Numeric Flow Metrics to Support Freshwater Bio-objectives, Hydromodification Management, and Nutrient Numeric Endpoints (aka Flow Ecology)

IRWM Regional Advisory Committee Meeting

August 5th, 2015

Agenda for Today

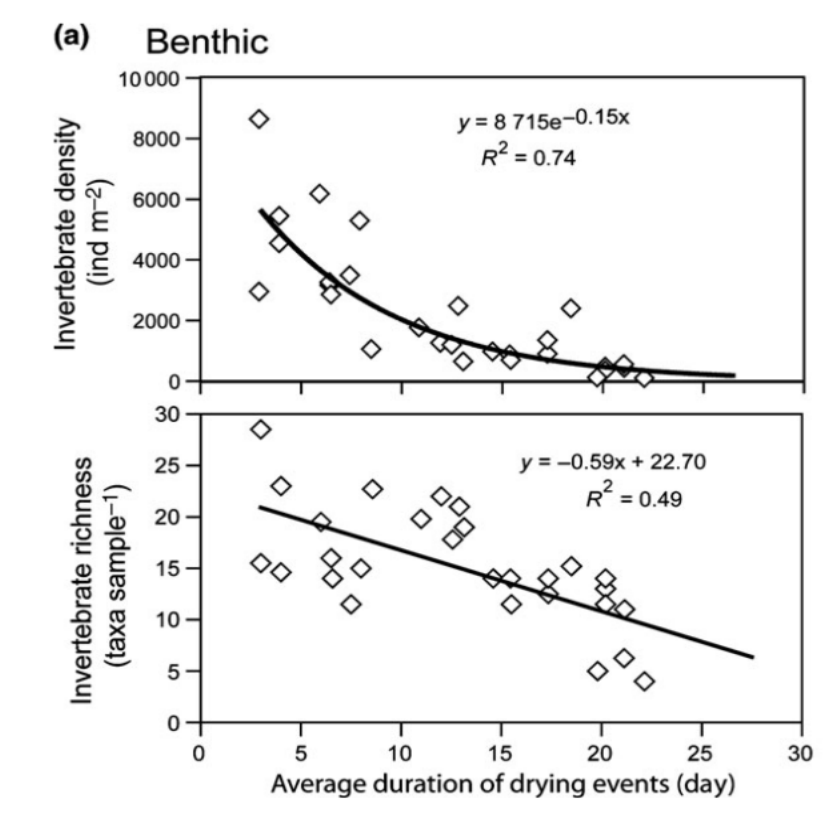
- ❖Overview of Flow-ecology project
- ❖Goals of the Watershed Demonstration
- ❖Partnership opportunities and potential interactions
- ❖Next steps

Rationale for the Project

- Biological endpoints are increasingly used for ambient and compliance monitoring in streams

- Instream biological communities are sensitive to changes in flow and physical structure of streams

- Improved understanding of the relationship between flow and biological assessment indicators will aid in development of monitoring targets and causal assessment



