Exercise 4a: Identifying Human Activity on Imagery and Creating New Data with Human Geography Attributes

Lecture: Imagery as a Data Source and Attributing Human Activity by Social Theme.

Description: This exercise has two parts: an activity and a lab-based exercise.

- **Activity:** Use any available imagery (from the web or the commercial images provided to you) to find three features that fit your assigned human geography theme. Use an image graphic template (from ArcGis or the one provided to you as a ppt) and create three image graphics displaying these locations. Your group will present these graphics to the class and identify the key image characteristics used to identify the features that fit in your theme. Discuss these questions with your team as you select these features:
  - Do the features in your theme have distinct features observable from overhead imagery?
  - Which of the eight key imagery characteristics will be useful to identify features in your theme?
  - What other data sources are available to identify these feature locations?
  - What other data set(s) would you want to identify these locations?

  Class discussion: Save your graphics as separate jpgs and share your image graphics with the class. Present to the class the imagery characteristics most useful to identify the features that fit your assigned theme.

- **Lab:** In ArcMap, use satellite imagery to locate and identify your three features from the previous activity. Create a new data layer where you digitize polygons for each feature and add attribute information about those new features. We will want to standardize our information between groups so that all teams will use the same types of attribute data.

  Class discussion: What should be included in the attribute data? Human Geography group and theme? Formal name? Local name? URL? Human Geography-specific attributes?

Each group will create a data layer of their three features using the agreed upon categories.

The last step in the lab will be to develop a single data layer for each human geography theme (with no duplicates) and create maps displaying the human geography of Cusco. We will use the Geoprocessing tool, **Merge**. Then, each group will use the **Feature to Point** tool to create a layer of points from their polygons for later use.

- **Objective:** The objective of this exercise is to practice identification of human geography feature locations from imagery and to create new data layers. This data will use agreed upon attributes as a standard to form the basis for additional assessment and analysis. Students will learn to create data with useful attribute information that can be shared for multiple purposes and displayed as finished products.
- **Skills:** imagery interpretation, image graphic production, digitizing, data attribution, imagery graphic production

Data: We will create our own attributed data and share the data that we create.

Reference materials:

The 8 key imagery characteristics:

- Shape
- Size
- Shadow
- Scale
- Position
- Pattern
- Tone or Color
- Texture

The 13 themes of Human Geography:

General	**Theme**	**Data**	
Affiliations	Ethnicity	Population by ethnicity	
	Religion	Population by religion; Religious buildings (churches, synagogues, mosques)	
	Groups and Organizations	Formal and informal groups; headquarters	
Populations	Demography	Population characteristics (gender, age)	
	Economy	**Indicators**	**Infrastructure**
		Wealth indicators, Income indicators	Energy capacity (electricity grid, renewable energy)
	Education	Education/ Literacy rates	Schools
	Health and Medical	Health indicators	Infrastructure (hospitals, pharmacies, medical clinics)
Interactions	Language	Distribution of dialects	
	Communications and Media Use	Cell towers, Telephone lines Television stations, Post Offices	
	Transportation Use	Road network, Railways, Airports, Buses	
Environment	Water Supply and Control	Access points Water treatment facilities Rivers, Wells	
	Land	Land use/Land cover Ownership Cultural significance	
History	Significant Events	Natural disasters; Political changes; Treaties	

Exercise:

- To start today's lab, open **ArcMap**. Click on **ArcCatalog**  . A new window will open on the right of the screen. The instructor will give you directions about how and where to create a new folder where you will do your exercise.

- Create a folder: **Exercise4a/**

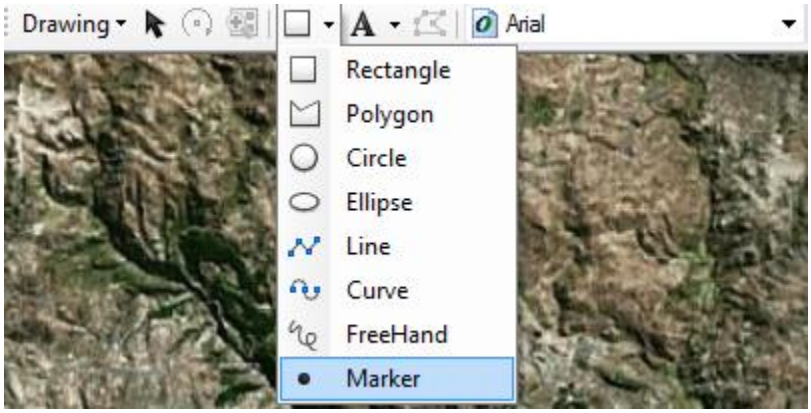
Step 1: Finding your sites and setting your projection

