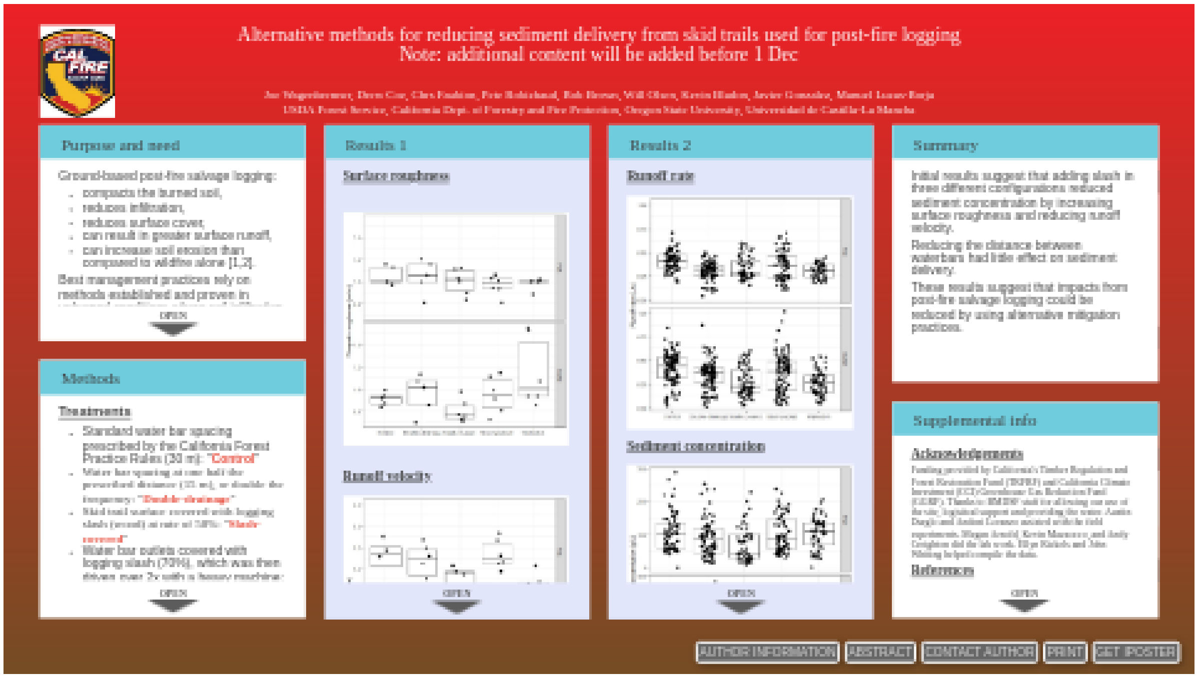
Alternative methods for reducing sediment delivery from skid trails used for post-fire logging



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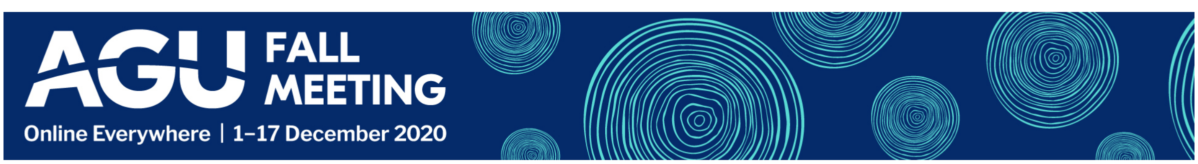


PURPOSE AND NEED

Ground-based post-fire salvage logging:

- compacts the burned soil,
- reduces infiltration,
- reduces surface cover,
- can result in greater surface runoff,
- can increase soil erosion than compared to wildfire alone [1,2].

Best management practices rely on methods established and proven in unburned conditions where soil infiltration rates are high.

But concentrated overland flow diverted from skid trails onto burned soils with low infiltration rates, often

- does not infiltrate,
- encounters little surface roughness, and
- can result in high rates of sediment delivery to streams [3].

We used runoff experiments on skid trails in a recently burned area to compare changes in runoff and sediment outputs among five mitigation techniques.

