"Exploring a Satellite Image"

MultiSpec© Freeware Tutorial

(Windows PC Version: Feb2008)

Installing MultiSpec on Your PC:

- Turn on you computer.
- Start Windows (if not already running)

  Download the appropriate MultiSpec software for your computer (or copy the files from CD) onto your computer's hard drive. The download site is:
  http://cobweb.ecn.purdue.edu/~biehl/MultiSpec/

- Note: If you download the files, you must unzip the files before they can be used. If you do not have the software to do this, let us know.

- If you download the software, keep track where the files are downloaded so that you can find the MultiSpec folder easily. The MultiSpec program file (MultiSpec.exe) will be in that folder and you can create a shortcut to that from your desktop. This is done by clicking on the right mouse button and choosing "Create Shortcut". Then drag the new icon to your desktop.

Step 1: Create a folder with your name on your computers desktop to save downloaded materials in.

Step 2: Download "MultiSpec" software from the MultiSpec website

http://cobweb.ecn.purdue.edu/~biehl/MultiSpec/

Step 3: Download the Beverly Massachusetts Landsat image from the UNH Globe website
http://www.globe.unh.edu

Follow the links
1. **MultiSpec Materials**
2. **Electronic Mapping**

Download the following image.
Bevsub.lan (Beverly.lan when downloaded)

Note: If problems arise with the Windows setup or the MultiSpec program will not start, send email to forestwatch@unh.edu or support@mvh.sr.unh.edu with subject line MULTISPEC for further guidance and troubleshooting.

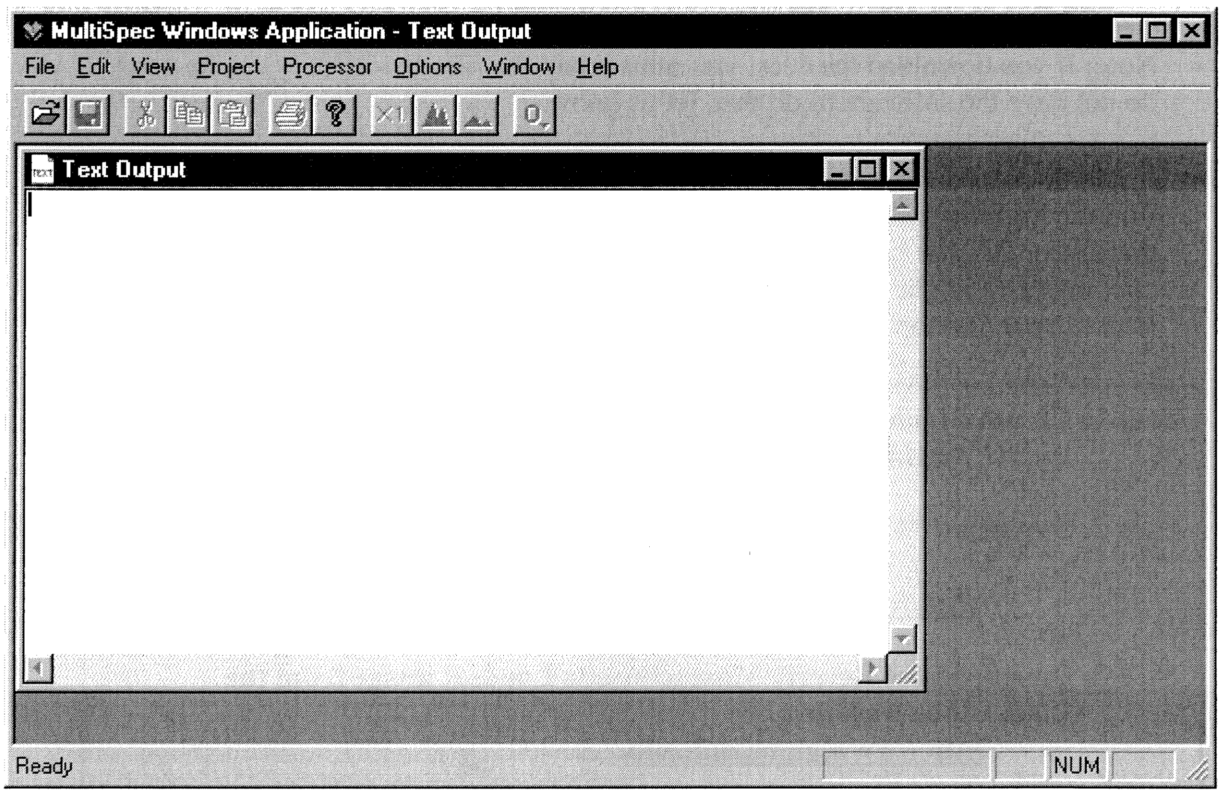
Materials needed:

PC with **'Beverly.lan'** image installed

Getting Started:

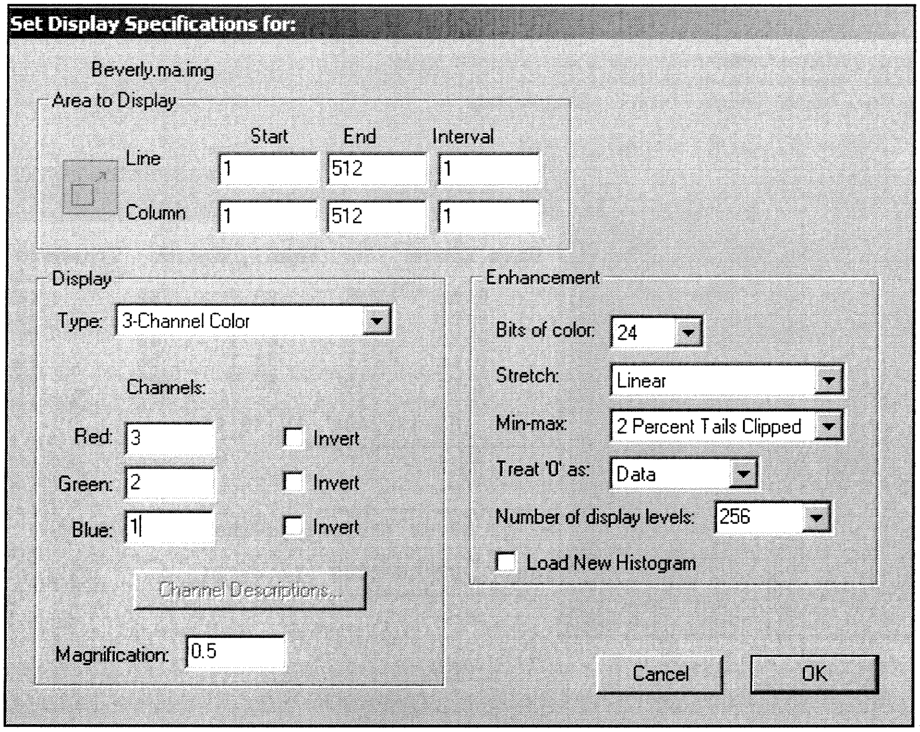
- After turning on your computer, start Windows.
- Double click on the **MultiSpec** icon to start the MultiSpec program. 

- The window labeled **Text Output** should appear. Your screen should be similar to the one shown in the diagram below.



- Pull down the **File** menu and select **Open Image**. Browse to, and Double click on **Beverly.lan** to select that Landsat satellite image

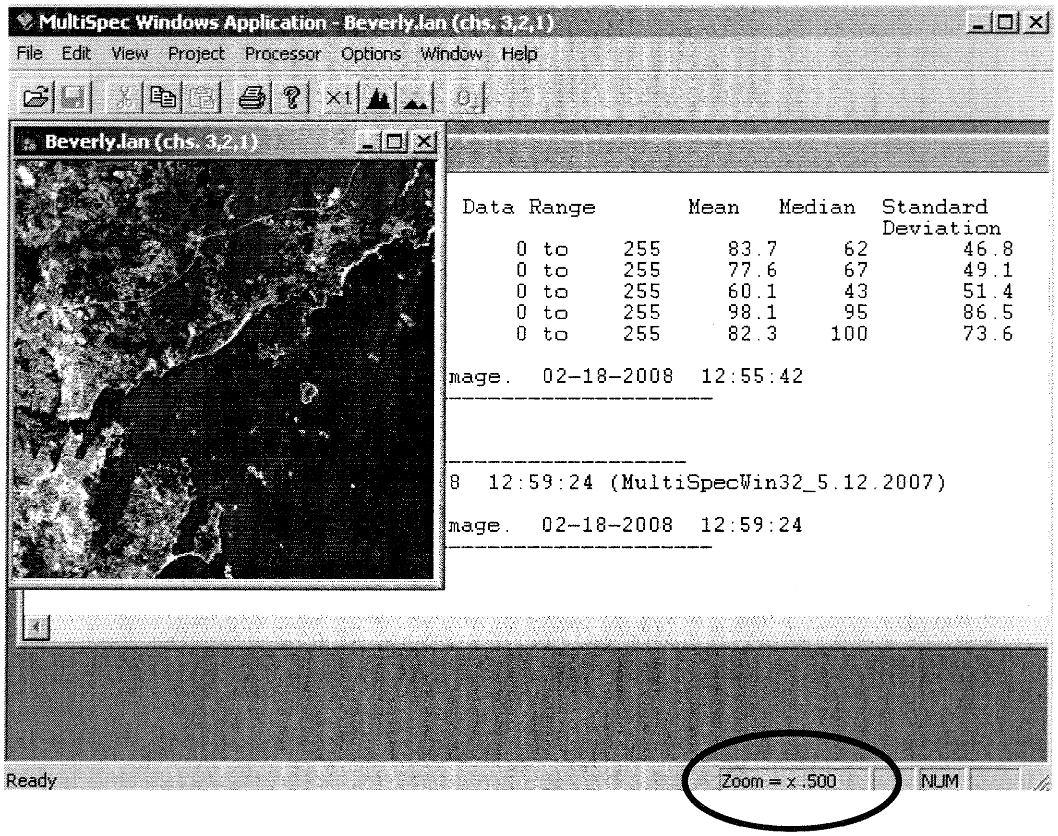
- You should now have a dialogue box entitled **Set Display Specifications for: 'Beverly.lan'** displayed on your screen.



In the top of the window is a box titled **Area to Display**. This box shows us that the image of entire image of Beverly Massachusetts that we have to work with is selected and is 512 pixels by 512pixels square or approximately five square kilometers. We will return to this coordinate system later on in the tutorial as well as alternatives.

- Click on the box labeled **Display Type** and be sure **3-Channel Color** is selected.
- Leave all other the settings as they are or correct them to match above if different.
- Under **Channels** set **Red** box to **3**, **Green** box to **2**, **Blue** box to **1** and click **OK**. To edit the number appearing by each color, click to the left of the number and, without releasing the mouse button, drag the mouse to the right or double-click on the box. This should highlight the number you want to change. When it is highlighted, release the mouse button. The box should stay highlighted. Now type the number you wish to enter in the box. You may use the **Tab** key to move between boxes on the screen.

