# Viewing and Stretching the Image Histogram in ArcGIS 8.3/9.x

A histogram can be defined as "a graph showing the distribution of values in a set of data. Individual values are displayed along a horizontal axis, and the frequency of their occurrence is displayed along a vertical axis". In the case of aerial imagery, the histogram is known as an "image histogram". An image histogram is a histogram of the values of the pixels in a digital image that shows the distribution of tone throughout an image. Understanding what a histogram is, how it is viewed, and how it is adjusted in ArcGIS can help imagery users see a better product.

## **I**. *Viewing the Histogram*

First, open an ArcMap session and add an image to the table of contents. Right click on the image and select "Properties".

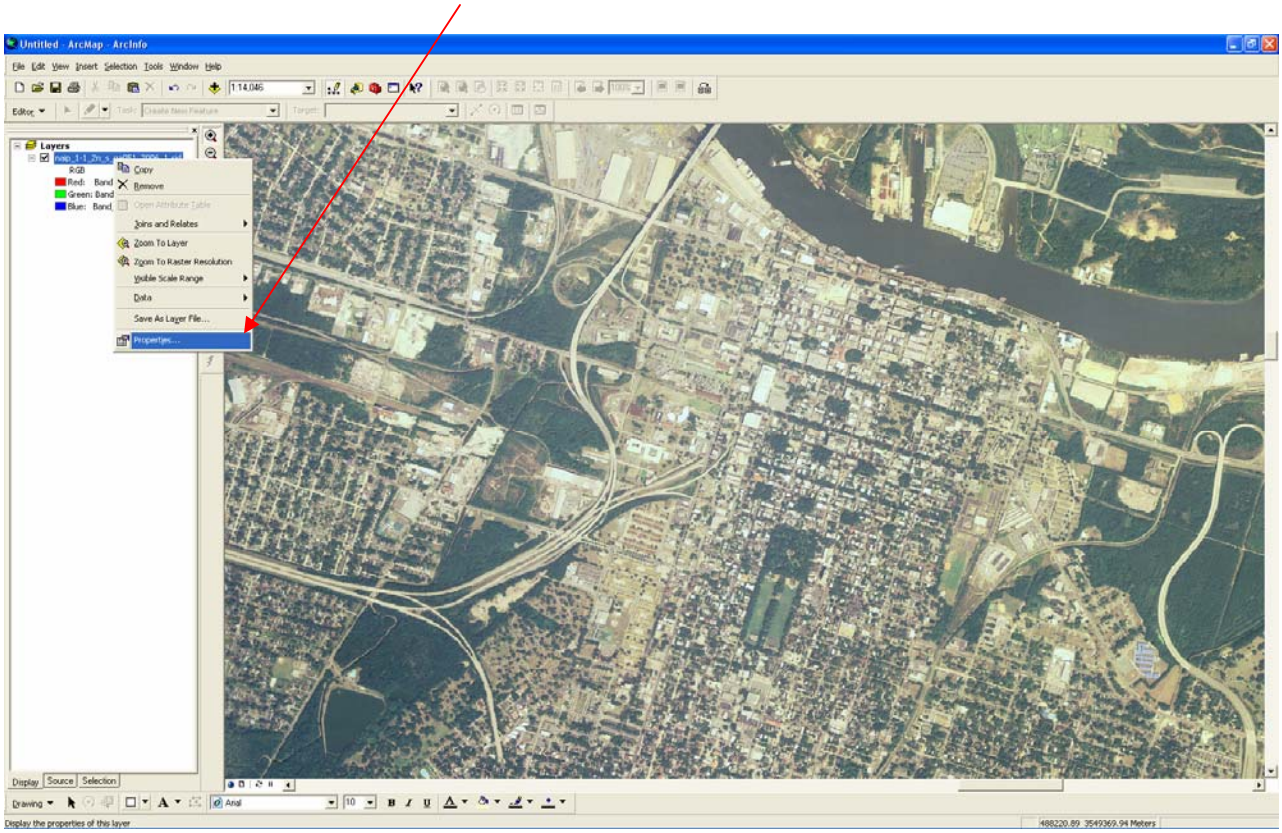


*Figure 1: Opening image properties window*

In the “Layer Properties” window, make sure the “Symbology” tab is selected and “RGB Composite” is highlighted.

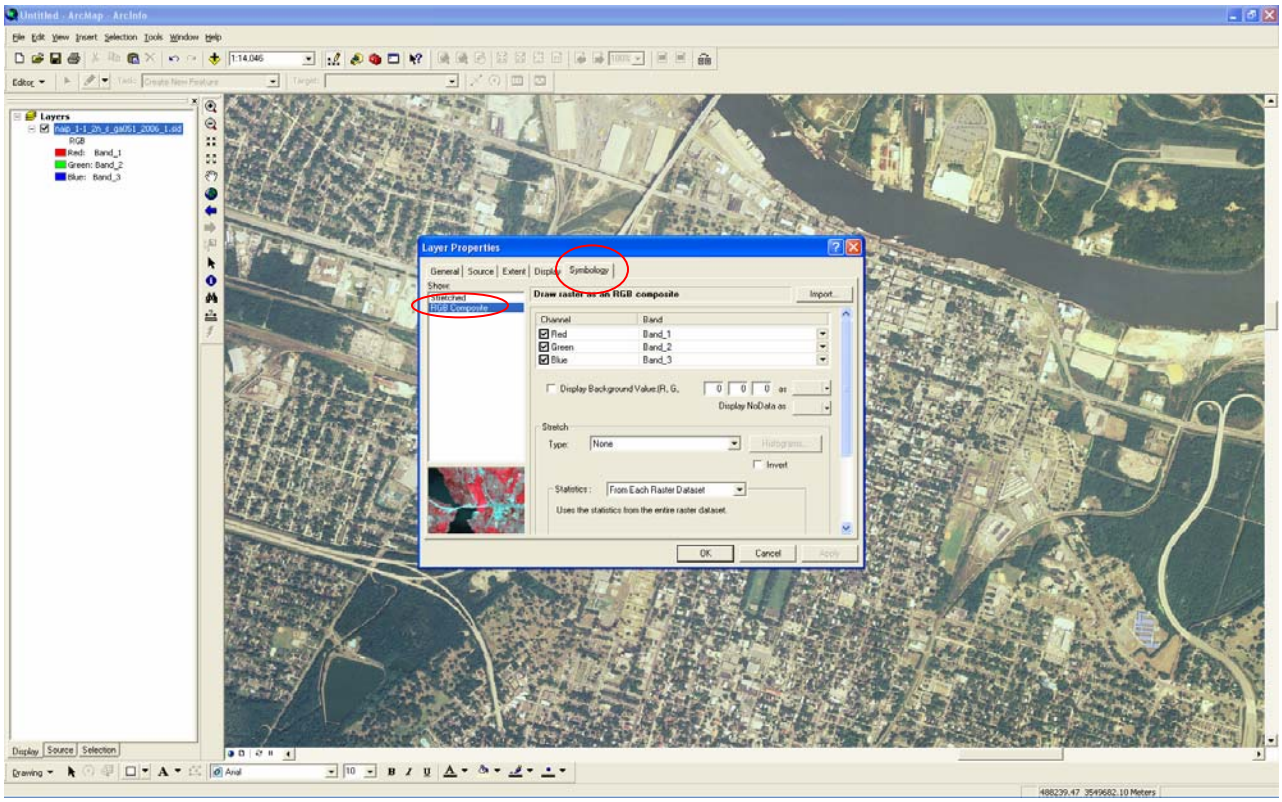


*Figure 2: Layer properties window*

Here, each band is displayed with its appropriate channel (red, green, blue) and options for the histogram are displayed. To view the actual histograms, a stretch must be applied. In the stretch “Type” window, select “Custom”, then click the “Histograms” button (figure 3).

