INTERNATIONAL COLLABORATION PROYECT
UDD – UC DAVIS – UTALCA

"Minimum flows and information of uses in superficial waters: Experiencies and challenges in Chile and California"

IR: Camila Boettiger (UDD)

Proyecto ANID FOVI220188

Objectives

- 1. Establish a network between researchers of Chile and California (EEUU) to study common problems related to water managment and protection.
- 2. Share strategies and methodologies to design, implement and evaluate instruments for superficial water resources managment, like instream flows and information systems.
- 3. Facilitate interaction of postgraduate students with researchers and interdisciplinary experts.
- 4. Diseminate knowledge / results to academics, and engage the discussion with authorities, policymakers and stakeholders affected by research topics.
- 5. Generate agreements for academic and scientific collaboration between members of the network for joint studies or other activities.

Research Group

INSTITUTION	RESEARCHERS
UC Davis	Jay Lund Sarah Yarnell Karrigan Börk
UDD	Camila Boettiger Diego Rivera Roberto Ponce Valentina Cisterna
U. Talca	Roberto Pizarro Claudia Sangüesa

Outcomes… so far

- **25.02.2024:** "Minimum Flow Laws in California and Chile", California Water Blog: https://californiawaterblog.com/2024/02/25/minimum-flow-laws-in-california-and-chile/

- **10.03.2024:** "A Functional Flows Approach for Environmental Flows in Chile", California Water Blog: https://californiawaterblog.com/2024/03/10/a-functional-flows-approach-for-environmental-flows-in-chile/

Today's Program

PROGRAM

INSTREAM MINIMUM FLOWS: EXPERIENCE AND LESSONS FROM CALIFORNIA TO CHILE

Tuesday, 12 March, 2024 | 3pm - 5:30pm
Edificio Postgrado, Auditorio JPOSTB
Universidad Del Desarrollo
Santiago, Chile

OPENING
3:00PM - 3:15PM

Welcome and opening
E. Silva (UDD)
Project briefing (10 min.)
C. Boettiger (UDD)

PANELS
3:15PM - 4:00PM

"Importance and benefits of instream flows" (20 min.)
D. Rivera (UDD) & R. Ponce (UDD)
"Situation in Chile and California" (20 min.)
C. Boettiger (UDD) & K. Börk (UCDAVIS)

COFFEE BREAK (15 min.)

PANELS
4:15PM - 5:30PM

"CEFF: Applicable to Chile" (20 min.)
S. Yarnell (UCDAVIS)
"Portfolio approach: Opportunities for collaboration" (20 min.)
J. Lund (UCDAVIS)
Questions and panel discussion (20 min.)
C. Sangüesa (U.Talca)

CLOSING COFFEE

UDD UCDAVIS

PROYECTO ANID FOVI220188

Universidad del Desarrollo
Facultad de Ingeniería

CRHIAM
CENTRO DE RECURSOS HÍDRICOS PARA LA AGRICULTURA Y LA MINERÍA

Fondecyt Regular 1230520
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Ministerio de Ciencia, Tecnología, Conocimiento e Innovación
Gobierno de Chile

Anillo ACT210080
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Importance and benefits of environmental flows

Roberto Ponce
Diego Rivera Salazar

Universidad del Desarrollo
UCDAVIS UNIVERSITY OF CALIFORNIA
TALCA UNIVERSIDAD CHILE
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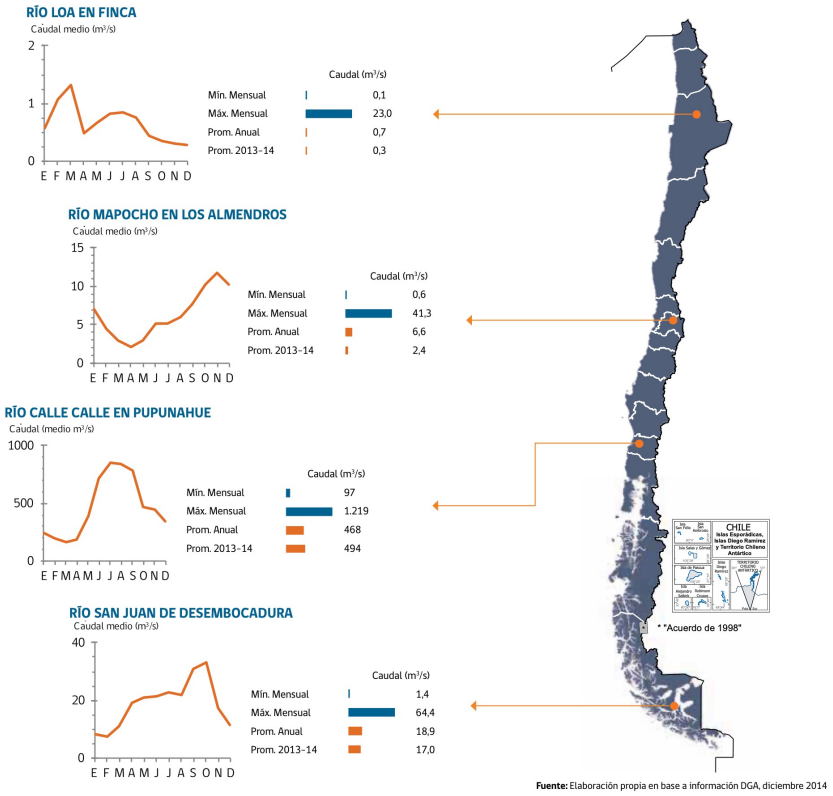
Environmental flows and the environment

Environmental flows and the environment

Quantity	Quality	Access	Timming
Demand		Availability	
Cities		Communities	
Environment		Agriculture	

Expected and desired outcomes
Frameworks and tools
Data sufficiency
Community engagement

Chile: many regimes, many territories



Fuente: Elaboración propia en base a información DGA, diciembre 2014

Atlas del Agua (2016)
Update son?

Resolution	**Coverage**
Annual	Basin
Monthly	Watershed
Daily	Sub-watershed
Hourly	

What are we capturing when we analyse streaflow data?

Rainfall-runoff
Land use (change)
Groundwater-Surface water interaction
Extraction and returns

➔ Importance of within-domain fluxes
➔ Other in- anf off-stream variables?

Benefits

- Adaptation to Ecological Variability
- Holistic Management
- Flexibility and Resilience
- Balanced Water Allocation

Needs

To identify critical natural flow components essential for habitat support
A framework instead of a single formula: California Environmental Flows Framework (CEFF),

Challenges

Provide Dynamic and actionable management strategies
Stakeholder involvement
Data

Proyecto ANID FOVI220188

INSTREAM MINIMUM FLOWS IN CHILE

Camila Boettiger

Universidad Del Desarrollo, Chile

Water Rights (WR) in Chile

- Water Rights in Chile are administrative concessions, which authorize a maximum volume of extraction, normally in liters per second (l/s), in a fixed intake point
- WR can be:
  - Consumptive or non-consumptive (with obligation to return the same volume downstream)
  - Permanent (senior) or eventual (junior) (whether they participate in proportional distribution when flow is not enough for all WR).
  - Continuous or discontinuous (in time or periods)
- Characteristics: Transferable, proprietary/ patrimonial and indefinite (no term of expiration)

History of instream flows (i)

- Before 1980's there was no limitation of extraction to WR in order to avoid "drying" fluvial courses (non used is wasted water)
- 1982: "Ecological flow" - DGA
- 1995 – 2005: DGA (water authority) starts imposing "minimum ecological flows" to new WR as an "administrative practice"

History of instream flows (ii)

- 1997: Enviromental Assesment System (environmental authority) starts requiring a minimum "environmental flow" to projects that divert superficial waters (e.g. hydroelectrical power plants)
- First uses the average flow, then instructs a broader scope: to maintain "uses" within the river course (natural life and anthropic uses)
- This minimum flow is applicable only to the Project´s intake point (individually asserted as a mitigation measure)

History of instream flows (iii)

- 2005: Water Code reform regulates these minimum ecological flows (MEF) by law, as a permanent restriction for new WR, in the ordinary exercise of the WR. Only applicable to new WR or new intake points
- Types:
  - i) Regular, established in the WR tittle, maximum 20% of average annual flow, monthly spread;
  - ii) Qualified, for biodiversity protected areas; requires report of the Ministry of Environment and can be up to 40% of average annual flow, monthly spread.

History of instream flows (iv)

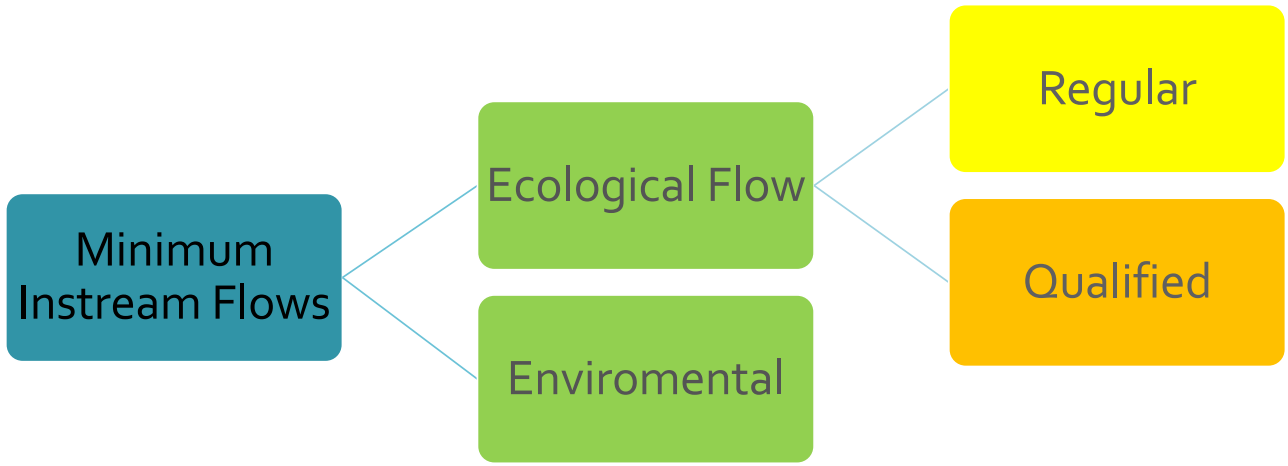
- **2016:** New methodology for Eflows in hydro projects
- **2016:** DGA Study: 8% of WR have MEFs, of which 40% don´t comply
- **2017:** 17% of WR had a EnvF
- **2022:** Qualified MEF for protected areas may affect existing WR in a certain area or section of the stream. (Pending: requires a new regulation to establish the criteria and particular rules on hoy these WR can be affected)

Concept and types of Minimum instream flows (CHILE)

