Fire Ecology Learning Lab
Agency and Informal Educator Lesson Plan: Fuel Properties

Grade Level: Middle School
Estimated Time per Class: 1.5 Hours in class Total (plan for 30 minutes before and after for set up and clean up)

Note: If teachers are doing the full FELL middle school unit, this is equivalent to Lesson 4.

Lesson Overview:	If you only have an hour, the following shortcuts are recommended:
Introduction and Safety - 10 minutes **Pre-Burning Observation** - 10 minutes **Burning Observation** - 40 minutes **Naming Fuel Properties** - 10 minutes **Discussion** - 10 minutes **Reflection/Closing Discussion** - 10 minutes **Homework (optional)** - 20 minutes	● Meet the class outside where you will do the experiment. ● Reduce introductions and the time students have to look at the pans before they burn. ● Stay outside to do the fuel card activity. ● Leave the reflection for the teacher to do in class the next day.

Student Materials	Teacher or Whole Class Materials
● Goggles ● Sterilizing wipes (if you will see more than one class you will need to clean goggles) ● Data collection worksheets, original provided, you will need to make enough copies for the entire class ● Fuel property vocabulary cards, precut in bags (15 sets). ● Homework handout, original provided, you will need to make enough copies for the entire class ● Pencil (ask teachers to provide) ● Science notebooks or clipboards (ask teachers to provide) ● *Optional*: phones or tablets to record the way the fire burns ● *Optional*: Images of different biotic communities (4 sets), to be used if	● Teacher letter, draft provided in binder ● Parent letter, draft provided in binder ● Safety checklist ● 3 pre-arranged trays to demonstrate different fuel properties (fuels will need to be collected before the lesson, see instructions below) ○ 3 disposable aluminum roasting pans or similar ○ Sand or soil to fill the bottom of each pan ○ Different fuel types ■ Wet fine fuels (green grass, green pine needles) ■ Dry fine fuels (dry grass, dry pine needles) ■ Fresh, live branch with leaves or similar from shrub or herbaceous plant

student did not do FELL lesson 1	■ Dry, dead branch and larger twigs from shrub or herbaceous plant ■ Dry twigs or small branches • Matches or other fire starter • Post-it Notes • Fire extinguisher • Water in buckets or hose • *Optional*: If you are unable to burn, you will need to project pre-recorded videos from YouTube.

Guiding Question and Assessment
Guiding Question: What are the properties of fuel and how do these relate to fire behavior? Assessment: Homework illustrating fuel properties (optional)

Vocabulary (See Fuel Properties cards for definitions)	
• Fuel chemical content: The sap and other chemicals that make a plant more or less flammable • Fuel compactness: How densely plants are packed together • Fuel load: The mass of combustible material • Fuel moisture content: How wet or dry fuels are • Fuel size: The size of the fuels	• Fire type: Where a fire is burning, see below: ○ Ground fire: burns under the surface of the soil ○ Surface fire: burns along the surface of the soil ○ Crown fire: Fires burning into the crowns or tops of plants • Volatile chemicals: store energy that is easily converted from chemical energy to heat energy. These include oil, resin, pitch, and wax.

Summary Agenda and Preparation	Notes
Prepare: • *At least 2 weeks before*: send letter for teacher to provide to families about trauma informed care, provided in binder • *1 week before:* Contact teacher	**Before visit:** • Ensure the teacher has informed school administration of the lesson and receive permission to burn material on the school grounds • Confirm that the teacher has checked

lesson to confirm details • Collect and prepare materials • Arrive 30 minutes before lesson to check in and set up materials • Set up outside (fire safety) and inside (pans with materials to burn) • Lay out all handouts somewhere they are easy to reach for each part of the lesson	in with families to identify any students who might have been impacted by fire, in line with trauma informed care • Discuss a plan for windy conditions • Discuss safety protocols. Ensure there is a hose nearby • Confirm the location of the burn • Make copies of handouts, including in class worksheets and homework, for each student. • Collect materials for experiment • Set up three pans with different fuel properties (setup details at the end of lesson) • Use Post-it notes to mark where each fire will be started.