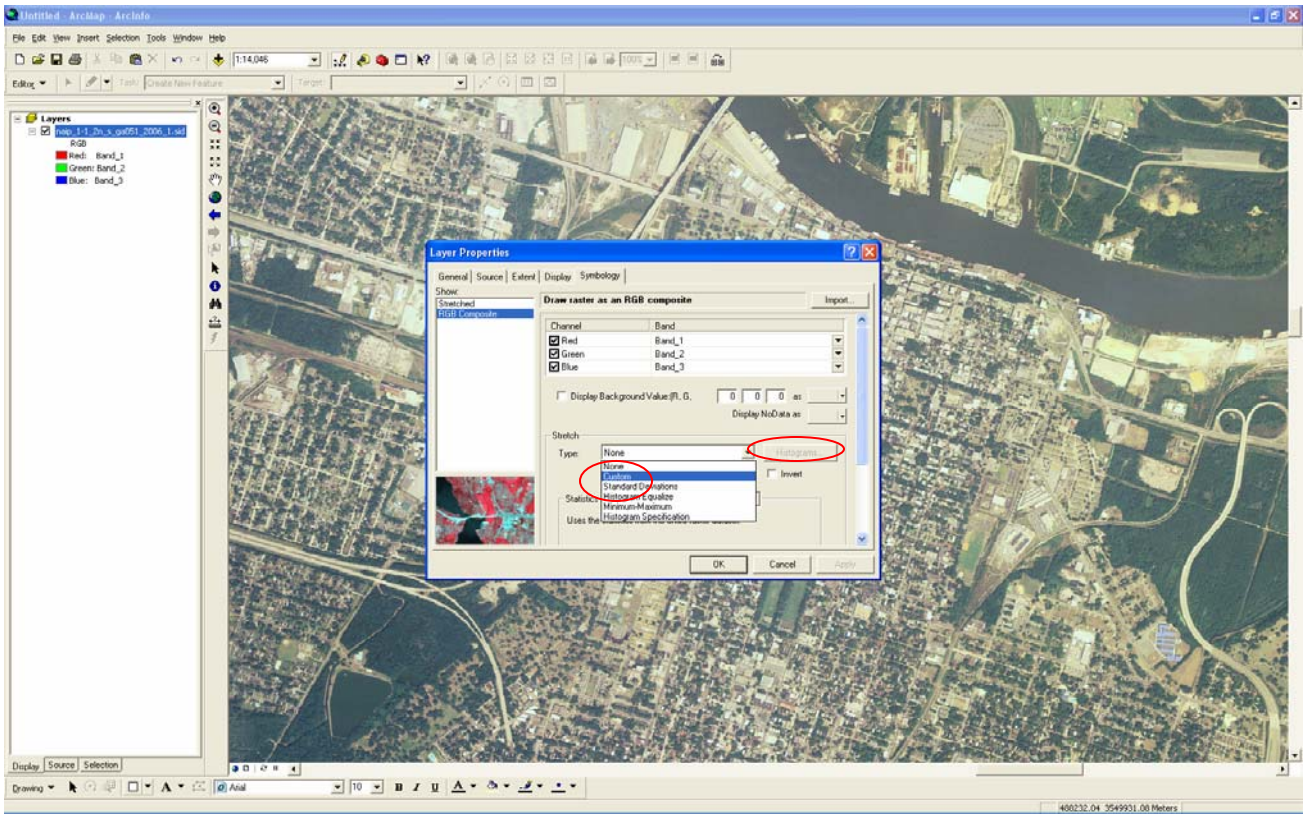


*Figure 3: Applying a stretch to the image*

The histogram window will appear with the viewing tabs for each band.

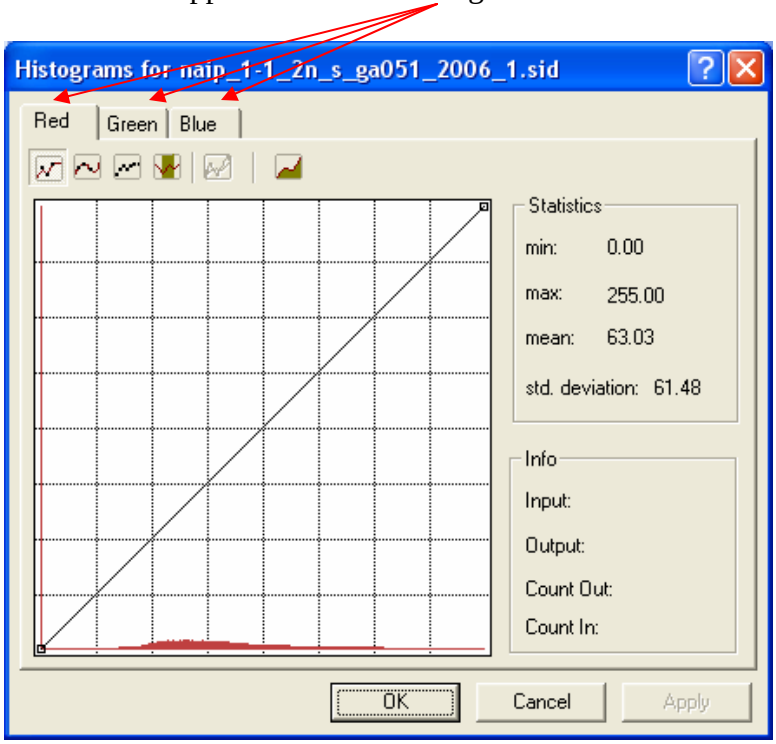


*Figure 4: Viewing histograms*

The straight line that runs diagonally across the graph is the "curve". If no stretching has been done, the input pixel value equals the output, and therefore the "curve" is straight. On the right side of the window, the pixel value statistics are summarized. Click on the tabs to see the statistics for each band. In the histogram graph, the x-axis displays the input pixel values and the y-axis displays the output pixel values. Note how as the cursor is navigated around the graph, the input and output values change. In the "Info" box, "Count Out" and "Count In" display the count, or the frequency, of each input value and output value in the data. For example, in figure 5 below, the input value of 129 occurs 1,976,562 times in the red band of the image and the output value of 130 occurs 1,976,652 times. Input count equals output count, indicating the image is unstretched.

