Statewide Assessment of the Biotic Condition of California's Perennial Streams and Rivers

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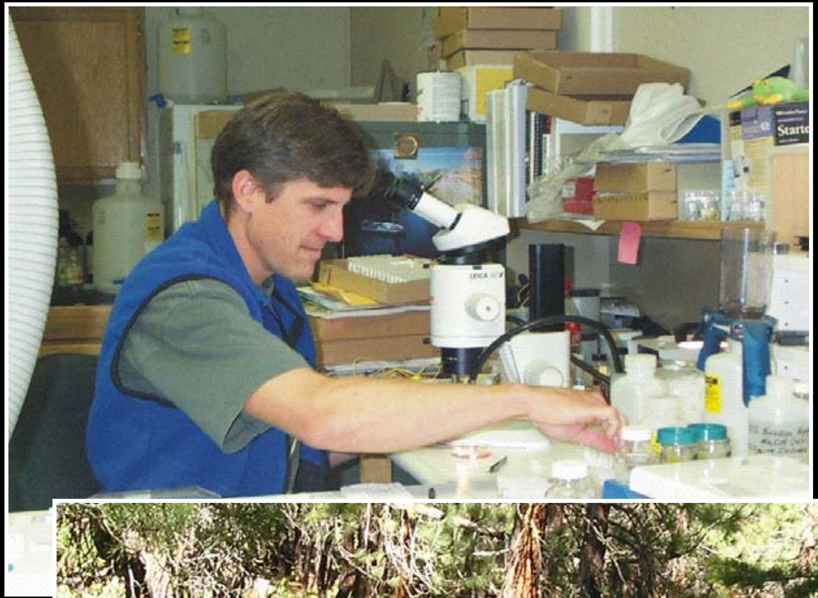


Acknowledgements

Technical Development:

EPA's Office of Research and Development, especially Tony Olson who created the survey design and produced the condition assessment

Chuck Hawkins, Utah State University, predictive model

bioassessments= making bouillabaisse

California condition assessments: context

Since the late 60's, there has been a lot of interest in water quality ...nationally and in California

A vast amount of good science has been applied to improving WQ

BUT… in late 1980's, Congress expressed frustration that we **still** can't answer some basic questions about our aquatic resources:

- What is the condition of the nation's waters?
- Is it getting better? Is it getting worse?
- Are we allocating $$$$ wisely?

"EPA and the States cannot make statistically valid inferences about water quality and lack data to make management decisions." ~GAO 2000

Hence… EMAP

"The EPA's Environmental Monitoring and Assessment Program (EMAP) is a long-term research effort to enable **status and trend** assessments of aquatic ecosystems ... with a **known statistical confidence**. "

"EMAP's goal is … **translating environmental monitoring data** … **into assessments of ecological condition** ... "

"…a **necessary first step** in the Agency's overall strategy for environmental protection and restoration"

EMAP Strategy

1. Use probabilistic survey design to select sites

   … each site represents a known stream length with known statistical precision

   … provides defensible answers and permits change detection

2. Collect extensive biological, chemical and physical data from each site:

   Biological: fish, algae, invertebrates

   Physical: channel morphology and condition, sedimentation index, riparian vegetation

   Chemical: nutrients, fish tissues, metals

3. Analyze data to make ecological assessments:

   - 25 ±7% of streams in California have degraded fish assemblages
   - 76 ±9% of biologically impaired northern coastal streams are also impaired by fine sediments, while only 6 ±5% of these streams are impaired by nutrients

EMAP Design:
Spatially Balanced Probability Survey

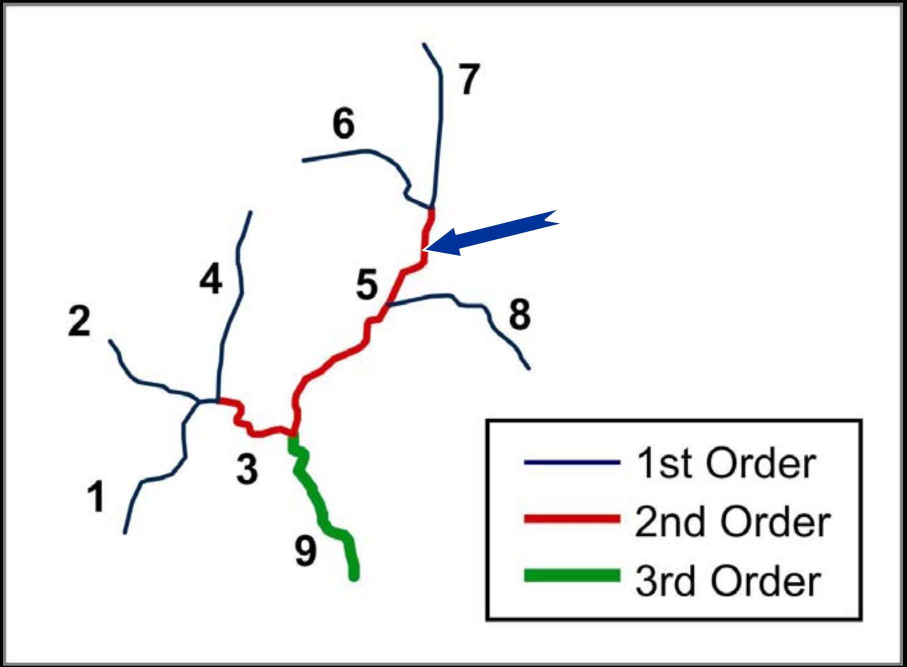
For design details:

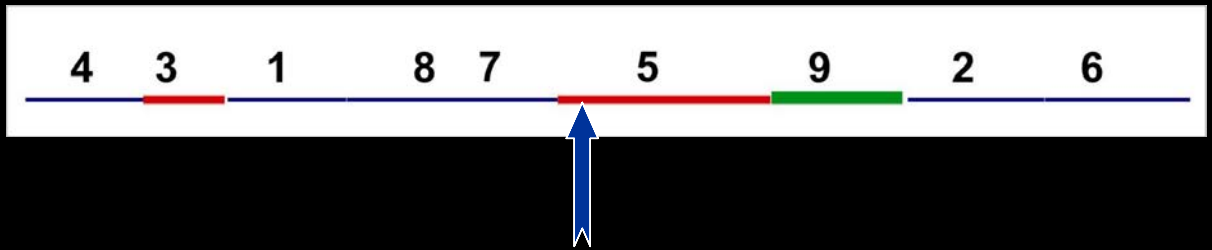
http://www.epa.gov/nheerl/arm/designpages/design&analysis.htm

How the survey design generates a list of target sampling locations (Lat/Long coordinates) from a stream network

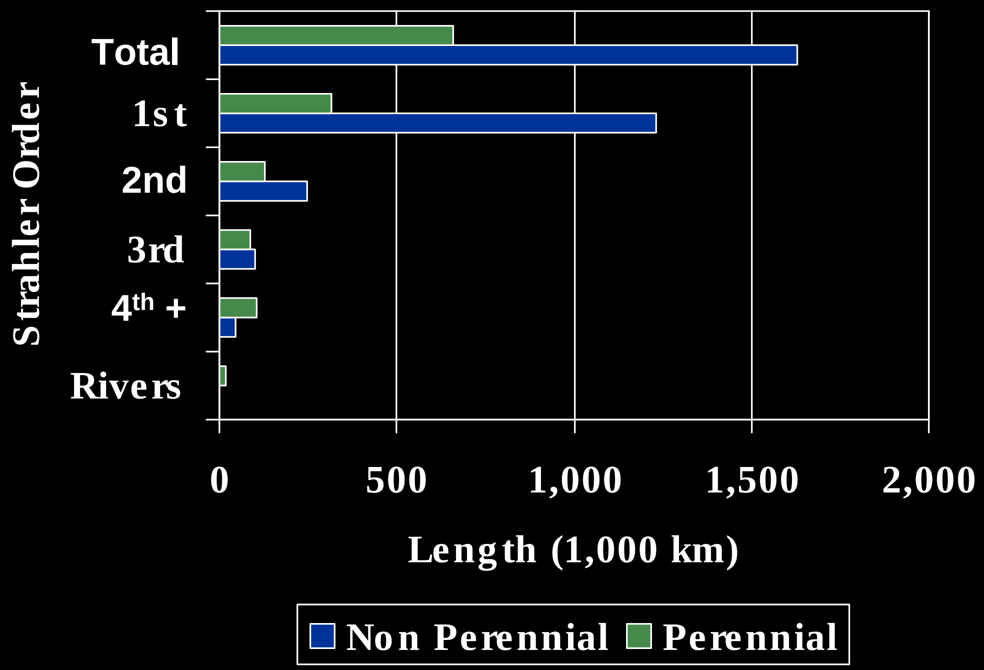
Selecting a Geographically Balanced Set of Sampling Points from a Stream Network

- Stream network is converted into a line
  - Segments all given IDs
  - Segment lengths are preserved
  - Segment arrangement is geographically balanced throughout the region of interest (i.e., California)





Dealing with disproportionate stream lengths:



PROBLEM: Smaller streams make up the vast majority of stream segments

Simple random selection of sites would bias toward small streams

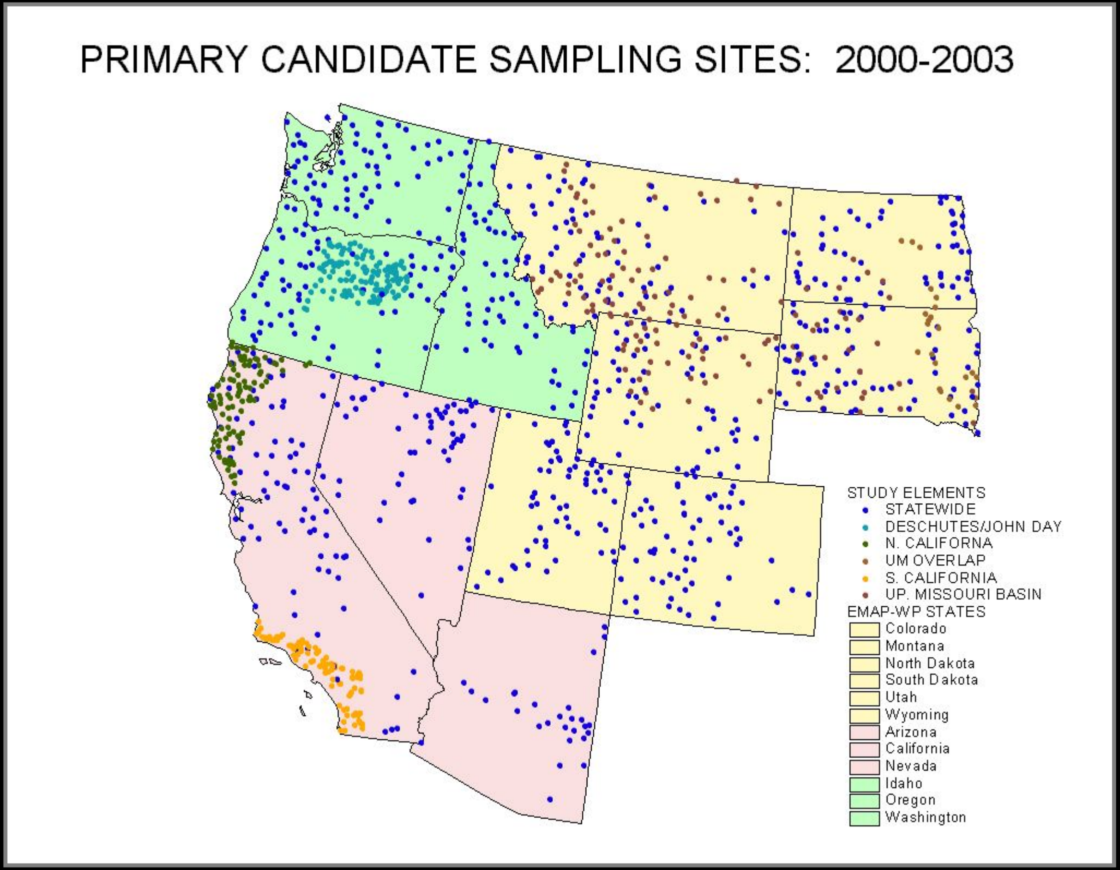
SOLUTION: Increase the probability of sampling large streams by increasing the segment length

Western EMAP Pilot:

Sampled over 1000 sites between 2000-2003

EPA's ORD is now working on a final condition assessment for the 12 western States

Now, we can create the first statistically-based statewide condition assessment for CA

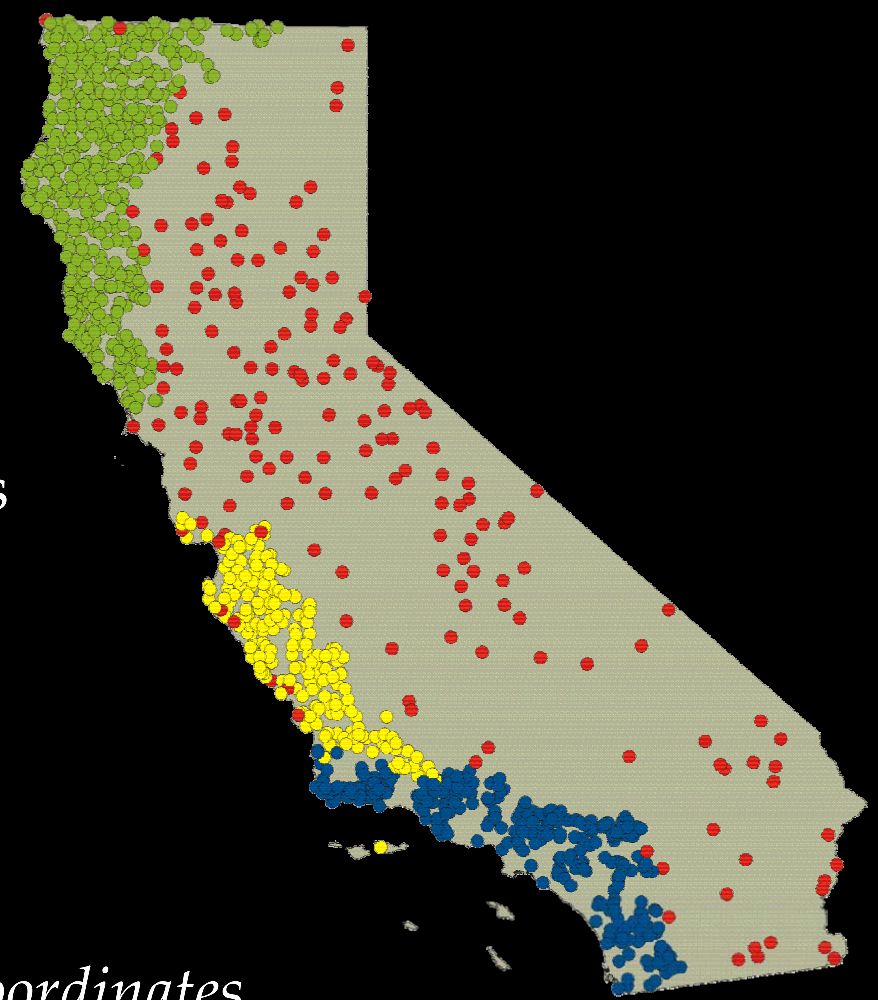


From Survey to Condition Assessment (4 steps)

Step I. The population of interest is defined (all perennial and wadeable streams in CA)

California Stream Condition Assessment

Step II. Probability design is used to generate a list of sites (each site represents a known length of stream)



California condition assessments based on 4 combined surveys:

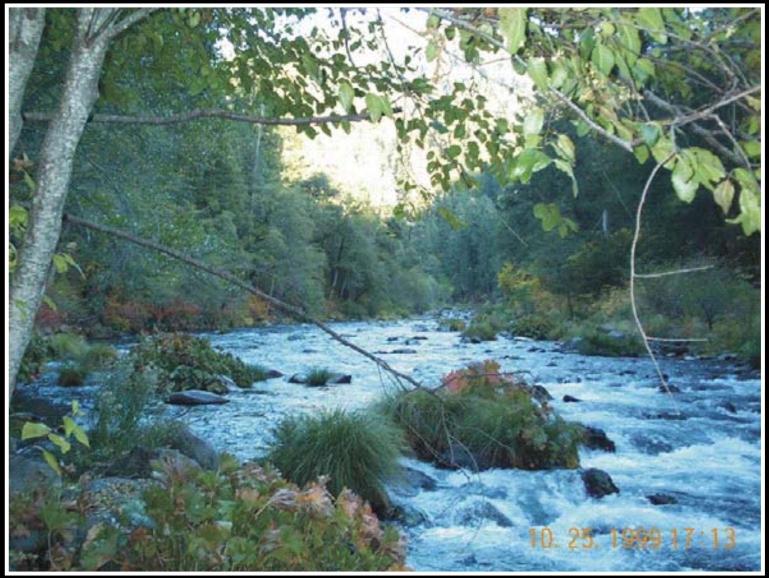
- Northern Coastal California
- Southern Coastal California
- Central Coastal California
- Statewide

