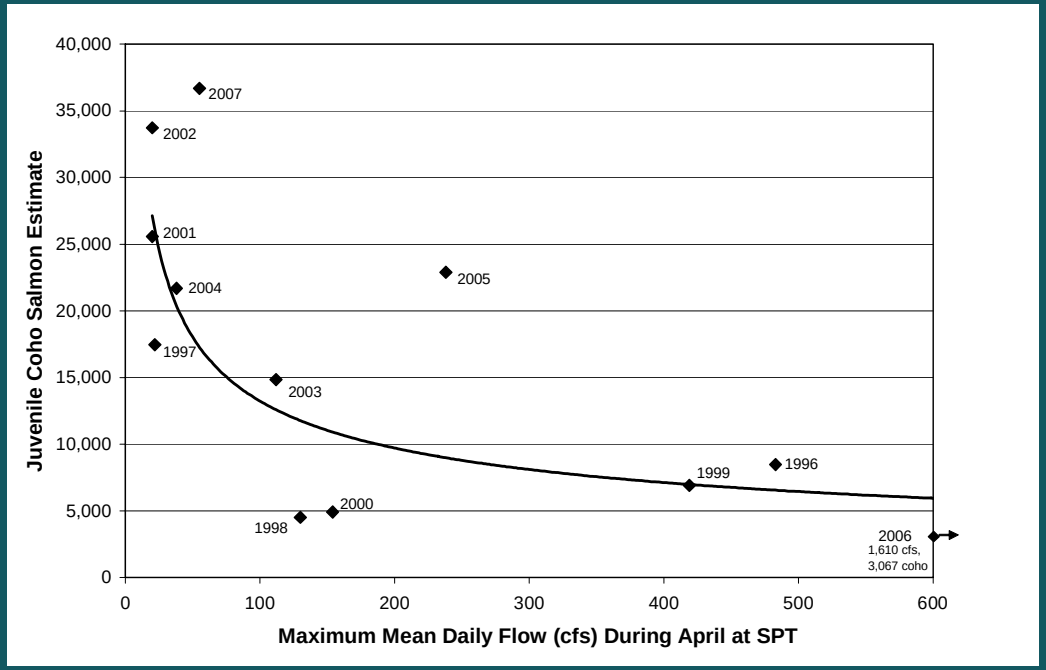
SPRING FLOW DISPLACEMENT

- **HYPOTHESIS:** Downstream displacement of fry during spring high flows can lead to high mortality prior to summer rearing period
- Somewhat confirmed by negative correlation between spring flow and juvenile coho abundance

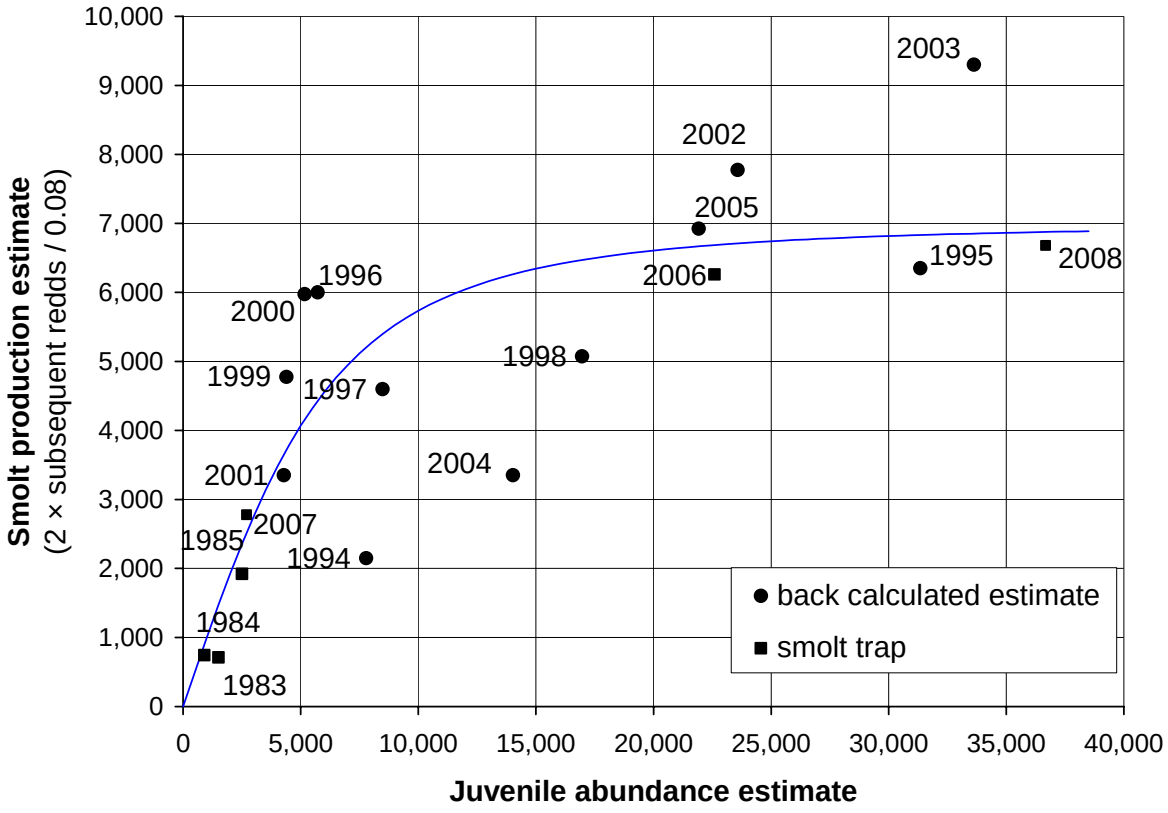


WINTER HABITAT LIMITATIONS/DISPLACEMENT

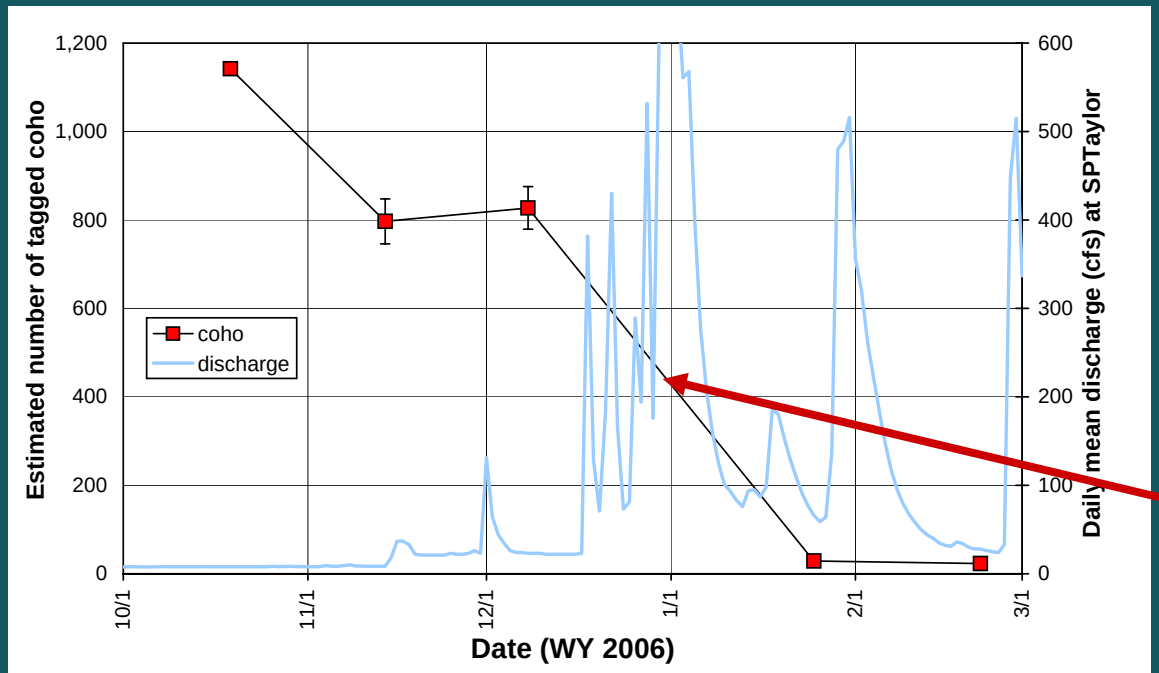
- **HYPOTHESIS:** winter habitat has been disproportionately degraded due to land use activities relative to summer habitat availability

