

# Hydraulic Mines and Process Based Restoration: A Pilot Project at Grizzly Creek Diggins

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*American  
Society of  
Reclamation  
Sciences  
Conference  
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2023*

*Boise, ID*



## Thank you to our Funders

US Endowment  
Sierra Nevada Conservancy  
Bella Vista  
Resources Legacy Fund  
Bay Area Council  
Yuba Water Agency

## Thank you to our Partners

Forest Service, Rocky Mountain Research Station  
Tahoe National Forest  
Mooretown Rancheria  
United States Geological Survey  
Yuba Water Agency  
World Resources Institute  
Restoration Fuels  
California State University, Chico  
Symbiotic Restoration  
Swiftwater Design



# THE SIERRA FUND

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# The Sierra Fund Strategy

Theory of Change Model







# Hydraulic and Hard Rock Mines

## California Gold Rush Impacts



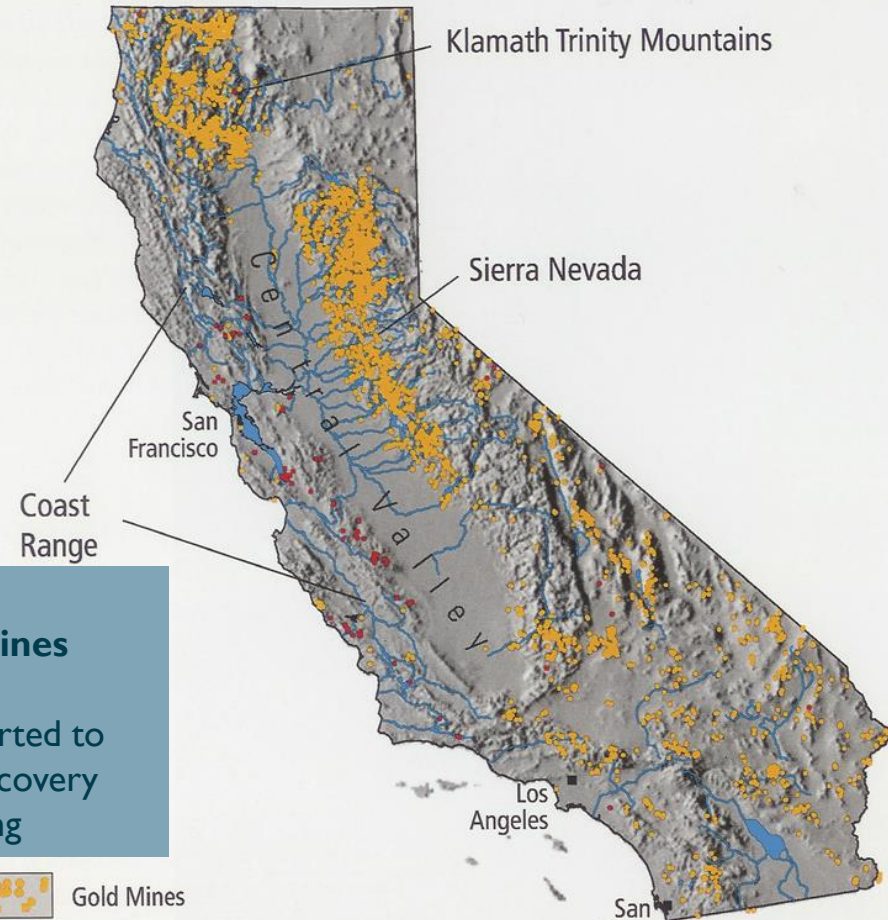
**Hydraulic Mining:** Access gold in ancient river deposits




**Hard Rock Mining:** Access gold in underground ore deposits

**Over 40,000  
Abandoned Mines**

**Mercury:** Imported to improve gold recovery during processing



 Gold Mines

 Mercury Mines

Map Source: USGS  
Fact Sheet 2005-3014

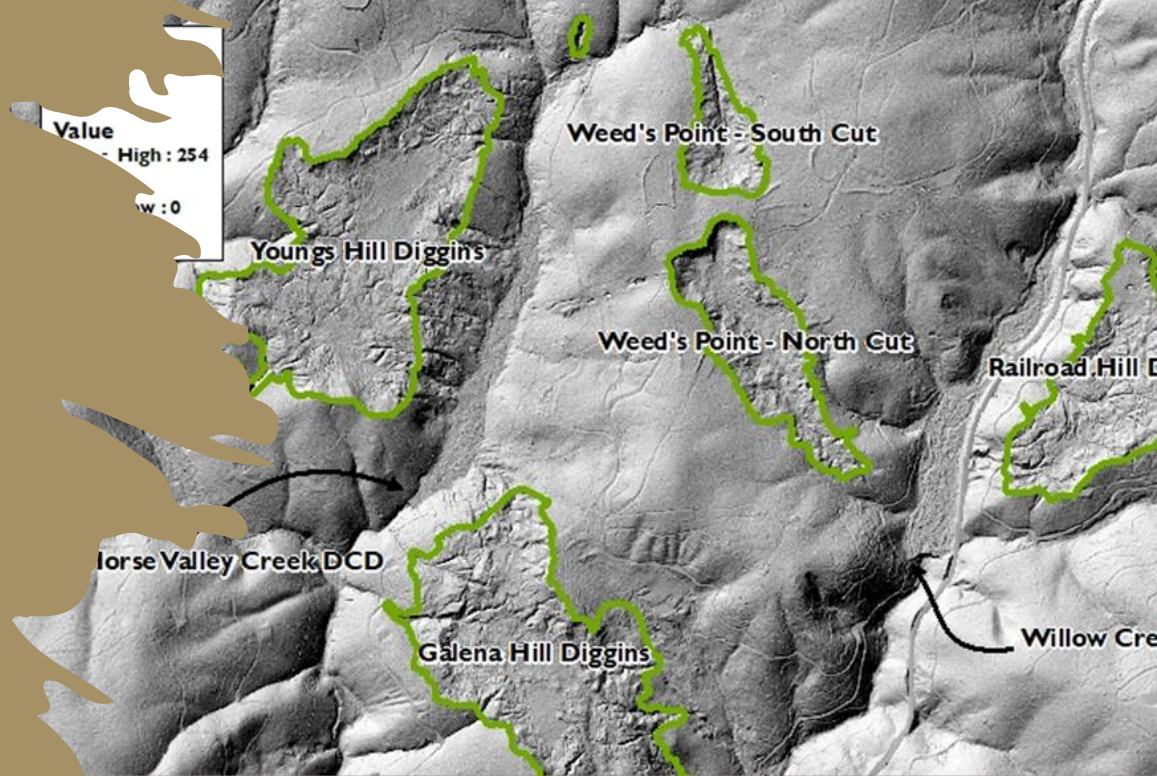






# Hydraulic Mine Characteristics

- 456 Hydraulic Mines in Tahoe National Forest
- ~18,000 Hydraulic Mine Acres



- Active Erosional Areas
- Drainage Tunnels
- Ditches
- Ponds
- Gullies / Headcuts
- Multiple Outflow Points
- High Fire Risk





# Biochar Lab Tests: Column Experiments

- Passed water through columns with 0, 2, 5% Biochar by weight
- Analyzed leachate for Turbidity, THg and f-THg analysis



