

Matchstick Forest

Learning Objectives:

Prep Time: 25-35 minutes

Students will

- Learn about the wildfire behavior's dependence on topography, weather, and fuel
- Be able to describe the potential benefits and drawbacks of different wildfire management strategies

NGSS Alignment:

- K-ESS2-2 Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.
- K-ESS3-3 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.
- 3-ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.
- 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.
- 5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
- MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Learning Content:

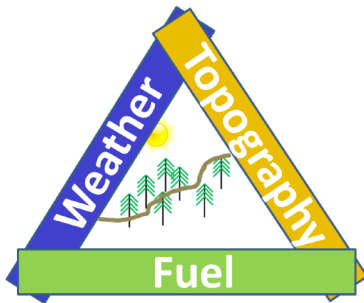
Forests change over time in a process called succession. Fire is a dramatic force for change, but change occurs without fire, too. Some plants need sunny openings to grow well, so they thrive in the first years after fire, and some animals thrive on these plants. Other plants reproduce almost anywhere, even in deep shade. Most wildfires occur in hot, dry months and start with a lightning strike. Wildfires are a natural part of the seasonal cycle but have become more frequent and extreme due to climate change. Wildfires affect humans when they are near population centers. Knowing how a wildfire may behave is key to control and management. Many factors affect how a wildfire burns, how fast it moves, and how difficult it is to control.

Wildfires are affected by variations in weather, topography, and fuel, known as the Wildfire Triangle. Weather includes wind, temperature, cloudiness, moisture and air pressure. High

temperatures and low humidity cause vegetation to dry and wildfires to burn rapidly. Wind not only moves wildfires across landscapes, but also supplies oxygen that can cause fires to grow swiftly. Wind can also blow embers for miles, igniting new spot fires. Rain and high humidity can slow or extinguish fires, while storms can cause fire activity to increase or become completely unpredictable.

Topography describes the physical features of an area, including slope and aspect (the direction a slope faces). Wildfires burn more rapidly when moving up a slope by preheating unburned fuels and making them more combustible. Wind also moves more rapidly up slopes, increasing the speed at which a fire can spread. Draws can act like chimneys and funnel flames upwards.

Fuels are vegetation and structures. Their characteristics have a great effect on wildfire behavior. Large, dense trees burn for hours and generate a lot of heat. Dried grasses, on the other hand, produce a flashy fire that burns quickly and does not generate much heat.



(Missoula Fire Sciences Laboratory)



Students use the model to test variables

Research around home destruction vs. home survival in wildfires point to embers and small flames as the main way that the majority of homes ignite in wildfires. Embers are burning pieces of airborne wood and/or vegetation that can be carried more than a mile through the wind, and can cause spot fires and ignite homes, debris and other objects.

There are methods for homeowners to prepare their homes to withstand ember attacks and minimize the likelihood of flames or surface fire touching the home or any attachments. Experiments, models and post-fire studies have shown homes ignite due to the condition of the home and everything around it, up to 200' from the foundation. This is called the Home Ignition Zone (HIZ). The concept of the home ignition zone was developed by retired USDA Forest Service fire scientist Jack Cohen in the late 1990s, following some breakthrough experimental research into how homes ignite due to the effects of radiant heat. The HIZ is divided into three zones.

The Immediate Zone: The home and the area 0-5' from the furthest attached exterior point of the home; defined as a non-combustible area. Science tells us this is the most important zone to take immediate action on as it is the most vulnerable to embers.

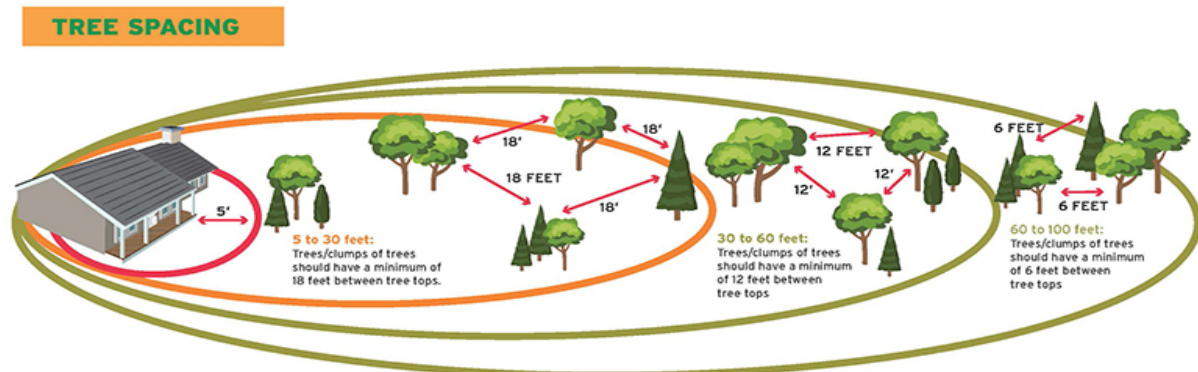
Prevent fire by: Moving any flammable material away from wall exteriors – mulch, flammable plants, leaves and needles, firewood piles – anything that can burn; removing anything stored underneath decks or porches; cleaning roofs and gutters of dead leaves, debris and pine

needles that could catch embers. Start with the house itself, then move into the landscaping section of the Immediate Zone.

Intermediate Zone: 5-30' from the furthest exterior point of the home.

Prevent fire by: employing careful landscaping or creating breaks that can help influence and decrease fire behavior; clearing vegetation from under large stationary propane tanks; keeping lawns and native grasses mowed to a height of four inches.