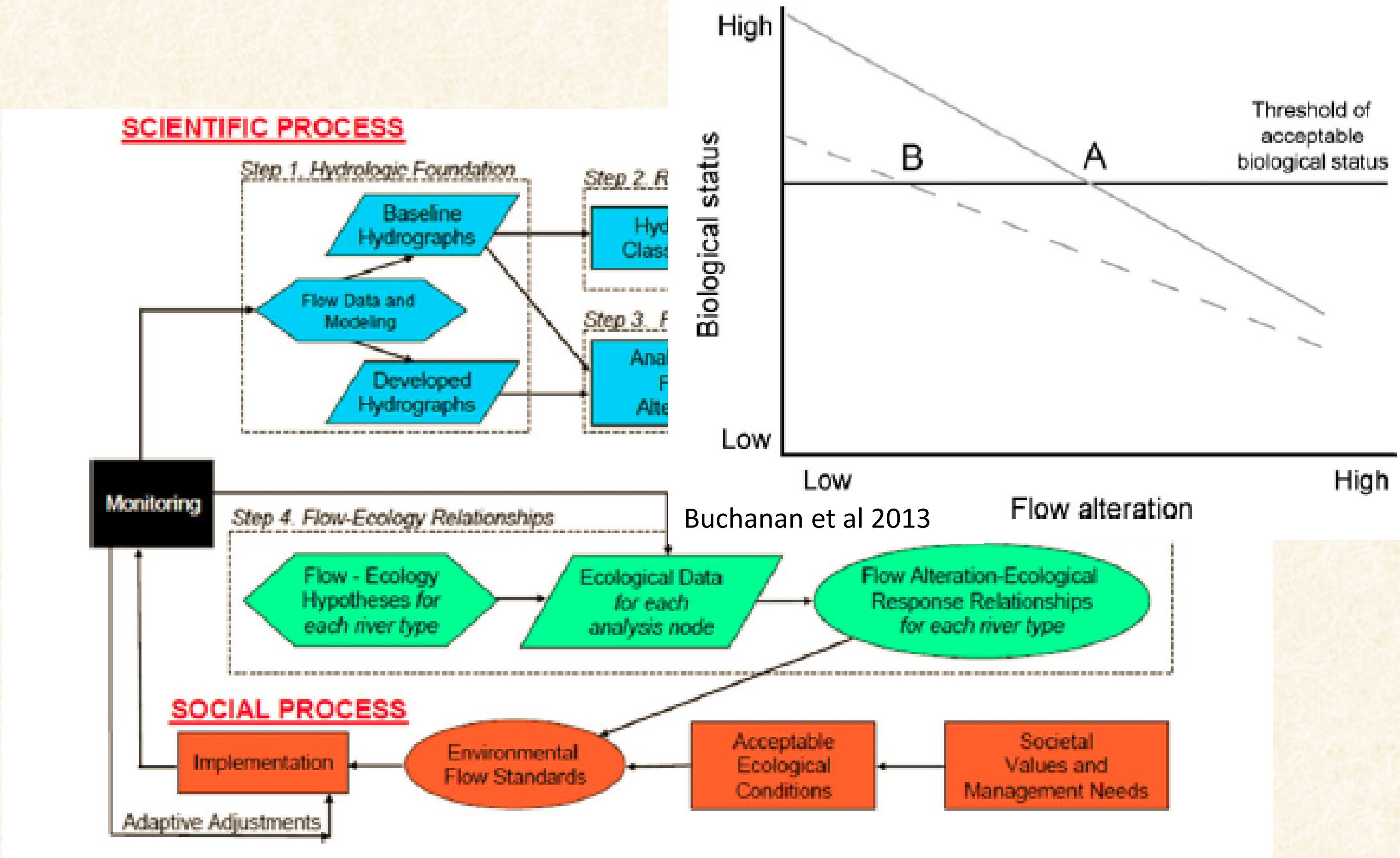
Datry 2012

Project Objectives

Develop an approach for establishing instream environmental flow requirements necessary to meet ecological benchmarks

1. How should streams in California be grouped or classified for the purposes of establishing environmental flow requirements?
2. What are the key hydrologic variables that should be used for environmental flow targets?
3. What are the key biological response variables that should be used when establishing environmental flow targets?
4. What is the appropriate framework/approach for setting actual flow targets for specific stream types?

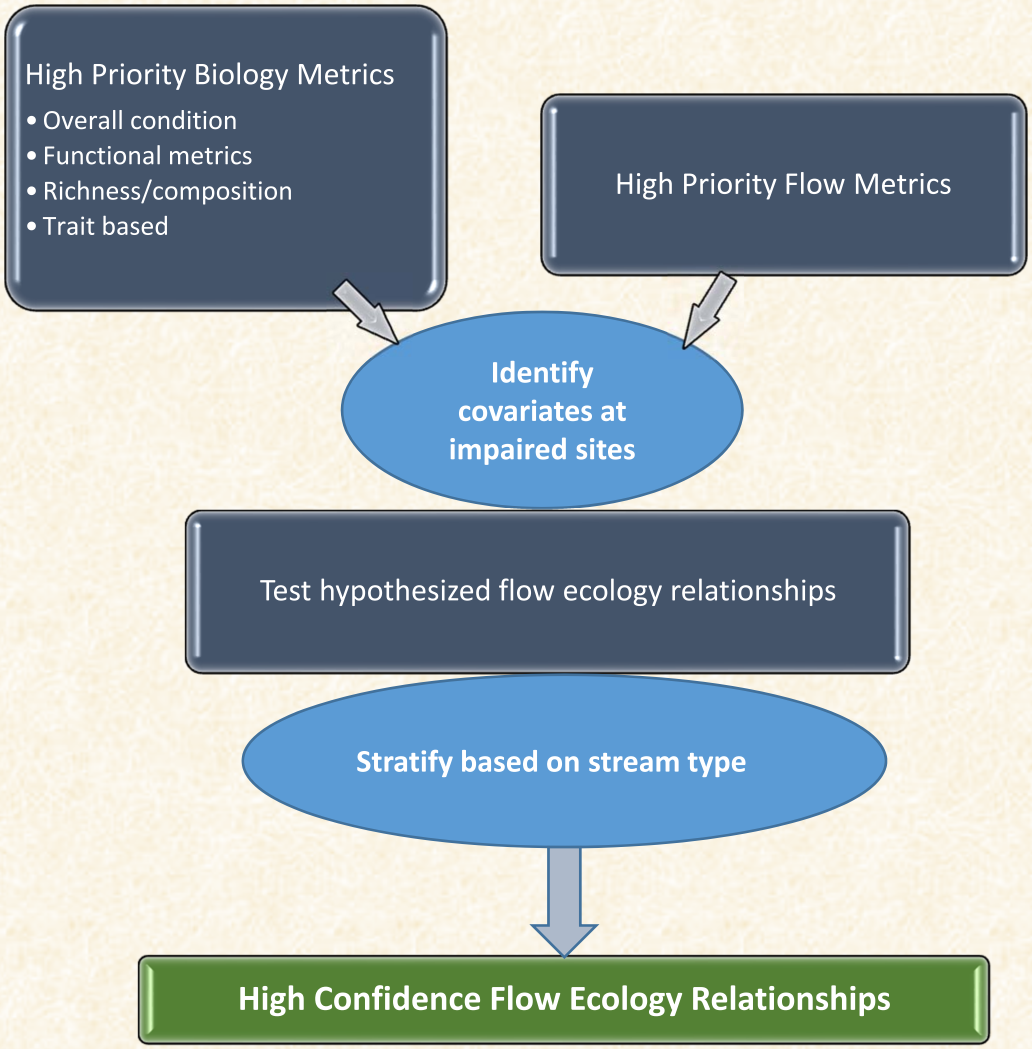
ELOHA Framework



Buchanan et al 2013

Fig. 1 The ELOHA framework (taken directly from Poff and others 2010)

