A process-based approach to prioritization and climate adaptation

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Setting restoration priorities

- Analytical approaches
  - Single species models, multiple species models, cost effectiveness
- Logic approaches
  - Project effectiveness, decision support systems, refugia

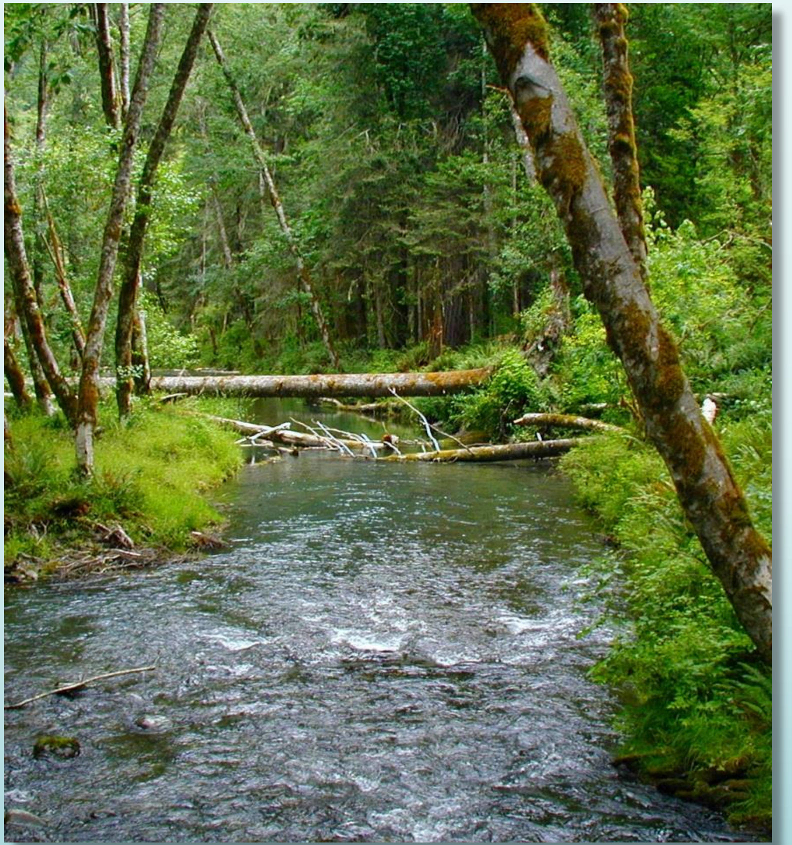
Beechie et al. (2008)

Setting restoration priorities

- What do we need to know?
  - Diagnosis of habitat ‘problems’
  - Identification of restoration needs
  - Evaluate which restoration actions are most important
  - How will climate change alter priorities?

The process-based approach

- Goal
  - Re-establish processes that sustain riverine ecosystems
- Key features
  - Not static – allows river dynamics
  - Self-sustaining – lower maintenance cost
  - Allows natural biodiversity to emerge



Process-based principles

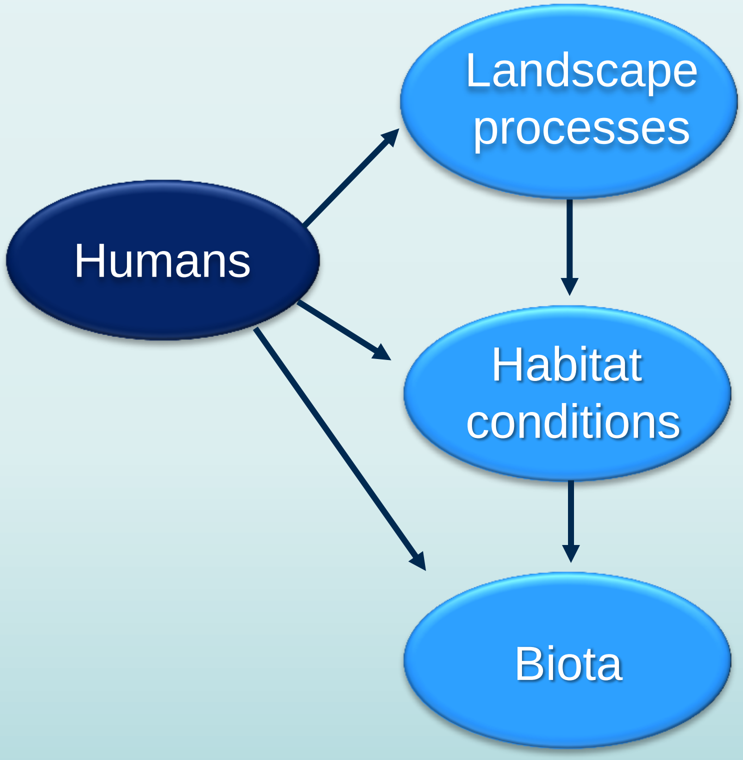
1. Treat root causes of ecosystem change

2. Target local restoration potential

3. Match the scale of restoration with the scale of physical and biological problems

4. Be explicit about expected outcomes and recovery time

Diagnosing the problems

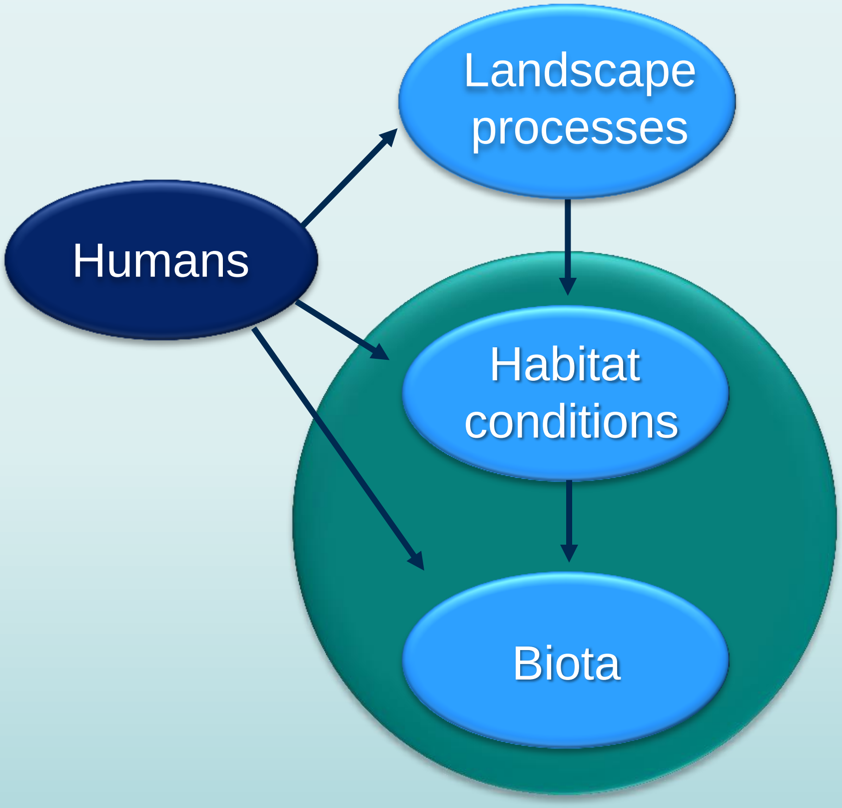


Beechie et al. (2008)

Diagnosing the problems

- What are the root causes of degradation?
  - Watershed process assessments

- How have habitats changed and altered biota?
  - Habitat assessments
  - Life cycle models



Beechie et al. (2008)

Diagnosing the problems

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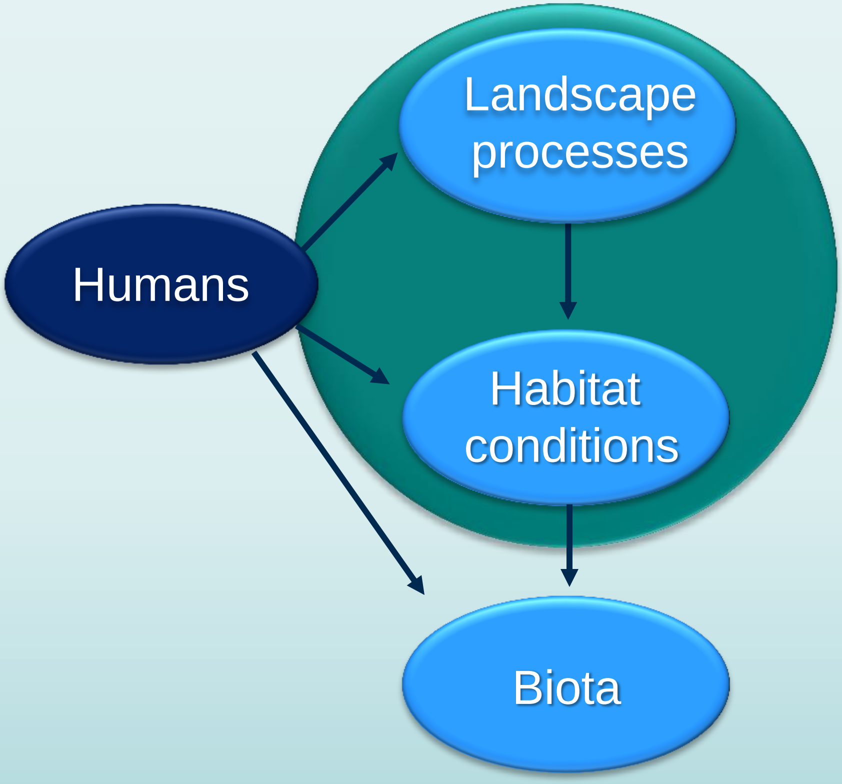
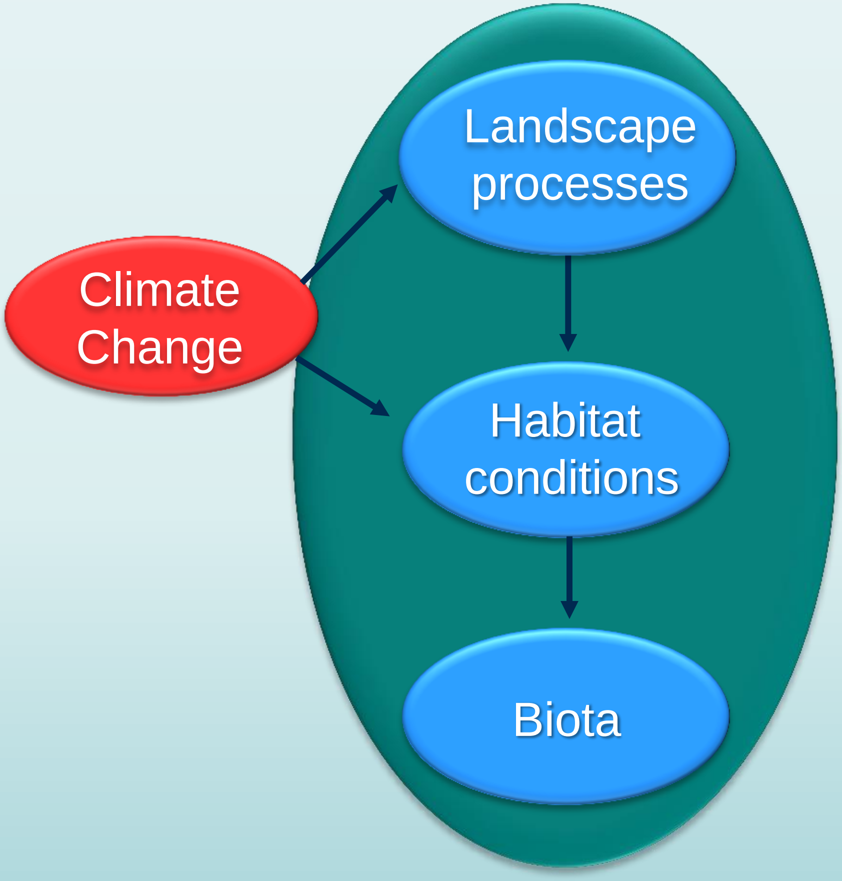


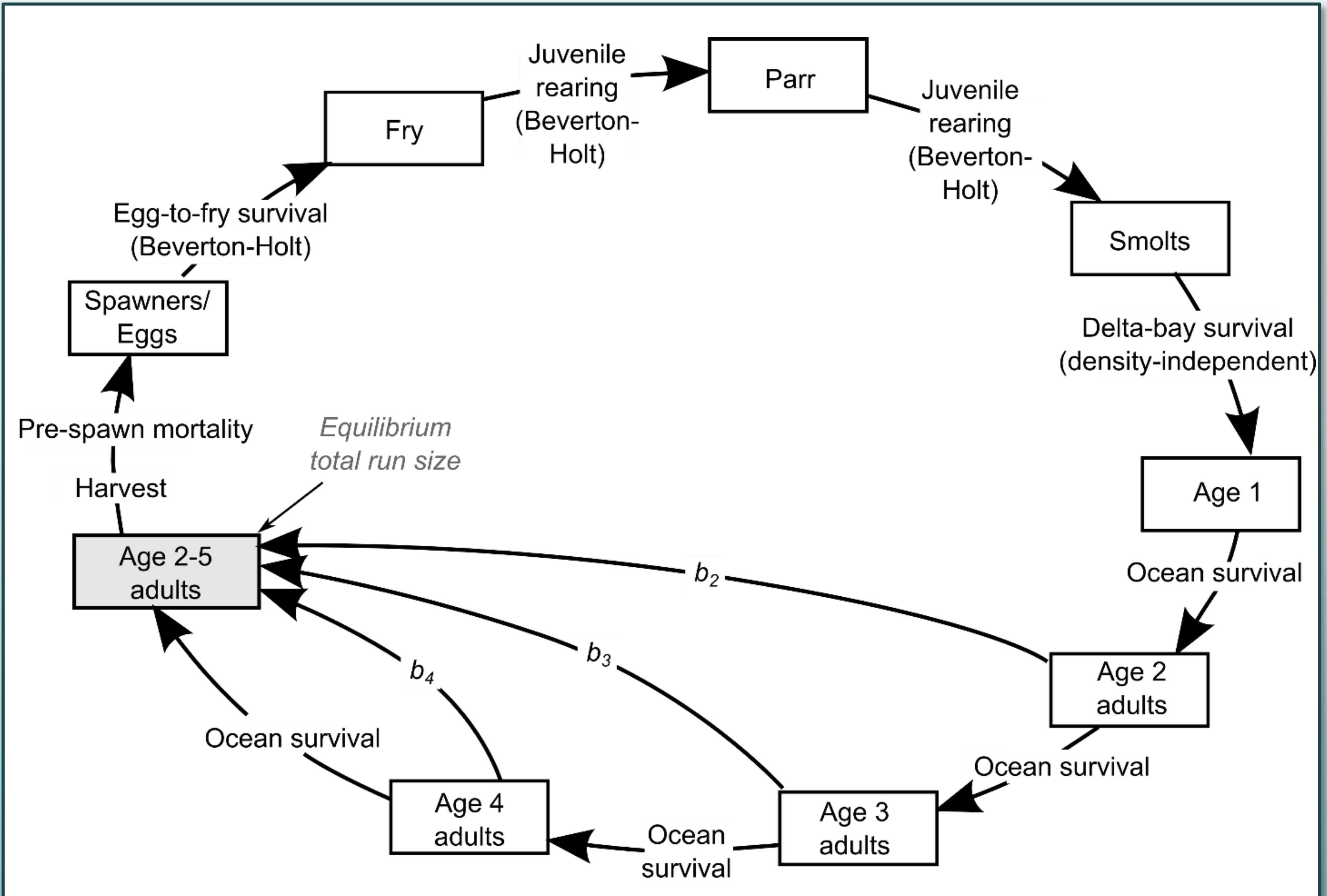
Beechie et al. (2008)