Blue Point Mine

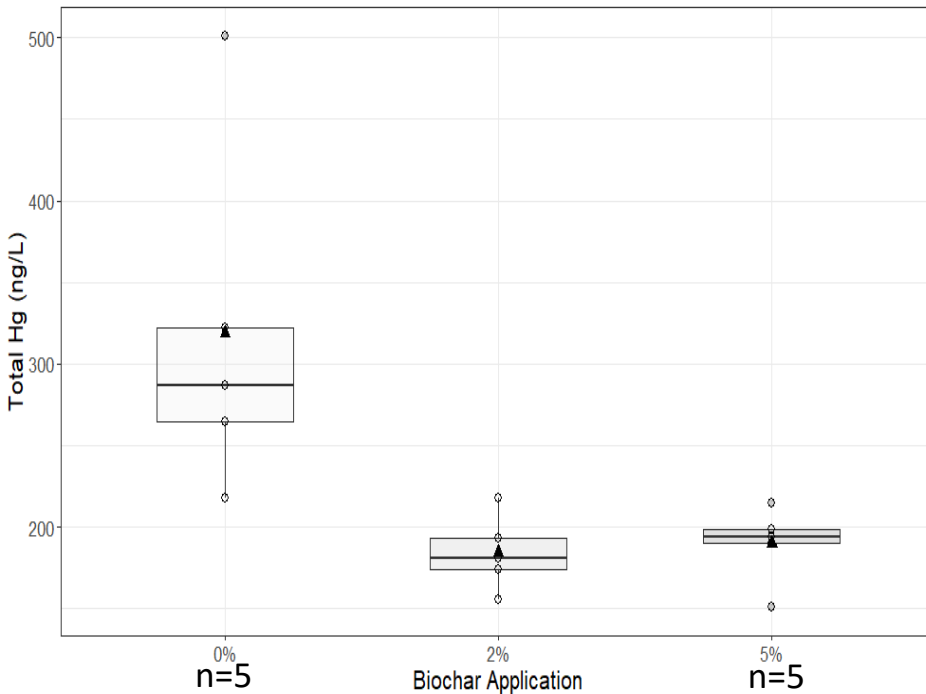




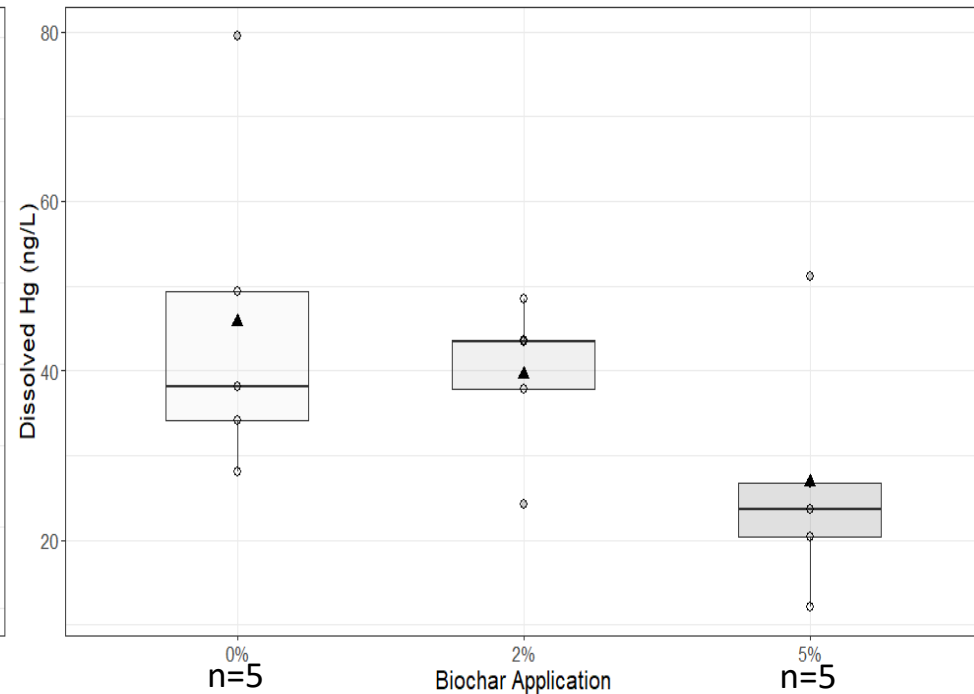


# Sediment Column Experiment

Total Hg in Blue Point Sediment Column Experiments (ng/L)

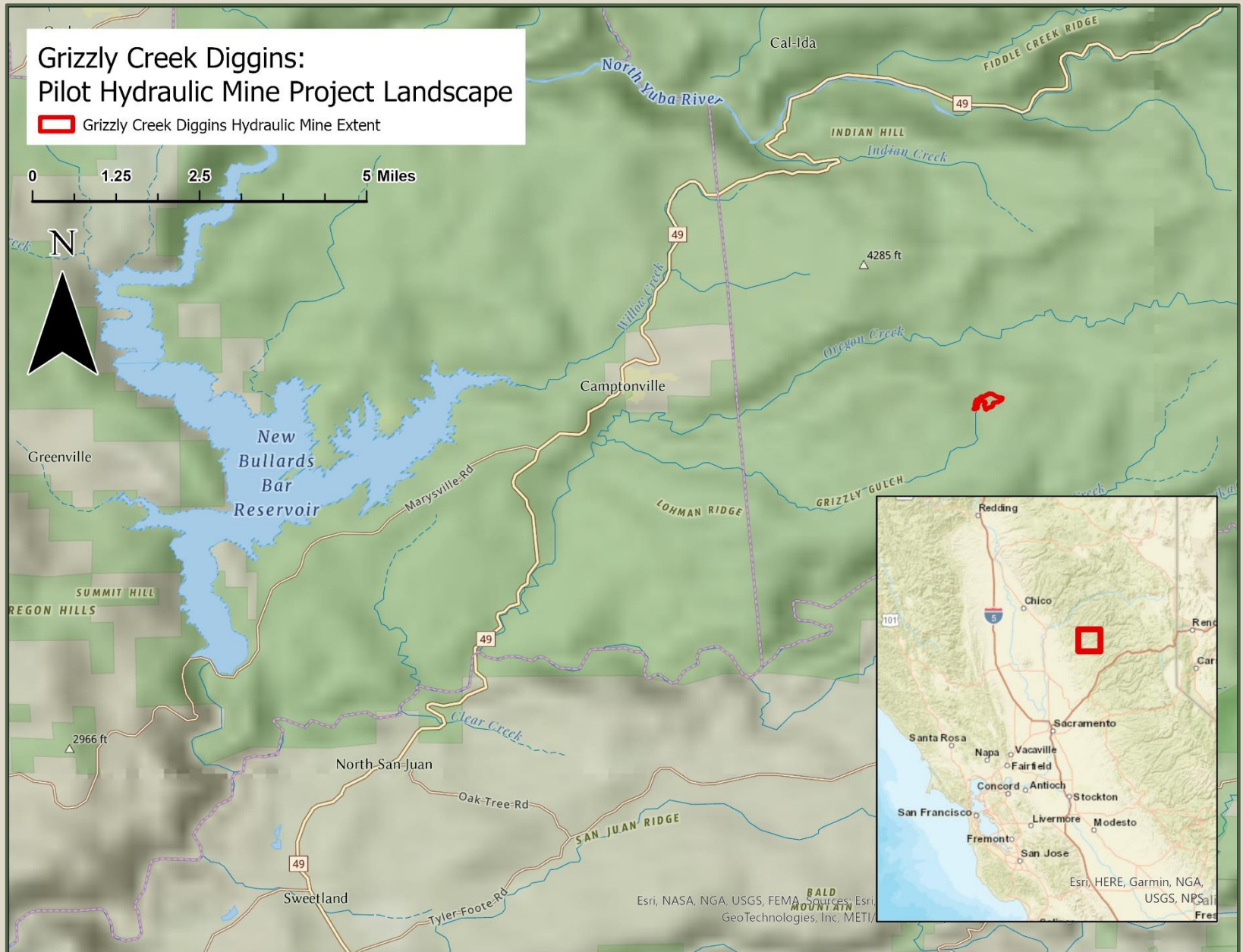


Dissolved Hg in Blue Point Sediment Column Experiments (ng/L)



Brandt M., D. Page-Dumroese, J. Webster and C. Monohan. Biochar as a Soil Amendment: Reduction of Mercury Transport from Hydraulic Mine Debris. *Energies*. 2021, 14.

