Biological Assessment Tools for California Streams

State Water Board Workshop

January 23, 2013

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Workshop Agenda

- Introduction & Background
- Defining Reference Condition
- Numeric Scoring Tools
- Stressor Identification Guidance
- Scientific Review Process
- Next Steps
- Public Comments

Bioassessment Principles

- Most streams are home to diverse groups of organisms
- Resident organisms provide a record of water body conditions over time
- Monitoring biology provides a direct measure of water body health
- Organisms respond to both chemical and non-chemical stresses

Bioassessment Program Foundation

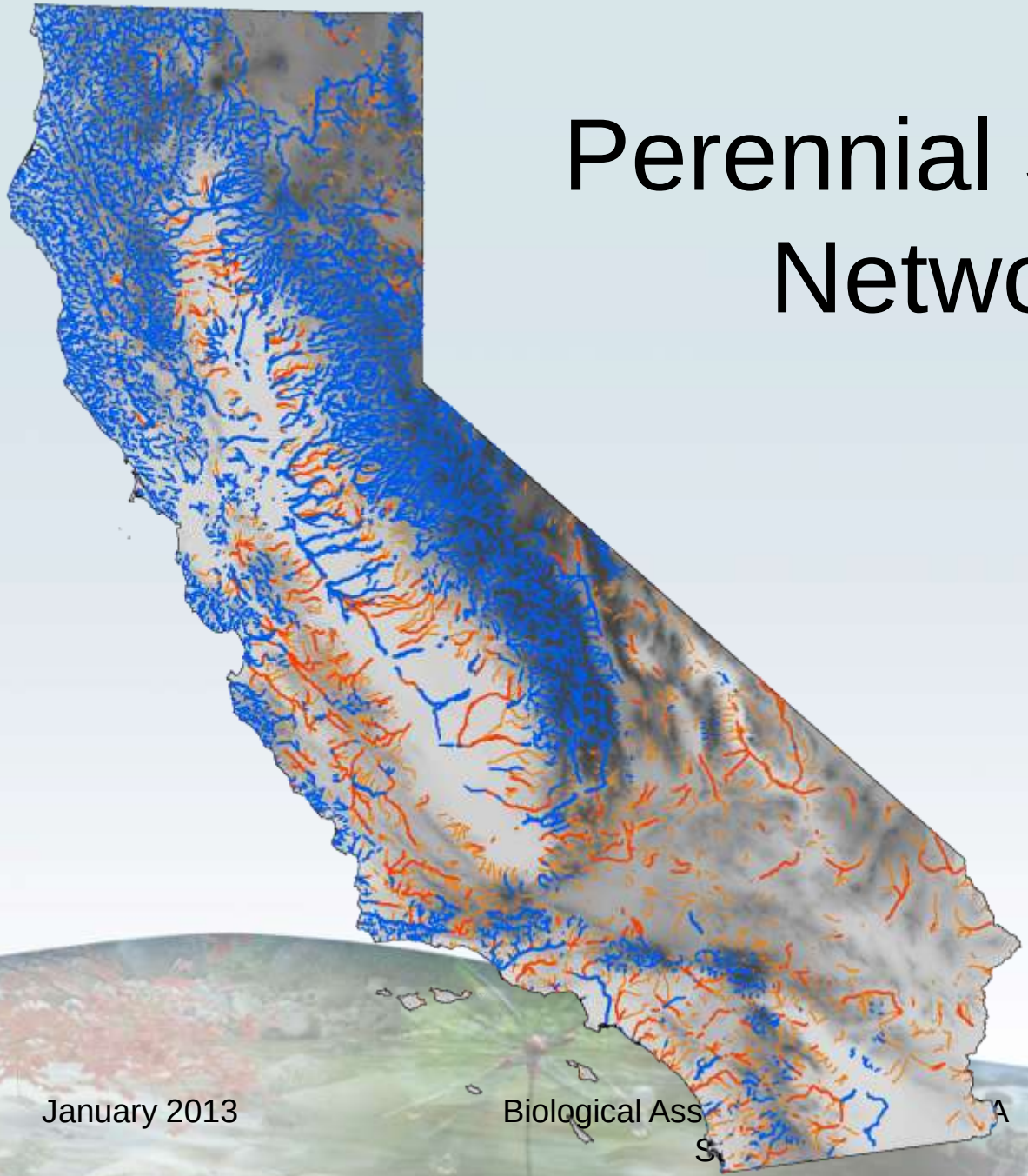
10 Years in the Making

- Indicators: Biology & Physical Habitat
- Standardized Methods: Field & Lab
- Reference Condition
- Quality Assurance
- Data Management & Reporting
- Training & Audits

Scope

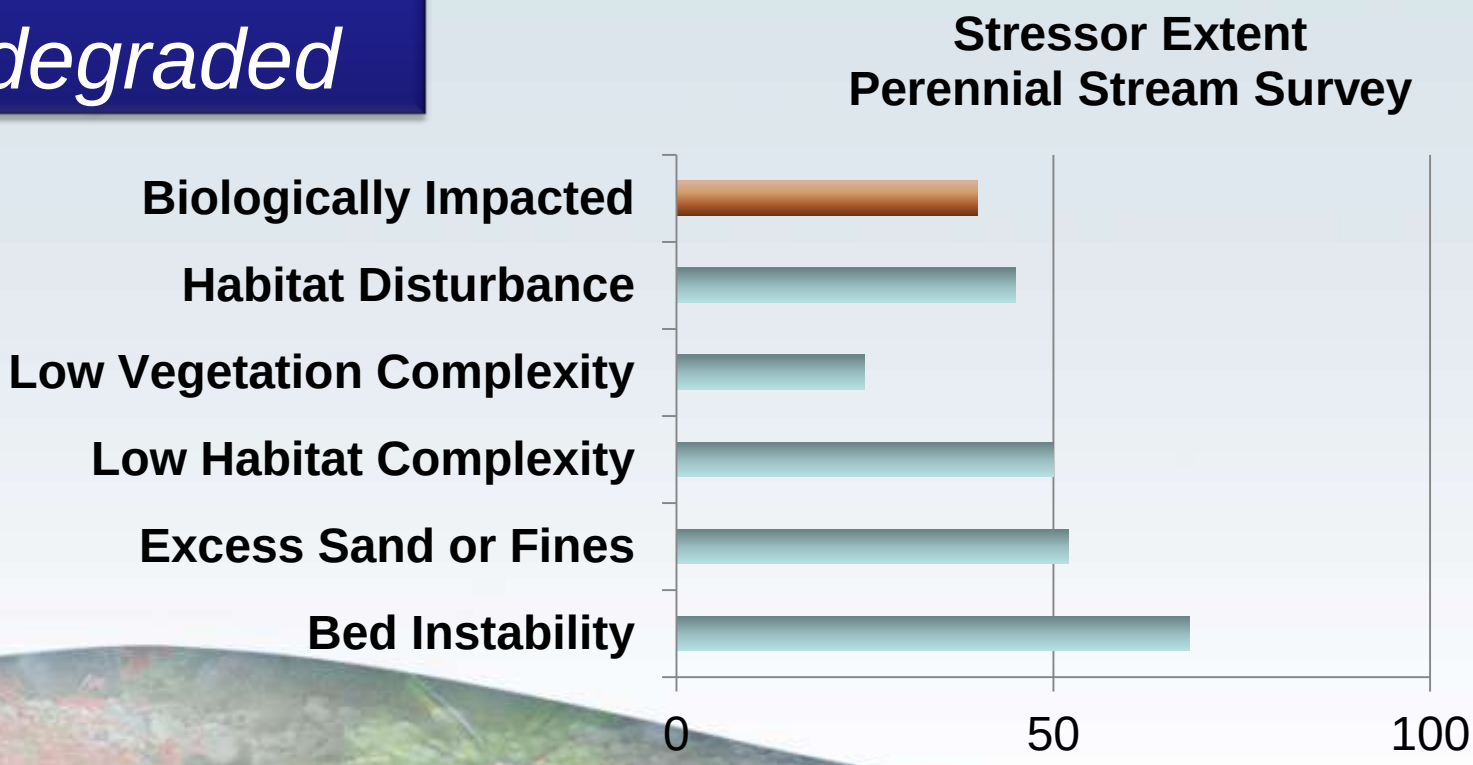
- Indicator – Benthic Macroinvertebrates
- Perennial Streams
  Streams with year-round surface water flow during a normal water year.
- Wadeable Streams
  Streams that can be crossed safely by wading during the standard sampling period.

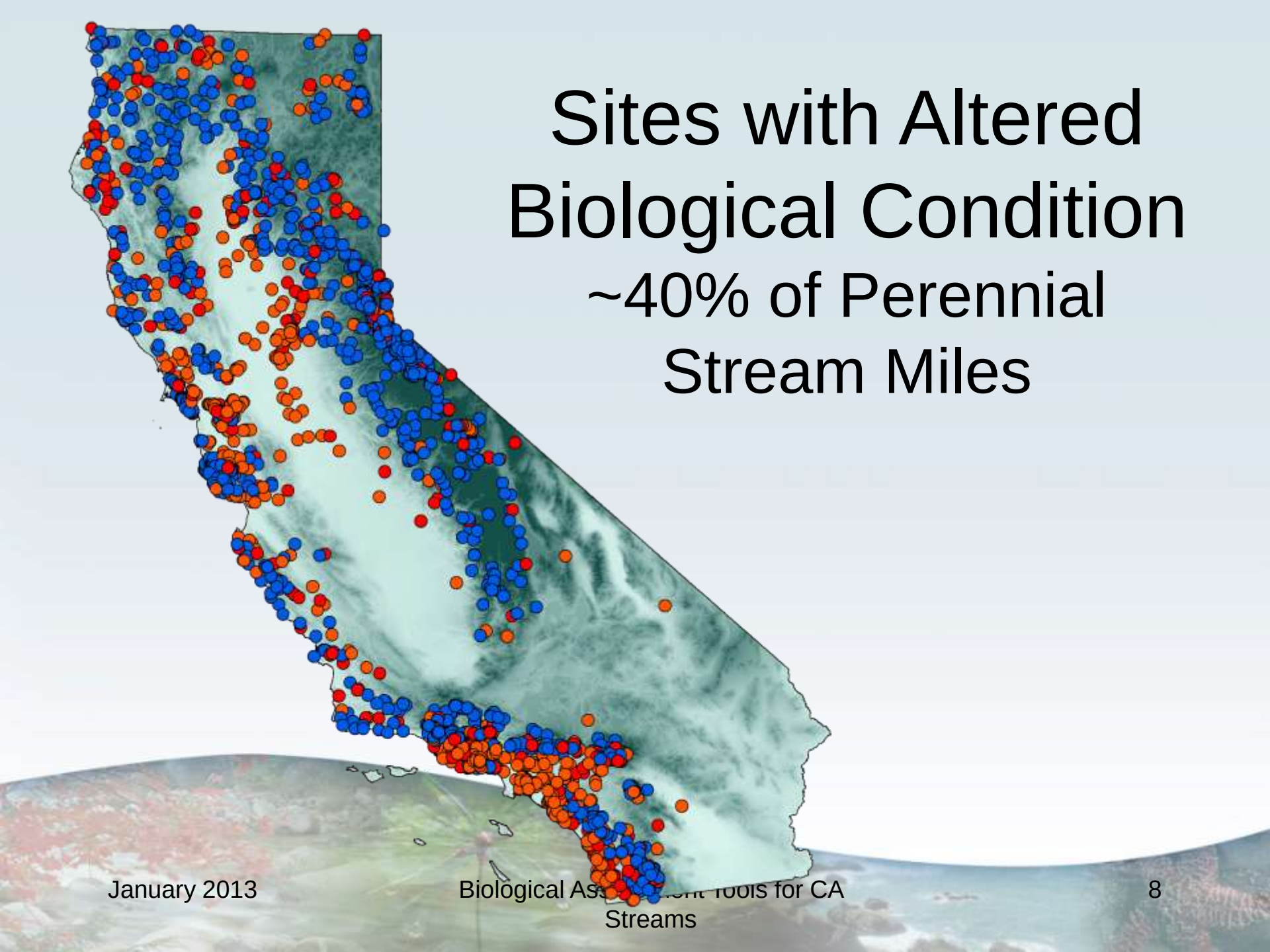
Perennial Stream Network



Why use biological assessment tools?

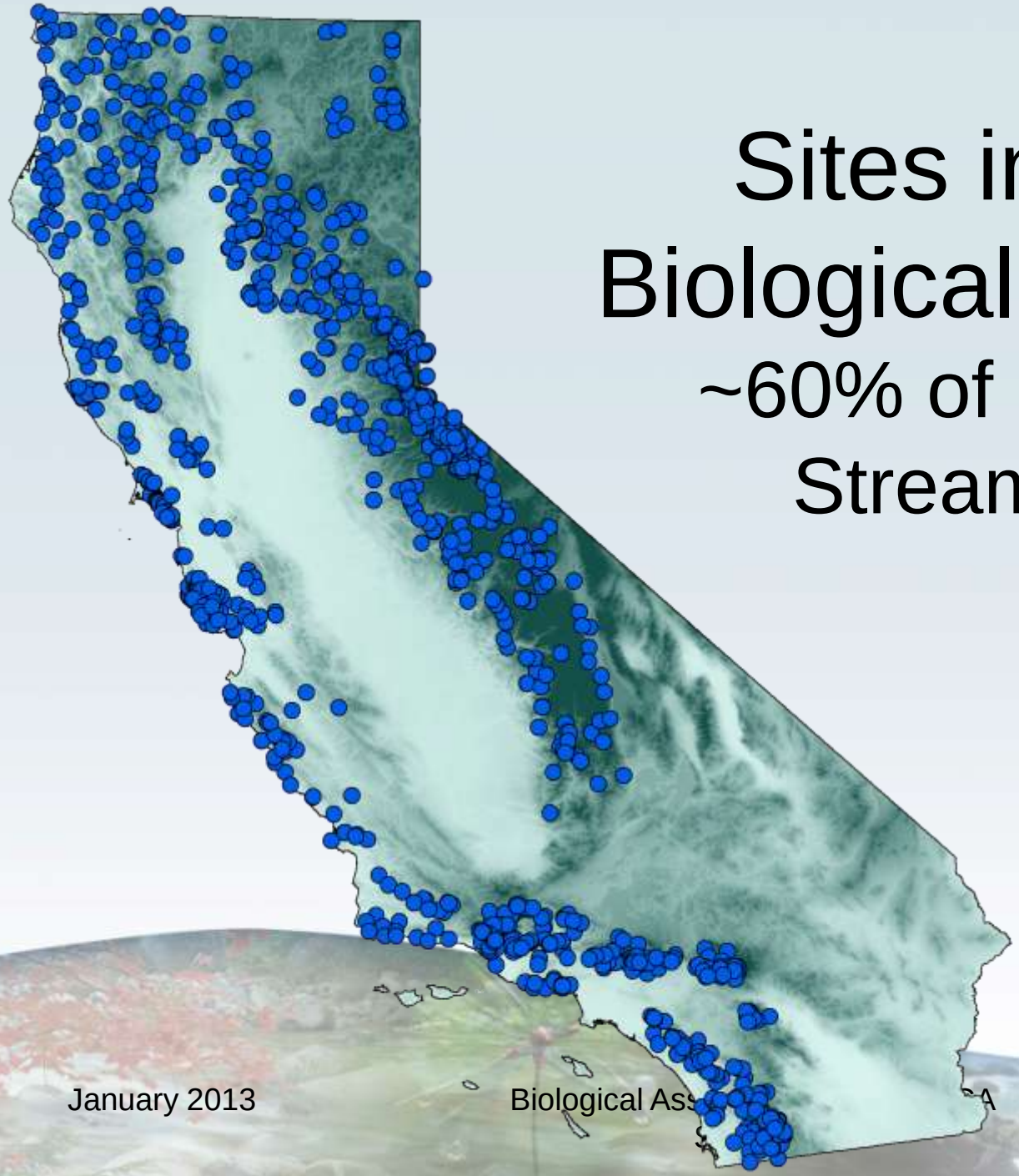
Streams are degraded




Sites with Altered Biological Condition
~40% of Perennial Stream Miles

Why use biological assessment tools?