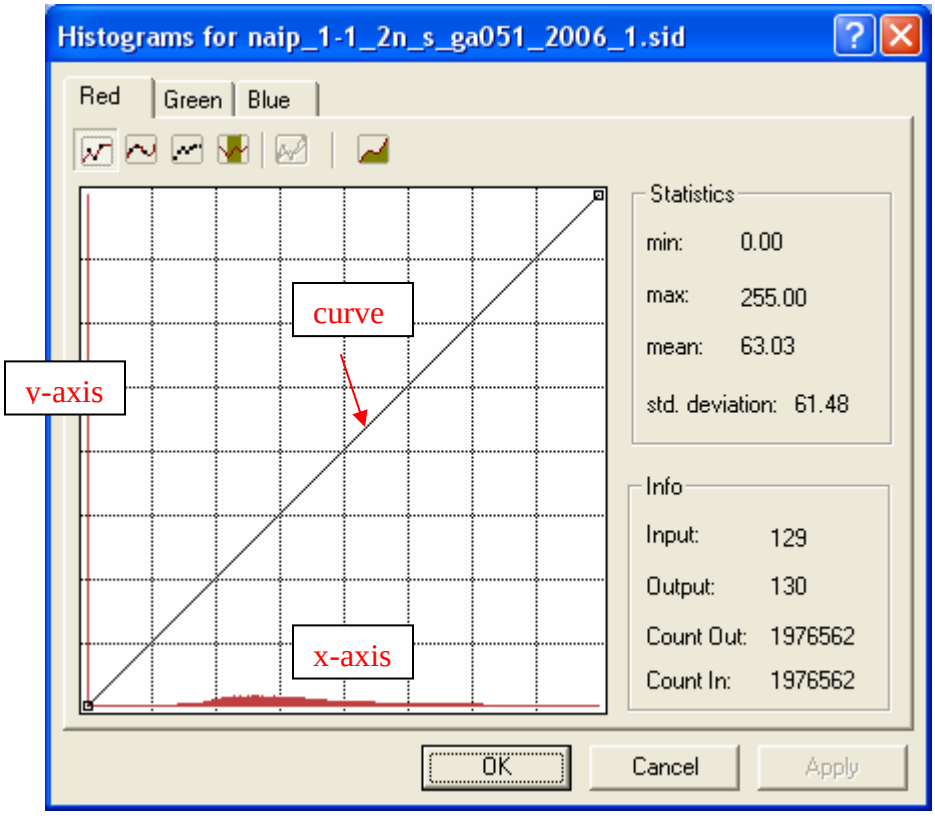


*Figure 5: x and y axes in the histogram*

There are several options for viewing the statistics of the histogram. Statistics can be displayed for the entire raster, the display extent, or user inputted custom settings (figure 6). Under the "custom settings" option, the statistics can be directly input for each band to stretch the image.

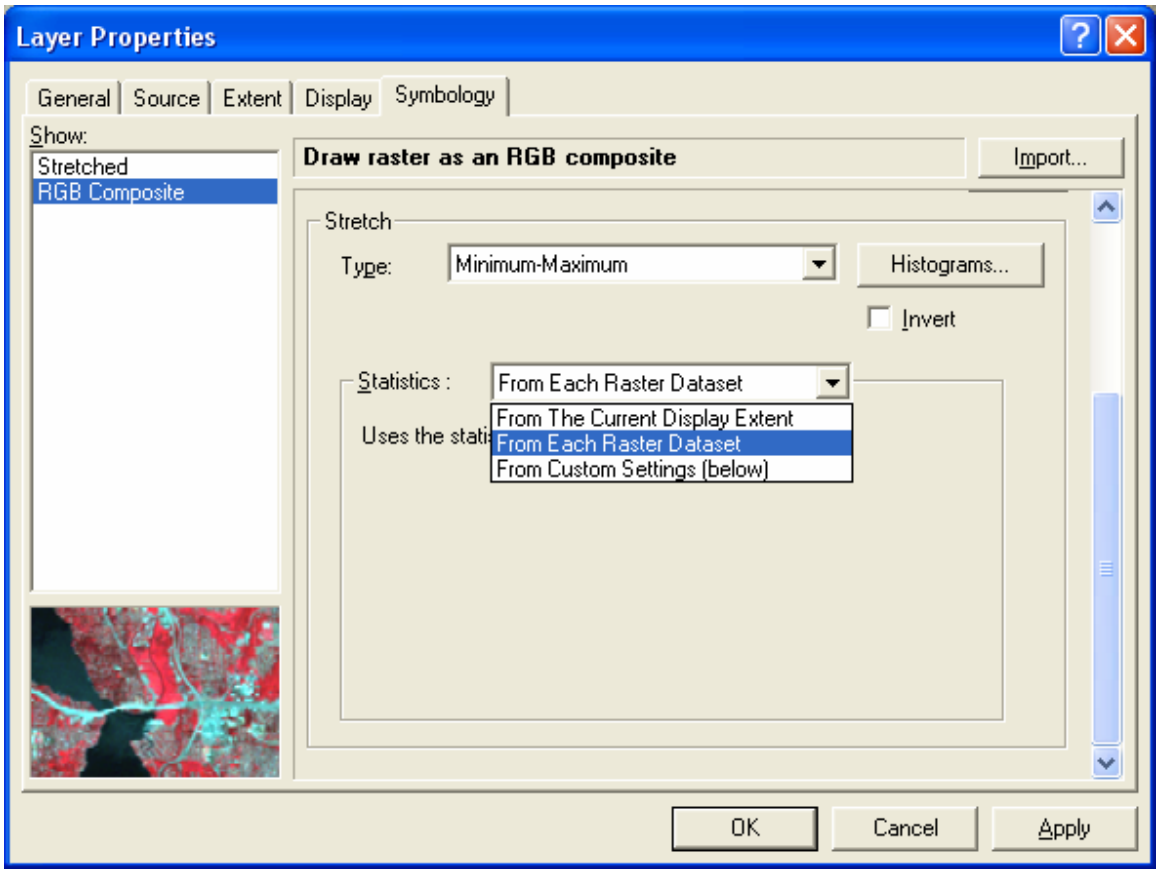


*Figure 6: statistics display options*

**II**. *Stretching the Histogram*

Stretches can be applied to an image's histogram to achieve a more visually pleasing image. In ArcGIS, the stretching can be done in a composite format where the entire image (all bands) is stretched, or each band can be stretched in a custom fashion. Custom stretching can be cumbersome in ArcGIS, whereas the composite stretching can easily create a quality image output. Keep in mind that the applied histogram stretches are not permanent in ArcGIS. They are not encoded in the image; this allows the user to freely experiment with stretching the histogram. If the stretches are to be kept, the image can be saved as a layer file. This is done by right-clicking on the image layer in the Table of Contents, and selecting the "Save As Layer File" option (Figure 7). This layer file can then be imported whenever a histogram stretch calls for the same stretch values (Figure 8).

