Don't Judge a Soil by Its Color:

Photo by Kari Greer, National Interagency Fire Center.

Exploring Forest Soil Following a Wildfire

Meet the Scientists

Dr. Jane E. Smith, Research Botanist: My most awe-inspiring moment as a scientist came when walking deep into an old-growth forest just a few weeks after a severe wildfire had killed all of the trees. The blackened trees towered in stark contrast against a background of reddish soil, which had practically no vegetation. The giant dark pillars towered in eerie silence.

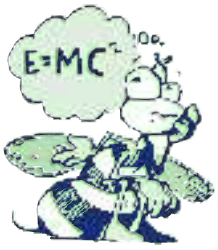
What for many might have been seen as devastation was somehow strikingly beautiful and powerfully exciting! Long red areas marked the previous location of logs, completely removed by the fire. Was there life in the soil? When would the soil **microorganisms,** important to forest life aboveground, return? We were mesmerized by the power of nature and inspired by this research opportunity.

Ms. Cassie Hebel, Soil Scientist: My favorite science experience is studying **mycology** (mī-'**kä**-lə-jē) and learning to identify all types of mushrooms. It is fun to look inside the wonderful kingdom of fungi. From the smallest underground truffle forming **mycorrhizal** (ˌ**mī**-kə-'rī-zəl) connections on plant roots to the largest conk decomposing dead logs, they are all fascinating. ▼

Thinking About Science

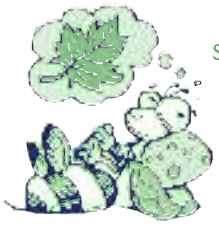
To become a research scientist, you must attend college and earn a series of **academic** degrees. After 4 or more years in college, you could earn a bachelor's ('**bach**-lərz) degree. A master's degree follows, usually after 2 to 3 more years of study. Finally, you may earn a doctoral degree, commonly called a Ph.D. (Ph.D. stands for Doctor of Philosophy (fə **lä** sə fē)).

It could take up to 4 more years to earn a Ph.D. For every year of study, a student becomes more expert in a particular area of study. One can become an expert in almost any area—from art to **zoology**. To earn a masters or doctoral degree, most students must do a research study. For a master's degree, this study is called a thesis ('**thē**-səs).



The research in this study was done by a student earning her master's degree. The student learned that asking research questions and solving them was fun for her. If you are interested in learning new things, you might discover that you like to ask and solve research questions too!

Thinking About the Environment



Do you ever think about what happens underground? The soil is a world about which we seldom think. It is a busy place, full of **microscopic** organisms, including bacteria and fungi. Bacteria and fungi are decomposers. Decomposers break down dead and decaying material. They recycle once-living and nonliving material and make it available for other organisms to use. Bacteria live everywhere on Earth where life is possible.

You have probably seen the fruits of some fungi on the ground or growing on tree trunks. Did you know that some fungi live on the underground roots of plants? These fungi, called mycorrhizal fungi, have an interesting relationship with plant roots. These fungi need plant roots to live, and plant roots need the fungi. Plants create carbon as they photosynthesize, and some of the carbon is sent to the plant's roots. Plant roots then provide carbon to the fungi. The fungi help the plant take in mineral nutrients, such as phosphorus, from the soil.

In this study, the scientists were interested in learning about what happens to mycorrhizal fungi after a forest fire. They wanted to know what happens when a fire burns large pieces of wood on the ground, causing the soil to be intensely heated. They also wondered how this would affect the growth of new plants following the wildfire.

Introduction

When a wildfire burns across a forest, logs and stumps on the ground may completely burn up. When this happens the soil beneath and near the logs and stumps is intensely heated. Soils heated in this way turn a light red color (**figure 1**). These soils, not surprisingly, are called "red soils" by soil scientists.

Scientists know that red soils have been damaged by fire. Bacteria and fungi are killed, and the chemical properties of the soils change. During a wildfire, the soils that did not have logs or stumps do not get as hot. The fire may burn shrubs and small trees, but the fire passes through quickly without hurting the soil. Soil scientists call these soils "black soils."

Figure 1. This is an area that had recently experienced a wildfire. Notice the different colors of the soil. The strips of lighter color are the red soils. They are in strips because a log completely burned, causing the soil beneath it to be intensely heated. Most of the soils, however, are black soils. Photo by Garrett Meigs.

Many scientists believe that, following a wildfire, **nonnative invasive** plants are likely to spread into the area. This might happen because the burned area is cleared of **native** plants, opening it for invasive plants. Invasive plants can spread and grow rapidly, which means that their roots may grow rapidly as well.

