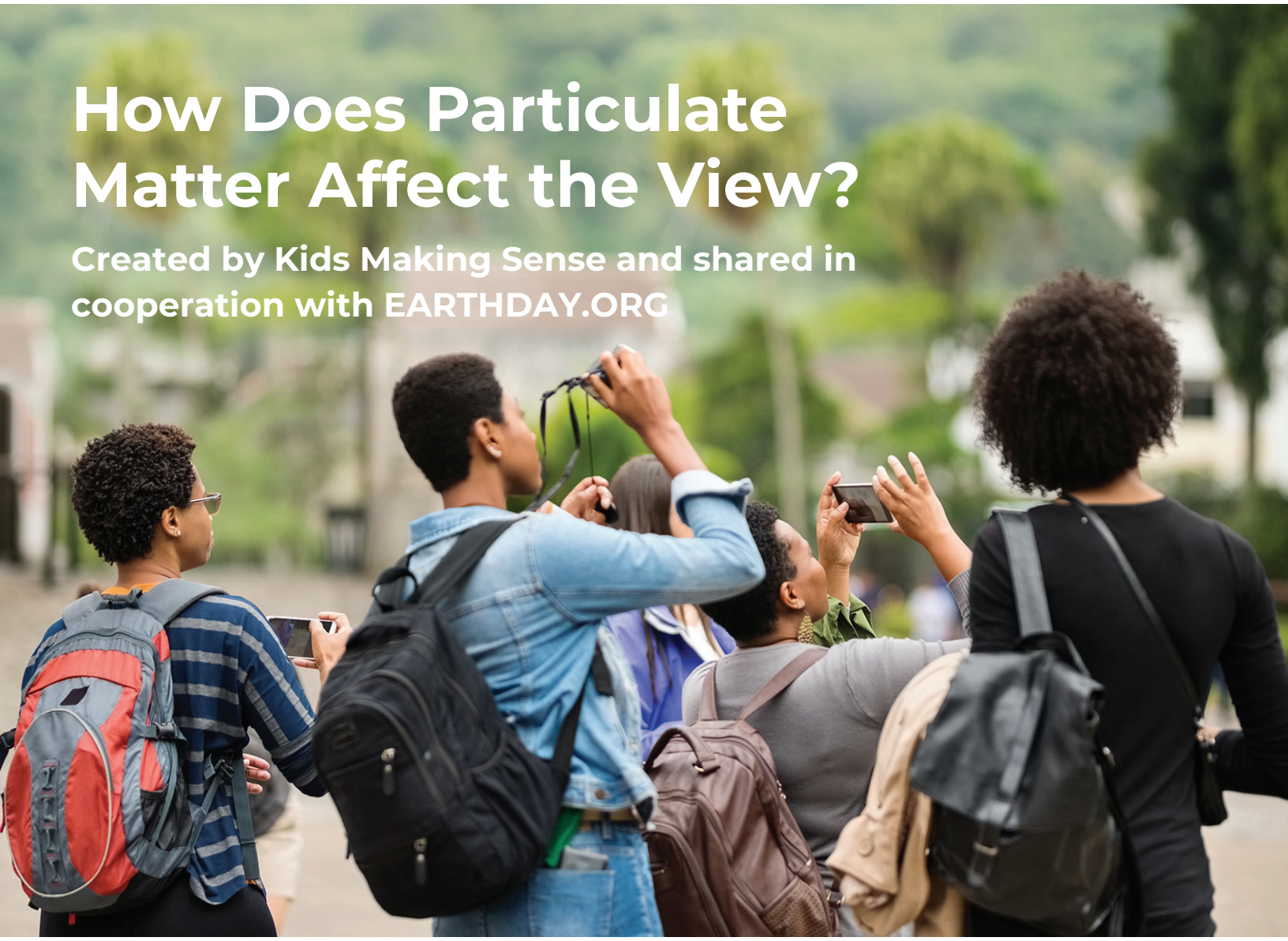
kids making sense®
OUR PLANET IS A CLASSROOM

EARTHDAY.ORG
RESTORE OUR EARTH

How Does Particulate Matter Affect the View?

