

Effectiveness of meadow and wet area restoration as an alternative to watercourse and lake protection (WLPZ) rules

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Final Presentation to California's Board of Forestry
Effectiveness Monitoring Committee



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IMPACT STATEMENT

CCR § 933.4 [e] states:

All trees within aspen stands, meadows and wet areas may be harvested or otherwise treated in order to restore, retain, or enhance these areas for ecological or range values.

PROBLEM

- Fire suppression, poor grazing practices, and climate change has accelerated encroachment of conifers (*specifically Pinus contorta*) into meadow habitat.
- Meadow habitat has been decreasing in the Sierra Nevada and Cascades.

BENEFITS

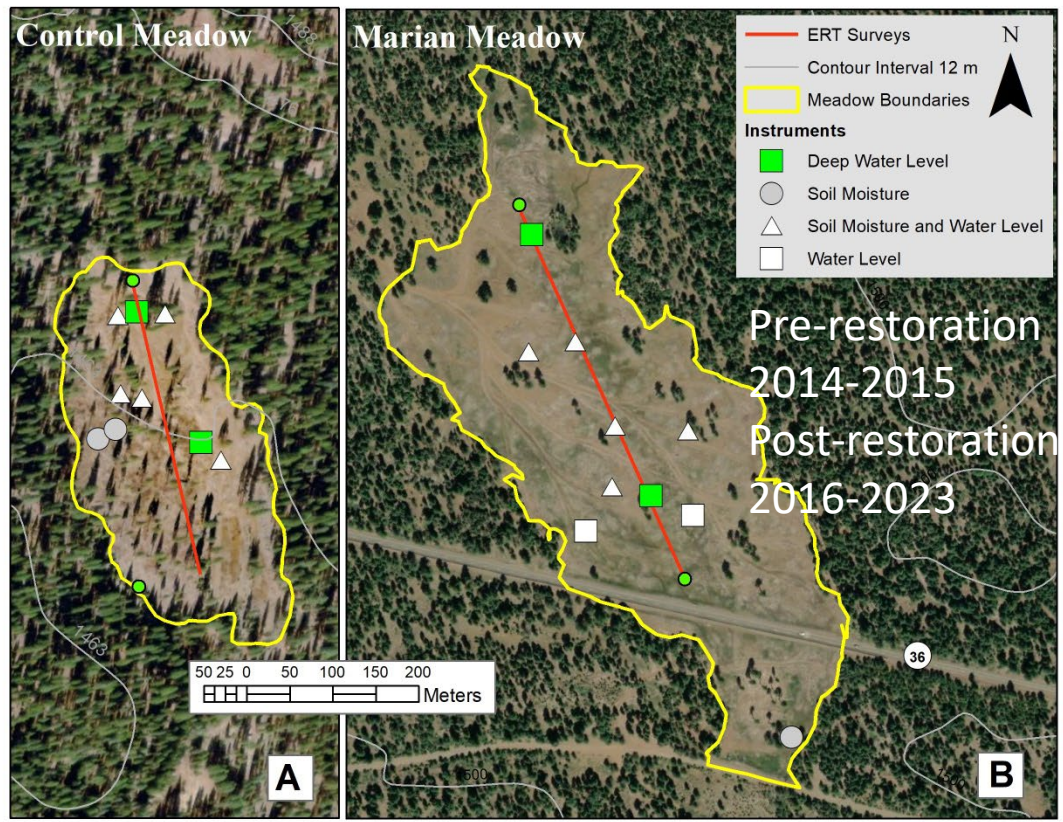
- Increased meadow habitat and its associated ecosystem services.
- Meadow openings create natural fire breaks in forested regions.
- Effective mitigation to industrial forest operations.
- Flexibility in forest practice regulations toward environmental goals.
- Training of environmental scientists in field data collection, analysis, and monitoring.



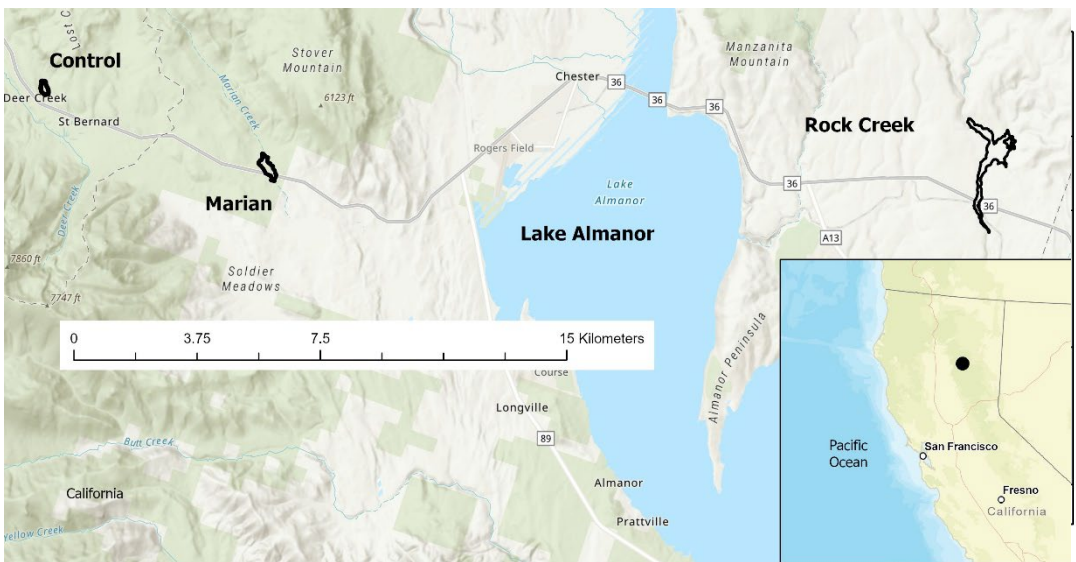
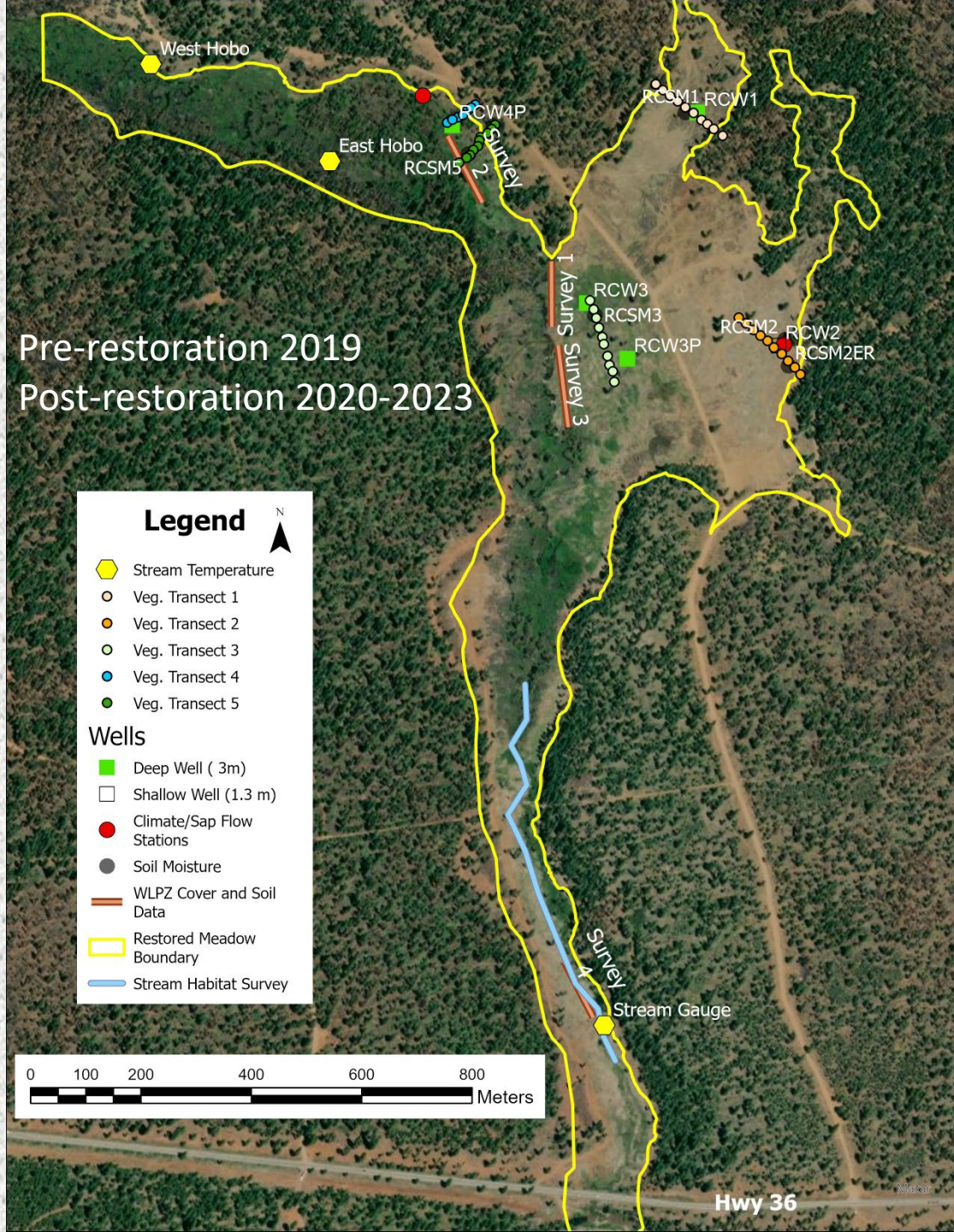
Research Objectives



- Objective 1. Quantify the hydrologic and vegetative response from removal of encroached *Pinus contorta* to restore meadow and wet area habitat across varied locations.
- Objective 2. Determine if key water quality metrics are affected by meadow restoration and WLPZ removal in Rock Creek.
- Objective 3. Quantify the amount of soil disturbance and compaction within the WLPZ and meadow following meadow restoration.



