Drought Response: Science, Policies and Projects Needed to Protect Fisheries and Water Resources

A Concurrent Session at the 39th Annual Salmonid Restoration Conference held in Santa Cruz, California from April 19 – 22, 2022.

- **Session Coordinator:**
  - Matt Clifford, Trout Unlimited
  - Monty Schmitt, The Nature Conservancy
  - Redgie Collins, California Trout

The health of California's rivers and fisheries is suffering as a result of persistent severely dry years. These events are not one offs but rather a harbinger of our future with climate change. By failing to effectively leverage lessons learned from recent dry years, we continue to be caught unprepared, with management actions coming too late and on too limited a scale to protect streamflows for fish, wildlife, and drinking water supplies. To address this problem, we need a new approach. Plans need to be formulated in advance, so that when dry conditions develop we have implementable, science-based management measure ready to be put into action to protect streamflows.

We must act now to be ready for future dry years or we risk extinction of salmon populations and loss of reliable water supplies for people. This session will explore the policies, science, and water management practices that will enable us to protect the rivers that provide fish habitat and human water supplies in the face of a rapidly drying climate

Presentations

Slide 4- **Drought Planning in the Western United States: A Review of Drought Plans in the Western States and Recommendations for California's Future Response**, Dan Wilson, *NOAA California Coastal Office*

Slide 25- **The Drought Flows Monitor: An Early Warning System for Freshwater Ecosystems**, Julie Zimmerman, PhD, *The Nature Conservancy*

Slide 43- **Lessons Learned from Recent Droughts**, Erin Ragazzi, *Division of Water Rights, State Water Resources Control Board*

Slide 61- **An Ecological Drought Indicator Framework for California**, Ted Grantham, PhD, *UC Berkeley*; and Jeffrey Mount, PhD, *Public Policy Institute of California*

Slide 95- **Watershed-scale Cooperative Solutions: Projects and Approaches to Increase Drought and Climate Resilience for Streamflow, Fish Habitat, and Water Supplies in Coastal Watersheds**, Mia van Docto, *Trout Unlimited*, and Monty Schmitt, *The Nature Conservancy*

Slide 128- **Drought Resiliency in the Klamath Basin: The Yurok Tribe's Strategies and Approach**, Mike Belchik, *Senior Fisheries Biologist, Yurok Tribe Fisheries Program*, and Thomas Starkey-Owens, *Water Program, Yurok Tribe Environmental Program*

Drought Planning in the Western United States:

A Review of Drought Plans in the Western States and Recommendations for California's Future Response

Dan Wilson
Dereka Chargualaf
Rick Rogers

The U.S. Drought Monitor

Category	Description	Possible Impacts	Ranges: Palmer Drought Severity Index (PDSI)	Ranges: CPC Soil Moisture Model (Percentiles)	Ranges: USGS Weekly Streamflow (Percentiles)	Ranges: Standardized Precipitation Index (SPI)	Ranges: Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

Effects of Drought on Fish and Habitat

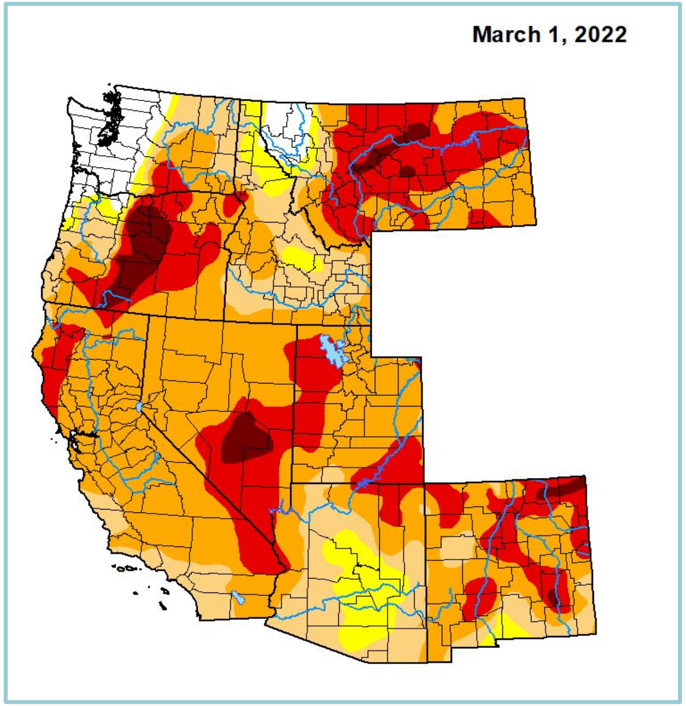
- Extreme and Severe drought reduces access to upstream spawning grounds and reduced spawning habitat area
- Extreme and Severe drought in the spring can reduce the ability for smolts to emigrate freshwater.
- Extreme and Severe drought conditions also have the potential to disconnect riffles from pools, leaving the pools isolated from one another. When pools become isolated, water temperature increases and dissolved oxygen content decreases, and the juveniles utilizing these pools as habitat refuges may not survive until adequate flows resume.

Percent of Species Range experiencing drought: US Drought Monitor (3-1-2022)

	Normal	D0 Abnormally Dry	D1 Moderate Drought	D2 Severe Drought	D3 Extreme Drought	D4 Exceptional Drought
CCC Coho Salmon	0.0%	0.0%	0.0%	67.6%	32.4%	0.0%
SONCC Coho Salmon	0.0%	0.0%	11.1%	50.2%	38.7%	0.0%
CC Chinook Salmon	0.0%	0.0%	0.8%	35.5%	63.6%	0.0%
CCC steelhead	0.0%	0.0%	0.0%	92.1%	7.9%	0.0%
SCC Steelhead	0.0%	0.0%	54.3%	45.7%	0.0%	0.0%
SC Steelhead	0.0%	0.0%	80.1%	19.9%	0.0%	0.0%
NC Steelhead	0.0%	0.0%	1.0%	28.7%	70.3%	0.0%

Introduction: Drought Planning in the Western States

- Does the State have a formal committee dedicated to drought response?
- How does the State handle Fish and Wildlife during drought?
- What are the State's Drought Response Tools?



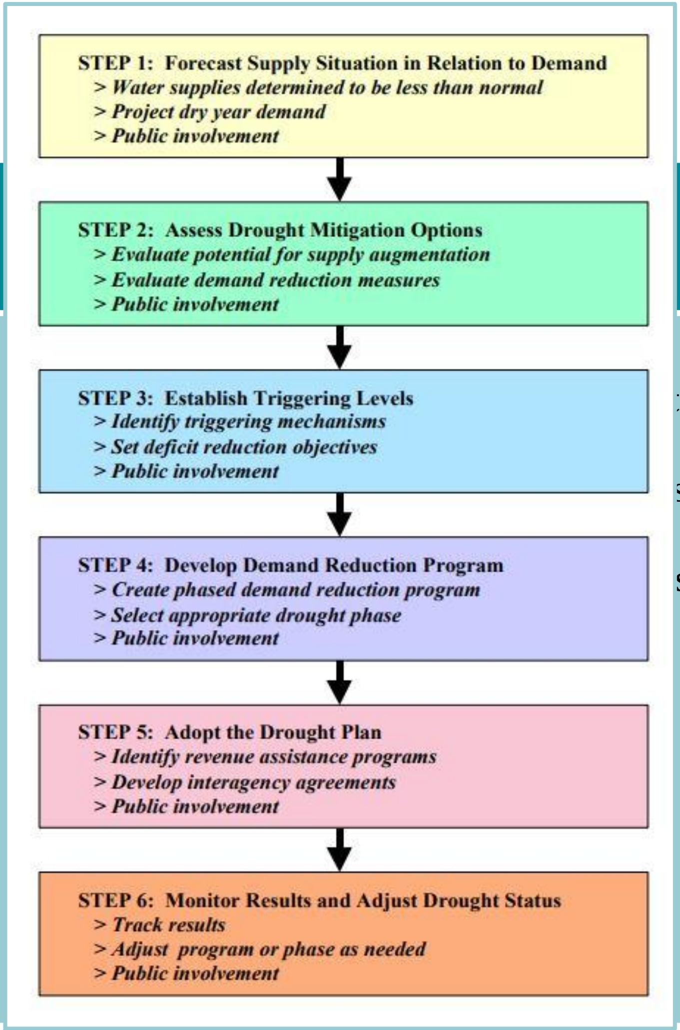
Source: The U.S. Drought Monitor

	Washington	Oregon	Idaho
Does the State have a committee dedicated to drought response?	Water Supply Availability Committee Executive Water Emergency Committee	Water Supply Availability Committee Drought Readiness Council	Water Supply Committee Subcommittees: • Water Data • Agricultural • Fish, Wildlife, Recreation, and Environmental • Municipal, Industrial, and Water Quality • Economic • Energy

	Washington	Oregon	Idaho
How does the State handle Fish and Wildlife during drought?	Washington Department of Fish and Wildlife • Resiliency and Response Actions for Fish in Nature • Resiliency and Response Actions for Fish in Hatcheries	Oregon Water Resources Department Oregon Department of Fish and Game	Idaho Department of Water Resources • Fish, Wildlife, Recreation, and Environmental Subcommittee

	Washington	Oregon	Idaho
What are the State's Drought Response Tools?	• Emergency water rights permitting • Potential funding	• Temporary Drought Permits • Temporary Water Transfers • Temporary Instream Leases • Temporary Substitutions (e.g., switch to groundwater) • Special Option Agreements • Temporary Exchange of Water	• Demand Reduction Program • Revenue Assistance Program

			Idaho
What are the State's Drought Response Tools?	• •	ts s s	• Demand Reduction Program • Revenue Assistance Program



Challenge #1: Normalizing Drought Response

California's water right system:

- California uses hybrid riparian and appropriative water rights
- Appropriative rights
  - Rule of Priority - all water rights are assigned "appropriation dates," where right to water is time stamped in relation to other water rights
  - Senior water rights holder is entitled to make full use of its rights before a junior rights holder is entitled to divert any water.
- Riparian rights
  - For riparian water rights, all users on a given body of water must curtail their use to what is "reasonable."
- Article X, Section 2 of the California Constitution requires all use of water to be "reasonable and beneficial."

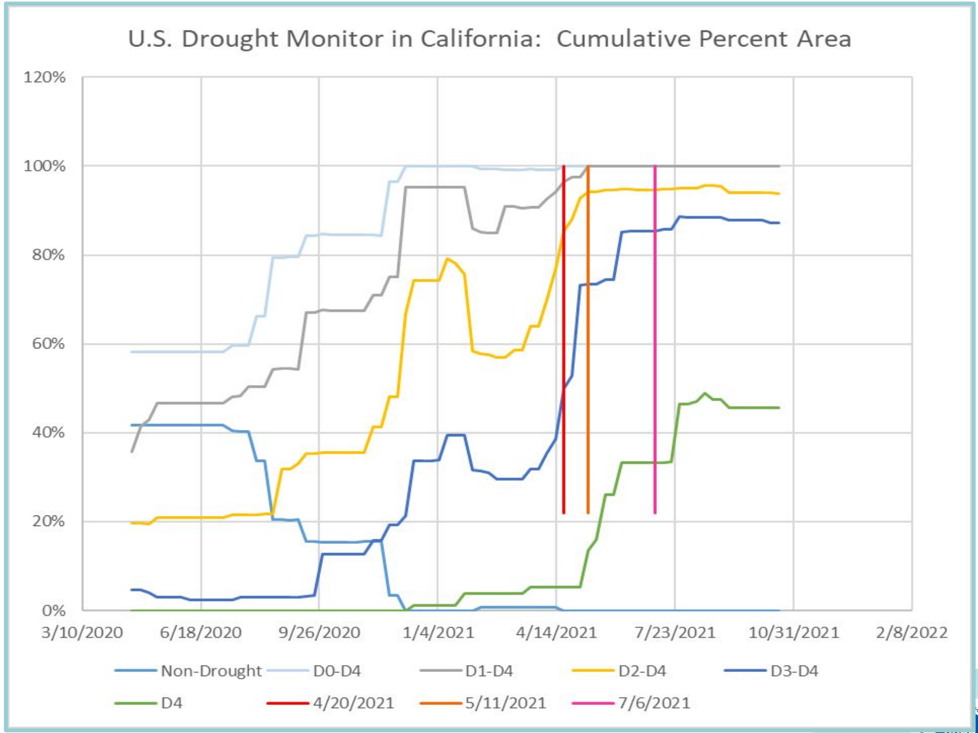
U.S. Drought Monitor in California

	D0	D1	D2	D3	D4
% of weeks in WY10-WY21	89%	83%	76%	57 %	34%

Source is U.S. Monitor

Challenge #2: Responding to drought early enough and at the right geographic scale

- **April 21, 2021** – Governor proclaimed a drought emergency, covering the Russian River watershed of Sonoma and Mendocino counties.
- **May 10, 2021** – Governor expanded the drought emergency proclamation to include Klamath River, Sacramento-San Joaquin Delta and Tulare Lake Watershed, covering 41 of 58 counties.
- **July 8, 2021** – Governor called on Californians to voluntarily reduce water use by 15% and expanded drought emergency proclamation to include nine additional counties, covering 50 of 58 counties.
- **October 19, 2021** – Governor expanded the drought emergency proclamation statewide to include eight remaining counties.

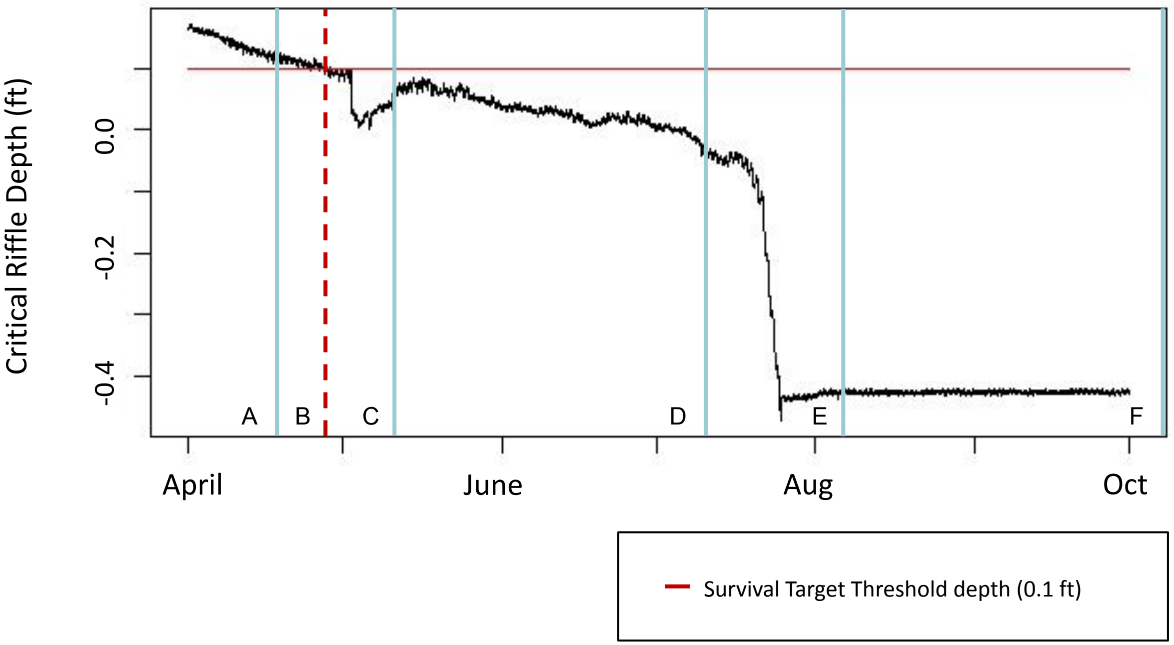


Source is U.S. Monitor

NOAA FISHERIES

Effects of California's Drought Response

Russian River Tributary - Upper Green Valley Creek (TU GV04)



California's Drought Response:

- **A.** **April 21, 2021** – Governor proclaimed a drought emergency, covering the Russian River watershed of Sonoma and Mendocino counties.
- **C.** **May 10, 2021** – Governor expanded the drought emergency proclamation to include Klamath River, Sacramento-San Joaquin Delta and Tulare Lake Watershed, covering 41 of 58 counties.
- **D.** **July 8, 2021** – Governor called on Californians to voluntarily reduce water use by 15% and expanded drought emergency proclamation to include nine additional counties, covering 50 of 58 counties.
- **E.** **August 2, 2021 –** Upper Russian River watershed curtailment orders were issued
- **F.** **October 19, 2021** – Governor expanded the drought emergency proclamation statewide to include eight remaining counties.

Survival Target Threshold depth

- **B.** **April 26, 2021 –** Flows were critically low and were at minimum Survival Target Threshold depths.

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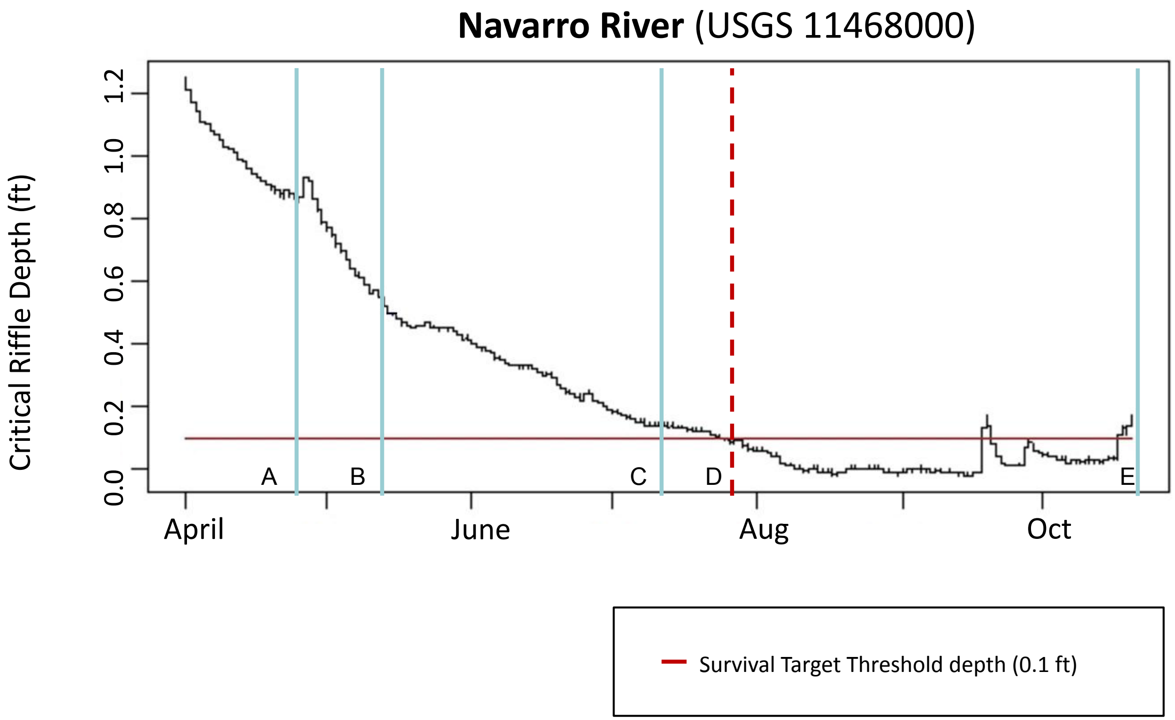
Effects of California's Drought Response



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E. **October 19, 2021** – Governor expanded the drought emergency proclamation statewide to include eight remaining counties.

Survival Target Threshold depths

D. **July 24, 2021 –** Flows were critically low and were at minimum Survival Target Threshold depths.

Effects of California's Drought

Challenge #2: Responding to drought early enough and at the right geographic scale

Existing Water Code creates a challenge:

Water Code 1058.5.

(a) This section applies to any emergency regulation adopted by the board for which the board makes both of the following findings:

(1) The emergency regulation is adopted to prevent the waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion, of water, to promote water recycling or water conservation, to require curtailment of diversions when water is not available under the diverter's priority of right, or in furtherance of any of the foregoing, to require reporting of diversion or use or the preparation of monitoring reports.

(2) The emergency regulation is adopted in *response to conditions which exist, or are threatened, in a critically dry year immediately preceded by two or more consecutive below normal, dry, or critically dry years* or during a period for which the *Governor has issued a proclamation of a state of emergency under the California Emergency Services Act* (Chapter 7 (commencing with Section 8550) of Division 1 of Title 2 of the Government Code) based on drought conditions.

(b) Notwithstanding Sections 11346.1 and 11349.6 of the Government Code, any findings of emergency adopted by the board, in connection with the adoption of an emergency regulation under this section, are not subject to review by the Office of Administrative Law.

Recommendation #1:

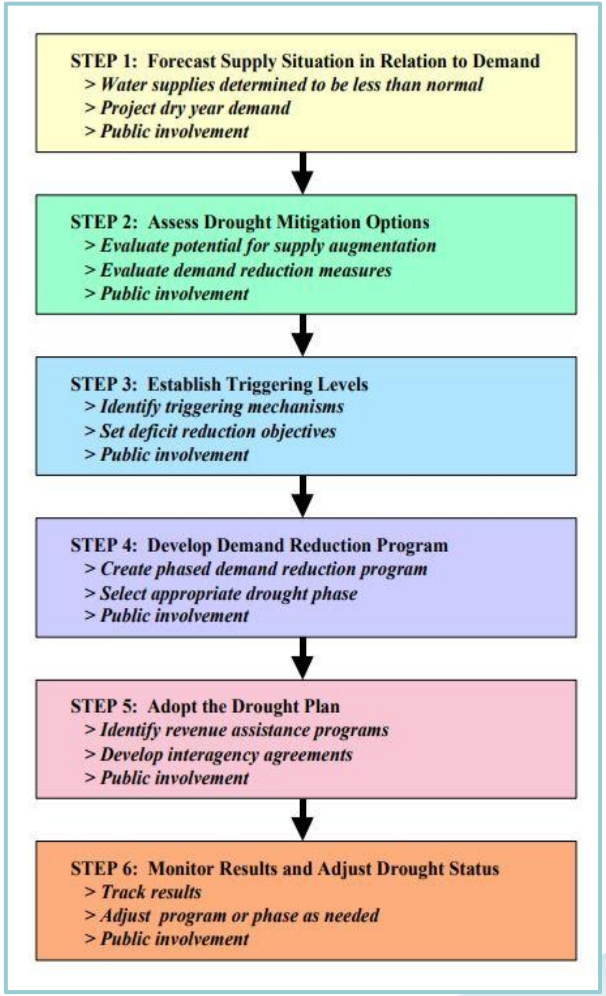
Develop permanent curtailment regulations:

Implement the water rights process annually and standardize process for water shortages and drought

Recommendation #2:

Staff a Drought Program:

1) Develop regulation;
2) Manage its implementation
    a) Monitor water availability
    b) Curtailment system



NOAA FISHERIES

Recommendation #3:

Set instream flow thresholds for fisheries and public trust:

- California Environmental Flow Framework

Recommendation #4:

Consider using regional index to identify fisheries and public trust thresholds:

- E.g., Moidu, H., Obedzinski, M., Carlson, S. M., & Grantham, T. E. (2021). Spatial patterns and sensitivity of intermittent stream drying to climate variability. *Water Resources Research*, *57*(11), e2021WR030314.

- California Environmental Flow Framework

Recommendation #5:

Establish voluntary programs or plans that can be used in-lieu of curtailment

NMFS Recommendations:	Challenge #1	Challenge #2
1. Develop permanent curtailment regulations that implements the water rights process annually	X	It depends
2. Dedicate staff for monitoring water availability and managing curtailment regulation	X	X
3. Set instream flow thresholds for fisheries and public trust	X	It depends
4. Consider using regional index to identify public trust thresholds	X	X
5. Establish voluntary programs or plans that can be used in-lieu of curtailment	It depends	It depends

Thank you

Questions / Comments

The Drought Flows Monitor

An early warning system for freshwater ecosystems

Julie Zimmerman, Kirk Klausmeyer, Gabe Rossi, Jennifer Carah, Mia van Docto, Alyssa Obester, Jeanette Howard, Robert Holmes, Monty Schmitt, Matt Clifford, Charlie Schneider

Are there early indicators for critically dry conditions in the coming dry season?

Can we identify critically dry conditions without stream gages?

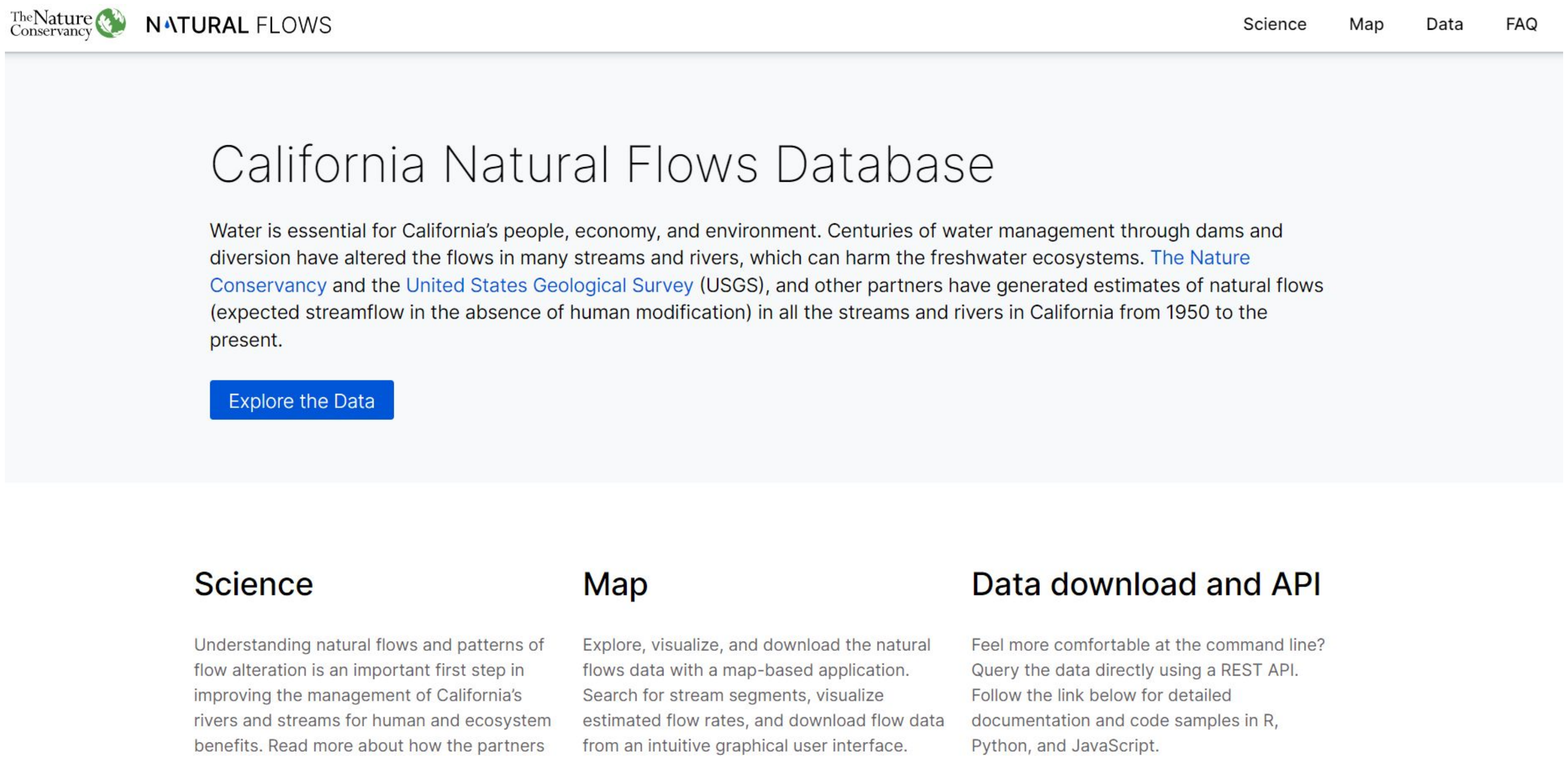
Objectives

- ID coastal streams expected to be critically dry at any point in the year, leading to ecosystem stress

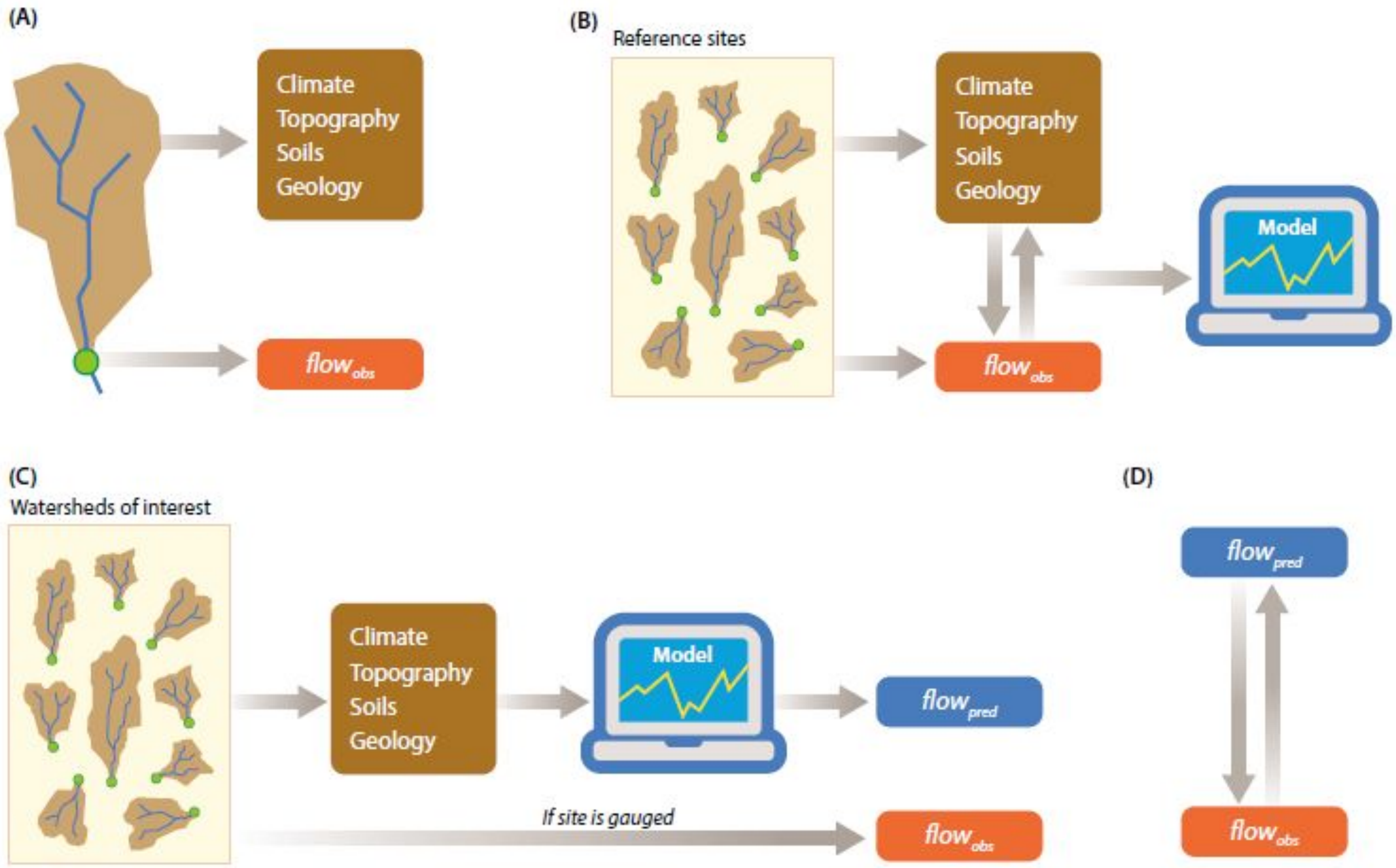
- ID streams with a high risk of critically dry flows during the dry season baseflow period that warrant changes in water management or other drought management actions

Approach

Uses the Natural Flows Database (monthly natural flow predictions, 1950-present): https://rivers.codefornature.org/#/home



Monthly flow models

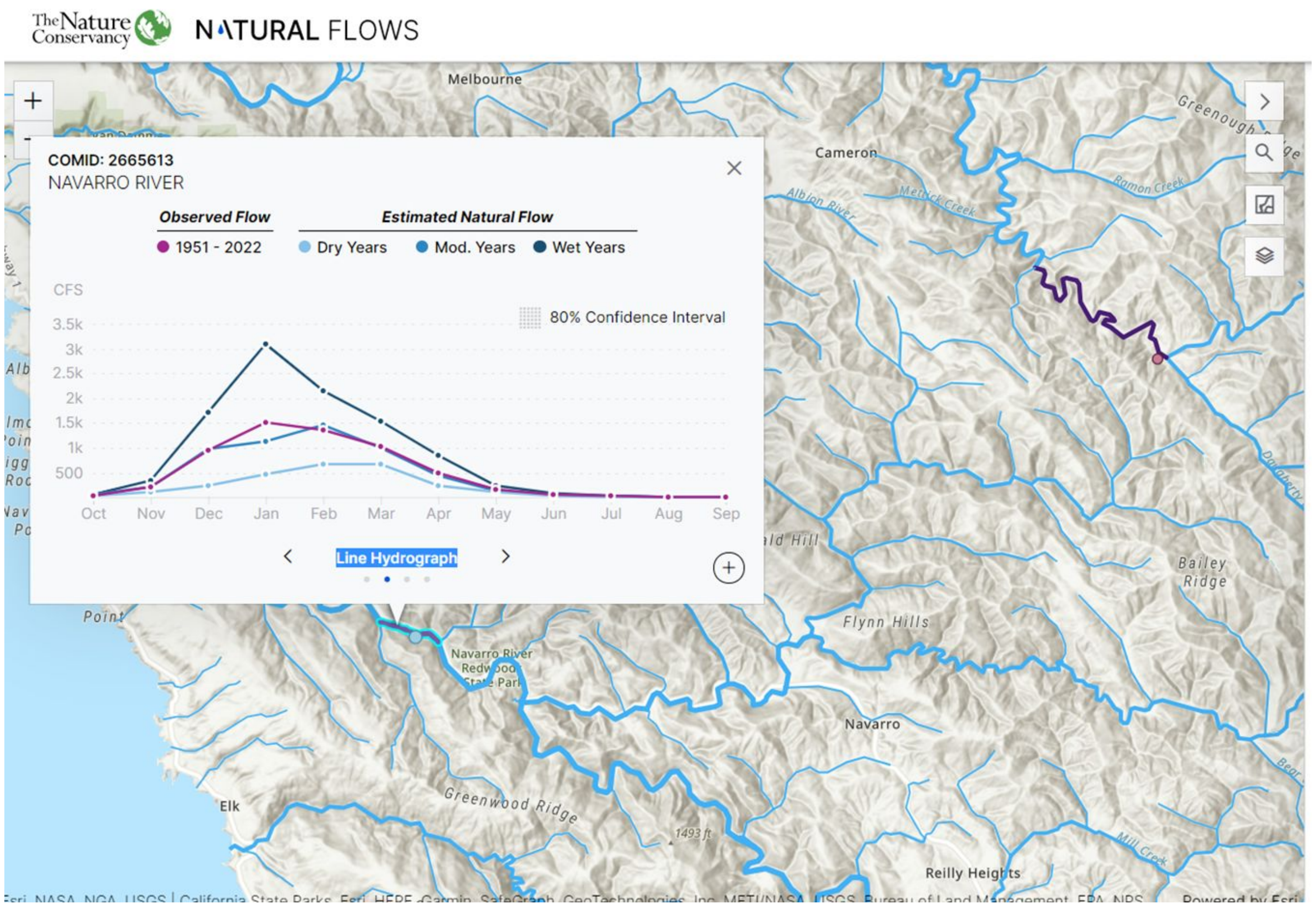


250 reference sites

See Zimmerman et al. 2018 for methods

Approach

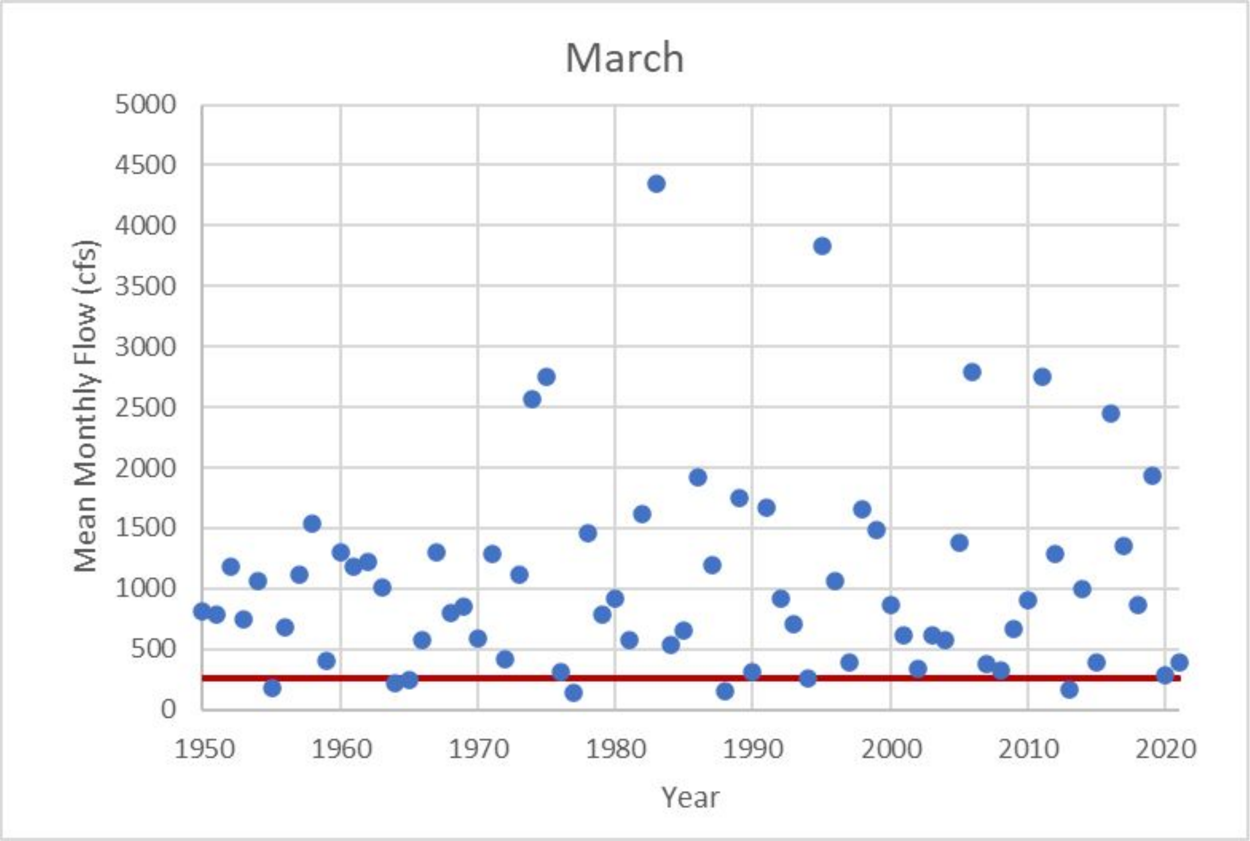
Predicted flow for each month calculated as a percentile of the range of predicted flows from 1950-2022 for the same month, assigned to river reaches (COMID)



Approach

- Critically dry conditions = monthly predicted natural flow ≤10th percentile of the distribution of natural flow for the same month

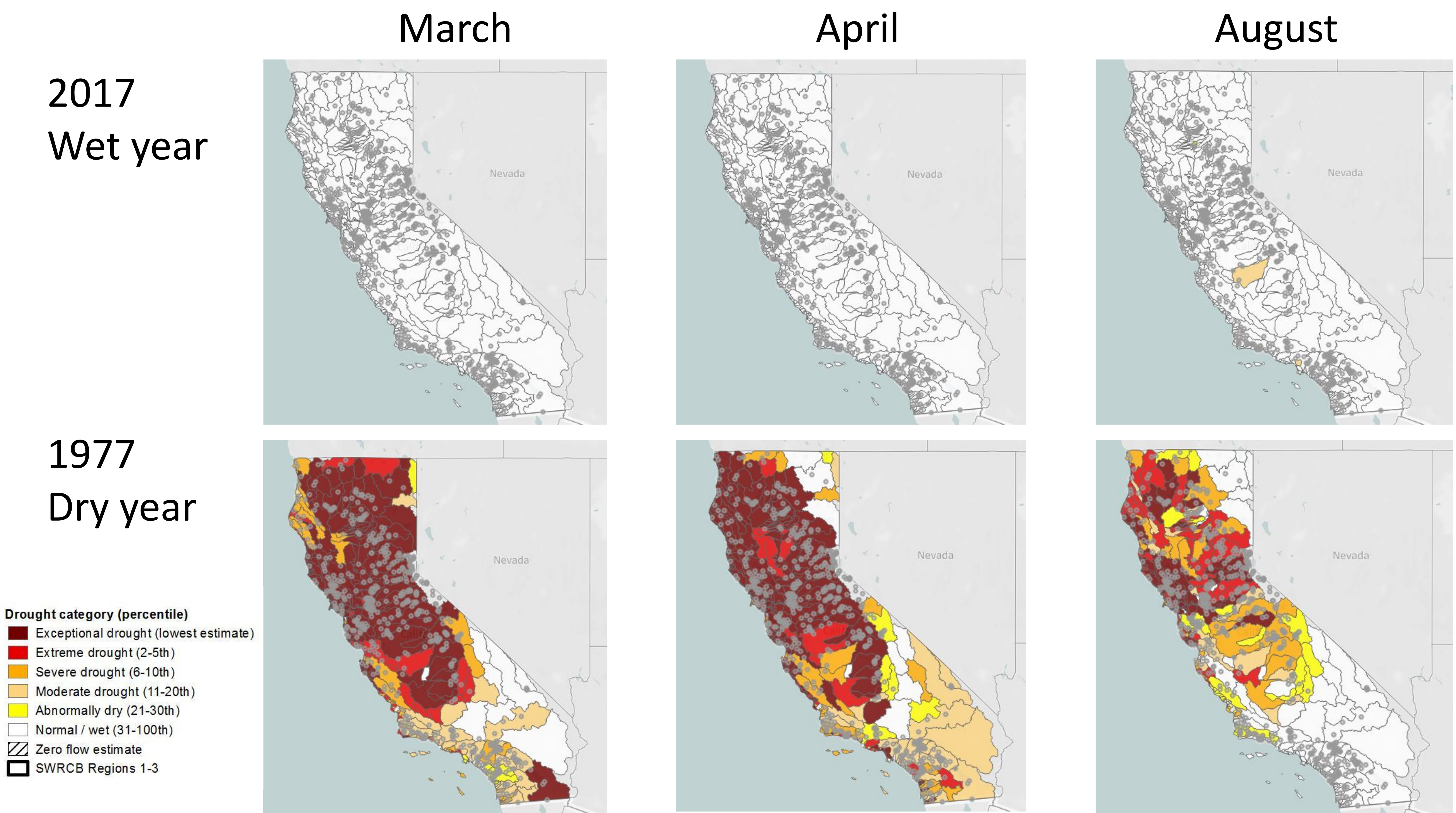
- HUC 8/12 watersheds combined by large named streams, most downstream reach of largest river used for summary



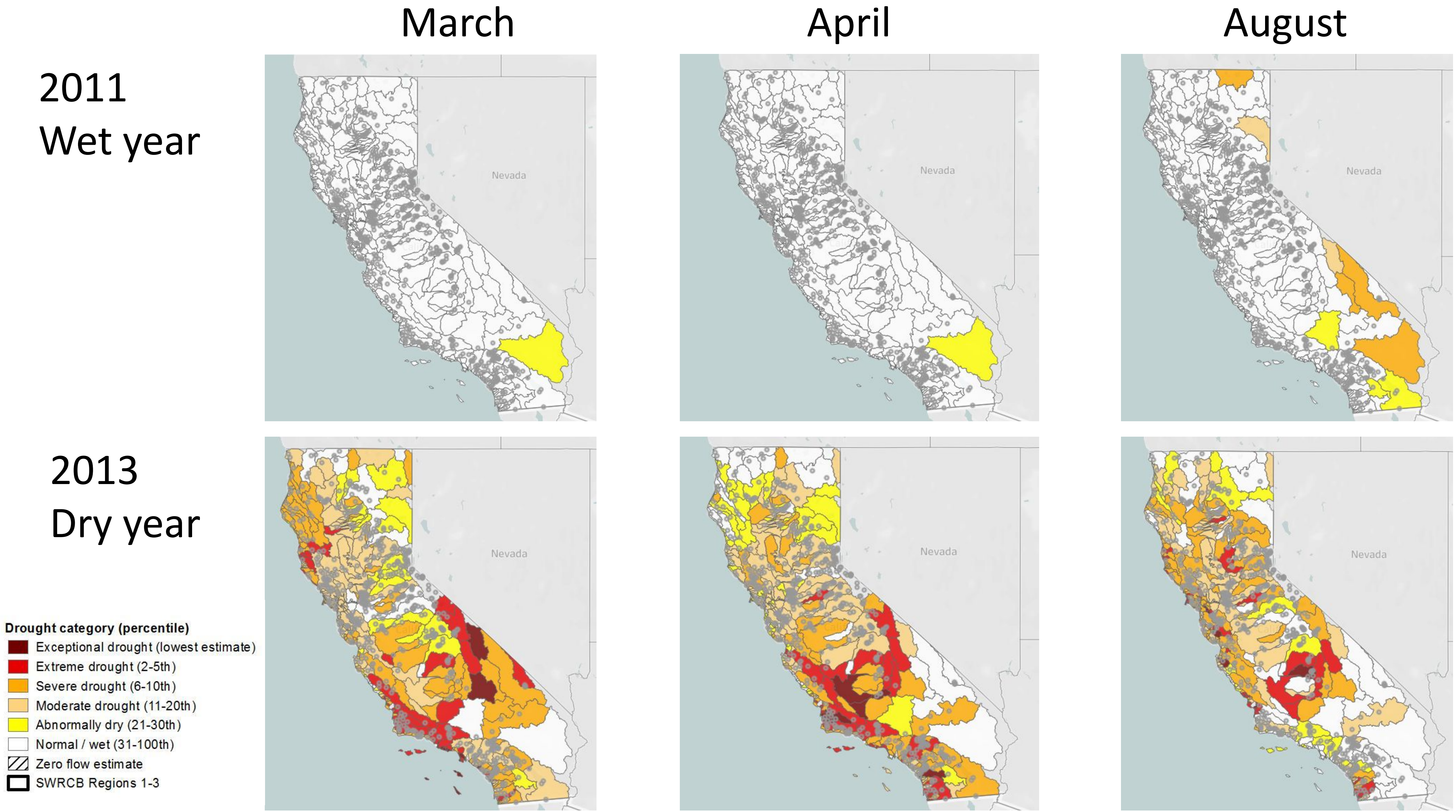
Categories follow U.S. Drought Monitor

https://droughtmonitor.unl.edu/

Category	Description	Possible Impacts	USGS Weekly Streamflow (Percentiles)
D0	Abnormally Dry	Going into drought: • short-term dryness slowing planting, growth of crops or pastures Coming out of drought: • some lingering water deficits • pastures or crops not fully recovered	21 to 30
D1	Moderate Drought	• Some damage to crops, pastures • Streams, reservoirs, or wells low, some water shortages developing or imminent • Voluntary water-use restrictions requested	11 to 20
D2	Severe Drought	• Crop or pasture losses likely • Water shortages common • Water restrictions imposed	6 to 10
D3	Extreme Drought	• Major crop/pasture losses • Widespread water shortages or restrictions	3 to 5
D4	Exceptional Drought	• Exceptional and widespread crop/pasture losses • Shortages of water in reservoirs, streams, and wells creating water emergencies	0 to 2



March
April
August
2017
Wet year
1977
Dry year
Nevada
Drought category (percentile)
Exceptional drought (lowest estimate)
Extreme drought (2-5th)
Severe drought (6-10th)
Moderate drought (11-20th)
Abnormally dry (21-30th)
Normal / wet (31-100th)
Zero flow estimate
SWRCB Regions 1-3


