Beaver and Process-Based Restoration: Opportunities and Obstacles 2

A Concurrent Session at the 41st Annual Salmonid Restoration Conference
Santa Rosa, California, March 26-29, 2024

Session Coordinator: Karen Pope, *USDA Forest Service*

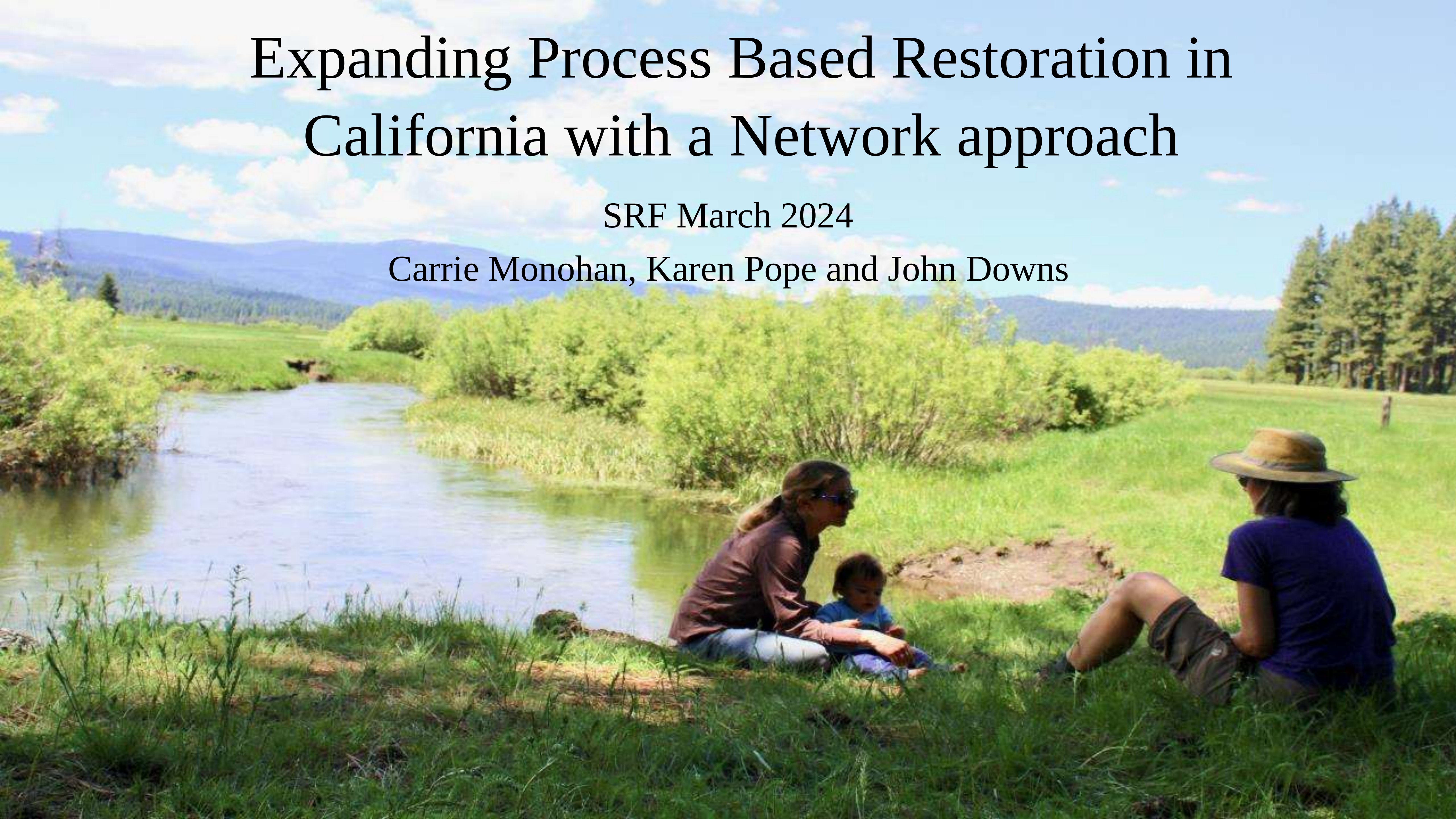
Climate change represents a major threat to freshwater aquatic ecosystems in California and the Pacific Northwest, home to important but increasingly sensitive taxa, including salmonids. The impacts of climate change on certain freshwater ecosystems may be ameliorated by the engineering activities of beavers (Castor canadensis), which were once common throughout North America but experienced dramatic declines due to fur harvest in the 18th and 19th centuries. Many streams and rivers have not been recolonized by beavers due to a lack of local source populations or because the habitats have been simplified and degraded, impairing beaver recolonization. Strategic stream, meadow, and river restoration applications with beaver and process-based restoration (PBR) have the potential to play a larger role in the multi-tiered efforts to manage pressing climate-related threats to forests and water supply by increasing resistance to wildfire, increasing base flows, and reducing sedimentation in unwanted reaches and reservoirs. In these systems, beaver restoration and PBR have the potential to recover stream complexity, increase surface and groundwater storage, and regain floodplain connectivity, resulting in improved salmonid habitat. However, we are just beginning to develop the restoration tools, scientific backing, and workforce to meet the demand for increasing the pace and scale. For example, we launched the new California Process-Based Restoration Network in 2022 with the goal of increasing capacity to restore degraded riverscapes in California (calpbr.org). In addition to building the human capacity to implement restoration projects, research and monitoring remain important for understanding and identifying where and when beaver restoration and PBR can succeed and what approaches are best to maximize ecohydrological benefits. The primary goals of this session are to (1) share what has been done, how it is working, and the scientific basis that supports it; and (2) explore the various impediments to scaling up the more effective practices.

Presentations

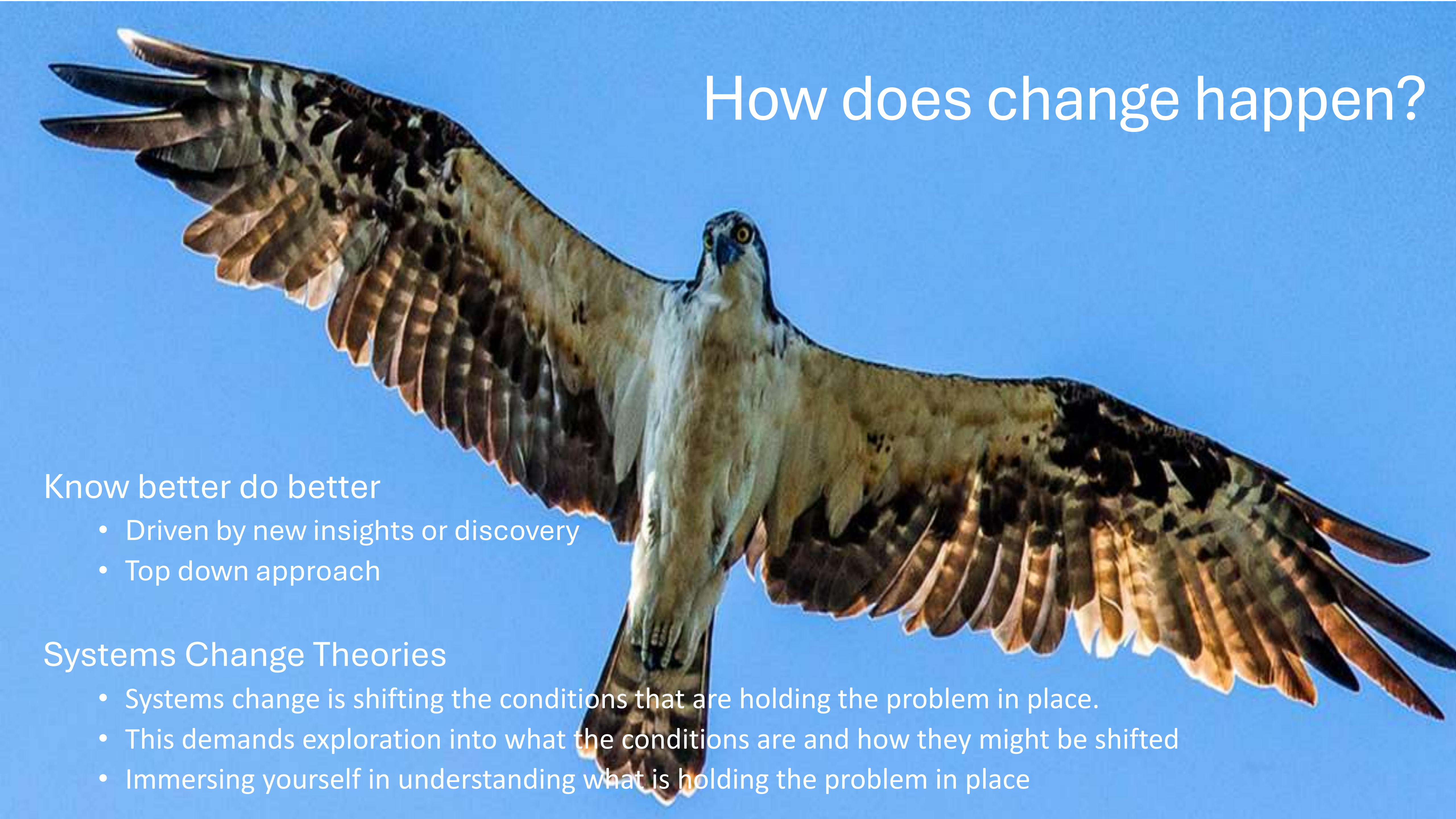
Expanding Process Based Restoration in California with a Network approach

SRF March 2024

Carrie Monohan, Karen Pope and John Downs



How does change happen?



Know better do better

- Driven by new insights or discovery
- Top down approach

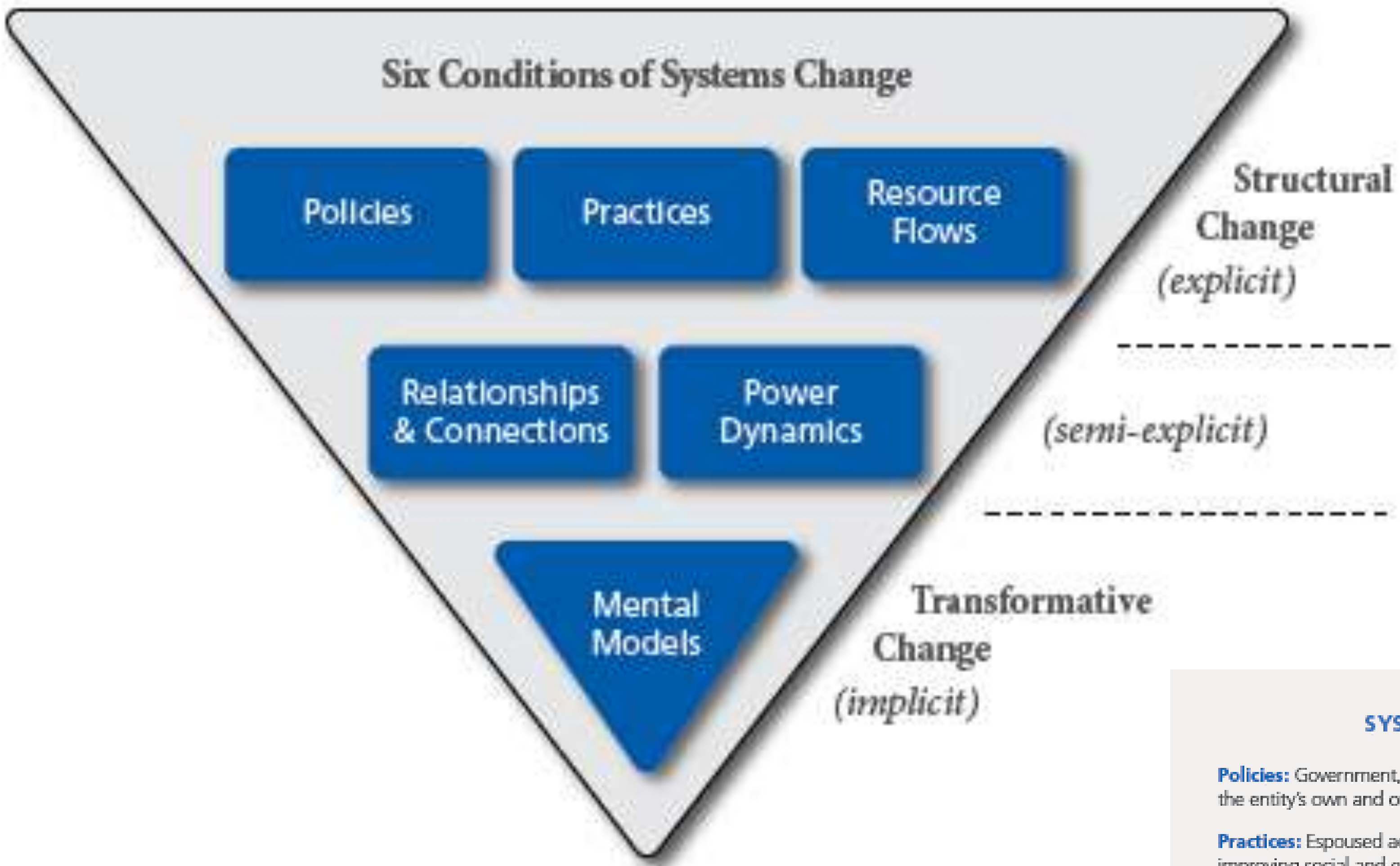
Systems Change Theories

- Systems change is shifting the conditions that are holding the problem in place.
- This demands exploration into what the conditions are and how they might be shifted
- Immersing yourself in understanding what is holding the problem in place

Building the capacity to see the water

A fish is swimming along one day when another fish comes up and says "Hey, how's the water?" The first fish stares back blankly at the second fish and then says "What's water?"

- Systems change is about recognizing the water we are swimming in all along *to* understand the constraints that surround us.
- Constraints include government policies, societal norms and goals, market forces, incentives, power imbalances, knowledge gaps, embedded social narratives, and many more.
- These surrounding conditions are the "water"



"Making big bets to tackle a problem without first immersing yourself in understanding what is holding the problem in place is a recipe for failure. "

(Kania et al, 2018)

SYSTEMS CHANGE CONDITIONS—DEFINITIONS

Policies: Government, institutional and organizational rules, regulations, and priorities that guide the entity's own and others' actions.

Practices: Espoused activities of institutions, coalitions, networks, and other entities targeted to improving social and environmental progress. Also, within the entity, the procedures, guidelines, or informal shared habits that comprise their work.

Resource Flows: How money, people, knowledge, information, and other assets such as infrastructure are allocated and distributed.

Relationships & Connections: Quality of connections and communication occurring among actors in the system, especially among those with differing histories and viewpoints.

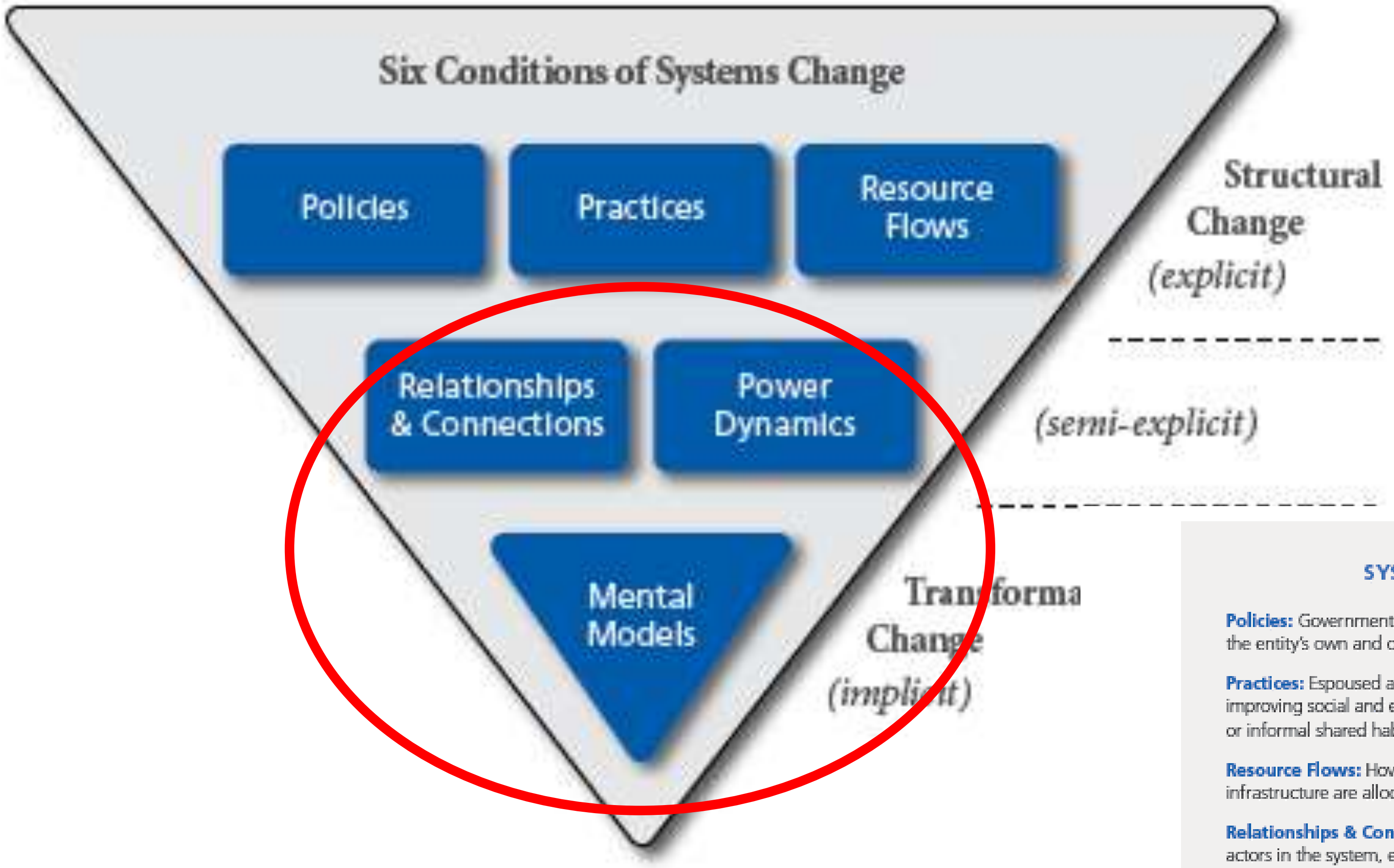
Power Dynamics: The distribution of decision-making power, authority, and both formal and informal influence among individuals and organizations.

Mental Models: Habits of thought—deeply held beliefs and assumptions and taken-for-granted ways of operating that influence how we think, what we do, and how we talk.

(Kania et al., The Water of Systems Change, 2018)


Networks are about transforming the relationships between people who make up the system.

FIGURE 1. SHIFTING THE CONDITIONS THAT HOLD THE PROBLEM IN PLACE



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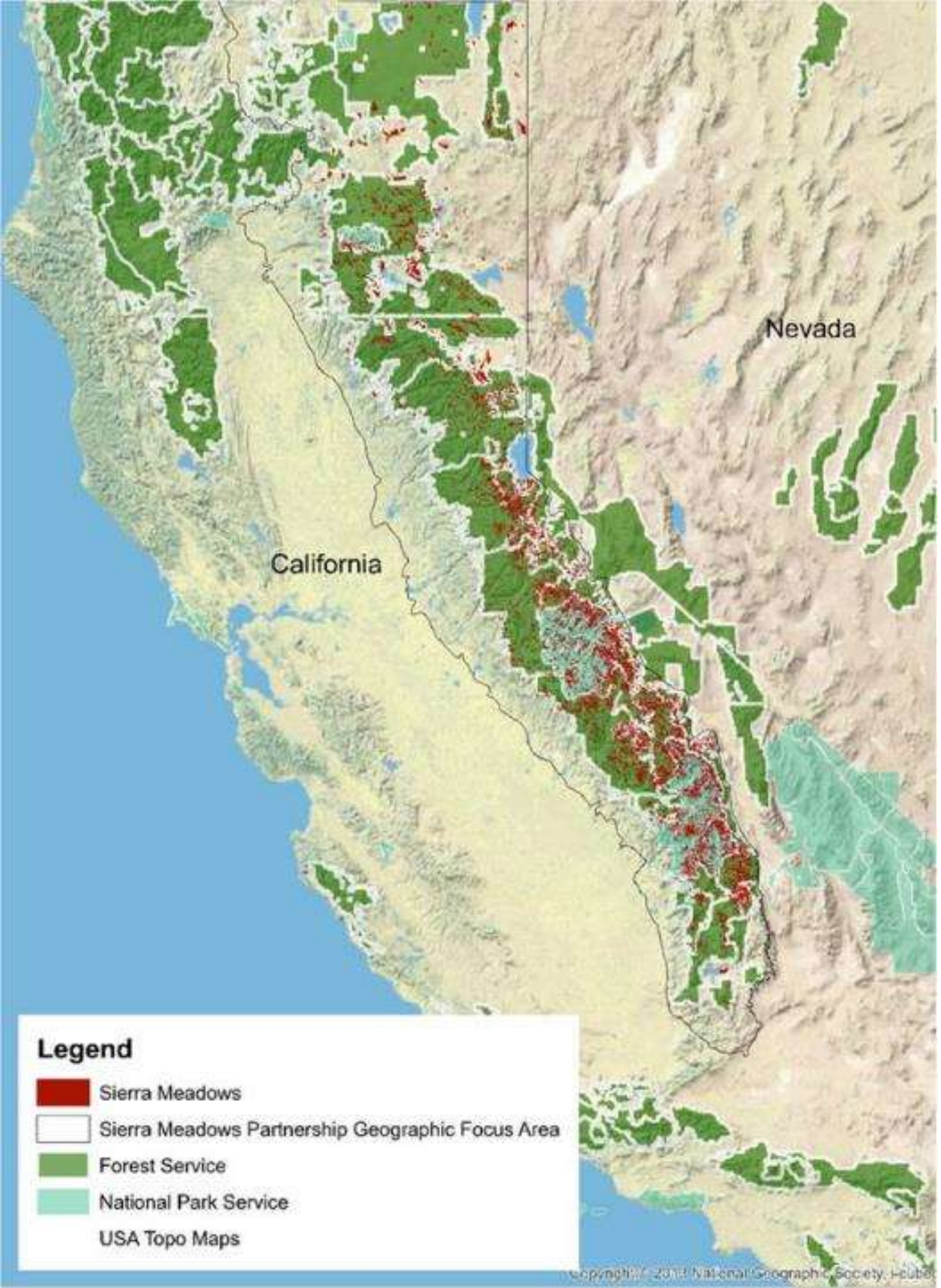
How does this relate to PBR?

- Process Based Restoration
  - Design philosophy: to work with nature to heal nature, not about superimposing a pre-determined idea of what should be there
  - Mental Model: you work with what is there, identifying constraints, removing those constraints and allowing the healing to happen
  - It is the what and the how

Process-based restoration focuses on restoring physical processes that lead to healthy riverscapes.

- Low-cost, simple, hand-built structures.
- Require that practitioners “let the system do the work.”
- The overarching goal of PBR is to improve the health of as many miles of riverscapes as possible and to **promote and maintain the full range of self-sustaining riverscape processes**.

(Weaton et al., 2019)



Where are the meadows? Who manages them and why?

Living landscapes for Native American Tribes

Livestock Grazing Leases

30x30 Nature Based Solution to Climate Change

(Vernon et al, 2022, Drew et al, 2016)

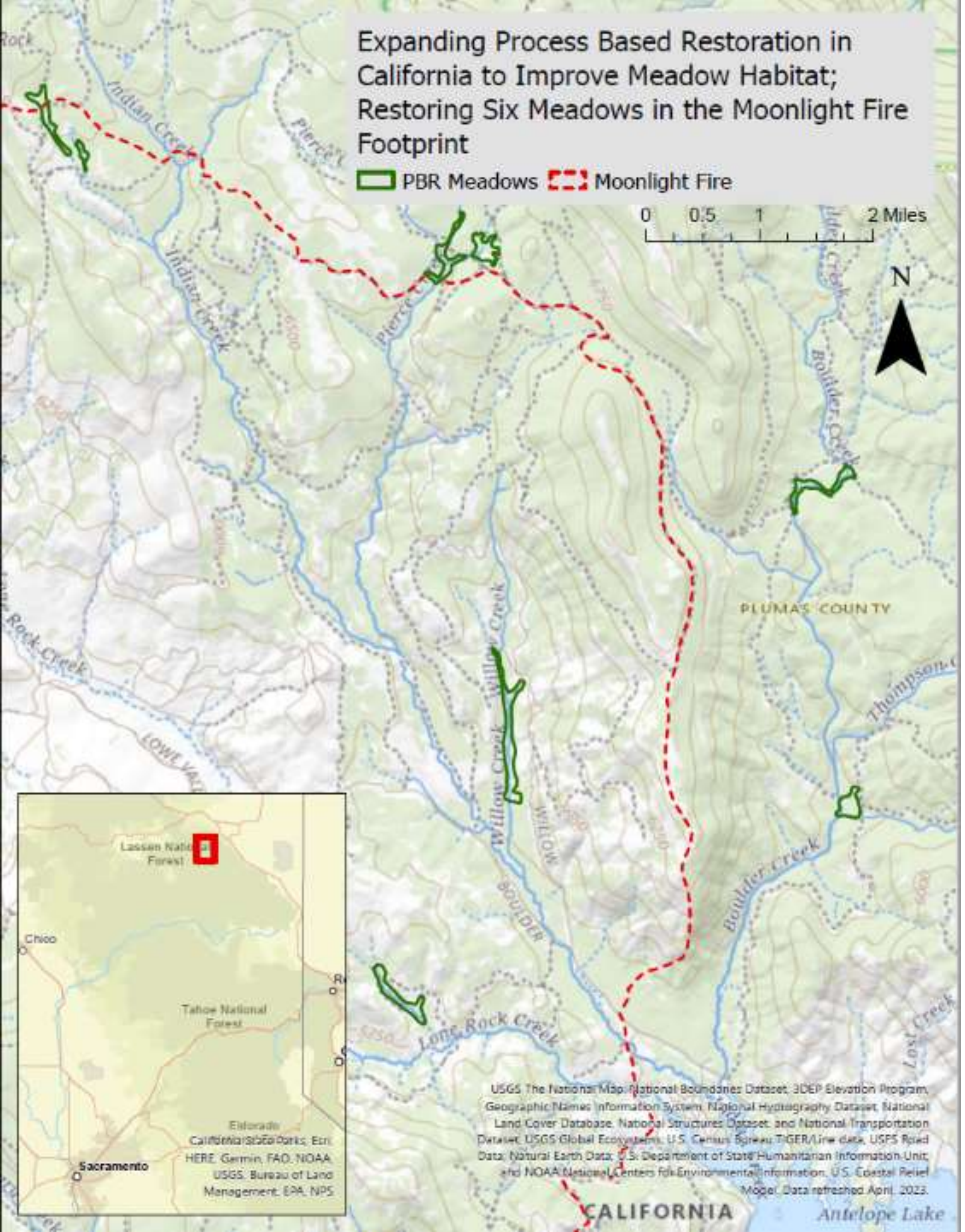
How do meadow restoration projects get selected?

Relationships with landowners.

Forest Service Districts are tasked with selecting areas of need but don’t have the staff or resources to implement as many projects as there are.

Bringing State dollars to federal lands.

A model for increasing the pace of restoration.



Planning Proposal (re) submitted March 1, 2024 to CDFW

1) Meadows selected by Plumas National Forest (PNF)
2) Meadow included in NEPA for PNF
3) Non-profit partner submit state grant proposal.

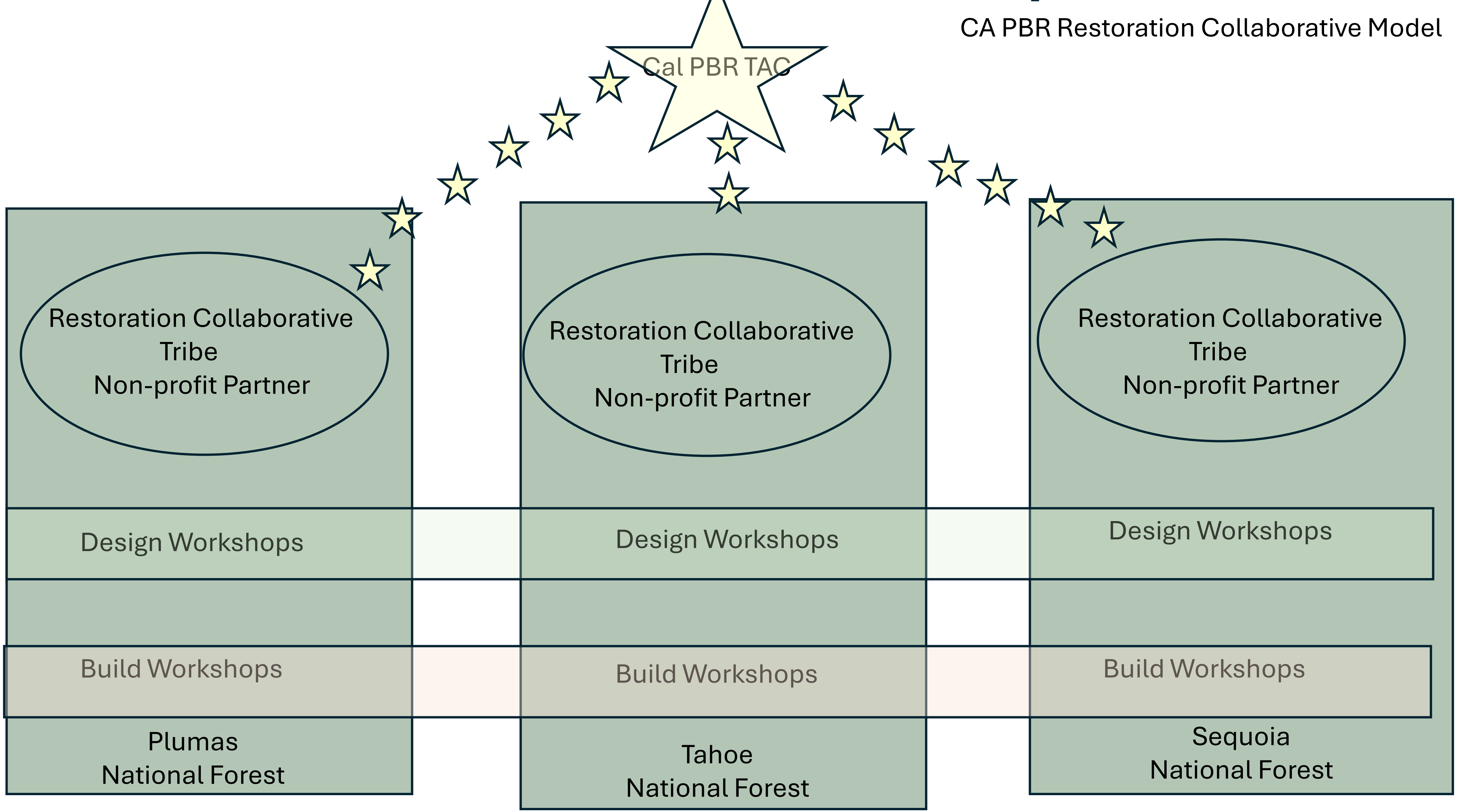
Restoration Collaborative for PNF:
1) Concow Maidu Forest Contract Service
2) Maidu Summit Consortium
3) Non-profit partners (administrative lead)
4) Cal PBR TAC (technical expertise)

Cal PBR TAC:
1) Swiftwater Design (design)
2) Symbiotic Restoration (design)
3) Non-profit Partners (permitting, funding, monitoring)
4) Federal Partners (technical expertise)

Cal PBR Design Workshops (in the field)
-to design on site with Restoration Collaborative

Cal PBR Build Like a Beaver Workshop
-to get the implementation done once permitted

CA PBR Restoration Collaborative Model



What can the Cal PBR Network do now?

Making big bets to tackle a problem without first immersing yourself in **understanding what is holding the problem in place** is a recipe for failure.

Find funding:

State Grants are for Planning OR Implementation AND NOT networks, workshops

Build Relationships:

Project selection is a process where we can build relationships that last

How do we start?

Start with Tribes and their National Forest Service relationships

- Government to government relations
- Co-Stewardship Agreements
- Access to Federal Funds not just State Funds

Take Away Messages

- Tribes are the rightful stewards of these lands
- Partnerships with Tribes is a key to a lasting stewardship model
- Meadows are just the starting place for PBR in CA
- Non-profit partners can play a pivotal role in connecting to funding and permitting
- **Its all about relationships**
- **Cal PBR expertise IS you-JOIN US**

Calpbr.org

Process-Based Restoration Enhances Geo-Hydro-Bio-Diversity in Riparian Systems Post Dam Removal: A Case Study of Dry Creek in the Northern Sierra Nevada Foothills

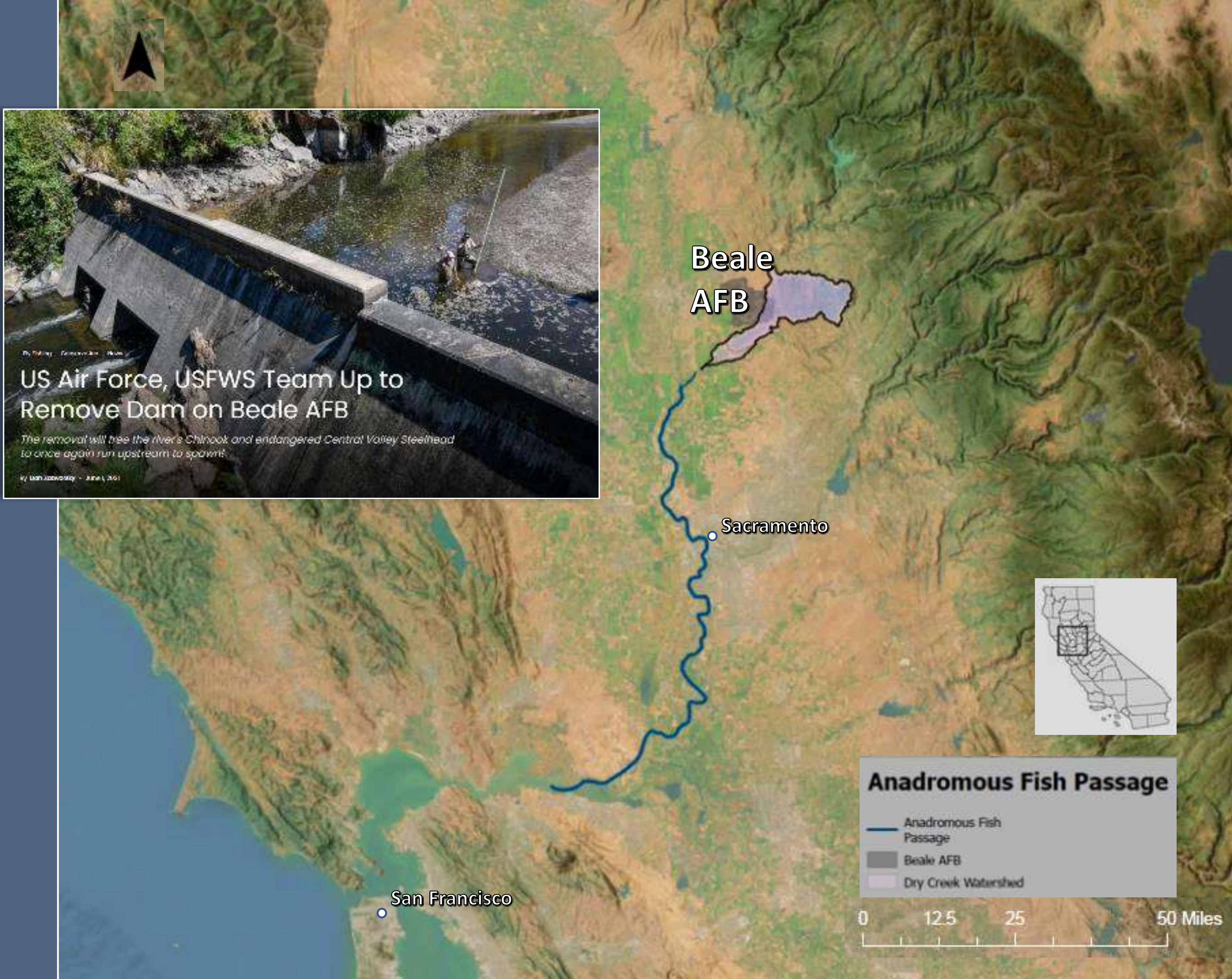
Matt Berry
Josh Zupan
Jonathan Gomez
Jeff Lauder

March 29th, 2024

Dry Creek, Beale AFB

Main Goal

- Increase habitat for salmonids
- Increase ability for upstream passage
- Restoration, Monitoring, Land Stewardship & education
- Collaborative agreement with CA Cooperative Ecosystems Studies Unit (CESU)

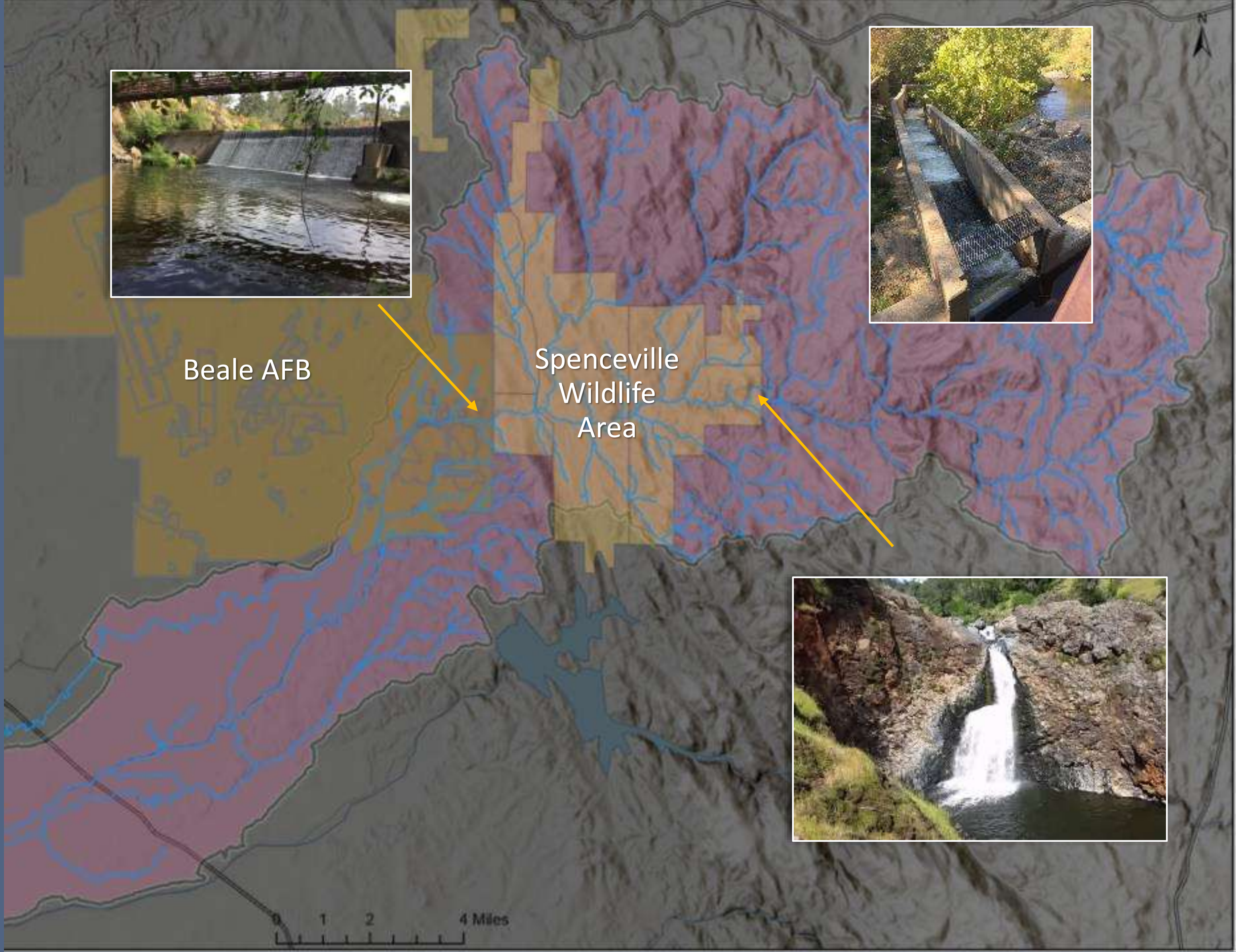


Beale AFB Dry Creek

- Dam and fish ladder Removed in 2020
- Six additional miles of upstream habitat

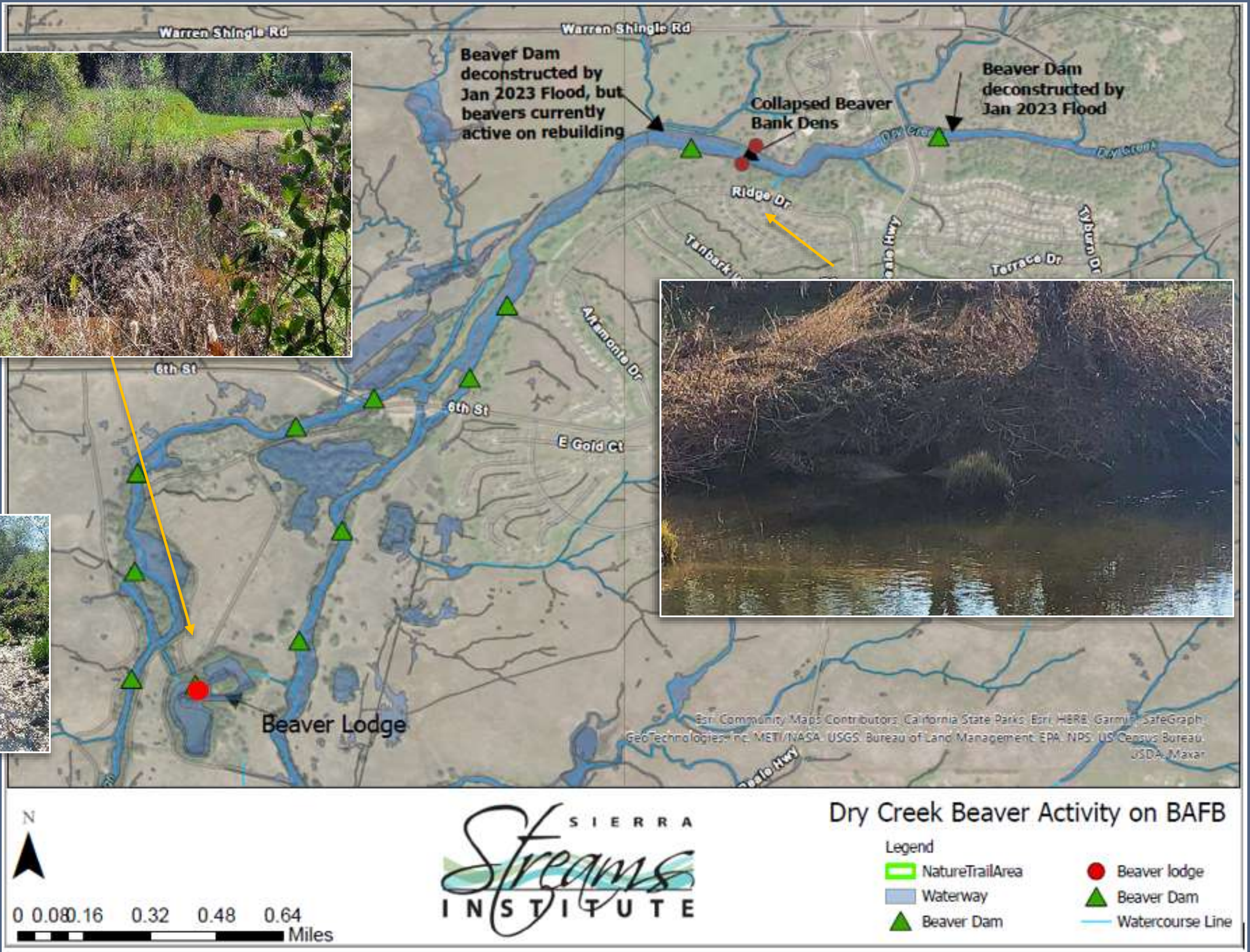
Central Valley Steelhead (*Oncorhynchus mykiss)*
Threatened

Fall-Run Chinook Salmon *(Oncorhynchus tshawytcha)*
Species of concern

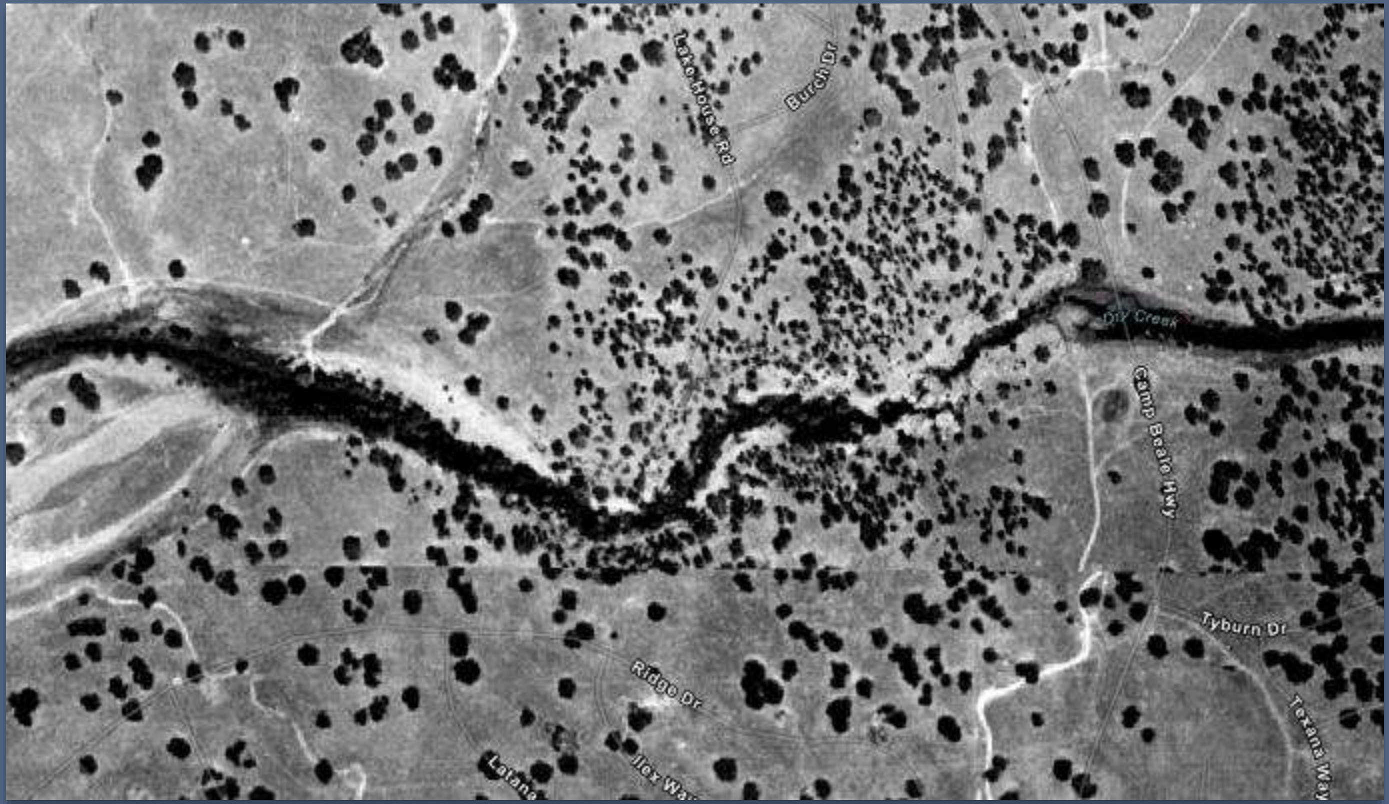


Beaver Activity

- 11 Active Dams
- 2 Collapsed bank dens
- 1 Beaver lodge



Pre-Dam Camp Beale 1942



Dam Construction 1947

Beale Lake


Beale Lake
Beale Lake

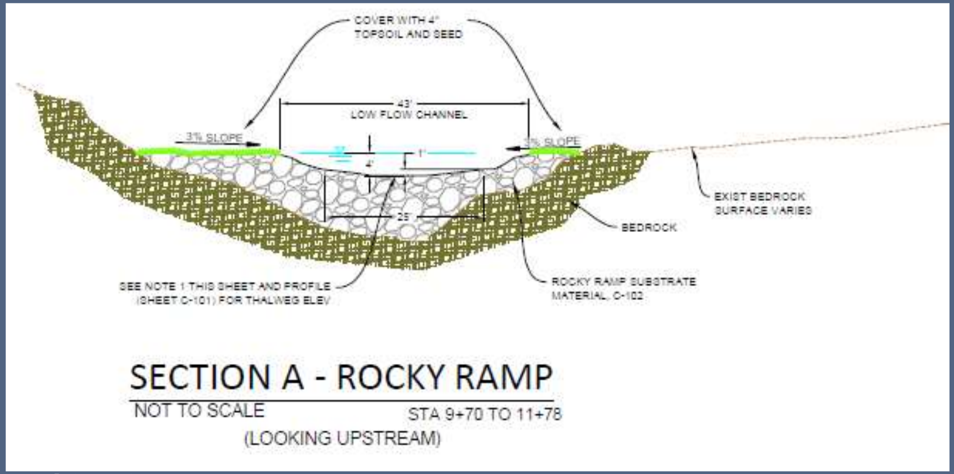

US Air Force, USFWS Team Up to
Remove Dam on Beale AFB


1940
2019
2020
2021
2022
2023
2024

7,000 cubic yards of sediment

Dam Removal

Roughened Channel Design



Gard (2018)

At the low design flow, roughened channel allows for 60cfs instead od 810cfs to allow fish passage.

Erosion & Sediment Control

4,900 restoration plantings

- 4,125 grasses, sedges, rushes
- 658 forbs
- 112 trees
- 200 willow cuttings

Low-flow channel constructed
60cfs for Salmon passage

Roughly 9,000 cubic yards of soil
and 10,000 cubic yards of rock imported

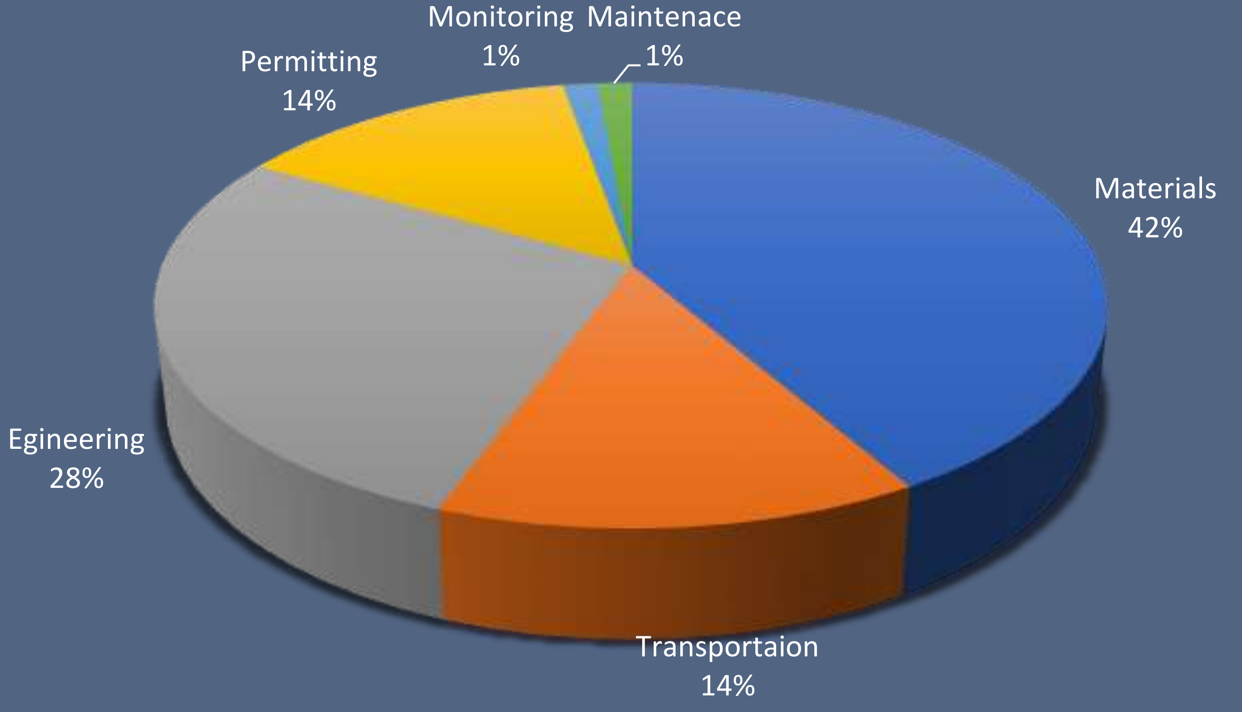
Project Costs

Total Cost Dam Removal: $4.5 million

Restoration dollars spent: $1 million

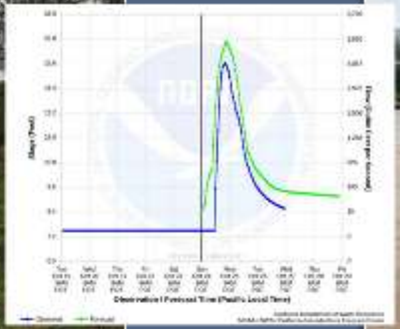
"process-based restoration strategies that are more apt to be self-sustaining and; therefore, less costly over the long term than attempts to impose and maintain a pre-envisioned channel structure"
Kondolf et al. 2006

Project Restoration Estimate Cost Breakdown

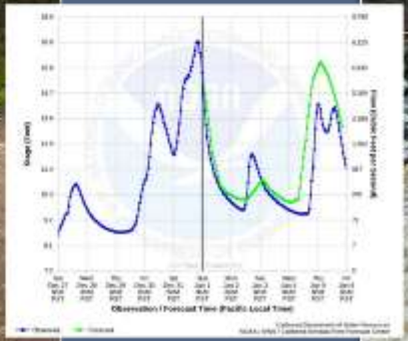


"Compared with engineered stable channel forms (Wohl et al. 2015), process-based restoration tactics are often inexpensive and relatively low tech, making them more scalable and therefore potentially more effective at achieving restoration goals" (Nagle 2007, Pollock et al. 2017, Silverman et al. 2019).