Created by Kids Making Sense and shared in cooperation with EARTHDAY.ORG



Introduction

Global Earth Challenge™ is the world's largest ever coordinated citizen science campaign. The initiative works to integrate existing citizen science projects, as well as build the capacity for new ones – all as part of a larger effort to grow citizen science worldwide.

Using mobile technology and open citizen science data, Global Earth Challenge™ empowers people around the world to help monitor and mitigate threats to environmental and human health in their community.

Coordinated in partnership with **EARTHDAY.ORG**, the Wilson Center and the U.S. Department of State, Global Earth Challenge™ connects, builds and enables global communities to leverage the power of scientific research to drive meaningful change.

Within the app there is an Air Quality Widget to help document your local air quality. To do this, you will take a picture of the horizon and rate your perception of your local air quality. Next, you will receive your location's Air Quality Index (AQI) reading or a number that can inform how clean or polluted your air is. We are designing an innovative data validation method that cross-references volunteer photos with other consumer-grade and reference-grade particulate matter ($PM_{2.5}$) devices.

Your photo and associated air quality data, along with those collected from citizen science volunteers around the world, will help researchers create ways to improve the amount and accuracy of air quality data. This will further our understanding of the relationship between air quality and the health of our planet.

This accompanying lesson can be used as a pre- or post-activity to help build on the concepts of air quality and what we can all do to take action to protect our air. This lesson was created by educators and scientists at **Kids Making Sense®** as part of their middle school and high school air quality curriculum, and can be used as a supplement to help build on the concepts presented in the Global Earth Challenge™ app. This lesson includes engaging activities that explore how PM impacts visibility, and an online component that examines haze and visibility in National Parks in the United States.

If you're interested in learning more about the Kids Making Sense curriculum or hosting a Kids Making Sense workshop in your classroom or community, please visit **kidsmakingsense.org** or call 707.665.9900 for more information.

Kids Making Sense®

Over the years, several organizations have helped support the development and growth of the Kids Making Sense program by funding Kids Making Sense deployments in the United States and abroad. Sonoma Technology would like to thank the following organizations. The acknowledgement of these organizations does not necessarily constitute their endorsement of this guide.

U.S. Environmental Protection Agency Office of Air Quality Planning and Standards

South Coast Air Quality Management District

Bay Area Air Quality Management District

Coalition for Clean Air

Strategic Energy Innovations (SEI)

Maricopa County Air Quality Department

Sacramento Metropolitan Air Quality Management District

Environmental Protection Administration Taiwan

Knight Foundation

Getting Started

How to Use this Lesson

This lesson was created by educators and scientists at Kids Making Sense® as part of their middle school and high school air quality curriculum, and can be used as a supplement to help build on the concepts presented in the Global Earth Challenge™ app. This lesson is part of the larger Kids Making Sense Advanced Curriculum, which was developed for honors and AP classes. To learn more about the Kids Making Sense program, please visit kidsmakingsense.org or call 707.665.990.

This lesson contains pages for teachers (which have borders), and pages for students (which have borders). The teacher's guide section provides (1) estimated lesson time, (2) any reading or short online videos required to understand the activity, (3) pre-lab guiding questions meant to be an oral discussion and elicit interest, (4) materials needed, (5) preparatory work for each activity, and (6) the answers or suggested responses to open-ended questions.

How Does PM Affect the View?

Kids Making Sense Activity

Introduction

This activity focuses on how particles interact with light. This property of particles is what air quality sensors, like the AirBeam2 handheld sensor, use to measure particles. It is also the reason that particles cause haze and reduced visibility in the air.

Time Required

- **One 50-minute class session:**
  - Assign reading and post-reading question as homework before the class.
  - During class, discuss the pre-extension guiding questions and have students work through the National Park exercise.
- **Two 50-minute class sessions:**
  - Session 1: Pre-extension guiding question class discussion; reading and answer post-reading question
  - Session 2: National Park exercise

Learning Objectives

1. Understand how particles interact with light.
2. Understand how particles in the air lead to reduced visibility.
3. Explore / critically assess the relationship between particle concentrations and how far you can see at the National Parks.
4. Students will also work with data to
   a. Interpret a plot of visibility vs. time (post-reading question).
   b. Take data from a plot in one form, make it into a table, and then plot it and add a trend line to understand how particle concentration is related to visibility.