Conceptual Approach



General Tasks

1. Classify streams based on natural hydroclimatic and physical characteristics
2. Evaluate candidate flow metrics based on ability to discern reference from non-reference
3. Relate streamflow metrics to changes in land use and other stressors
4. Collect supplemental biological data where long-term flow data exists
5. Develop models for predicting key flow metrics
6. Produce a tool for assigning models/parameters to “novel” sites of interest
7. Analyze relationship between changes in flow metrics and biological response
8. Evaluate performance of various scoring tools at predicting flow-ecology relationships
9. Develop framework for determining flow targets based on biological endpoints
10. Demonstrate application of flow-ecology (ELOHA) framework to develop flow criteria in a pilot watershed(s)

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Flow-Ecology Approach

- **Develop and test "hypotheses" about flow-ecology relationships**

- Identify hydrologic metrics of interest
  - Affect BMI metrics
  - Respond to human activity
  - Manageable
  - Can be modeled at ungaged sites

- Identify biological metrics of interest
  - CSCI and major components
  - Traits with plausible response to altered hydrology

- Develop relationships between Δhydrology ~Δbiology

Classes of Flow Metrics

Approximately 200 candidate flow metrics – All derived from daily flow data

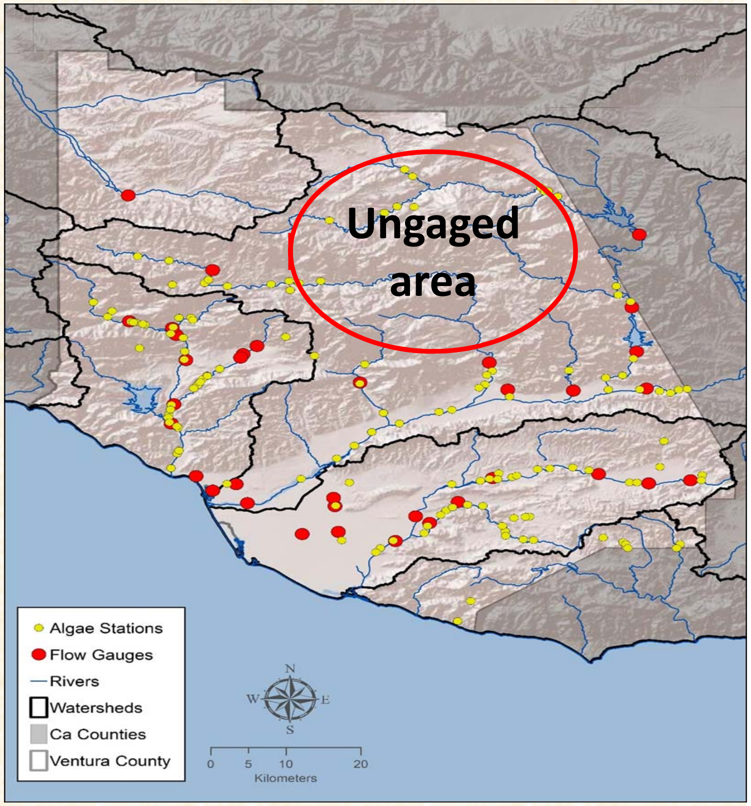
- Magnitude
  - streamflow (mean, max)
  - median annual number of high flow events
- Variability
  - median percent daily change in streamflow
  - Interannual variability (min, max, median)
- Duration
  - Storm flow recession
  - Base flow recession
  - Duration above baseflow
  - Duration of zero flow days
- Timing
  - month of minimum mean monthly streamflow
  - Frequency of high flow events

Isolate effects relative to other stressors

- **Physical habitat**
- **Chemistry (SC as a surrogate)**

Modeling Ungaged Streams

Need to estimate current and reference flow at ANY bioassessment site



- Few streams have long term flow gages
- Models can be used to generate flow data for ungaged systems
- Need to create set of ensemble models that capture the range of watershed types in the region
- Adjust parameters to simulate "reference conditions"

