Evaluating Process Based Restoration as a Method to Restore Ecosystem Resilience

A Concurrent Session at the 43rd Annual Salmonid Restoration Conference
Santa Cruz, California, April 29 - May 2, 2025

Session Coordinator: Carrie Monohan, California State University, Chico and Mooretown Rancheria of Maidu Indians

Process-based restoration involves restoring a sites' ability to withstand and recover from disturbance, also known as ecosystem resiliency. Measuring ecosystem resiliency with metrics using geospatial data, landscape pattern analysis and simulation modeling to evaluate ecosystem resilience at management scales is needed to operationalize the concepts of process-based restoration. Ideally managers are able to measure ecological resilience of current conditions and project resilience under future scenarios after restoration. As process-based restoration projects are implemented, and as they include upland management, how we measure near and long-term metrics of success will enable us to learn what techniques work best as well as what site conditions are best suited for process-based restoration. This session invites examples that include using remote sensing tools, chrono sequences, citizen science models and traditional ecological knowledge to evaluate process-based restoration success.

Presentations

Evaluating Process Based Restoration as a Method to Restore Ecosystem Resilience

Carrie Monohan, PhD

Mooretown Rancheria

CSU Chico

Our Mission

Promote process-based restoration approaches to increase the capacity of degraded river and stream ecosystems to retain water, support biodiversity, create fire resiliency, and adapt to climate change.

We are diverse collaborative of natural resource professionals with a shared mission to promote and advance process-based restoration in California.

Join us @ calpbr.org

Mailing List
Build Like a Beaver Workshop
Coordinating Committee

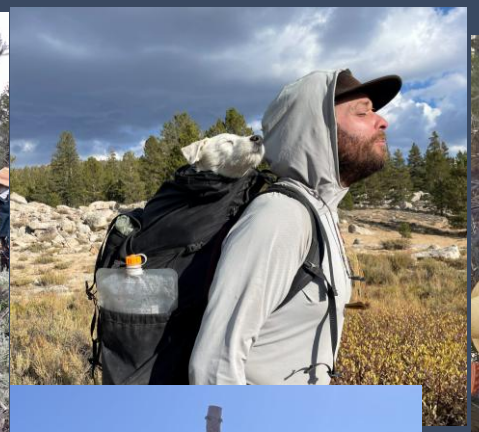
Sheli Wingo
sheli@calpbr.org

PBR in the Golden Trout Wilderness
Change Detection, Critical Metrics, and Restoration Effects

Sabra Purdy, Trout Unlimited, SRF 2026

Golden Trout Wilderness & Kern Plateau:

- 18 Meadows on the Kern Plateau, Inyo NF 2021-2026
- Sequoia NF 10 meadows (Some not Pictured)
- Majority in Designated Wilderness
- Remote Backcountry Field Camps
- Hand Tools, High Tolerance for Muck and Sap, Stubbornness, Sweat, Love, Dog/Log Carrying



The 4 essential components of Process Based Restoration

- Space
- Energy
- Materials
- Time

Ciotti et al. 2021

Design Criteria for Process Based Restoration of Fluvial Systems

Watershed Context HydroGeomorphic Understanding

The Assessment Process

- Understanding your process space
- Understanding your inputs, regimes, and available material: Flows, Sediment, Fuels, Fire
- Discovering Opportunities and Constraints
- Source Problems
- And more

PRIMARY GOAL 1:

Restore natural geomorphic, hydrologic, and biotic processes throughout meadow sites.

- **Objective 1-1***: Arrest and mitigate headcuts*
- **Objective 1-2***: Increase channel aggradation*
- **Objective 1-3:** *Increase structurally forced channel widening*
- **Objective 1-4***:* Increase channel length and complexity
- **Objective 1-5***: Increase water surface elevation (vertical connectivity)*
- **Objective 1-6***: Increase ground water table elevation (vertical connectivity)*
- **Objective 1-7***: Maximize active channel and floodplain proportion of the valley bottom (lateral connectivity)*

SMART Objectives:

Specific, Measurable, Achievable, Relevant, and Time-Bound

Objectives with Associated Performance Measures, Monitoring Metrics, and Indicators

Achievable

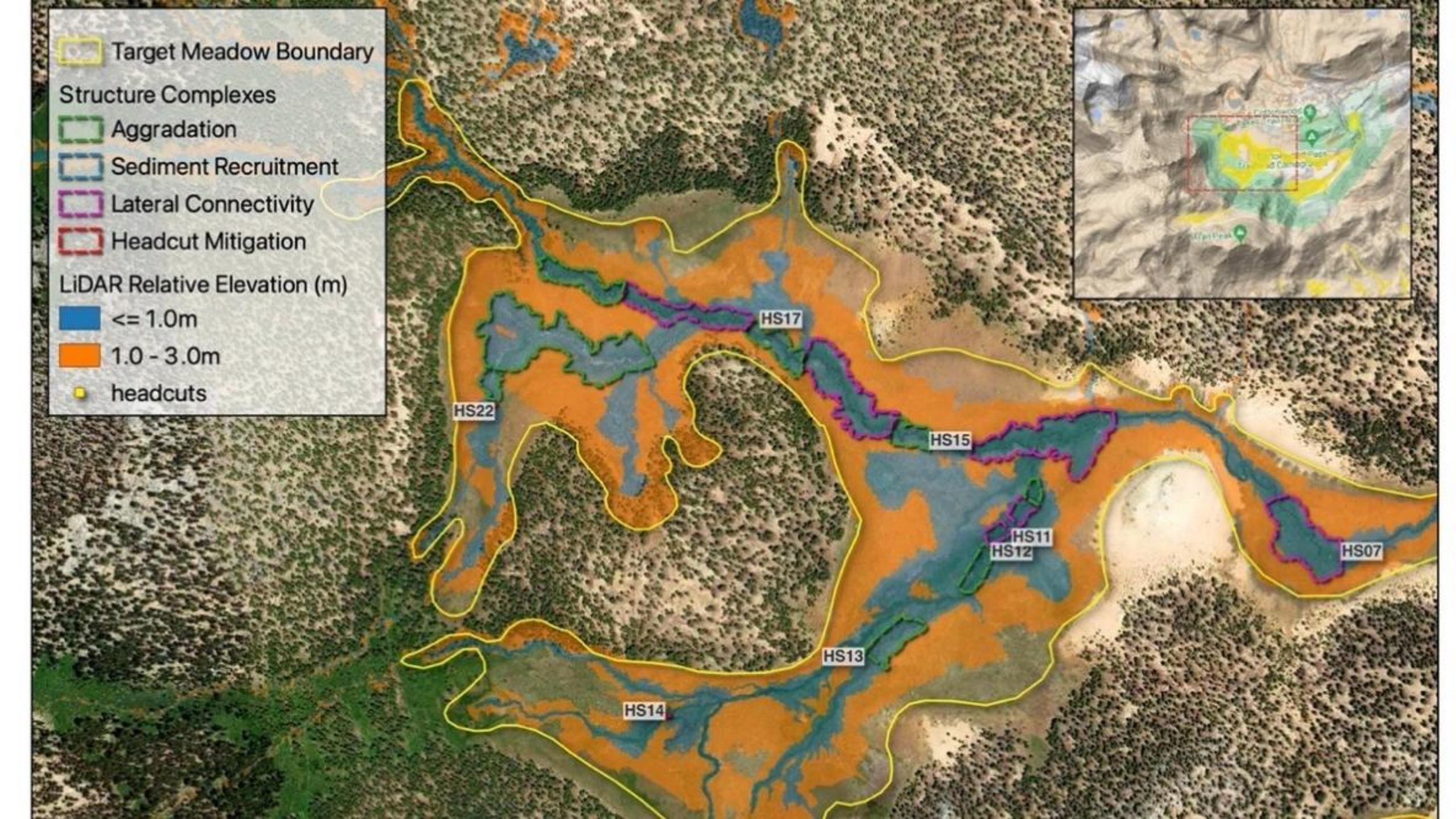
Relevant

Objective 1-2: Increase channel aggradation	**PM1-2:** Structure will encourage sediment deposition and aggrade the channel. Structures will generally be <1m. Can be enhanced in subsequent phases. **Current:** Many channels are incised. **As-Built**: No change from current. **Moderate-Term :** Expect 50% structures at least 50% filled, 50% near 100% ready for next Phase. **Long-Term:** Expect 50% Phase 2 Structures at least 50% filled, 50% near 100%, ready for next Phase.	Aggradation rate (structure fill rate) Height of historical floodplain above current bankfull and above current channel	Erosion/deposition extent Channel and bankfull elevations

Specific

Time-Bound

Measurable


Target Meadow Boundary
Structure Complexes
Aggradation
Sediment Recruitment
Lateral Connectivity
Headcut Mitigation
LiDAR Relative Elevation (m)
<= 1.0m
1.0 - 3.0m
headcuts
HS22
HS17
HS15
HS11
HS12
HS07
HS13
HS14

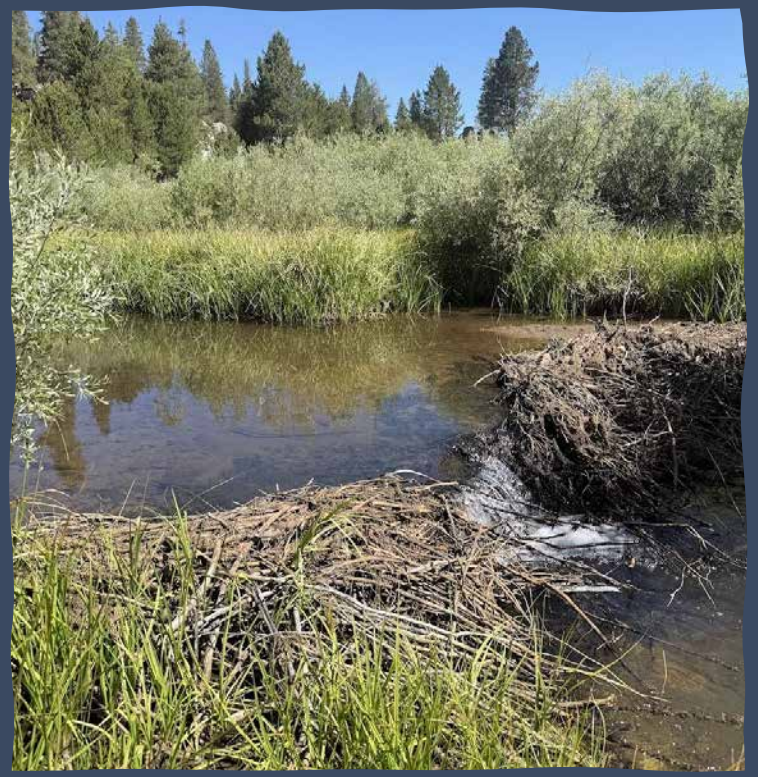
Potential Complex Objectives

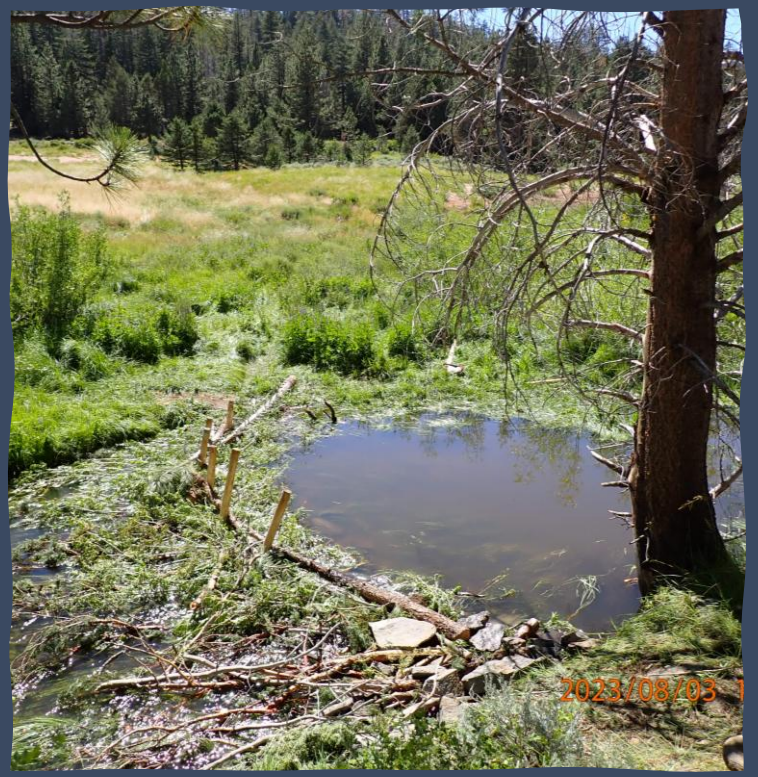
- Aggradation: Trying to capture and settle sediment out, build up the incised stream bed to meet the historic floodplain
- Lateral Connectivity: Trying to reconnect the historical floodplain, send water onto floodplain surface and into floodplain subsurface (hyporheic flow), engage soil storage and reduce stream power
- Pool Development: Trying to create or deepen existing pools to provide refugia, cool water temps, or create additional complexity in a homogenous reach, reduce velocity, settle out sediment
- Sediment Recruitment: Use strategic structure placement to create intentional erosion of a stream bank (increase sinuosity, sediment sorting, feed downstream structures, intentional widening of channel)

Complex Objectives Continued…

- Headcut Mitigation: The 4-part recipe…
- Fish Passage: Ways through or around impediments, floodplain
- Spawning Habitat: Shallow Riffles with nice gravel
- Rearing Habitat: Side Channels, Back waters, Emergent Marshes
- Water Quality Issues: Dissolved Oxygen, Turbidity, Temperature…
- Aggrade a Steep or Very Large channel: Non-Channel Spanning structures
- Homogenous channel: Increase complexity
- Velocity Reduction/Increased Roughness: Slow and spread the water
- Not Everything should be a pond, keep habitat complexity in mind

Structure Drives Complexity; Complexity Drives Diversity





Structure Types

- Beaver Dam Analog: Channel Spanning structure, mix of greens, sediment and wood intended to raise water table, slow flow, increase pool depth, lateral connectivity, aggrade sediment, etc…

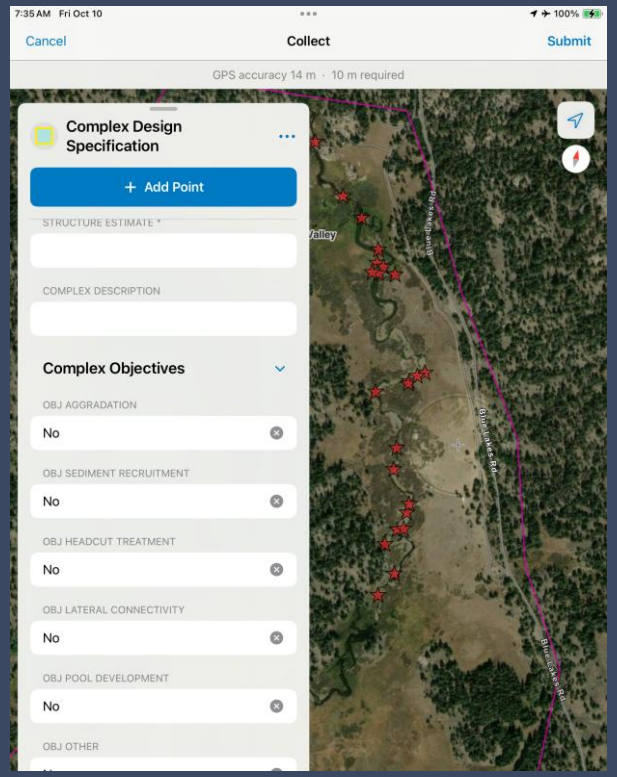
Log Structures: PALS/LS:

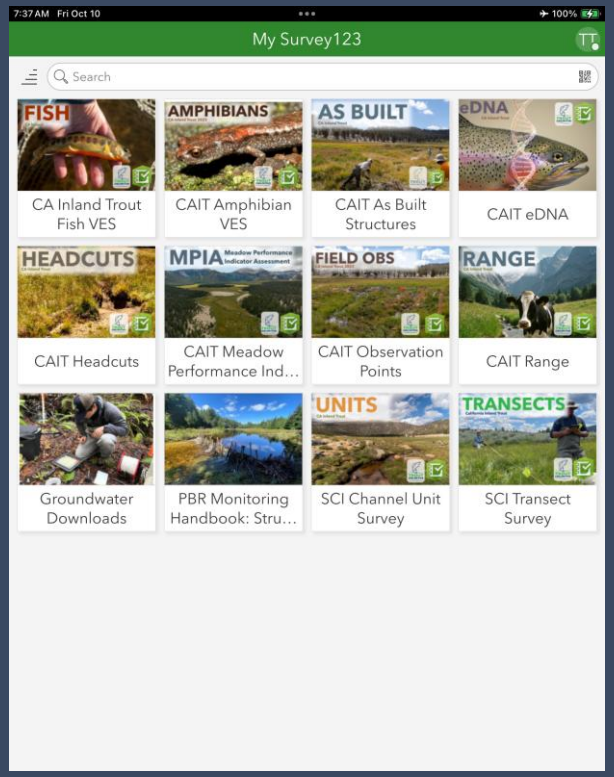
- Channel Spanning
- Bank Attached
- Mid-Channel
- Loose/Tight
- Rhino Horns
- Constriction Jets
- Bank Blasters
- Whole trees
- And on and on and on….

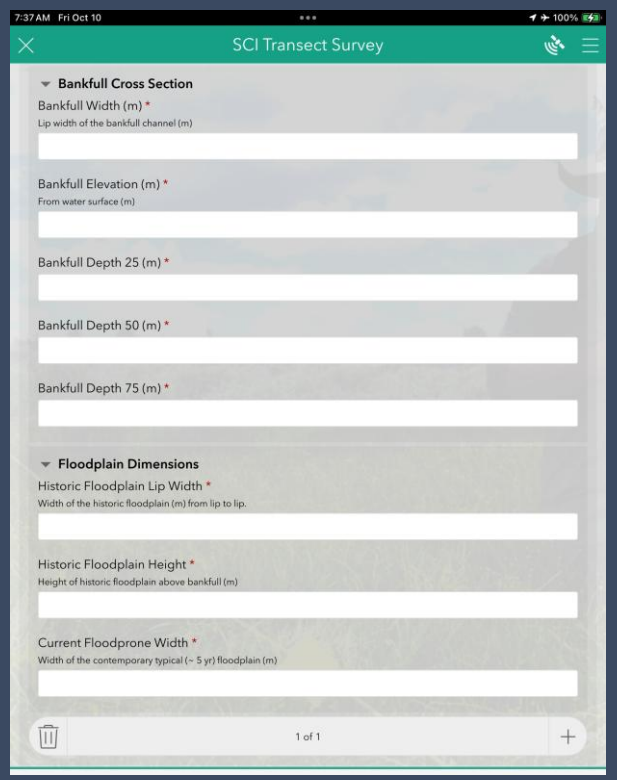
Tools for Change Detection and Restoration Effectiveness

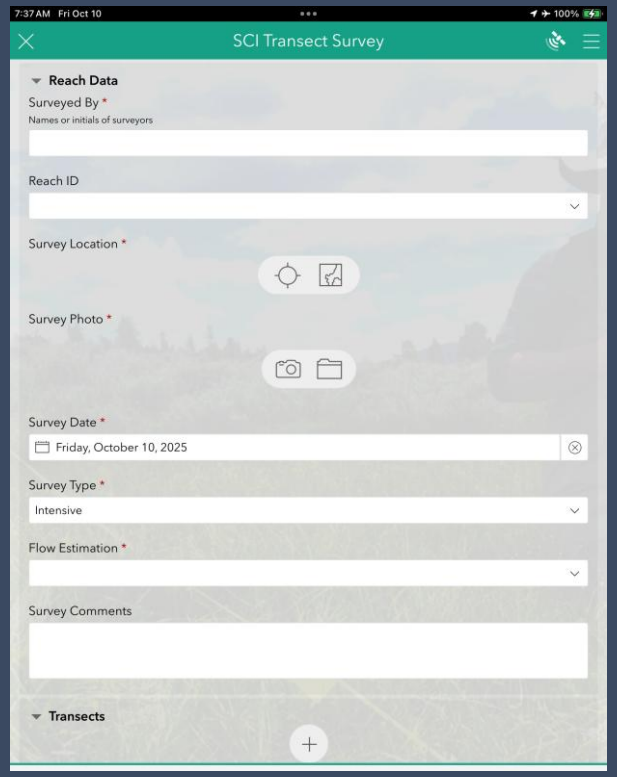
ARC GIS Field Maps, Survey 123

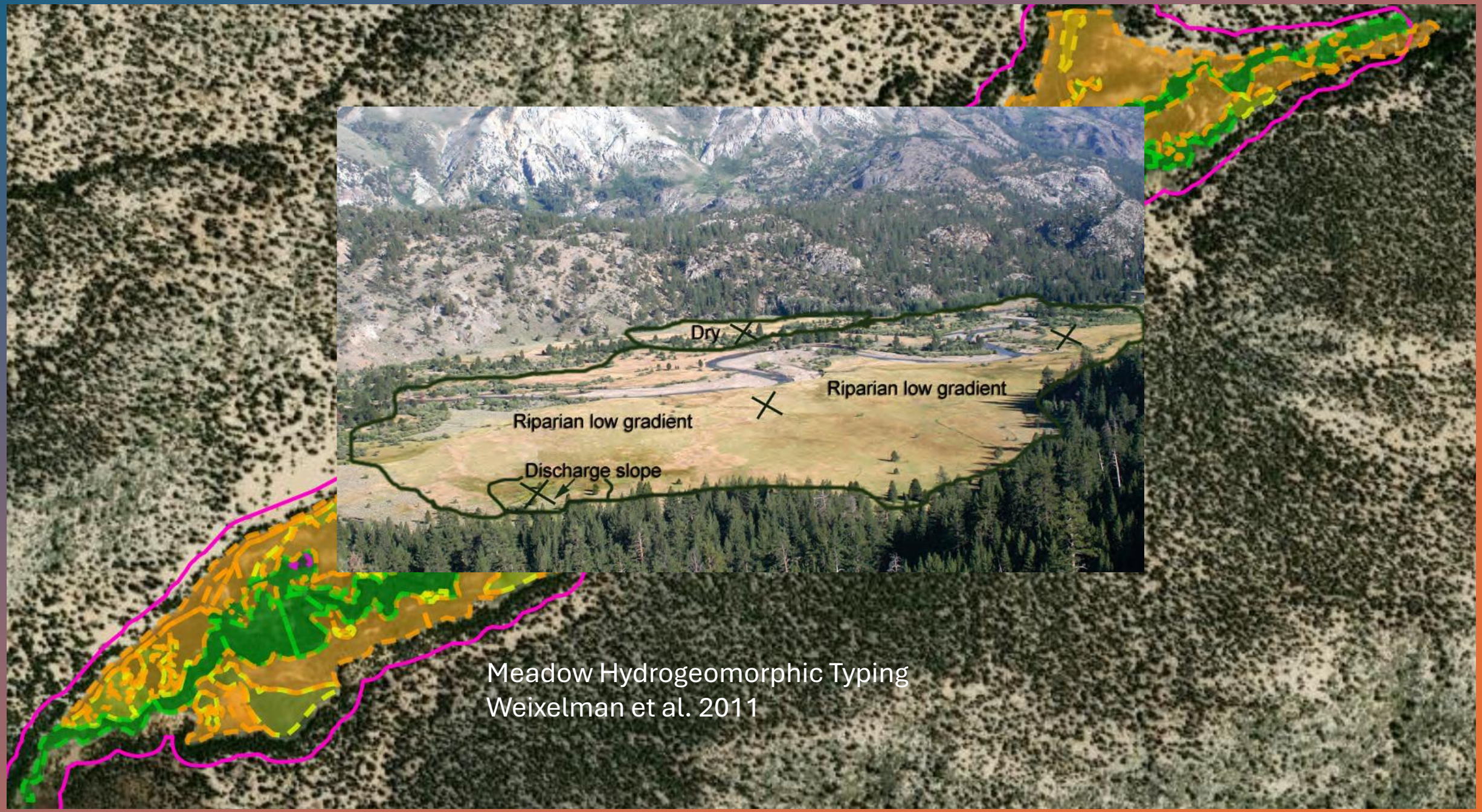
Monitoring Protocols: Vegetation Mapping, Geomorphology, Habitat Features, Meadow Hydrogeomorphic Types, Fish VES, Amphibian VES, Range, Headcuts, Structure/Complex performance, Ground Water Wells



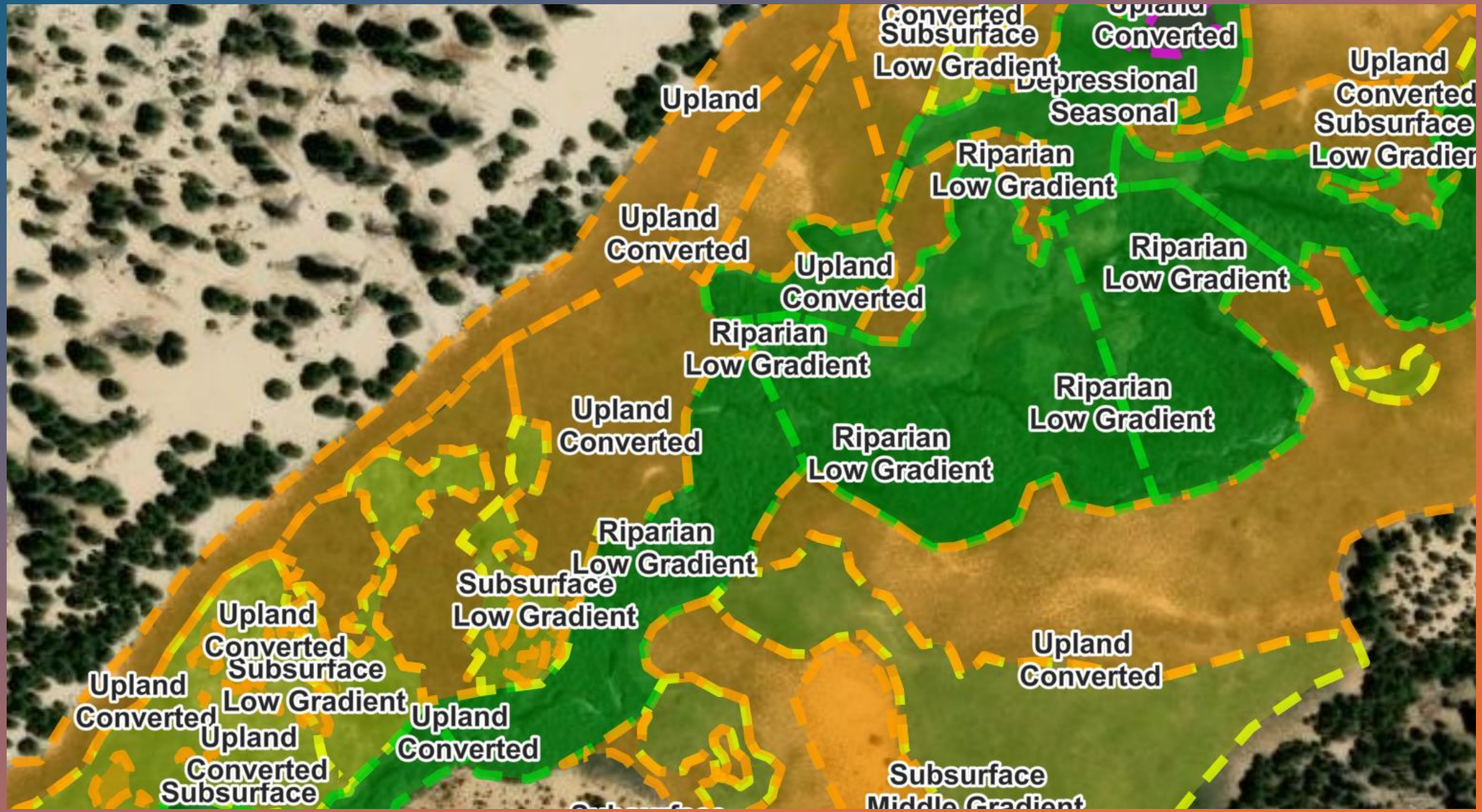








Meadow Hydrogeomorphic Typing
Weixelman et al. 2011


Converted
Subsurface
Low Gradient
Converted
Depressional
Seasonal
Upland
Converted
Subsurface
Low Gradier
Upland
Riparian
Low Gradient
Upland
Converted
Riparian
Low Gradient
Upland
Converted
Riparian
Low Gradient
Riparian
Low Gradient
Upland
Converted
Riparian
Low Gradient
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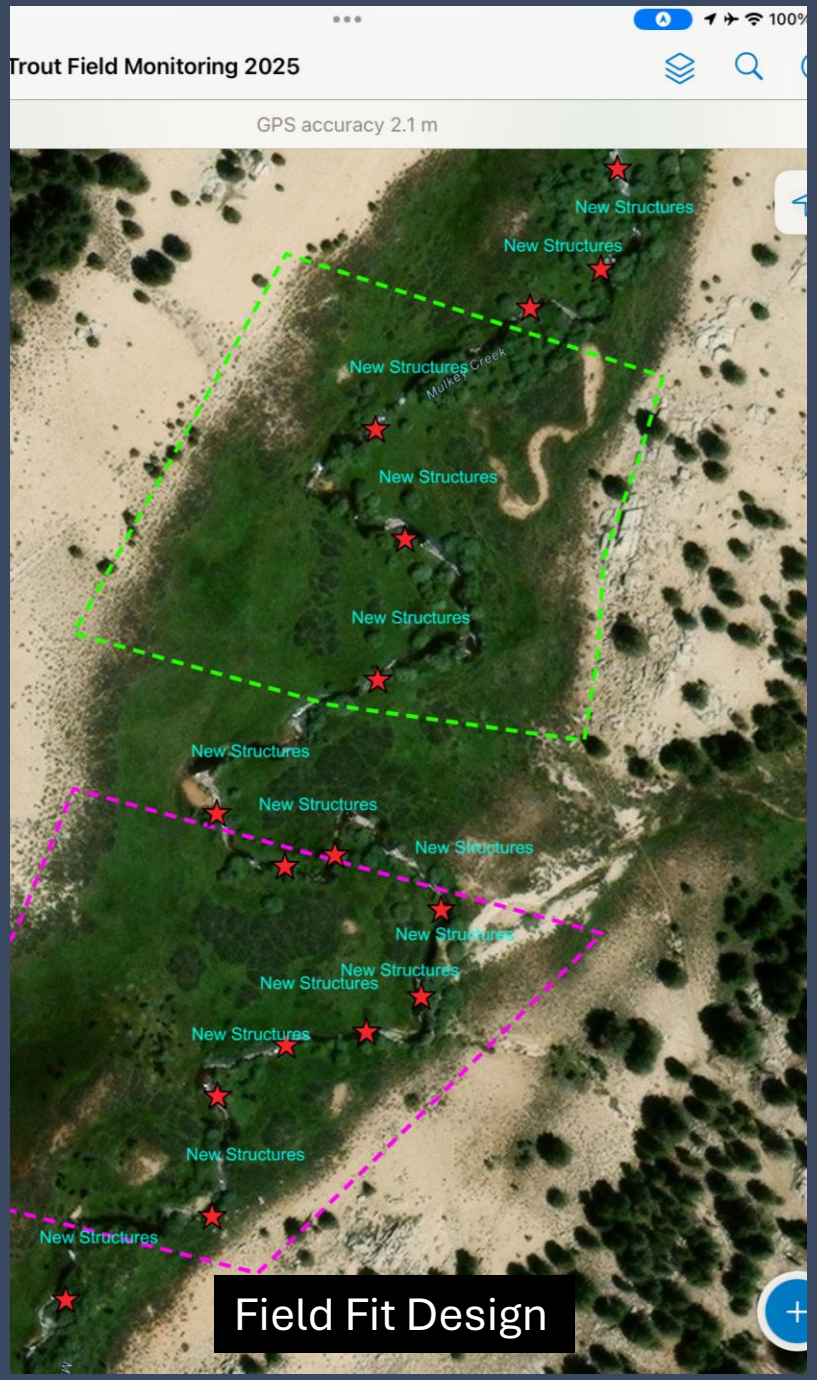
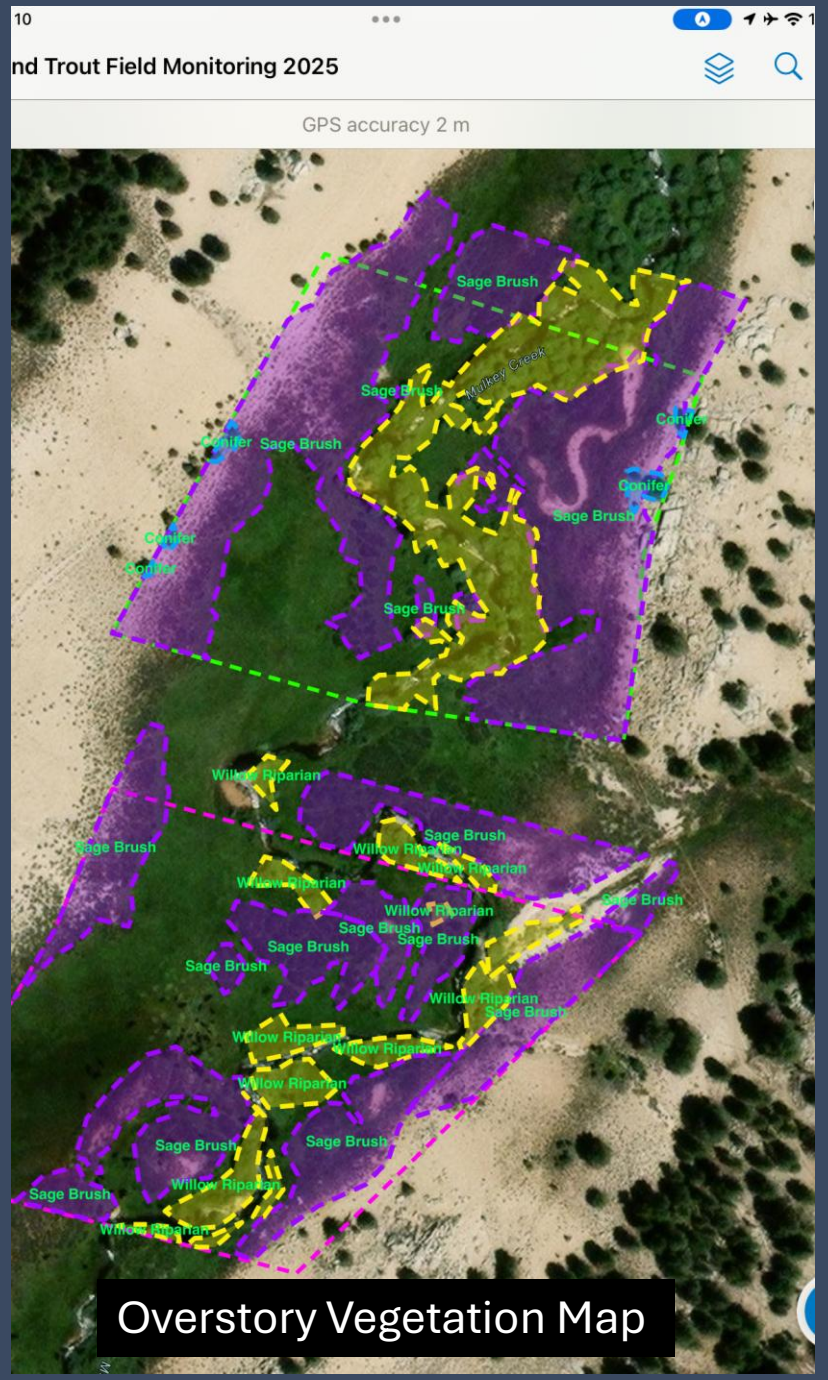
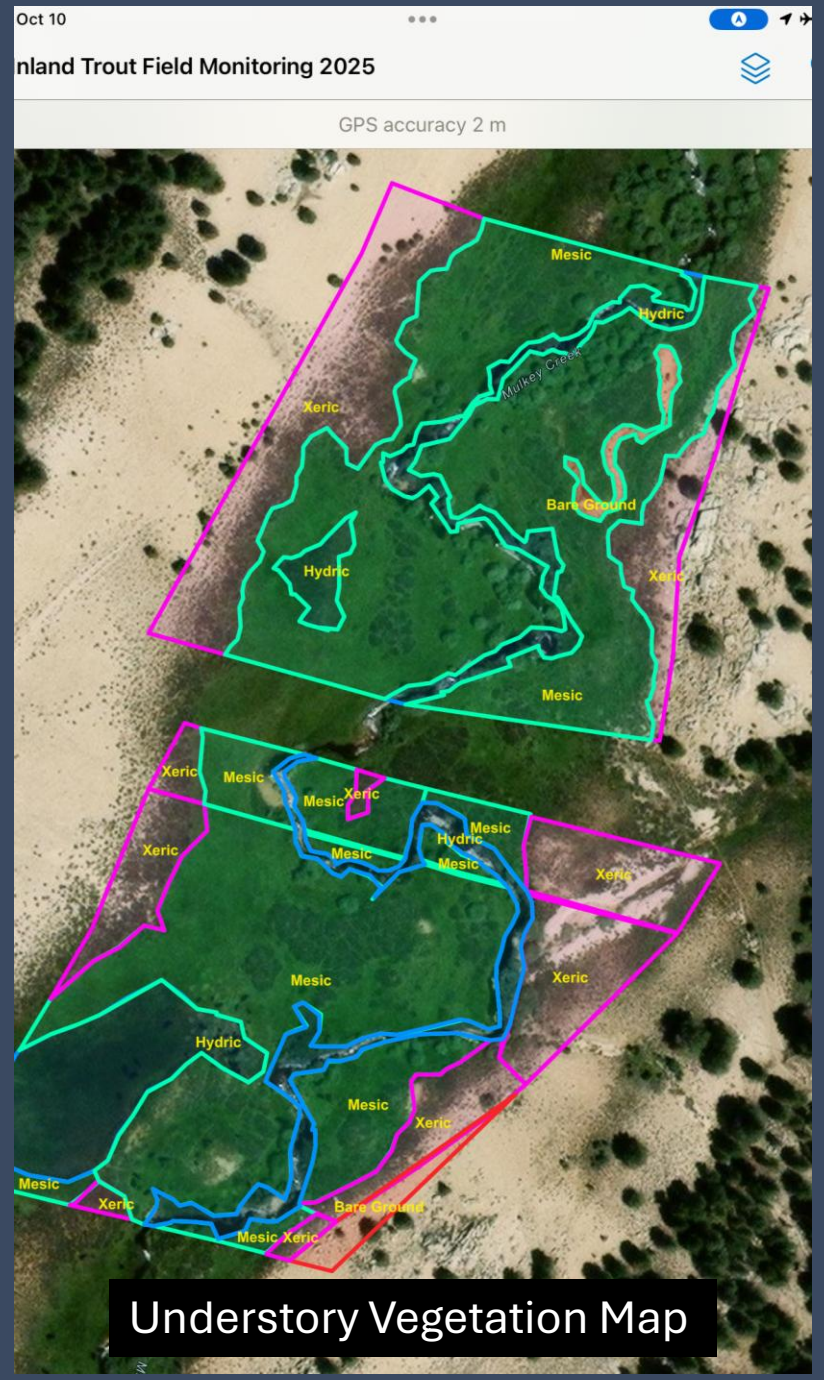
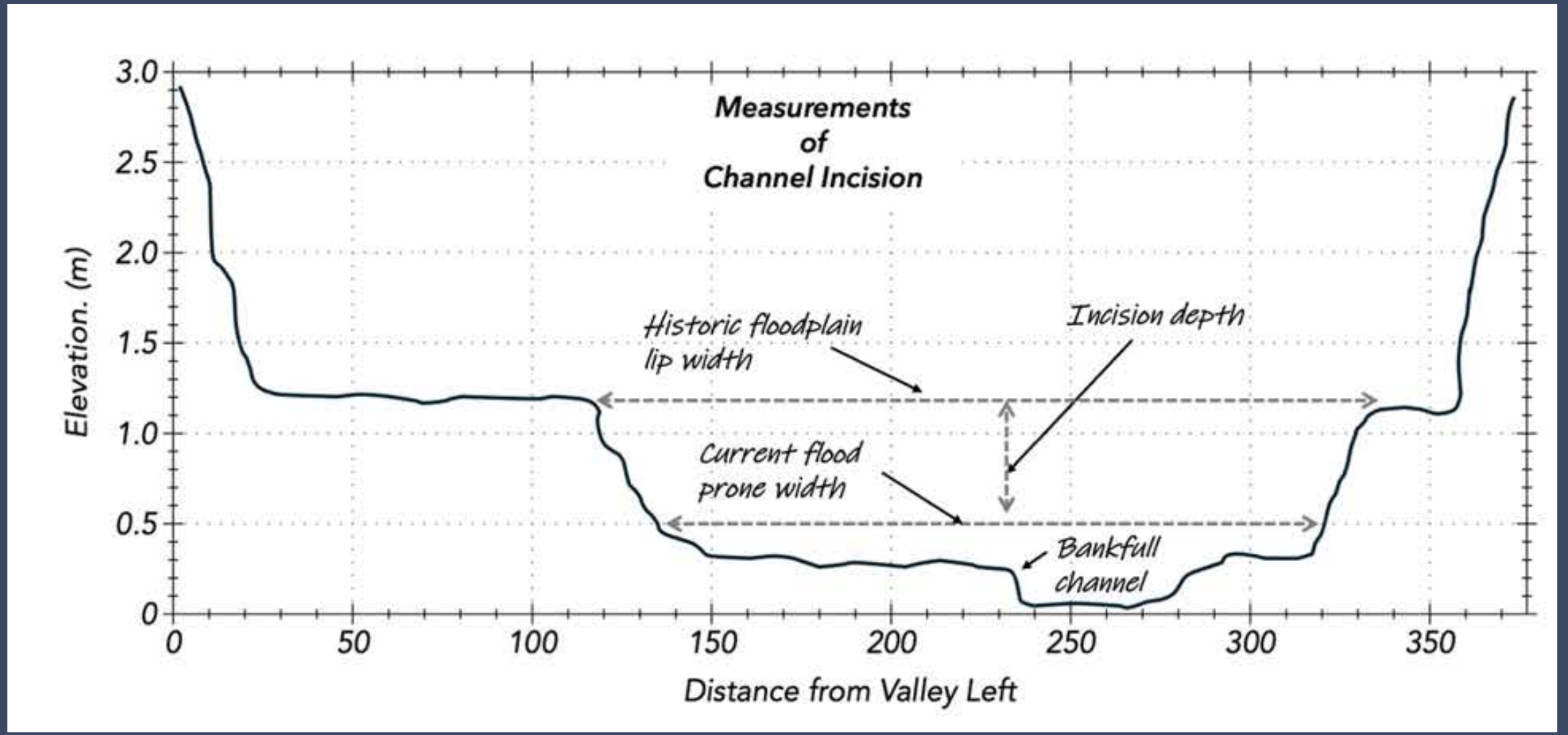
Subsurface
Subsurface


Trout Field Monitoring 2025
GPS accuracy 2.1 m
New Structures
Mulkey Creek
Field Fit Design


nd Trout Field Monitoring 2025
GPS accuracy 2 m
Sage Brush
Conifer
Willow Riparian
Mulkey Creek
Overstory Vegetation Map


nland Trout Field Monitoring 2025
GPS accuracy 2 m
Mesic
Hydric
Xeric
Bare Ground
Mulkey Creek
Understory Vegetation Map


Measurements
of
Channel Incision
Historic floodplain
lip width
Incision depth
Current flood
prone width
Bankfull
channel
Elevation. (m)
3.0
2.5
2.0
1.5
1.0
0.5
0
0
50
100
150
200
250
300
350
Distance from Valley Left

Dutch Meadow 2024, Before Implementation

Dutch Meadow 2024 After Implementation

Key Early Metrics:

Increased Wetted Width, Increased Pool Depth, Decreased Height to Historic Floodplain


Structure Performance Monitoring
Repeat measurements of pool formation and aggradation
Historic floodplain elevation
Vertical distance from water surface
Impoundment effectiveness behind structures
Depth 3 m
Depth 2 m
Depth 1 m


Incision Recovery Monitoring
Flood Prone Width
Larger is better
Historic Floodplain Elevation
Smaller is better

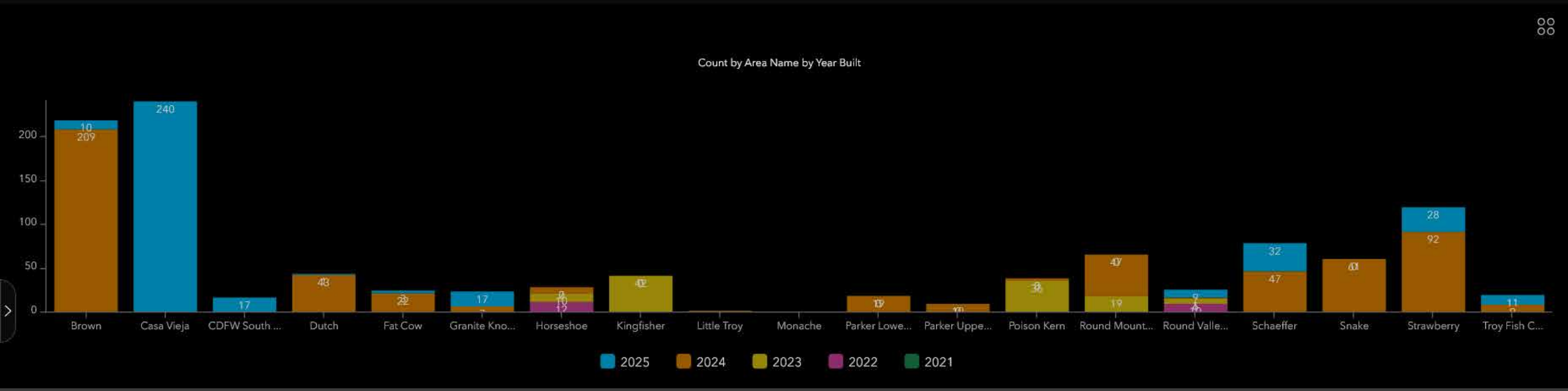
TROUT UNLIMITED

CA Inland Trout Data Manager
2025 Monitoring

Refresh | Help

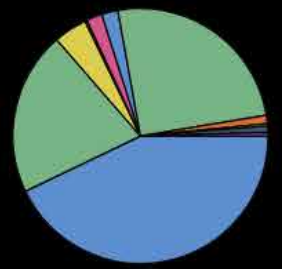
Map View | Photos | Summary

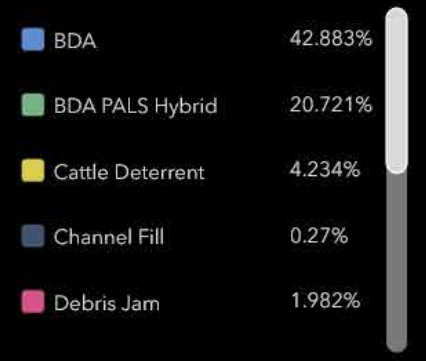
As Built | Headcuts | Unit | Transect | Veg

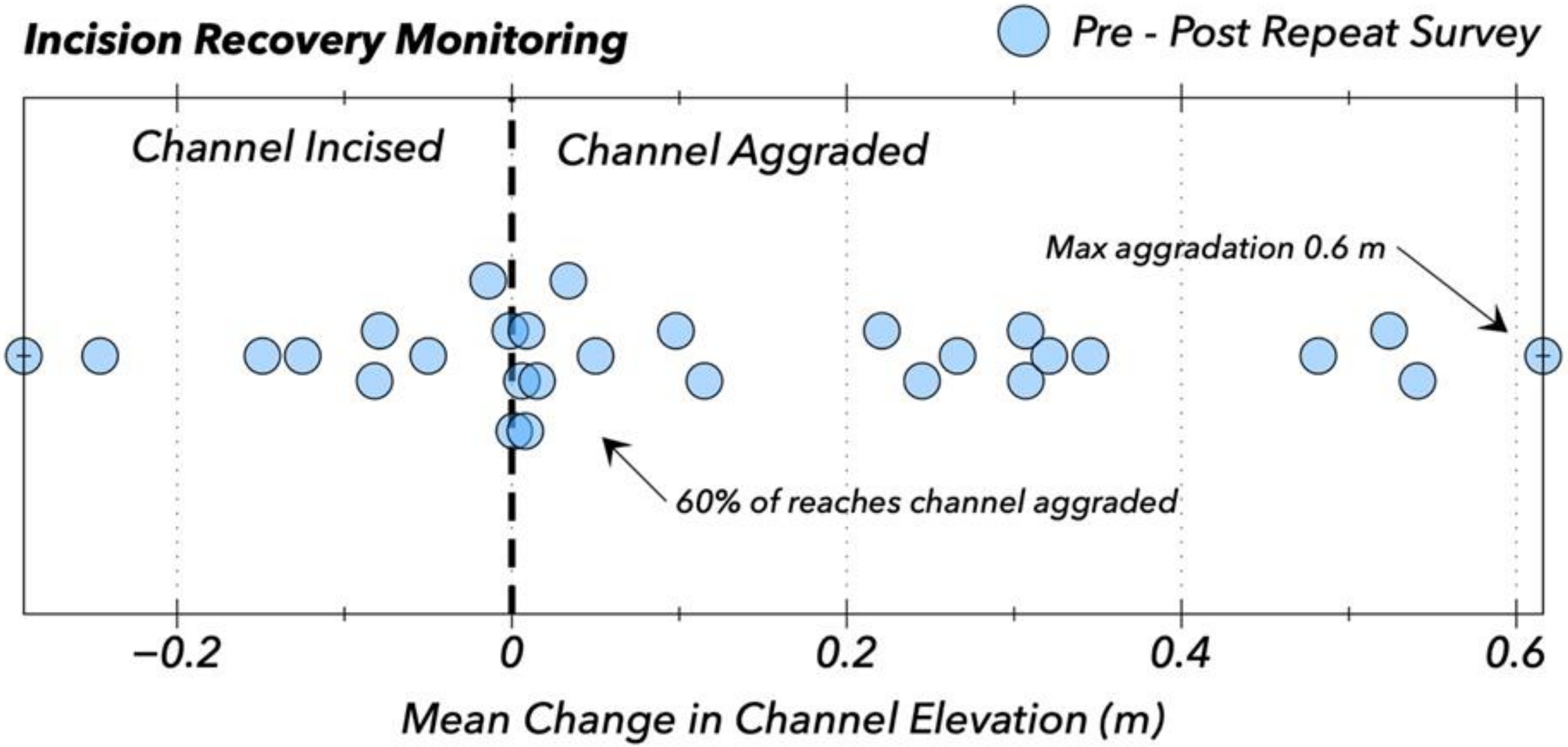


1,110

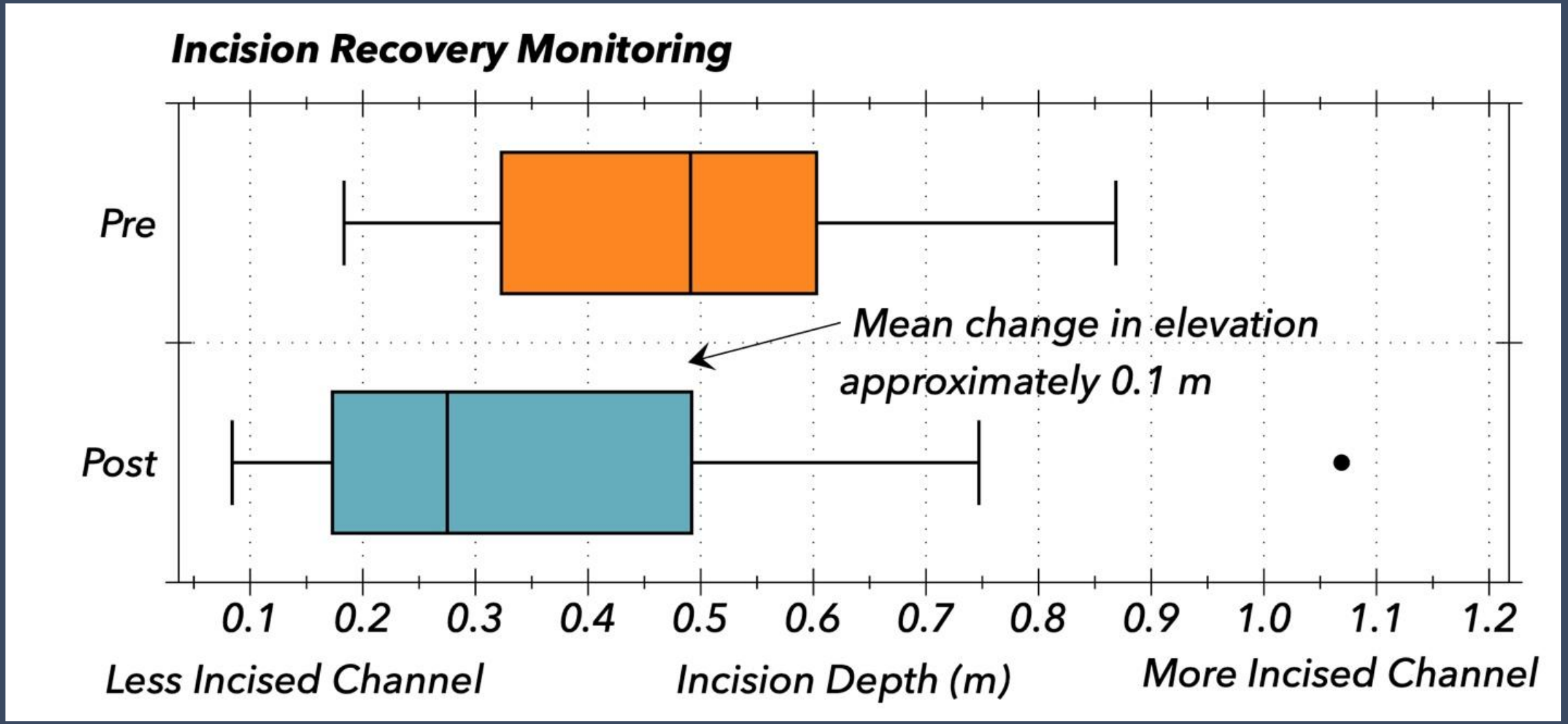
Total PBR Structures Built



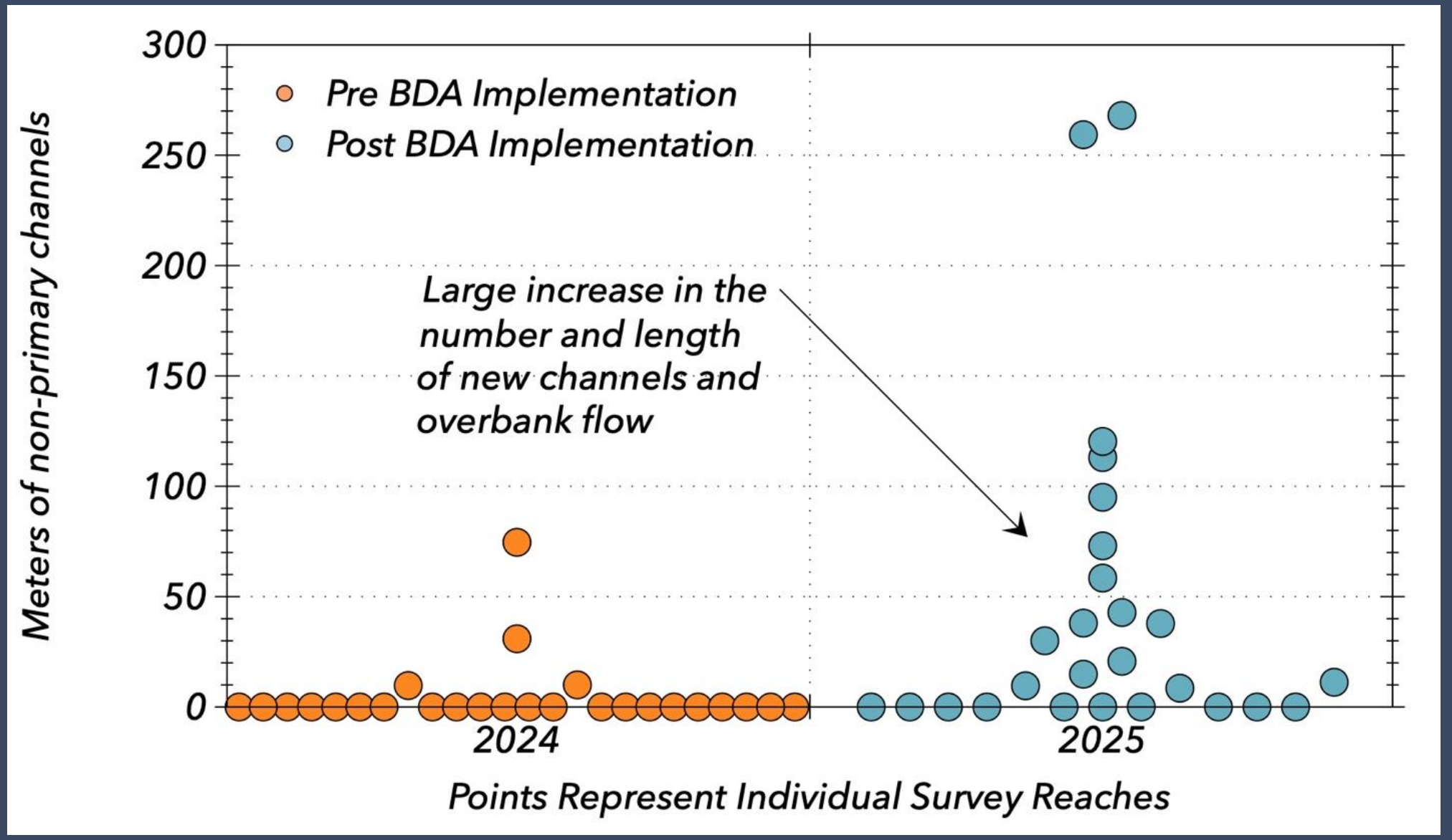


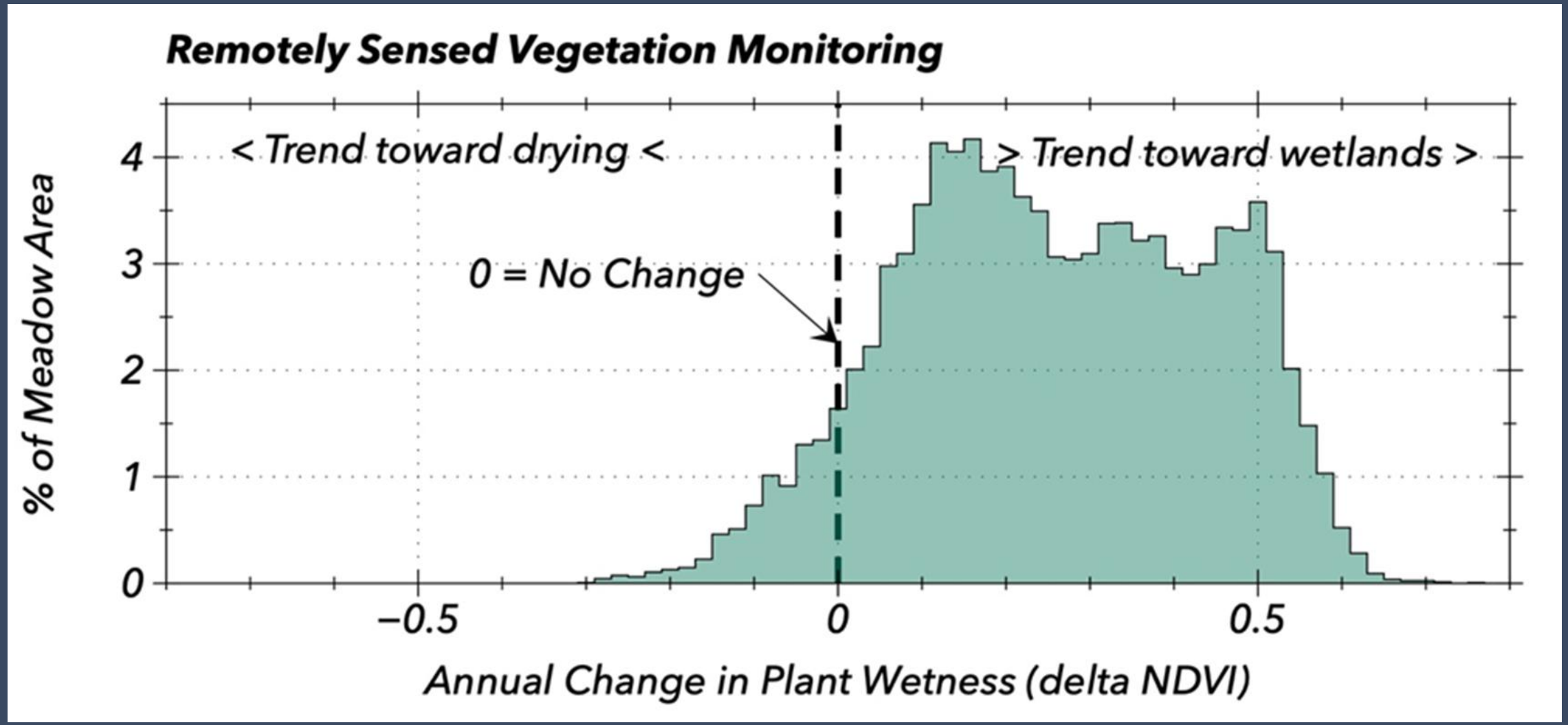


Incremental Change Leads to Tangible Results

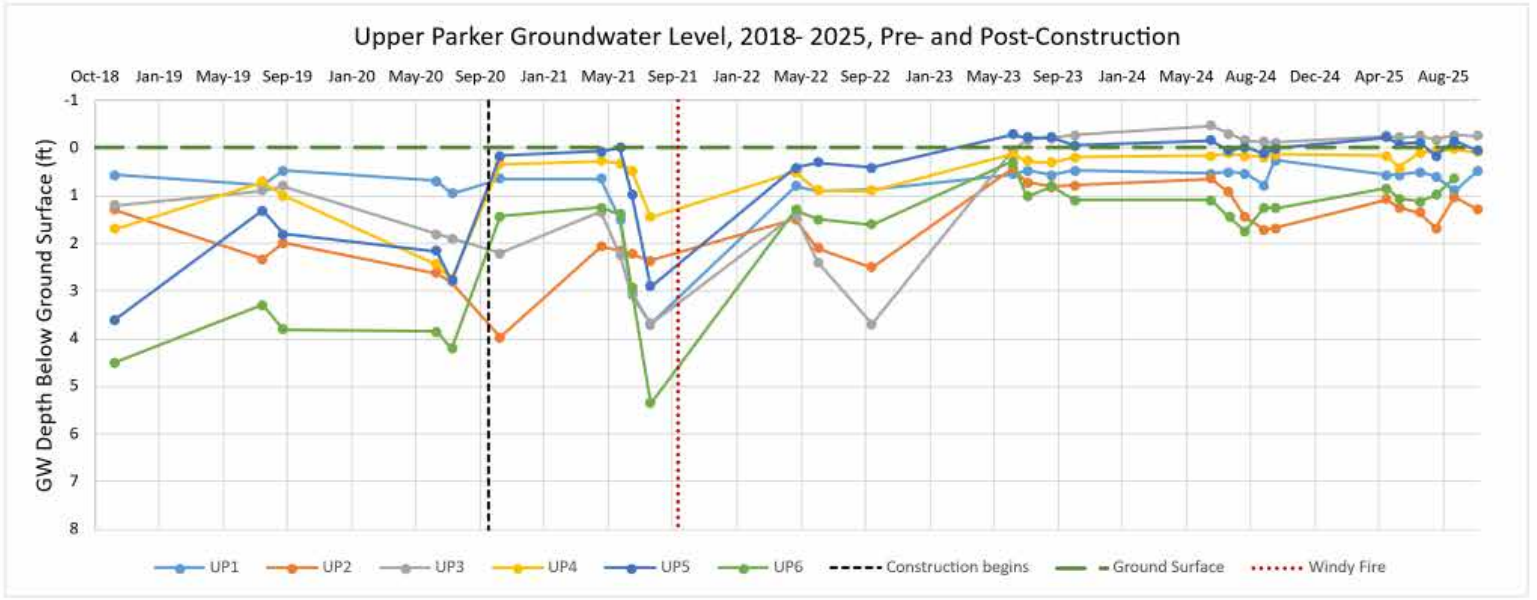


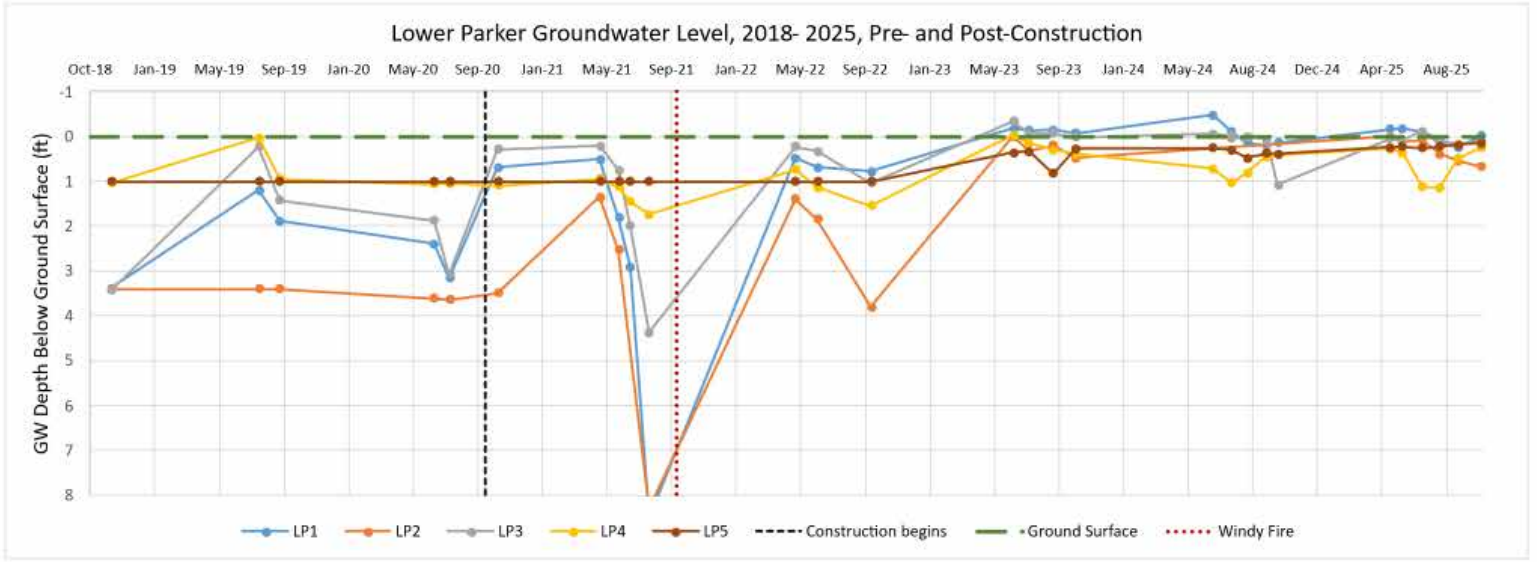
The mean change in the bed elevation among restoration reaches was approximately 0.10 m, but was as high as 0.6 m in some reaches. In most cases, these aggradation results occurred over just one year.