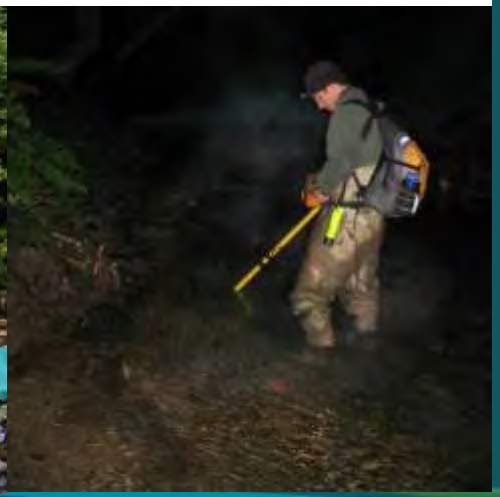
- If winter habitat is not limiting, expect smolt production similar to juveniles alive at the end of 1st summer

- Instead, see a cap in winter survival – suggesting winter habitat is limiting coho salmon populations



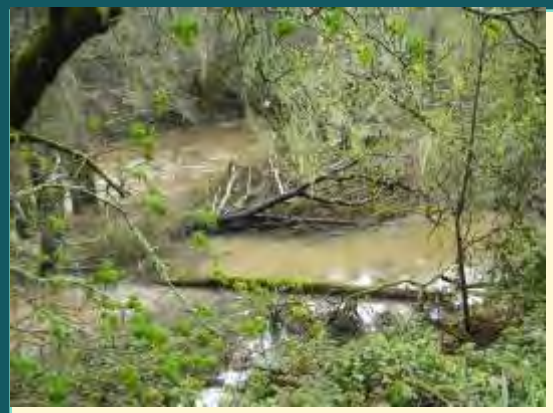
WINTER HABITAT LIMITATIONS *Devils Gulch*





- Capture, tagging, and relocation of juvenile salmonids
- 98% decline in coho salmon juvenile abundance from October 2005 to February 2006
- Few off-channel & marginal habitat features

WINTER HABITAT LIMITATIONS *Tocaloma Reach*

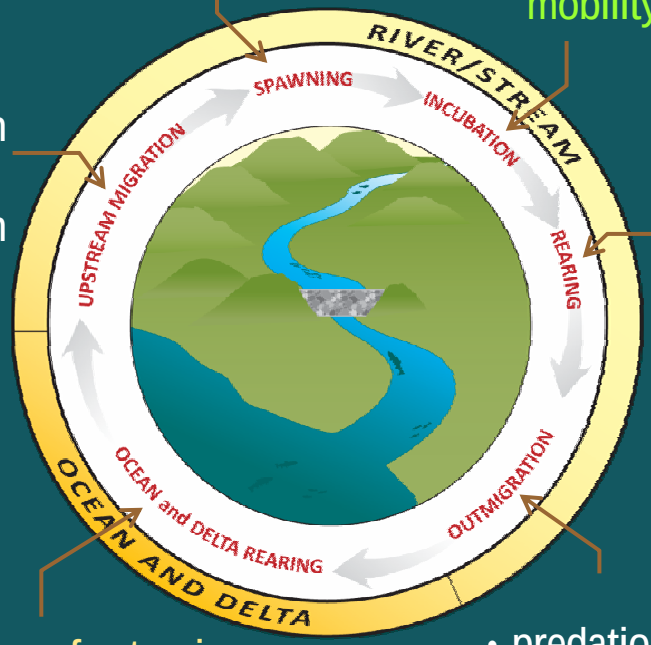


- Backwaters, side-channels, sloughs, large wood, inundated floodplains
- Greater number of larger fish (120-125 mm vs. 110-115 mm)
- Size at smolting positively influences ocean survival

Parameter	Trap Location		
	San Geronimo	Upper Lagunitas	Lower Lagunitas
Reach Measurements			
Distance above Hwy 1 Bridge (km)	18.00	9.28	3.65
Reach Length (km)	7.56	12.50	7.24
Coho salmon			
Estimated Abundance	2,268	2,397	6,261
Estimated Abundance- 95% CI	1,849 – 2,812	1,937 – 3,018	5,282 – 7,499
Coho captured within reach	2,268	129	3,864
Reach specific coho/km	300	10	534

COHO SALMON *Restoration recommendations*

- More research needed on early fry mortality
- Winter habitat appears to be greatest limiting factor on coho salmon production in majority of years
- Reach specific restoration potential:
  - **Tocaloma:** preservation of floodplain habitat
  - **Devil's Gulch and upper Lagunitas:** in-channel refuge enhancement (large wood)



- spawning habitat availability
- spawning habitat quality
- redd dewatering
- spawning gravel quality (permeability)
- spawning gravel mobility (redd scour)
- physical migration barriers
- migration hazards
- proximity of fry rearing habitat to spawning areas
- juvenile habitat availability
- stranding or displacement
- food availability
- water quality
- loss of estuarine rearing habitat
- water quality
- harvest
- ocean conditions
- predation
- diversion hazards

