v 1.0

ACTIVITY 9

Probabilistic Modeling

MODELING

ACTIVITY 9

Probabilistic Modeling

ACTIVITY SUMMARY

Students use a probabilistic model of a fictional wildfire to make predictions about its spread through a community and calculate the probability of its spread based on the model. Students practice using probabilistic reasoning to make recommendations about water drops and controlled burns in order to reduce the spread and risk of the fire.

ACTIVITY TYPE
MODELING

NUMBER OF
40–50 MINUTE
CLASS PERIODS
2

KEY CONCEPTS & PROCESS SKILLS

1. When there is scientific uncertainty in data, probabilistic reasoning is a method for determining the likelihood of different outcomes on which to base a decision.
2. Uncertainty in data is often a result of errors. Scientific errors can be random or systematic and can lead to conclusions that are less likely to be correct.
3. Confidence intervals, confidence levels, and error bars describe the uncertainty of data and the probability that data are accurate.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (*Science and Engineering Practice: Analyzing and Interpreting Data*)

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. (*Science and Engineering Practice: Analyzing and Interpreting Data*)

CONCEPTUAL TOOLS

PROBABILISTIC REASONING

FALSE POSITIVES & FALSE NEGATIVES

SYSTEMATIC & RANDOM ERROR

VOCABULARY DEVELOPMENT

probabilistic model
a tool that uses patterns in data to predict the likelihood of different outcomes

TEACHER BACKGROUND INFORMATION

Probabilistic Models vs. Deterministic Models

Scientists use statistics to uncover patterns in real-world data. To understand these patterns, they build models that mimic real-life situations. Models can vary in their complexity based on the number of factors, the interactions between factors, and the scientific principles that are built into the model. The more factors and the better the model simulates the relationships between the factors, the better its predictive power.

Probabilistic models are models that are based on data from observations; assumptions about the context; and consideration of probability theories, chance, variation, and randomness. Probabilistic modeling is used in contexts such as weather forecasting, diagnostic medicine, and artificial intelligence (AI). One example is what is called machine learning in AI applications. Machine learning uses probability theories and large data sets to train the computer algorithm to be able to recognize images or speech, generalize information, or perform tasks without instructions. Probabilistic models can be used to test hypotheses, predict what might happen in the future based on current trends, and solve problems by finding the best course of action in different scenarios. Given the same initial inputs, a probabilistic model is likely to produce different outcomes every time it is run. It accounts for uncertainty by including the probability of different parameters and gives the likelihood of different outcomes. Like other types of models, probabilistic models are most effective when they are frequently compared to real data and updated to improve the accuracy of their predictions.

In contrast, a deterministic model does not include random elements or consider the probability of events. Given the same initial information or inputs, a deterministic model will always result in the same outcome. An example might be using a simple equation to model the bounce of a ball. If a certain starting point and force are known, it will allow you to predict exactly how high the ball will go. Deterministic modeling is used for processes such as resource allocation, inventory management, automation processes in manufacturing, and projection of long-term investments. Deterministic models are not referenced in this unit.

Probabilistic Models and Wildfire Prediction

Wildfire modeling uses computational tools to make simulations of fire dynamics in specific locations. It is a tool that complements fire risk assessment, which assesses the likelihood and intensity of a fire should it occur. Wildfire modeling is used to forecast fire spread, shape, spotting potential (when new fires start because of flying embers or other materials), and even how much heat a fire may generate. Newer wildfire models based on research are sophisticated enough to include details such as spread by ground (surface fire); treetops (crown fire); and/or terrain including slope steepness, direction of approach (up vs. down a slope), fuel characteristics (density and moisture), fire intensity, and weather conditions. Some models include mathematical models of propagation and historical data from previous fires.

As the models improve, they are increasingly being used as fire management tools to prepare for, prevent, and fight wildfires. Wildfire modeling can help suppress fires in real time by informing where to deploy firefighting resources and can boost safety for firefighters and the public. Models can also help in pre- and post-fire management by informing where preventative measures such as controlled burns might be most effective to reduce the impacts of fires on watersheds, air quality, and sensitive habitats. Some new models use AI algorithms to help detect new fires. For example, in 2023, the University of California at San Diego worked with California's state firefighting agency, CAL FIRE, to develop a new fire monitoring system that uses more than a thousand camera feeds from across the state. The system is trained to detect smoke and other early signs of fire by machine learning.

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- TAPE (OR TACKS)

FOR EACH PAIR OF STUDENTS

- 2 NUMBER CUBES
- SET OF 8 COLORED PENCILS (red, orange, yellow, green, blue, purple, brown, and grey)

FOR EACH STUDENT

- 2 STUDENT SHEETS 9.1 "Map of Koheegee Park"
- 2 STUDENT SHEETS 9.2 "Modeling Wildfire Spread"
- 2 STUDENT SHEETS 9.3 "Data from the Wildfire Model"

Familiarize yourself with the Wildfire Model, using the model instructions in the Student Book. Since there are many potential outcomes of the model, It will be useful for you to be familiar with all 8 rounds of rolls, data collection, and mapping. Teaching Step 2 includes more information to support filling out the map, using the model rules.

Ensure that your students have similar sets of colored pencils with the appropriate colors. Students compare their maps during the activity, so the comparison will be easier if they are using similar colors in each round.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in mint.

