

San Diego Hydrologic Vulnerability Study

SDMMP Meeting – June 23, 2021

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Study Objectives

Evaluate extent of current hydrologic alteration and future risk of hydrologic degradation to streams in the San Diego Regional Board 9 jurisdiction

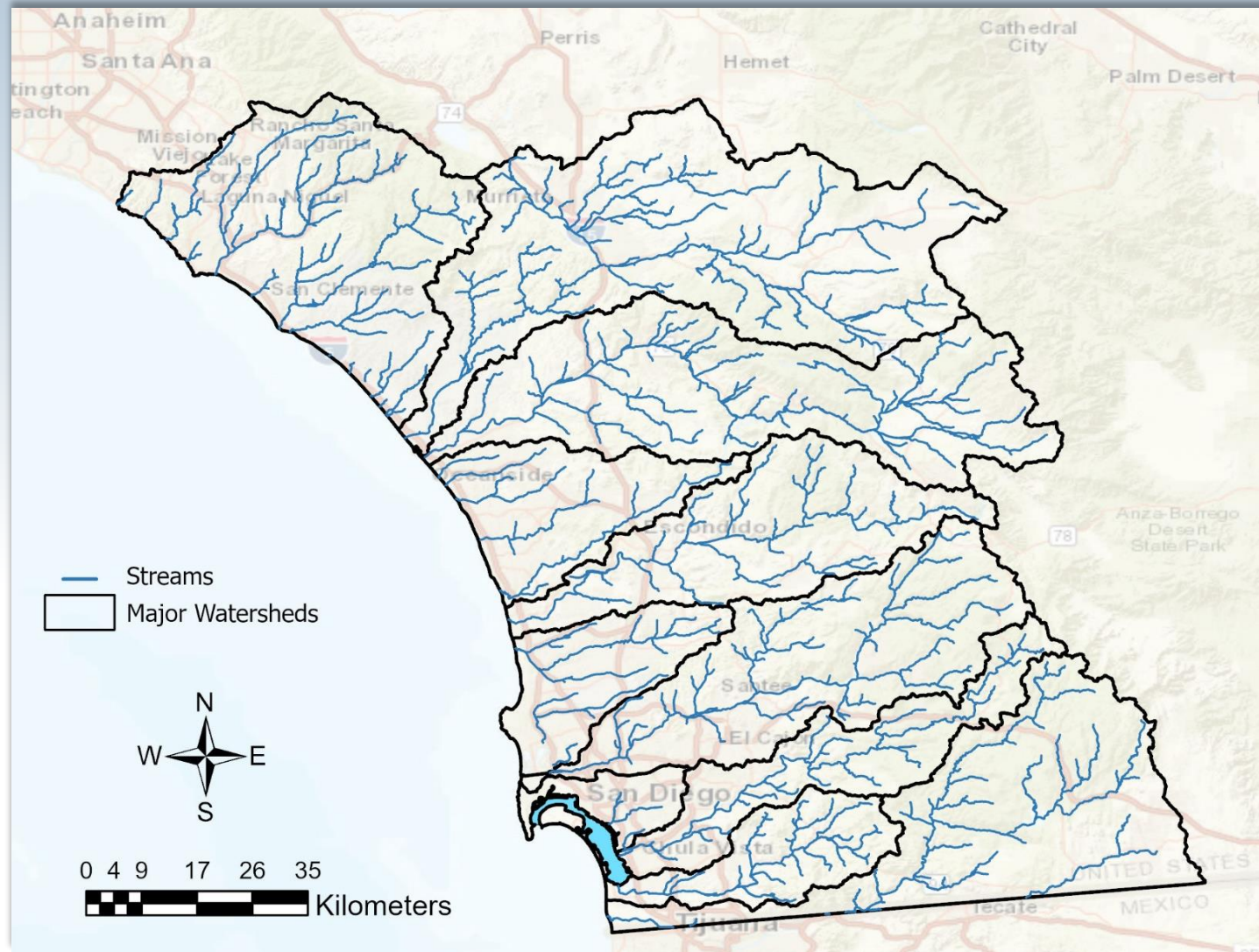
Develop a risk-decision framework to aid in prioritization of stream reaches for protection, restoration, or management actions – focusing on potential effects to aquatic life and riparian condition

Intended Uses and Application

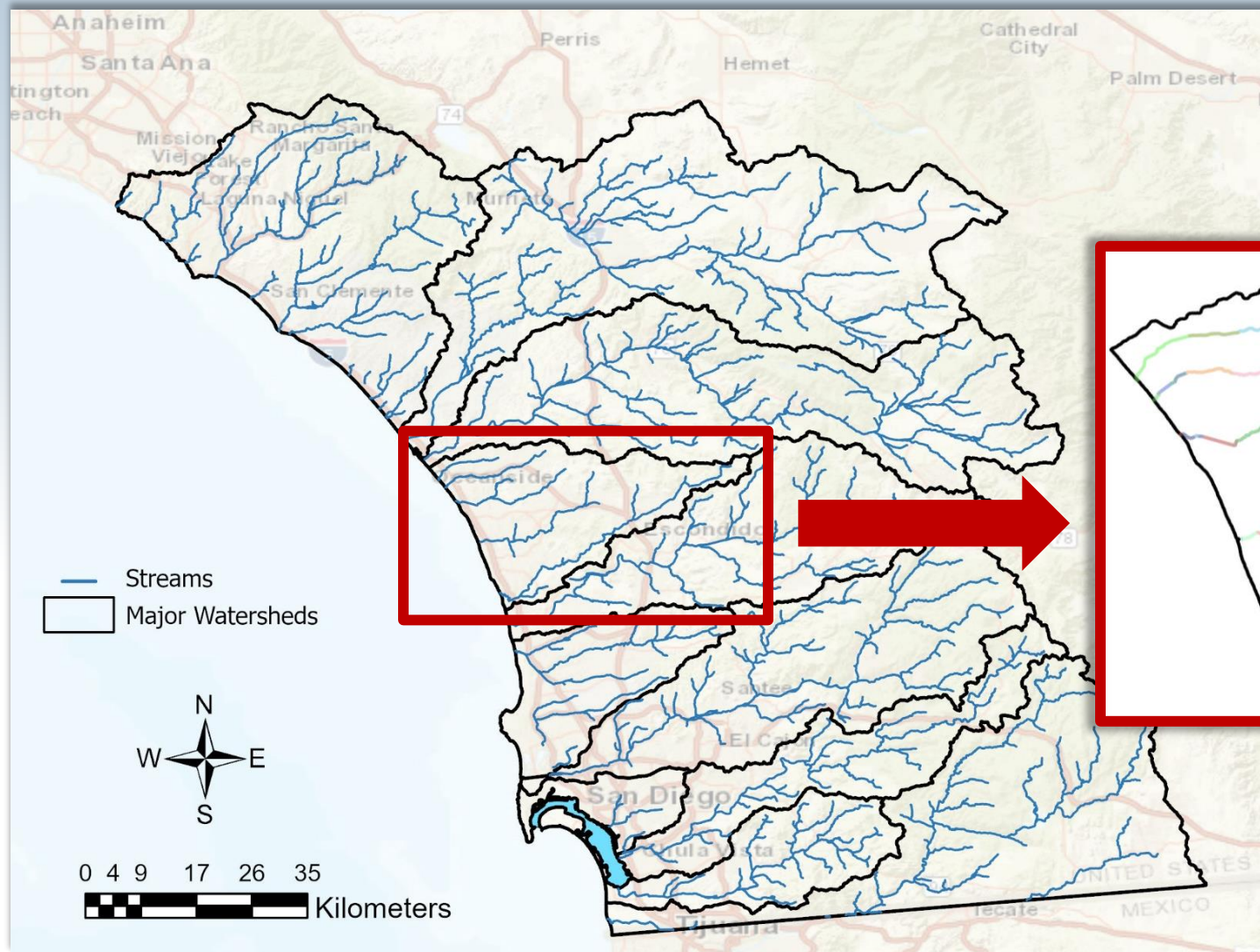
- Evaluate where current and future flow alteration may impact wildlife and sensitive species
- Identify priority areas of management concern and high-quality streams that may be vulnerable to hydrologic change
- Flag areas where additional monitoring and further investigation are of high importance