-field crews get a list of lat/long coordinates to evaluate

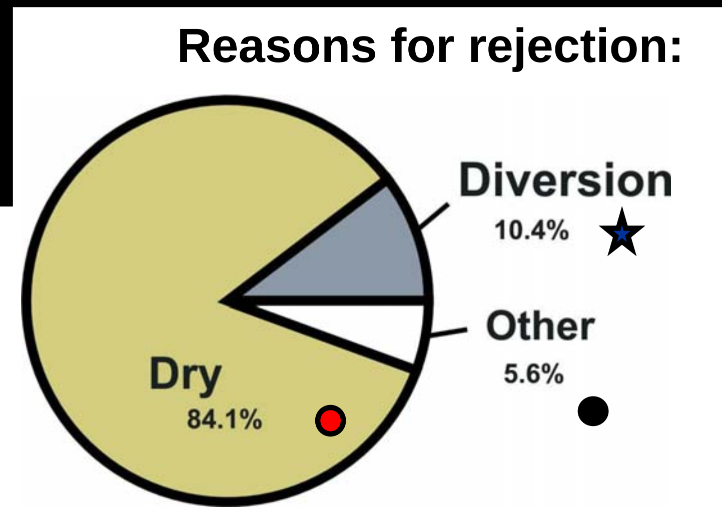
Step III. The Winter of our Discontent

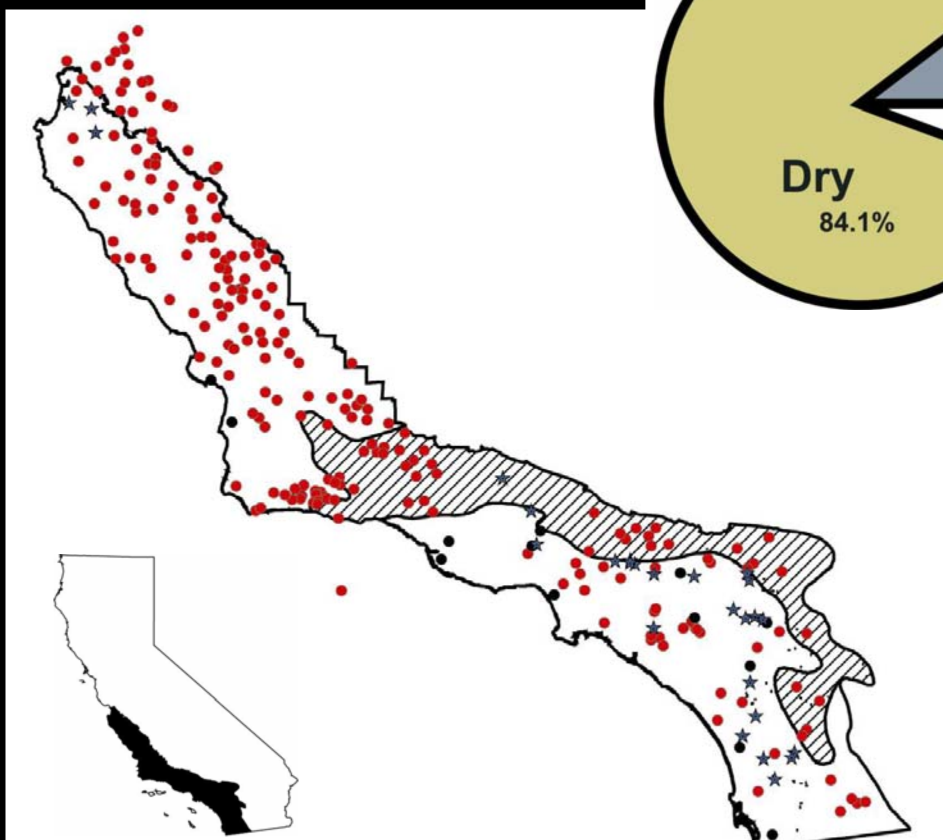
Field crews spend most of winter evaluating site list with desk work and field reconnaissance:

- visit county assessor's offices for ownership info
- obtain permits for sampling public sites, attempt to get permission for private sites…
- use field visits to evaluate sites and figure out access



Step III. Not all sites meet the target definition: much of field work goes into deciding which sites are part of the "target" population, which are "non-target":

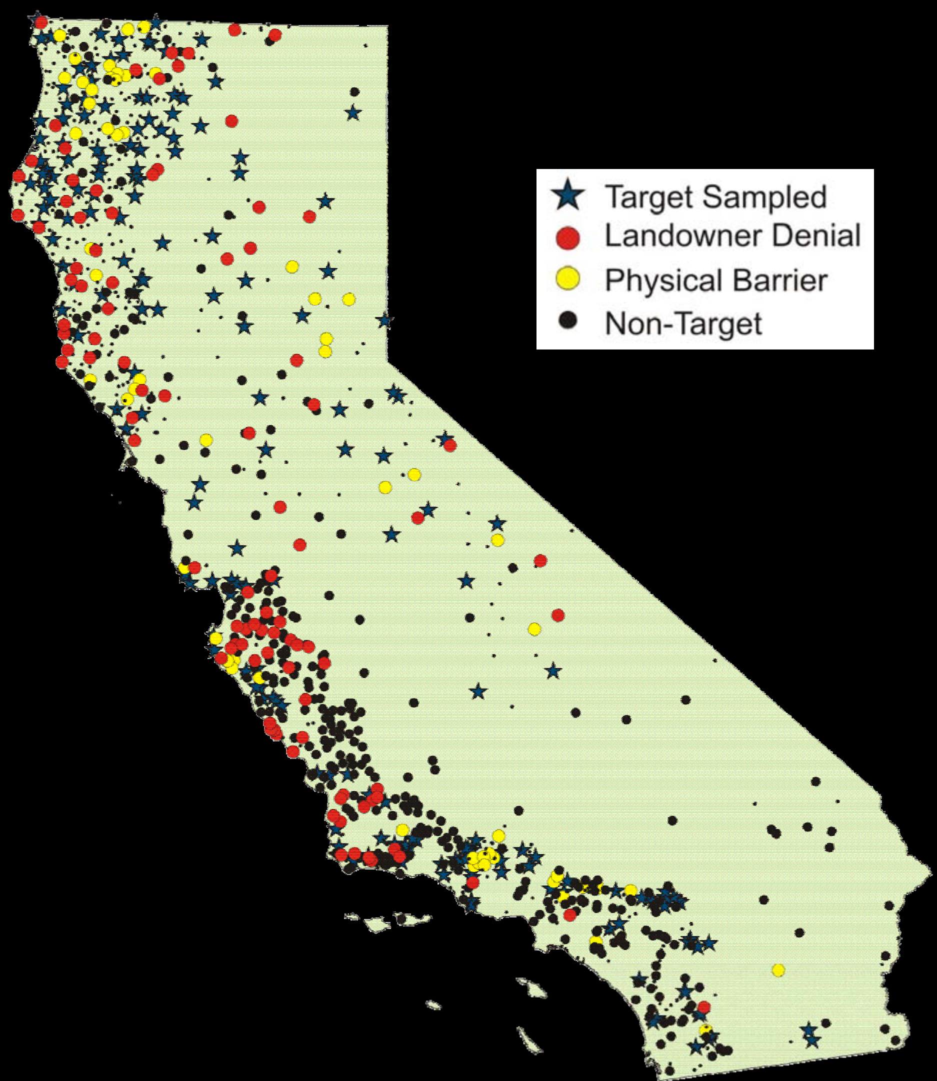


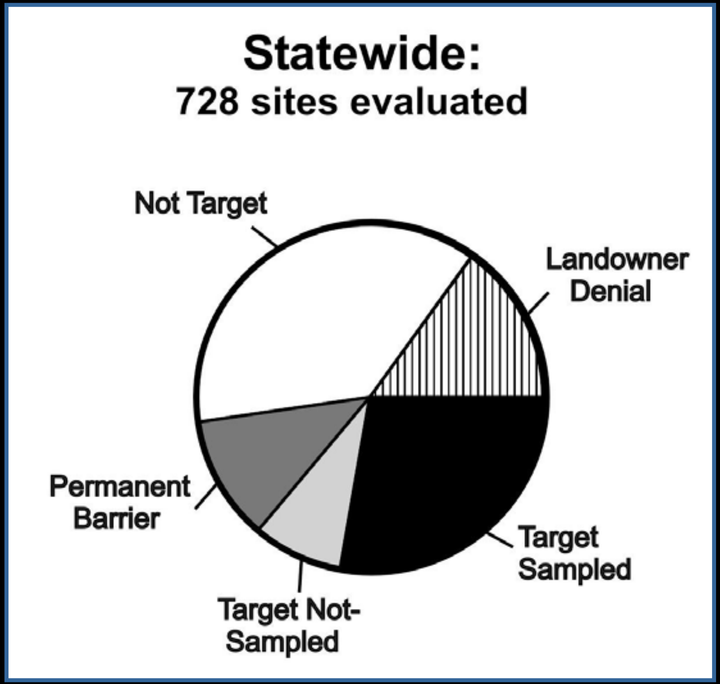


Southern Coastal California Example:

1. ~65% of SoCal streams were non-target (~35% statewide)
2. Most were dry (~85% non-perennial)
3. Streams diverted into transport pipes or paved over (~10%)

Step III: Sites are also eliminated if we couldn't access them (e.g., landowner denials or physical barriers)





Step IV. Target sites are sampled:

-bugs, fish, algae
-reach scale conditions
  .physical habitat
  .chemistry
  .riparian condition

Step V. Turning site data into ecological condition assessments

Bioassessment data are ideal for condition assessments:

- gives a direct measure of **<u>ecological</u>** condition

    ….not achievable through other means
- integrate effects over time and space
- incorporates measures of physical habitat condition
- provides a context for interpreting other WQ measures

Currently we focus on BMIs because we have tools for scoring them, but other assemblages are also good candidates …. will be coming eventually….

