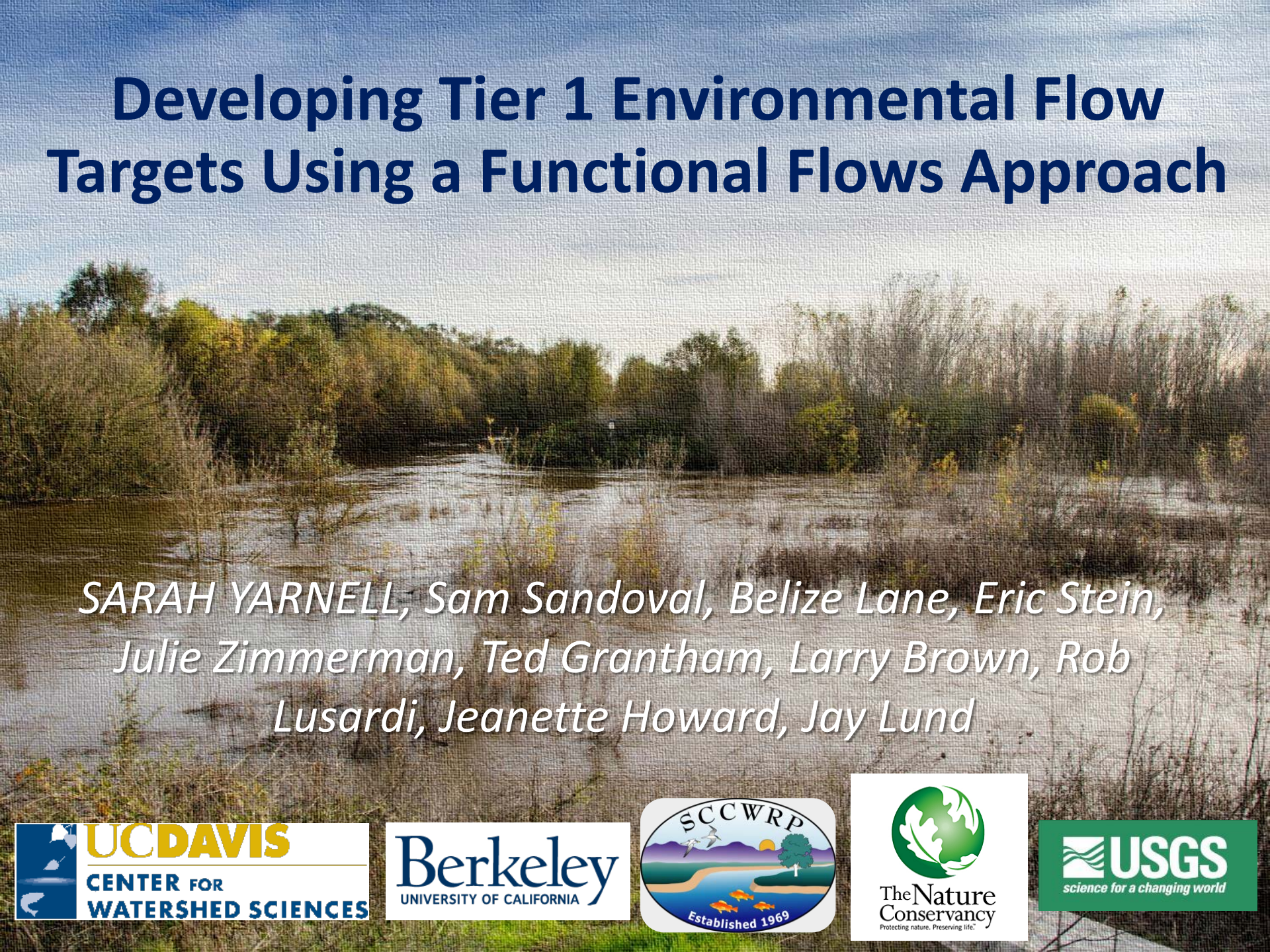
Developing Tier 1 Environmental Flow Targets Using a Functional Flows Approach



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Berkeley UNIVERSITY OF CALIFORNIA

SCCWRP Established 1969

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Tier 1 Environmental Flow Targets

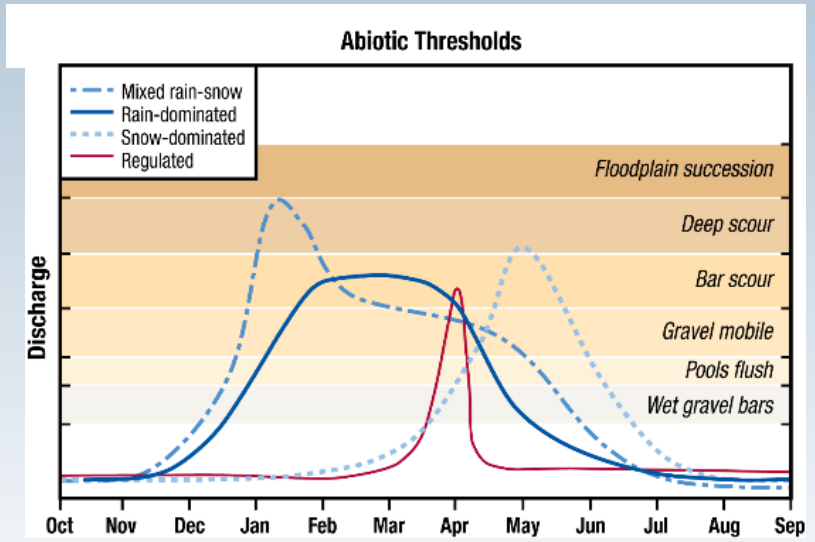
- Single method statewide based on functional flows approach
- Science-based analysis focusing on:
  - Stream classification
  - Dimensionless Reference Hydrographs
  - Functional flow metrics and ecological endpoints
- Resulting e-flow targets: rapid, coarse, comprehensive across state

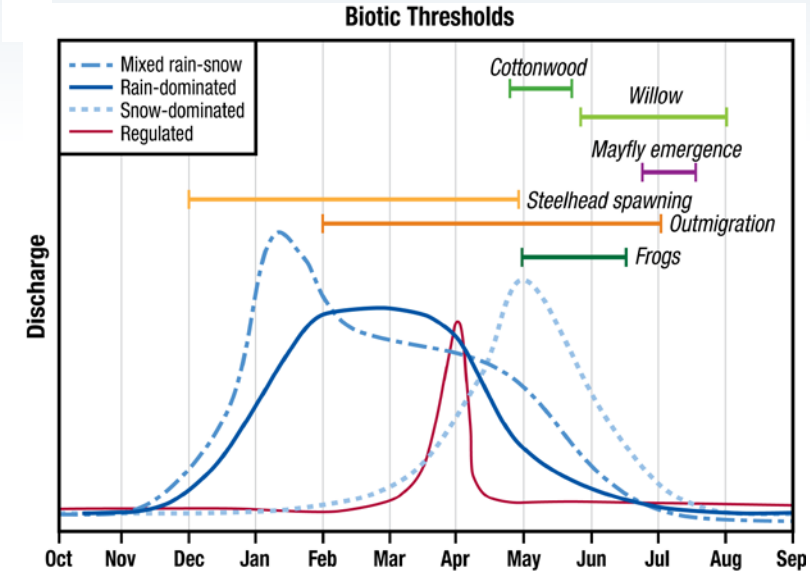
Functional Flows Approach

Focus on hydrograph flow components that:

- Support natural disturbances
- Promote physical dynamics
- Drive ecosystem functions
- Support high biodiversity

