

- “Exploring Energy: Infrared,” NASA Goddard, <https://www.youtube.com/watch?v=zmiU5tJRJd4>
- Food, Agriculture and Natural Resources Careers, USDA Living Science, <https://www.agriculture.purdue.edu/usda/careers/contactus.html>
- MyCAERT, <http://www.mycart.com/career-profiles/>
- Occupational Outlook Handbook, Bureau of Labor Statistics, US Department of Labor, <http://www.bls.gov/ooh/>
- Study.com, http://study.com/article_directory/q_p/page/Agriculture/q_p/Careers_and_Occupations_List.html

Sources/Credits

“Electronics/Electrician,” AgCareers.com, <http://www.agcareers.com/career-profiles/electrician-electronics-technician.cfm>

Herring, David, “Precision Farming,” Earth Observatory, NASA, <http://earthobservatory.nasa.gov/Features/PrecisionFarming/>

“The Herschel Experiment,” Cool Cosmos, Infrared Processing and Analysis Center, Science and Data Center for Infrared Astronomy, NASA: http://coolcosmos.ipac.caltech.edu/page/lesson_herschel_experiment

Thompson, Pat, “Making Sense of Sensors, Sensors and Satellites in Ag Technology,” Oklahoma Ag in the Classroom.

Discovering Infrared Light

Infrared is a form of light that we cannot see with our eyes but that we can sometimes feel on our skin as heat. Visible light, the only light our eyes can see, makes up just a tiny sliver of all the light in the world around us.

Infrared light falls just outside the visible spectrum, beyond the edge of what we can see. Sir William Herschel discovered the existence of infrared light by passing sunlight through a glass prism in an experiment similar to this one. As sunlight passed through the prism, it was dispersed into a rainbow of colors called a spectrum. A spectrum contains all of the visible colors that make up sunlight. Herschel was interested in measuring the amount of heat in each color and used thermometers with blackened bulbs to measure the various color temperatures. He noticed that the temperature increased from the blue to the red part of the visible spectrum. He then placed a thermometer just beyond the red part of the spectrum in a region where there was no visible light and found that the temperature was even higher. Herschel realized there must be another type of light beyond the red, which we cannot see. This type of light became known as infrared. Infra is derived from the Latin word for “below.”

Materials

- One glass prism (Plastic prisms do not work well for this experiment.)
 - Three good alcohol thermometers
 - Black paint
 - Scissors or a prism stand
 - Cardboard box (photocopier paper box works well)
 - 1 blank sheet of white paper
 - 1 halogen lamp, 100-watt bulb
1. The experiment may be conducted outdoors, around noon on a sunny day. However, results will be more consistent if conducted indoors with artificial light (halogen lamp).
 2. Blacken the thermometer bulbs with black paint or marker, covering each bulb with about the same amount of paint. (The bulbs of the thermometers are blackened in order to better absorb heat.)
 3. After the paint has completely dried on the thermometer bulbs, tape the thermometers together such that the temperature scales line up, as in Figure 1.
 4. Place the white sheet of paper flat in the bottom of the cardboard box.
 5. Carefully attach the glass prism near the top edge of the box facing the sun. If you do not have a prism stand (available from science supply stores), the easiest way to mount the prism is to cut out an area from the top edge of the box. The cutout notch should hold the prism snugly, while permitting its rotation about

