Introduction to GIS

(GEOG/ES 470)

Raster Data Model

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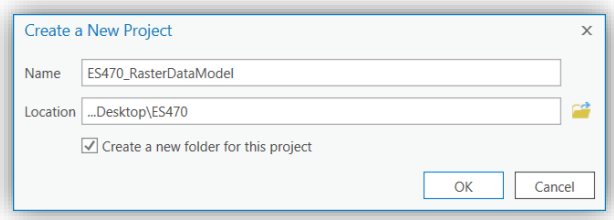
Raster Data Model

PART I: Image Enhancement

SUMMARY

In this part we'll learn how to work with different types of satellite images. Displaying Panchromatic as well as Multi-Spectral images will be presented. The goal of this exercise is to demonstrate how individual bands can be manipulated and enhanced for display using the contrast stretching techniques in conjunction of understanding the underlaying data using histogram manipulation. Multi-spectral band combination using color composites will also be demonstrated in this exercise.

I. Setting up ArcGIS Pro



A. Creating a New ArcGIS Pro Project

- Start ArcGIS Pro
- Under *New* click on *Map*
- Name the project *ES470_RasterDataModel* and change the *Location* to be under *Desktop >> ES470*
- Check the box next to "Create a new folder for this project"
- Click *OK*
- A new project will be created and a map with a basemap will be displayed.

B. Create a Downloads Folder

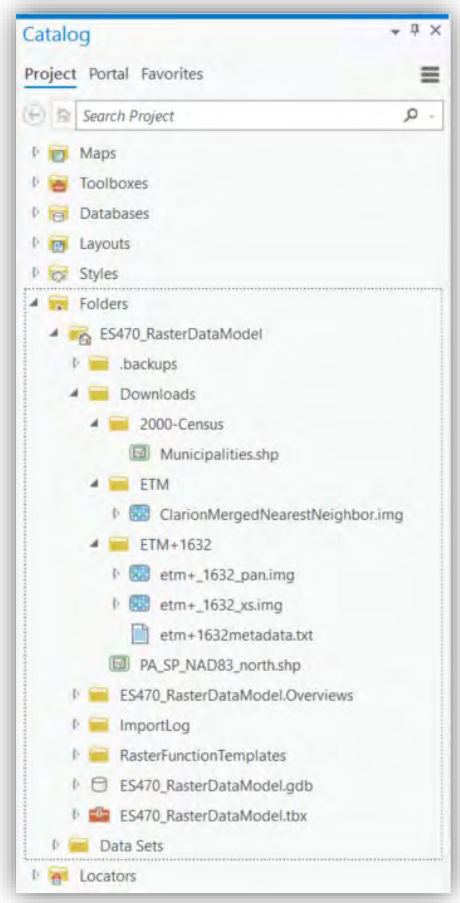
- From the Catalog pane, and under *Folders >> ES470_RasterDataModel* project folder, create a folder (*Downloads*) to hold the downloaded data.

II. Downloading Exercise Data

download the 3 available files, they are large downloads so plan accordingly. Store them all in the *Desktop >> ES470\ES470_RasterDataModel\Downloads* folder you created earlier:

- PA ETM+ (about 335Mb); and,
- Clarion ETM (about 175Mb)

After downloading all files, unzip them in the same folder. The Downloads folder should look similar to the following figure.

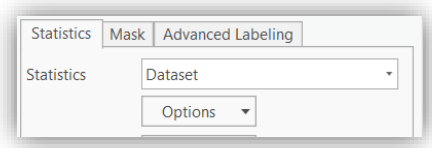


III. Displaying & Exploring Multi-Band & Panchromatic Satellite Images

In ArcGIS Pro, add *Folders\Downloads\ETM+1632\etm+_1632_xs.img* and *Folders\Downloads\ETM+1632\etm+_1632_pan.img* to the Contents (drag from the Catalog pane and drop onto the Map).

A. Panchromatic Image Manipulation

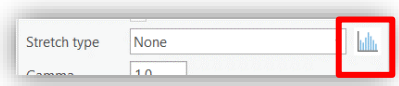
- Turn off the *etm+_1632_xs.img* image from the *Contents* and turn the panchromatic one on (*etm+_1632_pan.img*). Click on *Appearance* tab >> *Symbology* if it is not already active.
- By default, ArcGIS Pro displays the panchromatic image using a *Stretch* method and a gray scale color scheme instead of the *RGB* composite
- It also uses a stretch type of *Standard Deviation* in order to display the image. Change it to *Percent Clip* and notice the difference in clarity.
- Zoom into a portion of the image.