4c. INSTREAM FLOW MANAGEMENT BASED ON "POPULATION MODELING" REFERENCES

McKenzie River, OR

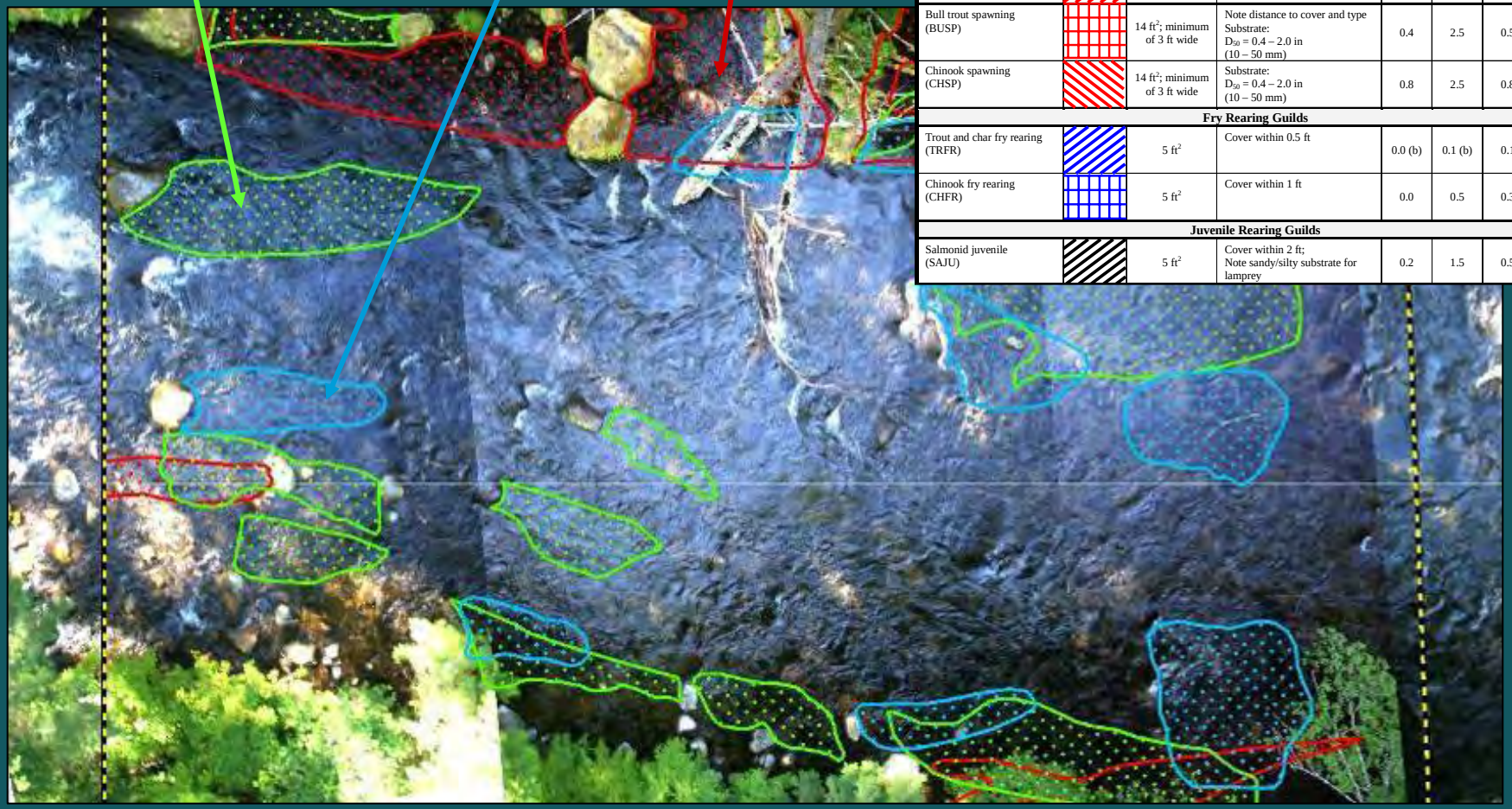
OBJECTIVE: Assess potential benefit to native fish popns of flow regime modifications through Carmen by-pass

METHOD: Assess habitat suitability in the reach for multiple fish species, at different life stages

1. Create detailed habitat maps using LEAP

(http://www.stillwatersci.com/tools.php?tid=23)

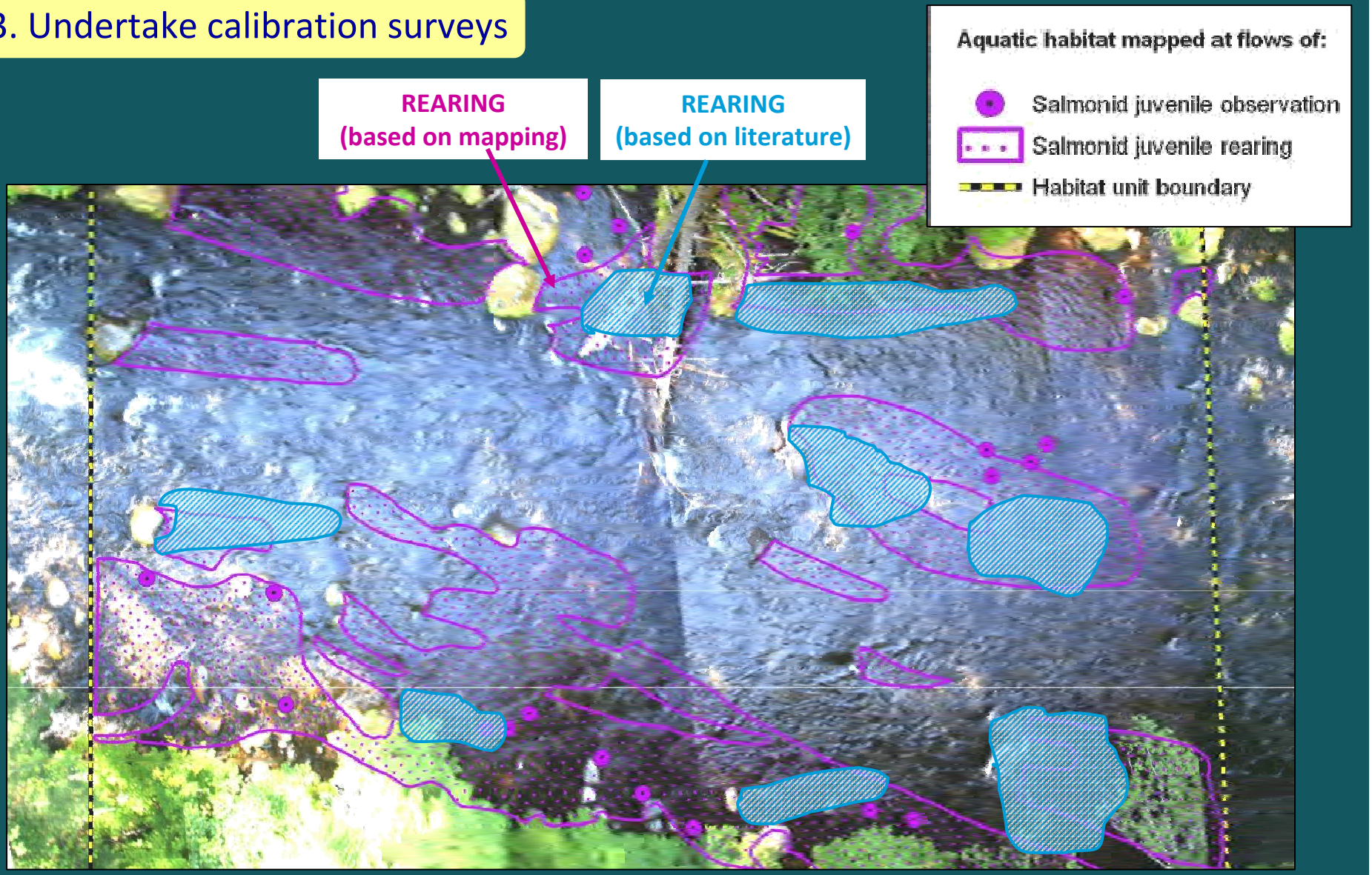
2. Map suitable habitat using literature criteria



Summary table of habitat suitability by species and life-stage

Guild name (Guild code)	Color code	Minimum polygon area (ft^2)	Cover criteria and/or substrate criteria	Water velocity[1] min (ft/s)	Water velocity[1] max (ft/s)	Water depth min (ft)	Water depth max (ft)
Adult Guilds							
Bull trout adults (BUAD)		21 ft^2		0.0	1.5	5.5	None
Cutthroat adults (CUAD)		21 ft^2		0.2	1.5	1.0	None
Spawning Guilds							
Adult resident trout spawning (ARSP)		3 ft^2	Substrate: D_{50} = 0.15 – 1.0 in (3.7 – 25 mm)	0.4	2.5	0.5	None
Bull trout spawning (BUSP)		14 ft^2; minimum of 3 ft wide	Note distance to cover and type Substrate: D_{50} = 0.4 – 2.0 in (10 – 50 mm)	0.4	2.5	0.5	None
Chinook spawning (CHSP)		14 ft^2; minimum of 3 ft wide	Substrate: D_{50} = 0.4 – 2.0 in (10 – 50 mm)	0.8	2.5	0.8	None
Fry Rearing Guilds							
Trout and char fry rearing (TRFR)		5 ft^2	Cover within 0.5 ft	0.0 (b)	0.1 (b)	0.1	1.3
Chinook fry rearing (CHFR)		5 ft^2	Cover within 1 ft	0.0	0.5	0.3	None
Juvenile Rearing Guilds							
Salmonid juvenile (SAJU)		5 ft^2	Cover within 2 ft; Note sandy/silty substrate for lamprey	0.2	1.5	0.5	None

