Hydrologic response of meadow restoration following the removal of encroached conifers

Oriana Ramirez
Dr. Christoper Surfleet, NRES

SAF NATIONAL CONVENTION | 2023

Background

Problem:
- Fire suppression, poor grazing practices, and climate change has accelerated the encroachment of conifers (specifically *Pinus contorta*) into meadow habitat.
- Extensive loss in meadow habitat within the Sierra Nevada Mountain Range.
- Degredation of meadows, floodplains, and stream channels.

Montane Meadows:
- Provide diverse species habitat
- Facilitate water cycling
- Helps with sediment capture
- Aid in carbon sequestration
- Create natural fire breaks in forested regions

Research Overview

Research Goal:
To quantify changes to meadow conditions once conifers have been cleared from the meadow and identify if there is an environmental benefit.

Research Question:
Does the removal of conifers on historical meadows, create a hydrologic response to restore montane meadow habitat?

Hypothesis:
The water availability of a montane meadow will improve in the long-term after conifer removal.

Study Area
The southern Cascades/northern Sierra Nevada mountain range, near Chester, CA.

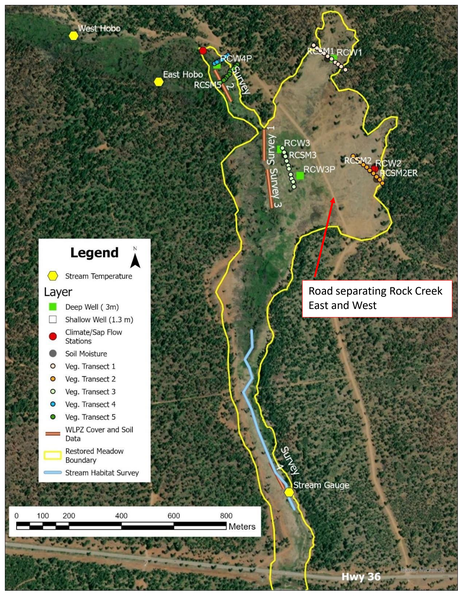


Figure 1. Rock Creek Meadow restoration area, which is located ~9 miles east of Chester, CA. The satellite base map is showing completion of the *Pinus contorta* removal.

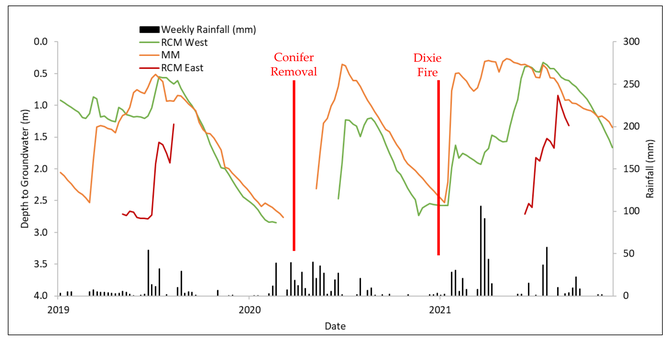


Figure 3. Weekly average depth to groundwater and weekly total precipitation for Rock Creek (RCM) and Marian Meadows (MM) between the 2020-2022 Water Years (WY). The RCM groundwater data is differentiated between the western and eastern portions of the meadow. The time of *Pinus contorta* removal and the Dixie Fire is denoted in the time series.

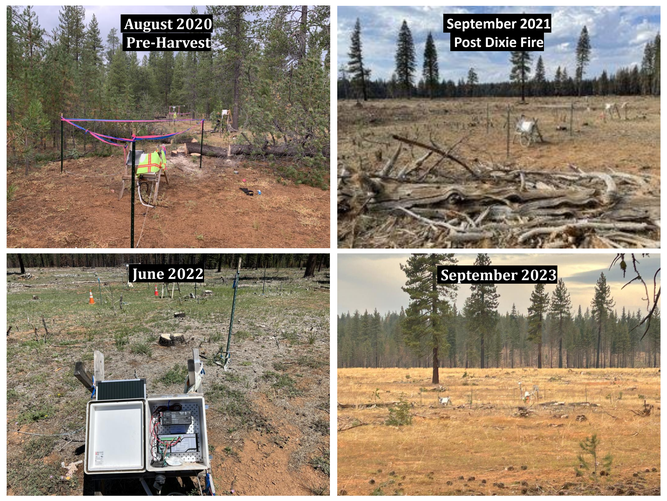


Figure 5. Visual timeline of meadow restoration at Rock Creek Meadow. All photos are of the area around RCSM2 (Figure 1) from different perspectives throughout the years this site was studied.

Results

Table 1. Linear regression coefficients and statistics of three-week average depth to groundwater between Rock Creek West and Marian Meadows for water years 2020-2022. Three-week averages were used to reduce chances of autocorrelation between datapoints.