Mechanisms for protecting streams are limited



Sites in Good Biological Condition

~60% of Perennial Stream Miles

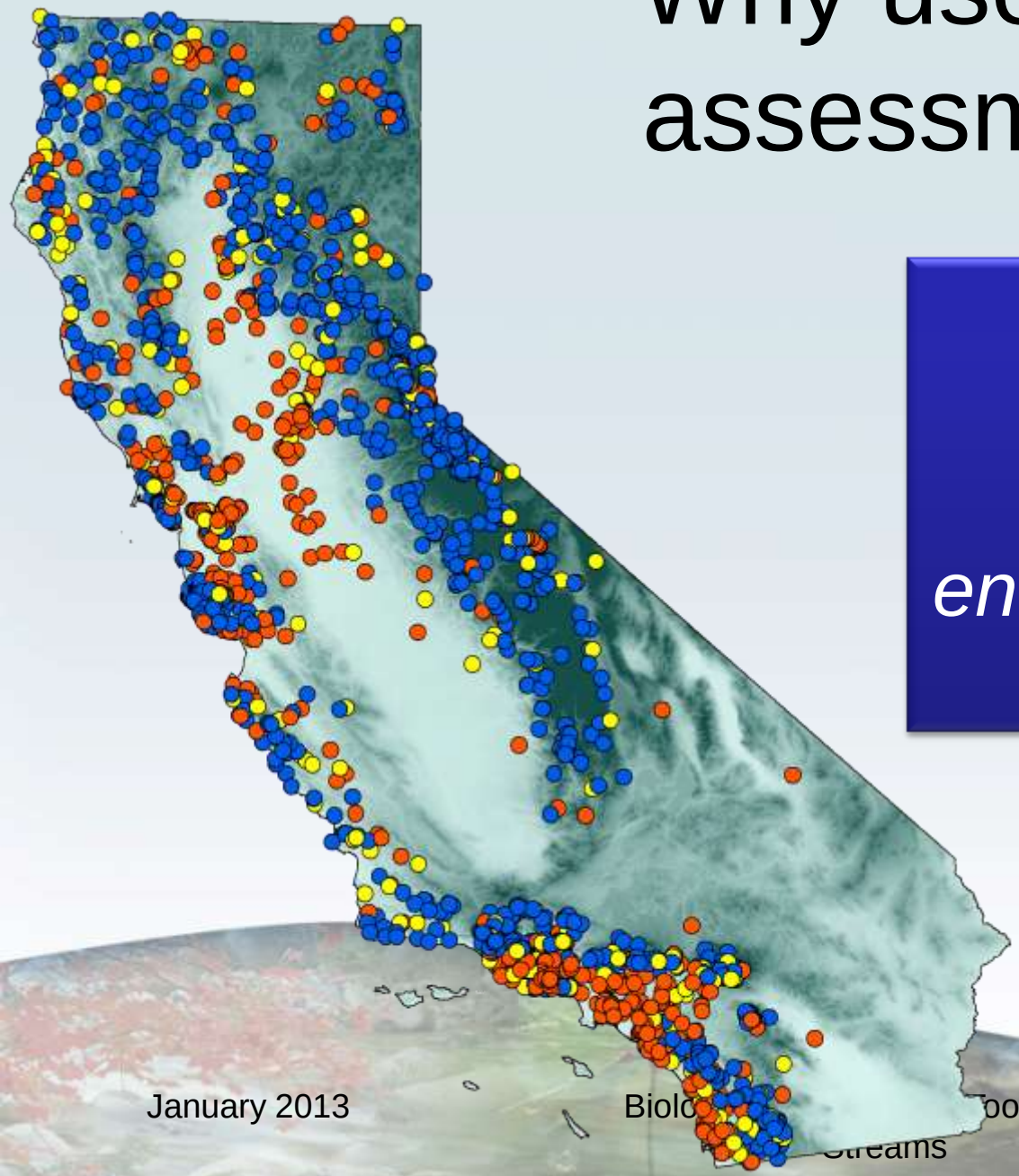
Why use biological assessment tools?

Mechanisms for restoring streams are limited

Why use biological assessment tools?

Biological monitoring data are not assessed consistently statewide

Why use biological assessment tools?



Regional Water Boards need measurable, enforceable biological thresholds

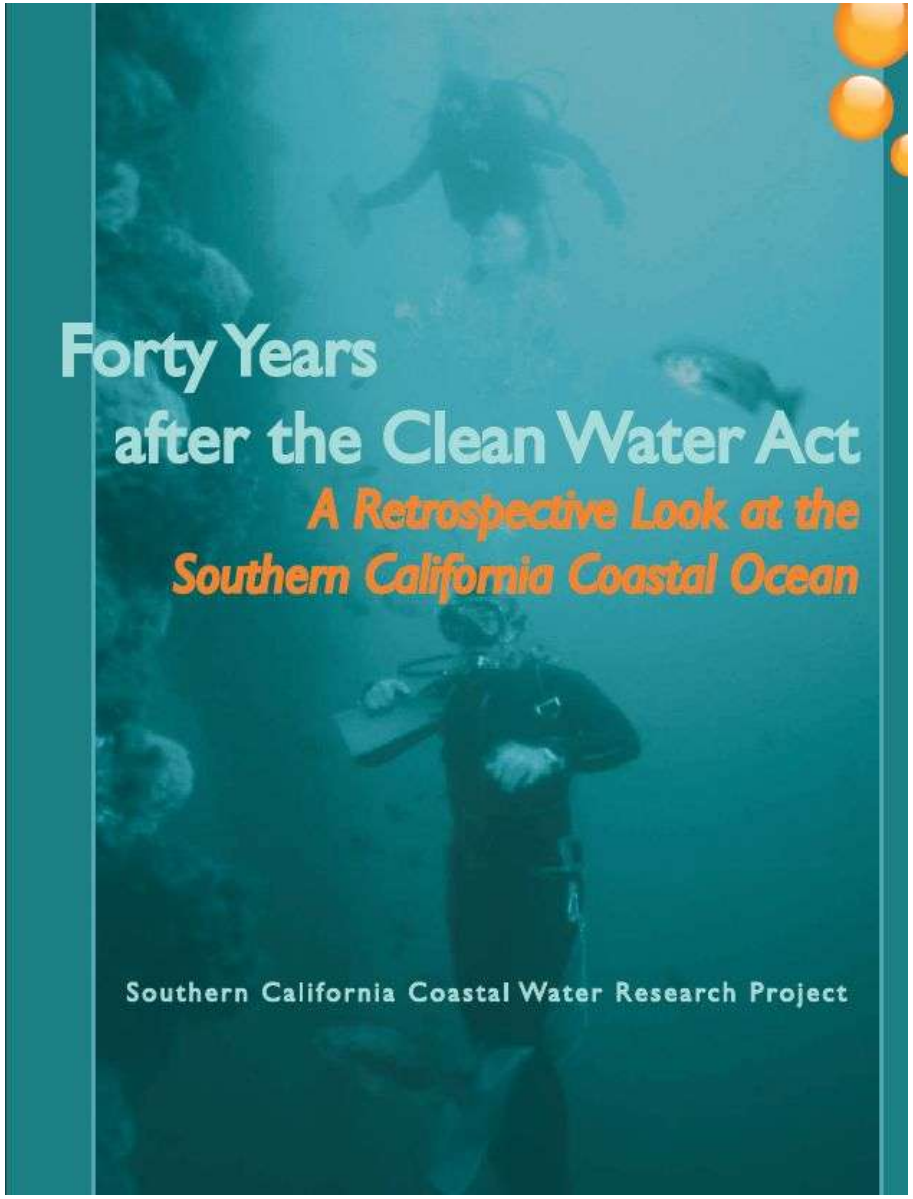
Policy Goals

- Formally adopt biological assessment methods and thresholds for assessing attainment of aquatic life beneficial uses
- Establish a consistent, statewide framework for interpreting biological data
- Institute policy with statewide consistency AND regional flexibility
- Establish policy for identifying and protecting high quality streams
- Set reasonable expectations for modified streams

David Gibson

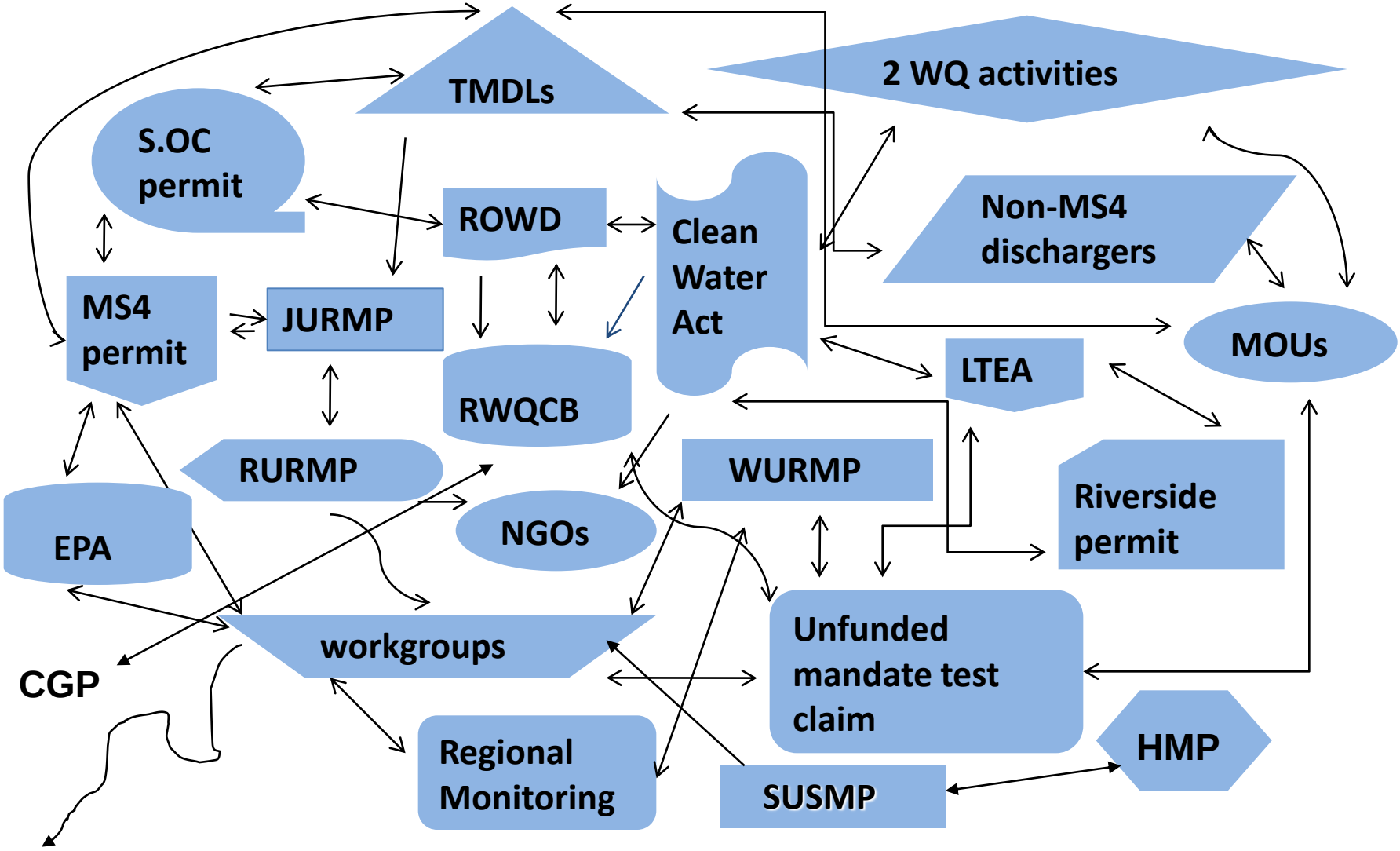
Executive Officer

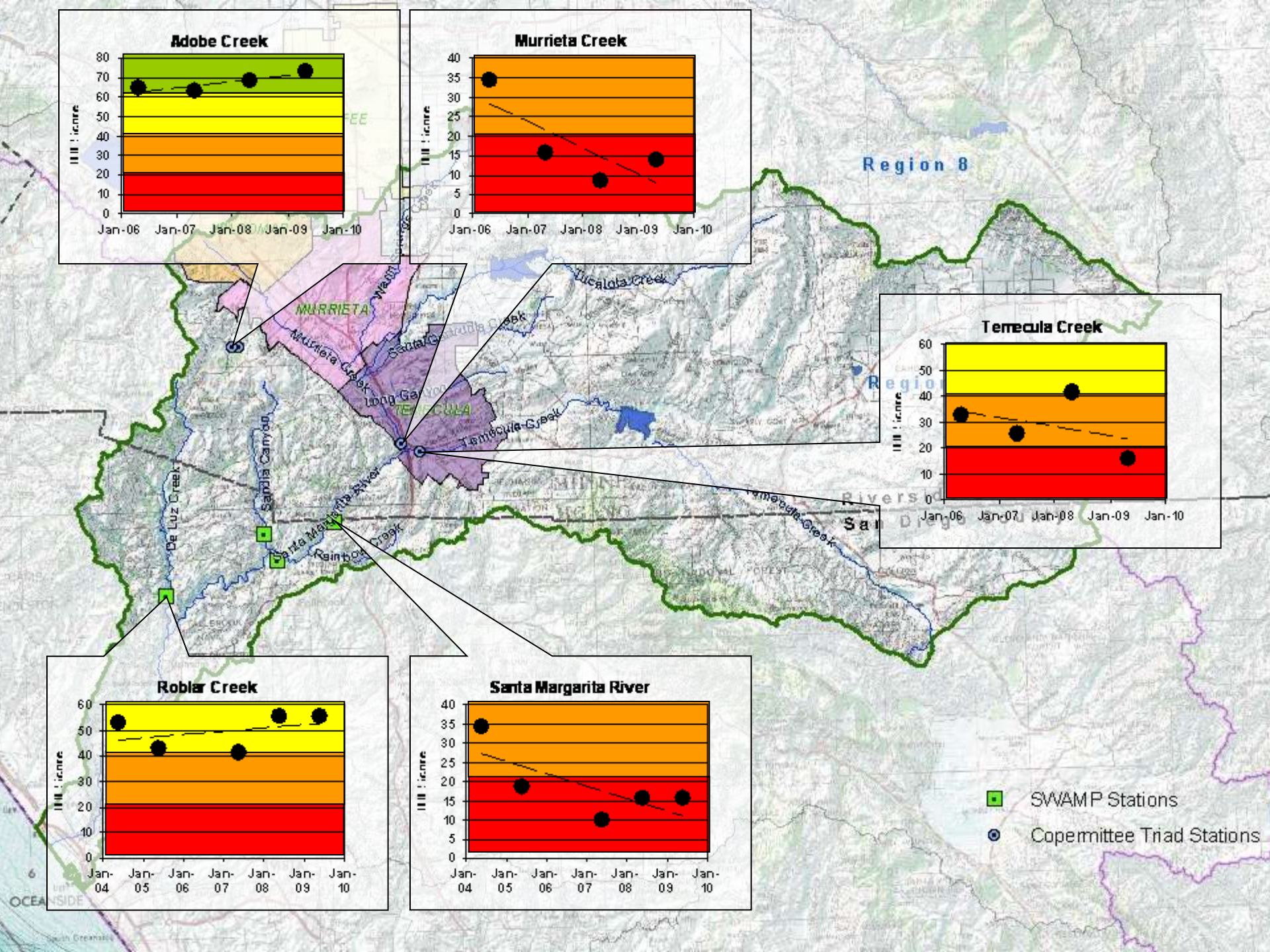
San Diego Regional Water Board


Forty Years
after the Clean Water Act
A Retrospective Look at the
Southern California Coastal Ocean
Southern California Coastal Water Research Project


