# Using Soil Productivity to Assess Agricultural Land Values in North Dakota

# STUDENT HANDOUT

**Overview**

Why is assigning a true and full value to agricultural land parcels important? Agricultural production is the largest component of the North Dakota economy, but agricultural land values were only recently updated for taxation purposes for the first time since the 1970s. Until 2009, many owners of agricultural land were taxed unjustly, since poor quality parcels were often taxed at the same rate as the most fertile parcels. As a result of hard work and much deliberation, the ND legislature concluded the 2007 Session by passing an Agricultural Land Valuation Mandate (House Bill 1303). The bill was introduced to require the consideration of an agricultural parcel's actual use, in the determination of its true and full value. This action was to be completed by all counties in ND by January of 2009.
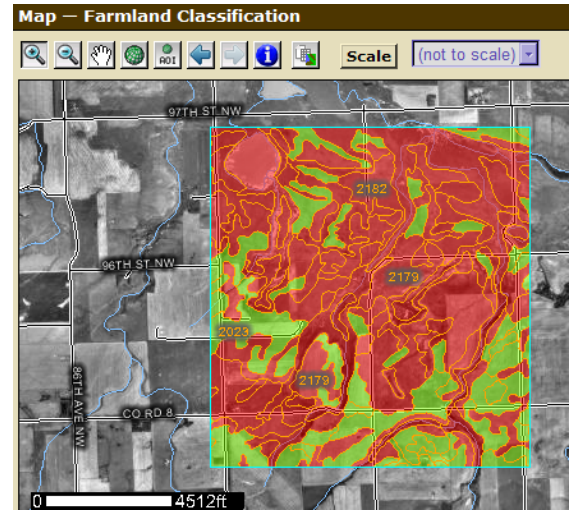


This lesson uses digital geospatial data (vector and raster data) along with Esri software to classify land use and land cover within one section of agricultural land in Burke County, in northwest ND, to demonstrate how soil productivity can be used to assess land values.

# Part I: Project Preparation

**A. Review North Dakota Congress legislation and North Dakota Association of Counties (NDACo) activities related to assessment of soil values.**

**Step 1:** Learn about agricultural land tax valuation (historical and current practices) by viewing the power point presentation, "GIS in Land Parcel Development."

**Step 2:** Read the North Dakota Association of Counties Background Memorandum (white paper) on property tax assessment as well as the Property Tax Assessment of Agricultural Land Background Memorandum prepared by the ND Legislative Council staff for the Taxation Committee (July 2001). Discuss, first in small groups then with the whole class, the issues and policies contained in these documents. Outline the ways in which GIS and remote sensing can streamline the assessment process for state and county governments.

**B. Set up project folder structure.**

**Step 1:** First you will need to create the folder structure for the data used in this project. Open **ArcCatalog** and navigate to your personal class folder. Inside your class folder, create a new folder named: **Ag_Land_Taxes**. Then create new folders inside named Ag_Land_Taxes, named: **BC_Soils**, **Downloads**, **Images** and **Scratch_Temp**. The structure should look like the one below:
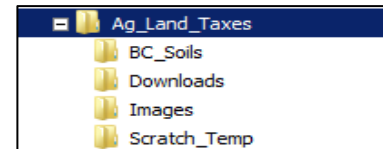
**Step 2:** Make a direct connection to the **Ag_Land_Taxes** folder through the **Connect to Folder** function.



**C. Use The Natural Resources Conservation Service (NRCS) ArcIMS Web Soil Survey (WSS) To Calculate Vegetative Soil Productivity And Acreage Within Agricultural Parcels**

GIS soils data layers can be downloaded from the Internet in many different ways. In this activity you will use the Internet to explore the Soil Data Viewer, Web Soil Survey, and Soil Data Mart. You will practice one way of obtaining the data through the Natural Resources Conservation Service Web Soil Survey. *What are the main differences between these three resources?*

Follow the steps below to download spatial and tabular soil survey data from the ArcIMS WSS:

**Step 1:** Do an Internet search. Locate and navigate to the NRCS WSS website. Start the Web Soil Survey (WSS).

**Step 2:** Navigate by PLSS to North Dakota, **Township 162 North**, **Range 93 West** and zoom to sections **8**, **9**, **17**, and **16** in Burke County. Create a soil area of interest (AOI), using the polygon AOI tool.



To request the data in both spatial and tabular format, click on the **Download Soils Data** menu. Fill out the form to include tabular data (un-checkmark "Template Database") and spatial data. Be sure that the Select Spatial Coordinate System is set for UTM Zone 13, Northern Hemisphere (NAD 83). Wait for the message (to the e-mail address that you specified) notifying you that your download is ready. It should only take a few minutes. You will receive the data in the order it was requested. Keep the Web Soil Survey open, as you will come back to it after downloading the data (or while waiting to download it, if that takes a while).

Note: Creating an AOI that is too large or too small will create database errors. Do not attempt to download an area larger than four sections.

**Questions**:
1. *What is the PLSS?*
2. *If PLSS information is not labeled on an aerial image, how would you visually interpret how much land area equals one section?*
3. *How many acres compose one section?*

**Step 3: Download** the soils data to your **Download** Folder. Unzip to the **BC_Soils** folder that you created. It will create a folder containing the spatial and tabular data. Navigate inside this folder to open the readme file. The shapefile and tabular data that you requested will look similar to the following example:



**Step 4:** Back in the Web Soil Survey, with the AOI still highlighted, click on the **Soil Map** tab. This will overlay soil type polygons in your area of interest. To the left is a Map Unit (MU) legend that will give you the name of the soil for the MU symbol. For example: symbol 674 is Farnuf Loam.

