

Registering Imagery, Downloading and Analyzing National Land Cover Data (NLCD)

Name _____

Overview and Objective

As you may know, a variety of datums, map projections, and coordinate systems are used for paper maps and for digital spatial data in a GIS. For many projects, you will need to incorporate data that are in different datums, map projections, and coordinate systems. A typical example is a project where the images are in a different coordinate system than the vector data. Another common example is when the images have no registration information, and you must create the registration information in order to use it.

In this lesson, you will have the opportunity to register images to vector maps, an essential GIS skill. Here, you will manually create two files that will register images, one for a state (Minnesota) and one for a Landsat image of the August 2002 St Francis wildfire on the Rosebud Sioux Reservation, South Dakota.

Skills Involved

- 1) Registering Imagery.
- 2) Downloading and analyzing land cover data.
- 3) Analyzing vector and raster data together.

Software Used

ArcGIS 8, ESRI.

Data Management

Create a folder for this exercise and name it *imageregistration*. As you know, it is best to name the folder without any spaces in the name.

Go to the following site for the data you will need for this lesson:

<http://rockyweb.cr.usgs.gov/public/outreach/gislessons/imageregistrationlesson.zip>

This file is named **imageregistrationlesson.zip** and totals approximately 2.2 MB.

After downloading, unzip the file using the Winzip program.

You now should have 14 files with the following names:

mn.tif
states.dbf
states.prj
states.sbn
states.sbx

states.shp
states.shx
stfrancisfire.jpg
toddroads.dbf
toddroads.shp
toddroads.shx
todhydro.dbf
todhydro.shp
todhydro.shx

Start ArcGIS with a blank map document.

Add the following layers:

states
mn.tif

Rename your data frame as "Minnesota"

- 1) Based on the main theme of this lesson, why do you suppose that at this point, the Minnesota image does not overlay on top of the boundaries for Minnesota?
- 2) Where does the Minnesota image lie in relation to the state outlines?
- 3) What coordinates do you observe for the northwest corner of the Minnesota image?
- 4) What are the coordinates (upper right hand corner) for the northwest corner of Minnesota on the state outline layer?

Therefore, no header information is associated with the image. ArcGIS does not know where to draw it.

- 5) What does ArcGIS do when no registration information exists for a layer?

You will create header information so you can register the image.

Save your map document as imageregistration and give it an appropriate name, placing it into your imageregistration folder.

Typical images used in GIS and remote sensing analysis are in .bil, .tif, .jpg, and .bip formats. The file extension for a header file is usually the first and last letters of the image file extension, with a “w” at the end for “world” file. For example, the header for mn.tif should be mn.tfw.

* Sometimes, image registration information is embedded inside the image itself. For example, geotiff image files do not have a separate header. Programs do exist that can pull out the header information into a separate file if the user needs it for any reason. However, all GIS software will read geotiffs and correctly place the image.

6) Enter the world file name for the following files under the column “world file name.”

image file name	world file name
rosebud.tif	
sheboygan.jpg	
southdakota.bil	

* Sometimes, image files have header files that are a different format than that discussed here. For example, some tif files will have a .hdr header.

Understanding Registration and World Files

A world (registration) file for an image is just a text file consisting of six lines. Here is a simple example, below. The simplest situation to describe is one using decimal degree (or “geographic projection”) data:

```
0.0107
0.0
0.0
-0.0087
-97.26
49.43
```

If the image is formatted in something like an Albers projection instead of decimal degree, it is still possible to create an effective world file; it just takes a little more tinkering.

Note: Creating a header file for a “projected image” involves basically the same process and header, except that the top left coordinates will be in numbers of meters away from a projection reference. Here is an example of a world file for an image in Albers projection:

```
4100.0
2.51179777165858
-0.08833980138674
-4050.0
-2360630.88315064972267
3182746.43488585297018
```

Each line in a registration file has a special purpose. The lines are not interchangeable, and must always be presented in this order, so writing a correct world file requires understanding the purpose and the data.

LINE1 = how much of a map unit (in this case, degrees) is represented by moving one pixel eastward from any spot (positive number).