Consideration of geomorphic setting and channel-floodplain dynamics

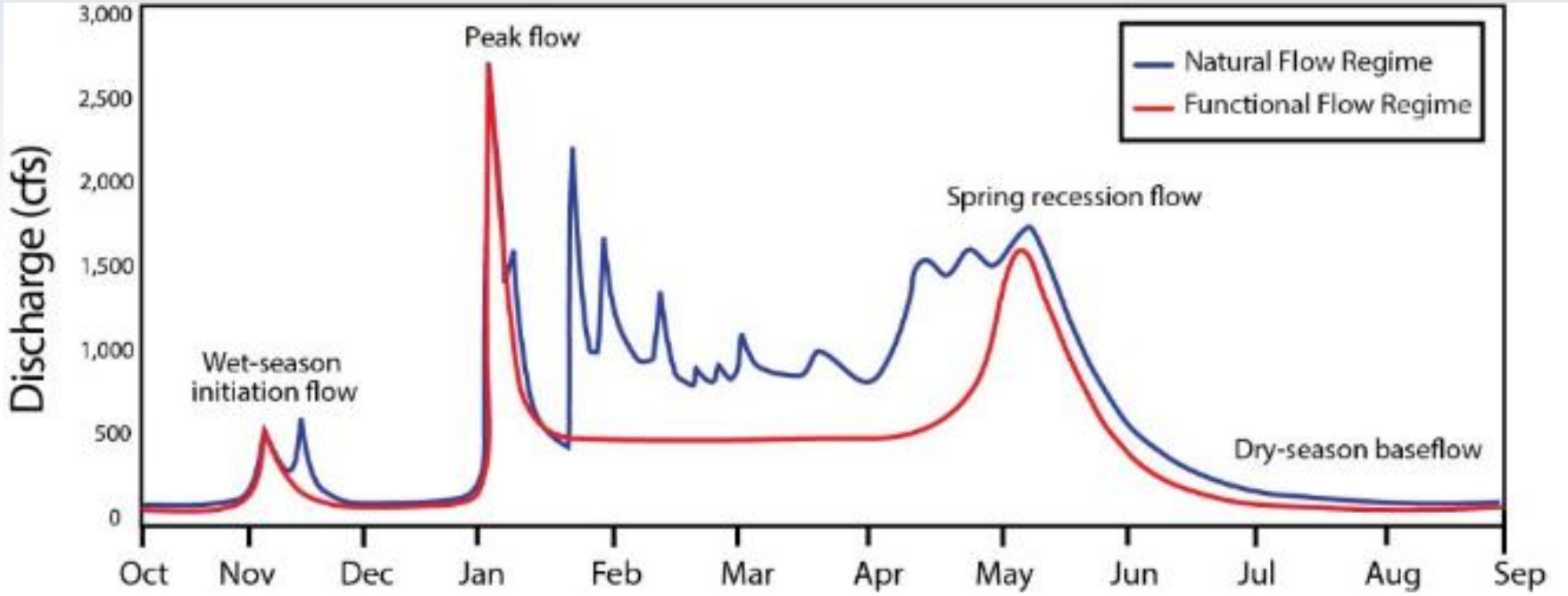




(Yarnell et al. 2010)

Functional Flows Approach

- "Functional Flow" = hydrograph component that provides a distinct geomorphic, ecologic or biogeochemical function
- Reflective of natural patterns that occur in space & time

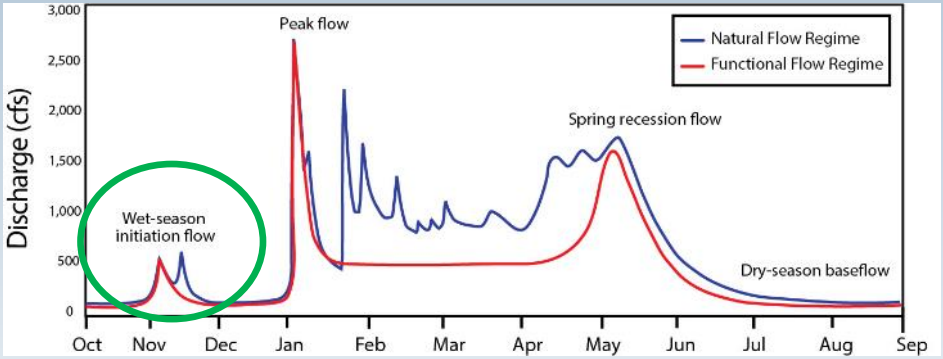


Yarnell et al. 2015

Wet Season Initiation Flow

First Flushing Flow

- prepares riverscape by:
  - clearing channel bed of organics, fine sediment
  - reconnecting channel-riparian-floodplain habitats
  - reactivating exchanges with hyporheic zone
- kick-starts ecological processes such as nutrient cycling
- provides key ecological cues for native species to migrate upstream

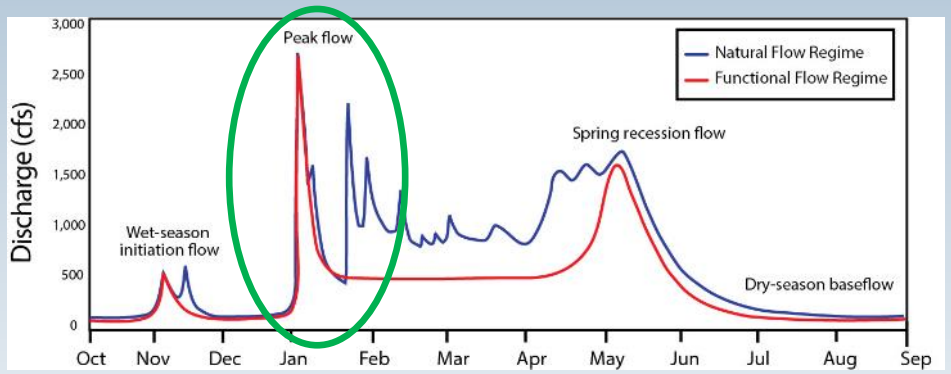


Cosumnes River, CA

Delta Smelt

Peak Magnitude Flow

- Primary geomorphic disturbance
- Resets natural processes such as succession
- Redistributes large volumes of sediment
- Prevents vegetation encroachment
- Reduces extent of exotic species not adapted to disturbance regime
- Most effective when given SPACE – levee setbacks, levee breaches to floodplain, tributary junctions

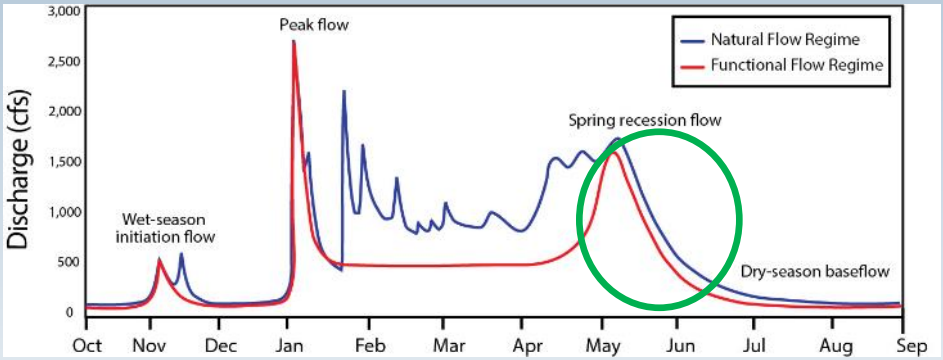


Cosumnes River, CA levee breaches

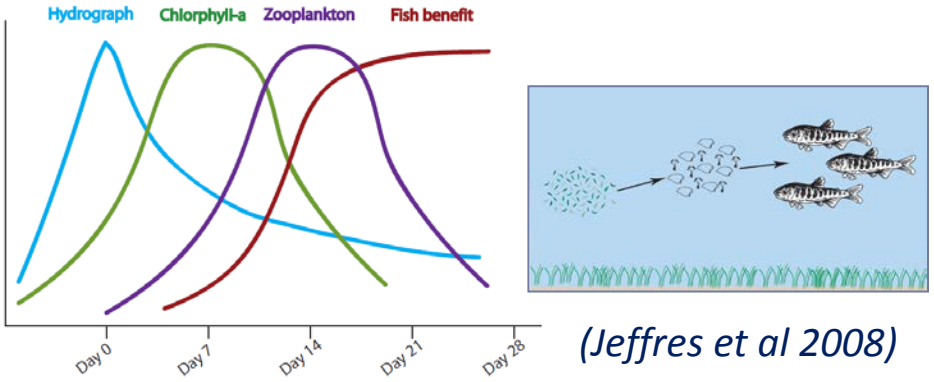
Spring Recession Flow

High to Low Flow Transition

- Redistributes and sorts sediment mobilized by high flows
- Limits riparian vegetation encroachment
- provides distinct annual cues for native species to reproduce and outmigrate
- Extended floodplain inundation