Meters of non-primary channels
300
250
200
150
100
50
0
Pre BDA Implementation
Post BDA Implementation
Large increase in the number and length of new channels and overbank flow
2024
2025
Points Represent Individual Survey Reaches



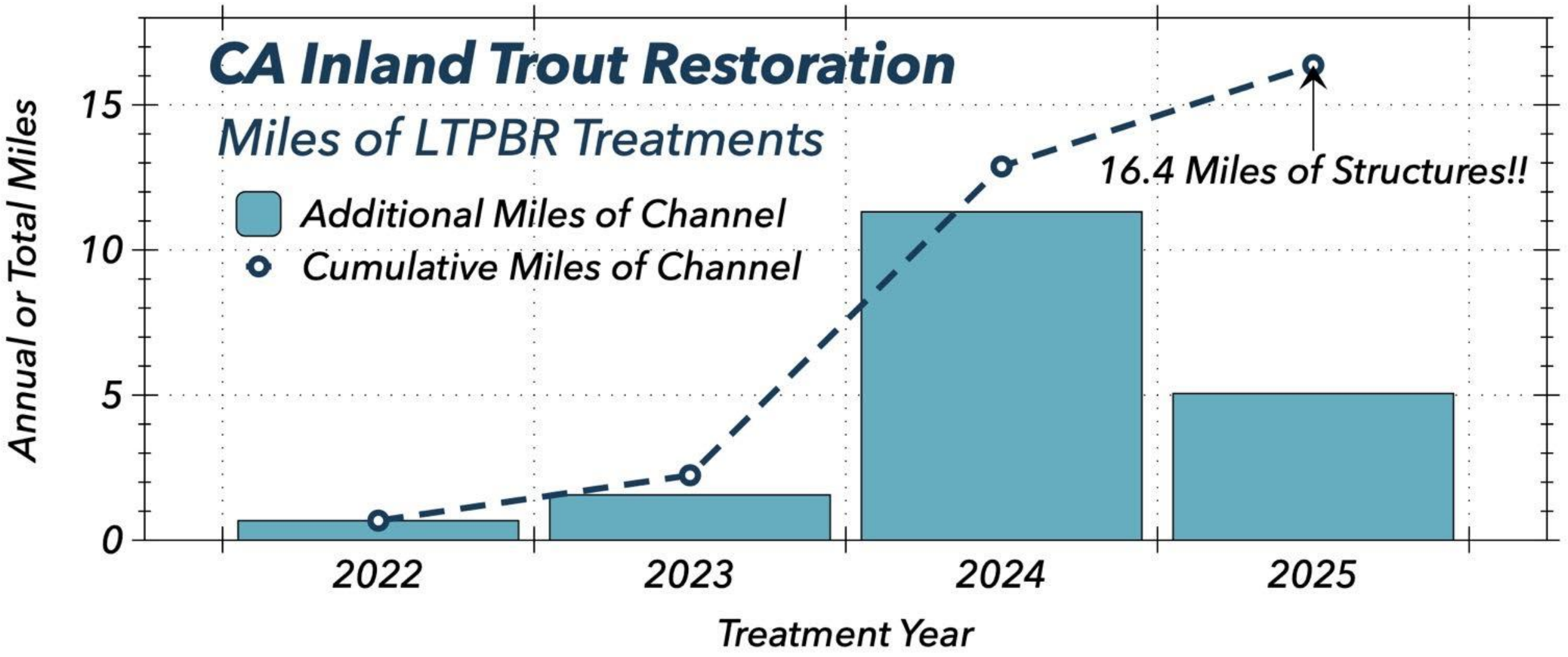
Preliminary analysis of the Normalized Differenced Vegetation Index (NDVI), a proximate measure of plant water content. This analysis is particularly suitable for monitoring the responses of restoration treatments. The figure illustrates the distribution of NDVI surfaces that have been differenced among years (2025 – 2023) in the vicinity of low-tech structural treatments constructed in 2024.


Upper Parker Groundwater Level, 2018- 2025, Pre- and Post-Construction
Oct-18 Jan-19 May-19 Sep-19 Jan-20 May-20 Sep-20 Jan-21 May-21 Sep-21 Jan-22 May-22 Sep-22 Jan-23 May-23 Sep-23 Jan-24 May-24 Aug-24 Dec-24 Apr-25 Aug-25
GW Depth Below Ground Surface (ft)
-1 0 1 2 3 4 5 6 7 8
UP1 UP2 UP3 UP4 UP5 UP6 Construction begins Ground Surface Windy Fire


Lower Parker Groundwater Level, 2018- 2025, Pre- and Post-Construction
Oct-18 Jan-19 May-19 Sep-19 Jan-20 May-20 Sep-20 Jan-21 May-21 Sep-21 Jan-22 May-22 Sep-22 Jan-23 May-23 Sep-23 Jan-24 May-24 Aug-24 Dec-24 Apr-25 Aug-25
GW Depth Below Ground Surface (ft)
-1 0 1 2 3 4 5 6 7 8
LP1 LP2 LP3 LP4 LP5 Construction begins Ground Surface Windy Fire

Key Metrics for Early Response Detection

- Channel Wetted Width and Depth (inundation area and volume)
- Incision Depth (Height from Bankfull to Historic Floodplain)
- Flood Prone Width/% Active Valley Bottom (will stay static until elevation threshold is crossed to access historic floodplain)
- Structure Specific: Aggradation, Pool Depth, Height to FP
- Number of Active Channels (Trying to create complex multithread habitat)
- Ground Water Wells (Depth to Groundwater, Rate of seasonal recession)
- Vegetation Changes (NDVI, Vegetation Mapping, HGM Mapping)


CA Inland Trout Restoration
Miles of LTPBR Treatments
Additional Miles of Channel
Cumulative Miles of Channel
16.4 Miles of Structures!!
Annual or Total Miles
15
10
5
0
2022
2023
2024
2025
Treatment Year

TROUT UNLIMITED

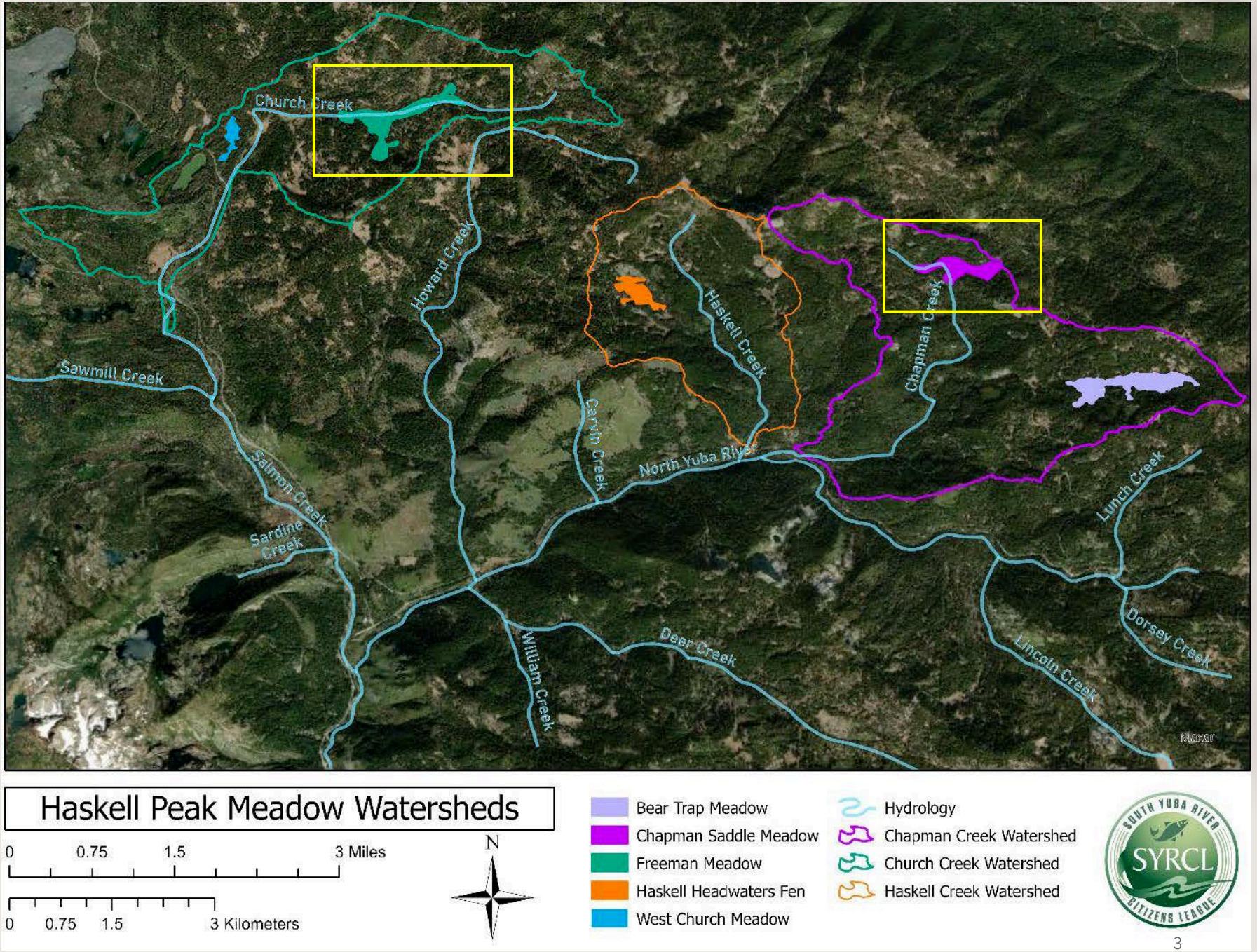
Measuring Success

Process Based Restoration In the Haskell Peak Meadows

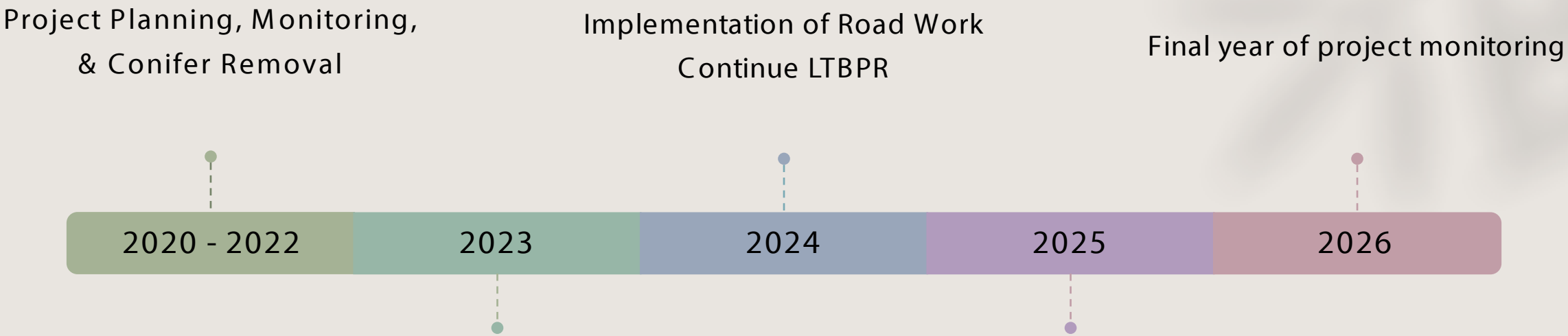
Rose Ledford

Project Manager

Five Meadows
One Project

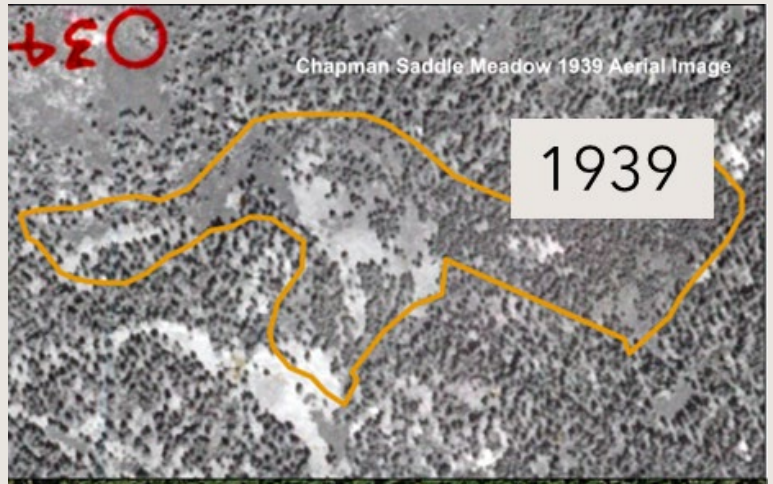


Timeline


Project Planning, Monitoring, & Conifer Removal
Implementation of Road Work Continue LTBPR
Final year of project monitoring
2020 - 2022
2023
2024
2025
2026
Implementation of BDAs Monitoring Conifer Removal
Continue LTPBR Post Project Monitoring

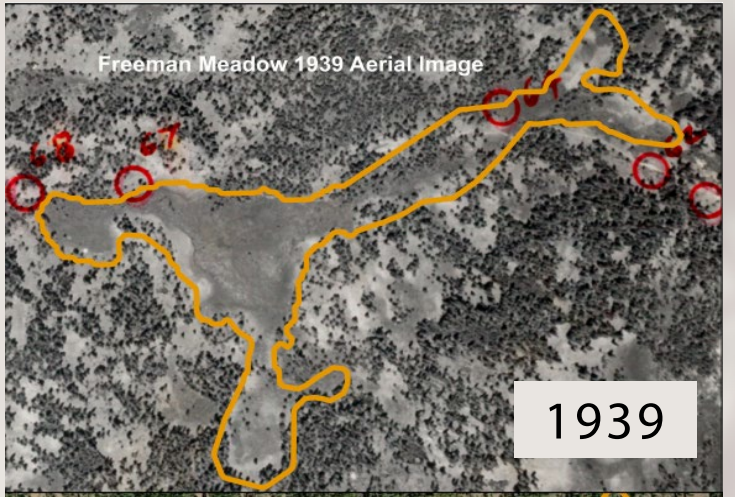
Disturbance Inventory

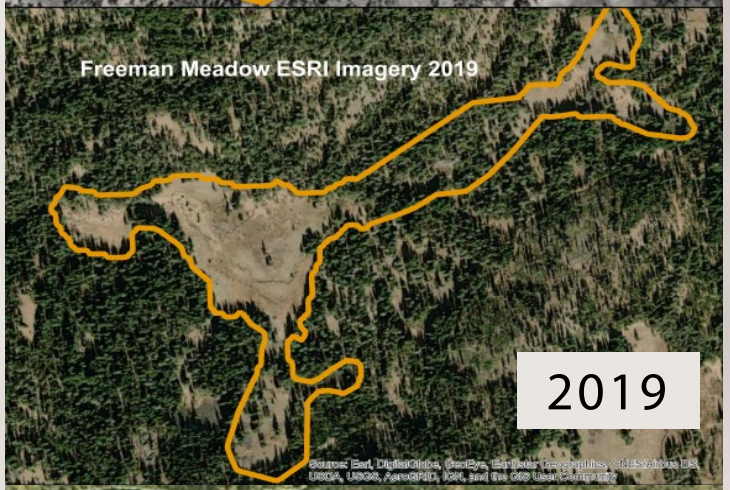
Relic roads, Culverts, Ongoing grazing



Conifer Encroachment

"Church Meadows [...] appears to have been not long-ago [a] marshy glade" John Leiberg, USGS 1902





Pre-Restoration Project Monitoring

Vegetation Monitoring

29 Belt Transects
85 Monitoring Plots

Hydrology

23 Ground Water Wells
13 Stream Gages

Carbon

Uni. Nevada – Reno
4 of 5 Meadows

Baseline Conifer

20 Monitoring Plots
2 Meadows

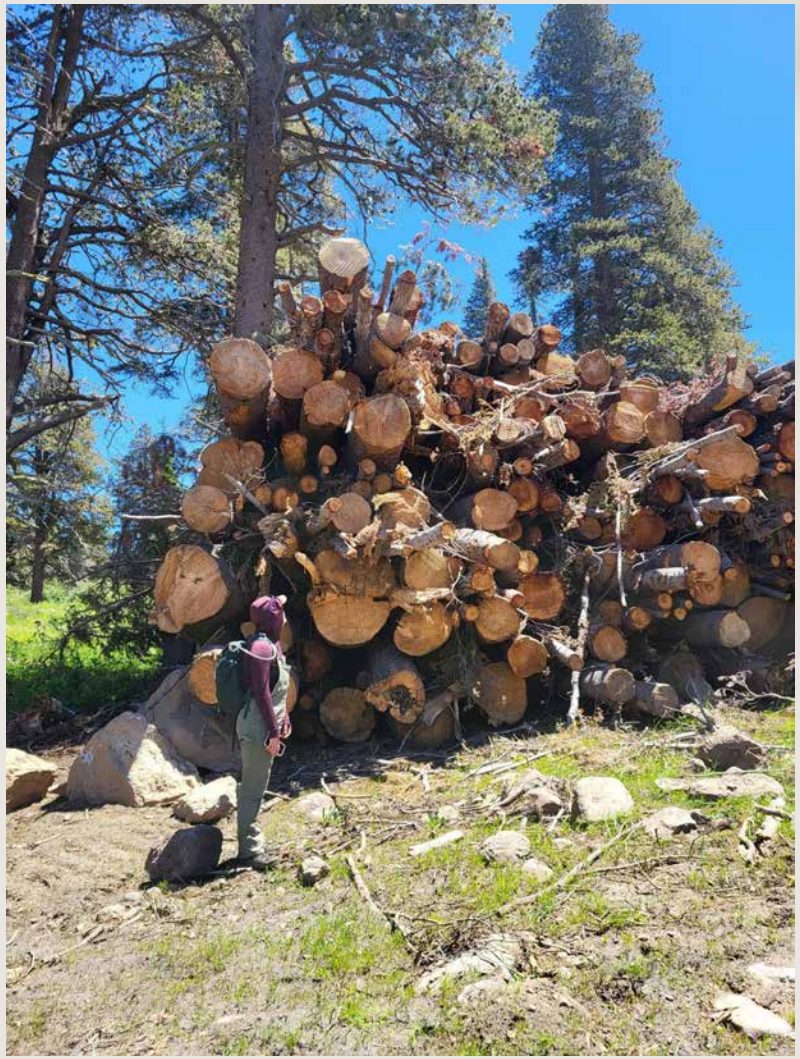
Project Goals and Research Questions

- Reestablishment of Native Wetland and Riparian Plant Communities
- Decreased Extent of Encroaching Conifers
- Increased Potential Beaver Habitat
- Improved Carbon Sequestration
- Improved Climate Resilience
- Restored Hydrologic Processes

Were these objectives met? How did results vary across unique sites?

Good Timing – YUBA Project

Chapman 2021 | Freeman 2022

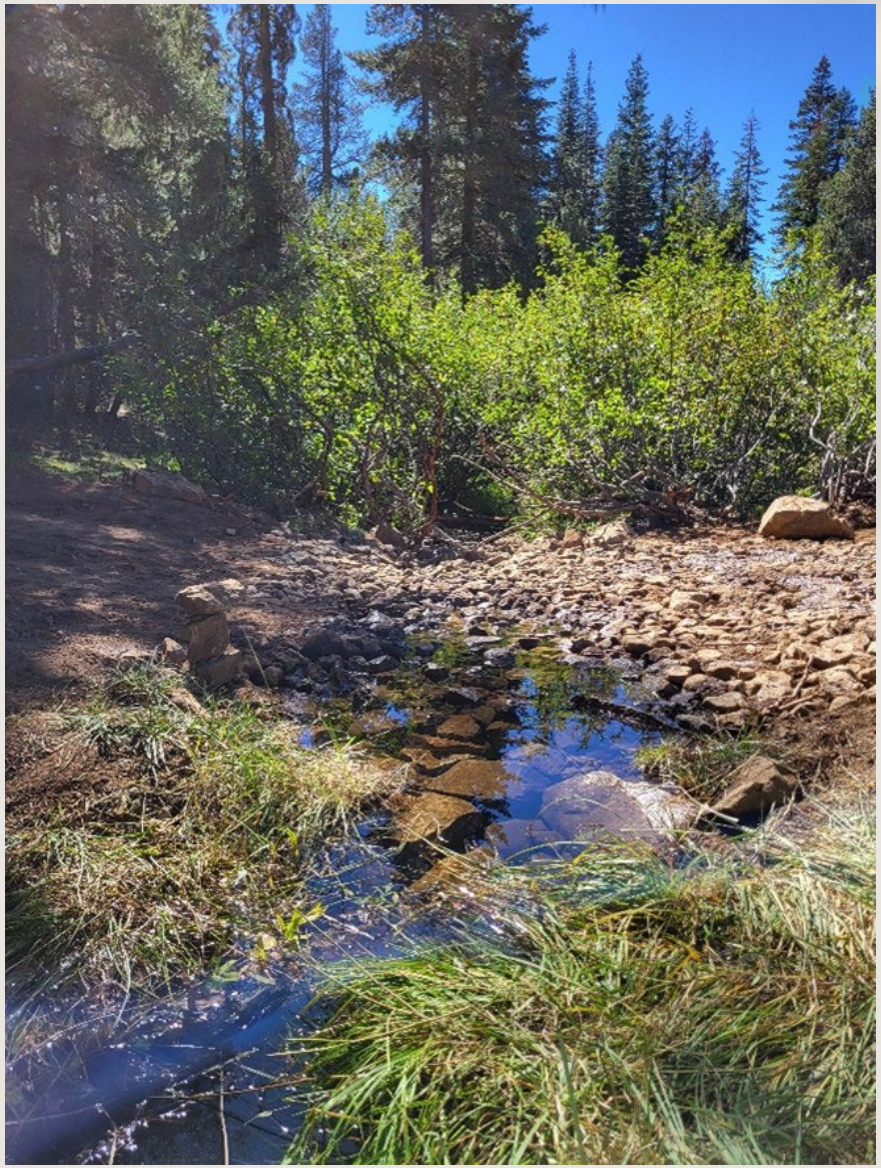


Beaver Dam Analogs (BDAs)

2023 – 2024 – 2025

Freeman Low Water Crossing

Post Implementation 2024



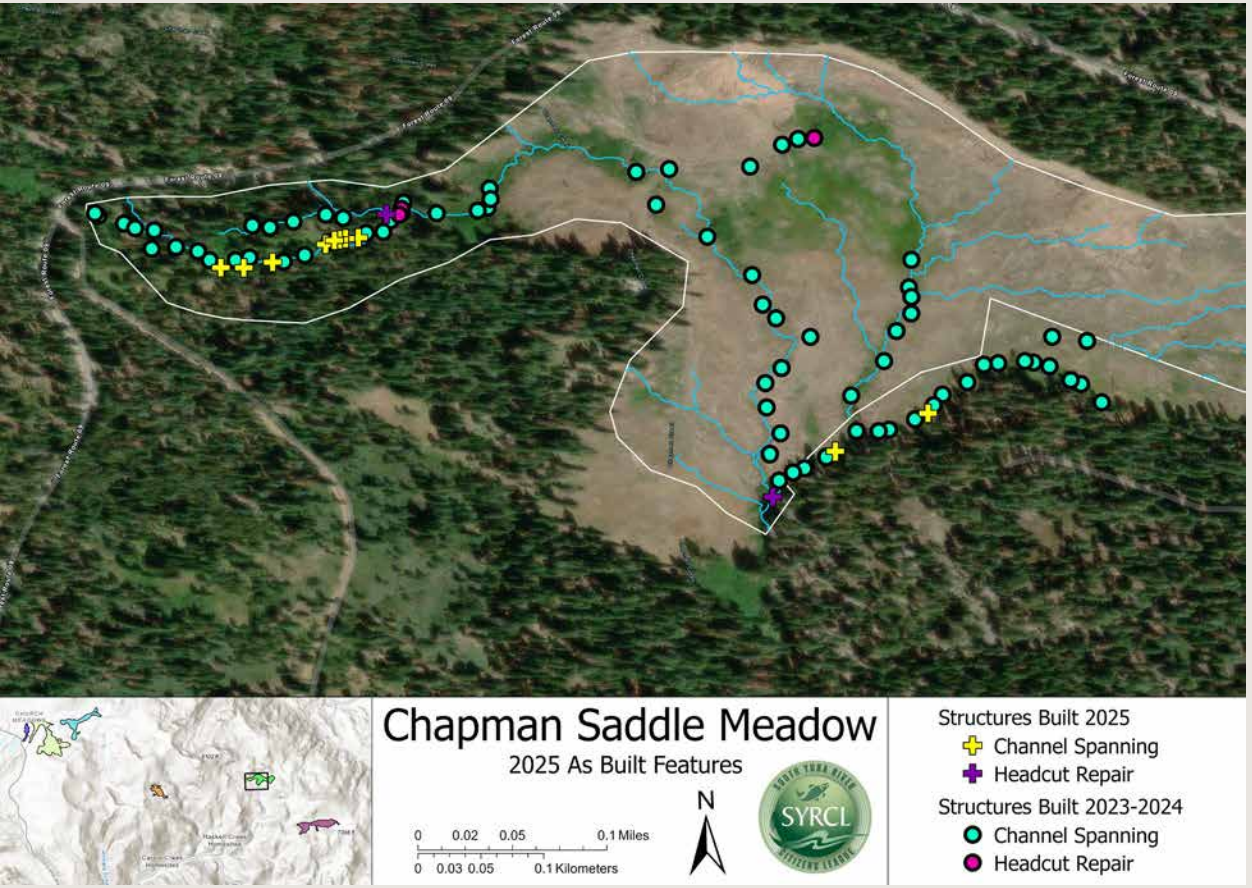
LTPBR Structures To-Date

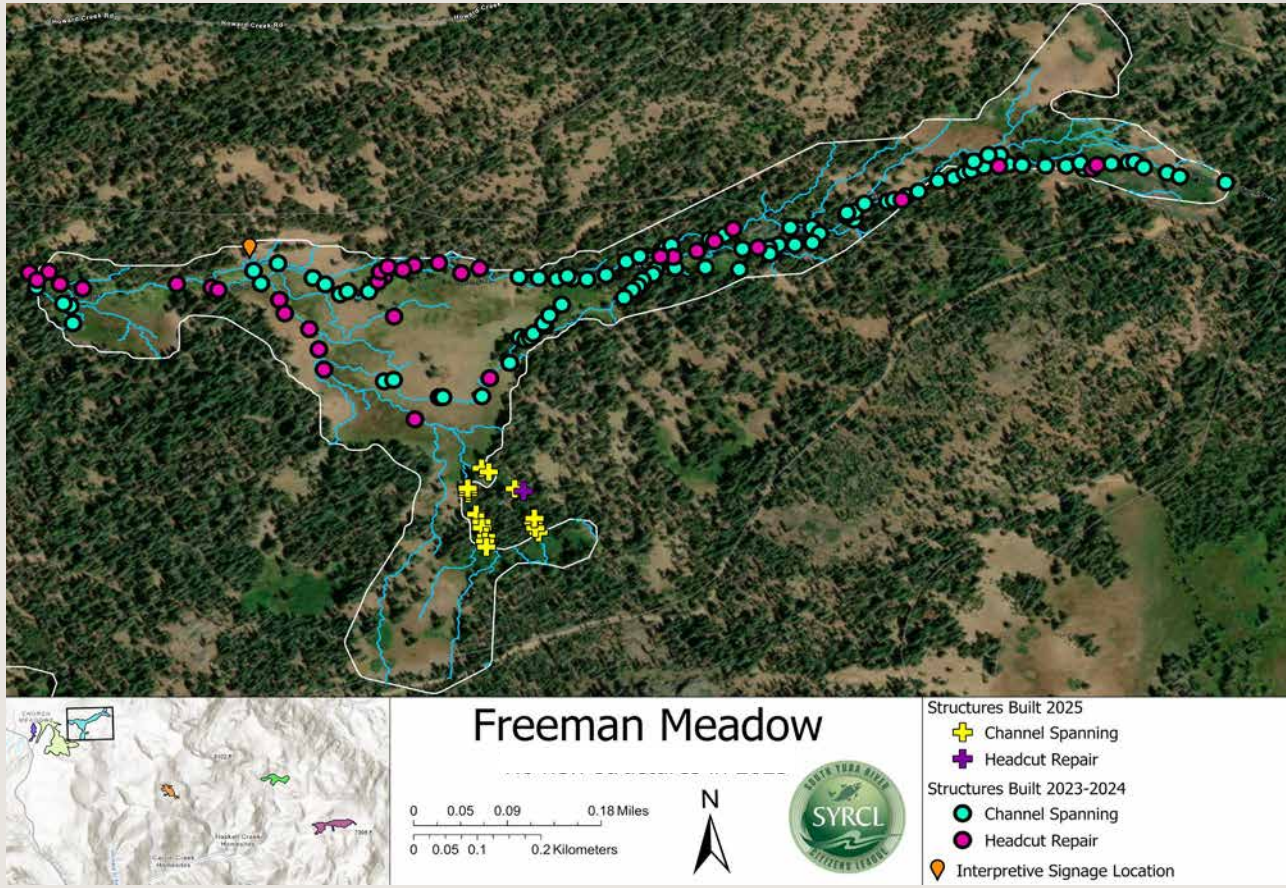
Meadow	Channel Spanning BDA	Headcut Repair Structure
Chapman Saddle	83	5
Freeman Meadow	108	35
West Church Meadow	59	0
Bear Trap Meadow	84	14
Haskell Headwaters Fen	55	1

444 TOTAL STRUCTURES BUILT!!

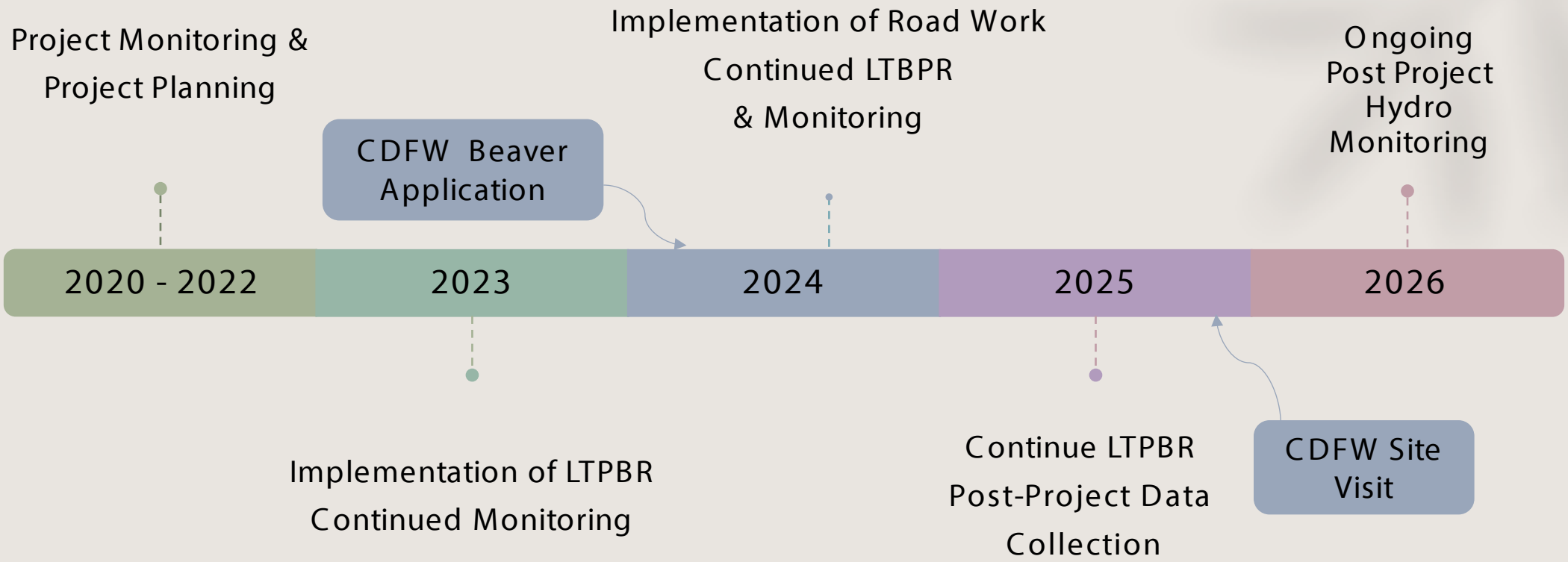
SWIFTWATERDESIGN

LTPBR Structures To-Date





Timeline


Project Monitoring &
Project Planning
CDFW Beaver
Application
Implementation of Road Work
Continued LTBPR
& Monitoring
Ongoing
Post Project
Hydro
Monitoring
2020 - 2022
2023
2024
2025
2026
Implementation of LTPBR
Continued Monitoring
Continue LTPBR
Post-Project Data
Collection
CDFW Site
Visit

Post Project Data Collection

Vegetation

29 Belt Transects
85 Monitoring Plots

Hydrology

23 Ground Water Wells
13 Stream Gages

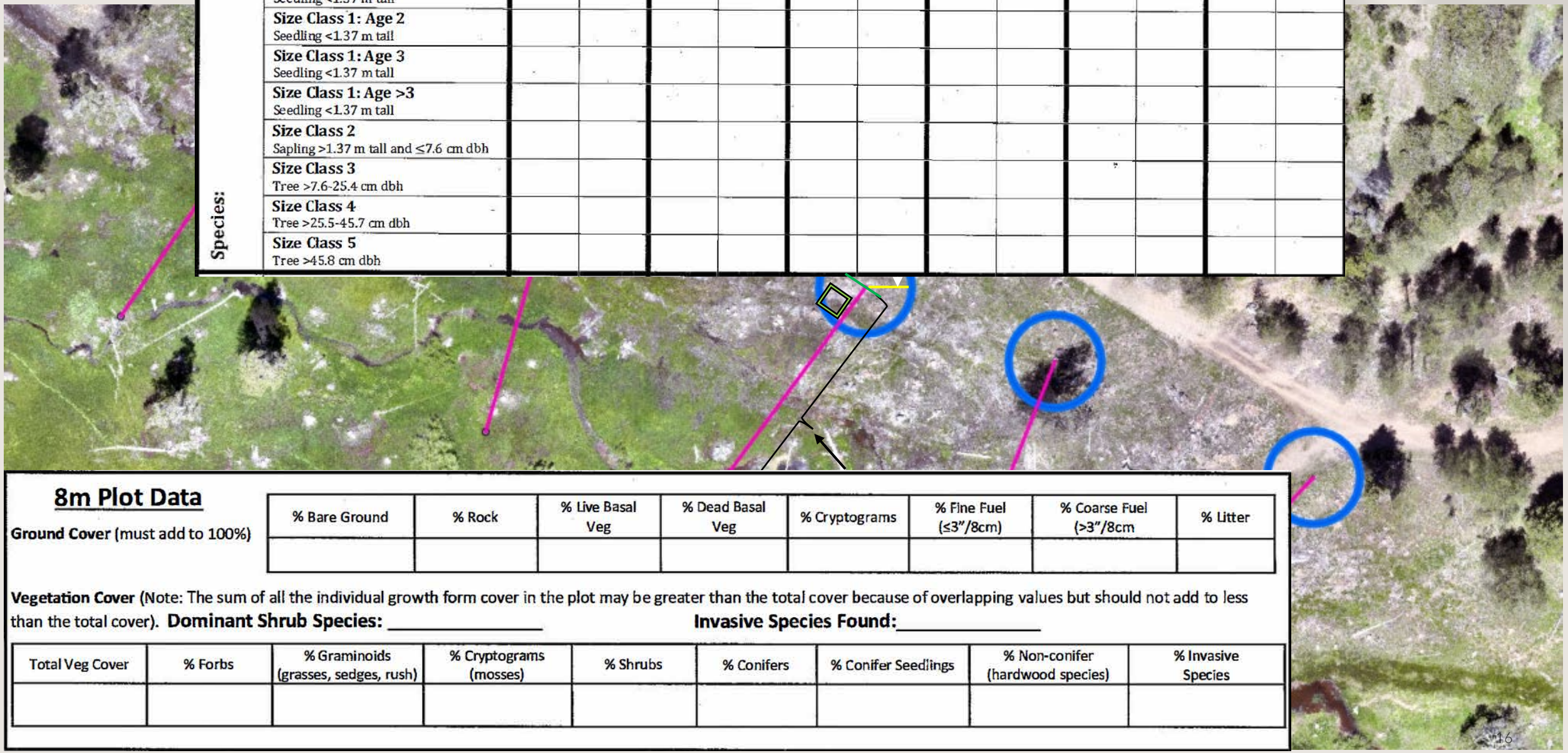
Carbon

Uni. Nevada – Reno
4 of 5 Meadows

Conifer Reestablishment

20 Monitoring Plots
2 Meadows

Species:	0-4m		4-8m		8-12m		12-16m		16-20m		20-24m	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Size Class 1: Age 0 Seedling <1.37 m tall												
Size Class 1: Age 1 Seedling <1.37 m tall												
Size Class 1: Age 2 Seedling <1.37 m tall												
Size Class 1: Age 3 Seedling <1.37 m tall												
Size Class 1: Age >3 Seedling <1.37 m tall												
Size Class 2 Sapling >1.37 m tall and ≤7.6 cm dbh												
Size Class 3 Tree >7.6-25.4 cm dbh												
Size Class 4 Tree >25.5-45.7 cm dbh												
Size Class 5 Tree >45.8 cm dbh												



8m Plot Data

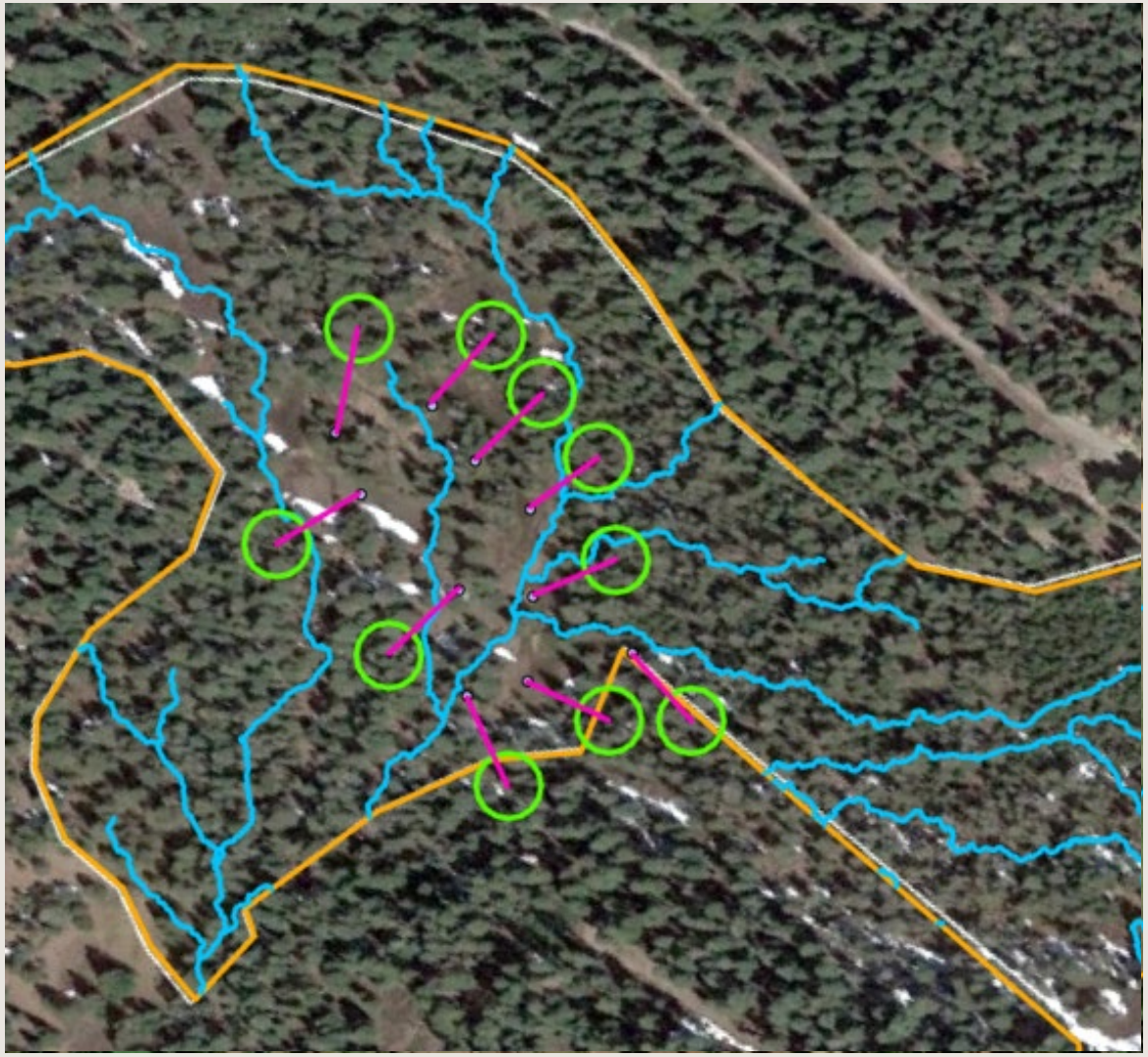
Ground Cover (must add to 100%)

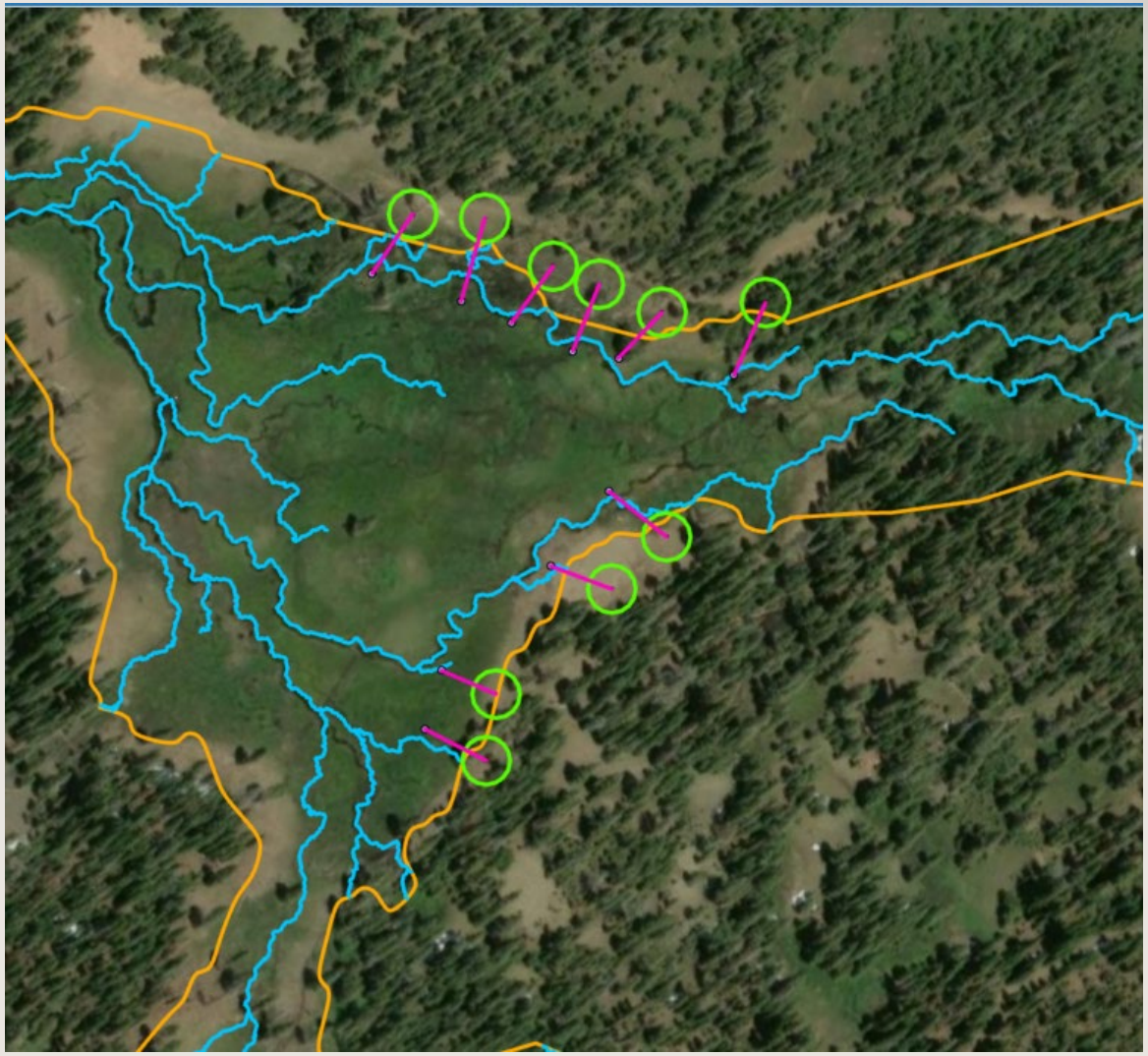
% Bare Ground	% Rock	% Live Basal Veg	% Dead Basal Veg	% Cryptograms	% Fine Fuel (≤3"/8cm)	% Coarse Fuel (>3"/8cm	% Litter

Vegetation Cover (Note: The sum of all the individual growth form cover in the plot may be greater than the total cover because of overlapping values but should not add to less than the total cover). **Dominant Shrub Species:** _____ **Invasive Species Found:**_____

Total Veg Cover	% Forbs	% Graminoids (grasses, sedges, rush)	% Cryptograms (mosses)	% Shrubs	% Conifers	% Conifer Seedlings	% Non-conifer (hardwood species)	% Invasive Species

Site Selection and Plot Locations





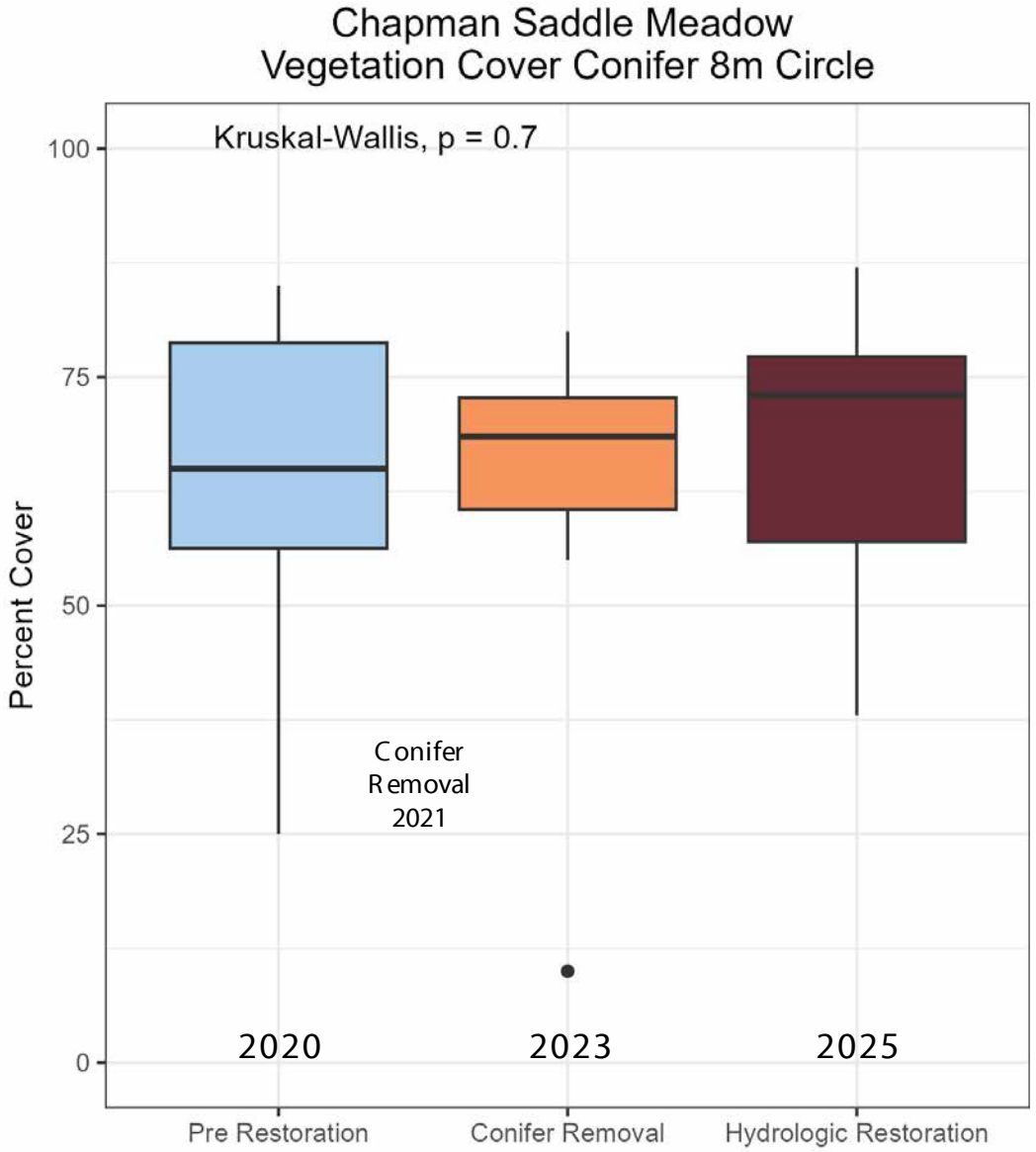
Case Study Sites
Chapman Freeman

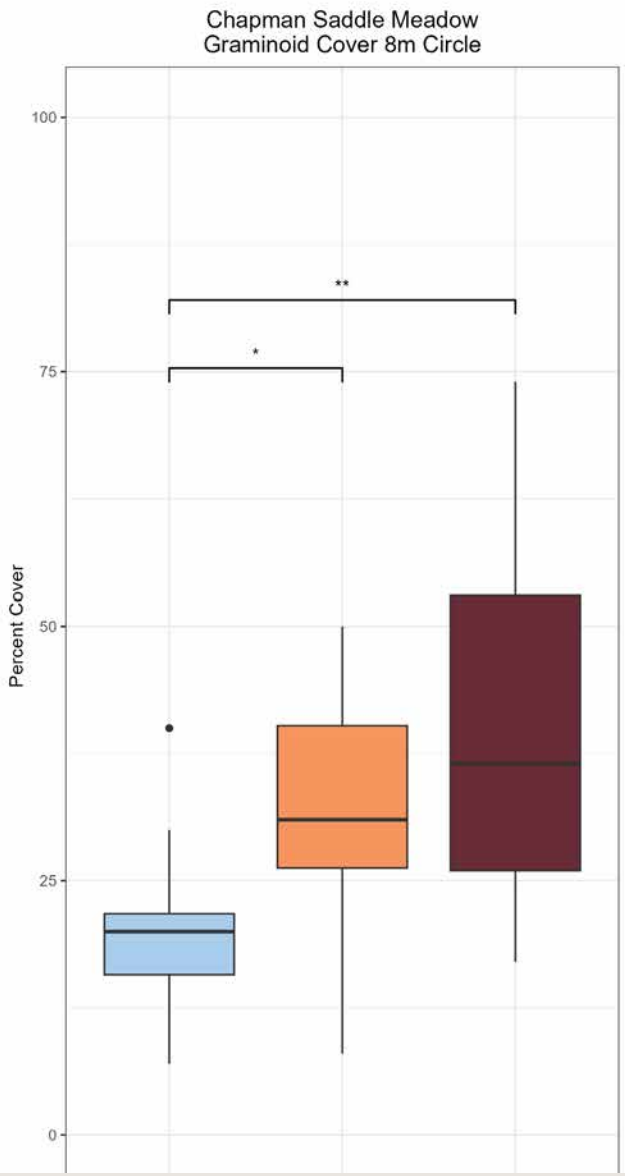
Similarities and Dissimilarities

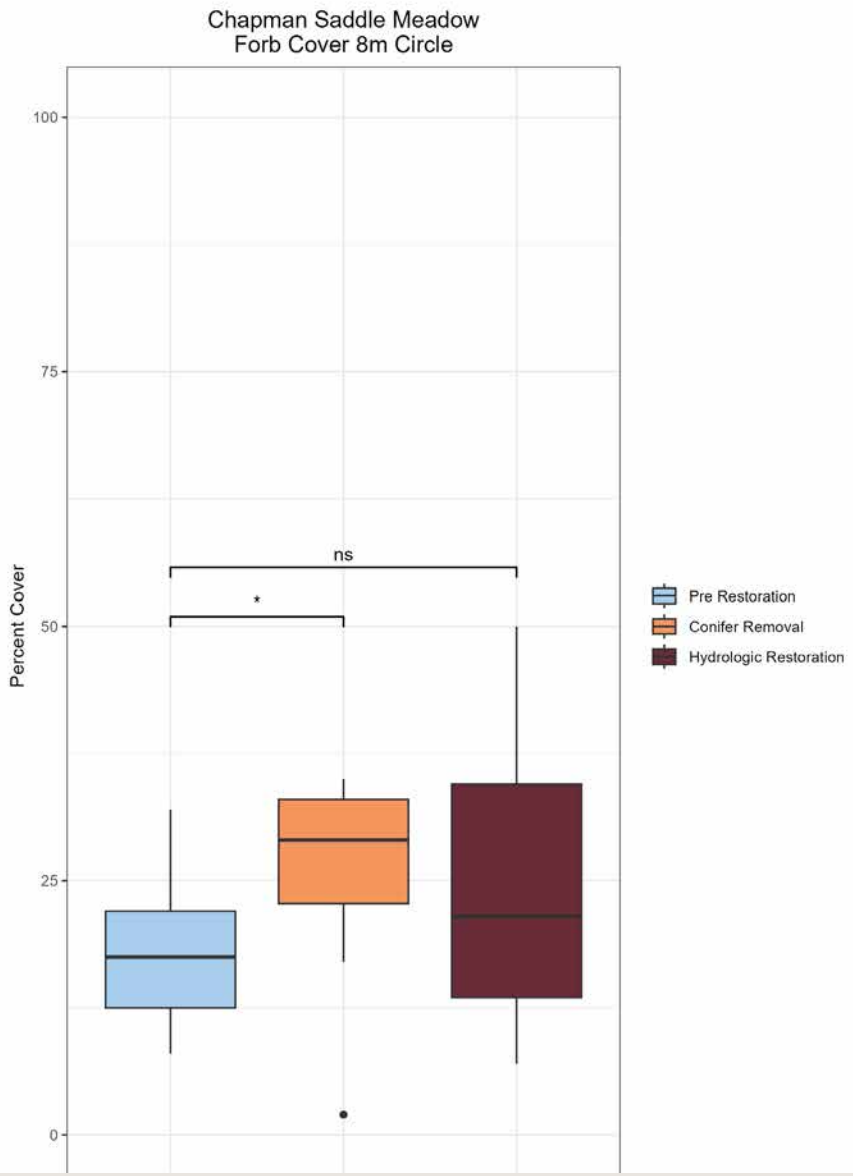
- Chapman – 41 acres
- Isolated PBR
- Site-wide Conifer Removal
  - Completed in 2021
- Higher Degree of Degradation

- Freeman – 73 acres
- Paired with Culvert Removal
- Meadow Edge Conifer Removal
  - Completed 2022
- “Healthy” central meadow