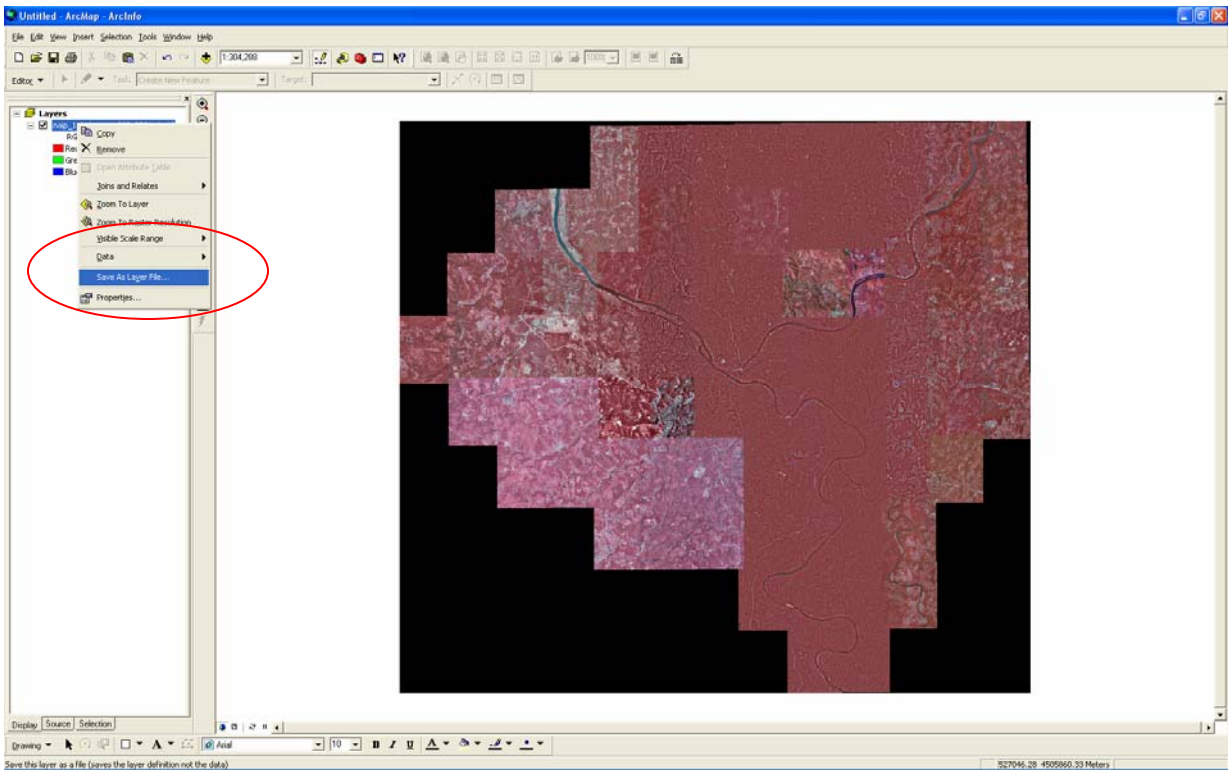


*Figure 7: Saving an image as a layer file*

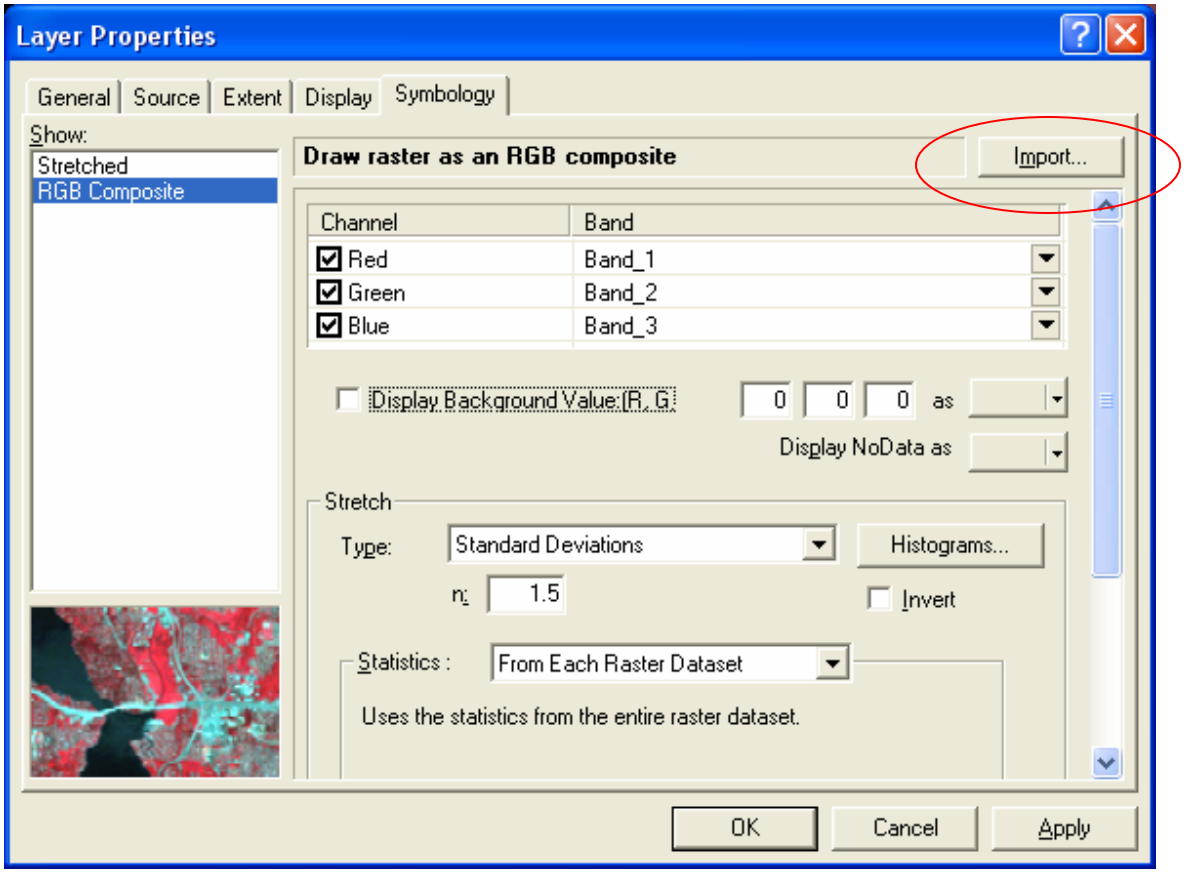


*Figure 8: Importing an image layer's histogram stretch values*

**a**. *Composite Stretching*

Stretching the histogram is easier when using a composite method. In ArcGIS, besides the interactive custom stretching, there are three options for "composite" stretching: **standard deviation**, **histogram equalized**, and **minimum maximum** (see figure 9).

The "standard deviation" option allows the standard deviation to be stretched by a constant "n" value. An "n" value of 2 is a good stretching option for brightening imagery that normally appears dark. However, whole numbers do not have to be used. A value of 1.8, 2.3, etc. can be used effectively.

"Histogram equalization" is effective in creating detail enhancement. It is limited in that it is capable of producing only one result: an image with a uniform intensity distribution. Equalization essentially creates a "flat" histogram of uniform pixel values; it creates an equal number of pixels at all brightness levels.

The "minimum maximum" stretch is used to spread out tightly grouped values in the histogram. It is used to optimize the full range of available brightness values in the image.

The "histogram specification" option is useful for compressing the dynamic range of an image in order to remove pixel values that contain very little information. This makes an image easier to view on a monitor.