PLEASE
DO NOT
DISTURB
ROCK BAGS
STORM WATER
POLLUTION
PREVENTION

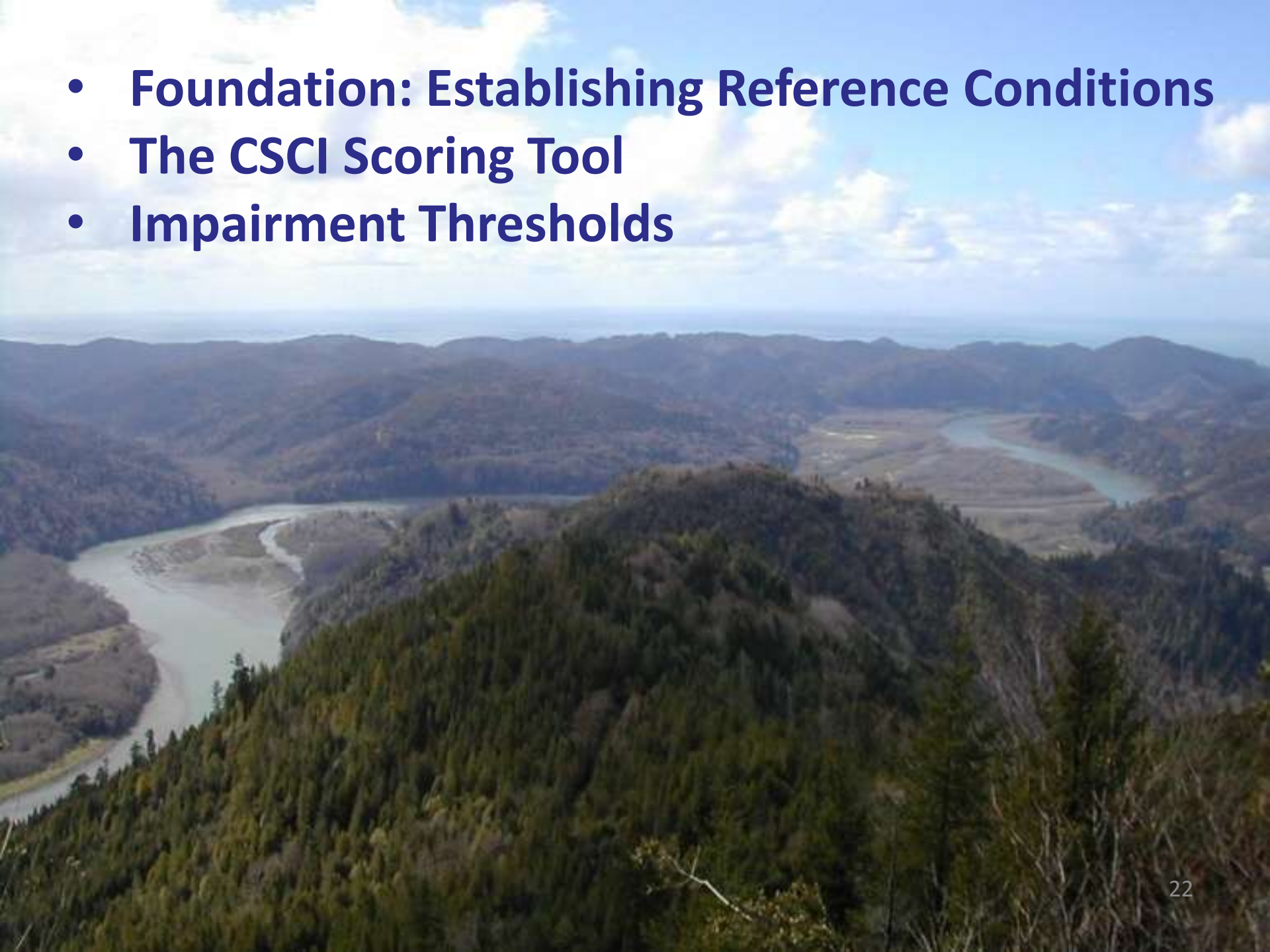

ROAD
CLOSED


TMDLs
2 WQ activities
S.OC permit
ROWD
Clean Water Act
Non-MS4 dischargers
MS4 permit
JURMP
MOUs
LTEA
RWQCB
RURMP
WURMP
Riverside permit
EPA
NGOs
workgroups
CGP
Unfunded mandate test claim
HMP
Regional Monitoring
SUSMP


Adobe Creek
IBI Score
80
70
60
50
40
30
20
10
0
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Murrieta Creek
IBI Score
40
35
30
25
20
15
10
5
0
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Temecula Creek
IBI Score
60
50
40
30
20
10
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Roblar Creek
IBI Score
60
50
40
30
20
10
0
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Santa Margarita River
IBI Score
40
35
30
25
20
15
10
5
0
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Region 8
MURRIETA
TEMECULA
Murrieta Creek
Temecula Creek
Long Canyon Creek
Santa Gertrudis Creek
Lucalota Creek
Warm Springs Creek
Santa Margarita River
De Luz Creek
Rainbow Creek
SWAMP Stations
Copermittee Triad Stations

An overview of the California Stream Condition Index (CSCI)

- **Foundation: Establishing Reference Conditions**
- **The CSCI Scoring Tool**
- **Impairment Thresholds**



SWAMP's Infrastructure Investments
(2000-2012)

- **SWAMP has standard methods:** field, lab, data management, reporting, QA
- **SWAMP methods used widely throughout CA**
- **Biological Objectives will standardize interpretation**

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Surface Water Ambient Monitoring Program

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

Benthic invertebrates are ideal ecological assessment tools

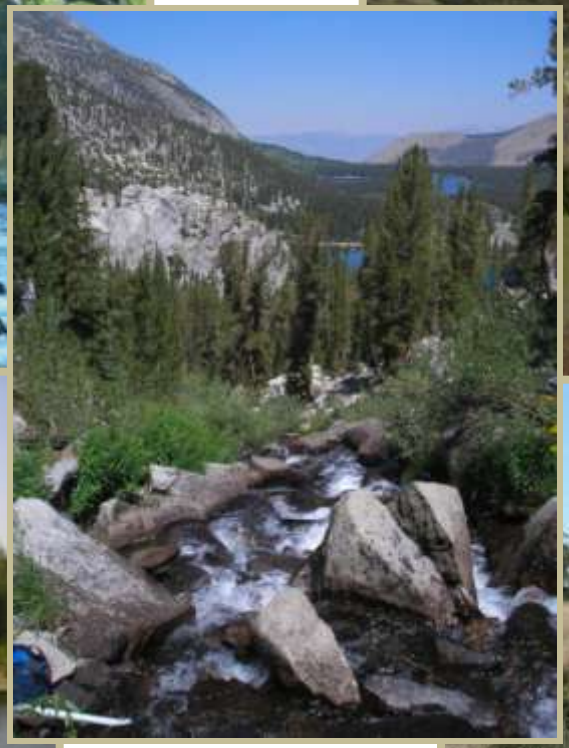
- *Ubiquitous, abundant and diverse*
- *Responsive to stress*
- *Information rich*

How to convert a list of species into a condition score?

Reference condition approach is a widely accepted standard

Compares biology at test sites to biology at similar **reference sites** (sites with low levels of disturbance)

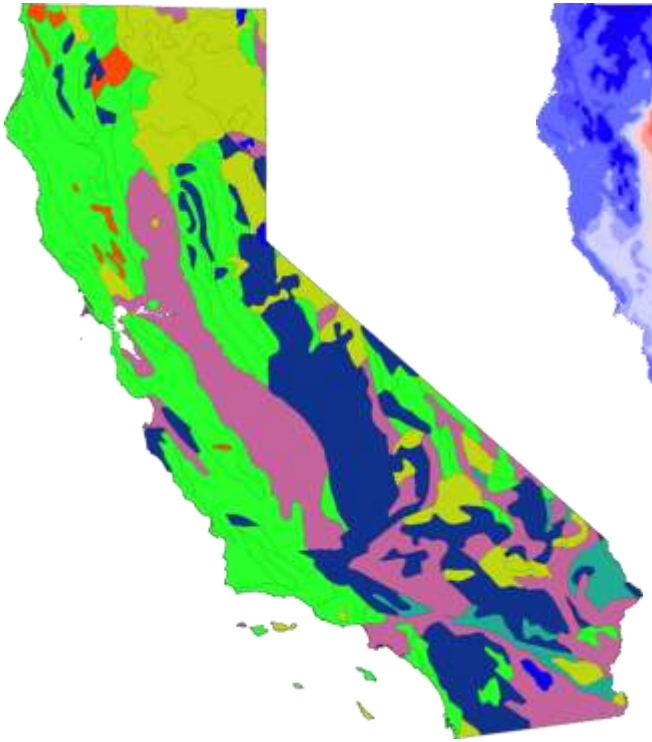
Scoring tools depend on reference sites to account for natural sources of variation



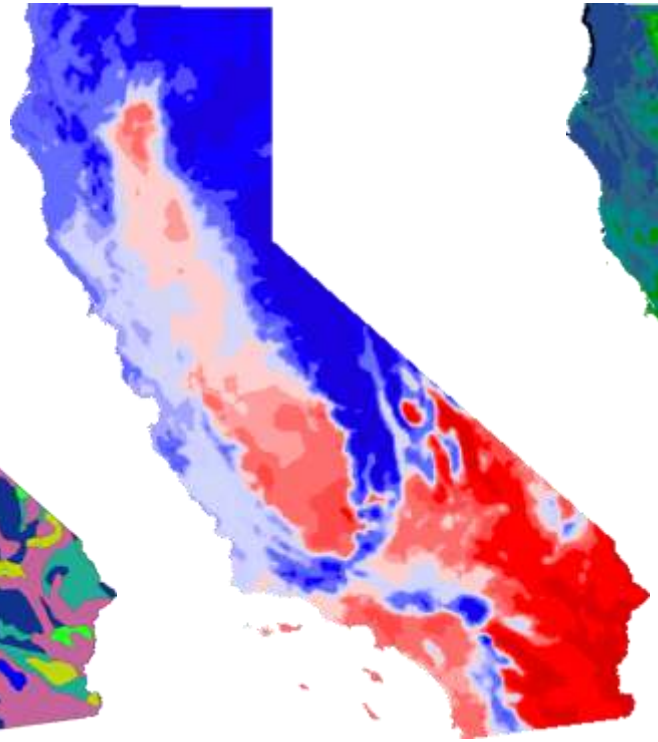
Technical Challenges: California is not Kansas

Strong natural gradients result in a large degree of **natural variation** in biological communities

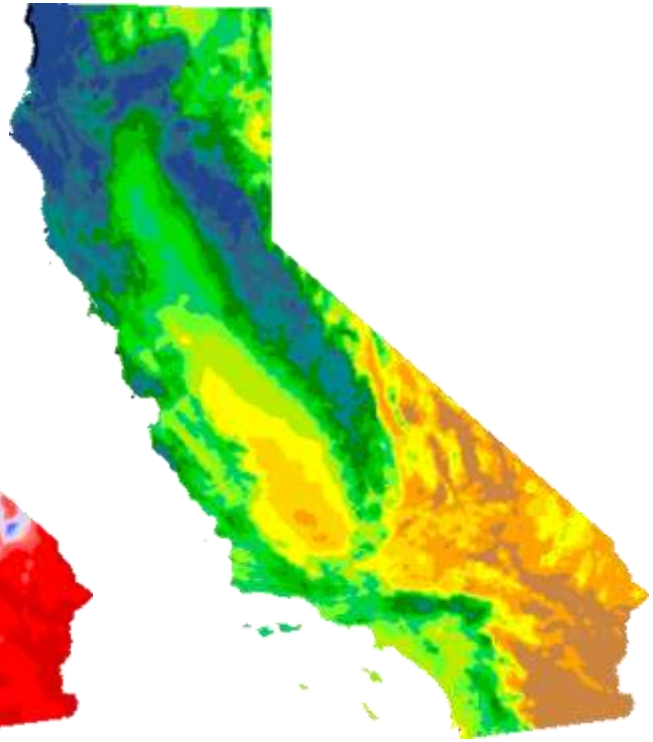
Geology



Temperature

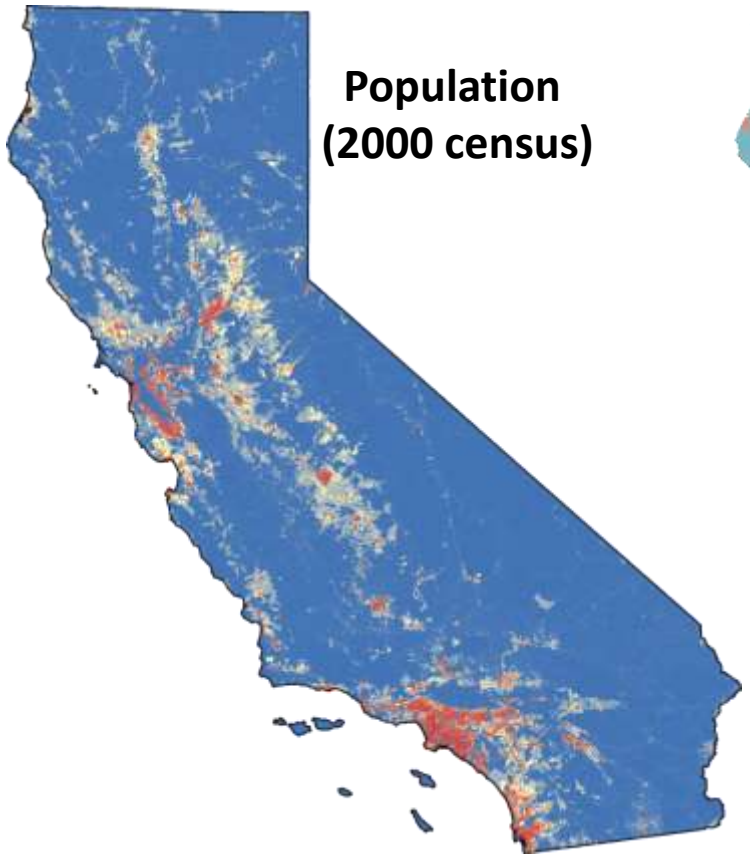


Precipitation

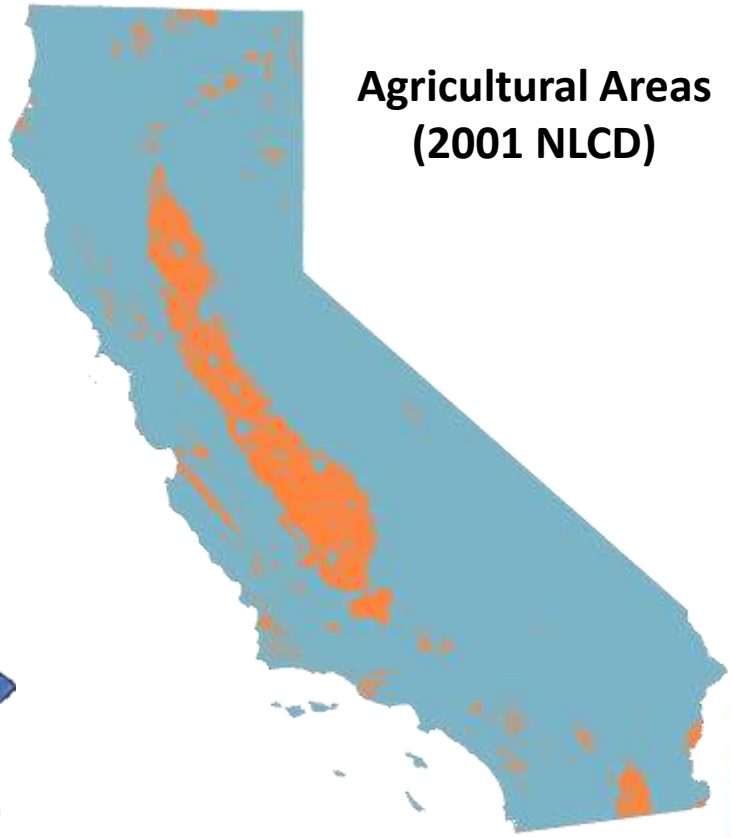


Technical Challenges: California IS Kansas

High degree of development (e.g., impervious surface and intensive agriculture) in some regions