LINE2 = how much the image should be skewed from the sides (negative number, but usually zero)

LINE3 = how much the image should be skewed from top and bottom (positive number, but usually zero)

LINE4 = how much of a map unit (in this case, degrees) is represented by moving one pixel southward from any spot (negative number)

LINE5 = X coordinate (in this case, decimal degrees longitude) of the top left (northwest) corner of the image (decimal degrees means negative number for 0-180 west, positive number for 0-180 east).

LINE6 = Y coordinate (in this case, decimal degrees latitude) of the top left (northwest) corner of the image (decimal degrees means negative number for 0-90 south, positive number for 0-90 north).

7) In the example header file above, is the image skewed?

8) In the example header file above, what is the latitude-longitude coordinate of the northwest corner of the image?

9) How many degrees are represented by moving any number of pixels in the E-W direction?

10) How many degrees are represented by moving any number of pixels in the N-S direction?

Creating a World File and Registering an Image

Minimize ArcGIS. Engage a graphics program such as Photo Editor under "Microsoft Office Tools" or another graphics program. Open the image "mn.tif". This is a Minnesota colorized image file based on a digital elevation model (DEM), with the different colors representing elevation.

Look in the lower right under "W" and "H" for the width and height of the image. If you are using Windows Paint, access "image" and then "attributes" for this information.

11) Enter width in pixels: _____

12) Enter height in pixels: _____

Access ArcGIS again.

Add Data and navigate to the location of your data for this lesson.

Access symbology for the states file. Make the states transparent and symbolize the state boundaries with a 2 or 3 thickness.

Scroll the mouse across the state outlines.

Zoom to the extent of Minnesota's image.

Determine the latitude and longitude coordinates for the top left and bottom right corners of the image, using decimal equivalents for easy fractions ($1/3 = .33$ and so on).

Fill in the following "worksheet," substituting known numbers. Assume that you do not want any skew.

Line 1 is the longitude of the SE corner minus longitude of NW corner) divided by image width in pixels. Show your work.

13) LINE1 = _____

14) LINE2 = _____

15) LINE3 = _____

Line 4 is the latitude of the SE corner minus latitude of NW corner) divided by the image height in pixels. Show your work.

16) LINE4 = _____

Line 5 is the northwest corner longitude.

17) LINE5 = _____

Line 6 is the northwest corner latitude.

18) LINE6 = _____

Examine the image below. When recording the NW and SE corners, use the locations of the + plus signs shown in this image, so you account for Minnesota's full extent. Don't cut off the Lake of the Woods area or the northeast corner of the state along Lake Superior. You don't want to shortchange any of those 10,000 lakes, eh!



Note that Lines 4 and 5 have to be negative numbers.

19) Why does line 5 have to be negative?

Create the world file with your data above and name it mn.tfw. Create it in WordPad or NotePad. You may use a Word Processor, but make sure you save it **in text file format**. Note that the header file must have the format (you will substitute your values, above):

```
0.01072
0.0
0.0
-0.0087
-105.10903
39.40582
```

Remove the mn.tif layer. Add the layer again after you create the header file. Remember to move your state outlines ABOVE your image and make the fill transparent as a guide in your registration.

20) Does the Minnesota image now overlay on top of your state outlines?

If the two layers are CLOSE, but do not exactly overlay, continue adjusting the header file, removing it and re-adding it to your ArcMap session until you are satisfied with the registration. Images may be offset from the vector data, depending on the accuracy of the image, the vector data used, and the coordinates you decided on. You can create an approximately correct world file through this method, but you may have to refine this file once you see how the image lines up with other known data sets. Each time you change and re-save the world file in your text editor, you must then delete and re-add the image in ArcGIS to test it. To do this in ArcGIS, remove layer. ArcGIS remembers the registration information for an image when it is first brought into a view, so changes to the world file will not re-position the image until the image is added again.

When refining the world file, first ensure the accuracy of Lines 5 and 6. Once this “starting point” is properly set, you can then tweak Lines 1 and 4 to stretch or shrink the image. Add a little bit at a time to the numbers in Lines 1 and 4 to expand an image; subtract from the numbers in Lines 1 and 4 to shrink an image.

21) What coordinate system have you registered your image to?

22) Name a few problems with the method you just used, considering data quality issues and GIS user issues.

