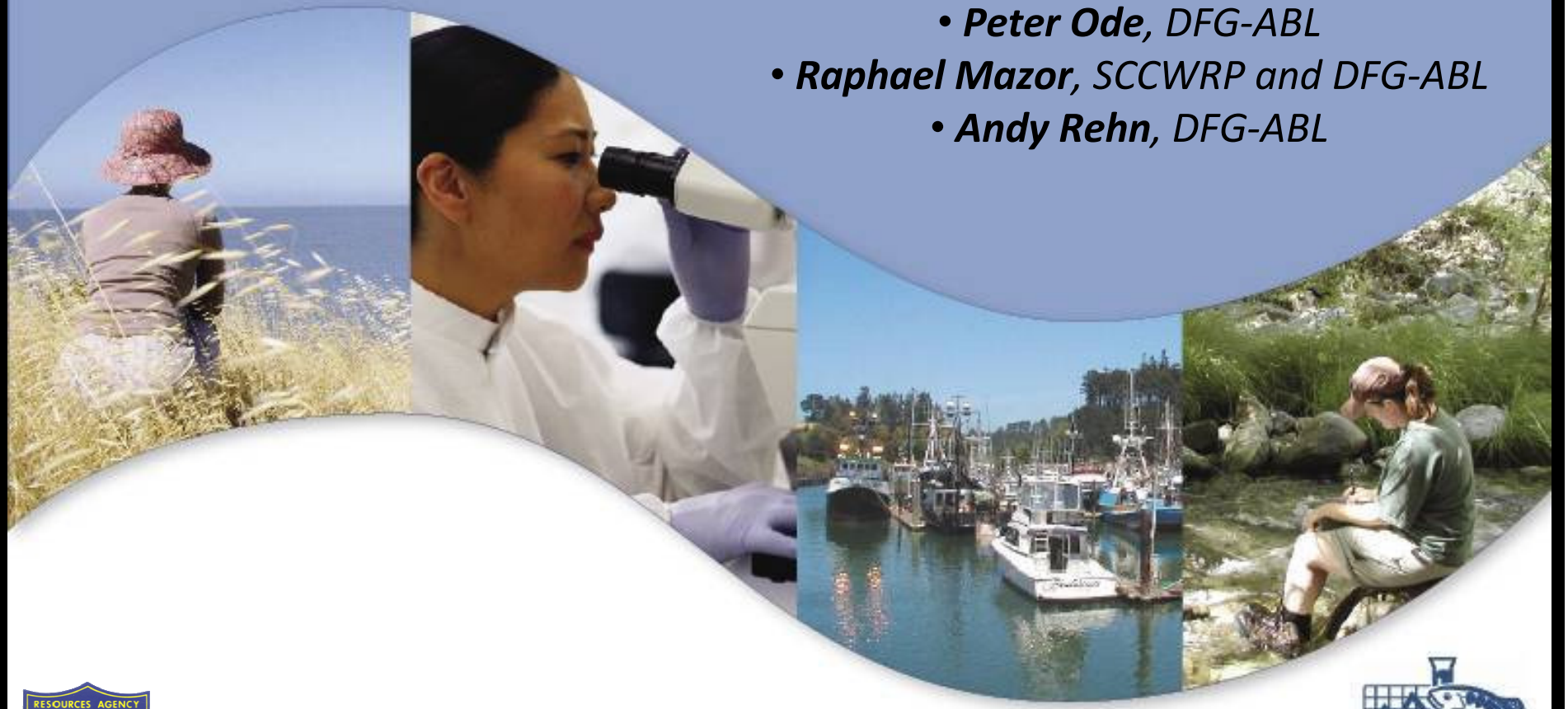
Establishing Reference Conditions for CA's Wadeable Perennial Streams

- ***Peter Ode**, DFG-ABL*
- ***Raphael Mazor**, SCCWRP and DFG-ABL*
- ***Andy Rehn**, DFG-ABL*

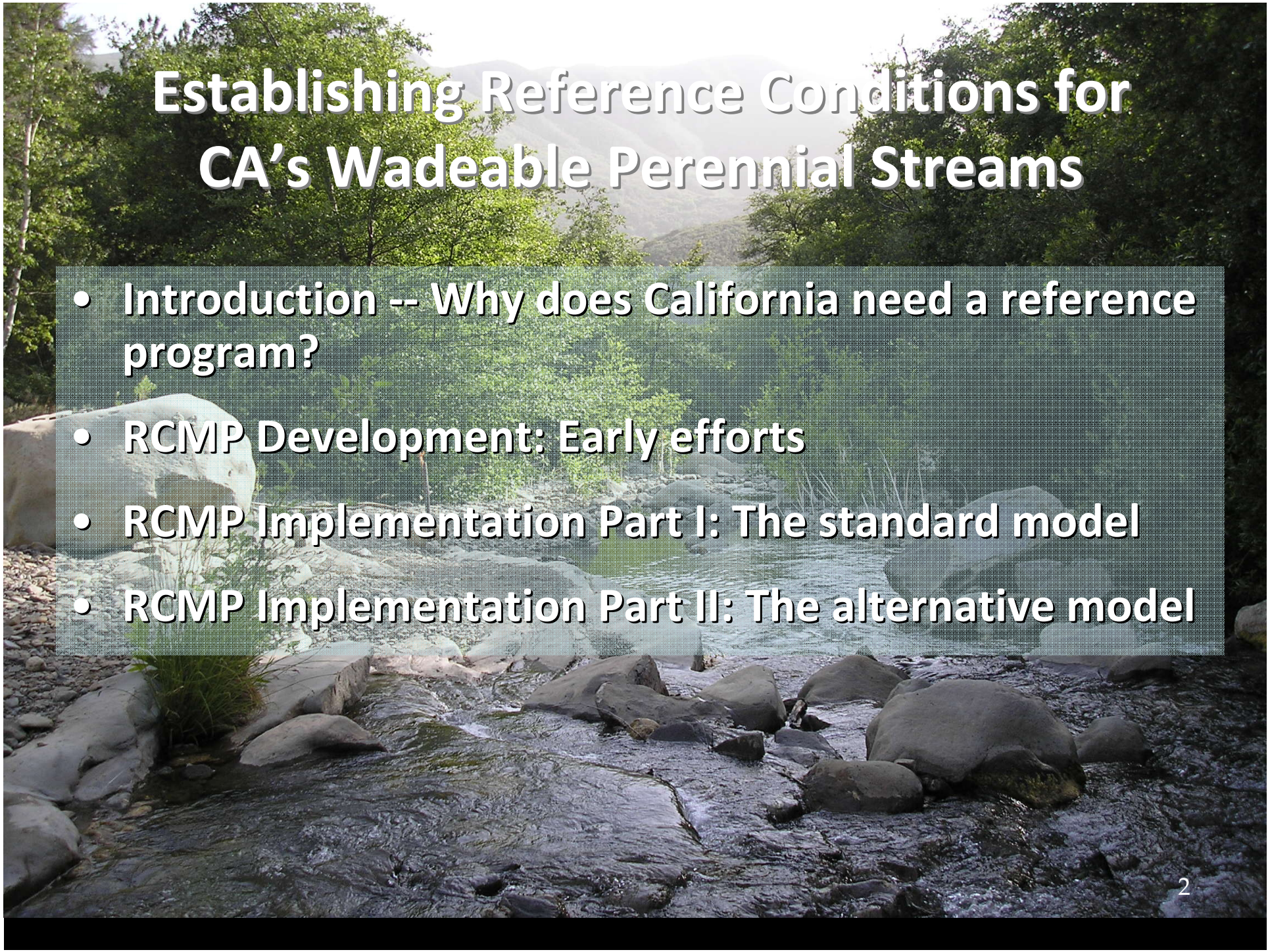


RESOURCES AGENCY CALIFORNIA DEPARTMENT FISH&GAME

Aquatic Bioassessment Laboratory

Water Boards

SWAMP Surface Water Ambient Monitoring Program



Establishing Reference Conditions for CA's Wadeable Perennial Streams

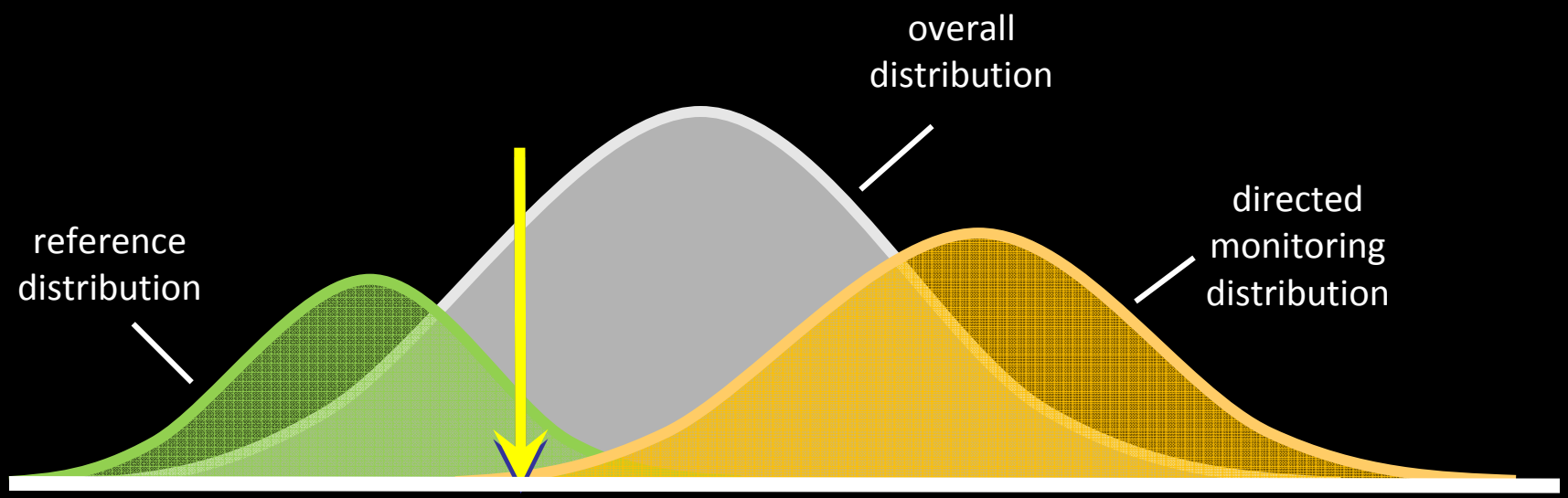
- Introduction -- Why does California need a reference program?
- RCMP Development: Early efforts
- RCMP Implementation Part I: The standard model
- RCMP Implementation Part II: The alternative model

Why a reference program?