Population (2000 census)



Agricultural Areas (2001 NLCD)

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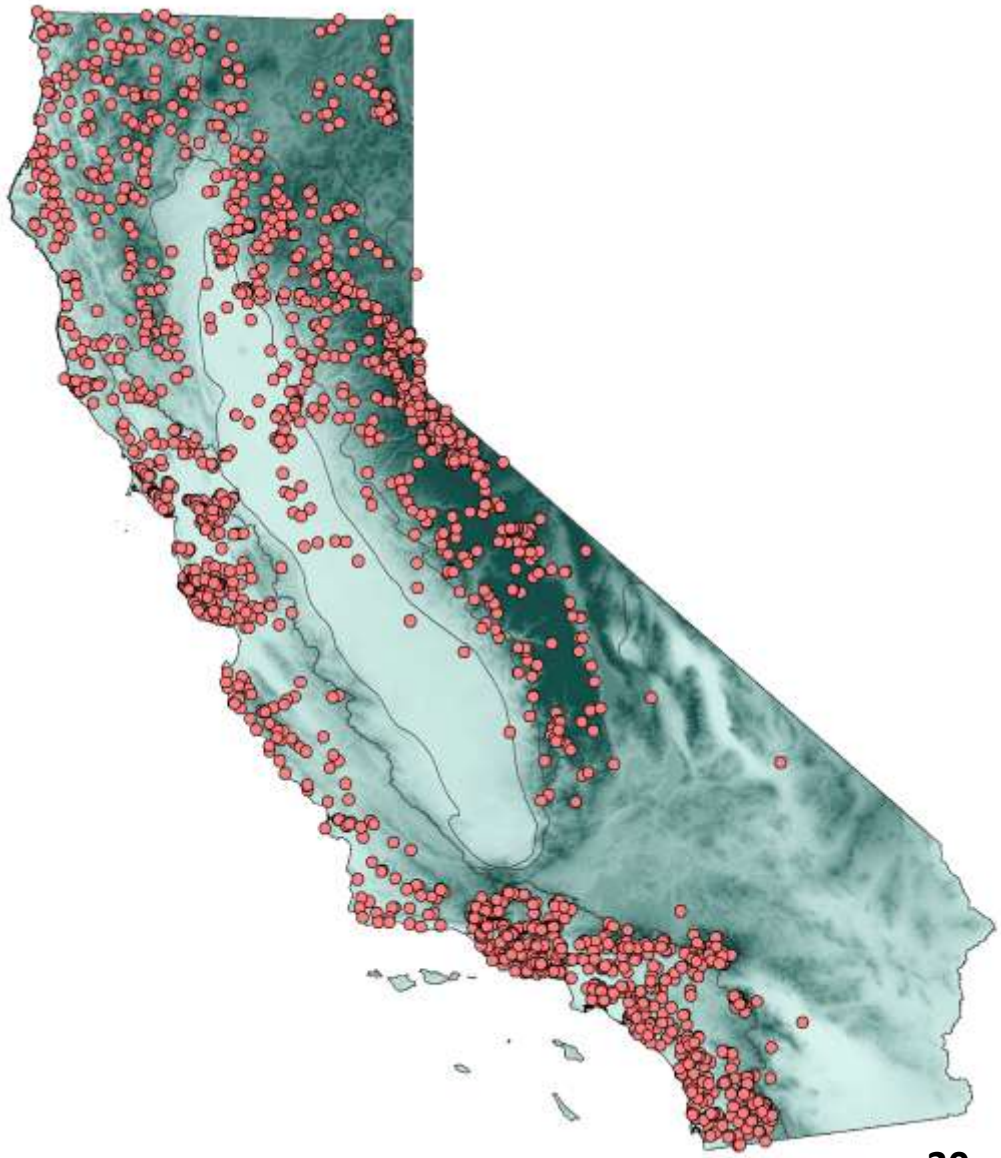
Reference site selection

Screened > 2400
candidate reference sites



Objectives:

- Reference pool represents CA stream diversity
- Biological at reference sites is minimally influenced by stress

Reference criteria: only allow sites with low levels of human activity

Filtered screening dataset with a large suite of GIS and reach-scale data (> 170 variables)

- Land Use
- Infrastructure
- Hydromodification
- Fire history, dams, mines
- Invasive invertebrates, plants
- In-stream and riparian habitat
- Water chemistry

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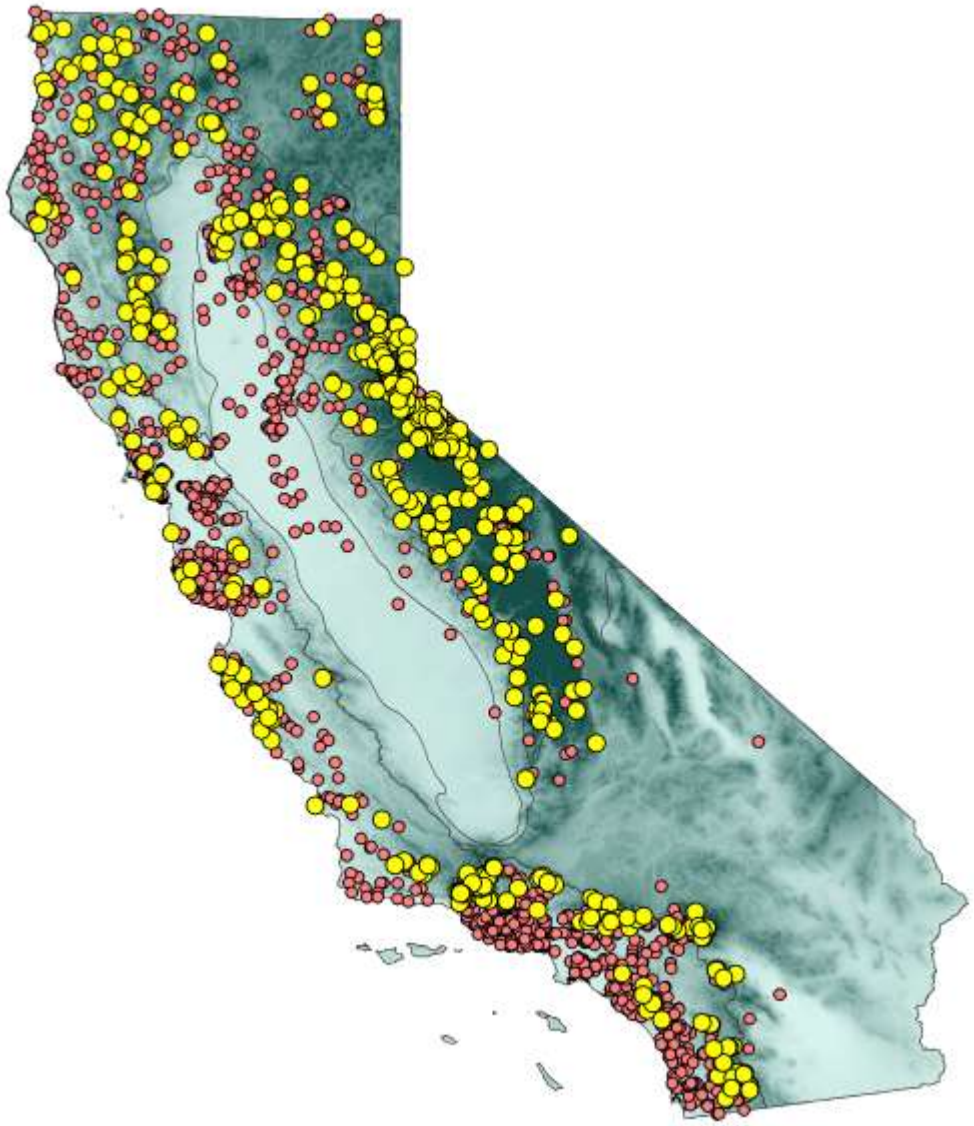
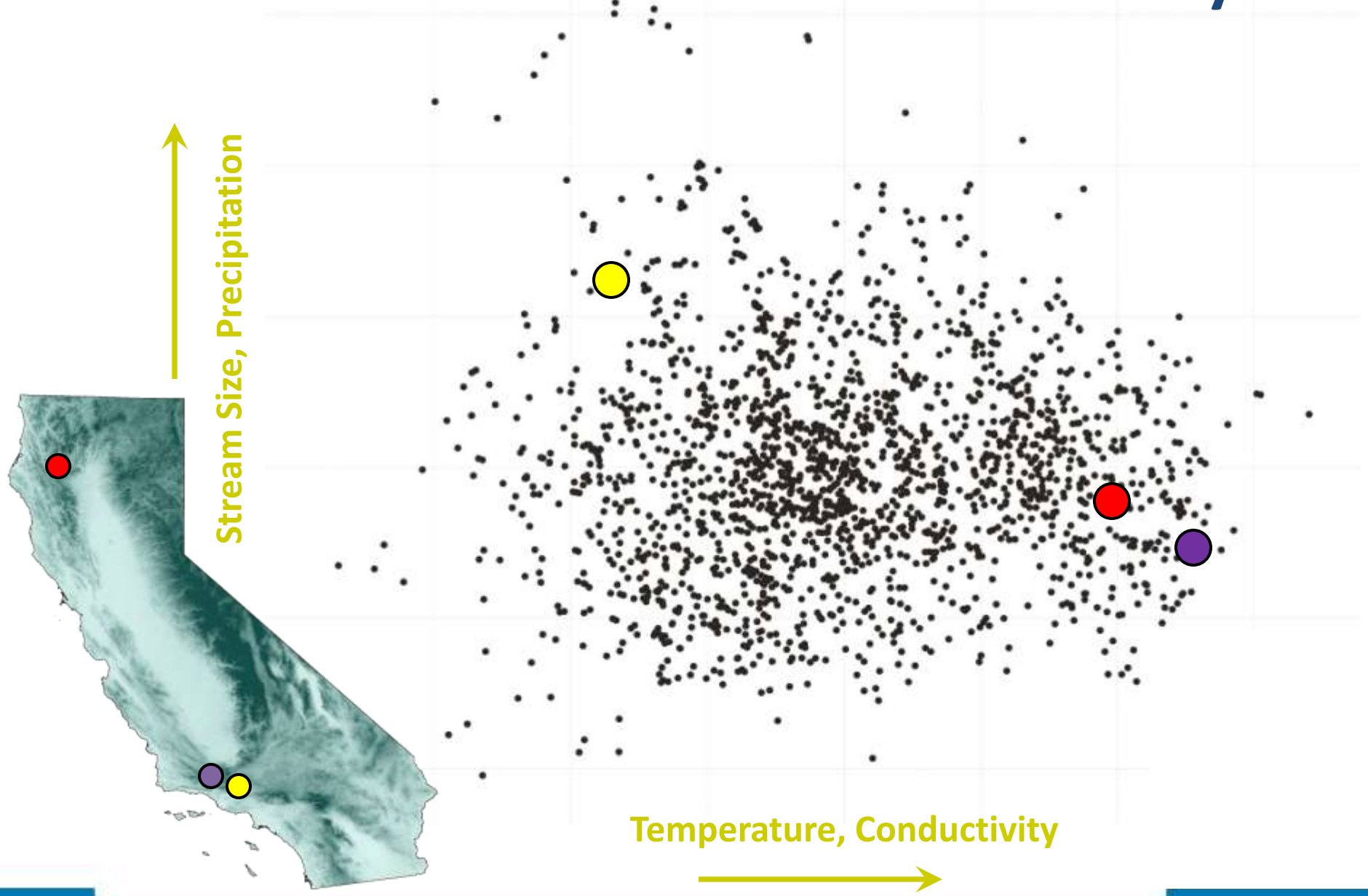
Broad geographic coverage

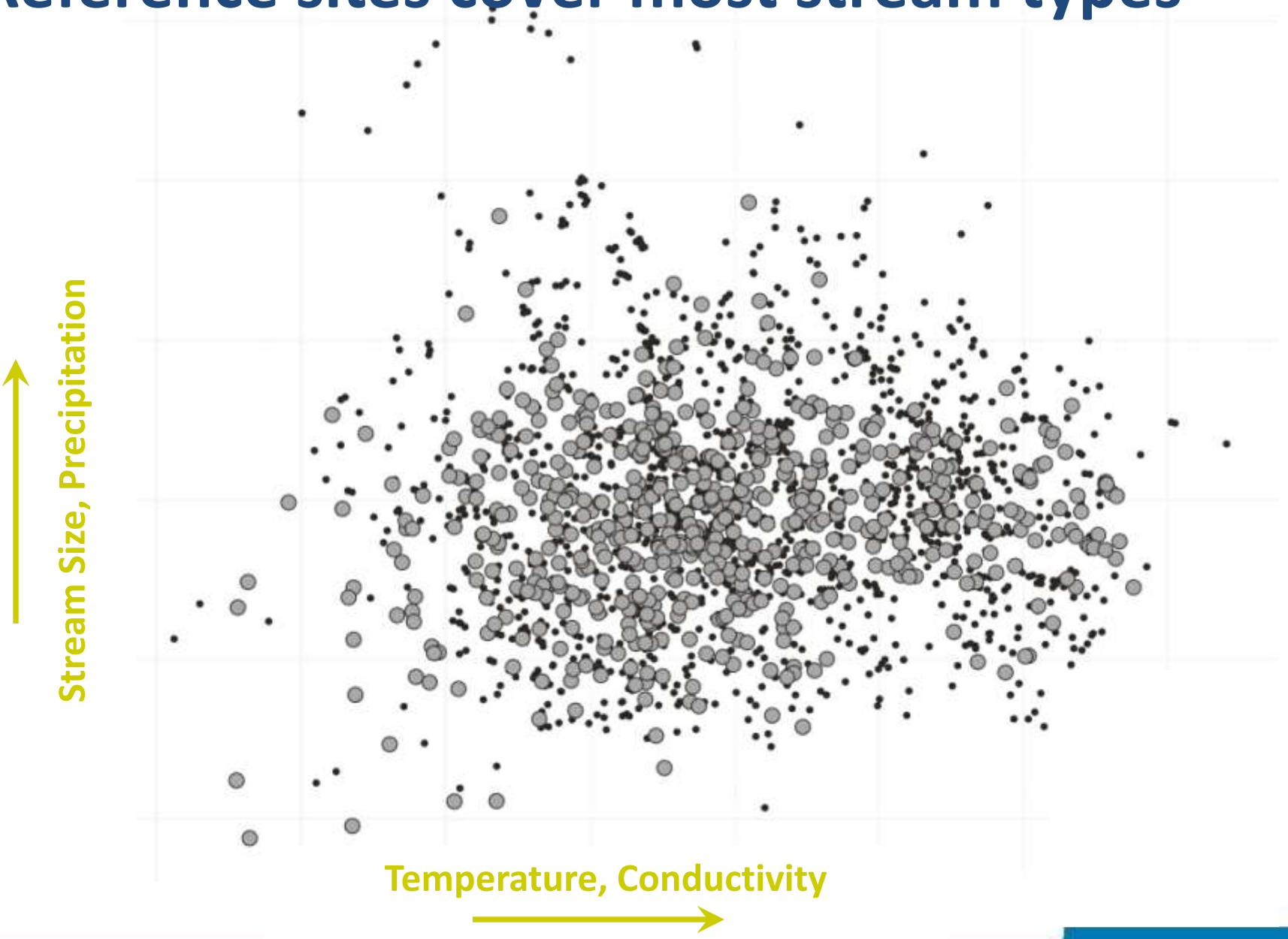
REGION	n
North Coast	75
Central Valley	1
Coastal Chaparral	57
Interior Chaparral	33
South Coast Mountains	85
South Coast Xeric	34
Western Sierra	131
Central Lahontan	114
Deserts + Modoc	27
TOTAL	**586**