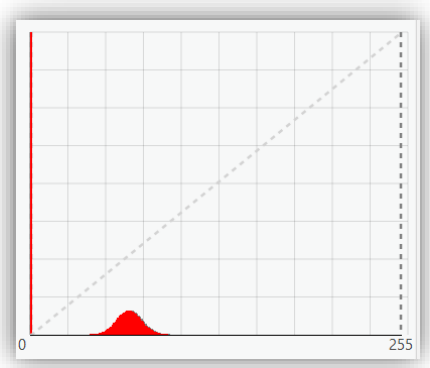


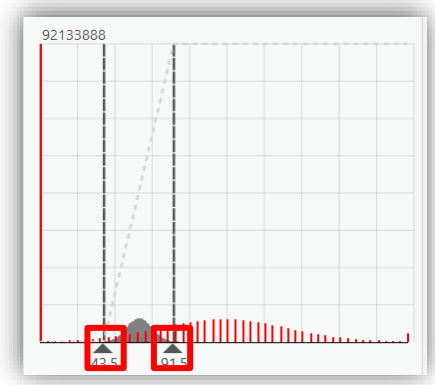
- The stretch is based on calculating the statistics of the whole image; as listed in the *Statistics* portion of the *Symbology* pane, the *Statistics* is derived from the *Dataset.*
- Try changing the *Statistics* to *DRA* (Dynamic Range Adjustment), which will change the image's stretch based on what is displayed in the Map, the stretch will be "dynamic" as you pan and zoom around the image, as the statistics are being updated according to what is being displayed on the screen instead of the full dataset.

B. Enhancing the Panchromatic Image Using Contrast Stretching

- Change the Statistics *DRA* back to *Dataset*
- Then change the *Stretch type* to *None*
- Notice that the image turns pretty dark gray with very little pixel value variation and therefore overall clarity.
- Click on the histogram icon next to the *Stretch type None* on the Symbology pane. The image's histogram will be displayed. It reveals that there is no stretch applied, the 0-255 range of pixel values are displayed as-is.







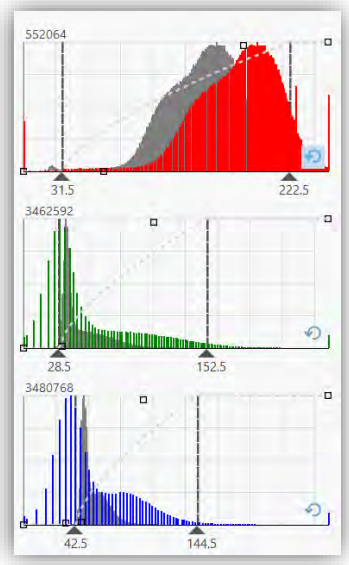
- Click the back arrow, then change the *Stretch type* back to *Percent Clip.* Click on the histogram icon next to the *Stretch type Percent Clip* on the Symbology pane. The image's histogram will now be displayed and the stretch method will be revealed.
- From looking at the histogram of the original image (dark gray) and comparing it to the *Percent Clip* method stretch type (red), it becomes obvious that this stretch type is looking at enhancing the data that constitute the majority in the display.
- The two black arrow handles located at the bottom of the histogram re-define the new minimum and maximum values for the stretch. In this case it is enhancing the majority of the pixels that are within the dark gray range of around 40 to 90
- The *Percent Clip* method avoided the display of the image in the dark gray way (stretch type: None) and, instead, used the 40-90 range to re-map those values from 0 to 255 and therefore increasing the contrast between the lower- and upper-pixel values.
- Rename the layer in the Contents pane from etm+_1632_pan.img to ETM+ Percent Clip
- Save the project