- For many WQ parameters (e.g., toxic substances), the desired value is 0 or "non-detect"… WQ objectives are established based on this assumption
- This is not the case for many parameters of interest: *(temperature, nutrients, fine sediments, conductivity, suspended sediments, metals, etc.)*

When natural values are NOT zero, we need another strategy for defining objective standards

Reference program provides perspective



WQ parameter →

(increasing pollution, decreasing biotic condition)

- Knowledge of the reference distribution can provide objective benchmarks for parameters with non-zero natural values
- This is especially relevant for ecological endpoints such as bioassessment indicators

Reference Condition is the Foundation of Bioassessment

Bioassessment is the science of interpreting ecological condition from the set of organisms occurring at a site

Bioassessment scoring tools (e.g., IBIs and OE models) convert organism lists into condition scores

All scoring tools rely on reference conditions to establish benchmarks for what organisms to expect at a given site

Many Uses of Reference Data in Bio-objectives Process

Tiering Objectives

- Defines biological expectation in least disturbed state (= y-axis: overall and within each tier)
- Anchors waterbody classification gradient (= x-axis for "tiering")

- Establishes upper limits for stressor modeling
- Defines the zoogeographic clustering dataset
- Essential for scoring tool development: (MMIs and O/Es)

Reference Conditions:
The primary technical goal

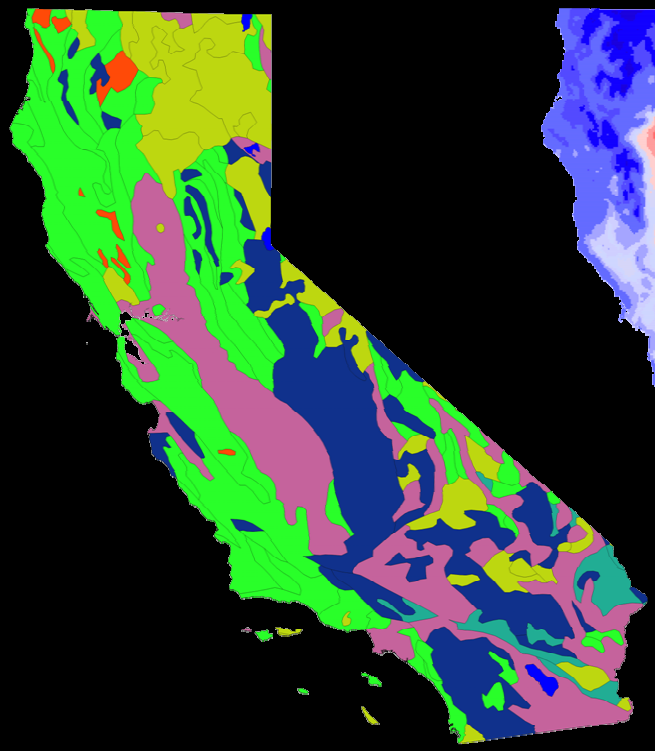
Establish an objective process for defining **biological** expectations in different environmental settings

Expectations must be **flexible** enough to accommodate CA's diverse ecological and landuse settings, but have **consistent** meaning throughout the state

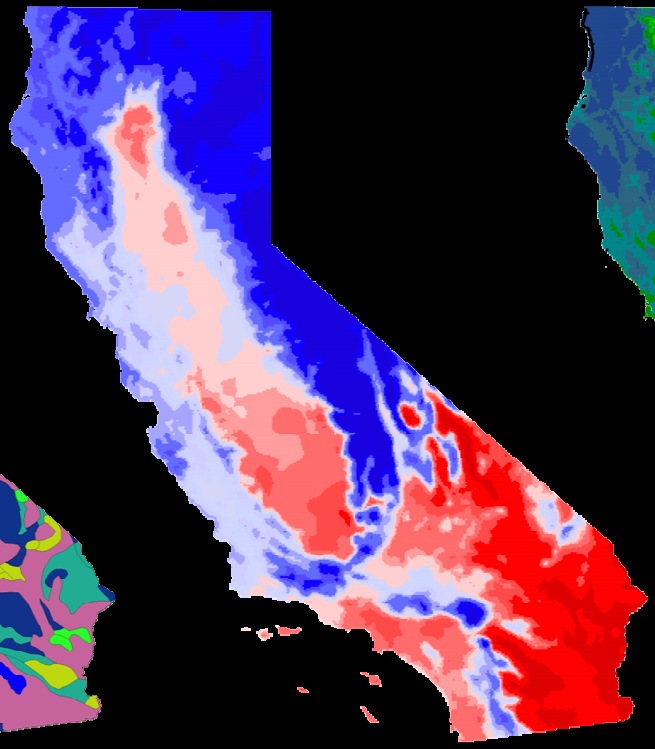
Technical Challenges: California is not Kansas

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

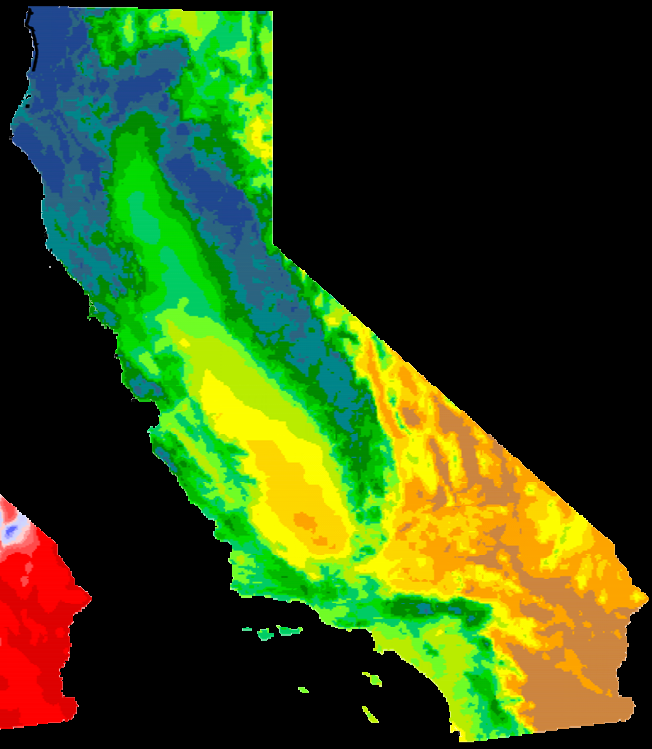
Geology



Temperature



Precipitation

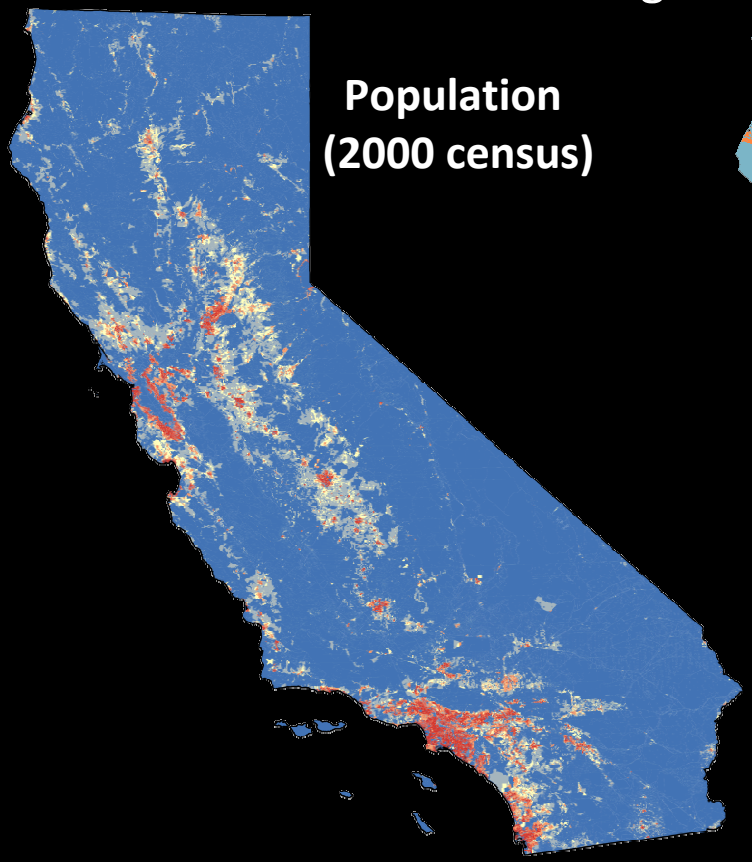


Management of biological variability requires good representation of biology at reference sites **across major gradients**

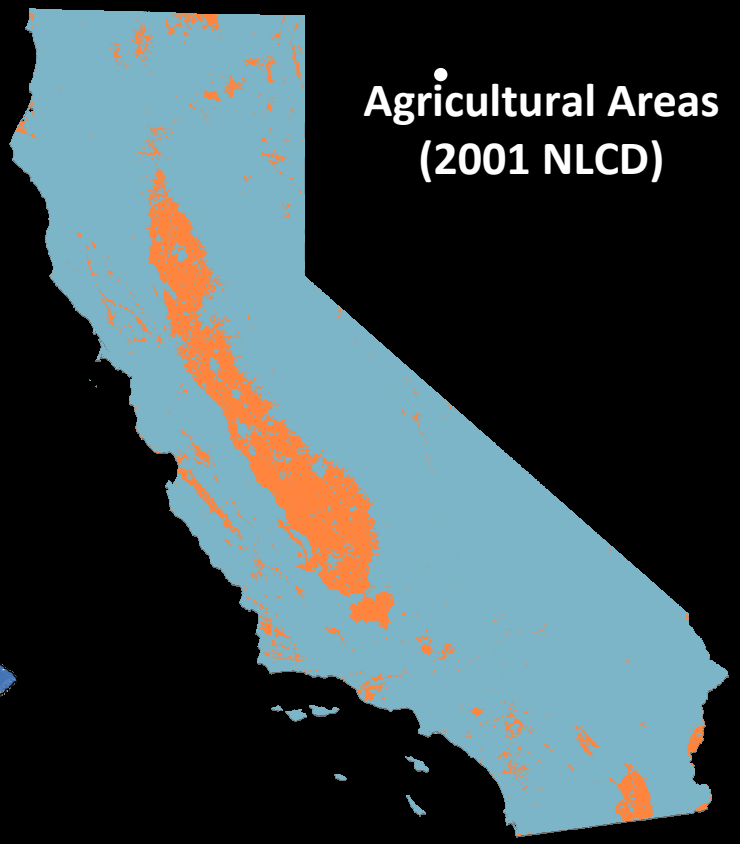
➔ **need 100s of sites in the reference pool**