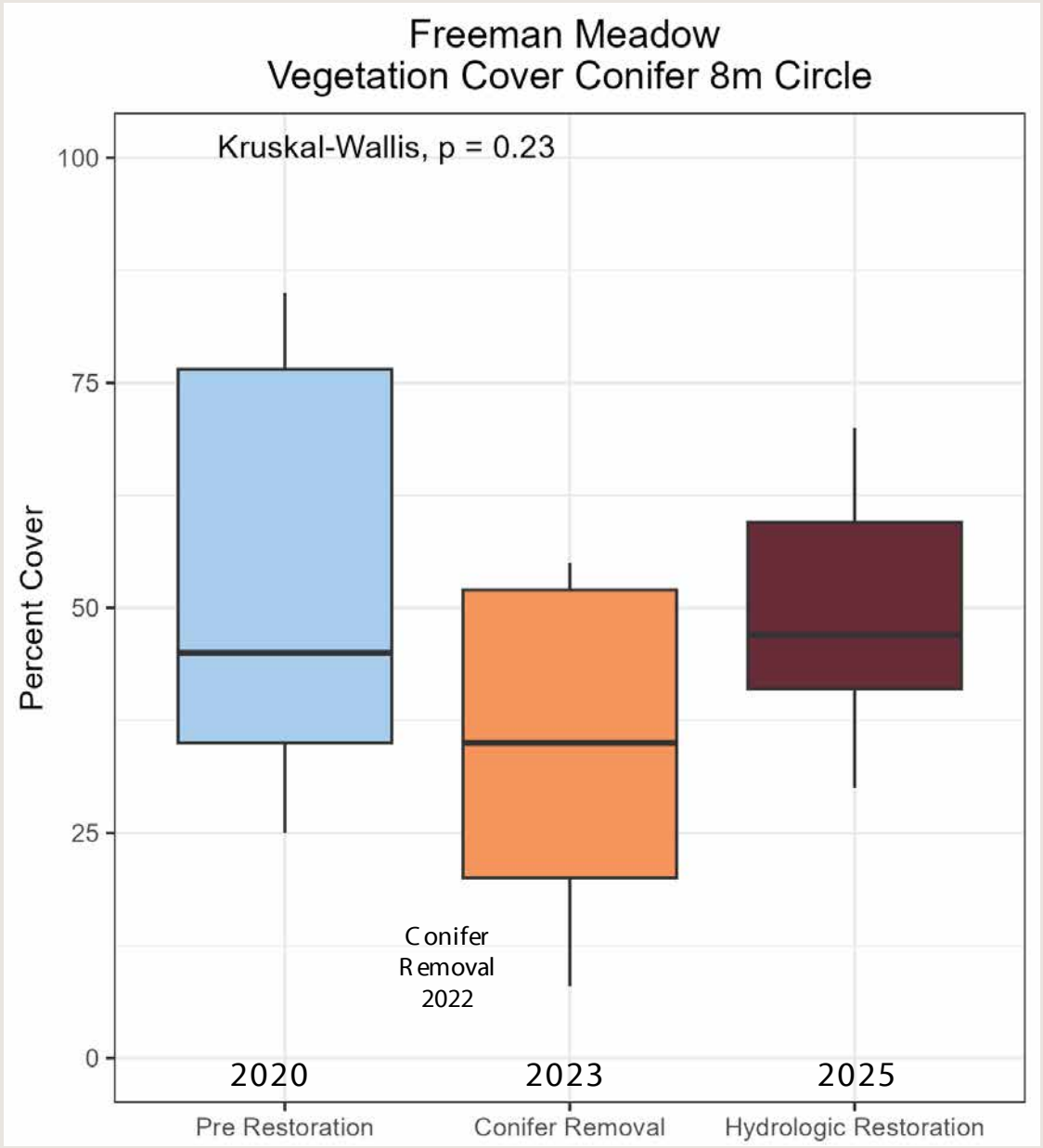
8m Vegetation – Chapman

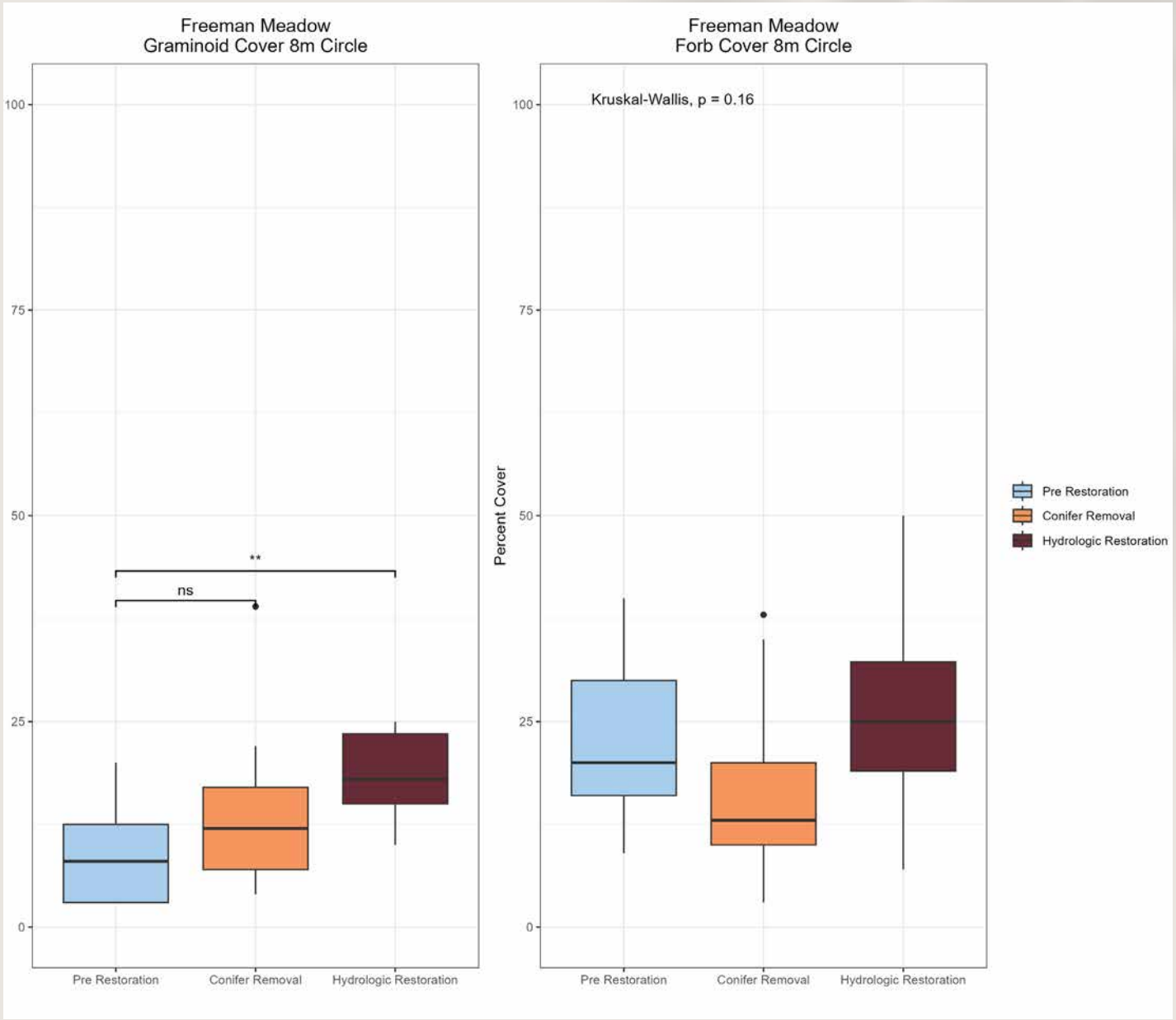




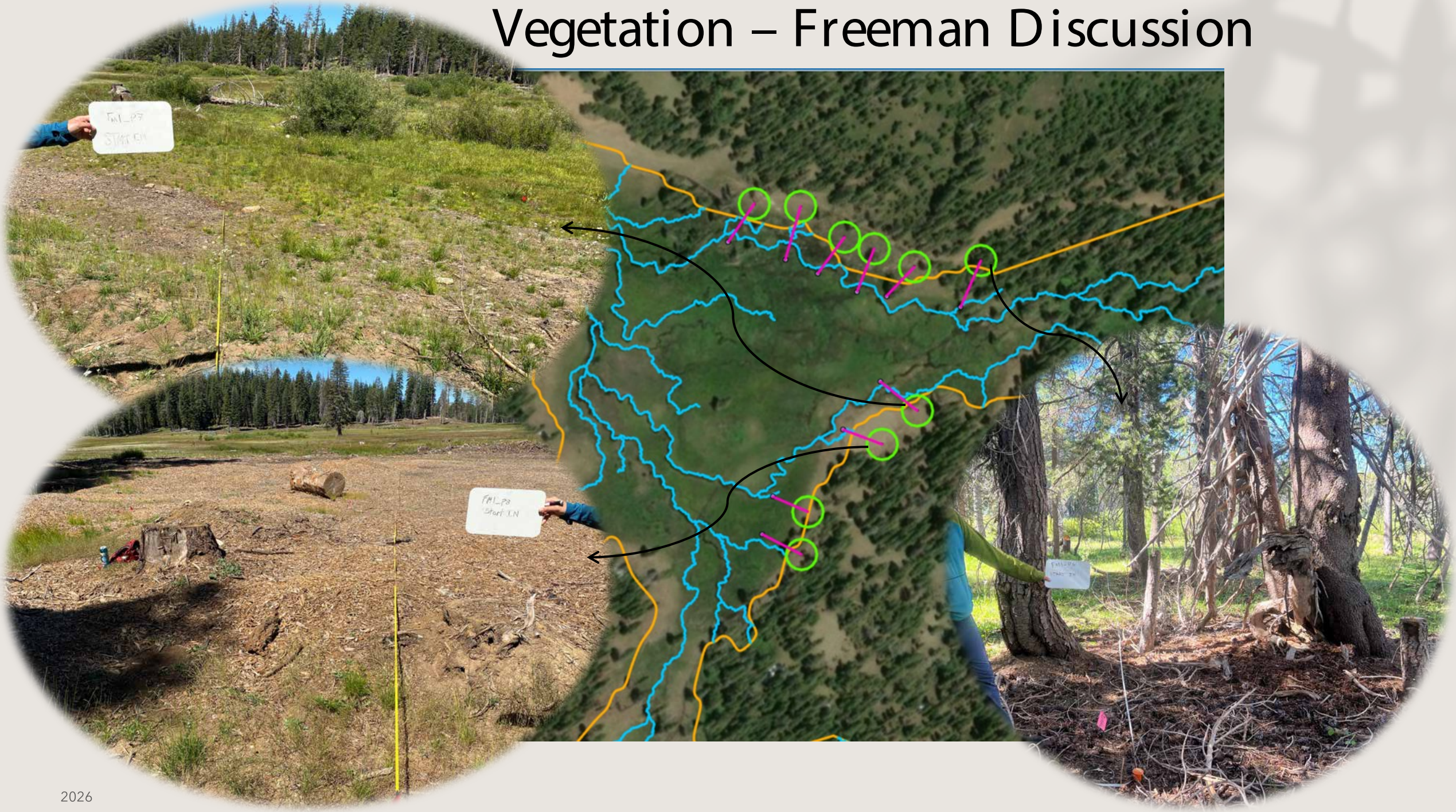


8m Vegetation – Freeman

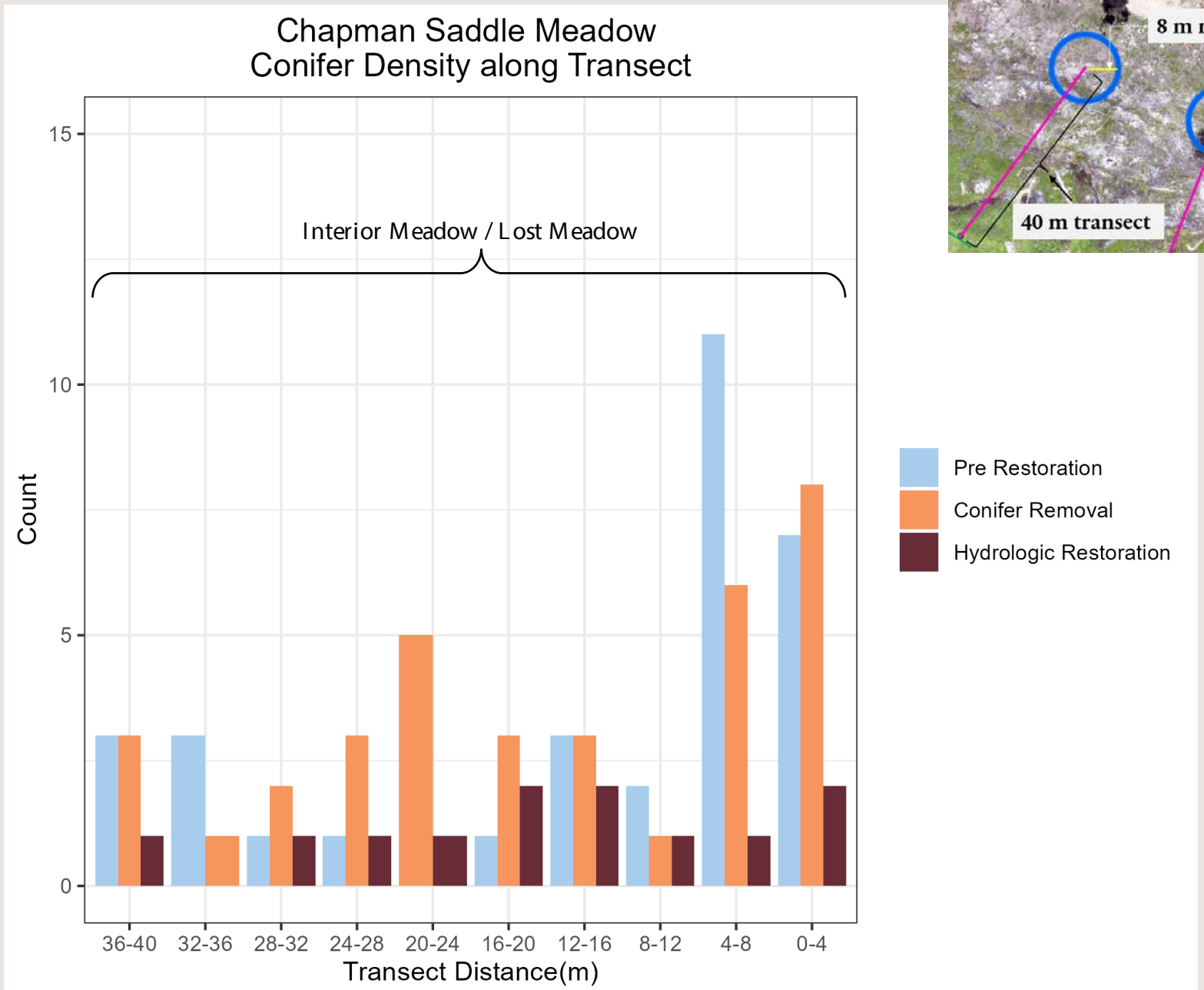


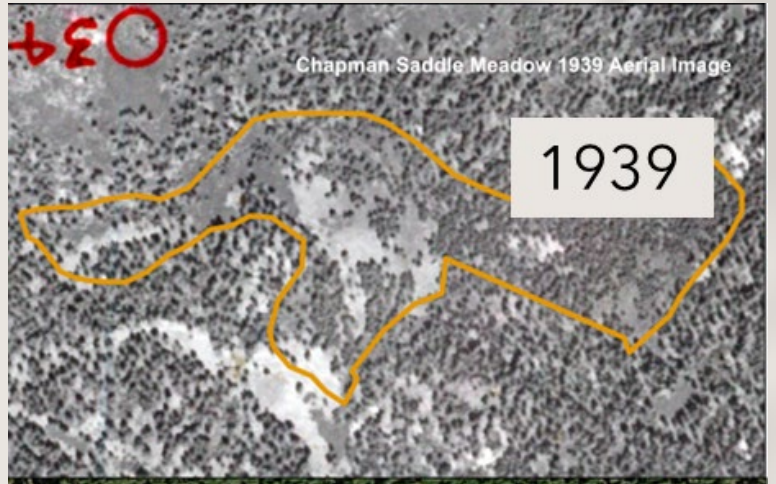


Vegetation – Freeman Discussion

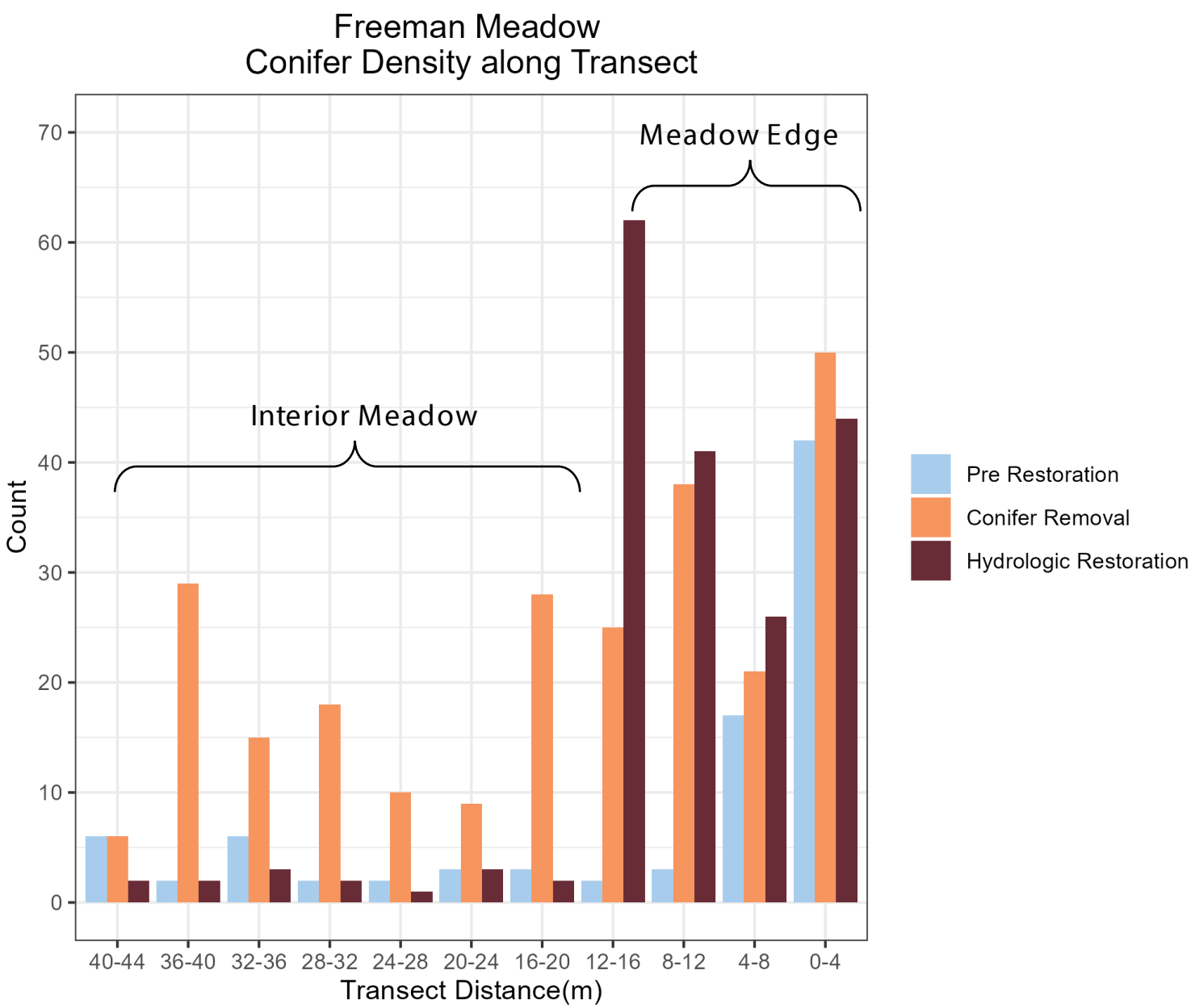


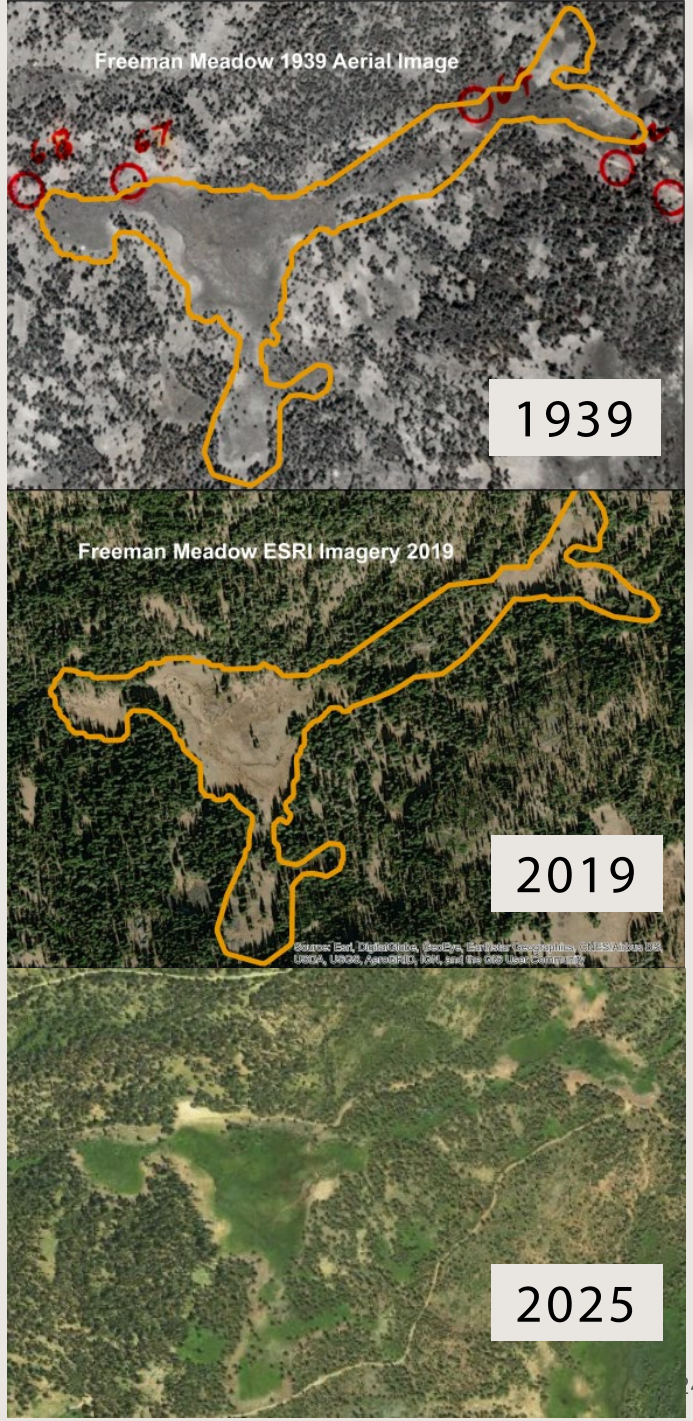
Vegetation – Chapman





Vegetation – Freeman





Post Project Data Collection

Vegetation

29 Belt Transects
85 Monitoring Plots

Hydrology

23 Ground Water Wells
13 Stream Gages

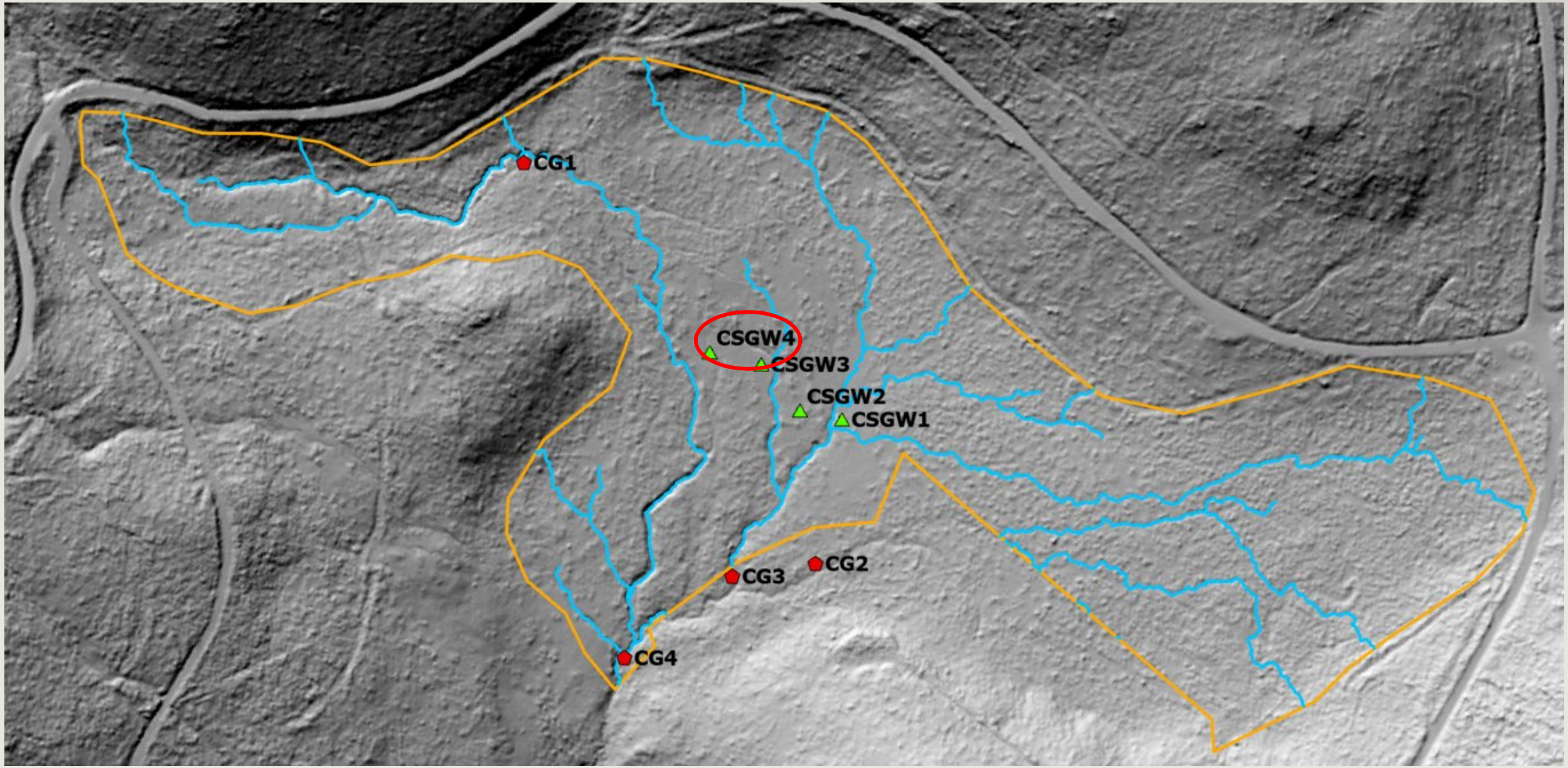
Carbon

Uni. Nevada – Reno
4 of 5 Meadows

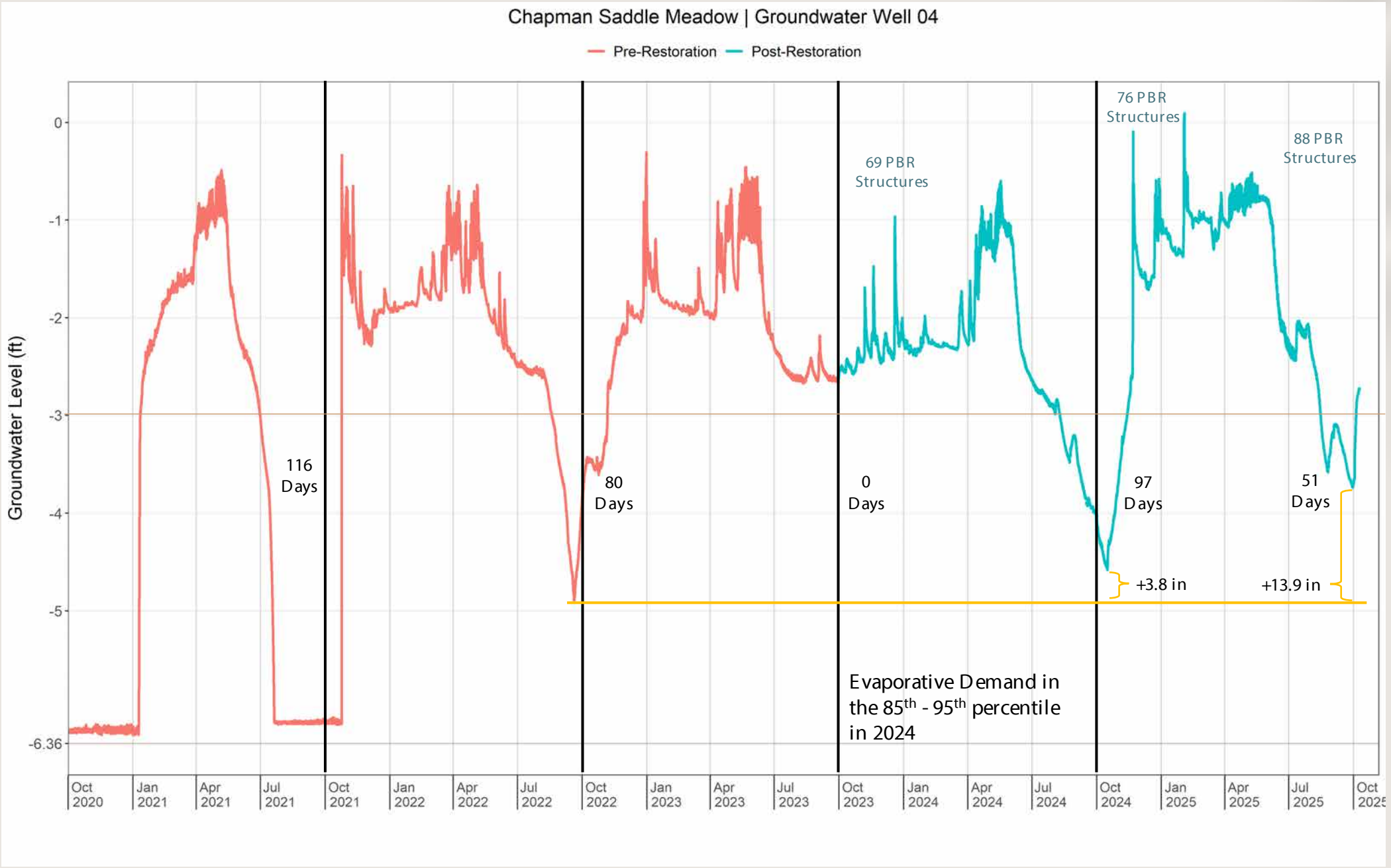
Conifer Reestablishment

20 Monitoring Plots
2 Meadows

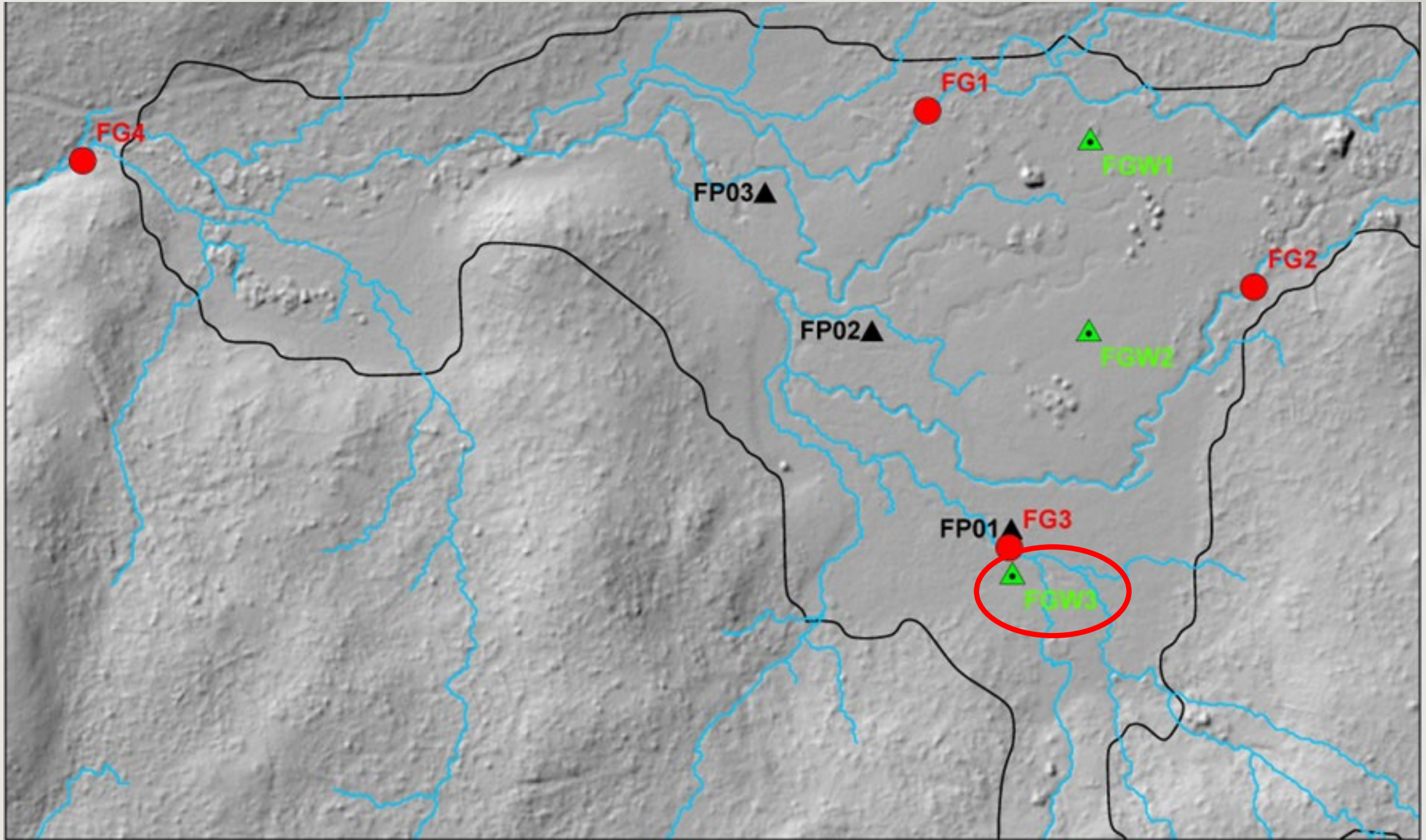
Chapman Saddle Hydrology



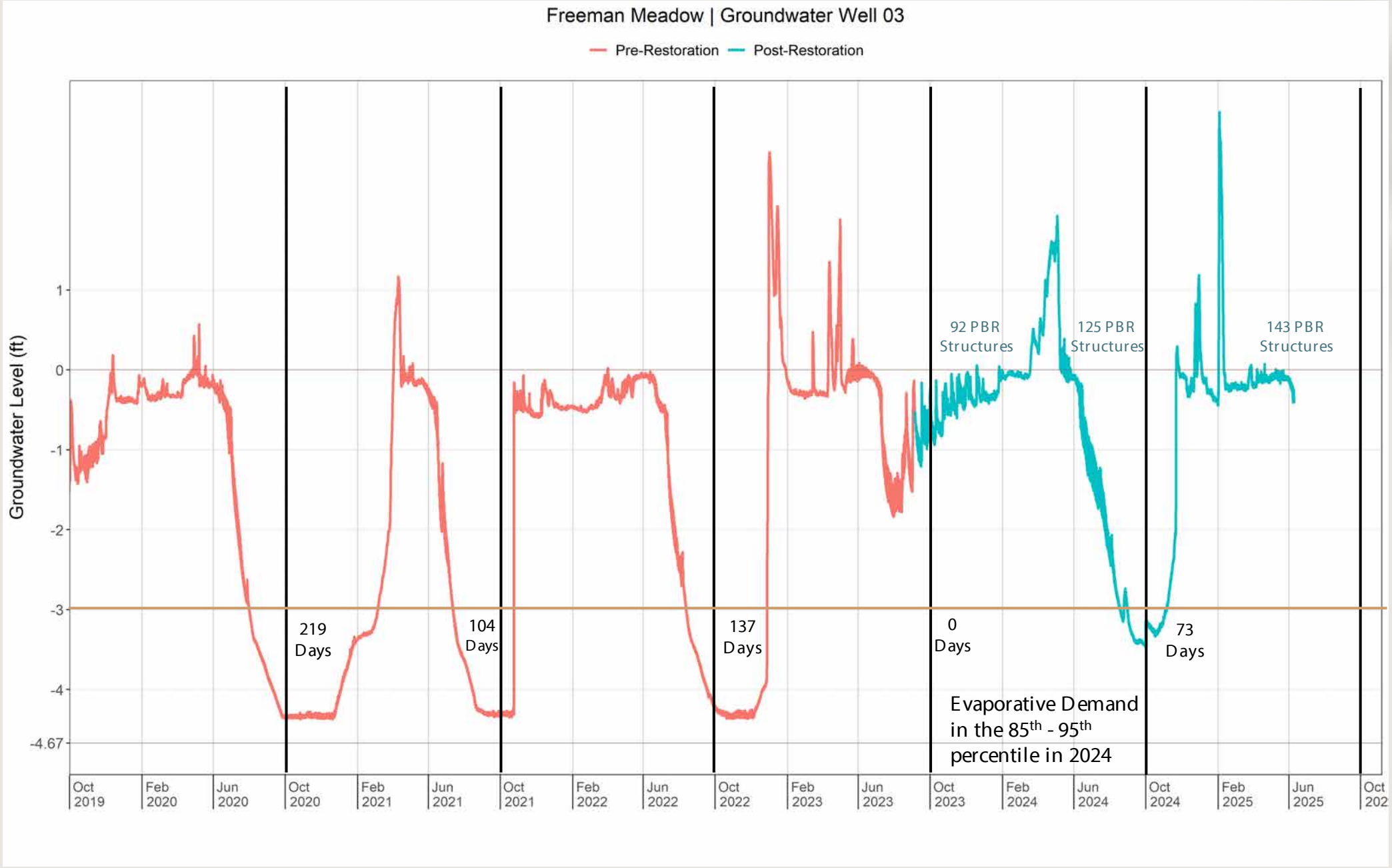
Hydrology


Chapman Saddle Meadow | Groundwater Well 04
Pre-Restoration
Post-Restoration
Groundwater Level (ft)
0
-1
-2
-3
-4
-5
-6.36
116 Days
80 Days
0 Days
97 Days
51 Days
69 PBR Structures
76 PBR Structures
88 PBR Structures
+3.8 in
+13.9 in
Evaporative Demand in the 85th - 95th percentile in 2024
Oct 2020
Jan 2021
Apr 2021
Jul 2021
Oct 2021
Jan 2022
Apr 2022
Jul 2022
Oct 2022
Jan 2023
Apr 2023
Jul 2023
Oct 2023
Jan 2024
Apr 2024
Jul 2024
Oct 2024
Jan 2025
Apr 2025
Jul 2025
Oct 2025

Freeman Hydrology

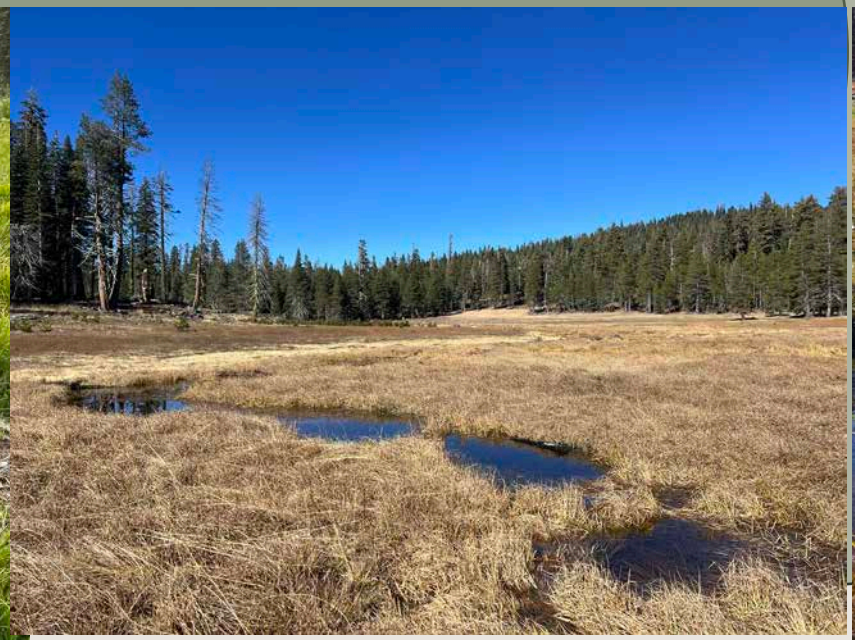


Hydrology


Freeman Meadow | Groundwater Well 03
Pre-Restoration
Post-Restoration
Groundwater Level (ft)
1
0
-1
-2
-3
-4
-4.67
219 Days
104 Days
137 Days
0 Days
73 Days
92 PBR Structures
125 PBR Structures
143 PBR Structures
Evaporative Demand in the 85th - 95th percentile in 2024
Oct 2019
Feb 2020
Jun 2020
Oct 2020
Feb 2021
Jun 2021
Oct 2021
Feb 2022
Jun 2022
Oct 2022
Feb 2023
Jun 2023
Oct 2023
Feb 2024
Jun 2024
Oct 2024
Feb 2025
Jun 2025
Oct 202


Before


After



Thank You

We still have lots of data to play with and analyze. I am excited to learn what other messages the meadows have for us.

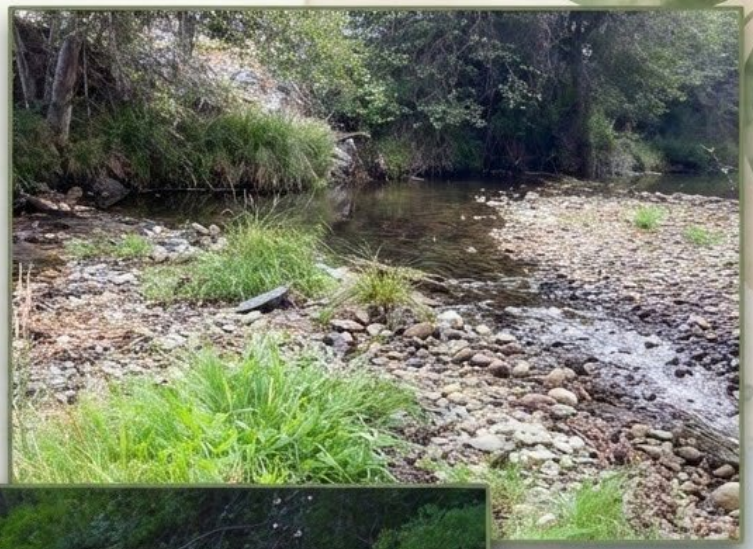
Like an Ecosystem, Good Restoration Planning is a Web

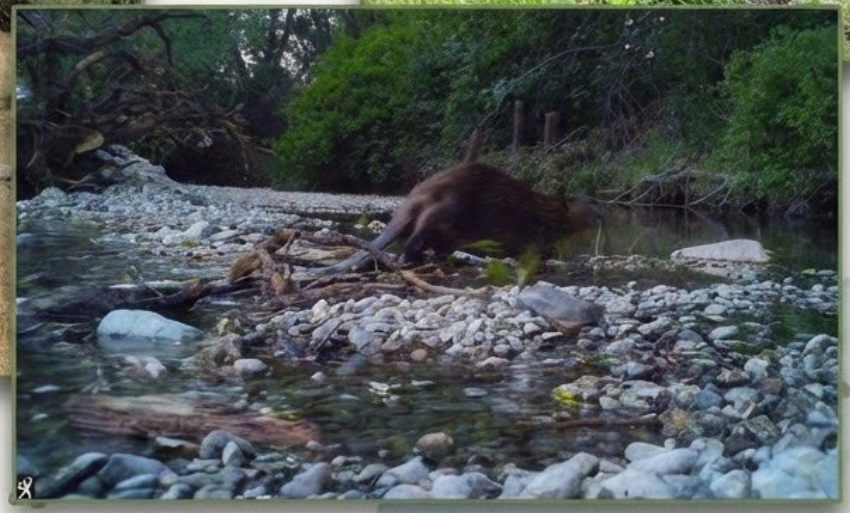
Betsy Stapleton & Megan Ireson, Scott River Watershed Council
Adam Cummings, The Watershed Research and Training Center • **Jay Stallman**, Stillwater Sciences


It's a web!
Consider all the threads for effective restoration
It takes a team to understand the web
Lessons learned (including analysis tools) can carry over between projects. We'll share some of ours.

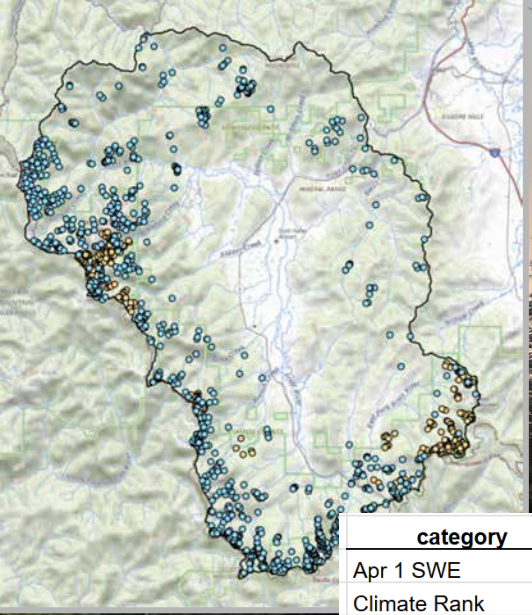
Why Meadows?

Water, Water, Water



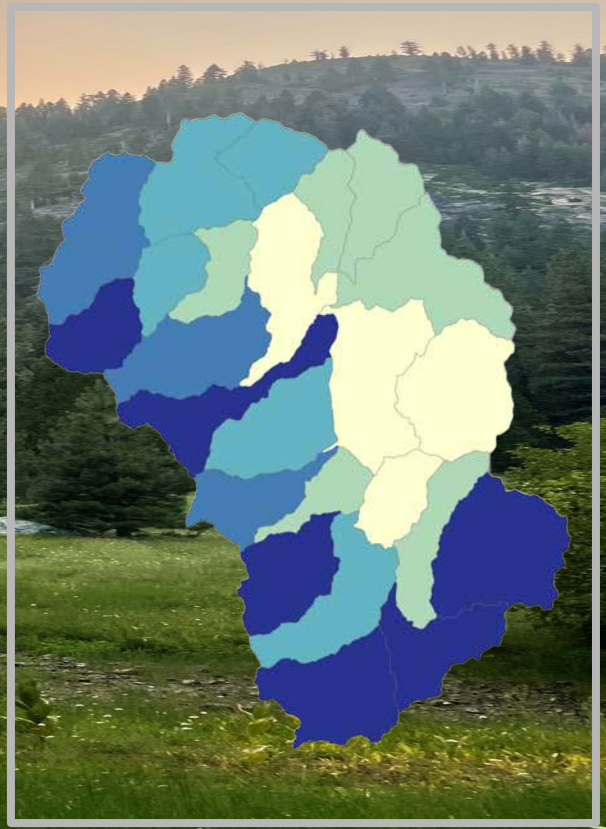


Which HUC 12?

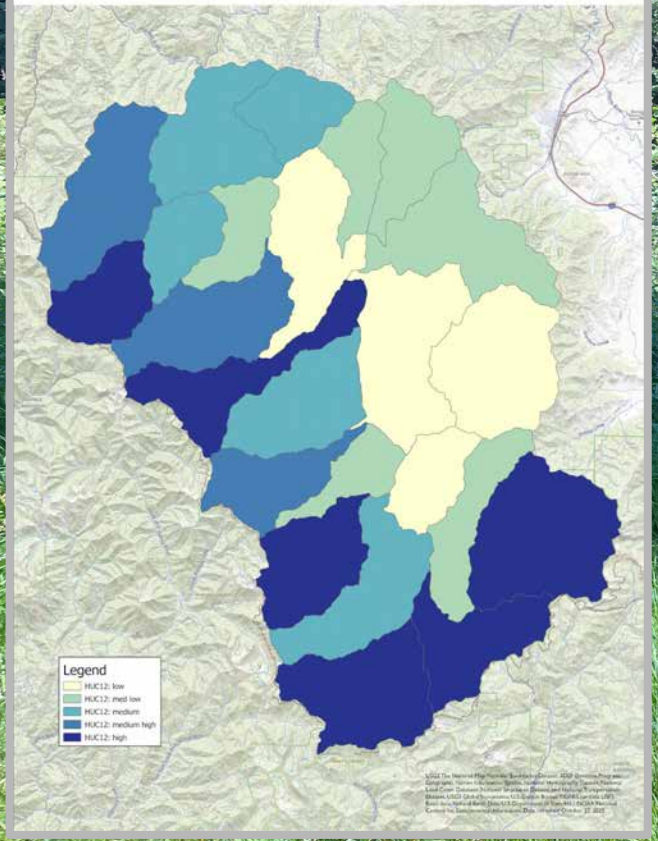


category	weight
Apr 1 SWE	1
Climate Rank	1
coho	1
Cascades frog	1
aspen	1
darlingtonia	1
rare amphibians	1
rare plants	1
inventoried meadow	1
meadow with NEPA	1
recent fire	1
LMM high	1
EFM land	1
Federal land	1
connectivity rank	1

HUC12 name	final score
Lower East Fork Scott River	27.329
Upper East Fork Scott River	25.996
Kelsey Creek	24.33
South Fork Scott River	24.329
Kidder Creek	23.33
Canyon Creek	21.996
Shackleford Creek	21.996
Etna Creek	19.331
French Creek	19.329
Boulder Creek-Scott River	18.331
Patterson Creek	17.664
Mill Creek	16.664
Tompkins Creek-Scott River	16.664
Sugar Creek-Scott River	16.663
Noyes Valley Creek	15.665
Town of Scott Bar-Scott River	14.331
Sniktaw Creek-Scott River	13.332
McAdam Creek	12.332
Clark Creek-Scott River	11.332
Indian Creek	11.332
Upper Moffett Creek	10.333
Lower Moffett Creek	8.665
Oro Fino Creek-Scott River	6.999
McConaughy Gulch	6.333
Hamlin Gulch-Scott River	2.666



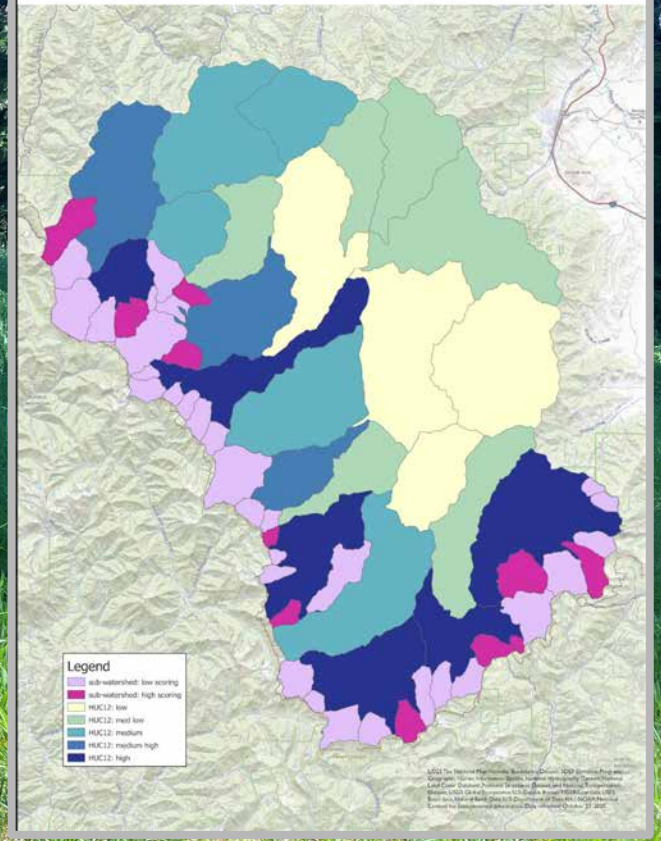
HUC12 Scores

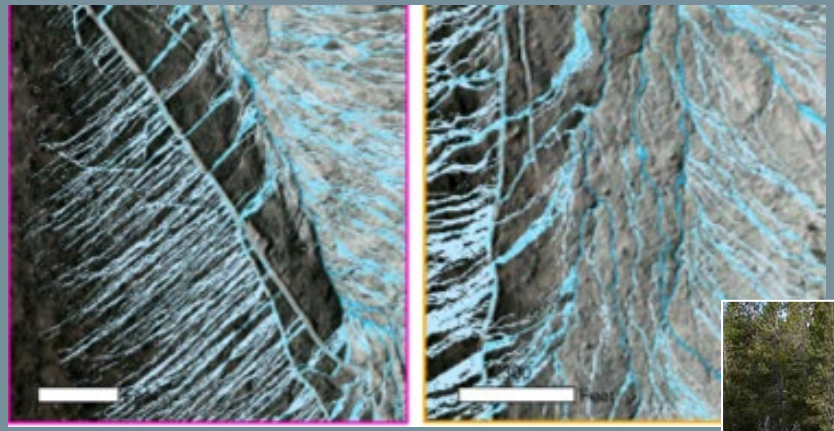


Which Meadow Systems?

- Meadow Density
- Access
- Climate Resilience
- Connectivity
- Rare Amphibians
- Rare Plants

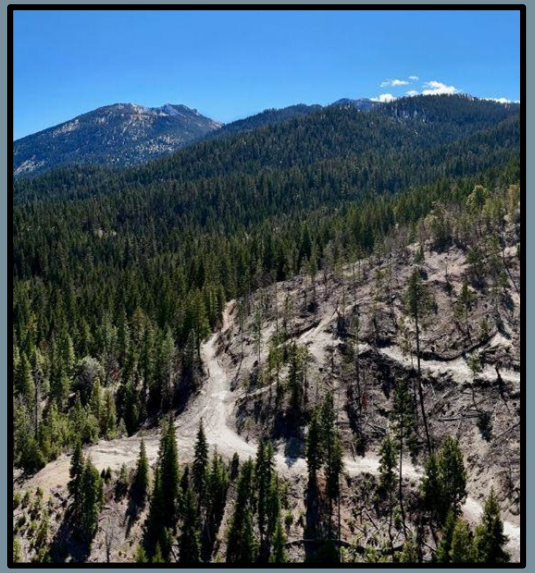
HUC12 & Sub-Watershed Scores



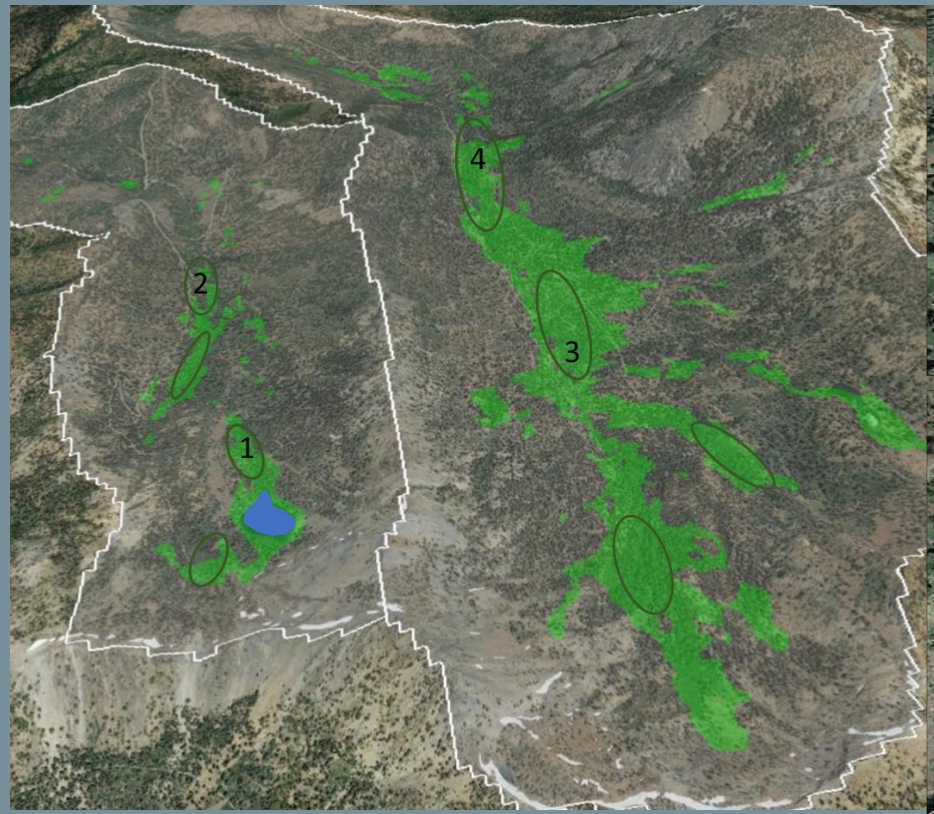


What Now:

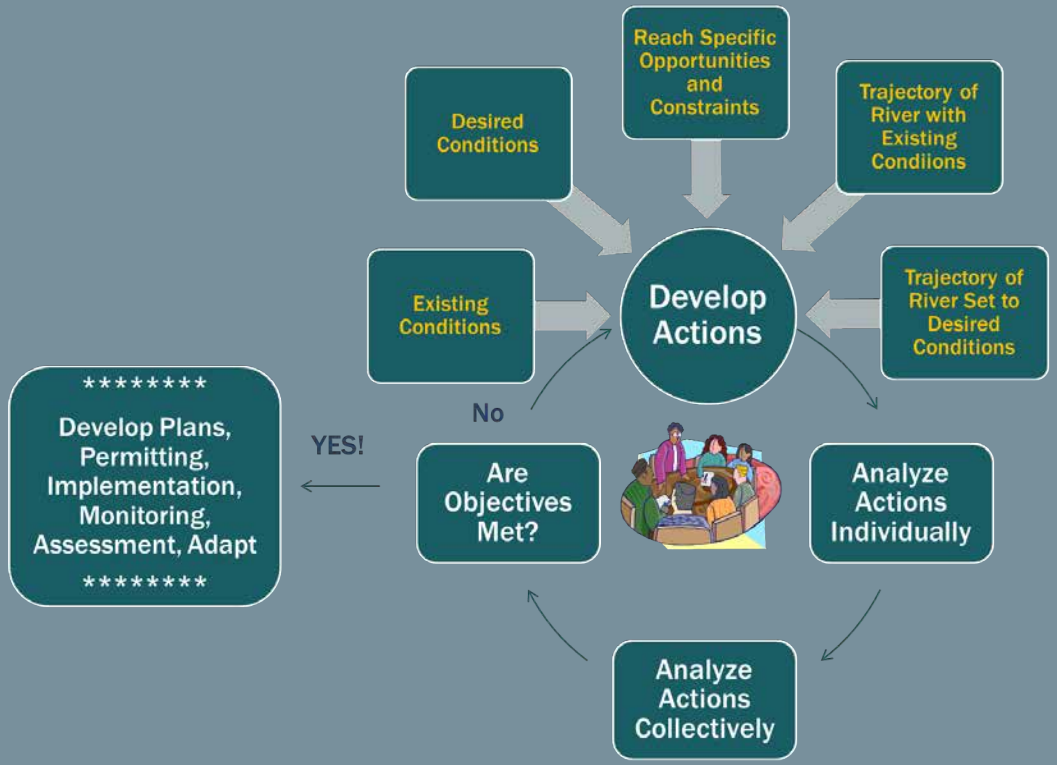
Issues and Team-
Hydrology, Roads, Incision, Sediment



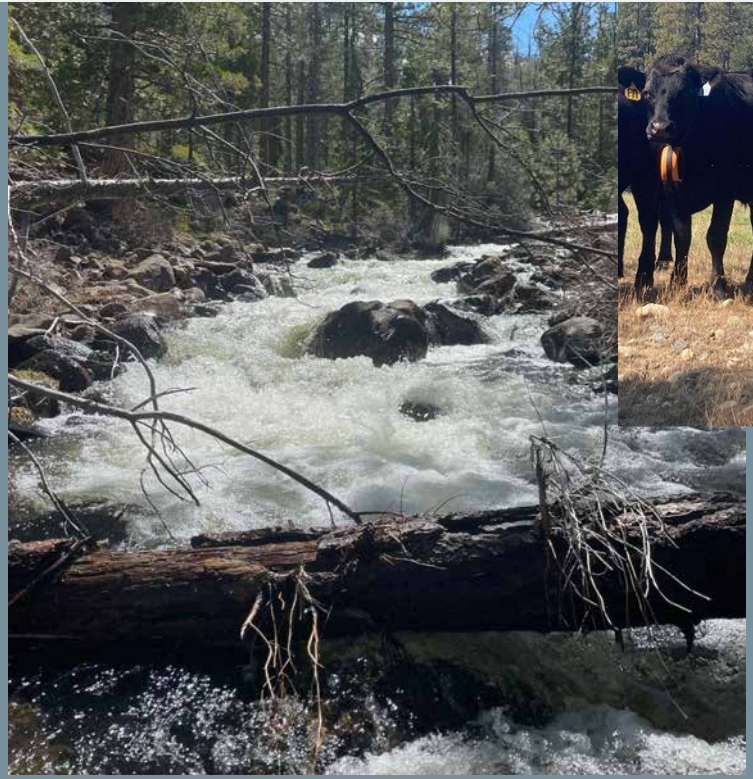
Issues and Team: Conifer Intrusion, Tree Mortality, Fire Suppression, Legacy Trees



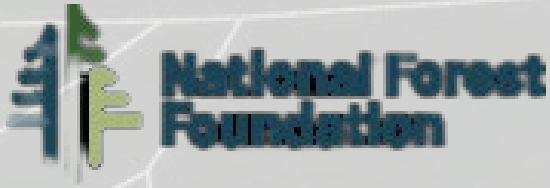
Issues and Team: Vegetation, Cows, Frogs, TEK


Reach Specific Opportunities and Constraints
Desired Conditions
Trajectory of River with Existing Condiions
Existing Conditions
Develop Actions
Trajectory of River Set to Desired Conditions
No
YES!
Are Objectives Met?
Analyze Actions Individually
Analyze Actions Collectively
****
Develop Plans, Permitting, Implementation, Monitoring, Assessment, Adapt
****

Goals:
Hydrological and Ecological Function, Restoration Function and E ciency, Knowledge Exchange.



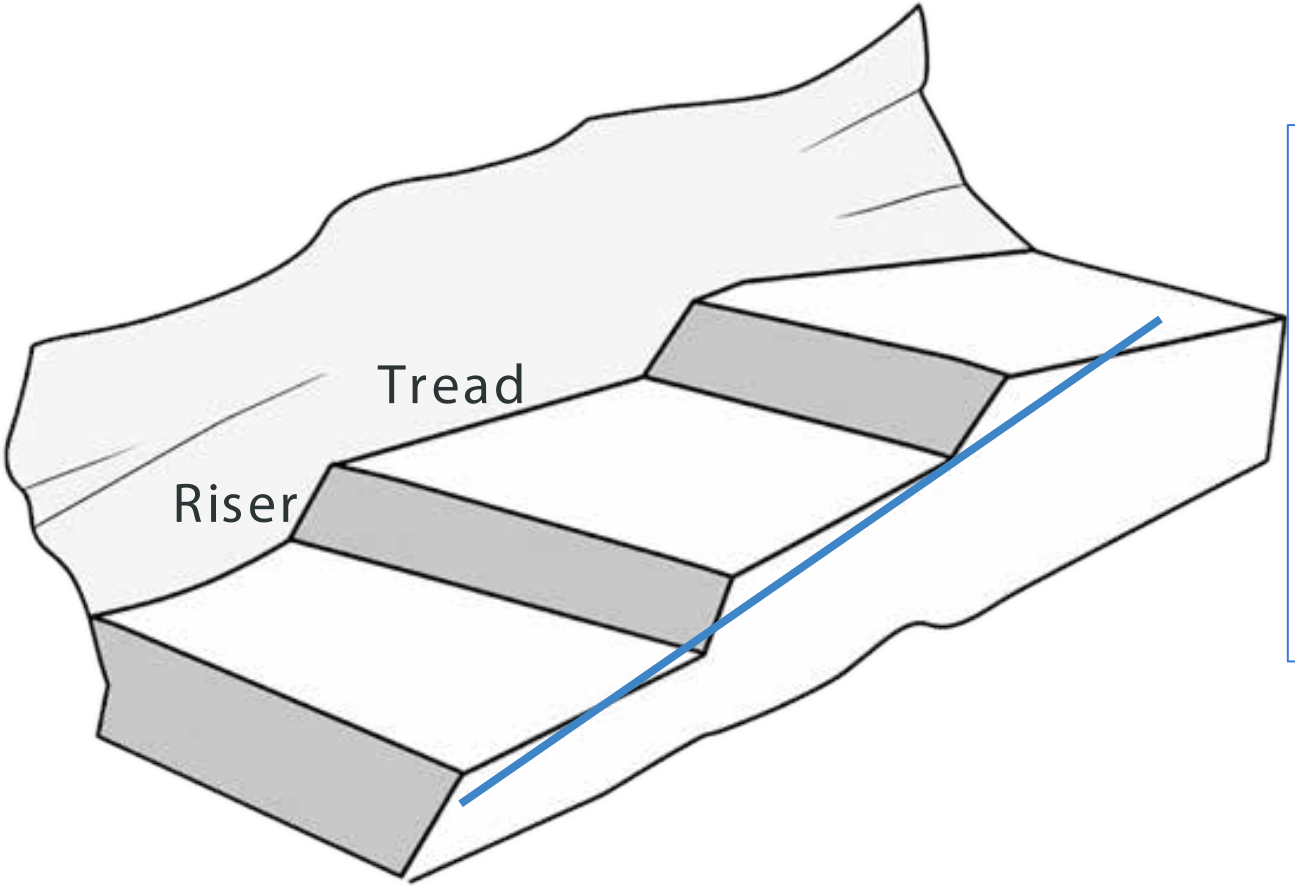
KMP



Teams and Tools

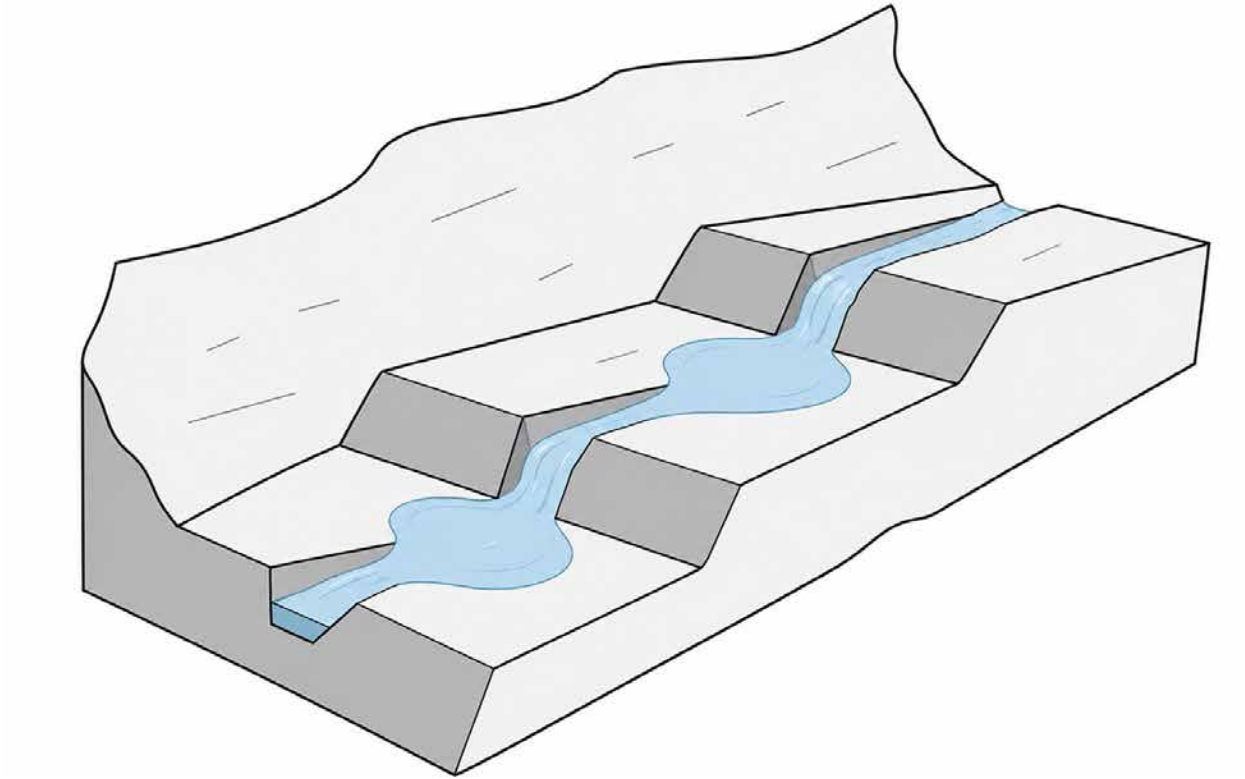
Walking with Jay Stallman

Understanding Processes for Better Outcomes

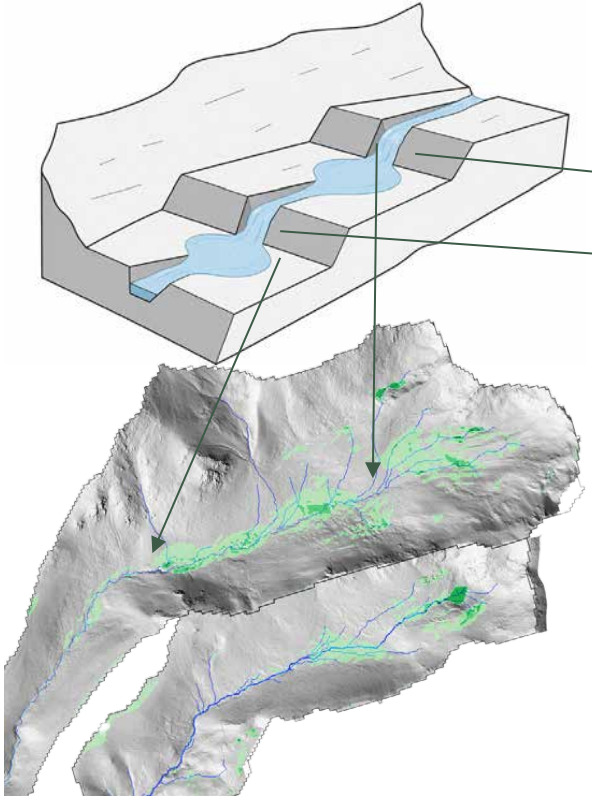


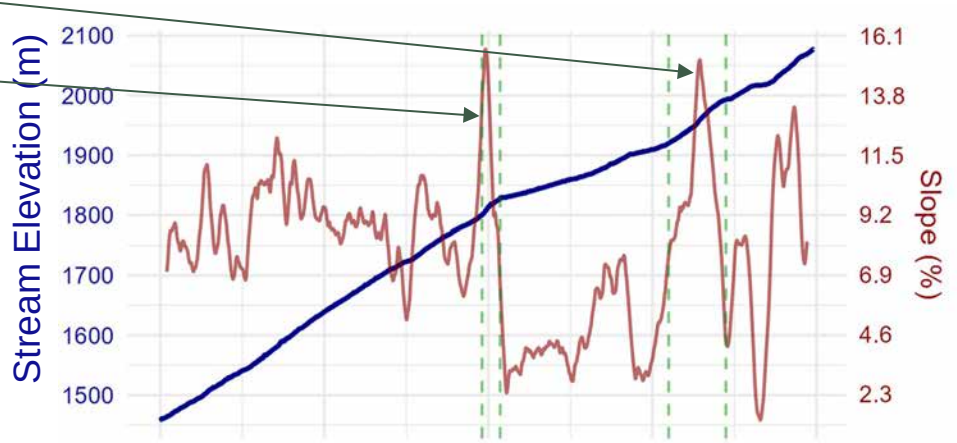
Post-glaciation stream evolves toward a constant grade with pattern of connection and disconnection.