1. Open **ArcMap**. To correctly load the imagery you will build your new feature layer from, we need **Specify a Coordinate System**. Right click on **Layers** in your **Table of Contents** and open **Properties**. In the **Data Frame Properties box** select the **Coordinate Systems** tab. Navigate to **Projected Coordinate Systems, UTM, South America** and select **Provisional South American Datum UTM Zone 19S**. Click **Apply** and **OK**. Now, when you open the images, they will be converted on the fly to the projection you will want to use to create your dataset.
   NOTE: In ArcGIS help, read "Specifying a coordinate system".
2. Click on the **Add Data** button  , from the dropdown select **Add Data**. Navigate to <**image**>. Click **YES** to build pyramids. This will open in the Data Frame. You may have to zoom in and pan to see the high resolution imagery.
3. Orient yourself on the image. Locate your sites. Zoom in to your features and identify which of the 8 key characteristics of imagery interpretation you can observe from this imagery.
4. Examine your Data Frame to see if the spatial extent captures all of your sites. Zoom and pan around to see all the sites. Think about what you can and cannot see.
5. We want to set the parameters of the Data Frame. First, give your Data Frame a meaningful name: *Cusco <YourTheme> Sites* (right click on the **Data Frame title**, select **Properties/General**).

Step 2: Creating new data – Polygons (Reference: Exercise 2, Step 2)

1. Right click anywhere in the menu bar of ArcMap. A dropdown list will appear with all of the extensions for ArcGIS. We are going to create data. Click on **Drawing**. (You can move the Drawing tool bar and dock it on the tool bar.) The Drawing toolbar has several tools.

   Click on the **Shapes** dropdown and select **Polygon**.



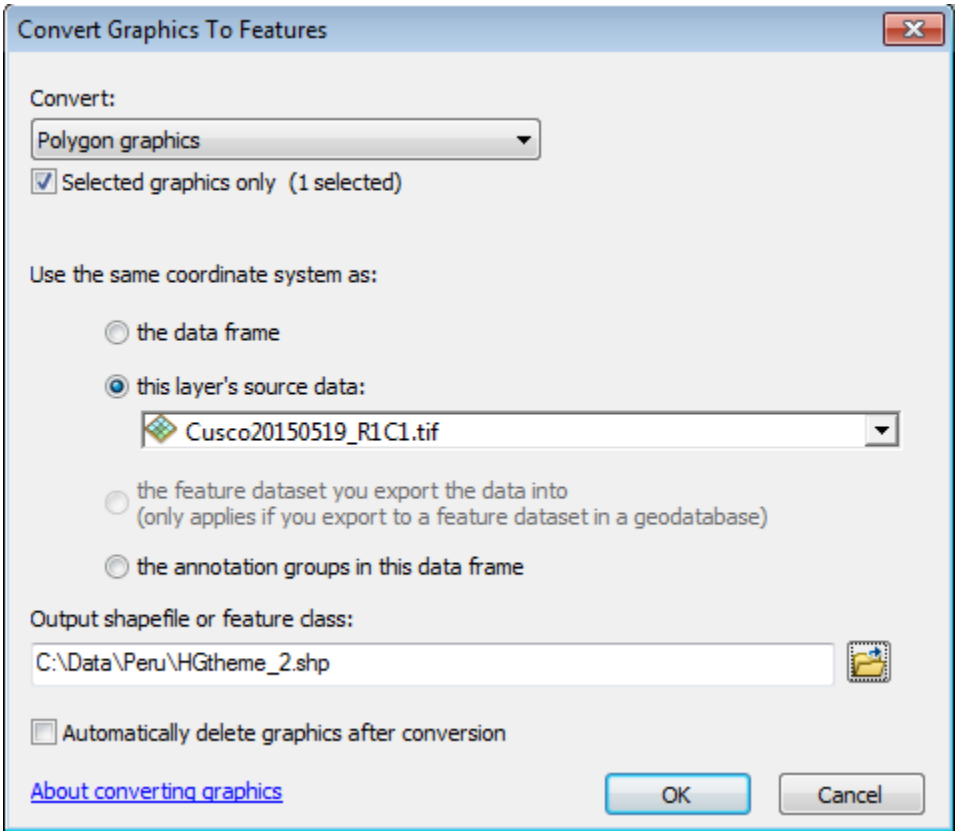
2. Click on the **Polygon** icon, then zoom to your point of interest. You will want to create one polygon for each of your features. To do this you will left click once each time you want to drop a point for your polygon, then double click to finish the polygon.