Diagnosing the problems

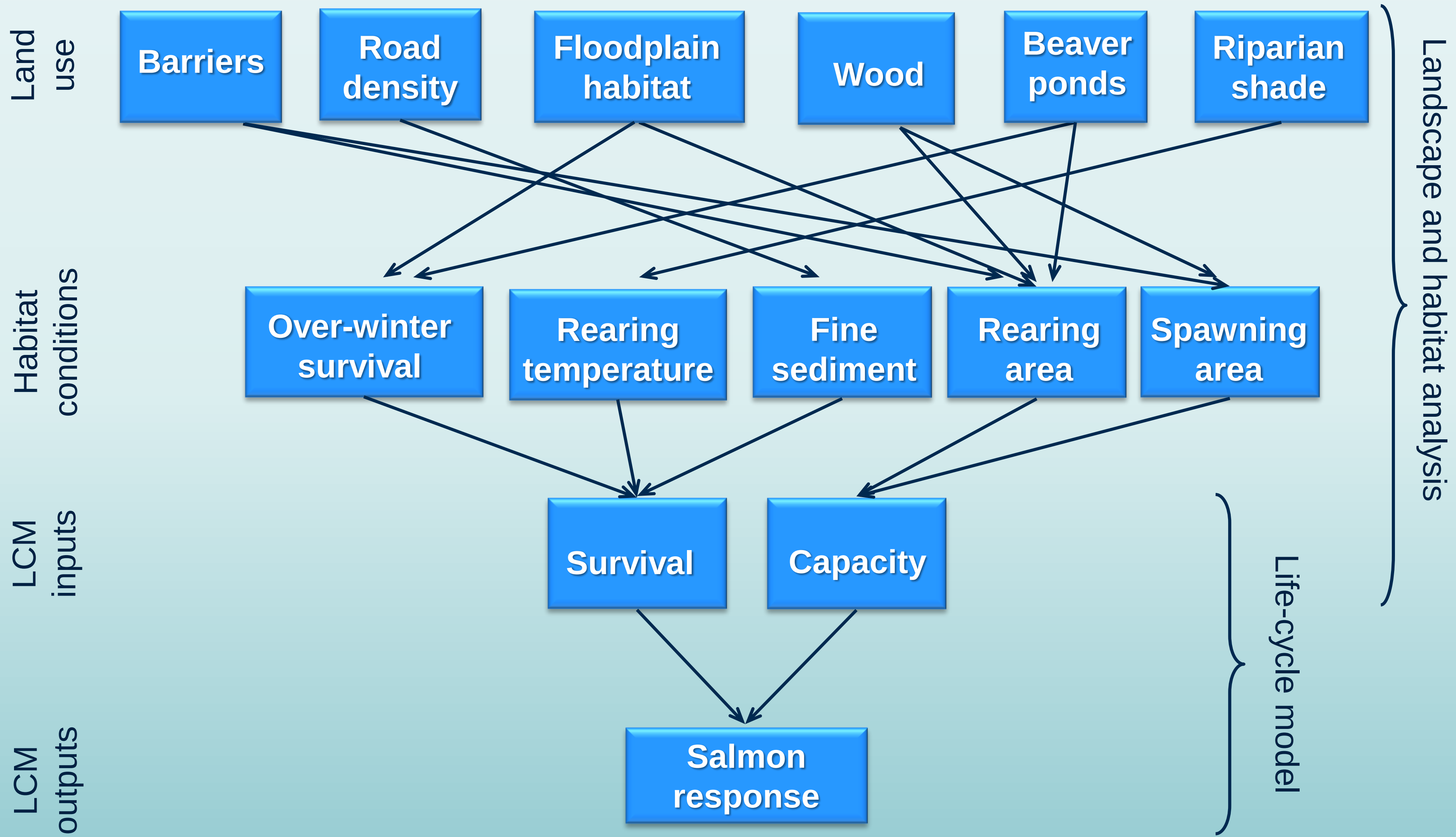
- How will climate change affect habitats and fish?
  - Climate projections
  - Habitat change assessment
  - Life cycle model



The life cycle model analysis



Watershed process analyses



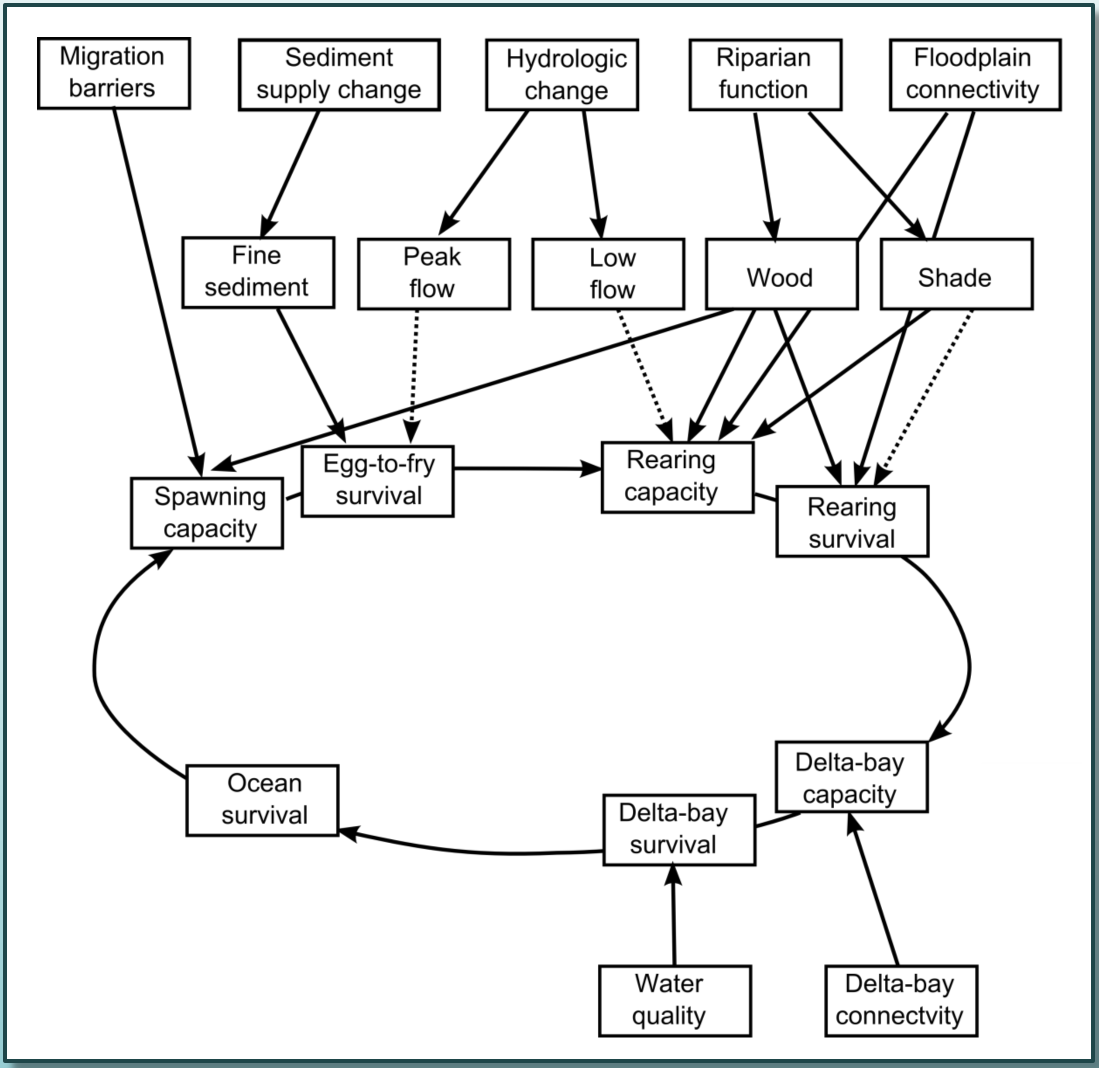
See examples in Bartz et al. 2006, Scheuerell et al. 2006

Integration of analysis components

Watershed process and habitat changes

Life cycle model

Delta habitat changes



Habitat analyses

- Four main habitat areas
  - Small stream (<20 m bankfull width)
  - Large river (>20 m bankfull width)
  - Floodplain habitats
  - Delta/bay habitats
- For each habitat area
  - Historical and current habitat quantity and quality
  - Density and survival by habitat type and life stage

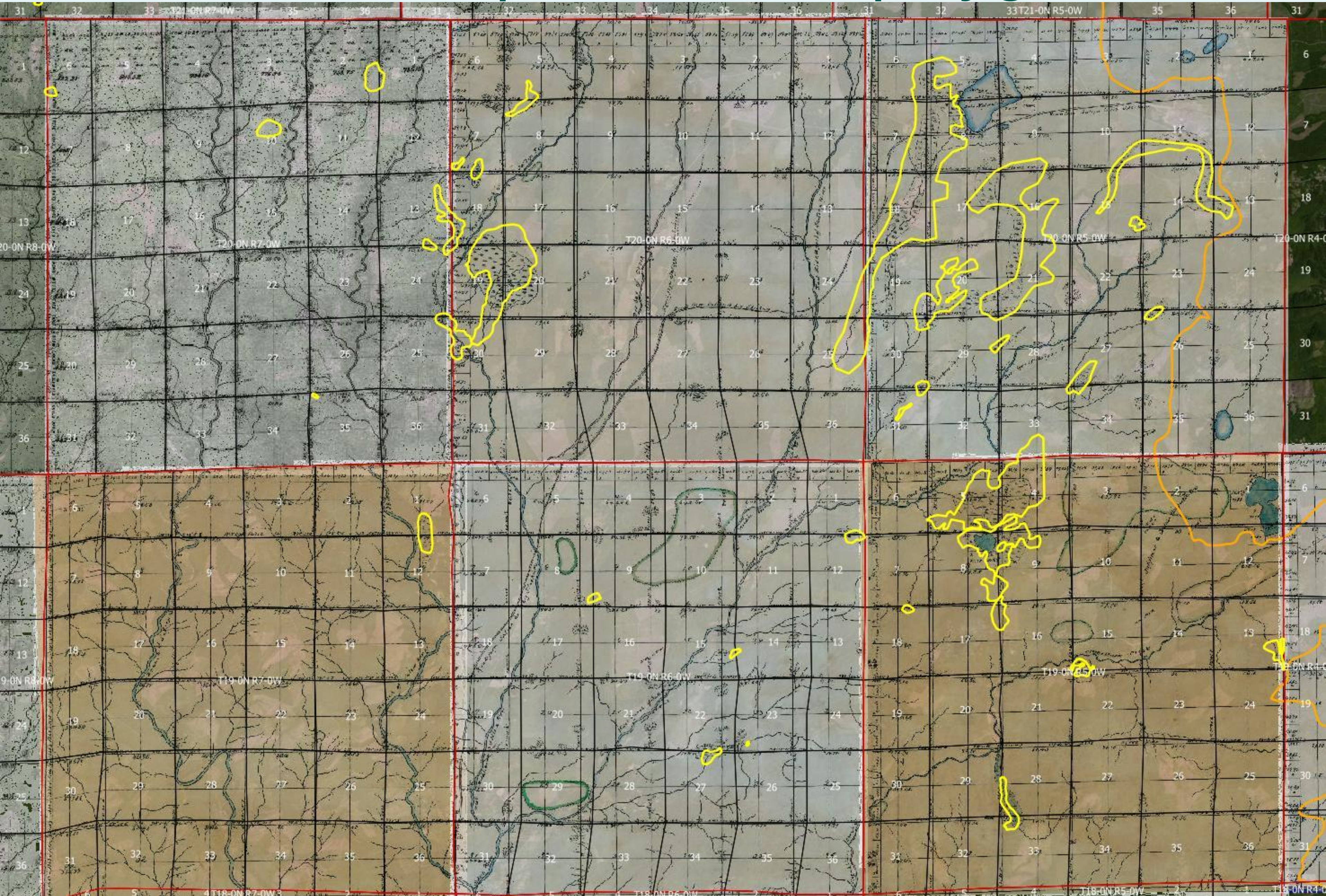
Habitat analyses

- Three main methods for analyzing historical or pre-impact conditions
  - Historical maps and data
  - Contemporary reference sites
  - Models

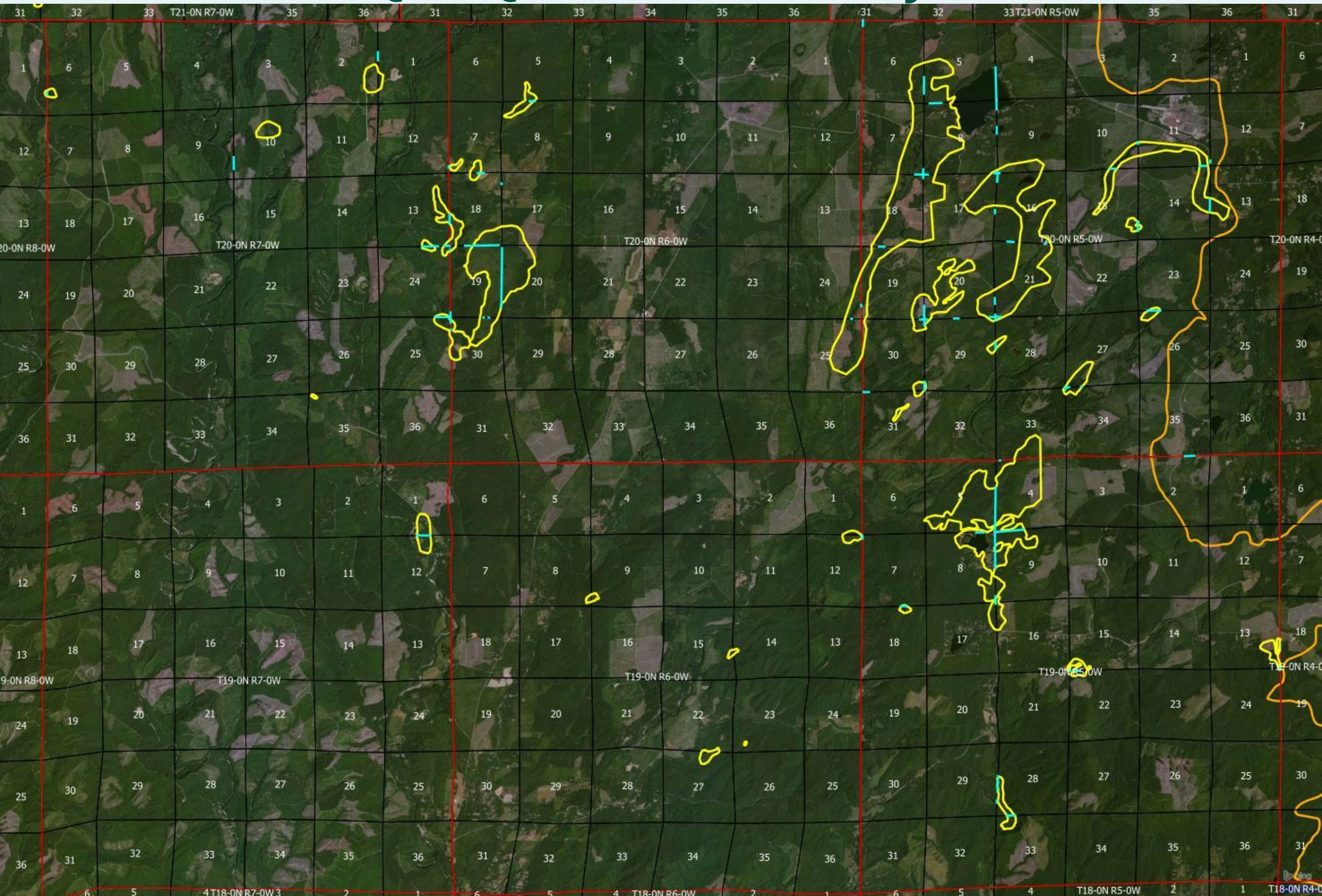
Floodplain habitat mapping

- Map historical floodplain habitats from General Land Office (GLO) surveys (1853-1901)
- Merge with current datasets (e.g., NHD, WBHYDRO)
- Summarize historical and current habitat availability

