12. Fire, Soil, and Water Interactions

Lesson Overview: In this activity, students view and discuss a presentation that describes fire's effects on soils and how these effects are measured. They also observe or conduct an experiment that illustrates how wildland fires affect the potential for soil erosion. They learn that soil burn severity varies greatly and that when fires remove the litter, duff, and plant cover on the ground, the risk of soil erosion increases. They apply this information to management of a real-world landscape after a large wildland fire.

Lesson Goal: Increase students' understanding of the effects of wildland fire on soil properties, things that live in the soil, and the likelihood of erosion after fire.

Subjects: Science, Mathematics, Reading, Writing, Speaking and Listening, Health Enhancement

Duration: Two half-hour sessions plus out-of-class preparation

Group size: Entire class

Setting: Classroom

Vocabulary: *burn severity, char depth, duff, erode/erosion, ground cover, ground fire, infiltration, litter, organic matter, slash, soil burn severity, soil structure, vegetation burn severity, water repellency*

Before beginning this lesson, watch the video demonstration of precipitation's impact on bare soil versus vegetation-covered soil: https://www.youtube.com/watch?v=im4HVXMGI68**. Decide if you want to do the demonstration in class or just view the video.** If you decide to do the demonstration in class, you need a container containing young grass stems that were <u>started from seed 6-8 weeks before</u>. <u>But consider</u> -- you may be able to use a cut piece of sod instead.

ALTERNATIVE LAB: consider using Activity M15 (Bark and Soil: Nature's Insulators) as a lab for this class.

Objectives:

- Students can use information from a presentation and a demonstration (on video or done in the classroom) to interpret technical information on the effects of a real wildland fire on soils.
- Students can communicate technical information about a fire's effects on soils in a clear, engaging way.

Standards:		9th	10th	11th	12th
CCSS	Reading Informational Text	2, 4, 10		2, 4, 10	
	Writing Standards	2, 4, 8, 10		2, 4, 8, 10	
	Speaking and Listening Standards	1, 2, 4, 6		1, 2, 4, 6	
	Language	1, 2, 3		1, 2, 3	
	Reading Science/Technical Subjects	1, 2, 4, 9, 10		1, 2, 4, 9, 10	
	Writing Science/Technical Subjects	2, 4, 9, 10		2, 4, 9, 10	
NGSS	Ecosystems: Interactions, Energy, and Dynamics	LS2.A, LS2.C			
	Earth's Systems	ESS2.D			
	Earth and Human Activity	ESS2.D, ESS3.B			
EEEGL	Strand 1	A,B,C,D,E,F,G			

Teacher Background: Fire severity is a concept that includes all of the physical, biological, and ecological effects of a wildland fire. Vegetation burn severity refers to changes aboveground; soil burn severity refers to changes belowground, the degree of change in soil characteristics caused by fire. Changes in the soil have profound effects on what happens in a burned area after fire. These can include reduced water infiltration and hence increased runoff, accelerated erosion, changes in stream channels, loss of cover and resultant warming of streams, death of underground plant parts that enable sprouting, increases in invasive plant populations, and damage to archaeological artifacts and other cultural resources.

Here is a summary of the information in the PowerPoint presentation used in this lesson (***H12_FireSoilWater.pptx***). Consult the presentation itself for more details.

After fire, common changes to the soil include:

- loss of ground cover due to consumption of litter and duff;
- changes in soil surface color due to char, ash cover, or soil oxidation;
- changes in soil structure due to consumption of soil organic matter;
- death and consumption of fine roots and microorganisms in the soil; and
- formation of water repellent layers that reduce infiltration.

The degree of soil burn severity varies widely from fire to fire and within individual burns. It depends on many factors, including the **weather** at the time of burning, fire behavior, the amount, type, and distribution of **fuels**, type of soil, and **slope**. Notice that the Fire Environment Triangle studied in **Unit III** includes all of these factors.

- **Fuel** loading, particle size, spatial distribution, chemical composition, and moisture (in both live and dead fuels) influence soil burn severity. So does the type of vegetation present.
- **Weather** conditions, including temperature, relative humidity, wind, and rainfall (before and after the fire) affect soil burn severity.

- **Topography** (slope, aspect, landform) and the properties of soils themselves (texture, moisture, organic matter, and soil type) affect soil burn severity.

Behavior of the fire itself matters too – its intensity, the duration of burning, and the type of fire (crown, surface, or ground fire).

The more severe a fire's effects on the soil, the more likely the soil will erode in subsequent rainstorms – especially in places with steep slopes. In the first year or two after a fire, fire-caused erosion can damage watersheds and destroy buildings and infrastructure downstream.

This lesson is assessed by an activity in which students read a technical document about soil burn severity in a real fire - the Lolo Peak Fire of 2017in western Montana (**LoloPeakFire_BAER-ReportSummary.pdf**) - and communicate its results to a local audience in the area of the fire. The report was created by a Burned Area Emergency Response (BAER) team. BAER is a program in which resource professionals assess a burned area during and/or shortly after a fire. They figure out what actions are needed to protect human life, property, and critical natural and cultural resources and then get this work started as soon as possible (see https://www.fs.usda.gov/naturalresources/watershed/burnedareas-background.shtml).