**Step 5:** Click on the **Soil Data Explorer** tab. Make sure that the "View Soil Information By Use" is directed to **All Uses**.

**Step 6:** To create a **Crop Productivity Index** of the AOI (summarized by map unit) using the Web Soil Survey, under **Suitabilities and Limitations for Use** click on **Vegetative Productivity >> Crop Productivity Index**. Make sure that **map**, **table**, and **description of rating**, and **detailed descriptions** are **check-marked,** then click on **view rating**. The ratings map will appear and below it the Table for Crop Productivity Index – Summary by Map Unit. Notice the tabular data totals for the Percent of AOI. They should add up to 100%.

*As stated by the NRCS-WSS, "the crop productivity index ratings provide a relative ranking of soils based on their potential for intensive crop production. An index can be used to rate the potential yield of one soil against that of another over a period of time. The rating is not crop specific."*

*Assessing a value to soils based on their productivity allows for a more fair taxation of that agricultural parcel. The web soil survey is a useful tool for people wanting a specific map that this ArcIMS based map service can offer, but the user is confined to the limitations of the WSS.*

**Step 7:** Click on the **Printable Version** button (you may have to turn your popup blocker off) to print a color copy of the vegetative productivity map you just created, and save it for future reference. If possible, save as a .pdf as well. It should look like the one below. If you were provided a .pdf of Web_SoilSurvey_Final, you may use that instead for final comparison with the Landsat image that you will process and analyze later in this activity.



Crop Productivity Index–Burke County, North Dakota
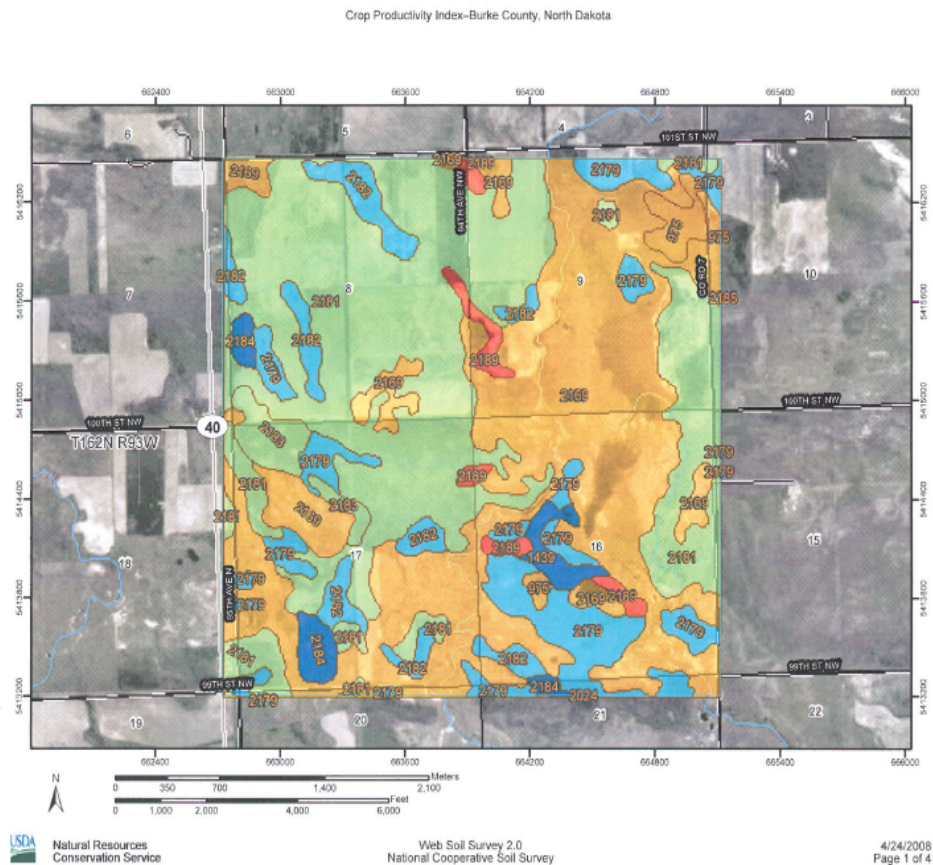
**Soil Ratings**

- ☐ <= 19
- ☐ > 19 AND <= 37
- ☐ > 37 AND <= 48
- ☐ > 48 AND <= 57
- ☐ > 57 AND <= 76

**Questions**

1. *How many acres of land are in your AOI?*
2. *What percentage of the AOI is covered by the Miranda-Noonan loams, 0 to 3 percent slope?*
3. *What is the productivity index of that soil series?*
4. *What does that number mean?*


## Part II: Use ArcGIS to delineate soil productivity with Web Soil Survey data

Next, you will use ArcGIS to recreate the online (ArcIMS) map that was automatically generated for you in the previous exercise. The algorithms written into the WSS ArcIMS application execute GIS functions suitable for a quick reference map. You will be calculating soil productivity from WSS data that will ultimately be used to cross reference information against Landsat satellite data. Remember to save your work often and to set relative paths in your map document before starting the project.

**Step 1:** Start a new ArcMap session, with a new blank map, to begin the project.

**Step 2:** Navigate to the BC_Soils folder\ wss_aoi_2011-07-06_13-16-10\ to load the two polygon data **layers aoi_a_aoi.shp** and **soilmu_a_aoi.shp**. Note that your wss_aoi folder will have a different date because this folder is named after the data the data was prepared for you on the WSS website.

