Use of biological indicators in hydromodification monitoring

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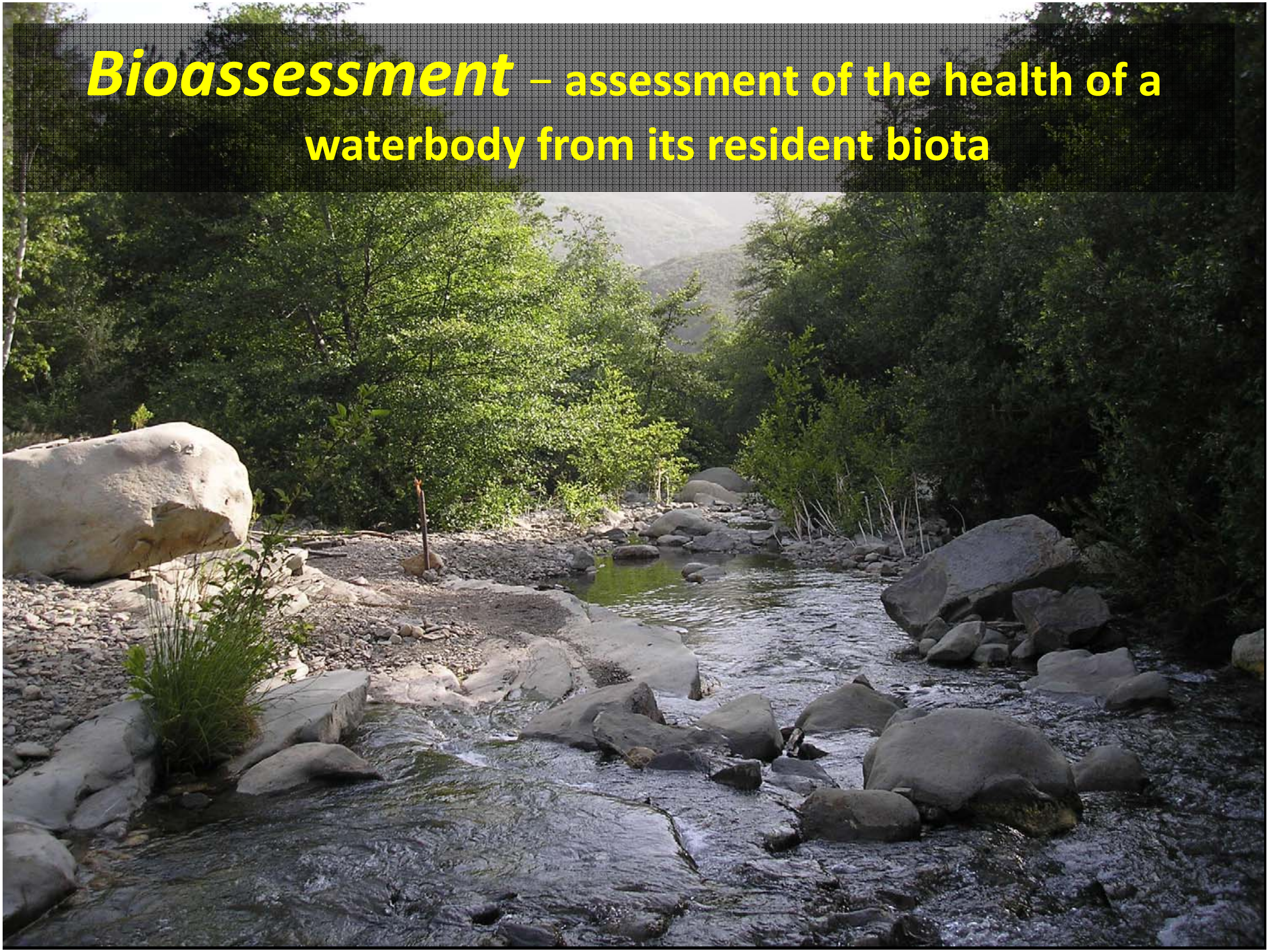
- **Bioassessment fundamentals**
- **Biological responses to hydromodification**
- **Current research priorities**

Bioassessment – assessment of the health of a waterbody from its resident biota



Why Develop Ecological Indicators?

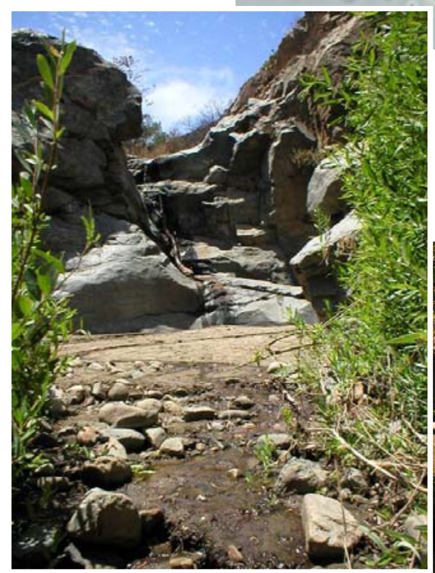
- Global paradigm shift toward ecological indicators
- Provide direct evidence about resources we are trying to protect
- Integrate information about **chemical** and **non-chemical** stressors over time
- Links resource protection across multiple agencies by focus on ultimate policy goals

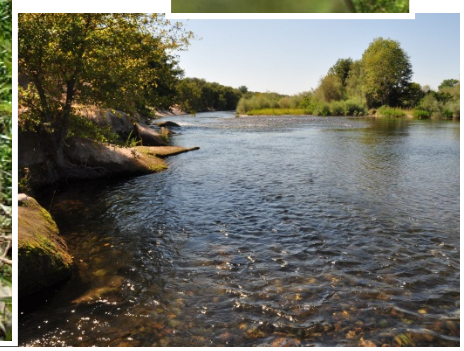
CA’s Ecological Indicators

Multiple Indicators – BMIs, algae, (fish), riparian vegetation

Multiple waterbody types – large rivers, non-perennial streams, lakes, wetlands

Start with invertebrates and perennial streams





invertebrates:
the backbone of bioassessment

- ***Abundant***
- ***Diverse***
- ***Informative***

Standardized Bioassessment Infrastructure Elements

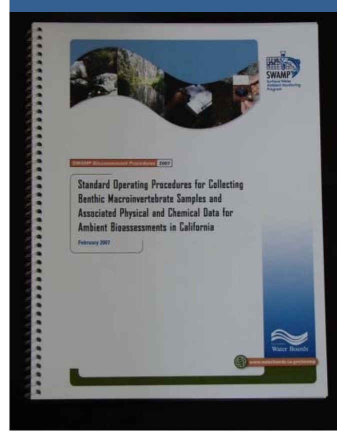
Surface Water Ambient Monitoring Program (SWAMP)

Field Methods


Data Management + Reporting

Lab Methods

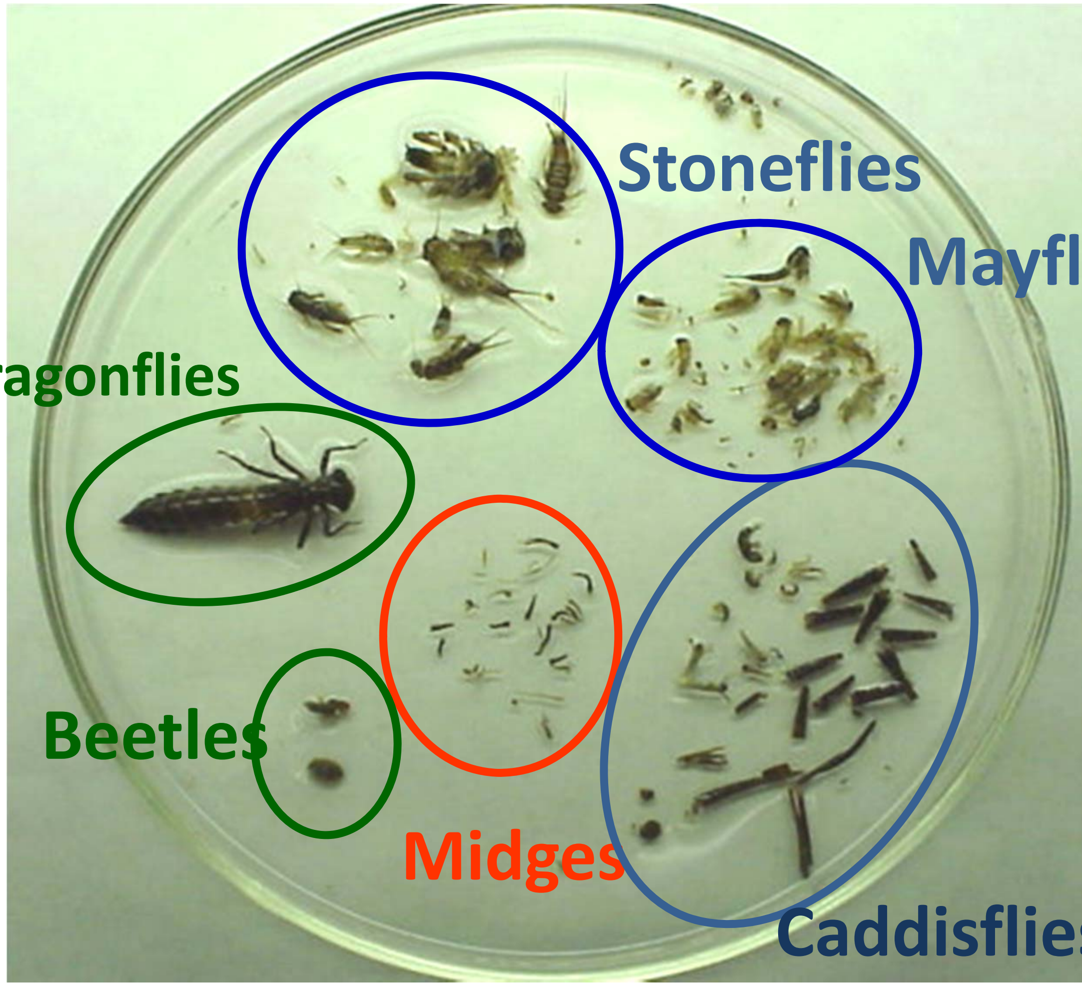

Quality Assurance Documentation



SWAMP
Surface Water Ambient Monitoring Program

Regulatory Biological Objectives

How do we convert a list of species into a condition score?

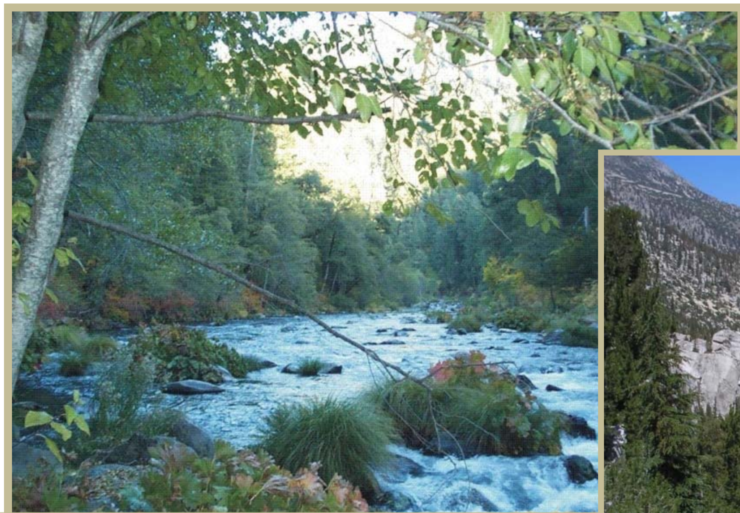


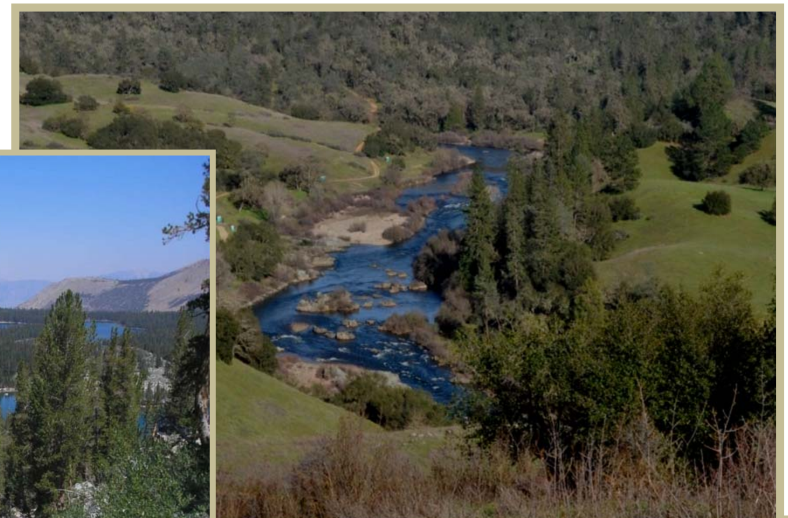
SWAMP
Surface Water Ambient Monitoring Program