Study Areas





Before
Control



After
Intervention (BACI)

**Encroached Conifer Marian
Meadow Basal Area
2014-2016**

110 (ft²/ac)

**Post Restoration Marian Meadow
2016-2023**

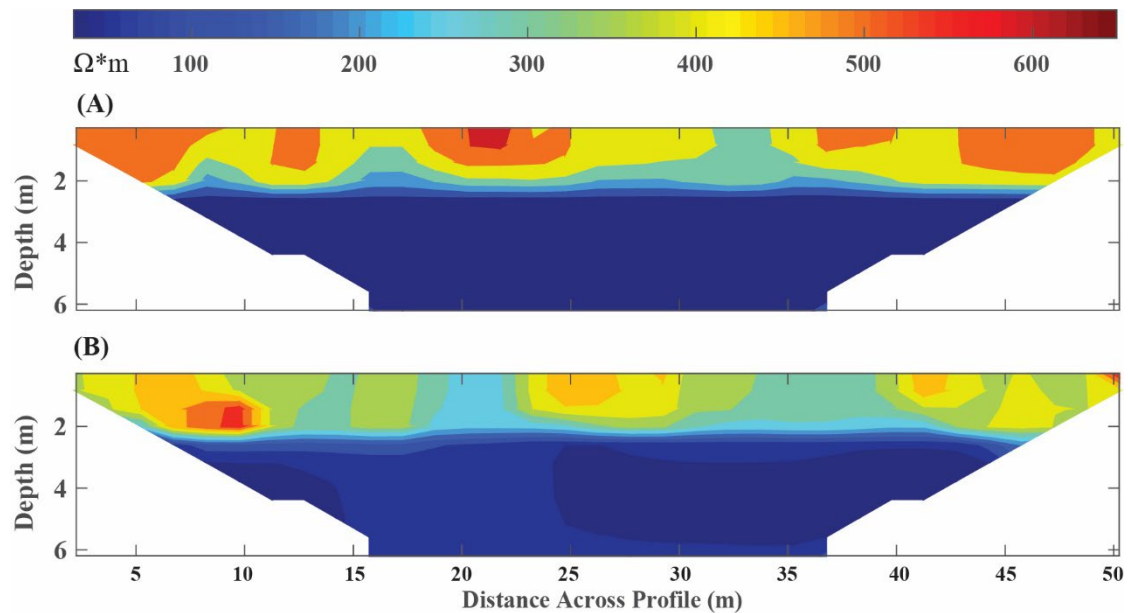


Hydrologic Measurements

- Soil Moisture 10-100 cm depths
- Groundwater wells 1.3 -3 m deep
- Climate Stations
- Sap flow (2019-2020)

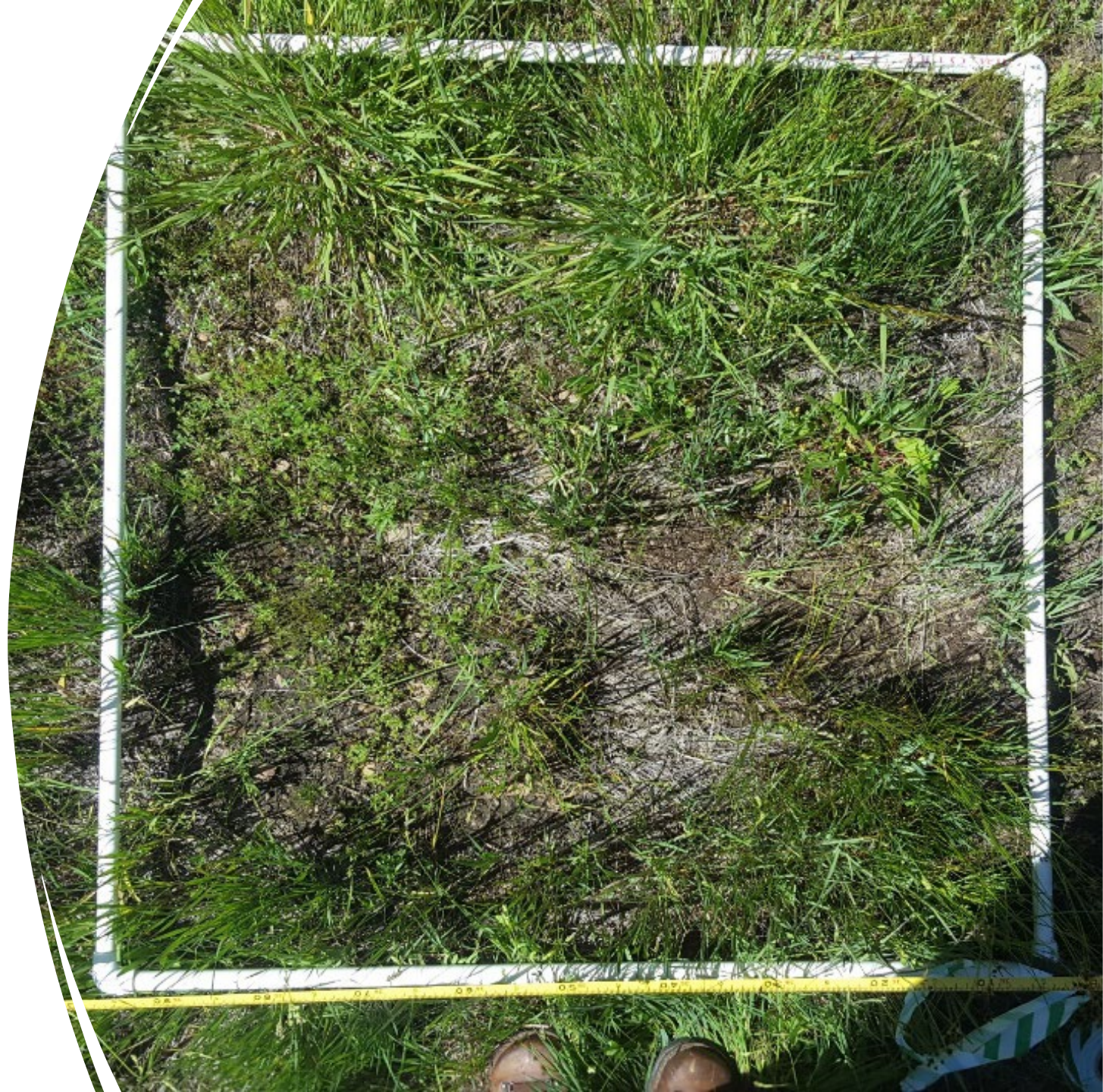
Electroresistivity Tomography

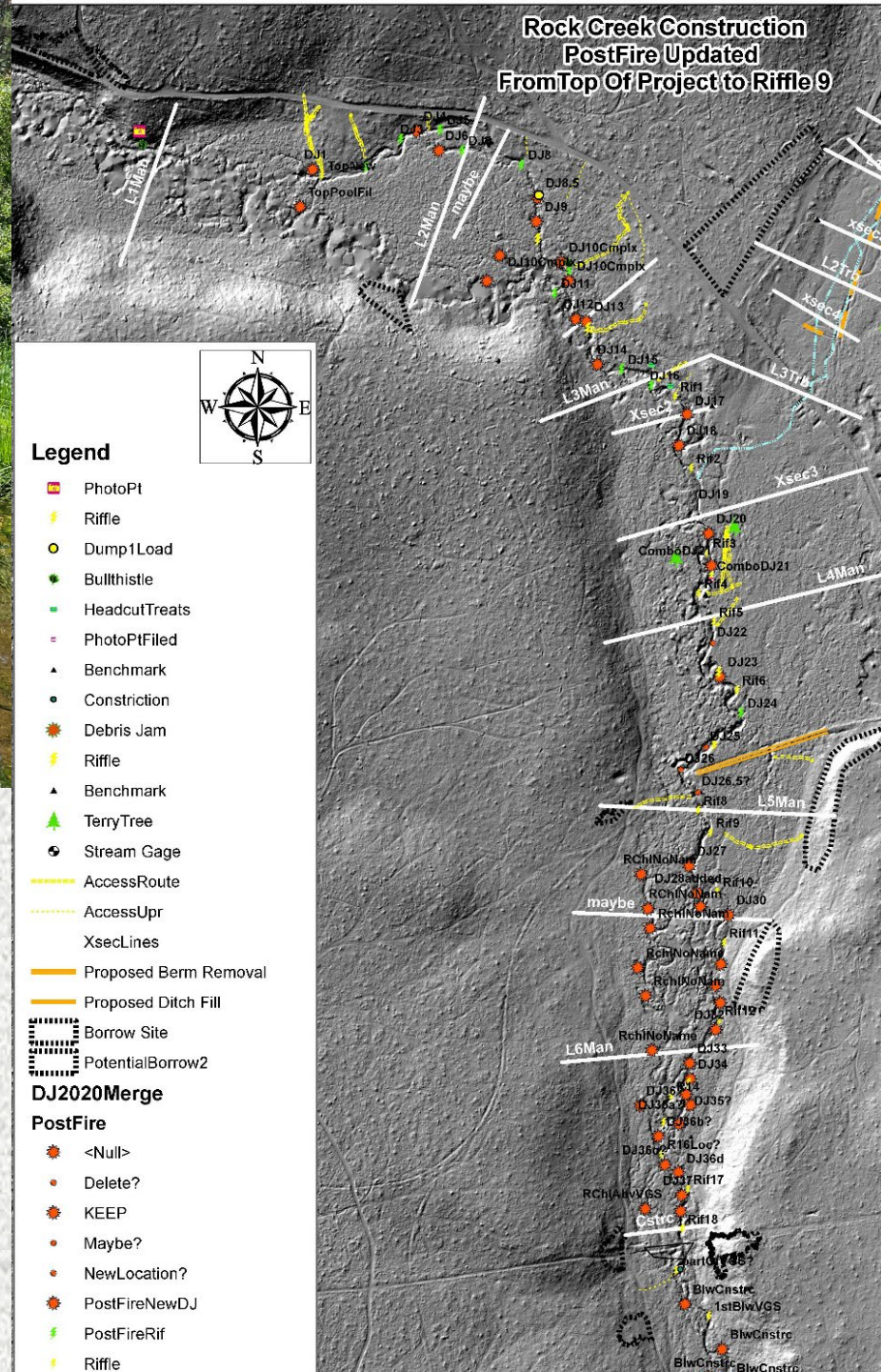
- Long deep plots at Marian, Control, Rock Creek Meadows
- 3-D image pre- and post-restoration Rock Creek Meadow