March
April
August
2011
Wet year
2013
Dry year
Nevada
Nevada
Nevada
Nevada
Nevada
Nevada
Drought category (percentile)
Exceptional drought (lowest estimate)
Extreme drought (2-5th)
Severe drought (6-10th)
Moderate drought (11-20th)
Abnormally dry (21-30th)
Normal / wet (31-100th)
Zero flow estimate
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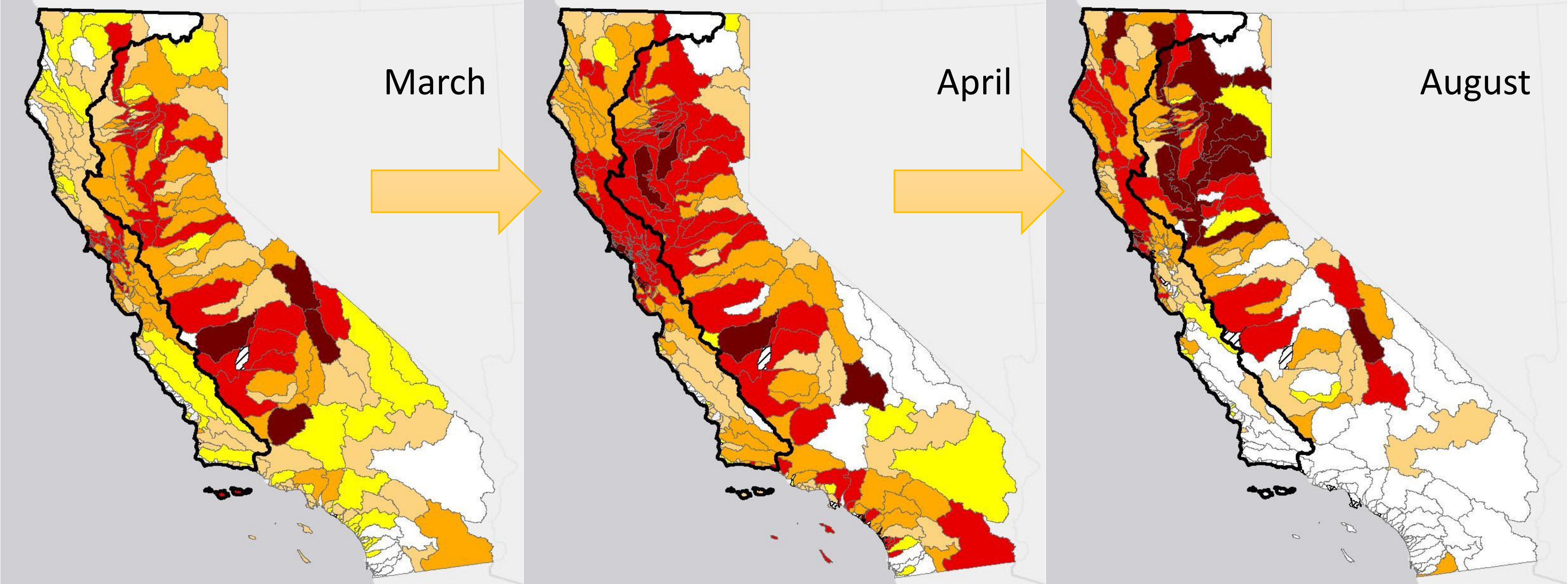
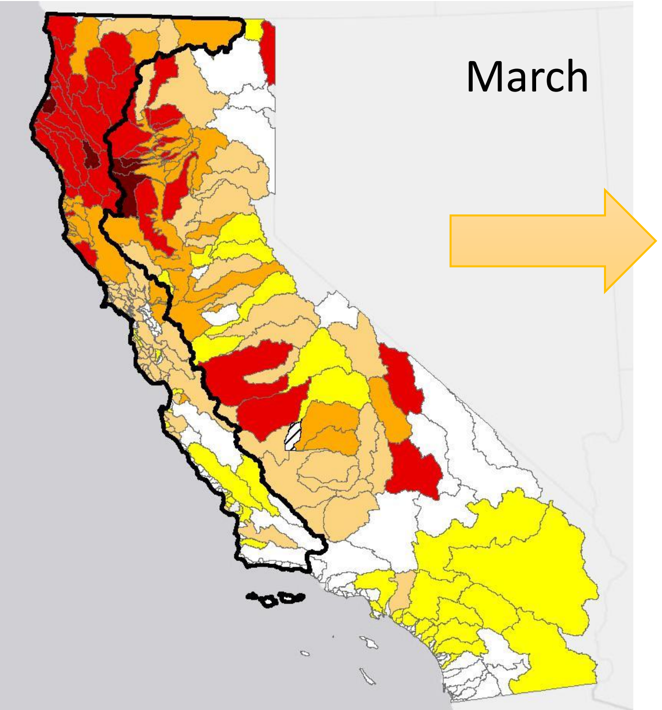
2021



2022

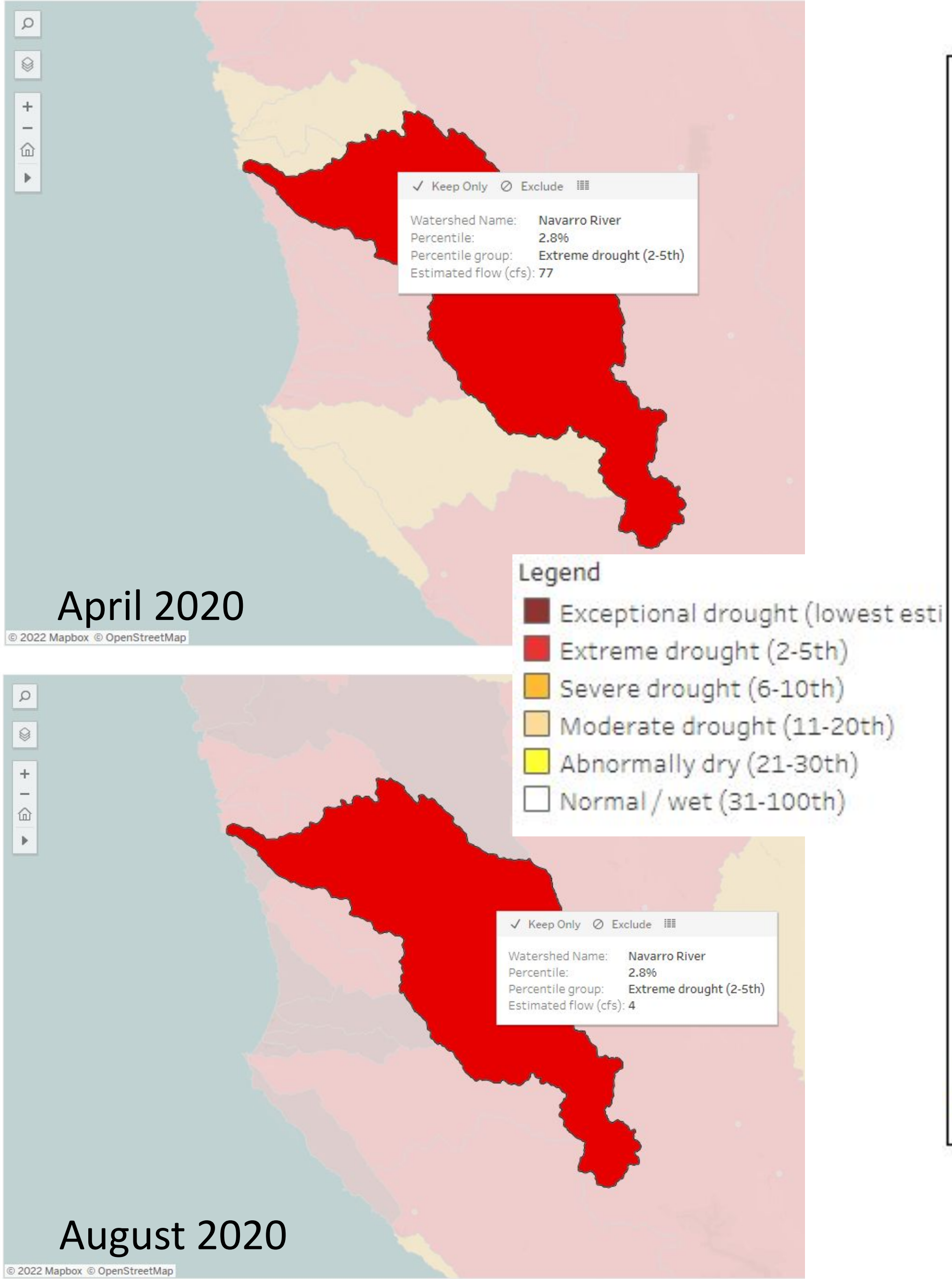


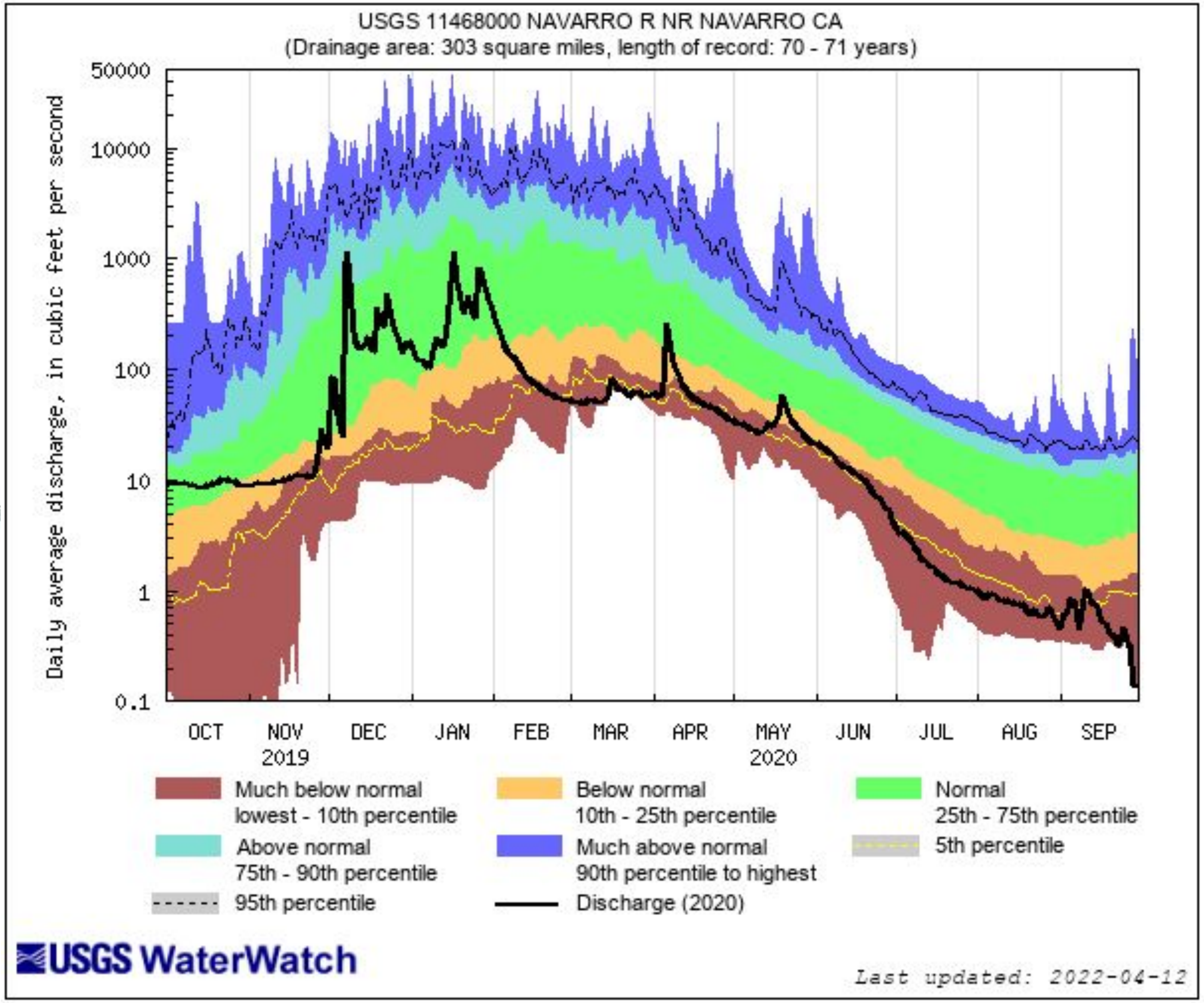
?

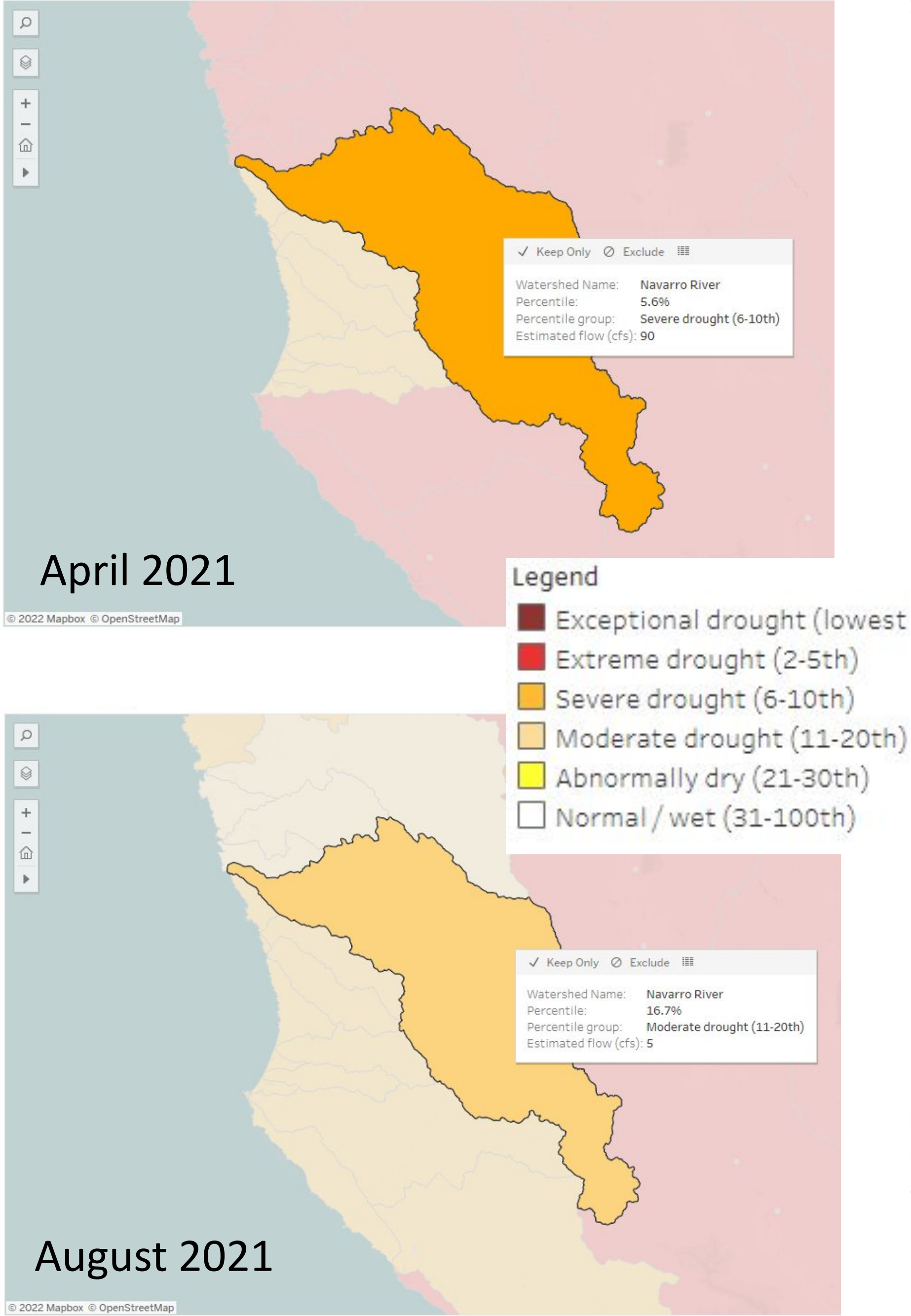
These maps will be updated in May when the April climate data becomes available

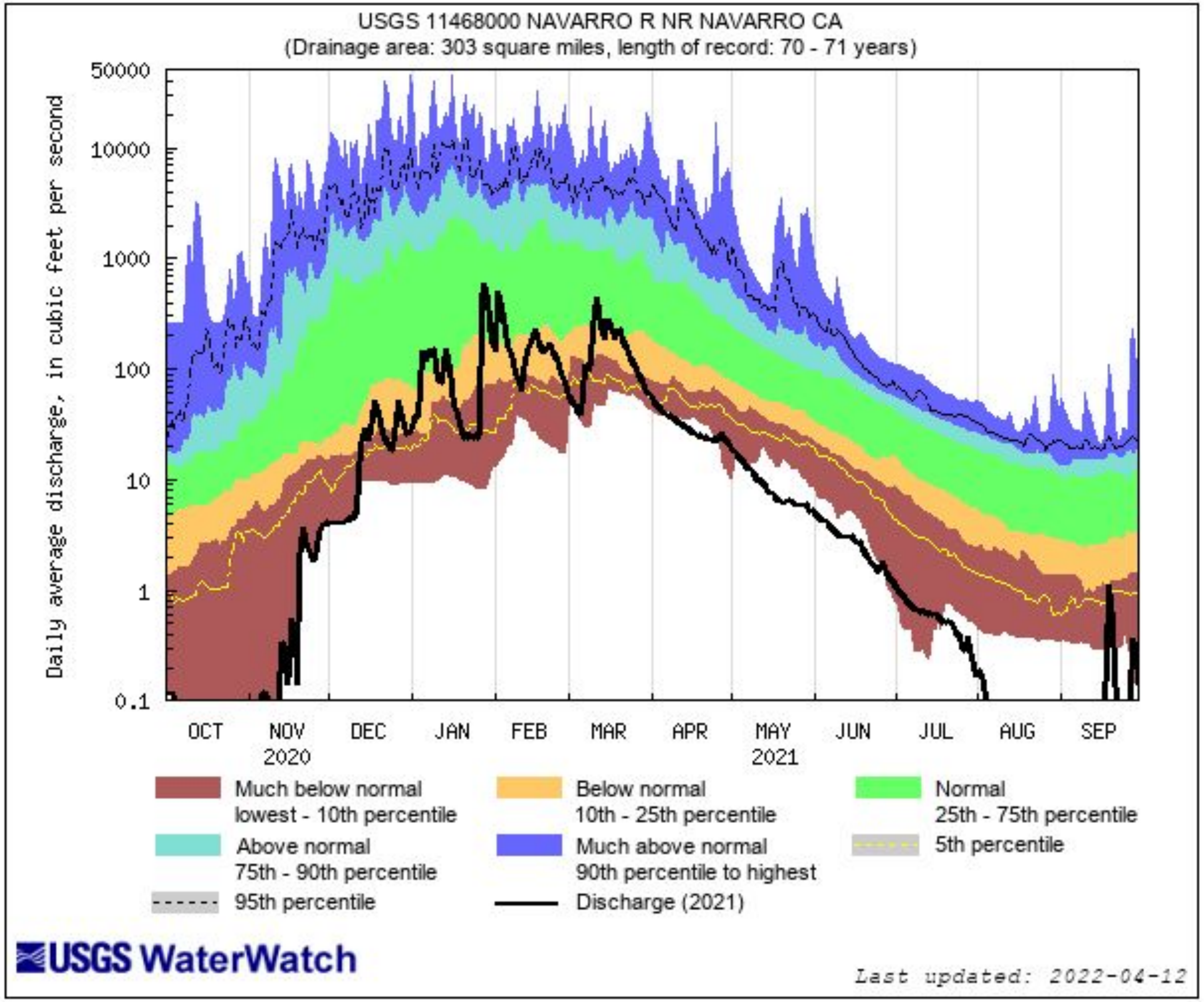
Drought category (percentile)

- Exceptional drought (lowest estimate)
- Extreme drought (2-5th)
- Severe drought (6-10th)
- Moderate drought (11-20th)
- Abnormally dry (21-30th)
- Normal / wet (31-100th)
- Zero flow estimate
- SWRCB Regions 1-3


Keep Only
Exclude
Watershed Name: Navarro River
Percentile: 2.8%
Percentile group: Extreme drought (2-5th)
Estimated flow (cfs): 77
April 2020
© 2022 Mapbox © OpenStreetMap
Legend
Exceptional drought (lowest esti
Extreme drought (2-5th)
Severe drought (6-10th)
Moderate drought (11-20th)
Abnormally dry (21-30th)
Normal / wet (31-100th)
Keep Only
Exclude
Watershed Name: Navarro River
Percentile: 2.8%
Percentile group: Extreme drought (2-5th)
Estimated flow (cfs): 4
August 2020
© 2022 Mapbox © OpenStreetMap


USGS 11468000 NAVARRO R NR NAVARRO CA
(Drainage area: 303 square miles, length of record: 70 - 71 years)
Daily average discharge, in cubic feet per second
50000
10000
1000
100
10
1
0.1
OCT
NOV
2019
DEC
JAN
FEB
MAR
APR
MAY
2020
JUN
JUL
AUG
SEP
Much below normal
lowest - 10th percentile
Below normal
10th - 25th percentile
Normal
25th - 75th percentile
Above normal
75th - 90th percentile
Much above normal
90th percentile to highest
5th percentile
95th percentile
Discharge (2020)
USGS WaterWatch
Last updated: 2022-04-12


Keep Only Exclude
Watershed Name: Navarro River
Percentile: 5.6%
Percentile group: Severe drought (6-10th)
Estimated flow (cfs): 90
April 2021
© 2022 Mapbox © OpenStreetMap
Legend
Exceptional drought (lowest
Extreme drought (2-5th)
Severe drought (6-10th)
Moderate drought (11-20th)
Abnormally dry (21-30th)
Normal / wet (31-100th)
Keep Only Exclude
Watershed Name: Navarro River
Percentile: 16.7%
Percentile group: Moderate drought (11-20th)
Estimated flow (cfs): 5
August 2021
© 2022 Mapbox © OpenStreetMap


USGS 11468000 NAVARRO R NR NAVARRO CA
(Drainage area: 303 square miles, length of record: 70 - 71 years)
Daily average discharge, in cubic feet per second
50000
10000
1000
100
10
1
0.1
OCT
NOV 2020
DEC
JAN
FEB
MAR
APR
MAY 2021
JUN
JUL
AUG
SEP
Much below normal lowest - 10th percentile
Below normal 10th - 25th percentile
Normal 25th - 75th percentile
Above normal 75th - 90th percentile
Much above normal 90th percentile to highest
5th percentile
95th percentile
Discharge (2021)
USGS WaterWatch
Last updated: 2022-04-12

Legend

- Exceptional drought (lowest estimate)
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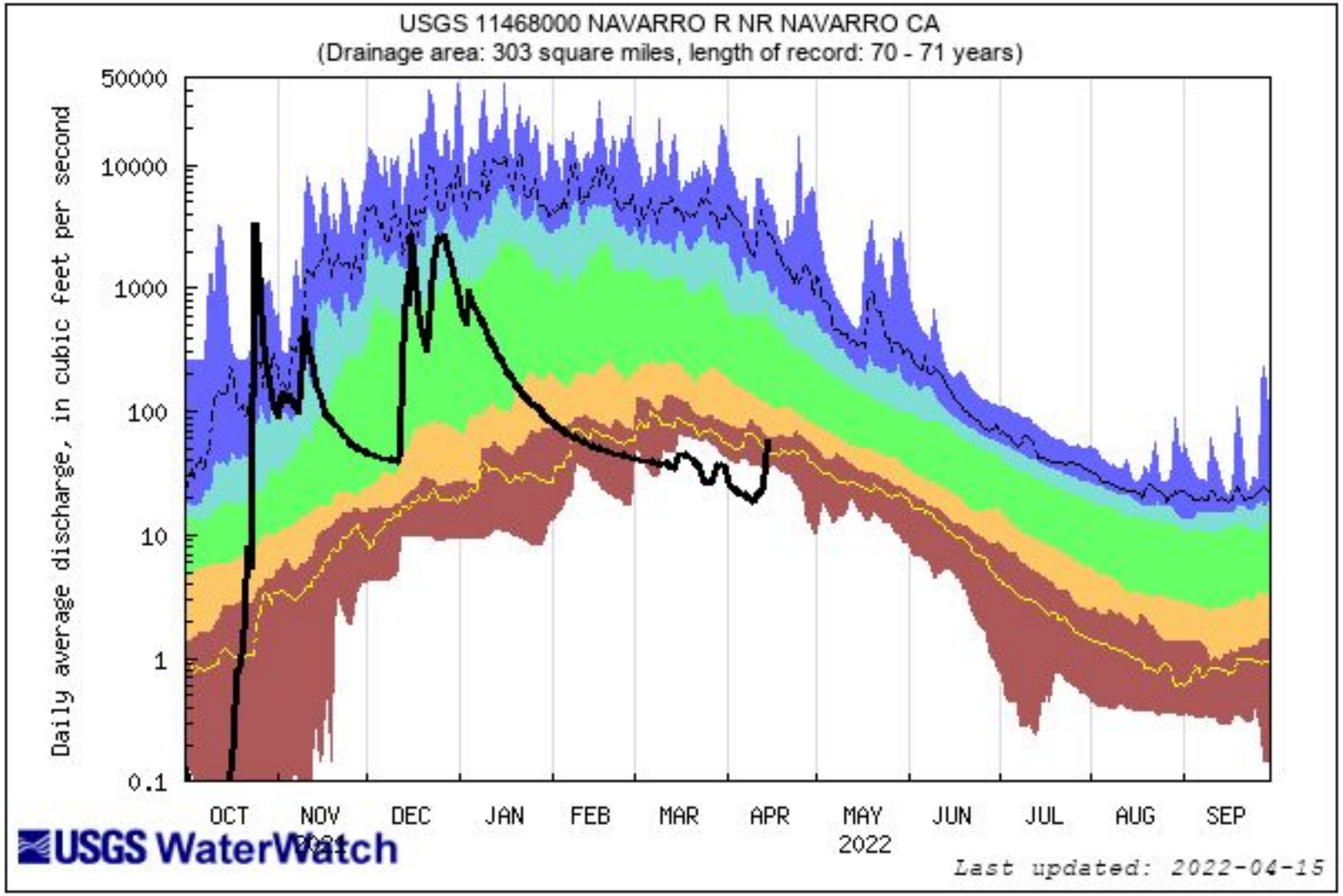
- Normal / wet (31-100th)



Conclusions

- Critically dry conditions in late spring are unlikely to improve over the dry season
  - March and April conditions tend to persist
- Many individual stream reaches go dry by late summer even under normal conditions
  - Summarizing by larger watershed evaluates conditions in perennial streams and is a good indicator of overall watershed condition
- Natural flow conditions that are expected to be critically dry will result in ecosystem stress
  - Reducing alteration from human use is warranted

Applications

- Curtailments
  - Critically dry conditions indicate further alteration from human use should be minimized
  - March and April conditions can indicate curtailments or other drought management actions are needed
  - Alteration analyses can prioritize watersheds for actions, but data are limited to stream gages
- Stream drying
  - Critically dry conditions in watersheds prone to drying can indicate action is needed to prevent further ecosystem stress
  - Watersheds with salmon or other listed species can be prioritized

LowFlow | Tableau Public

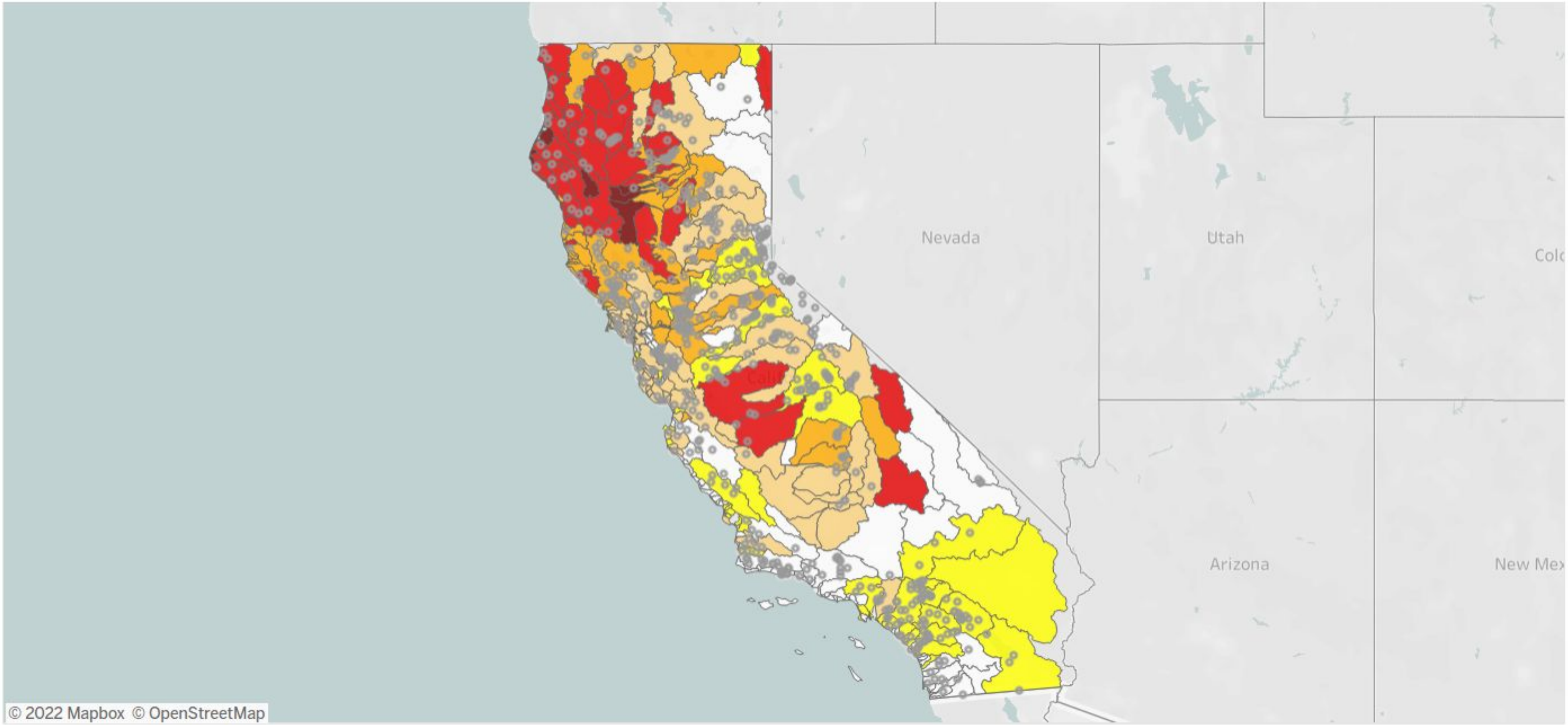
public.tableau.com/app/profile/kklausmeyer/viz/LowFlow_16461846588220/Dashboard1

LowFlow by Kirk Klausmeyer

Year: 2022

Month: 3

Watershed Map



Driest Watersheds

SU Name	
Davis Creek	1.4%
Elder Creek	1.4%
Guthrie Creek	1.4%
Humboldt Bay Creeks	1.4%
North Fork Eel River	1.4%
Thomes Creek	1.4%
Upper Stony Creek	1.4%
Big Flat Creek	2.7%
Cottonwood Creek	2.7%
Cow Creek	2.7%
Dye Creek	2.7%
Lower Trinity River	2.7%
Mad River	2.7%
McCloud River	2.7%
New River	2.7%

Legend

- Exceptional drought (lowest estimate)
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- Abnormally dry (21-30th)
- Normal / wet (31-100th)

Lessons Learned from Recent Droughts

Salmonid Restoration Federation

April 21, 2022

Erin Ragazzi

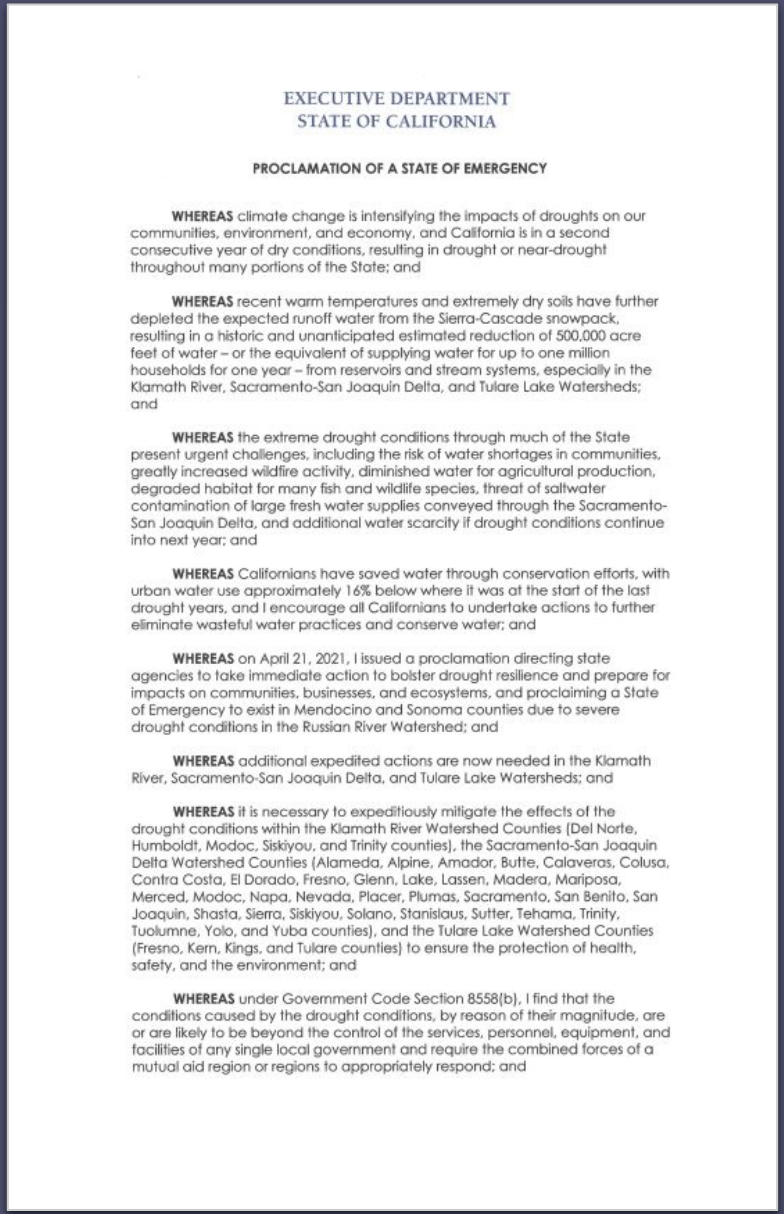
CALIFORNIA Water Boards

Presentation Overview

- Components of a Successful Drought Emergency Regulation
- Lessons Learned
- Next Steps

Components of Successful Drought Emergency Regulation (for fisheries)

- Authority
- Flows for Drought Conditions
- Other Uses
- Extensive Coordination with Fish Agencies
- Opportunity for Local Actions & Solutions
- Public Engagement
- Ability to Learn and Adapt



EXECUTIVE DEPARTMENT
STATE OF CALIFORNIA

PROCLAMATION OF A STATE OF EMERGENCY

WHEREAS climate change is intensifying the impacts of droughts on our communities, environment, and economy, and California is in a second consecutive year of dry conditions, resulting in drought or near-drought throughout many portions of the State; and

WHEREAS recent warm temperatures and extremely dry soils have further depleted the expected runoff water from the Sierra-Cascade snowpack, resulting in a historic and unanticipated estimated reduction of 500,000 acre feet of water – or the equivalent of supplying water for up to one million households for one year – from reservoirs and stream systems, especially in the Klamath River, Sacramento-San Joaquin Delta, and Tulare Lake Watersheds; and

WHEREAS the extreme drought conditions through much of the State present urgent challenges, including the risk of water shortages in communities, greatly increased wildfire activity, diminished water for agricultural production, degraded habitat for many fish and wildlife species, threat of saltwater contamination of large fresh water supplies conveyed through the Sacramento-San Joaquin Delta, and additional water scarcity if drought conditions continue into next year; and

WHEREAS Californians have saved water through conservation efforts, with urban water use approximately 16% below where it was at the start of the last drought years, and I encourage all Californians to undertake actions to further eliminate wasteful water practices and conserve water; and

WHEREAS on April 21, 2021, I issued a proclamation directing state agencies to take immediate action to bolster drought resilience and prepare for impacts on communities, businesses, and ecosystems, and proclaiming a State of Emergency to exist in Mendocino and Sonoma counties due to severe drought conditions in the Russian River Watershed; and

WHEREAS additional expedited actions are now needed in the Klamath River, Sacramento-San Joaquin Delta, and Tulare Lake Watersheds; and

WHEREAS it is necessary to expeditiously mitigate the effects of the drought conditions within the Klamath River Watershed Counties (Del Norte, Humboldt, Modoc, Siskiyou, and Trinity counties), the Sacramento-San Joaquin Delta Watershed Counties (Alameda, Alpine, Amador, Butte, Calaveras, Colusa, Contra Costa, El Dorado, Fresno, Glenn, Lake, Lassen, Madera, Mariposa, Merced, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, San Benito, San Joaquin, Shasta, Sierra, Siskiyou, Solano, Stanislaus, Sutter, Tehama, Trinity, Tuolumne, Yolo, and Yuba counties), and the Tulare Lake Watershed Counties (Fresno, Kern, Kings, and Tulare counties) to ensure the protection of health, safety, and the environment; and

WHEREAS under Government Code Section 8558(b), I find that the conditions caused by the drought conditions, by reason of their magnitude, are or are likely to be beyond the control of the services, personnel, equipment, and facilities of any single local government and require the combined forces of a mutual aid region or regions to appropriately respond; and

Authority

- Water Code section 1058.5
- Governor issues drought proclamation(s) that provides direction and authority to Water Board
  - Board to consider adoption of emergency regulations "to curtail water diversions when water is not available at water right holders' priority of right or to protect releases of stored water." (paragraph 5)
  - "to ensure critical instream flows for species protection in the Klamath..." [State Water Board & CDFW] "shall evaluate the instream flows and other actions needed **to protect salmon, steelhead, and other native fishes...**" (paragraph 6)
  - Environmental review by state agencies required by CEQA are suspended to extent necessary for drought (paragraph 11)

Flows for Drought Conditions

- Establishing flow requirements in California is inherently contentious and controversial
- Most streams lack comprehensive flow requirements
- Drought (bare minimum) flows are needed
  - Mill and Deer (2014 – 15, + Antelope; 2021 - ??)
  - Scott and Shasta (2021 - ??)

Recognize and Provide for Other Uses

- Minimum diversions for:
  - Human Health and Safety
  - Livestock
- Instream Uses
- Substitutions of Water

Extensive Coordination with Fish Agencies

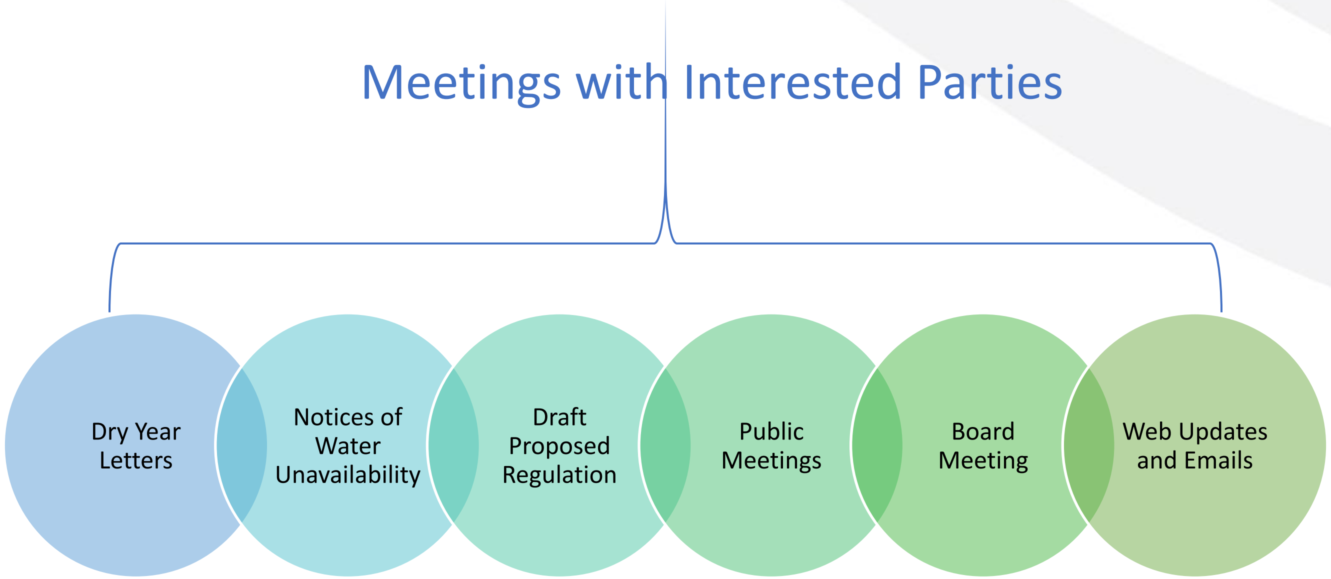
- Drought Flow Recommendation
- Ongoing Implementation

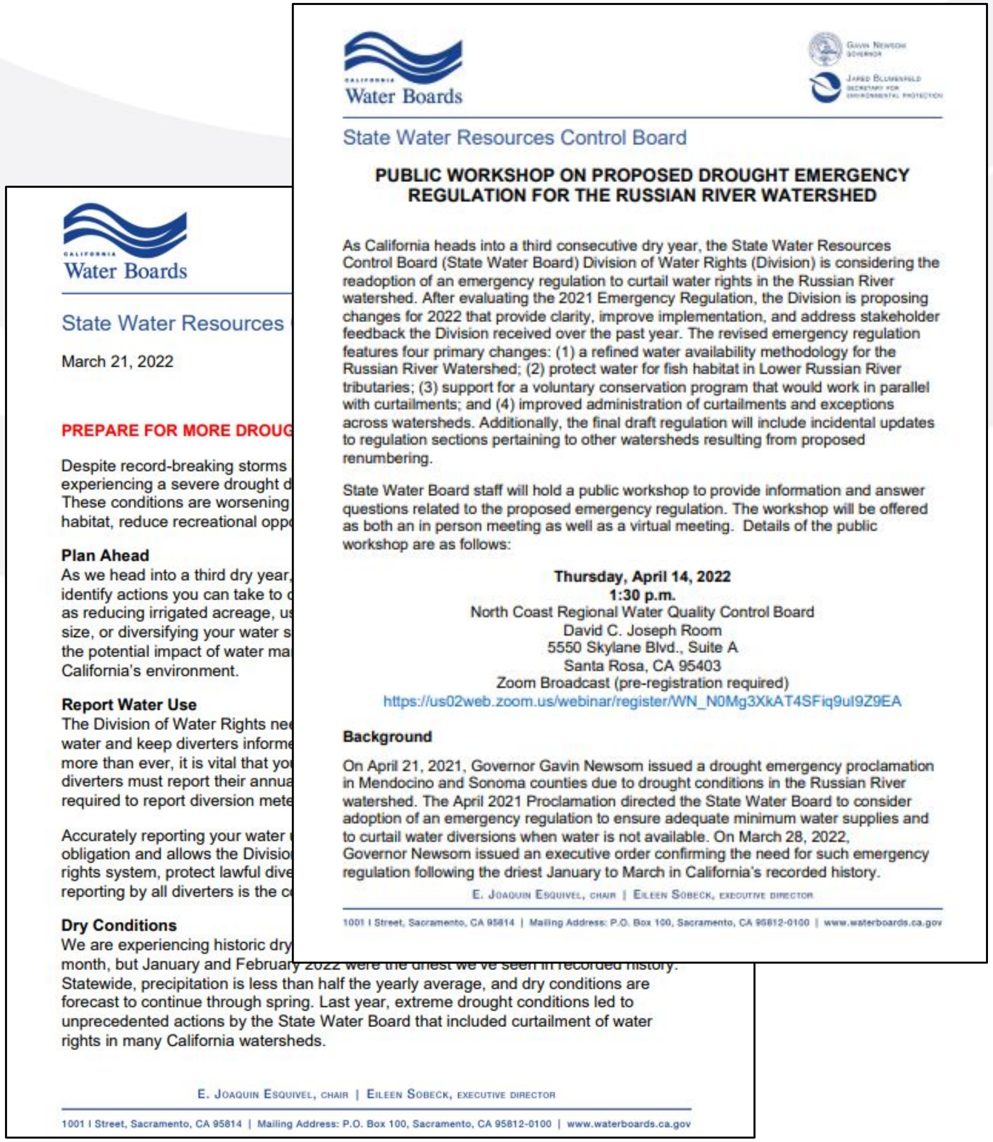
Source: Stream Flow Enhancement Program (ca.gov)

Opportunity for Local Actions and Solutions

- Alternative means to meet minimum flows or provide other fishery benefits
  - Solutions can be on three different scales:
    - Watershed-wide;
    - Tributary-wide; or
    - Individual
  - Must provide equal or better protection in comparison to flow requirements
  - Offers flexibility
  - State Water Board approval required

Public Engagement




Water Boards

State Water Resources

March 21, 2022

PREPARE FOR MORE DROUG

Despite record-breaking storms
experiencing a severe drought d
These conditions are worsening
habitat, reduce recreational opp

Plan Ahead
As we head into a third dry year,
identify actions you can take to c
as reducing irrigated acreage, us
size, or diversifying your water s
the potential impact of water ma
California's environment.

Report Water Use
The Division of Water Rights nee
water and keep diverters informe
more than ever, it is vital that yo
diverters must report their annua
required to report diversion mete

Accurately reporting your water
obligation and allows the Divisio
rights system, protect lawful dive
reporting by all diverters is the c

Dry Conditions
We are experiencing historic dry
month, but January and February 2022 were the driest we've seen in recorded history.
Statewide, precipitation is less than half the yearly average, and dry conditions are forecast to continue through spring. Last year, extreme drought conditions led to unprecedented actions by the State Water Board that included curtailment of water rights in many California watersheds.

E. Joaquin Esquivel, chair | Eileen Sobeck, executive director

1001 I Street, Sacramento, CA 95814 | Mailing Address: P.O. Box 100, Sacramento, CA 95812-0100 | www.waterboards.ca.gov

Water Boards

State Water Resources Control Board

PUBLIC WORKSHOP ON PROPOSED DROUGHT EMERGENCY REGULATION FOR THE RUSSIAN RIVER WATERSHED

As California heads into a third consecutive dry year, the State Water Resources Control Board (State Water Board) Division of Water Rights (Division) is considering the readoption of an emergency regulation to curtail water rights in the Russian River watershed. After evaluating the 2021 Emergency Regulation, the Division is proposing changes for 2022 that provide clarity, improve implementation, and address stakeholder feedback the Division received over the past year. The revised emergency regulation features four primary changes: (1) a refined water availability methodology for the Russian River Watershed; (2) protect water for fish habitat in Lower Russian River tributaries; (3) support for a voluntary conservation program that would work in parallel with curtailments; and (4) improved administration of curtailments and exceptions across watersheds. Additionally, the final draft regulation will include incidental updates to regulation sections pertaining to other watersheds resulting from proposed renumbering.

State Water Board staff will hold a public workshop to provide information and answer questions related to the proposed emergency regulation. The workshop will be offered as both an in person meeting as well as a virtual meeting. Details of the public workshop are as follows:

Thursday, April 14, 2022
1:30 p.m.
North Coast Regional Water Quality Control Board
David C. Joseph Room
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403
Zoom Broadcast (pre-registration required)
https://us02web.zoom.us/webinar/register/WN_N0Mg3XkAT4SFiq9ul9Z9EA

Background

On April 21, 2021, Governor Gavin Newsom issued a drought emergency proclamation in Mendocino and Sonoma counties due to drought conditions in the Russian River watershed. The April 2021 Proclamation directed the State Water Board to consider adoption of an emergency regulation to ensure adequate minimum water supplies and to curtail water diversions when water is not available. On March 28, 2022, Governor Newsom issued an executive order confirming the need for such emergency regulation following the driest January to March in California's recorded history.