3. Undertake calibration surveys

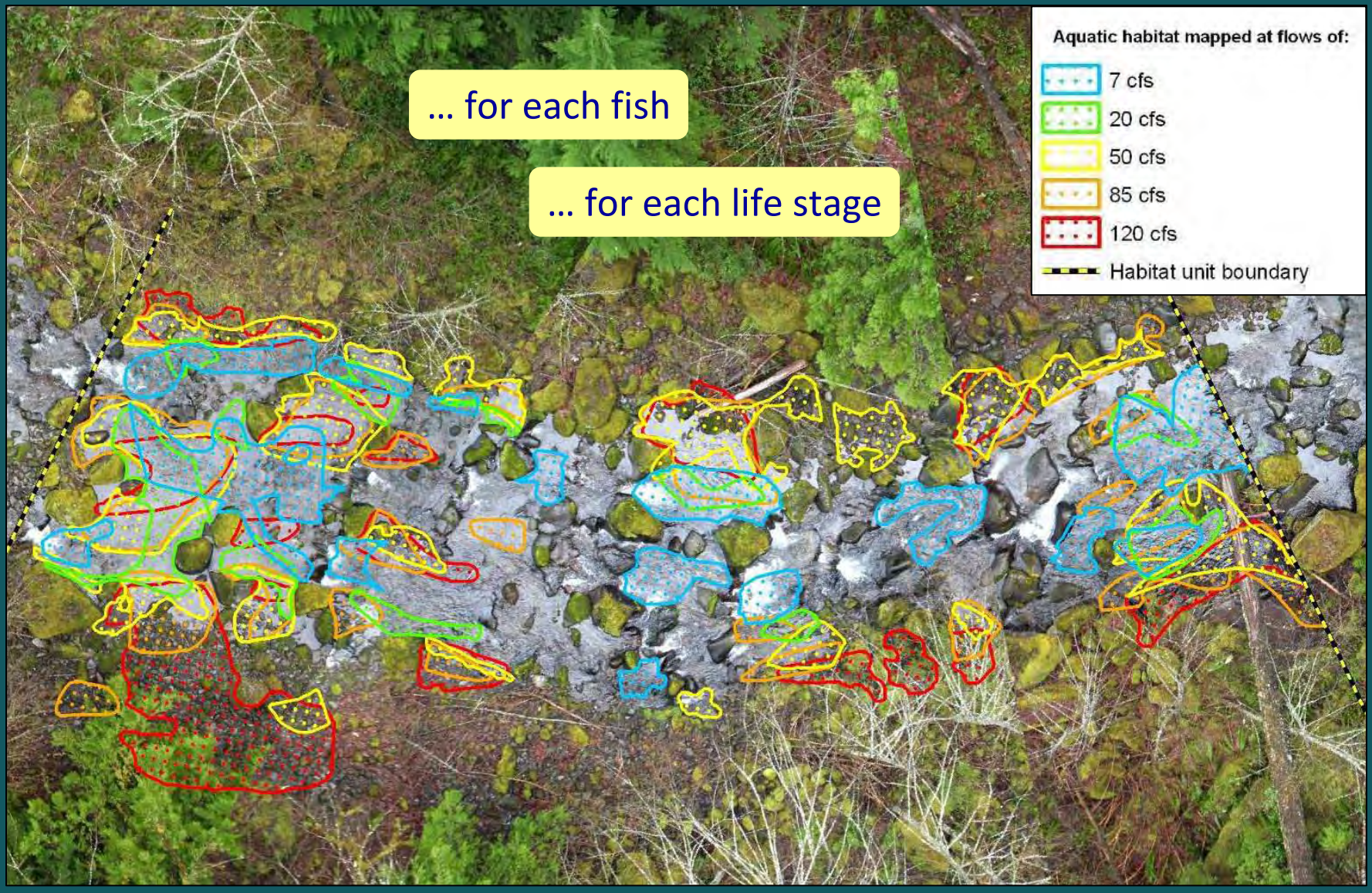


4. Revise mapping following calibration,
Using different surveyors

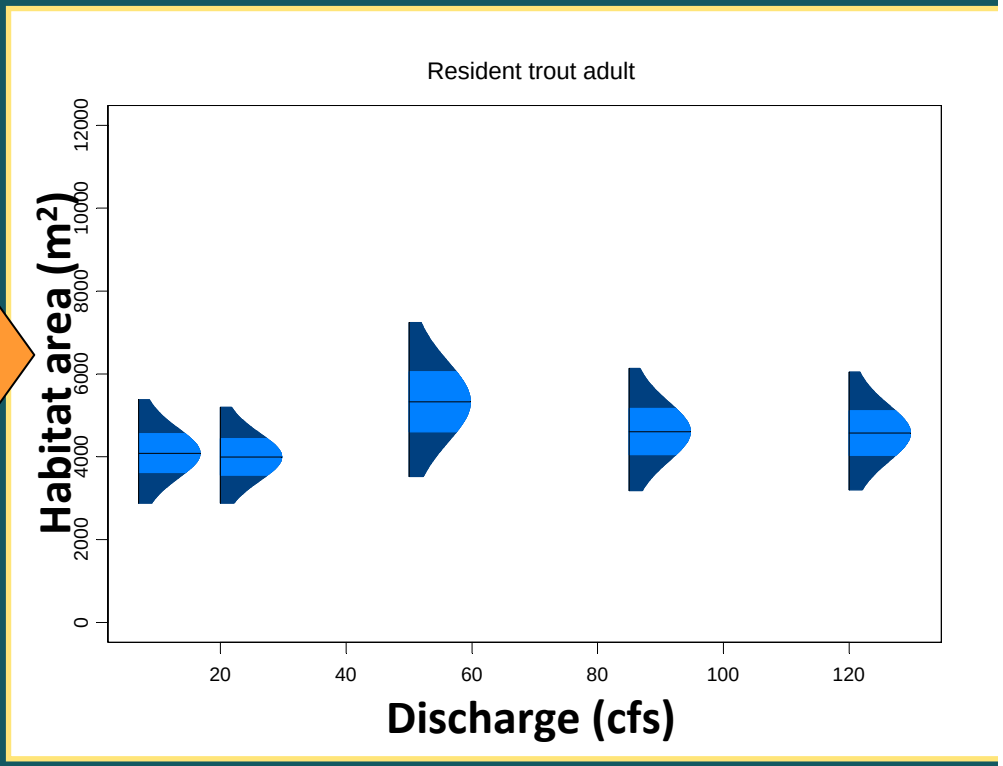
PRIMARY MAPPING

CALIBRATION MAPPING