3. These **Polygons** are only graphics on your map. They are not geographic data that has any coordinates or attribute data. We will convert our **Polygons** to feature data.

a. From the **Menu** bar, click on **Edit/Select All Elements**. All graphics will selected.

b. Right click on the Data Frame title **- Cusco <YourTheme> Sites**, select **Convert Graphics to Features**.

Enter the following information. Output filename should be **<YourTheme>sites_team#.** Adding your team# is important for later in the lab!



Step 3: Adding attribute data to the table (See Exercise 2, Step 3)

1. As a class, we will come up with the list of attribute data to include in the table. What kinds of information might we want to include? Human Geography group and theme and Name (of the site). What other types of information might we want to include? We want to be sure we all have the same table structure so that we can easily merge our data.
2. See Exercise 2, Step 3 to open and add the additional agreed upon human geography attribute fields to your table.
3. Next, enter the **Attribute** information. These values will also show up in your table. Enter all the information for your polygons.
4. When you are done, select **Editor/Stop Editing**. Click **Yes** to **Save Edits**. Close your table and **Attribute** window.

Step 4: Creating new data: Merge (See Exercise 2, Step 5)

1. We want to take all of our polygons and make a single layer for each human geography theme features collected by the class.
2. In ArcGIS, you will **Merge** multiple datasets of the same data type into a single dataset.
3. Using **ArcCatalog**  , **Copy** and **Paste** your shapefile **<YourTheme>sites_team#** into the folder: **CuscoWorkshopData/SharedData**. This way everyone can access everyone's data.
4. Once all teams have put their data to that folder, copy that folder to your working directory: **Exercise 4**.
5. In the **Menu** bar, click on **Geoprocessing/Merge**. Click on the **Tool Help** to read about what **Merge** does. In Input Datasets, include all the team **<YourTheme>sites_team#** shapefiles. Click **OK**.
6. A new shapefile will added to your **Table of Contents**. Give it a meaningful name: **Class <YourTheme> Sites in Cusco.**
7. Open the attribute table for Class <YourTheme> Sites in Cusco. Examine the table. *What do you notice about the table?*
8. You will have to clean up the table so that it does not have fields with null values.
9. Further examine all of the polygons and identify any duplicates –polygons which identify the same feature. *What do you notice about how duplicate features have been digitized? If you knew you would be combining your layer with others, how might you have planned or standardized your digitizing for later use?* You will need to remove any duplicates. Keep only the polygon that you think best outline the features.
10. Close the table.
11. You can change the way the labels are displayed for Class<YourTheme>sites if you prefer.

Step 5: Transforming the data for small scale display

Later you may wish to display your dataset at a smaller scale, possibly at a district or provincial level.

1. Open a basemap (see instructions in exercise 2, Step 1), and deselect the commercial imagery you have loaded, so that it does not display. Zoom out on your map, do your polygons disappear as you look at a larger area on the map?
2. To make these features easier to see at a small scale, we will convert these polygons to points.
   -Add X, Y fields to your attribute table.
   -Right click and calculate geometry.
   -Export the DBF to a new SHP.

Step 6: Make a map (See Exercise 2, Step 6)

1. Create a map following the instructions in Exercise 2, Step 6.
2. Add one of your graphics from the Activity as an inset to your map, using **Insert, Picture.**
3. Examine your map. Compare your map with other teams.
4. Save your project.

Congratulations! You have completed Exercise 4a, created new data from imagery and made new graphic products.

Exercise 4b: Image classification and comparing images over time

Lecture: Classification and Change Detection

Description: For this exercise we will use Landsat imagery to examine Cusco over time by classifying images and conducting a change analysis using images from 2000 and 2014.

Objective: Using Image Analysis in ArcGIS will provide students with hands-on techniques for working with remotely sensed data. In this exercise we will be focusing on detecting urban areas. In this exercise we are using a Landsat 7 image from July 1, 2000 and a Landsat 8 image from Aug 9, 2014. Classifying images for change detection is one of the key tools of a geospatial scientist.

