
Climate Change Beyond Borders

Bilingual Lesson Plans for the Binational Santa Cruz Watershed

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Subject Areas

Science, Social Studies, Language Arts, Math, Art.

Grade Level

Adaptable for 4th-8th Grade. Fits with Arizona Standards for Grade 4 Science & Social Studies.

Summary

The students will learn about climate change through interactive activities that emphasize questions, discussions, group work, and problem solving. The lesson plan contains five activities, each of which could take one to two hours. The activities build on each other and are best done in consecutive order; however, the activities could be done exclusively. The lessons are geared towards students that living in Southern Arizona and Northern Sonora, with case studies specific to the Santa Cruz Watershed. The lessons are also meant to increase the awareness of the regional nature of these issues, and therefore they include activities about the U.S.-Mexico border area.

Goal

To explore the concept of climate change and climate variability and examine the social and environmental consequences of climate change.

Objectives

Students will be able to:

- Demonstrate an understanding of climate change terminology
- Distinguish between local climate and weather
- Understand the meaning of average climate data by calculating average temperatures
- Explain the meaning of climate change, global warming, and the greenhouse effect
- Describe human's contribution to global warming and devise ways to reduce greenhouse gases on the local scale
- Demonstrate an understanding of different points of view regarding climate change
- Explain the concept of adaptation to climate change and compare the adaptations of plants, animals, and humans to climate change

Important Vocabulary

(All these terms are defined within the text of the curriculum)

- Climate
- Weather
- Climatic variability
- Paleoclimatology
- Dendrochronology
- Climate change
- Global warming
- Greenhouse gases
- Adaptation

Homework

If the lesson plan is followed over the course of one or two weeks, homework related to the unit can be completed in a *Climate Change Journal*. The entries in the Climate change journal will consist of homework and in-class activities. In addition, have the students create a section in their journal for weather observation. For the weather observation, have the students would write a short observation on local weather conditions each day and the weather's impact on human activities. At the end of the unit, students will hand in their climate log for teachers to evaluate their work.

<i>Climate Change Journal Evaluation Matrix</i>		
<i>Assignment</i>	Description for Evaluation	Maximum Points
<i>Activity 1, homework</i>	Must have weather observation entry for every day during climate change unit. Should include daily observed weather and daily impacts of weather on humans.	50 points
<i>Activity 2, homework</i>	Written summary of weather report viewed from media. Should include reported high and low temperatures and average high and low temperatures. Should include their explanation of average weather.	10 points
<i>Activity 2, in class</i>	Answers to questions 1 - 6. If done on worksheet, have students staple worksheet in journal. Answers in box, pg. 8	5 points
<i>Activity 3, homework</i>	Response to climate change article. Should include 2 important facts and 2 questions.	10 points
<i>Activity 3, in class</i>	Entry on 3 ways to reduce human emissions of greenhouse gases	5 points
<i>Activity 4, homework</i>	Climate change/global warming billboard. Look for creativity and if it serves an educational purpose.	10 points
<i>Activity 5, homework</i>	One page entry on how climate change would affect their family. Look for understanding of the concept of climate change (not to be confused with impacts of weather).	10 points
<i>Activity 5, in class</i>	One to two paragraph response to: Do you think it is easier for humans to adapt to climate change or for plants and animals to adapt to climate change? Why?	10 points
<i>Participation</i>	Participation in group activities and class discussions	10 points
<i>Total Points</i>		120 points

Arizona Standards

Science, Grade 4

Strand 3: Science in Personal and Social Perspectives

Concept 1: Changes in Environment

PO1: Describe how natural events and human activities have positive and negative impacts on environment (e.g., fire, floods, pollution, dams)

PO2: Evaluate the consequences of environmental occurrences that happen either rapidly (e.g., fire, flood, tornado) or over a long period of time (e.g., drought, melting ice caps, the greenhouse effect, erosion)

Strand 6: Earth and Space Science

Concept 2: Earth’s Processes and Systems

PO6: Analyze evidence that indicates life and environmental conditions have changed (e.g., tree rings, fish fossils in desert regions, ice cores)

Concept 3: Changes in the Earth and Sky

PO3: Differentiate between weather and climate as they relate in the southwestern United States

PO6: Compare weather conditions in various locations (e.g., regions of Arizona, various U.S. cities, coastal vs. interior geographical regions)

Social Studies, Grades 4-5

Standard 3: Geography

3SS-E2: Describe the impact of interactions between people and the natural environment on the development of places and regions in Arizona, including how people have adapted to and modified the environment, with emphasis on:

PO2: how places are connected by movement of people, goods, and ideas, including the connection of Mexico to Arizona

PO4: how people have depended on the physical environment and its natural resources to satisfy their basic needs, including the consequences of Arizonans’ adaptation to, and modification of, the natural environment

Additional Sources of Information

For Teachers	
CLIMAS (Climate Assessment for the Southwest)	http://www.ispe.arizona.edu/climas/
EcoHealth	http://ecohealth101.org/
Global Warming and Climate Change Resources	http://www.istl.org/01-fall/internet.html
U.S. Global Change Research Information Office	http://www.gcric.org/edu/
Udall Center – Environmental Research on the U.S.-Mexico Border Area	http://udallcenter.arizona.edu/
SAHRA (Sustainability of Semi-Arid Hydrology and Riparian Areas)	www.sahra.arizona.edu/newswatch/index.html
University Corporation for Atmospheric Research (UCAR), Introduction to Climate	http://www.ucar.edu/learn/1_2_1.htm
For Students	
UCAR – Kids Crossing	http://www.eo.ucar.edu/kids/green/index.htm
EPA Global Warming	http://www.epa.gov/globalwarming/kids/gw.html
Global Warming: Focus on the Future	http://globalwarming.enviroweb.org
Related Curriculum	
Project WET	http://ag.arizona.edu/AZWATER/wet/
SCRIBE (The Santa Cruz River, Its People and Environment)	http://www.sccedu.org/scribe/
GeoMath and Geoliteracy - Created by the Arizona Geographic Alliance	http://alliance.la.asu.edu/azga/

