Section 2. Introduction for Students

2.1 What is Remote Sensing?

Remote sensing involves gathering information about our surroundings without physical contact with the observed objects. We can hear a ringing telephone without holding it to our ear. We can feel the heat from a fire without touching it. We can smell cookies baking in the kitchen, from our living room. We can also see different colors in a picture or in our surroundings, from a distance. Scientists who observe the Earth use a variety of remote sensing instruments that view the Earth from above its surface. Such instruments also view the atmosphere between the aircraft, balloon, drone, satellite, or other platform that carries the sensing instrument(s). Instruments may be cameras (film or digital) or scanners that record reflected light in visible and non-visible wavelengths. They may be radiometers that measure thermal or radio wavelengths emitted in longer wavelengths, or radar scanners that measure reflected radio wavelengths. Figure 2.1.1 shows the electromagnetic spectrum; the visible wavelengths are a small portion of the range.

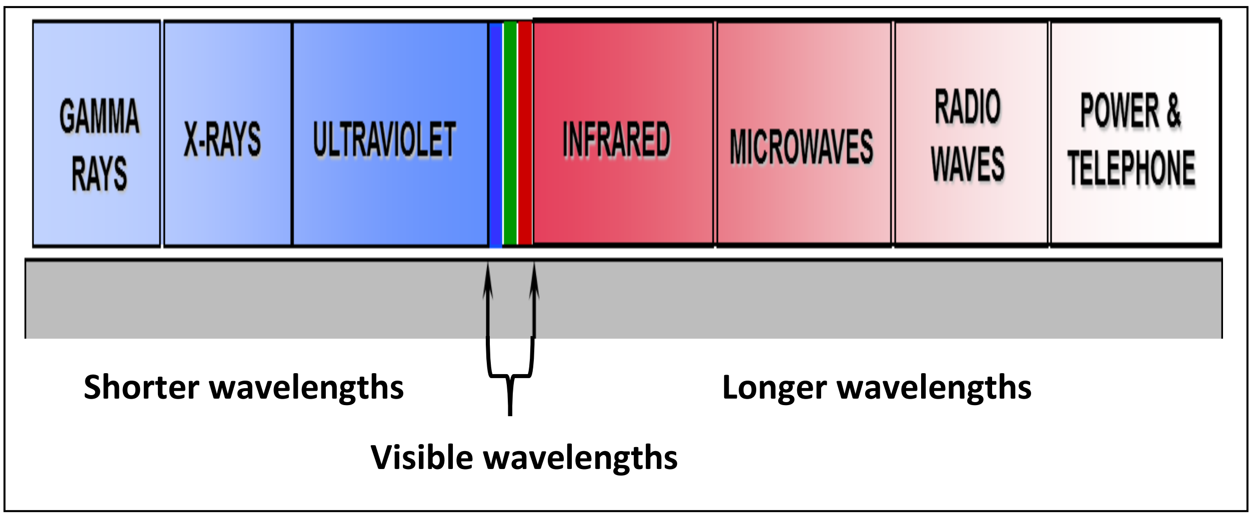


Figure 2.1.1 The electromagnetic spectrum

The imagery used in this book is from the Landsat series of satellites. Landsat 1 was launched in 1972, and Landsat 9 was launched in 2021. Since Landsat 5, launched in 1984, the satellites have carried instruments that not only record multiple wavelengths of reflected visible and non-visible electromagnetic radiation, but also record emitted thermal wavelengths of electromagnetic radiation. The color response for any imaged object depends on how it absorbs, reflects, an emits electromagnetic radiation (Figure 2.1.2). Sometimes a distinctive signature is related to the reflectance or emittance properties from non-visible wavelengths. With multiple wavelengths to choose from (Figure 2.1.3), it is possible to create both natural- and false-color images. False-color images show non-visible reflectance and emittance from Earth's surface in colors we can see.

