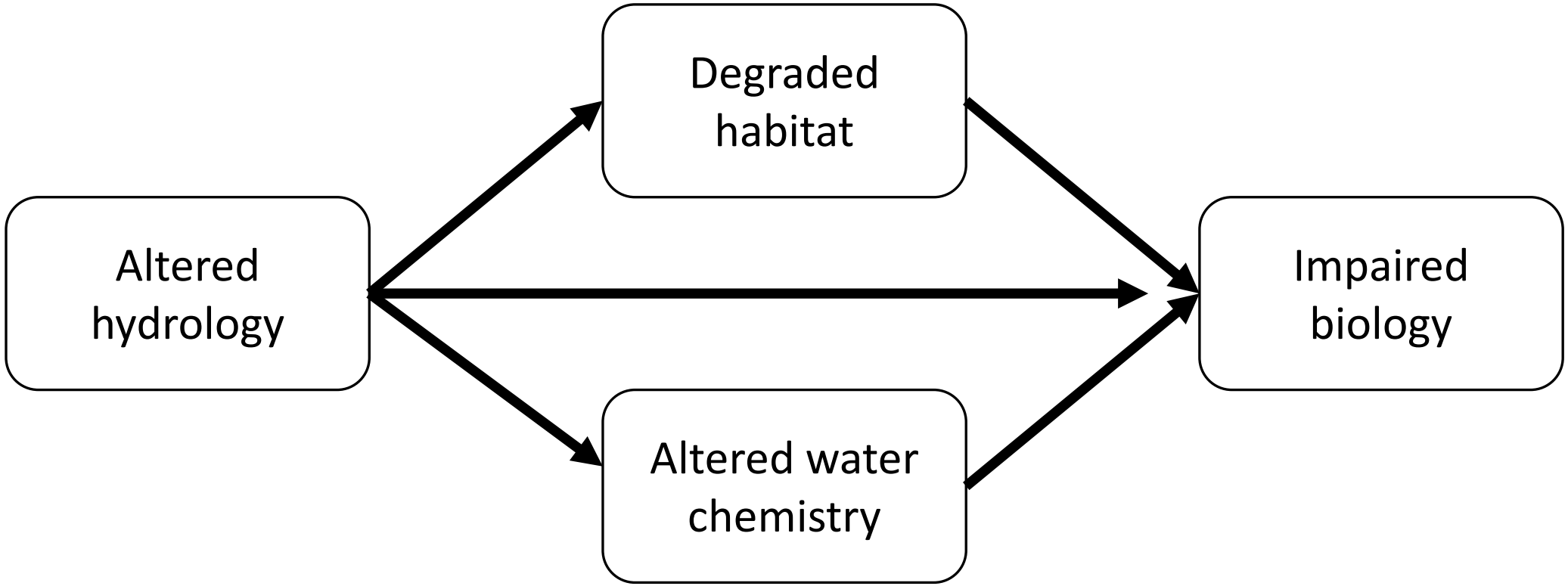
Setting regional targets based on flow-ecology relationships to support biological integrity

PRESENTATION TO CABW

OCT 18, 2016

Hydrology is an integrative driver



How can you set targets for flow?

Relate biological alteration (ΔB) to hydrologic alteration (ΔH)

We can already measure ΔB

- California Stream Condition Index (CSCI) and its components express ΔB as difference between observed and expected (i.e., reference) biology
- Expanding to algae indices, other bug metrics

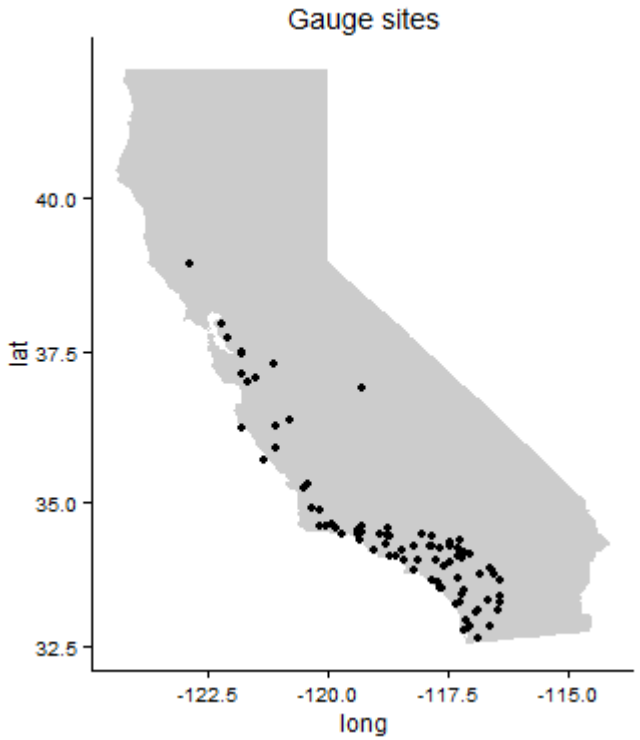
Harder to measure ΔH, especially at ungauged sites

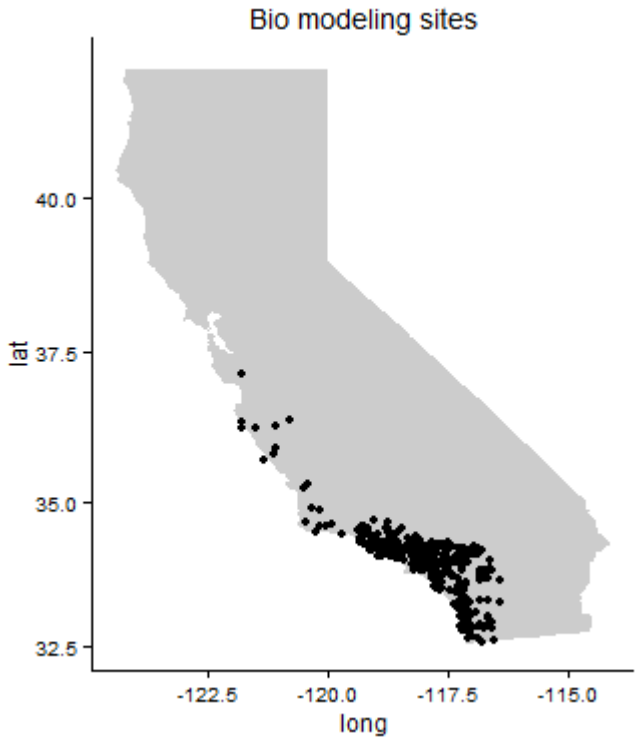
- How do you know current hydrology?
- How do you know reference hydrology?

Why are ungauged sites so important?

More power to explore biological responses

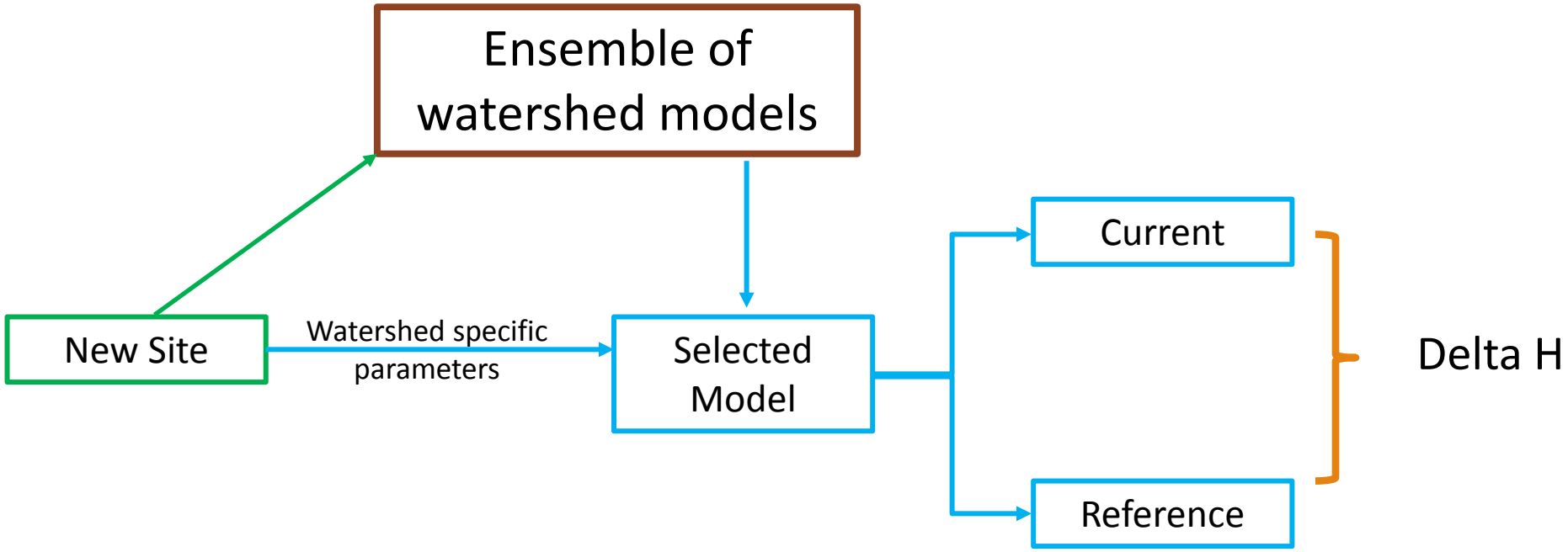
Ultimately, we need to manage ungauged sites





Predicting flows and alteration at ungaged locations

Assumption: Certain catchment and hydrologic parameters can transfer to other catchments given adequate similarities.



Flow metrics characterize different components of the hydrograph

Class	Example metrics
Magnitude	Mean annual flow Maximum flow
Duration	Duration of high-flow events Hydroperiod
Frequency	Frequency of low-flow events Frequency of drying events
Variability	Flashiness Storm-flow recession
Timing	Inter-annual predictability Month of minimum flow