**Step 3:** Zoom in on the dataset. Create a bookmark named **Soil Parcel Clipped**.

**Step 4:** Open the Data Frame Properties and double-check that the special reference is set as shown, below:

| | |
|---|---|
| Projected Coordinate System: | **NAD_1983_UTM_Zone_13N** |
| Geographic Coordinate System: | **GCS_North_American_1983** |
| Datum: | **D_North_American_1983** |

**Step 5:** Change the name of **aoi_a_aoi** to **Area of Interest**, symbolized with a hollow fill and red outline. Symbolize the Soils layer using **MUSYM** field and delineate unique values by category. Rename it **Soil Types**. Choose the brown color ramp. The soils data should now be symbolized by color based on soil (Map Unit) type.

**Step 6:** Create a new field in the Soils layer's attribute table named **Acres**, type = **Double**, Precision = **7**, Scale = **1**. Use Calculate Geometry, **Acres** for Units, to calculate the number of acres of each soil type.

**Step 7:** **Summarize** based on the **MUSYM** field, choosing summary statistics for the output table for the **Acres** field – **Sum**. Save as type **dBase** Table, inside the BC_Soils folder as **Sum_MUKEY_Acres.dbf**. Add the results to the map when prompted. Open the table to view. Double-check the values in your summary table to the Map Unit legend on the Web Soil Survey. Your values should be very close, but a slight difference in your area of interest delineation will result in slightly different sums for some of the categories.

**Questions**

1. *How many soil types are in the study area?*
2. *How many acres are there of each soil type?*

The answers to these two questions constitute the baseline data needed to assess proper taxation for agricultural land based on soil types.

**Step 8:** **Save** your project in your Ag_Land_Taxes folder as **Soil_Taxation.mxd**.

**Step 9:** Next you will create a map in ArcMap to display the crop productivity of the soil layers. Make a copy of the Soil Types layer. Name it **Soils**. In the Soils attribute table, create a new field Text field named **SoilRating**. Calculate the values using the legend and map above. Symbolize using the **SoilRating** field and matching the colors in the map and legend below.
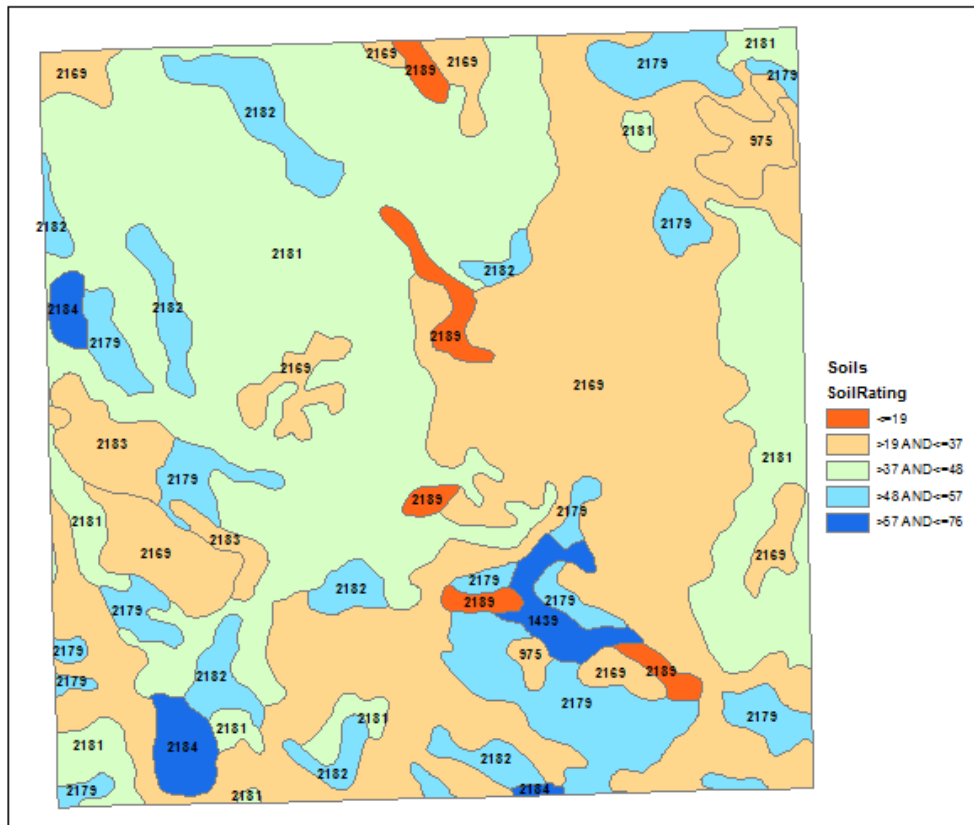


**Step 10:** Save the project when you are done and close ArcMap.

In the next part, you will download Landsat imagery. Then you will use ArcGIS10 to perform an unsupervised classification on the Landsat scene.  It will be useful to delineate land use and land cover for the agricultural land parcel in Burke County.

**Optional:** Make a copy of the SoilRating layer. Symbolize using a graduated color map. This may make it easier to determine the change in soil rating across the project area.

# Part III: Selecting and Downloading Data with the Viewer

## The USGS GloVis Web Site

**Step 1:** Go to the GloVis web site http://glovis.usgs.gov. The world map is yo point of entry. At this map, from the collection dropdown menu, you can select the **Landsat Archive >> L4-5 TM**. Select the location by entering for Path/Row: **34/26**. The selected image will be displayed, indicated by a yellow bounding box, with 8 neighboring images displayed around it. Use the **Month** and **Year** pull-down boxes to select the scene for August 29, 2006. Use **<PREV SCENE>** and **<NEXT SCENE>** to move within the collection as needed.