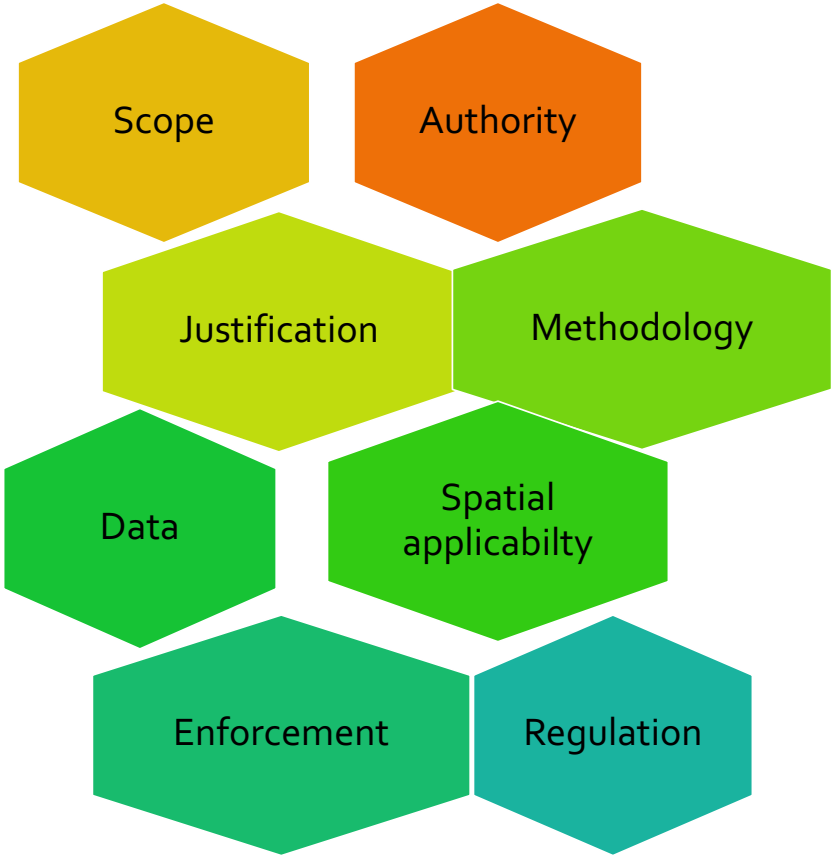
Minimum Flows: Flow that needs to be maintained instream to protect river life or certain uses

- Ecological Flow: Minimum Flow to maintain the natural life of a river, according to its specific conditions, for the preservation of nature in fluvial ecosystems
- Environmental Flow: Minimum Flow that allows the maintenance of means of subsistence and welfare of the people who depend on the fluvial ecosystem

Concept and types of Minimum instream flows (CHILE)



Different instruments…



Difficulties for implementation of MEF and EF

- Restrictions must by enforced by DGA and require information on extractions and distribution by the WR holders and user organizations.
- Incomplete information on WR titles and authorized volumes
- Lack of extraction information (catching instant flows)
- MEF and EF are fixed only for the intake point, not for the watershed or some section
- Majority of existing WR don`t have MEF (almost no water available)

Thanks!

California Instream Flows

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Irrigation . . . is a religious rite. Such a prayer for rain is intelligent, scientific, and worthy of man's divinity. And it is answered.

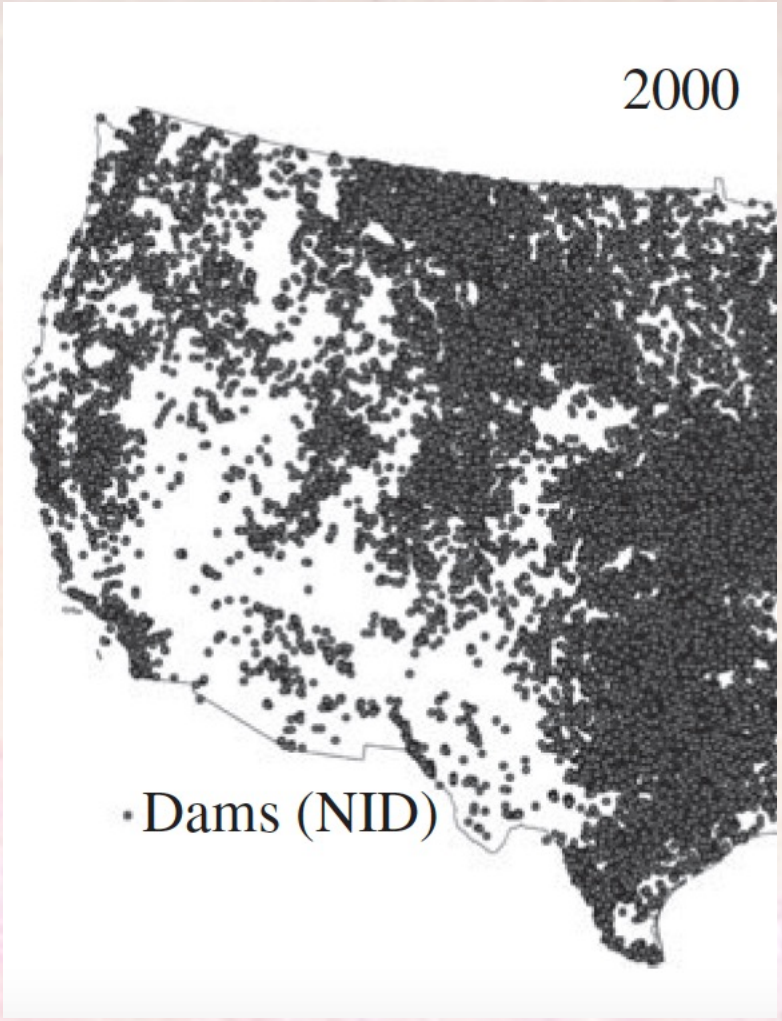
– William Smythe, irrigation proponent, 1905

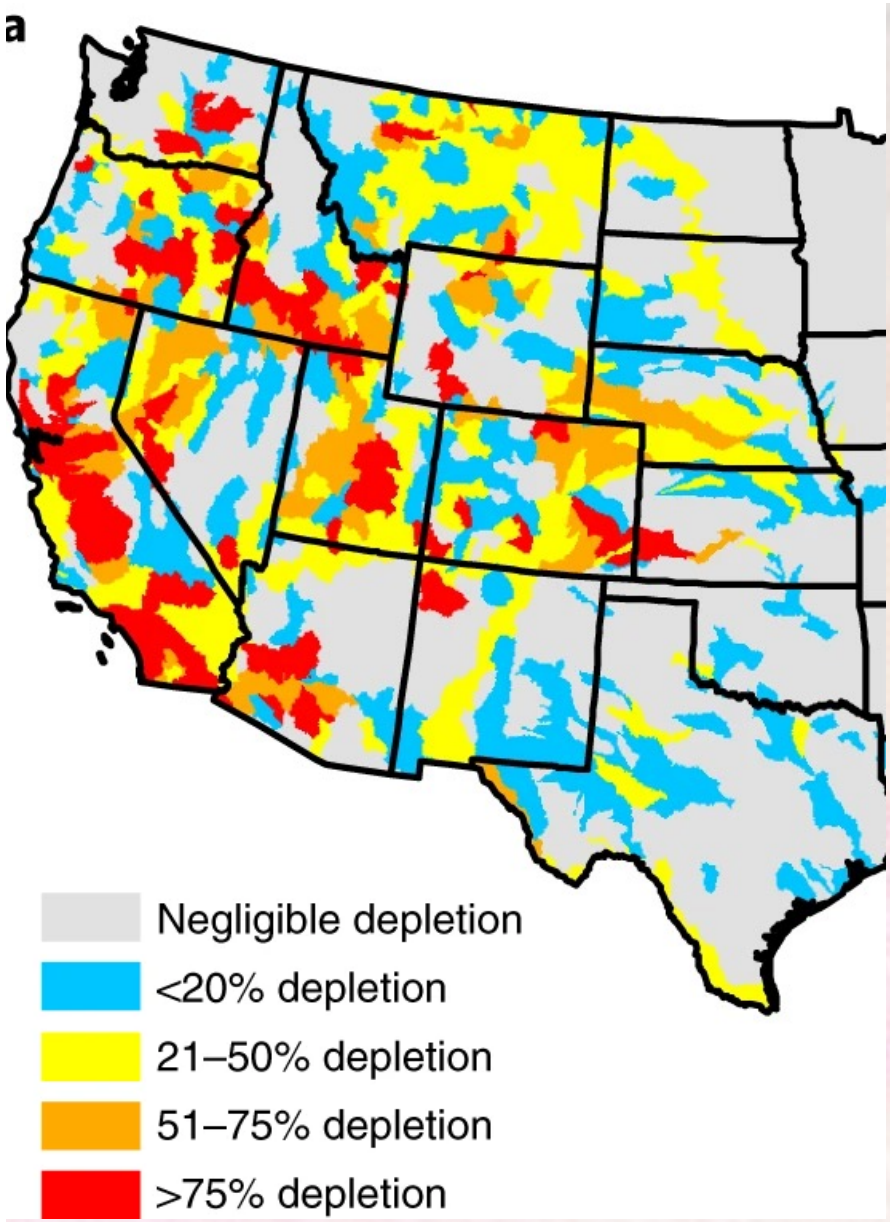
[T]he Division of Water Rights has not the authority to deny appropriations upon the mere basis that fish life will be imperiled by depletion of supply.

