



ACTIVITY 2

Signal and Noise

DATA ANALYSIS



← Imagine trying to spot
a single moth on the
bark of a large tree.
How could you find
this signal among the
environmental noise?



2 : SIGNAL AND NOISE

GUIDING QUESTION

How do you identify the meaningful data in a data set?

INTRODUCTION

What effect do wildfires have on indoor air quality? One group studying this is atmospheric chemists who research the chemistry of the air. Atmospheric chemists, like other scientists, try to separate the meaningful information about the phenomenon that is being investigated—the **signal**—from other factors that might interfere with it. These interfering factors are called **noise**. Noise is any information that hides, distracts from, or falsely resembles the meaningful information that is being investigated. For example, think of a search-and-find book where you need to find a cookie jar in a kitchen scene full of items. The cookie jar is the signal, and the other items are noise. While noise can increase uncertainty in science, probabilistic reasoning can help identify the signal being investigated. In this activity, you will act as an atmospheric chemist trying to separate the signal from the noise while studying data on wildfires and indoor air quality.



Researchers conduct experiments on indoor air quality at the Net Zero Energy Residential Test Facility in Gaithersburg, Maryland. The Chemical Assessment of Surface and Air (CASA) project aims to learn more about the chemical reactions affecting air and surfaces inside homes.

CONCEPTUAL
TOOLS



SIGNAL & NOISE

MATERIALS LIST

FOR EACH GROUP
OF FOUR STUDENTS

— SET OF COLORED PENCILS
(3 DIFFERENT COLORS)

FOR EACH STUDENT

— STUDENT SHEET 2.1
"Outdoor vs. Indoor Air
Quality Measurements"

PROCEDURE

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

IS COOKING WORSE THAN WILDFIRES FOR INDOOR AIR QUALITY?



When an extreme wildfire occurs, most people head indoors to avoid poor air quality outdoors. They may close windows, run an air purifier, or wear a face mask to avoid exposure to particulate matter and pollutants in the air. These actions may not be enough to prevent negative health effects such as asthma, dry eyes, and even lung disease. Yet most people are concerned about the air quality only when it's bad outside. In many places, people spend more than 90% of their time indoors.

Scientists are now investigating factors that affect indoor air quality, including wildfires. They are also concerned that indoor air quality can become worse when people cook large meals or do a lot of frying.

- 2 In your group of four, examine the two graphs on Student Sheet 2.1, “Outdoor vs. Indoor Air Quality Measurements,” and discuss what conclusions you can make about outdoor air quality vs. indoor air quality during a wildfire. The graphs show air quality measurements taken by both an outdoor and an indoor air sensor placed on opposite sides of the same wall at a home where wildfires are occurring nearby. Remember to listen to and consider the ideas of group members. If you disagree with other group members, explain why you disagree.
- 3 Use Student Sheet 2.1 to evaluate whether outside air quality during a wildfire affects indoor air quality.
 - a Draw boxes vertically around sections of both graphs where you think poor indoor air quality could have been caused by poor outdoor air quality.
 - b Make a hypothesis about whether outside air quality during a wildfire affects indoor air quality. Identify at least three dates (and approximate times) that provide evidence to support your hypothesis. Record your hypothesis and evidence in your science notebook.
- 4 Share your hypothesis and evidence with your group.
- 5 As an atmospheric scientist, you contact the residents of the home and ask questions about factors that could affect their indoor air quality. You find out that the following events occurred:
 - A house fan was running near the indoor sensor on the evening of September 15.
 - A neighbor was smoking outside near the outdoor sensor in the middle of the day on September 13 and on the afternoon of September 14.
 - The family was cooking large meals indoors at midday September 15, the mornings of September 16 and September 18, and late at night on September 19.

