

Lesson Plan

Purpose of the lesson

How does satellite imagery illustrate global change on Earth? Landsat 7 is a tool used to achieve improved understanding of the Earth's land surfaces and the impact of humans on the environment. Use the Earth Images for Education: Tracking Change Over Time folder with the accompanying CD, or the Classroom Activity Guide on page 4 of this insert, to help students investigate how satellite images are used to study land surface change over time.

Background

The USGS EROS Data Center (EDC) houses a remarkable archive. Archives are like libraries. But instead of books, the archive at EDC contains satellite images. These images provide scientists with a unique historical record of global change. One of the primary satellites used by scientists at the Data Center is Landsat 7. Landsat 7 images the Earth from 705 kilometers (km) above the planet's surface. The satellite makes a complete trip around the Earth every 99 minutes and takes a complete set of images of the land surfaces every 16 days. A single satellite image, or scene, covers an area that is 183 km wide by 170 km long. One pixel on the image represents 30 meters on the Earth. Using multiple spectral bands, images are created that scientists use to monitor rainforest deforestation, droughts, coastline change, floods, the impact of wars, and many other changes to the land surface.

Image Set 1 – Black Hills, South Dakota¹ This series of images demonstrates the amount of change that can be seen over a relatively brief period. Fire can change the landscape tremendously and an example is the Black Hills of South Dakota. In the images, compare how the landscape changed after each fire season. The fire scars are clearly visible in shades of red. Using short-wave infrared (bands 5,4,2), fire scars are easily discernable from the green coniferous forests surrounding them. Some estimates put the total acreage burned in this four-year period at around 10% of the Black Hills.

Image Set 2 – Las Vegas, Nevada² Las Vegas provides a dramatic illustration of the spatial patterns and rates of change that result in urban sprawl. Population growth in the Las Vegas Valley was fairly slow during the first half of this century, but as the gaming and tourism industry blossomed, population began to increase rapidly. For example, the population of Las Vegas in 1950 was 24,624; in 1960 it increased to 64,405. By 1980 the city had a population of 164,674 and today, Las Vegas Valley's population tops one million – and this doesn't include the tourists! The 1972 satellite image shows the status of Las Vegas as just a stop along the railroad that passed through the town. By 2000, the town had grown and sprawled in almost all directions, but primarily to the northwest and southeast.

Image Set 3 – Mississippi Delta, Louisiana³ This comparison shows three decades of change in the birdsfoot delta of the Mississippi River. The delta marks the termination of the Mississippi River as it deposits sediments into the Gulf of Mexico in Louisiana. The Mississippi-Missouri River system collects eroded debris from the entire central half of the United States. Upon reaching the gulf, the river's velocity slows abruptly, reducing its capacity to carry suspended mud and sand. This sediment is deposited in an alluvial fan pattern. The delta has changed form many times over the past 10,000 years, and has varied in location along a 200-mile stretch of coastline. The birdsfoot delta has only occupied its current location for approximately 600 years. Indications that the Mississippi River was about to abandon its current course and divert through the Atchafalaya River led the U.S. Army Corps of Engineers to construct a series of dams, locks, and canals to ensure that the river channel did not change its course and negatively impact New Orleans and the region's shipping industry. In order to maintain a navigable river system, it is vital that the river does not

change its current path. The images shown here from 1973, 1989, and 2003 show a delta that has experienced significant changes in just the past three decades. The most notable change is the loss of marsh along the southern edge of the delta on the left side of each image. The seafood industry is very concerned about this loss. Fish and wildlife populations are threatened as their natural habitat slowly disappears. The appearance of dams and artificial channeling along the Mississippi-Missouri River system has decreased the amount of sediment that the currents carry. The Mississippi Delta undergoes subsidence, or the gradual sinking of the delta into the gulf, over time. Before the dams and channeling were incorporated into the Mississippi-Missouri River system, sediments would cause the delta to grow at a faster rate than the subsidence could cause it to disappear. However, with a lighter sediment load moving down the channel, the opposite condition exists, where the delta subsides faster than it can be built up.