Skills: imagery interpretation and classification,

Data: Landsat 7 image, July 1, 2000; Landsat 8 image, Aug 9, 2014; 30 m resolution (for most bands)

Landsat represents the world's longest continuously acquired collection of space-based moderate-resolution land remote sensing data. Four decades of imagery provides a unique resource for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research. Landsat images are also invaluable for emergency response and disaster relief. (http://landsat.usgs.gov/about_project_descriptions.php)

Where you can download: http://earthexplorer.usgs.gov/
http://landsatlook.usgs.gov/
Guide to downloading Landsat data using USGS Earth Explorer:
http://earthobservatory.nasa.gov/blogs/elegantfigures/2013/05/31/a-quick-guide-to-earth-explorer-for-landsat-8/

Landsat Resources: Landsat images are composed of spectral bands that measure reflected energy as detected from the electromagnetic spectrum. We can use the different spectral signatures of an image to assess different characteristics of the landscape.

Read about these different band designations at these sites:

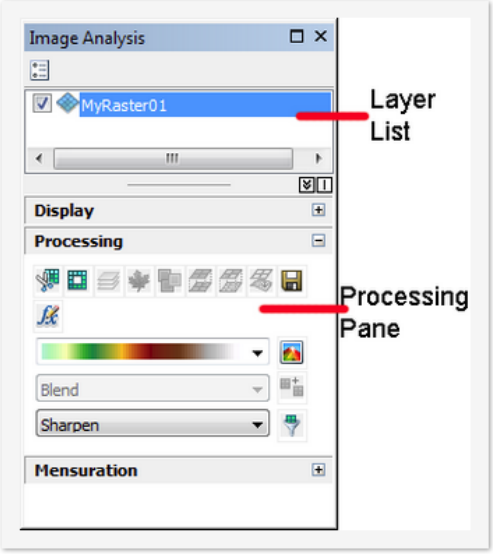
Band designations: http://landsat.usgs.gov/best_spectral_bands_to_use.php
Differences in band designations between Landsat 7 and Landsat 8:
http://landsat.usgs.gov/L8_band_combos.php

- Set up a folder for Exercise 4b.

We will use the image processing tools in ArcGIS for this exercise. The **Image Analysis window** supports the analysis and exploitation of image and raster data in ArcMap with a collection of commonly used display capabilities, processes, and measurement tools.

Read *What is the Image Analysis Window* in ArcGIS Help:
http://resources.arcgis.com/en/help/main/10.1/index.html#//009t000001tm000000.

1) Open your Image Analysis window (**Windows → Image Analysis**)

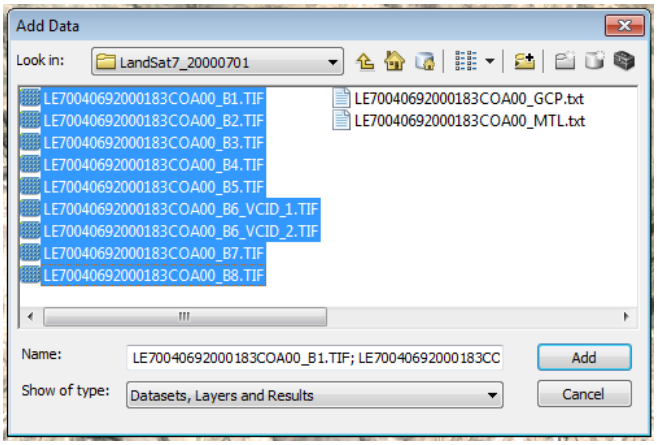


The **Image Analysis window** should pop up.

The Processing buttons are defined below:

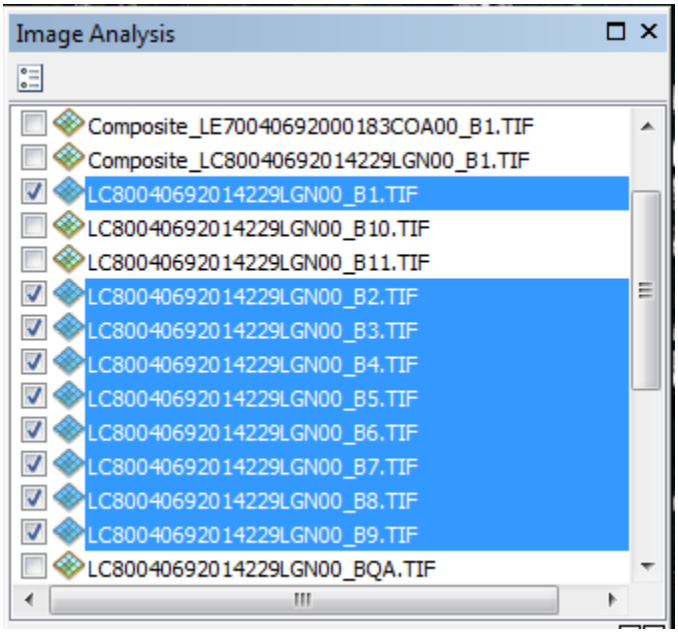
Button	Name	Conditions
	Clip	Enabled when 1 or more layers are selected.
	Mask	Enabled when 1 or more layers are selected.
	Composite Bands	Enabled when 2 or more layers are selected.
	NDVI	Enabled when a multiple band layer is selected, or 2 single band layers.
	Colormap To RGB	Enabled when a colormap layer is selected.
	Difference	Enabled when 2 layers with the same number of bands are selected.
	Pan-sharpening	Enabled when a multiple band layer and a single band layers are selected.
	Orthorectify	Enabled when a layer with rational polynomial coefficients and a single band (DEM) layer are selected.
	Export	Enabled when any one layer is selected.
	Function Editor	Enabled when any one layer is selected.
	Shaded Relief	Enabled when 1 or more single band rasters are selected.
	Mosaic	Enabled when 2 layers with the same number of bands are selected.
	Filter	Enabled when 1 or more layers are selected.

2) **Load the Landsat imagery to ArcGIS**. Each scene has a layer for the multiple bands. Load all of the bands. **Create pyramids as well**. Pyramids allows the raster image to load faster and enhance display performance and visual quality.



You will see all of the separate bands in the Table of Contents, and you will only be able to see one at a time for now. We will use the Image Analysis Window to combine different bands together into composite images.

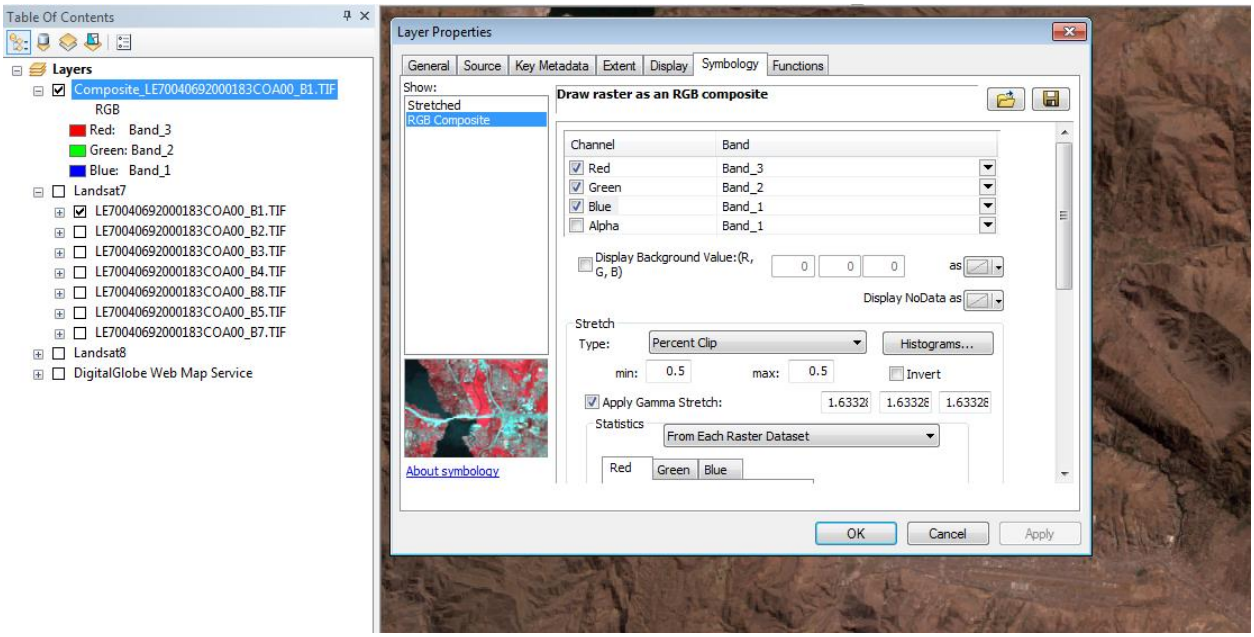
3) **In the Image Analysis window, select all the bands for each Landsat image. Then click on the Composite Bands button to make a composite layer.**
(**Tip**: for Landsat 8 you must select only bands 1-9 to avoid an error.)



