POST-FIRE FALLOUT: MEASURING FALLOUT RADIONUCLIDES TO UNDERSTAND SOIL EROSION IN A BURN SCAR

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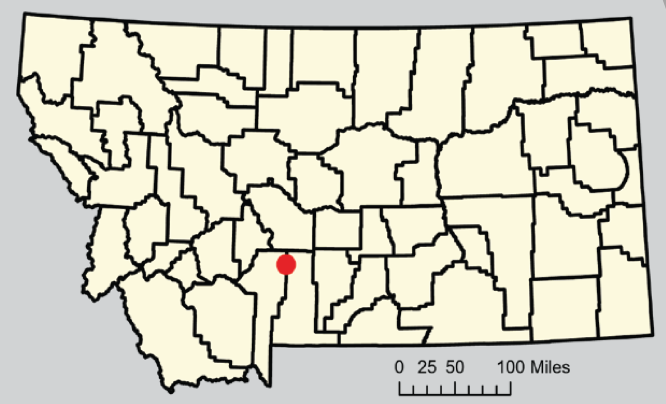
I. FIRE AS A DRIVER

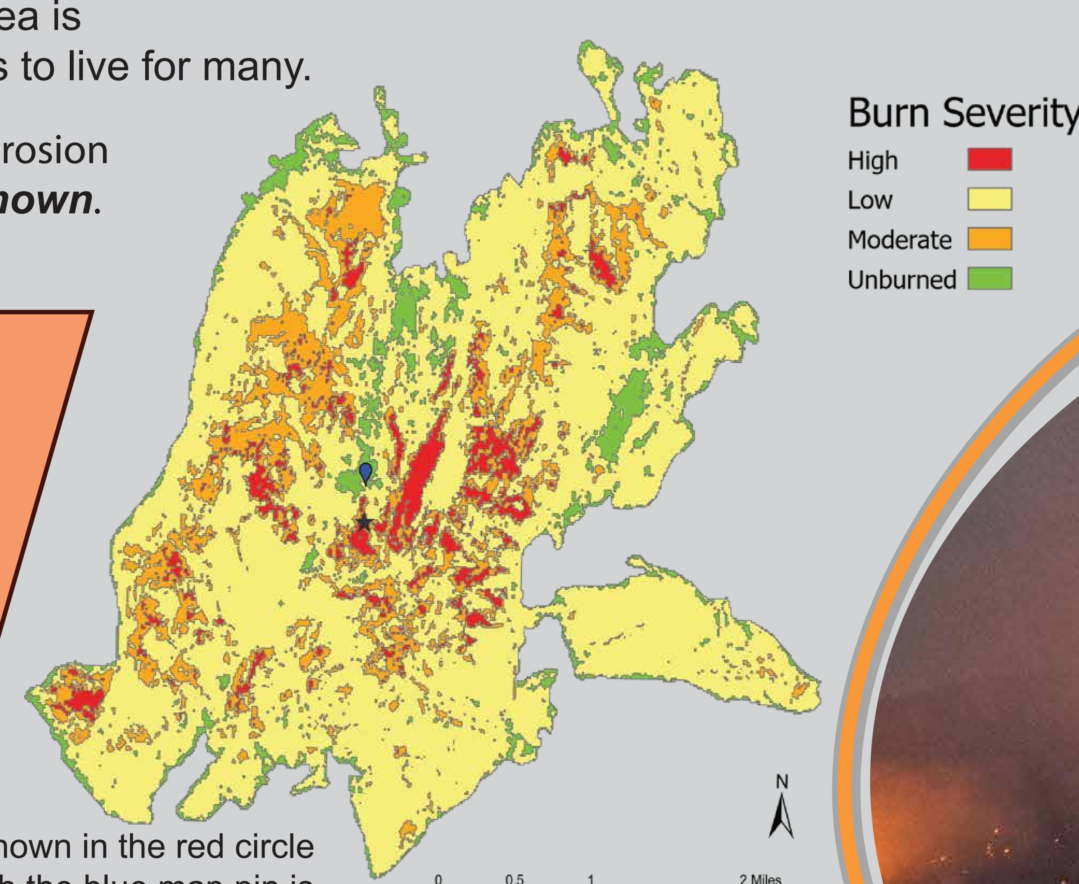
Fire increases erosion by removing vegetation and priming soil for removal by rain, snow and other weather events. This erosion can be hazardous to communities and serves as a pollutant to streams. ***Most erosion occurs 1 year after a fire (Robichaud et al. 2010).***

- Post-fire erosion is traditionally quantified using methods that are large-scale, and field and time intensive. (Benavides-Solorio & MacDonald, 2005).
- There is a need for rapid research response, and fallout radionuclides (FRNs) may be improvements over traditional methods.



