

OVER THE COURSE of this unit, you have learned about different aspects of Earth's weather and atmosphere. You have also learned that there is a connection between global warming and climate change. Atmospheric scientists, climatologists, hydrologists, and meteorologists all study how Earth's weather, atmosphere, and climates work. Some of these scientists also study the interactions of humans with Earth's natural systems. In this activity, you will investigate the possible connection between the population of Sunbeam City and its weather, climate, and atmosphere.

Imagine living in Sunbeam City, a rapidly growing city that has experienced population growth partly because of its sunny weather and dry climate. The economy is growing, and many people are happy with the city's growth, but some city planners are concerned. They worry that the increase in population might cause changes to the weather, climate, atmosphere, and water availability of Sunbeam City.

GUIDING QUESTION

Is the growth of Sunbeam City affecting its weather, atmosphere, and water availability?



MATERIALS

For each group of four students

- 1 Student Sheet 17.1, "Atmospheric Scientist's Report"
- 1 Student Sheet 17.2, "Climatologist's Report"
- 1 Student Sheet 17.3, "Hydrologist's Report"
- 1 Student Sheet 17.4, "Meteorologist's Report"

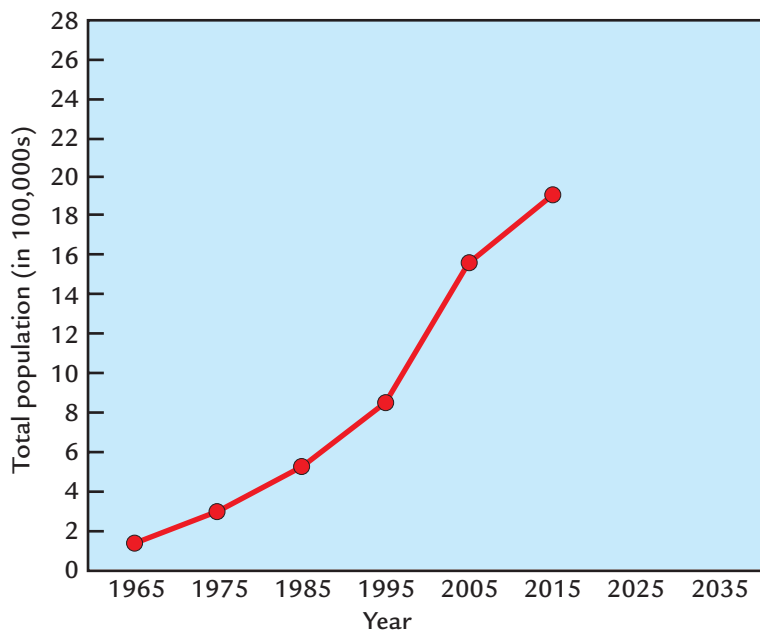
For each student

- 1 Student Sheet 2.1, "Scientific Careers in Weather"
- 1 Student Sheet 17.5, "Intra-act Discussion: People, Weather, and Climate"

PROCEDURE

1. Look at the graph below. Discuss with your group how the population of the city has changed during the past 40 years, and what you think the size of the population will be in the years 2025 and 2035.

Population of Sunbeam City



2. Each person in your group will role play a scientist studying the weather and atmosphere of Sunbeam City. Decide which person in your group will be the
 - atmospheric scientist.
 - climatologist.
 - hydrologist.
 - meteorologist.

3. Have each scientist from your group attend a “regional meeting” with other scientists who are studying the same data. At the meeting, you will receive one of the following Student Sheets:
 - Student Sheet 17.1, “Atmospheric Scientist’s Report”
 - Student Sheet 17.2, “Climatologist’s Report”
 - Student Sheet 17.3, “Hydrologist’s Report”
 - Student Sheet 17.4, “Meteorologist’s Report”
4. At the regional meeting, read the summary on the pages that follow that is most relevant to your type of scientist. For example, students who are role playing atmospheric scientists should read the “Summary of Atmospheric Pollutants in Sunbeam City.”
5. Work with the other scientists at the regional meeting, and use the information in the summary to complete your Student Sheet.