GETTING STARTED (10 MIN)

1 **Students think about why multiple factors can make a prediction difficult.**

- In the previous activity, students tested various types of fuel sources, but there are many other factors that can affect a fire. Ask, Why do you think it can be very difficult to predict where and how fast a fire will spread? Student responses may include: there are many factors that affect wildfire spread; some of the factors interact with each other; some factors (such as rain) may change during the course of a wildfire, and some factors may not be accounted for.
- After students read the Introduction, review the term *probabilistic model*. If you have begun a word wall, support students, particularly emerging multilingual learners, in sensemaking and language acquisition by adding the term probabilistic model to the word wall. It may help to provide an example of a *probabilistic model*, such as weather apps, which provide a range of possible outcomes along with the likelihood of each one occurring. Ask, What factors do you think these weather models are using? Students may respond that weather apps rely on various data collected about atmospheric conditions such as temperature, precipitation, and air pressure as well as satellite and doppler readings that track the movement of storms. All these data are factored into a prediction about the likely weather in the near future.
- Point out that the purpose of many probabilistic models is to help people make predictions and inform decisions. This could include helping scientists learn more about how a natural phenomena behaves, preparing communities for a hazardous event, or even just making everyday plans (as in the case of a weather app). Let students know that in this activity, they will be using a probabilistic model to make predictions about wildfire spread.

PROCEDURE SUPPORT (60 MIN)

2 **Prepare students to use the wildfire models.**

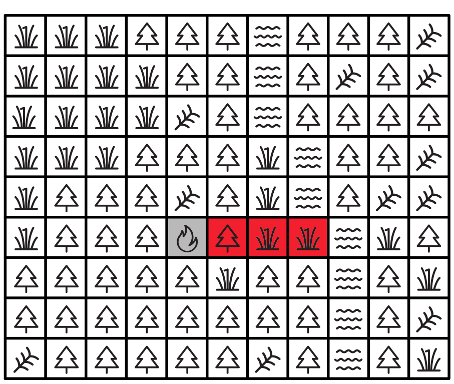
- Distribute one copy of Student Sheet 9.1, “Map of Koheegee Park,” one copy of Student Sheet 9.2, “Modeling Wildfire Spread,” and one copy of Student Sheet 9.3, “Data from the Wildfire Model,” to each student. Have students read the fictional scenario in Procedure Step 1 and review the map on Student Sheet 9.1. Answer any questions students have about the scenario and the map. Depending on your student population, you may wish to review the use of the compass and the abbreviations for north, south, east, and west.

- Wait to hand out the number cubes and colored pencils until after students have made their predictions in Procedure Step 2 and you have reviewed the model rules in Procedure Step 3.
- Demonstrate how to complete the first few rounds of the model, ideally by projecting Student Sheets 9.1 and 9.3 on a document camera so you can roll the number cube, record the data on Student Sheet 9.3, and color the map on Student Sheet 9.1. Follow the rules in Procedure Step 3 for the Wildfire Model. Make sure students know that they will need to proceed through each action in order—rolling the number cube and coloring the map—before moving on to the next action. Sample data for the first 3 hours of the teacher demonstration is shown in the following table and maps. Let students know not to copy the data from the demonstration onto their student sheets.

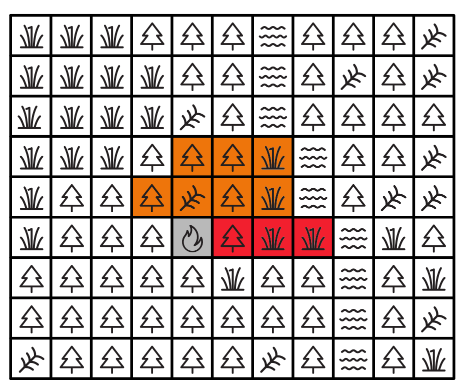
Sample Data for the First 3 Hours

HOUR 0: **Fire starts**	STEP 1: **Wind Direction** Roll #: Action	STEP 2: **Wind Speed** Roll #: Action	STEP 3: **Fuel sources that cause spread**
Hour 1 (red)	*Rolled 3: moved East*	*Rolled 4: Wind 15 mph*	*grasses*
Hour 2 (orange)	*Rolled 1: moved North*	*Rolled 5: Wind 15 mph*	*grasses and dry vegetation*
Hour 3 (yellow)	*Rolled 5: moved South*	*Rolled 3: Wind 5 mph*	*grasses*

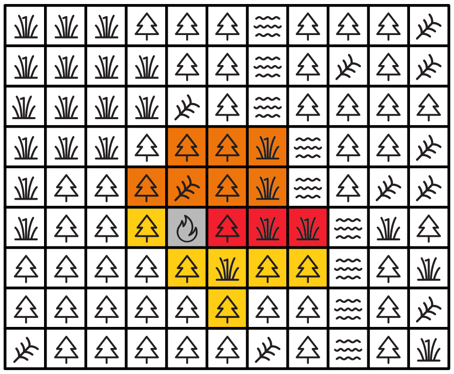
Map After Hour 1



Map After Hour 2



Map After Hour 3



- In Procedure Step 4, students calculate probabilities of various factors in the Wildfire Model before using the model themselves. Students who struggle with math may require additional support to calculate the probabilities. You may want to have students read the Science Review in Activity 1 of the Student Book and model how to complete the probability calculations. Review the responses as a class and have students update their predictions from Procedure Step 2 as needed.

Sample Student Response, Procedure Step 4

a The probability of each wind direction:

North = 1:6 (16.7%)
East = 2:6 or 1:3 (33.3%)
South = 2:6 or 1:3 (33.3%)
West = 1:6 (16.7%)

b The probability of each wind speed:

5 mph = 3:6 or 1:2 (50%)
15 mph = 2:6 or 1:3 (33.3%)
30 mph = 1:6 (16.7%)

c The fuel type that is least likely to spread a fire:

Trees, because during the fuel source action, trees don't spread the fire to additional squares, whereas grasses and dry vegetation do.