*Note: At the top of the GloVis Visualization Viewer, the **Map Layers** dropdown menu allows the user to select information such as administrative boundaries, cities, and other contextual information. This information will assist the user to determine whether the scene covers the desired geographic extent. In the Resolution menu, the resolution can be changed to 240m for a closer look. For more information on using GloVis than is covered in this activity, see the USGS online User Guide: http://glovis.usgs.gov/ImgViewerHelp.shtml.*
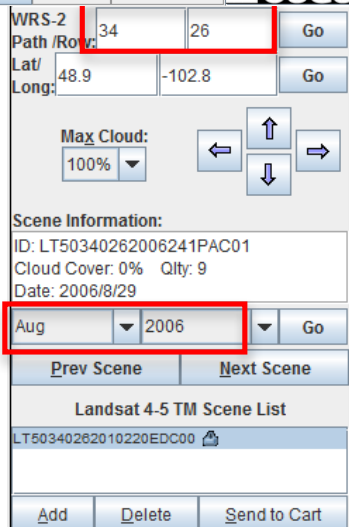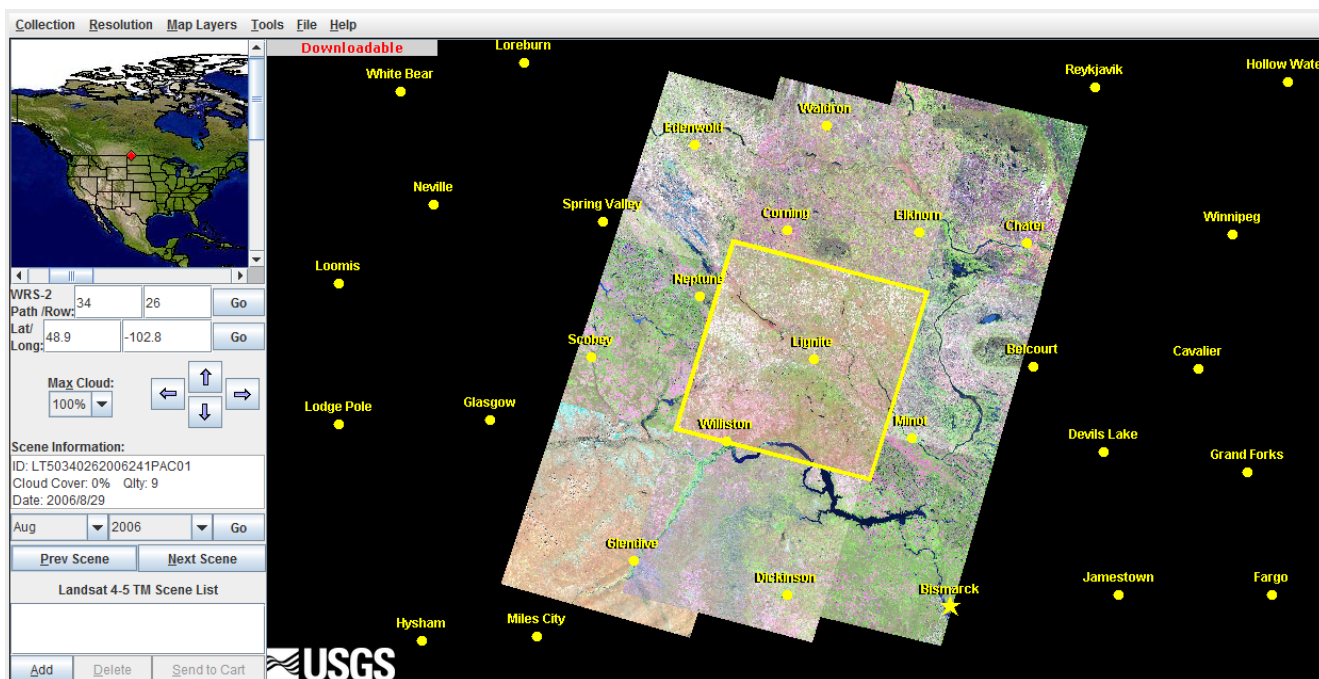




Once you have verified that you have the correct scene, click the **Add** button. The scene will be added to the scene list. Then, Click "**Send to Cart.**"

A registration window will pop up, where you will be required to register (for free) to obtain a login and password to use for downloads from this site. If you already have done this, you will only need to login. Note: this window may come up behind the viewer.

Once you have logged in, click on the Download icon, under Operations, in the Orders window, under Downloads, as shown to the right.



For download options, be sure to click on the radio button for the **Level 1 Product (159.1 mb Geotiff)**. Then click the **Select Download Option** button.



In the Download Scene window, click the **Download** button and save the file in your Downloads folder. The file is quite large, and it may take 10-20 minutes to download. When the download is complete, use Windows Explorer to confirm that the following file is in your project download folder:



**Step 2:** Unzip the Landsat data that you just downloaded to your **Images** folder using Winzip or other compression software such as the free 7-zip or J-zip. This unzips a file with a zip extension.

You will need to unzip this file as well, before you are done. Your images folder should look like the one to the right. You may see file extensions if you have this option turned on in Windows Explorer.