October 2021 Dry Creek Peak Flow 2022 13,125cfs

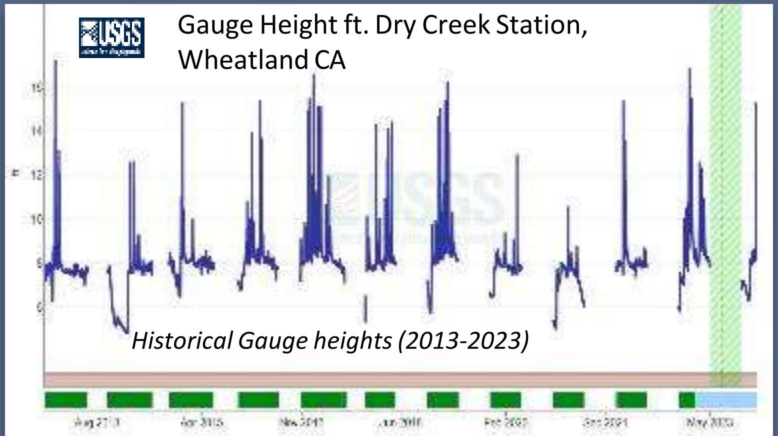


December 2022 Dry Creek Peak Flow 2023 16,815cfs



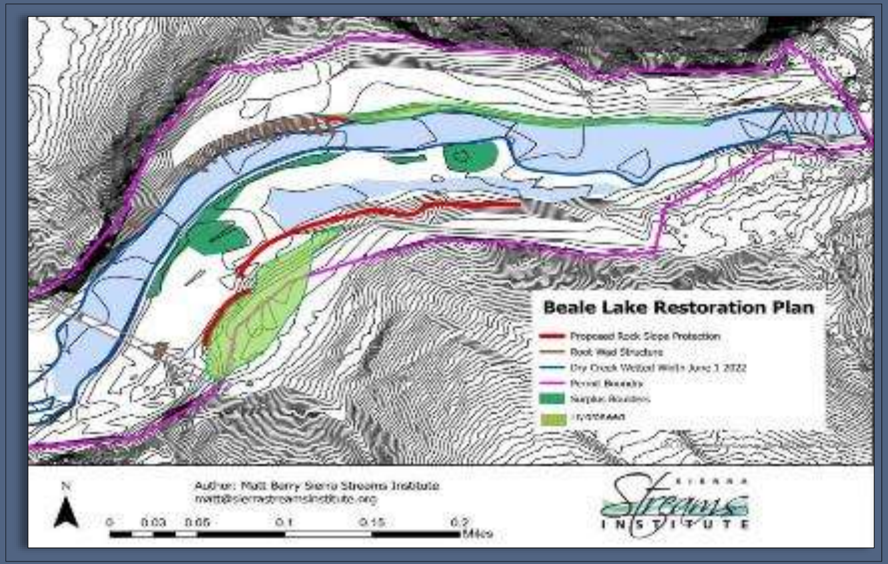
Recurrence Interval	Flow Value (cfs)
2	2,340
5	5,020
10	7,010
25	9,490
50	11,600
100	13,700
200	15,800
500	18,600

Flood Frequency Statistics (USFWS 2018)



- 1,900 CY of imported soil mobilized downstream
- An estimated 30% of imported rock was displaced

Fall 2022 Form-Based Restoration (Post Oct 2021 high flow event)



Moving onsite surplus rock
for bank slope protection

Fluvial Hydrogeomorphic Work

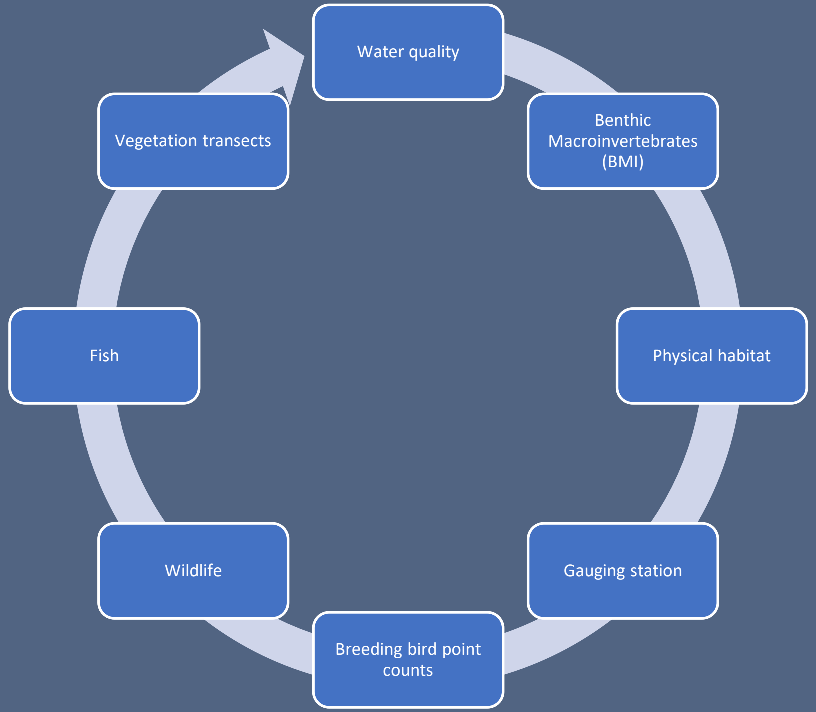
Large 5’ Boulders stayed put

Bio-Hydro-Geomorphic Work

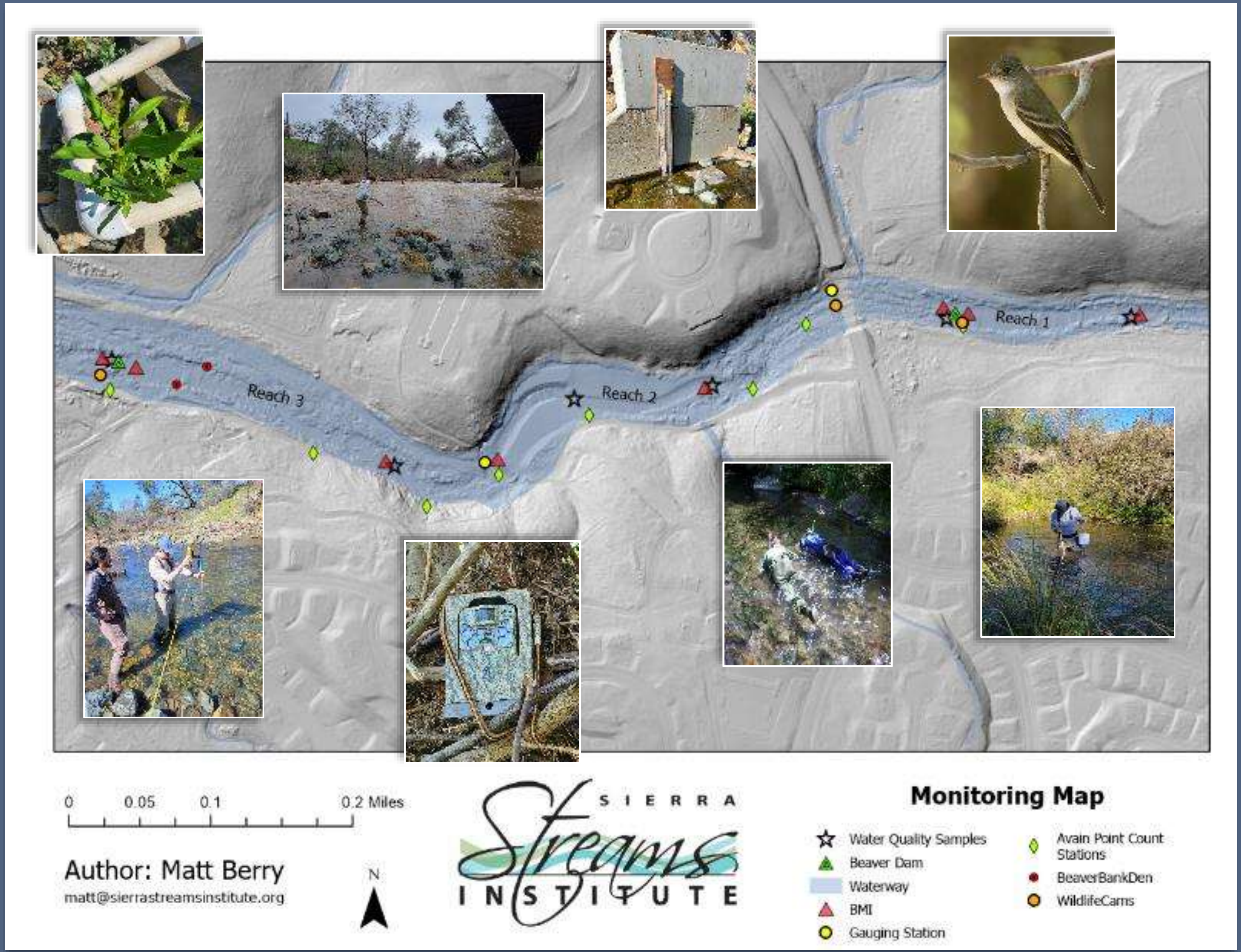
Stream Revolution

1940 2019 2020 2021 2022 2023 2024

Monitoring



Water quality
Benthic Macroinvertebrates (BMI)
Physical habitat
Gauging station
Breeding bird point counts
Wildlife
Fish
Vegetation transects



Reach 1
Reach 2
Reach 3
0 0.05 0.1 0.2 Miles
Author: Matt Berry
matt@sierrastreamsinstitute.org
N
SIERRA Streams INSTITUTE
Monitoring Map
Water Quality Samples
Beaver Dam
Waterway
BMI
Gauging Station
Avain Point Count Stations
BeaverBankDen
WildlifeCams

Snorkel Surveys

Native fish

March/April

- Sacramento sucker
- Many larval fish too small to ID

May/June

- **Seven Rainbow trout/steelhead!**
  - **100-400 mm (4-16in)**
  - **Associated with boulders, overhanging vegetation**
- Sacramento sucker

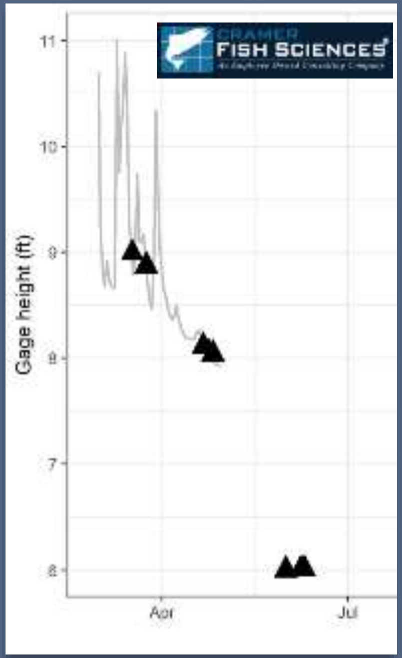
September

- Sacramento Sucker and Hardhead

- Non-native bass, sunfish golden shiner abundant year-round


Rainbow Trout/Steelhead


Sacramento Sucker




Large Mouth Bass


Hardhead/Pike minnow

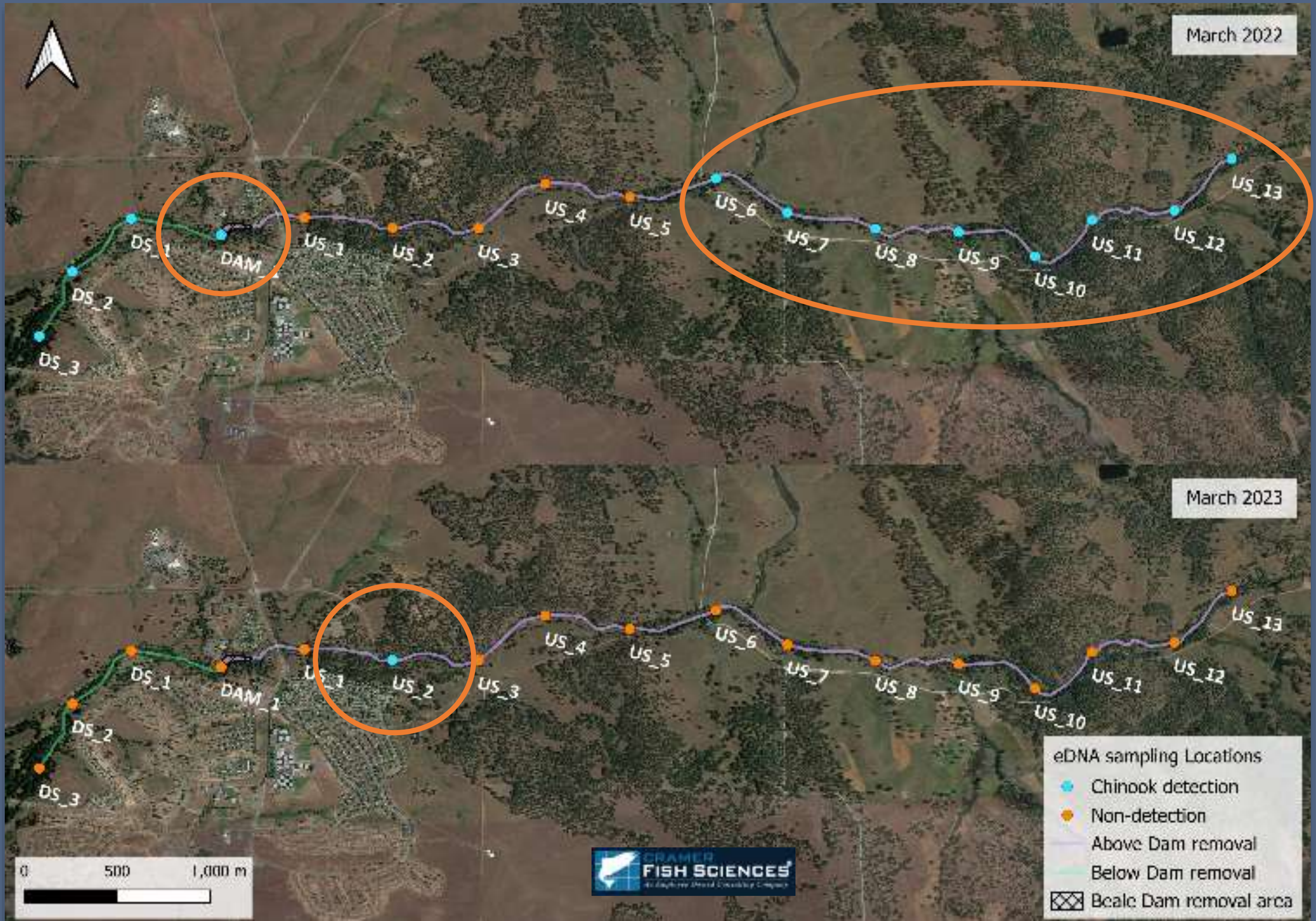

Sunfish

Photos: Cramer Fish Sciences

eDNA surveys

- March, May and September
- Samples collected at ~0.5km intervals
- Only March samples processed
- 2022 – Multiple Chinook salmon detections throughout study reach
    - *High flows in late October 2021*
- 2023 - Single Chinook salmon just upstream from dam removal site

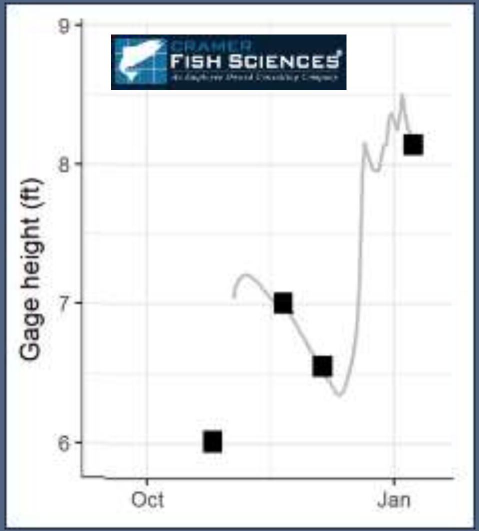
Steelhead *(Oncorhynchus mykiss)*



Chinook Salmon *(Oncorhynchus tshawytscha)*

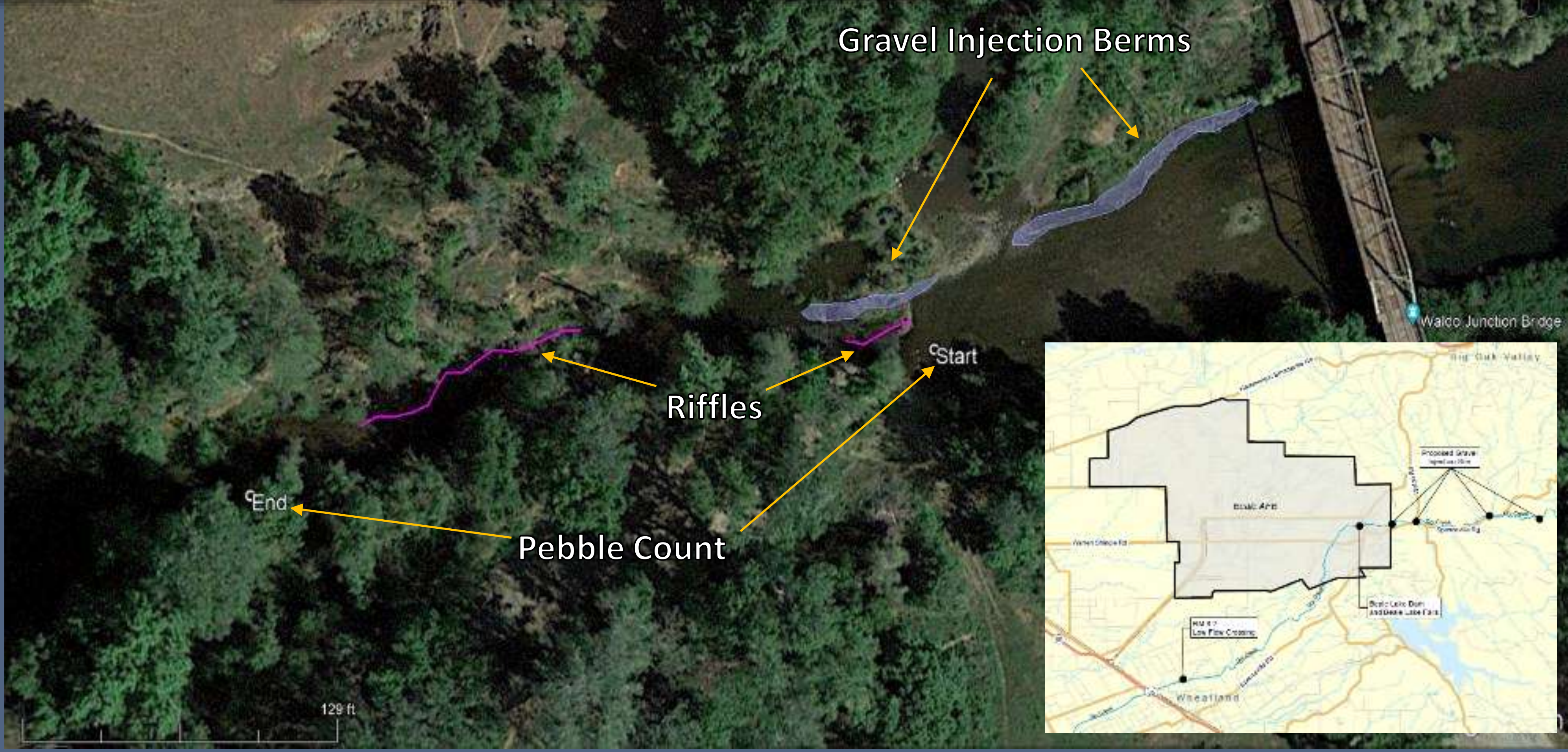
Spawner Surveys

- October 2023 - January 2024
- Strategic sampling in areas likely to contain spawning habitat
- No Chinook salmon redds observed
  - Low flow crossing possible temporary migration barrier just downstream of base
  - Chinook spawning observation in 2021 at Prickett Bridge
    - suggests higher fall flows could support adult upstream migration
    - survey reach gravel limited



Beaver dam Inundation

Gravel Augmentation Site Map



250 tons of Spawning Gravel at Spenceville Wildlife Area

Pebble Count

Painted rocks for tracer study

Funded By

Sutter Buttes Regional Land Trust

Gravel Augmentation

250 tons of spawning Gravel at Spenceville Wildlife Area

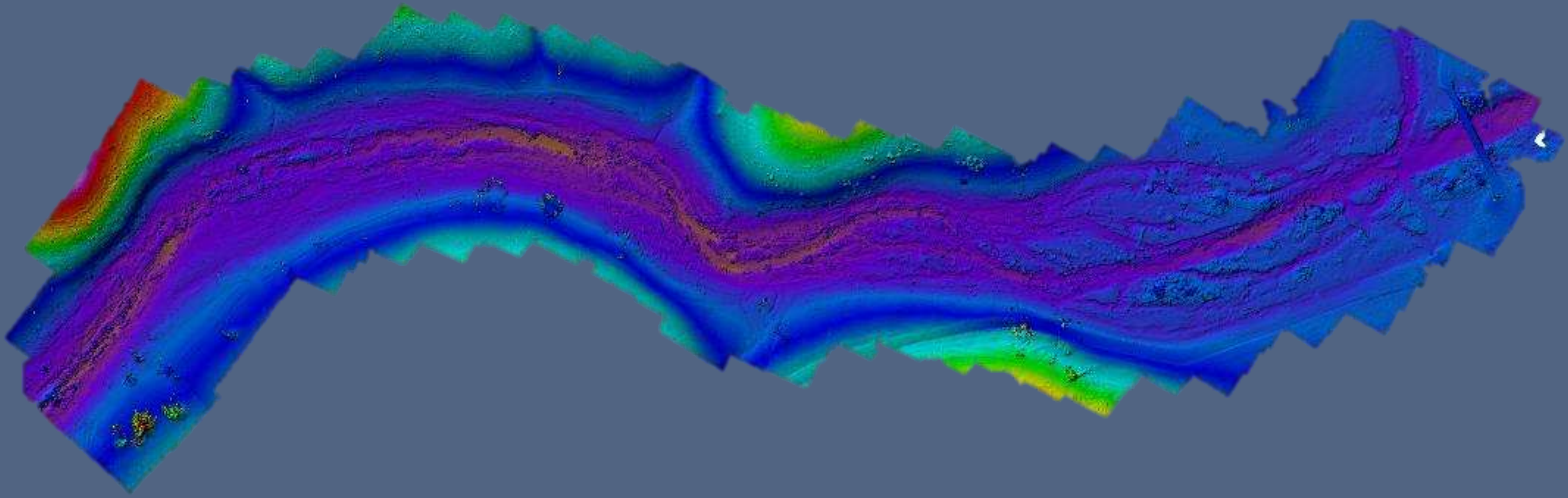
Pebble Count

Painted rocks for Tracer Study

Funded By Sutter Buttes Regional Land Trust

Airborne Imagery at Spenceville
Digital Elevation Model (DEM)

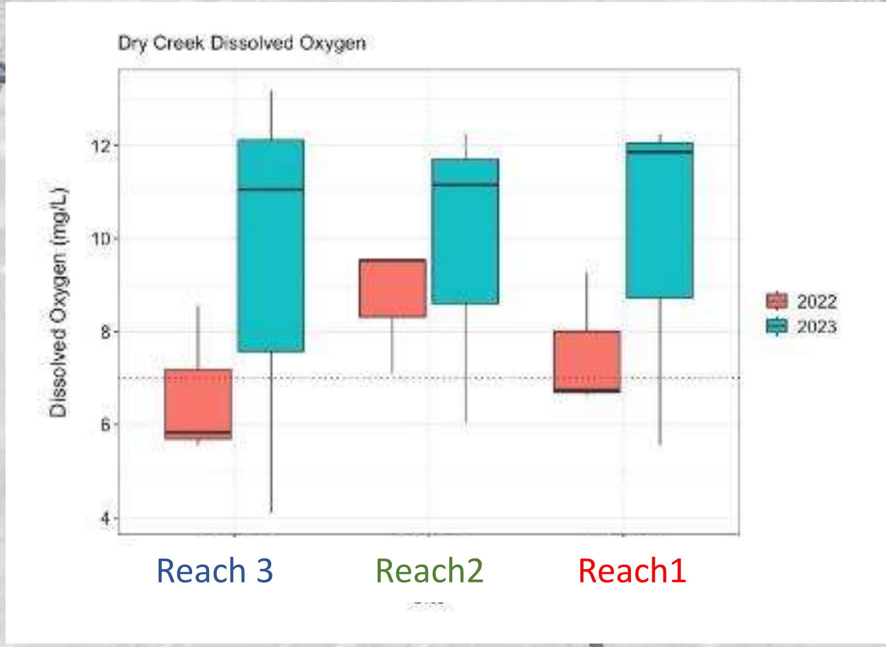
Baseline for Gravel Augmentation



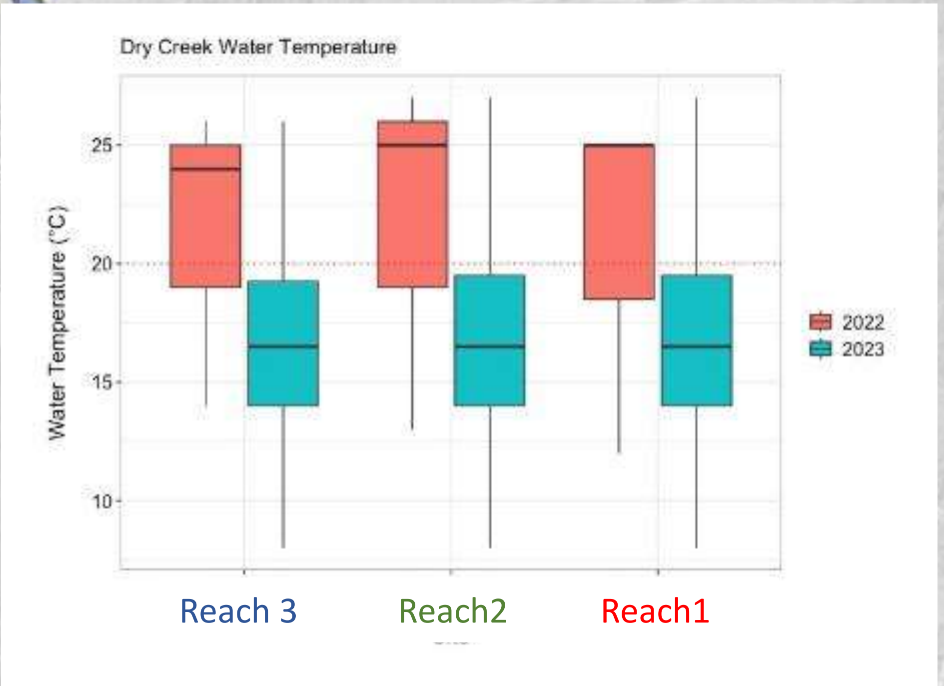
PBR Unexpected Outcomes

Dry Creek Water Quality Trends

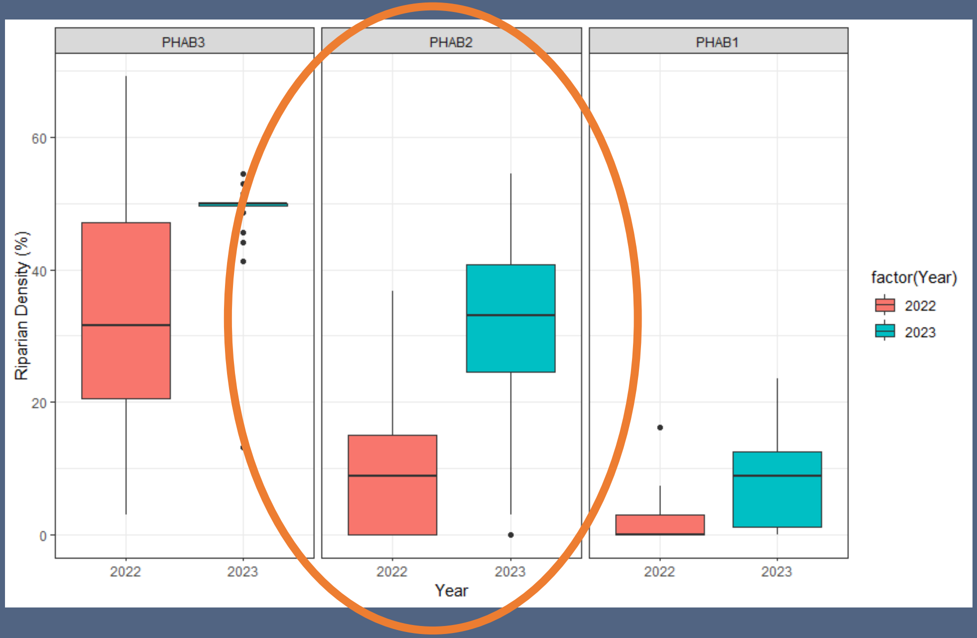
Increase in Dissolved Oxygen



Decrease in Water Temp



Vegetation



Baseline data collected in 2022

Seed collection and Greenhouse

Blue Oak Acorn

Collected native seed and cuttings from site

- Buckeye
- Coyote Brush
- Mule Fat
- Buttonbush
- Western Redbud
- Wavy-leafed Soap Root
- Elderberry
- Blue Oak
- Valley Oak
- Milkweeds
- Pipevine

Next steps

- Gravel Augmentation

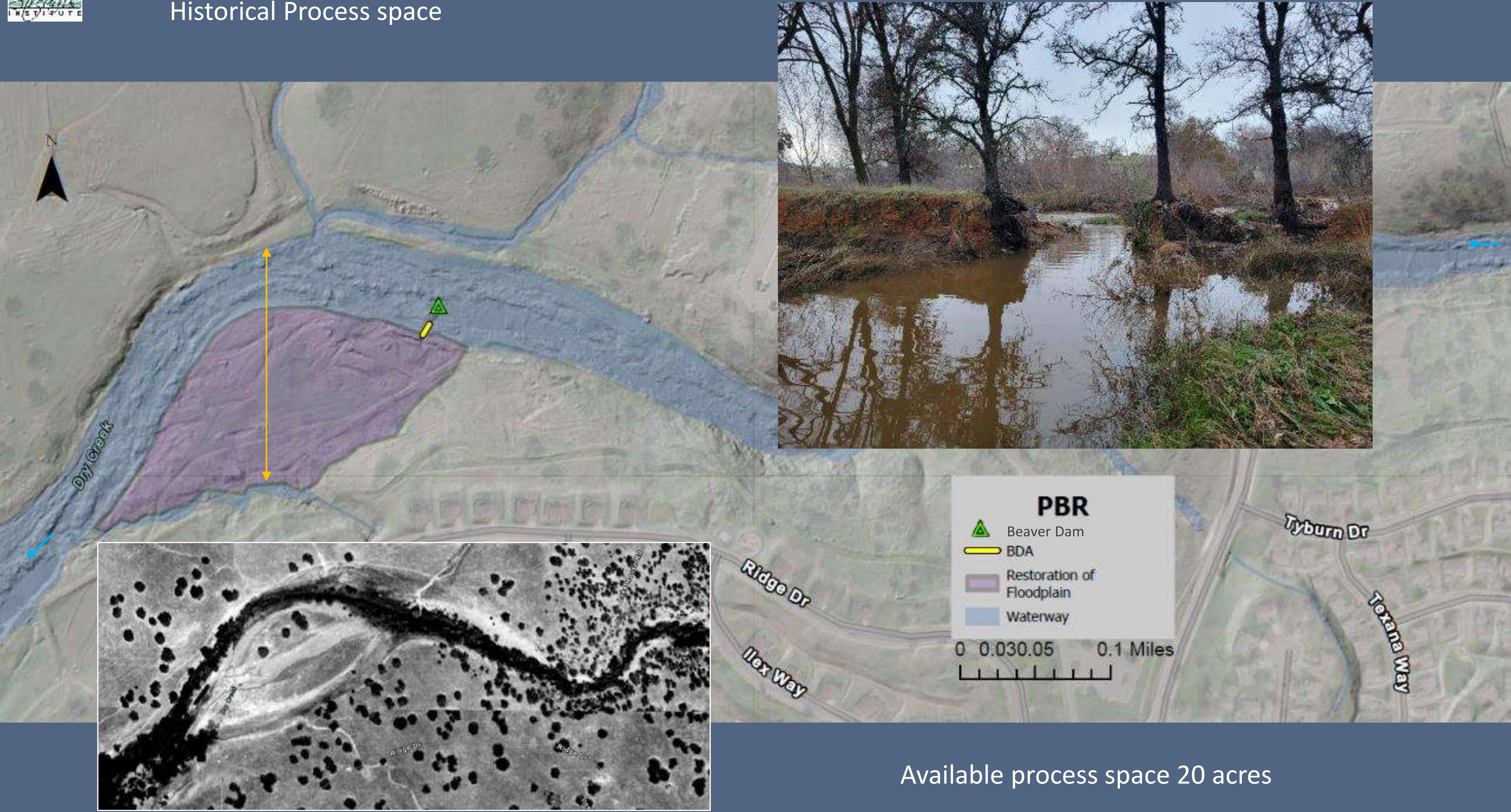
- Remove Low flow crossing

- Process-Based Restoration

- Prescribed Burning

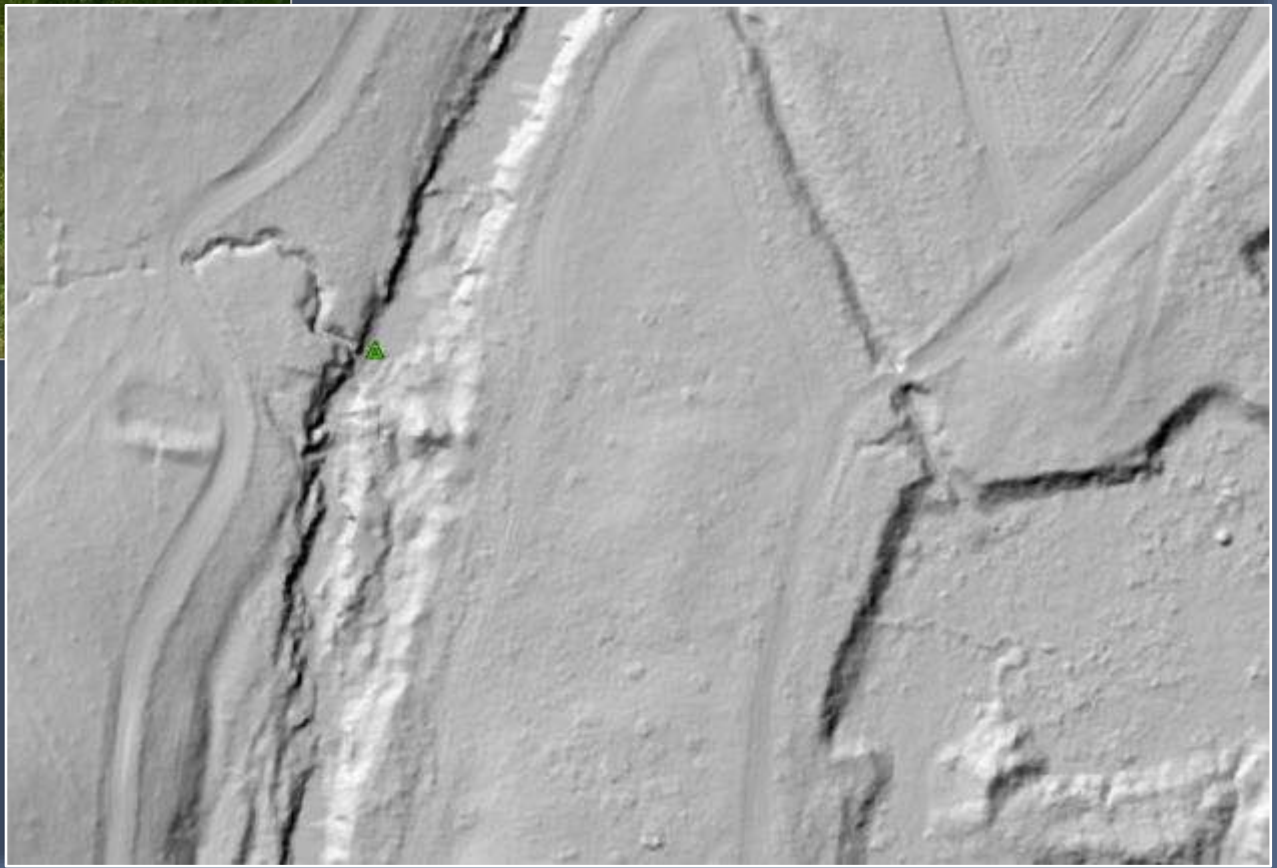
- Nature trail

Historical Process space

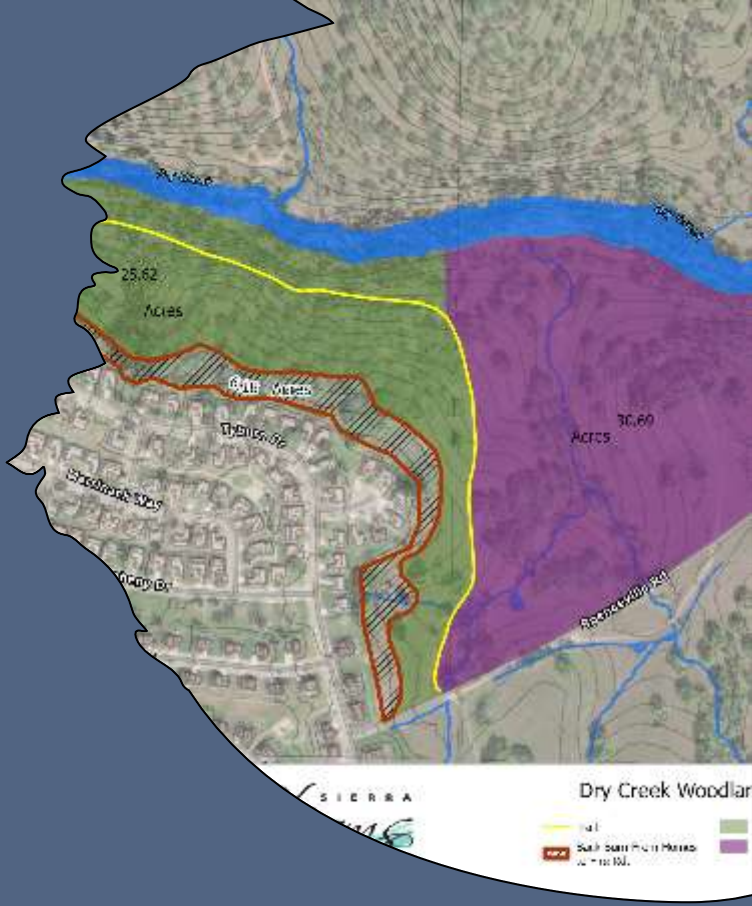


Available process space 20 acres

Future PBR Project



Slash Ain't Trash, it's Beneficial Biomass!
Brock Dolman



Beneficial Burning:

Invasive Plants

Cultural

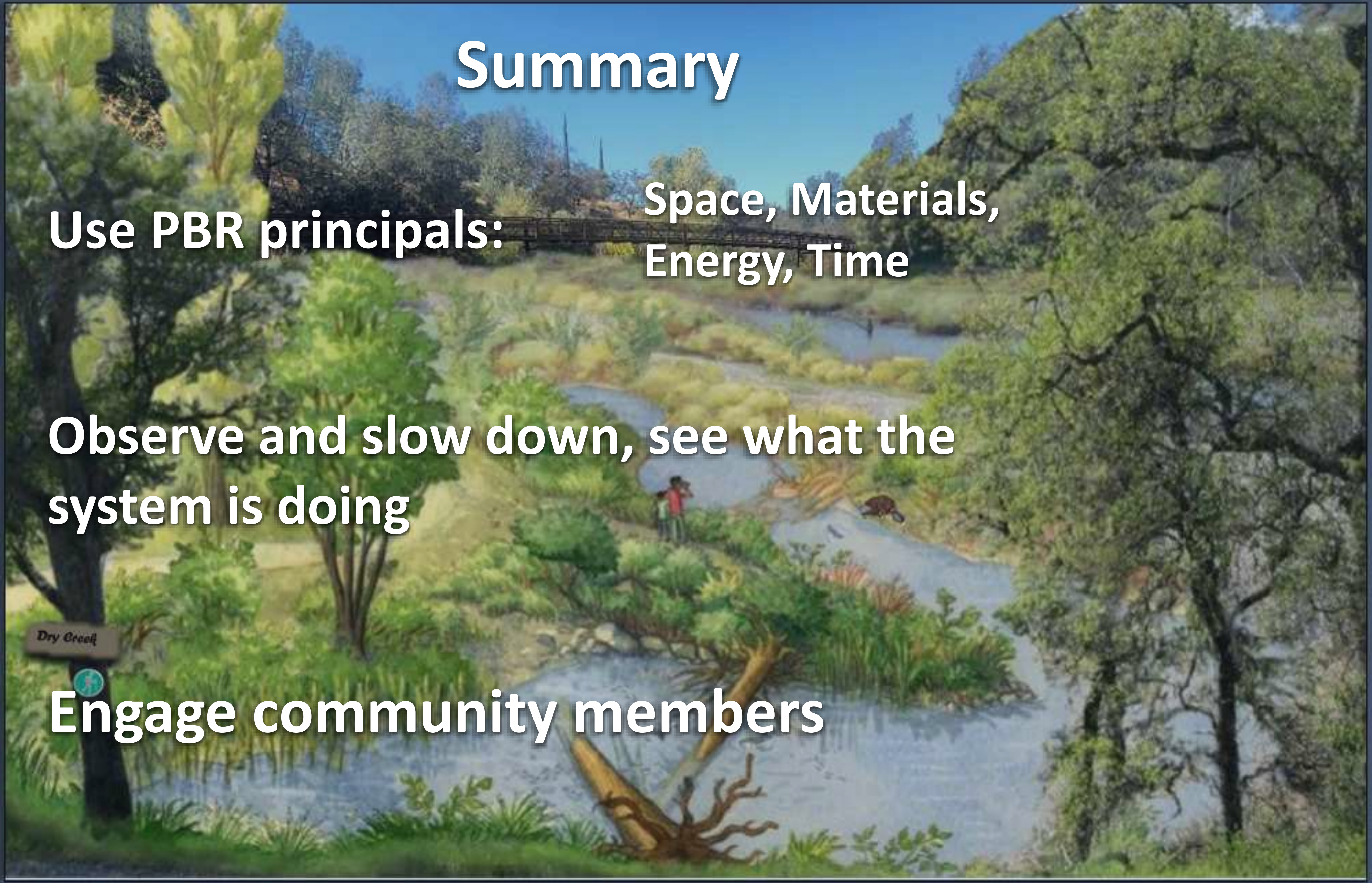
Community Engagement

Summary

Use PBR principals: Space, Materials, Energy, Time

Observe and slow down, see what the system is doing

Engage community members



Process- based restoration concepts post-dam removal visualization at Dry Creek at Beale AFB. Adapted from conceptual drawing by Mona Carlon and Derek Hitchcock 2010.

Summary

Have Fun!

Process- based restoration concepts post-dam removal visualization at Dry Creek at Beale AFB. Adapted from conceptual drawing by Mona Carlon and Derek Hitchcock 2010.

Thank You!   Questions?   matt@sierrastreamsinstitute.org

SSI Website

Beale iNat Project

4 Elements Earth Education

Cramer Fish Sciences

Colorado State University CEMML

Swiftwater Design

Lion Hound

CESU

California Department of Fish & Wildlife

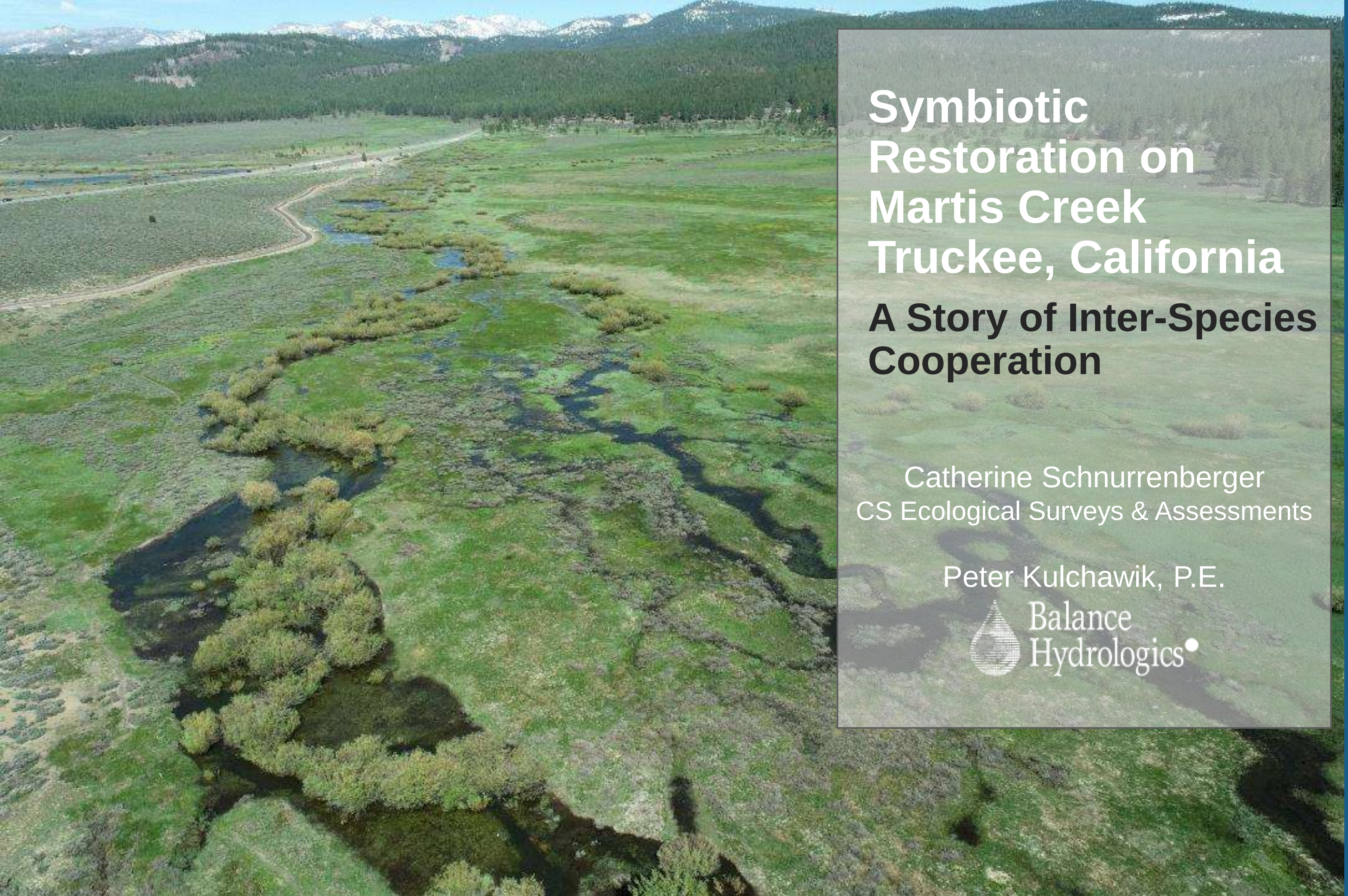
CyberTracker

EA Engineering, Science, and Technology, Inc., PBC

Beale Air Force Base

U.S. Fish & Wildlife Service

Sutter Buttes Regional Land Trust



Symbiotic Restoration on Martis Creek Truckee, California

A Story of Inter-Species Cooperation

Catherine Schnurrenberger
CS Ecological Surveys & Assessments

Peter Kulchawik, P.E.
Balance Hydrologics

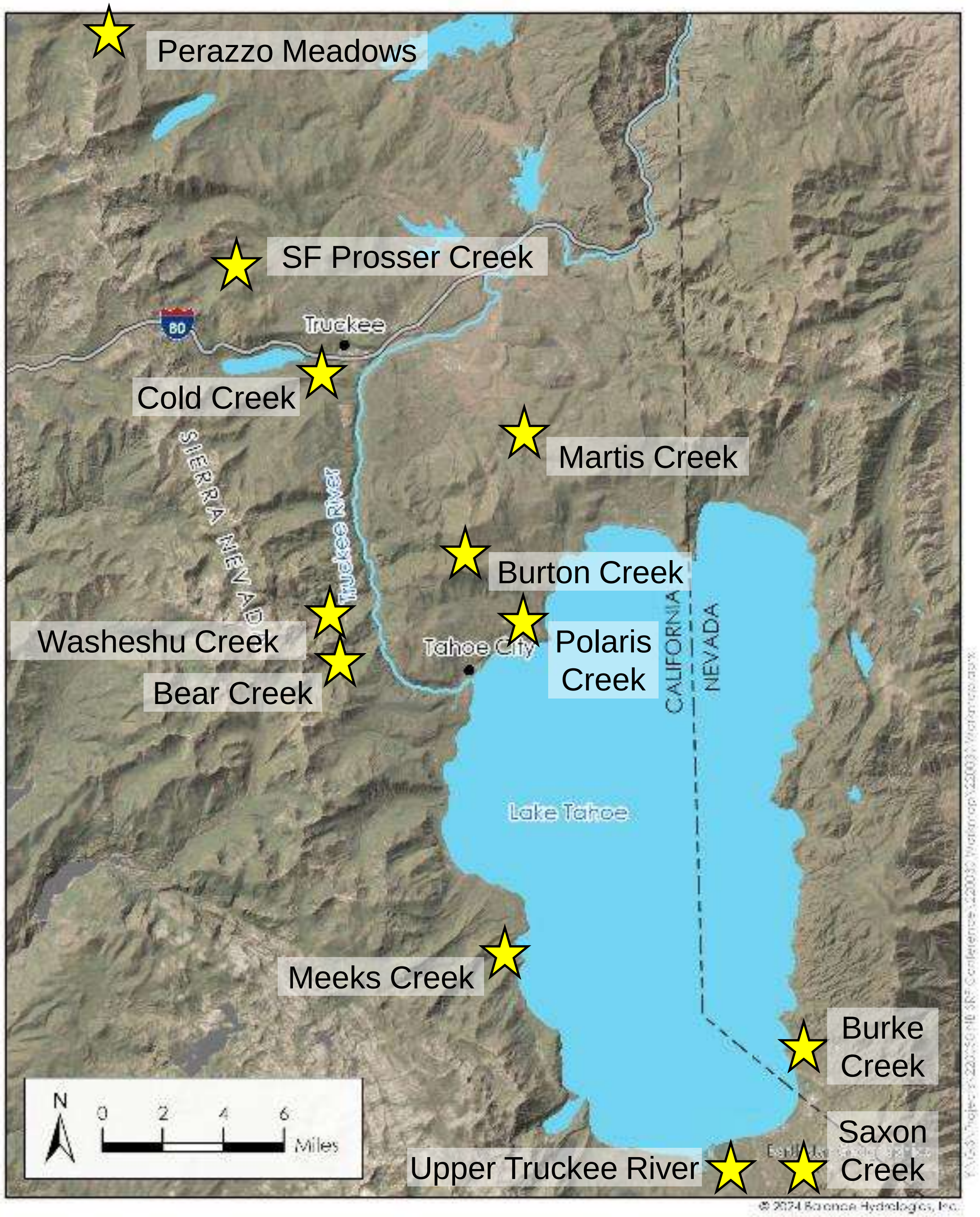
Salmonid Restoration Federation 2024

Outline

- Project Background
- Design Challenge: uncertainty in how beaver will (or will not) be a part of ecosystem recovery
- Hybrid Design Approach
- What happened?
  - Beaver response
  - Vegetation response

Beaver presence in Northern Sierra Nevada

- Beaver are present in most systems in the Northern Sierra
- Mostly on tributaries to the Truckee River