Pollution and the cutting of new waterways for petroleum exploration and drilling have also taken their toll on the delta. An increase in mean sea level during the past century has increased erosion of delta material and marshes. Due to subsidence, erosion, and sea-level rise, saltwater intrusion has occurred in freshwater habitats. As freshwater vegetation died, erosion continued and allowed more saltwater intrusion. This condition has been exacerbated by less fresh water arriving in the delta due to river control and bayou restoration projects directing water to other drainage channels. Other marsh reductions have occurred from controlled burns to promote muskrat habitat and nutria grazing.

Another change that has occurred within the past three decades is due to the lengthening of the navigation channels, which makes it appear that the overall delta is growing when it is actually shrinking. This effect is most notable in the "toes" of the birdsfoot at the southeastern edge of the delta. As you can see, the channels are much better defined in the 2003 image than in the other images. The main visible change to the birdsfoot portion of the delta in the 2003 image is the emergence of new marsh vegetation. This is directly caused by the addition of artificial "crevasses" (cuts in the natural river levee). These have resulted in emergent marsh formation within a couple of years of creating the crevasses. This technique would work higher in the delta as well, but breaching the levee in upstream locations is not feasible.

Image Set 4 – Al Isawiyah, Saudi Arabia⁴ Saudi Arabia, although rich with oil, is lacking a more vital natural resource: water. The kingdom decided to diversify its economy and modernize its agricultural sector in order to become more self-supporting to meet the country's growing demand for wheat. Since Saudi Arabia has severely limited water resources, the government decided to use the revenues from the oil industry to adopt the best technologies available for farming in arid and semi-arid environments. Center pivot irrigation was introduced in Wadi as Sirhan, an area that lies 300 meters below the surrounding plateau. Located in the extreme north along the border with Jordan, Wadi as Sirhan is a remnant of an ancient inland sea and is underlain by four aquifers, two of which contain ancient water more than 20,000 years old. These three satellite images from 1986 to 2000 show the transformation of desert to agriculture through center pivot irrigation. The 1986 image shows Wadi as Sirhan near the village of Al Isawiyah before the introduction of center pivot irrigation. The 1991 image shows the region shortly after the introduction of center pivot irrigation (green circles are irrigated fields). The 2000 image shows the spread of center pivot irrigation throughout the region.

¹UNEP (2003). "Selected Satellite Images of Our Changing Environment." UNEP/DEWA/RS.03-1. Division of Early Warning and Assessment (DEWA). United Nations Environment Programme (UNEP), P.O. Box 30552, Nairobi, Kenya

²same

³USGS. 2003. Landsat Project Change Over Time. USGS. <http://landsat7.usgs.gov/gallery/change/218/>

⁴USGS. 2003. Landsat Project Change Over Time. USGS. <http://landsat7.usgs.gov/gallery/change/210/>

Landsat 7: Explanation of Bands

Band 1 0.45-0.52 micrometers	Band 2 0.52-0.60 micrometers	Band 3 0.63-0.69 micrometers	Band 4 0.76-0.90 micrometers	Band 5 1.55-1.75 micrometers	Band 6 10.5-12.5 micrometers	Band 7 2.08-2.35 micrometers
(blue-green)	(green)	(red)	(near-infrared)	(mid-infrared)	(thermal infrared)	(mid-infrared)
Recommended for water body penetration, soil and vegetation discrimination, and forest-type mapping (deciduous/coniferous).	Recommended for vegetation discrimination and plant vigor. This band corresponds to the green reflectance of healthy vegetation.	Recommended for detecting cultural features, bare soils, and vegetation types. This band operates in the chlorophyll absorption region. The red chlorophyll absorption band of healthy green vegetation is one of the most important bands for vegetation discrimination. It is also useful for soil boundary and geological boundary mapping.	Recommended for separating water bodies from vegetation and discriminating soil moisture. It is not as effective as Band 3 for road identification. It is useful for crop identification, and emphasizes soil, crop, and land-water contrasts.	Recommended for determining roads, bare soils, and water. It also provides a good contrast between different types of vegetation and has excellent atmospheric and haze penetration. This reflective-IR band is sensitive to turgidity -- the amount of water in plants. Turgidity is useful in drought and plant vigor studies. In addition, this band can be used to discriminate among clouds, snow, and ice (important in hydrologic research) as well as to remove the effects of thin clouds and smoke. Band 5 is considered to be the best single band.	Recommended for measuring plant heat stress and thermal mapping. This band responds to thermal (heat) radiation. Thermal radiation is closely related to soil moisture and the height and temperature of vegetation. This band measures the amount of infrared radiant flux (heat) emitted from surfaces. Band 6 is used in locating geothermal activity, thermal inertia mapping, vegetation classification, vegetation stress analysis, and in measuring soil moisture.	Recommended for detecting mineral and rock types, interpreting vegetation coverage, and soil moisture. This band is used to discriminate among various rock formations. It is particularly effective in identifying zones of hydrothermal alteration in rocks.