23) Create a layout that includes the state outlines and your image, along with any other pertinent information that you consider to be appropriate. Zoom the extent to Minnesota and portions of the adjacent states and provinces. Print this and attach it to these lesson sheets.

Once you've done the best you can do with adjusting the image, do the following:

24) Write the contents of your final header file below:

Save your ArcGIS map document again.

Image Registration Using Georegister Tool in ArcMap

In this section, you will use the Georegister Tool in ArcMap to register your image.

Start a new ArcMap session.

It is important to start working with an **unregistered** mn.tif image. If you registered your mn.tif above and have a mn.tfw file, the easiest thing to do to “disconnect” the registration information from your image is to rename mn.tif to minnesota.tif.

25) Why does renaming “disconnect” the image registration information from the image itself?

Add minnesota.tif to your data frame.

Add states.shp to the data frame and change the symbology to hollow. Increase the outline width to 2.

Your minnesota image file should once again be sitting down at 0 latitude, 0 longitude.

26) Why is the image at 0 latitude 0 longitude?

View toolbars and access the georegister tool.

The general steps for georeferencing a raster using the georegister tool are:

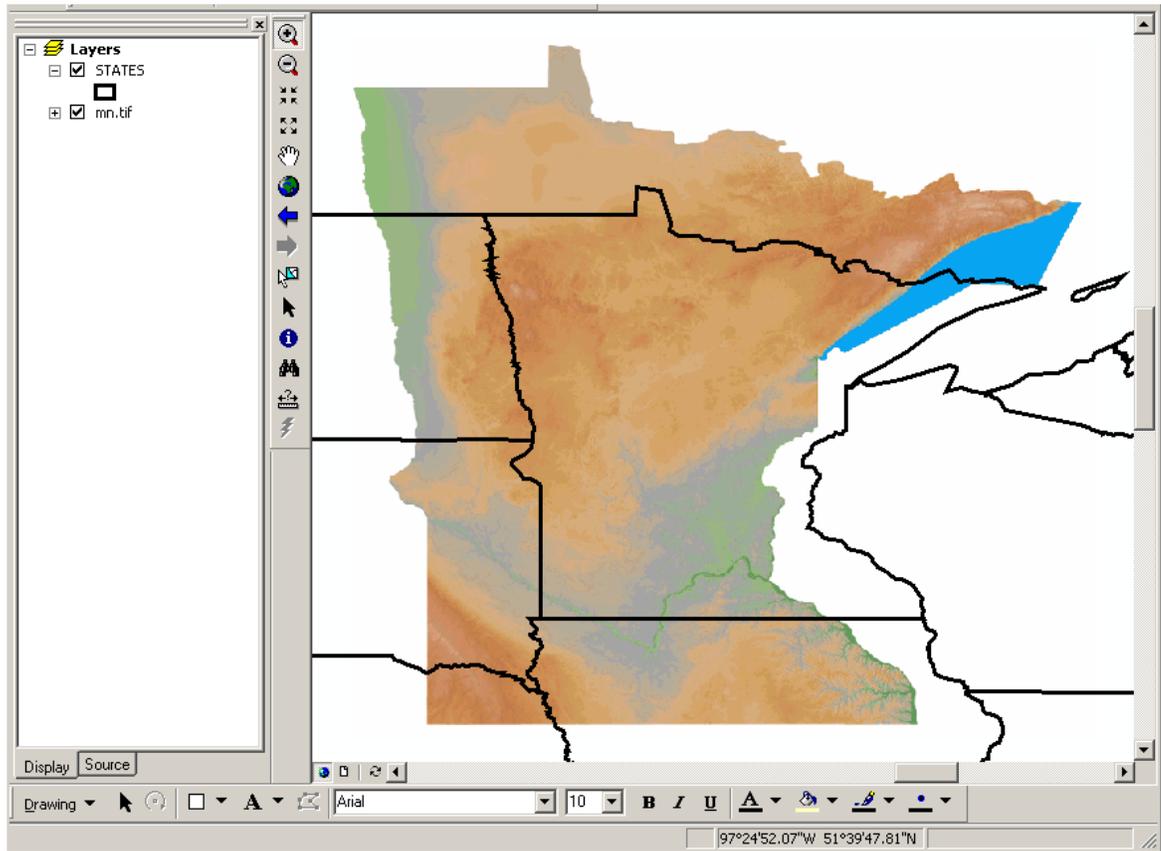
1. Add to your map the raster and the vector layers (target data) to which you want to align the raster.
2. Add control points that link known raster positions to known target data positions in map coordinates.
3. When you're satisfied with the registration, save the georeferencing information with the raster.