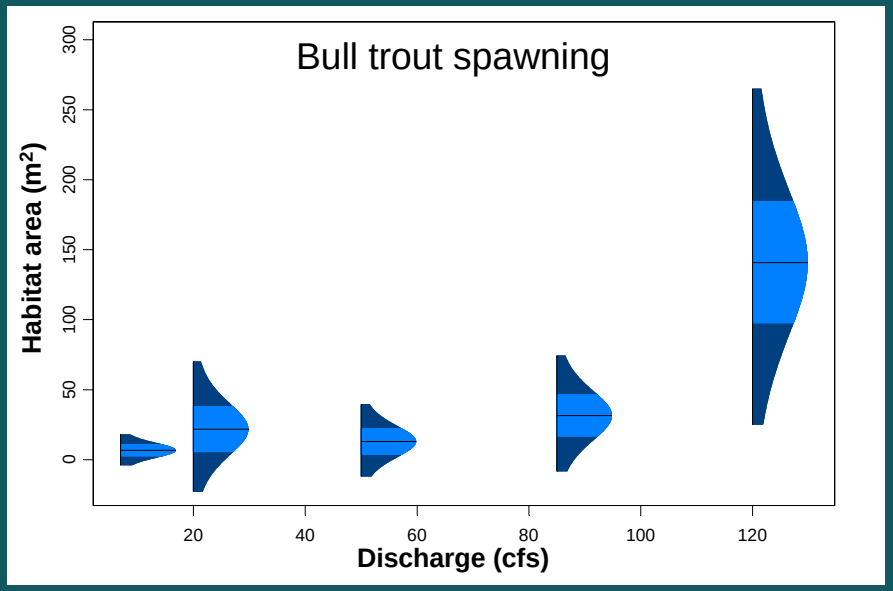
5. Repeat surveys at different flows

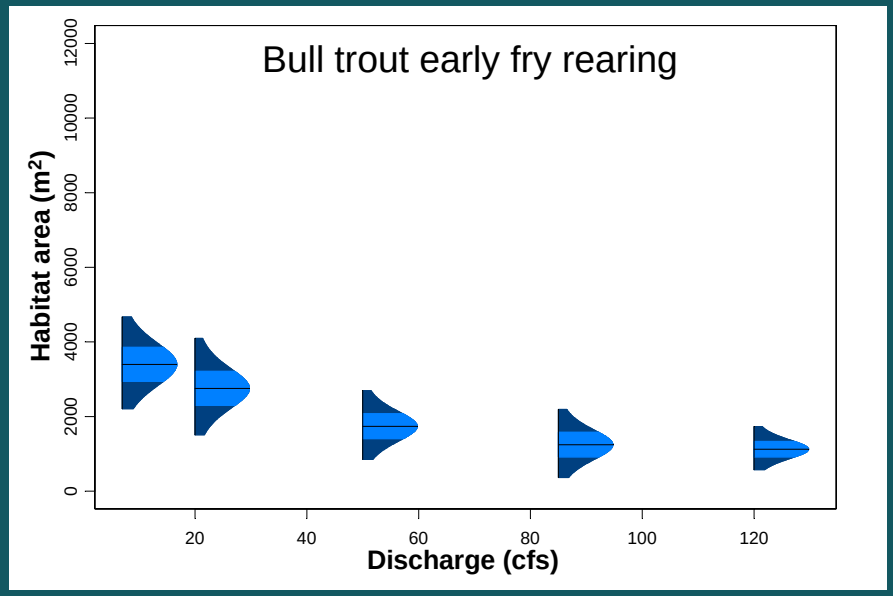


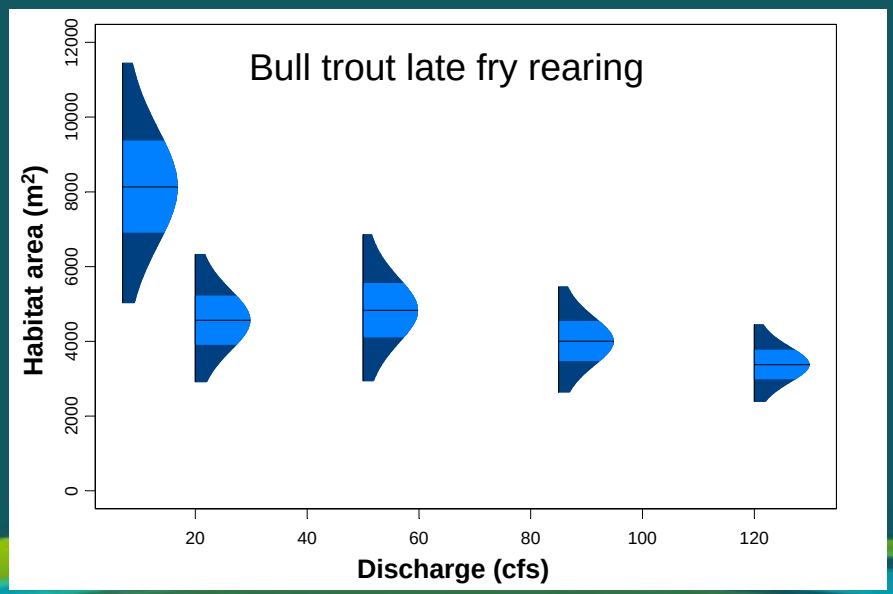
6. Translate mapping into habitat areas at different flows

