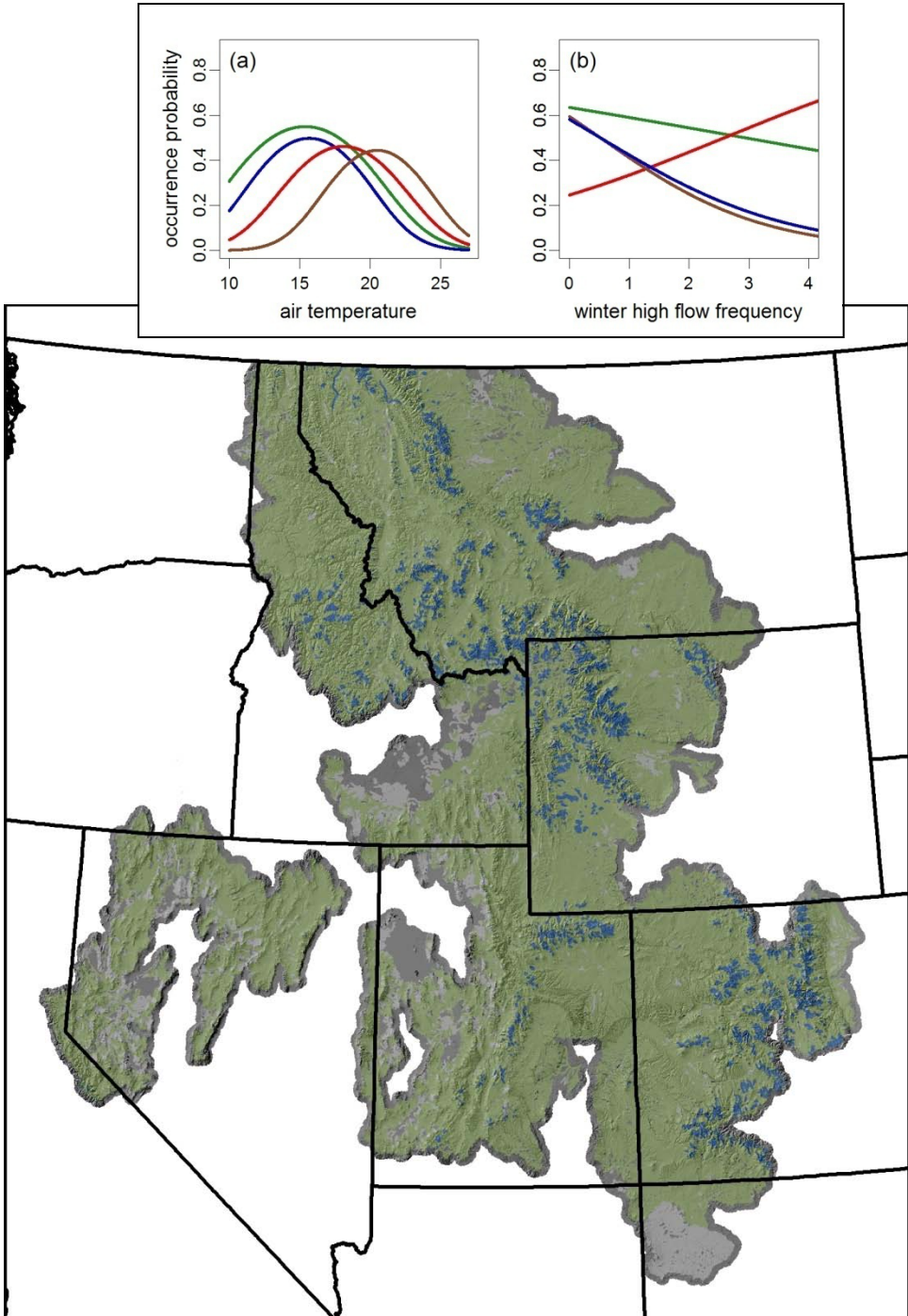
Fish population response to climate change

Seth Wenger
Trout Unlimited



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