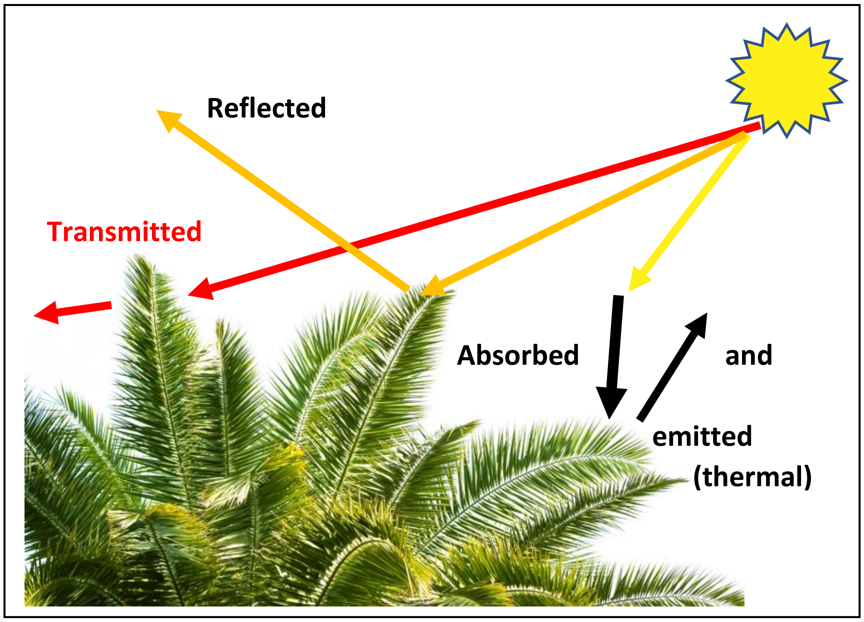


Figure 2.1.2 Possible interactions between electromagnatic radiation and an object or surface. The Landsat satellite records visible and short-wave infrared reflected sunlight and emitted thermal radiation in individual bands. Surface objects are heated by absorbing shorter wavelengths and then emit longer thermal wavelengths.

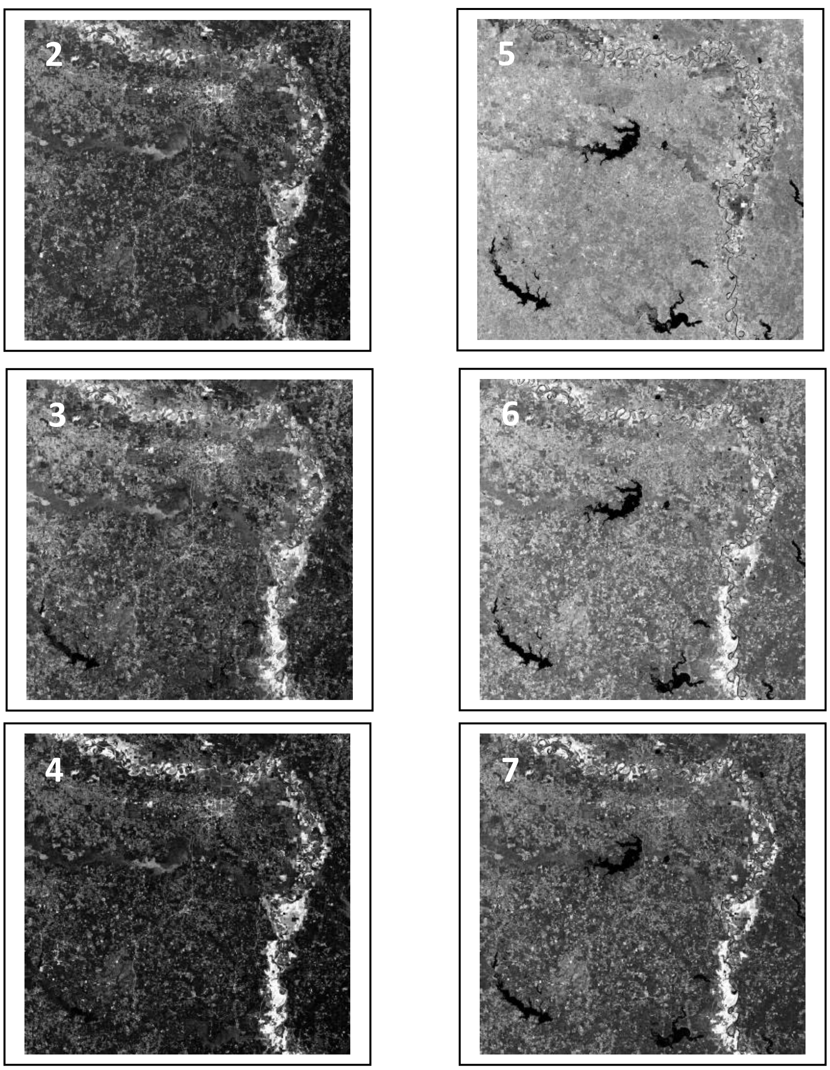
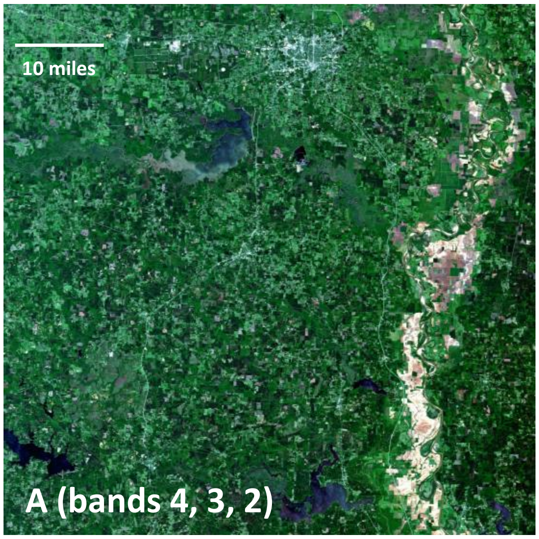