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Ability to Learn and Adapt

- Emergency regulations in effect for short period of time
  - Feedback Loop - readoption provides opportunity to assess what worked, what did not work so well, and make updates
- Built in flexibility, when appropriate:
  - Scott-Shasta regulation provides for update to flows with new information supported by CDFW after coordination with NMFS
  - Mill-Deer regulation provides for pulse flows based on fish presence and coordination with CDFW (diverters consulted)
  - Local Cooperative Solutions
- Information order authority
  - Provides information to support regulation implementation

Lessons Learned & Areas for Improvement

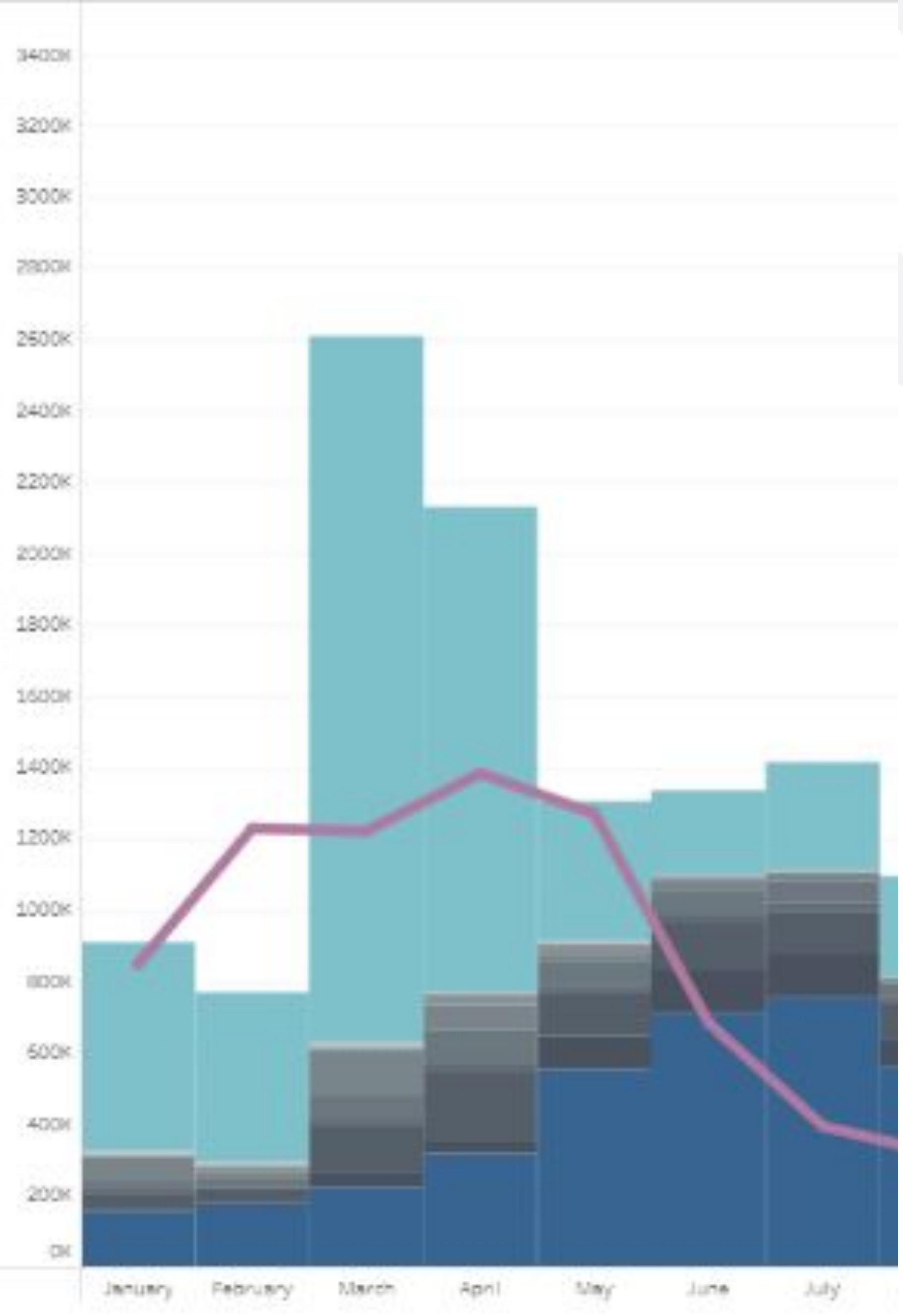
- Feedback Loop
- Communication of Regulation
- Data
- Tools (ongoing development underway)

Communication of Regulation

- Distilling down complex regulation is difficult and offers room for improvement
  - Fact Sheets
  - Curtailment Status in Multiple Formats (lists, graphics)
  - Simplify Curtailment & Information Order Letters
  - Recorded Webinars
  - Word of Mouth or Other Community Driven Methods of Communication
  - Meet with Engaged Community Members
  - Media

Data (areas for improvement)

- Water Measurement Regulations
  - Improved compliance
  - Improved data quality
- Annual water use data
  - Unreported water use
  - Errors in reported data
- Climate and streamflow forecasting data
- Gaging

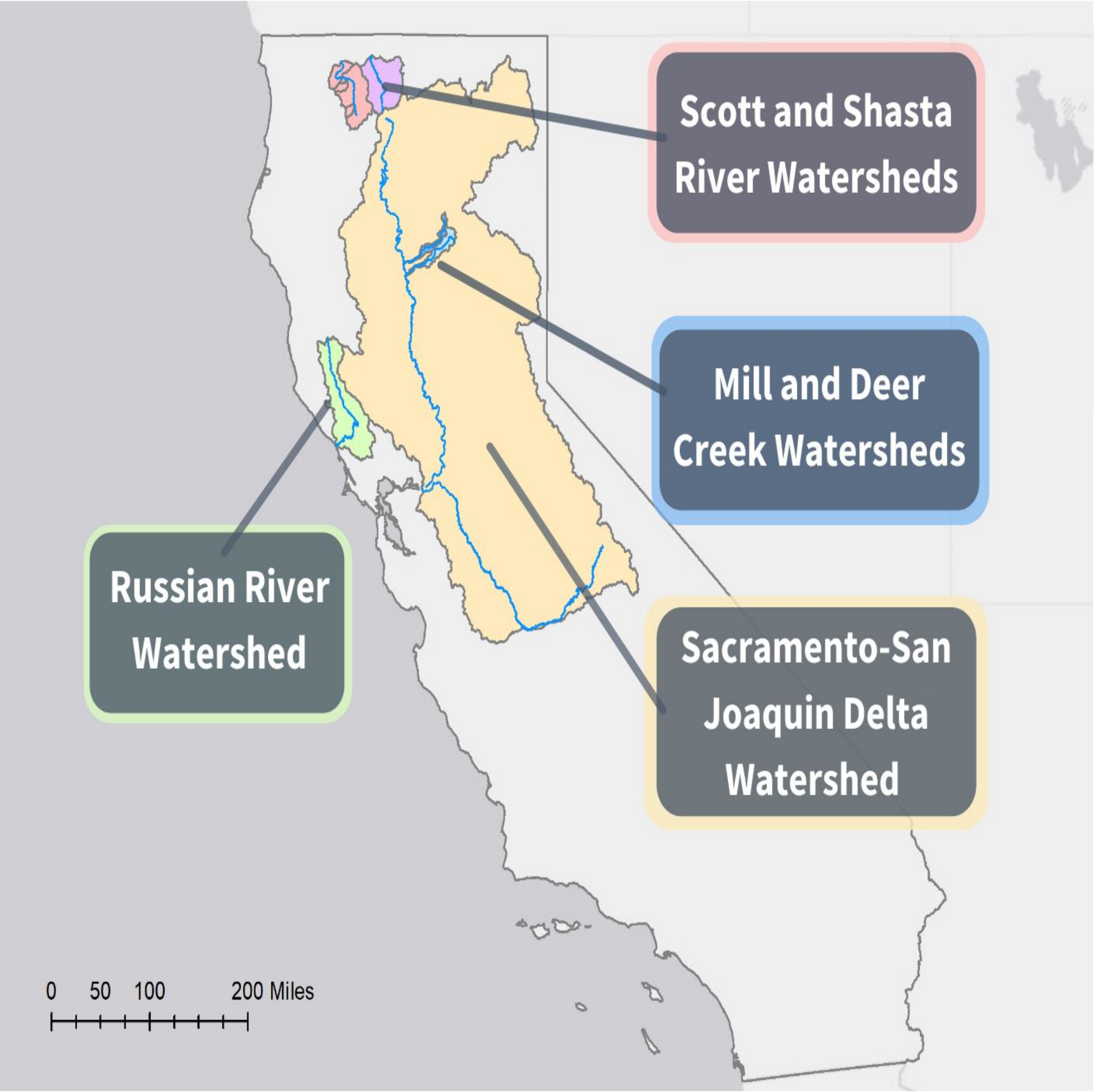


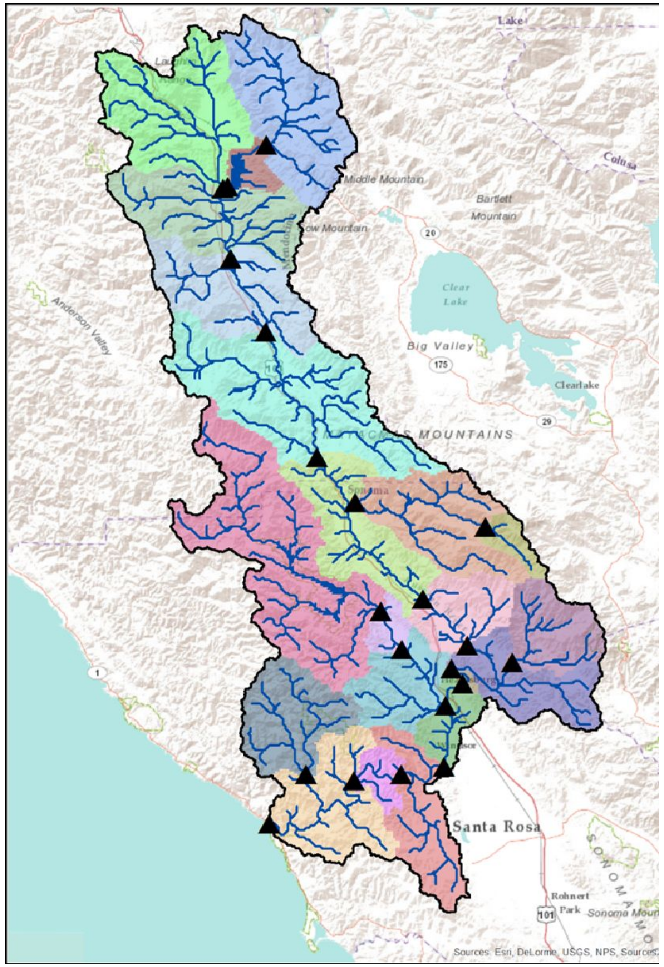
Tools
(leaps and bounds beyond 2014-16 drought)

- Water Unavailability Methodology for the Delta Watershed
- Water Supply and Demand Visualization Tool
- Water Rights Demand Data Analysis Methodology
- Initial Hydrology Modeling (Coming 2022)
- Water Allocation Tool (Coming 2022)
- Develop tools to inform assessment of trade-offs of flow alternatives and other uses

Next Steps

- Short-term:
  - Update and maintain existing efforts (hang in there)
  - Education and outreach to local communities
  - Support CDFW and NMFS voluntary drought initiative program
  - Funding for water conservation, with focus long-term actions
- Mid-term: Cover more watersheds
  - Resources
  - Drought Flow Recommendations or **Other Criteria**





Next Steps

- Long-term: Establish year-round, long-term flows in key watersheds
  - Resources
  - Flow Recommendations
  - Flow Setting/CEQA
  - Ongoing Implementation & Adaptive Management

Additional Information & Updates

- Drought Webpage:
  - www.waterboards.ca.gov/drought
- Email Subscription Lists :
  - https://www.waterboards.ca.gov/resources/email_subscriptions/
    - Under “State Water Resources Control Board”, then “Water Rights”
  - Bay-Delta: “Delta Drought”
  - Mill & Deer Creeks: “Mill Deer Drought”
  - Russian River: “Russian River Drought”
  - Scott & Shasta Rivers: “Scott-Shasta Drought”

Questions?

An Ecological Drought Indicator Framework for California

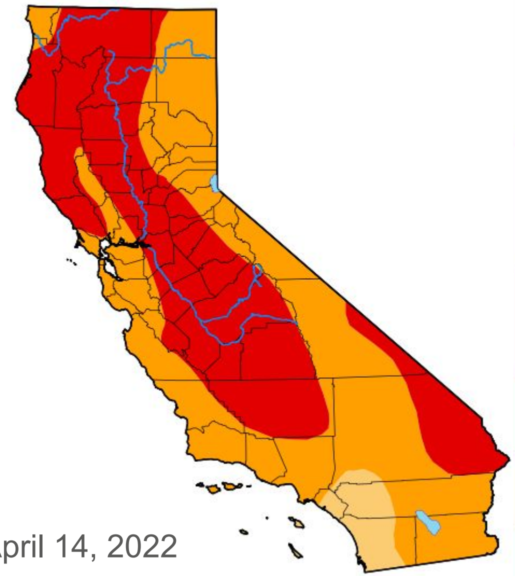
SRF 2022: Drought Response Session

April 21, 2022

Ted Grantham and Jeff Mount

Supported by funding from National Oceanic Atmospheric Administration’s (NOAA) National Integrated Drought Information System (NIDIS)

Current US Drought Monitor



Category	Description	Possible Impacts	Ranges: Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: ▪ short-term dryness slowing planting, growth of crops or pastures Coming out of drought: ▪ some lingering water deficits ▪ pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	▪ Some damage to crops, pastures ▪ Streams, reservoirs, or wells low, some water shortages developing or imminent ▪ Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	▪ Crop or pasture losses likely ▪ Water shortages common ▪ Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	▪ Major crop/pasture losses ▪ Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	▪ Exceptional and widespread crop/pasture losses ▪ Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

NIDIS drought categories

D0 - Abnormally Dry
- Soil is dry; irrigation delivery begins early
- Dryland crop germination is stunted
- Active fire season begins

100.0% of CA (D0–D4)

D1 - Moderate Drought
- Dryland pasture growth is stunted; producers give supplemental feed to cattle
- Landscaping and gardens need irrigation earlier; wildlife patterns begin to change
- Stock ponds and creeks are lower than usual

100.0% of CA (D1–D4)

D2 - Severe Drought
- Grazing land is inadequate
- Fire season is longer, with high burn intensity, dry fuels, and large fire spatial extent
- Trees are stressed; plants increase reproductive mechanisms; wildlife diseases increase

92.4% of CA (D2–D4)

D3 - Extreme Drought
- Livestock need expensive supplemental feed; cattle and horses are sold; little pasture remains; fruit trees bud early; producers begin irrigating in the winter
- Fire season lasts year-round; fires occur in typically wet parts of state; burn bans are implemented
- Water is inadequate for agriculture, wildlife, and urban needs; reservoirs are extremely low; hydropower is restricted

80.3% of CA (D3–D4)

D4 - Exceptional Drought
- Fields are left fallow; orchards are removed; vegetable yields are low; honey harvest is small
- Fire season is very costly; number of fires and area burned are extensive
- Fish rescue and relocation begins; pine beetle infestation occurs; forest mortality is high; wetlands dry up; survival of native plants and animals is low; fewer wildflowers bloom; wildlife death is widespread; algae blooms appear

28.3% of CA (D4)

Source(s): NDMC, NOAA, USDA

Limitations of drought monitor

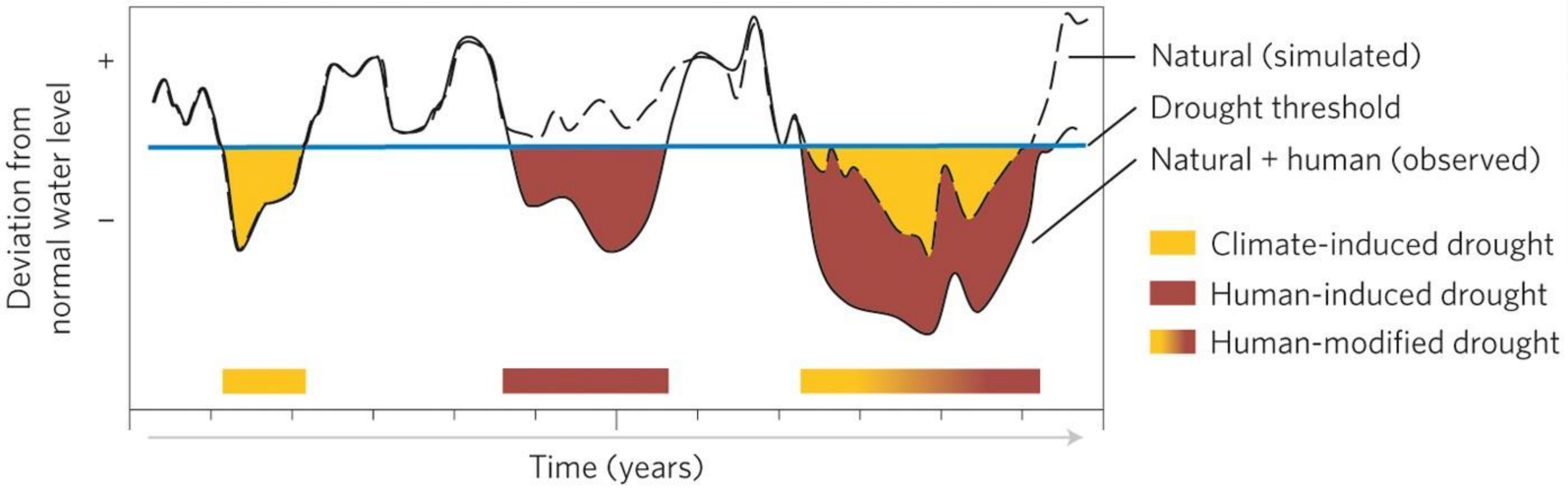
- Relies primarily on meteorological indicators, which may not reflect ecologically available water
- Does not account for impacts of water management operations, including reservoirs and conveyance infrastructure
- Antecedent conditions not considered, which affect ecological response to drought
- Lack of transparency around drought status calculation

What is ecological drought?

"episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability, impacts ecosystem services, and triggers feedback in natural and/or human systems"

Source: Crausbay et al. 2017 *AMS*

Ecological drought intensified by human activities



Source: Van Loon et al. 2016 *Nature Geoscience*

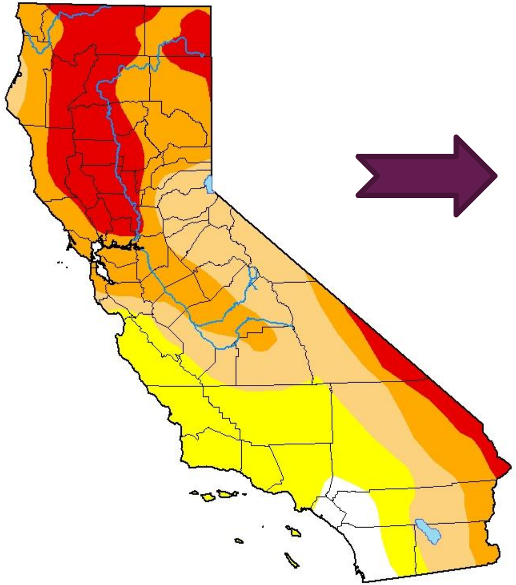
Goals for an ecological drought indicator

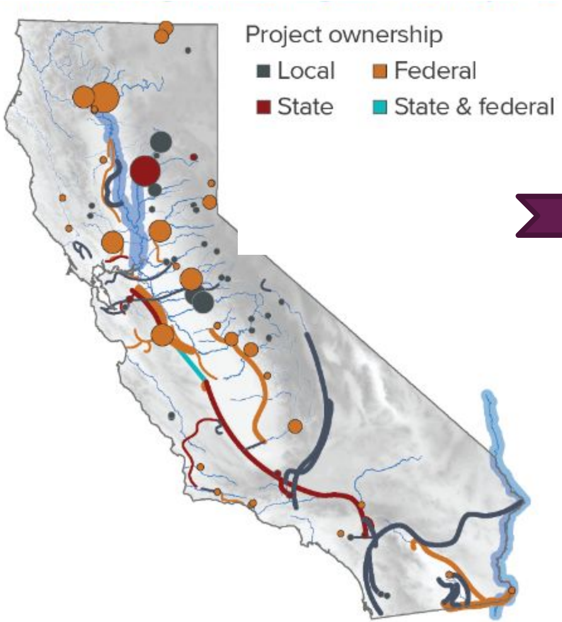
- Represent ecologically available water
- Reflect stress to ecosystem from both hydro-meteorological drought and management actions.
- Account for antecedent climate conditions (lag effects)
- Use transparent, quantitative methods for indicator calculation
- Applicable to different ecosystems and management contexts

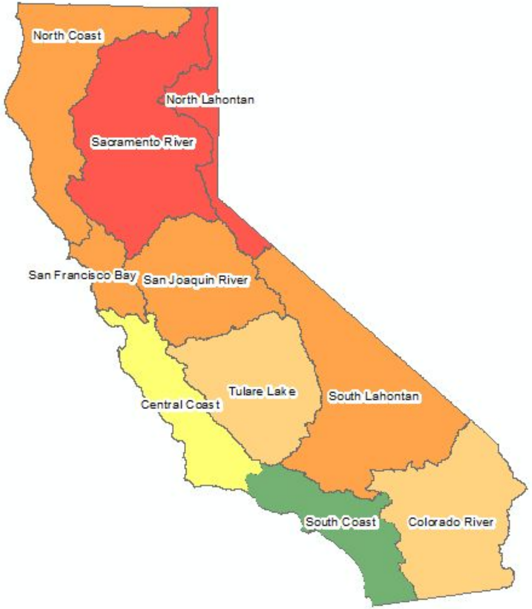
"Linking indicators of drought to multi-sectoral impacts" project

- Funded by NOAA's National Integrated Drought Information System (NIDIS) Program
- Overarching goal is to develop new drought indicators that:
  - Account for the "water grid"
  - Consider sector-specific impacts (including **ecosystems**)
- "Proof of concept" to guide improvements to the NIDIS Drought Monitor

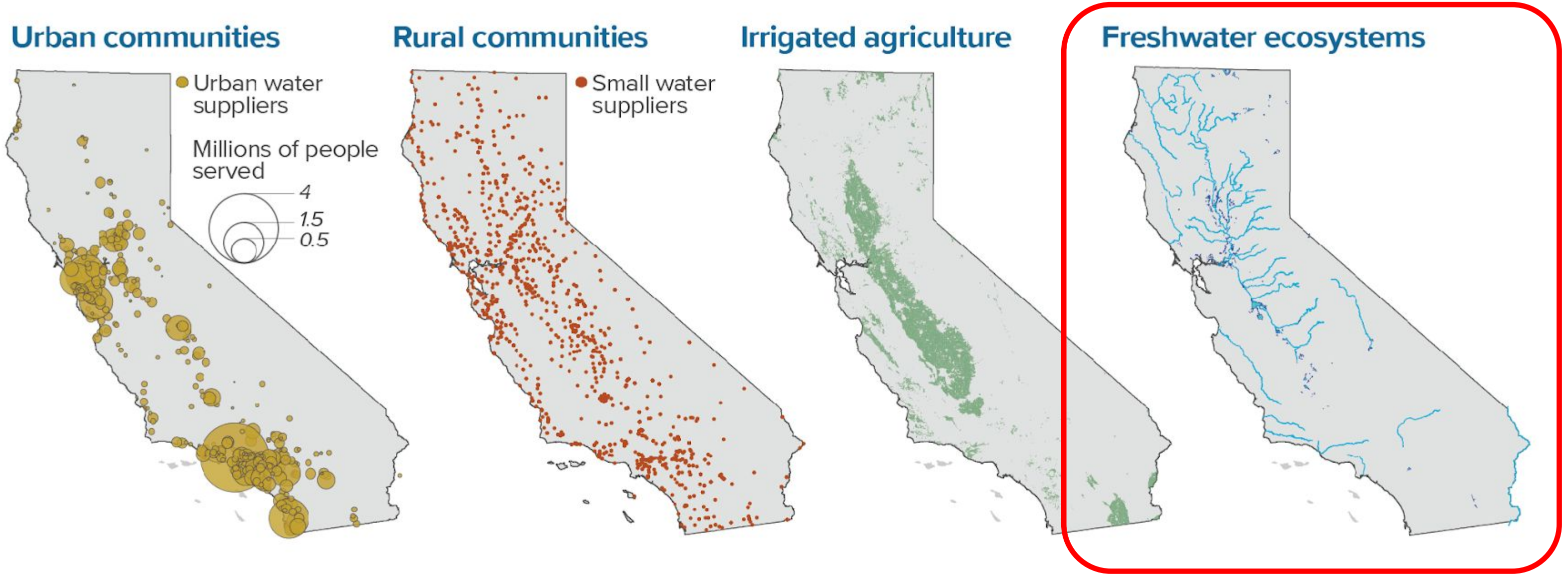
California water grid



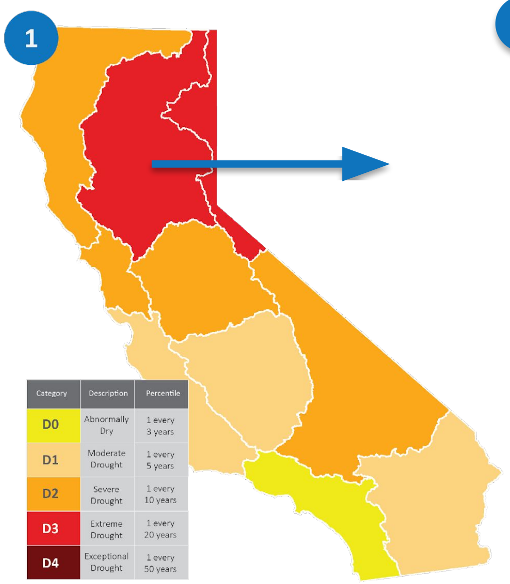




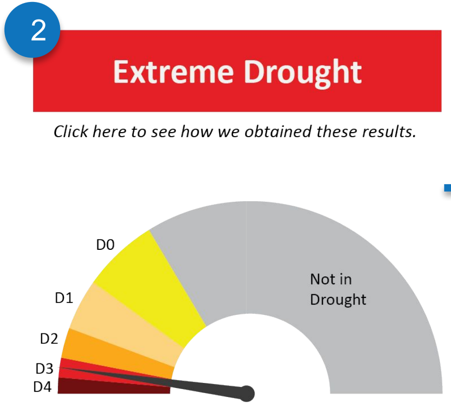
California water sectors

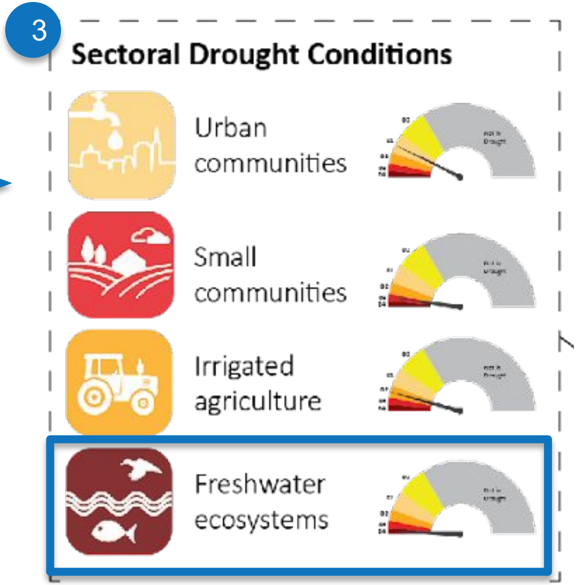


Vision for drought monitor 2.0

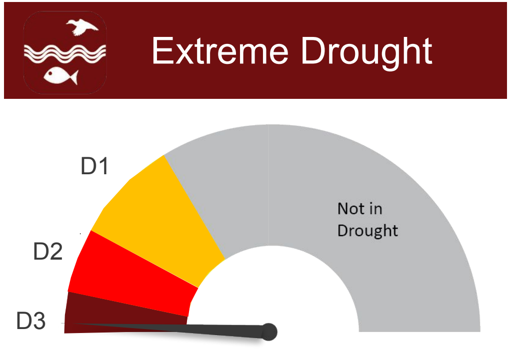


Category	Description	Percentile
D0	Abnormally Dry	1 every 3 years
D1	Moderate Drought	1 every 5 years
D2	Severe Drought	1 every 10 years
D3	Extreme Drought	1 every 20 years
D4	Exceptional Drought	1 every 50 years

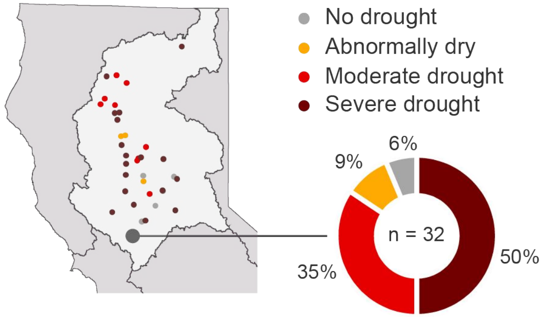




Ecosystem drought indicator dashboard



Streamflow conditions for regional gages



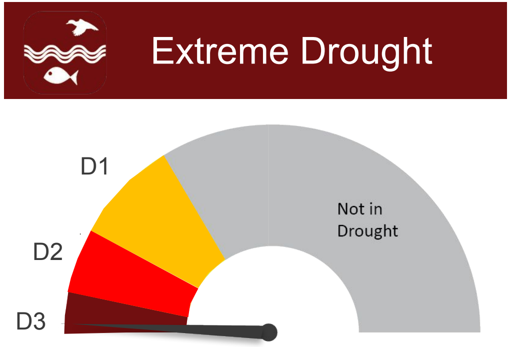
- Freshwater ecosystems are experiencing **extreme drought** stress as a consequences of extreme low precipitation, high evapotranspiration, and low snowpack, and warm temperatures.
- Stream flows in the region exhibit **extreme drought** conditions
- Native freshwater species are likely experiencing high physiological stress, reproductive failure, and high mortality from limited water availability and water quality degradation.

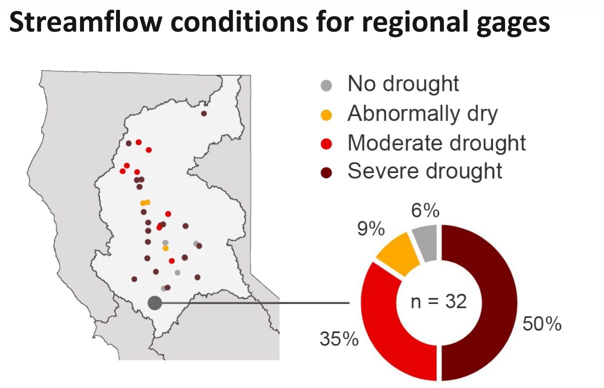
PPIC

Ecosystem drought indicator categories

Drought Category	Indicator Range	NIDIS Drought Category	Range
Non-drought	> 40	Non-drought	>30
Moderate drought	25 - 40	Abnormally dry (DO) Moderate drought (D1)	20 - 30 10 - 20
Severe drought	10 - 25	Abnormally dry (DO) Moderate drought (D1)	20 - 30 10 - 20
Extreme drought	< 10	Severe drought (D2) Extreme drought (D3) Exceptional drought (D4)	5 - 10 2 – 5 0 - 2

Ecosystem drought indicator dashboard





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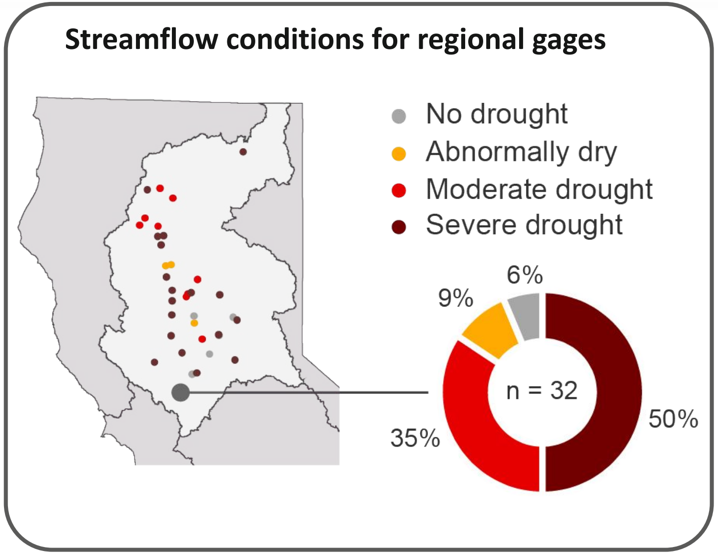
PPIC

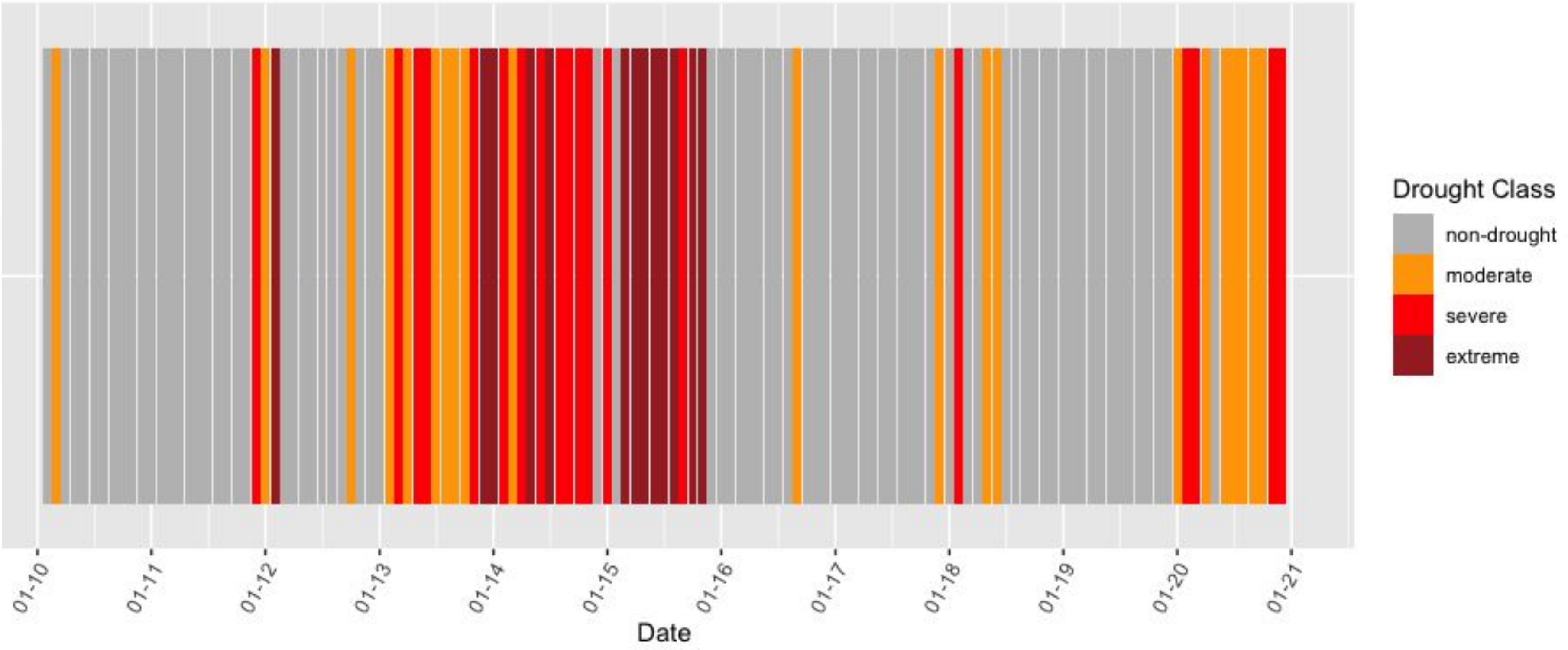
Regional streamflow drought indicator



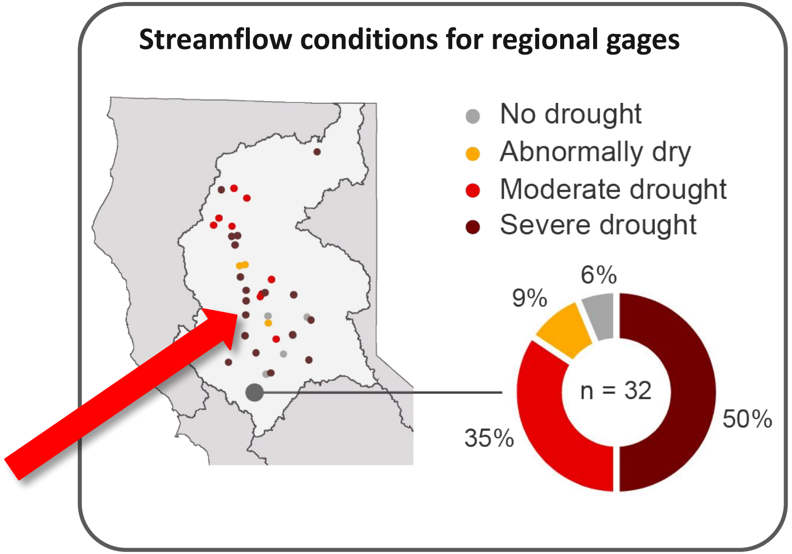
Streamflow indicator classification

Non-drought (D0)	<50% of gages in D1, D2, and D3
Moderate drought (D1)	≥50% of gages in D1, D2, and D3
Severe drought (D2)	≥50% of gages in D2 and D3
Extreme drought (D3)	≥50% of gages in D3

Streamflow drought series (2010 – 2022)



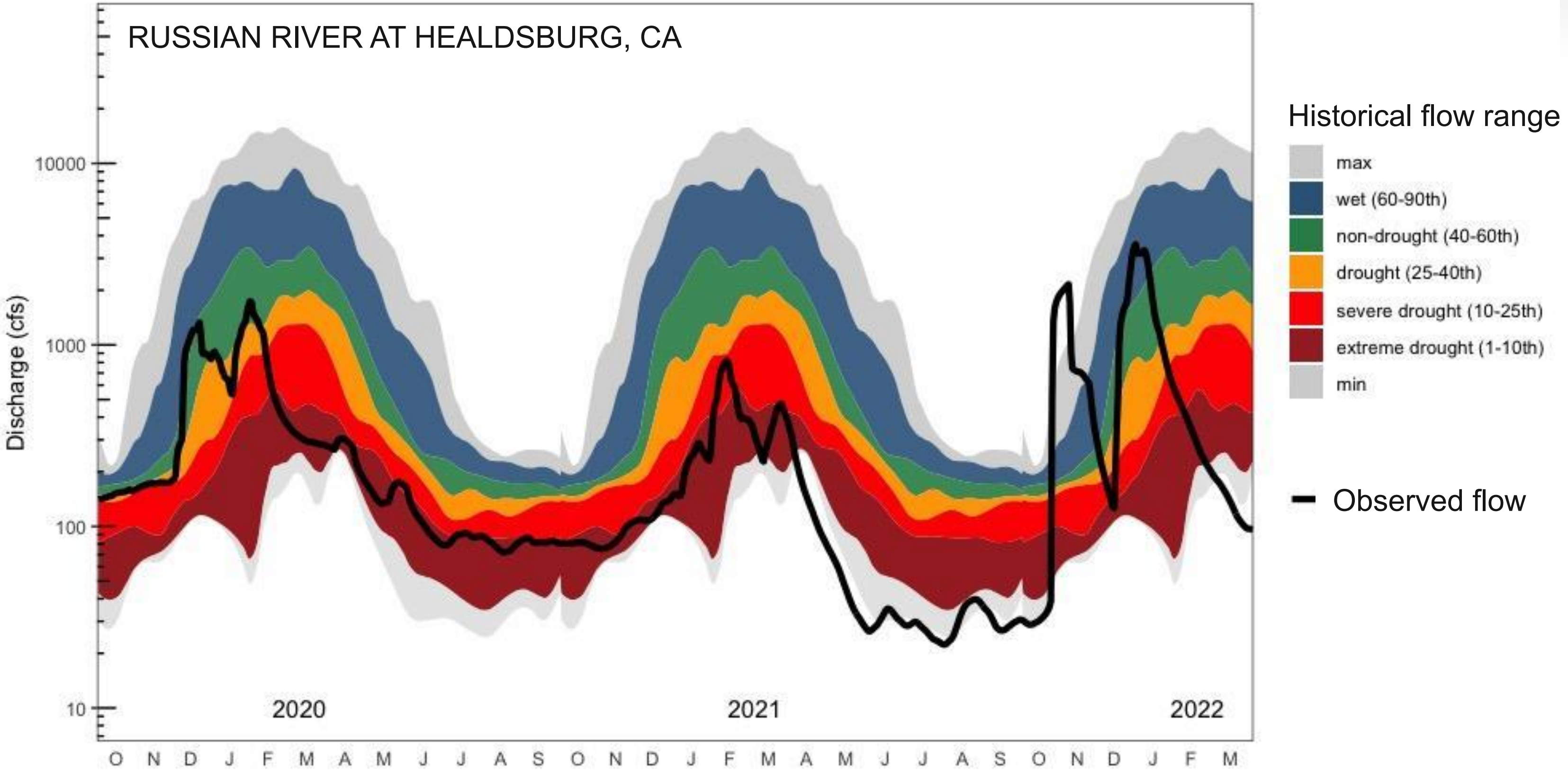
Regional streamflow drought indicator



Streamflow index classification

Non-drought (D0)	<50% of gages in D1, D2, and D3
Moderate drought (D1)	≥50% of gages in D1, D2, and D3
Severe drought (D2)	≥50% of gages in D2 and D3
Extreme drought (D3)	≥50% of gages in D3

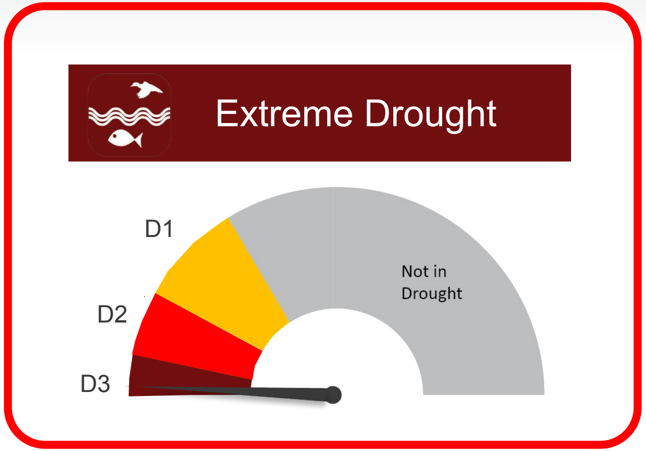
Station specific flow conditions



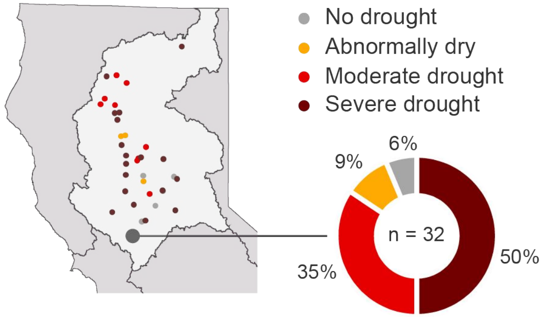
Streamflow indicator advantages and limitations

- Integrates hydrometeorological conditions and management actions
- Gages over-represent large, dam-regulated rivers and under-represent, smaller, unregulated streams
- Number of long-term gages limited in some hydrologic regions

Ecosystem drought indicator dashboard



Streamflow conditions for regional gages



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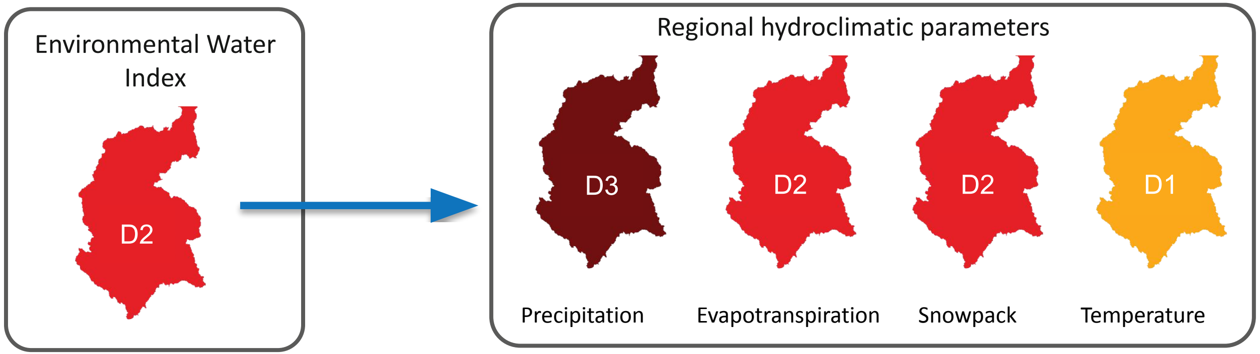
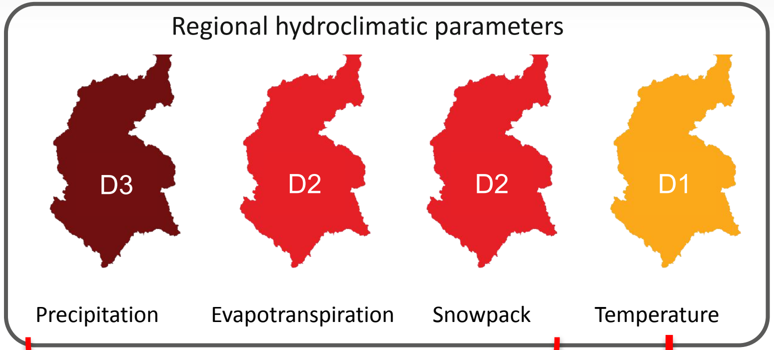
Environmental water indicator



Environmental water indicator components



Runoff = Precip – ET – ΔSnowpack

Max monthly temp

Runoff index mean monthly values (1985-2020)

MONTH	PPT	ET	SWE	delta(SWE)	Runoff Index
Jan	162	37	72	38	86
Feb	155	49	108	36	70
Mar	141	81	139	31	28
Apr	70	113	129	-11	-33
May	52	158	65	-64	-43
Jun	18	190	15	-50	-122
Jul	3	216	1	-14	-199
Aug	4	196	0	0	-192
Sep	14	149	0	0	-135
Oct	50	99	1	1	-50
Nov	99	48	8	7	44
Dec	161	34	33	25	102

Regional environmental water indicator

$$
\begin{aligned}
E\text{-}water_i = \;& \beta_{1,i} \text{ x } runoff_i \; + \\
& \beta_{2,i} \text{ x } runoff_{i\text{-}3} \; + \\
& \beta_{3,i} \text{ x } runoff_{i\text{-}11} \; + \\
& \beta_{4,i} \text{ x } temp_i
\end{aligned}
$$

Runoff for current month

Mean runoff for current and previous 3 months

Mean runoff for current and previous 11 months

Mean max monthly temperature for current month

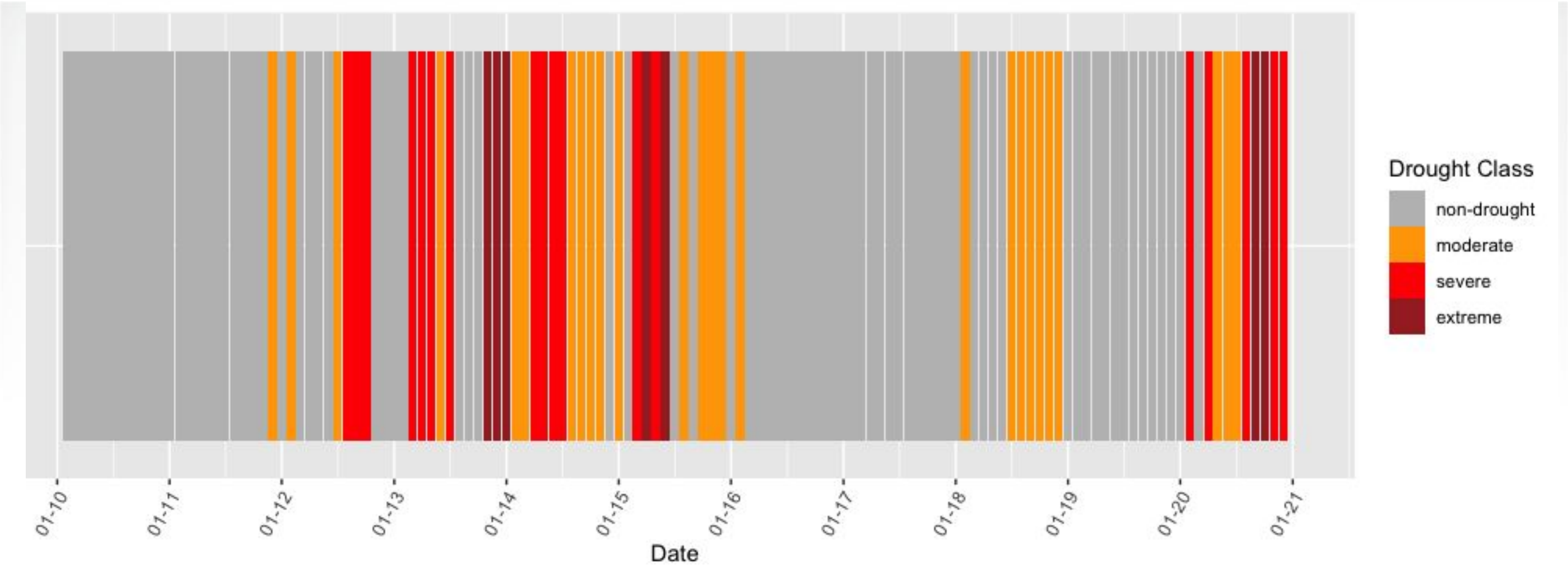
where i = month, x = antecedent period,
$\beta_{x,i}$ = monthly parameter weight (0 - 1)

Parameter weighting*

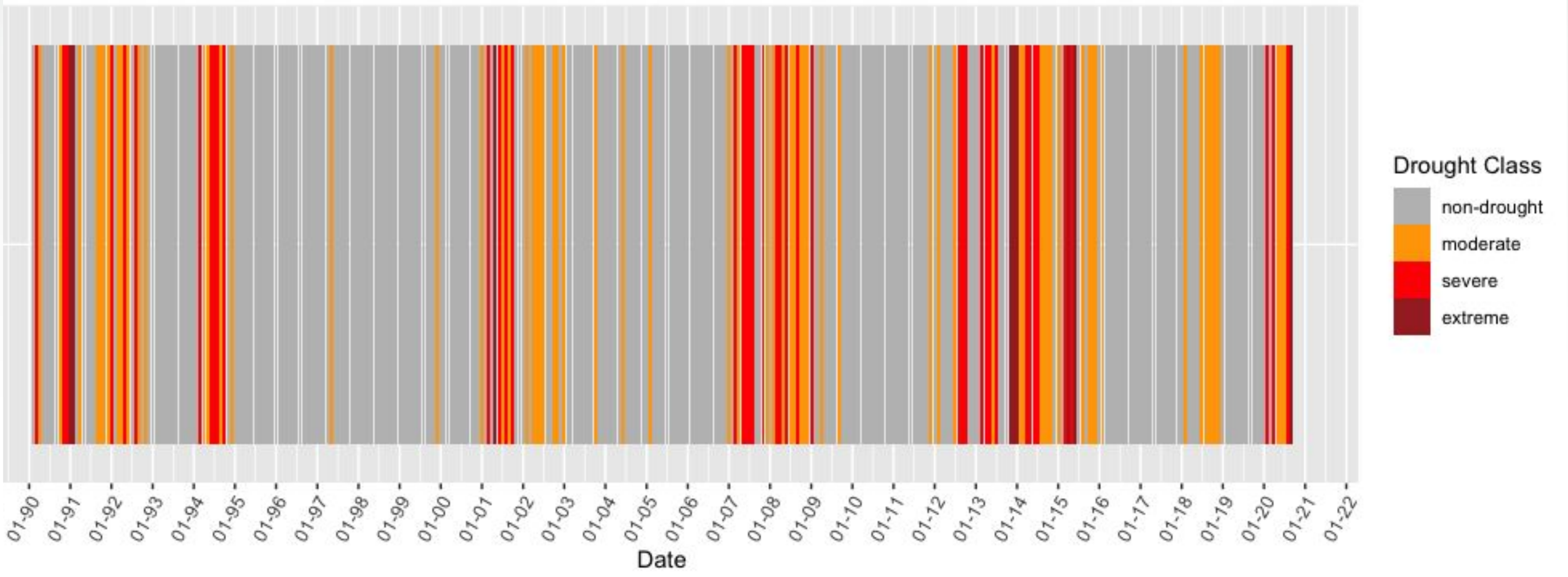
	Fall	Winter	Spring	Summer
Current runoff	0.1	0.3	0.2	0.1
Antecedent runoff (3 months)	0.1	0.3	0.3	0.2
Antecedent runoff (12 months)	0.5	0.3	0.3	0.4
Monthly max temperature	0.3	0.1	0.2	0.3