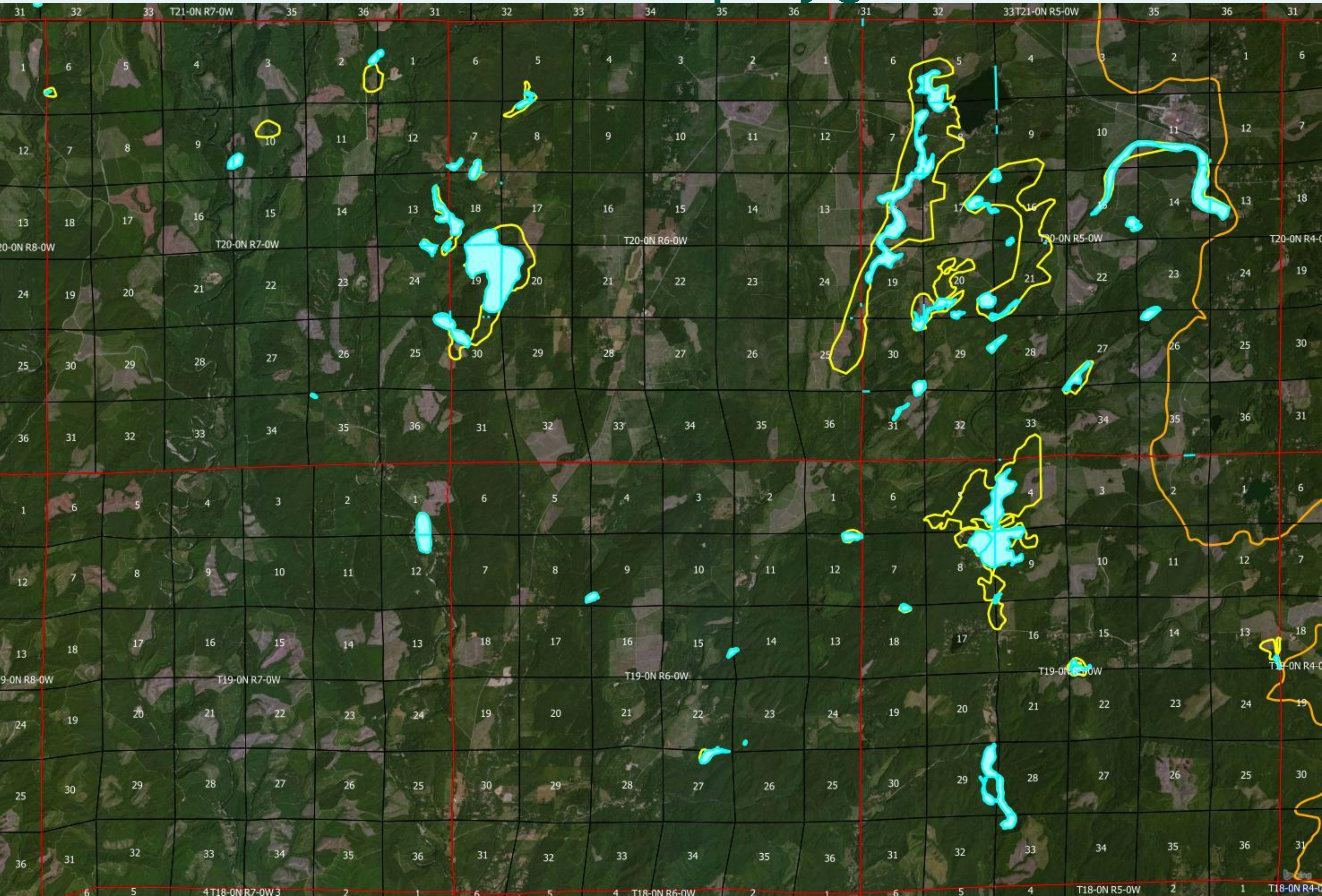
Draft floodplain habitat polygons



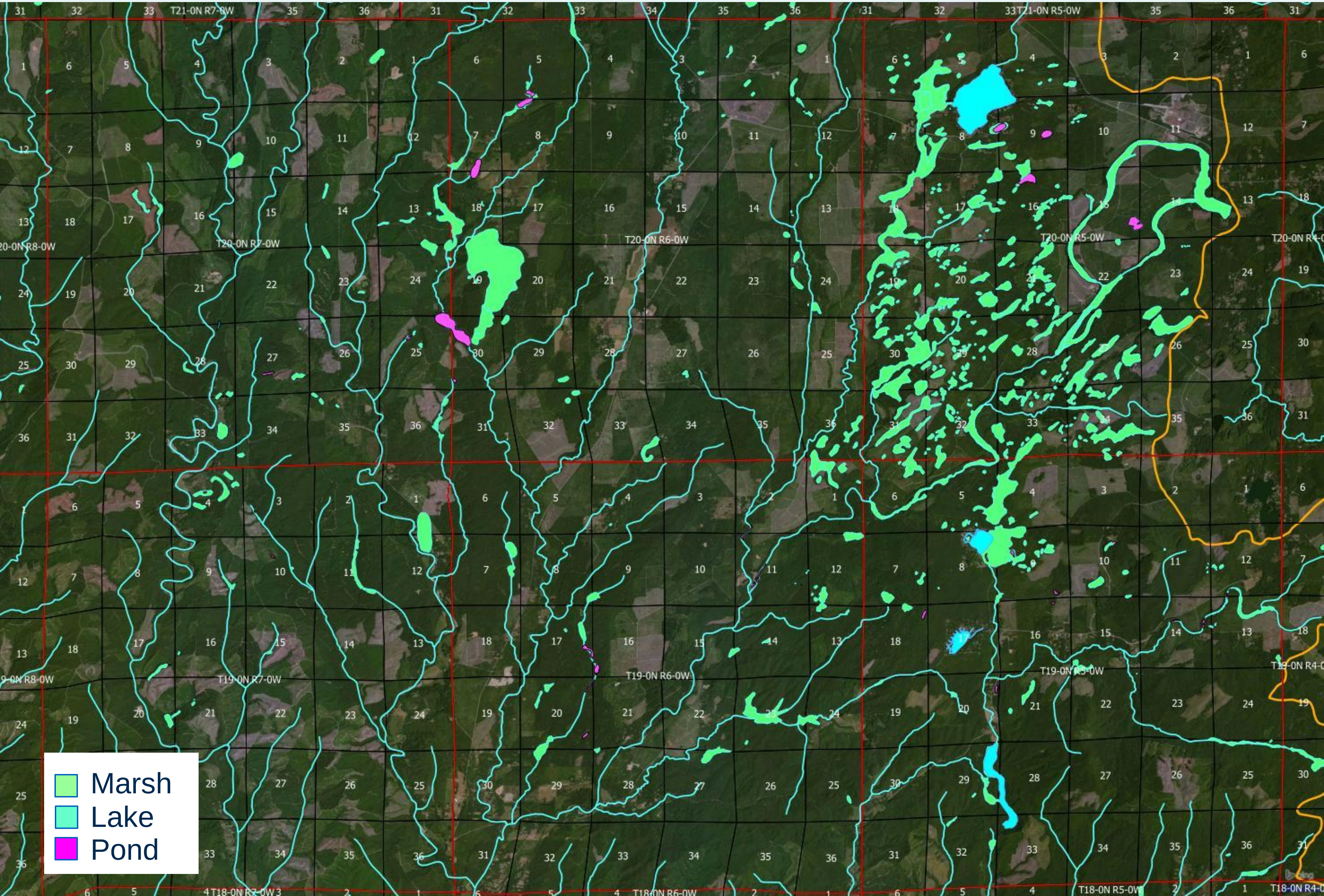
GLO QA/QC from survey notes



Edited GLO polygons



Merge GLO with NHD and other datasets

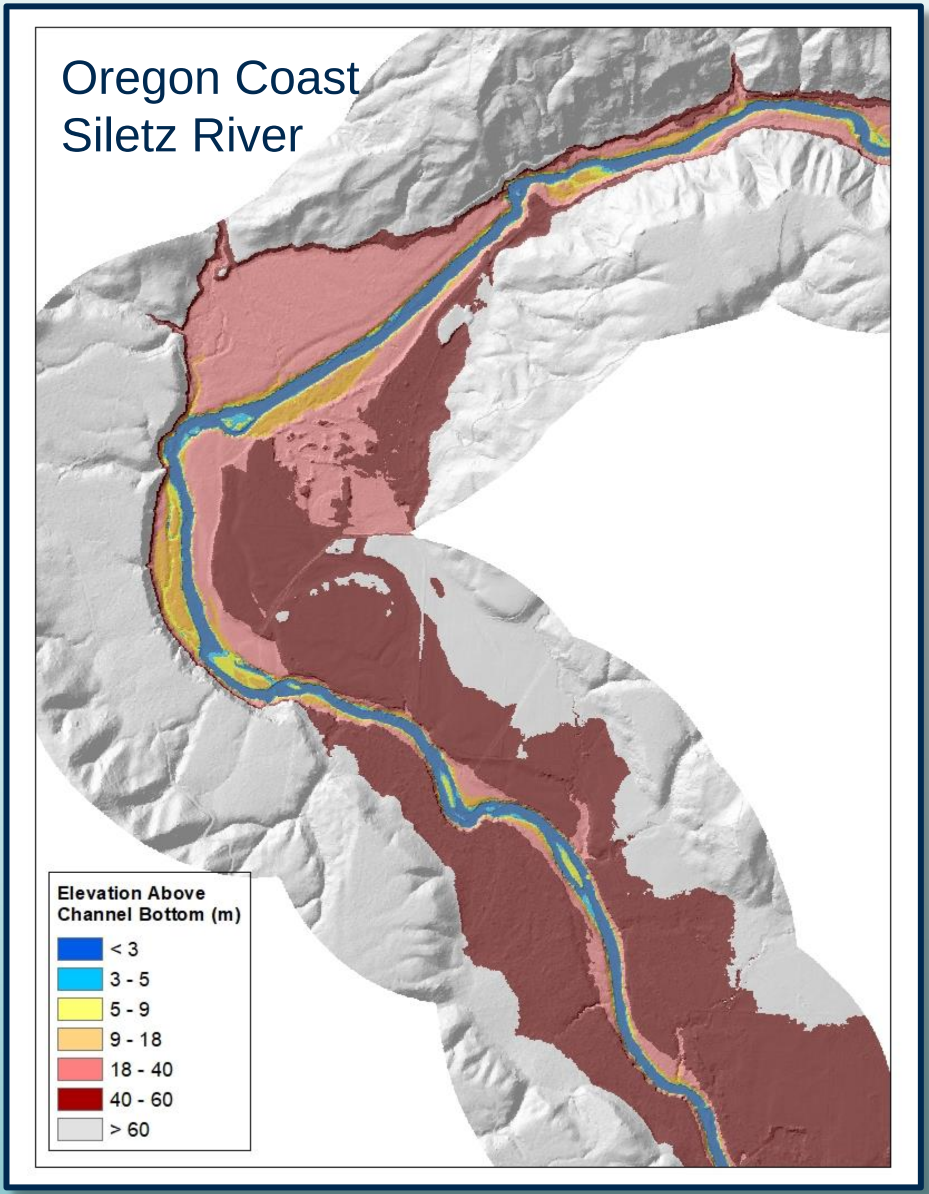


Can also use LiDAR as an aid

- Where can we restore floodplains?

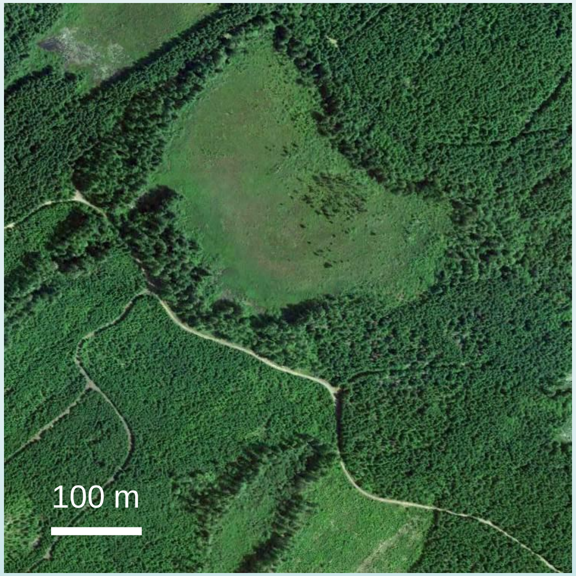
Can also use LiDAR as an aid

- Where can we restore floodplains?
  - Terraces >60 feet above the channel not restorable (pink and dark red)
  - Most re-connectable surfaces are <30 feet above the channel (blue and yellow)

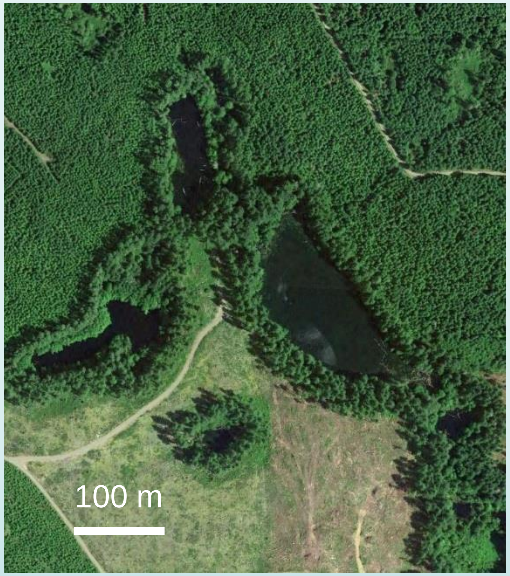


Floodplain habitat fish densities

Marsh



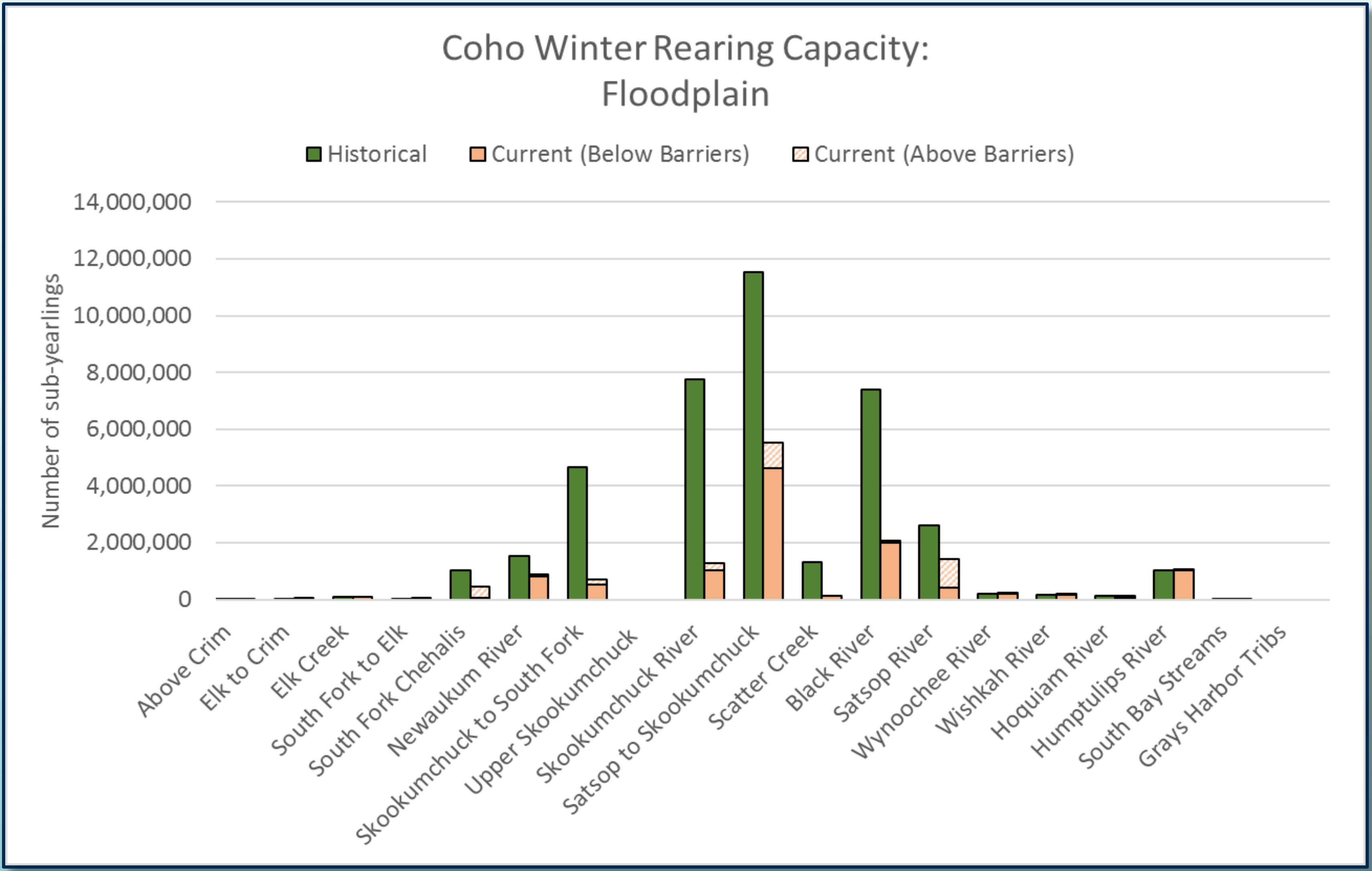
Pond



Side-channel

	Fish Density (fish/m²)				
Habitat Type	Chinook Sub-yearling	Coho (summer)	Coho (winter)	Steelhead (summer)	Steelhead (winter)
Marsh	0	0	0.32	0	0
Pond	0	1.50	3.75	0.10	0
Side Channel	0.04	1.28	1.28	0	0
Slough	0.12	1.28	2.50	0	0