The scientists in this study wanted to answer two questions: (1) What are the differences, if any, between the growth of nonnative invasive species and the growth of native species in red and black soils following a wildfire? (2) What happens to mycorrhizal fungi following a wildfire?

Reflection Section

- Explain why red soils are either found in strips or in round shapes following a wildfire. Do you think that more area is in red soils or black soils following a wildfire? Why?
- If nonnative invasive plants grow more rapidly than native plants, how might mycorrhizal fungi be involved with this process?

Methods

The study was done in Oregon, in an area that had experienced a wildfire in the summer of 2003 (**figure 2**). This fire burned 36,733 hectares of forest.

Figure 2. The study was done in the Deschutes (dā-'**shüt**) National Forest in Oregon.

Number Crunches

How many acres burned in the Deschutes National Forest in 2003? Multiply 36,733 by 2.47 to find out.

In 2004, the scientists collected **samples** of red soil and black soil from 10 areas. They selected these areas **randomly**. The scientists collected the samples in pairs, so that each pair of red and black soil had been collected less than 1 meter apart. Each soil sample weighed at least 6.5 kg, and was taken from the top 5 centimeters of soil.

Number Crunches

How many total soil samples did the scientists collect? How heavy in pounds was each soil sample? Multiply 6.5 by 2.20 to find out. How deep in inches is 5 centimeters? Multiply 5 by 0.394 to find out.

The scientists collected seeds from three native plant **species** and three invasive plants species that could grow in the area (**figures 3 and 4**). They germinated the seeds and planted the seedlings in plastic pots. Each of the pots was filled with one of the soil samples. The seedlings were placed in a special room in a laboratory and allowed to grow for 10 weeks (**figure 5**).

Figure 3. One of the native plant species studied was snowbrush (*Ceanothus velutinus*). Photo by Dave Powell, courtesy of http://Invasives.org.

Figure 4. One of the nonnative invasive plant species studied was spotted knapweed (*Centaurea maculosa*). Photo by James H. Miller, Forest Service, courtesy of http://Bugwood.org.

Figure 5. The seedlings were grown for 10 weeks in a special room. Photo by Cassie Hebel.

Number Crunches

- How many total seedlings were growing in the pots?

After 10 weeks, the scientists cleaned off the roots of all seedlings and stained them with a special dye. Using a special microscope, the roots were examined (**figure 6**). The percentage of each root with mycorrhizal fungi was recorded.

In July 2005, the scientists went back to the 10 sites where the soil sample pairs had been collected. The type of plants growing on each of the 20 sites was identified and recorded.

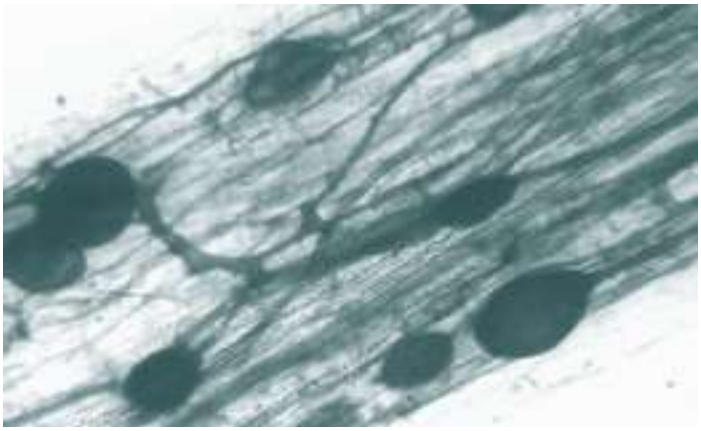


Figure 6. The roots were examined using a special microscope.

Reflection Section

- Why do you think the scientists only took samples from the top 5 centimeters of soil?
- Why did the scientists wait a year to go back and identify the species of plants growing in the red and black soils?

Findings

The seedlings grown in red soil had fewer fungi growing on their roots than seedlings grown in black soil. This was true of both native and invasive plants. Invasive plants grown in red soil had between 79 and 98 percent fewer fungi growing on their roots than plants growing in black soil. Native plants grown in red soil had between 61 percent and 98 percent fewer fungi growing on their roots than native plants growing in black soil.

Two years after the wildfire, the scientists found that areas with red soil had 50 percent less plant cover than areas with black soil. They found no invasive species growing in the area.