3 Support students as they use the Wildfire Model in Part A.

- In Procedure Step 5, hand out 2 number cubes and a set of colored pencils to each pair of students. Partners begin working with the Wildfire Model together. Have students label the fire on Student Sheet 9.3 as Fire A. A sample student response is shown at the end of this activity.

- Decide whether you want partners to take turns rolling the number cubes to create two different maps of Fire A, or if you want them to roll together, which would result in both students creating the same map. For students who are more advanced, rolling separately will give them an additional opportunity to see how chance and probability can affect the path of the fire. For students who struggle to follow the model's instructions, we recommend having partners roll together so students can help each other to follow the steps of the model by comparing their maps and results as they progress through the model.

- Circulate to ensure students are following the rules of the model and color-coding each hour on the map properly.

- In Procedure Step 7, have students display their maps of Fire A by taping them on the wall. If partners created the same map, only one student needs to post their map. Allow partners time to observe and compare the results across all the maps.

- Ask, Based on everyone's results, is there a shape, direction, and size of the fire that seems more likely to occur in the park? Students may recognize that the fire tends to go east and south but that sometimes, random variations can cause the fire to go in other directions and have a different shape every time the model is run. As a class, discuss the differences in the maps and then ask, Which factors in the model do you think have the biggest impact on where and how the fire spreads and why? Students may recognize that wind speed played a big role in spreading the fire very quickly when the wind was really strong. Vegetation type also had a big role in spreading the fire, especially dry vegetation, which could spread the fire in all directions. Wind direction determined the general direction of the fire but could also make the fire spread randomly in other directions.

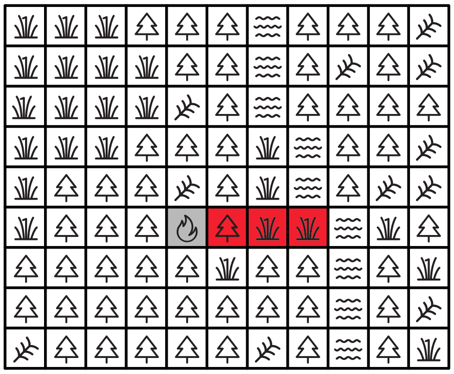
4 Support students as they use the Wildfire Model to manage a second fire in Part B.

- For Part B, provide each student with a second copy of Student Sheets 9.1, 9.2, and 9.3. A sample student response for Student Sheet 9.1 for Fire B is shown at the end of this activity.

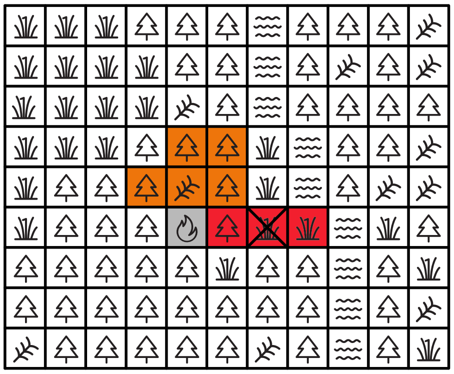
- Have students read the scenario in Procedure Step 8 and record a prediction (on their new copy of Student Sheet 9.2) for the second fire. Have students label this fire as Fire B. Explain that now that students are familiar with the model, they will have a chance to prevent the fire from spreading by dropping water on a single burning square on the map *at the beginning of each hour, starting in Hour 2*. By marking the square with an X (on their new copy of Student Sheet 9.1), the water will prevent fire from spreading from this square in any future hours. Point out that water drops are often used to contain real wildfires, but they must be planned carefully to avoid wasting resources and time.

- If needed, model how to conduct the first few hours of Fire B with water drops, using the modified instructions from Procedure Step 8. (Sample data for the first 3 hours are shown in Teaching Step 2.) The following maps show the data as it is recorded for each roll with the water drops added after Hour 1 and Hour 2.

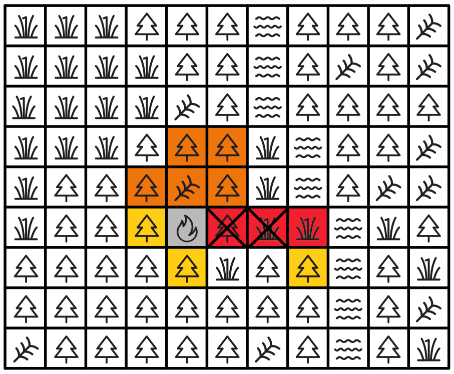
Map After Hour 1



Map After Hour 2
with Water Drop After Hour 1



Map After Hour 3
with Water Drop After Hour 2



- In Procedure Step 9, have students share their results from Part B and the insights they gained when comparing their map to the map of another pair of students.

Sample Student Response, Procedure Step 9

Compare your results with another pair of students. Determine:

- in which direction the fire moved the most.

  The fire is still most likely to move east and south

- what factor(s) most influenced the outcome.

  The wind strength and type of fuel had big effects on how easily the fire spread throughout the region, though being able to drop water on certain areas helped us reduce the spread of the fire.

- how the different factors interacted in a way that caused the fire to spread.

  The wind direction and speed were due to chance, but the spread of the fire depended on what types of vegetation were present in that direction. This made it so that everyone's maps were a little different.

