Climate Change *and Wildfire*



DESCRIPTION

Students explore how a history of fire suppression and current and future effects of climate change inform management of wildfires through a competitive game.

PHENOMENON

Fire suppression and climate change lead to more destructive wildfires, and people can take action to protect communities from their effects.

GRADE LEVEL

9-12

OBJECTIVES

Students will:

- Create a model to show the effects of fire suppression and climate change on forested ecosystems.
- Interpret information to understand two methods to protect communities from wildfire: defensible space and prescribed burning.
- Construct a wildfire-safe community and provide evidence of the management methods that make it safe.

TIME

50 MINUTES

COMMON CORE STATE STANDARDS

English Language Arts

CCSS.ELA-LITERACY.W.9-10.1.E. Provide a concluding statement or section that follows from and supports the argument presented.

CCSS.ELA-LITERACY.RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

NEXT GENERATION SCIENCE STANDARDS

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence	ESS3.C Human Impacts on Earth Systems	Systems and System Models
	ESS3.D Global Climate Change	Stability and Change

AGRICULTURE, FOOD, AND NATURAL RESOURCES (AFNR) STANDARDS

CCTC Standard: NRS.04 Demonstrate responsible management procedures and techniques to protect, maintain, enhance, and improve natural resources.

Performance Indicator: NRS.04.04 Manage fires in natural resource systems.

Sample Measurements:

NRS.04.04.01b Assess and apply techniques used to fight wildfires, manage prescribed fires and ensure human safety.

NRS.04.04.02c Anticipate and predict how fire management techniques will evolve in the future.

BACKGROUND

Wildfires are a natural and important part of most ecosystems, but intense fires can cause severe damage to human structures and ecosystems. A combination of decades of fire suppression and climate change is already causing and will continue to cause more frequent damaging wildfires. In forested ecosystems, vegetation causes wildfires to be more frequent and have greater impacts to humans than in other ecosystems. While wildfire also plays a role in desert and grassland ecosystems, the largest fires occur in forest ecosystems and cause greater release of carbon into the atmosphere.

Forests can be managed to adapt to these changing conditions in order to mitigate damage to ecosystem services and human interests. Landowners in vulnerable areas should create defensible space around structures by following

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FEMA guidelines to remove vegetation and other flammable materials from three concentric zones surrounding buildings (see https://www.fema.gov/sites/default/files/2020-08/fema_p_754.pdf). Wildland firefighters and land managers can conduct prescribed burns on small pieces of land under optimal weather conditions to reduce the build-up of fuels.

MATERIALS

- Playing with Fire instructional video, optional introduction to the demonstration for the instructor
- PowerPoint presentation
- Wildfire demonstration supplies
  - Aluminum baking pan
  - 4 cups of sand
  - 18 cotton balls
  - 45 toothpicks
  - 15 toothpicks soaked in a cup of water
  - Lighter
- Board game supplies [per group of 4 students]
  - Game rules handout
  - Game board (printed on two pieces of 8.5 x 11" paper, taped together)
  - 4 unique player tokens (such as 4 different coins, colored chips, or buttons)
  - 66 hazard pieces (any small item, such as beans, pebbles, beads, or buttons)
  - 1 set of career cards (4)
  - 1 set of wildfire hazard cards (48)
  - Die
- Posters or large paper [1 per group of 4 students]
- Markers, colored pencils, crayons, etc. [a small assortment per group of 4 students]

PREPARATION

1. If possible, watch the Playing with Fire instructional video for an introduction to the demonstration.
2. Prepare supplies for the wildfire demonstration.
   a. Fill the aluminum baking pan with 4 cups of sand.
   b. Place 15 toothpicks in a cup of water at least 5 minutes before beginning the demonstration.
3. Prepare supplies for the board game.
   a. Print, cut, and tape game boards.
   b. Print and cut career cards.
   c. Print and cut wildfire hazard cards.
4. Prepare to put students in groups of four.

PROCEDURES

INTRODUCTION

1. Give a short introduction about the effects of wildfire on ecosystems using the PowerPoint presentation.
2. **Slide 2**: Many ecosystems depend on fire. This map shows the results of a study that mapped fire-dependent ecosystems. You can see that a large portion of ecosystems in North America are fire-dependent, which means that low-intensity fires are fundamental to the survival of some plants and provide critical habitat for animals. These ecosystems have evolved to bounce back following a fire event. Ask students to describe the type of ecosystem they live in, and notice where they live on the map. Is the area where they live affected by fire?
3. **Slide 3**: Some types of trees require fire for reproduction. They have cones that only open to release seeds if they are heated enough to melt the resin coating the outside. These are called serotinous cones.
4. **Slide 4**: Wildfires can also clear accumulated leaf litter and small understory plants, creating space that certain tree species need to grow. Today we are focusing on forest ecosystems because they have the most damaging wildfires. When a tree burns, carbon is released into the atmosphere, contributing to climate change. Even if you don't live in a place with forests, wildfires in forests still impact you.
5. **Slide 5**: There are three main types of wildfires. Ground fires burn accumulated dead vegetation below the surface of the ground. Surface fires burn leaf litter and smaller understory plants. Crown fires burn entire trees up to the tops. Which type of fire looks like it would do the best job of clearing the understory to allow for new tree growth? [Answer: surface or ground fire]. Which of these photos looks like a more destructive fire, like the ones you see on the news? [Answer: crown fire].
6. **Slide 6**: Tell students that we will use a model to learn more about these different types of fires and how our current fire regime in forests came to be.

