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International Conference on Engineering and Ecohydrology for Fish Passage

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Complex effects of partial barriers on a simulated watershed trout population

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A nagging question...

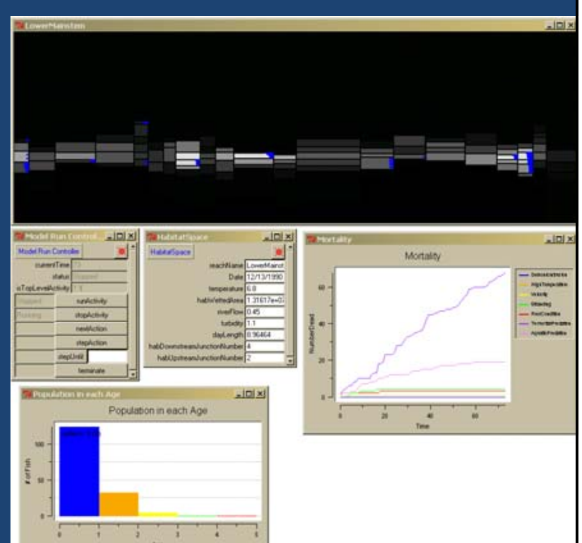
- Is all this money for fish passage well-spent?
- How important is it to eliminate partial barriers?
  - that block some fish, at some flows
- Field studies alone are not likely to answer this

A marriage of convenience

- inSTREAM: an individual-based trout population model that can represent barriers
- FishXing to predict passage flows at barriers
- How does the abundance & persistence of a (simulated) trout population vary with partial passage characteristics?

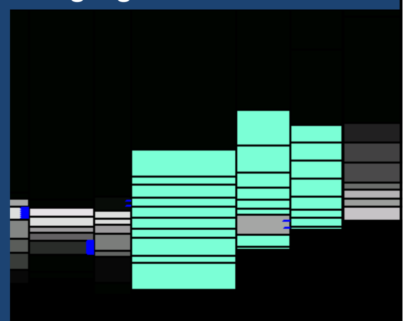
inSTREAM
www.humboldt.edu/ecomodel

- Sites made up of cells
- Individual trout, redds
- Daily time step
- Processes:
  - Habitat selection
  - Feeding & growth
  - Survival
  - Spawning



Fish movement in inSTREAM is *habitat selection*

- Each day, each trout
  - Examines cells within a radius that increases with trout size
  - Moves to the cell offering best foraging (a tradeoff of growth and risk)
- Not represented:
  - Spawning migrations
  - Long-distance exploration
  - “Site fidelity”
  - Downstream transport
  - ...