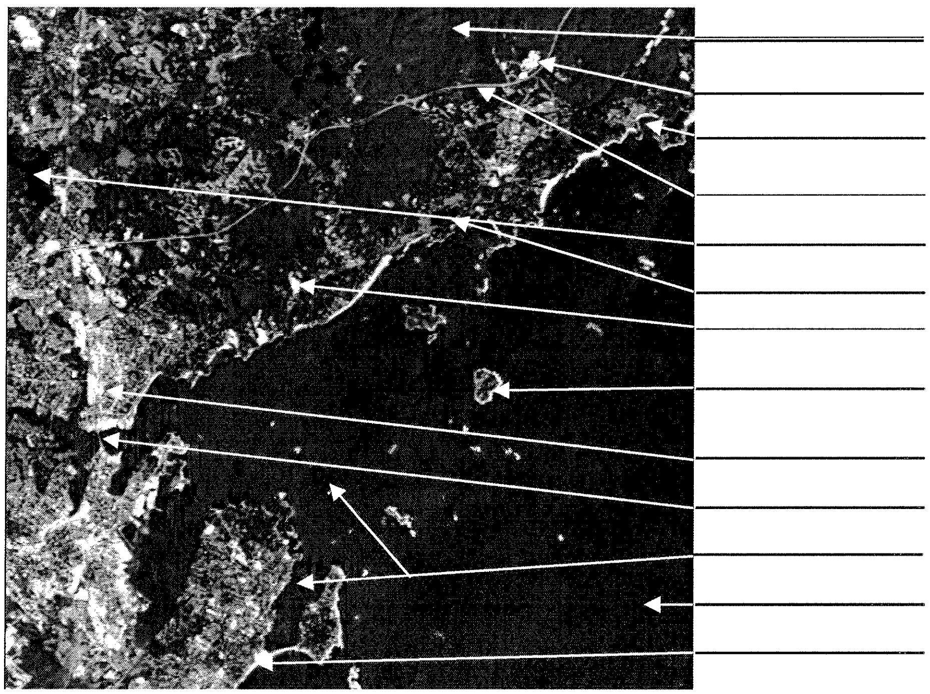
- Click **OK**. The image display should now appear in the upper left of your screen. At **x.500** magnification you can see the entire image at once.



- To enlarge the window, click on the lower right corner (a striped triangle) of the image window and drag the box to the right and down. The window can be made as large as your whole screen. In the lower right hand corner of the application window, is a box that shows **Zoom=X .500**. This box depicts the current magnification factor being used to display the image.

Identifying features in the image:

Try to identify highways, bridges, cities, lakes, forests, beaches, marshy regions near the shore, shallow ocean waters, deep ocean waters, clouds and shadows, gravel pits, islands, tidal areas, etc.



See Page 36 for Answers.

Zooming:

- The right three boxes in the toolbar, located directly above the image window, control the magnification factor. The box shown as **X1.**, when clicked on, will always return the factor to **1**. Click on this box now. The box in the lower right hand corner of the application window should now read **Zoom = X 1.0** and the image should enlarge and fill the viewing window depending on how much you enlarged the image window.

- Notice the images that look like mountains in the tool bar to the right of the **X1**. box on the toolbar. Use large mountains to **zoom in** with and small mountains to **zoom out** with. These zoom boxes allow you to zoom in and out from the current image scale. (From now on the large mountain box will be abbreviated as **i** and the small mountain box as **o**.) The box in the lower right hand corner of the application window (hereafter referred to as the zoom box) will change every time the **i** or **o** box is clicked on the toolbar.

Click the **i** once. Now click on **i** many, many times. You should eventually see the image appear as a mosaic of squares (pixels) on the screen. Before proceeding to #2, click on the **X1**. Box.

The image should now be full size and the zoom box should read **X l.O**.

Questions:

a. What do you notice about the length of objects when you zoom in? when you zoom out?

Objects increase/decrease in length proportionately with the zoom factor.

b. What information is gained when you zoom in or out? What information is lost?

When you zoom in, you can focus on a smaller region. Eventually the image becomes a mosaic of pixels. When you zoom out, you can see a larger region at once.

Zoom Box:

You also can zoom in on a specific region by boxing the region and zooming. Place the mouse pointer at the upper left corner of the area you wish to box. Then click and hold the mouse button while moving the mouse to the right and down. When you have boxed off the desired area, release the mouse button. Notice that the region you selected is delineated by dashed lines. Click on the **i** box. You can continue to zoom in on the selected region by continuing to click on i. What do you observe? If the zoom box is not square, do the image proportions appear to change? Give reasons for your answer.

The proportions of a figure do not change. Lengths all change proportionately. Shape stays the same, size changes.

To zoom in or out by tenths, hold down the **Ctrl** key while clicking on the **i** or **o** box.

Return to the full image by clicking on the **X1**. box so the zoom box reads **Zoom=X l.O**.

Panning:

In order to move (pan) around the image, you can use the scroll bars at the right and bottom of your screen. If your mouse has a center wheel between the right and left click buttons you may use this or scrolling up and down.

Investigating color in a satellite image

Image Display:

Under the Processor menu select **Display Image**

Please read the following information about color and Landsat satellite images. The colors red, green, and blue refer to the computer monitor color guns. (They apply red, green and blue light to each pixel in specific intensities.) The **channels** (often called bands) refer to bands of reflected light sensed by the satellite from the objects in the image.

- **Band 1 is reflected blue light,**
- **Band 2 is reflected green light**
- **Band 3 is reflected red light.**

Red, green, and blue are the primary colors of visible energy. Different hues (shades) of color are obtained on the screen when color guns apply different intensities of red, green, and blue light to the same pixel. For example, equal intensities of red and green light produce yellow; equal intensities of blue and green light produce cyan; and equal intensities of blue and red light produce magenta. Bands 4 and 5 receive reflected near infrared and mid infrared energy, respectively.

We will use the following red, green, and blue (RGB) channel settings in order to get a feel for different channel (band) combinations.

True color images - This band combination presents an image as it would appear to the human eye, looking back from space.

Red 3 (the visible red band)
Green 2 (the visible green band)
Blue 1 (the visible blue band)

Other band combinations result in images that do not appear as they would to the human eye. These images are called **false color images**. To observe in the infrared which the human eye cannot see we must apply a color to the infrared portion of the spectrum in order to see it. Enter the following band combinations and observe the results.

A. The band combination below mimics infrared aerial photographs. Plant material, which reflects a great deal of infrared energy, will stand out as bright red with this band combination. This is useful to people studying forests.

Red 4 (the near Infrared band)
Green 3 (the visible red band)
Blue 2 (the visible green band)

B. This band combination is especially good for separating trees and grassland. The conifer or evergreen trees appear as intense dark green, deciduous trees appear as medium green, and grassland appears as light green or yellowish green.

Red 5 (the mid Infrared band)
Green 4 (the near Infrared band)
Blue 2 (the visible green band)

Use the computer image of **Beverly.lan** for the following activity.

Locate the features in the chart below using each of the Red, Green, Blue (RGB) channel settings listed. Record the color of each feature under each channel (band) combination. RGB 321 means assign Channel 3 to the red color gun, Channel 2 to the green color gun and Channel 1 to the blue color gun.

To change the gun color assignments pull down the processor menu and select **Display Image** or press **Control + D**

Trouble shooting hints:

If by mistake, you pull down the File menu and select open image, you will have to correct ALL settings, instead of just the color assignments. To do this, go back to the GETTING STARTED directions to be sure you do this correctly.

If you end up with a very tiny image it means you selected a small piece of the image by mistake and asked to have it displayed. Under the **Processor** menu select **Display Image**. Click on the small box in the upper left hand corner to the left of the words: **Line** and **Column**. This will return the image to the full 512 by 512 pixel display.

Complete the chart, recording the color of each feature under each channel (band) combination.

	RGB 3 2 1	RGB 4 3 2	RGB 5 4 2
- Beaches			
- Highways			
- Regions with trees			
- Ocean			
- Cities or towns			

Try other channel (or band) combinations and write your observations.

Reference Page
MultiSpec Bands and Their Uses

Band	Principal applications
1 Blue visible	Useful for mapping water near coasts, differentiating between soil and plants, and identifying human made objects such as roads and buildings (cultural features).
2 Green visible light	Useful for differentiating between types of plants, determining the health of plants, and identifying cultural features.
3 Red visible	Useful in differentiating between plant species Differentiation and identifying cultural features.
4. Near Infrared energy	Most useful for determining plant types and plant health, for seeing the boundaries of bodies of water, and discrimination of soil moisture
5. Mid-infrared energy	Useful for distinguishing snow from clouds and Determining vegetation and soil moisture content.
6. Thermal-infrared energy	(Separate downloadable image) Useful in determining relative temperature and determining the amount of soil moisture.
7. Mid-infrared energy (longer wavelength than band 5)	(Not featured in this image) Useful for differentiating between mineral and rock types and telling how much moisture plants are retaining.

Reference: Lillesand, Thomas M. & Kiefer, Ralph W. (1987), Remote Sensing and Image Interpreration. 2nd Edition. New York: John Wiley and Sons. P. 567.

Color My World

Preparation Reading:

Previously you changed the colors on the computer image. When you change the colors, objects may be distinguishable as different colors or become indistinguishable when they blend with the color of other objects around them. The six channels on the images portrayed by the computer imaging program MultiSpec contain data from one of five different bands (six bands with Landsat 7) of the electromagnetic spectrum. For each of the bands, Landsat senses reflected light or energy and assigns a reflectance number to represent the brightness level.

Three of these bands are in the visible range: channel 1 is blue reflected light, channel 2 is green reflected light, and channel 3 is red reflected light. Reflected red, green, and blue light are all useful for distinguishing between human made objects, such as roads and buildings, and natural features, such as rivers, lakes, and mountains.

The other channels, channels 4, 5, and 6 (actually Landsat band 7) are in the infrared range, invisible to the human eye. Reflected infrared energy is useful if you wish to determine plant types, determine plant health, distinguish between snow and clouds, or identify mineral and rock types. When you selected different numbers for 3-channel color for Beverly.lan, you asked the computer to display three bands of the electromagnetic spectrum.

You can also display an image in 1-channel color. Your image will then display brightness levels of only one band of the electromagnetic spectrum, such as red visible light or near infrared energy.

In this lesson you should try to become comfortable with categories of objects based on their reflectance in the different bands of the electromagnetic spectrum. This will help you better understand the Landsat imagery.

Materials you will need:

Two PC computers with **MultiSpec** installed and the **Beverly.lan** image on each.

This activity can also be accomplished on one computer by opening multiple copies of the **Beverly.lan** image and sizing each image window appropriately to viewed side by side. See: "Tips for working on a single computer" Page 18.