Timing and Instructions Introduction and Safety (10 minutes)	Notes
5 minutes • Introduce yourself and your agency, give a brief explanation of how you started in this field (education, experience, interests) and what you usually do in a day • Ask students to ask any initial questions • Share the guiding question you will be working on today: *What are the properties of fuel and how do these relate to fire behavior?* 5 minutes • Review fire safety, including how to use an extinguisher. • Assign safety related jobs to students or teachers	Safety: If the teacher has a flame hood, the experiment could be done inside, otherwise choose an outdoor location on a cement or asphalt pad away from any flammable material. • Make sure you have a charged fire extinguisher (for inside or out) If outside: • DO NOT do this activity on a windy day • If possible, have a hose and wet down any surrounding plantings • If no hose, have a bucket of water

Timing and Instructions Pre-Burning Observation (10 minutes)	Notes
2 minutes • Explain that students will have 5 minutes to look at the three different trays that will be burned and give instructions on what data they should be collecting.	• This can be conducted outside to limit transition time during the program. • If you use the videos instead of burning the fuels, it is recommended

6 minutes ● Students will look at all three trays, make notes, predict what will happen, draw, and ask questions in their science journals. 2 minutes ● Pair and share ● Students have a minute each to reflect with their lab partner(s) about what they predict will happen when these burn.	that you still create the trays for students to observe and make predictions about what will happen.

Timing and Instructions Burning Observation (40 minutes)	Notes
10 minutes - Transition and safety ● Move to the outdoor space ● Review safety protocols again, especially the distance students need to be from the fire. ● Describe why this area was chosen to conduct the experiment. 25 minutes - Experiment ● Set each of the models on fire, one at a time, starting the fire at the designated point. ● Have students watch how it burns and make detailed notes in their journals. ● Have students discuss what they noticed as a pair-share or with the whole class. 5 minutes - Transition ● Clean up area and move back inside	● Ask specific students for help carrying models ● *Optional*: Have a student from each table group record the fires on their phones to revisit and look at later to find examples of each fuel property in action. Safety note: show students how to make sure there are no live embers that could reignite or harm anyone.

Timing and Instructions Work Time (20 minutes)	Notes
10 minutes - Small group discussion ● Ask students to identify trends and describe different fuels and fire behavior (how it moved or didn't move, etc.) that they observed during the experiment. ● Hand out Fuel Property vocabulary cards ● Have students compare what they noticed to each of the cards	● This can be conducted outside, to limit transition time during the program.

● When did they see evidence of each example? Ask them to be specific. ● Check in with the groups to ensure there is understanding 10 minutes Option 1: (If teachers did FELL lesson 1) ● If they are not already with their biotic community partners, have them meet back with those groups and look at the images of the biotic community from Lesson 1. What do they notice about the fuel properties and how ● Check in with the groups to ensure there is understanding Option 2: (if this is a stand-alone fire lesson) ● Hand out pictures of different biotic communities. ● Have students compare what they observed in the pans with what they see in the pictures of different biotic communities, reflecting on how the fuel properties relate to each one.	Not all teachers will complete the middle school FELL lessons, so confirm their participation before you assign this.

Reflection/Closing Discussion (10 minutes)	Notes
2 minutes ● Explain fuel properties homework (optional) 8 minutes ● Ask students if they have any questions for you about your career or agency	● Hand out any materials you brought with you as give aways.

Post-Lesson Activities and Homework (optional)	Notes
20 minutes: ● Students should complete the Fuel Properties homework sheet, if the teacher wants this activity added. These can be left with the teacher.	● Share a copy or link to the fuel property cards with the teacher to ensure they have these terms for future conversations.

Common Questions
● Are fires bad? *or* Aren't all fires bad?

    - Fire isn't good or bad on its own. Fires can be dangerous if they are burning near human habitation. Many landscapes, like grasslands and some forest types, are adapted to burning. Other ecosystems can be damaged if they burn. It is important to remember that fires have always been a part of the landscape. In many locations, people have used fire to clear areas for croplands, improve the health of vegetation to benefit people and wildlife, and for ceremonial uses. These practices by Indigenous peoples continue today and are often called "cultural burning."
- Is your job scary?
- How did you get your job?
- How much do you get paid?
- How will climate change change how fires burn?
- Be ready for questions about prescribed burns, especially in New Mexico.