Term	Water Years	Slope Coefficient	Intercept	p-value
Pre-restoration	2020	0.416	0.68	<0.001
Year 1 post-restoration	2021	0.416	1.49	0.02
Year 2 post-restoration	2022	0.416	0.16	0.34

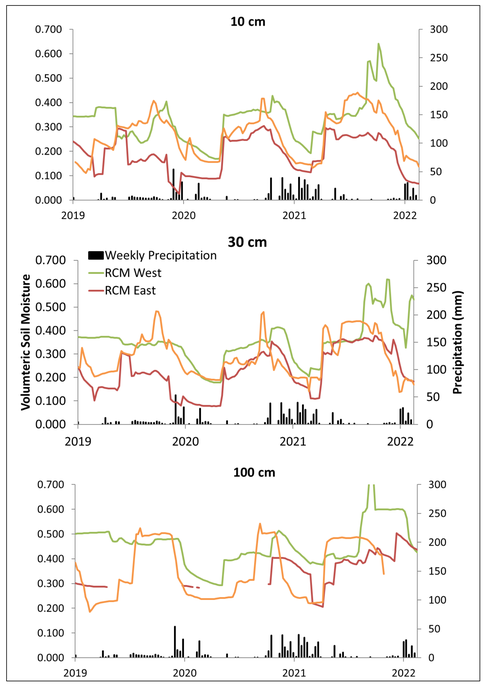


Figure 6. Weekly average volumetric soil moisture percentage and weekly total precipitation for Rock Creek (RCM) and Marian Meadows (MM) between the 2020-2022WY at depths of 10, 30 and 100 cm. The RCM soil moisture data is differentiated between the western and eastern portions of the meadow.

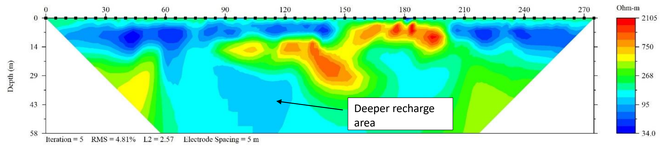


Figure 4. RCM Deep Electrical Resistivity Profile. This profile trends from the road bisecting RCM toward instrument and vegetation transect site 1 (Figure 1). The right side of the image (horizontal position of 275 meters) is located at (40.3307°, -121.0873°), with a heading of 40°. The electrode spacing is 5 meters. Data was collected with a dipole-dipole-gradient pattern.

Table 2. Linear regression coefficients and statistics of three-week average volumetric soil moisture percentage at a depth of 30 cm between Rock Creek and Marian Meadows for water years 2020-2022. Three-week averages were used to reduce chances of autocorrelation between datapoints.

Term	Water Years	Slope Coefficient	Intercept	p-value
Pre-restoration	2020	0.289	0.198	<0.001
Year 1 post-restoration	2021	0.289	0.212	0.45
Year 2 post-restoration	2022	0.289	0.29	<0.001

Table 3. Linear regression coefficients and statistics of three-week average volumetric soil moisture percentage at a depth of 30 cm between the eastern and western portions of Rock Creek and Marian Meadows for water years 2020-2022.

Term	Water Years	Slope Coefficient	Intercept	p-value
RCM West Pre-restoration	2020	0.25	0.261	<0.001
RCM West Year 1 post-restoration	2021	0.25	0.242	0.46
RCM West Year 2 post-restoration	2022	0.25	0.34	0.004
RCM East Pre-restoration	2020	0.56	0.014	<0.001
RCM East Year 1 post-restoration	2021	0.56	0.08	0.002
RCM East Year 2 post-restoration	2022	0.56	0.125	<0.001

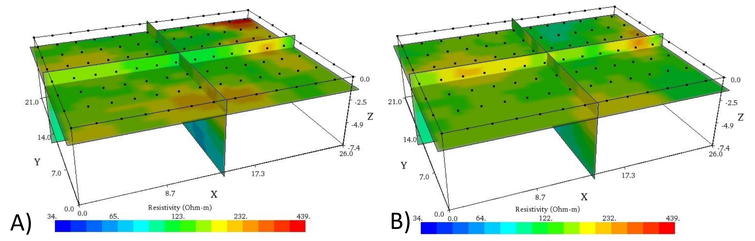


Figure 7. Three dimensional images of electrical resistivity in A) 2020 pre-restoration and, B) 2021 following Pinus contorta removal. The XYZ coordinates are in units of meters. Lower resistivity values reflect high soil water, while higher resistivity values demonstrate drier soil media.

2021 Dixie Fire Impacts

Figure 8. Soil burn severity distribution of the 2021 Dixie Fire for areas within and around the research meadows.

