

Wildfire and Extreme Rainfall Reduce Soil Carbon & Nitrogen Pools in a Semiarid Shrubland Ecosystem



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Wildfires and extreme climatic events such as heat waves, drought, and intense storms are becoming more frequent in semiarid regions such as southern California. The combined effects of these disturbances on ecosystems are uncertain, and greater understanding is needed to manage the effects of fire and extreme climatic events. This study established rain shelters that blocked 66% of incoming rainfall, paired with control plots that received 100% of rainfall, in areas of a landscape that had recently experienced wildfire and in adjacent areas outside the fire perimeter. Soils from the burned areas had reduced organic carbon and nitrogen content, deteriorated structure (destruction of soil aggregates and pores), and slower drainage of water to lower layers compared to the unburned area. In 2023, the region received twice the normal amount of rainfall, following two years of drought. In this extreme rainfall year, the rain shelters prevented loss of organic matter from the soil and reduced excessive runoff from burned areas during large rain events. This shows that when rainfall exceeds a certain level in recently burned landscapes, it speeds up degradation of soil and slows recovery of soil structure, creating a cycle that can cause further damage to soil quality.

MANAGEMENT IMPLICATIONS

- Wildfire damages soil structure, shifting soil organic matter storage to more vulnerable pools and slowing water infiltration, thereby increasing runoff and erosion during extreme rain events.
- Restoration measures to reduce the impacts of fire on soil erosion could help interrupt this feedback cycle.
- The loss of particulate organic matter in this study implies that mulch addition might help make soils less vulnerable to erosion from extreme rain events after a wildfire.
- This study implicates high Mg/Ca as a contributing factor to soil degradation after wildfire, suggesting a possible remediation approach. Applying Ca²⁺ after wildfire might stabilize soil structure in some cases.

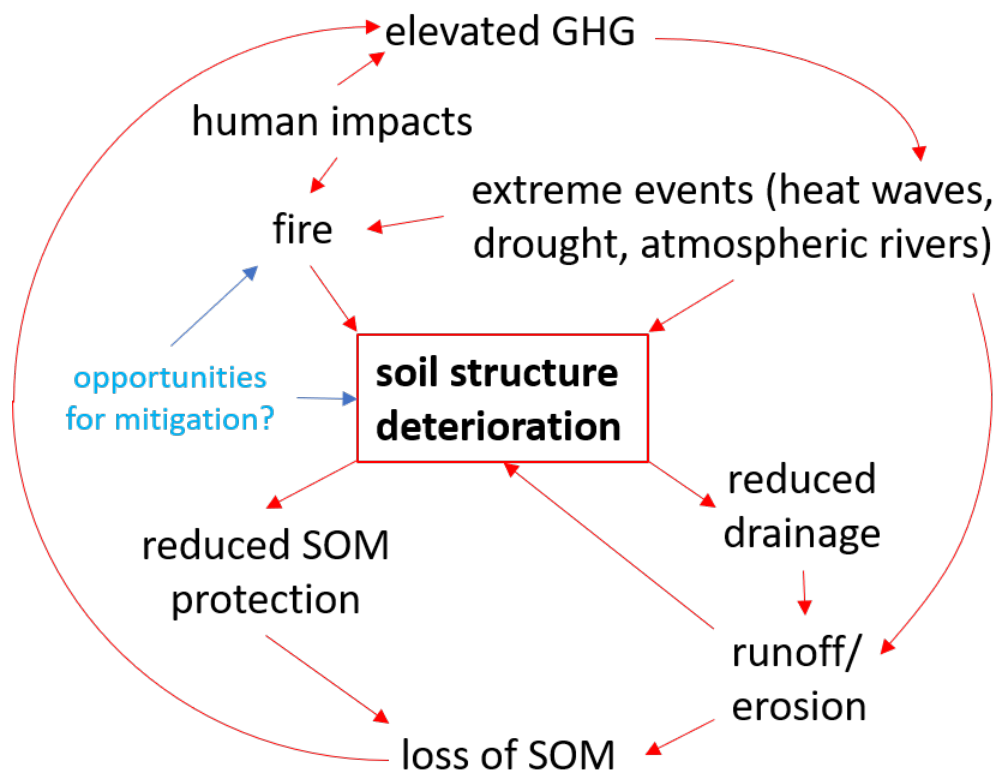


Figure 1. Diagram of effects of fire and extreme climate on soil properties, feedbacks that amplify these impacts locally and globally, and the potential to mitigate these feedbacks through local interventions such as soil restoration or fire management. GHG = greenhouse gases, SOM = soil organic matter.

Additional Information

This brief is based on the following article:

Lipson, D. A., A. G. Alvarez, J. N. Brouwer, E. E. Cleland, J. B. Lively, D. S. Parsons, Fortunato Vincente Rivas, K. L. Smith, E. L. Varon, and X. Xu. "Wildfire and extreme rainfall reduce soil carbon and nitrogen pools in a semiarid shrubland ecosystem." *Journal of Geophysical Research: Biogeosciences* 131, no. 2 (2026): e2025JG009183.

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Suggestions for further information:

He, Liyuan, David A. Lipson, Elsa E. Cleland, and Xiaofeng Xu. "Reduce revenue versus increase expenditure: Fires and plant invasion drive soil carbon loss with different mechanisms in a Mediterranean shrubland." *Journal of Geophysical Research: Biogeosciences* 130, no. 7 (2025): e2025JG008964. <https://doi.org/10.1029/2025JG008964>

Smith, Karagan L., Rachel K. Brown, Kristal S. Lam, David A. Lipson, and Elsa E. Cleland. "Moderate burn severity, invasive competitors, and herbivory reduce post-fire shrub recovery in semi-arid shrubland." *Fire Ecology* 22, no. 1 (2026): 66. <https://link.springer.com/article/10.1186/s42408-026-00483-7>