Martis Creek Watershed

Watershed Area

- **42.7 sq. mi**

Elevation Range

- **8,617 ft (max)**
- **5,680 ft (min)**

Mean Annual Precipitation

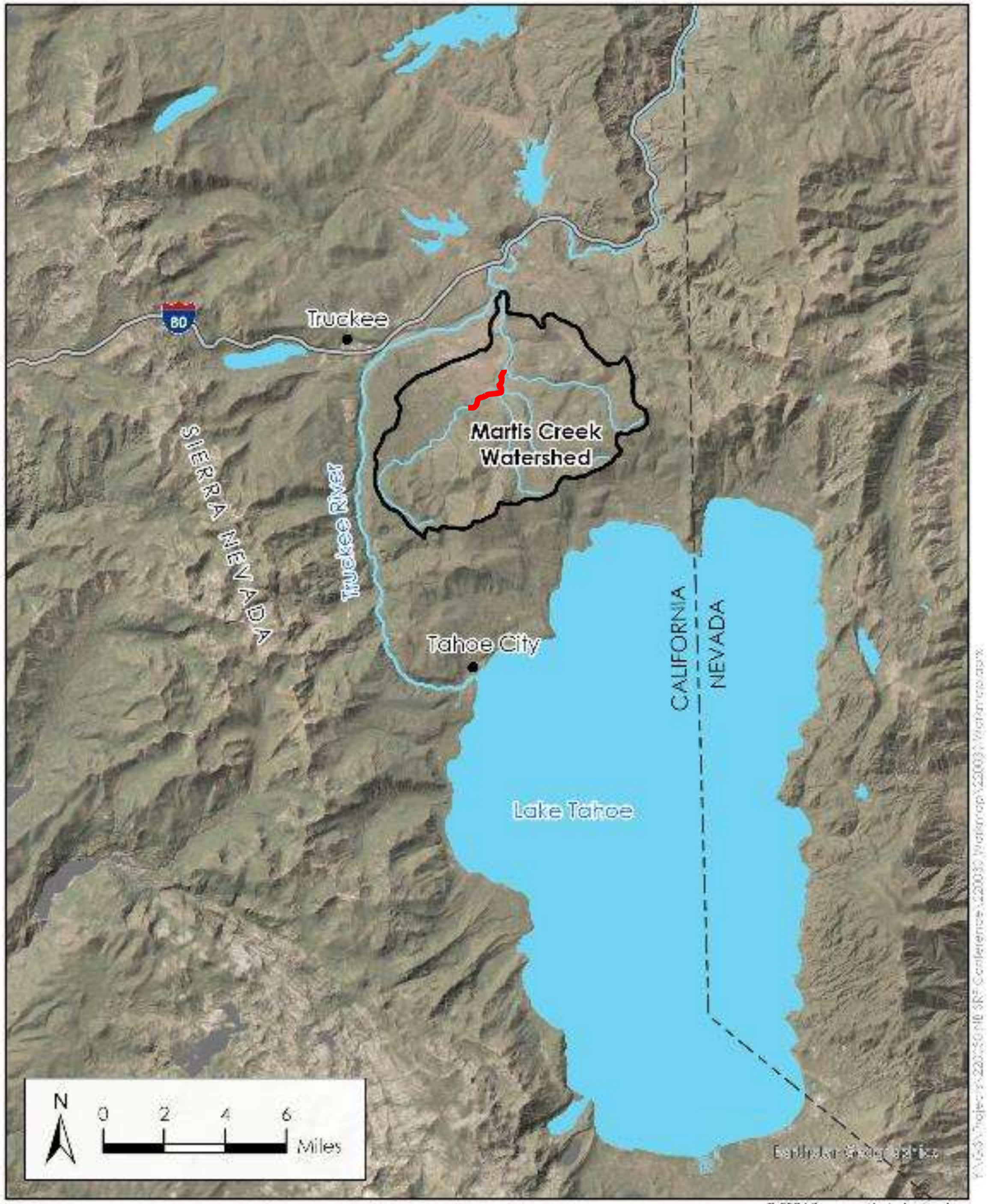
- **30-45 inches**

Hydrology

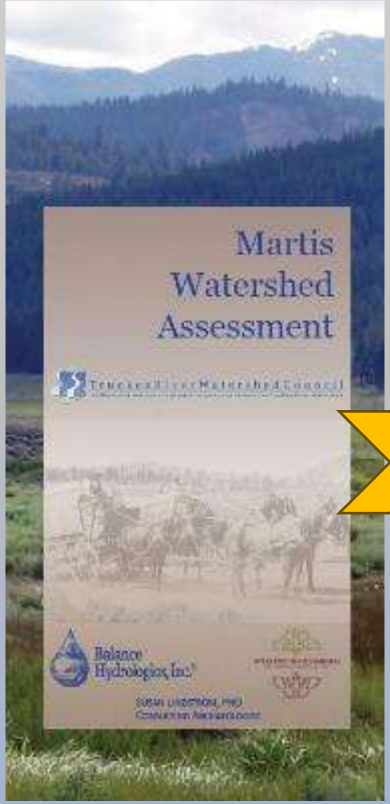
- **Perennial / snowmelt / springs**
- **Baseflow 0.5 - 3.0 cfs**
- **Annual Flood ~85 cfs**

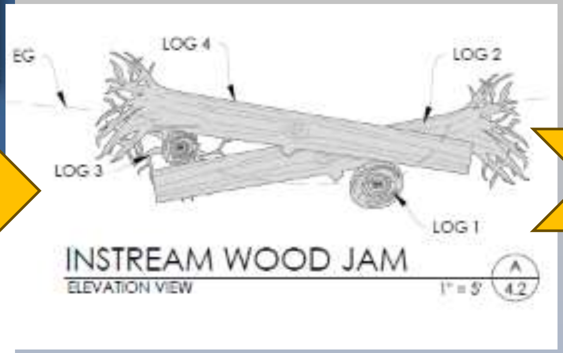
Geomorphology

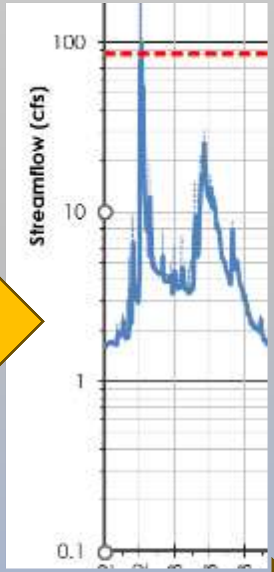
- **Volcanic bedrock Uplands**
- **Glacial outwash + alluvium**
- **Slope: < 1.0 %**



Timeline of Events







Baseline Monitoring

Monitoring

2011

2015

2018

2019

2020 to present

Timeline of Beaver Literature

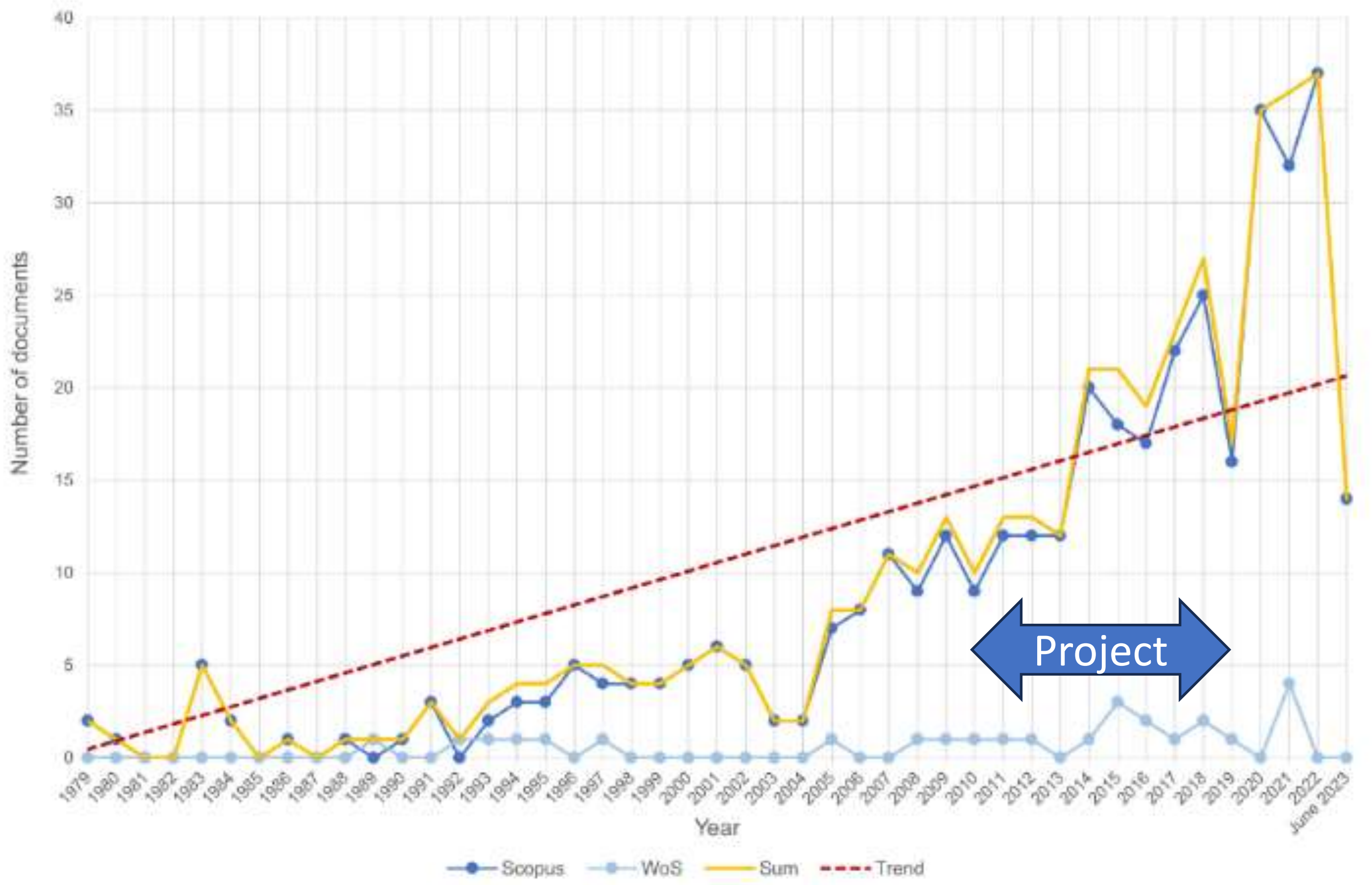
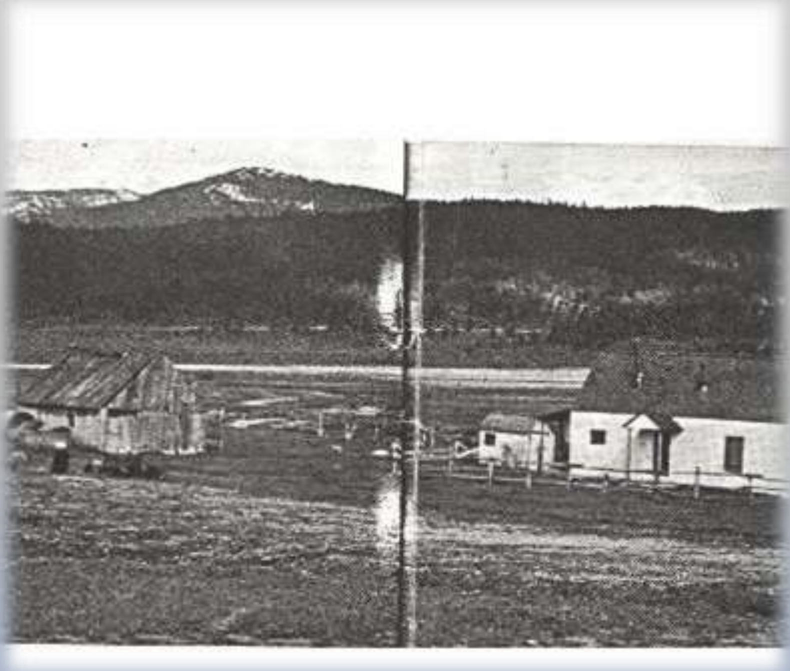


Fig. 1. Annual scientific production obtained with Biblioshiny and then elaborated with Excel to merge metadata of Scopus (dark blue) and WoS (light blue). The orange line shows the metadata merging, while the dashed red line highlights the increasing trend of documents number production. The year 2023 considers documents until June.

Historical Land-Use and Legacy Impacts

Logging
(1860s-1990s)

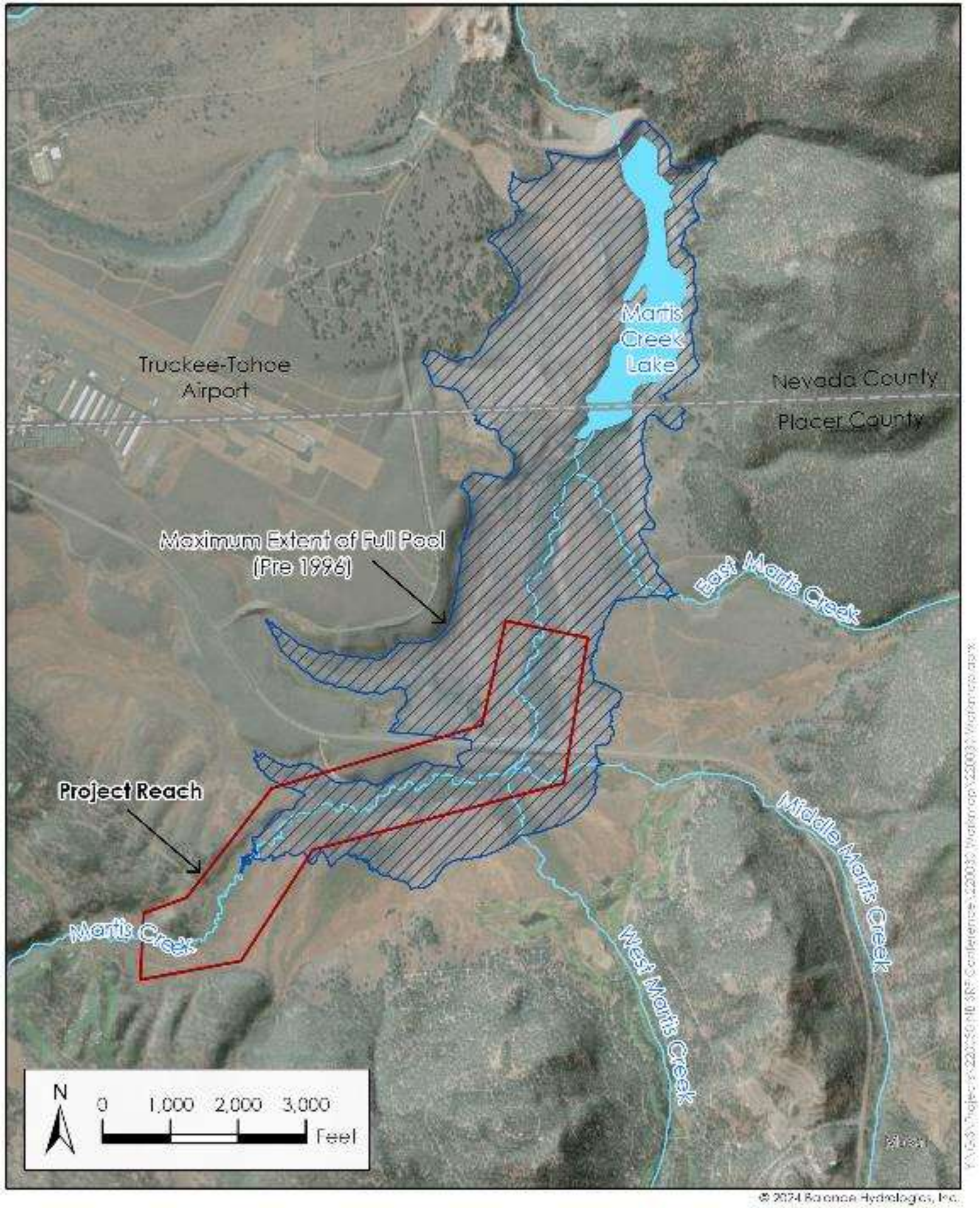


Ranching
(1876-1940s)

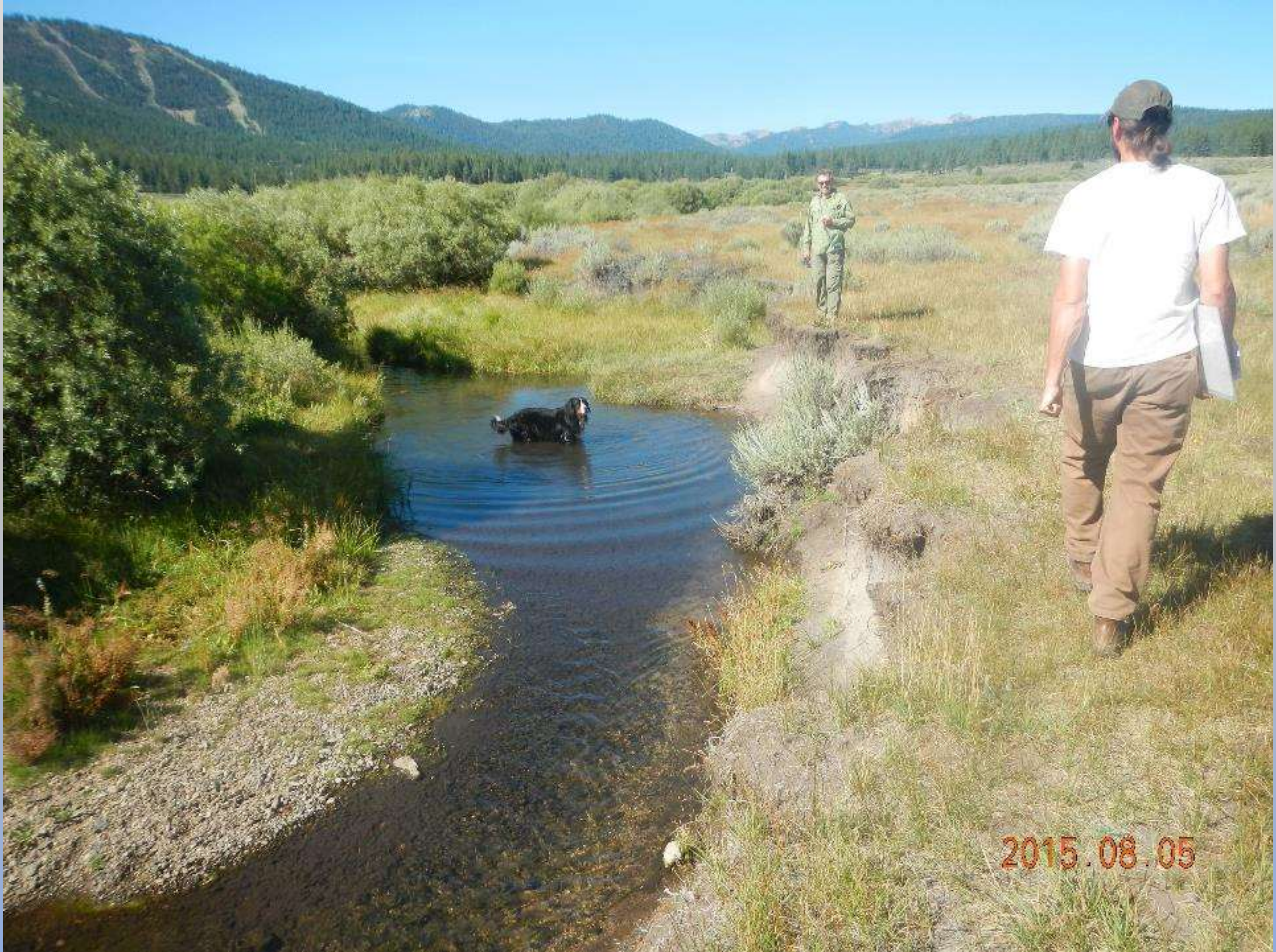
Reservoir Operations
(1972-1996, during test fills and extreme storms)

Mainstem Martis Creek

- 2-mile reach
- Overlap with Martis Reservoir full pool




2015.08.05


2015.08.05

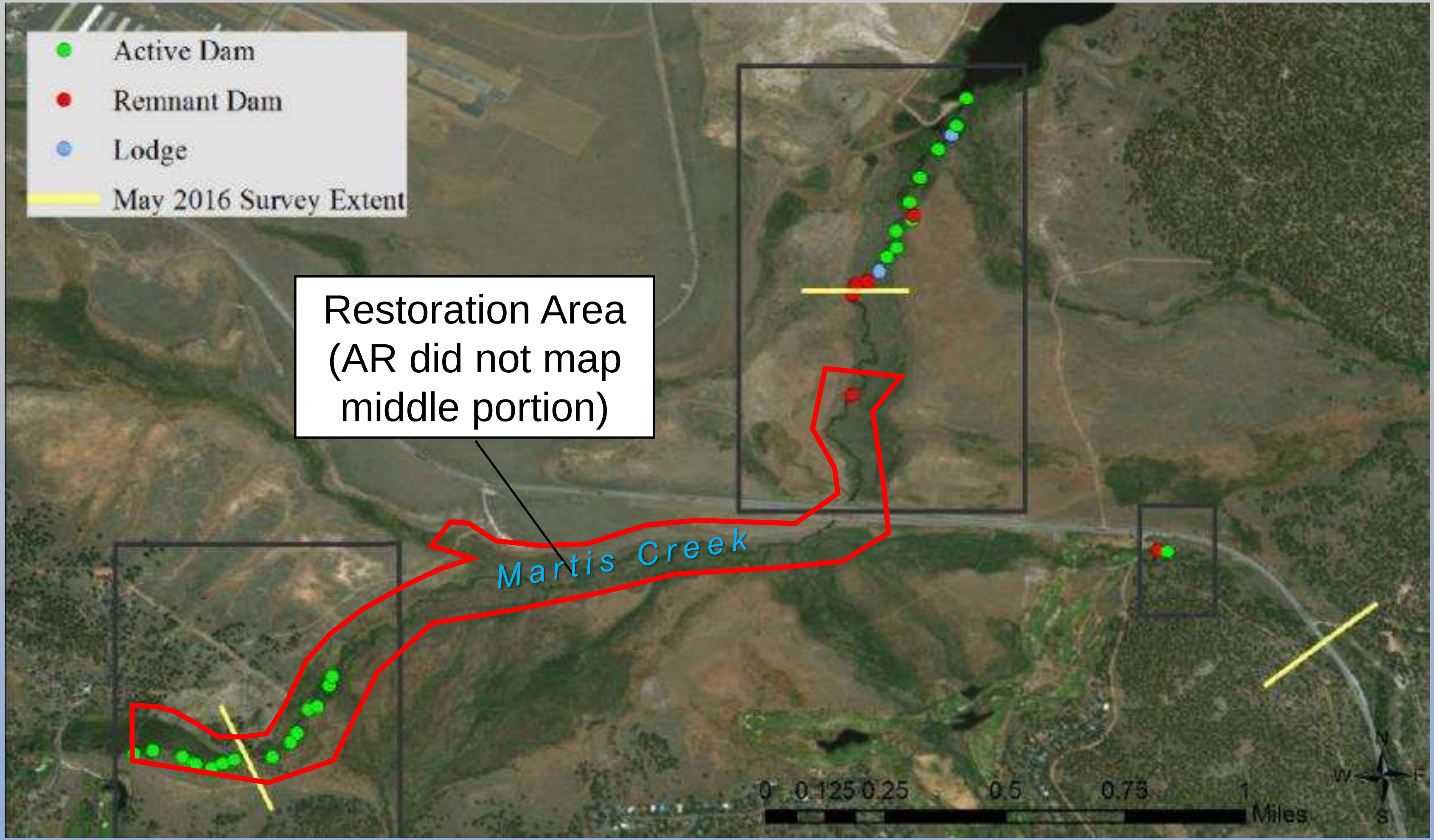
Project Goals

- Protect functioning areas and existing habitat
- Restore channel-wet meadow hydrologic connectivity in degraded reaches
- Enhance floodplain functions (shallow GW storage, sedimentation)
- Enhance diversity, vigor, and cover of wetland vegetation
- Work with existing beaver population (?)


2015 08 05

Pre-Project Beaver Activity 2016-2017, American Rivers

Map adapted from Friesen and Fair, 2018



- 24 active dams in 2017
- 85% were aggrading sediment
- Most were not providing full reconnection with the meadow surface
- 10 remnant dams were detected in 2016 but were no longer present in 2017

Design Challenge: hedging our bets

- Put all of our money on beaver maintaining structures in perpetuity?
- Are there enough beaver in the system to reverse incision over the 2-mile project reach?
- Are incision depths more than what can be undone by beaver only?
- Do stakeholders have resources for ongoing stewardship?
- Impacts to project goals if beaver activity is underwhelming?

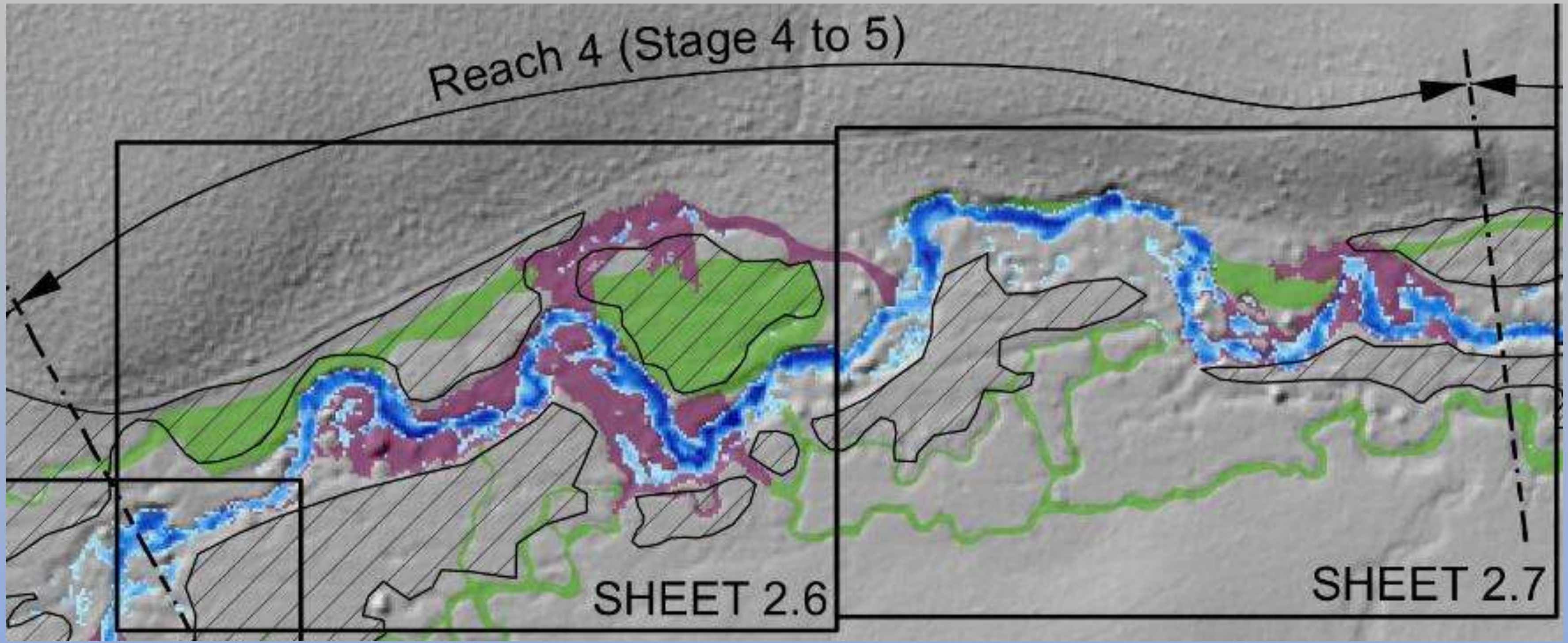
Solution: hybrid approach

In-channel Elements

- Instream wood
  - Outside of dam pool
  - Within reaches having LWD sources
- BDAs
  - Contractor
  - Volunteers
  - Beaver

Grading Elements

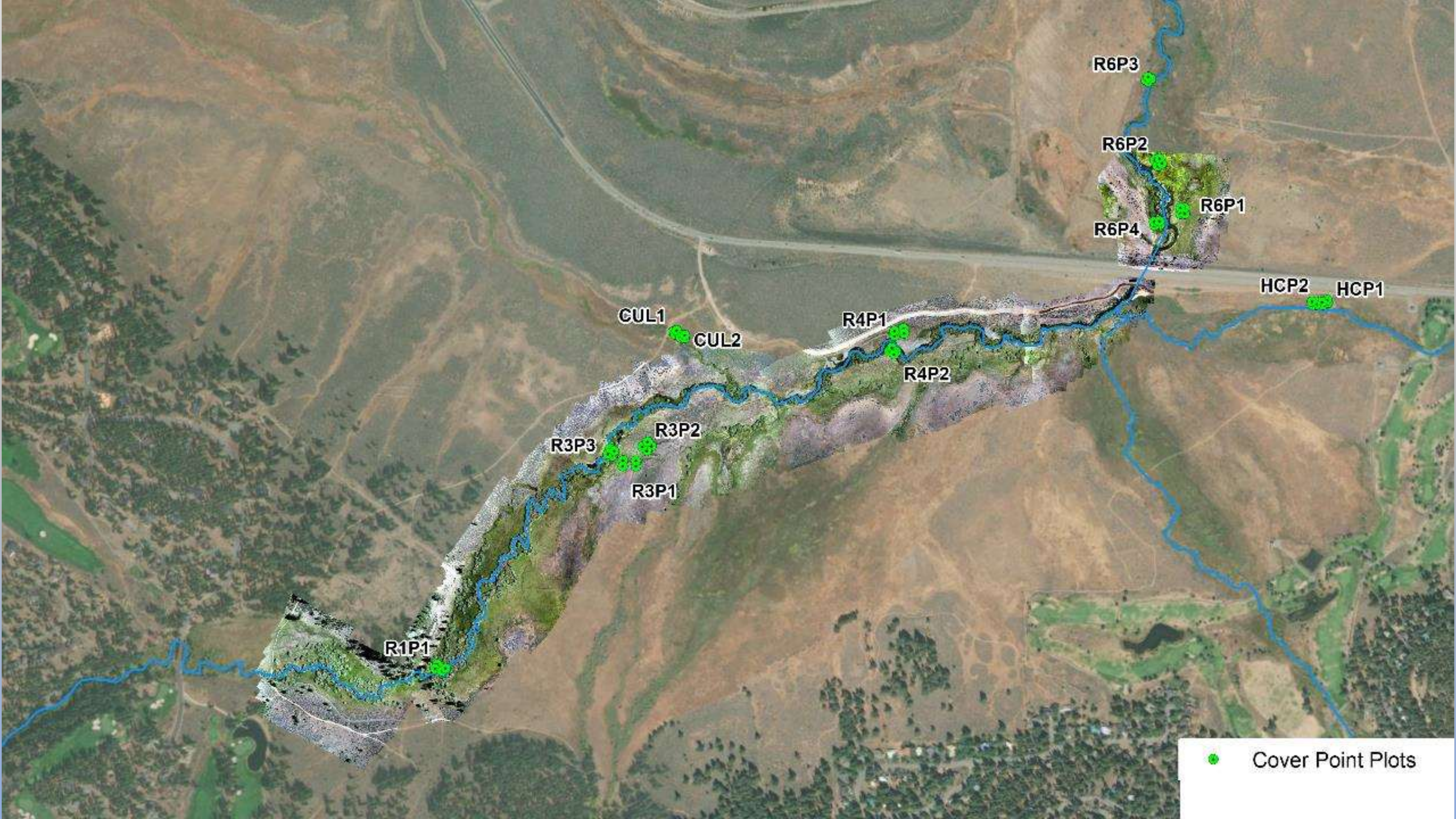
- Inset floodplains
- Pilot Channels
- Diversion ditch fill

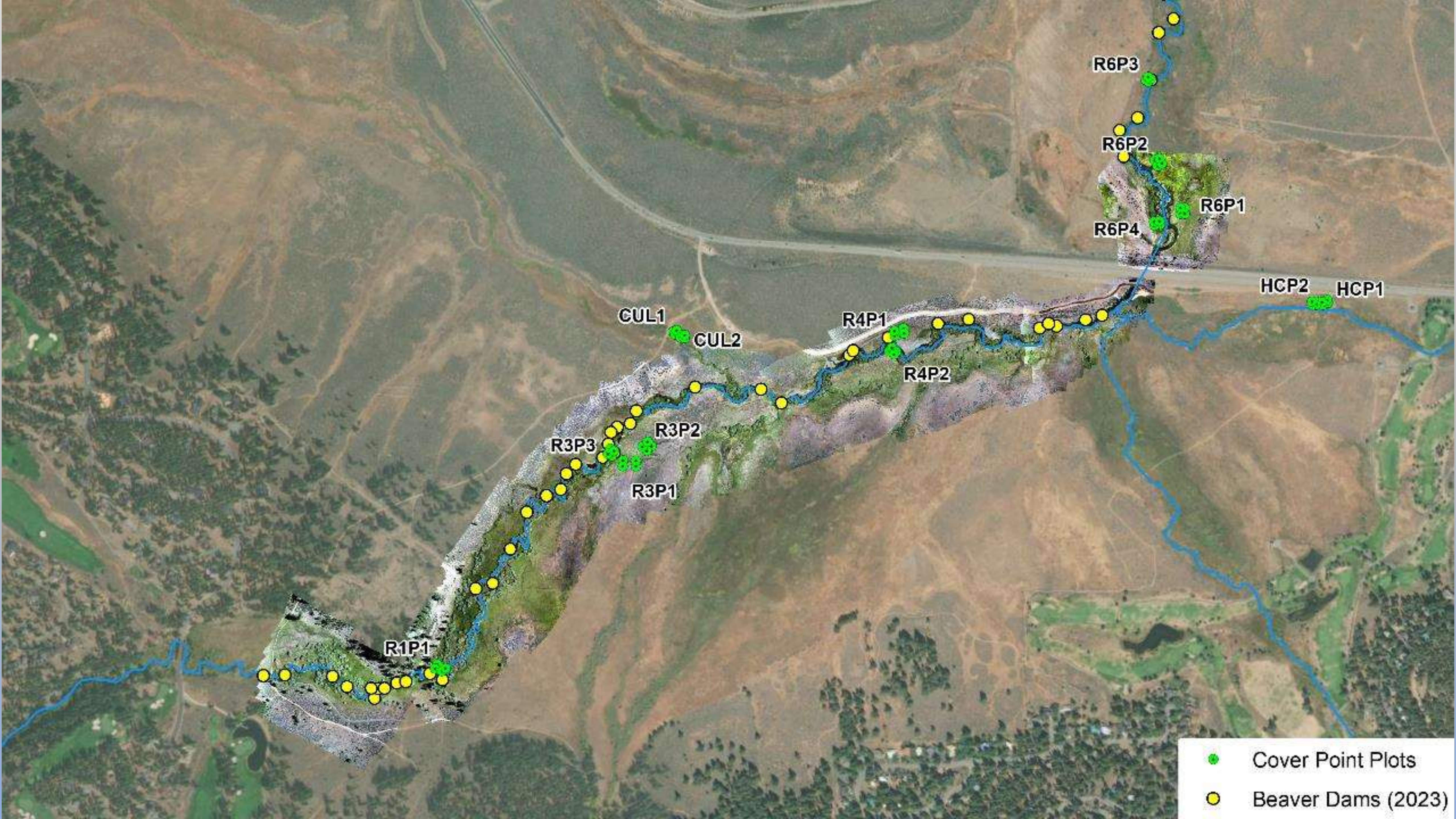


Vegetation monitoring methods, metrics and locations

Wetland Rank Category*	Observed Occurrence in Wetlands
Obligate (OBL)	Occur > 99% of the time in wetlands
Facultative Wetland (FACW)	Occur in wetlands 67 – 98% of the time
Facultative (FAC)	Occur in wetland 34 – 66% of the time
Facultative Upland (FACU)	Occur in wetlands less than 34% of the time
Upland (UPL)	Occur in wetland only 1% of the time
Not listed (NL)	Not evaluated (most of these species are upland species)

- Three monitoring methods: Cover Point, Greenline Transects and Plant Community Mapping
- Metric: Wetland Ranking U.S Army Corp. of Engineers.
- Location: Cover Point Plots areas where change was expected, disconnected floodplains, relic channels, areas adjacent to creek. Plant Community Mapping reaches with active restoration, expanded in 2022 to include all reaches. Greenline three locations discontinued after 2021.

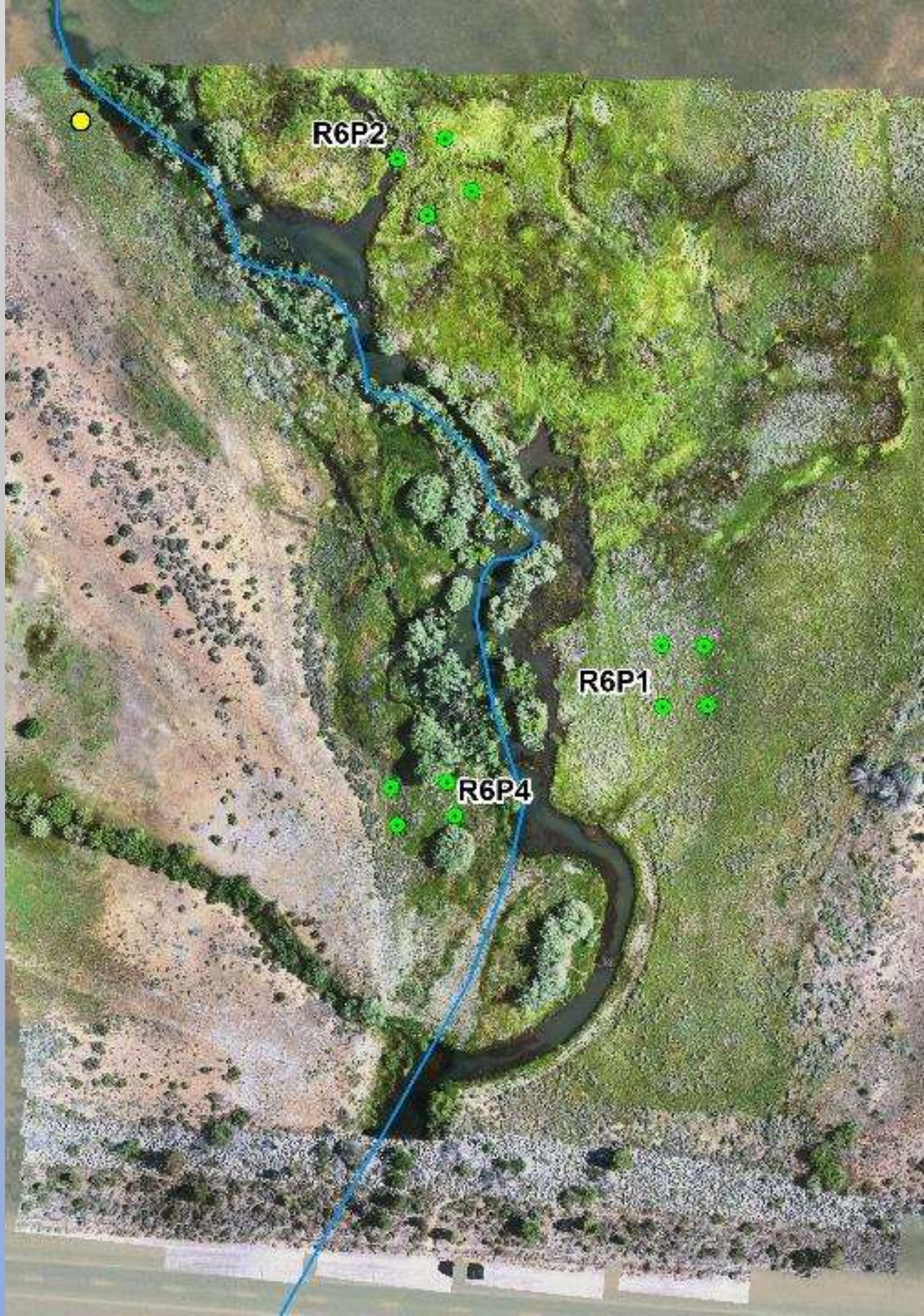

R6P3
R6P2
R6P1
R6P4
HCP2
HCP1
CUL1
CUL2
R4P1
R4P2
R3P2
R3P3
R3P1
R1P1
Cover Point Plots



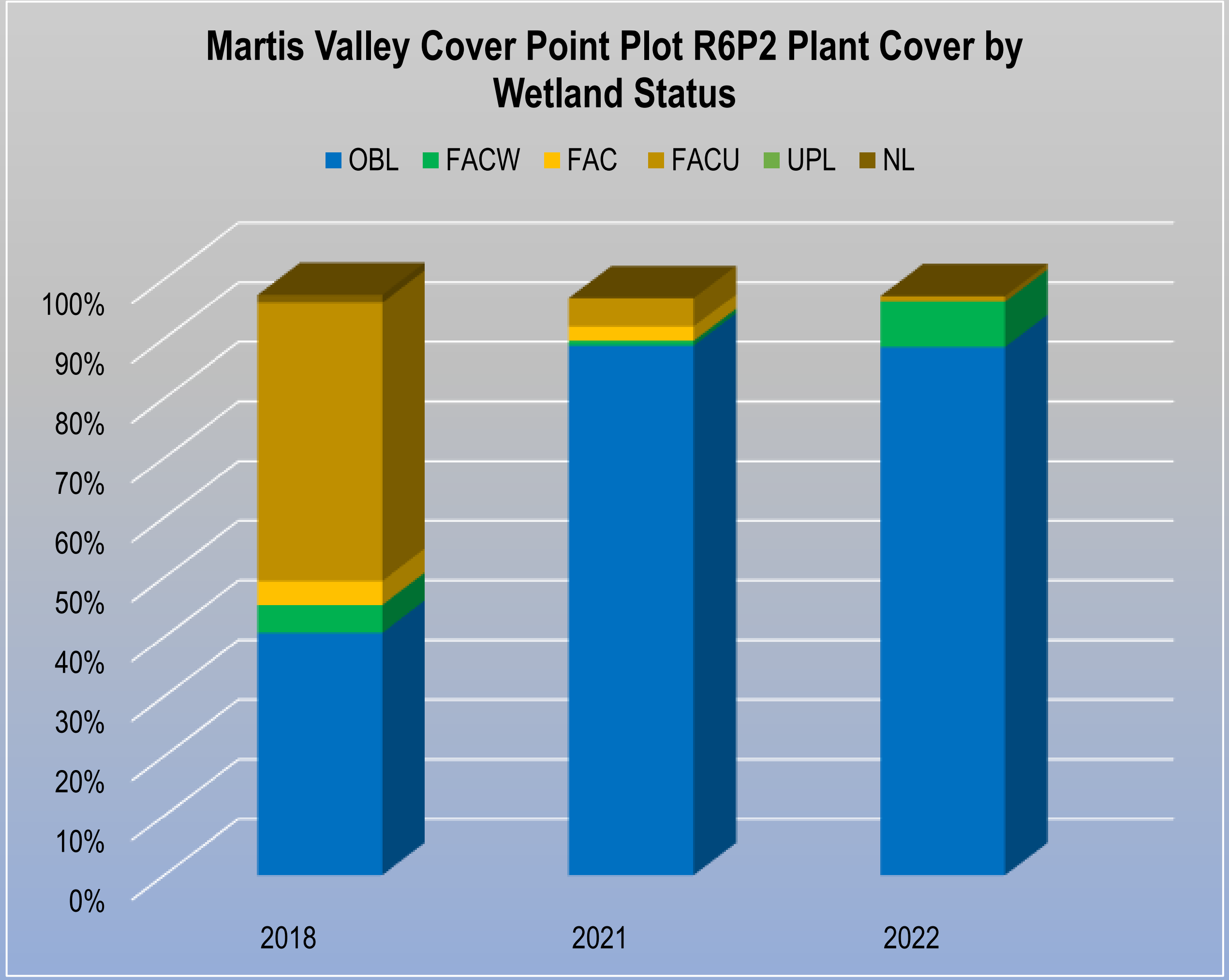
R6P3
R6P2
R6P1
R6P4
HCP2
HCP1
CUL1
CUL2
R4P1
R4P2
R3P2
R3P3
R3P1
R1P1
Cover Point Plots
Beaver Dams (2023)

Reach 6 - where we saw the first response

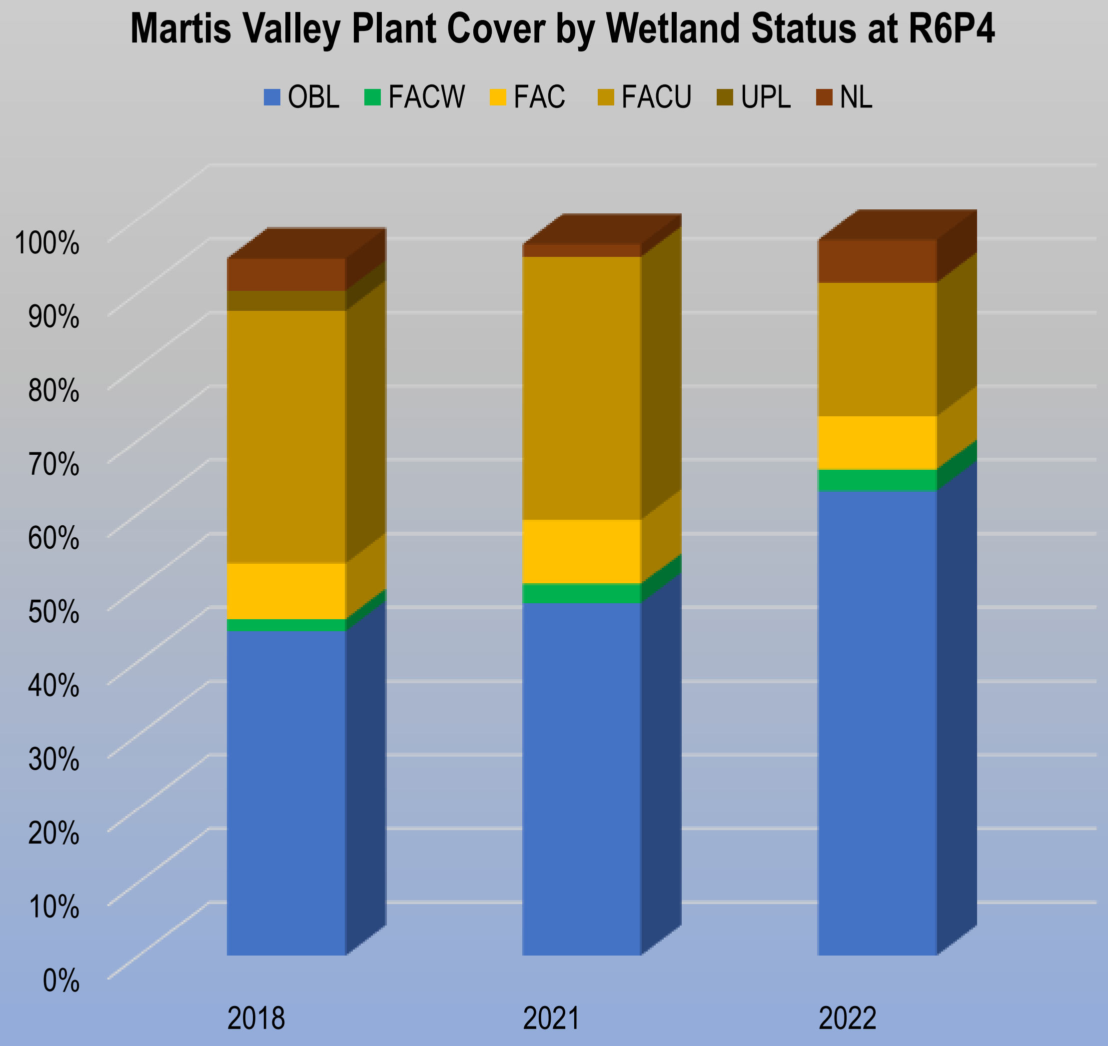
- Beaver were already established in this reach but farther downstream.
- This is the area where was saw the largest response early on
- Majority of response in 2021 was on the south side (right side looking downstream)
- In 2022 and to a greater extent in 2023 water expanded on the left side looking downstream.



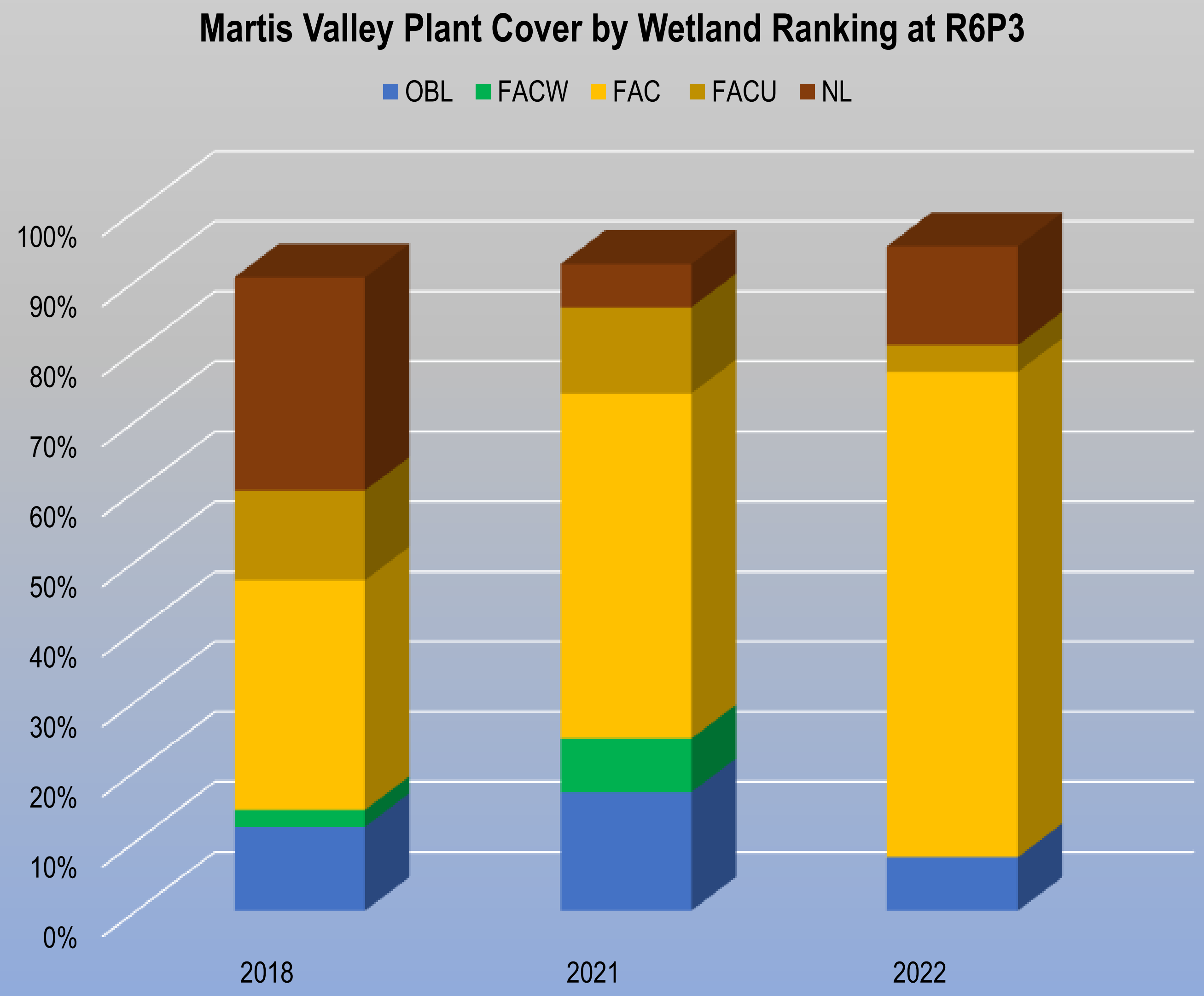
Amazing response at Reach 6 Plot 2 – from silver sagebrush to obligate wetland sedges.