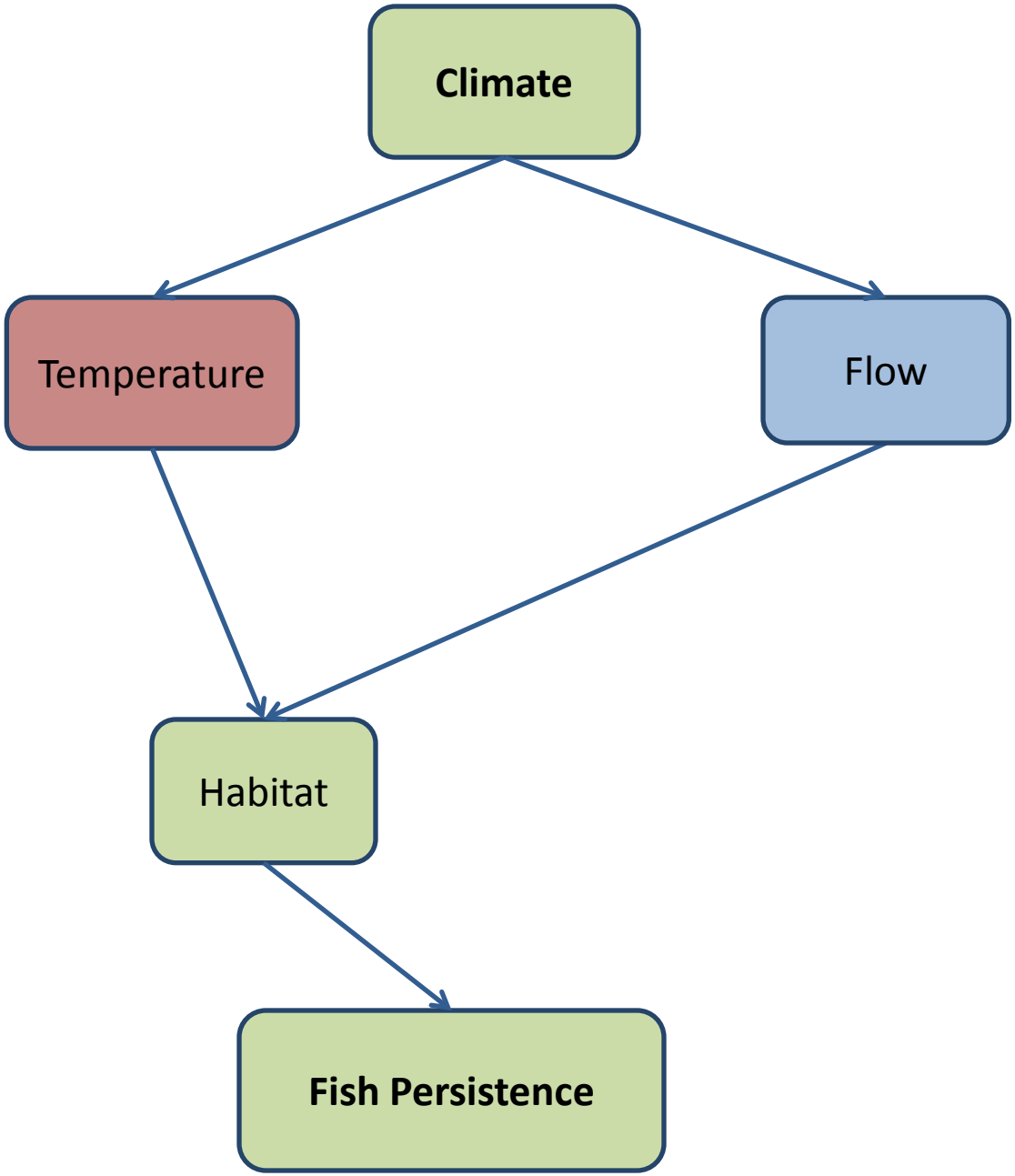
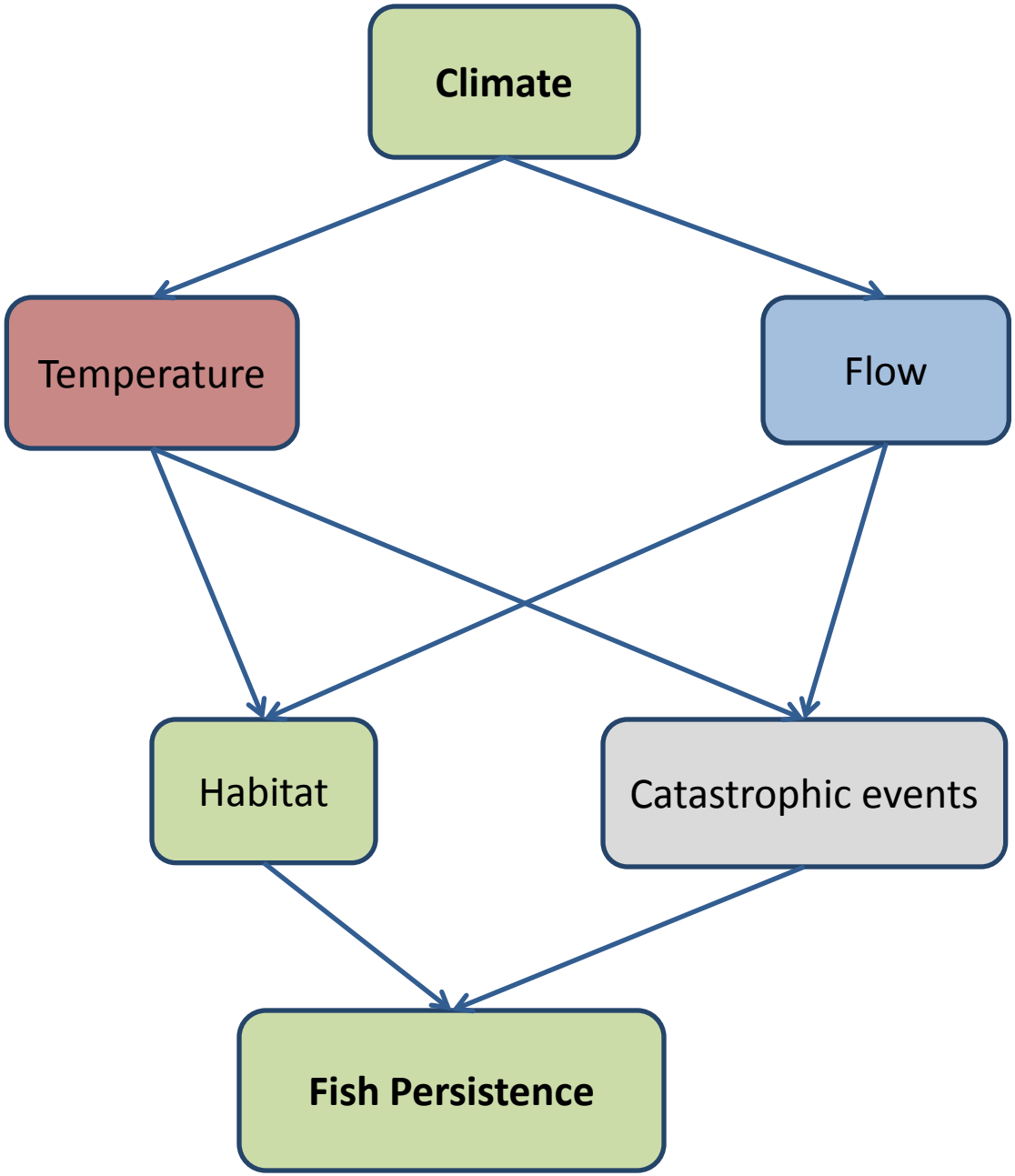
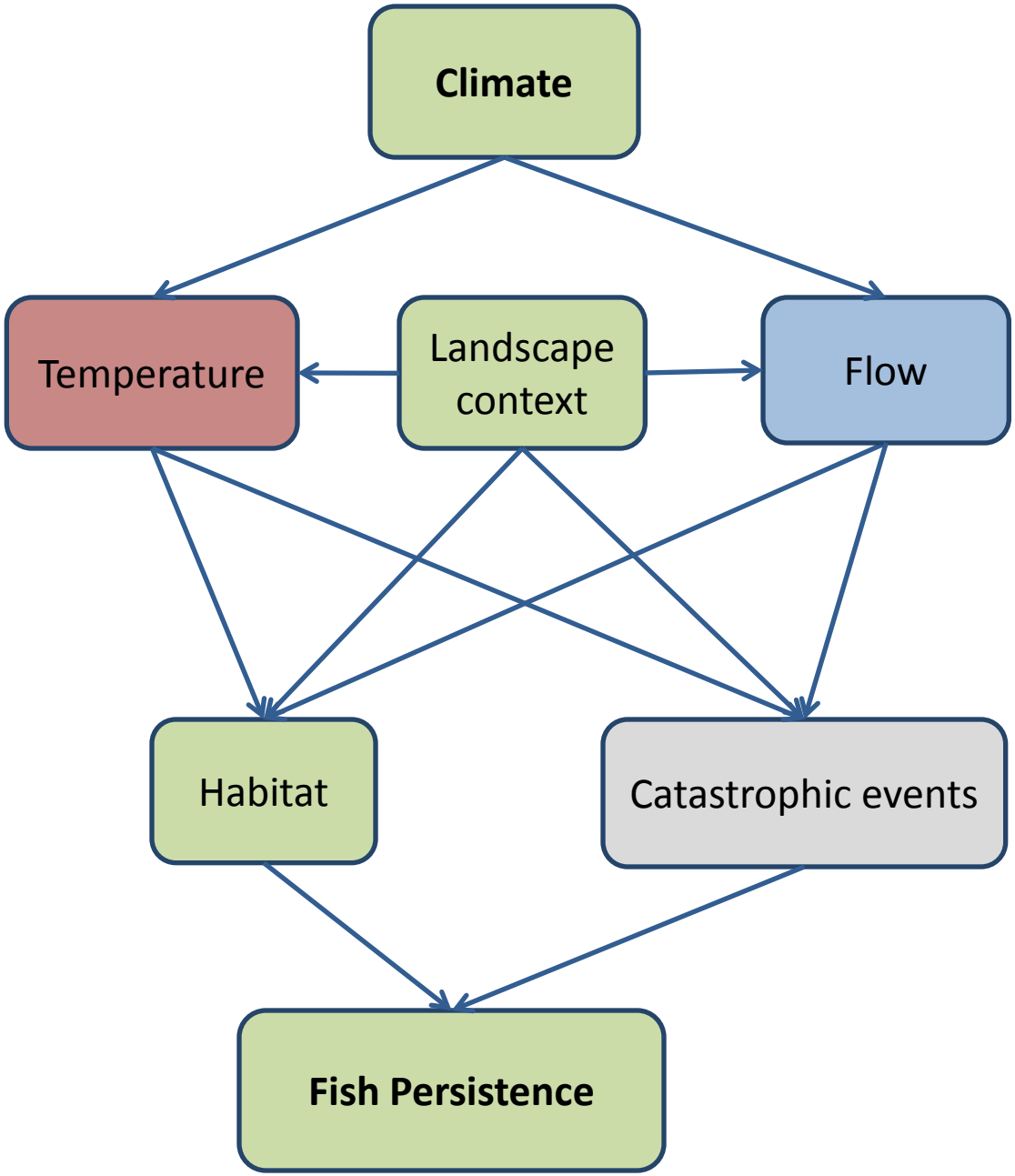
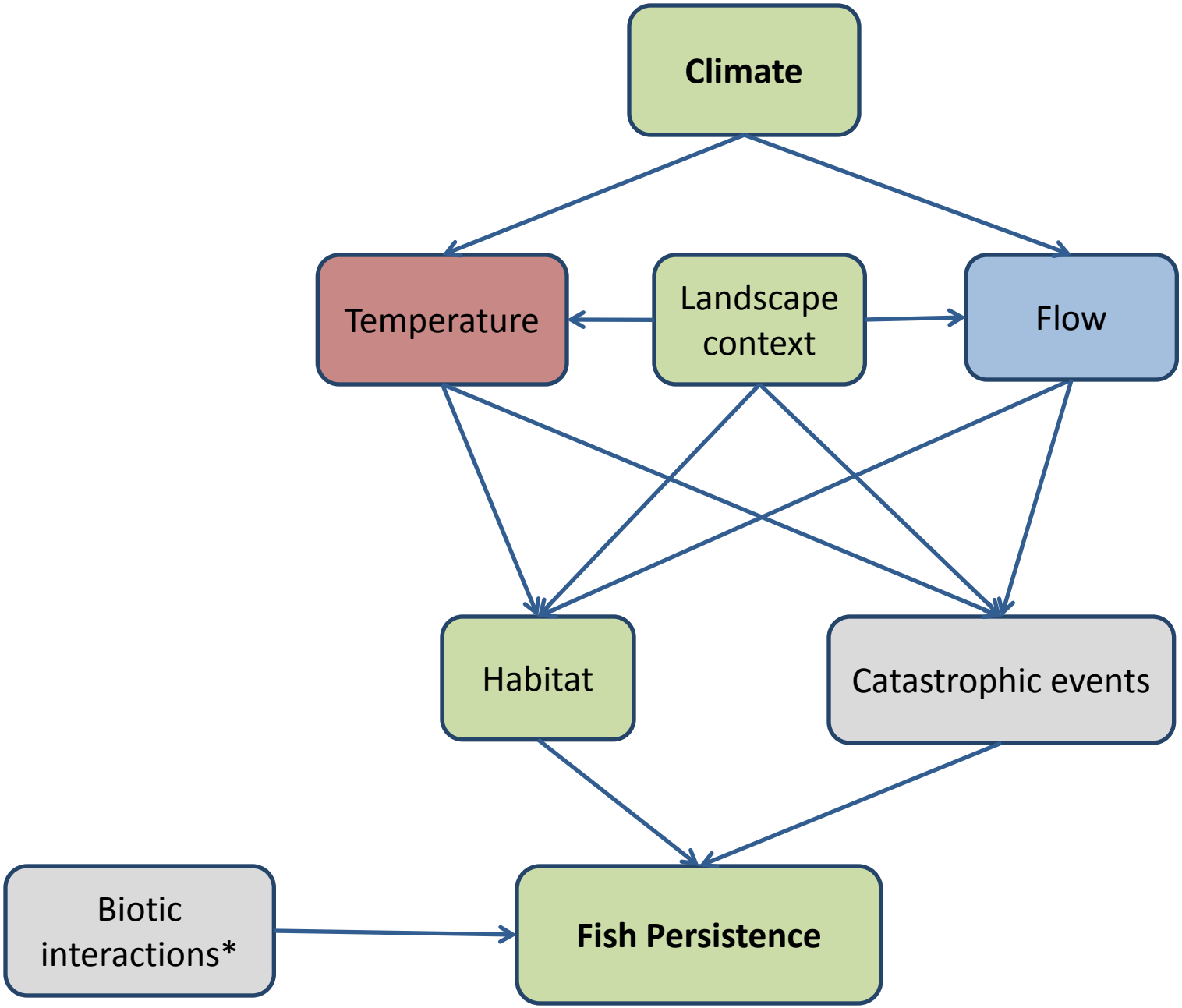
Climate