For most rasters, the georeferencing information is stored in a separate file with the same name as the raster but with an .aux file extension. You can permanently transform the raster by using the Rectify command on the georeferencing toolbar. The coordinate system assigned to the raster is the same as the coordinate system defined on the data frame the raster is part of.

Zoom in on the state of Minnesota **on the states outline map.**

From the Georeferencing toolbar, click the Layer dropdown arrow and click the raster layer you want to georeference.

Click Georeferencing and click Fit to Display. This will display the raster in the same area as the target layers. You can also use the Shift and Rotate tools to move the raster as needed. The view frame should look similar to that below:



Click the Control Points button to add control points. The button looks like 2 crosses with a line joining them:



To add a link, click the mouse pointer over a known location on the raster, then over a known location on the state line (target) data. You may find it useful to zoom in to add your links.

Add enough links for the transformation order. You need a minimum of six links for a second order transformation—that means 12 clicks of the mouse.

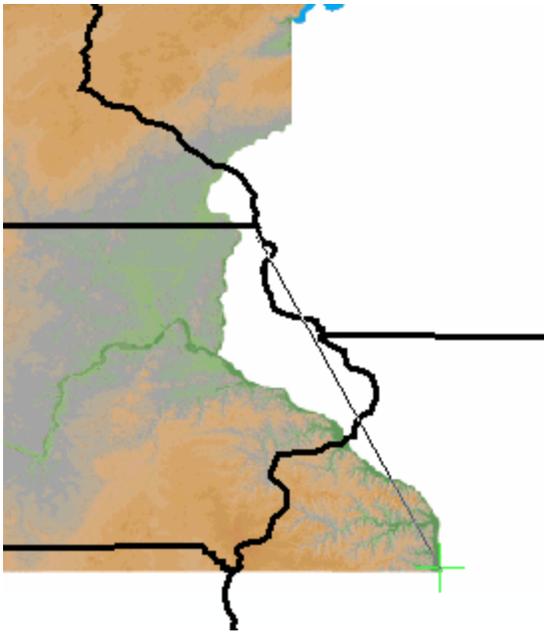
Try to select points that are easily identifiable on each data set, and points that are scattered throughout the data sets for the best registration, such as the corners of the

state. Also, select points that are on all major corners of the state, not just one side. If the image becomes skewed beyond recovery, it is best to delete the data sets from the view frame and start your session over.

Remember that you are drawing links FROM the raster TO the vector (state lines) files.

27) Why is your destination the vector file?

For example, to register the southeast corner of the image to the southeast corner of the state lines file, you would click on the southeast corner of the image FIRST, then the southeast corner of the state lines, as follows:



Click View Link Table to evaluate the transformation. You can examine the residual error for each link and the RMS (Root Mean Square) error. If any of the errors is much higher than the rest, you can delete that row in the table.

28) What is your total residual error?

When you are satisfied with the registration, you can stop entering links.

Click Georeferencing and click Update Georeferencing to save the transformation information with the raster. This creates a new file with the same name as the raster but with an .aux file extension.

29) Using Windows Explorer, browse to your folder and answer the following question:

What new file(s) were just created by the georeferencing method?

Save your map document.

Image Registration At A Different Scale Using Landsat Image

In ArcMap, go to the Insert menu and insert a new data frame.

Name this data frame “St Francis Fire.”

Now, you will have the opportunity to practice image registration one more time, this time using a Landsat satellite image of the St Francis wildfire, that burned during August 2002, west of St Francis, South Dakota on the Rosebud Sioux Reservation.

First, add the layers "toddhidro" and "toddroads" in your St Francis Fire data frame.

These are roads and hydrography files from the 2000 TIGER files from the US Census Bureau. They are the same files that you downloaded and analyzed in a previous lesson for Denver County.

Add the layer “St Francis Fire”. Do not double click on this image name so that you see Band 1, Band 2, and Band 3. Rather, single-click on the file name so that it is highlighted, and select “Add.”