You should now see a new temporary composite layer in your Table of Contents. This layer consists of all of the bands collected in the Landsat image and you can specify which three bands are represented by Red, Green and Blue channels.

4) In the **Properties** of your composite layer **adjust the bands to make sure the Red, Green, and Blue channels are reading from the correct Landsat band.**

The Landsat 7 bands for Natural Color are: Red = Band 3; Green = Band 2; Blue = Band 1
The Landsat 8 bands for Natural Color are: Red = Band 4; Green = Band 3; Blue = Band 2



5) Experiment with different band combinations.

A common question is what spectral bands should be used for a study area. Each Landsat band represents a different portion of the electromagnetic spectrum, and certain bands and band combinations are better suited for identifying particular types of surface materials.

The Red, Green, Blue band combination is the closest to true color that we can get from a Landsat image.

The Infrared, Red, Green band combination produces what is called a 'false-color composite' and is often used to detect vegetation. The human eye can't naturally see light in the infrared spectrum, but here the red channel is representing the infrared signal the Landsat sensor is picking up. Vegetation has a high reflectance value in the infrared spectrum and shows up brightly.

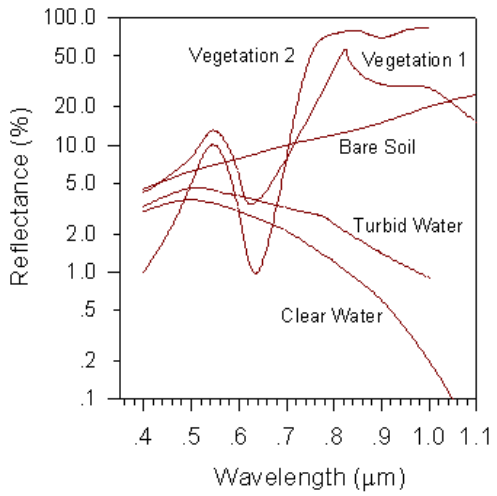


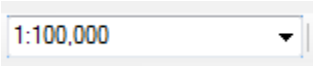
Figure 1 Read about Spectral Reflectance Signature: http://www.crisp.nus.edu.sg/~research/tutorial/optical.htm#spectral_signature

For Landsat 7: Band 7 (Red), Band 4 (Green), Band 3 (Blue) can work well for detecting urban areas. Band 7 (MID or SWIR spectrum) can pick up minerals and human-made materials well, so you can expect them to look red or pinkish.

NOTE: the bands in Landsat 7 are different than Landsat 8. Look into the source materials to figure out what bands you need to choose to make both composite images be comparable to each other. Check out this: http://blogs.esri.com/esri/arcgis/2013/07/24/band-combinations-for-landsat-8/ You can compare the bands between Landsat 7 and Landsat 8 and determine what would work best to use to compare between images. (**HINT:** Try Red = 7; Green = 5; Blue = 4)

- **Zoom** into Cusco on the Landsat 7 image: Latitude: 13°32'S; Longitude: 71°56'W
  Do you remember how to set the Data Frame properties and change the units in the lower right corner of the Data Frame window?

6) **Clip extent to narrow the area of classification. Set the scale to: 1:100,000.**



In the Image Analysis window select both Landsat layers then click on the Clip button on the Image Analysis window's Processing section. It will create new temporary clip layers for both images.

7) **Perform Supervised classification on both images to detect urban areas**
Resource: Links to Remote Sensing tutorials are provided at the end of the exercise, in particular check out videos 19a and 19b.)

NOTE: Before you do this, you need to think about what classes of landcover you want to identify. Discuss with your team the different land cover classes you want to use. Assess the image to see what classes are visible and that you are able to classify. The resolution of the data will determine how refined you can make your classification system. For example, you might want to use water bodies, vegetation, urban area, agriculture, etc….