Study Domain

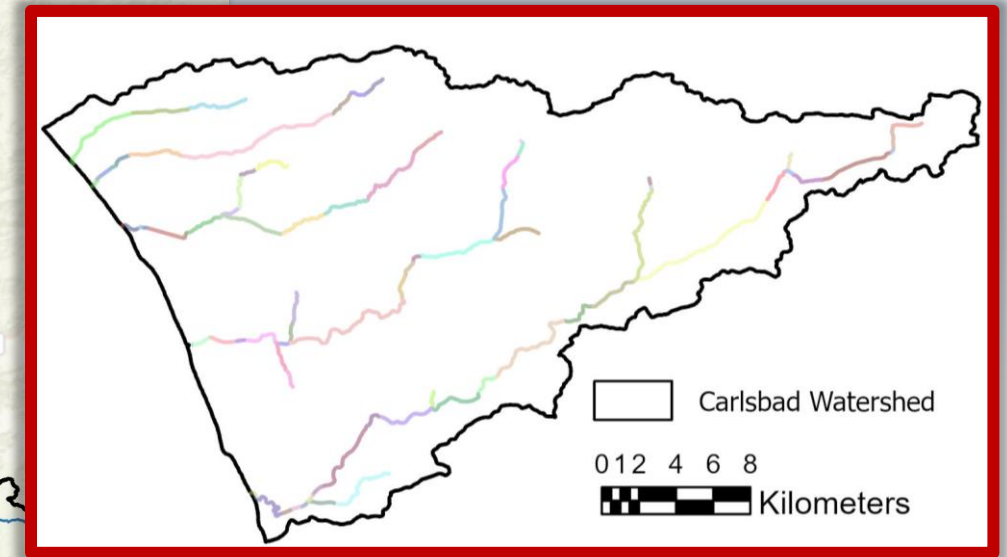
San Diego Regional Board 9



Spatial Resolution



NHD Stream Reach Scale



[USGS National Hydrography Dataset \(NHD\)](#)

Vulnerability Definition

- Probability that biological condition decreases due to hydrologic change beyond a critical threshold
 - Function of:
 - Current conditions
 - Expected future change
 - Resistance of a site
- 
- Proximity to critical threshold

Proposed Tasks

1. Assess current hydrologic alteration
2. Relate hydrologic alteration to biology
3. Predict probability of future change
4. Map vulnerability of hydrologic alteration

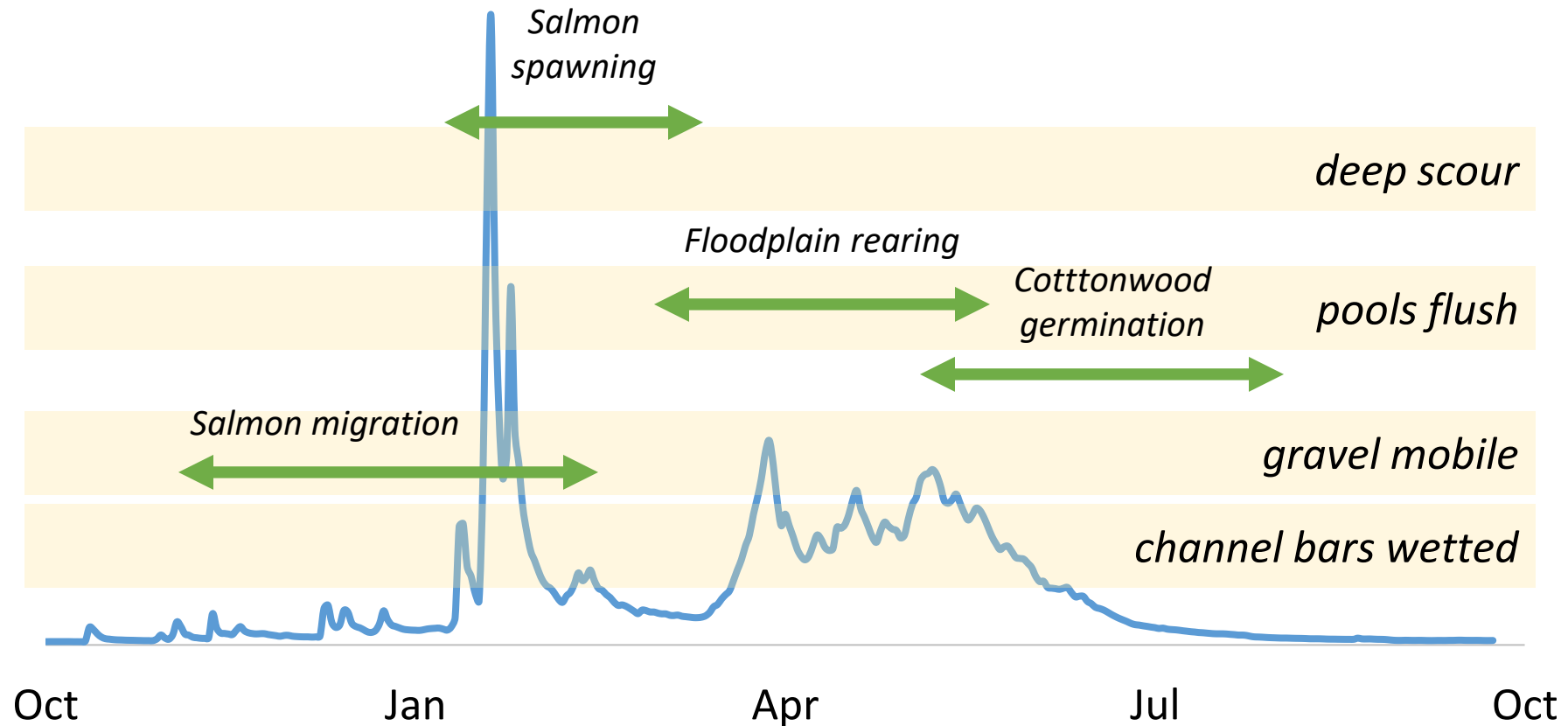
Conceptual Approach

- Evaluating hydrologic alteration through the lens of biology
 - Basing alteration on hydrology, not considering other factors (e.g., water quality, predation, etc.)
- Probabilistic risk-based approach versus deterministic
- Assessing vulnerability using a multi-endpoint analysis
 - Current and potential future conditions
 - Multiple ecological endpoints (i.e., focal species)
- Degree of vulnerability considers inherent sensitivity of system (maybe)
- Vulnerability is not limited to high quality streams

Task 1: Assess Current Hydrologic Alteration

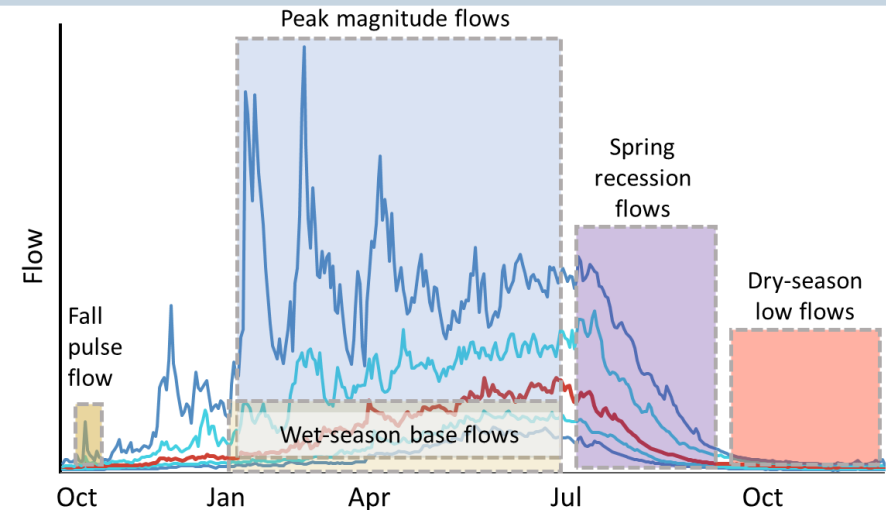
- Model and map current hydrologic alteration relative to expected reference conditions
- Based on functional flow metrics:
 - Key aspects of the annual hydrograph that support biologic and geomorphic functions
- Requires prediction of both reference and current hydrology at all stream reaches (ΔH)

Functional Flows



modified from Yarnell et al. 2010, 2015 *BioScience*

Functional Flow Metrics (FFM)



