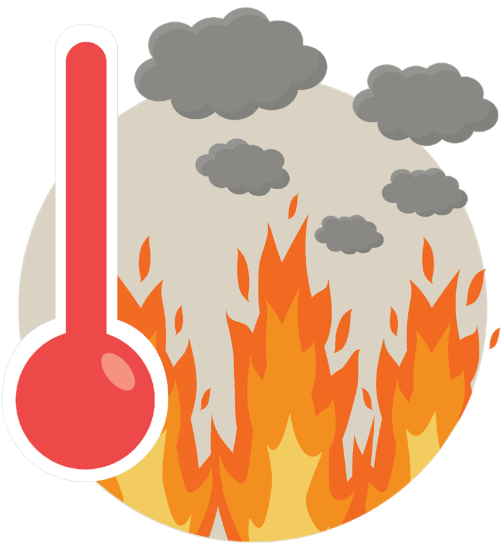
CLIMATE CHANGE and WILDFIRE



A 5-Hour Curriculum Unit for High School Students

CLIMATE CHANGE AND WILDFIRE

A Curriculum Unit for High School Students

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CURRICULUM DEVELOPMENT
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CLIMATE CHANGE AND WILDFIRE

A Curriculum Unit for 9-12 Grade Students

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CLIMATE CHANGE AND WILDFIRE

A Curriculum Unit for High School Students

Welcome! This unit was designed to introduce high school students to climate change, wildfire, and the effects of changing temperature and moisture levels on wildfire risk. The activities in this guide are appropriate for both formal and informal education settings, and they can be modified to fit the needs of students. All activities are aligned to Common Core State Standards, Next Generation Science Standards, and Agriculture, Food, and Natural Resources Standards.

This curriculum is organized as a 5-hour unit, with each activity building on the last. The unit need not be completed in its entirety, however. All of the activities can be conducted individually as well. There are three activities, and one spans three days (or class periods). The Unit Schedule outlines a proposed schedule of activity completion, assuming 50-minute periods. Each activity includes an estimated time for completion.

The materials required for the activities can generally be purchased at a household goods store, and some are items that many educators often have available. There are very few specialized supplies needed. Each activity includes a materials section that lists the items required to complete the activity, with provided resources, such as handouts and PowerPoint files, listed first. When viewing this guide electronically with an internet connection, the links within the materials section will navigate to each of the listed resources.

We hope that you and your students enjoy these activities! Please contact information@asombro.org with questions and feedback.

CLIMATE CHANGE AND WILDFIRE

Unit Schedule

This unit is designed to be conducted over five hours. The unit need not be completed in its entirety, however. The activities can be conducted individually as well.

Day 1 **WILDFIRE: PAST AND FUTURE**	*Day 2* **WILDFIRE DATA JAM** ***Day 1 - Introduction and Identifying a Data Trend***
Day 3 **WILDFIRE DATA JAM** ***Day 2 - Creative Project Preparation***	*Day 4* **WILDFIRE DATA JAM** ***Day 3 - Presentations***
Day 5 **PLAYING WITH FIRE**	

Climate Change *and Wildfire*

DESCRIPTION

Students investigate the impacts of climate change on wildfire. They will interpret graphs to see the connections between temperature and wildfire, then conduct an experiment to understand why increasing temperature plays a role in wildfire risk and severity.

PHENOMENON

Wildfire risk, severity, and size are affected by temperature.

GRADE LEVEL
9-12

OBJECTIVES

Students will:

- Understand that fires are a natural part of ecosystems, and fire regimes vary across ecosystems.
- Understand the effects of climate change on forest ecosystems.

TIME
50 MINUTES

COMMON CORE STATE STANDARDS

English Language Arts

CCSS.ELA-LITERACY.W.9-10.1/ W.11-12.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

CCSS.ELA-LITERACY.RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

NEXT GENERATION SCIENCE STANDARDS

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Developing and Using Models Constructing Explanations and Designing Solutions	LS2.C Ecosystem Dynamics, Functioning, and Resilience	Patterns Cause and Effect

AGRICULTURE, FOOD, AND NATURAL RESOURCES (AFNR) STANDARDS

CCTC Standard: NRS.01 Plan and conduct natural resource management activities that apply logical, reasoned, and scientifically based solutions to natural resource issues and goals.

Performance Indicator: NRS.01.03 Apply ecological concepts and principles to atmospheric natural resource systems.

Sample Measurements:

NRS.01.03.02a Research and summarize how climate factors influence natural resource systems.

BACKGROUND

Wildfires are a natural part of many ecosystems. Each ecosystem has a unique fire regime, or pattern of how frequent, large, and severe fires are when naturally caused by lightning strikes. These fires can be catastrophic and destructive. However, when fires happen regularly, they can support healthy ecosystems by clearing away the dead plant material that may build up or preventing a forest from becoming too crowded with small trees. Humans have altered fire regimes in many ways by introducing new ignition sources (e.g., cars, cigarettes, campfires, fireworks, and power lines), by altering fuel loads and plant communities (e.g., introducing new plant species or removing others and introducing grazing livestock that eats small plants), and by suppressing fires through constant firefighting. These changes have led to a build-up of flammable materials in some ecosystems.

Climate change adds another layer of complexity to changing fire regimes. Climate change is predicted to increase wildfire danger in two ways: 1) increased evapotranspiration and 2) increased fuel load. Evapotranspiration is the combination of evaporation from the earth's surface and transpiration by plants, which pull water in through their roots and release it out through pores in their leaves. As temperatures increase, so does evapotranspiration. When evapotranspiration increases, soil moisture decreases, resulting in drier systems. Higher temperatures also result in a longer growing season for most plants. With a longer growing season, there is an increase in plant growth and biomass. This is especially true for small plants; when they die, they leave behind fuel that will burn easily.

MATERIALS

- Wildfire: Past and Future instructional video, optional introduction to the experiment for the instructor
- PowerPoint presentation
- Student handout [1 per student]
- Model description [1/3 page per group]
- Experiment materials [1 set per group plus 2 sets for class demonstrations]:
  - 1 small aluminum pie plate
  - Approximately 1/2 cup of sand or soil
  - 15 toothpicks to represent trees
  - 1 cotton ball pulled apart into about 12 pieces to represent shrubs
  - A spoonful (about ½ tsp) of small paper shreds to represent grass (We suggest emptying a hole punch or chopping up shredded paper. We used a small spoonful of hole punch chads.)
  - Note: if you would like to tailor your ecosystem model to represent a local ecosystem, leave out the unnecessary plants (e.g., use paper shreds only to represent a grassland, or paper and cotton balls to represent a grassy shrubland).
  - 1 spray bottle with water (groups can share if necessary)
  - 1 scale (groups can share if necessary)
  - 1 lighter (groups can share if necessary)
  - 1 thermometer (or 1 per 2-3 groups if placed under lamps next to models)
- Extra toothpicks, cotton balls, and paper shreds for students to choose from
- Desk or clamp lamps with incandescent or heat bulbs (LED bulbs do not produce enough heat - 1 per 2-3 groups)
- Optional: aluminum baking pans or aluminum foil for students to place models in/on before lighting them on fire.

PREPARATION

1. If possible, watch the Wildfire: Past and Future instructional video for an introduction to the experiment.
2. Create two ecosystem models (Figure 1). These will be the experiment controls ("Current Temperature" and "Increased Temperature").
3. The model is made up of:
   a. 1 small aluminum pie plate
   b. 1 cup of sand
   c. 15 toothpicks to represent trees
   d. 1 cotton ball pulled apart into about 12 pieces to represent shrubs
   e. A spoonful of small paper shreds to represent grass
4. Print student handouts (1 per student).
5. Print and cut the model description pages (1 description per group, 8 groups per class).
6. Find a place to plug in lamps so students can place models under the lamps. The bottom of the lamp needs to be 6-10 inches off of the table surface. If using clamp lamps, we suggest clamping multiple lamps to a box so students can set their models around the box.
7. Options for model extensions or alterations:
   a. If you would like to tailor your ecosystem model to represent a local ecosystem, remove the unnecessary plants from your model (e.g., use paper shreds only to represent a grassland, or paper and cotton balls to represent a grassy shrubland).
   b. You can compare live versus dead fuel by soaking some of the toothpicks in water before placing them in the model; it will be very unlikely that wet toothpicks light on fire.