Scoring Tools Depend on Reference Sites

(sites with low levels of disturbance)

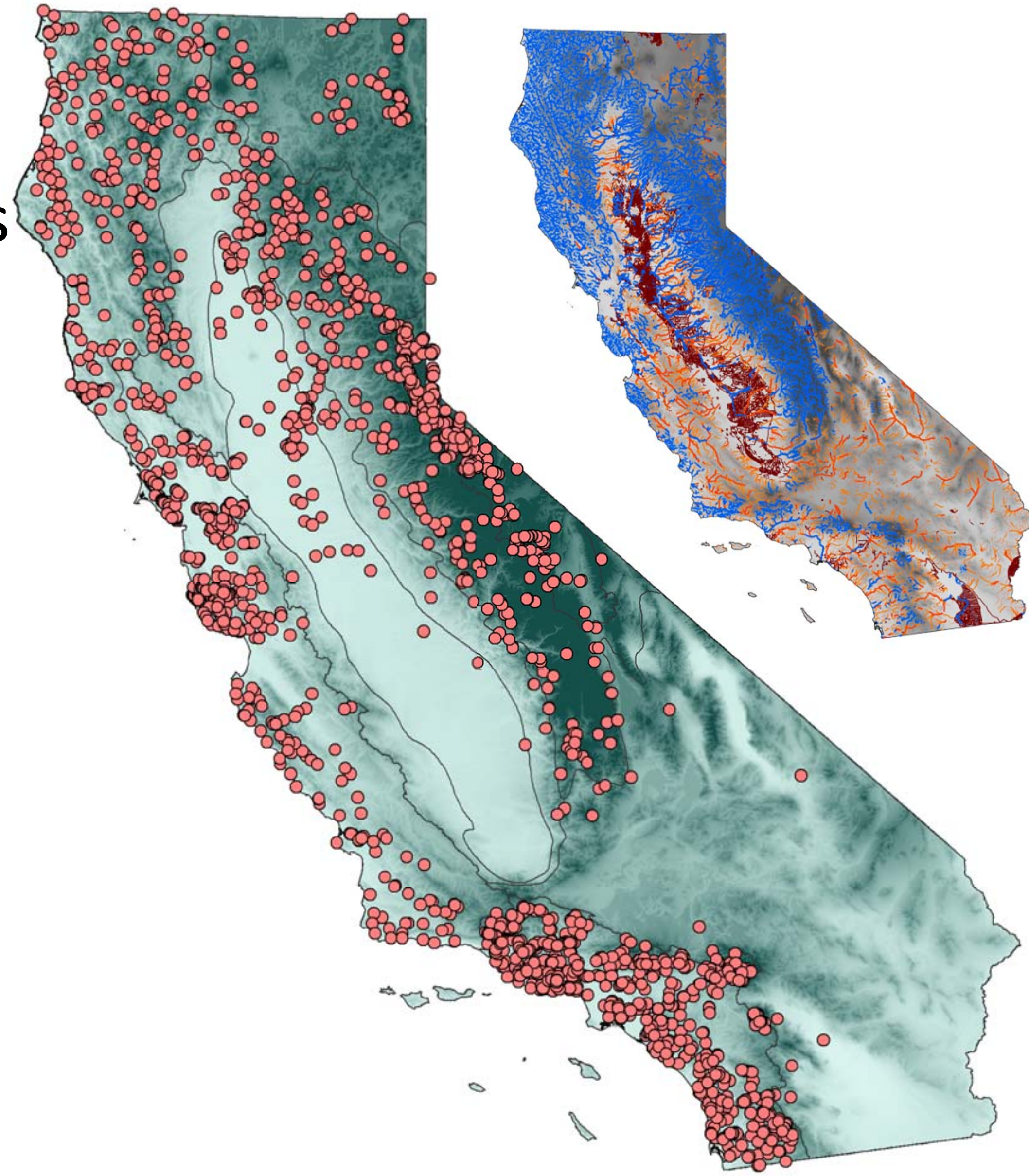
"What should the biology look like at a test site?"





Reference site selection

Screened > 2400
candidate reference sites



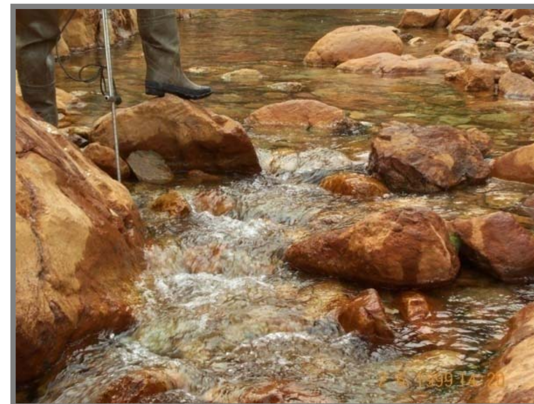
Objectives:

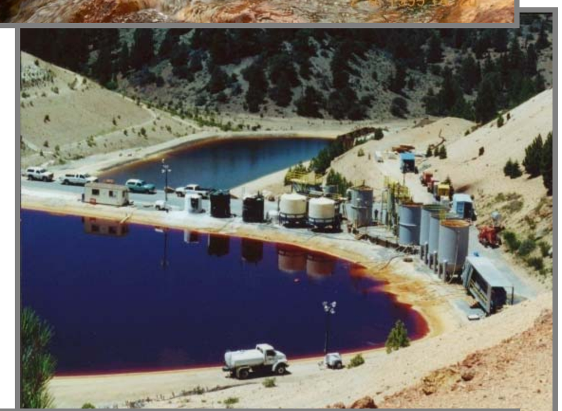
1. Reference pool represents CA stream diversity

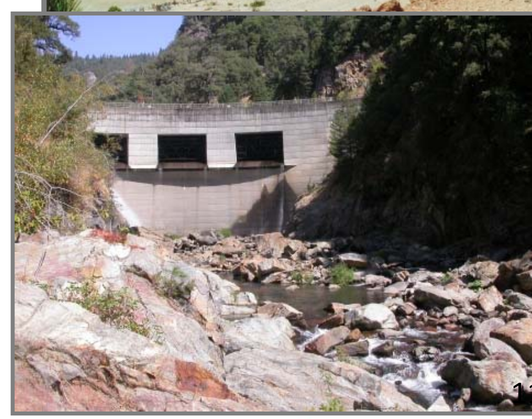
2. Biological at reference sites is minimally influenced by stress

Reference sites have few sources of human stress

- **Infrastructure**: roads, railroads
- **Population**
- **Hydromodification**
  - manmade channels, canals, pipelines
- **Landuse**
  - Ag/Urban development
  - Timber Harvest, Grazing
- Fire history, dams, mines
- 303d list, known discharges
- Invasive invertebrates, plants
- **Instream and riparian habitat**
- **Water chemistry**