The Bridger Foothills Fire occurred in September 2020, burning > 8,000 acres of land near Bozeman, MT (Gabbert, 2020). This area is used for recreation and provides places to live for many.

- There is concern about post-fire erosion in this area, ***but the risk is unknown***.

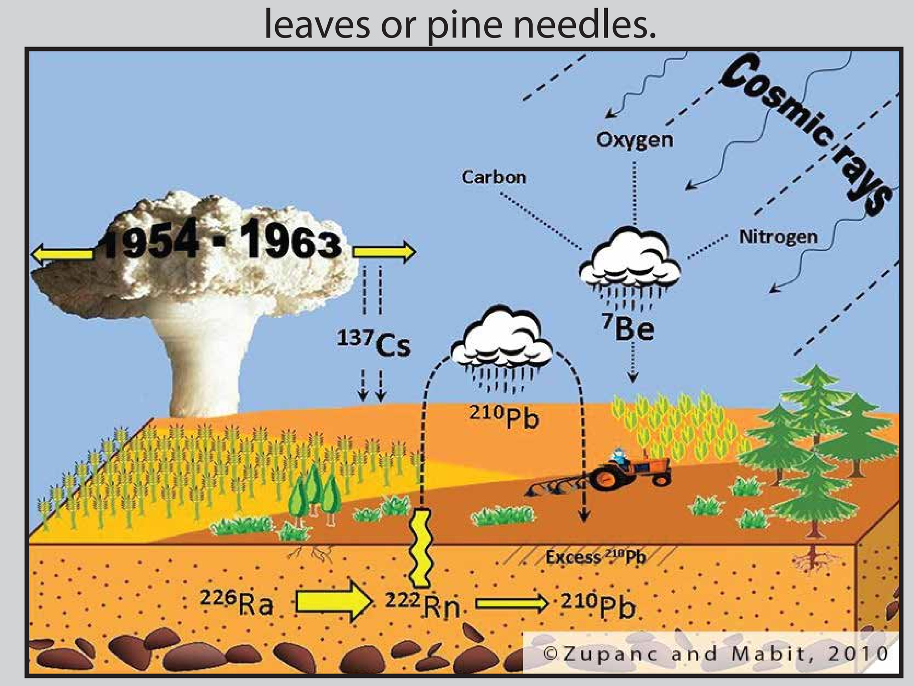


To address this need, we used FRN analysis to quantify small scale soil movement and erosion one-year after the fire.

Burn severity map for the Bridger foothills fire, shown in the red circle on full Montana extent map. The area shown with the blue map pin is the unburnt area sampled, and the black star shows the burn areas (High 1, High 2, and Burn 3).

II. TRACING EROSION USING ISOTOPES

- Fallout Radionuclides (FRNs) are isotopes with known decay rates
- Can be produced as cosmogenic nuclides or from nuclear weapons testing
- FRNs are deposited on soil surface & can be taken up by plants
- Isotopes can reenter the system through deposition of vegetation debris, like leaves or pine needles.