Activity 1: Knowing Your Local Climate

Estimated Time	One and a half to two hours
Homework	Ask the students to observe the weather conditions every morning and every evening and write their observations in their climate change journal. Each time the student should record how the weather conditions affect his/her activities or those of his/her family.
Materials Provided	Descriptions of the Seasons of Arizona (p. 18)
Objective	Distinguish between local climate and weather

Step 1

Assign five students to represent each of the five seasons of Arizona (fall, winter, spring, dry summer and summer monsoon). Give each student a description of a season, which is provided at the end of the packet (pg. 18). Have each student read the description of their season out loud to the class, without telling the class which season they represent. Then have the class guess what season they are describing.

Step 2

After the students have guessed all the seasons, divide up the students into groups for each season. Provide a large sheet of paper or poster board and have the students create an illustration to represent their season. Have each group share their illustration with the class.

Step 3

Now explain the concept of climate to the students. Explain that the seasons, as seen on the posters, represent the climate of Arizona. The seasons represent a period of time during the year that is characterized by certain trends in weather. Each season describes the climate of an area. **Climate** describes the conditions of temperature, rain, wind, etc. over a long period of time in a given area. The climate includes average conditions, regular weather patterns, and infrequent events such as hurricanes or floods.

Step 4

Now teach the students the concept of weather. **Weather** describes the observed conditions of temperature, rain, wind, etc. You determine the weather by looking outside or listening to the news. Go over terms like high temperature, low temperature, wind, precipitation, and humidity. Show the students samples of local weather reports from newspapers or the internet. You could also show a weather report that has been taped from a news station. Weather describes daily details, whereas climate describes long-term patterns.

Step 5

Have the students in each season group write a 'weather report' appropriate for their season. For example, have each student in the winter season write their own weather report that includes temperature high and lows, wind, precipitation, and humidity. Have each student write their own weather report on an index card. Have some of the students from each group share their weather report. Then have the students staple their index cards around the outside of their season poster.

Step 6

Use the posters with the season illustrations and the weather reports to reiterate the difference between climate and weather one more time. Explain that the weather reports give specifics on daily weather – conditions that change every day. The details of the weather reports create the patterns and trends that make a season and the seasons make up the climate.

Activity 2: What Is Average Climate Data?

Estimated Time	One to one and a half hours
Homework	Have the students find the weather report in the newspaper, internet, or TV from the previous day. Have them find out the high and low temperature recorded for that day. In addition they should find out what the average high and low temperatures are for that day. Have them summarize this information in their journal and then write a short paragraph explaining what they think average weather means.
Materials Provided	Tucson Climate Data worksheet (pgs. 19-20)
Materials Needed	Calculators, pictures of tree rings: http://www.ltrr.arizona.edu/ and ice cores: http://www.ncdc.noaa.gov/paleo/education.html
Objective	Understand that climate is variable by calculating average temperatures

Step 1

To start, discuss the following questions with the students:

- What does average temperature mean?
- How do you think average temperatures are found?
- Do you think it is normal for temperatures to be different than the average temperature? Why?

Step 2

Put the students in pairs to figure out how average temperatures are determined. Have them calculate the average maximum temperature and average minimum temperature for the four different groupings of years given below. Give them a copy of the handout *Tucson Climate Data* (handouts included at the end of the packet) or write the information on the board from the worksheet.

The data given in the Tucson Climate Data Worksheet is from the National Climate Data Center (<http://cdo.ncdc.noaa.gov/CDO/cdo>). The data on the worksheet goes up to 2004, so if you would like to supplement with current data, you can find data on the website.

*If the students are not proficient in finding averages, review this mathematical concept with the whole class. Do some of the work on the board in front of the whole class. Have the students find averages for only the two and five year groupings, instead of all the year groupings.

Have the students calculate the following:

The average maximum temperature on February 1st in Tucson for the following time periods:

- 2003-2004 (answer: 69)
- 2000-2004 (answer: 65.6)
- 1995-2004 (answer: 66.9)
- 1975-2004 (answer: 65.6)

The average minimum temperature on February 1st in Tucson for the following time periods:

- 2003-2004 (answer: 45.5)
- 2000-2004 (answer: 39.6)
- 1995-2004 (answer: 42.1)
- 1975-2004 (answer: 43.4)

Step 3

Have the groups discuss and write down answers to the following questions in their *climate change journal* (Questions included on handout or write on the board)

- 1) Did the average change with each group of years?
- 2) Which group of years do you think would be the best to use for an average? Why?
- 3) From the maximum temperatures given over the 30-year period, what are the highest and lowest maximum temperatures? What is the difference between the highest and lowest temperatures?
- 4) From the minimum temperatures given over the 30-year period, what are the highest and lowest minimum temperatures? What is the difference between the highest and lowest temperature?
- 5) Using the 30 year average for maximum temperature (66) and the minimum temperature (43), how many times were the maximum and minimum temperatures from 1975 to 2004 the same as the average?
- 6) Questions 3 and 4 shows that there is a wide range of maximum and minimum recorded temperatures on February 1st. Question 5 shows that the maximum and minimum recorded temperatures are rarely the same as the average temperature. Based on this information, do you think it is normal for temperatures to vary from year to year?