Figure 1. Control model set-up.

PROCEDURES

INTRODUCTION

1. **Slide 2**: Think about a time you've heard about wildfires. Were you affected by the wildfire? How can wildfires affect you? In recent years, we've heard more about large fires, and they are linked to climate change.
   a. Wildfires are a natural part of many ecosystems, often originating from dry lightning strikes. They can support ecosystem health, promote certain plant species, and help nutrient cycling in the soil. However, depending on the fire's frequency, severity, and size, they can also be catastrophic and destroy habitats, decrease water and air quality, and decrease the availability of natural resources like lumber or grazing land. Most ecosystems naturally experience large catastrophic fires at some point. Forests in the Southwest have catastrophic fires every 200-500 years.
2. **Slide 3**: Climate change is caused by increased atmospheric carbon dioxide, which leads to higher atmospheric temperatures. This increase in temperatures has many cascading effects.
3. **Slide 4**: Based on the graphs, what trends do you see in the relationship between wildfire and temperature? The red y-axis on the left side of the graph shows wildfire frequency, represented by the red bars. The black y-axis on the right side of the graph shows temperature, represented by the black line [Answer: Years with higher temperatures have higher fire frequency]. You might expect the amount of rain to be linked to fire severity, but why temperature? Two major factors affect wildfire risk and severity, (1) moisture levels, or how much water is in the plants and soil, and (2) fuel levels, or how much burnable material, usually dead plants, is present.
4. **Slide 5**: What do you need to make a fire? [Click to show answer: fuel, oxygen, and ignition.]
   a. Which of these is most likely to be influenced by climate change? [Answer: Fuel. Oxygen and ignition sources will not change due to climate change, but the amount of plants and dead, dry plant material is likely to change as the temperature and precipitation patterns change.]
5. **Slide 6**: Which of these ecosystems is more likely to burn? [Answer: #1. This is a ponderosa pine forest with little bare ground. The grass on the ground can carry fire between larger plants. Generally, fire is more likely to spread in a forest with more grass and shrubs in the understory. Picture #2 is creosote shrubland, with little vegetation between shrubs, making it hard for fire to spread.]
6. **Slide 7**: Which of these ecosystems is more likely to burn [Answer #1, Again, picture #1 is a ponderosa pine forest, which is much drier than the rainforest shown in picture #2. So despite having more fuel, picture #2 is less likely to catch fire. These three pictures highlight that fuel and moisture levels are important aspects of fire risk.]

EXPERIMENT SET-UP

1. **Slide 8**: We will experiment with how higher temperatures affect wildfire risk, size, and severity. Imagine you're a part of a research team trying to determine how climate change and future changes in moisture and fuel levels impact wildfire. Each group will build an ecosystem.
2. **Slide 9**: Show the students the control models you have already made; students will use EXACTLY the same amount of materials as the control models, EXCEPT that they will change one variable by adding more or less of that material to understand the impact of that variable on fire risk. You will assign a change for each group to make. Wet both of your control models by spraying the entire model with five sprays of water from a spray bottle and weigh each model. Students should record these weights on their worksheets.
3. Place one of your control models under a lamp with a thermometer next to the model; this is the climate change control. The other is the no climate change control. Set it aside, far enough away from the light that it will not be warmed by it, and place a thermometer next to the model.
4. **Slide 10**: Assign students to small groups (8 groups per class). Give them the materials to make their ecosystem models, and assign each group one of the eight changes on the Model Description Page (adding more or fewer trees, shrubs, grass, or water). If you prefer, you can give students the goal of increasing or decreasing the fire risk. Encourage students to build their models quickly and get them under the lights in the next 5-7 minutes (Figure 2). Students should follow the instructions on their worksheet and then answer questions 1-3.

Figure 2. Experiment set-up.

5. The models should sit under the lights for 15-20 minutes. Models will need time to dry out; you may choose to leave them longer if you have time, but do your best to use the same time for both control and experimental models.

DISCUSSION

1. While the models warm, students should answer questions 1-3. Then have a class discussion using Slides 11-15.
2. **Slide 11**: Ask students to share their observations of the models so far and their predictions for which will have the greatest fire risk.
3. **Slide 12**: One of the changes we see when temperatures increase is an increase in *evapotranspiration*. Plants act like straws that pull water out of the soil and release it into the air as water vapor through pores in their leaves (stomata). This process is called transpiration and is also how plants regulate their leaf temperature. Evapotranspiration is the combination of evaporation from the earth's surface and transpiration.
4. **Slide 13**: Increasing air temperatures mean more water is lost through evapotranspiration. Warmer temperatures also result in a longer growing season, allowing more small plants to grow. This increased plant biomass can later become fuel in a fire.
5. **Slide 14**: Warmer temperatures and increased evapotranspiration weaken plants and lead to more disease and plant death. An increase in dead plant material in an ecosystem means more fuel for fires.
6. **Slide 15**: Remember that fire is a natural part of ecosystems. Many ecosystems go through cycles of large and small fires. These graphs show the area burned in wildfires since 1915. What do you notice about the size and frequency of fires across western North America? [Answer: The area burned in wildfires has been increasing in recent years, especially compared to the mid-1900s. This also has to do with a history of fire suppression, which is explored more in the lesson Playing with Fire.]

EXPERIMENT WRAP-UP

1. **Slide 16**: As a class, record the temperature and mass of each control model in the table at the top of the worksheet. Calculate the mass of water lost.
2. Give students time to record the temperature and mass of their models.
3. You will then attempt to light each model on fire (Figure 3). Do this by lighting an extra toothpick on fire and laying it down in the middle of the model.
    a. Note: we suggest that students light their models outside on a sidewalk for safety.

Figure 3. Model burning.

4. Some models may be hard to light, especially if they are still wet. Give students a limit of two tries to set their model on fire. The room temperature control should be too wet to light, but the climate change control should light. Fires will burn out after a minute or two. Leave slide 16 up so students can refer to the instructions.
5. **Slide 17**: Ask some groups to share their results and observations with the class.
    a. What was the effect of the warming on moisture in the ecosystem, and why? [Answer: It decreased due to increased evaporation. Even though we started with the same amount of water in both controls, we lose more to evapotranspiration when it is warmer.]
    b. What happens when we increase the fuel load and why? [Answer: We see larger fires. Fuel loads are likely to increase for two reasons; the longer growing season means more small plants can grow, but if/when they dry out, they become fuel. Increased drought will kill trees, and dry/dead trees are great fuel for big fires.] Have students answer questions 4-6 on their worksheets.
6. **Slide 18**: The combination of drier ecosystems and more fuel is predicted to impact fire risk, severity, and size. Fire risk is the likelihood that a fire will start; click to show animation. How did climate change affect the fire risk in our experiment? [Answer: It increased because the ecosystem was drier.]
7. **Slide 19**: Fire severity is how much vegetation burns in a fire; click to show animation. How did climate change impact the fire severity in our experiment? [Answer: It increased because the ecosystem was drier, and more fuel allowed the fire to reach the tops of the trees more easily.]
8. **Slide 20**: Fire size is how large an area burns; click to show animation. How did climate change impact the fire size in our experiment? [Answer: It increased because more dry fuels in the ecosystem allowed the fire to spread.]
9. **Slide 21**: Students should look back at their answers to questions 4-6 and expand on them using the words fire risk, severity, and size.

EXTENSIONS

1. Discussion Question: After a fire, ecosystems recover, plants regrow, and they provide shelter and food to animals. Small fires are easier to recover from than large fires. Do you think climate change will affect how well ecosystems can recover from fires?

ADDITIONAL RESOURCES

Grissino, Mayer, and Swetnam. Century scale forcing of fire regimes in the American Southwest, *Holocene*. 2000.

Scatsa, J.D., Weir, J.R., and Stambaugh, M.C. Droughts and wildfires in western U.S. rangelands. *Rangelands*: 38.4. August 2018: 197-203.

Westerling, A.L., Hidalgo, H.G. Cayan, D.R., Swetnam, T.W. Warming and earlier spring increase western U.S. forest wildfire activity. Science. 18 August 2006: 940-943.