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Most successful predictions

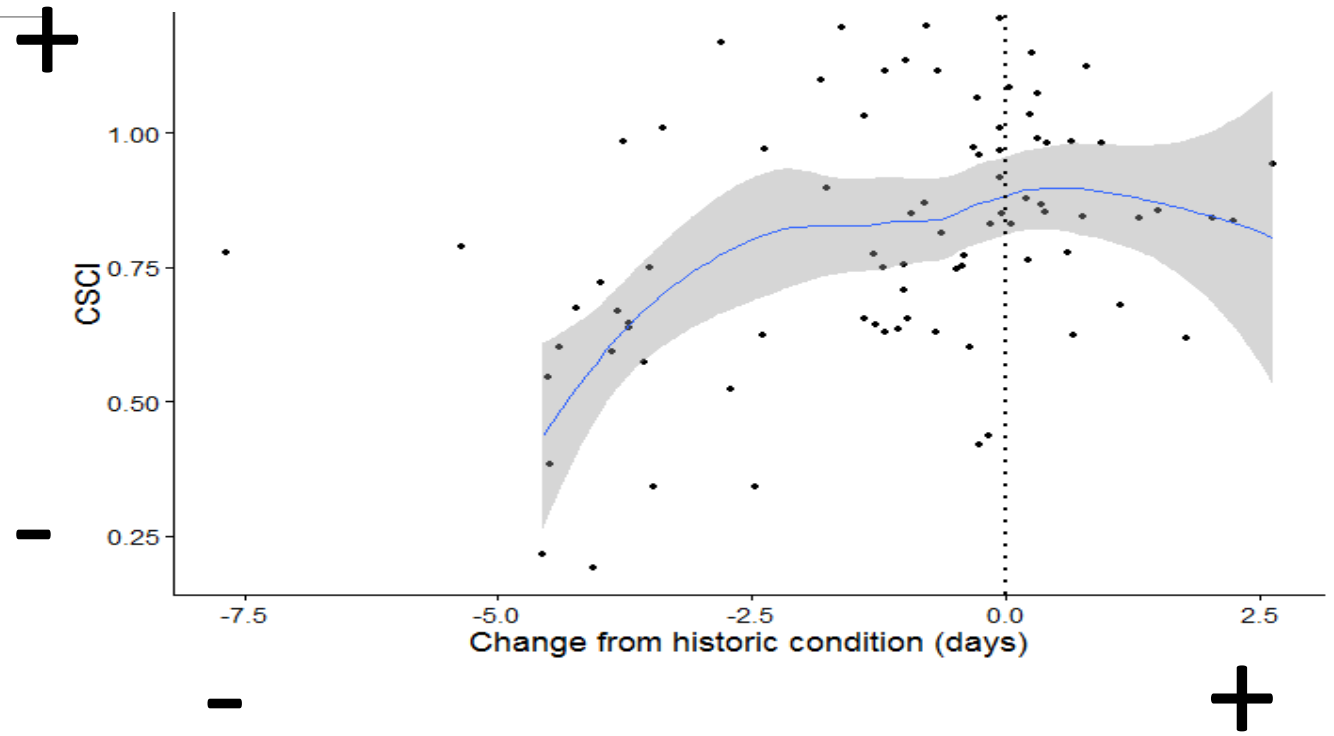
- Magnitude metrics
- Duration, frequency of *high* flows

Least successful predictions

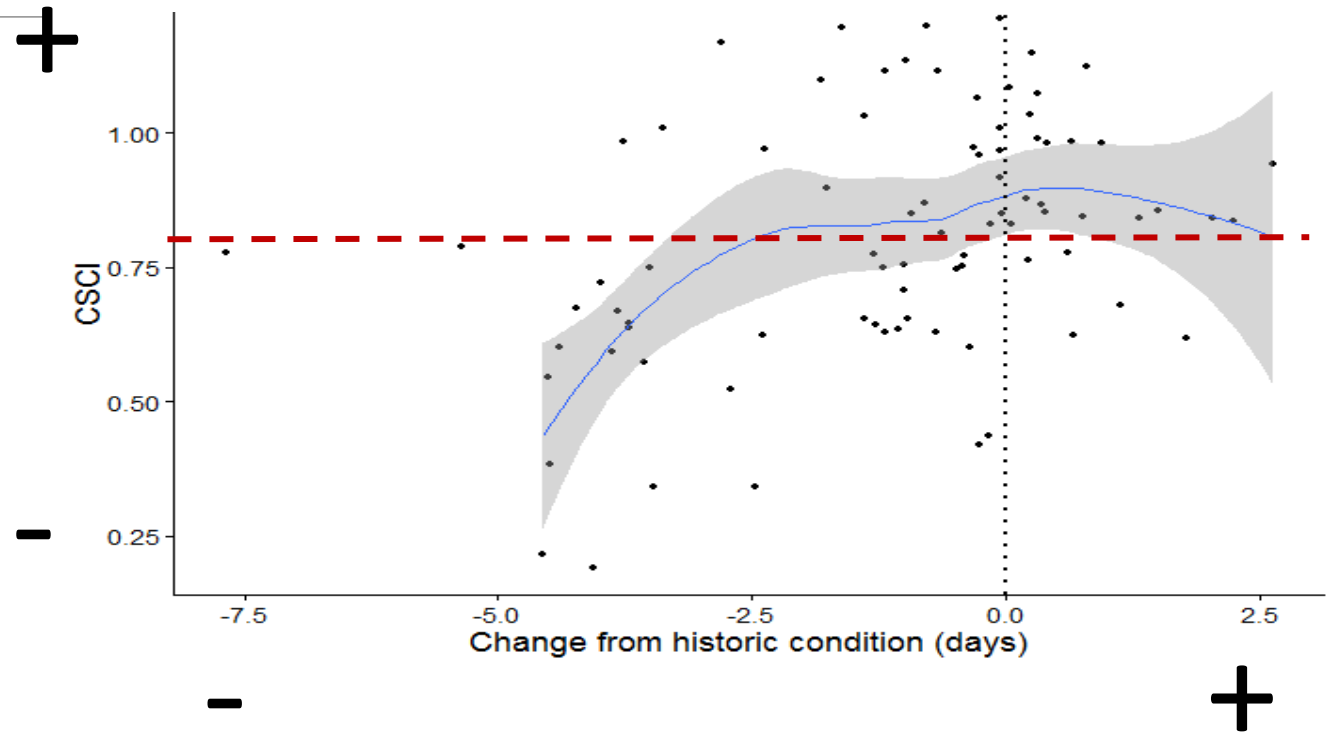
- Variability metrics
- Duration, frequency of *low* flows