Reflection Section

- Why do you think plants growing in red soil had fewer fungi growing on their roots than plants growing in black soil?
- What effect did wildfire have on the growth of new plants in some of the areas that were burned?

Discussion

The scientists wondered why they found no invasive species in the areas they studied 2 years after the wildfire. One reason may be that there were few nonnative invasive species in the area before the fire. This would have limited the source of nonnative invasive plant seeds. Another explanation may be that nonnative invasive species are not able to compete well with native species in areas where a wildfire has severely heated the soil.

The scientists found that areas of forest that have a lot of logs and stumps may not recover as quickly after a wildfire. Plants that grow well in soils that have been heated by fire may be the first to take root and grow in red soils. In the first years after a fire, the type of native plants growing may be different than before the wildfire. When wildfire severely heats the top layer of soil and the roots found there, it appears to harm the fungi that were living on the roots.

Reflection Section

- If logs and stumps on the ground cause a slower recovery of a forest following wildfire, should the logs and stumps be removed? Why or why not?
- Do you think the fungi will ever come back to the areas of red soil? Why or why not?

Adapted from Hebel, C.; Smith, J.E.; and Kermit, C., Jr. 2009. Invasive plant species and soil microbial response to wildfire burn severity in the Cascade Range of Oregon, *Applied Soil Ecology*. 42: 150-159. http://www.treesearch.fs.fed.us/pubs/34600.

Glossary

Academic (ˌa-kə-'**de**-mik): Having to do with an institution of learning.

Fledgling ('**flej**-liŋ): An inexperienced person.

Inquisitive (in-'**kwi**-zə-tiv): Inclined to ask questions.

Invasive (in-'**vā**-siv): Tending to spread or infringe upon.

Microorganism ('**mī**-(ˌ)krō-'**ȯr**-gə-ˌni-zəm): An organism or life form of microscopic size.

Microscopic (ˌ**mī**-krə-'**skä**-pik): Invisible or nearly so without the use of a microscope.

Mycology (mī-'**kä**-lə-jē): The study of fungi.

Mycorrhizal (ˌmī-kə-'**rī**-zəl): The cooperative relationship between a fungus and the roots of a plant.

Native ('**nā**-tiv): Naturally occurring in an area.

Nonnative ((')nän-'**nā**-tiv): Not naturally occurring in an area.

Randomly ('**ran**-dəm-lē): A way of selecting a smaller number from a group in such a way that all members of the group have the same chance of being selected.

Sample ('**sam**-pəl): A part or piece that shows what the whole group or thing is like.

Species ('**spē**-(ˌ)shēz): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

Accented syllables are in **bold.** Marks taken from Merriam-Webster Pronunciation Guide.

FACTivity

The question to be answered in this FACTivity is: What are some of the things that make up soil?

The procedure to be used to answer the question is an adaptation of the game Sudoko. This is Soildoko! Complete the Soildoko puzzle below by filling in the blank spaces. Six different things that make up soil are listed in the puzzle. In each row and column of the puzzle, each of the six should appear only once. After the puzzle is finished, the answer to the question should be obvious. What are some of the things that make up soil?

Bacteria and Fungi	Clay, Silt, and Sand		Water		Minerals
Air		Bacteria and Fungi		Animals and Plants	
Clay, Silt, and Sand		Water		Minerals	Bacteria and Fungi
	Water				Clay, Silt, and Sand
Water		Minerals		Clay, Silt, and Sand	
	Bacteria and Fungi	Clay, Silt, and Sand	Animals and Plants		Air

This FACTivity was adapted from http://www.soil-net.com.

National Science Education Standards

Science as Inquiry:
Abilities Necessary To Do Scientific Inquiry;
Understanding About Scientific Inquiry

Life Science:
Structure & Function in Living Systems;
Populations and Ecosystems;
Reproduction and Heredity;
Diversity and Adaptation of Organisms

Science in Personal & Social Perspectives:
Populations, Resources, and Environments;
Natural Hazards;
Risk & Benefits

History & Nature of Science:
Science as a Human Endeavor;
Nature of Science

Teachers: If you are a PLT-trained educator, you may use Activity #24, "Nature's Recyclers," and #80, "Nothing Succeeds Like Succession," as additional resources.

Additional Web Resources

National Science and Technology Center: Mycorrhizal Fungi
http://www.blm.gov/nstc/soil/fungi/index.html

Benefits of Soil Microbes
http://www.rivenrock.com/soilmicrobes.htm