Model Extrapolation

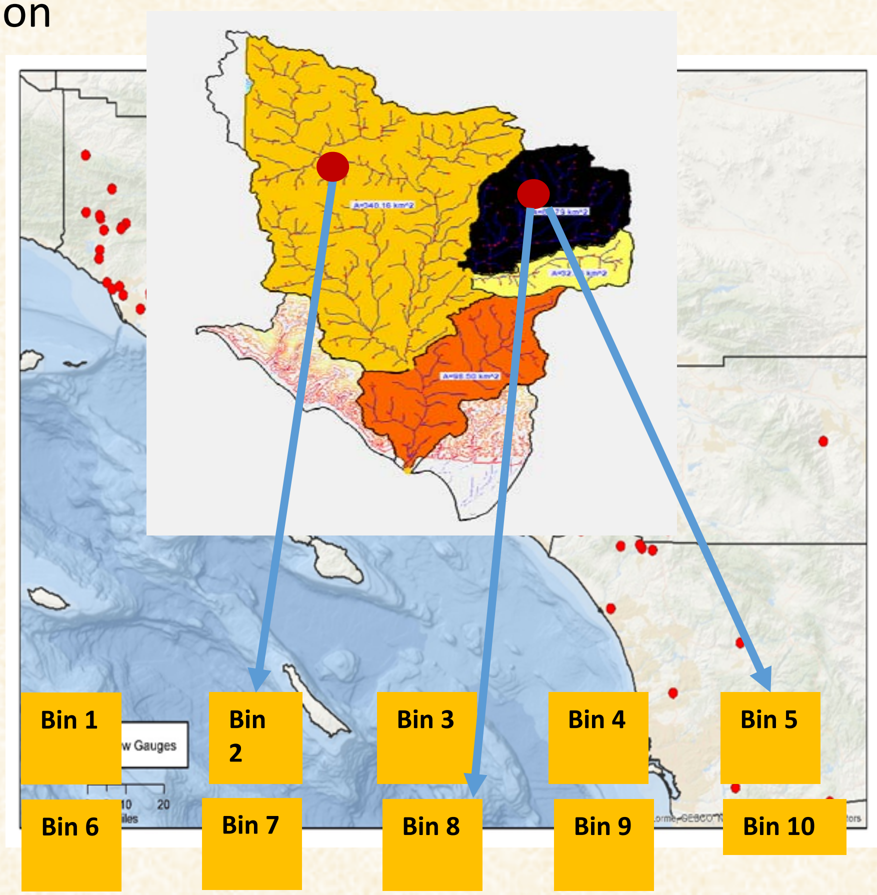
❖Calibrate 43 hydrological models at gaged subbasins

- ❑ Optimize for flashiness and % low flow prediction

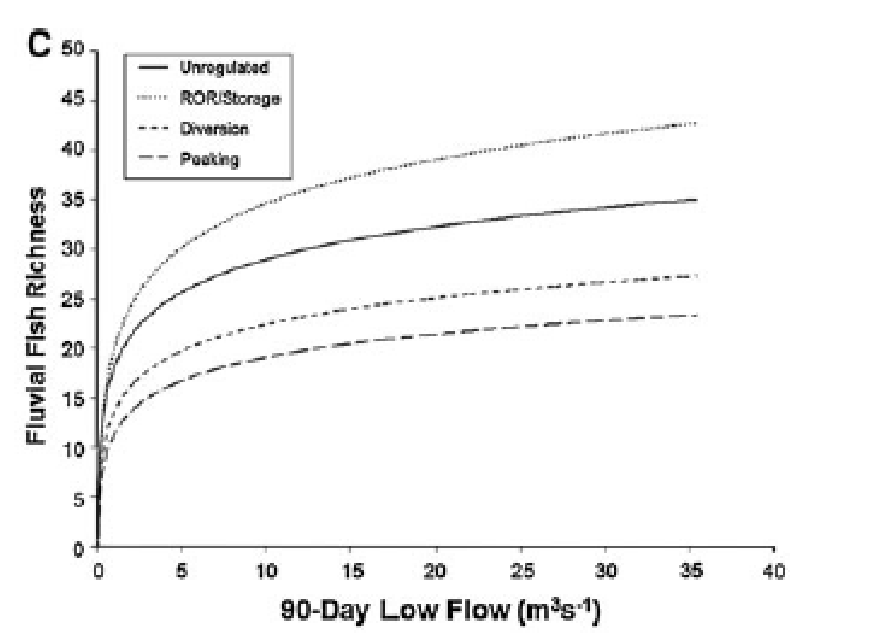
❖Use classification analysis to identify key characteristics for assigning a model to a "novel" site