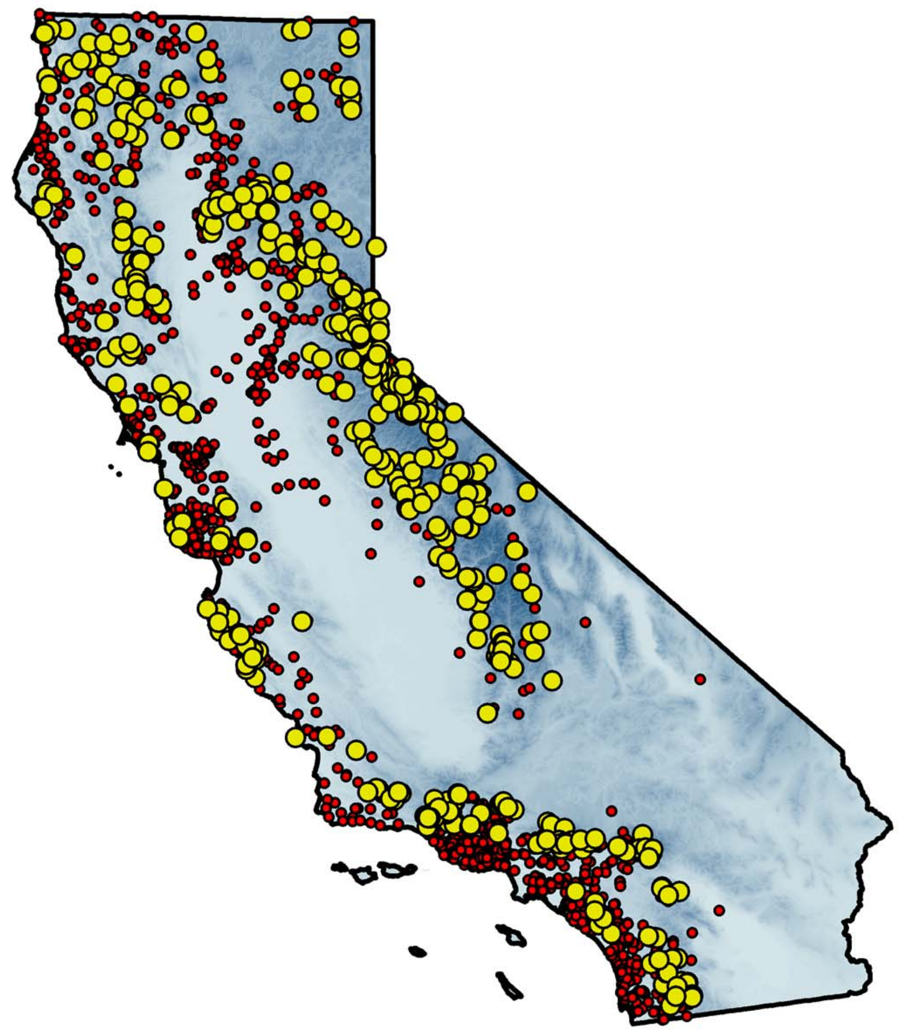




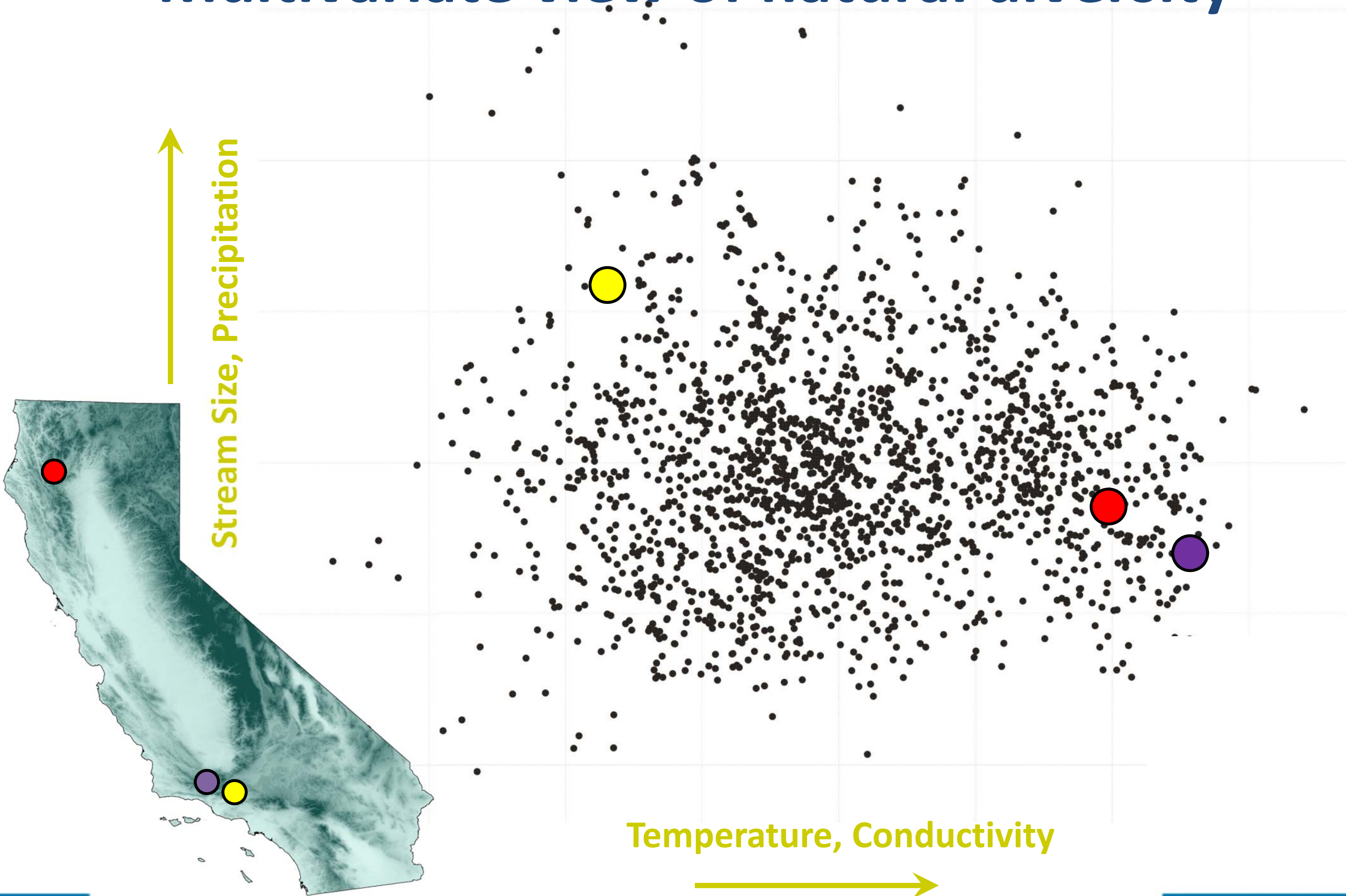


Very good geographic coverage

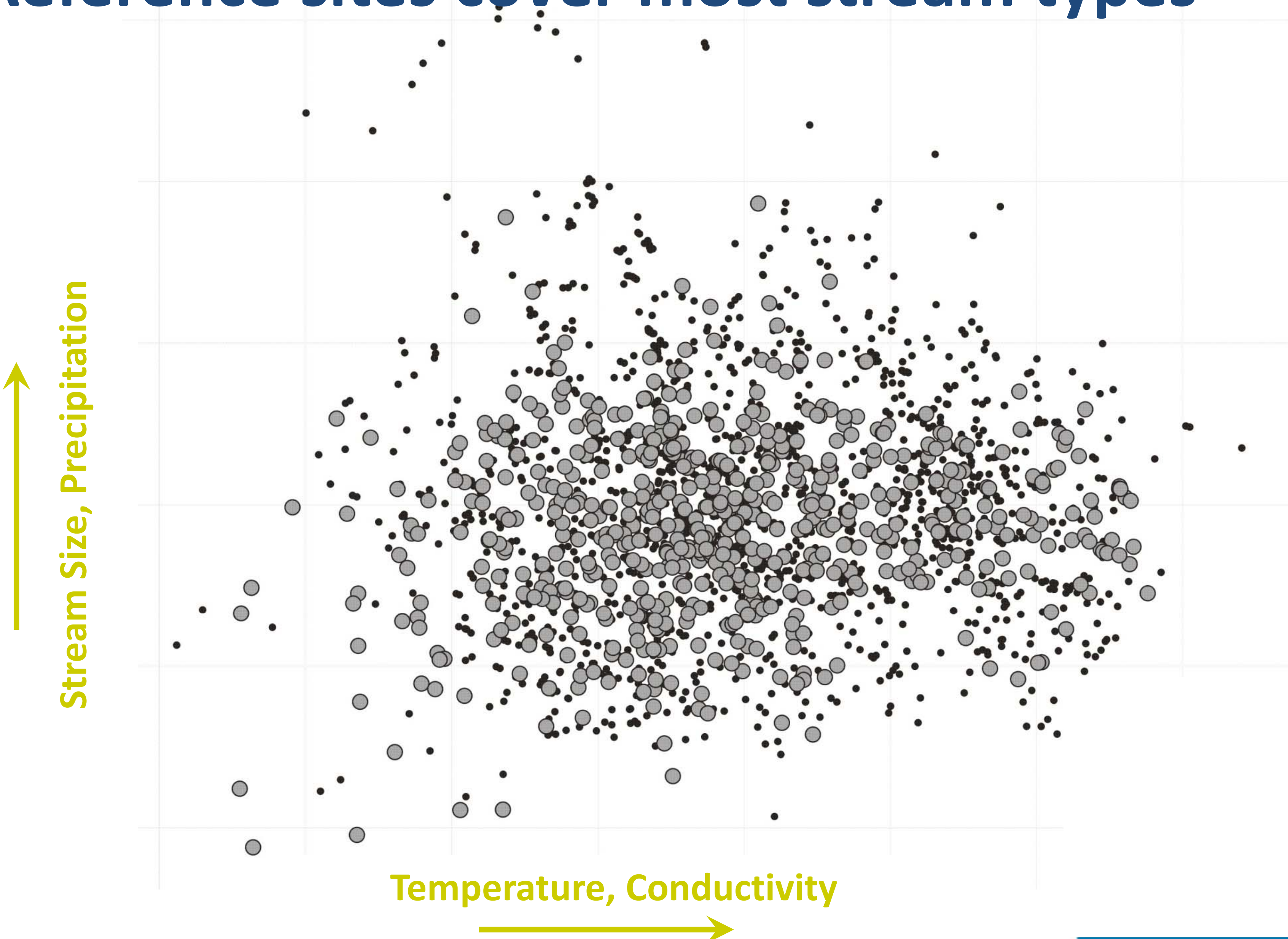
REGION	n
North Coast	75
Central Valley	1
Coastal Chaparral	57
Interior Chaparral	33
South Coast Mountains	85
South Coast Xeric	34
Western Sierra	131
Central Lahontan	114
Deserts + Modoc	27
TOTAL	**586**



Multivariate view of natural diversity



Reference sites cover most stream types



California Stream Condition Index (CSCI)

Part A: Ecological Structure Component (pMMI)

Part B: Taxonomic Loss Component (O/E)

BMI Species List from Sample

Taxon	Count
Mayfly species 1	43
Mayfly species 2	12
Mayfly species 3	2
Beetle species 1	1
Beetle species 2	1
Midge genus 1	65
Midge species 1	3
Midge species 2	10
Midge genus 2	3
Dragonfly species 1	2
Stonefly species 1	1
Stonefly species 2	14
Worm species 1	9
Worm species 2	2