Answers:

- 1) Yes
- 2) 1975-2004. The 30 years of data is best because it more accurately reflects year-to-year changes in temperatures.
- 3) Highest: 84, lowest: 44, difference: 40
- 4) Highest: 56, lowest: 28, difference: 28
- 5) Maximum: none, Minimum: twice
- 6) Yes.

Step 4

Now explain the concept of climate variability. **Climate variability** refers to the normal variations in climate, like when variables such as temperature and precipitation depart from the average.¹

¹ From 'Climate Variability' available at www.ucar.edu/learn/1_2_2_9t.htm.

Show how this activity illustrates variability within a climate. When the students calculated the average, they could see that the maximum and minimum temperatures changed every year. Some years were above average, and some years were below average. Therefore, within the climate there is a range of possibilities in temperatures, precipitation, wind, humidity, etc.

Explain to the students the importance of understanding the concept of climate variability to understand climate change. Students must understand that variations within the climate are normal. There are changes from year to year, decade to decade, and in longer periods like 30 to 50 years. The climate is stable if long-term averages do not change substantially. Climate change occurs when there is a steady increase or decrease in the average value.²

Extension Activity

Explain that weather has only been recorded for about the last 130 years. This is called instrumented data. To determine climate before the time of instrumented data, climate is determined by other methods referred to as **paleoclimatology**. Paleoclimatology is the study of past climates, before recorded climate data.

Ask the students to brainstorm how you might figure out climate data before instrumental recordings. After brainstorming, explain the concepts of tree ring data and ice cores. Show them pictures of tree rings and ice cores. The study of tree rings is known as **dendrochronology**. The study of past climate through studying tree rings is called **dendroclimatology**. There is a lot of dendrochronology work done on the University of Arizona Tree Ring Lab. Their website is: <http://www.ltrr.arizona.edu/>. They provide information and activities for students and educators on their website.

Activity 3: What are Climate Change and Global Warming?

Estimated Time	One and a half to two hours
Homework	Have the students read an article on climate change/global warming. In their climate change journal, they should write down two important facts they learned from the article and two questions. There are links to news articles on various websites like Ecohealth: http://ecohealth101.org/news/news.html and http://www.isl.org/01-fall/internet.html#news . Pick out an article that you think the students would enjoy.
Materials Provided	Climate Change & Global Warming handout (pgs. 21-23)
Objectives	Learn the meaning of climate change, global warming, and the greenhouse effect. Understand human's contribution to global warming and devise ways to reduce greenhouse gases on the local scale.

² From 'Climate Variability' available at www.ucar.edu/learn/1_2_2_9t.htm.

Step 1

After completing activity 1 and 2, the students should understand their local climate and the concept of average climate data. Now have the students explore the concept of changing climate. Write **climate change** and **global warming** on the board. Ask the students to describe what these terms mean. After some discussion, give the definitions of climate change and global warming. Definitions are given in the blue box below.

Step 2

Now give the students the handout *Climate Change and Global Warming*. Have students take turns reading aloud the handout.

Step 3

Ask the students the following questions to generate discussion. The discussion will reinforce concepts from the handout.

- Is climate change and global warming natural, human-caused, or both?
- How are greenhouse gases related to global warming?
- How do humans contribute to global warming?
- What are the impacts of climate change on humans?

Step 4

After the discussion, read the following case scenario about greenhouse gases to the class.

Climate change is when long-term patterns of weather shift. A long-term decrease in temperature, a long-term increase in temperature, or a change in precipitation patterns are all examples of climate change. **Global warming** is one type of climate change characterized by a general warming in the Earth's average temperatures. Scientists agree that the Earth is currently in a state of global warming. Some of the debate about global warming is related to the cause of warming and to what degree humans are causing global warming. One cause of global warming is the increase in **greenhouse gases**. Greenhouse gases, such as carbon dioxide and water vapor, are found in the atmosphere and keep heat waves from escaping the earth. Greenhouse gases exist naturally, however human activities are increasing the amount of greenhouse gases in the atmosphere. The burning of fossil fuels is the largest source of greenhouse gases.

Greenhouse Gas Scenario I: Crossing the Border in Nogales

The towns of Nogales, Arizona and Nogales, Sonora are located on the border between the U.S. and Mexico. There are two main highways that cross the border. Many people cross the border for many reasons like to visit family, to go shopping, to take a vacation, for educational purposes, and for work. At these border crossings, there are a number of security checks. There are security checks for all people, vehicles, and trucks crossing the border. If you have ever crossed the border, you might know that it can take up to 2 hours to cross the border from Mexico into the U.S. There is always a long line of cars sitting at the border with the engines running, just waiting to cross. This is a large source of the carbon dioxide, which is a greenhouse gas! The pollution from cars is very bad for the air quality in the cities on both sides of the border. What could be done to reduce air pollution at the border crossing?