Understanding Processes for Better Outcomes

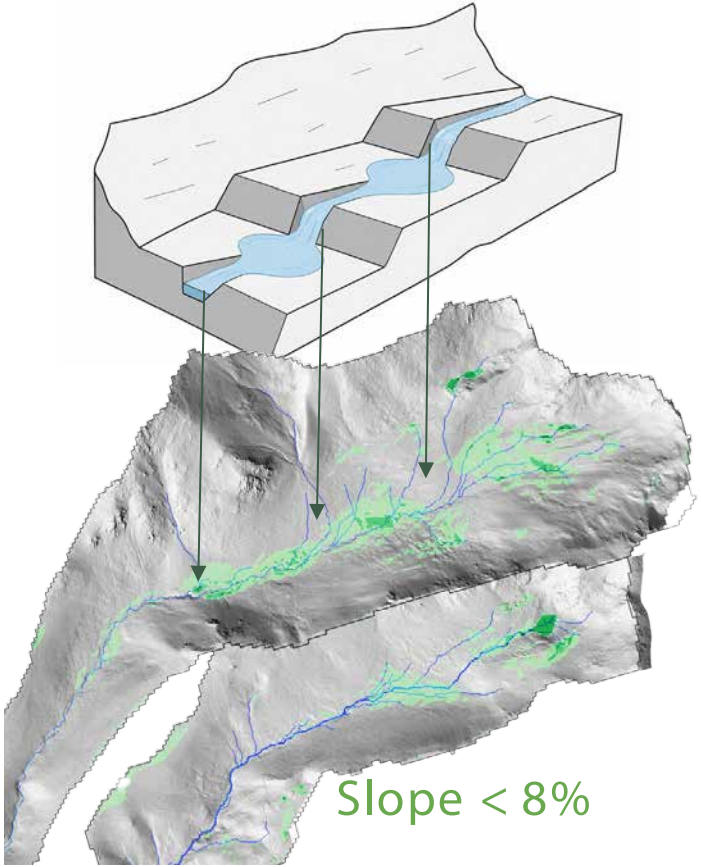


Understanding Processes for Better Outcomes





Understanding Processes for Better Outcomes

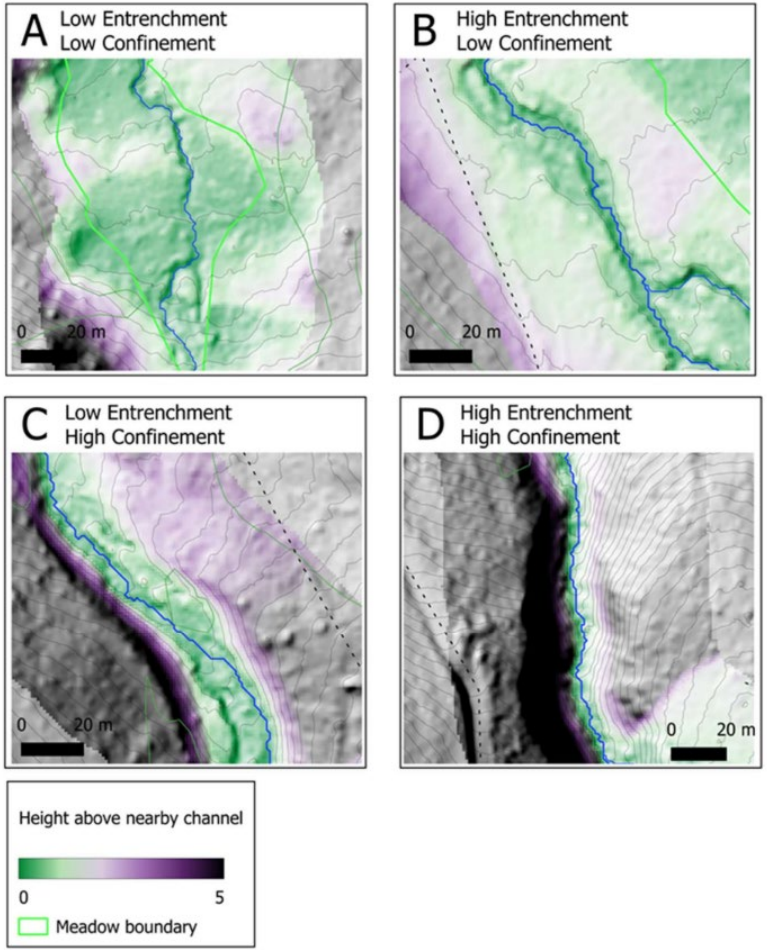


Tread - Riser pattern informs:

- Slope
- Con□nement
- Entrenchment
- Grain size
- Erodibility
- Surface and Groundwater interactions

Ignore at your peril

Healthy meadow

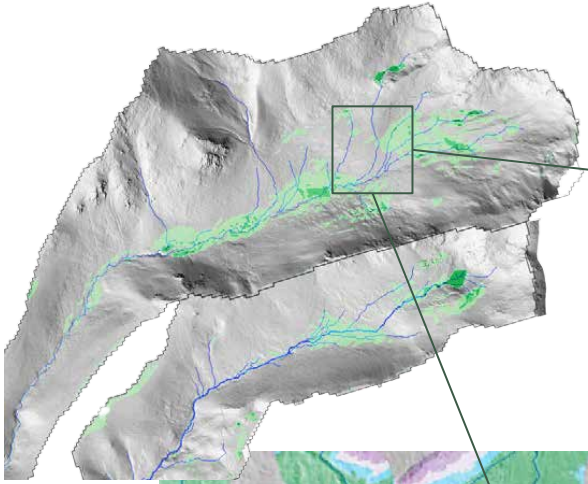


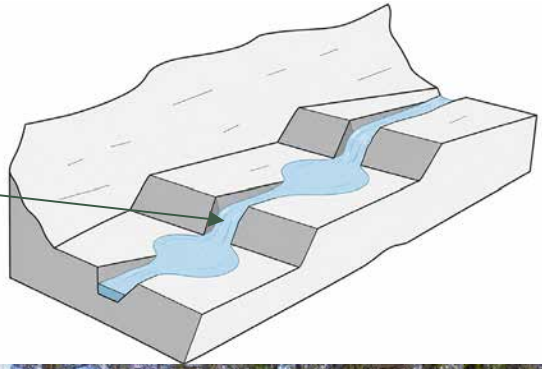
Excellent restoration potential

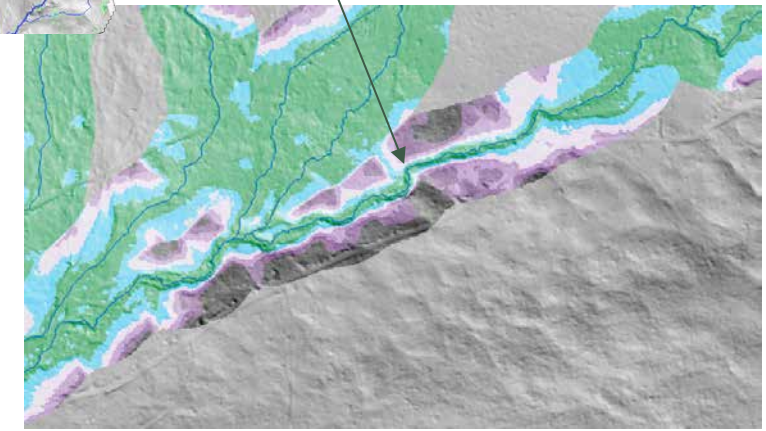
Connect oodplain

?

Channel disconnects from oodplain in risers, as predicted







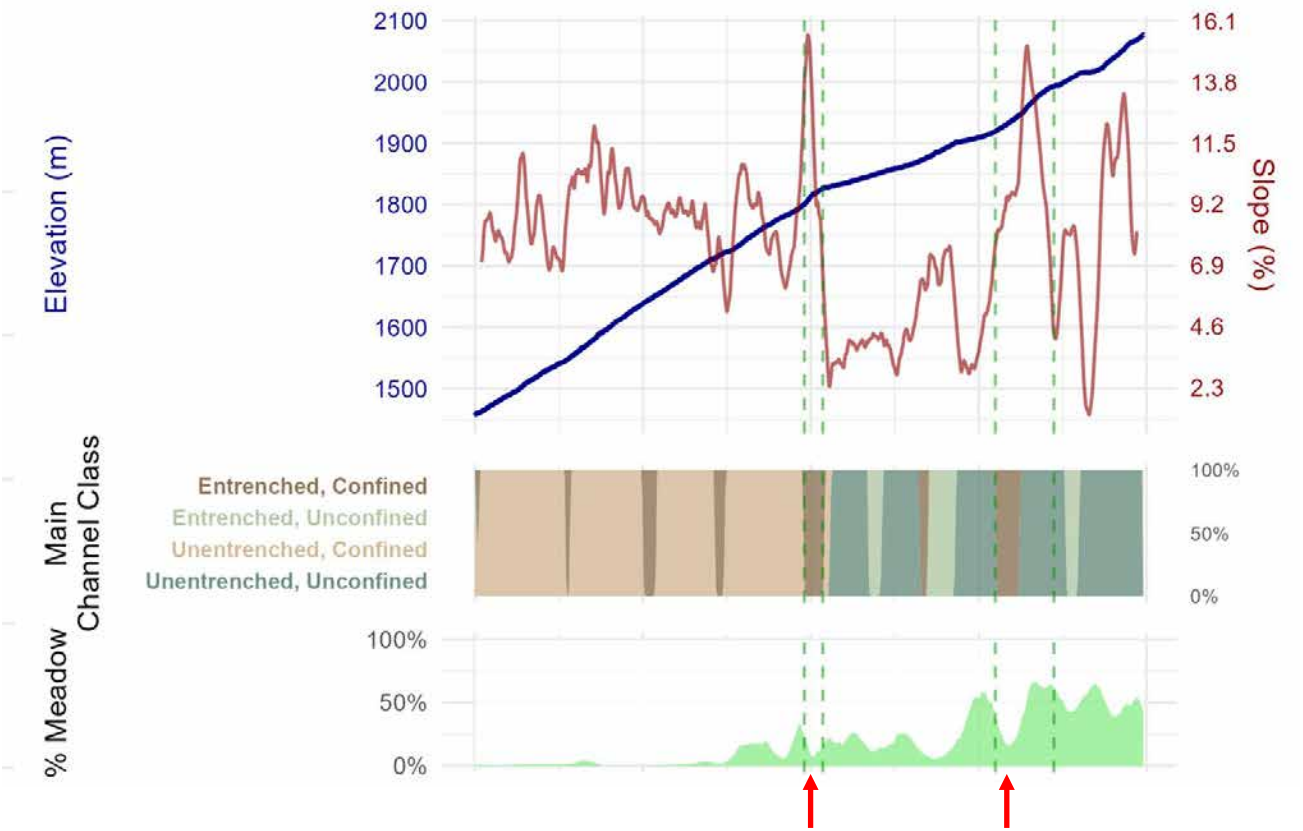
Colors = Detrended elevation

Glacial history informs channel condition

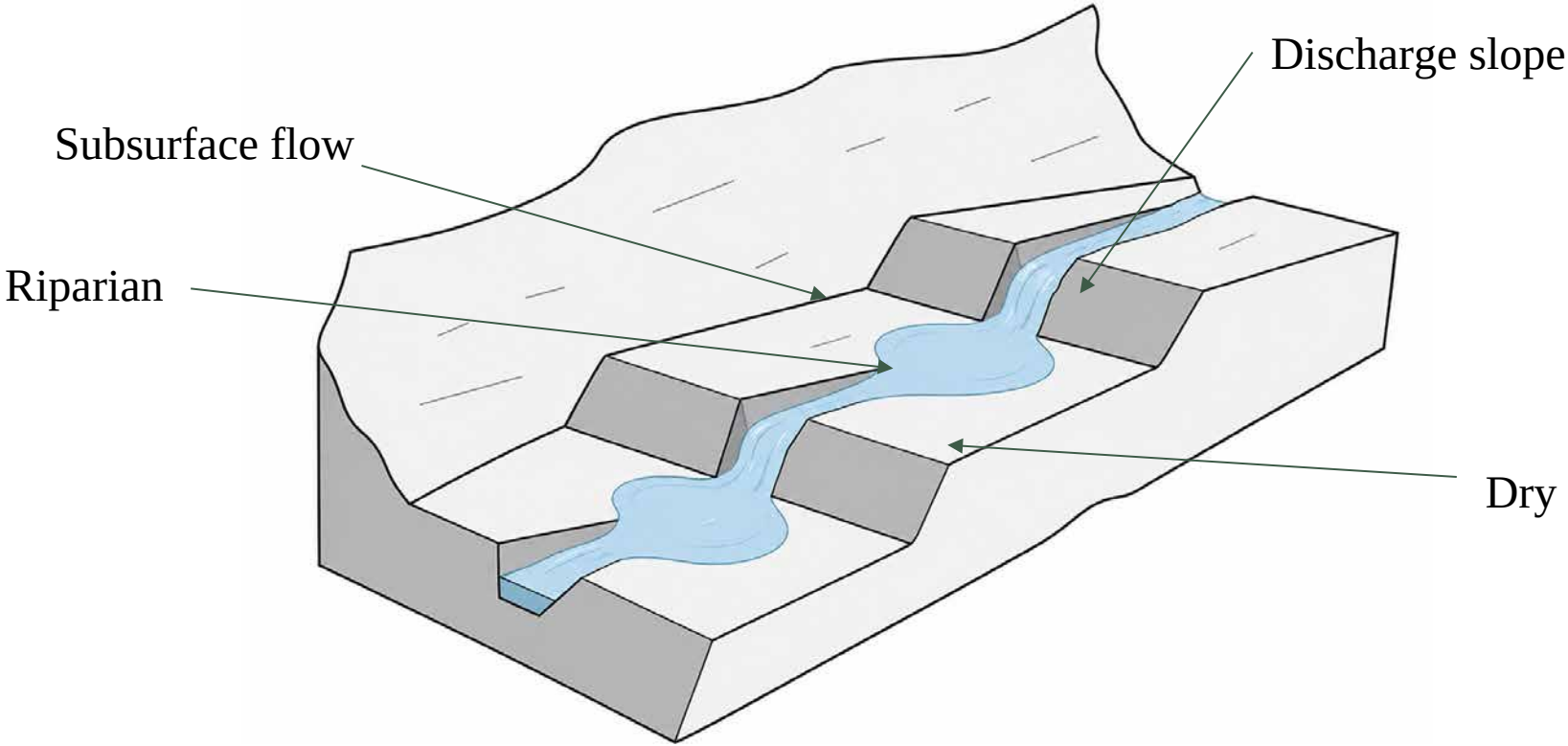
And channel potential

And meadow positions

And meadow potential

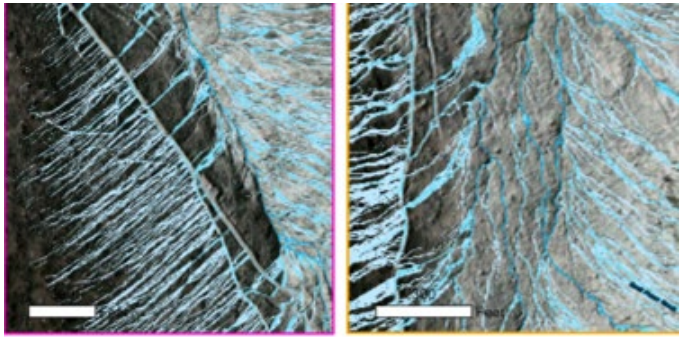


Meadows hydrogeomorphic type predictions

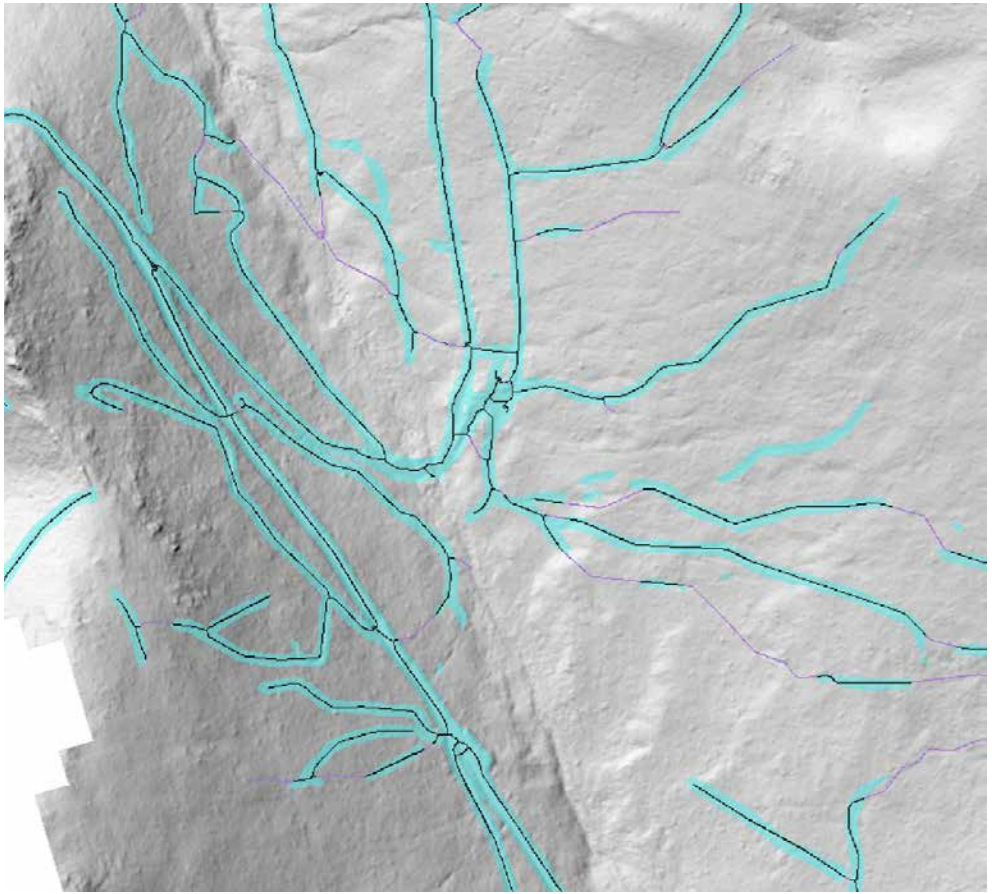



So go walk with your team and with curiosity

Roads & Impacts



Spatial analysis tools that informed and improve field evaluations.



Cabin Meadow / Rock Fence Planning Outcomes

Meadow plans
Site-specific prescriptions
Priority actions
Timelines and phasing

Stream plans
Reach-specific treatments
Process-based restoration
Expected outcomes

Road plans
Priority road treatments
Drainage improvements
Decommissioning targets

Forest & fuels plans
Fuels reduction prescriptions
Forest health treatments
Integration with fire management

Applying lessons and tools across the broader landscape

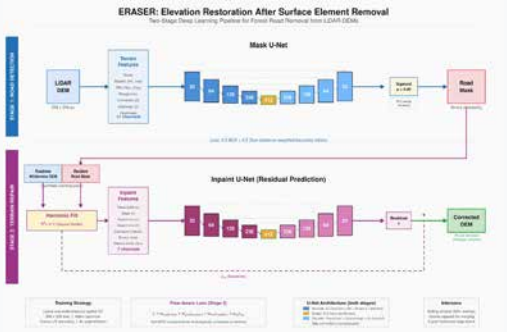
Cabin Meadow / Rock Fence Broader Klamath Mountains

The Klamath Meadow Partnership

- The team/tools/analyses described here are expanding across the Klamath Mountains, facilitated by the Klamath Meadows Partnership.

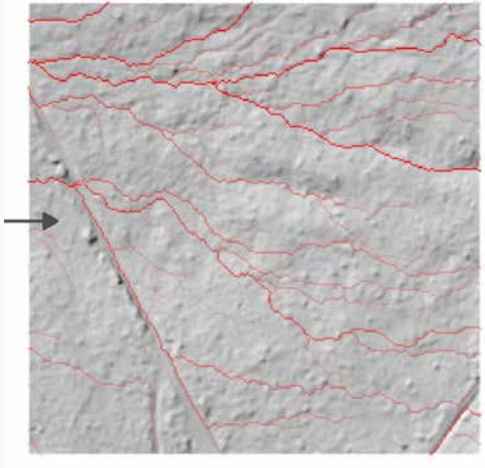
Applying Tools Across the KMP

ERASER: Road detection and removal model

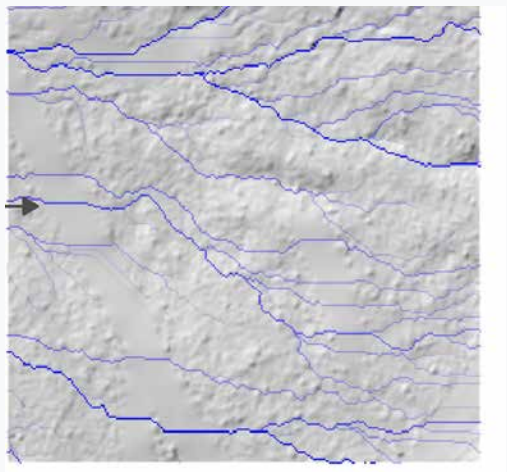


Model Overview

See poster session for more information

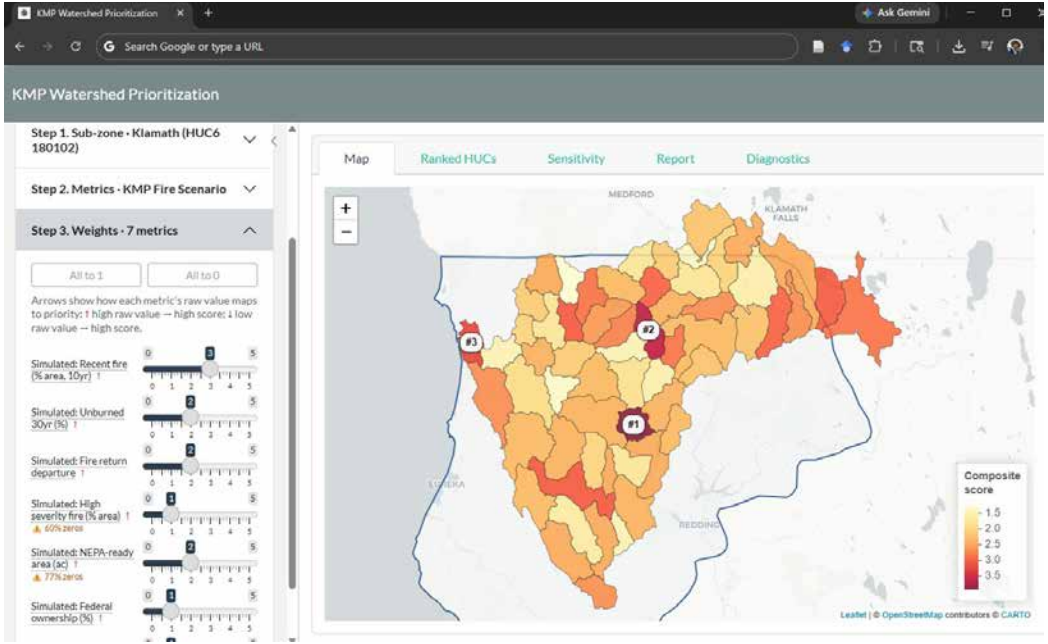


(b) Flow Accumulation (Original)



(f) Flow Accumulation (Corrected)

Applying Tools Across the KMP



Interactive Watershed Prioritization Tool

We are currently selecting metrics to include in the tool. Your input is valuable!

Join the KMP to help!

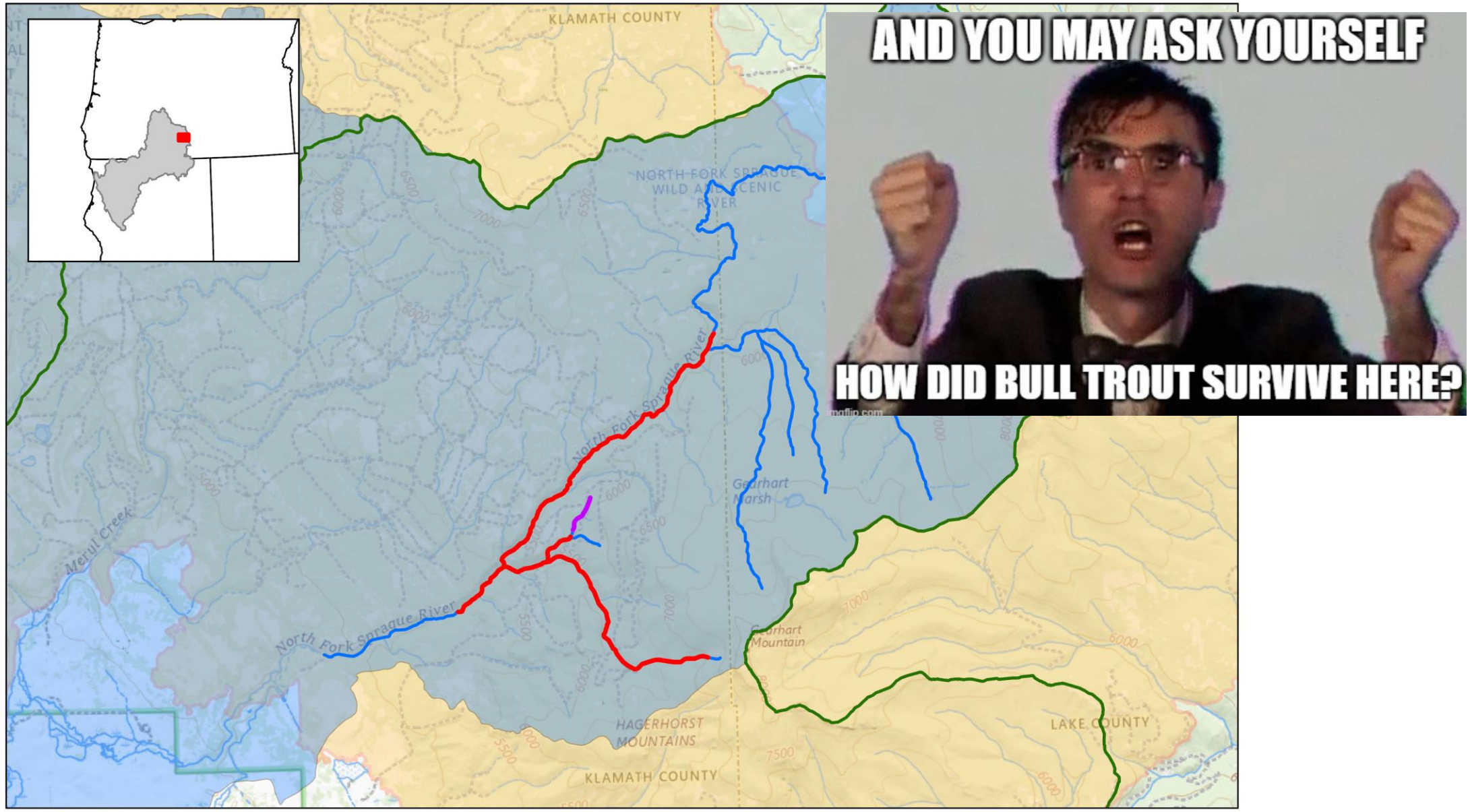

It's a web!
Consider all the threads for effective restoration
It takes a team to understand the web
Lessons learned (including analysis tools) can carry over between projects. We'll share some of ours.


Questions?

Can Bull Trout Navigate Non-wicker Weave Beaver Dam Analogs? A Case Study of Fish Passage at Beaver Dam Analogs Constructed Using Modern Techniques in the Upper Klamath Basin, Oregon

Charlie Erdman, Tommy Cianciolo, Dave Hering

Salmonid Restoration Federation - 2026

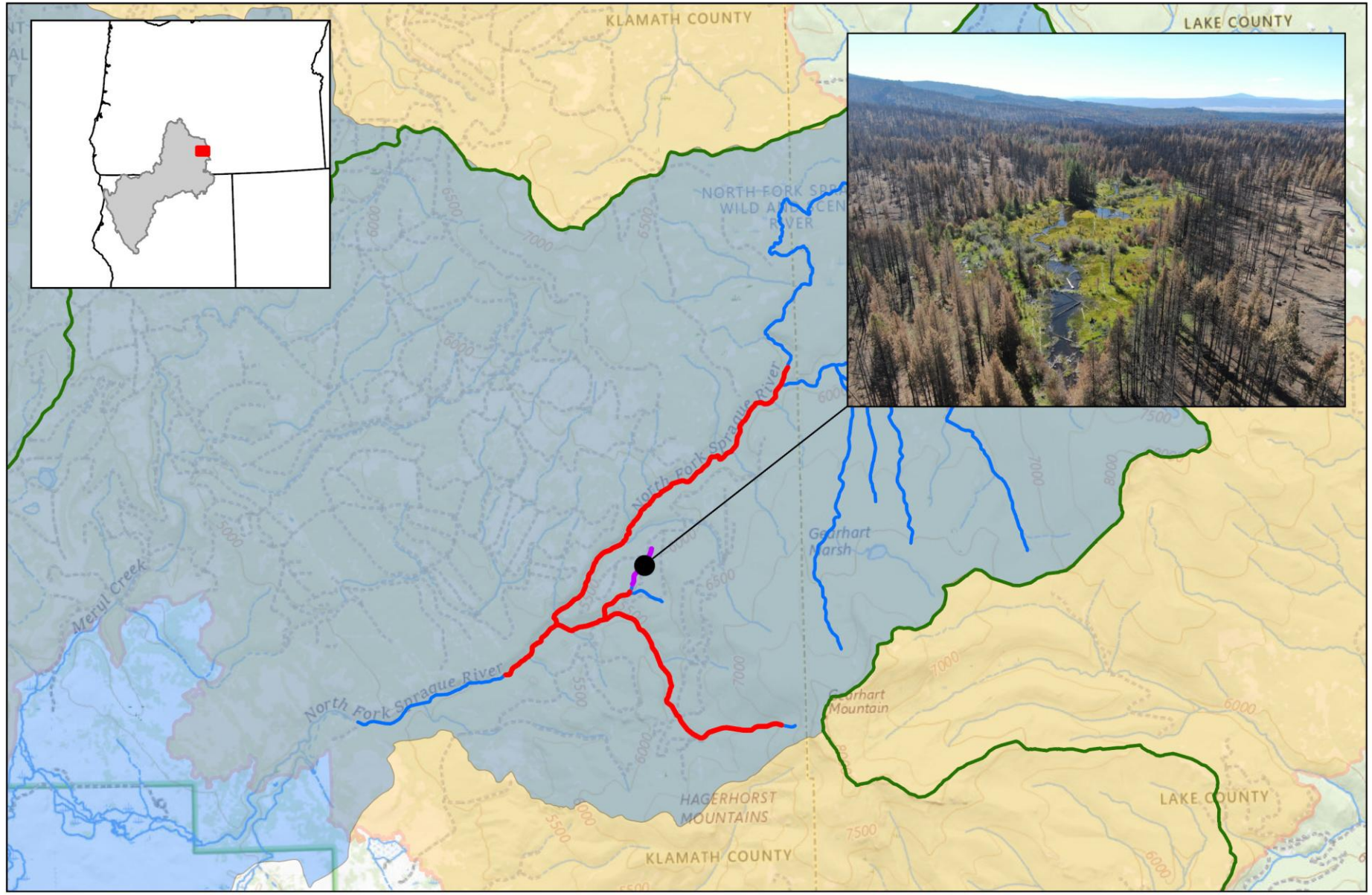


Bull Trout in the NF Sprague River Watershed

- Recently Extirpated
- Currently Occupied
- Bull Trout Critical Habitat
- Upper Sprague Core Area
- NF Sprague River Watershed
- Bootleg Fire

N

0 2 4 8 Kilometers



Bull Trout in the NF Sprague River Watershed

- Recently Extirpated
- Currently Occupied
- Bull Trout Critical Habitat
- Upper Sprague Core Area
- NF Sprague River Watershed
- Bootleg Fire

N

0 2 4 8 Kilometers

Bull Trout and Beaver and Beaver-Related Restoration

Habitat:

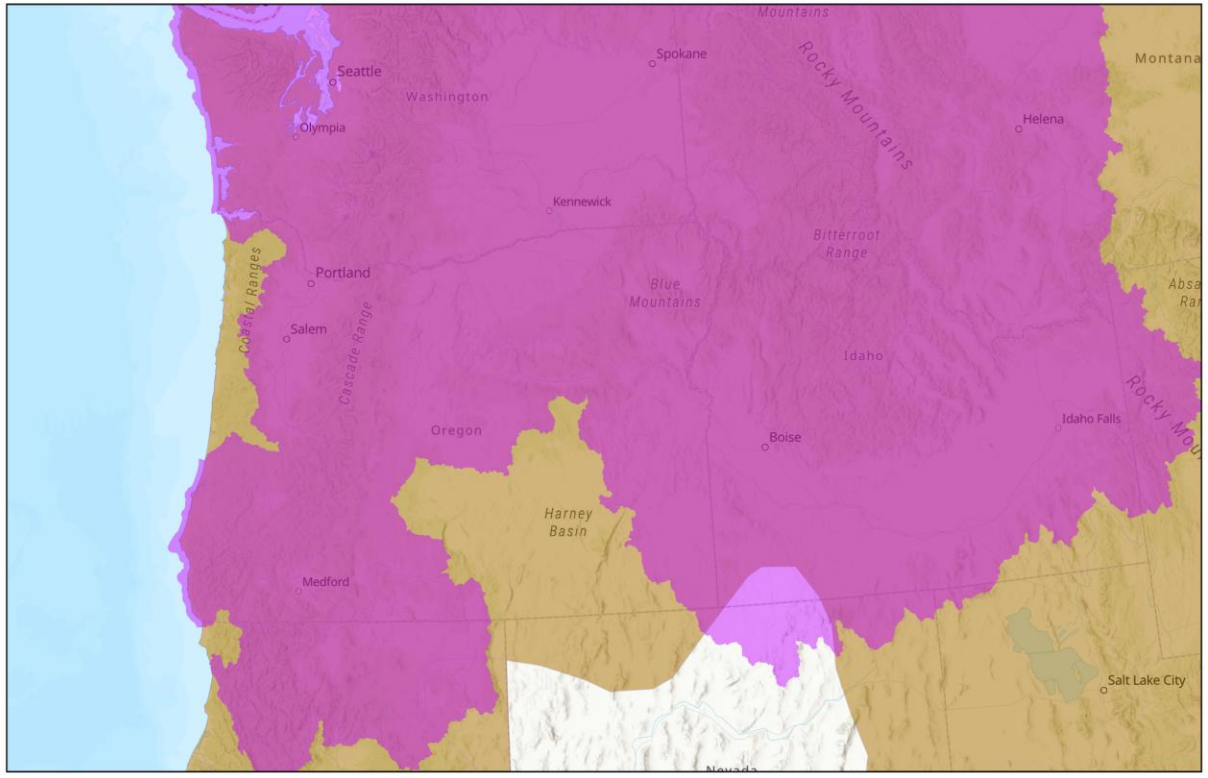
- Overwinter in beaver ponds (Jakober et al. 1998)

Passage:

- Detected upstream of dams (Boag 1987; Wolf et al. 2024)
- Redds detected above dams (Bustard 2017; Wolf et al. 2024,)
- Beaver dams can delay downstream migration, especially during periods of unusually low precipitation (Dupont et al. 2007)

LTPBR:

- Minimal increase in density (Mackey 2025)



Sun Creek

Extensive habitat and BLT recovery efforts since 1989

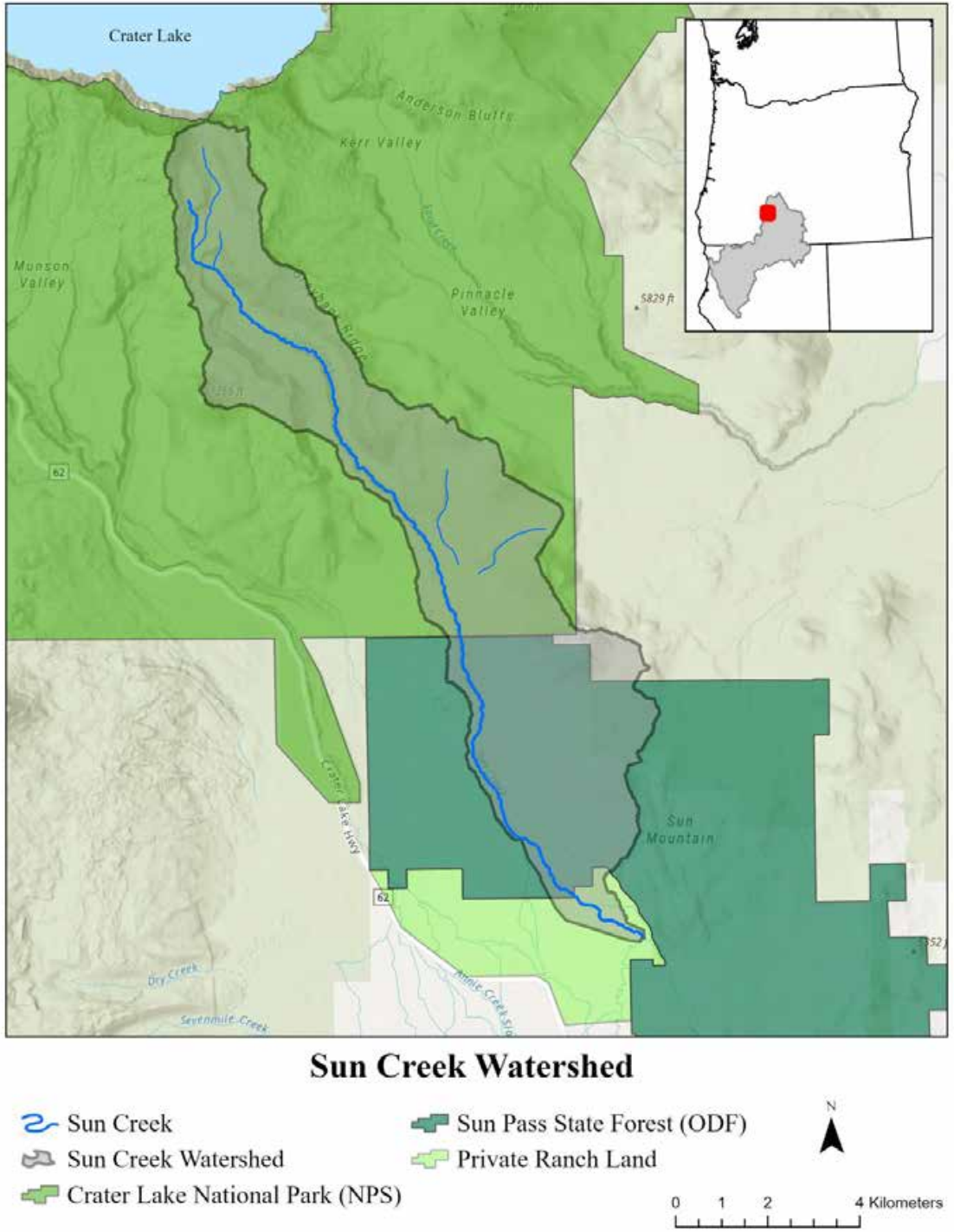
- Barrier construction
- Fish screen installation
- Brook Trout removal
- Instream water right transfer
- Channel reconnection
- LTPBR

Collaborative effort

- Led by NPS with assistance from state, NGOs, private landowners

Successful in increasing BLT abundance and distribution

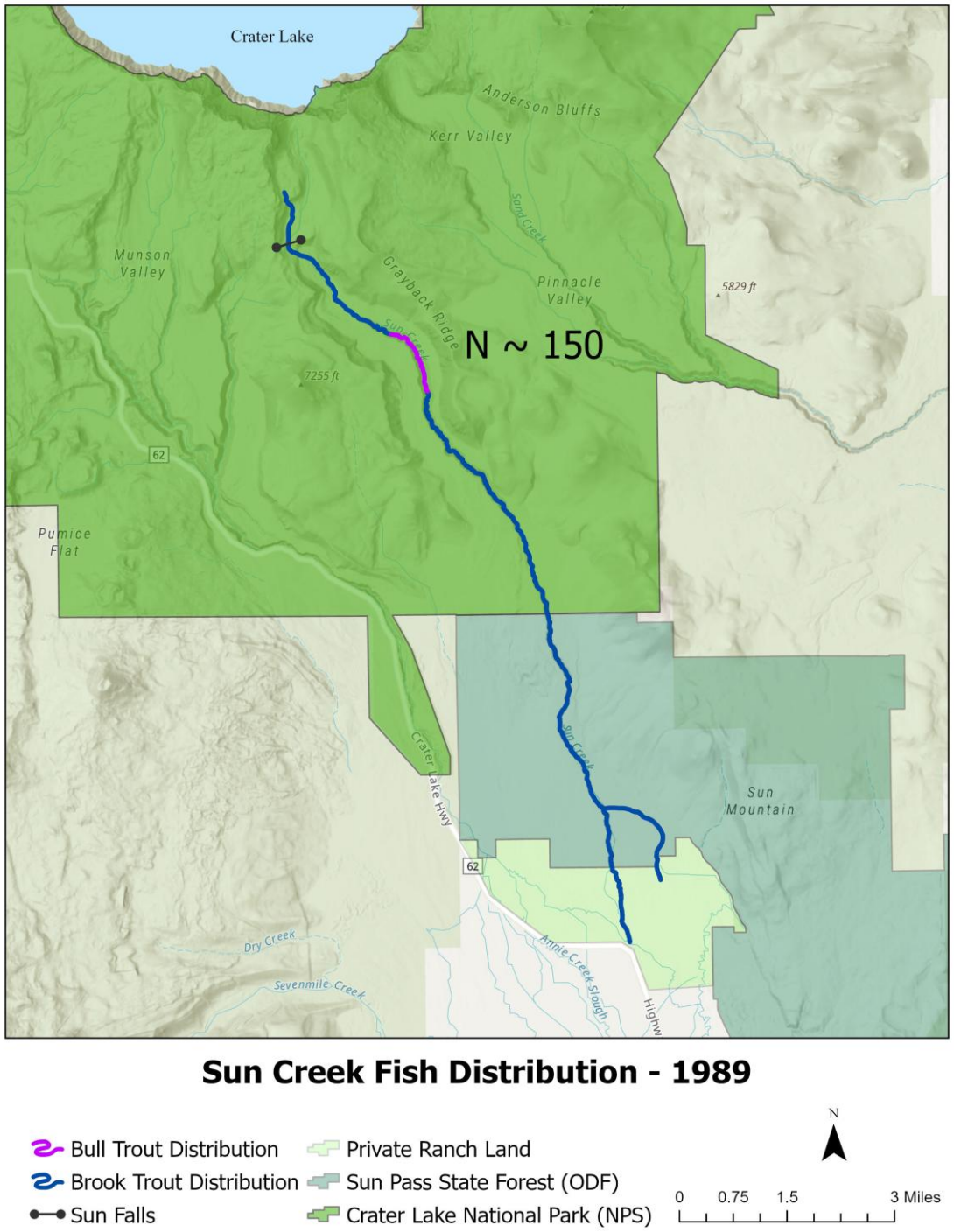
More information: Buktenica et al. 2018



Sun Creek

1989:

- BLT limited to ~ 2km
- BLT population ~ 150 fish
- Brook Trout distributed throughout entirety of Sun Creek

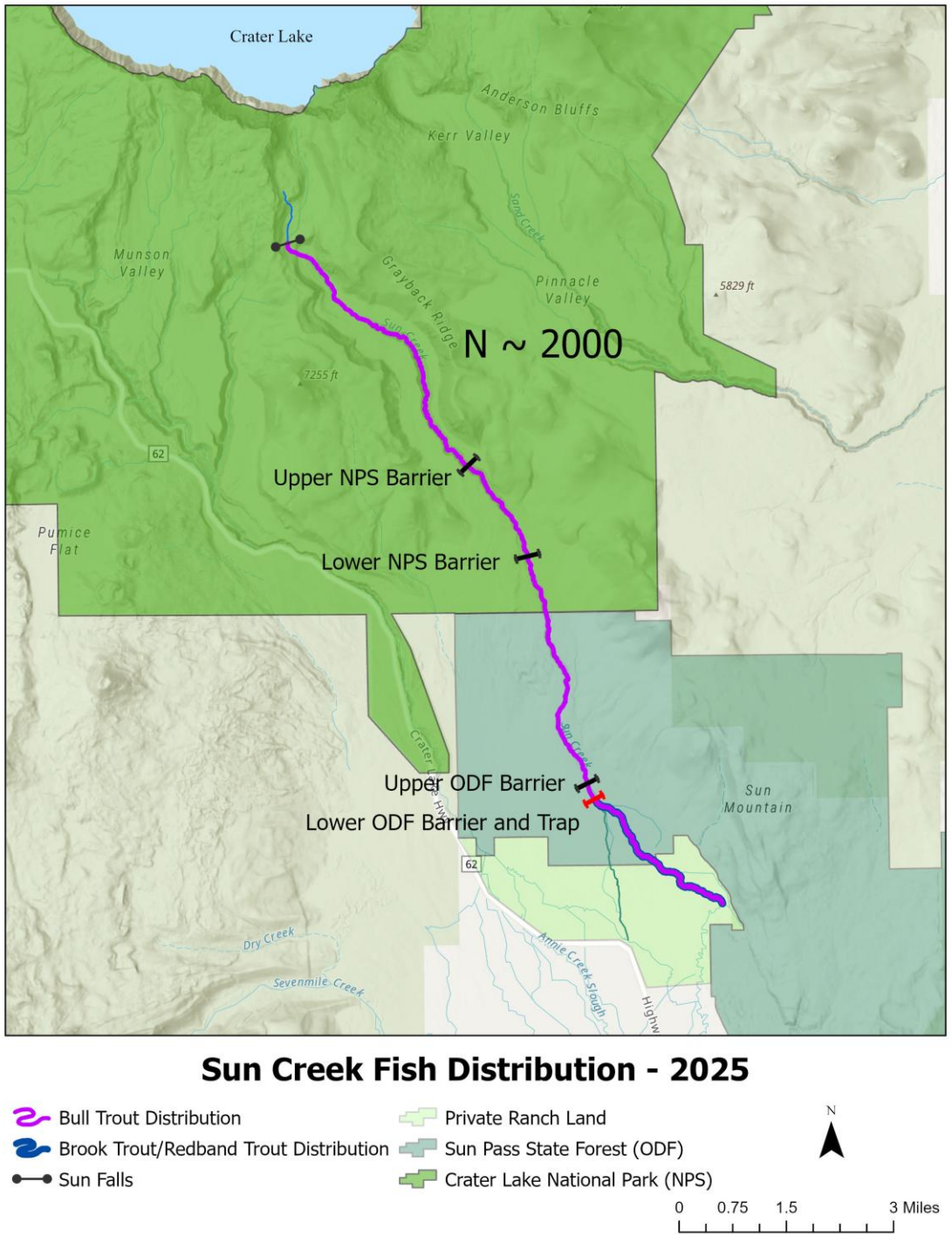


Sun Creek Fish Distribution - 1989

Sun Creek

2025:

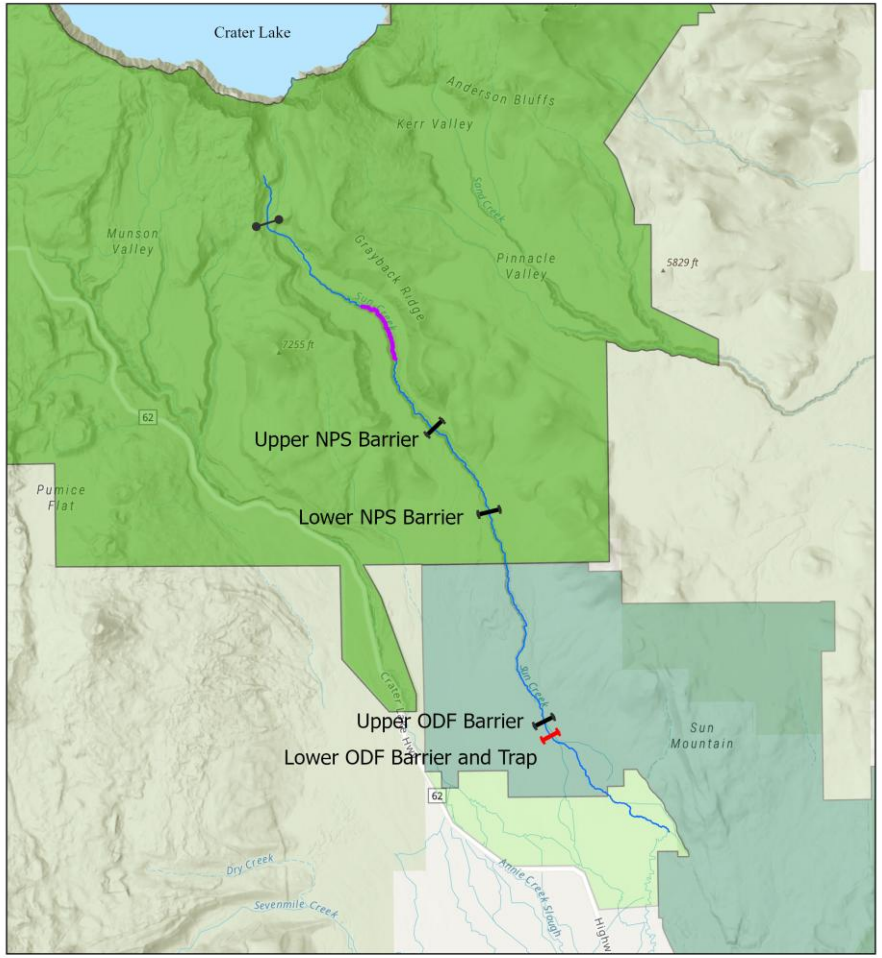
- BLT between falls and mouth
- BLT population ~ 2000 fish
- Brook Trout and Redband Trout below lower ODF barrier



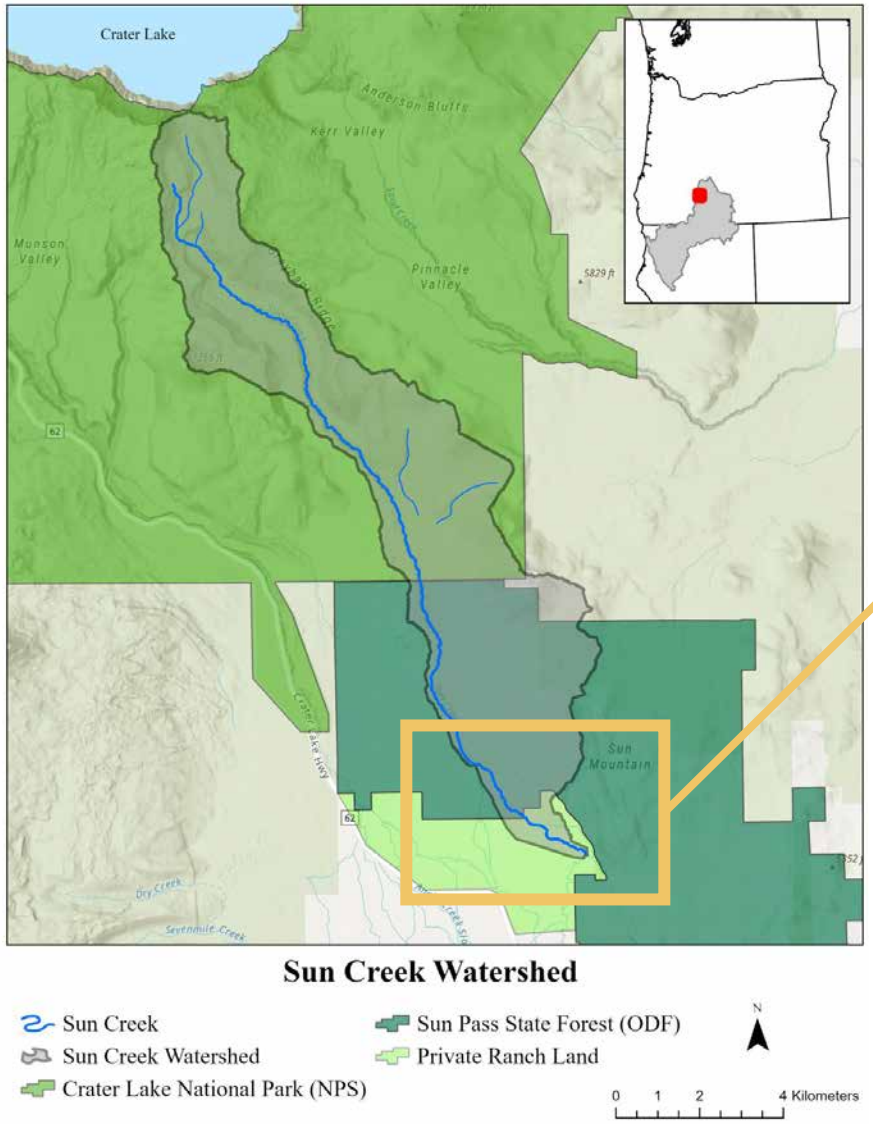
Sun Creek Fish Distribution - 2025

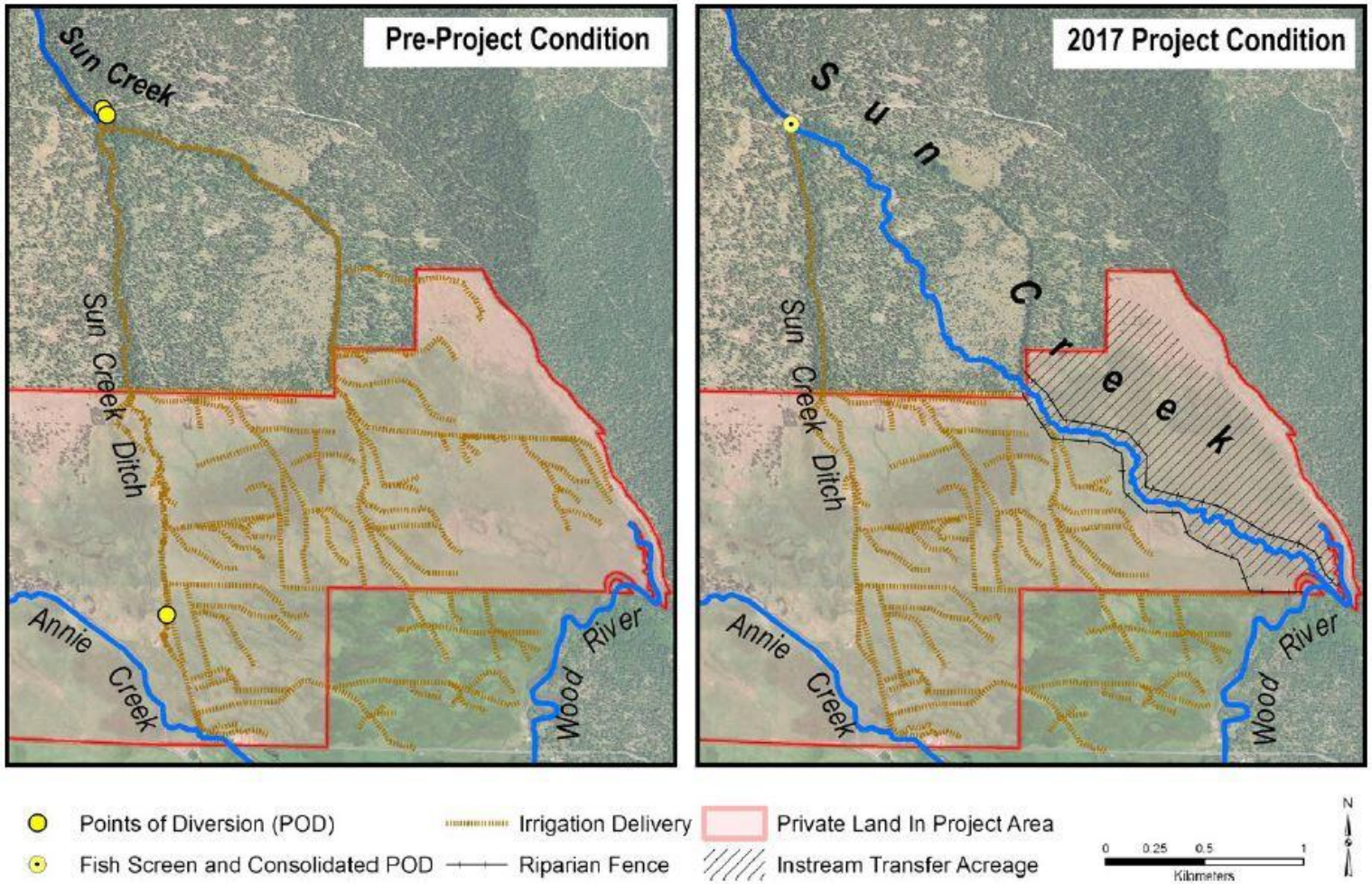
Bull Trout Distribution
Brook Trout/Redband Trout Distribution
Sun Falls
Private Ranch Land

Sun Creek Lower ODF Barrier and Trap - 2011



Sun Creek Channel Reconnection – 2016 and 2017






July 2014


June 2025

LTPBR Build – Lower Sun Creek (2.1km)

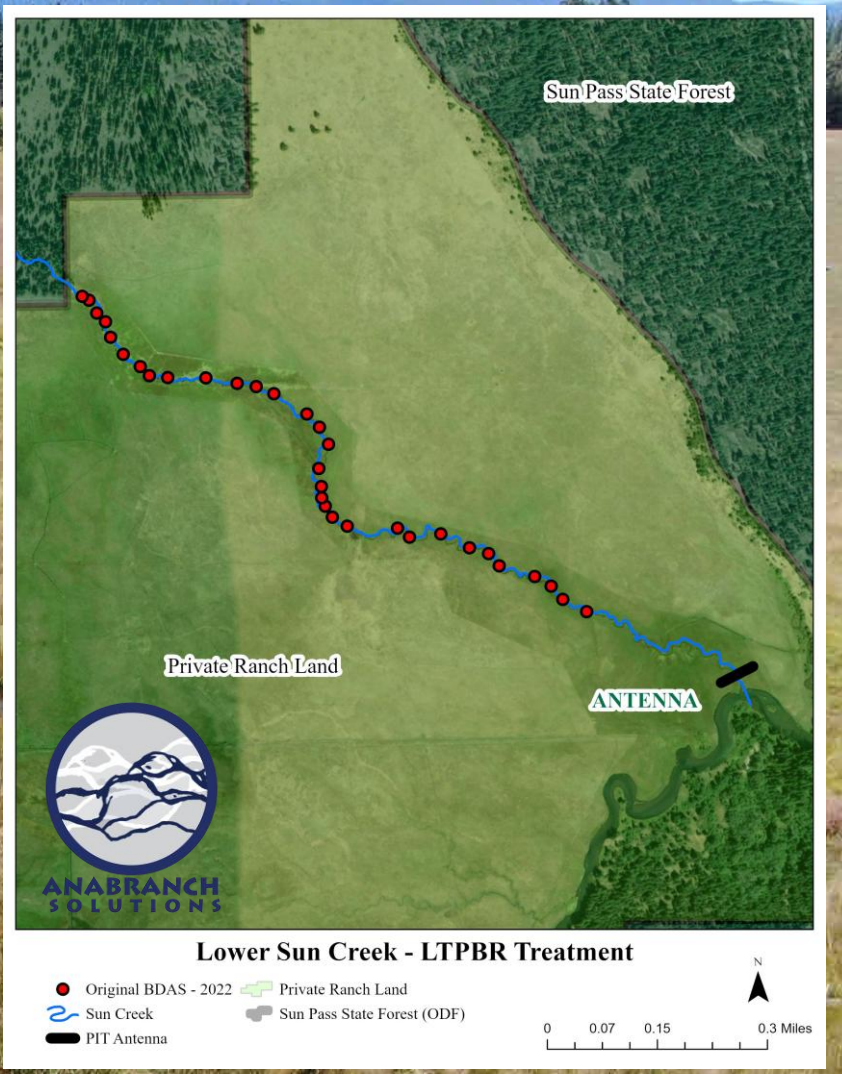
Fall 2022

- 32 BDAs, 20 PALS installed

Fall 2024

- Maintenance on 18 BDAS

All with posts but using the postless method (Appendix E; Wheaton et al. 2019)



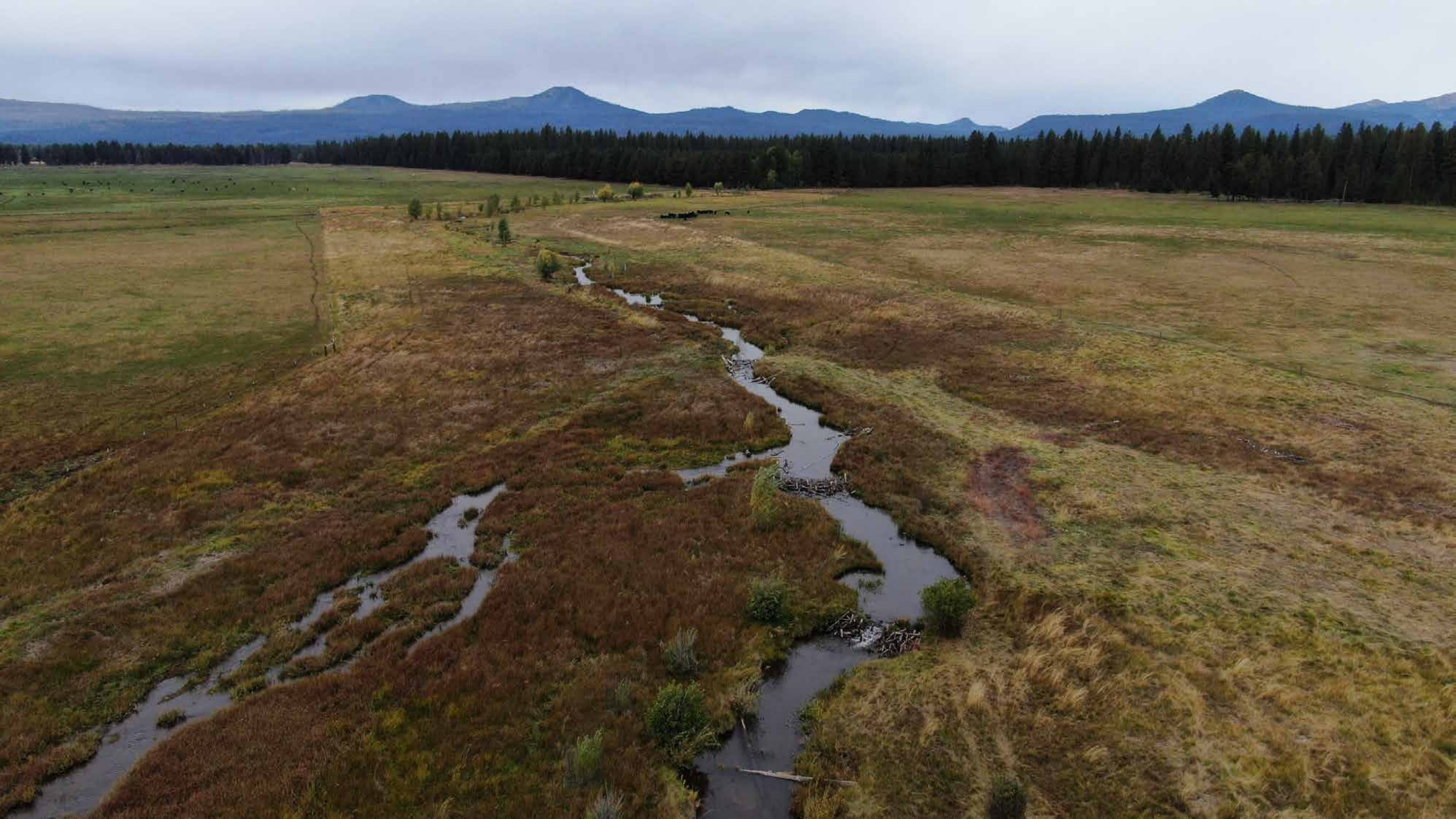
BDA.20


May 2023


September 2024


291°W (M) 42.747824°N, 121.995093°W ±9ft
September 2025
BDA
Sun Creek
Sep 30 2025