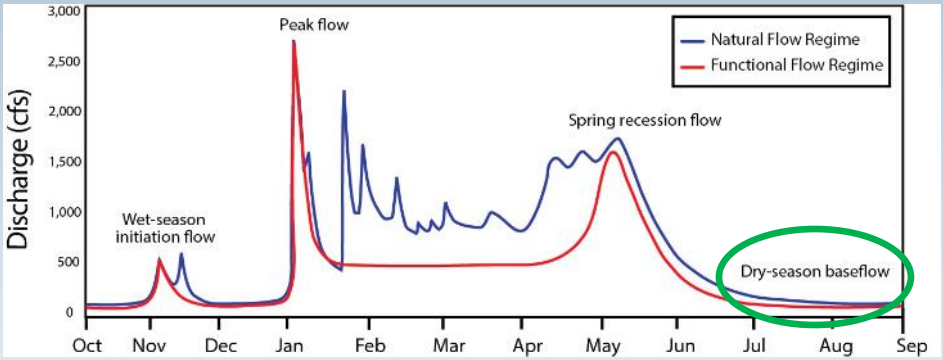
Sacramento River, CA



(Jeffres et al 2008)

Dry Season Low Flow

- Driver of seasonal river ecosystems
- Dictates extent and quality of physical instream habitat
- Creates ecological niche partitioning with native species utilizing refugia
- More effective when geormorphic diversity provides varied refugia
- Reduces extent of exotic species not adapted to limiting conditions

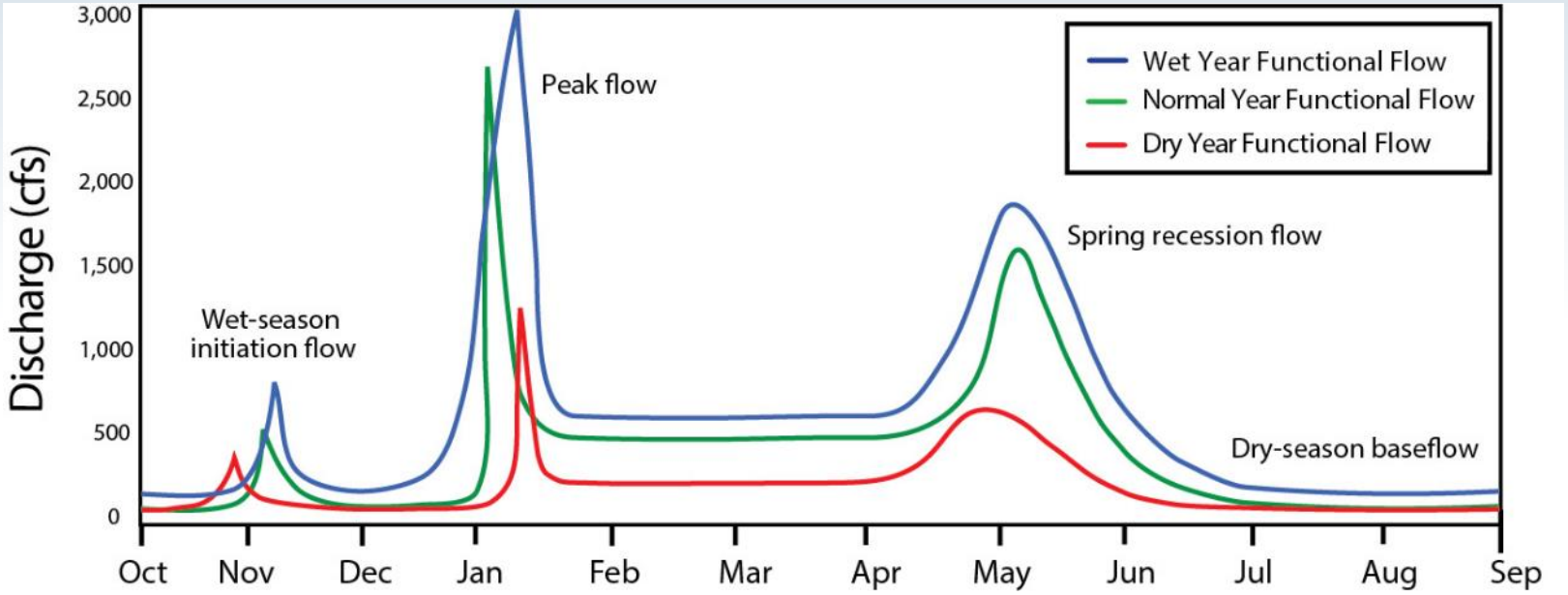


Santa Clara River, CA

Interannual Flow Variability

Magnitude, timing and duration of specific flow events vary:

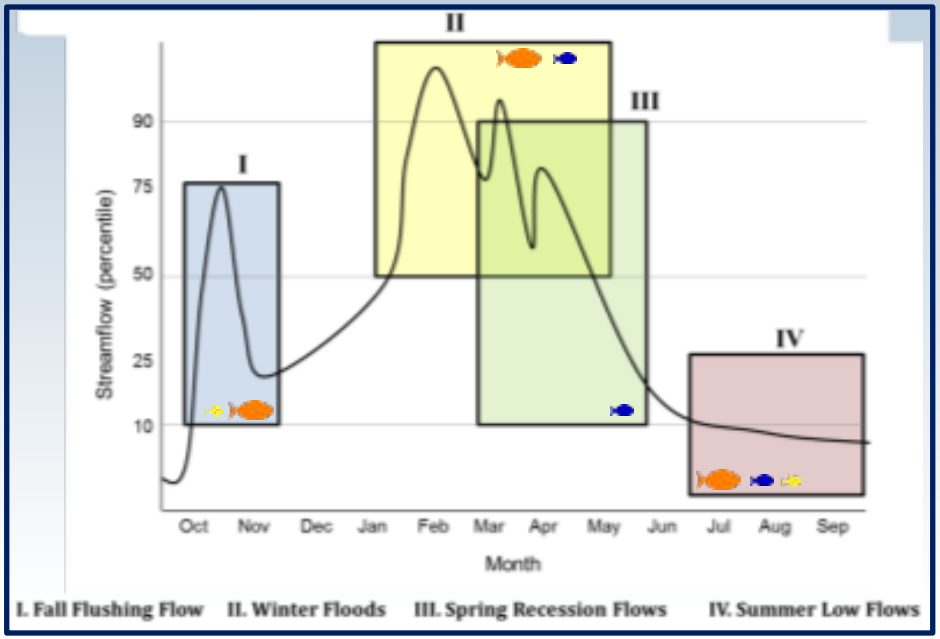
within their associated season depending on regional climatic conditions, and *between* years depending on global climate conditions



