

Instructional Value

Soil is often overlooked when considering the impacts of wildfires. This activity addresses those often-overlooked impacts.

Grade Level: 6-8, 9-12

Type of Lesson:
Activity

Materials Needed

- Disposable pipette (1 or 3 ml)- alternative: squeeze water bottle capable of emitting a drop of water)
- Distilled water
- Stopwatch
- Soil Aggregates (see note on page 2)

Time

Teacher Prep: 30 minutes or 2 hours if hydrophobic soil needs to be made

Student Class Time: 45 minutes

Student Learning Objectives:

- Analyze data to determine the impact of wildfires on soils.
- Construct an explanation for the differences in impacts in various locations where wildfires have occurred.

Keywords

Fire, hydrophobic, ash,

NGSS Standards

MS-ESS3.B and HSESS3.B

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Soil and Wildfire Recovery: Hydrophobicity

Overview

Large wildfires are becoming more common across the Great Plains, Southwest and western United States. The terrain and type of fuel - dried grass, shrubs, deciduous or coniferous trees – affects how fast the fires can travel across the landscape, which can affect how fast the fires move – grass fires on the open plains can travel as much 100 kph (about 60 mph).

Fast-moving grass fires generally are not as hot as forest fires. The leaf composition also affects the heat of the fire and the aftermath; conifers have waxy resins on the needles which can coat soil particles when they melt. Soil particles coated with these waxes repel water – become hydrophobic.

Hydrophobic layers may form at different depths, and their thickness varies depending upon the nature of the fire. Though the problem is more severe in coniferous wildfires, any fire may cause soils to repel water. Water-repellent soils lead to several management challenges during recovery.



Hydrophobicity-water droplet does not infiltrate

Hydrophobicity decreases infiltration, increasing runoff and erosion in sloping landscapes. In flat landscapes, reduced infiltration leads to water ponding on the surface in low spots. It also can lead to greater preferential flow – the water moves downward through cracks in the soil faster because it is not absorbed into soil aggregates (soil particles clumped together).

Preferential flow increases the potential for leaching and groundwater contamination. Wildfires and hydrophobicity also affect the soil microbial communities due to the changes in water status in the soil.

There are two main methods used by the USDA Natural Resources Conservation Service to determine the degree of hydrophobicity; the simplest method is the water drop penetration test, which is described here.

Soils and Wildfire Recovery: Hydrophobicity

Soil Science Society of America

Hydrophobic soils repel water, so the degree of hydrophobicity can be determined by the amount of time it takes a drop of water to infiltrate the soil – the water drop penetration test (WDPT). In the field, the test is done to determine the depth and degree of the hydrophobic layer by scraping off sequential layers of soil and repeating the test. The ash layer is always hydrophobic. In the lab or classroom, scrape away the ash layer and collect aggregates from different depths in soils that have been affected by wildfires and soils that have not for comparison.

(Note on materials: This activity uses soil aggregates from different depths from soils affected by wildfires and from soils that have not suffered a wildfire – an aggregate is a clump of sand, silt and clay particles held together by the cohesion of clay particles and various organic compounds that act like glues.)

Method for lab or classroom

1. Use the introductory content to discuss the impacts of wildfires and how the impacts may vary depending on the conditions of the location.
2. Ask students to describe what might happen to soil if it is heated by wildfire, and why.
3. Define the term “hydrophobicity” and mention that they will test multiple soils for their degree of hydrophobicity by using the following protocol:
 1. Place 1 drop of water 2 or 3 places on an aggregate (more on a larger aggregate).
 2. Start the stopwatch at the same time.
 3. Record the time it takes for the water drop to penetrate (be absorbed by) the soil.
 4. Repeat for the other aggregates

Interpretation

Five classes are used to identify the degree of hydrophobicity.

Class I, wettable, not water repellent (< 5 seconds)

Class II, slightly water repellent (>5 to <60 seconds)

Class III, strongly water repellent (>60 to <600 seconds)

Class IV, severely water repellent (>600 to <3600 seconds)

Class V, extremely water repellent (>3600 seconds)

Discussion Questions:

1. Analyze and interpret the data you collected: What did you notice about the amount of time it took for water to penetrate the wildfire soil and non-wildfire-soil?
2. What is the cause and effect relationship between wildfires and soil? Under what conditions would you expect the impacts to differ from one location to another where there were wildfires?
3. Why is hydrophobicity a concern?

Source: USDA Natural Resources Conservation Service. 2014. Soil Survey Field and Laboratory Methods Manual: Soil Survey Investigations Report No. 51, Version 2. Section 3.8 Soil Water Repellency, pp. 162-164.

Photo credit: USDA USFS, Parsons, A., P. R. Robichaud, S. A. Lewis, C. Napper, and J. T. Clark. 2010. Field guide for mapping post-fire soil burn severity. Gen. Tech. Rep. RMRS-GTR-243. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station

Make Your Own “Fire-Affected” Hydrophobic Soil

Author: Gordon Rees

Materials needed:

- Sand (natural, or bagged from a hardware store)
- Organic amendments (potting soil, peat moss, well decomposed compost, etc.) *
- Aluminum pans

*Note: Some organic materials may produce better results than others – try with a few different options to see which works best for you. **Avoid any material that may contain synthetic fertilizers, pesticides, or other components which may produce harmful fumes when heated.**

Procedure

1. Mix 9 parts sand with 1-part organic material (by volume) in a bucket and spread into aluminum pans filling to about an inch deep.
2. Heat in an oven IN A WELL-VENTILATED SPACE at 350° F for at least an hour. Test your hydrophobic soil after an hour. If water still enters quickly, increase the heating time to 2 hours. Be careful to avoid breathing fumes that may be released during heating.
3. Hydrophobicity should last for a few weeks but may fade over time.

Experiment Ideas:

To examine how different conditions impact hydrophobicity, try using different materials, changing ratios, heating at different temperatures, and heating for different amounts of time. Example questions to explore:

- Does loamy or clayey soil become hydrophobic as easily as sand?
- Is there a temperature that maximizes hydrophobicity?
- How long does hydrophobicity last in soils?
- Does increasing/decreasing the amount of organic material in the mix impact hydrophobicity?
- Do different organic materials change how hydrophobic the soil becomes?

Adapted from:

McMillan, M., Williams, K., Moore, K., Daroub, S., Erickson, J. E., Kostka, S., & Fidanza, M. (2023). Evaluation of a Method to Induce Hydrophobicity on Sand. *HortScience*, 58(12), 1573–1578.

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