# Grizzly Creek Diggings Pilot Project







# Grizzly Creek Diggins Pilot Project Overview

Biochar Test Plots

Vegetation Management

Process Based Restoration

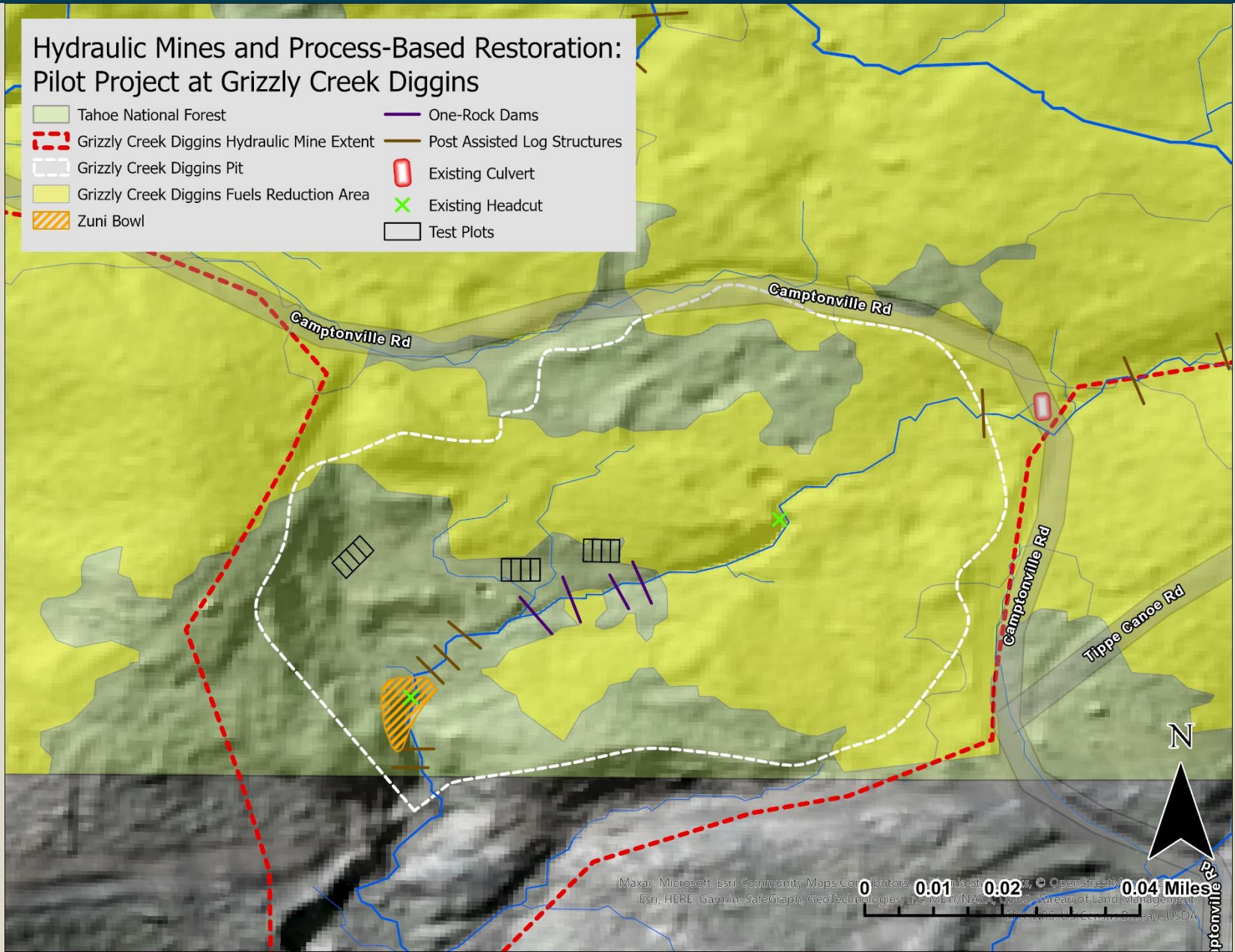




# Grizzly Creek Diggings Pilot Project

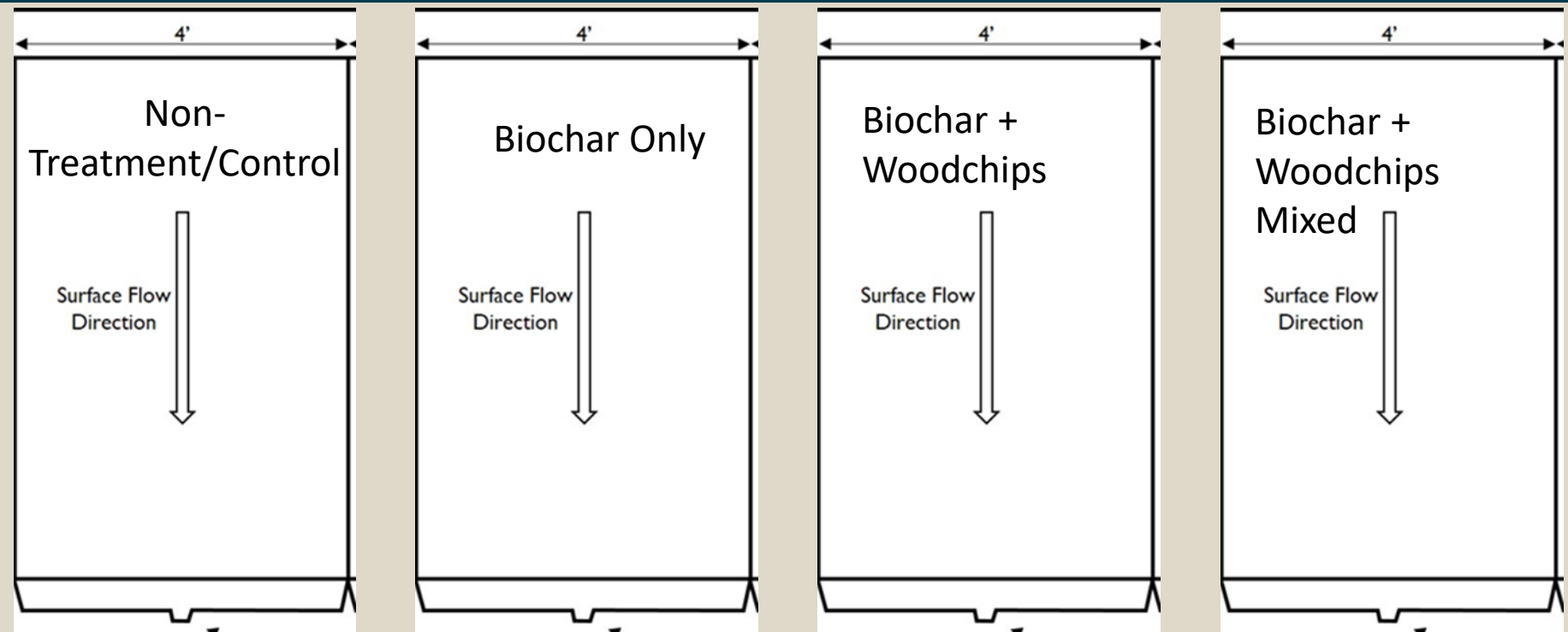
## Hydraulic Mines and Process-Based Restoration: Pilot Project at Grizzly Creek Diggings

- Tahoe National Forest
- Grizzly Creek Diggings Hydraulic Mine Extent
- Grizzly Creek Diggings Pit
- Grizzly Creek Diggings Fuels Reduction Area
- Zuni Bowl
- One-Rock Dams
- Post Assisted Log Structures
- Existing Culvert
- Existing Headcut
- Test Plots



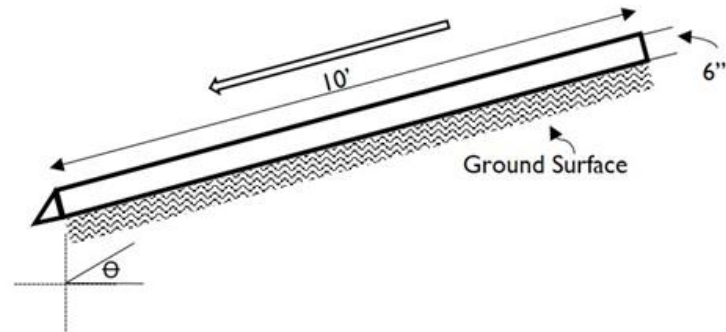


# Grizzly Creek Diggins Biochar Test Plots Design



Funneled Surface Flow Sampling Locations

- Total Mercury (THg)
- Filtered-Total Mercury (f-THg)
- Total Suspended Sediment (TSS)
- Turbidity (NTU)











# Biochar Properties and Characterization

- Restoration Fuels in John Day, Oregon
  - Wood based
  - Slow pyrolysis ( $<2^{\circ}\text{C/s}$ )
  - Low temp ( $<300^{\circ}\text{C}$ )
- Biochar source testing
  - Trace Element Screen by ICP
  - Percent Carbon & Nitrogen