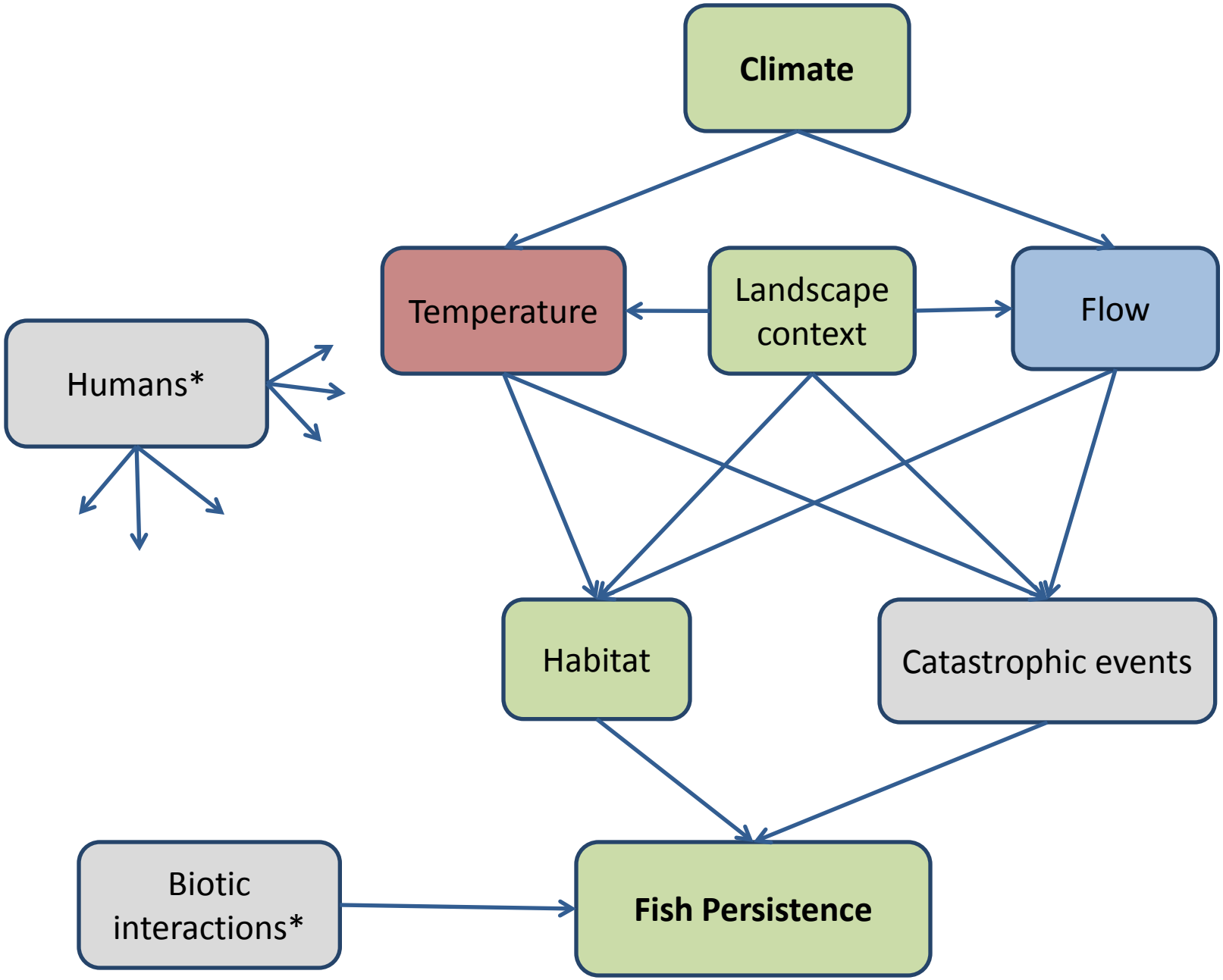
Fish Persistence


Climate
Temperature
Flow
Habitat
Fish Persistence

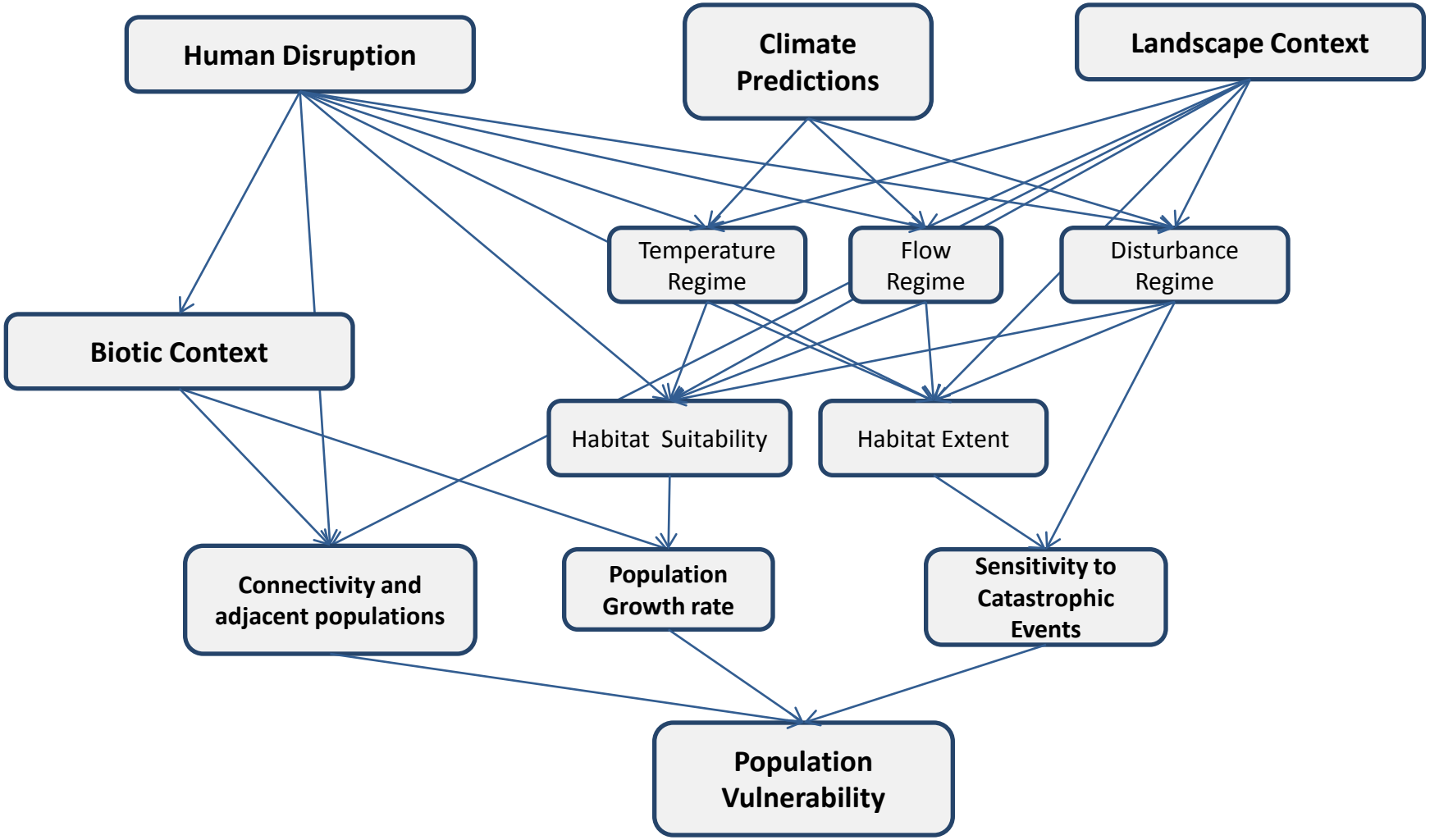

Climate
Temperature
Flow
Habitat
Catastrophic events
Fish Persistence


Climate
Temperature
Landscape context
Flow
Habitat
Catastrophic events
Fish Persistence

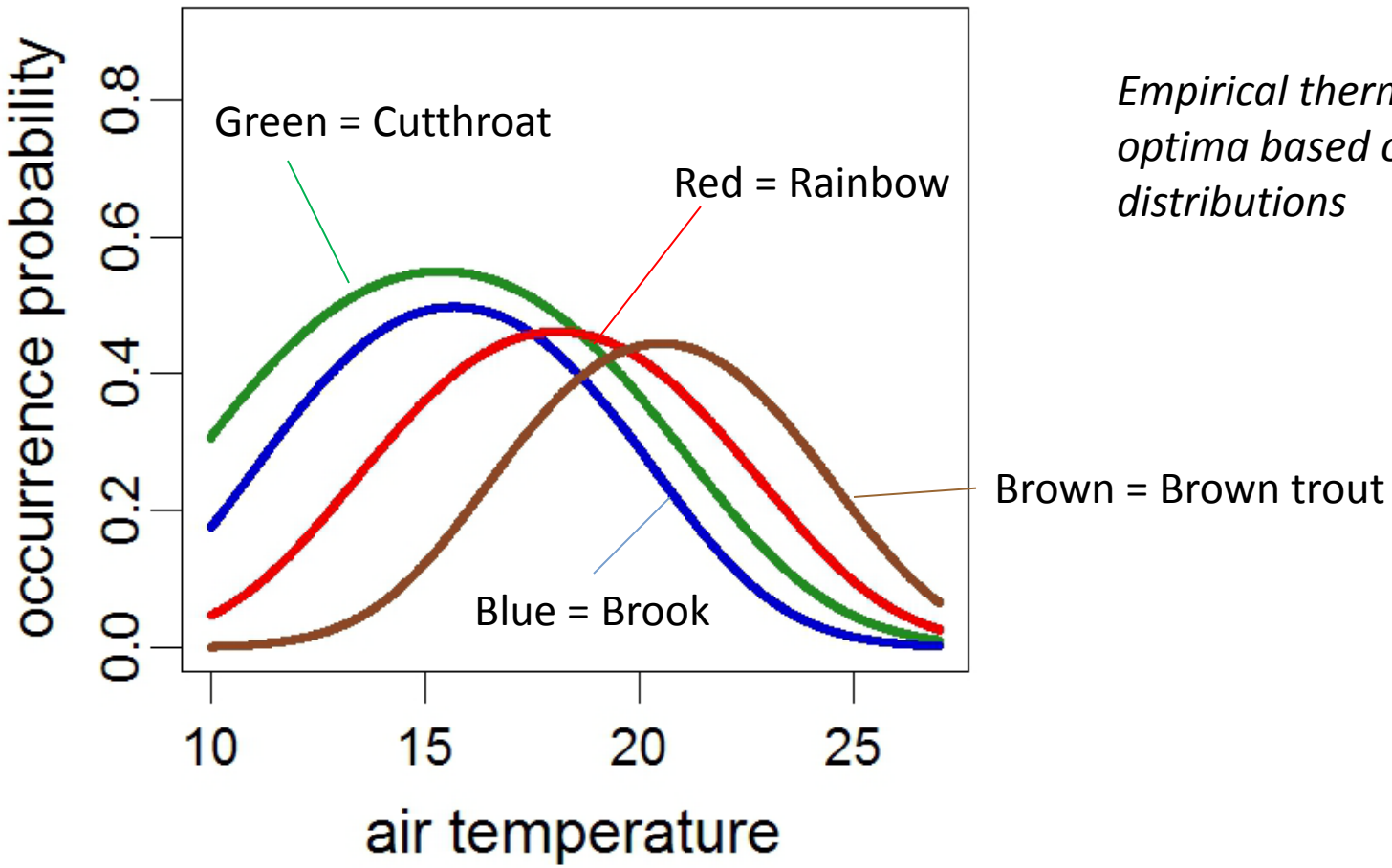

Climate
Temperature
Landscape context
Flow
Habitat
Catastrophic events
Biotic interactions*
Fish Persistence


Climate
Temperature
Landscape context
Flow
Humans*
Habitat
Catastrophic events
Biotic interactions*
Fish Persistence

Or (more or less) equivalently:



Temperature and fish



Empirical thermal optima based on distributions

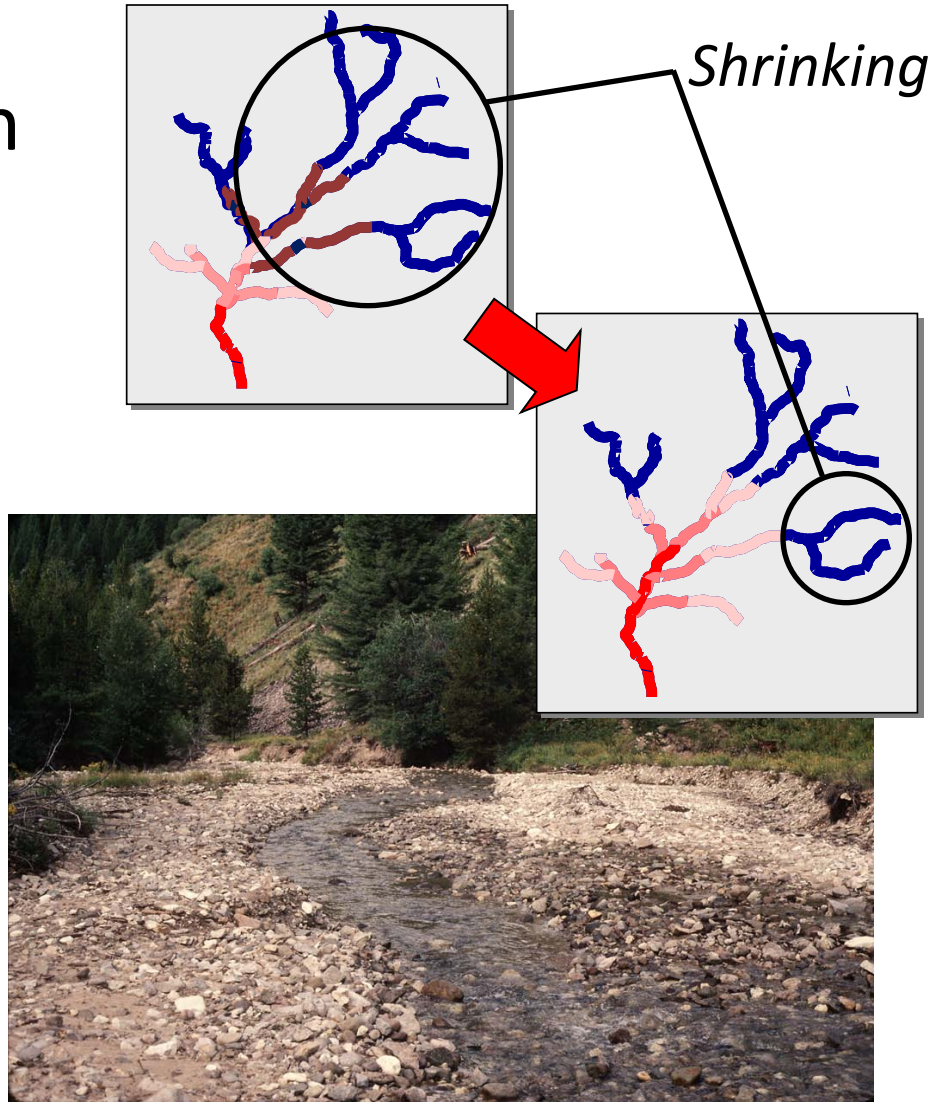
Timing: migrations, spawning, incubation

- Changes in migration timing to avoid high temperatures
- Shorter incubation times
- Potential de-synchronization with prey availability

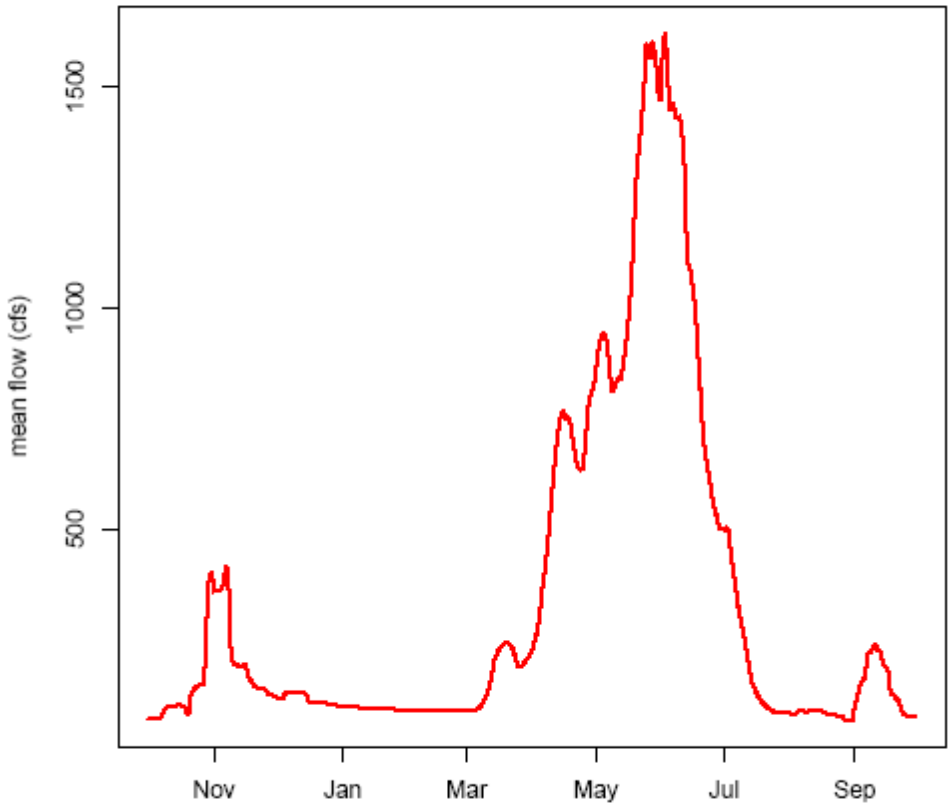
- Traits related to timing are usually very plastic