IBIs and Predictive Models: tools for scoring ecological condition from benthic macroinvertebrates

IBIs are available for sections of California … North and South coasts, Eastern Sierra *see David Herbst presention after lunch*)

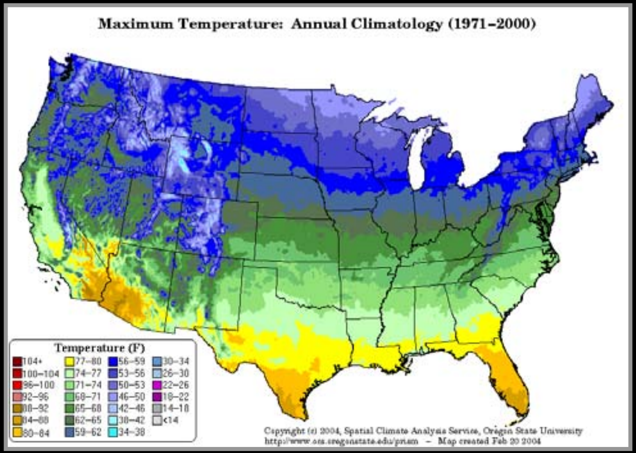
Newly developed California predictive models (RIVPACS) give us the ability to score ecological condition for sites throughout the state *see earlier presentation by Chuck Hawkins*

Applying the predictive model

Step 1: Assign all EMAP sites to appropriate submodel

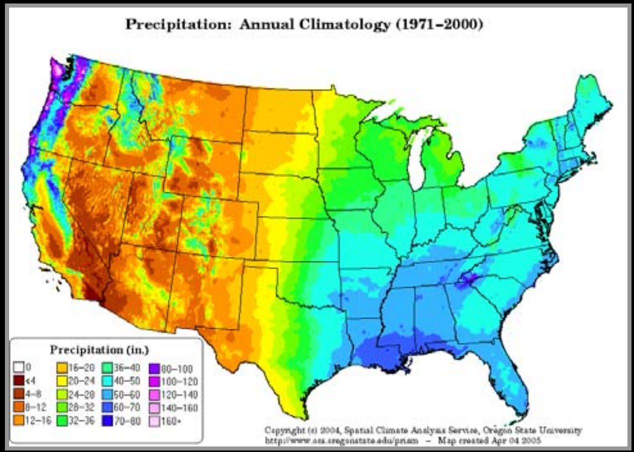
(Oregon Climate Center PRISM)

If mean monthly Temperature < 9.9°C



Submodel 3

If mean monthly Temperature > 9.9°C



If log mean monthly Precipitation <2.952

Submodel 1

If log mean monthly Precipitation >2.952

Submodel 2

Step 2: Calculate predictor variables for sub-models (midges to subfamily)

Submodel 1

Watershed Area
Temperature
Latitude

Submodel 2

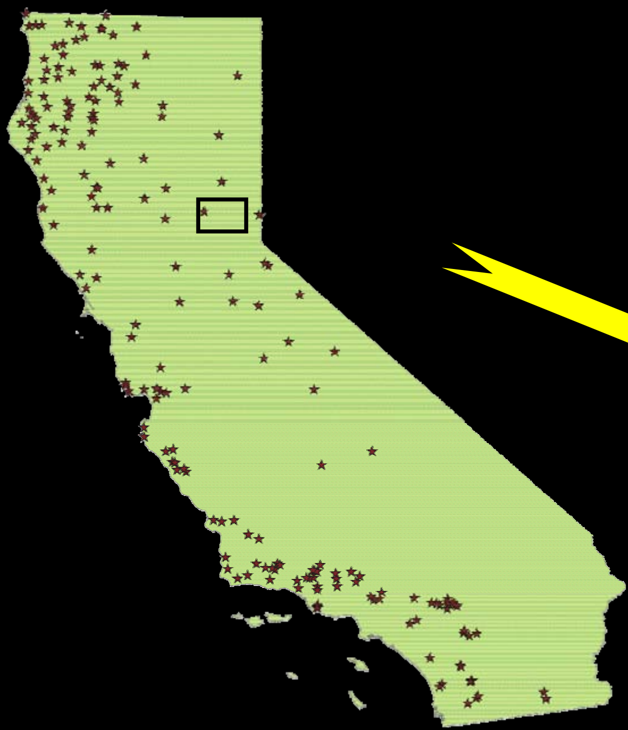
Longitude
% Sedimentary Geology
Precipitation

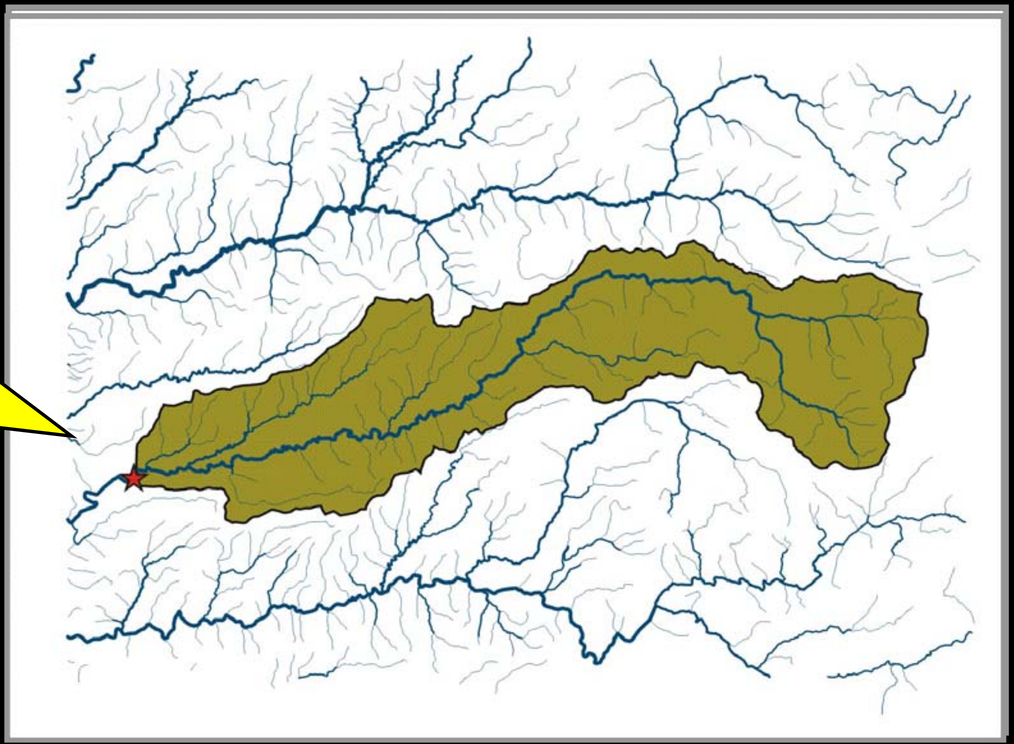
Submodel 3

Watershed Area
Temperature

=% sedimentary geology (summarized from USGS maps, John Olsen, Utah State University)

Step 2 (continued). Delineate Watershed Areas

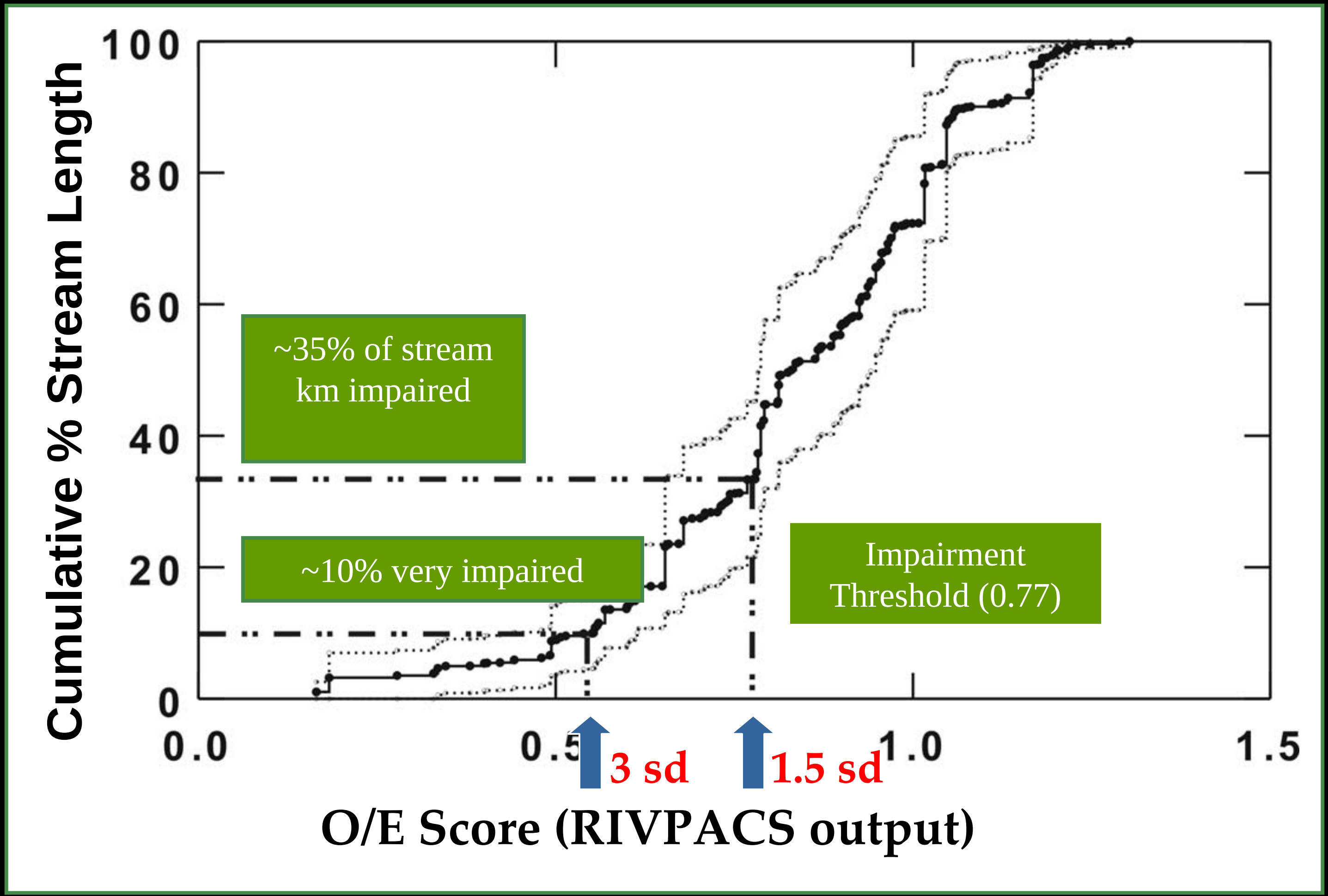




Step 3. Upload bug data and predictor data to Chuck's USU website: output = O/E scores