This activity focuses mainly on the potential for negative effects of fire on soils. But some fire effects on soils are positive; for instance, while fire's consumption of litter and duff may increase weed populations, it also prepares an ideal seedbed for the establishment of many plant species, including most pine trees. Ecological effects of fire on soils, streams, and aquatic organisms are described in articles cited below by DeBano (1990), Howell (2006), Neary and others (1999), Neary and others (2008), and Rieman and others (2012).

Sources and additional reading:

DeBano, Leaonard F. 1990. The effect of fire on soil properties. Paper presented at the Symposium on Management and Productivity of Western-Montane Forest Soils, Boise, ID, April 10-12, 1990. Available: http://forest.moscowfsl.wsu.edu/smp/solo/documents/GTRs/INT_280/DeBano_INT-280.php

Howell, Philip J. 2006. Effects of wildfire and subsequent hydrologic events on fish distribution and abundance in tributaries of North Fork John Day River. North American Journal of Fisheries Management. 26: 983-994. https://www.tandfonline.com/doi/abs/10.1577/M05-114.1

Neary, Daniel G.; Klopatek, Carole C.; DeBano, Leonard F.; Ffolliott, Peter F. 1999. Fire effects on belowground sustainability: A review and synthesis. Forest Ecology and Management. 122(1-2): 51-71. http://www.treesearch.fs.usda.gov/pubs/33598

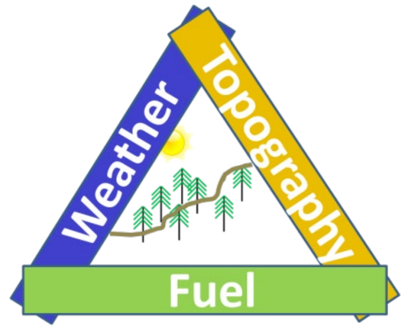
Neary, Daniel G.; Ryan, Kevin C.; DeBano, Leonard F.; Landsberg, Johanna D.; Brown, James K. 2005. [revised 2008]. Introduction. In: Neary, Daniel G.; Ryan, Kevin C.; DeBano, Leonard F., eds. Wildland fire in ecosystems: effects of fire on soil and water. Gen. Tech. Rep. RMRS-GTR-42-vol. 4. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 1-18. In https://www.fs.usda.gov/treesearch/pubs/20912

Parsons, Annette; Robichaud, Peter R.; Lewis, Sarah A.; Napper, Carolyn; Clark, Jess T. 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. 49 p. http://www.treesearch.fs.usda.gov/pubs/36236

Rieman, Bruce; Gresswell, Robert; Rinne, John. 2012. Fire and fish: a synthesis of observation and experience. In: Luce, Charles; Morgan, Penny; Dwire, Kathleen; Isaak, Daniel; Holden, Zachary; Rieman, Bruce, eds. Climate

change, forests, fire, water, and fish: building resilient landscapes, streams, and managers. General Technical Report RMRS-GTR-290. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 159-175. https://www.fs.usda.gov/treesearch/pubs/41933

Materials and preparation:



1. Display the Fire Environment Triangle (you can use the ***FireEnvironmentTriangle poster.pptx*** poster from **Activity H08** or sketch it yourself).
2. Download the presentation ***H12_FireSoilWater.pptx***.
3. Arrange for each student to have a printed copy or electronic access to:
   a) the **Lolo Peak Post-Fire BAER Assessment Report Summary** (**LoloPeakFire_BAER-ReportSummary.pdf**). **(**This is the students' main source of information for the **Assessment.**)
   b) the full Burned-Area Report for the Lolo Peak Fire (**LoloPeakFire_BAER-ReportFull.pdf**). (This is supplemental information that students may or may not need to complete the assessment.)
4. Make 1 copy/student or team: **Handout H12-1. Effects of the Lolo Peak Fire on Soils.**
5. View this video about erosion: https://www.youtube.com/watch?v=im4HVXMGI68. In step 4 below, you will either conduct this demonstration in class or show the video. If you do the demonstration in class you will need:
   - Three empty 2-liter plastic soda bottles
   - Three empty plastic soda bottles (about 1-liter size)
   - Three pieces of string/yarn
   - Soil
   - Dead leaves/needles
   - Grass seed (planted in the soil 4-8 weeks ahead of time – a cut piece of sod may work instead)
   - Pitcher of water

Procedures:

1. Explain: Fires change more in the environment than just the aboveground plants; they change the soil too. Think about the Fire Environment Triangle that we studied in **Activity H08,** when we experimented with the "matchstick forests." The 3 parts of the Fire Environment Triangle are fuels, weather, and topography. All of these things influence how

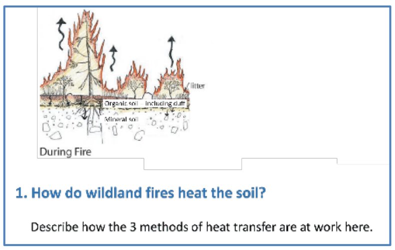
fires affect soils, and these changes can affect plants, wildlife, and us – if we use the burned area or live downstream from it. That's what we'll learn about today.

2. Present and discuss the presentation: ***H12_FireSoilWater.pptx:***

Slide 1

What do wildland fires do to soils? Why should we care? This presentation answers 7 questions about fires' effects on soils and how those changes affect things that we care about, such as human safety, water quality, and plant and animal habitat.