SYNTHESIS OF IDEAS (20 MIN)

5 **Facilitate a class discussion to highlight that probabilistic reasoning is useful because it can be based on available data, even when the data is incomplete.**

- Ask students to share and explain their results from Procedure Part B. Ask, Why were you successful or unsuccessful in preventing the fire from spreading? Student responses will vary. Many students will report that they were able to use the probabilities of wind speed and direction along with what they knew about the different fuel types to limit the fire spread. Some students may report that they were unsuccessful due to the randomness of rolling the number cubes, which could have made the fire behave in ways that were different than expected.
- Ask, How did completing the model in Part A help you make your choices for water drops in Part B? Student responses should indicate that completing Part A gave them a better understanding of what is more likely and less likely to happen, even though their predictions were not always correct. Point out that this is what makes probabilistic reasoning useful—it allows people to use what they know, even when what they know is incomplete.
- Ask, What happens if you run the model numerous times? Student responses should indicate that it provides different possible outcomes of the fire and improves the quality of predictions based on which outcomes are most likely.
- Evaluate if your students are able to identify the essential ideas of the activity by reviewing student responses to Build Understanding items 1 and 2. Students apply what they've learned using the model to make a recommendation about controlled burns as well as to make a prediction about air quality in nearby cities.
- Build Understanding item 3 gives students an opportunity to reflect on the limitations of the Wildfire Model and how it is an example of a probabilistic model. Students may realize that the model did not incorporate all the complex aspects of wildfire conditions, such as the wetness of the area, complexities in wind movement, landscape features, and location to resources. These aspects make modeling more of a challenge than in the model they ran. Even so, a more sophisticated model would include a combination of aspects that can be accurately predicted and aspects that cannot.
- Build Understanding items 4 and 5 give students an opportunity to connect the use of the probabilistic model back to concepts learned earlier in the unit: false positives, false negatives, and confidence levels. Students may need additional review of these concepts to support their responses to these items.
- Connections to Everyday Life item 6 provides the class an opportunity to discuss how AI uses probabilistic reasoning and how sometimes this can be a problem because it can reinforce harmful stereotypes.
- To conclude the activity, evaluate whether your students are able to answer the Guiding Question, *How can probabilistic reasoning be used to predict an outcome?*

EXTENSION (50 MIN)

6 **Use the Extension as an opportunity for advanced learning.**

- National Oceanic and Atmospheric Administration's (NOAA) HYSPLIT computer model is an online probabilistic model used to predict the trajectory of air parcels across a location. Students can use HYSPLIT to simulate the spread of smoke in their local area over an 8–hour period from a controlled burn, also called a prescribed burn. Note that the model allows for many different inputs, many of which can be ignored for the purposes of this Extension.

- Important steps for students when using the model:
  - On the first page of the model, go to "Release Type" and select one of the two PRESCRIBED BURN options.
  - For "Source Location," select a location on the map that you would like to model. Then scroll to the bottom of the page and select the NEXT button.
  - On the second page of the model, go to "Choose an archived meteorological file" and select any file other than "Current7days." Then select the NEXT button.
  - On the third page of the model, it is possible to change many parameters (burn area, flaming burn duration, etc.). Go to "Runtime Parameters" and set the "Total duration" to 8 hours at most (longer times take longer to run) and the "Averaging period/Output interval" to 1. You may also find it helpful to scroll down to "U.S. county borders" and select "yes." Then scroll to the bottom of the page and select the REQUEST DISPERSION RUN button.
  - On the final page of the model, the page will reload every 10 seconds until the model and graphics have finished uploading. Note that the graphics may take up to 5 minutes (or longer) to display. Students should eventually observe a plume indicating the general direction of the likely spread of particles in the selected location, and they can zoom in or out of this location on the map. (If impacts are not very clear, go to "Burn Area" under "Source Term Parameters" on the third page of the model and input 1,000 acres. Students may need to troubleshoot—for example, the model may crash if using a location in Canada.)

- After examining the data from the model, have students reflect on how local officials and residents could use the information from the model to make plans or decisions related to controlled burns in the area.

- Though not a probabilistic model, a user-friendly website for looking at wildfires and wildfire smoke plumes from satellite data is https://worldview.earthdata.nasa.gov/ where it is easy to select dates. For example, you can select August 21, 2020 for California Wildfires, turn on "place layers," add "Fires - thermal anomalies" layer and zoom in to California.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

1. **Based on the Wildfire Model from this activity, make a recommendation to Koheegee Park Rangers about what areas would benefit from controlled burning. Support your reasoning with evidence from the model.**

   Based on the Wildfire Model, I would recommend doing a controlled burn in the southeast section of the park, especially east of the river. My reasoning is that according to the model, the most likely wind directions are south and east. Looking at the data from our whole class, a lot of groups had fires that progressed south and east. Setting a controlled burn in that direction might make a wildfire less likely. Second, near the southeast part of the river, there was a lot more dried vegetation. In the Wildfire Model, this type of fuel spreads the fire a lot more than any other type of fuel, even grasses, because the fire can spread in any direction.

2. **Kairoba City is north of Koheegee Park, while Meso City is east of Koheegee Park. According to the Wildfire Model, which city is more likely to have poor air quality as a result of the fire in Koheegee Park? Explain your reasoning.**

   According to the Wildfire Model, the winds in the area are more likely to blow toward the south (33.3% chance) and the east (33% chance) compared to the north (16.7% chance). I think that Meso City is more likely to have poor air quality than Kairoba City because Meso City is east of Koheegee Park.