Working with Middle School Classes

Tips and Tricks:

- Confirm with the teacher that you expect them to intervene with any behavior issues.
- Remember you are a subject expert. Avoid using acronyms and big words. Students (and even teachers!) will be unlikely to tell you they are confused.
- Your teacher might want you to visit multiple classes in a day. You might need to shorten parts of this lesson to fit into their schedule.
- Middle school students like being treated like young adults, not children, for example say "people" not "kids." Give them some space to make choices and share their thoughts. They are able to make fairly complex connections.
- Set clear expectations and know you will need to repeat these. Expectations that you should share include that students should listen to you and one another, safety protocols, and other behaviors.
- Set clear consequences for not listening or not following directions, especially when doing the fire. Follow these consequences immediately. Consequences should include having students move groups or even being sent inside, if there is a safety concern.
- Don't try to talk over students. Lower your voice and wait.

The state standards and 5-E Lesson Plan below are provided to share with teachers. These are topics they are responsible for covering in a year. By sharing these with teachers they will be more likely to justify having you visit their classroom. NGSS stands for Next Generation Science Standards. These are used in New Mexico, sometimes called STEM Ready! Science Standards. Arizona standards are similar, but have a slightly different numbering convention. Both are included below. Common Core standards are the language arts and math standards. The lesson plan follows the "5E" model of instruction - Engage, Explore, Explain, Elaborate, Evaluate.

5-E Summary	Student Differentiation and Supports
Engage - 20 minutes ● Introductions ● Expectations and safety ● Have the three unburned trays on three tables for the students to observe, have students walk around the pans, and discuss what they think will happen when each is set on fire **Explore** - 40 minutes ● Observe how the the three pans burn ● Have students take notes and record the fire on phone or tablets, if possible ● Have students discuss what they noticed **Explain** - 10 minutes ● Share the fuel properties vocabulary cards with each table group and have students find examples of when they witnessed each fuel property ● Discuss thoughts as a whole group **Elaborate** - 10 minutes ● Option 1: If students are doing the FELL Curriculum in class: Have students get back into their Biotic Community groups and discuss how these fuel properties can be related to what they learned about the different plants that live in those areas ● Option 2: Have students discuss how these properties might impact how fires burn in the wild	This 5-E lesson plan allows students to engage directly with science and construct their own knowledge. They start by making their own observations and are given key vocabulary and additional information after these initial explorations. If you only have an hour, the following shortcuts are recommended: ● Meet the class outside where you will do the experiment. ● Reduce introductions and the time students have to look at the pans before they burn. ● Stay outside to do the fuel card activity. ● Leave the reflection for the teacher to do in class the next day.

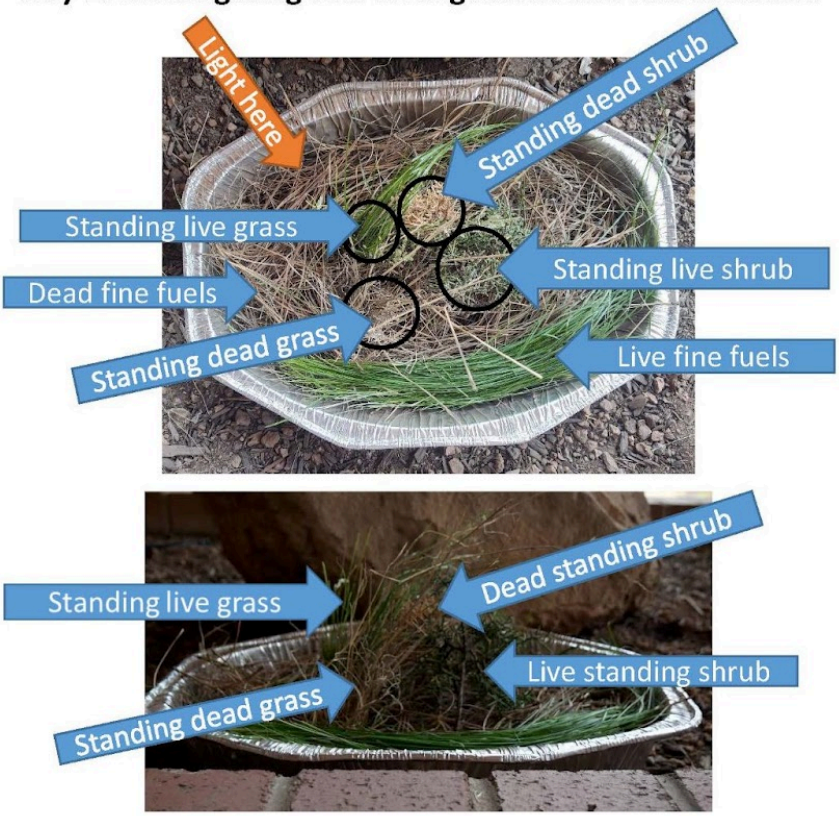
Evaluate - 10 minutes, 20 minutes homework ● Have students create a cheat sheet that has drawings and notes to describe each fuel property, Homework handout ● Allow time for student questions.	