Scarcity of good rainfall data was the most frequent problem

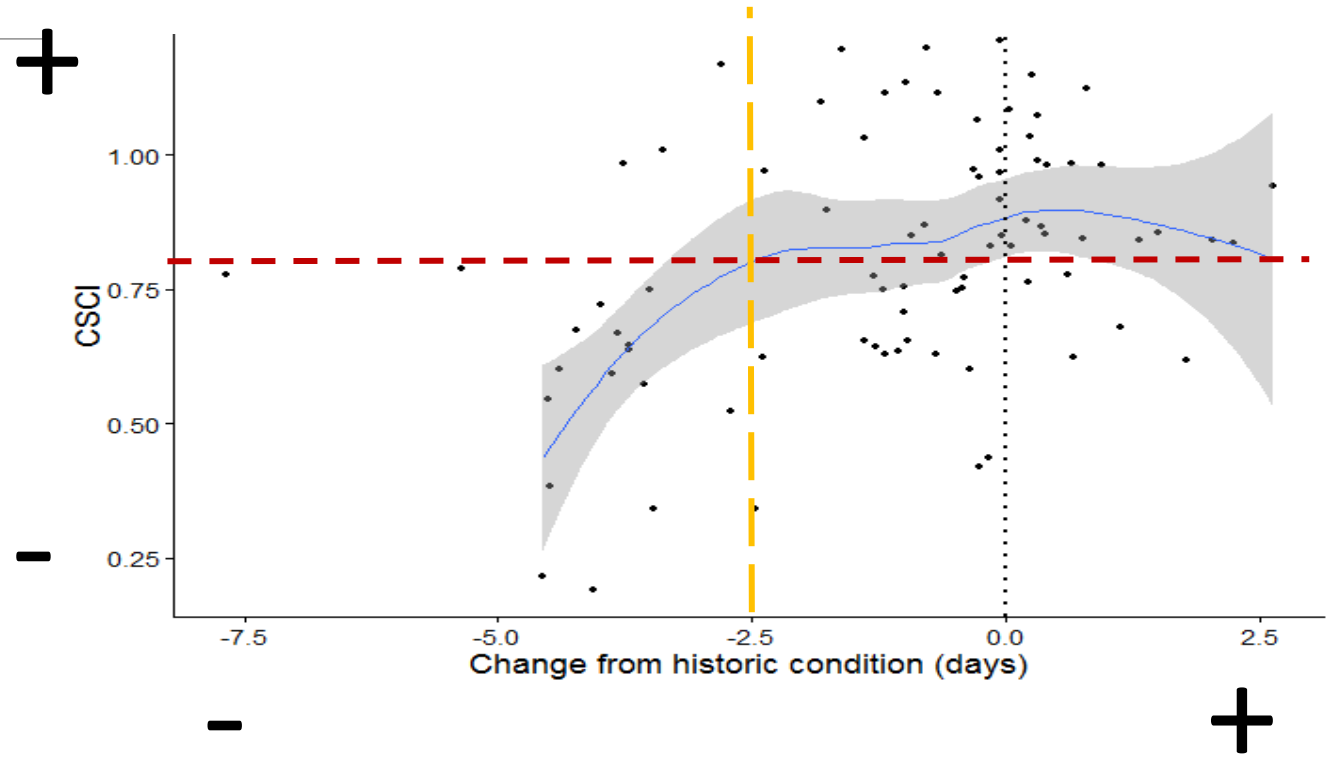
Relating hydrology to biology



Relating hydrology to biology

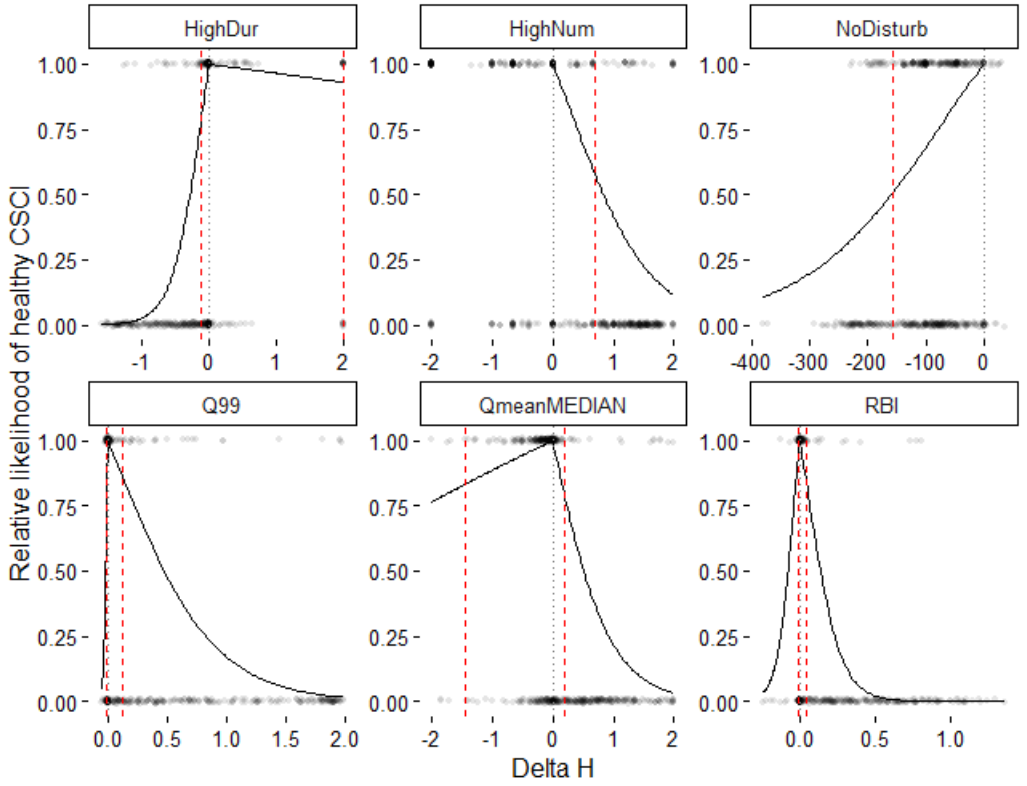


Relating hydrology to biology



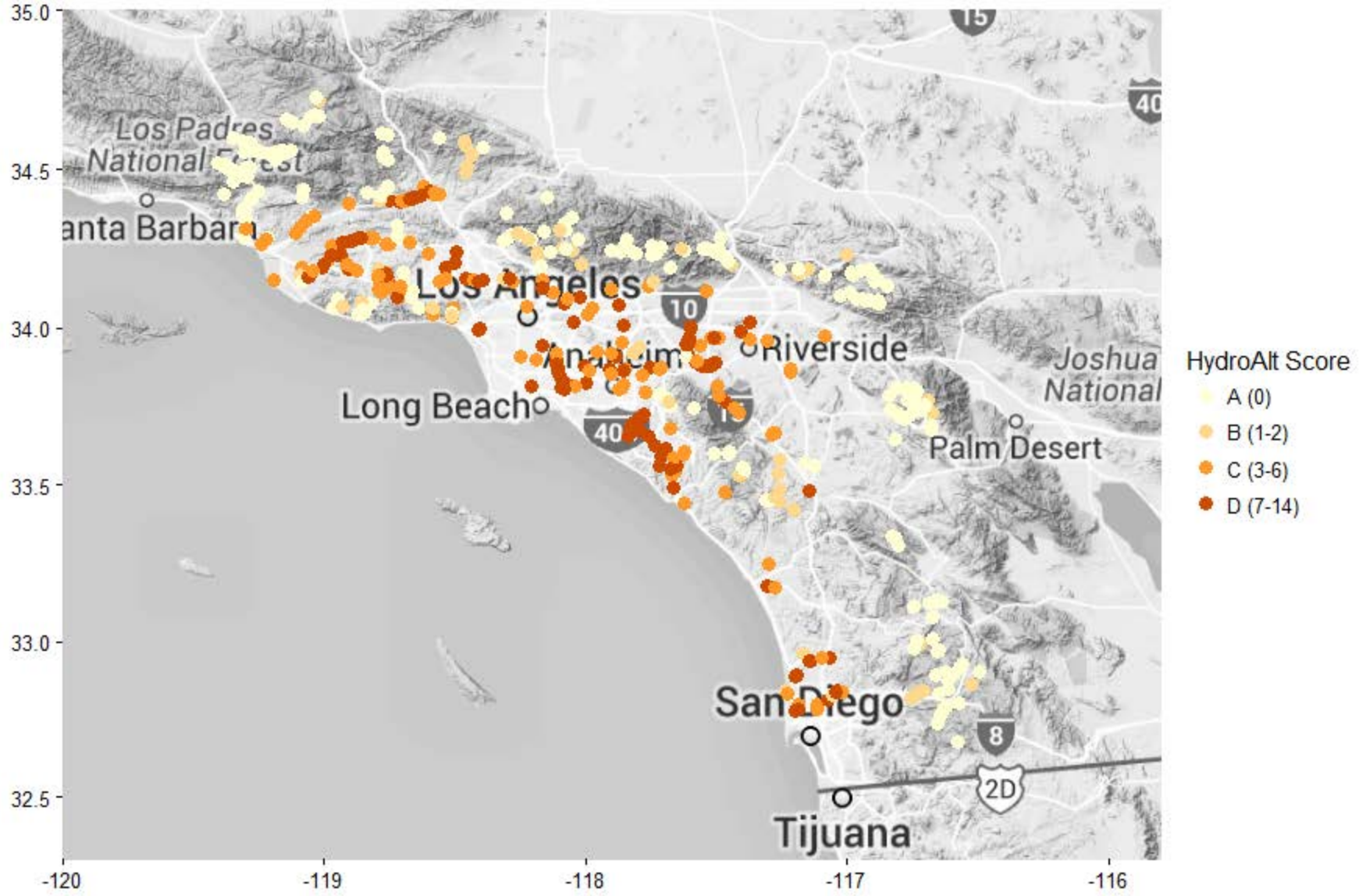
Relating hydrology to biology

- Logistic regression: Probability of healthy biological condition (score > 10th percentile of reference) at a given level of alteration. Repeat for CSCI and components.
- Evaluate increasing and decreasing gradients separately
- Even hydrologically unaltered sites may be in poor condition! Rescale probabilities by max to reduce confounding factors
- Select the most conservative threshold across endpoints.



Hydrologic alteration index

- Pick metrics based on importance in BRT models to predict each endpoint (CSCI, O/E, MMI, and each metric)
- Select no more than 2 metrics in each class
- Simple scoring: 0: Meets target. 1: Fails target. 2: Fails target by twice the amount.
- Sum of scores:
  A. 0 points. Unaltered
  B. 1 to 2. Mild alteration
  C. 3 to 6. Moderate alteration
  D. 7 to 14. Severe alteration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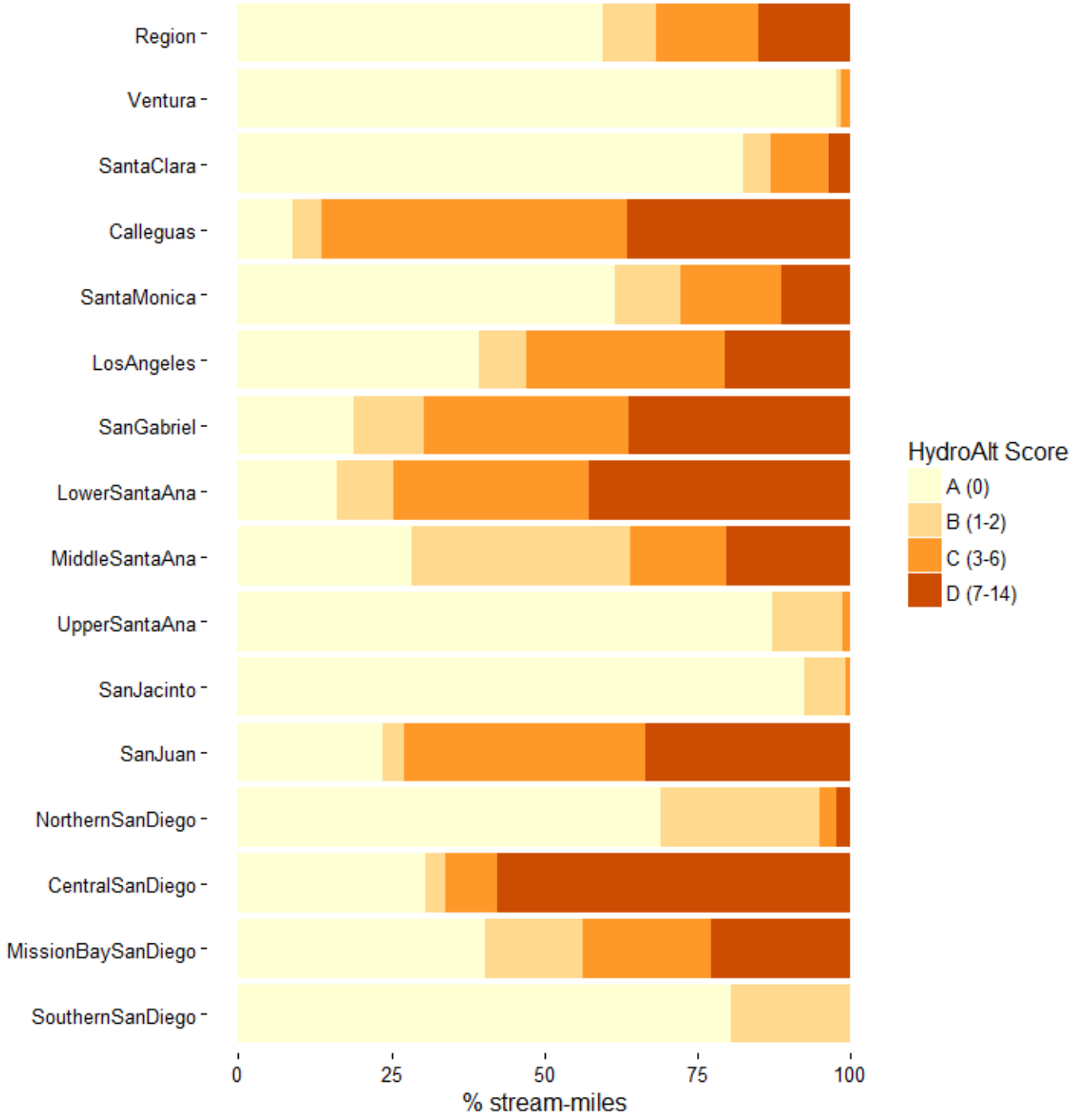
Los Padres
National Forest
anta Barbara
Los Angeles
Anaheim
Riverside
Long Beach
Joshua
National
Palm Desert
San Diego
Tijuana
15
40
10
40
15
8
2D
HydroAlt Score
A (0)
B (1-2)
C (3-6)
D (7-14)

Where are unaltered streams extensive?