Materials Needed

Students will need access to a computer with internet access

Students will need access to a program like Microsoft Excel or Google Sheets

How Does PM Affect the View?

NGSS and Common Core Standard Alignment

NGSS Standards

- **HS-ESS3-5 Earth and Human Activity:** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. Performance Expectation High School (9-12)

Common Core Standards

- **CCSS.MATH.CONTENT.HSS.ID.B.5:** Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

- **CCSS.MATH.CONTENT.HSS.ID.B.6:** Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

- **CCSS.ELA-LITERACY.W.11-12.1.B:** Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level, concerns, values, and possible biases.

- **CCSS.ELA-LITERACY.RST.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Teacher/Class Demonstration

1. A useful demo for this activity is to illustrate that particles scatter light. To do this you will need a match, a clear container (such as a glass beaker or votive candle holder, preferably with a lid) and a laser pointer.

2. Shine the laser pointer through the clear container (make sure the laser will not be pointing at student's eyes while doing this).
   a. Ask students what they see.
   b. They shouldn't really be able to see much of anything. They may think they see the light because it reflects or refracts off the sides of the glass container. There may also be particles in the air that allow you to see a faint laser line.

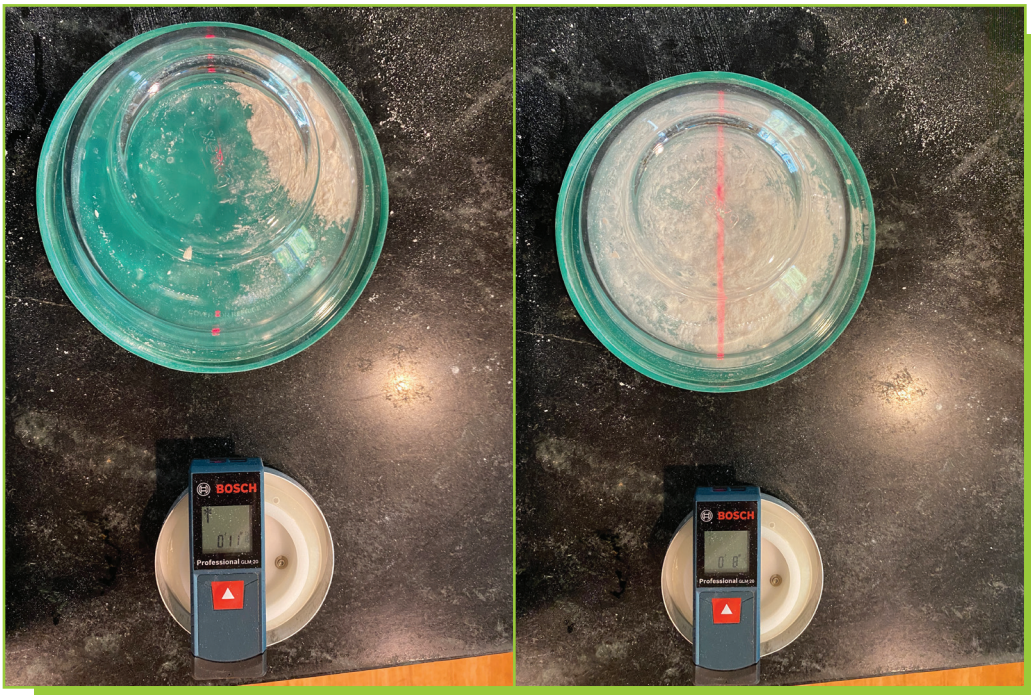
How Does PM Affect the View?

3. Now light the match and blow it out. Drop it into the glass container and close the lid.

4. Now, shine the laser pointer through the glass container again and ask students what they see. They will see a brighter laser line as the particle concentration is now higher, meaning there are more particles for the light to scatter off. When the particles scatter light, they scatter some of it toward our eyes, which is why we see the light.