Flow and fish: low flows

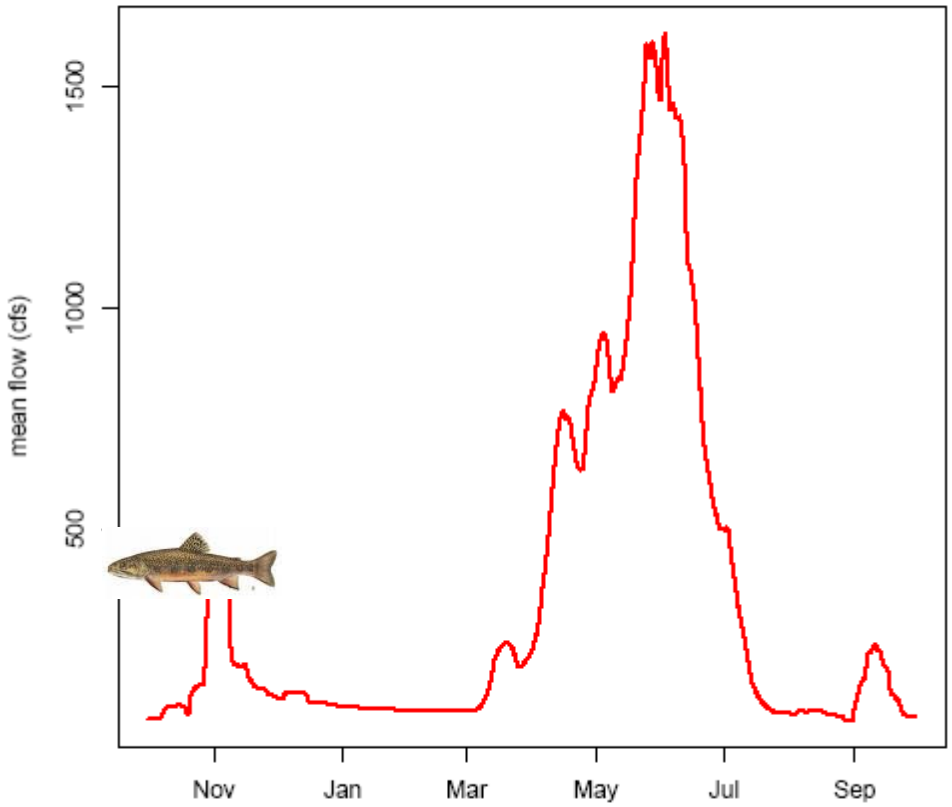
- Less water = fewer fish
- Less water = warmer water
- Reduced access, restricted movement



Flow and fish: high flows



Flow and fish: high flows



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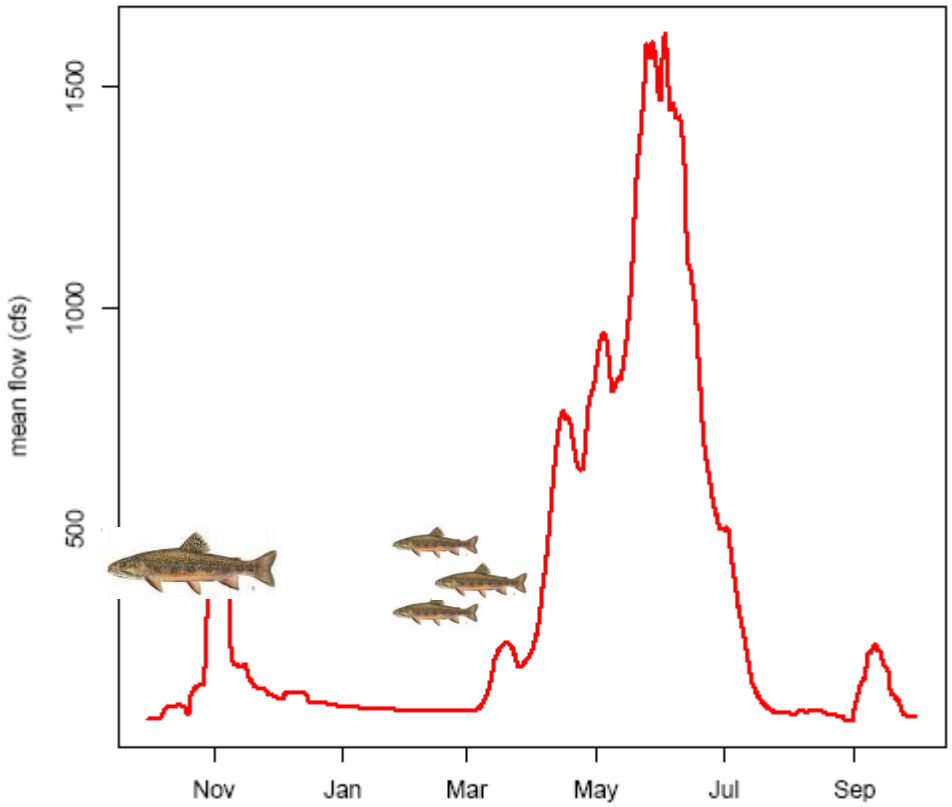
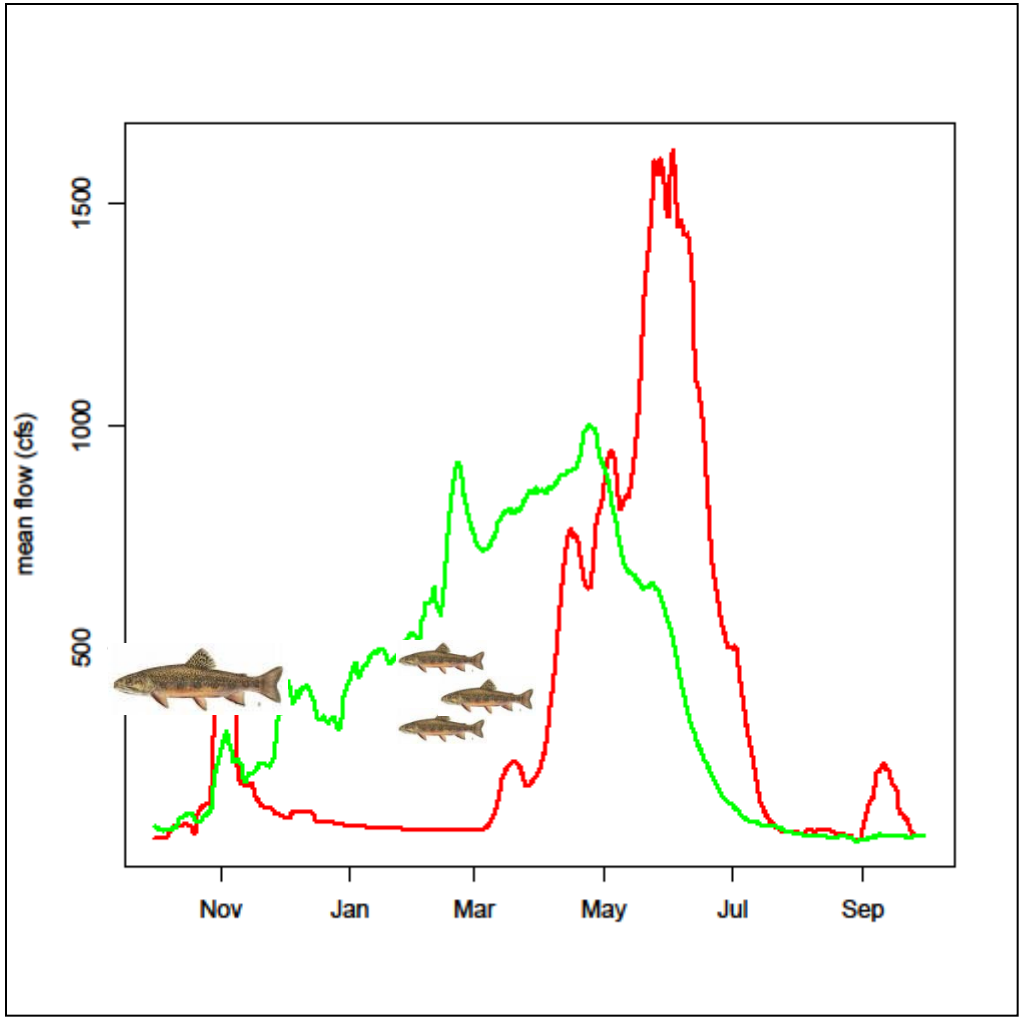
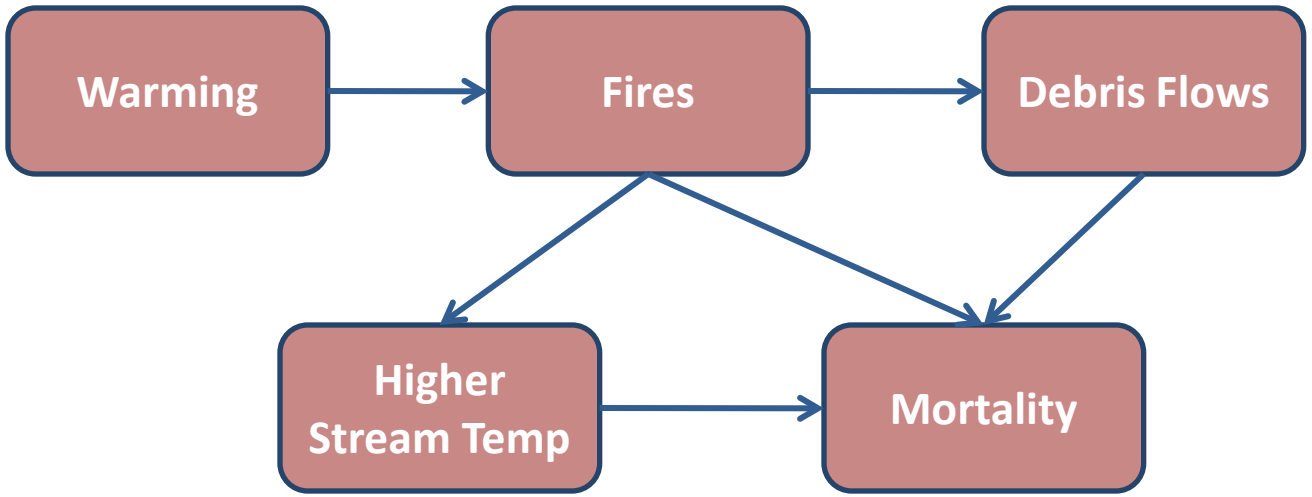