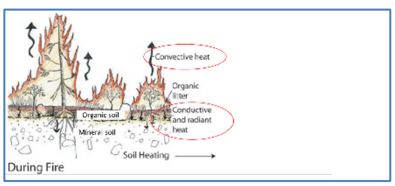
Slide 2



What is soil anyway? Soil is the surface layer of the earth. It contains *mineral particles* and also *organic matter* – duff, plant roots, fungi, dead wood, and microorganisms. Organic materials are often mixed with mineral particles.

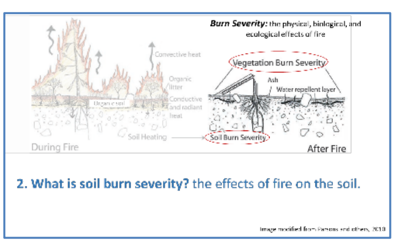
So here's the first of our 7 questions: **How do wildland fires heat the soil?** The arrows show where the heat from the fire is going. How are the 3 methods of heat transfer at work here?

Slide 3



The 3 methods of heat transfer are convection, conduction, and radiation. During a wildland fire, convection lifts some of the fire's heat up, away from the soil. Conduction transfers some of the heat through solids, including wood and soil particles. Radiation transfers heat through space, including the spaces between soil particles. The downward flow of heat is not as dramatic as the upward flow, but it can have dramatic consequences.

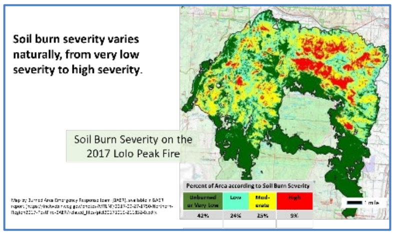
Slide 4



Ask/explain: Here's our 2nd question: **What does the heat from burning fuels do to plants, ground cover, and soil?** It depends on many things, so it varies! The physical, biological, and ecological effects of fire – all lumped together – are called burn severity.

The diagram shows that there are 2 kinds of burn severity: *Vegetation burn severity* describes how the vegetation changes as a result of the fire. Vegetation burn severity is likely the first thing you notice when you look at burned forest, and we'll study it more in later lessons. But we can also see changes in the soil surface and even deep into the soil: Most of the duff and other organic matter has been consumed, and a few patches of water-repellent soils have formed. This is *soil burn severity* - the effects of fire on the soil. That's what we'll learn about today.

Slide 5

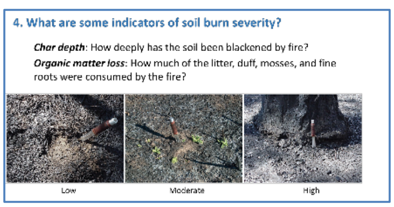


Variation in *soil burn severity* is part of the natural variation that wildland fires cause on a landscape. The 2017 Lolo Peak Fire that occurred in western Montana had an area of more than 80 square miles, but much of the area inside the fire's boundary was either unburned or had low soil burn severity. About how many square miles had high soil burn severity? You can estimate it from this graphic. About 7 square miles.

Slide 6

Question 3. If severely burned soils are natural, why should we care about them – why do they matter? Where soils are severely burned, there are increased chances of erosion and flooding; vegetation recovery may be slow, and weeds may increase. Managers identify the locations with high soil burn severity and then try to prevent some of the negative consequences, such as damage to homes, roads, trails, drainages, fish habitat, and other parts of the ecosystem.

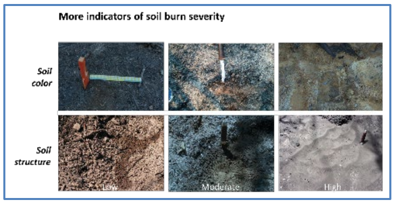
Slide 7



Question 4. What are some indicators of soil burn severity? How can we measure it? Scientists use satellite imagery to make a map that shows an estimate of soil burn severity. That's what we saw in the previous slide). Then the map is refined using the results of on-the-ground measurements. These photos show *char depth* (depth to which the soil has been blackened by ash) and *organic matter loss* (duff consumed and other indicators) for plots with low, moderate, and high soil burn severity.

If a fire burns through the duff layer and burns most of the organic particles within the soil – such as tree roots, underground plant stems, seeds, and partly-decayed wood – we call it a ground fire. How are ground fires different from surface fires and crown fires (which we studied in **Activity H09_Ladder Fuels**)? Ground fires tend to burn much more slowly than the other 2 kinds of fire. When they burn in deep duff, they may continue for many days after the fire's flames have moved on.

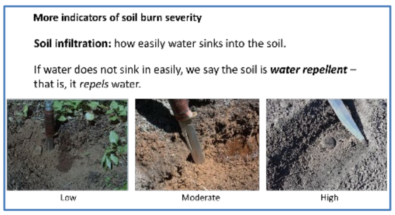
Slide 8



Soil burn severity includes *changes in soil color and structure*. How might a fire change soil color? Look at the top row of photos. Soil color is typically black or brown in areas with low soil burn severity (that is, very little change from the color of unburned soils). It is gray to white in more severely burned soils, and it may be orangeish or reddish in areas with high soil burn severity.

