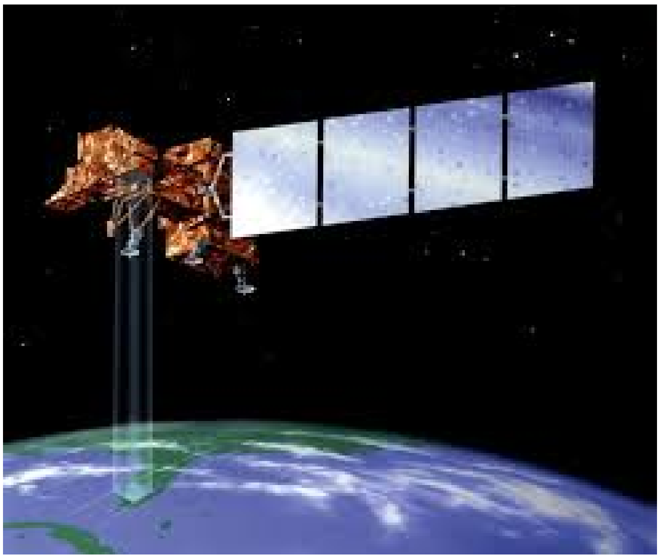
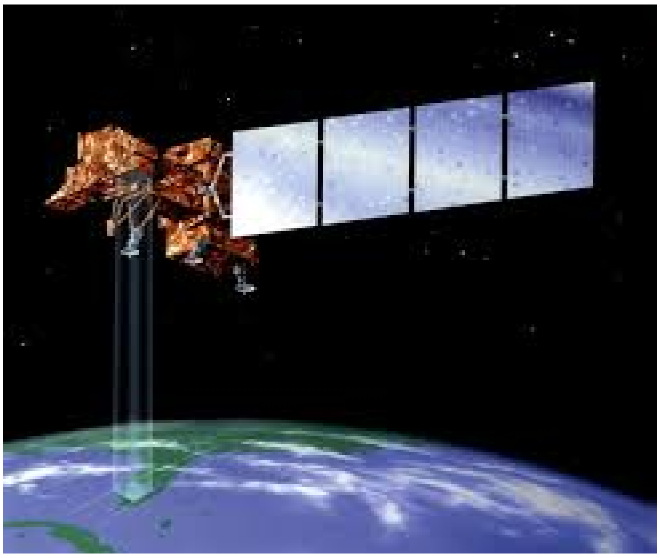
My NASA Data - Lesson Plans

Analyzing Land Changes Over Time



Overview

Students identify and classify kinds of land cover (such as vegetation, urban areas, water, and bare soil) in Landsat satellite images of Phoenix, Arizona taken in 1984 and 2018. ***This lesson is a modification of the original lesson, Quantifying Changes in the Land Over Time with Landsat.***



Credit: Landsat

Learning Objectives

Students will:

- Identify major land cover types in a land remote sensing image
- Develop maps of land cover at a regional (landscape) scale
- Quantify land cover change over time
- Predict ways and directions that an urban area might grow

Why Does NASA Study This Phenomenon?

Our land is changing. Land covered by forest is changing to farmland, land covered by farmland is changing to suburbs; cities are growing. Shorelines are shifting; glaciers are melting; and ecosystem boundaries are moving. As human population numbers have been rising, natural resource consumption has been increasing both in our country and elsewhere. We are altering the surface of the Earth on a grand scale. Nobel Prize recipient Paul J. Crutzen has said, “Humans have become a geologic agent comparable to erosion and [volcanic] eruptions…”

Land cover change has effects and consequences at all geographic scales: local, regional, and global. These changes have enabled the human population to grow, but they also affect the capacity of the land to produce food, maintain fresh water and forests, regulate climate and air quality, and provide other essential “services.” (See Foley, et. al,) It is critical for us to understand the changes we are bringing about to Earth’s systems, and to understand the effects and consequences of those changes for life on our planet. Landsat satellites enable studies of change at the regional or landscape scale.