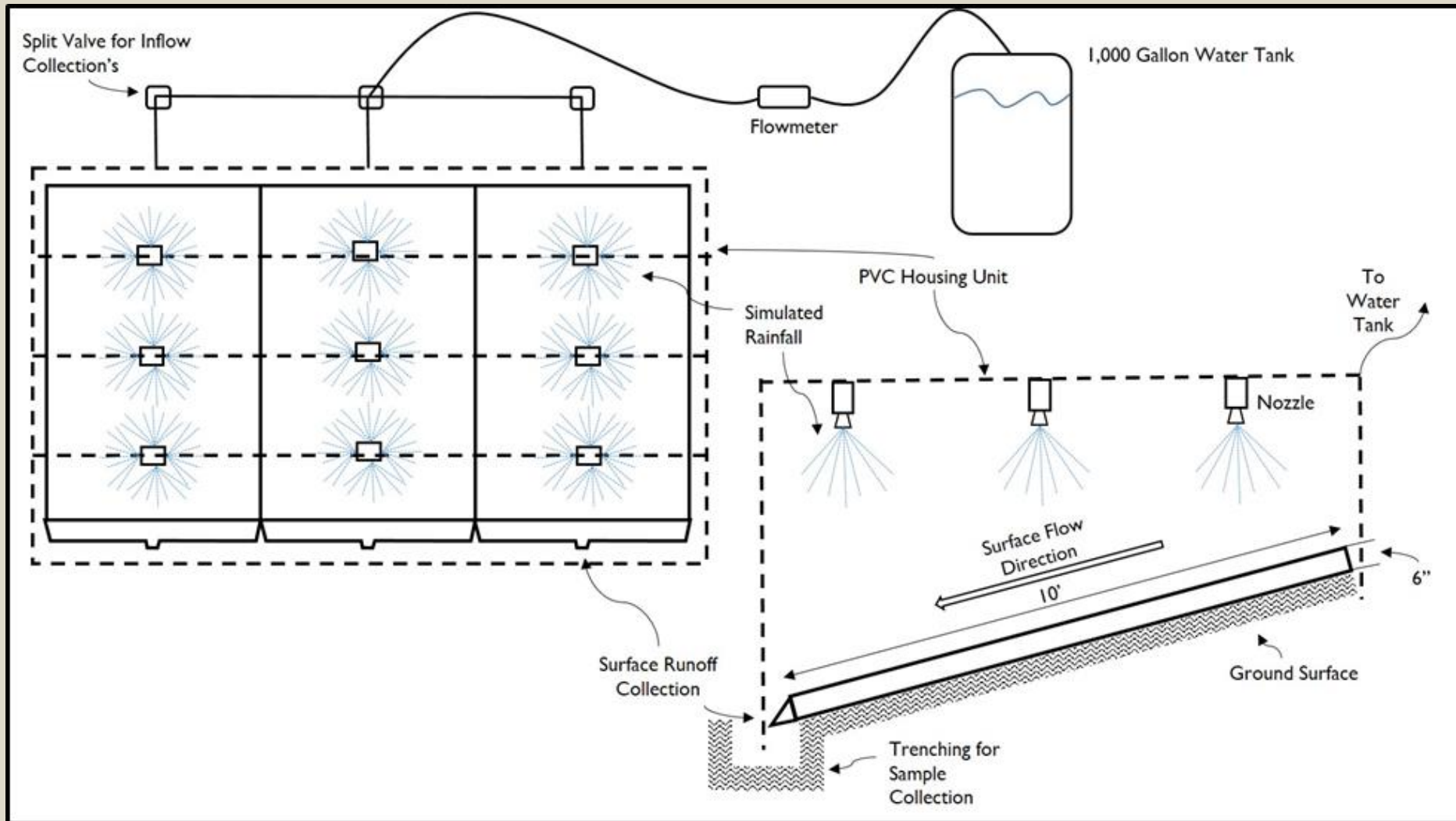


Vegetation Management with  
Mooretown Rancheria of the Concow Maidu  
Tribe



# Grizzly Creek Diggins

## Biochar Test Plots, Simulated Rainfall





# Grizzly Creek Diggins Biochar Test Plots, Simulated Rainfall

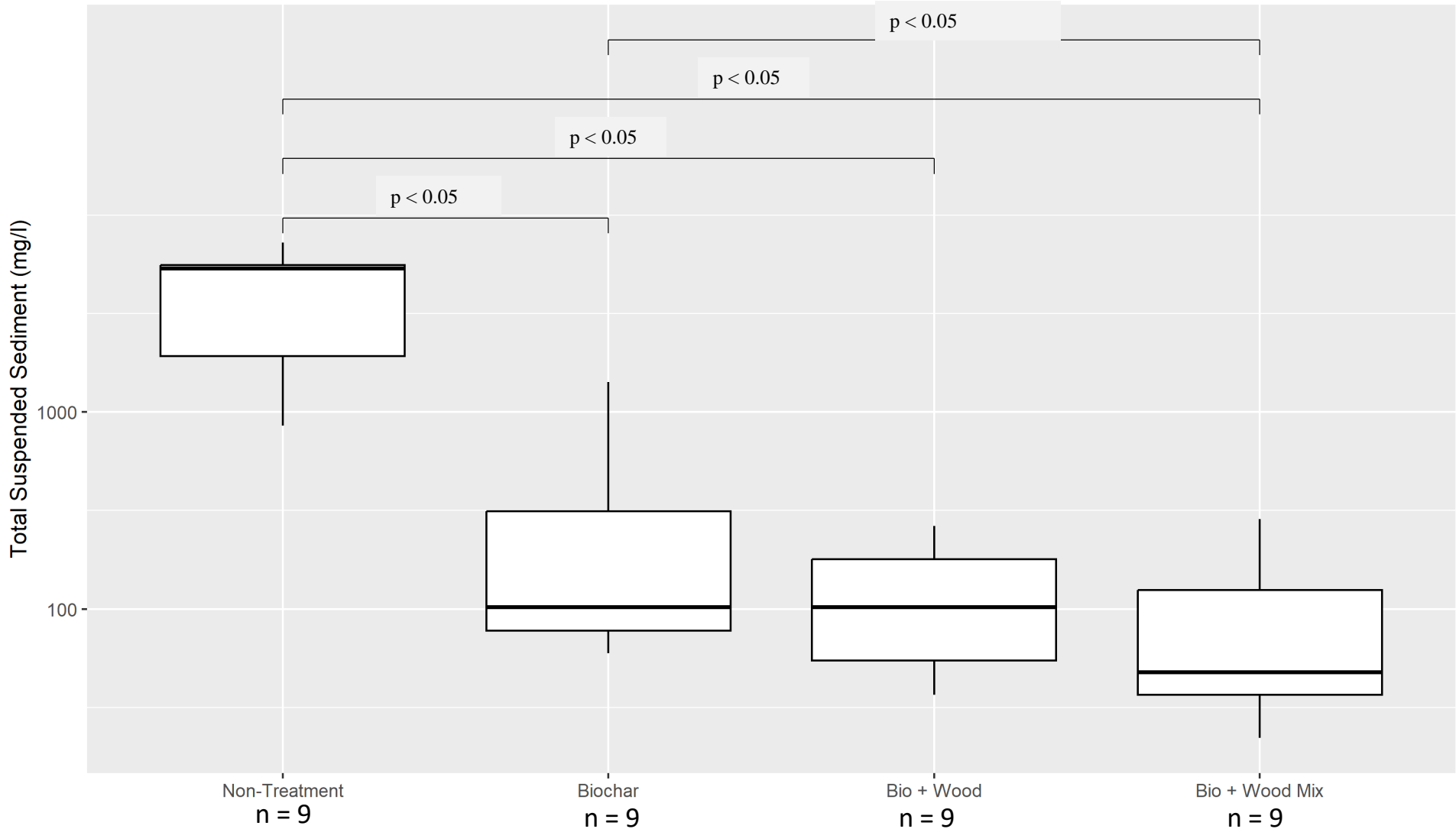




# Grizzly Creek Diggins

## Biochar Test Plots, Simulated Rainfall Analysis

Grizzly Diggins Test Plots







# Grizzly Creek Diggins

## Biochar Test Plots, Simulated Rainfall Analysis

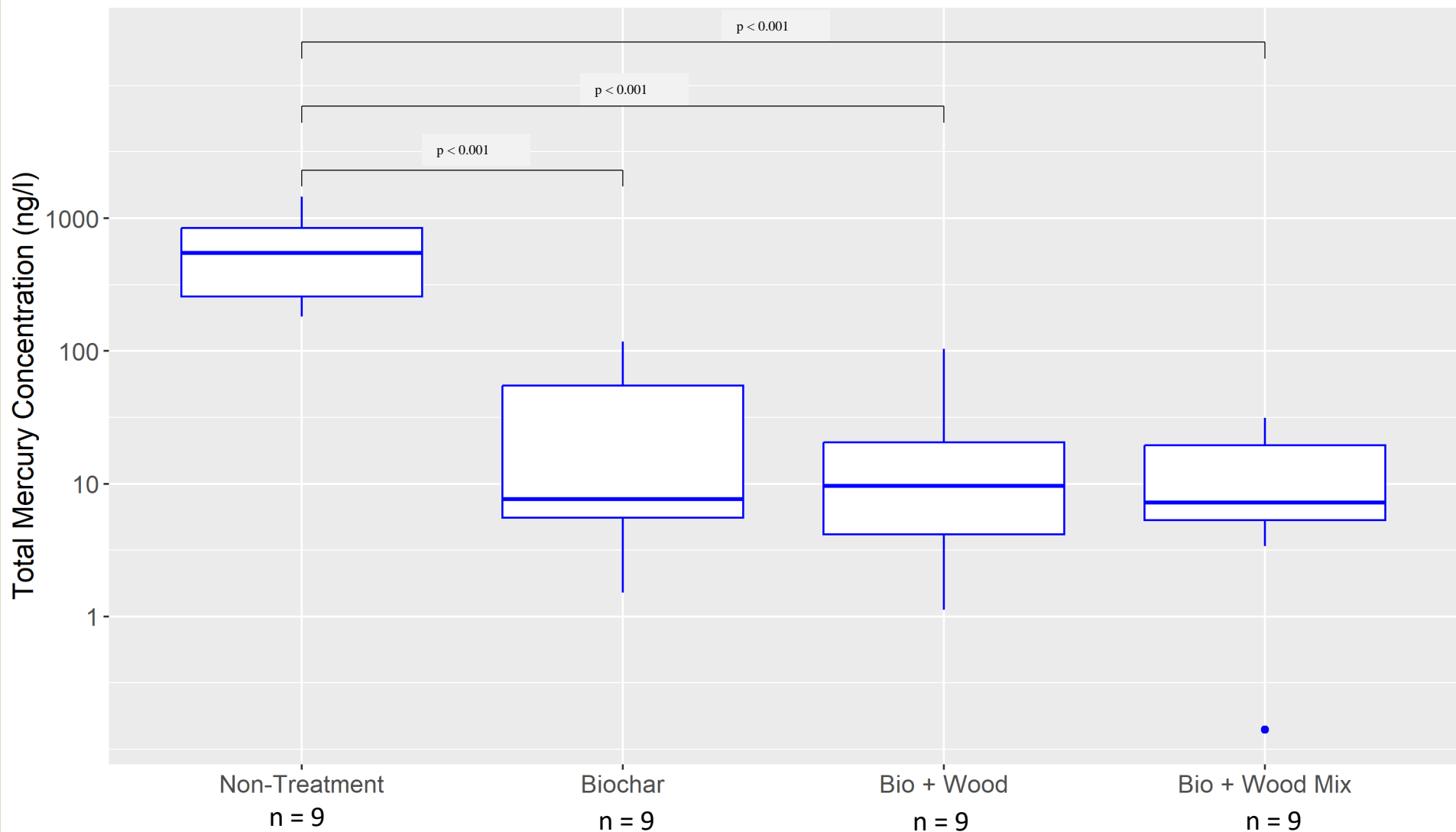