NGSS and AZ Science Standards	Related Learning Goals
NGSS Content: MS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. MS-ESS3-2 Earth and Human Activity: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. **Arizona Science Standards:** AZ U1: Scientists explain phenomena using evidence obtained from observations and or scientific investigations. Evidence may lead to developing models and or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. AZ 6.L2U1.13: Develop and use models to demonstrate the interdependence of organisms and their environment including biotic and abiotic factors. AZ 7.E1U1.5: Construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere. AZ8.P1U1.2: Obtain and evaluate information regarding how scientists identify substances based on unique physical and chemical properties. **NGSS Practices:** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. Analyze and interpret data to provide evidence for phenomena. Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	Students will know: ● Energy is stored in plant materials ● What fuel properties are ● How the properties of fuel relate to the way that the fuels burn ● The fuel properties are exhibited in the biotic communities they studied and these can become hazardous to communities Students will be able to: ● Observe the phenomena presented by the fuels and make inferences about how this relates to the larger environment around us ● Use scientific vocabulary to explain phenomena ● Use evidence to support claims

Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **NGSS Crosscutting Concept:** Systems and system models: Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering. Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.	
Common Core CCSS RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. CCSS WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.	

Link to YouTube videos: https://www.youtube.com/channel/UCs3JeynHSJlf1sLJEDFgVnA/featured

Tray 1: Investigating fuel arrangement and fuel moisture



Layout steps:

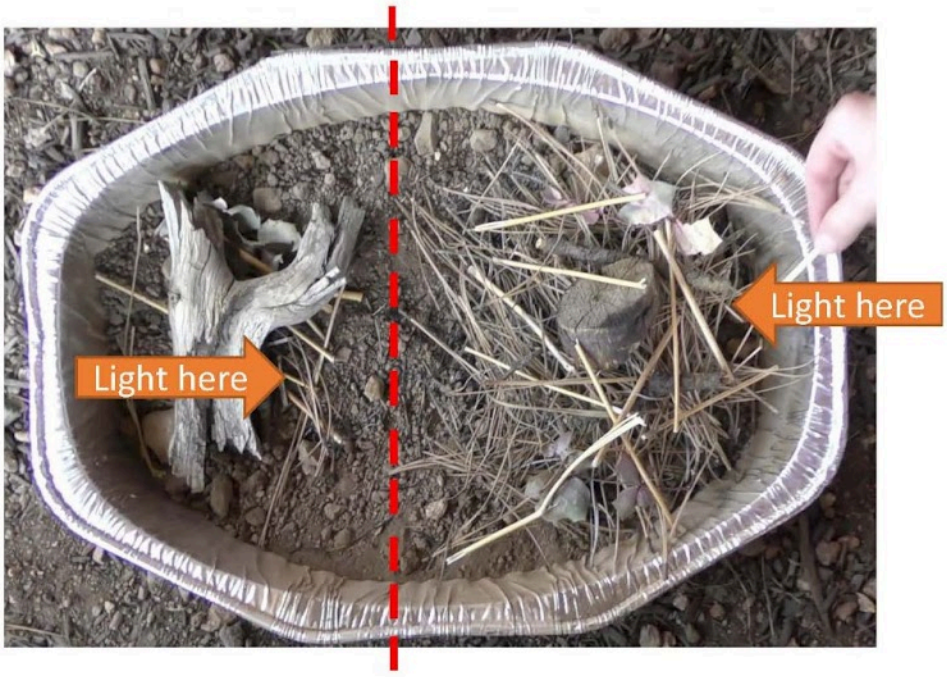
1. Fill pan with 2" of dirt/soil.
2. Fill entire pan with a layer of dead fine fuels.
3. In center, add live grass standing up by folding at the bottom and pressing into dirt.
4. Add upright dead grass next to that.
5. Add a small dead branch of a shrub or herbaceous plant, upright and also in the center.
6. Add a small live branch of a shrub or herbaceous plant, upright in the center.
7. Add live grass flat along one side.