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

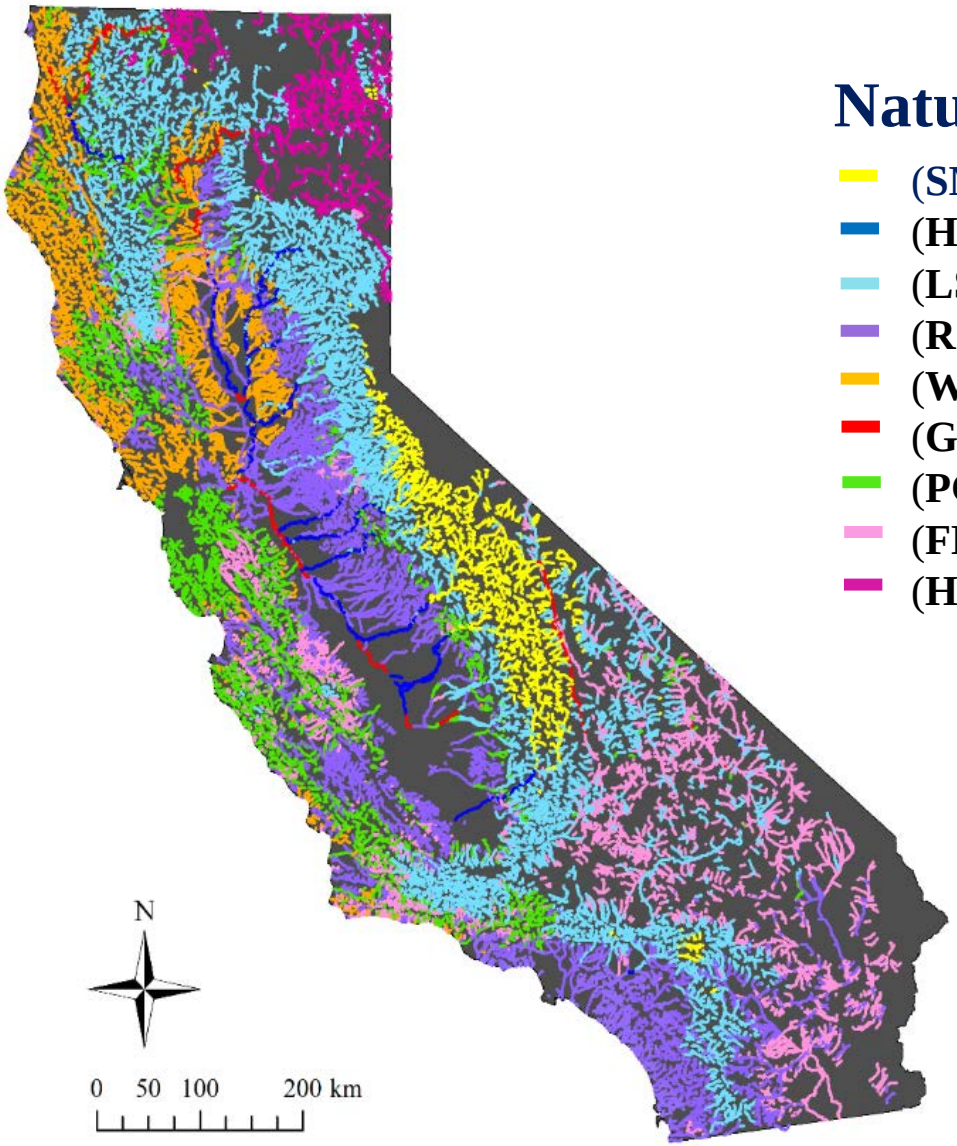
Functionality in Practice

- Develop a non-dimensional hydrograph for a hydrologic stream class
- Magnitude, duration set by statistical variability of unimpaired system
- Timing set by aquatic species needs
- Flow targets set based on water year type



Example hydrograph for a hydrologic stream class with key functional flows required for a particular group of aquatic species

Hydrologic Classification



Natural Flow Classes

- (SM) Snowmelt
- (**HSR**) High-volume snowmelt and rain
- (**LSR**) Low-volume snowmelt and rain
- (**RGW**) Rain and seasonal groundwater
- (**WS**) Winter storms
- (**GW**) Groundwater
- (**PGR**) Perennial groundwater and rain
- (**FER**) Flashy, ephemeral rain
- (**HLP**) High elevation, low precipitation

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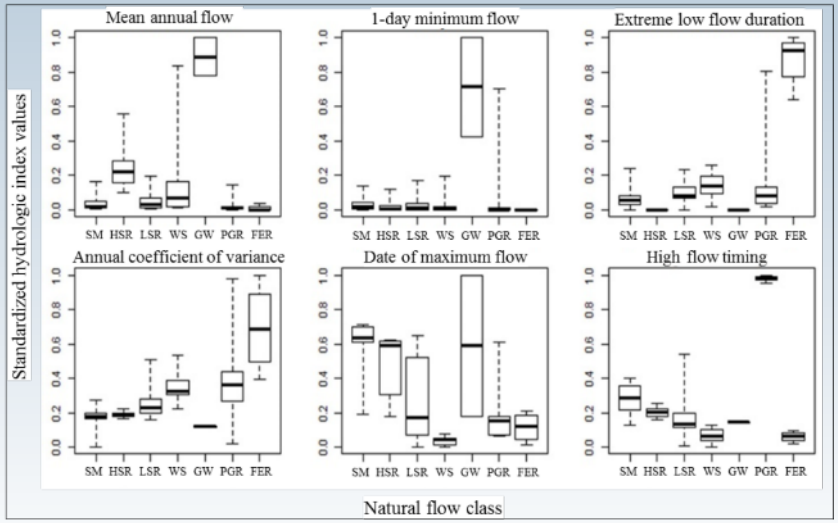
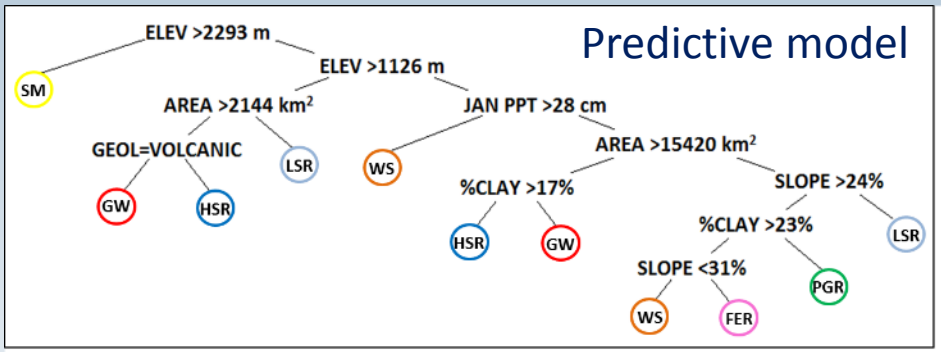
Hydrologic Classification