Figure 2.1.3

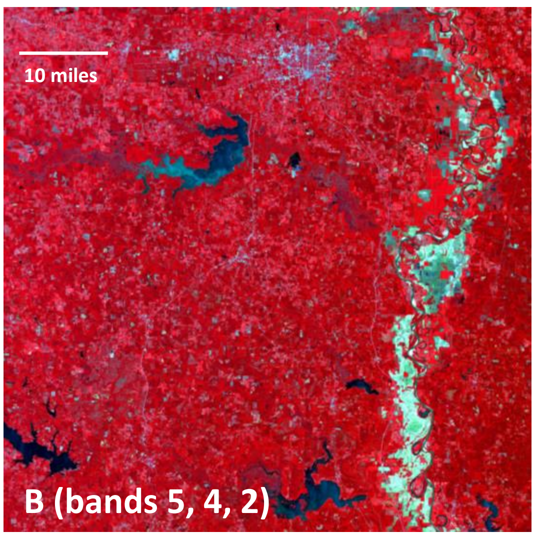
Six of the separate visible and infrared wavelength bands of reflected sunlight recorded by the Landsat 8 satellite, ranging from visible wavelengths (2,3,4) into the reflected infrared wavelengths (5,6,7). This 2017 image of east Texas has heavy vegetation cover.

- Vegetation absorbs sunlight strongly in the visible wavelengths (bands 2, 3, & 4), with slightly higher reflectance in band 3, (green light)
- Vegetation reflects sunlight most strongly in the near infrared (band 5).
- Absorption by vegetation increases slightly in bands 6 and 7, longer reflected infrared wavelengths.

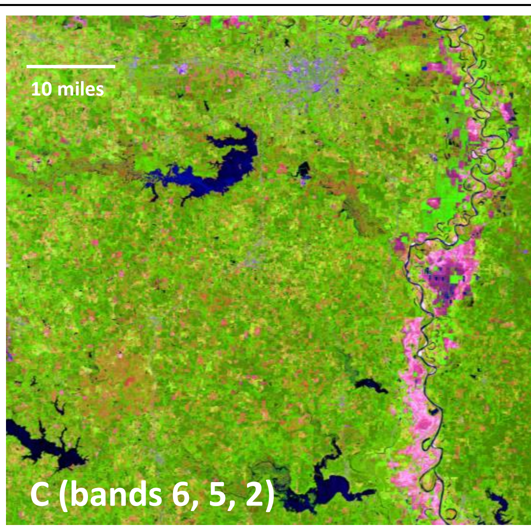
Figure 2.1.4. Comparison of natural- and false-color imagery from Landsat 8 data.



A. A natural-color image combines the blue, green, and red wavelengths of visible light, all shown in their natural color. Vegetation is green (4 = red; 3 = green; 2 = blue).
   a. Trees are medium to dark green.
   b. Grass is light green to brownish green.
   c. Concrete-rich developed areas and roads are grey.
   d. Bare ground is shades of brown.
   e. Clear water appears blue; muddy water appears light brownish-blue.