METHODS

Treatments

Standard water bar spacing prescribed by the California Forest Practice Rules (30 m): "**Control**"

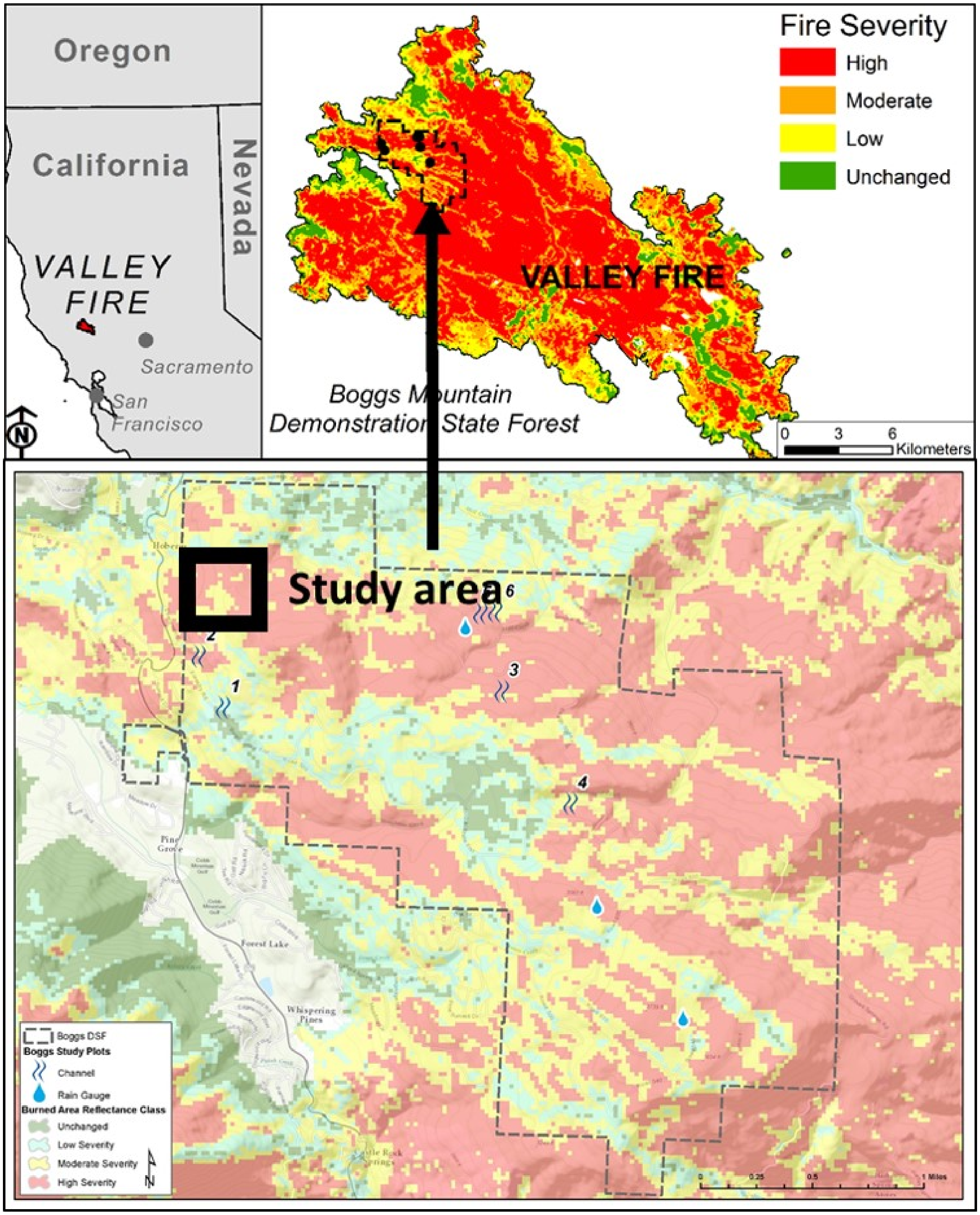
Water bar spacing set to 1/2 the prescribed distance (15 m), or double the frequency: "**Double-drainage**"

Skid trail surface covered with logging slash (wood) at rate of 50%: "**Slash-covered**"

Water bar outlets covered with logging slash (70%), which was then driven over 2x with a heavy machine: "**Slash-packed**"

Both skid trail surface and water bar outlet covered by logging slash (50% and 70% respectively), which was then driven over 2x with a heavy machine: "**Walked-in**"

Site



Boggs Mountain Demonstration State Forest (BMDSF), dashed outline, was burned by the 2015 Valley Fire. Map shows burn severity by color and location of the study site within BMDSF.