Floodplain habitat capacity change

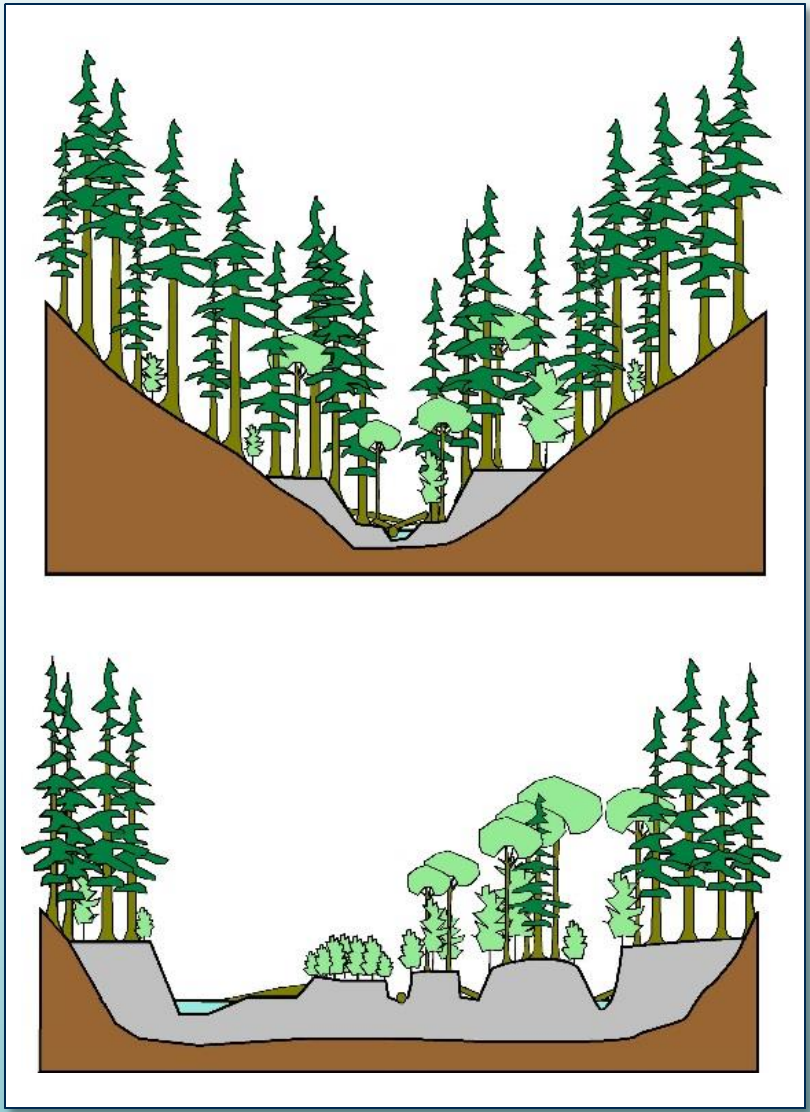


Watershed process analyses

- Watershed process analyses include:
  - Riparian functions
  - Sediment supply
  - Hydrologic change
  - Connectivity
- For each process
  - Historical and current condition or rate
  - Influence on habitat capacity or survival

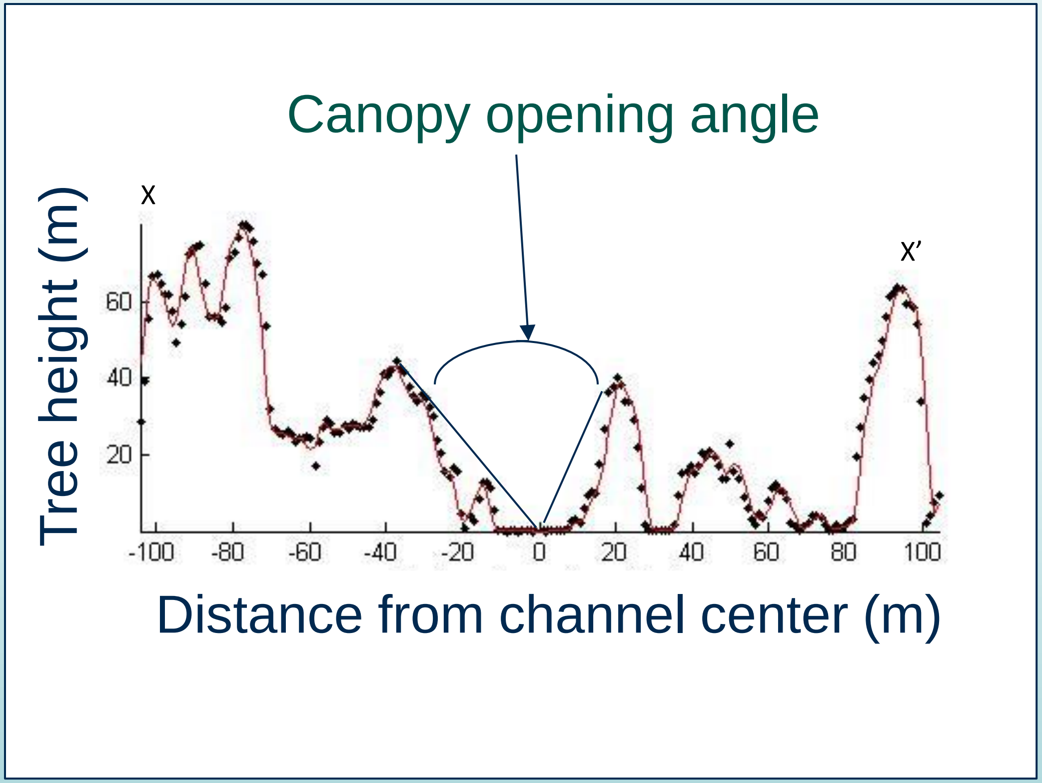
Riparian analysis

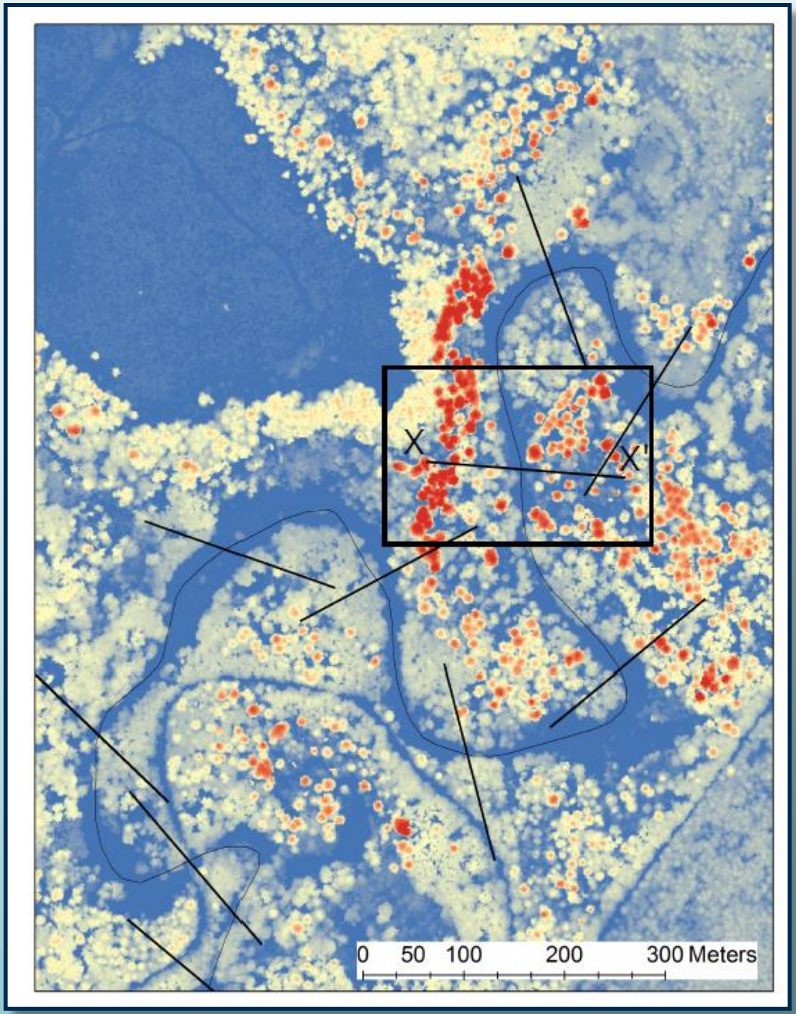
- Assess historical and current riparian functions:
  - Shade
  - Wood recruitment
- Reference condition based on contemporary reference sites