March 2026



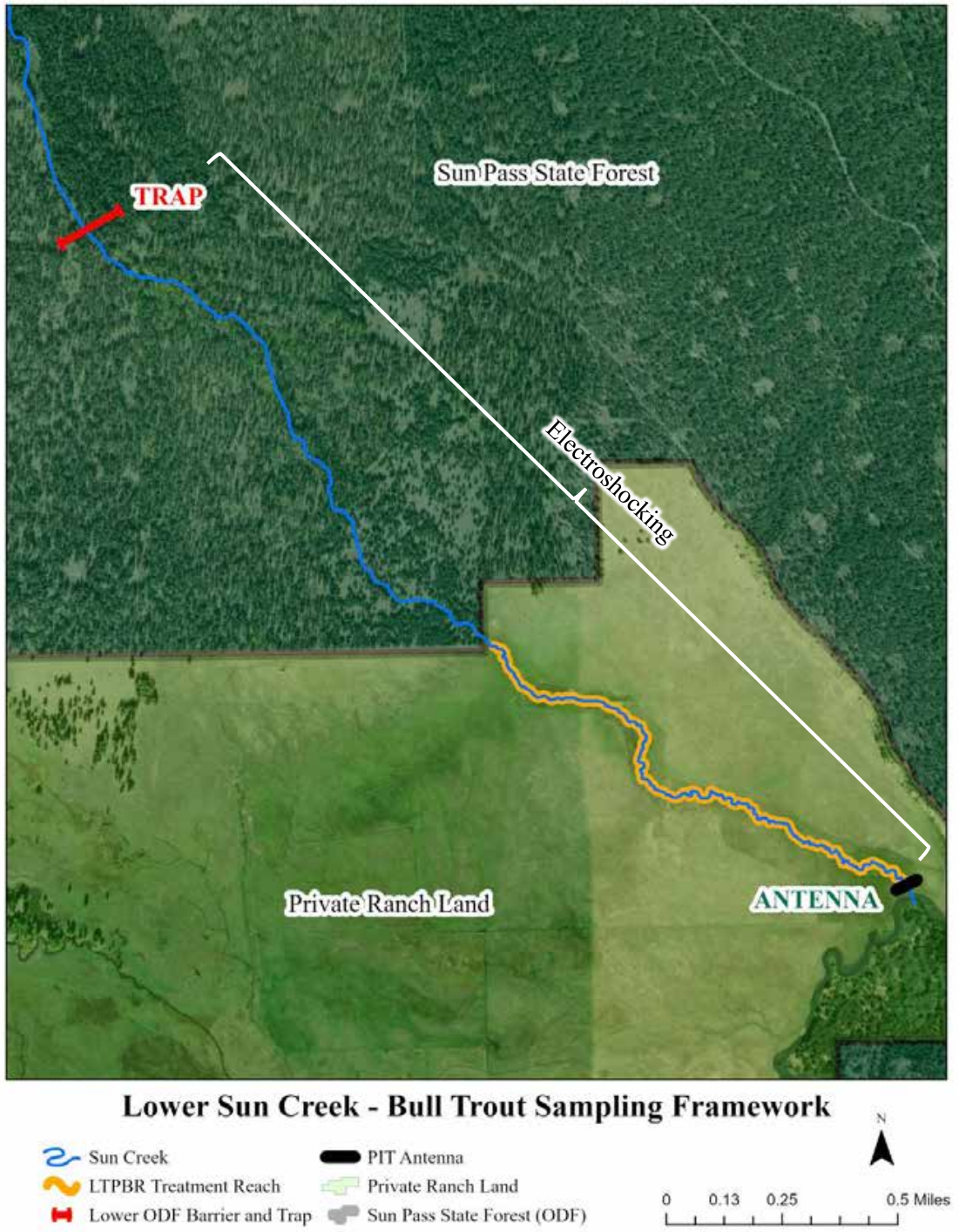
Methods

BLT collected at trap and during electrofishing surveys

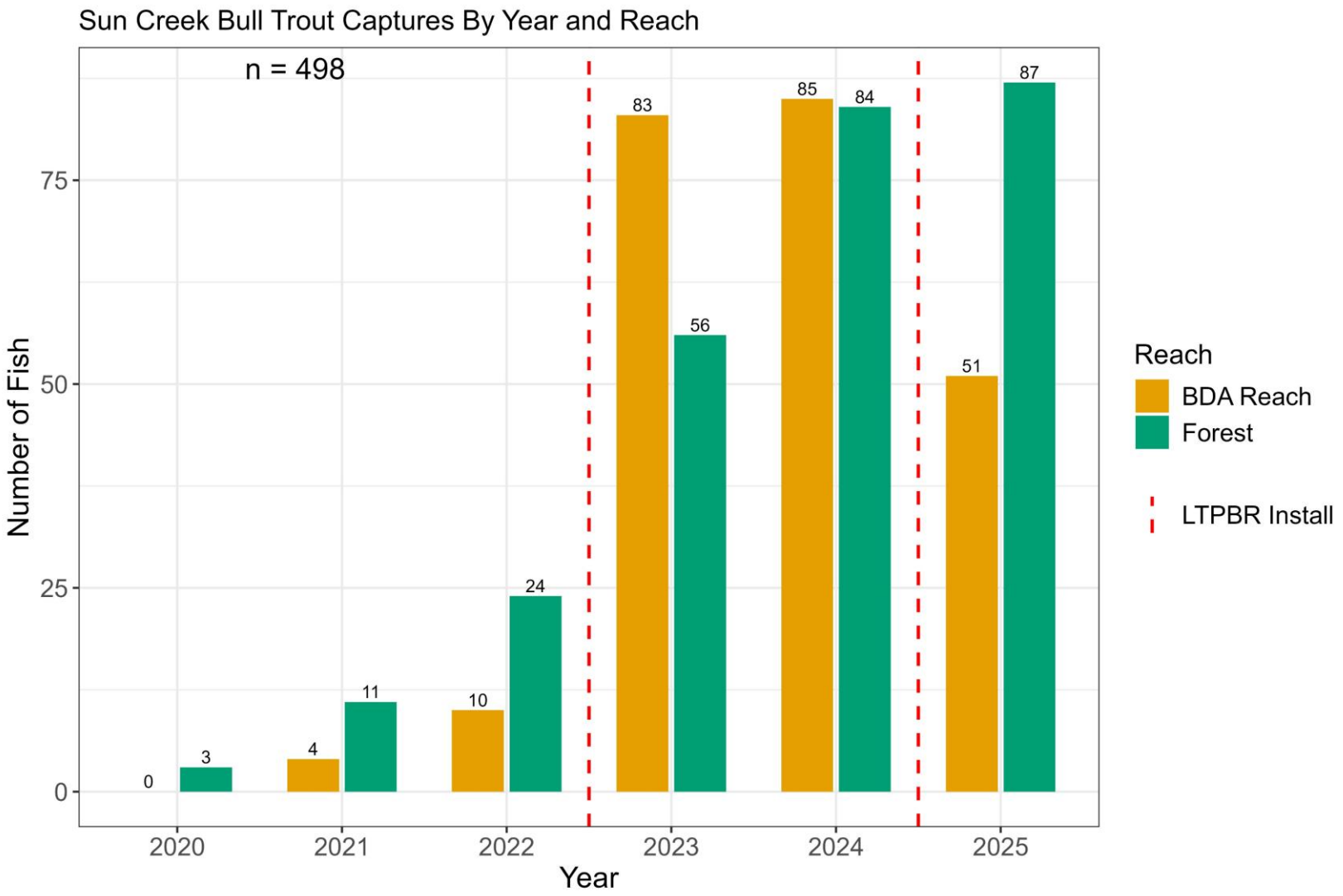
- Trap operated from 2021-2025
- Spring and fall electrofishing surveys from 2017-2025

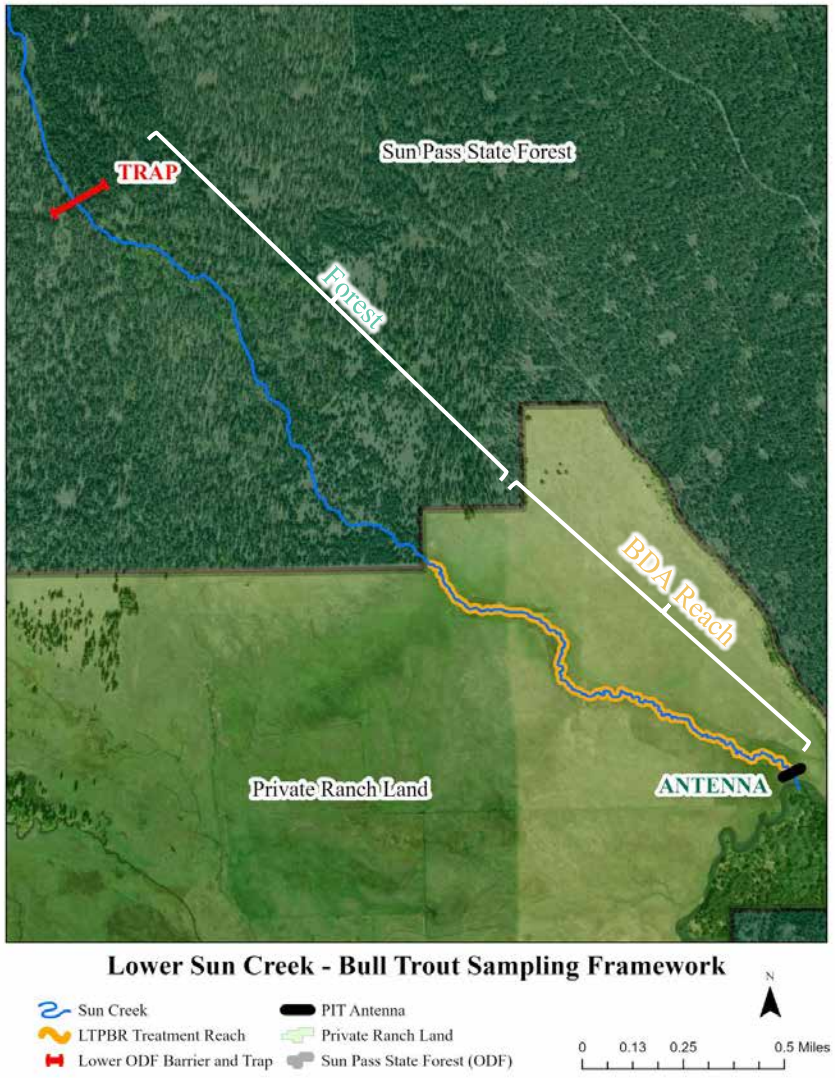
Dual antenna array at mouth

- Operated from 2018-2025



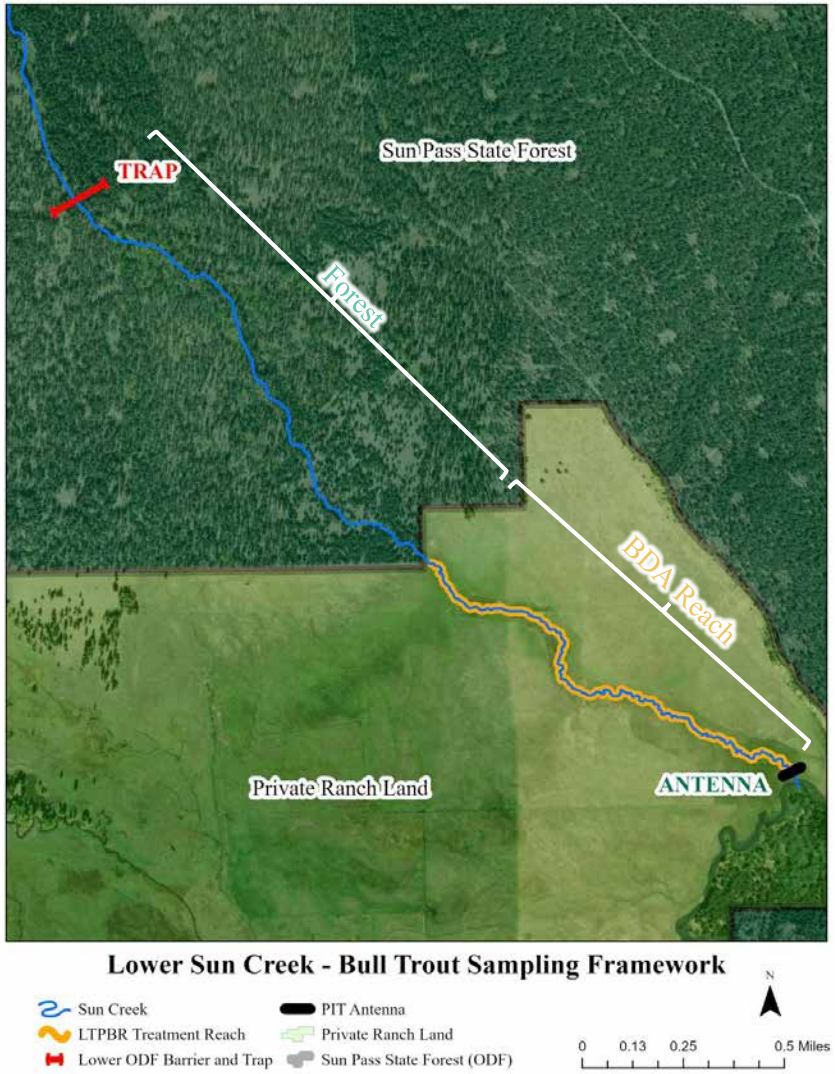
Are BLT in the reconnected reach?



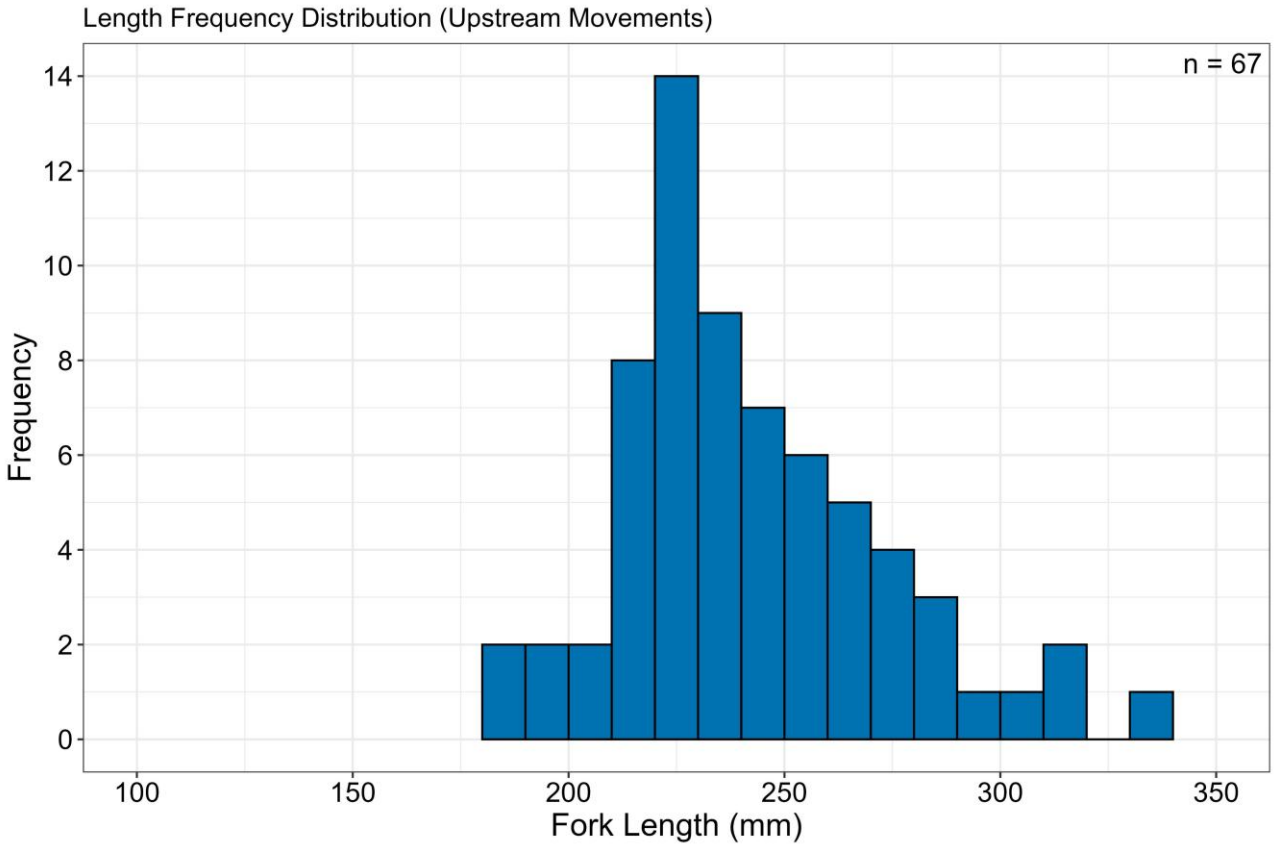


Are BLT moving upstream and downstream through the BDA reach?

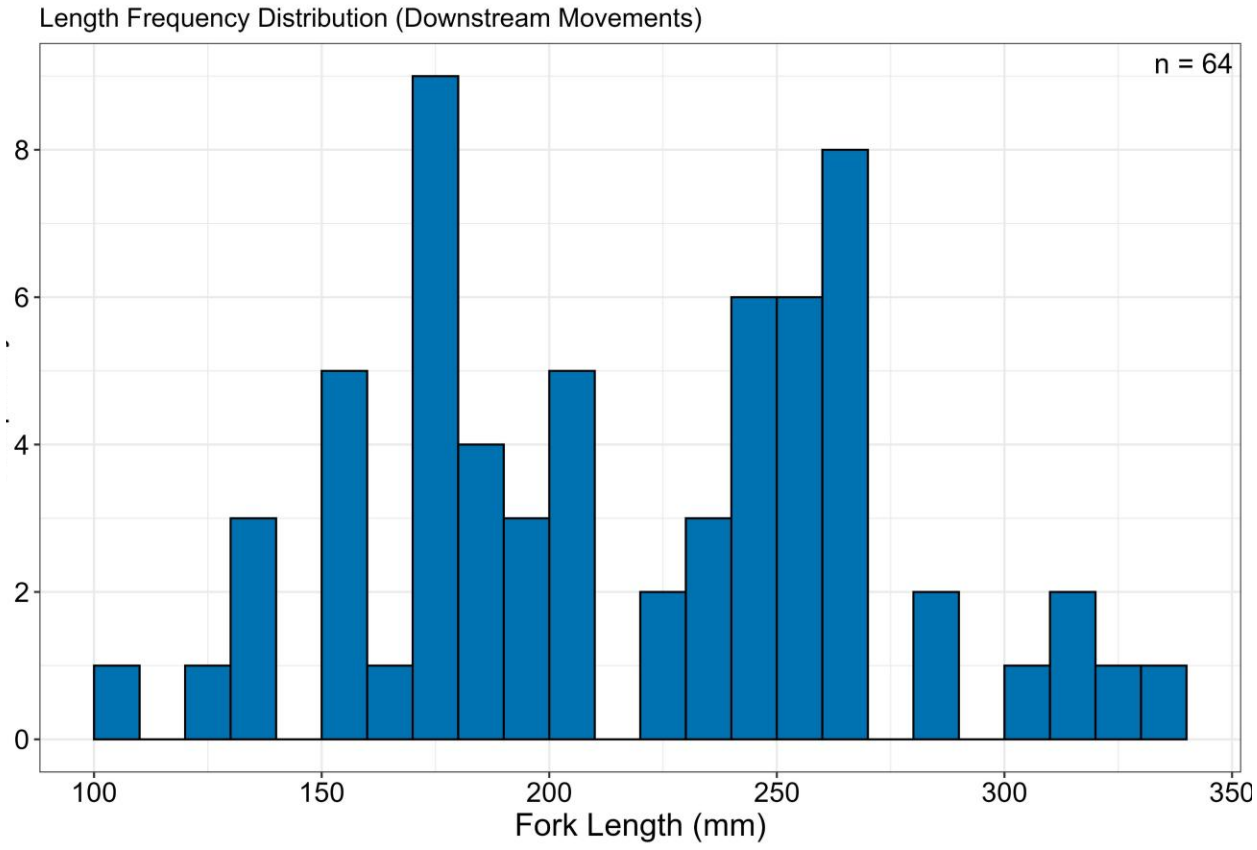
- **67** BLT passed at least 1 BDA during upstream movement (detected at mouth or during electroshocking and then at trap)
- **64** BLT passed at least 1 BDA during downstream movement (detected at trap or during electroshocking and then at mouth)



What size are BLT that make upstream and downstream movements through the BDA reach?

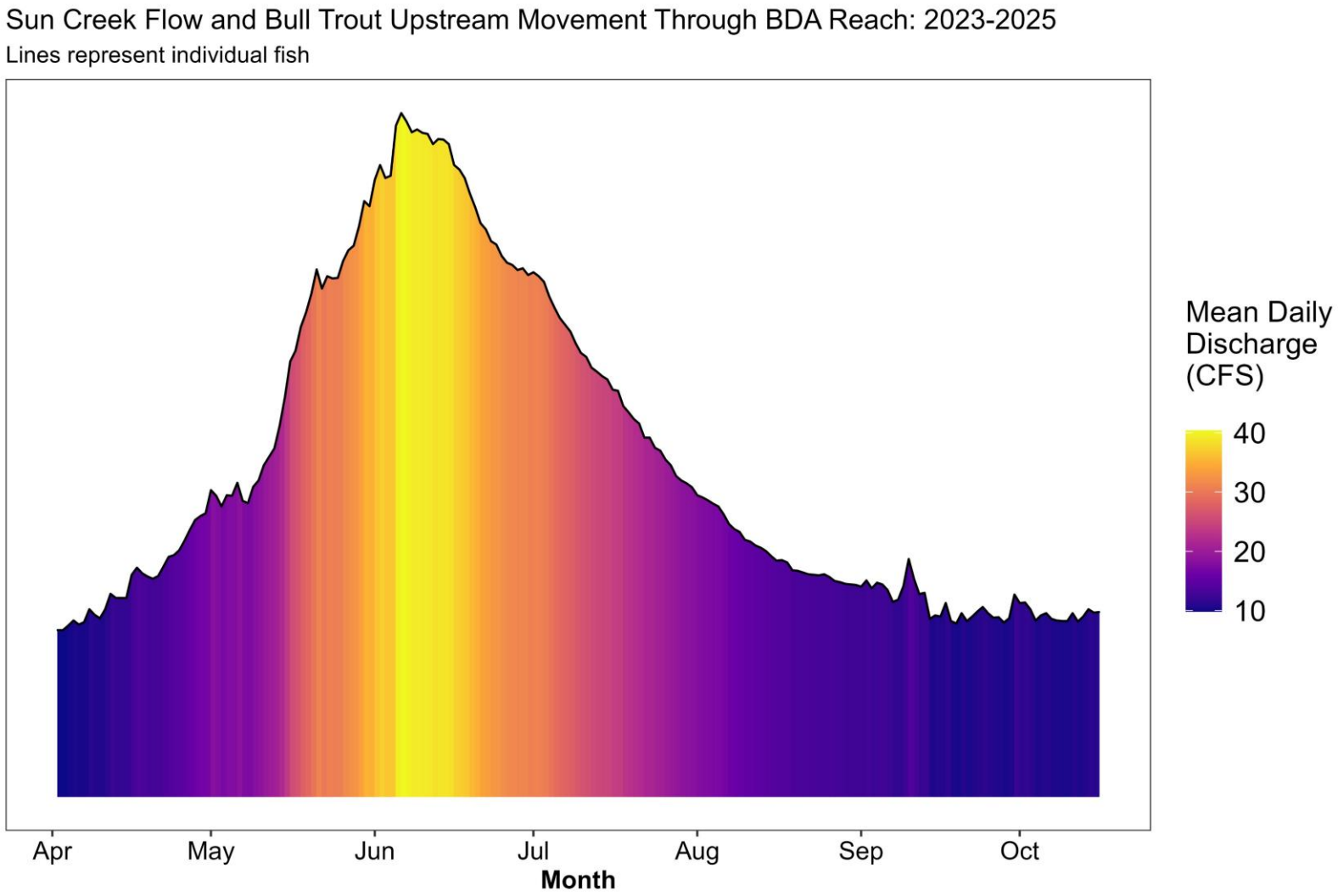


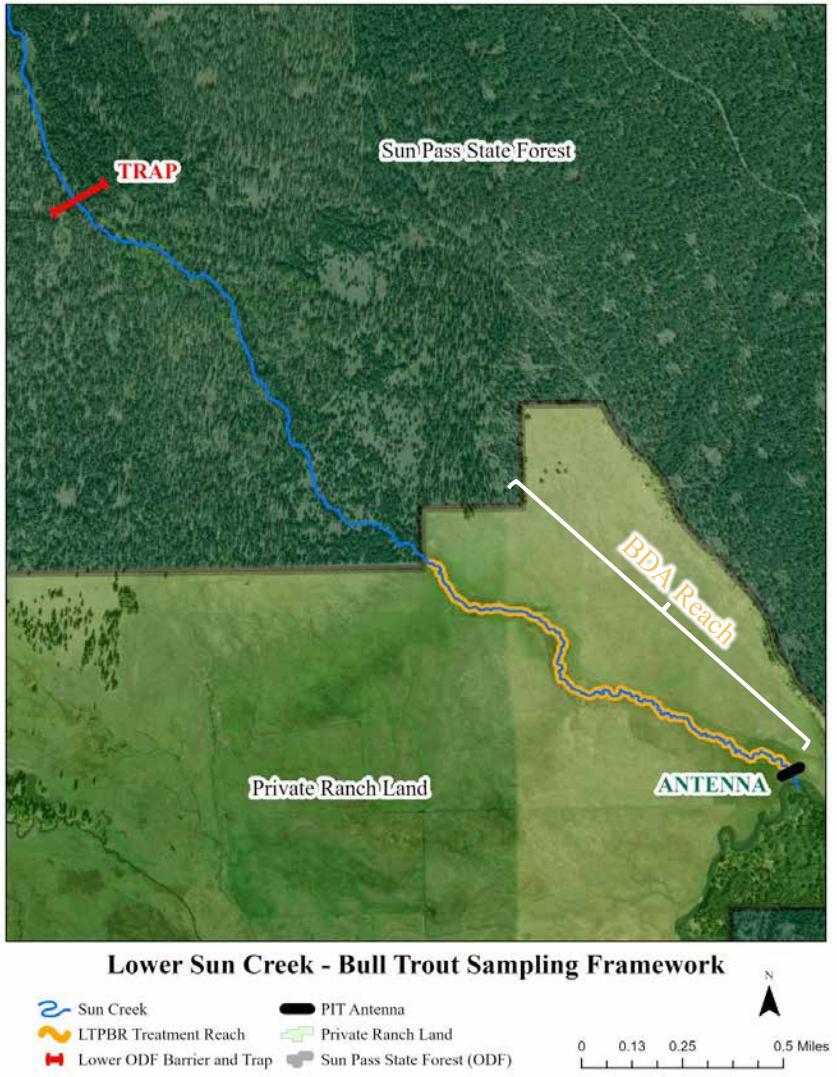
Upstream Movements



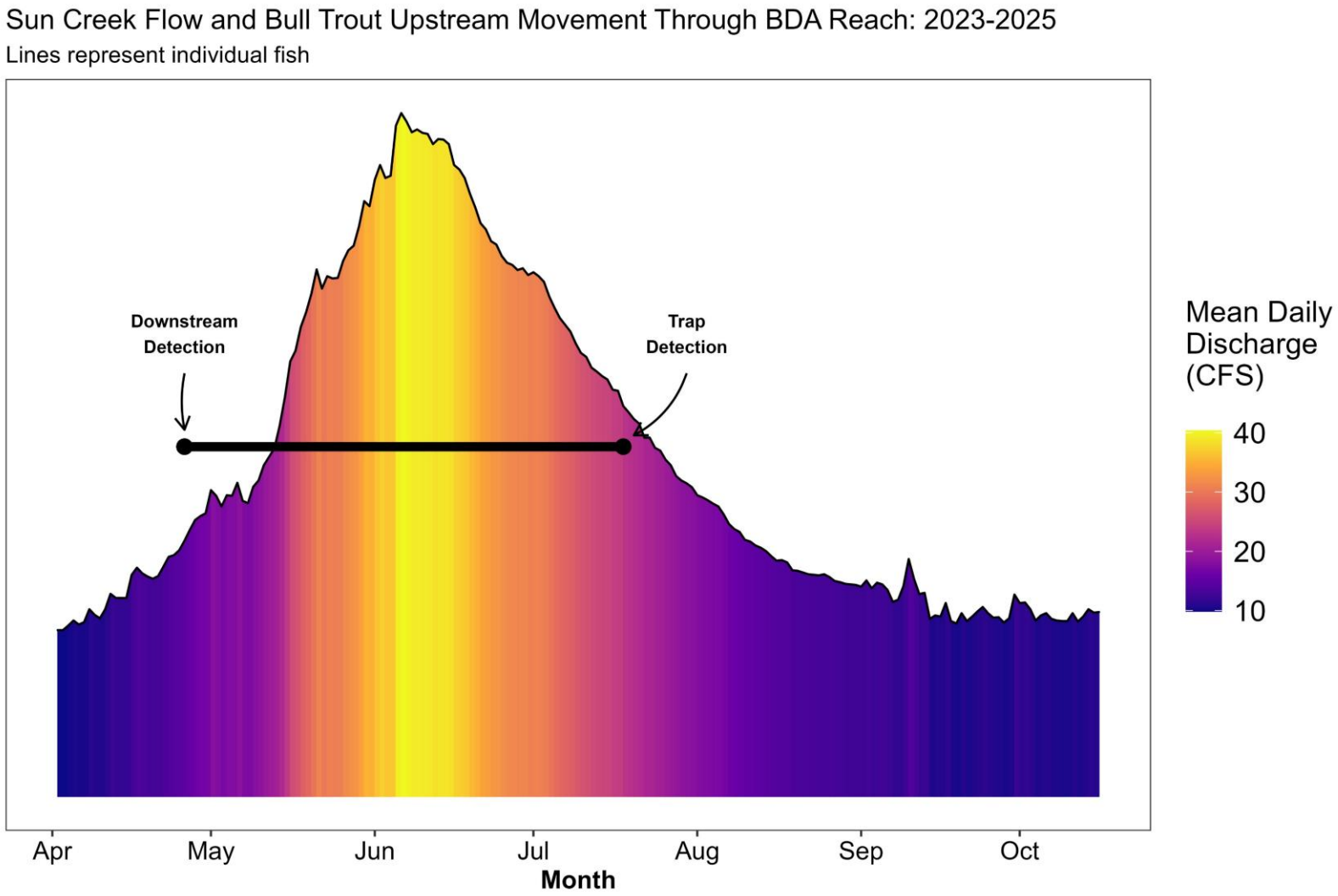
Downstream Movements

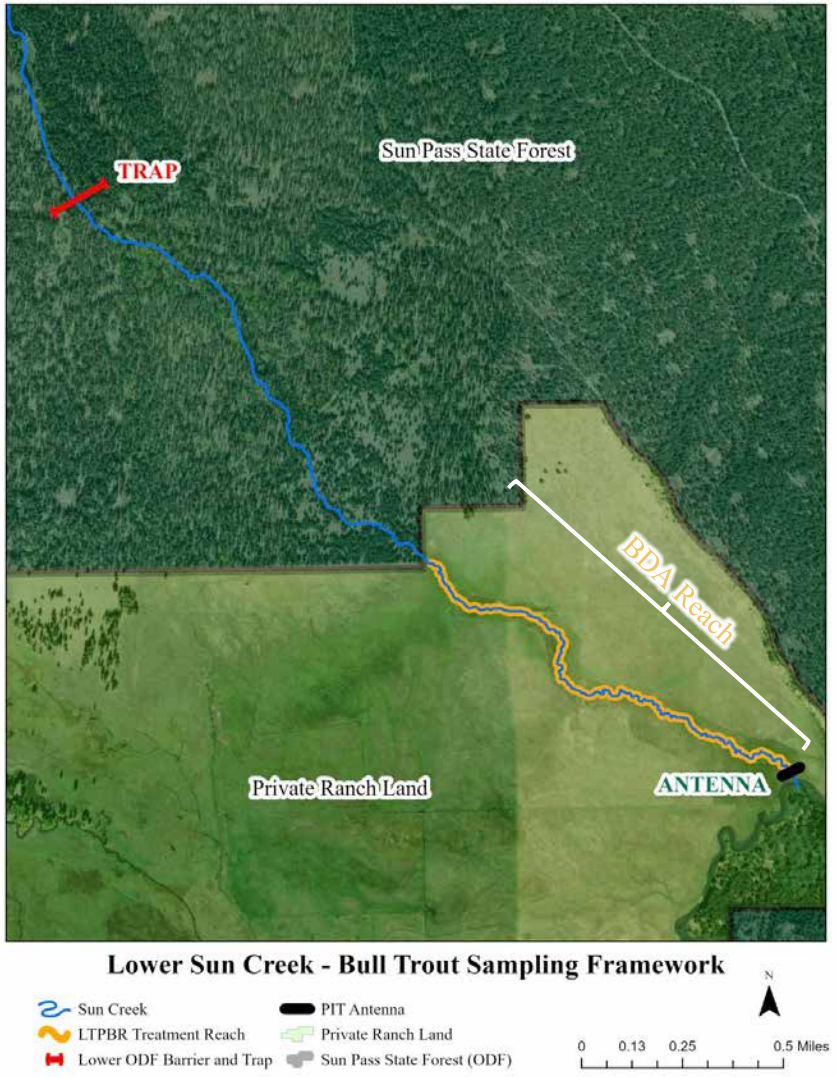
When are BLT moving upstream through the BDA reach?





When are BLT moving upstream through the BDA reach?





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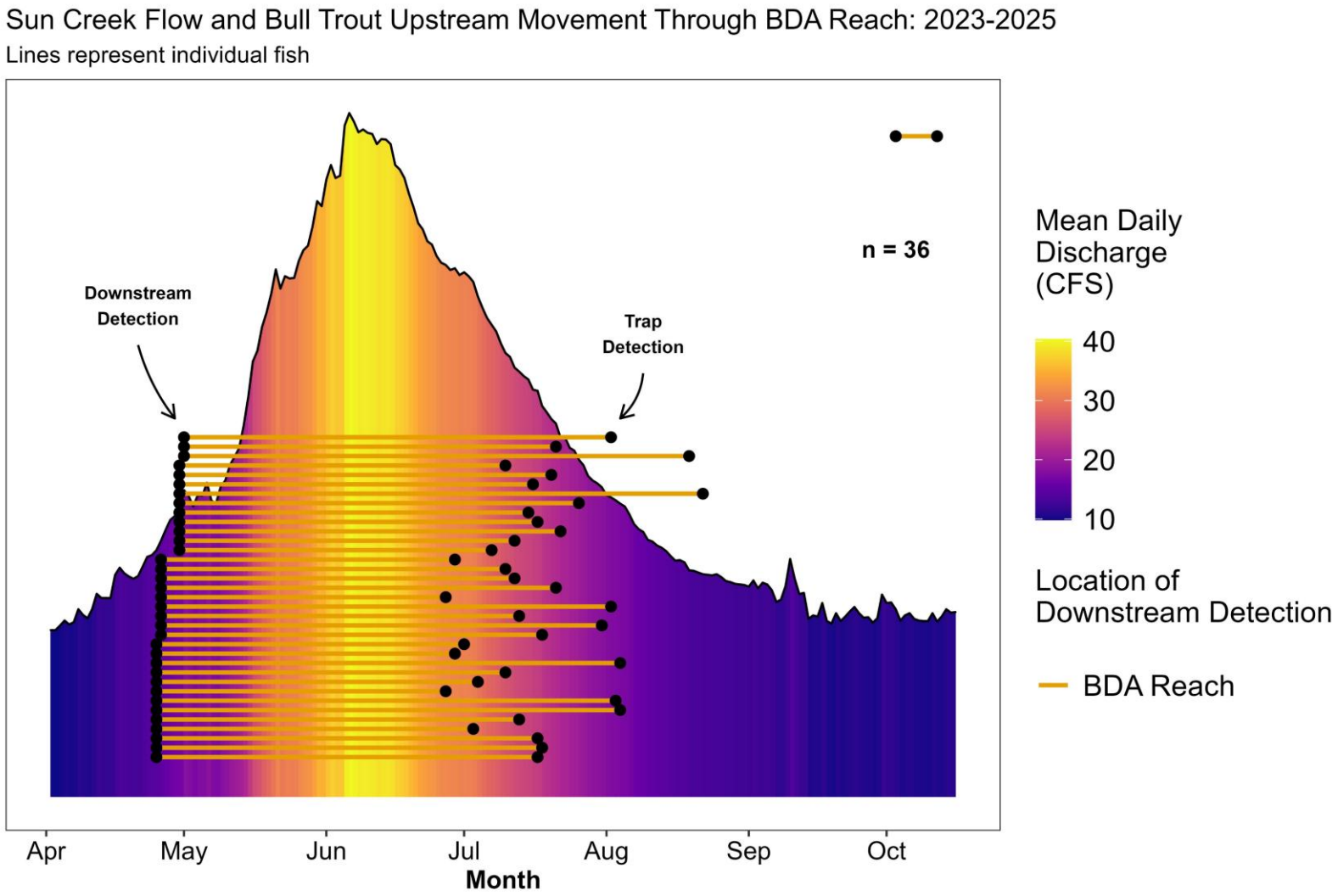

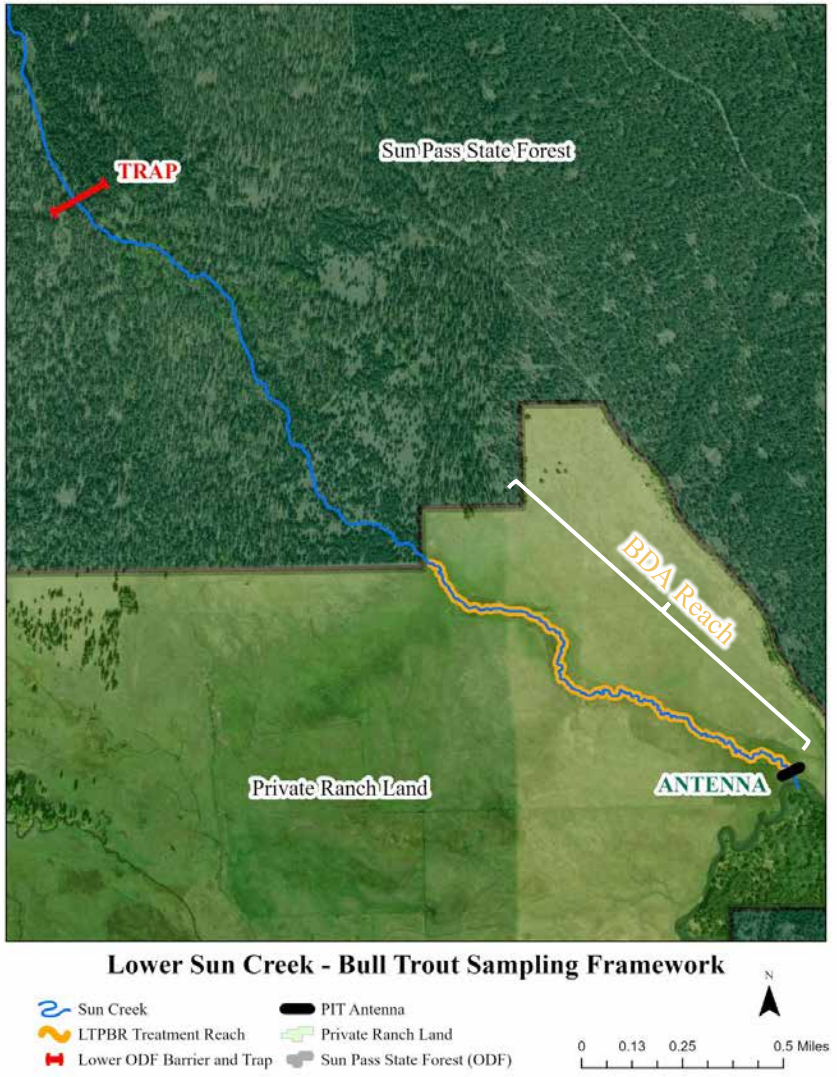

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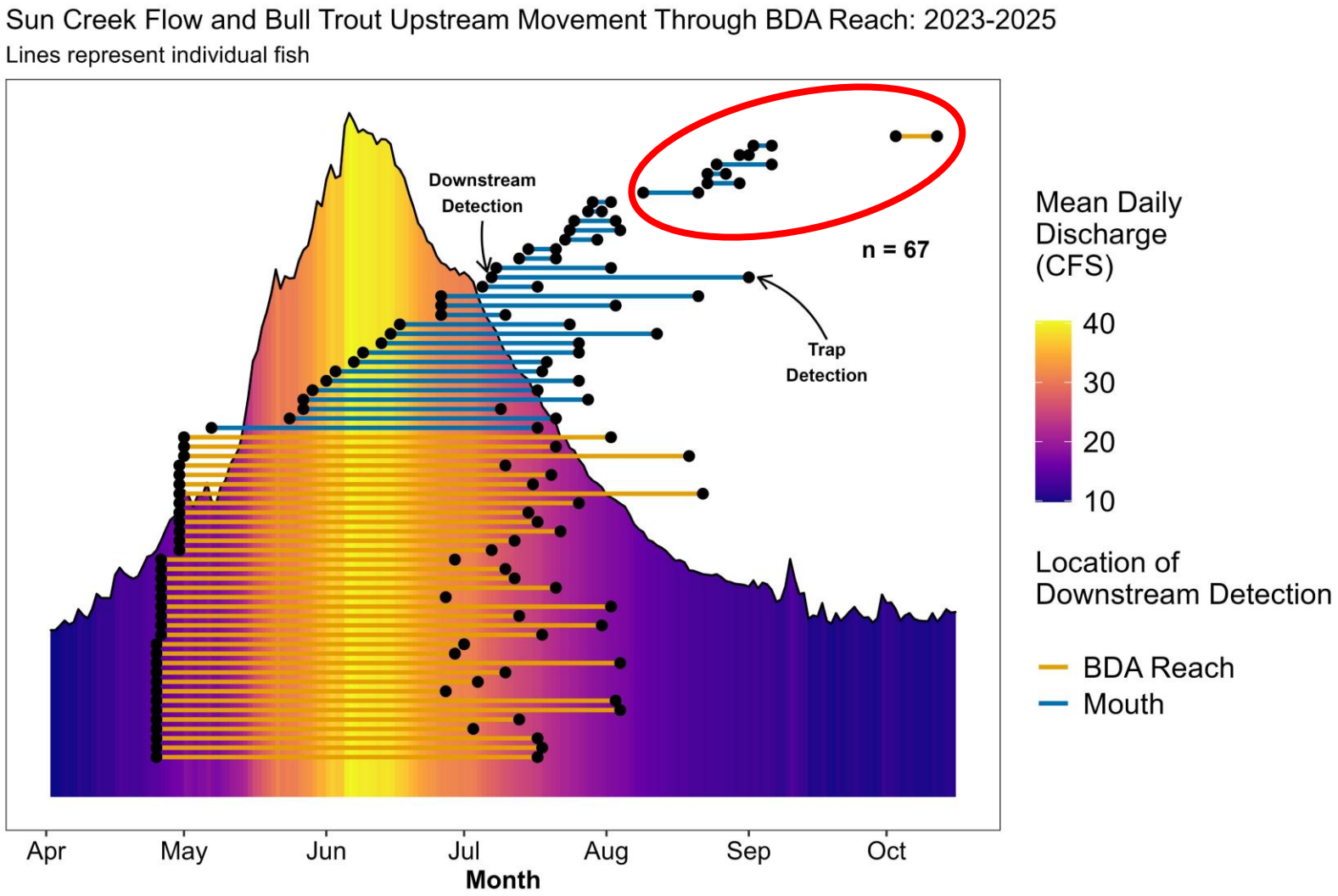
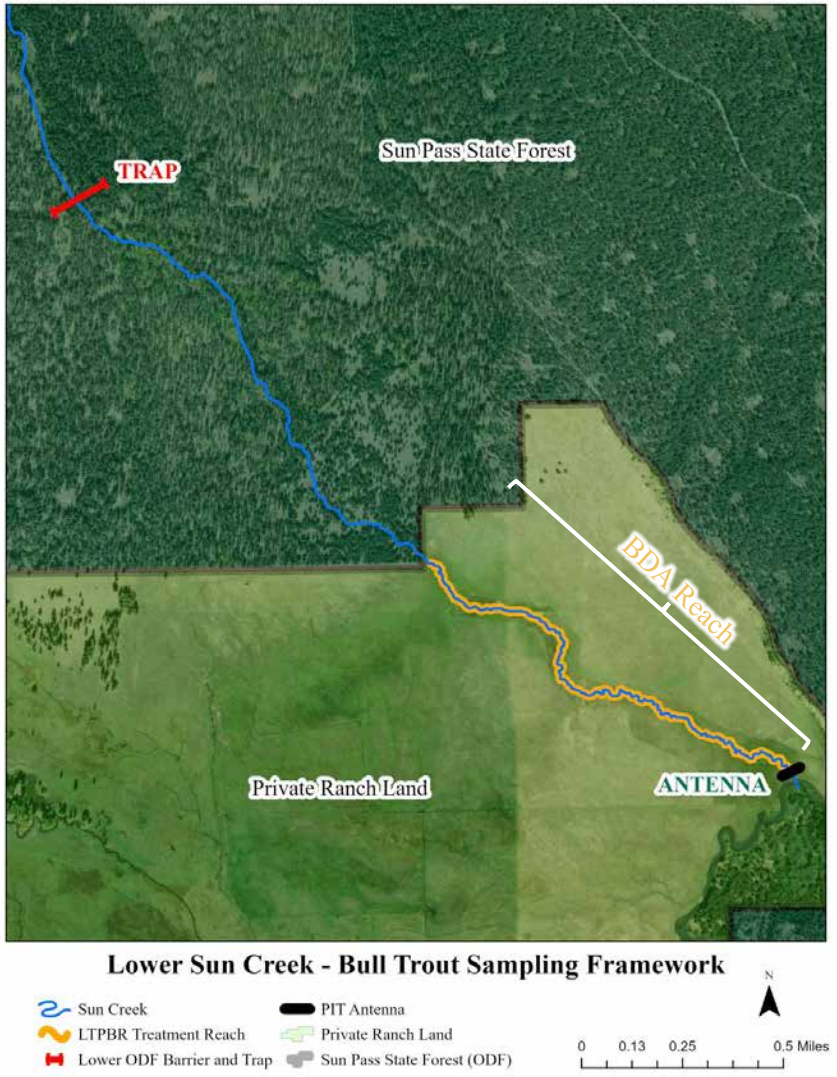
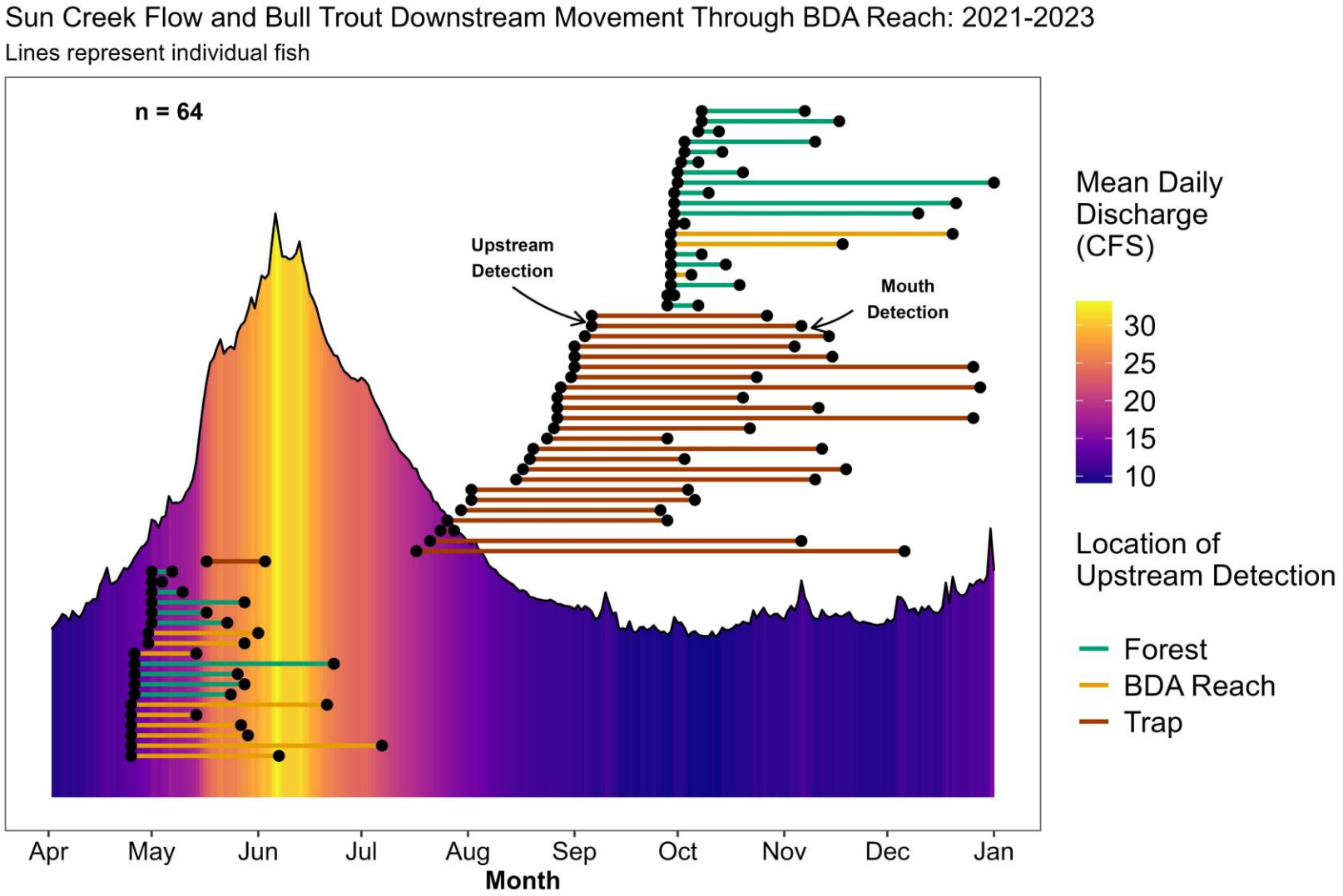
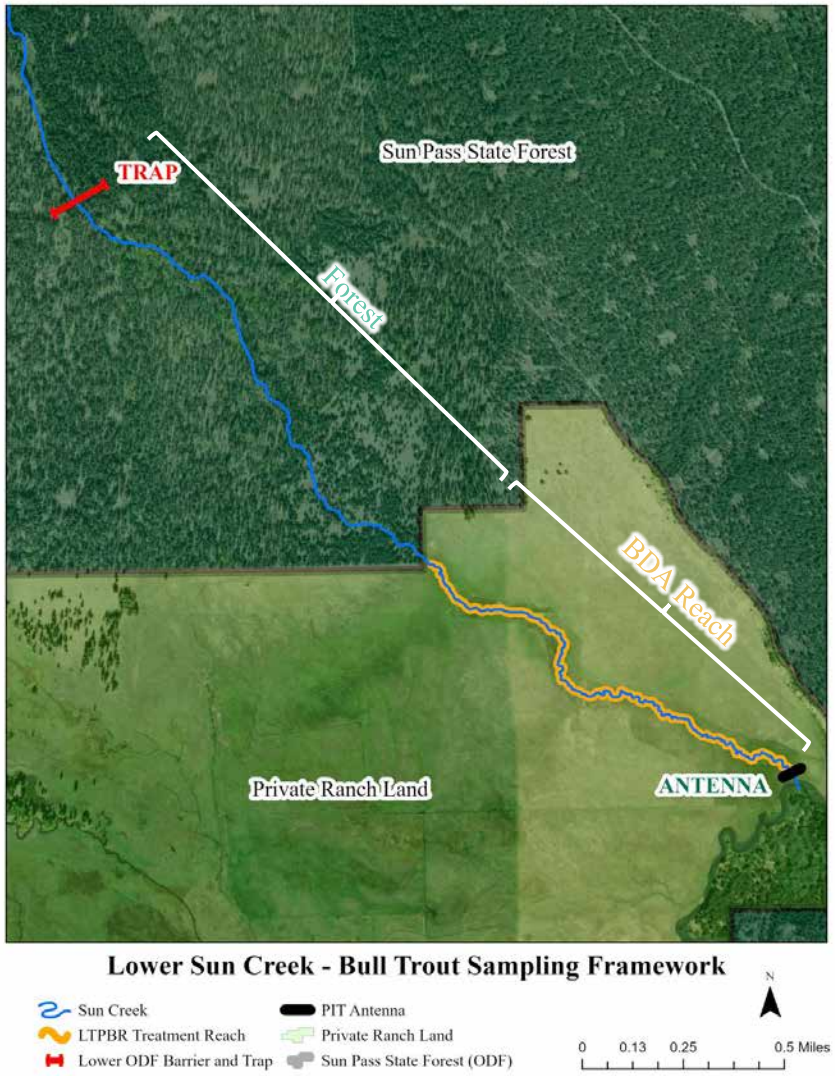




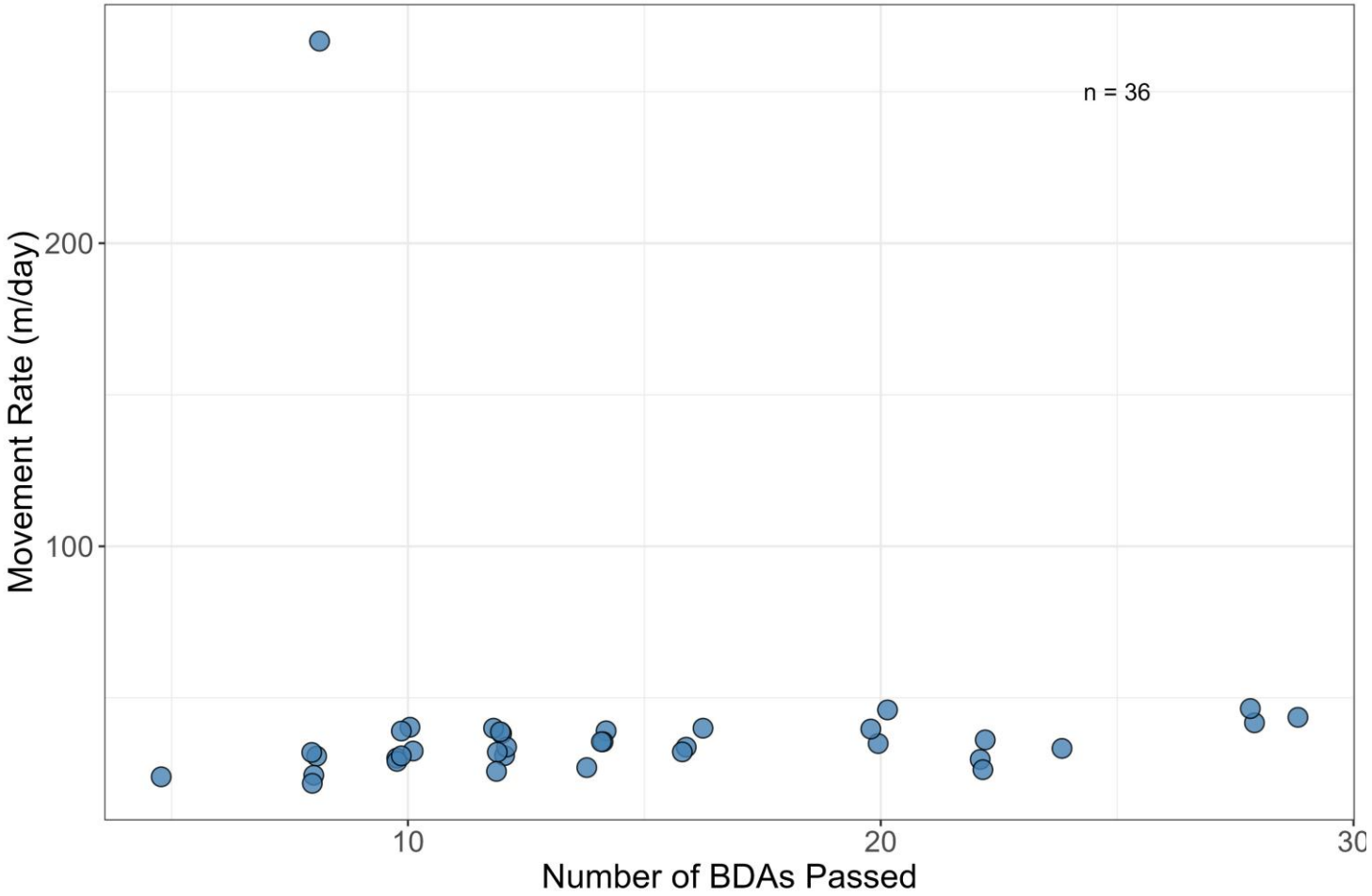
When are BLT moving downstream through the BDA reach?

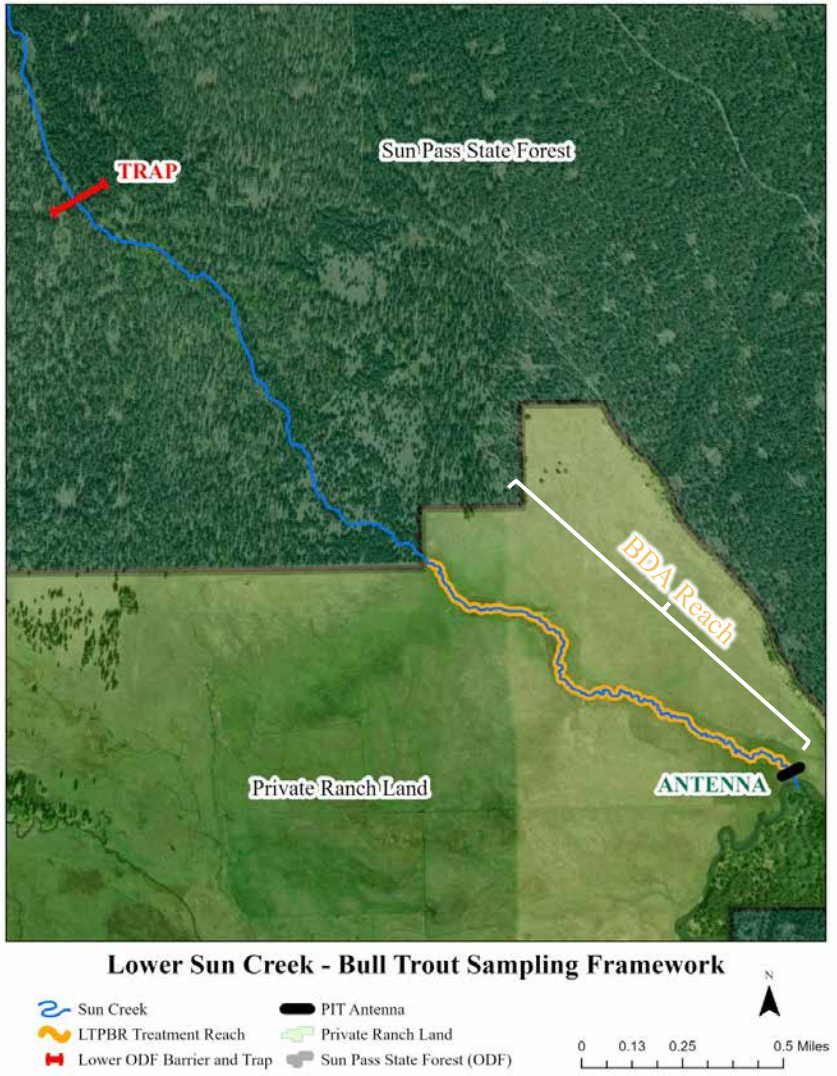




Does the number of BDAs passed impact movement rate (m/day)?

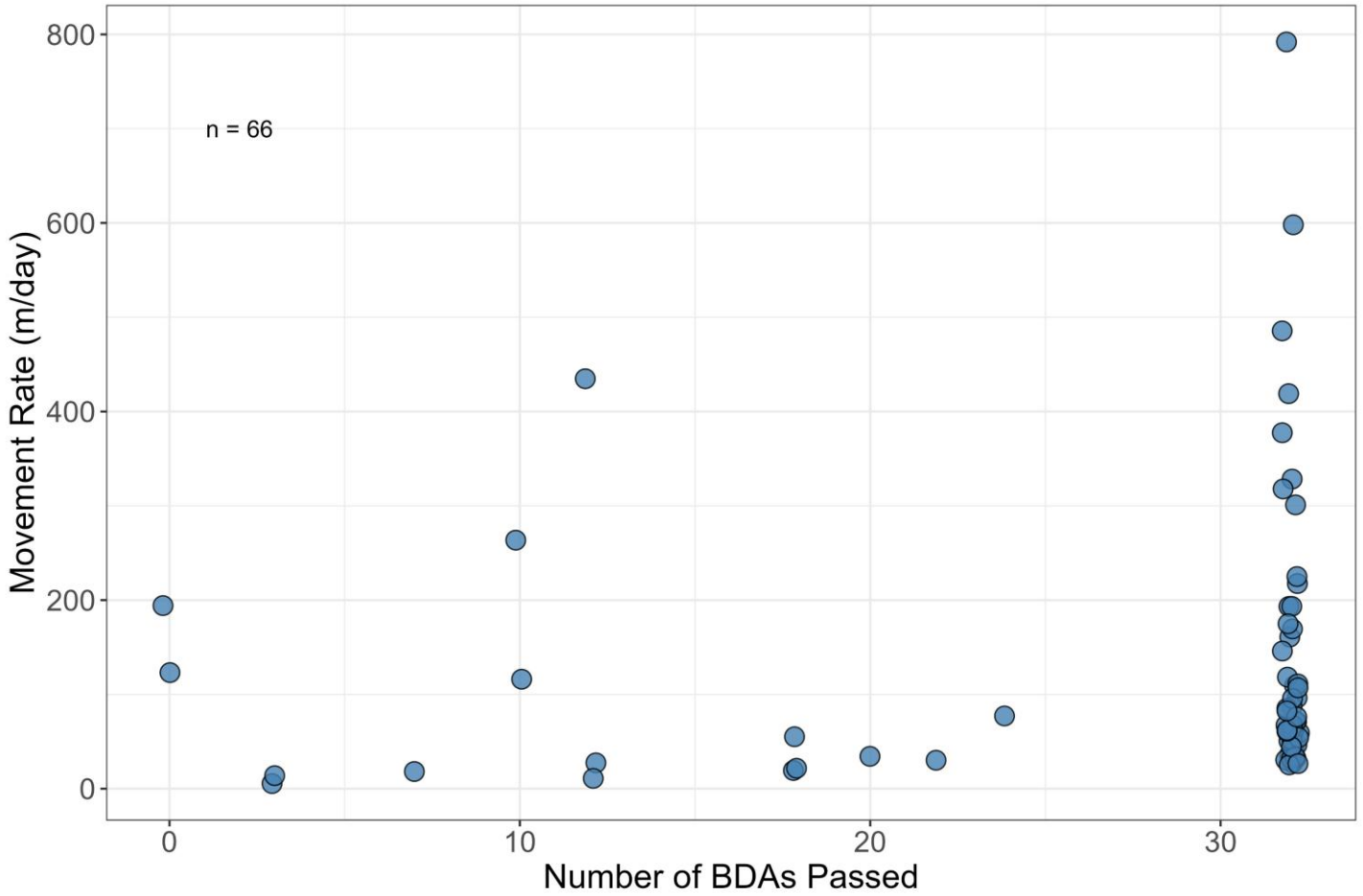
- No clear evidence that passing more BDAs slowed **upstream** movement (*only observed in 2024 and 2025)

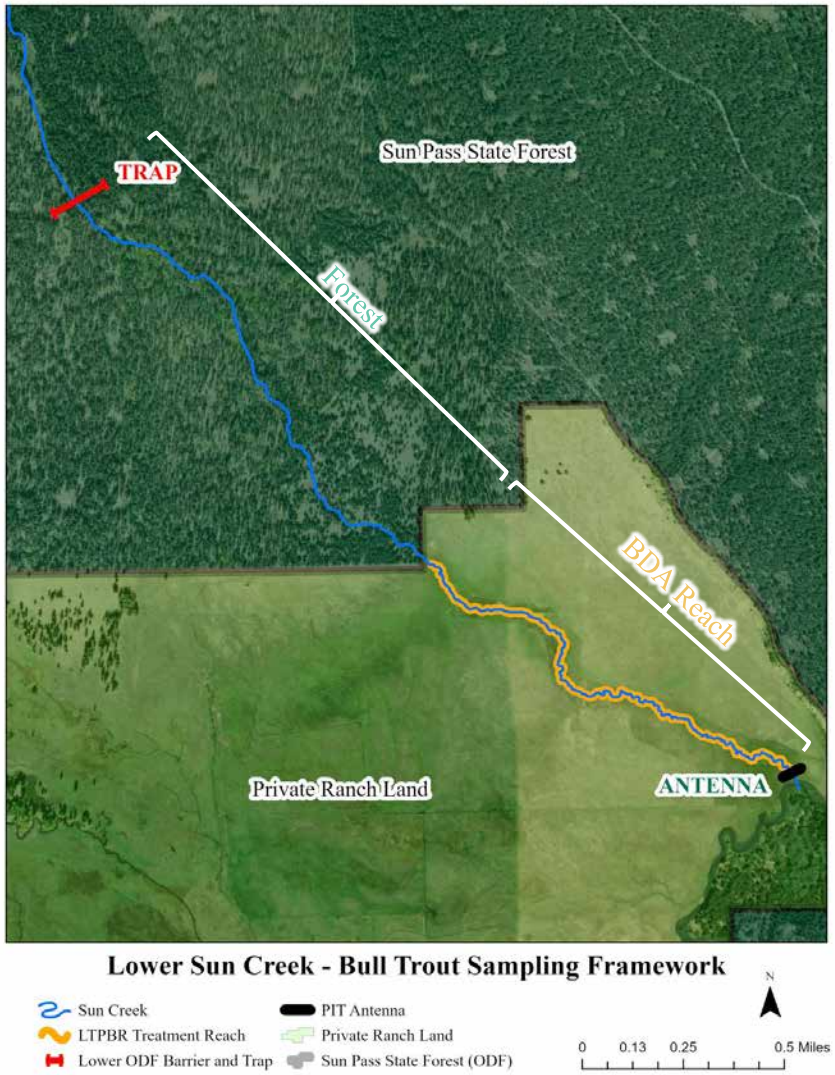




Does the number of BDAs passed impact movement rate (m/day)?