Remember to listen to and consider the ideas of other members of your group. If you disagree with someone, explain to the rest of the group why you disagree.
6. At the regional meeting, discuss the following questions with the other scientists. You will later present this information to your group.
 - What patterns do you observe in your data?
 - Do your data sets help explain why people would like to live in Sunbeam City? If so, how?
 - Compare your data to the population changes in Sunbeam City shown in the graph on the previous page. Do your data sets indicate that the weather, atmosphere, or available water of Sunbeam City has been affected by an increase in its population? If so, how?
 - What will you tell scientists from other regions about your findings?
7. Return to your group. Present the data on your Student Sheet, pointing out any patterns that you observed in the data, and state your conclusions about the relationship between Sunbeam City’s population growth and any changes in its local environment. Then listen as other group members present their data.

8. Work with your group to summarize the data by discussing the following questions:
 - Which data set(s) help(s) explain why people would like to live in Sunbeam City?
 - Which data set(s) show(s) that the weather, atmosphere, or water availability of Sunbeam City may have been affected by an increase in its population?
9. Mark whether you agree or disagree with the statements on Student Sheet 17.5, “Intra-act Discussion: People and Weather.” Predict what you think other members of your group will say.
10. Discuss the statements with your group. Have each person share their opinion about each statement, and have them explain why they agreed or disagreed.
11. As a group, brainstorm all of the possible actions that the Sunbeam City planners could recommend to city residents to reduce the possible impact of people on the city’s weather, atmosphere, and water availability.
12. Discuss the advantages and disadvantages of each option.

Summary of Atmospheric Pollutants in Sunbeam City

CARBON MONOXIDE is a colorless, odorless gas that forms during the incomplete burning of such fuels as gasoline, oil, and wood. In high concentrations, it is poisonous to humans. More than half of the carbon monoxide released in the United States is from car exhaust. In cities, 85–95% of carbon monoxide in the air may come from car exhaust. In 2015, Sunbeam City's carbon monoxide releases were greater than the concentration limits set by the U.S. Environmental Protection Agency.

NITROGEN OXIDES are gases that form from the burning of fuels at high temperatures. Most of them are colorless and odorless, but one of them—nitrogen dioxide—is a brownish gas that can sometimes be seen in a smog layer above a city. These gases can form acid rain, ground-level ozone, and other chemicals that affect human health. More than half of the nitrogen oxides released in the United States are from car exhaust. Prevailing winds can blow nitrogen oxides over long distances.

SULFUR DIOXIDE is a colorless, odorless gas that dissolves easily in water. It can be harmful to animals and humans, especially those with asthma, other lung problems, or heart disease. It forms from the burning of sulfur-containing fuels, such as coal. Sulfur dioxide can be blown over long distances, affecting air quality far from its original release.

PARTICULATE MATTER refers to microscopic particles of solid and liquid chemicals, including metals, smoke, and even soil, that float in the air. The particles are small enough that people can inhale them into their lungs, sometimes causing health problems. Some particles are released into the air from human sources such as cars, power plants, and construction sites. Other particles are from natural sources and include dust and pollen. In 2015, the concentrations of particulate matter in Sunbeam City exceeded limits set by the U.S. Environmental Protection Agency.

Release of Air Pollutants in Sunbeam City

AIR POLLUTANT	2005 RELEASE (METRIC TONS)	2015 RELEASE (METRIC TONS)
Carbon monoxide	793,225	943,680
Nitrogen oxides	132,563	143,212
Sulfur dioxide	65,816	63,466
Particulate matter	123,458	234,650

Climate Summary for Sunbeam City

Sunbeam City is located in a flat valley in the western United States. The valley is bordered on the east and west by mountains ranging in height from 610 m (2,000 feet) to 3,048 m (10,000 feet) above the valley floor. The city itself is approximately 610 m (2,000 feet) above sea level. This altitude contributes to its cooler nighttime temperatures, which can be more than 15°C (27°F) lower than daytime highs.

The prevailing winds, which are primarily from the south/southwest, can cause severe dust storms and sandstorms. Sunbeam City is 434 km (270 miles) from the ocean, but the mountains block most of the precipitation that the city might otherwise receive. Thunderstorms are rare but can occur with the arrival of a low-pressure system. Summer thunderstorms can cause flash flooding. In general, the region has a desert-like climate with very little precipitation year round.

Sunbeam City has warm temperatures and more than 300 days of sunshine per year. Skies are usually clear, without much cloud cover. In the summer, daytime temperatures exceed 38°C (100°F). During summer nights, temperatures drop into the low 20s°C (70°F). In the winter, daytime temperatures average about 16°C (60°F). During winter nights, temperatures can drop as low as 2°C (36°F).