** Summarized here at seasonal scale; weightings for index defined at monthly scale*

Regional environmental water time series (2010 – 2020)



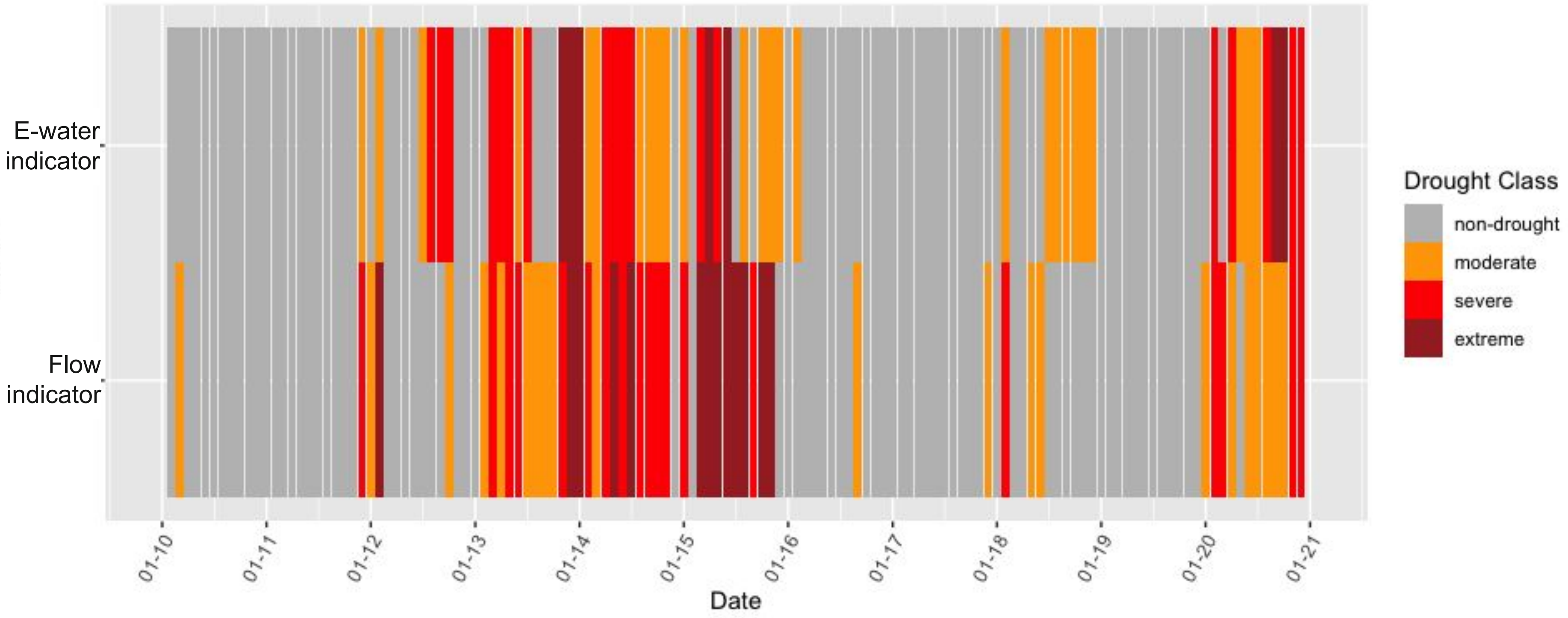
Environmental water (1990 – 2020)



Environmental water indicator advantages and limitations

- Represents water available to ecosystem, based on commonly used hydrometeorological variables
- Accounts for antecedent climate conditions
- Does not account for influence of water management (e.g., reservoir operations and diversions)
- Spatially comprehensive

Regional environmental water drought indicator vs. streamflow drought indicator (2010 – 2021)



Ecosystem responses to drought

Declining water quantity and quality

- Lower flows
- Wetland contraction
- Habitat loss
- Higher temperatures
- Higher contaminant conc.
- Lower dissolved oxygen

Physiological stress

- Higher metabolic costs
- Increased competition
- Reduced food supplies
- Higher susceptibility to and prevalence of disease

Recruitment failure and mortality

- Lower fitness & survival
- Loss of reproductive cues
- Reduced (access to) habitat required for reproduction

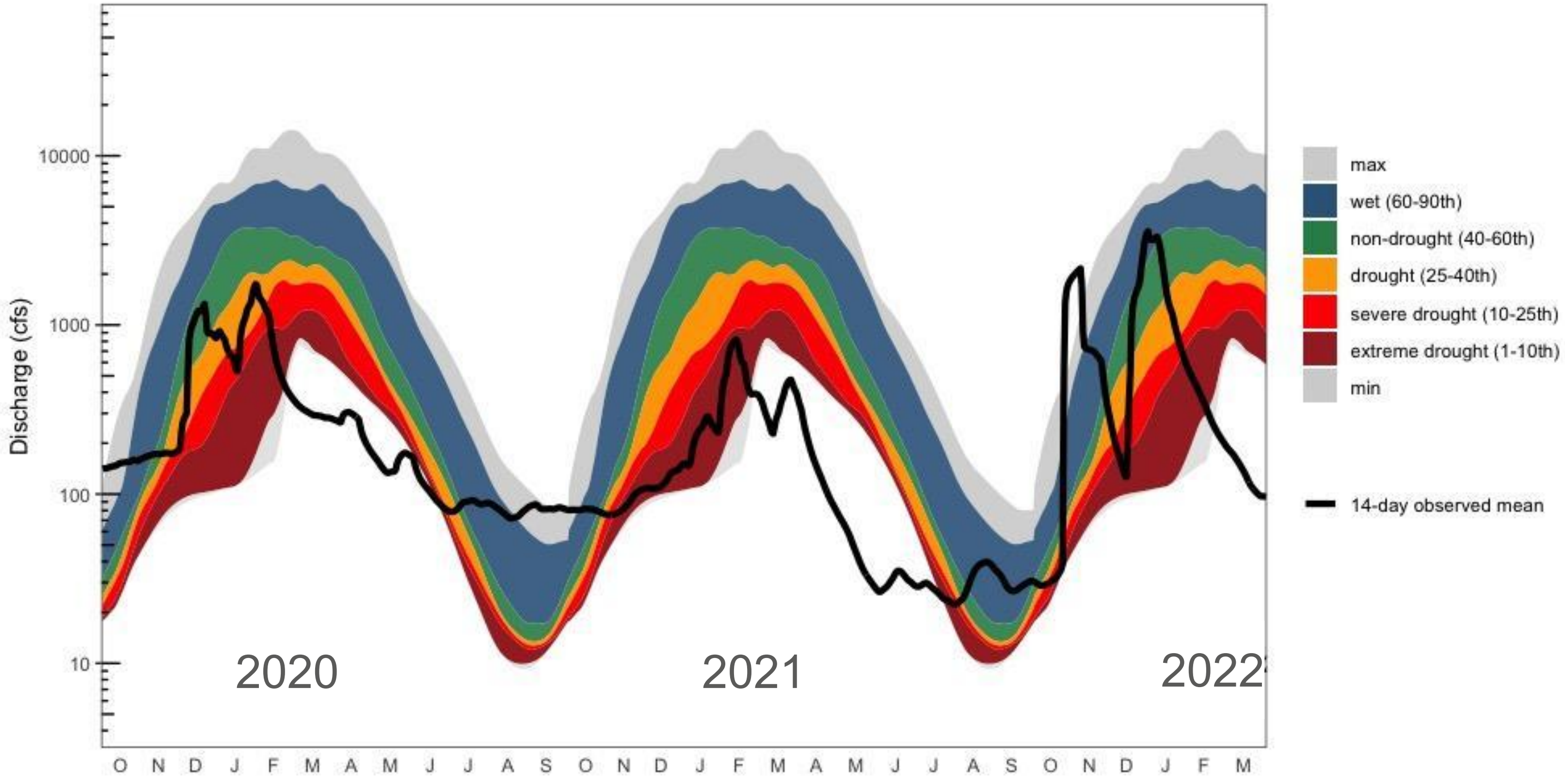
Changes in assemblages

- Population declines
- Shifts in community composition
- Range contractions
- Local and regional extinction

Ecosystem vulnerability to drought

- Flow regime alteration
- Passage barriers
- Loss of floodplain connectivity
- Habitat degradation

Observed vs. natural flows in the Russian River

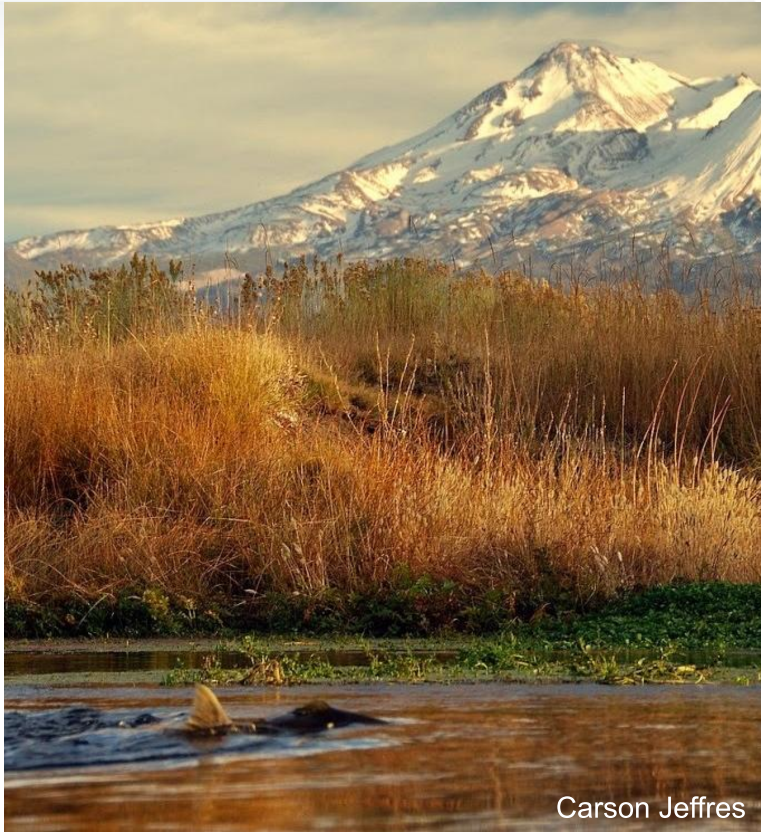


Conclusions

- Indicators provide a transparent and flexible tool to assess ecological drought risk in California
- Indicators reflect ecologically available water and account for influence of management operations and antecedent conditions
- Further analysis needed to link indicators to specific ecological drought impacts
- Indicators can be integrated in drought monitoring tool or adapted to specific decision contexts to trigger management actions

Acknowledgements

- Technical Advisory Group
- NOAA NIDIS Program
- Session coordinators and SRF!


Carson Jeffres

PPIC

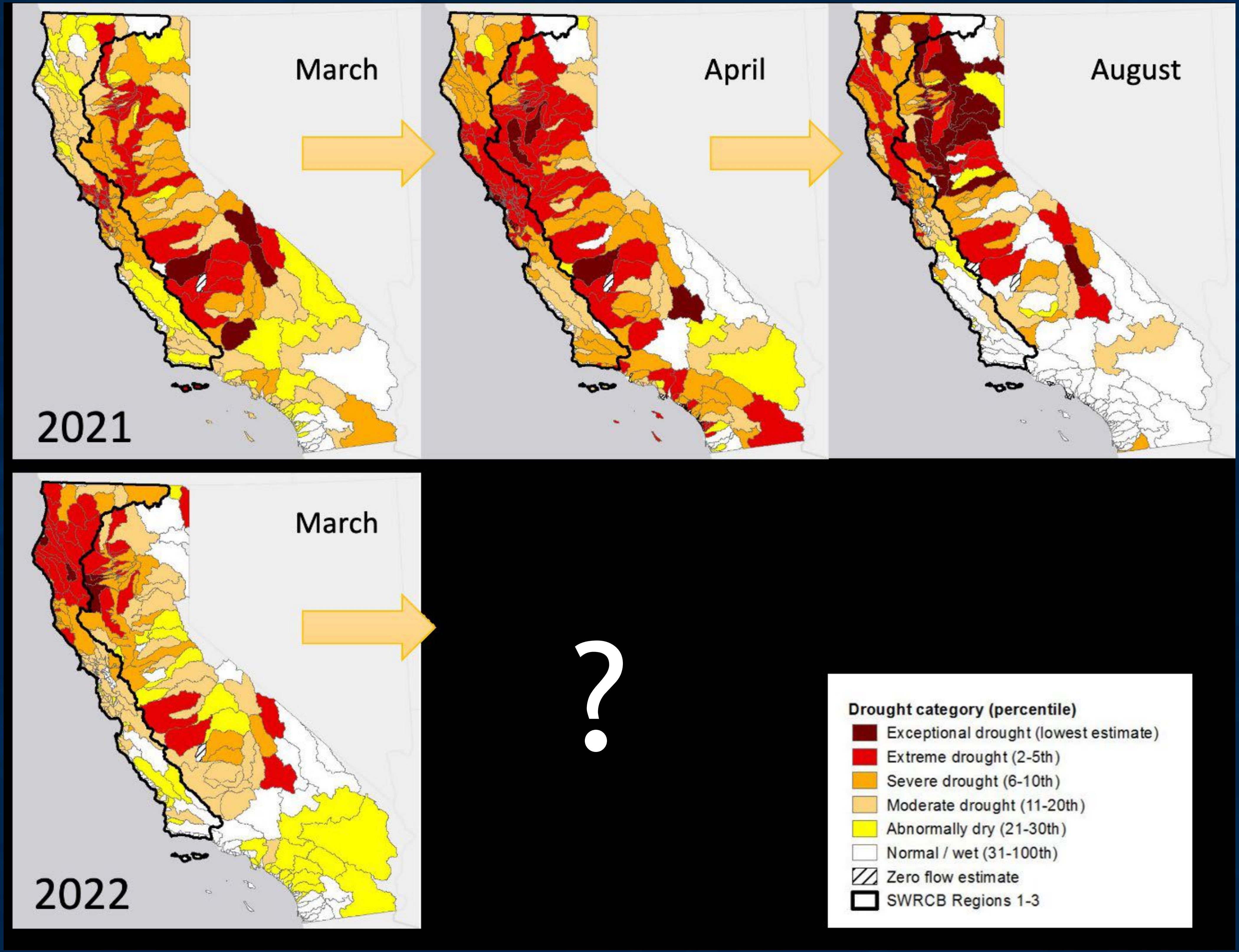
Watershed-scale Cooperative Solutions:

Projects and Approaches to Increase Drought and Climate Resilience for Streamflow, Fish Habitat and Water Supplies in Coastal Watersheds

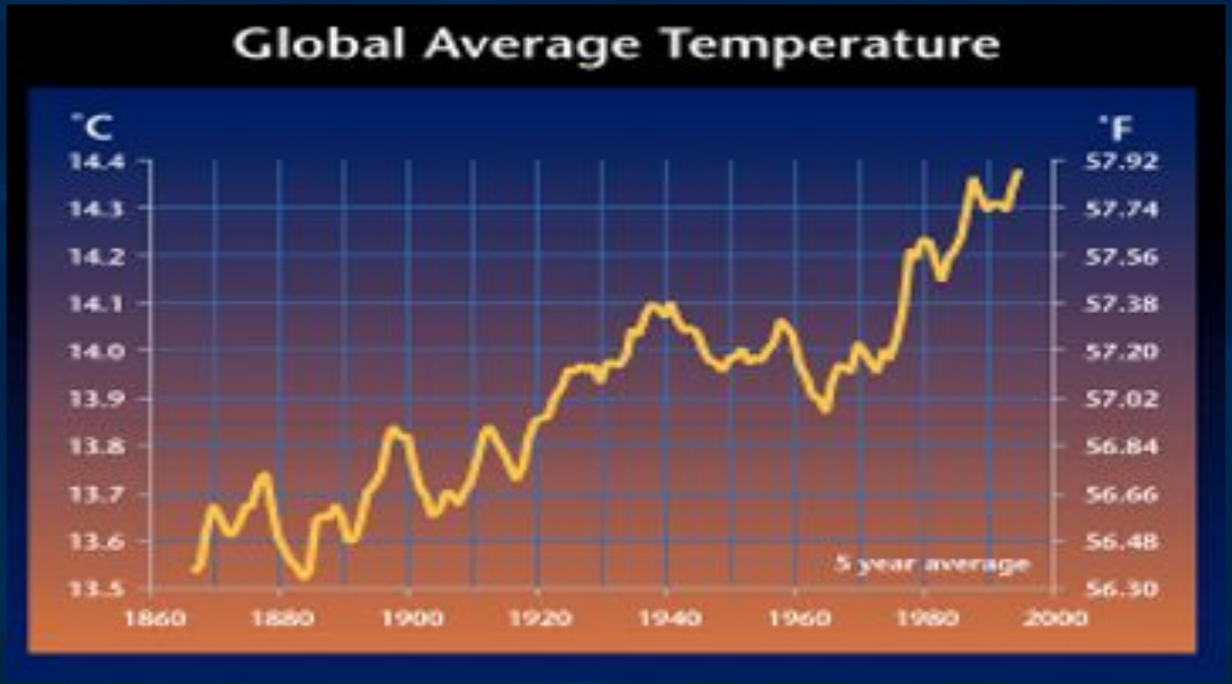
Presentation to the Salmonid Restoration Federation Conference
Santa Cruz, CA
April 21, 2022

Mia van Docto
Trout Unlimited

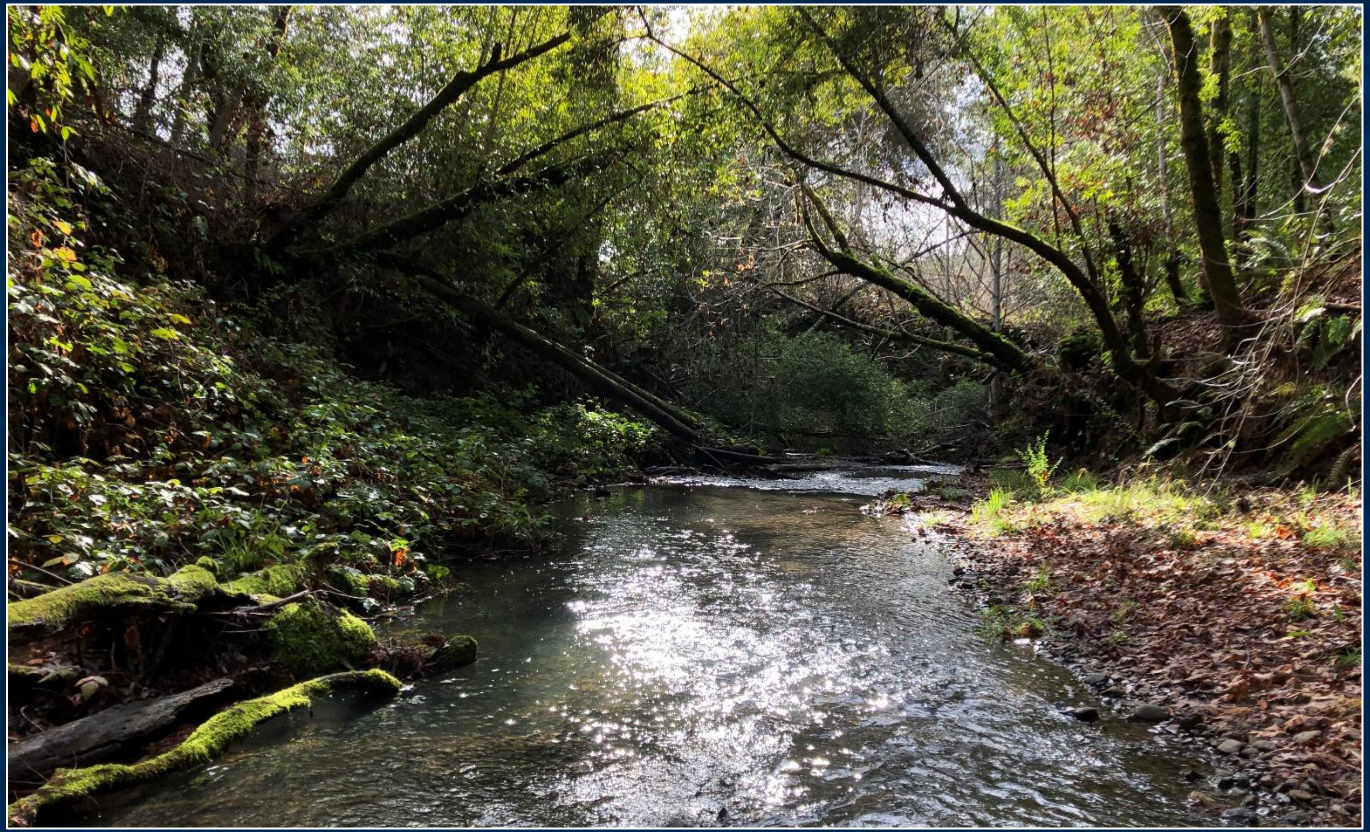
Monty Schmitt
The Nature Conservancy


March
April
August
2021
March
2022
?
Drought category (percentile)
Exceptional drought (lowest estimate)
Extreme drought (2-5th)
Severe drought (6-10th)
Moderate drought (11-20th)
Abnormally dry (21-30th)
Normal / wet (31-100th)
Zero flow estimate
SWRCB Regions 1-3

North Coast water management challenges



Is this the new normal?



Water demand vs the timing of water availability

Navarro River Watershed

Water Use

- Annual water use = 1,700 Acre-Feet
  - Summer water use = 1,400 Acre-Feet
  - *82% of all water is use in summer*

Water Supply

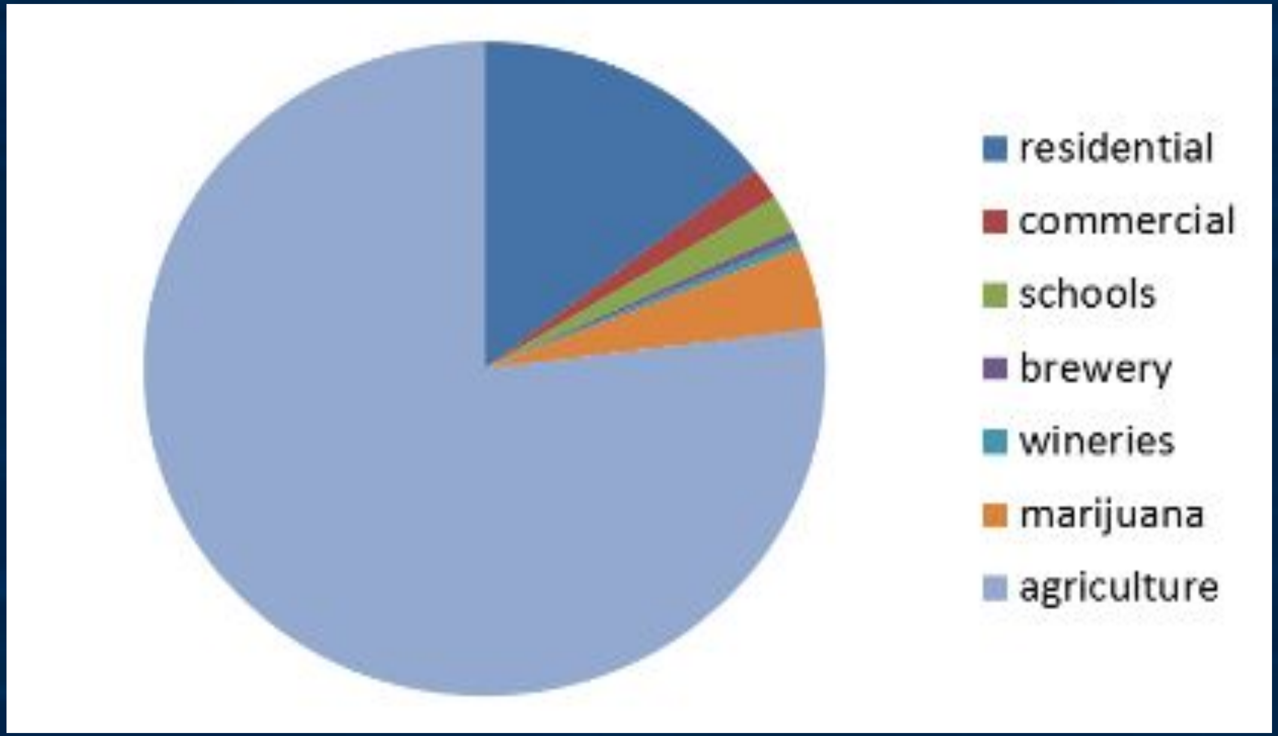
Average annual runoff = 240,000 Acre-Feet

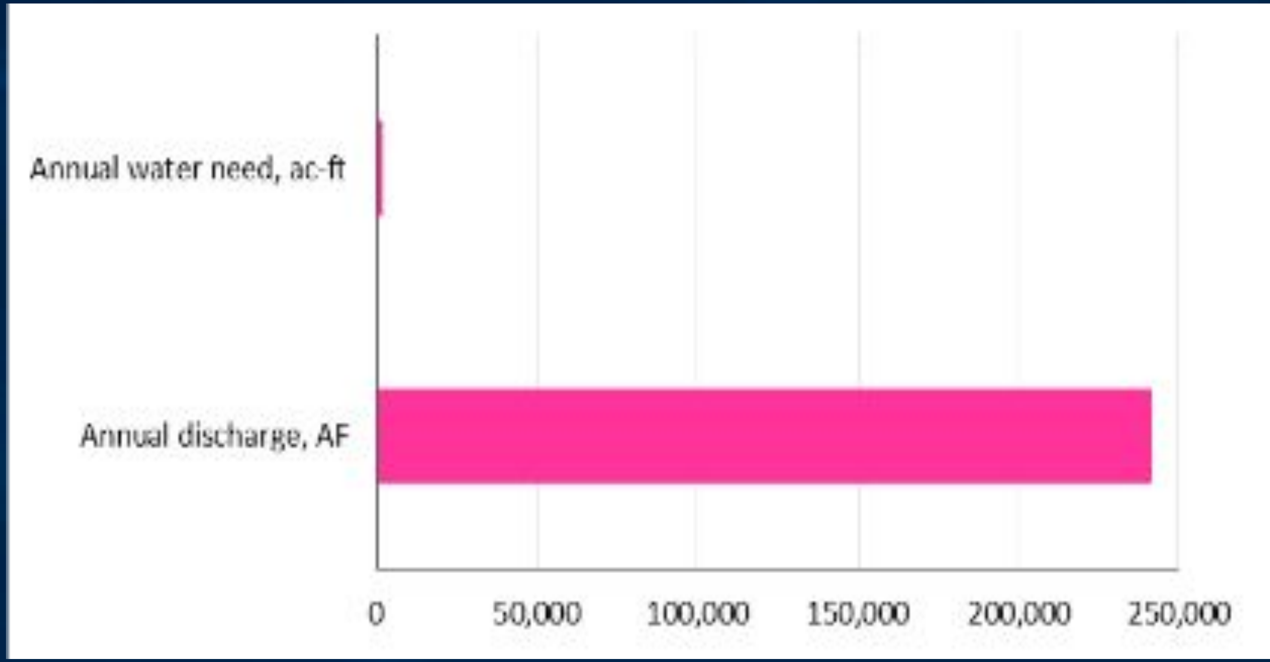
Supply vs Need

- *Human water need = ~ 1% of runoff*

The Solution

Reduce reliance on dry season diversions by using wet season water to meet human needs





Drought resilient water management & streamflow enhancement project types

Management based


Irrigation efficiency


Storage and forbearance

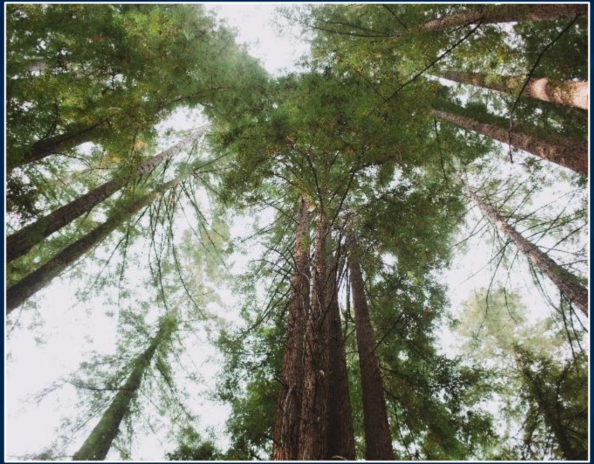

Coordinated diversion


Flow releases

Process based


Groundwater infiltration


Floodplain reconnection

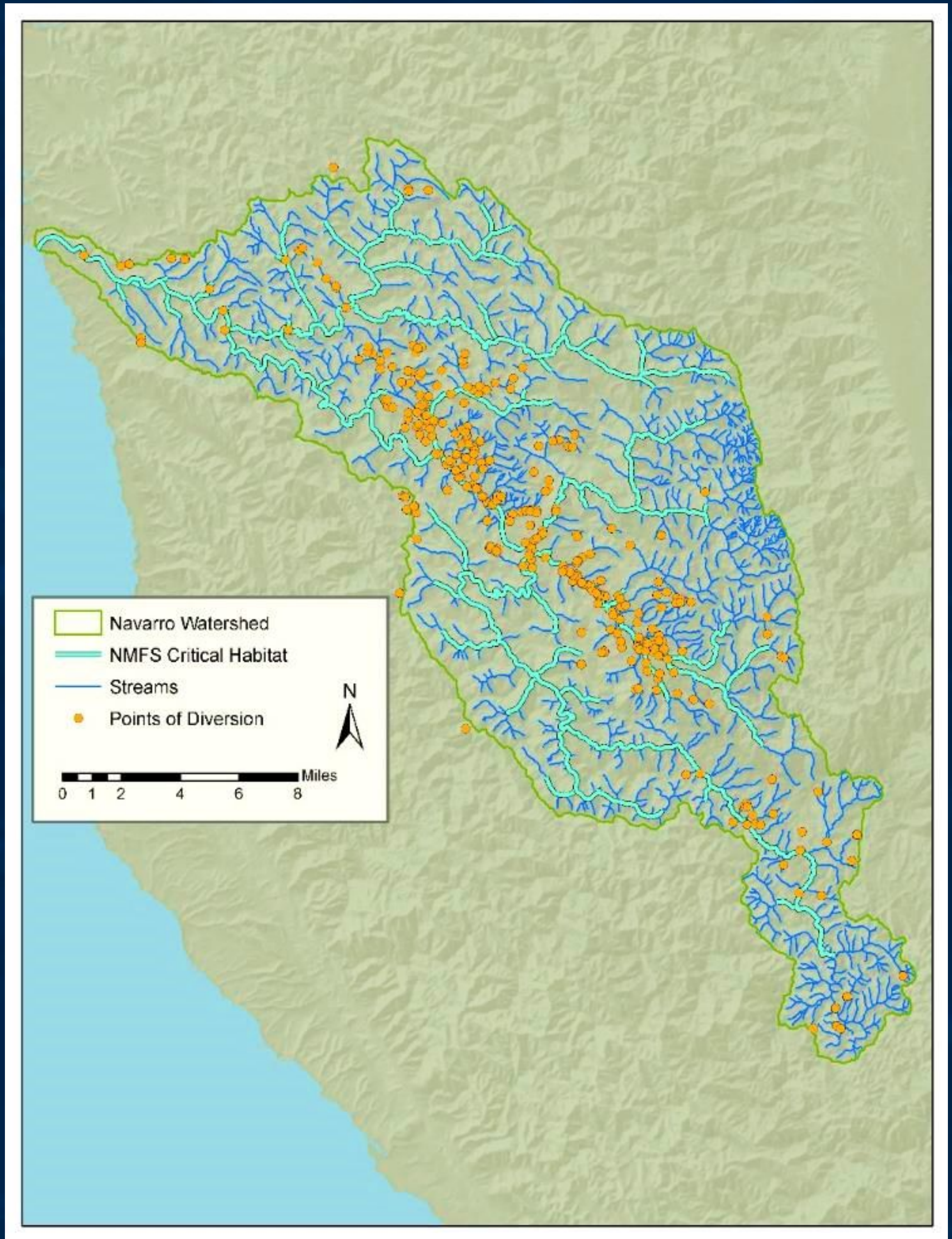

Forest management


Cultural burns & land back

Photo cred: Linda Macelwee (1,2,3), Ca Sea Grant (4), Mercury News (8)

Challenges to increasing drought resilience:

- Decentralized Water Supply Systems
- Pace and Scale of Implementing Projects
  - Slow to implement
  - Incremental benefits
  - Permitting
  - Programmatic vs project based
  - Funding for projects and sustain programs

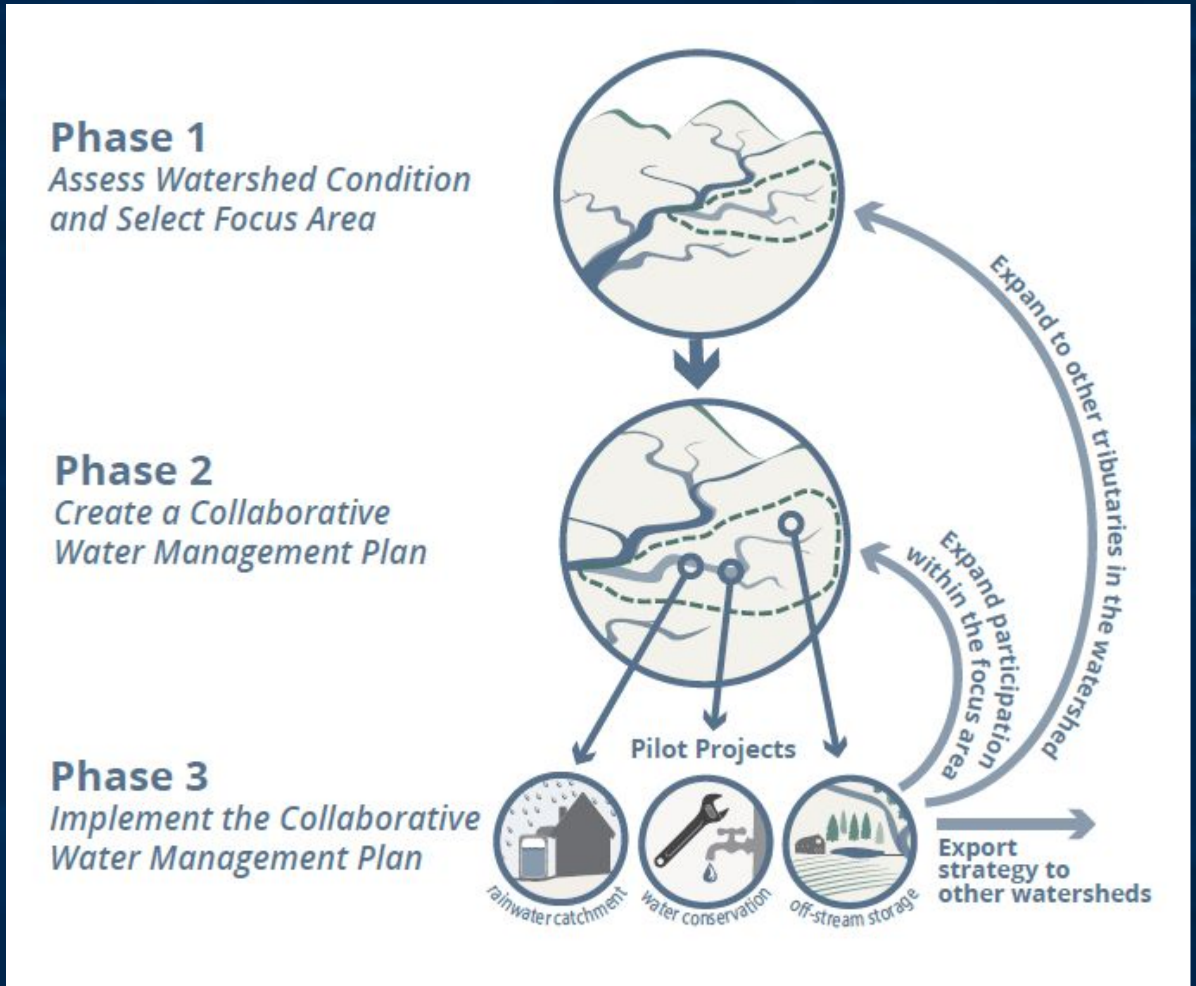


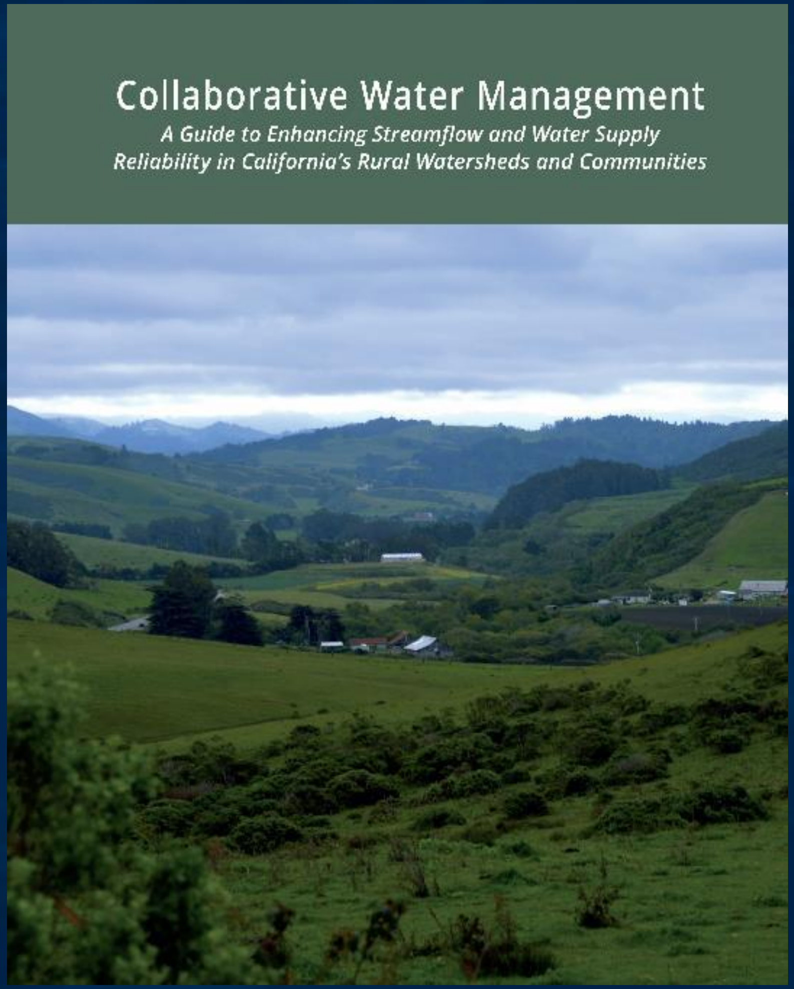
Drought resilience requires planning and cooperative solutions

We need regional / watershed scale water management plans that are:

- Community based and collaborative
- Incentivized and stakeholder-driven
- Solutions tailored to the watershed
- Strong monitoring program
- Clear management goals (i.e. flow criteria)
- Streamline permitting
- Continuous funding

Lessons learned from our work in the Navarro and Russian river watersheds





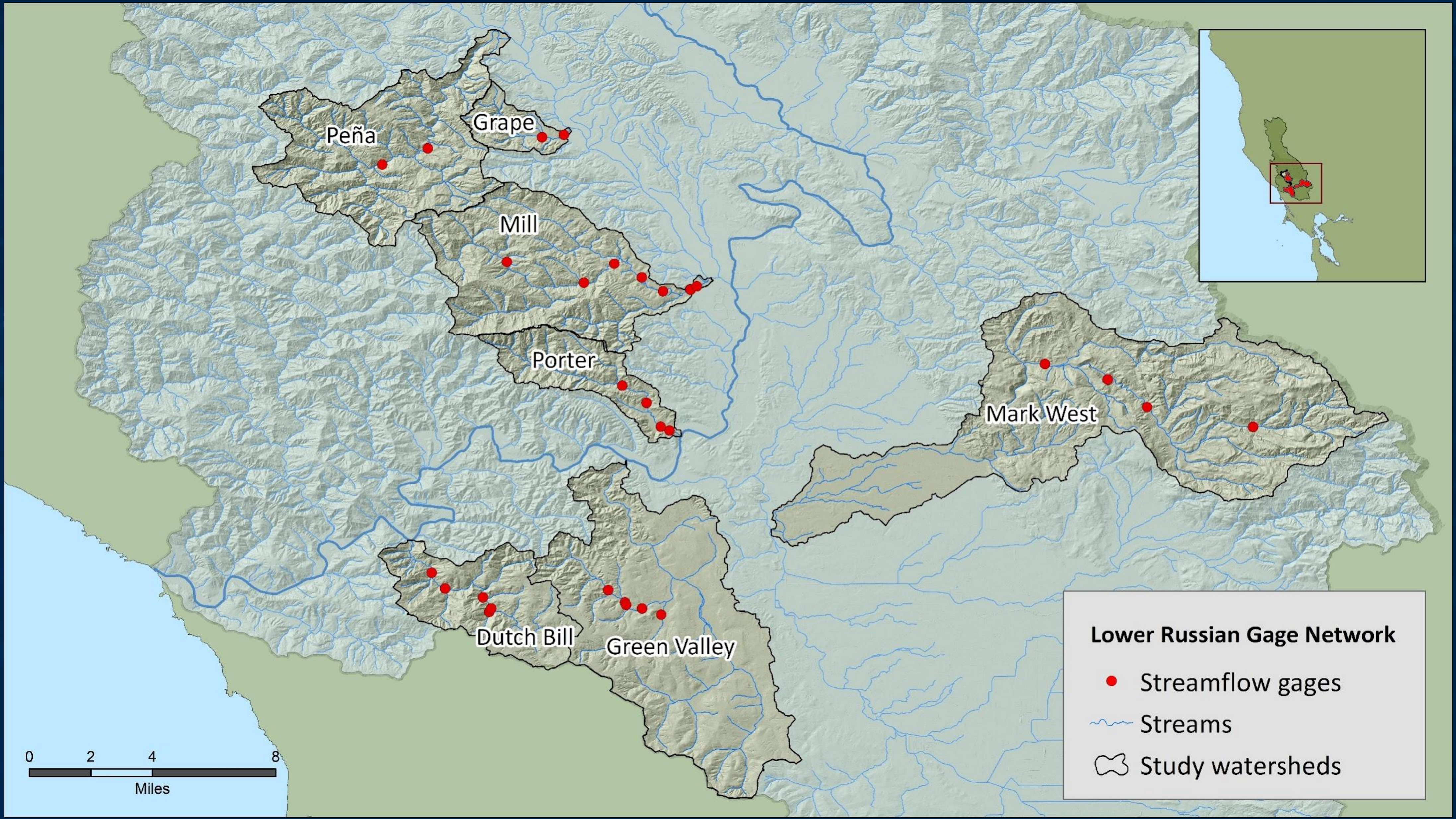
Alford, C., D. Stolzman, and M. Schmitt. 2021.