Study site within BMDSF:

- Annual precipitation of 1800 mm
- Sandy loam soils from volcanic parent material
- Pre-fire vegetation was a mix of ponderosa pine, sugar pine, Douglas-fir, and oak
- High soil burn severity (2015)
- Salvage logged in 2016
- Sprayed with herbicide then planted with conifer seedlings in 2018

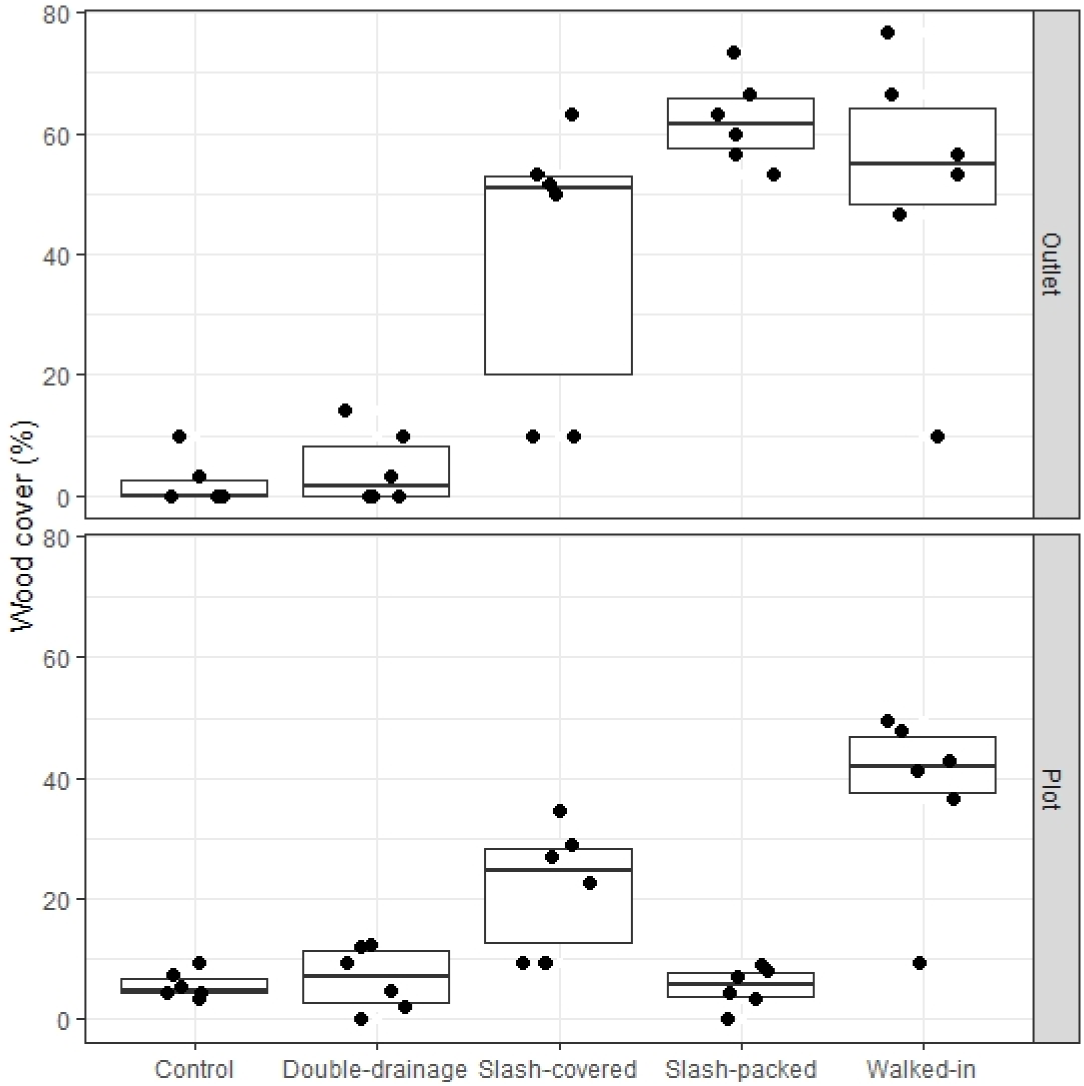
- Slopes of 30-40%
- 3 m wide skid trails installed by a licensed timber operator using tracked equipment (Caterpillar bulldozer and a Komatsu excavator) to make 4 round trips on each trail
- Waterbars installed by operator at treatment specified frequency
- Slash added or removed by hand or machine to achieve the 50% skid trail and 70% waterbar outlet cover targets
- Added slash was left on the surface or packed by machine as specified by treatment