C. Multi-Spectral Image Manipulation

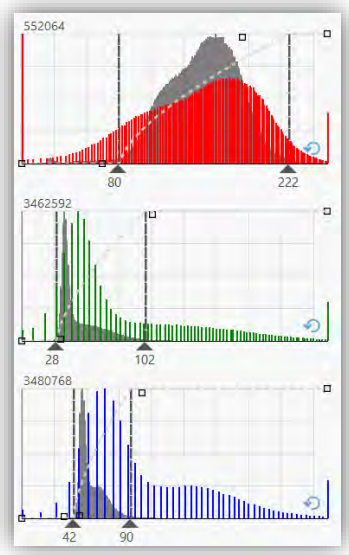
- In the *Contents* pane, turn off the *ETM+ Percent Clip* layer and turn on the *etm+_1632_xs.img.* This image is an Enhanced Thematic Mapper satellite image and it contains only the Multi-Bands (XS). The other image *etm+_1632_pan.img* contains the panchromatic (B&W) band.
- By default, ArcGIS Pro assigns bands 1, 2, and 3 to the Red, Green, and Blue respectively for the multi-band image. This is not a common way of presenting multi-band imagery.
- Since bands 3, 2, and 1 of the ETM data are captured in the Red, Green and Blue wavelengths (in that order), we can change the band assignments (321RGB) in order to view the "Natural" Color Composite.
- Select the *etm+_1632_xs.img* image from the *Contents* pane and select *Appearance* tab >> *Symbology* and change the band assignments to match the 321RGB scheme (*Layer_3 >> Red, Layer_2 >> Green*, and *Layer_1 >> Blue*). The true color composite is displayed. Navigate (zoom in/out and pan around) the image to view different locations and land-cover. Notice that all the vegetative areas are presented in different shades of green and open fields that don't have much vegetation cover are brownish in color. Those are real-life color representation of the features.
- Now let's display the IR band. Using the same method. But instead assign the following scheme: 432RGB.

- Since Band #4 is an infrared band and we know that vegetation is highly reflective in the IR range, it is expected that the red color on this composite to be very prominent. Browse through the image and notice how it is much easier to differentiate between vegetation and non-vegetation covers.
- Following the same rules, refer to the table of band combinations at the end of this document to explore the different RGBs and their uses.

D. Enhancing the Multi-Spectral Image Using Contrast Stretching



- The displayed False Color Composite image is clear but can be enhanced to show better contrast in certain locations. We are going to manually add some stretching to each of the band histograms.
- Select the *etm+_1632_xs.img* image from the *Contents* pane and select *Appearance* tab >> *Symbology*
- Click on the histogram icon located next to *Stretch type: Percent Clip*
- The histogram of the three bands and their associated RGB colors will be displayed (top figure on the right).
- Here you can control the amount of stretch applied to each band and therefore change its corresponding color saturation and brightness (Red, green or blue content)

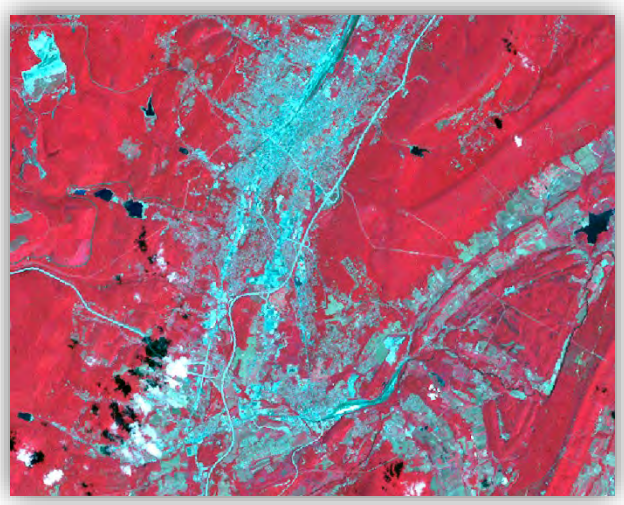


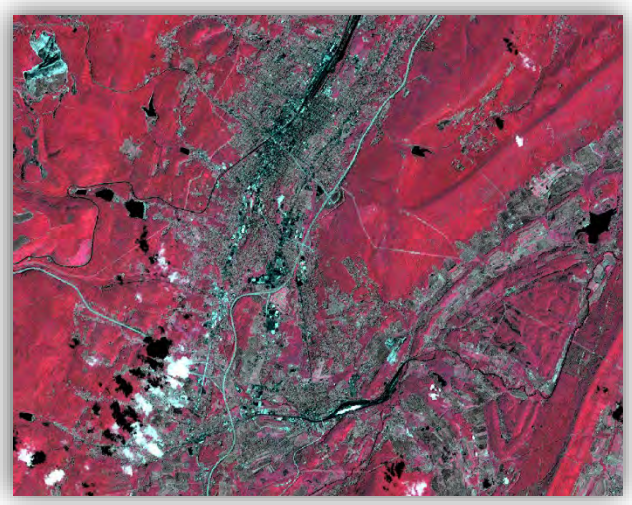
- Grab the left handle of the red histogram and move it closer to the beginning of the curve of the original histogram (gray) around the 80 mark. Also move the right handle of the green band to towards the left till the beginning of the gray histogram (around 102). Similarly, move the right handle of the blue band's histogram (around 90). The final histograms should look similar to the bottom figure to the right.
- The image will also change every time you alter any of the histogram. Notice the difference you're making to the quality, clarity, and color blending of the image.
- In the Contents, rename the etm+_1632_xs.img layer to ETM+ 432RGB
- Save the project