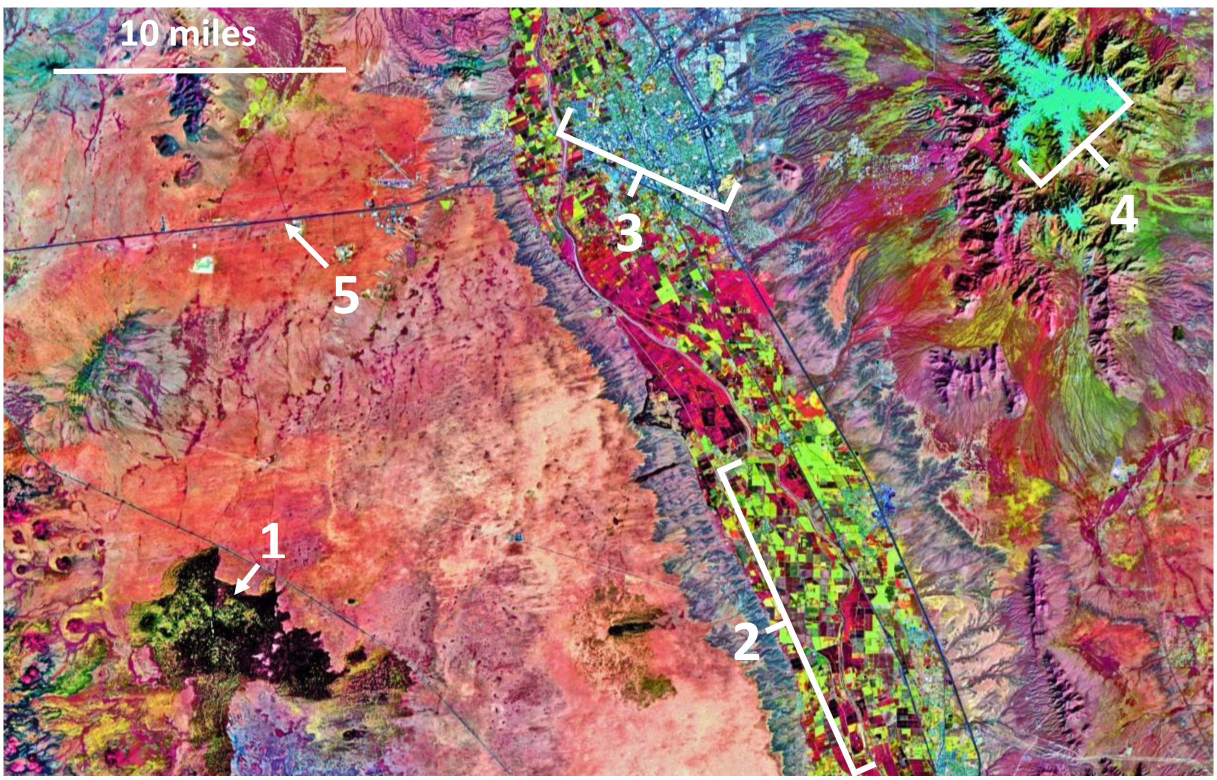
B. A false-color image in which reflected infrared wavelength band 5, where vegetation is highly reflective, is shown in red (5 = red; 4 = green; 2 = blue).
   a. Vegetation is shades of red.
   b. Developed areas and roads are shades of bluish gray.
   c. Bare ground appears gray.
   d. Water appears dark blue to black. (water progressively absorbs more of the longer wavelengths of visible and infrared light); muddy water appears light blue.



C. A false-color image in which band 5, where vegetation is highly reflective, is shown in green. (6 = red; 5 = green; 2 = blue).
   a. Vegetation is shades of green.
   b. Developed areas appear purplish.
   c. Bare ground appears in shades of pink.
   d. Water appears dark blue to black (water progressively absorbs more of the longer wavelengths of visible and infrared light); muddy water appears blue.

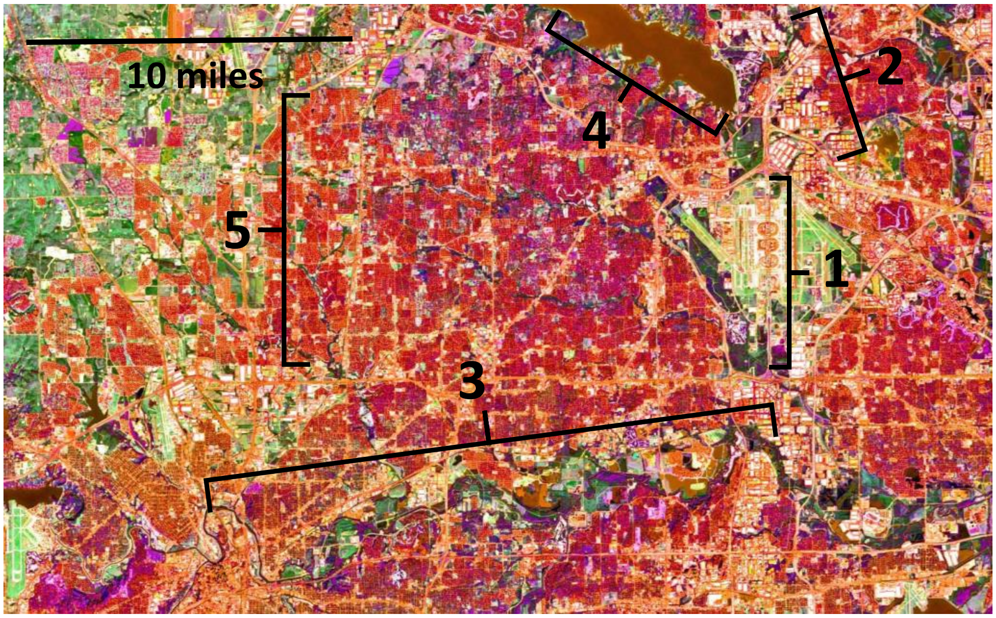
2.2 What can you see on a satellite image?

Imagine that you are on the International Space Station, looking down at the Earth. You look out the window at Earth and see reflected visible wavelengths of light with your own eyes. You can record reflected infrared wavelengths of light with digital imaging devices. You can record emitted wavelengths of infrared light (aka heat waves) with other digital imaging devices. Earth imaging satellites record all of these wavelengths and more. We can show any of these wavelengths in the visible light colors we are able to see. This is why the colors in the following images are not the natural colors you would see from the ISS with your own eyes; the satellites see the rainbow – and beyond! These images are from the art exhibit designed to engage students, teachers, and the public with Landsat applications; more on how art enhances STEM education in Section 4 - Texas as Art. The following images show a diverse set of things we can see on satellite images.