Multivariate view of natural diversity



Reference sites cover most stream types



Using reference sites to set expectations for test sites

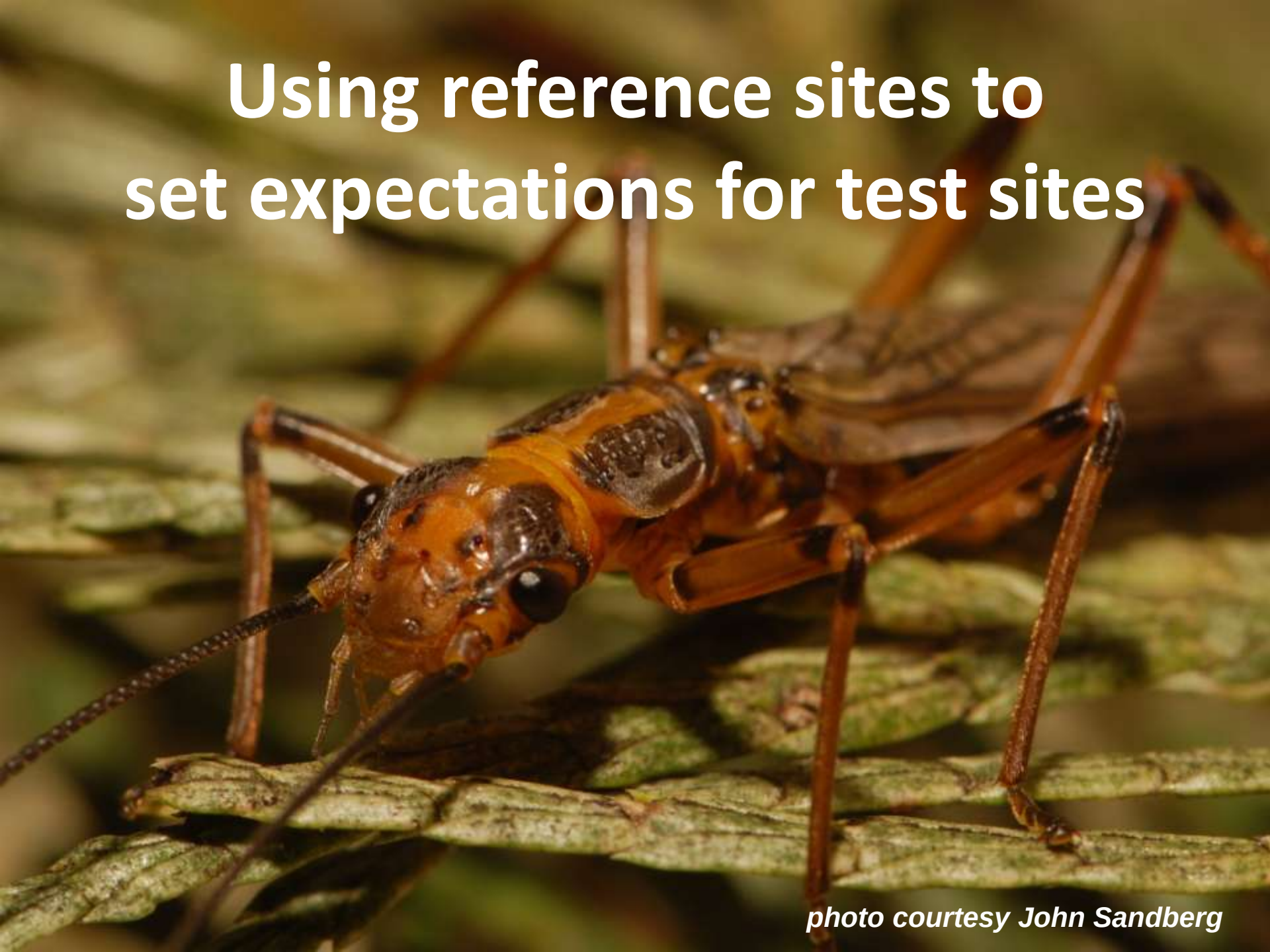


photo courtesy John Sandberg

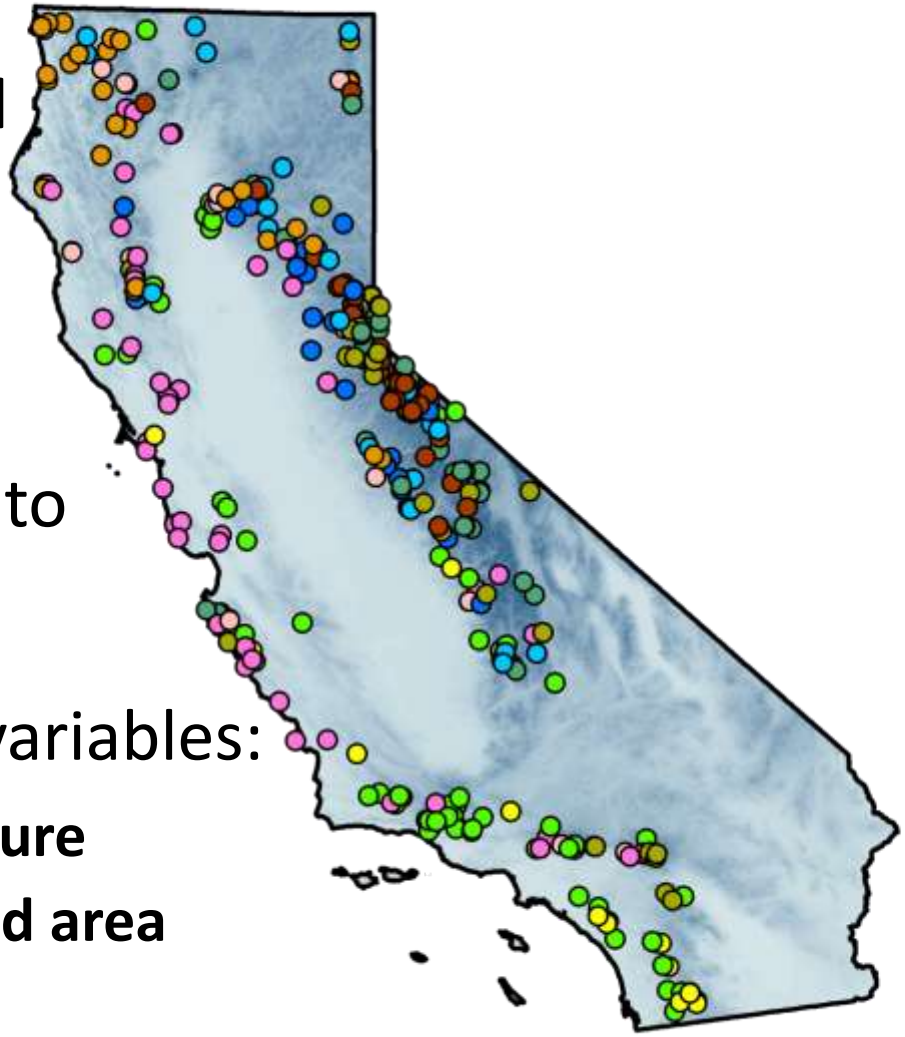
The California Stream Condition Index (CSCI) combines two common approaches

- **Species loss component (taxonomic completeness)**
- **Ecological structure component**

Both account for natural sources of variation, but measure different aspects of biological health

Species Loss Component

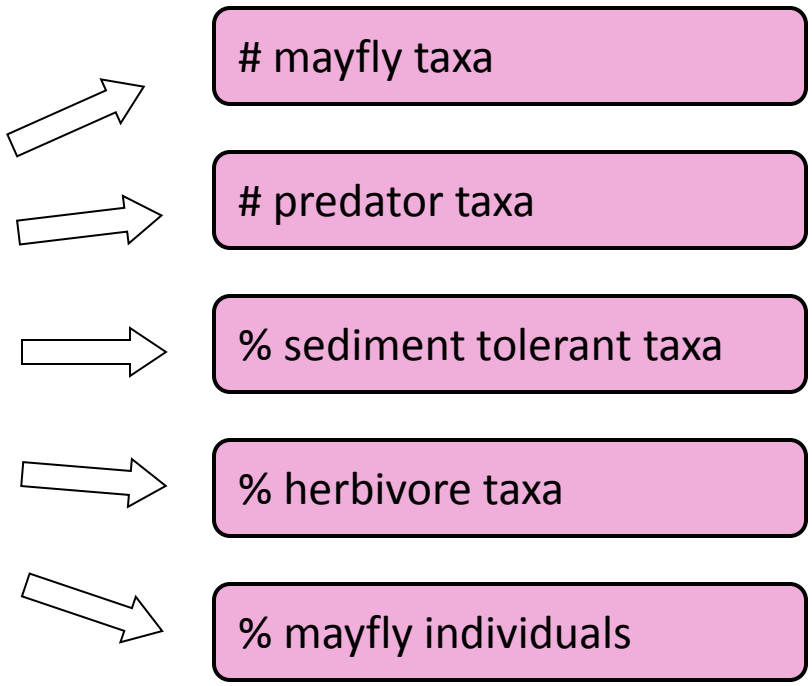
- Compare number of **observed** to number of **expected** taxa
- Test sites are compared to **groups of similar reference sites** to determine which taxa to "expect"
- Similarity based on 5 natural variables:
  - **Latitude**
  - **Elevation**
  - **Precipitation**
  - **Temperature**
  - **Watershed area**



Ecological Structure Component

Species list is converted into metrics representing diversity, ecosystem function, and sensitivity to stress

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 Structure Component

- Expected metric values are based on reference sites
- Expected metric values are adjusted to account for major natural gradients

CSCI predicts the species and metric values to expect at a test site based on **natural environmental factors**

- **Location** – elevation, latitude, longitude
- **Watershed size**
- **Climate** – precipitation, temperature
- **Geology** – mineral content, soils

species and metrics **measured** at test site = **Observed**

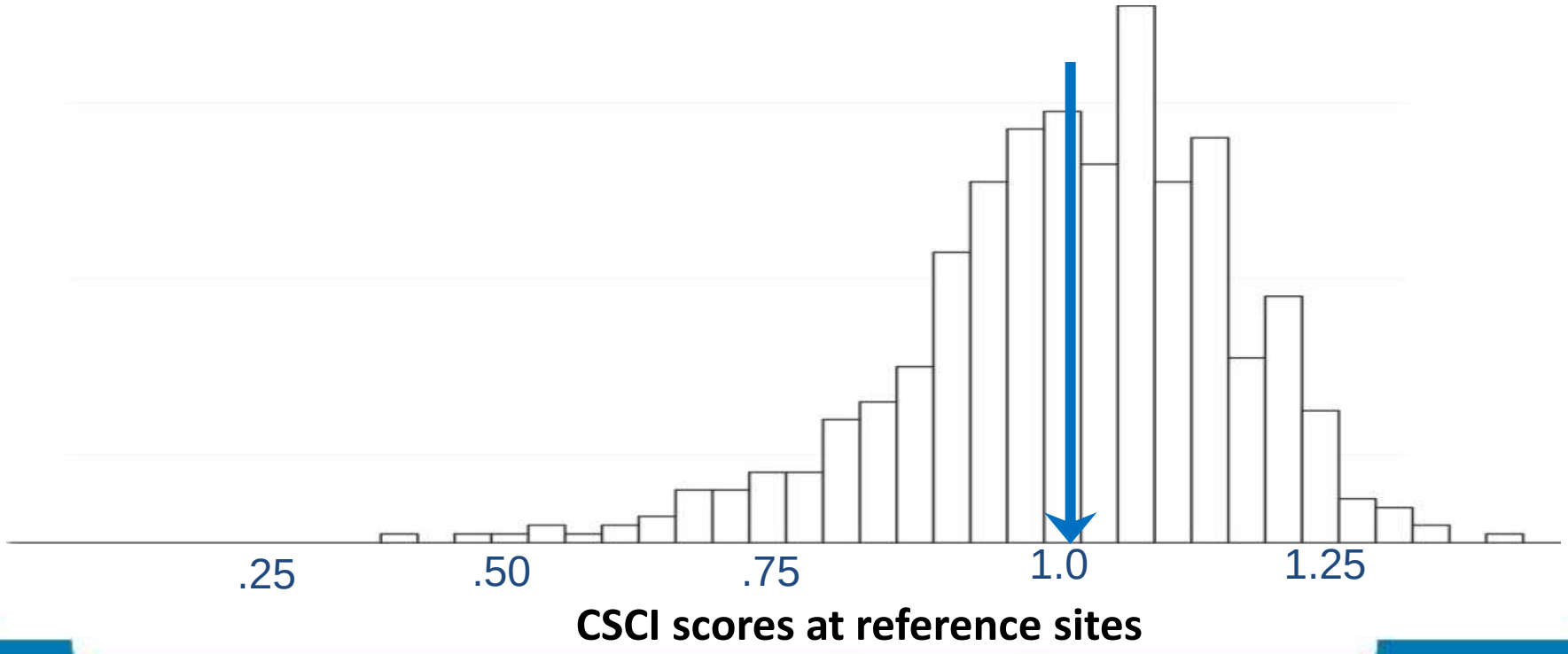
species and metrics **predicted** at site = **Expected**