Technical Challenges: California IS Kansas

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



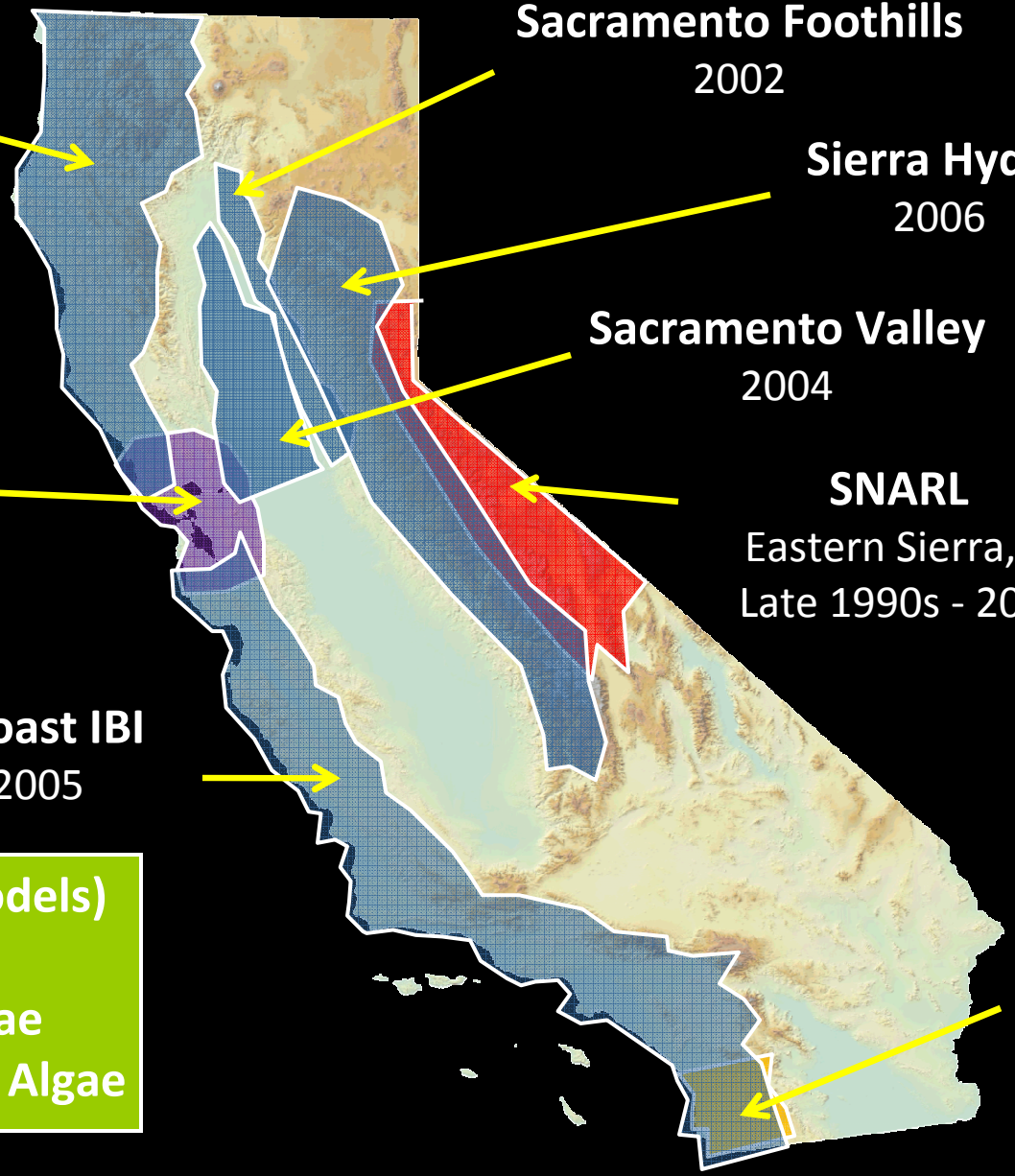
Population (2000 census)



Agricultural Areas (2001 NLCD)

- Extensive human modification complicates the reference selection process because it introduces gaps in representation of natural gradients
- Intense development pressures make some regions unsuited for standard reference approaches

Significant CA Reference Projects (1997 – 2010)



North Coast IBI
2000-2005

Sacramento Foothills
2002

Sierra Hydro
2006

Sacramento Valley
2004

SF Bay Area
In progress

SNARL
Eastern Sierra, some Sierra
Late 1990s - 2008

South Coast IBI
2000-2005

San Diego IBI
2001

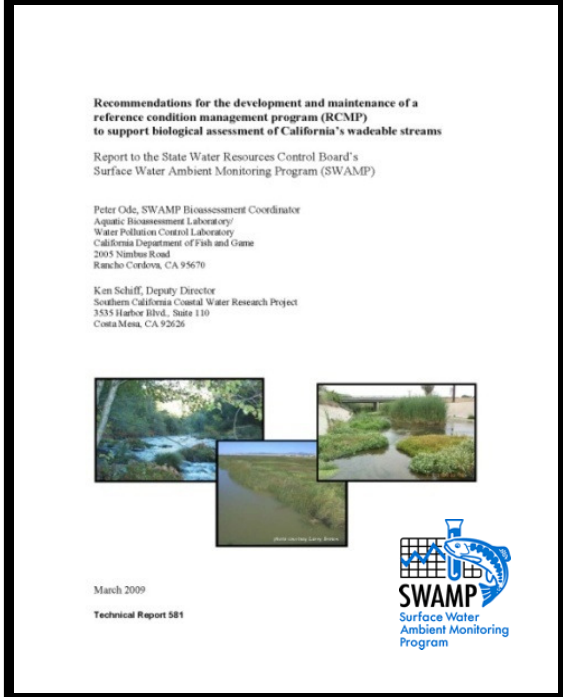
- **USFS (OE models)**
- **EMAP**
- **SoCal Algae**
- **Central Coast Algae**

CA's Reference Condition Management Plan (RCMP)

A robust reference program was the highest initial priority of SWAMP's bioassessment program

One of the first tasks was to assemble a panel to outline the plan …

RCMP Development Panel *(met October 2007)*



Recommendations for the development and maintenance of a reference condition management program (RCMP) to support biological assessment of California's wadeable streams

Report to the State Water Resources Control Board's
Surface Water Ambient Monitoring Program (SWAMP)

Peter Ode, SWAMP Bioassessment Coordinator
Aquatic Bioassessment Laboratory/
Water Pollution Control Laboratory
California Department of Fish and Game
2005 Nimbus Road
Rancho Cordova, CA 95670

Ken Schiff, Deputy Director
Southern California Coastal Water Research Project
3535 Harbor Blvd., Suite 110
Costa Mesa, CA 92626

March 2009

Technical Report 581

SWAMP
Surface Water
Ambient Monitoring
Program

- David Herbst, *UC Santa Barbara-SNARL*
- Peter Ode, *ABL*
- Raphael Mazor, *SCCWRP/ABL*
- Phil Larsen, *EPA-ORD*
- Andy Rehn, *ABL*
- Lenwood Hall, *U. Maryland*
- Terry Fleming, *EPA Region 9*
- Chuck Hawkins, *Utah State*
- Alan Herlihy, *Oregon State*
- Ken Schiff, *SCCWRP*

RCMP: Guiding Philosophies

- **Use natural condition as the desired state whenever possible** - However, highly developed regions still require tools for setting expectations
- **Balance statewide consistency with regional flexibility**

  Strategy should balance a set of desirable, but sometimes conflicting traits: *objectivity, consistency and flexibility*
- **Reference site management is an iterative process**

  The strategy should build in continuing analysis of data to tailor reference pool to the way the data are used in practice
- **The RCMP should be transparent**

  Transparency of the RCMP process will facilitate discussions about how to set objective and fair standards