The first step in understanding change is monitoring, and the second step is analysis. Doing this activity will enable your students to take these steps at an introductory level.

Essential Questions

- What is the practical value of remote sensing?
- How widespread is urban development and what are the impacts on natural resources as land cover changes?
- How can landscapes change regionally and locally?

Cross-Curricular Connections

- National Geography Education Standards: The World in Spatial Terms
  - Standard 1: How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information
  - Standard 3: How to analyze the spatial organization of people, places, and environments on Earth’s surface

Materials Required

- Student Sheets

Technology Requirements

- Internet Required

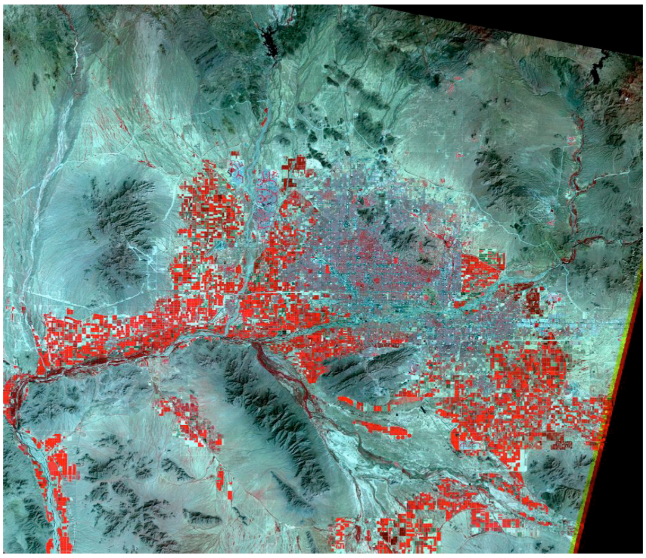
- One-to-One (tablet, laptop, or CPU)
- One-to-a-Group
- Color Printer

Teacher Background Information

About Phoenix, Arizona's Land Cover

Phoenix, Arizona, and its suburbs are growing rapidly, both in population and area. Landsat images show striking changes in the Phoenix metropolitan area in only a few decades. The most noticeable change is residential areas spreading over agricultural fields, which are shown in the images as bright red squares and rectangles. But in other areas, the urban growth expands over what was once bare desert.

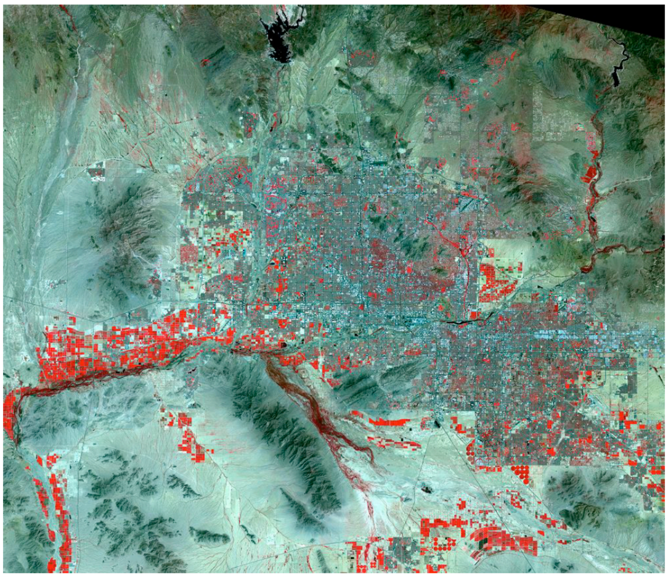
My NASA Data - Quantifying Land Changes Land Over Time



Phoenix, Arizona 1984

Image Credit: "USGS/NASA Landsat"

My NASA Data - Quantifying Land Changes Land Over Time



Phoenix, Arizona 2018

Image Credit: "USGS/NASA Landsat"

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 2017, the population of the Phoenix metropolitan area grew by about 388 percent.