Example of How Different Band Combinations Reveal Different Kinds of Information

Martis Forest Fire, Reno, NV

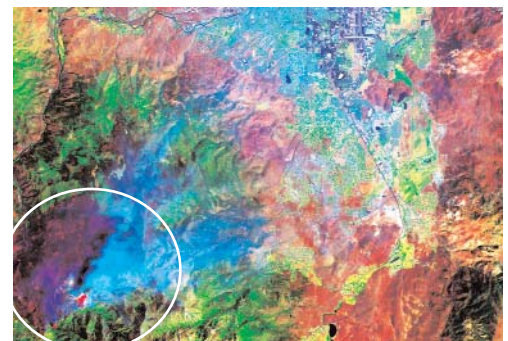
Landsat 7 images acquired June 19, 2001

Pixel size = 30 meter, including the thermal band, which is usually 60-meter resolution

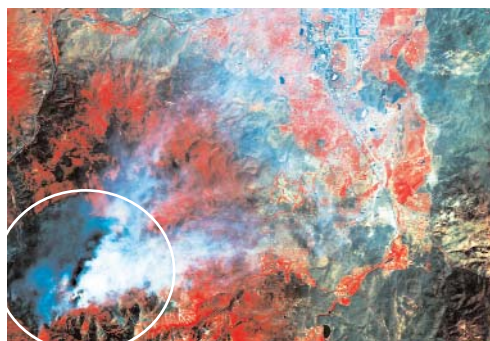
Since different kinds of surface features reflect energy picked up by satellite sensors in different amounts in each band, the appearance of surface features may vary with different band combinations. Refer to the chart above for band descriptions as you examine the images to the right and read the descriptions at the top of the following page.



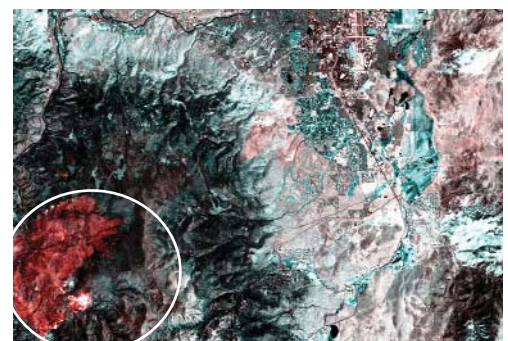
Bands 3, 2, 1



Bands 5, 4, 2



Bands 4, 3, 2



Bands 6, 5, 5

Example Bands 3,2,1 – Bands 3,2,1 show what our eyes would see, that is, natural color. With this combination it is difficult to locate the fire or extent of the burn. Smoke obscures the fire area. The city of Reno is in the top right corner. Features to investigate: the fire area, hot spots along the edge of the fire, and areas of urban growth. Look for roads; they appear white/blue.

Example Bands 5,4,2 – Bands 5,4,2 reveal the fire (red) in the center of the circle but smoke still covers the area. Other red areas indicate land; green indicates vegetation and purple shows the extent of the fire. The city is peeking through the top right corner; roads are light purple.