– In re Bank of Italy as Trustee for A.K. Detweiler, No. D-227, (Div. of Water Res. May 6, 1929)

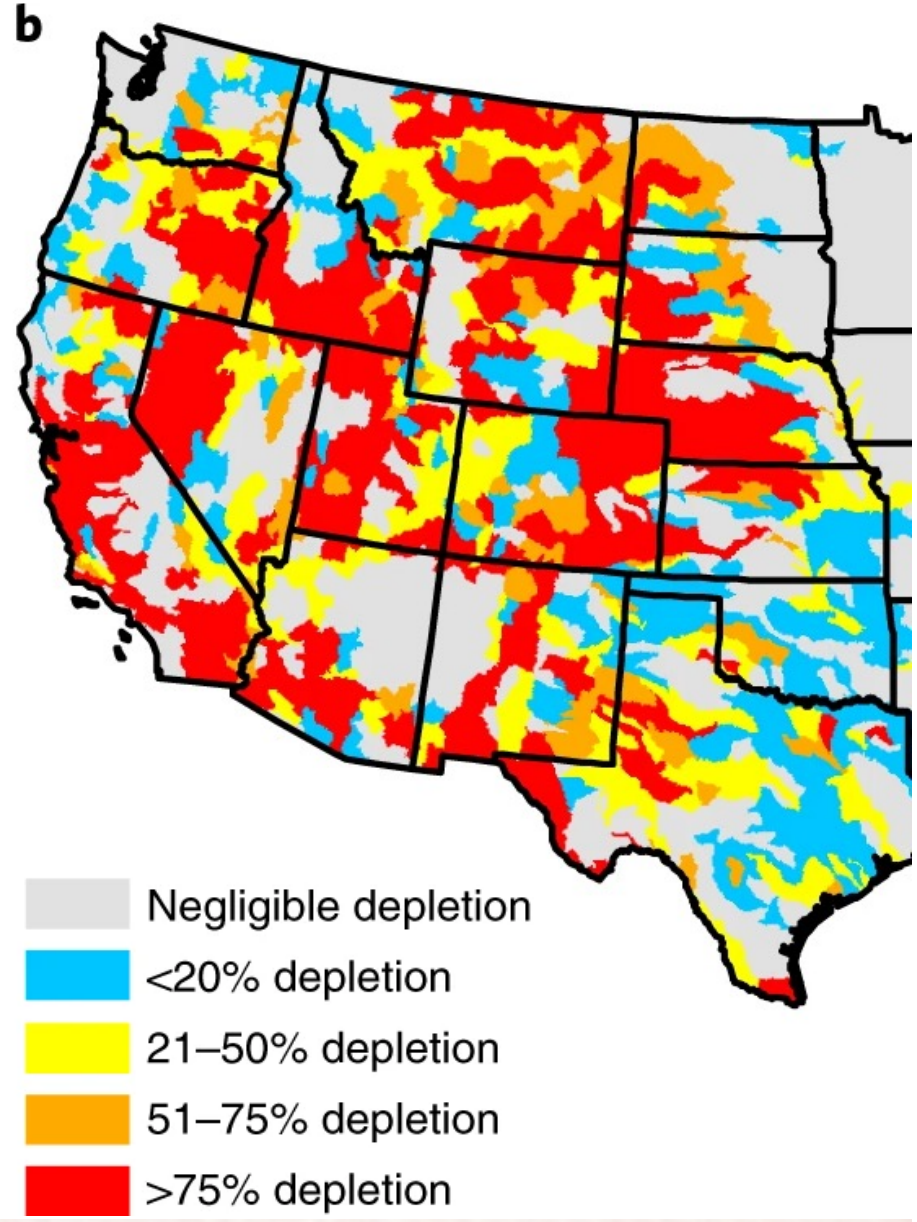
We should not relax until every drop of fresh water has been put to work!”

– CA Gov. Earl Warren, 1944





Modeled Summer, 2001-15



Modeled Driest 10% of Summers, 1961–2015

Turning Point – Birth of the Modern Environmental Movement

- Pre-1970, many laws, little enforcement
- First major dam defeated in California – Eel River dam at Dos Rios (late 1960s)
- Followed by Public Trust doctrine (1983), Endangered Species Act (1973), Clean Water Act (1972), etc.

Restrictions on Water Use?

- CA Constitution – Reasonable Use
- Public Trust Doctrine
- State Statutory Law
- Federal Law

Public Trust Doctrine

- Government holds some property as a trustee for the people
- Covers tidelands, navigable lakes/streams, and nonnavigable waters/groundwaters to protect navigable waters
- Protects commerce, navigation, fisheries, and recreational and ecological values
- Private standing to sue

CA Statutes

- No unified minimum flow law!
- Permitting Requirements
- PRC 10000, priority streams
- FGC 1602, streambed modification
- FGC 5937, minimum below-dam flow
- Various fish passage and barrier removal statutes
- CESA
- CEQA
- Porter Cologne (water quality law)
- California Wild and Scenic Rivers Act

Federal Laws

- ESA for waters with protected species
- NEPA
- FERC for nonfederal hydropower
- Tribal fishing rights

Pulling it all together

- Primary challenge is changing past allocations
- No single minimum flow law
  - Portfolio approach to minimum flows
- Enforcement via state agencies, federal agencies, private citizens and nonprofits
  - Few rivers and streams have minimum flow requirements
  - Generally driven by private litigation
- Conflict motivates collaboration

Thank you!

California Environmental Flows Framework

A Functional Flows Approach

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CHILE

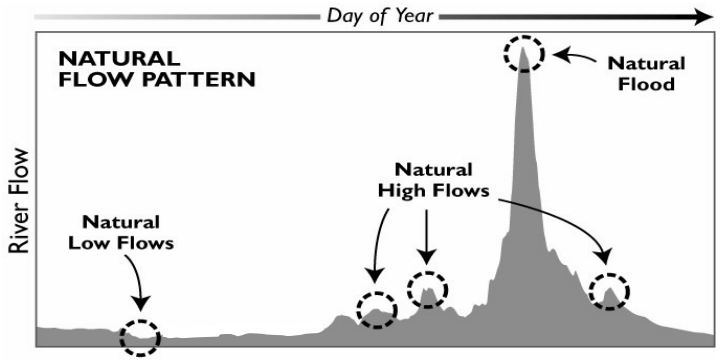
Proyecto ANID FOVI220188

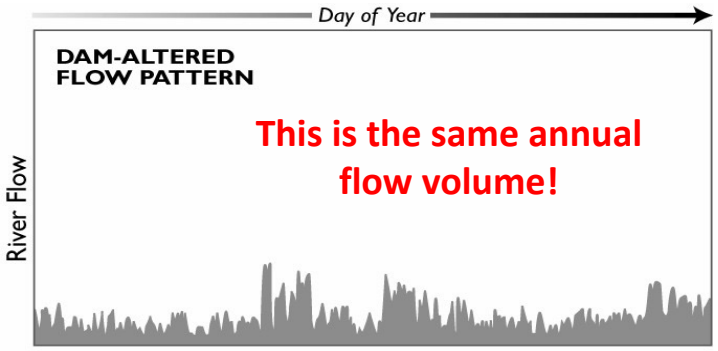
Sarah Yarnell, PhD.
Center for Watershed Sciences,
University of California, Davis

Mar 12, 2024

Holistic Approach:

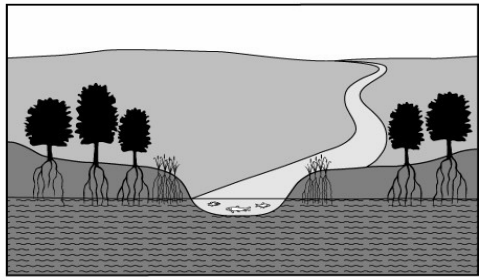
It's flow pattern more than flow volume





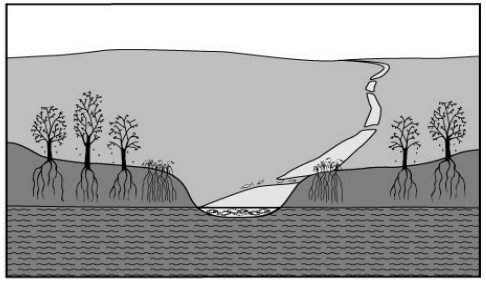
Natural Low Flow

- Fish have adequate oxygen and can move up- or downstream to feed
- Riparian vegetation sustained by shallow ground water table
- Insects feed on organic material carried downstream
- Birds supported by healthy riparian vegetation and aquatic prey



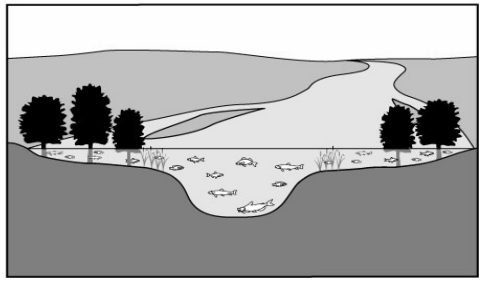
Inadequate Low Flow

- Fish are overcrowded in poor-quality water, cannot move to other feeding areas
- Riparian plants wilt when ground water table drops too low
- Insects suffer when water levels rise and fall erratically
- Birds unable to feed, rest, or breed in tree canopy



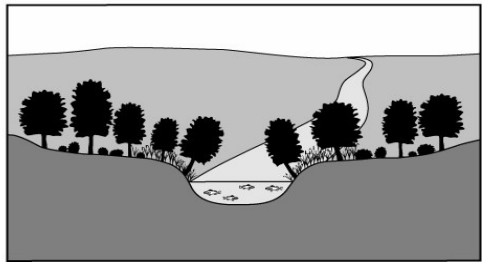
Natural Flood

- Fish are able to feed and spawn in floodplain areas
- Riparian plant seeds germinate on flood-deposited sediments
- Insects emerge from water to complete their lifecycle
- Wading birds and waterfowl feed on fish and plants in shallow flooded areas



Absence of Flood

- Fish unable to access floodplain for spawning and feeding
- Riparian vegetation encroaches into river channel
- Insect habitats smothered by silt and sand
- Many birds cannot use riparian areas when plant species change

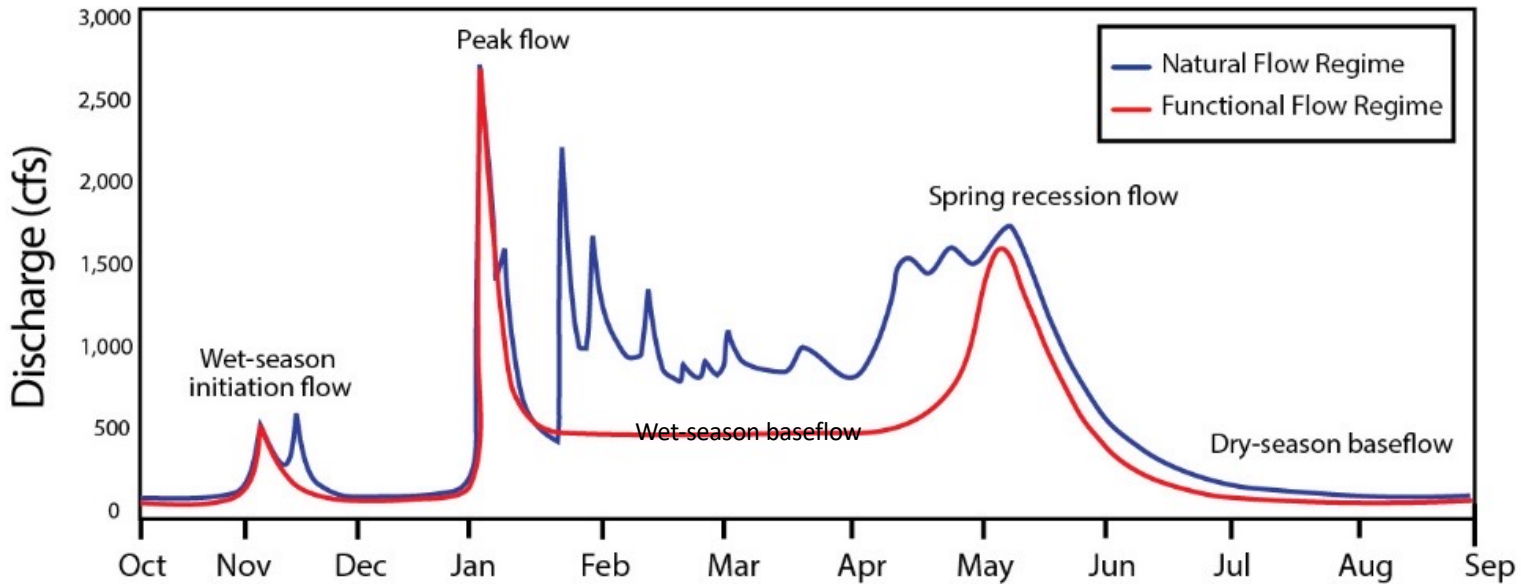


Postel & Richter 2003

Functional Flows Approach

- "Functional Flow" = hydrograph element that provides a distinct geomorphic, ecologic, or biogeochemical function
- Reflects natural patterns that occur in space and time