Experiment

- 6 plots of each treatment
- **Plot test sections** were 1/2 the distance between waterbars and the full skid trail width
- Waterbar outlets were 7 m starting at the point where the skid trail met the waterbar
- **Outlet test sections** were the lower 3 m of waterbar outlet
- Inflow was applied across each **plot** at the mid-point between waterbars
- Inflow was applied across the full width of each **plot** using an adjustable-width sheetflow simulator [4]
- Inflow rate was 28 mm/hr for 30 min to match runoff from an accompanying rainfall simulation study [5]
- Inflow rates adjusted width and length of each **plot**
- Point-intercept surface cover along 3 downslope transects in the skid trail (**plot**) and one transect in the outlet test section (**outlet**)
- Surface roughness along flow path by 1-cm roller chain after simulation
- Runoff velocity by pulsed saline injection near the bottom of the skid trail section (**plot**) and in the outlet test section (**outlet**)
- Timed runoff samples were collected at **plot** and **outlet** locations
- Sample volume and sediment concentration by loss on drying

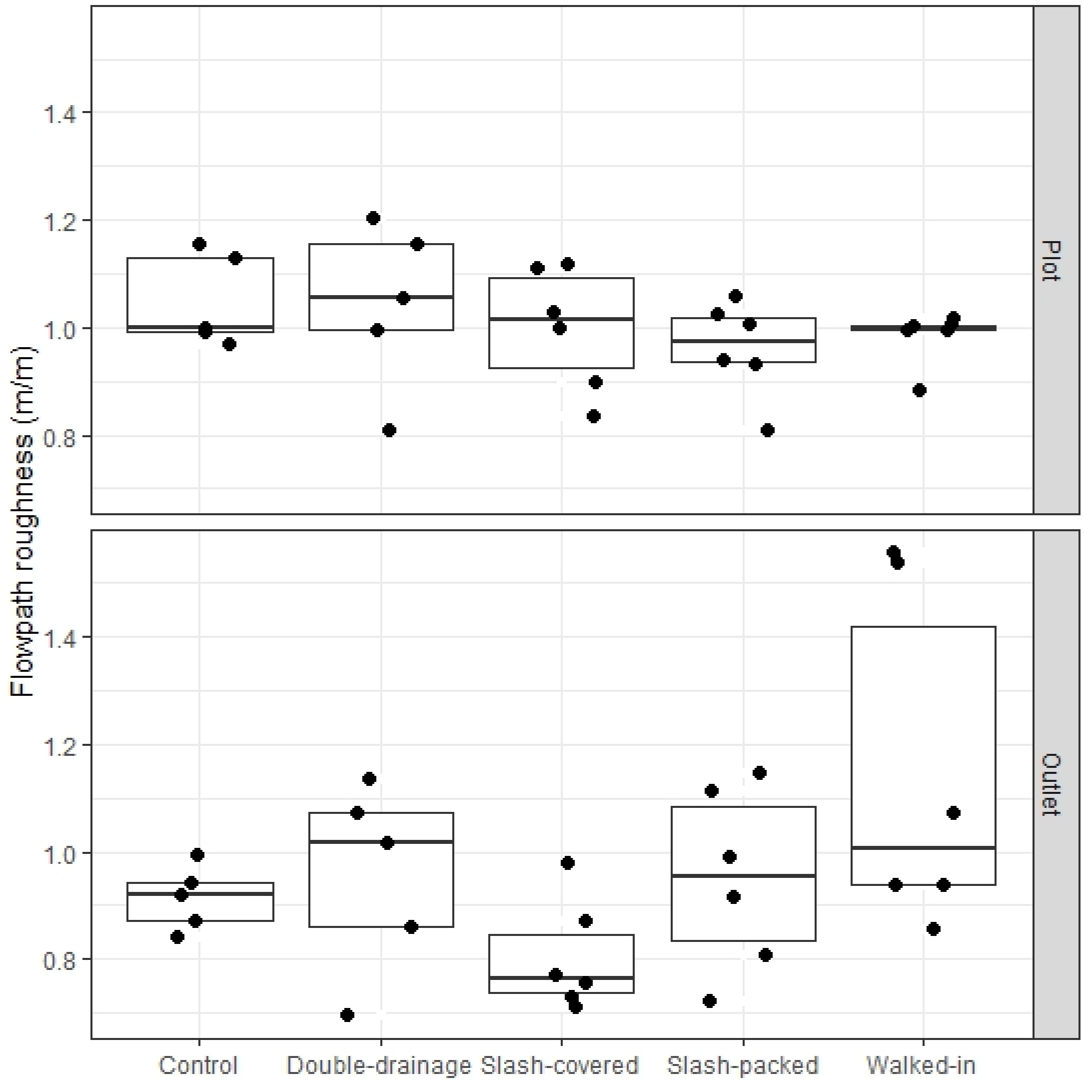
RESULTS 1

Wood cover



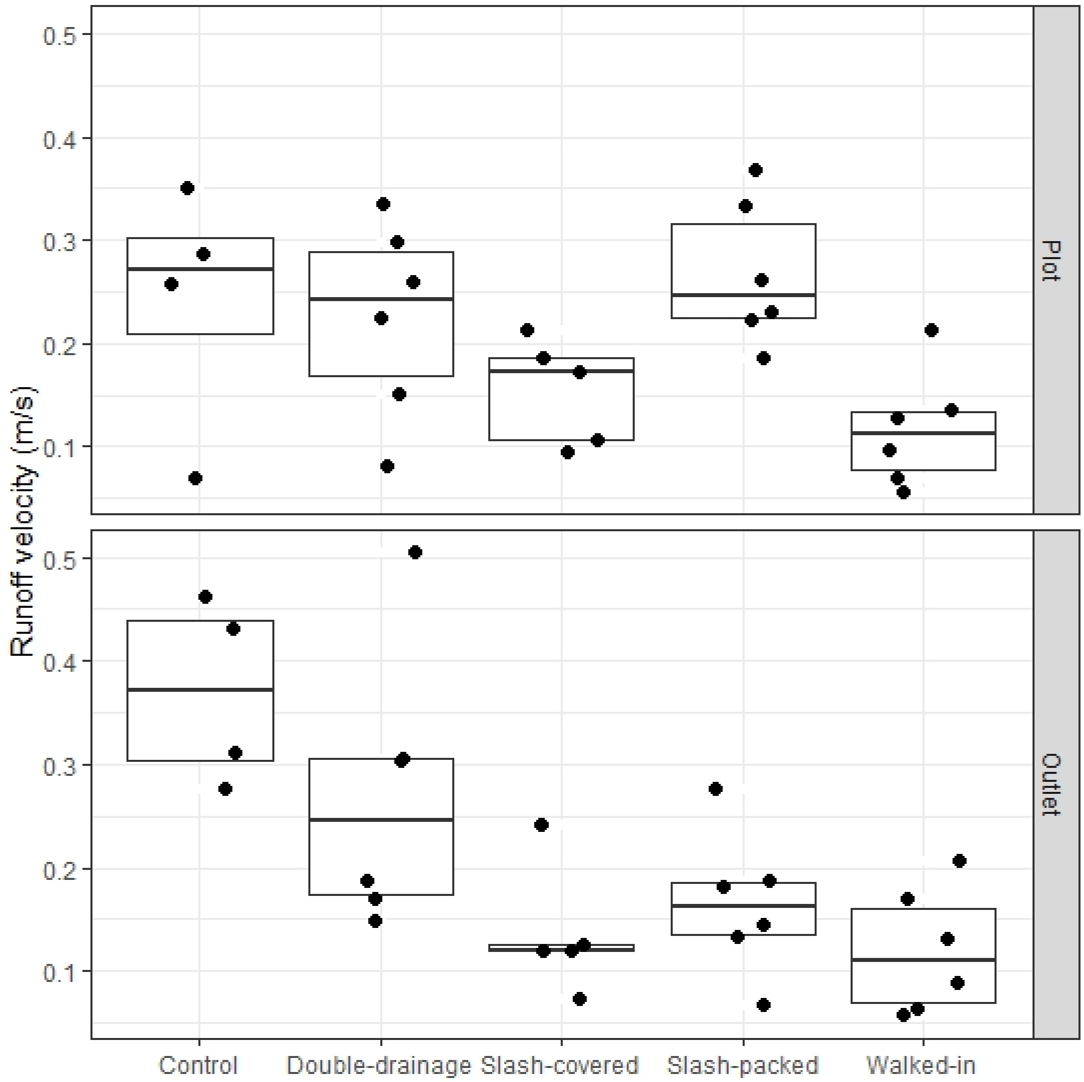
There was no difference in wood cover between the **Control** and **Double-drainage** **plots** or **outlets**. As expected, **plot** wood cover was greater for the **Slash-covered** and **Walked-in** treatments, which included addition of wood on the skid trail surface. **Outlet** wood cover was greater for **Slash-covered**, **Slash-packed,** and **Walked-in** treatments.