   You can explain that this is the same way the AirBeam2 and other particle sensors measure particles. They contain photo-detectors that collect the scattered light and use math formulas to convert the amount of light they collect into a particle concentration.

Image of a visible and invisible/less visible laser beam.



Cautions and Adjustments

- In the optional teacher demo, be sure to blow the match out before dropping into the container.
- Caution should be used when using a laser pointer to prevent eye injury.

How Does PM Affect the View?

Required Reading and Video

- **How Air Pollution Affects the View:** *https://kidsmakingsense.org/curriculum/adv-aq/haze-brochure.*
- **Protecting our Nation's Treasured Vistas:** *https://kidsmakingsense.org/curriculum/adv-aq/treasured-vistas.*
- Students will also be accessing: *https://kidsmakingsense.org/curriculum/adv-aq/pm-estimates.*

Discussion Questions

1. In spy movies, when the hero is looking for laser beams in a room, why can't the beams be seen until something is sprayed?

   Our eyes cannot see light beams in the air unless something is scattering the light towards our eyes. Think about shining a light at night or driving with the headlights on at night. Unless there are particles, you cannot see the actual beam of light.

2. Why does spraying the air make the laser beams visible?

   Spraying the air adds particulate matter to the air. When a particle crosses into the laser beam, it scatters the light, making it visible to the eye. This is the same way the AirBeam2 and other small sensors work to measure particles (as described in the main activity).

How Does PM Affect the View?

Kids Making Sense Activity

Introduction

Light Scattering by Particles: How does it Affect the Air?

Do you know what's in the air you're breathing? Some of it is gas, and some is very small particles. Particle pollution is a complex mixture of extremely small solid and liquid components. Particles may be made of many different materials, including water vapor, organic compounds (carbon), dust, pollen, and metals. Whether it's a cloud droplet or soot from a factory, these particles will scatter light. This characteristic of particles allows us to measure particle concentrations with sensors. However, particles do not only scatter laser light - they also interact with sunlight in the atmosphere. When this happens, the air may look hazy and you cannot see as far into the distance. Another way to say this is that particles reduce visibility, or our ability to see long distances.