Each group will need to team with another group and use both computers. If you are fortunate and have one computer available for each student or pair of students, you may want to do this activity in a larger group using the three computers

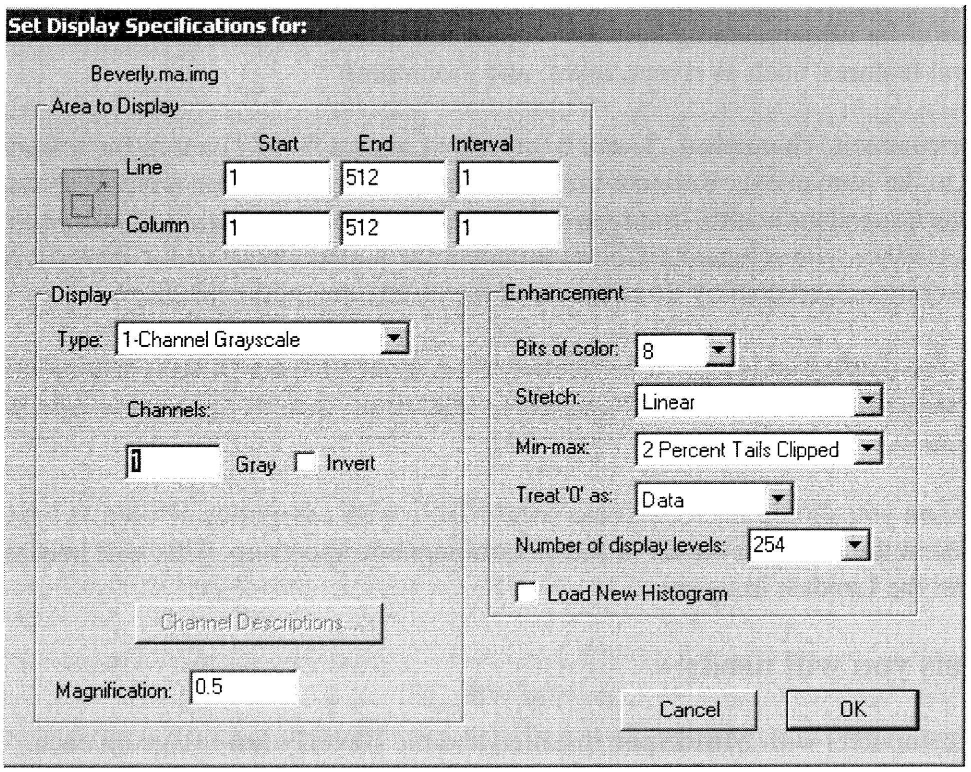
If you are working alone with only one computer you can open multiple copies of the **Beverly.lan** and set different display specifications for each image.

- For those using one computer. Pull down the **File** menu and select **Open Image**. Double click on **Beverly.lan** image to select that Landsat satellite image. You should now have two separate images of Beverly MA open.

We will explore the connection between electromagnetic energy and the channels, which can be selected in the **Display Image** option under **Processor** in the MultiSpec menu. You will probably want to keep handy the "Reference Page: MultiSpec Bands and Their Uses".

- If you are restarting your computer, follow the first few steps in Investigating a Satellite Image to get to the dialogue box entitled **Set Display Specifications for Beverly.lan.**

- Click on the box labeled **Display type** and select **1-Channel Grayscale**



- Now the directions change for the two computers or images.

-On one computer, type in **4** for the channel (next to the word 'Gray"). (Remember to highlight the number to be changed and then type the new number. Backspacing or deleting the old number first does not always work in this program.) Press **Enter** or click on **OK**.

The gray scale image you see represents the reflectance levels of one band of electromagnetic energy.

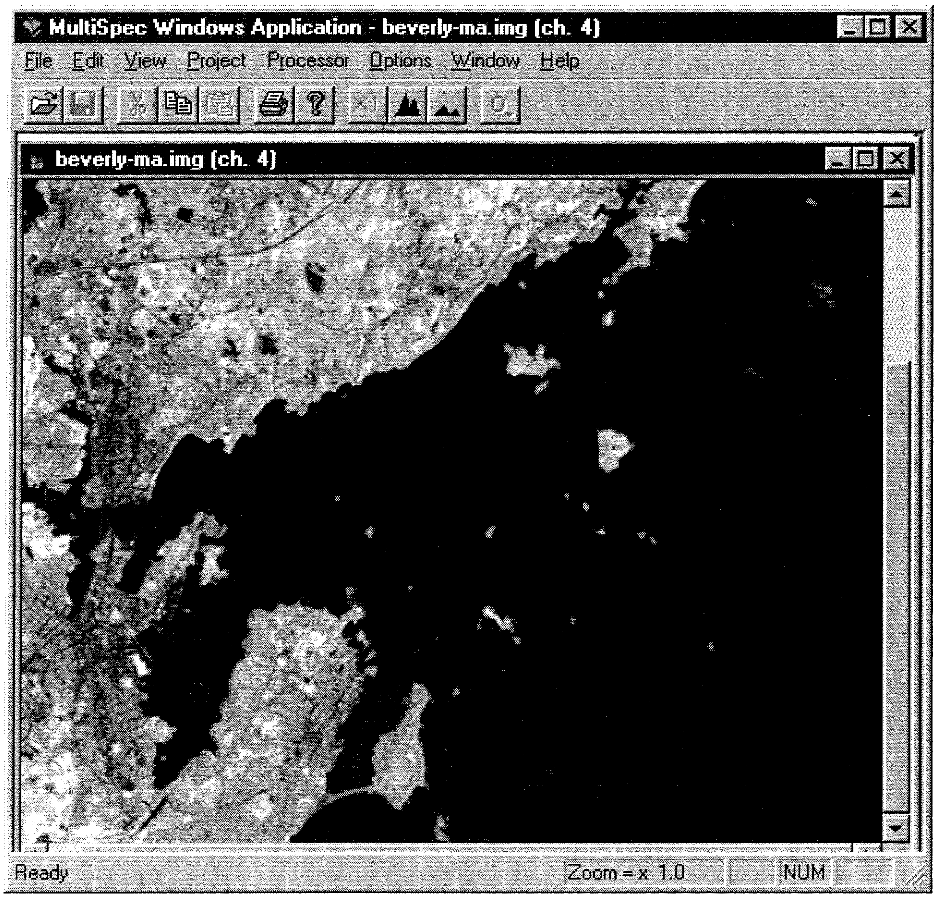
What band is that?
Is it a visible band?

- On the other computer, type in **3.** Press **Enter** or click on **OK**.

What band of electromagnetic energy is transmitted through channel 3?
Is it a visible band?

- If you have a third computer, select another visible band to view, or if working on one computer, open a third Beverly.lan image, and repeat the previous steps.

- After the image is displayed, enlarge the viewing window to approximately twice the size. Click on the **X1**. box in the toolbar to enlarge the image. Your monitor should look similar to the image that follows.



- Scroll to make sure the display on each computer shows the same region of the image.

- Keep the three images on the screens of the respective computers, making sure everyone can see all three screens or all three images. The images will be in shades of gray.

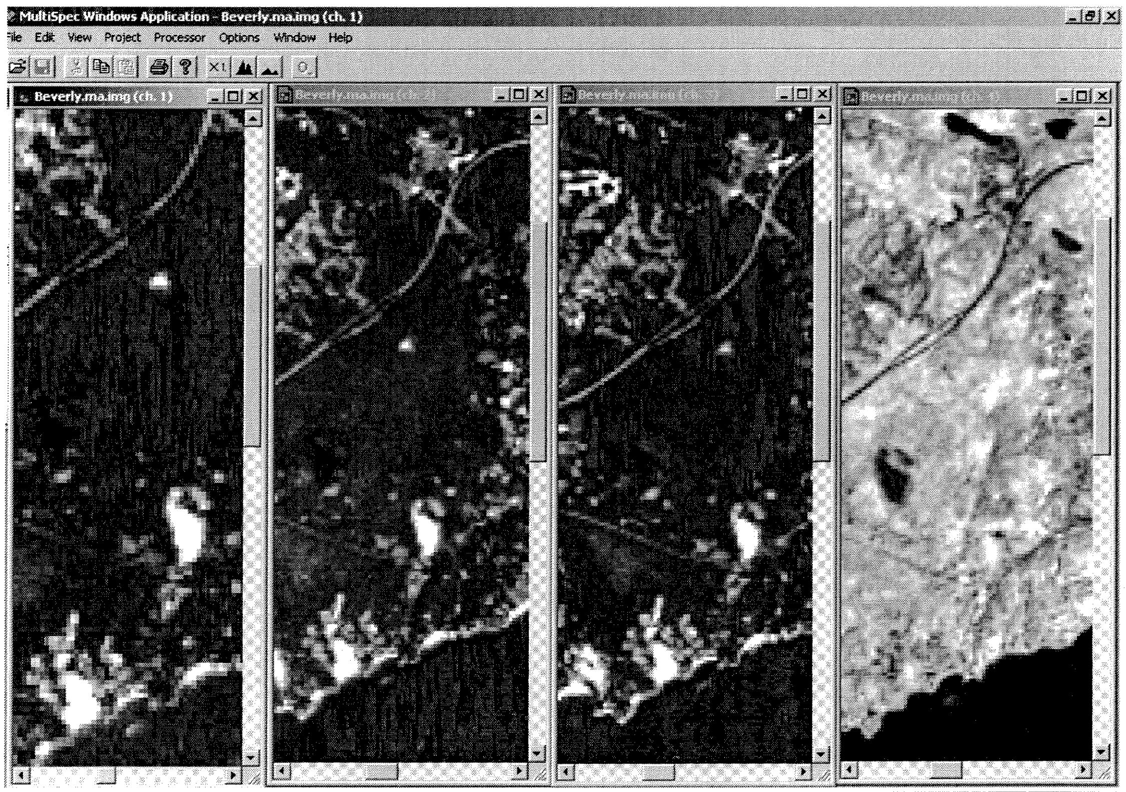
- You will need to change the channels on the computers you are using to answer the questions below. To do that, select the **Display Image** option under **Processor** in the MultiSpec menu and just change the channel number.

Tips for working on a single computer:

The image below shows four copies of the Beverly MA, image open on a single computer.

Each image is set to 1-Channel Grayscale and from left to right Channels 1,2,3 and 4 are displayed.

Once four images are open you can carefully re-size the windows and into four equal Panels utilizing the entire monitor display area. After re-sizing the images, set all four to a similar zoom factor. In the image below this was done by selecting each open image and clicking the large mountains 3-times for each image. Once the zoom factors are all equal, it will take a little careful panning in order to set the same view area for each image similar to the picture shown below.



Channel #1 **Channel #2** **Channel #3** **Channel #4**

Please read:

If an object has a high reflectance level for a particular band, it appears very bright (nearly white). If it has a very low reflectance, it absorbs most of that band and appears very dark (nearly black). For example if an object reflects more blue light than red light, it will appear lighter in the image for which the selected channel is 1 for blue light than in the image for which the selected channel is 3 for red light.

Answer the following as completely as you can:

1. You should be able to distinguish trees, the railroad bridge between Beverly and Salem, and shallow bays more easily in one image display, but not in the other. Roads are bright in one image and dark in the other. Explain these observations with reference to the red and near-infrared bands of the electromagnetic spectrum.

   Trees absorb red light and appear dark in the red band and can be distinguished from beaches and grasslands. In the near-infrared band the trees appear very bright because they reflect near-infrared energy. They are not easily distinguishable from the grassland.

   The shallow water east of the Beverly-Salem bridge reflects a small level of visible red light and appears lighter than the deeper ocean. A11 water areas absorb near-infrared energy and mid-infrared energy.

   The railroad bridge reflects red light and is visible in the red band. It absorbs near-infrared energy and is not easily distinguishable in the infrared band.

   Highways reflect red visible light and absorb near infrared energy.

2. List other objects that have either high reflectance of visible red light and low reflectance of near infrared energy or high infrared and low visible red.

   Buildings, often called cultural features because they are human made, reflect visible red light but absorb near infrared energy.

Note: To answer the following questions you will have to change the bands on the computers and make comparisons.

3. Cultural features are human-made features such as roads, buildings, and bridges. What do you notice about their reflectance of visible light and infrared energy? On the computer that displays visible red light, change the channel to visible green (band 2) and then visible blue (band 1) to answer this question.

   Cultural features have high reflectance of all visible light and low reflectance of near-infrared energy.

4. What do you observe about the relative reflectance of a) red, b) blue, and c) green light; and d) near-infrared energy by the ocean? For an extra project, you may want to do some library research to determine why bodies of water appear blue when you actually look at them.