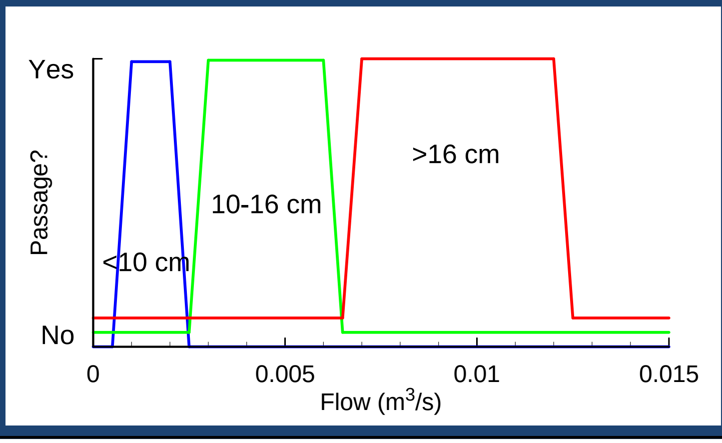


How inSTREAM represents barriers

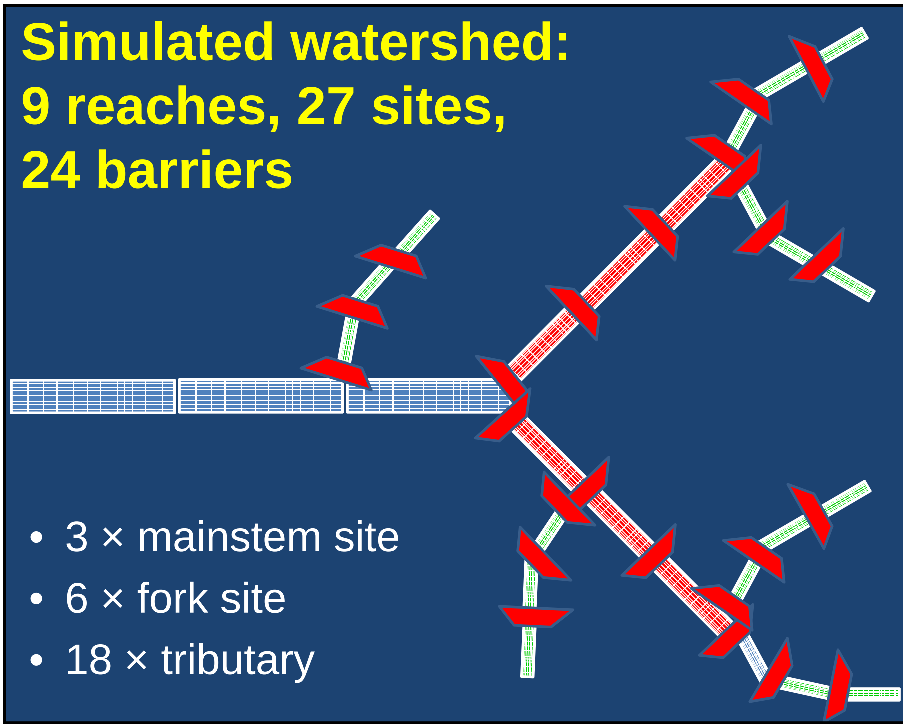
- Upstream: Fish cannot examine or move to cells upstream of a barrier
- Downstream:
  - Fish have no information about habitat downstream of a barrier
  - Fish move down over a barrier only if life above it stinks–
    estimated P(90-day survival) < 0.1

How inSTREAM represents *partial* barriers

- Minimum, maximum passage flows
- Three size classes of fish



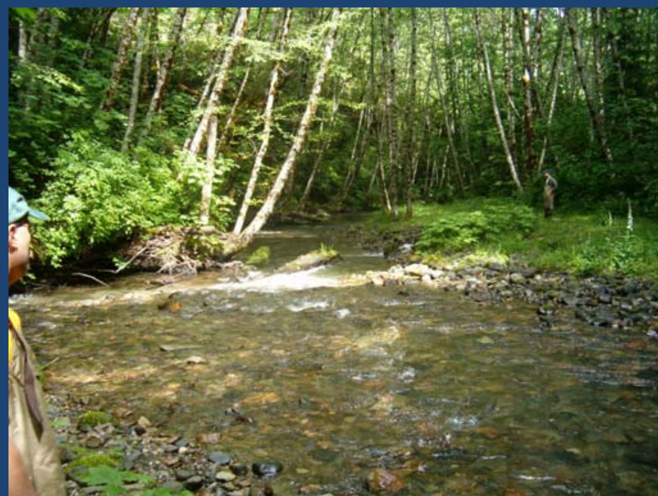
Simulated watershed: 9 reaches, 27 sites, 24 barriers



- 3 × mainstem site
- 6 × fork site
- 18 × tributary

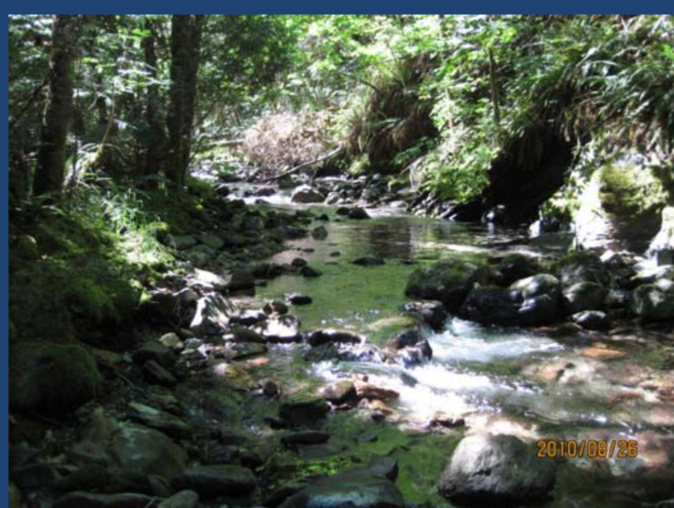
Little Jones Creek
Smith River basin, NW California