Rock Creek Meadow Vegetation Response 2019-2022

- 5 Vegetation transects with 10 – 1 m² plots
- Evaluate shift to wetland functional plants, species diversity following conifer removal.





Instream Restoration Work at Rock Creek by Plumas Corporation

- Permitting done through the Timber Harvest Plan process.
- Completed in 2021; just before the Dixie Fire.

Soil Disturbance and Compaction



4 locations – 500 feet long

Transects at 30, 50 and 75 feet from watercourse.

Classified by length:

Cover Designations
Vegetation
Litter
Rock or Gravel
Large Wood
Other: Woody Litter
Bare Soil Designations
Undisturbed
Road
Disturbed
Burned

Randomly selected soil bulk density samples at transects at all 4 locations.

Stream Conditions (2,125 feet of Rock Creek)

Measured particle size distribution and cobble embeddedness

Evaluated the pool:riffle percentage and residual pool depths

Stream temperature above and below treatment area.





Dixie Fire Effect
2021

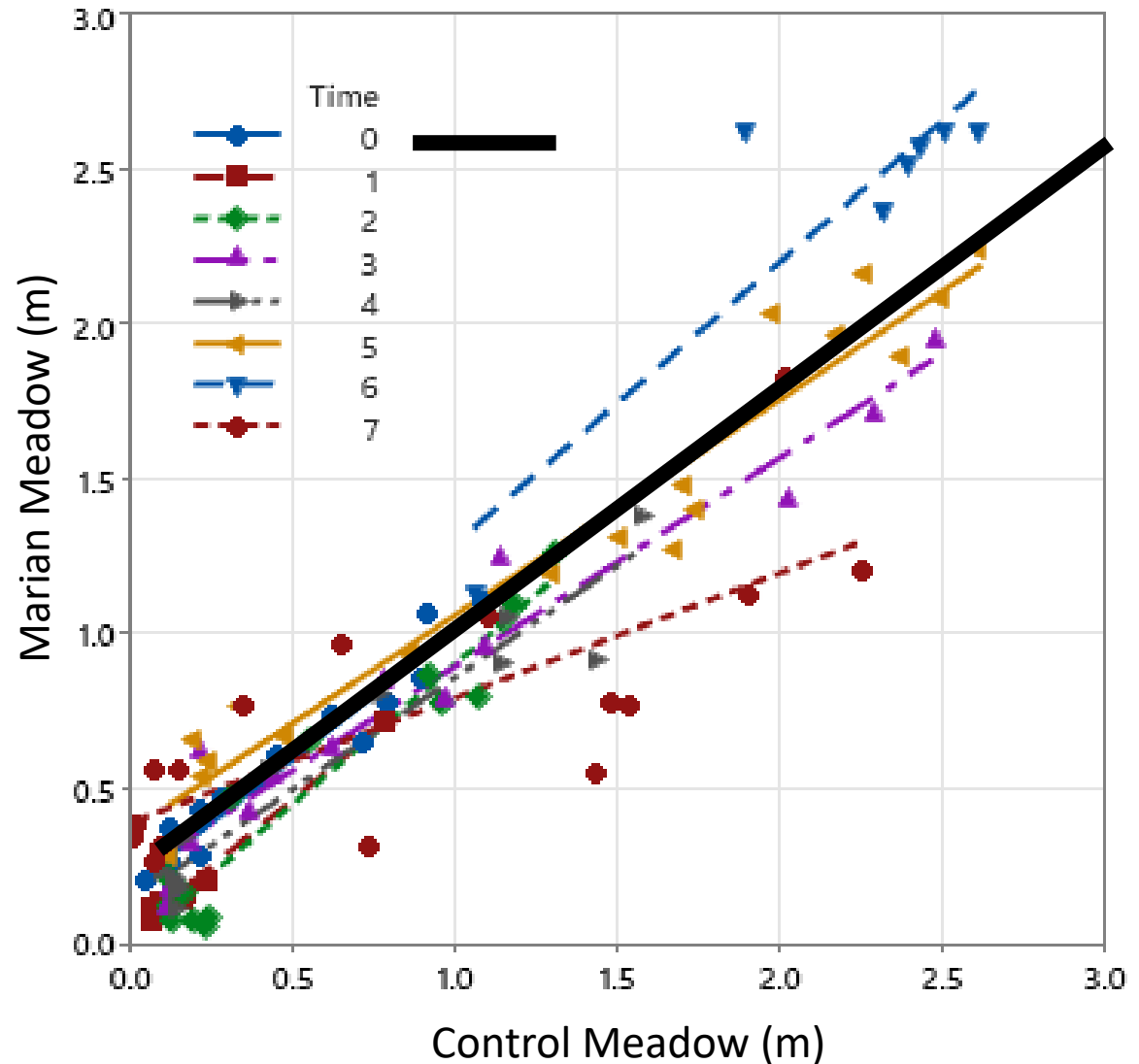
Fire road through Rock Creek
Meadow during Dixie Fire



Marian Meadow Study 2013-2022

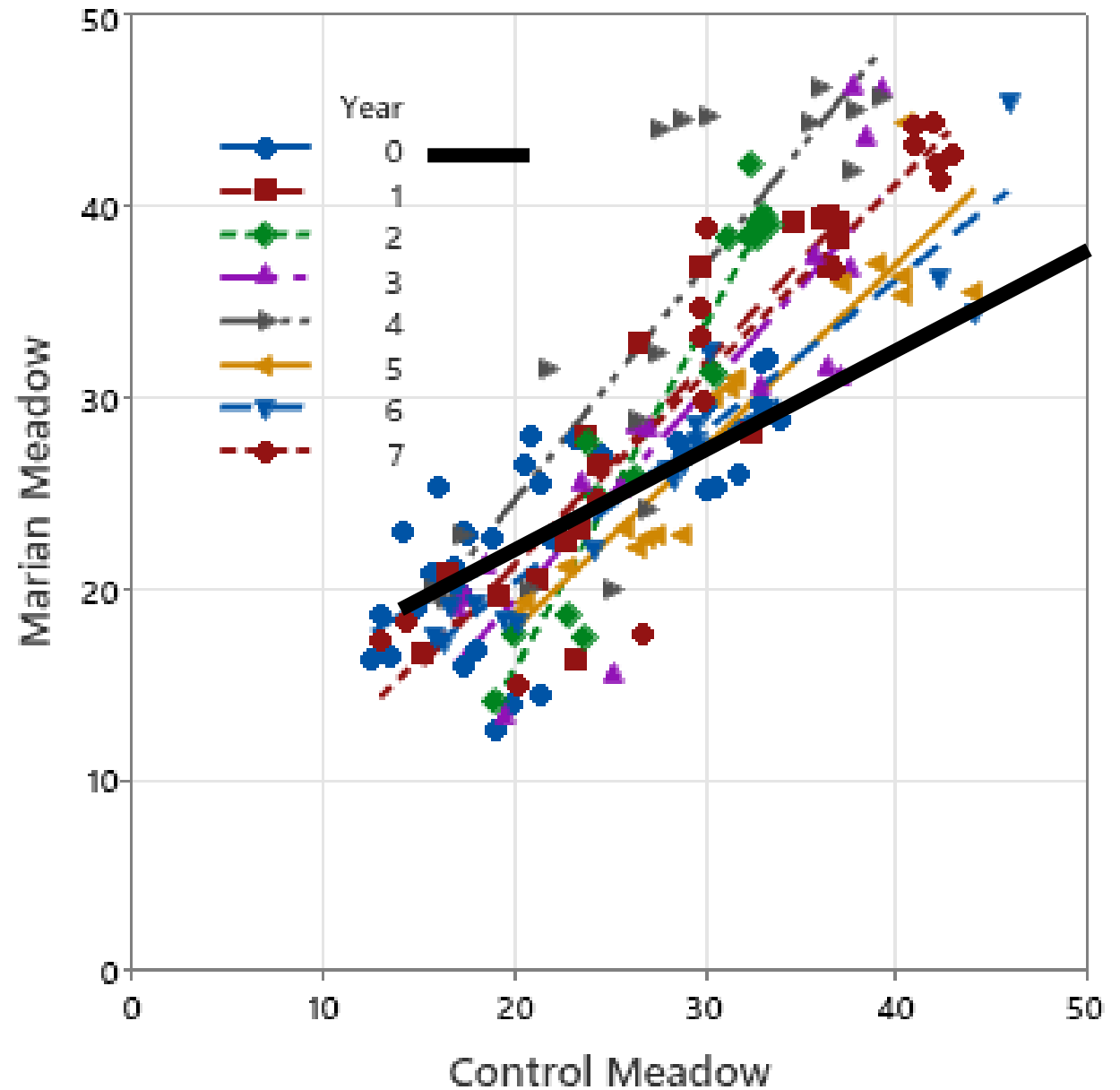
- Increase in groundwater in Marian Meadow following conifer removal, except for 2020-2021.
- Average 0.06 m increase in groundwater depth
- Increase attributed to loss of interception from removal of encroached conifer (Surfleet et al., 2020).