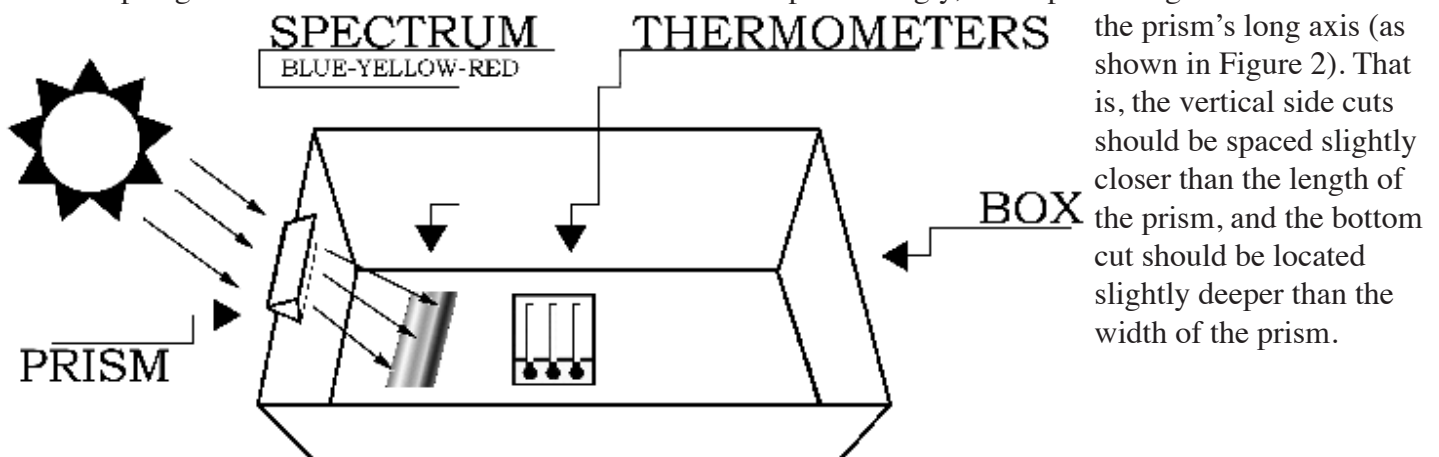


Figure 1

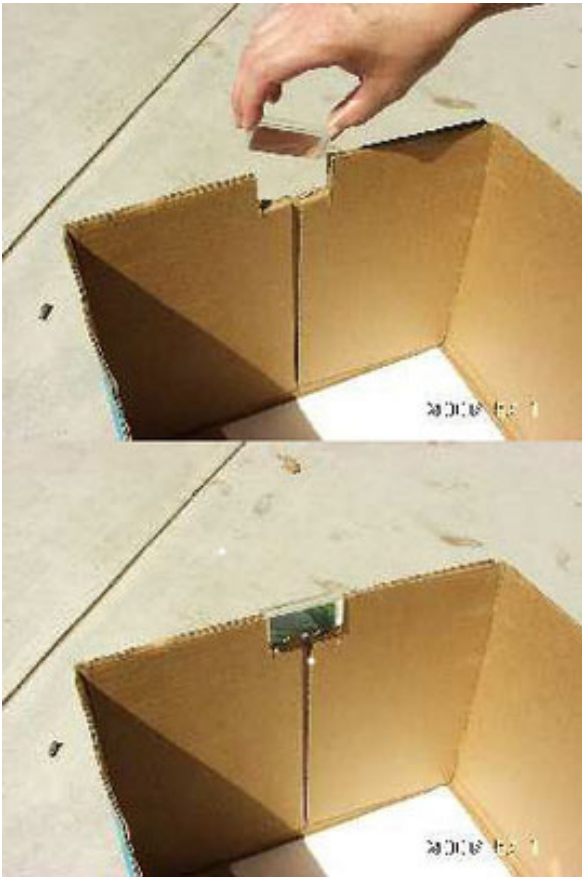


Figure 2

6. Slide the prism into the notch cut from the box. Place the halogen lamp so it shines on the prism. Rotate the prism until the widest possible spectrum appears on a shaded portion of the white sheet of paper at the bottom of the box. The light-facing side of the box may have to be elevated to produce a sufficiently wide spectrum.
7. After the prism is secured in the notch, place the thermometers in the shade if you are working outdoors or simply away from your artificial light source if you are working indoors. Record the ambient air temperature. Then place the thermometers in the spectrum such that one of the bulbs is in the blue region, another is in the yellow region, and the third is just beyond the (visible) red region (as in Figure 3). Note: Depending on the position of the prism relative to the light, the colors of the spectrum may be reversed from what is shown in the figures.
8. It will take about five minutes for the temperatures to reach their final values. Record the temperatures in each of the three regions of the spectrum: blue, yellow, and just beyond the red. Do not remove the thermometers from the spectrum or block the spectrum while reading the temperatures.