- Mainstem site



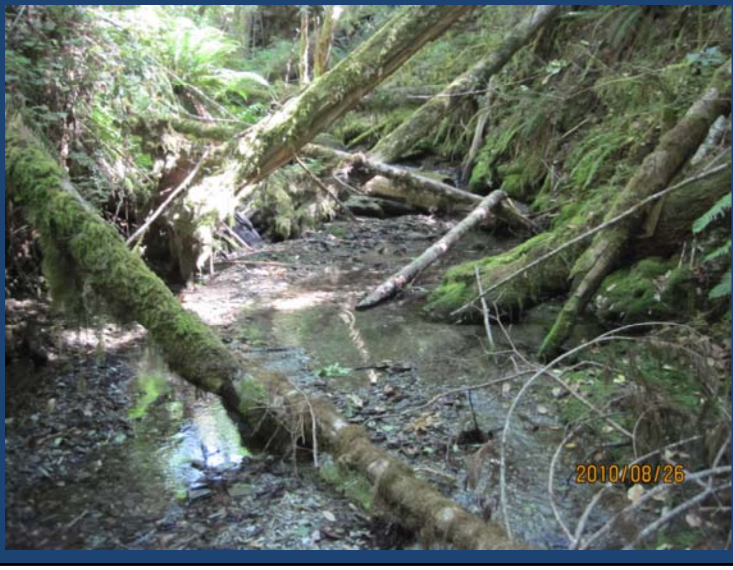
Little Jones Creek
Smith River basin, NW California

- Fork site



Little Jones Creek
Smith River basin, NW California

- Trib site



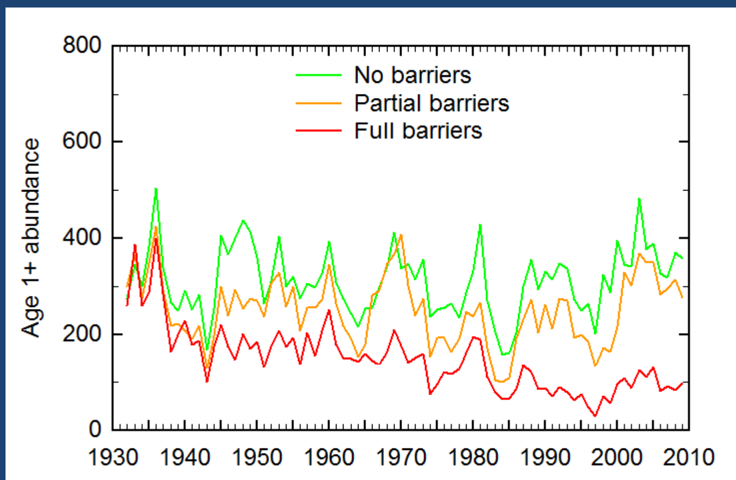
FishXing results:
Percentage of days with passage

	Small fish (<10 cm)	Medium fish	Large fish (>16 cm)
Fork – min passage	100%	100%	100%
Fork – max passage	0%	0%	10%
Both flows met:	0%	0%	10%
Tributary— min passage	100%	81%	64%
Tributary— max passage	10%	34%	44%
Both flows met:	10%	15%	8%