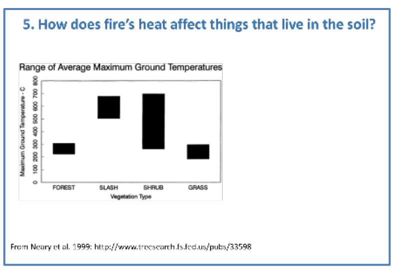
How might a fire change soil structure? Look at the bottom row of photos. Soil particles break apart as soil burn severity goes from low to high. Soils with high burn severity may look powdery or loose.

Slide 9



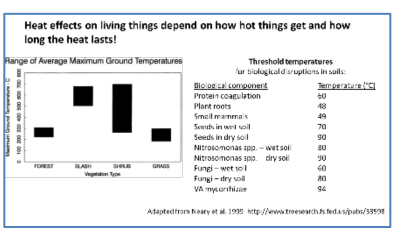
Infiltration refers to how easily water sinks into the soil. Fires may change infiltration, although infiltration also depends on soil type. In these photos, a drop of water has been placed on each sample of burned soil. What differences do you see? The water on the severely burned soil does not sink in. Instead, it beads up on top. We say this soil is *water repellent;* it *repels* water. If water-repellent soil is on a steep slope, it is likely to wash away in heavy rainstorms. But note that water repellency is affected by many things, so some soils repel water even when they have not been burned.

Slide 10



Question 5. How does fire's heat affect the living things in the soil? First we have to know how hot it actually gets down there! Interpret the graph: During forest fires, maximum ground temperatures typically range from 200 to 300 °C. In heavy fuels like slash (materials left on the ground after timber harvest), maximum ground temperatures are usually around 500 to 700 °C, but temperatures above 1500 °C can occur briefly. Fire-prone shrublands like chaparral commonly burn with lower maximum temperatures but have a wider range. Fires in grasslands that lack woody fuels usually have maximum ground temperatures <225 °C, although higher temperatures have been measured.

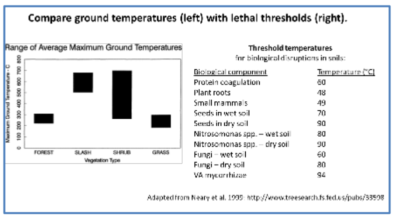
Slide 11



Fire's effects on living things in the soil depend on how hot they organisms get, how long the heat lasts, and how moist the soil is. This data table shows the "threshold temperatures" for harm to living things – that is, the lowest temperatures at which they are likely to be injured or die. Interpret the table: Protein structures change at around 60 °C, give or take 10 degrees or so. When proteins change their shape, living tissues can't function anymore, so the organisms die. Things that live in the soil begin to die at about 40 to 70 °C.

- Roots and small mammals can be killed at soil temperatures around 50 °C.
- The embryos in seeds often die between about 70 and 90 °C, depending on the soil moisture.
- Microbes (including *Nitrosomonas,* an important soil bacterium) generally die between 50 and 121 °C, depending on soil moisture.
- Fungi may be more vulnerable to high temperatures than bacteria, dying between 60 and 80 °C.
- Vesicular-arbuscular ("VA") mycorrhizae, which are important companions of plant roots, die when temperatures get above 90 °C.

Slide 12



Can lethal temperatures occur underground in wildland fires? Interpret the data (compare the information in the table with the data in the graph). Yes. The range of maximum ground temperatures (shown in the graph) greatly exceeds the lethal temperatures of the things that live in the soil (listed in the table).

So how do you think anything in the ground can survive?

- The graph reports <u>maximum</u> ground temperature. Temperatures are not likely to exceed those listed here, but they do not always get this high, and they may not persist long at these temperatures.
- Some areas are missed by the fire. That is, fires do not burn uniformly across the land, and some areas that do burn experience lower temperatures than the maximum.
- It takes more energy to heat wet soils than dry soils (although wet soils hold the heat longer than dry soils do).
- Duff is an excellent insulator, as long as it does not burn. But when duff burns, much of its heat is conducted down into the soil. Areas where deep duff has burned may have high soil burn severity.
- Mineral soil (without any organic matter) is another good insulator. The deeper you go in the soil, the lower the temperature. Therefore, things that are deep in the soil are protected from much of the heat from fire.

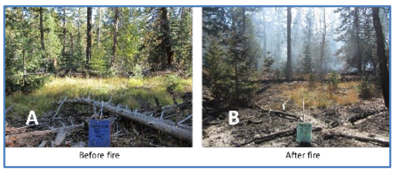
Slide 13

Question 6. What does soil burn severity look like in forests? Since soil burn severity depends mainly on the amount of heat and duration of heating, think about these 2 photos. If a fire burned the surface fuels in these 2 photos under the same conditions, which fire would produce more heat? Which would burn for a longer time? If the large fuels are dry enough to burn, the fuels in Photo B, which include many

logs, would produce higher temperatures and more heat than the fuels in Photo A, and the fuels in Photo B would also burn longer.

More details: Recall the activity about fuel properties (**Activity H05_FuelProperties_generic**). A fire burning in the fine fuels of Photo A is likely to move quickly. But a fast fire in fine fuels will not burn long enough to transfer a lot of heat into the soil. A fire burning in the heavy fuels of Photo B may spread more slowly, but it is likely to burn a long time, transferring a lot of heat into the soil and therefore causing much greater soil burn severity than a fast-moving fire, regardless of how much energy is produced aboveground and how long the flames are.