   Bodies of water absorb almost all energy, but blue visible light will reflect more than other bands.

5. What do you observe about the relative reflectance of a) red, b) blue, and c) green light, and d) near-infrared energy by trees?

Trees reflect low levels of red and blue visible light and slightly higher levels of visible green light. They reflect high levels of near and mid infrared energy.

6. What do you observe about the relative reflectance of a) red, b) blue, and c) green light; and d) near-infrared energy by "cultural features"?

Cultural features reflect all visible light and low levels of near-infrared energy.

7. There is a cloud over Beverly and several other small clouds in the image. Try various bands to make observations about the reflectance of clouds?

Clouds reflect all visible light and all infrared energy. This is why cloud free images are important to distinguish surface features of the earth. Clouds "hide" the earth. Radar does penetrate clouds. Landsat 6, which was not successfully launched, had a radar sensor.

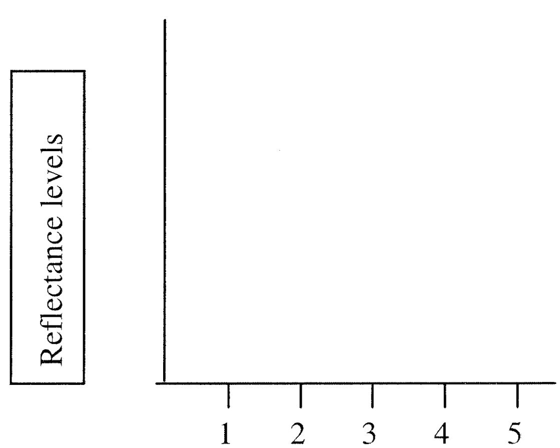
8. Shadows of clouds and lakes appear dark in the image. Try various bands to develop ways to distinguish cloud shadows from lakes.

Lakes reflect low levels of visible light and essentially no infrared energy. Shadows are "transparent" and reflect whatever is beneath them. This means that if they are over trees, the region in the shadow will reflect high levels of infrared energy

9. Write a question about color and images and either answer it yourself or have a neighboring group try to answer it. Write the question and answer here.

Answers will vary.

10. The designer of the chart below did not finish her work. a. Insert the scale on the "reflectance levels" axis. b. Insert the words that go with the numbers on the "channel" axis. (See page 36 for answer)



11. Suppose you had selected a pixel that contained only trees. On the chart in #10, try to predict a channel reflectance value for each band. Use your answer to question 5 for help in answering this question (See page 36 for answer).

Graphing

Preparation Reading:

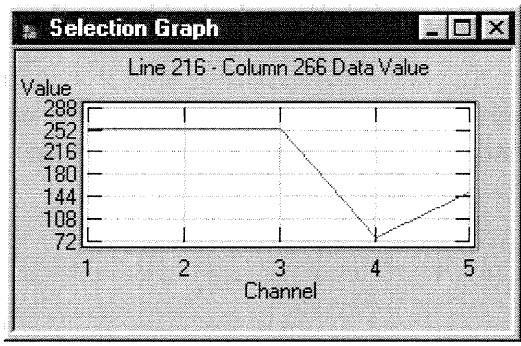
The histograms you will be studying are of the reflectance values at each of the 5 wavelengths the satellite measures. On the horizontal scale the numbers 1 through 5 refer respectively to the blue, green, red, near-infrared, and mid-infrared wavelengths. The vertical scale ranges from 0 (no reflectance) to 255 (maximum reflectance). Sometimes the vertical scale will go beyond 255, but the values plotted never exceed 255. Note that the graph really only has meaning when read at the horizontal positions of 1, 2, 3, 4, or 5. The line segments that connect the points don't represent reflectance values of other wavelengths. They simply make the graph easier to read.

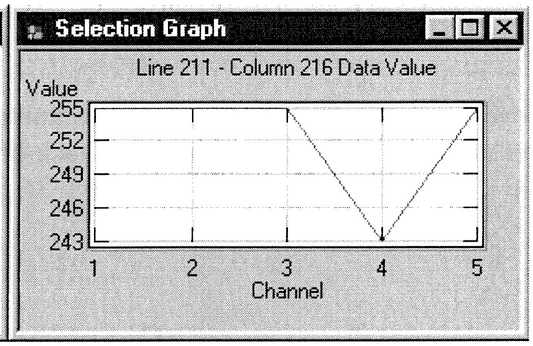
The **red line is the average** of the reflectance of all the pixels in the selected area. The **green lines mark off all reflectance within 1 standard deviation of the average**, and the **blue lines mark the minimum and maximum values**. A formal definition of standard deviation is not developed. You are simply instructed that the green lines contain about 66% of the reflectance in the selected area.

Comparing Graphs between two separate images:

Mathematically the primary emphasis should be on the interpretation of graphs. You will be viewing graphs that are automatically scaled to fill the window. While convenient, this feature can be confusing as the vertical scale can change dramatically from one region to the next. So although two graphs may look the same their vertical scales could be vastly different. This phenomenon highlights the difference between two graphs having the same relative shape but different absolute shapes.

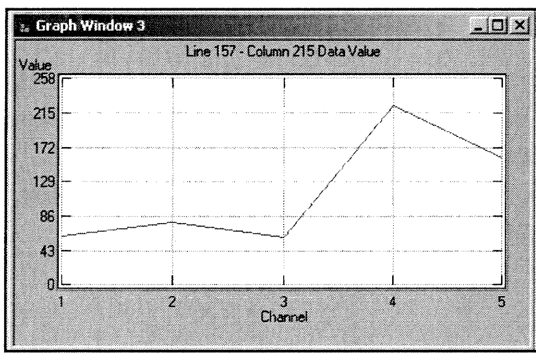
For example, consider the two graphs below; while the relative shapes are about the same, the absolute shapes are very different. The histogram on the left has a dip on band 4 as does the histogram on the right; however, the dip on the histogram on the right is very small compared to the one on the left! Note that the dip on the right actually looks larger than the dip on the left. It is when we look carefully at the vertical scales, however, that we discover that the dip on the left is a change of almost 200 intensity values while the dip on the right is of only 12 intensity values! The dips are in the same relative position on both graphs but of very different absolute sizes.

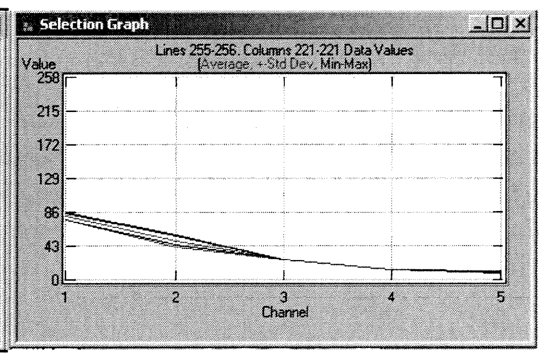




Comparing or displaying multiple graphs from the same image:

Varying scales will only cause interpretation problems when trying to compare graphs from two separate images. When opening multiple graphs from the same image, scales will automatically be re-scaled equally. The two graphs below display large differences in reflectance, yet the scales are both set equally and this makes for easier visual comparison between the two.





How can we classify and discriminate between regions on an image using histograms?

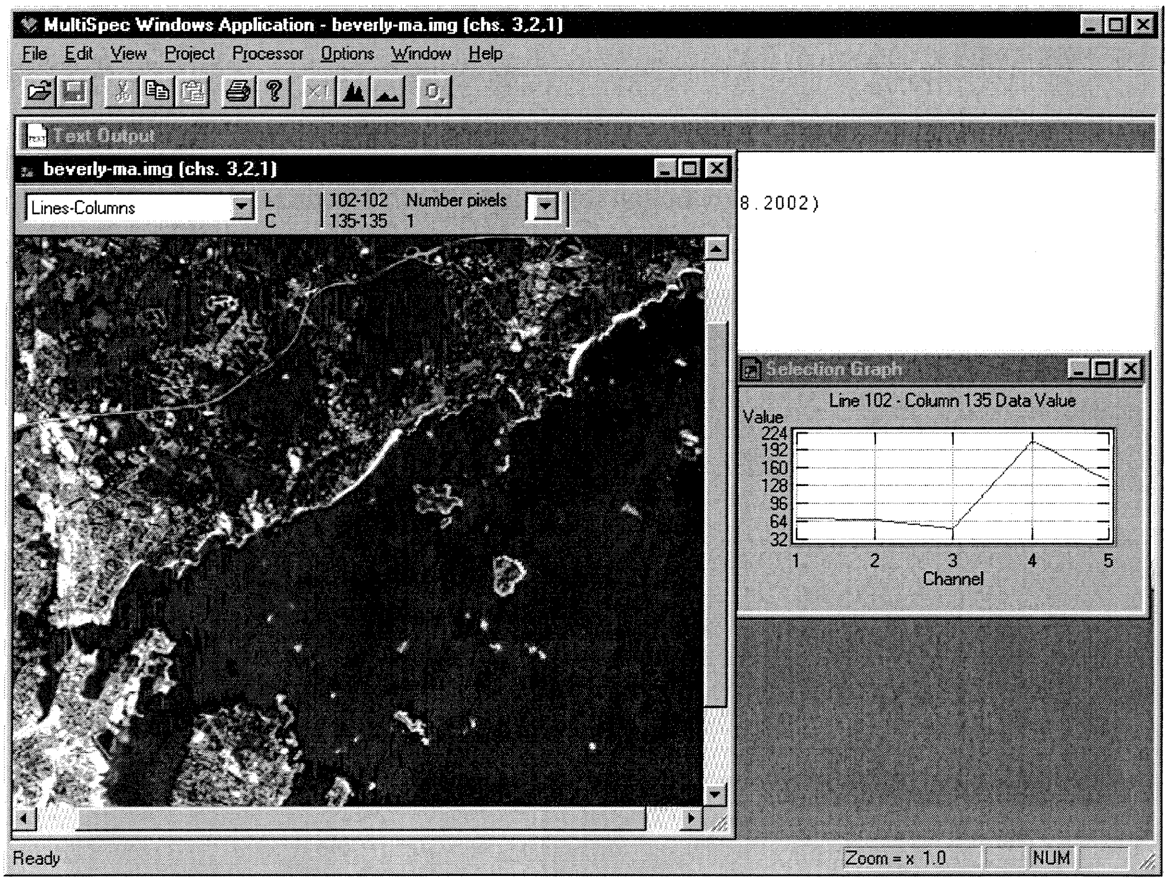
By now you should understand that the images we have been studying are based on numbers that represent the intensity of reflected light at five different wavelengths. Stretching the image and assigning various colors to different wavelengths helped us discriminate between similar looking regions that were in fact different. But some regions still may appear similar on the computer screen even though they represent different objects on earth. In this lesson we learn how to use another tool of the MultiSpec program to help us classify regions, and discriminate between different regions.

Which of These Things Doesn't Belong?

At the computer, start the MultiSpec program and open the image of Beverly, MA, if it is not already done. Assign the colors red, green, and blue to bands 3,2,1 to generate a true color image.

Now from the **View** menu choose the **Coordinates View**. Now from the **Window** menu select **New Selection Graph**. Click anywhere on the image window to highlight it, and click again on any one pixel of the image.

By re-sizing the windows (lower right corner of a window) and moving the windows around the desktop (drag the window by its title bar) arrange the windows so that they appear similar to the figure that follows.