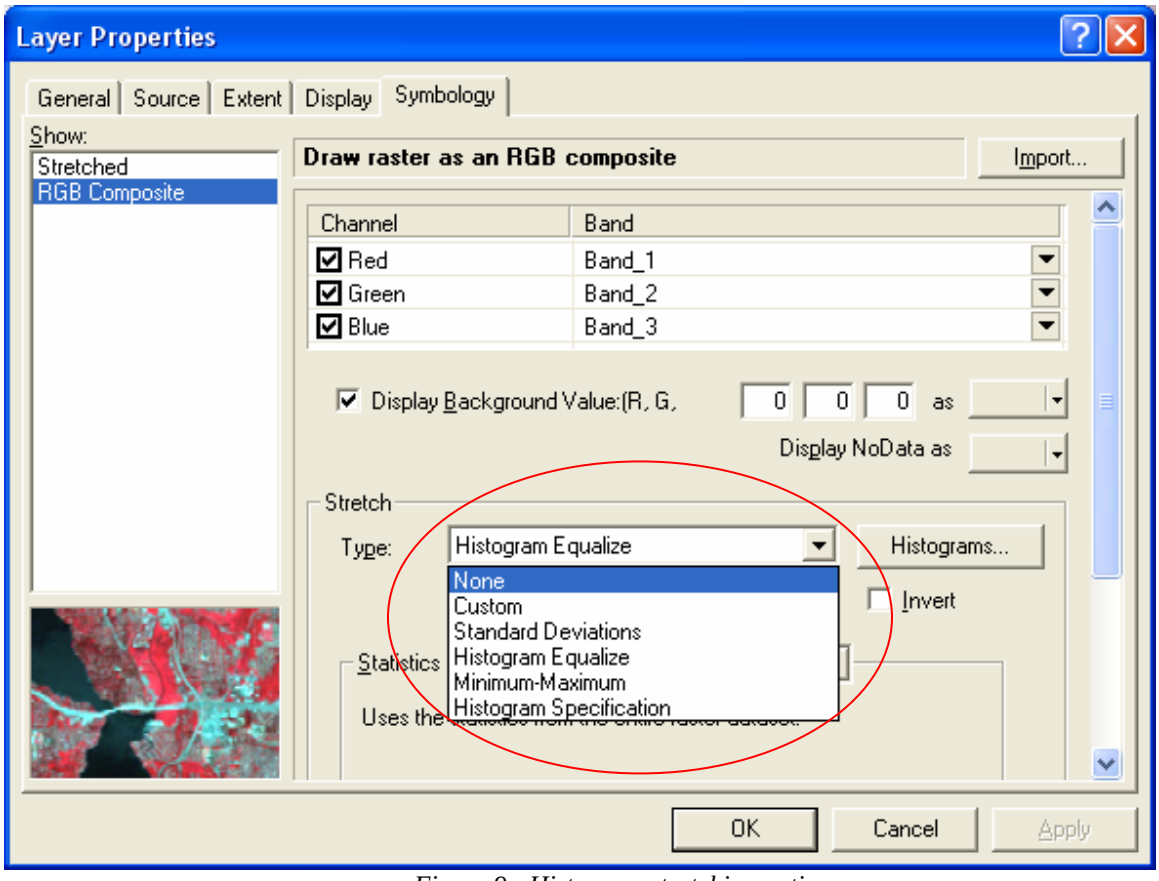


*Figure 9: Histogram stretching options*

The following are examples of a natural color NAIP 2006 image of Savannah, GA and a CIR NAIP 2004 image of Pittsburgh, PA with and without stretches.

*Figure 10: Savannah, GA unstretched NAIP image*

*Figure 11: Stretched NAIP image using the standard deviation method with "n" value of 2*

*Figure 12: Stretched NAIP image using the histogram equalize method*

*Figure 13: Stretched NAIP image using the minimum/maximum method*

In the "minimum/maximum" example above, there isn't much difference from the unstretched image. This is because the brightness values in the unstretched image are well optimized.