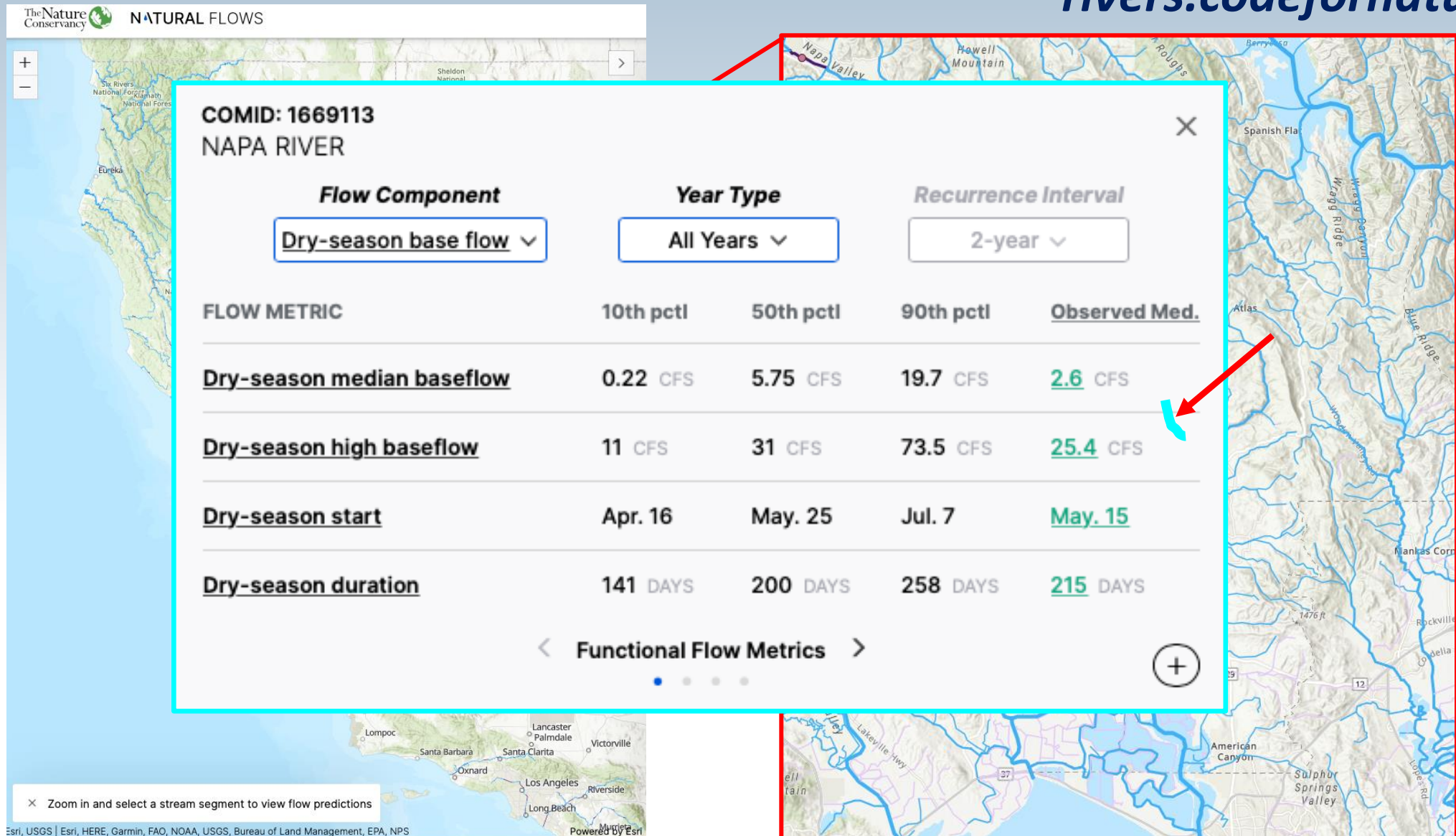
Five functional flow components for CA

Yarnell et al., 2019

Flow Component	Flow Characteristic	Flow Metric
Fall pulse flow	Magnitude (cfs)	Peak magnitude of fall season pulse event (maximum daily peak flow during event)
	Timing (date)	Start date of fall pulse event
	Duration (days)	Duration of fall pulse event (# of days start-end)
Wet-season base flows	Magnitude (cfs)	Magnitude of wet season baseflows (10th and 50th percentile of daily flows within that season, including peak flow events)
	Timing (date)	Start date of wet season
	Duration (days)	Wet season baseflow duration (# of days from start of wet season to start of spring season)
Peak flow	Magnitude (cfs)	Peak-flow magnitude (50%, 20%, 10% exceedance values of annual peak flow --> 2, 5, and 10 year recurrence intervals)
	Duration (days)	Duration of peak flows over wet season (cumulative number of days in which a given peak-flow recurrence interval is exceeded in a year).
	Frequency	Frequency of peak flow events over wet season (number of times in which a given peak-flow recurrence interval is exceeded in a year).
Spring recession flows	Magnitude (cfs)	Spring peak magnitude (daily flow on start date of spring-flow period)
	Timing (date)	Start date of spring (date)
	Duration (days)	Spring flow recession duration (# of days from start of spring to start of summer base flow period)
	Rate of change (%)	Spring flow recession rate (Percent decrease per day over spring recession period)
Dry-season base flows	Magnitude (cfs)	Base flow magnitude (50th and 90th percentile of daily flow within summer season, calculated on an annual basis)
	Timing (date)	Summer timing (start date of summer)
	Duration (days)	Summer flow duration (# of days from start of summer to start of wet season)

Natural Flows Database (modeled natural FFM)