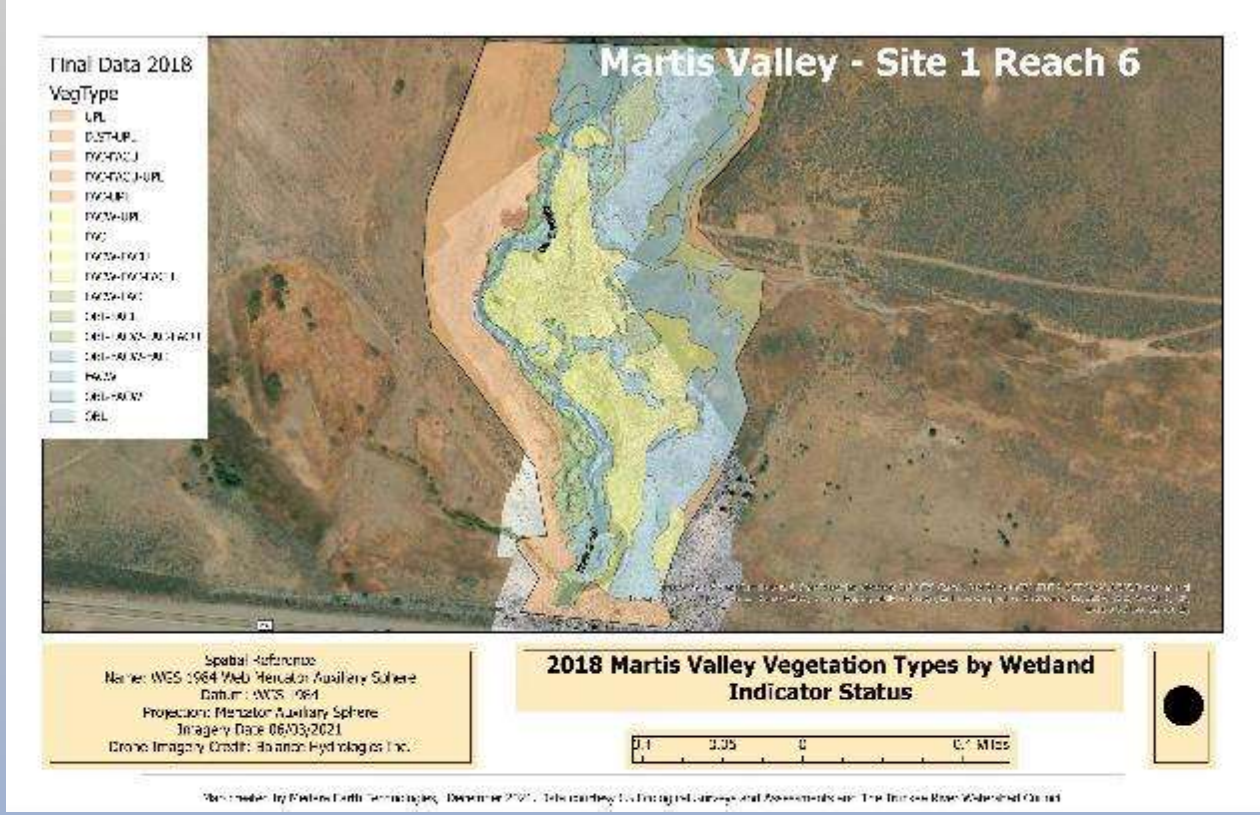
At Plot 4 in Reach 6 silver sagebrush is dying off and Nebraska sedge, beaked sedge and narrow leaved sedge are now the dominant species

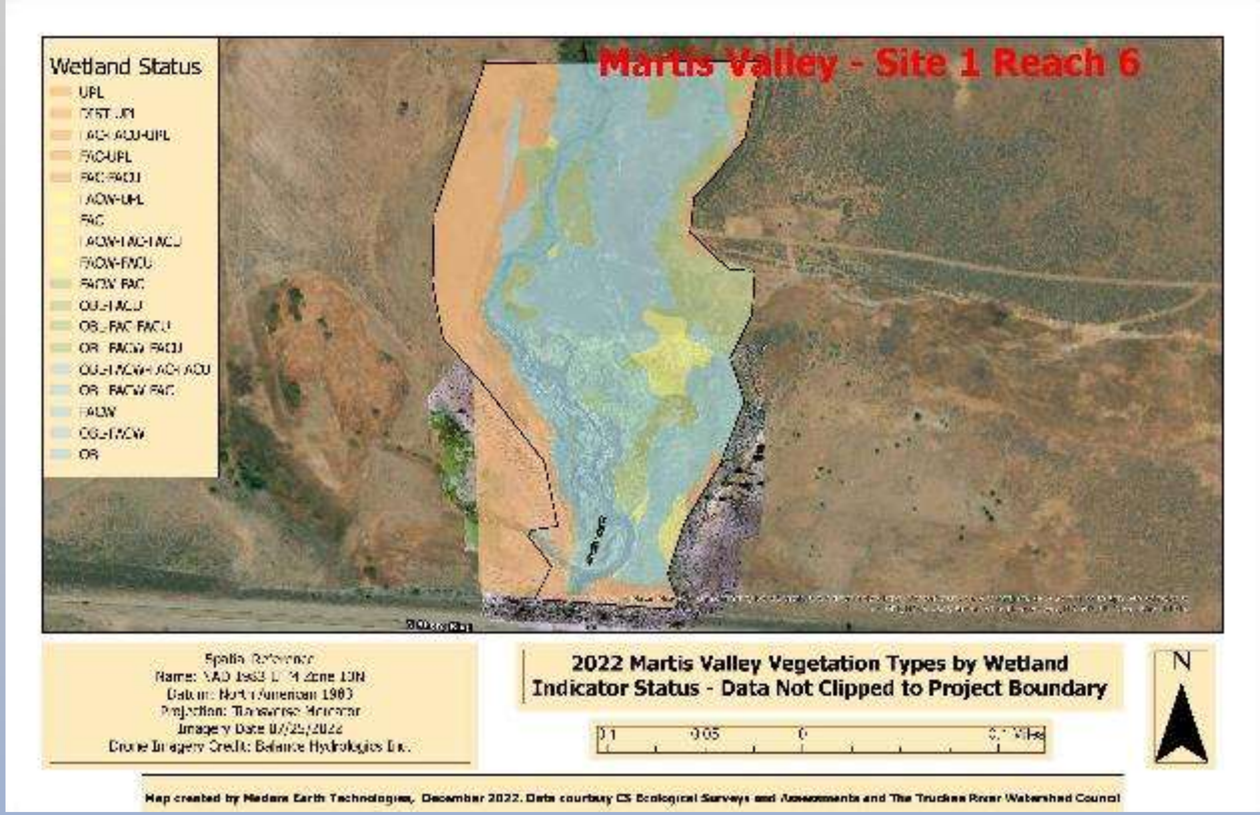


Plot 3 in Reach 6 has been variable with a trend towards a reduction in sagebrush cover and an increase in Kentucky Bluegrass a FAC rated species.

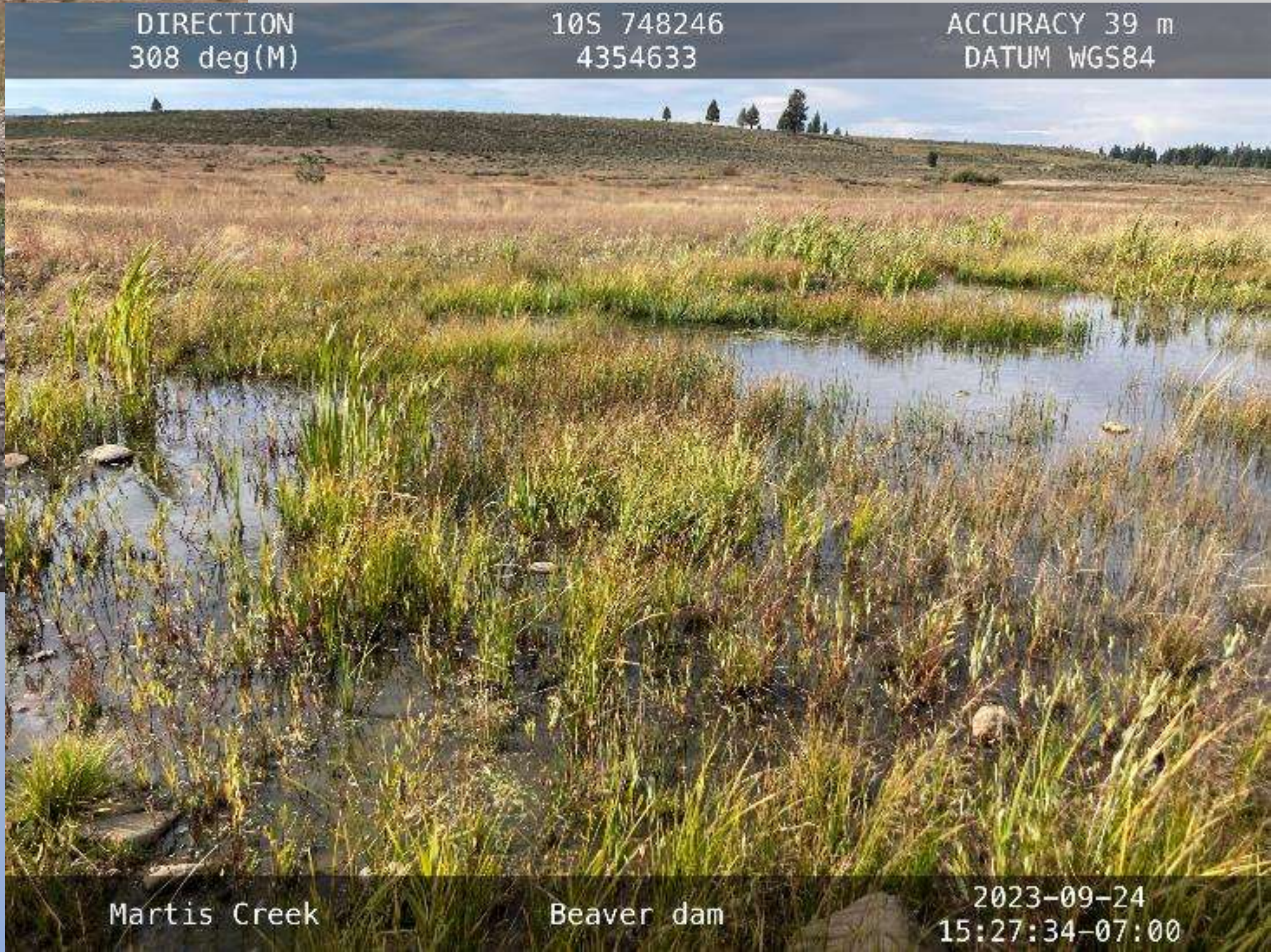


Plant community maps for reach 6 by wetland status of each polygon for 2018 and 2022



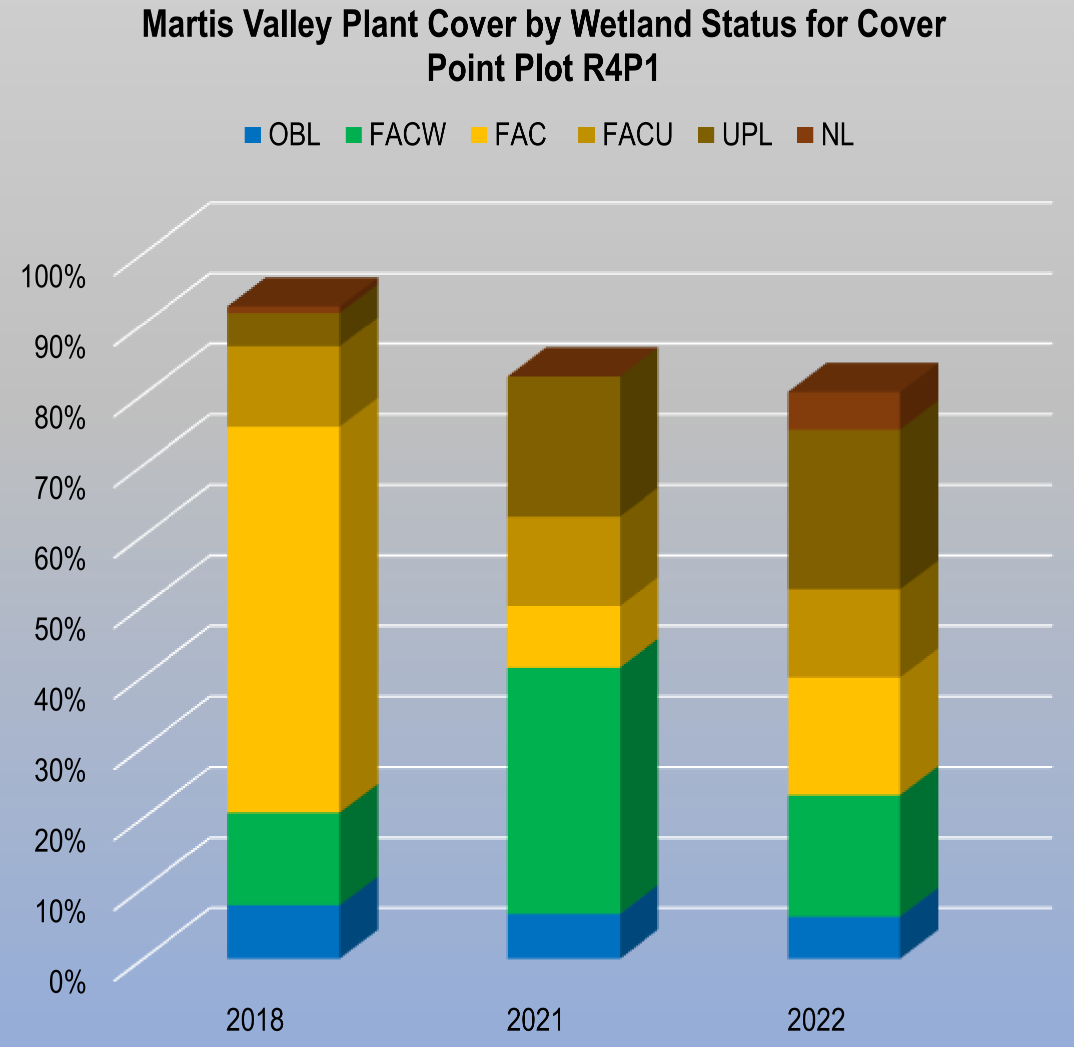



DIRECTION
201 deg(M)
10S 748245
4354647
ACCURACY 5 m
DATUM WGS84
Martis valley
P31
7/23/22


DIRECTION
308 deg(M)
10S 748246
4354633
ACCURACY 39 m
DATUM WGS84
Martis Creek
Beaver dam
2023-09-24
15:27:34-07:00


CUL1
CUL2
R4P1
R4P2
R3P3
R3P2
R3P1
R1P1
Cover Point Plots
Beaver Dams (2023)

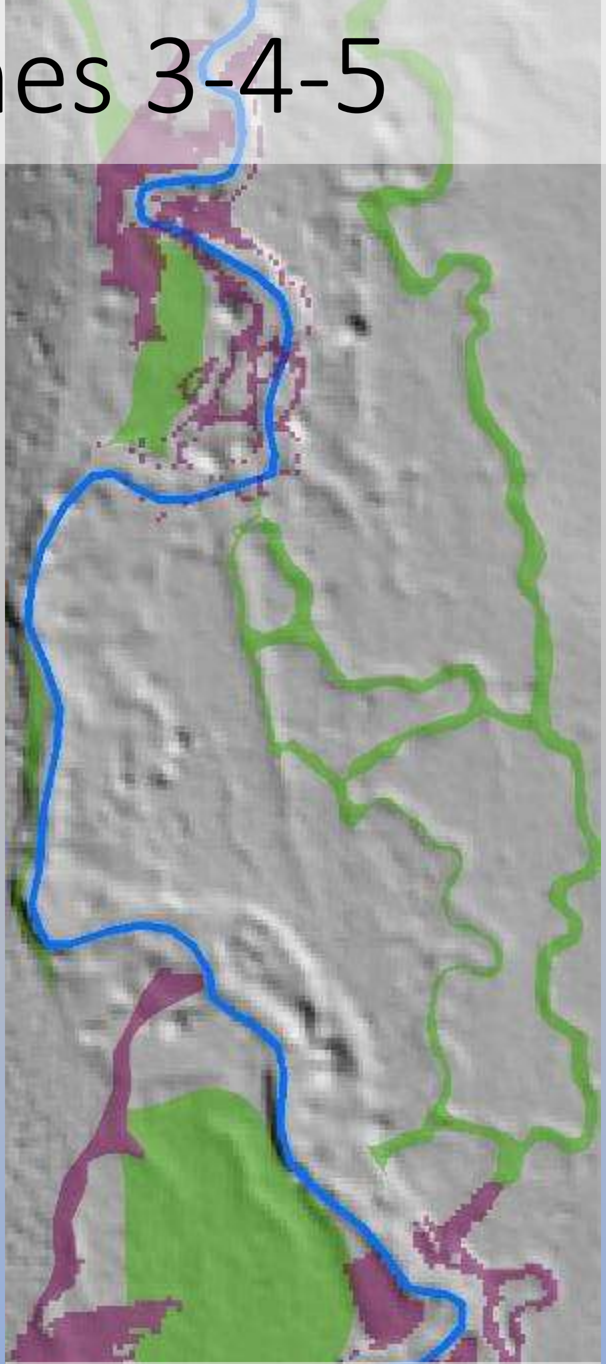
Plot 1 in Reach 4 had mixed composition, in 2021 and 2022. In 2023 the area was much wetter.




DIRECTION
25 deg(M)
10S 747651
4354120
ACCURACY 5 m
DATUM WGS84
Martis valley veg.
Mapping
P49


DIRECTION
204 deg(M)
10S 747661
4354141
ACCURACY 5 m
DATUM WGS84
TRWC Martis Valley
Water spreading from
beaver dams
2023-10-28
14:57:02-07:00

Reaches 3-4-5



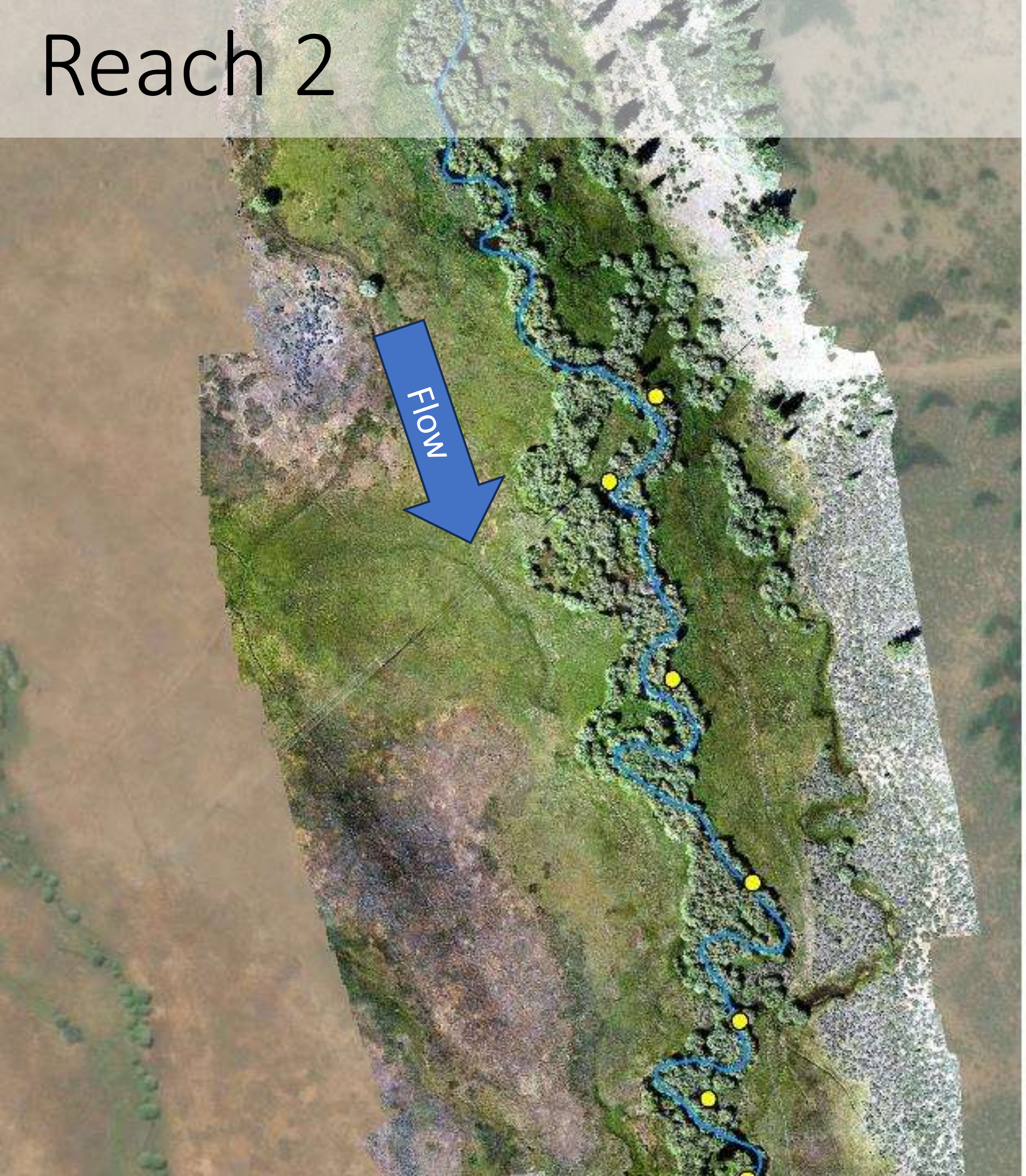
Design Phase Modeling

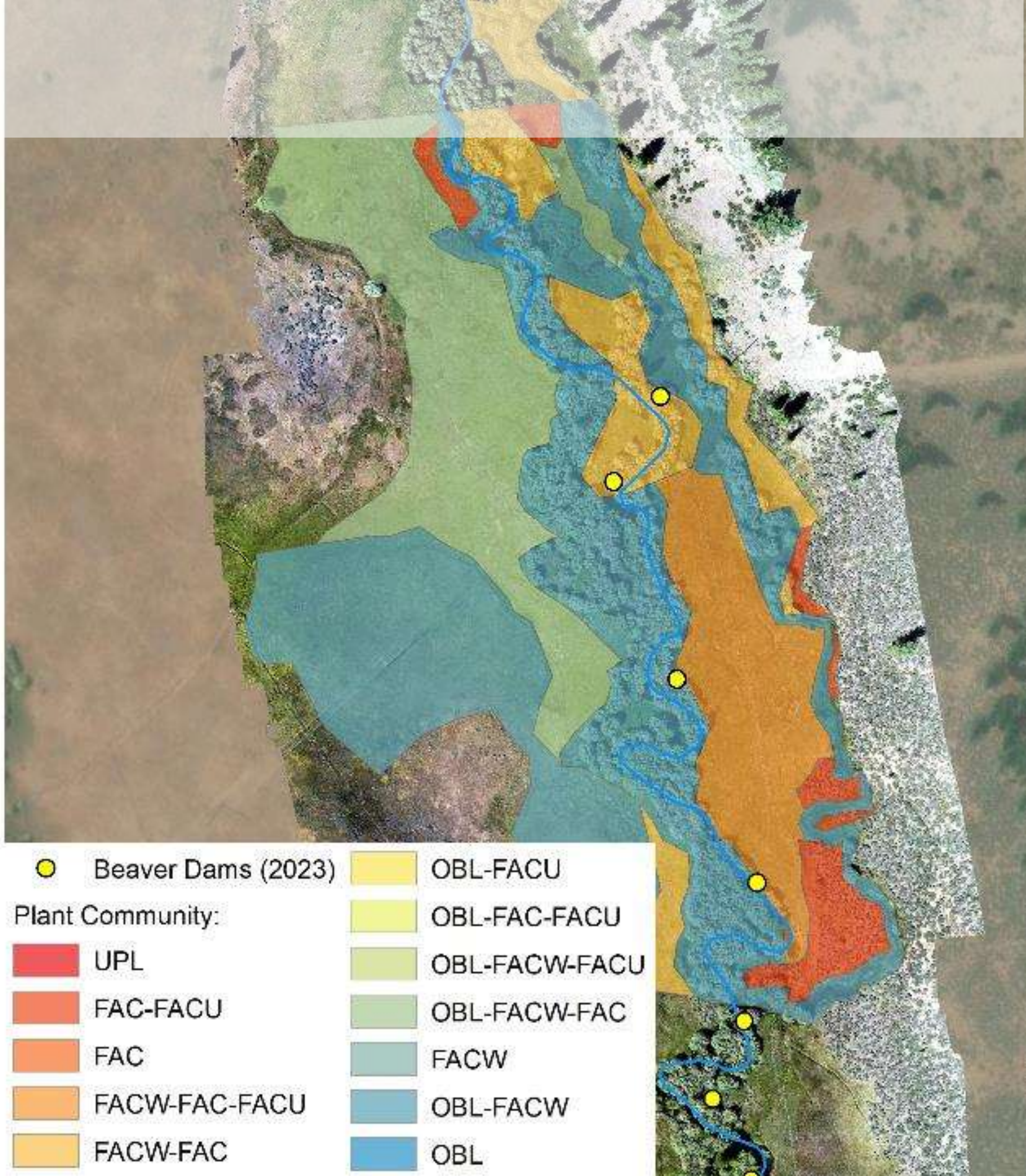
Peak Flow 2022

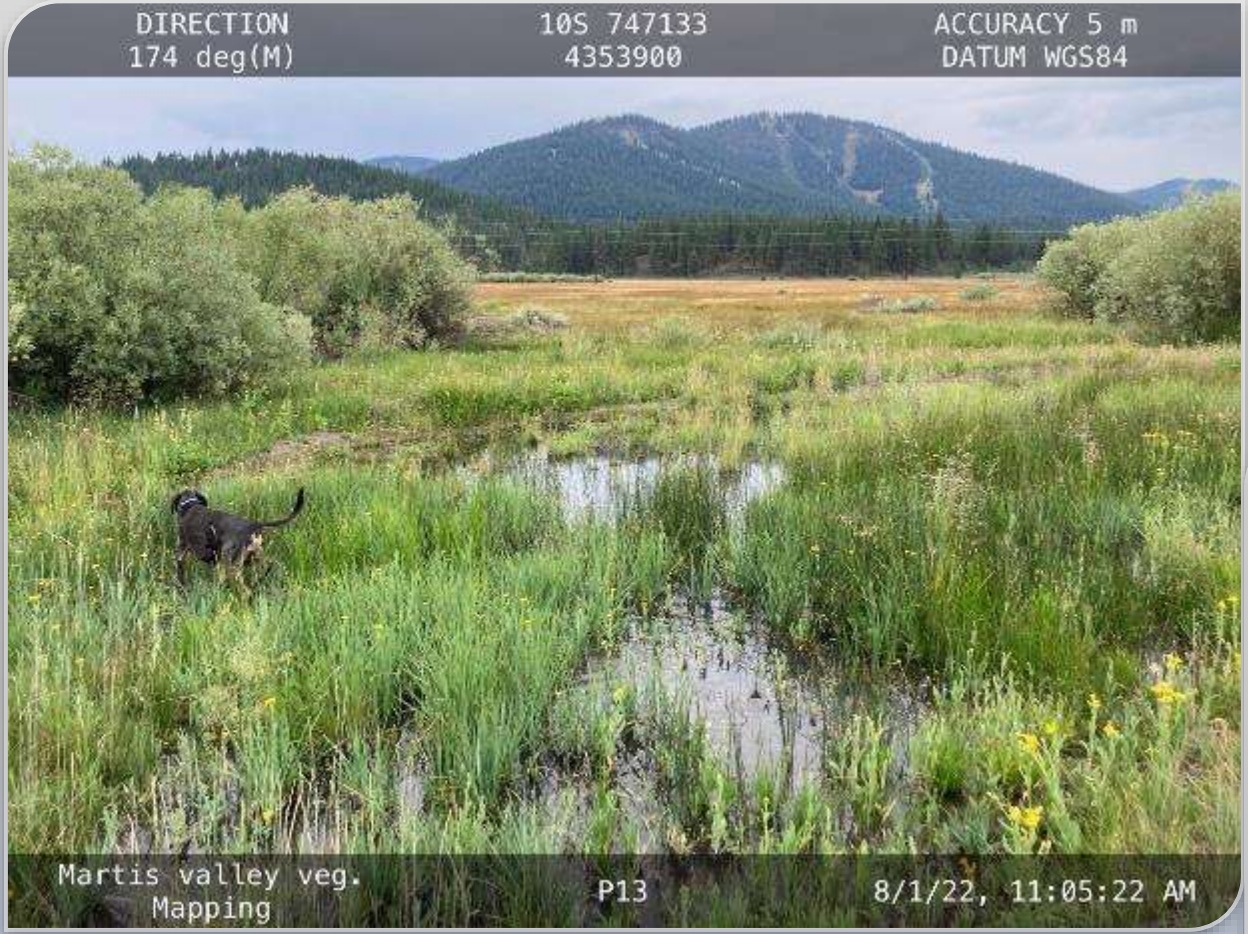
Veg Mapping 2022

Reaches 3-4-5

Reach 2


Flow

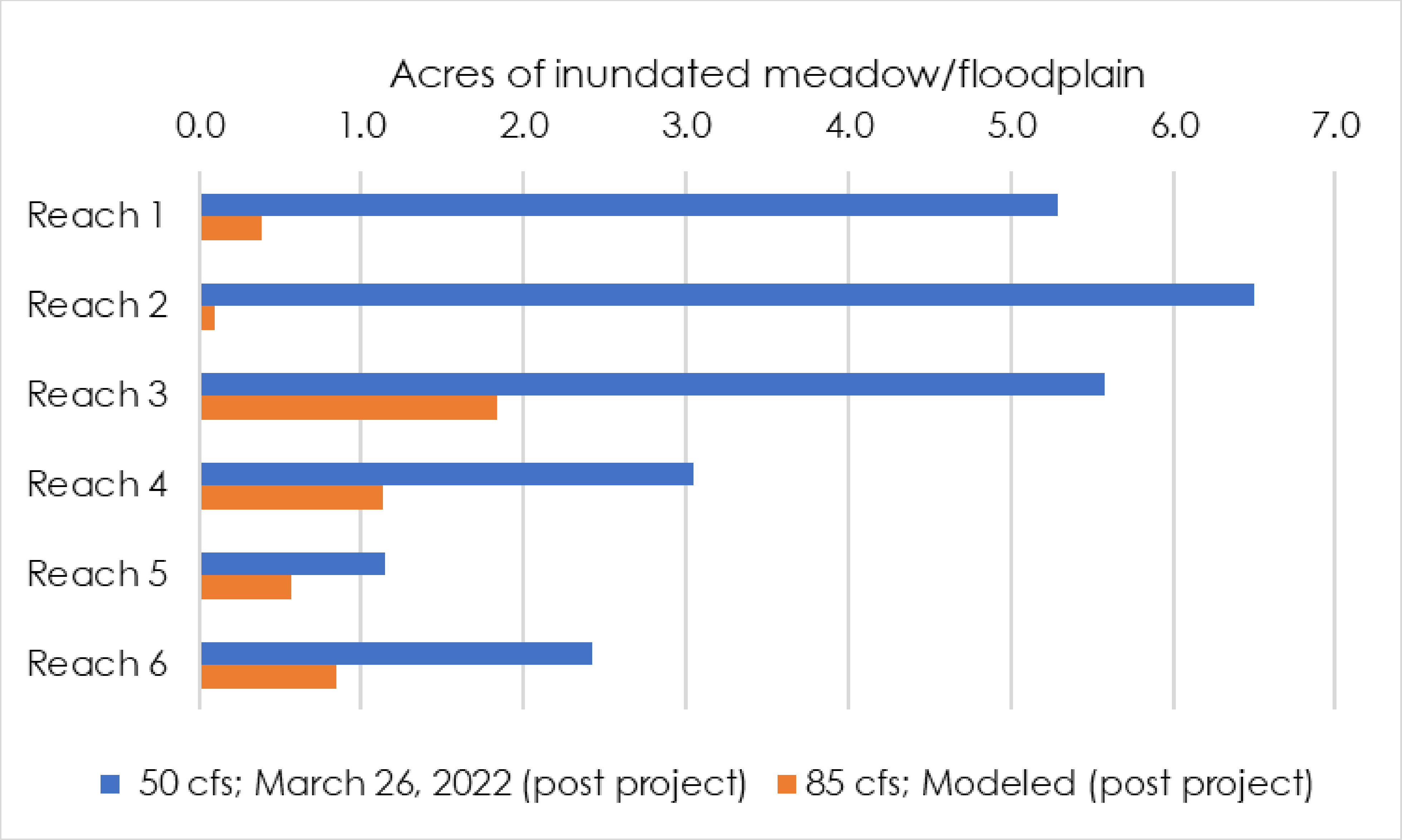

Beaver Dams (2023)
Plant Community:
UPL
FAC-FACU
FAC
FACW-FAC-FACU
FACW-FAC
OBL-FACU
OBL-FAC-FACU
OBL-FACW-FACU
OBL-FACW-FAC
FACW
OBL-FACW
OBL


DIRECTION
174 deg(M)
10S 747133
4353900
ACCURACY 5 m
DATUM WGS84
Martis valley veg.
Mapping
P13
8/1/22, 11:05:22 AM


DIRECTION
293 deg(M)
10S 747005
4353835
ACCURACY 5 m
DATUM WGS84
Martis valley veg.
Mapping
P14
8/1/22, 11:16:25 AM

Reach 2

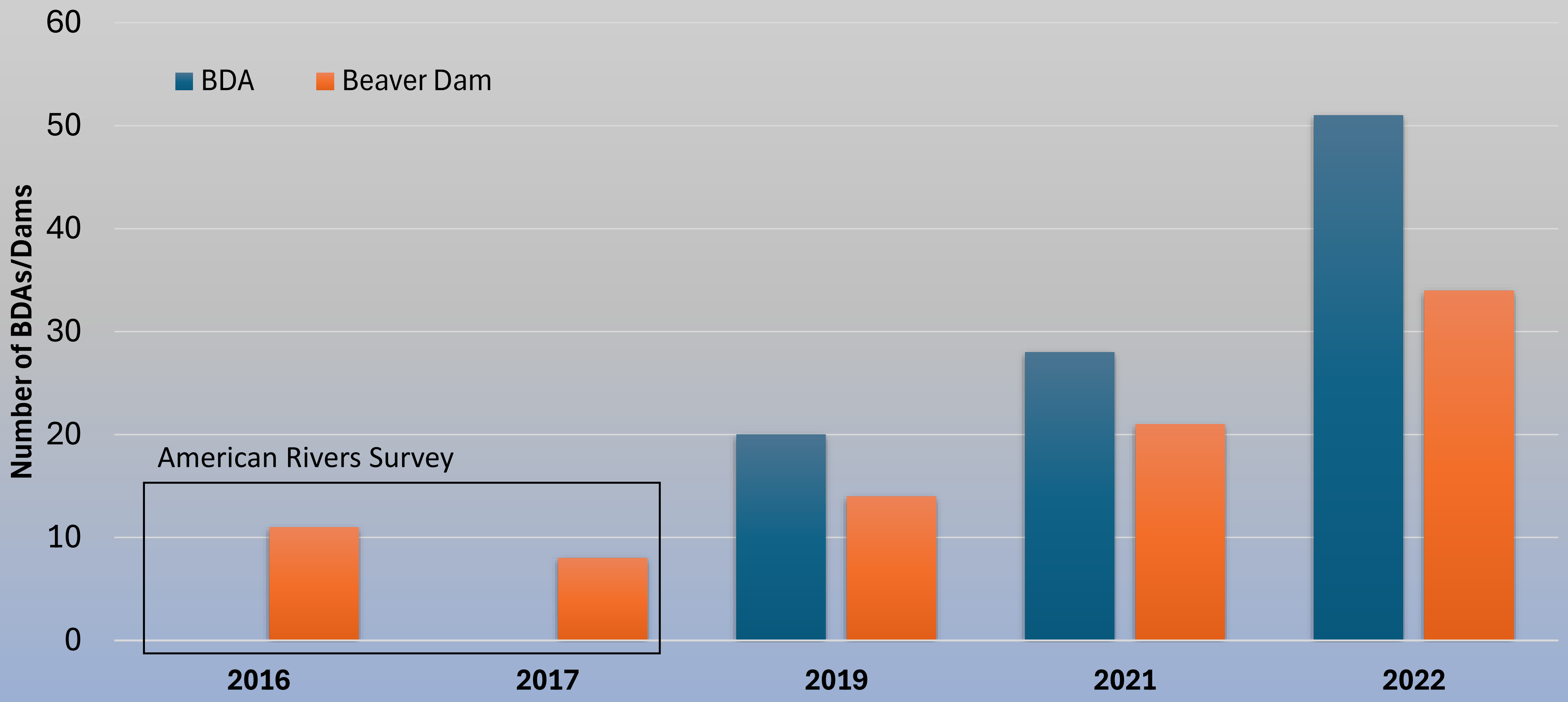
Predicted vs. Actual Inundation



In summary….

- Beaver activity increased the inundated area
  - Took over BDAs (in a few cases)
  - New beaver dam next to BDA (more common)
- Greater-than-expected vegetation response, more abundant species from the seed bank in first few years
- Redundancy in vegetation monitoring methods
  - Plots are accurate but results depend heavily on placement
  - Mapping of plant communities is more subjective but captures change over larger area
- Important to understand timeframe of hydrologic and vegetation response, 3 years post-project monitoring not enough to show sustained response (especially in the Sierra)

In summary ….



60
50
40
30
20
10
0
Number of BDAs/Dams
BDA
Beaver Dam
American Rivers Survey
2016
2017
2019
2021
2022

This project was made possible by:

Funders:

- Donors to the Truckee River Watershed Council
- CA Department of Fish and Wildlife
- US Bureau of Reclamation
- Martis Fund
- Bella Vista Foundation

Stakeholders:

- US Army Corps of Engineers
- Washoe Tribe of Nevada and California
- Northstar Community Services District
- Northstar California

This project was made possible by:

- The volunteers who help each year on Truckee River Day
- And finally, the Castor canadensis families of Martis Valley!

Well, Did It Work?

Research Paper Audience

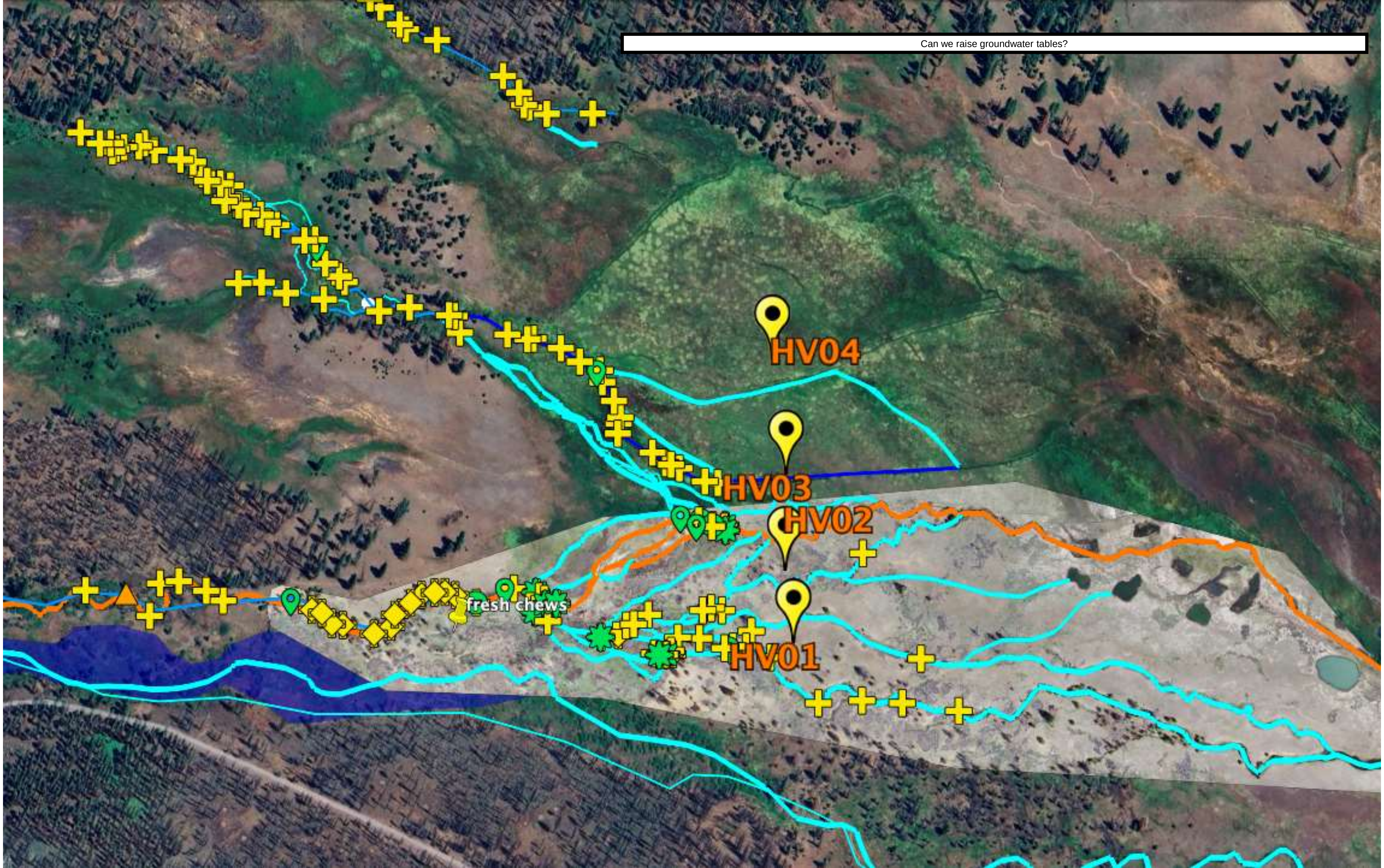
See Like A Beaver

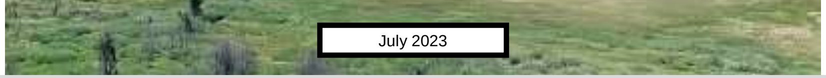
1. Take a walk
2. Magic flying robots
3. Beavers with cameras
4. Repeat 1 and 2
5. Repeat all next season

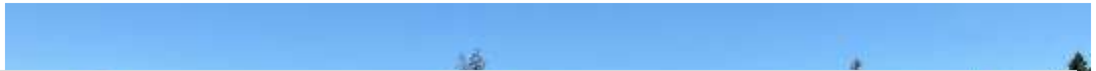
Specific Goals?

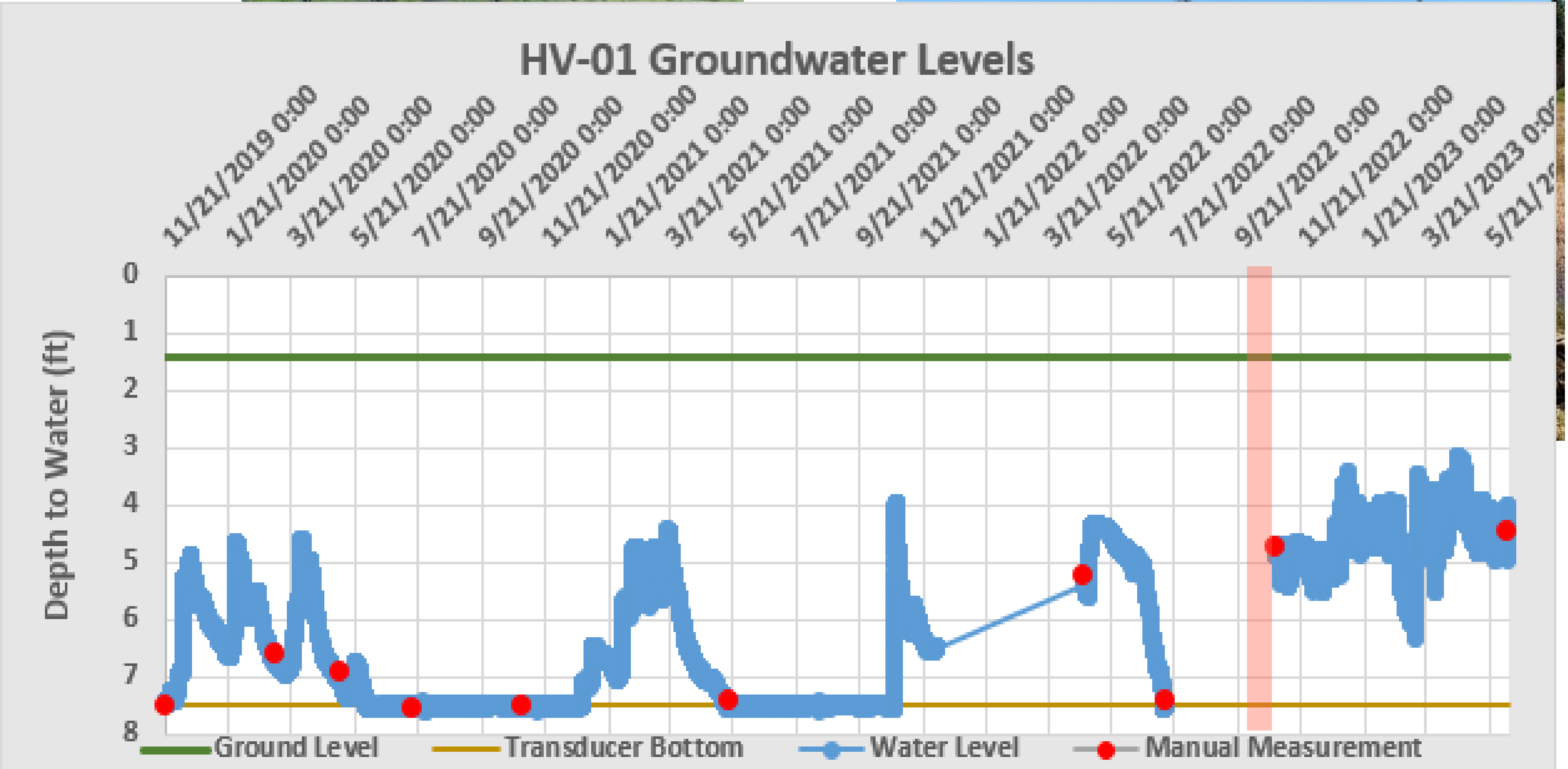
6. Spaceballs and Math
7. Drill Holes
8. Count Plants
9. Measure Mud
10. Spend Money

Can we raise groundwater tables?