# Grizzly Creek Diggins

## Biochar Test Plots, Simulated Rainfall

Grizzly Diggins Test Plots



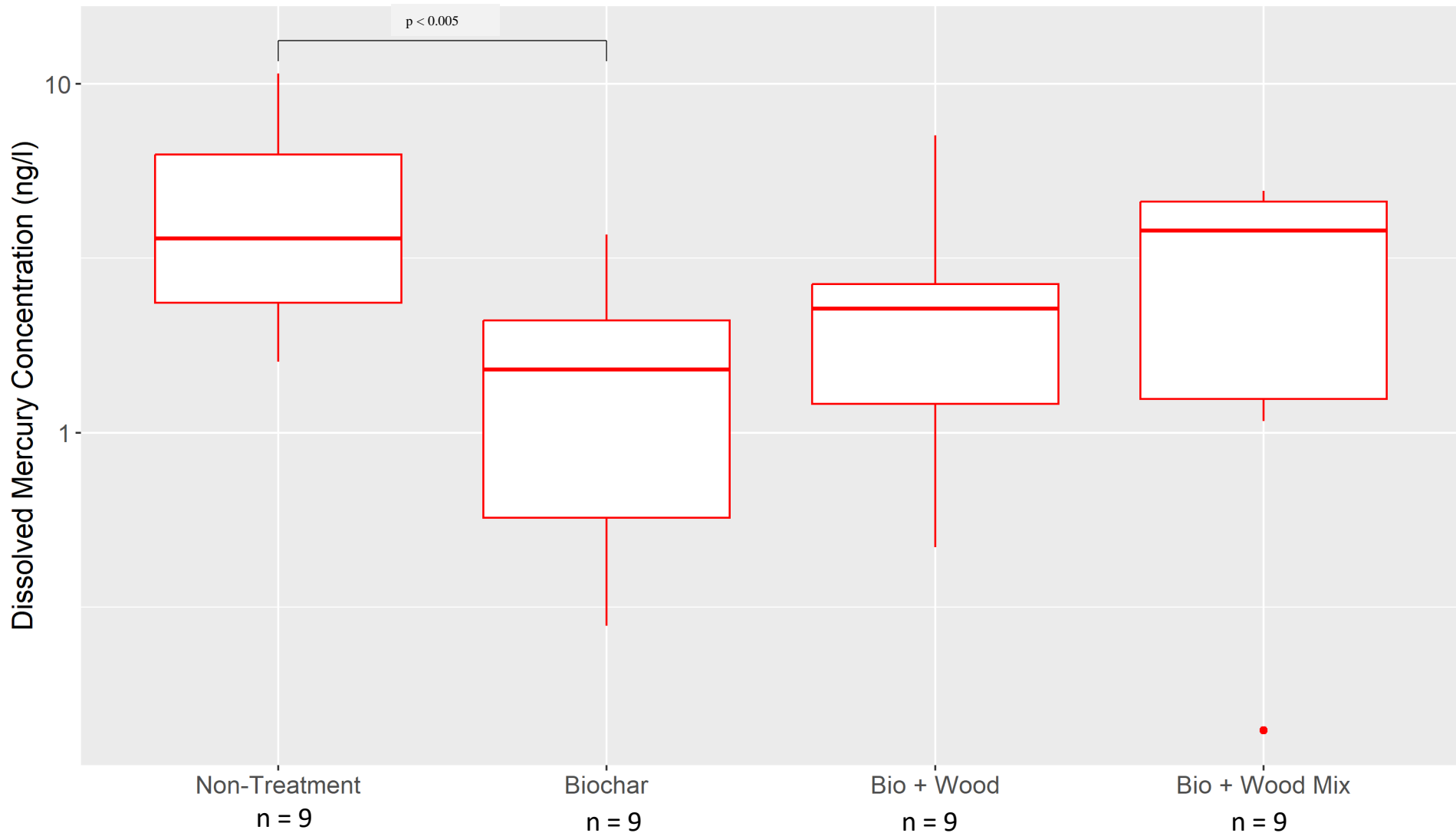




# Grizzly Creek Diggins

## Biochar Test Plots, Simulated Rainfall

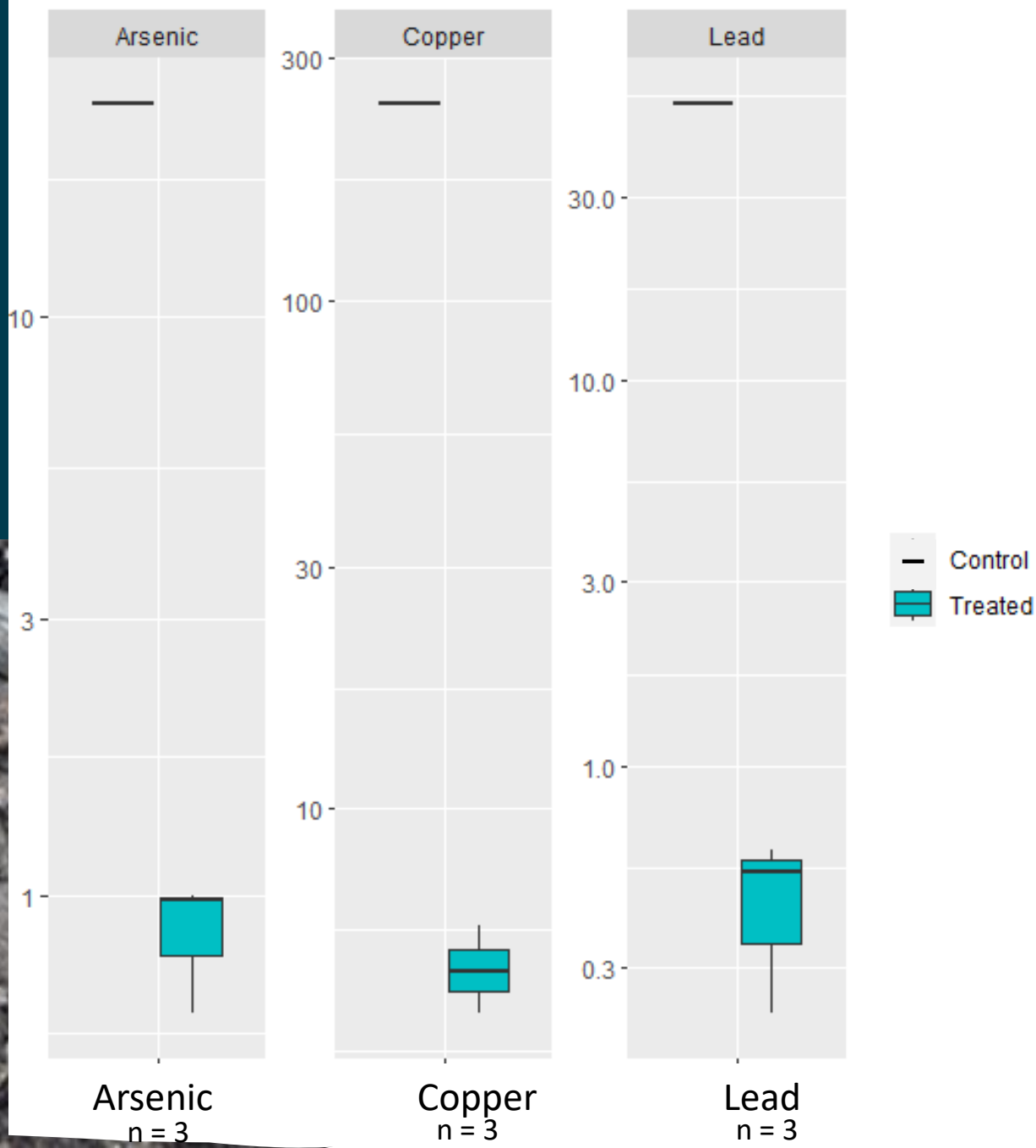
Grizzly Diggins Test Plots



# Grizzly Creek Diggins Biochar Test Plots, Simulated Rainfall



## Grizzly Diggins Test Plots Title 22 Metals





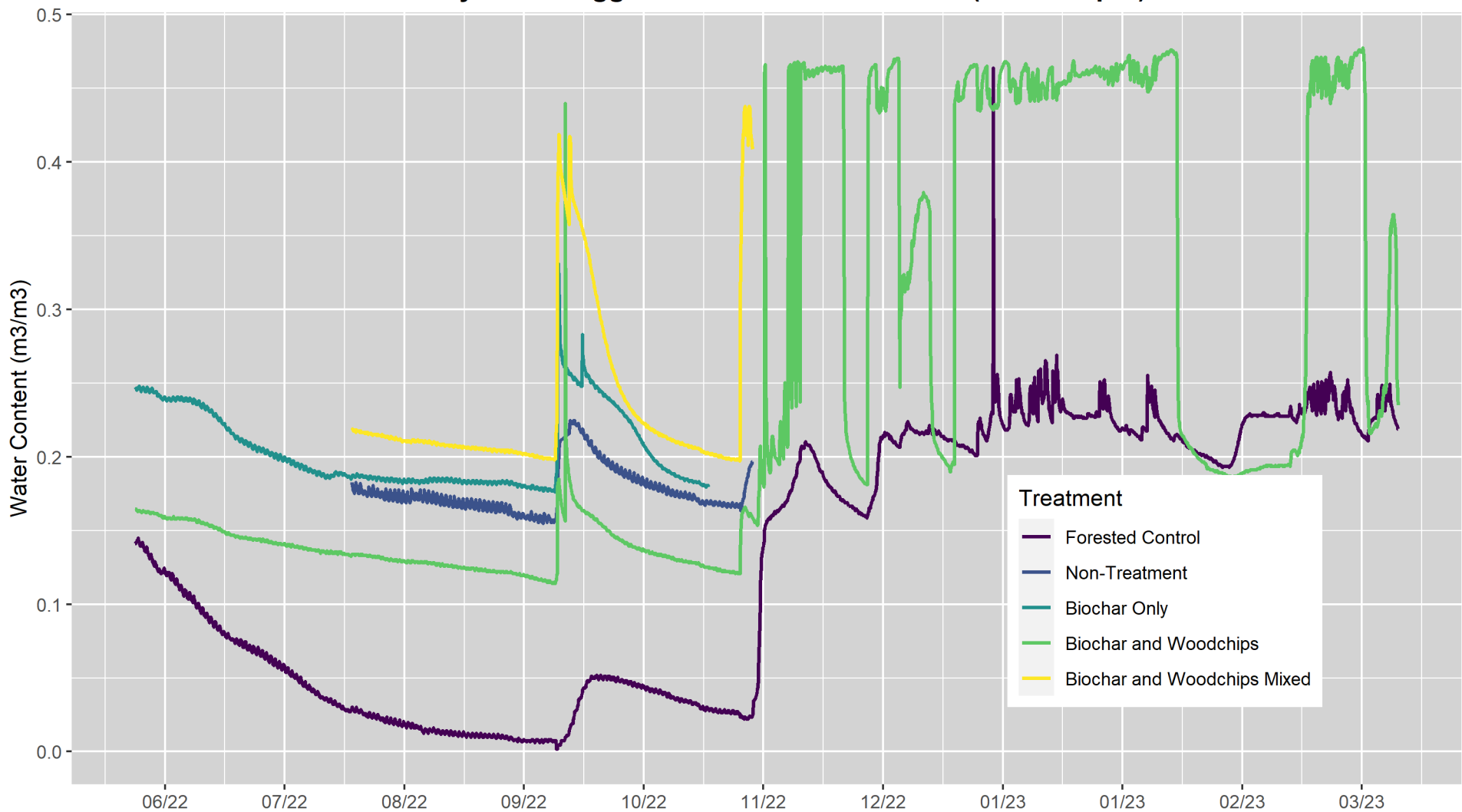
# Grizzly Creek Diggins Soil Health Monitoring; Soil Temperature and Soil Moisture