Depth to Groundwater



Marian Meadow Study 2013-2022

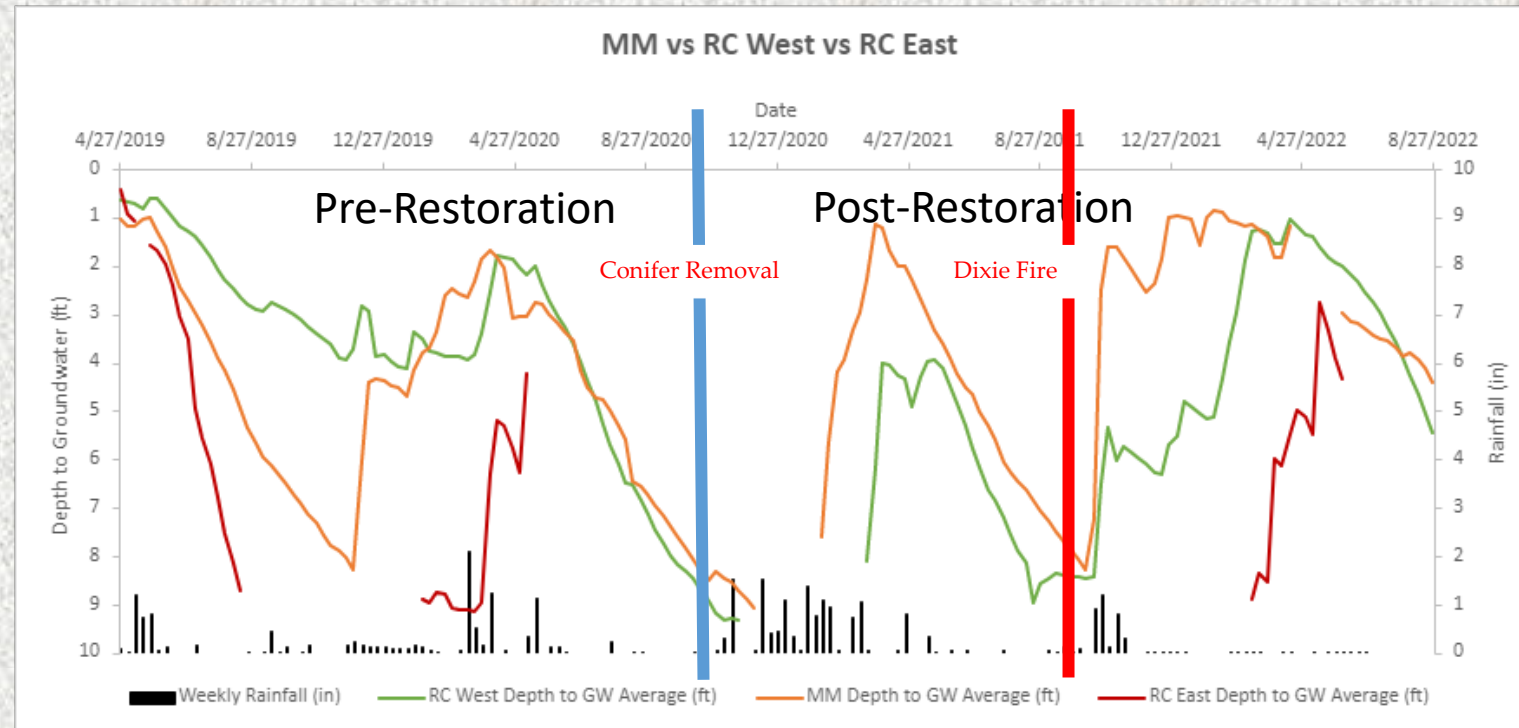
- Increase in shallow soil moisture in wet season.
- Decrease in soil moisture in dry season in years directly after tree removal.
- Decrease attributed to loss of shade cover or increased transpiration of meadow vegetation from removal of encroached conifers.



Rock Creek Meadow Study 2019-2022

- No statistical difference in groundwater 2nd year following restoration.
- First year decrease in groundwater. This was a drought year

Depth to Groundwater

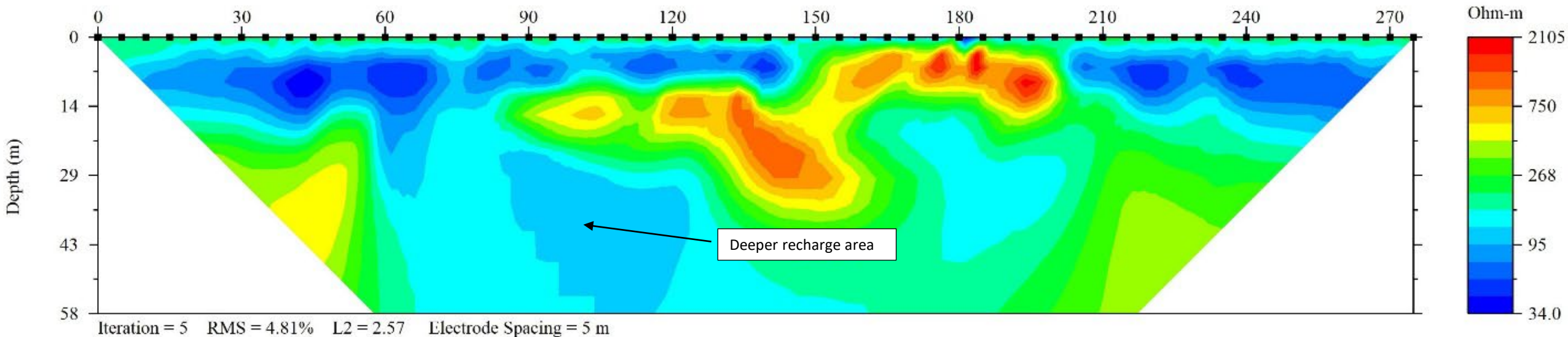
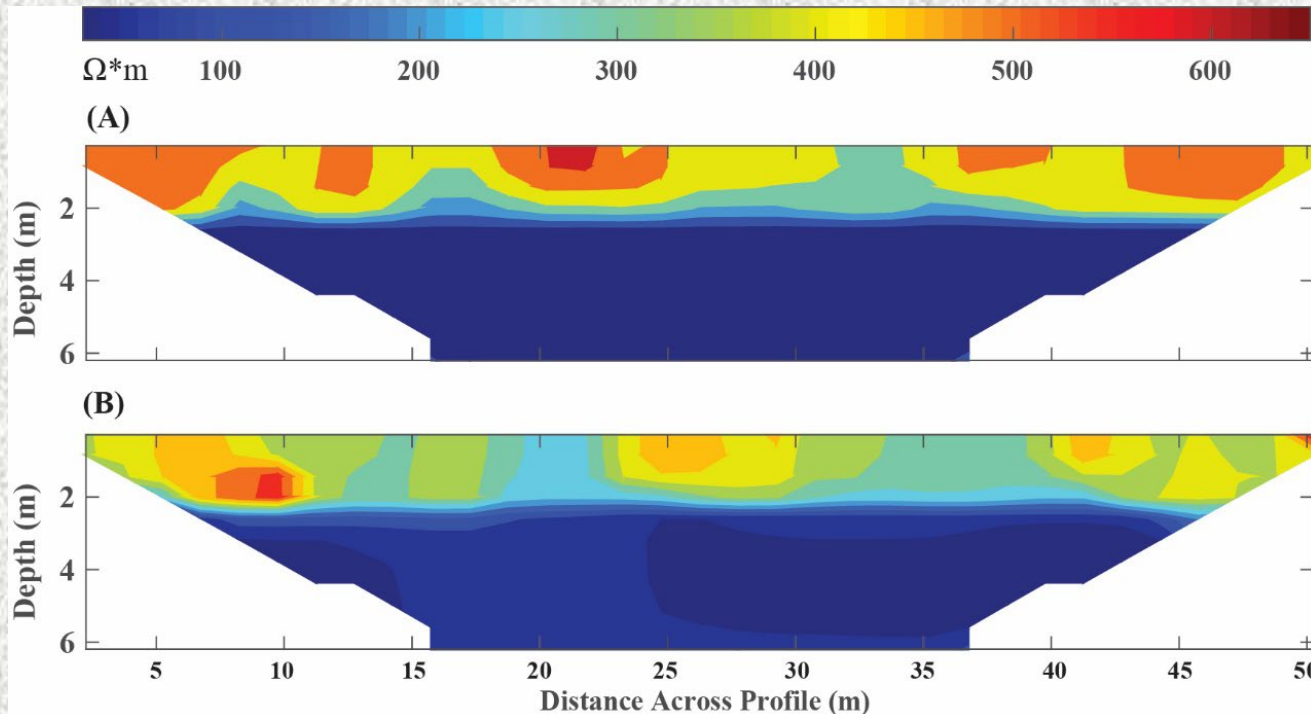