Slide 14



Let's look at soil burn severity in a small area – not much bigger than a classroom. Photo A shows this area before it was burned by a prescribed fire. Photo B shows what it looked like afterward. Can you see diversity in soil burn severity? Describe differences in severity by using the measurement methods that we learned earlier: **char depth, soil color, and soil structure**. Some patches show no evidence of fire at all. Some patches have low soil burn severity, based on the black ground surface and the fact that some woody fuels remain above the ash. Some patches show evidence of being severely burned: The ash is completely white (no carbon left), and woody fuels are nearly gone. The lines of thick white ash, where the logs were before the fire, are places where the soil probably experienced hotter temperatures for longer periods of time than most of the other areas in this photo. That is, the areas underneath the logs experienced high soil burn severity.

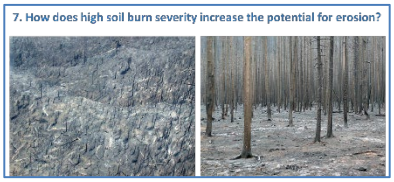
Slide 15

Now try to estimate soil burn severity over a larger area. Which areas of soil do you think burned most severely in this photo? Which areas burned less severely?

- You can see lightly burned surface and ground fuels on the back-left side of this photo. Chances are the soil experienced low or moderate burn severity.
- In the middle of the photo, you can see patches of white ash and no remaining stems of small trees or shrubs. You can also see white lines where logs have been completely consumed, leaving nothing but white ash. If the site had duff cover before the fire, it is all gone from these patches. Underneath some of these white ash patches may be patches of severely burned soil.
- In the left foreground, it looks like some of the surface fuels aren't completely consumed, so maybe the soil was only moderately burned.

A caution: Just because the vegetation appears severely burned, the soil may not be and vice-versa (i.e., vegetation burn severity does not necessarily equal soil burn severity). How can that happen? It could be caused by variation in the duff layer, organic matter within the soil, soil texture, moisture content, and other factors.

Slide 16

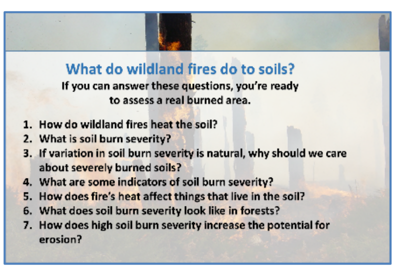


Finally, Question 7. How does high soil burn severity increase the potential for erosion? Both of these photos show places where most of the vegetation and most of the ground cover have burned away. The soil does not have any protection from raindrops. What will happen in the next big thunderstorm? Erosion is likely, especially on steep slopes. In other words, if there is no litter, duff, plant cover, or root material to hold the soil in place, the soil is vulnerable to washing away after heavy rains – even if it is not water repellent. (Water repellency was covered in Slide 9).

Slide 17

In the corner, you can see the splash from a single raindrop. What happens when billions of raindrops fall on an area with severely burned soils? What if the area is on a steep hillside? Areas with severely burned soils on steep slopes are very vulnerable to erosion. Sometimes heavy rain on these soils removes tons of soil, causes big mudslides, fills in drainages downstream, and leads to floods that destroy roads, bridges, houses, and other structures.

Slide 18



We've looked at several important questions about fire effects on soils. With this understanding, we can now study a report that describes soil burn severity for a specific fire and consider the management actions that might reduce the negative impacts of the fire due to high soil burn severity.

3. Explain: We've seen that soil erosion is a big worry after fire. Let's see how that occurs – whether or not the soil has been burned.

4. Either watch this video as a class: https://www.youtube.com/watch?v=im4HVXMGI68 or do the activity shown in the video.

Assessment:

1. Explain: Now that you are experts on soil burn severity and soil erosion, you can study a report from a wildland fire that occurred in western Montana in 2017 and present some of its results to the public in a radio spot.
2. Explain: Your main information source will be the **Summary of the Lolo Peak Post-Fire BAER Assessment Report** (**LoloPeakFire_BAER-ReportSummary.pdf**). Hand out copies of the report or provide it online.
3. Explain: You may also want information from the full report (**LoloPeakFire_BAER-ReportFull.pdf**). Explain how to access it – online? printed copies?
4. Explain: The BAER report was produced by a team of 26 specialists, experts in fire, soils, hydrology, and ecology. It came out on September 29, 2017, when the fire was nearly out. BAER (Burned Area Emergency Response) reports are completed to
   - identify places where the fire changed the soil in ways that might endanger people or degrade important habitats, and
   - recommend ways to minimize these damages.

4\. Explain: You are a news reporter for a local radio station. The report has just come out. You are going to use it to answer some urgent questions from your listeners.

5. Give each student or team a copy of **Handout H12-1. Effects of the Lolo Peak Fire on Soils.** Go through the instructions at the top of the handout. Assign ONE of the 5 assessment question sets (A-E) to each student or team.
6. Explain/provide technology for students to record their radio spots.
7. When the radio spots are completed and recorded, play them in class. After each, ask the class to discuss (or assess on a half-sheet of paper) if the radio spot answers the question set. Explain why or why not.

