ACTIVITY 10

Applying Probabilistic Reasoning

CARD-BASED INVESTIGATION


High winds can knock trees onto powerlines, sparking wildfires in dry, fire-prone areas.

10: APPLYING PROBABILISTIC REASONING

GUIDING QUESTION

How can you use probabilistic reasoning to reduce risk?

INTRODUCTION

The risk of wildfires starting from sparks from electric power lines is a growing concern. To reduce this risk, many electric companies turn off power lines during bad weather. These power shutoffs help prevent wildfires. In the past, power shutoffs were based on historical records of past wildfires. But in 2023, Professor Paolo Bocchini and student Xinyue Wang from Lehigh University in Pennsylvania created a new probabilistic model to predict the risk of fire from power lines during strong wind storms. They looked at factors such as how close power lines are to vegetation, how wind affects the cables, wind strength, and how long the wind lasts. According to Professor Bocchini, their team used a careful probabilistic approach to the problem. This new model can help people better predict the probability of a wildfire due to a spark from a power line and decide if a power shutoff is needed. In this activity, you will use probabilistic reasoning to help a fictional power company decide where and when to turn off power.

Signs can alert visitors to the level of fire risk in an area.

CONCEPTUAL TOOLS

MATERIALS LIST

FOR EACH GROUP OF FOUR STUDENTS

- CALCULATOR
- SET OF 4 FIRE RISK CARDS

FOR EACH STUDENT

- STUDENT SHEET 10.1 "Determining Fire Risk"

PROCEDURE

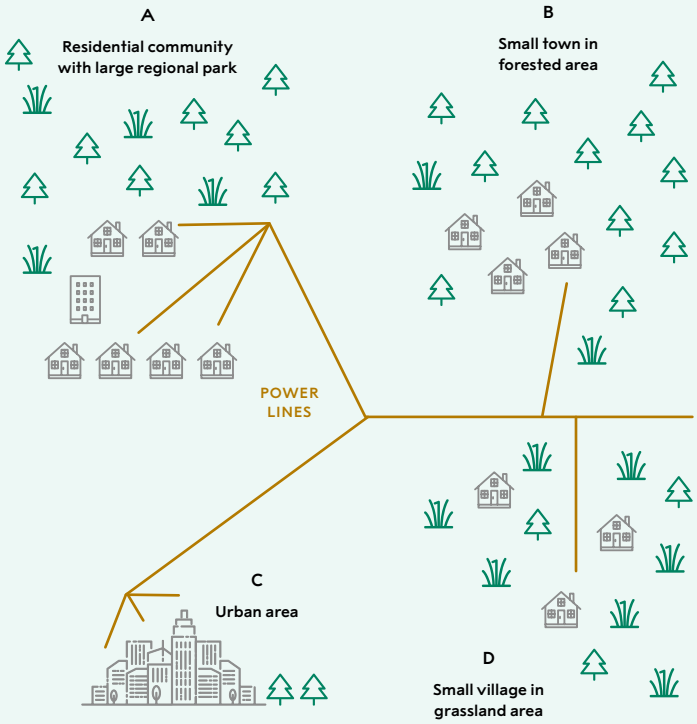
1 With your group of four, read the following fictional article.

POWER SHUTOFFS LIKELY DUE TO HIGH WINDS

Wind gusts of up to 72 kilometers per hour (45 miles per hour) are forecast over the next 3 days in Futura County. This, in addition to dry conditions throughout the region, has officials concerned. When winds are strong, like those predicted, it can cause branches to fall onto electrical power lines. This can start a fire, which then spreads quickly by the wind.

The local power company has shared the following map of areas of concern. Each of these four locations may experience a power shutoff during this period of particularly high winds.

FIGURE 10.1
Map of Major Power Lines to Each Area



2 Work with your partner to examine Figure 10.1.

a In the first row of the table on Student Sheet 10.1, "Determining Fire Risk," record the number of major power lines terminating in each location.

b In the second row of the table, describe the type and amount of vegetation at each location.

c In the third row of the table, describe the location of power lines relative to the vegetation at each location.

3 Based on the data you recorded on your student sheet so far, make an initial prediction about which location(s) has the highest risk for wildfire for the next 8 hours.

a Record your prediction in your science notebook and explain your reasoning.

b Determine how sure you are of your decision, using a scale of 0–100% where:

0% = there is no chance your prediction will be correct
50% = your prediction is just as likely to be wrong as it is to be correct
100% = you are absolutely sure that your prediction will be correct

c Share your prediction and reasoning with the rest of your group. Remember to listen to and consider the ideas of other group members. If you disagree with others, explain why you disagree.

4 Using your set of Fire Risk cards, examine Fire Risk 1: Vegetation Dryness by Location. Record notes about vegetation dryness for each location in the "Current Dryness Level" row on the student sheet.

Clearing dry vegetation is one way to create a defensible space and reduce wildfire risk.

5 The frequency of fires in the past has often been used to determine the risk of fires today. Examine Fire Risk 2: Past Fire Data by Location. Calculate the percentage likelihood of a significant fire in any given year in each location based on the past number of wildfires greater than 41 hectares (100 acres) in the last 50 years. Record this percentage in the "Likelihood of Fire Each Year (%)" row on the student sheet.

HINT: Divide the number of past wildfires for each location by the length of the time period (50 years) to get the average number of fires per year. Then multiply by 100 to get a percentage.