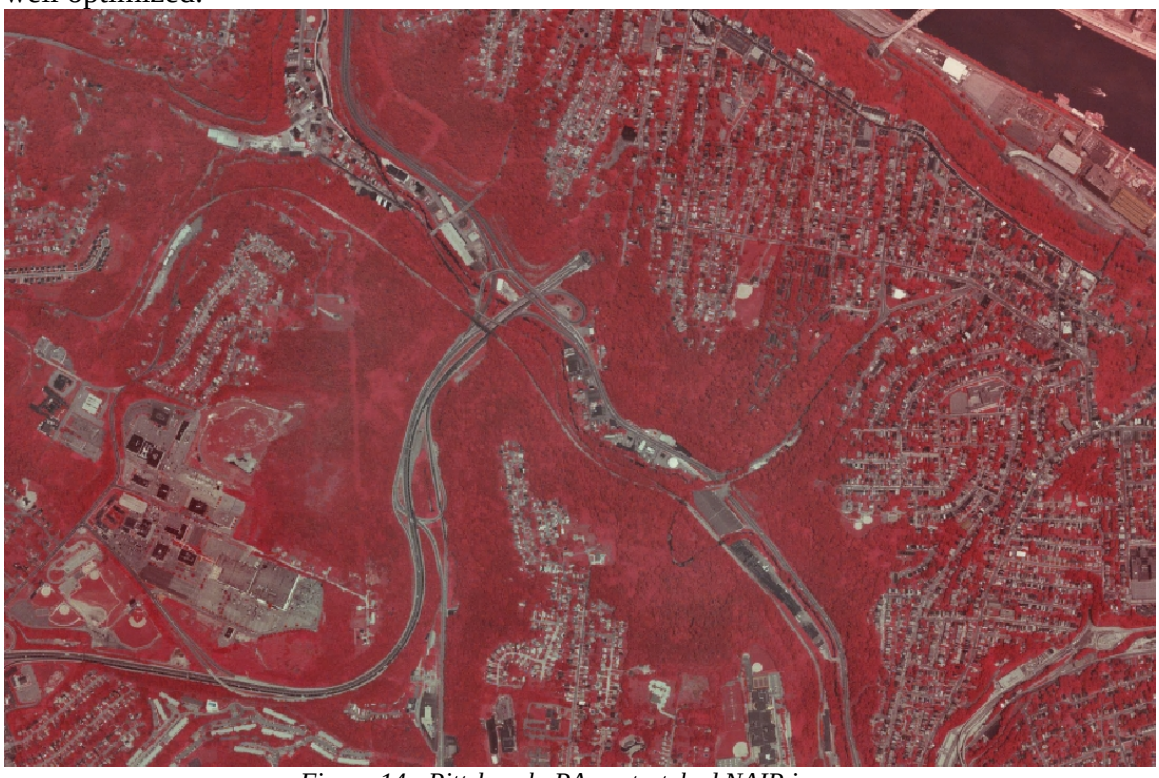

*Figure 14: Pittsburgh, PA unstretched NAIP image*

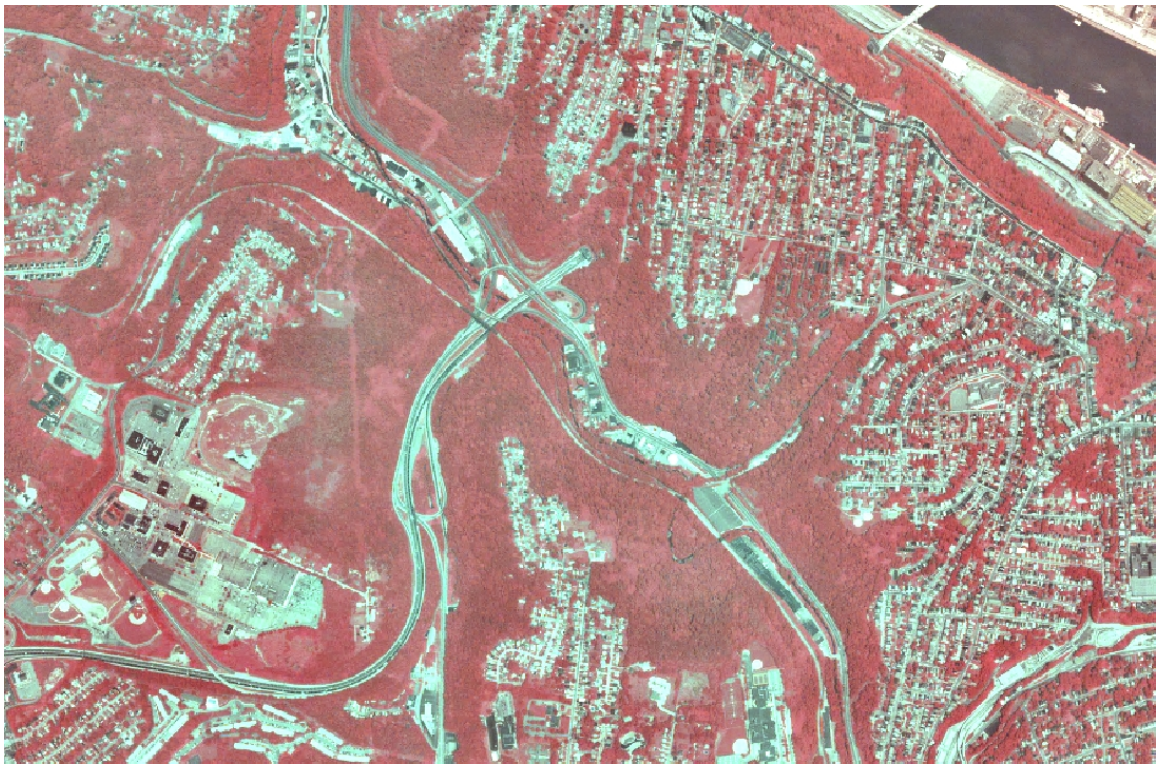

*Figure 15: Stretched NAIP image using the standard deviation method with "n" value of 1.5*

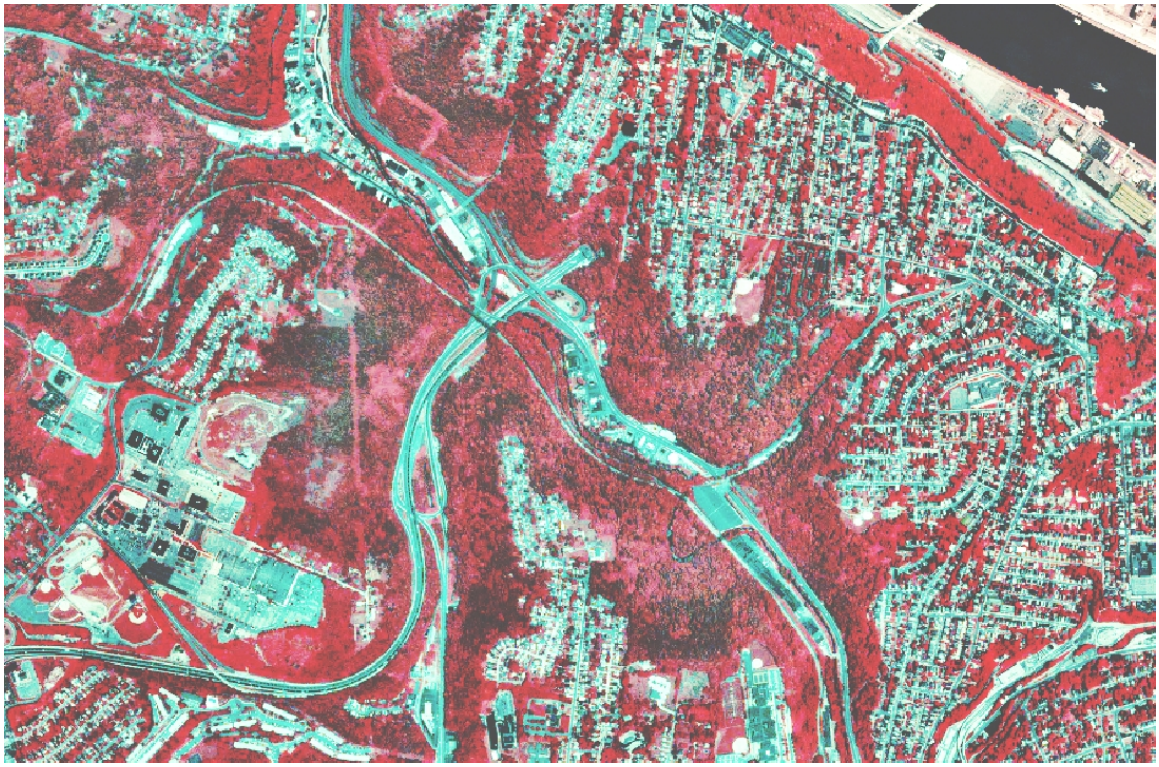

*Figure 16: Stretched NAIP image using the histogram equalize method*

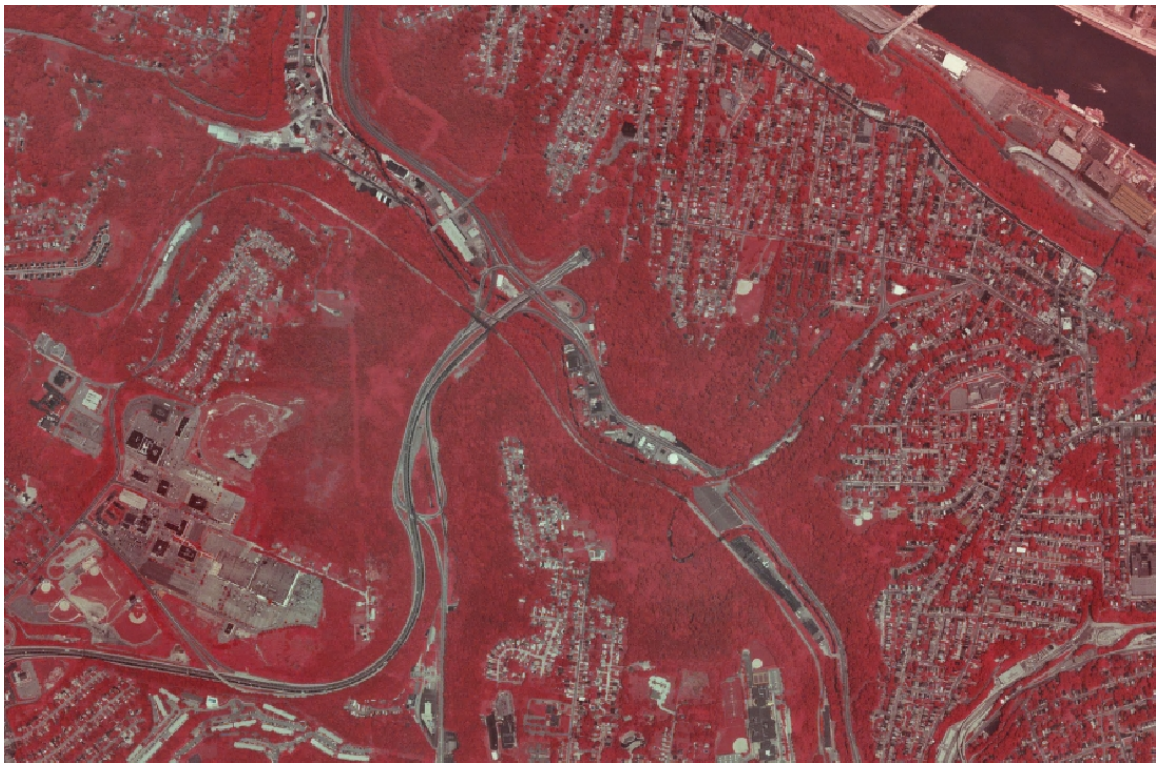

*Figure 17: Stretched NAIP image using the minimum/maximum method*

**b**. *Custom Stretching*

Custom stretching of the histogram is done in the histogram window (see figs. 3, 4 and 5); the greater the stretch, the larger the difference between the input pixel values and the output pixel values. A custom stretch is basically adding breakpoints to the histogram graph line and then moving them to the required location to stretch particular pixel values. There are three main types of custom stretches; **piecewise linear stretch**, **nonlinear stretch**, and a **stretch based on points**.