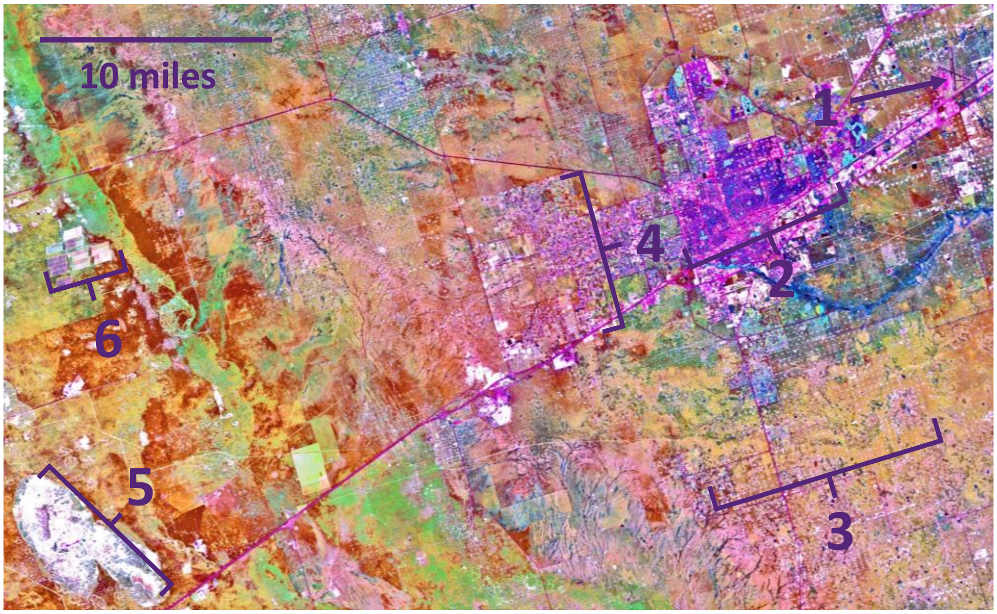
In this view of the Texas/New Mexico border area, you can see:

1. A lava field in a large lava flow (black)
2. A river valley with dense agricultural fields (patchwork)
3. A city (blue-gray)
4. A snow-covered mountain range (blue-green)
5. A highway (dark gray)



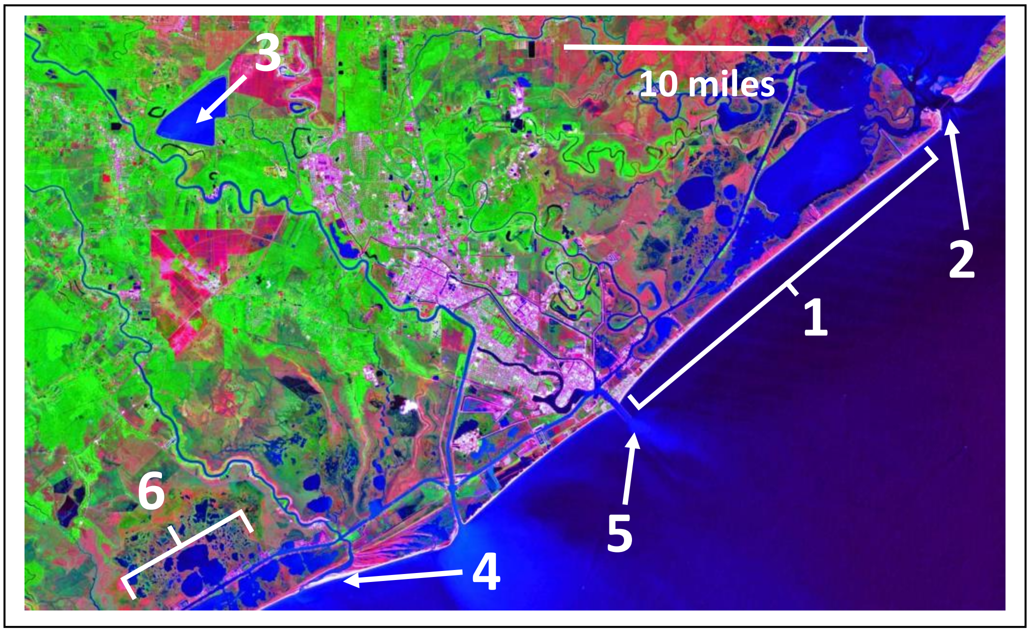
In this view of the city of Fort Worth, Texas and the DFW Airport, you can see:

1. A large airport with multiple runways
2. Industrial warehouses
3. A meandering river running through populated area
4. A drinking water reservoir with muddy water
5. Residential neighborhoods