Electroresistivity Tomography



Marian Meadow

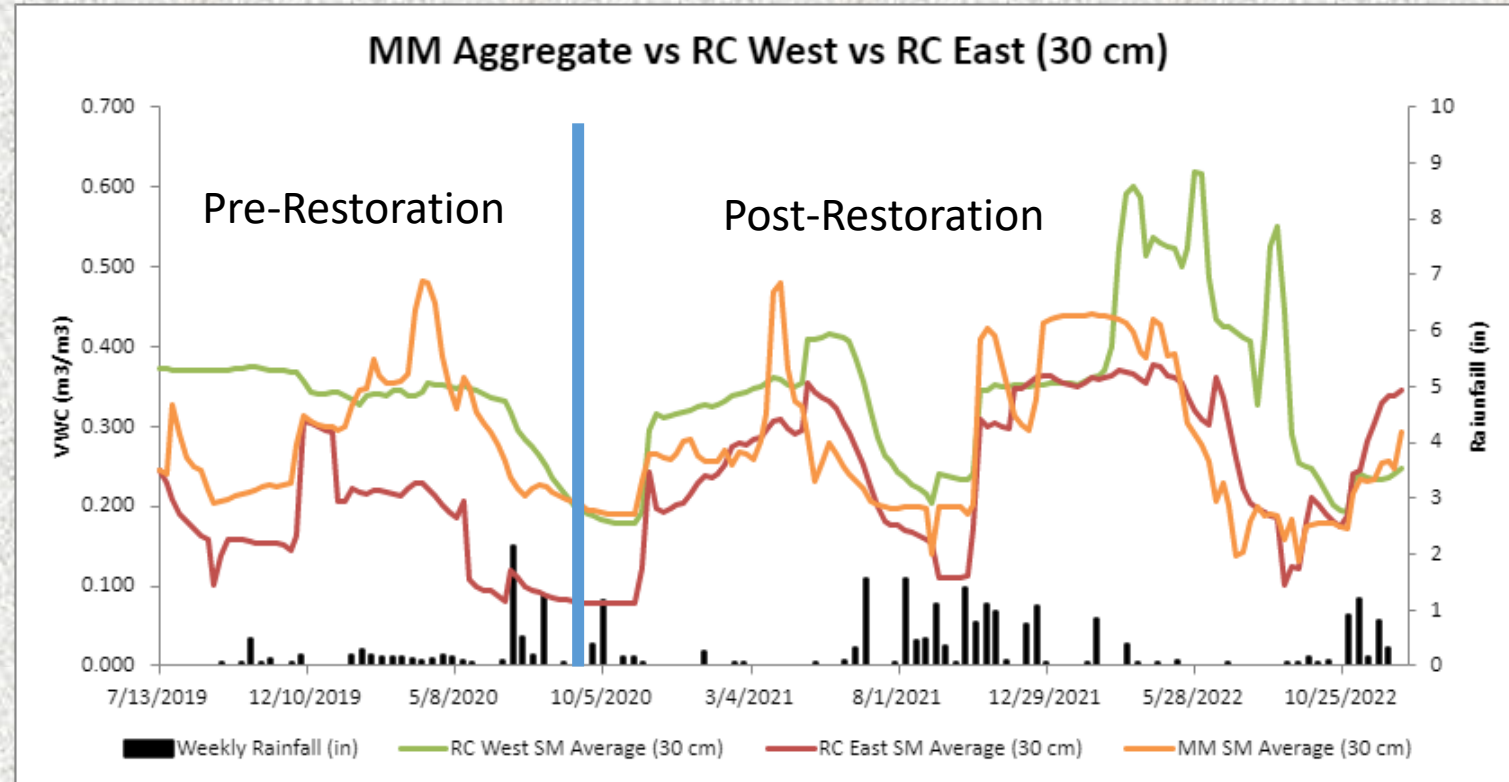
Rock Creek Meadow



Rock Creek Meadow Study 2019-2022

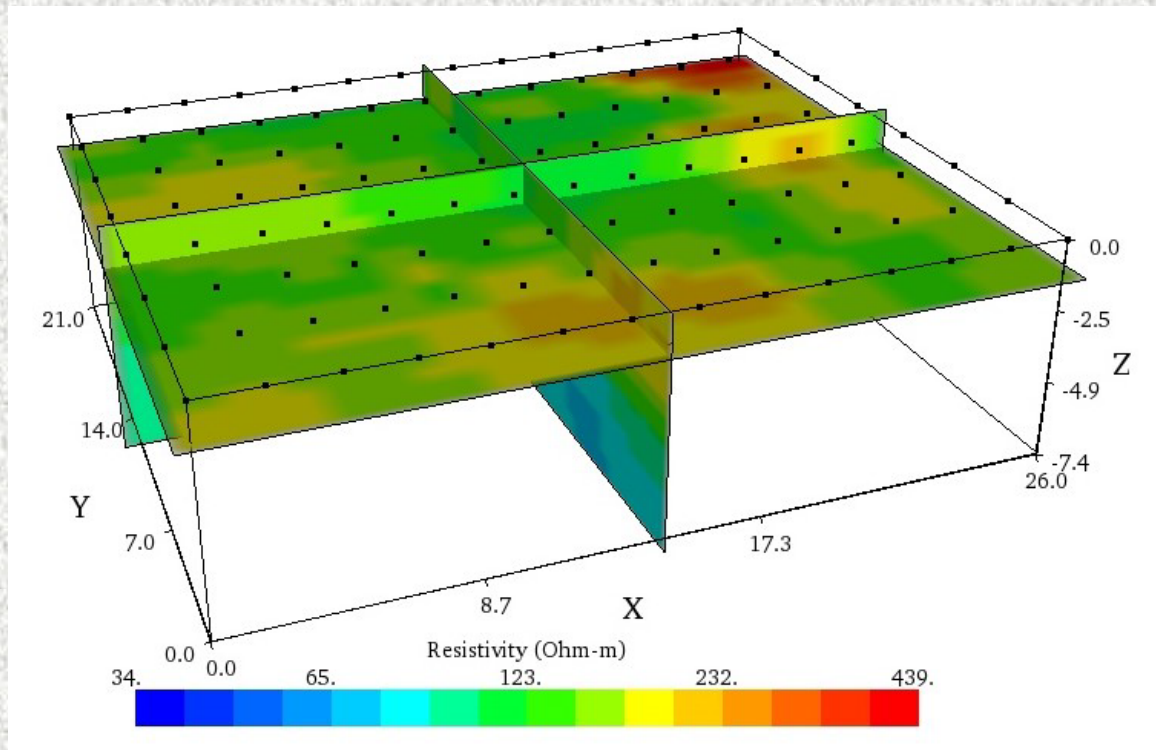
- Increased soil moisture in Rock Creek following *Pinus Contorta* removal.
- *Pinus Contorta* transpiration 200-300 mm/yr.

Preliminary Results

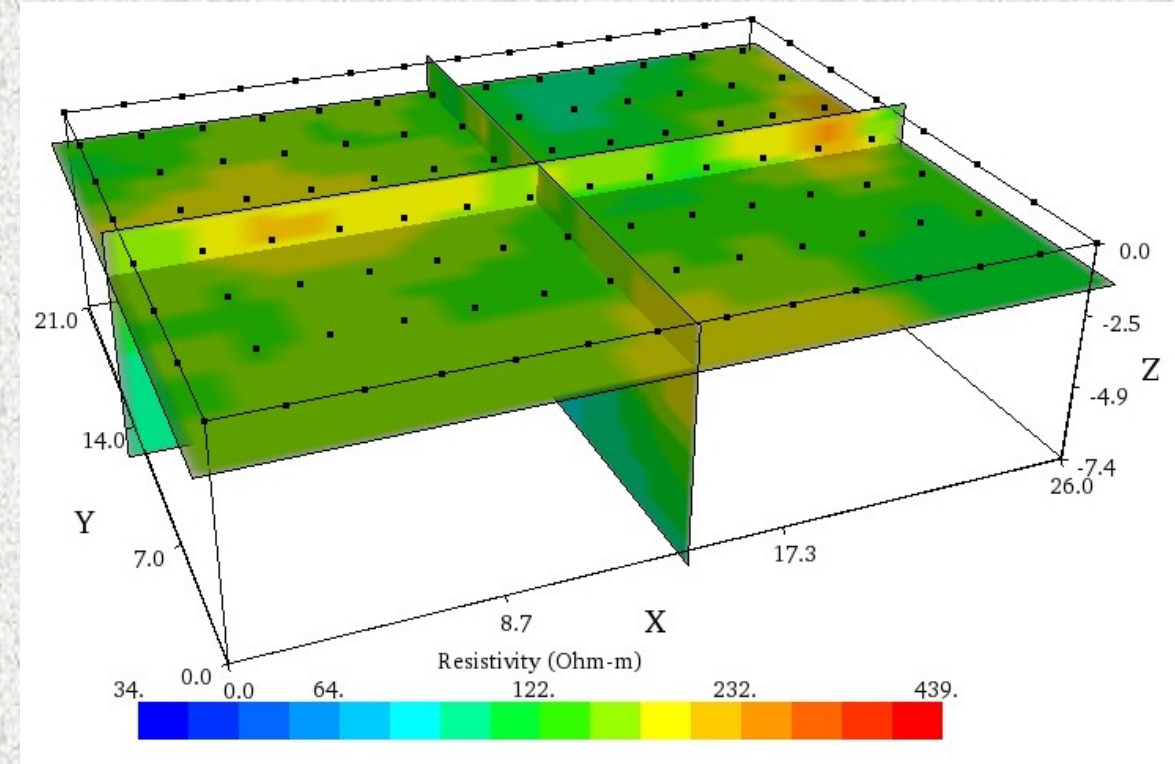


Three Dimensional Images of Electrical Resistivity

Rock Creek Meadow – Site 2



2020 pre-restoration



2021 post-restoration

Evapotranspiration and transpiration changes

2020 WY Rock Creek Meadow Sap Flow Results

Eastern Stratum 207 mm +/- 88 mm

Western Stratum 330 mm +/- 113 mm

Marian Meadow Water Budget Estimates

Meadow	WY	P (mm)	ET _s (mm)	Ic (mm)	ET (mm)	Error (mm)
Marian	2014	489	285	172	457	10
Marian	2015	636	268	214	482	7
Marian	2016*	937	318	107	425	-17
Marian	2017*	1169	276	124	401	-76
Marian	2018*	605	314	101	415	29
Marian	2019*	1019	299	100	399	53

* Post Restoration



Surfleet et al., 2019
Surfleet et al., 2020

Cost in US dollars for Plug and Pond Method meadow restoration per 1000 liter (1000 gallons). Adapted from American Rivers, 2012.