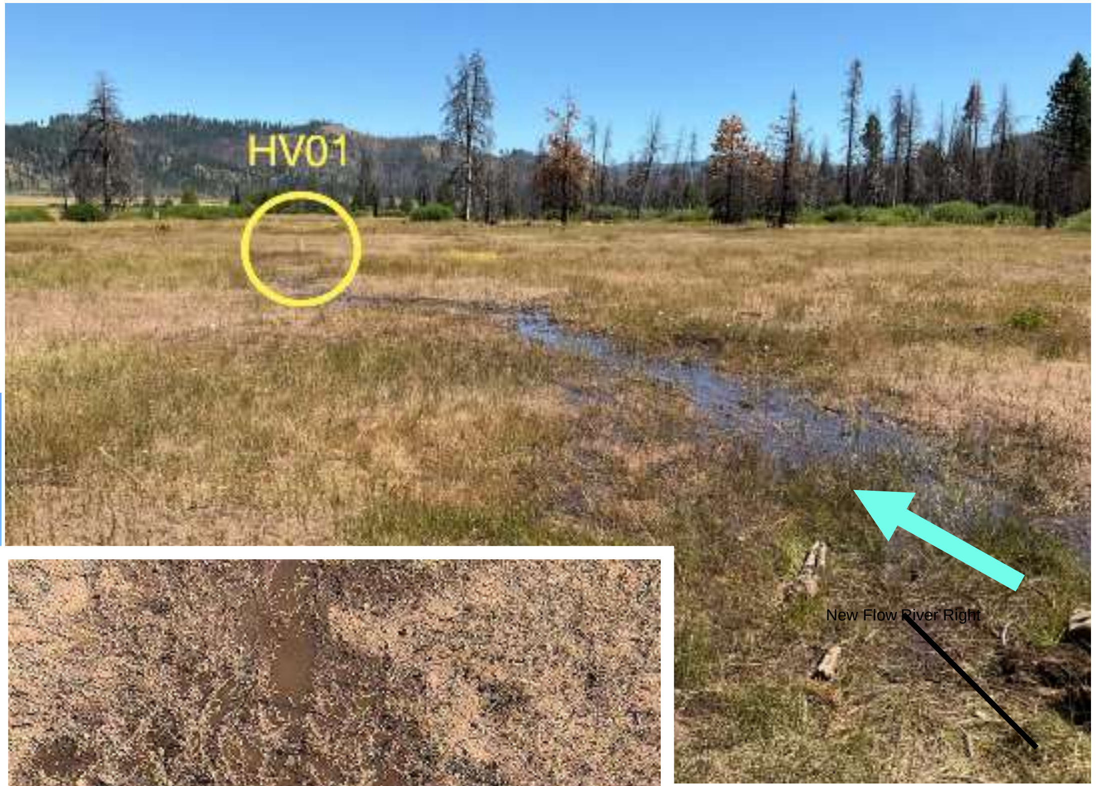


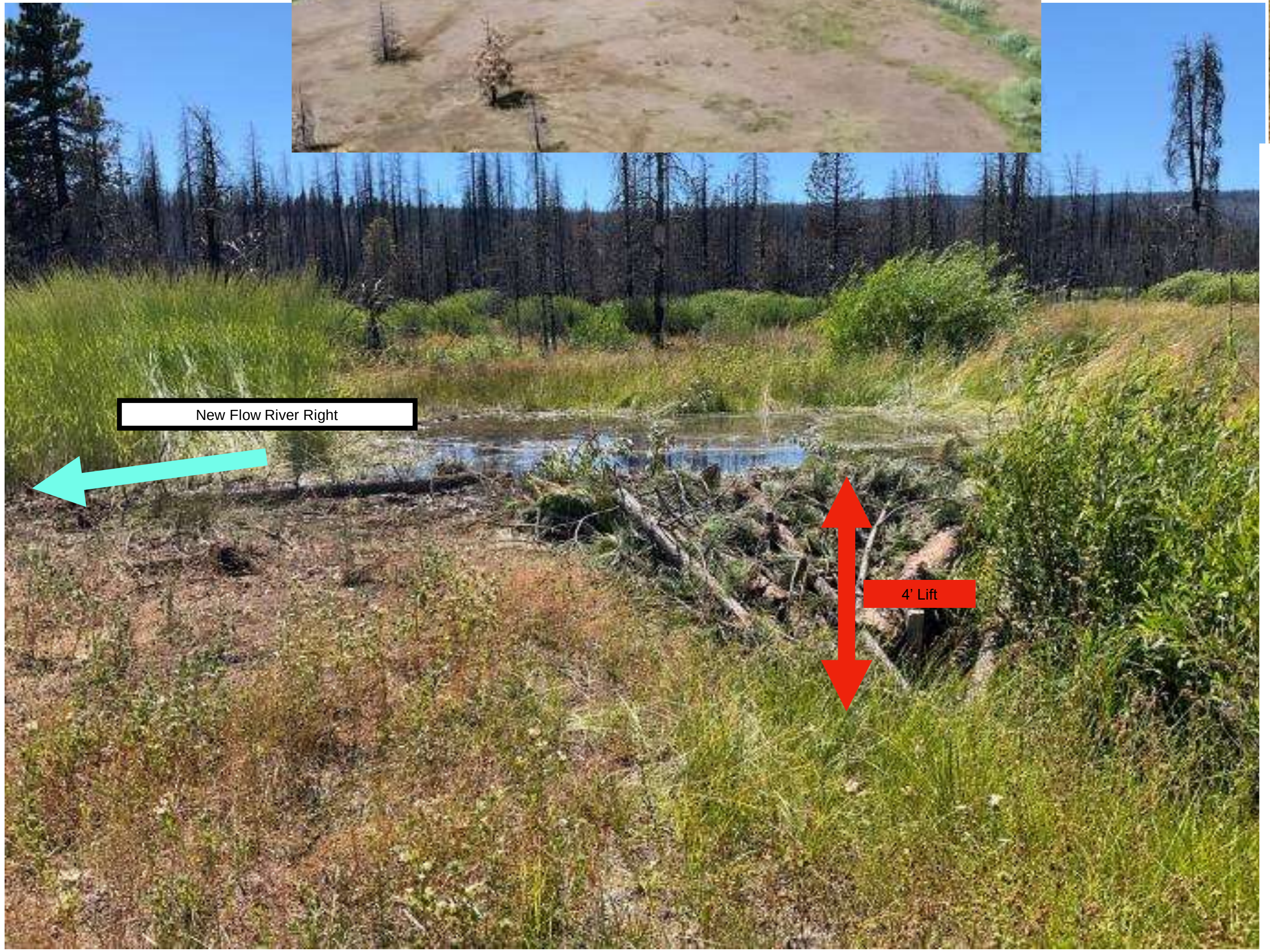


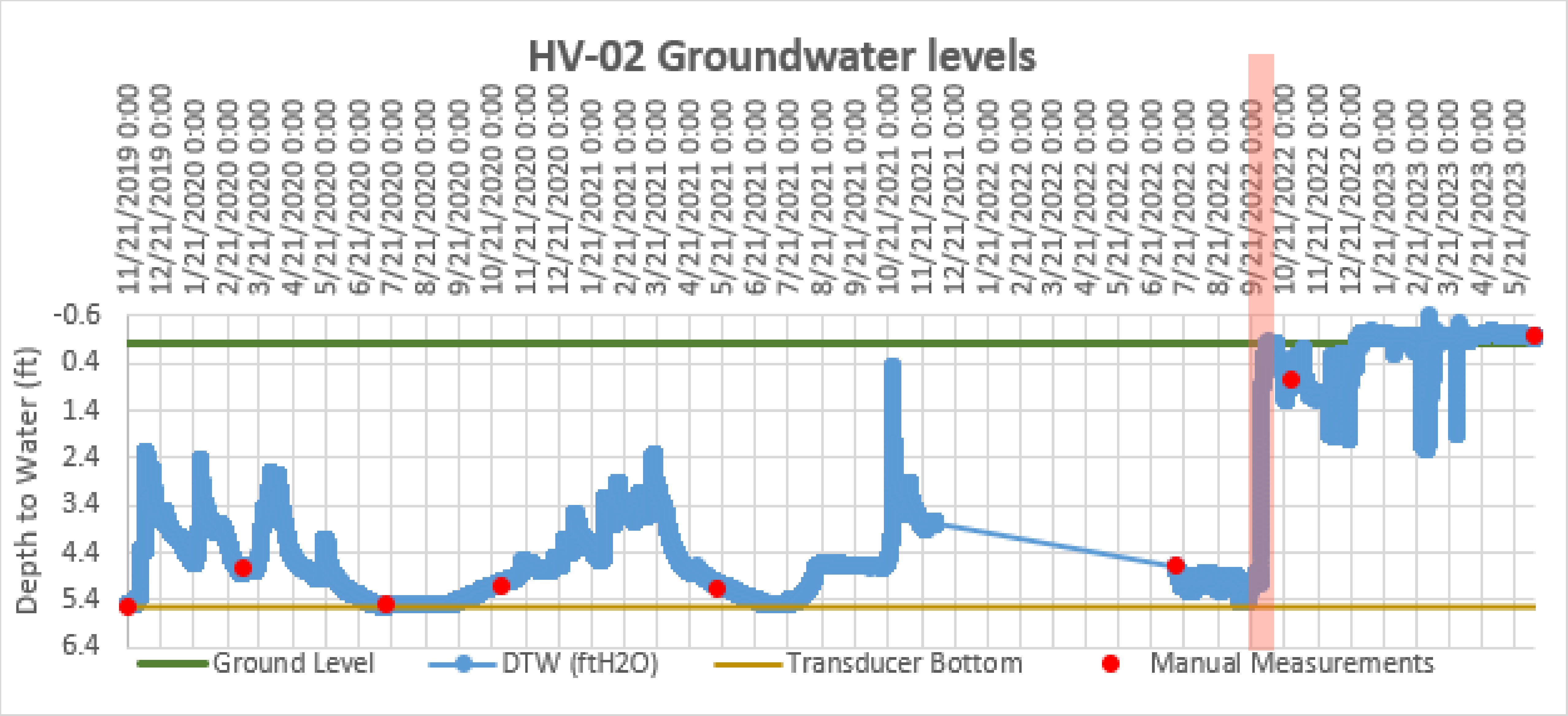


Patrick Jarrett, DWR

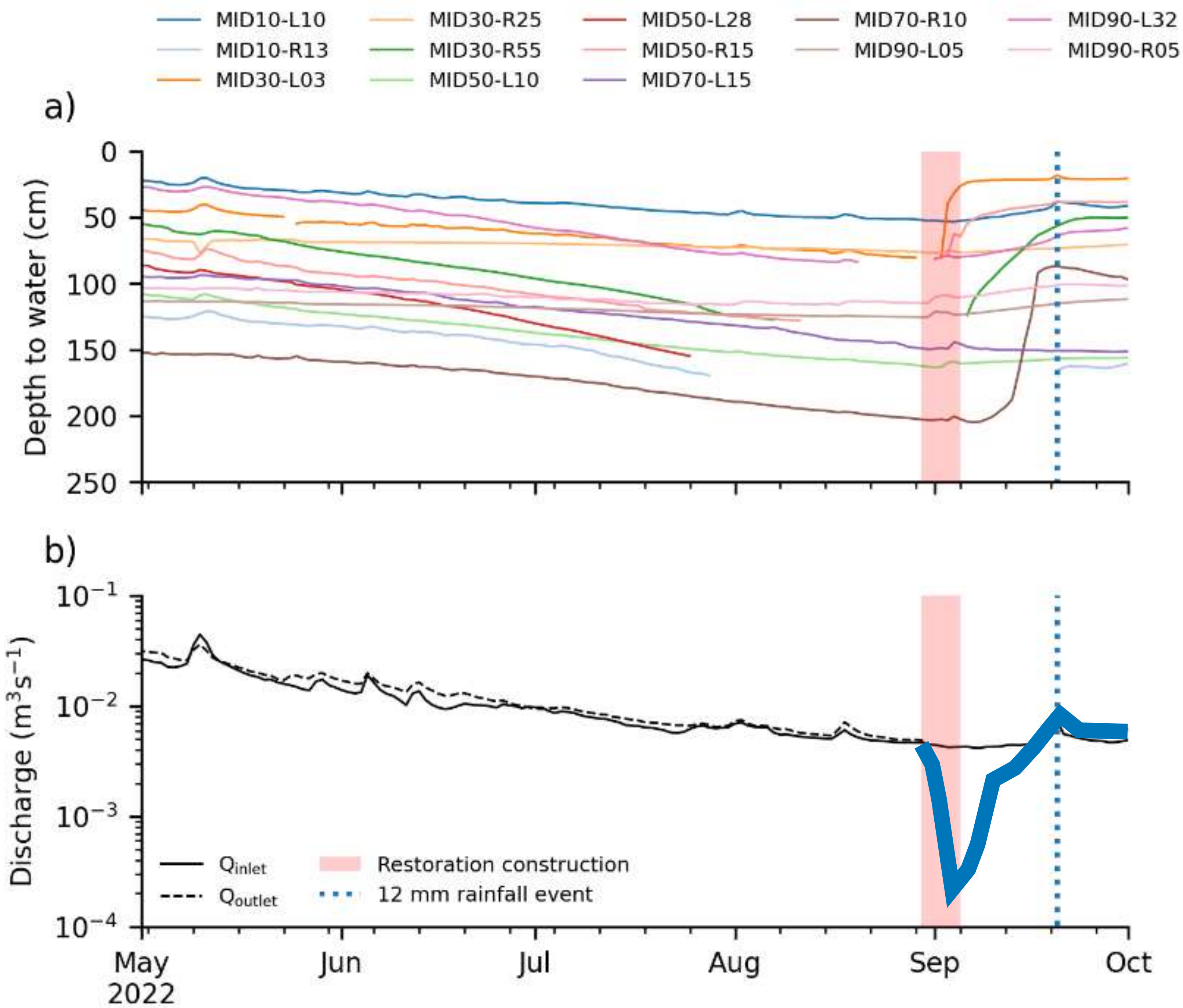

July 2023
HV01


HV01
New Flow River Right

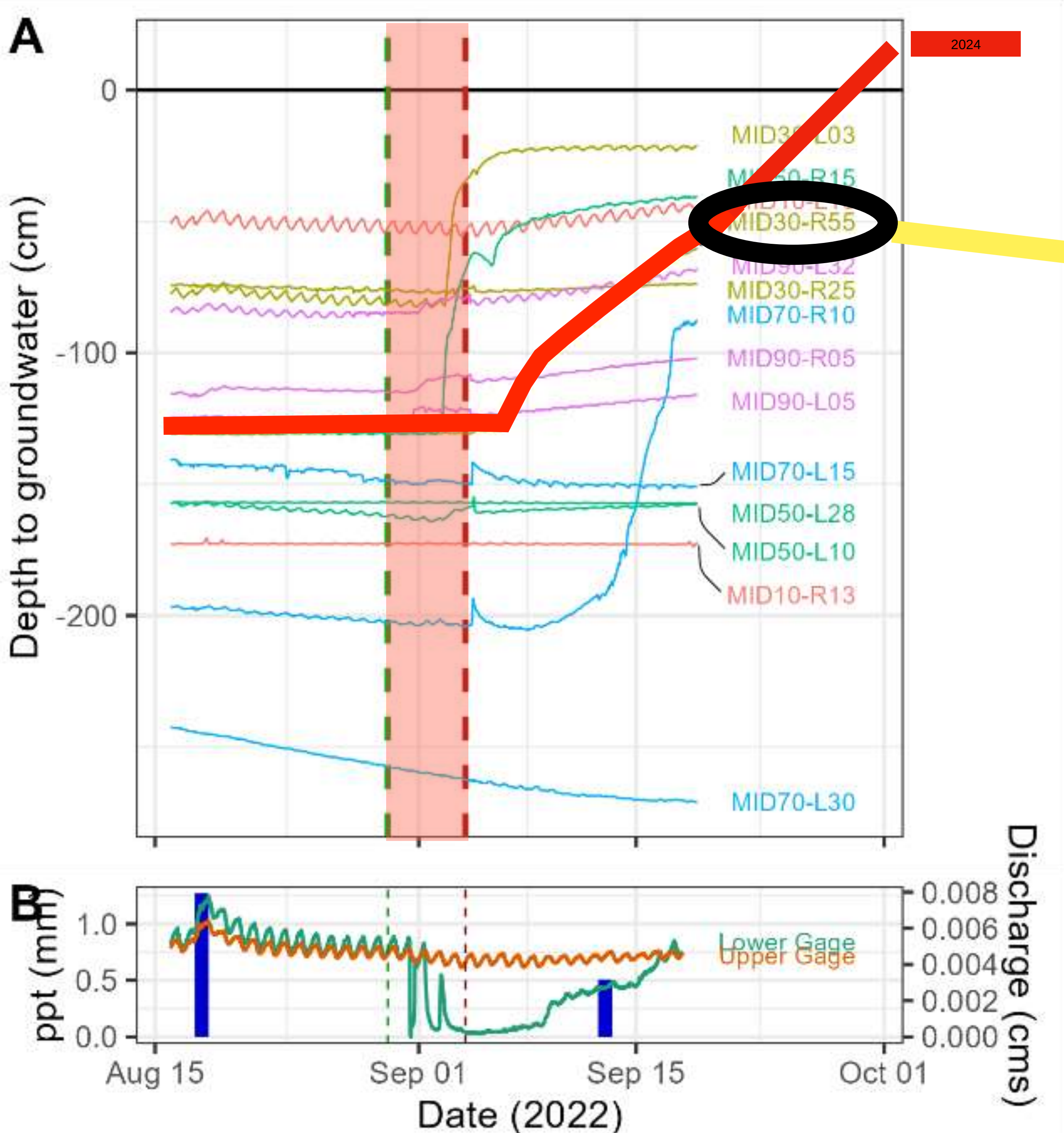

New Flow River Right
4' Lift

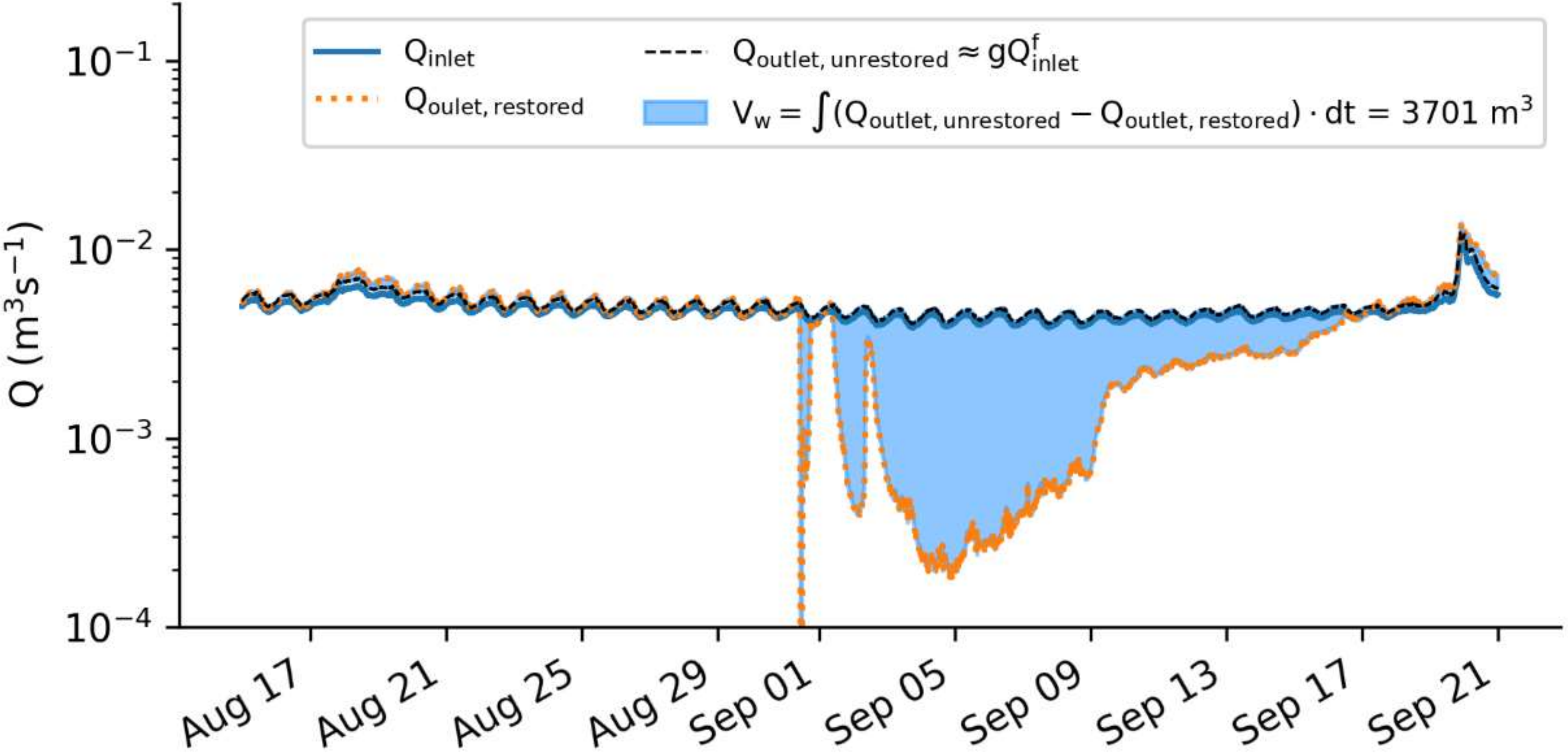
Patrick Jarrett, DWR



David Dralle, Sevier Et Al



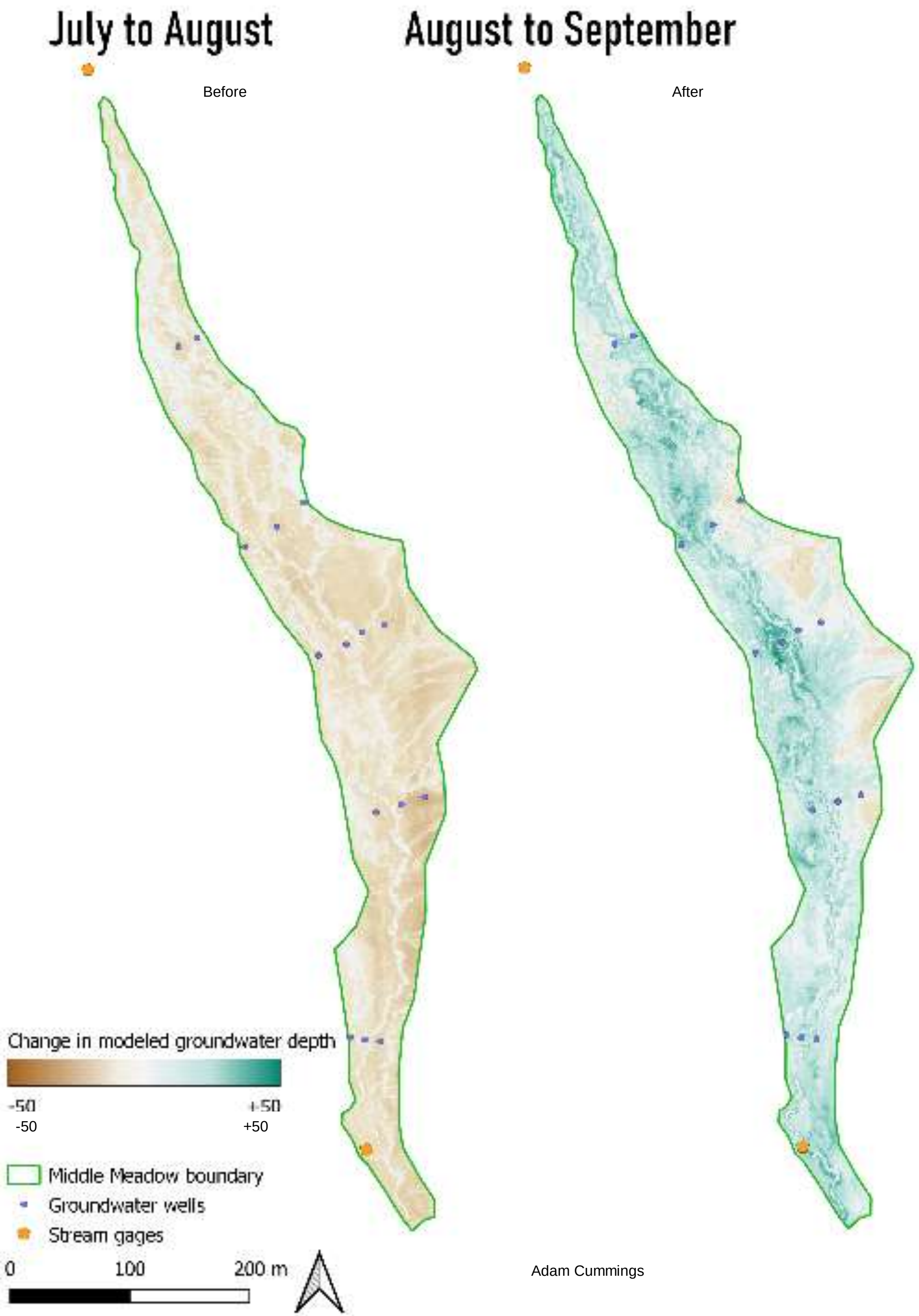
Adam Cummings



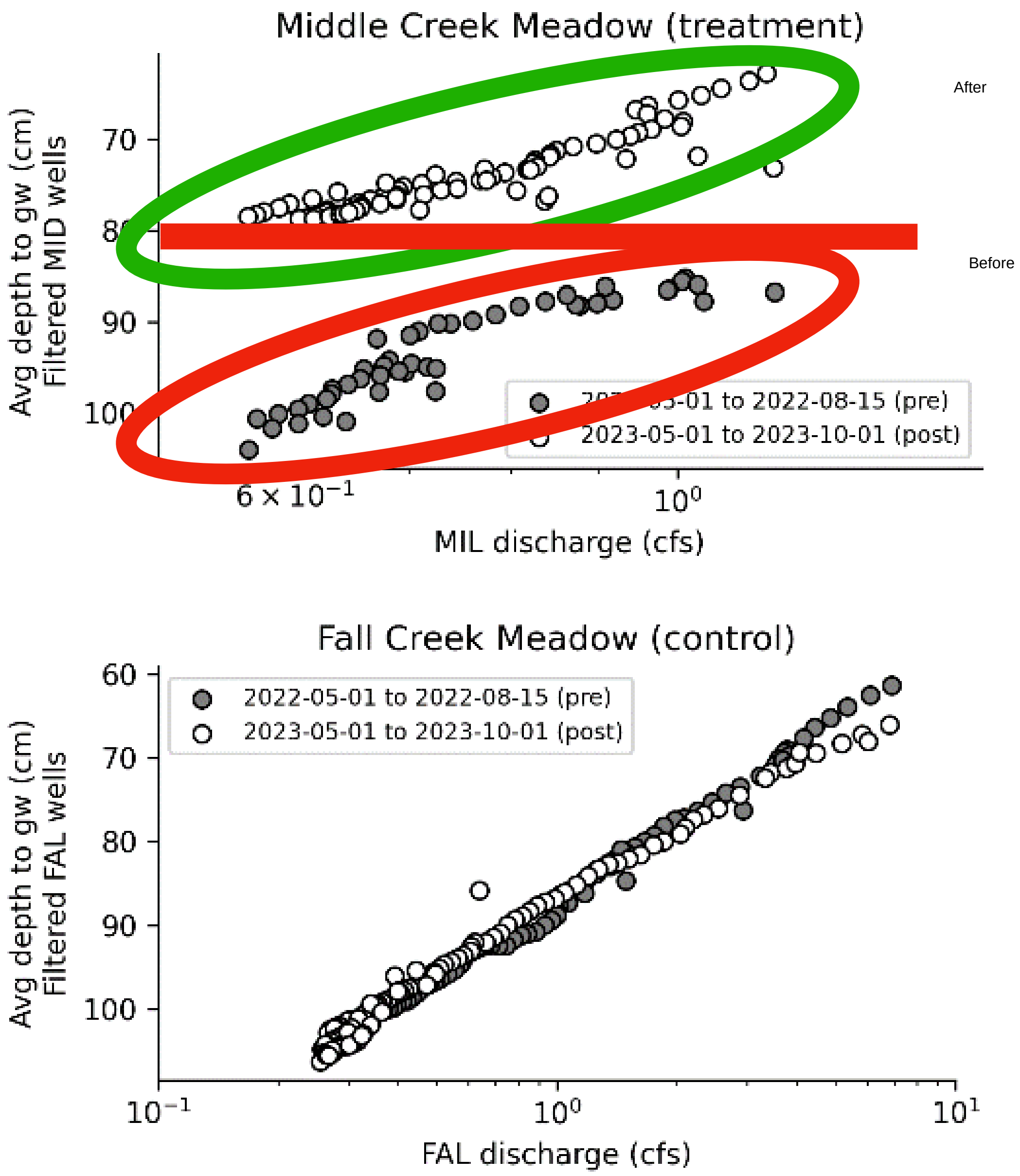
Q_inlet
Q_outlet, unrestored ≈ gQ^f_inlet
Q_oulet, restored
V_w = ∫(Q_outlet, unrestored − Q_outlet, restored) · dt = 3701 m^3
Q (m^3 s^−1)
10^−1
10^−2
10^−3
10^−4
Aug 17
Aug 21
Aug 25
Aug 29
Sep 01
Sep 05
Sep 09
Sep 13
Sep 17
Sep 21

Sevier Et AL

Groundwater elevation

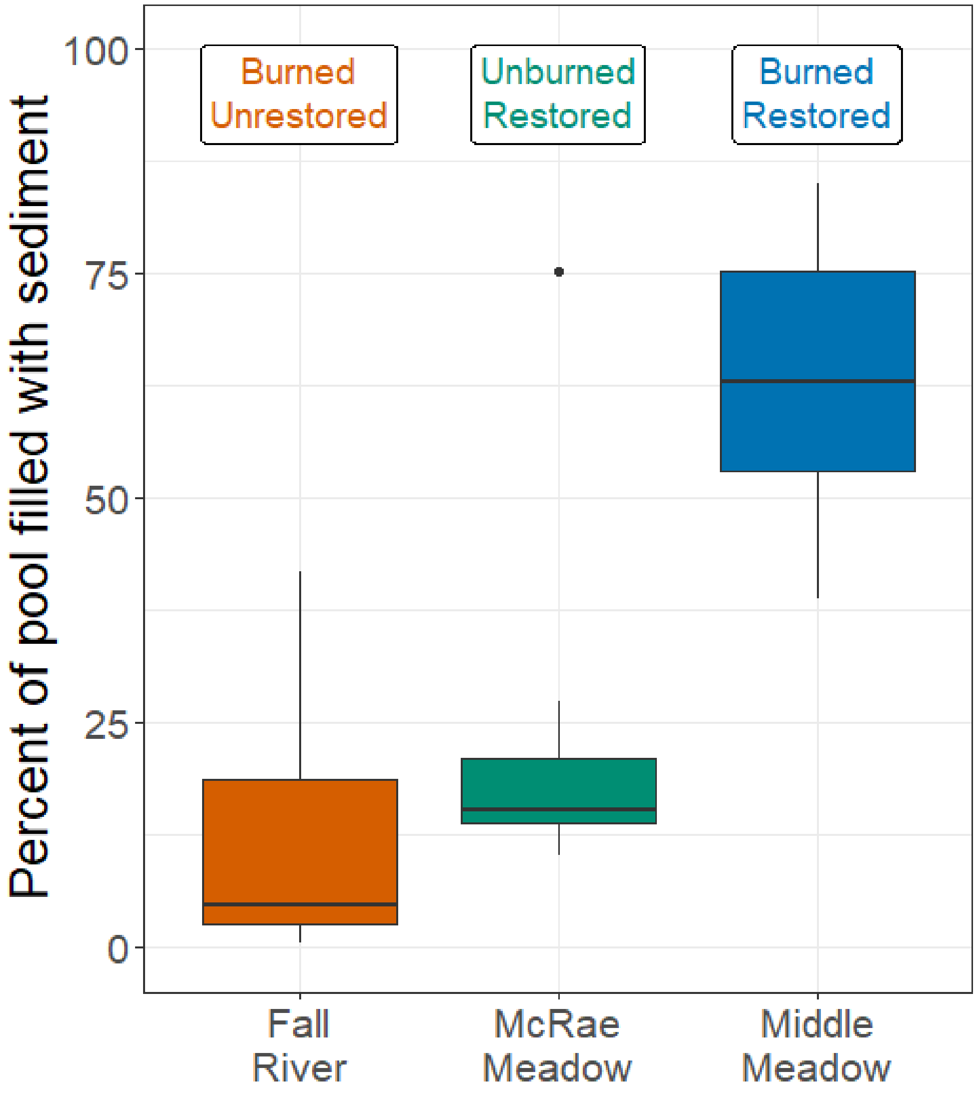


Adam Cummings



David Dralle

Sediment capture can be dramatic in burned landscapes

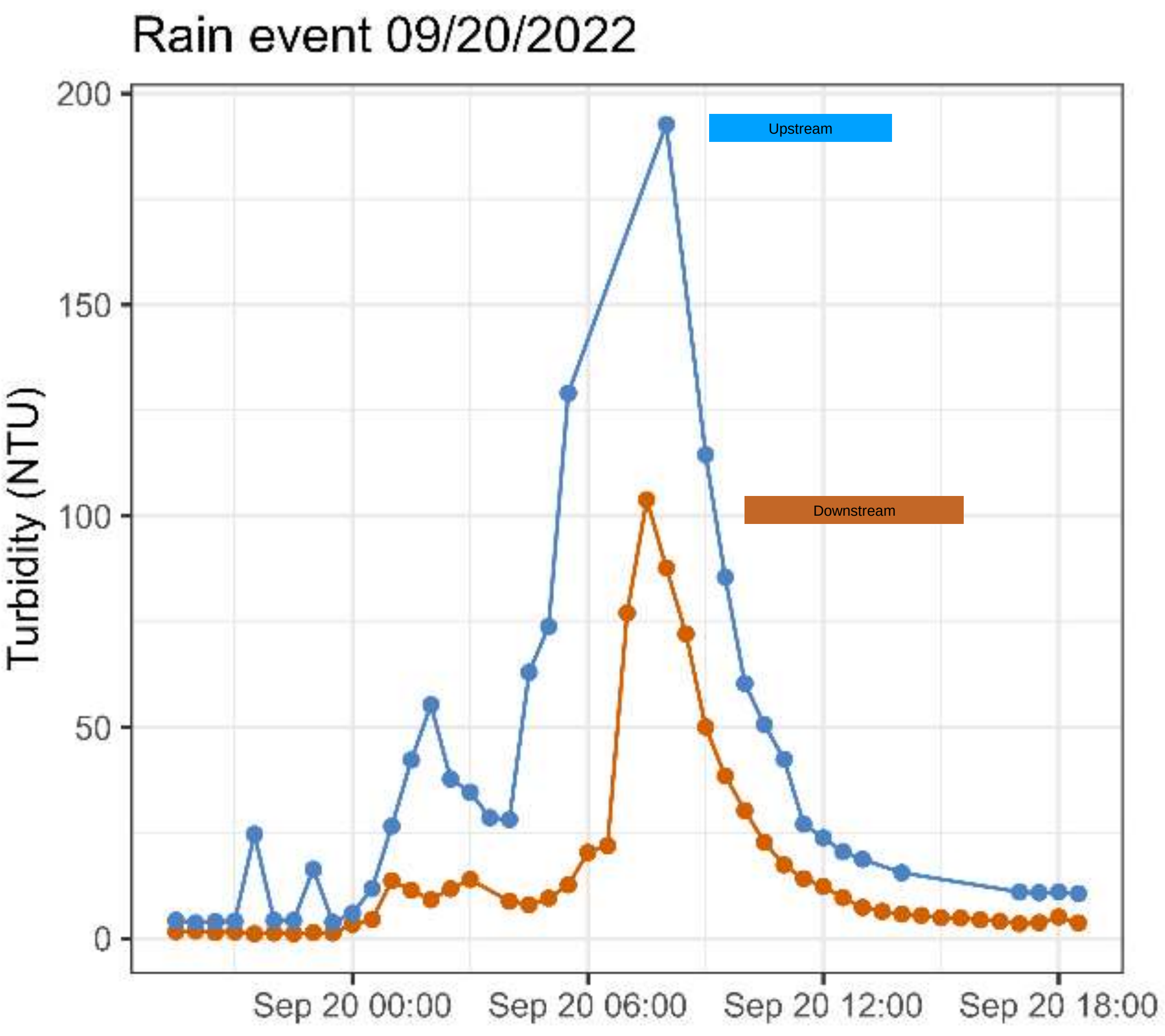


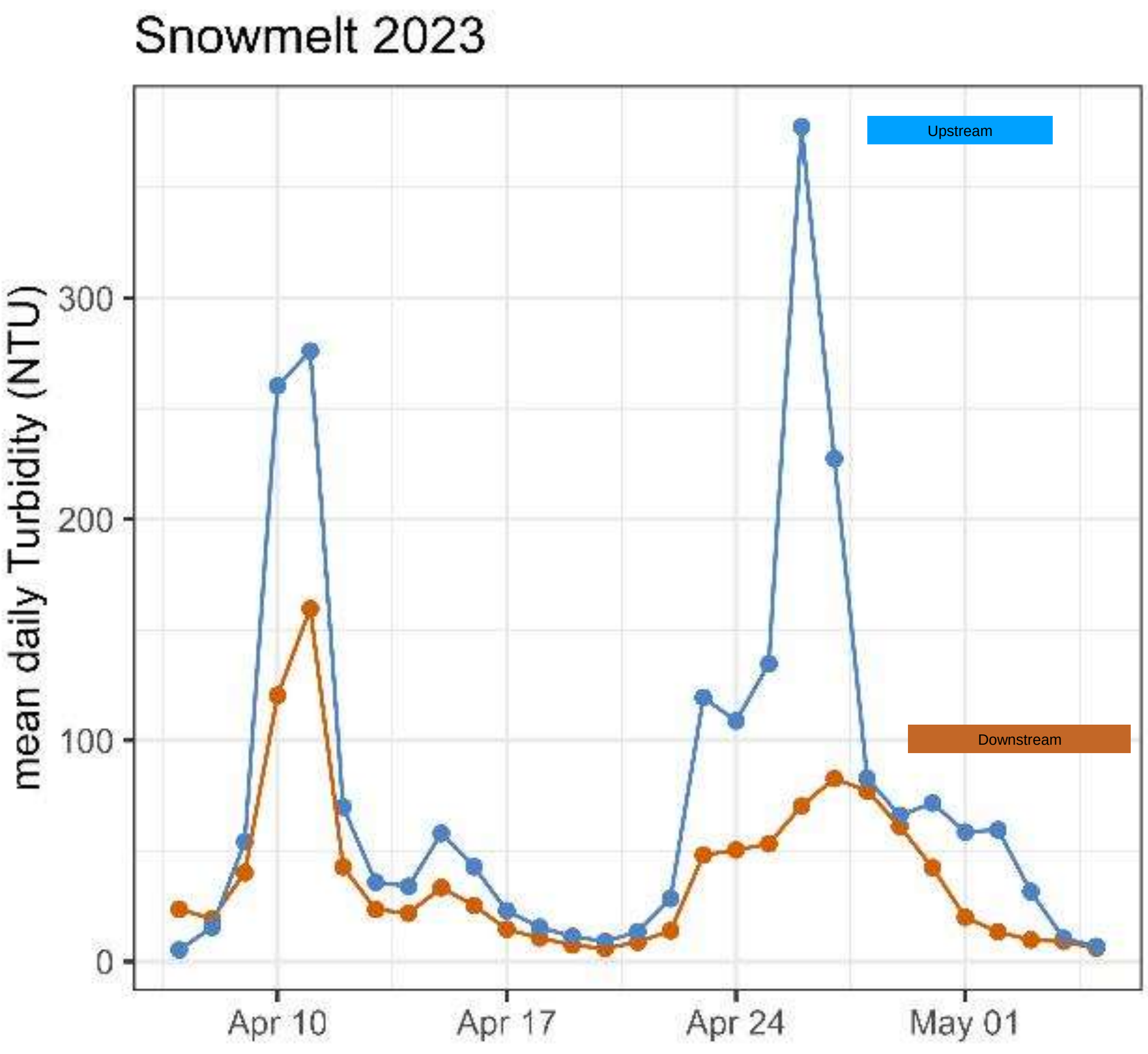
Karen Pope (K-Po)


CS 24
CS 23
CS 22
CS 19
CS 20
CS 21
CS 18
CS 15
CS 16
CS 12
CS 14
CS 13
CS 10
CS 8
CS 9
CS 7
CS 26
CS 25
CS 6
CS 4
CS 5
CS 3
CS 2
CS 1
CS 27
CS 28


New Flow

Leonard Creek, Upper Klamath



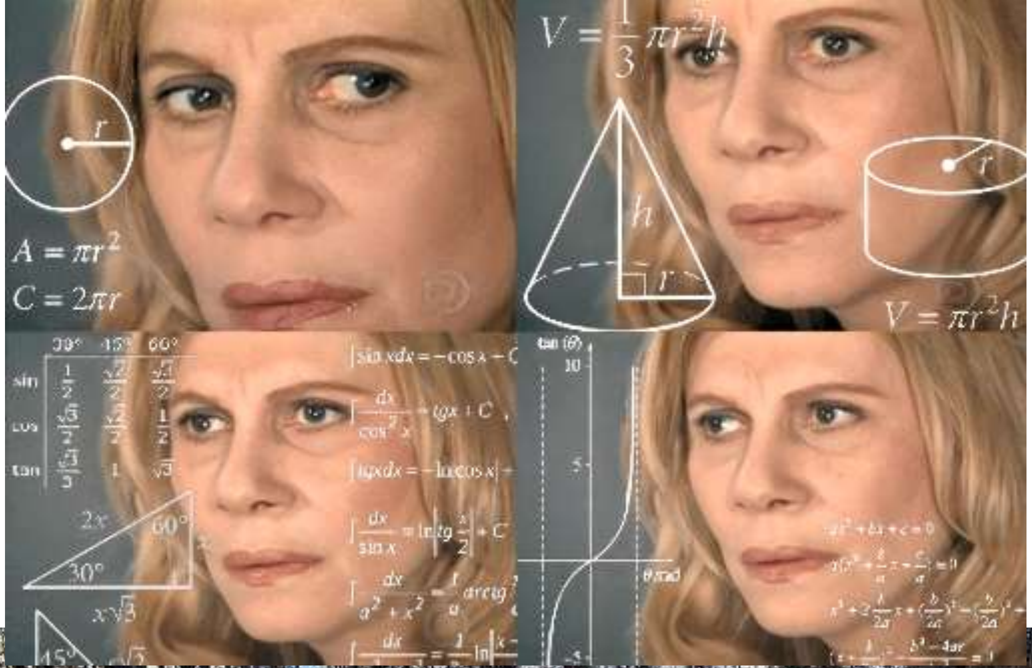


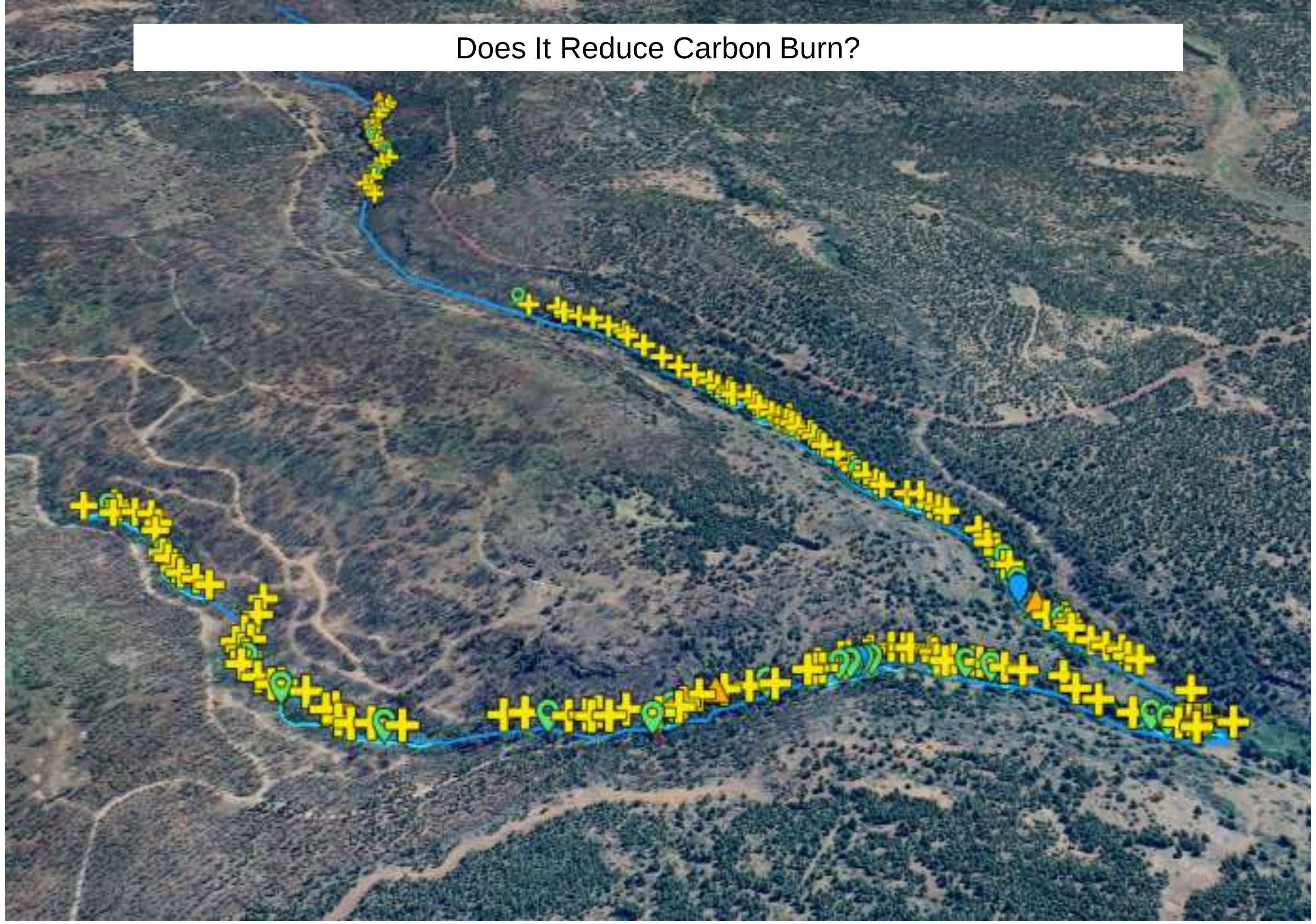

May 3, 2023


October 13, 2022
1M of aggradation
April, 2022


October 13, 2022

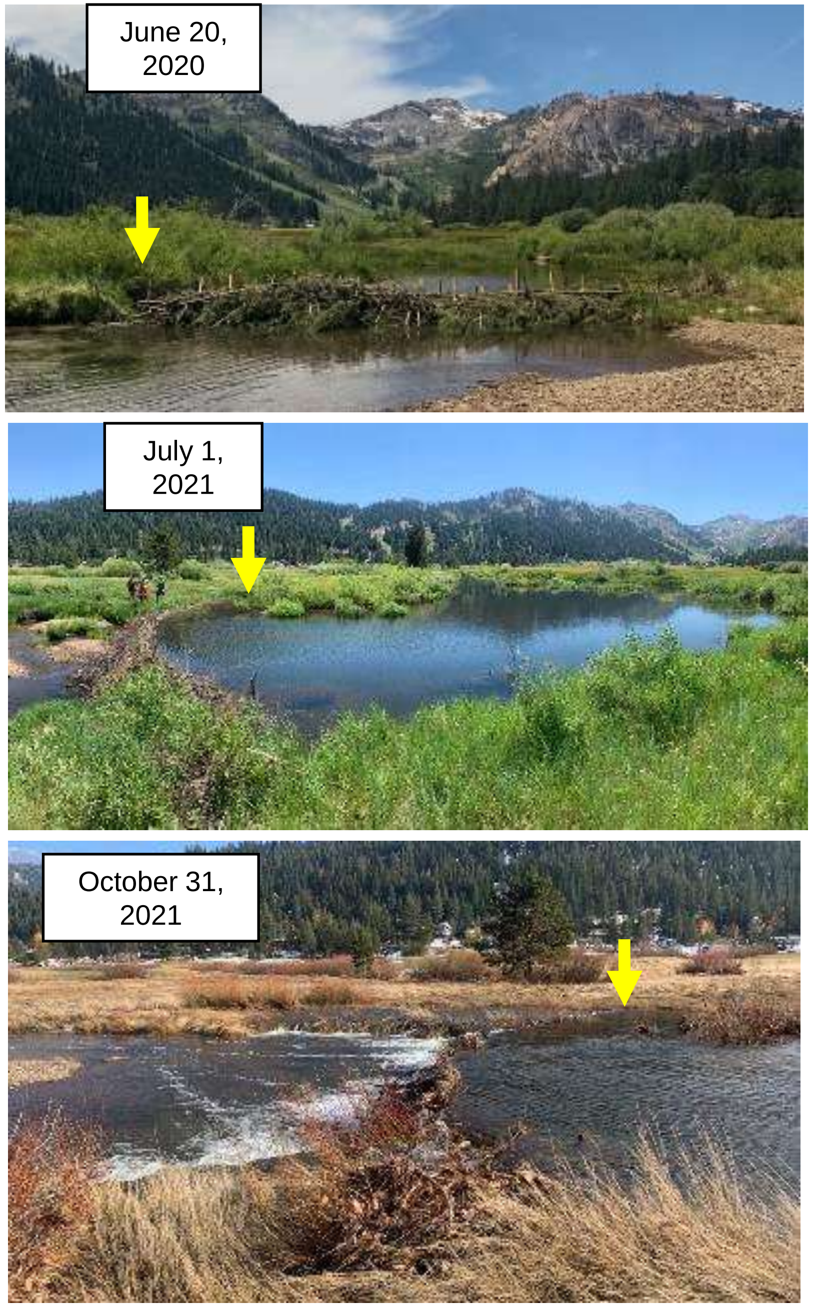
Does It Reduce Carbon Burn?





Deming Creek

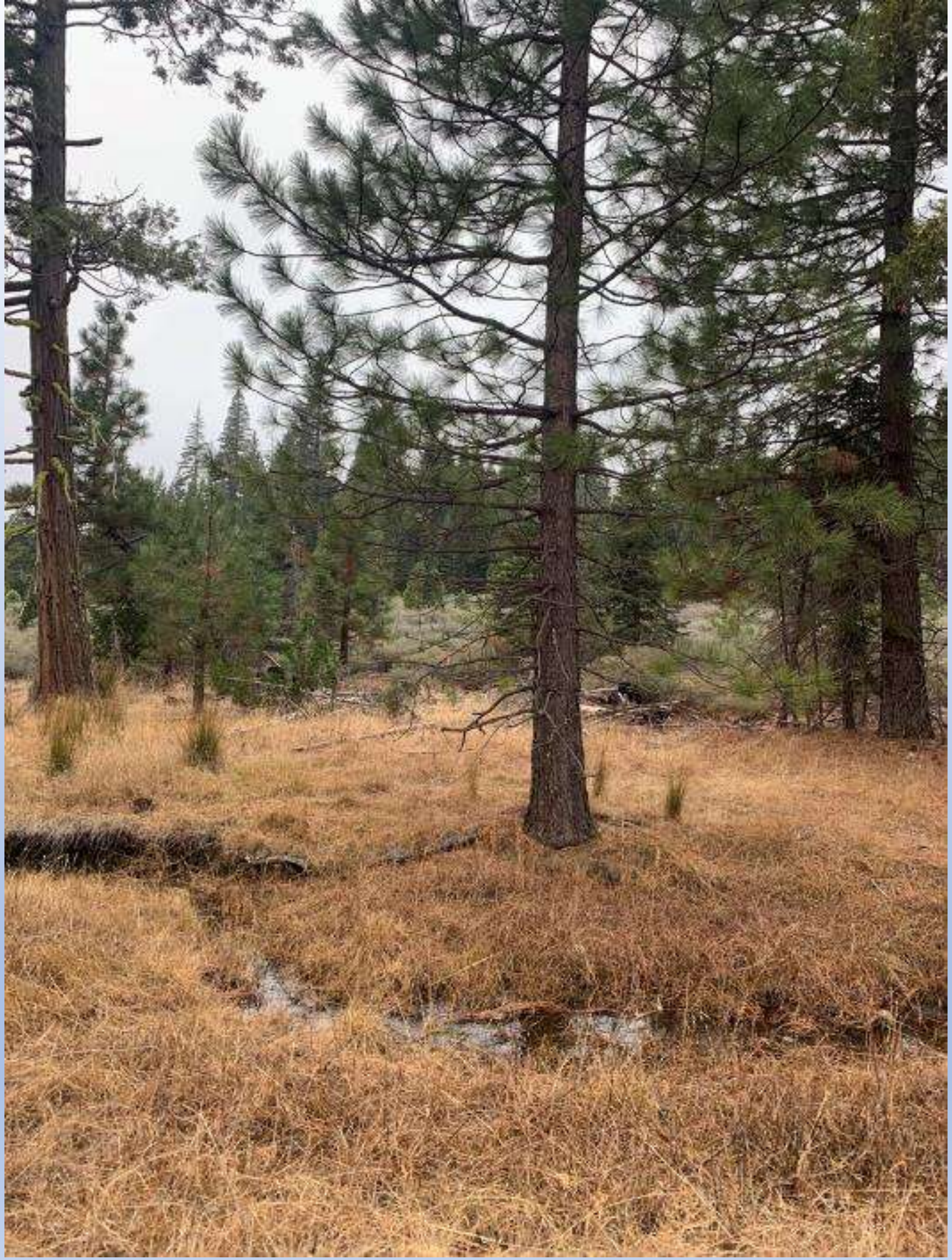
Ozempic Valley (Palisades)



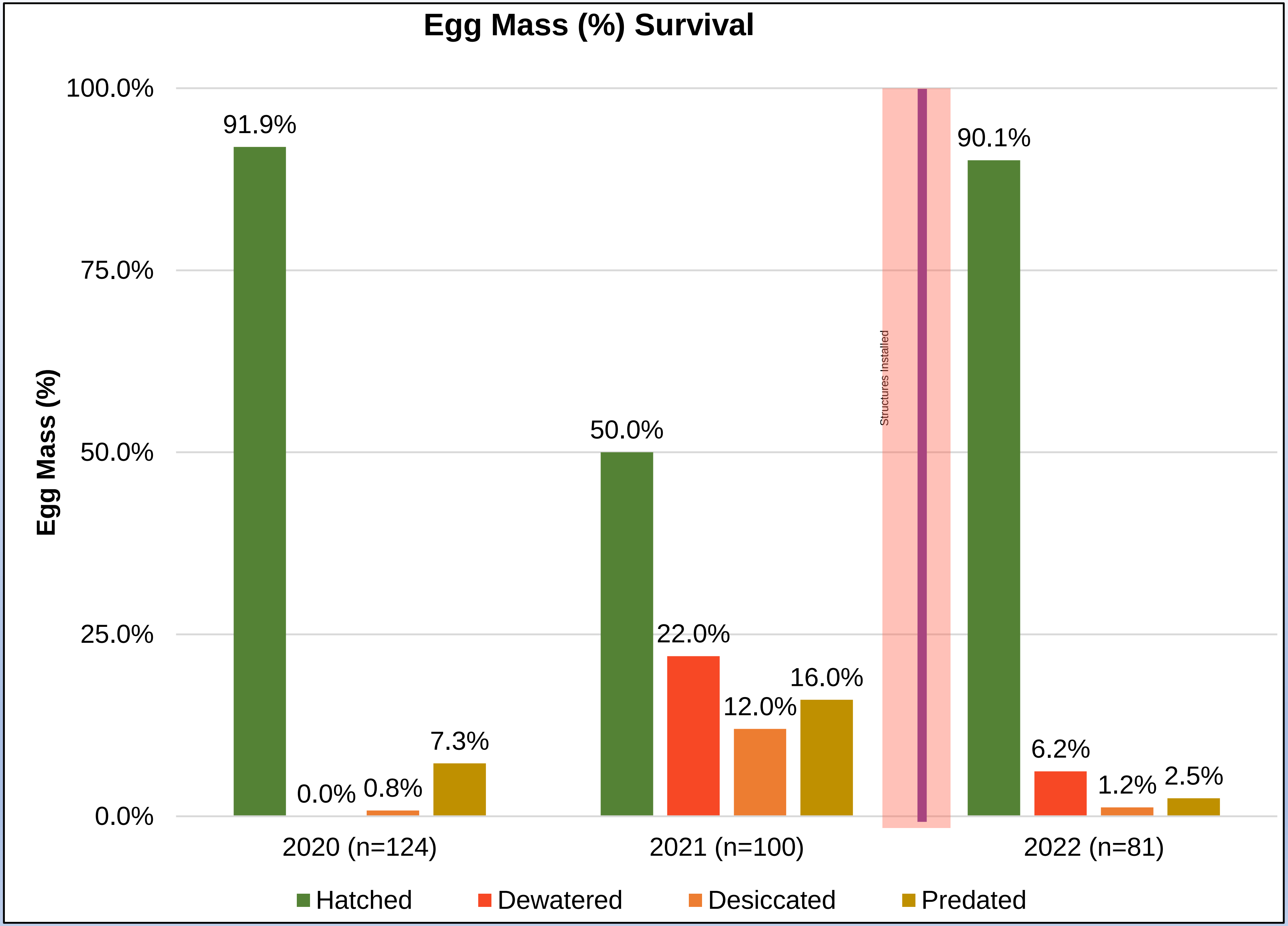
Is It Fast?

Maybe it's fast, but does it work for RTE species?