Yarnell et al. 2015

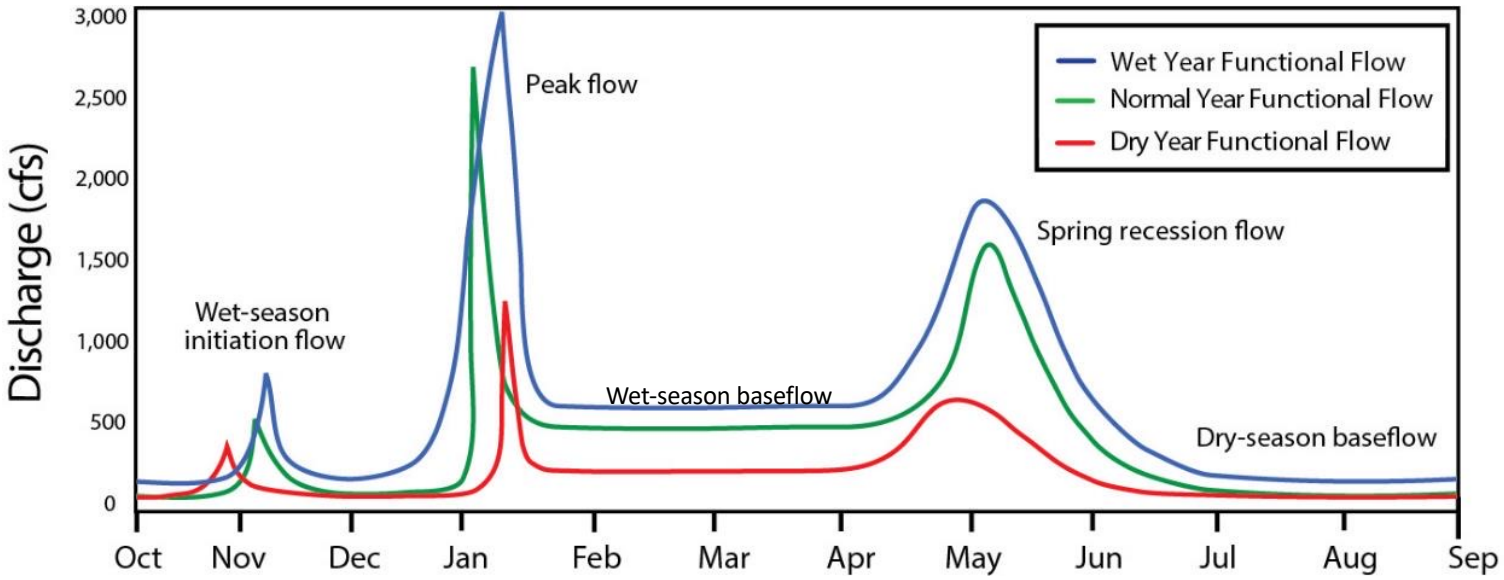


Interannual Flow Variability

Magnitude, timing and duration of each flow event varies

within its season depending on regional climatic, and

between years depending on global climate conditions

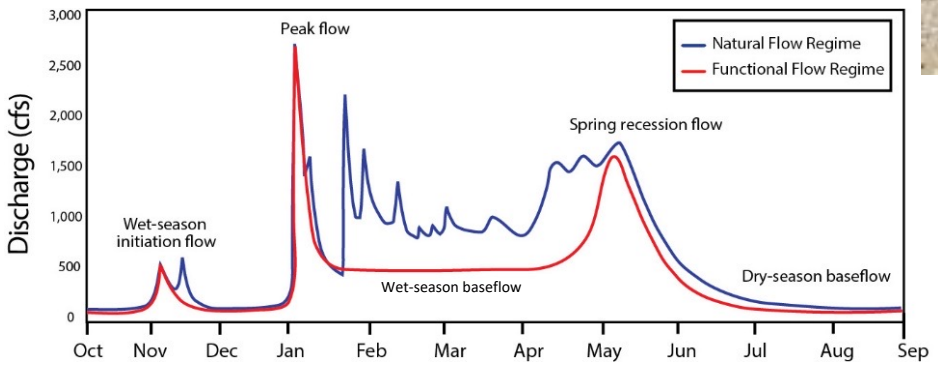


Supports diversity in geomorphic habitat and diversity in native species over the long-term

Functional Flows need to “Function”

Restoring Landscape Connections

- Physical Habitat Restoration
- “Room for the River” to move



Yarnell et al. 2015; Yarnell and Thoms, 2022

Functioning Rivers provide Resiliency

Resilient river systems provide ecosystem services for societies:

Provisioning
- products, economic

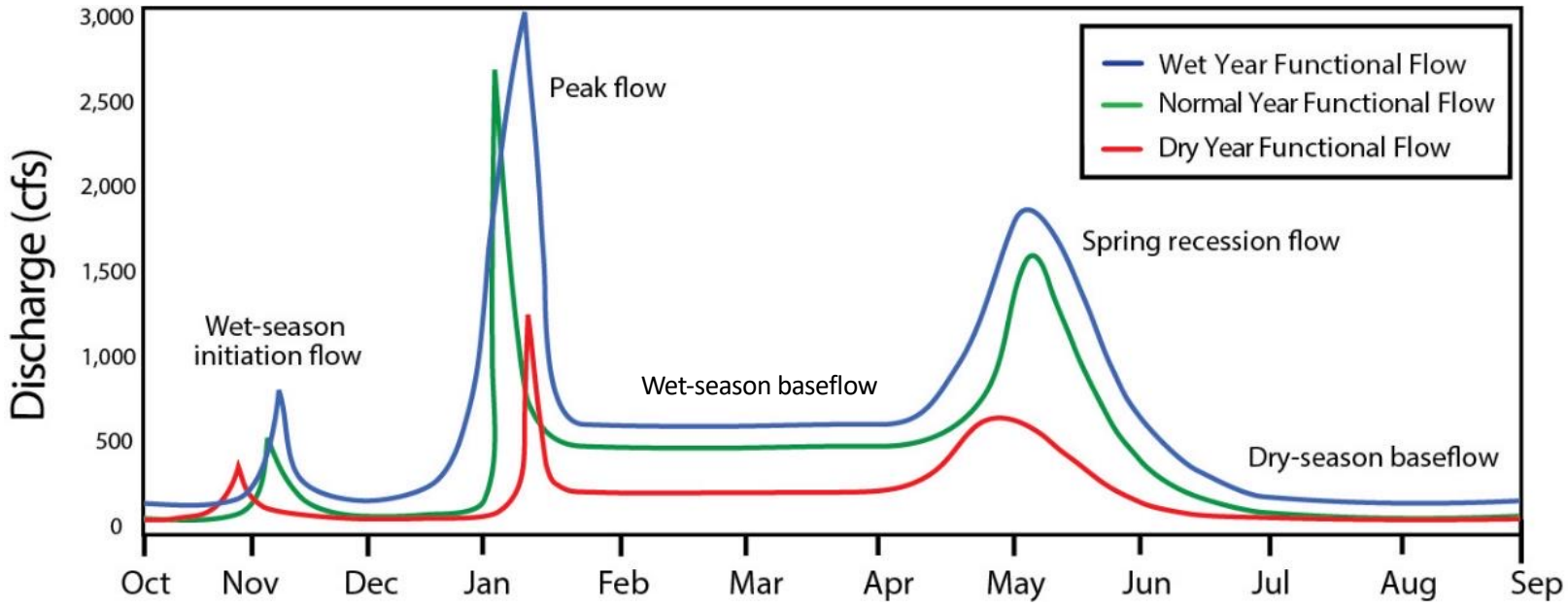
Regulating
- water quality, floods

Supporting
- ecological, nutrients, habitat

Cultural
- spiritual, recreation

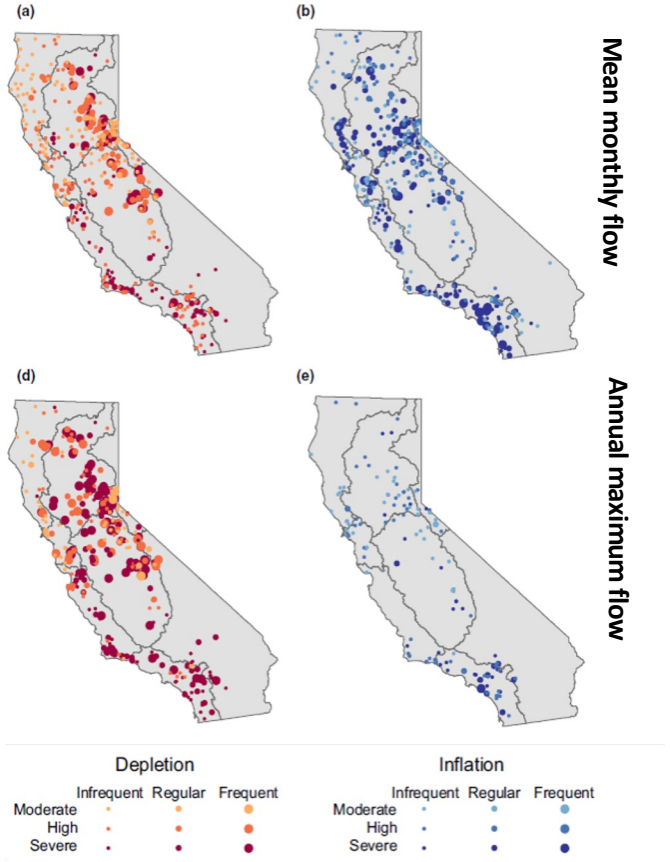
freshwaterwatch.thewaterhub.org

How to Implement Functional Environmental Flows throughout California?