Phase 1: Selecting focus area
- Science and monitoring
- Planning
- Outreach

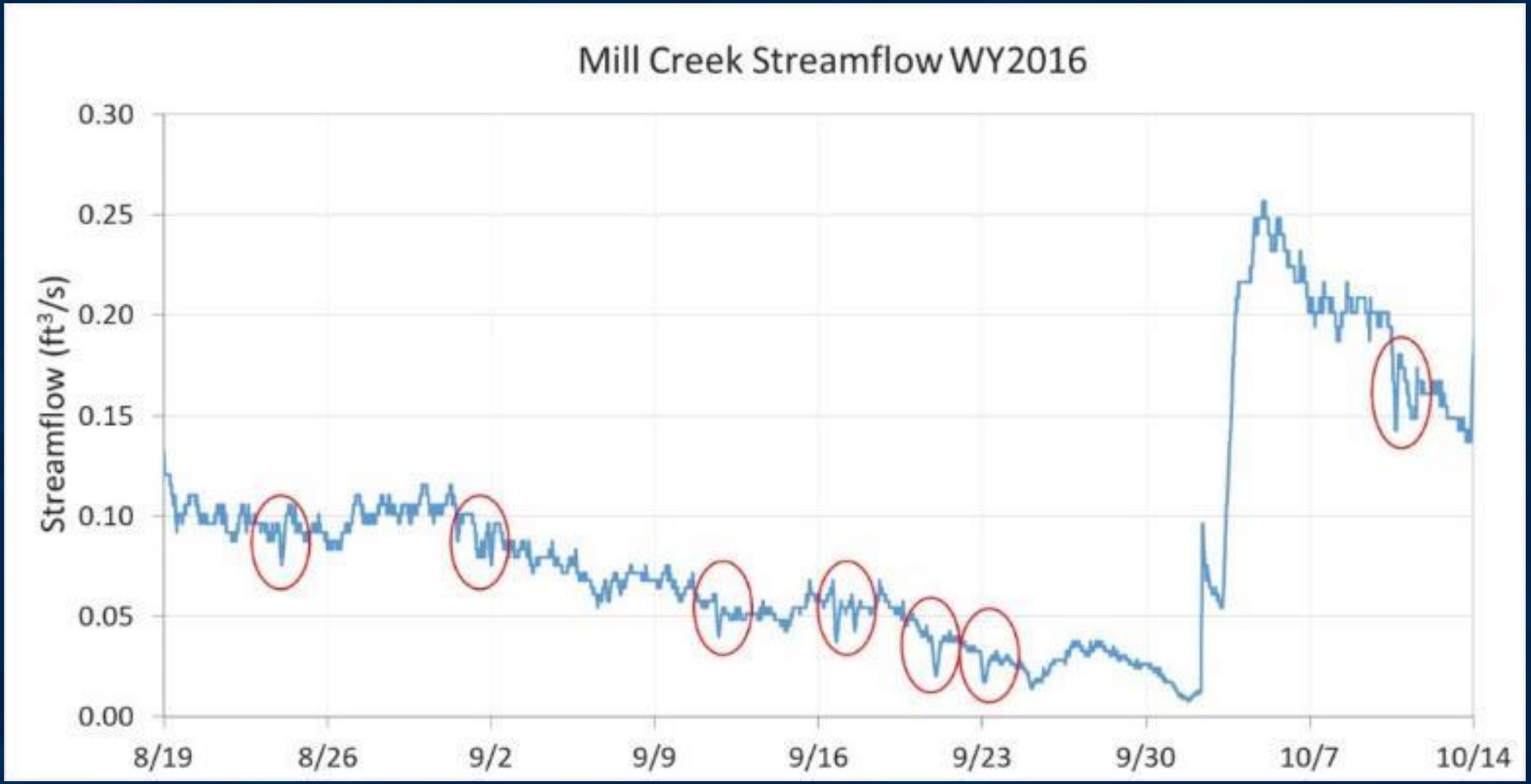
Phase 2: Planning
- Develop a water management plan
- Develop projects

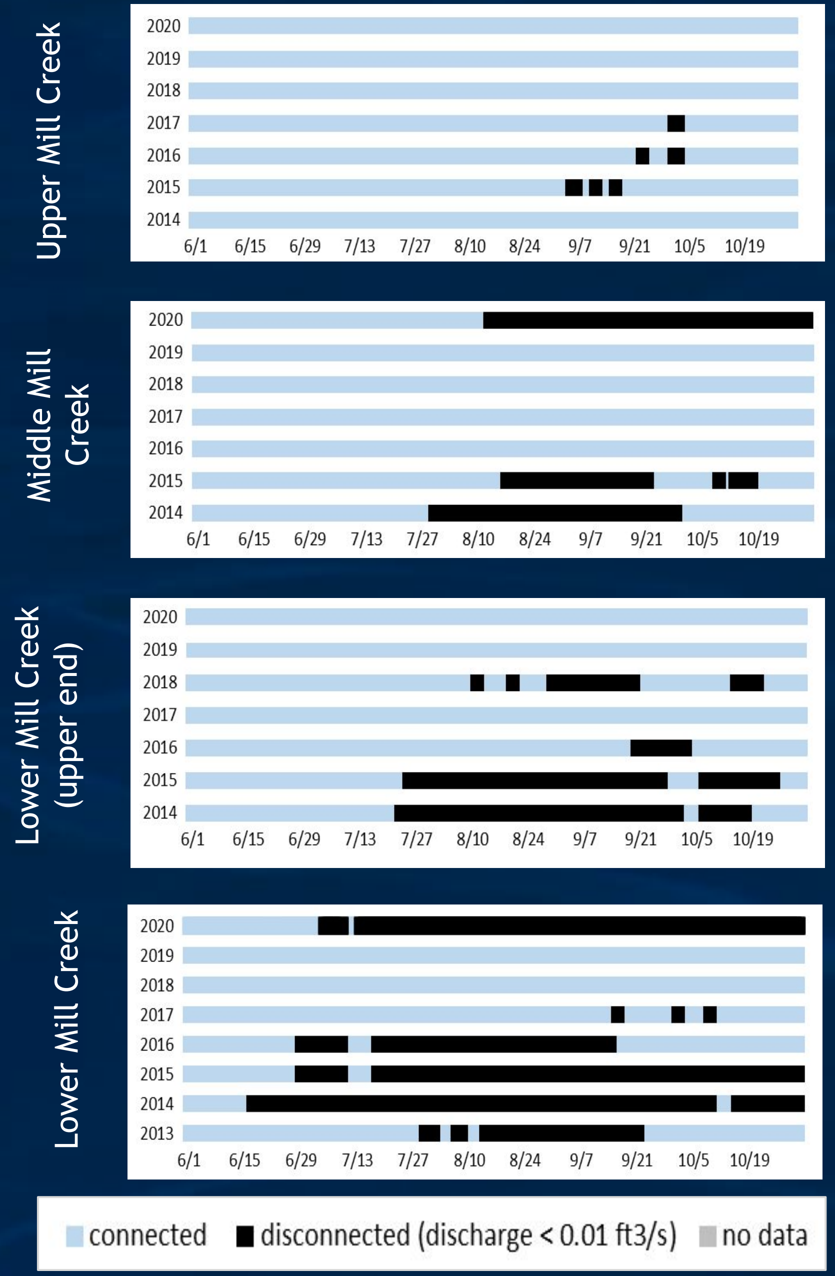
Phase 3: Implementation
- Implement projects
- Monitor impacts
- Assess additional needs

Assessing watershed conditions to select focus area



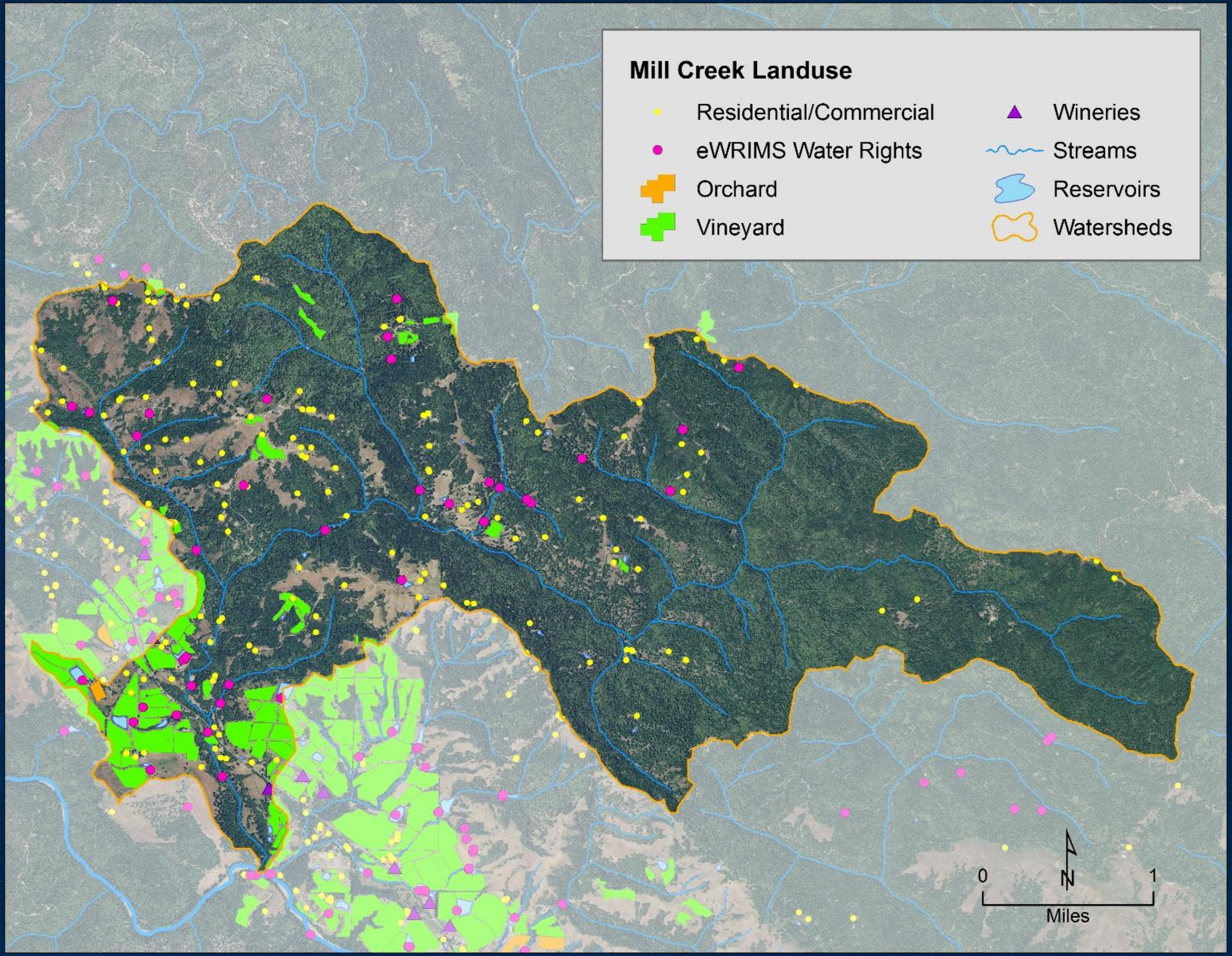
Assessing watershed conditions to select focus area

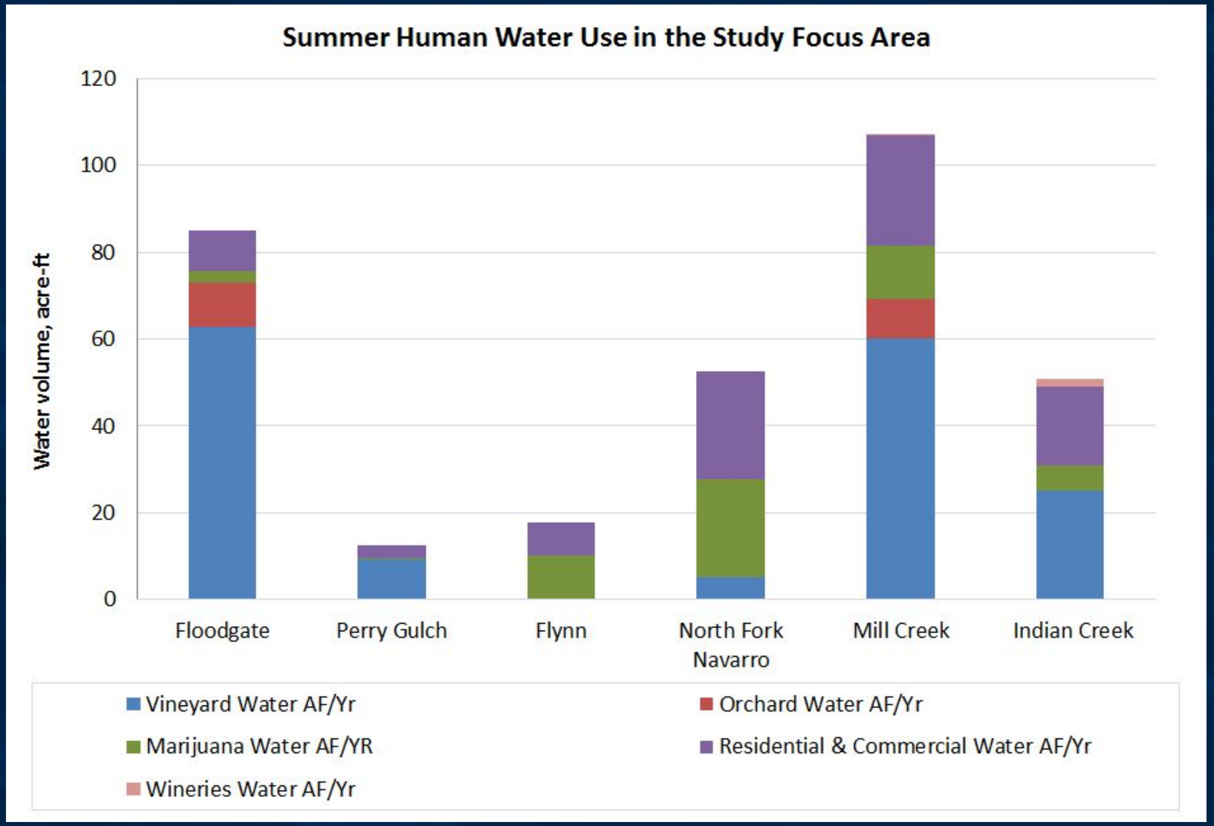




- Identify direct diversions
- Determine impact of diversions
- Document how impact changes over time and in different water years

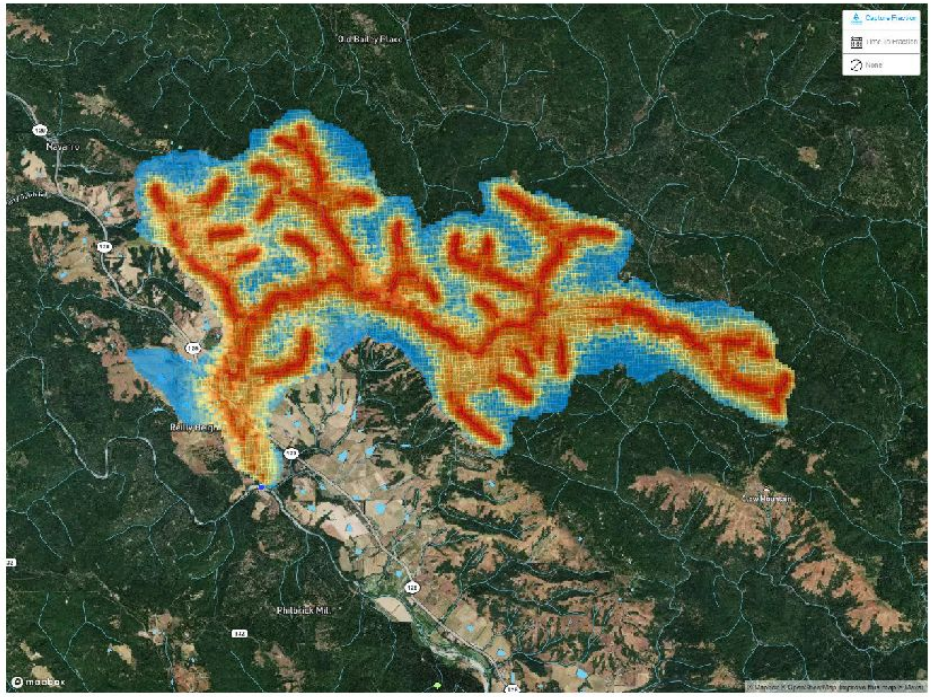
Assessing watershed conditions to select focus area





- What are the biggest water uses?
- Where are they located?
- What kind of impact are they having?

Assessing watershed conditions to select focus area



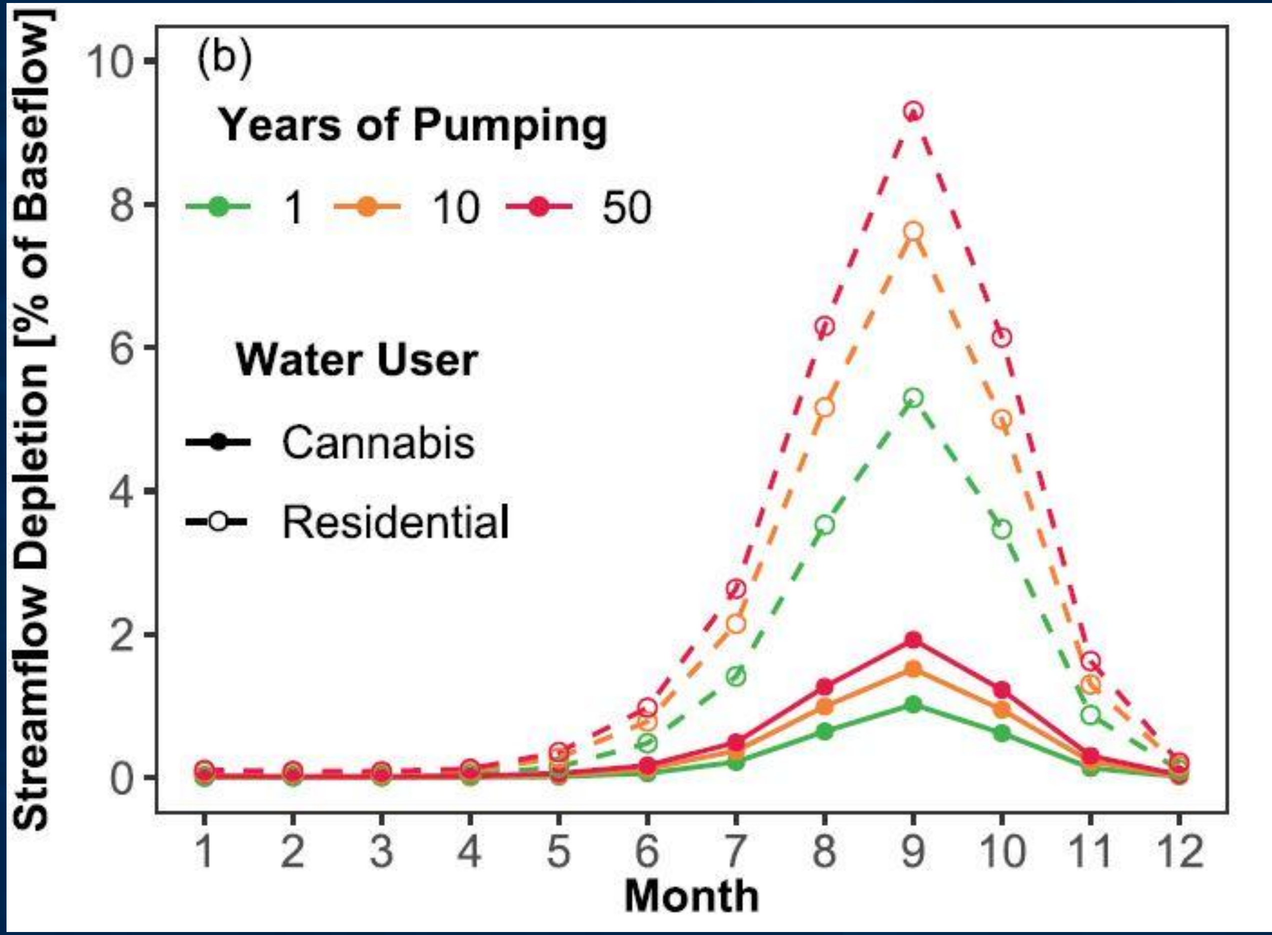
Mill Creek Streamflow Depletion

Scenarios for modified groundwater pumping - Report

2020.05.25

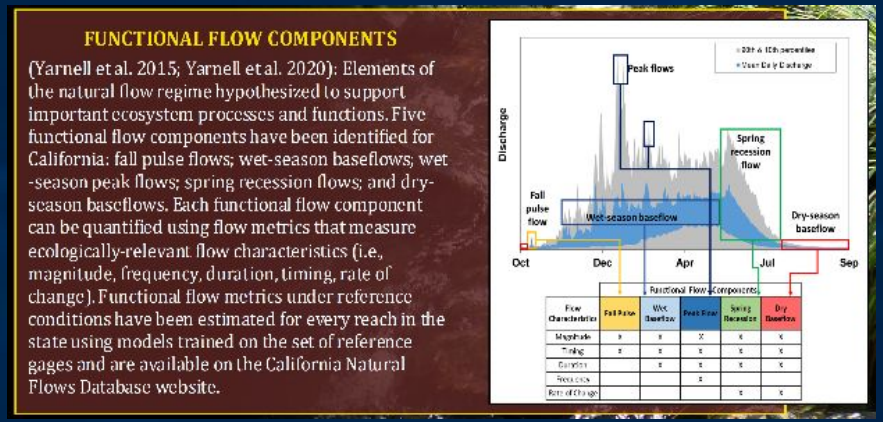
Foundry Spatial Ltd.
3947-A Quadra St.
Victoria, BC
V8X 1J5

FOUNDRY SPATIAL



- How is groundwater pumping impacting streamflow?

Assessing watershed conditions to select focus area



Flow Component	Flow Metric	Predicted Range at Lower Mill - Na02 and Na13 (COMID 2664783); median (10th–90th percentile	Predicted Range at Middle Mill - Na12 (COMID 2664737); median (10th–90th percentile)	Predicted Range at Upper Mill - Na11 (COMID 2664723); median (10th–90th percentile)	Predicted Range at Little Mill (COMID 2664675); median (10th–90th percentile)	Predicted Range at Meyer Gulch (COMID 2664715); median (10th–90th percentile)
Fall pulse flow	Fall pulse magnitude	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered
	Fall pulse timing	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered
	Fall pulse duration	likely unaltered	likely unaltered	likely unaltered	no data	no data
Wet season baseflow	Wet season baseflow (median magnitude)	unclear if altered*	unclear if altered*	likely altered (low)*	unclear if altered*	likely unaltered*
	Wet season start date	unclear if altered	likely unaltered	unclear if altered	likely unaltered	likely unaltered
	Wet season duration	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered
Peak flows	5-year flood magnitude	likely altered (low)*	likely altered (low)*	likely altered (low)*	likely altered (low)*	likely altered (low)*
	5-year flood duration	likely unaltered	likely unaltered	likely unaltered	no data	no data
	5-year flood frequency (number of 5-year floods/ year)	likely unaltered	likely unaltered	likely unaltered	no data	no data
Spring recession flows	Spring recession magnitude	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered
	Spring recession timing	unclear if altered	unclear if altered	unclear if altered	likely altered (early)	likely altered (early)
	Spring recession duration	likely unaltered	likely unaltered	likely unaltered	unclear if altered	likely unaltered
	Spring recession rate of change	likely unaltered	likely unaltered	likely unaltered	no data	no data
Dry season baseflow	Dry season (median) baseflow	likely altered (low)	likely altered (low)	likely unaltered	likely altered (low)	likely altered (low)
	Dry season start date	likely unaltered	likely unaltered	unclear if altered	likely unaltered	likely unaltered
	Dry season duration	likely unaltered	likely unaltered	likely unaltered	likely unaltered	likely unaltered

- Confirms alteration
- How altered is the system?
- What should natural flows be like?
- Establish flow objective goals

Assessing watershed conditions

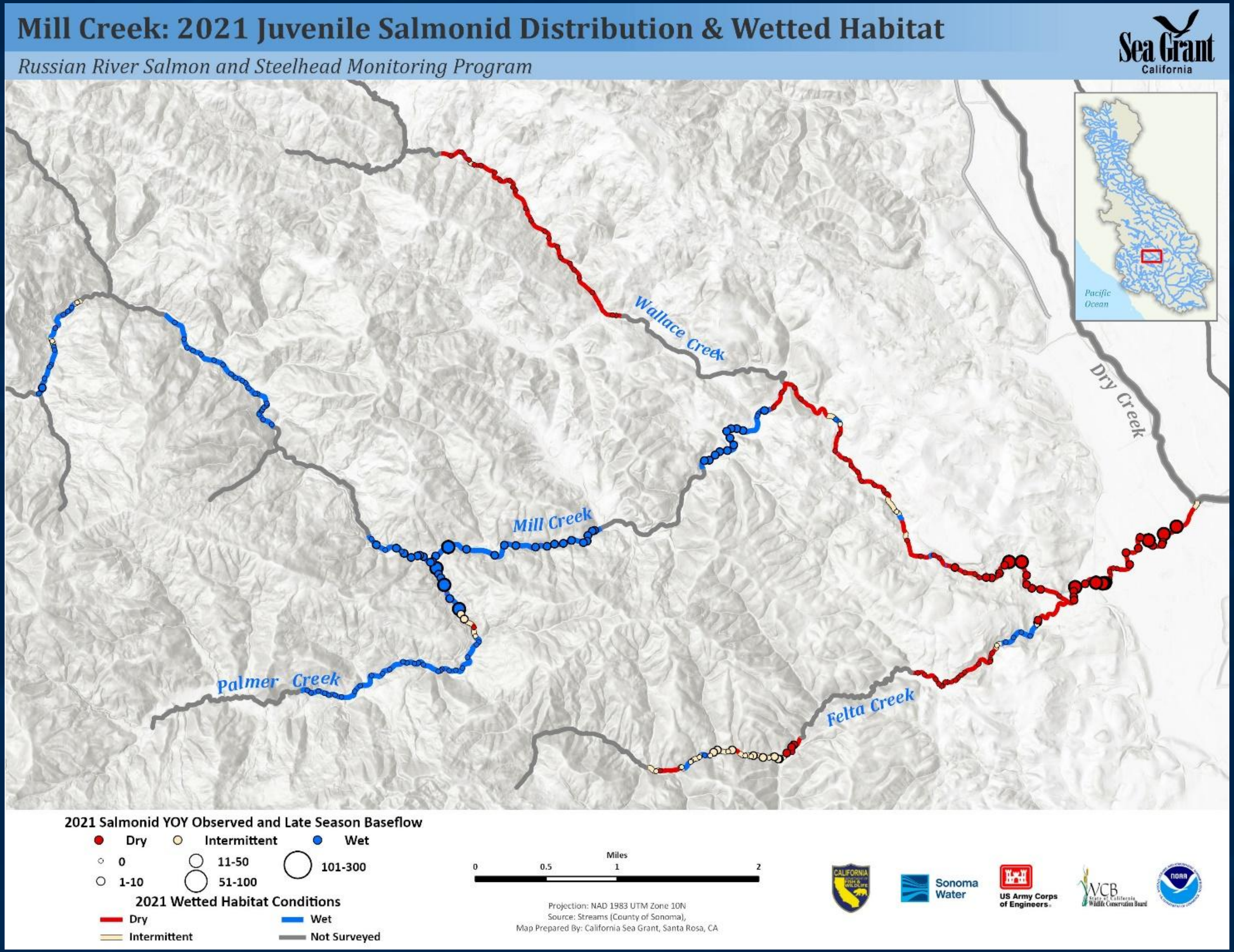
How much water do you need to keep pools connected?

Determine pool connectivity thresholds for different reaches.

Ex. Green Valley Creek pool connectivity = 0.2 cfs

Ex. Dutch Bill Creek pool connectivity = 0.05 cfs

Assessing watershed conditions



Wet/dry surveys to documented wetted habitat.

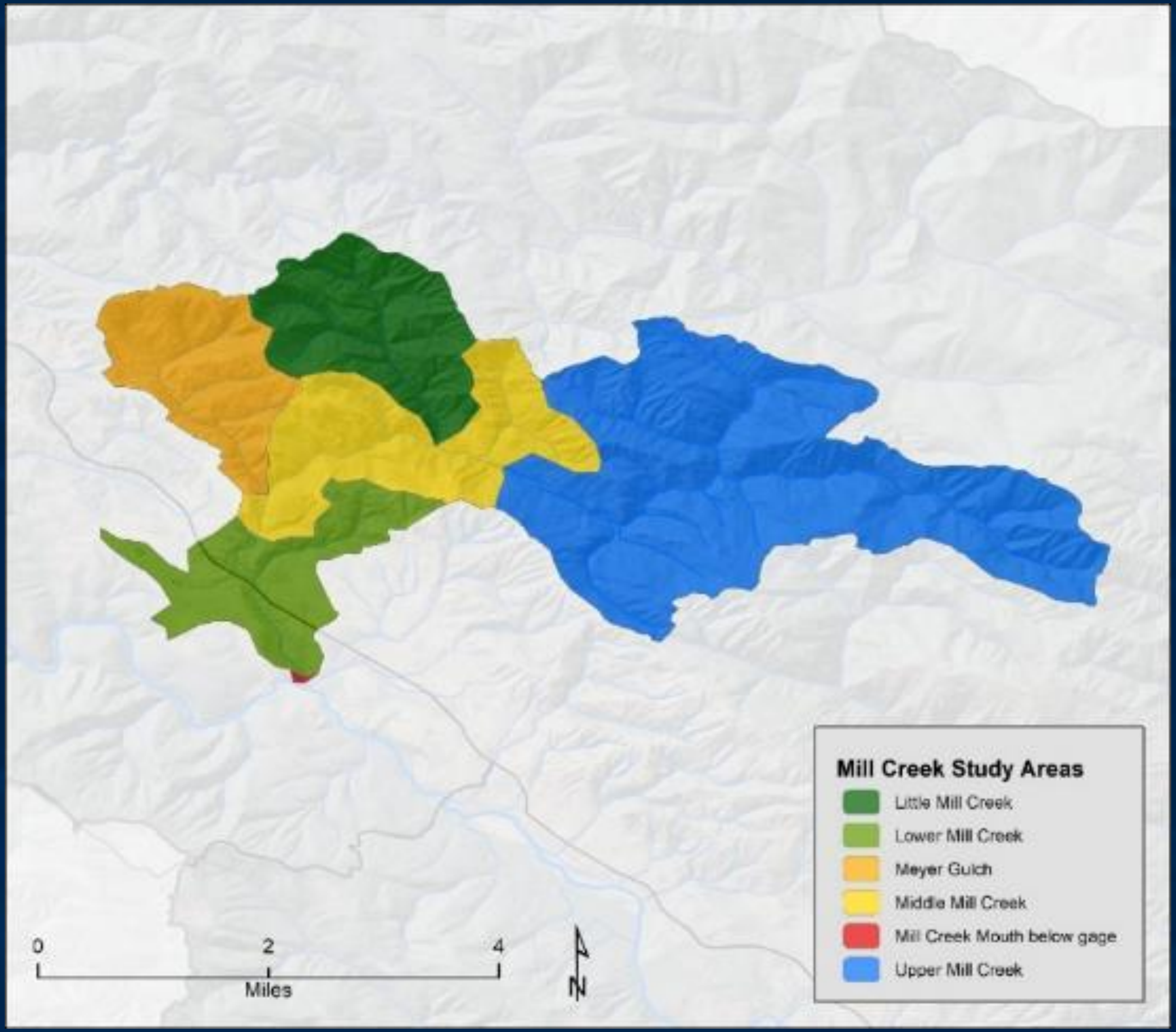
Paired with fish distribution to assess vulnerability.

Credit: Ca Sea Grant

Doing the work and assessing success

How do you get from where you are → to where you want to be?

Reach specific recommendations

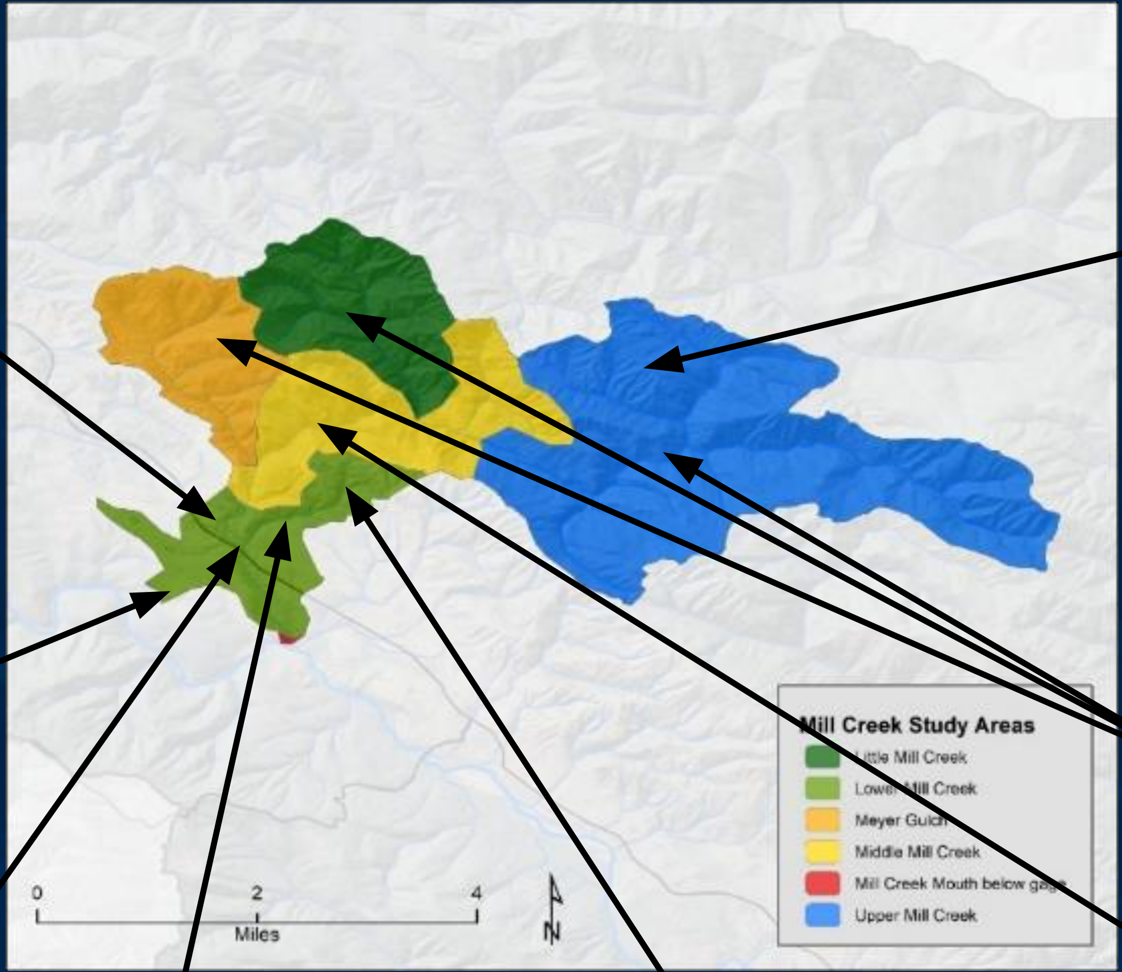


Watershed conditions, water demand, and project opportunities vary throughout a watershed.

It's important to develop projects that fit the specific needs and opportunities.

Reach specific recommendations

Storage and forbearance



Forest management

Irrigation efficiency

Cultural burns & land back

Coordinated diversions

Floodplain reconnection

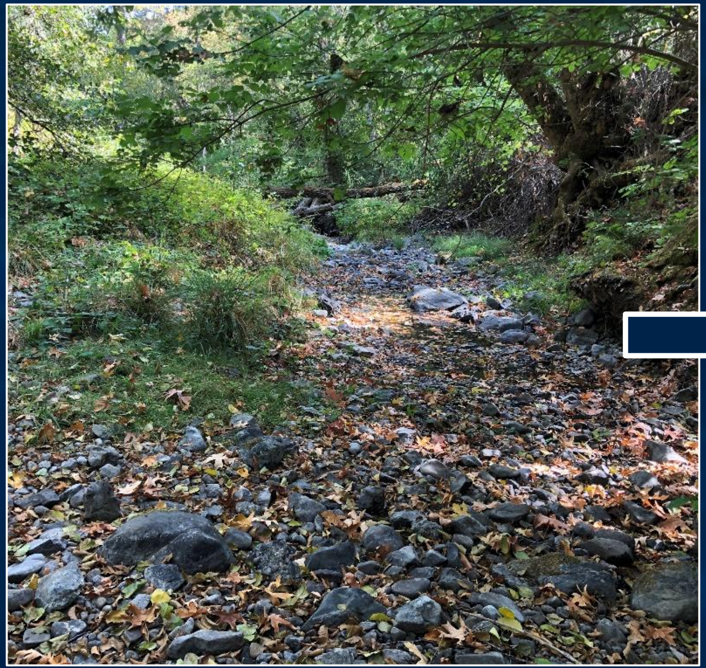
Groundwater infiltration

Flow releases

Focused outreach and community awareness

How do you assess success?

Tracking success after project implementation and utilizing your monitoring data to build your program in a drying climate



0.000 cfs

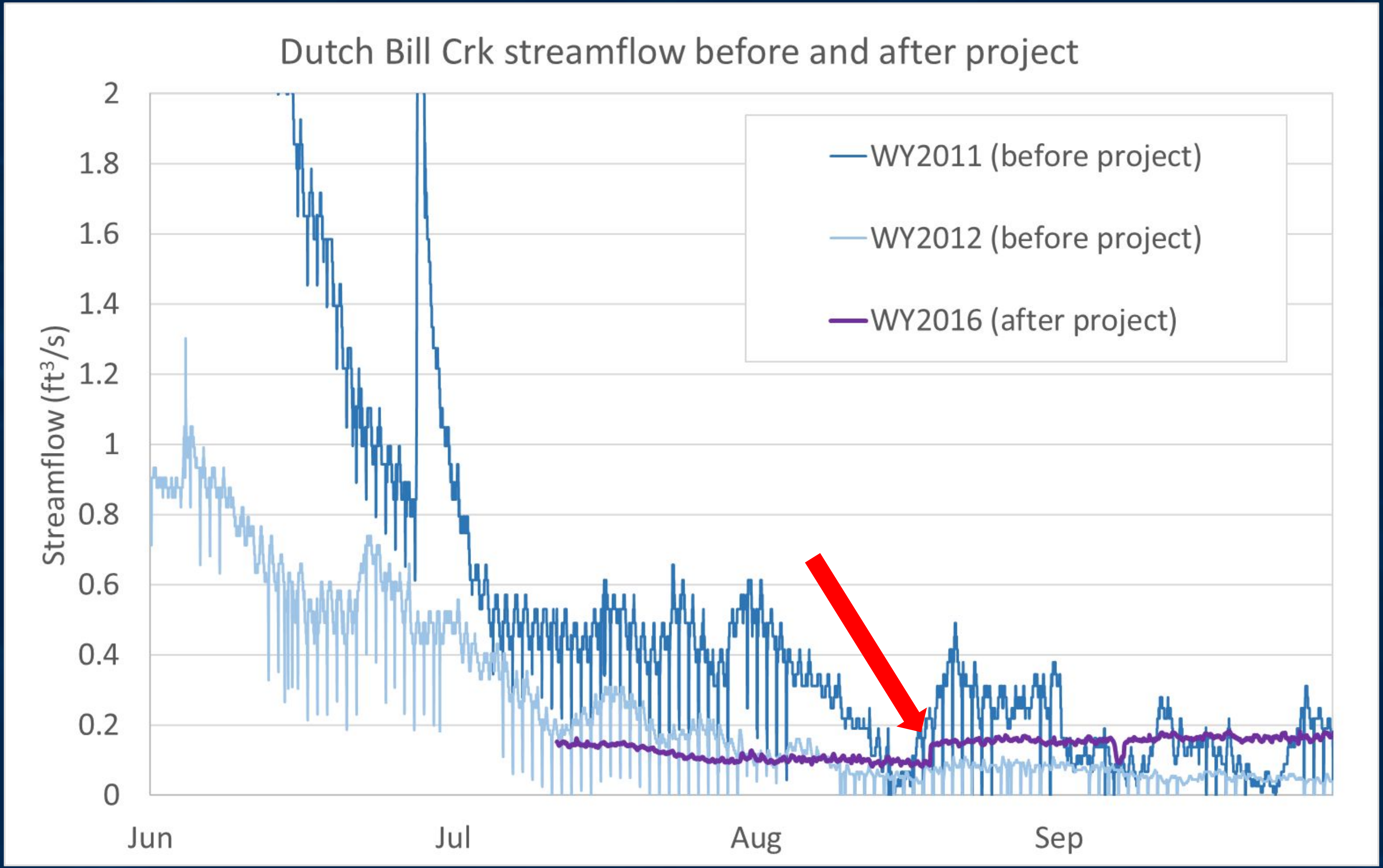
0.087 cfs

0.320 cfs

1.56 cfs

Assessing success

Lessons learned from gage network

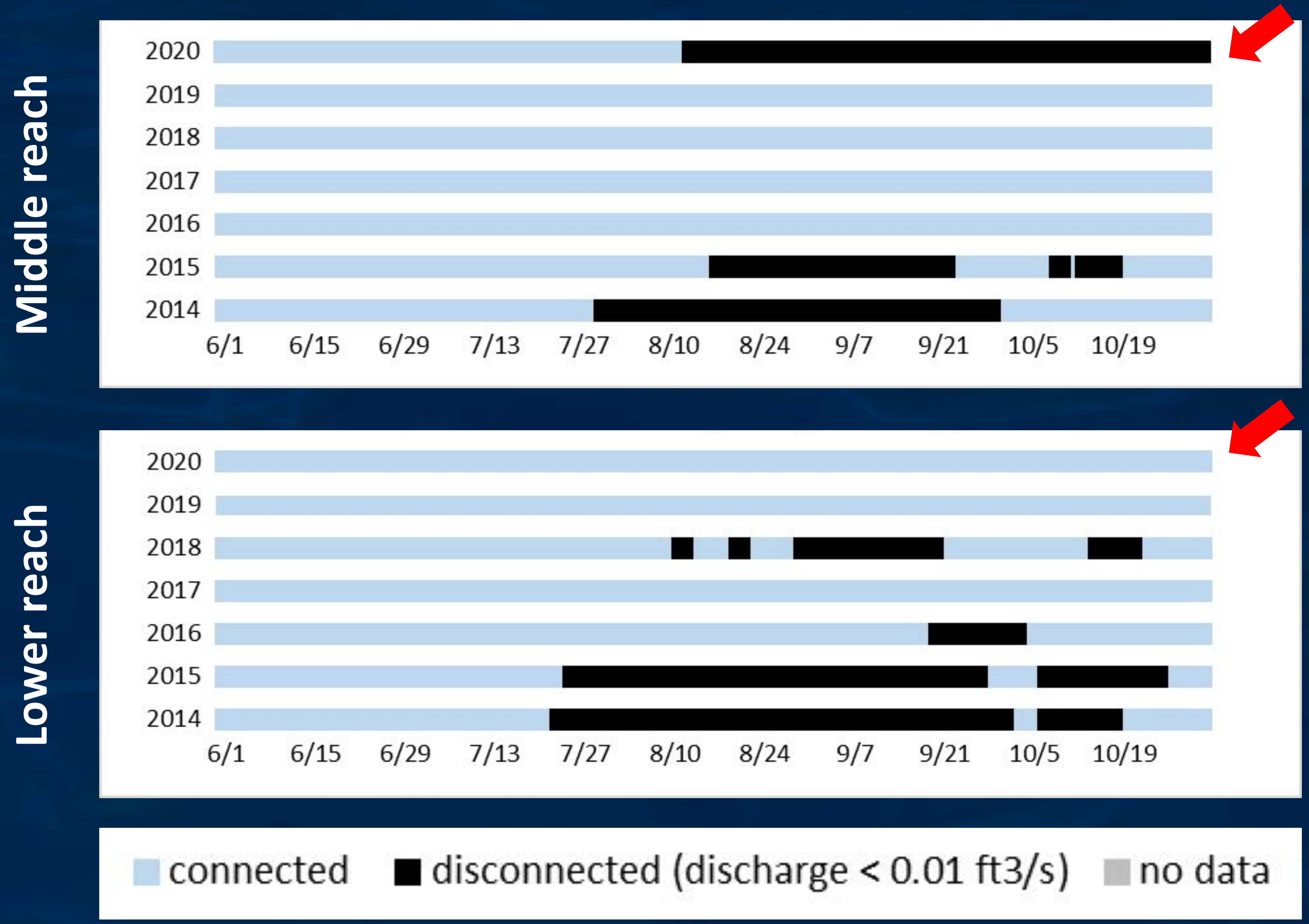


Gage data documents improvements to streamflow after project implementation

And impacts of flow release

Assessing success

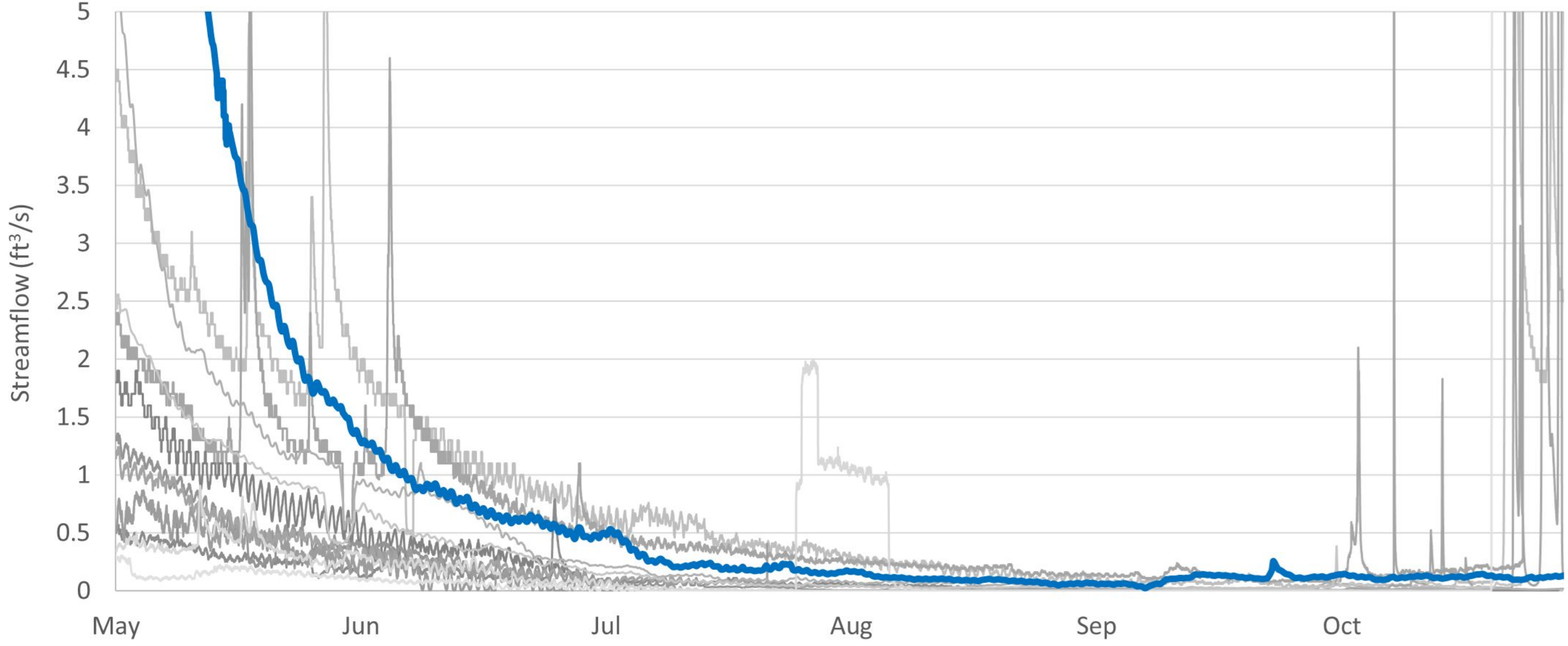
Lessons learned from gage network



Gage data documents improvements to pool connectivity between stream reaches

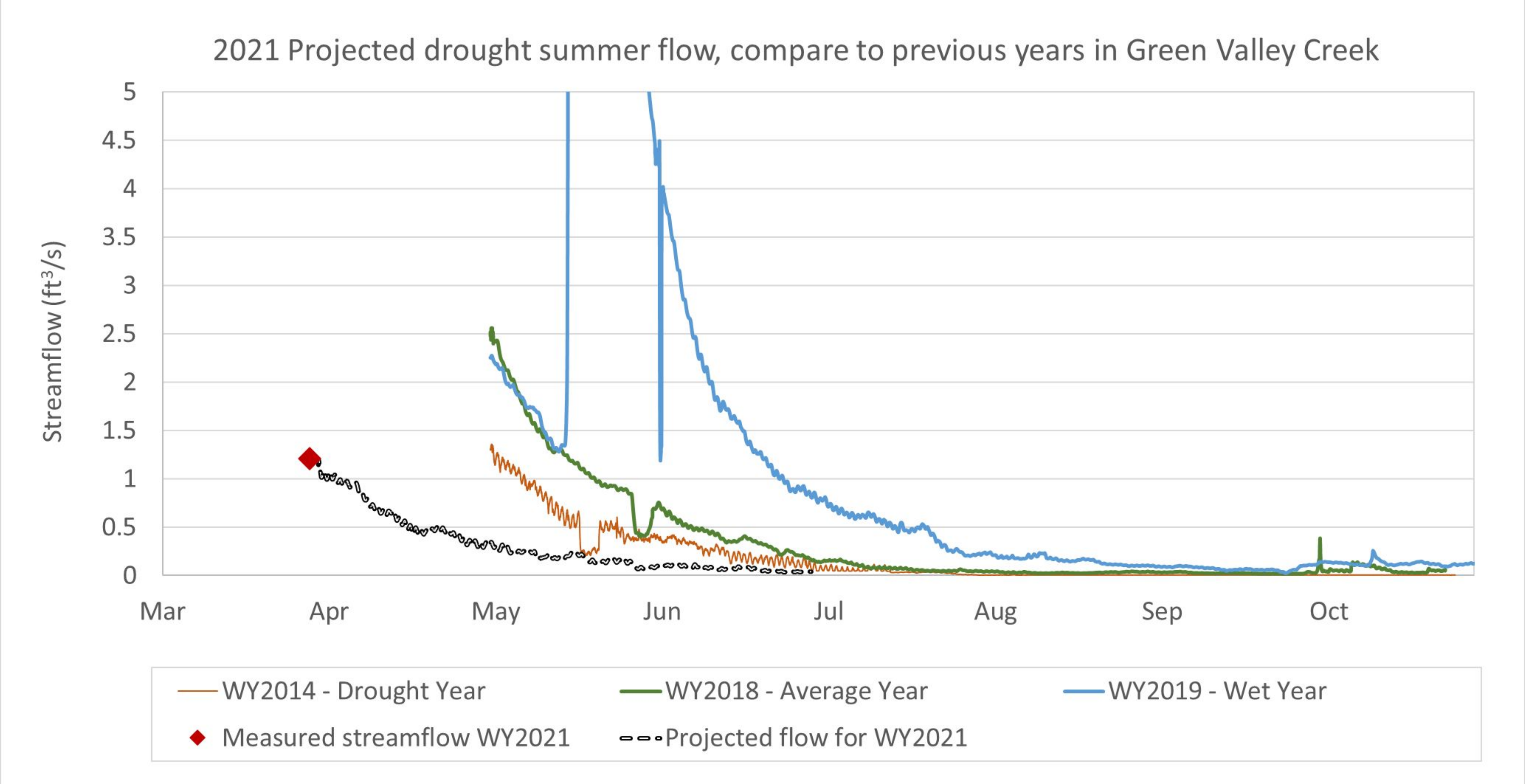
Lessons learned from gage network

Landscape's unique signature



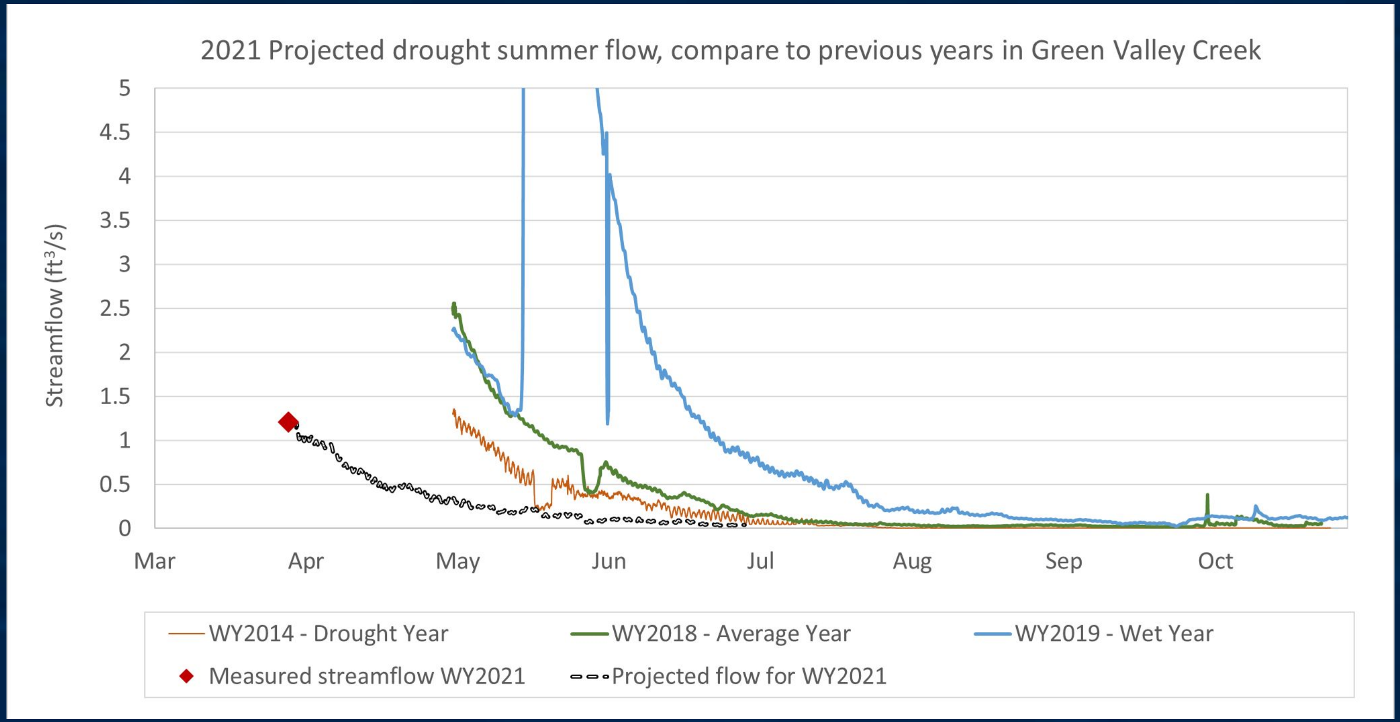
Lessons learned from gage network

Summer streamflow forecasting



Lessons learned from gage network

Summer streamflow forecasting



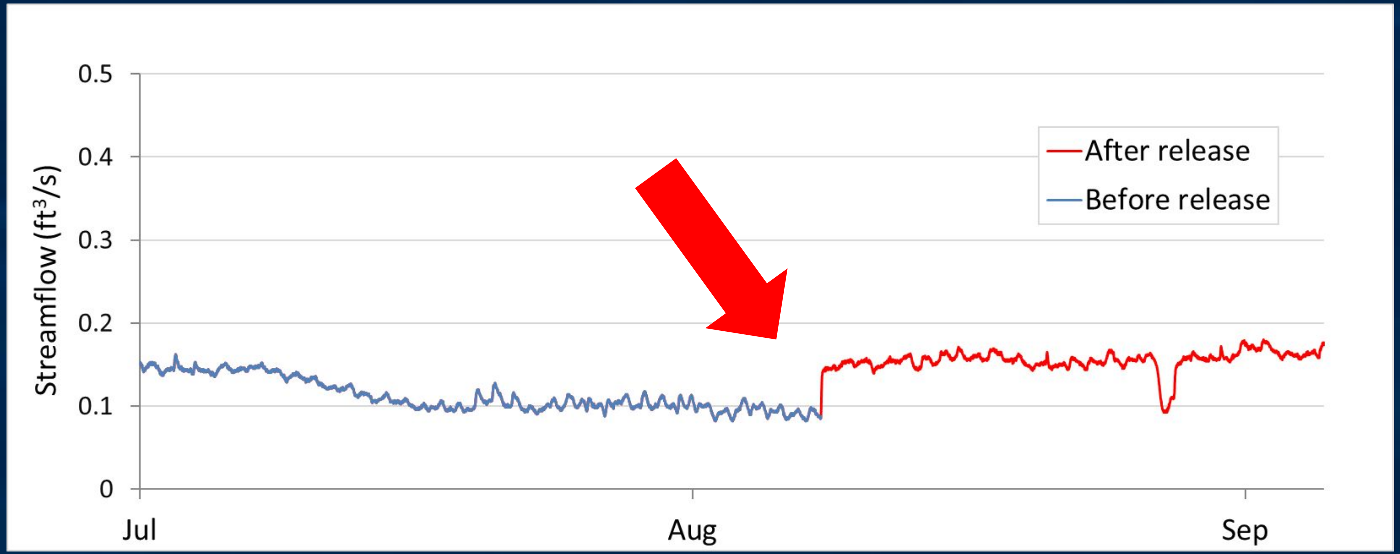
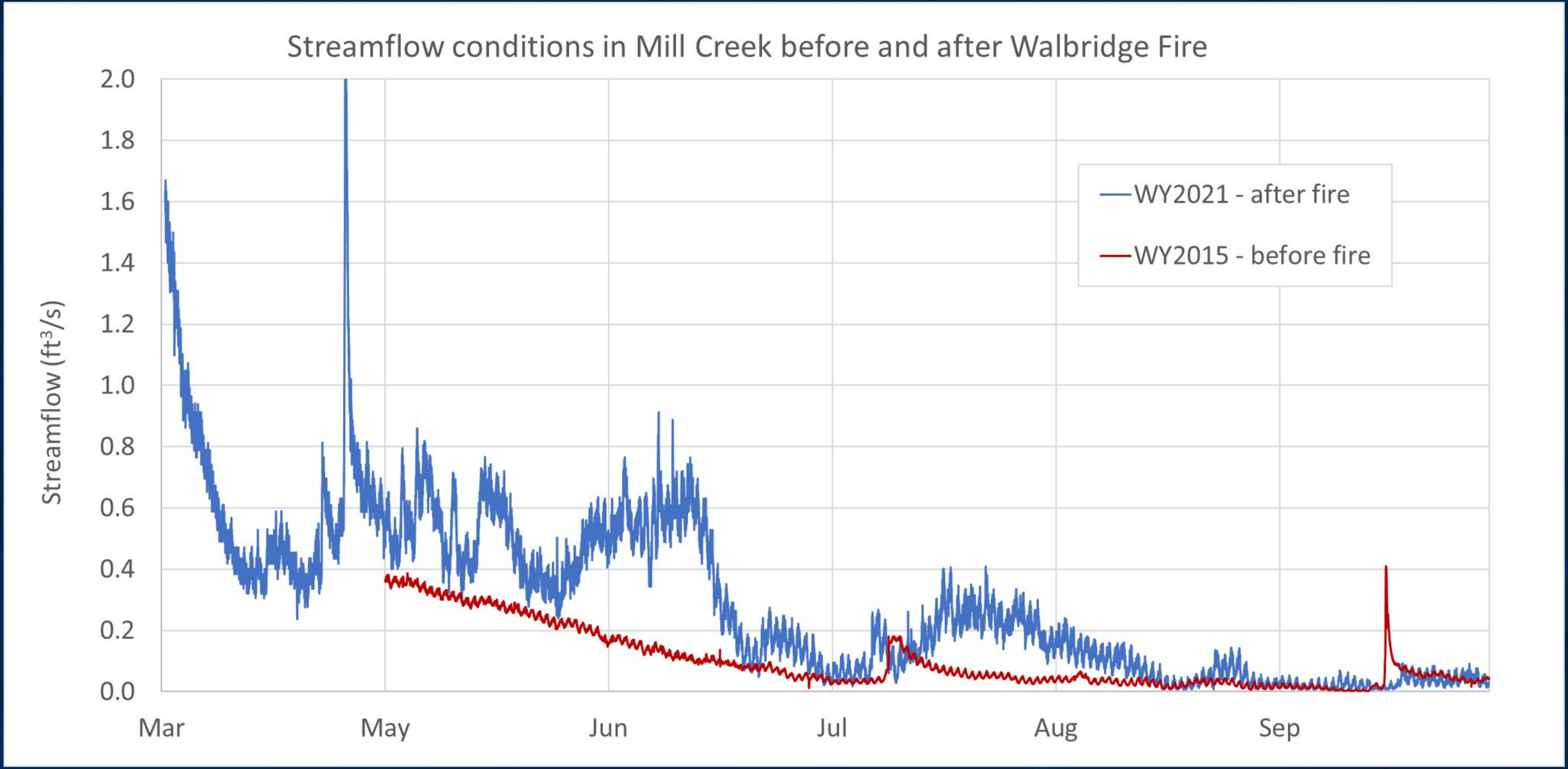