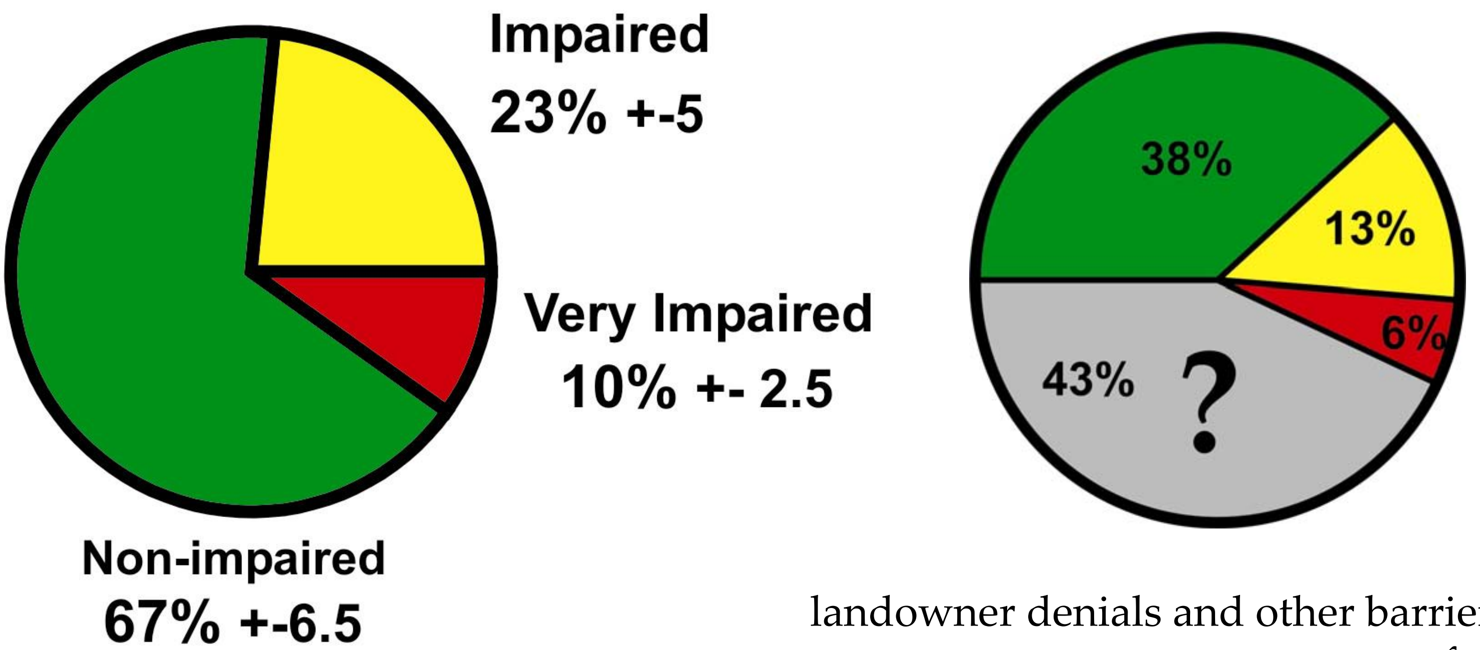
Step 4. Combine scores with site weights (from probability design…weighted by length it represents) to create CDFs

Cumulative Distribution Function: O/E scores vs. cumulative stream length assessed =the condition assessment



For ease of presentation we can convert these to pie charts, but exact numbers depend on where you draw the cutoffs = societal/political decisions

- To avoid understating impairment, use higher cutoffs
- To avoid overstating impairment, use lower cutoffs

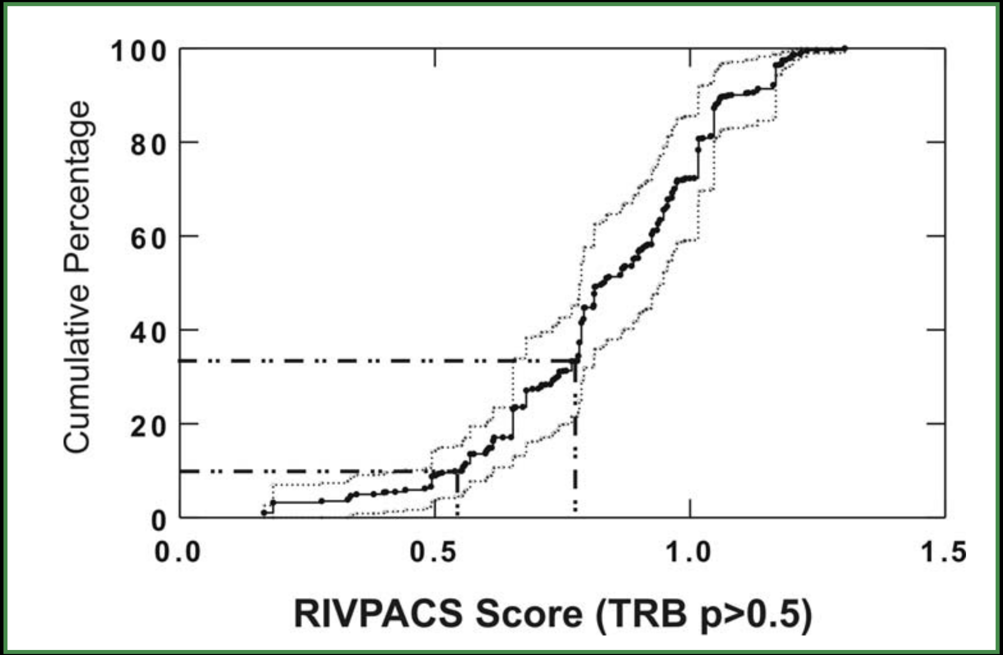


landowner denials and other barriers to access prevent assessment of some of the stream length

Key issues when interpreting condition assessments:

1. Bias in unsampled locations (e.g., if landowner denial sites are much better or worse than average)

2. Where impairment cutoffs are drawn



… the CDF gives a way of tying the cutoffs to the underlying science….

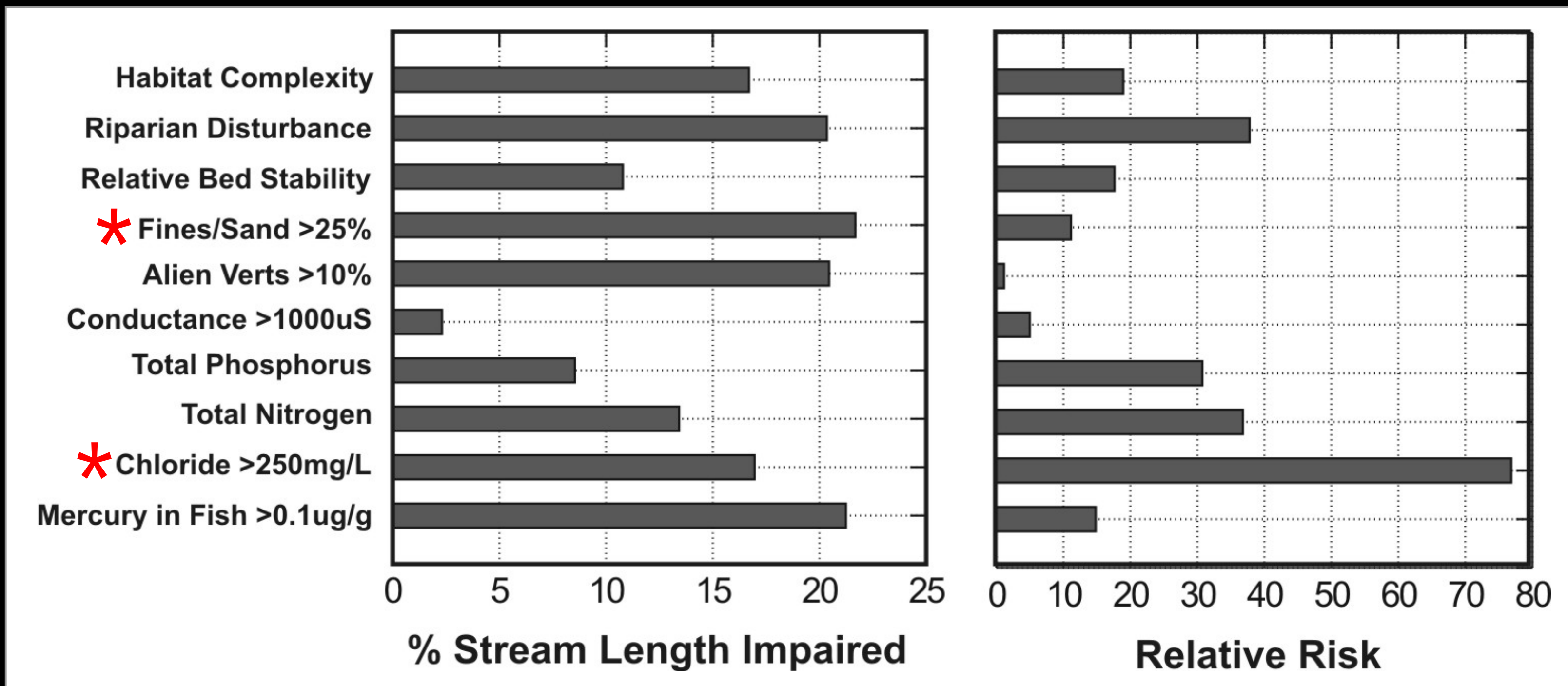
Concept of relative risk

Analogous to medical health advisories (e.g., "smoking is associated with a 12 fold increase in risk of lung cancer")