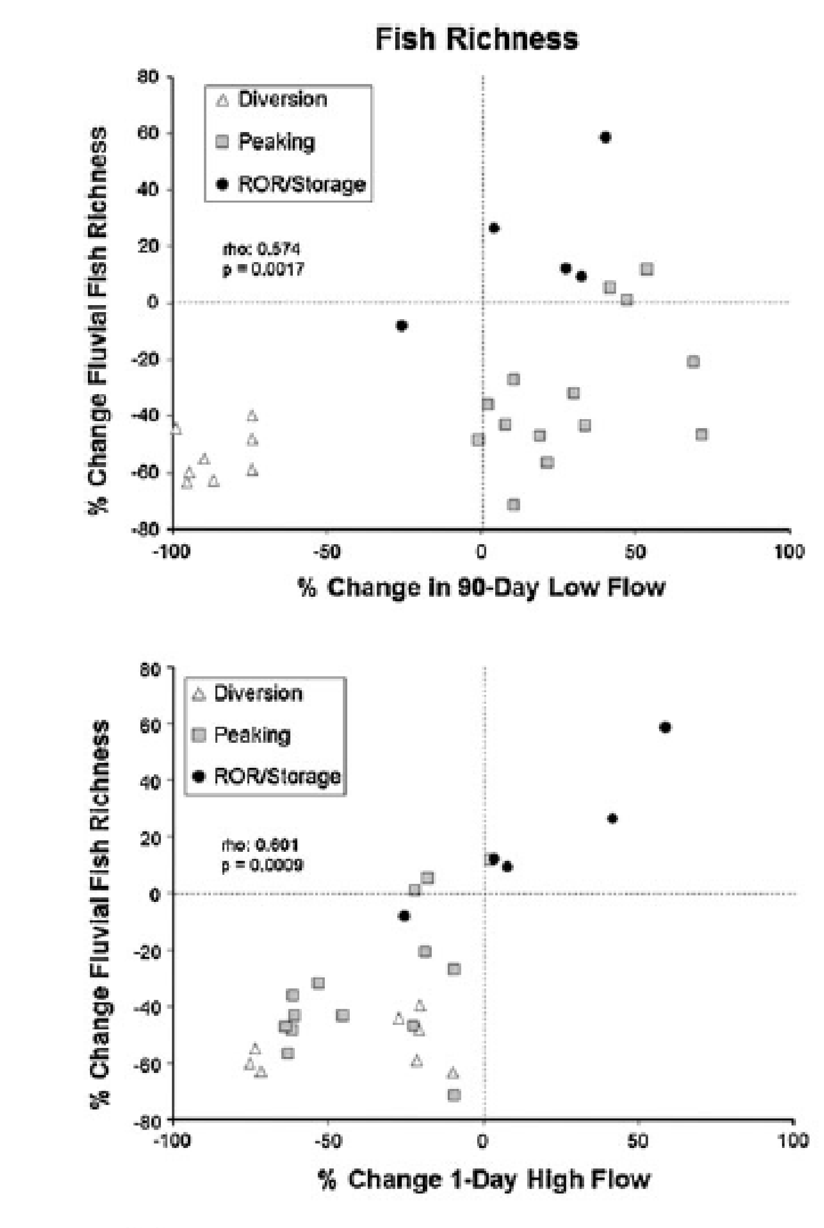
- ❑ Watershed area
- ❑ Soil permeability
- ❑ Precipitation (summer and annual)
- ❑ % sedimentary geology
- ❑ Elevation range

❖Predict flow and flow metrics for the ungaged site using the selected models



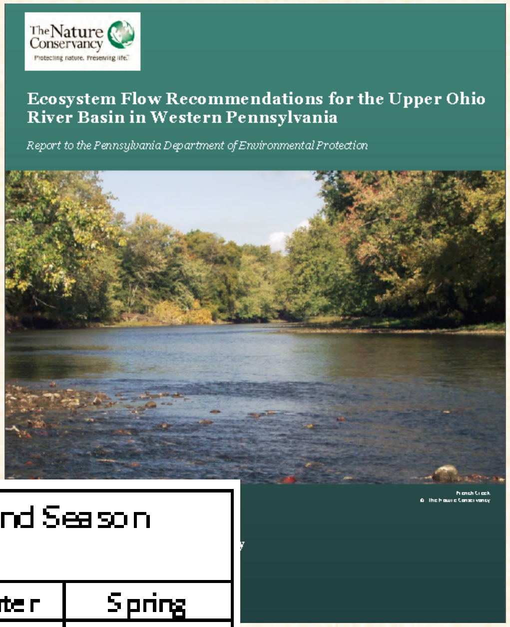
Relate Hydrologic Change to Biological Response