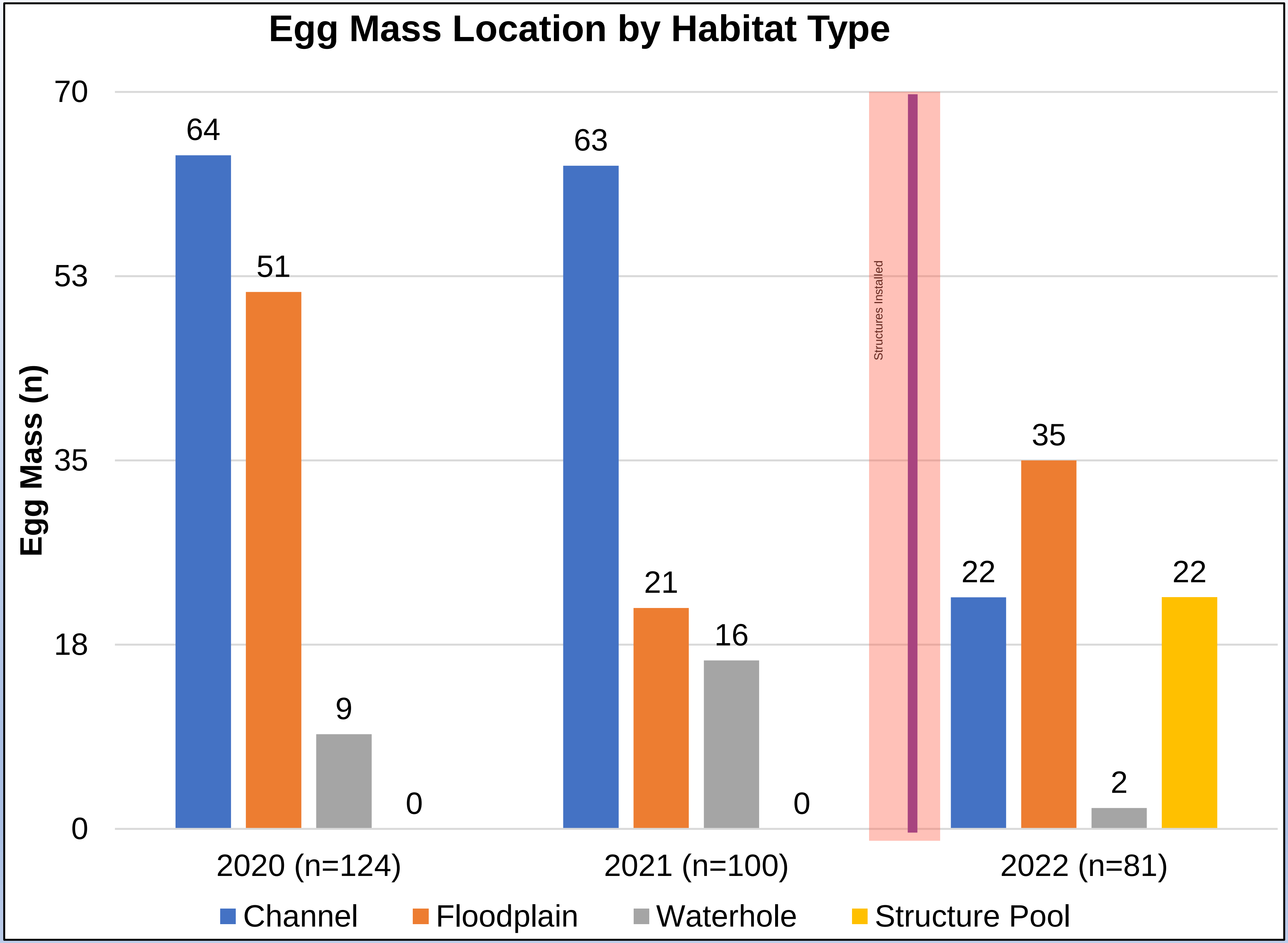
Before —December 11, 2020

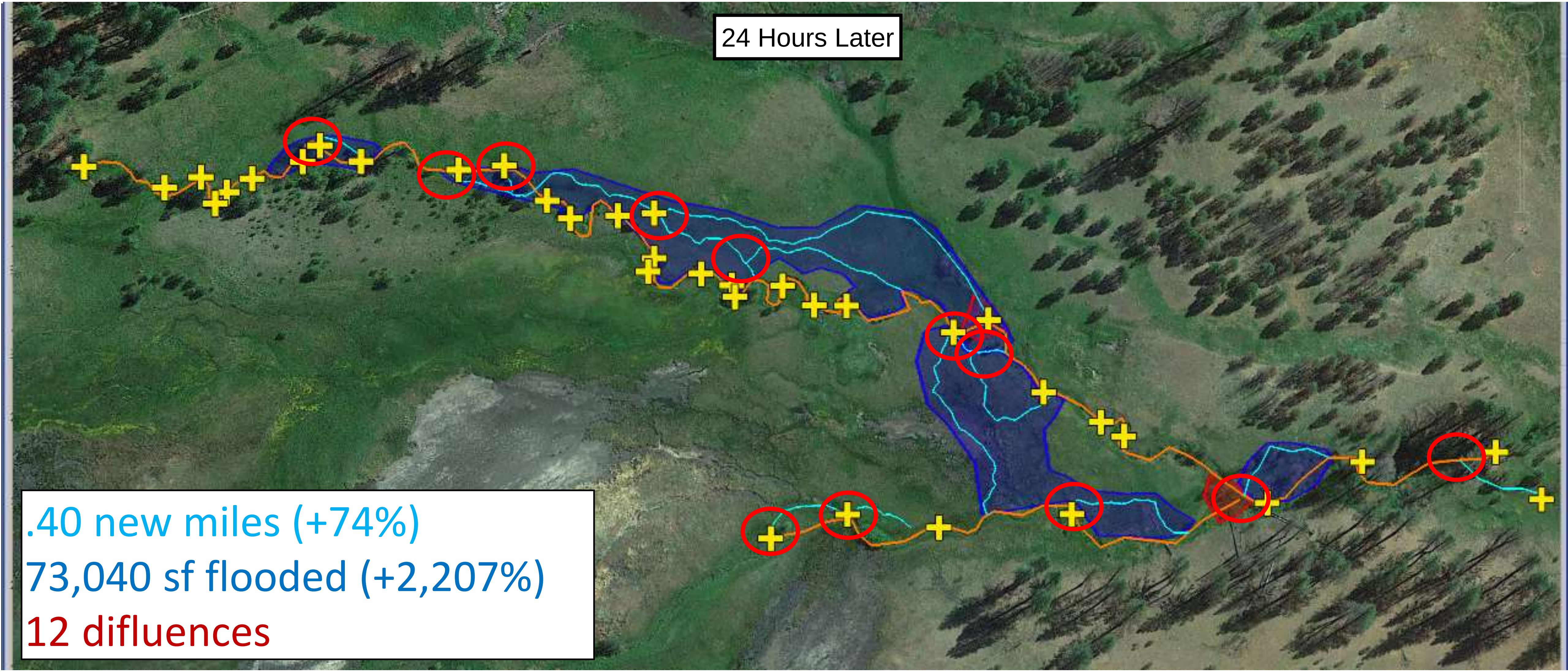


After — November 6, 2021

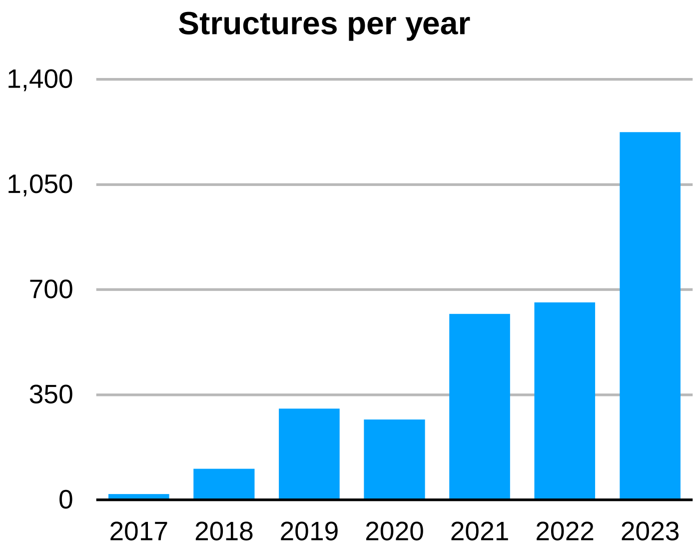


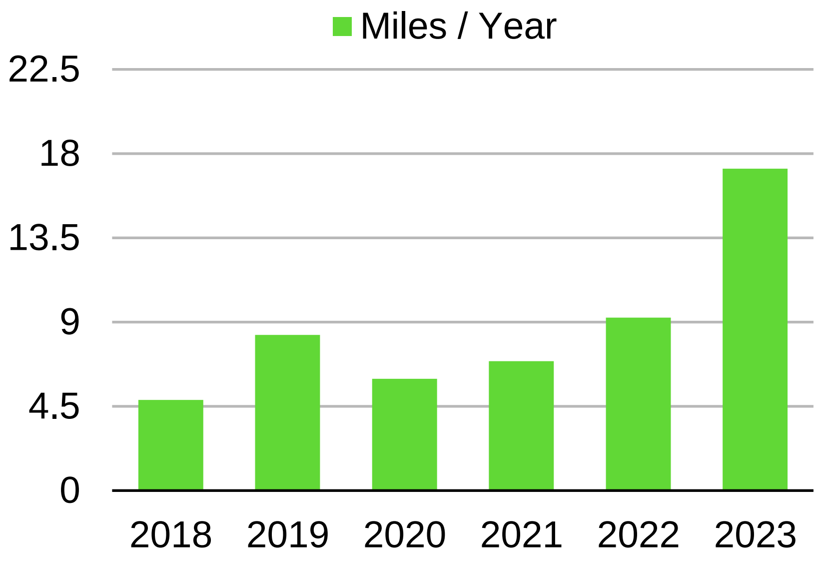
Egg Mass (%) Survival
Egg Mass (%)
100.0%
75.0%
50.0%
25.0%
0.0%
91.9%
0.0%
0.8%
7.3%
50.0%
22.0%
12.0%
16.0%
Structures Installed
90.1%
6.2%
1.2%
2.5%
2020 (n=124)
2021 (n=100)
2022 (n=81)
Hatched
Dewatered
Desiccated
Predated

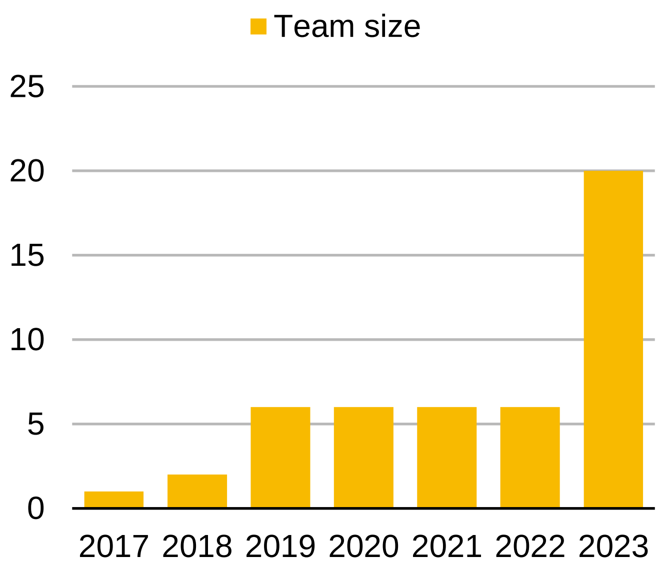

Egg Mass Location by Habitat Type
Egg Mass (n)
70
53
35
18
0
64
51
9
0
63
21
16
0
Structures Installed
22
35
2
22
2020 (n=124)
2021 (n=100)
2022 (n=81)
Channel
Floodplain
Waterhole
Structure Pool

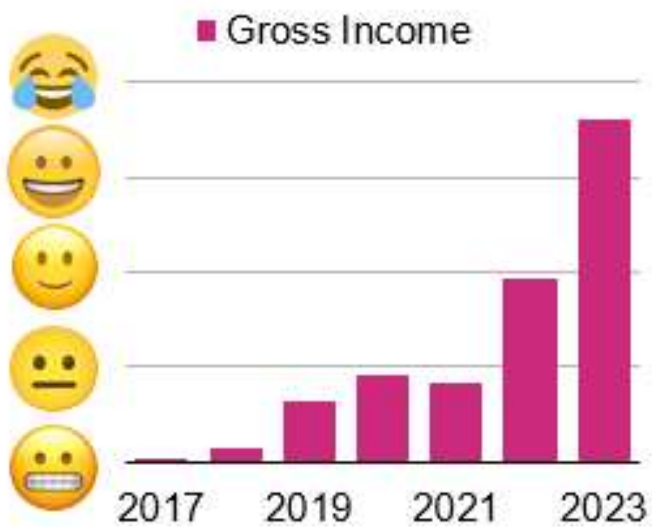

24 Hours Later
.40 new miles (+74%)
73,040 sf flooded (+2,207%)
12 difluences

Does It Work As A Business?









How DYNAMITE *streamlines streams*

Straightening of Pequest River in New Jersey by CCC workers stopped its yearly floods. Location of new channel is seen at right. Note temporary dam at left to provide volume of water for scouring blasted channel.

Explosion of dynamite charge by propagation excavates new channel.

Immediately after explosion, water is entering new channel, whose banks will be smoothed and "stream-lined" by the speedier flow of water.

CROOKED STREAMS are a menace to life and crops in the areas bordering on their banks. The twisting and turning of the channel retards the flow and reduces the capacity of the stream to handle large volumes of water. Floods result. Crops are ruined. Lives are lost. Banks are undermined, causing cave-ins that steal valuable acreage.

In many instances straightening out a stream has doubled its capacity for disposing of run-off water.

DYNAMITE may be used most efficiently and economically in taking the kinks out of a crooked stream. The dynamite is loaded along the length of "cut-off" channel. When fired, the dirt and other debris is heaved high in the air and is scattered over the adjoining territory—leaving practically no spoil-banks. In addition to the material actually thrown out, much dirt is loosened and is later scoured out by the water which rushes swiftly through the straightened channel.

Du Pont Dynamite has straightened many thousands of miles of crooked streams. Du Pont engineers have worked for years to develop the best blasting methods for the cleaning out and straightening of streams. All their data is in a 48-page book, "Ditching with Dynamite." It is for your use. Write for it.

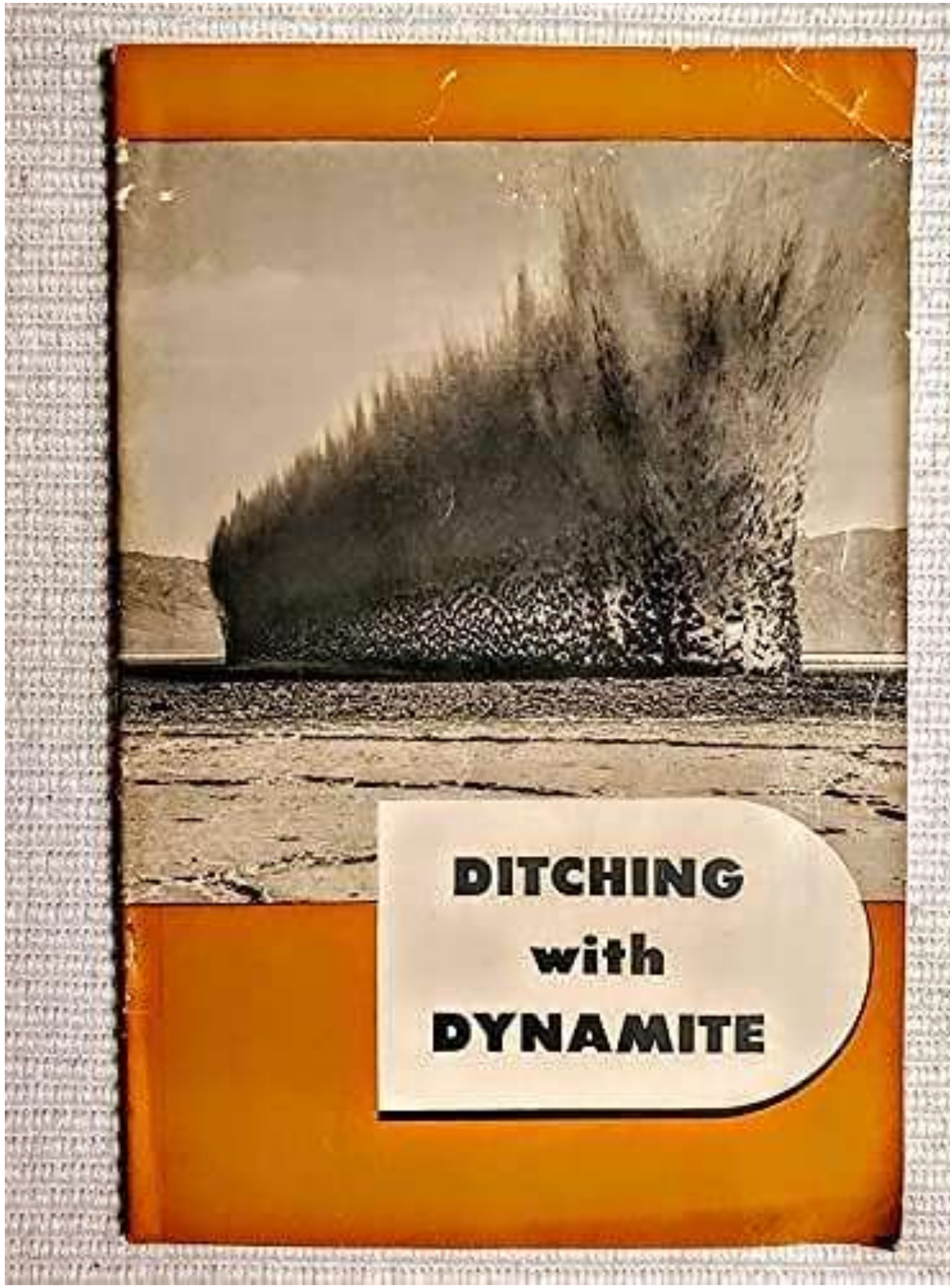
Dynamite can help you do other jobs, too. It can help you build highways, dams; fight soil erosion; work quarries. Du Pont has an explosive for every purpose.

DUPONT

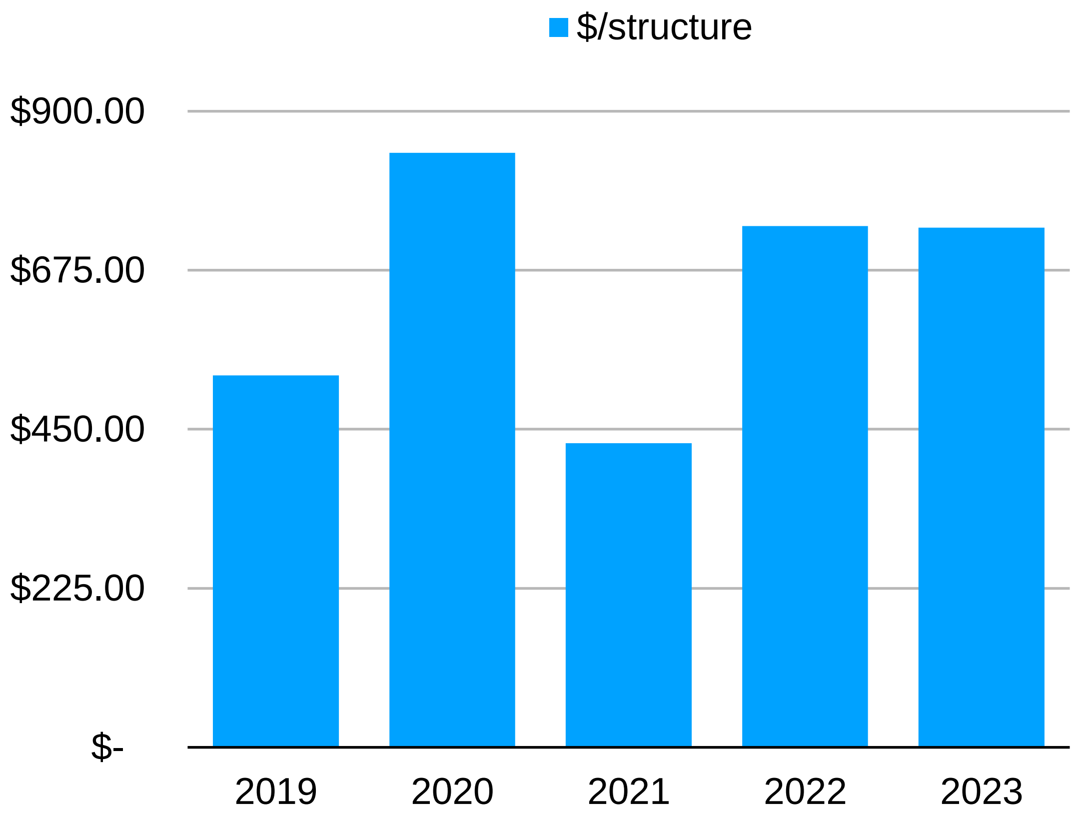
E. I. du Pont de Nemours & Co. Inc.
Explosives Department
6107 du Pont Building

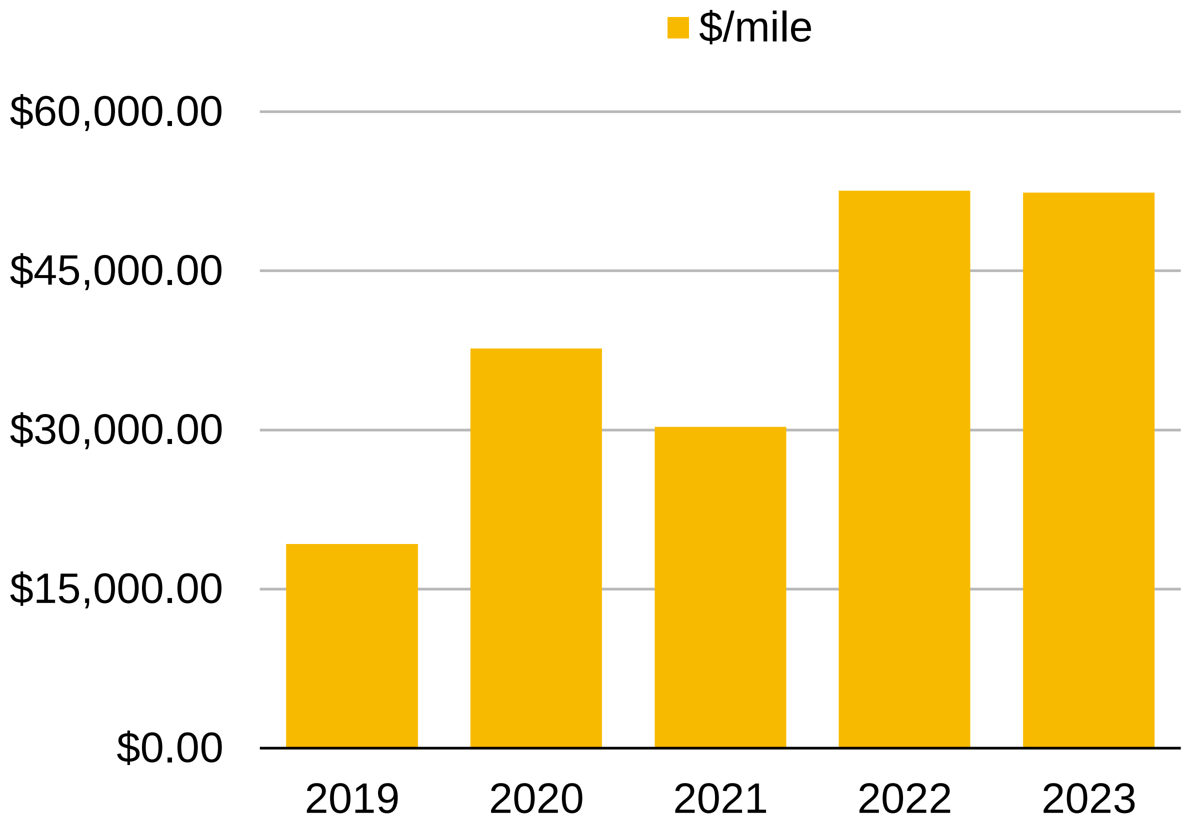
"Crooked streams are a menace to life and crops in the areas bordering on their banks."

"DuPont Dynamite has straightened **many thousands of miles** of crooked streams."



Does it Scale,
or does it get 4x more expensive with 4x the people?



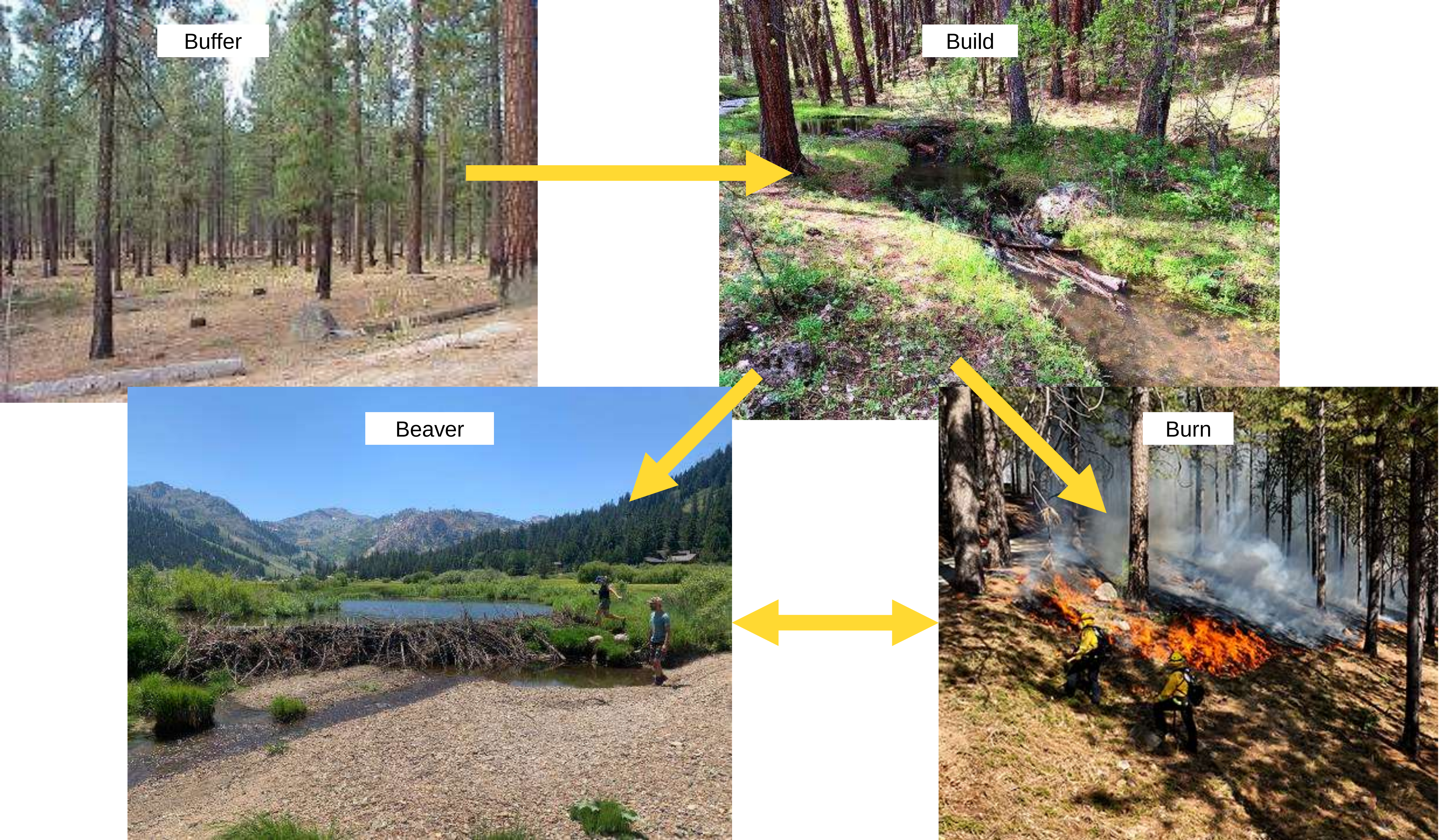


Does it work for local economies?

Worker Owned

VS

Owned by Darth Vader


Buffer
Build
Beaver
Burn

Process-based restoration in burned headwater meadows: exploring potential for sediment storage and floodplain reconnection

Authors: Kate Wilcox, Adam Cummings, Chris Pluhar, David Dralle, Kevin Swift, Emma Sevier, Joe Wagenbrenner, John Whiting, Paul Richardson, Karen Pope

FRESNO STATE
College of Science and Mathematics

THE GEOLOGICAL SOCIETY OF AMERICA

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

Pacific Southwest Research Station

System losing sediment

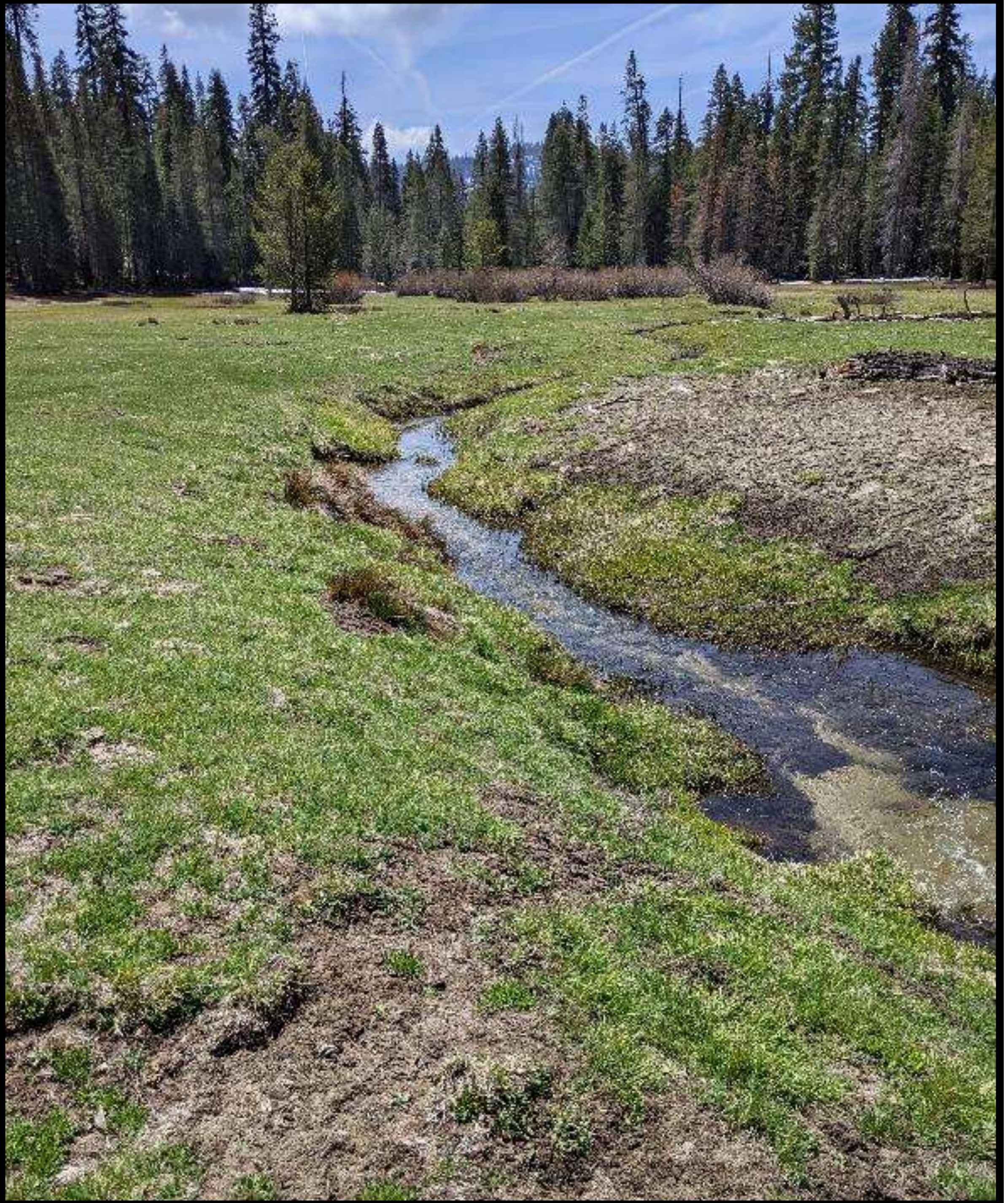
Sediment available for potential transport

Process-based restoration

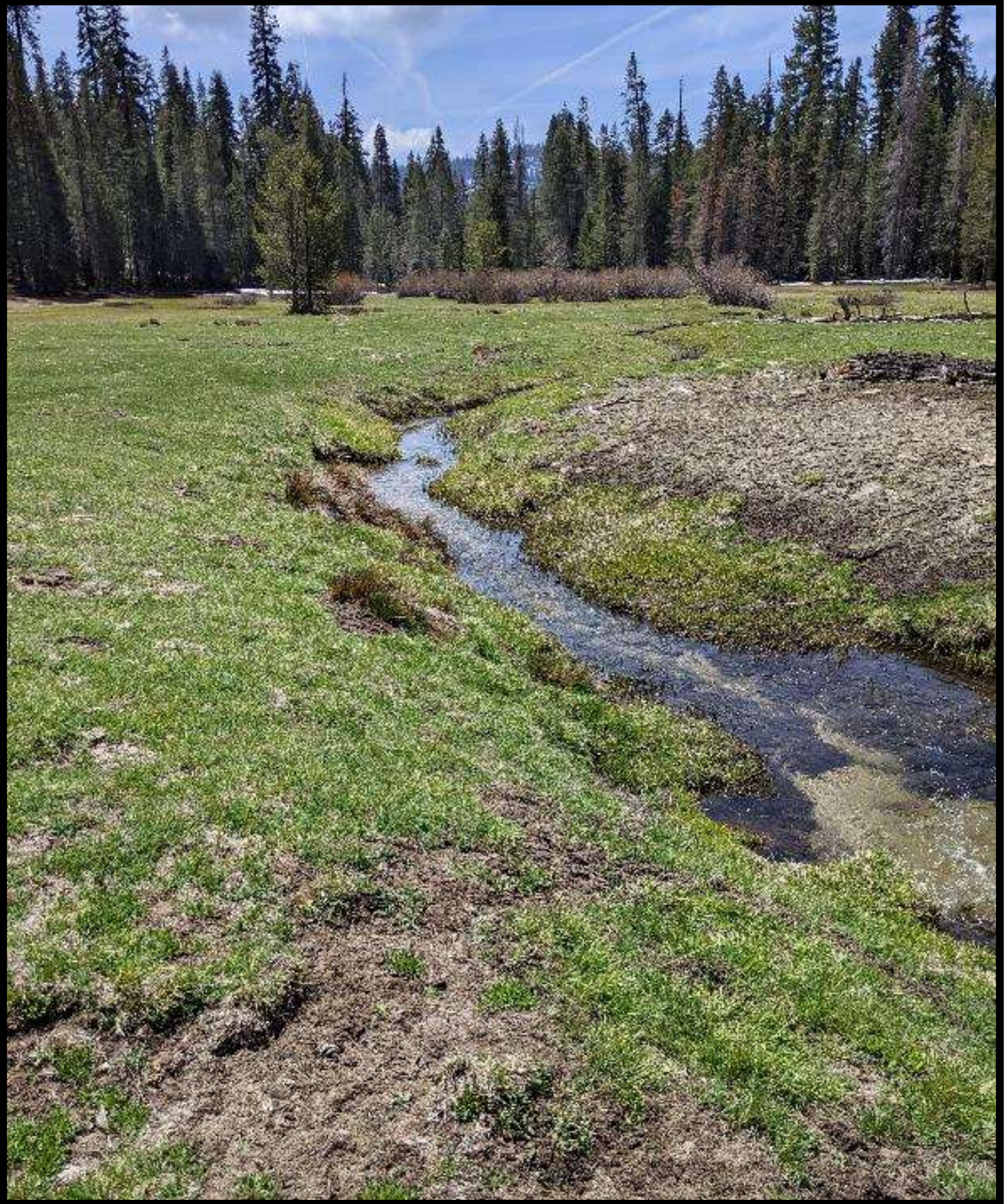
Too much sediment

Losing sediment

Process-based restoration in burned landscapes

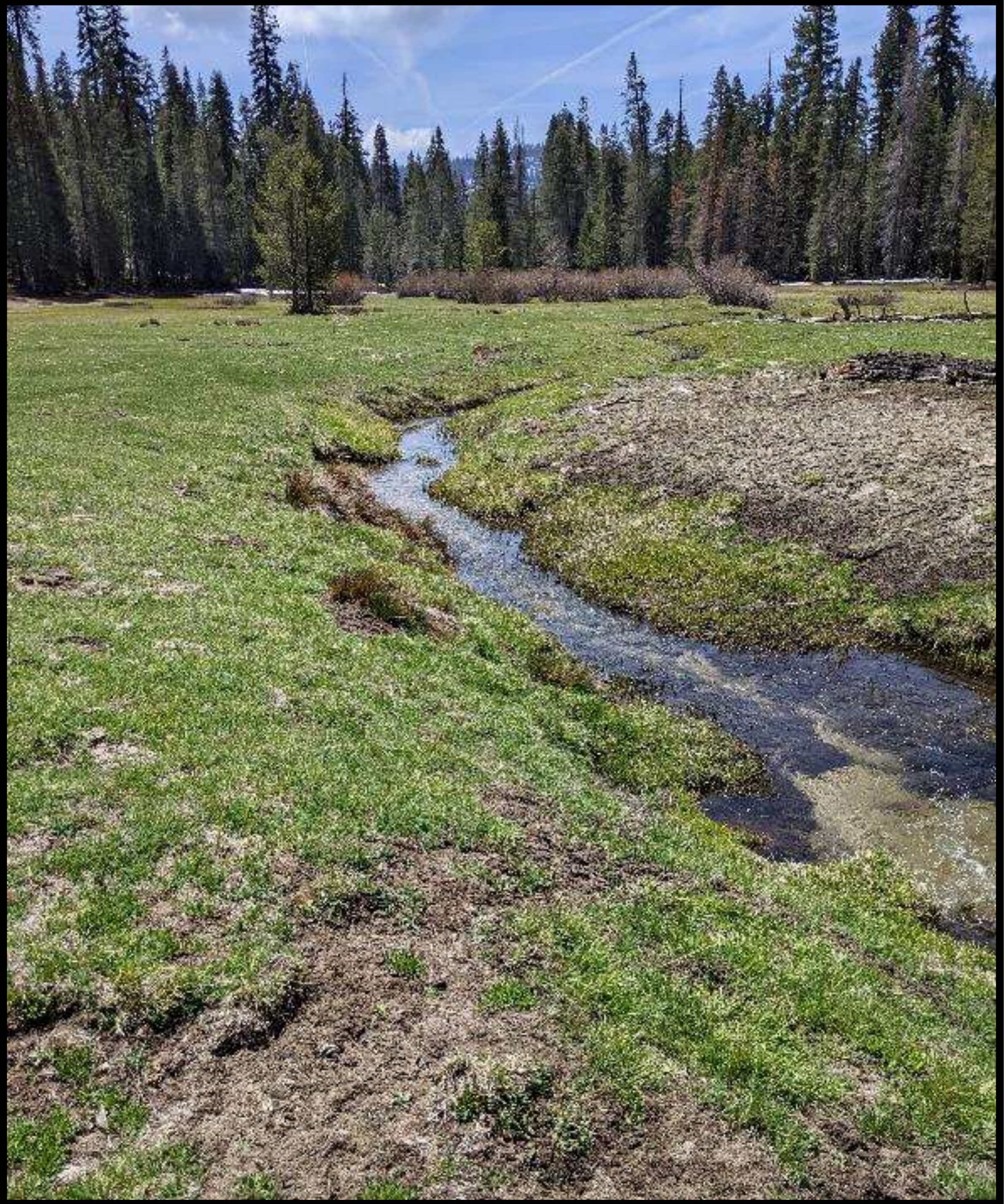


H1) More sediment is transported in burned than unburned meadows



H1) More sediment is transported in burned than unburned meadows

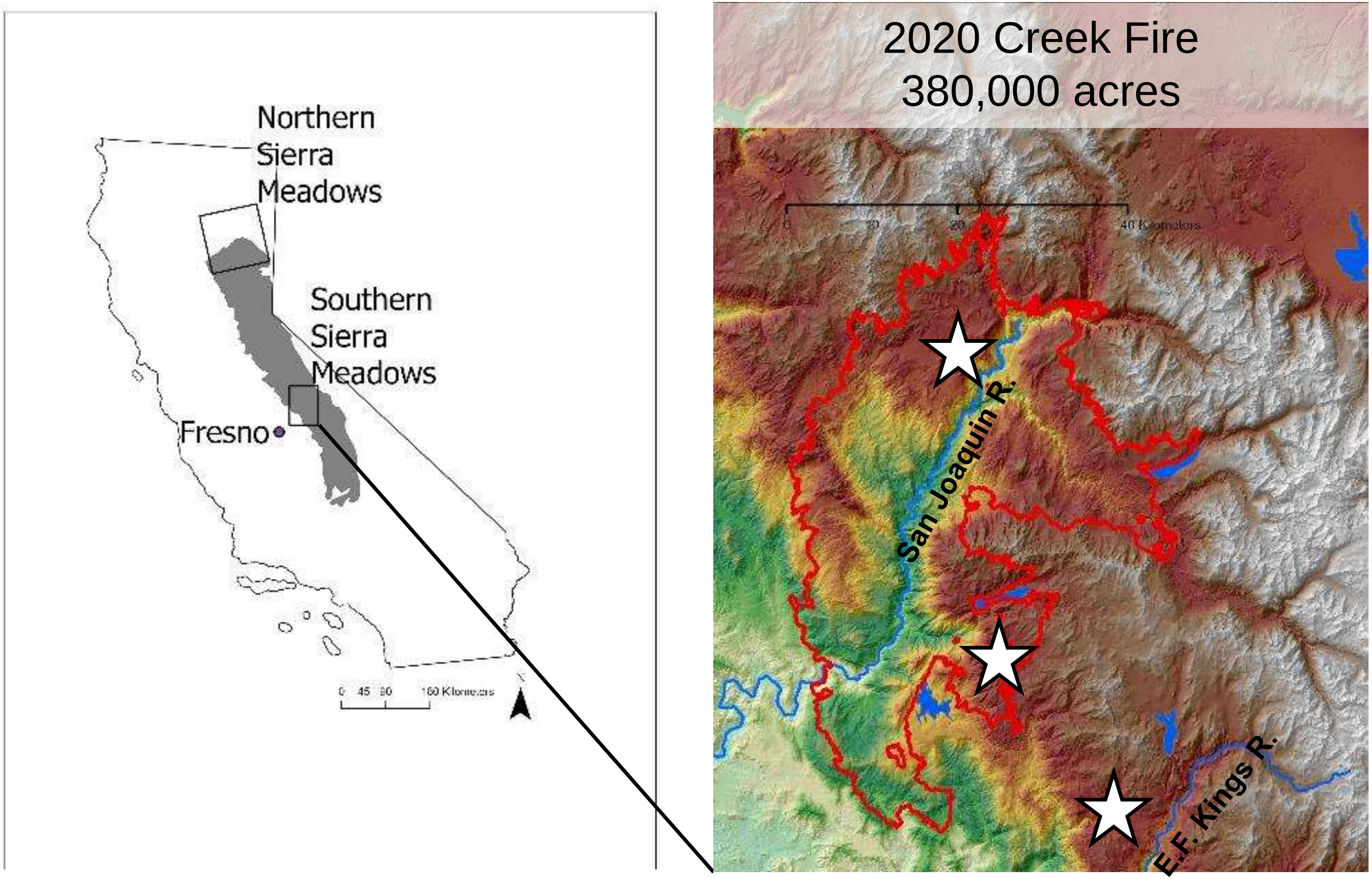
H2) Degraded reaches with process-based restoration structures capture more fine sediment than unrestored, degraded reaches.



H1) More sediment is transported in burned than unburned meadows.

H2) Degraded reaches with process-based restoration structures capture more fine sediment than unrestored, degraded reaches.

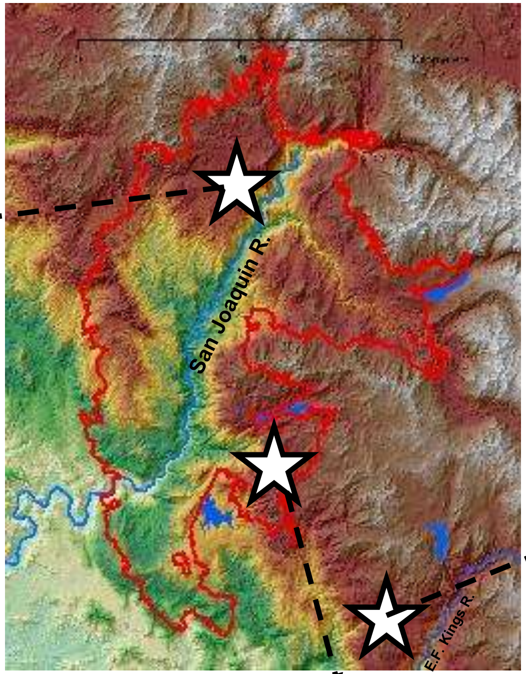
H3) Process-based restoration structures drive rapid meadow re-wetting and hydrologic complexity.



Northern Sierra Meadows
Southern Sierra Meadows
Fresno
2020 Creek Fire
380,000 acres
San Joaquin R.
E.F. Kings R.

McCreary Meadow

Burned
Elevation: 2036 m
Meadow: 6.1 hectares
Watershed: 414 hectares



Lower Grouse Meadow

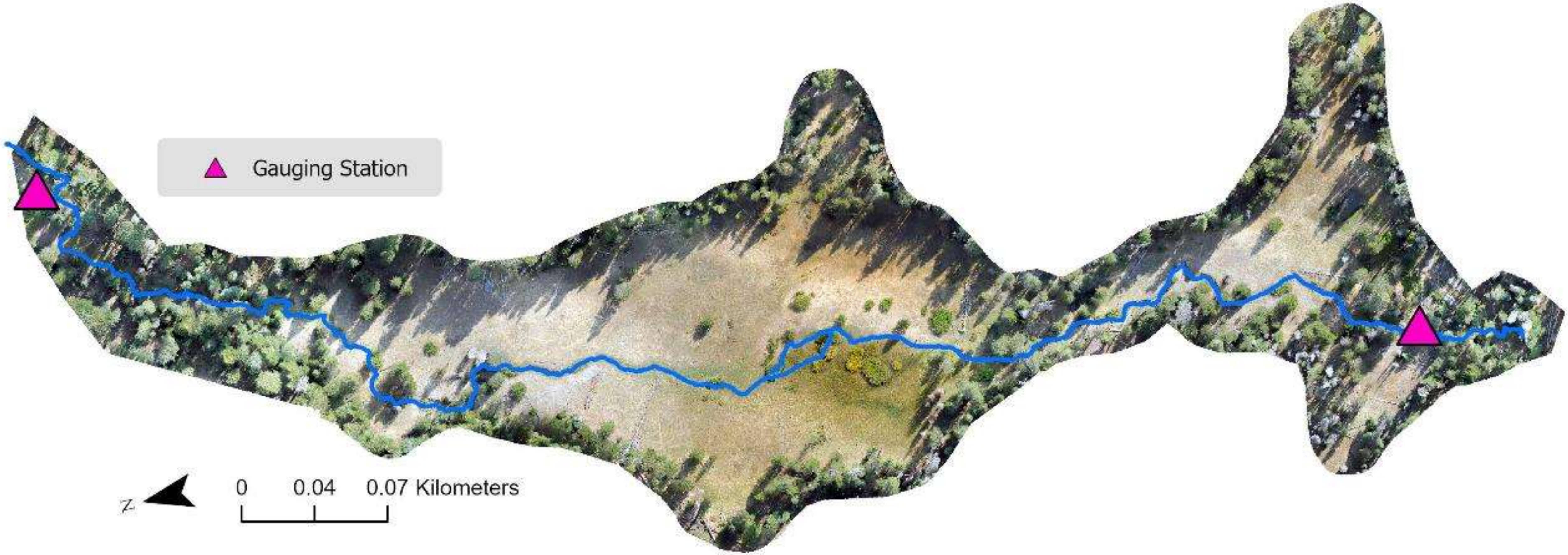
Burned
Elevation: 2230 m
Meadow: 3.56 hectares
Watershed: 104 hectares

Ahart Meadow

Unburned
Elevation: 2179 m
Meadow: 4.9 hectares
Watershed: 363 hectares

H1) More sediment is transported in burned than unburned meadows.

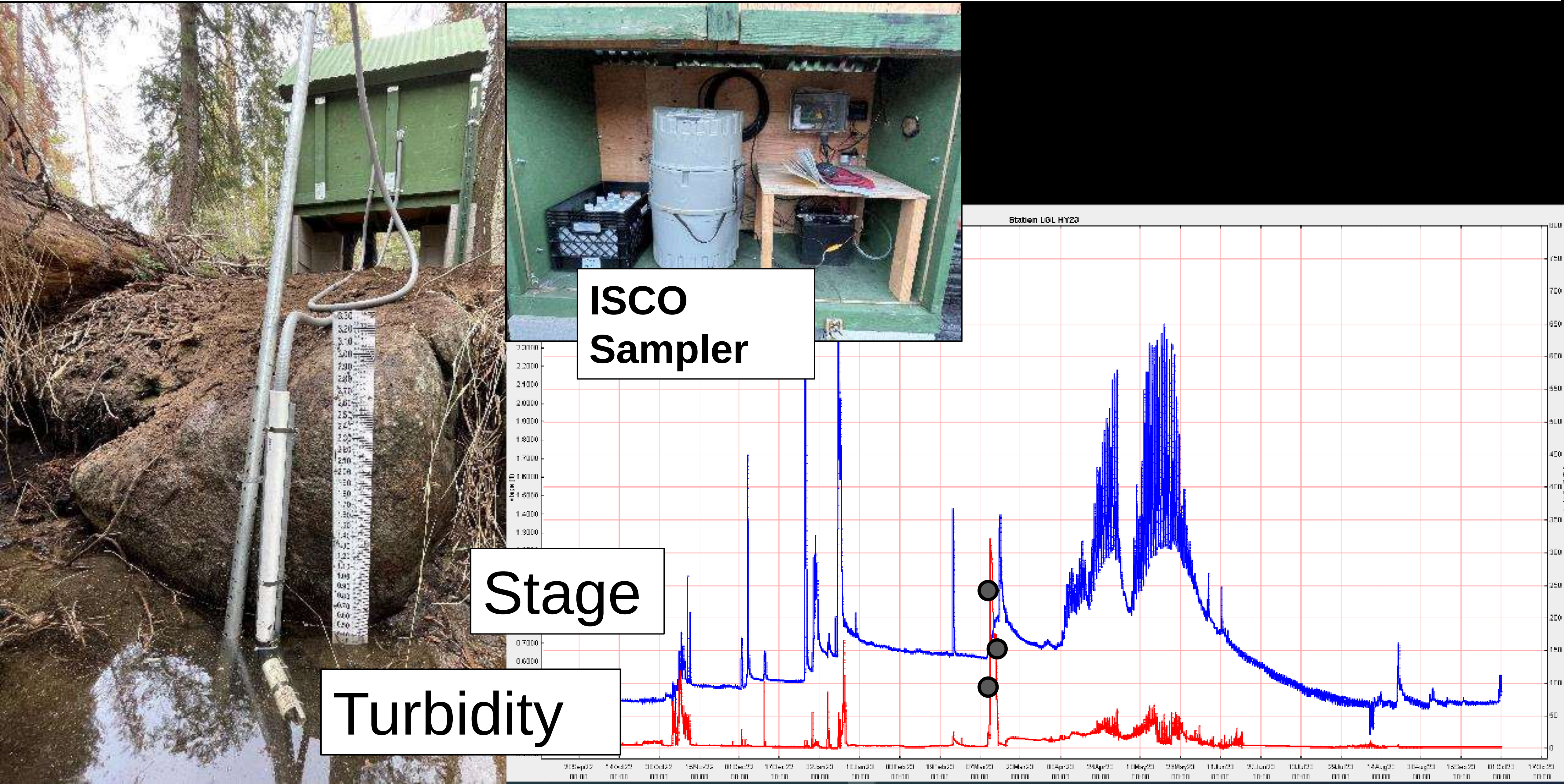
Upstream and downstream gauging stations



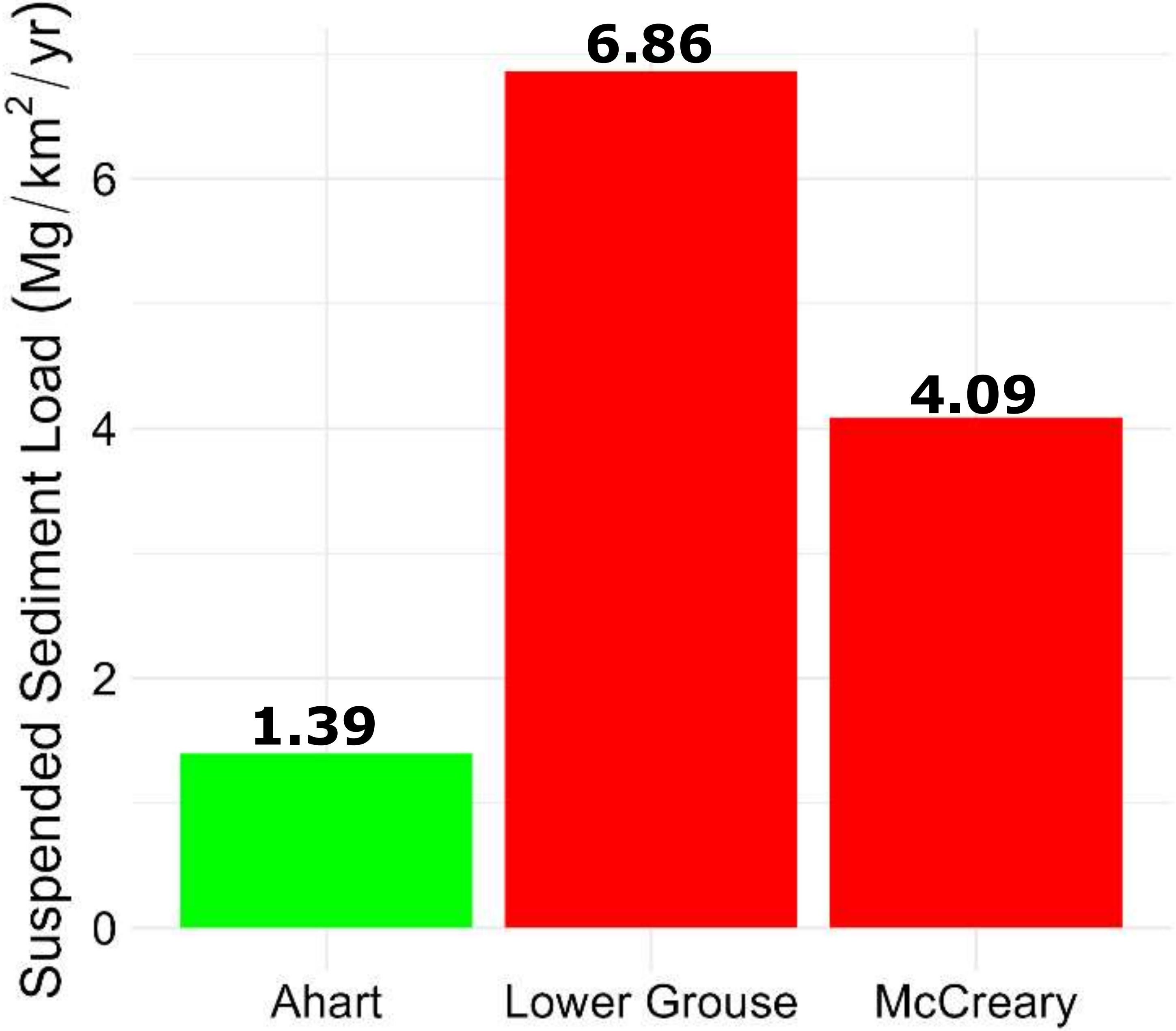
Direction of flow

Ahart Meadow
Imagery: USFS

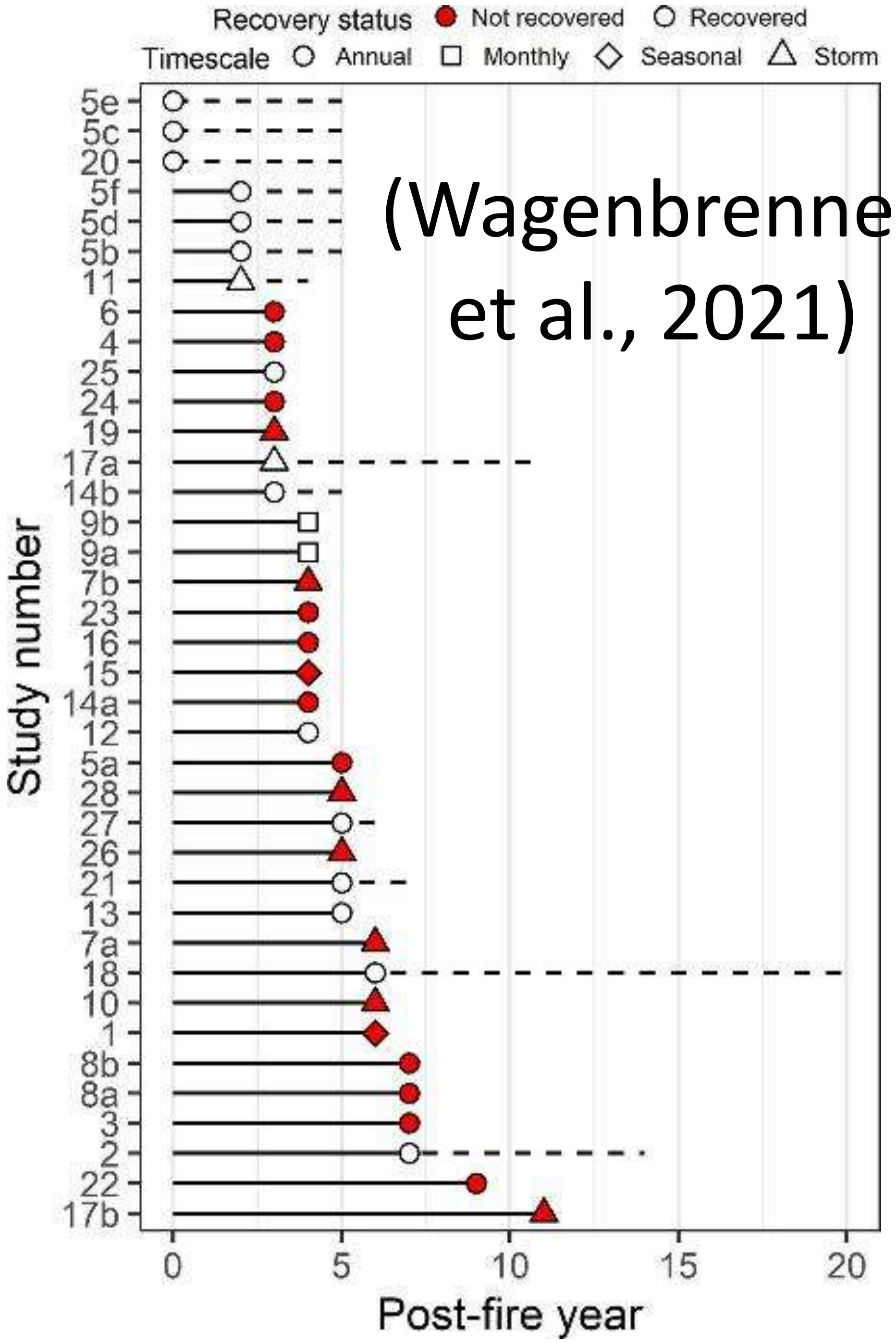
Measuring suspended sediment loads



Low sediment yields during 2022 drought year



- USFS predicted a 30-fold increase in sediment yields for a single 2-year storm event during the first winter (WERT).
- 2 years post-fire
- 2022 was a drought year