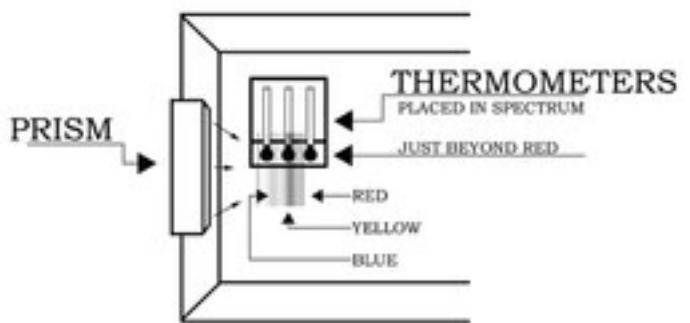


Figure 3

The temperatures of the colors should increase from the blue to red part of the spectrum. The highest temperature should be just beyond the red portion of the visible light spectrum. This is the infrared region of the spectrum.

Herschel's experiment was important not only because it led to the discovery of infrared light, but also because it was the first time that it was shown that there were forms of light that we cannot see with our eyes.

Source: "The Herschel Experiment," Cool Cosmos, Infrared Processing and Analysis Center, Science and Data Center for Infrared Astronomy, NASA: http://coolcosmos.ipac.caltech.edu/page/lesson_herschel_experiment

Name _____

Discovering Infrared Light Worksheet

DATA/OBSERVATIONS

Record the temperature of the three thermometers in the shade or away from the light (indoors)

	Thermometer #1 (blue)	Thermometer #2 (yellow)	Thermometer #3 (just beyond red)
Temperature			

Place the thermometers in the box in the spectrum such that one of the bulbs is in the blue region, another is in the yellow region, and the third is just beyond the (visible) red region. Now record the temperatures in each of the three regions of the spectrum: "blue", "yellow" and "just beyond red" after 1, 2, 3, 4 and 5 minutes.

	Thermometer # 1 (blue)	Thermometer # 2 (yellow)	Thermometer # 3 (just beyond red)
Temperature at 1 minute			
Temperature at 2 minutes			
Temperature at 3 minutes			
Temperature at 4 minutes			
Temperature at 5 minutes			

Calculate the differences between the final temperatures measured in the spectrum and the temperatures measured away from the light for the three thermometers.

	Thermometer # 1 (blue)	Thermometer # 2 (yellow)	Thermometer # 3 (just beyond red)
Temperature in the spectrum (T_{spectrum})			
Temperature in the shade (T_{shade})			
Difference ($T_{\text{spectrum}} - T_{\text{shade}}$)			

Calculate the differences between the final temperatures in each part of the spectrum

$T_{\text{yellow}} - T_{\text{blue}}$	$T_{\text{just beyond red}} - T_{\text{yellow}}$	$T_{\text{just beyond red}} - T_{\text{blue}}$

Class Average Temperatures

Compute the average final temperature measured by the class in each part of the spectrum.

	Sum of all class temperatures (T_{sum})	Total number of observations (N)	Class Average (T_{sum}/N)
Yellow			
Blue			
Just Beyond Red			

Compute the average differences measured by the class between the final temperature in the spectrum and the shade temperatures for the three thermometers.

	Sum of class temperature differences (T_{sum})	Total number of observations (N)	Class Average (T_{sum}/N)
$T_{yellow} - T_{blue}$			
$T_{just\ beyond\ red} - T_{yellow}$			
$T_{just\ beyond\ red} - T_{blue}$			

Questions

What did you notice about your temperature readings?