**Part IV: Examine the Data in ArcMap**

**Step 3:** Start ArcGIS and open your **Ag_Land_Taxes.mxd** project. Turn off the Soils and Soil Types layers.

**Step 4:** Add the six Landsat bands (1-5 and 7), from your Images folder to your ArcMap project. <u>Note</u>: you will not use the thermal band (band 6). They should load below the Soils, Soil Types and Area of Interest layers.
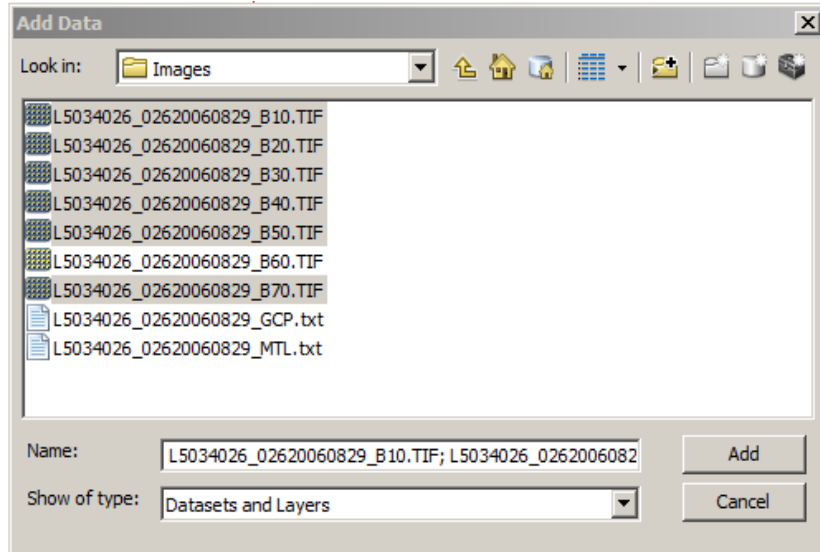


Zoom to the Full Extent of the image layers. Notice how much smaller the study area extent is than the Landsat layers.

**Step 5:** Zoom to the extent of the Area of Interest layer. To better compare the Landsat bands, right click on one of the bands and click on Zoom to raster resolution (30 m). Turn the various bands off and on to examine each of the Landsat band layers within the study area boundary. Notice how different land uses and landscape features are emphasized or de-emphasized depending on the band viewed. The Specifications Table, below, from a NOAA web page includes more information about the bands (http://www.csc.noaa.gov/crs/rs_apps/sensors/landsat.htm).

*Note:* *shortwave infrared is also commonly referred to as mid-infrared or middle infrared.*

**Specifications**

| Band | Spatial Resolution | | Spectral Resolution | |
|------|------|------|------|------|
| | TM | ETM+ | TM | ETM+ |
| 1 (Blue) | 30 m | 30 m | 0.45-0.52 µm | 0.45-0.52 µm |
| 2 (Green) | 30 m | 30 m | 0.52-0.60 µm | 0.53-0.61 µm |
| 3 (Red) | 30 m | 30 m | 0.63-0.69 µm | 0.63-0.69 µm |
| 4 (Near IR) | 30 m | 30 m | 0.76-0.90 µm | 0.78-0.90 µm |
| 5 (Middle IR) | 30 m | 30 m | 1.55-1.75 µm | 1.55-1.75 µm |
| 6 (Thermal IR)* | 120 m | 60 m | 10.4-12.5 µm | 10.4-12.5 µm |
| 7 (Middle IR) | 30 m | 30 m | 2.08-2.35µm | 2.09-2.35 µm |
| 8 (Panchromatic)** | | 15 m | | 0.52-0.90 µm |

\* - ETM+ Band 6 (Thermal IR) includes both high and low gain settings.
\*\* - ETM+ Band 8 (Panchromatic) - most visible & near-IR data in single band.

**Step 6:** When you are done exploring, remove all the bands except for bands 4, 3, and 2. Turn off the legends.

Your table of contents should look as follows:
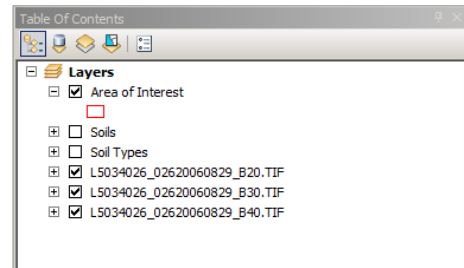


**Questions:** *Answer the following questions about the Landsat scene bands that you loaded into ArcGIS.*

1.  *Is the Landsat image georeferenced? How do you know?*
2.  *What Projection is used?*
3.  *What Datum is used?*
4.  *What it the pixel resolution?*

# Part V: Prepare for Analysis

## A. Create Composite for the Landsat image
Of the six Landsat bands contained in the Landsat image folder, you will only use bands 2, 3, and 4 for the composites, as they are optimum for this study. Band 2 is useful for differentiating between types of plants, determining the health of plants, and identifying man-made features; band 3 is useful for plant species identification and man-made feature identification; and band 4 receives reflected near-infrared. These three bands will be combined into one raster with the composite tool.

**Step 1:** In the **Customize** menu, choose **Extensions**. Be sure the **Spatial Analyst** extension is check marked.

**Step 2:** Open Arc Toolbox. Click on Data Management Tools >> Raster >> Raster Processing >> Composite Bands. Double-Click to open the **Composite Bands** tool.