Ecological Function Metrics

- # mayfly taxa
- # predator taxa
- % sediment tolerant taxa
- % non-insect taxa

Species Loss Component

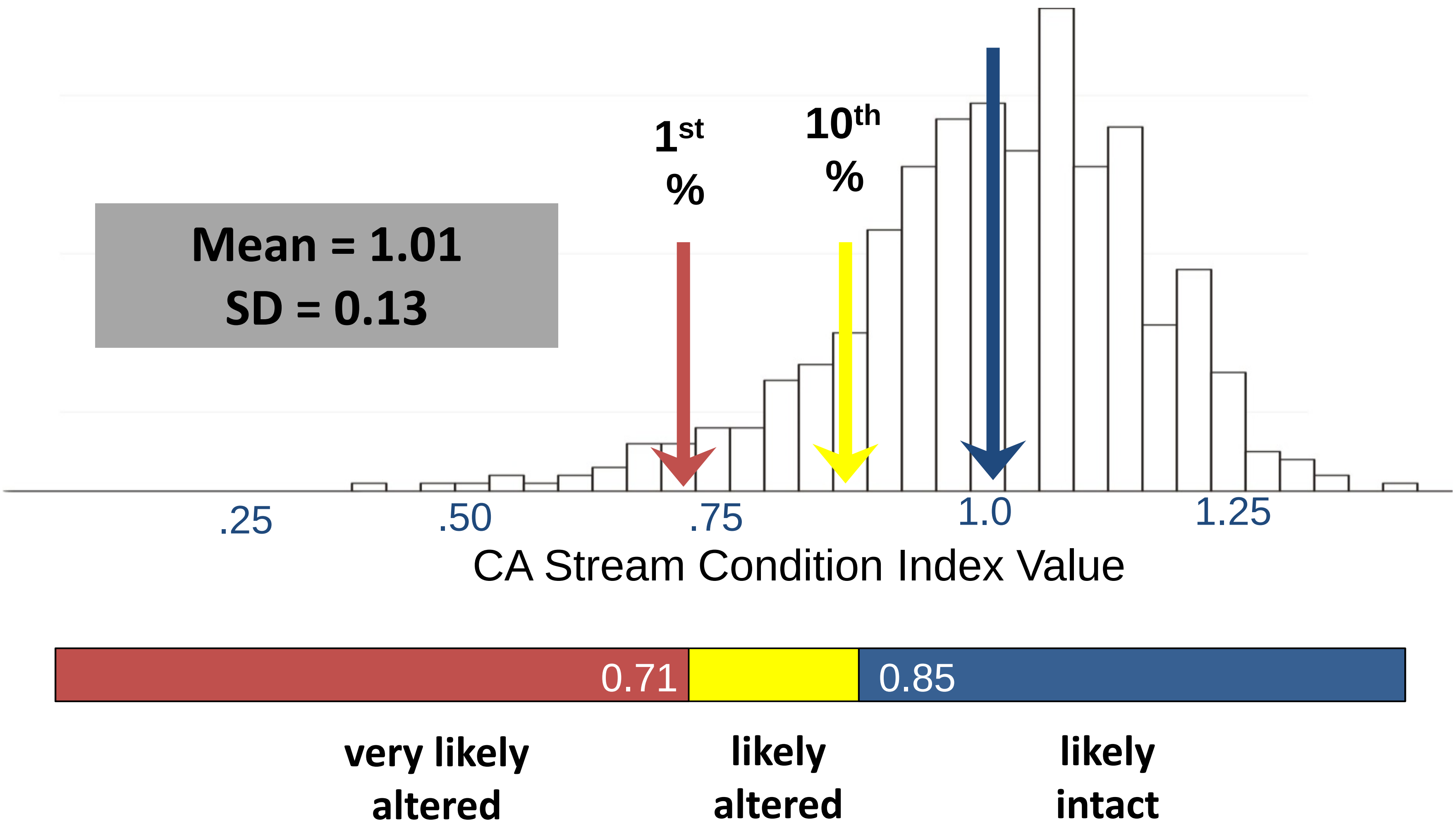
E = 8 taxa   O = 3 taxa

Scores are adjusted to account for major natural gradients

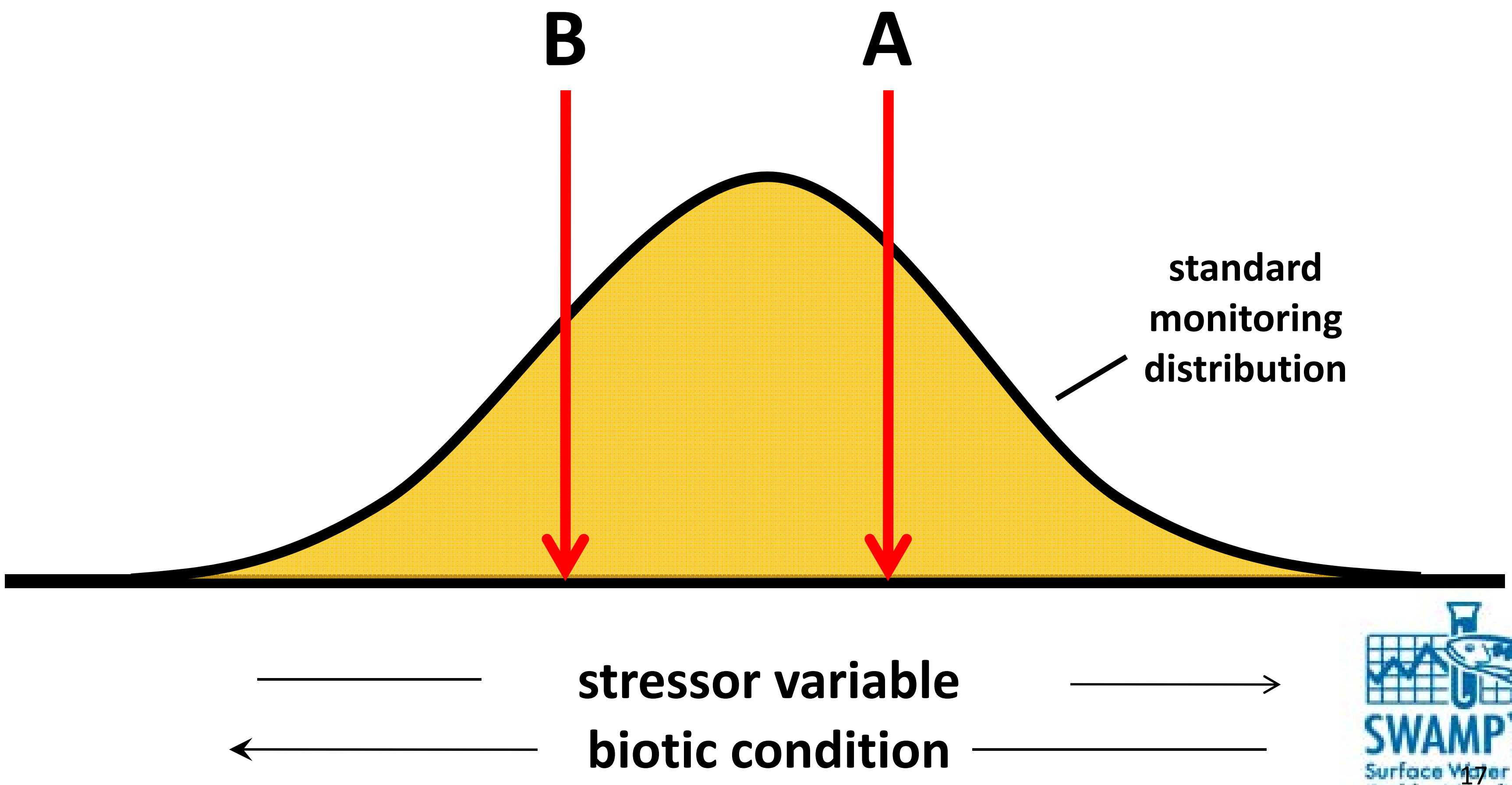
- Elevation
- Latitude
- Longitude
- Conductivity
- PPT, Temp
- Mineral Content

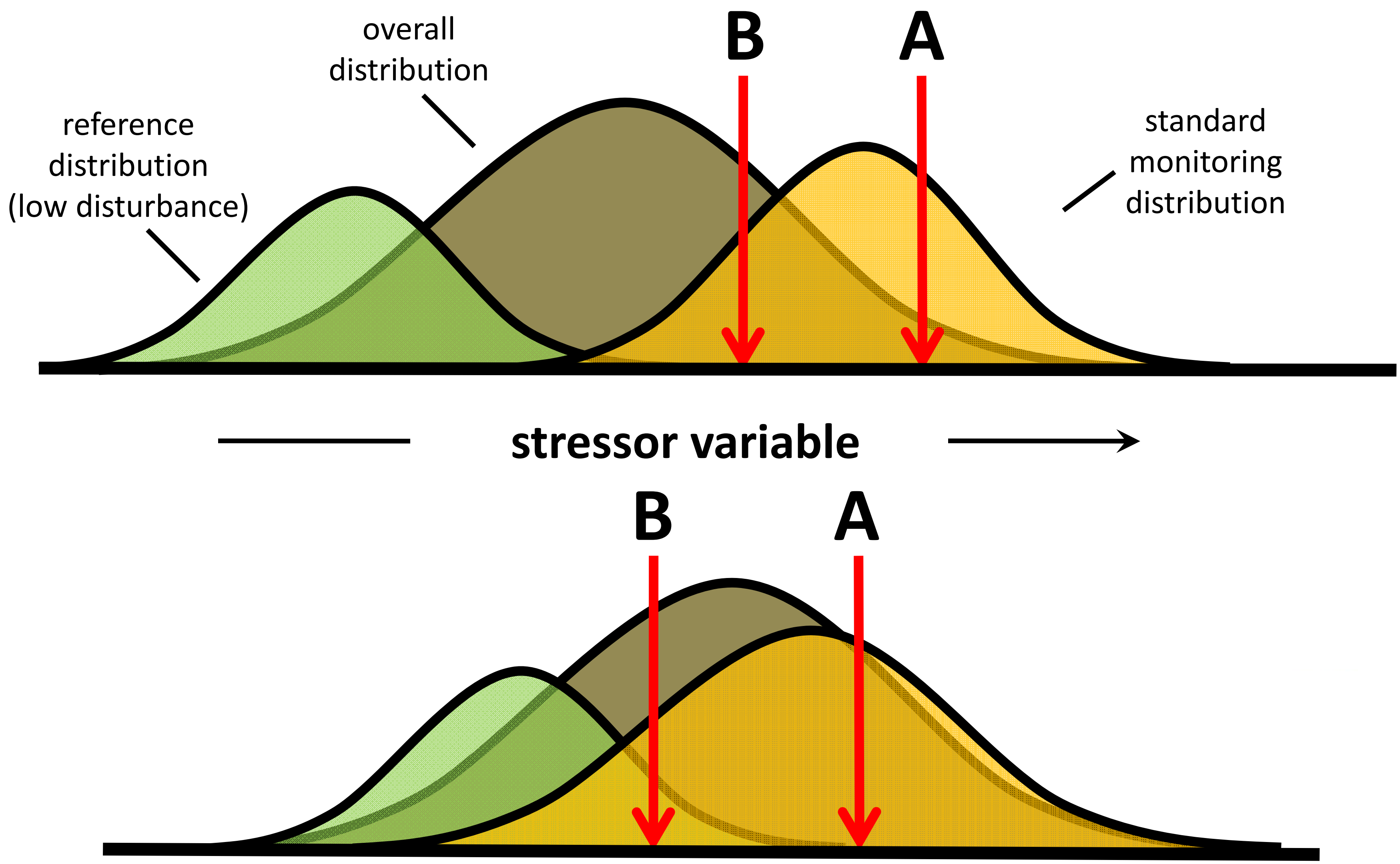
- **Both components adjust for environmental setting**
  - **CSCI is a simple average of the two scores**

Distribution based thresholds:



Probability surveys and reference data provide context for interpreting targeted monitoring data




overall
distribution
B
A
reference
distribution
(low disturbance)
standard
monitoring
distribution
stressor variable
B
A

Hydromod has multiple effects on biology

Changing from complex dynamic systems to simpler static systems

- alterations of hydrology and physical structure tend to reduce habitat diversity

Changing the hydrograph and temperature regime

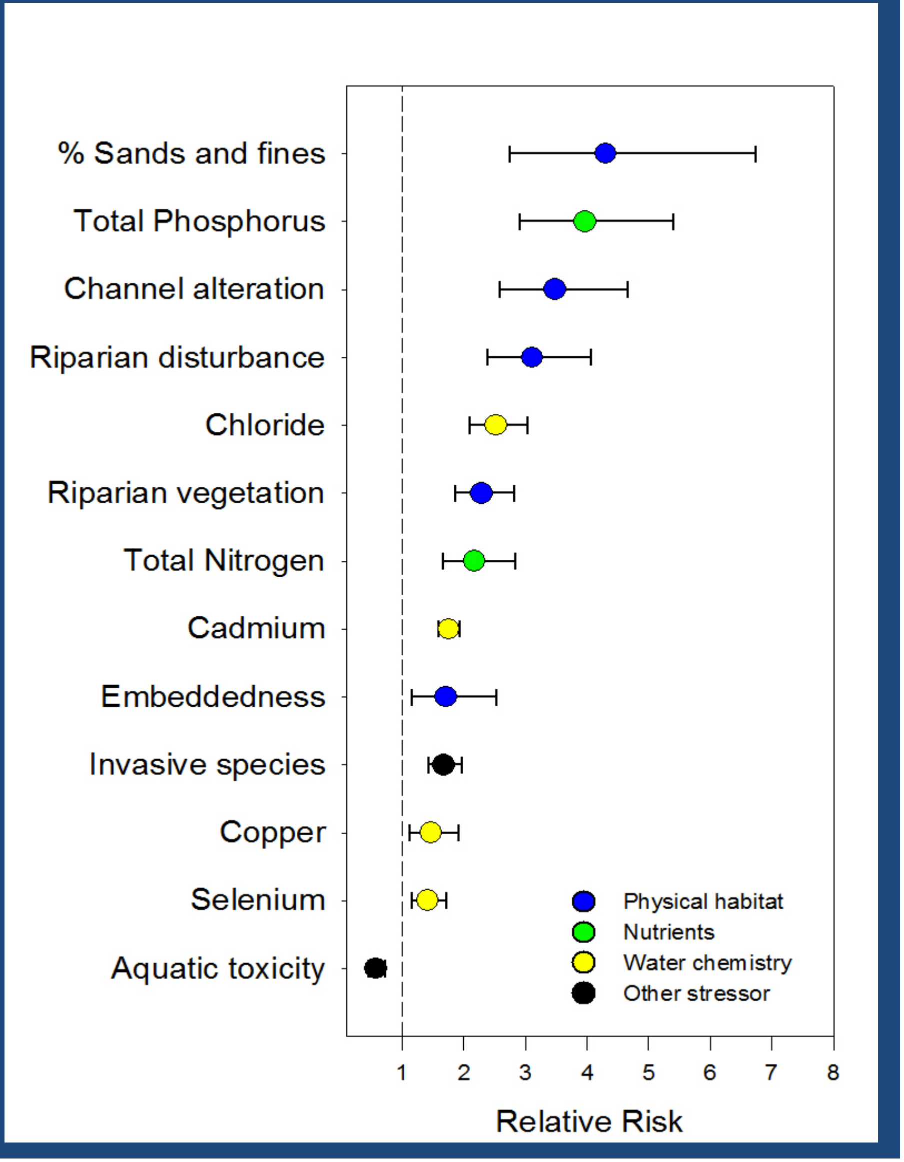
- flow magnitude/timing and temp drive life history strategies
- alterations limit ability of streams to support native biota

Physical stressors are among the most significant impacts to biology

Relative Risk:
Increased risk of biological impairment in presence of high stressor levels

(analogous to medical risk advisories – e.g., 10x higher risk of emphysema associated with smoking)

Data from SMC probability survey (Mazor et al. 2011)