Evaluation: An annotated copy of this report – without illustrations - is shown at the end of this activity (**Answer Key to Handout H12-1. Effects of the Lolo Peak Fire on Soils**); it contains text boxes to help you assess the content of students' radio productions.

Criterion		Completely successful	Partially successful	Unsuccessful
Appropriate, accurate technical information		Evaluate based on content of the **Summary of the Lolo Peak Post-Fire BAER Assessment Report.** The **Answer Key** below is an annotated copy of this document. It contains text boxes that identify the passages most relevant to each of the 5 question sets in the assessment.		
Clarity of communication in radio spot		Information is clear. No jargon or acronyms are used. Technical terms are used only as needed and are defined.	Information is slightly unclear; or jargon, acronyms, or technical terms are used without definitions.	Information is unclear. Jargon or acronyms are used. Technical terms are used without definitions.
Relevance of information to local audience		Recording gives persuasive reasons why the information is important to listeners.	Recording gives at least one reason why the information is important to listeners.	Recording does not give any reasons why listeners should care.
Creativity		Recording uses 2 or more sound effects appropriately.	Recording uses at least 1 sound effect appropriately.	Recording does not use any sound effects.

Handout H12-1. Effects of the Lolo Peak Fire on Soils

Read the **Summary of the Lolo Peak Fire Burned-Area Report** (**LoloPeakFire_BAER-ReportSummary.pdf**), which was completed by a group of 26 experts when the fire was mostly contained. Use the information in the report to answer ONE of the question sets below in a 3-minute broadcast for a local radio station. If you need more information, consult the full Burned-Area Report (**LoloPeakFire_BAER-ReportFull.pdf**). You may also obtain information on your topic from other sources.

Since you cannot include graphics in your radio spot, be careful to explain any information that you get from maps and graphs very clearly. Include appropriate sound effects. Do not use jargon or acronyms. If you absolutely must use technical terms, define them.

Record your radio spot. It will be "assigned listening" for the class.

Address ONE of these question sets:

A. **FLOODS:** How has the Lolo Peak Fire increased the possibility of flooding in the forest and in areas downstream? When is flooding most likely to occur? How long will the danger last? What can listeners do to stay safe?

B. **FISHERIES:** It is hard for fish to stay healthy if their water gets murky with sediment or gets too warm in the summer. How might severely burned soils in the Lolo Peak Fire damage fish populations and habitat, especially that of the endangered bull trout? What can be done to prevent or reduce the damage?

C. **SAFETY:** How have fire-caused changes to soils created hazards for people who are working or recreating in the burned area? Recreational activities could include hiking, skiing and snowshoeing, hunting, fishing, biking, and sledding. Local residents might be logging or cutting firewood in the burned area. What can be done to protect these people?

D. **WEEDS:** Weeds are likely to invade and spread in places with bare soil, where there is little native vegetation. How have fire-caused changes to soils increased the likelihood that weeds will invade and spread in the burned area? What can be done to prevent or reduce increases in weeds?

E. **HYDROPHOBICITY:** What are hydrophobic soils? Why should we worry about them? How much of the area burned by the Lolo Peak Fire has hydrophobic soils? What can be done about them? Will they stay hydrophobic forever?

Answer Key to Handout H12-1.
Effects of the Lolo Peak Fire on Soils

Below is the text of the **Summary of the Lolo Peak Post-Fire BAER Assessment Report** (***LoloPeakFire_BAER-ReportSummary.pdf***). Text boxes indicate what parts of the report may be most useful for student radio spots on each of the 5 question sets above (on floods, fisheries, safety, weeds, and hydrophobicity).

FS-2500-8 Burned-Area Report: Watershed Analysis, Condition, and Response

The Lolo Peak Fire, which was ignited by a lightning strike on July 15, 2017, is located on the Bitterroot, Lolo and Nez Perce-Clearwater National Forests (NFs), southwest of Lolo, Montana. The fire was managed for full suppression since its start, but steep terrain, high temperatures, low relative humidity, high pre-existing tree mortality, and gusty winds promoted fire spread. For about six weeks, the fire spread steadily to the east toward Lolo. As of September 28, 2017, the fire burned 43,096 acres on Forest Service System (NFS) land, 845 acres on state land, and 9,522 acres on private land.

The Lolo Peak Fire includes a variety of vegetation types that are aspect, elevation, and slope dependent. The dominant vegetation types within the burned area are dry, mixed coniferous forests (lodgepole pine, western larch, Douglas fir, and ponderosa pine) and cool moist coniferous forests (subalpine fir). At lower elevations and on south facing slopes, open grown ponderosa pine forests are common.

The burned area was surveyed and assessed by a BAER team comprised of Forest Service scientists and specialists. The BAER team evaluated the burned watersheds to determine post-fire conditions, and identify values-at-risk such as threats to human life and safety, property, and critical natural and cultural resources. In addition to these critical values, other threats were also assessed, such as the risk for increased post-fire flooding, sediment flows, rock slides, hazard trees and noxious weed spread.

Relevant to all questions

The BAER assessment team's analysis of the burned area and recommended emergency treatments are documented in a Forest Service (FS) Burned-Area 2500-8 Report. This report was submitted to the Northern Region (Region 1) Regional Forester by the Forest Supervisor for the Bitterroot and Lolo NFs for review and funding.