The piecewise linear stretch results in a segmented graph line representing the differences between your input and output values. Use this method to increase the contrast over ranges you specify. Begin by clicking the "Lines" button in the upper left of the histogram graph. Next, click points on the graph to stretch the histogram to the desired pixel values (see figure 18). Click the "Apply" button and repeat the process for the other bands of the image.

The nonlinear stretch results in a curved graph line representing the differences between your input and output values. This method is used to increase the contrast over a particular range of values, while decreasing the contrast over other ranges of values. In the histogram graph, click the "Splines" button (see figure 19). Next, click points in the graph to stretch the histogram to the desired pixel values. Click the apply button and repeat the process for the other bands.

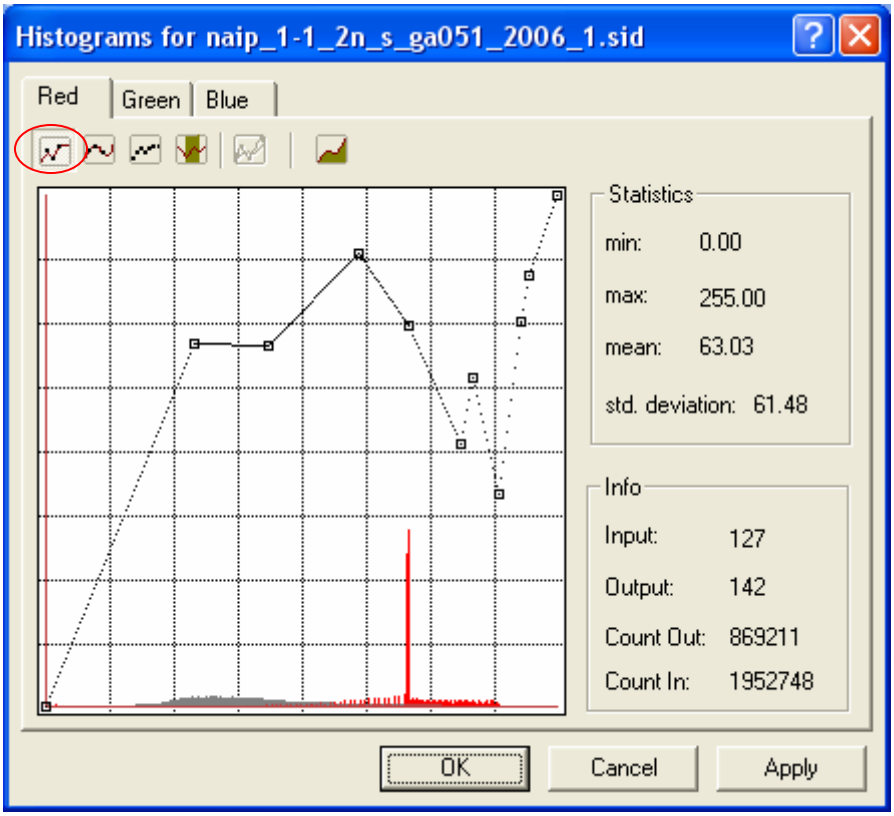


*Figure 18: "Lines" button for piecewise linear stretch*

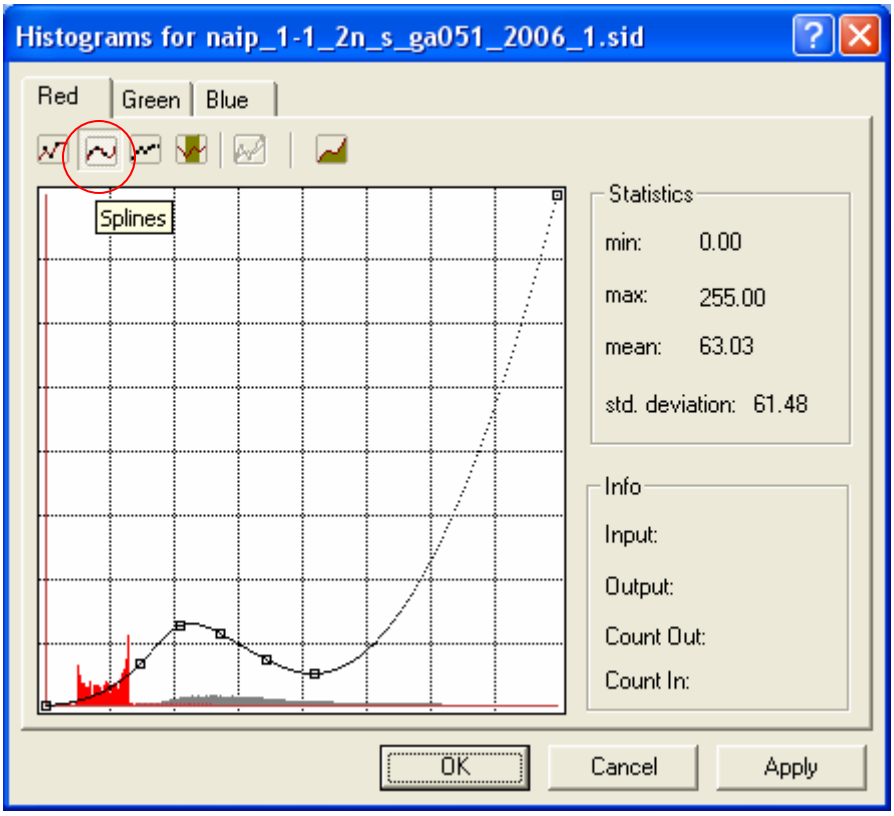


*Figure 19: "Splines" button for nonlinear stretch*

The stretch based on points is dependant upon where you place the points representing the differences between your input and output values. Use this method to control the contrast over your customized points. Begin by clicking the "Points" button (see figure 20). Now, points can be clicked in the histogram to create break points. Drag these to the appropriate location to apply a stretch to certain values. If you know which values you want to stretch, place the cursor over the histogram and locate the input values along the X-axis of the graph line. Place breakpoints at these points, then move the graph line up to the required output value on the Y-axis. The breakpoints are the small squares on the curve. To delete breakpoints, hold the cursor over one, then click and drag the breakpoint off the graph line.