We are following the RCMP framework

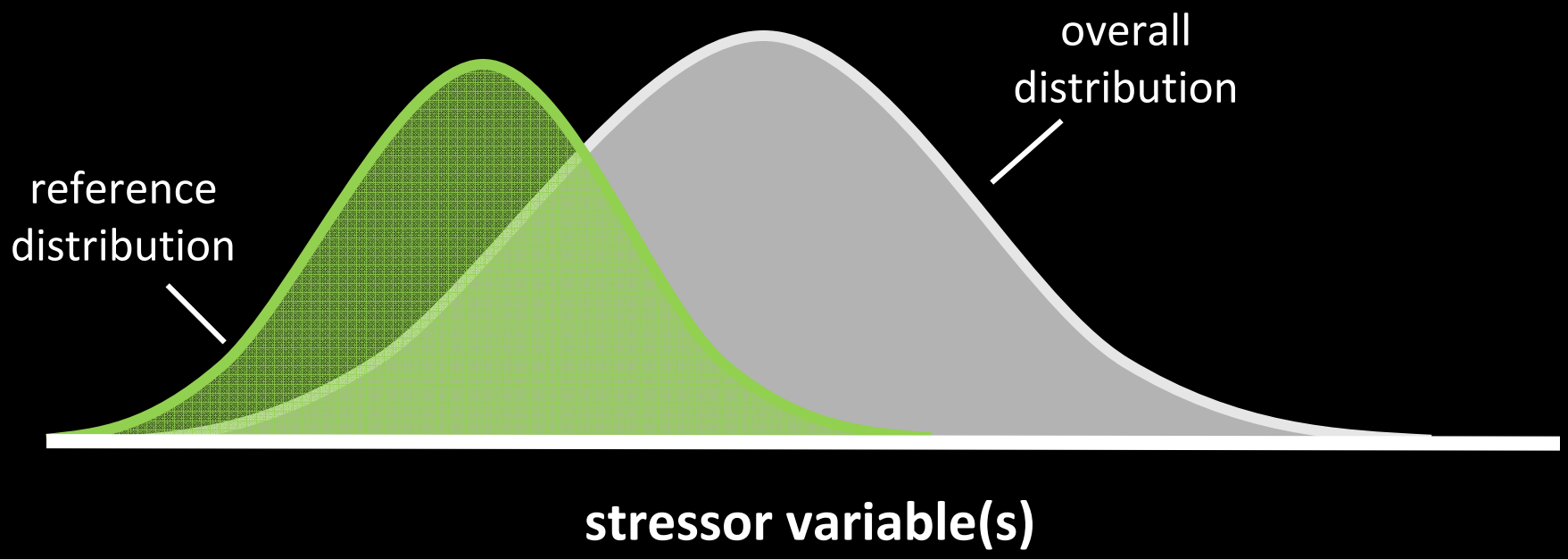
- **RCMP Implementation Part I: The Standard Model**
  - Step 1 – **Assemble Candidate Data**
  - Step 2 – **Calculate Metrics for Candidate Sites** (natural and stressor gradients)
  - Step 3 – **Develop Initial Screening Criteria**
  - Step 4 – **Evaluate Representation of Gradients** --- > identify gaps

    …. target new collection efforts in data gaps
  - Step 5 – **Cluster Reference Biology** --- > revise sub-regions as necessary and revise screening criteria (Steps 3-5 may need multiple iterations)
  - Step 6 – **Align Threshold Setting Process Among Regions** *… data ready for MMIs/OEs*

- **RCMP Implementation Part II: The Alternative Models**
  - Overview of approaches we're considering

Step 1: Assemble candidate data

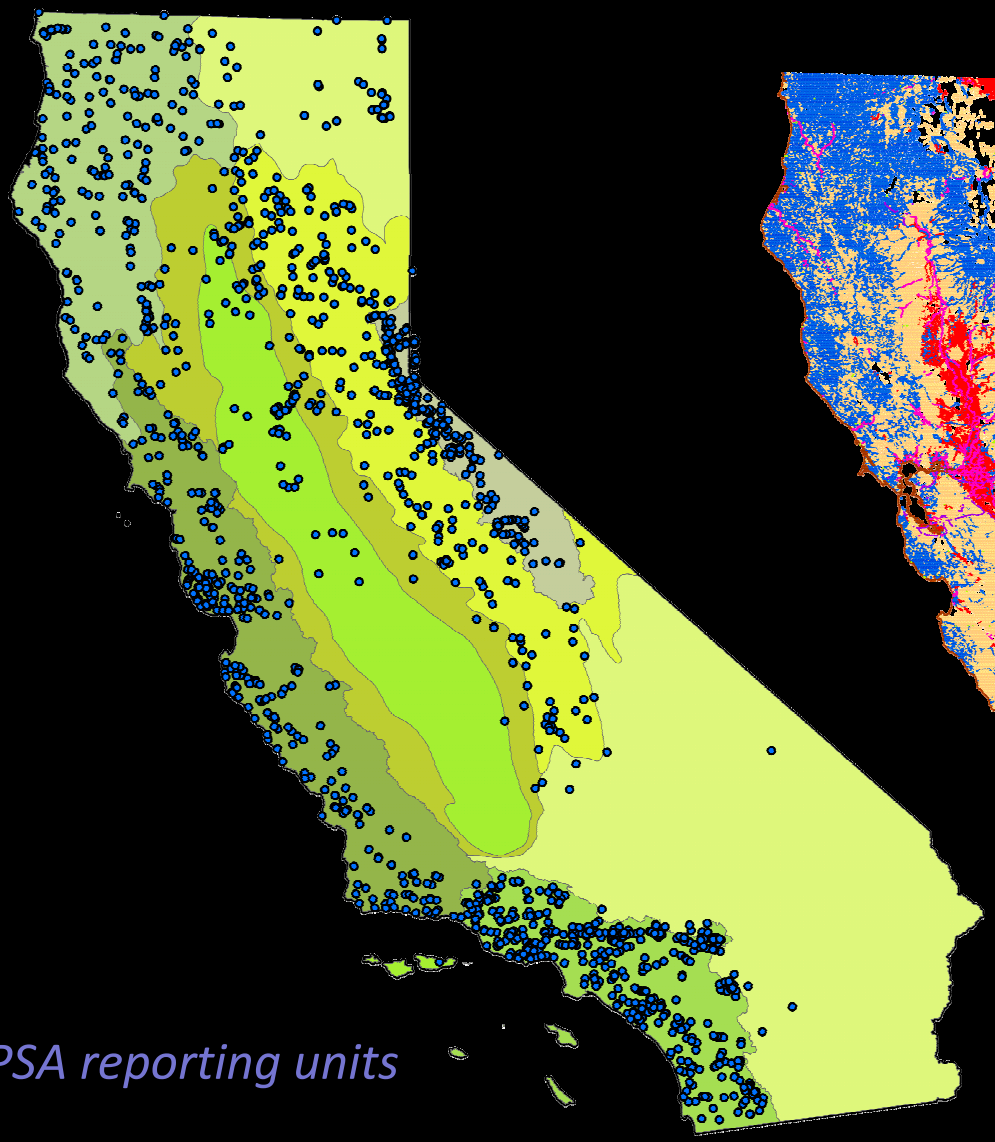
reference candidates + probability sites

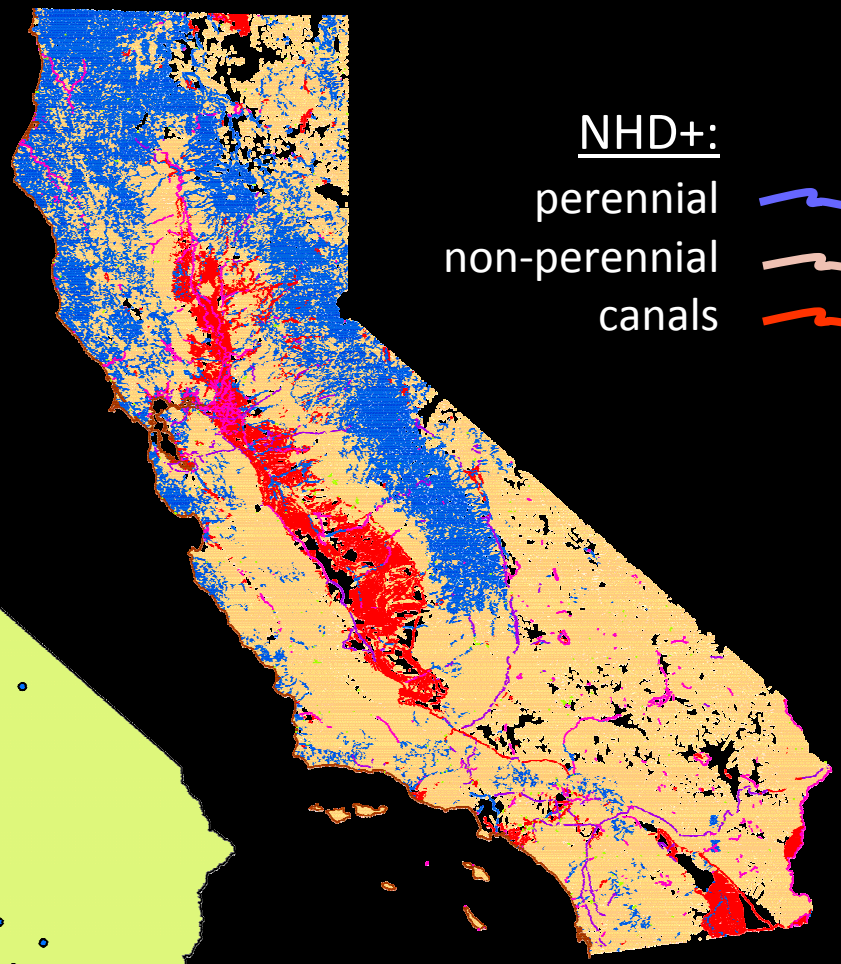


Probability Datasets (EMAP/CMAP/PSA, SMC, USFS, TRPA, others) will be used to generate the distribution curves needed for setting regional thresholds and for evaluating gradient representation

> 1700 sites

(½ probability/ ½ reference candidates)





