**Lab 3:**  **Exploring digital data and Reflectance**

**More on exploring digital data**

Modern remote sensing uses digital data, and it is critical that you understand what this means so you can manipulate digital images. Even imagery collected using film is usually digitized (scanned) so that it can be manipulated on the computer.

As discussed in lecture, the fundamental processing unit in digital imagery is the pixel. Each pixel represents an area on the ground, the size of which is determined by the spatial resolution of the sensor. In imagery, each pixel is described by *one digital number* (DN) *for each band*, representing the amount of light that traveled from the pixel area on the ground to the sensor (satellite or airborne “camera”). A DN is usually a unitless *index* of an amount of light, not actual radiance. Typically, these numbers are integers ranging from 0 to some maximum value determined by the radiometric resolution of the sensor (255 in the case of landsat 4/5 TM data and 16 bit for landsat 8).

The image pixels collectively cover an area on the earth represented by the image. The width of the image is determined by the swath width of the sensor. Polar orbiting sensors collect imagery in continuous north-south swaths, so the height of an image (# of rows) is determined by how the data get divided into images after collection. Typically, imagery is divided into square *scenes*, so that the height is about the same as the swath width, but this isn’t always the case.

Finally, sensors often collect data across multiple wavelengths (*e.g.*, blue, green, red, near-infrared, *etc.*). Each wavelength region captured by the sensor is stored in a separate image layer or *band* (sometimes called a *channel* or *layer*). A typical satellite image is like a layer cake, with bands for layers. If a sensor has 6 bands, each area on the ground (pixel) will be represented by 6 DNs, one for each band. Collectively, these digital numbers can be used to describe the pattern of reflectance (the spectral signature) from the area on the ground covered by each pixel’s “footprint.”

In today’s lab, you will continue examining digital satellite data and begin learning some simple image processing techniques. Start by downloading the lab 3 folder to your flash drive. Within is a LANDSAT 8 full scene. I’ve included only the mstir (multispectral and thermal infrared) and pan (panchromatic images). All the .img files are erdas images. The .rrd files are the pyramid layers – always make sure you get both. The text file contains metadata.

1. **Start Erdas Imagine** and open the image called **lc80450272014196lgn00-msi.img – lab 3 subdirectory** (the msi stands for multispectral imagery). Check notes, etc to see which bands these are). Display the image as a false color infrared image (remember, the band numbers are different for landsat 8 than they are for earlier versions – verify the erdas defaults, because they are often wrong.)
2. Full Landsat images are called ***scenes***, in remote sensing jargon. A Landsat scene is about 185 km wide (the swath width of the sensor) and are cut into squares so that a scene covers an area of 185 km x 185 km (a little over 100 miles on a side) on the ground. For particular research projects, we often require only part of a scene, and it requires less hard drive space and less processing time if we use only the portion of a scene we need. Technical terms for “chopping” are **subsetting** or **clipping**. Now you will subset it further, isolating a small area of lush vegetation (what color is lush vegetation in your false color IR image?).
	1. In Erdas, you can perform image processing operations on small parts of images called **“areas of interest” (AOI’s)**. The user (you!) can use a tool to draw the boundaries of AOI’s, which can be of any shape or size. Then you can tell Erdas to use only the area inside the AOI boundary for various operations. We will use an AOI to subset the Ellensburg image (this is not the only way to define subset areas [*e.g.*, see inquire box on ribbon], but it’s handy).
		1. First, **zoom in** on a bright red the center-pivot (circular) field east of the Columbia. Pick one with a little water right next to it (dark pixels. Note that at this zoom level, you can see the individual pixels.
		2. To capture this area in an AOI, **click on the Drawing tab** in the Raster area of your main ribbon and then click the **elliptical icon** in the **Insert Geometry** area of the Ribbon.
		3. Use your mouse to draw a circle that captures most or all of this field. Note that you can change the size and shape of the ellipse and drag it around. (If you make a mistake you can select it and delete). Be sure to include at least a few of the water pixels.
		4. **Now Save the AOI** by clicking on the **File tab** and choosing **Save as/AOI layer as…**, browse to your flash drive if necessary, and **give the AOI a name (like centerpivotfield.aoi)**.