Land Use	% Class A
Ag	20
Open	82
Urban	6



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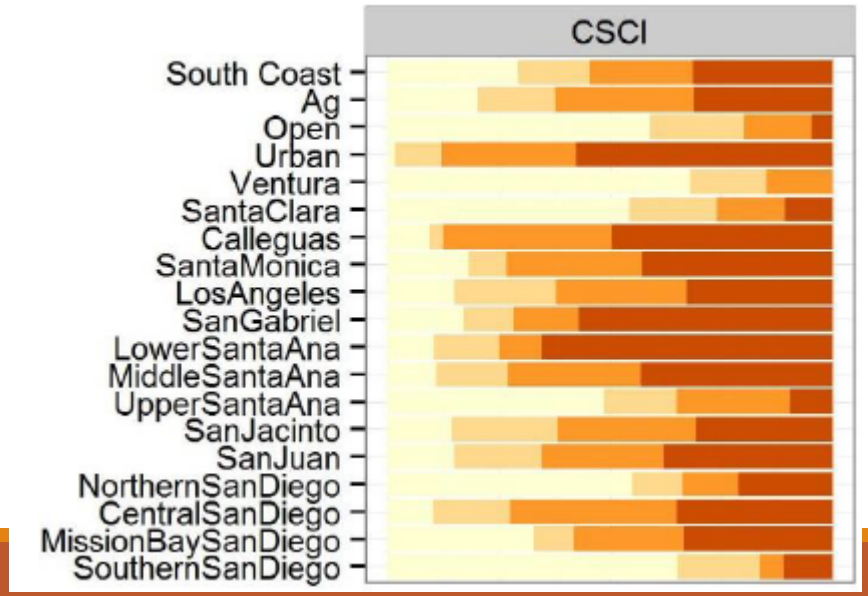
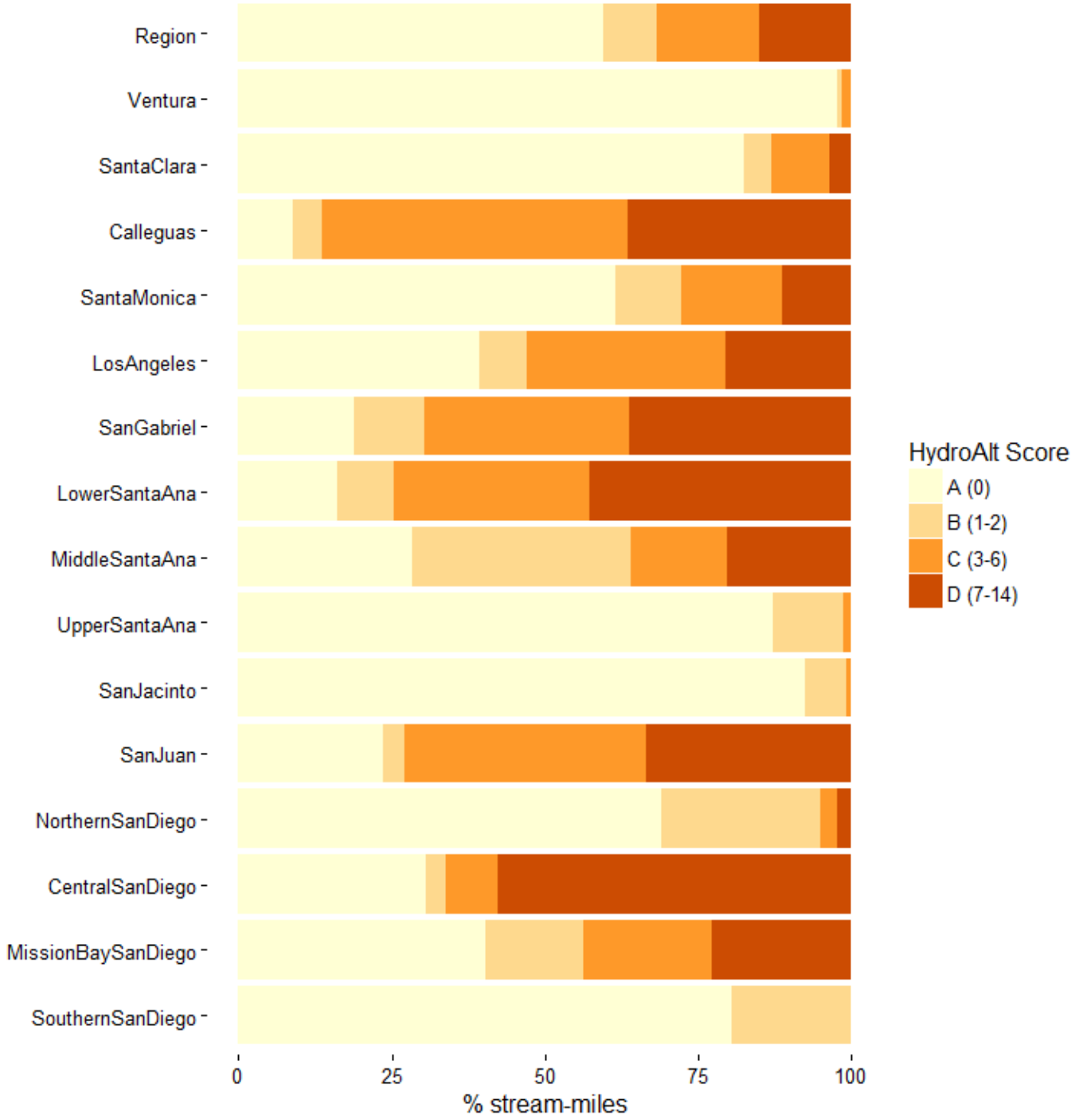
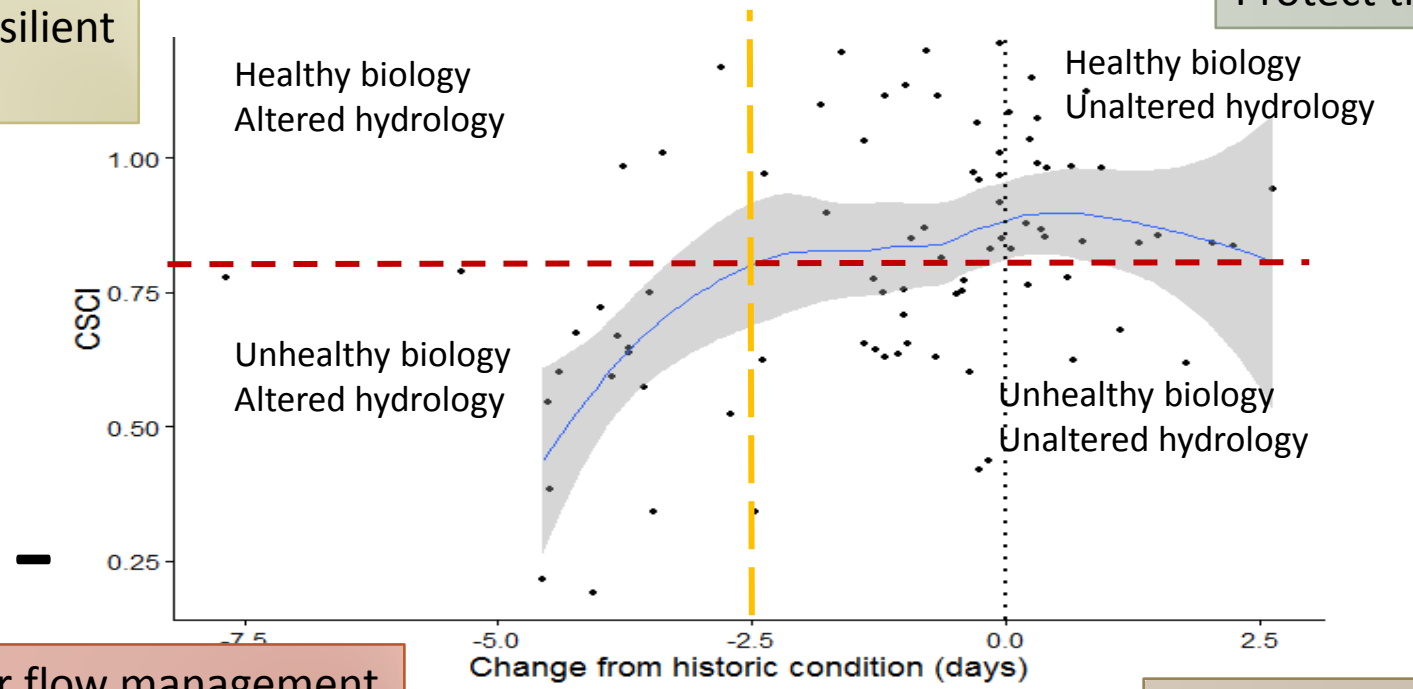




Is flow management likely to help?

Naturally resilient
- monitor

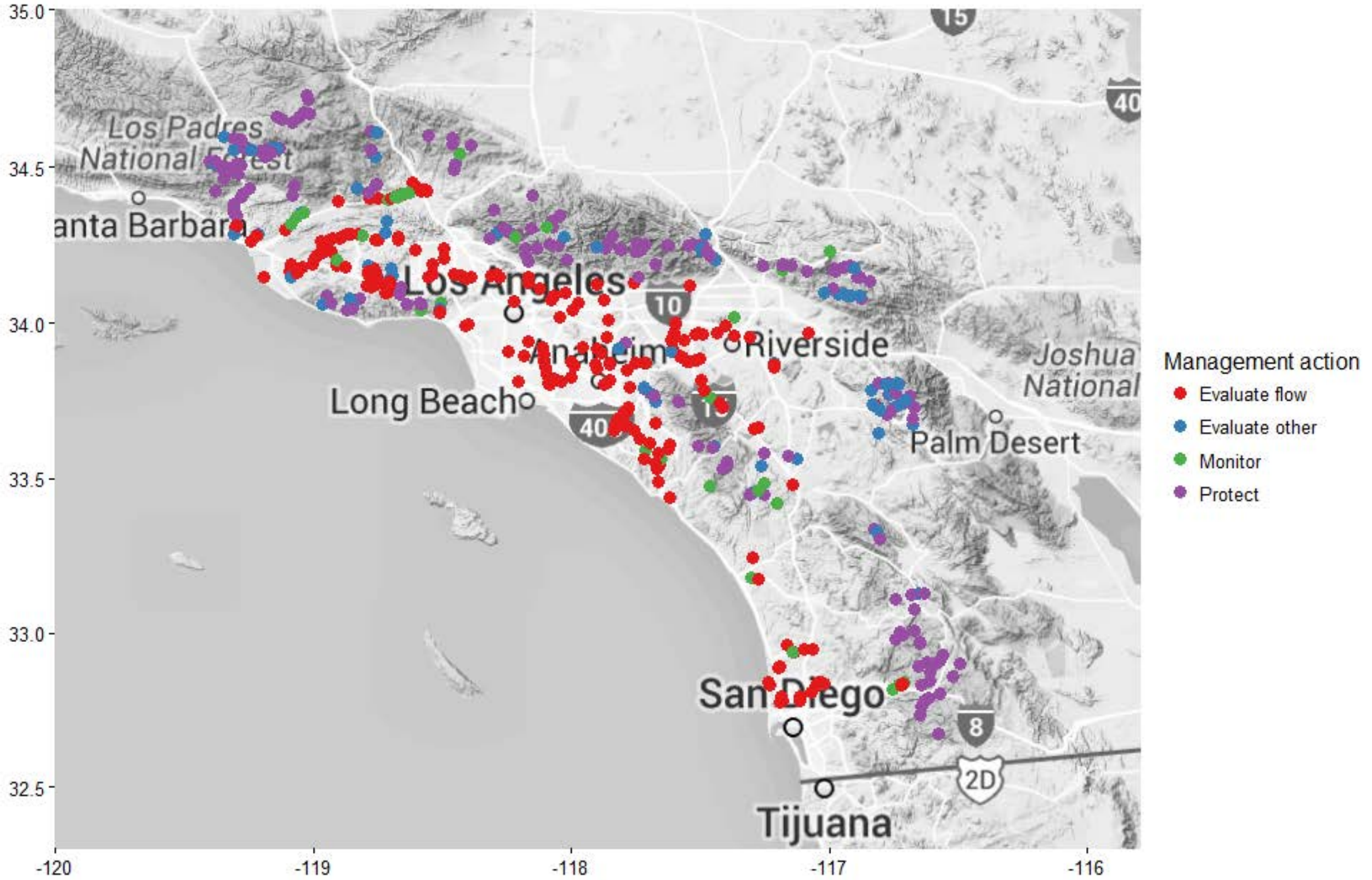
Protect these areas



Priorities for flow management
- Evaluate need for targets

Evaluate other stressors

Different management actions are appropriate for each situation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40
10
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8
2D
Management action
Evaluate flow
Evaluate other
Monitor
Protect