# Grizzly Creek Diggins Soil Health Monitoring; Soil Moisture

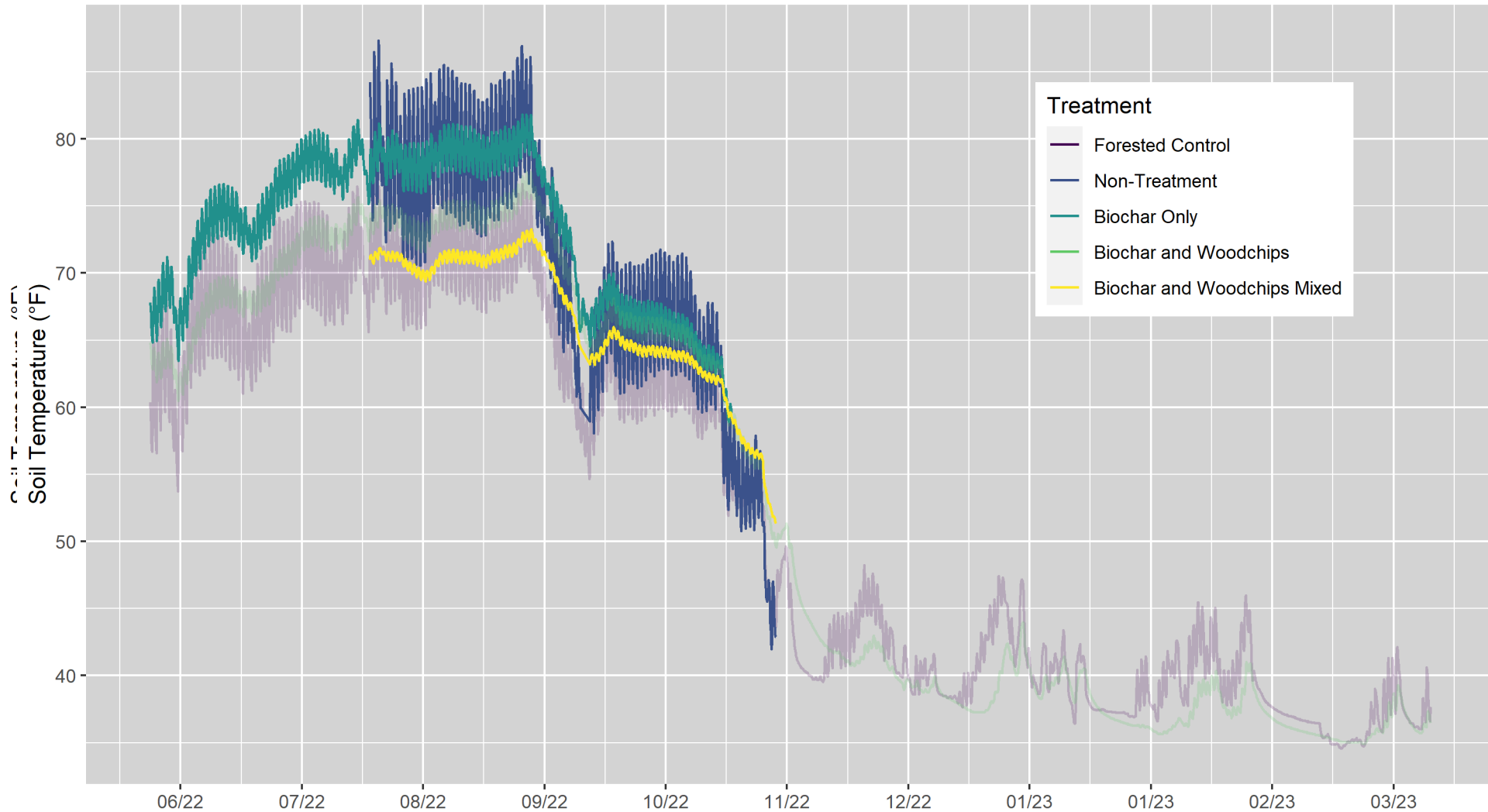
Grizzly Creek Diggins Test Plot Soil Moisture (10 cm depth)





# Grizzly Creek Diggins Soil Health Monitoring; Soil Temperature

Grizzly Creek Diggins Test Plot Soil Temperature (10 cm depth)





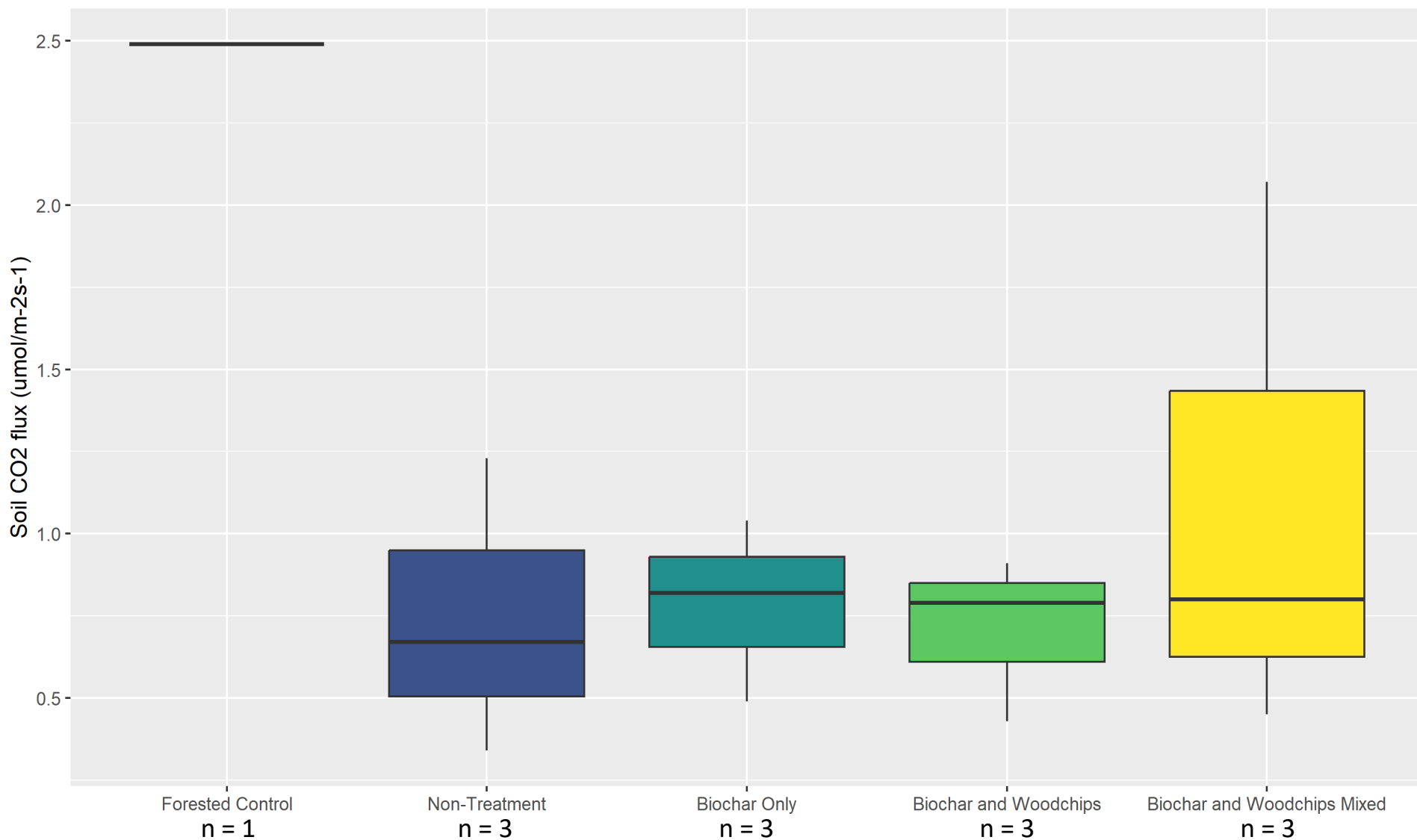
# Grizzly Creek Diggins Soil Health Monitoring: Soil CO<sub>2</sub> gas flux