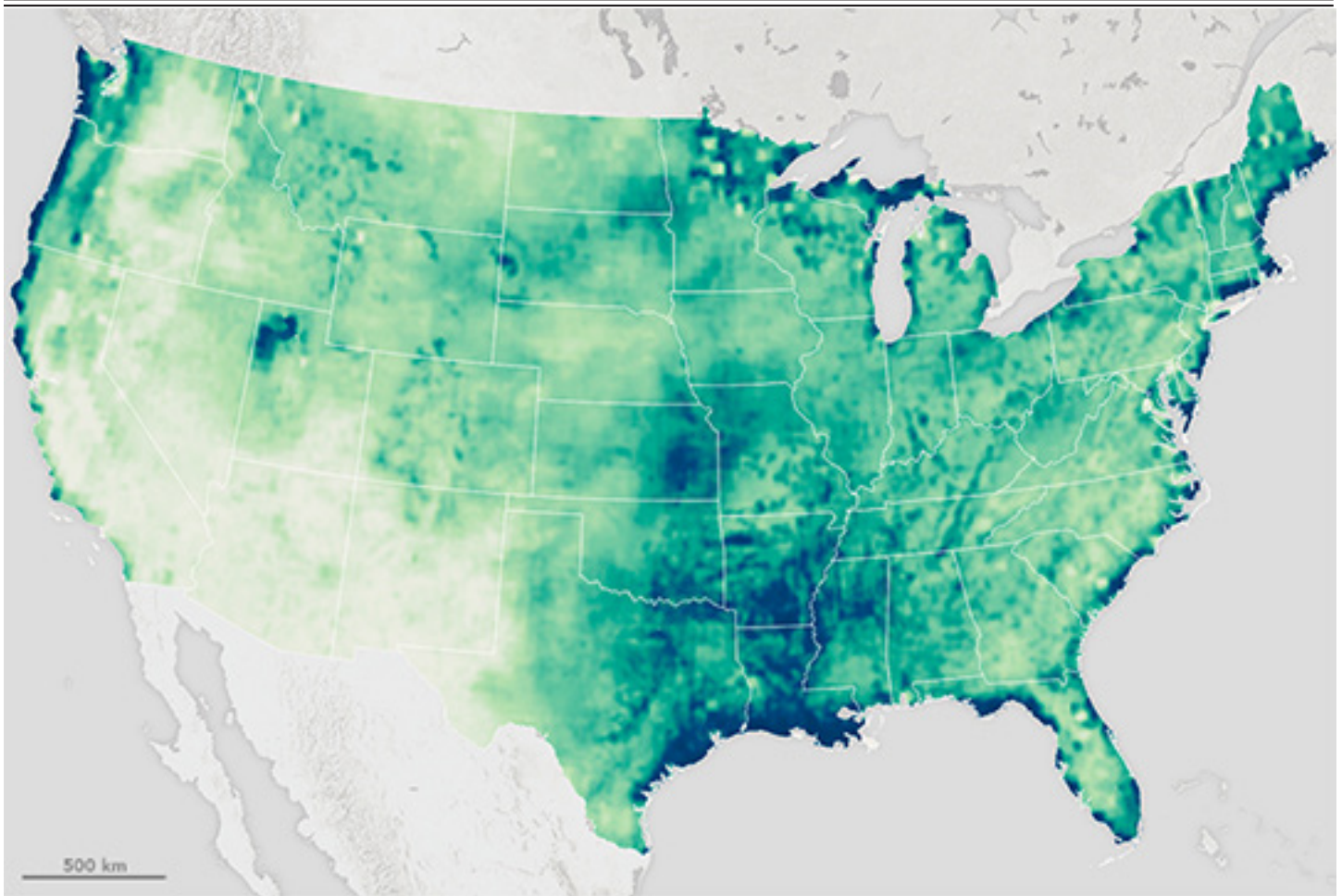
Did you see any trends?