For Input Rasters, Use the Input Rasters dropdown to add layers to add the Landsat bands ending in **B20, B30** and **B40** into the Composite Bands box. Be sure to add them in order, with B20 first. The order is very important.
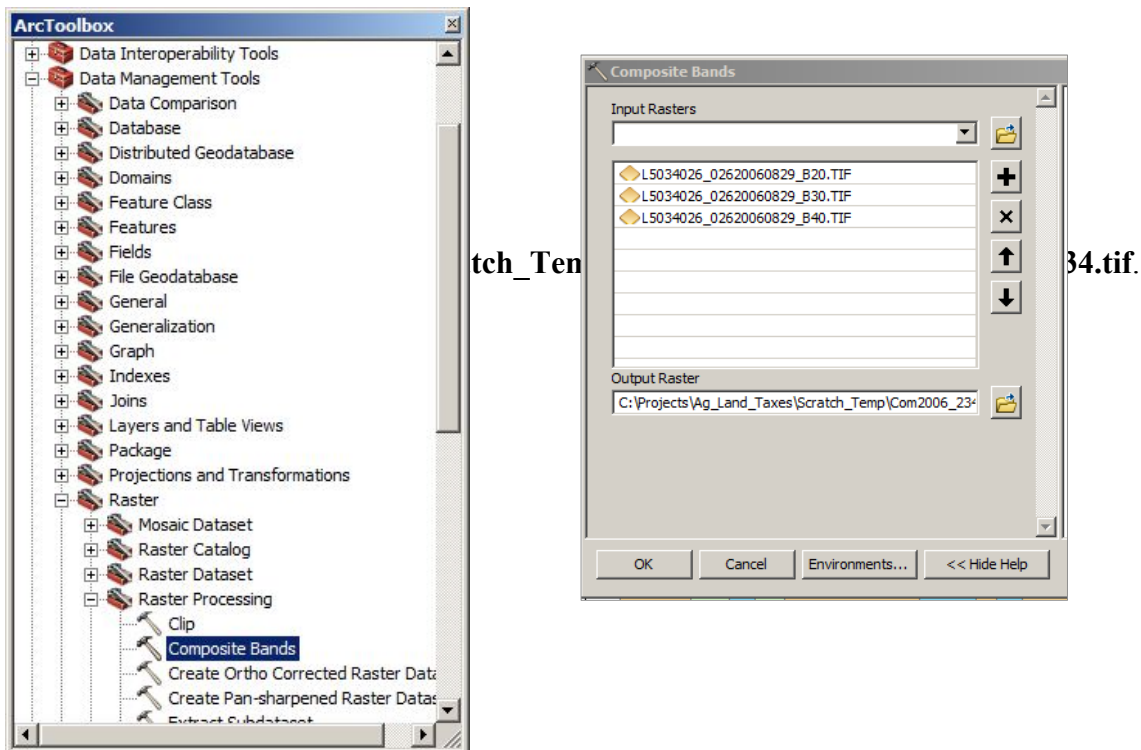


Click **Save**, then **OK**.

The composite image is automatically added to the ArcMap Table of Contents. Right-click on **Com2006_234.tif** and Zoom to raster resolution. Examine the legend and notice the default Red, Green, Blue (RGB) band assignments. ArcGIS automatically assigns the incoming bands to: Band 1 (incoming band 2), Band 2 (incoming band 3) and Band 3 (incoming band 4). You could change the names to reflect the actual bands; however, you will be further processing and, therefore, not using this layer for the analysis. Thus, you will leave it as is. Remove the individual Landsat bands from the TOC. SAVE the project.

**B. Create a subset of the 2006 Composite image.**

The downloaded Landsat scene is much larger than the Burke County Study area, so the first thing you will do is subset the composite image, before analysis.

**Step 1:** Be sure the **Area of Interest** layer is turned on. Use the "Select by Rectangle" tool to select the Area of Interest polygon.
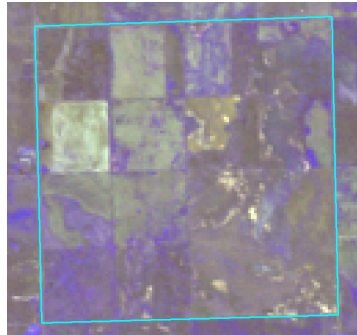


**Step 2:** In the ArcMap **Windows** menu, select **Image Analysis**. When it opens, dock it to the right side of the ArcMap application window. Click on Com2006_234 to select it.

With the Area of Interest polygon still selected around the image, click on the **Clip** tool that is near the bottom of the Image Analysis Window, under Processing.

A new temporary layer named "**Clip_Com2006_234**" will be added to the TOC.

In the TOC, turn off all of the layers, except for Clip_Com2006_234 and the Area of Interest layer.
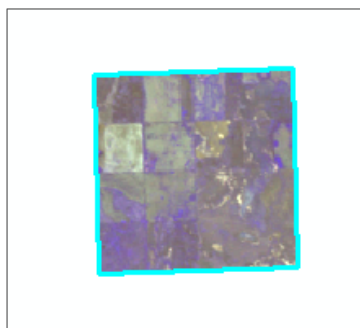


Zoom in closely to the edge of the clipped image, so that you are able to see individual pixels. Notice that most of the pixels along the edge are split. This isn't always desirable for later analysis. Therefore, you will clip the image using the Spatial Analyst Extraction tool in ArcToolbox to use for later analysis.

Zoom out to the extent of the clipped image. **SAVE** the project.
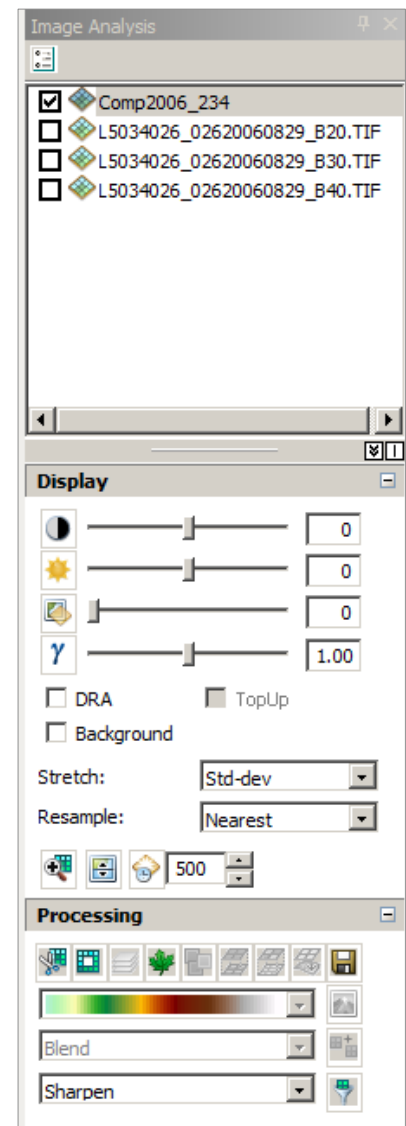
## C. Use ArcGIS Toolbox to Clip the Landsat Image to the Parcel Layer Boundary.

