



Ozark Highlands Tree Model



Lesson 5

Based on the US Forest Service's

["FireWorks Northern Rocky Mountains & Northern Cascades Curriculum"](#)

Smith, Jane Kapler; Abrahamson, Ilana; Berkowitz, Caitlyn; and McMurray, Nancy. 2018. FireWorks curriculum featuring ponderosa, lodgepole, and whitebark pine forests. Missoula, MT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory (Producer).

Lesson Overview In this lesson, students use a physical model to learn how the vertical arrangement of fuels affects the potential for fires to spread vertically in a plant community. This model can be used to simulate Ozark Highlands fire behavior in woodlands and forests. The results of this activity will help students better understand land management decisions associated with wooded areas.

Lesson Goal Students will increase their understanding of the relationship between fuel arrangement and vertical fire spread, especially in forests, woodlands, and savannas. Students can apply their knowledge of fuels and fire to real-world problems.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Subjects: Science, Mathematics, Reading and Writing

Duration: 60 minutes (one class period)

Group Size: Individuals or Groups of 2

Setting: Classroom

Vocabulary: Canopy, Crown, Crown Fire, Debris, Duff, Fine Fuels, Fuels, Litter, Shrub Layer, Stand, Standing Fuels, Surface Fuels, Surface/Floor Layer, Treatment, Trial, Understory

Objectives

- Students can list and describe the four layers in a temperate plant community: 1) surface/floor layer; 2) shrub layer; 3) understory layer; and 4) canopy layer.
- Students can define fuel for an ecosystem where fires occur.
- Students can list and describe the following three fuel types: 1) surface fuels; 2) debris; and 3) ladder fuels.
- Students can describe the fuel types that can contribute to the vertical spread of fire in a plant community.
- Students can explain how ladder fuels allow surface fires to move into the canopy or crowns of trees..
- Students can develop and test a hypothesis appropriate for this activity.
- Students can organize and graphically represent collected data.
- Students can apply their knowledge of fuels and fire to real-world problems.

Academic Standards

Table 1: Next Generation Science Standards - Science & Engineering Practices (SEP)

Engaging in Argument from Evidence	Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
Asking Questions and Defining Problems	Analyze complex real-world problems by specifying criteria and constraints for successful solutions.
Constructing Explanations and Designing Solutions	Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
Analyzing and Interpreting Data	Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Table 2a: Next Generation Science Standards - Performance Expectations

<u>HS-LS2</u> Ecosystems: Interactions, Energy, and Dynamics	HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
<u>HS-ESS3</u> Earth and Human Activity	HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
<u>HS-ETS1</u> Engineering Design	HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Table 2b: Next Generation Science Standards - Disciplinary Core Ideas (DCI)

<u>HS-LS2</u> Ecosystems: Interactions, Energy, and Dynamics	HS-LS2.C: Ecosystem Dynamics, Functioning, and Resilience • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. • Moreover, anthropogenic changes (induced by human activity) in the environment - including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change - can disrupt an ecosystem and threaten the survival of some species.
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<u>HS-ESS3</u> Earth and Human Activity	ESS3.C: Human Impacts on Earth Systems The sustainability of human societies and the biodiversity that support them require responsible management of natural resources.
<u>HS-ETS1</u> Engineering Design	ETS1.B: Developing Possible Solutions When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

Table 3: Next Generation Science Standards - Crosscutting Concepts (CC)

Cause and Effect	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
Systems and System Models	Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions - including energy, matter, and information flows - within and between systems at different scales.
Science Addresses Questions About the Natural and Material World	Scientific knowledge indicates what can happen in natural systems - not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.

Teacher Background In this lesson, students use a physical model to learn how the vertical arrangement of fuels affects the potential for fires to spread vertically in a plant community. Because the model provides a demonstration of the way fire behaves in a woodland or forest, it will be referred to as the “Ozark Highlands Tree Model.” However, it could represent any array of standing fuels with flammable crowns, such as shrubs.

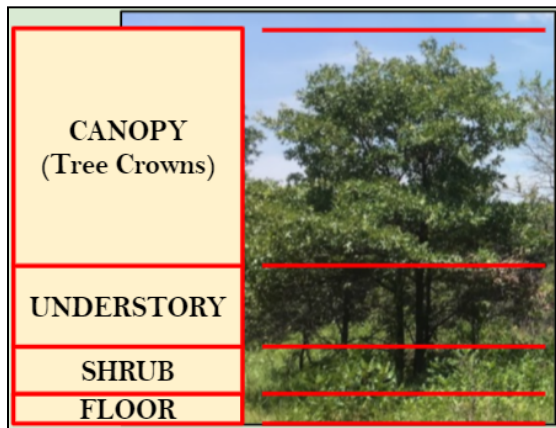
In a natural setting, fuels are anything that can burn. This activity focuses on how a system’s fire behavior can change

Fire in the Ozark Highlands



depending on the types of living and dead vegetative fuels that are present.