What was the highest temperature?

What do you think exists just beyond the red part of the spectrum?

Discuss any other observations or problems.

Soil Moisture Map



Soil Moisture (m^3 water/ m^3 soil)



Knowing something about the moisture in the soil is important before, during, and after the growing season. For example, will mud prevent wheat harvesters from getting into the fields? How much water will crops have available at each stage of growth, from germination through harvest? Satellite and ground-based sensors help farmers find out.

The map above shows the amount of moisture in the top five centimeters of the ground across the US. It was produced with data collected with the radar and radiometer instruments on NASA's Soil Moisture Active Passive (SMAP) satellite during May, 2015. Colors show the volume of water contained in a volume of soil. Dark green and blue areas are progressively wetter, up to the point of saturation.

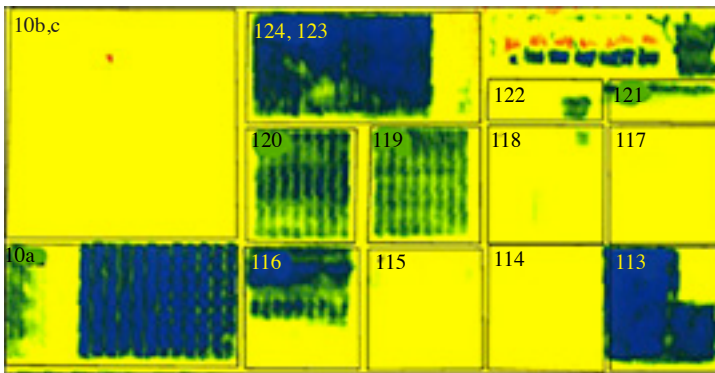
At the same time, ground-based sensors monitor soil moisture over small areas—typically less than one square meter. There are more than 1,200 ground-based stations across the US.

Source: NASA Earth Observatory, <http://earthobservatory.nasa.gov/IOTD/view.php?id=87036>

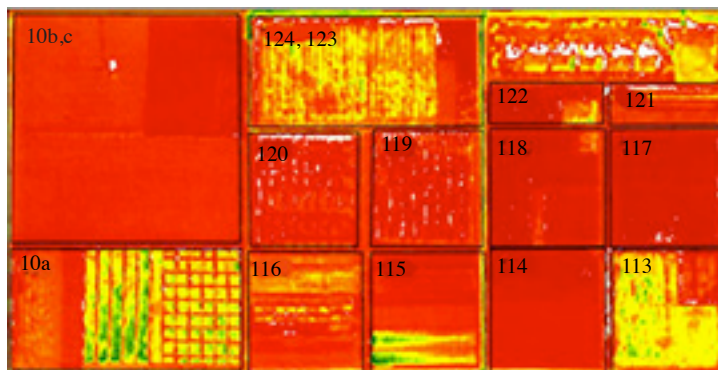
Reading Satellite Images

Satellites use remote sensing instruments to collect data, which is transmitted from the satellite to the ground as radar or microwave signals. Raw satellite data are just sets of numbers registered by digital equipment. By itself, raw data does not make an image. Converting raw data into an image requires computer software that converts ranges of radiation values into “false colors,” or colors we can see.