NHD+:

perennial

non-perennial

canals

PSA reporting units

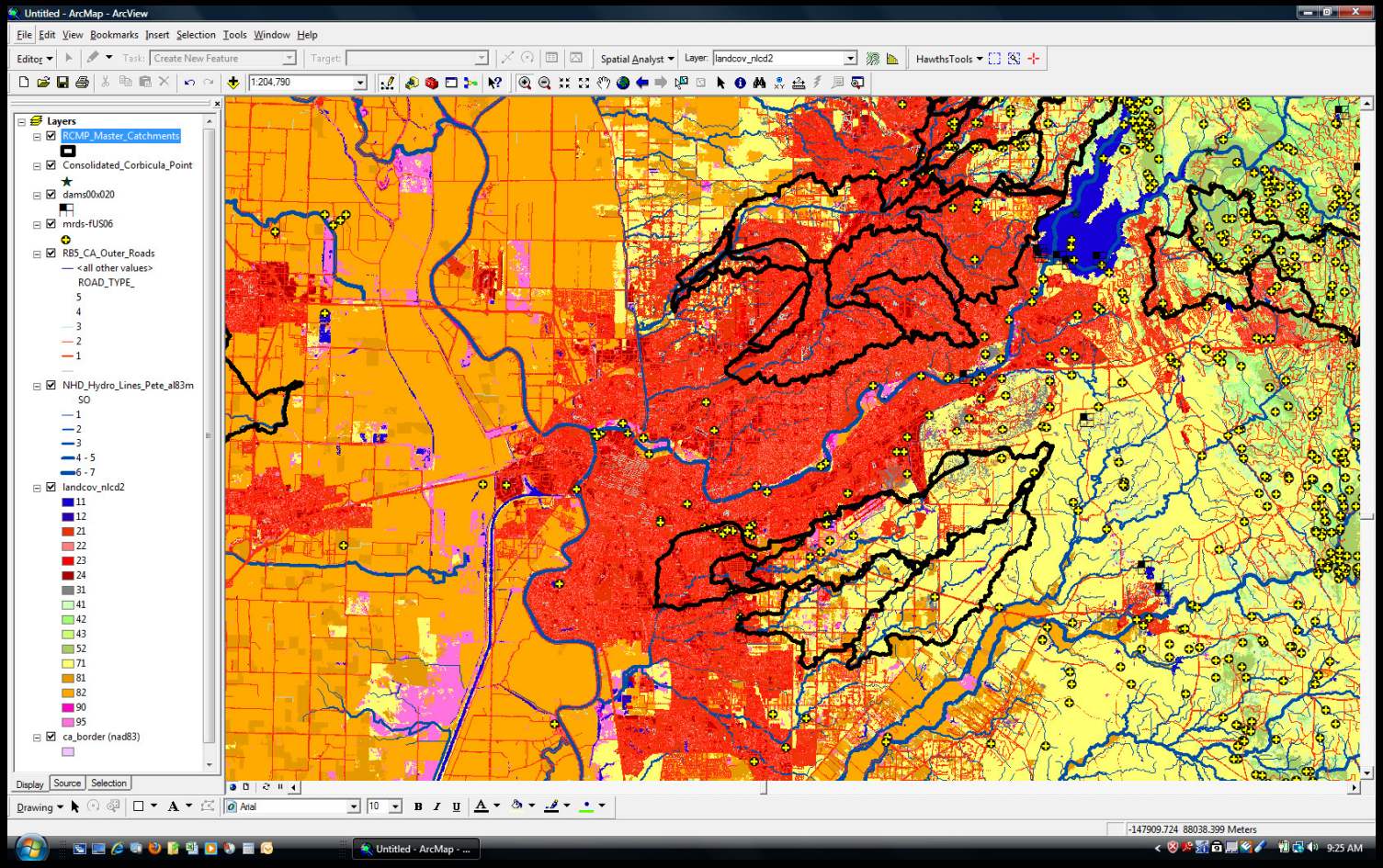
Step 2: Calculate metrics

Lots of GIS data

- Natural gradients
- Stressor gradients

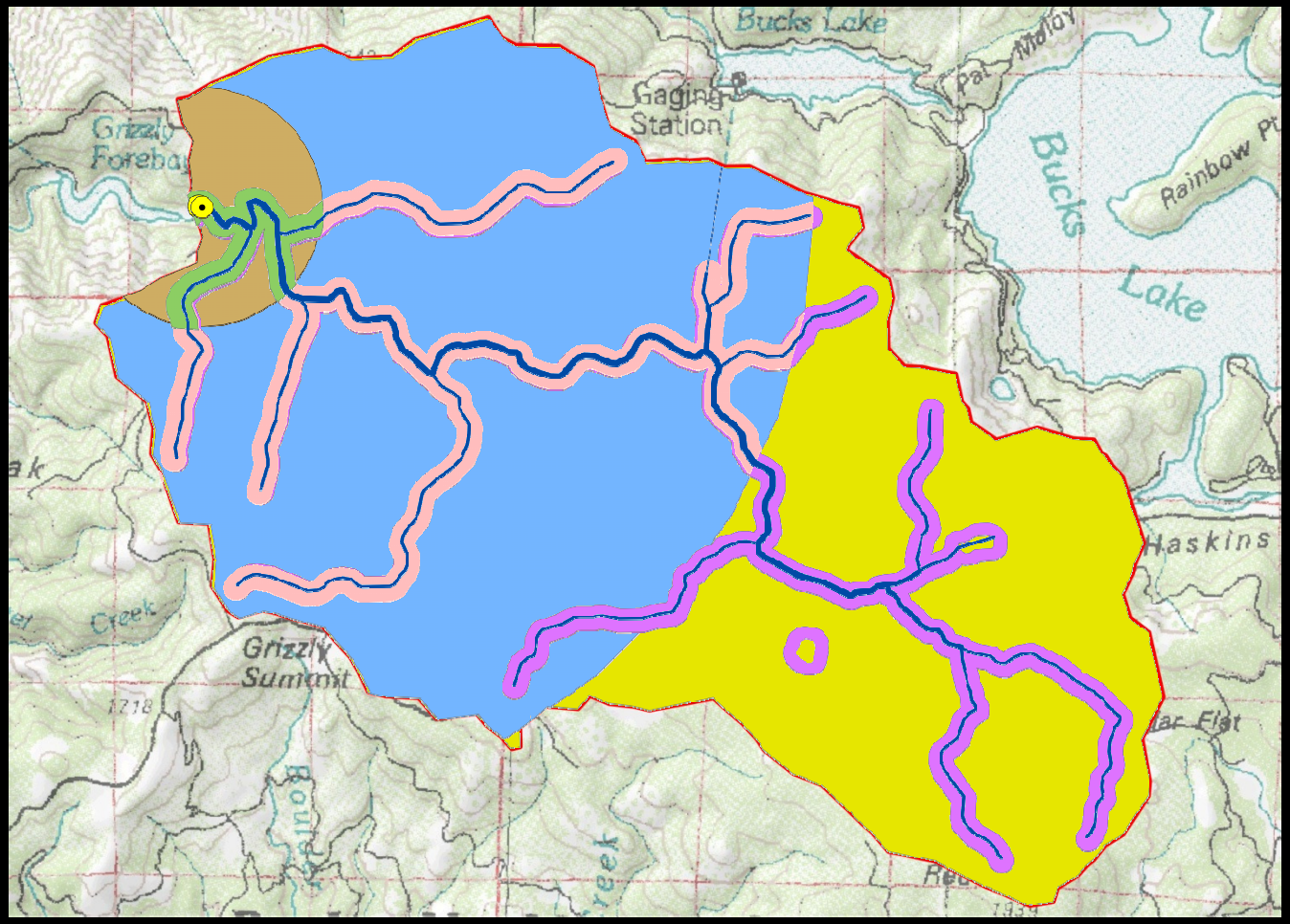
Local condition data

- Chemistry (nutrients, cond, pH, etc.)
- Physical habitat (instream and riparian condition)



Standardized Spatial Analysis

Position of stressors in watershed influences their impact



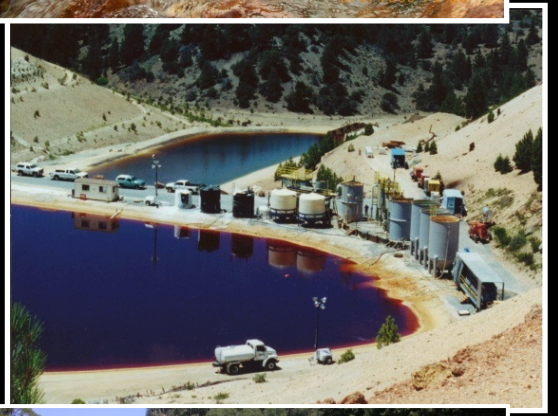
Metric Overview:
station data + natural gradients

- **Station Data**
  - Regional board, PSA region, county, HUC/CalWaterID, stream ID, ownership information
- **Natural Gradients**
  - **POINT DATA:** Coordinates, elevation, climate (PPT/T), ecoregion, stream order, stream volume, stream gradient
  - **BASIN DATA:** area, stream length, basin geology, mineral content

Metric Overview: stressors

(> 150 metrics)

- **Infrastructure**: roads, railroads
- **Population**
- **Hydromodification**
  - manmade channels, canals, pipelines
- **Landuse**
  - NLCD metrics, NLCD change (1992-2001), NLCD % Impervious
  - Timber Harvest, Grazing
- Fire history, dams, mines
- 303d list, NPDES/CWIQS discharges
- Invasive invertebrates, plants