Relative Risk: increased probability of biotic impairment that is associated with high stressor levels

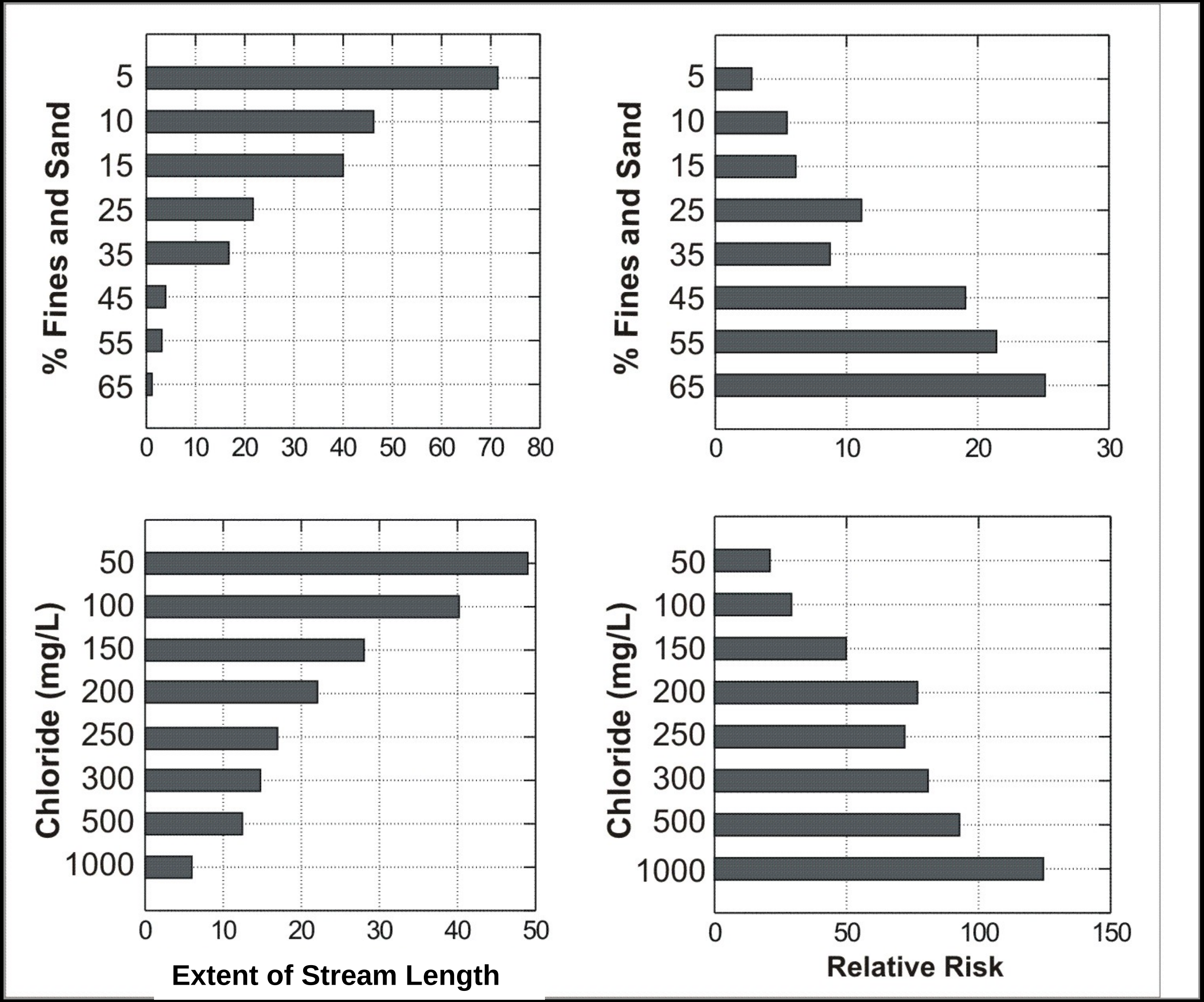
$$\frac{\dfrac{\text{Biologically Impaired Length ASSOCIATED with Stressor X}}{\text{Total Stream Length Impaired by Stressor X}}}{\dfrac{\text{Biologically Impaired Length NOT ASSOCIATED with Stressor X}}{\text{Total Stream Length Not Impaired by Stressor X}}}$$

Comparing stressor extent and relative risk
(all examples have high risk)



technique provides an objective mechanism
for determining greatest threats to stream condition

Approach allows us to see how extent and risk varies with stressor concentration



From EMAP to CMAP

EMAP was intended to be a partnership between EPA and states. Now that the Western EMAP effort is ending, EPA is encouraging states to keep the EMAP ball rolling

CA State Water Board has interest in using this type of survey for:
- -statewide 305(b) reporting
- -Non-Point Source (NPS) pollution questions

EPA Region 9's WQ and NPS units decided to try to combine these into one program and provided $$$ from EPA's NPS allocation to get CMAP started

California EMAP (CMAP)

- Five year design stratified by four landcover classes: urban, agricultural, forested, other

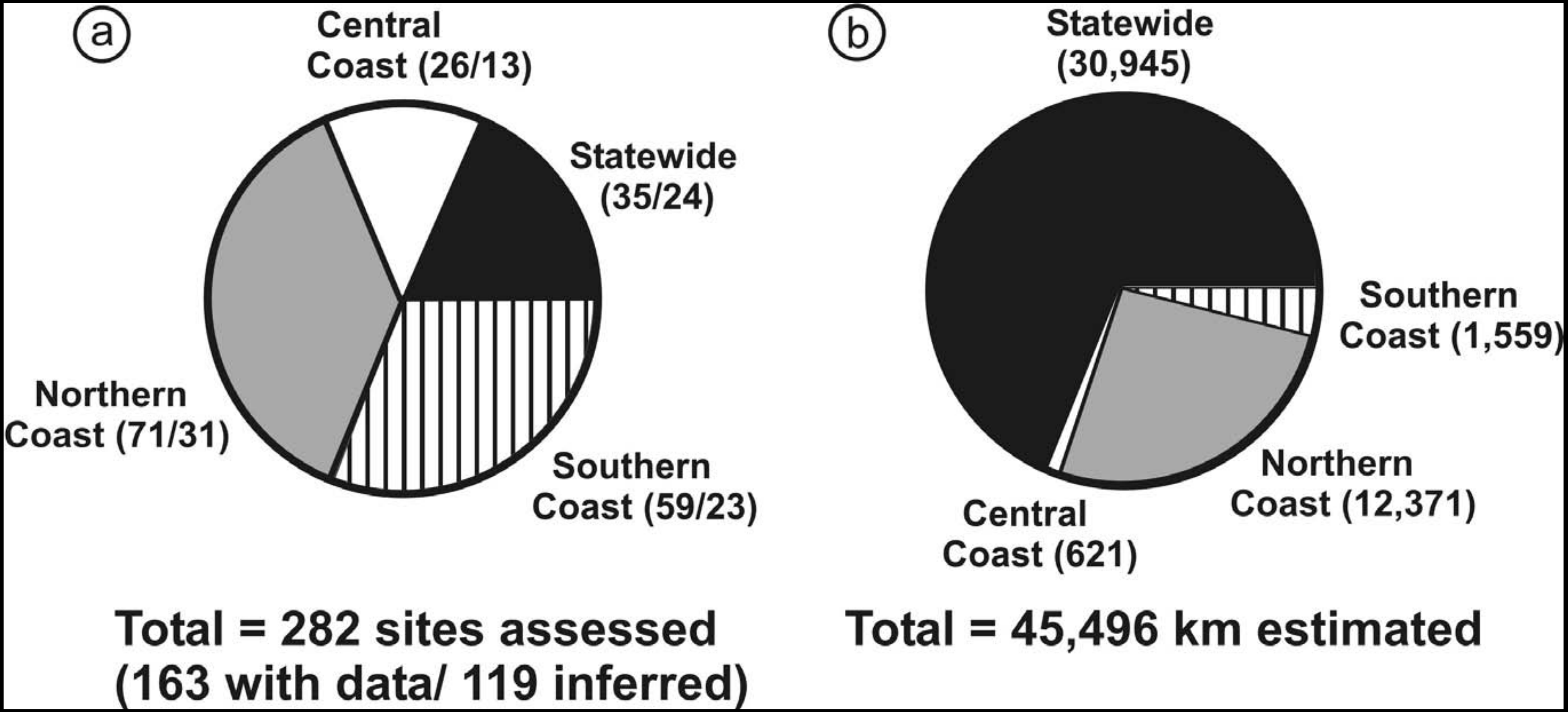
- 50-60 sites/ year sampled statewide starting in 2004, same data collected as EMAP

What's next?