Riparian analysis

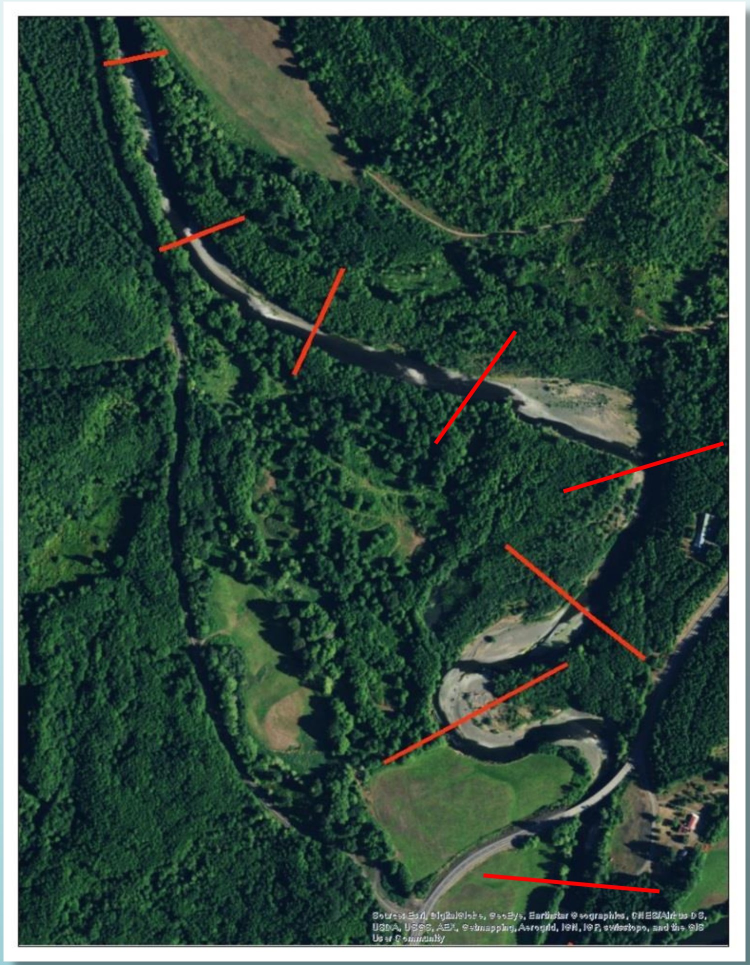
Lidar data to calculate shade

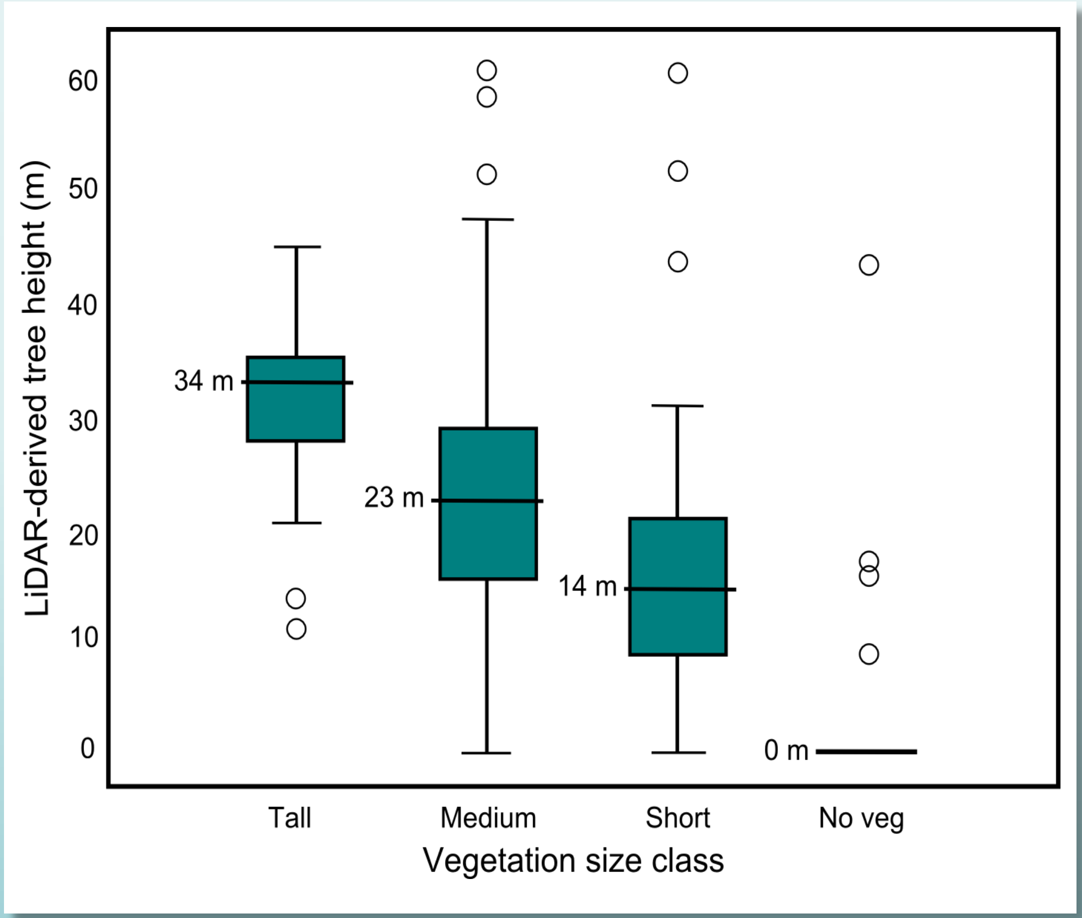




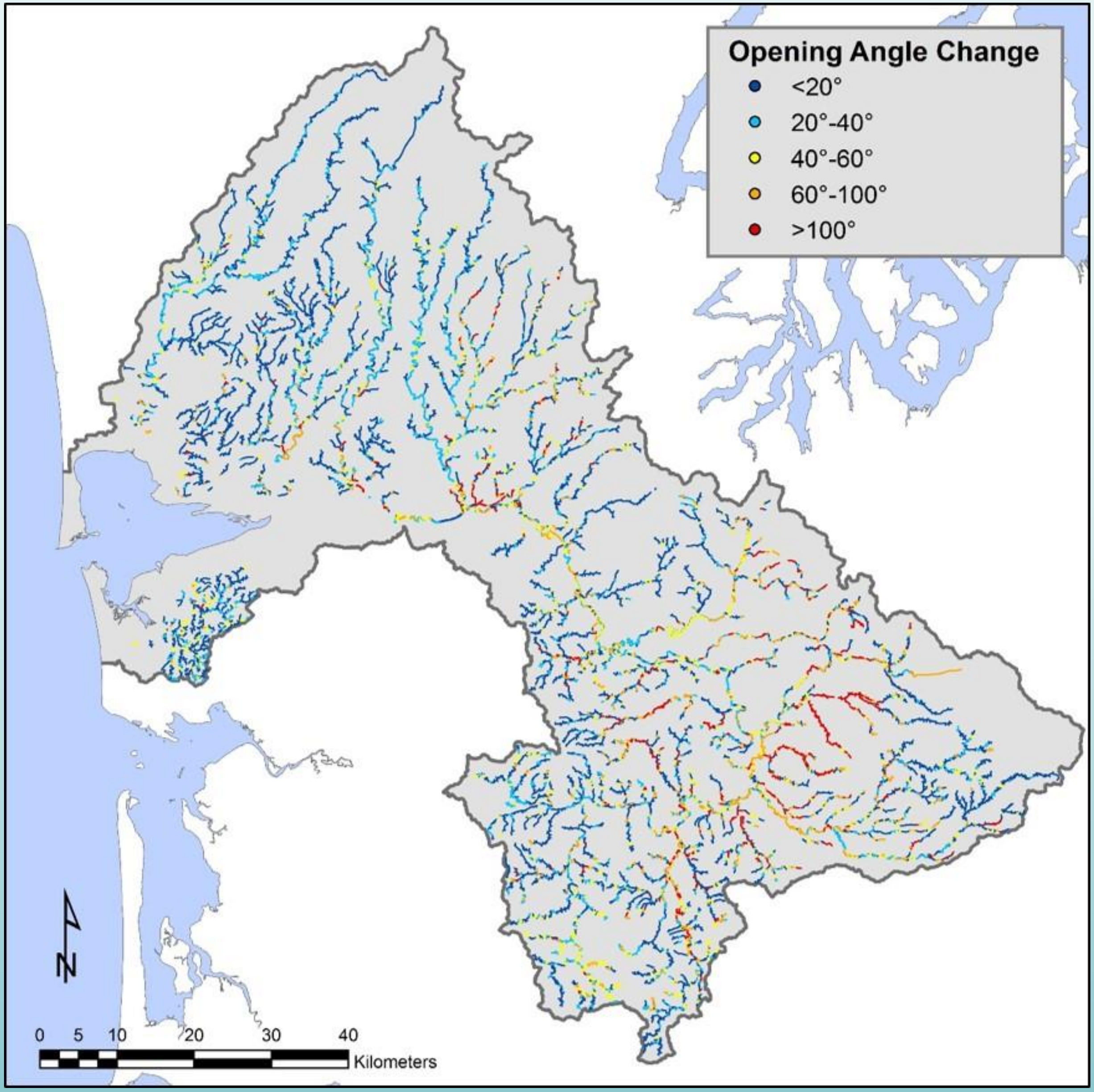
Riparian analysis

Aerial photograph data

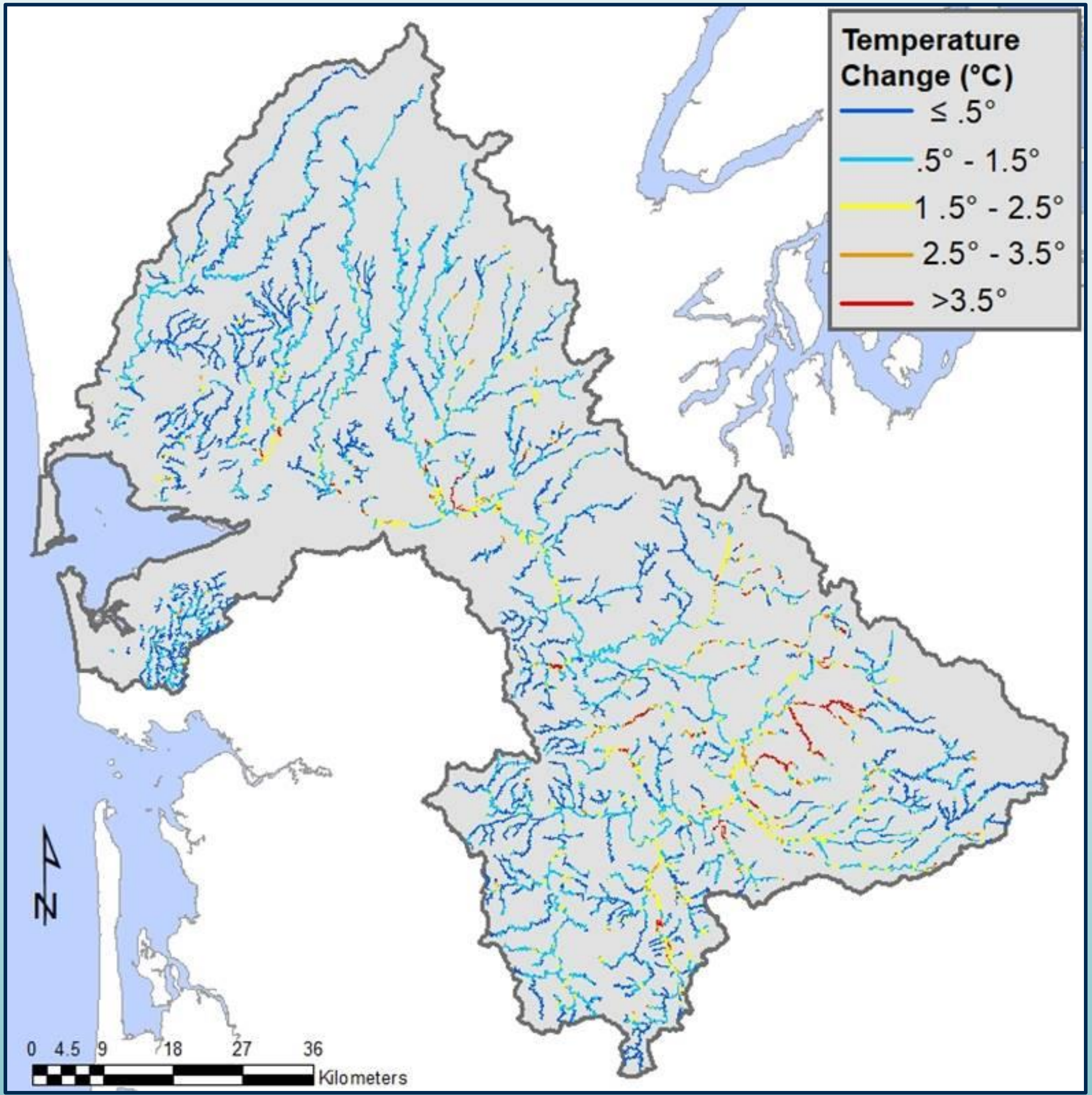




Shade change – historical to current

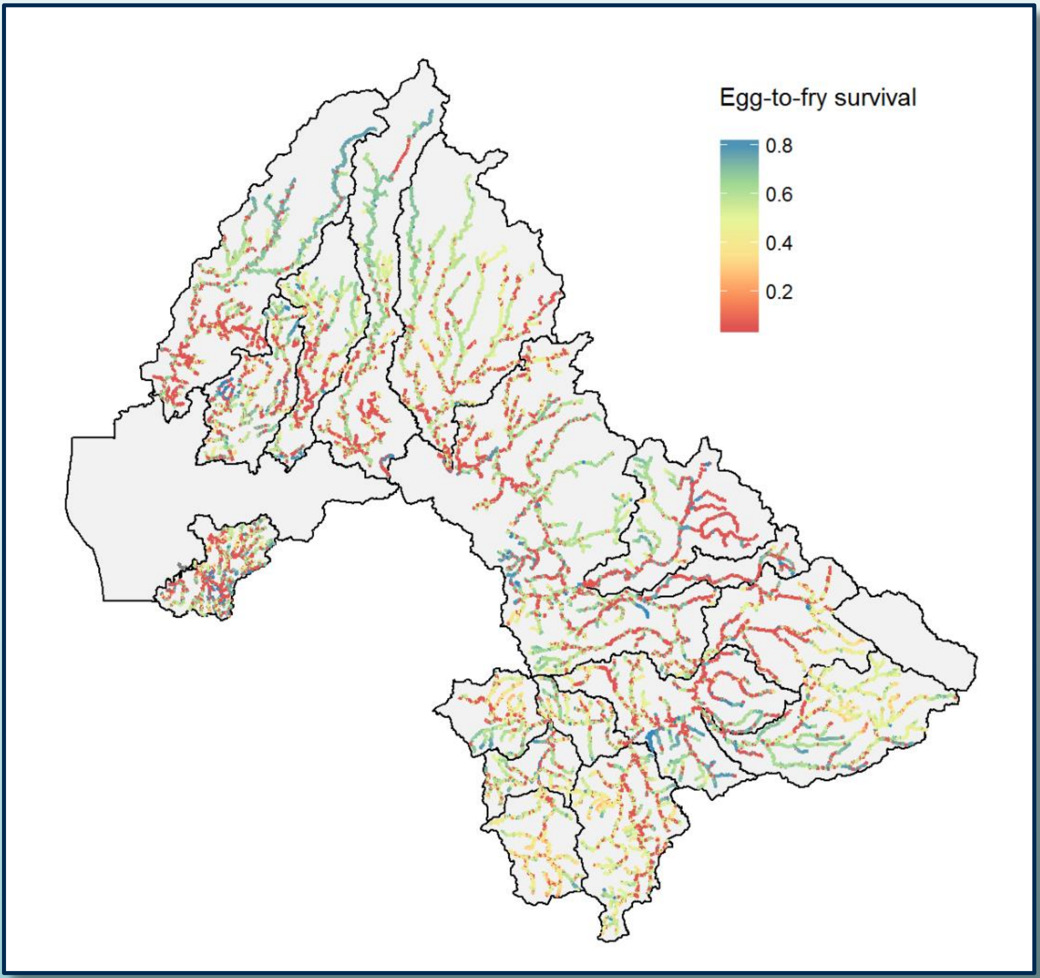


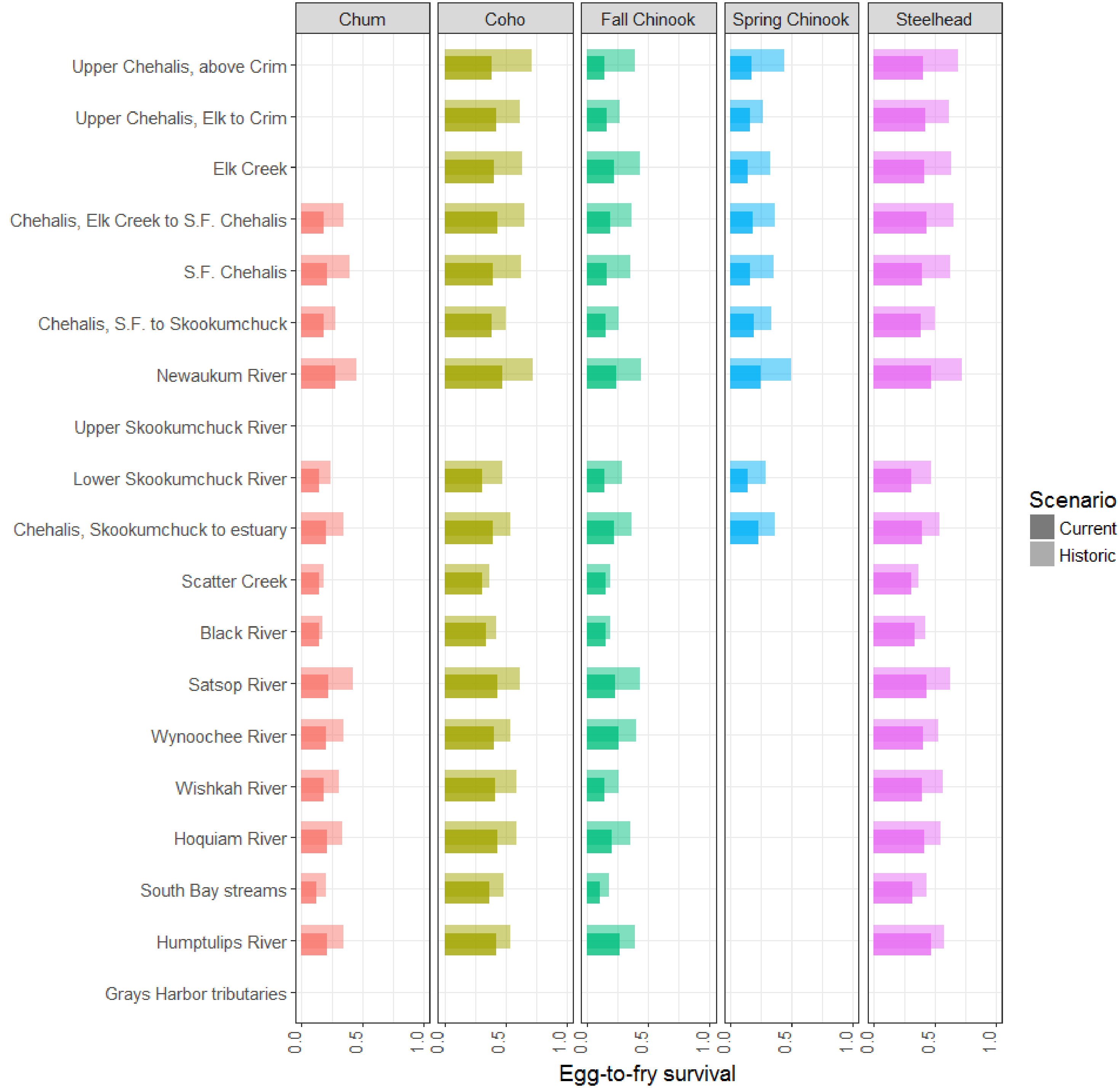
Temperature change – historical to current



Habitat quality – fine sediment

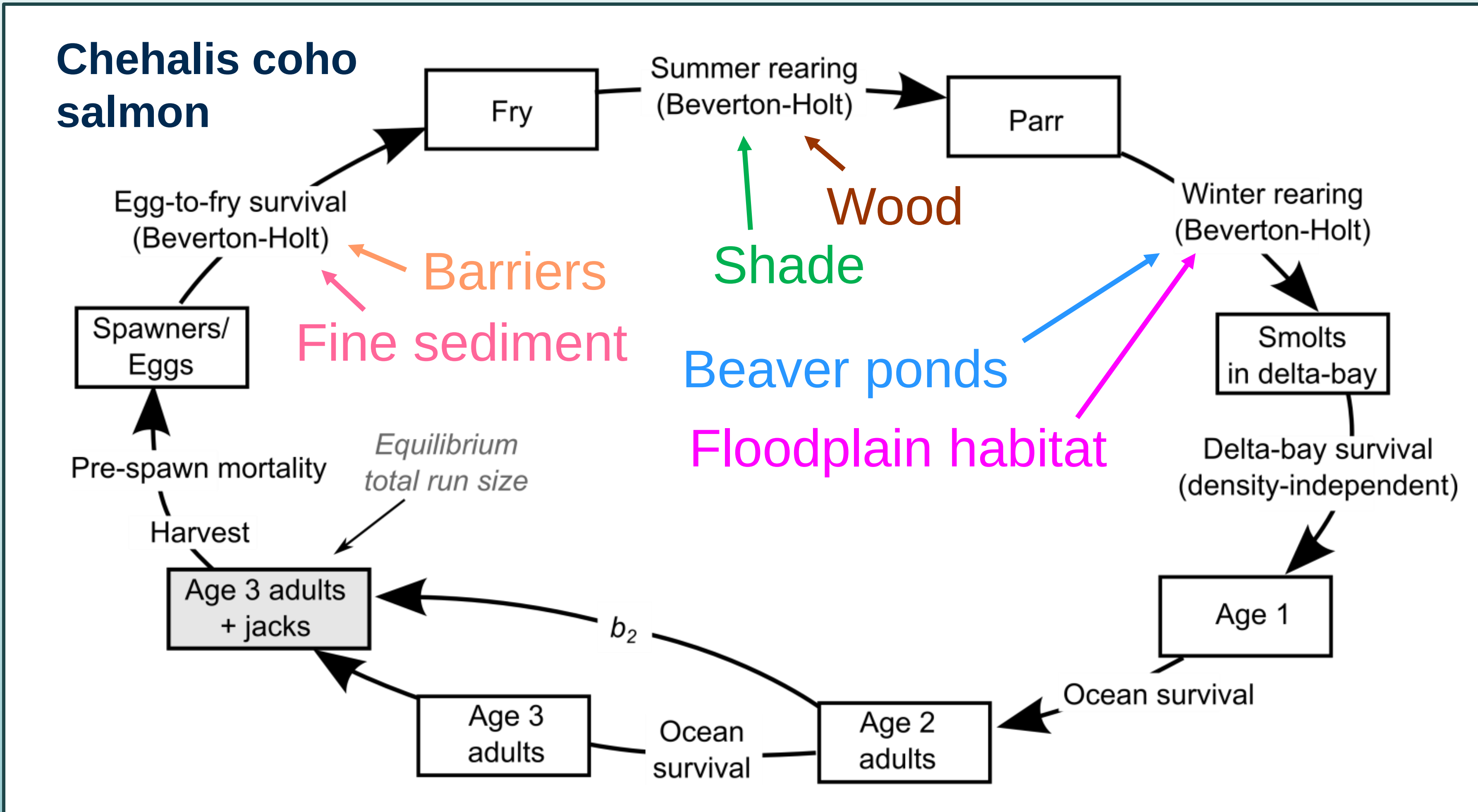
- Modeled egg-to-fry survival as a function of fine sediment levels
- Also model changes to:
  - Summer survival
  - Winter survival