Surface roughness



Surface roughness by the chain method showed no real differences in the **plots**, even in those treatments where slash was added to the skid trails (**Slash-covered** and **Walked-in**). Roughness in the **outlets** was more variable within each treatment than in the **plots**, and none of the treatments appeared to affect surface roughness.

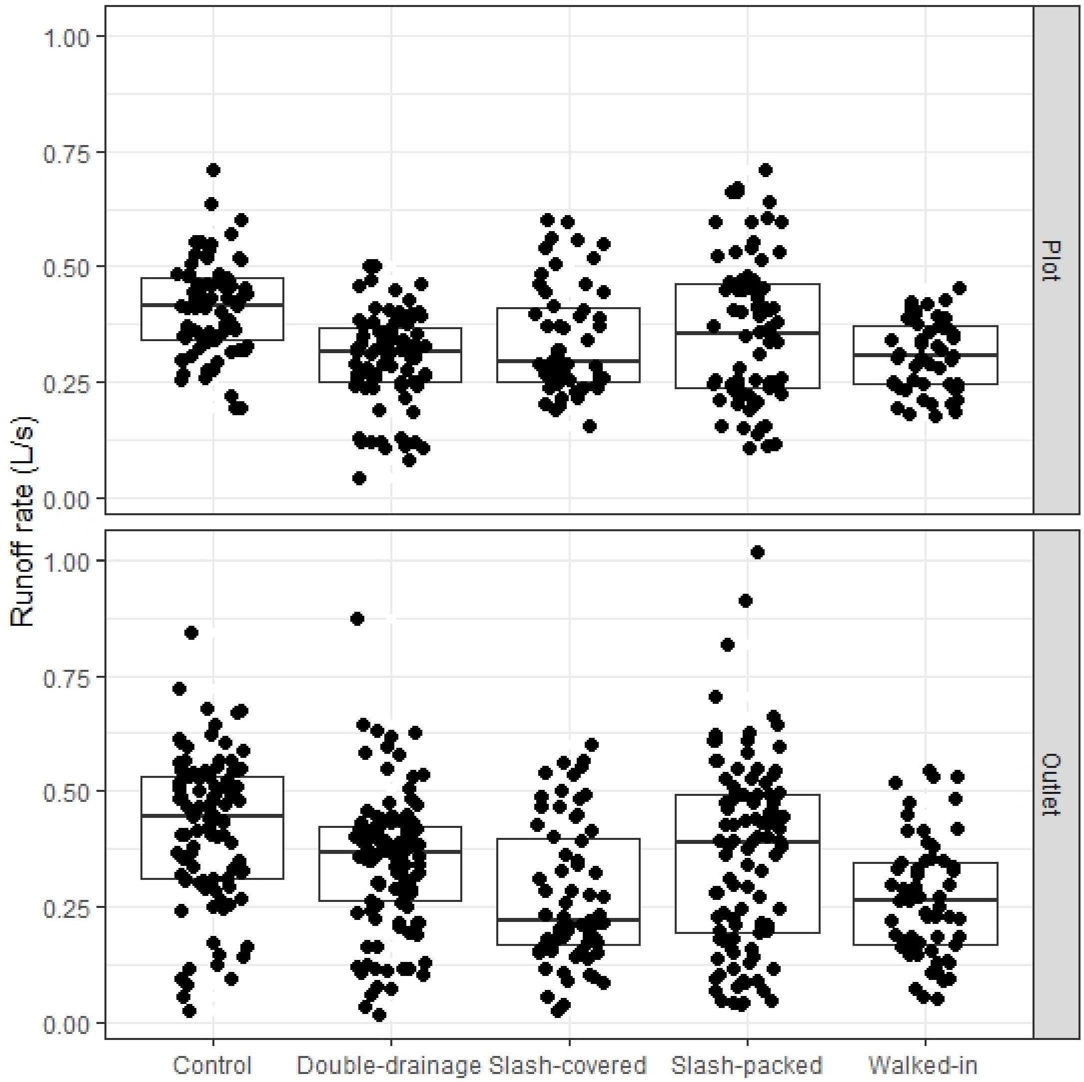
Runoff velocity



Despite the lack of detection of differences among treatments in surface roughness, the **plot** runoff velocities appear lower for the treatments where slash was added to the skid trails (**Slash-covered** and **Walked-in**). All treatments had lower runoff velocities in the **outlets** than the **Controls**, particularly where slash was added to the waterbar outlets (**Slash-covered, Slash-packed,** and **Walked-in**).