Name: ______________________ Date: ______________________ Period: ______________

Climate Change

and Wildfire

MODEL	BEGINNING MASS (g)	END MASS (g)	MASS OF WATER LOST (g)	END TEMPERATURE (° C)	OBSERVATIONS FROM BURNING
CONTROL: Room Temperature					
CONTROL: Climate Change					
YOUR MODEL: Climate Change + 1 variable change					

EXPERIMENT SET UP

A. Circle the variable you will change.

More Grass	More Shrubs	More Trees	More Water
Less Grass	Fewer Shrubs	Fewer Trees	Less Water

B. Build your ecosystem model, changing the variable you circled above.

Control Model:	**My Model:**
1 small aluminum pie plate	1 small aluminum pie plate
1/2 cup of sand	1/2 cup of sand
1 spoonful of paper shreds (grass)	____________ paper shreds (grass)
1 cotton ball pulled apart into about 12 pieces (shrubs)	____________ cotton balls
15 toothpicks (trees)	____________ toothpicks (trees)
5 sprays of water	____________ sprays of water

C. After spraying your model with water, take the mass and record it in the table above.

D. Place your model under a lamp, and place a thermometer next to your model.

E. Fill out the model description and place it next to your model.

F. Answer questions 1-3 on page 2.

1. Look at the models other groups have made. Describe the model you think has the lowest fire risk and what makes it low risk.

2. Look at the models other groups have made. Describe the model you think has the greatest fire risk and what makes it high risk.

3. Draw a picture of an ecosystem that is at high risk of fire due to climate change. Make sure you:
   - Label the fuel types (what types of plants)
   - Note the moisture level

CONCLUSIONS

4. Compare the control model and the climate change model. Based on the class results, what was the overall effect of increased temperature on fire danger?

5. Based on the class results, how did changing the fuel load affect fire danger?

6. Based on the class results, how did changing the moisture levels affect fire danger?

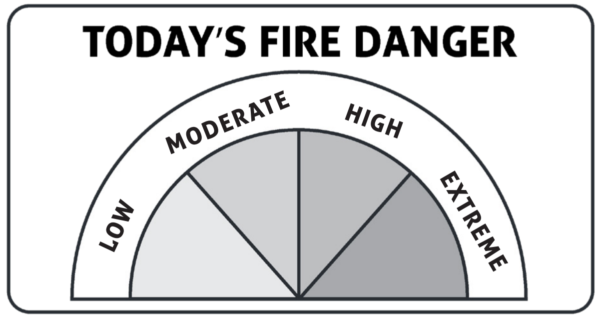
MODEL DESCRIPTION

1. Group Names: ____

2. Circle the variable you changed in your model.

More Grass	More Shrubs	More Trees	More Water
Less Grass	Fewer Shrubs	Fewer Trees	Less Water

3. Fire danger: Make a hypothesis about the fire risk in your model ecosystem and draw an arrow on the Fire Danger sign to show your hypothesis.



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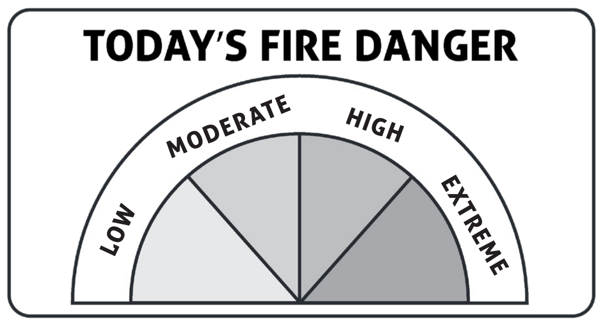

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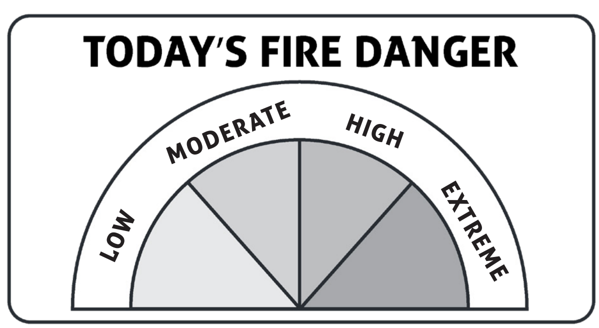


Climate Change  *and Wildfire*

WILDFIRE DATA JAM

DESCRIPTION
Students analyze and then showcase wildfire and climate data by developing a creative project to communicate data trends to nonscientist audiences.

PHENOMENON
Is there a relationship between the number of large wildfires in the western U.S. and increased temperatures, evapotranspiration or fuel?

GRADE LEVEL
9-12

OBJECTIVES
Students will:

- Evaluate factors that contribute to large wildfire occurrence in different ecosystems.
- Analyze data to determine patterns in wildfire and climate change across different regions of the western U.S.
- Develop a creative project to communicate a data trend to a non-scientist audience and present to the class.

TIME
2.5 HOURS TOTAL OVER 3 DAYS

COMMON CORE STATE STANDARDS

English Language Arts

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.

CCSS.ELA-LITERACY.RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCSS.ELA-LITERACY.RST.11-12.4. 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 11-12 texts and topics.

CCSS.ELA-LITERACY.RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

NEXT GENERATION SCIENCE STANDARDS

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data	ESS3.B: Natural Hazards	Patterns
Using Mathematics and Computational Thinking	ESS3.C: Human Impacts on Earth Systems	Cause and Effect
Constructing Explanations and Designing Solutions	ESS3.D Global Climate Change	Scale, Proportion, and Quantity
Obtaining, Evaluating, and Communicating Information		

AGRICULTURE, FOOD, AND NATURAL RESOURCES (AFNR) STANDARDS

CCTC Standard: NRS.01 Plan and conduct natural resource management activities that apply logical, reasoned, and scientifically based solutions to natural resource issues and goals.

Performance Indicator: NRS.01.03 Apply ecological concepts and principles to atmospheric natural resource systems.

Sample Measurements:

NRS.01.03.02a Research and summarize how climate factors influence natural resource systems.

NRS.01.03.02b Analyze the impact that climate has on natural resources and debate how this impact has changed due to human activity.

BACKGROUND

Wildfires are a natural part of many ecosystems. Many ecosystems have a unique fire regime, or pattern of how frequent, large, and severe fires are when naturally caused by lightning strikes. These fires can be catastrophic and destructive. However, when fires happen regularly, they can support healthy ecosystems by clearing away the dead plant material that may build up or by preventing a forest from becoming too crowded with small trees. Humans have altered fire regimes in many ways by introducing new ignition sources (cars, cigarettes, campfires, fireworks and power lines, to name a few), by altering fuel loads and plant communities (introducing new plant species or removing others and by introducing grazing livestock that eat small plants), and by suppressing fires through constant firefighting, leading to a build-up of flammable materials in some ecosystems. Climate change adds another layer of complexity to changing fire regimes.

Very Large Fires (VLFs) are fires that burn more than 5,000 hectares (12,355 acres). They account for a very small percentage of large wildfires but make up a majority of burned area. Under climate change modeling scenarios, VLFs are projected to increase in the majority of the western U.S. in the future. Several climatic factors influence the occurrence of these fires, including temperature, precipitation, relative humidity, and drought severity. Climate change is predicted to increase wildfire danger in two ways: 1) increased evapotranspiration and 2) increased fuel load (see "Wildfire: Past and Future" for more information). Potential evapotranspiration (PET) is defined as the amount of water transpired by a plant given an adequate amount of water. Above ground dead biomass is a characteristic that indicates fuel load in an area and is measured in grams of carbon per meter squared.

The U.S. is divided into ecoregions, or areas with similar ecosystems, at different hierarchical levels. The majority of the western U.S. can be classified as one of five ecoregions, although there are several other ecoregions or classifications that can be used (EPA). In areas that are flammability-limited (i.e., wet forests in the Pacific Northwest), fires will increase as it gets hotter and drier. In areas that are fuel-limited (i.e., deserts, non-forested ecosystems), warmer temperatures will cause existing vegetation to die. This reduces connectivity of fuels, and fires may not increase as much as in other places.