If O/E is ~1.0, biological integrity is intact

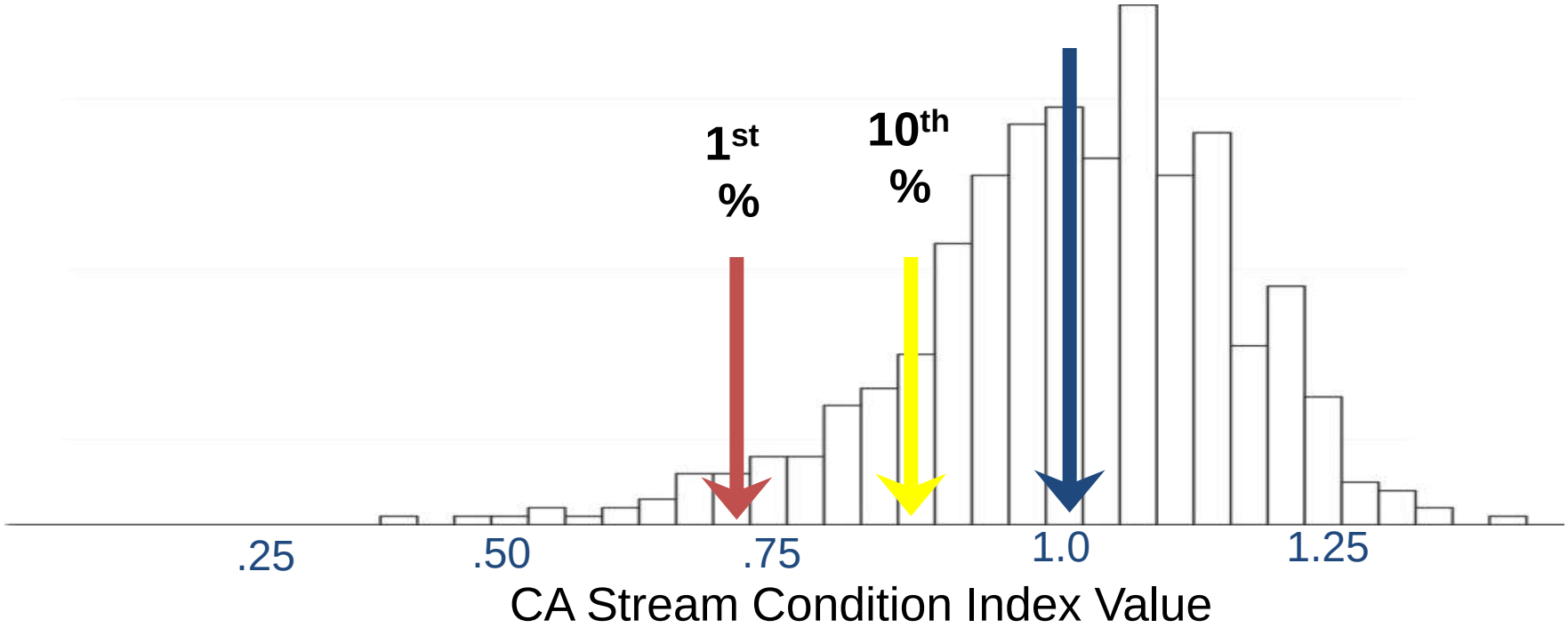
If O/E < 1.0, biological integrity is altered

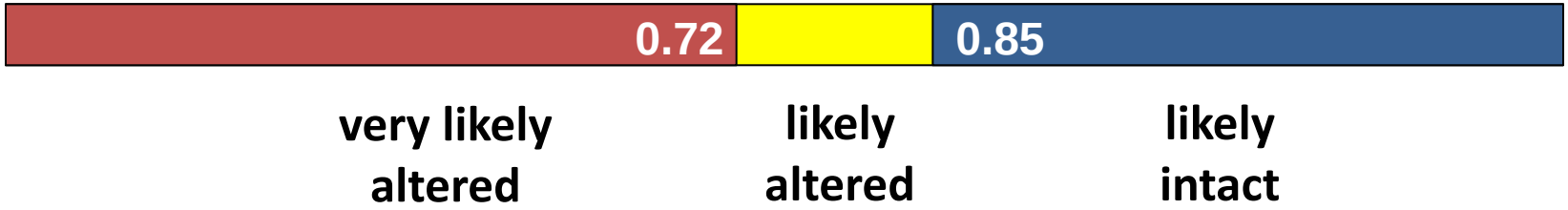
California Stream Condition Index (CSCI) is an average of the two component scores

- CSCI ranges from 0 to >1
- Mean of reference sites 1.01
- Variability in scores is known (±0.12 sd)



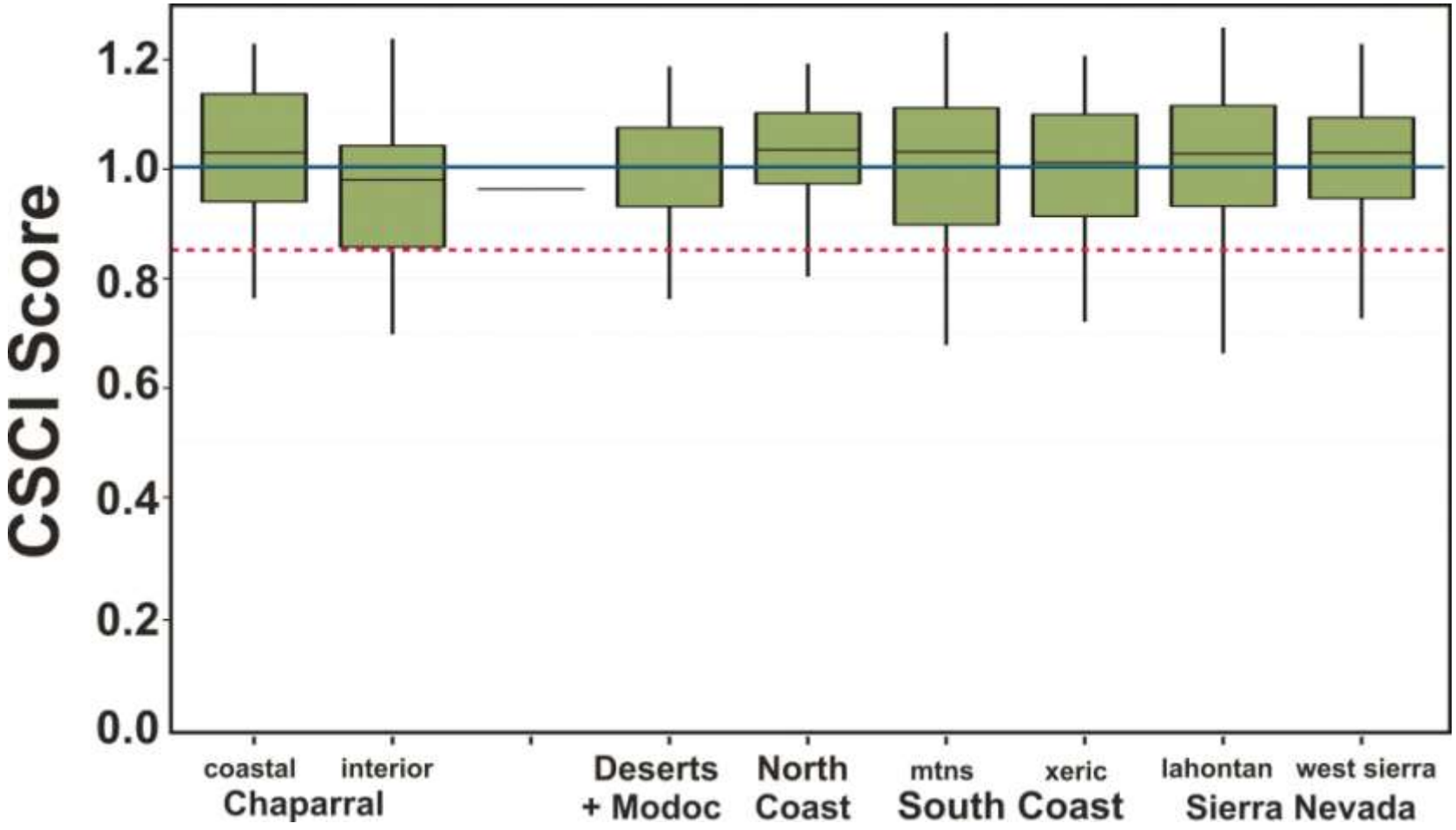
Statistical thresholds





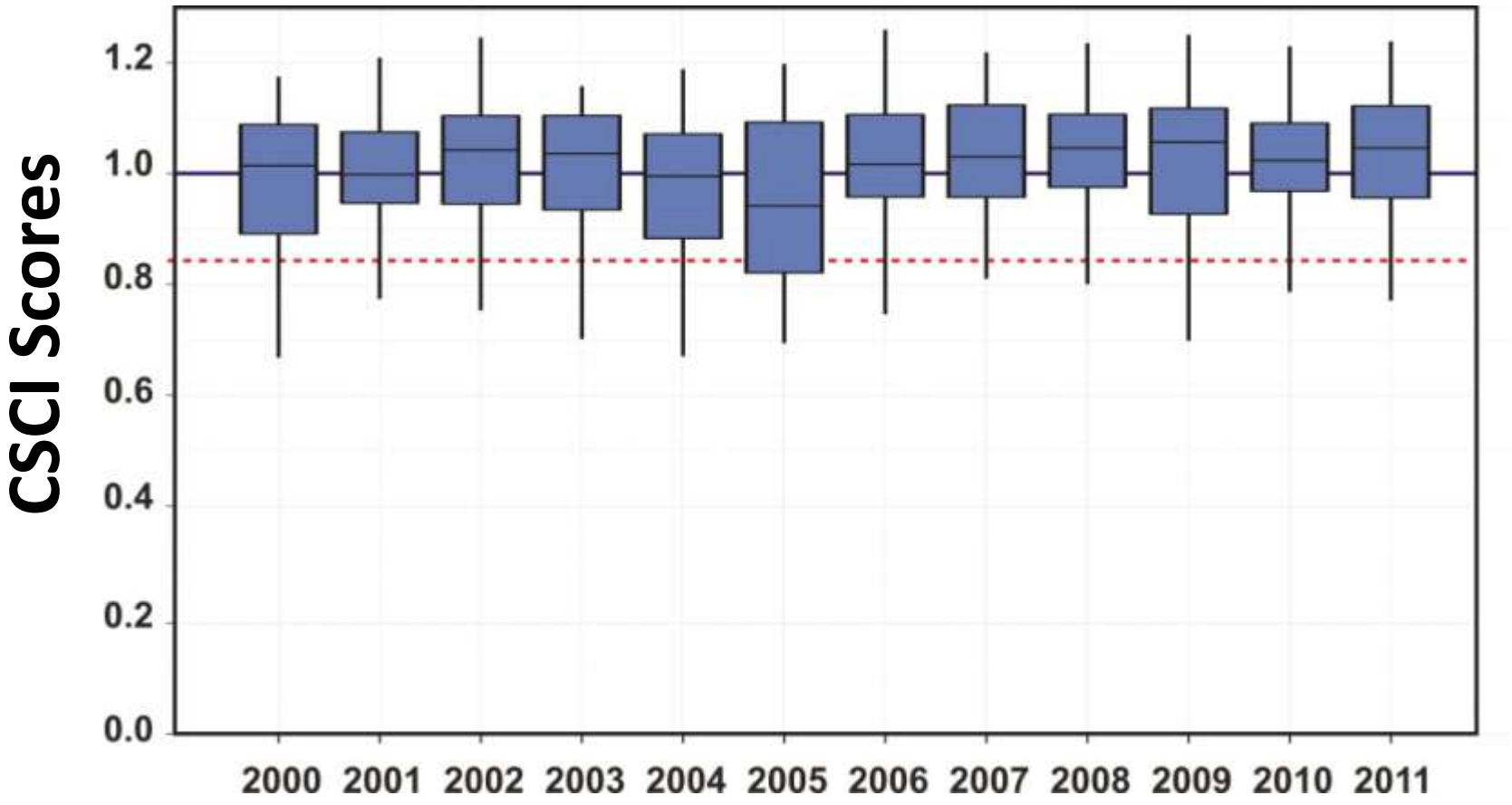
CSCI is consistent in all regions

CSCI scores at reference sites in major CA ecoregions

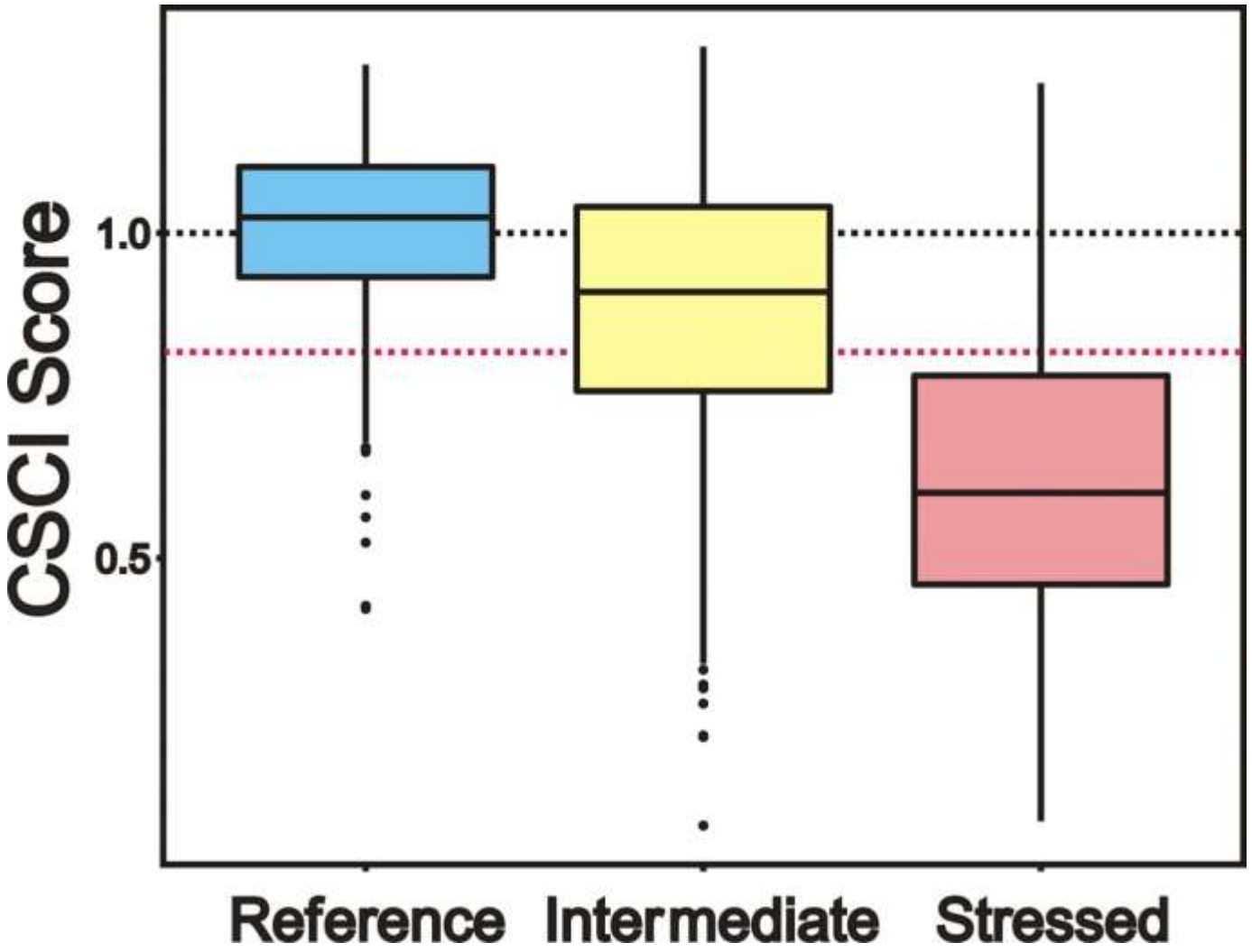


CSCI is consistent over time

CSCI scores at reference sites 2000 - 2011



CSCI is responsive to stress



Considerations for modified streams

- We have deliberately expended many resources addressing highly modified streams
  - Enables constructive stakeholder and regulatory advisory group discussions
- Explored several options in multiple pilot studies
  - How to define, where located, what is their range of biological condition
- Can still apply the CSCI in modified streams
  - Still deciding what are appropriate thresholds

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Summary: The CSCI is a significant advance over previous CA biotic indices

- ***Much better reference data set***
  - Bigger, broader, and more rigorously screened
- ***More comprehensive*** assessment of biological integrity
- ***Site-specific expectations***
  - Expected values are customized to each location
- ***Statewide applicability***
  - All perennial wadeable streams can be assessed
  - Consistent meaning throughout California

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STRESSOR IDENTIFICATION OVERVIEW

January 23, 2013

Why Stressor Identification?