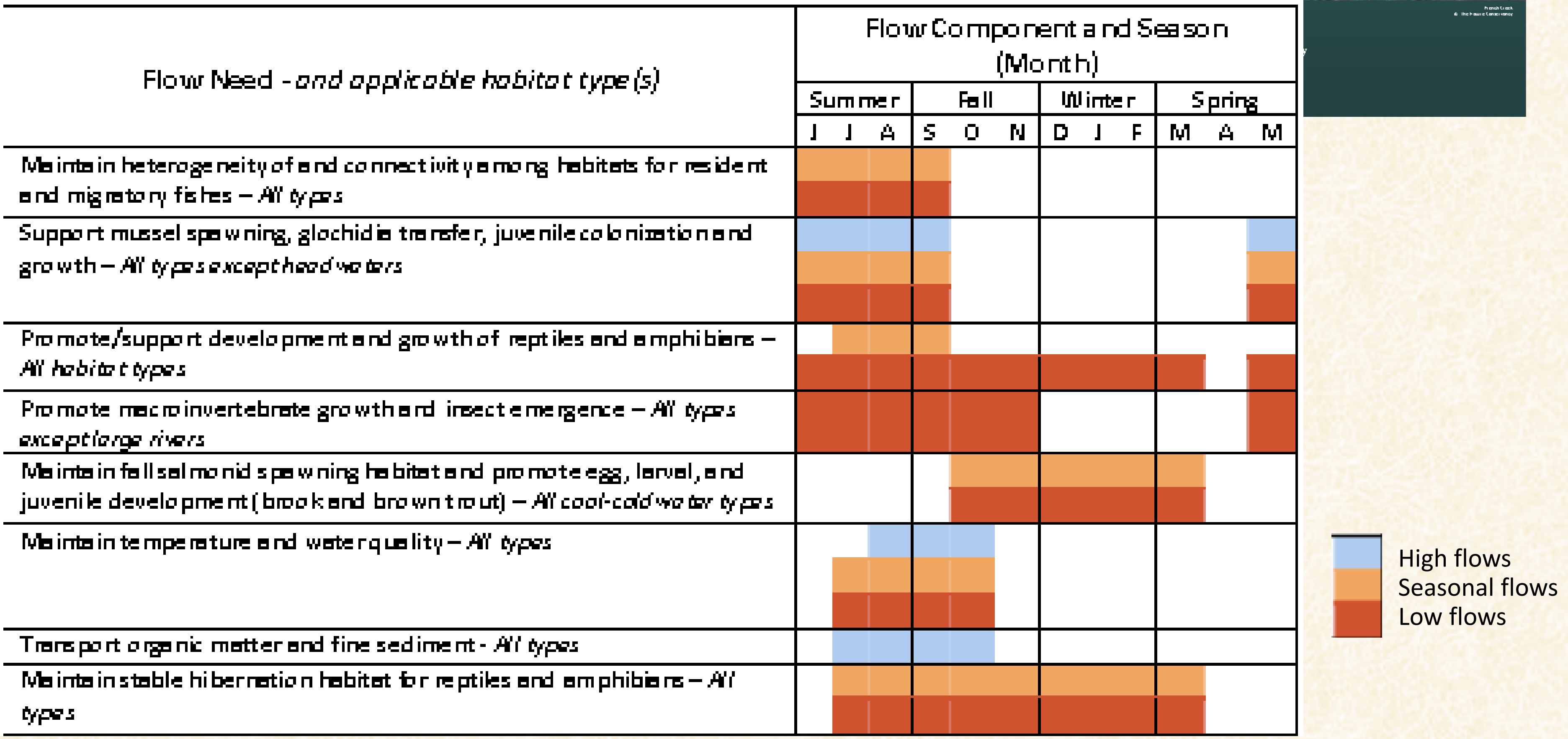




McManamay et al 2013

Operational Results





Operational Results

Summary of Flow Recommendations for all Habitat Types – Upper Ohio River Basin

		Summer	Fall	Winter	Spring
High flows	**All habitat types**	Maintain magnitude and frequency of 20-year (large) flood Maintain magnitude and frequency of 5-year (small) flood Maintain magnitude and frequency of bankfull (1 to 2-year) high flow event			
High flows	**All habitat types**	< 10% change to magnitude of **monthly Q10**			
High flows			Maintain **frequency of high flow pulses > Q10** during fall		Maintain **frequency of high flow pulses** > Q10 during spring
Seasonal flows	**All habitat types**	Less than 20% change to **seasonal flow range (monthly Q10 to Q50)**			
Seasonal flows	Headwaters and Creeks	No change to **monthly median** No change to **seasonal flow range (monthly Q50-Q75)**			
Seasonal flows	Small Rivers	Less than 10% change to **monthly median** Less than 10% change to **seasonal flow range (monthly Q50-Q75)**			
Seasonal flows	Medium Tributaries and Large Rivers	Less than 15% change to **monthly median** Less than 15% change to seasonal **flow range (monthly Q50-Q75)**			
Low flows	Headwaters and Creeks	No change to **monthly Q75** No change to **low flow range (monthly Q75 to Q99)**			
Low flows	Small Rivers and Medium Tributaries and Large Rivers	Less than 10% change to **low flow range (monthly Q75 to Q99)**			
Low flows	Small Rivers and Medium Tributaries and Large Rivers	***Summer and Fall*** No change to **monthly Q90**		***Winter and Spring*** Less than 10% change to **monthly Q90**	

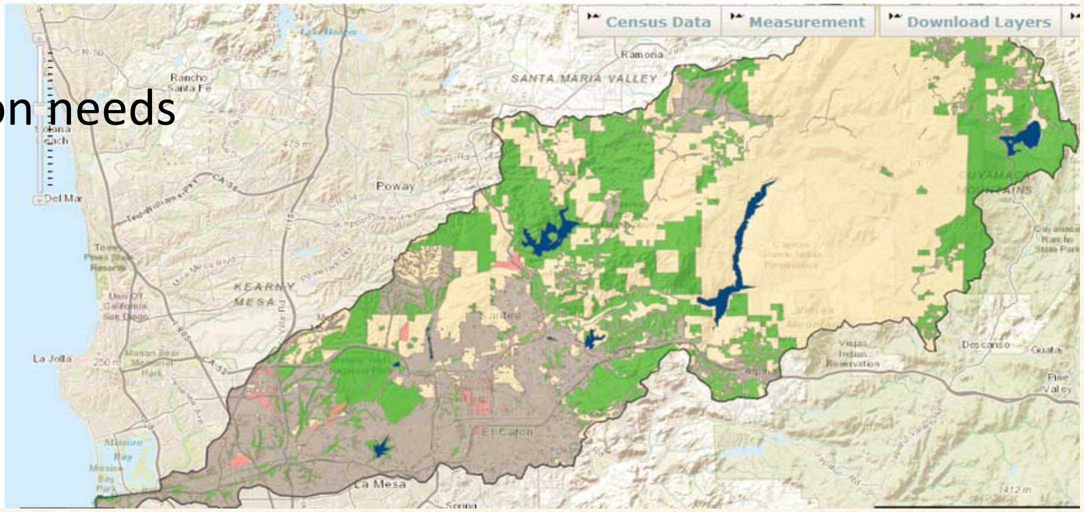
Demonstrating the ELOHA Framework

***Goal** = To demonstrate how flow-ecology relationships can be implemented at a watershed scale to guide management targets/decisions*