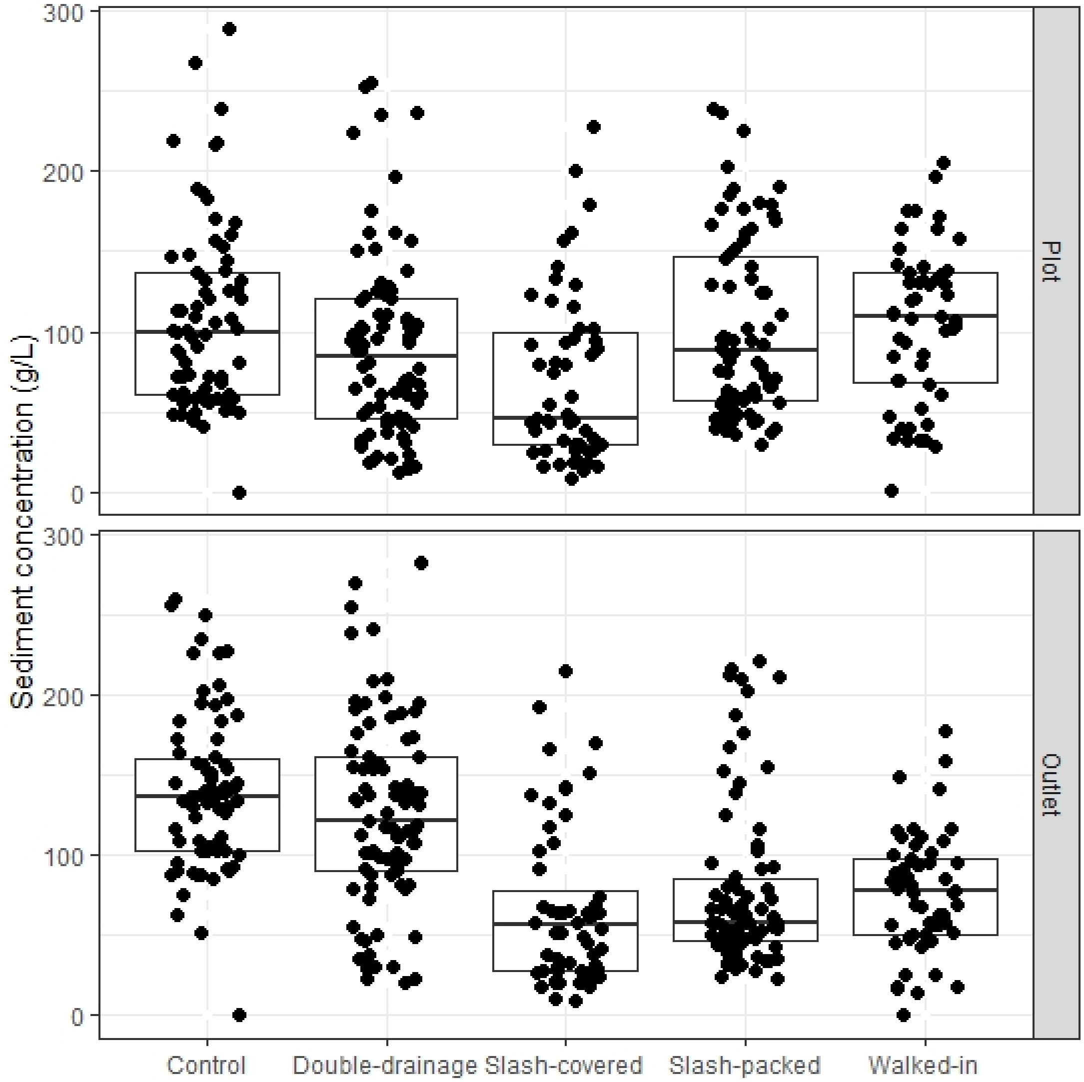
RESULTS 2

Runoff rate



Runoff rates across all treatments were highly variable. Two plots (one **Control** and one **Walked-in**) did not produce runoff after 30 min despite the relatively high inflow rate (data not shown in figure). Runoff rates in the **Double-drainage** treatment were lower than the **Controls** because of the higher frequency of waterbars and shorter plot lengths. Runoff rates in the **Slash-covered** and **Walked-in** treatments appear lower than the **Controls** despite the same **plot** lengths.

Sediment concentration



Sediment concentrations were similar at the **plot** sample location across treatments except for the **Slash-covered** which was slightly lower. At the **outlets**, there was no difference in sediment concentration between the **Controls** and **Double-drainage** treatments, and the **Slash-covered**, **Slash-packed**, and **Walked-in** treatments appear to have lower concencentrations.

SUMMARY

Despite plot-plot variability, initial results suggest:

- Reducing the distance between waterbars in the **Double-drainage** treatment had little effect on sediment delivery.
- Adding slash in three different configurations reduced sediment concentration by increasing surface cover and reducing runoff velocity.
- By comparing the results from the **plots** and **outlets**, the addition of slash to the waterbar **outlets** seemed to have greater influence on the sediment delivery than slash added to the skid trails.

These results combined with observations and studies on sediment delivery and skid trail connectivity to stream networks in burned and logged areas [3] suggest that adding slash to skid trails, and especially to waterbar outlets on skid trails, can reduce sediment delivery from post-fire salvage logging operations at larger spatial scales. Additional analyses, including statistical comparisons and runoff rates relative to inflow rates, are underway.

SUPPLEMENTAL INFO

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ABSTRACT

Ground-based salvage logging after wildfires generally compacts the burned soil, reduces infiltration, and reduces surface cover, resulting in greater runoff generation and soil erosion than compared to wildfire alone. Management options to mitigate soil erosion and sediment delivery from post-fire logging sites rely on methods established for unburned conditions, where water is diverted from skid trails and other compacted surfaces such as landings, firebreaks, and roads, and infiltrates into relatively undisturbed forest soils. These techniques are well established and effective in unburned forests. However, in burned conditions, the infiltration rate of the soil is often reduced by fire, resulting in increased overland flow and often little reduction in sediment delivery to streams when the runoff is diverted onto burned soil. We used runoff experiments on skid trails in a recently burned area to compare changes in runoff and sediment outputs among five mitigation techniques, including the current standard waterbar spacing for the site conditions. Initial results suggest that adding downed wood (logging slash) in three different configurations, including across the skid trail and only at the waterbar outlet, reduced sediment concentration by increasing surface roughness and reducing runoff velocity. Increasing the frequency of waterbars had little effect on sediment delivery. These results suggest that impacts from post-fire salvage logging could be reduced by using alternative mitigation practices.