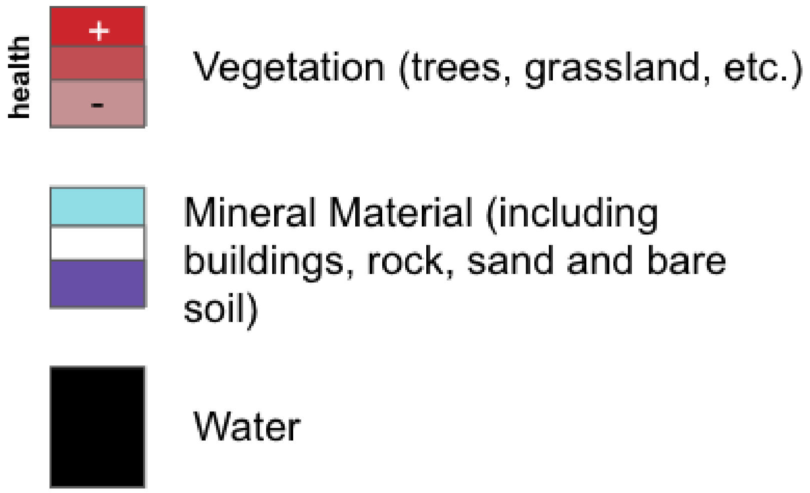
Phoenix doesn't have many cloudy days, so it's perfect for studying urban growth with satellite images. Scientists and city planners study population growth and urban expansion in fast-growing cities like Phoenix to determine the changes that have occurred over time and to see how those changes impact the surrounding environment, affect the availability of natural resources such as water, and alter the landscape and how it's used. That information can help people plan for future changes as cities continue to grow.

About the Colors of Landsat Images

True color images show how the land would look if you were observing it from space with your own eyes. But our eyes don't tell us everything there is to know. Sensors such as the one on Landsat give us extra insight into nature. The sensor on the Landsat satellite makes observations of light reflected from the Earth in both **visible** and **infrared** (invisible) wavelengths of the electromagnetic spectrum. So with Landsat, we can see more about nature than we can when we use our eyes alone.

The **false color** Landsat image shows information in some infrared wavelengths of light. Normally infrared wavelengths are invisible to us. In order for you to be able to detect it, information about these infrared wavelengths have been colored in a special way in this "false color" pair. Compare the true color and false color images. Do the true color images show you the most about difference in land cover, or do the false color images show you the most? Which would you choose to detect land cover change over time, true color or false color?

Here are some details about the false color images provided for this activity:



About Pervious and Impervious Surfaces

When rain falls or the snow melts on pervious surfaces such as grassland or fields, that water percolates through the ground, reaching and replenishing our ground-water supply. But when rain or snow falls on surfaces such as pavement and sidewalks, it can’t get through. Those surfaces are impervious to water. The water glides along the pavement and picks up contaminates along the way such as oil, gas, fertilizers, sediment and even bacteria. When the water does finally reach a pervious surface, or a water body, it can be full of all these pollutants. That can introduce a huge surge of contamination into our water supply. On the other hand, when precipitation falls on pervious surfaces, it gradually penetrates the ground, and many contaminants are naturally filtered out before they reach the ground-water supply.

“There is a link between impervious surfaces within a watershed and the water quality within the watershed. In general, once 10-15 percent of an area is covered by impervious surfaces, increased sediments and chemical pollutants in runoff have a measurable effect on water quality. When 15-25 percent of a watershed is paved or impervious to drainage, increased runoff leads to reduced oxygen levels and impaired stream life. When more then 25 percent of surfaces are paved, many types of stream life die from the concentrated runoff and sediments.” (NASA Goddard Space Flight Center News Release, “New Satellite Maps Provide Planners Improved Urban Sprawl Insight.”)