(Wagenbrenner et al., 2021)

Drought may extend watershed vulnerability (Mayor et al., 2007)

Little precipitation

Sparse vegetation recovery

Lower Grouse Meadow Watershed, two-years post-fire

Partial Restoration of Lower Grouse Meadow November 2022


Photo: John Whiting


Photo: John Whiting

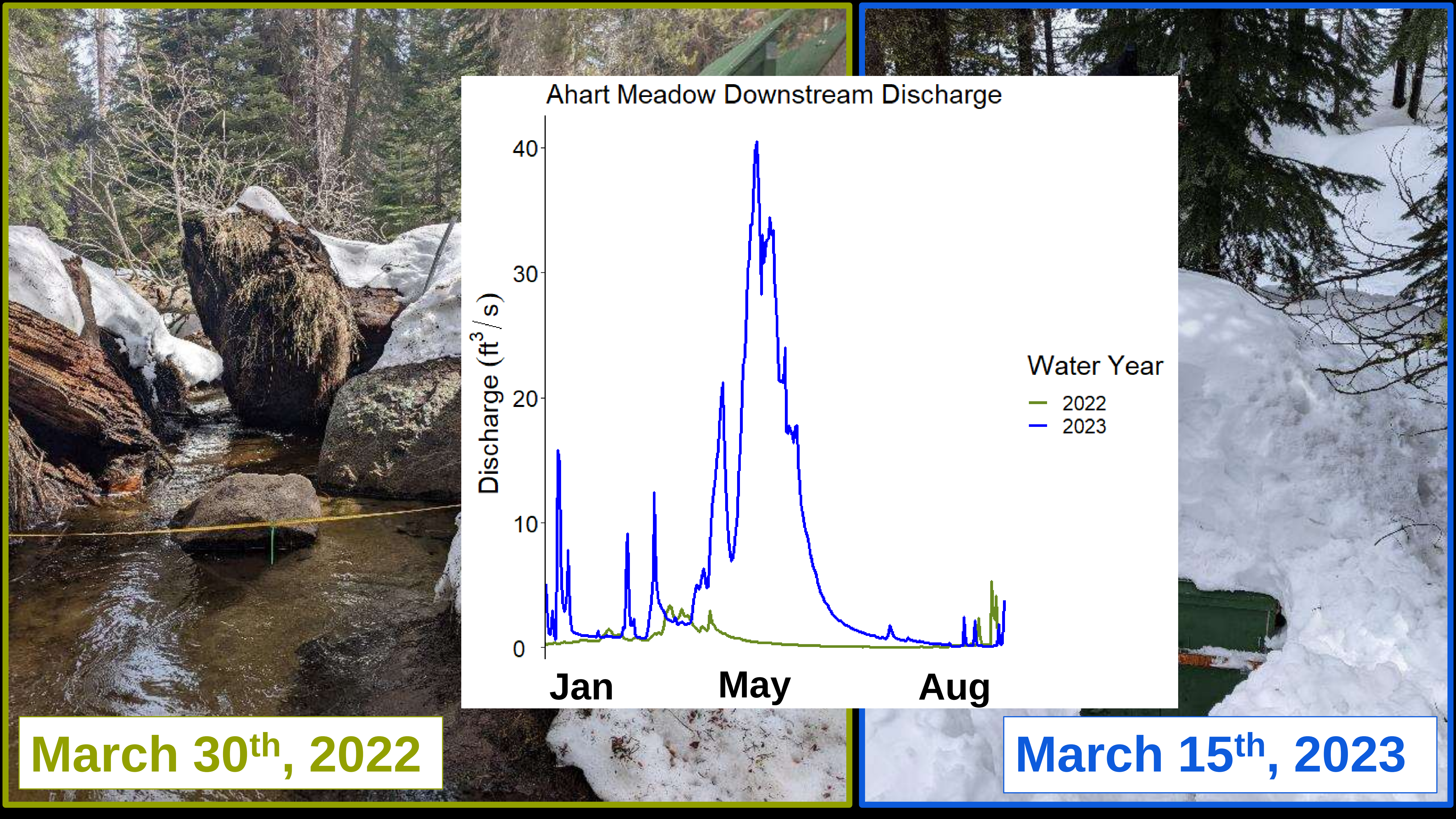

Photo: Stephanie Barnes

Rapid side channel development two days after restoration

Extremely wet winter of 2023

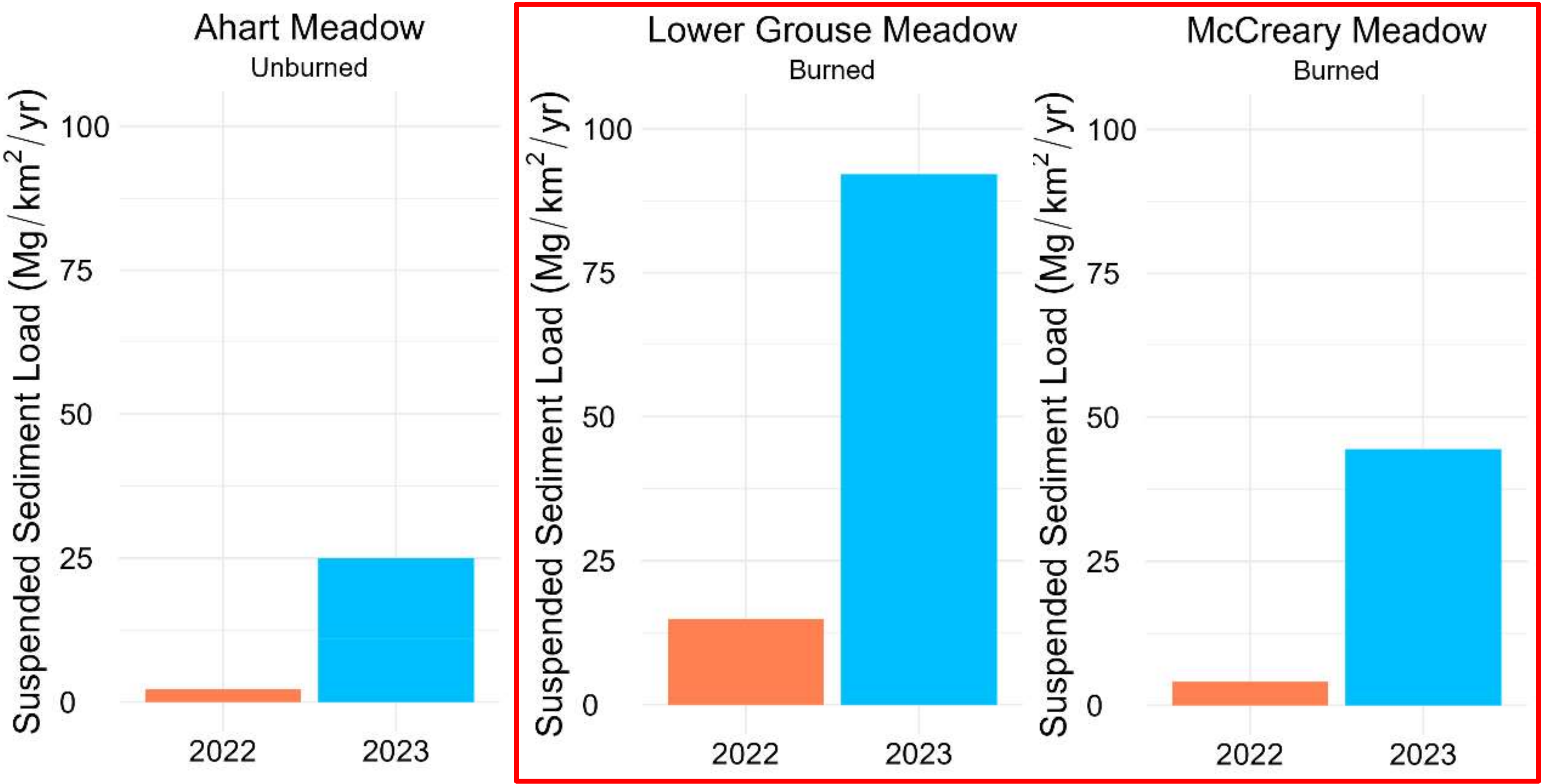

March 30th, 2022


March 15th, 2023



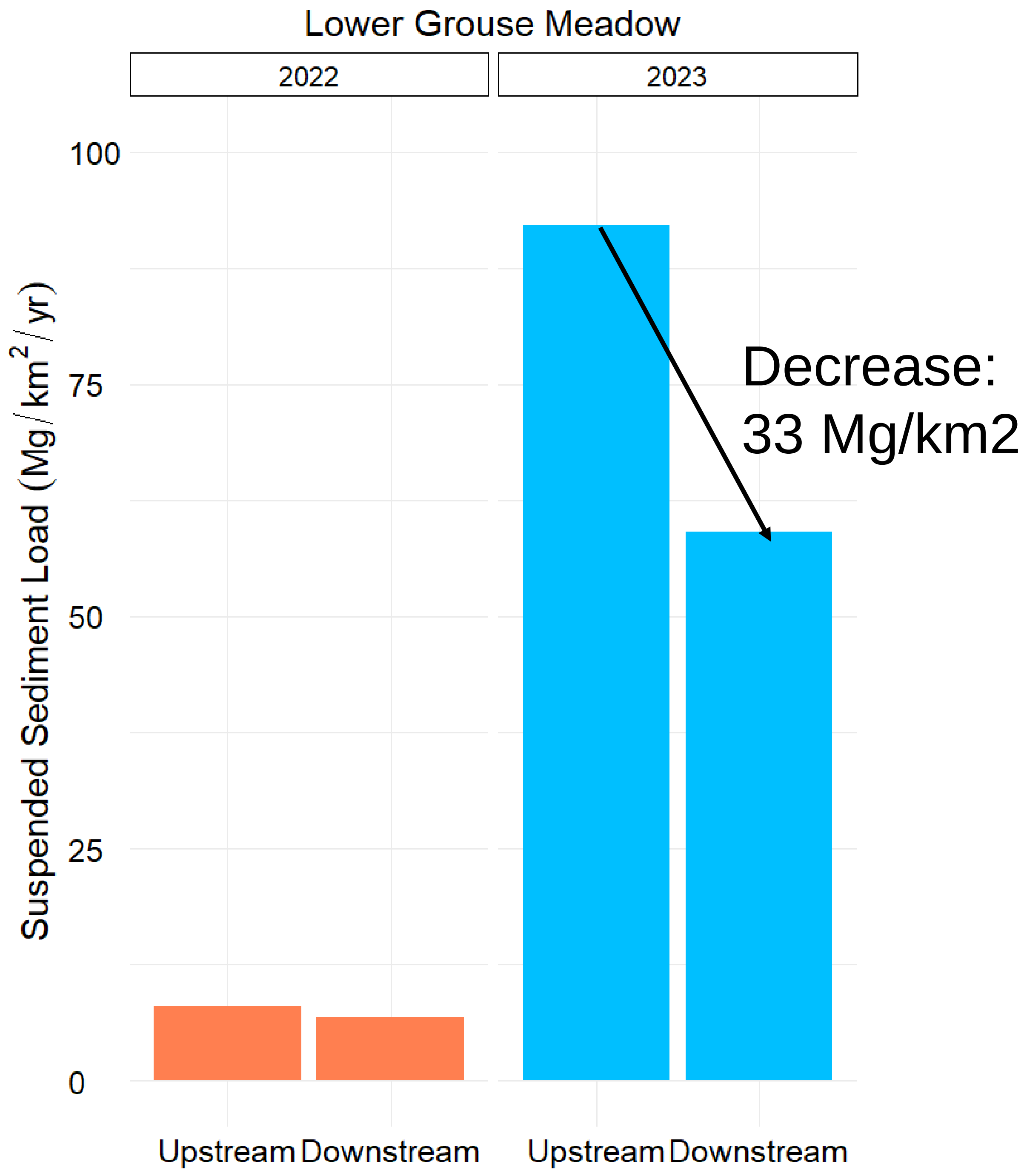
Ahart Meadow Downstream Discharge
Discharge (ft^3 / s)
40
30
20
10
0
Jan
May
Aug
Water Year
2022
2023
March 30th, 2022
March 15th, 2023

Higher sediment yields in 2023 and in burned meadows



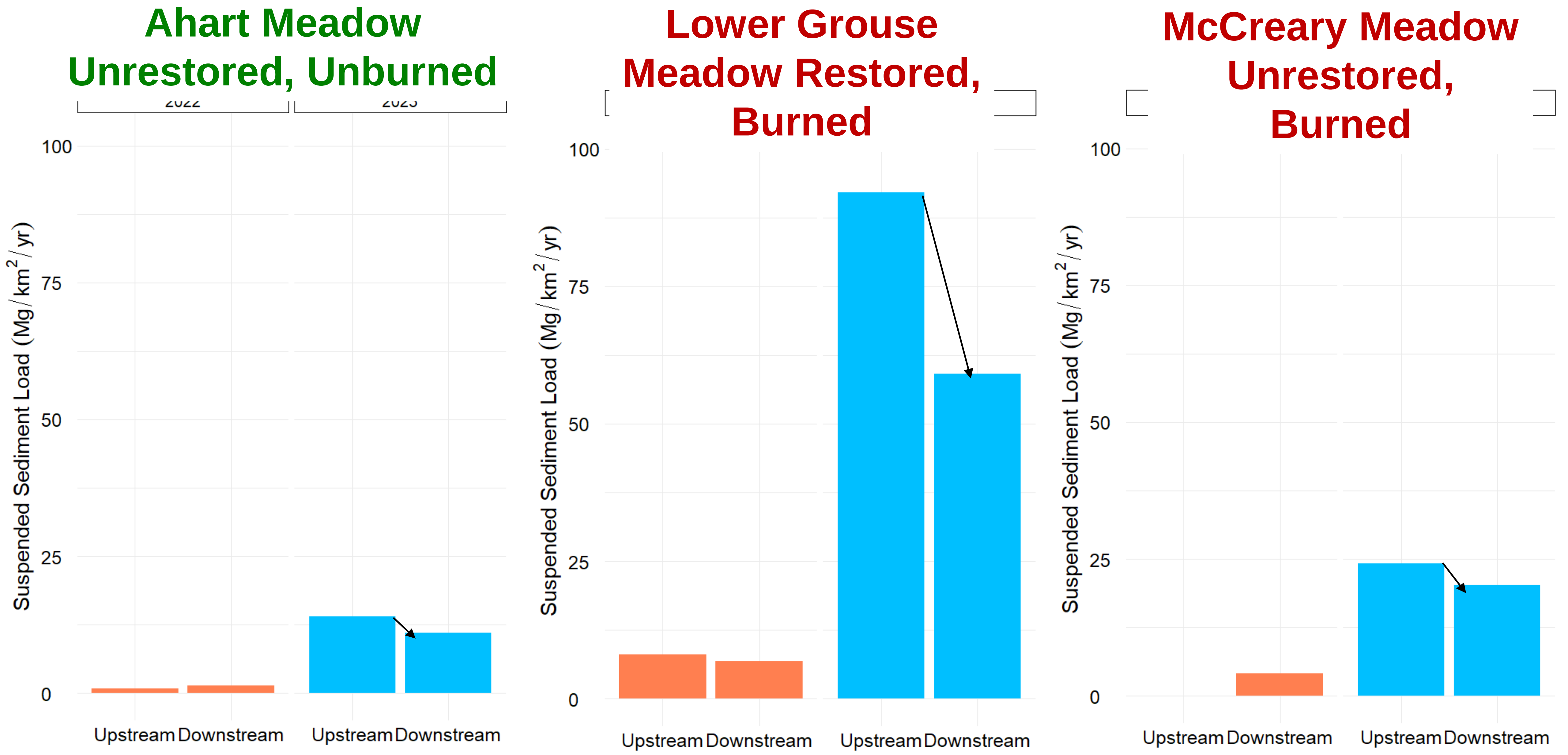
Measured more suspended sediment in burned than unburned meadows.

H2) Degraded reaches with process-based restoration structures capture more fine sediment than unrestored, degraded reaches.

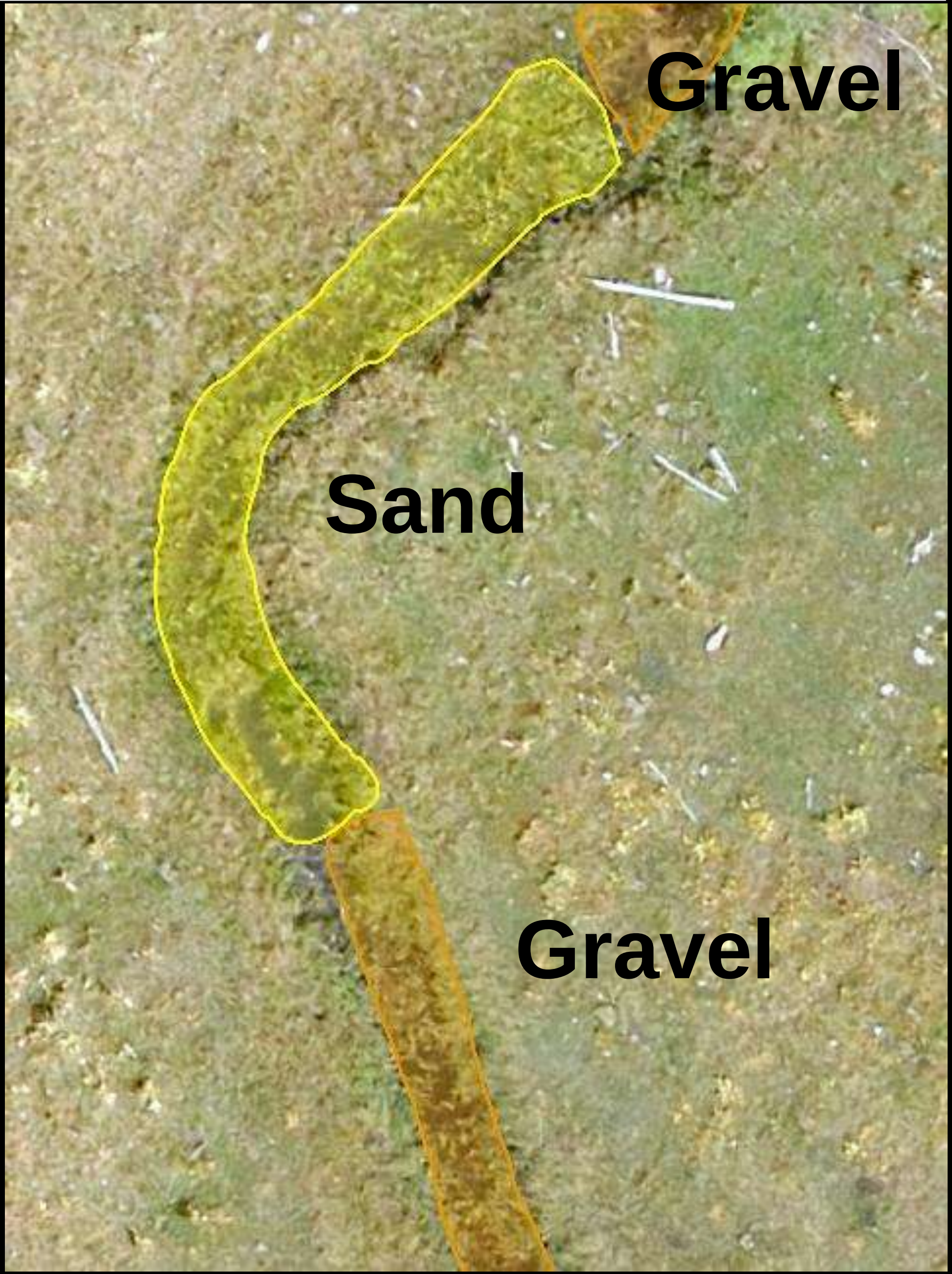


Lower Grouse Meadow
2022
2023
Suspended Sediment Load (Mg / km^2 / yr)
100
75
50
25
0
Upstream
Downstream
Upstream
Downstream
Decrease:
33 Mg/km2

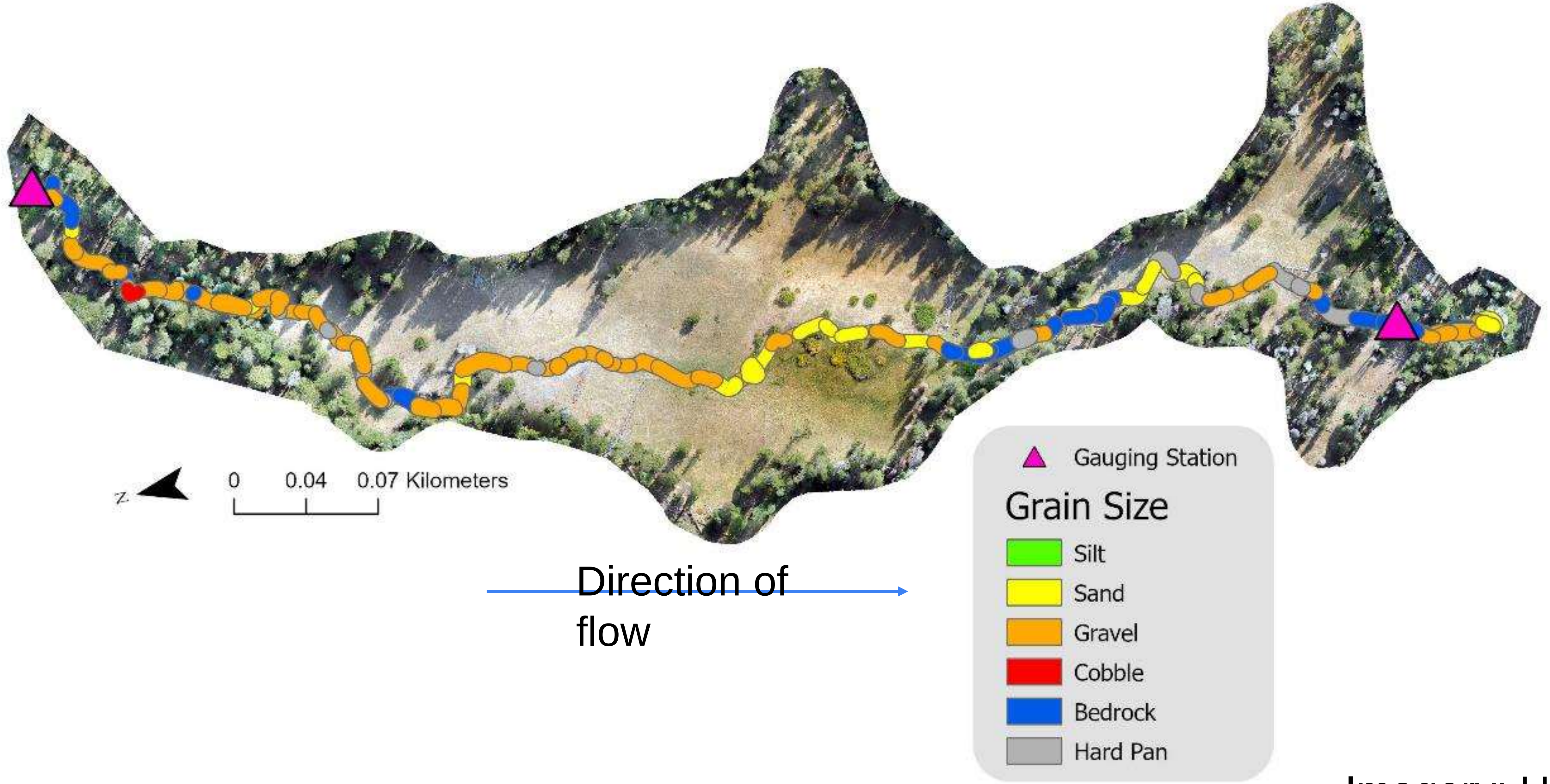
Higher yields at upstream gauging station



Changes in channel bed grain size



Ahart Meadow channel bed grain size in 2023

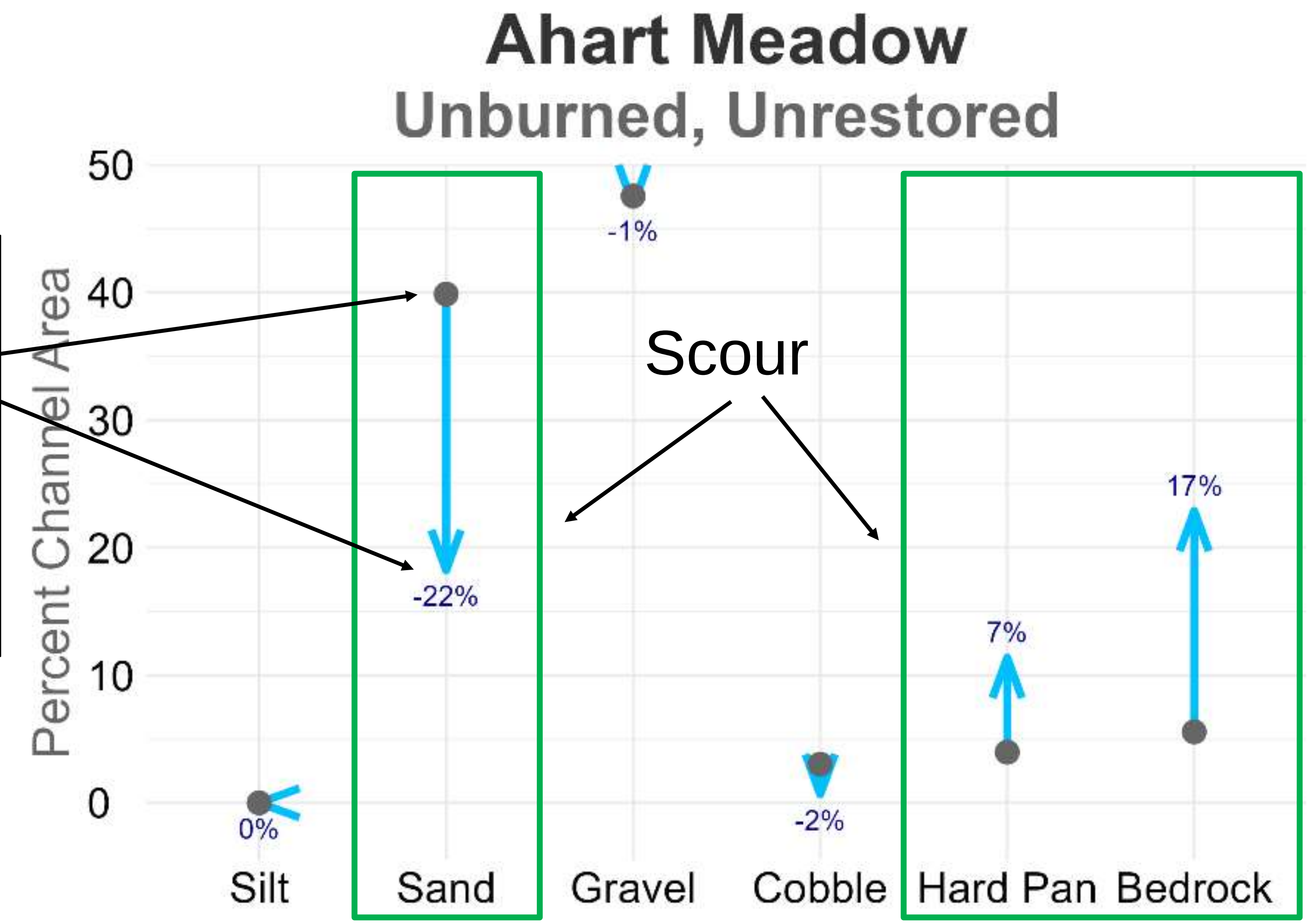


Direction of flow

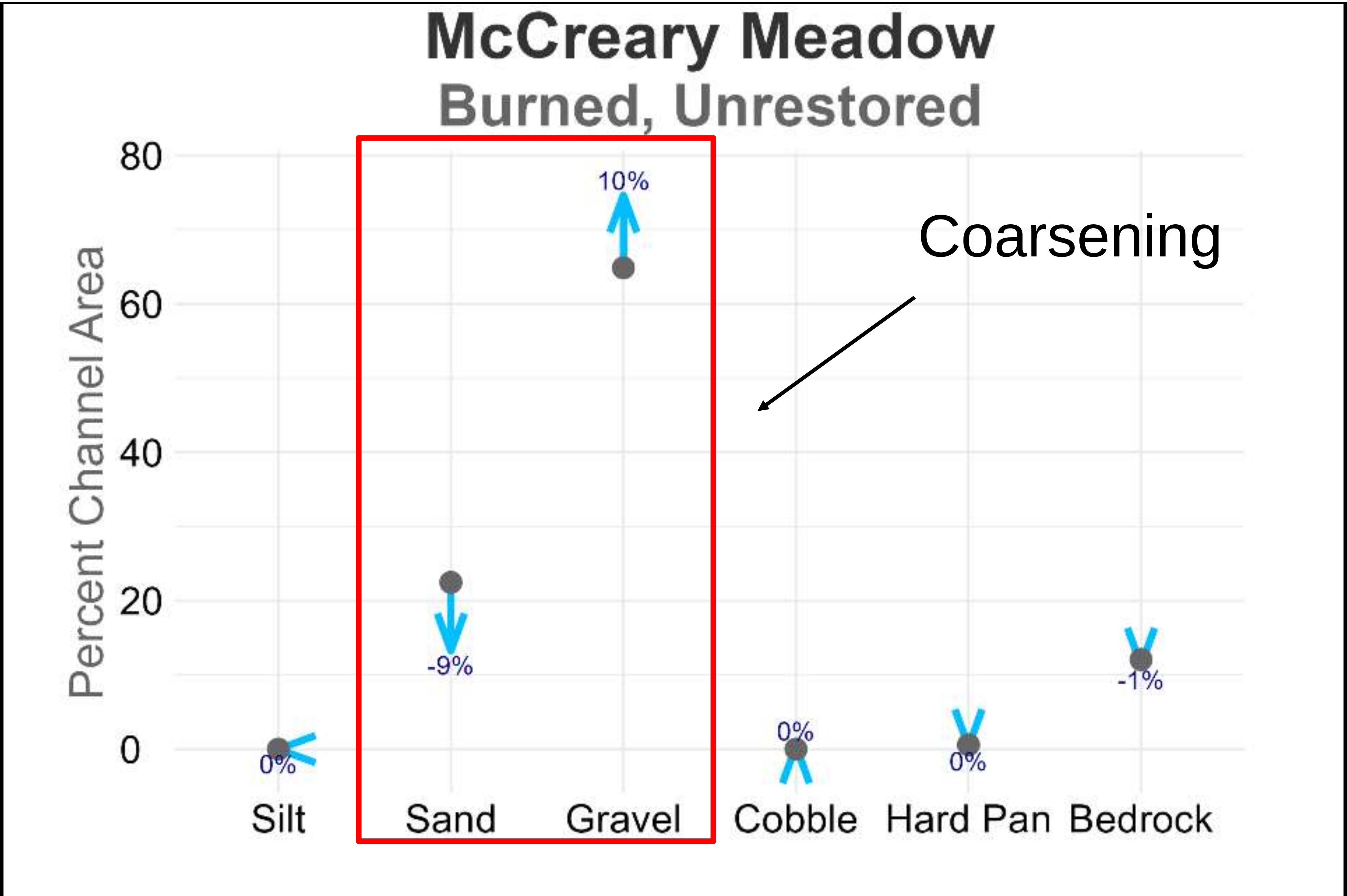
Imagery: US

2023 flows scoured the unburned, unrestored meadow

Change in percent area of channel bed grain size from 2022 to 2023

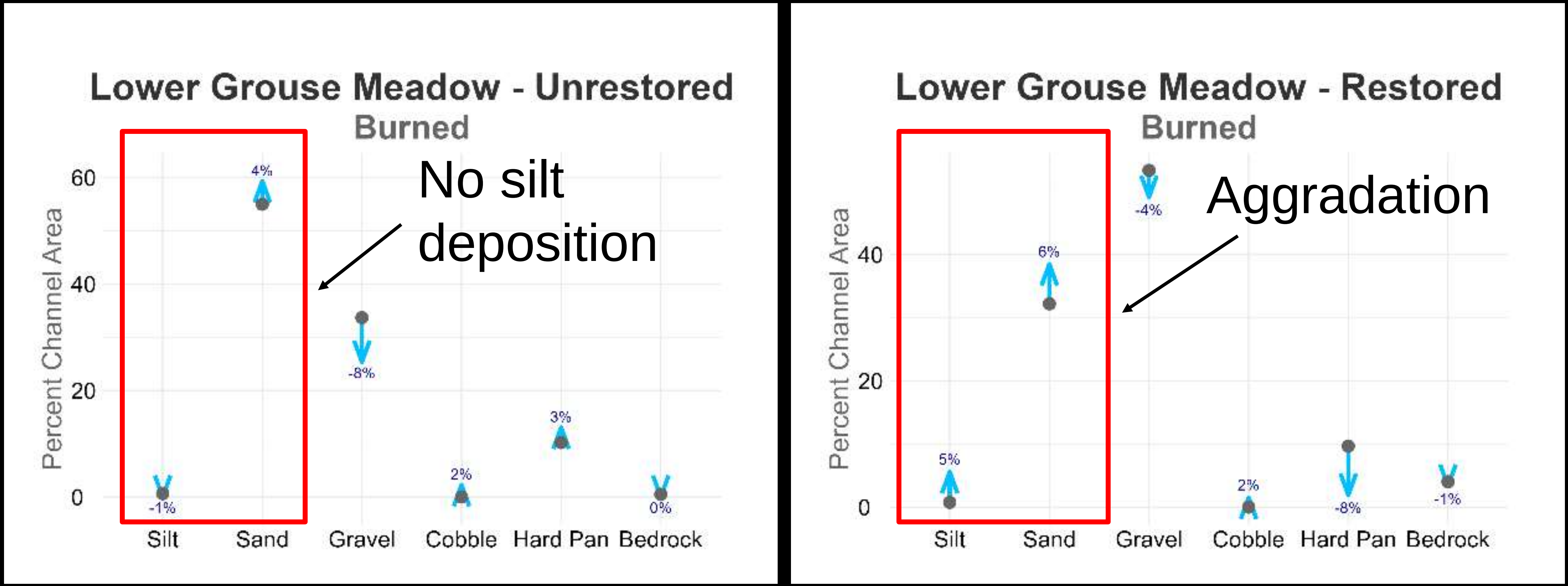


Grain size coarsened in burned, unrestored meadow



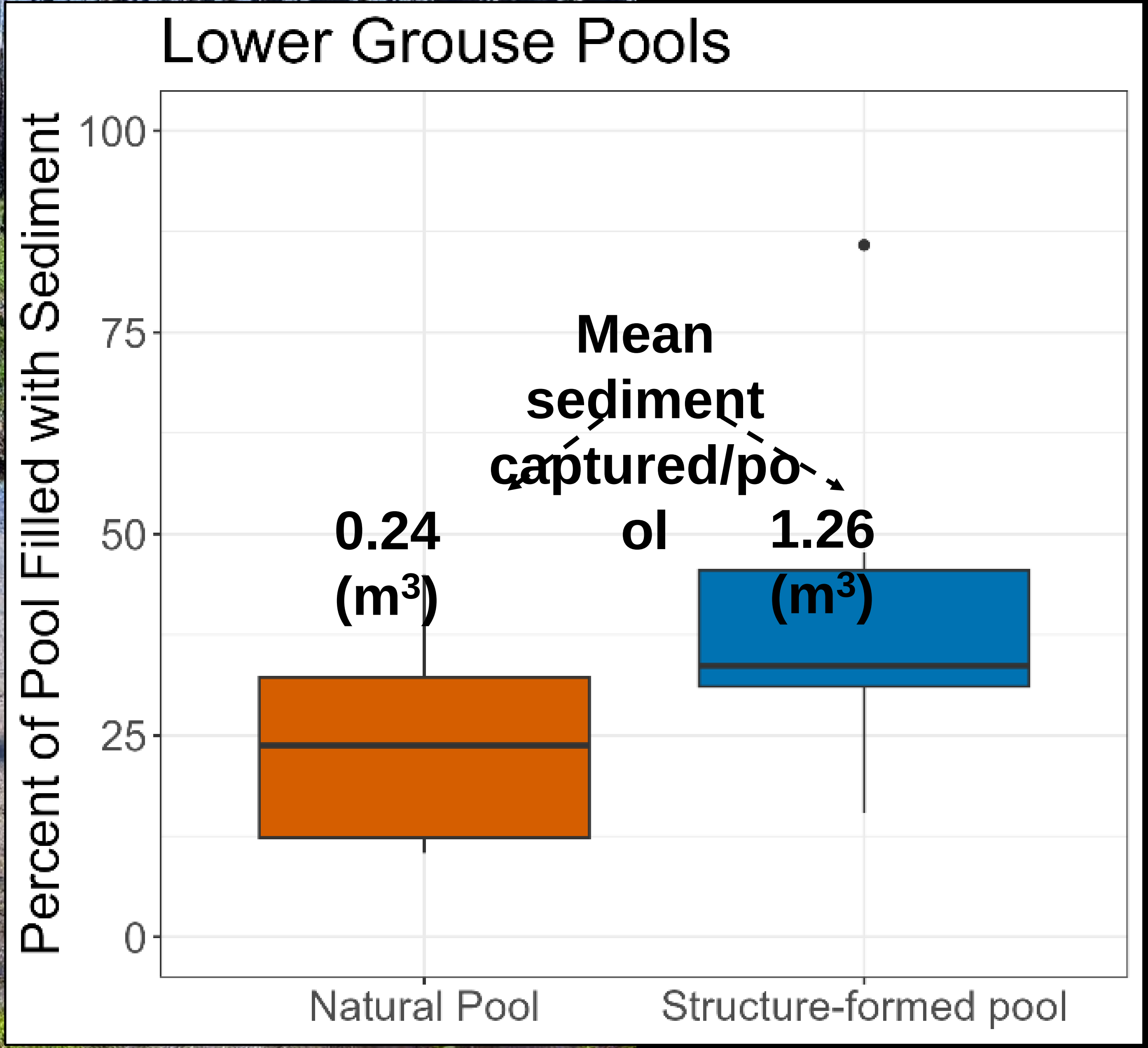
High density of large wood in McCreary Meadow did not capture fine sediment

More aggradation in restored reach




Boot trap
Lower Grouse Meadow, 2023

Restored reach capture more sediment than unrestored reach



Reaches with restoration structures installed captured more fine sediment than unrestored meadows

2023 Restoration of Lower Grouse and Ahart Meadows

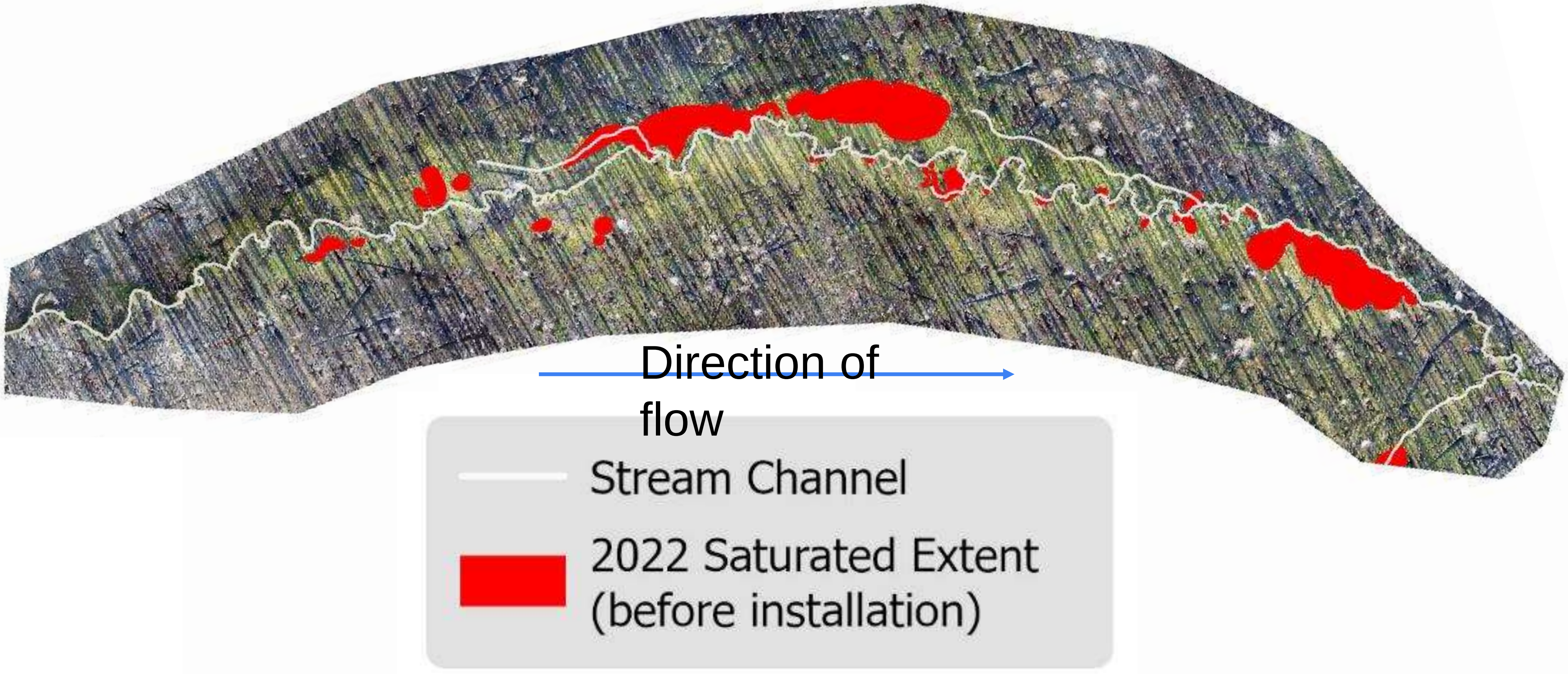
Restoration design

SWIFTWATERDESIGN

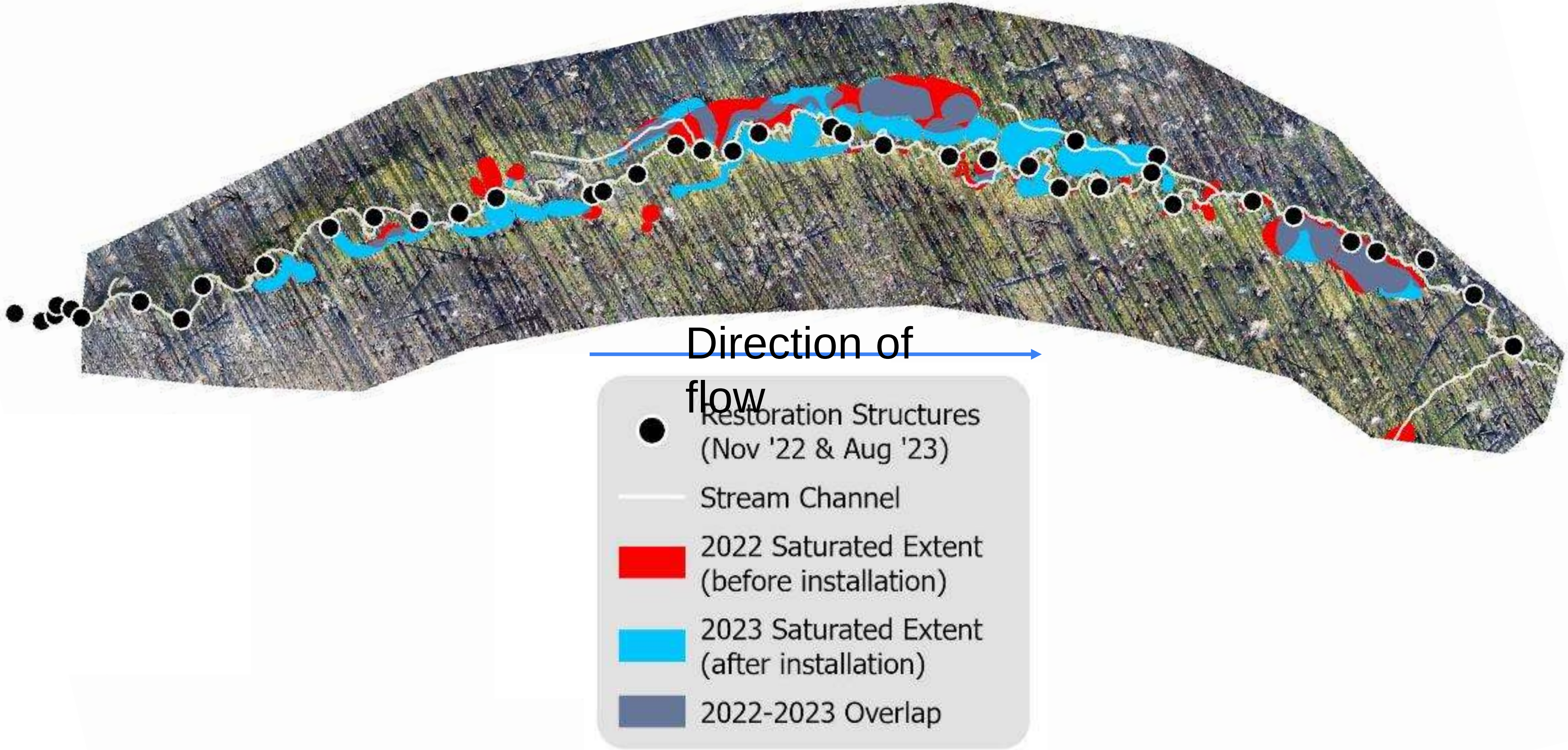
45 structures in Lower Grouse
47 structures in Ahart

H3) Process-based restoration structures drive rapid meadow re-wetting and hydrologic complexity.

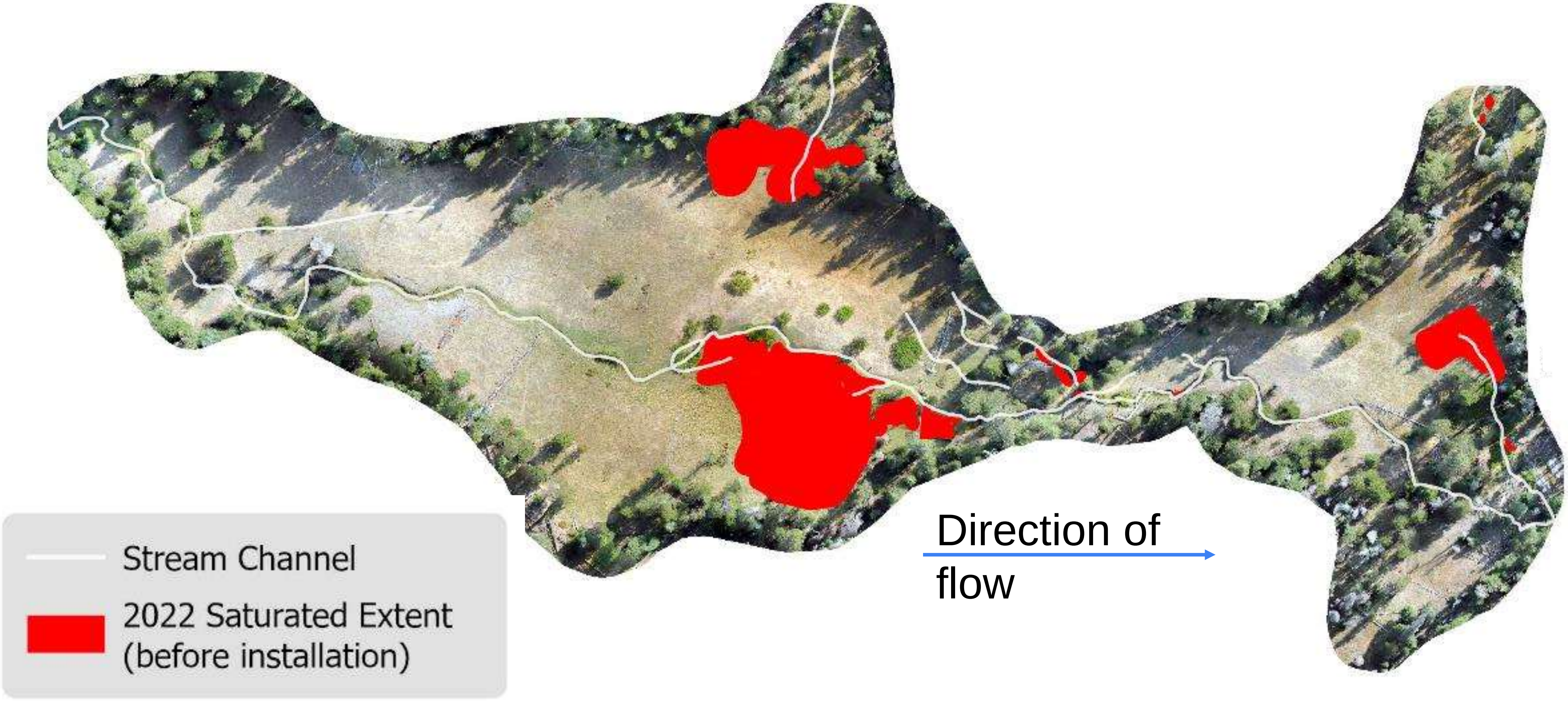
Lower Grouse Meadow, Pre-restoration 2022



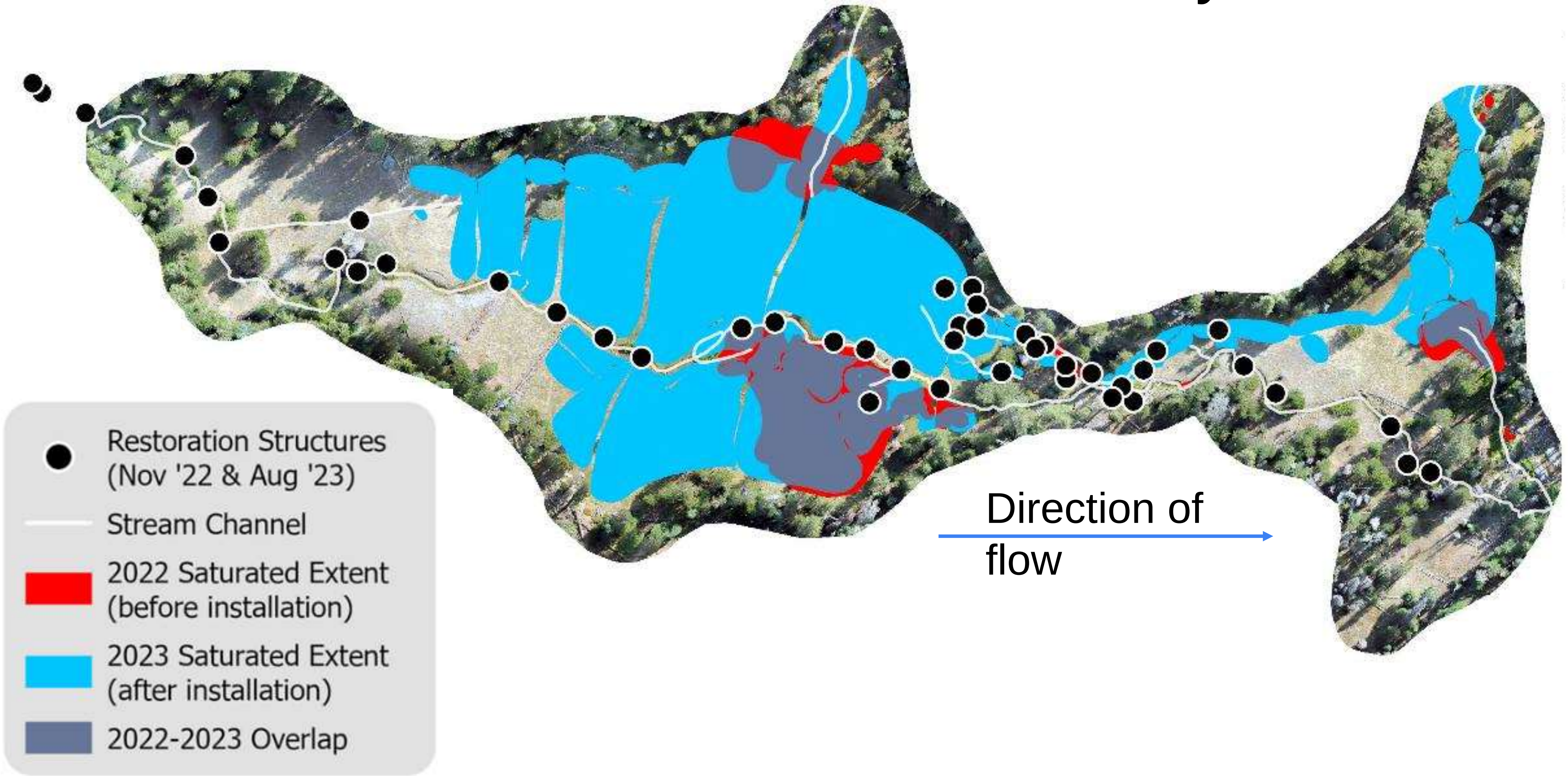
Lower Grouse Meadow, Post-restoration 2023
Saturate area increased by 39%



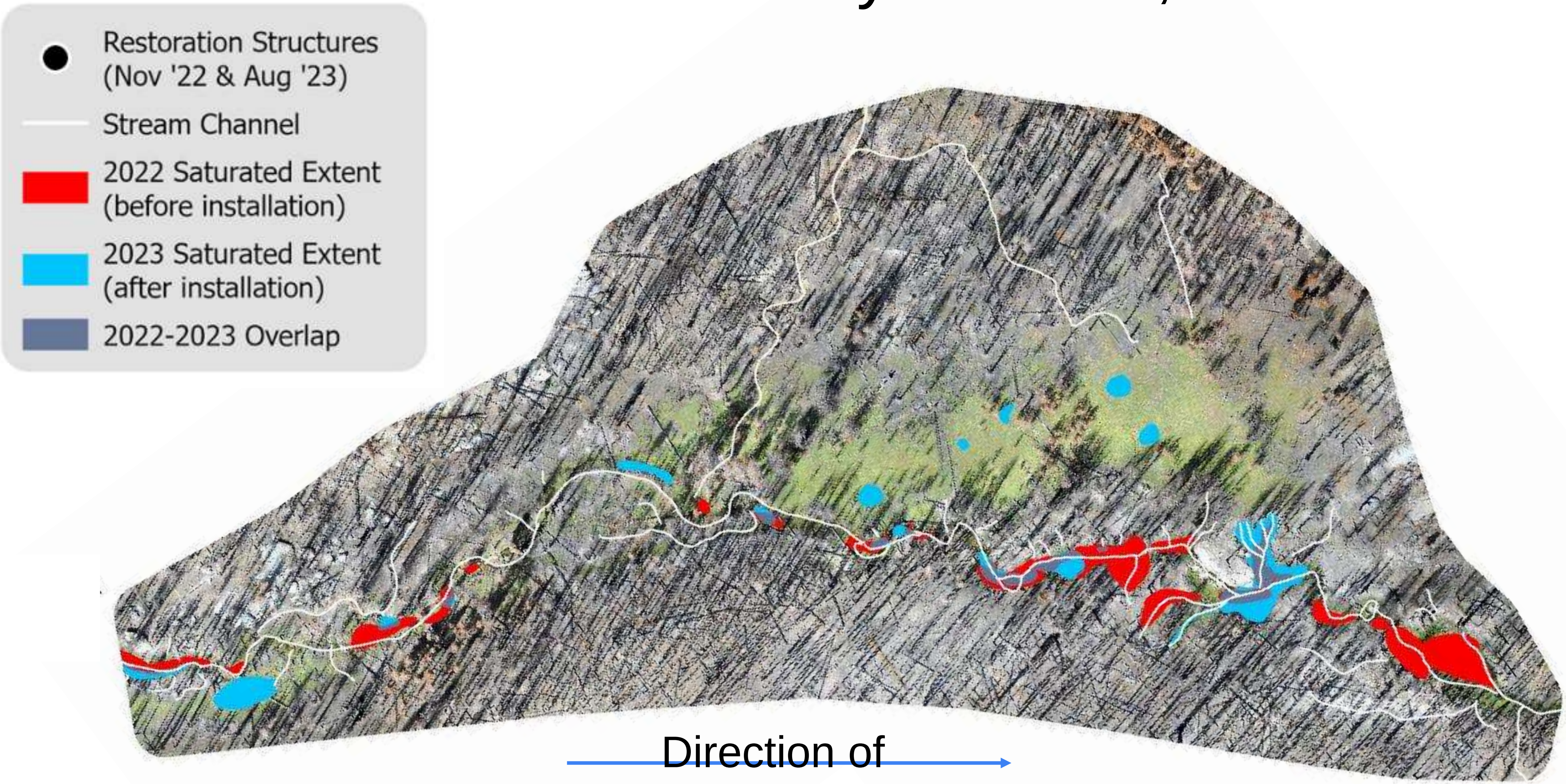
Ahart Meadow, Pre-restoration 2022



Ahart Meadow, Post-restoration 2023
Saturated area increased by 304%



McCreary Meadow, 2023



Direction of flow

After restoration structures were installed, saturated area increased in incised meadows

Conclusions

- H1) More sediment is transported in burned than unburned meadows.
- H2) Degraded reaches with process-based restoration structures capture more fine sediment than unrestored, degraded reaches.
- H3) Process-based restoration structures drive rapid meadow re-wetting and hydrologic complexity.