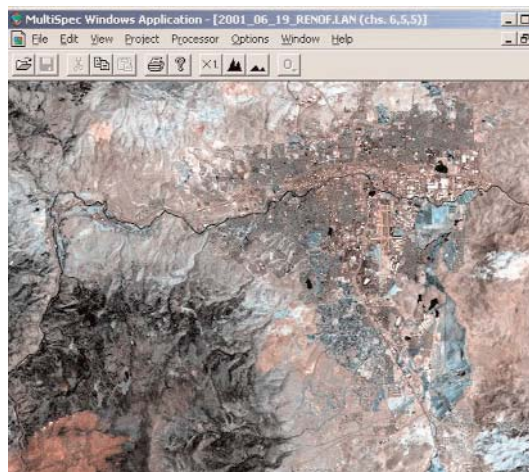
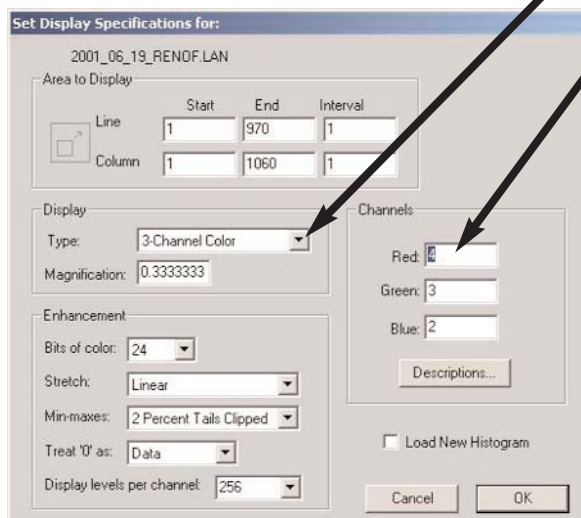
Example Bands 4,3,2 – Bands 4,3,2 indicate vegetation; forested areas appear red. The actual fire area is still clouded in smoke. The streets of the city are barely visible in the upper right quadrant (look for white areas with straight shapes).

Example Bands 6,5,5 – Bands 6,5,5 shows the fire burn area as bright red. By using band 5 in both the green and blue wavelengths, it is possible to filter through the smoke layer entirely.

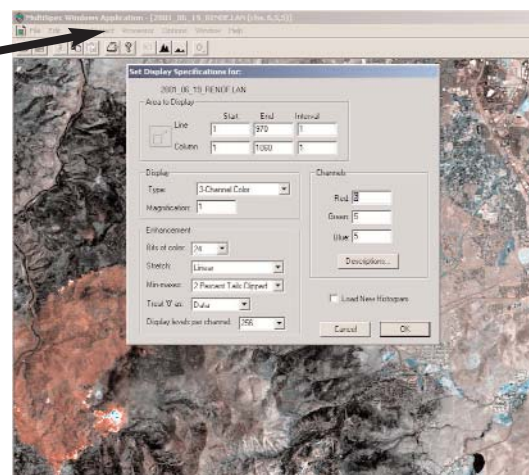
For the Computer User: Using MultiSpec and Image CD

To run MultiSpec:

1. Go to File.
2. Click on Open.
3. Open Folder and select an image.
4. This screen will appear:
5. Under Display, Type, select 3-Channel Color.
6. Under Channels, enter desired band numbers for RED, GREEN, and BLUE. (see chart on previous page)
7. Click OK; the image will appear:



8. To change bands, click Processor, then click Display Image to display screen.
9. Experiment with different band combinations to find those that are best for seeing roads, vegetation, lakes, and so on.



For the Non-Computer User: A Classroom Activity Guide

Image Set 1 Black Hills, South Dakota

1. What color are fire scars in these images? (shades of red)
2. Fire has the ability to change the landscape over a short period of time. What changes can you see from these images? (see background material)