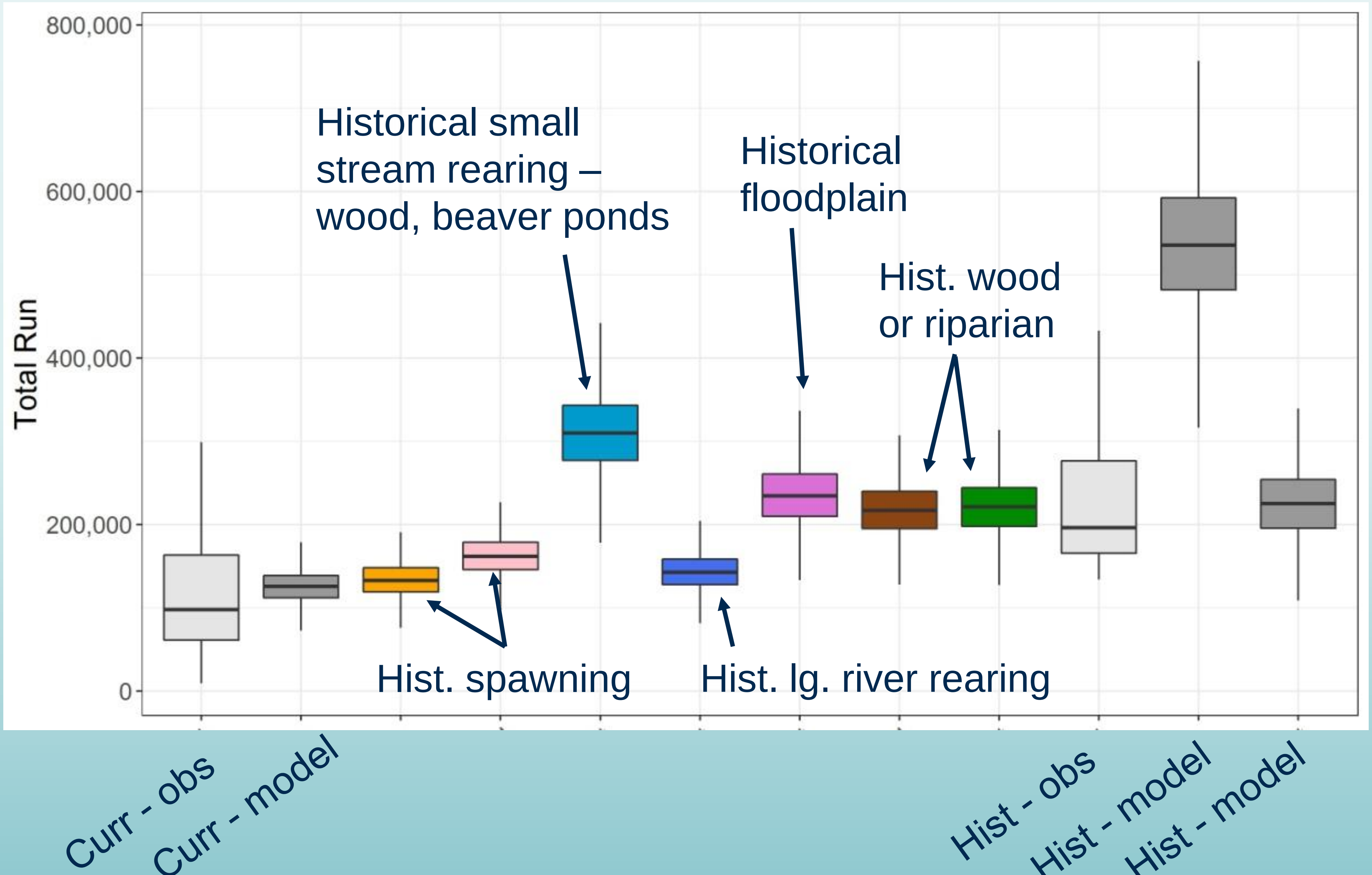


Chum
Coho
Fall Chinook
Spring Chinook
Steelhead
Upper Chehalis, above Crim
Upper Chehalis, Elk to Crim
Elk Creek
Chehalis, Elk Creek to S.F. Chehalis
S.F. Chehalis
Chehalis, S.F. to Skookumchuck
Newaukum River
Upper Skookumchuck River
Lower Skookumchuck River
Chehalis, Skookumchuck to estuary
Scatter Creek
Black River
Satsop River
Wynoochee River
Wishkah River
Hoquiam River
South Bay streams
Humptulips River
Grays Harbor tributaries
0.0
0.5
1.0
Egg-to-fry survival
Scenario
Current
Historic

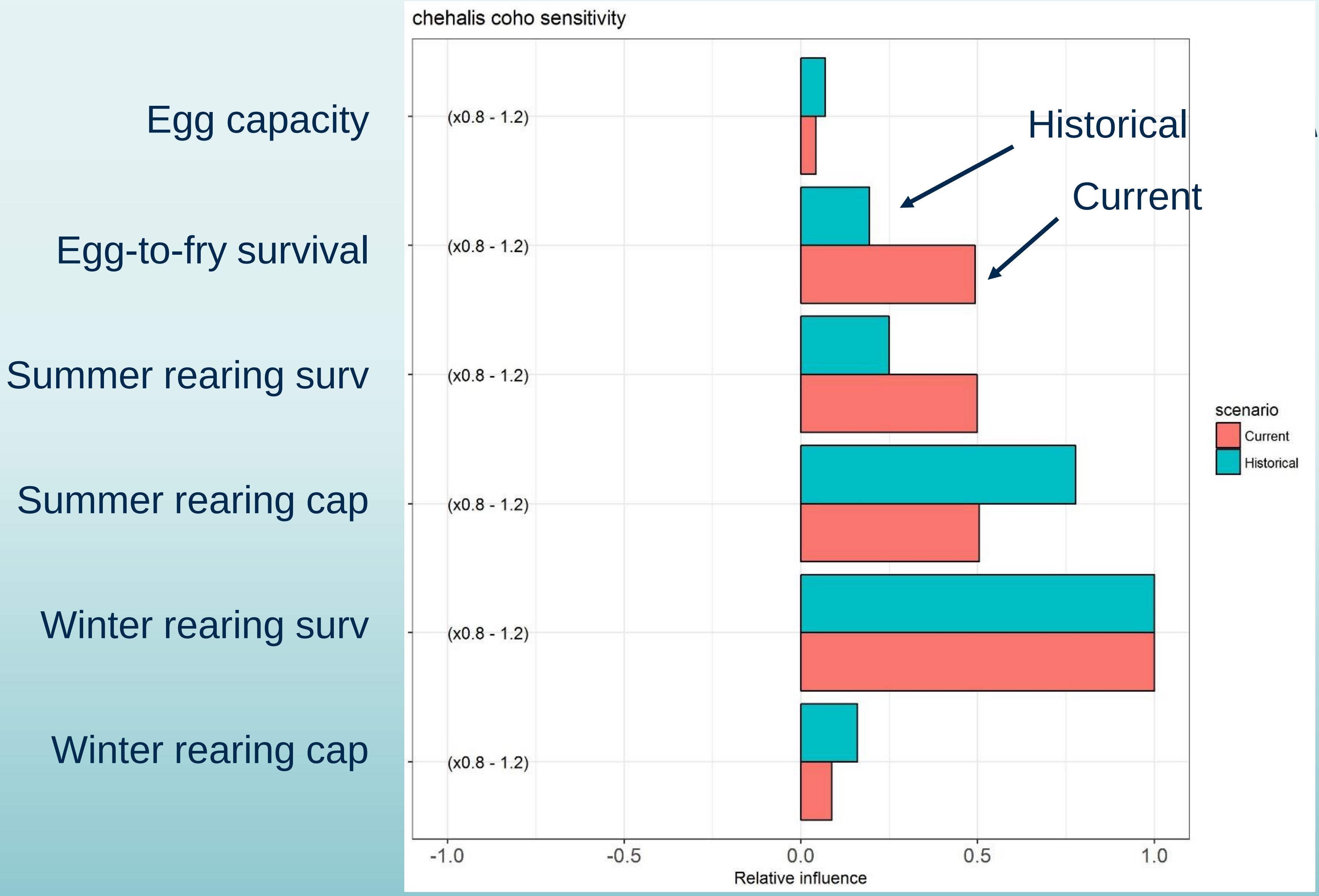
Life cycle model to diagnose problems



Coho model results



Coho model sensitivities

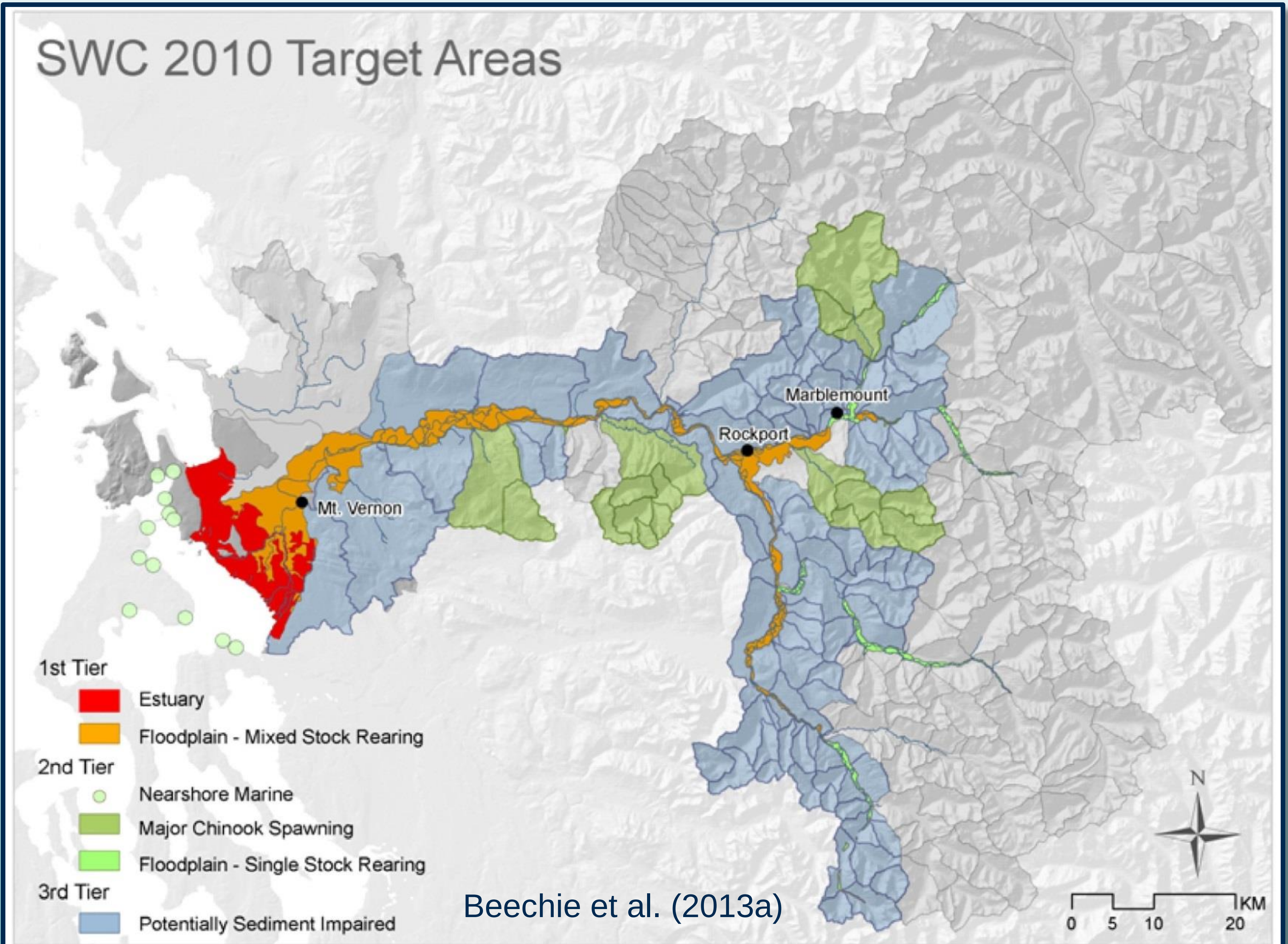


How do we use the results?

- Summarize results of the habitat change analysis
- Summarize results of the life-cycle model
- Summarize results of the process assessments

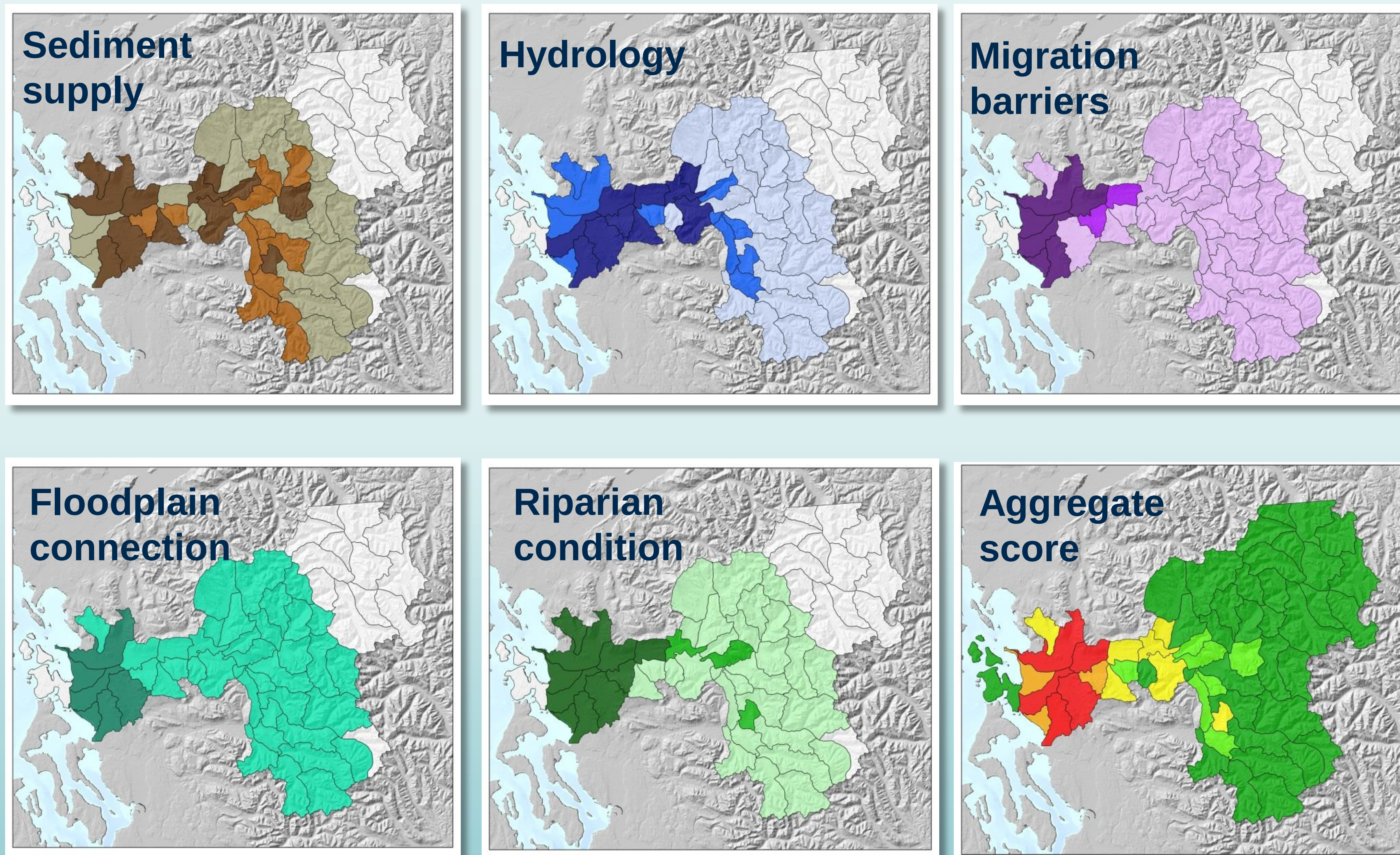
- All results inform development of the restoration strategy and priorities

Developing a restoration strategy



Beechie et al. (2013a)

Developing a restoration strategy



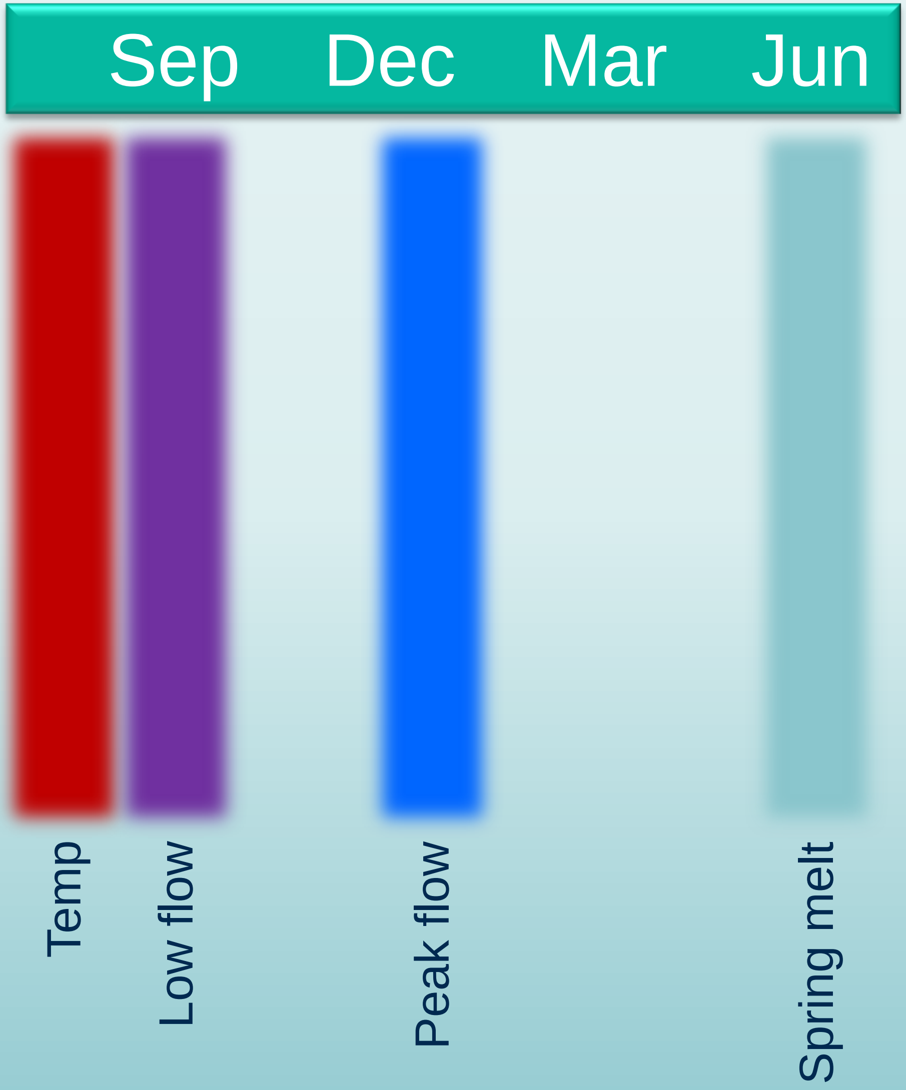
Beechie et al. (2013a)