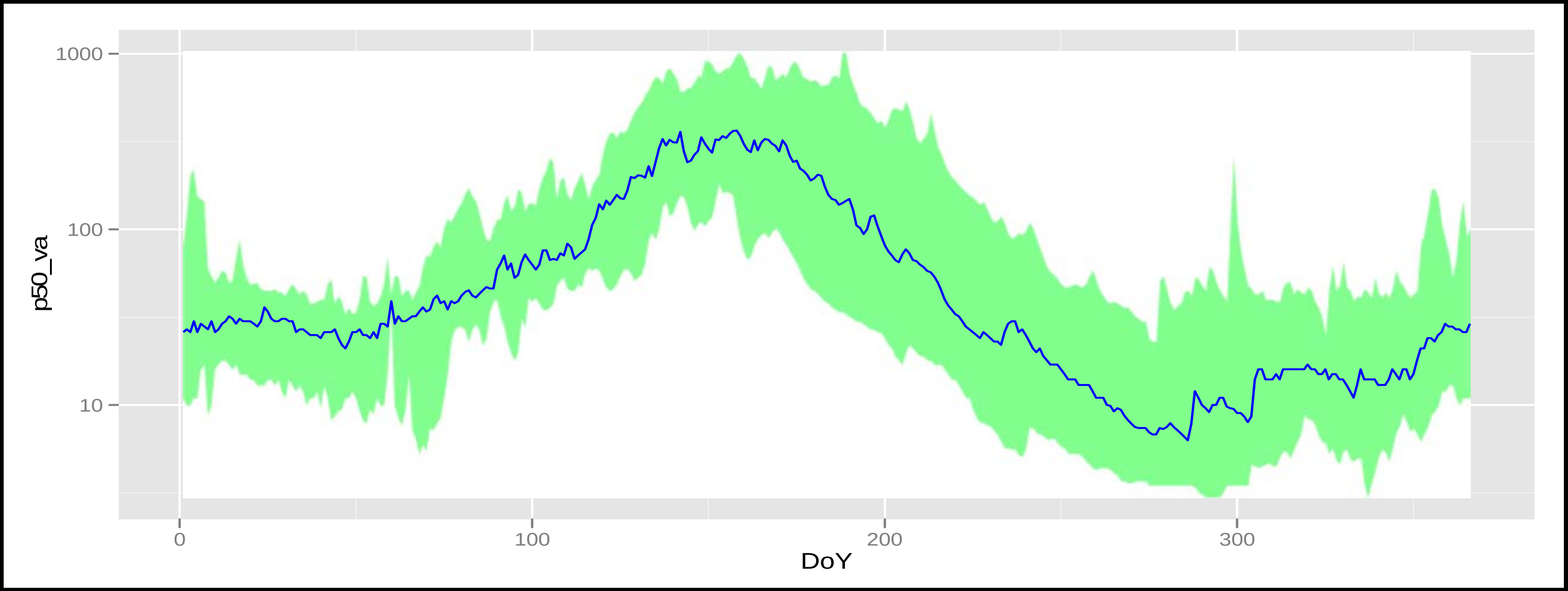
Biological Responses to Hydromodification

Physical changes to channel

- Habitat is a primary driver of species distributions
  - Filling interstitial spaces
  - Channel modification usually results in reduced habitat diversity
  - fine sediment smothering

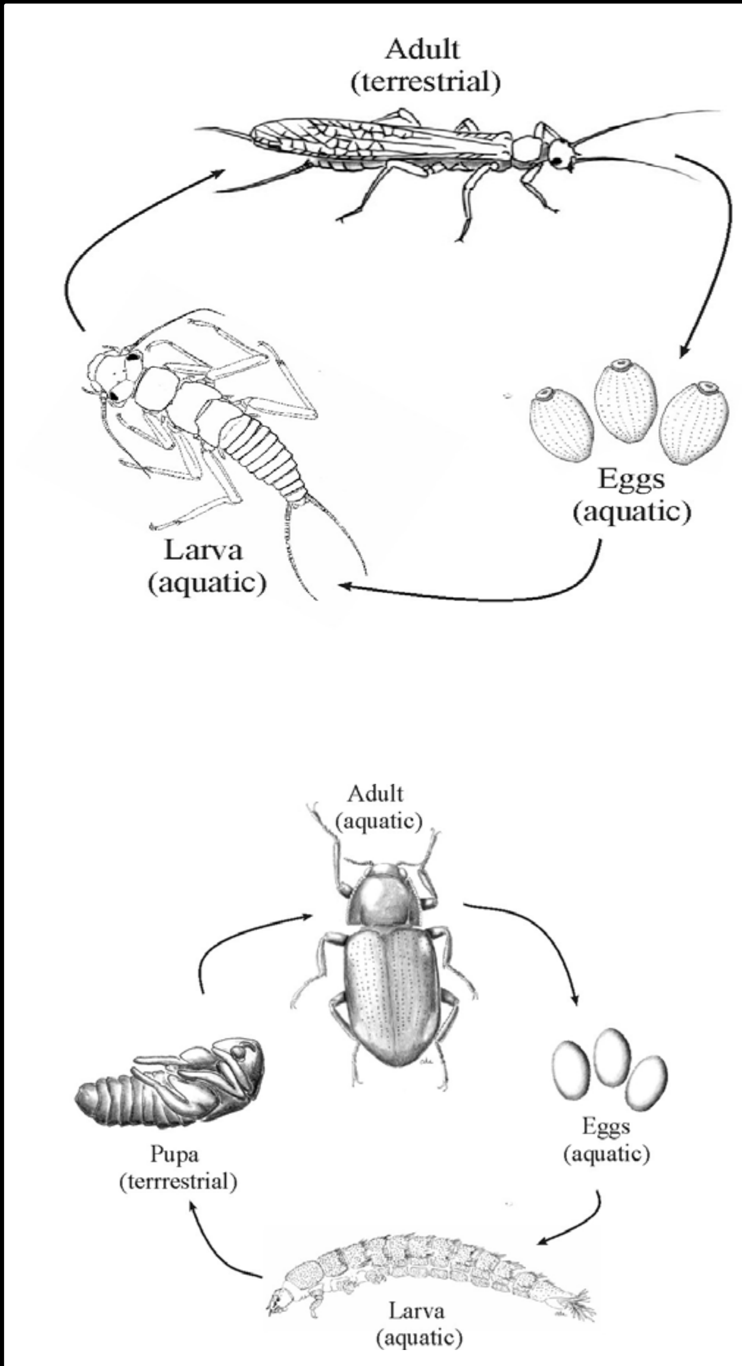
Responses to associated environmental changes

- Flow (magnitude, timing, duration,)
- Water source (surface: groundwater ratio)
- Temperature, DO

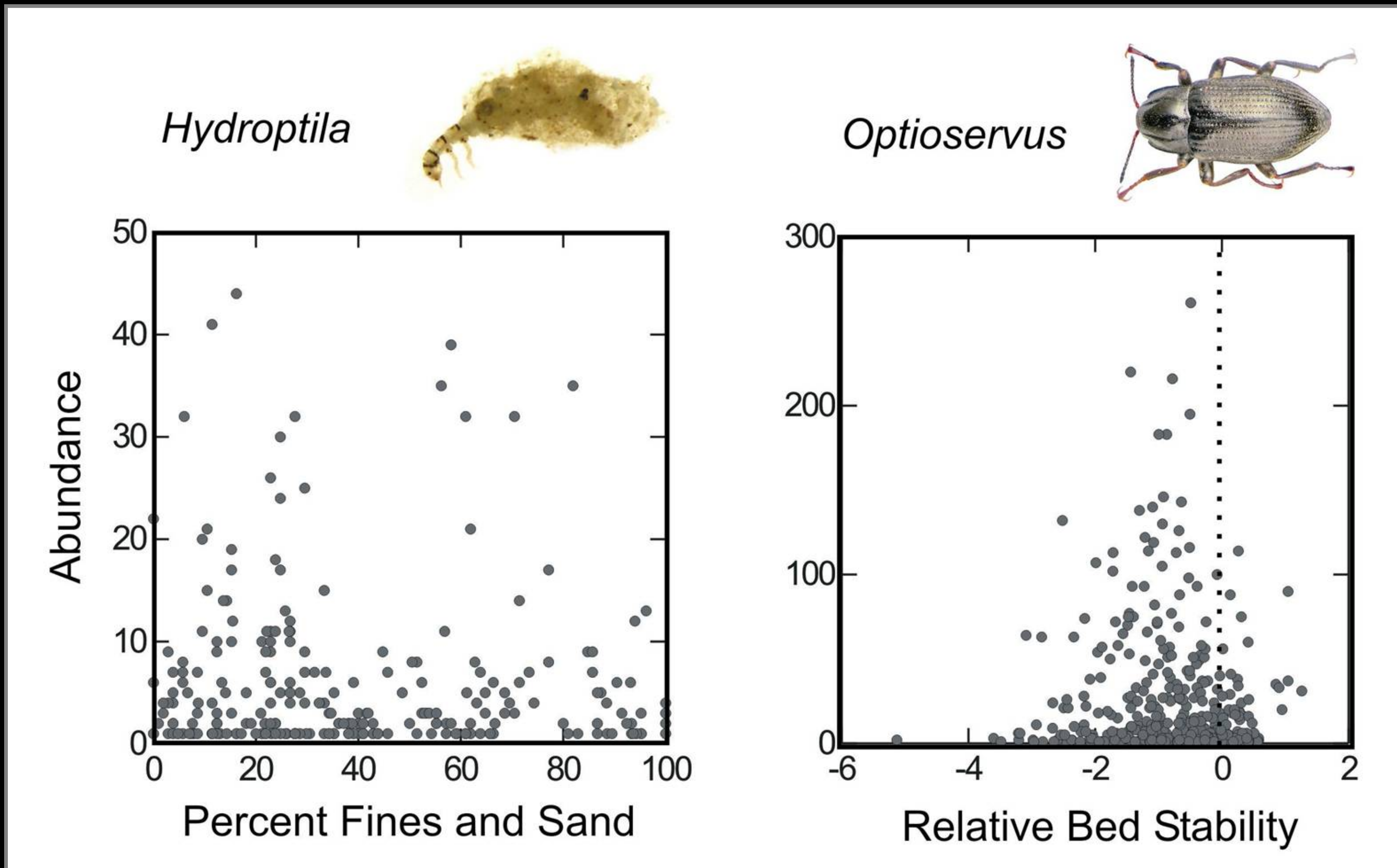


Hydromodification stressors interfere with physical requirements and life history strategies

- **Smothering** (not just fish!)
- **Loss of interstitial spaces/habitat diversity** – competition for space and food
- **Thermal impacts-** life history timing, resting stages, reproduction, dispersal, egg-laying preferences, etc.