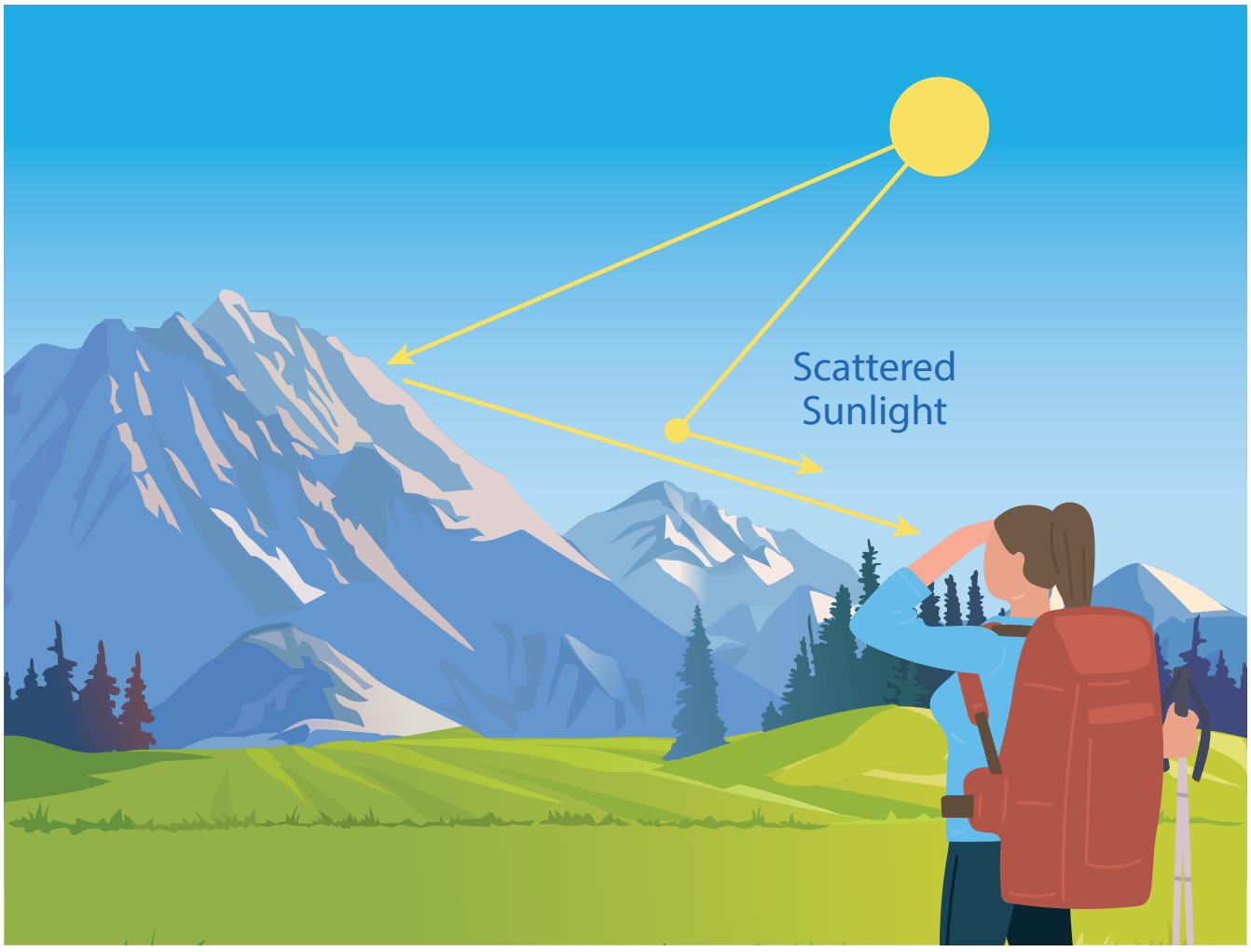
Los Angeles, California, on a clear and on a hazy day.

Particles can reduce visibility by interacting with light in the atmosphere. Depending on the characteristics of the particles, some particles may absorb light, while others scatter light. When particles interact with light in these ways, they can impact visibility by producing "haze." Haze makes the air seem less clear, affecting how far we can see and how well we can see the colors, forms, and details of scenery (see photo above). On a good visibility day, the air appears "clear" and you can see the hills in the distance, their colors, and the trees on the hills. On a bad visibility day, the air appears hazy and gray and you cannot see the hills in the distance very well—details on those hills, such as trees or other vegetation, are not distinguishable.

How Does PM Affect the View?

As you can imagine, particles that cause haze and reduce visibility can affect the experience people have at scenic places, such as National Parks. Since this is an important topic, the Interagency Monitoring of Protected Visual Environments (IMPROVE) program was started in 1985 under the Clean Air Act legislation initiated by Congress. The aim of this program is to fix existing visibility problems and preserve visibility in National Parks and Wilderness Areas. Through this program, monitoring stations across the nation monitor visibility conditions, track changes in visibility, and determine the reason for the changes.

The IMPROVE program notes, “As the result of reduced emissions due to the Clean Air Act and Regional Haze Rule, as well as the ongoing efforts of IMPROVE and other state, regional and national programs, visibility has improved dramatically in the US. However, new sources related to climate change and oil and gas development are expected to impact all aspects of air quality in the US, including visibility, and continued efforts are needed to ensure that impacts from new and existing sources are well understood and controlled.”