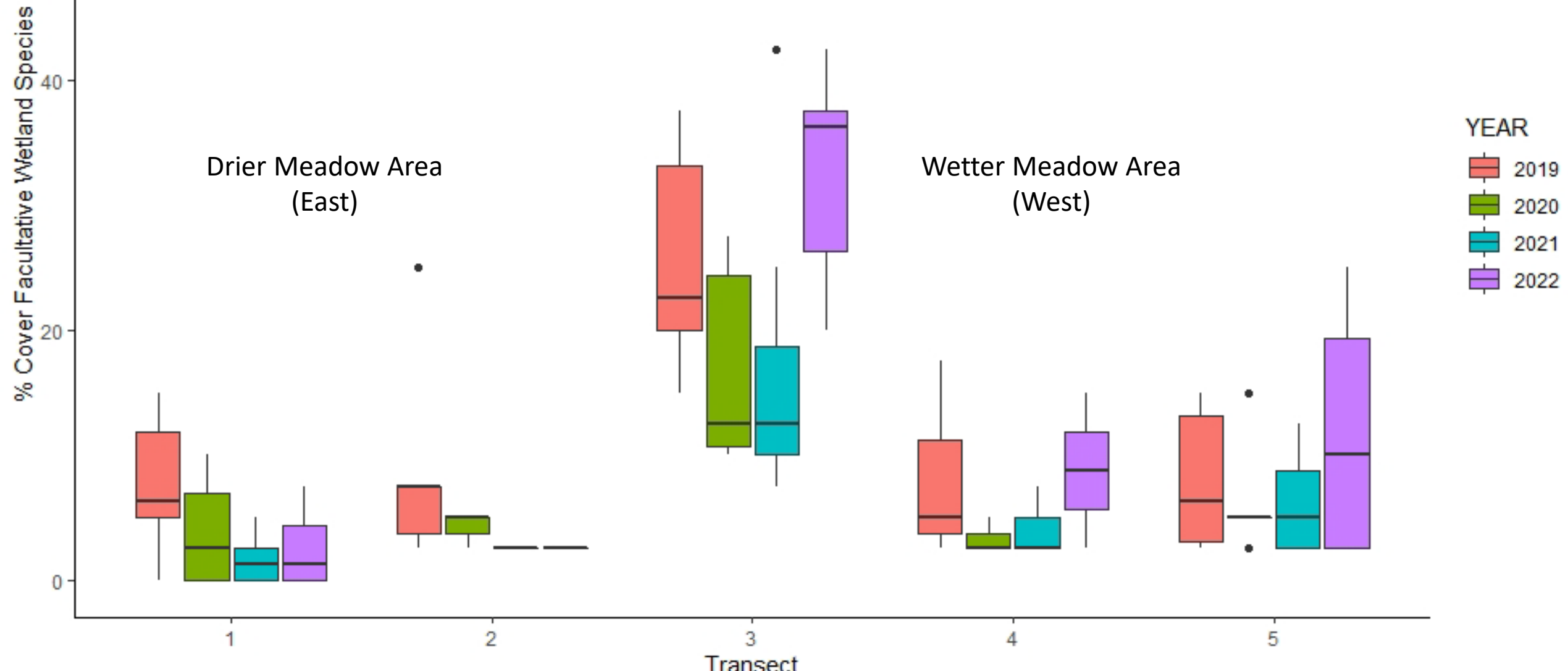
25 percentile cost/ 75 percentile increase in storage	\$1.32/1000 L (\$5/1000 gal.)
Median cost/ Median increase in storage	\$2.64/1000 L (\$10/1000 gal.)
75 percentile cost/ 25 percentile increase in storage	\$5.55/1000 L (\$21/1000 gal.)

The cost of conifer removal was \$78,750 United States dollars (USD).

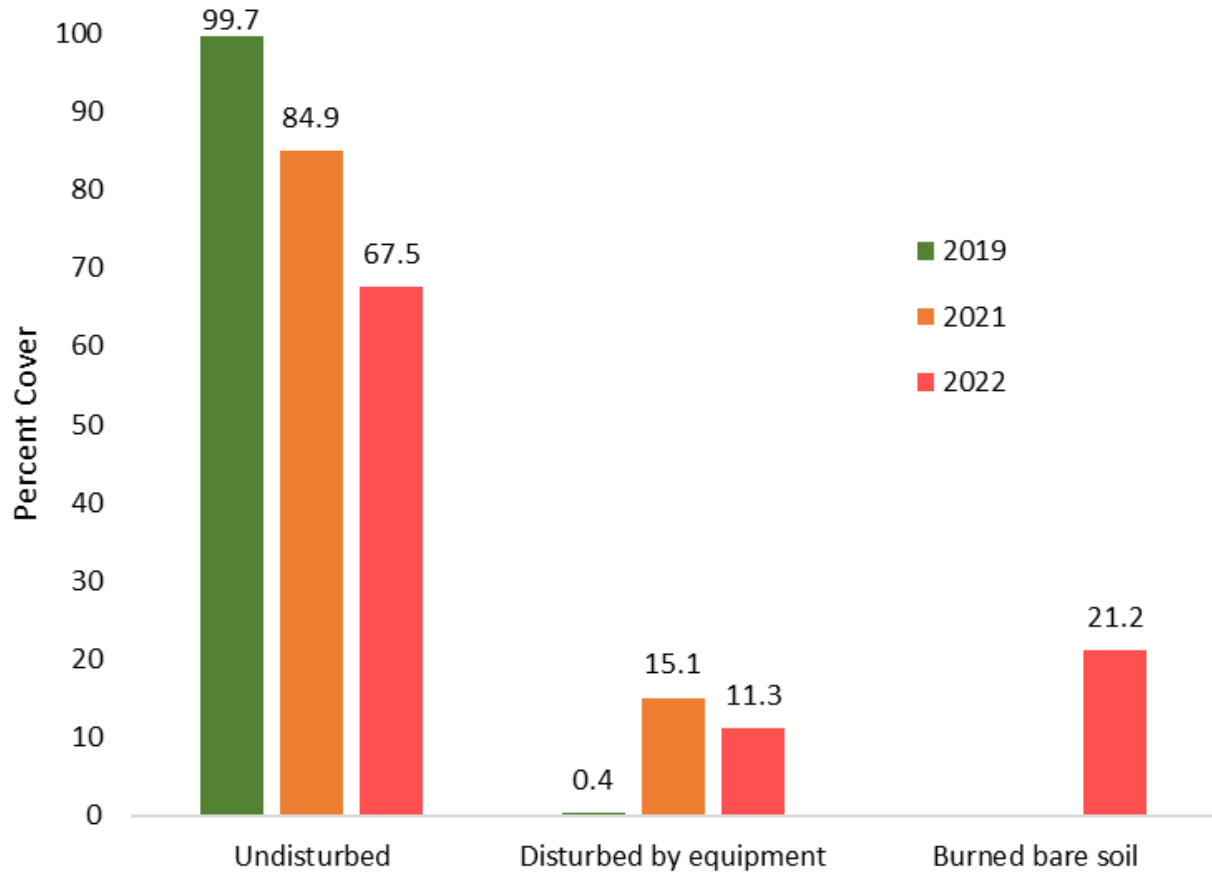
Cost per water Marian Meadow Restoration

\$0.69 USD/1000 L or \$2.62/1000 gal.