- Develop decision support tools that can be used to affect criteria or management actions

- Summarize lessons learned and transferability to other areas of the State

- Summarize data and information needs



Demonstration Project Steps

1. Apply hydrologic models
   - Map of current deviations from expected hydrology
   - Develop hydrologic model to predict changes in the priority flow metrics under future land use conditions

2. Apply flow-ecology models to predict changes in bioassessment indices under future scenarios

3. Identify priority management areas

4. Develop "desired conditions"

5. Identify a range of management actions to achieve desired conditions

6. Create framework document for future implementation of ELOHA approach in other watersheds
   - Summarize lessons learned and need for future work

Anticipated Products

- GIS maps of watershed showing current hydrologic conditions
- Evaluation of current conditions relative to flow-ecology relationships
- Recommended hydrologic “profiles” that would support identified biological endpoints
  - Estimates of risks of ΔB given small changes in ΔH
- Recommended actions for key regions/management units
- Recommendations for future monitoring that will help validate predicted flow-ecology relationships
- Lessons learned and recommendations for future implementation

Prototype application of flow “requirements” to affect management actions

Desired Interactions

- Input on how to define management subunits for the watershed
- Local data on flow, physical habitat, or biology, including prior hydrologic analysis (e.g. IHA)
- Input on determination of hydrologic targets
- Insight on local factors that could be influencing observed flow-ecology relationships
- Recommendations for management measures, opportunities, and constraints
- Insight into feasibility of specific management approaches
- Ideas about how to incorporate social/economic aspects
- Input on development of monitoring recommendations
- *Ideas for spin-off or ancillary projects*