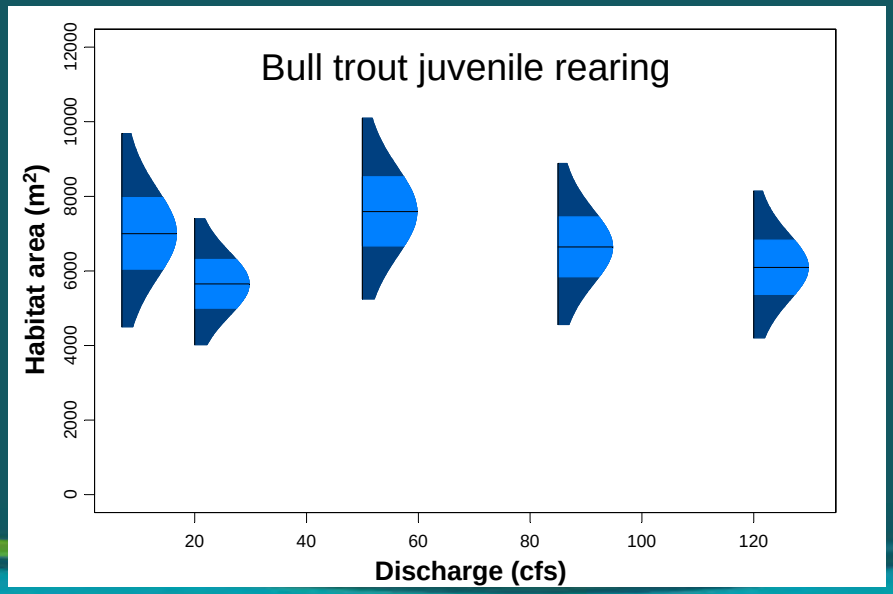


7. Quantify “most productive” flows for habitat requirements





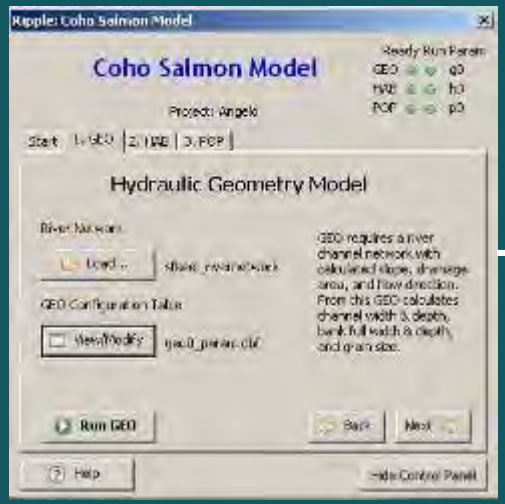


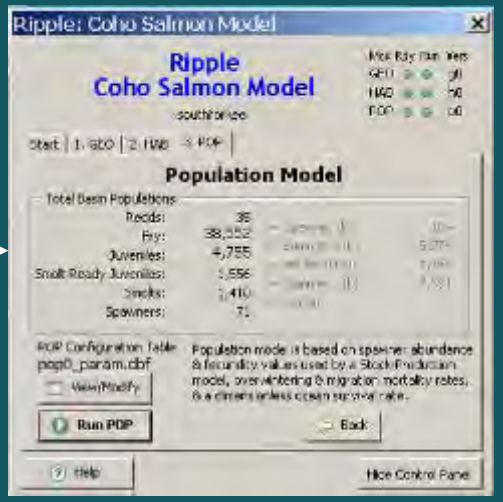


8. Integrate HABitat features into POPulation models

DEM

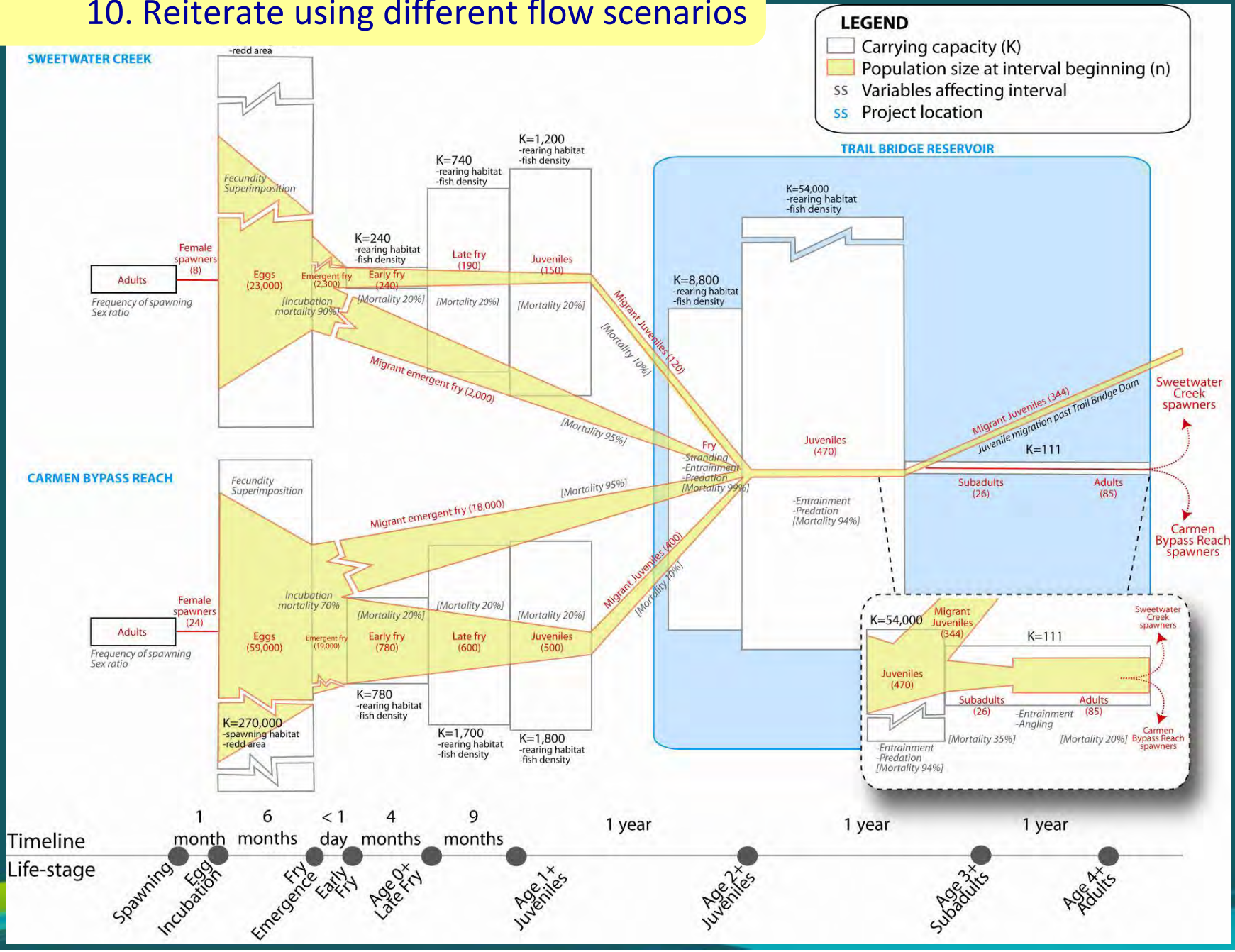
GEO MODULE → **HAB** MODULE → **POP** MODULE





http://software.nced.umn.edu/ripple/index.html

9. Assess factors limiting success in pop model
10. Reiterate using different flow scenarios



5. DISCUSSION: ECOLOGICAL REFERENCES IN PRACTICE

"Pop Modelling" refs:
Empirical: existing data summary, habitat preferences, population dynamics
Field monitoring: focused-research / monitoring

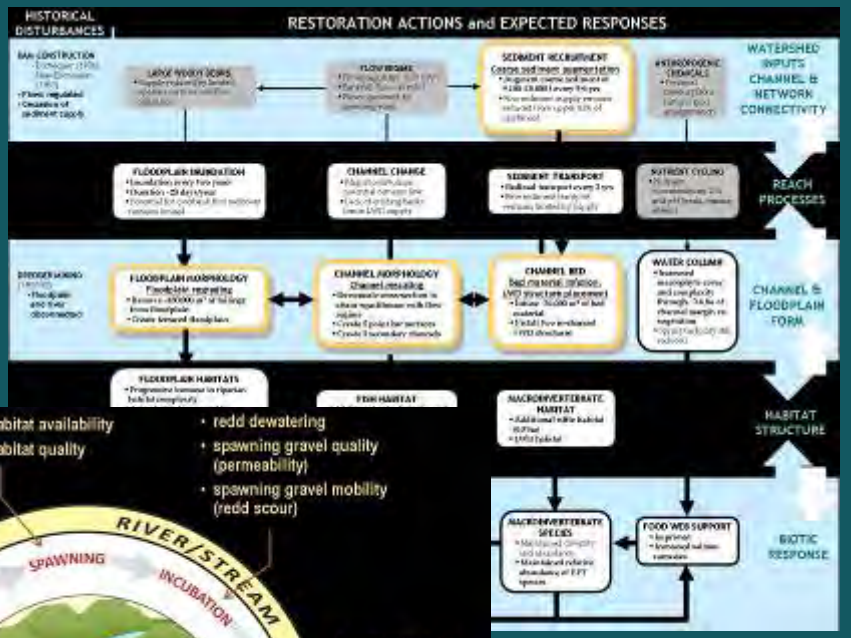
"Geomorphic" refs:
Physics: sediment transport
Empirical: hydraulic geometry, planform, hydrology
Field experiment: tree growth

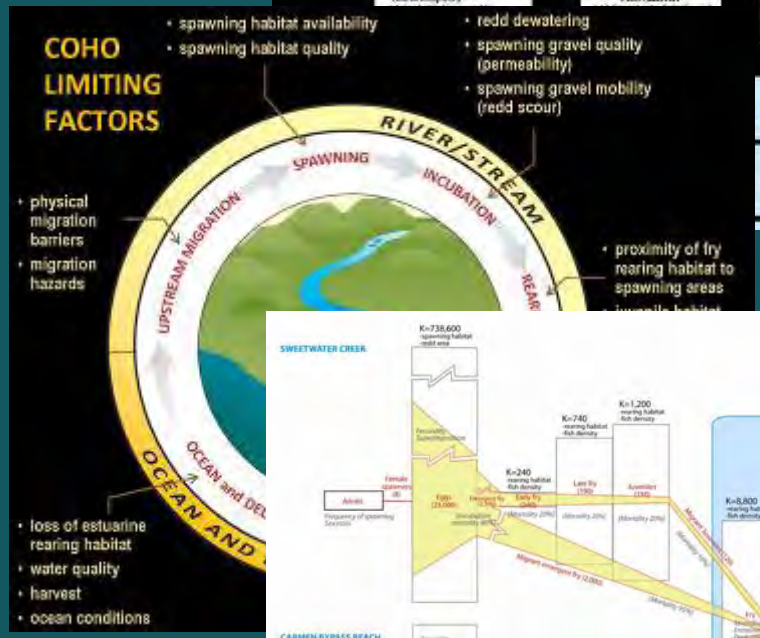
"Focal Species" refs:
Empirical: existing data summary,
Field monitoring: focused-research / monitoring