Metric Overview: local conditions

- **Chemistry:** nutrients, conductance, pH, Cl^-, turbidity

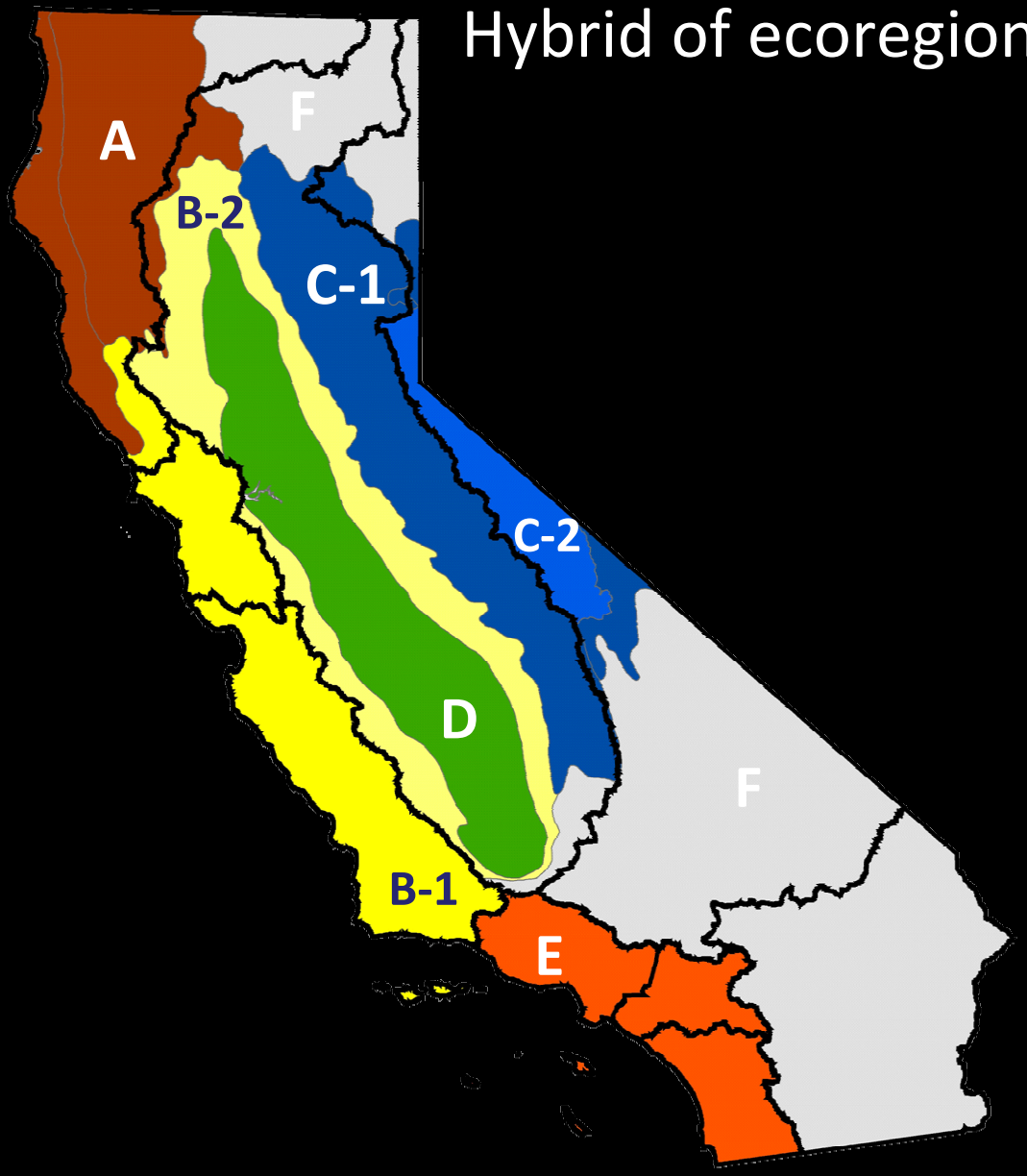
- **Habitat** (SWAMP metrics at many sites … similar to EMAP):
  - Riparian condition, canopy
  - Instream condition, fines
  - Human disturbance

Lots of metrics + Lots of QC

- 1700 sites x 180 metrics x 1-6 spatial scales
  > 1 million records
- Automated data generation requires careful review
- Just completed this phase

Working with Metrics: PSA Regions

Hybrid of ecoregion and political boundaries



A= North Coast
B = Oak Chaparral
1= Coastal Chaparral
2= Interior Chaparral
C = Sierra
1= Main Sierra
2= Central Lahontan
D = Central Valley
E = South Coast (SMC)
F = Other:
- Modoc Plateau
- Deserts

Steps 3-6: Working with Metrics

(overview only … in progress next 6-12 months)

Step 3 –**Develop Initial Screening Criteria**

Step 4 – **Evaluate representation of gradients in each region** … where do we have gaps?

…. target new collection efforts in data gaps

Step 5 – **Cluster Reference Biology** --- > revise sub-regions as necessary and **revise screening criteria**

(Steps 3-6 may need multiple iterations)

Step 6 – **Align threshold setting process among regions** …… *data ready for MMIs/OEs*

Data reduction

- Minimize redundancy
  - Spatial correlation
  - Stressor correlation
- Balance redundancy reduction with loss of unique information at different scales
  - Any given variable may occur at one scale but not another

Metric Evaluation:
Different Approaches for Different Metrics

Quantitative:

- Filter approach: each metric is applied independently
- Multi-metric approach: each site gets a composite score
- "Kill switch": extreme values of certain metrics invalidate an otherwise acceptable site

Qualitative:

- Visual screening (e.g., aerial photos)
- Local history information

RCMP Panel recommended starting with a hybrid approach: multi-metric approach + kill switches

Setting thresholds

Identify appropriate thresholds for different regions

- statistical thresholds (e.g., 10th percentile of overall dist.)
- natural breaks (e.g., Jenks)
- published thresholds

Zero tolerance: some factors act as “kill switches”

- 303d listed streams
- nearby mines, other significant discharge sources
- very high (or low) values of certain metrics

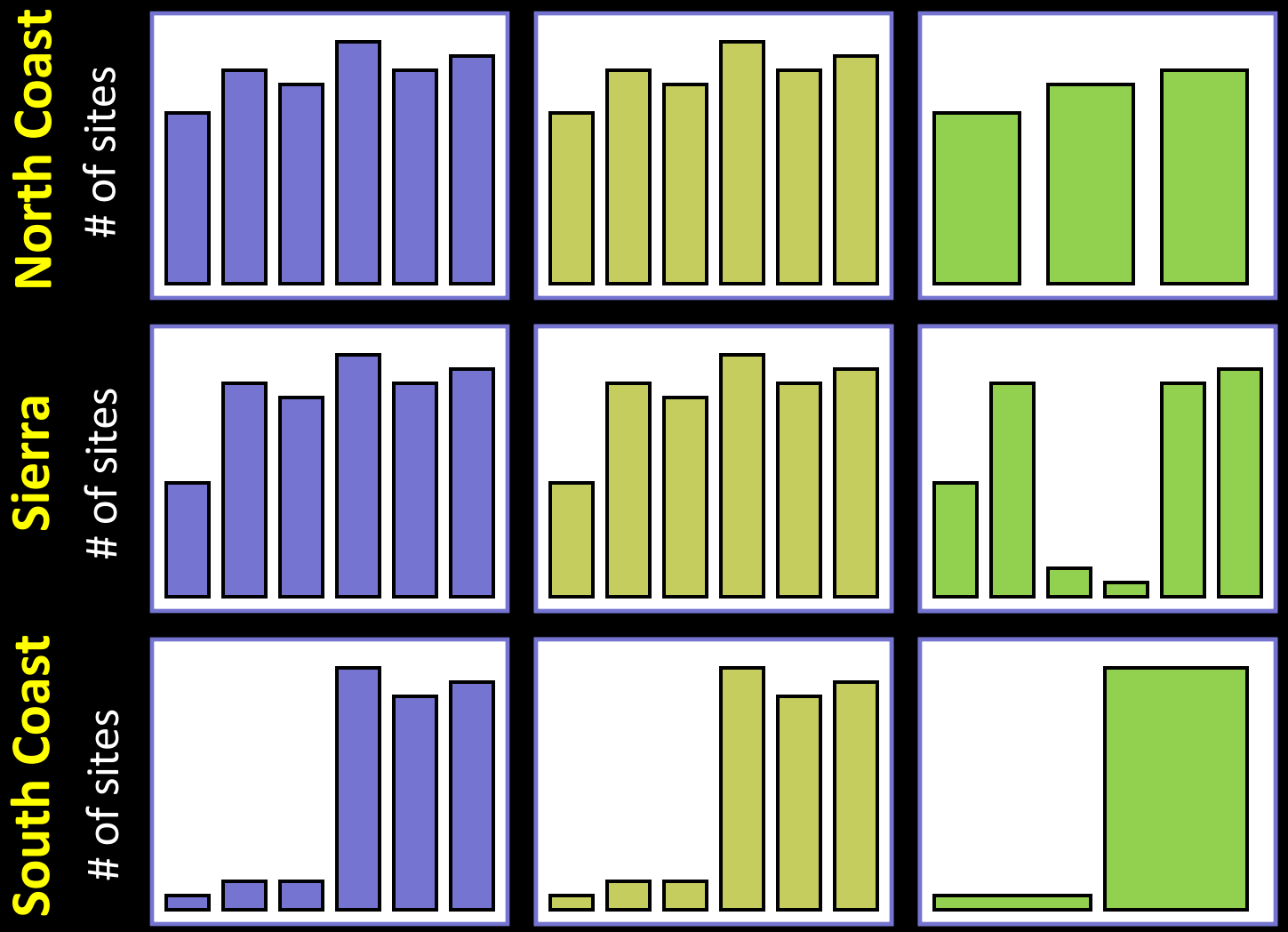
Combining metrics:
issues we are currently exploring

1. How best to integrate local and remote sensing data?
2. Strategies for combining filter and multi-metric approaches
3. (How) should we weight different metrics? All metrics are not equal.
4. What are appropriate kill-switches?

The Reference Pool

- Objective is to develop a large pool of sites that represents the full range of natural gradients in all regions
- A subset of sites (~50 sites) will be monitored each year
    - Start with randomly selected sites from each region
    - Resample a subset of sites in consecutive years to assess inter-annual variation and trends
- Final numbers will depend on how variable the natural gradients are in each region … more variability will require more sites to get same level of precision in our scoring tools

Examples of data gaps



PHASE II of Standard Model:
Adding new sites to the pool

1. Apply new regional screening criteria
2. Desktop review of candidate watersheds

   … select target stream sites
3. Field reconnaissance of candidate sites
   i. Local condition screens
      a. Missed point sources
      b. Recent fires, grazing, etc.
      c. Erosion, bank stability problems
      d. Hydromodification
   ii. Access- short term, long term

Reference Timeline

- SWAMP has been targeting data gaps for last 3 years to establish the reference pool
- Focused on screening thresholds over next 6-12 months
- Committed SWAMP funds (FY07-09, FY09/10) will cover development expenses and >75 sites next year