# Grizzly Creek Diggins Soil Health Monitoring: Soil CO<sub>2</sub> gas flux Sept 23<sup>rd</sup>, 2022

Grizzly Creek Diggins Soil CO<sub>2</sub> flux



# Grizzly Creek Diggins Soil Health Monitoring: Seeding and Ground Cover Monitoring

Revegetated

Nov 4<sup>th</sup>, 2022

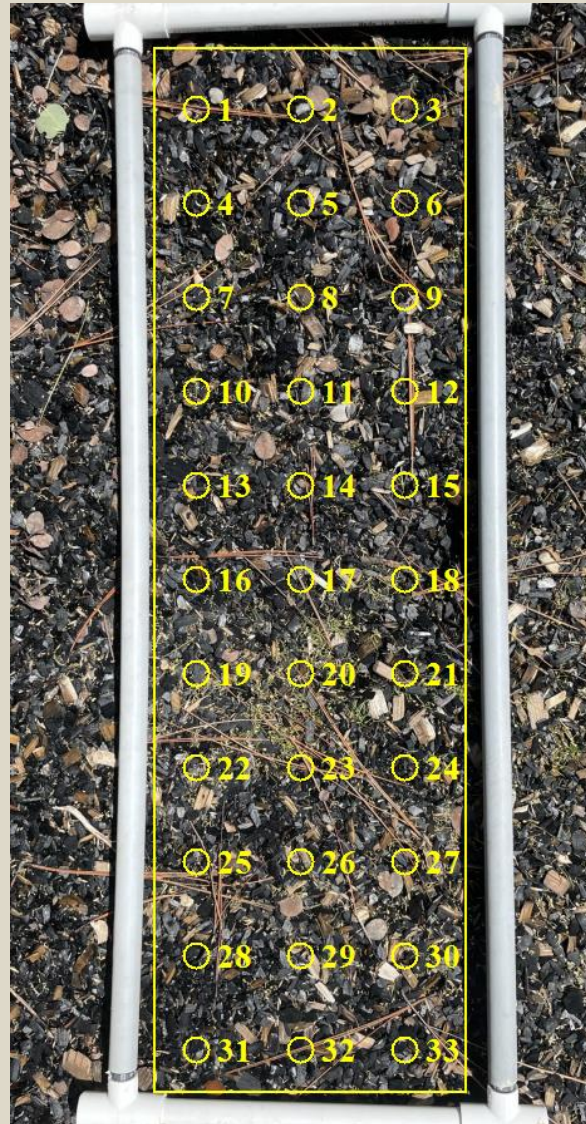
Ground Cover Monitoring

April 4<sup>th</sup>, 2023 (5 months)

May 9<sup>th</sup>, 2023 (6 months)

Aug 2023 (9 months)

Nov 2023 (12 months)

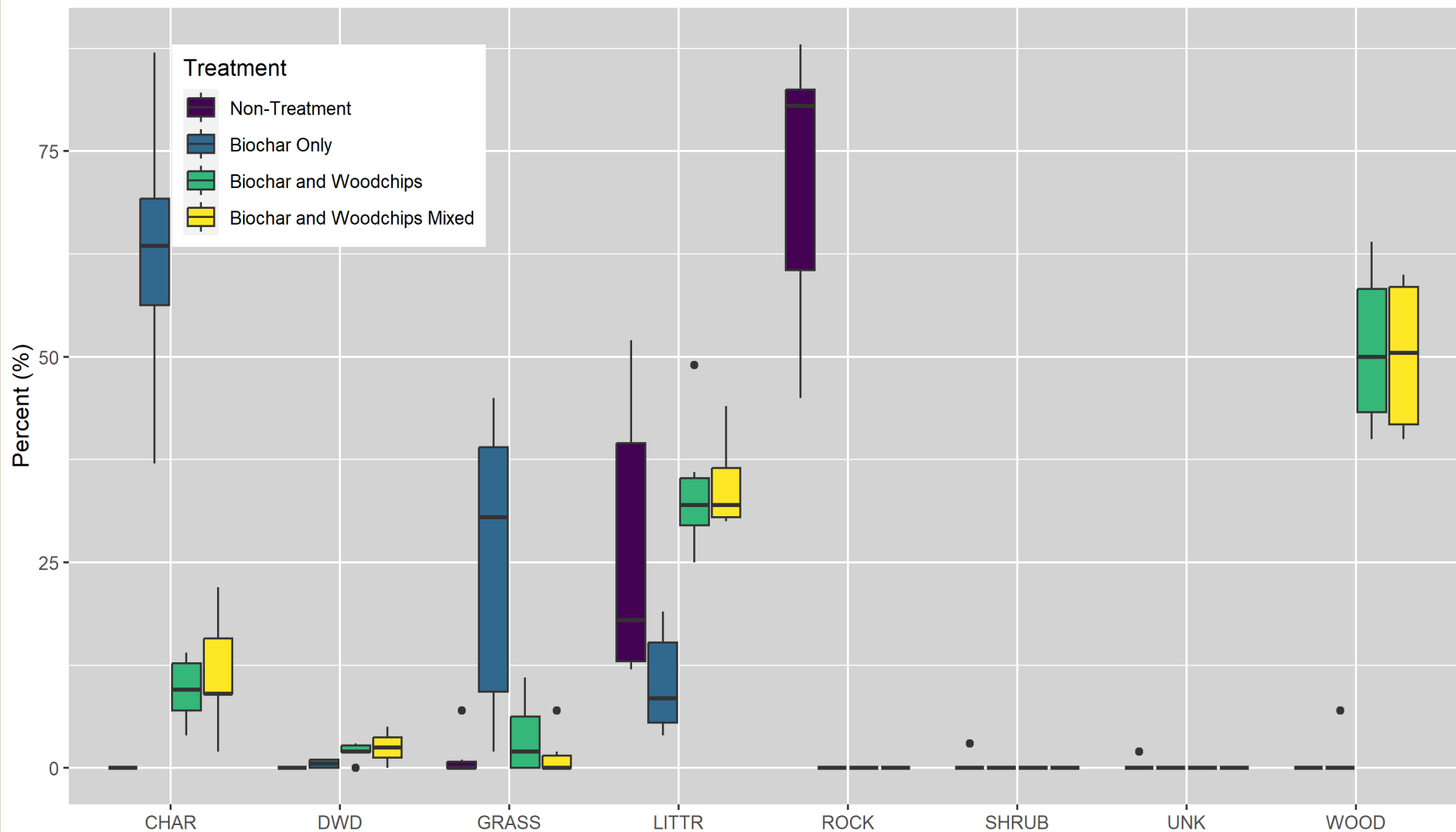


Cover Management Assistant (CMA)  
Protocol (Steinfeld et al. 2011)