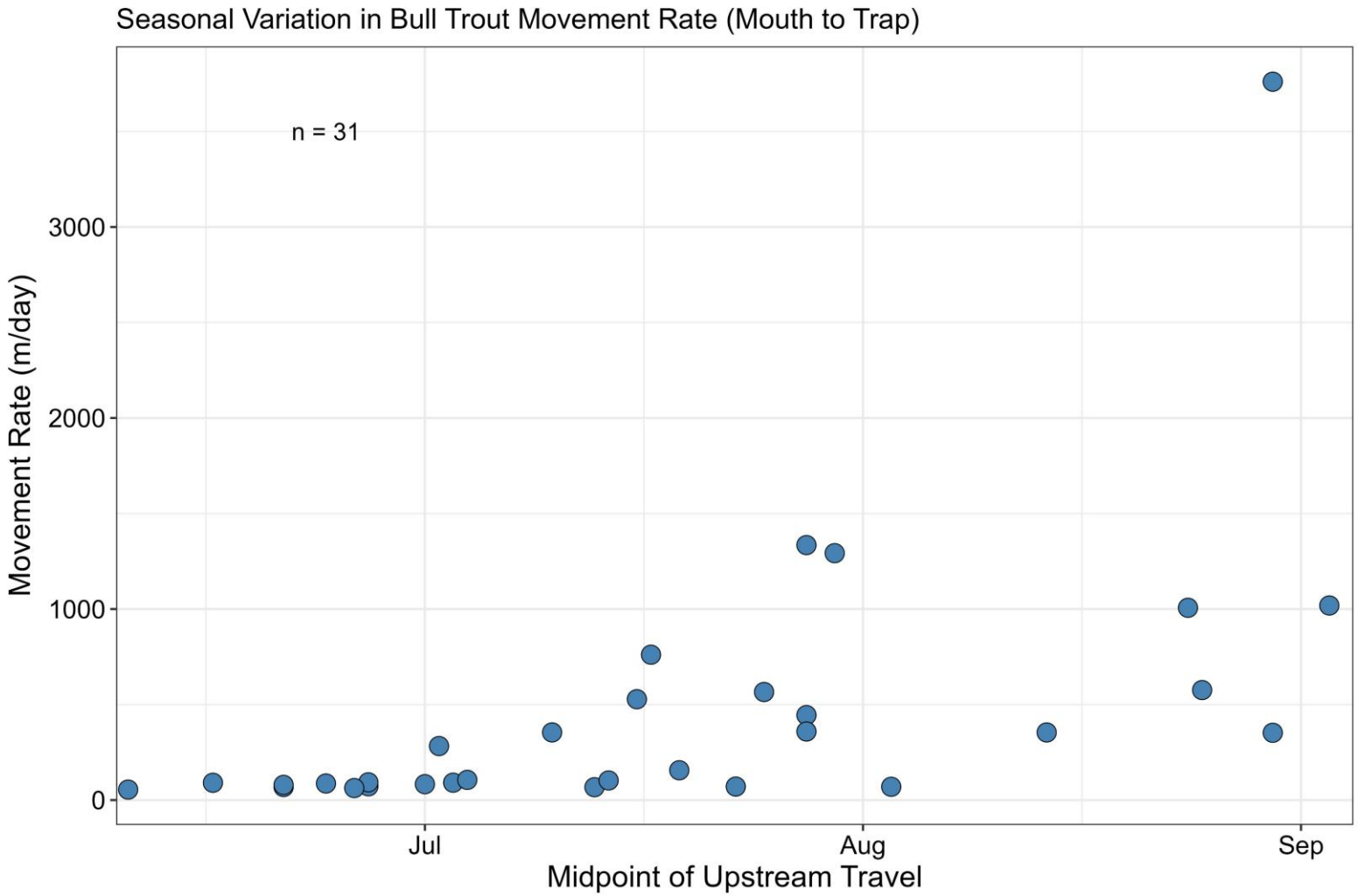
- No clear evidence that passing more BDAs slowed **downstream** movement (*observed in 2021-2025)

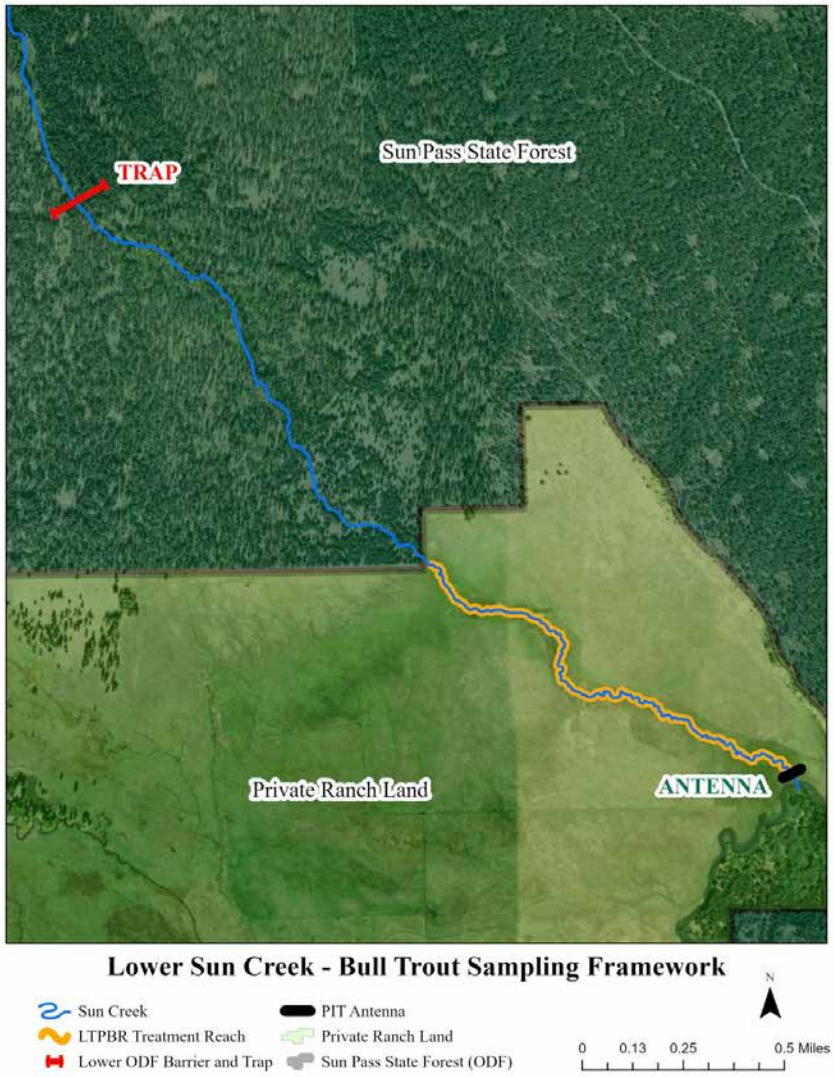




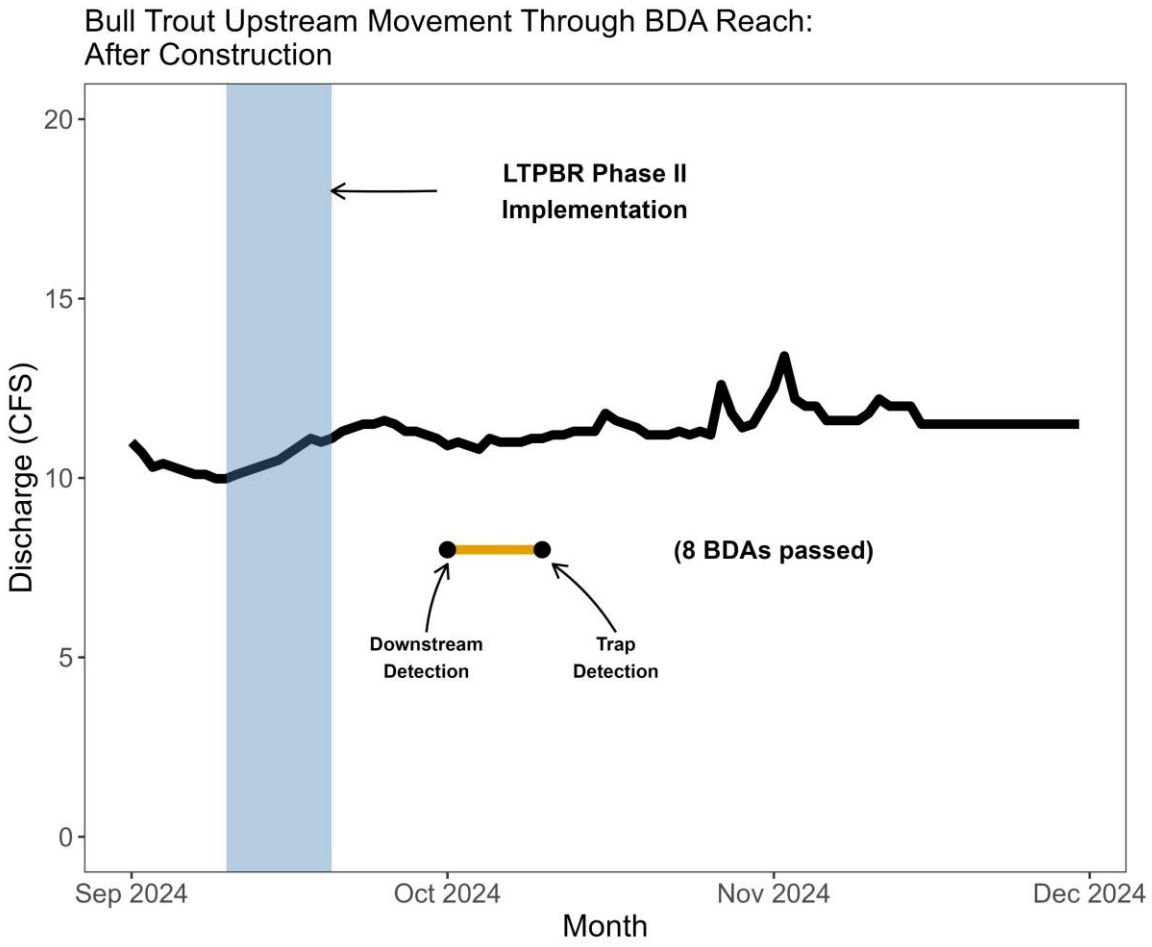
Do low flows slow movement rates?

- Low flows do not slow **upstream** movement rate through BDA reach





Can fish move during low flows and immediately after implementation?



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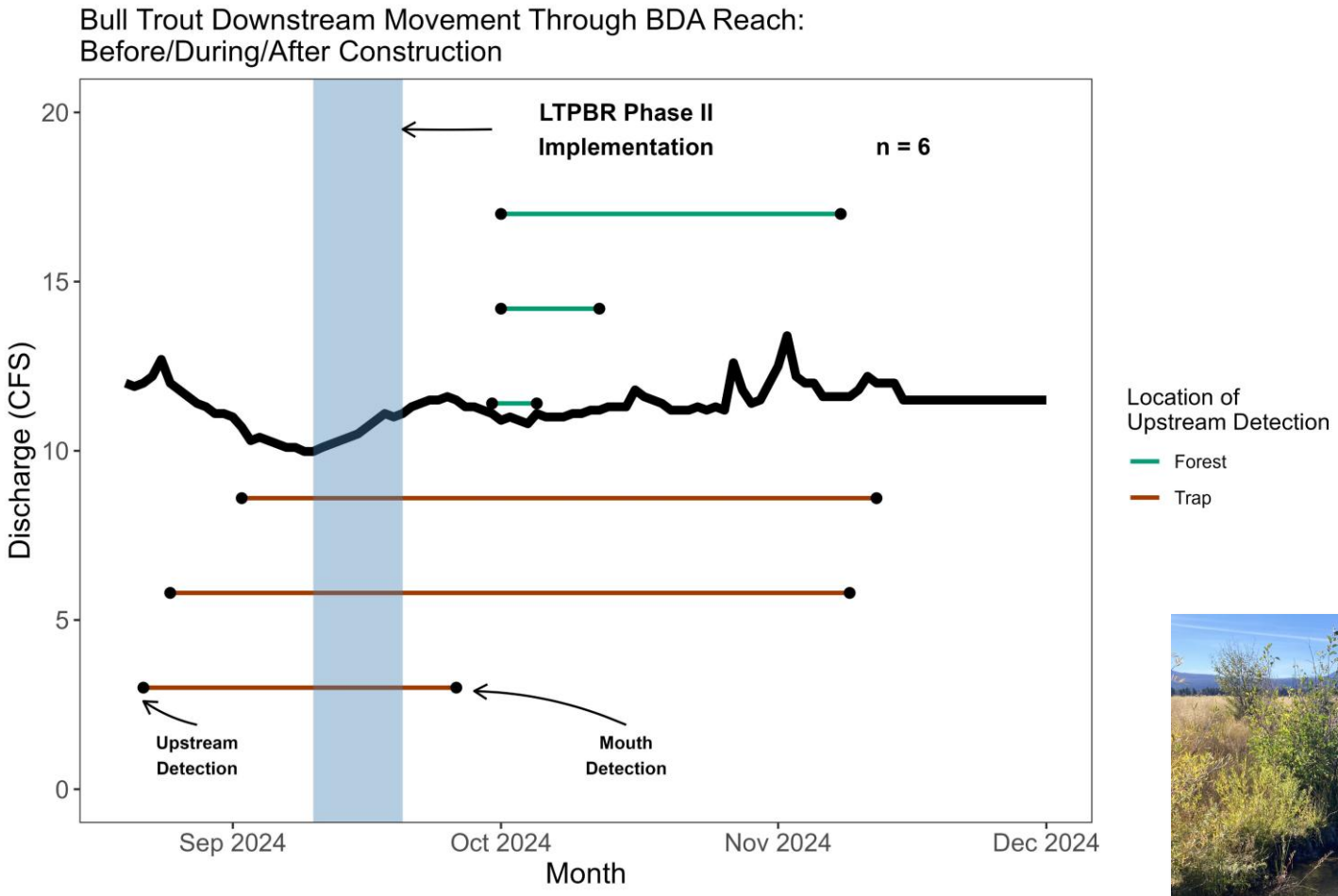
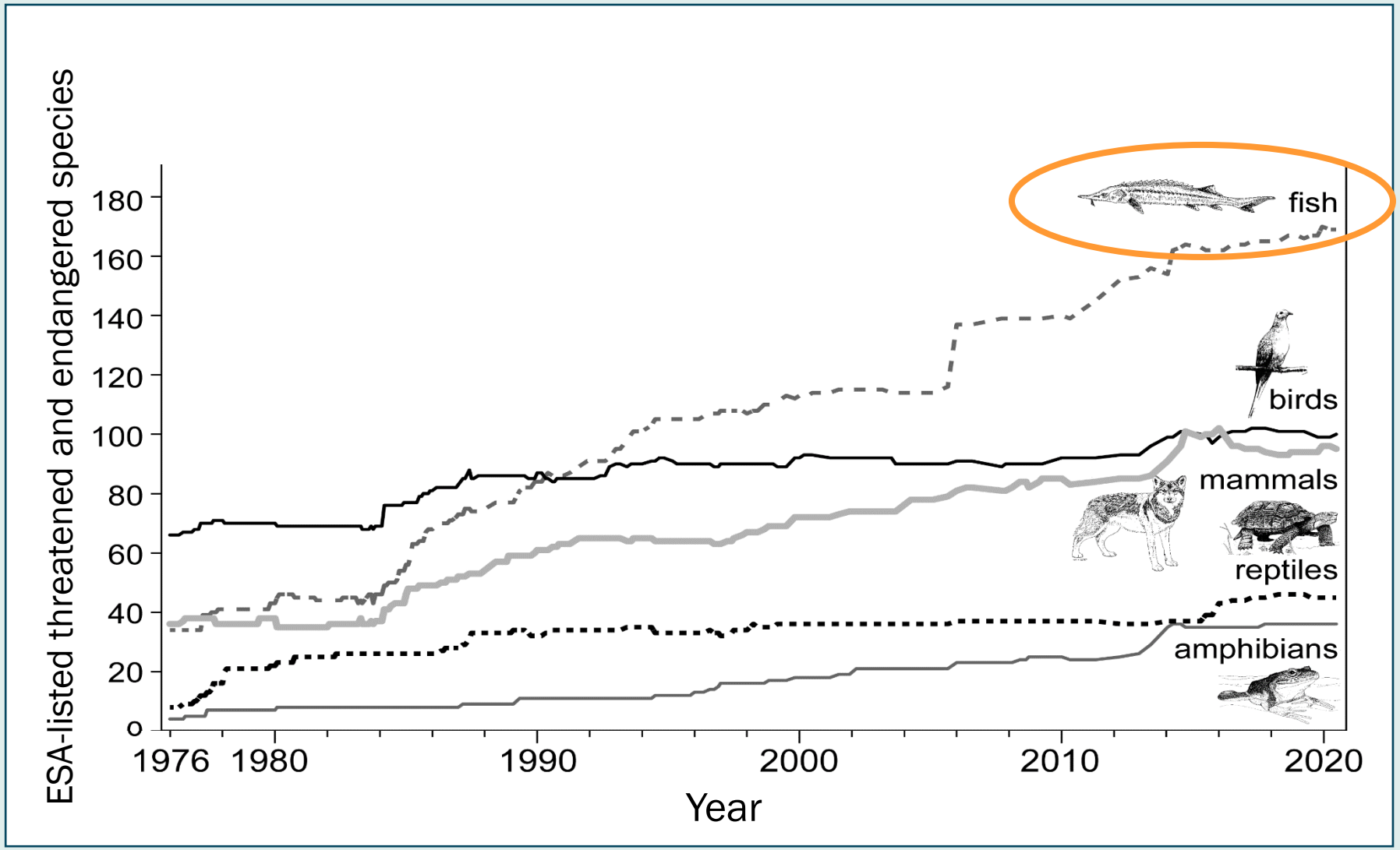


Take Homes

- BLT documented moving upstream and downstream throughout entire BDA reach in all years post-builds
- BLT passed BDAs in all flow conditions
- No clear evidence that passing more BDAs slowed movement
- Low flows did not slow movement rates
- BLT documented moving upstream and downstream immediately after a build


Thanks!
Suzanne Husky

Across taxonomic groups, the number of species listed under the ESA is increasing over time, with few species de-listed



Flitcroft et al., 2023

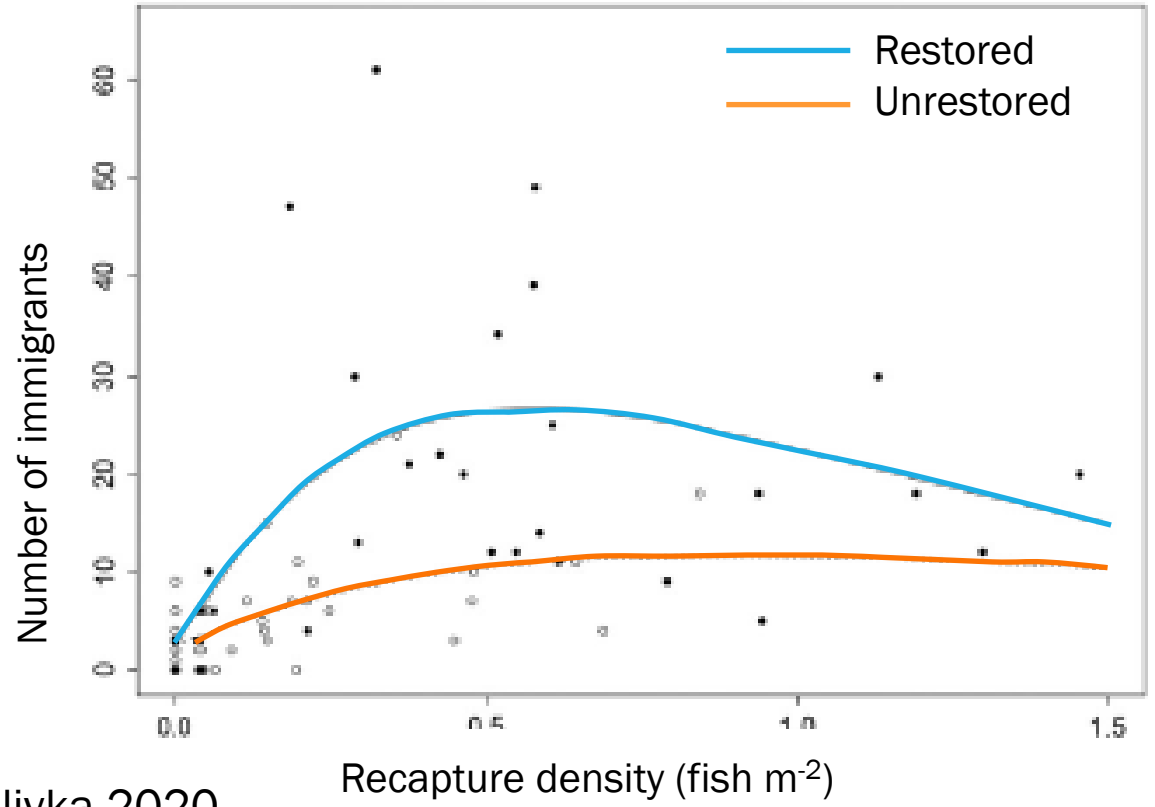
Different forms of restoration are designed for different environments, habitats, and purposes

Has restoration been effective?

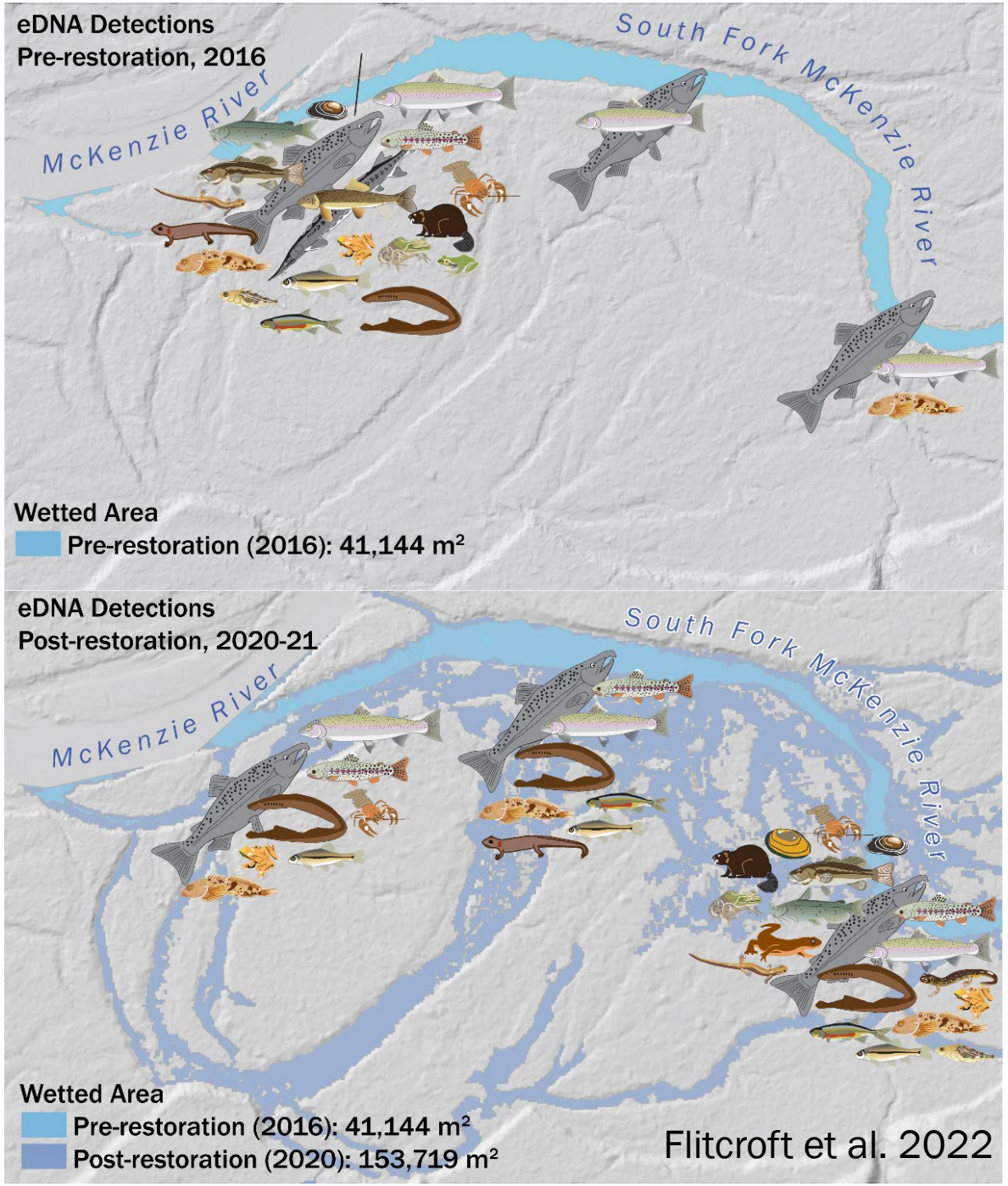
It depends.....

Juvenile Chinook response to large-river restoration (Entiat River Basin)

Young of year Chinook salmon

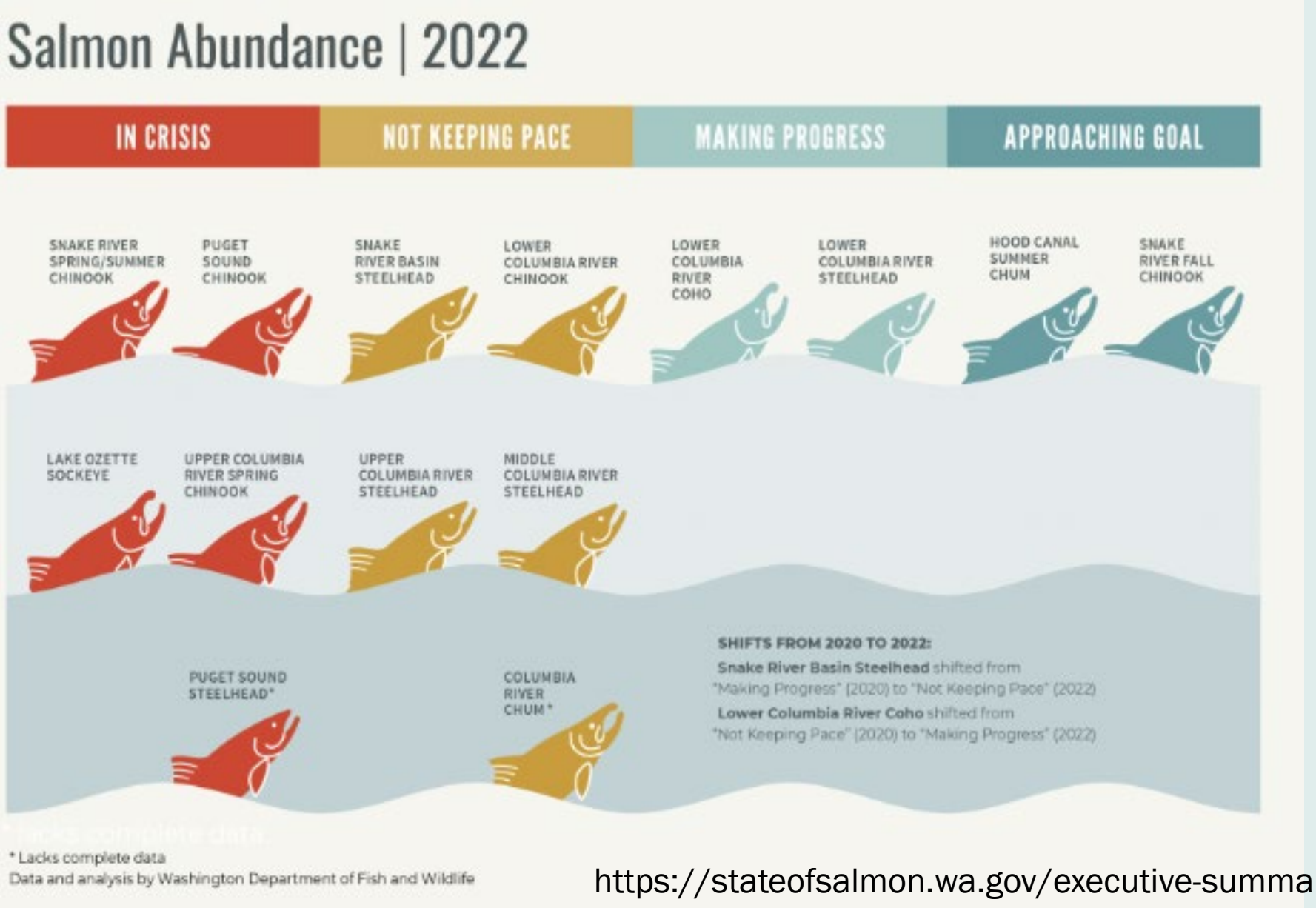


Polivka 2020



Flitcroft et al. 2022

Why then are all fish populations not recovering?



https://stateofsalmon.wa.gov/executive-summary/salmon-status/

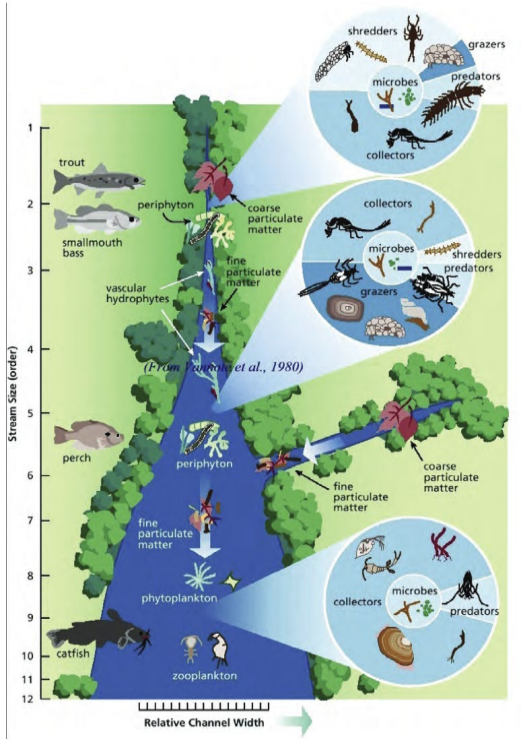
What ELSE might we consider?

- Are connectivity and variability inextricably linked?
- Has the current modified configuration of rivers affected how we “see” freshwater dynamism?
- How can restoration enhance the capacity of freshwater systems to support diverse habitats?

What ELSE might we consider?

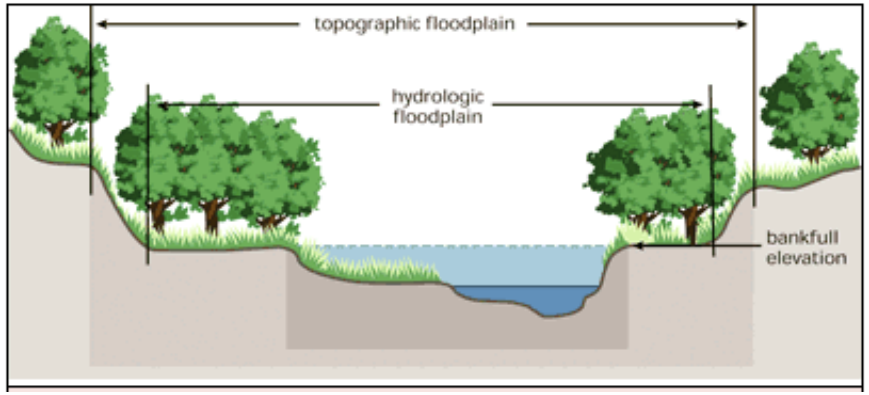
- **Are connectivity and variability inextricably linked?**
- Has the current modified configuration of rivers affected how we “see” freshwater dynamism?
- How can restoration enhance the capacity of freshwater systems to support diverse habitats?

Freshwater connectivity



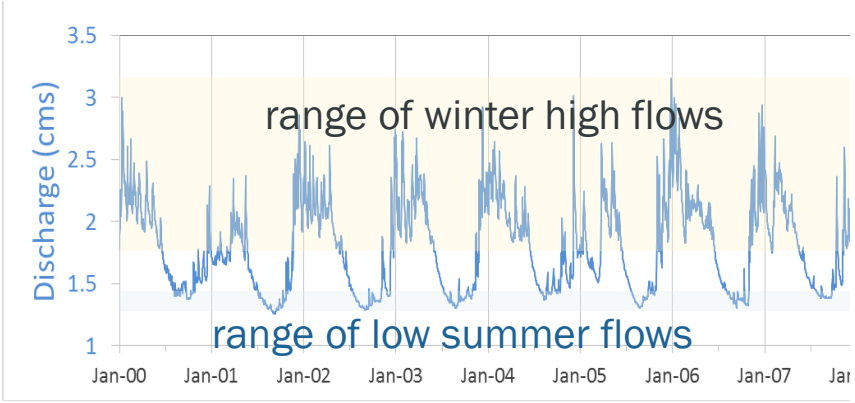
Vannote et al. 1980; graphic adapted by Peters et al., 2011

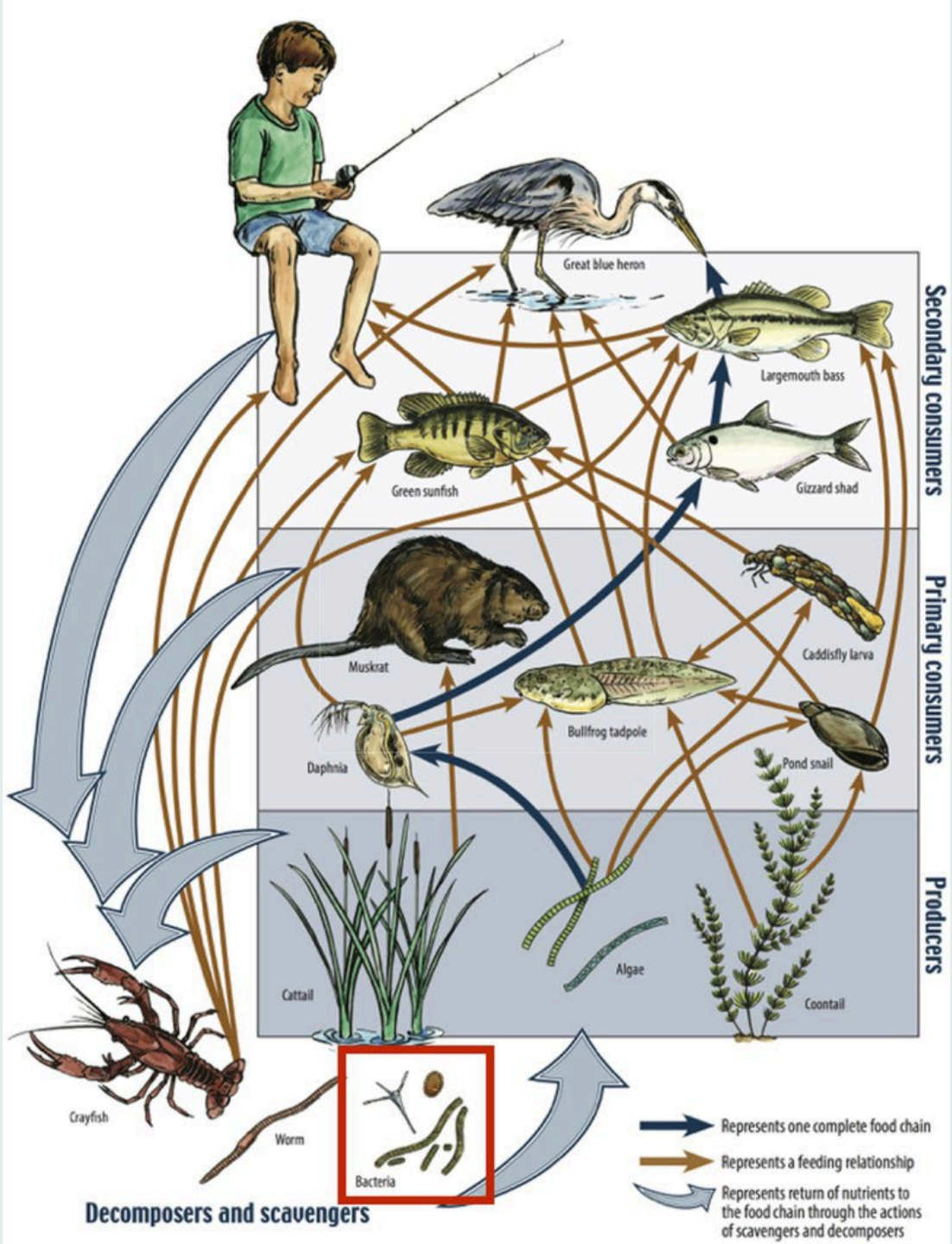
- Longitudinal – linear connectivity
- Lateral – floodplain connectivity
- Vertical – hyporheic
- Temporal – seasonal, multi-year, etc.



EPA – Watershed Academy

Karen Jackson 2021, Clemson University

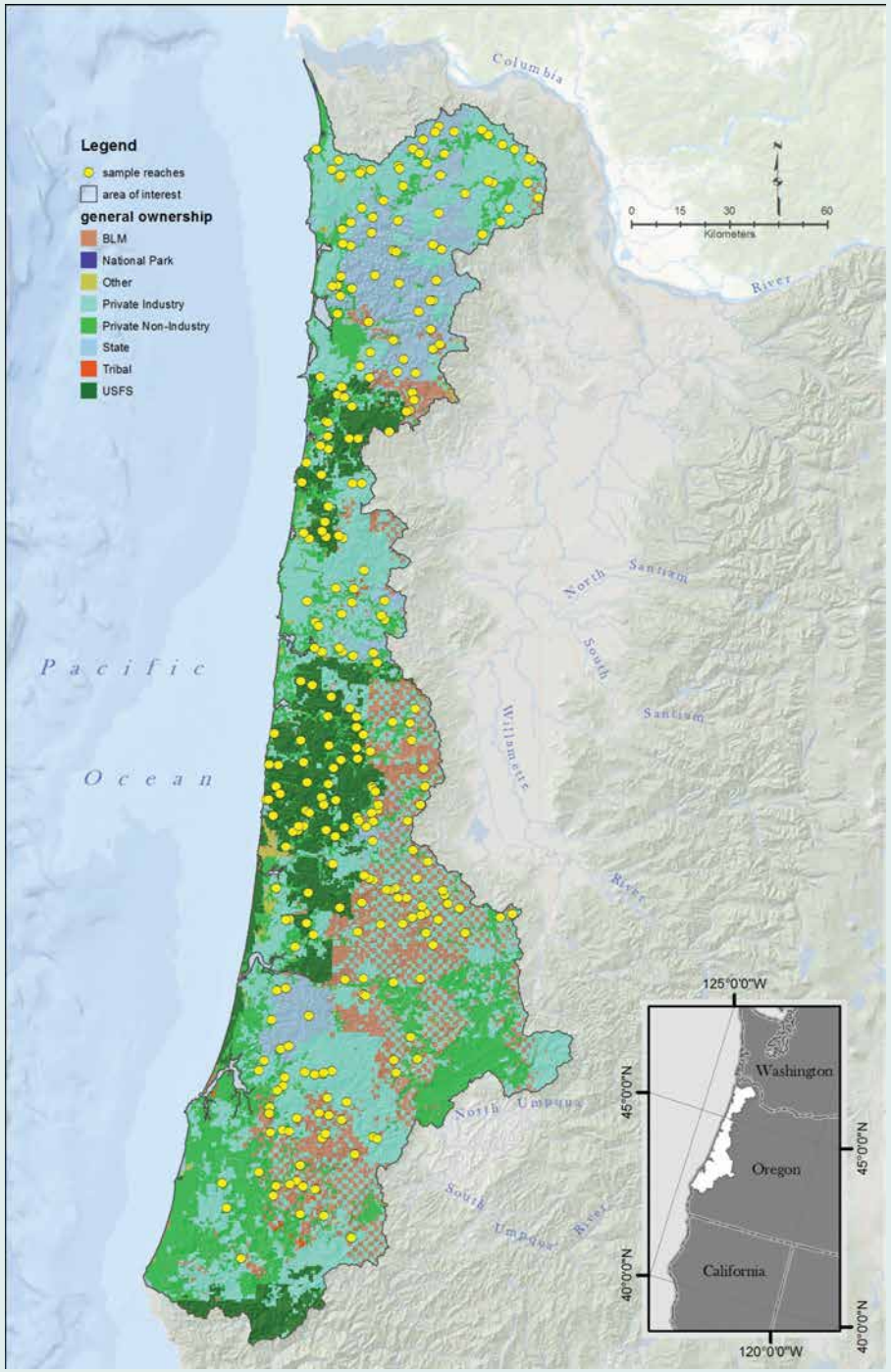


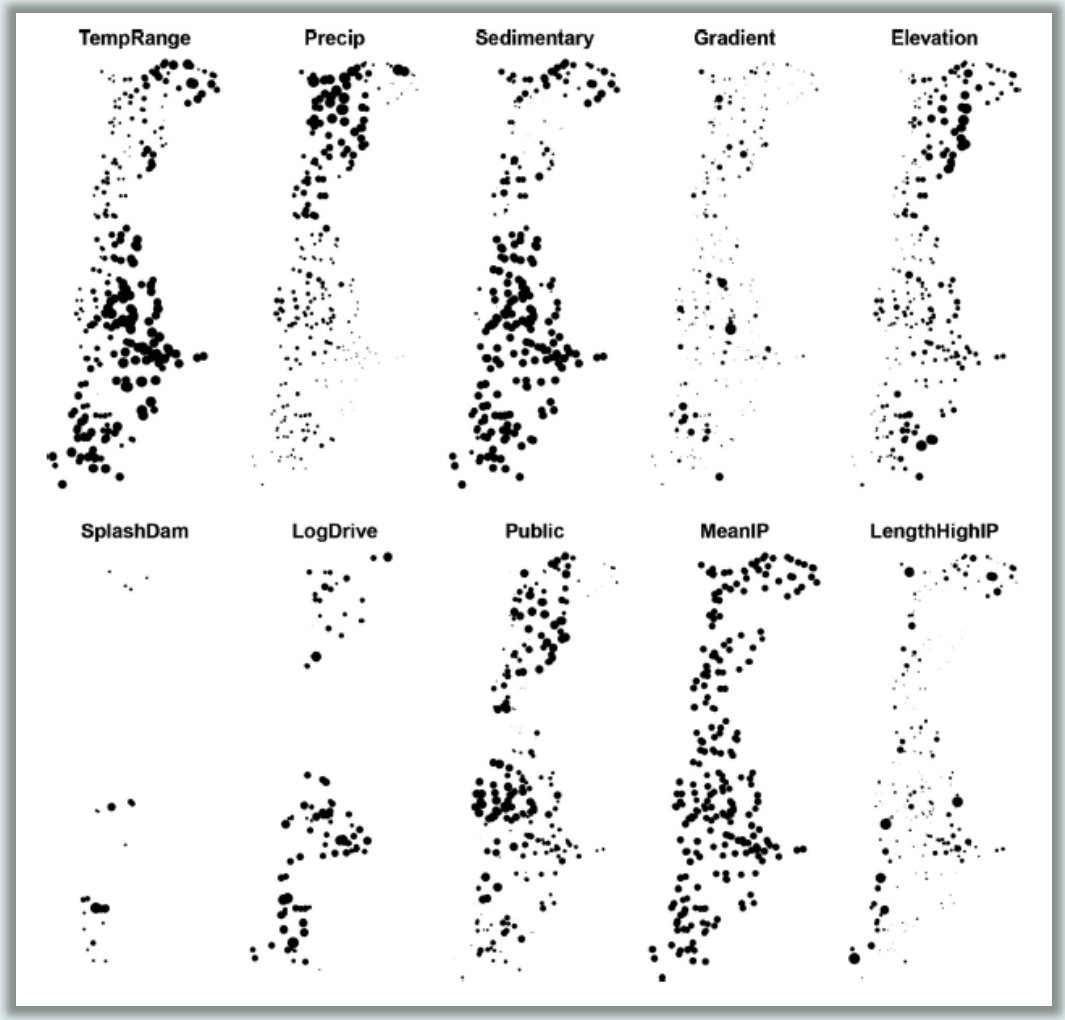


Complexity in nutrient pathways is reflected by food webs that can measure species richness as well as food-web stability (connectedness) and complexity

Image courtesy of Wikimedia Commons

Variability reflects environmental, geophysical, and human influences.

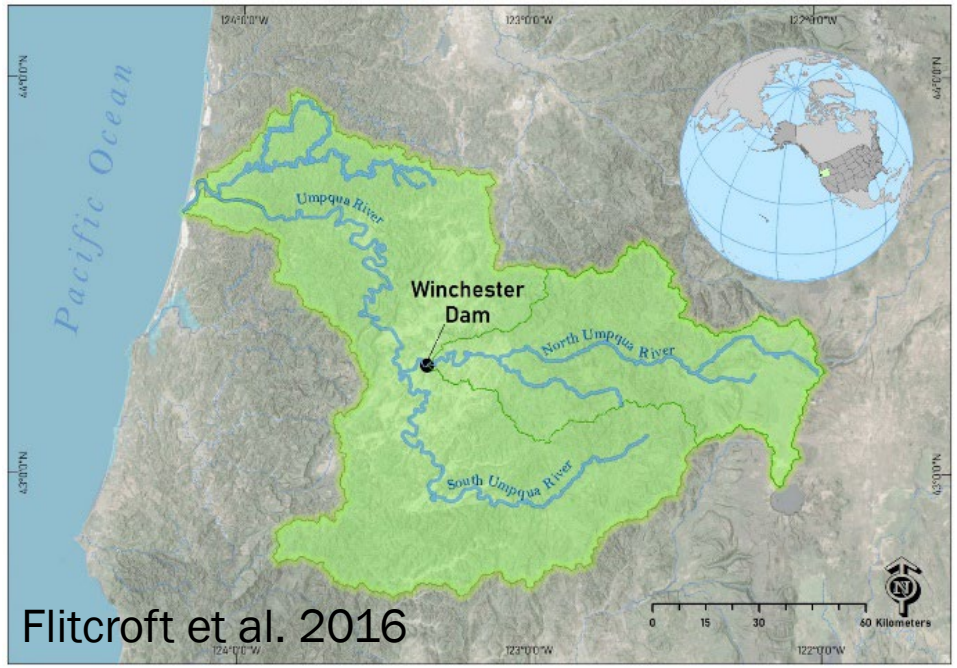




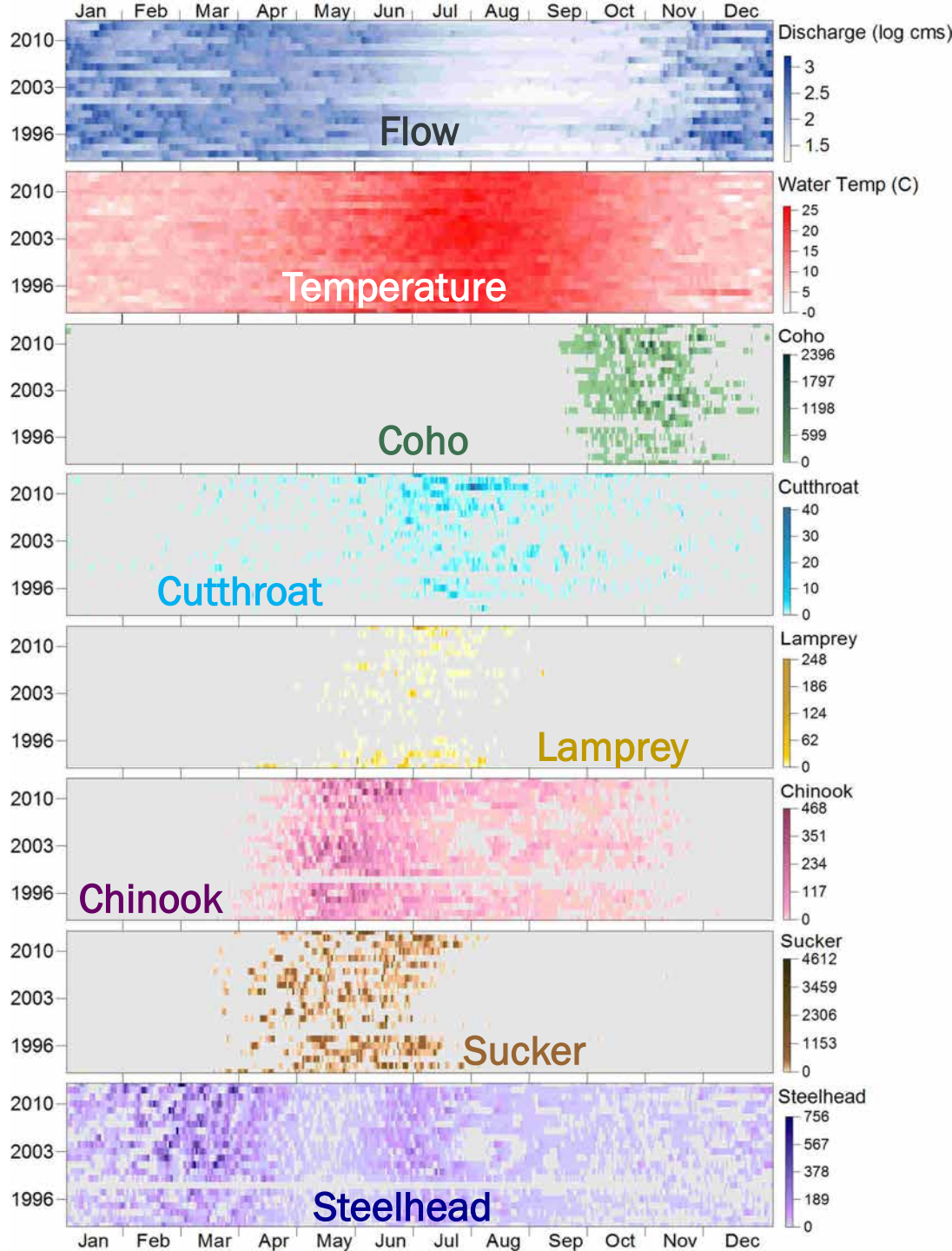
Steel et al. 2017

Native aquatic species have variable windows of adaptation to locally expressed environmental conditions

Upriver Fish Migrations
North Umpqua R, Oregon, USA
1992-2013



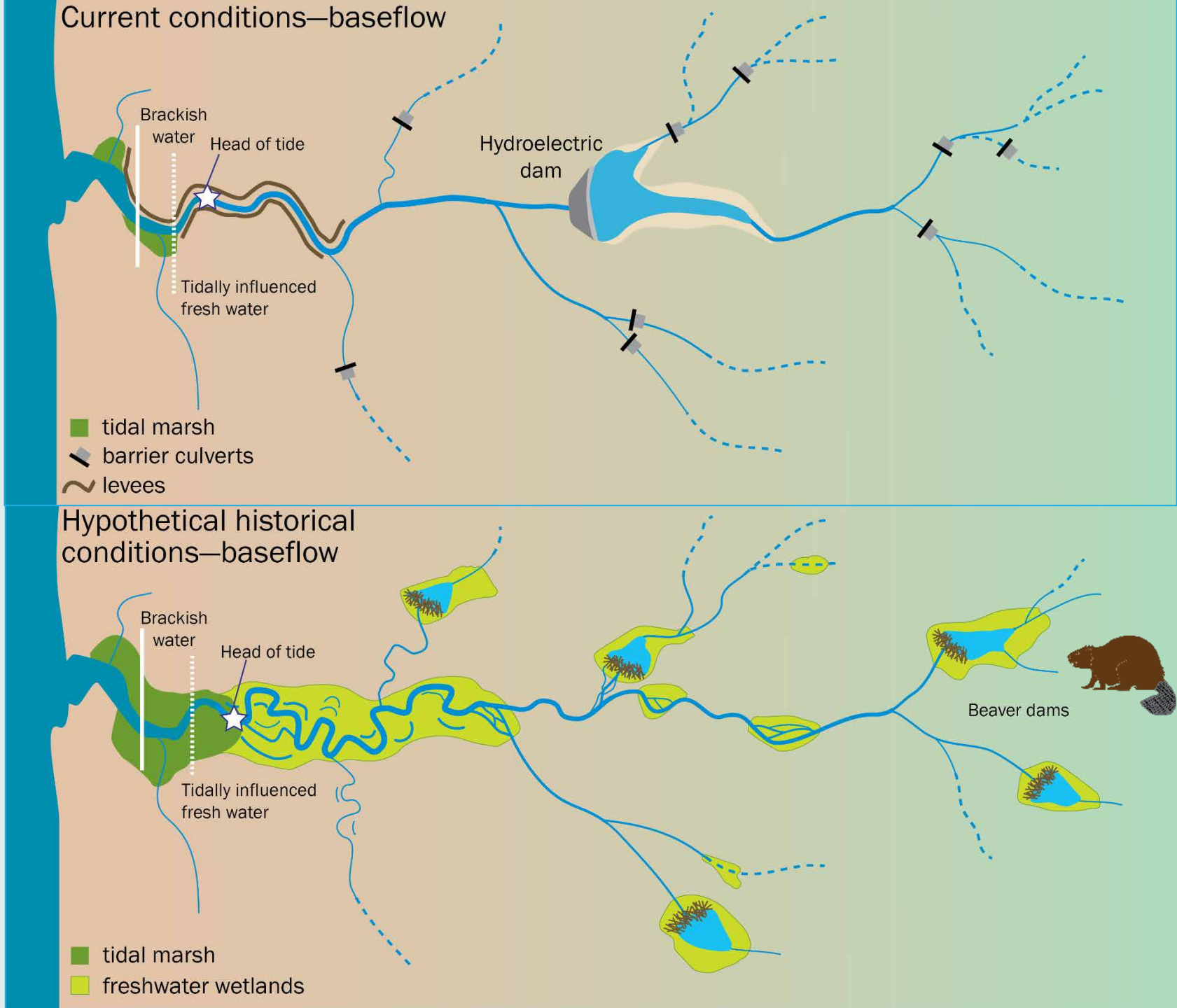
Flitcroft et al. 2016



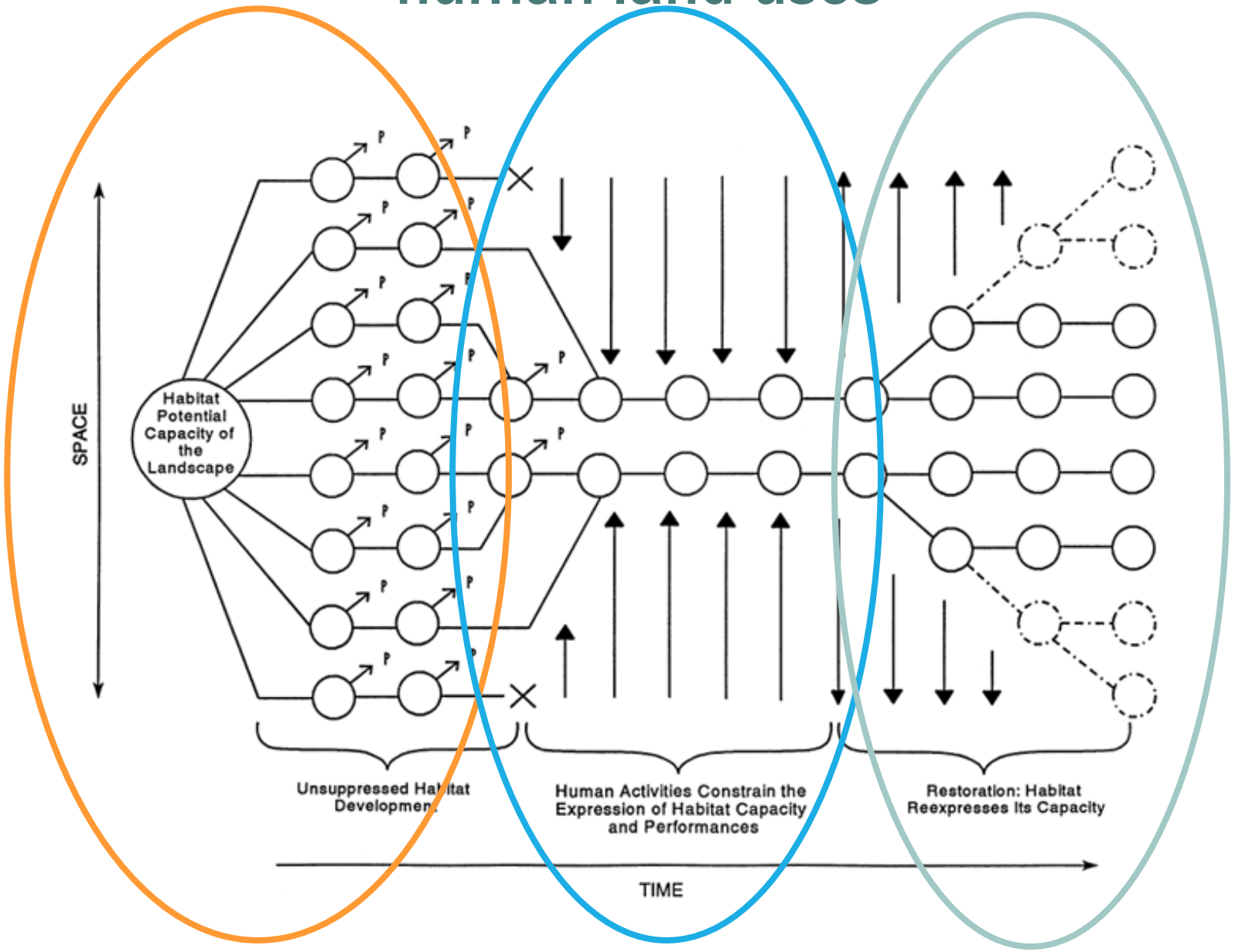
What ELSE might we consider?

- Are connectivity and variability inextricably linked?
- **Has the current modified configuration of rivers affected how we "see" freshwater dynamism?**
- How can restoration enhance the capacity of freshwater systems to support diverse habitats?

Current conditions tend be more fragmented compared with connection in historic riverscapes



Habitat capacity to support life-history diversity is constrained by human land uses

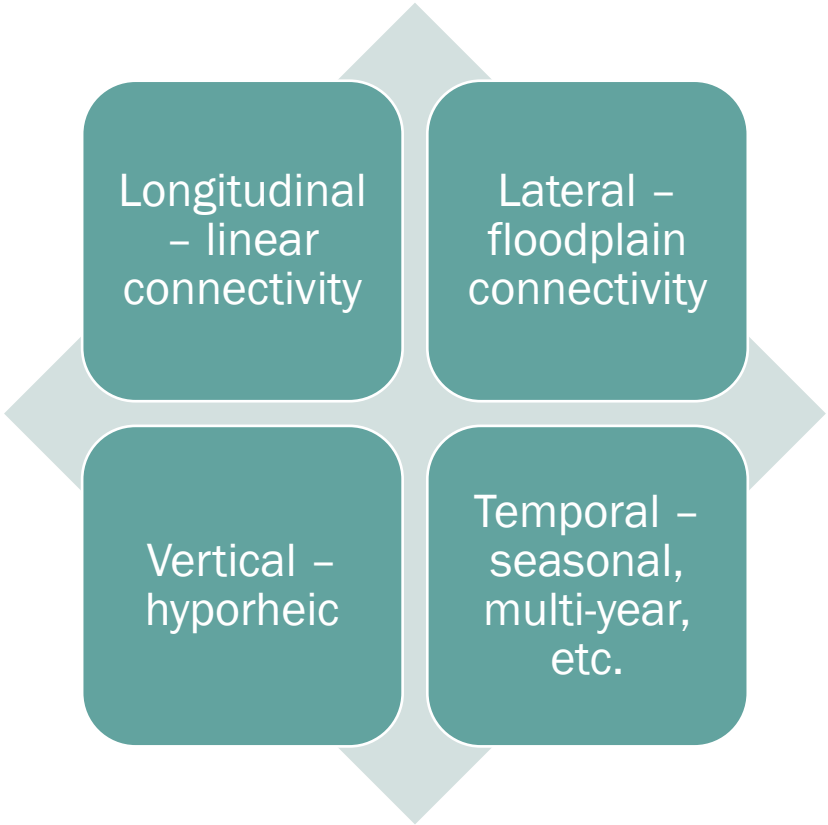


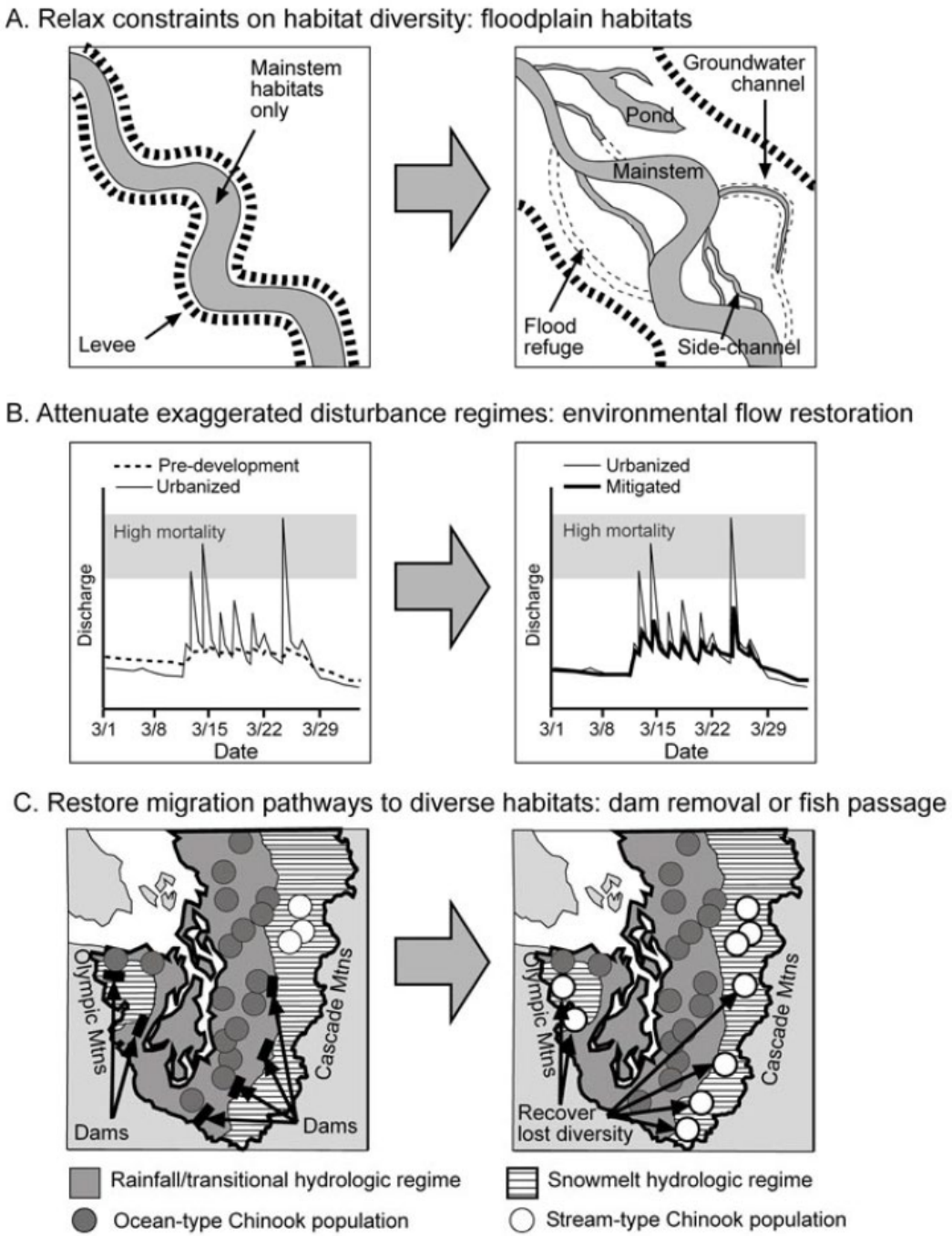
Ebersole et al. 1997

What ELSE might we consider?

