USGS
science for a changing world

Teacher Guide

Module 1

Tracking Change Over Time: Urban Area Change—Phoenix, AZ

Time Estimate: 1–2 class periods

Suggested grade levels: 5–8

Materials needed: projection system (computer with projector or SMART Board)

Vocabulary: urban, suburbs, agricultural, residential, center-pivot irrigation, urbanization

National Science Education Standards (NSES)

- Science in Personal and Social Perspective:
  - Populations, resources, and environments
- History and Nature of Science
  - Science as a human endeavor
  - Nature of science

American Association for the Advancement of Science (AAAS) Benchmarks

- **Physical Setting/Processes that Shape the Earth/ Interdependence of Life; Use of Earth's Resources; Weather and Climate (4C/M7)** Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms.

National Geographic Education Standards

- Standard 14: "Environmental modifications have economic, social, and political implications for most of the world's people. Therefore, the geographically informed person must understand the reasons for and consequences of human modifications of the environment in different parts of the world."
- Standard 18: "Through its spatial emphasis, geography enables students to comprehend spatial patterns and spatial contexts; connections and movements between places; the integration of local, regional, national, and global scales; diversity; and systems. Through its ecological emphasis geography enables students to comprehend physical processes and patterns; ecosystems; the physical interconnections between local and global environments; and the impact of people on the physical environment."

National Council of Mathematics Standards

- Measurement
  - understand both metric and customary systems of measurement
  - understand relationships among units and convert from one unit to another within the same system
  - understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume

Overview

In this module, background information and study questions for analysis and interpretation lead students to discover how Phoenix's urban extent changed from 1991 to 2010. The module takes a problem-based approach to show students how satellite images can be used to solve problems related to urban change and to gather information for urban planning.

In the Analysis and Interpretation section, you will find five essential questions that are central to understanding urban change. As time permits, the additional questions can be used for extended learning. Of course, you may choose the questions you feel are most appropriate for your class. You could assign individual students to answer specific questions, or divide the questions up among the class. Students could also work in pairs or teams.

U.S. Department of the Interior
U.S. Geological Survey

General Information Product 133

Learning Goals

Students will

- Explore the land surface features of Phoenix and its suburbs with Landsat images and the MultiSpec software.
- Use specific study questions to analyze urban change in the Phoenix area.

Background

These three Landsat 5 images lie entirely within south-central Arizona and encompass the city of Phoenix, its suburbs, and surrounding desert. The city and its suburbs are growing rapidly, both in terms of population and area, so considerable change can be seen in only a few decades.

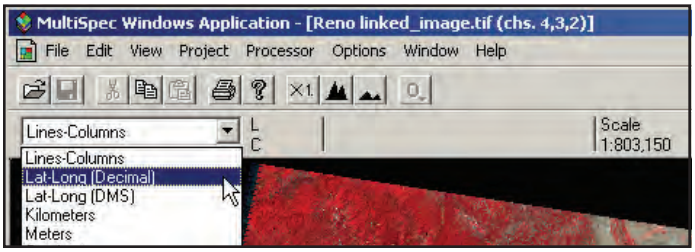
Population of Greater Phoenix

Year	Population
2009	4,023,331
2000	3,072,149
1990	2,122,101
1980	1,509,175

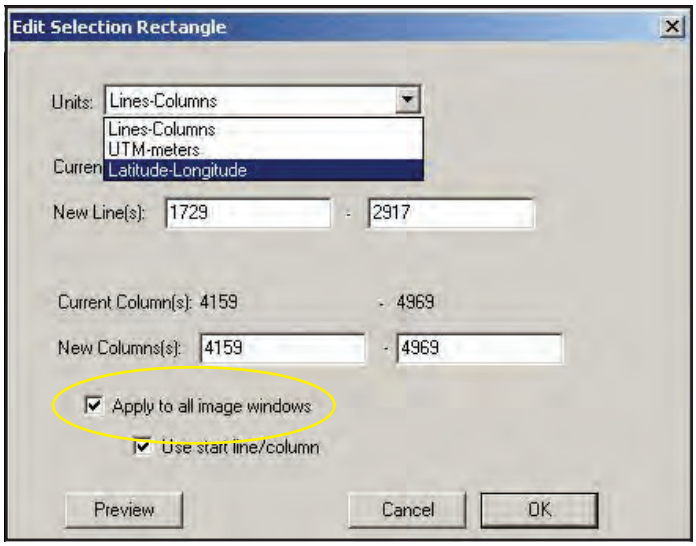
MultiSpec application: crop all images to the exact same area

The purpose of this lesson is to detect change over time in a particular place using satellite images. To do this accurately, you first need to crop the images so the areas you are comparing are all the same size. MultiSpec can automatically do this.