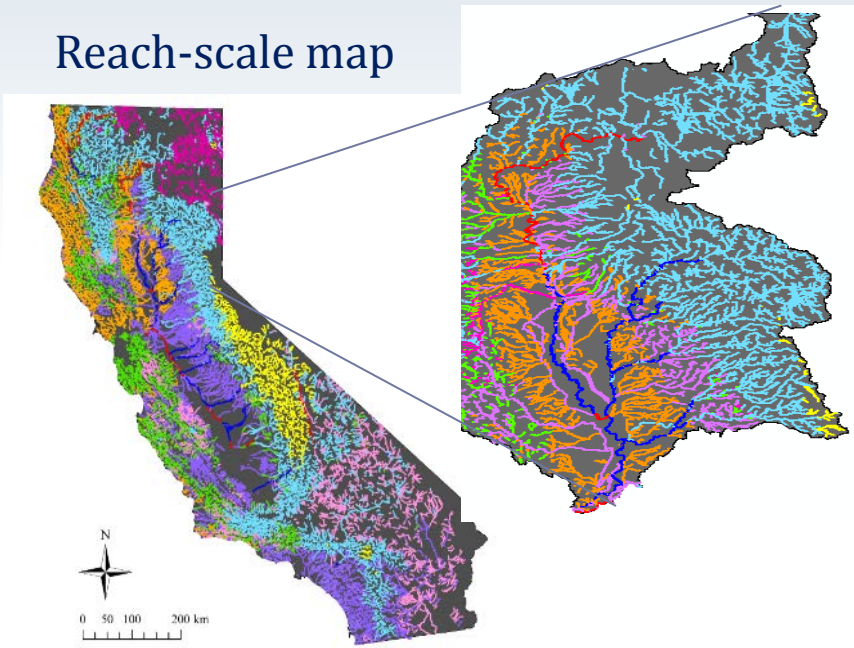
Hydrologic attributes



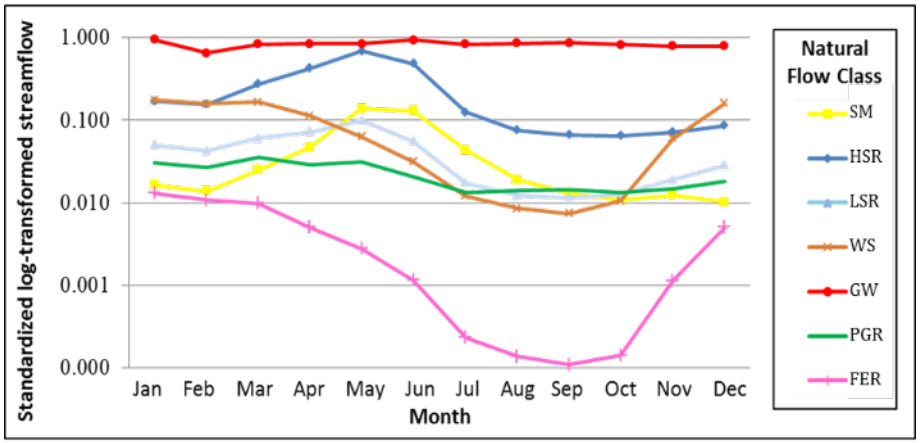
Predictive model



Reach-scale map

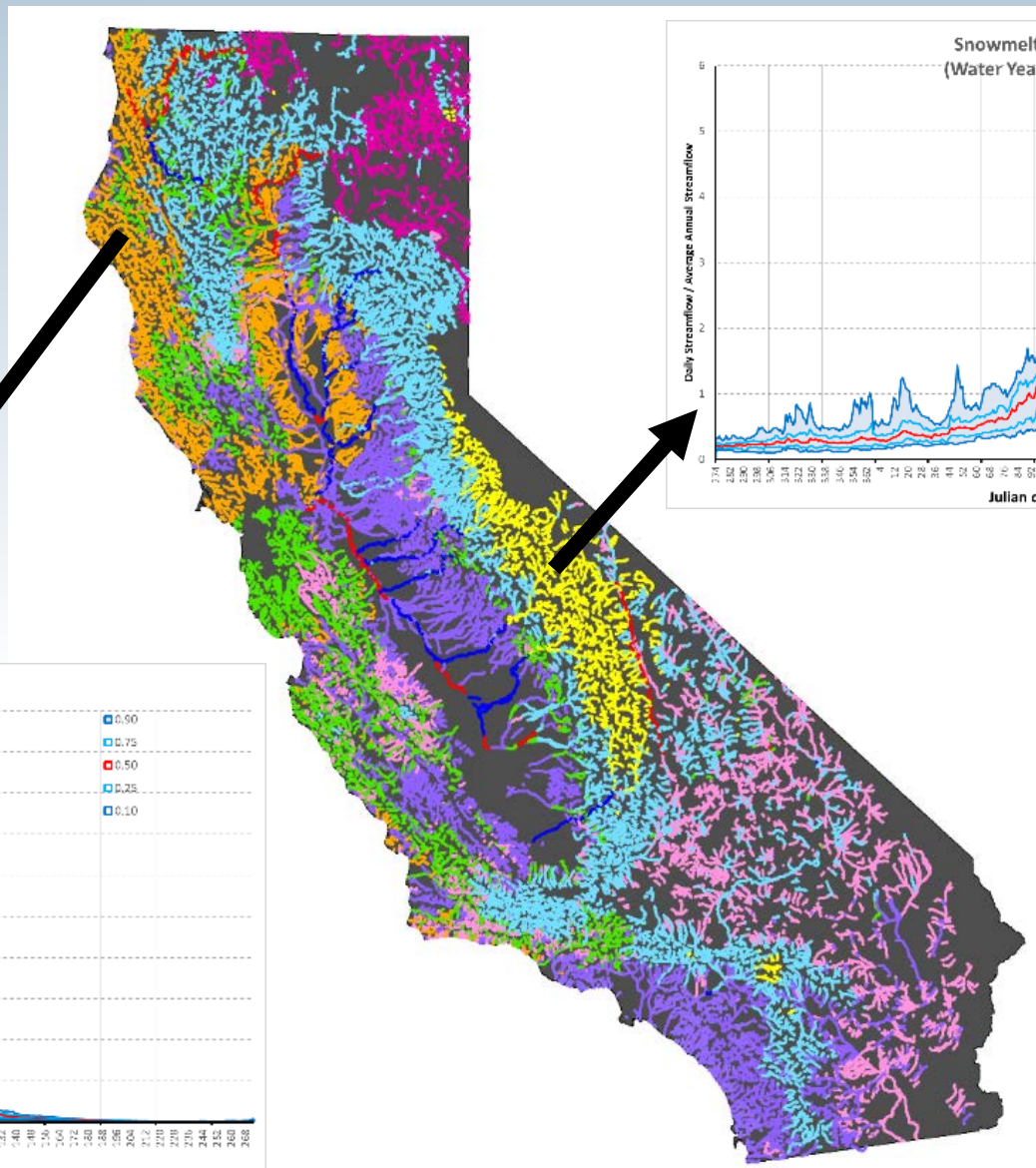


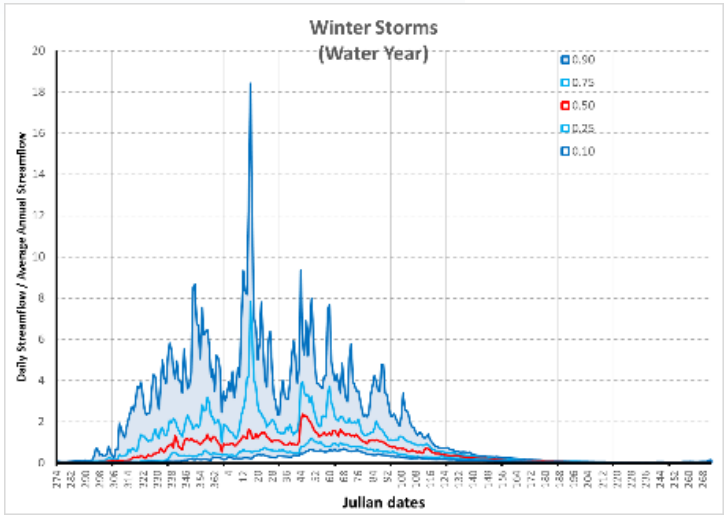
Seasonal variability and relative magnitude of flow