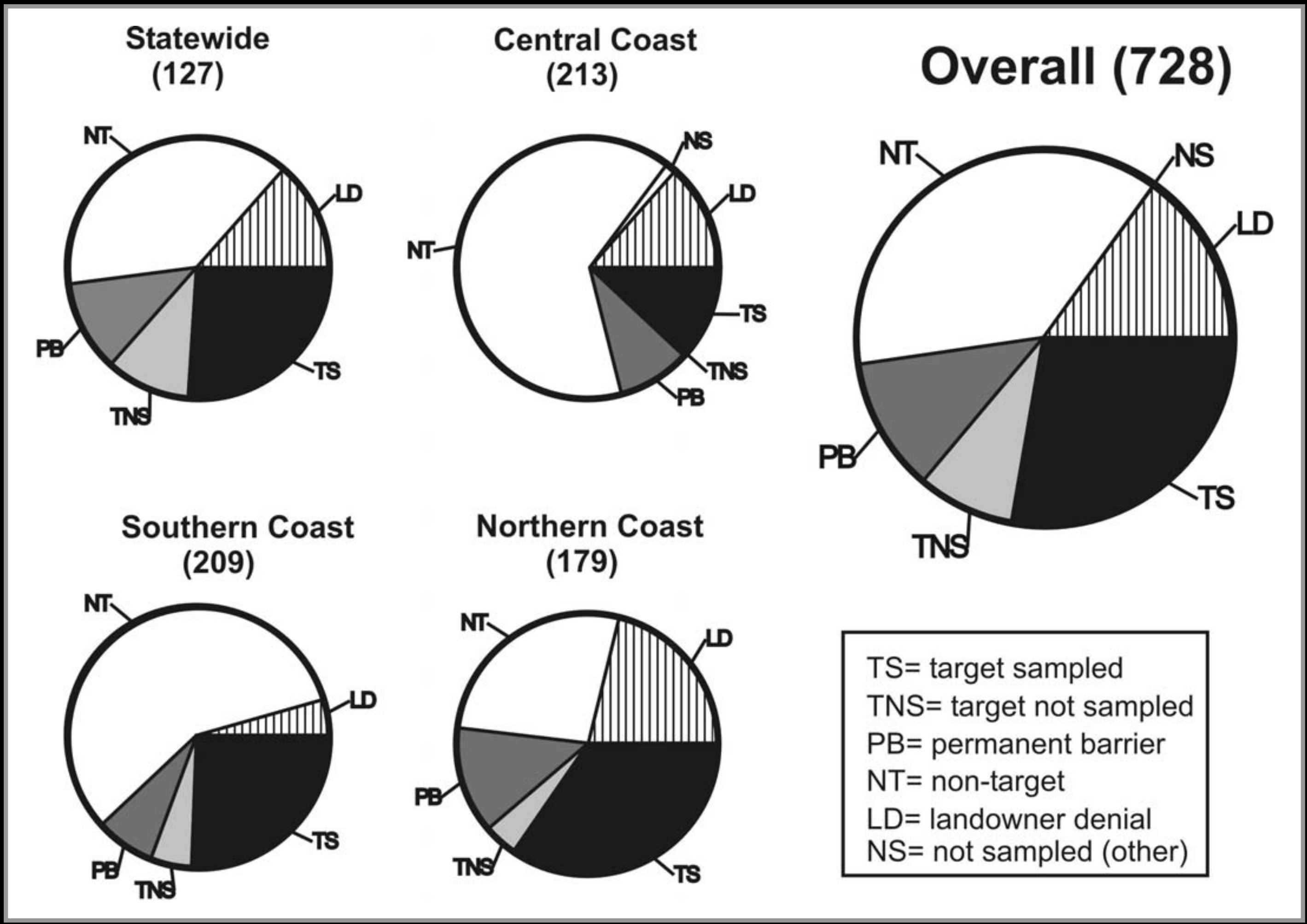
- Work with FISH and ALGAE data to develop indicators
- Build on current RIVPACS models with new reference sites
- Improve our understanding of BMI response to key stressors
  - Timber harvest plan (THP) data
  - AG data
- Develop better BMI tolerance values using EMAP datasets

Probability surveys have a great deal to offer California water quality community: directly through the assessments they enable; indirectly through tool development

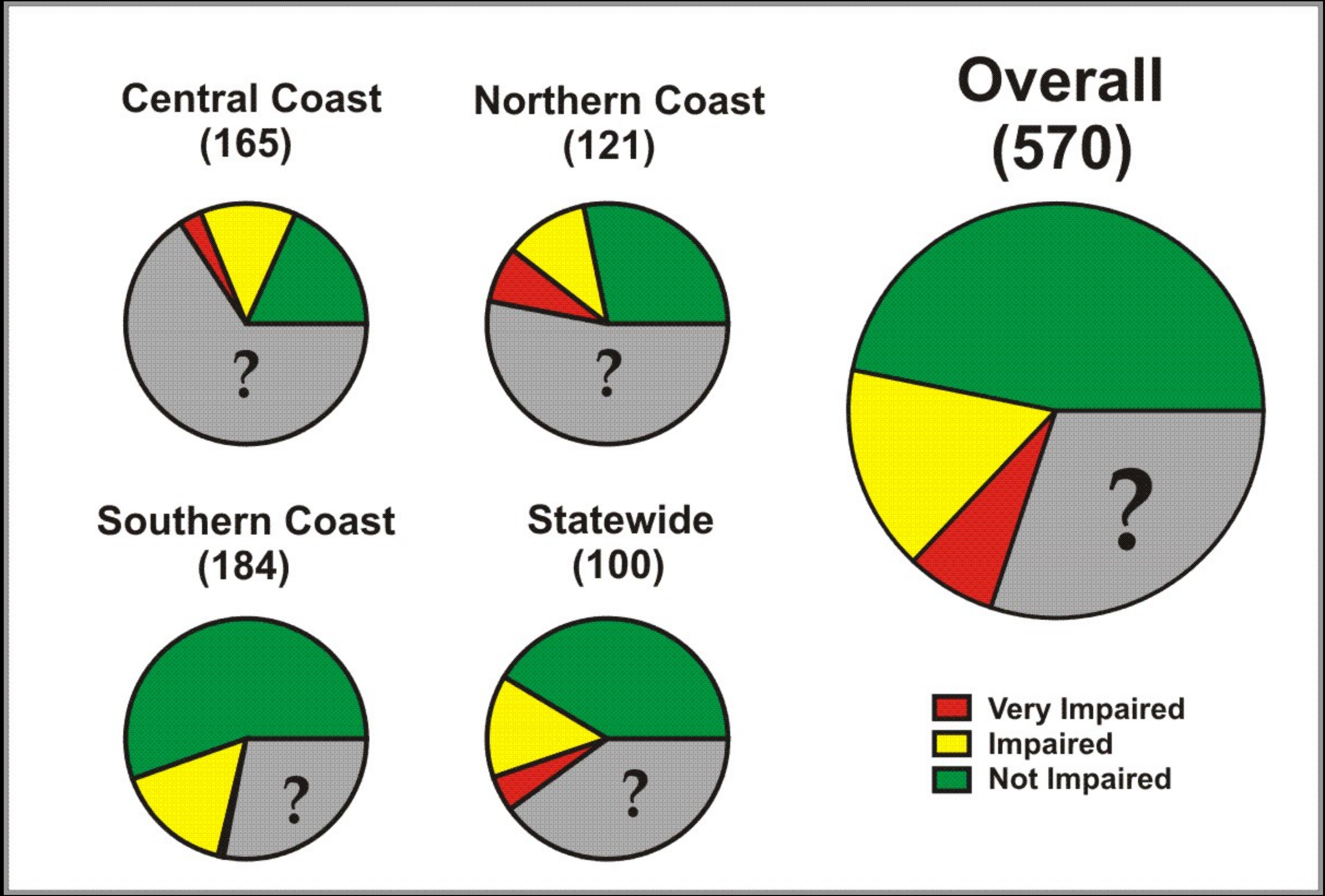
Sites from different surveys have different weights in the combined assessments; based on proportion of total stream length



Results of site status vary with region

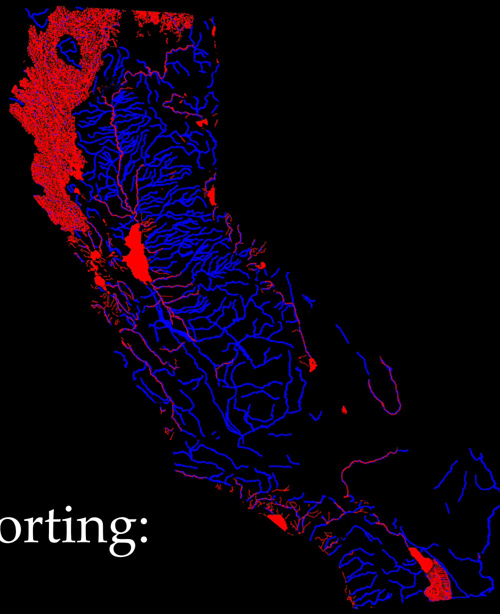


4 combined surveys permit regional assessments



….. size of ? reflects variation in access

Application of IBI to 305(b) reporting: BMI-based stream condition assessments



Section 305(b) of the Clean Water Act requires states to report on the **chemical**, **physical** and **biotic** condition of their streams:

- -reports provide an overview of stream health
- -help agencies optimize allocation of limited WQ resources