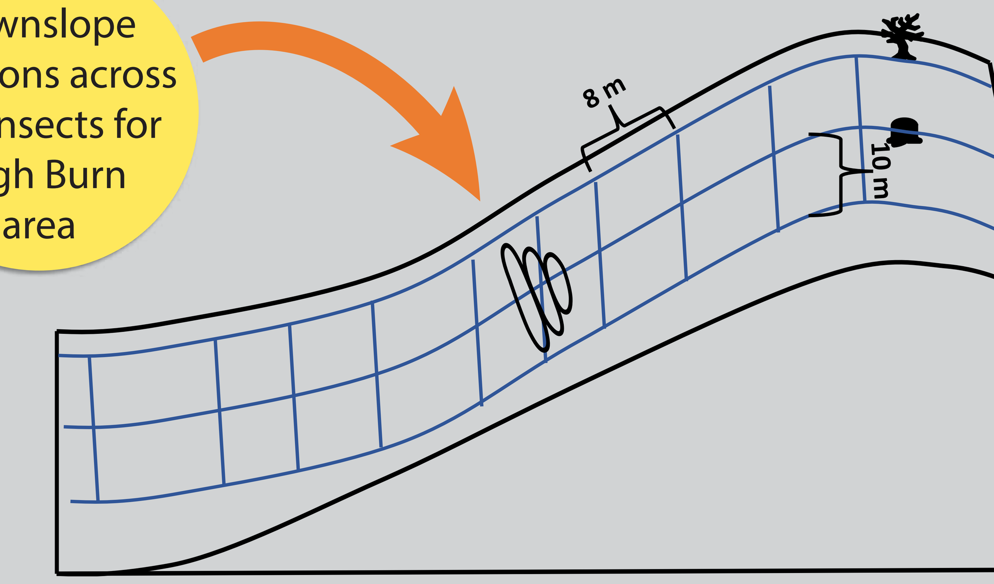


Zupanc, V., & Mabit, L. (2010). Nuclear techniques support to assess erosion and sedimentation processes: preliminary results of the use of 137Cs as soil tracer in Slovenia. Dela, 33(2), 21-36

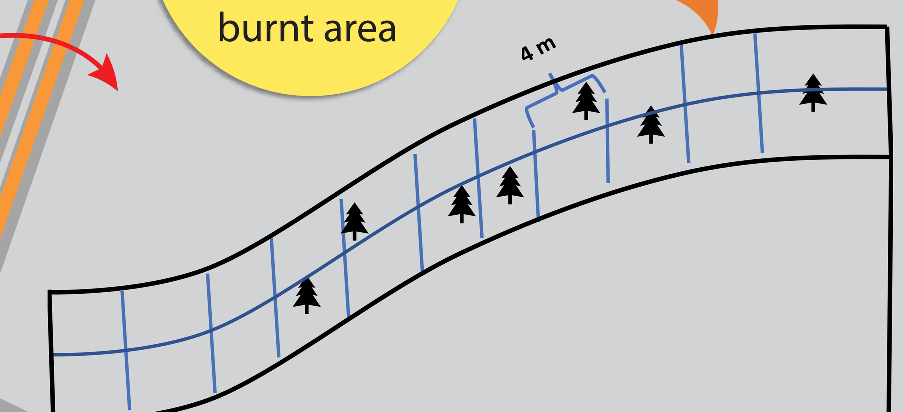
Center photo courtesy of Lance Gilliland