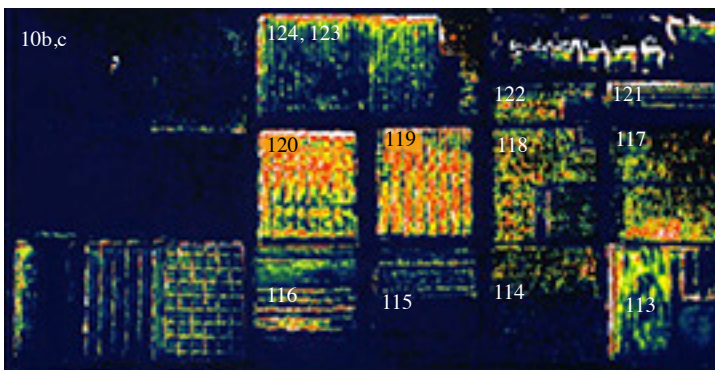
To determine the density of green on a patch of land, researchers observe the distinct colors (wavelengths) of visible and near-infrared sunlight reflected by the plants. When sunlight strikes objects, certain wavelengths are absorbed and other wavelengths are reflected. The pigment in plant leaves—chlorophyll—strongly absorbs visible light for use in photosynthesis. The cell structure of the leaves, on the other hand, strongly reflects near-infrared light. The more leaves a plant has, the more these wavelengths of light are affected, respectively.



Vegetation Density



Water Deficit



Crop Stress

The images at left are all satellite images of the same section of land.

- The top image shows vegetation density, with the darker colors indicating the most dense vegetation.
- The middle image shows water deficit. Green indicates wet soil and red indicates dry soil.
- The bottom image shows crops under stress, indicated by red and yellow.

For example, a farmer looking at field 119 from all three views would see that the field has a moderate amount of vegetation, is fairly dry and is under stress.

1. In which section is vegetation most dense? Can you tell why by looking at the other images?
2. Why do fields 120 and 119 have stripes?
3. Which fields have crops that are under stress? Why?
4. Which field is the best for growing crops? Why?
5. How would you describe field 10b,c just by looking at the satellite images?

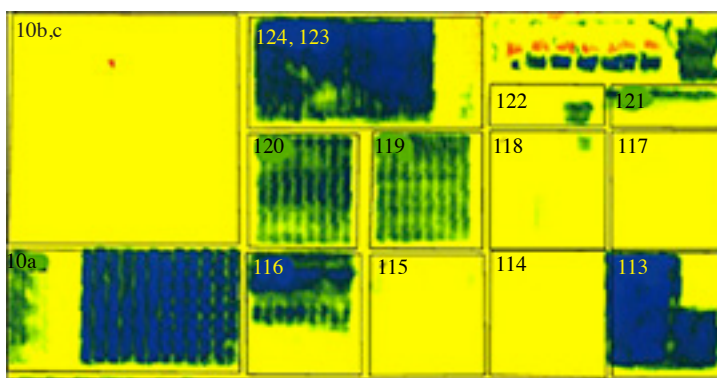
As a group, devise a plan for the best use of this land, based on what you can see from the satellite image. Does it need fertilizer? If so, what? What else does it need?

Sources: <http://earthobservatory.nasa.gov/IOTD/view.php?id=1139&src=ve>; Susan Moran, Landsat 7 Science Team and USDA Agricultural Research Service

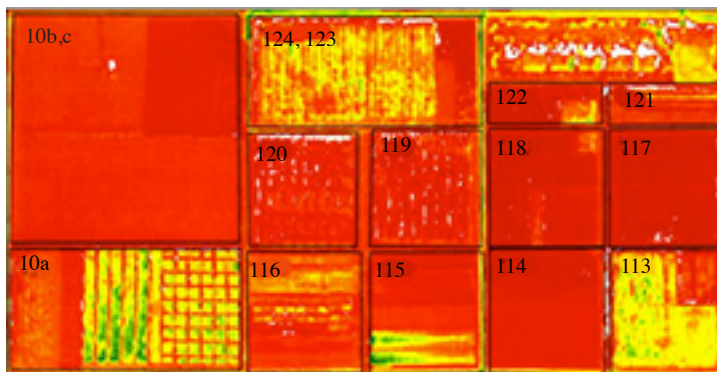
Reading Satellite Images (answers)

Satellites use remote sensing instruments to collect data, which are transmitted from the satellite to the ground as radar or microwave signals. Raw satellite data are just sets of numbers registered by digital equipment. By itself, raw data does not make an image. Converting raw data into an image requires computer software that converts ranges of radiation values into “false colors,” colors we can see.