3. **Consider the factors that contribute to wildfire in the model.**

   a. **What are some ways that the model is realistic?**

   The model is realistic in that it shows the randomness of wind patterns, which can often be unpredictable in real life. It also shows that a fire can't move across rivers as easily and that different types of vegetation spread fires at different rates.

   b. **What are some other factors that could affect wildfire spread that are not included in the model?**

   Rainfall and humidity are not included in the model, as well as other physical features of the land such as mountains, hills, and roads. These things all might affect the direction and speed of fire spread.

   c. **How is the Wildfire Model an example of a probabilistic model?**

   The model has probability built into it. It can help you see that while there is most likely a wind direction and wind speed, it doesn't always happen that way. By running the model many times, you can see the possible different outcomes of the fire and then make predictions based on which outcomes are most likely.

4. **Suppose you want to use the Wildfire Model to plan water drops to contain a fire in Koheegee Park. You have numerous helicopters and can drop water on as many locations as you want. However, each water drop costs $2,000 and can be dangerous to firefighting crews that will need to navigate difficult weather conditions and terrains**

   a. **A probabilistic wildfire model predicts a fire to spread south of the park. People there are warned, and firefighters are sent to assess the situation and do a water drop if needed. When they arrive, there is no fire. What might be one consequence of this false positive?**

      One consequence might be that they send a firefighting team out somewhere that it is not needed when they could have gone somewhere it was needed. Also, people who were warned probably got worried and started to evacuate even though it wasn't necessary.

   b. **Describe how a probabilistic wildfire model could result in a false negative and what one consequence of this false negative could be.**

      A false negative in this situation would be when the Wildfire Model did not predict a fire at a location that ended up actually having a fire. A consequence would be that there was no firefighting team on hand to control the fire, and people would not be given enough warning to evacuate, so there could be injuries or damage to property.

5. **Imagine 2 different wildfire models are being tested to make predictions about local wildfires. Model A predicts that a fire at a particular location will burn between 1,000 and 2,000 hectares (2,471–4,942 acres) under certain wind and weather conditions and has a 95% confidence level. Model B predicts that a fire at the same location will burn between 1,000 and 2,000 hectares under certain wind and weather conditions and has a 90% confidence level. Explain which model you would prefer to use when making wildfire predictions for this area and why.**

   I prefer to use Model A to make predictions because it has a higher confidence level than Model B. This means that Model A is more successful at predicting wildfires within the correct range and is only incorrect 5% of the time compared with Model B, which is incorrect 10% of the time.

CONNECTIONS TO EVERYDAY LIFE

6. **Probabilistic reasoning is a key component of several decision-making systems, including those used in AI tools. For example, an image-generating AI tool learns to make images by looking at millions of images in a database. It finds patterns in the data it is given and uses those patterns to project how things should look. A problem arises because the data the AI learns from can be unbalanced or biased. For example, if most of the pictures the AI learns from show only certain types of people (such as men as doctors and women as nurses), the AI might recreate those stereotypes in its images. Discuss with your class whether this represents random error, systematic error, or both in the AI image-generator system.**

   This is an example of systematic error. The data used to train the AI doesn't include representation from all groups of people in society. This affects the products it generates, leading to images that also misrepresent all groups of people. The error is not random because it does not come about from chance but by a consistent bias in the images it is using.

REFERENCES

Elbein, S. (January 18, 2021). Wildfire modeling: What the complex math of fire modeling tells us about the future of California's forests. *MIT Technology Review*. https://www.technologyreview.com/2021/01/18/1016215/complex-math-fire-modeling-future-california-forests/

Hansen, J., & Schmidt, J. (July 26, 2018). *Timber treatments successfully reduce wildfire risk in Utah*. Fire Adapted Communities Learning Network. https://fireadaptednetwork.org/timber-treatments-and-chip-wattles-reduce-wildfire-risk-in-utah

Jolley, A. (October 25, 2018). *Does wildfire mitigation work? 16 examples and counting!* Fire Adapted Communities Learning Network. https://fireadaptednetwork.org/does-wildfire-mitigation-work-16-examples-and-counting

Morgan, R. (June 17, 2017). *Fire threatens Brian Head; town evacuated, highway closed*. KSL.com. https://www.ksl.com/article/44682869/fire-threatens-brian-head-town-evacuated-highway-closed

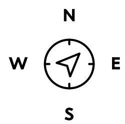
Pinto, R. M., Benali, A., Sá, A. C. L. *et al*. (2016). Probabilistic fire spread forecast as a management tool in an operational setting. *SpringerPlus 5*, 1205. https://doi.org/10.1186/s40064-016-2842-9