Coordinates Bar:

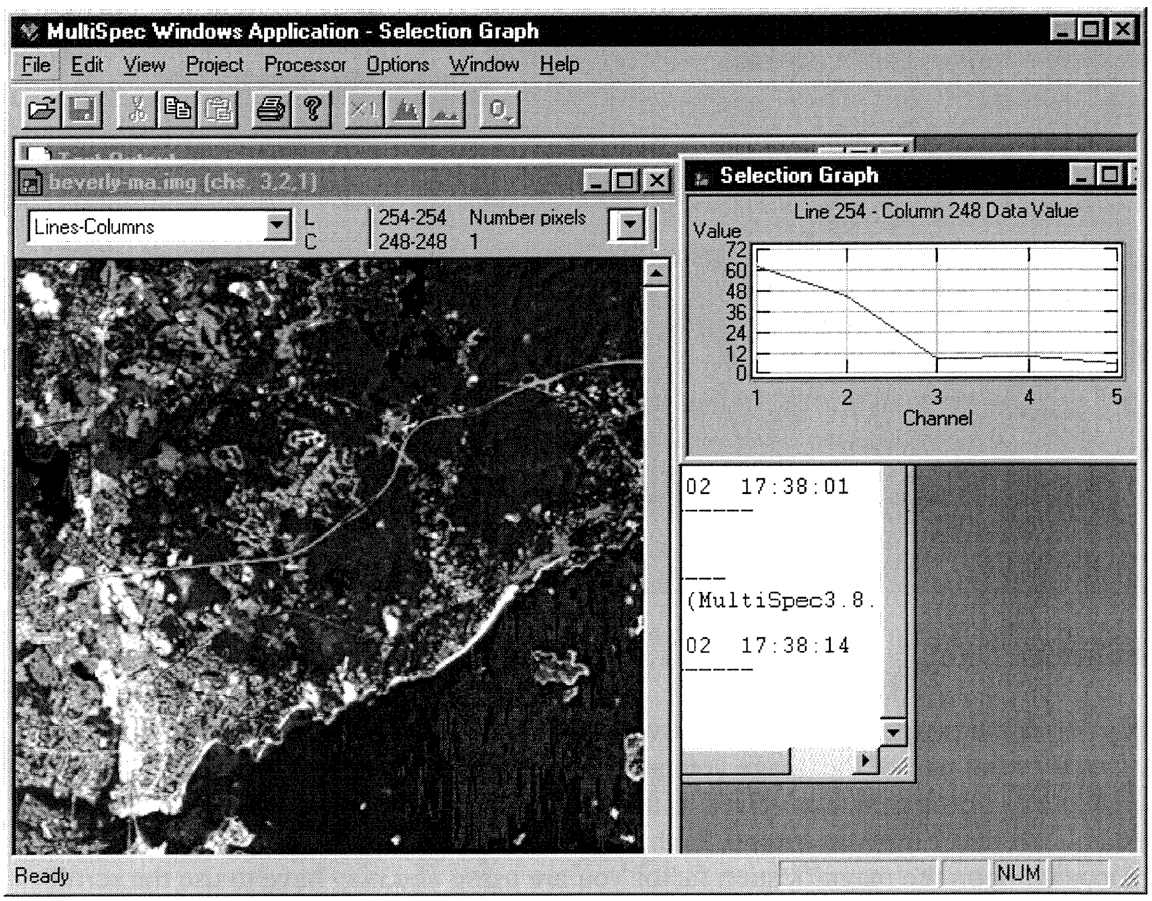
Directly above the image in the figure above is the Coordinates bar. This bar allows you to know exactly what part of the image you are selecting when you click on the image window. The coordinates of the cursor are given as an ordered pair with the line number given first and the column number given second. In this figure the pixel selected is the one at (102, 135). Depending on the magnification factor you are using you may have to use the scroll bars on the image window to find a particular pixel.

Selection Graph:

To the right of the Image window is the Selection Graph window. This is the window you should learn to use during this computer session. It is a graph of the reflectance values of the pixel (or pixels) you have selected. In the above figure the graph is for the pixel located at (102,135).

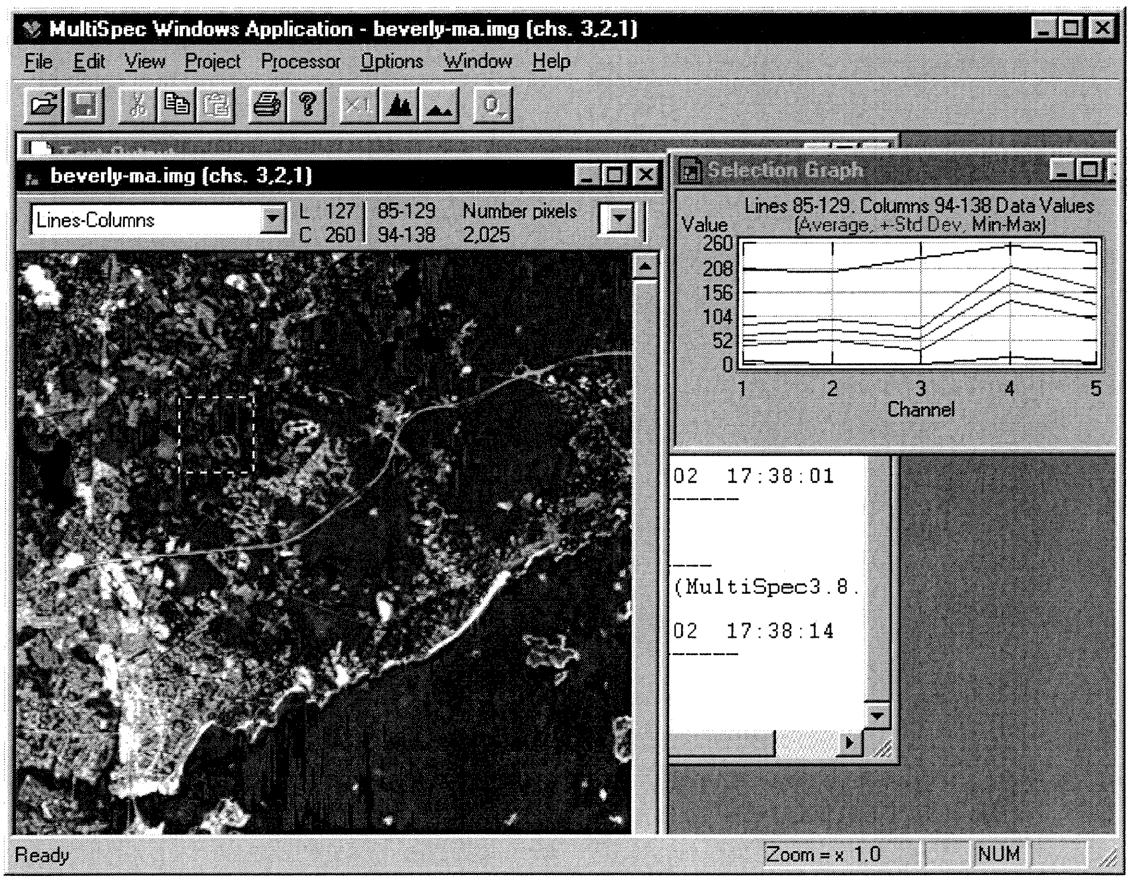
This graph provides much information. The bottom axis has labels 1, 2, 3, 4, and 5 that correspond to the blue, green, red, near-infrared, and mid-infrared wavelengths that Landsat monitors. The vertical scale corresponds to the numerical value of the reflectance. This scale can range from 0 to 255. A 0 would represent no reflected light and a 255 would represent maximum reflected light. Remember that these values may be the result of stretching the data. The pixel we have selected is brightest in bands 4, and darkest in band 3. This means that the object at this location on the earth is reflecting more near-infrared light than light of the other wavelengths.

Now click anywhere on the image window to activate it. Then click on the pixel with coordinates (L,C) = (254,248) that is down on the ocean. At this point we find reflectance's of about 60, 44, 10, 11, and 6. See figure below for an idea of what your screen should resemble.



Note that the reflectances are lower at every one of the five bands than for the previous pixel at (102,135). This difference makes sense since we expect the ocean to be darker than ground. If you have ever flown over ocean and trees you will have noticed how the ocean appears almost black while the trees do appear brighter. The fact that water absorbs almost all of the energy that falls on it can help us determine if an unknown dark region is water or not.

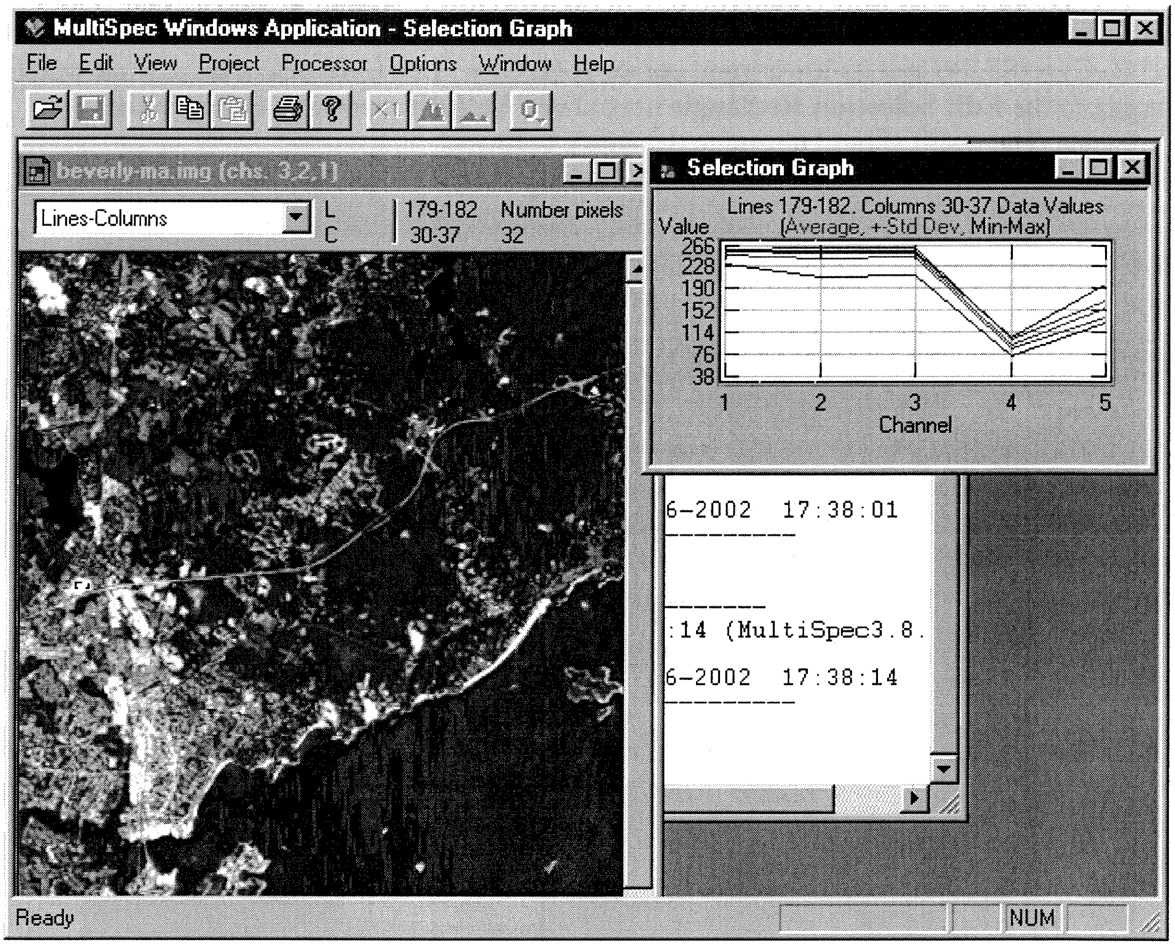
Now select a rectangle of many pixels. We selected a rectangle with its upper left corner at pixel (L,C) = (85,94) and its lower right corner at (L,C) = (129,138). Select these same pixels by going to the **Edit Selection Rectangle** item under the **Edit** menu and typing in the coordinates. The result should resemble the figure below.