This time you will clip (or subset) the image using the "Extract by Rectangle" tool. Unlike the Image Analysis window Clip tool, this method of subsetting the image will maintain entire pixels. Therefore, the resulting image will extend slightly beyond the Area of Interest polygon. It also will create a permanent layer, rather than a temporary layer.

**Step 1:**  Be sure the Area of Interest layer is turned on and still selected.

**Step 2:**  Open ArcToolbox >> Spatial Analyst Tools >> Extraction >> Extract by Rectangle.

**Step 3:**  For the Input raster choose the full scene composite, **Comp2006_234**. For the Extent, choose the **Area of Interest** layer. Save the Output raster to your Images folder with the name **Com06_234**. Click **OK** to run the Extract process.

You have successfully clipped the Landsat image based on a vector file. Your new clipped image will appear in the TOC. Congratulations!

**Step 4:**  Before moving on, take a few minutes to zoom in closely on a few pixels and use the Identify tool to click on a pixel in the same location for the two clipped composites and the full scene composite. They should be the same. If they are different, look to see that the RGB is assigned to the same bands in each one.

**Step 5:**  Remove the Clip_comp2006_234 and the Comp2006_234 images.
You should now only have the extracted image Com06_234, Area of Interest, Soils and the Soil Types layers left in the TOC. **SAVE** the project.

## D. Differences between Low and High Pass Filters
The use of filters makes it possible to smooth noise in an image and detect a more defined edge where there are changes in land cover. Filters are transparent materials that absorb or reflect energy in specified wavelengths. Low pass filters average out low and high values, reducing extreme values to smooth the data. High pass filters emphasize higher frequencies and de-emphasize lower frequencies to enhance the edges in the output image. For more information on Filters, search ArcGIS help on the term Convolution Function, or on a particular filter you are interested in learning more about.

First, you will display the image as False Color (4, 3, 2), which will look like traditional infrared aerial photography. This combination of bands is useful for vegetation and soil pattern studies. Vegetation will appear in shades of red with coniferous trees appearing darker than hardwoods or healthy crop growth. Dense urban areas will appear in cyan blue and soil will appear in dark to light browns. For more information on band combinations, go to: http://web.pdx.edu/~emch/ip1/bandcombinations.html.

**Step 1:** Turn the Area of Interest layer off. In the Com06_234 layer properties → Symbology, change the RGB color to Red: band 4, Green: band 3, Blue: band 2. Hint: Recall that when you created the first composite that band 2 from the original Landsat scene was assigned to band 1, band 3 was assigned to band 2 and band 4 was assigned to band 3. This can be hard to keep track of! Before you click OK, be sure that you have assigned the bands correctly, as shown in the window below.
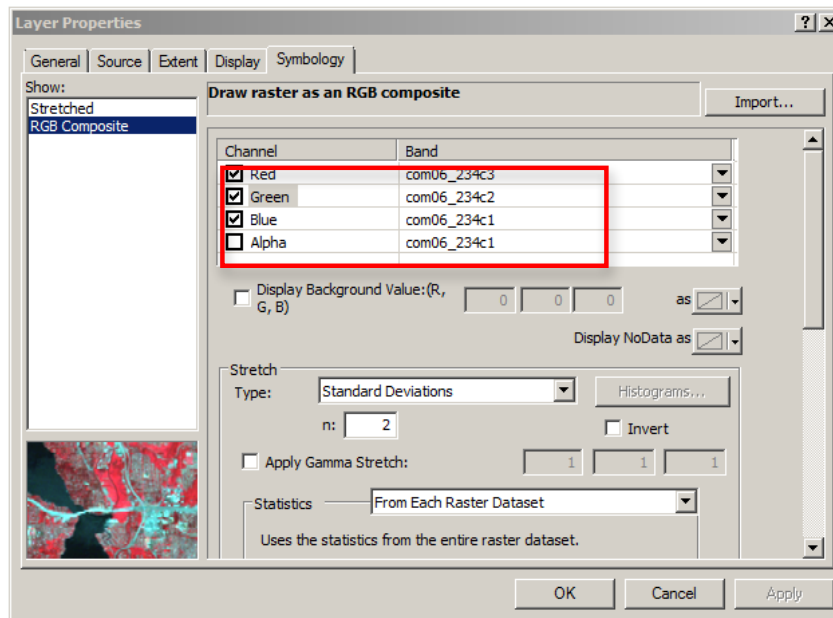
The image should now look like the one below.
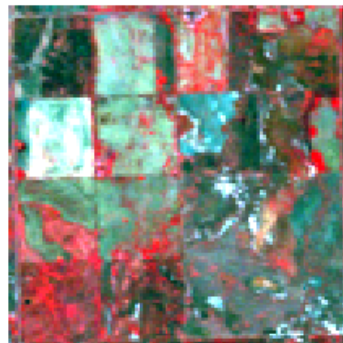


**Step 2:** To clarify the band assignments in the TOC, click next to the Com06_234 Red: and change the text com06_234c3 to band 4. Repeat to change the text next to Green to band 3 and the text next to Blue to band 2.



**Step 3:** In the Image Analysis window, click on the Com06_234 image. Under Processing, choose "**Smooth arithmetic mean**" from the bottom most dropdown menu. Click on the **filter** button next to the drop down to create a temporary low pass 3x3 filtered layer, which will be added to the TOC.