Challenges to Implementation in California

- California is a very complex/diverse state
- Hard to balance environmental flows with many other demands
- 95% of gauged locations have altered flows



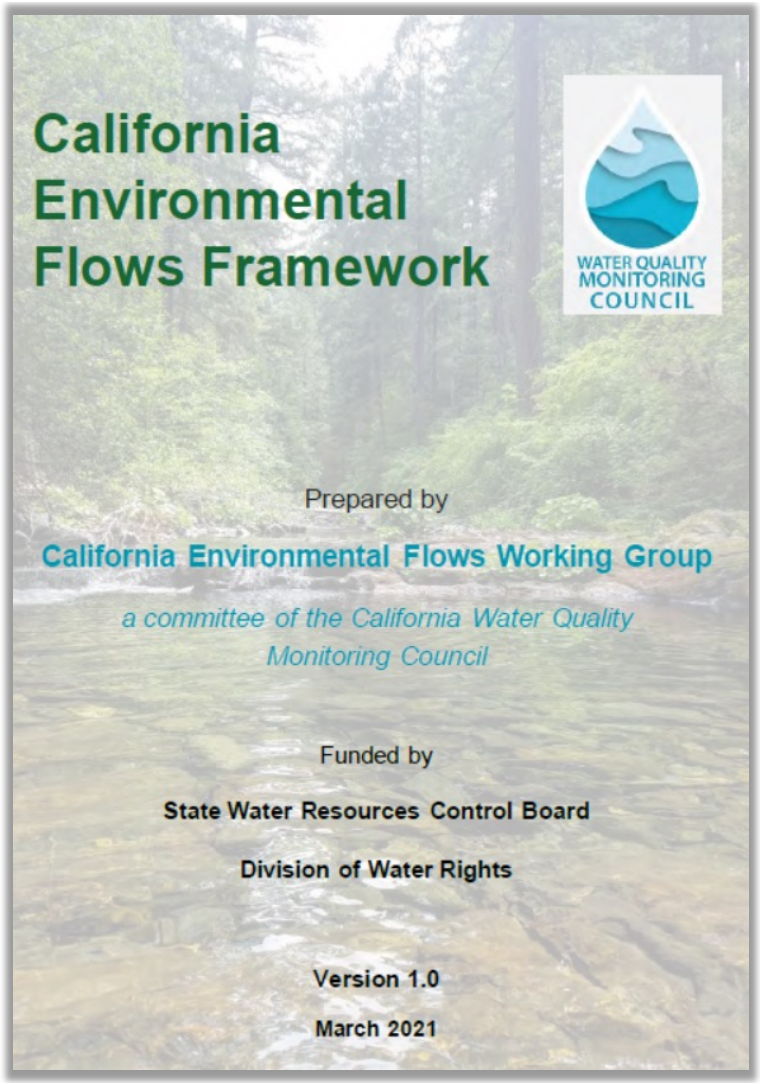
Zimmerman et al 2018

Need a Coordinated Framework

Many programs are attempting to set environmental flows

- **Different basins**
- **Different goals**
- **Different management needs**
- **Different stakeholder priorities**

- **Poor coordination**
- **Challenge sharing data**
- **Uncertainty in which methods are most appropriate**
- **Inefficiencies/redundancy in developing requirements**
- **Difficulty communicating to managers and the public**



CEFF TECHNICAL TEAM

- CA Department of Fish and Wildlife
- State Water Resources Control Board
- Southern CA Coastal Water Research Project
- The Nature Conservancy
- Utah State University
- CalTrout
- University of California, Davis
- University of California, Berkeley

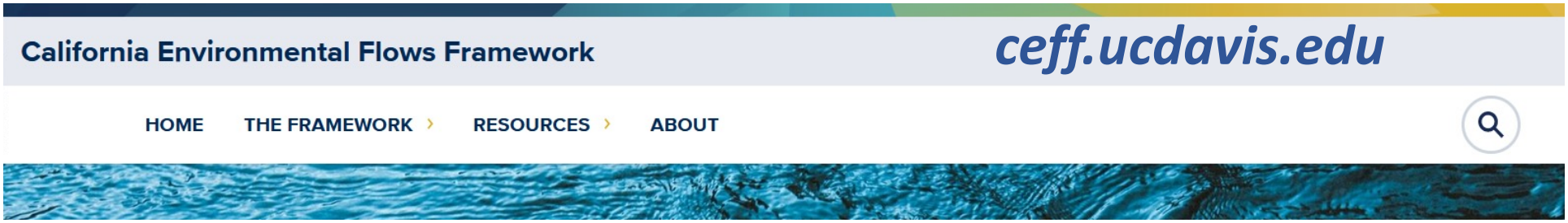
ceff.ucdavis.edu

CA Environmental Flows Framework (CEFF)

Provides technical guidance to quickly develop scientifically based environmental flow recommendations following a functional flows approach.

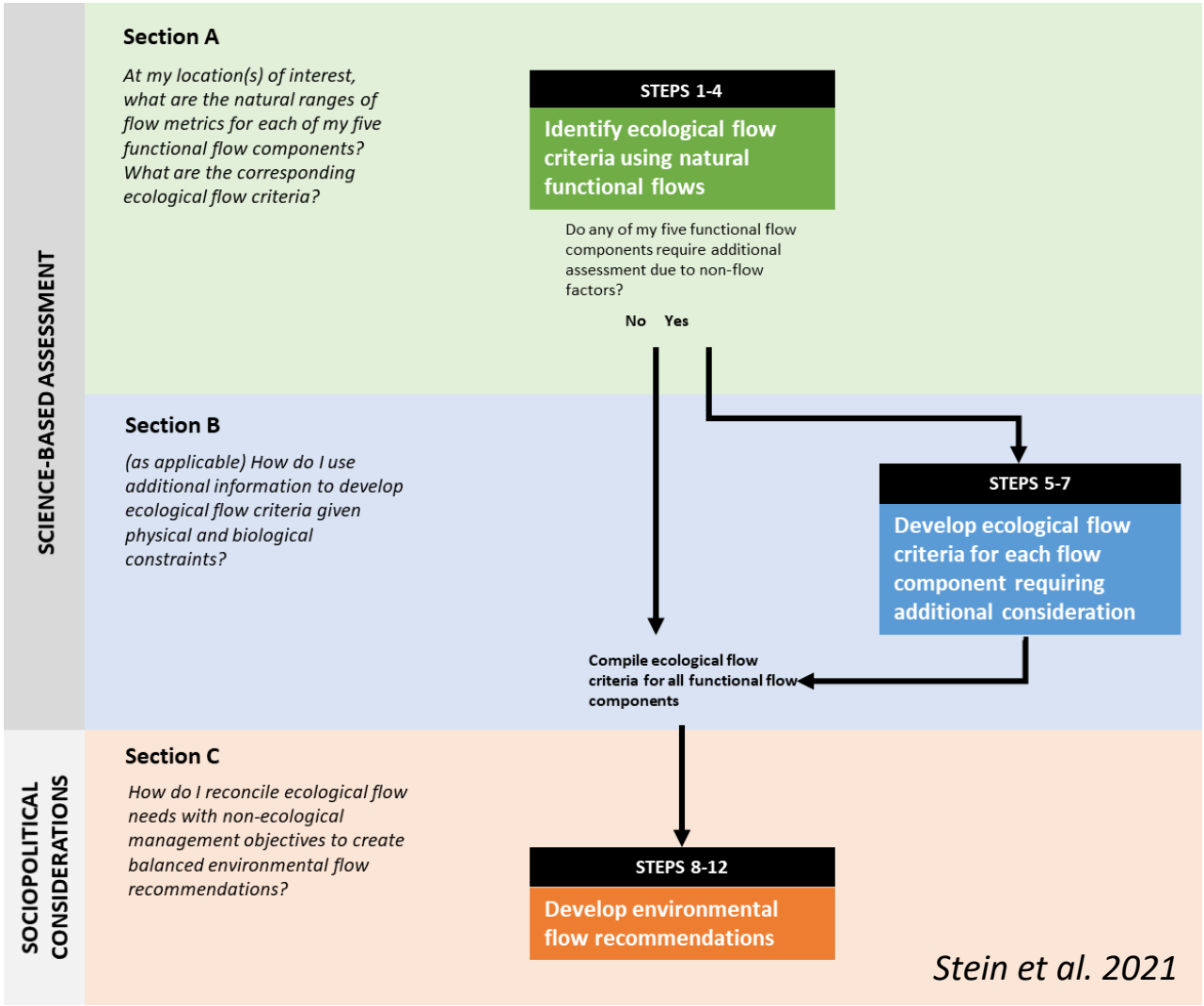
Multi-step process to define:

- **Ecological flow criteria:** Metrics describing the range of flows to be maintained within a stream and its margins to support the natural functions of healthy ecosystems
- **Environmental flow recommendations:** Metrics considering human uses and other management objectives along with ecological flow criteria