1. First, open all three Landsat images of Phoenix using MultiSpec (Phoenix1991.tif, Phoenix2000.tif, and Phoenix2010.tif).
2. In the Window menu, select "Show Coordinate View."
3. In the dropdown menu at the upper left, change the units to "Lat-Long (Decimal)."



4. In one of the images, select an area beginning with lat-long 33.5605, -112.4069 and ending with 33.2262, -111.6350 (about 3 million pixels; it doesn't have to be too exact). Click and hold while dragging the mouse to choose a rectangular area.
5. In the Edit menu, choose "Edit Selection Rectangle."
6. In the "Edit Selection Rectangle" window, check the box next to "Apply to all image windows."
7. In the "Units" drop-down, choose "Latitude-Longitude."

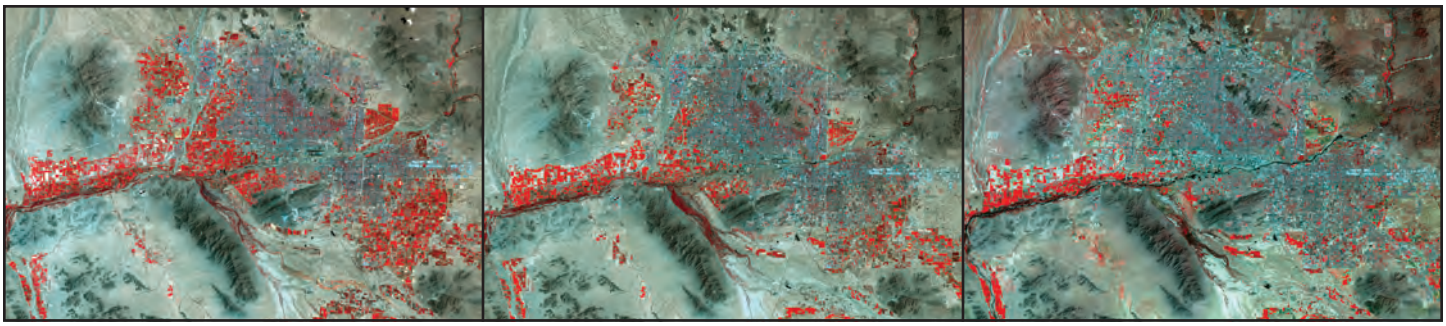


8. Click OK.
9. Now the exact same area is selected in the other images. For all three images, follow the cropping procedures as described in the "Using MultiSpec to Interpret Satellite Imagery" section, "How to Crop" (Step 6).
10. Now you can compare the images.

Analysis and Interpretation

Essential Questions

1. Open the cropped image you chose in the MultiSpec Application section above. How many airport runways can you find? (In this area, there are five that are easy to spot.)



July 8, 1991 — Landsat 5 **August 1, 2000 — Landsat 5** **April 7, 2010 — Landsat 5**

2. In the area you chose in the MultiSpec Application section above, what do you think the bumpy looking features could be? (Mountains—especially prominent are the South Mountains on the southern side of Phoenix, and the Phoenix Mountain Preserve toward the northeastern part of Phoenix entirely within the urban area.)
3. In the entire Phoenix region, what natural land features are affecting the shape of the urban area? Explain your choice. (Mountains and the Salt River are the major geographical features that affect where the urban area may expand.)
4. Select the 2010 image and go to Lat. 33.671, Long. -112.000. At this point, two highways intersect; Highway 51 runs north-south and Highway 101 runs east-west. Now go to the 2000 image. You should be able to see that these highways are under construction at this time. In the 1991 image, they do not yet exist. What other changes in this location can you spot between 1991 and 2010?
   a. What effects do new highways have on a location?
   b. Locate other highways you think might be under construction in the 2010 image. (Go north and west a little bit, and you'll see a line of bare ground heading from east to west then curving toward the south. This is the Loop 303 freeway, which is under construction in the 2010 image. It will loop around the west side of Phoenix. In a rapidly growing urban area like this, highway construction is common.)
   c. What do you think the large rectangles northwest of this intersection might be? (There is a complex of soccer fields here, which are bright red in the 4,3,2 band combination or bright green in the 7,4,3 band combination. This is the Reach 11 Sports Complex, and it is only in the 2010 image.)
5. Which of the commonly used band combinations from the MultiSpec Introduction reveals vegetation the best? Explain your decision. (4,3,2 is a common band combination to use for vegetation studies—healthy vegetation appears red. With 7,4,2, vegetation is bright green.)