Greenhouse Gas Scenario II: Transportation in Tucson

The urban city of Tucson has many people that get around by car. There is substantial traffic and air pollution, like carbon dioxide, from all the cars. Tucson does have a bus system, with buses that run every half an hour. There are some bike lanes in Tucson, mostly in central Tucson around the University area. There is little in the way of bus and bike infrastructure on the outskirts of town. There are no train or light rail systems in the city. Urban planners in Tucson want to improve transportation in Tucson and reduce air pollution. To reduce air pollution and traffic, urban planners want to encourage Tucson residents to use public transportation like buses or ride their bikes. What could be done to reduce the amount of people driving their own car in Tucson?

The Changing Climate of the Santa Cruz Watershed (Background information for Activity 3)

Climate changes in the Southwest are evident through tree ring studies and archeological evidence. The migration and ‘disappearance’ of ancient indigenous groups in the Southwest also suggest changes in climate. Semiarid conditions in the Santa Cruz watershed have been prevalent in the last 6,000 to 8,000 years. Prior to that, the area was cooler and wetter during the period known as the last Ice Age. The area experienced heavier rains during the winter months. Wetter conditions created a river that was different from the one we know today. The stream was meandering or braided and was likely more broad and shallow. Wetter conditions also created lush grasslands and more trees and shrubs at lower elevations. The grassy plains and tree covered slopes provided ideal habitat for a number of grazing animals such as bison, ground sloths, camels, horses, and mammoths. The first humans of the area, known as Paleo-Indians, came into the area to hunt the big game animals. As the last Ice Age ended, dryer warmer conditions prevailed. During this climatic transition, large mammals disappeared from the area. Scholars believe large mammal populations were stressed by hunting and/or climatic changes. The populations may have gone extinct, or the herds migrated to more favorable conditions. When the mammals left, the human populations also abandoned the region. The Santa Cruz River also changed with drier conditions. The stream transformed to a slow meander, with cienegas and dry stretches. From the archeological evidence in the Santa Cruz watershed, we can see that climate change creates changes in plants, wildlife, streams, and human habitation.

Logan, Michael. 2002. *The lessoning stream: an environmental history of the Santa Cruz River*. Tucson: University of Arizona Press.

Step 5

Now have the students get into two groups to discuss possible solutions to Greenhouse Gas Scenario I and II. Have them write a plan to reduce air pollution either at the border or in Tucson. Their plan should include three substantial steps to reduce air pollution from cars. Have the students write their plan as an entry in their *climate change journal*. Then have each group share their solutions with the class.

Activity 4: Community Perspectives on Climate Change

Estimated Time	One and half hours
Homework	Have the students design an illustration for a billboard that would educate people about climate change and global warming. The billboard design can include both pictures and words. The students can create a small version of the billboard that would fit on a sheet in their climate change journal.
Materials Provided	Descriptions of Community Members (p. 24)
Objective	Demonstrate an understanding of different points of view regarding climate change

Step 1

Students will role-play as different members of a local community that is concerned about climate change and global warming. Assign a group of students to role-play as each of the following community members. Give each group a description of their community members to better understand the perspective they represent (find descriptions on pg. 24).

- Farmers
- City officials
- Conservation group
- Industry group
- School teachers
- Business owners

Step 2

Once in their respective groups, the students will decide why they are concerned about global warming and how it would affect them. They will come up with two facts about climate change/global warming that they think are important from their perspective. Then they will make three suggestions about how to deal with these changes.

Step 3

Have each group (farmers, city officials, etc.) create a poster to educate their community about global warming. The poster will include: 1) why their group is concerned about global warming 2) two important facts about global warming and 3) suggestions to deal with global warming.

Step 4

After the posters are complete, have each group present their poster to the class in a ‘town hall’ style meeting. Each group can role-play using hats, name tags, or other props that indicate who they represent.

Activity 5: Adaptations to Changing Climate

Estimated Time	One to two hours
Homework	Have the students write a one page entry in their climate change journal to the following question: How does climate affect the lives of humans? The students should pick one example of a change in climate and how it would affect their family. The students may ask a family member for help on this question. Make sure the students are clear on the difference between weather and climate for this activity.
Materials Provided	Water Connections Handout (pgs. 25-26)
Objective	Explain the concept of adaptation to climate change and compare the adaptation of plants, animals, and humans to climate change

Step 1

Give the students the *Water Connections* handout. The handout includes the questions and discussion points as given below. Explain that the Santa Cruz River is found in southeast Arizona and northern Sonora and is a major source of water in this area. Explain in what way the Santa Cruz River provides water for your hometown (if applicable). *This activity could also be adapted for the San Pedro River, also found in southeast Arizona and northern Sonora.

Step 2

Use the illustration to describe how the plants, animals, people, and industry in Southeast Arizona all rely on water. Discuss the relationships of the plants, animals, people, and industry within the Santa Cruz River environment. Use the following questions to guide your discussion. Ask the students for their ideas, and then add to the discussion with the points given in the box below.

1. How does wildlife depend on the Santa Cruz River environment?
2. How do plants depend on the Santa Cruz River environment?
3. How do the ranchers and farmers depend on the Santa Cruz River?
4. How does industry depend on the Santa Cruz River?