# Grizzly Creek Diggins Soil Health Monitoring: Seeding and Ground Cover Monitoring

## Grizzly Creek Diggins Percent Ground Cover



# Grizzly Creek Diggins Soil Health Monitoring:

## On-Going Soil Health Monitoring:

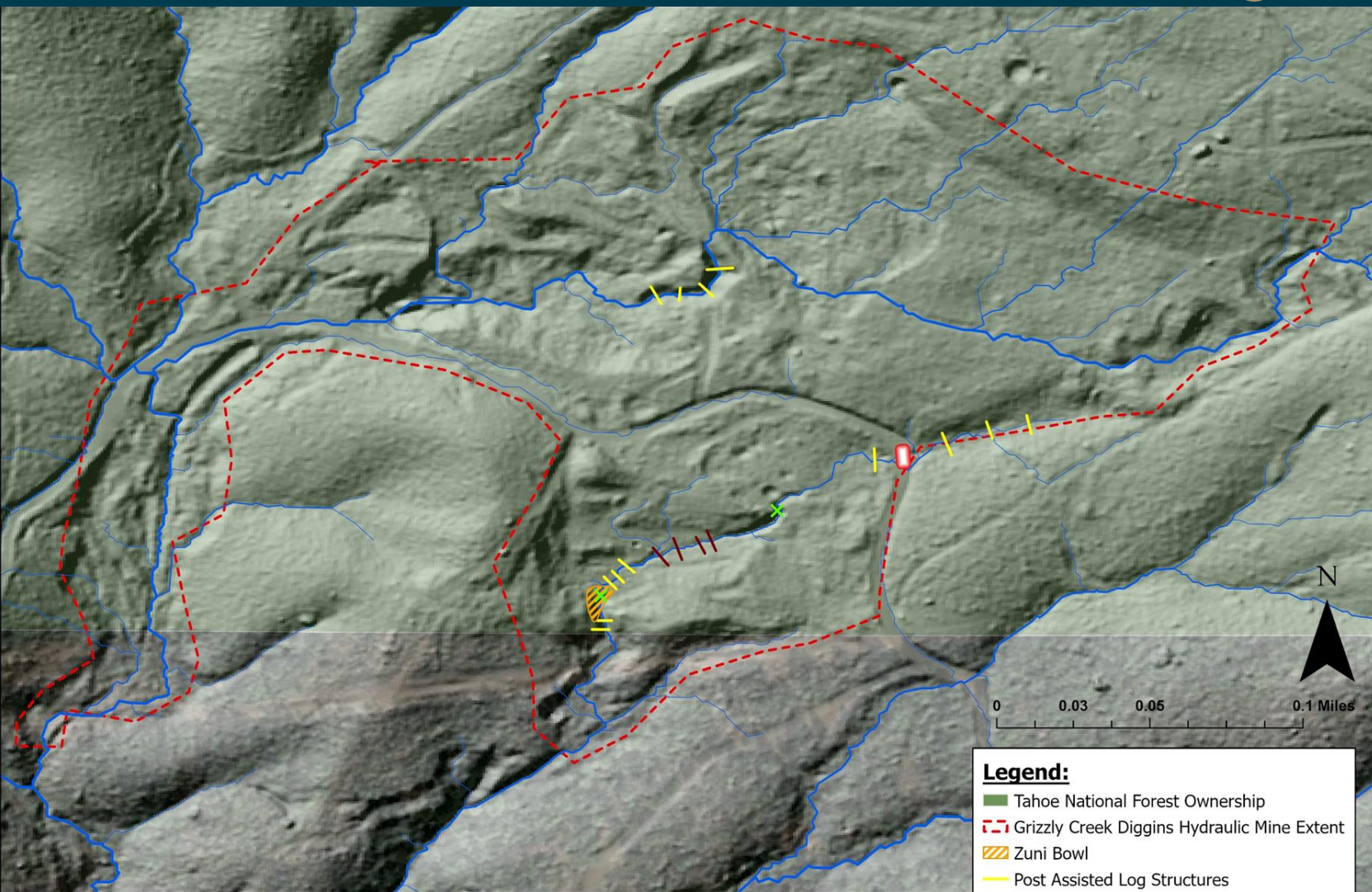
- Belowground Biomass
- Soil Carbon and Nitrogen
- Soil pH
- Soil Organic Matter
- Stability Tests
- Soil Water Holding Capacity







# Grizzly Creek Diggins; Process Based Restoration Design



**Legend:**

- Tahoe National Forest Ownership
- Grizzly Creek Diggins Hydraulic Mine Extent
- Zuni Bowl
- Post Assisted Log Structures
- One-Rock Dams
- Existing Culvert
- Existing Headcut

NOTES: For more information on PBR design see Exhibit A: Low-Tech Process Based Restoration (PBR) Design for Grizzly Creek Diggins Hydraulic Mine.

Number of PBR structures and structure locations are subject to field adjustments as necessary.

**ABBREVIATIONS:**

PBR = Process Based Restoration

PALS = Post Assisted Log Structures

Low-Tech Process Based Restoration (PBR) for Grizzly Creek Diggins Hydraulic Mine

Property Owner:

Tahoe National Forest (TNF)

Applicant:



204 Providence Mine Rd  
Suite 214  
Nevada City, CA 95959  
P: 530.265.8451  
F: 530.265.8176  
E: info@sierrafund.org  
www.sierrafund.org

CA USGS Quad

PIKE 39120-D8

Township and Range

T18N R09E

Date of Plan Preparation:

December 12, 2022

Designed NG	Drawn NG	Checked
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File Date:

Sheet Title:

SITE PLAN

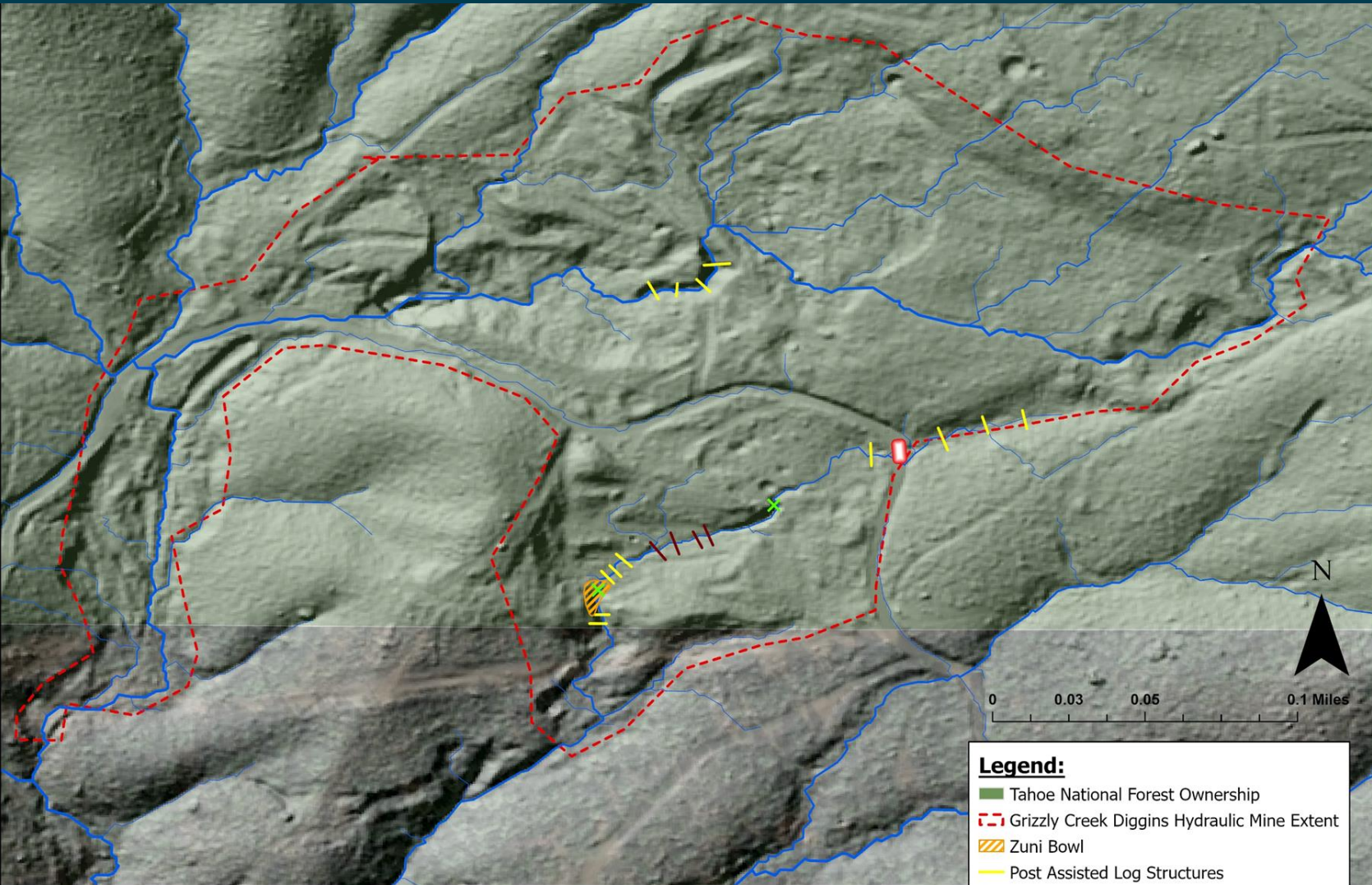
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As Noted. Sheet Number: 1





# What is Process Based Restoration?



**Legend:**


- Tahoe National Forest Ownership
- Grizzly Creek Diggins Hydraulic Mine Extent
- Zuni Bowl
- Post Assisted Log Structures
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As Noted.	Sheet Number: 1





# Grizzly Creek Diggins PBR Design: Post-Assisted Log Structures (PALS)







# Grizzly Creek Diggins PBR Design: One-Rock Dams (ORD's)





# Grizzly Creek Diggins PBR Design: Zuni Bowl

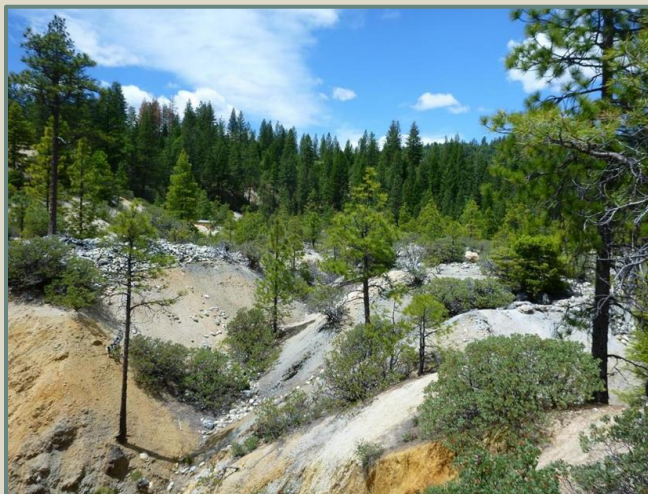






# Next Steps

- Continue soil health monitoring
- Expand biochar and woodchip applications
- Conduct fuels reduction actions
- Quantify benefits of avoided erosion







Contact Us!

The Sierra Fund

204 Providence Mine Road, Suite 214

Nevada City, CA 95959

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[Nick.Graham@sierrafund.org](mailto:Nick.Graham@sierrafund.org) or [Carrie.Monohan@sierrafund.org](mailto:Carrie.Monohan@sierrafund.org)