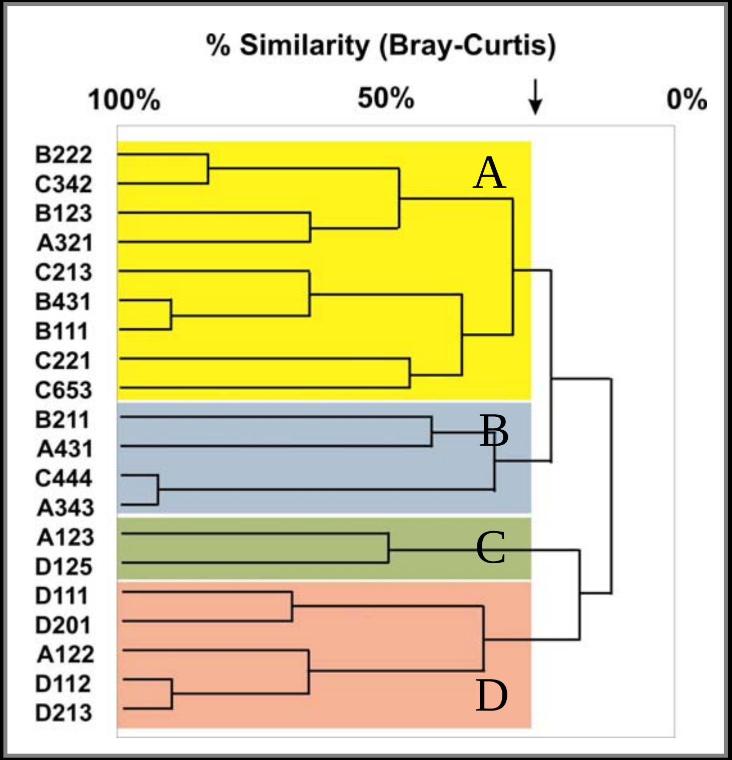
To date, California has taken a regional approach to reporting:

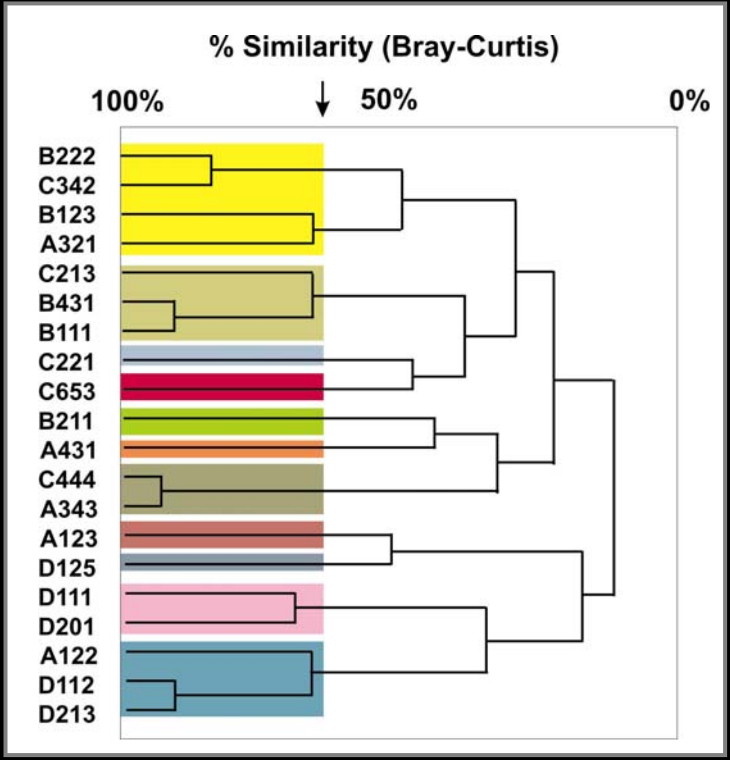
- -corresponds to structure of 9 regional WQCBs
- -inconsistent criteria for targeting sites and assessing condition
- -large gaps of unassessed streams throughout the state

Estimating "E"

Step 1. Classify reference sites based on biological similarity

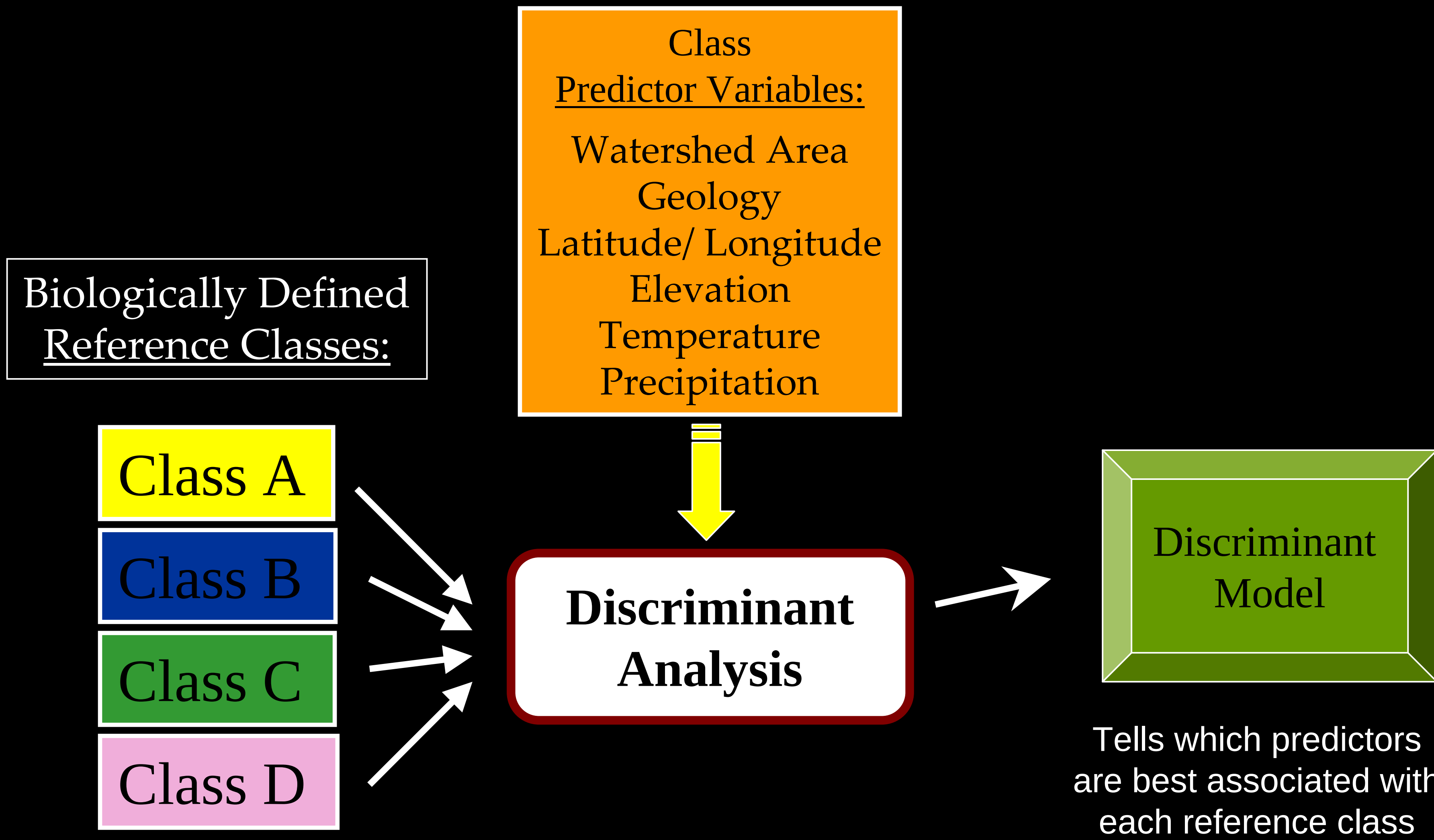
Clustering techniques used to identify classes of reference sites with similar species composition





Estimating “E”

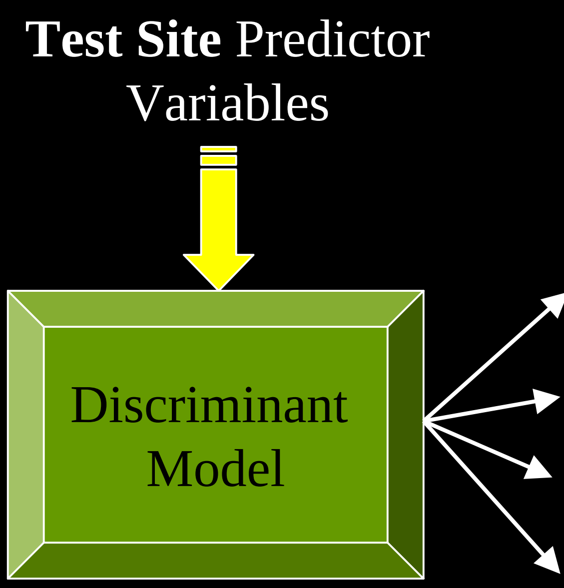
Step 2. Develop discriminant model that will predict class membership for **test sites**



Estimating "E"

Step 3. Estimate capture probabilities for test sites

Use discriminant model output + frequencies of occurrence within each class to estimate probabilities of capture (PC) for each taxon



Class	Probability of Class Membership	Frequency of Species X (*Farula*) in Class	**Expected** Contribution to PC
Class A	0.5	0.6	0.30
Class B	0.4	0.2	0.08
Class C	0.1	0.0	0.00
Class D	0.0	0.0	0.00

Probability of *Farula* being in sample if Test Site is in Reference Condition = 0.38

Estimating "E"

Step 4. Sum of taxon occurrence probabilities estimates the number of native taxa that we expect to capture (E)

Taxon	pc	O
Atherix	0.70	*
Baetis	0.92	*
Caenis	0.86	
Drunella	0.63	
Epeorus	0.51	*
Farula	**0.38**	
Gyrinus	0.07	
Hyalella	0.00	*
E	4.07	3

Observed Native Taxa = 3

O/E = 3 / 4.07

O/E = 0.74

O/E (scaled 0.0 to 1.0): represents proportion of native assemblage present at test site