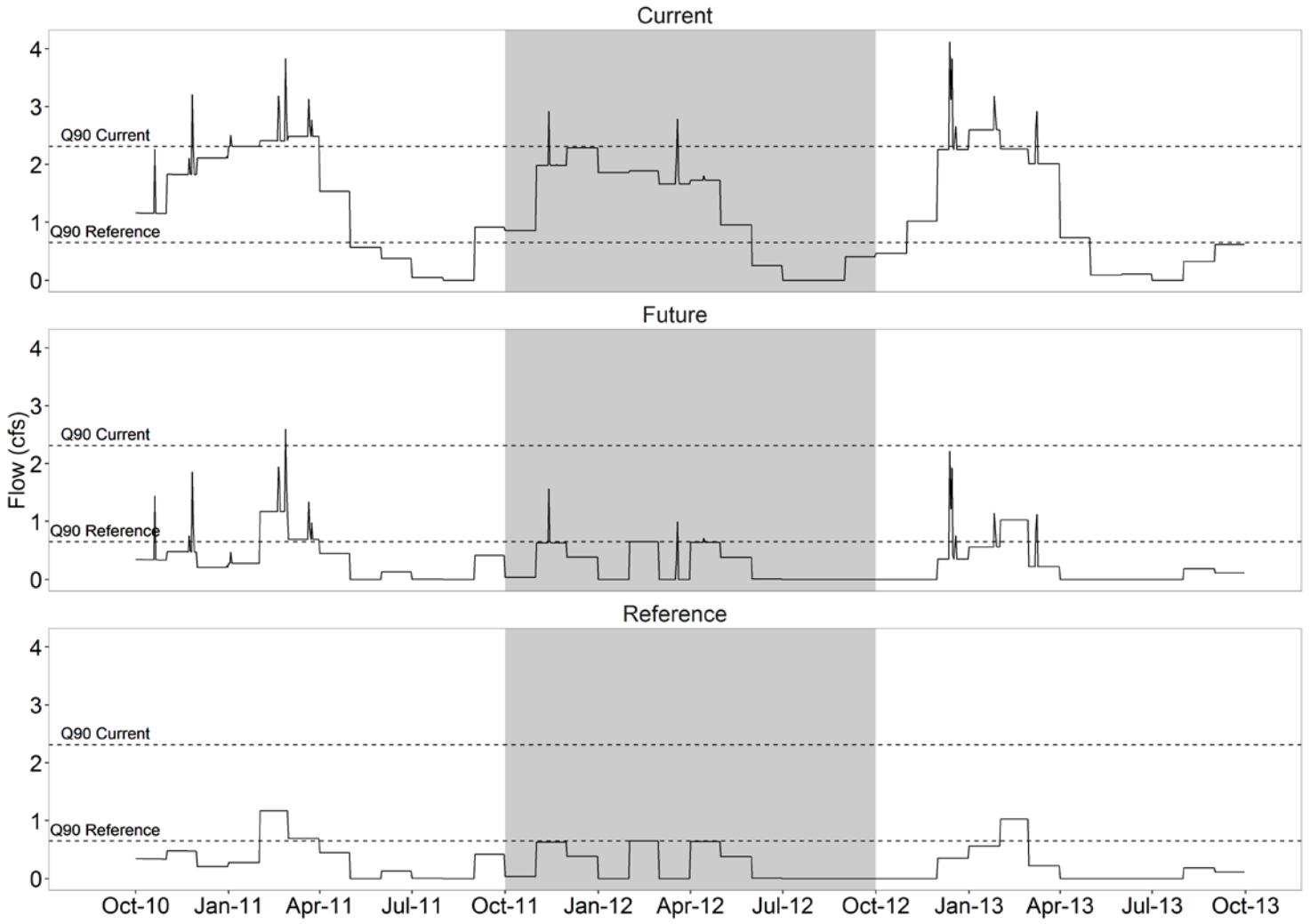
How can this help stream management?

A few examples from San Diego River case study

- Rapid causal assessments
- Forecasting impacts of increased imperviousness
- Assess impacts of increased water reuse/decreased discharge from Santee Lakes
- Determine required flows to improve the health of Alvarado Creek

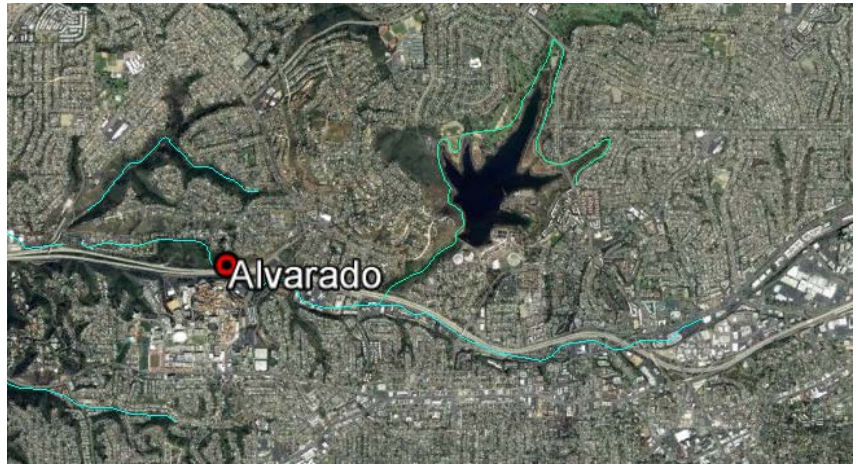
Reducing discharge from Santee restores a more natural hydrograph

Scenario	HighNum (mean #/y)	HighDur (median d/y)
Reference	1.7	28
Current	1.3	212
Future	1.7	28



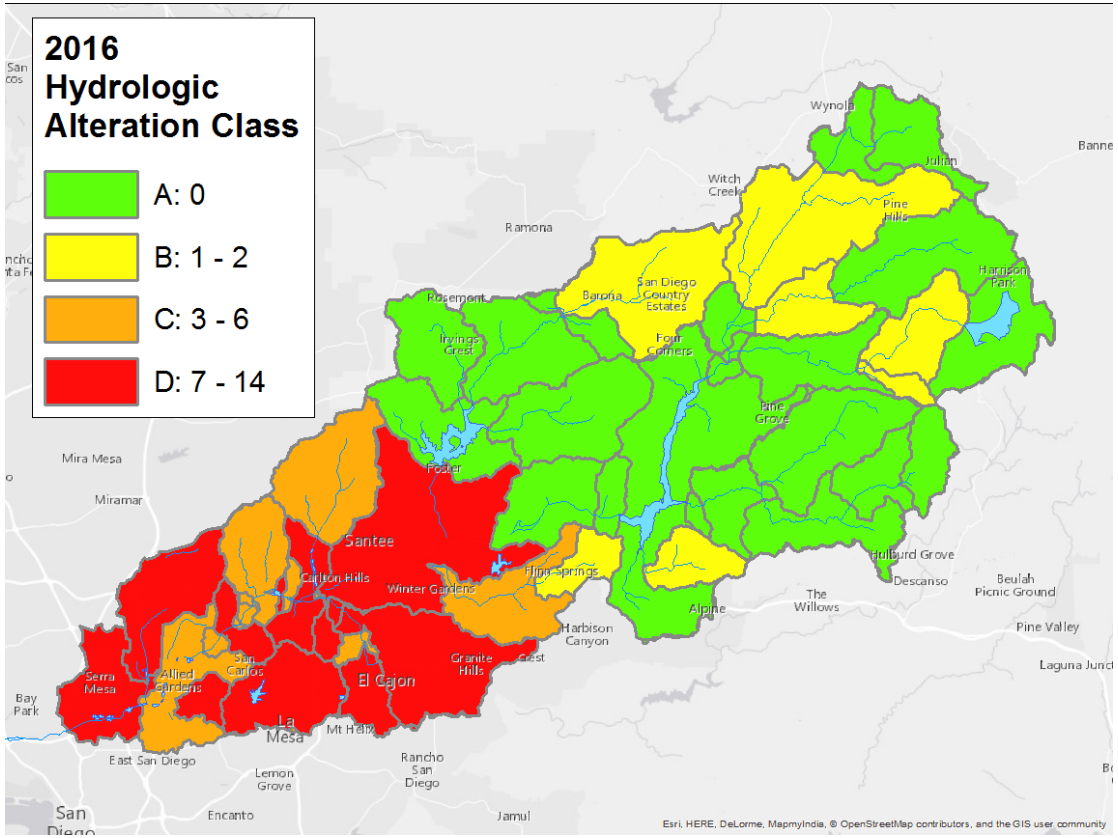
Runoff capture is more effective than reducing impervious cover at restoring healthy flows

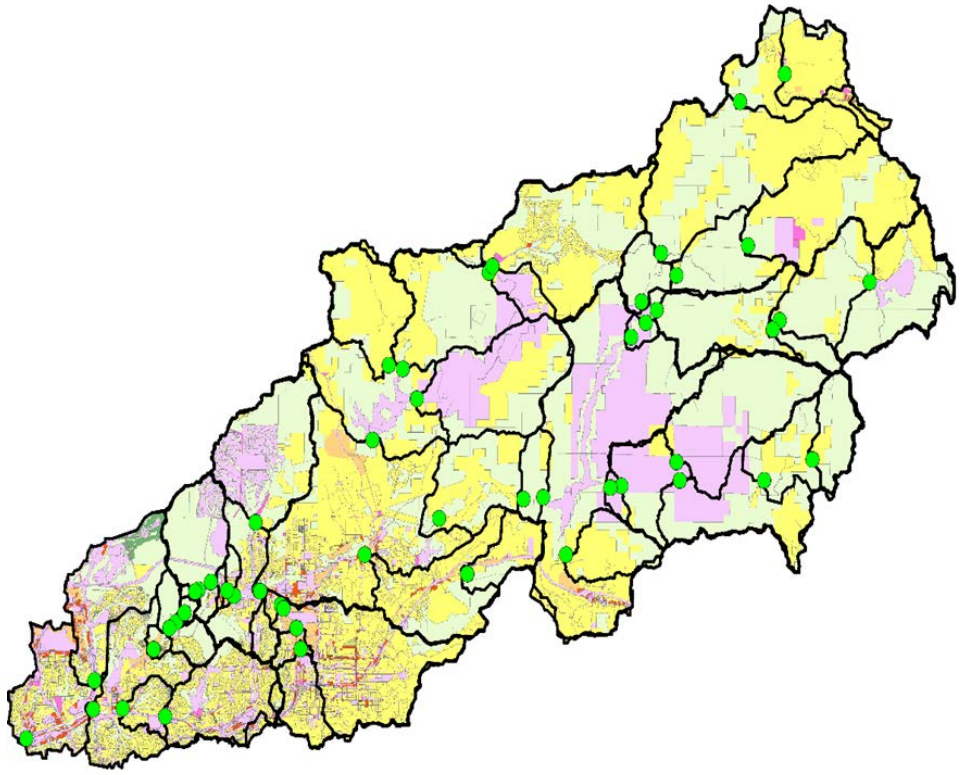
Restoration scenarios at Alvarado Creek



Metric	Current (50% impervious)	25% impervious	10% impervious	Runoff capture (85% of 24-hour storm)	Target
Q99	142	71	69	3	70
Qmean	5.62	2.81	1.12	0.10	0.20