Where to light: opposite corner away from live grass in dead fine fuels.

Materials:

- Dead fine fuels (pine needles, grass, leaves)
- Live (green) fine fuels (grass, leaves)
- Dead shrub or herbaceous plant
- Live (green) shrub or herbaceous plant

Tray 2: Investigating fuel load and fuel size



Layout steps:

1. Fill pan with 1" of dirt/soil.
2. Fill half of pan with lots of all sizes of fuels, layering with the fine fuels first.
3. Fill other half with smaller amounts of all sizes of fuels, again layering with fine fuels on the bottom.

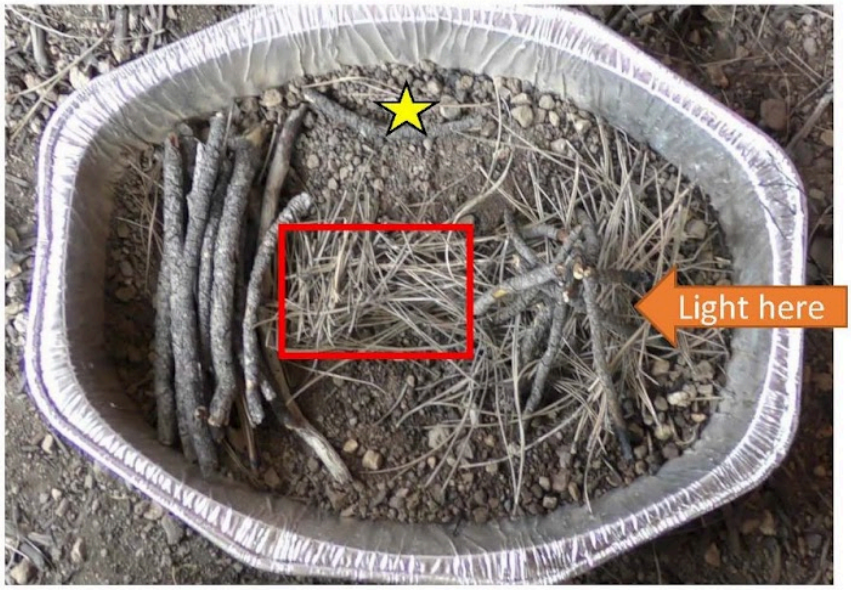
TIP: make sure both sides have similar sized and types of fuels.

Where to light: Each half will need to be lit independently. Always ignite the fine fuels as they ignite quickly and easily. On the side with less fuel, you may need to light the fine fuels around the larger (heavier) fuels more than once, as this will demonstrate that heavy fuels are harder to ignite.

Materials:

- Dead fine fuels (pine needles, grass, leaves)
- Dead twigs, small and medium branches

Tray 3: Investigating fuel compactness and fuel continuity



Layout steps:

1. Fill pan with 1" of dirt/soil.
2. Fill half of pan with a layer of fine fuels first, then build a tent with twigs (on right).
3. Fill other half with a layer of fine fuels, then tightly stack (lay flat) twigs on top.
4. Build a narrow bridge connecting the two with a layer of fine fuels.
5. Add 1 fine fuel and 1 twig on one side to demonstrate lack of continuity. This should not burn. ☆

TIP: make sure both sides have similar sized and types of fuels.

Where to light: ignite under twig tent first. The bridge of fine fuels will hopefully carry the flame to the stack of twigs, but if not, go ahead and light the bridge with a second match.

Materials:

- Dead fine fuels (pine needles, grass, leaves)
- Dead twigs