Photo credit: Jim Coleman, OAEC

Lessons learned from gage network

Fire and flow



Lessons learned from gage network

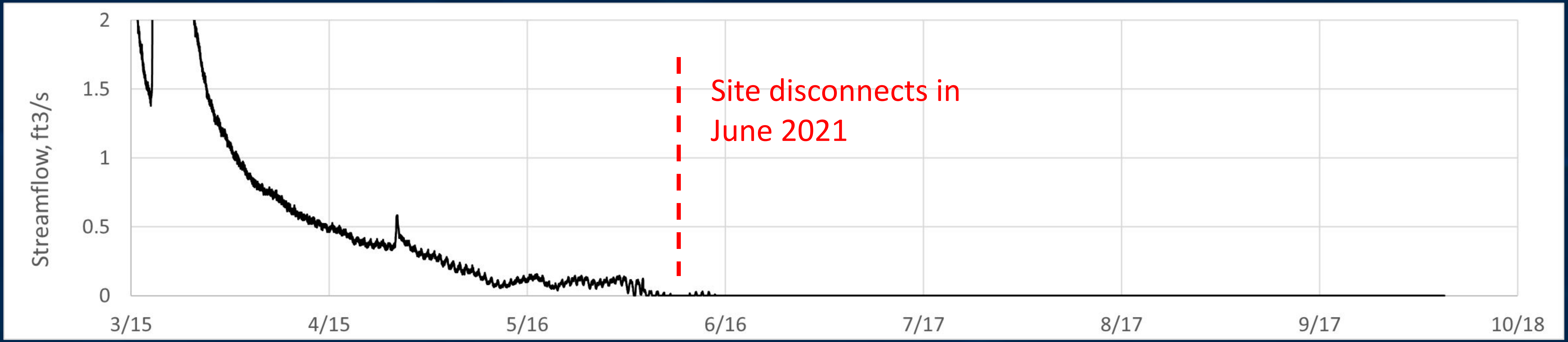
Awareness of how what conditions are like – keeps the working moving

March
2.73 cfs

April
0.626 cfs

June
0.00 cfs

September
0.000 cfs



Drought resilience requires planning and cooperative solutions

- Community based, incentivized and stakeholder-driven
- Solutions tailored to the watershed
- Strong monitoring program
- Clear management goals (i.e. flow criteria)
- Streamline permitting
- Continuous funding
- AB 2451 (Wood) – drought preparedness
  - Dedicated drought division in the Water Board
  - Generates drought management plans in coastal watersheds

Thank you!

- California Department of Fish and Wildlife
- California Department of Water Resources
- California Sea Grant
- California State Coastal Conservancy
- California State Parks
- California Trout
- Camp Meeker Recreation and Park District
- Gallo Glass
- Gold Ridge Resource Conservation District
- Mendocino Resource Conservation District
- The Nature Conservancy
- NOAA Restoration Center
- National Fish and Wildlife Foundation
- National Marine Fisheries Service
- North Coast Regional Water Quality Control Board
- Occidental Arts and Ecology Center
- Prunuske Chatham, Inc.
- San Mateo Resource Conservation District
- Salmonid Restoration Federation
- Sanctuary Forest
- Santa Cruz Resource Conservation District
- Sonoma County Water Agency

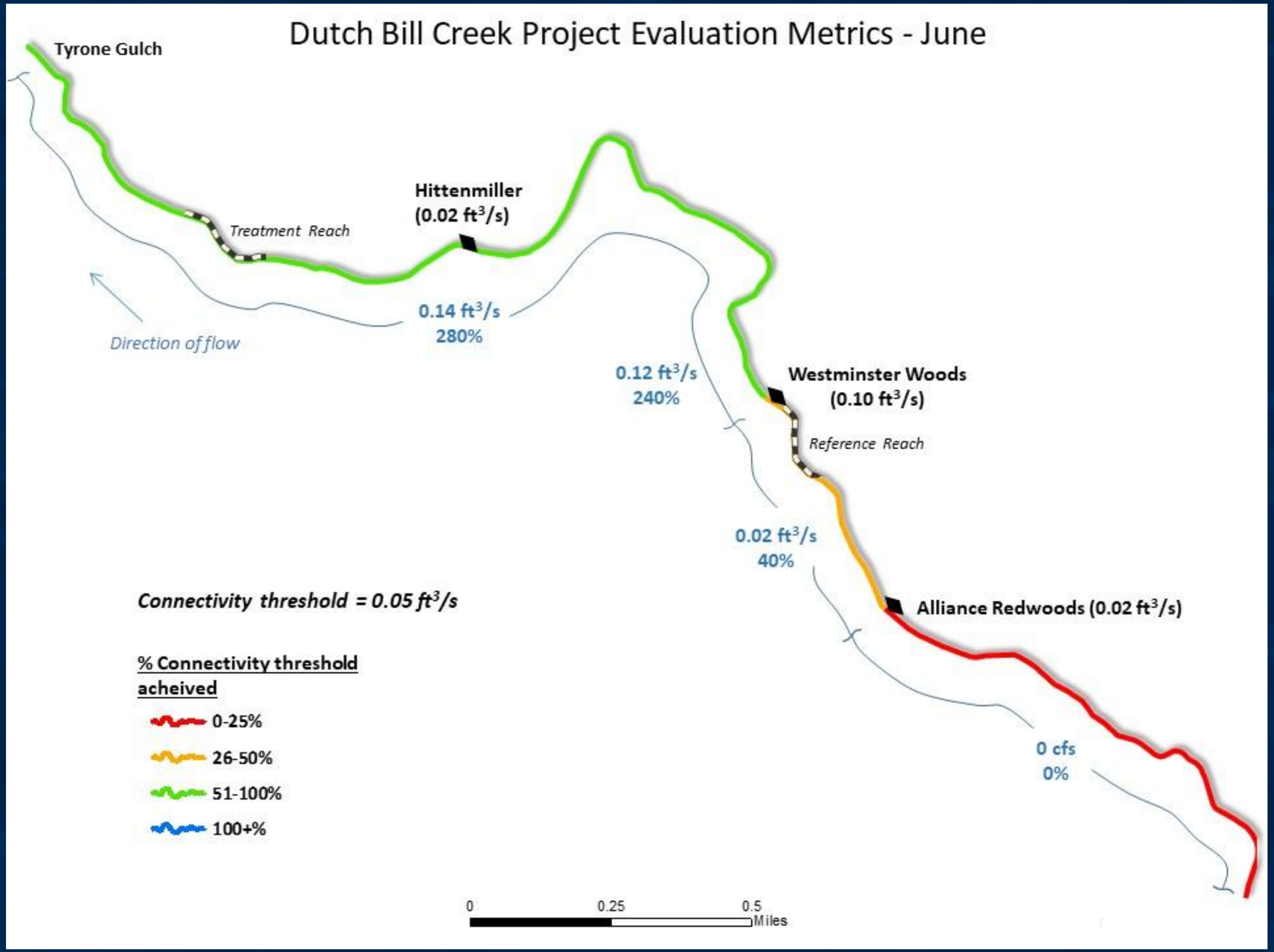
Mia van Docto
Mia.vanDocto@tu.org

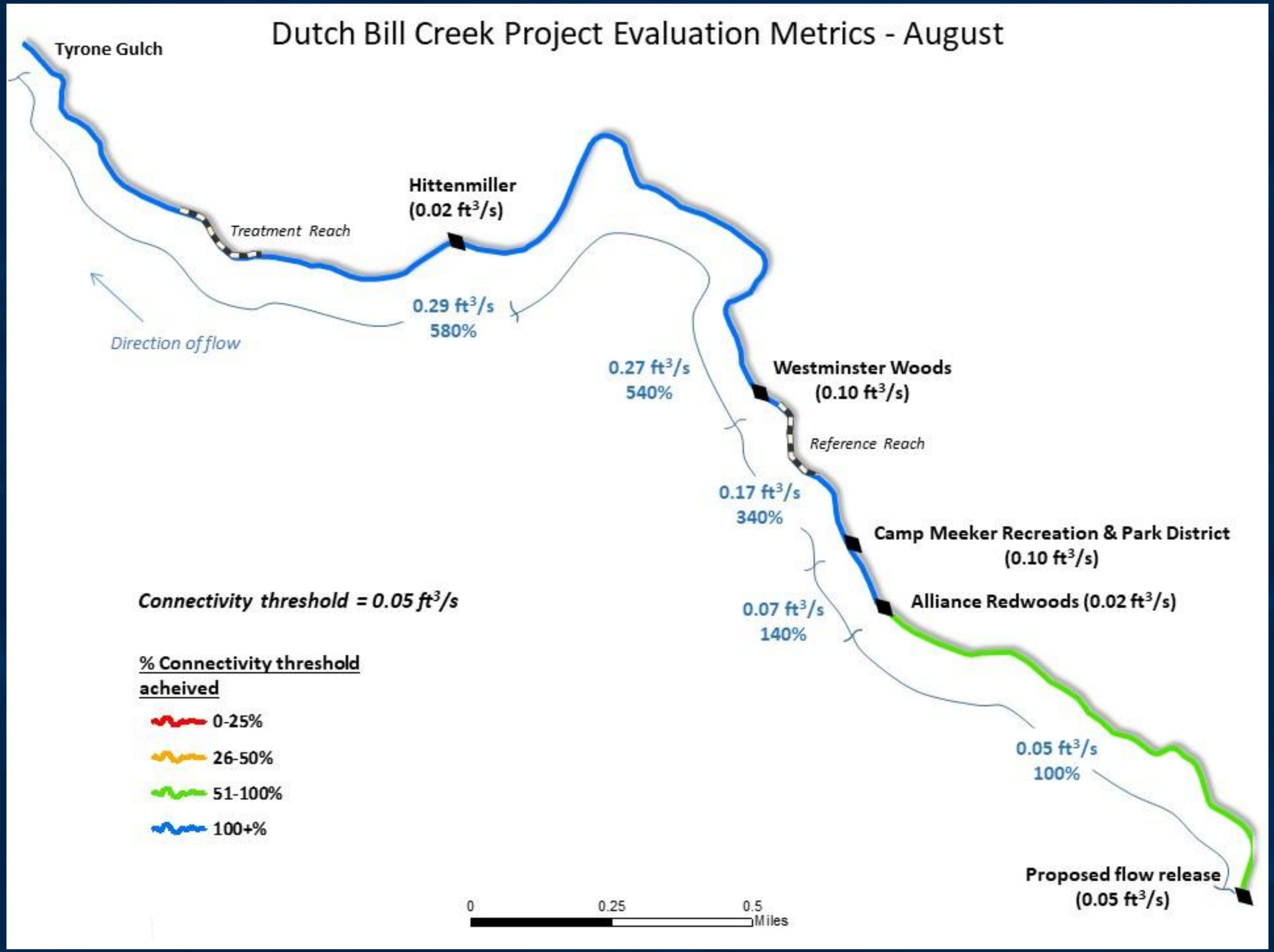
Monty Schmitt
Monty.Schmitt@tnc.org

- SWRCB Curtailment Orders
    - Local Cooperative Solutions
- Sustainable Groundwater Management Act
- AB 2451 (Wood) - Drought Preparedness

Assessing success

Lessons learned from gage network



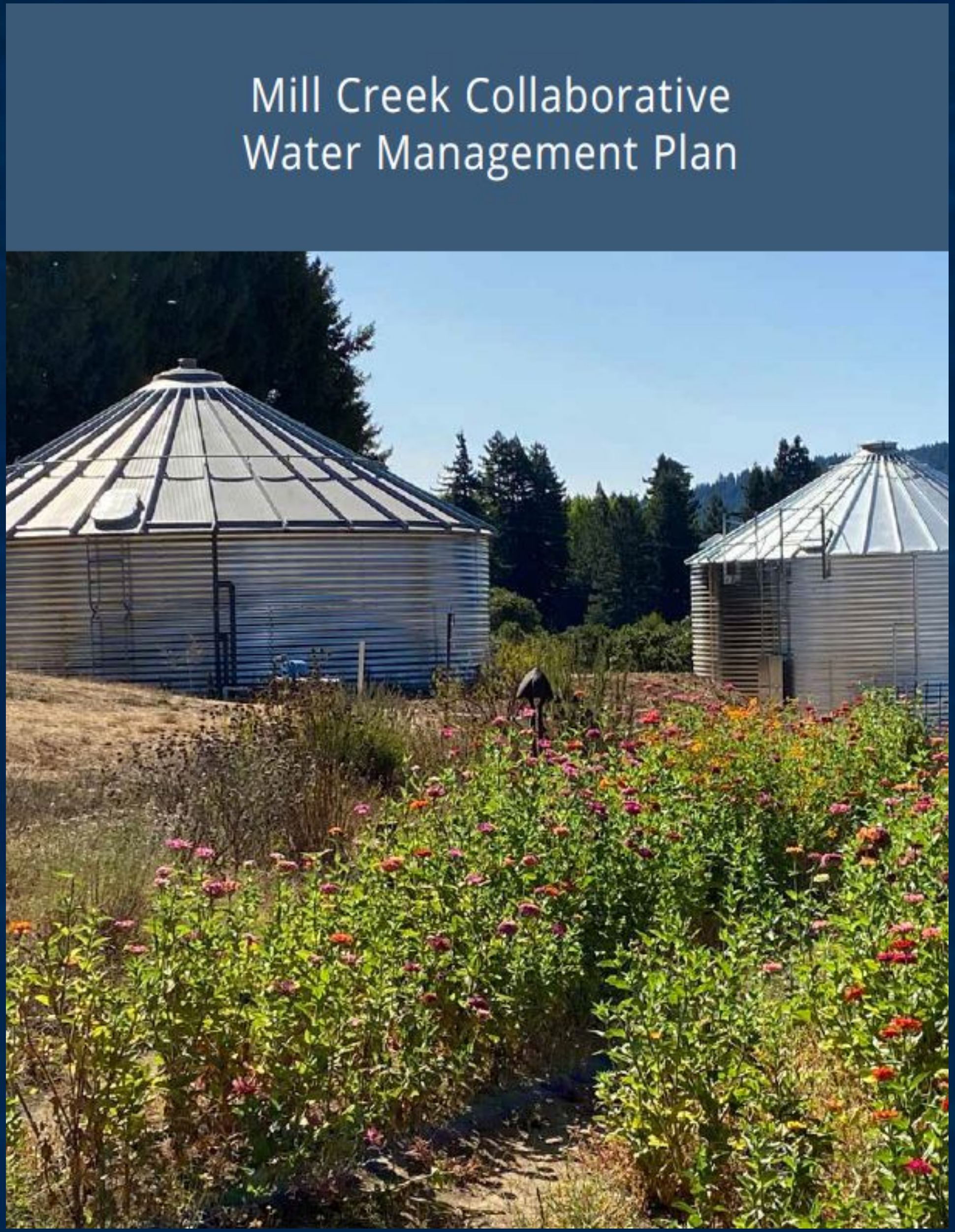


Connectivity thresholds provides metric for assessing project success

Credit: Coho Partnership

Sustaining the program

Key lessons learned through our partnership work



- Work with partners
- Solid monitoring program
- Develop drought/water management plan
- Develop projects to meet reach needs
- Continuous funding
- Evolve project types

Drought Resiliency in the Klamath Basin: The Yurok Tribe's Strategies and Approach

Securing the Future of Salmon

The Yurok Culture and Constitution Define its Approach to Restoration

"We also have practiced our stewardship of the land in the prairies and forests through ***controlled burns*** *that improve wildlife habitat and enhance the health and growth of the tan oak acorns, hazelnuts, pepperwood nuts, berries, grasses and bushes, all of which are used and provide materials for baskets, fabrics, and utensils.*

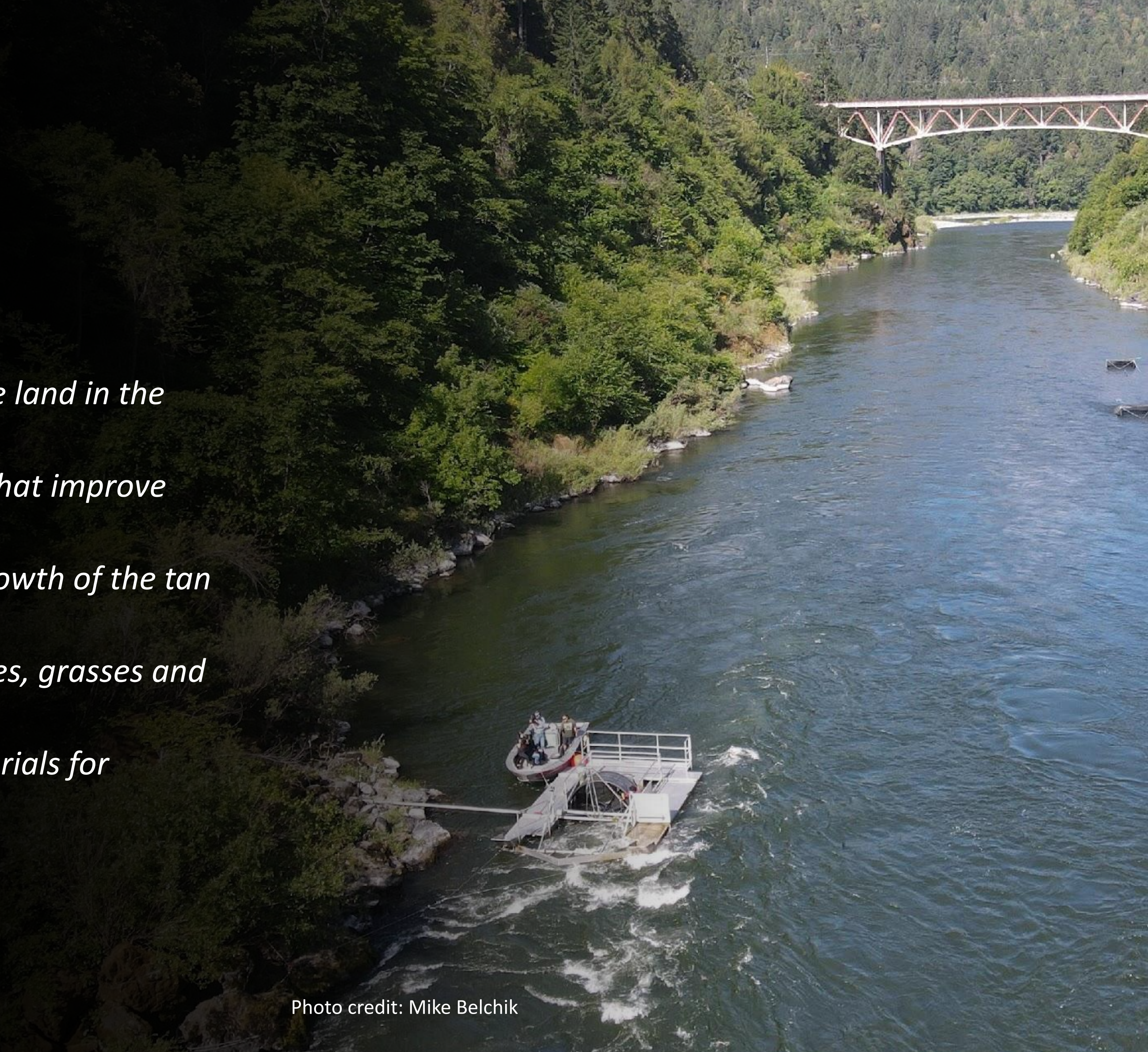


Photo credit: Mike Belchik

Drought Impacts to Tribe

- Drought stresses aquatic and terrestrial ecosystems
- Profound impacts to fisheries
- Domestic water supply issues for upper reservation citizens
- FIRE

Photo art credit: Louisa McCovey

Drought Resiliency

- Because the Tribe is focused on natural systems and people as part of that system, drought monitoring extends beyond simple monitoring
- The best way to make aquatic systems resilient to drought is to have intact ecosystems, high quality habitat and biodiversity.
- This is rooted in TEK, which emphasizes each species’ role in contributing to overall ecosystem health
- Ecosystem health translates directly to human health.

Photo art credit: Louisa McCovey

YTED Climate Change Adaptation Plan (2017)

He-we-chek' – *I live, I am healthy, I get well, I survive*

The health of the Yurok people depends on the health of the species, which depends on the health of the Klamath River and the health of the entire ecosystem…

It isn't possible to talk about the river without talking about the fish, without talking about the trees, flowers and plants and the animals; deer and elk, salamanders and birds.

They work together, collectively. It is important to keep this holistic Yurok worldview

Photo credit: Kaitlyn Woolling

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Photo credit: Kaitlyn Woolling

YTED Benthic Macroinvertebrate (BMI) Monitoring

- Decades long dataset: 2002-2022
- BMIs collected within vicinity to YTED stream gauging station
- YTED BMI taxa and flow duration statistics represent long-term monitoring efforts in lower Klamath River tributaries
- Long-term datasets collected during periods of drought and extreme flooding

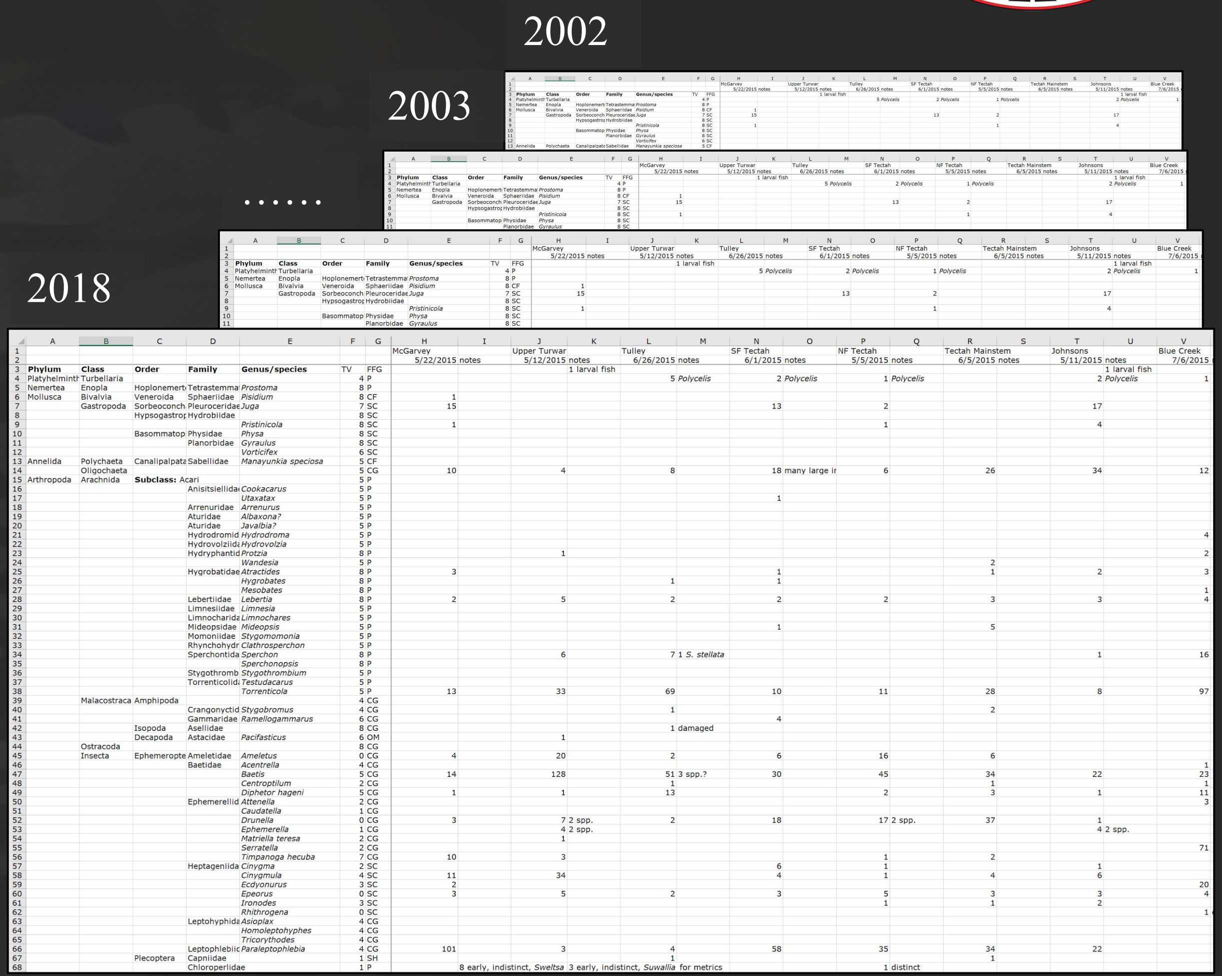

Photo credit: Kaitlyn Woolling

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- YTED BMI taxa and flow duration statistics represent long-term monitoring efforts in lower Klamath River tributaries
- Long-term datasets collected during periods of drought and extreme flooding
- For this analysis, a period 2007-2018 is used

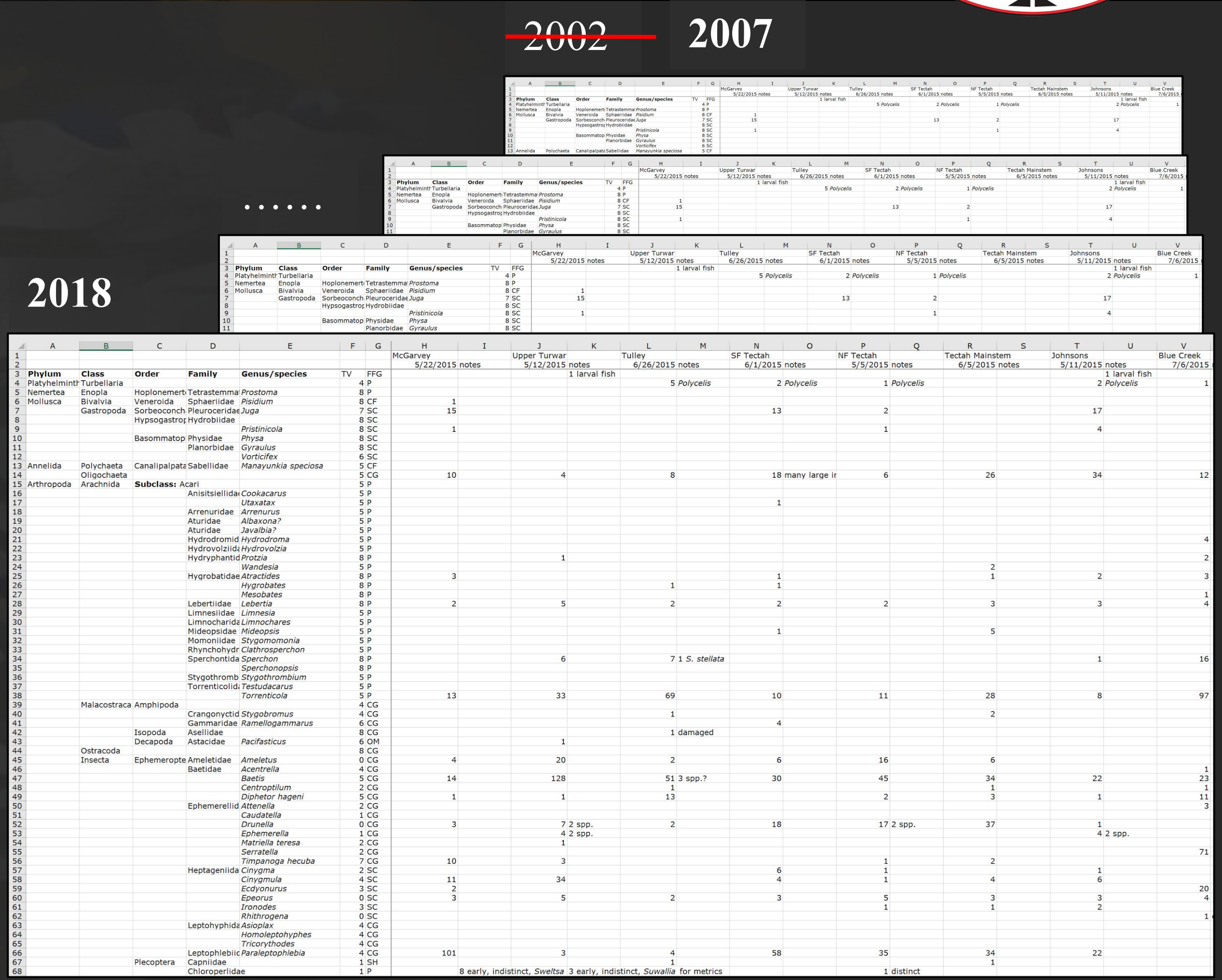

Photo credit: Kaitlyn Woolling

YTED Benthic Macroinvertebrate (BMI) Monitoring

Field Methods

- Standard rapid bioassessment protocols
- 100-200m, multiple transect study reaches
- BMIs collected in multiple habitats with D-frame nets
- Samples preserved in field with 95% ethanol

Lab Methods

- Jon Lee Taxonomic Services, processed and ID taxa to genus/species
- Fixed count ~500 individuals after removing large and rare
- Northern California Index of Biological Integrity (NORCAL-IBI) and other water quality metrics

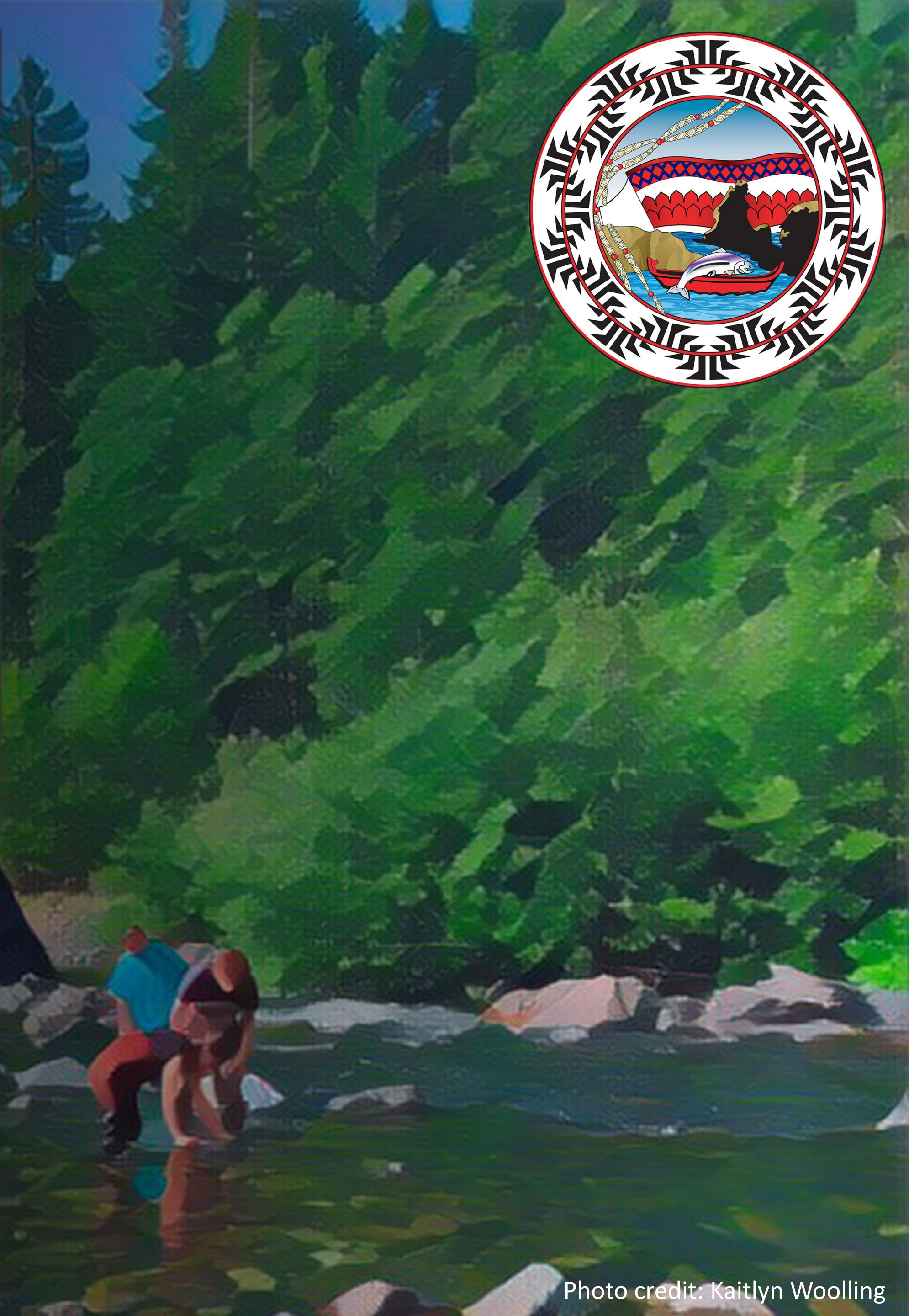

Photo credit: Kaitlyn Woolling

YTED Benthic Macroinvertebrate (BMI) Monitoring

Additional Monitoring

- Lower 44 miles of Klamath River within and adjacent to Yurok Tribe Reservation

Photo credit: Kaitlyn Woolling

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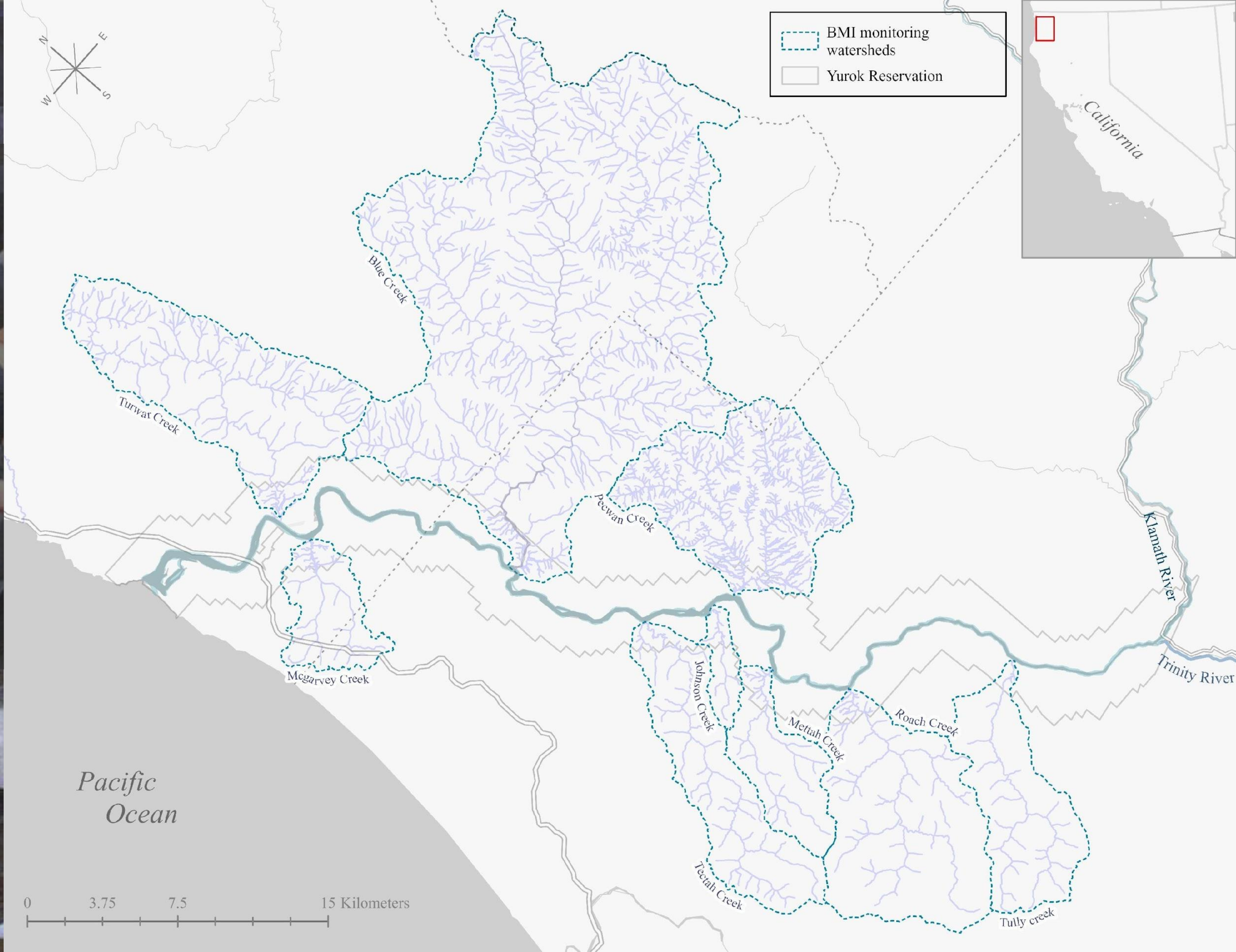

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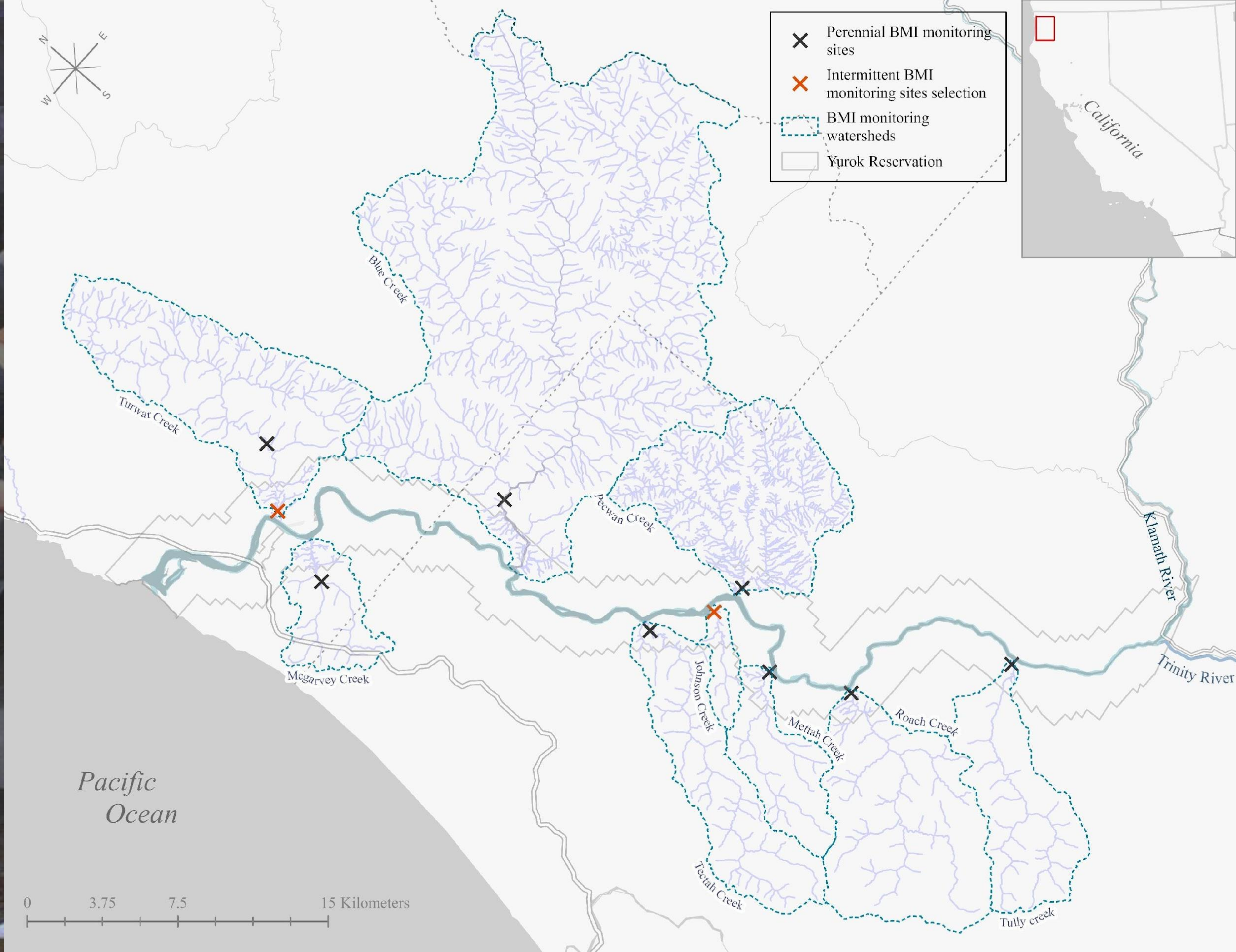

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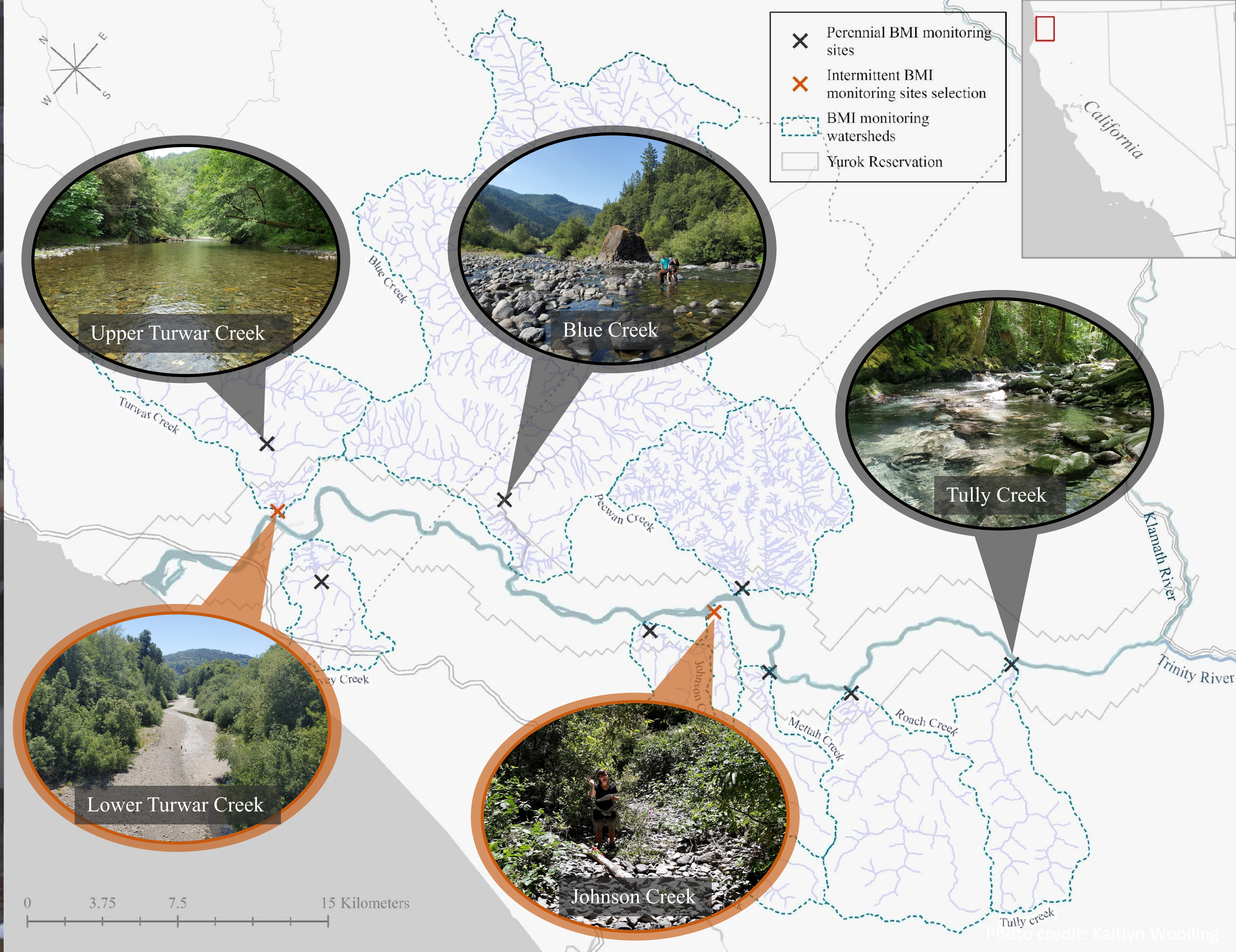
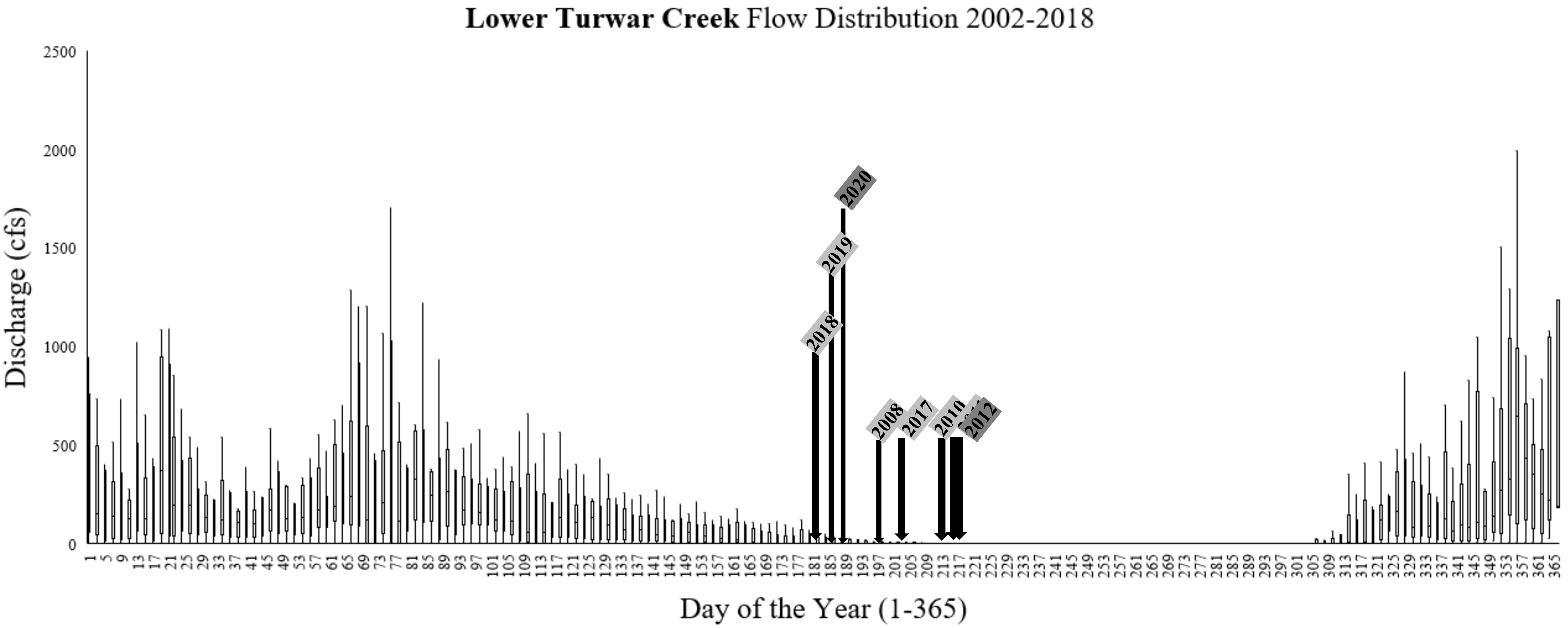