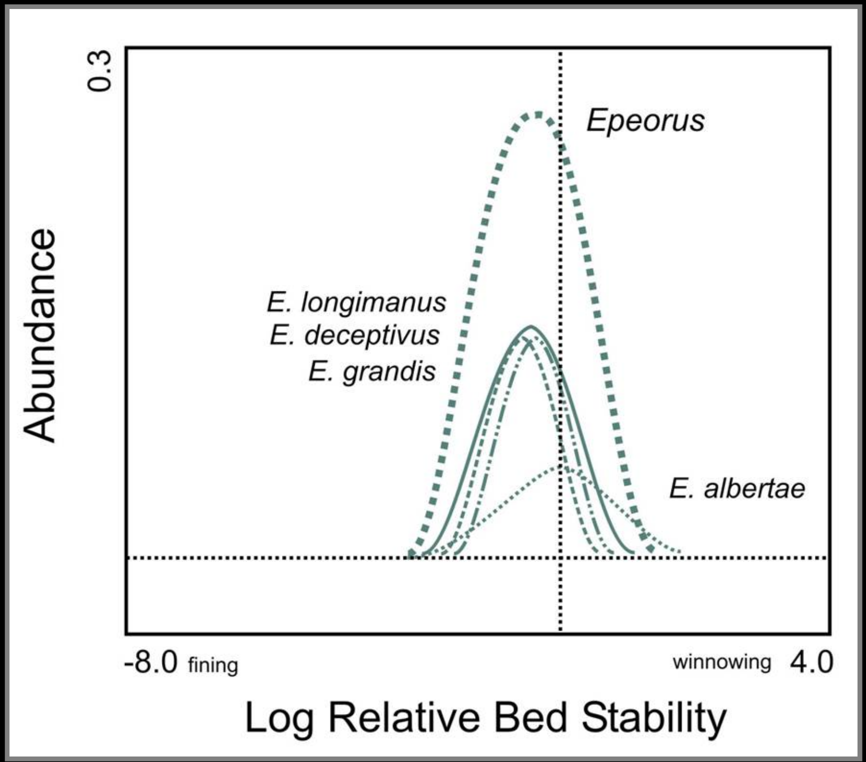
Response to fine sediment

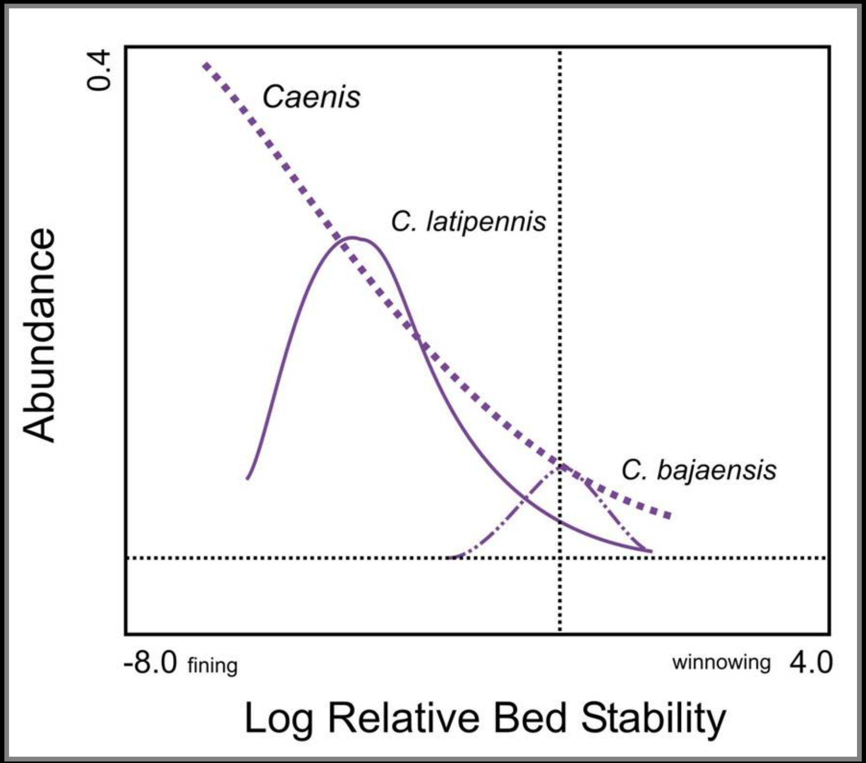


Sediment intolerant vs. sediment tolerant

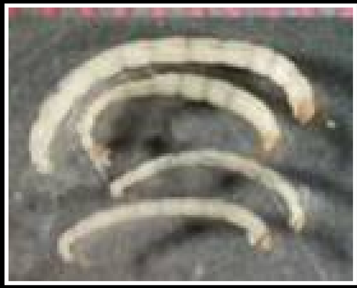
Epeorus

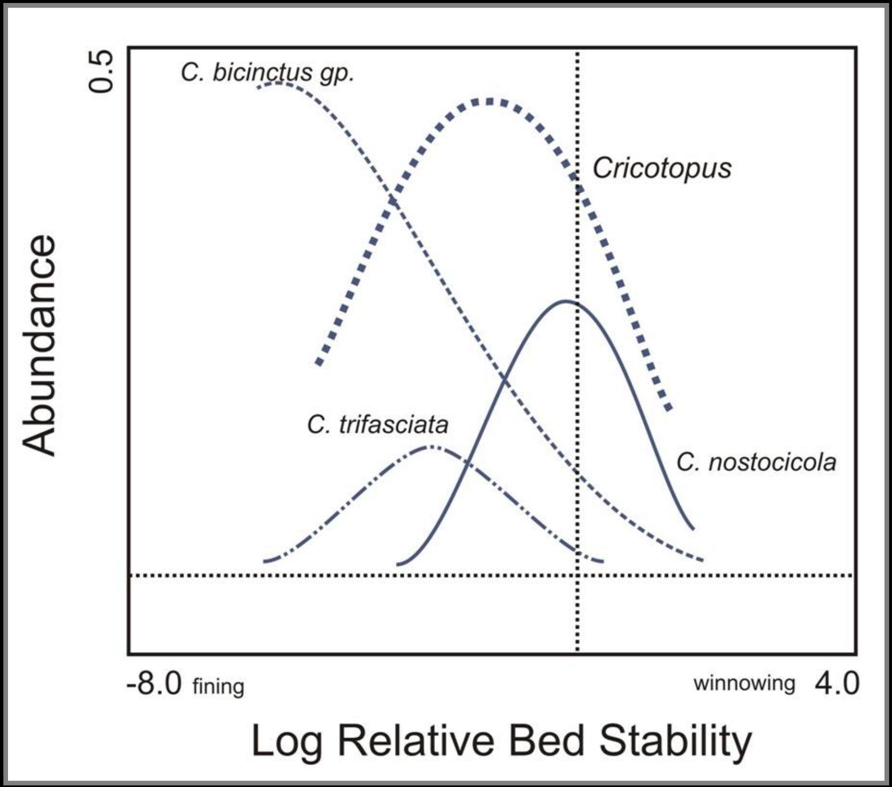
Caenis

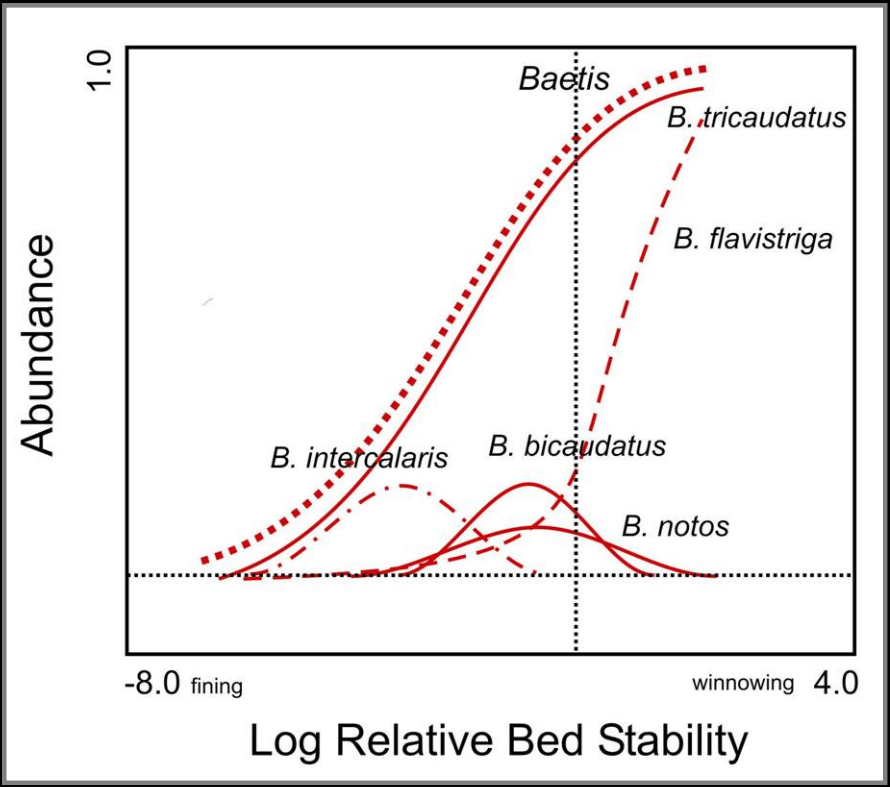




Species level IDs matter in some cases



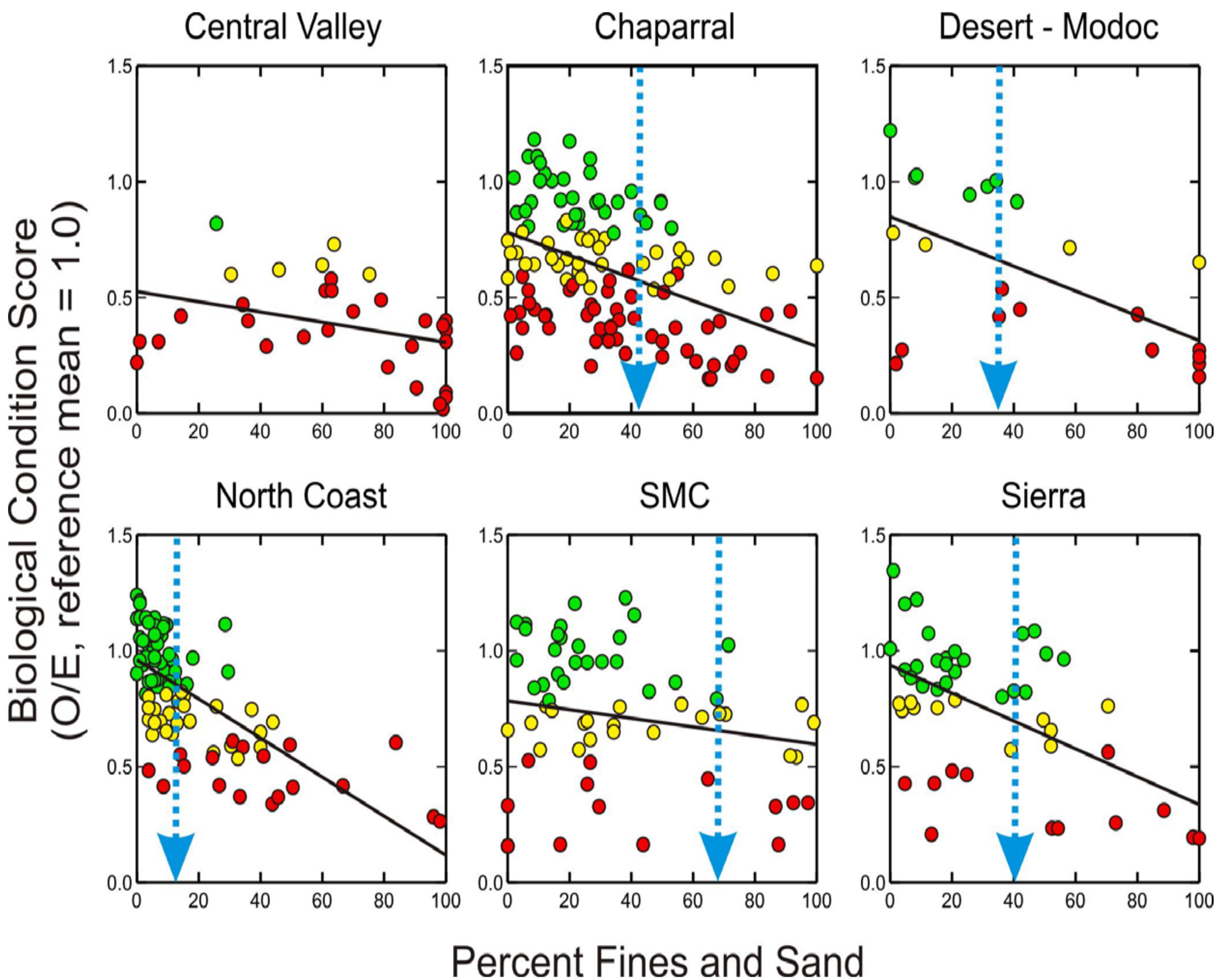




In some cases, genus level ID is OK for tolerance values, in others it is misleading

Fine sediment thresholds differ regionally

(data from SWAMP's Perennial Streams Assessment)



Biological Monitoring Research Priorities

Emphasis on tools for supporting long term monitoring strategies

- Biology can help focus these and give intermediate feedback

- We've built tools and a framework for this kind of monitoring, but most tools are general … need more stressor-specific focus

- How much resilience/resistance to different modifications

- What aspects of hydromod matter most to biota?