MATERIALS

- PowerPoint presentation
- Student handout [1 per student]
- Dataset [1 per student]
- An assortment of supplies to be used for creative projects such as:
  - Rulers
  - Colored pencils and/or markers
  - Poster board
  - Paper

PREPARATION

1. Set up a computer and projector and display the PowerPoint presentation.
2. Prepare creative project supplies for student use. If you have space, it is helpful to lay the supplies out on a surface so that students can more quickly access available supplies and develop project ideas. Supplies will not be used until day 2.

PROCEDURES

DAY 1: INTRODUCTION AND IDENTIFYING A DATA TREND

Introduction

1. **Slide 1**: Today, we are going to talk about the effects of climate change on wildfire in various ecosystems and start on a project to analyze data on wildfires.
2. **Slide 2**: On July 27, 2018, a pair of wildfires started in California. These wildfires (separately called the Ranch and River fires and collectively referred to as the Mendocino Complex Fire due to their close proximity) got very large very quickly, due to a combination of hot temperatures, low humidity, and strong winds. This made it hard for firefighters to contain, and by August 7, 2018, the fires had burned 443 square miles. That sounds large, but how big is that really?
3. **Slide 3**: This infographic shows us that on August 7th, the Mendocino Complex Fire was bigger than Paris and New York City.
4. **Slide 4**: The Mendocino Complex Fire was fully contained on September 19, 2018, meaning that it burned for 56 days total and devastated over 717 square miles. These photos were taken on August 3, 2018 from the International Space Station, which orbits at over 250 miles above the surface of the earth. Even if we don't live in California, large wildfires can affect us. Point out the smoke visible in the photo. Wildfires are a natural part of ecosystem health (and some vegetation types require fire for reproduction), but large wildfires can have negative effects on humans and the environment.
5. **Slide 5**: The goal of a data jam is to examine data and

communicate it in a unique way through a creative project. Today we will start by looking at a dataset about wildfire and identifying a data trend.

6. **Slide 6**: The US is divided into ecoregions. What does ecoregion mean? Eco – ecosystem, region – an area defined by similar characteristics. Ecoregions are areas defined by similar ecosystems.
7. **Slide 7**: The dataset we will be using focuses on these 5 ecoregions that make up the majority of land in the Western US.
   a. Northwestern great plains
   b. Western cordillera (cordillera means "mountain range" in Spanish, parallel mountain ranges and spaces in between, includes the Rocky Mountains, Cascades, Sierra Nevada mountains, and many smaller ranges)
   c. Cold desert (primarily represented by the Great Basin Desert in Nevada and Utah)
   d. Warm desert (Chihuahuan Desert in southern New Mexico and west Texas)
   e. South-central semi-arid prairie (What does arid mean? Dry. What is a prairie? Open grassland.)
8. **Slide 8**: Show students photos of each ecoregion. Ask students what ecoregion looks the coldest, warmest, wettest, or driest. Point out the differences in vegetation.
9. **Slide 9**: The main variable in our dataset is VLFs, or Very Large Fires.
10. **Slide 10**: The Mendocino Complex Fire is an example of a VLF. VLFs are wildfires burning over 5,000 hectares (12,355 acres, or 19.3 square miles). That is larger than 9,000 football fields (9343.67 football fields exactly). They account for only the top 5 – 10% of large wildfires, but they make up a majority of burned area. They are important to study because they have large impacts on humans and the ecosystem.
11. **Slide 11**: The frequency of large wildfires is changing across the globe. What is happening that could cause this? [Answer: climate change].
    a. This map shows changes to "fire weather season", which affects how often areas can expect conditions suitable for wildfires. Red indicates longer or more frequent long fire seasons, and blue indicates shorter or less frequent long fire seasons. The map uses data from 1979 – 2013, so this map indicates that the majority of the earth is experiencing some change in conditions that affect wildfire occurrence.
12. **Slide 12**: For this project, we will focus on the western US. This map shows historic (1971 – 2000) VLF potential for 5 regions that make up the majority of the western US. VLF potential is defined as the mean annual VLF's per 10,000 km^2 area. The height of the flame is scaled to represent the VLF potential of each region. Do all regions historically have the same VLF potential? [Answer: No, some are higher than others.]
13. **Slide 13**: This map shows the future (2041 – 2070) predicted VLF potential for the same regions. Will the VLF potential be higher or lower in the future? [Answer: All regions will see increases in VLF potential].
14. **Slide 14**: The second table in the dataset includes data on factors that may affect VLF potential. This includes average maximum temperature in each ecoregion.
15. **Slide 15**: This map shows that average maximum temperatures are increasing in most parts of the United States. Ask students how temperature increases due to climate change can affect VLF potential. Increasing temperatures lead to dry and flammable fuel. Drought also kills plants, which become fuel for fire.
16. **Slide 16**: Another variable we will be using in our data jam projects is "potential ET," or potential evapotranspiration. Evapotranspiration has to do with how much moisture is in an ecosystem.
17. **Slide 17**: Which of the locations shown in these photos would have a more severe wildfire? Students likely already have some prior knowledge about fire that will help them make an educated prediction. They can discuss with their neighbor, and then hold up either a one or two to vote. [Answer: Photo 1, because photo 2 is a rainforest and contains a lot of moisture, so it would be more difficult for a fire to ignite.]
18. **Slide 18**: Evapotranspiration is the process of water entering the atmosphere from evaporation and transpiration (from plants). Potential evapotranspiration takes into account temperature, wind speed, solar radiation, and relative humidity. What do hotter temperatures mean for evapotranspiration? [Answer: More evapotranspiration.] The dry forest in Photo 1 may be experiencing greater evapotranspiration than the rainforest in Photo 2.
19. **Slide 19**: Another variable that can affect large wildfire potential is above ground dead biomass.
20. **Slide 20**: Which location would have a more severe wildfire? Students can discuss with their neighbor, and then hold up one or two fingers to vote. [Answer: Photo number 2 would ignite and spread more easily, burning more severely because it has more dead, dry fuel which is flammable.]
21. **Slide 21**: Biomass means organic matter – dead leaves, stems, bark, branches, tree trunks etc. Carbon is stored in biomass, and this is represented in units of grams of carbon per meter squared. Photo 2 would have more above ground dead biomass than Photo 1.
22. **Slide 22**: We just reviewed variables in our dataset, or things scientists collected data on. You can find variables in the column titles on the data tables. Have students answer questions 1 and 2 on their handout.

Identifying a Data Trend

1. **Slide 23**: A data trend is a pattern in a dataset. You are going to look for a data trend that includes data about VLF potential from table 1. Question 3 on the handout includes four fill-in-the-blank sentences to help you find patterns in table 1. If needed, answer question 3a as a class [All ecoregions are expected to increase in VLF potential], then have students work with their groups to answer the rest of question 3.
2. **Slide 24**: Your data trend should also include at least one variable from table 2 of your dataset. Have students choose a sentence starter from question 3 to complete using data from table 2, and answer question 4 on their handout. There is not a "correct answer" – meaning that there's not just one factor that influences VLF potential.
   a. Example: All ecoregions are expected to __*increase*___ in VLF potential… and the temperature is expected to increase.
3. **Slide 25**: The data trend you choose for your project does not have to include all the information seen in the data tables. It should include variables from table 1 and table 2, it should be specific, and it should be concise. Students should combine their answers to questions 3 and 4 to write a one-sentence data trend to answer question 5. This is the data trend they will represent creatively in their data jam project.
   a. By the end of class, groups should have a data trend written down and be ready to start on their creative project next time.
   b. Example data trends from this dataset:
      i. All ecoregions are expected to increase in VLF potential, average maximum temperature, and potential evapotranspiration.
      ii. South central semi-arid prairies and warm deserts will experience the smallest absolute increase in VLF potential, and they are the ecoregions with the warmest future and historic temperatures.
      iii. In the future, cold deserts, western cordillera, and northwestern great plains will have the highest VLF potential, and they will have the highest percent change in potential ET.
      iv. Western Cordillera and cold deserts will have the greatest changes in above ground dead biomass, and they are the two ecoregions with the greatest future VLF potential.
      v. Cold deserts will see the greatest absolute increase in VLF potential, and they are also one of only two ecoregions expected to have an increase in above ground dead biomass.

*Note: If your students are familiar with Claim Evidence Reasoning writing, they can think of their data trend as a claim, the data is the evidence, and they are giving their reasoning in question 6.