- Are connectivity and variability inextricably linked?
- Has the current modified configuration of rivers affected how we “see” freshwater dynamism?
- **How can restoration enhance the capacity of freshwater systems to support diverse habitats?**

Restoration that enhances river/floodplain diversity, mimics natural cycles and targets adaptive life-history and behavior characteristics may buffer future uncertainty





Waples et al., 2009 (informed by Pess et al., 2005 and Beechie et al., 2006)

Restoration to restore floodplains may mimic natural disturbance processes

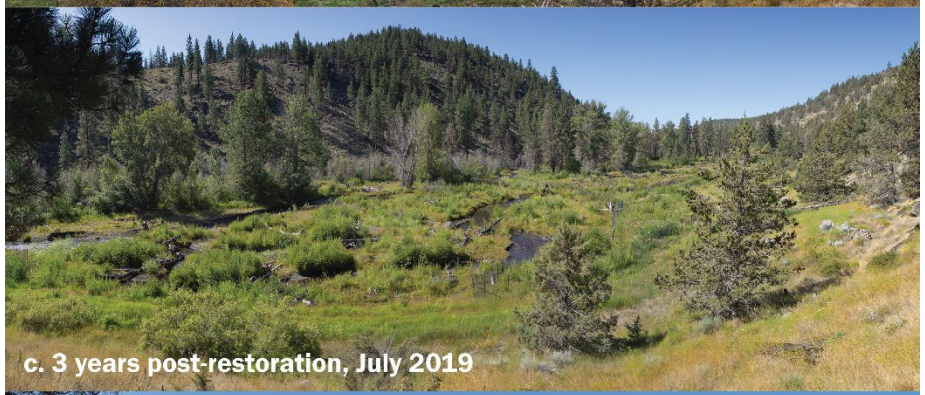
- Longitudinal – linear connectivity
- Lateral – floodplain connectivity
- Vertical – hyporheic
- Temporal – seasonal, multi-year, etc.


Deer Creek, Oregon – Floodplain re-set

Whychus Creek, Deschutes Land Trust Whychus Canyon Preserve

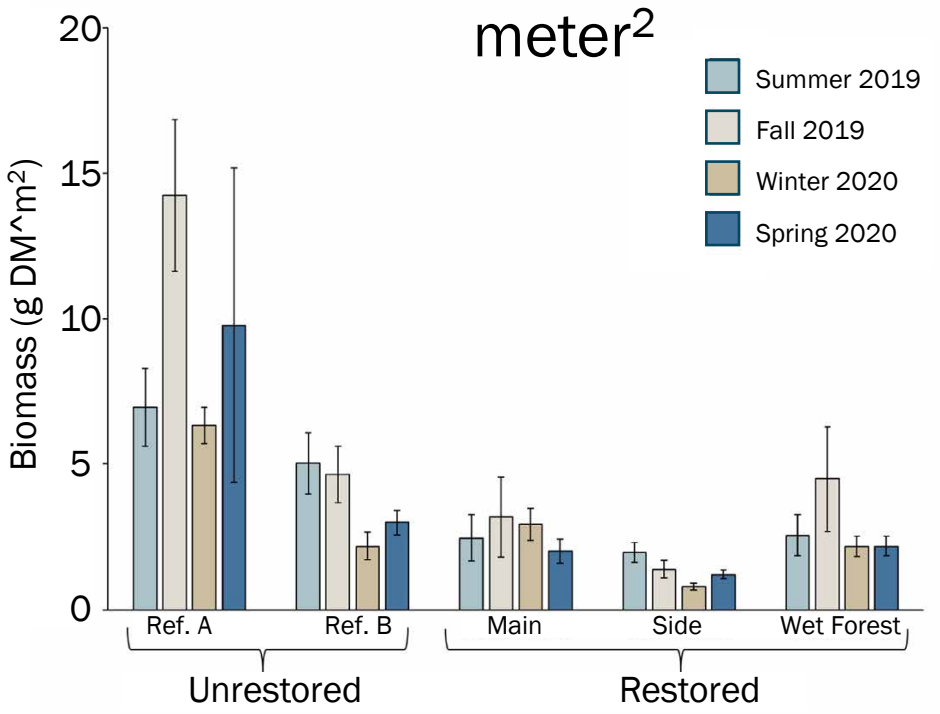

a. pre-restoration, July 2016 *Deschutes Land Trust/Jay Mather*

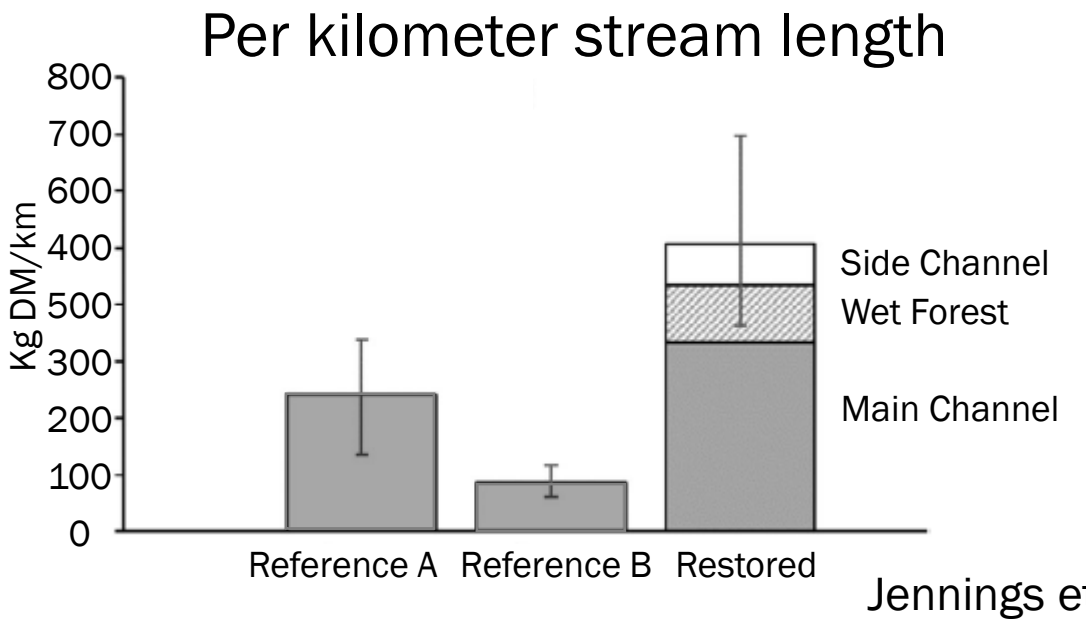

b. post-implementation, 2016


c. 3 years post-restoration, July 2019


d. 5 years post-restoration, July 2021

Biomass at fine scales (m^2) declined in the fires years post valley-floor reset restoration. However, with increased inundation, biomass was higher across the valley even in the immediate post-restoration environment

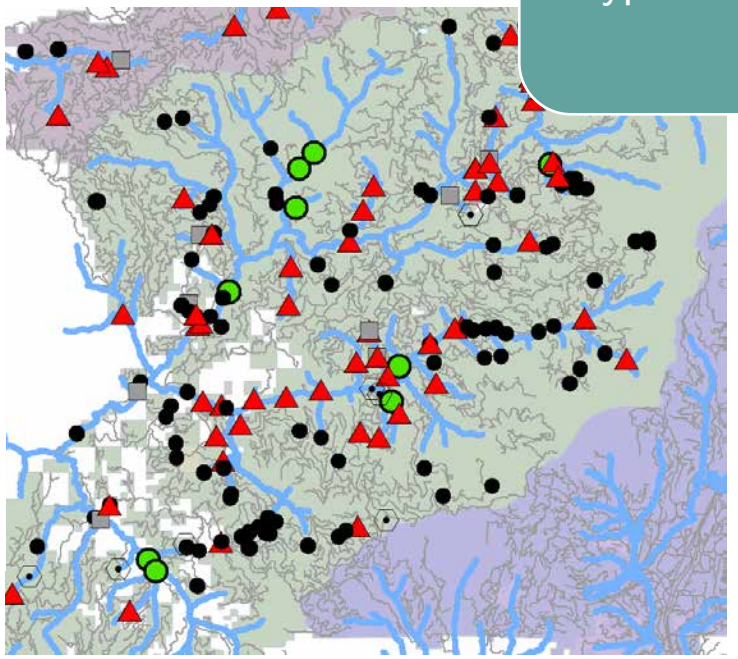




Jennings et al. 2023

Barrier culverts fragment networks, reducing the ability of native fish to express their adaptation to dynamic conditions

- Longitudinal – linear connectivity
- Lateral – floodplain connectivity
- Vertical – hyporheic
- Temporal – seasonal, multi-year, etc.

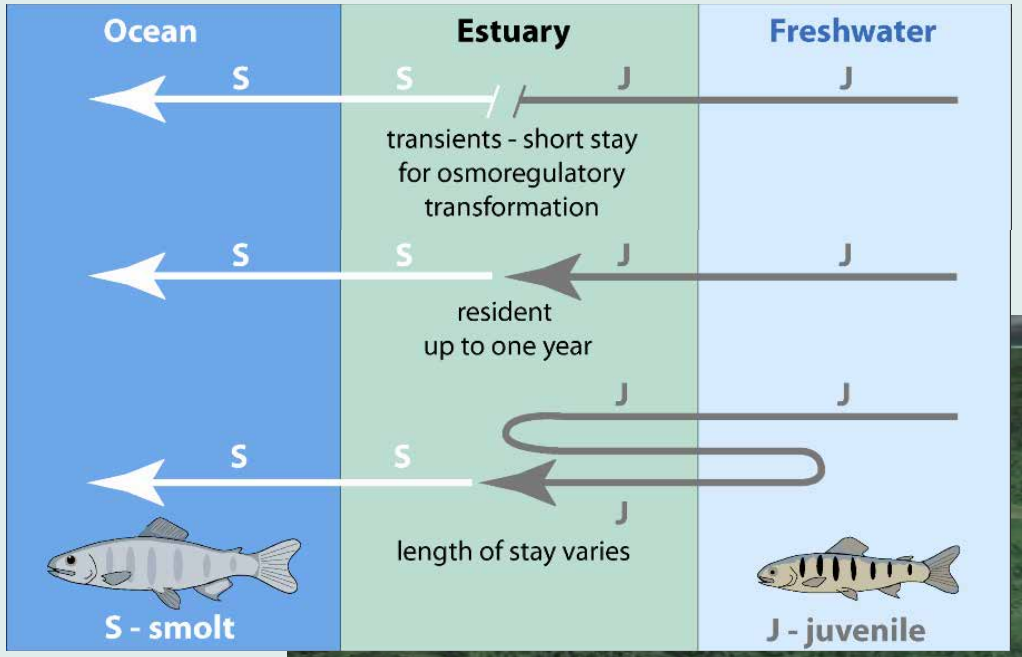


Culverts

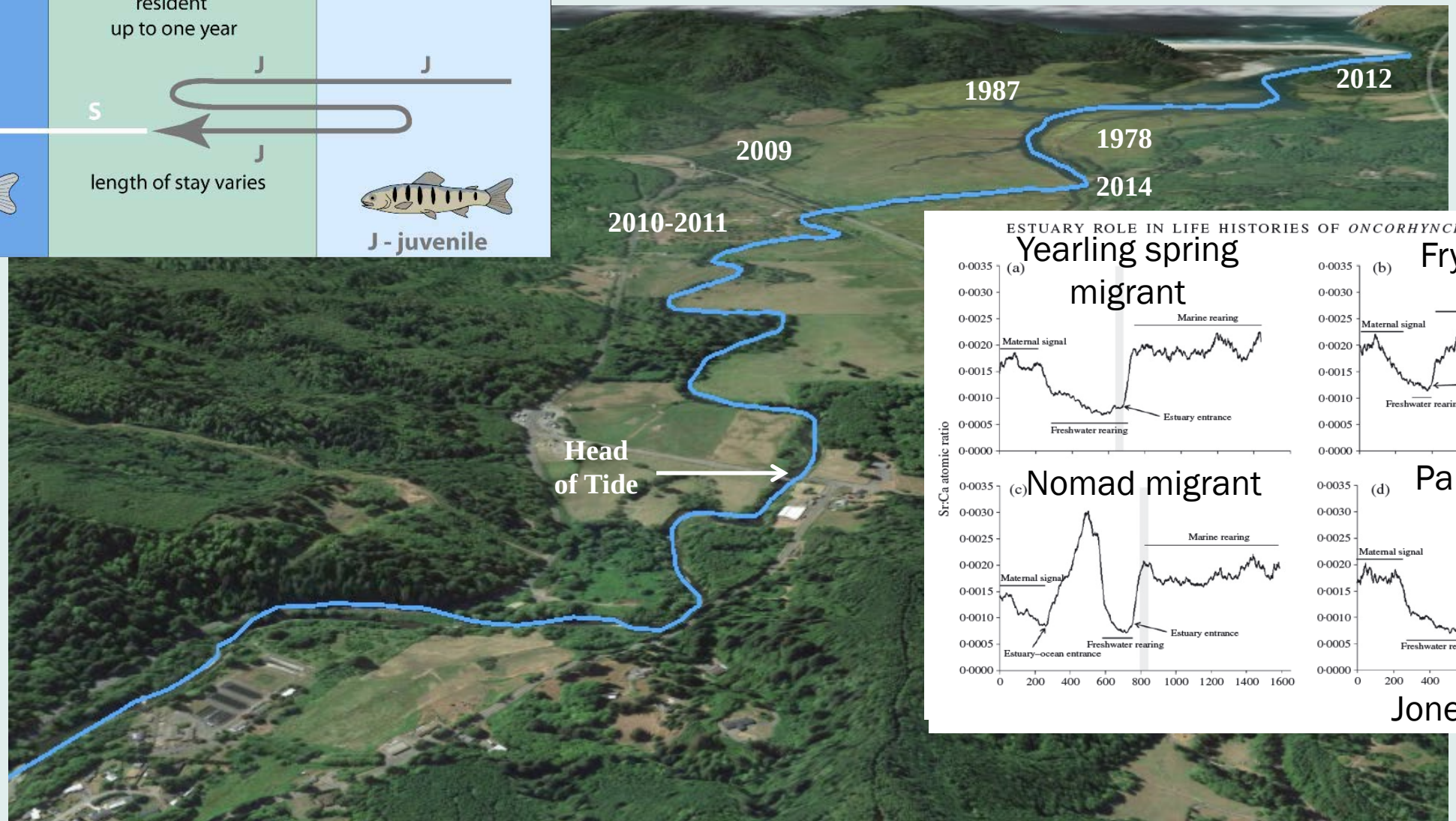
Fish Passage Barriers Results

- Green
- Red
- Gray
- No Fish
- No Data

Restoration and protection resulted in the re-emergence of coho salmon life-history expression



Flitcroft et al. 2013

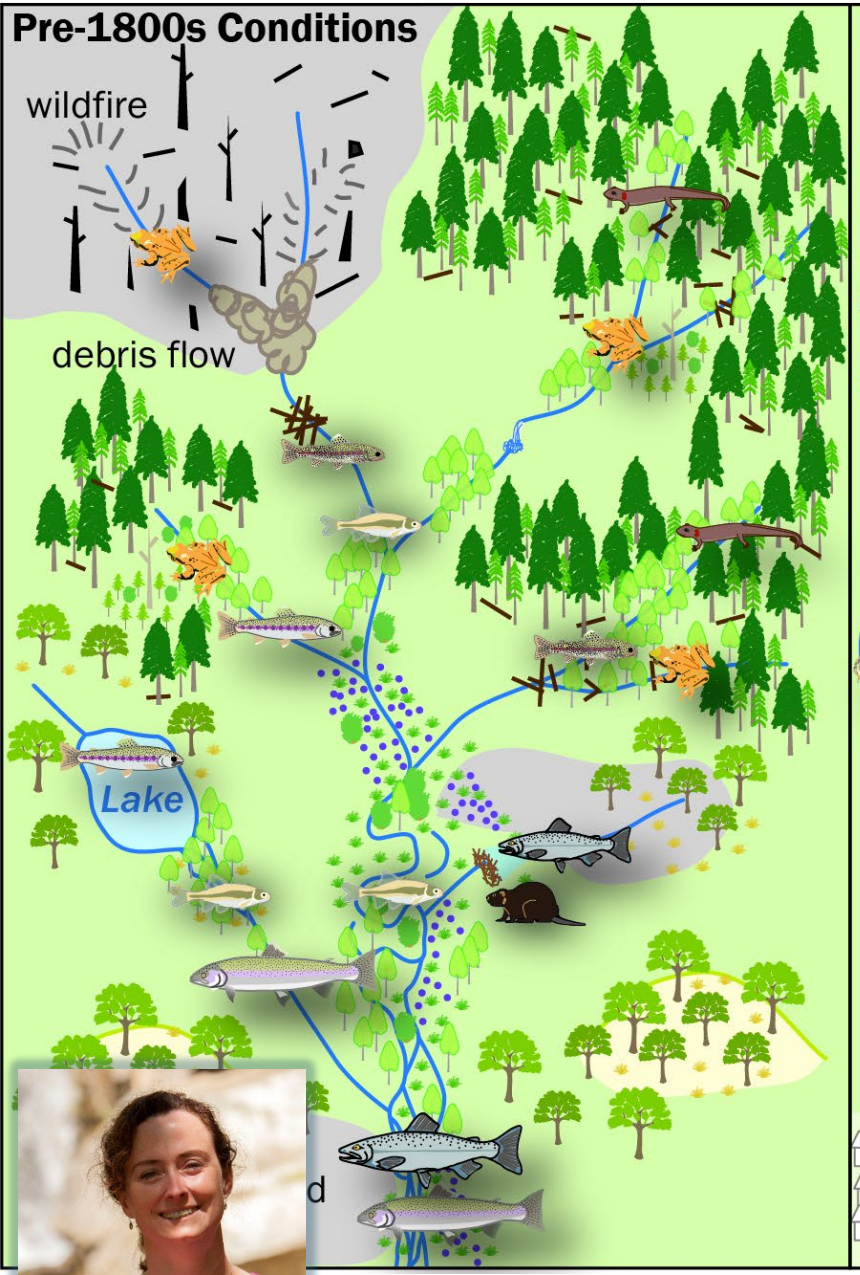


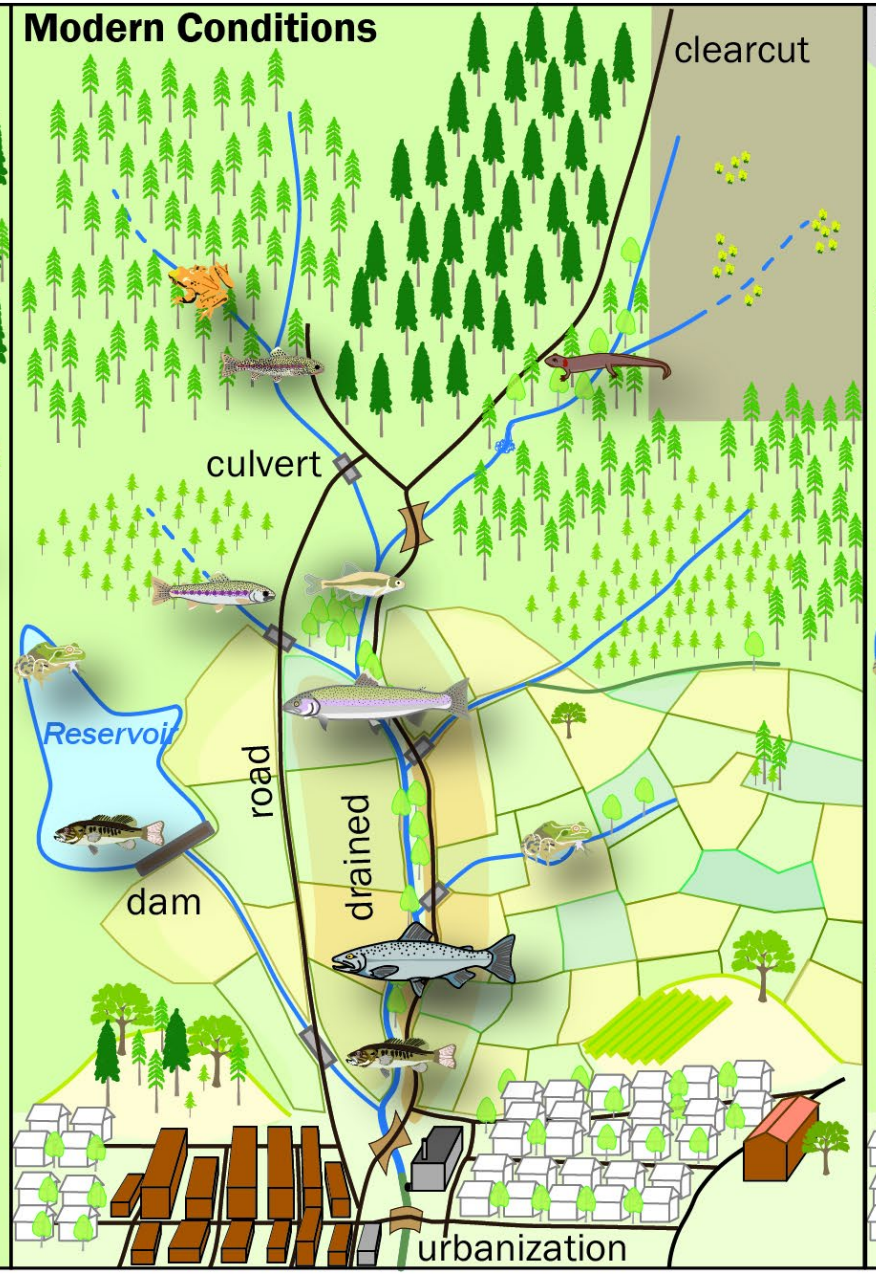
Jones et al. 2014

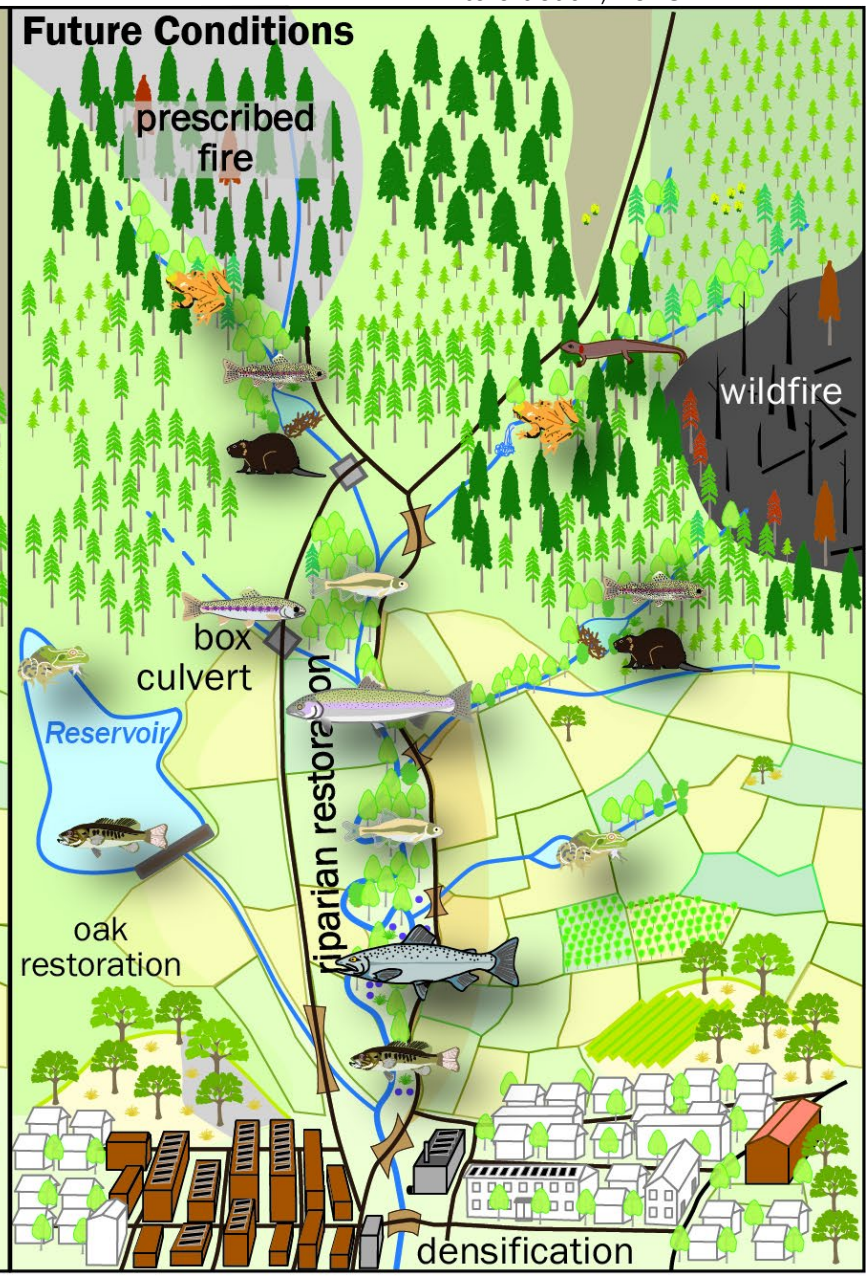
Closing Thoughts

- Native salmon are adapted to connectivity and variation over space and time.
- Current understandings of life history diversity may reflect observations formed under western disturbed environments including single thread channels rather than historic conditions.
- Need to recover whole ecosystems to support individual species recovery.
- Phenology is likely to need to change in response to changes in environmental conditions.
- Restoration that allows for all the dimensions of connectivity is critical for single-species conservation AND healthy ecosystems.

Flitcroft et al., 2023







Rebecca Flitcroft

Rebecca.Flitcroft@usda.gov

Thank you

When Process-Based Restoration Also Refers to People Dynamics: Redwood Creek Estuary Restoration

Presentation to the 2026 Salmon Restoration Federation Conference

Mary Burke, California Trout
Joél Flannery, Army Corps of Engineers

30 April 2026

U.S. ARMY

US Army Corps of Engineers®

COUNTY of HUMBOLDT The Home of the Redwoods

CALIFORNIA TROUT

Presentation Objective

As a case study for salmon recovery the Redwood Creek Estuary Restoration Project shows how an Army Corps–local partnership pairs **community-rooted collaboration with a complex Federal planning process** to restore a dynamic estuary.

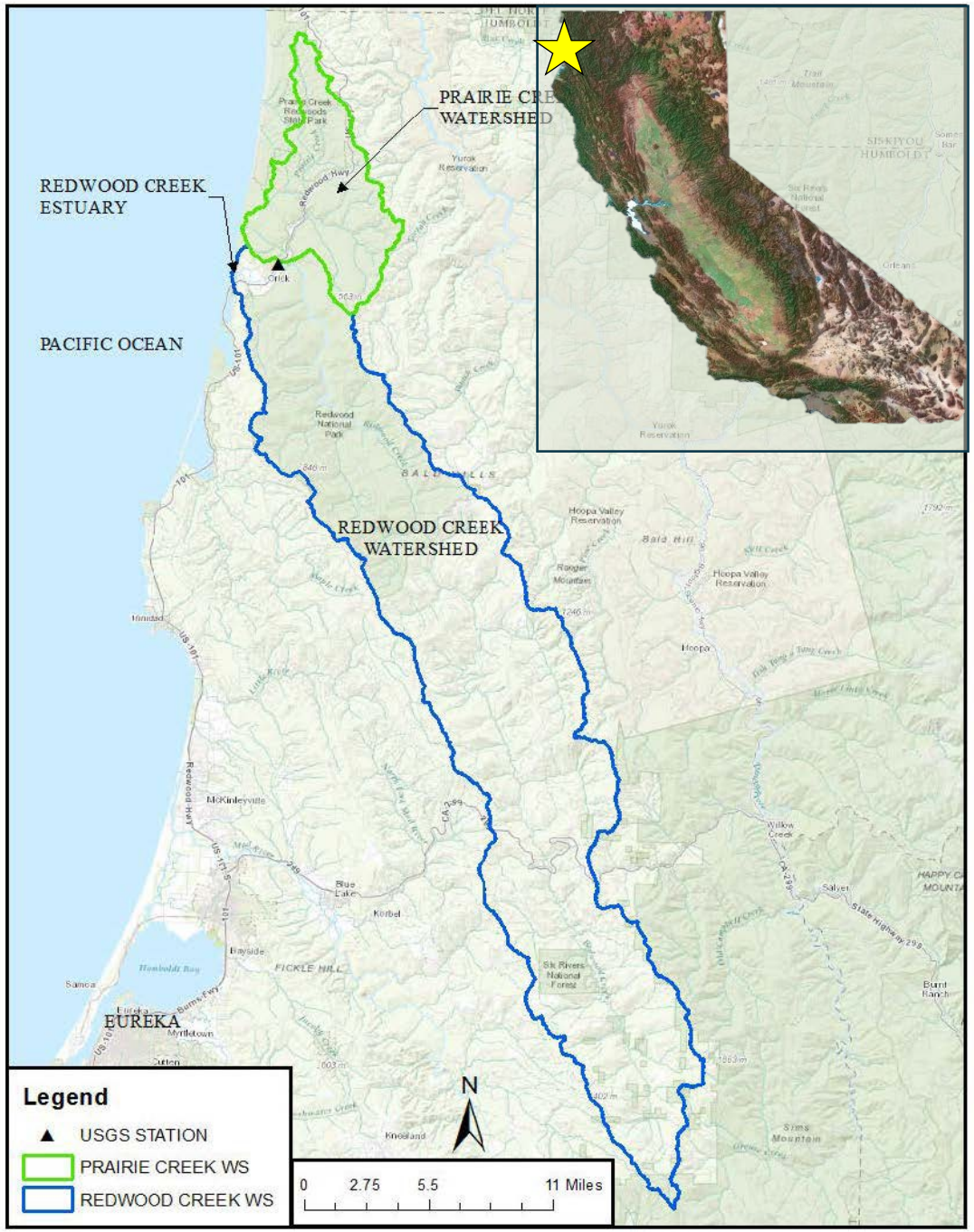


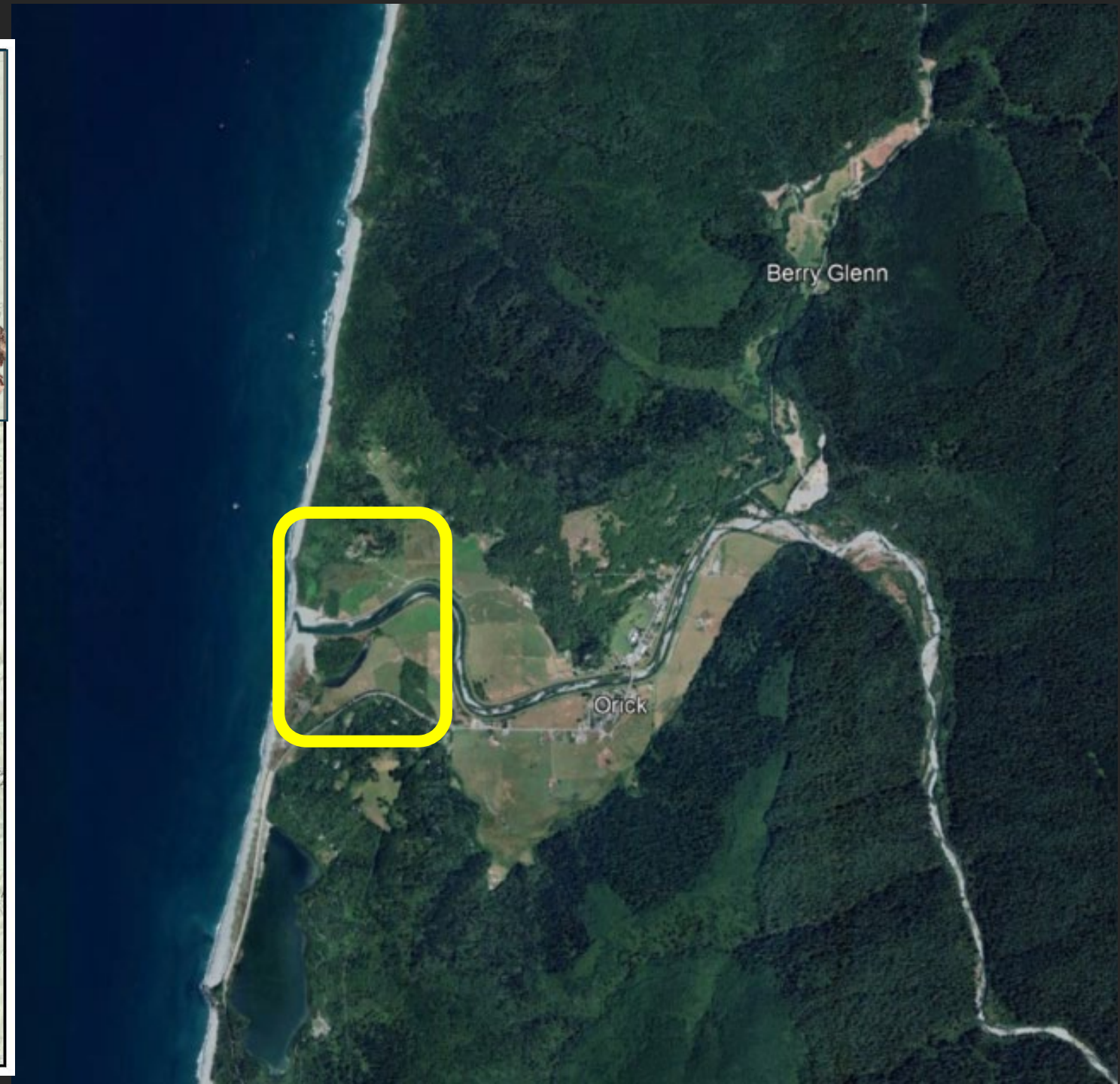

Study Area and Background

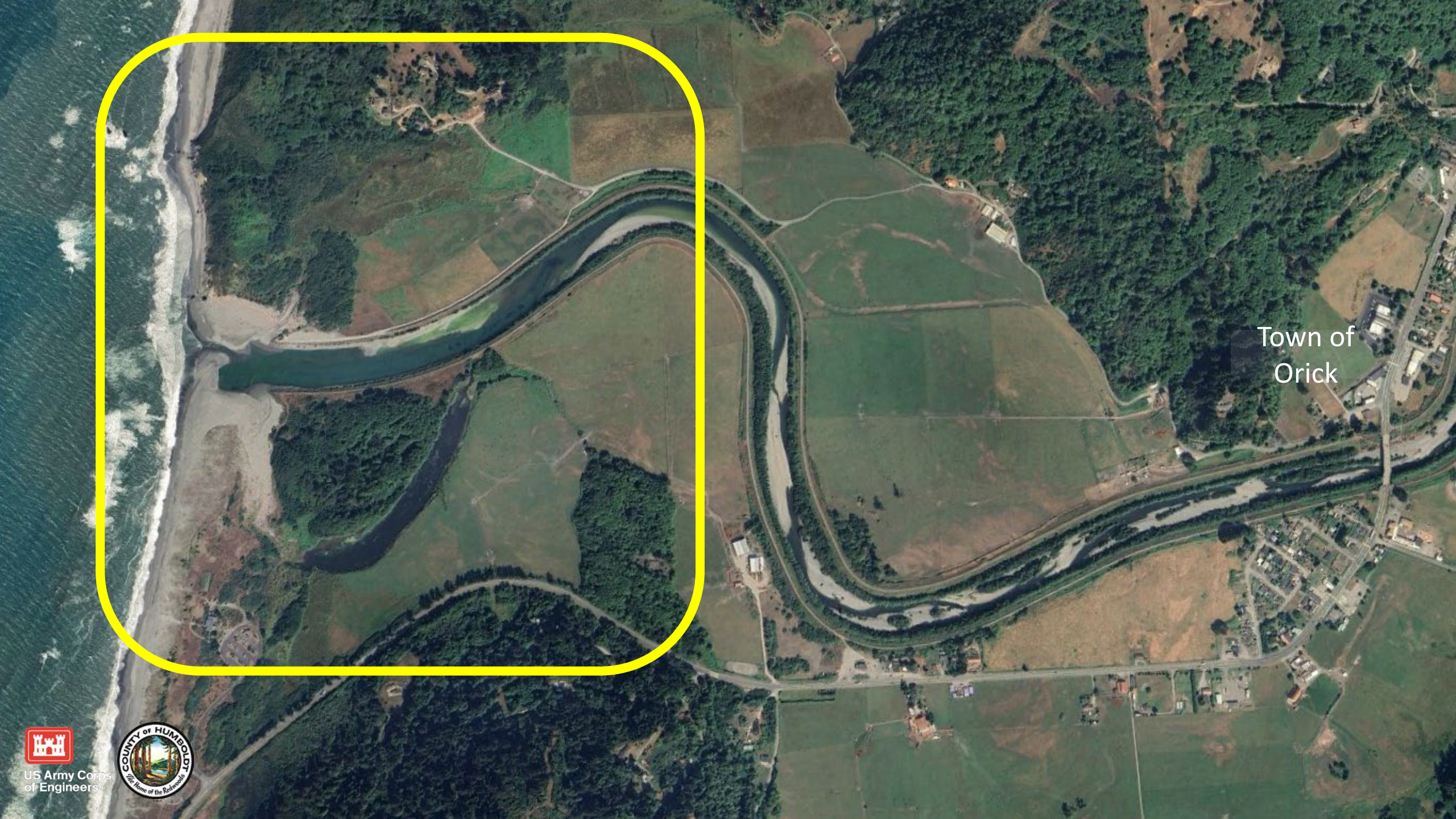
US Army Corps of Engineers®

COUNTY OF HUMBOLDT — The Home of the Redwoods

CALIFORNIA TROUT


PRAIRIE CREEK WATERSHED
REDWOOD CREEK ESTUARY
PACIFIC OCEAN
REDWOOD CREEK WATERSHED
EUREKA
Legend
USGS STATION
PRAIRIE CREEK WS
REDWOOD CREEK WS
N
0 2.75 5.5 11 Miles


Berry Glenn
Orick


Town of
Orick
US Army Corps
of Engineers
COUNTY OF HUMBOLDT
The Home of the Redwoods

Redwood Creek Estuary: Historical Context

- Yurok unceded ancestral territory
- Late 1800s European settlement
- 1920s conversion from spruce-alder forest wetland complex to agriculture
- 1953-1981 upper watershed timber harvest
- 1968 Redwood National Park established
- 1966-1968 USACE/Humboldt County build 3.4 miles of levees
- 1969 Local evidence of process dysfunction

Image: Pre-project USGS Topo

US Army Corps of Engineers®

Redwood Creek Estuary Before Federal Levees

US Army Corps of Engineers

Photos courtesy of David Anderson of the National Park Service

Redwood Creek Flooding & Federal Levee Project Dates

1950, 1953, 1955, 1964
Damaging floods in Orick

1962
Redwood Creek Flood Control Project
Authorized by Congress

1966-1968
Levees constructed

Downtown Orick during the 1964 flood

1964 flood in Orick from the Alice Dorsey collection, courtesy of the Palm Cafe.

Redwood Creek Estuary Before and After Federal Levees

1941

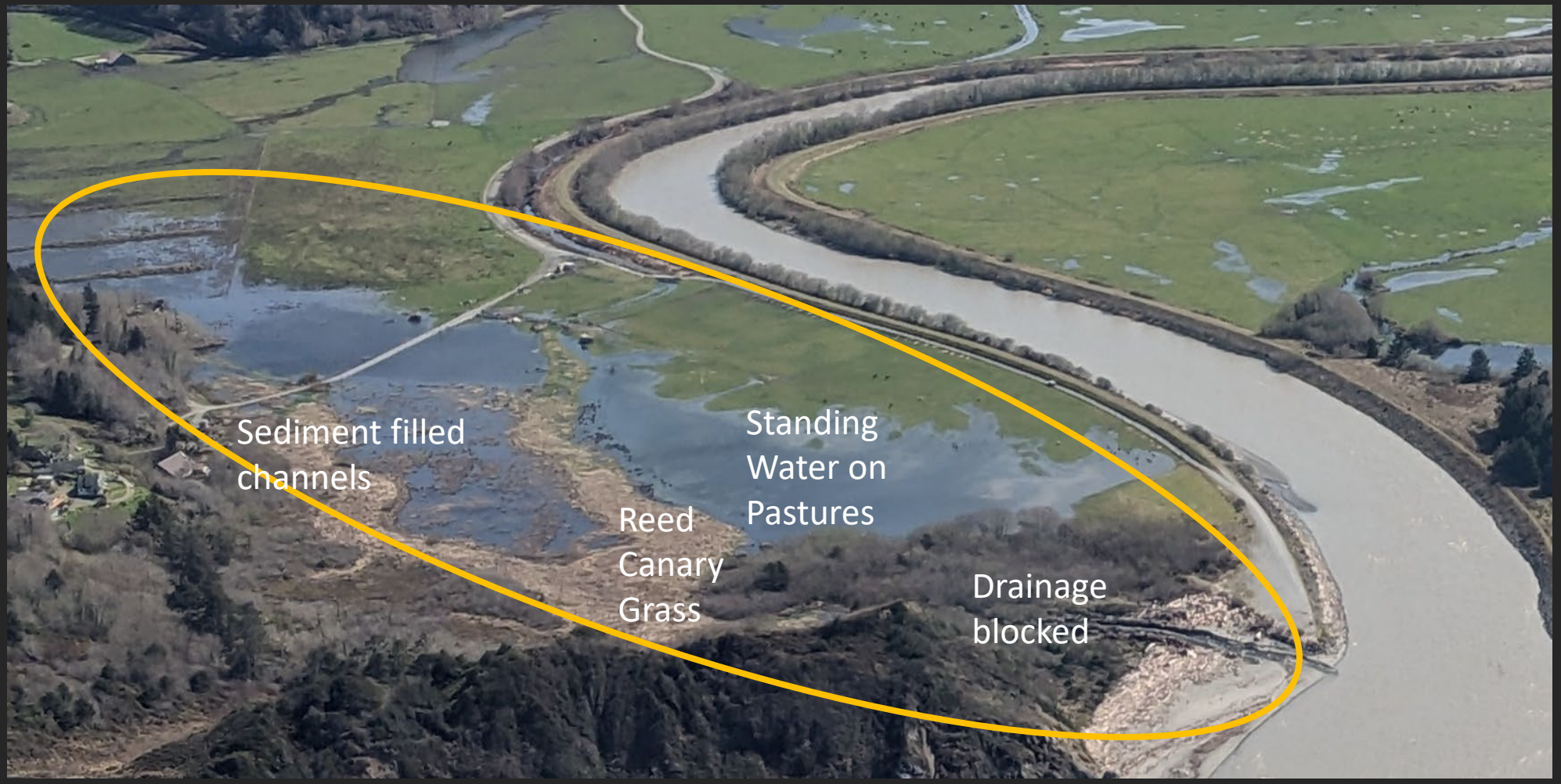
2012

US Army Corps of Engineers®

Estuarine & Fluvial Losses:

Estuary footprint reduced from 84 acres to 20 acres

Drainage Impacts to Private Lands



2022

Collaborative Based Federal Planning

US Army Corps of Engineers ®

COUNTY OF HUMBOLDT
The Home of the Redwoods

CALIFORNIA TROUT

Collaboration Formation

- Previous efforts to address problems in estuary:
  - Early and sustained questions about a “design deficiency”
  - More recent threats of jeopardy opinion
  - Outside restoration entities turned away
  - For many years, private landowners were not engaged in project development. However, more recently impacts to private land became much worse.
- Any restoration effort had to be locally initiated and sustained
- 2017 – Landowners initiated contact with CalTrout and the RCE Collaborative began

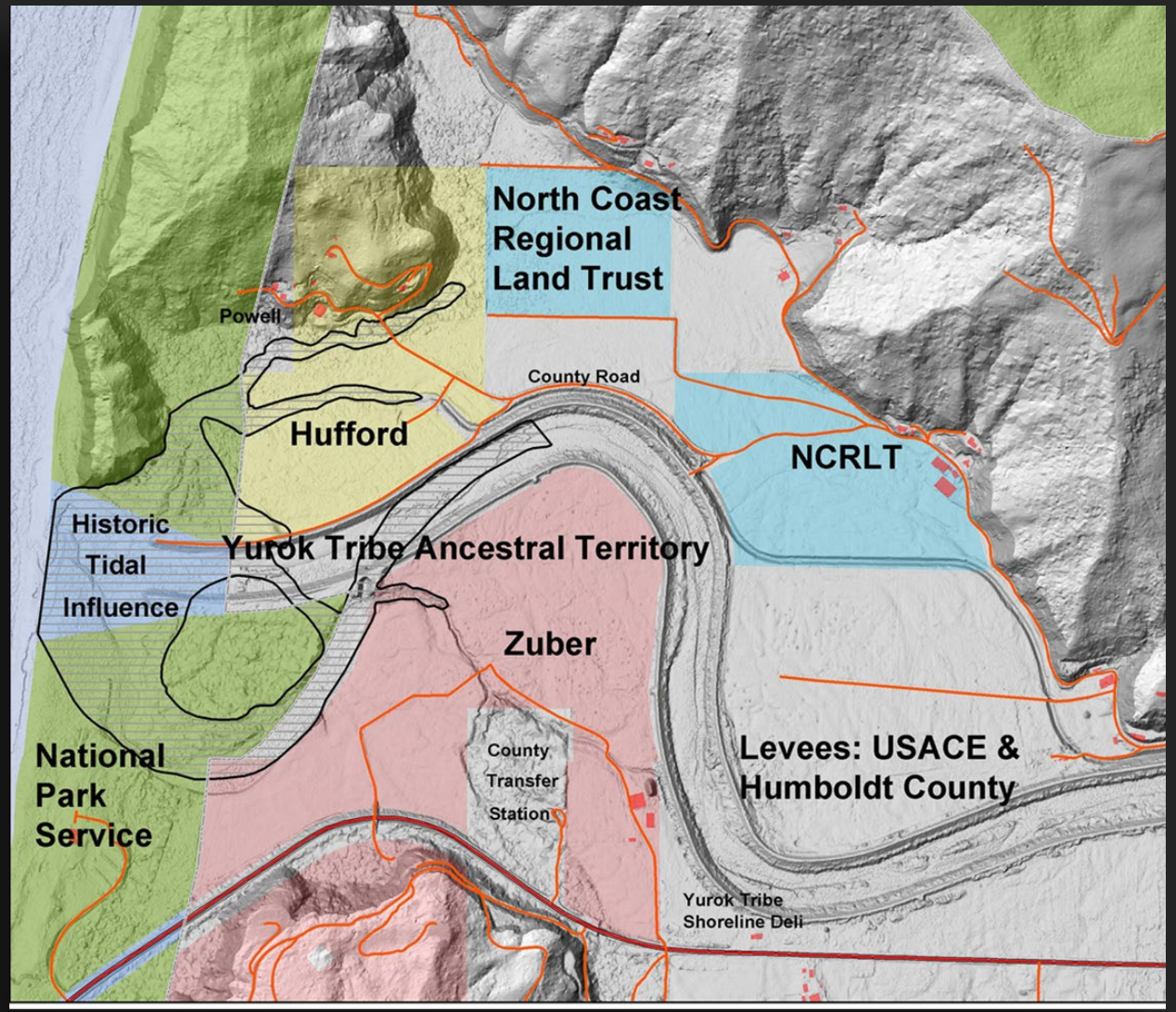
Collaboration's Role in Federal Study Initiation

Challenge Meets Opportunity

- Federal levees create impacts to private landowners
- Modification of Federal levees requires USACE project and/or Congressional action

<u>Interdependent path forward</u>:

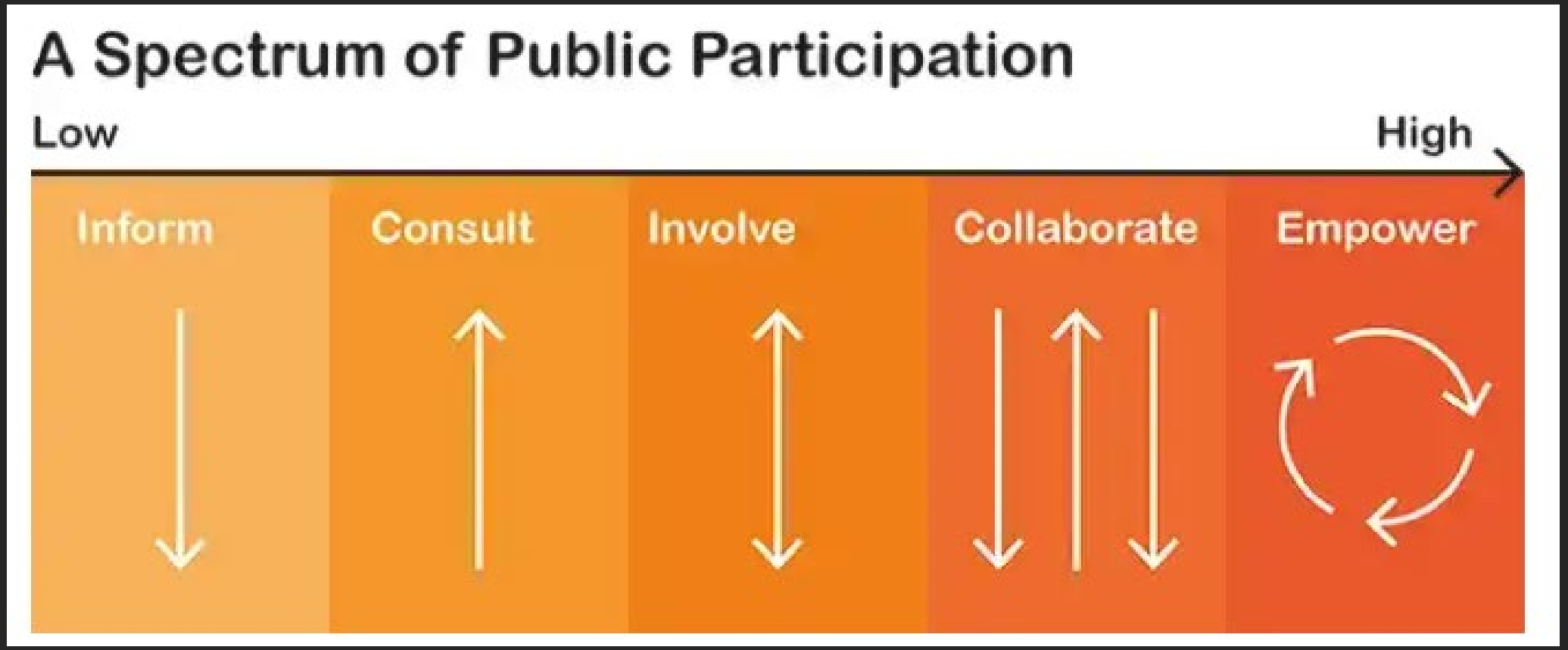
Private Landowners, CalTrout, NPS, Humboldt County, USACE, Yurok Tribe, NOAA Fisheries, USFWS , CDFW, Land Trust,



Redwood Creek Estuary Collaborative (No USACE Participation)

- Conveners: Landowners and CalTrout
- Interdependent Collaborative formed
- Purpose: all looking to improve their outcomes
- Define interests based on values & understanding of independence (1 year of meetings)
- Sought win-win/mutual wins/BATNAs
- Development of decision-making framework
- Joint Discovery
- Collaboratively developed conceptual design based on science, geomorphic hydraulic engineering, landowner knowledge
- **Ultimately, the Collaborative worked with Humboldt County to request a CAP 1135 new start - and we started!**

Incorporating interdependence and collaboration into a USACE feasibility study



Incorporating interdependence and collaboration into a USACE feasibility study

Collaborative Agency Representatives on the USACE Project Development Team

Redwood Creek Estuary Collaborative:
Hosts workshops & meetings
Collect formal feedback for planning decisions
Allows full inclusion of landowners

Federal Scope:
Project Delivery Team
Technical Team
Real Estate Team
Etc
Public Involvement Plan

Non-Federal Sponsor: Formal team roles for Yurok Tribe and CalTrout and local consultant

The Federal Feasibility Study

US Army Corps of Engineers ®

COUNTY OF HUMBOLDT
The Home of the Redwoods

CALIFORNIA TROUT

Setting the Stage: Army Corps' Planning Process

- Request to Initiate Study: March 2021
- Feasibility Study Kickoff: Oct 2024
- Study is costshared 50/50 between Corps and Humboldt County
- Federal planning process is highly structured and onerous; also invaluable in advancing project within structured process.
- Collaboration and maintaining trust as central to each step

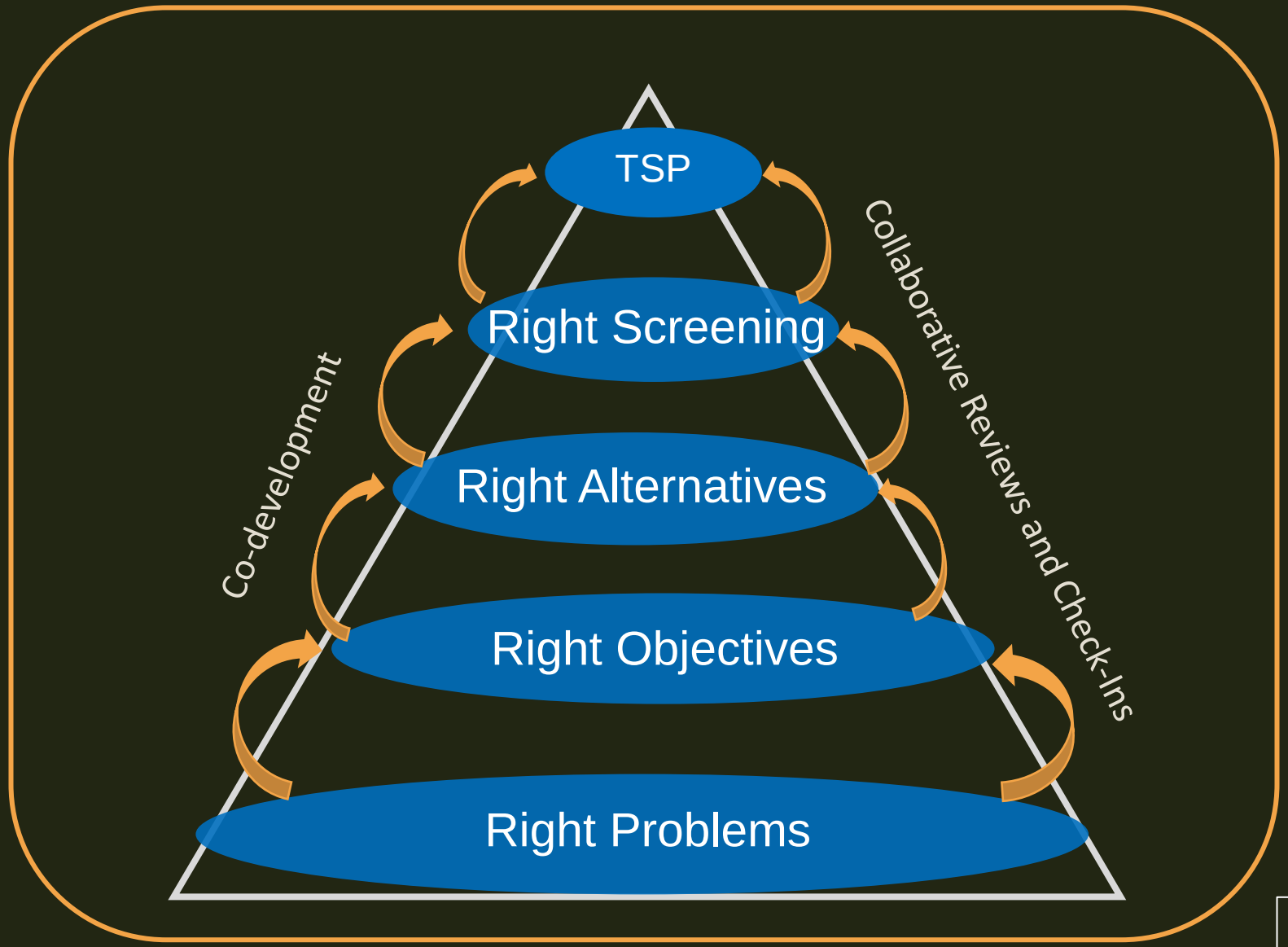




Planning Process: Getting It “Right”

1. “Right” People
2. “Right” Federal Planning Problems
3. “Right” Federal Planning Objectives
4. “Right” Alternatives
5. “Right” Screening
6. “Right” Engineering

Federal Planning Process: Getting it “Right”



TSP: Tentatively Selected Plan

1. "Right" People: *Project Delivery Team* and Partners

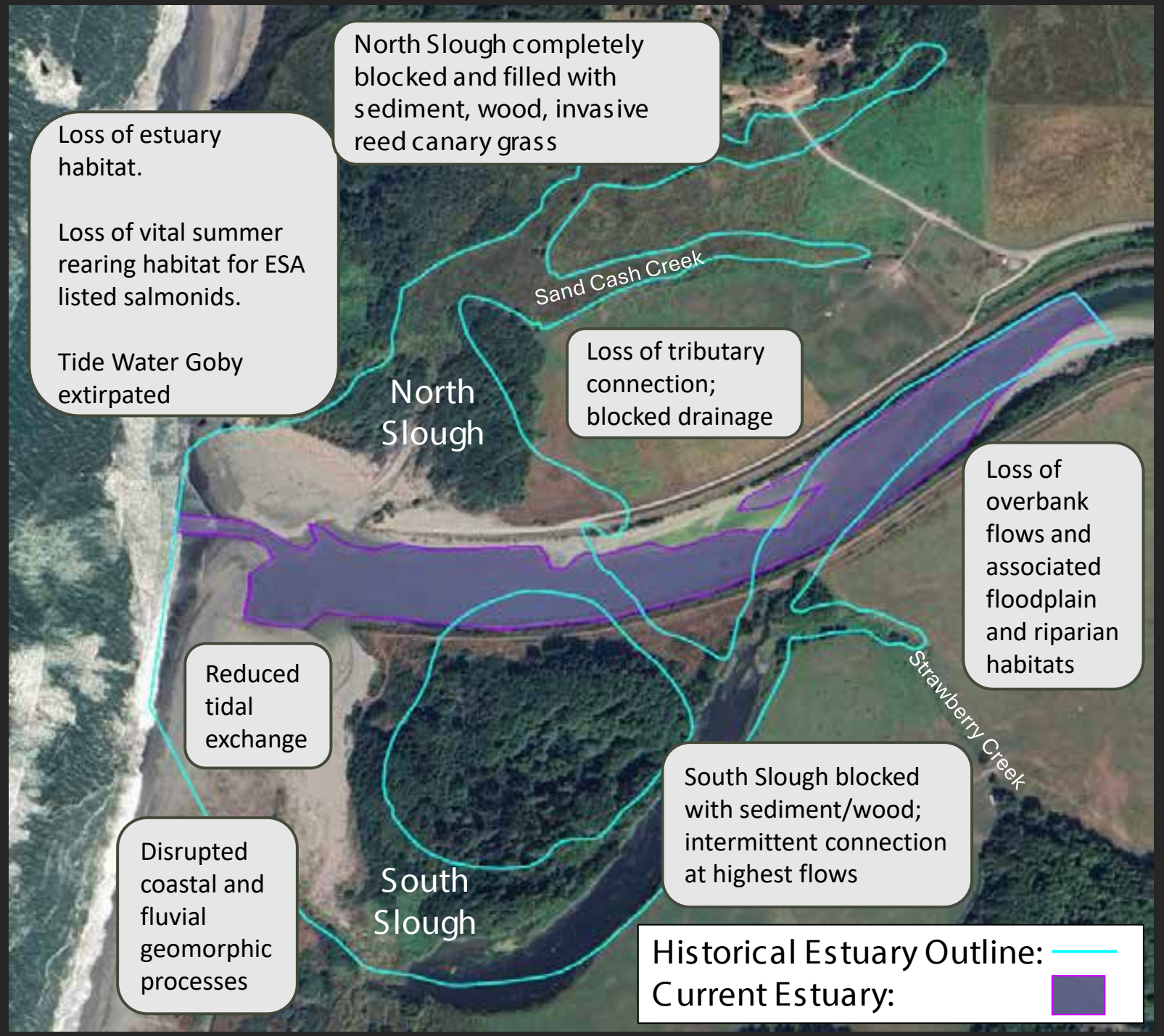
Army Corps of Engineers	Joél Flannery, Project Management Elizabeth Murray, Planning Tyler Miller, Engineering Technical Lead Jeff Hoeft, Geotech/Geology Tiffany Cheng, Coastal Engineer Rana Mishra, Cost Engineering Grace Wieland, Economics Daniel Ruane, Planning Support Savannah Fahning, Environmental Planner Ruzel Ednalino, Cultural Resources Pamela Fischer, Real Estate Specialist Josh Miller, GIS Coordinator Sarafina Maraschino, Tribal Liaison
Humboldt County (Non-Federal Sponsor)	Steve Madrone, Humboldt County Supervisor Hank Seemann, Deputy Director, Environmental Services Danith Davis, Senior Environmental Analyst Contracted: • Travis James, Senior Project Engineer, Yurok Tribe • Ish-Kaysh Tripp, Yurok Tribe, Civil design • Mary Burke, Caltrout • Conor Shea, GHD, Hydraulic Engineer

USFWS	Natalie Okun, Restoration Biologist
NOAA	Bob Pagliuco, Marine Habitat Resource Specialist
National Park Service	Leonel Arguello, Deputy Superintendent Chad Anderson, Natural Resources Manager
Yurok Tribe*	Travis James, Senior Civil Engineer Ish-Kaysh Tripp, Civil Engineer
Landowners	Greg Hufford, Hufford Family Marla Zuber, Zuber Family
CalTrout	Darren Mierau, Director of Science Mary Burke, North Coast Regional Manager Ashley Shannon, Project Manager
Northcoast Regional Land Trust	Dan Ehresman, Executive Director
CA Dept Fish & Wildlife	James Ray, Senior Env. Scientist

*The Yurok Tribe's role includes being a civil design team member (subcontractor of Humboldt County: being one of the Tribal sovereign nations with interest in this study, supporting the study through section 106 consultations, and as a stakeholder/unit of the public with interest in the study.