Increasing intermittency observable at tributaries within and adjacent to Yurok reservation



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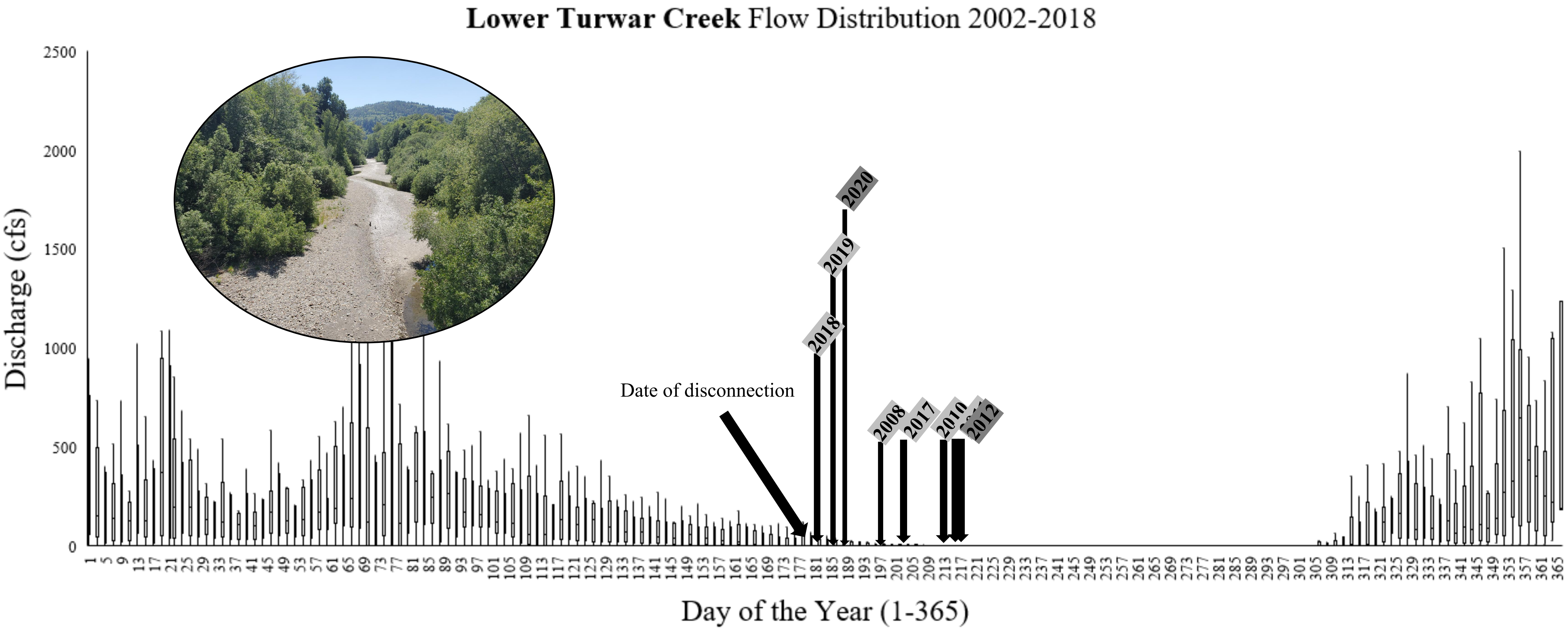

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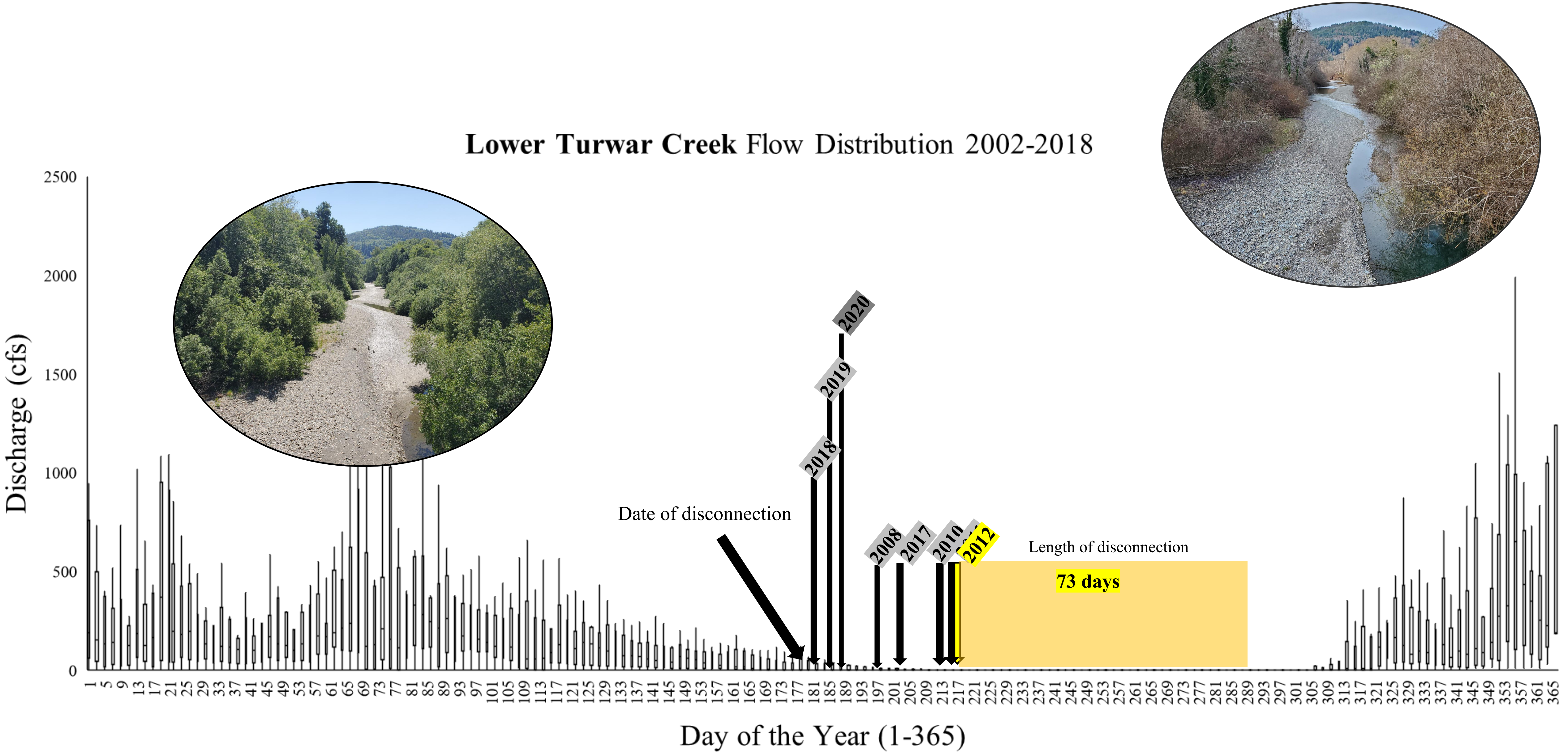

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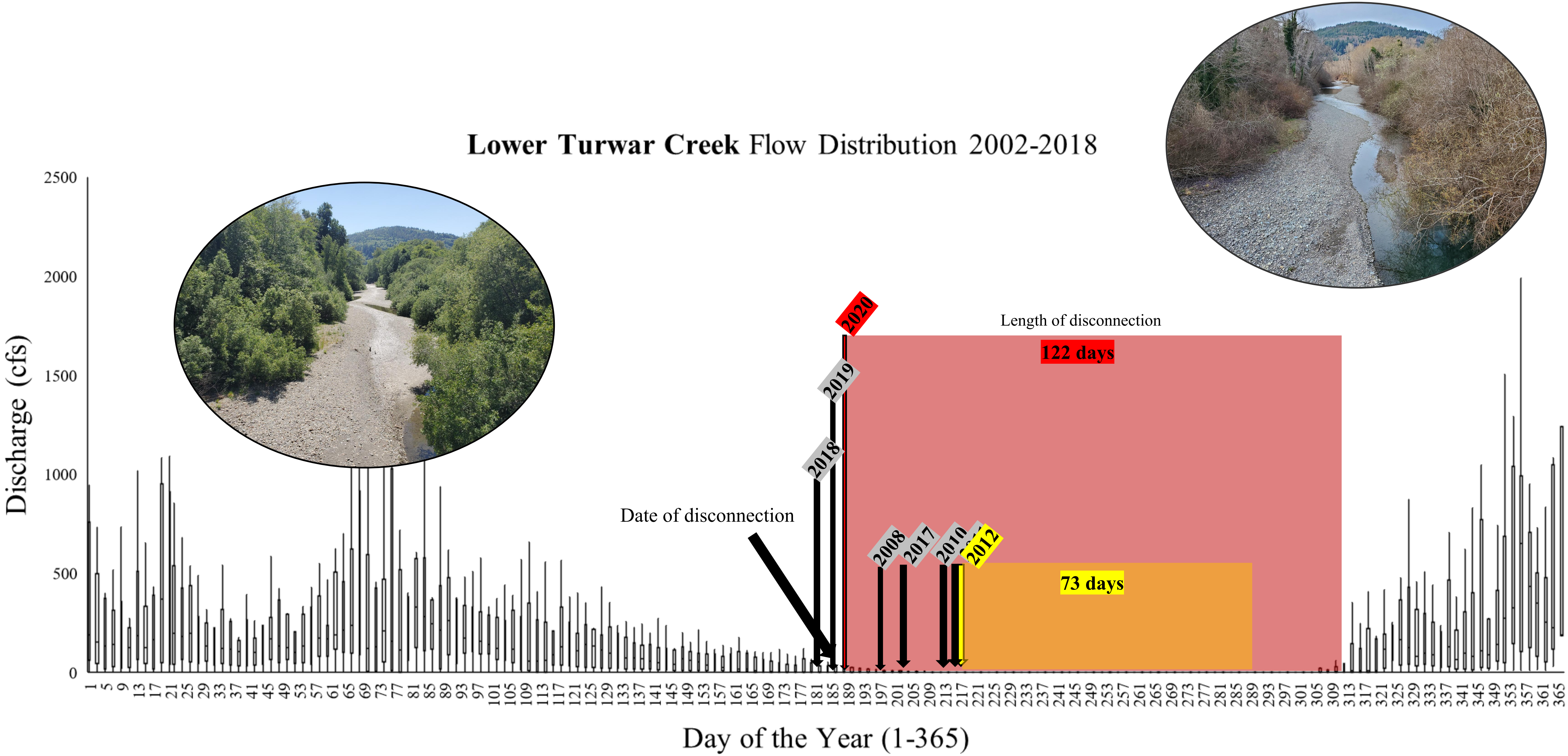

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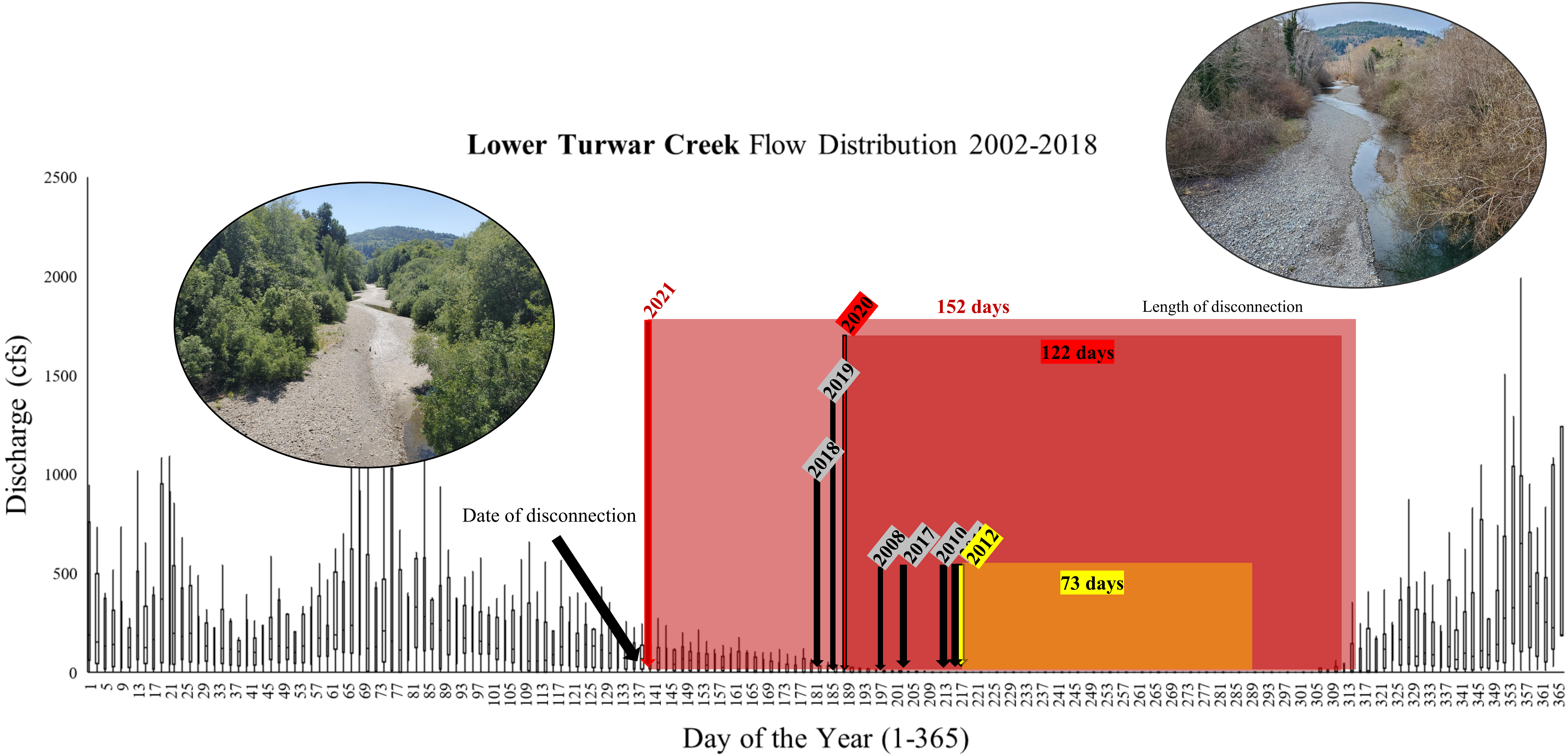
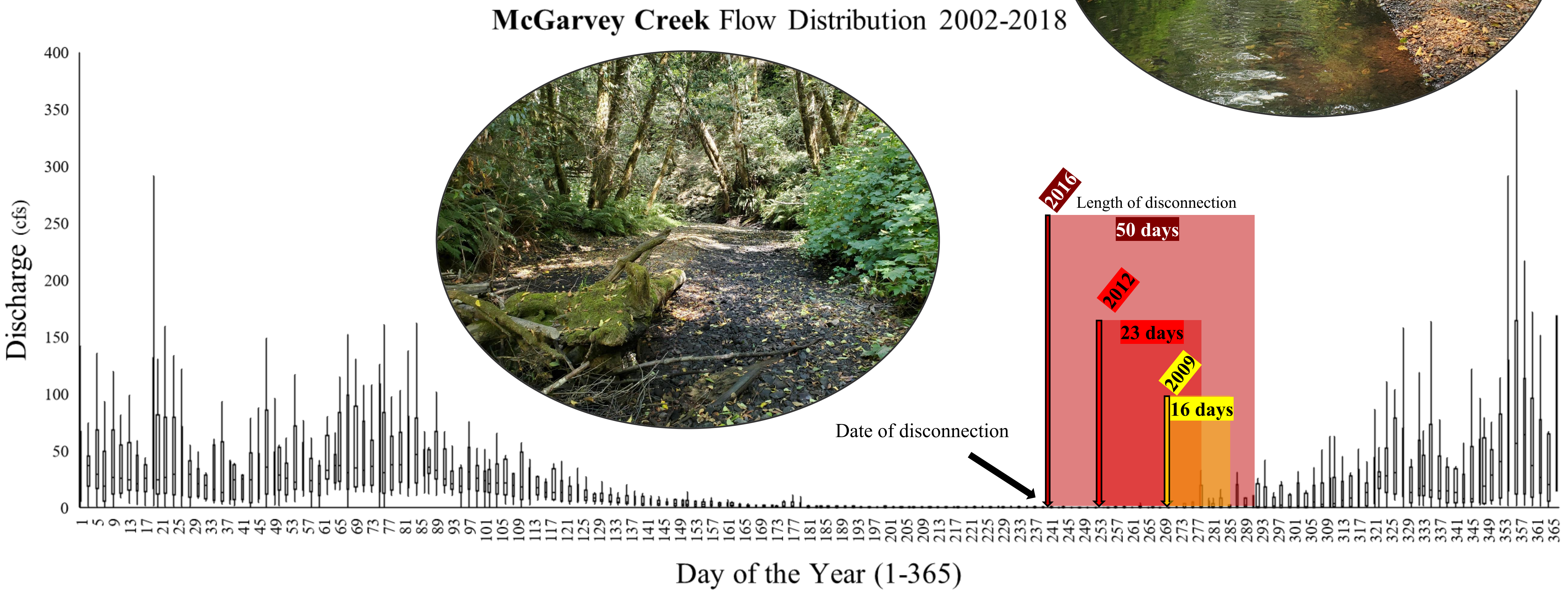


Historically perennial sites experiencing worsening drought observe periods of **disconnection and subsurface flows**



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- BMI life cycle lengths can lead to unique invert composition,
  - some taxa live multiple years (Merrit & Cummins 2008)
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Photo credit: Kaitlyn Woolling

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  - Shortened food chains due to drought

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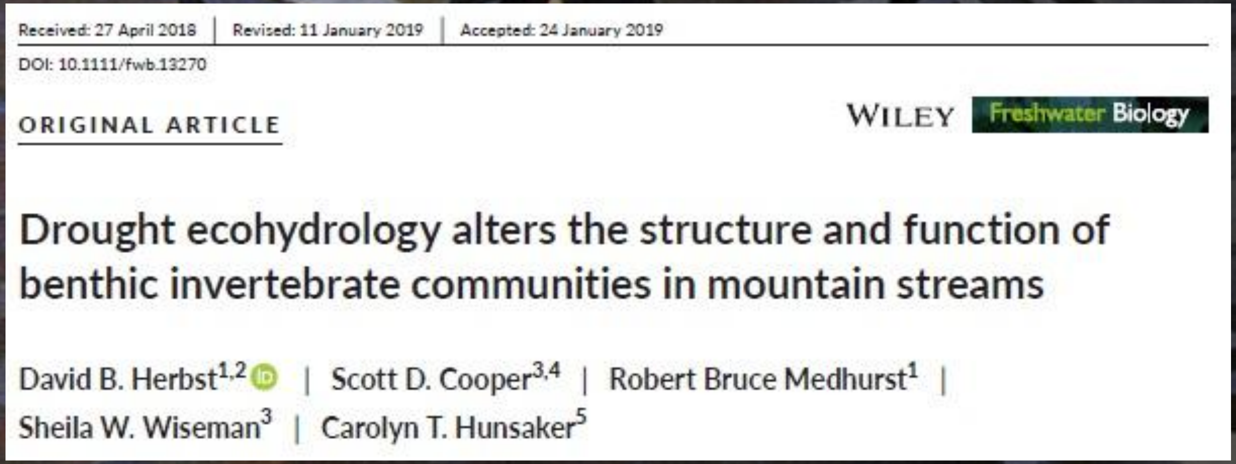

Received: 27 April 2018 | Revised: 11 January 2019 | Accepted: 24 January 2019
DOI: 10.1111/fwb.13270

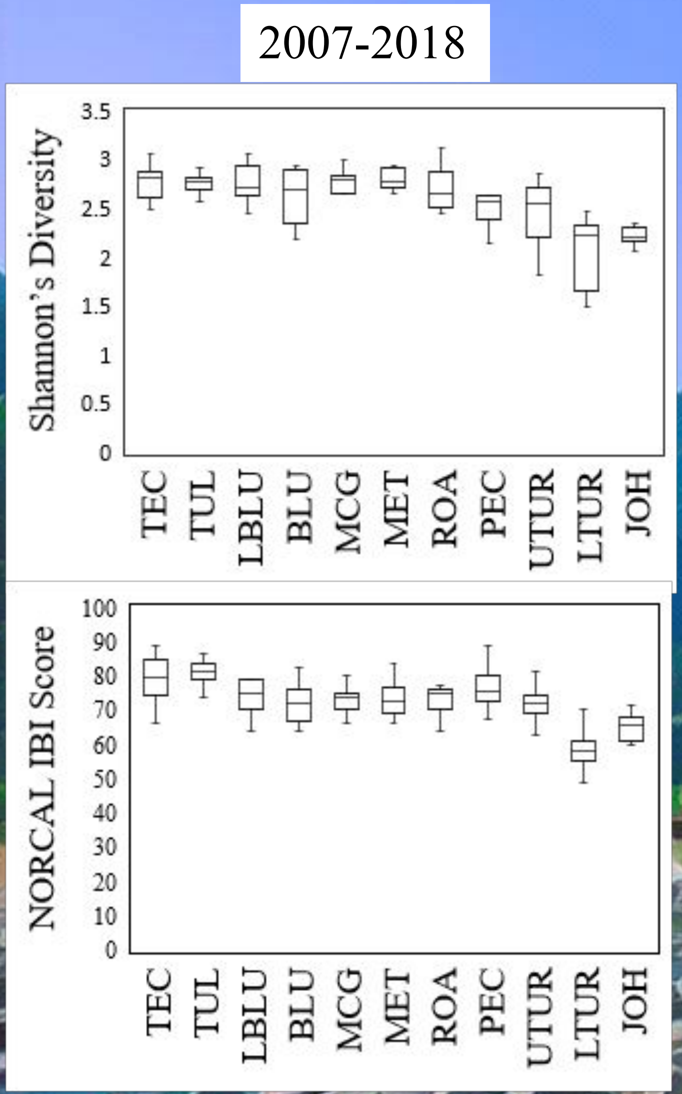
ORIGINAL ARTICLE

WILEY Freshwater Biology

Drought ecohydrology alters the structure and function of benthic invertebrate communities in mountain streams

David B. Herbst[1,2] | Scott D. Cooper[3,4] | Robert Bruce Medhurst[1] | Sheila W. Wiseman[3] | Carolyn T. Hunsaker[5]

Photo credit: Kaitlyn Woolling


2007-2018
Shannon's Diversity
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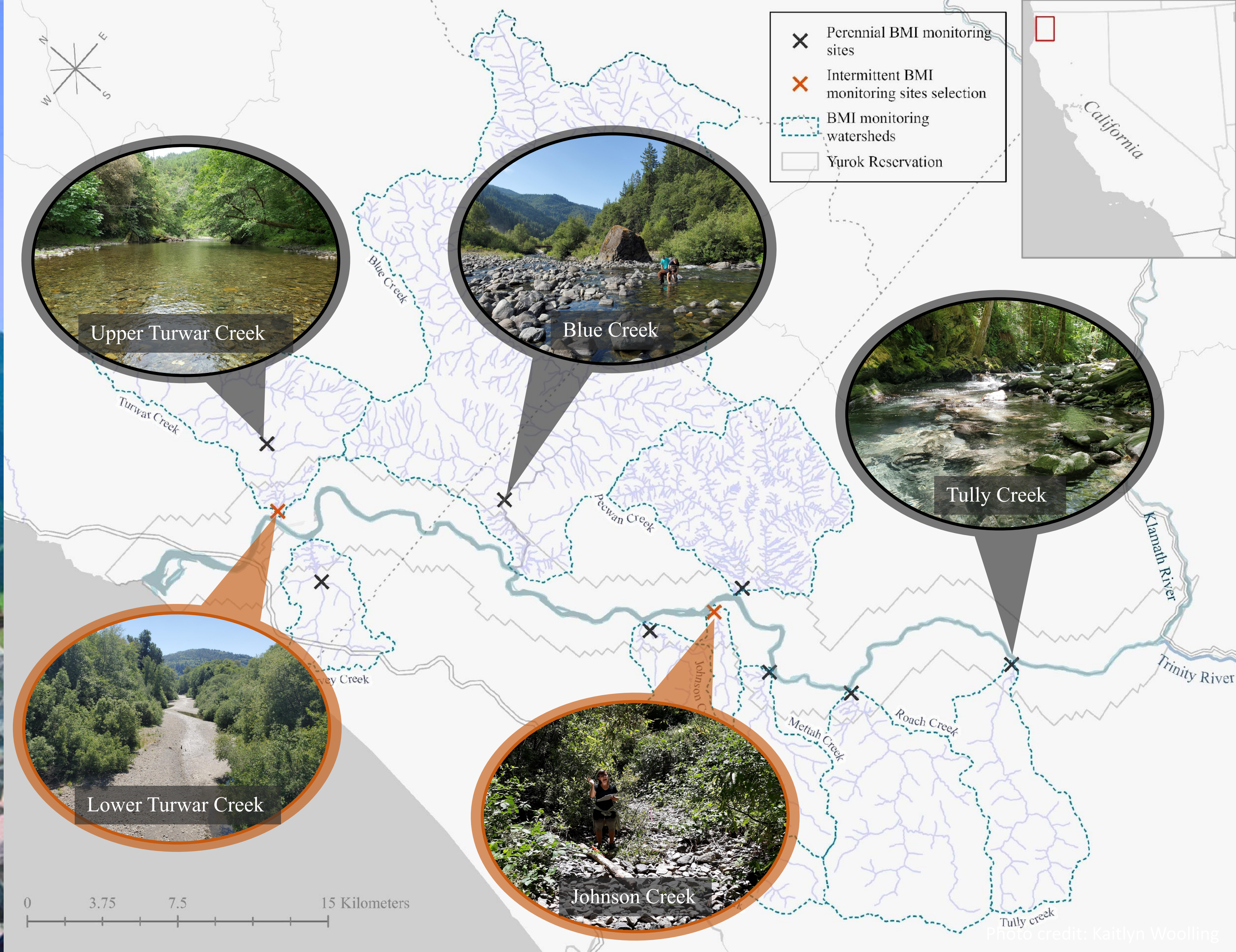
Perennial BMI monitoring sites
Intermittent BMI monitoring sites selection
BMI monitoring watersheds
Yurok Reservation
California
Upper Turwar Creek
Blue Creek
Tully Creek
Lower Turwar Creek
Johnson Creek
Turwar Creek
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Pecwan Creek
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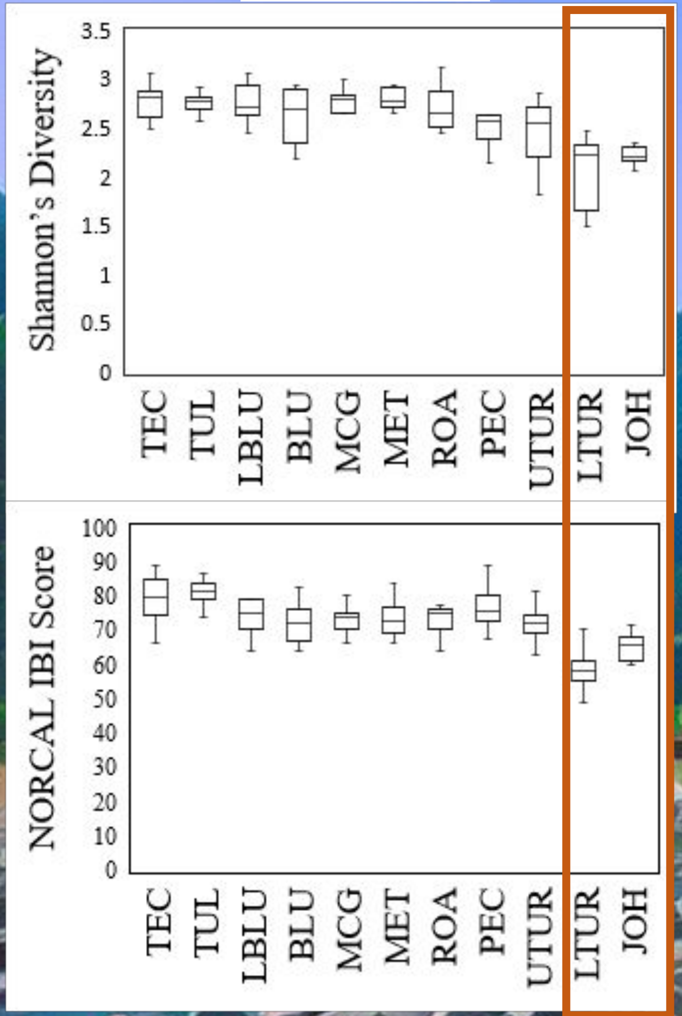
Mettah Creek
Roach Creek
Tully creek
0
3.75
7.5
15 Kilometers
Photo credit: Kaitlyn Woolling

2007-2018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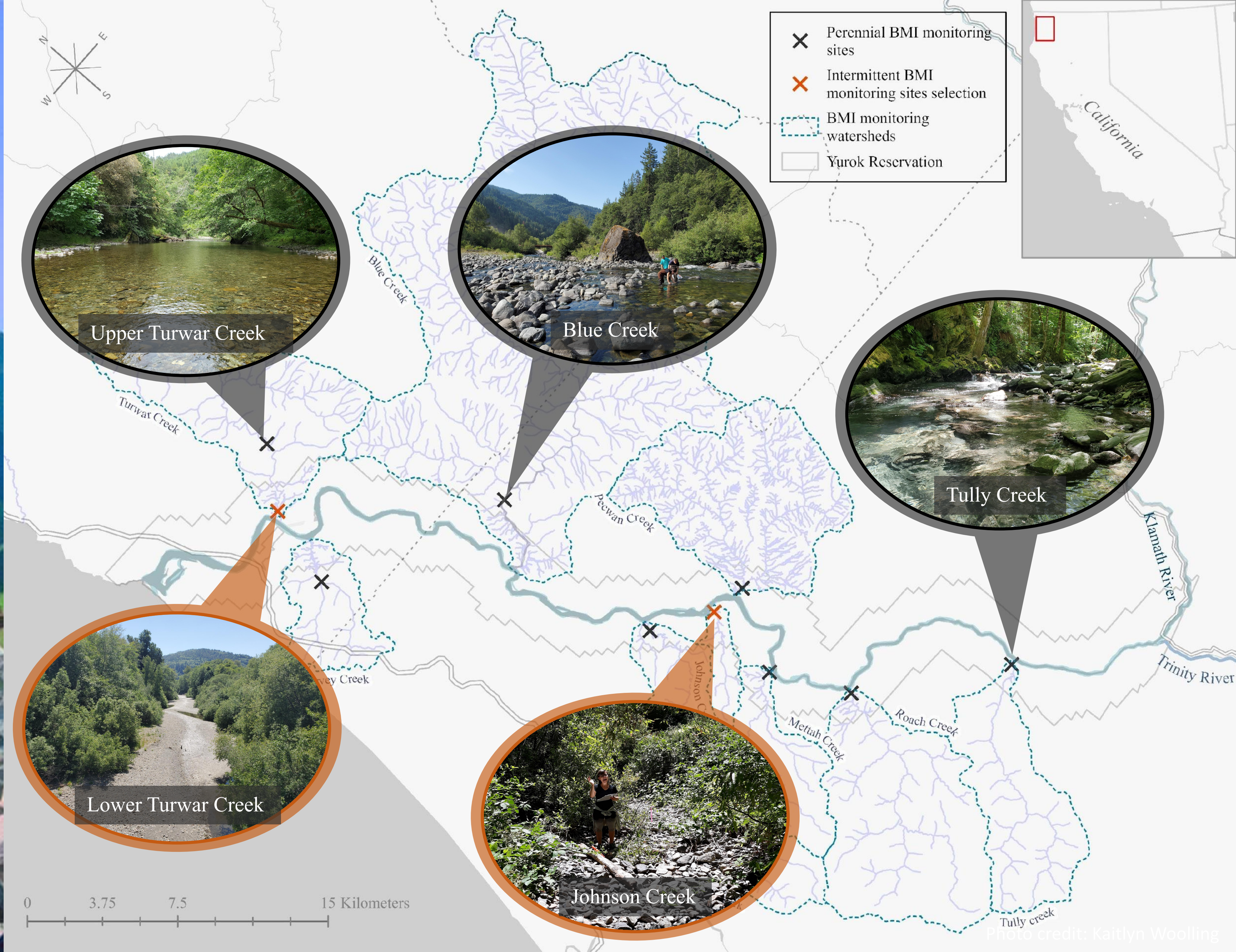
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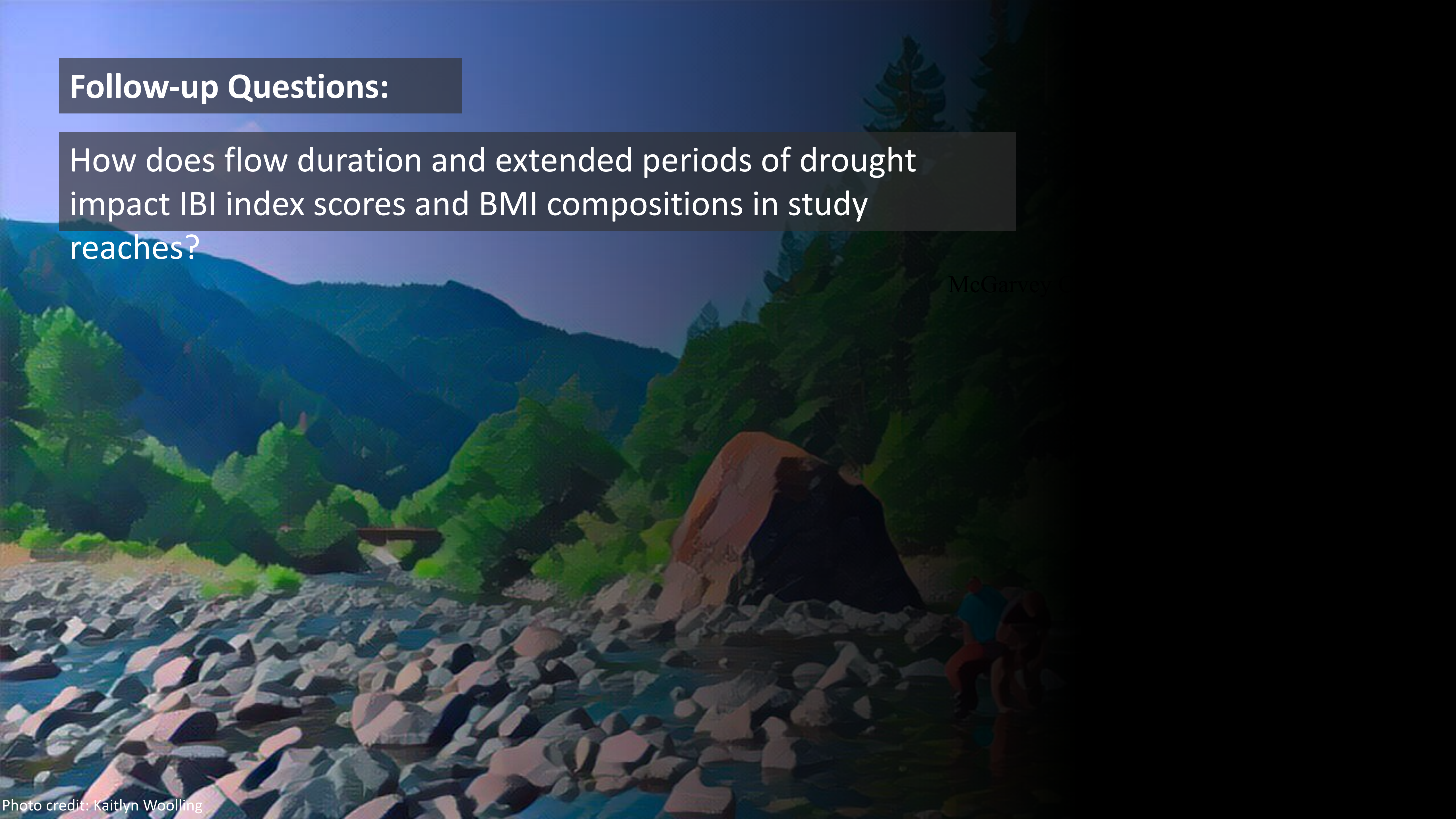

Follow-up Questions:

How does flow duration and extended periods of drought impact IBI index scores and BMI compositions in study reaches?

Photo credit: Kaitlyn Woolling

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How does flow duration and extended periods of drought impact IBI index scores and BMI compositions in study reaches?

Data Analysis

- Produced flow duration curves for each YTED gauging location, 50% exceedances used
- Grouped data by stream type and water year
- Removed rare BMI taxa <5% relative abundance
- Standardized dataset to better control for taxa variability
- nMDS ordinations using Bray-Curtis Dissimilarity Index
- Indicator Species Analysis using permutations to test for significance by randomly subsetting data
- SIMPER

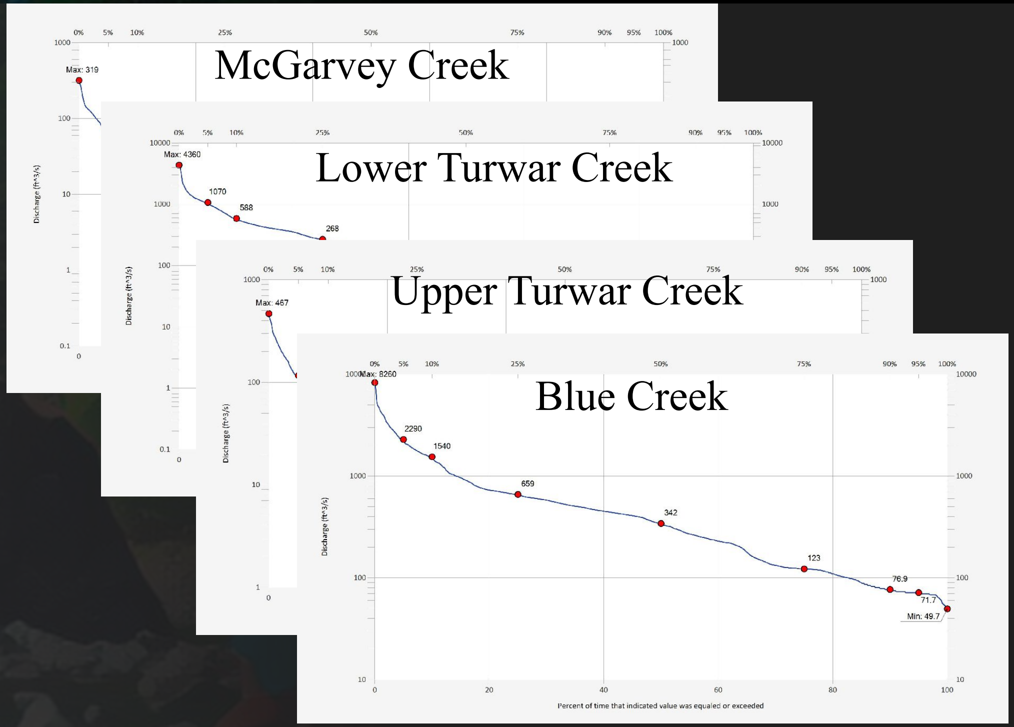
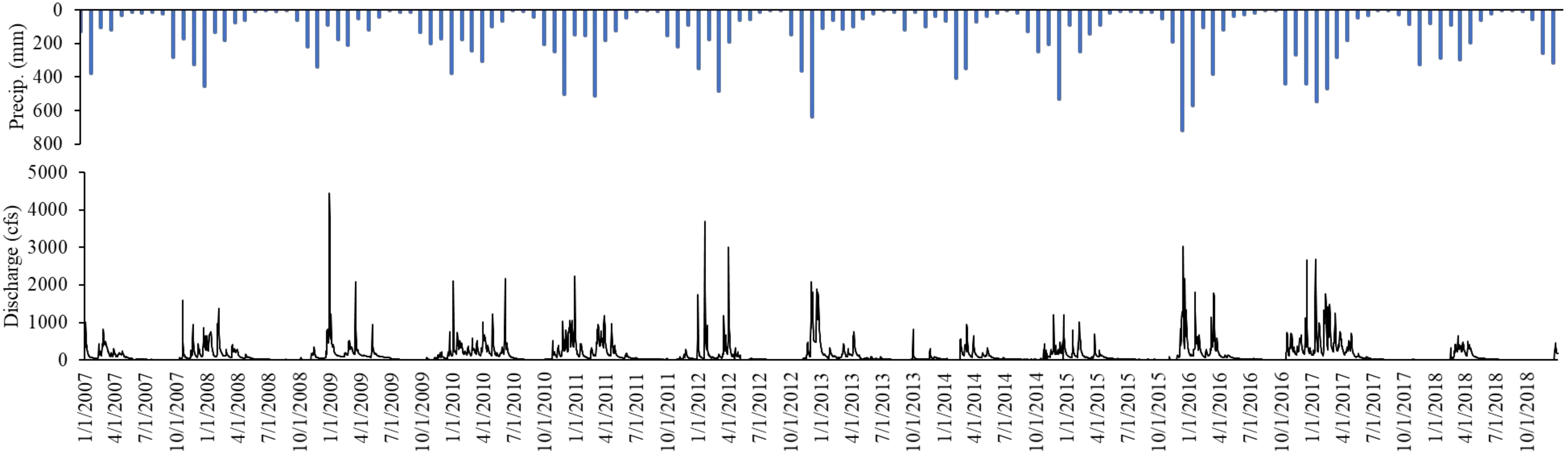


Photo credit: Kaitlyn Woolling

Upper Turwar Creek YTED Gauge

	Perennial	Intermittent
Dry year	PD	ID
Wet year	PW	IW

Upper Turwar Creek Discharge and Monthly Precipitation (2007-2018)



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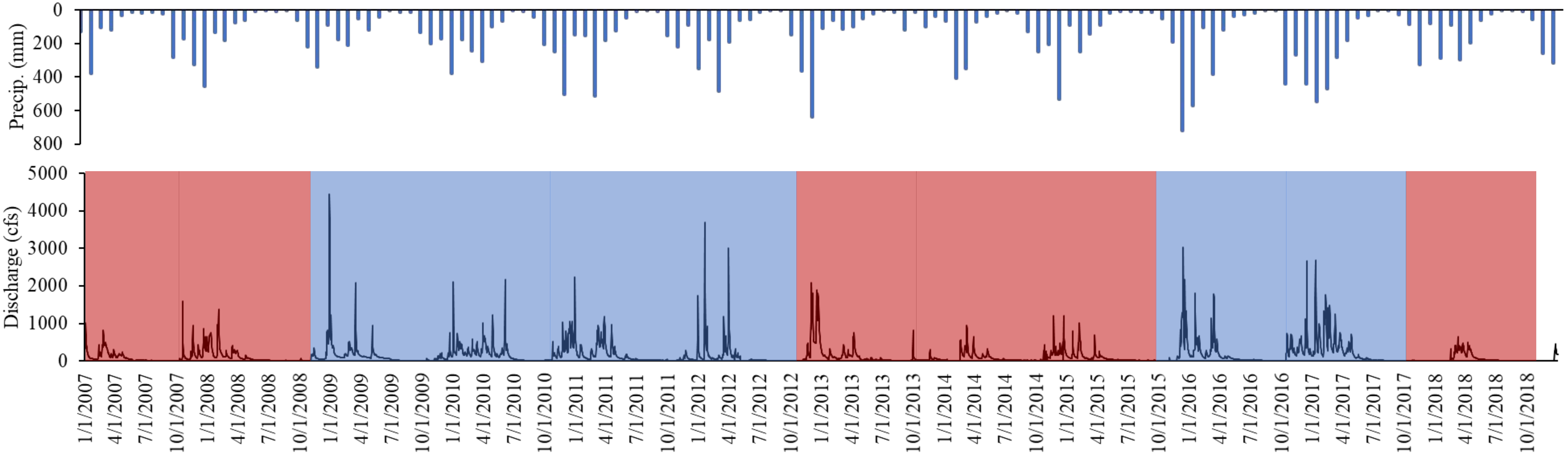

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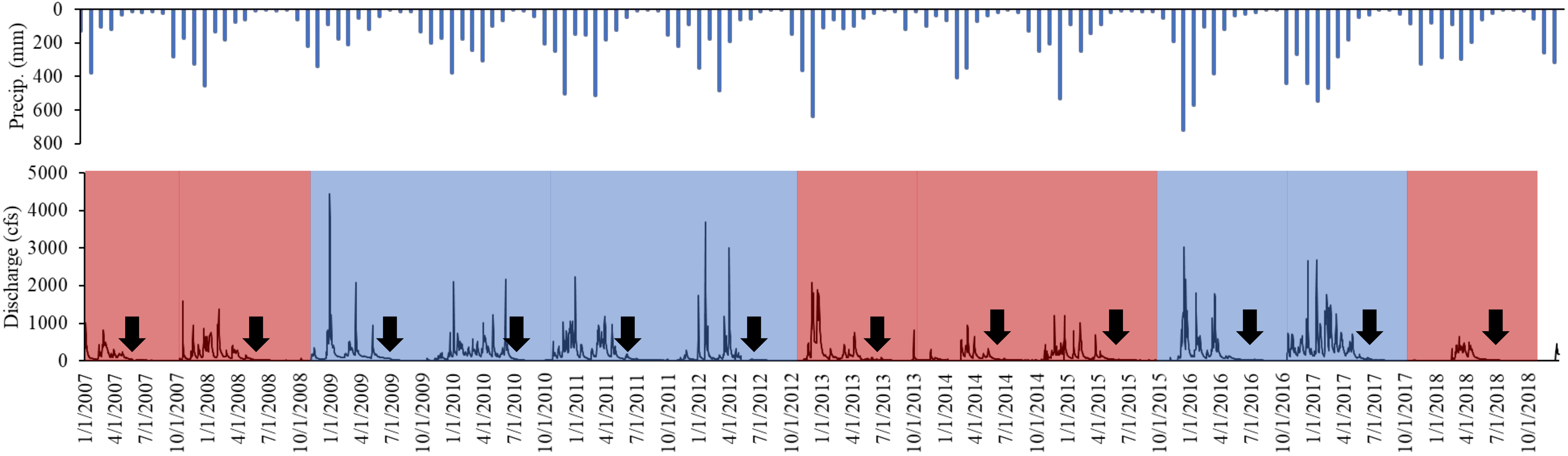

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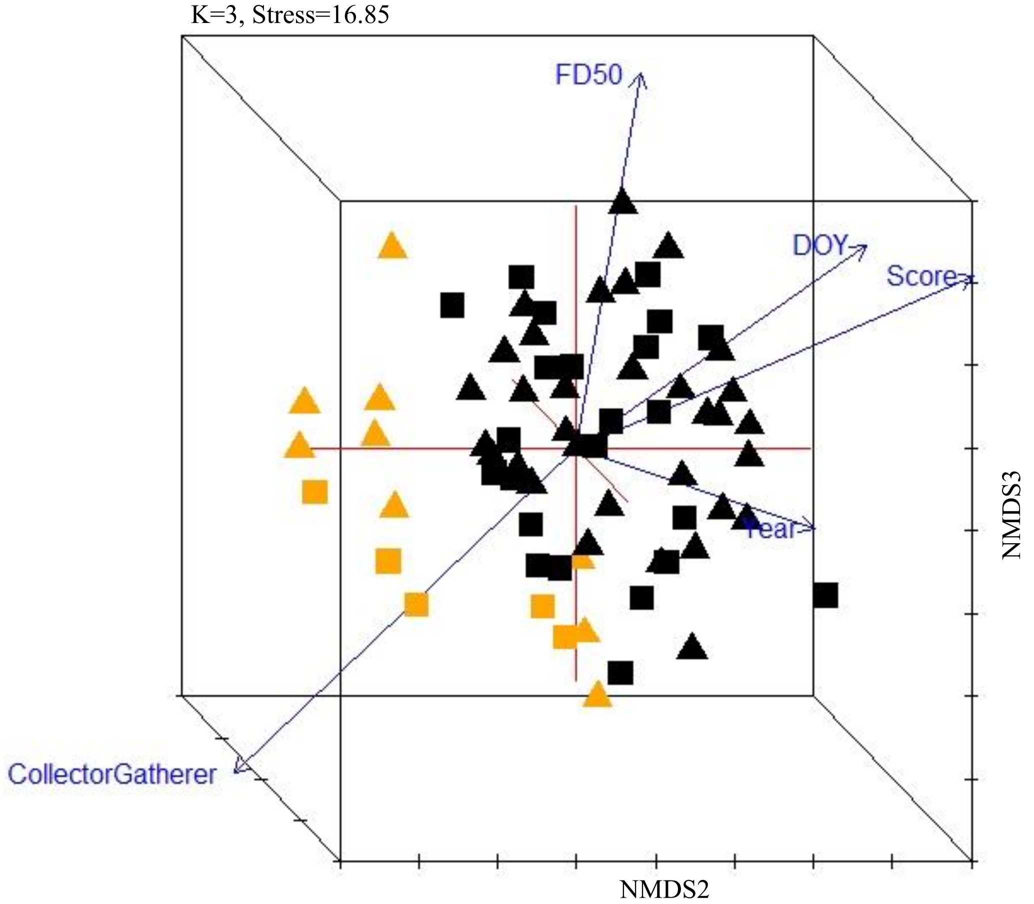

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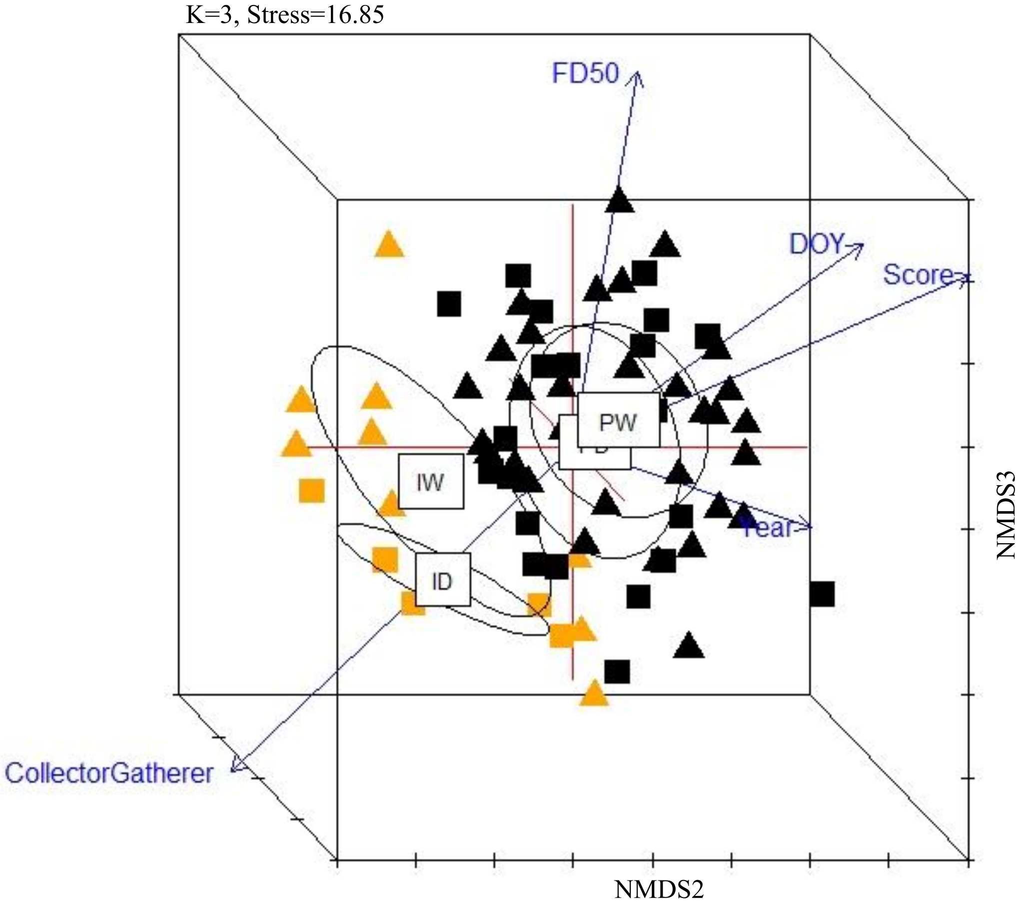

Indicator Species Analysis

Intermittent Dry Years (ID)

Neophylax (p=0.026 *)
Oligochaeta (p=0.057 .)