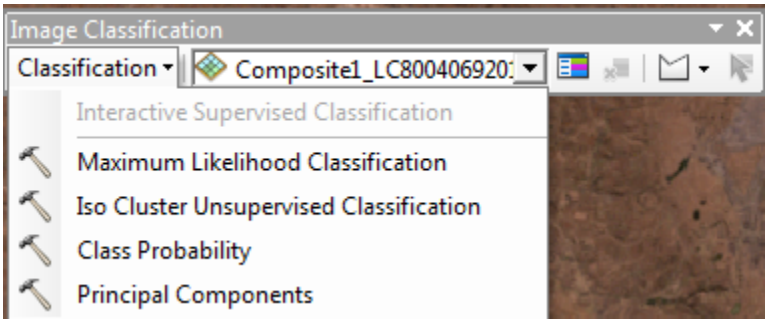


Figure 2 The Image Classification toolbar

Read *An Overview of the Image Classification toolbar in ArcGIS Help*:
http://resources.arcgis.com/en/help/main/10.1/index.html#/An_overview_of_the_Image_Classification_toolbar/00nv00000008000000/

Supervised classification is the essential tool used to classify remotely sensed imagery. Using this method the analyst creates training samples that identify groups of pixels representing particular classes or known land cover categories. Then the classifier is used to attach labels to all of the image pixels according to the trained parameters. The most commonly used supervised classification is maximum likelihood classification (MLC). Maximum likelihood classification is based on statistics (mean, variance/covariance) to determine how likely a pixel will fall into a particular class.

a) Turn on the **Image Classification** toolbar. Right click in the menu bar and the tools dropdown will appear. Check **Image Classification**.

Make sure the correct clipped composite layer is selected as your image classification layer on the Image Classification toolbar.

b) **In the Image Classification toolbar click on the Training Sample Manager button**  **.** This is where your training samples will show up. You need to **create a training sample for all the different classes that show up on your image. Now click on the 'Draw Polygon' button in the Image Classification toolbar and start drawing your training samples.**

c) In the classification drop-down menu on the Image Classification toolbar, **select Interactive Supervised Classification.**

Read *Interactive Supervised Classification tool* in ArcGIS Help: http://resources.arcgis.com/en/help/main/10.1/index.html#/Interactive_Supervised_Classification_tool/00nv0000000z000000/. The **Interactive Supervised Classification** tool works the same as the **Maximum Likelihood Classification** tool with default parameters.

Supervised classification can be an iterative process where initial results can be evaluated to create better training samples.

d) *How did your initial results turn out? Can you improve on them?* **Try adding or subtracting training samples and re-running Interactive Supervised Classification.**

- You can do this by removing the polygon from the Training Sample Manager list.

Try adjusting the transparency of the classification and see if it helps you visualize the results.

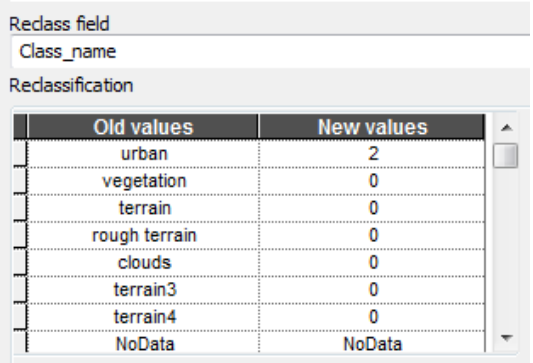
- You can do this by **right clicking** on the **Classification Composite name**, select **Properties/Display**. Set T**ransparency** to **50%**.

If possible load high-resolution imagery from 2014 and see if this can help you refine your training samples.

8) *We want to compare both images and calculate the differences. To do this we will do Map Algebra. Examine the tables for the two Classified Clipped Composite images (Right click – Open Attribute Table). We have unique classification for our pixels into different land cover classes. Now we want to re-classify the rasters to have the pixels store values indicating only two values: if there is urban area or no urban area. Then we will be able to use Map Algebra subtract pixels from each other and calculate differences.*

a) We are interested in classifying urban change so we want to re-classify our rasters to include one class representing the urban areas and another class representing everything else.