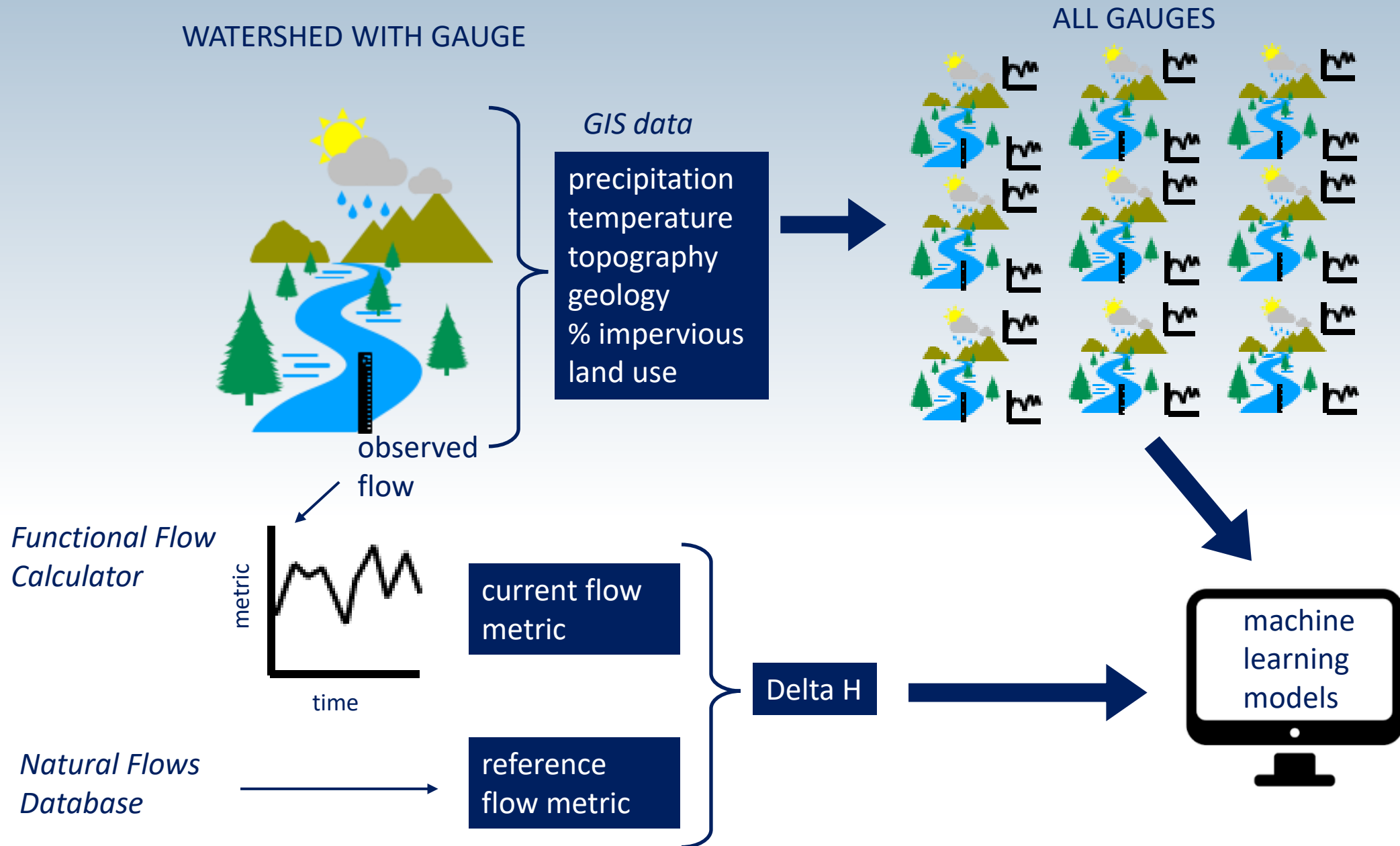
rivers.codefornature.org



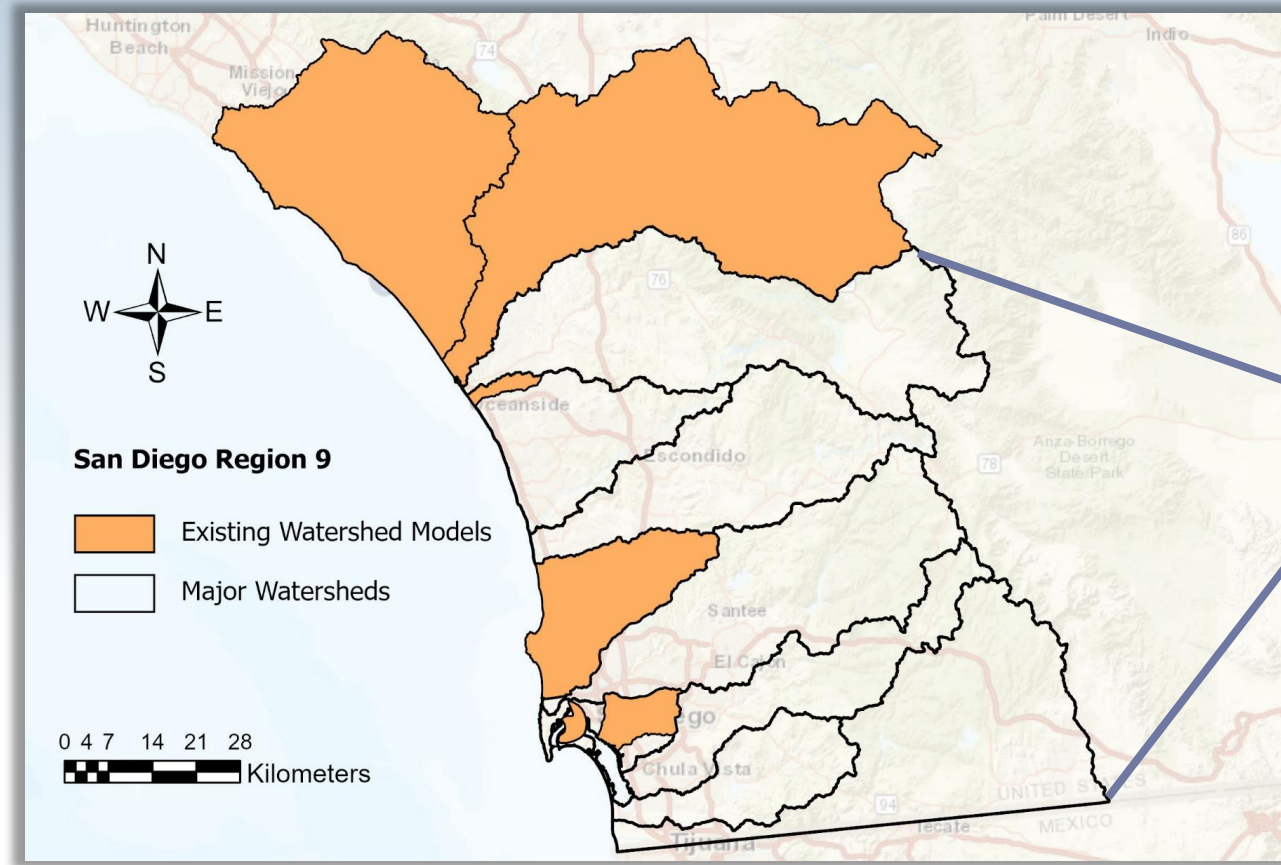
Model Current Hydrology

- Model current FFM and alteration for all stream reaches in the region
 - *Challenge: predictions in ungauged, urban watersheds*
- Approaches we are exploring:
 1. Random forest model: predict Delta H in functional flow metrics based on watershed characteristics and climate (SDSU, Hilary McMillan)
 2. Logistic regression: predict probability of alteration of functional flow metrics (for watersheds with high uncertainty using approach 1)

Random Forest Approach



Validating using Observed Data and Existing Watershed Models



**Existing Models
or Data?**

Existing watershed models and/or hydrologic data that we could leverage?

Task 2: Relate Hydrologic Alteration to Biology

- Assess hydrologic alteration relative to:
 - Bioassessment indicators for bugs and algae (CSCI & ASCI)
 - Focal species of management concern (future TAG meeting)
- What are the alteration thresholds that determine effects on biology?