CEFF Steps Overview

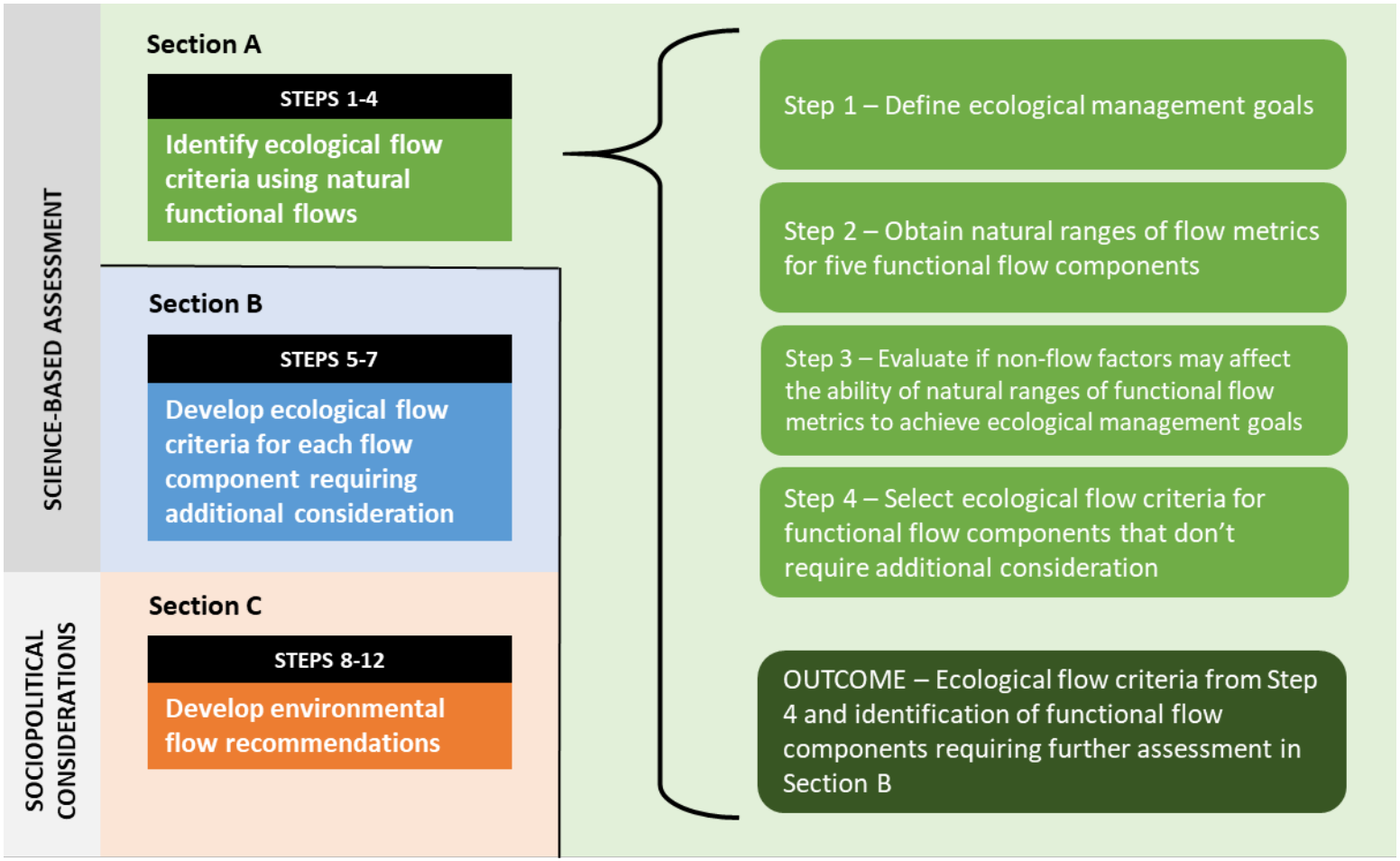
ceff.ucdavis.edu



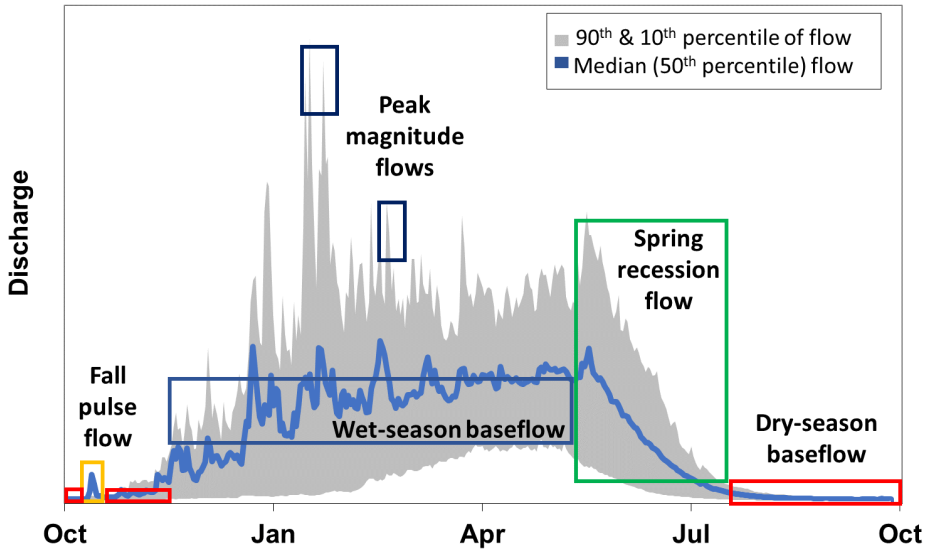
Stein et al. 2021

CEFF Section A

Natural flow metrics



Functional Flow Metrics

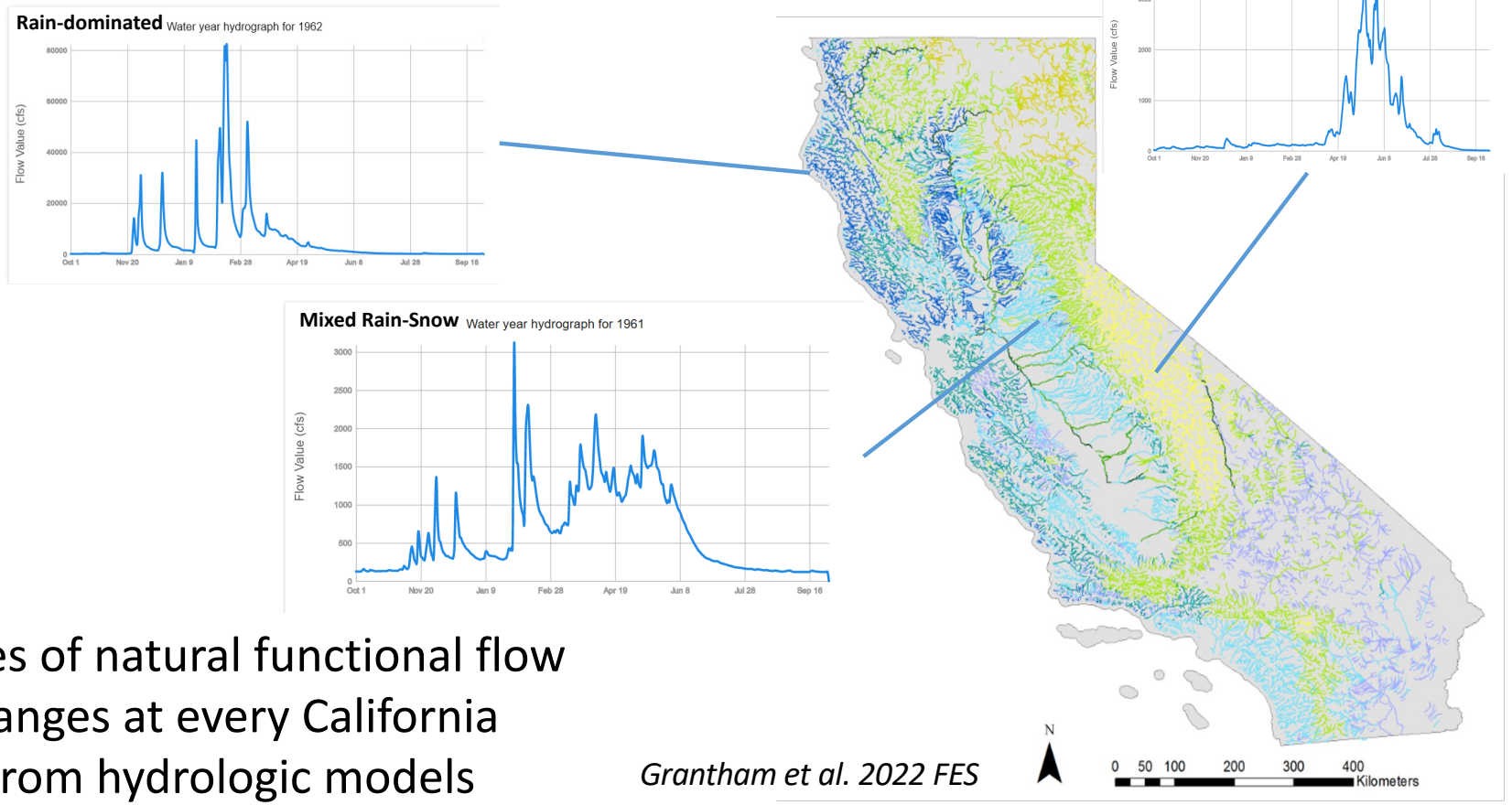


Metrics relate to general stream health based on *natural flow conditions*

Yarnell et al. 2020 RRA

Flow Component	Flow Metrics
Fall pulse flow	Magnitude (cfs)
	Timing (date)
	Duration (days)
Wet-season base flow	Magnitude (cfs)
	Timing (date)
	Duration (days)
Wet-season peak flow	Magnitude (cfs)
	Duration (days)
	Frequency
Spring recession flow	Magnitude (cfs)
	Timing (date)
	Duration (days)
	Rate of change (%)
Dry-season base flow	Magnitude (cfs)
	Timing (date)
	Duration (days)

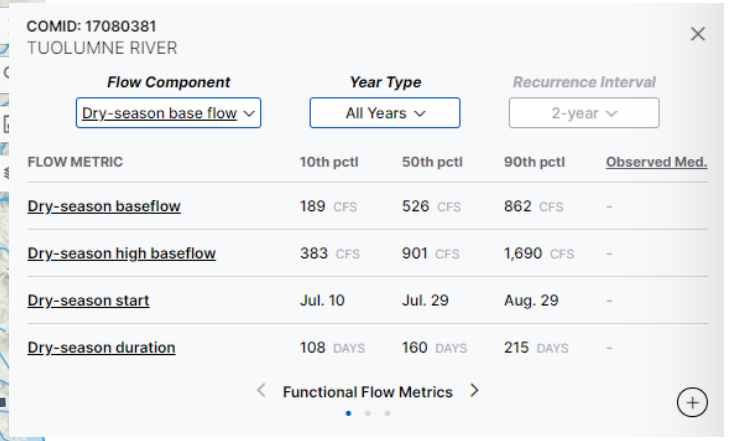
Modeled Natural Functional Flows



Estimates of natural functional flow metric ranges at every California stream from hydrologic models