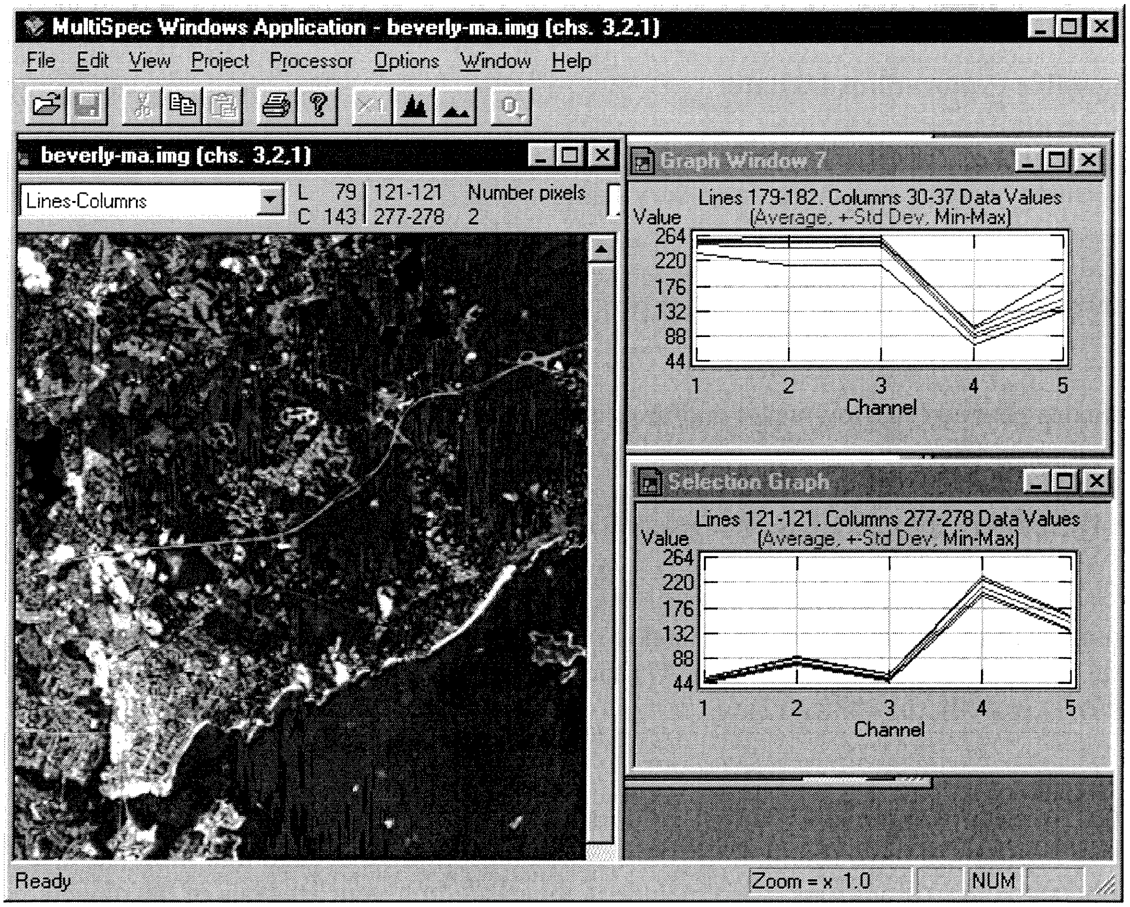
Note that now the selection graph contains 5 lines. The **red line** is the average of the reflectance of all the pixels in the rectangle we selected. The **green lines** mark off a range that contains the middle 66% of the reflectance values. The **blue lines** indicate where the minimum and maximum values are for the reflectance of all the pixels we selected. For example look at the reflectance on band 4. Of all the pixels selected in the rectangle the lowest reflectance is about 10, the highest reflectance value is around 255, 66% of the reflectance is between 130 and 208, and the average reflectance is about 160.

Using the Histogram Window to Discriminate Between Different Regions

We can use the histogram window to help us identify similar and different regions. What we will do is find an area of interest and save its histogram to compare with a second histogram of another area of interest. Go to a magnification of **x2.0.** Again go to the **Edit Selection Rectangle** item under the **Edit** menu and enter a rectangle with upper left corner (L,C) = (179,30) and lower right corner (L,C) = (182,37). Your screen should resemble the figure below.



Now choose **New Selection Graph** from the **Windows Menu**. A new selection graph appears and the old selection graph will remain fixed even if you select a new set of pixels. Position the second selection graph below the first graph so that your display resembles the figure below.



After your screen looks similar to the one in the figure above, click in the image window to activate it, and then click on an image pixel. Note that the top graph stays the same and only the bottom graph changes. Displaying both graphs allows us to compare the histogram of a new region with the saved histogram of the white region visible in the image. This white region is near a road and in the city limits of Beverly. It is very likely that this bright area is caused by light reflecting off large buildings with metal or concrete roofs.

What's That?!

Using the reflectance histogram tool, explore the Beverly, MA image and see if you can find other examples of regions on the screen image that appear the same to your eyes but have very different histograms. You can display up to 12 histograms on the screen at one time for comparison of features.

Some possible explorations include:

Distinguishing beaches and shore, from very shallow water.

Differences between pavement on roads or parking lots and buildings.

Comparisons between shallow water and deep water.

Exploring similarly colored areas of vegetation that may have different histograms.

Examining in detail the transition from land to ocean. For example look at the histogram for one pixel at a time beginning with (138,397) and moving east through pixels (138,398), (138,399), (138,400), ..., (138,412).

If you find something interesting write a paragraph that provides a guide to exploring the interesting feature you have found. The guide should be complete enough that someone else can reproduce your explorations. Also include in the paragraph your analysis of the objects you are examining. Support any conclusions you make with arguments based on the histograms of the relevant objects. You can also copy histograms to the clipboard and paste them into another application, such as a word processor, to form a library of representative histograms of specific features. You can then investigate an unknown image and identify features by finding similar histograms to those in the library.

Finding the area of irregularly shaped regions

Forested regions and lakes generally have irregular boundaries. In this portion of the tutorial, you will be asked to find the area of an irregularly shaped object.

Inscribed/Circumscribed Rectangle Method

In this method you overestimate the area of a region with one rectangle and underestimate the area of a region with a smaller rectangle. Averaging the areas gives a quick estimate of the area of the irregularly shaped region. For our example, we will find the area of an off-shore island near Beverly, MA. In Figure 1, a rectangle defines a region with area larger than that of the island.

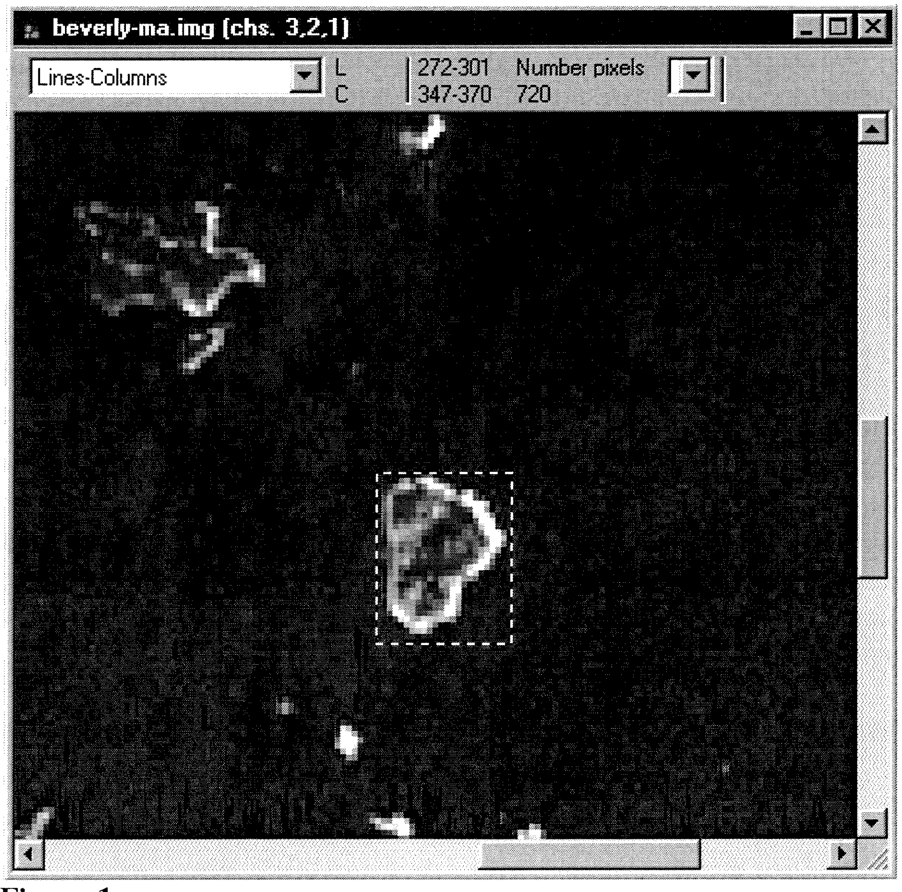


Figure 1.

To determine the coordinates of the selected region, under the **View** menu, select **Coordinates View**. Note the Coordinates in the figure.

Consider the screen to be a large coordinate graph with (0,0) in the upper left corner, (512,0) in the upper right hand corner, (0,512) in the lower left, and (512,512) in the lower right as shown in Figure 2. **Lines are horizontal** and can be thought of as rows in a matrix. **Columns are vertical** and can be thought of as columns in a matrix.