WILDFIRE DEMO

1. Take students outside, and bring supplies for the wildfire demonstration.
2. *Typical fire-dependent forest ecosystem model*: Ask students to help tear apart five cotton balls

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and lay them on the surface of the sand. Explain that the cotton balls are modeling understory plants, like grasses, forbs, and shrubs.

3. Add 15 water-soaked toothpicks spaced evenly apart. Do not tell students that these toothpicks have been soaked in water. Explain that the toothpicks are modeling trees. Tell students that this is a model of how a typical fire-dependent ecosystem should function. If we have an ignition source like a lightning strike, let's see what happens to our plants.
4. Light a cotton ball in the center of the model. Most cotton balls should burn, and most toothpicks should remain unburned. Ask students what happened to the understory plants? What happened to the trees? Ask what type of fire this was – crown, surface, or ground fire? Students should notice that this was a low-intensity surface fire that burned understory plants primarily. Explain that this is how a natural fire-dependent ecosystem behaves – fires ignite every so often but remain low-intensity surface fires that burn understory plants and leave the larger trees untouched. If time allows, you can replace the five cotton balls and light the fire again to demonstrate the cyclical nature of low-intensity fires.
5. *Forest ecosystem with fire suppression model*: Introduce the concept of fire suppression. Ask students if a wildfire ignited near their home, what would they want to be done about it? In 1935, following a series of large wildfires, the US Forest Service implemented the 10 AM policy, which required that all fires be suppressed (put out or contained) by 10 AM the following day. This policy guided forest management until the mid-1970s.
6. Have students help re-build the ecosystem model by tearing apart five cotton balls and carefully placing them between the remaining toothpicks. Explain that we're fast-forwarding years into the future, and the understory plants have re-grown following our previous fire. We have also been suppressing fire in this ecosystem, causing an overgrowth of plants. Have them add an extra torn-apart cotton ball and 15 toothpicks. Ask students to predict what will happen when we have a lightning strike in this ecosystem.
7. Light a cotton ball in the center of the model. Most cotton balls should burn completely, as well as more of the toothpicks. Ask students what happened to the understory plants? What happened to the trees? Ask what type of fire this was – crown, surface, or ground fire? Students should notice that this fire was a higher-intensity crown fire that burned to the tops of many trees. Based on this model, ask students what potential problems they see with the 10 AM fire suppression policy. [Answer: Ecosystems need fire for plants to reproduce and to clear understory plants; if not allowed to happen, more wildfires would become destructive crown fires].
8. *Forest ecosystem with fire suppression and climate change model*: In addition to the legacy of fire suppression, we also have climate change, where global temperatures are rising. Increasing temperatures lead to more evapotranspiration (evaporation plus transpiration from plants), which results in plants not retaining enough moisture, and many die due to drought stress. What does that mean for wildfire? [Answer: More dead plants mean more fuels available for more intense fires].
9. Explain that next, we will model an ecosystem affected by both fire suppression and climate change. Have students help re-build the ecosystem model by tearing apart five cotton balls and carefully placing them between the remaining toothpicks. Have them add two extra torn-apart cotton balls and 30 toothpicks (either standing or laying down on the sand). Light a cotton ball in the center of the model. After the model burns, ask students what they observed.
10. In the western United States, we have a history of fire suppression causing a build-up of fuels in forests, and climate change causing drought, which also leads to a build-up of fuel, and a longer fire season. These factors are leading to more frequent, severe, and destructive fires.

ADAPTATION AND MITIGATION DISCUSSION

1. **Slide 7**: Humans can mitigate (or reduce) the effects of climate change, but we also need to adapt to life in a changing climate. Optional extension: Write "History of fire suppression," "Climate change," and "More frequent, severe, and destructive fires" on the board or on posters around the room. Give each group a stack of post-it notes, and have them brainstorm solutions for each of these three problems.
2. **Slide 8**: In May 2000, the Cerro Grande fire ignited in Los Alamos, NM. It burned 261 houses and caused millions of dollars in damage. What do you notice about this photo? [Answer: Every house except one burned]. Why do you think that house survived?
3. **Slide 9**: One example of something people can do to adapt to the effects of more severe wildfires is to create defensible space – an area around buildings and homes that is easy to protect from fire. What fire hazards do you notice in these photos? [Answer: pine needles on roof, trees close to building could increase damage from the fire]. To minimize the risk of fire damaging buildings, these should be removed.
4. **Slide 10**: This is an example of a building with defensible space.