Future Work

- Complete sediment budget (including bedload)
- Keep sediment in the meadows

Challenges

- Implementing restoration immediately after fire

- Building BDAs in severely burned locations without live material


Thank you!

Food Web Reconstruction: What Stable Isotopes can Teach Us About Coho Trophic Pathways in Beaver Dam Analogues (BDAs)

Presented by: Brandi Goss
PhD Candidate, UC Davis

Co-authors: Dr. Robert A. Lusardi, UC Davis
Dr. Ethan Baruch, California Department of Fish and Wildlife

Freshwater biodiversity: importance, threats, status and conservation challenges

David Dudgeon[1]*, Angela H. Arthington[2], Mark O. Gessner[3], Zen-Ichiro Kawabata[4], Duncan J. Knowler[5], Christian Lévêque[6], Robert J. Naiman[7], Anne-Hélène Prieur-Richard[8], Doris Soto[9], Melanie L. J. Stiassny[10] and Caroline A. Sullivan[11]

ABSTRACT

Freshwater biodiversity is *the* over-riding conservation priority during the International Decade for Action – 'Water for Life' – 2005 to 2015. Fresh water makes up only 0.01 % of the World's water and approximately 0.8 % of the Earth's surface, yet this tiny fraction of global water supports at least 100 000 species out of approximately 1.8 million – almost 6 % of all described species. Inland waters and freshwater biodiversity constitute a valuable natural resource, in economic, cultural, aesthetic, scientific and educational terms. Their conservation and management are critical to the interests of all humans, nations and governments. Yet this precious heritage is in crisis. Fresh waters are experiencing declines in biodiversity far greater than those in the most affected terrestrial ecosystems, and if trends in human demands for water remain unaltered and species

State of the Salmonids:
Status of California's Emblematic Fishes
2017

A report commissioned by California Trout

Peter B. Moyle[1], Robert A. Lusardi[2], Patrick J. Samuel[3], and Jacob V. E. Katz[3]

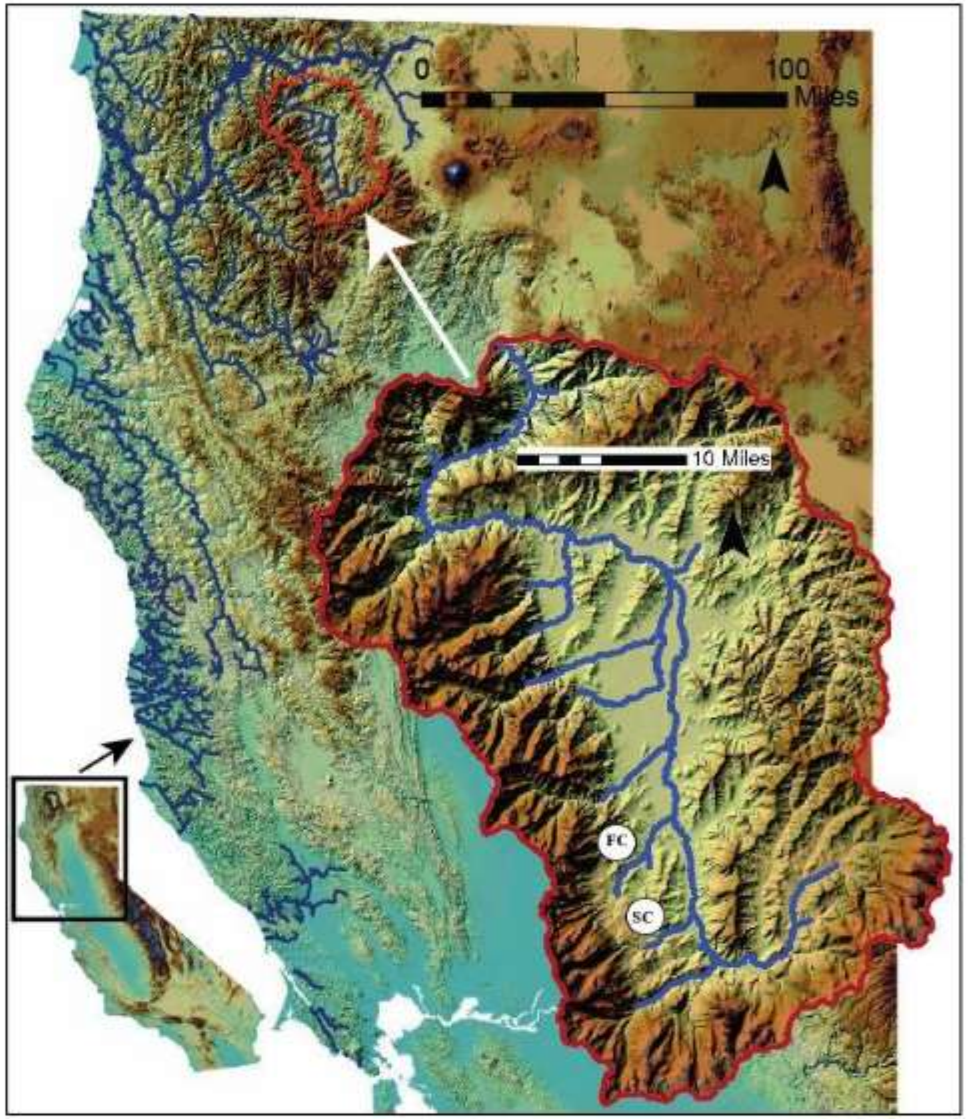
[1] Center for Watershed Sciences, University of California, Davis – Davis, CA 95616

[2] Center for Watershed Sciences, University of California, Davis/California Trout – Davis, CA 95616

[3] California Trout – San Francisco, CA 94104

ABSTRACT

California has, or had, 32 distinct kinds of salmonid fishes. They are either endemic to California or at the southern end of their ranges. Most are in serious decline: 45% and 74% of all salmonids will likely become extirpated from California in the next 50 and 100 years, respectively, if present trends continue. Our results suggest that California will lose more than half (52%) of its native



SONCC (Southern Oregon/Northern California Coast Coho Salmon

State and Federally Threatened

Scott River tributaries like Sugar Creek a remaining stronghold for these fish

Beaver Restoration

- Beaver dams known to be keystone structures
- Beaver restoration a top priority for SONCC coho according to NOAA's recovery plan
- Extirpations reduced prevalence of beaver and their structures
- Reintroductions both ecologically and socially challenging
- Beaver dam analogs might be an alternative to reintroduction

Beaver Dam Analog, April 2019

Natural Beaver Dam, January 2023

Beaver Dam Analogues (BDAs)

What do we know about Beaver Dam Analogs (BDAs) so far?

- Increased habitat heterogeneity (Corline et al. 2022, Bouwes et al. 2016)
- Thermal buffering & groundwater recharge (Corline et al. 2022, Weber 2017, Orr 2020)
- Increased resilience for the macroinvertebrate community (Corline et al. 2022)
- Some evidence for increased smolt production (Bouwes et al. 2016)
- But…

Beaver historically influenced the Scott Valley ecosystem

Beaver populations significantly reduced by fur trapping – and still haven't recovered

Beaver provide significant benefits for stream organisms – including Coho salmon

Re-introductions can be hard, and are not always successful

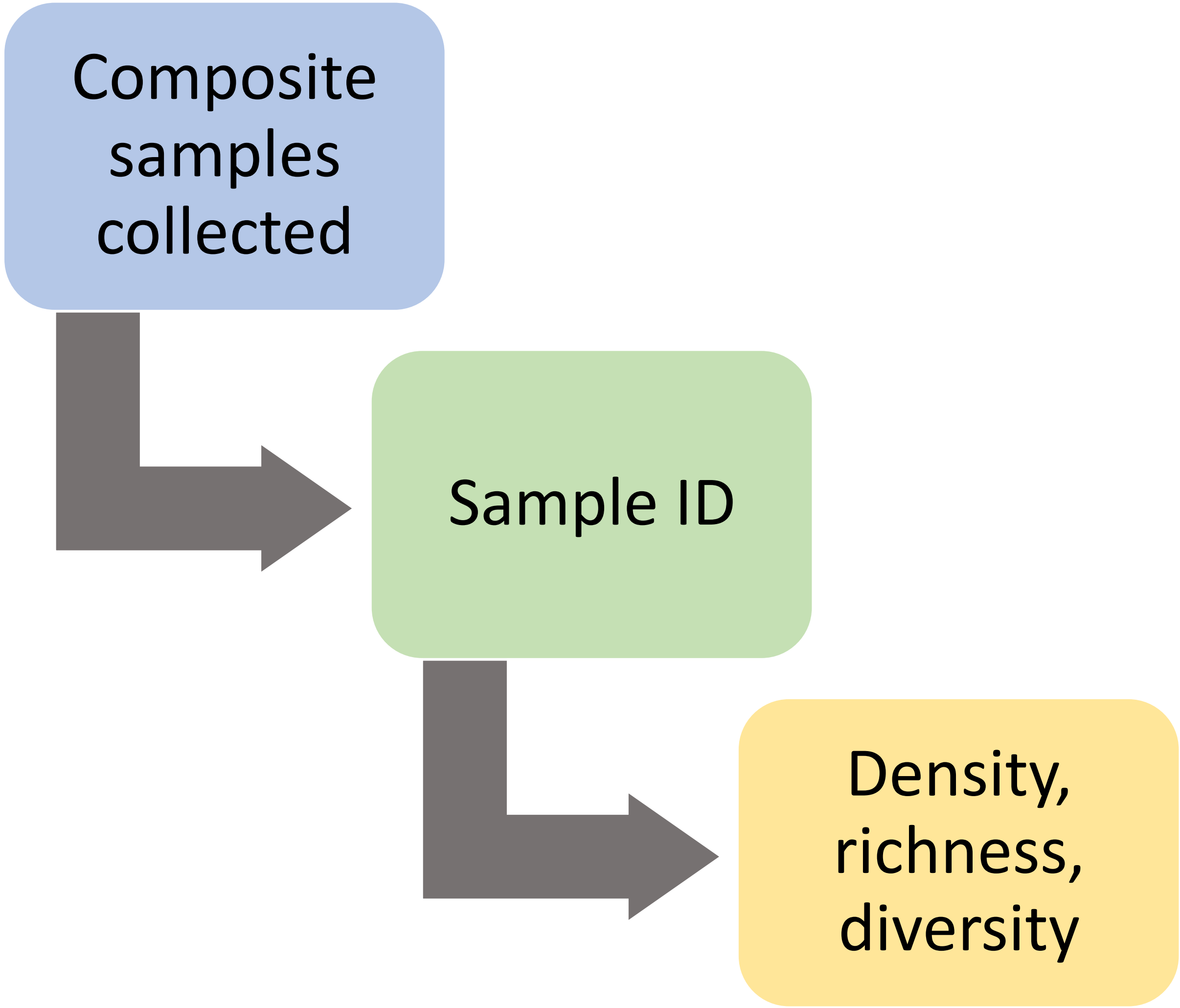
BDAs may be a viable option for providing abiotic and biotic benefits for coho salmon

Broader Question: How do beaver dam analogs influence coho trophic pathways when compared with the reference habitat?

Reference Habitat vs. BDA

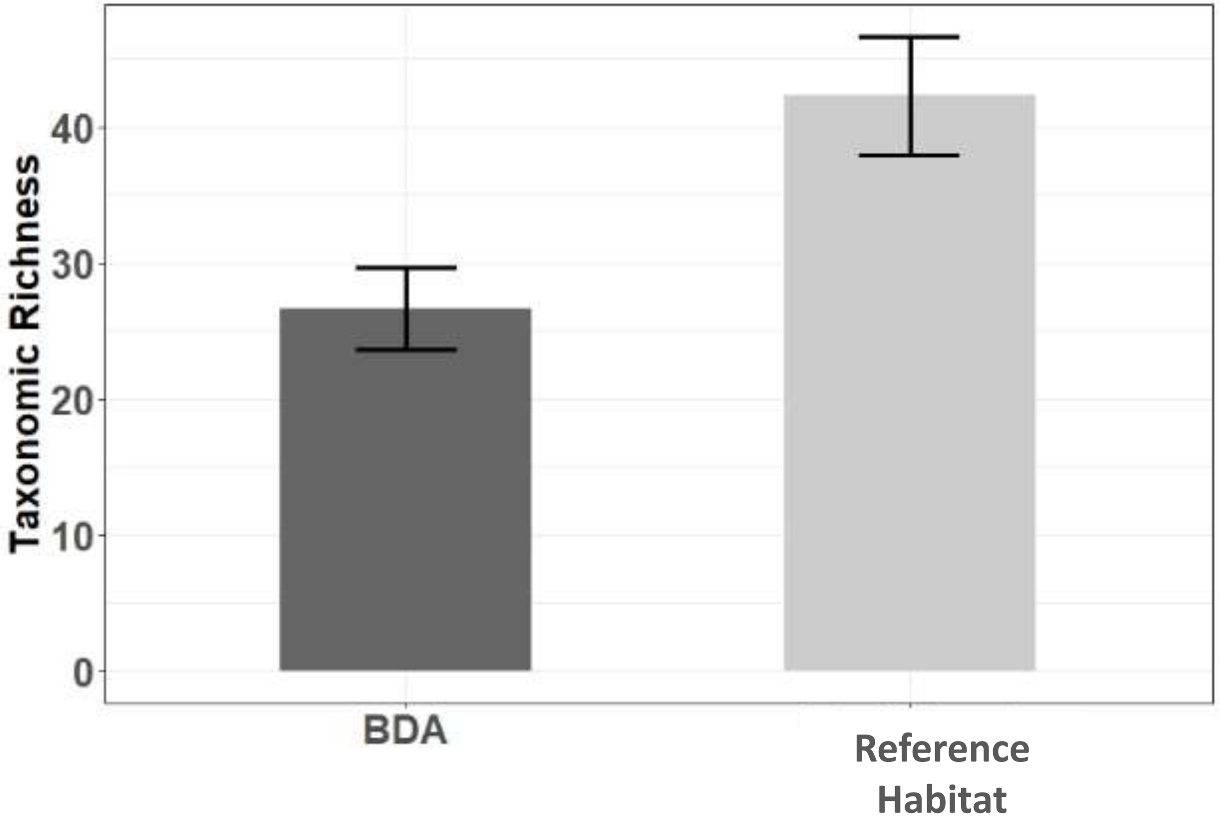
Q1: Do aquatic macroinvertebrate communities differ between BDA and the reference habitat?

Q1 Do aquatic macroinvertebrate communities differ between BDA and the reference habitat?



Results: Macroinvertebrate Taxonomic Richness

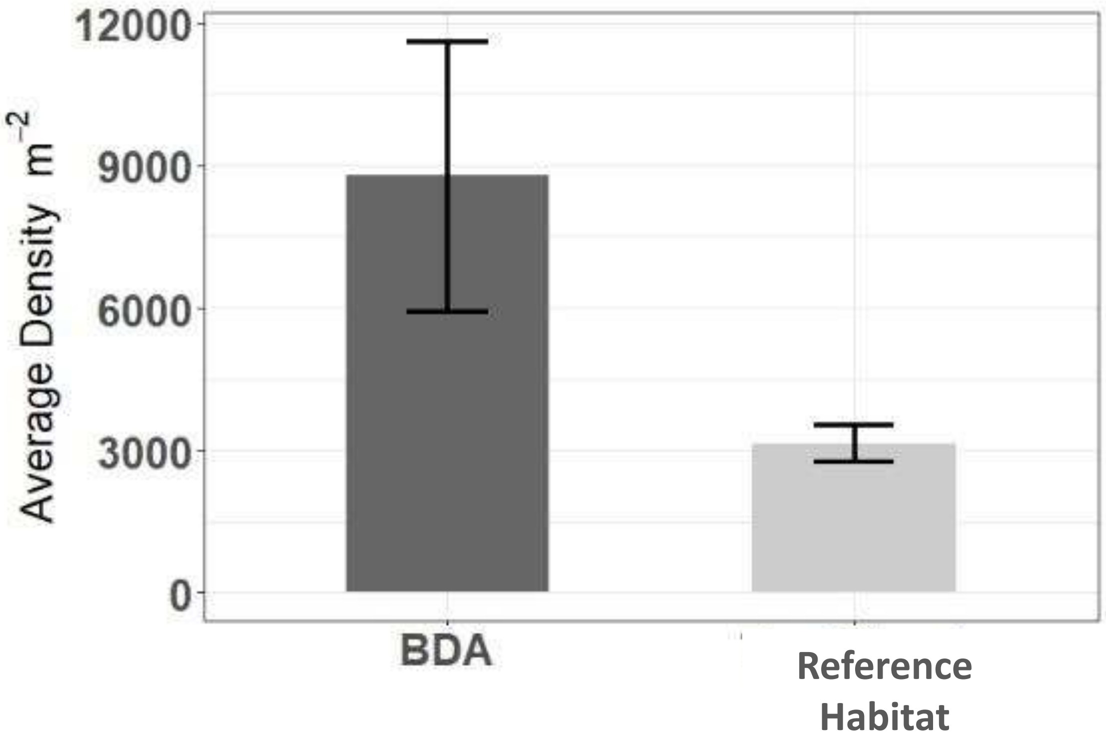
- Reduced species richness in BDA habitat



Error Bars = Standard Error

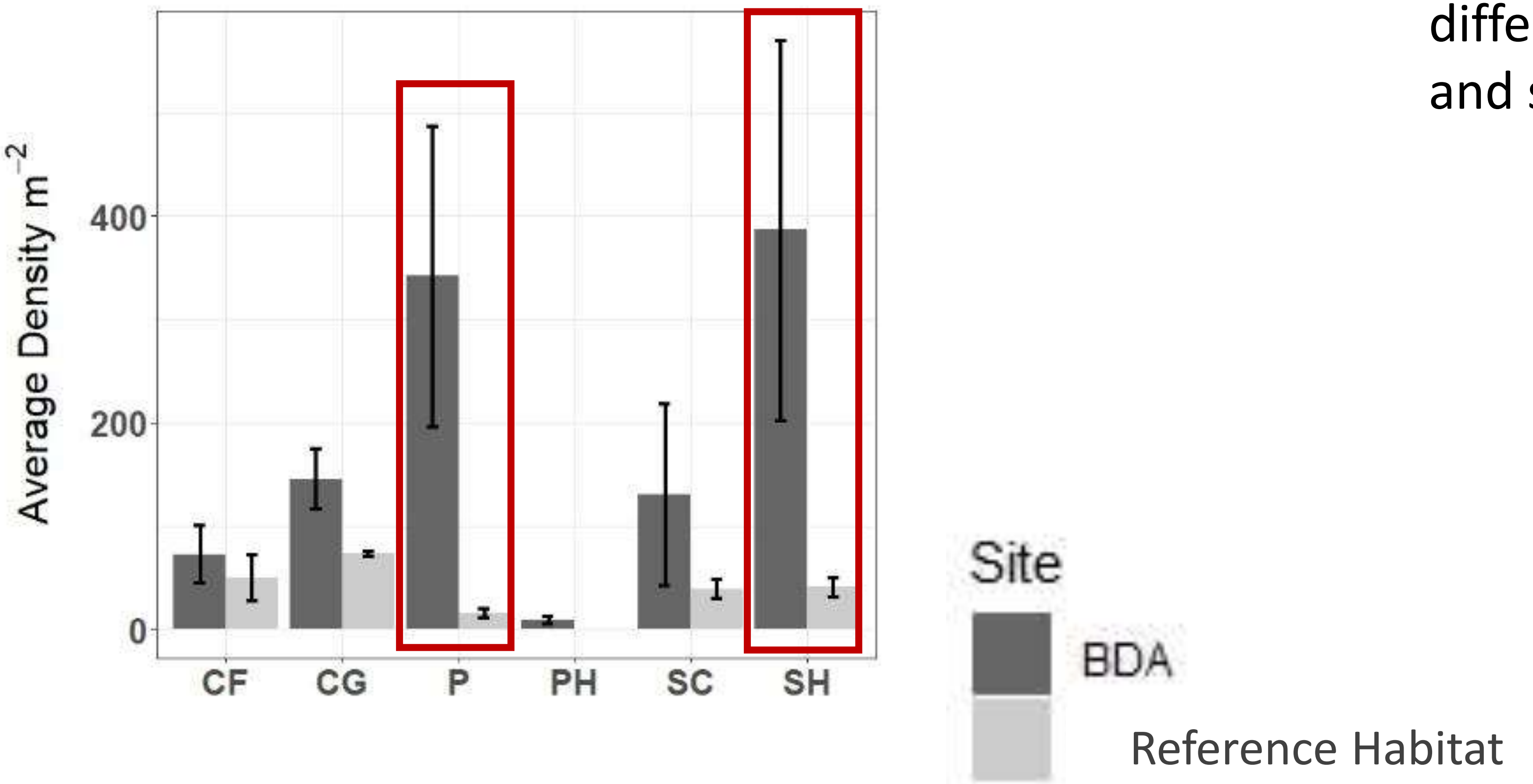
Results: Macroinvertebrate density

- Increased density in the BDA habitat
- More variation across samples taken in different micro-habitats in the BDA



Error Bars = Standard Error

Results: Macroinvertebrate density



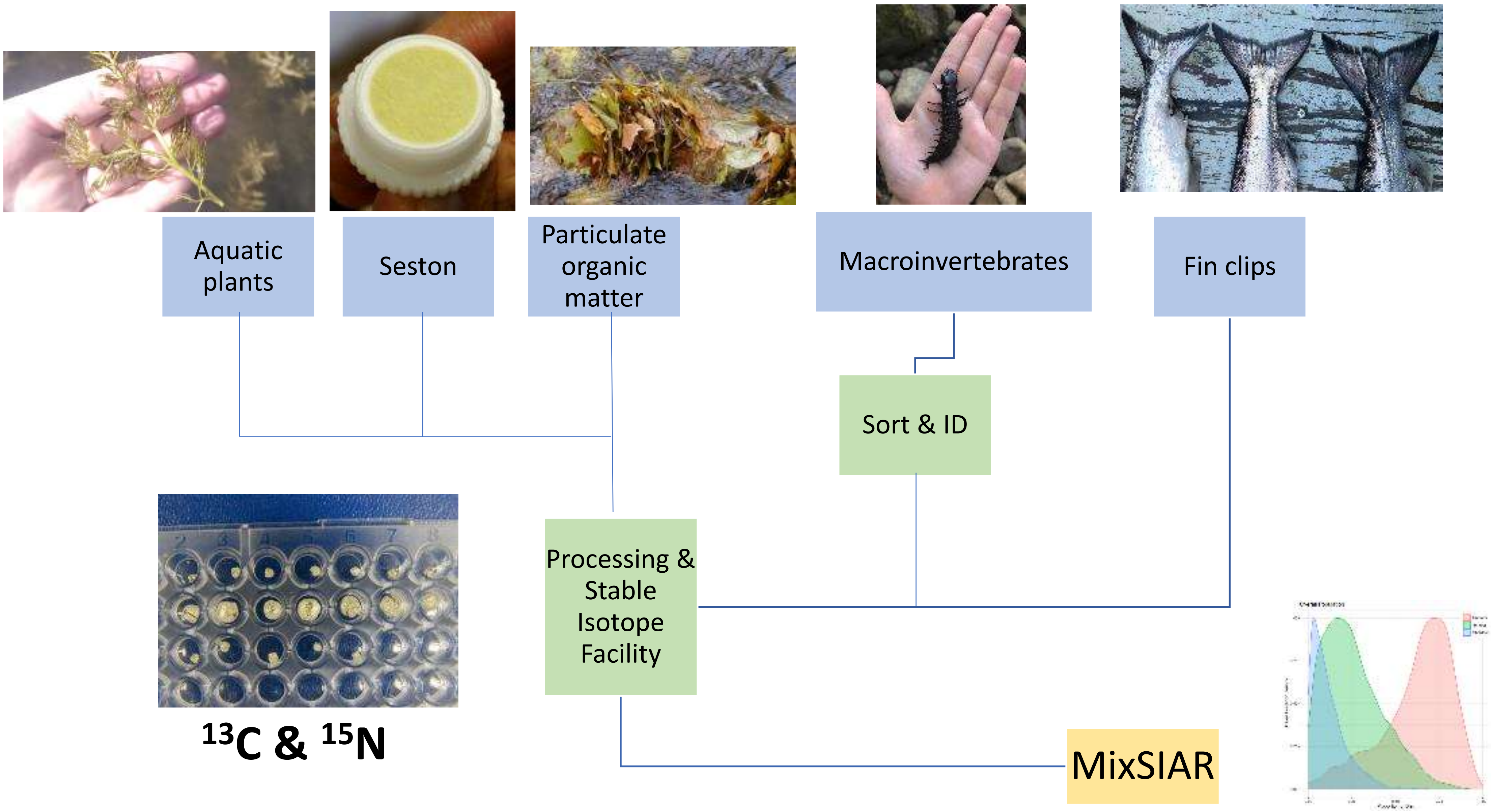
Error Bars = Standard Error

- Higher density of all functional feeding groups in the BDA
- Notably greater differences for predators and shredders

CF – Collector Filterers
CG – Collector Gatherers
P – Predators
PH – Piercing herbivores
SC – Scrapers
SH - Shredders

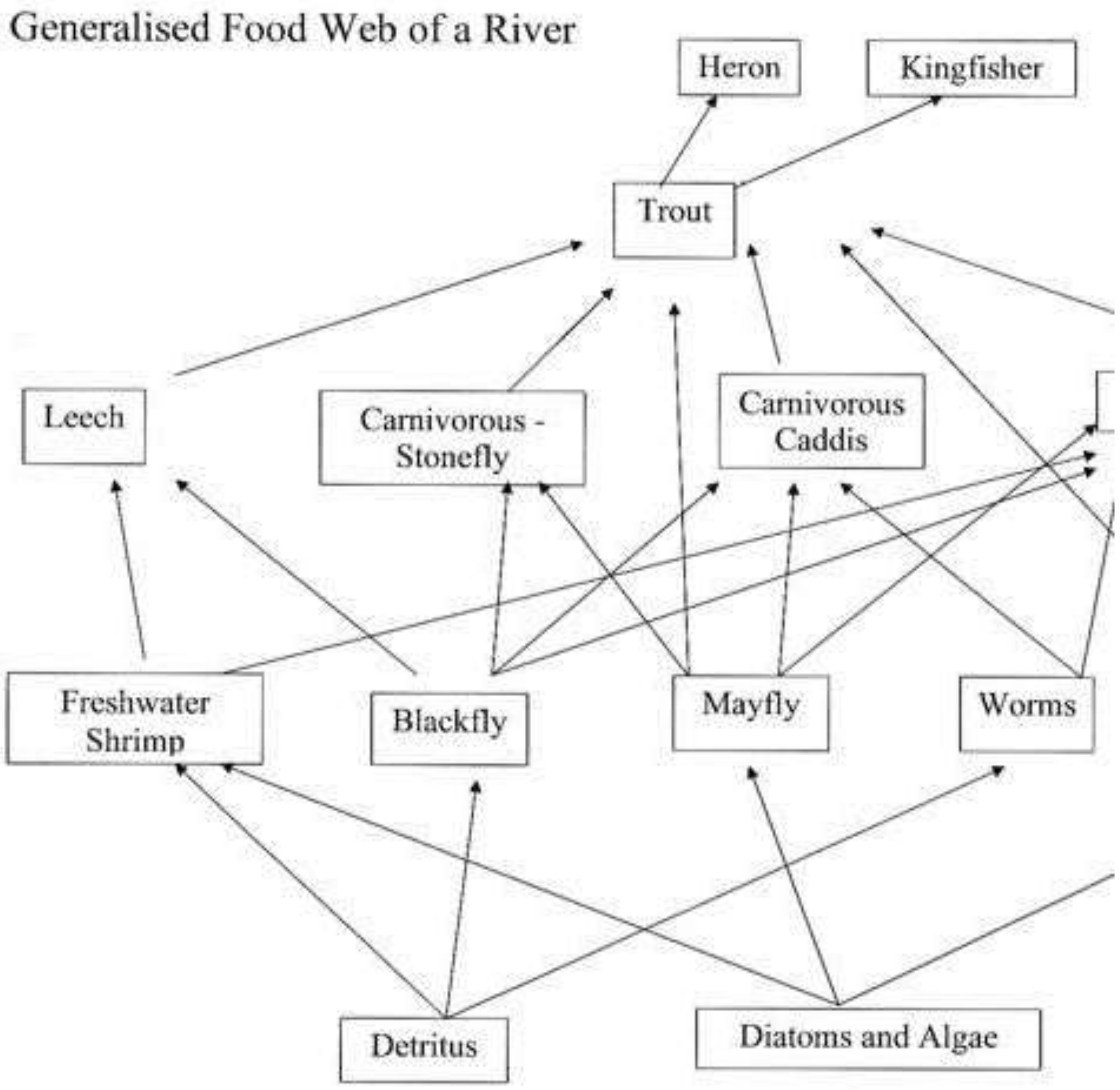
Q2: Do coho trophic pathways differ between BDA and the reference habitat?

Q2 Do coho trophic pathways differ between BDA and the reference habitat?



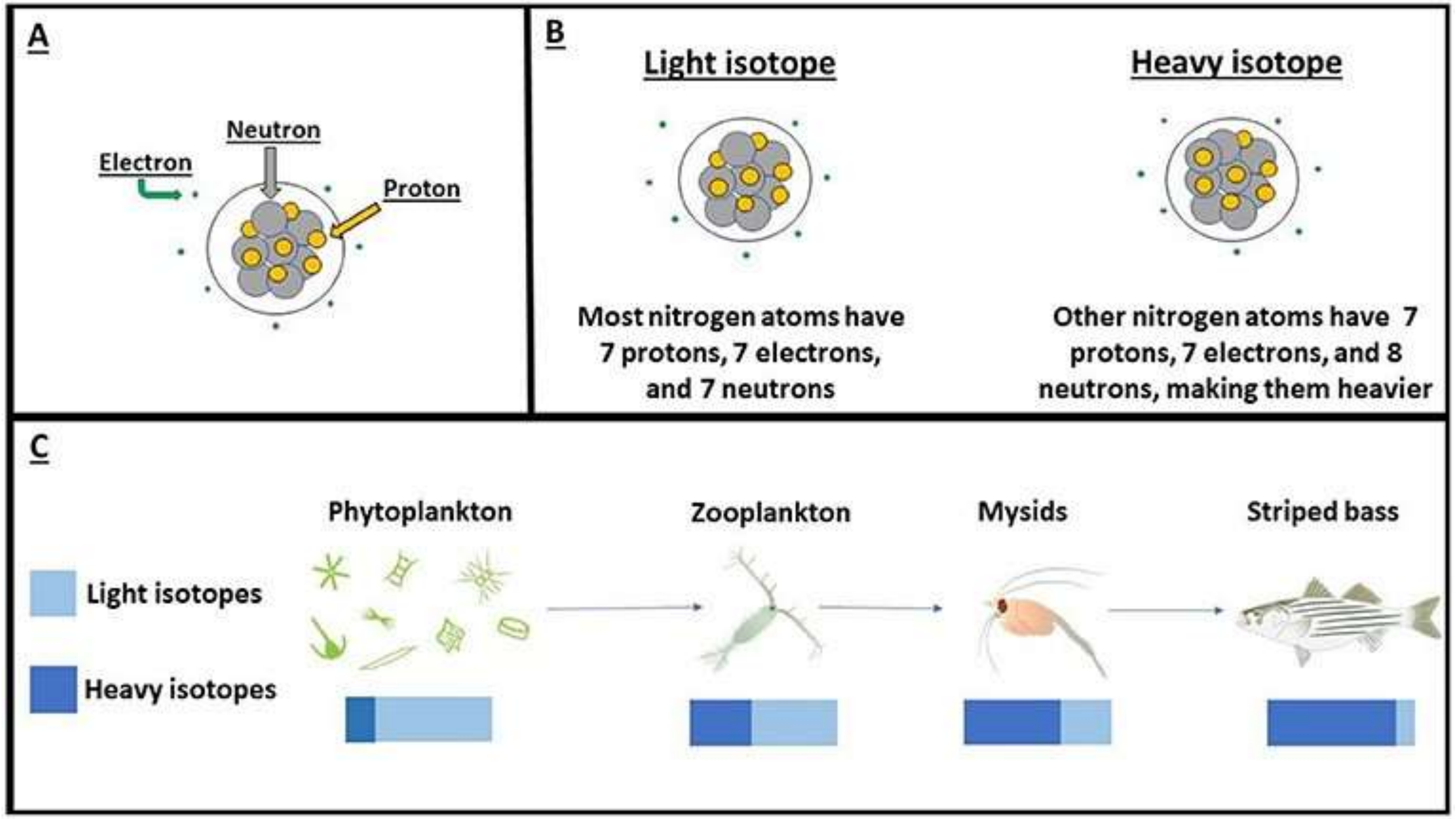
Why Use Stable Isotopes?

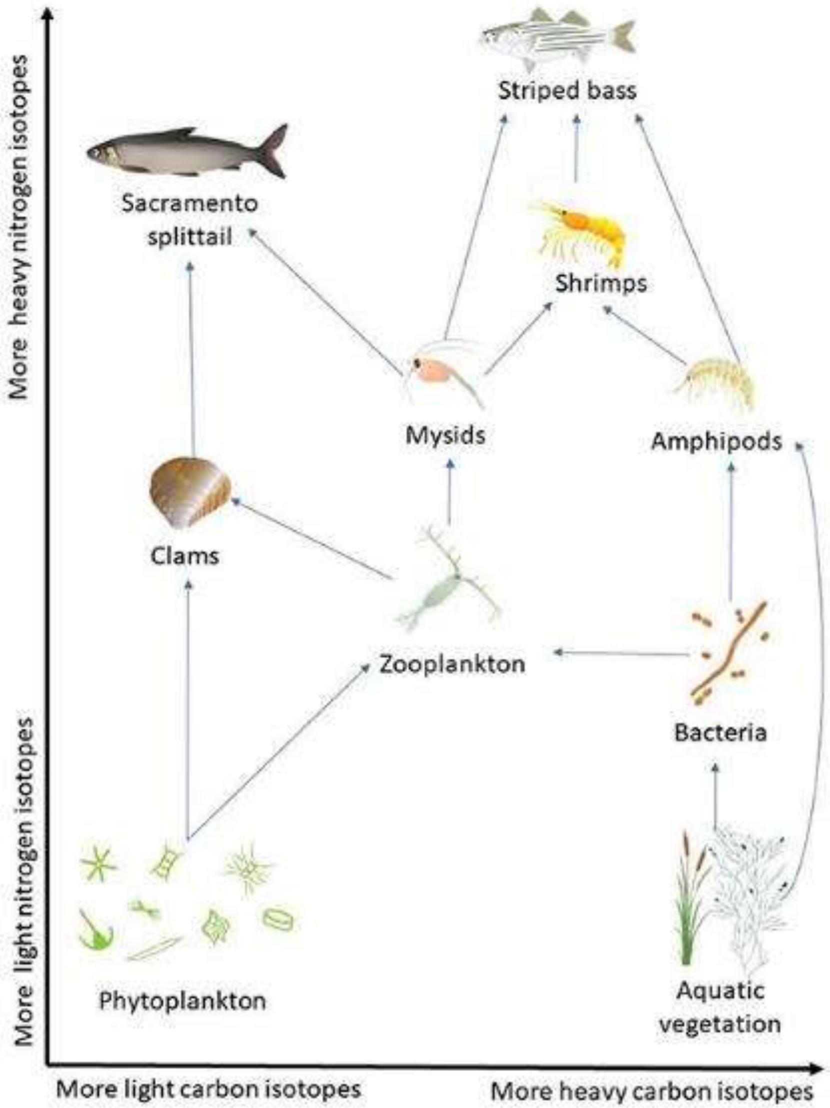
- Accuracy
- Time integrated information
- Relatively non-intensive and inexpensive
- Full trophic pathways



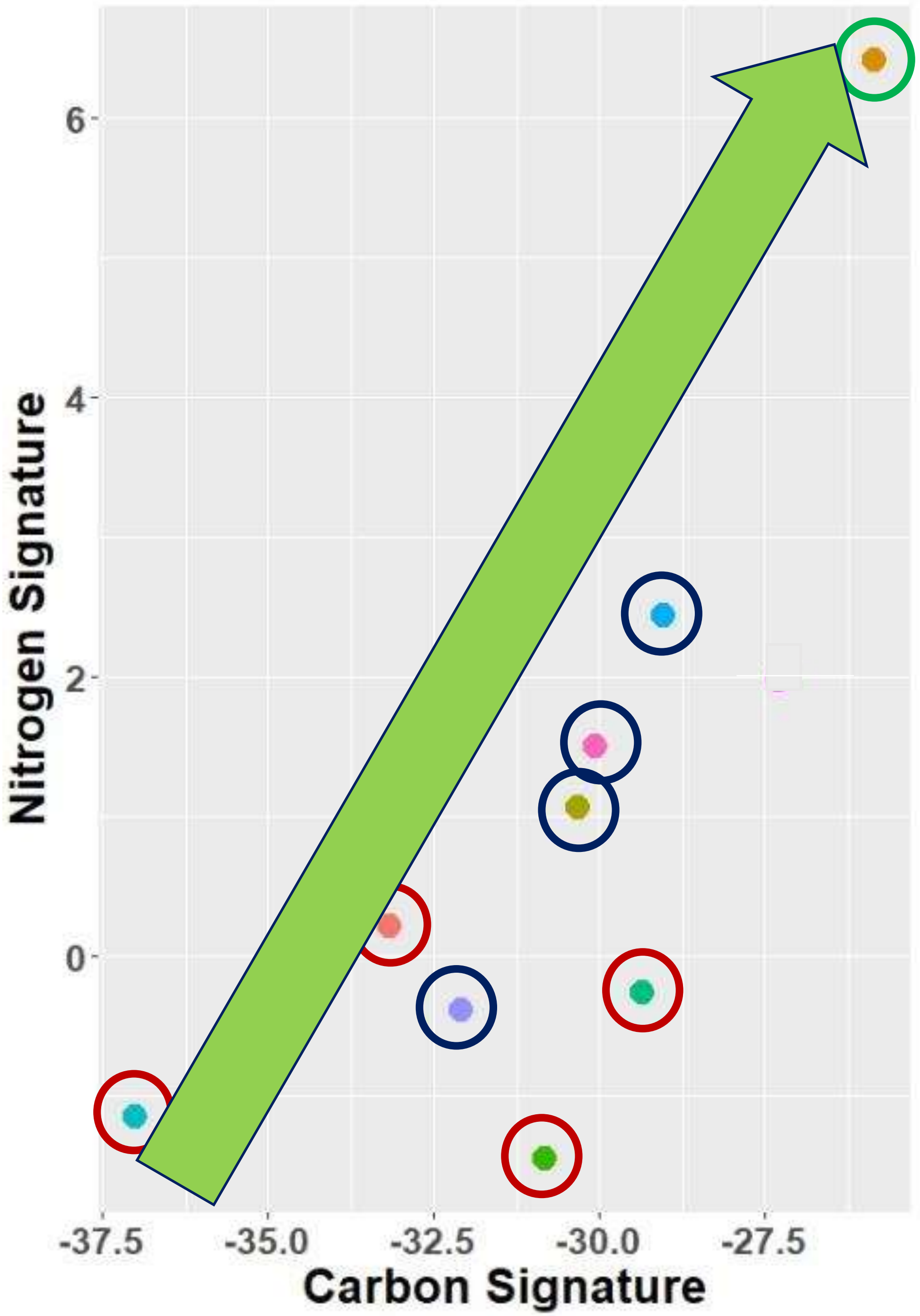
Q2 Do coho trophic pathways differ between BDA and the reference habitat?

- Why Carbon and Nitrogen for food web reconstruction?





Newell et al. 2022



Collector	• Seston (Filterer) • FPOM (Filterer or Gatherer)
Predator	• Other invertebrates
Scraper	• Plant matter on surfaces • Biofilm
Shredder	• CPOM

MixSIAR

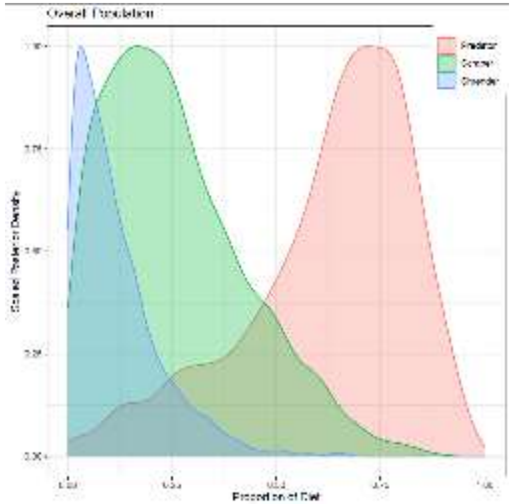
Consumer C & N means & variation

Source C & N means & variation

Trophic enrichment factors

$$Y_j = \sum_k p_k \mu^s_{jk},$$

Mixing Equation

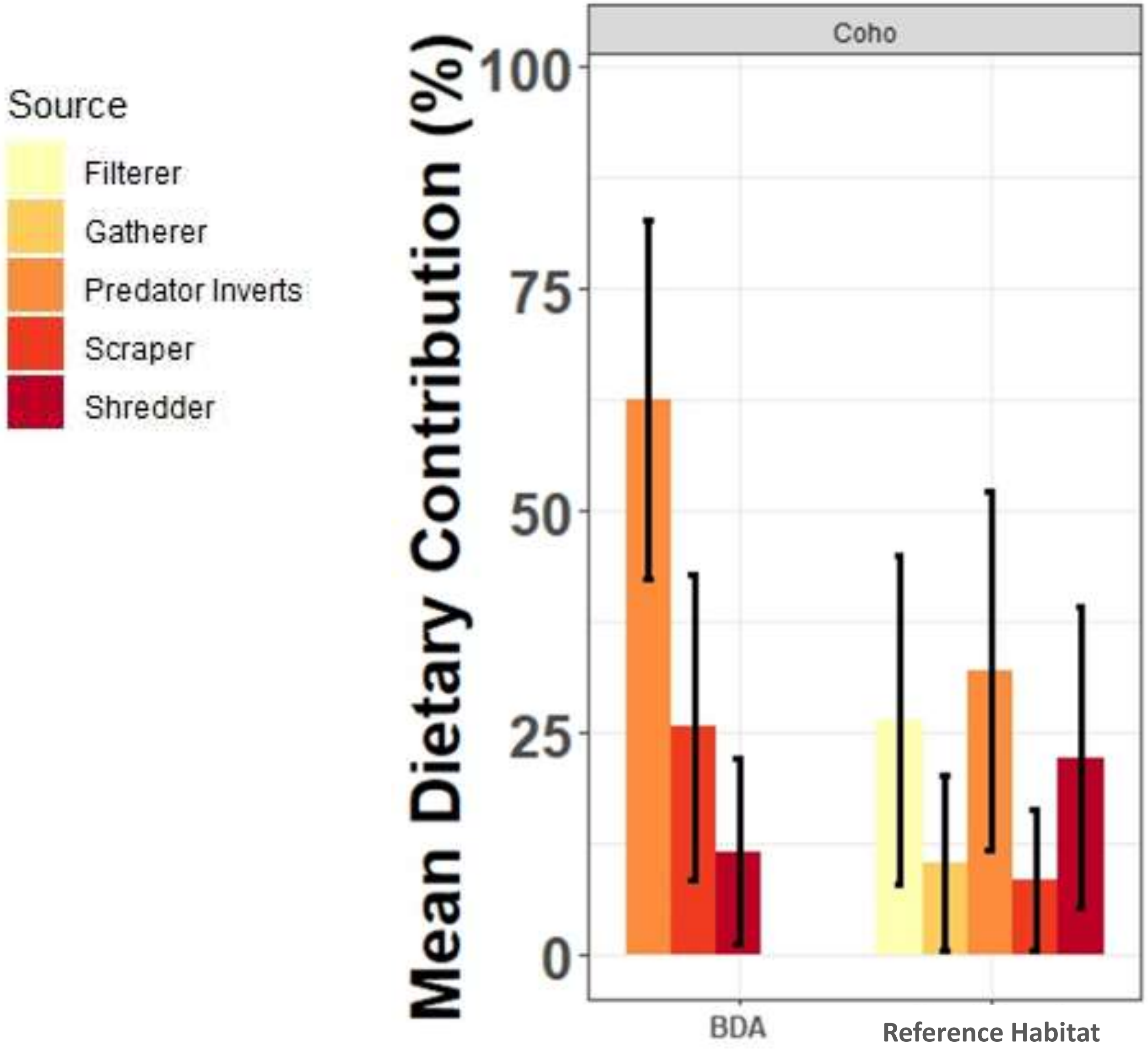


Percent Dietary Contribution for each source

Stock et al. 2018

Results:
Dietary contributions

- Predatory inverts compose ~32% (reference habitat) and ~63% (BDA) of coho diet
- Diet much more varied in the reference habitat



Error Bars = Standard deviation

Q3: If differences in trophic pathways are present, how do they correlate with differences in food abundance and community composition between BDA and the reference habitat?

percent diet contribution : relative abundance of macroinvertebrates

Greater than 1 -> contributing disproportionately to coho diet

Results:
Relative dietary contributions

Site	Source	Relative Contrib.
BDA	Predator	1.99
Reference Habitat	Predator	4.45

- **Coho are feeding on predatory invertebrates at rates 2-4 times greater than their relative abundance in the macroinvertebrate community**

Results:
Relative dietary contributions

- Predatory invertebrates are frequently larger in size
- Predatory invertebrates present in greater densities in BDA habitat
- Reduced species richness in the BDA habitat
- BDA habitat may have more heterogeneity in macroinvertebrate density between patches

These characteristics may improve fish feeding efficiency

•These trends correlate with a wealth of research that has shown that prey size and abundance are two key factors influencing prey selection by salmonids

Conclusions

- Diverse and resilient habitats will be crucial for coho conservation; Beaver restoration might be part of that
- BDAs appear to deliver both abiotic and biotic benefits for coho
  - Part of the story here might be more optimal foraging for juvenile fish in BDAs

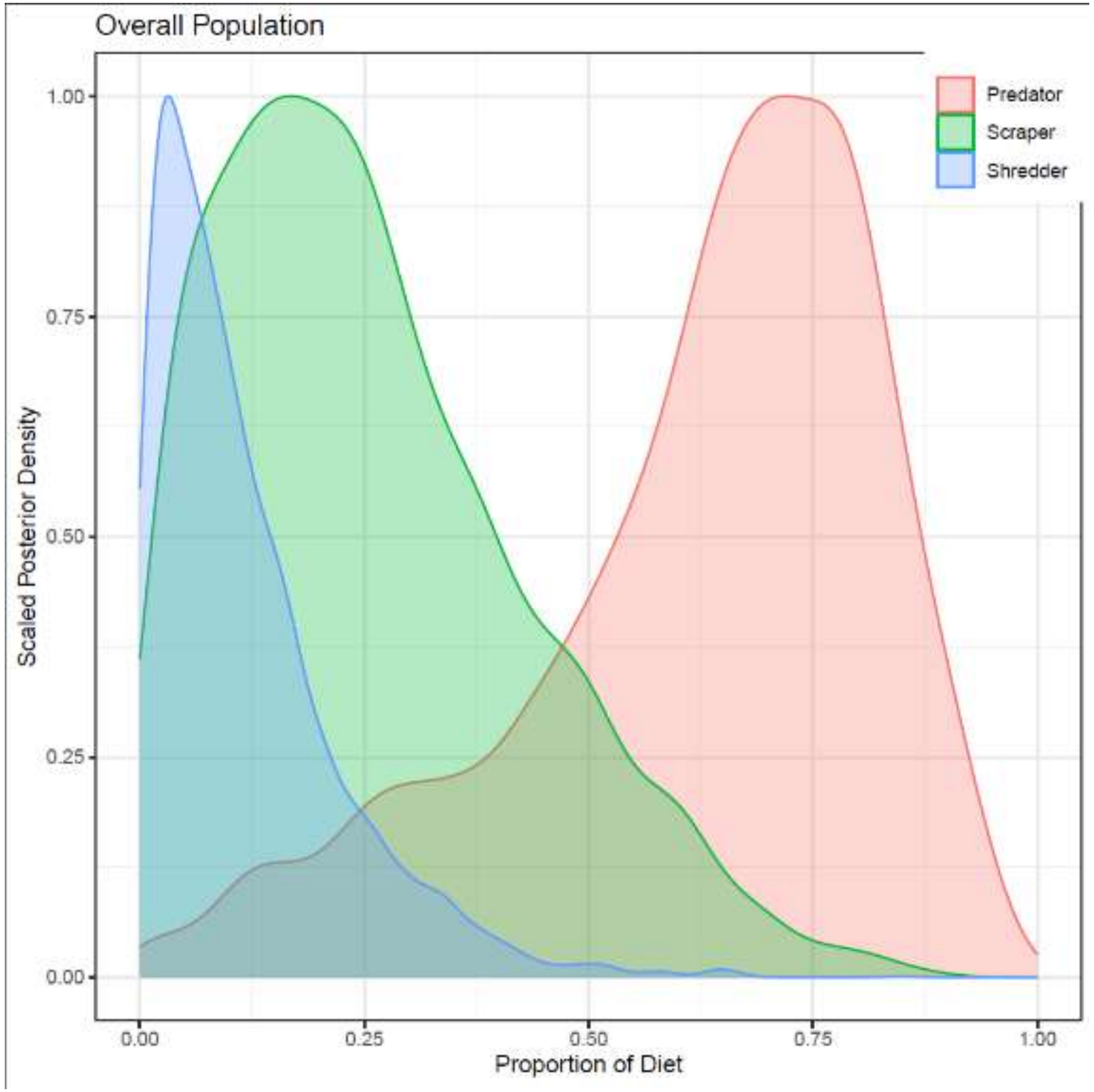
Acknowledgements:

- Dr. Robert A. Lusardi, Advisor, UC Davis
- Dr. Ethan Baruch, Environmental Scientist, CDFW
- Erich Yokel, Scott River Watershed Council
- Misa Terrel, Junior Specialist, UC Davis
- Adrianna Alarcon, Junior Specialist, UC Davis
- Scott River Watershed Council

UCDAVIS
UNIVERSITY OF CALIFORNIA

SCOTT RIVER
WATERSHED COUNCIL

Questions?



MixSIAR

- Bayesian mixing model
  - Prior knowledge (e.g. relative source abundance)
  - Better tolerates uncertainty
  - Output is a likelihood distribution