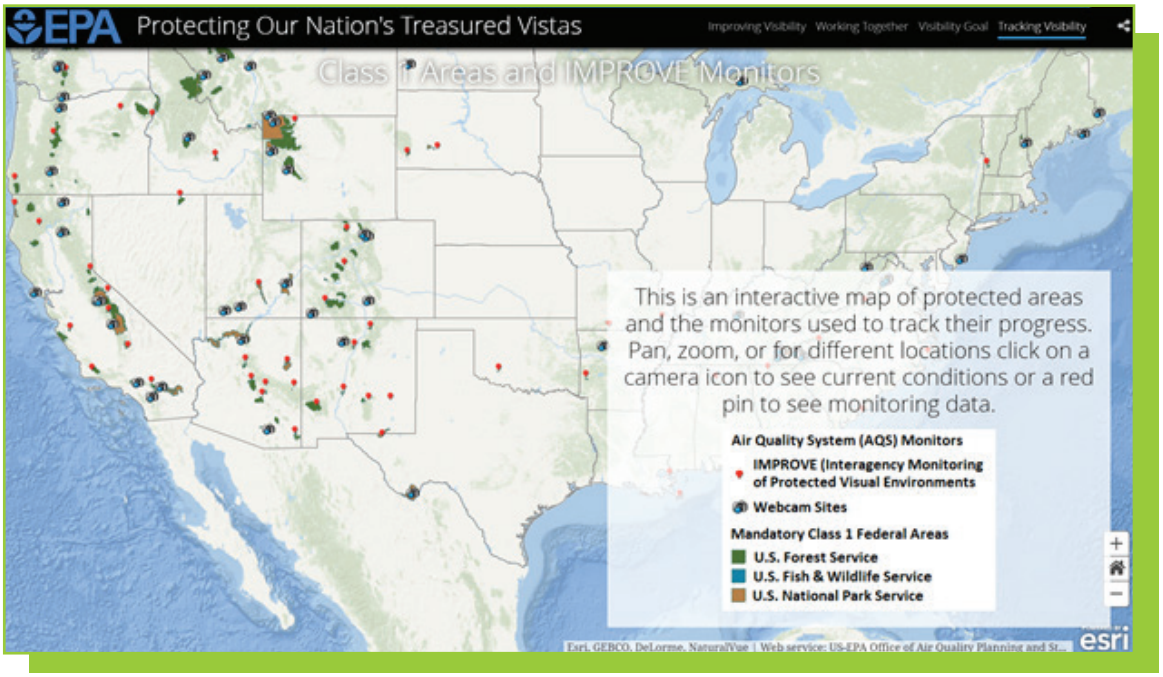
How Does PM Affect the View?

Reading List

- **How Air Pollution Affects the View:** *https://kidsmakingsense.org/curriculum/adv-aq/haze-brochure*.
- **Protecting our Nation's Treasured Vistas:** *https://kidsmakingsense.org/curriculum/adv-aq/treasured-vistas*.

Post-Reading Questions

Visit the *Protecting our Nation's Treasured Vistas* website listed above. The interactive map (you can navigate to this section by clicking the **Tracking Visibility** tab at the top of the page and then scrolling down) shows the locations of monitors across the nation that are used to determine visibility.



Click on the red marker nearest to where you live. A graph in the pop-up window should show the trends in visibility at this monitoring station over a number of years. The x-axis is the year and the y-axis shows the average visibility in miles (also known as visual range). Visual range indicates how far into the distance someone can see as the visual range.

How Does PM Affect the View?