Compare this filtered image with the original image. Use the Identify tool to compare the values for cells in each image in the same location. Notice that the smoothing modifies the values.

**Question**

*1. Can you more easily see differences in land cover in the filtered image? Why or why not?*

**Step 4:** Repeat step 3 above on the Com06_234 image, but this time choose "**Sharpening 3x3**" (a High Pass filter).

**Questions**

1. *How does this compare with the other images?*
2. *Can you more easily tell the difference between land cover types? Why or why not?*

# Part VI: Analysis

**A. Perform an Unsupervised Classification**

Classification is a computationally intensive process that identifies pixels with similar spectral signatures through statistical analysis of the multi-band image. This will separate the image into distinct spectral classes based on natural groupings of "like" pixels. In this activity you will perform an unsupervised classification, using the Image Analysis toolbar "**Iso Cluster Unsupervised Classification**" option. This works similarly to the ArcToolbox Spatial Analyst Iso Cluster tool. Both use clustering routines to create the specified number of pixel classes. While it is common to run more than one type of classification (supervised and unsupervised), or to run the unsupervised process with different numbers of classes, you will only run one classification. You are encouraged, however, to run additional classification processes on your own to see how the results affect the final results.

**Step 1:** If the Image Analysis toolbar is not displayed, go to **Customize >> Toolbars** and checkmark it.
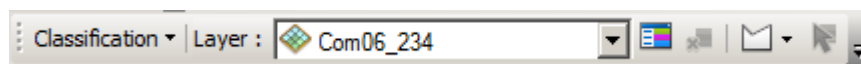


In the Image Analysis window, remove the checkmark from the filtered image and click on **Com06_234** to select it. Then, from the Image Analysis toolbar, click on the **Classification** menu. Choose **Iso Cluster Unsupervised**. Under Input raster bands choose **Com06_234**.

For Number of classes enter **8**. Save the output classified raster in your Image folder and name it Com06_234_ic. For minimum class size enter **5**, for Sample interval enter **2**. Save the Output Signature file in the Scratch_Temp folder as **Com06_234_sig.gsg**.

**Questions**

1. *What does Minimum Class Size refer to?*
2. *Why did you use the number 8 for the number of classes*

**Step 2:** The classified raster will show up in the TOC. In Layer Properties >> Symbology, change the Color Scheme to gray light to dark; then click on **symbol** to select "**flip the colors**" so they are displayed dark to light.

**Step 3:** Turn the Com06_234_ic (classified) layer on and off to see how it compares with the Com06_234 layer. In the Image Analysis window select **Com06_234_ic**; and then use the **Swipe** tool at the bottom of the Image Analysis window Display area to further compare the two images.

**Questions**

1. *What are the major differences between your new unsupervised classification images?*
2. *Name one advantage and one disadvantage of the classified image.*

**Step 4:** Selecting a grayscale made the classified image easier to decipher. The next step is to examine each class, assign class names, and real world coloration to the classified image. Take a few minutes to go back and forth and determine what you see. Assign colors and names.

**Step 5:** From the ArcMap Add button dropdown, chose Esri Base Map. Select imagery. Use this and Google Earth to help determine the land use categories on the map.

**Questions**

1. *Do you think the classification would have been closer to what you would see on the ground if you had conducted a supervised classification and collected training samples before classification?*
2. *Would running a NDVI process be helpful? Why or why not?*

**Step 5:** Compare the unsupervised image(s) you created to the copy of the soils map that you created with the ArcIMS Web Soil Survey application earlier in this exercise.

You are looking at a soils classification and an unsupervised classification of land use, and in a way you are comparing apples to oranges. *Although this is the case, can you make assumptions about the use of ArcGIS to analyze Landsat remotely sensed imagery as an accurate or inaccurate land use evaluator for applying taxation parameters to an agricultural land tax?*

Make judgments about which classification (soils or land use) fits the project parameters better. Save your work in the appropriate file folder. ).

**You will be able to answer the following questions after successfully completing the lesson:**

1. *Can a GIS effectively evaluate, model, assess, and assign values to agricultural land parcels through soils valuations?*
2. *Can remotely sensed imagery enhance a GIS soils model for agricultural land?*
3. *What are strengths and weaknesses of using unclassified remotely-sensed imagery to determine areas of high crop productivity?*
4. *Is it more effective and correct to assign tax values to soils based on regions (entire soil survey series) or by county?*
5. *Name at least three reasons why knowing the true and full value of a land parcel is important.*

**Supplemental resources**

- Property Tax Assessment of Agricultural Land – Background Memorandum
  North Dakota Association of Counties
  http://www.legis.nd.gov/assembly/57-2001/docs/pdf/39007.pdf
- Agricultural Property Tax Equity in North Dakota
  http://www.unorealestate.org/pdf/ND_Tax_Inequity_Study.pdf
- North Dakota State Tax Department
  http://www.nd.gov/tax/misc/faq/property/index.html
- Summary of How ND Handles Agricultural Land Tax
  http://leg.mt.gov/content/committees/interim/2001_2002/rev_trans/assigned_studies/rtic_sjr21_statecomparisonchart.pdf
- Ward County Tax Equalization Assessment Process
  http://www.co.ward.nd.us/taxequalization/appraisal-process/appraisal.shtml
- Esri Library
  http://esri.com – Library
- Electronic Field Office Technical Guide
  http://www.nrcs.usda.gov/technical/efotg
- Soil Data Mart
  http://soildatamart.nrcs.usda.gov/default/aspx
- Web Soil Survey
  http://websoilsurvey.nrcs.usda.gov/app/