Discussion

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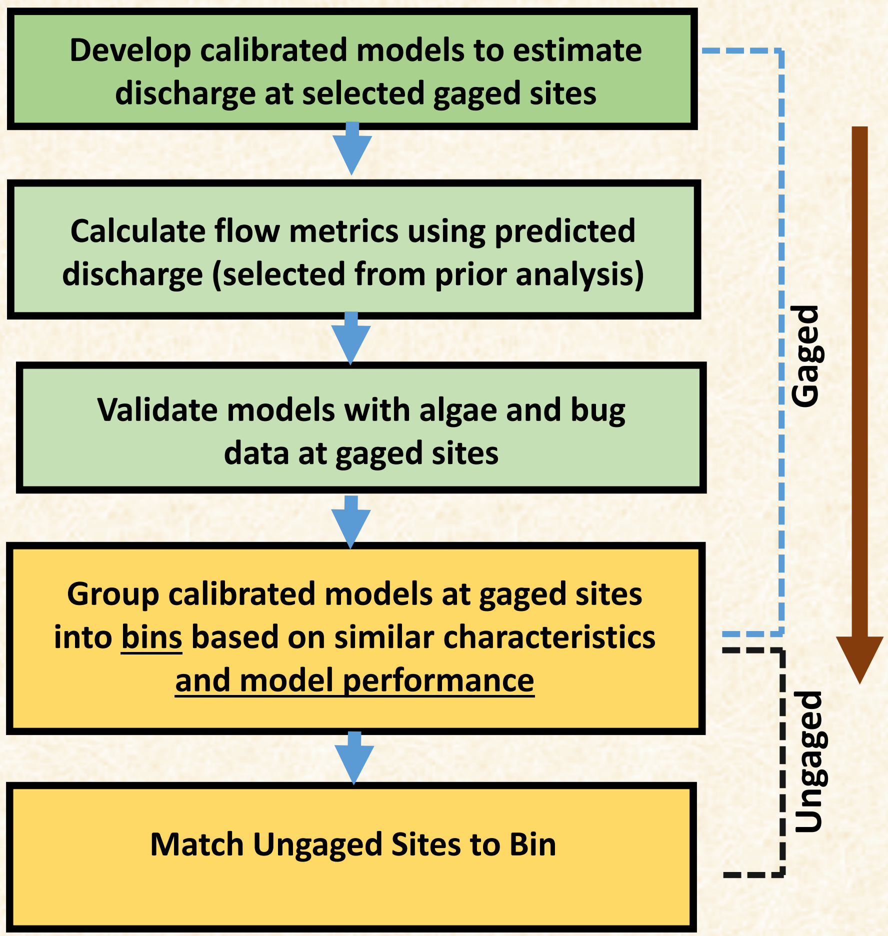
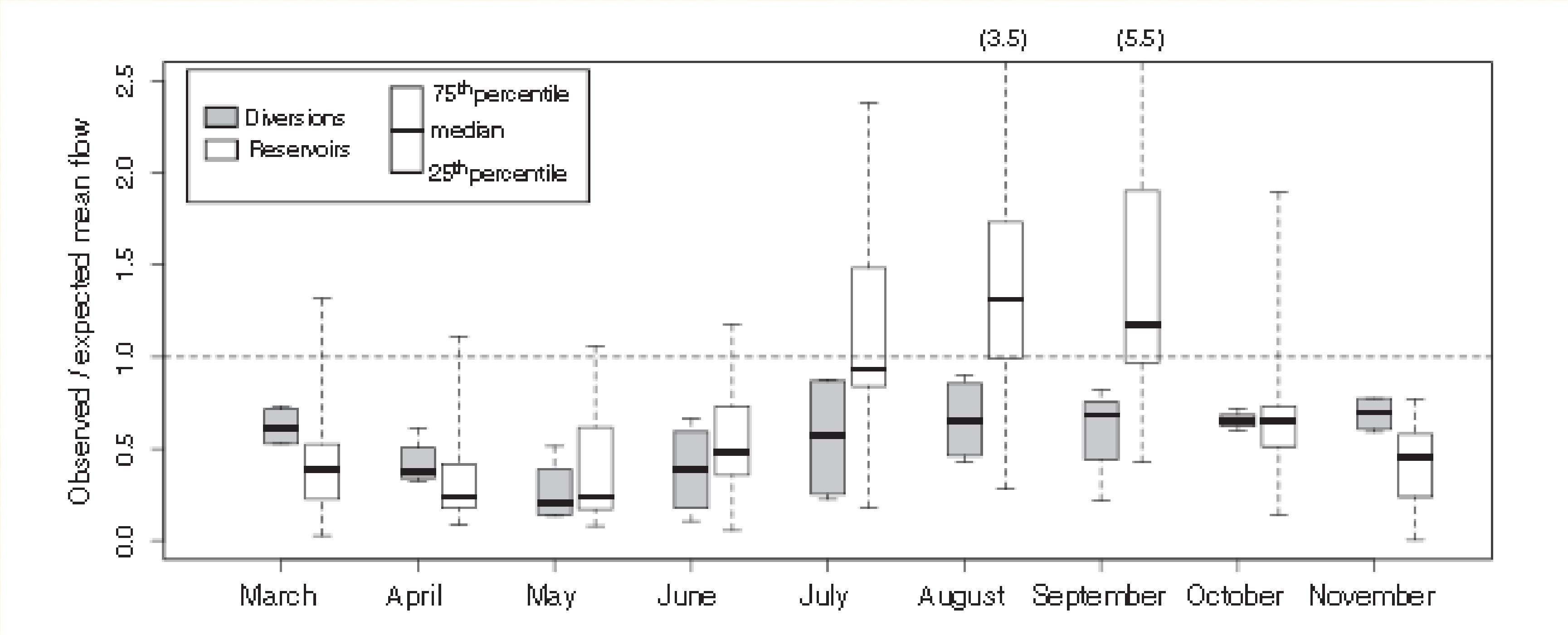
EXTRA SLIDES

General Approach: Gaged Systems to Ungaged Systems



Differences in Flow Metrics Due to Anthropogenic Actions



Carlisle et al 2012

Potential Hydrologic Responses

- Streams get flashier (increased imperviousness)
  - HighDur ↓
  - LowDur, LowNum, HighNum, QMaxIDR, PDC50, BFR, SFR ↑
- Streams get drier (increased withdrawals)
  - Hydroperiod, Qmean ↓
  - MinMonth, marzero ↑
- Streams get wetter (perennialization)
  - Hydroperiod, Qmean ↑
  - MinMonth, marzero ↓

Other responses possible (e.g., increased stability from controlled releases), but less prevalent in S. Ca.

Predicting Changes in Hydrology

- OH: Observed hydrologic metric value
  - Both reference and non-reference gages

- EH_C: Hydrologic metric value expected under current conditions (modeled for ungaged sites).
  - Can also be modified to reflect forecasted conditions.

- EH_R: Hydrologic metric value expected under reference conditions (modeled)

Hypothesized Trait Response

Trait	Response to increased flashiness	Response to reduced flows
Voltinism	↓ semivoltine	↓ semivoltine
Development rate	↑ rate	↑ rate
Synchronization of emergence	???	↑ synchrony
Adult life span	???	???
Female dispersal	↑ dispersal	↑ dispersal
Adult fllying strength	↑ strength	↑ strength
Adult exiting ability	???	???
Occurrence in drift	↑ drifters	
Maximum crawling rate	???	???
Swimming ability	???	???
Attachment	↓ attachment	???
Armoring	???	???
Rheophily	↓ rheophily	↓ rheophily
Dessication resistance	↑ resistance	↑ resistance
Shape	???	???
Size at maturity	↓ size	↓ size
Habit	↓ clingers	↓ clingers
Feeding habits	↓ predators	↑ predators
Thermal	↓ cold	↓ cold
Respiration	↓ gill/tegument	↓ gill/tegument