Simulation experiments

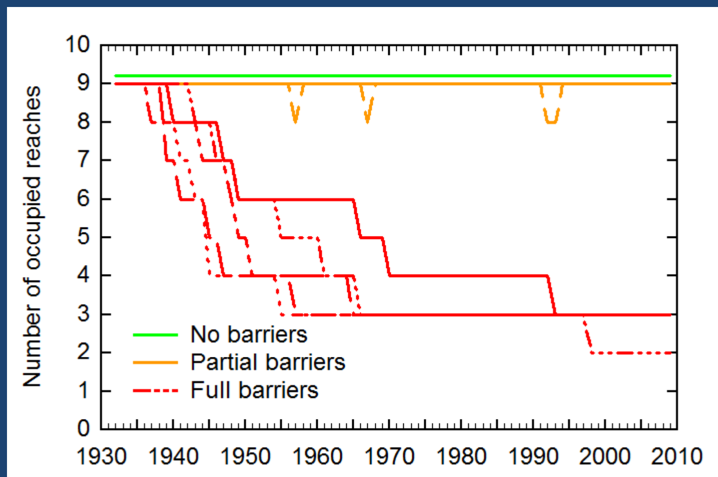
- 78 years (1932-2009) but with 4 × frequency of extreme high and low flow years
- Three barrier scenarios:
  - No barriers
  - Partial barriers with passage predicted by FishXing
  - Full barriers (no passage at any flow)
- Results analyzed:
  - Abundance of age 1 and older trout at September
  - Number of reaches (out of 9) still occupied by any trout

Results (1): Adult trout abundance



- Small effect of partial barriers...

Results (2): reach occupancy (5 replicates)



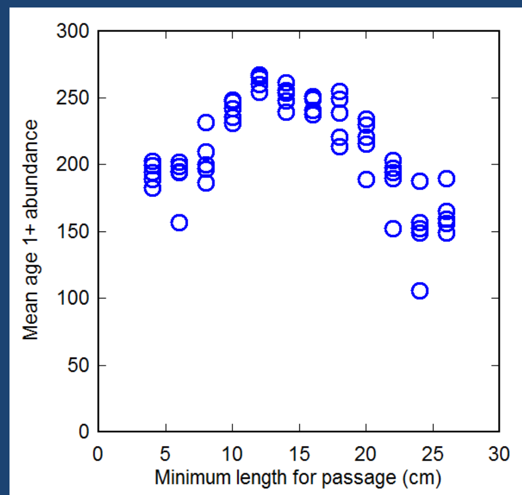
- Partial barriers allow all reaches to be occupied.

What's going on?

- Why does only very limited passage strongly reduce the negative effects of barriers?
- What barrier characteristics allow populations to persist without unlimited passage?

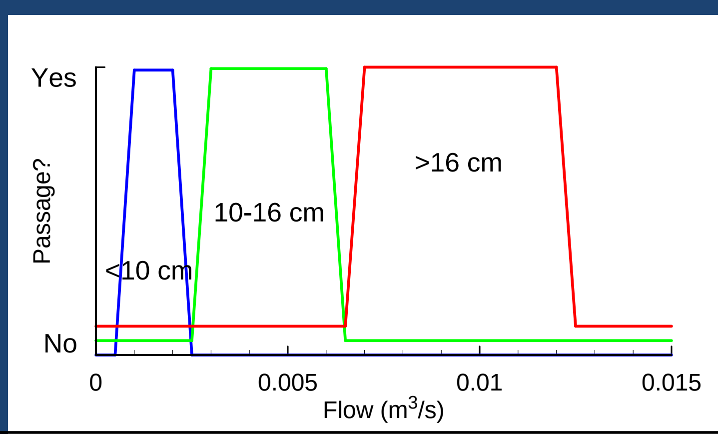
Fish size:
Effect of minimum passage length

- Experiment: Fish with length > passage minimum can pass at all flows; otherwise never
- Conclusions:
  - passage of small fish not necessarily good
  - passage of fish >12 cm seems especially important