Perennial Wet and Dry Years (PD & PW)

Optioservus (p=0.015 *)
Zaitzevia (p=0.010 **)
Torrenticola (p=0.020 *)
Calineuria californica (p=0.046 *)
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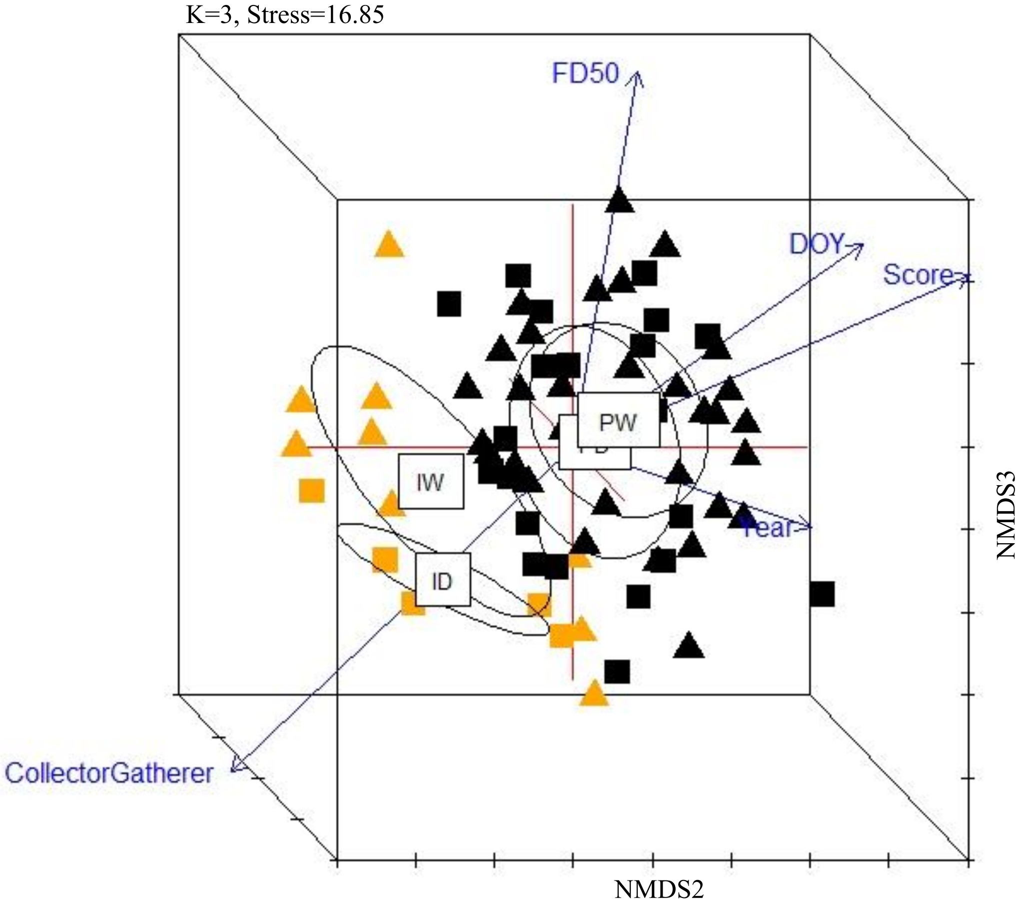

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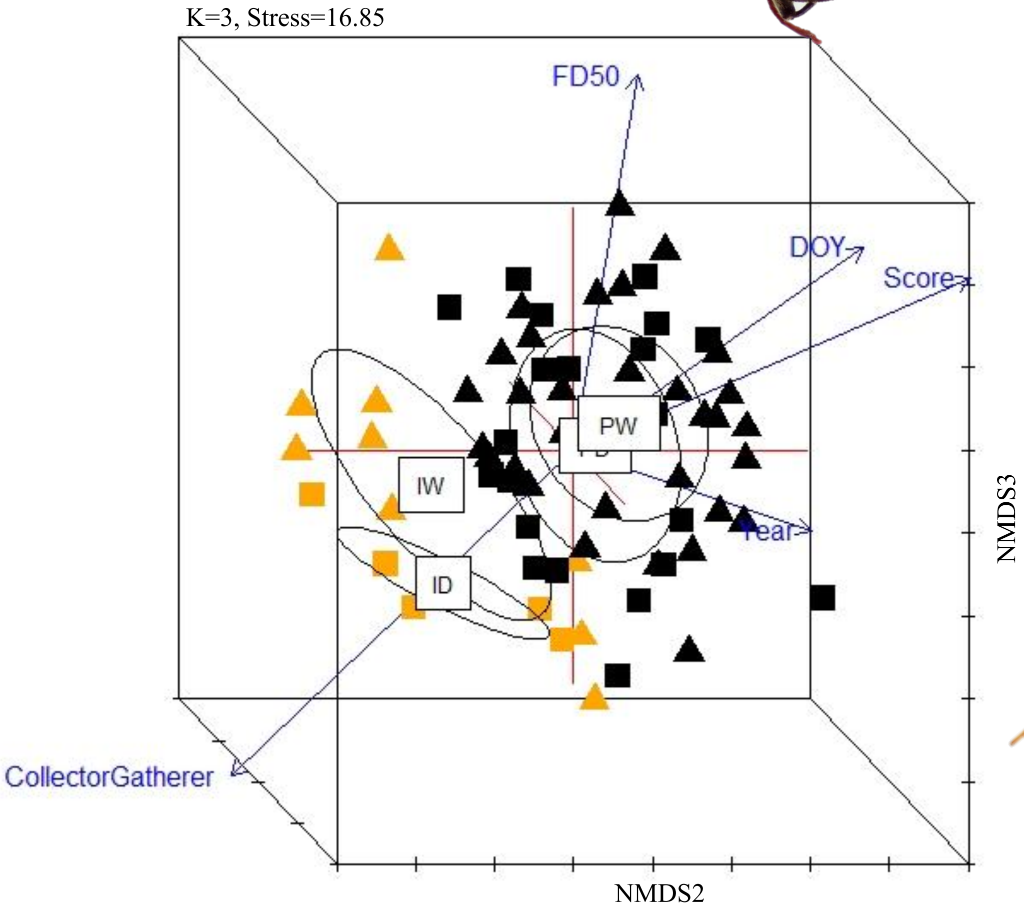

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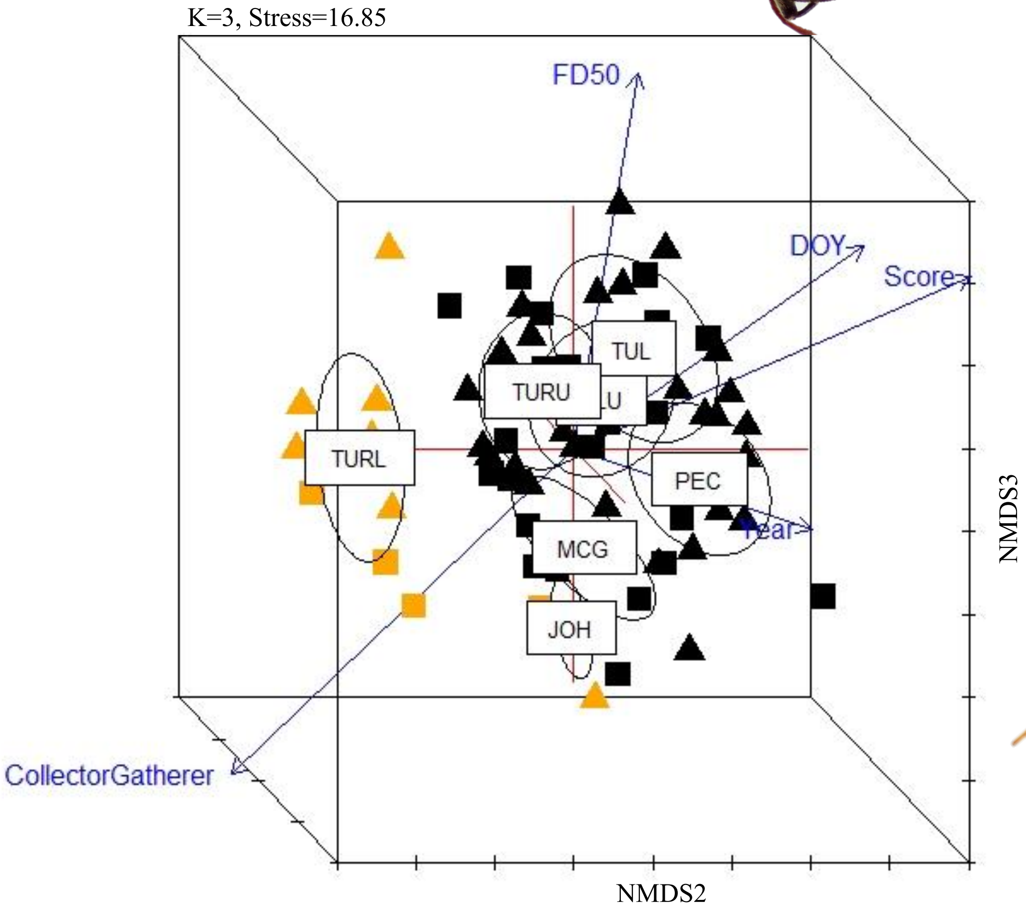

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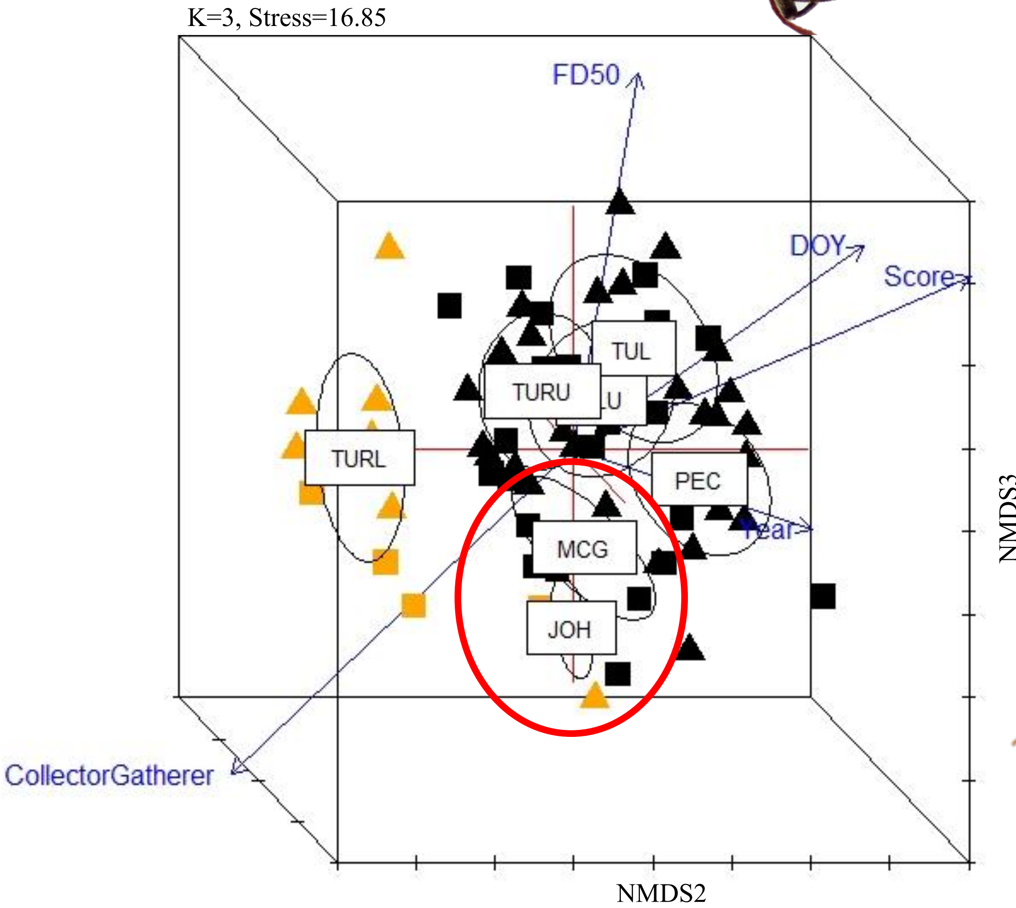

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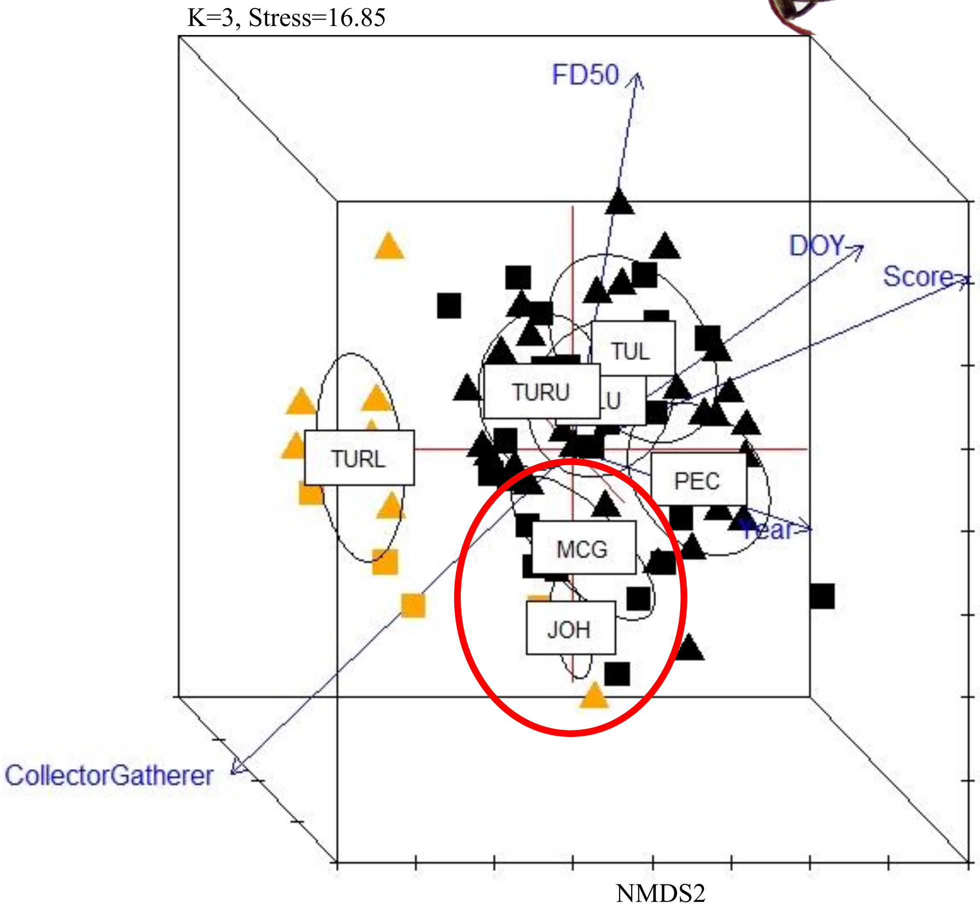

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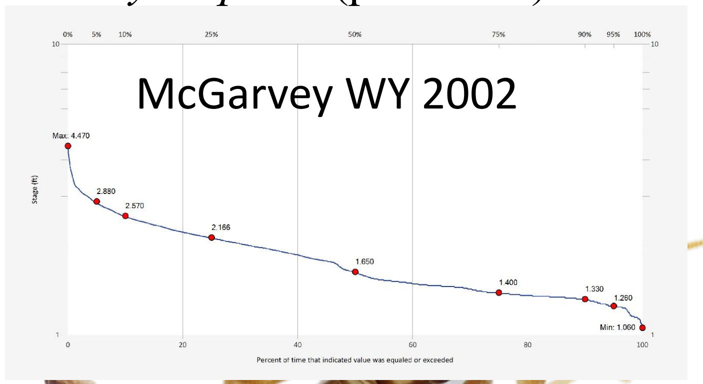

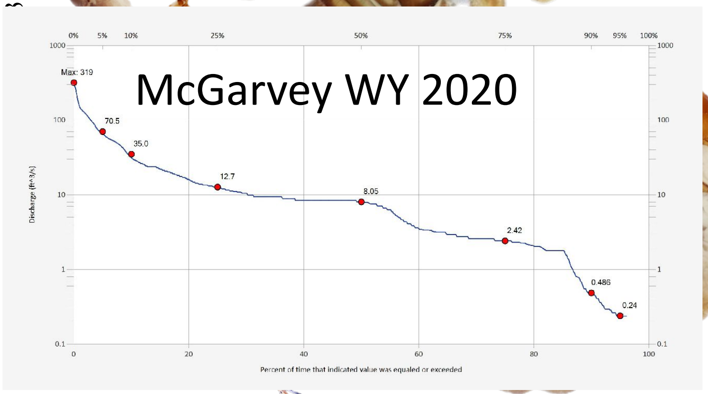

Potential Research Questions

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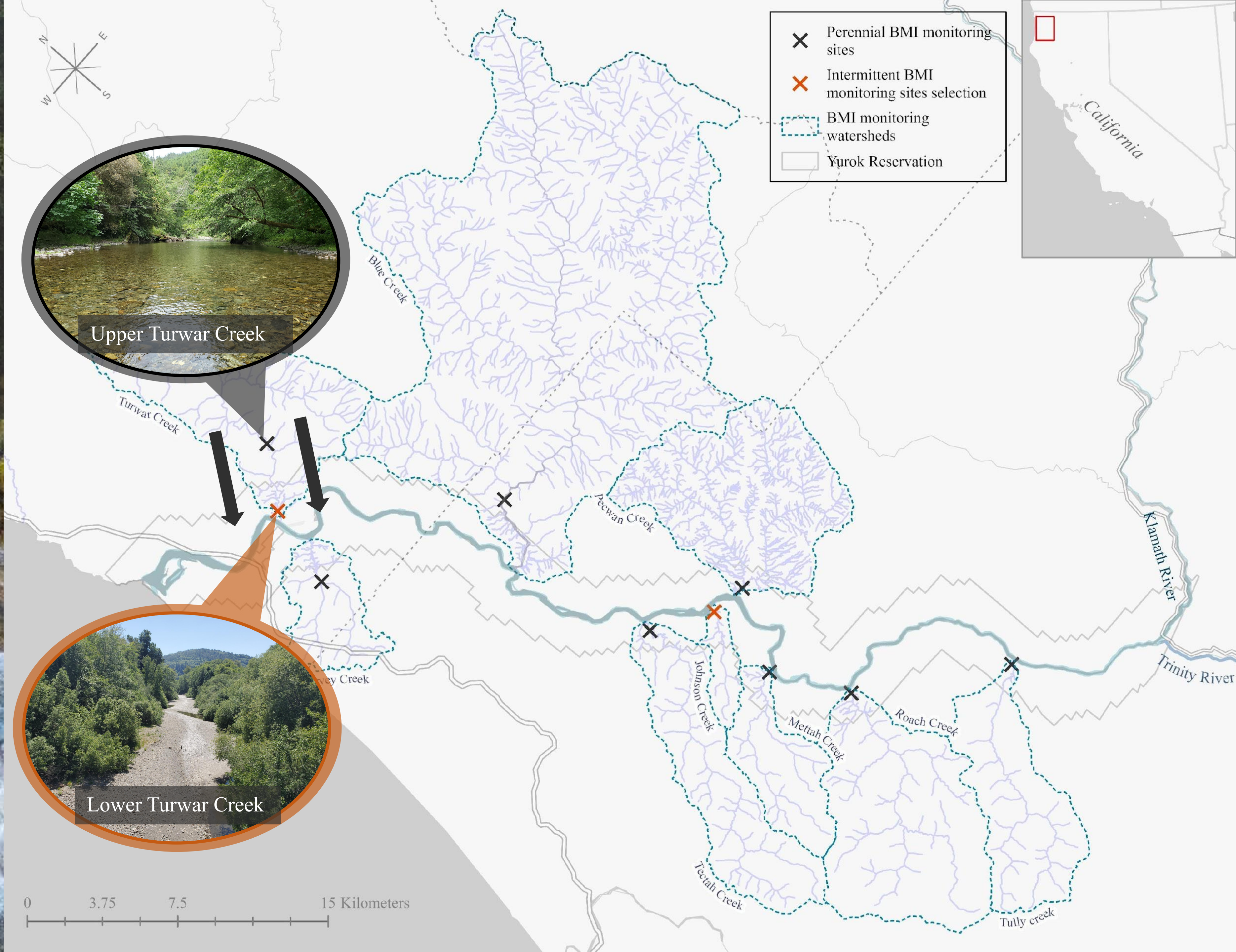

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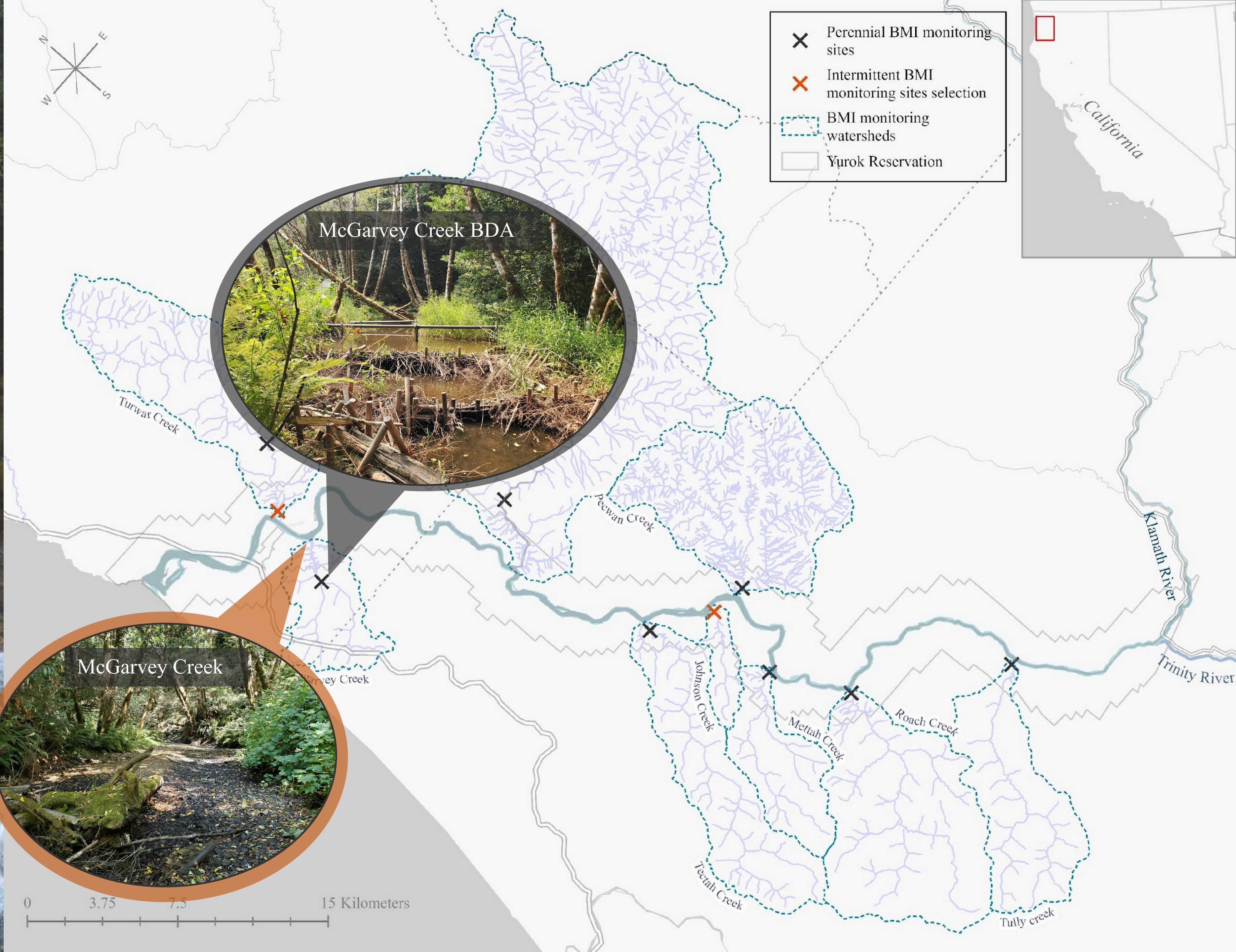
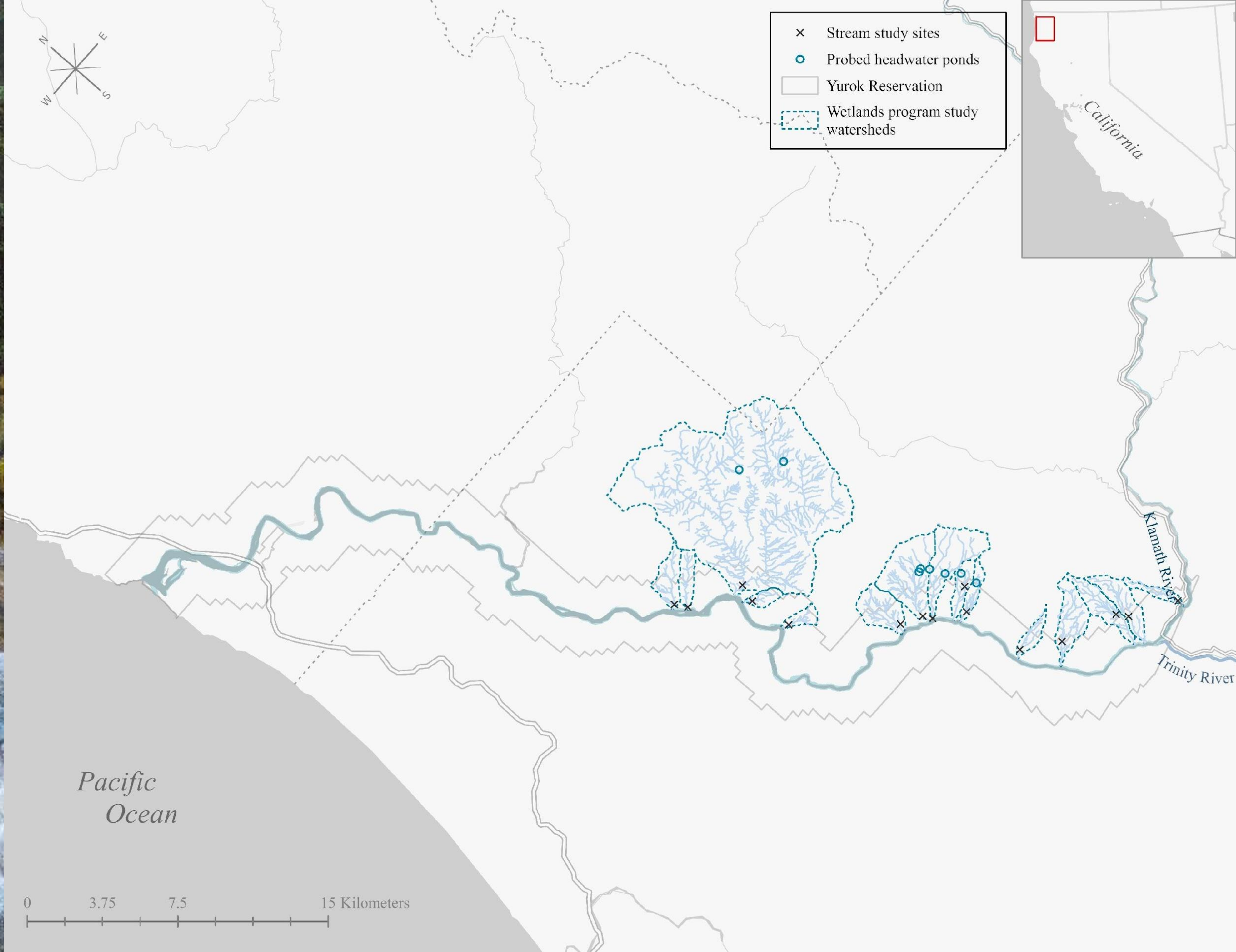
How do instream restoration projects designed to improve surface flows impact BMIs in critically important perennial reaches?



Closing Remarks

YTED Wetlands Development Project



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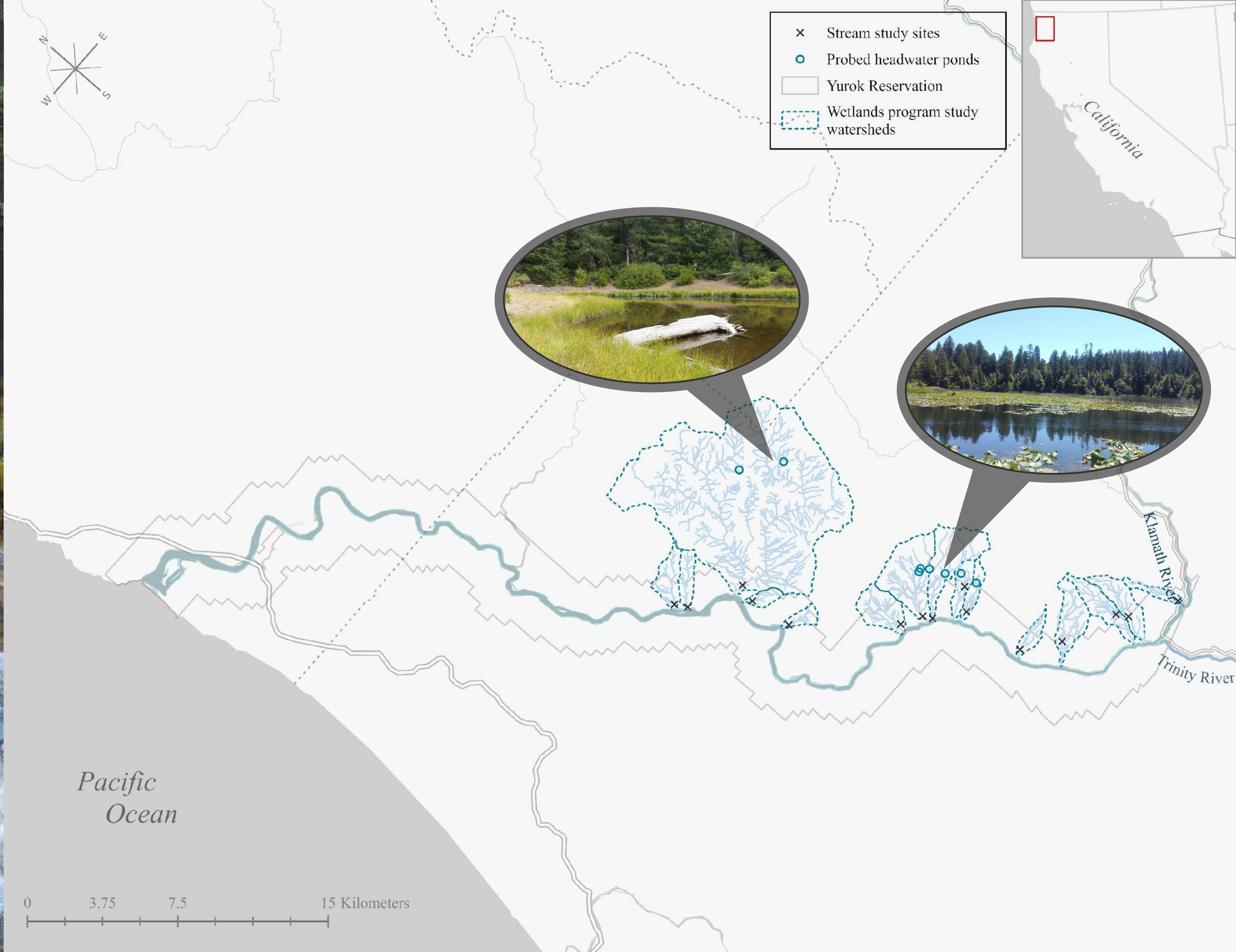
YTED Wetlands Development Project

Use of indicators to target "at-risk" headwaters for potential restoration:



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Use of indicators to target "at-risk" headwaters for potential restoration:

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- Beaver dam analogues,
- road decommissioning,
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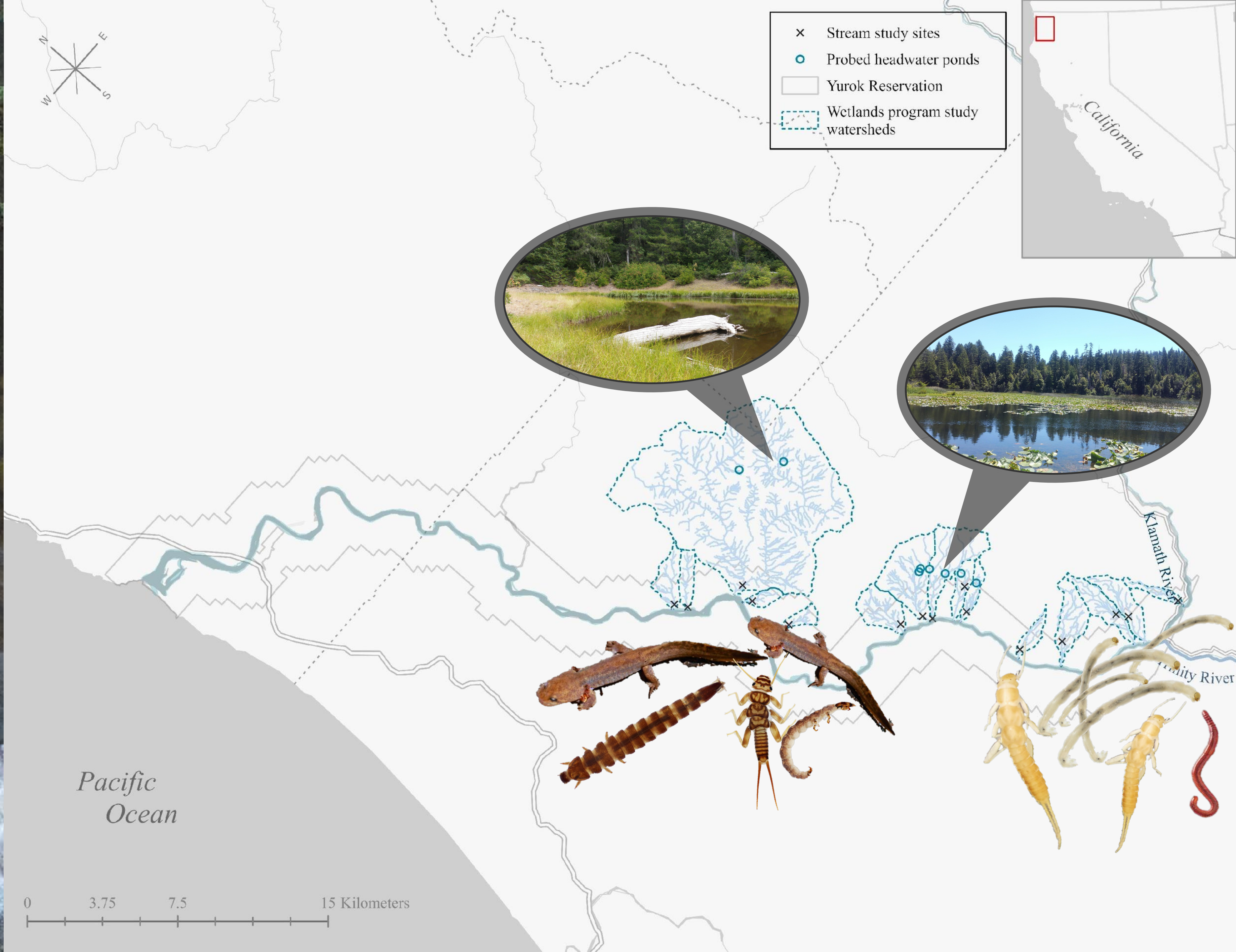

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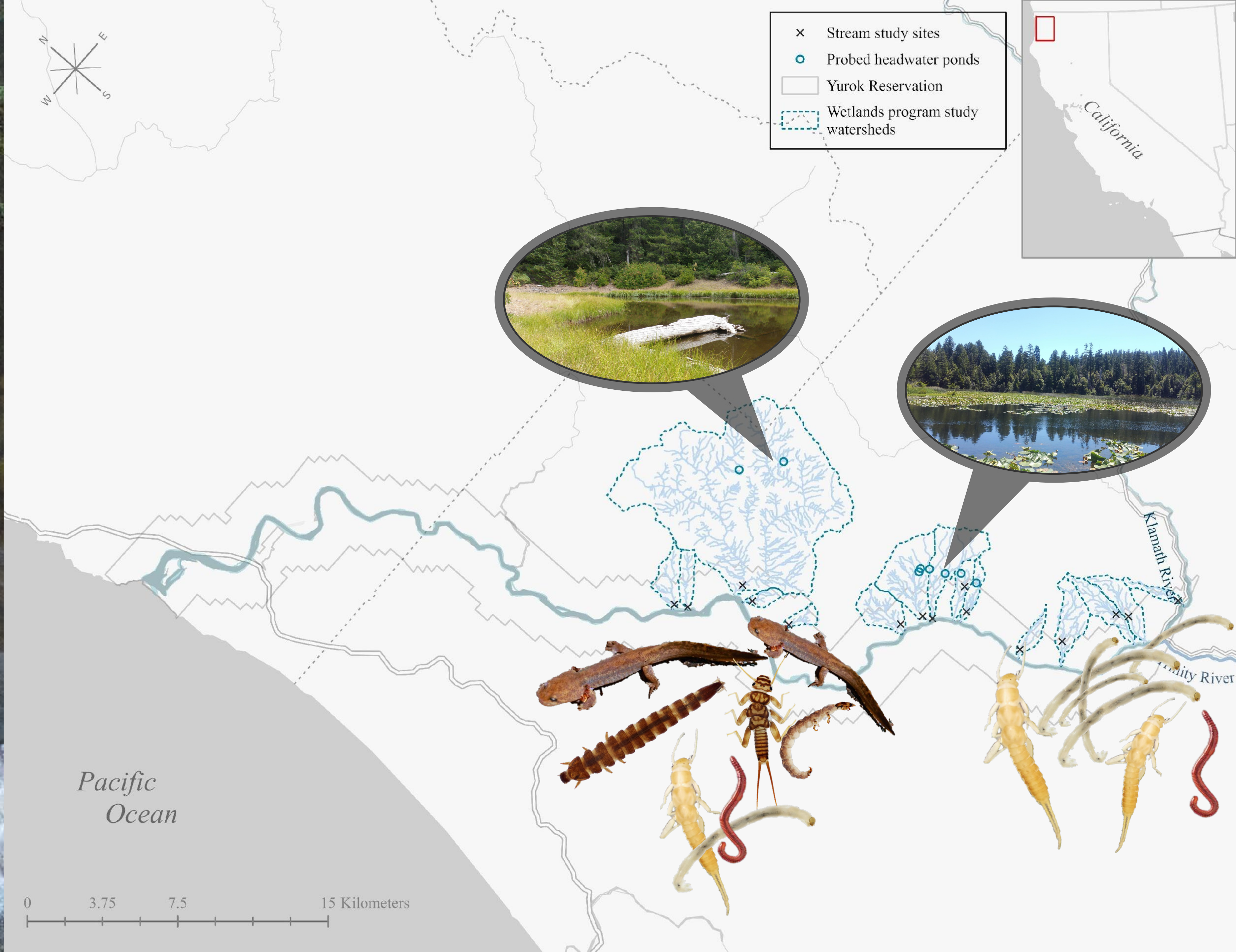

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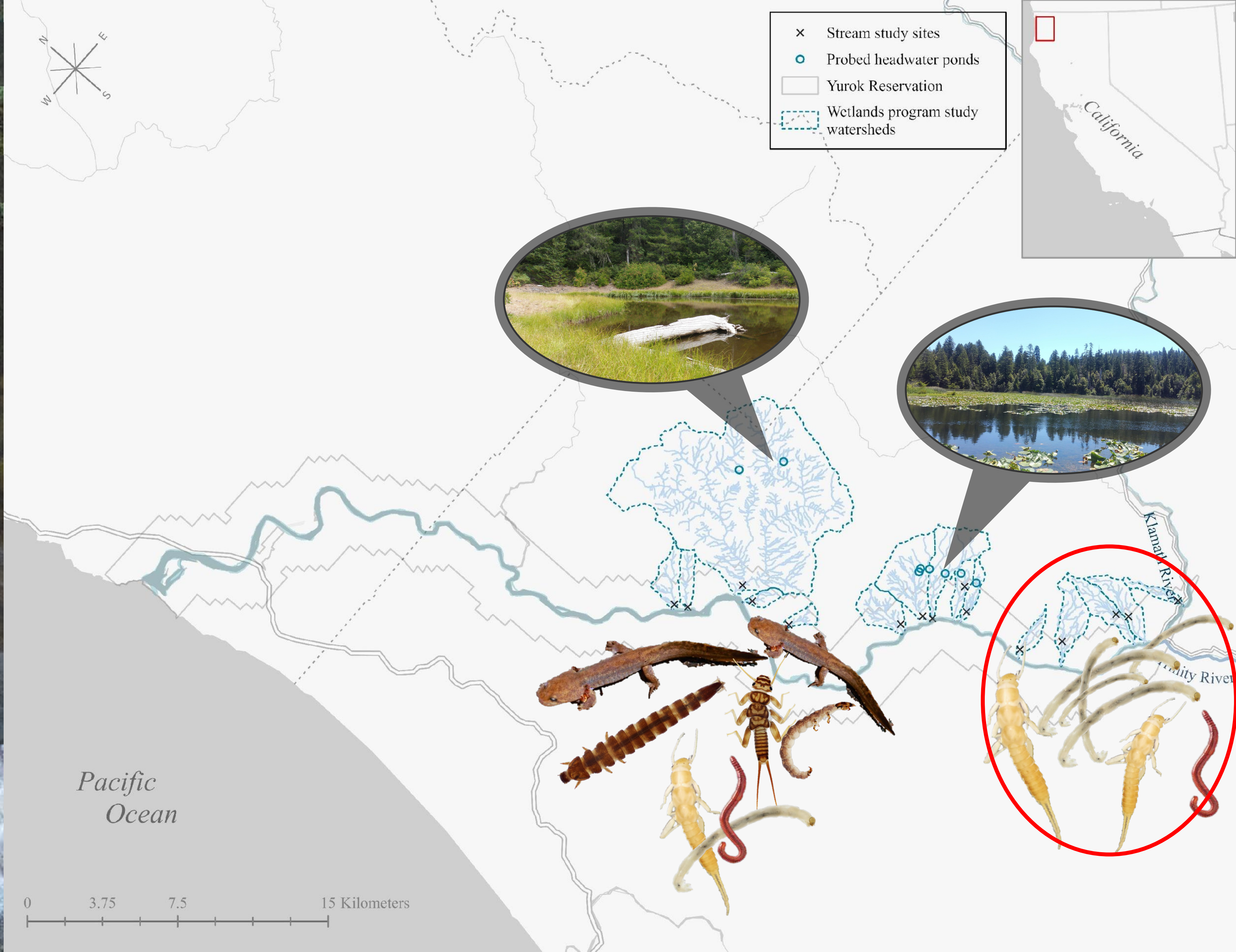

Acknowledgements

Thanks to the amazing Yurok tribe staff for help in the field and inspiration:

Matt Hanington, Kaitlyn Woolling, Christine Cosby, Josh Cahill, Louisa McCovey, Micah Gibson, Raphael Cedillo, Roger Buckskin, Richard Meyers, Sarah Beesley, Rocco Fiori, Tori McConnel, Chimaway Lopez, Kassandra Grimm, Jennifer Brown, Aurelia Knight, Koiya Tuttle

Funding provided by Environmental Protection Agency (EPA) Clean Water Act and EPA Tribal Wetlands Development Grant, Region 9

Special thanks the AmeriCorps Watershed Stewards Program corps members for the assistance over the years and collaboration with YTED

Photo credit: Kaitlyn Woolling

Extra Slides

Yurok Tribe Environmental Department (YTED) Impacts from Climate Change

- Drought over the past two decades greater than during preceding century (Diffenbaugh et al. 2015).

- Intermittence in stream flow expected to increase in regions experiencing drought due to climate change and water use (Acuna et al. 2014; Larned et al. 2010; Gerstengarbe et al. 2003)

- Anticipated and observed impacts in Yurok country:
    - rising air temperatures,
    - heavier and unpredictable precipitation,
    - increasing winter flows and flooding,
    - decreasing snowpack,
    - reduced late spring and summer flows,
    - increasing intermittence of stream flow,
    - increasing surface water temperatures,
    - expanding harmful algae blooms and water-borne pathogens,
    - longer and higher intensity fire season,
    - and more.

Lower Turwar Creek

Photo credit: Kaitlyn Woolling