Prerequisites Student Knowledge

Students must:

- have a basic level of ability to understand and interpret visual representations of Earth’s surface from above, such as maps and aerial photographs;
- understand the meaning of wavelengths of light;
- be able to define “electromagnetic spectrum,” at an introductory level

Student Misconception

Students might think the Landsat images are photographs. They are actually "false color" images. There is information about "false color" images in the lesson.

Procedure

For classes with limited experience with reading/interpreting false color satellite images, consider doing the "Exploring Satellite Imagery and False Color Images" lesson first.

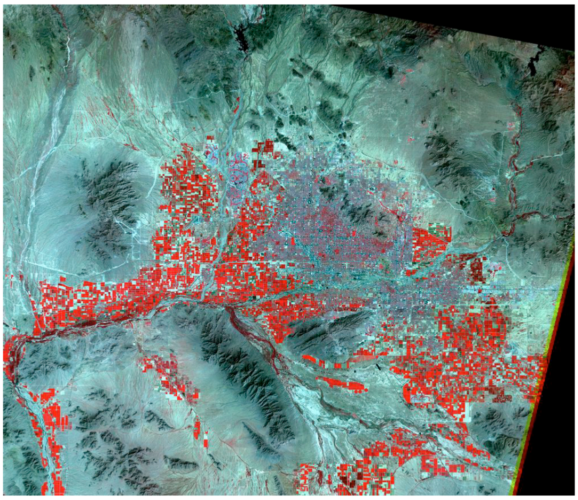
1. Engage Prior Knowledge

1. In a Think-Pair-Share, present the following question: What are different land covers that come to mind and how are they different?
2. Review land cover types with your students. Students may suggest the following land cover types. Discuss these as a class:
    - Suburban
    - Urban
    - Highways and Roads
    - Forest
    - Grassland
    - Cropland/Agricultural land
    - Bare soil
    - Water (lakes, ponds, streams, rivers, etc.)
3. Have students decide which of the land cover type/s allow water to penetrate the surface (**pervious**), and which types do not (**impervious**).

2. Making Observations of the Data

1. The Landsat images are “false color.” Students will analyze the false color image and have students identify as many land cover types possible (bare soil, urban areas, roads,

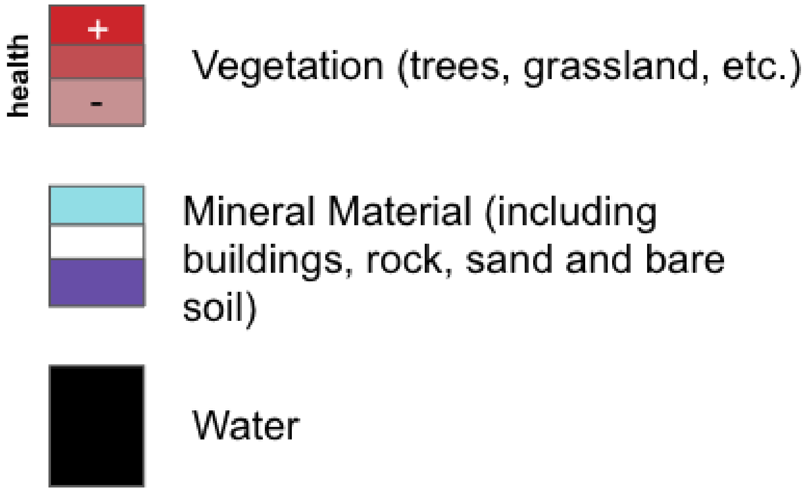
My NASA Data - Quantifying Land Changes Land Over Time



Phoenix, Arizona 1984

Image Credit: "USGS/NASA Landsat"