Bioassessment Indices

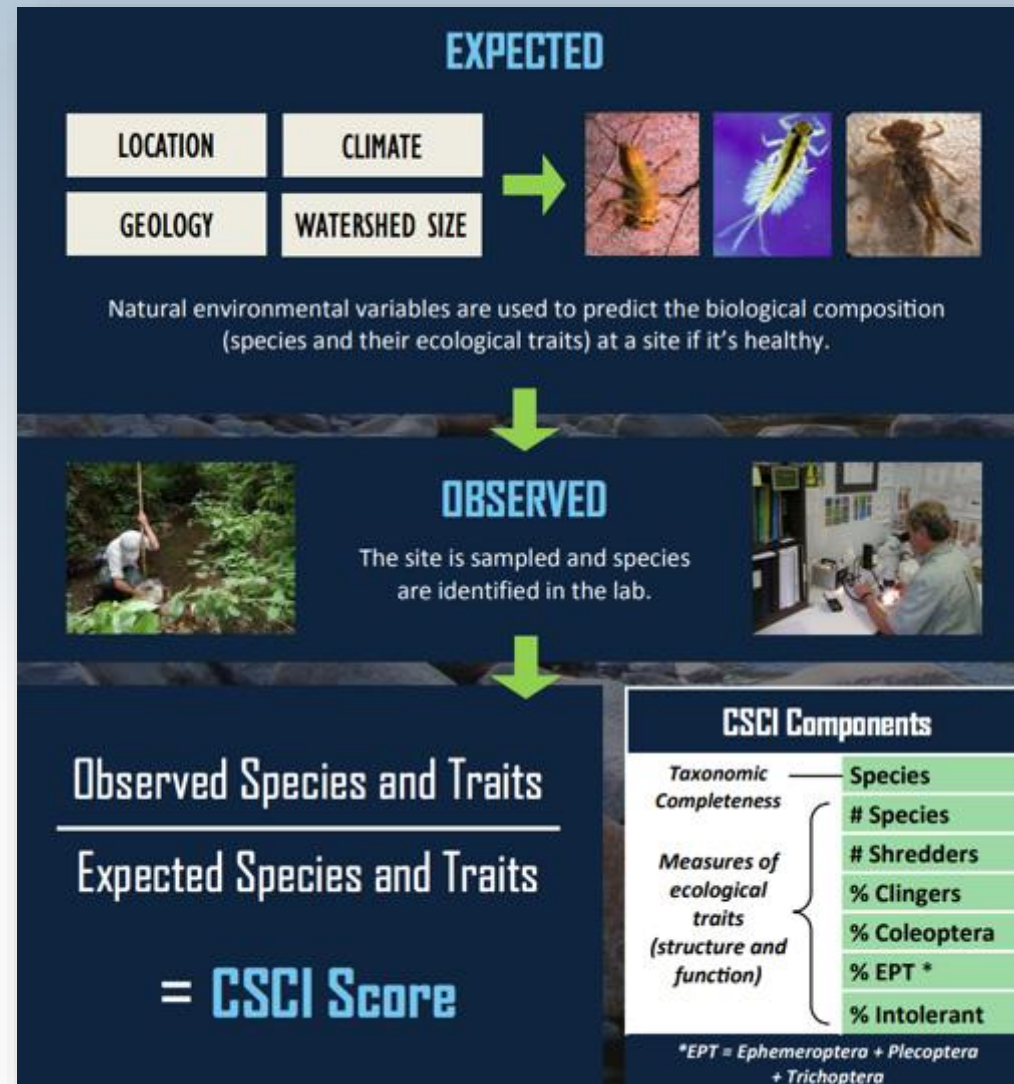
Determine reference expectations



Compare to observed



Determine index score



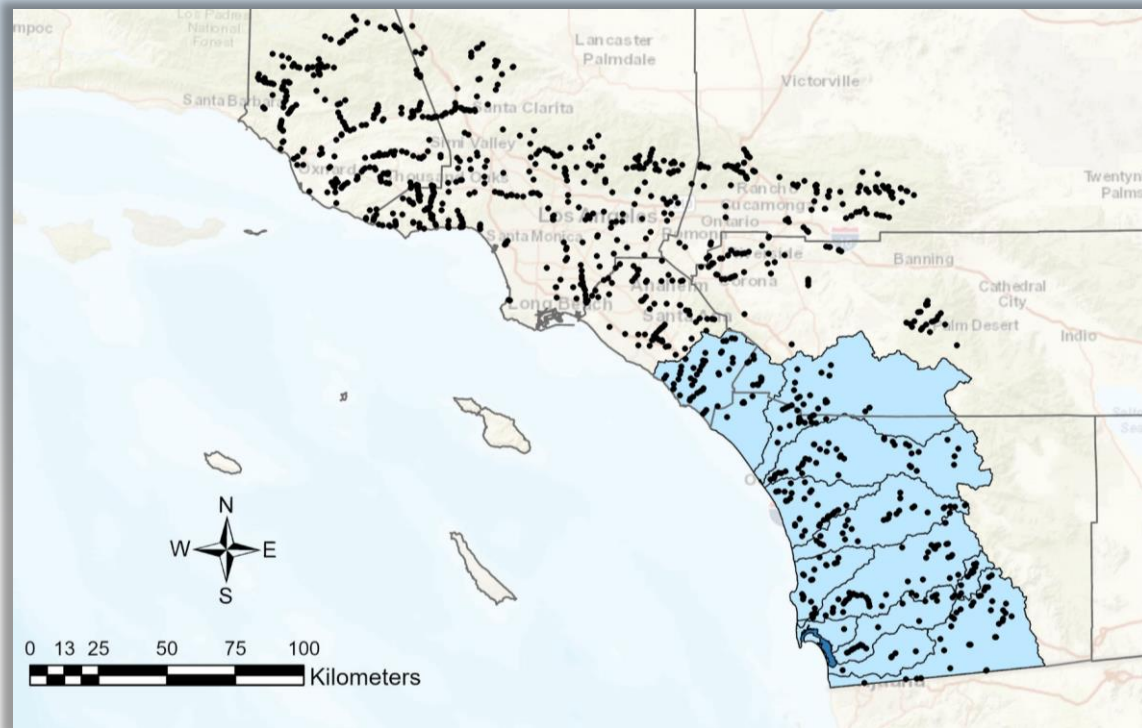
CA Stream Condition Index (CSCI)



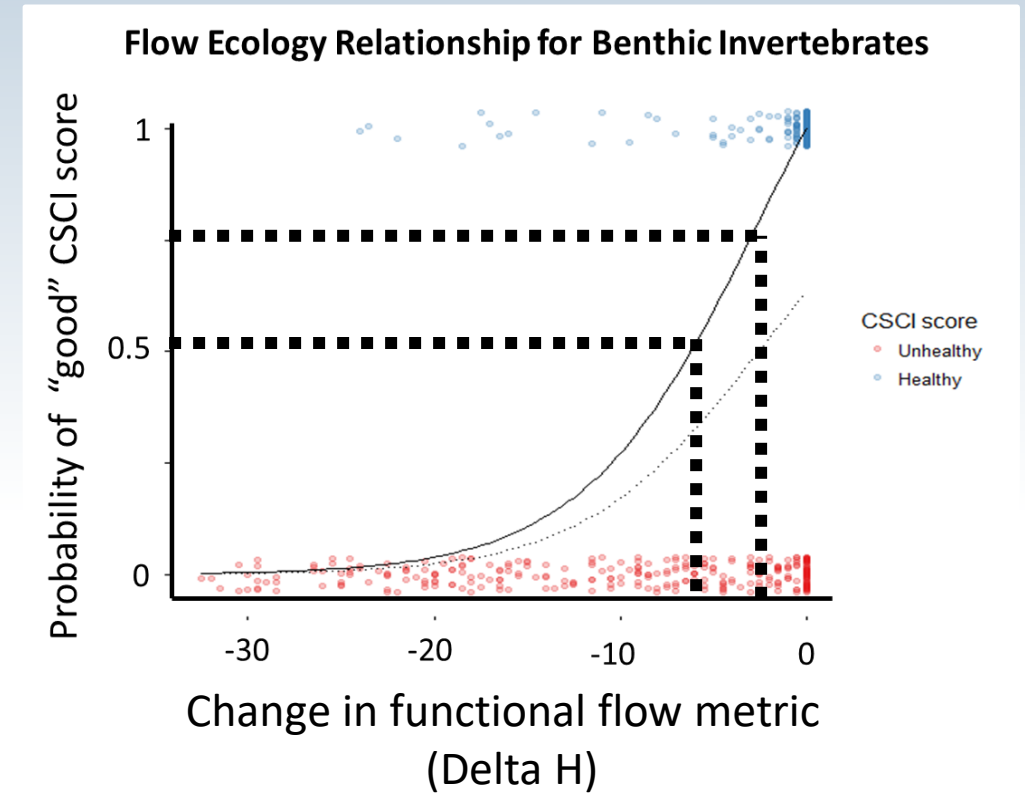
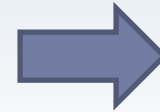
Algal Stream Condition Index (ASCI)



Alteration Based on Bioassessment Indicators



Southern CA Bioassessment Sites



Focal Species of Management Concern



Arroyo Chub



Western Pond Turtle



Black Crowned Night Heron



Tricolored Blackbird



Arroyo Toad



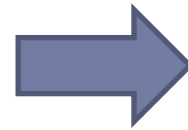
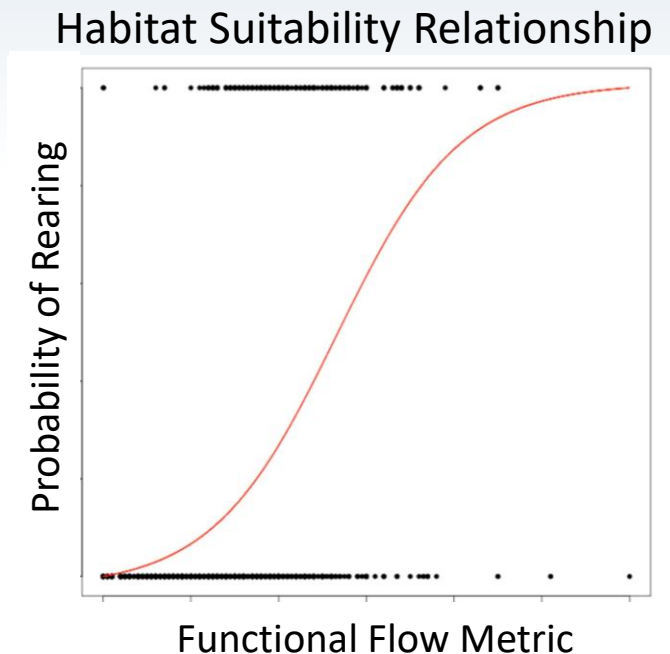
Least Bell's Vireo

What we are Considering

- Changes in flow due to:
 - Changing discharges, climate, and land use
- We are **NOT** considering:
 - Changes in temperature, habitat, groundwater

Alteration Based on Focal Species

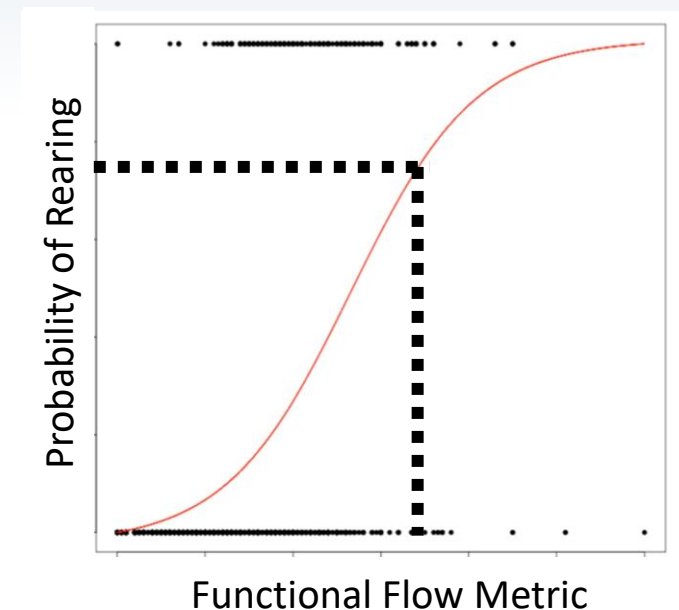
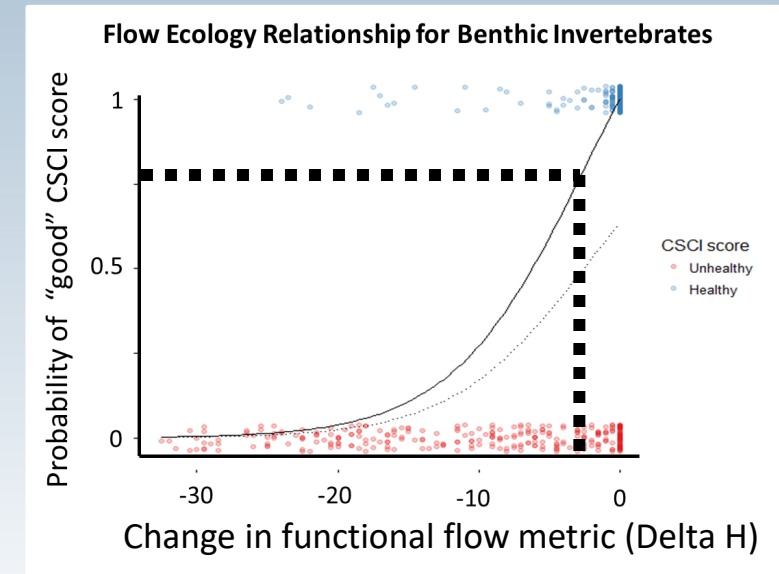
- Map current known species occurrence and habitats across region
- Select focal species of management concern
- Develop or refine existing ecological response models