Mean Monthly Temperature and Precipitation for Sunbeam City (1986–2015)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Temperature (°C)	9	12	16	20	25	30	34	33	28	21	14	9
Precipitation (cm)	4	9	1.0	0.4	0.3	0.2	1.0	1.0	0.6	0.7	0.9	1.3

Hydrological Summary for Sunbeam City

Historically, most of the water used in Sunbeam Valley came from groundwater—water found beneath Earth’s surface. In 1980, the city passed a law that limited the amount of groundwater that could be removed each year. Today, Sunbeam City and the surrounding area get 10–15% of their water from groundwater and 85–90% of their water from the Cross Country River. The river gets its start hundreds of kilometers away as snow melts in the high mountains. The freshwater from the river is shared with nearby states.

Sunbeam City is allowed to use 370 billion liters of water per year from the Cross Country River. The only way for Sunbeam City to get more water from Cross Country River is to regularly pay one of the other states for its share of the water.

About 65% of the water used by Sunbeam City each year is used by households. Each home uses an average of 800,000 liters per year. About 60% of this water is for outdoor use, such as watering lawns.

The remaining 10–15% of water used by Sunbeam City is mostly from groundwater. It collects from the rain and the snow that melts into the ground from the mountains surrounding Sunbeam City. It can take thousands of years for the water to travel from the mountaintops to the groundwater basin in the center of the valley, with precipitation from the mountains replenishing the groundwater at a rate of about 49 billion liters per year.

Groundwater Use Since 1945

YEAR	GROUNDWATER USED (BILLIONS OF LITERS PER YEAR)
1945	26
1955	43
1965	59
1975	110
1985	92
1995	76
2005	92
2015	83



Meteorological Summary for Sunbeam City

As the population of Sunbeam City grows, city planners and scientists wonder if it is becoming an “urban heat island.” An *urban heat island* is a city or suburban area that experiences hotter temperatures than the surrounding rural areas. Heat islands can develop as cities grow and areas of natural vegetation are replaced by concrete sidewalks, roads, and buildings. Buildings and roadways absorb more of the sun’s energy and can result in an increase in local

surface and air temperatures. The U.S. Environmental Protection Agency reports that urban areas can be anywhere from 1°C (2°F) to 6°C (11°F) warmer than surrounding rural areas.

The following temperature data sets were collected for Sunbeam City as well as for the surrounding rural area to determine if the growth of the city is affecting its mean temperature.

Mean Monthly Temperature (°C) in Sunbeam City

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1961–1975	7	11	10	17	23	29	33	30	26	16	8.5	8
2001–2015	9	13	16	20	26	30	34	33	29	22	14	10

Mean Monthly Temperature (°C) in Rural Areas Outside Sunbeam City

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1961–1975	7.5	11	12	16	22	29	33	29	25	17	12	7
2001–2015	10	13	16	19	25	30	34	32	28	20	14	10

ANALYSIS

1. Would a weather map provide more evidence about a possible relationship between population growth and changes in the weather and atmosphere of Sunbeam City? Explain why or why not.
2. Based on the evidence in the scientists' reports, is there any possible relationship between population growth and the weather, atmosphere, or water availability of Sunbeam City? Support your answer with evidence from this activity and this unit.
3. What do you think the people of Sunbeam City could do to reduce the possible effects of population growth on their weather, atmosphere, and water availability? Make a recommendation to Sunbeam City's residents, explaining what you think should be done and why. Be sure to support your recommendation with evidence and identify the trade-offs.
4. In this unit, you have learned about global climate change and what the possible effects on Earth's climate could be.
 - a. What do you think might be happening to Sunbeam City's climate?
 - b. What do you predict will happen to Sunbeam City's climate in the future? Explain.
 - c. How certain are you of your prediction? What would make you more certain?
5. **Reflection:** In this unit, you learned about weather-related careers and the kind of work that scientists in these careers do. Which of these careers is most interesting to you? What kinds of scientific questions or issues would you be most interested in investigating? Why?

EXTENSION

Find more information about the weather-related career of your choice. You may want to investigate the type of education, training, and salary associated with this career. Begin by going to the *SEPUP Third Edition Weather and Climate* page of the SEPUP website at www.sepuplhs.org/middle/third-edition for career-related links.