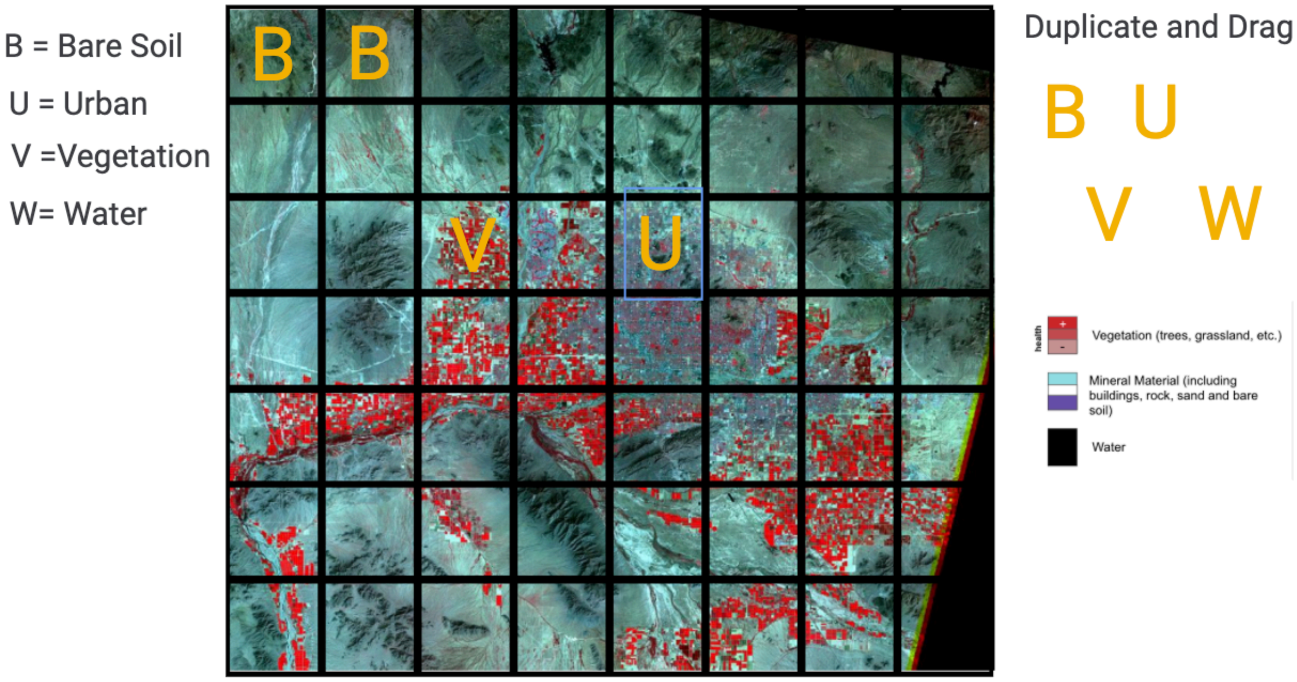
2. Review the colors found on the 1984 map and what these represent. **Pointers about the Desert Ecosystem**: Remember that the natural ecosystem of Phoenix is desert. In the false color image, the desert's bare soil appears gray/green. Areas that show red are vegetated areas; visible bright red have likely received water recently and are considered more healthy.



3. Consider asking students the following qualitative questions to engage them in analyzing the image:
   - What features strike you as interesting in the 1984 image?
   - What significant landforms do you observe that may influence the various land use patterns?
   - Prior to human settlement in Phoenix, what do you believe could have been the dominant landcover? What evidence do you have to support your idea?
4. Students will use the materials provided to quantify the land cover of each grid. agricultural fields, water, etc.) in the 1984 image. (Students should estimate the dominate land cover in each grid and mark the grid as B for bare land, U for urban areas, V for vegetation, or W for water.) Students will also identify the dominant land cover as pervious or impervious for each grid square on the map.

5. Provide students with time to complete the analysis and mark up the 7 x 8 grid space with estimated land cover types for 1984. Note: The black area on the bottom right should be left

bank as this is the extent of the Landsat image and does not represent a landcover classification. NOTE: Students should focus on one part of the geographic area, at a time, to identify specific areas of change. Students will notice that some grid squares contain more than one land cover type. The most dominant land cover type in that grid square dictates which land cover type to assign to that square. For example if a square is 75 percent Vegetation and 25 percent Water, use the code for Vegetation. Some students may disagree about which type is dominant. Professional land cover analysts occasionally disagree, too.