E. Using Layer Blending

Layer blending visually displays two overlaying layers in different ways. Some of those blending options would visually enhance the image. Let's first explore the properties of each of the XS and panchromatic images

- From the *Contents*, right-click on each of the layers and select *Properties*
- Under *Source,* click on *Raster Information* and check the *Cell Size X* and *Cell Size Y* values for each of the images.
- Notice that the panchromatic (*ETM+ Percent Clip*) image has a **14.25 Meters** pixel size while the multi-spectral (*ETM+ 432RGB*) image has a **28.5 Meters** pixel size.
- Blending those two layers might enhance the clarity of objects for the RGB image. Since the RGB image would be blended with higher spatial resolution information and more details from the panchromatic image.
- Select the *ETM+ 432RGB* layer from the *Contents*, then select the *Appearance* tab and change the *Layer Blend* to *Darken*
- Zoom to a built-up area and notice the difference between the no blend option (*Normal*, left figure) and the *Darken* one (right figure).



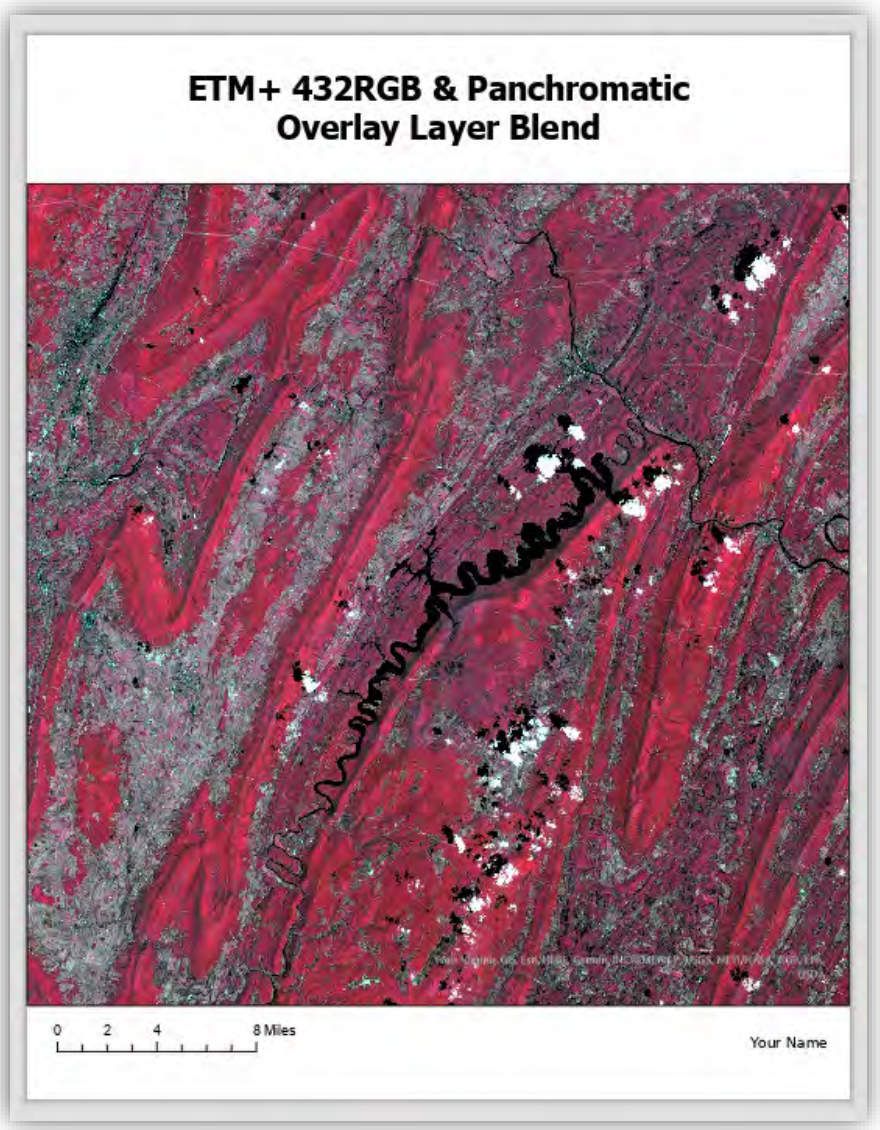


- Not only the image becomes crisper, due to the fact that the panchromatic image has a finer spatial resolution (pixel size), but also the depth of the colors changes according to the panchromatic representation of parts of the IR wavelengths, darkening the red color of those vegetation areas that has more water content.

F. Creating a Layout

- From the *Insert* tab, create a *New Layout* (Letter 8.5x11 portrait).
- From the *Insert* tab, *Map Frames* group, click on Map Frame and insert the map you just created.

- Resize the map frame to 8.5 in x 8.5 in (select the map frame, click on *Format* tab the change the *width* and *height* under the *Size & Position group*).
