FireWorks Curriculum Featuring Ponderosa, Lodgepole, and Whitebark Pines

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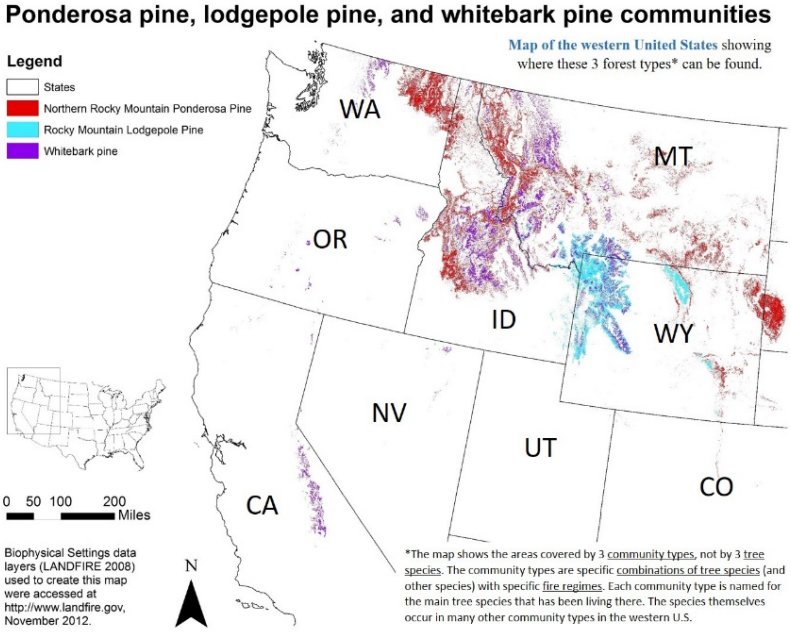
FireWorks: Why?

Change is an integral part of healthy, enduring ecosystems in most temperate regions of the world. *FireWorks* provides students with interactive, hands-on materials to study the forces that cause change, particularly wildland fire. The program is based on the science of wildland fire, a highly interdisciplinary field, so it provides a context for learning about properties of matter, chemical and physical processes, ecosystem fluctuations and cycles, habitat and survival, and human interactions with ecosystems. These concepts are considered important for science literacy (American Association for the Advancement of Science 1993). Students using *FireWorks* ask questions, gather information, analyze and interpret it, and communicate their discoveries. They often work in pairs or small groups. These are learning styles that enhance understanding, cognitive skills, and social skills (Moreno 1999; National Research Council 1996).

Local learning:

Students learn best about ecology when it is close to home—when they can study the plants, animals, and fire regimes typical of local ecological communities (Lindholdt 1999; North American Association for Environmental Education 1999). This version of *FireWorks* focuses on 3 communities that occur from the northern Rocky Mountains through the "intermountain" region to the North Cascades: Northern Rocky Mountain Ponderosa pine[1] (dominated mostly by ponderosa



[1] Common names are used for all species mentioned in the text and associated materials. Corresponding scientific names are available online in the Fire Effects Information System (https://www.feis-crs.org/feis/).

pine and Douglas-fir, Rocky Mountain Lodgepole pine (dominated by lodgepole pine and subalpine fir, and Whitebark Pine (dominated by whitebark pine, sometimes with subalpine fir).

The 3 forest types featured in this curriculum have long, intimate relationships with fire. The photo presentation created for **Activity 1** in the Elementary and Middle School curricula shows many inhabitants of these communities and the different types of fire that occur in them. **Table I-1** summarizes this information.

Table I-1—Summary of ecology and "fire story" of some forest communities of the northern Rocky Mountains and North Cascades.

Elevation		**Low**	**Middle**	**High**
Pine species (grows well in sunny, open areas with bare soil)		ponderosa pine	lodgepole pine	whitebark pine
Shade-tolerant species (grows better than pine in shady places and in litter and duff)		Douglas-fir	subalpine fir	subalpine fir
Pine traits for surviving or reproducing well after fire		Open, high crown thick buds thick bark	serotinous cones	Trees in clusters open, high crown seeds planted by nutcrackers
Historical fire regime	Fire severity	Majority of fires are low-severity; some mixed-severity & occasional stand-replacing	Stand-replacing and mixed-severity, with occasional low-severity	Often patchy, mixed-severity. Highly variable in size and severity
	Average fire interval	Ranges from about 6 years to 50 years	Ranges from about 90 years to more than 300 years	Ranges from about 40 years to more than 250 years
Some animals in this community (not limited to this community)		Pileated woodpecker Flammulated owl Elk (especially spring)	Black-backed woodpecker Mountain pine beetle Elk (hiding cover in fall)	Clark's nutcracker Grizzly bear Elk (summer)
Example of traditional use by Native Americans		Peeled bark for nutrition	Cut poles for tipis	Collected pine nuts for nutrition
Disturbances besides fire		Douglas-fir dwarf mistletoe	Mountain pine beetle	Mountain pine beetle, white pine blister rust