***NOTE: WHENEVER WORKING IN ARC OR ERDAS, NEVER PUT SPACES OR ODD CHARACTERS INTO FILE OR FOLDER NAMES. STUFF MIGHT NOT WORK, AND YOU WILL HAVE NO CLUE WHY. AND KEEP FILENAMES SHORT (less than 8 characters). SERIOUSLY.***

* 1. Now you will use your saved AOI to subset the image (clip out the field).
		1. Click on the **Raster tab** and in the **Geometry area** choose **Subset & Chip/Create Subset Image**.
		2. In the window that appears, browse to the **lc80450272014196lgn00-msi.img** image for your input image and **browse to your flash drive and give the output image a name (like field.img)**.
		3. Note that there are several ways to define the subset area (Inquire box, two or four corners, *etc*.). We will use the AOI. At the bottom of the Subset window, **click on the AOI button**. In the window that appears, choose **AOI file**, browse to your saved AOI, and choose it. Leave other defaults unchanged (note that you are clipping all 9 layers, and that this image is a 16-bit image—this refers to radiometric resolution).
		4. **Click OK** to subset your image.
	2. **Open a new 2D viewer** and **display your field subset as a false color infrared image**. Notice that the subset (clipped) field image looks different than it does in the unclipped Ellensburg image. This is because Erdas automatically adjusts the image contrast (we will experiment with this later) to take advantage of the full range of colors available for display; since we are viewing a small piece of imagery that includes black pixels (DN = 0) around the edges, this results in the field looking washed out. (**Worksheet question #1**). **Keep this image displayed!**
1. When you created this subset, Erdas automatically calculated image statistics (min, max, and mean pixel values, *etc.*), that it uses to display the imagery. The problem is that images are always square, so there are “empty” (black) pixels around the round field you chose. All of these black pixels influenced the display, causing the field pixels to be displayed at the bright end of the available scale, leading to a low contrast image with washed out pixels. We can fix this!
	1. Open the metadata window for this image and examine the min and max pixel values for Band 5 (**Worksheet question #2a**)
	2. Now, at the top of the metadata window, choose **Edit/Compute Pyramid Layers/Statistics**. Check the little box that says Ignore Value, and choose 0, which should appear by default when you check the box. Click OK to recalculate the statistics. Erdas will generate new statistics but it will ignore the black pixels.
	3. Now open a new viewer window (don’t close the old one or do anything to it!), and display the same file as a false color infrared image.
	4. Finally, with the two clipped images displayed side by side, link the views (**Home tab/link views/link views**), open an inquire tool for each of the two views, and compare the band 5 pixel values for the same pixel in each view (you can switch back and forth between views in the inquire tool using the little circular arrow at the top right of the inquire tool window). Note the “File Pixel” values and the “LUT Value.” (**Worksheet question #2b**). The File Pixel value is the original DN from the image; the LUT Value is a “temporary” value that Erdas uses for image display only. LUT stands for “Look Up Table.” Erdas converts pixel values to a range from 0 – 255 for display, and it does this using a table that tells it what value to use for each “File Pixel” value. It changes the LUT Values to optimize the image display, but does not change the original data (the File Pixel values) unless you explicitly force it to.

1. You can control the way Erdas displays imagery by changing the Look Up Table Values yourself. This is called Contrast Enhancement. Erdas is pretty good at choosing optimal contrast, but this is not always true. Experiment with the **contrast enhancement tools**, found in the **Multispectral Tab** in the **Enhancement Area,** by clicking on **General Contrast** under **Adjust Radiometry**. There are also built in contrast enhancements here. Contrast enhancement changes the brightness with which particular DN’s are displayed on your computer. Typically, this is applied temporarily (the image DN’s are not permanently changed) to help make it easier to see the variations of tone and color in images.
	1. **Close your open image and then create two 2D viewing areas**. In one, open the full mstir image, **BUT** in the **Select Layer to Add** window go to the **Raster Options tab** and **click the No Stretch box**. In the other viewer area, open the same Ellensburg image but let Erdas do its default contrast stretch. Display both as false color infrared images (note that you can do this either from the **Raster Options** area when you open the image, or in the **Multispectral Tab** after you have opened them, as you have done before) (**Worksheet question #3a**)
	2. Highlight the 2D View (click on it) containing the *stretched* image, and apply the **Histogram Equalize** stretch in the **General Contrast pull-down**. How does the result look? (**Worksheet question #3b**)
	3. Under **General Contrast, click General Contrast** and using the window that appears, experiment with options. **Try a level slice with 2, 3, 4, or 256 levels**. This takes all of the pixel values in each band and forces them into 2, 3, 4, or 256 values, respectively. This should result in what looks like a crude map of parts of the Ellensburg area that have similar DNs. There are many other contrast stretching options. Contrast stretching can sometimes allow you to enhance your image display so that you can see differences that might otherwise be obscured. This isn’t always necessary, but sometimes it can be informative, and is a good tool to have in your arsenal.
	4. **Close the two images** and **reopen** your field image **as a false color IR** image in a single viewer.
2. Erdas provides tools for exporting your image data to many other data formats. This can be valuable for converting images for use with other software that may not recognize Erdas Imaging files (.img). You will export your field image as a jpeg file and insert it into the answer sheet
	1. In Erdas, click on the **Manage Data tab**, and choose **Export Data**. In the dialog box that opens, **choose JFIF (JPEG)** from the pull-down. For your **input file** choose your field image, and for the **output file**, navigate to your flash drive and give the file a meaningful name. **Click OK**.
	2. Another dialog box appears. Leave the defaults, but click on the **Export Options** button and change the Select Layers to 5,4,3 to export a false color IR jpeg. Click OK on this box and on the original box to create your jpeg. You can open it from your Windows Explorer by double clicking on the filename and then zooming in on the file in the Windows Photo Viewer.
	3. You can also create a jpeg file from a View by using the “**Send to JPEG**” option (or to Powerpoint or Word!) on the ribbon (upper right). This is easy, but has less options than **Export**.