30) What is the file extension for this image?

31) What type of file is this image?

Change the display units to decimal degrees.

Zoom to the extent of all layers in the data frame.

32) Does the stfrancisfire image overlay on top of the vector data?

33) Why or why not?

Therefore, you must create a header file that registers the fire image to the streams and roads.

Zoom to the area west of St Francis, near 101.5 west longitude and 43.24 north latitude. Zoom to the extent of the streams and roads. Then, make the St. Francis fire image active and zoom to the extent of it.

34) What features can give you a clue about how to register the image?

Create a registration file for the St Francis image. All you know about the image is as follows:

(1) The spatial resolution of Landsat data is 30 meters in both the north-south and the east-west directions.

(2) The image covering the fire is northwest of St Francis, South Dakota, at 100.90 west longitude and 43.14 north latitude.

35) What does this registration file need to be named?

Your goal is to adjust the numbers in the header file until the image is registered as closely as possible to the roads and rivers.

Adjust the first and fourth lines until the scale of the image matches the scale of the roads and hydrography.

The vector data is in geographic coordinates: latitude and longitude. Therefore, the first and fourth lines need to represent how many degrees of latitude and longitude each one of these 30 meter pixels cover.

36) How many degrees of longitude is 30 meters at approximately 43 degrees north latitude?

Adjust the origin point where the image starts drawing. This will be the fifth and sixth lines of the registration file.

37) Write your final registration file below.

38) Comment about how you derived your final registration file.

39) Which is greater in geographic extent--the Todd County hydro and roads data, or the image?

40) Approximately how many square kilometers does the image cover?

41) How many square kilometers does the smoke in the image cover?

42) How did you determine the amount of area in the questions above?

43) Make two observations about the features in the Landsat image.

44) What are the large circles that appear in the southern and southeastern portions of the image?

45) Create a layout for printing that contains the results of your fire image along with the roads and hydrography. Print it and attach to these lesson sheets.

Next, register the image using the georegistration tools that you used earlier. Before doing so, disconnect the registration information from the image.

46) Recalling what you did earlier with the Minnesota image, how would you accomplish this?

47) What was your final RMS error using the georegistration tool?

48) Which method is easier to use—the georegistration or the manual header method? Why?

Save your map document.

Downloading National Land Cover Data

You now need to download and use some National Land Cover Data (NLCD) for the area of the fire so that you can further analyze the area burned.

The NLCD data contains 21 different land cover categories with a spatial resolution of 30 meters. The NLCD was produced as a cooperative effort between the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (US EPA) to produce a consistent, land cover data layer for the conterminous U.S. using early 1990s Landsat thematic mapper (TM) data purchased by the Multi-resolution Land Characterization (MRLC) Consortium. The MRLC Consortium is a partnership of federal agencies that produce or use land cover data.

Partners include the USGS the EPA, the U.S. Forest Service, and the National Oceanic and Atmospheric Administration. The main objective of this project was to generate a generalized and nationally consistent land cover data layer for the entire conterminous United States. These data can be used as a layer in a GIS for assessing wildlife habitat, water quality and pesticide runoff, land use change, and so on.

First, you need to find out what area to download:

Go to the following site: geonames.usgs.gov

Perform a query of Saint Francis as a populated place in South Dakota.

49) In what county is Saint Francis located?

[Show Feature Location](#) using maps produced from the U.S. Census Bureau's Tiger Map Server.

50) What part of the state is Saint Francis located in?