Goals

FireWorks aims to increase understanding

- of the physical science of combustion, especially in wildland fuels
- that an ecosystem has many kinds of plants and animals, which change over time and influence one another
- that fire is an important natural process in many ecosystems
- that native plants and animals have ways to survive fire or reproduce after fire, or both
- that people influence the fire-dependent ecosystems where they live, and they always have done so

Meeting these goals helps implement the vision of the National Cohesive Wildland Fire Management Strategy (U.S. Department of Agriculture, Forest Service; Department of the Interior, Office of Wildland Fire Coordination. 2011) to "…safely and effectively extinguish fire when needed; use fire where allowable; manage our natural resources; and as a nation, to live with wildland fire."

FireWorks also aims to increase student skills in

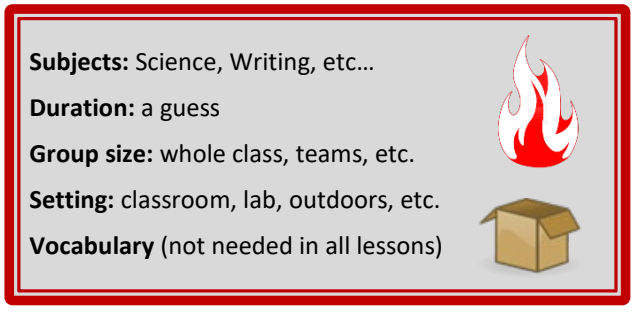
- making observations
- classifying information
- measuring, counting, and computing
- stating and testing hypotheses
- describing observations, both qualitatively and quantitatively
- explaining reasoning
- identifying and expressing responses to science-related questions
- working in teams to solve problems and
- critical listening and reading

These skills are crucial for developing an adult citizenry literate in science and attracting students to professional work in the sciences (National Research Council 1996).

Design and Layout of Lessons in This Curriculum

Each *FireWorks* activity has the following sections:

Lesson Overview
Lesson Goal
Objectives
Teacher Background
Materials and Preparation
Procedure
Assessment
Evaluation rubrics
Handouts (if needed)



Instructions for each activity also include a text box (example above) that lists subjects covered, the possible duration of the activity (a guess –take this with many grains of salt), group size, setting (laboratory, classroom, outdoors, etc.), and suggested vocabulary terms. The text box may also contain one or two icons – a red-and-white flame if the activity uses fire, and a brown box if the activity requires materials from a *FireWorks* trunk.

Handouts and other materials meant for students all begin with a large, bold-face header in **blue font**. Handout answer keys and other materials meant for teachers all begin with a large, bold-face header in **maroon font**. In the Procedures section and in answer keys, answers to questions are given in red font.

Links to Educational Standards

FireWorks need not compete with core curriculum for classroom time. Instead, it can help teachers cover required curriculum and meet required standards by using hands-on materials based on science from the local area. To help teachers identify the ways in which *FireWorks* can be used to meet their curriculum requirements, each activity is linked to relevant standards from:

- Common Core State Standards in English Language Arts (CCSS-ELA), Math (CCSS-Math), Science, and Technical Subjects
- Next Generation Science Standards (NGSS)
- Excellence in Environmental Education: Guidelines for Learning standards (EEEGL)[2]

[2] Abbreviations and links to standards:

- CCSS-ELA: Common Core State Standards—English Language Arts (http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf)
- CCSS-Math: Common Core State Standards—Math (http://www.corestandards.org/wp-content/uploads/Math_Standards.pdf)
- NGSS: Next Generation Science Standards (http://www.nextgenscience.org/sites/ngss/files/NGSS%20DCI%20Combined%2011.6.13.pdf)
- EEEGL: Excellence in Environmental Education: Guidelines for Learning (http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf)

If a lesson does not have standards listed from a particular standard framework, then it probably does not meet standards in that framework. However, teachers are encouraged to reinterpret standards and lessons and also to adapt lessons to meet their educational objectives and particular standards. This diagram shows how to use the table of standards provided with each activity:

1. Find the relevant grade(s).

2. Access the relevant publication (see the links in the footnote above).

Standards:		**6th**	**7th**	**8th**
CCSS	Writing	2, 4, 7, 10	2, 4, 7, 10	2, 4, 7, 10
	Speaking and Listening	1, 2, 4, 6	1, 2, 4, 6	1, 2, 4, 6
	Language	1, 2, 3, 4, 6	1, 2, 3, 4, 6	1, 2, 3, 4, 6
	Writing Standards Science/Tech	1, 2, 4, 7, 10	1, 2, 4, 7, 10	1, 2, 4, 7, 10
	Math	MP.4	MP.4	MP.4
NGSS	Matter and Its Interactions	ETS1.B		
	Earth's Systems	ESS2.D		
	Earth and Human Activity	ESS3.A, ESS3.B, ESS3.C		
	Engineering Design	ETS1.B		
EEEGL	Strand 1	A,B,C,E,F,G		

3. Open standards publication to the appropriate grade and section.

4. Locate these numbers and read the associated standards.

Safety

Many of the experiments in *FireWorks* use fire and natural fuels. In these structured, well supervised environments, students can make discoveries about fire and improve their habits regarding fire safety. Help students learn about safe laboratory practices, such as using protective eyewear and wearing appropriate clothing. Help them learn that professional skills and years of experience are needed to use fire safely in wildlands. The following steps will help you run the activities smoothly and help your students grow in responsibility and competence regarding lab safety and fire safety:

- Inform maintenance staff about activities in which you will use fire.
- Inform your local fire protection unit if you plan to use fire outdoors.
- Consider informing parents about your plans and goals for teaching about fire.
- Choose your work space carefully, especially if you will not be using a laboratory. The fire engine may be required to respond to every alarm, even if you tell them it's "only" an experiment.

- If you are working outdoors, watch carefully to prevent smoldering material from igniting schoolyard vegetation.
- Keep spray bottles filled with water. Have students use them to extinguish smoldering material at the end of each experiment. This will prevent trash-can fires.
- If you are working outdoors, keep a hose available and ready to use. Have a bucket or two of water available as well.
- Keep a fire extinguisher ready for use. Know how to use it. If you discharge a fire extinguisher, refill or replace it immediately. Don't burn anything without a charged fire extinguisher in the room.
- If you or any of your students have asthma or other respiratory problems, consider having them wear protective masks while working with fire.

Three Curricula for Three Grade Levels

FireWorks includes curricula for 3 grade levels: Elementary (grades 1-5), Middle (grades 6-8), and High (grades 9-12). The Elementary curriculum encourages students to learn from demonstrations and simple models and to become acquainted with plants and animals in the local area. The Middle School curriculum challenges students to conduct experiments to answer questions and use information from technical readings to describe fire's role in various ecosystems. The High School curriculum asks students to design and conduct experiments and to apply information from technical articles to management questions. Activities for different grade levels may use the same materials, but the curricula differentiate across grade levels; content is more detailed and the activities are more challenging for older students. You can use **Table I-2** to compare activities on the same theme for different grade levels and select the best approach for meeting your objectives with your students.

Literature cited

American Association for the Advancement of Science. 1993. Benchmarks for science literacy. New York: Oxford University Press. 418 p.

Lindholdt, Paul. 1999. Viewpoint: writing from a sense of place. Journal of environmental education: 30(4): 4-10.

Moreno, Nancy P. 1999. K-12 science education reform—a primer for scientists. BioScience. 49(7): 569-576.

National Research Council. 1996. National science education standards. Washington, DC: National Academy Press. 262 p.

North American Association for Environmental Education. 1999. Excellence in EE—guidelines for learning (K-12). Rock Spring, GA: NAAEE Publications and Membership Office. 107 p.

Smith, Jane Kapler; McMurray, Nancy E. 2000. FireWorks curriculum featuring ponderosa, lodgepole, and whitebark pine forests. Gen. Tech. Rep. RMRS-GTR-65. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 270 p.

U.S. Department of Agriculture, Forest Service; Department of the Interior, Office of Wildland Fire Coordination. 2011. A national cohesive wildland fire management strategy. Washington, DC: Wildland Fire Leadership Council. 43 p

Table I-2. *FireWorks* Curriculum Plan for the Northern Rocky Mountains and the North Cascades. Read across the table to find similar activities for students at all 3 grade levels.