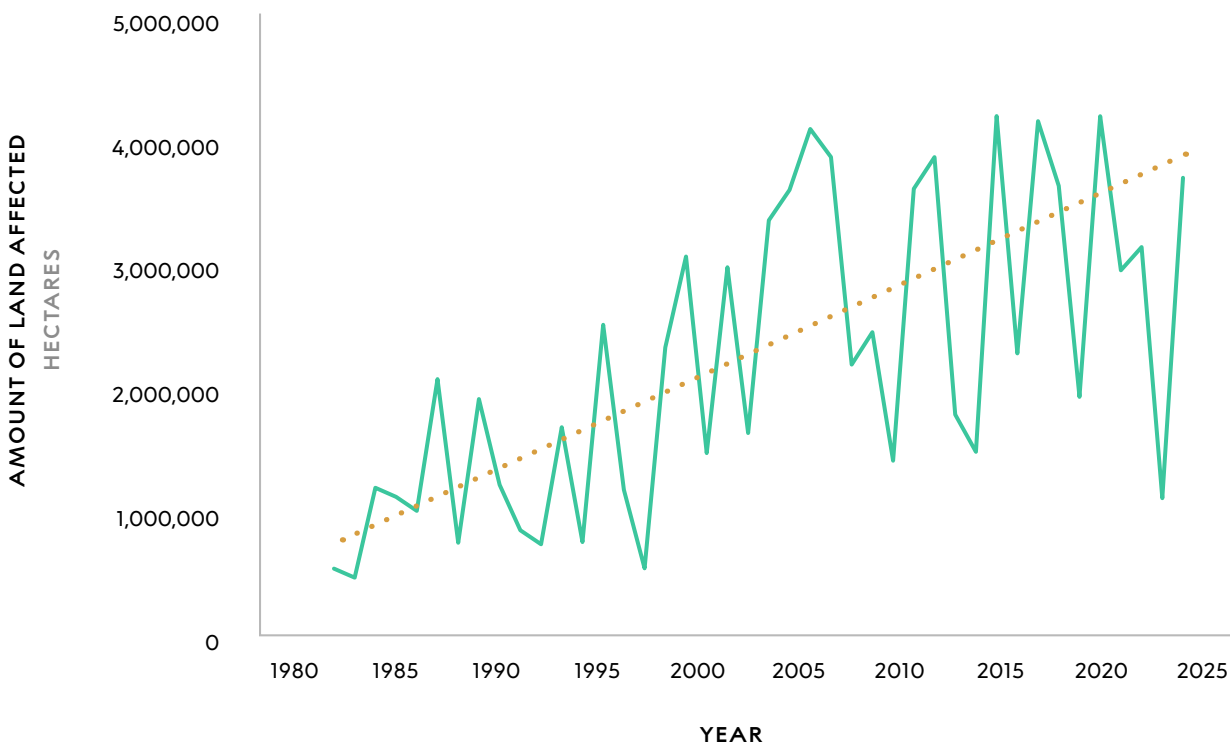
On Student Sheet 2.1, use three different colored pencils (one for each type of event) to highlight the dates and approximate times on which these three different events occurred. Label each colored area with the event that occurred at that time.
- 6 Discuss with your group what effect, if any, each event appeared to have on indoor air quality.
- 7 Work with your group to identify the signal and the noise in determining whether outdoor air quality is affecting indoor air quality during a wildfire. Do this by labeling each vertical box on Student Sheet 2.1 as either signal or noise.
- 8 Revisit your hypothesis and make any needed changes.
- 9 With your group, brainstorm actions you could take to improve indoor air quality in your home.
- 10 Share your ideas with the class.

BUILD UNDERSTANDING

- ① Would you prefer to stay indoors or be outdoors on a day when there are extreme wildfires in your area and your family is cooking a large meal? Explain your reasoning and support your answer with data from this activity.
- ② Figure 2.1 is a graph that shows the land area affected by wildfires in the United States since 1983. A hectare is a metric unit for measuring land area, equal to 2.47 acres or 10,000 square meters.

FIGURE 2.1

Land Area Affected by Wildfires in the United States, 1983–2024



- a What is the signal?
- b Describe what the noise looks like in the graphed data.
- c Based on the signal, what can you conclude about land area in the United States burned by wildfires over time?
- d How might this pattern be similar or different from the area in which you live?

CONNECTIONS TO EVERYDAY LIFE

- ③ You are watching a movie with friends. Another friend is joining you later.
- a Your dog is barking, making it difficult for you to hear what's happening in the movie. What is the signal and what is the noise?
 - b You move your dog to another room. He later barks to let you know that someone is at the door. Is your dog's bark a signal or a noise?
 - c Explain how identifying the signal vs. the noise depends on the information you are interested in.
- ④ You may have heard warnings about contaminated food, such as to avoid eating lettuce that has been recalled. In many cases, scientists gather data from individuals who fall sick to determine the common cause of their illness. The U.S. Centers for Disease Control and Prevention (CDC) uses this information and has estimated the annual number of foodborne illnesses in the United States to be 47.8 million cases. In the case of detecting foodborne illness:
- a What is the signal?
 - b What is a possible source of noise in the data? (What other explanation[s] could there be for the data?)
 - c For its estimate, the CDC accounted for scientific uncertainty and identified that the range of actual cases of foodborne illness in the United States per year may be as low as 28.7 million and as high as 71.1 million cases. Would you expect that reducing noise in this data would increase or decrease the estimated range of the data? Explain your reasoning.

KEY SCIENTIFIC TERMS

noise
signal