Extended Learning

1. In the area you chose in the MultiSpec Application section above, find a few golf courses. Golf is popular in Phoenix because of the year-round nice weather. Compare the 1991 and 2010 images. In which image are there more golf courses? Choose a different rectangle in the image and count the golf courses there. You have now developed a random sampling of data. Compare the number of golf courses between the two rectangles you chose. Check with others in the class and compare results.
2. In most of the residential areas, streets are laid out in roughly a square pattern. Most are 1 square mile in size. Use MultiSpec to convert one square mile to square kilometers, acres, or other units of area. (This is the kind of information planners might need to plan for future residential neighborhoods.)
   a. Can you find any neighborhoods that do not use this pattern?
3. As a city planner, you are tasked with guiding the growth of the city. In which direction do you think the city of Phoenix and its suburbs can most easily expand? What obstacles might prevent expansion in other directions? Explain your answers. (Examine where urban areas have expanded over these three images, and see if it is reasonable to assume that future growth will continue these patterns. Will mountains prevent future growth in a particular direction? Could the urban area eventually surround the mountains? Look especially at the mountains south and west of Phoenix.)
4. A city engineer wants to know what band combination best shows streets. What do you recommend? (Streets show up pretty well in 7,4,3 or 7,4,1.)
5. At the lat-long coordinates of 33.544°, -111.8654° in the 2010 image, you can see a golf course. There appears to be a lot of land that is not urban around it. And to the south are some rectangular shapes, which indicate farm fields. How can you account for this type of land cover in the midst of the urban areas? (This is the Salt River Indian Reservation—the tribe owns this golf course.)
6. In any of the three entire images, identify any specific location that looks intriguing. A weird shape or color, or a place that seems puzzling. To learn more about it, you may need to do further research. Try finding the same place on Google Earth and see if it provides more clues about your area of interest.

Lesson Extension: Scavenger Hunt

Using any of the three entire images, send students on a scavenger hunt to find the following features or structures: (answers for the teacher provided in lat-long)

Using any of the three entire images, see if you can find the following features or structures. Provide the latitude/longitude coordinates of the locations.

- Automobile racetrack (Phoenix International Raceway is at roughly 33.375°, -112.311°)
- Stadium (hint: structure has a white roof) (University of Phoenix Stadium is at 33.527°, -112.263°—bright white of the roof surrounded by dark parking lots and a couple of small areas of grass; grass is red in 4,3,2 band combination. This is only in the 2010 image.)
- Lake (33.569°, -111.525° is Saguaro Lake, formed behind a dam on the Salt River. Another reservoir, Lake Pleasant, is at 33.882°, -112.280°)
- Highway or freeway interchange (there are several—a noticeable one is at 33.297°, -111.972°)
- Crop fields that are circles (these are farms with center-pivot irrigation, 33.209°, -111.541°)
- A place where the edge of a residential area is right up against desert (in the 2010 image, at about 33.346°, -111.589°, is one area. There are probably others and in the other years too.)
- Where you would likely get a good view of agriculture from a highway (one spot is 32.917°, -112.910°—ask students, how would you know this for sure?)

More about Phoenix

Phoenix is one of the fastest growing cities in the United States; much of its population growth is happening in its suburbs. New residents and tourists are attracted to Phoenix by the warm weather and abundant sunshine. Phoenix has maintained rapid and sustained growth, and its location in a wide valley allows neighborhoods to be built with houses that can have a lot of space around them. From 1970 to 2008, the population of the Phoenix metropolitan area grew by 307 percent. A city growing this fast and is usually cloud-free is perfect for studying urban growth with satellite images.

But Phoenix's growth comes with some problems. As the city has grown, so has its need for water. Much of the city's water supply now comes from the Colorado River. The enormous demand for water has created conflicts between Arizona and neighboring states that also share the river, and between farmers, who need water for irrigating crops, and city dwellers. Demand for electricity, especially for air conditioning, continues to escalate as the city grows. An abundance of motor vehicles also has led to increased air pollution and traffic congestion.

Scientists, city planners, and other people study population growth and urban expansion in places like Phoenix to determine the changes that have occurred over time and how those changes impact the surrounding environment, affect the availability of natural resources such as water, and alter the landscape and how it's used. That information, in turn, can help people anticipate and plan for future changes as cities continue to grow.

Phoenix is in the Sonoran Desert, an arid region covering 310,800 square kilometers (120,000 square miles) in southwestern Arizona and southeastern California, as well as most of Baja California and the western half of the state of Sonora, Mexico. Irrigation produces many fertile agricultural areas. The Sonoran Desert is the most biologically diverse of the North American deserts and home to abundant wildlife and a variety of plants that have adapted to the desert environment.

Phoenix Weather

Average annual rainfall: 7.66 inches
Average high temperature, January: 66.8° F
Average high temperature, July: 105.9° F
Average number of days of sunny days per year: 334

Resources

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