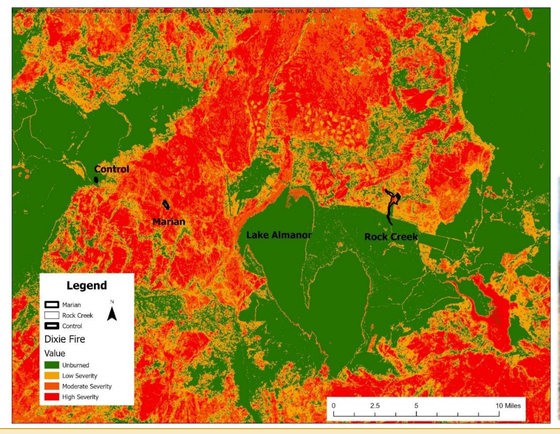


Figure 9. The left image is of Rock Creek Meadow with patches of burnt meadow vegetation. The right image is of Marian Meadow with moderate to high soil burn severity around one of the soil moisture data loggers. Both photos were taken by Dr. Surfleet one month after the Dixie Fire in September 2021.

Table 4. Description of burn severity impacts on the watershed associated with each meadow and the meadow vegetation.

Meadow	Watershed Contributing Area km² (mile²)	Percentage Moderate and High Burn Severity in Watershed	Meadow Vegetation Post Fire
Marian Meadow (MM)	19.4 (7.5)	87%	Moderate to high burn severity in the meadow
Rock Creek Meadow (RCM)	67.3 (26)	48%	Patches of burned vegetation with varied burn severity.

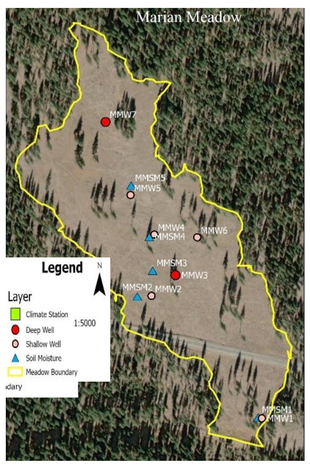
Methods

Before-After Control-Impact (BACI) study design:
- Rock Creek Meadow (RCM) as the study site
- Marian Meadow (MM) as the control site
- 1 year of pre-restoration data (2020 Water Year)
- 3 years of post-restoration data (2021-2023 Water Years)
- The majority of the *Pinus contorta* was removed from RCM during fall 2020
- Rock Creek was divided into an east and west portion due to the eastern portion being drier and the western portion being wetter.

Groundwater Wells
- 1.3 to 3 m deep

Soil Moisture Probes
- 10 to 100 cm deep

Climate Stations
- Precipitation, temperature, & atmospheric pressure



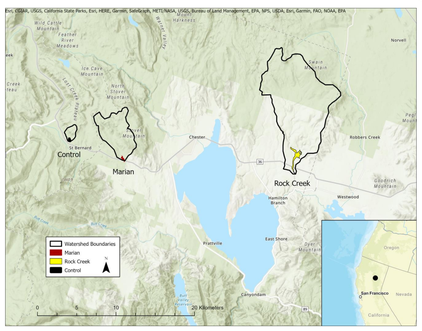


Figure 2. The left image is of Marian Meadow instruments and boundaries. The right image is of study meadow's locations, including their respective watershed boundaries, near Chester and Lake Almanor, California. The meadows are on land owned by Collins Pine Company.

Conclusions

- Improvement in Rock Creek Meadow groundwater (Figure 3) is mixed following the removal of *Pinus contorta,* likely due to severe drought in the 2020 and 2021 water years.
- The 2022 water year shows increased groundwater following the 2021 Dixie Fire (Figure 3). This is further supported by the Year 2 post-restoration 0.34 p-value (Table 1) which indicates similar groundwater levels between Rock Creek and Marian Meadows despite a likely increase in runoff and groundwater recharge in Marian Meadow due to high soil burn severity (Table 4).
- Rock Creek Meadow soil moisture appeared to increase (Figure 6) within the first year following the removal of *Pinus contorta.* This is further illustrated by Figure 7.

Acknowledgements

This research would not have been possible without access to Collin Pines Company land, or funding from the California Board of Forestry's Monitoring Effectiveness Committee; the California State University Agricultural Research Initiative (ARI); the National Institute of Food and Agriculture (NIFA) McIntire Stennis funds; and the Sierra Institute for Community and the Environment, through a Cal Fire California Climate Investments (CCI) Forest Health Grant.

Special thank you to Dr. Surfleet for this research opportunity and his constant support. Tyler Peterson and all other Cal Poly undergraduate students that helped with the data collection. I also acknowledge the previous Cal Poly graduate students whose field work and data analysis I have been able to build off.