6 You will use Fire Risk cards 3 and 4 to determine the size of a possible fire at each location. Examine Fire Risk 3: 8–Hour Forecasted Maximum Wind Speed in Each Location, which shows the forecasted maximum wind speeds over the next 8 hours for each location. Record this data in the "Forecasted Maximum Wind Speed" row on the student sheet.

7 Examine the graph on Fire Risk 4: Wildfire Size Relative to Maximum Wind Speed and describe:

- any patterns you see in the graph.
- what conclusions you can make about the relationship between maximum wind speed and fire size.
- what role the size of error bars plays in your conclusions about the data.

8 Based on the data for each location on Fire Risk Card 3 and the graph on Fire Risk Card 4, determine the size of a possible fire at each location. Record this information in the "Size of Possible Fire Under Forecasted Maximum Wind Speed (hectares or acres)" row on the student sheet.

9 Based on all the data in Table 1 on your student sheet so far, revise your prediction about which location(s) has the highest risk for wildfire in the next 8 hours.

a Record your revised prediction in your science notebook and explain your reasoning.

b Determine how sure you are of your decision and compare how it changed as you gathered more data. Use a scale of 0–100% where:

0% = there is no chance your prediction will be correct
50% = your prediction is just as likely to be wrong as it is to be correct
100% = you are absolutely sure that your prediction will be correct

c Share your revised prediction and reasoning with the rest of your group. Remember to listen to and consider the ideas of other group members. If you disagree with others in your group, explain why you disagree.

d Work with your group to describe at least two sources of scientific uncertainty, including systematic errors or random errors, that could have affected the data or your predictions.

10 The power lines directed to the different communities have different energy loads based on local energy needs. Table 10.1 shows the energy required by each community and the vulnerability of each community to a loss of power, where a higher number indicates increased vulnerability. Vulnerability is a result of multiple factors such as income, health, and age. During a power outage, there are no traffic lights, no household refrigeration, and no power for medical devices. The ability of customers to cope with power outages varies, with some populations more vulnerable to its effects.

Examine the data in Table 10.1. Discuss with your group the trade-offs of shutting off the power to each location. Record notes for each location in the "Trade-Offs of Power Shutoff" row on your student sheet.

TABLE 10.1
Energy Load and Vulnerability Index

LOCATION	ENERGY LOAD CARRIED BY A POWER LINE (kW)	POPULATION	VULNERABILITY INDEX OF LOCAL POPULATION 0 = LOWEST VULNERABILITY 10 = HIGHEST VULNERABILITY
A	2,453	4,672	4
B	185	1,109	2
C	1,013	20,941	2
D	200	477	9

11 Use all the information on your student sheet to discuss which communities should have a power shutoff for the next 8 hours in order to reduce wildfire risk. Share your ideas and reasoning with the rest of your group. If you disagree with others in your group, explain why you disagree.

12 Follow your teacher's instructions to share your thinking with the class about which location(s) should experience a power shutoff to reduce wildfire risk.

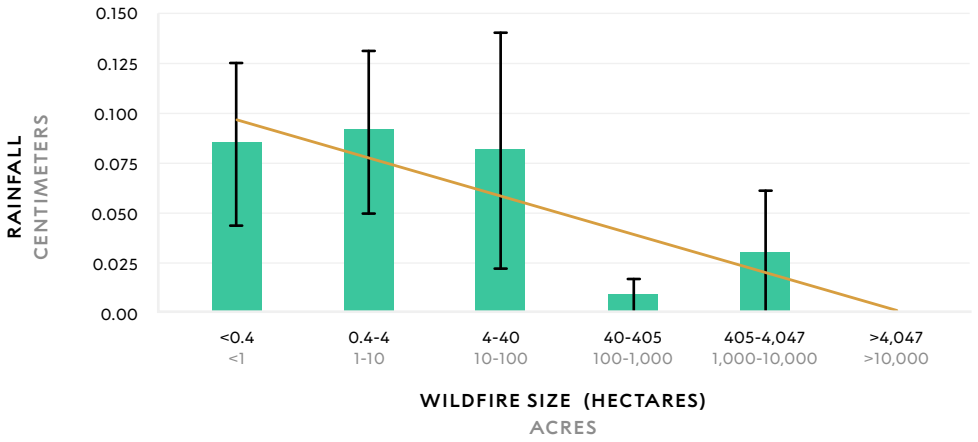
BUILD UNDERSTANDING

1. With the available data and under current conditions, in which location(s) do you recommend shutting off the power during the next 8 hours to reduce wildfire risk? Support your answer with evidence and identify the trade-offs of your decision.

2. Figure 10.2 shows the average size of wildfires in this region when there are different amounts of rainfall during the wildfire events. Explain what conclusions you can make based on the data in the graph. Be sure to include the following in your explanation:

   - Describe what patterns you observe between wildfire size and rainfall.
   - Explain what conclusions you can make about the relationship between wildfire size and rainfall.
   - Explain at least two possible sources of scientific uncertainty, including scientific errors, that may have affected the data.

FIGURE 10.2
Regional Wildfire Size During Different Rainfall Amounts



3. The power company decides to install sensors along power lines that would result in an automatic shutoff if a tree branch touches a power line.

   a What would be a false positive in this situation?

   b What would be a false negative in this situation?

   c Which would be a greater concern for community safety: a false positive or a false negative from the shutoff sensor? Explain your reasoning.

CONNECTIONS TO EVERYDAY LIFE

4. Your friend says that since there is uncertainty in science, no one can really know anything in science. Explain why you agree or disagree with your friend. Support your answer with an example from this unit.