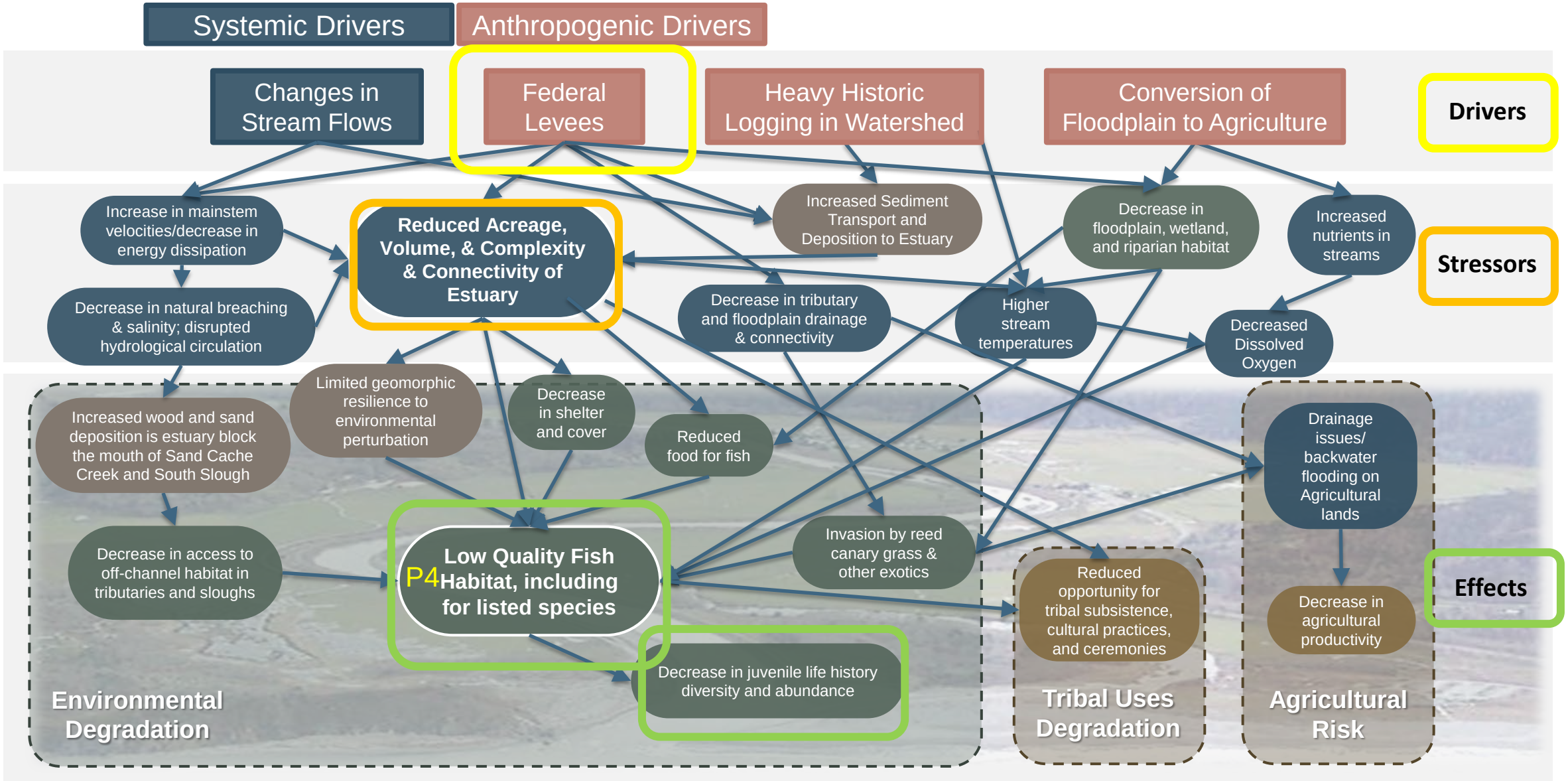
2. “Right” Problems:

Problems based on drivers, stressors & effects



CONCEPTUAL ECOLOGICAL MODEL

Getting the Problems "Right"



3. "Right" Objectives: Ensure your objectives solve your problems ***and are measurable***

Ecosystem Restoration

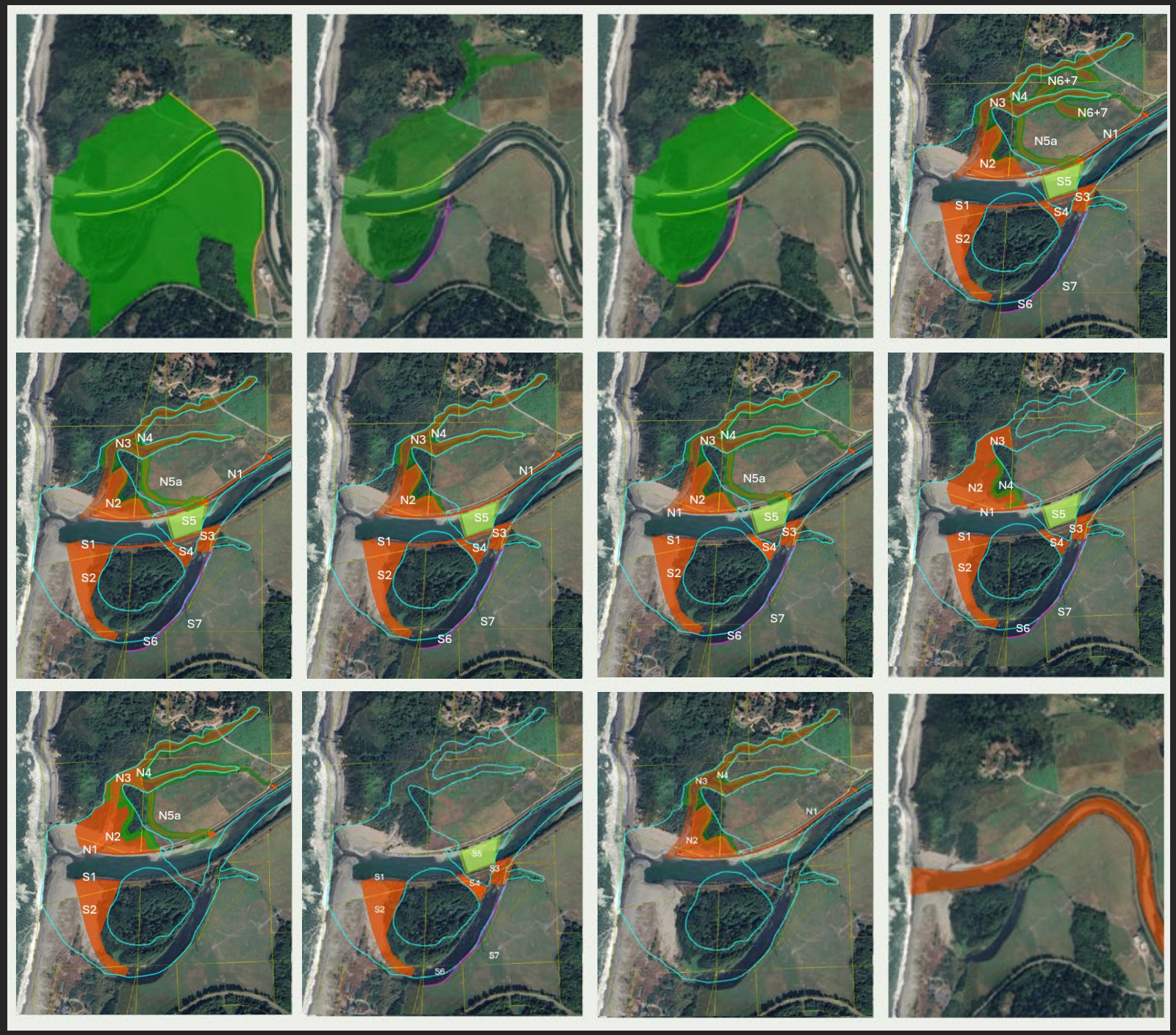
1. Expand estuary size, volume, and structural complexity, *and restore physical and biological processes to sustain them*
2. Restore floodplain and tributary connectivity and drainage in Sand Cache and Strawberry Creeks
3. Increase cover and diversity of native riparian and wetland vegetation
4. Increase shelter, cover, food resources to enhance juvenile fish growth and survival

Other

1. Improve drainage on adjacent agricultural lands
2. Restore opportunities for Tribal cultural practices and ceremonies

5. Develop “Right” Alternatives:

12 alternatives developed initially; 1 added during modeling



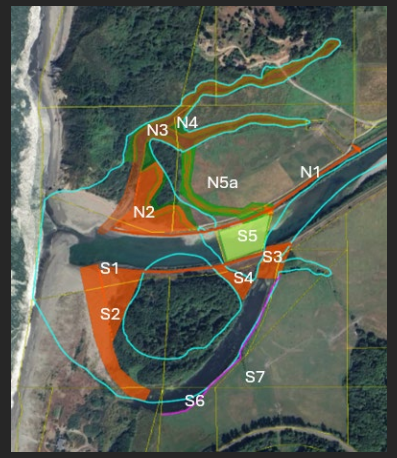
5. “Right” Screening

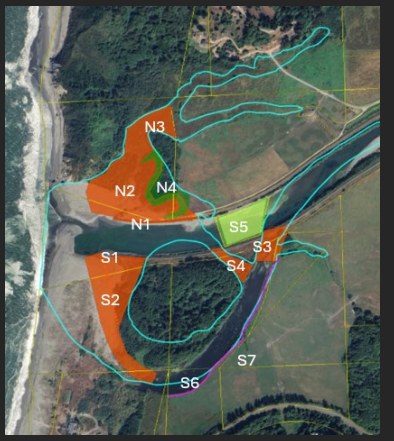
Alternatives Screened:

1. Does not meet objectives
2. Real estate availability
3. Not affordable

5. “Right” Screening

Focused Array of Alternatives

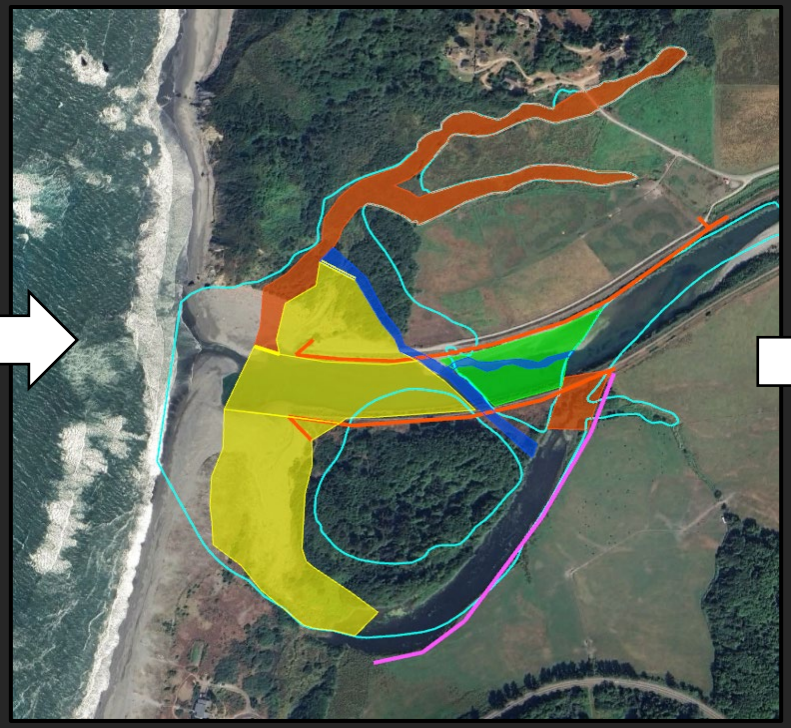




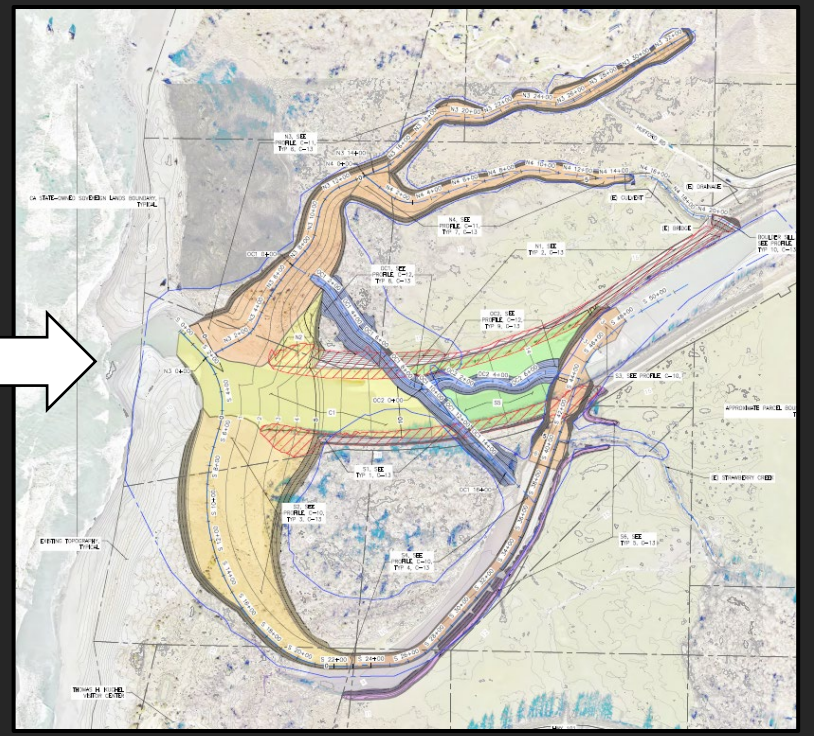
4. Iteration: Develop “Right” Alternatives:

Start with Historical Condition

Develop Concepts

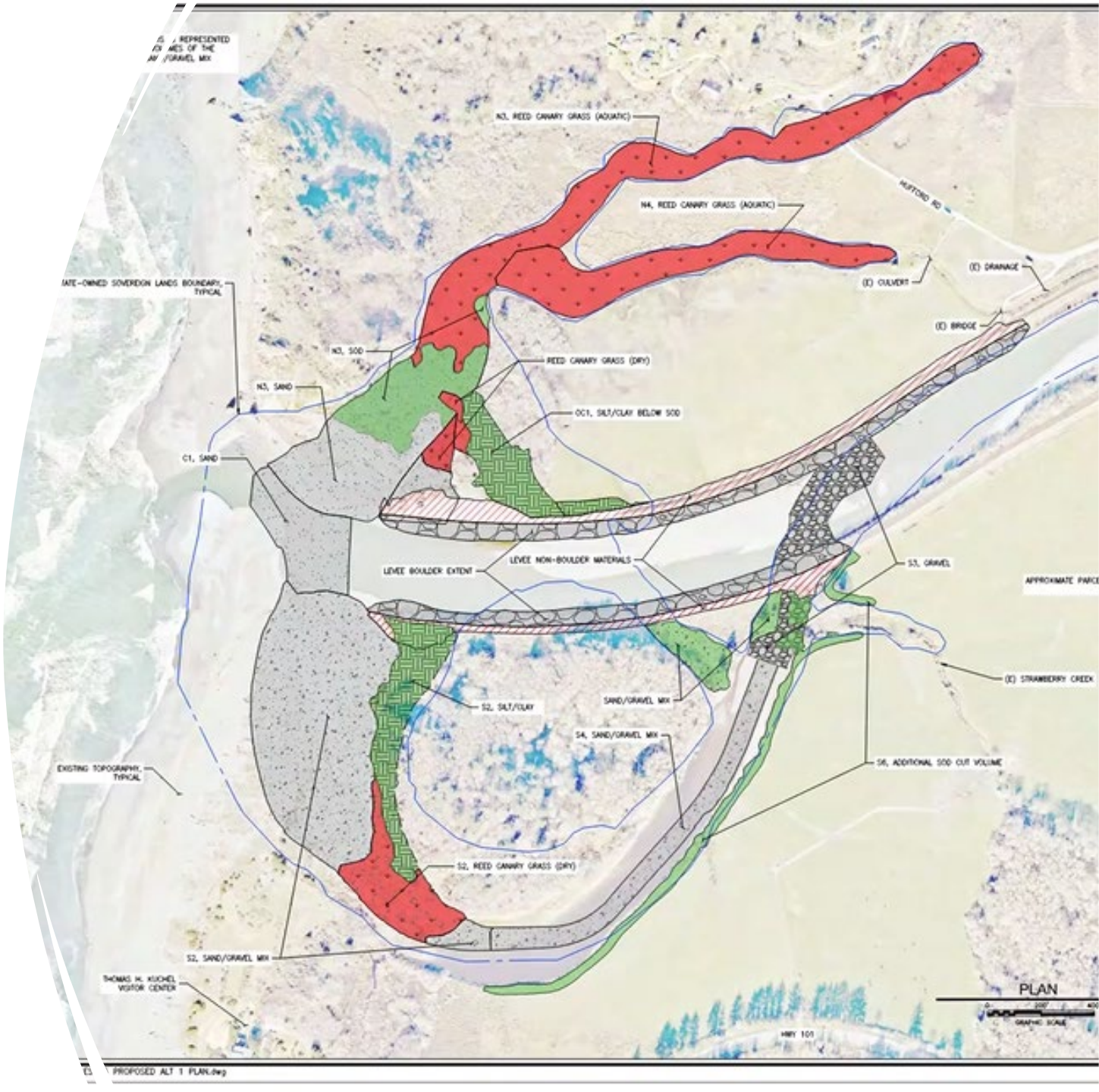


Refine With Modeling



6. "Right Engineering"

- Design solutions that understand landowner needs and concerns
- Design with the natural system as vision/goal
- Coastal and fluvial geomorphology as design foundation
- Design with understanding that ecosystem is out of balance and goal is to leverage structural changes to bring the system to an improved dynamic equilibrium
- Build resiliency into design that allows for continuous change within the bounds of a new stable state




Thank you!

Introducing California's Beaver Coexistence Program: Yet Another Process-based Salmonid Recovery Tool

Painting: www.suzannehusky.com

Salmonid Restoration Federation • April 30, 2026

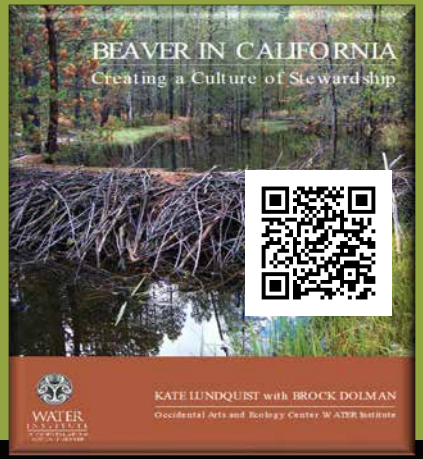
Grey Hayes, PhD • WATER Institute Beaver Coexistence Program Manager

Occidental Arts & Ecology Center • www.oaec.org/water

COLLABORATIVE CONSERVATION FROM RIDGELINE TO RIVER TO REEF

Occidental Arts & Ecology Center

Occidental Arts & Ecology Center Water Institute



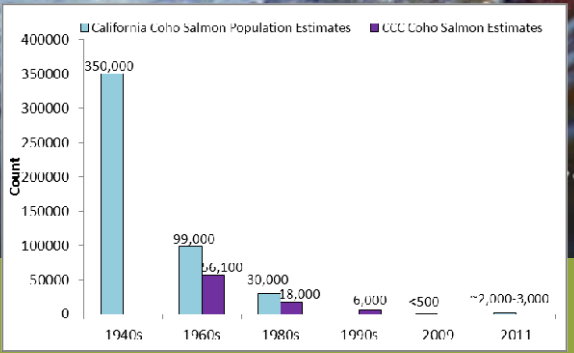
Beaver Coexistence Training and Support Program funded by the CDFW Nature Based Solutions: Wetlands and Mountain Meadows Grant Program

Photo: Kholood Eid / National Geographic

California Department of Fish & Wildlife · NOAA · U.S. Department of Commerce · U.S. Forest Service · U.S. Department of Agriculture · U.S. Fish & Wildlife Service · Caltrans · National Fish and Wildlife Foundation · The Nature Conservancy · Utah State University · Trout Unlimited · California Trout · Point Blue Conservation Science · Maidu Summit Consortium · The Yurok Tribe · Mountain Rancheria · Swift Water Design · California · The Sierra Meadows Partnership

COHO SALMON (*Oncorhynchus kisutch*) ARE IN SERIOUS DECLINE IN CALIFORNIA

Photo: Tom and Pat Leeson



The Importance of Beaver Ponds to Coho Salmon Production in the Stillaguamish River Basin, Washington, USA

Article | Full-text available | August 2004

North American Journal of Fisheries Management

Michael M. Pollock · G. R. Pess · Timothy Beechie · David R Montgomery

Hydrologic and Geomorphic Effects of Beaver Dams and Their Influence on Influence on Fishes

Chapter | Full-text available | January 2003

Michael M. Pollock · Morgan Heim · Danielle Werner

Geomorphic changes upstream of beaver dams in Bridge Creek, an incised stream channel in the interior Columbia River Basin, eastern Oregon

Article | Full-text available | July 2007

Earth Surface Processes and Landforms

Michael M. Pollock · Timothy Beechie · Chris Jordan

Working with Beaver to Restore Salmon Habitat in the Bridge Creek Intensively Monitored Watershed-Design Rationale and Hypotheses.

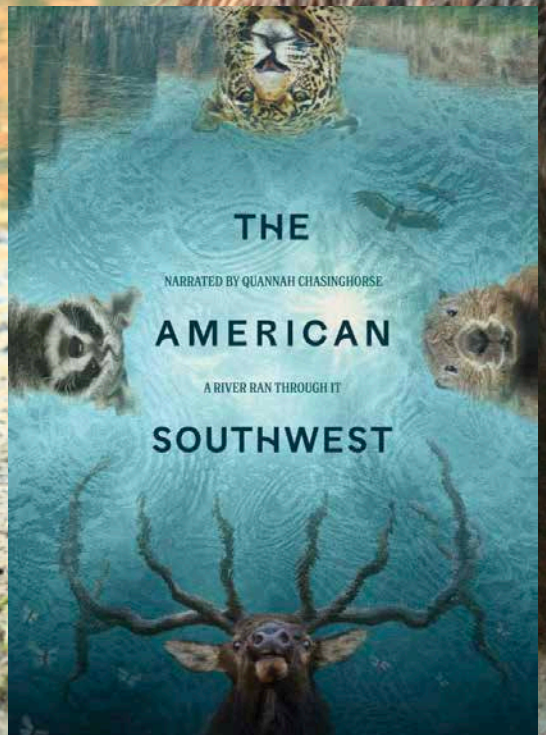
Article | Full-text available | January 2012

Michael M. Pollock · Joseph M. Wheaton · Nick Bouwes · [...] · Chris Jordan

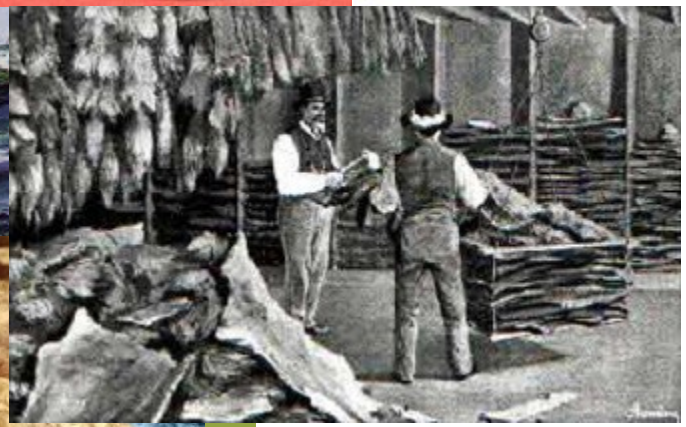
NORTH AMERICAN BEAVER (*Castor canadensis*)

Photo: Cheryl Reynolds, Worth A Dam

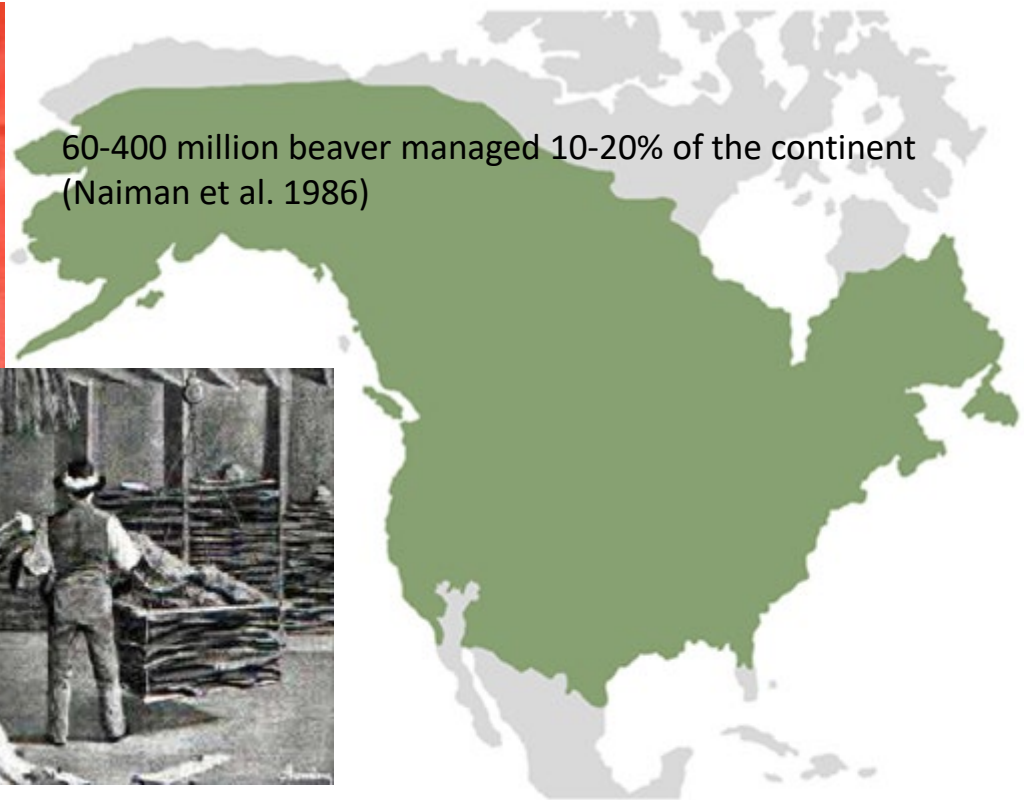
NORTH AMERICAN BEAVER (*Castor canadensis*)



THE NORTH AMERICAN BEAVER WAS NEARLY TRAPPED TO EXTINCTION DURING THE “FUR RUSH”

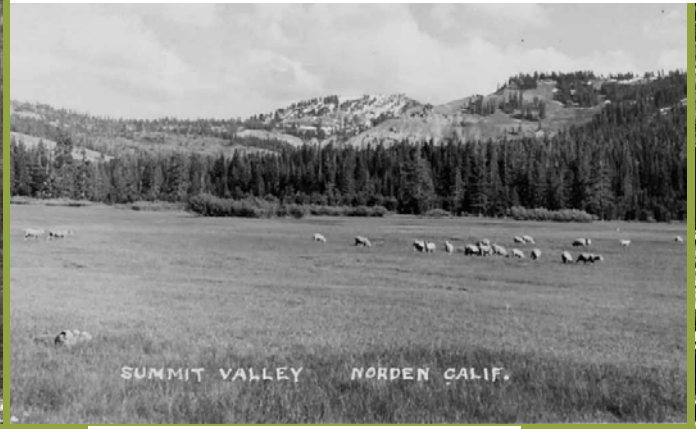


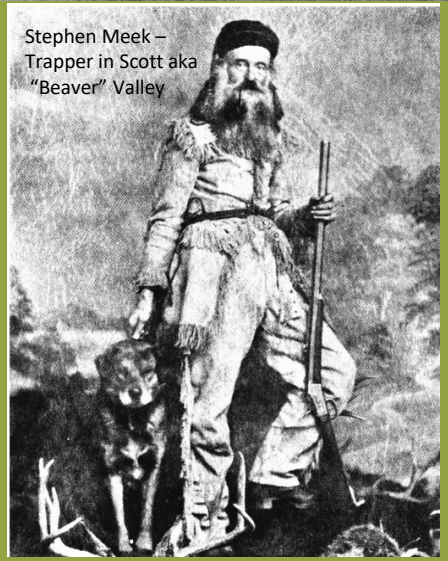
60-400 million beaver managed 10-20% of the continent (Naiman et al. 1986)



Approximate historical range of beavers in North America, based on a map produced by the US Fish and Wildlife Service

LEGACY IMPACTS





Occidental Arts & Ecology Center

Occidental Arts & Ecology Center Water Institute

Bring Back the Beaver

How We're Winning the Campaign to Rehydrate the West

About the Campaign | Beaver Restoration | Got Beaver Problems? | Beaver Facts | Resources | WATER Institute Home

Beaver Web Portal
www.oaec.org/beaver

California Beaver Coexistence Training and Support Program

Funded in part by the CDFW Nature Based Solutions: Wetlands and Mountain Meadows Grant Program

BEAVER ARE NATIVE TO MUCH OF CALIFORNIA

Novel Physical Evidence that Beaver were Native to the Sierra Nevada

James and Lanman 2012
California Fish and Game Journal

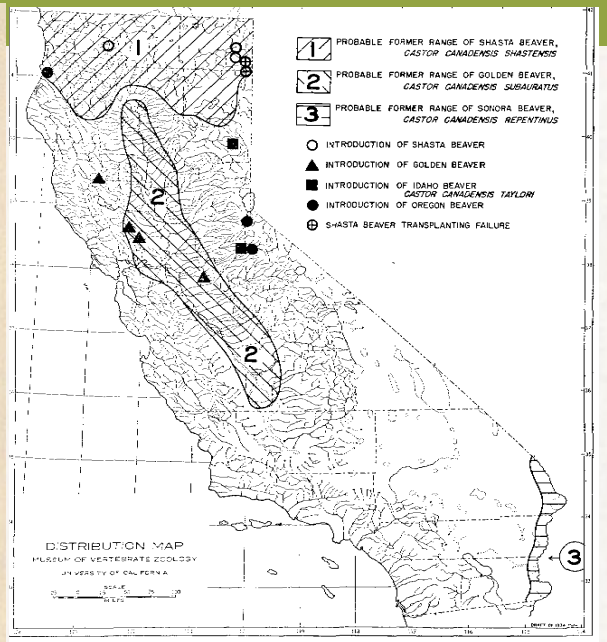
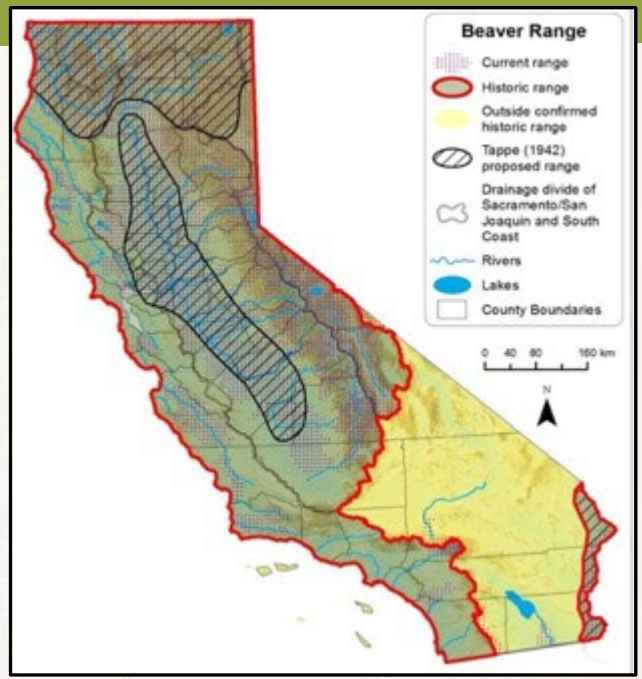


Fig. 2. Probable former range of beavers in California, with location of sites where beavers have been transplanted by governmental agencies in recent years.

The Historic Range of Beaver in the Sierra Nevada

Lanman et al. 2012
California Fish and Game Journal



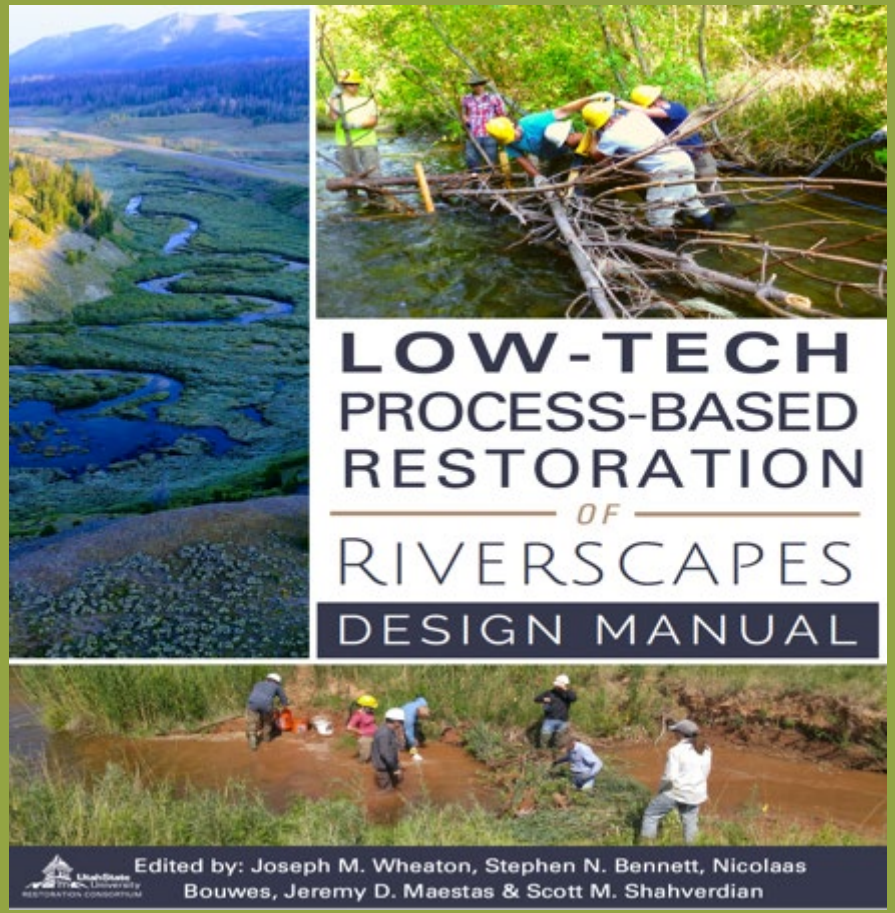
The Historical Range of Beaver in Coastal California (Update)

Lanman et al. 2013
California Fish and Game Journal

https://oaec.org/historic-range-of-beaver-in-california/

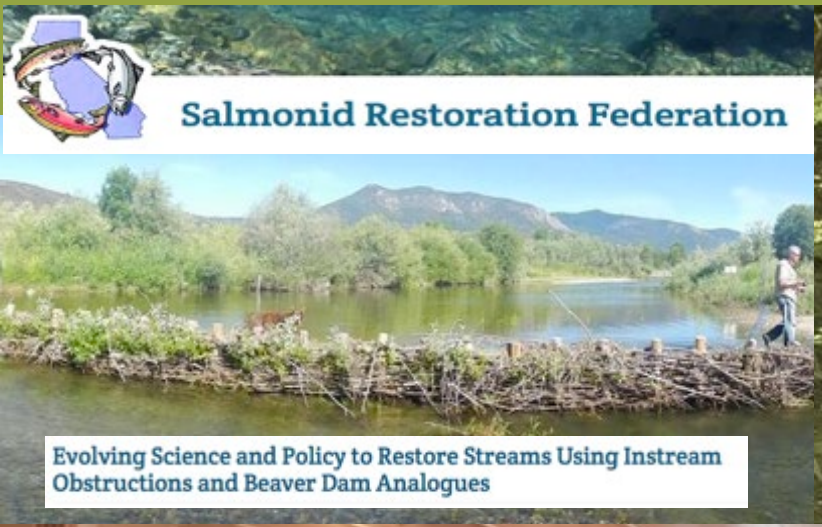
BEAVER & PROCESS-BASED RESTORATION SCIENCE IS GROWING

https://www.fws.gov/media/beaver-restoration-guidebook



http://lowtechpbr.restoration.usu.edu/

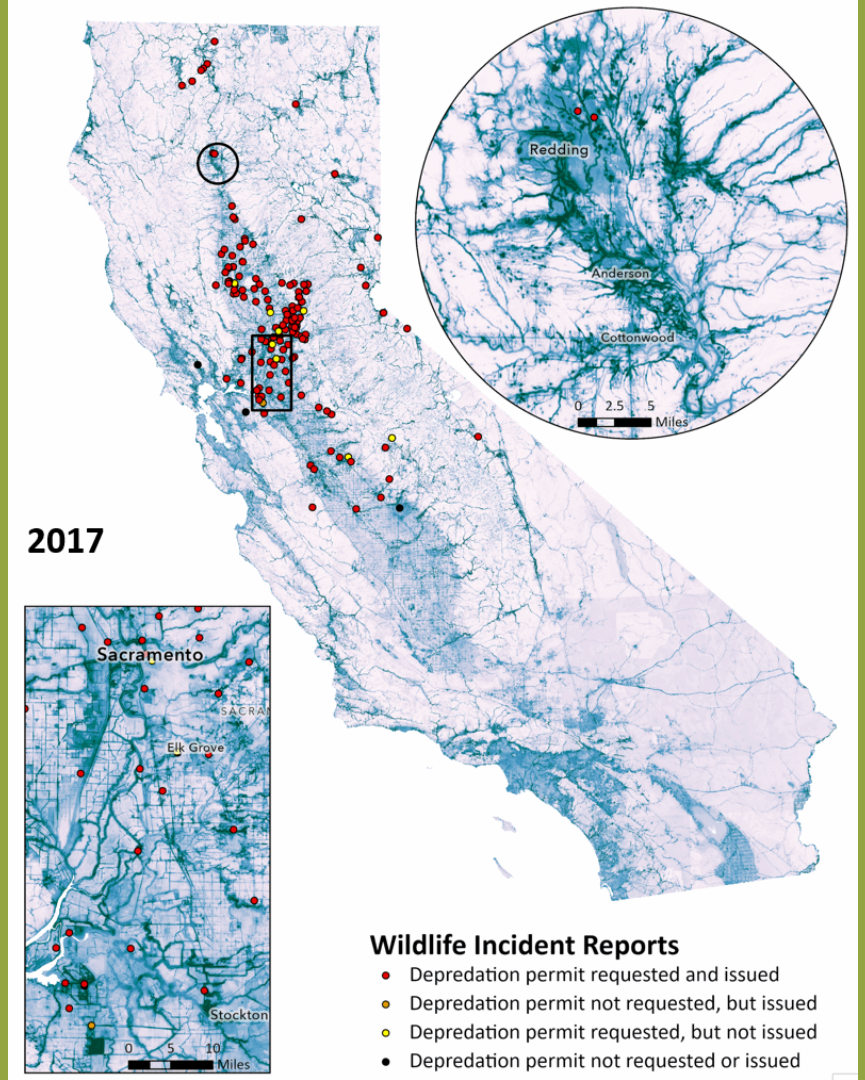
RESTORATION COMMUNITIES ARE WORKING WITH BEAVER TO ACHIEVE THEIR RESTORATION GOALS



The Sierra Meadows Partnership

California Rangeland Conservation Coalition

THE ARGYLE SWEATER **BY SCOTT HILBURN**


Redding
Anderson
Cottonwood
0 2.5 5
Miles
2017
Sacramento
Elk Grove
Stockton
0 5 10
Miles
Wildlife Incident Reports
Depredation permit requested and issued
Depredation permit not requested, but issued
Depredation permit requested, but not issued
Depredation permit not requested or issued

HIGHLY ADAPTABLE / HABITAT GENERALISTS

BEAVER WETLANDS IMPROVE WATER QUALITY, TRAP NUTRIENTS AND BUILD SOILS

Muskopf 2007 – Beaver dam removal and phosphorus study on South Lake Tahoe

BEAVERS KEEP TAHOE BLUE

BEAVER DAMS HELP RECHARGE GROUNDWATER AND DELAY RELEASE INTO THE DRY SEASON

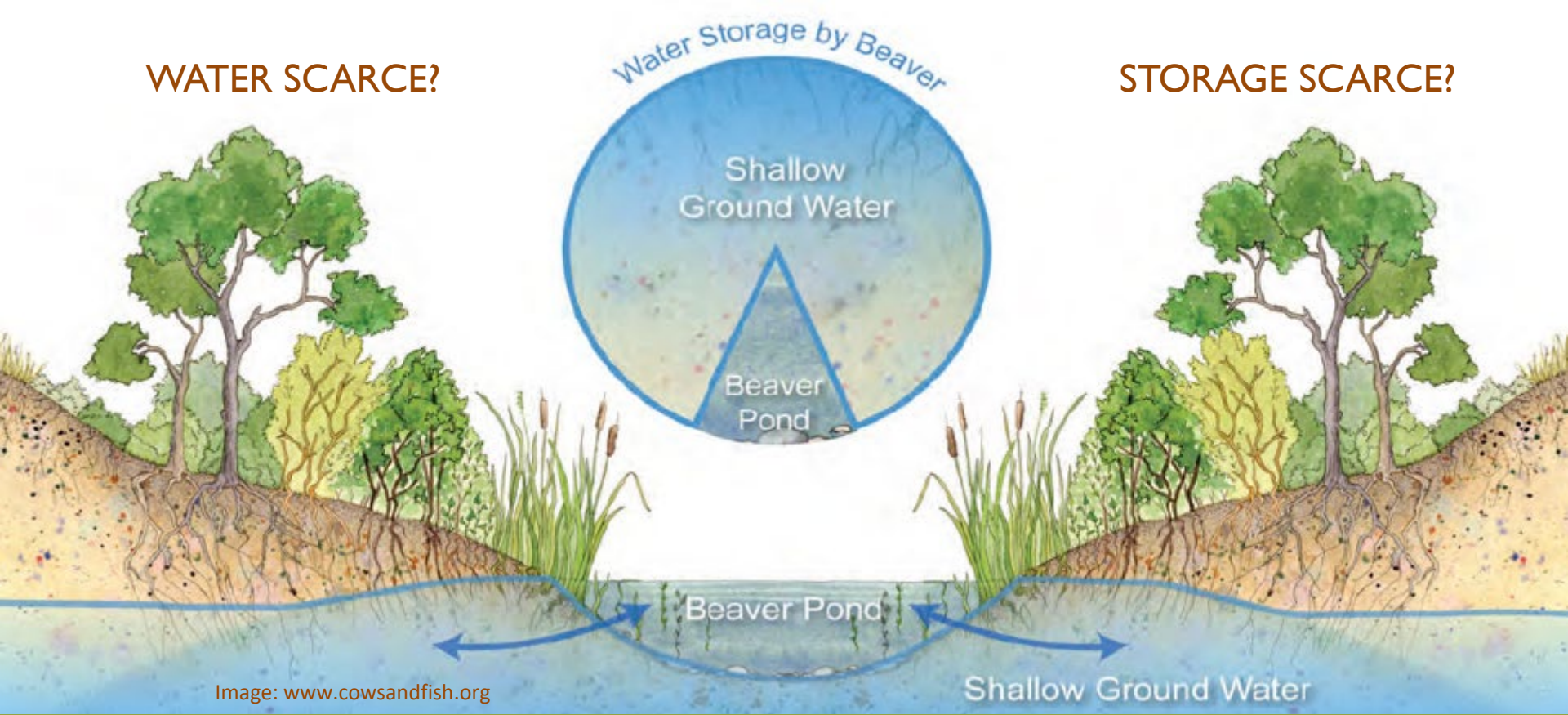
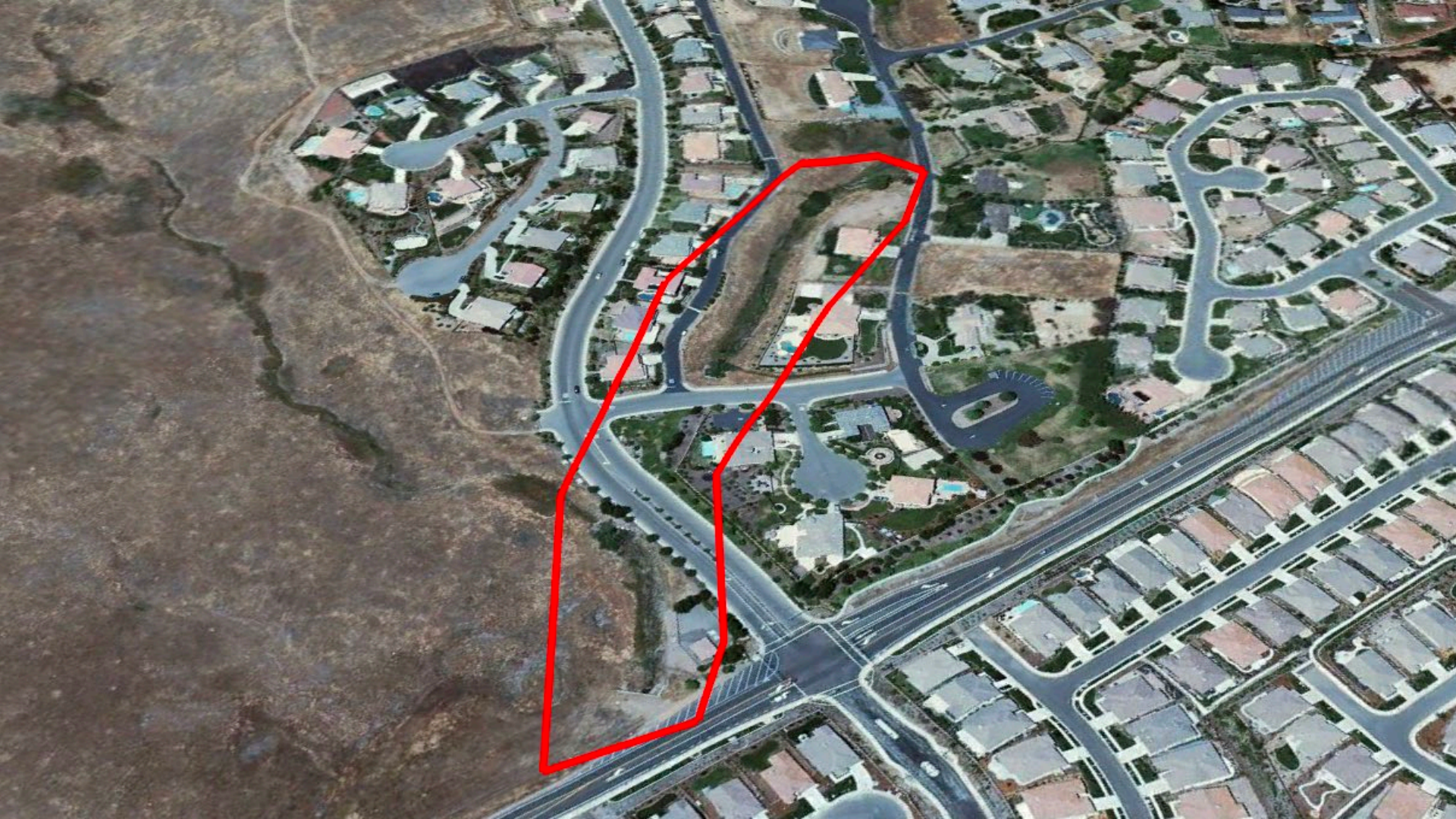
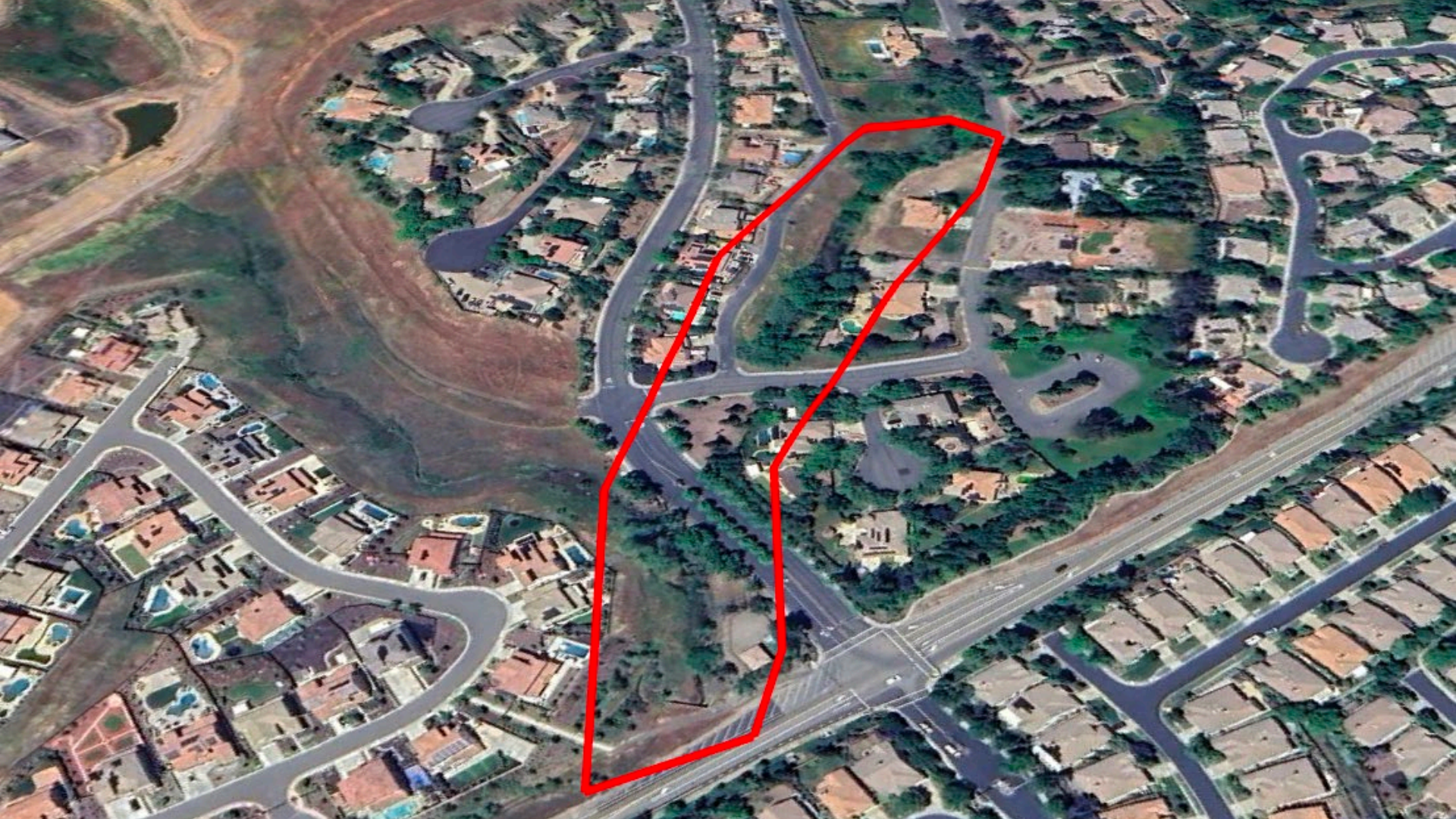
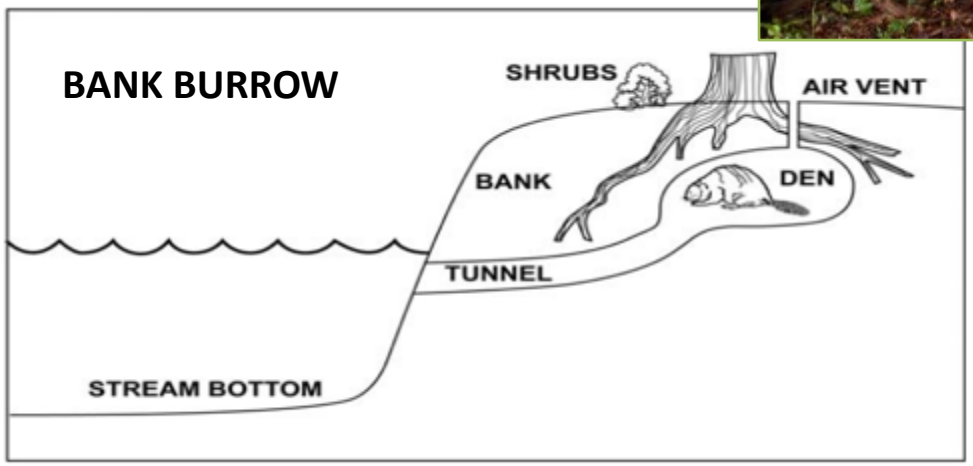


Image: www.cowsandfish.org





AQUATIC HABITAT IS CRITICAL TO BEAVERS' SUCCESS



SCIENCE SHOWS BEAVER WETLANDS HELP BUFFER CLIMATE EXTREMES

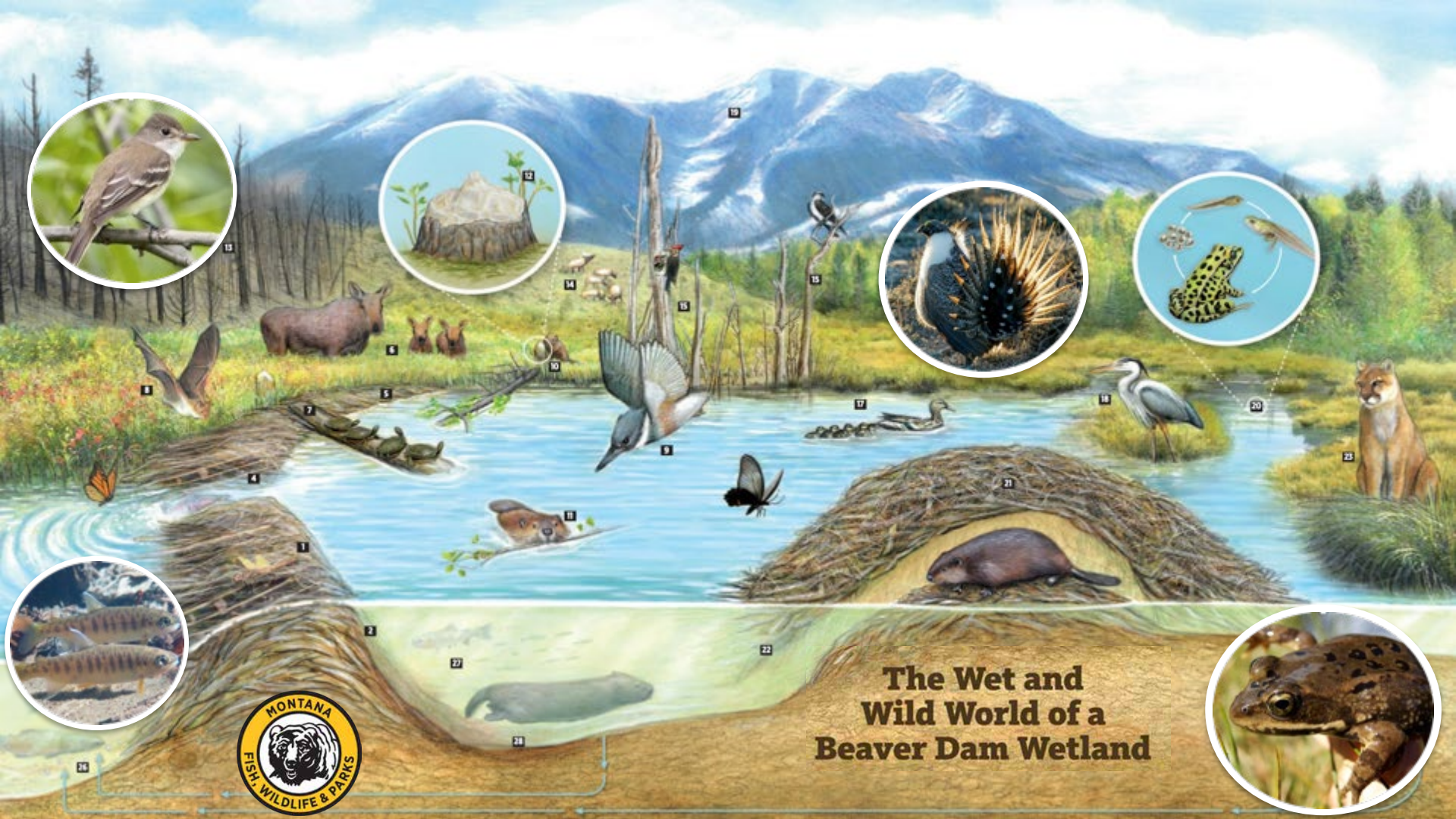
Photo: www.cowsandfish.org

- INCREASE WATER SURFACE AREA EVEN DURING DROUGHTS
- **ABSORB ENERGY FROM FLOODS AND INCREASES RIPARIAN RESILIENCY TO WILDFIRE**

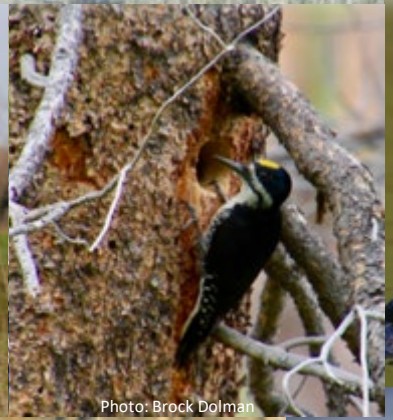
Photo: www.joewheaton.org

"Smokey the Beaver: beaver–dammed riparian corridors stay green during wildfire throughout the western USA"
by Fairfax and Whittle, 2020

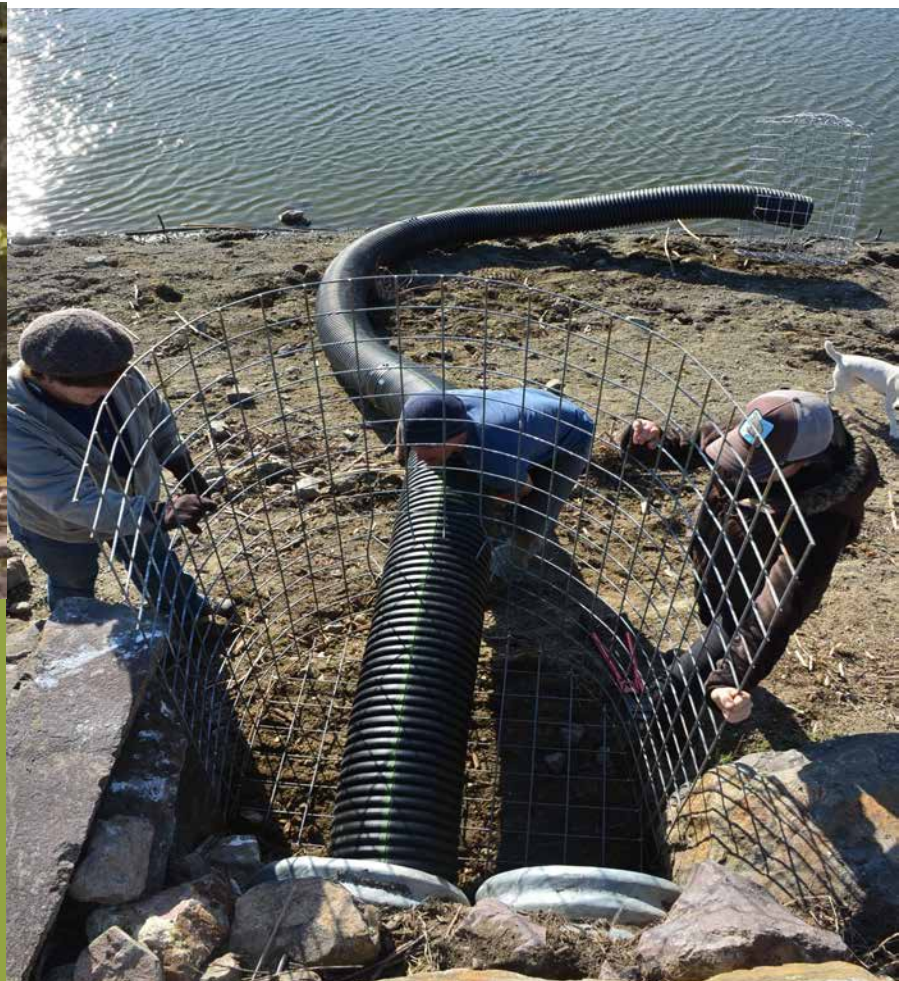
http://doi.org/10.1002/eap.2225

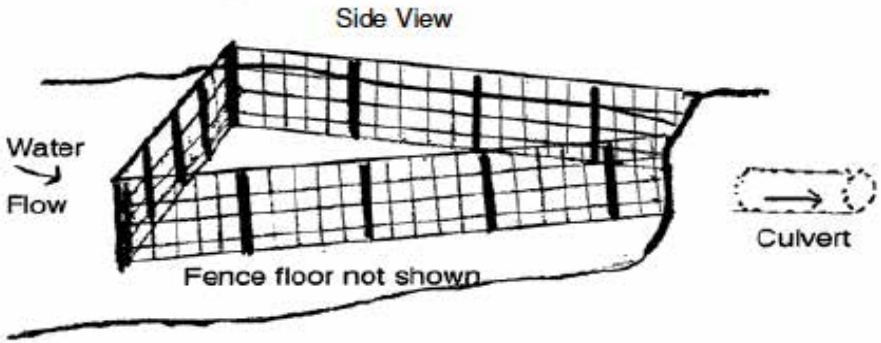

The Wet and
Wild World of a
Beaver Dam Wetland
MONTANA
FISH, WILDLIFE & PARKS

MANY FOCAL SPECIES OF CONCERN BENEFIT FROM BEAVER AND PROCESS-BASED RESTORATION



COEXISTENCE - PROTECT CULVERTS AND DRAINS





STOP FLOODING WITH FLEXIBLE POND LEVELERS

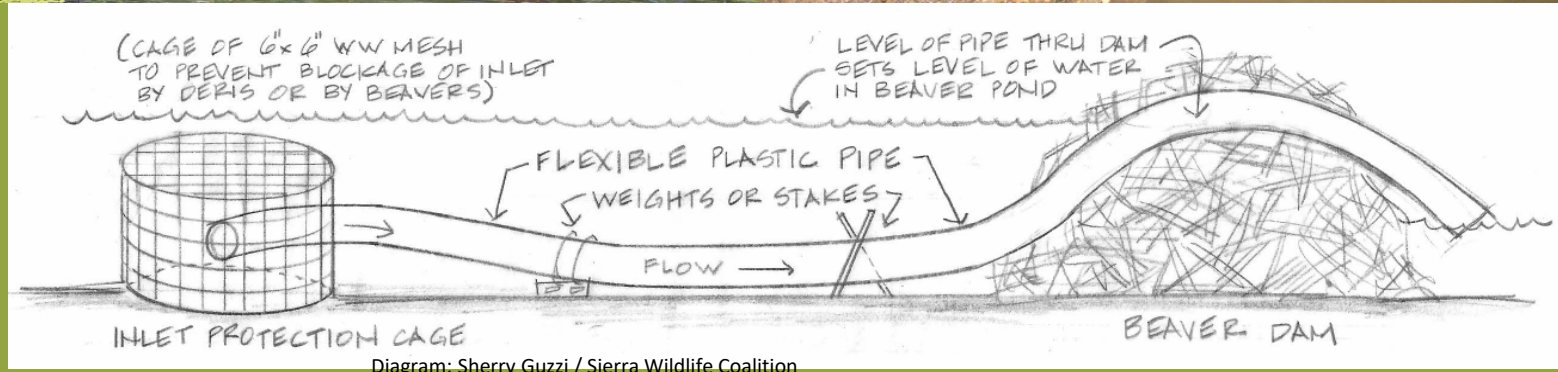
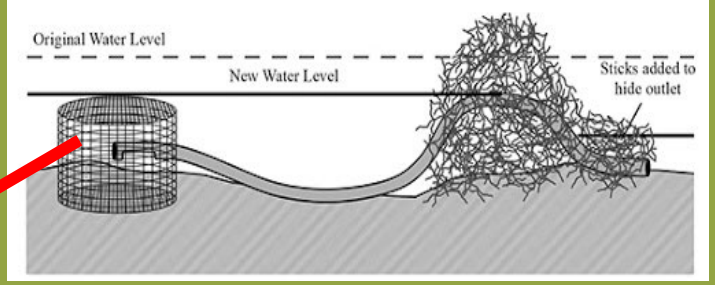
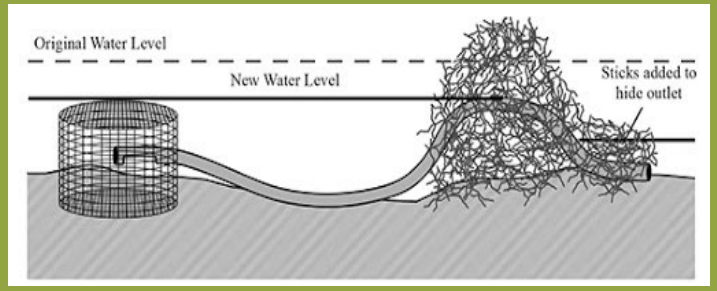


Diagram: Sherry Guzzi / Sierra Wildlife Coalition



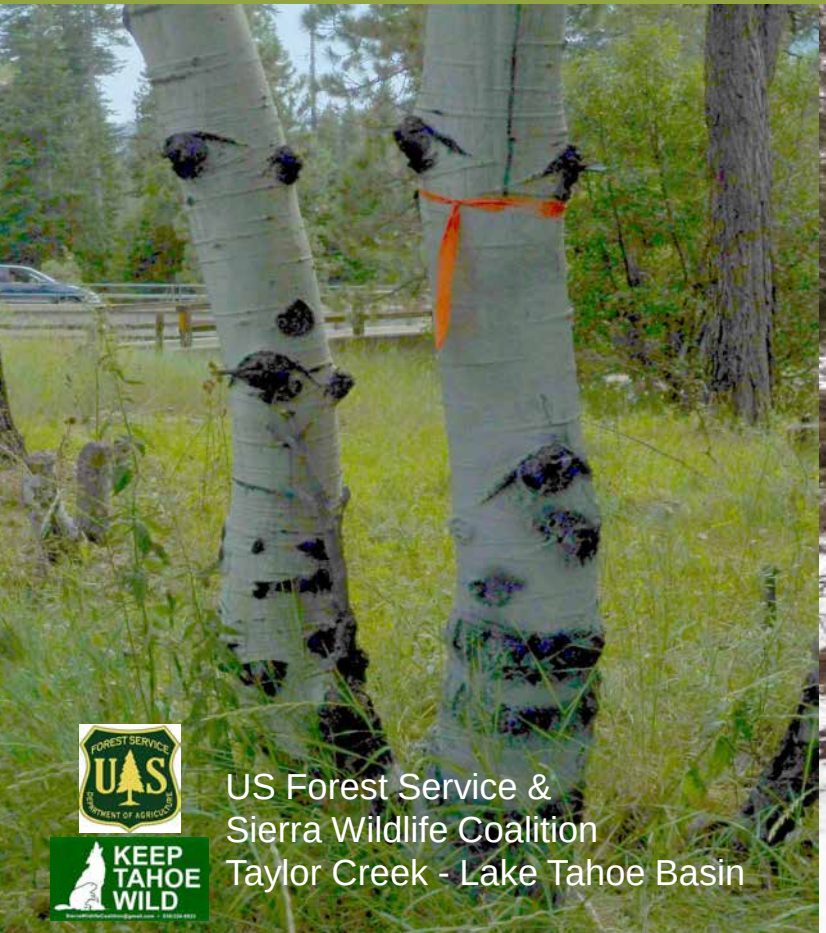
Pond leveler device



Pond leveler device

Sanitary manhole

PAINT OR FENCE VEGETATION



US Forest Service &
Sierra Wildlife Coalition
Taylor Creek - Lake Tahoe Basin

Welcome to the California Beaver Help Desk

Living alongside beaver can be a challenge. Explore the Help Desk to find technical support, financial assistance, and training opportunities that turn beaver problems into beaver solutions.

GET STARTED

WATCH PRIOR WEBINAR RECORDING

https://youtu.be/_46bdPJUxyk?si=n0Xr7PWtoi3xNJ1d

Beaver Coexistence Program Page

https://oaec.org/projects/california-beaver-coexistence-training-and-support-program/

Beaver Help Request Form

https://docs.google.com/forms/d/e/1FAIpQLSe1N80DC-fvMMxCiLnWdaJnYMla8nci-SZI3dQb3pS3nqOlaQ/viewform

Beaver Restoration Web Portal

www.oaec.org/beaver

Serving…

- Duck clubs
- Parks (local, regional, State, Federal)
- Wetlands Managers
- Homeowners
- Farmers- especially almond growers
- Ranchers

<u>Contact</u>

cabeaverhelp.org

Dr. Grey Hayes – *grey@oaec.org*