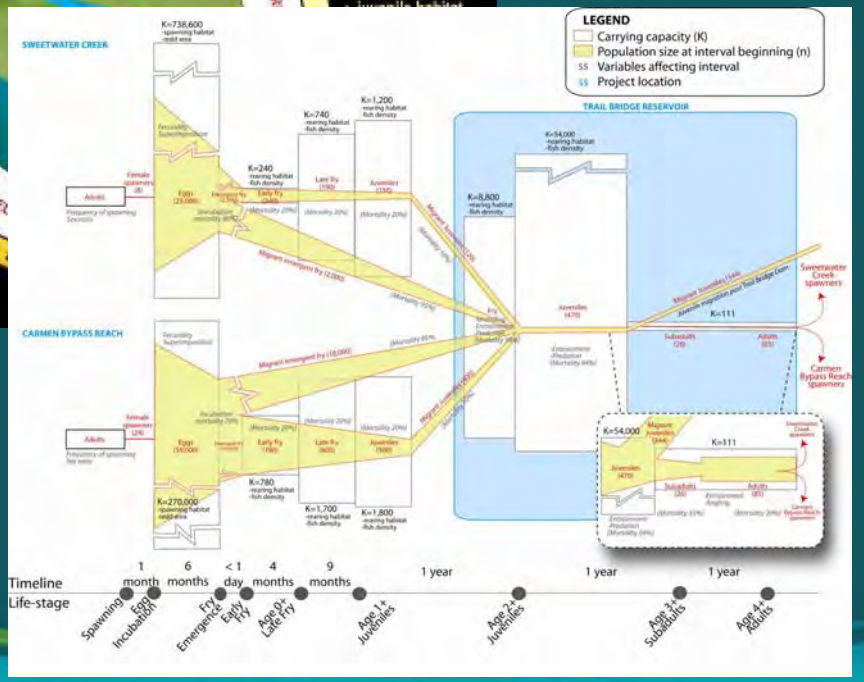
3 benefits to restoration science >>

i. ECOLOGICAL REFERENCES AND CONCEPTUAL MODELS

- Demands development of conceptual models
- **Merced:** identified "problems" – restoration of components to stimulate process linkages
- **Lagunitas:** evaluate limiting factors to focus on processes underpinning critical linkages
- **McKenzie:** quantify limiting factors to focus on processes that relieve critical population bottlenecks



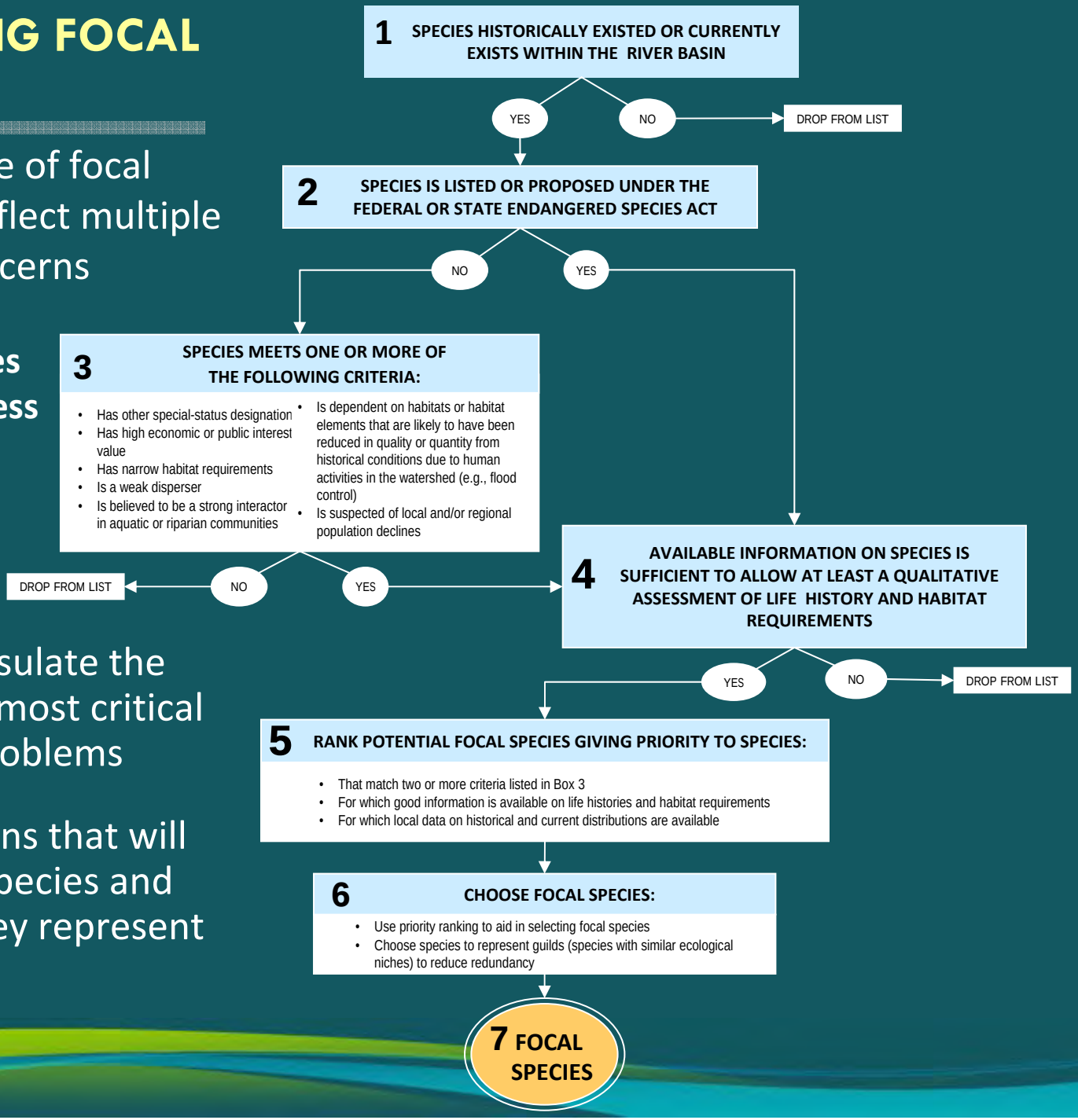




ii. CHOOSING FOCAL SPECIES

Requires choice of focal species that reflect multiple ecosystem concerns

Focal Species Vetting Process



- Helps: encapsulate the ecosystem's most critical issues and problems
- identify actions that will benefit the species and the guilds they represent