DAY 2: CREATIVE PROJECT PREPARATION

1. **Slide 27**: Remind students that the goal of a data jam is to communicate wildfire data in a creative way. Last time, we identified the data trend you will use in your project. Today we will find a way to creatively represent that data trend.
2. **Slide 28**: A creative representation of data can make the information more accessible to someone that may not know much about the topic you are representing.
   a. This necklace, created by data artist Stefanie Posavec, represents a week of data on air quality (amount of particulates) in Sheffield, UK. The smooth pieces represent few particulates, and the large spiky pieces represent high levels of particulates. The large red spike represents the city's annual "bonfire night", which is celebrated with fireworks displays and large bonfires.
   b. You can see that it has a scale, where the darker red and larger spikes represent worse air quality.
3. **Slide 29**: A science journalist is responsible for understanding scientific information and communicating it to the general public. They might make an infographic that represents the data in a visually appealing and accurate way. If you make an infographic, you need to have a scale and key that explain how your visuals represent the data. A scale can be created by multiplying or dividing your data by the same numbers to scale your data up or down in a way that works for your project.
4. **Slide 30**: In this infographic we looked at earlier, the height of the flame is scaled to represent the VLF potential of each ecoregion. 1-inch height of the flame (measured with a ruler) is equal to 1 VLF per 10,000 km^2 per year. Scaling the data accurately allows us to represent numbers with images.
5. **Slide 31**: Some artists choose to represent environmental issues through poems, songs, or other artwork. If you would like to write a poem, song, or create other artwork to communicate your data trend, make sure to include specific references to the actual data like this poem does. This example of an acrostic poem was written about data on water use in different countries. Notice how specific data are incorporated for each country.
6. **Slide 32**: Instructions for the rest of class –
   a. Decide on what type of creative project you would like to make.
   b. Brainstorm your project, and use the rest of class to create it.

c. If you finish early, start thinking about how you will present your project to the class next time.

7. Direct students to work in their groups to decide what creative project they would like to make, and answer questions in the Creative Project section on their worksheet. Use the rest of class to complete their creative projects.
8. If they finish early, they can start thinking about their presentation for next class.

DAY 3: PRESENTATIONS

1. Have students prepare a short (~2-3 minute) presentation of their data trend and creative project. They should tell everyone what their data trend was and explain the creative project they made.
2. After each group presents, lead a class discussion. Ask students if they noticed any common themes in the data trends presented by other groups. What are the characteristics of different ecoregions that could influence the VLF potential? Is climate change expected to have an impact on wildfire? Why?

ADDITIONAL RESOURCES

Barbero, R., Abatzoglu, J.T., Larkin, N.K., Kolden, C.A., Stocks, B. 2015. Climate change presents increased potential for very large fires in the contiguous United States. International Journal of Wildland Fire 24(7).

CONUS Climate Console. Climate projections for the continental United States. Conservation Biology Institute. Web. <http://climateconsole.org/conus>

Environmental Protection Agency (EPA), Ecoregions. Modified 27 Mar 2018, Web. Accessed 26 Jun 2020. <https://www.epa.gov/eco-research/ecoregions>.

DATASET INFORMATION

Dataset Table 1

Historic VLF potential (1971 - 2000) was calculated using recorded historic fire occurrence data. Future VLF potential (2041 - 2070) was calculated by using a variety of predictors proven to be linked to fire occurrence in each ecoregion (temperature, precipitation, relative humidity, drought severity, and fire danger indices).

Dataset Table 2

Data from CONUS was divided ecoregions into smaller “sections”. Sections were chosen that represented the general characteristics of the larger ecoregion.

Western cordillera ecoregion -"beaverhead mountains" section
*Northwestern great plains - "northwestern great plains" section
South-central semiarid prairies - "pecos valley" section
Cold deserts - "bonneville basin" section
Warm deserts - "basin and range" section

*Barbero et al. (2015) refers to west-central semi-arid prairies, which is synonymous with northwestern great plains. The latter was chosen to simplify the dataset for student use.

Historic values were calculated from 1981 - 2000 based on measured climatological data. Future values were modeled for the years 2061 - 2070 using the Beijing Climate Center Climate System Model (BCC-CSM1.1), and are representative of an average of models.

Name: ______________________________ Date: ____________________ Period: ____________

Climate Change **WILDFIRE DATA JAM** *and Wildfire*

GOAL - Identify a data trend in the wildfire data from different ecoregions, and then design a creative project that explains this trend to a non-scientist audience.

A good Data Jam project is:

- Clear: represent the data accurately and in a way that is understandable to non-scientists.
- Concise: keep it short and to the point. It is more effective to focus on one important trend in the data than to try to explain it all.
- Creative: use your imagination!

DATA TREND

1. What are the variables listed in Table 1 of the dataset?

    a) c)

    b) d)

2. Look at the variables in Table 2 of the dataset. List three that could be related to the variables in Table 1.

    a)

    b)

    c)

3. Using data from table 1, fill in the blanks below.

   a. All ecoregions are expected to ________________________________ in VLF potential.

   b. _________________________________ and _______________________________ will experience the greatest increase in VLF potential.

   c. _________________________________ and ________________________________ will experience the smallest increase in VLF potential.

   d. In the future, _____________________________, ___________________________, and ___________________________ will have the highest VLF potential.

4. Choose one sentence starter from question 3 and find data in table 2 that can help to explain it.

5. Combine your answers to questions 3 and 4 to write a one-sentence data trend.

6. Based on what you know about fires and ecosystems, what reasoning can you give to explain the data trend?

WILDFIRE DATA JAM

Dataset Pg. 1

TABLE 1. VERY LARGE FIRE (VLF) POTENTIAL FOR 5 ECOREGIONS IN THE WESTERN U.S.
DATA FROM BARBERO ET AL. (2015).

ECOREGION	HISTORIC VLF POTENTIAL (1971 - 2000)	FUTURE VLF POTENTIAL (2041 - 2070)	CHANGE IN VLF POTENTIAL (FUTURE - HISTORIC)
Western cordillera	0.8	3.3	2.5
Northwestern great plains	0.2	1.3	1.1
South-central semiarid prairies	0.3	0.4	0.1
Cold deserts	1.0	3.6	2.6
Warm deserts	0.4	1.2	0.8
Average	0.5	2.0	1.4

VLF: Very Large Fire; a wildfire that burns an area greater than 5,000 hectares (12,355 acres).
VLF Potential: mean number of annual VLF's per 10,000 km^2 (1,000,000 hectare) area.

TABLE 2. HISTORIC AND PREDICTED FUTURE MAXIMUM TEMPERATURE AND POTENTIAL EVAPOTRANSPIRATION.
DATA FROM HTTP://CLIMATECONSOLE.ORG/CONUS

ECOREGION	HISTORIC AVERAGE MAXIMUM TEMP. 1981 - 2000 (°F)	FUTURE AVERAGE MAXIMUM TEMP. 2061 - 2070 (°F)	PERCENT CHANGE IN MAXIMUM TEMP. 1981 - 2010 (°F)	HISTORIC AVERAGE POTENTIAL ET 1981 - 2000 (IN.)	FUTURE AVERAGE POTENTIAL ET 2061 - 2070 (IN.)	PERCENT CHANGE IN POTENTIAL ET 1981 - 2070 (%)	CURRENT ABOVE GROUND DEAD BIOMASS 2011 (GC/M^2)	FUTURE ABOVE GROUND DEAD BIOMASS 2071 (GC/M^2)	PERCENT CHANGE IN ABOVE GROUND DEAD BIOMASS 2011 - 2071 (%)
Western cordillera	50.7	57.9	14.2	3.1	4.5	43.4	3418	2596	-24
Northwestern great plains	58.4	65.5	12.2	5.1	6.9	35.2	555	527	-5
South-central semiarid prairies	71.2	77.3	8.6	6.3	8.1	29.1	374	345	-8
Cold deserts	63.1	70.2	11.2	5.5	7.3	33.6	711	867	22
Warm deserts	76.6	82.9	8.3	7.2	9.1	26.3	340	380	12
Average	64.0	70.8	10.9	5.4	7.2	33.5	1080	943	-1