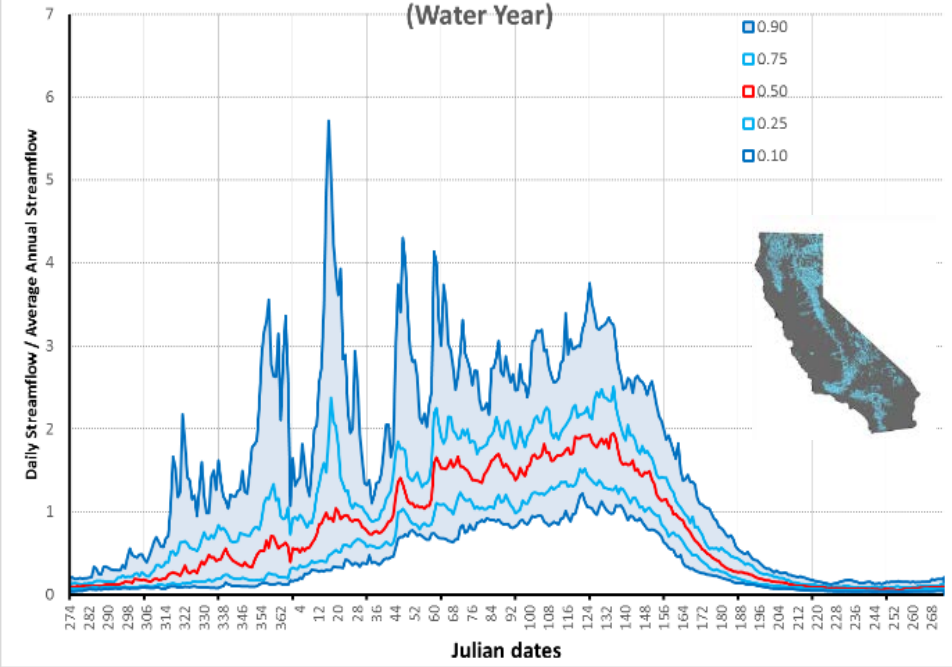
Lane et al. 2016; Stein et al 2016

Dimensionless Reference Hydrographs

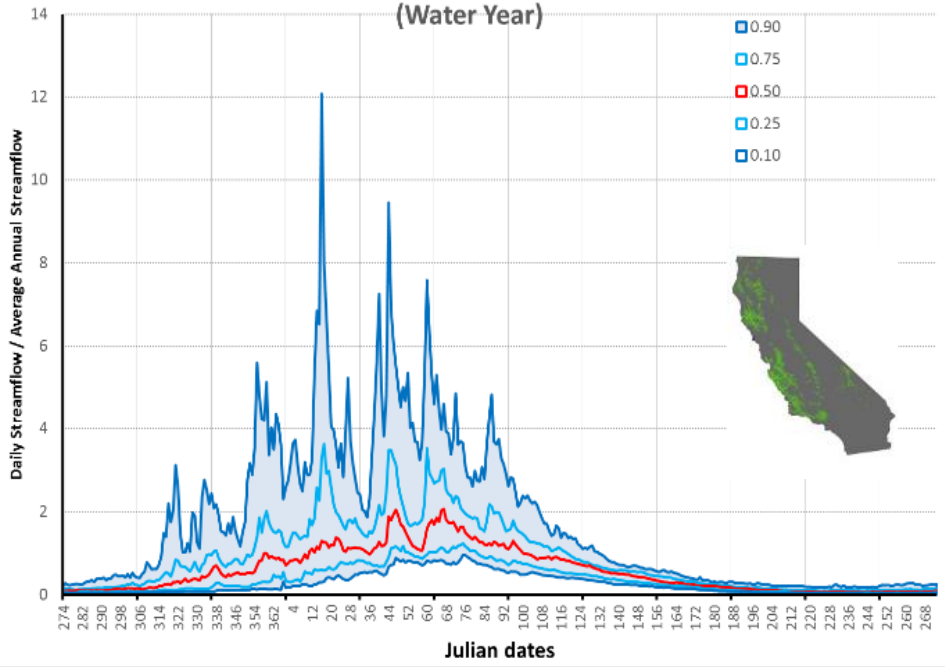




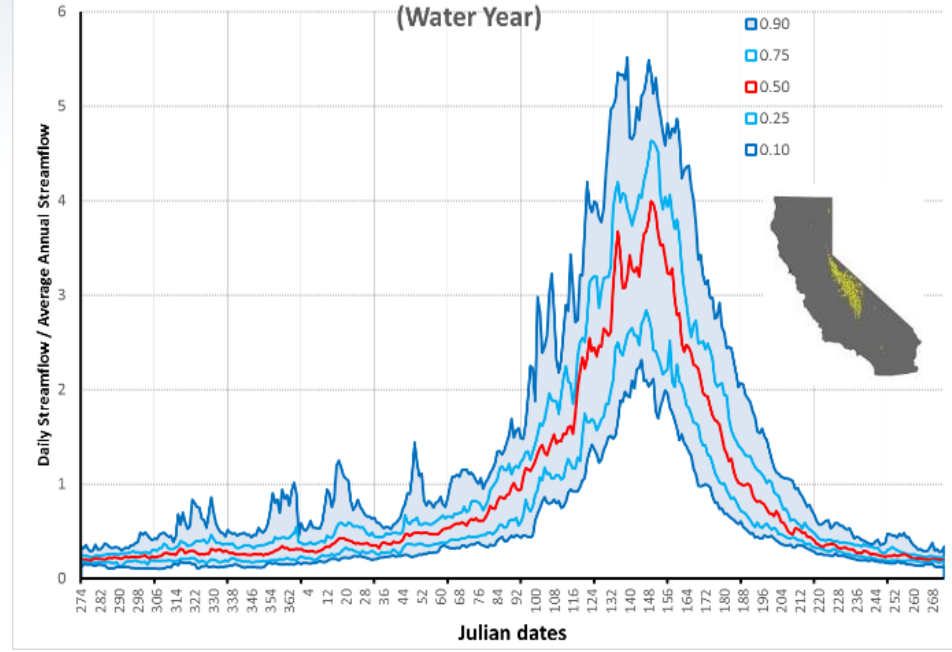
Low Volume Snowmelt and Rain (Water Year)



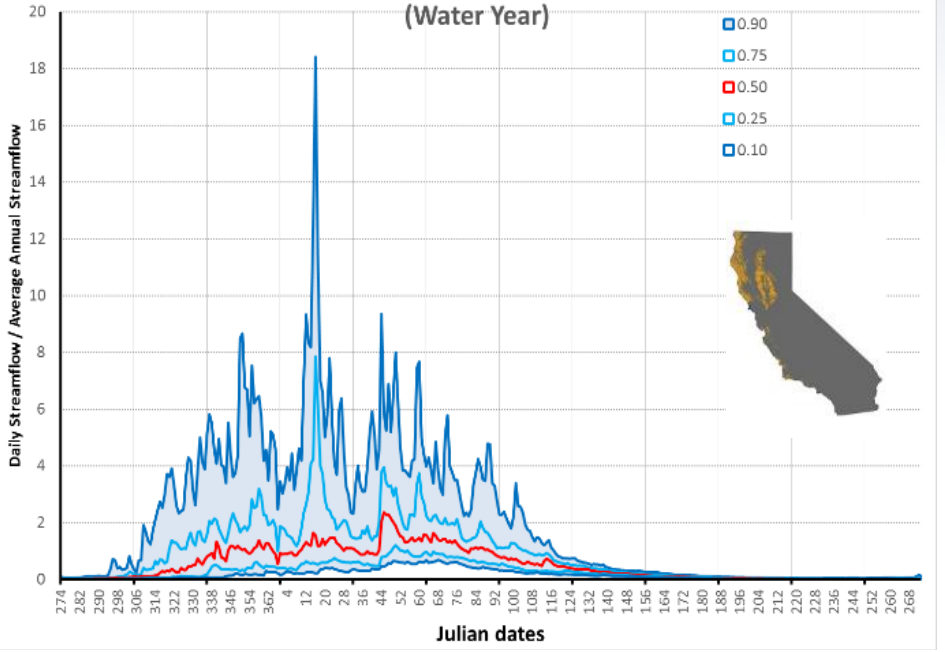
Perennial Groundwater and Rain (Water Year)