Discussion Points for Step 2

1. The Santa Cruz River provides a habitat with abundant water and plants in comparison with surrounding desert habitat. The river itself provides a habitat for species of fish, frogs, and many insects. The river provides drinking water for larger animals like deer and coyotes. The river habitat provides food and shelter for many species. Many bird species thrive in river ecosystems. The Santa Cruz River is known as an important habitat for birds migrating north and south.
2. Since more water is available in river habitats, plants grow more abundantly here. There are different plants than those found in the desert. Trees such as cottonwoods, willows, and walnuts thrive here. Mesquite trees grow abundantly in the upper river ecosystems. The plants close to the river depend on both surface and ground water. Surface water also brings nutrients to the plants.
3. Ranchers depend on the river as a source of water for their cattle. Farmers depend on surface and groundwater to irrigate their crops. Farmers and ranchers use the floodplains (the low-lying flat land near the river) of the Santa Cruz River to grow crops or grow food for the cattle. Ranchers depend on the surface and groundwater of the river to grow the food for their cattle.
4. Industry depends on the water of the river to perform different operations. Running water can be used as power, and water is often used as coolants. Water can be used in mines to process ores. Industries use a steady water supply just to perform daily operations in their plant.

Step 3

Now read the following scenario of climate change to the students. After reading the scenario, explain to the students that a change of 3 degrees in 50 years is a big change! Tell them that average temperatures change very slowly over time.

The example below is just one possible scenario of climate change in Southeastern Arizona. Other possible climate change could be: more weather extremes such as drought and flooding, increasing temperatures leading to more precipitation that falls as rain rather than snow, earlier melting of snowpack, or more winter rains and less summer rains.

Climate Change in Southeastern Arizona

Imagine that over the next 50 years the average temperature increases by 3 degrees Fahrenheit in Southeastern Arizona. Along with the change in temperature, the precipitation changes. There is less rain in the winter, although the summer rain stays about the same. Overall the yearly average rainfall is 9 inches instead of 14.3 inches. As these hot, dry conditions continue, there is less water going into the Santa Cruz River. These conditions are no longer favorable to some of the plant and animal communities in the surrounding area. What will happen?

Step 4

Use the following questions to lead a discussion with the students regarding the climate change scenario. If the students do not have the handout, write them on the board to guide the students.

1. Who will be affected by the climate change first – the plants, animals, or people?
2. Can the plants survive the changes in climate? Can they survive a long-term shortage of water? Can they move to a better climate?
3. Can the animals survive the changes in climate? Can they move to a better climate?
4. Will the farmers and ranchers be affected by the changes in climate? How will they respond to the climate changes?
5. What will happen to the industries? How will industry respond to a shortage of water?

Discussion Points for Step 4

1. If there is a shortage of water, the wildlife and plants (the river environment) will be affected first by the shortage. The wildlife and plants of the Santa Cruz River have no guaranteed water supply. The river ecosystem has no legal rights to the water, so human uses will have first priority.
2. If there is less water over a long-period of time, the plants will probably die off. With less surface and groundwater, the plants that depend on this water will not be able to survive. The temperatures may also be too hot for certain plant species to survive. Plants can move very slowly through seed dispersion, but these climate changes may occur too fast for the plants to adapt. As these plants die off, different plants will start to grow in the area.
3. The animals that live in the river may not survive either, if the river does not maintain a constant flow. Fish species may disappear. Snakes, frogs, and insects that depend on the river ecosystem may disappear. Migrating bird species that depend on the river environment will try to find another habitat to migrate to. For the most part, species that live in the river habitat will not be able to adapt to these rapid climate changes, and they will not survive. Those species that are more mobile, like birds and large mammals will seek out similar habitats elsewhere, which are limited in Arizona.
4. Ranchers will be negatively affected by the shortage of water. Less rainfall will mean the grasslands will be in poor condition. This will be difficult for the rancher, because the rancher will have to buy additional food for the cattle. With the expense of buying food, ranching may no longer be profitable. It is more likely that ranchers will sell their land and find different jobs, than move somewhere else to practice ranching. Farmers will also be hurt by the shortage of water. It may become more expensive for farmers to use groundwater to irrigate their crops. Farmers may turn to crops that require less water, or they may decide to sell their land. Changes in temperature may also affect what crops they can grow. If farming becomes too expensive, the government may decide to decrease the cost of water for farmers.
5. Industries will probably not be affected very much by the climate changes. If water becomes more limited, it may become more expensive, which will make operations more expensive. Unless the industry relies heavily on water, it will probably not be affected, and it will maintain its normal operations.

Step 5

Now discuss the concept of adaptation with the students. **Adaptation** is a concept with different meanings depending on the context in which it is used. Adaptation will have different meanings

for humans, animals, and plants. You may want to focus on a particular meaning on adaptation depending on what subject you are teaching. Give some examples of adaptations that could occur in SE Arizona.

Human Adaptations to Climate Change

(Corresponds with Step 5)

Humans are always adapting to changes in their local climate. Finan et al. (2002) explains the concept of adaptation as follows, “If climate vulnerability is an undesirable state of risk faced by an individual or group, adaptation can be seen as the sets of system changes, or behavioral responses, that seek to diminish this vulnerability.”

Ideally, the adaptation would reduce human’s vulnerability over the long term. Unfortunately, adaptations can be short term responses that may backfire in the long term. For example, in a time of drought, a city may draw additional water supplies out of an aquifer. If the city draws too much water, they may jeopardize future water supplies and cause detrimental drops in the water table. A more sustainable adaptation might utilize conservation measures that would reduce the demand on water. The second adaptation requires more planning and lifestyle changes, so it will be more difficult to implement in the short term.

There are many factors that affect the ability of a person or group to adapt to climate changes such as financial resources, access to information, outside aid, and cultural practices. A person or group may not be able to change their lifestyle if they do not have the resources to do so. For example, think about the victims of a flood or hurricane who rebuild their home in a place that is vulnerable to these type of events.