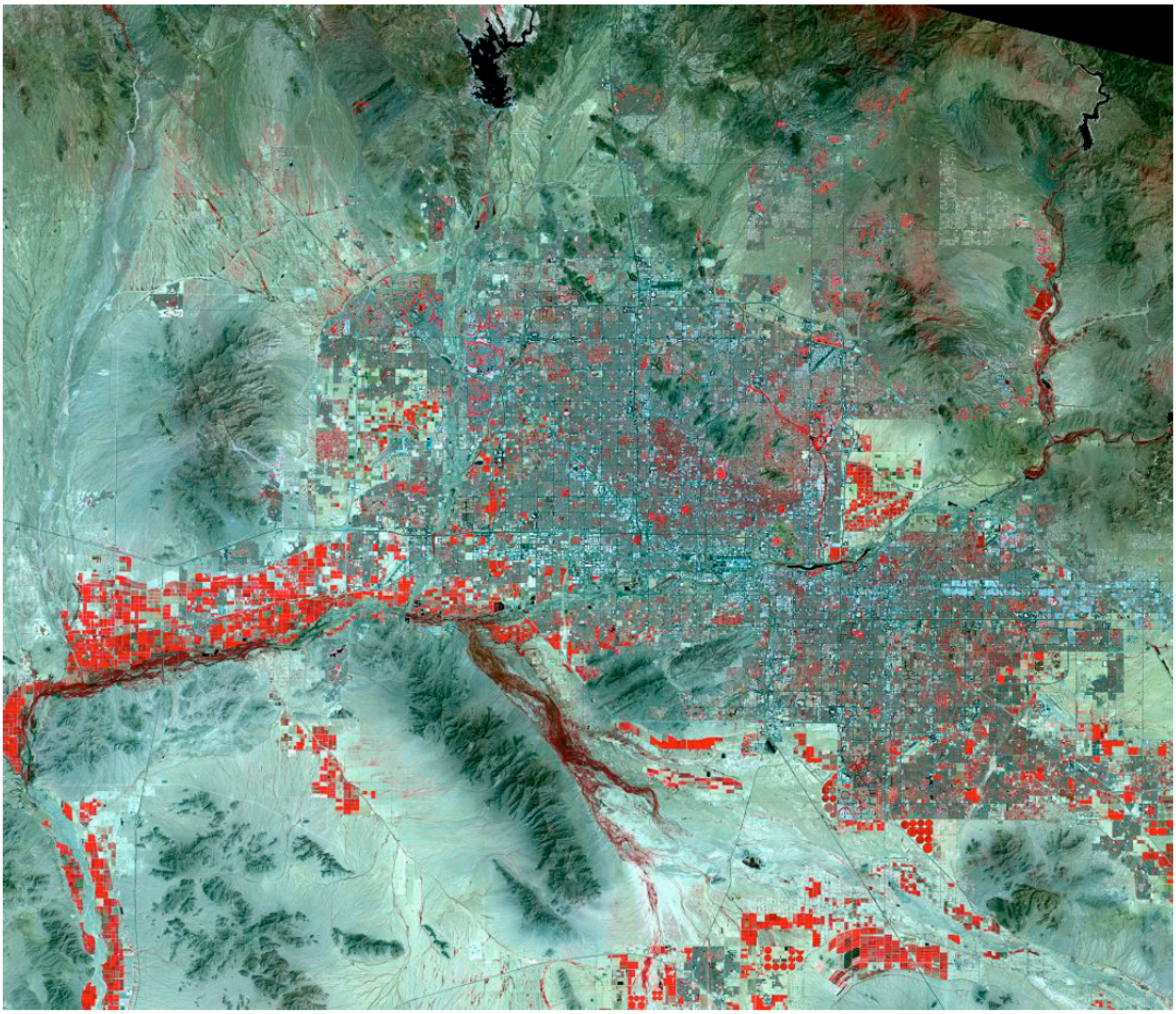
Phoenix, Arizona 1984

False Color Infrared

Image Credit: "USGS/NASA Landsat"

This image shows the gridded 1984 map with several grids marked with dominant land cover type. Note: Students will complete the entire map.