Impacts of planned development

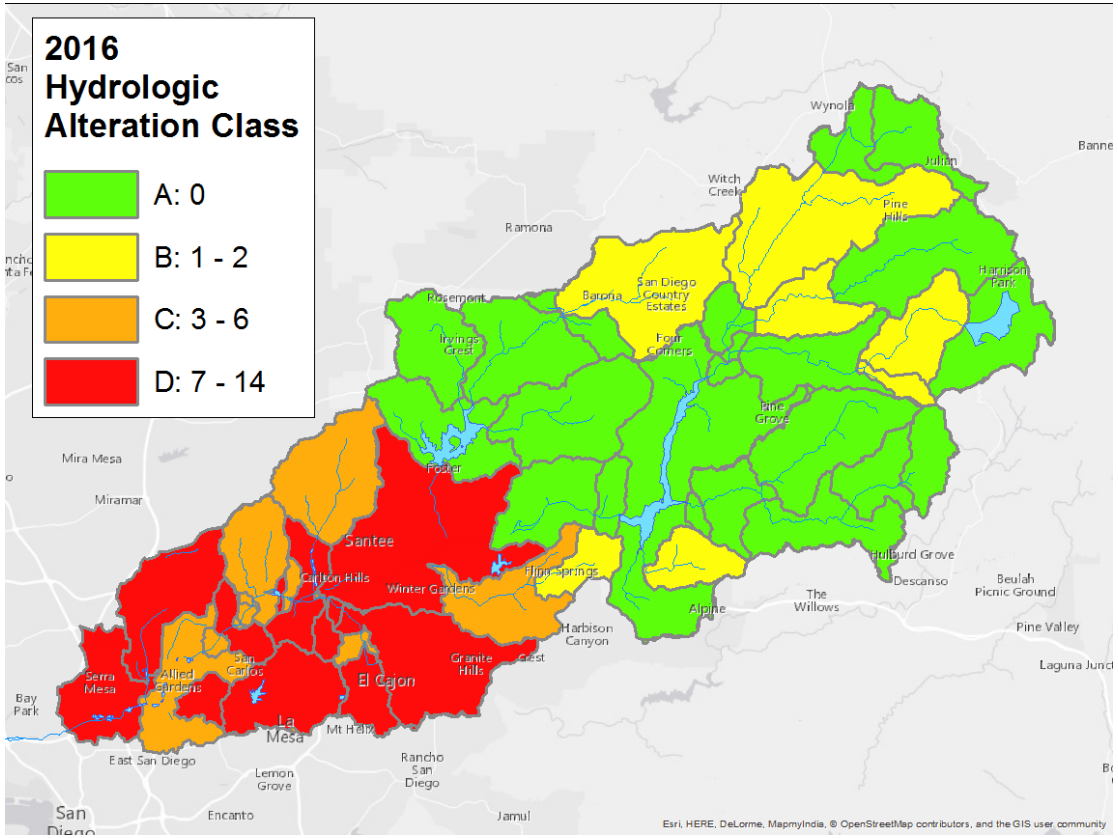




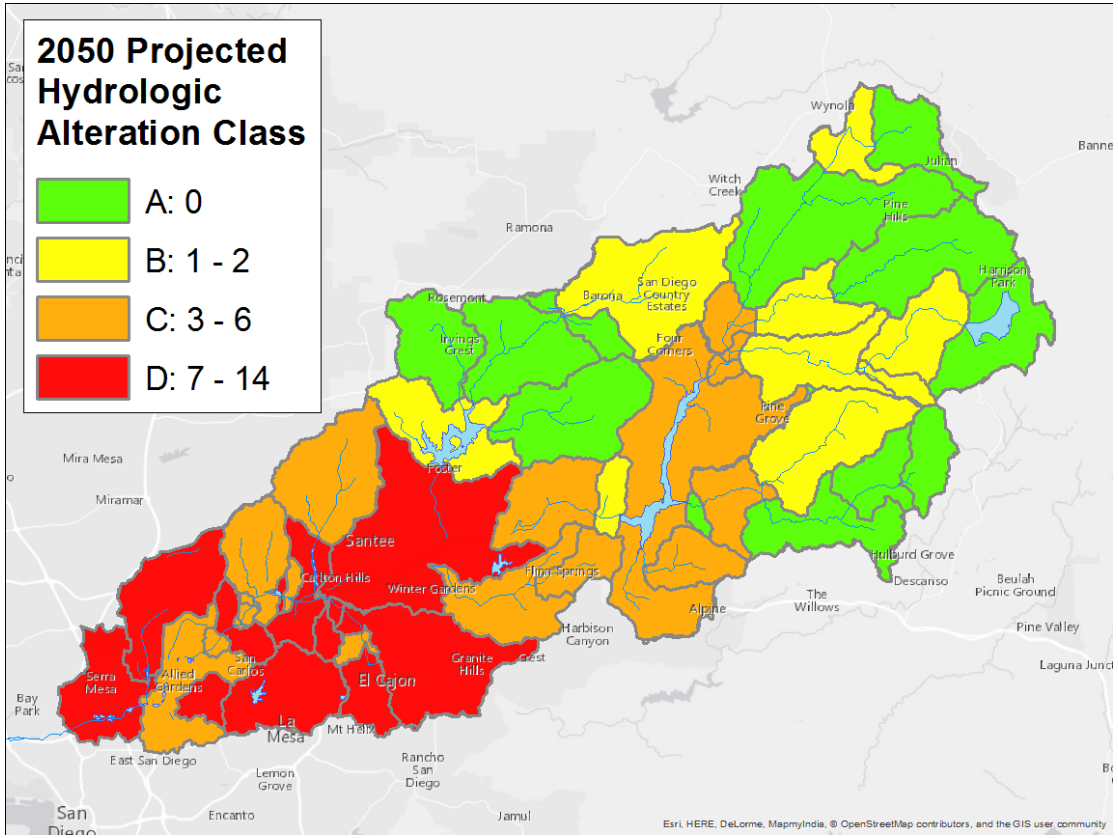
Current

2050

Impacts of planned development



Current



2050

Prioritize vulnerable catchments to protect source waters

Future developments

More sophisticated models (incorporation of groundwater, dam operations, etc.)

Broader biological responses

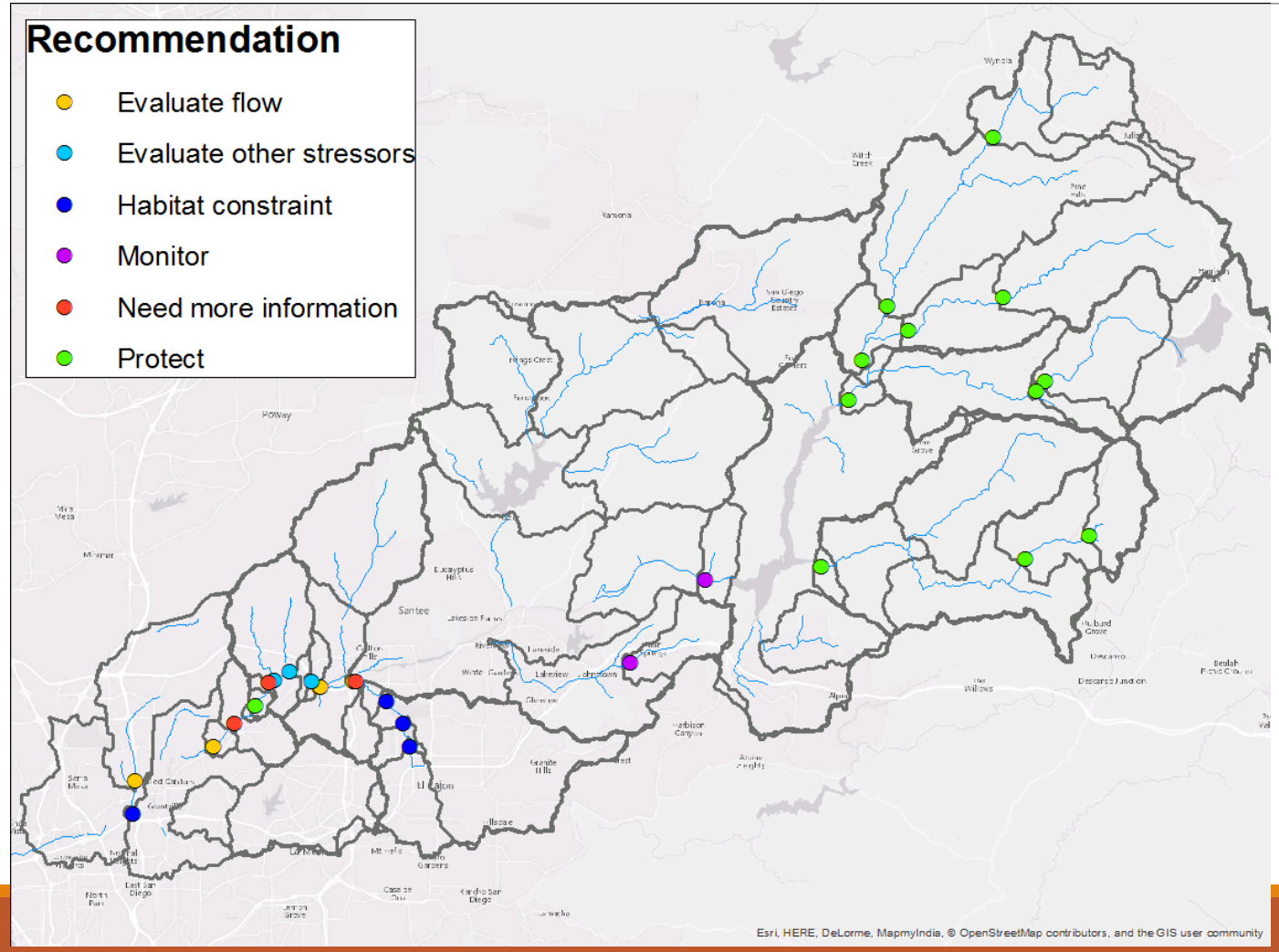
- Algae IBIs
- Processes, like eutrophication, cyanotoxin production
- Vertebrates
- Riparian vegetation

Physical habitat and hydromod responses

Improved causal screening, better recommendations for management actions

Thank you!

Rapid causal assessment screening

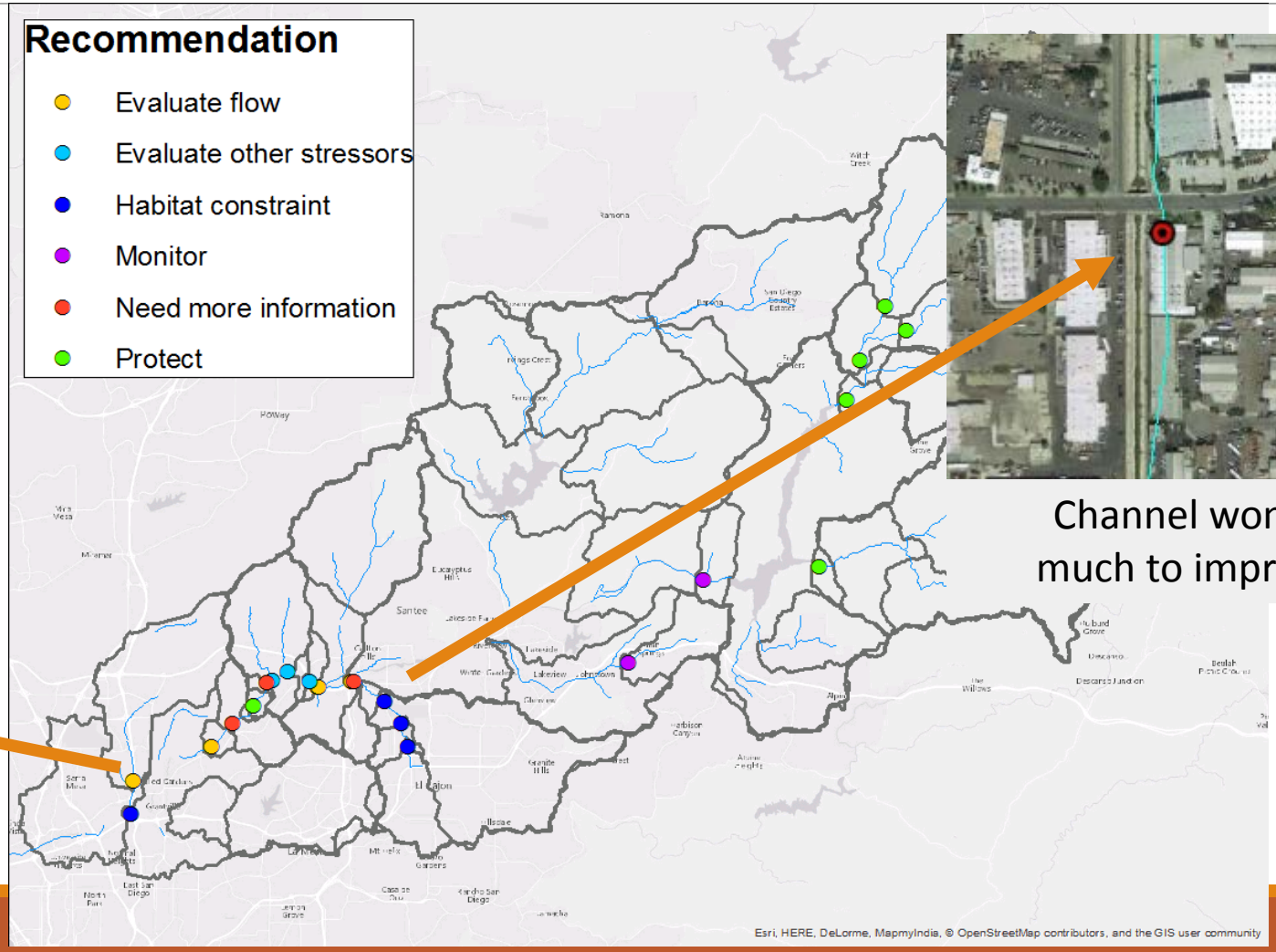


For the “Evaluate flow” sites, will flow management help?