Finan, T.J., West, C.T., Austin, D. and McGuire, T. 2002. Processes of adaptation to climate variability: a case study from the US Southwest. *Climate Research* 21, 299-310.

Here are some websites that provide additional information on the subject of adaptation to climate change:

<http://www.ispe.arizona.edu/climas/learning.html> on southwest climate

<http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewwest.htm>

<http://www.epa.gov/globalwarming/kids/index.html>

<http://yosemite.epa.gov/oar/globalwarming.nsf/content/VisitorCenterEducators.html>

Step 6

As a final wrap up question, have each student write a paragraph in their *climate change journal* in response to the following question: Do you think it is easier for humans to adapt to climate change or for plants and animals to adapt to climate change? Why?

Worksheets and Handouts for Climate Change Lessons

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Activity 1: Seasons of Arizona

This season is characterized by moderate temperatures. The temperatures are warm during the day and cool at night. There is the potential for rain during this season, however this season is not known for rain. Deciduous trees, like cottonwoods and aspens, begin to lose their leaves, and wild grasses dry out.

Fall (mid-September – November)

This season has the coldest temperatures of all the seasons in Arizona. This season is known for low-intensity rains that are widespread and longer in duration. The rain in this season is a major source of groundwater recharge. During this season, it rains at lower elevations and can snow at high elevations like in the mountains.

Winter (December & January)

This season is characterized by moderate temperatures. If there was average or above average rainfall in the previous season, the landscape will be green with beautiful wildflower blooms. This season is also known for gusty winds.

Spring (February – April)

This season has the hottest temperatures of the year. It is very dry during this season, and it is unusual for rainfall to occur. At this time of the year, plants are trying to conserve energy until the next rains come.

Dry Summer (May & June)

This season has warm temperatures and high humidity. It is known for big cloud buildups and intense rainfall in short periods of time. Lightning and thunder frequently occur along with gusty winds. During this season, if there is a lot of rain, the landscape will become very green.

Summer Monsoon (July to mid-September)

Tucson Climate Data: What is Average Weather?

The following data is the recorded climate data at a weather station located at the University of Arizona. The data shows the maximum temperature and the minimum temperature for February 1st over a period of 30 years.

Month/Day/Year	Max Temp (F)	Min Temp (F)
2/1/1975	63	40
2/1/1976	78	42
2/1/1977	70	39
2/1/1978	67	51
2/1/1979	61	42
2/1/1980	74	53
2/1/1981	58	36
2/1/1982	58	38
2/1/1983	58	39
2/1/1984	73	50
2/1/1985	44	28
2/1/1986	64	55
2/1/1987	68	42
2/1/1988	62	47
2/1/1989	70	54
2/1/1990	54	41
2/1/1991	77	51
2/1/1992	74	56
2/1/1993	65	43
2/1/1994	60	33
2/1/1995	77	44
2/1/1996	63	52
2/1/1997	73	45
2/1/1998	64	43
2/1/1999	64	39
2/1/2000	65	41
2/1/2001	61	35
2/1/2002	64	31
2/1/2003	84	49
2/1/2004	54	42

Data from the National Climate Data Center (<http://cdo.ncdc.noaa.gov/CDO/cdo>)

Using a calculator, determine the average maximum temperature on February 1st in Tucson for the following time periods:

- 2003-2004
- 2000-2004

- 1995-2004
- 1975-2004

Using a calculator, determine the average minimum temperature on February 1st in Tucson for the following time periods:

- 2003-2004
- 2000-2004
- 1995-2004
- 1975-2004

Questions

- 1) Did the average change with each group of years?
- 2) Which group of years do you think would be the best to use for an average? Why?
- 3) From the maximum temperatures given over the 30-year period, what are the highest and lowest maximum temperatures? What is the difference between the highest and lowest temperatures?
- 4) From the minimum temperatures given over the 30-year period, what are the highest and lowest minimum temperatures? What is the difference between the highest and lowest temperature?
- 5) Using the 30 year average for maximum temperature (66) and the minimum temperature (43), how many times were the maximum and minimum temperatures from 1975 to 2004 the same as the average?
- 6) Questions 3 and 4 shows that there is a wide range of maximum and minimum recorded temperatures on February 1st. Question 5 shows that the maximum and minimum recorded temperatures are rarely the same as the average temperature. Based on this information, do you think it is normal for temperatures to vary from year to year?

Climate Change and Global Warming

Definitions

Climate Change is a shift in long-term patterns of weather.

Global Warming is one type of climate change characterized by a general warming trend in the Earth's average temperatures.

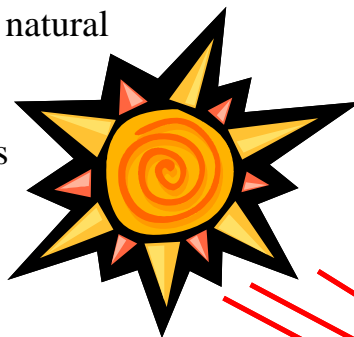


Greenhouse Gases are gases in the atmosphere that reflect heat back to the Earth. Some greenhouse gases are carbon dioxide, methane, nitrous oxide, and water vapor.

Climate change is a natural process, but scientists have found that humans are contributing to climate change. Humans are increasing the amount of greenhouse gases in the atmosphere, which is contributing to global warming.