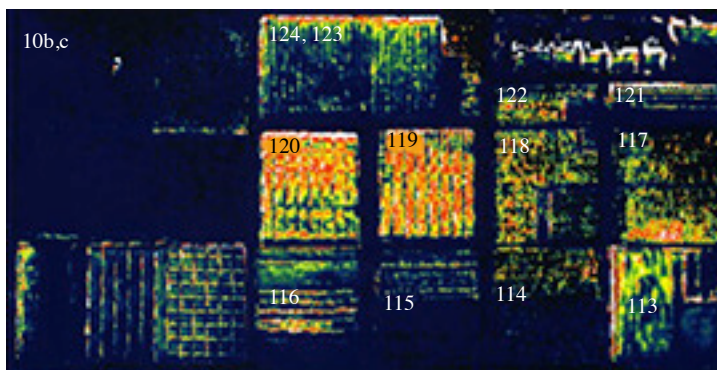
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For example, a farmer looking at field 119 from all three views would see that the field has a moderate amount of vegetation, is fairly dry and is under stress.

1. In which section is vegetation most dense? Can you tell why by looking at the other images?
Vegetation is most dense in sections 124, 123; 10a, 116 and 113 because they are the fields that do not have a water deficit.
2. Why do fields 120 and 119 have stripes?
The stripes in fields 120 and 119 are probably cultivated rows.
3. Which fields have crops that are under stress? Why?
Fields 120 and 119 are under stress because they need water.
4. Which field is the best for growing crops? Why?
Field 124, 123 is probably the best for growing crops because it has dense vegetation, doesn't have a serious water deficit and doesn't show very much crop stress.
5. How would you describe field 10b,c just by looking at the satellite images?
Field 10b,c has very little vegetation except in one tiny spot (might be a tree), has very little water and no crop stress. It probably is an unplanted field.

Careers in Ag Technology

New technology helps wheat harvesters and producers with the problem of labor shortage. With new technology workers are still needed, but the jobs often require specialized skills for operating and maintaining complicated equipment. Farm equipment dealers and manufacturers, grain milling operations, research firms, as well as some state and government agencies are all employers looking for employees with knowledge of and skills in the fields of electronics and computer sciences. A sampling of some of the electronics skills required include the following:

- Installation, maintenance and repair of electrical systems
- Reading blueprints and diagrams while troubleshooting and diagnosing electrical problems
- Performing preventative maintenance to avoid operational failures of electrical systems
- Installing electrical wiring, assembling electrical parts and test fixtures and components that provide electricity to related instruments
- Tearing apart and reassembling equipment
- Reading dials and meters to determine amperage, voltage, electrical output and input at specific operating temperature to analyze parts performance
- Remote sensing data collection and management
- Big data mining, including pattern detection, graph analysis, or statistical analyses from a variety of disparate sources.

Use one or more of the career websites listed to locate five job openings related to agricultural electronics and technology. Use the information you find to fill in the blanks below:

- Agriculture and Forestry Careers: <http://www.environmentalscience.org/careers/agriculture-and-forestry>
- Careers in Agriculture (Georgia Agricultural Education): <http://www.gaaged.org/page.aspx?ID=353>
- Food, Agriculture and Natural Resources Careers, USDA Living Science, <https://www.agriculture.purdue.edu/usda/careers/contactus.html>
- MyCAERT, <http://www.mycart.com/career-profiles/>
- Occupational Outlook Handbook, Bureau of Labor Statistics, US Department of Labor, <http://www.bls.gov/ooh/>
- Study.com, http://study.com/article_directory/q_p/page/Agriculture/q_p/Careers_and_Occupations_List.html

Name of Company _____ Location _____

Job Description:

Job Requirements (Education/Training)

Salary Range