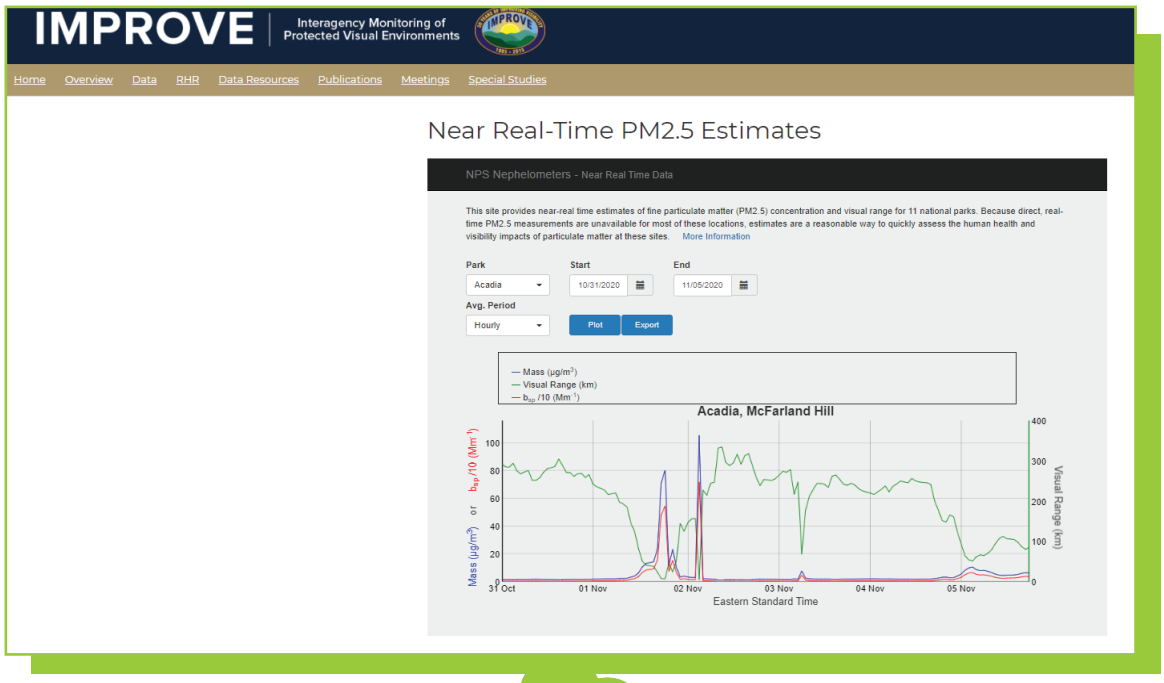
Using the plot, answer the following questions. Remember: increases in visual range means there have been improvements in visibility due to less haze.

1. Which monitoring station did you choose_____?

2. Describe the trend you see in the visibility data. Has the visibility improved over the years or has it become worse?

Comparing Particle Concentrations and Visibility at National Parks

In this section you will look at real data from the National Parks to investigate how particles affect visibility at a National Park of your choosing. Go to *https://kidsmakingsense.org/curriculum/adv-aq/pm-estimates*.



How Does PM Affect the View?

This website estimates the $PM_{2.5}$ concentration in the air and the visibility conditions (how far you can see) at different National Parks across the country. It then allows you to plot the $PM_{2.5}$ concentration data along with visibility information at the park over different periods of time. This helps you to see trends over time.

We will use the plots provided to determine the trends in $PM_{2.5}$ concentrations, the trends in visibility, and the relationship between the two.

- Choose a National Park
- Choose the date range of August 15 - August 22, 2020
- Keep the averaging period as hourly (this is the resolution of the data you will see), and click “plot”
- We will not be using the red line, so just pay attention to the:
  - **Blue line**: Estimated $PM_{2.5}$ concentration.
  - **Green line:** Visual range in kilometers. This is how far you are able to see in the current conditions at the park.

Park chosen: _____

1. Do you notice any overall trends or patterns in the $PM_{2.5}$ data?

How Does PM Affect the View?

2. As you move your cursor along the plot, the box at the top of the plot shows the date, $PM_{2.5}$, and visual range values. Using the table below, or in a separate table, record any 10 points on the plot. For each point, record the date/ time and then record the $PM_{2.5}$ concentration and visual range associated with that time point. Consider choosing a variety of points - some where the visual range is high, and some where the visual range is low.

Date	$PM_{2.5}$ ($\mu g/m^3$)	Visual Range (km)

How Does PM Affect the View?

3. Using the data from your table, create a scatter plot of the $PM_{2.5}$ vs. visual range data using Excel or similar software. Add a trend line and make sure the axes are labeled. Study your plot to make sure you understand what it is showing and the conclusion you can draw from it.

4. Using the plot you have created along with the plot from the website, describe the relationship you see between the visual range and PM2.5 concentrations. How does your plot show this relationship?

5. Explain in your own words the reason for the relationship you reported above.

6. What impact do you think rain would have on haze? What about after the rain has ended? Explain your thinking.