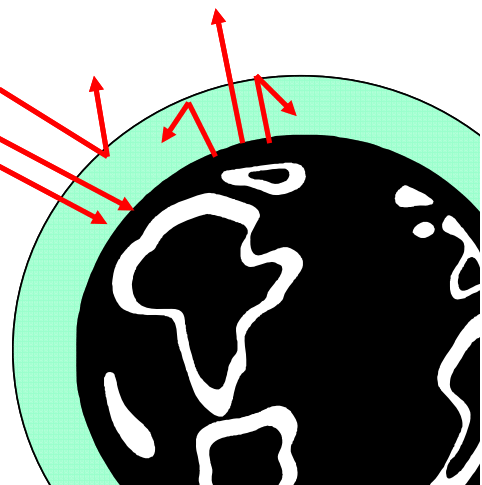
These gases occur naturally in the atmosphere, and there are both natural and human sources of these gases.

The **Green house Effect** is a natural process that traps heat on the Earth's surface. Heat waves from the sun enter the Earth's atmosphere and are either absorbed by the Earth's surface or reflected back to the atmosphere.



The atmosphere, like glass on a greenhouse, allows the sun's rays to enter but prevents some reflected rays from leaving.

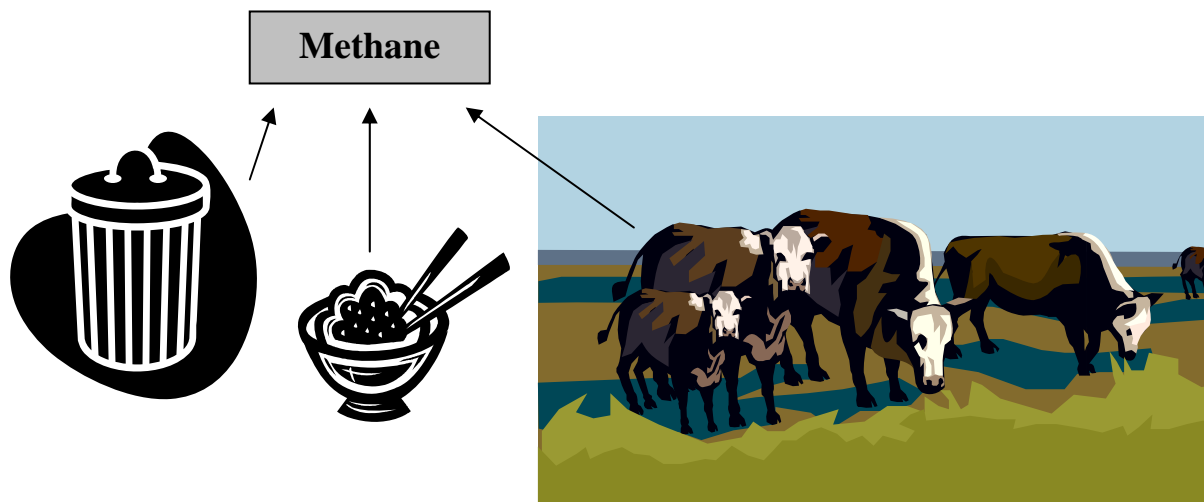
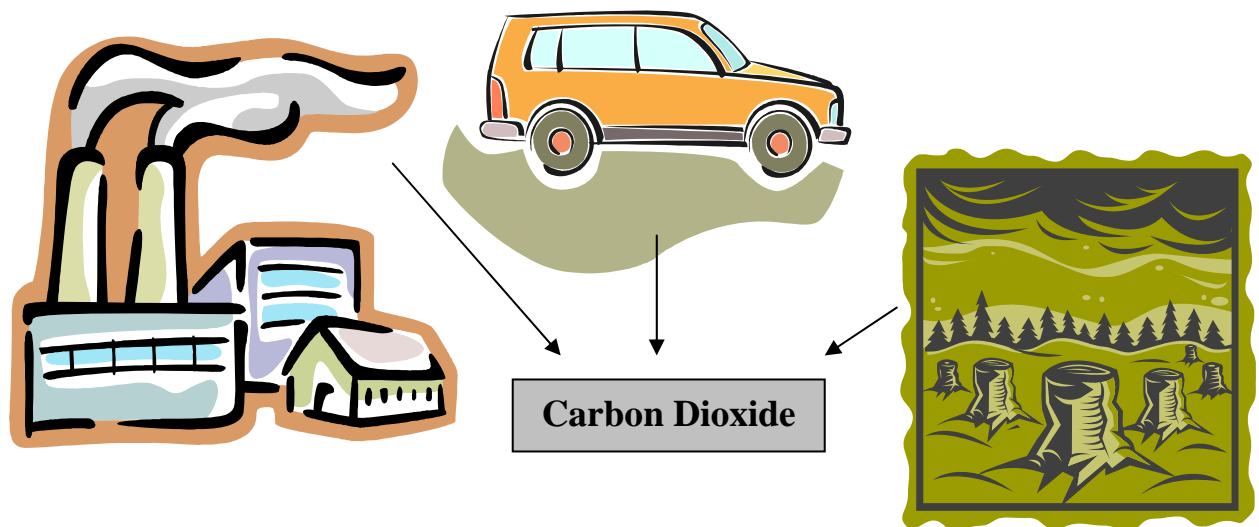
Greenhouse gases in the atmosphere prevent reflected heat waves from leaving the atmosphere and therefore keep the Earth warm. If the Earth's atmosphere did not have greenhouse gases, then the Earth would be very cold like Mars and not fit for humans and other life!