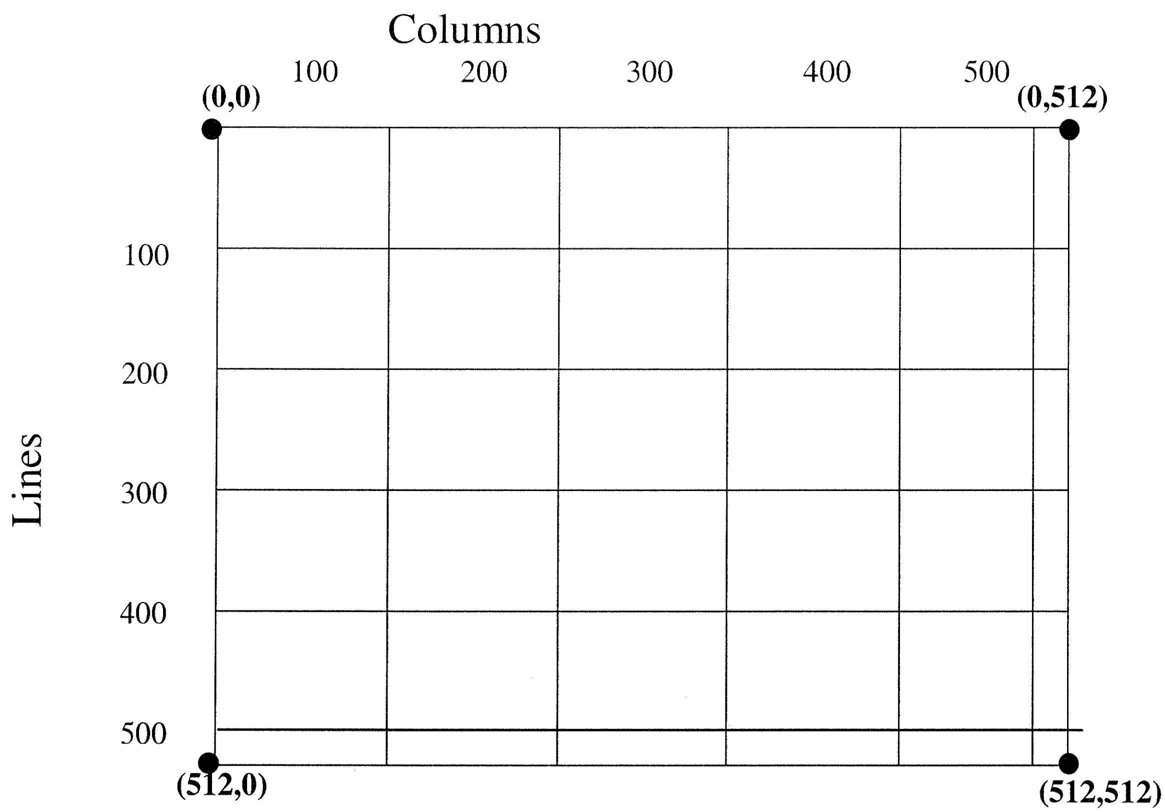


Figure 2.

The coordinates in Figure 1 are lines 272 to 301 and columns 347 to 370. Since 301 - 272 = 29, the highlighted rectangle is 29 pixels in length (vertical) or 30 meters * 29 = 870 meters. The difference of the columns is 370 - 347 = 23 pixels. Multiplying, 30 meters * 23 = 690 meters. The area of the highlighted rectangular region is 870 meters * 690 meters or 600,300 square meters.

Follow the same procedure to determine the area of the highlighted region in Figure 3 on the next page.

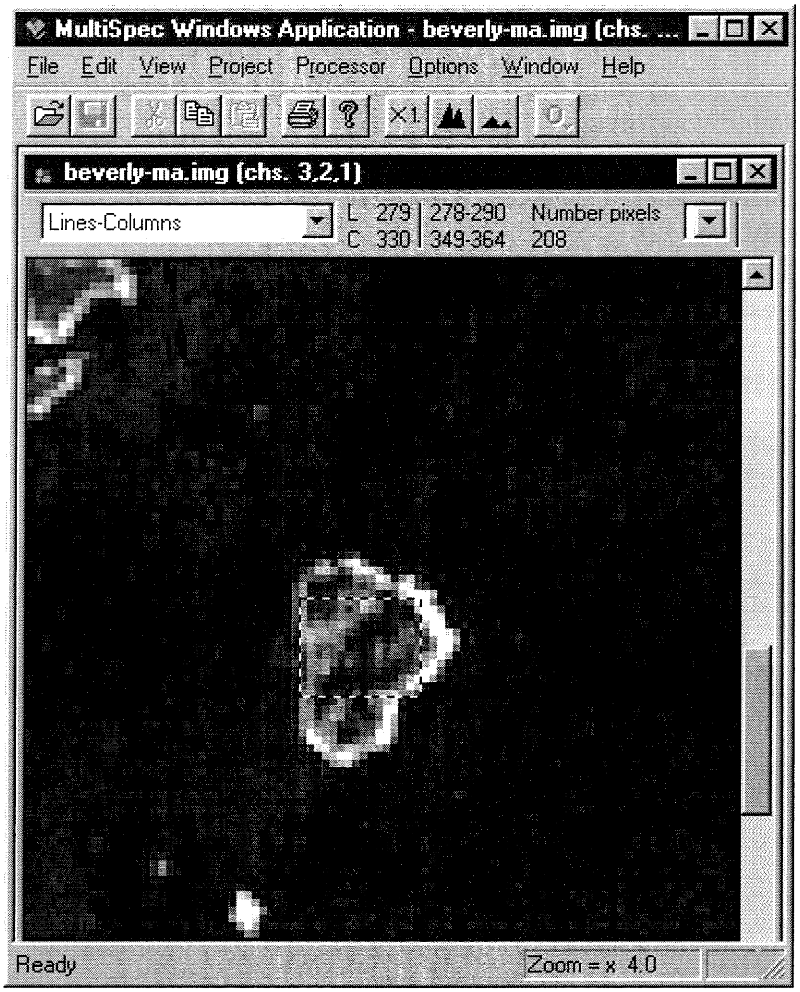


Figure 3.

(290-278) * 30 = 360 meters; (364 - 349) * 30 = 450 meters. The area is 360 meters * 450 meters = 162,000 square meters.

Use the information just computed to determine the area of the island.

(600,300 + 162,000)/2 = 381,150 square meters. Assuming one digit accuracy, the area is approximately 400,000 square meters.

This concludes the basic portion of the MultiSpec tutorial. You should now be able to use what you have learned here to investigate images of your own area. There are many other capabilities of this software program that are addressed in the advanced portion of this tutorial that will follow.

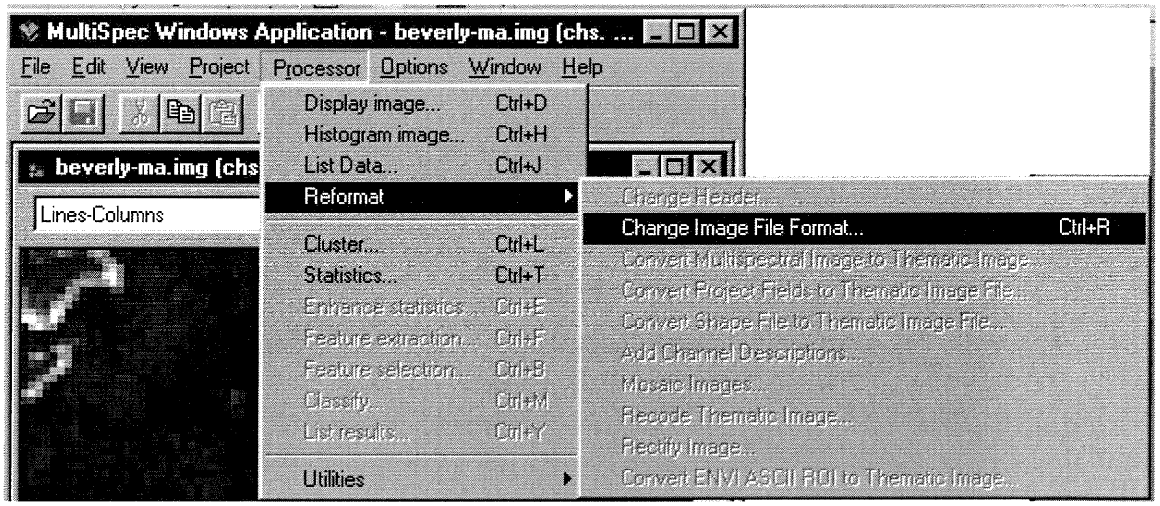
CREATING THE TM5/TM4 BAND

Below are directions for creating the TM5/TM4 artificial band that will allow you to look for stressed vegetation in your image.

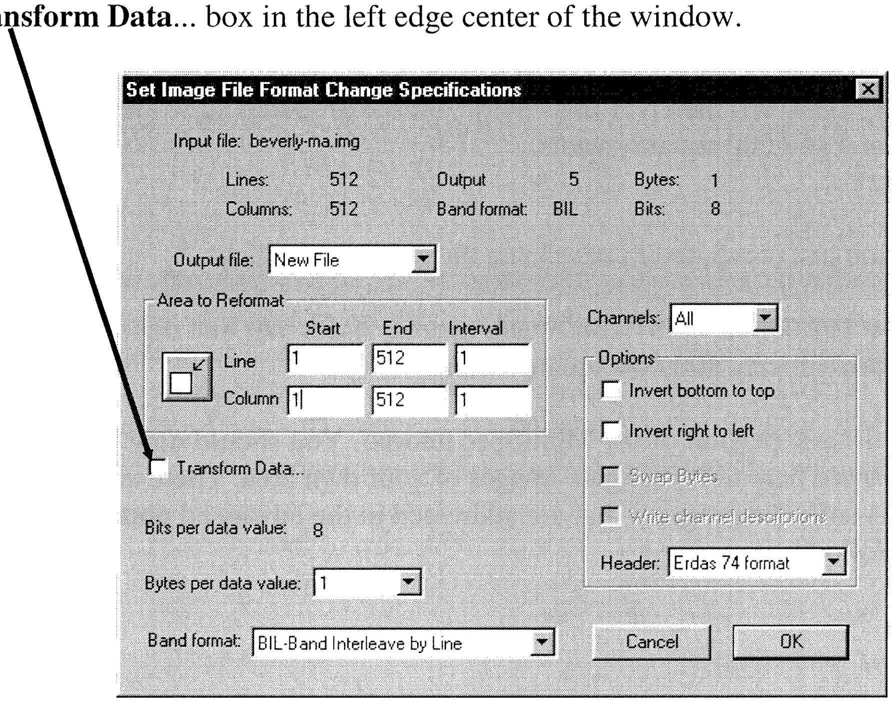
1. From the **File Menu** select **Open Image** and then select the image you want the new band created in (**Beverly.lan**).

2. From the **Processor Menu** select **Reformat**...

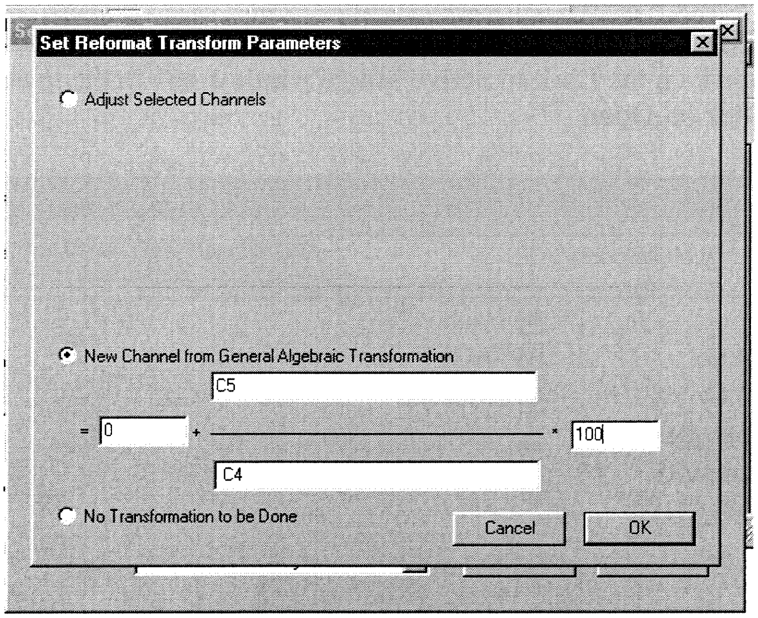
3. Select **Change Image File Format.**



4. The **Set Image File Format Change Specifications** window will appear. Click on the **Transform Data**... box in the left edge center of the window.