To investigate how fuel distribution can influence fire behavior, understanding plant community stratification is important. Temperate forests, like the Ozark Highlands, can be separated into four layers. The **canopy**, or the **crowns** of trees, is the top layer of woody species



consisting of overlapping leaves and branches. The **understory** is confined by the first branches of dominant/mature trees and the top of the shrub layer. The **shrub layer** is made up of woody, perennial plants that usually have many stems and that are shorter in stature than trees. The lowest layer is the **floor** which is dominated by herbaceous vegetation, such as grasses and wildflowers, that does not produce persistent

woody tissue like trees and shrubs.

The three generalized categories of fuel that will be included in this lesson are: 1) **surface fuels**; 2) **debris**; and 3) **ladder fuels**.

Surface fuels include a wide variety of living and dead vegetative material found on the surface of the ground. Such fuels include grasses, forbes, leaves, needles, pine cones, twigs, small branches, etc. Surface fuels allow fire to move, or to carry, across the ground. Fuels that are dead or dormant are typically drier and will ignite and burn more easily than green or growing vegetation that has a higher moisture content. The more “continuously” the ground fuels are spread, the more easily fire will carry across the surface of the ground. A lower amount of fuel, a “lighter” fuel load, will burn less intensely than a larger or “heavy” fuel load.



Woody debris on the ground could contribute not only to the “horizontal” movement of fire but also to the “vertical”



movement of fire from the surface/floor into the canopy or crowns of trees. Dead branches or trees found on the ground could act as a surface fuel or as a ladder fuel.

Ladder fuels provide pathways for a surface fire to move from the surface/floor through the shrub layer and understory into the canopy.

Fires that are able to spread into the canopy or into the crowns of trees are called crown fires. Such fires are very intense, dangerous, and difficult to control because they are off the ground and in the canopy layer. Land management typically attempts to avoid crown fires because of their intensity and because they are extremely difficult or impossible to suppress. One of the phenomena fire ecologists deal with is the patchiness of fires; why certain fuels or plants are consumed while others are not. **The primary purpose of this lesson is to investigate which fuels contribute most to tree mortality resulting from passing fires.**



Table 4: Key Terms

Canopy	The top layer of a wooded ecosystem consisting of overlapping leaves and branches of trees (Art, 1993).
Crown	The leaves and branches above the main trunk or trunks of trees (Art,

	1993).
Crown Fire	A very intense and dangerous fire that is difficult to control because it is in the canopy layer.
Debris	Dead branches or trees found on the ground that could act as a surface fuel or as a ladder fuel.
Duff	Partially decomposed organic matter lying beneath the litter layer and above the mineral soil. Includes the fermentation and humus layers of the forest floor (FEIS Glossary).
Fine Fuels	Dead fuels comprised primarily of herbaceous plants (e.g., grasses and forbes) but which could also include woody plants less than 0.25 inch (6.4 mm) in diameter and litter found on the ground surface (adapted from FEIS Glossary).
Fuels	Both the living and dead vegetation that can potentially burn in a fire. Fuel components refer to such items as downed dead woody material in various size classes, litter, duff, herbaceous vegetation, live foliage, etc. (FEIS Glossary).
Litter	Recently fallen plant material, including leaves, needles, fine twigs, and other organic material on the forest floor, that is only partially decomposed and is still discernible (FEIS Glossary).
Shrub Layer	The vegetative layer between the understory and surface/floor which is made up of woody, perennial plants that usually have many stems and that are shorter in stature than trees.
Stand	An aggregation of trees or other growth occupying a specific area and sufficiently uniform in species composition, size, age, arrangement, and condition as to be distinguished from the forest or other growth on adjoining areas.
Standing Fuels	Fuels that are arranged in a vertical, or nearly vertical, arrangement relative to the horizontal. Grasses, shrubs, and trees could be considered standing fuels.

Surface Fuels	Dead or living vegetation found on the ground surface.
Surface/Floor Layer	This vegetative layer between the ground and the shrub layer is dominated by herbaceous vegetation, such as grasses and wildflowers, that does not produce persistent woody tissue like trees and shrubs.
Treatment	The way investigators change the independent variable from one trial to the next.
Trial	A unique test of the relationship between the independent and dependent variables in a controlled experiment. A trial could have a change or variation in the independent variable, or a trial could repeat or replicate a specific value/setting for an independent variable.
Understory	The lowest layer of trees; the layer between the canopy/crown layer and the shrub layer. The understory may contain immature trees or large shrubs.

Materials and Preparation This activity requires that students have access to computers/Chromebooks connected to the internet. There are no “physical” materials to prepare unless paper copies of the student worksheet will be used.

Table 5: “Ozark Highlands Tree Model” Resources

“Ozark Highlands Tree Model” Resources
<u>Student Worksheet</u>
<u>Student Worksheet Key</u>
<u>Tree Model Webpage (JenksFERST)</u>

The student worksheet is a great reference to become familiar with the progression of this activity. Links to the student worksheet as well as a worksheet “key” for instructors can be found in Table 5 (above).

