Change Detection Tutorial

Introduction

A major goal of the Land Cover portion of the *Biosphere Investigation* of The GLOBE Program is the documentation of the types of land cover present in a school's 15 km x 15 km GLOBE Study Site. Schools produce land cover maps that are classified using the *Modified UNESCO Classification (MUC) System*. These maps will be of great value to the world scientific community. However, change does occur in land cover, and GLOBE schools have been working with satellite images that are generally four to six years old. This tutorial will give you practice in using two images of the same area, acquired at different times, to investigate the nature of the changes that have occurred. The techniques can be applied later on to the development of change maps for your GLOBE Study Site.

Note: This tutorial requires the user to be comfortable with the software MultiSpec©, produced at Purdue University, and distributed freely on the Internet. MultiSpec© is used in The GLOBE Program to analyze Landsat images and to prepare digital land cover maps.

For this tutorial we will use two images of Durham, New Hampshire (USA).

Materials and Equipment:

- A computer capable of running the MultiSpec software.
- A copy of the MultiSpec software. If you do not have a current version, you may download the latest version, for Macintosh or PC platforms, from the Purdue site at: https://engineering.purdue.edu/~biehl/MultiSpec/

  or download it from the GLOBE website.
- Printed and electronic copies of the Dur990.lan and Dur796.lan images. These are "sub-images," small sections copied from images of Durham acquired in September of 1990 and July of 1996. The printed copies should include the visible band combination (3, 2, 1) and the false-color infrared combination (4, 3, 2).

Before Beginning

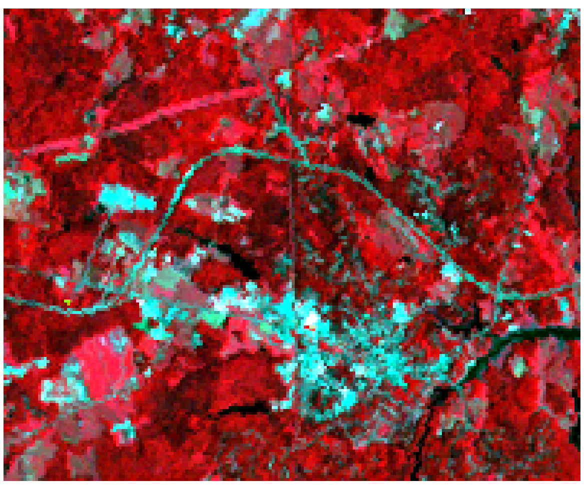
Examine the printed copies of the Durham images.

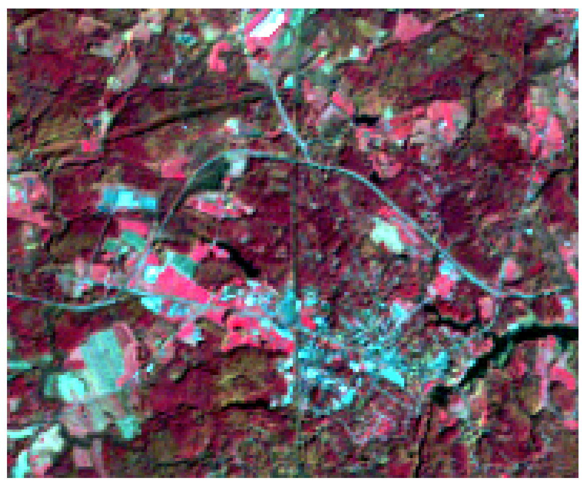
- What are some obvious differences between the two?
- Are there any places that seem to show a significant increase or decrease in vegetated or developed areas between the two images?

To help you answer these questions, open both images (**Dur_990.lan** and **Dur_796.lan**) in the same band combination and arrange them side-by-side at the same magnification[1]. You can then compare areas to see if you can spot changes between them. For your convenience, these images are shown below in the (4, 3, 2) false color infrared band combination.