The following is a summary of the BAER team's burned area assessment report for the Lolo Peak Fire:

- 10 sub-watersheds were analyzed and modeled to compare pre-fire conditions to post-fire predicted response: East Fork Lolo Creek, West Fork Butte Creek, South Fork Lolo Creek, Lower Lolo Creek, Bass Creek, Sweeney Creek, Upper Brushy Fork, Larry Creek-Bitterroot River, One Horse Creek-Sin-tin-tin-em-ska Creek, and North Woodchuck Creek-Bitterroot River.

- There are 38 miles of perennial stream, and 123 miles of intermittent streams.

Relevant to flooding & fisheries

- There are 74.4 miles of NF system roads, 23.9 miles of NF non-system roads, and 39.5 miles of NF trails.

Relevant to safety & weeds

- Post-fire, there are 6,047 acres with high hazard ratings for soil erosion, 24,731 acres with moderate ratings for soil erosion, and 5,123 acres with low hazard ratings for soil erosion. Elevated soil erosion hazard is only applicable for the first few years following the Lolo Peak Fire - until revegetation occurs to stabilize the slopes.

Relevant to flooding & fisheries

- There are about 13,914 (32%) unburned acres, 10,137 (23%) acres of low soil burn severity, 13,487 (31%) acres of moderate soil burn severity and 6,507 (14%) acres of high soil burn severity.

Relevant to all questions

- There are 6,507 acres of water repellent (hydrophobic) soils scattered around the fire area. Hydrophobic soil conditions are common within moderate and high burn severity areas and rare in the low burn severity areas.

Relevant to hydrophobicity

Hydrophobic soil conditions may be the result of two processes; the first is a natural accumulation of waxy resins at the soil surface as plant litter and organic material decomposes. The second is a result of hot temperatures volatilizing organic compounds, destroying soil structure and redepositing water-resistant compounds deeper in the soil profile, and is common of areas of high and moderate severity burn. Increased run-off due to hydrophobic conditions is reflected in the peak flow analysis of the watersheds. Hydrophobic layers usually take 6 months to 2 years to break down. Plant root development, soil microbial activity, and freeze-thaw cycling all contribute to the degradation of hydrophobic conditions. Rains in September and October have started the breakdown of the hydrophobic layer. Recovery of pre-fire slope stability and watershed hydrologic response is dependent on many factors and typically occurs within 3-5 years following the fire. Recovery of high burn severity areas is slower because little or no vegetative ground cover remains and soils may be susceptible to erosion.

The different soil burn severity categories reflect changes in soil properties and are a key element BAER specialists use to determine if post-fire threats exist. The distribution of unburned, low, moderate, and high soil burn severity levels become a baseline for resource specialists to monitor changes in soil hydrologic function and vegetative productivity as the burned watersheds recover.

High and moderate soil burn severity categories often have evidence of severe soil heating and the consumption of organic material. Soil seedbank and water infiltration characteristics are reduced in areas that have burned at high or moderate severity. Natural recovery is slower where little or no vegetative ground cover remains, and increased surface water runoff will result in increased soil erosion at these sites. Areas of moderate soil burn severity may have viable roots and some soil cover, but may still be vulnerable to erosion on steep slopes. The low to very low soil burn severity areas still have good surface soil structure, intact fine roots and organic matter, and will recover more quickly as revegetation begins very soon after the fire and the soil cover is re-established.

Relevant to weeds

Relevant to flooding & fisheries

Field observations and modeling of the burned area support a general trend of increased flows, sedimentation, and erosion due to post-fire effects especially in sub-watersheds with the most burned acres, specifically moderate and high soil burn severity, high erosion hazard ratings, and the steepest slopes. Areas most at-risk from post-fire flooding, erosion, and sedimentation are within the burn area or within close proximity to the burn area, although some sites outside of the burn perimeter that are down slope or downstream of the burn

Relevant to flooding & fisheries

area are still at-risk from increased post-fire effects. Ash transport into area streams is virtually guaranteed to occur several times before plant re-growth stabilizes the soil.

Identified Values-at-Risk, Threats, and Emergency Conditions

Relevant to flooding, safety, fisheries, & weeds

Summer thunderstorms have the greatest likelihood of generating large run-off and soil erosion events. If large summer thunderstorms occur, the primary values-at-risk within the burned area are human life and safety, transportation infrastructure (roads and trails), soil productivity, water quality, bull trout habitat, and native vegetation communities. The primary threats caused by the fire include 1) increased run-off, which is expected to intensify the first 2-3 years following the fire until the burned watersheds recover, and 2) accelerated hillslope erosion - as a result of increased run-off and decreased infiltration rates. High intensity, short duration rainfall may result in valley bottom flooding and localized debris flows, primarily in Mormon and John creeks. Additional threats originating from the destabilized hillslopes throughout the burned area include falling trees and rolling rocks.

Emergency post-fire conditions for the Lolo Peak Fire were identified by the BAER team for the following on-forest values-at-risk:

Relevant to safety

- Human Life and Safety: There are potential impacts to the safety of forest recreating visitors and Forest Service employees entering the burned area, and residents of private lands within and adjacent to the burned area. Generally, increased risk occurs within or directly down-slope from high and moderate soil burn severity areas. Potential threats exist along roads, trails, trailheads, and other recreation areas. Risks for the general public include rolling rocks, flash flooding, flooding, debris flows, slope failure, falling trees, and loss of ingress/egress access. Locations with increased risk include road systems within the upper Mormon Creek drainage, Mill Creek Trail, and long the South Fork of the Lolo Creek drainage.