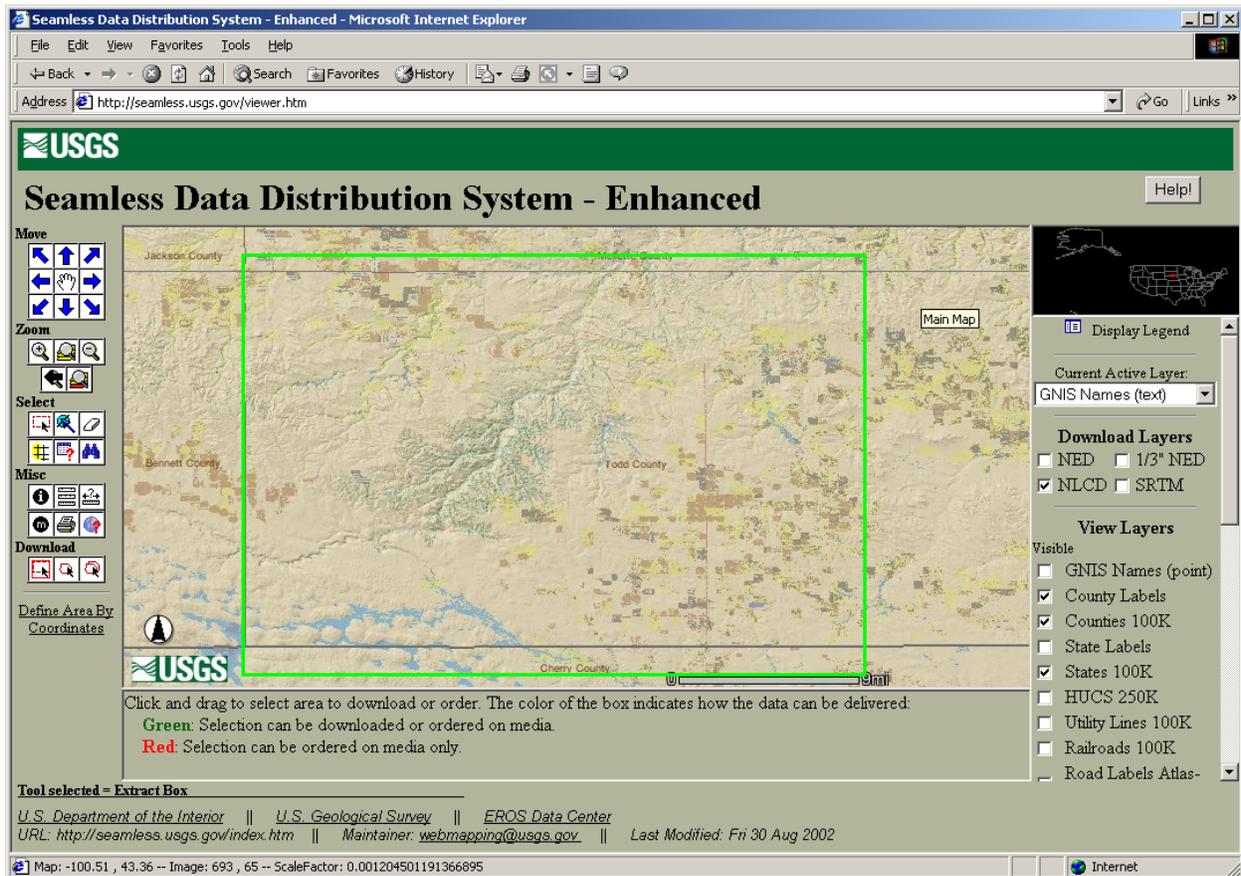
Now you are ready to download your data.

Go to the following site: seamless.usgs.gov

Go to “View and Order Data Sets.”

Zoom in to Todd County, South Dakota. View county names and labels to guide you. Turn off all layers under “download layers” on the right except NLCD.

When you have Todd County in your view, select the first button under the “download” tool and band an area that encompasses the western 2/3 of the county. See the screen image below for clarification.



