Science News
EDUCATOR GUIDE

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January 15, 2022

Wildfires May Boost Urban Ozone Levels

SOCIETY FOR SCIENCE

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About this Guide

In this Guide, based on the online *Science News* article "Wildfire smoke may ramp up toxic ozone production in cities," students will explore chemical interactions within wildfire smoke and how urban air pollution can influence the reactions.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the online *Science News* article "Wildfire smoke may ramp up toxic ozone production in cities," which explores new research into the interactions between wildfire smoke and air pollution in cities. A version of the article, "Wildfires may boost urban ozone levels," appears in the January 15, 2022 issue of *Science News*. Related standards include NGSS-DCI: HS-PS1; HS-ESS2.

> **Student Comprehension Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

Cross-curricular Discussion Q&A — Students will discuss the properties of air and wildfire smoke before exploring how substances in smoke react to ramp up a certain type of air pollution. Related standards include NGSS-DCI: HS-PS1; HS-ESS2.

> **Student Discussion Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

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Article-based Comprehension, Q&A

Directions for teachers: Ask students to read the online *Science News* article "Wildfire smoke may ramp up toxic ozone production in cities," which explores new research into the interactions between wildfire smoke and air pollution in cities, and answer the following questions. A version of the article, "Wildfires may boost urban ozone levels," appears in the January 15, 2022 issue of *Science News*.

1. Wildfire smoke contains a dizzying array of organic compounds and nitrogen oxides among other molecules. How did the scientists described in the article study the chemistry of wildfire smoke in action?

Scientists flew a jet in and out of smoke as the plumes drifted downwind of wildfires. The team collected air samples and recorded the kinds and amounts of each molecule detected in the smoky air. That let the team see how the smoke's chemical composition changed over time.

2. Ozone can form as ingredients in wildfire smoke interact. How did scientists calculate the amount of ozone produced by wildfire emissions? What did the calculations show?

The researchers used the air measurements along with wind patterns and fuel from sampled wildfires to create an equation that estimates ozone production. The scientists found that the concentrations of nitrogen oxides in wildfire smoke decline as the plumes move downwind, so ozone production slows over time.

3. Based on the scientists' findings, what can happen when wildfire smoke drifts into urban areas?

When wildfire smoke blows over cities, the smoke could get an infusion of nitrogen oxides — toxic gases found in car exhaust. When nitrogen oxides in city air mix with the wildfire smoke, ozone production could ramp up again.

4. What are the possible implications for urban air quality and human health?

Ozone levels could increase by as much as 3 parts per billion in the U.S. West during a typical fire season, worsening air quality. Though that increase is small, the researchers say it still could pose a health risk for people who are regularly exposed to smoke.

5. How might climate change make the situation worse?

Climate change is fueling more frequent and intense wildfires. More smoke means more ozone production. In addition to the health risks, the changes could complicate efforts to set meaningful air quality standards.

6. Choose a word from the story that you don't use all the time and write a dictionary definition for the word using only context clues from the article. Don't forget to include the word's part of speech.

Student answers will vary. Noxious is an adjective. It means harmful or poisonous. Ozone is a noxious gas when people inhale it.

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Student Comprehension Worksheet

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Cross-curricular Discussion, Q&A

Directions for teachers:
Ask students to read the online *Science News* article "Wildfire smoke may ramp up toxic ozone production in cities" and answer the following questions with a partner. Afterward, discuss the answers as a class. A version of the article, "Wildfires may boost urban ozone levels," appears in the January 15, 2022 issue of *Science News*.

Want to make it a virtual lesson? Post the online *Science News* article and video link to your virtual classroom. Discuss the article and questions with your class on your virtual platform.

Gaseous solutions
1. What is air? Define its phase of matter and explain what it is composed of. Is it an element or a mixture of elements and/or molecules? Would you describe it as homogeneous or heterogeneous?

Air is a homogeneous mixture of many gases. Some of the gases are elements and some are molecules. For example, air contains argon, which is an element. Carbon dioxide, oxygen, nitrogen and water vapor exist as molecules in air.

2. What is smoke? Define its phase of matter and explain what it is composed of. Is it an element or a mixture of elements and/or molecules? Would you describe it to be homogeneous or heterogeneous?

Smoke is a homogeneous mixture of small particles that are created when hydrocarbons are burned, as well as water vapor and other gases, such as carbon dioxide, carbon monoxide, nitrogen oxide and so on.

3. Wildfire smoke is created from a chemical reaction. What are the typical reactants and products of the reaction?

Smoke is often generated when a hydrocarbon is burned. The general chemical reaction of hydrocarbon combustion is a hydrocarbon plus oxygen gas yields carbon dioxide and water vapor.

4. What properties of gases can be quantifiably measured? List as many as you can think of and give examples of the units of measurement associated with each.

Pressure, measured in atmospheres.
Temperature, measured in degrees Celsius.
Humidity, measured in percent.

Quantities and reactions

1. What aspects of wildfire smoke did the scientists mentioned in the article study? What were the scientists trying to determine?

Scientists measured both the types of molecules and the amount of those molecules in the smoke plume — in other words, the plume's chemical composition. Scientists were trying to determine the chemical makeup of the smoke to determine how factors such as wind patterns and proximity to city centers impact its composition.

2. According to the article, what is one gaseous chemical found in wildfire smoke that is harmful to humans when inhaled? How do scientists think the chemical is formed in wildfire smoke? Write a general chemical reaction without using chemical formulas.

Ozone is found in wildfire smoke. Nitrogen oxides plus other organic compounds found in wildfire smoke create ozone. As ozone forms, the nitrogen oxides in the wildfire smoke are used up and ozone eventually stops being created. Ozone formation could ramp up if an outside source of nitrogen oxide is introduced to the wildfire smoke.

3. Using the chemical reaction that you created in your answer to the previous question, explain why there may be higher levels of ozone in wildfire smoke over city centers.

City centers often have polluted air containing nitrous oxides. Nitrous oxides are reactants needed to form ozone. When polluted city air interacts with a wildfire plume, additional ozone is created if the other reactants are present.

Smoky implications

1. This article offers one example why measuring and understanding the gaseous chemistry of an environment is important. Explain why.

Scientists and policy makers need to know when breathing the air will be harmful to human health in order to create appropriate preventative measures and policies.

2. Why is studying wildfire smoke so difficult in the real world?

A smoke plume is not a closed system. All properties of the plume (including temperature, pressure, and so on) are constantly changing based on the location of the plume and its surrounding conditions. The composition of the plume is also constantly changing due to reacting gases within it as well as the plume interacting with air it passes through. Collecting airborne measurements poses its own set of challenges, including the cost of planes and other instruments needed to conduct this research.

3. Why would it be difficult to create a science word problem like ones found in chemistry textbooks for the creation of ozone in wildfire smoke? Why would it be difficult to check the problem's validity with real measurements?

We would have to first identify a main chemical reaction to use for the word problem. However, it would be difficult to use only one reaction because of the many reactions and changes that happen in a smoke plume. It would be difficult to check the validity with the same method that the scientists used. The plane would move through the plume collecting samples as it goes, so it would not collect samples from the same area twice. Measuring the amount of gas before and after a chemical reaction occurs this way would be nearly impossible.

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2. What is smoke? Define its phase of matter and explain what it is composed of. Is it an element or a mixture of elements and/or molecules? Would you describe it to be homogeneous or heterogeneous?

3. Wildfire smoke is created from a chemical reaction. What are the typical reactants and products of the reaction?

4. What properties of gases can be quantifiably measured? List as many as you can think of and give examples of the units of measurement associated with each.

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