Since both of these images are false-color infrared composites, the major difference is the degree of "redness" in the later, July 1996, image. This is a summer image with healthy, vigorously growing vegetation, while the earlier image was acquired in September of 1990. The September image shows a period of decreased chlorophyll content related to decreasing plant activity in the fall.

Other than the color difference, you will probably not see any major areas of change between the two images. This does not mean that change has not occurred, only that the changes are relatively small. Remember also, we are only looking at three of the five channels of data contained in these images, and that each of the different Landsat channels has its own uses in examining surface features. These uses are summarized on the next page.





[1] If you are not familiar with doing this, directions for viewing two images at once can be found in Helpful Hints at the end of this tutorial.

Landsat Band	Resolution	Useful for Mapping
Band 1 - coastal aerosol	30 meter	Coastal and aerosol studies
Band 2 - blue	30 meter	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 - green	30 meter	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - red	30 meter	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	30 meter	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	30 meter	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	30 meter	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	15 meter	Sharper image definition
Band 9 – Cirrus	30 meter	Improved detection of cirrus cloud contamination
Band 10 – Thermal Infrared Sensor (TIRS) 1	100 meter	Thermal mapping and estimated soil moisture
Band 11 – Thermal Infrared Sensor (TIRS) 2	100 meter	Improved thermal mapping and estimated soil moisture

Source: http://landsat.usgs.gov

To detect changes in the amount of cultural features between two images, we should examine a visible channel. Changes in the state of vegetation would be best detected by examining channel 5, the near-infrared band.

If we are to find all the areas that have undergone noticeable change, we will need to examine an image pixel-by-pixel. MultiSpec© software allows this to be done easily.

Analysis of Change Using MultiSpec

To examine the same pixel in two different images, we will use MultiSpec to combine the two images into one, producing a new image. This process is called "compositing." Since each original image has five Landsat channels, the new image will contain ten channels, five from each image. If you are using both a Landsat 7 and a Landsat8 image keep in mind that not all bands in Landsat 8 correspond directly with those in Landsat 7 (e.g., band 1 from Landsat 8 doesn't have a corresponding band in earlier Landsat images). Therefore designate the assignments for these channels (bands) according to the following table:

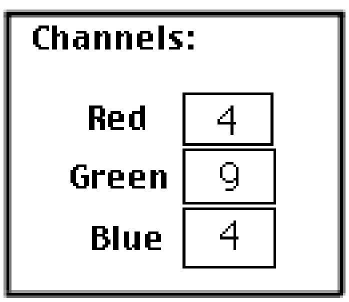
New Image Channels	Contents
1	Older Image, Blue Visible
2	Older Image, Green Visible
3	Older Image, Red Visible
4	Older Image, Near Infrared
5	Older Image, Middle Infrared
6	Newer Image, Blue Visible
7	Newer Image, Green Visible
8	Newer Image, Red Visible
9	Newer Image, Near Infrared
10	Newer Image, Middle Infrared

We will then view the same channel from *both images at once*. For example, to detect changes in cultural features, we could view channel 1 from both the older and newer images at the same time.

In doing this however, we need a protocol for assigning colors to the channels. Established practice makes the following assignments:

Computer Color Gun	**Channel from New Image**
Red	Channel “X” from Older Image
Green	Channel “X” from Newer Image
Blue	Channel “X” from Older Image

For example, strong reflectance in channel 4, the near infrared, is an indicator of vegetation. We assign channel 4 from the old image to red and blue, and channel 4 from the new image (channel 9) to the green, as shown in the figure below.