**More on Reflectance!**

Erdas provides many tools for analyzing spectral data, some of which you will use as we go through the semester. We will look at a few of them today. You will also use a USGS tool that allows you to view Landsat 8 bands overlaid on spectral signatures of various materials.

For the first part of this lab we will be using a Landsat 8 image of Ellensburg – check the lab3 subdirectory in the class drive in the lab. The image includes 7 reflective bands (layers) that correspond to the electromagnetic spectrum (Table 1).

 **Table 1: Landsat 8 reflective bands.**

|  |  |  |
| --- | --- | --- |
| **Band (Layer)** | **Wavelength Range (nm)** | **Common name** |
| 1 | 430-450 | Coastal aerosol (blue visible) |
| 2 | 450-510 | Blue visible |
| 3 | 530-590 | Green visible |
| 4 | 640-670 | Red visible |
| 5 | 850-880 | Near infrared (NIR) |
| 6 | 1570-1650 | SWIR1 (Mid-IR) |
| 7 | 2110-2290 | SWIR2 (Mid-IR) |

1. Open the Ellensburg image. **Change the band to color assignments** **so that the image resembles a false color infrared image (see the intro lab if necessary)**.
2. The **Inquire Tool** is useful for looking at pixel values across bands at particular points in images. **Click on the Inquire button** (blue cross hair) in the Home ribbon or in the viewer window. Intersecting white lines will appear centered on your image, and a window will open that shows you the pixel values (FILE PIXEL column, **not** the LUT VALUE column!).
	1. Use your mouse to move the crosshairs to an area of dense vegetation. Look at the pixel values across the 7 bands. (**Worksheet Question #1 a-b**)
	2. Move the crosshairs to a natural grassland area (shrub steppe) (**Worksheet Question #1c**)
	3. Move it to a river or lake. (**Worksheet Question #1d**)
	4. When you are done, **close the Inquire tool**.
3. Erdas can also graph the digital numbers to create spectral curves (a.k.a. spectral signatures, spectral reflectance curves). To do this click on the **Multispectral Tab** and choose **Spectral Profile/Spectral Profile** in the Utilities area. A graph window will appear that has Pixel Value (DN) on the y-axis and Band # on the x-axis. To use the tool, click on the crosshair at the top of the graph window and then on a location in the image for which you would like to see a spectral curve.
	1. Use this tool to create spectral curves for dense vegetation (trees), grasslands (shrub steppe), asphalt, concrete, and water. Be sure to pick representative pixels! Note that you can change the color and name of the lines using the **Edit/Chart Legend** button at the top of the graph window. (**Worksheet Question #2**).
4. Now, because things vary, let’s look at some variation within a class. The two things we’ll look at are water and the shrub steppe. (**Worksheet Question #3a and b**). Remember that to distinguish materials using satellite data, differences in the spectral reflectances of the materials MUST be captured by the satellite. Also remember that, in nature, materials have variable spectral reflectance. In other words, different aspen trees can have somewhat different reflectance, due to differences in leaf chemistry, plant health, plant structure, time of year, *etc*. We call this “spectral variability,” and it affects our ability to distinguish materials. We’ll talk about this more later in the semester.