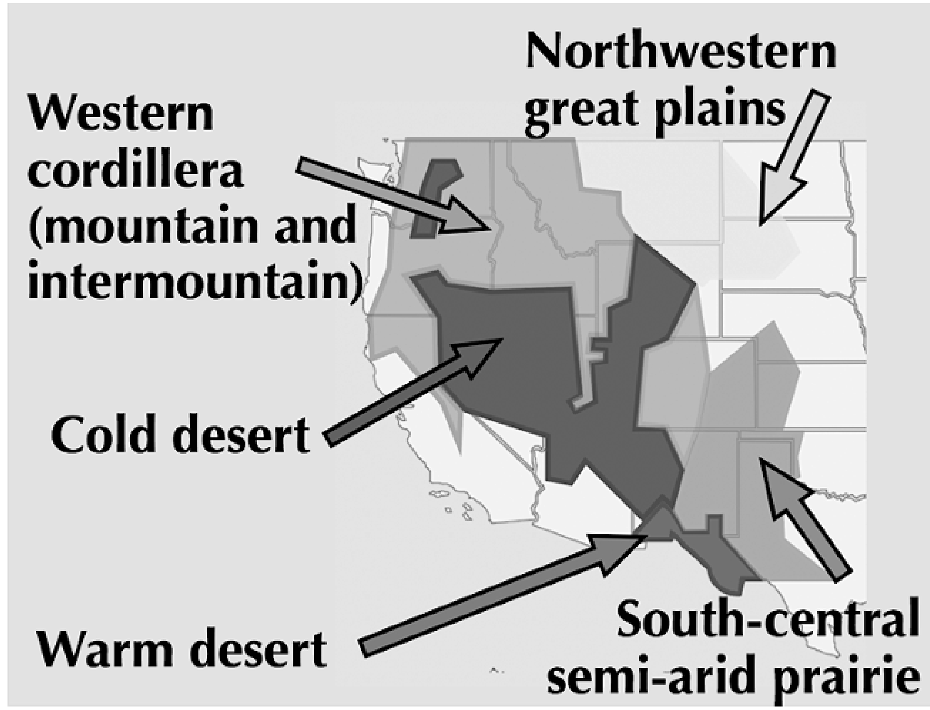
Potential evapotranspiration (ET): the potential for evapotranspiration (water entering the air from evaporation and transpiration). Takes into account temperature, wind speed, solar radiation, and relative humidity.
Above ground dead biomass: dead organic matter (leaves, stems, branches, bark, tree trunks, etc.). Measured in grams of carbon per meter squared.

WILDFIRE DATA JAM

Dataset Pg. 2

ADDITIONAL INFORMATION

FIGURE 1. MAP SHOWING LOCATION OF MAJOR ECOREGIONS IN THE WESTERN U.S.



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 ESS3.D Global Climate Change	Systems and System Models 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

FEMA guidelines to remove vegetation and other flammable materials from three concentric zones surrounding buildings (see https://www.fema.gov/media-library-data/20130726-1652-20490-9209/fema_p_737_fs_4.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

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.

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?

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>.

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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/Internet/FSE_DOCUMENTS/stelprdb5181242.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.

Climate Change

and Wildfire

GAME RULES

SUPPLIES:

- 4 player tokens
- Die
- 66 hazard pieces (beans, pebbles, chips, buttons, etc.)
- 1 set of career cards (4)
- 1 set of wildfire hazard cards (48)

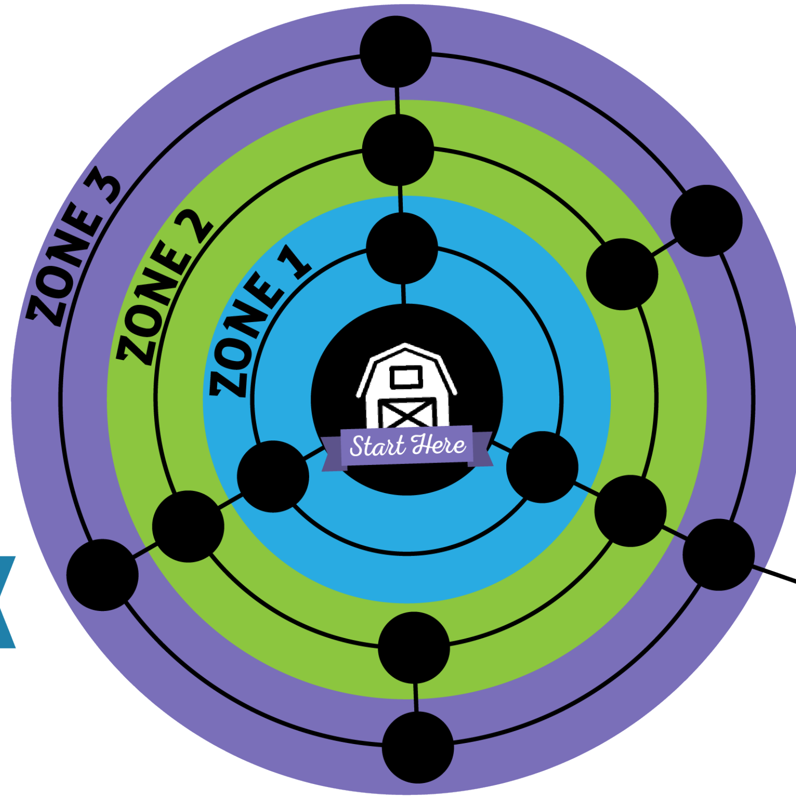
SET-UP:

- To set up the game, place 25 hazard pieces randomly throughout the board, one per space.
- Each player chooses a building that they are responsible for and places their player piece on their building in the center of their inner circle. There are also 6 community forest spaces in the middle.
- Each player draws a career card that they will keep with them for the rest of the game, which gives them a special action they are allowed to take during the game.
- Shuffle and place the wildfire hazard cards face down on the draw pile space.

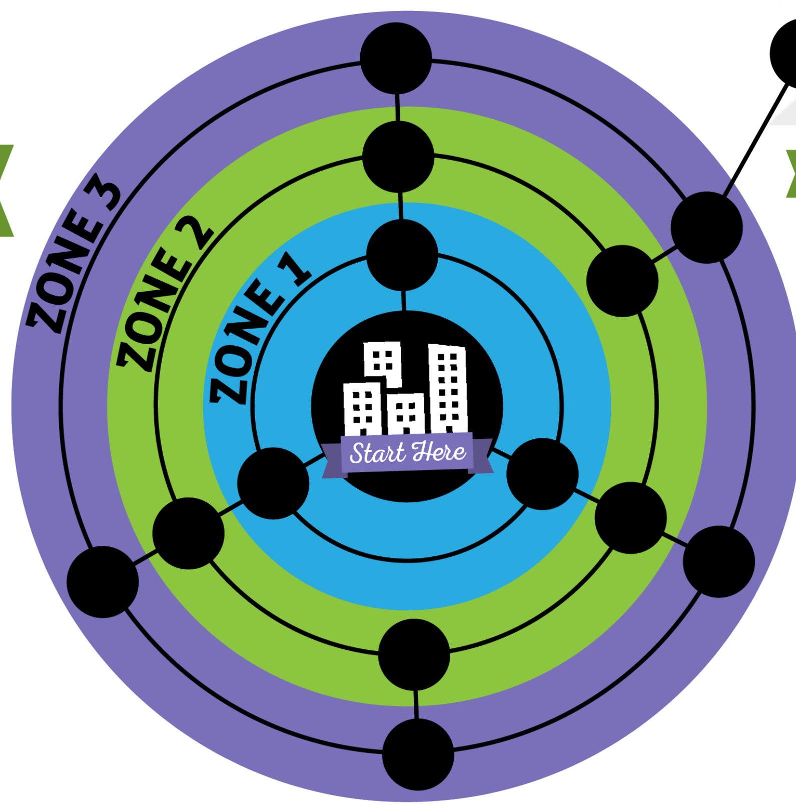
GAMEPLAY:

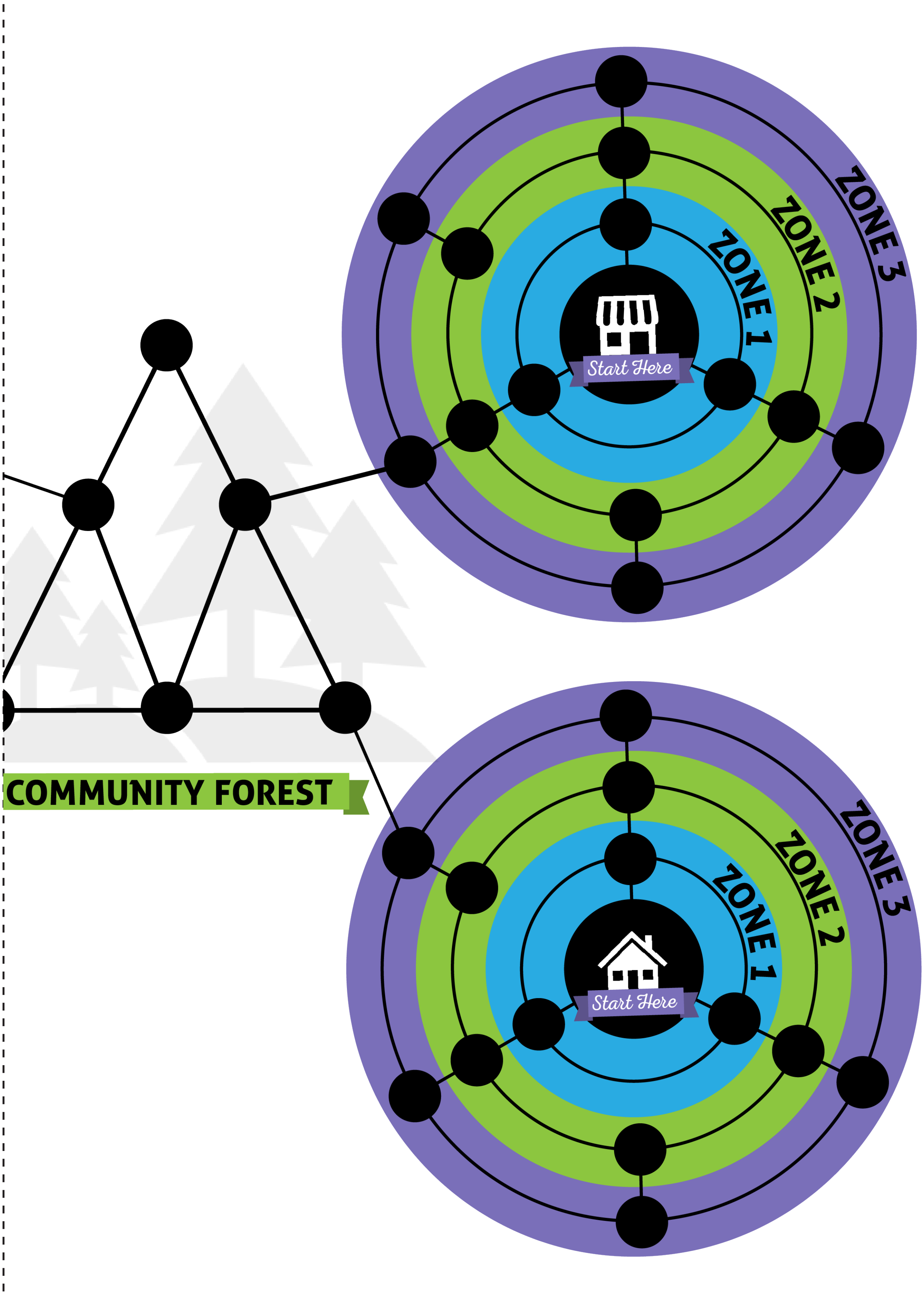
1. The objective of the game is to clear the board of all fire hazards.
2. Set up the game board.
3. The youngest player goes first, and play moves to the left of that player.
4. Start your turn by rolling the dice. Move that number of spaces, in any direction, as long as the spaces are connected.
5. If your final landing space has a fire hazard, you can remove it.
6. Flip over the top hazard card, and follow the instructions on the card. If you run out of cards in the draw pile, shuffle discarded cards and replace in the draw pile.
7. Next player's turn.
8. Play the game until time is up. The first player to remove all hazard pieces from their three circles AND the community forest wins!


WILDFIRE HAZARD
Draw
Here


ZONE 3
ZONE 2
ZONE 1
Start Here


WILDFIRE HAZARD
Discard
Here


ZONE 3
ZONE 2
ZONE 1
Start Here


ZONE 3
ZONE 2
ZONE 1
Start Here
COMMUNITY FOREST
ZONE 3
ZONE 2
ZONE 1
Start Here

CAREER CARD

Community Organizer

As a community organizer, you are passionate about the needs of your community and helping others. You run a grassroots organization that focuses on reducing the impacts of climate change to your community. Anyone can be a community organizer, but a degree in social work can give you a leg up in this field.

Special Skill:
For every hazard piece you remove from your building, you get to remove an extra one from someone else's.

CAREER CARD

Meteorologist

When planning a prescribed burn, it's important to stay informed of the weather conditions. You communicate with wildland firefighters about wind, precipitation, and temperature conditions. You'll need a bachelor's degree in atmospheric sciences and strong communication skills to be a meteorologist.

Special Skill:
Forecast the fire weather. When it's your turn, you can peek at the next Hazard Card. Decide if you want to draw it, or put it back at the bottom of the draw pile.

CAREER CARD

Forest Manager

You are the district forest manager for the local national forest. Your job is to implement management plans that focus on improving ecosystem health and reducing wildfire risk. A forest manager typically has a degree in forestry or biology.

Special Skill:
Prevent fire risks in the community forest. Don't add any hazards to the community forest.

CAREER CARD

Wildland Firefighter

There are many types of wildland firefighters. You are a prescribed fire manager, responsible for implementing prescribed burns with your crew of firefighters. To be a firefighter, you will need to pass rigorous physical fitness tests and be certified. Many agencies also require college experience in a variety of fields.

Special Skill:
For every hazard piece you remove from the community forest, you get to remove an extra one.

WILDFIRE HAZARD

Conduct a successful prescribed burn on the community forest.

Remove 2 hazards from the community forest.

WILDFIRE HAZARD

A wind storm rips through the community forest. Unfortunately, this year has been exceptionally warm and the trees are stressed from drought.

Add 2 hazards to the community forest.

WILDFIRE HAZARD

A wind storm rips through your community, knocking down trees. Luckily, you have removed all trees surrounding your building.

Add 1 hazard to any other player's zone 3.

WILDFIRE HAZARD

A wind storm rips through your community, knocking down trees.

Add 1 hazard to any of the zones around your building.

WILDFIRE HAZARD

Drought!

Trees are dying due to drought caused by climate change.

Add 1 hazard to each player's zone 3.

WILDFIRE HAZARD

Ignition! A fire starts in your building.

If you have 0, 1, or 2 pieces in your zone 1, you are able to suppress the fire. Do nothing.

If you have more than 2 pieces, the fire spreads. Add 2 pieces to your zone 2.

WILDFIRE HAZARD

Ignition! An illegal campfire gets out of control on a windy day in the community forest.

If there are 0, 1, 2, or 3 hazards in the community forest, firefighters are able to put it out by spraying it with water. Do nothing.

If there are more than 3 hazards, the fire spreads. Add 1 hazard to each player's zone 3.

WILDFIRE HAZARD

Ignition! Lightning strikes the community forest.

If there are 0, 1, 2, or 3 hazards in the community forest, firefighters are able to put it out by spraying it with water. Do nothing.

If there are more than 3 hazards, the fire spreads. Add 1 hazard to each player's zone 3.

WILDFIRE HAZARD

Collaborate with your community to develop a management plan that includes a prescribed burn.

Remove 1 hazard from everybody's zone 3.

WILDFIRE HAZARD

After learning about the history of fire suppression in your area, conduct a successful prescribed burn on the land surrounding your building.

Remove 1 hazard from your zone 3.

WILDFIRE HAZARD

Beetle outbreak! Drought-stressed trees provide an opportunity for beetles to invade and kill trees. If there are more than 5 hazard pieces on the board, the beetle outbreak spreads.

Add one hazard to every empty space that's touching your current space.

WILDFIRE HAZARD

Ignition! A fire starts in the community forest. You're in charge of a crew of firefighters. Should you:

1. Dig a firebreak to remove all combustible vegetation to reduce the spread? Or
2. Should you call in a helicopter to drop fire retardant?

Make a decision, then remove 1 hazard from the community forest.