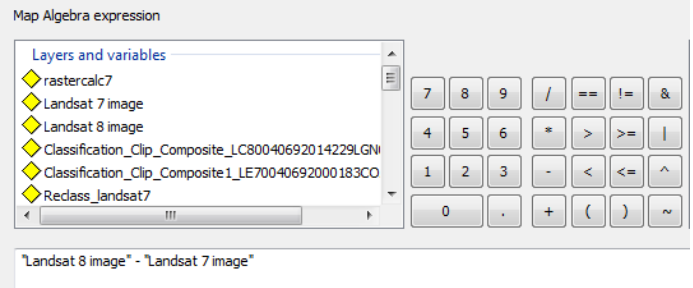
b) **Open ArcToolbox**  **and go to Spatial Analyst Tools → Reclass →Reclassify.**
Select the Landsat 8 clipped classified composite as your input, select the classification Reclass field: Class Name, and click on the 'Add Entries' button. Enter new values so you just have '2' for urban, '0' for the other classes, and keep 'NoData' for the 'NoData' categories. BE SURE TO HIT ENTER after each entry.
Give your Reclassed Image a meaningful name.



c) **Do the same thing as the previous step for the Landsat 7 clipped classified composite except for the new values input '1' for urban, '0' for the other classes, and keep 'NoData' for the 'NoData' categories.**

Think about when you subtract the Landsat 7 image from the Landsat 8 image what the pixel values will range from. What will each pixel class mean?

d) **Open ArcToolbox and go to Spatial Analyst Tools → Map Algebra →Raster Calculator.**



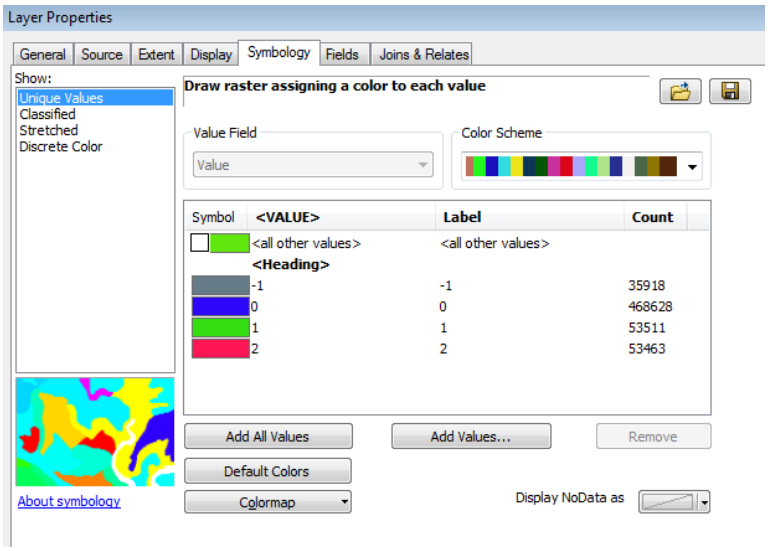
Subtract the Landsat 7 image from the Landsat 8 image and click OK. You should see a new raster with your results. There are four classes.

The value '2' represents new urban growth.

The value '1' represents existing urban areas.

The value '0' represents non-urban areas which haven't changed

The value '-1' values represent areas where urban areas have disappeared.



Calculate percentage change in urban pixels between the two dates. Right-click on your layer and click on the Symbology tab. You are able to see each class and the count of the pixels for each class.

Estimate the urban growth in Cusco from 2000 to 2014. Then discuss and compare results with your neighbors.

Calculate Percent Change:

((new growth – disappeared urban areas) / existing urban areas) * 100 = percentage change

To get percent urban growth, subtract the pixel count of the urban areas that disappeared (-1) from the pixel count of the urban growth areas (2) and add the result to the pixel count representing the original urban area (1).

Ex:

((53,462 – 35,918) / 53,511)*100 = 32%

Calculate Area:

You could also calculate the area of urban change. *How would you do this? What is the area of each cell? How many cells do you have of new urban area? What is the area in hectares?*

<u>Challenge Activities: (Choose one)</u>

a) Perform change detection between Landsat 8 images from 2013 and 2015
b) Perform unsupervised classification in the first exercise and compare with your supervised classification results.

Resources –
Online Videos:
Remote Sensing in ArcGIS Tutorial 19a: Supervised classification of Landsat Imagery (https://www.youtube.com/watch?v=_EBlOeybWl4)

Remote Sensing in ArcGIS Tutorial 19b. Supervised Classification of Landsat Imagery (https://www.youtube.com/watch?v=IfjWNYYJ1LA)
Other materials:
Remote Sensing in an ArcMap Environment: http://virginiaview.cnre.vt.edu/tutorial/Chapter_12_Band%20Combinations%20Using%20Landsat%20Imagery.pdf

How Landsat Images are Made: http://landsat.gsfc.nasa.gov/pdf_archive/How2make.pdf