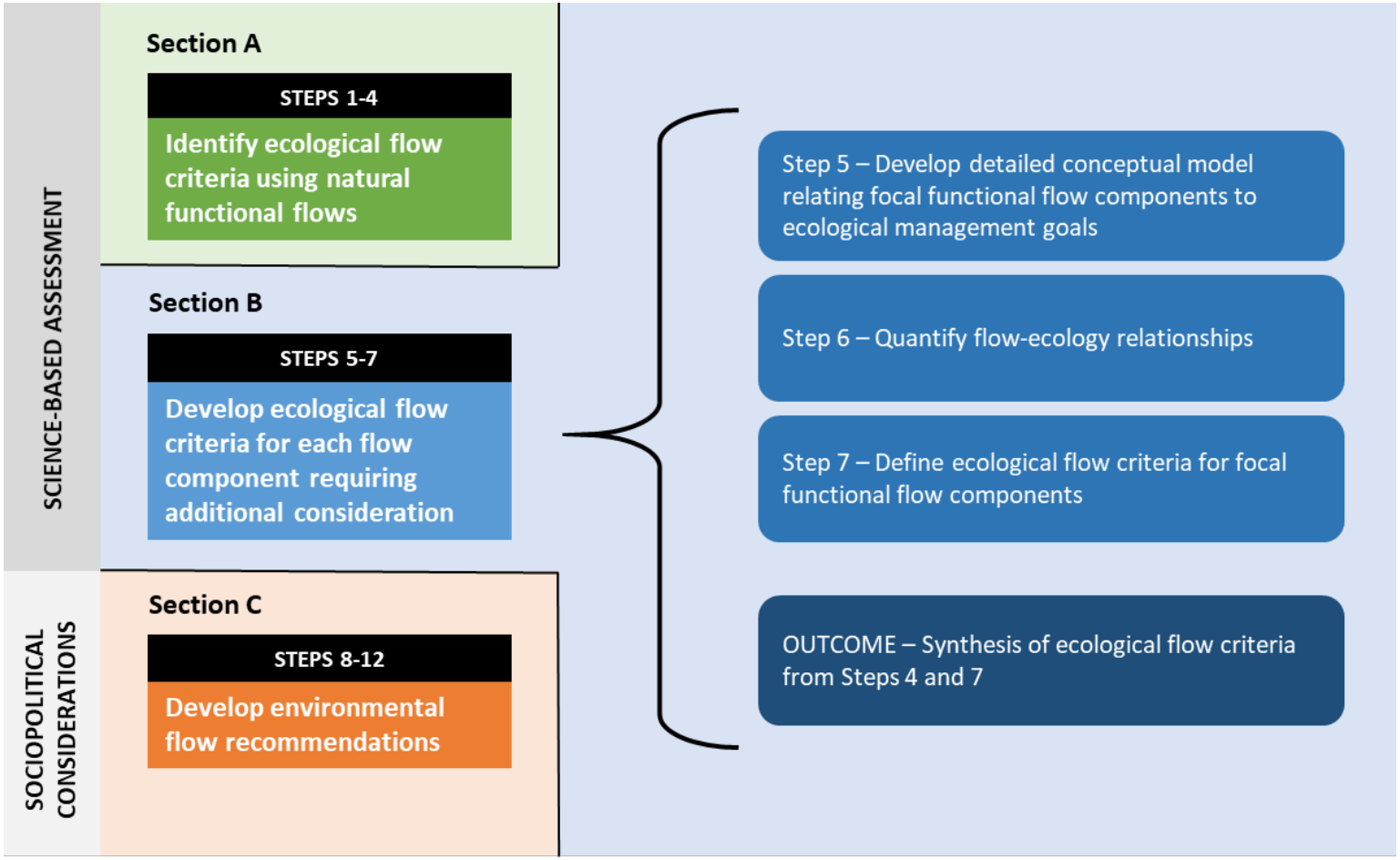
Grantham et al. 2022 FES

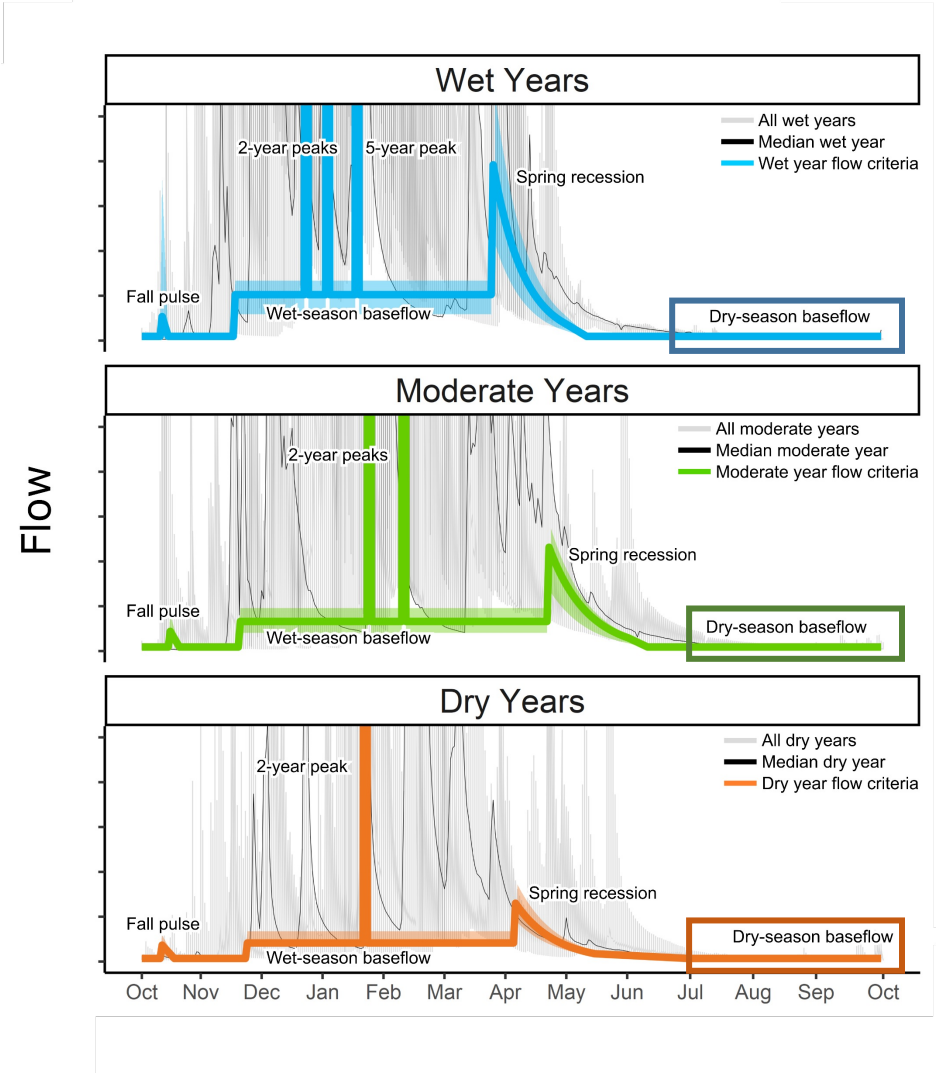
Natural Flows Web Tool: rivers.codefornature.org



CEFF Section B

Metric adjustments



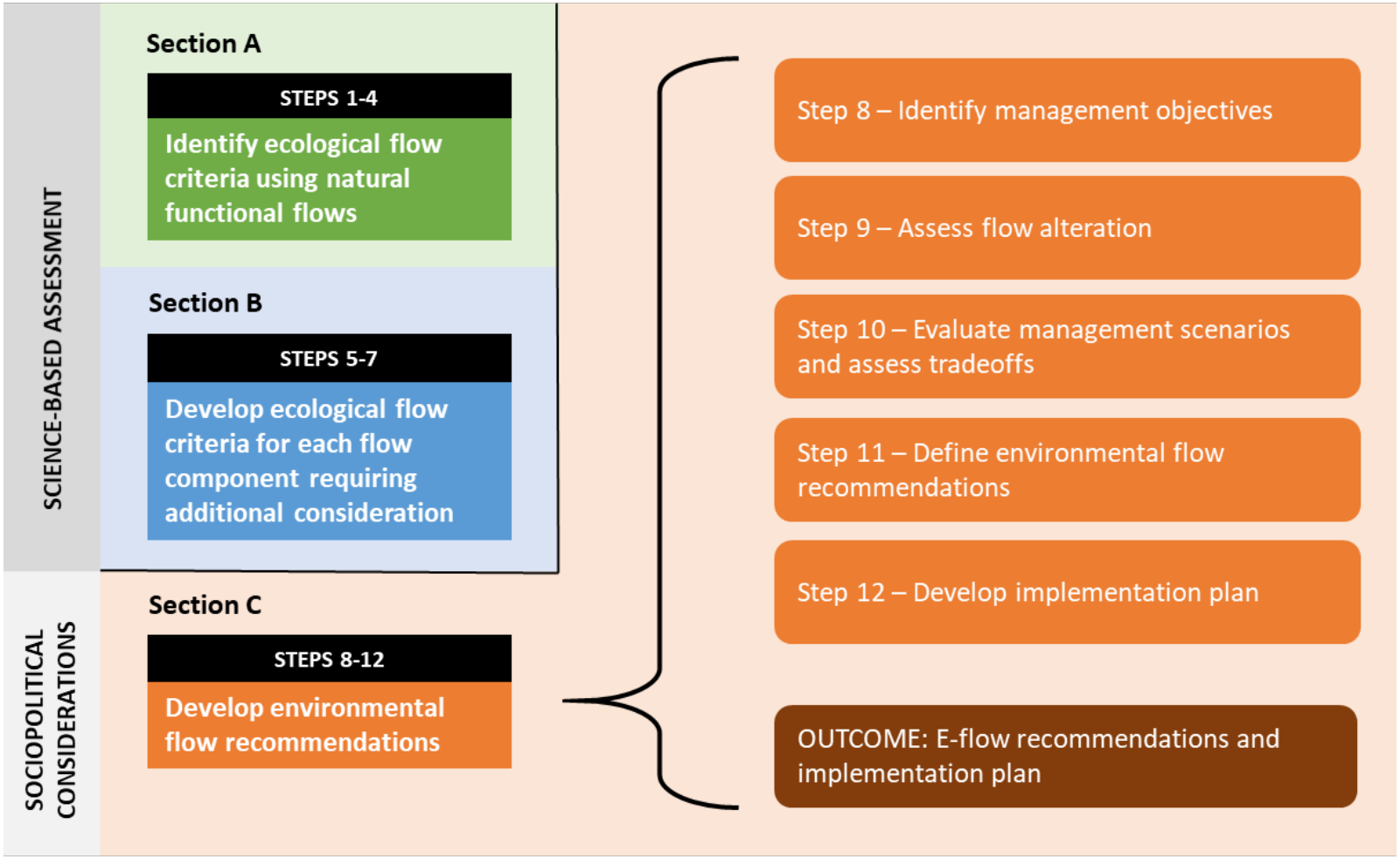


Sections A & B Outcome:

Ecological flow criteria provides measurable objectives that vary by water year type