It is important to plan how students will submit their worksheets and to communicate that process. If students are using Chromebooks, they can save the worksheet as a Google document after it has been opened as a Word document.

Instructors should visit the webpage that contains the “video trials” for the various fuel treatments investigated in the activity. Becoming familiar with the procedure used for the trials and the possible outcomes will be beneficial when students begin collecting data from the videos.

If you decide to make your own tree model from the materials listed on the webpage’s “Physical Model Description” and to use the process shown in the videos as a live demonstration or to have students conduct the experiment:

FIRE LESSON: Matches and stove lighters are used in this activity to model physical phenomena that students will investigate. Exercise caution when conducting this activity. This activity should only be conducted in an appropriate laboratory setting under instructor supervision. If this is the first time students will be investigating physical phenomena with fire, links to a safety checklist and a safety quiz are included in this activity’s “Materials and Preparation” section.

Do this activity in only a properly equipped laboratory with adequate ventilation and fire suppression equipment or outdoors. Note that even the air currents created by the laboratory’s ventilation system will affect the experimental results.

- ➔ If this is the first time students will be investigating physical phenomena with fire, slides 2-8 of the [slideshow for “Lesson 2: The Heat Plume of a Fire”](#) must be shown and discussed.
- ➔ The day before the activity, review the “Safety Checklist for Fire Activities” and remind students to follow safety guidelines about clothing and hair when they get ready for school the day of the activity.
- ➔ Display the “[Safety Checklist for Fire Activities](#)” poster/slide so it is visible in the area where the activity will be conducted or review/discuss the poster.

Procedure

1. If paper copies of the student worksheet will be used, distribute them to students. If an “electronic” copy of the student worksheet will be used, be sure that students have used the link provided in “**Table 5**” to prepare their own document file.
2. Present the slideshow. Students should complete “Part A” of their worksheets during the presentation.
3. At the conclusion of the slideshow, have students proceed to “Part B” and subsequent parts on their worksheets to complete the activity.
 - a. If paper copies are being used, be sure to provide students with the treatment/trials webpage link found in “Table 5.”
 - b. Be available to discuss hypotheses, experimental design, data collection approaches, data table setup, and appropriate graphing of data.
4. Once all worksheet parts/prompts have been completed, have students submit their worksheets.
5. **Time permitting, class discussions could be conducted which compare hypotheses, data collection, and the results.**

Assessment

➔ Sample quiz/review questions for “Ozark Highlands Tree Model”

- 1) Which of the following has the correct order of layers in the Ozark Highlands from lowest to highest?
 - a) Canopy, Shrubs, Understory, Floor
 - b) Canopy, Understory, Shrubs, Floor
 - c) Floor, Shrubs, Understory, Canopy
 - d) Floor, Understory, Shrubs, Canopy

Answer: c

2) Which layer in the Ozark Highlands is composed primarily of herbaceous vegetation, such as grasses and forbes?

- a) Canopy
- b) Floor
- c) Shrub
- d) Understory

Answer: b

3) Which is the best definition of ladder fuels?

- a) Vines, shrubs, and young trees that allow fire to move from the surface/floor into the canopy or crowns of dominant trees.
- b) Fuels that are made up of a wide variety of living and dead vegetative material found on the surface of the ground.
- c) Fuels that are made up of dead branches or trees found on the ground.
- d) The living and dead vegetation that can potentially burn in a fire.

Answer: a

4) How are the independent and dependent variables related to each other in an experiment?

- a) There is no difference between the two variables if they are both part of the same experiment.
- b) Because it is changed by the investigator, the dependent variable differs in each experimental trial and, since it is “independent,” the independent variable never changes.
- c) The dependent variable could change between experimental trials as the independent variable is changed by the investigator.
- d) The independent variable could change between experimental trials as the dependent variable is changed by the investigator.

Answer: c

5) Which of the following answers best describes a crown fire?

- a) A low-intensity fire in the canopy layer that is easy to suppress or put out.
- b) A very intense and dangerous fire that is difficult to control because it is in the canopy layer.
- c) A high-intensity fire that occurs in the understory layer and results in high ladder vegetation mortality.
- d) A quickly moving, high-intensity surface fire that passes through a wooded area without causing damage to tree crowns.

Answer: b

Evaluation

Student Worksheet

A key for the student worksheet can be found as a separate document entitled “Student Worksheet - Key” in **Table 5** (above).

Sample quiz/review questions for the “Ozark Highlands Tree Model”

Answers provided with the questions in the **Assessment** section.

Extensions There are no extensions for this activity.

References/Resources

Images and diagrams by Bryan Yockers unless cited/listed below or in the lesson materials.

Art, H. W. (Ed.). *The Dictionary of Ecology and Environmental Science*. Henry Holt, 1993.