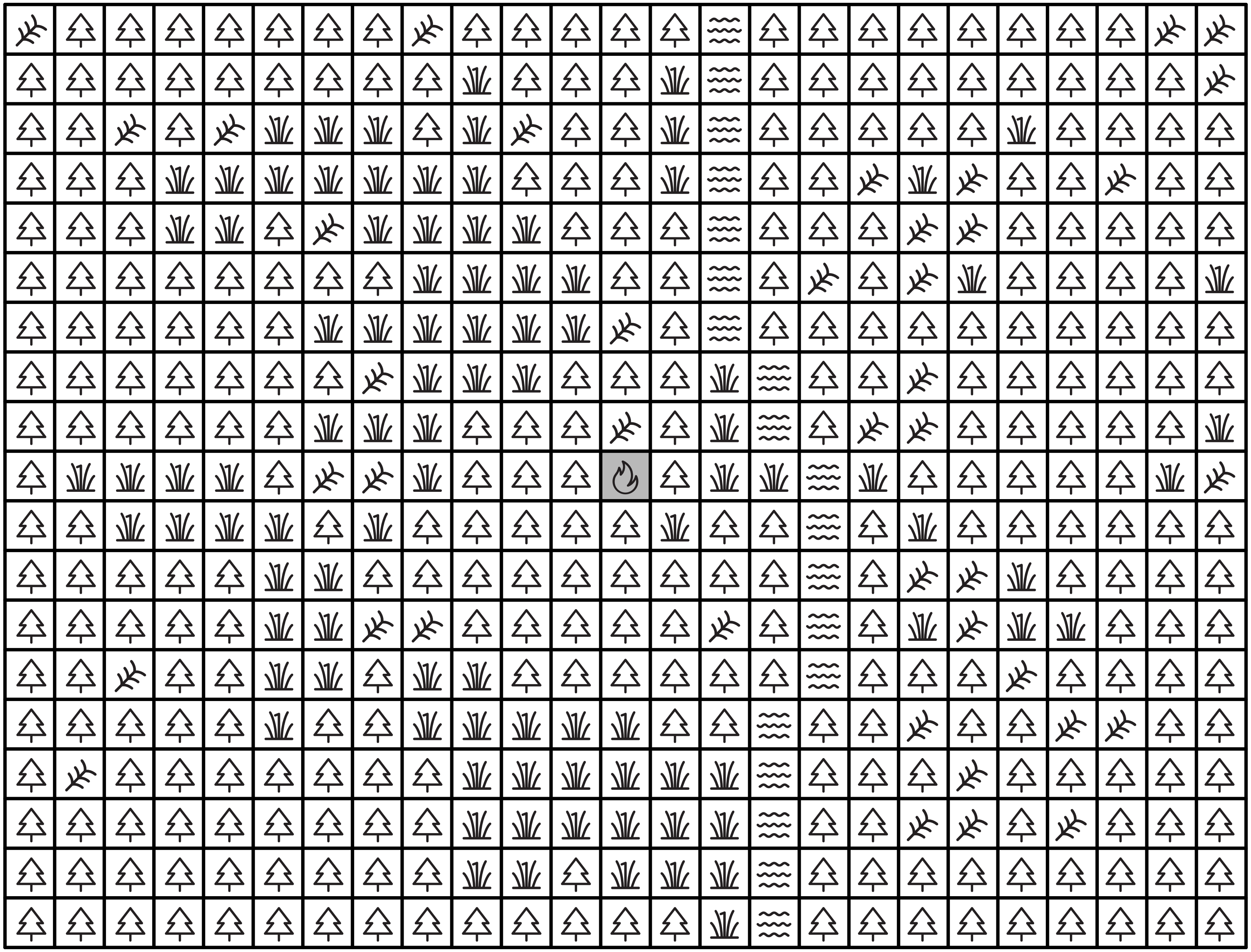
Prell, A. (June 23, 2017).*'Extreme' Brian Head fire destroys 13 homes*. RedZone. https://www.redzone.co/2017/06/23/extreme-brian-head-fire-destroys-13-homes/

USDA and the U.S. Forest Service. (2024). *Wildfire risk to communities*. Wildfirerisk.org https://wildfirerisk.org/