6. Lead a class discussion about land cover types as shown in the images and have students share their observations and make predictions about what changes they might observe when analyzing a map taken from the current year.
7. Discuss with the class the type/s of land cover that are considered *pervious* to water and which kinds were *impervious*.
8. Now, repeat the process for the 2018 image. Students work with a partner to look for and identify the types of land cover they found in the 1984 satellite image. Some examples of land cover types are urban, water, forest, grassland, or anything covering significant amounts of the land surface.



Phoenix, Arizona 2018

Image Credit: "USGS/NASA Landsat"

3. Organizing the Data

Students complete the table below to organize their data values. Students quantify their landcover classifications by summarizing the number of grid space identified for each category: Bare soil (B), Urban (U), Vegetation (V), Water (W).

Total Number of Observed Grid Spaces				
Date	Bare soil (B)	Urban (U)	Vegetation (V)	Water (W)
1984				
2018				

4. Analyzing the Data

1. Provide time for students to examine the two images and become familiar with the similarities and differences in these images that are over 30 years apart. Students should get a general sense of how much the land cover has changed over that time: where, how, and by how much.

2. Students then analyze the data in the data tables and calculate change in the Student Sheet.

5. Interpreting the Data

1. Students complete this section in the Student Sheets.
2. Then, discuss their answers and supporting evidence (based on observations and land cover calculations).

   10. How confident are you with the accuracy of your data and the conclusions you drew from this information? Why?

11. How might you improve the accuracy of your map and your calculations, if at all?
12. What, if anything, do the difference between individual results tell you about science as a human activity?
13. If you were to change the scale of the grid, how might grid size impact your analysis and interpretation of the land cover data change in Phoenix, Arizona over the 35 years?
    1. Effects of using a larger grid size -
    2. Effects of using a smaller grid size -

Reasoning about the Conclusions

Present the following scenario and following questions... *(This section is included in the Student Sheet.)*

14. As land cover changes over time, what are the impacts of these changes to humans living in these areas? The different spheres of the Earth system?

15. Researchers indicate that if ten percent of the land cover in a given watershed changes, the water cycling through that watershed changes in significant ways. Water quality is affected, and run-off increases.

1. How concerned should people be about the cycling of water in Phoenix, Arizona?
2. What specific ecological effects of land cover change should be looked into for the geographic area you studied? (Consider air, water, soil, and living things.)
3. What data would we need to investigate some of those ecological effects?

Extensions

- Find additional locations at https://earthshots.usgs.gov/earthshots/. Other images can be found by clicking on Cities.
- If two or more student teams analyze change in the same geographic area, compare teams' results and comment on any differences.
    - Did your team identify the same kinds of land cover changes as the other team did?
    - If your team did identify the same kinds of land cover as another team, did the two teams arrive at created & produced by the NASA Landsat Education Team 16 Quantifying Changes in the Land Over Time with Landsat the same percent change from pervious to impervious surface area (or from impervious to pervious surface area)? If not, discuss between teams how your perceptions and/or methods of calculating change may have been different.
    - Provide notes about this discussion on the student sheet for Extension - Comparing Different Teams' Results for the Same Areas of Change.
- Assuming the same rate and nature of change, make a predictive map of land cover in 2030. Describe and explain the 2030 map and any ecological consequences that might be expected from the change.
    - Describe the map and any changes you project from pervious to impervious surface or from impervious to pervious surface. (Remember to take the effects of major transportation arteries and geologic features such as mountains and rivers into account.) Explain why you have predicted this kind and amount of change.