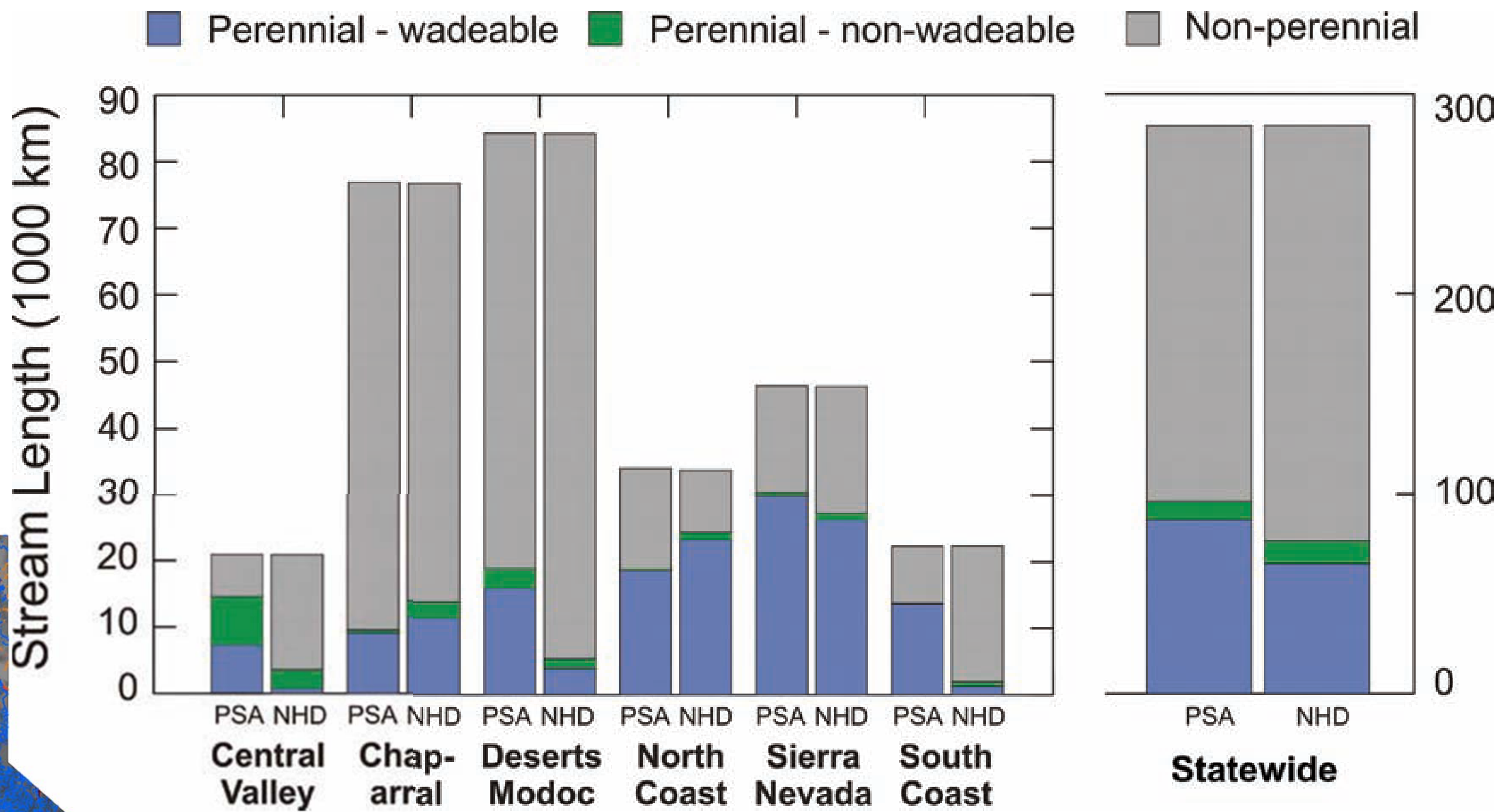
Current priorities

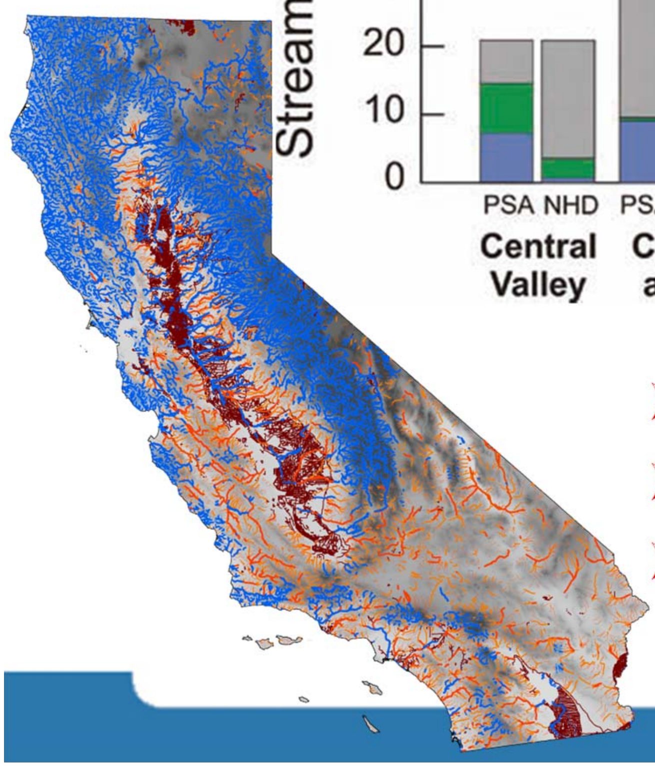
1. **Support for Causal Analysis**
   (stressors are multivariate and span multiple spatial scales)
   - **Stressor-specific analyses**
   - **Functional group indicators**
   - **Improved relative risk models**

2. **Adapting bioassessment for non-perennial streams**

3. **Bioassessment and flow alteration**

Majority of stream length is non-perennial





- ~75% of CA stream length is non-perennial
- current maps are frequently inaccurate
- neglected target for monitoring and protection

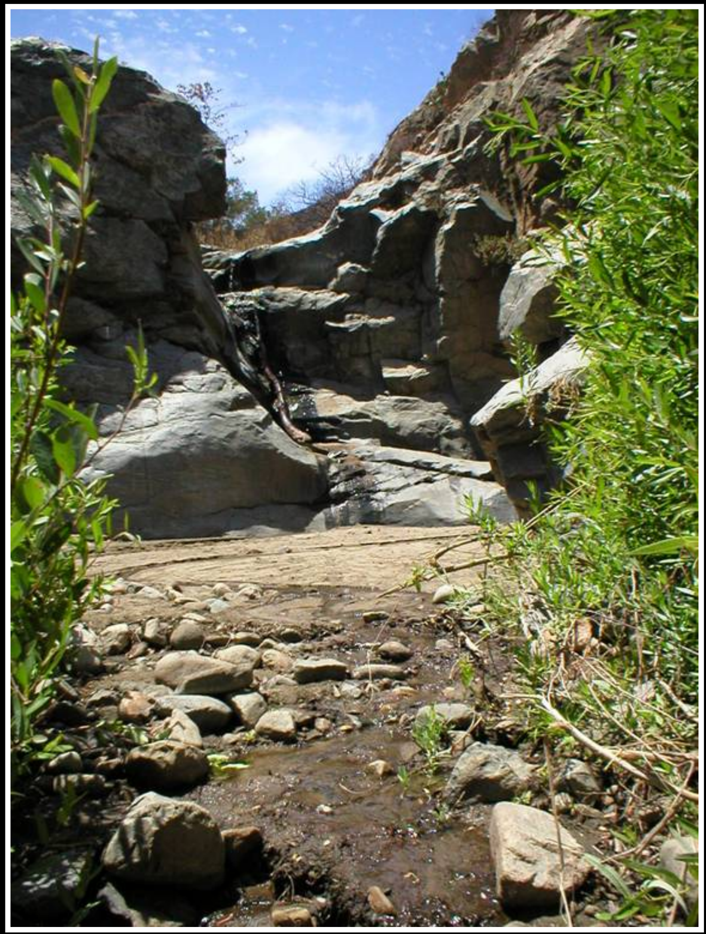
Non-perennial streams

Non-perennial streams are the primary interface between downstream perennial streams and the activities on the landscape

Intense seasonality (Gasith & Resh 1999)

- Flooding/Drying
- Increased chemical concentrations
- Increased biotic interactions

Susceptible to hydromodification



Non-perennial streams

Initial studies designed to ask whether bioassessment tools for perennial streams work in intermittent streams

Initial results are very promising

New SCCWRP/ABL studies sponsored by San Diego RB designed to expand upon this work

Numeric Flow Metrics to Support Freshwater Bio-objectives, Hydromodification Management, and Nutrient Numeric Endpoints

ERIC STEIN

BIOLOGY DEPARTMENT

Colorado State University

USGS science for a changing world

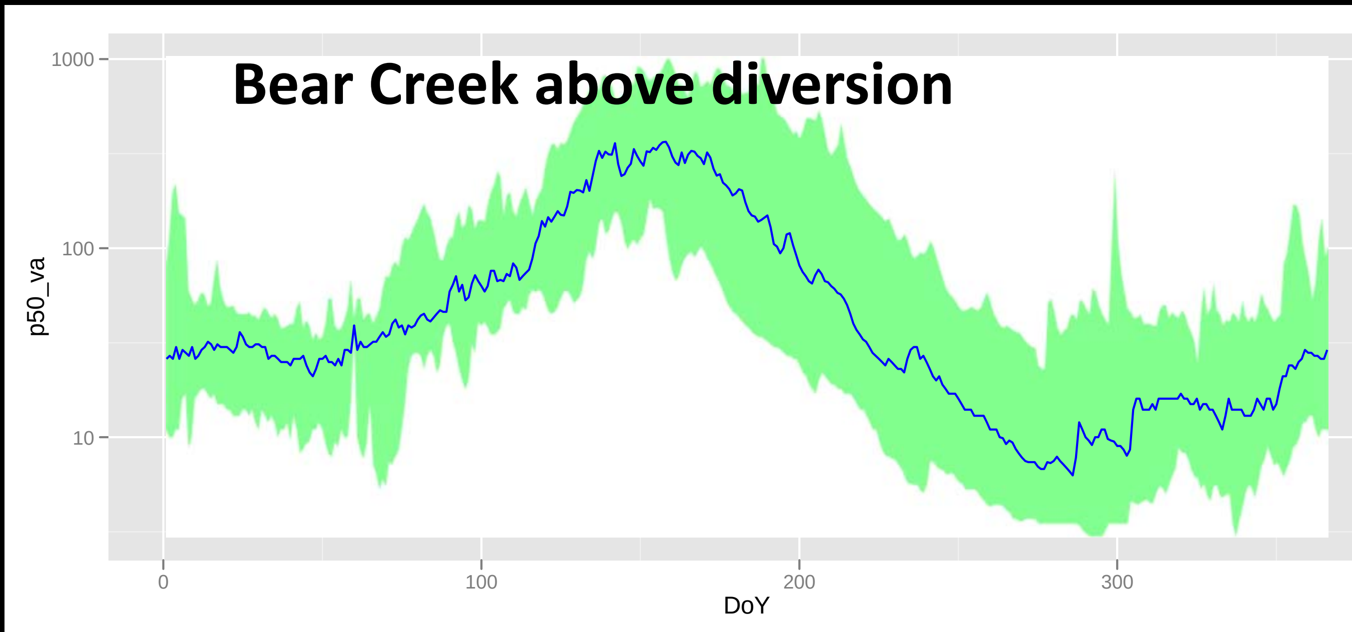
Objectives

Develop an approach for establishing instream environmental flow requirements necessary to meet ecological benchmarks

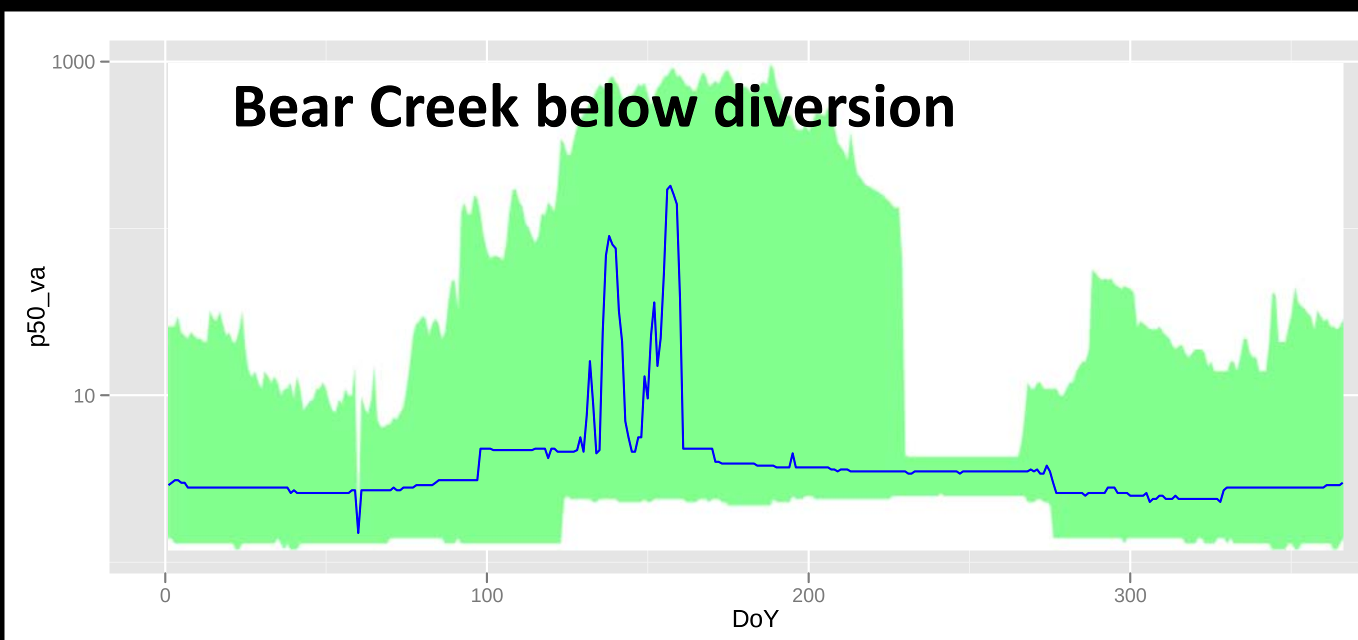
1. How should streams in California be grouped or classified for the purposes of establishing environmental flow requirements
2. What are the key hydrologic variables that should be used for environmental flow requirements
3. What are the key biological response variables that should be used when establishing environmental flow requirements
4. What is the appropriate framework/approach for setting actual flow requirements for specific stream types.