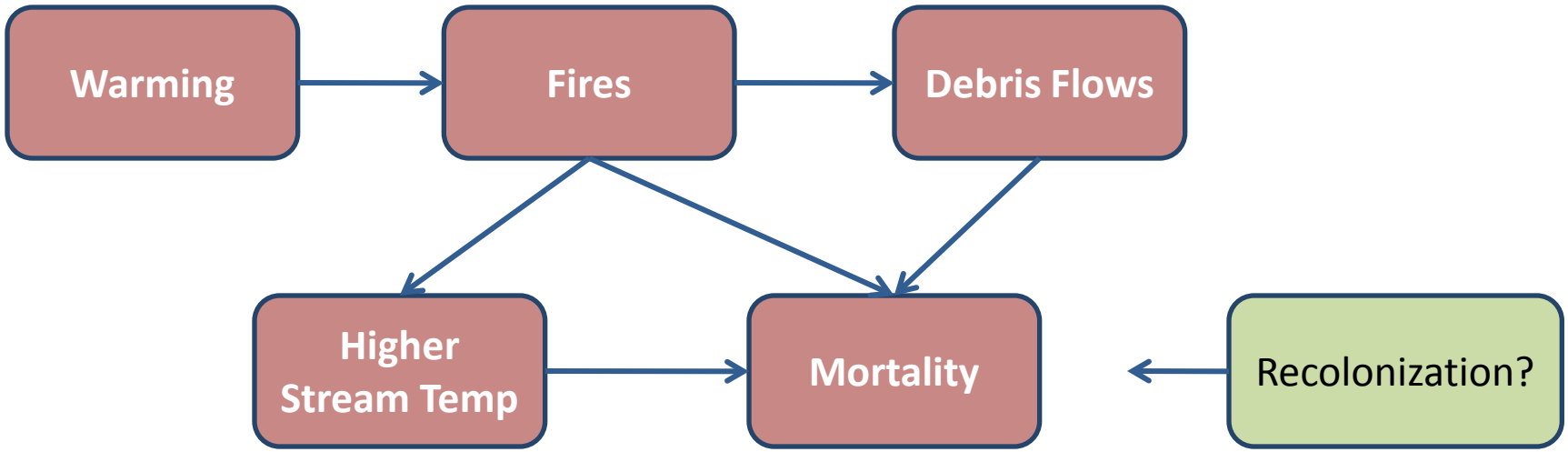
Flow and fish: high flows



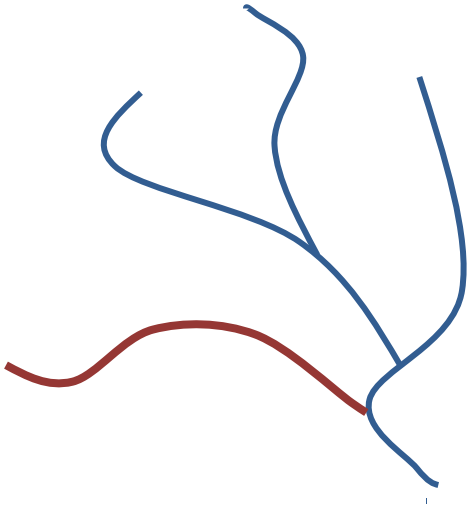
Catastrophic events



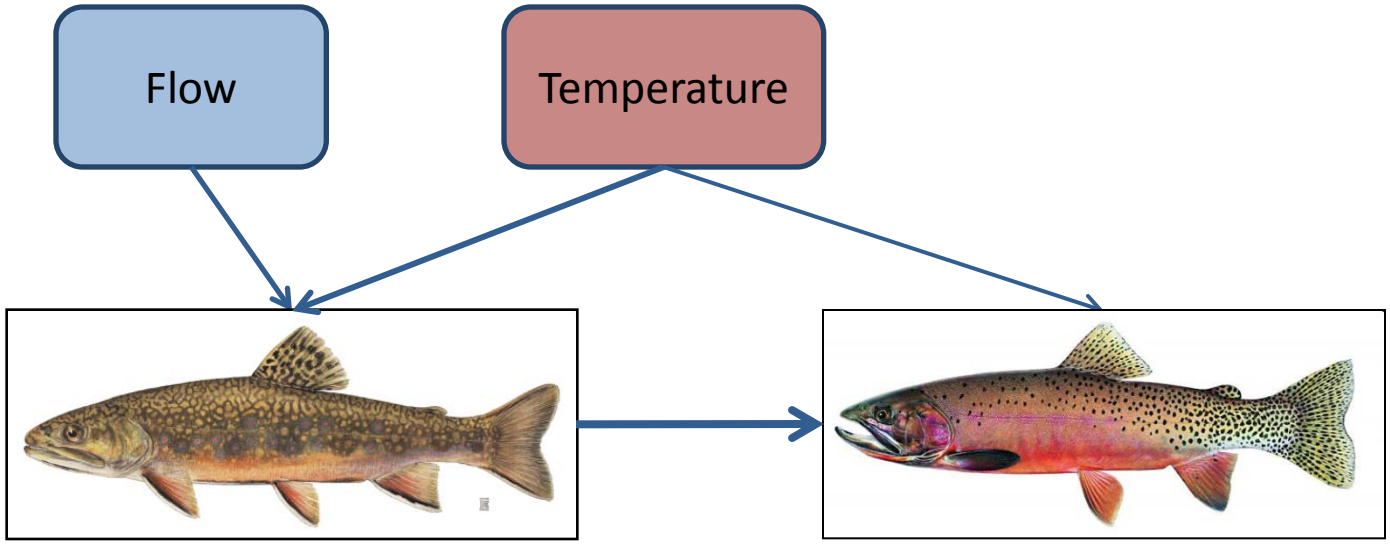
Catastrophic events



Impact depends on size and connectivity of habitat patches

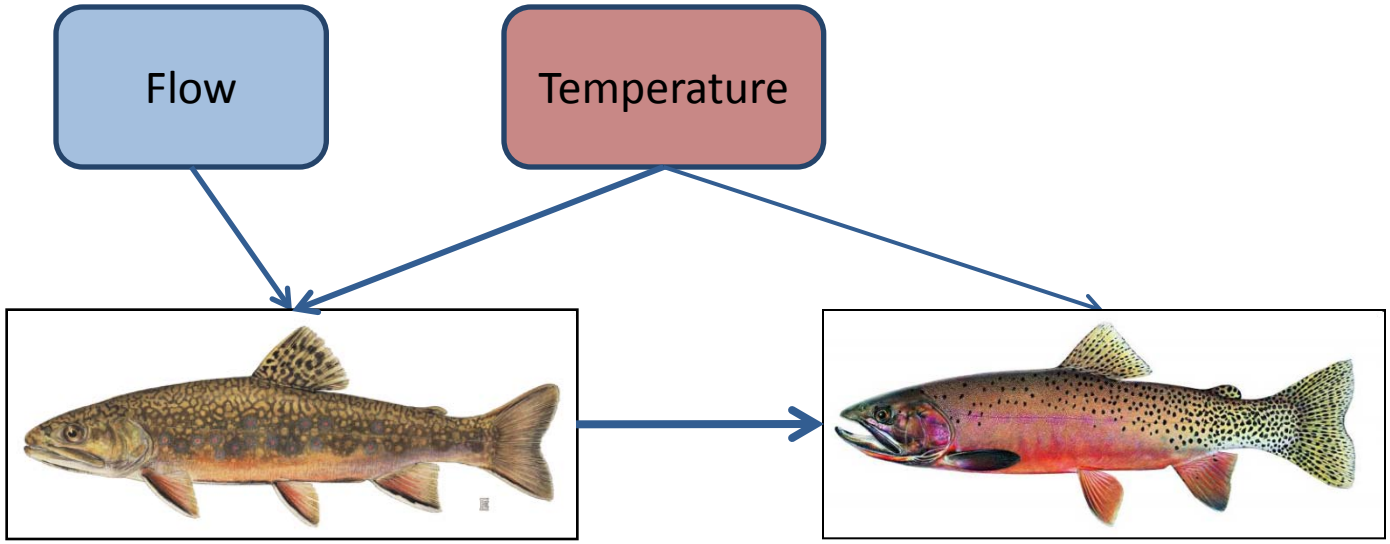


Biotic interactions



Cascading effects

Biotic interactions



Cascading effects

Potentially even more important: Disease

The missing evidence

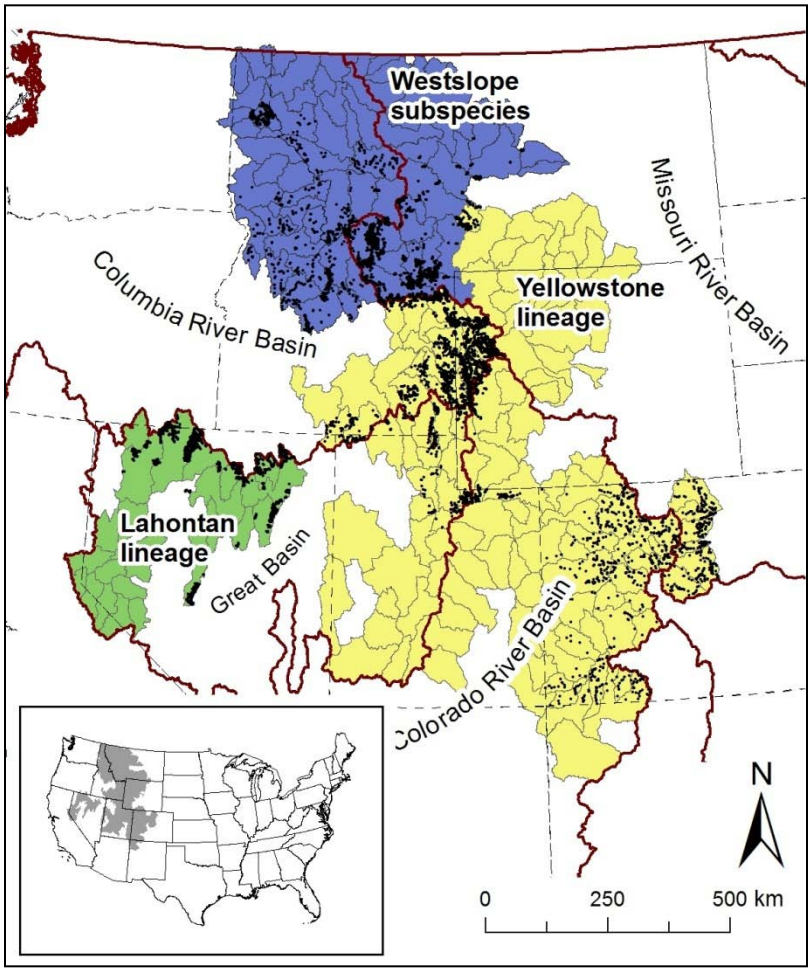
- Few documented cases of population losses due to climate change. Why?
  - Maybe we're not looking in the right places
  - Maybe changes aren't gradual, but punctuated
  - Maybe fish are resilient / adapting
  - Maybe we have the wrong model– do we really understand the process?

Adaptation & Evolution

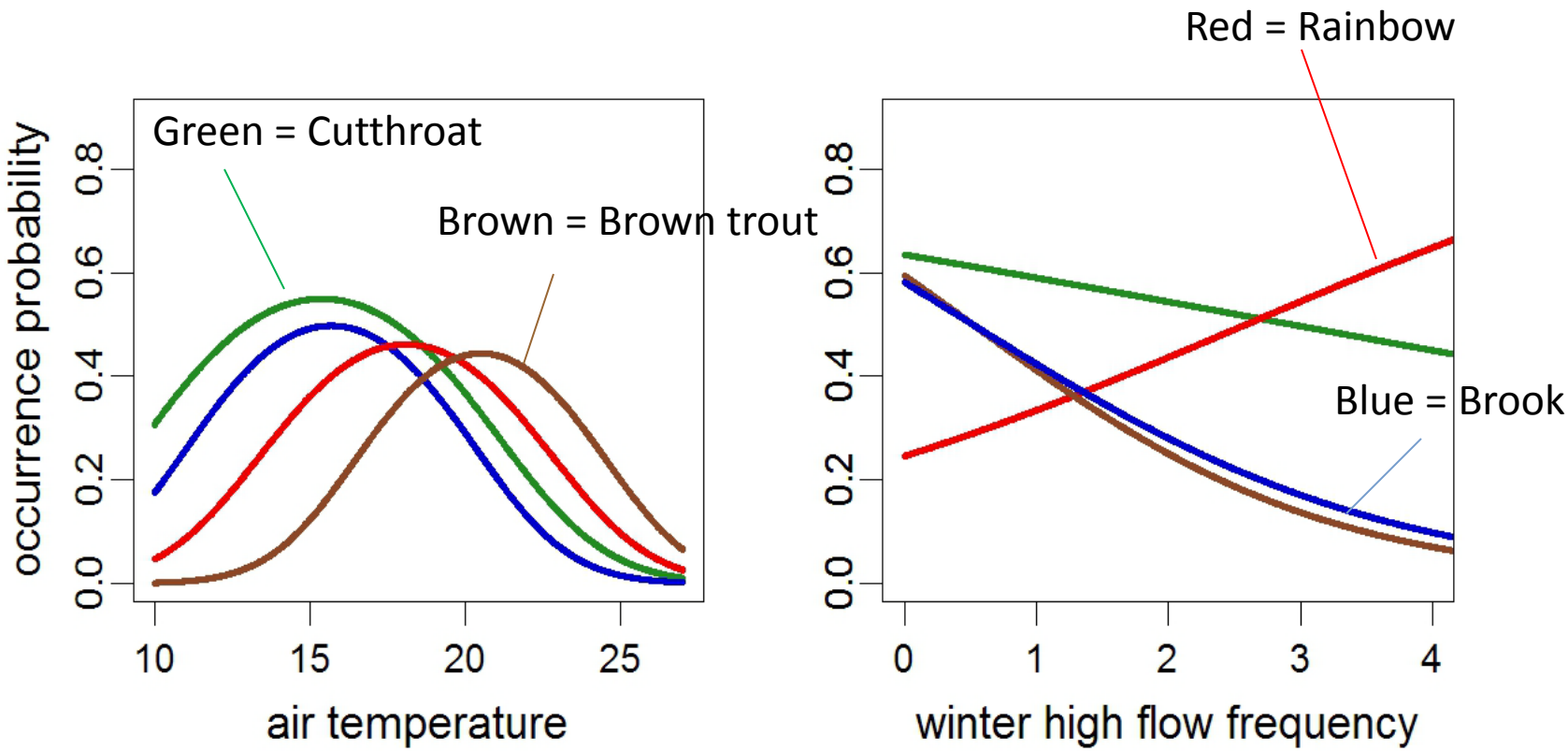
- Most fish are very plastic in behaviors
- Even if you can adapt or evolve, if someone else is better adapted, you still lose
- Need to retain diversity in life history expression and potential for evolution