Snowmelt (Water Year)

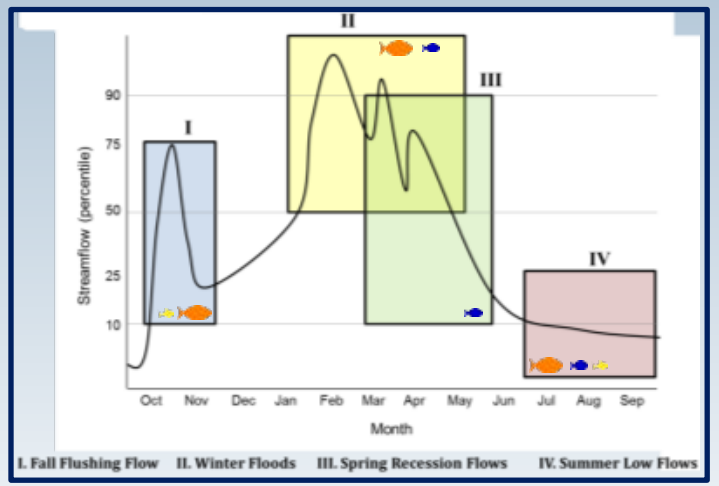


Winter Storms (Water Year)



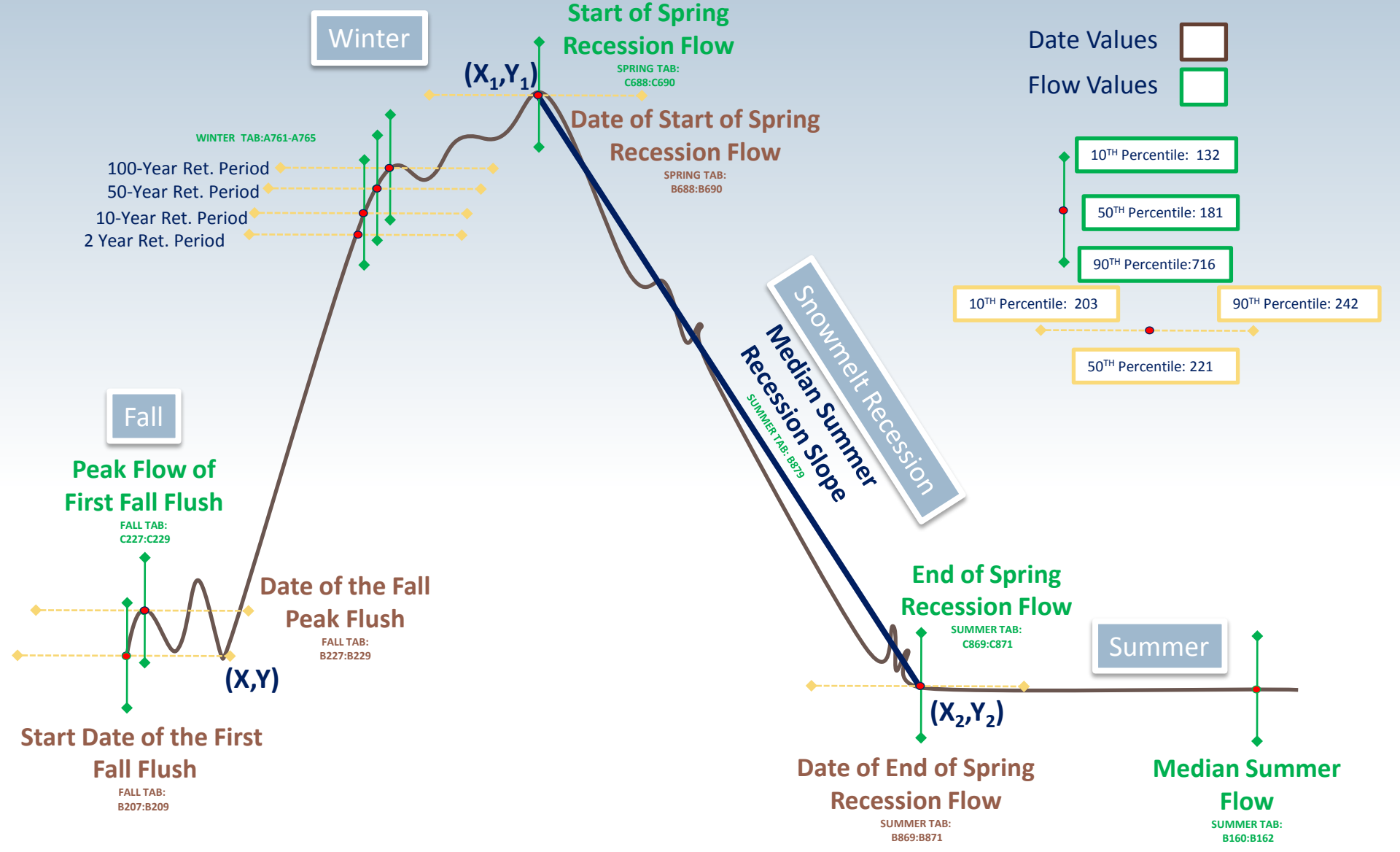
Functional Flow Metrics

Focus on quantitative metrics related to an ecological function

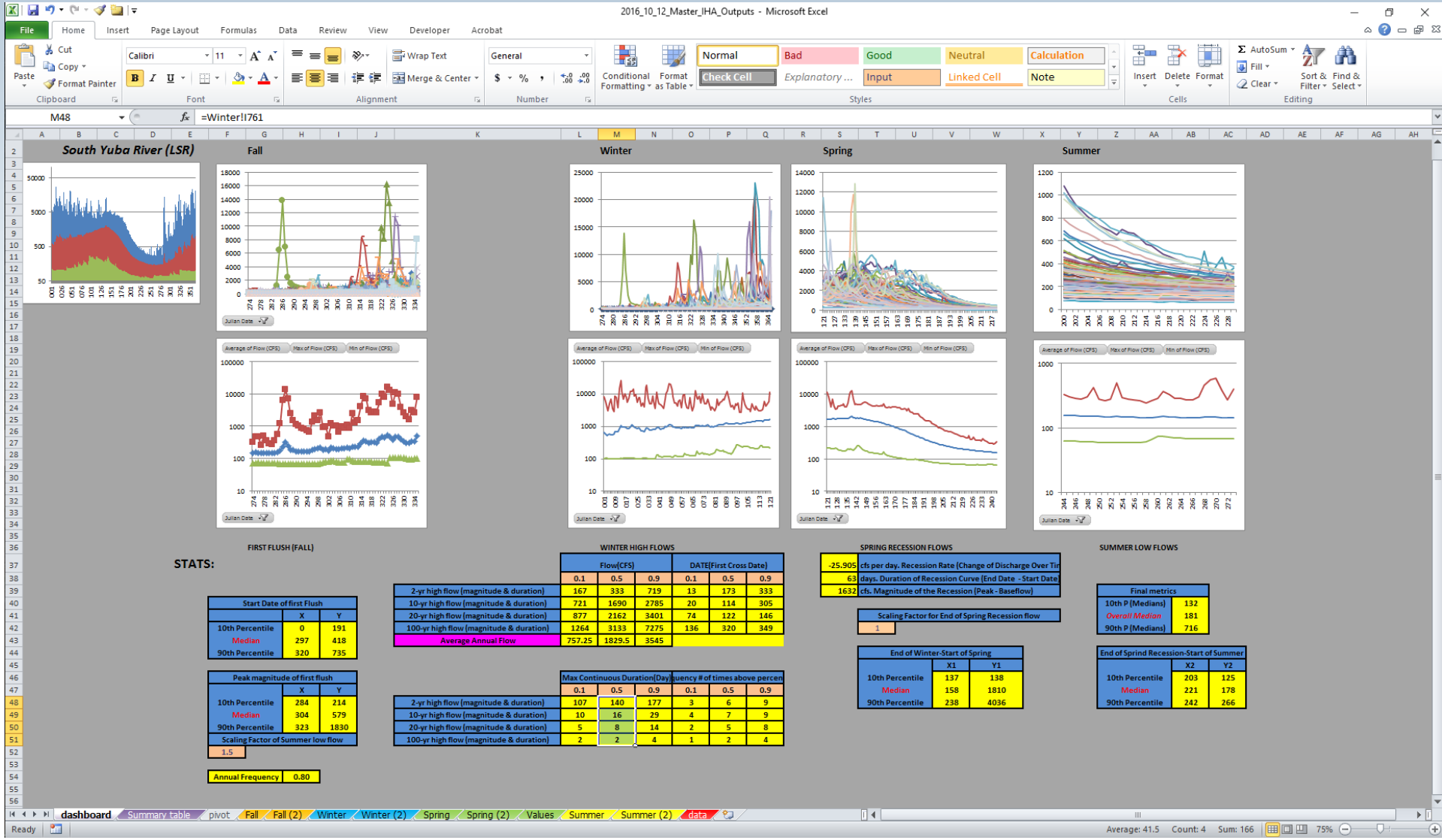


Season	Function	Timing	Flow Metrics	Frequency (duration)
Fall	Cue fish migration	Sept 1 - Nov 30	peak magnitude, percent over baseflow	Annually (2 weeks)
Winter	Clean spawning gravels	Dec 1 – Apr 1	Peak magnitude, recurrence interval	Once every 5 years (2-4 weeks)
Spring	Cue and support spawning	March 1 – May 30	Recession rate, duration	Annually (6-8 weeks)
Summer	Oversummering habitat	Apr 1-Sept 30	Magnitude, recurrence interval	Annually

Functional Flow Metrics



Functional Flow Calculator



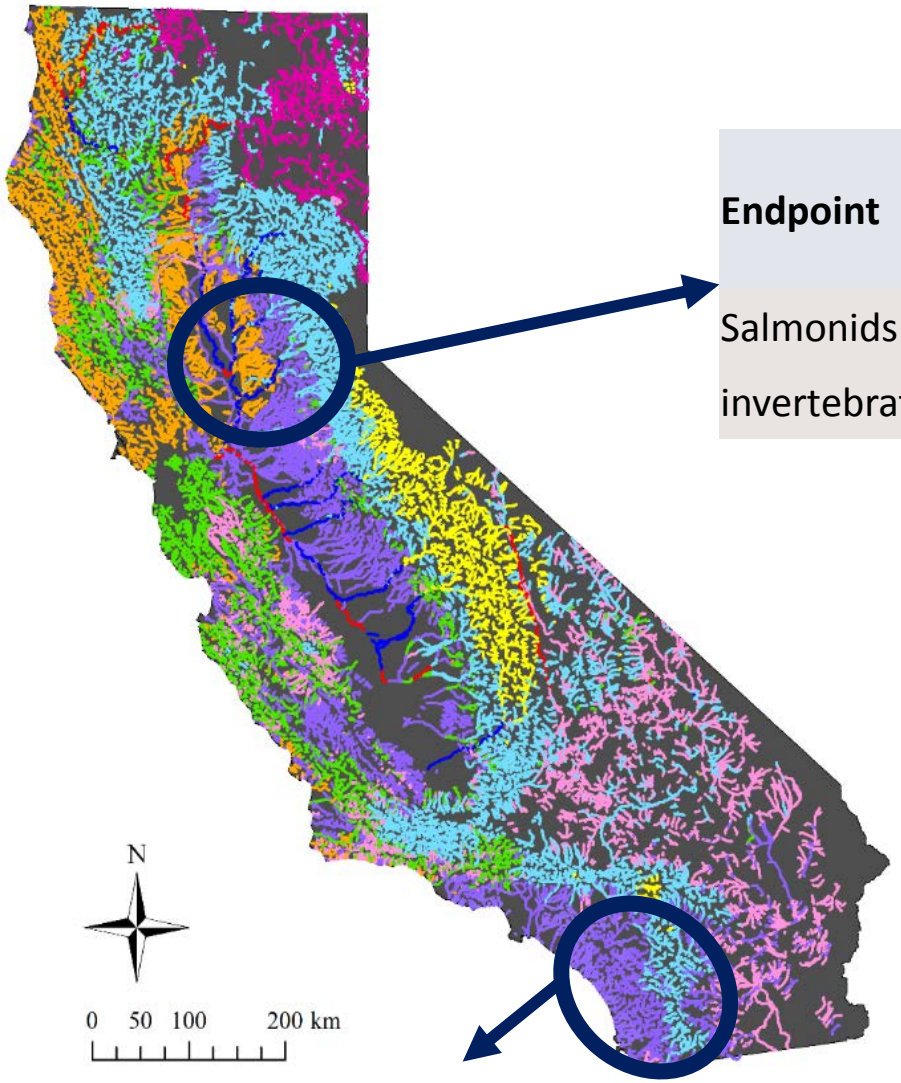
Functional Flow Calculator

WINTER HIGH FLOWS

	Flow(CFS)			DATE(First Cross Date)		
	0.1	0.5	0.9	0.1	0.5	0.9
2-yr high flow (magnitude & duration)	167	333	719	13	173	333
10-yr high flow (magnitude & duration)	721	1690	2785	20	114	305
20-yr high flow (magnitude & duration)	877	2162	3401	74	122	146
100-yr high flow (magnitude & duration)	1264	3133	7275	136	320	349
Average Annual Flow	757.25	1829.5	3545			

	Max Continuous Duration(Day)			quency # of times above percen		