Unit & Theme	ELEMENTARY	MIDDLE	HIGH
Unit I. Introduction to Wildland Fire	E01. Visiting Wildland Fire in the Northern Rocky Mountains and North Cascades	M01. Visiting Wildland Fire in the Northern Rocky Mountains and North Cascades	H01. Introduction to Wildland Fire in the Northern Rocky Mountains and North Cascades
Unit II. Physical Science of Wildland Fire	E02. Making Fires Burn or Go Out 1: Introduction to the Fire Triangle	M02. Where Does Heat Go? The Heat Plume from a Fire	H02. The Fire Triangle: Fuel, Heat, and Oxygen
	E03. Making Fires Burn or Go Out 2: Demonstrating the Fire Triangle and Heat Plume	M03. What Makes Fires Burn? The Fire Triangle 1—Heat and Fuel	H03. The Fire Triangle, Combustion, and the Carbon Cycle
		M04. What Makes Fires Burn? The Fire Triangle 2—Oxygen	H04. Heat Transfer
Unit III. The Wildland Fire Environment			H05. Fuel Properties
			H06. Pyrolysis
			H07. Fire Spread Processes: Putting it all together: Heat transfer, fuel properties, and pyrolysis
	E04. How Wildland Fires Spread 1: Experiment with a Matchstick Forest	M05. How Do Wildland Fires Spread? The Matchstick Forest Model	H08A. Fire Environment Triangle and Fire Spread: The Matchstick Model
			H08B. Fire Environment Triangle and Fire Spread: The Landscape Matchstick Model
		M06. Ladder Fuels and Fire Spread: The Tinker Tree Derby	H09. Ladder Fuels and Fire Spread
	E05. Fuel Properties: The Campfire Challenge	M07. Fuel Properties: The Campfire Challenge	See H05.
	E06. Effect of Wind: How Wildland Fires Spread	M08. Fire Behavior, Fire Weather, and Climate	H10. Fire Behavior, Fire Weather, and Climate

Unit IV. Fire Effects on the Environment	E07. Smoke from Wildland Fire: Just Hanging Around?	M09. Smoke from Wildland Fire: Just Hanging Around?	H11-1. Smoke from Wildland Fire: Just Hanging Around?
		M10. Fire, Soil, and Water Interactions	H12. Fire, Soil, and Water Interactions
Unit V. Fire's Relationship with Organisms and Communities	E08-1. What's a Community? All the Living Things in the Ecosystem	M11. Who Lives Here? Adopting a Plant, Animal, or Fungus	H14. Researching a Plant, Animal, or Fungus
	E08-2. Who Lives Here? Adopting a Plant, Animal, or Fungus		
	E09. Tree Parts and Fire: The Class Models a Living Tree	M12. Tree Parts and Fire: "Working Trees" Jeopardy-style Game	
	E10. Tree Identification: Using a Key to Identify "Mystery Trees"	M13. Tree Identification: Figure out the "Mystery Trees"	H13. Tree Identification: Create a Dichotomous Key
	E11. Recipe for a Lodgepole Pine Forest: Serotinous Cones	E11. Is appropriate for middle school	
		M14. Who Lives Here and Why? Modeling Forest Communities	H15. Forest Communities and Climate Change
		M15. Bark and Soil: Nature's Insulators	
	E12. Buried Treasure: Underground Parts that Help Plants Survive Fire	M16. Buried Treasures: Identifying Plants by their Underground Parts	

Unit VI. Fire History and Succession	E13-1. My Tree Autobiography: Seeing History through Trees' Annual Rings		
		M17-H16. Dating Fires Using Dendrochronology	M17-H16. Dating Fires Using Dendrochronology
		M18-H17. History of Stand-replacing Fire	M18-H17. History of Stand-replacing Fire
	E13-2. Tree Biography, Forest Biography	M19-H18. History of Low-severity Fire	M19-H18. History of Low-severity Fire
		M20. Fire History in Ponderosa, Lodgepole, and Whitebark Pine Forest Communities	H19. History of Mixed-severity Fire
	E14. Story Time: Fire and Succession	M21. Drama in the Forest: Fire and Succession, a Class Production	H20. Why Do Historical Fire Regimes Matter?
		M22. Fire Ecology Puzzler	
Unit VII. People in Fire's Homeland	E15. Carrying Fire the Pikuni Way	M23. Carrying Fire the Pikuni Way	H21. Carrying Fire the Pikuni Way
	E16. Homes in the Forest: An Introduction to Firewise Practices	M24. Homes in the Forest: An Introduction to Firewise Practices	
	E17. Revisiting Wildland Fire	M25. Revisiting Wildland Fire	H22. Northern Rocky Mountain and Northern Cascades Forests Today