Vegetation Response Facultative Wetland Cover



WLPZ Soil Disturbance



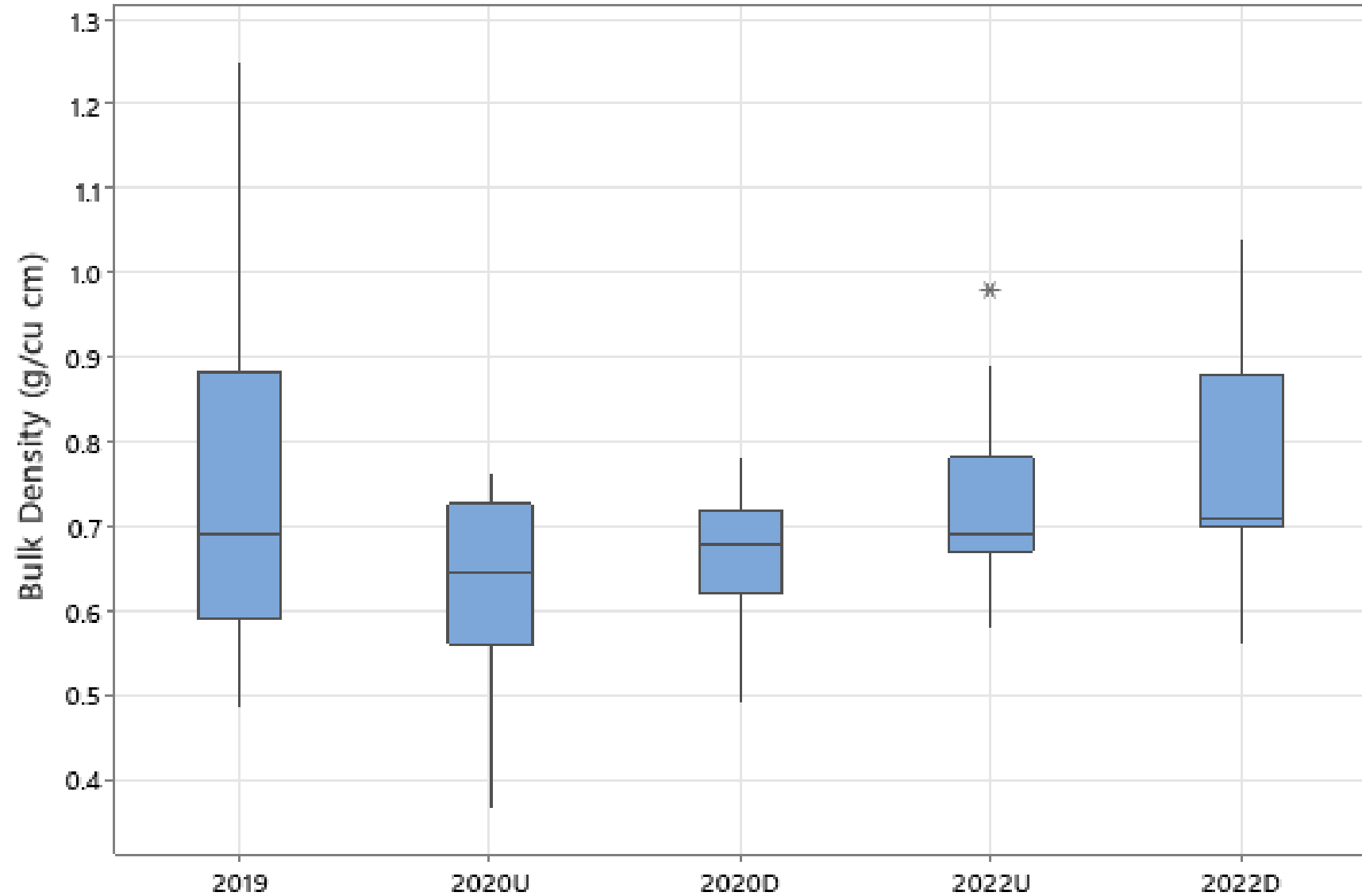
Meadow Soil Disturbance (bare soil)

Year	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
2019	9%	18%	0%	4%	1%
2020	7%	35%	0%	2%	2%
2021	28%	39%	1%	4%	3%
2022	47%	48%	12%	25%	37%

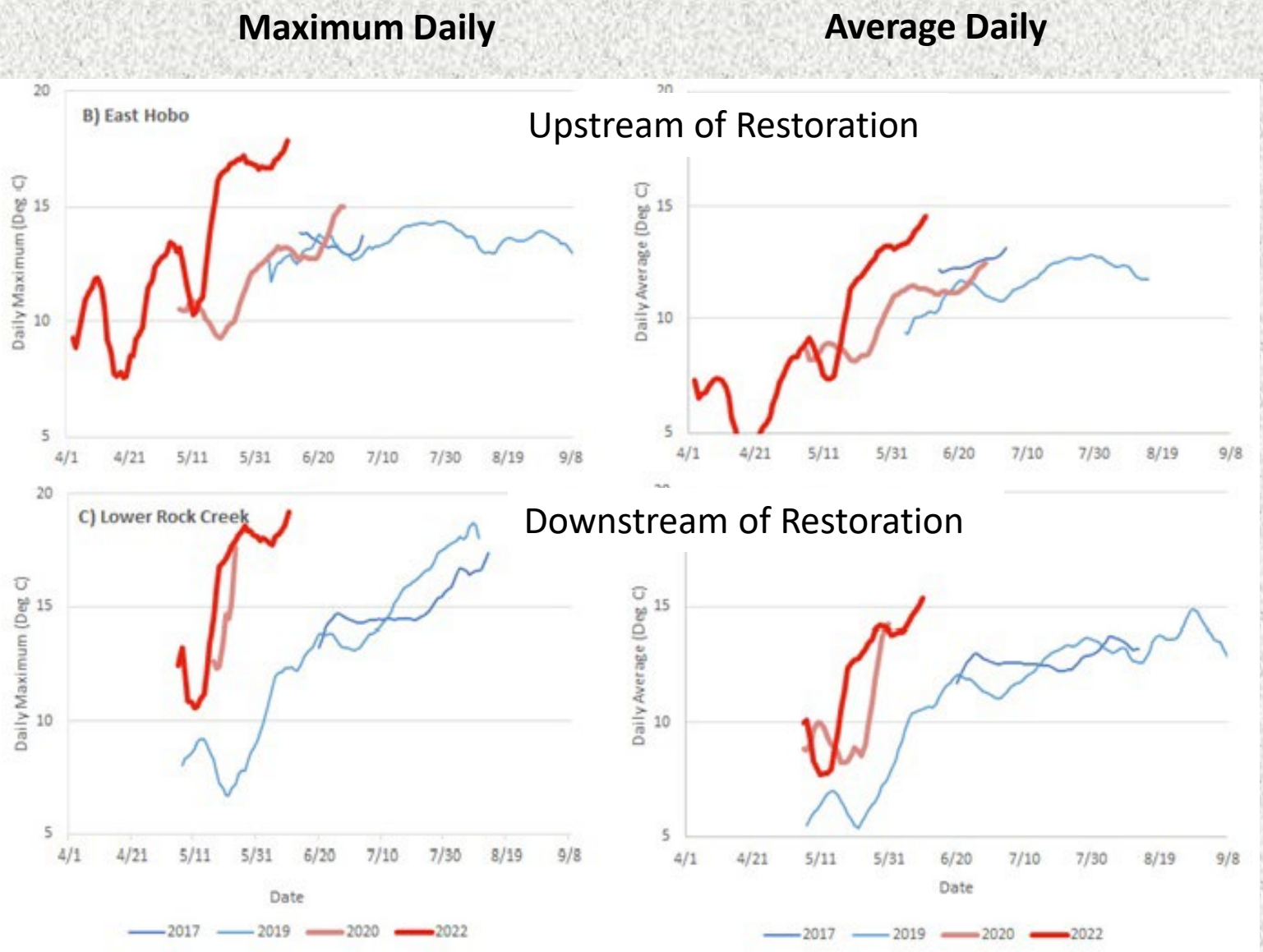
Soil Bulk Density in the WLPZ

No statistical difference

- Low soil moisture
- Limits on equipment in WLPZ
- High organic matter in soil



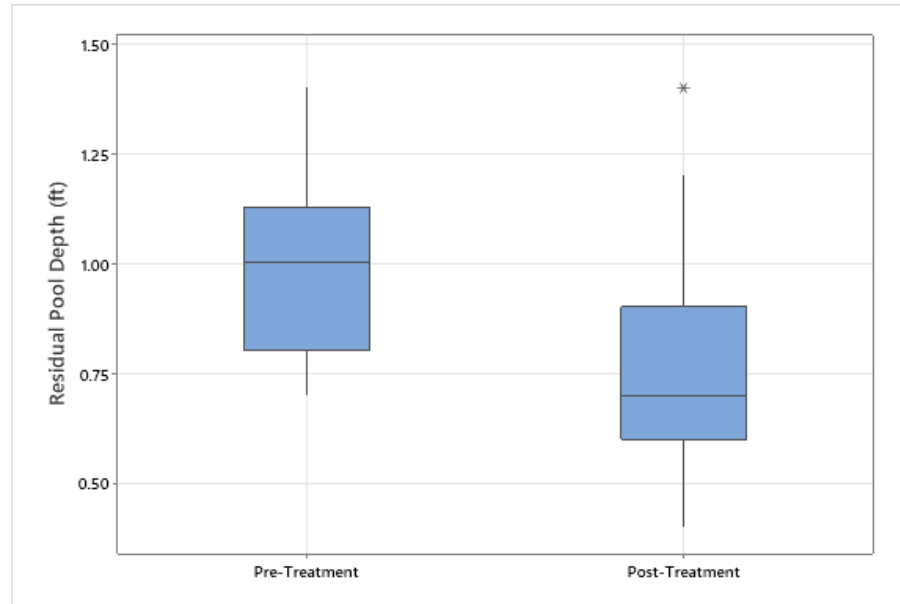
Stream Habitat Response



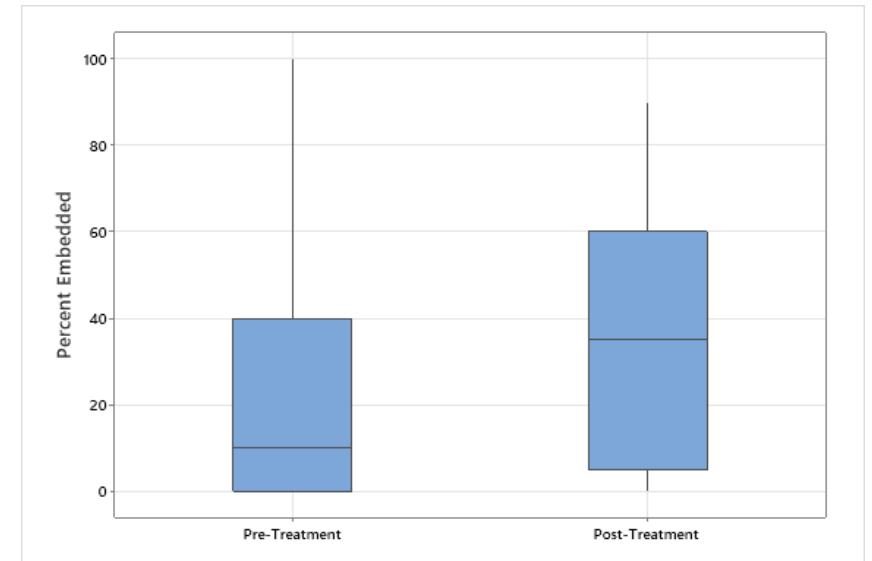
- Before
- After
- After Fire

Stream Habitat Response

Slight decrease in pool habitat and pool depths following restoration and fire.