Study: climate effects on trout

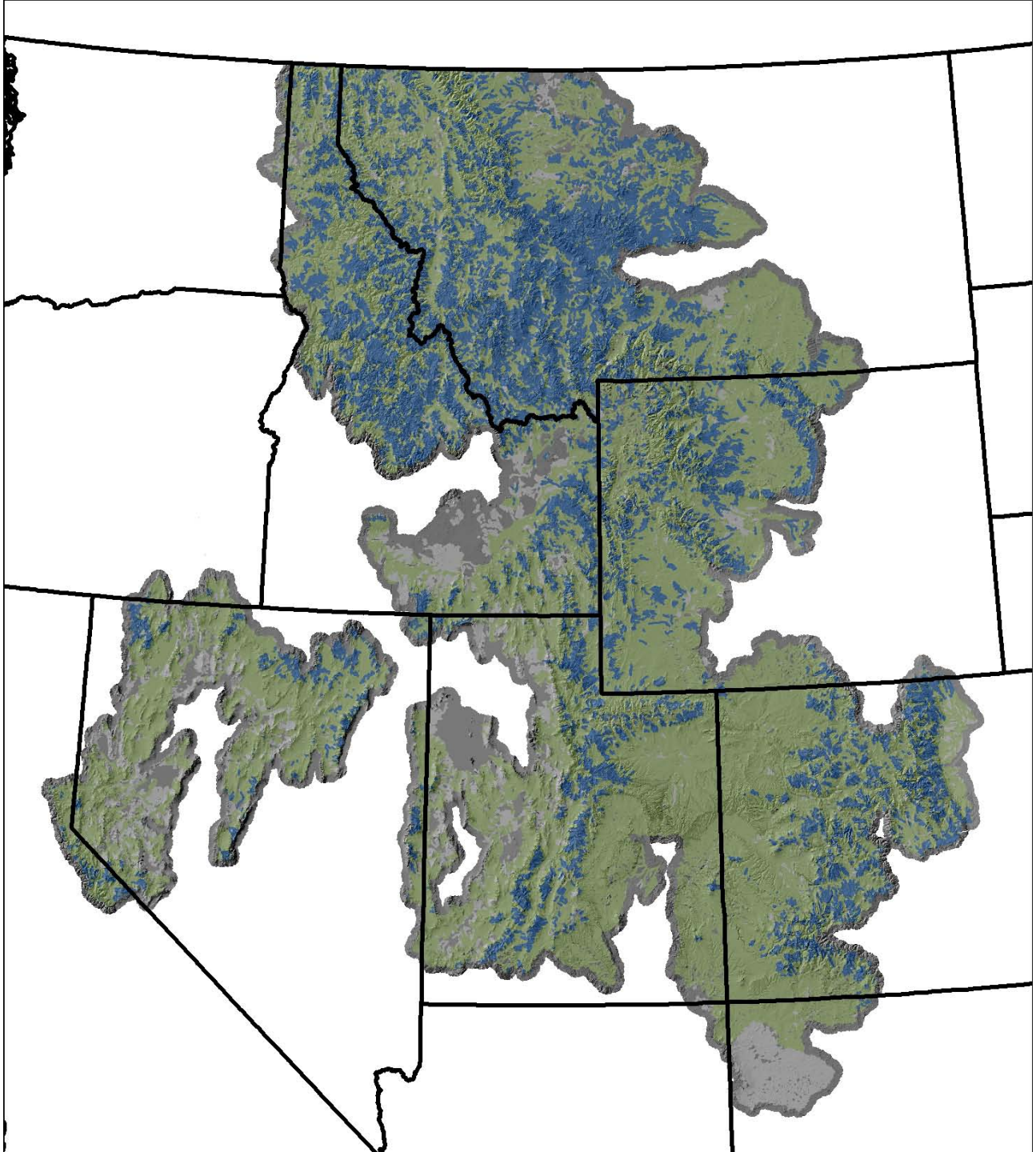
- 9890 sites
- Four species
- GCM predictions of temperature, flow
- Correlation analysis of empirical relations



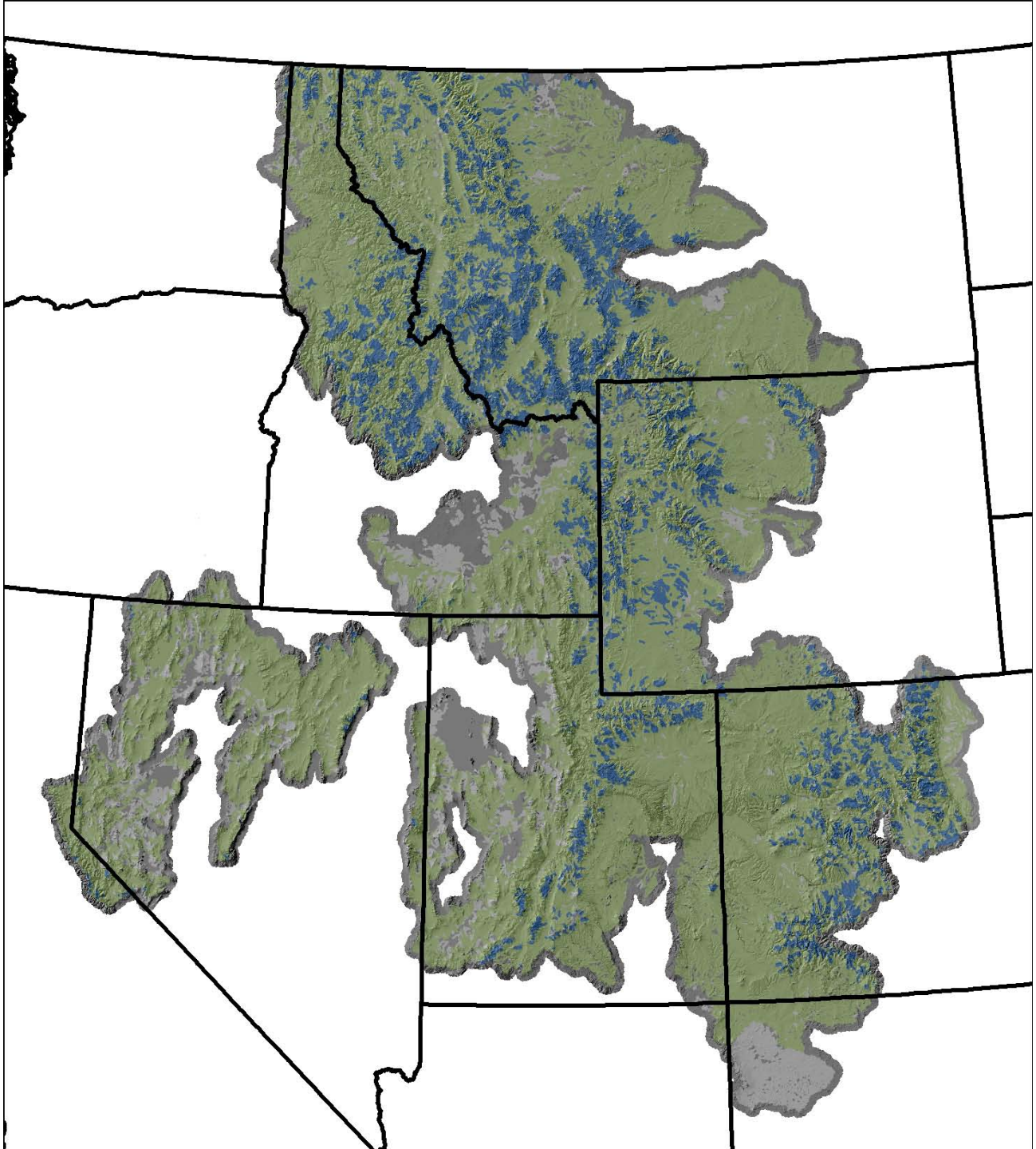
Empirical fish-climate relations



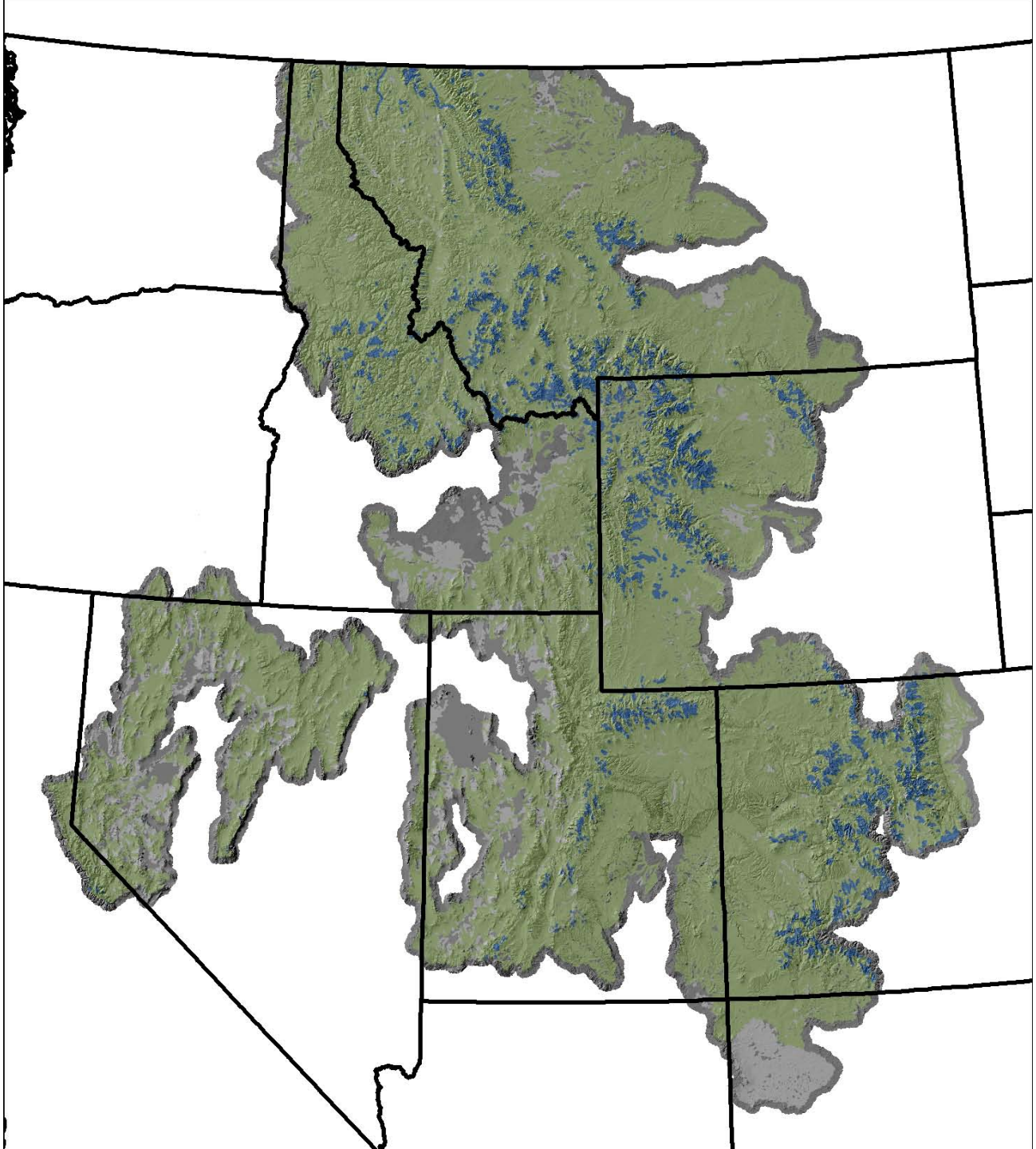
Also: strong negative biotic interactions on cutthroat trout