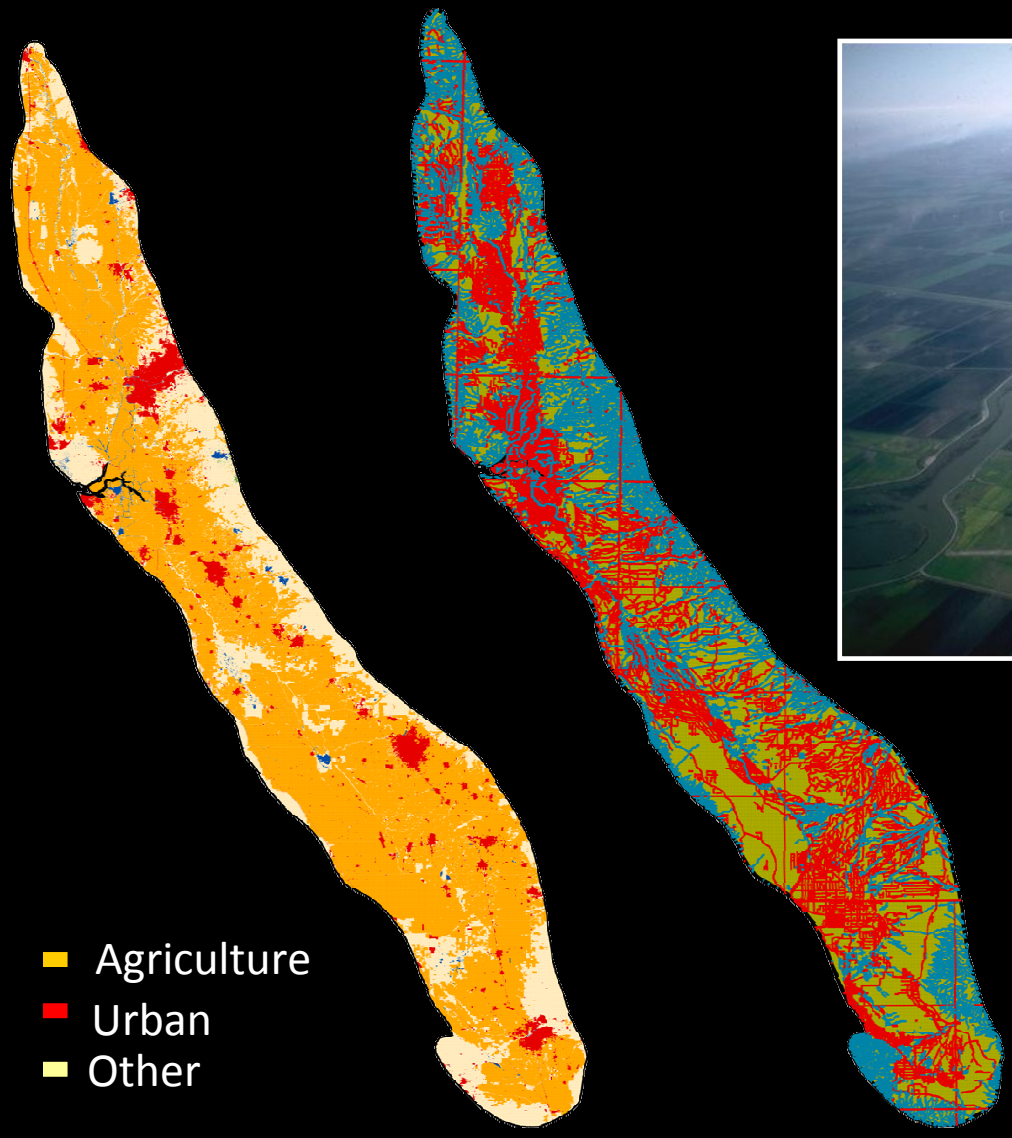
- Won’t know exact site needs until we know where data gaps
- We expect fewer reference sites will be needed in 2012, then move to monitoring phase of RCMP to coincide with bio-objectives

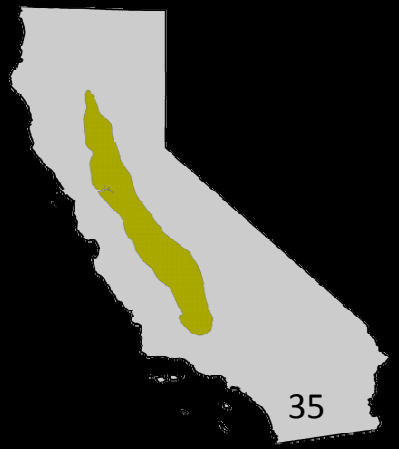

Alternative Reference Models:
Develop process for setting biological expectations in non-standard areas

How to set standards for biotic condition where reference streams are hard to find?

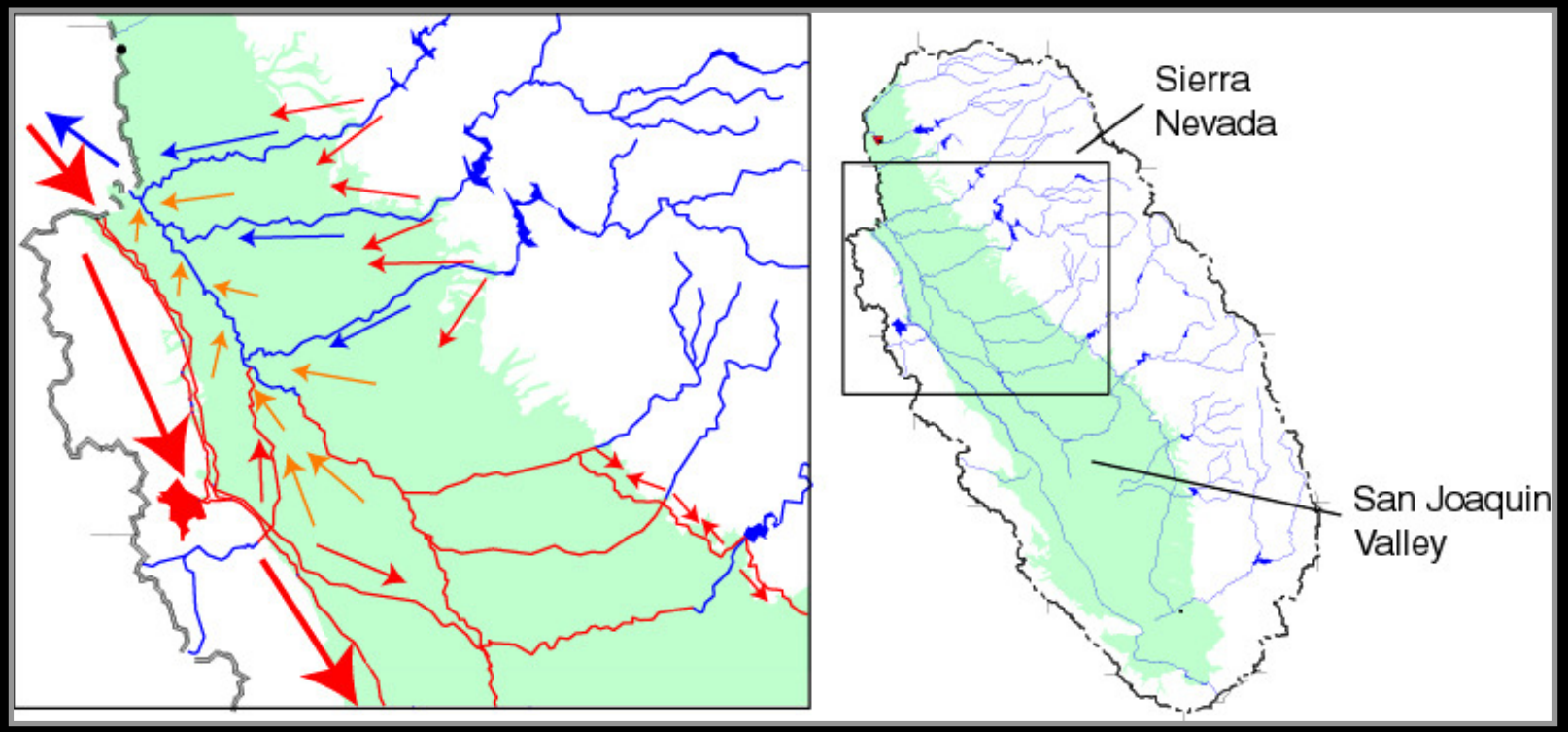
Ode, P., D. Pickard, J.Slusark and A. Rehn. 2005. Adaptation of a bioassessment reference site selection methodology to creeks and sloughs of California's Sacramento Valley and alternative strategies for applying bioassessment in the valley. Report to Central Valley Regional Water Quality Control Board.

Valley floor almost completely converted to agricultural/ urban land uses and extensively “plumbed”





Altered flows in the southern Central Valley



- Instream flows (natural flow routes)
- Diversions, canals, and dry streambeds
- Agricultural and other return flows

Can't use standard watershed flow model to quantify upstream stressor sources if there is no "upstream"

slide courtesy Larry Brown, USGS


Southern Coast has similar issues with urbanization

Alternate Models for Setting Biological Expectations

1. Use a modified version of the standard approach (e.g., use less stringent thresholds, emphasize local condition measures, emphasize other data sources -- pesticide records, historic data?)

2. Alternate approaches (*see RCMP document for detail*)

- Use existing scoring tools (e.g., IBIs, O/Es) to screen sites, pick
- Species pool approach
- Factor-ceiling approach (Carter and Fend)
- Model taxon preferences for key environmental gradients and use to predict expected assemblage