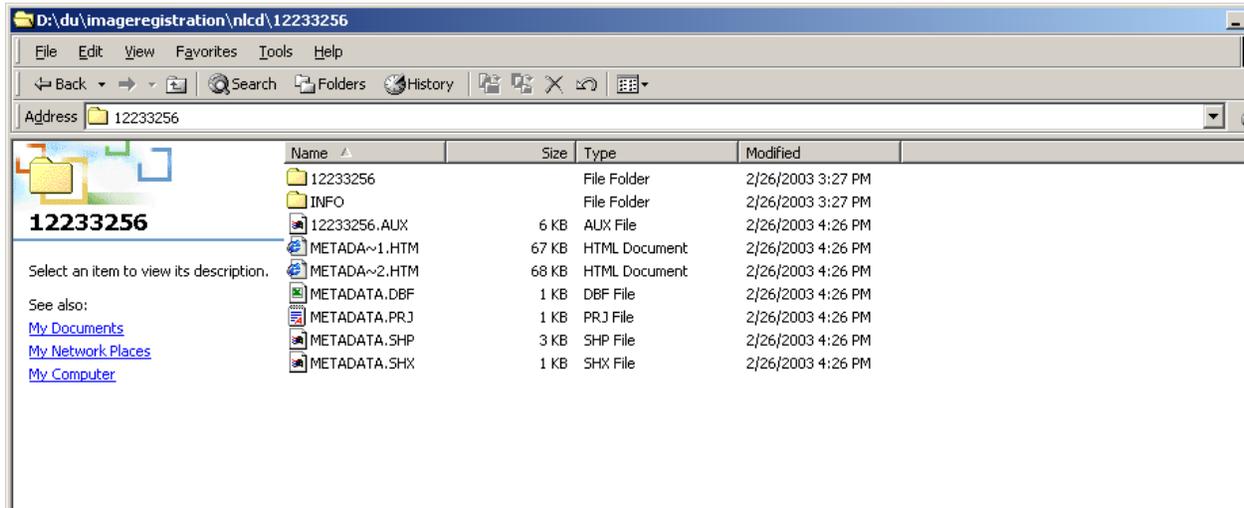
After the file processes, answer the following:

51) How large (in MB) is your file?

Click on Download.

Unzip the file *into a folder underneath your imageryregistration folder, called nlcd*. Be sure to **Use Folder Names** so that your result will be similar to the screen below.

The NLCD data will be an ArcInfo grid. You should have an INFO folder for the attributes, metadata files, and a folder containing the geographic data. The folder containing the geographic data will be named as a number. Example below is 12233256.



Using National Land Cover Data

In ArcGIS, add the national land cover data file. It should be underneath your nlcd folder. Build pyramids if prompted.

52) Did you receive a warning about the projection of the NLCD data?

53) Examine the metada~1.htm file. What is the projection of the NLCD data?

54) What is the projection of your roads, Landsat fire image, and rivers layers?

Note that ArcGIS's projection on the fly allows the data to be projected into the same view frame for analysis purposes but that the data are in different projections.

55) How is the NLCD data classified?

Examine the metadata file again. About 80% of the way through the metadata file, note that each of the numbers that you saw for the question above has a corresponding land use/land cover classification.

Open the attribute table for your NLCD data. Add a text field that will contain your land cover information. Populate the table with the land cover classes that you found in the metadata file.

56) What is the most common land cover class for your study area?

Next, you'll need to clip your data sources to the extent of the image file. Access the GeoProcessing Wizard under "Tools."

57) Is clip an option?

You cannot use the Geoprocessing Wizard to clip because you are working with some raster data sets.

First, you'll need to create a clipping vector file. Then you will convert your land cover data into a vector file and clip it.

Go to ArcCatalog.

Navigate to and click on your imageregistration folder.

Go to New→ Shape File. Name it "studyarea" and use "EDIT" to set the projection of the studyarea shape file to be the same as that for Todd Roads.

Now that you have created the shape file, you will need to add the polygon to it. Go to ArcMap and view the editor toolbar.

In the editor toolbar, start editing the studyarea shape file. Make sure studyarea is the target. Use the pencil tool to create a polygon. Add one polygon that is the same extent as your St Francis Fire image. Don't worry about matching it exactly. Double click the polygon when finished. When complete, save edits and stop editing.

58) Examine the attribute table behind studyarea.shp. How many records does it have?

59) Why?

Make sure the Spatial Analyst extension is on and the Toolbar for Spatial Analyst is on as well.

Under Spatial Analyst's drop down menu, convert raster to features. Convert your NLCD grid to features. Name it nlcd.shp. Make sure the field "value" is the field to use. Save the result in your folder.

60) How many records does your nlcd.shp table have?

61) Is it more or less than the number of records in your nlcd grid? Why?

62) What field now stores what was in the grid's VALUE?

Using the Geoprocessing wizard, CLIP the nlcd.shp file to the extent of your study area. If your system cannot handle this operation, skip the final questions.

63) What is the most common land use in your study area?

64) What is the least common land use in your study area?

65) Explain the relationship to land use and wildfires in this region.

66) Summarize in a few sentences what you have learned about image registration, creating coverages, and raster and vector processing in this lesson.

*** End of Registration and NLCD Lesson ***