- Reposition the map frame on the layout so that you have enough space for a title on the top, and a scale bar and your name in the bottom. Insert a title, scalebar and your name. Change the font sizes accordingly. Your final layout should look similar to the following figure:



- Export this layout inside the Project's folder as a PDF: *Share* tab >> *Export* group >> *Layout.* Name the file ***ES470_RasterImageManipulation.pdf***

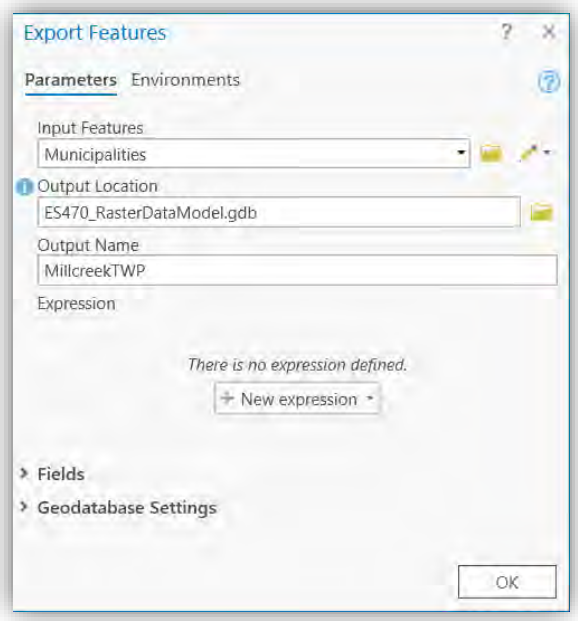
IV. Clipping an Image to a Shape

In many cases, you may want to work on a subset of an image based on an irregular border, such as a county or municipality border. We use a clipping method to achieve the result. In this section we are going to extract Millcreek township from an ETM satellite image.

- Insert a new Map from the *Insert* tab >> *New Map* then add the following layers:
    - *Downloads\ETM\ClarionMergedNearestNeighbor.img*; and,
    - *Downloads\2000-Census\Municipalities.shp*

A. Extracting the Study Area Boundaries

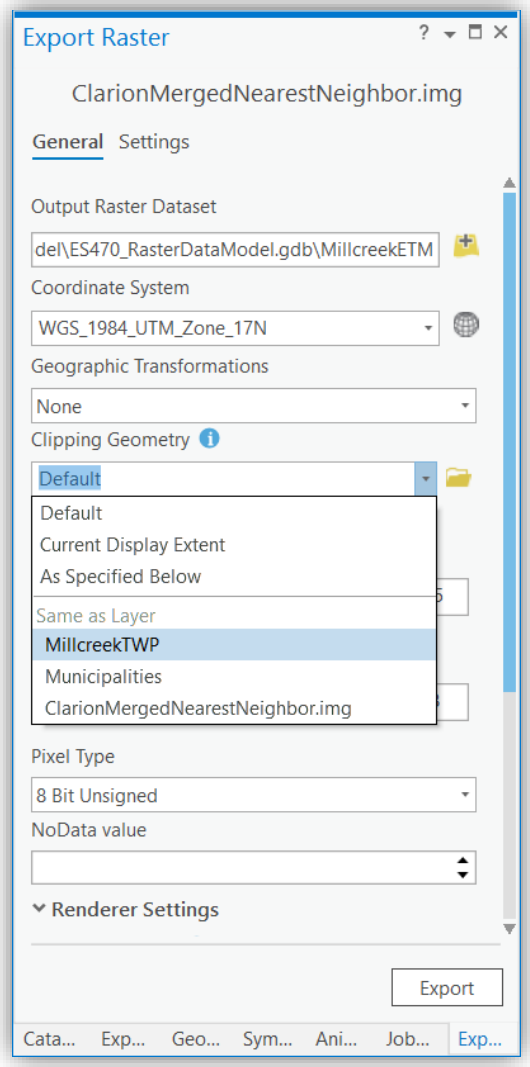
- Make sure that the *Municipalities* layer is on top of the *ClarionMergedNearestNeighbor.img* ETM one.
- Select "***Millcreek***" Township from the Municipalities layer. You may identify it by adding *labels* to the layer and interactively select it or by chosing *Select by attributes*.
- While *Millcreek* township is selected, right-click on the *Municipalities* layer from the *Contents* pane and select *Data >> Export Features*.
- Make sure that the *Output Location* is the Project's database, and type ***MillcreekTWP*** as the *Output Name*. Click OK.
- Turn off the *Municipalities* layer in the *Contents* pane. The newly created *MillcreekTWP* layer is displayed.