- Not every stream is going to meet biological objectives
- When a stream is non-compliant, site-specific causes need to be determined for remediation
- Stressor Identification approaches have not been well-vetted in California

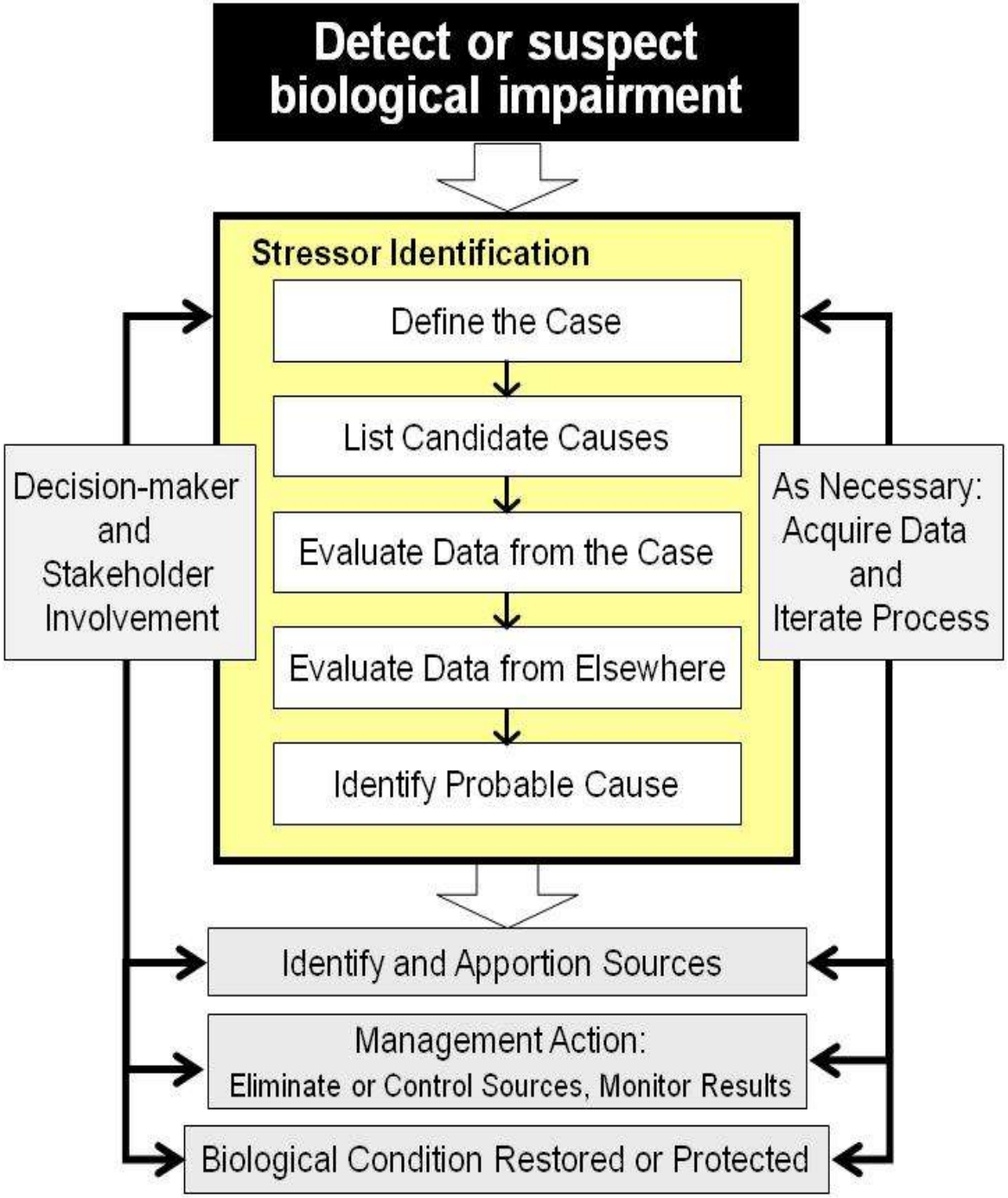
Goal To Support Biological Objectives

- Produce a Guidance Document as a resource for stakeholders and regulatory agencies

- Highlight important considerations
  - Optimize stressor identification designs for California
  - Distinguish tools that work (or don't work)
  - Identify data gaps or new tools that need to be refined/created

We're Lucky To Have Partners

- US EPA has, over the past 15 years, developed a causal assessment framework
  - EPA (National Center for Environmental Assessment) joined our Science Team
- Causal Assessment Diagnostic/Decision Information System
  - www.epa.gov/CADDIS
- Utilized CADDIS for three case studies in California
  - Interactive relationship with local stakeholders


Detect or suspect biological impairment
Stressor Identification
Define the Case
List Candidate Causes
Evaluate Data from the Case
Evaluate Data from Elsewhere
Identify Probable Cause
Decision-maker and Stakeholder Involvement
As Necessary: Acquire Data and Iterate Process
Identify and Apportion Sources
Management Action:
Eliminate or Control Sources, Monitor Results
Biological Condition Restored or Protected

The Five Steps

- Define the case
- List candidate causes
- Evaluate data from the case
- Evaluate data from outside the case
- Identify probable causes
  - Refute causes

The Five Steps

- **Define the case**
- **List candidate causes**
- **Evaluate data from the case**
- **Evaluate data from outside the case**
- **Identify probable causes**
  - **Refute causes**

Our Three Case Studies

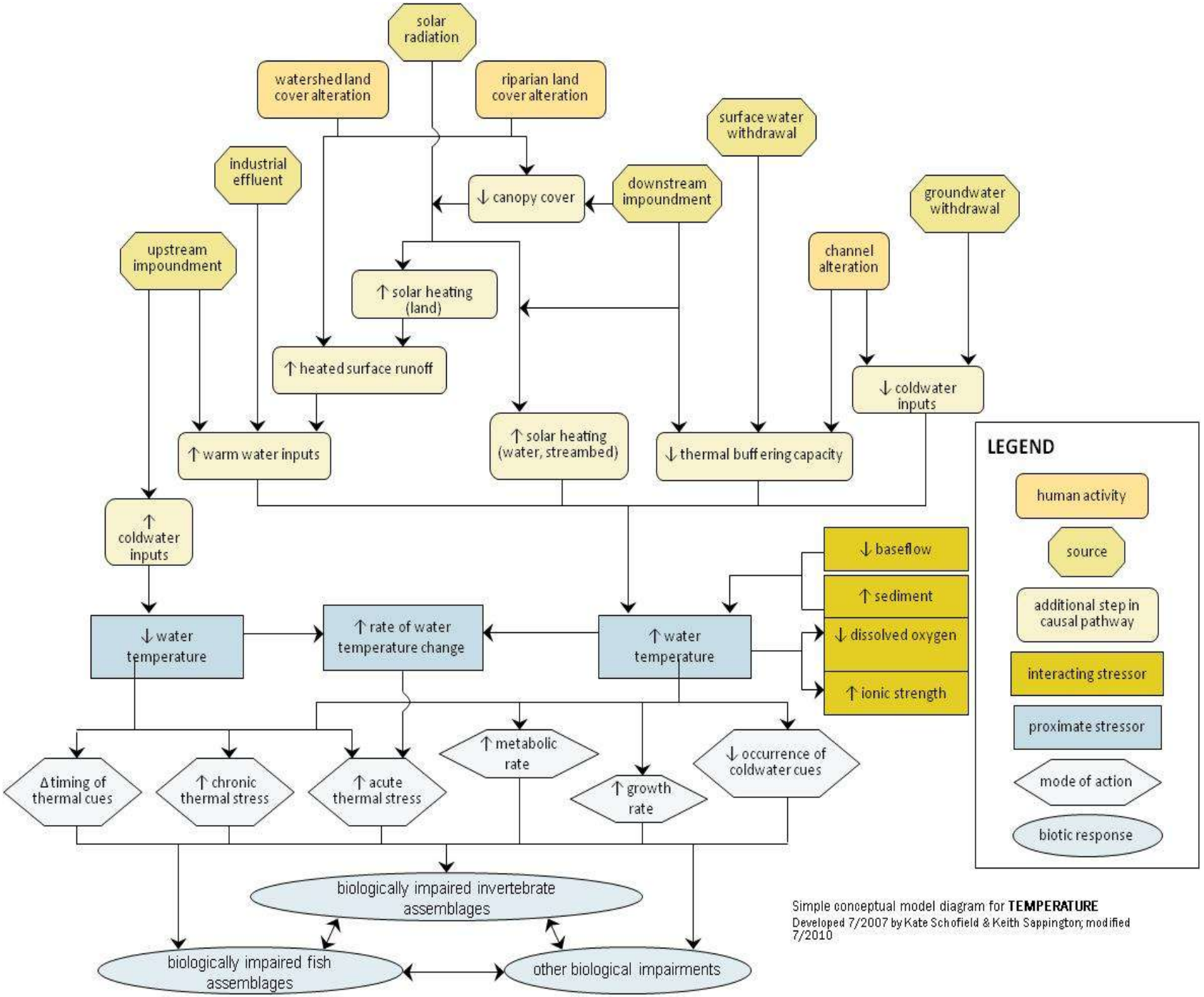
- **Selection criteria**
  - Representativeness, stressor diversity, data availability, willing partners
- **Garcia River in Northern California**
  - RWQCB, Nature Conservancy
- **Salinas River in Central California**
  - RWQCB, Agriculture collaborative
- **Santa Clara and San Diego Rivers in Southern California**
  - RWQCBs, Wastewater Treatment Plant, Municipal Stormwater

The Five Steps

- Define the case
- List candidate causes
- Evaluate data from the case
- Evaluate data from outside the case
- Identify probable causes
  - Refute causes

CUMULATIVE LIST OF CANDIDATE CAUSES

- Flow alteration
- Physical habitat loss or alteration
- Temperature
- Dissolved oxygen
- Conductivity, TDS
- Sediment
- Nutrients
- Trace metals
- Pesticides
- PAHs
- Invasive species



Simple conceptual model diagram for **TEMPERATURE**

Developed 7/2007 by Kate Schofield & Keith Sappington; modified 7/2010

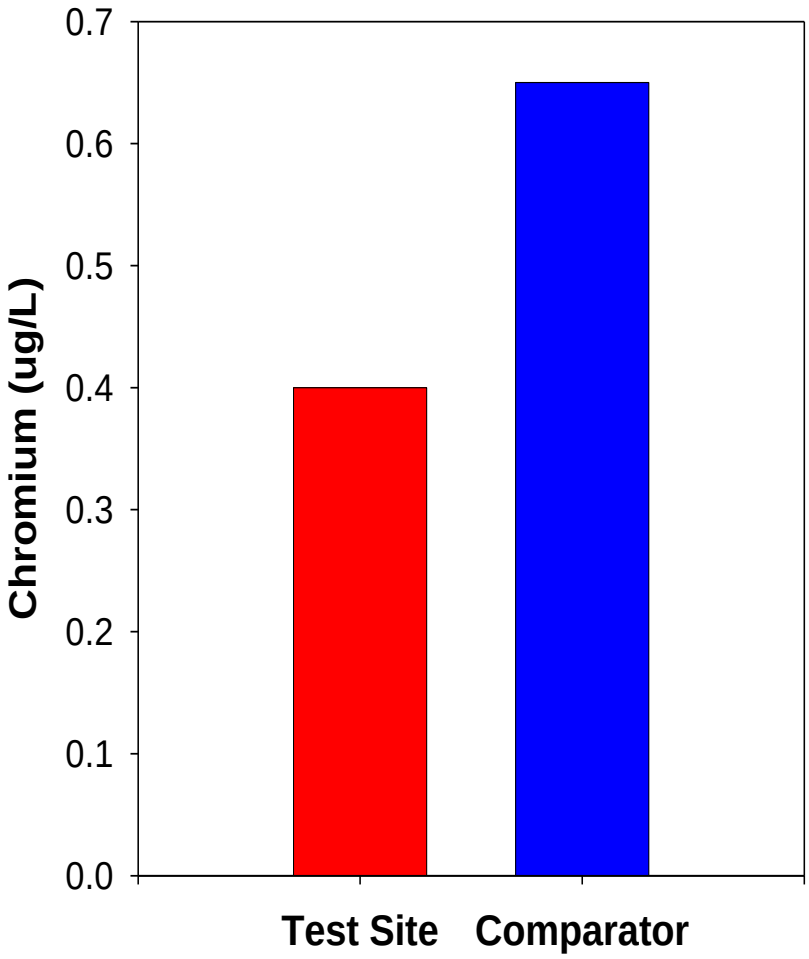
The Five Steps

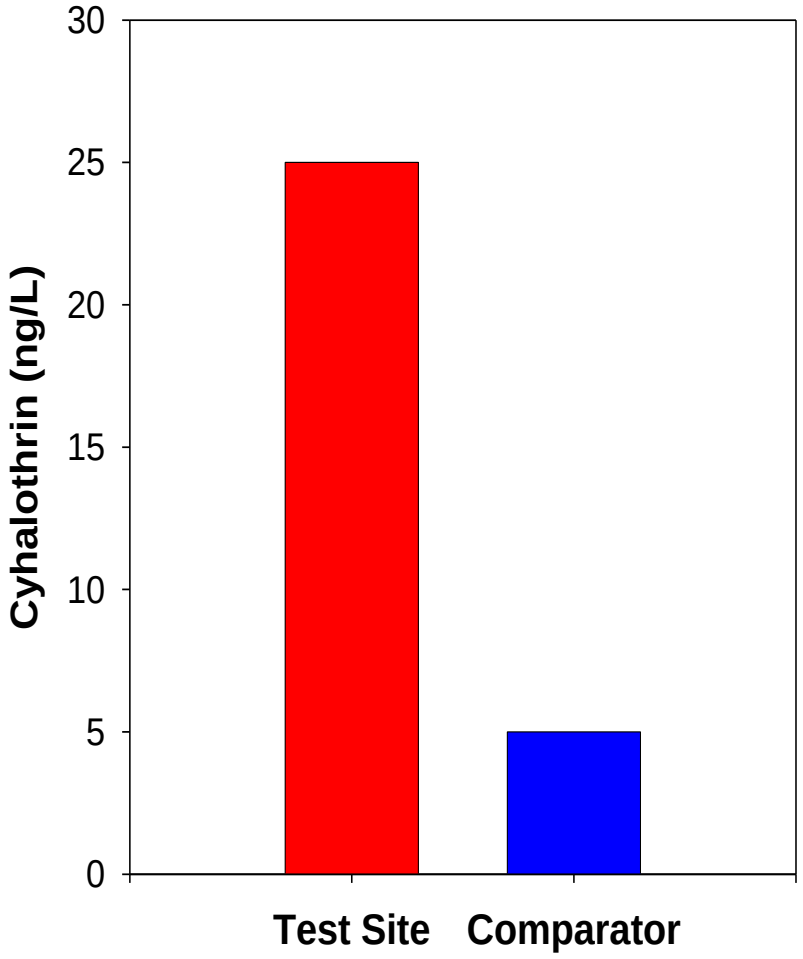
- Define the case
- List candidate causes
- **Evaluate data from the case**
- Evaluate data from outside the case
- Identify probable causes
  - Refute causes