STUDENT SHEET 9.1 | MAP OF KOHEEGEE PARK | NAME

FIRE





KEY

Start of fire

Trees

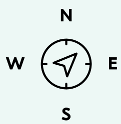
Grasses

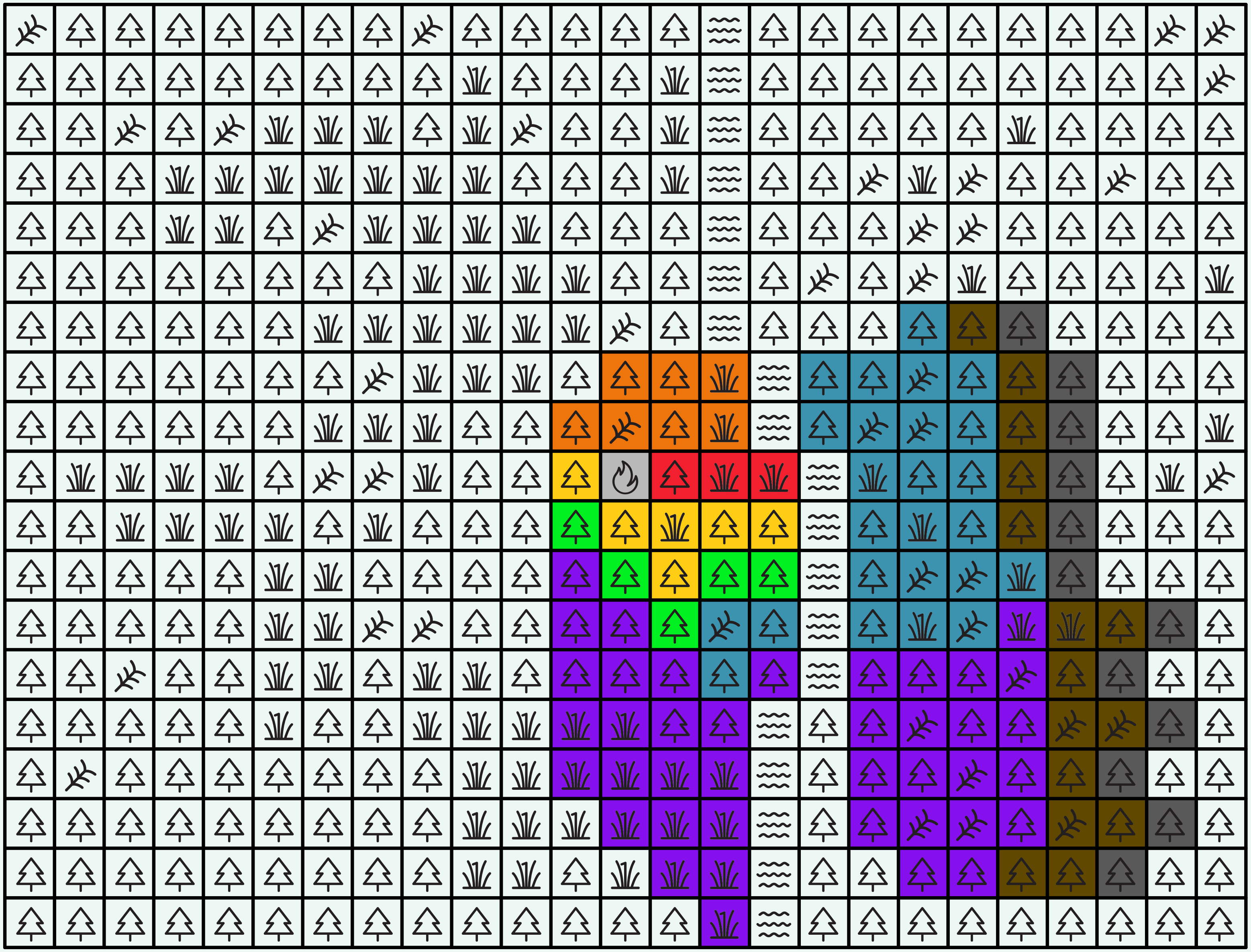
Dry vegetation

River

NAME SAMPLE STUDENT RESPONSE

FIRE A



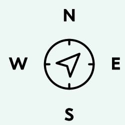


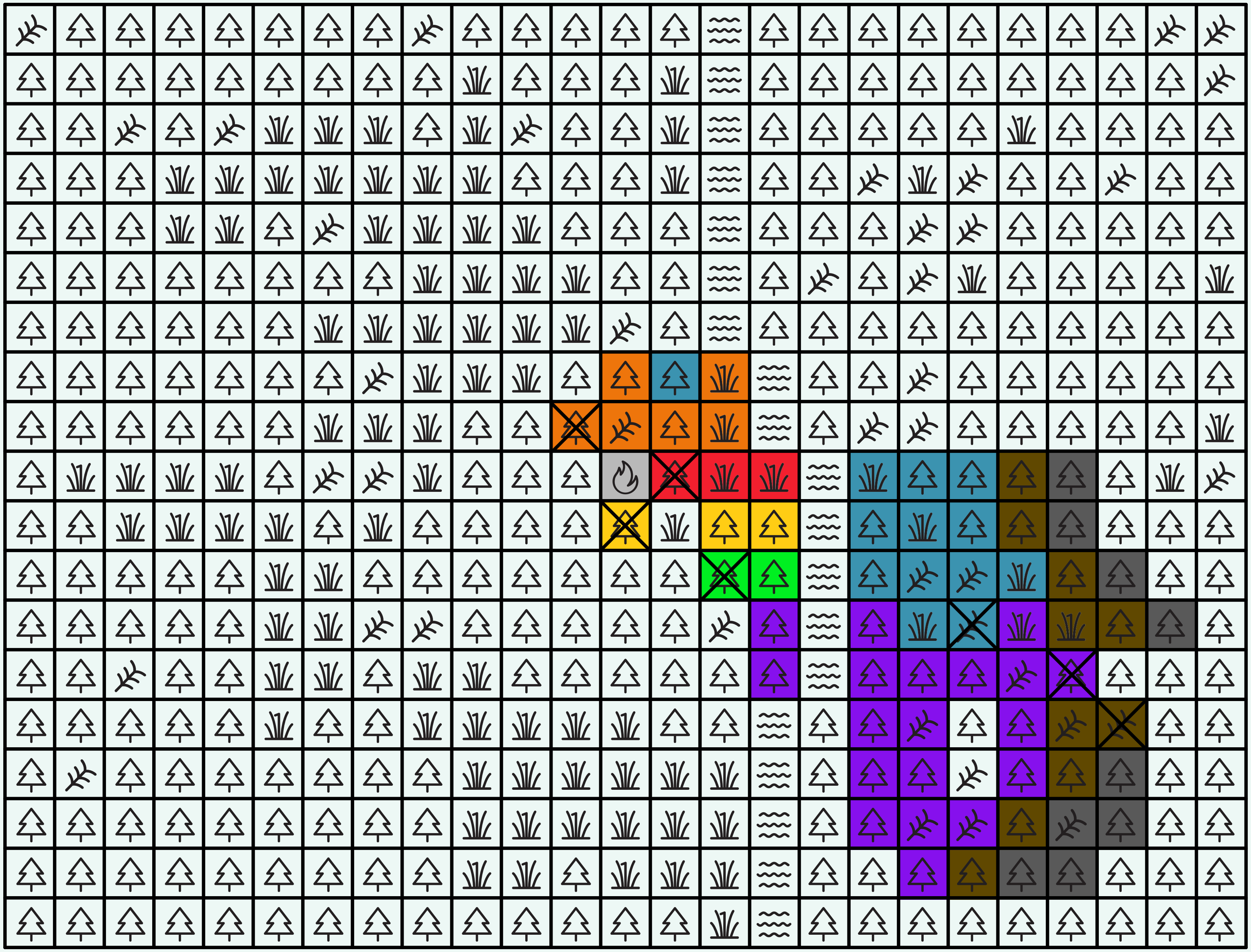
KEY

- Start of fire
- Trees
- Grasses
- Dry vegetation
- River

STUDENT SHEET 9.1 | MAP OF KOHEEGEE PARK | NAME SAMPLE STUDENT RESPONSE

FIRE B





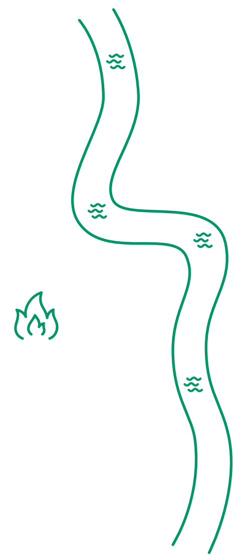
KEY

- Start of fire
- Trees
- Grasses
- Dry vegetation
- River

STUDENT SHEET 9.2 | MODELING WILDFIRE SPREAD | NAME

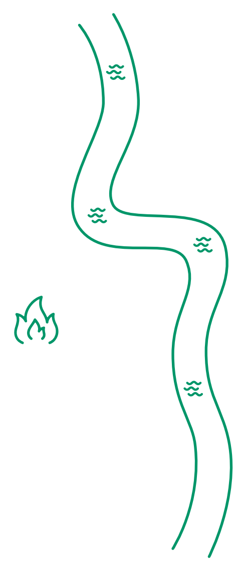
FIRE

Prediction *before* the fire:
Sketch a shape on this miniature map to predict where you think the fire will spread over the next 8 hours.



What factors did you base your prediction on?

Actual fire spread:
Sketch a shape to represent where the fire spread *after 8 hours.*

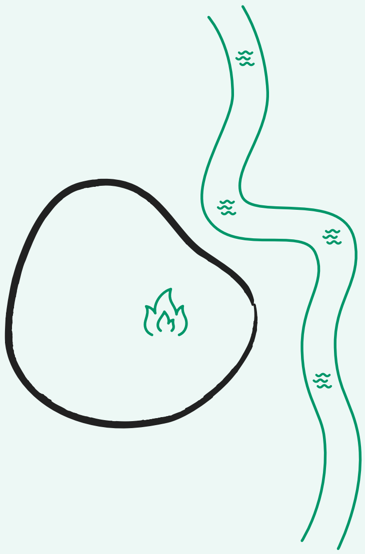


What factors affected the outcome the most?

 SAMPLE STUDENT RESPONSE

FIRE A

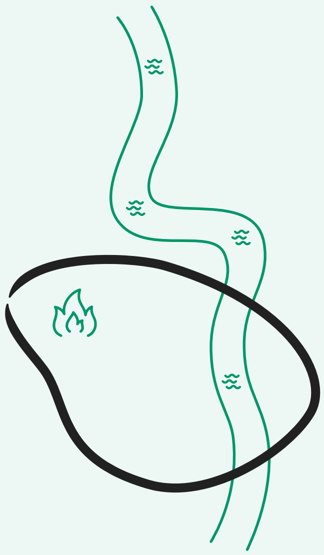
Prediction *before* the fire:
Sketch a shape on this miniature map to predict where you think the fire will spread over the next 8 hours.



What factors did you base your prediction on?

There are a lot of grasses in this area that burn easily.

Actual fire spread:
Sketch a shape to represent where the fire spread *after 8 hours.*



What factors affected the outcome the most?

Wind direction and speed had huge effects, especially when there was a firestorm.

STUDENT SHEET 9.3	DATA FROM THE WILDFIRE MODEL	NAME

FIRE

HOUR 0: Fire starts	STEP 1: Wind Direction Roll #: Action	STEP 2: Wind Speed Roll #: Action	STEP 3: Fuel sources that cause spread
Hour 1 (red)			
Hour 2 (orange)			
Hour 3 (yellow)			
Hour 4 (green)			
Hour 5 (blue)			
Hour 6 (purple)			
Hour 7 (brown)			
Hour 8 (grey)			

STUDENT SHEET 9.3 | DATA FROM THE WILDFIRE MODEL | NAME SAMPLE STUDENT RESPONSE

FIRE A

HOUR 0: Fire starts	STEP 1: Wind Direction Roll #: Action	STEP 2: Wind Speed Roll #: Action	STEP 3: Fuel sources that cause spread
Hour 1 (red)	*Rolled 3: moved East*	*Rolled 4: wind 15 mph*	*grasses*
Hour 2 (orange)	*Rolled 1: moved North*	*Rolled 5: wind 15 mph*	*grasses and dry vegetation*
Hour 3 (yellow)	*Rolled 5: moved South*	*Rolled 3: wind 5 mph*	*grasses*
Hour 4 (green)	*Rolled 4: moved South*	*Rolled 2: wind 5 mph*	*trees, no spread*
Hour 5 (blue)	*Rolled 2: moved East*	*Rolled 6: wind 30 mph Firestorm!*	*grasses and dry vegetation*
Hour 6 (purple)	*Rolled 4: moved South*	*Rolled 6: wind 30 mph Firestorm!*	*grasses and dry vegetation*
Hour 7 (brown)	*Rolled 2: moved East*	*Rolled 1: wind 5 mph*	*grasses and dry vegetation*
Hour 8 (grey)	*Rolled 2: moved East*	*Rolled 1: wind 5 mph*	*trees, no spread*