Adapting restoration plans for climate change

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

Beechie et al. (2013b)

Climate change and the salmon life cycle



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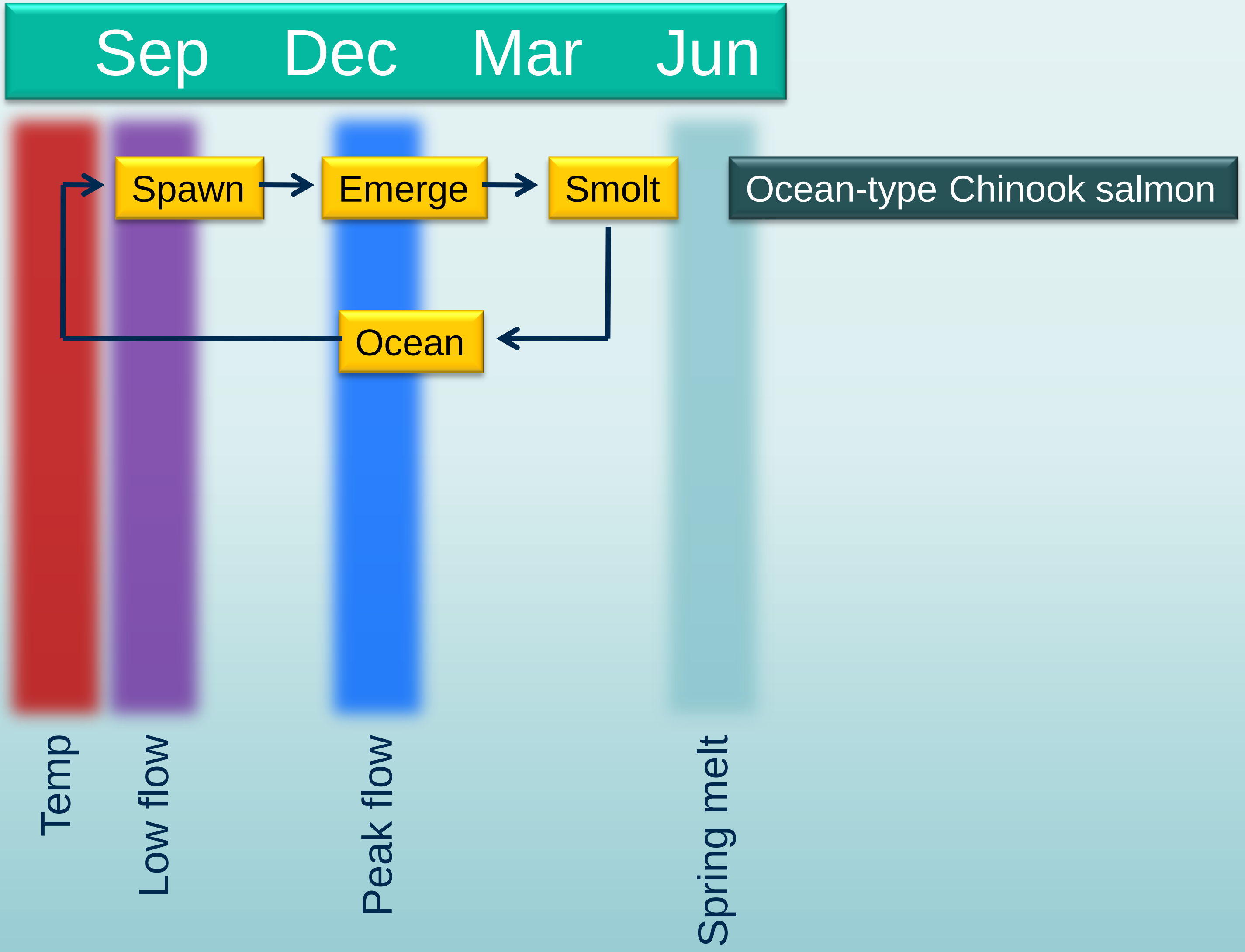

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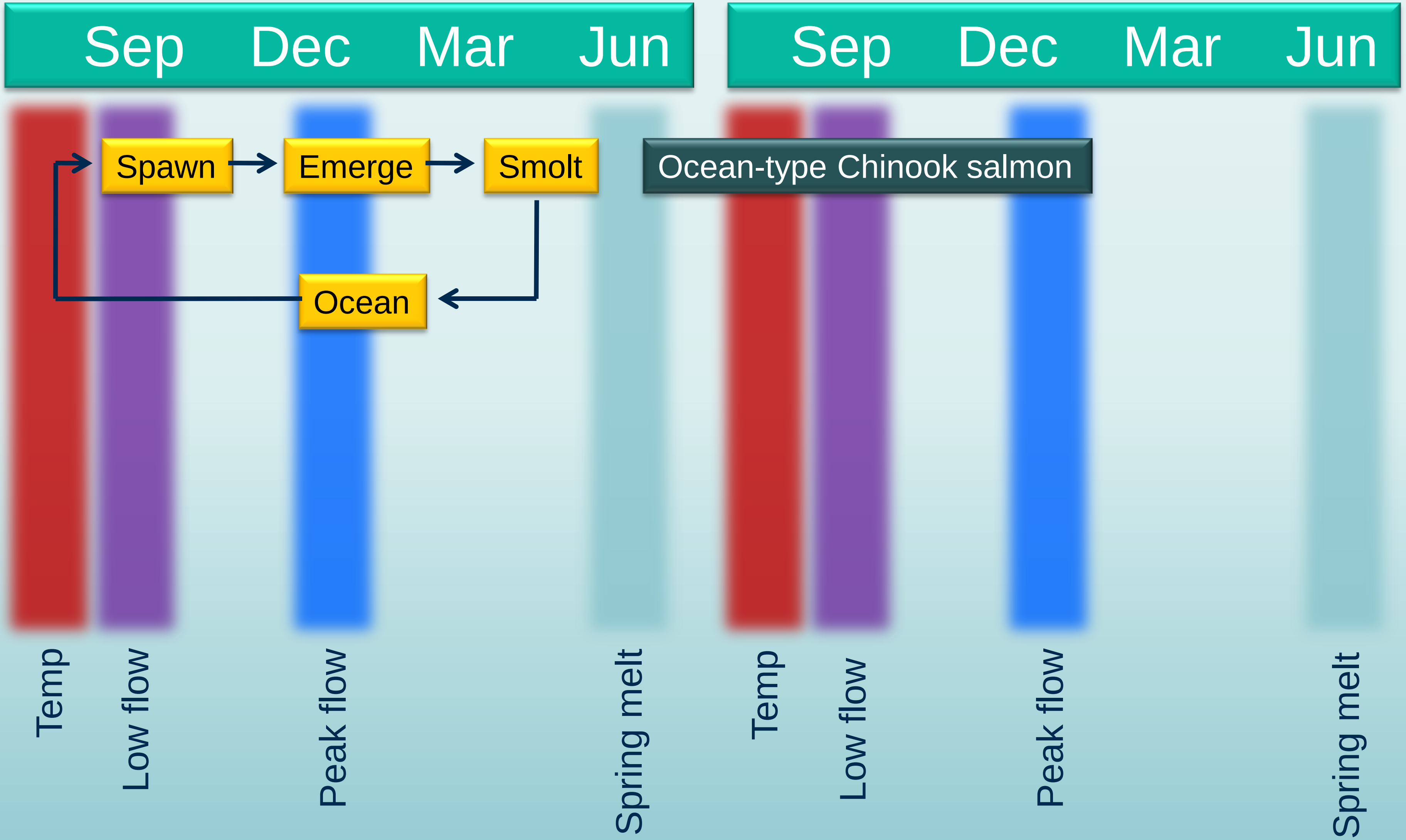

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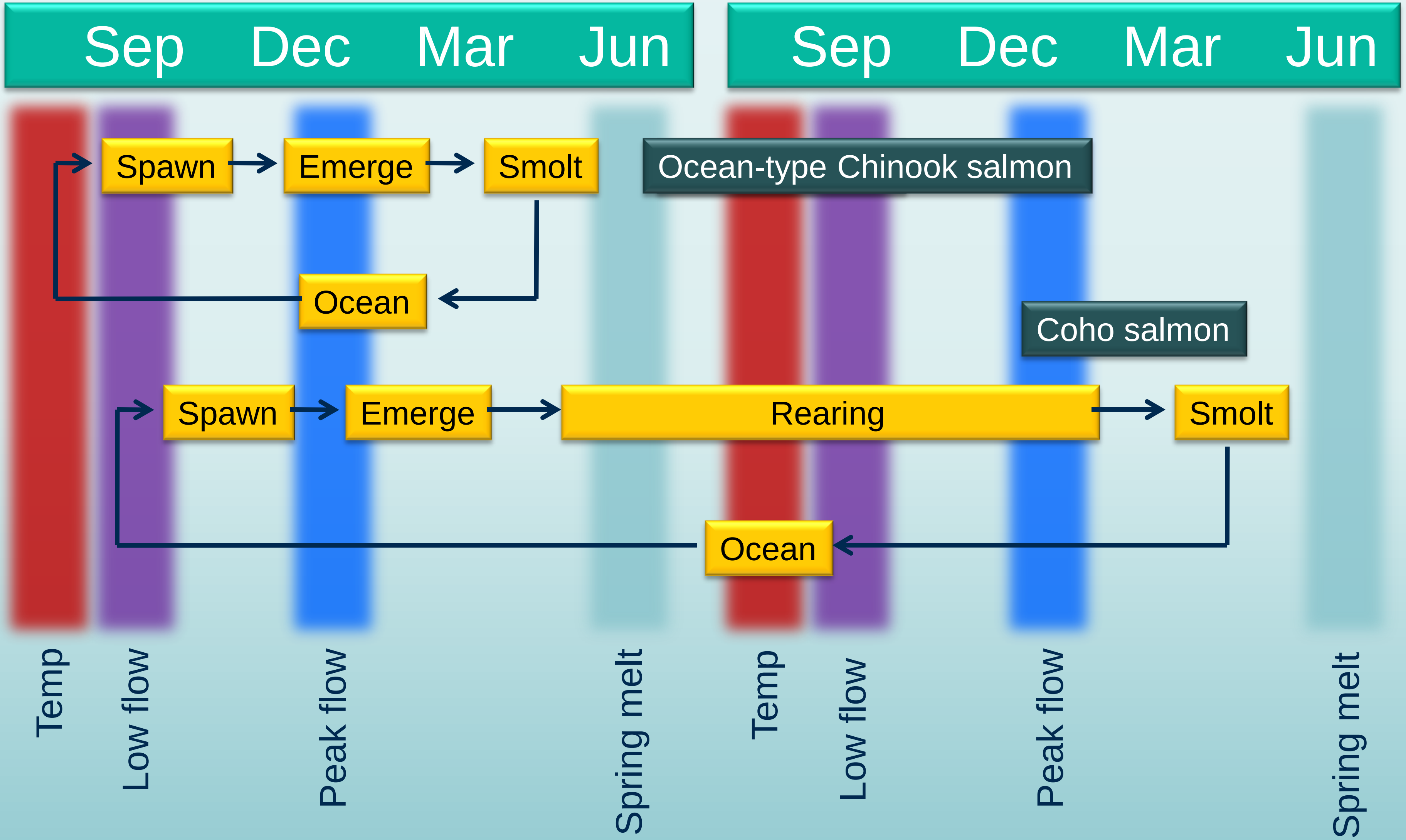


Restoration actions and climate change

Restoration action	Temperature increase	Low flow decrease	Peak flow increase	Increase resilience
Longitudinal connectivity	Y	Y	N	Y
Floodplain connectivity	Y	N	Y	Y
Restore incised channel	Y	Y	Y	Y
Restore in-stream flow	Y	Y	N	N/Y
Riparian rehabilitation	Y	N/Y	N	N
Sediment reduction	N	N	N	N
In-stream habitat	N	N	N	N
Nutrient enrichment	N	N	N	N

Beechie et al. (2013b)

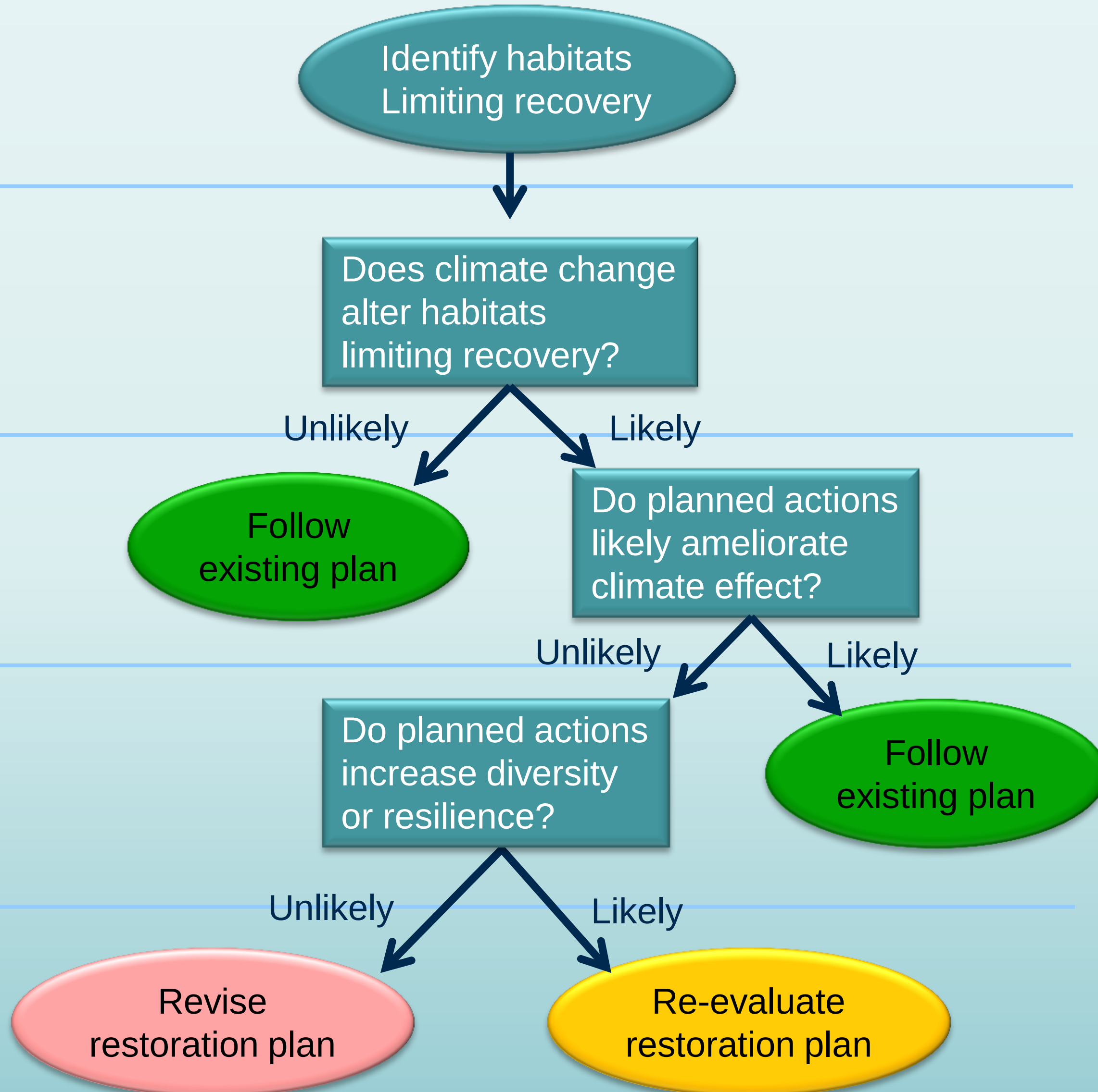
Evaluating a restoration plan

Question 1: What habitats limit salmon recovery?

Question 2: What are local predicted climate effects?

Question 3: Does the plan reduce the effect?

Question 4: Does the plan increase resilience?