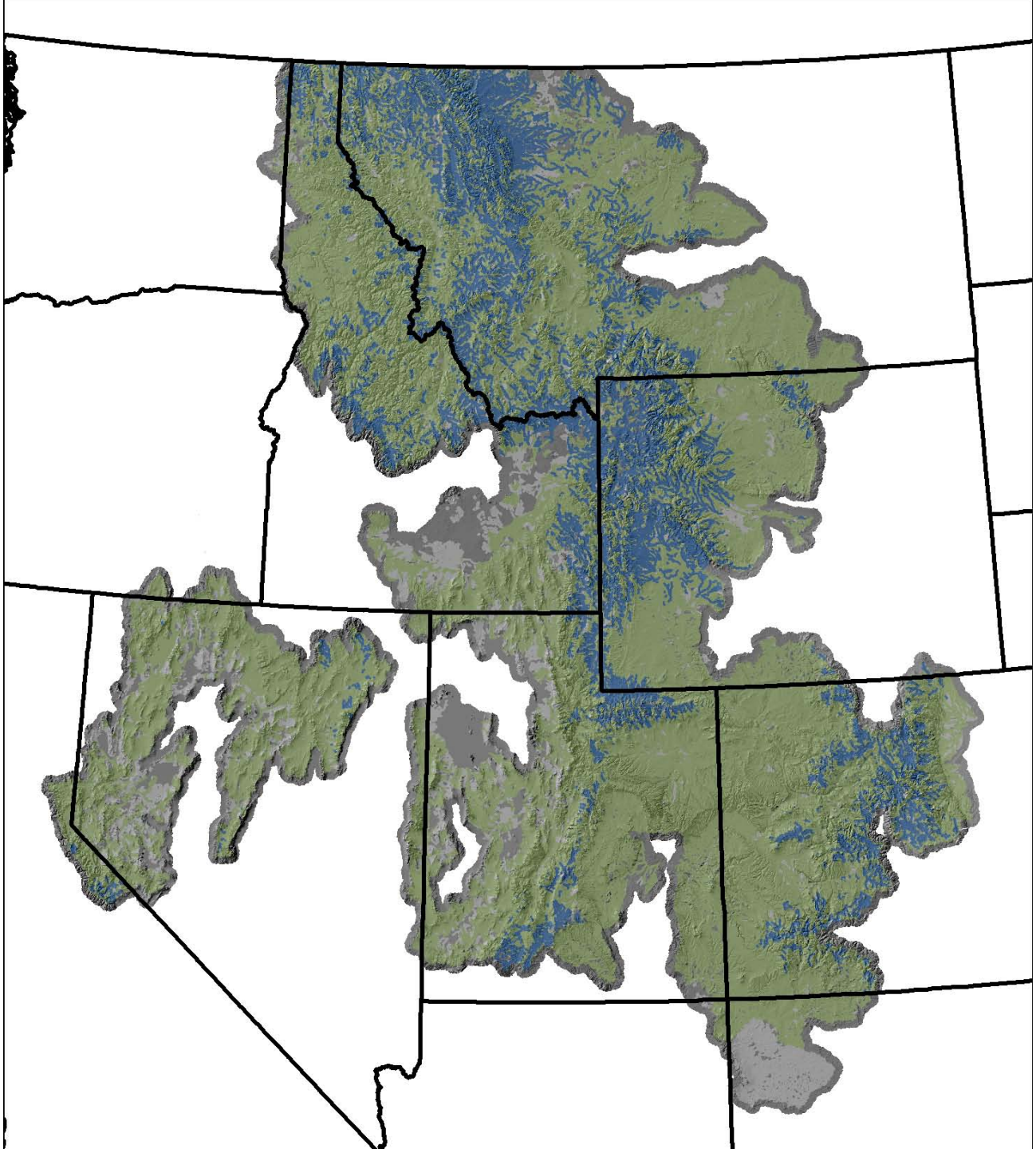
Cutthroat current



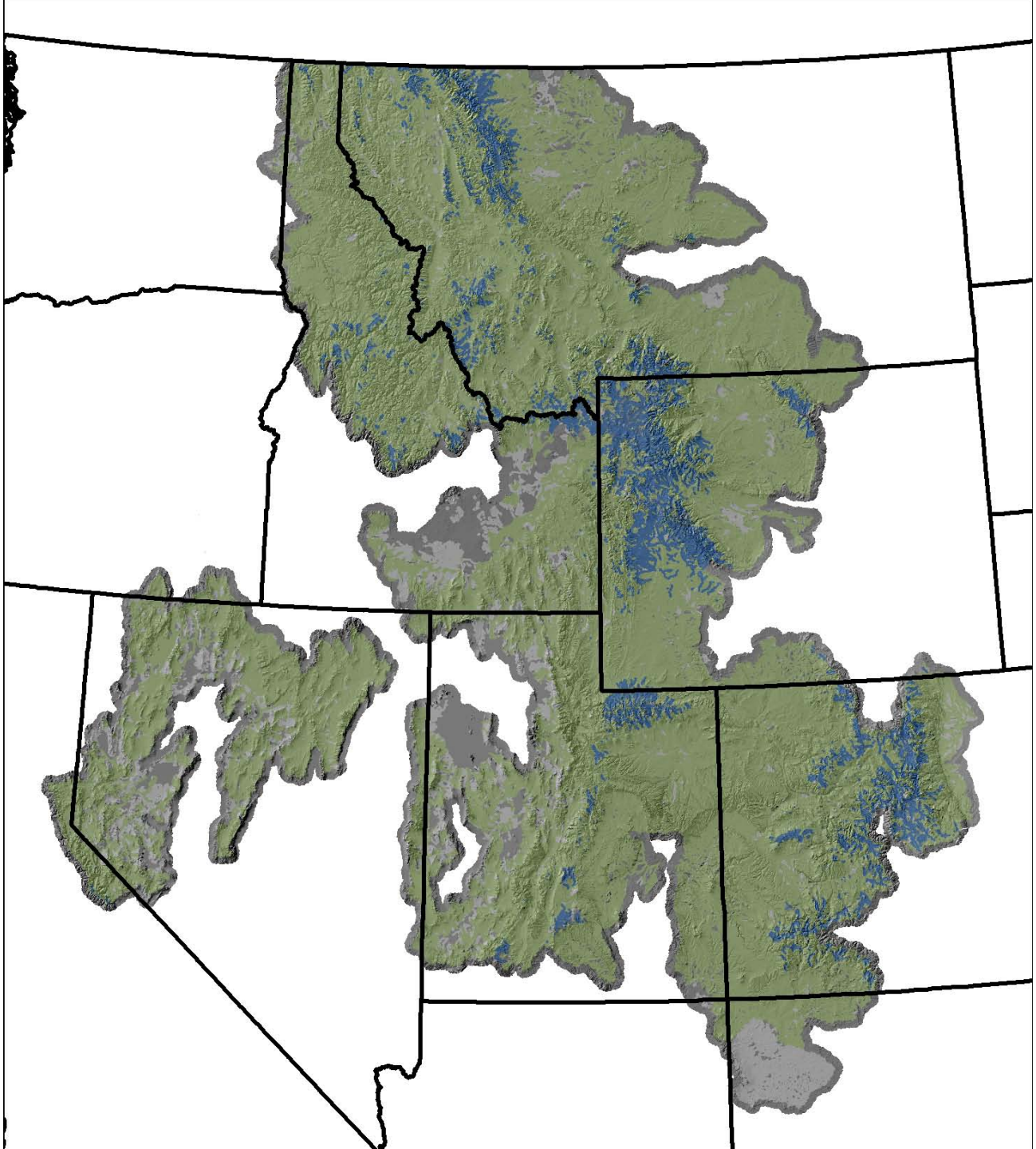
Cutthroat
2040s



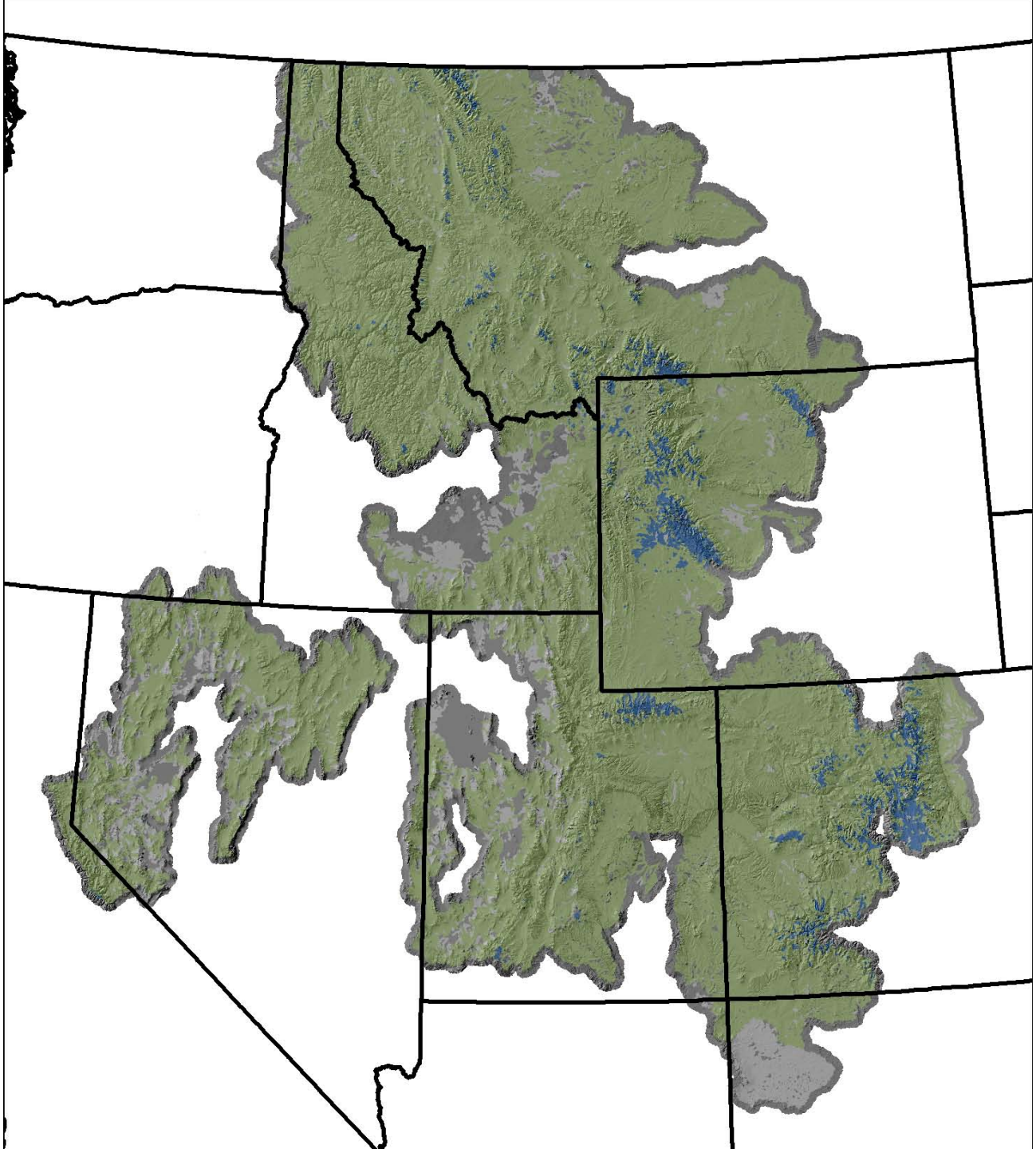
Cutthroat
2080s



Brook current



Brook
2040s



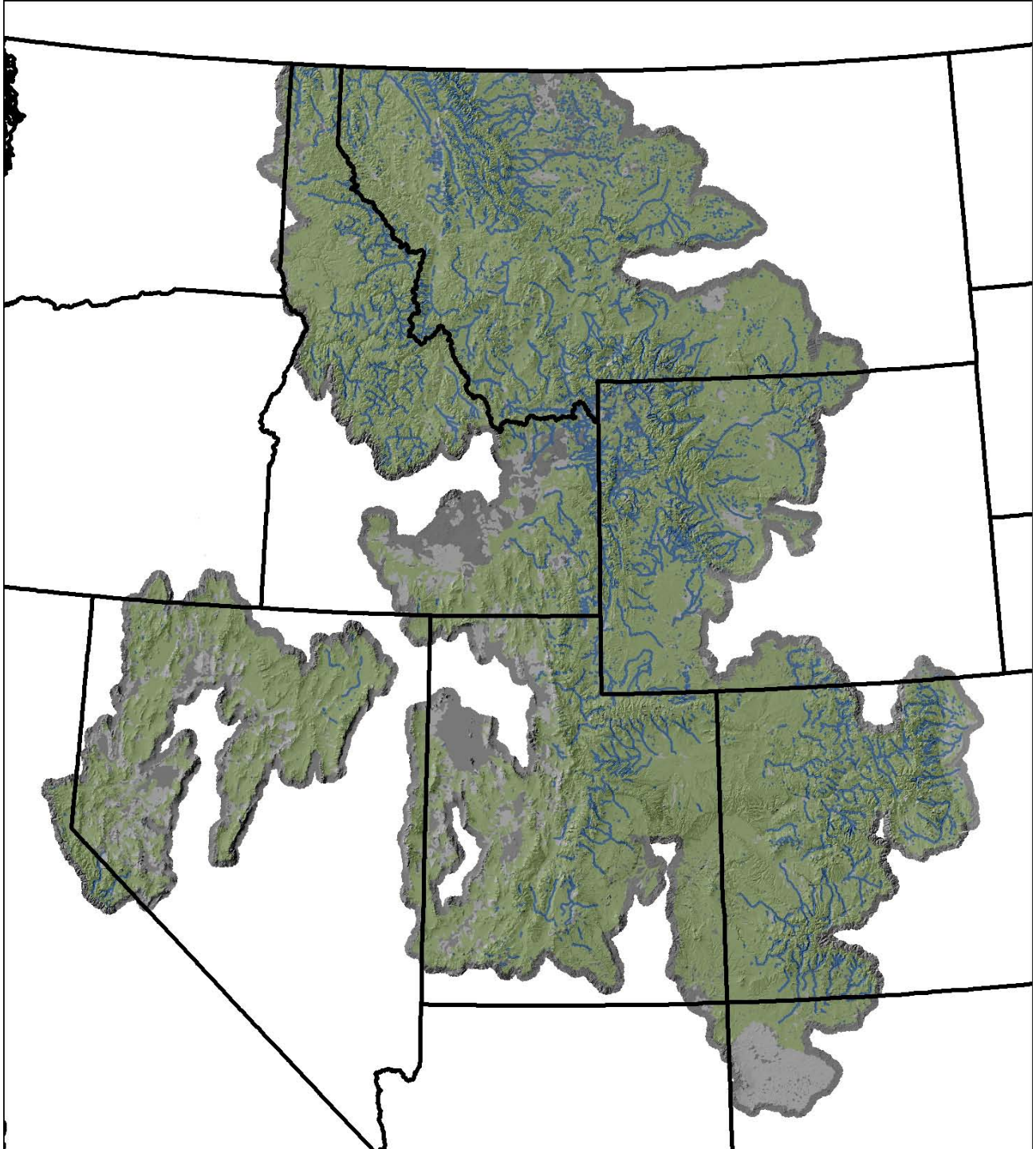
Brook
2080s

Rainbow current

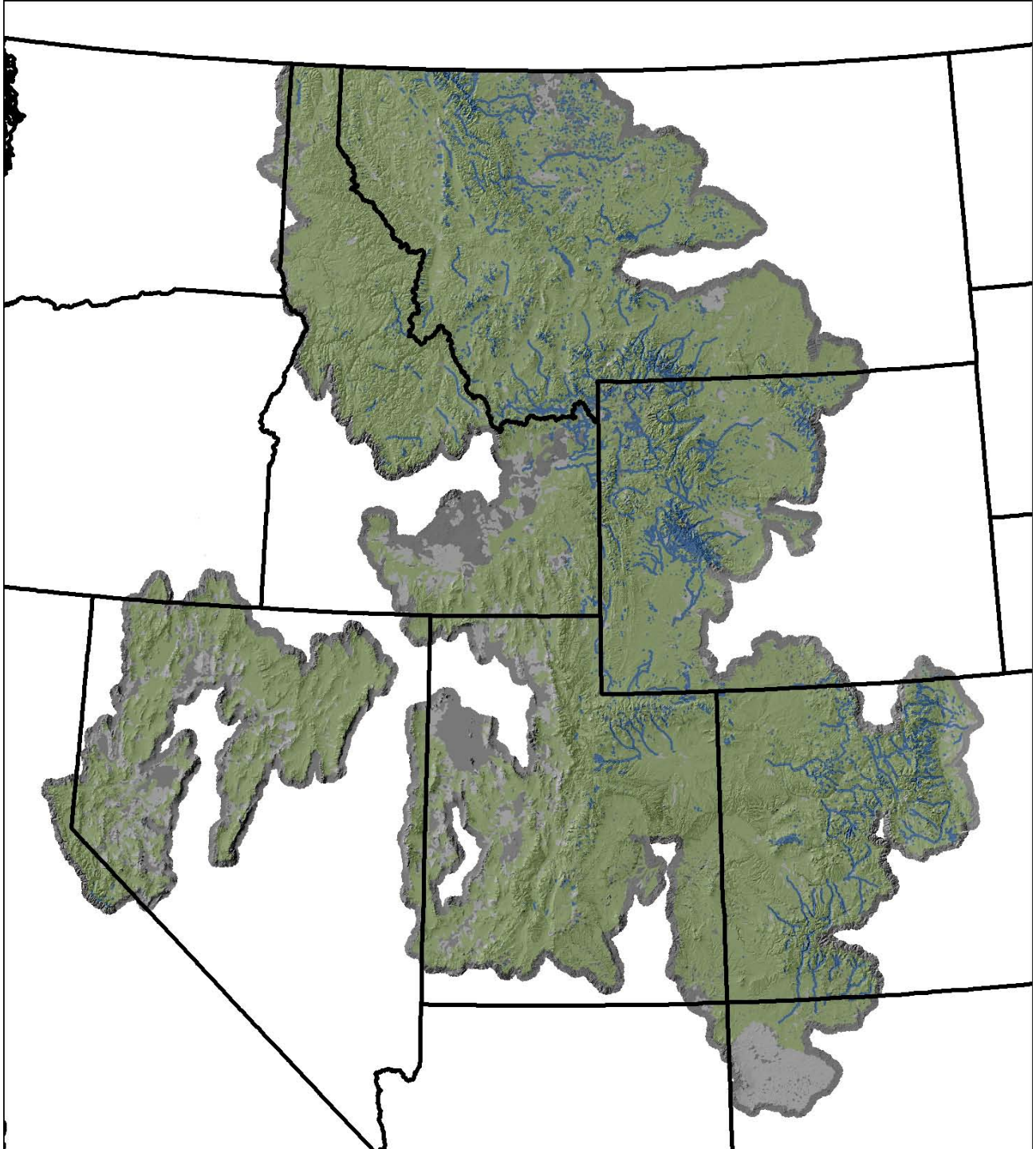
Rainbow
2040s

Rainbow
2080s

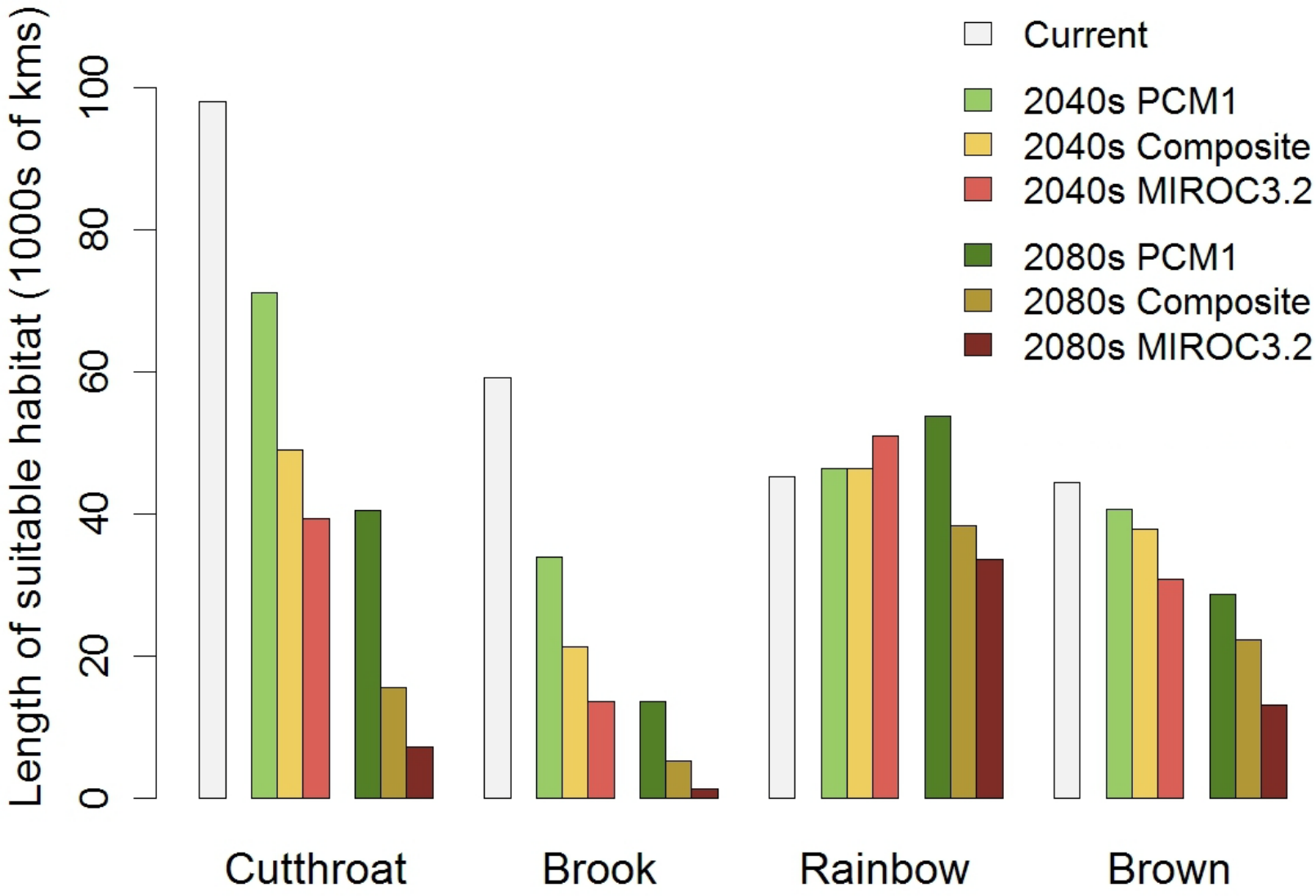
Brown current