	0.1	0.5	0.9	0.1	0.5	0.9
2-yr high flow (magnitude & duration)	107	140	177	3	6	9
10-yr high flow (magnitude & duration)	10	16	29	4	7	9
20-yr high flow (magnitude & duration)	5	8	14	2	5	8
100-yr high flow (magnitude & duration)	2	2	4	1	2	4

Season	Function	Timing	Flow Metrics	Frequency (duration)
Winter	Clean spawning gravels; clear riparian	Nov 1 – Apr 24	Peak magnitude (720-2785 cfs)	Once every 5-8 years (10-29 days)



Endpoint	Fall flows	Winter peaks	spring recession	summer baseflow
Salmonids				
invertebrates				

Endpoint	Fall flows	Winter peaks	spring recession	summer baseflow
amphibians				
riparian habitat				

- Choose ecological endpoints for each stream class based on scientific literature
- Ecological endpoints and flow metrics vary by stream class
- Relationships based on scientific hypotheses, not detailed analyses

Tier 1 Environmental Flows

- Functional Flows approach focuses on quantifying and restoring flow components with greatest link to processes
- Use of reference hydrographs from each hydrologic stream class to quantify functional flow metrics can ***rapidly*** provide a range of environmental flow targets from which to choose
- Tier 1 flows serve as the 'first cut'; Tier 2 flows can be developed if site specific refinement is needed
- More information coming!