Identify actions that address long-term limiting habitats

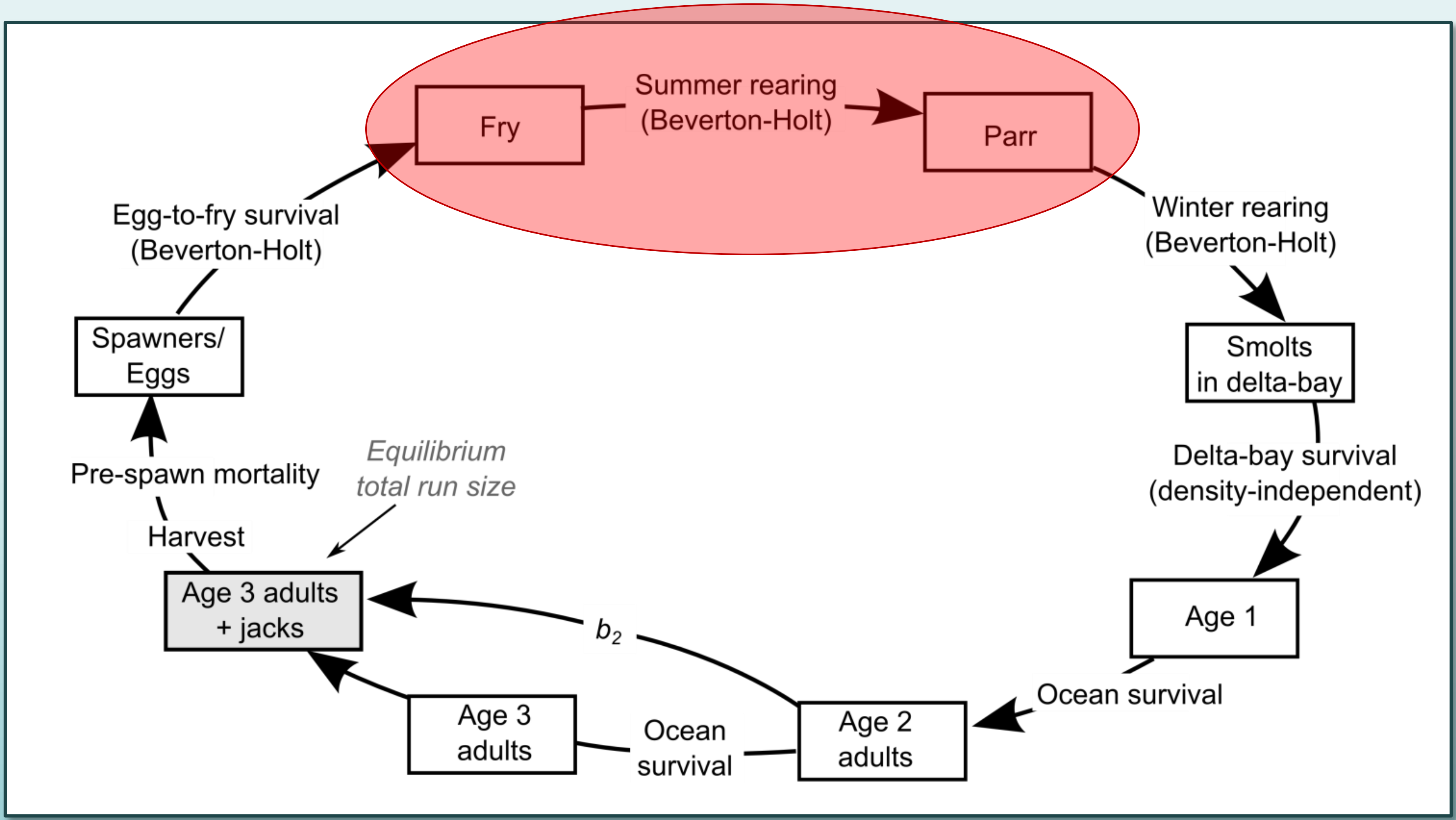
Are there alternative actions that ameliorate climate effect?

Beechie et al. (2013)

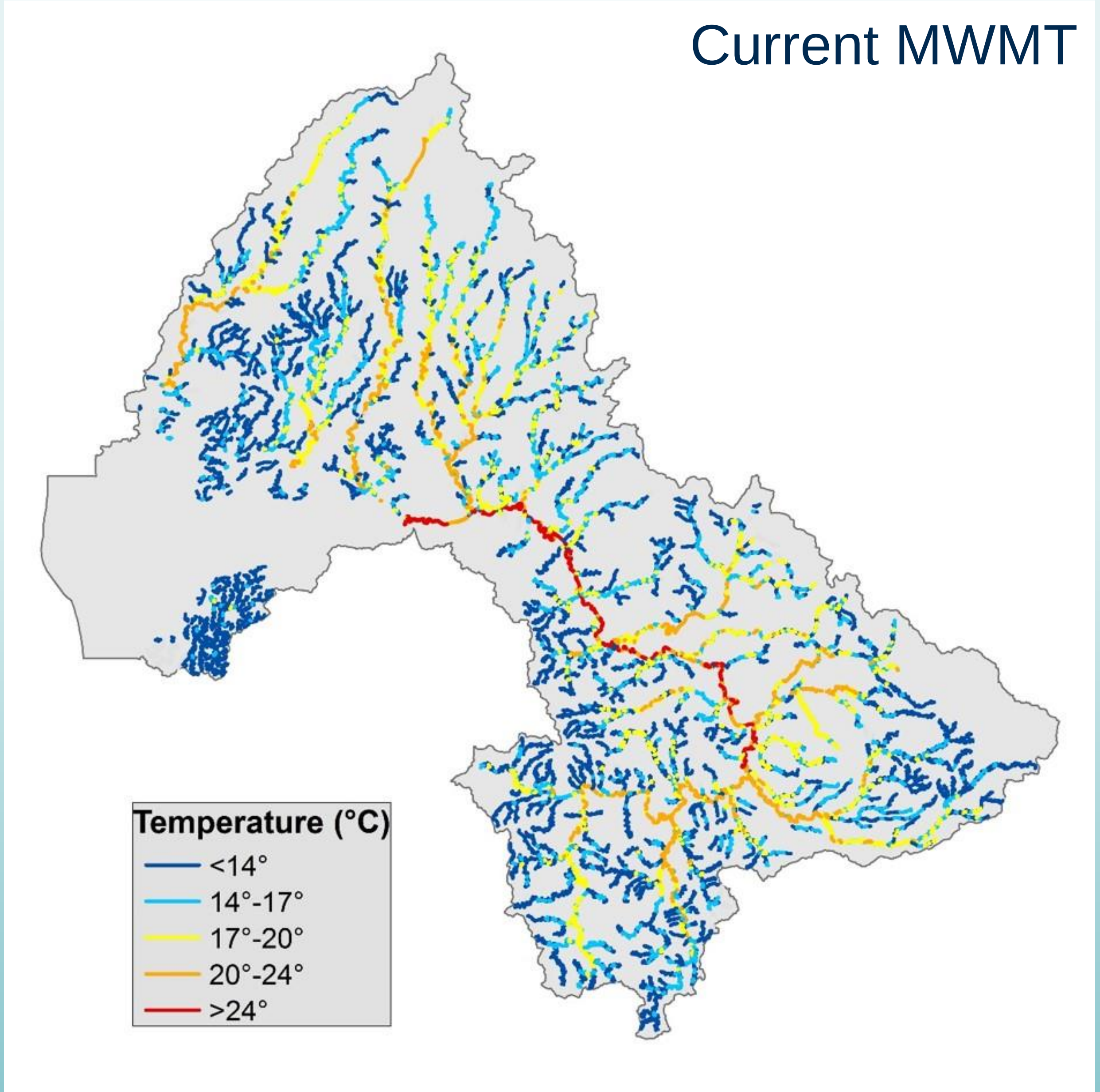
Nooksack River application

Category	Technique	Ameliorates Climate Change Effects?					Priority of Action (by Reach)				
		Temper-ature increase	Base Flow decrease	Peak Flow increase	Sediment increase	Increase salmon resilience	Rch 1	Rch 2	Rch 3	Rch 4	Rch 5
Barrier removal	Improve passage	○	○	○	○	●	N/A	N/A	Mod	Mod	N/A
Floodplain reconnection	Dike setback	●	○	●	●	●	High	Low	Low	Low	Low
	Log jams	●	●	●	●	○	High	Low	Mod	Low	Low
Stream flow regimes	Reduce water use	●	●	○	○	○	High	Low	N/A	N/A	N/A
	Floodplain wetlands	●	●	●	○	○	High	Low	Mod	Low	Low
Sediment delivery	Reduce erosion	○	○	○	○	○	Low	Low	Low	Low	Low
Riparian Functions	Planting	●	○	○	○	○	High	High	High	High	High
	Thinning	○	○	○	○	○	High	High	High	High	High
	Remove non-natives	◓	◓	○	○	○	High	High	High	High	High
Instream Rehabilitation	Log jams	◓	○	○	○	○	High	Low	High	Low	Low

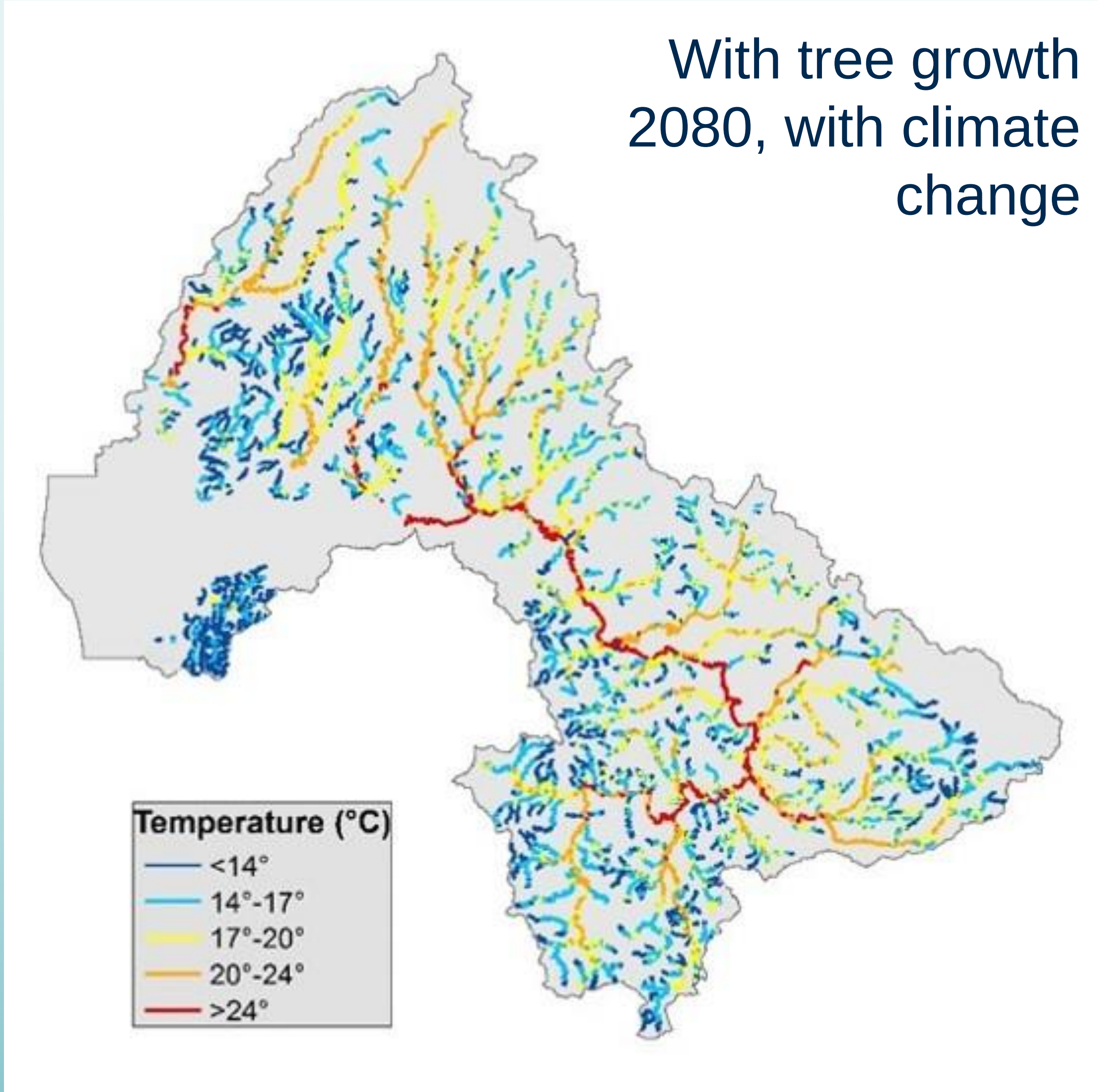
LCM to evaluate climate change



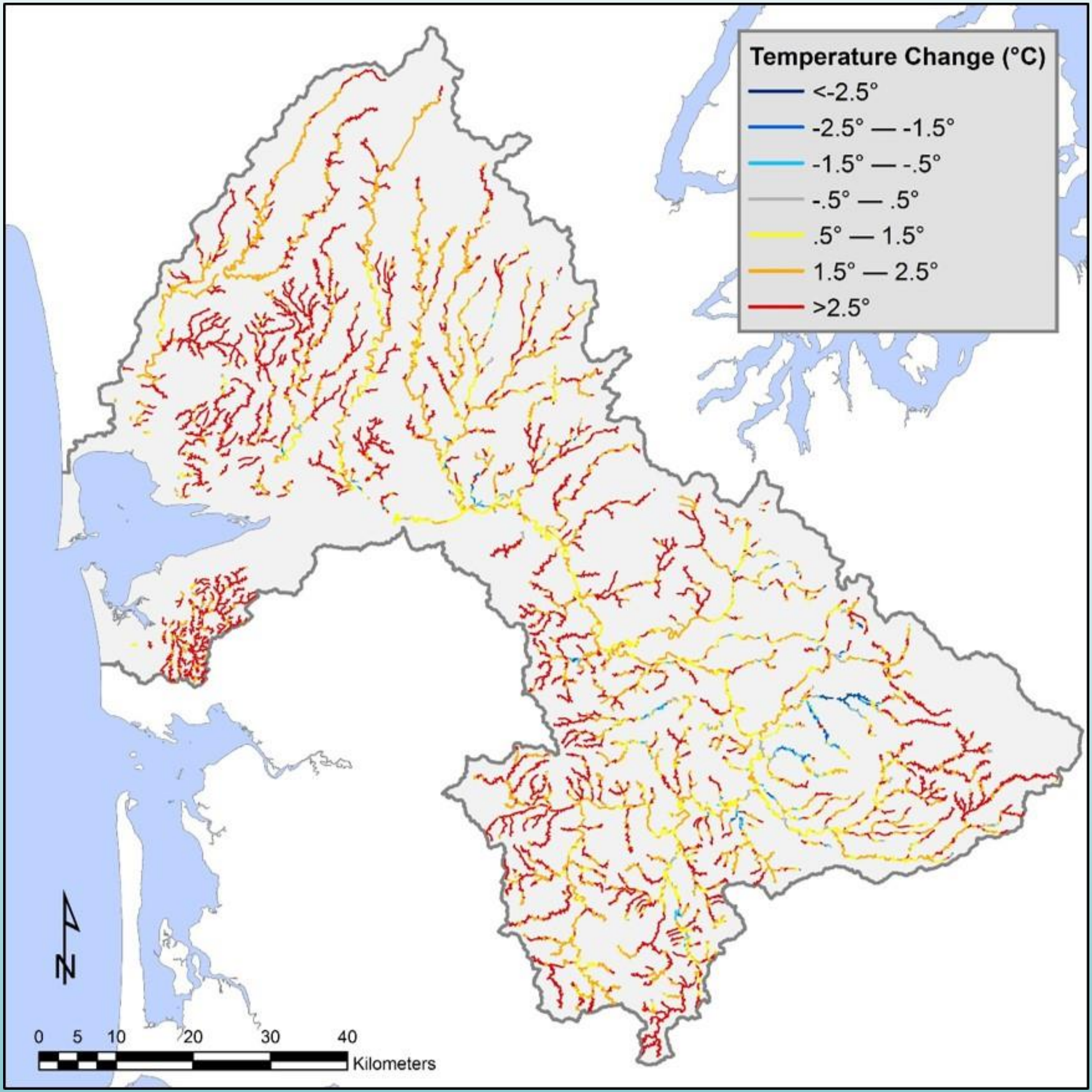
Future temperature change



Future temperature change



Temperature change – 2080s



Summary

- The process-based approach identifies needed restoration actions and their importance

- Restoration actions vary in their ability to reduce climate change effects or increase resilience
  - Restore connectivity
  - Increase habitat diversity (floodplains)

- Decision support framework helps evaluate whether and how to adjust restoration plans or actions for climate change

References

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