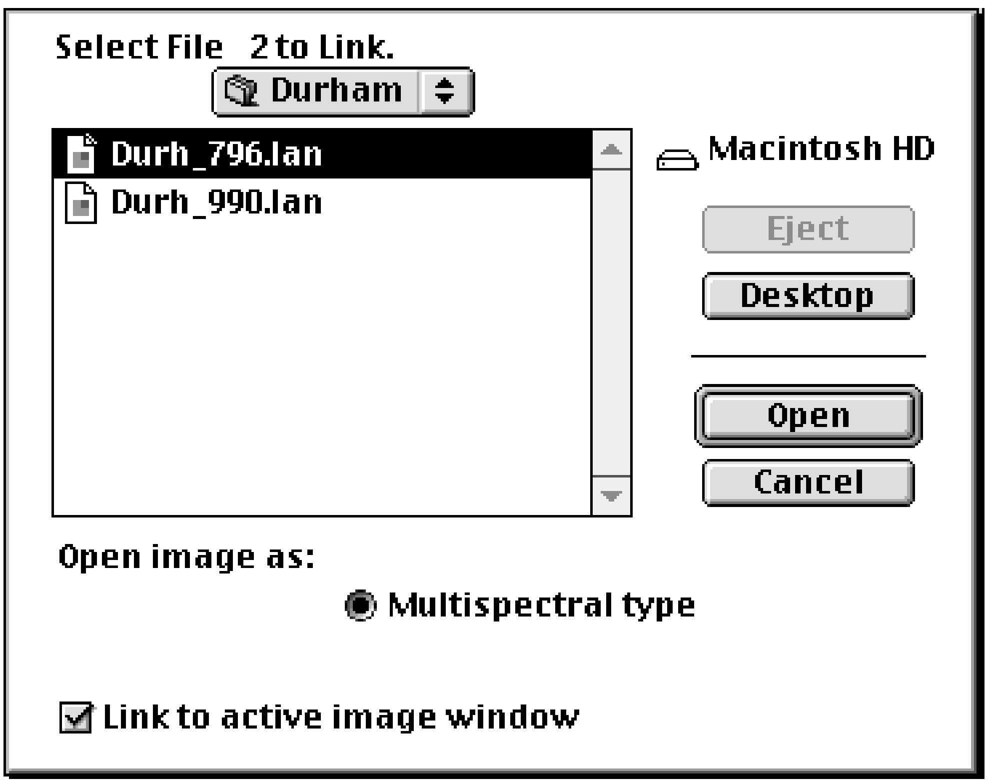
If a pixel in the **newer** image is brighter in channel 4 than in the **older one**, that pixel will show **green**. This means an **increase** in the property being measured. If a pixel in the **older** image has a higher reflectance, the red and blue will produce **magenta**, indicating a **decrease** in the measured quantity in the **newer** image.

The new change image will contain areas of **green** color which show an **increase** in reflectance in the channel we are viewing, and areas of **magenta** which show a **decrease** in reflectance for that channel.

Doing the Change Protocol

The following will lead you step-by-step through creating the new composite image, and analyzing it for changes in several different areas. Experienced MultiSpec users may be able to skip the section on “compositing” (putting together) the two images and move directly to the analysis of the new image.