B. Clipping the Study Area Satellite Image

- In the *Contents* pane, right-click on the *ClarionMergedNearestNeighbor.img* image and select *Data >> Export Raster*

- For the *Output Raster Dataset*, make sure that it is stored inside the Project's database as ***MillcreekETM***
- Change the *Clipping Geometry* to the boundaries of Millcreek municipality that we created earlier: *MillcreekTWP*
- Click *Export*
- The clipped raster for Millcreek township will be created and added in the *Contents* pane (if it is not displaying, you may browse the Project's database and manually add it to the contents).
- Turn off the *ClarionMergedNearesNeighbor.img* image as well as the *MillcreekTWP* polygon layer.
- The *MillcreekETM* only shows.



C. Enhancing the Clipped Image

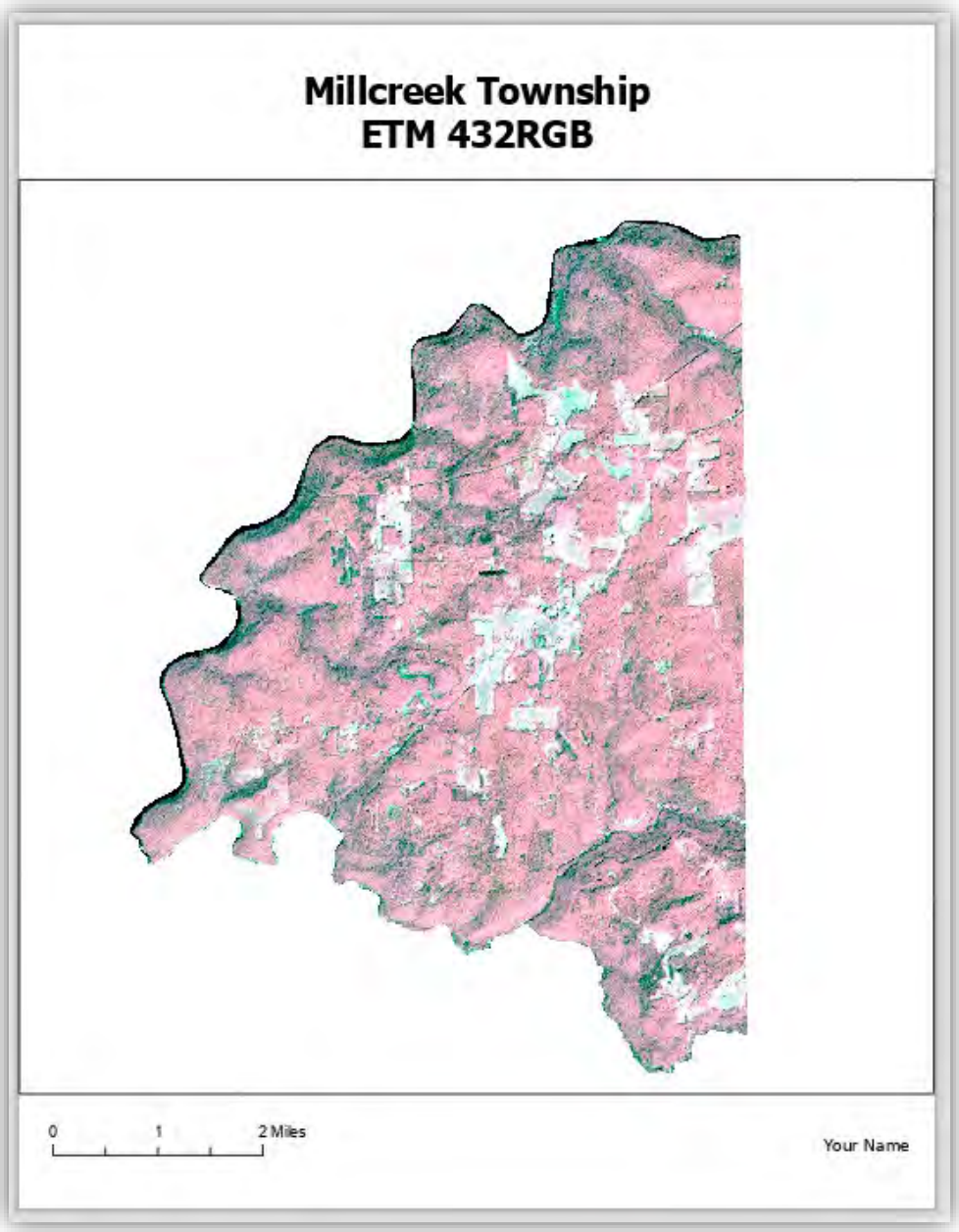
Using the previous section's directions, change the band combination of the clipped image (MillcreekETM) to 432RGB. Adjust the histograms to achieve the best visual representation possible within the available range of pixel values.

