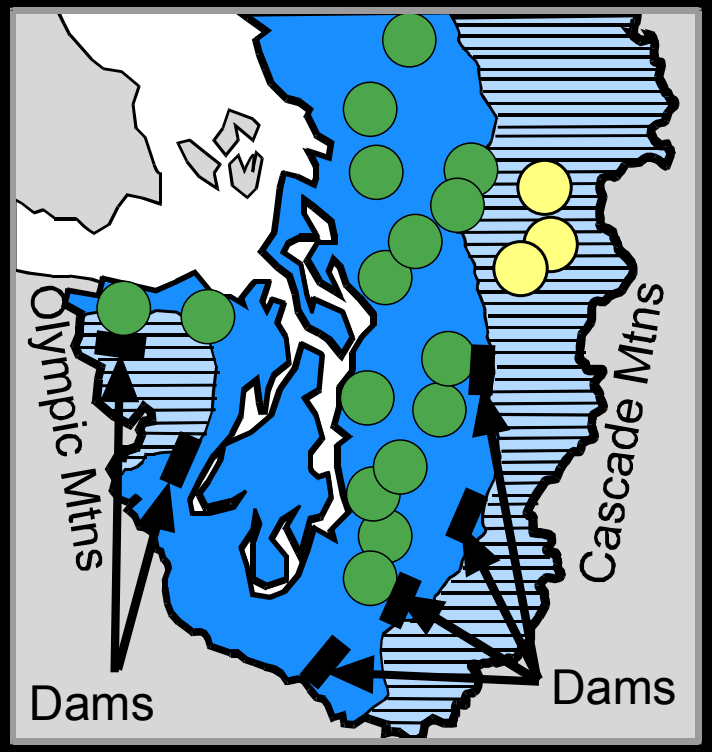
Snowmelt hydrologic regime

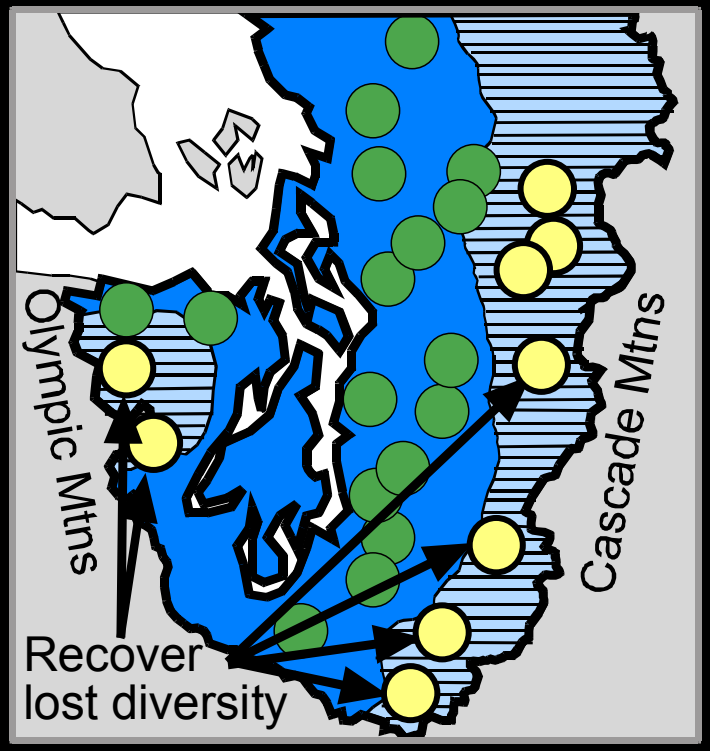
Ocean-type Chinook population

Stream-type Chinook population

Waples et al. 2008

Restore access to diverse habitats





Rainfall/transitional hydrologic regime

Ocean-type Chinook population

Snowmelt hydrologic regime

Stream-type Chinook population

Waples et al. 2008

Restore flow regimes

Summary

- Does climate change alter restoration plans?
  - Climate change effects vary across the region
  - Restoration actions vary in their ability to ameliorate climate change effects
- Restoration strategies to increase resilience
  - Restore connectivity
  - Increase habitat diversity (floodplains)
  - Restore flow regimes