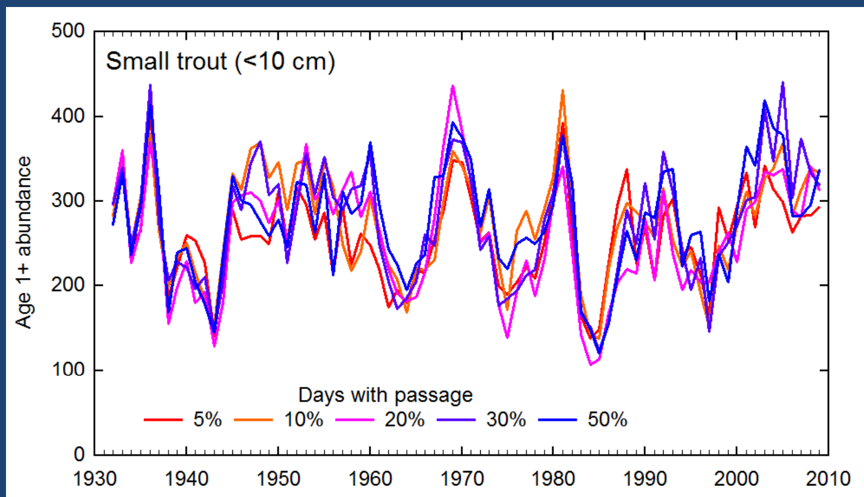


Fish size *and* passage frequency:
Effect of maximum passage flow

- Vary the maximum passage flow, separately for each length class

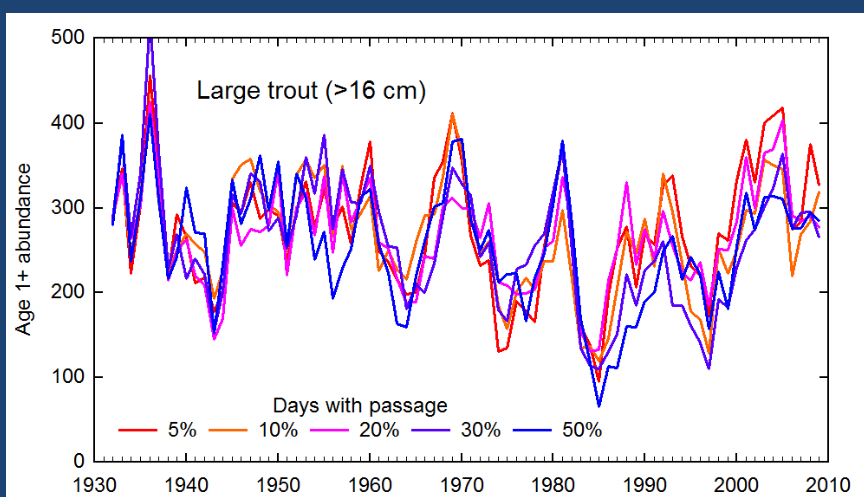


Does improved passage of small fish help?



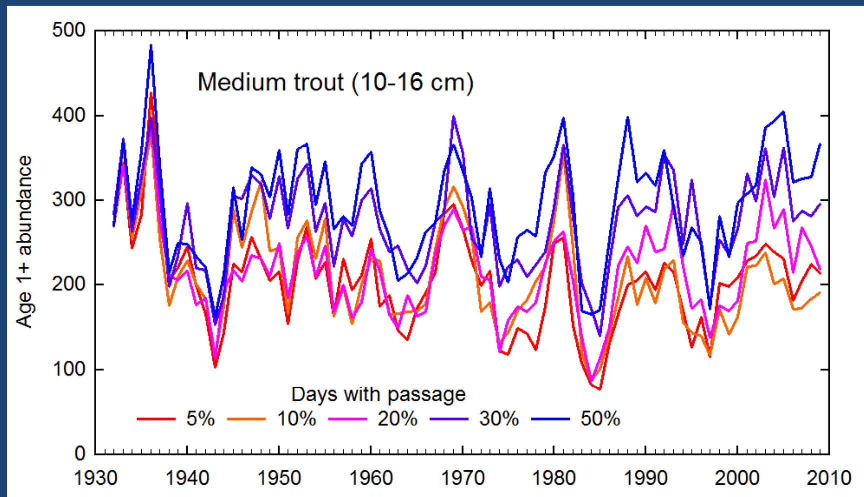
- No– as indicated by fish size experiment

Does improved passage of large fish help?



- No...

Does improved passage of medium fish help?



- Just right!

Why does improved passage for only medium-sized trout benefit the simulated population?

- Small trout can't move as far
- Large trout:
  - are few
  - don't do well in small tributaries
- Medium trout:
  - are many
  - can have high survival in small streams
  - are big enough to spawn and repopulate sites

What does this simulation study say about fish passage design?

- Think about:
  - What size fish can thrive above barriers on small streams
  - Small spawners can repopulate reaches
- Low passage for small fish may not cause populations to be smaller or less persistent

HUMBOLDT STATE UNIVERSITY

- inSTREAM, publications etc.: www.humboldt.edu/ecomodel
- FishXing: www.fishxing.org