Where do habitat constraints limit options?

Different recommendations for “altered + unhealthy” sites

Flow management could work here



Channel won’t respond much to improved flows

Three challenges

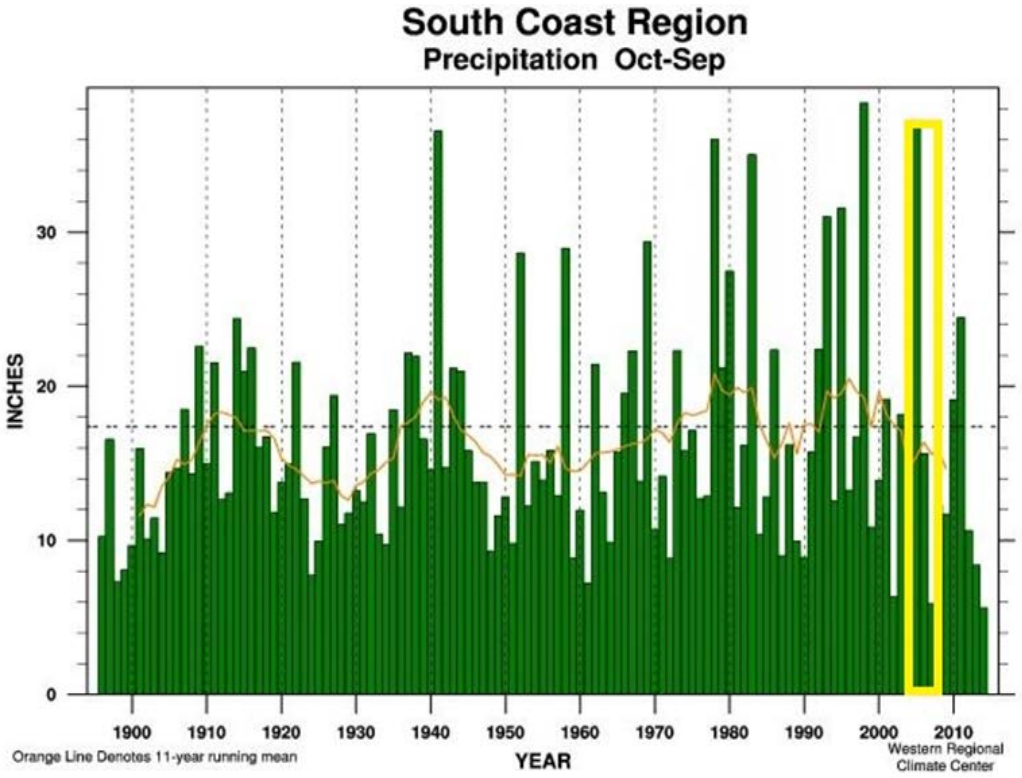
1. Measuring hydrology at ungauged sites
2. Estimating hydrology under historic conditions (or under future management scenarios)
3. Relating measures of hydrologic alteration to biological condition

Building an Ensemble Model

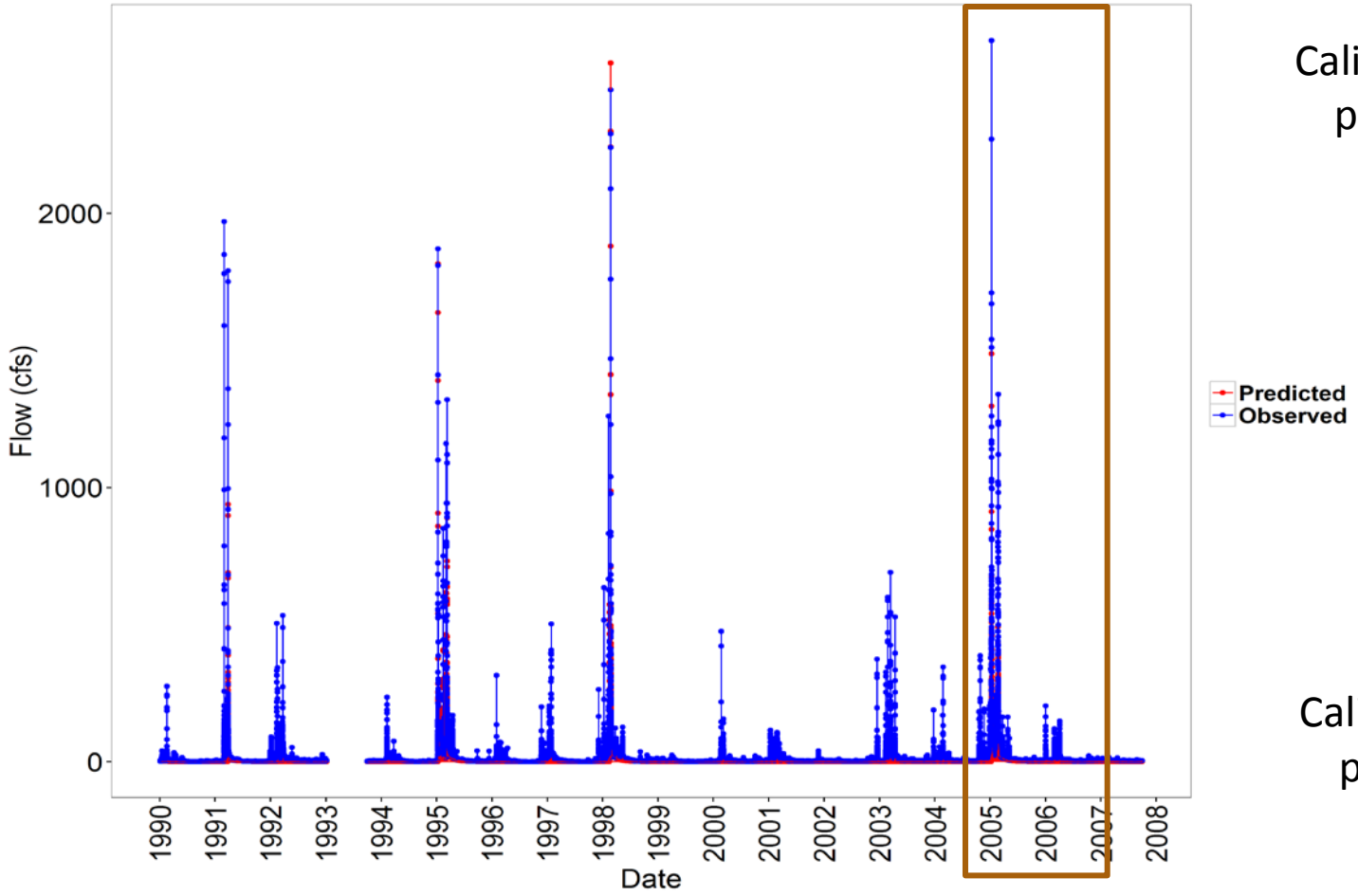
26 gages selected for ensemble

- Catchment area: 1.1 sq.mi – 1500 sq.mi
- Elevation range: 20 ft – 3500 ft
- Imperviousness: 0 – 27%

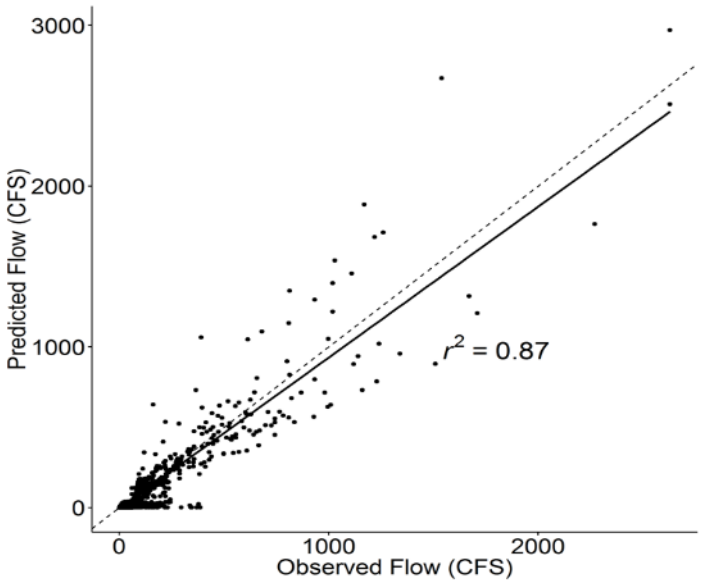
Model period: 3 years (2005-2007)