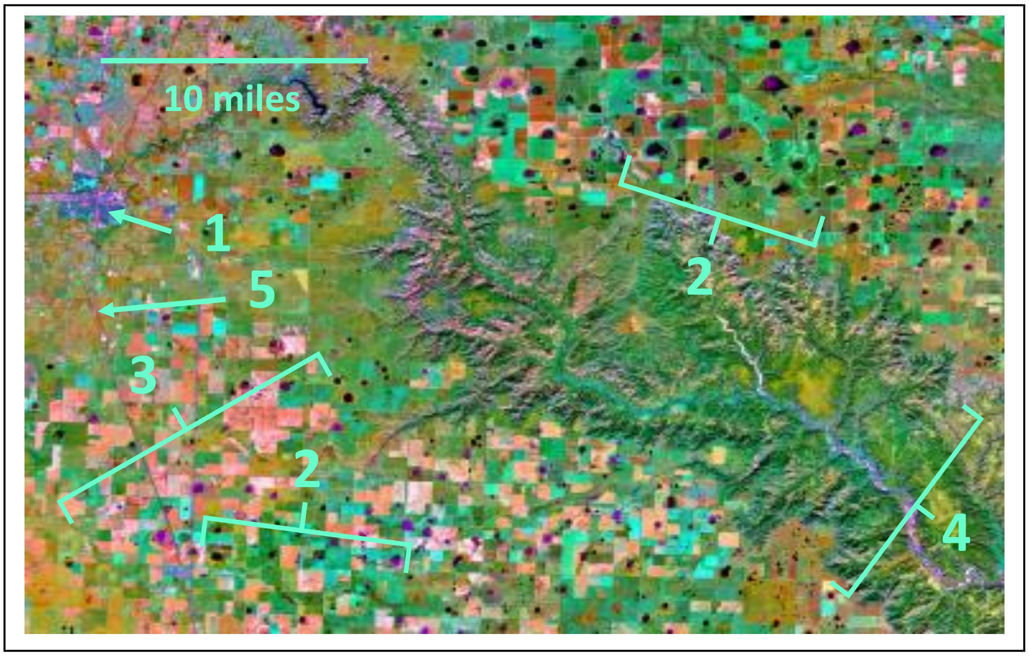
In this view of the city of Odessa, Texas, you can see:

1. A small airport
2. A city
3. Oil fields with numerous well sites
4. Residential neighborhoods
5. A large dune field
6. A solar farm



In this view of the Texas coastline and the city of Freeport you can see:

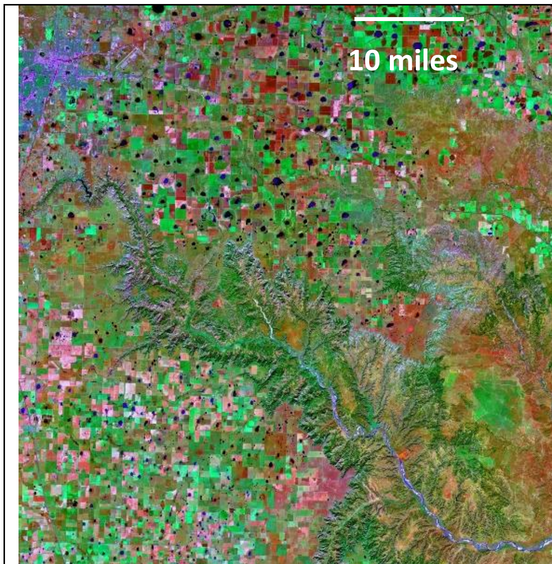
1. A barrier island
2. A tidal inlet
3. A water reservoir
4. A beach
5. Sediment-rich water entering the Gulf of Mexico
6. Coastal marshes



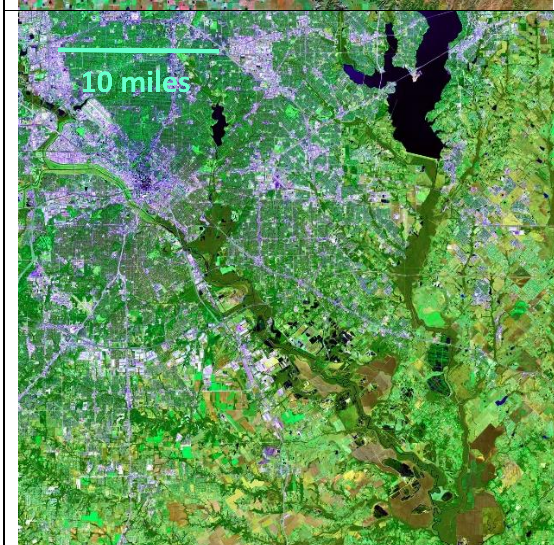
In this view of the city of Canyon, Texas, and Palo Duro Canyon, you can see:

1. A small town
2. Playa lakes filled by seasonal rainfall
3. Agricultural fields
4. A deep canyon carved in a flat plateau
5. A road

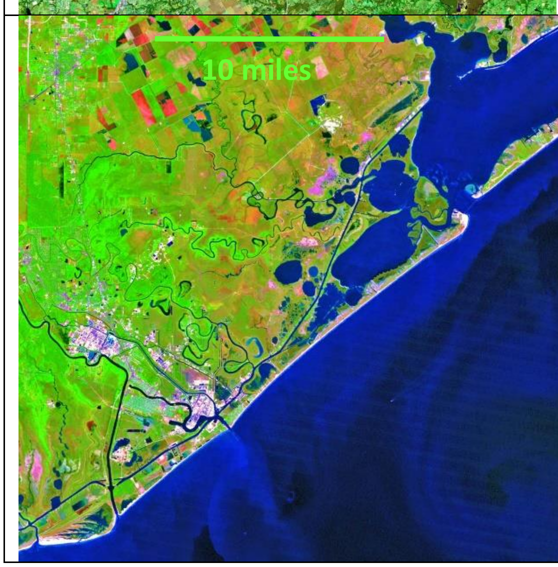
2.3 How do we use satellite imagery?



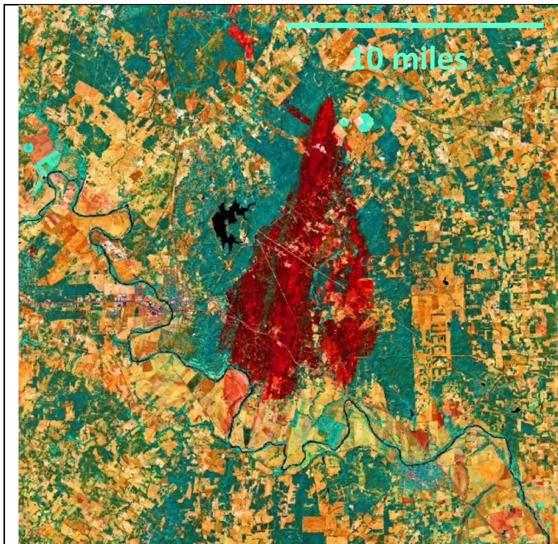
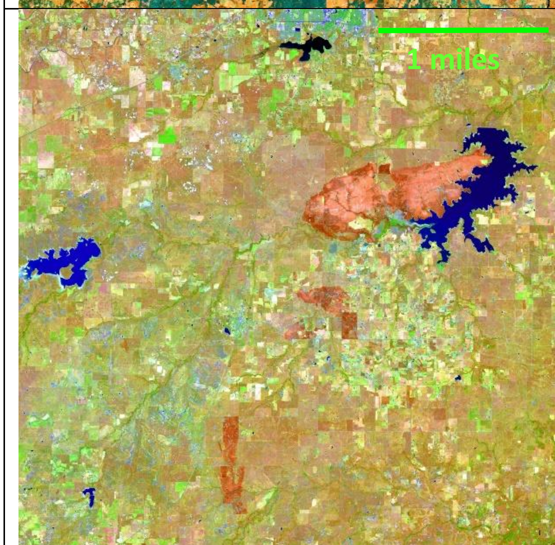
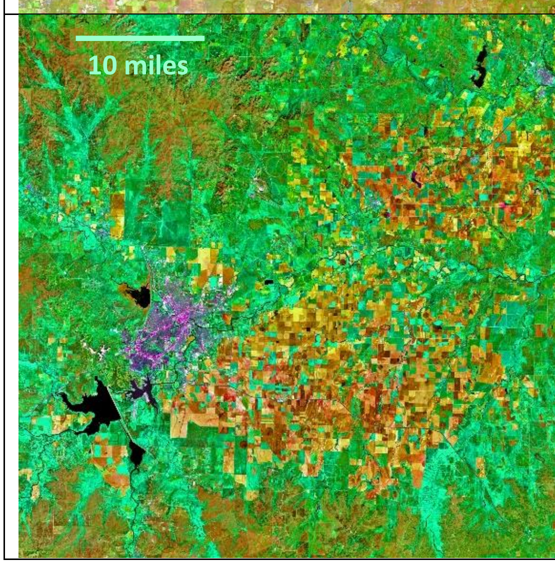
Hydrologists and farmers monitor scattered playa lakes (black circular areas) near Amarillo to predict recharge rates for groundwater reservoirs that support agricultural development. Wildlife managers monitor lakes as they offer migrating bird habitat.
TPWD_Playas for the Plains