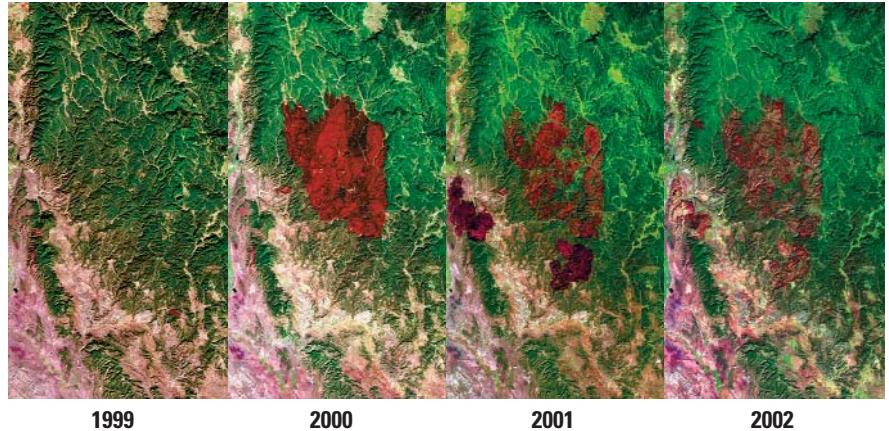


Image Set 2 Las Vegas, Nevada

1. What do you think the red spidery looking places on the images are? (golf courses)
2. The areas in purple represent concrete or roads on the images. Find two areas that have dramatically changed over time. (runway in the upper-right; middle of image)
3. In which direction would you predict the city of Las Vegas is least likely to expand in the future? (to the east; mountains are in the way)

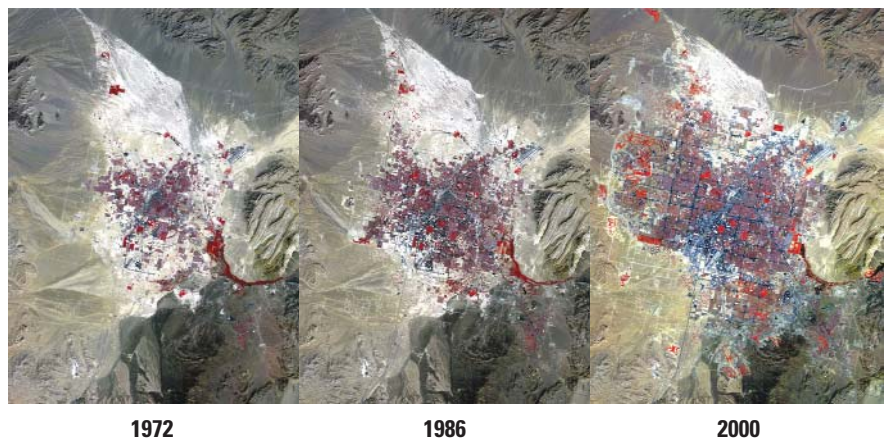


Image Set 3 Mississippi Delta, Louisiana

1. Describe how the delta area has changed from image to image. Find the marsh areas along the southern edge of the delta on the left side. Note the decrease. The seafood industry is concerned about this decrease. Why? (see background material)
2. New marsh is emerging within the toes of the birdsfoot area of the delta. Explain how this is happening. (see background material)

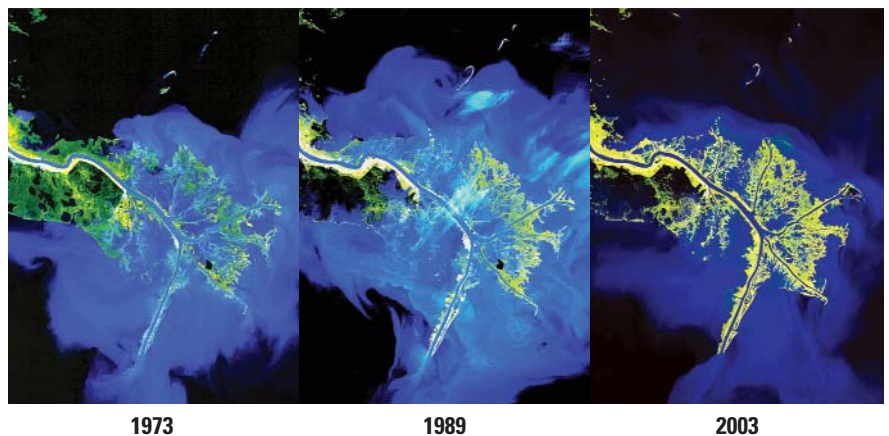


Image Set 4 Al Isawiyah, Saudi Arabia

1. What do you think the green circles are? (see background material)
2. Why have they appeared? (see background material)
3. Where does the water come from to irrigate? (see background material)