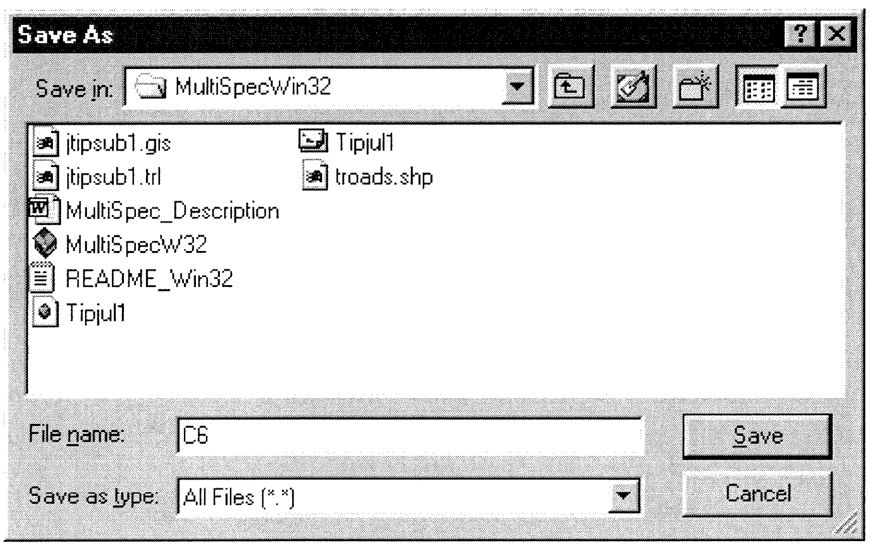
5. The **Set Reformat Transform Parameters** window will appear. Click on **New Channel from General Algebraic Transformation** circle.



6. Enter the formula for the transformation as shown and click on **OK**.

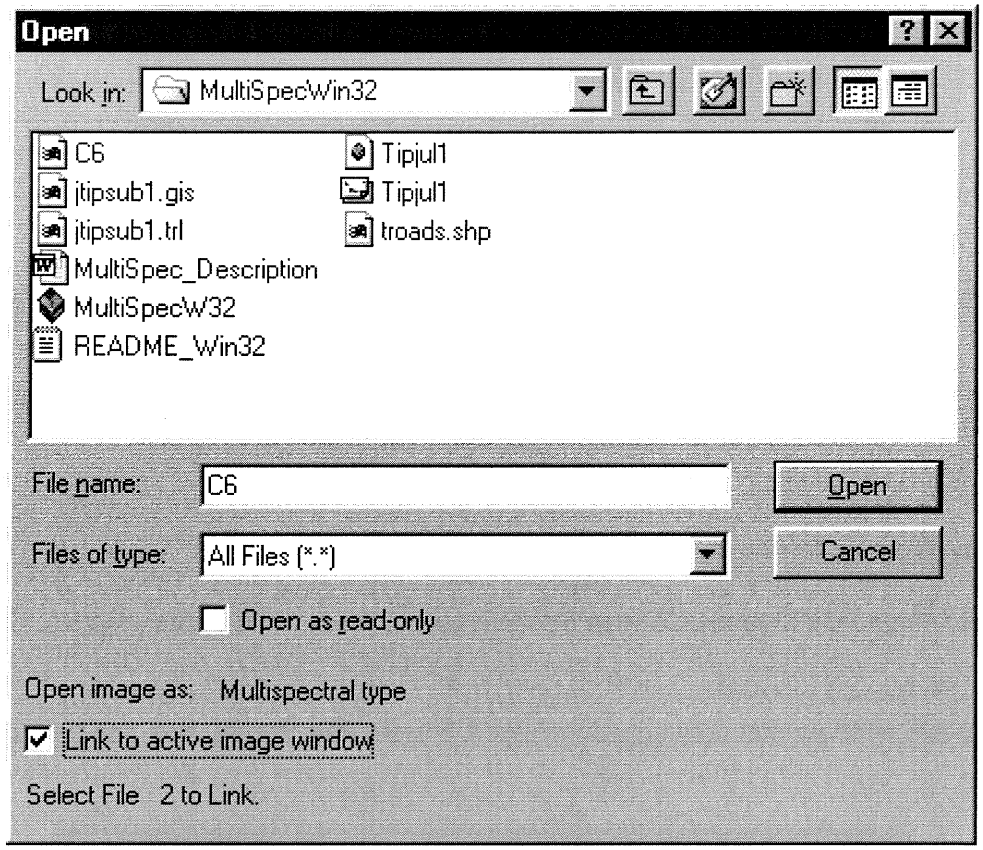
7. The **Set Image File Format Change Specifications** window will appear again. Click on **OK**.

8. In **Save As:** window that now appears, enter **C6** in the **File Name**: box and then click on **OK**.

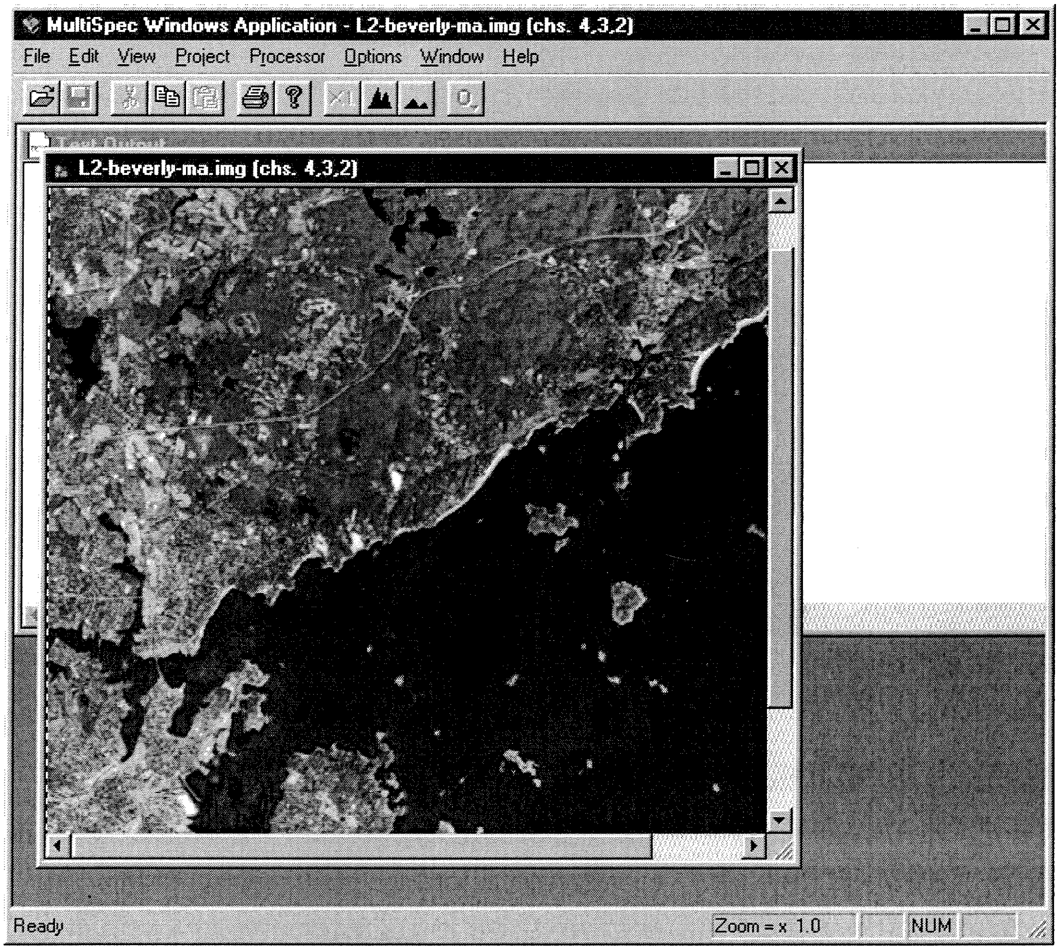


The new band will now be created and saved as **C6.** Only half the job is complete at this point. We must now append this band to the old image and create a new image file with all six bands.

9. With the original image still on the screen, open the **File Menu** and select **Open Image**. In the **Open** window click on the **Link to active image window** box in the lower left corner. Highlight **C6** and click on **Open**.



When the window reappears click on **Cancel.** The filename at the top of the image window will now read **L2image name.**



10. From the **Processor Menu** select **Reformat...**

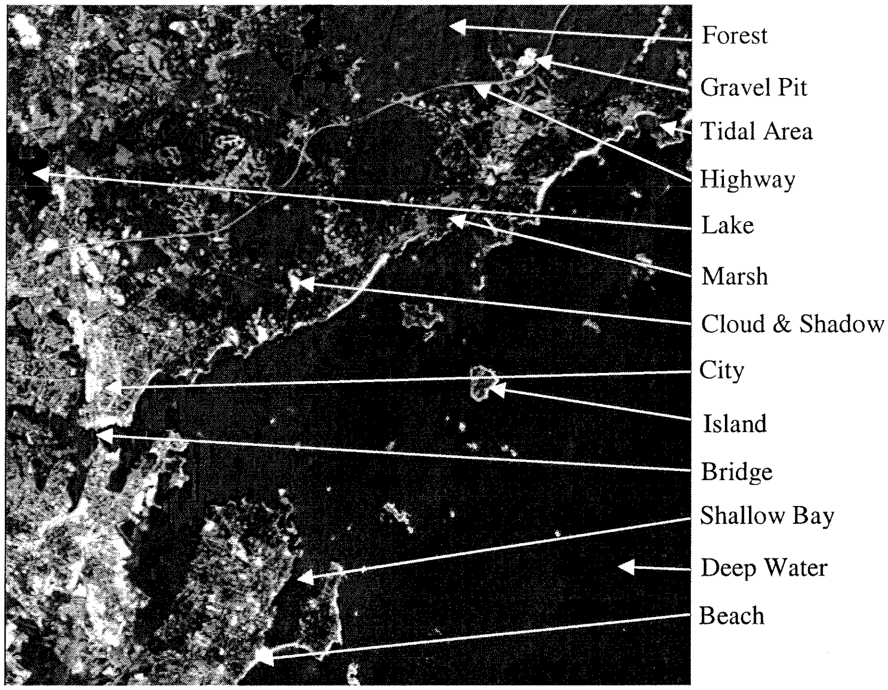
11. Click on **Change Image File Format**.

12. The **Set Image File Format Change Specifications** window will appear. Click on **OK**.

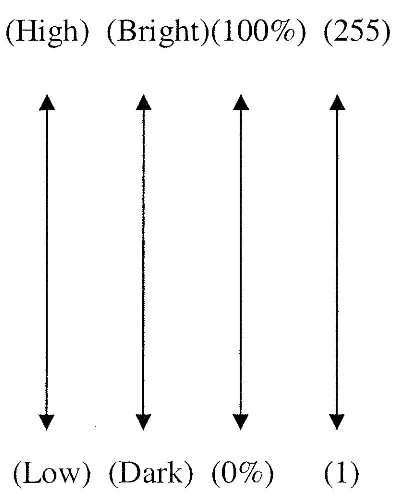
13. In the window that now appears, enter **any file name you want other than the current image** in the **Save As:** box and then click on **Save.**

The new file is now created with the TM5/TM4 band appended as band 6. (1- blue visible, 2- green visible, 3- red visible, 4- near infrared, 5- mid infrared, and 6- TM5/TM4 ratio band) To depict stressed vegetation as red, display band 6 with the red color gun, band 4 with the green, and band 3 with the blue.

Answers to Figure on page 9:



Answers to graph from page 20:



All of the above are possible scales for the y axis.

A typical forested pixel representation.