WILDFIRE HAZARD

You are managing the outer circle of your building and want to keep some vegetation for aesthetic reasons. You remove a couple trees that are close together but leave the rest.

Remove 1 hazard from your zone 3.

WILDFIRE HAZARD

You are managing the outer circle of your building. You get lazy and decide to leave some dead plants, increasing the risk of fire.

Add 2 hazards to your zone 3.

WILDFIRE HAZARD

Your community has decided to reduce funding to land management.

Add 1 hazard to the community forest.

WILDFIRE HAZARD

You are managing the outer circle of your building, and you choose to thin vegetation by removing every other tree.

Remove 1 hazard from your zone 3.

WILDFIRE HAZARD

You are managing the outer circle of your building, and you choose to prune vegetation by removing dead branches.

Remove 1 hazard from your zone 3.

WILDFIRE HAZARD

A fireworks display gets out of control in your community.

If there are more than 7 hazards total on the board, the fire spreads. Every player adds one hazard to each of their zones.

WILDFIRE HAZARD

A campfire in the community forest gets out of control!

Add a hazard to every empty space that's touching another hazard in the community forest.

WILDFIRE HAZARD

Your community has decided to increase funding to land management.

Remove 1 hazard from the community forest.

WILDFIRE HAZARD

Organize a bike-to-work program in your community to reduce carbon emissions.

Remove 1 hazard from each building's zone 3.

WILDFIRE HAZARD

Drought caused by climate change has allowed a bark beetle population to explode, causing many trees to die.

Add 1 hazard to the community forest.

WILDFIRE HAZARD

Decide to switch to a plant-based diet to reduce your individual carbon emissions.

Remove 1 hazard from your zone 3.

WILDFIRE HAZARD

You learn that over ¼ of greenhouse gas emissions in the U.S. come from transportation.

Tell your group one thing you could do to reduce your greenhouse gas emissions from transportation, then remove 1 hazard from your zone 3.

WILDFIRE HAZARD

You learn that managed forests act as a carbon sink and absorb more carbon from the atmosphere than they release.

Report this information to another group, then remove 1 hazard from any one of your zones.

WILDFIRE HAZARD

You learn that the government offers a tax credit which saves you money if you install solar panels. You know that renewable energy will reduce your carbon emissions, so you decide to buy solar panels.

Remove 1 hazard from your zone 1.

WILDFIRE HAZARD

Create a community education campaign to help your neighbors invest in renewable energy.

Remove 1 hazard from the community forest.

WILDFIRE HAZARD

Consult with local land managers to improve forest health by planting more native tree species, which help to remove carbon from the atmosphere.

Remove 1 hazard from the community forest.

WILDFIRE HAZARD

You learn that over ¼ of greenhouse gas emissions in the U.S. come from the production of electricity from nonrenewable sources.

Tell your group one thing you could do to reduce your greenhouse gas emissions from electricity, then remove 1 hazard from your zone 3.

WILDFIRE HAZARD

What is one way your community could take action against climate change?

Share your answer with your group, then remove 1 hazard from everyone's zone 3.

WILDFIRE HAZARD

You learn that defensible space requires all combustible materials to be removed within 5 feet of a building.

Sabotage the other players by adding one hazard to each player's zone 1.

WILDFIRE HAZARD

Move a firewood stack away from your building, from 10 feet away to 50 feet.

Remove 1 hazard from your zone 1.

WILDFIRE HAZARD

Which type of outdoor furniture should you decide to buy for your patio that's 10 feet away from your building?

Choose plastic, wooden, or metal and tell your group. If your group agrees with your answer, remove 1 hazard from your zone 1.

WILDFIRE HAZARD

Clean your roof of any debris before fire season starts.

Remove 1 hazard from your zone 1.

WILDFIRE HAZARD

Trim tree branches that were hanging over your roof.

Remove 1 hazard from your zone 1.

WILDFIRE HAZARD

You recently bought a new grill for your patio. A fire ignites!

If you have any hazards on your zone 1, the fire spreads. Add one hazard to every empty space that's touching the hazards in your zone 1.

WILDFIRE HAZARD

You want to build a driveway near your building. Explain to your group how a driveway could help reduce risk of fire to your building.

Remove 1 hazard from your zone 2.

WILDFIRE HAZARD

You've recently purchased a new car and want to build a detached garage. You decide to build it at least 50 feet away from your building to reduce fire risk.

Remove 1 hazard from your zone 2.

WILDFIRE HAZARD

You're doing some landscaping and decide you want to plant your trees really close together. You know that this increases fire risk, but you do it anyways.

Add 1 hazard to your zone 2.

WILDFIRE HAZARD

You do a scan of your yard and decide you need to remove 3 combustible items.

Tell your group the 3 items you would remove, then remove all hazards from your zone 2.

WILDFIRE HAZARD

You're thinking about conducting a prescribed burn on the community forest today. Winds are expected today at 30 mph, but you already have a crew in place to do the burn. Tomorrow should be less windy, with winds around 10 mph.

You decide to wait till a less windy day, remove 1 hazard from the community forest.

WILDFIRE HAZARD

You learn that relative humidity means how much moisture is in the air, and that a prescribed fire can't burn if relative humidity is too high.

Report this information to another group, then remove 1 hazard from anywhere on the board.

WILDFIRE HAZARD

You're excited to learn that smokejumpers are special types of wildland firefighters that jump out of helicopters and have decided to start a new career.

If you don't already have the wildland firefighter career card, trade cards with the person that has it.

WILDFIRE HAZARD

Prune all of the trees you see between 30-100 feet away from your building.

Remove all hazards from your zone 2.

WILDFIRE HAZARD

Choose to replace an existing rock garden near your building with a plant garden.

Add 1 hazard to your zone 1.

WILDFIRE HAZARD

You're having a mid-life crisis and want to explore new career opportunities.

Trade career cards with anyone.

WILDFIRE HAZARD

A wildland firefighter needs to be in good physical condition to pass a "pack test", where they have to carry a heavy backpack several miles.

Speed walk around the room, then remove one hazard piece from any space.

WILDFIRE HAZARD

Upon finding a broken window at your building, you decide not to replace it. A wildfire starts nearby. The embers are able to get inside your building, causing the fire to spread.

Add 1 hazard to each of your 3 zones.

CLIMATE CHANGE AND WILDFIRE
COMMON CORE STATE STANDARDS ACTIVITY CHARTS

This chart identifies the Climate Change and Wildfire activities that apply to each of the listed Common Core State Standards.

ENGLISH LANGUAGE ARTS			
	Wildfire: Past and Future	**Wildfire Data Jam**	**Playing With Fire**
CCSS.ELA-LITERACY.W.9-10.1.E.	●		●
CCSS.ELA-LITERACY.W.11-12.1.	●		
CCSS.ELA-LITERACY.RST.9-10.7.	●	●	
CCSS.ELA-LITERACY.RST.9-10.4.		●	●
CCSS.ELA-LITERACY.RST.11-12.4.		●	
CCSS.ELA-LITERACY.RST.11-12.7.		●	

CLIMATE CHANGE AND WILDFIRE
NEXT GENERATION SCIENCE STANDARDS ACTIVITY CHARTS

Three Dimensions
This chart identifies the Climate Change and Wildfire activities that address each of the listed three dimensions of the Next Generation Science Standards.

NGSS THREE DIMENSIONS			
	Wildfire: Past And Future	**Wildfire Data Jam**	**Playing With Fire**
SCIENCE AND ENGINEERING PRACTICES			
Planning and Carrying Out Investigations	●		
Developing and Using Models	●		
Analyzing and Interpreting Data		●	
Using Mathematics and Computational Thinking		●	
Constructing Explanations and Designing Solutions	●	●	
Engaging in Argument from Evidence			●
Obtaining, Evaluating, and Communicating Information		●	
DISCIPLINARY CORE IDEAS			
ESS3.B Natural Hazards		●	
ESS3.C Human Impacts on Earth Systems		●	●
ESS3.D Global Climate Change		●	●
LS2.C Ecosystem Dynamics, Functioning, and Resilience	●		
CROSSCUTTING CONCEPTS			
Patterns	●	●	
Cause and Effect	●	●	
Scale, Proportion, and Quantity		●	
Systems and System Models			●
Stability and Change			●