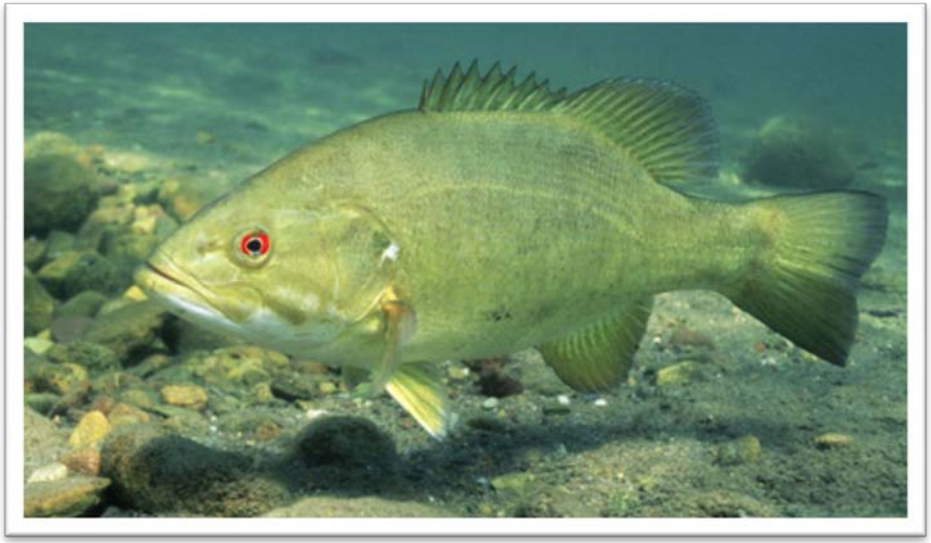


Brown
2040s



Brown
2080s


Length of suitable habitat (1000s of kms)
0
20
40
60
80
100
Current
2040s PCM1
2040s Composite
2040s MIROC3.2
2080s PCM1
2080s Composite
2080s MIROC3.2
Cutthroat
Brook
Rainbow
Brown

The big picture

- Over the next century, we expect to see a shift from cold-water fish to cool-water fish and warm-water fish, except at high elevations