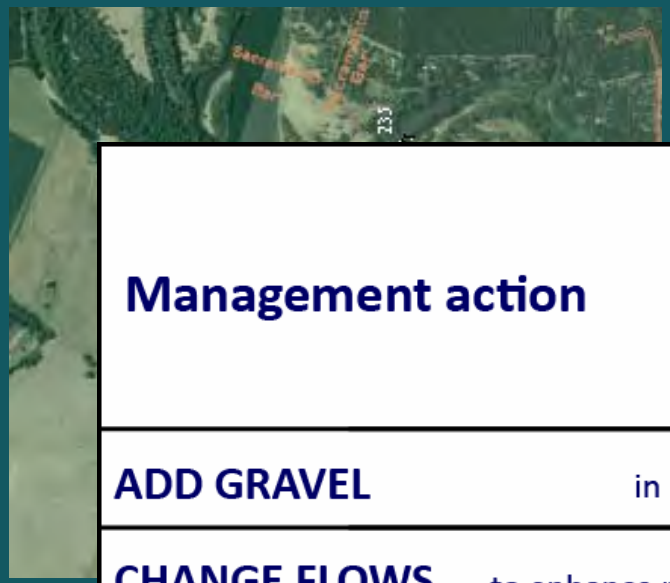
Sacramento River

Needed focal species representative of a wide range of mainstem and off-channel habitat types:

- Fast, deep, turbulent water: **green sturgeon**
- Riffles, pools, eddy-bar complexes**:** **chinook salmon**; **steelhead**
- Cutbanks in actively migrating bends: **bank swallow**
- Oxbow lakes, sloughs, side channels: **western pond turtle**
- Point bars and older floodplain surfaces (in later successional stages): **fremont cottonwood**

Sacramento River

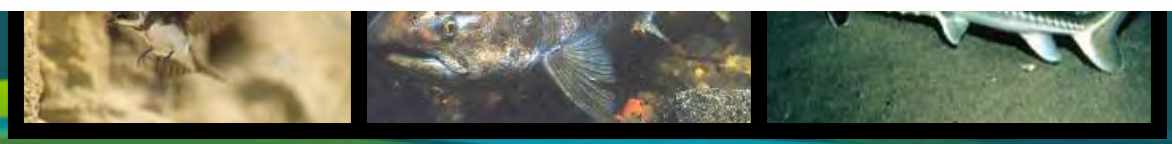
Needed focal species representative of a wide range of mainstem and off-channel habitat types:



- Fast, deep, turbulent water: green sturgeon

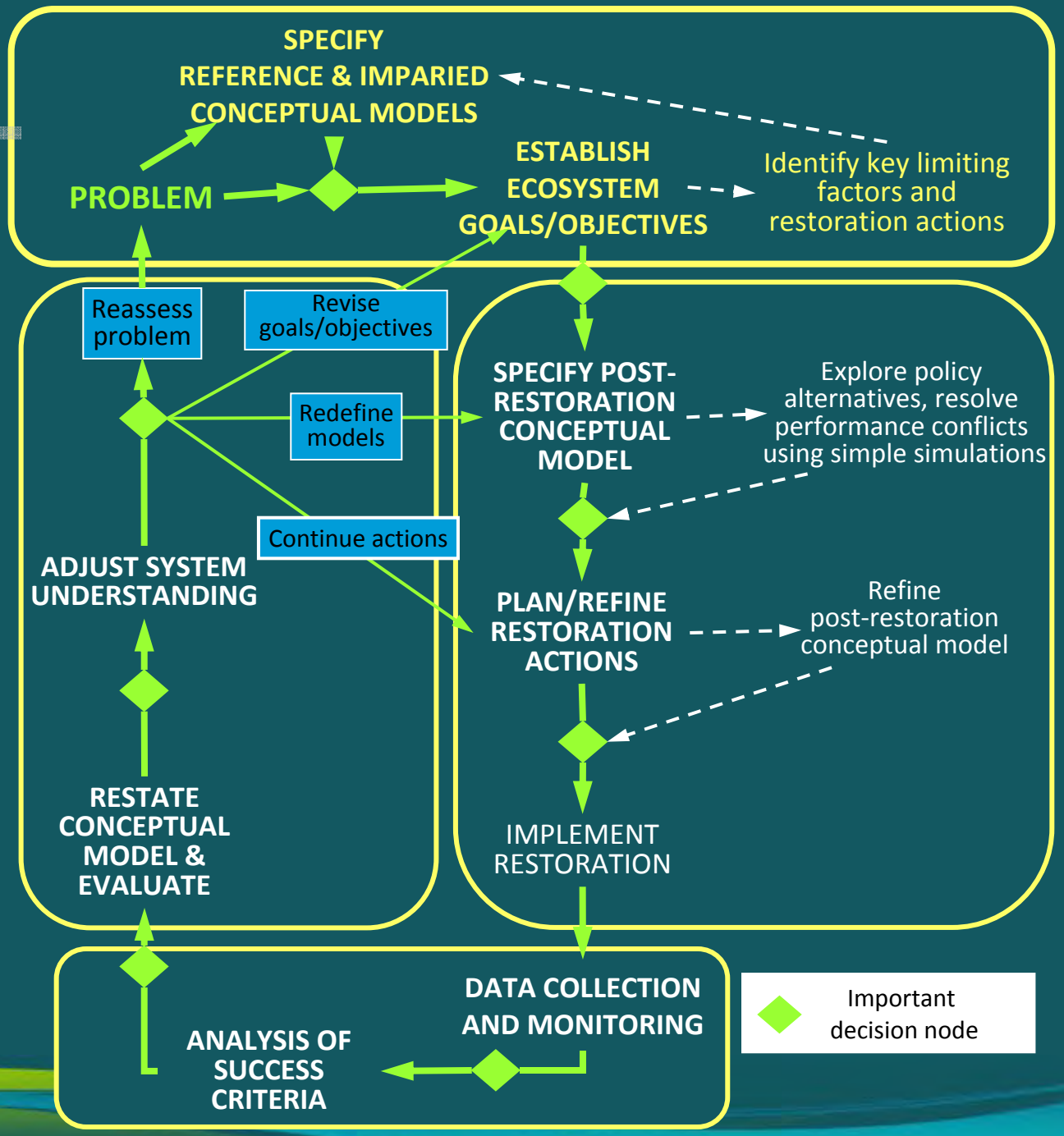
Management action	Species affected					
	Chinook	steelhead	green sturgeon	bank swallow	western pond turtle	Fremont cottonwood
ADD GRAVEL in upper river	■	■	□			
CHANGE FLOWS to enhance meander migration	□	□		■	■	■
CHANGE FLOWS to promote plant succession				?	?	■
CHANGE FLOWS to promote off-channel rearing	■	■				
REMOVE REVETMENT	□	□		■	■	■

■ primary benefit to species □ secondary benefit or potentially adverse impact ? effects depend on timing and magnitude of flows



iii. IMPROVING FUTURE PRACTICE

Generally requires baseline monitoring, so improves basis for post-project monitoring and evaluation, and future practice



ECOLOGICAL REFERENCES AND LFA contd.

Practical advantages

- Catchment-contextualized, but results in discrete actions ("fine tuning")
- Does not imply return to pristine condition: works in disturbed reaches/accommodates altered conditions (incl. the future)
- Appropriate to regulatory context: links directly to threatened species

Perceived disadvantages

- Too much science…
- Historical references may be preferred (pristine / early childhood)
- Not seen as quick fix, construction-oriented, or "shovel-ready"

6. CONCLUSION

In the EU Water Framework Directive (2000/60/EC) it is a major and perhaps unrealistic aim to use a network of near-natural references systems so that the ecological status of rivers can be measured against them

(F. Hughes et al. 2008, p92)

Hydromorphological condition & links to ecology…

- Process-based restoration demands process-based references: ecological references focus on causal relationships, rather than form
- Allow iterative accumulation of progressively better "references conditions"
- Conceptual models assist defining hydromorphology – ecology linkages
- As an aid to communication?!