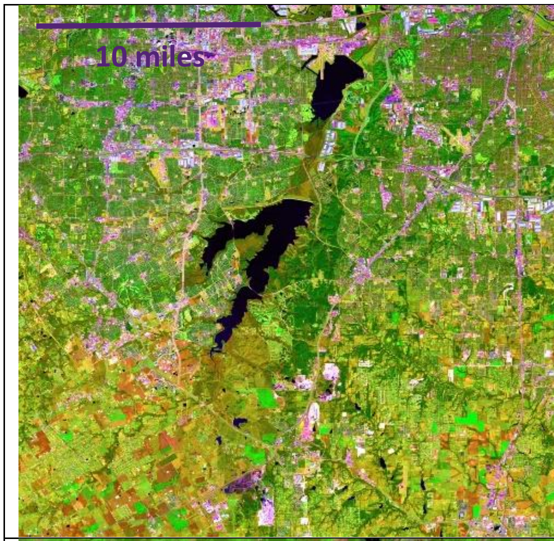
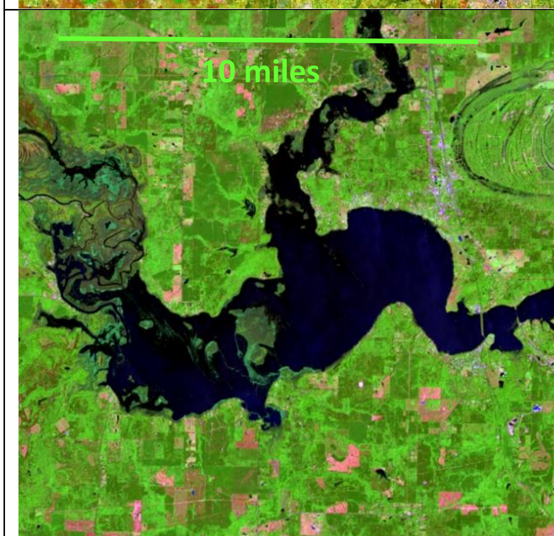
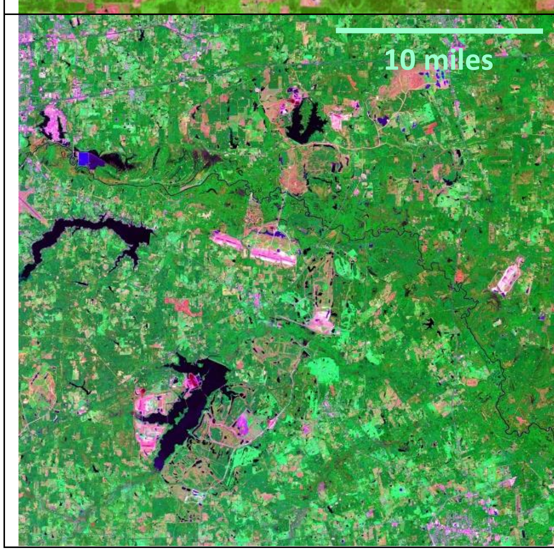


City planners and farmers can map floodplains (dark green) near Dallas to predict and monitor floods that could affect cities and agricultural fields. Wildlife managers monitor floodplains as wildlife habitat.
TPWD_Benefits of Flooding



Coastal managers monitor shoreline changes and observe changes in coastal beaches and marshes near Freeport caused by development and by storms. Fishery managers can monitor sediment input into coastal areas.
TPWD_Man of the Marsh: restoring Texas Coastal Marshes

	Foresters and wildlife managers map the extent and intensity of wildfire damage (red) to forest remnants (dark green) near Bastrop. Imagery over time helps with monitoring recovery, restoration, and mitigation efforts for forests and wildlife. TPWD_Bastrop State Park The Wildfire Recovery Guy_Bastrop SP
	Ranchers monitor the damage to grazing lands from drought and wildfires. Brown areas indicate drought damage to grasslands near Wichita Falls, and red areas are burn scars from drought-induced wildfires. TPWD_Panhandle Wildfires; Fire on the Prairie
	Farmers and water resource/quality managers monitor agricultural conservation practices around San Angelo. Pre-planting imagery shows the prevalence of cover crops (green rectangles) versus bare fields (shades of brown). Bare fields can lose soil into water courses, introducing agricultural chemicals into drinking water. Cover Crops in the Texas High Plains

	Environmental managers and city planners can monitor the encroachment of urban areas like Dallas (with intricate road networks) and water supply reservoirs (black) into agricultural areas (patchwork patterns of green and brown rectangles). [TPWD_Big City Biologists]
	Water resource managers can monitor invasive weed infestation outbreaks (green streaks in Caddo Lake) in lakes, to monitor the progress of the outbreak and plan remediation efforts. [TPWD_Giant Salvinia Invading Caddo Lake]
	Environmental managers can monitor active surface mining operations (pink) and remediation operations that restore mined areas (bright green) near Longview. [TPWD_2011 Lone Star Land Steward: North American Coal] [Lone Star Lands Steward: Jewett Lignite Mine]