Predicting Flow in California Streams

(Daren Carlisle – USGS,
Jeanette Howard – TNC)



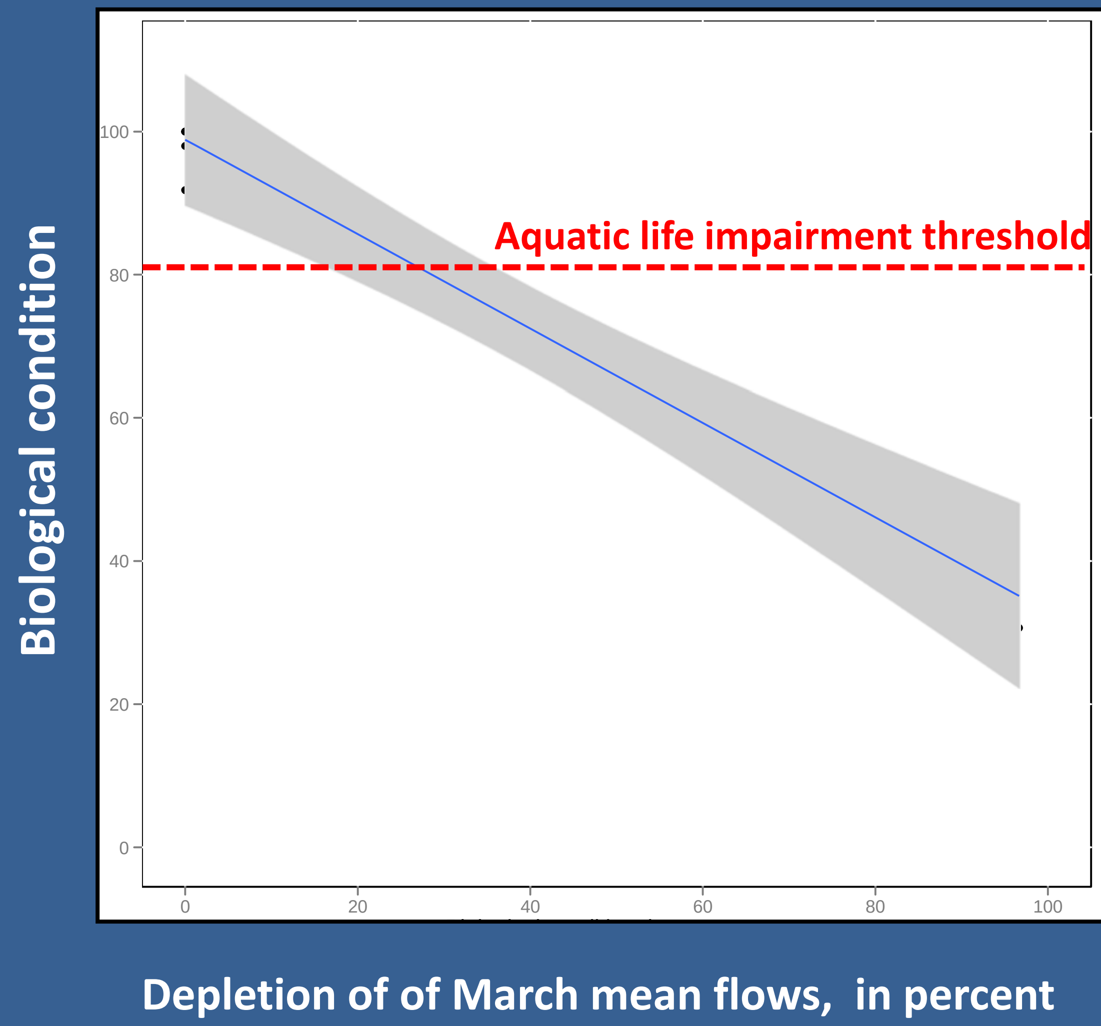
Bear Creek above diversion
1000
100
10
p50_va
0
100
200
300
DoY



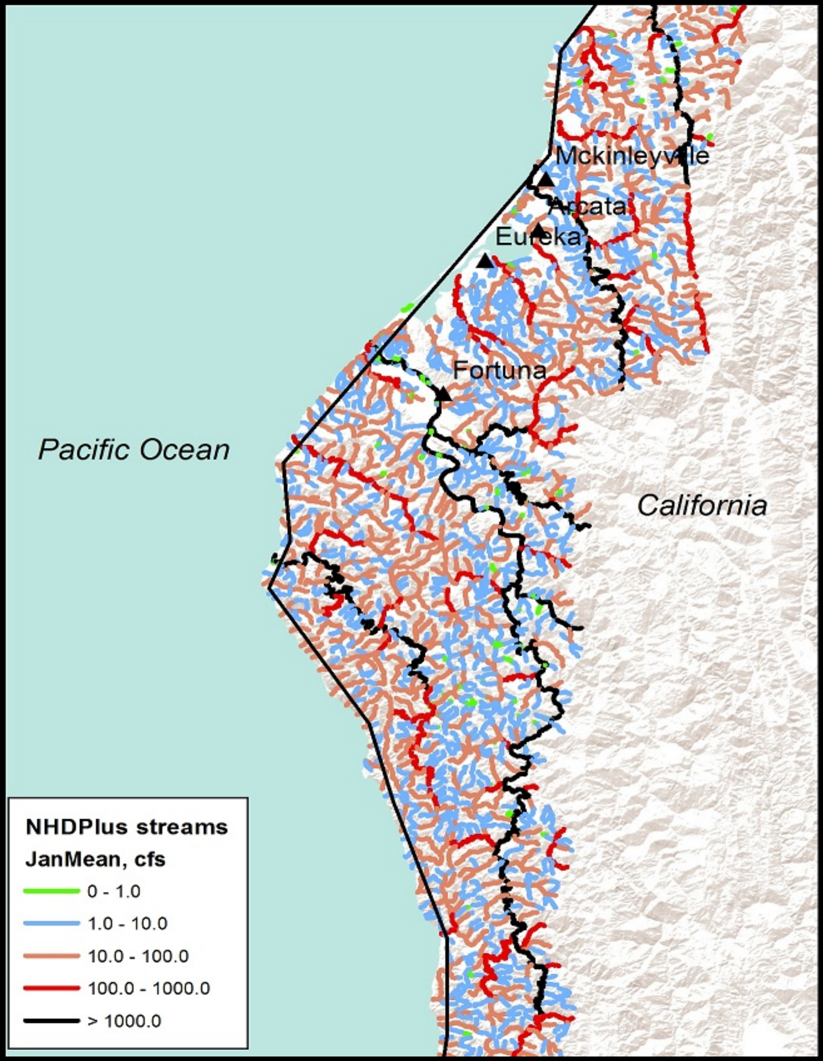
Bear Creek below diversion
1000
10
p50_va
0
100
200
300
DoY

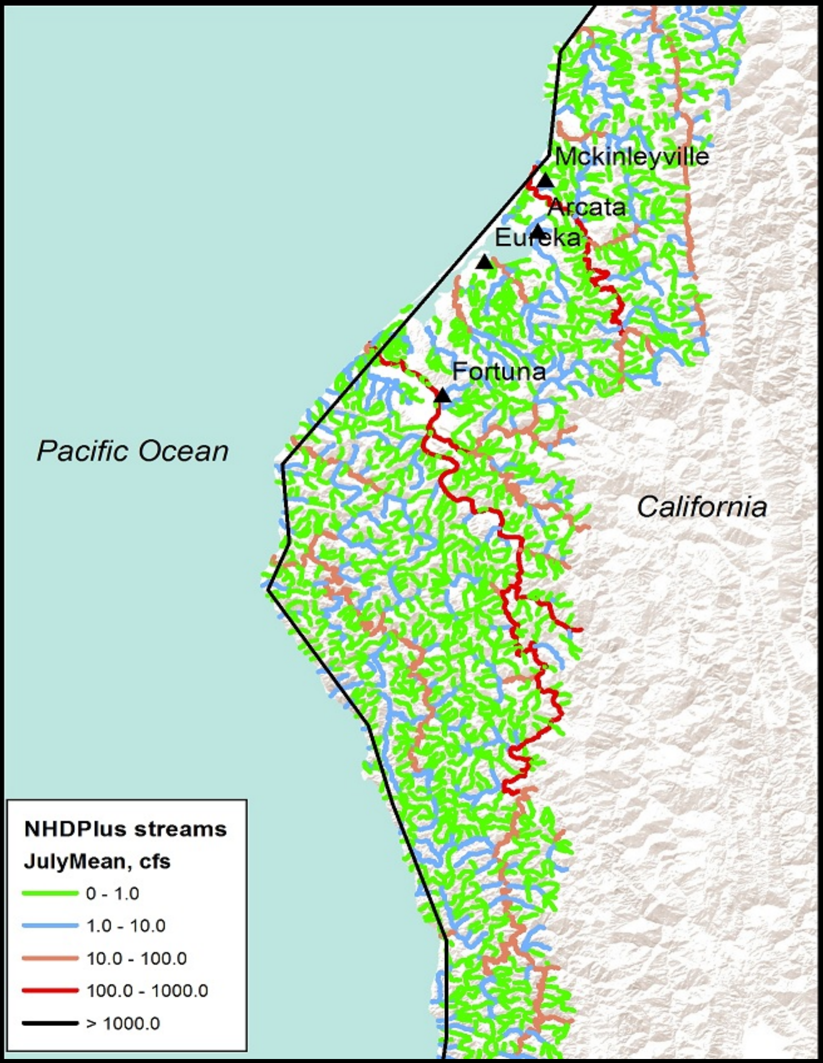
Predicting monthly mean flows
(modeled from landscape, landuse, withdrawals, diversions, etc.)

- If we can predict normal flow, we can measure deviation from normal conditions
- Use to identify best biotic indicators of hydrologic alteration



Predicted monthly mean flows





Key Messages

Altering complex dynamic systems affects many variables that biota respond to

Stream biota are reliable indicators of deviation from normal hydrology and physical characteristics of streams

- "how much change is too much"
- recovery measures

Watershed monitoring approach is ideal for biological indicators, especially in a screening/ integrative role

Questions?

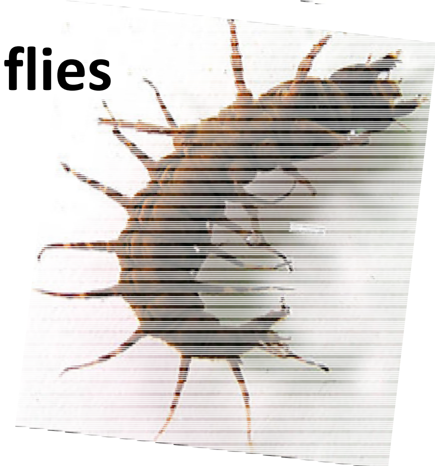

photo courtesy John Sandberg

Intermittent obligates and specialists: *how do they survive?*

1. *Diapausing egg or larva*

Stoneflies

Dobsonflies



2. *Vagile adults & rapid development time*

Diving beetles

3. *Unknown: diapause & rapid development?*

Midges

Blackflies

Michael Bogan, Oregon State University