- Determine optimal flow range for focal species
- Evaluate current or future alteration impacts on focal species suitability

Determine Critical Thresholds of Alteration

- Flow thresholds for multiple endpoints
 - Probability based
- Evaluate where flow alteration is likely affecting aquatic life beneficial use



Task 3: Predict Probability of Future Change

Use models to predict probability of future changes in flow and potential impacts to biology

- What future changes should we evaluate?
 - Climate change projections
 - Projected land use changes
 - Other scenarios?

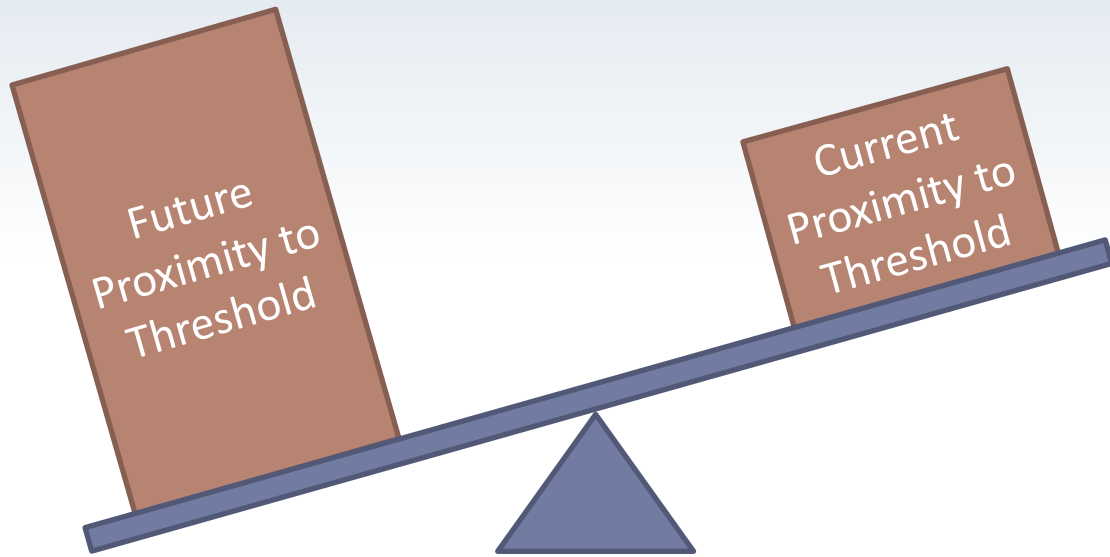
Task 4: Map Vulnerability of Hydrologic Alteration in Consideration of Sensitivity

- Define vulnerability and develop vulnerability framework
 - Based on current (Task 1, 2) and future (Task 3) conditions
- Quantify and map vulnerability across region

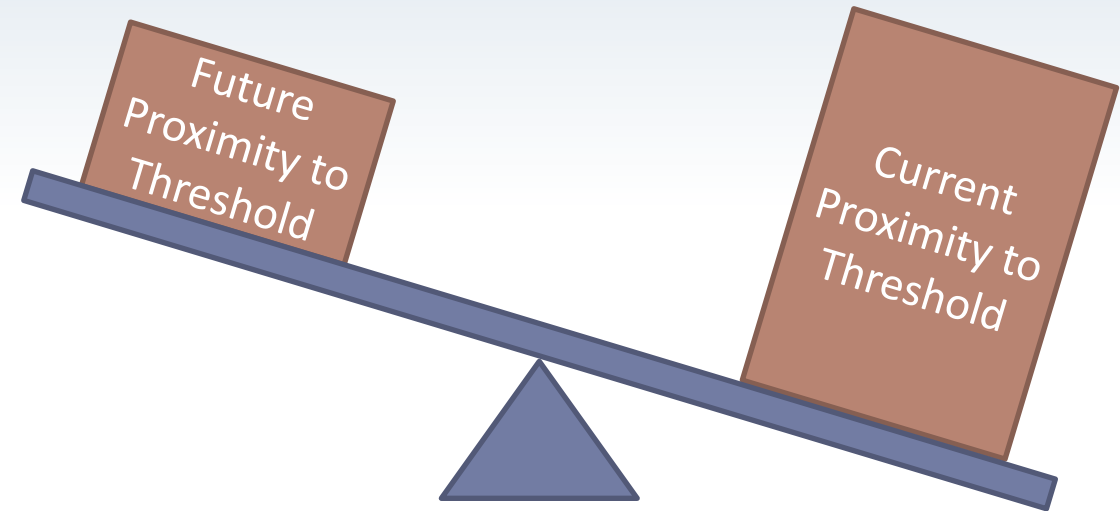
Challenge: how to integrate Task 1-3 to get overall vulnerability score?