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You can see that a large amount of vegetation surrounding the house has been removed. Even though we can't see it, it's also likely that combustible materials (like pine needles on the roof, wooden lawn furniture) have been removed from outside and on the house. If we can remove flammable things near buildings, can we also do that in the forest?

5. **Slide 11**: When fire risk is low, firefighters conduct prescribed burns to clear areas of vegetation that can lead to crown fires. The top left photo shows a wildland firefighter igniting a prescribed fire using a flare gun, and the bottom photo shows a drip torch. Native tribes like the North Fork Mono in California have been doing this for centuries – called cultural burning, for ceremonial and land management purposes.

PLAYING WITH FIRE GAME

1. **Slide 12**: Now, you will use what you know about wildfire to play a game in small groups. Show the video to explain how to play the game.
2. **Slide 13**: After playing the game, you will design your own community that's protected from wildfire based on what you learn, so keep that in mind. Gameplay may last 8-20 minutes; if students finish early, they can play again or start on their poster. See the handout for a reminder of the game rules.
3. **Slide 14**: As students finish playing the game, pass out a poster to each group. Tell students that their goal is to design a community that is protected from wildfire. Students can write or draw, but they must describe or label at least five examples of strategies they included to adapt to the effects of wildfire. Tell students that as a starting point, they can select one of the cards they used in the game and see if it describes a strategy they could use. For example, if they have a card that mentions prescribed burning, they could draw firefighters in the forest near their community. The slide shows this example of what they should include on their poster.

WRAP UP

1. **Slide 15**: This graph shows the increase in temperature and number of wildfires from 1970 to 2005. What is causing the increase in the number of wildfires? [Answer: temperatures increase from climate change, leading to more tree mortality. A history of fire suppression led to increased fuels in forests, leading to more frequent and severe fires.] How will land and fire management evolve in the future? What can we do about these problems? [Possible answers could include: reduce our greenhouse gas emissions to reduce climate change, allocate more funding to land management, change policies to allow for more prescribed burning, educate people about creating defensible space around buildings, etc.] How would fire management look different in your community, based on the ecosystem you live in (i.e., desert, grassland, city)?

EXTENSIONS

1. Do a gallery walk or presentations for student posters. Students should ask questions about the design solutions each group presents, and the group should be able to argue why their solution is effective. Optional: create a discussion board online and have students post and respond to posters virtually.
2. Wildfires are most active from May to October, although climate change continues to cause changes to the typical fire season. Go to inciweb.nwcg.gov, and see if any wildfires are burning (active or contained) near your community. Click on a fire marker (Figure 1) to learn more about it. Find out its size and current containment percentage. Click "Go to Incident" to find more details, including a map, cause, date of origin, and fuels involved. Discuss the effects wildfires can have on communities nearby (risk to buildings, people, soil erosion, flooding, wildlife habitat) and far away (air quality, water quality, carbon emissions).



Figure 1. Example fire marker from Inciweb.

3. Explore careers in wildfire. Watch a video about smokejumpers (firefighters that reach remote locations using parachutes) or the Apache hotshot crew (elite wildland firefighters that travel to fight fires). Discuss what skills and education would be needed for a career in wildland firefighting. How is wildland firefighting different from urban firefighting?

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ADDITIONAL RESOURCES

Federal Emergency Management Agency (FEMA). Defensible Space, Home Builder's Guide to Construction in Wildfire Zones, Technical Fact Sheet No. 4. Published 2008. Accessed online 09 Nov. 2020. <https://www.fema.gov/sites/default/files/2020-08/fema_p_737_0.pdf>.

Kent, L.Y. 2015. Climate Change and Fire in the Southwest. ERI Working Paper No. 34. Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University: Flagstaff, AZ. Accessed online 09 Nov. 2020. <http://swfireconsortium.org/wpcontent/uploads/2015/06/Yocom_Climate_Fire_SW.pdf>.

United States Department of Agriculture (USDA) Forest Service. Southwestern Region Climate Change Trends and Forest Planning. Published May 2010. Accessed online 09 Nov. 2020. <https://www.fs.usda.gov/sites/nfs/files/legacy-media/r03/FPR%20Guidance%20Climate%20Chg%20Trends%2005-2010.pdf>.

Wynes, S. and Nicholas, K.A. 2017. The climate mitigation gap: education and government recommendations miss the most effective individual actions. Environmental Research Letters: 12.

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