Extended zone: 30-100 feet, out to 200 feet. Landscaping – the goal here is not to eliminate fire but to interrupt fire's path and keep flames smaller and on the ground. Prevent fire by: disposing of heavy accumulations of ground litter/debris; removing dead plant and tree material; removing small conifers growing between mature trees.



Fire management strategies apply to the wildland-urban interface (UWI), as described above, but we are also interested in how to lower the likelihood of extreme fire in wilderness areas, far from human-made structures. Researchers at the University of Montana's Lubrecht Experimental Forest have undergone a 20-year study, comparing different techniques for forest management and how well they work to prevent severe fires over a long period of time.

The four test sites were each assigned a different method of forest management:

- Control – where the forest was allowed to grow unchecked by any interference
- Fire – where the forest was exposed to a controlled burn
- Mechanical – where the forest was mechanically thinned, with smaller trees, bushes, and deadfall cleared and removed
- Mechanical + Fire – where the forest was cleared and then burned

Over time, the four sites regrew, and new plants and species returned, but the resulting forest was different across the different sites. What they found was that the Mechanical + Fire treatment was the most effective, with the lowest fire hazard and the highest tree survival over the time period. The tradeoff is that this method is expensive and time-consuming. In contrast, the Control site and the Fire site demonstrated high fire hazard and large mountain pine beetle outbreaks.

Control



Fire



Mech



Mech+Fire



Hood, Crotteau, & Cleveland (2024, Ecological Applications)

Supplies:

- Matches
- Matchstick boards (flame resistant 6” by 6” board with 49 holes)
- Baking trays or flame-resistant lab trays
- Fire extinguisher
- Spray bottles filled with water
- Matchstick board nuts and bolts (to adjust slope of board)
- Lighter

Set Up:

- Using the matchstick board nuts and bolts, set each board at the same slope.
- Place matchstick boards on baking trays.
- Count the same number of matchsticks for each board and set aside.
- Set up a “control” board by placing matches in every slot in a board.
- Indicate on each matchstick board where a building might be by marking that spot with an “X”. Note that they should be in different locations for each matchstick board. Break a matchstick in half and place in the slot where the building is supposed to be.

Safety:

Set boundaries and expectations for students to remain safe during fire experiments. Baking trays, matchstick boards, fire extinguisher, and spray bottle should be made readily available to ensure the fire is contained. Matchstick forests should be lit outdoors on a paved surface and on a baking sheet, under the supervision of an adult, with a fire extinguisher and spray bottle handy.

Activity:

1. **Introduce** the topic. Ask students questions like, “what happens during a wildfire?” and “why are some wildfires harder to put out than others?”
2. Discuss the **Wildfire Triangle** and how it describes the behavior of fire.
3. If working with a group, split students into groups and **share the challenge**. They will be using models of forests, called Matchstick Forests, to understand how changing a landscape can save a building from a wildfire.
4. Students must **use all the matches**. Students may break matches to use as “fallen trees” or understory. Students may not make any other alterations to their matches or board. Students may not light their matchstick forest.
5. When matchstick forests are complete, each group should **share their design** with the class and make predictions about how a wildfire will behave on their board.
6. Lead students outside to the burning zone with their matchstick forests and **discuss** what external things may affect the behavior of their wildfires using the Wildfire Triangle. Discuss how the wildfire triangle might impact their matchstick forests – what are the weather, topography, and fuel conditions?
7. Review ways to **stay safe**.
8. **Light matchstick forests** and invite students to make observations and comparisons. Note: using a lighter rather than matches will ignite the forests more easily in outdoor conditions.
9. **Light the control forest**: in scientific experiments a control is one in which the subject or a group would not be tested for the dependent variable(s).
10. Bring students inside to **discuss** their observations.

Extensions:

- Limiting changes during an experiment and making comparisons across the group helps students learn how that change impacts fire behavior. Extend the activity by experimenting with more variables:
 - Changing slope – how does fire behave on a steeper mountain or flat prairie?
 - Changing fuel – how does fire behave with more or less matchsticks?
 - Changing weather – how does fire behave with a fan or wet matches?
- Model the treatment conditions that were tested in the Lubrecht study.
 - How does fire move through the landscape if it has already experienced a burn and then some new matches were introduced?
 - What if some of the matches are removed?
 - What if some of the matches are burned and some are removed?
 - What if there are matches scattered around or matches of different heights?
- Use sensors to explore how fire changes humidity, temperature, or carbon dioxide levels.
- Older students may benefit from reading a scientific journal article about the work happening at the Lubrecht Experimental Forest: <https://doi.org/10.1002/eap.2940>
- Use the CSKT website Fire on the Land to reflect and learn some Indigenous perspectives about wildfire and land management. <https://fwrconline.csktnrd.org/Fire/FireOnTheLand/>
- Take a forest field trip and see if you can identify signs of previous fires or methods for suppressing fire.

spectrUM Pedagogy:

Inspire Curiosity: Ask open-ended questions and encourage creative thinking.

Encourage Growth Mindset: Encourage students to use critical thinking when changing the landscape of the matchstick forest. Praise their patience and be available to help when invited. Do not give away the answer right away.

Make Meaning: Create personal connections between science and students by asking them about their relationship with fire and land.

Navigate Your Future: Let students know about resources and opportunities for them to continue to pursue an interest in wildfire, such as classes, clubs, camps, and higher education.

Collaborate With Communities: spectrUM has collaborated with many tribal representatives to connect science with Indigenous traditions. These resources can be found on spectrUM's website, umt.edu/spectrUM.

Try It: Encourage student autonomy by providing them the opportunity to participate as much as possible.