Vulnerability Based on Proximity to Thresholds

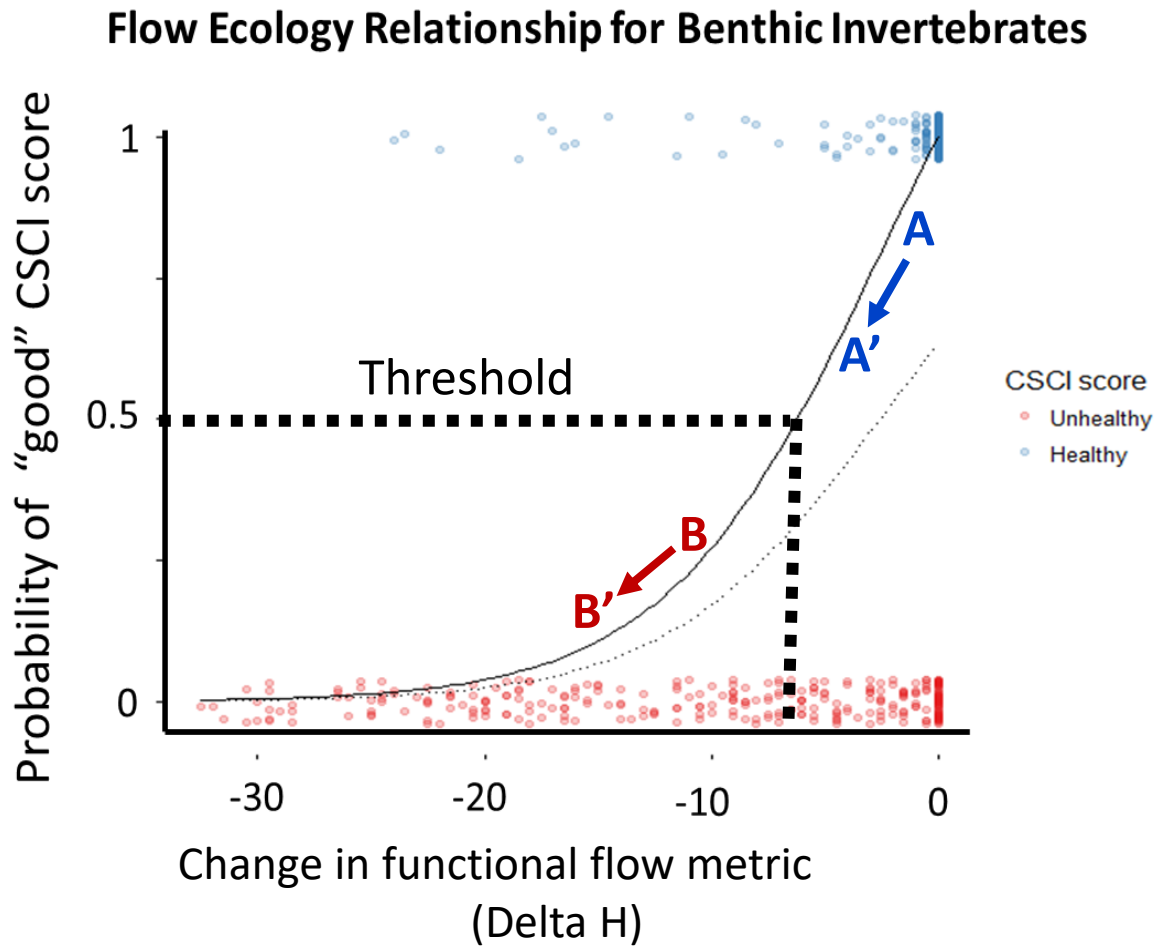
- Vulnerability +



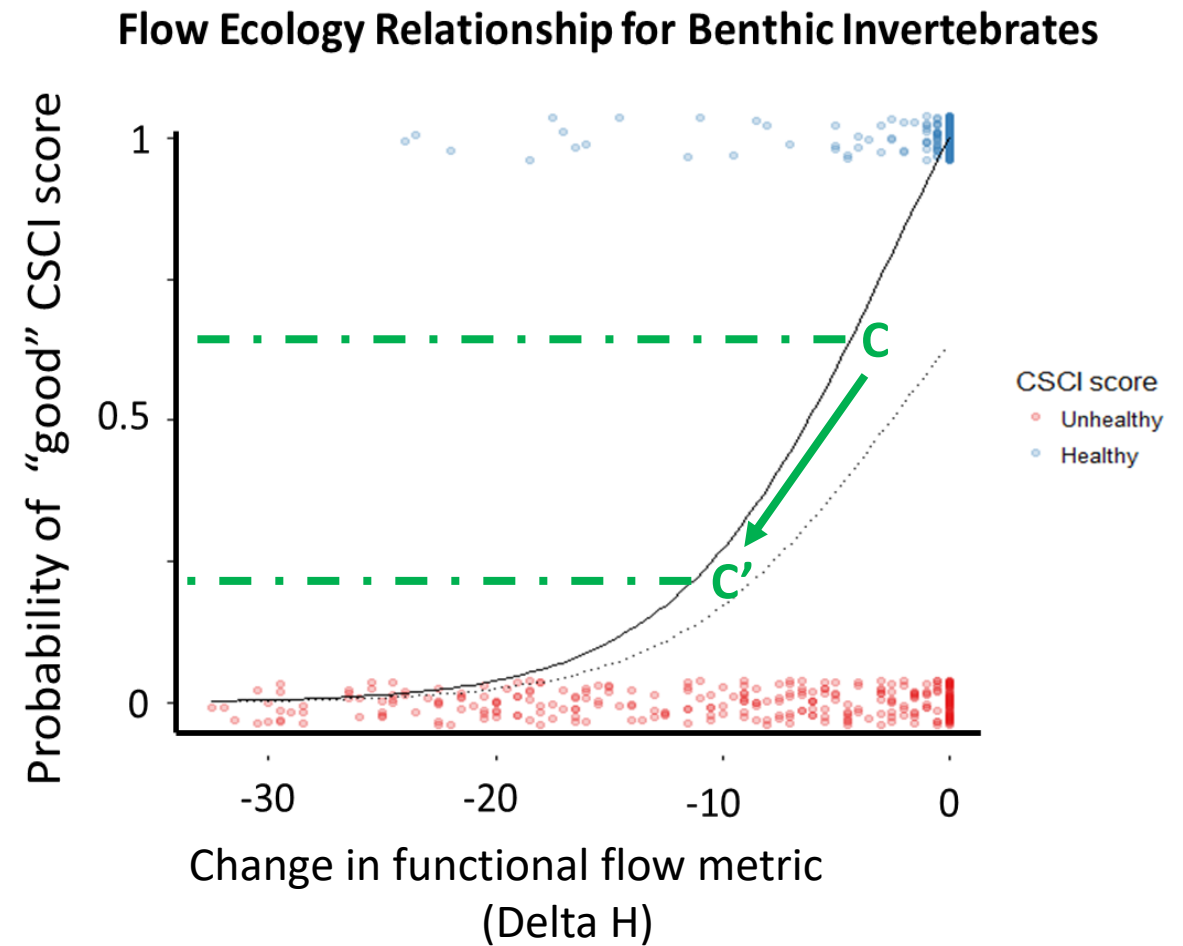
- Vulnerability +



Vulnerability Based on Change in Probability of Condition

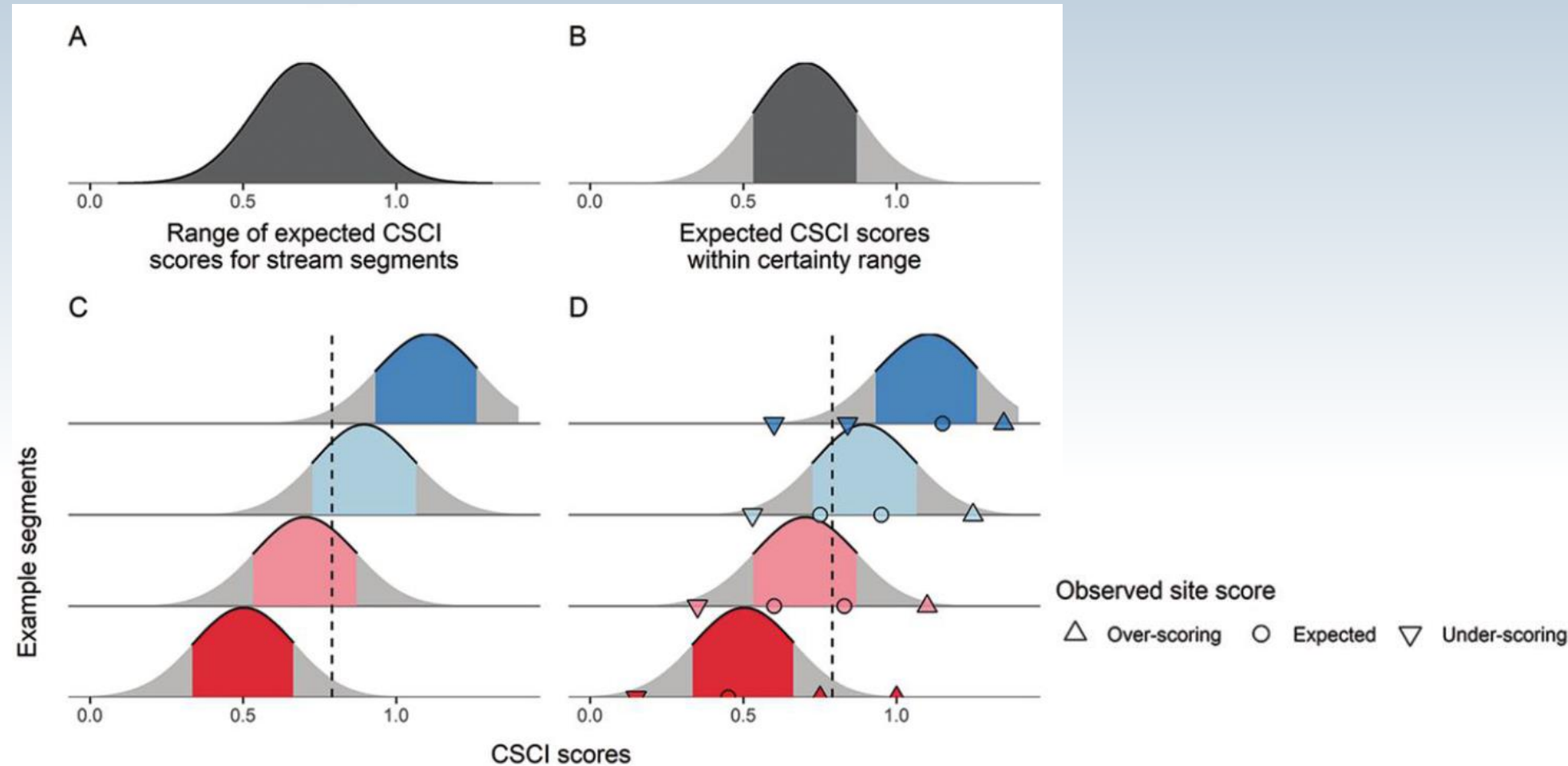


Change relative to thresholds



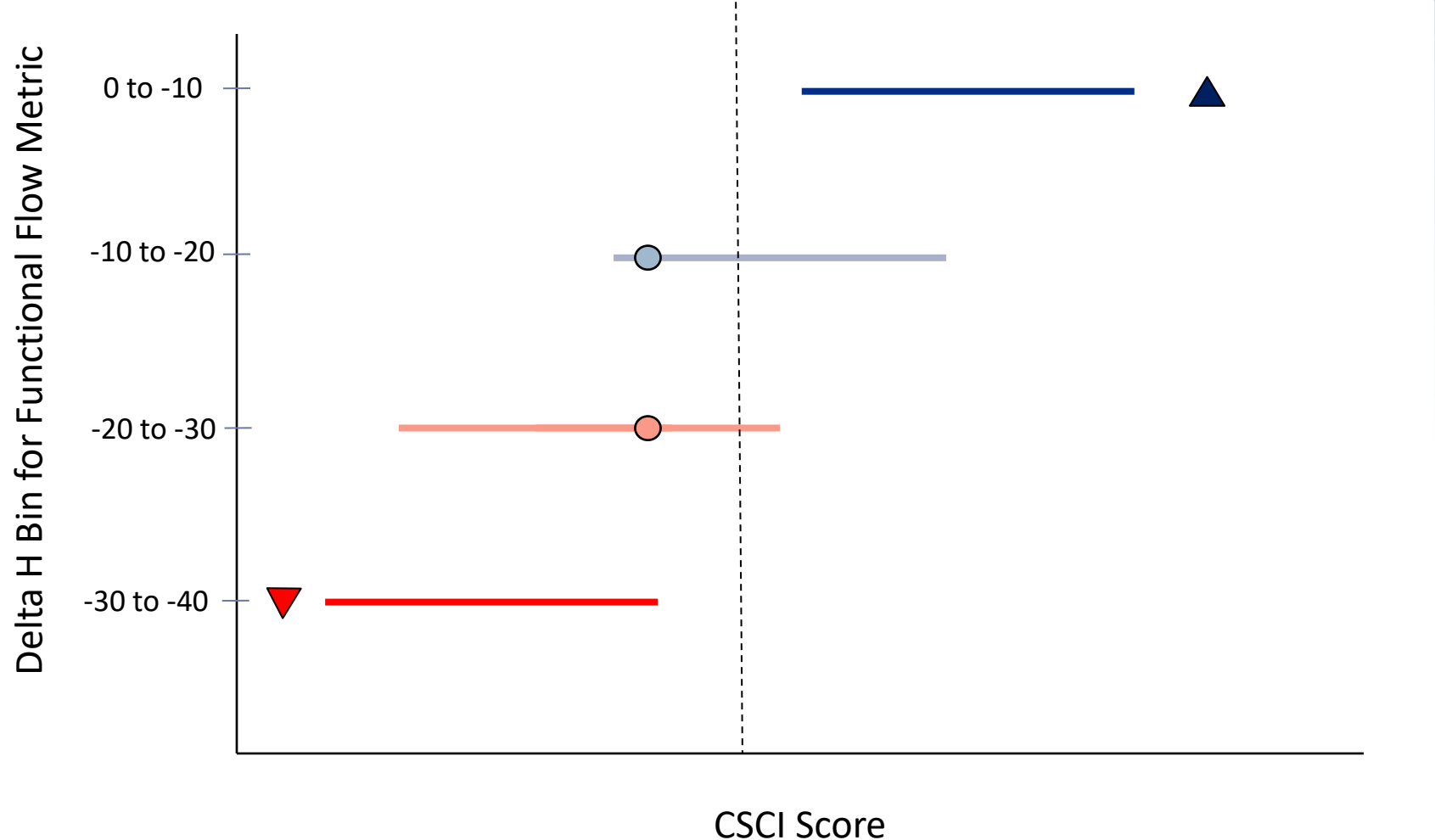
Change relative to probability of condition

Vulnerability Based on Potential Range of Expectations



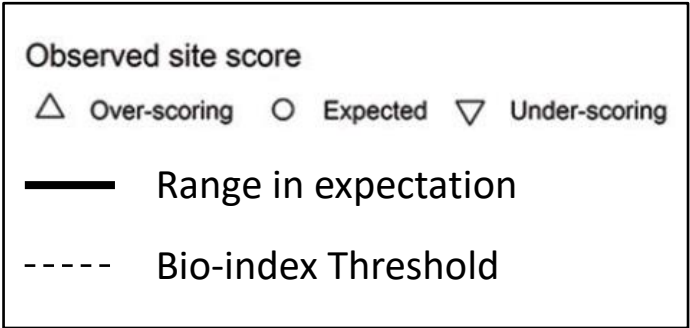
Statewide landscape models estimate range of CSCI expectations (Beck et al., 2019)

Vulnerability Based on Position Relative to Expectations



Random forest models used to generate range of expectations for each location based on level of alteration

Vulnerability based on current condition relative to range of expectations



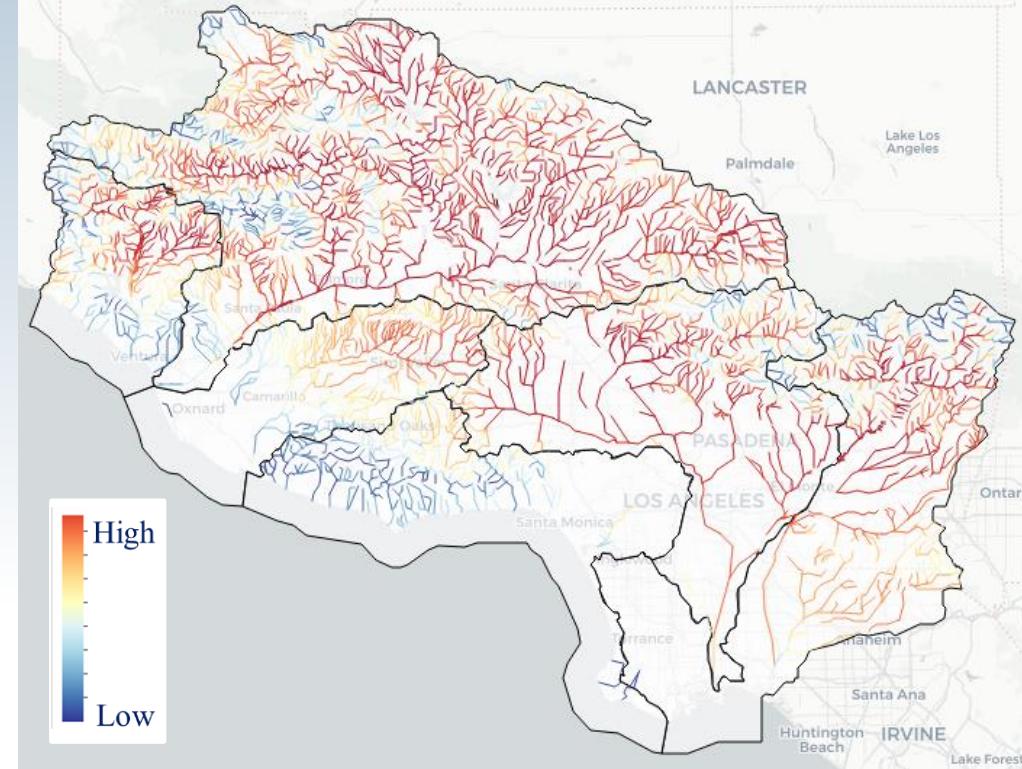
Data Gaps

- Observed streamflow records
- Existing watershed models
- **Species occurrence data**
- **Habitat mapping**

User Friendly Products

- Maps of currently altered and vulnerable areas
- Maps of currently observed species and potential occurrences
- App to explore “beneficial use” status based on flow thresholds
- App to explore vulnerability based on future scenarios
- Guidelines on use and interpretation of tools

Vulnerability in 2050



Downscaled GCM: CanESM2 (RCP 8.5)

***Products will be refined based on discussion with TAG and Water Board
Sophistication of products will partly be determined by available budget***

General Schedule

Task	Oct 20	Jan 21	Apr 21	July 21	Oct 21	Jan 22	Apr 22	July 22	Oct 22	Jan 23
Current Alteration										
Alteration Impacts to Bio										
Future Alteration										
Map Vulnerability										
TAG meetings										



Next TAG meeting: modeling current
hydrologic alteration (Task 1)

Potential Partnership with SDMMP

- Identification of priority areas of management concern
- Collaborate on project elements:
 - Existing species and habitat mapping
 - Focal species selection
 - Development of future scenarios
- Tools and products to inform management and monitoring strategic plans
 - Vulnerability mapping to inform priority areas for monitoring
 - Data sharing and potential tools training with SDMMP

Questions

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