III. FIELD METHODS

10 downslope positions across 3 transects for High Burn area

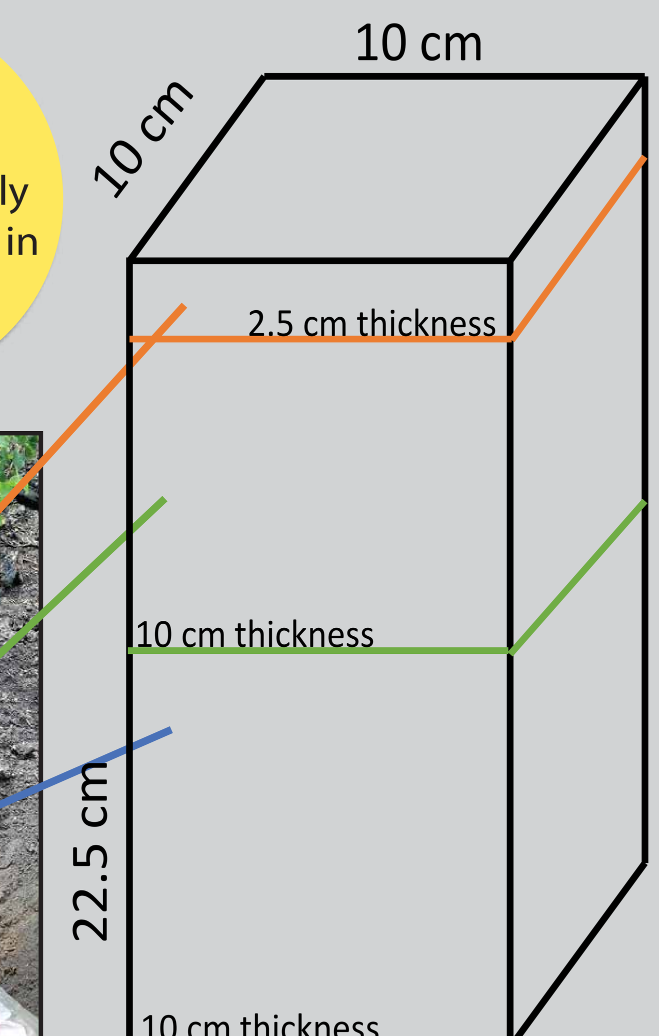


10 downslope positions across 1 transect for un-burnt area



Only top 12.5 cm were actually packed and run in detectors

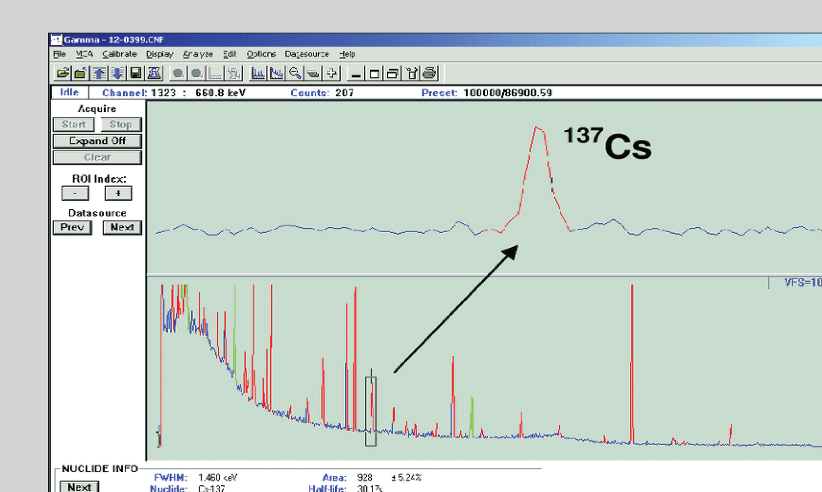
10x10x22.5 cm chunks of soil were sampled from each position. Each sample was dried and weighed for the detectors.



IV. ANALYTICAL METHODS

Broad Energy Germanium Detectors (BEGD).

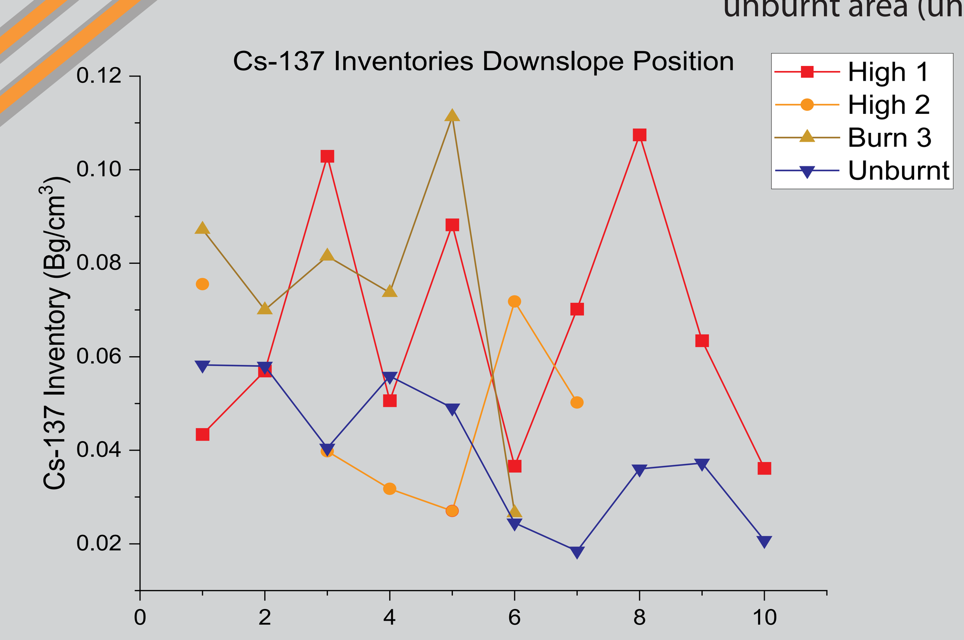
The soil samples were placed in Broad Energy Germanium Detectors that measure gamma radiation. The counts of decays for different isotopes were collected by the detectors for the top two depths of each sample collected at each position.