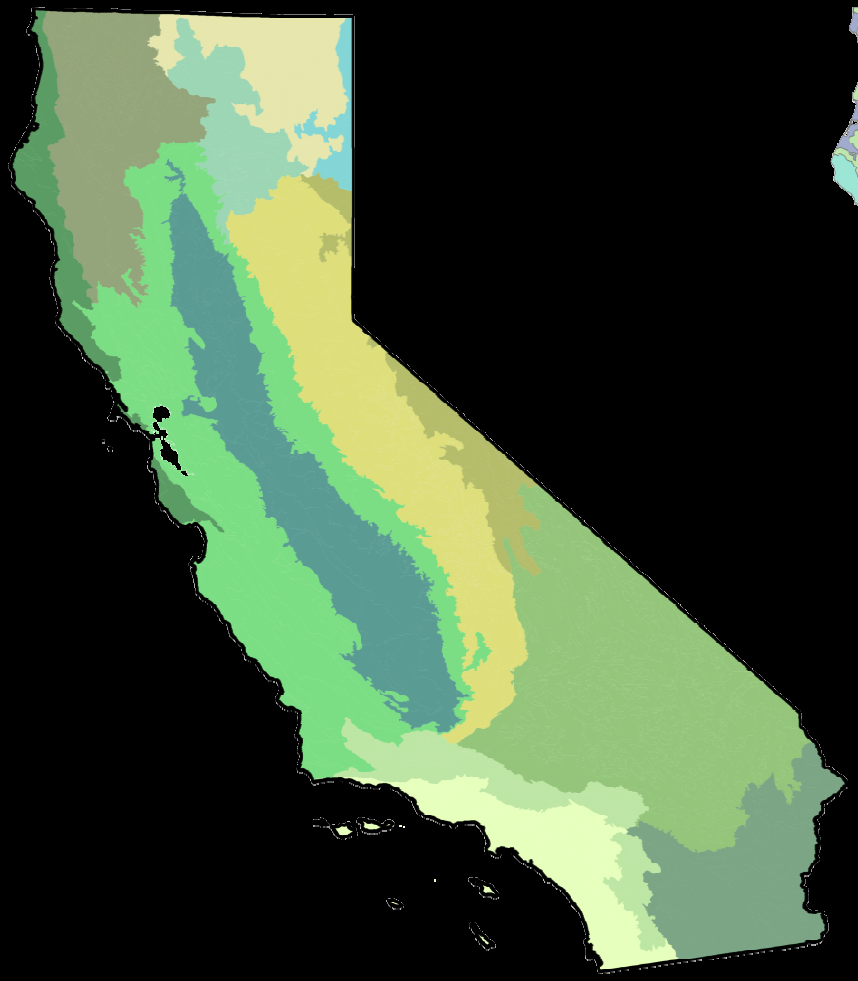
Initial Steps in Alternate Process (useful for most alternates strategies)

1. Relax restriction against using biology – identify sites with high quality biology in region of interest
2. Use environmental data from these sites to identify key physical, chemical and landscape characteristics that are associated with best sites
3. Identify new sites with these characteristics

2011 sampling effort will include lower elevation SMC and Central Valley sites

Omernik Ecoregions (Draft II, April 2010)

Level III – 13 Level IV - 189



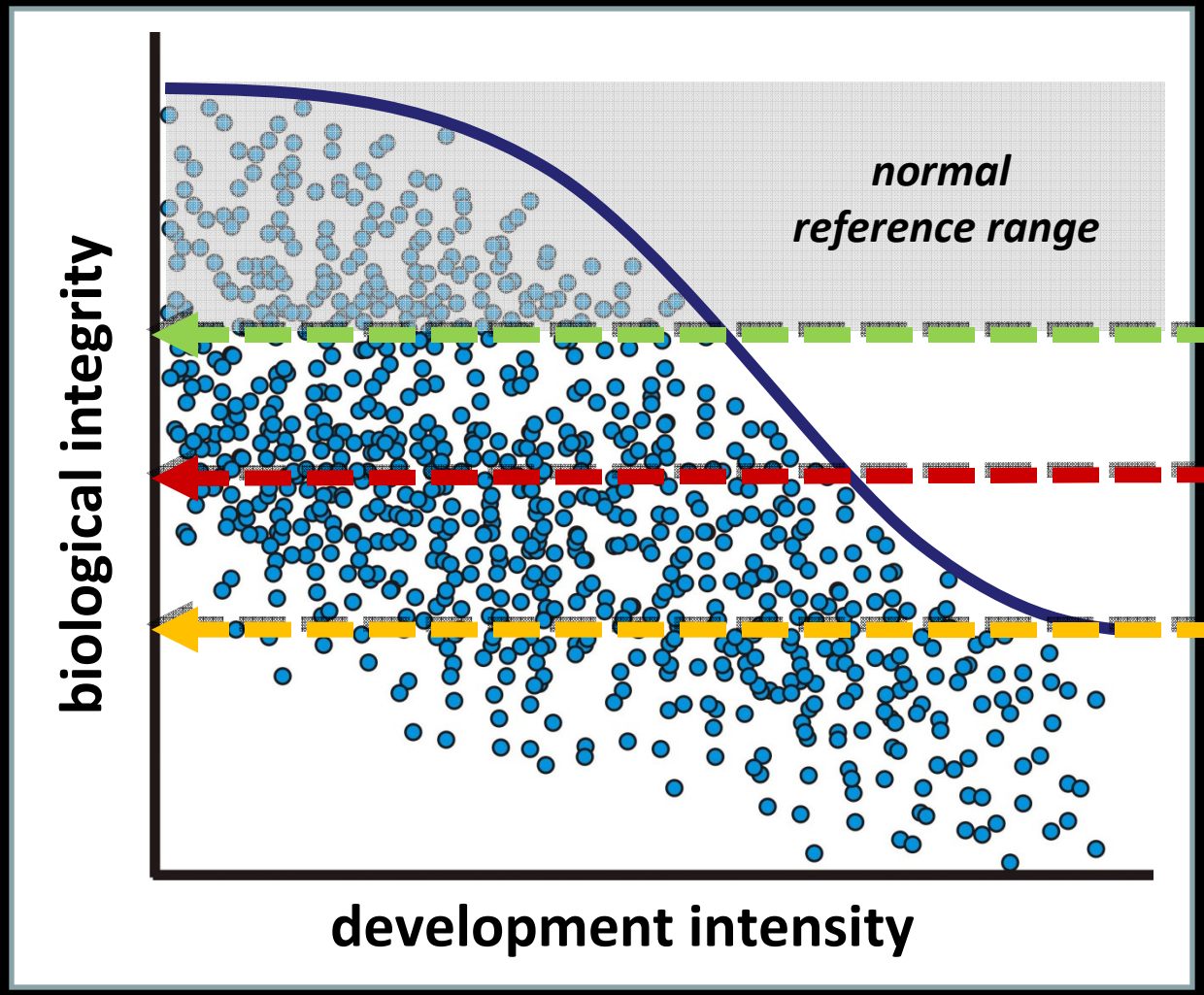
Biological Objectives: The Policy Goal

To establish standards for aquatic life use protection that are appropriate for all wadeable streams in California.

Expectations need to both: i) accommodate CA's natural diversity and ii) recognize that even the most protected streams in highly developed regions are unlikely to ever achieve the same standard of ecological integrity as in less developed regions

- *Standard biological assessment techniques are designed to account for natural sources of variation*
- *Accounting for development intensity requires additional structure*

Where to set an impairment threshold?



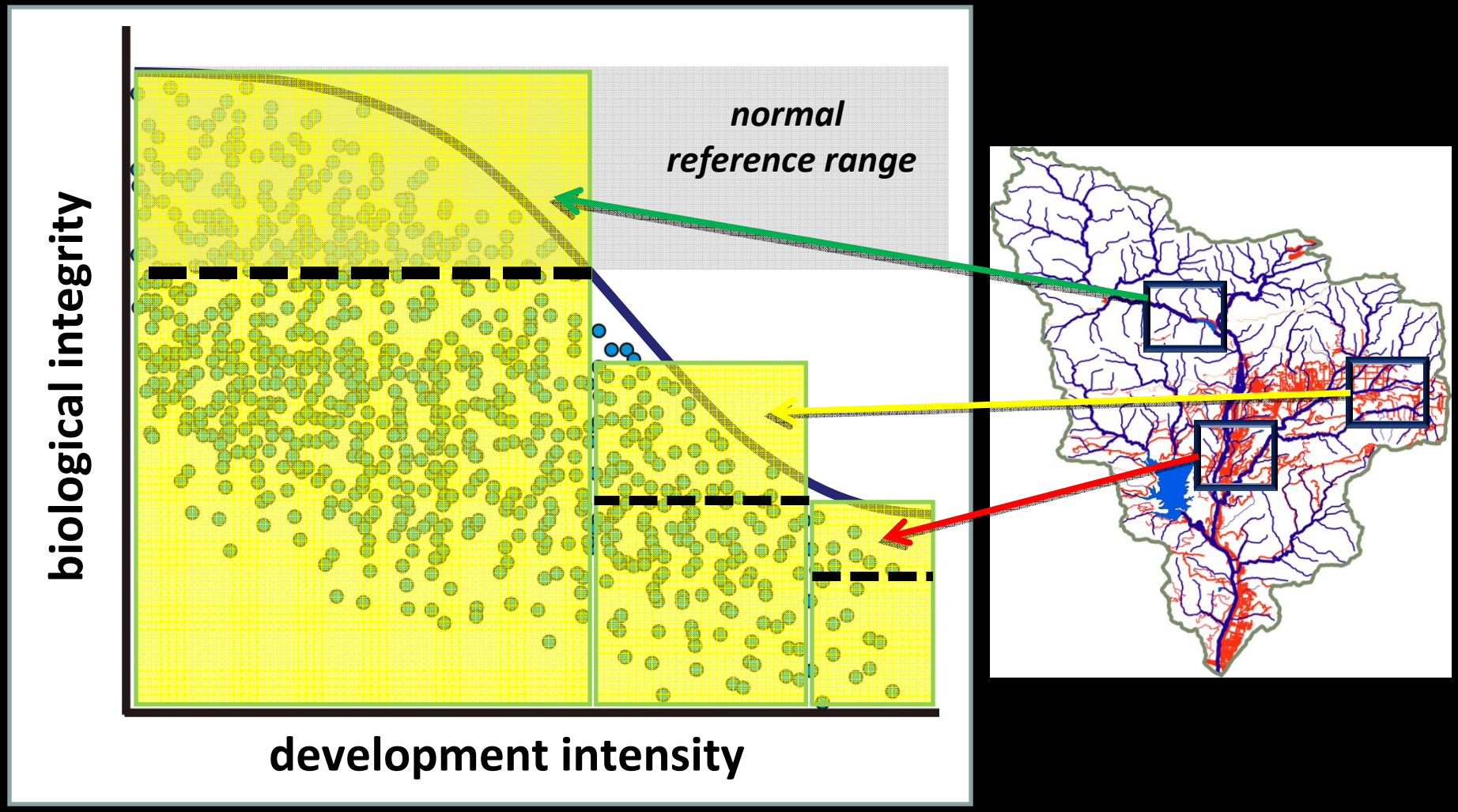
protective, but sets unrealistic standard for many streams

neither protective nor realistic

achievable in most cases, but not protective

No single threshold can achieve our policy goals

Tiered objectives



Permits high level of protection for high quality watersheds and realistic targets for highly developed watersheds

Assign all CA streams to an expectation class