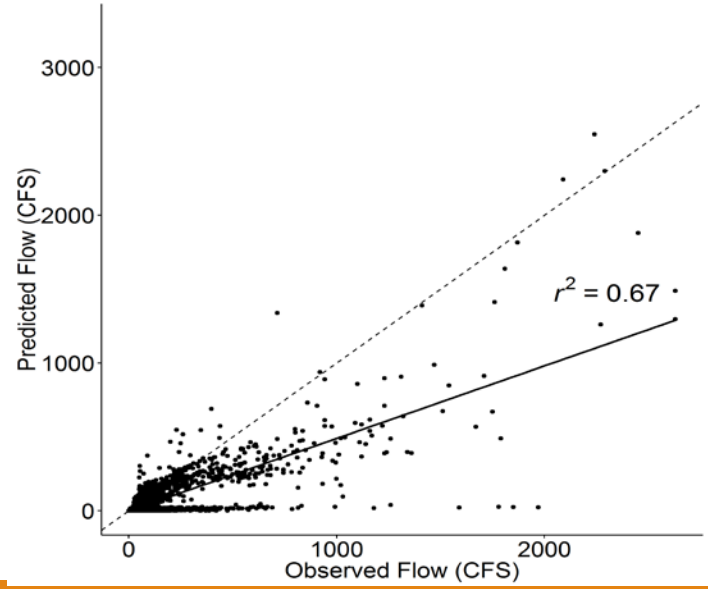
Calibration and Validation at a Gage



Calibration period

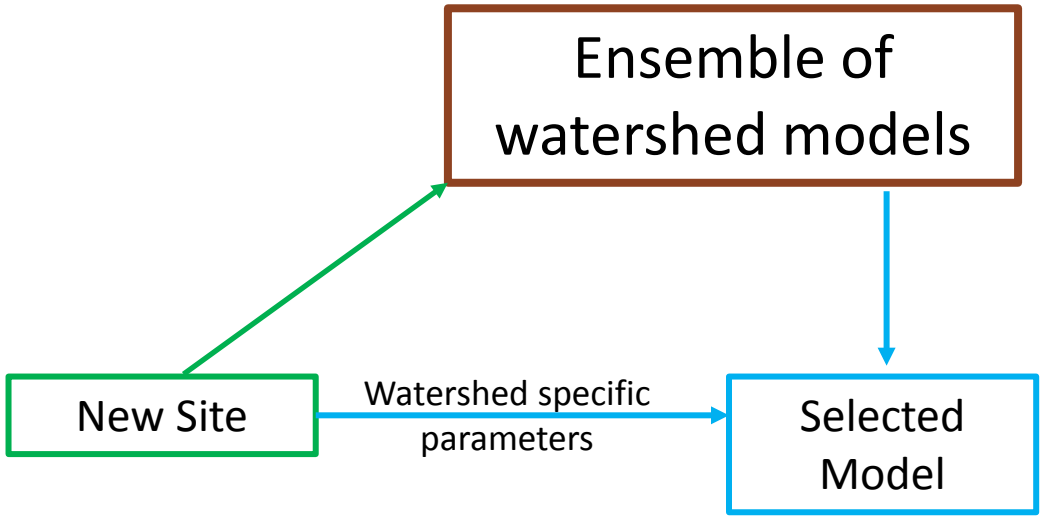


Non Calibration period



Model Selection → Calibration → Validation → Application

How do you assign a model to an ungaged site?



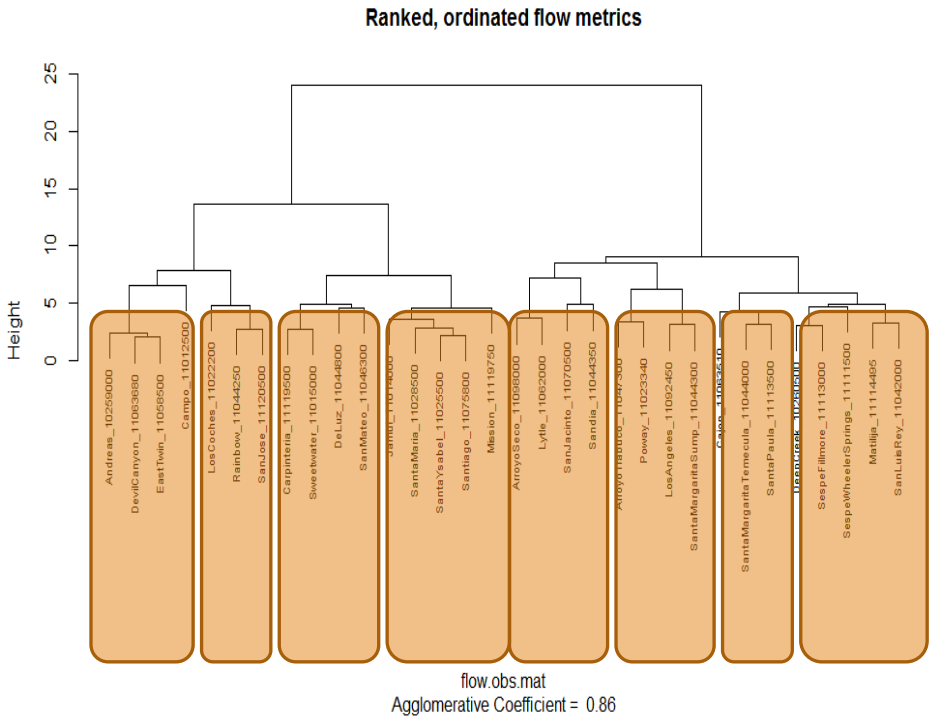
How do you assign a model to an ungaged site?

Cluster gage models

Based on flow metrics

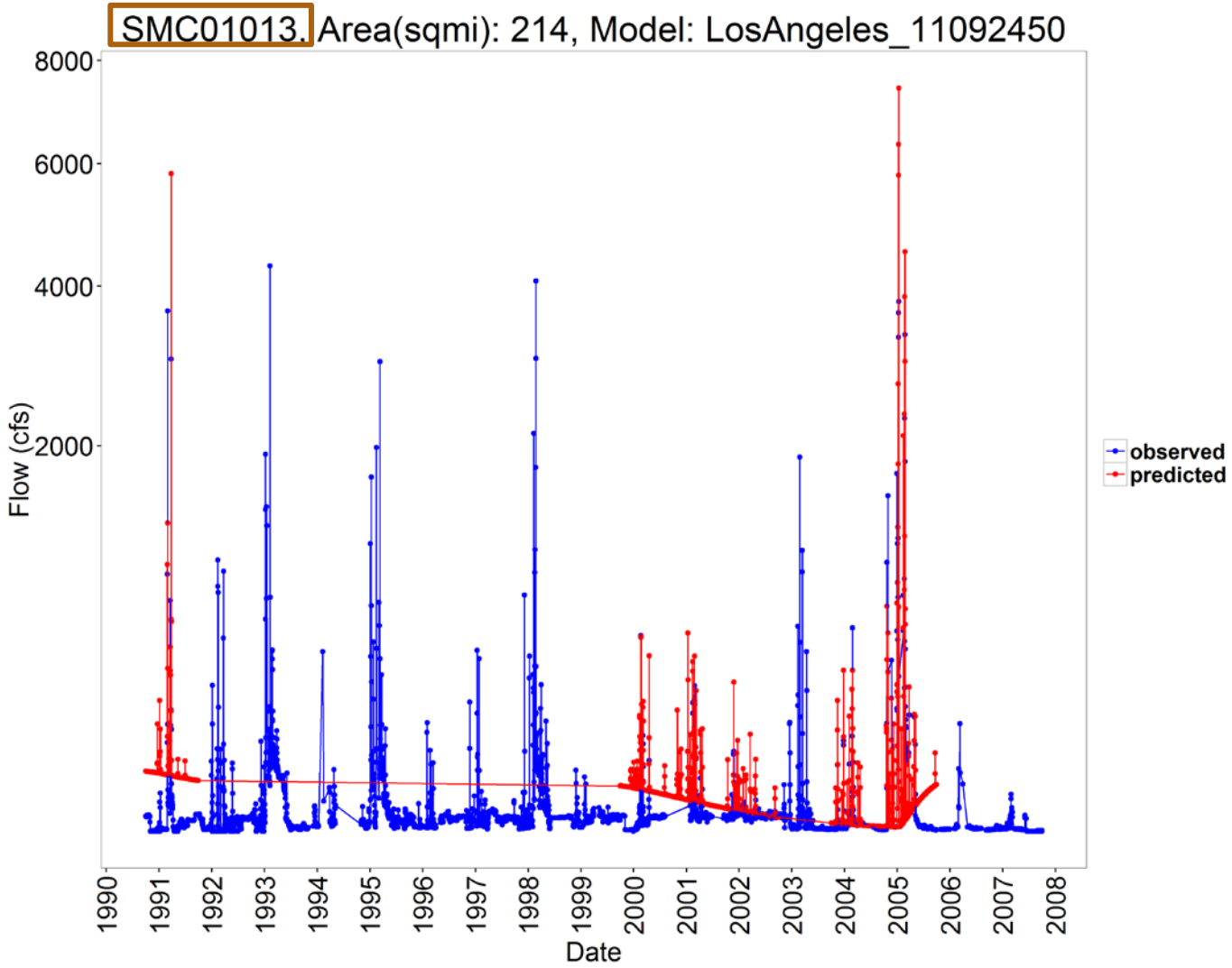
Assign bioassessment sites to a gaged model

- Build Random forest model to predict cluster membership
- Use RF to rank similarity of models to test sites
- Run top matched model to predict current and reference at test site (Delta H)

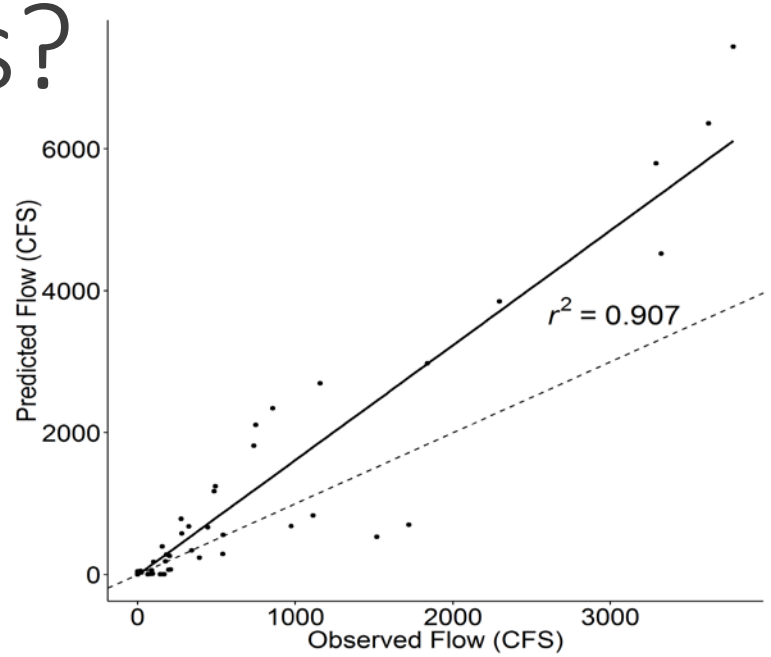


Does it Work for Validation Sites?

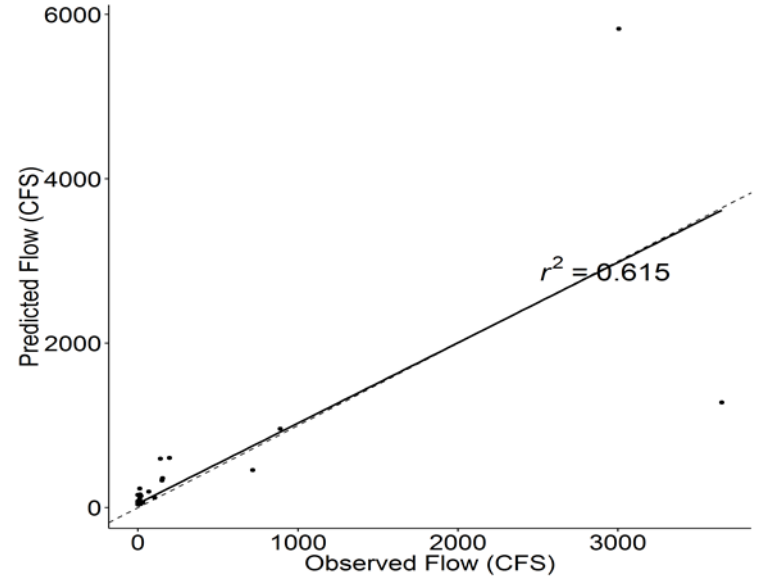
"Ungaged" Site



2004



1991



Where are unaltered streams extensive?

Land Use	% Class A
Ag	20
Open	82
Urban	6

County	% Class A
Ventura	78
LA	38
Orange	6
San Bernardino	73
Riverside	82
San Diego	53