TYPES OF EVIDENCE

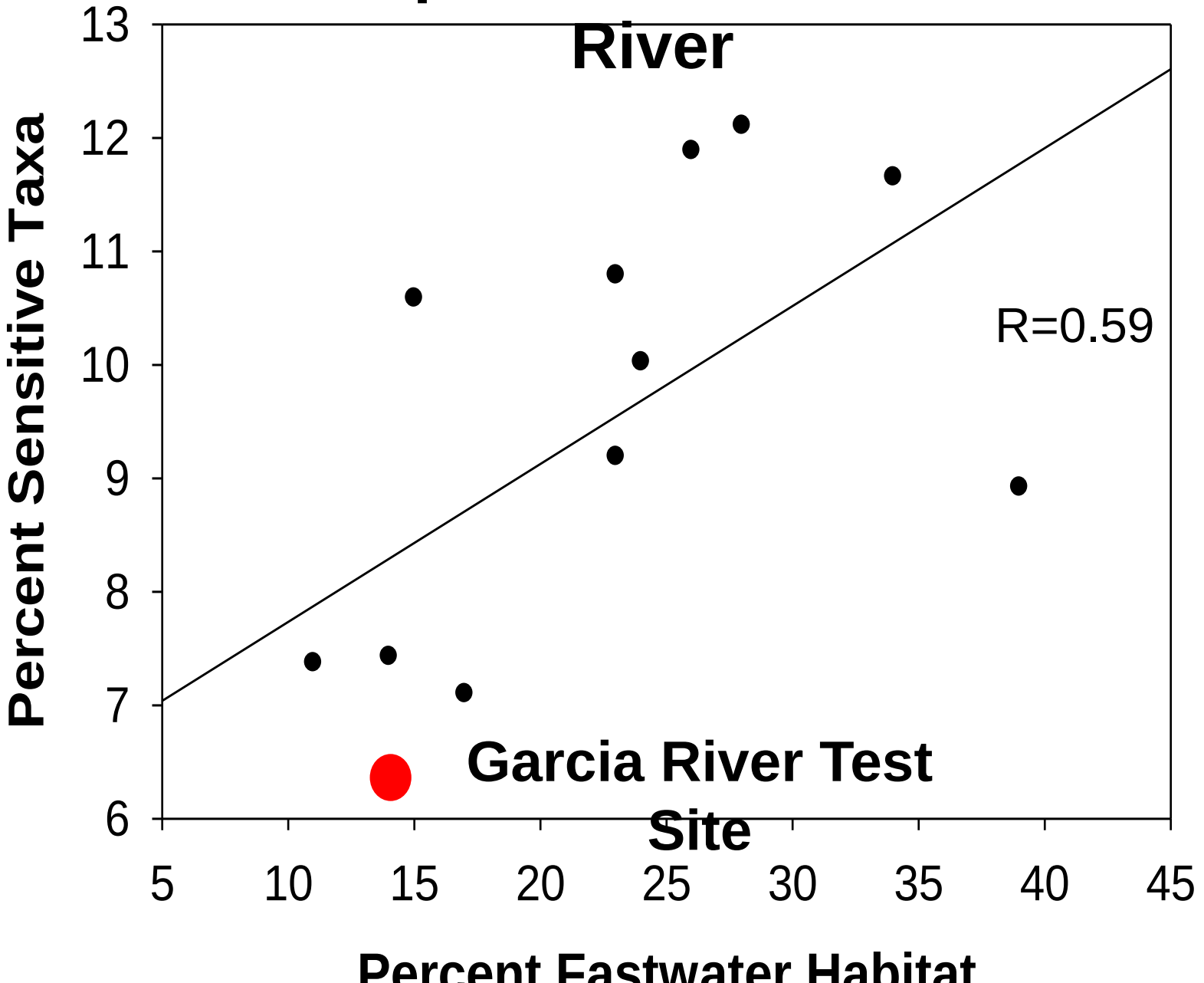
- Spatial/temporal co-occurrence
- Exposure
- Biological mechanism
- Field based stress-response relationship
- Causal pathway
- Manipulation of exposure
- Laboratory tests of site media
- Temporal sequence
- Verified predictions
- Symptoms

Spatial-Temporal Co-Occurrence From the Field: San Diego River





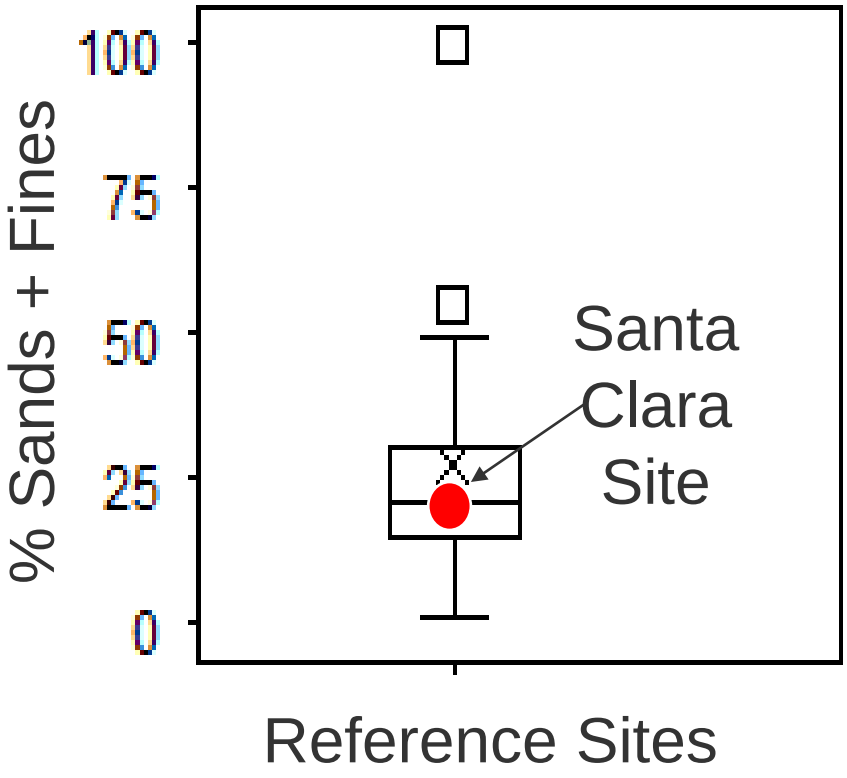
Stressor-Response from the Field: Garcia River

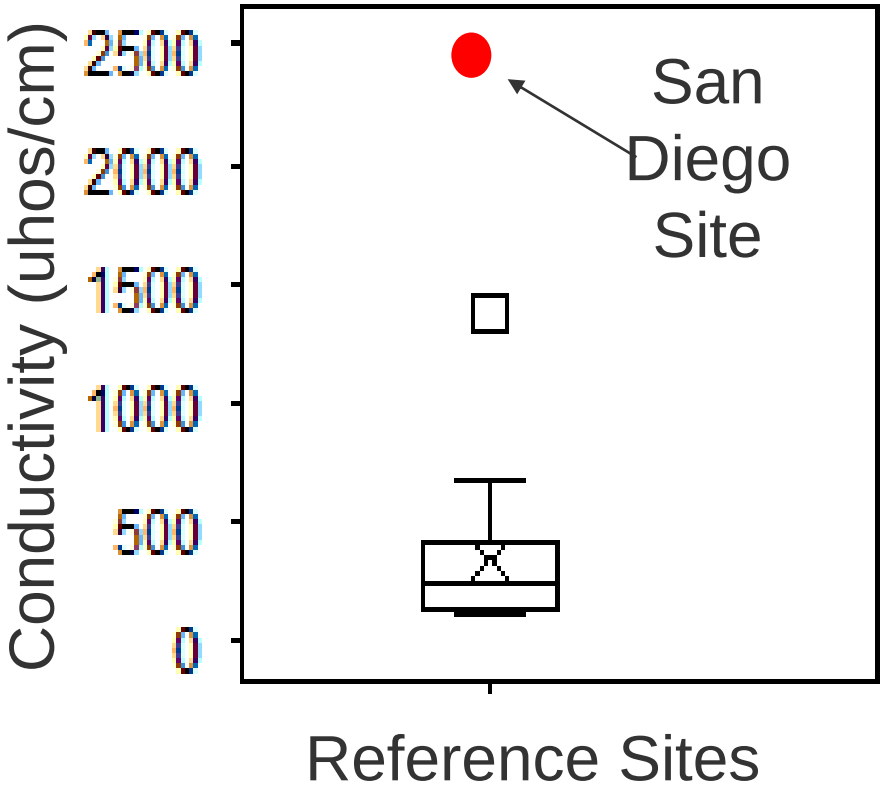


The Five Steps

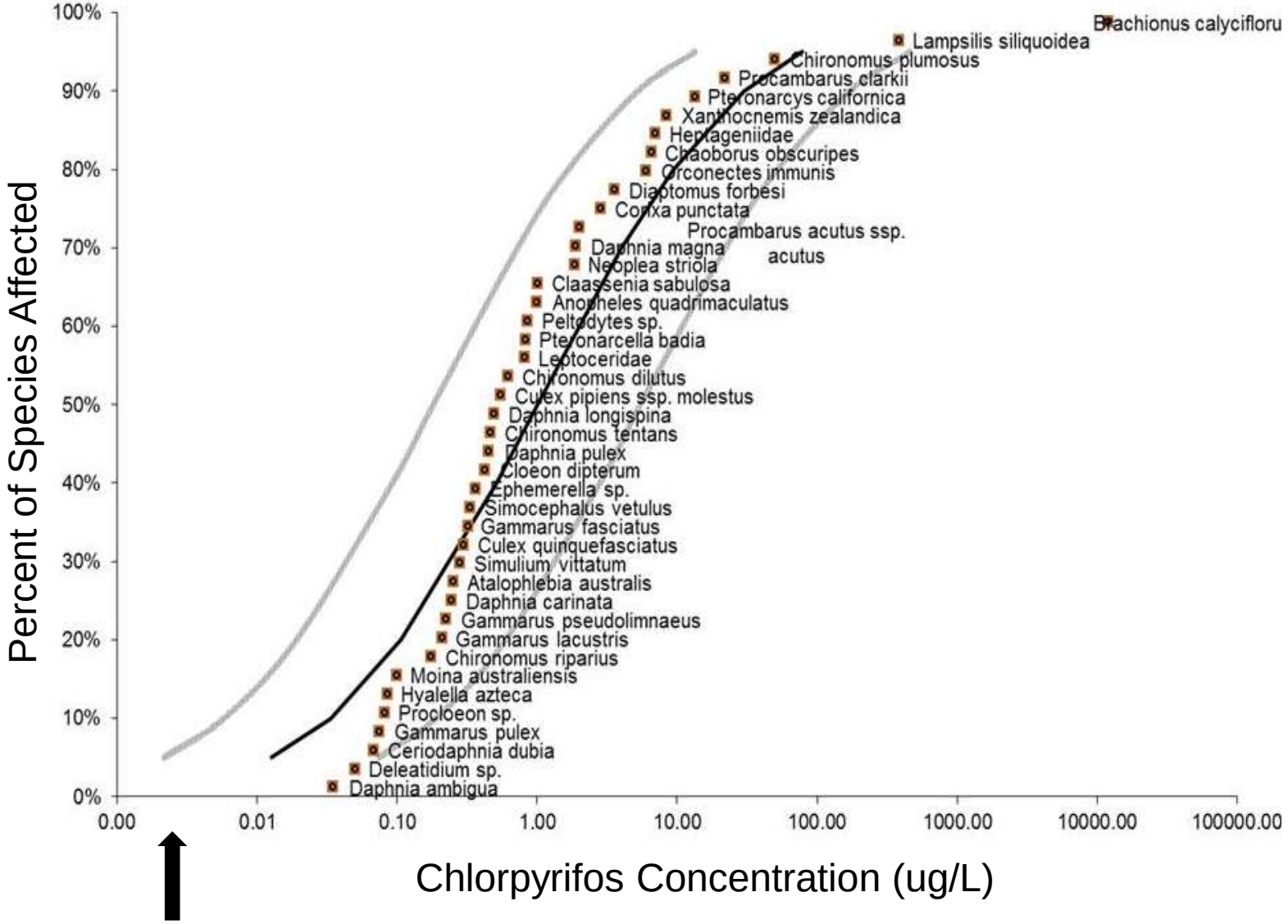
- Define the case
- List candidate causes
- Evaluate data from the case
- **Evaluate data from outside the case**
- Identify probable causes
  - Refute causes

Co-Occurrence from Outside the Case
Santa Clara and San Diego Rivers





Species Sensitivity Distributions



Max Concentration at Salinas River Test Site

Our Overall Evaluation

- Bioobjectives needs a stressor identification component to be successful
- CADDIS is an appropriate framework, but it isn't perfect
  - Has strengths and weaknesses
- A guidance manual can be written
  - Because California has some unique issues, implementing the recommendations will be important

CADDIS Strengths For California

- Already built and documented
  - Creates a solid foundation for regulatory interactions
- Adept at ruling out causes
- Wonderful communication tool

CADDIS Weaknesses For California

- Don’t expect to always find the smoking gun
  - nonpoint, cumulative stressors are difficult to diagnose
- Challenges finding appropriate comparator sites
- Need for additional data analysis tools

Recommendations

- Take advantage of our large statewide data set for comparator site selection
  - Can be automated
- Data analysis tools need to be built and/or refined
  - Reduce uncertainty for taking appropriate actions
- Monitoring recommendations to ensure adequate data collection

The Guidance Manual

- Target audience are Stakeholders and RWQCB staff ("Informed managers", but not biologists)
- Describe CADDIS (not a cookbook, pointers to SOPs)
- Case Study summaries (utilize as teaching illustrations)
- Important considerations (insights for California users)
- Recommendations (describe needs for future improvements)

We Are Working on Documentation and Automation

- Method Manuals and Quality Assurance Plans already available through SWAMP
  - Help desk, trainings, audits, annual workshops
- Manuscripts for Reference Condition and CSCI Scoring Tool
- Guidance Manual for Stressor Identification
- Dedicated web access for users
  - Bioassessment 101
  - Integration with CEDEN
  - Online calculators

Charles Hawkins, PhD

Chair, Science Advisory Group

Utah State University

The Science Advisory Panel

David Buchwalter – North Carolina State University (ecotoxicology and causal assessment)

Rick Hafele – Oregon DEQ, retired (bioassessment application)

Charles Hawkins – Utah State University (reference condition, biological indices, modeling)

Chris Konrad – USGS (hydrology, environmental flows)

LeRoy Poff – Colorado State University (stream ecology, environmental flows)

John Van Sickle – USEPA (monitoring, statistics, modeling)

Lester Yuan – USEPA (causal assessment, modeling)

Main Points

- Advisory panel consisted of internationally recognized experts in bioassessment and freshwater science.
- All panel members were deeply engaged in providing objective, candid advice regarding all aspects of program development.
- Regular physical meetings (2 times a year) and conference calls ensured timely feedback to the science team.
- The frequent and deep interactions between the science team and the science advisory panel resulted in a ‘state-of-the science’ bioassessment program of which California can be proud.

Next Steps

Major Milestones	Estimated Date
✓CEQA scoping meetings	Sep 2012
✓Board workshop information item on science	Jan 2013
Scientific documentation review & comment	Feb-Mar 2013
CEQA re-Scoping	If Needed
Develop & complete draft policy	July 2013
Scientific peer review	Aug-Nov 2013
Release public review draft policy	Jan 2014
Public workshops	Apr 2014
Public comment period closes	Jun 2014
Board Meeting/Adoption	2nd half 2014

Questions?