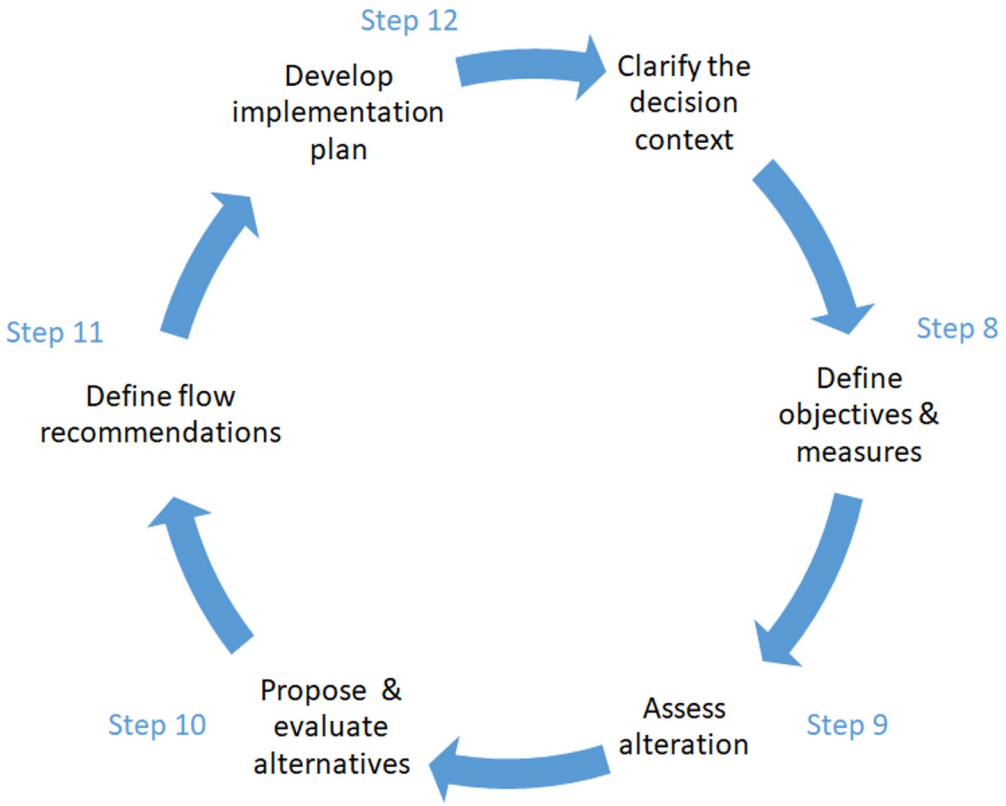
CEFF Section C

Trade-offs & Plans



Section C
Develop Environmental Flow Recommendations

Adaptive Management Cycle



Outcomes of CEFF

- Ecological flow criteria
  - Required by multiple regulatory processes (federal, state, local)
- Environmental flow recommendations (via community process)
- Guidance for implementation, monitoring and adaptive management plans
- Online web tools:
  - natural flows database (rivers.codefornature.org)
  - information repository (ceff.ucdavis.edu)

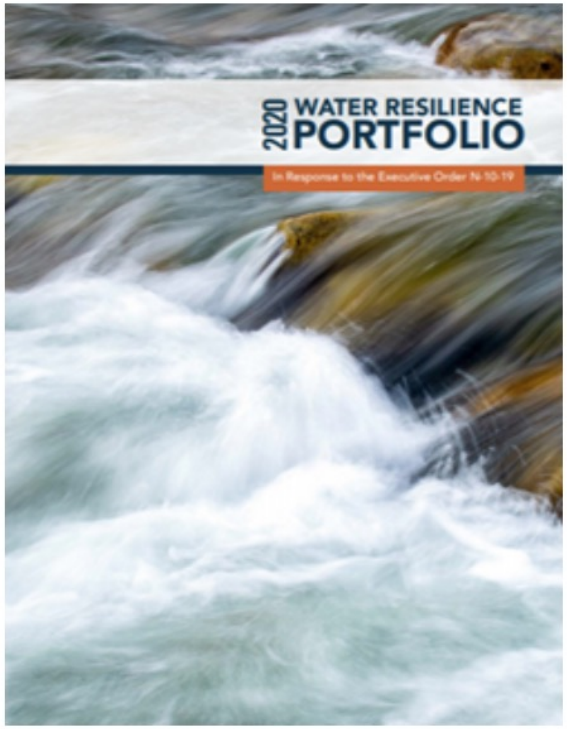
CEFF Implementation in California

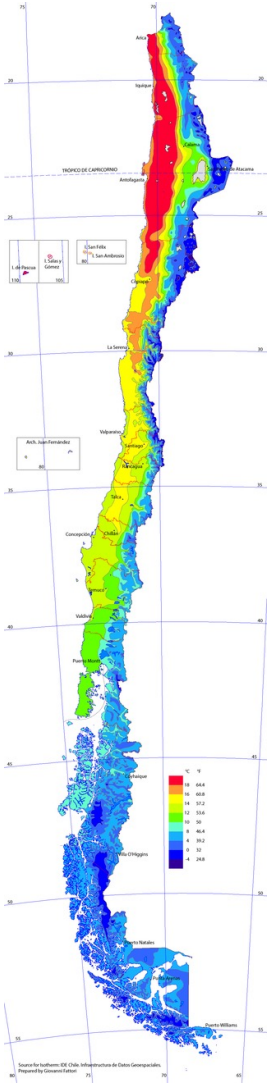
Supported by CA Natural Resource Agencies

- Part of Governor's Water Resilience Portfolio Program
- Incorporated in CDFW's Instream Flow Program, Instream flow recommendations
- Incorporated in SWB's Cannabis Program

Multiple case studies completed and under development

- Little Shasta, Cosumnes, Napa River – groundwater-surface water interactions (SGMA)
- SF Eel River – flow diversions for cannabis permits
- Los Angeles River – flow assessment and impacts for restoration efforts
- Southern California – flow requirements for water quality

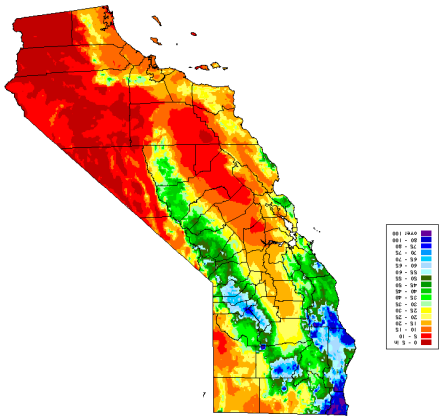




Portfolio Approach for diverse rivers

Jay Lund

University of California - Davis



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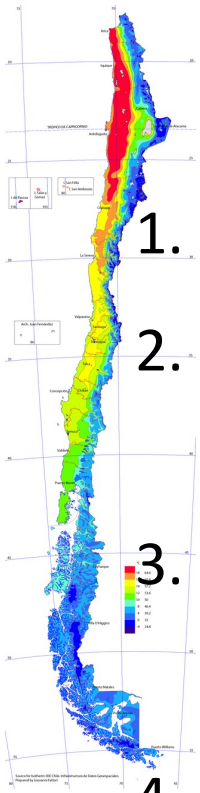
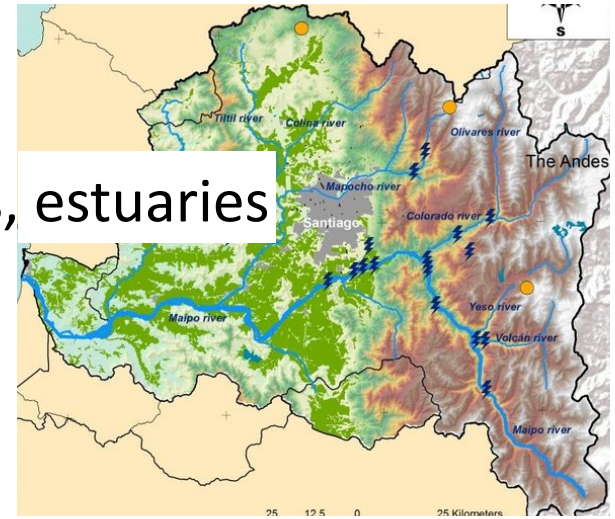


Flows for Chilean ecosystems

1. 130 river basins from 18 degrees to 55 degrees of latitude



2. Range of local river environments:

   Headwaters, tributaries, middle reaches, estuaries

3. Infrastructure and operations:

   Reservoirs, diversions, dams, weirs, etc.

4. Range of ecosystems, water uses, infrastructure, and operations

5. Why would a fixed set of flows work well?

Portfolio Elements

Multiple barrier portfolios for waterborne diseases

Multiple-barriers Infrastructure	Multiple Accountability
1. Banned/regulated chemicals and activities	Local water utility, elected boards
2. Source protection: Rivers, lakes, reservoirs, groundwater	Public health agencies
3. Drinking water treatment	State regulators
4. Distribution system	Federal regulators
5. Public health system	Professional societies
	Universities, NGOs, media

Water supply system portfolio actions

Water supply	
Water Source availability	**Treatment**
Capture of fog, precipitation, streams, groundwater, wastewater	Existing water and wastewater treatment
Protection of source water quality	New water and wastewater treatment
Conveyance capacities	Wastewater reuse
Canals, pipelines, aquifers, tankers (sea or land), bottles, etc.	Ocean Desalination
	Contaminated aquifers
Storage capacities	**Operations**
Surface reservoirs, aquifers and recharge, tanks, snowpack, etc.	Reoperation of storage and conveyance
	Conjunctive use
Water demands and allocation	
Agricultural use efficiencies and reductions	Ecosystem demand management
Urban water use efficiencies and reductions	Recreation water use efficiencies
Incentives to work well together	
Pricing	Subsidies, taxes
Markets	Education
"Norming", shaming	

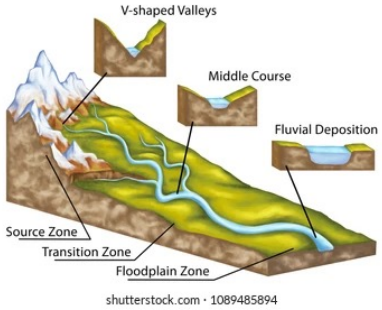
Flood management - portfolio of actions

Preparatory actions	
Protection	**Vulnerability reduction (reduced damage and casualty potential)**
Levees	Relocation of vulnerable human activities
Flood walls and doors	Floodplain zoning and building codes
Closed conduits	Floodproofing–raising structures, sacrificial first floor, flood doors
Channel improvements and flood corridors	Flood warning and evacuation systems
Reservoirs	Flood insurance and reinsurance
Bypasses	Flood risk disclosure
Sacrificial flooding	Public and policymaker education
Flood easements (bypasses, designated flood areas)	Flood preparation and training exercises
Local detention basins, drainage, and pumps	Floodplain mapping, gaging, data collection
Regular inspections, assessments, and maintenance	Community engagement and multi-hazard planning
Response actions	
Levee and flood wall monitoring	Warnings, evacuation calls, and emergency mobilization
Flood fighting–sandbagging, sheet pile installation, wave wash protection, splash cap installation, ring levee construction, relief cut, pumping, and breach closure	High water staking
Flood door closure and gate operation	
Reservoir operation–including coordinated operations, rule curve operations and encroachment, flash board installation, surcharging	
Recovery actions	
Reconstruction and repair of flood infrastructure	Flood damage assessment–flood infrastructure surveys, system performance, damage, response costs
	Flood insurance and reinsurance
	Reconstruction and repair
	Relocation/reconstruction to reduce future vulnerability

Also need portfolios for ecosystem management?

Managing portfolios across sectors?

Main conclusions



1. The world is struggling to make river flows better for ecosystems

2. Chile has diverse climates, ecosystems, and human uses in its many rivers

3. CEFF is a good adaptable approach to environmental flow regulation

4. Current Chilean regulation is rather fixed

5. How could Chilean flow regulations support more variable and adaptable environmental flows?

6. Portfolios of actions can improve performance, compromises, and adaptability.