How do humans contribute to global warming?

Humans contribute to global warming through the production of greenhouse gases such as carbon dioxide. Carbon dioxide is the largest human source of greenhouse gases. Carbon dioxide comes from the burning of fossil fuels (to fuel cars, heat homes, and power factories) and deforestation. Clearing and burning forests releases carbon dioxide and other greenhouse gases into the atmosphere. In addition, trees also absorb carbon dioxide as part of a natural process to fuel their growth. Methane is the second largest source of greenhouse gases and comes from domesticated animals (such as cows), rice cultivation, and from human waste and garbage.

Human Related Sources of Greenhouse Gases



If the climate is always changing, why are people concerned about climate change and global warming?

There is concern about climate change because scientists are realizing that humans are contributing to climate change through the addition of greenhouse gases. With humans contributing to climate change, the changes may occur at a more rapid rate. When changes occur rapidly, it is difficult for humans, plants, and animals to respond in time. Global warming will lead to many environmental changes that will impact human populations. Some changes that are already seen as a result of global warming are the melting of glaciers, rising sea levels, and changing plant communities.

The Earth is currently in a period of global warming. The Earth's average temperature has risen 1° F in the last 100 years. Scientists predict a 3 - 7° F rise in temperatures in the next 50 to 100 years!

Potential Impacts of Global Warming on Humans

Rising sea levels may lead to the loss of coastal communities and islands



All these examples will have impacts on the economy and where people live.



Severe weather such as drought, flooding, and hurricanes may occur more frequently.

Changes in temperature and rainfall will affect agriculture. Areas ideal for agriculture may become too hot or too dry for certain crops to grow, therefore agriculture will move to other areas.



Activity 4: Descriptions of Community Members

Farmers

The farmers grow pecans and seasonal fruits and vegetables. In the summer they grow melons and in the winter they grow lettuce. They depend on ground water for irrigating their crops. They sell their crops both regionally and nationally.

City Officials

This group of city officials includes the mayor and city planners. The mayor is concerned with the general well-being of the community and maintaining a strong economy. The city planners deal with infrastructure for public services such as water supply and transportation. They want to make the community attractive to new industry and tourists.

Conservation Group

The conservation group is a committee of local residents formed to protect their local watershed. They work on a range of issues from water conservation, to air quality, to protecting wildlife. Currently, they are working on a campaign to get more people to bike and walk instead of driving.

Industry Group

This group has representatives from the local car manufacturing plant. They produce mid-size cars, trucks, and SUVs. The car plant has been in the community now for 20 years, and many of the local residents work for this plant.

School Teachers

The school teachers are a group from the local high school. They teach science and social studies. These teachers run community outreach activities with the students. They focus their efforts on educating community members about environmental and health issues.

Business Owners

The business owners have restaurants and hotels in the community. They are locally owned businesses that cater to tourists during the winter months. Tourists come to the community for the sunny and mild weather, and they enjoy activities like shopping, golf, horseback riding, and hiking.

Conexiones del Agua

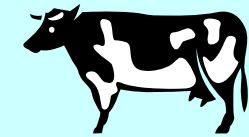
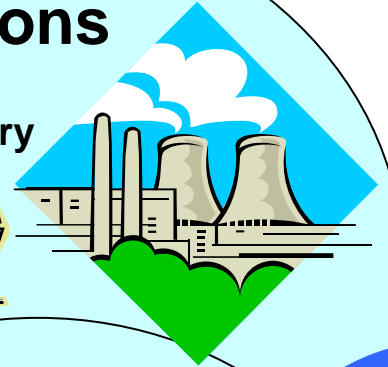
Water Connections

Wildlife



Santa Cruz
River

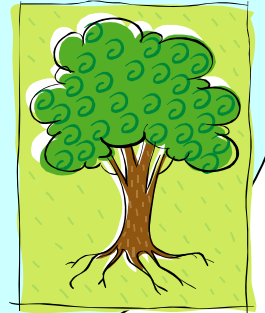
Industry



Agriculture
and Cattle
Ranching



Plants



WATER CONNECTIONS: The Santa Cruz River

Discussion Questions I:

1. How does wildlife depend on the Santa Cruz River environment?
2. How do plants depend on the Santa Cruz River environment?
3. How do the ranchers and farmers depend on the Santa Cruz River?
4. How does industry depend on the Santa Cruz River?

II. Now read the following hypothetical climate change scenario in Southeastern Arizona:

Imagine that over the next 50 years the average temperature increases by 3 degrees Fahrenheit in Southeastern Arizona. Along with the change in temperature, the precipitation changes. There is less rain in the winter, although the summer rain stays about the same. Overall the yearly average rainfall is 9 inches instead of 14.3 inches. As these hot, dry conditions continue, there is less water going into the Santa Cruz River. These conditions are no longer favorable to some of the plant and animal communities in the surrounding area. What will happen?

Discussion Questions II:

1. Who will be affected by the climate change first – the plants, animals, or people?
2. Can the plants survive the changes in climate? Can they survive a long-term shortage of water? Can they move to a better climate?
3. Can the animals survive the changes in climate? Can they move to a better climate?
4. Will the farmers and ranchers be affected by the changes in climate? How will they respond to the climate changes?
5. What will happen to the industries? How will industry respond to a shortage of water?

III. Write a paragraph in your climate change journal in response to the following question:

Do you think it is easier for humans to adapt to climate change or for plants and animals to adapt to climate change? Why?