- Save the project.

D. Creating a Layout

- From the *Insert* tab, create a *New Layout* (Letter 8.5x11 portrait).
- From the *Insert* tab, *Map Frames* group, click on Map Frame and insert the map you just created (*Map1*).
- Resize the map frame to 8.5 in x 8.5 in (select the map frame, click on *Format* tab the change the *width* and *height* under the *Size & Position group*).
- Reposition the map frame on the layout so that you have enough space for a title on the top, and a scale bar and your name in the bottom. Insert a title, scalebar and your name.

Change the font sizes accordingly. Your final layout should look similar to the following figure:



- Export this layout inside the Project's folder as a PDF: *Share* tab >> *Export* group >> *Layout.* Name the file ***ES470_MillcreekETM.pdf***

V. Your Turn

- Create a color composite image like the one you created earlier on step ***III. Displaying & Exploring Multi-Band & Panchromatic Satellite Images*** but with the following guidelines:
  - Use band combination: 753RGB, change the layout title accordingly
  - Explore the *Multiply* option for layer blending
  - Recreate the layout and export to: ***ES470_RasterImageManipulation_MyTurn.pdf***
- Pick a large municipality comparable in size as Millcreek and clip the ETM image to its shape using the same steps in ***IV. Clipping an Image to a Shape***
  - Export the adjusted layout to ***ES470_****<Municipalityname>****ETM.pdf***

VI. Submit your Work

- Upload the 4 PDFs that you created for this exercise to the corresponding D2L Assignment:
  - ***ES470_RasterImageManipulation.pdf***;
  - ***ES470_RasterImageManipulation_MyTurn.pdf***;
  - ***ES470_MillcreekETM.pdf***; and,
  - ***ES470_****<Municipalityname>****ETM.pdf***

VII. Grading Rubric

- *ES470_RasterImageManipulation.pdf* 10pts
- *ES470_RasterImageManipulation_MyTurn.pdf* 10pts
- *ES470_MillcreekETM.pdf* 10pts
- *ES470_<Municipalityname>ETM.pdf* 10pts