Relevant to flooding, fisheries, safety

- Property: There are potential impacts and threats to Forest Service System roads, trails, and associated infrastructure during and following high-intensity precipitation events. During these events, there is high potential for failure to road drainage due to increased post-fire flows and thus potential for erosion of trail surface tread and sediment delivery to streams. Soil deposition on road and trail surfaces from adjacent hillslopes may also occur. The potential threats are from increased water, sediment flows, soil erosion, loss of capacity, and overtopping and breaching during flood events. Roads at-risk include the Mormon Peak road, Mormon Creek road and associated spurs, John Creek road, Tevis Creek road, Elk Meadows road and surrounding roads, McClain Creek roads within the McClain Creek area, and Johnny Creek road.

Relevant to fisheries, safety, weeds

- Natural Resources: There are threats and increased risks to water quality, fish (bull trout) communities and habitat, native plant vegetation recovery, increased spread of noxious weeds, reduced soil productivity and hydrologic function from increased sediment flows and accelerated erosion. Mormon Creek and South Fork Lolo Creek are the primary streams of interest for potential risk to bull trout populations and its critical habitat, due to the fire coverage within those watersheds. Over 1,500 acres of known noxious weed infestations occur within the Lolo Peak Fire. There are no known aquatic invasive species with the fire perimeter.

- Cultural/Heritage Resources: A low to moderate risk is anticipated to cultural and heritage resources within the Lolo Peak burn perimeter, due to the increased threat of flooding, deposition, and erosion from upslope burned areas due to loss of pre-fire ground cover.

Emergency Stabilization Treatments

Treatment Objectives

The BAER assessment team's emergency stabilization objectives for the burned areas are to protect, mitigate and reduce the potential for identified post-fire threats, including increased water run-off flows and soil erosion/sediment yield, for:

1. Human life, safety, and property within and downstream of the burned area;

Relevant to fisheries & safety

2. Forest Service infrastructure and investments such as roads and trails;

Relevant to flooding & safety

3. Critical natural and cultural resources; and

Relevant to fisheries

4. Native and naturalized plant communities from new noxious weed infestations.

Relevant to weeds

In addition to on-Forest efforts to reduce the threats to National Forest values and resources, the BAER team and the Forest warn users of Forest Service roads and trails of hazards present in the burned area, and communicate and coordinate with other agencies such as the National Resource Conservation Service (NRCS), National Weather Service (NWS), State of Montana, local counties, and cities to assist private entities and communities including private residents and businesses to achieve post-fire recovery objectives.

The following post-fire emergency stabilization measures and treatments have been approved:

- Continue to communicate risks to the public, community groups, and cooperating agencies.

Relevant to all questions

- Continue to work and coordinate with interagency cooperators, partners, and affected parties and stakeholders.

- Assist cooperators, including local, county, state, and federal agencies with the interpretation of BAER assessment findings to identify potential post-fire impacts to communities and private land owners, domestic and agricultural water supplies, and public utilities (such as power lines, state roads, county roads, and other infrastructure).

Relevant to flooding & safety

- Install burned area warning signs to caution forest visitors traveling and recreating within the burned area.

Relevant to safety

- Storm-proof and stabilize approximately 34 miles of Forest Service (FS) System transportation roads and stream crossings with improved water drainage structures and features to prevent damage resulting from post-fire watershed conditions such as soil erosion, storm water run-off, and public safety hazards to improve the safety of forest visitors and employees. Conduct storm patrol monitoring to ensure road treatments are functioning as intended.

Relevant to flooding, fisheries, safety

- Provide for worker safety during implementation of road and trail drainage improvements by removing hazard trees along the roads and trails where treatment crews are operating for extended periods of time.

Relevant to safety

- Storm-proof and stabilize approximately 12 miles of burned area FS trails with improved water drainage structures and features to prevent damage resulting from post-fire watershed conditions. Conduct post-storm inspection of problem areas and implement emergency repairs if needed.

Relevant to flooding, fisheries, safety

- Conduct early detection surveys and rapid response eradication with herbicide application on noxious weeds along areas disturbed by fire suppression activities, equipment concentration points, high and moderate soil burn severity areas near these fire suppression disturbed areas, and other high priority areas, to reduce the potential for impaired native vegetative recovery and the introduction and spread of invasive weeds. The total treatment area comprises approximately 940 acres. Educational signage would be installed at trailheads to reduce noxious weed spread and encourage users to stay on trails. Early detection would also be conducted by surveying backcountry lakes for aquatic invasive species (AIS). An eradication plan would be developed if any AIS are detected.

Relevant to weeds

- Cultural resource concerns will be evaluated at a later time within the burned area to determine if future management actions are required.

SPECIAL NOTE: *Everyone near and downstream from the burned areas should remain alert and stay updated on weather conditions that may result in heavy rains over the burn scars. Flash flooding may occur quickly during heavy rain events. BAER actions are intended to reduce, but cannot eliminate risks. Current weather and emergency notifications can be found at the* ***National Weather Service*** *(https://www.weather.gov/mso/) website.*

Relevant to flooding & safety