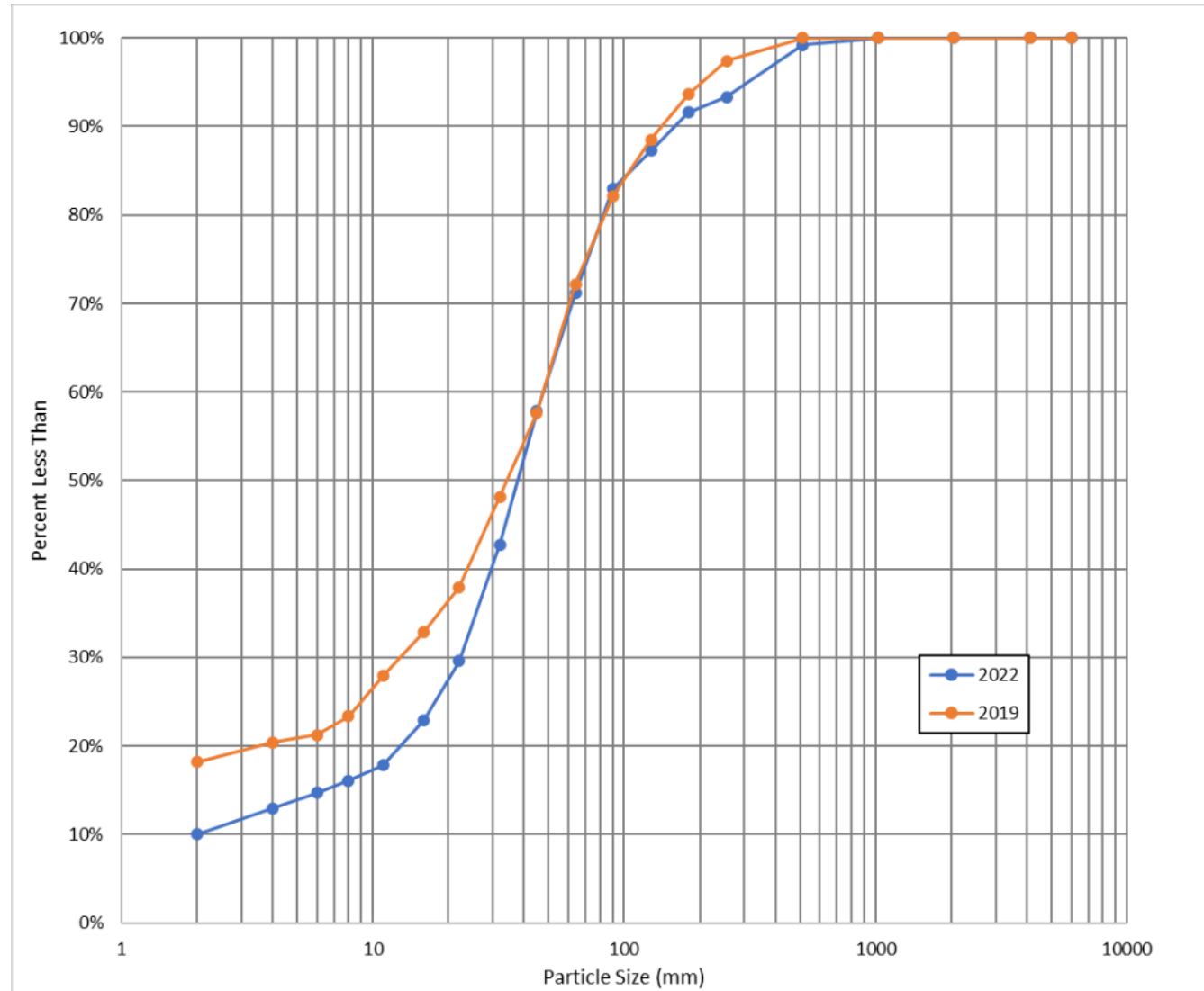


Stream bed had slightly higher embeddedness following restoration and fire



Stream Habitat Response

Increased fine sediments
following restoration and
fire



Conclusions

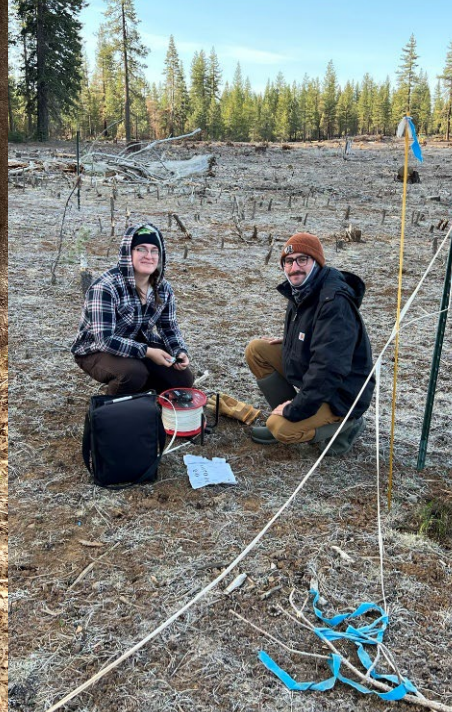
- This study showed that CCR § 933.4 [e] was applied for the removal of encroached conifer trees in meadows and wet areas to enhance these areas for ecological or range values with minimal disturbance.
- Meadow enhancement
 - Groundwater and soil moisture increased in the meadows following removal of *Pinus contorta*. Except for drought years.
 - The groundwater and soil moisture increase persisted for the 6 years post restoration measured at Marian Meadow.
 - Meadow vegetation recovery was observed in transects in the wetter areas of Rock Creek meadow, slower recovery in the drier areas.

Conclusions

- This study showed that CCR § 933.4 [e] was applied for the removal of encroached conifer trees in meadows and wet areas to enhance these areas for ecological or range values with minimal disturbance.
- Disturbance
 - Disturbance in the WLPZ was minimal, there was a small increase in disturbed ground, but no increase in soil compaction.
 - WLPZ restrictions on amount of skid trails and harvest operations occurred in late summer and early fall when soil moisture was lowest.
 - The Dixie Fire disturbed more WLPZ ground cover than the removal of *Pinus contorta*. This resulted in slightly lower stream habitat conditions.
 - Recovery of the soil disturbance by logging equipment was

Restoration Perspectives (observations from the field)

- THP umbrella for permitting stream work created problems.
 - State regulators would not allow stream work until after all vegetation removal was completed.
 - This delayed implementation by over a year.
 - Made for ineffective stream structure implementation.
 - Confusion between State and Federal permits (e.g. US Army Corp)
- Greater oversight of the logger to reduce impacts.
 - Good job in WLPZ, not so good outside of the WLPZ.



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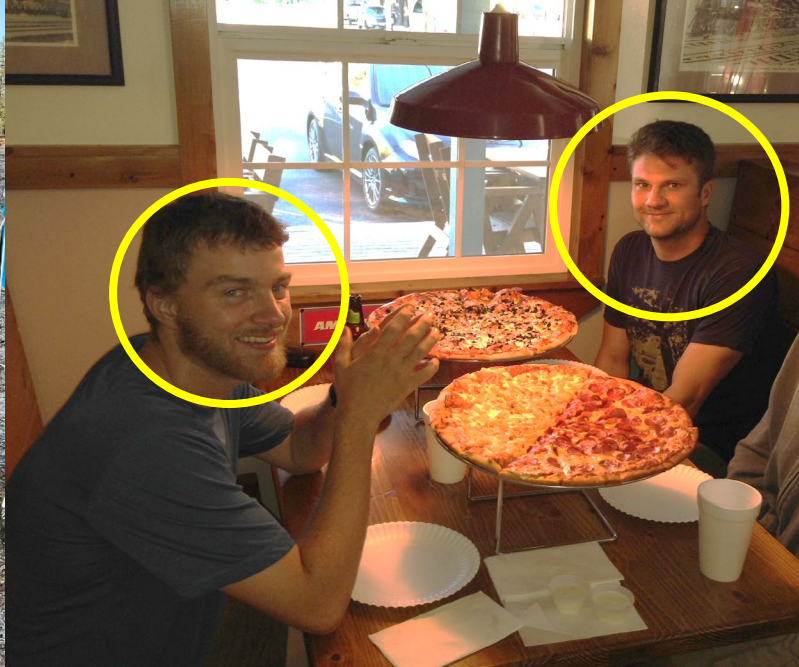
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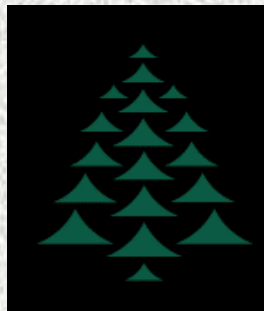


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