R,G,B	Potential Information Content
4,3,2	The standard "false color" composite. Vegetation appears in shades of red, urban areas are cyan blue, and soils vary from dark to light browns. Ice, snow and clouds are white or light cyan. Coniferous trees will appear darker red than hardwoods. This is a very popular band combination and is useful for vegetation studies, monitoring drainage and soil patterns and various stages of crop growth. Generally, deep red hues indicate broad leaf and/or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas. Densely populated urban areas are shown in light blue. This TM band combination gives results similar to traditional color infrared aerial photography.
3,2,1	The "natural color" band combination. Because the visible bands are used in this combination, ground features appear in colors similar to their appearance to the human visual system, healthy vegetation is green, recently cleared fields are very light, unhealthy vegetation is brown and yellow, roads are gray, and shorelines are white. This band combination provides the most water penetration and superior sediment and bathymetric information. It is also used for urban studies. Cleared and sparsely vegetated areas are not as easily detected here as in the 4 5 1 or 4 3 2 combination. Clouds and snow appear white and are difficult to distinguish. Also note that vegetation types are not as easily distinguished as the 4 5 1 combination. The 3 2 1 combination does not distinguish shallow water from soil as well as the 7 5 3 combination does.
7,4,2	This combination provides a "natural-like" rendition, while also penetrating atmospheric particles and smoke. Healthy vegetation will be a bright green and can saturate in seasons of heavy growth, grasslands will appear green, pink areas represent barren soil, oranges and browns represent sparsely vegetated areas. Dry vegetation will be orange and water will be blue. Sands, soils and minerals are highlighted in a multitude of colors. This band combination provides striking imagery for desert regions. It is useful for geological, agricultural and wetland studies. If there were any fires in this image they would appear red. This combination is used in the fire management applications for post-fire analysis of burned and non burned forested areas. Urban areas appear in varying shades of magenta. Grasslands appear as light green. The light-green spots inside the city indicate grassy land cover - parks, cemeteries, golf courses. Olive-green to bright-green hues normally indicate forested areas with coniferous forest being darker green than deciduous.
4,5,1	Healthy vegetation appears in shades of reds, browns, oranges and yellows. Soils may be in greens and browns, urban features are white, cyan and gray, bright blue areas represent recently clearcut areas and reddish areas show new vegetation growth, probably sparse grasslands. Clear, deep water will be very dark in this combination, if the water is shallow or contains sediments it would appear as shades of lighter blue. For vegetation studies, the addition of the Mid-IR band increases sensitivity of detecting various stages of plant growth or stress; however care must be taken in interpretation if acquisition closely follows precipitation. Use of TM 4 and TM 5 shows high reflectance in healthy vegetated areas. It is helpful to compare flooded areas and red vegetated areas with the corresponding colors in the 3 2 1 combination to assure correct interpretation. This is not a good band combination for studying cultural features such as roads and runways.
4,5,3	This combination of near-IR (Band 4), mid-IR (Band 5) and red (Band 3) offers added definition of land-water boundaries and highlights subtle details not readily apparent in the visible bands alone. Inland lakes and streams can be located with greater precision when more infrared bands are used. With this band combination, vegetation type and condition show as variations of hues (browns, greens and oranges), as well as in tone. The 4,5,3 combination demonstrates moisture differences and is useful for analysis of soil and vegetation conditions. Generally, the wetter the soil, the darker it appears, because of the infrared absorption capabilities of water.
7,5,3	This band combination also provides a "natural-like" rendition while also penetrating atmospheric particles, smoke and haze. Vegetation appears in shades of dark and light green during the growing season, urban features are white, gray, cyan or purple, sands, soils and minerals appear in a variety of colors. The almost complete absorption of Mid-IR bands in water, ice and snow provides well defined coast lines and highlighted sources of water within the image. Snow and ice appear as dark blue, water is black or dark blue. Hot surfaces such as forest fires and volcano calderas saturate the Mid-IR bands and appear in shades of red or yellow. One particular application for this combination is monitoring forest fires. During seasons of little vegetation growth the 7 4 2 combination should be substituted. Flooded areas should look very dark blue or black, compared with the 3 2 1 combination in which shallow flooded regions appear gray and are difficult to distinguish.
5,4,3	Like the 4 5 1 combination, this combination provides the user with a great amount of information and color contrast. Healthy vegetation is bright green and soils are mauve. While the 7 4 2 combination includes TM 7, which has the geological information, the 5 4 3 combination uses TM 5 which has the most agricultural information. This combination is useful for vegetation studies, and is widely used in the areas of timber management and pest infestation.
5,4,1	This will look similar to the 7 4 2 combination in that healthy vegetation will be bright green, except the 5 4 1 combination is better for agricultural studies.
7,5,4	This combination involves no visible bands. It provides the best atmospheric penetration. Coast lines and shores are well defined. It may be used to find textural and moisture characteristics of soils. Vegetation appears blue. If the user prefers green vegetation, a 7 4 5 combination should be substituted. This band combination can be useful for geological studies.
5,3,1	This combination display topographic textures while 7 3 1 may display differences in rock types.

Source: http://web.pdx.edu/~nauna/resources/10_BandCombinations.htm