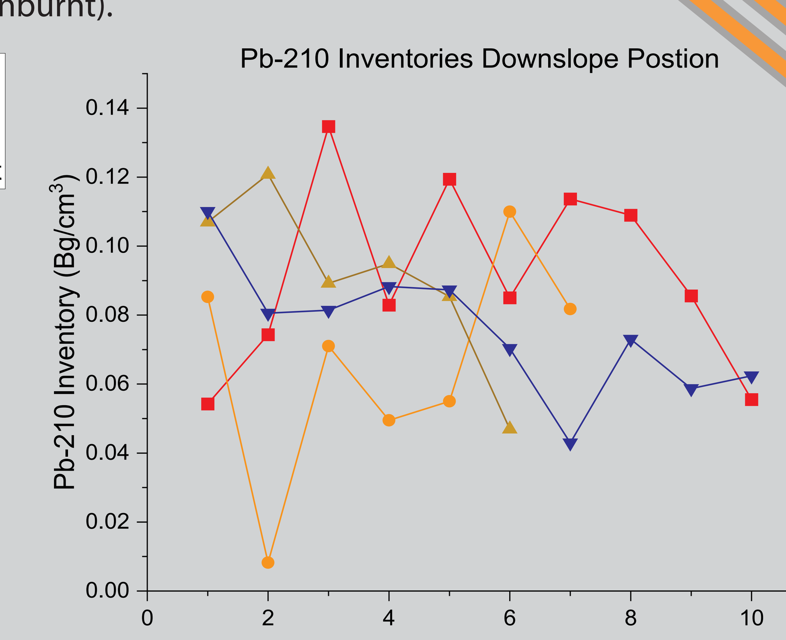


Example spectrumfrom BEGD detectors, highlighting Cs-137 decay counts (Rodriguez et al.)

V. RESULTS

Inventories of Cesium 137 (Cs-137) and Lead 210 (Pb-210) for four sampled transects across ten positions downslope. Three transects were in burnt areas, two in high intensity (High 1 & High 2) and a third in a transitional area (Burn 3), and one transect in the unburnt area (unburnt).





VI. CONCLUSIONS AND IMPLICATIONS

- The high burn areas exhibited higher inventories when compared to unburnt areas across all downslope positions.
- Variation in the high intensity site (High 1) could have resulted from the FRNs being reintroduced to the soil via vegetation litter, as about 20% of the FRN inventory can be held in conifer needles (Landis, 2014).
- Sampling methods most likely resulted in the variation across all four sites, as the FRN invetories are highly variable as we move downslope.
- Through improved sampling methods and potentially repeated sampling in similar sites, local changes can be observed and applied to other hillslopes that have experienced fire.

References:

Benavides-Solorio, J., & MacDonald, L. (2005). Measurement and prediction of post-fire erosion at the hillslope scale, Colorado Front Range. International Journal of Wildland Fire, 14(4), 457-474. https://doi.org/10.1071/WF0504

Gabbert, Bill. (2020). Report released for fire shelter deployment on Bridger Foothills fire in Montana. Wildfire Today. https://wildfiretoday.com/2020/12/08/report-released-for-fire-shelter-deployment-on-bridger-foothills-fire-in-montana/

Landis, Renshaw, and Kaste, “Quantitative Retention of Atmospherically Deposited Elements by Native Vegetation Is Traced by the Fallout Radionuclides 7Be and 210Pb.”

Robichaud, P., Ashmun, L., Sims, B. (2010). Post-fire treatment effectiveness for hillslope stabilization. USDA General Technical Report RMRS-GTR-240. https://www.fws.gov/fire/downloads/ES_BAR/Post-Fire_Hillslope_Treatment_Synthesis.pdf

Rodriguez et al., “Radionuclide Determination Techniques and Spectroradiometry as Tools to Determine Soil Erosion.”