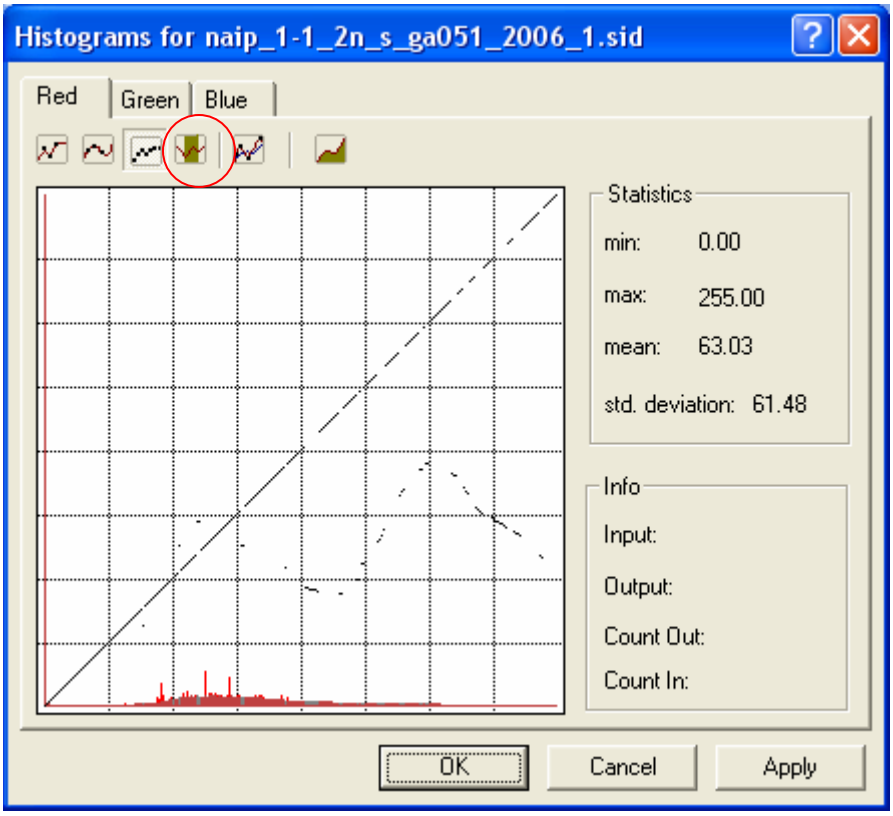


*Figure 20: "Points" button for a stretch based on point values*

Click the "Apply" button when finished and repeat on the other bands. After placing all desired break points, click the "Smooth" button to smooth out the stretch that has been applied to the point stretch (see figure 21). This results in a smoother curve, rather than jagged transitions. This button can be clicked until the desired smoothness is reached.

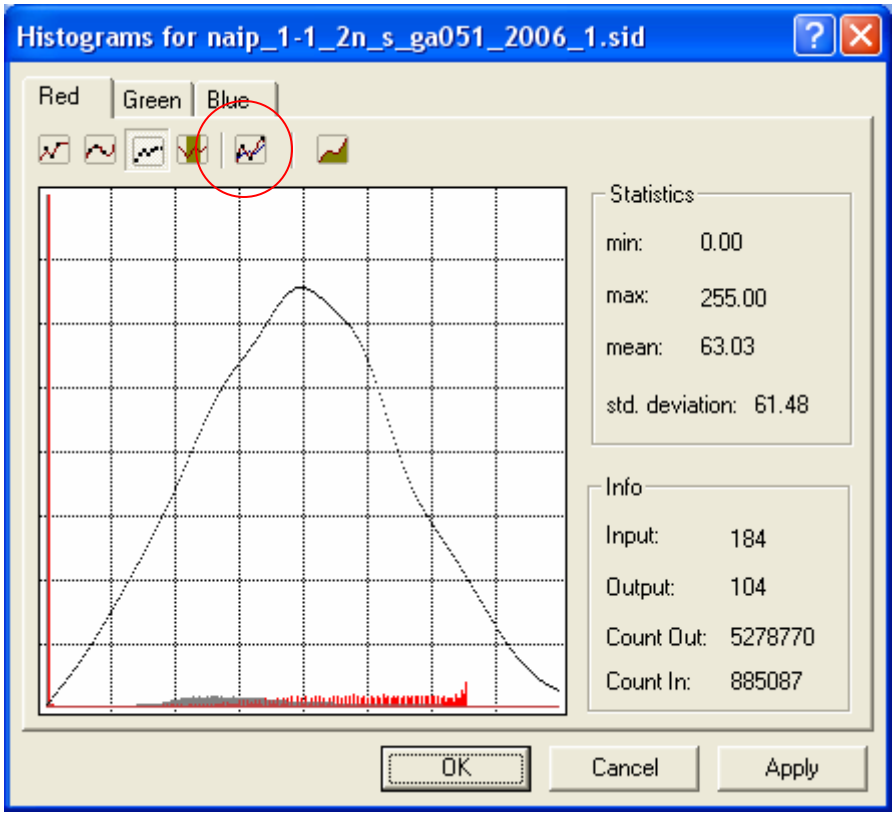


*Figure 21: "Smooth" button for smoothing point values*

The "Cumulative" button shows the histogram with a cumulative output (y), as the cursor moves along the input (x) axis. Click the button to display this (see figure 22).

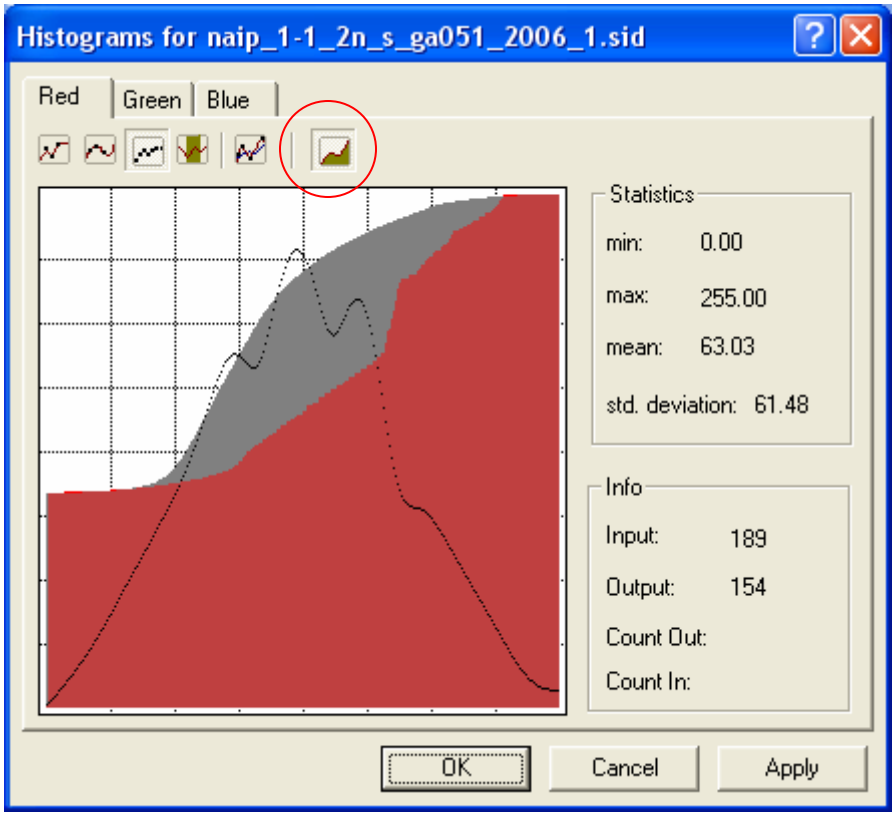


*Figure 22: "Cumulative" button for smoothing point values*

Custom stretching the histogram in ArcGIS can be difficult. It should only be attempted by individuals with some experience in color balancing and histogram manipulation. Achieving the desired output image requires pinpointing of individual pixel values in each band. Unless the exact values are known, the color balance of the image can become severely warped when stretching the histograms.

For more information, please contact the USDA/FSA/Aerial Photography Field Office, Service Center Support Section.

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