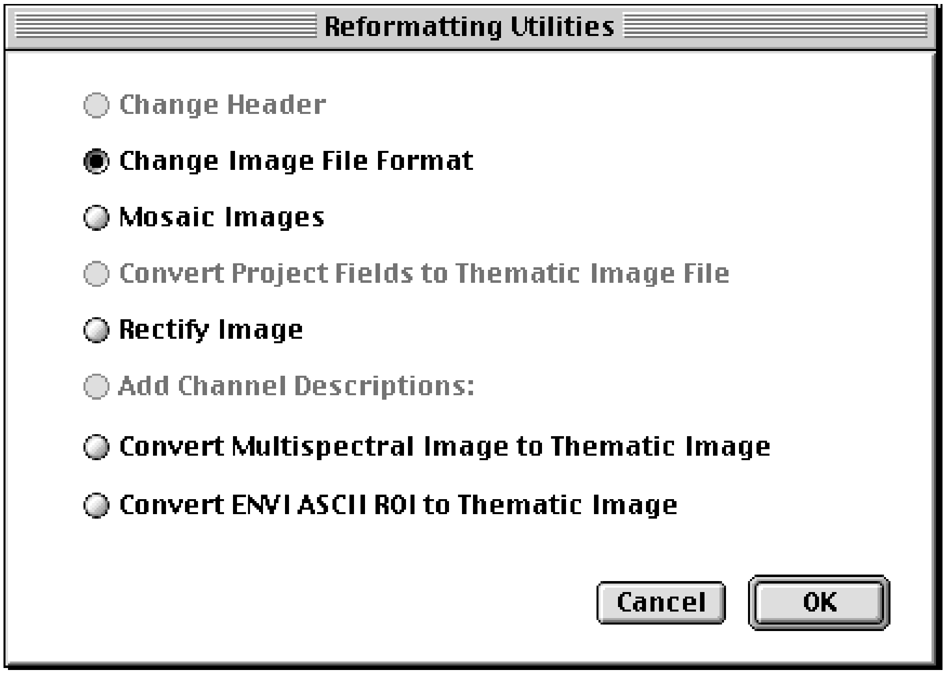
- Use your computer’s Control Panel to set the monitor display to either “thousands” or “millions” of colors.
- Launch MultiSpec.
- From the **File** menu select **Open Image**.
- Select the **Dur990.lan** image and click **Open**.
- For now, the band combination we use does not matter, so click **OK** in the **Set Thematic Display Specifications** window.
- With the **Dur990.lan** image open, from the **File** menu, select **Open Image**.
- Select the **Dur796.lan** image and check the **Link to Active File** box as shown in the illustration below.



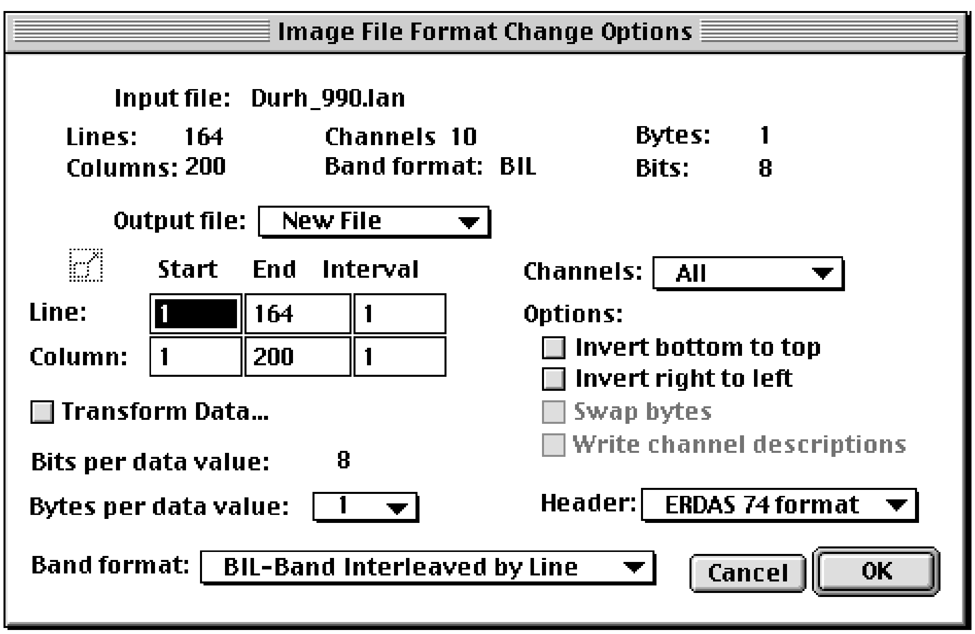
- Click **Open**.
- The same screen will appear again. The system is asking if you have any more files to link (join). Click **Cancel**.

The newer image has been added to the older image. Save this combination as a new file to keep the original images intact.

- From the **Processor** menu, select **Reformat**. The following screen appears.

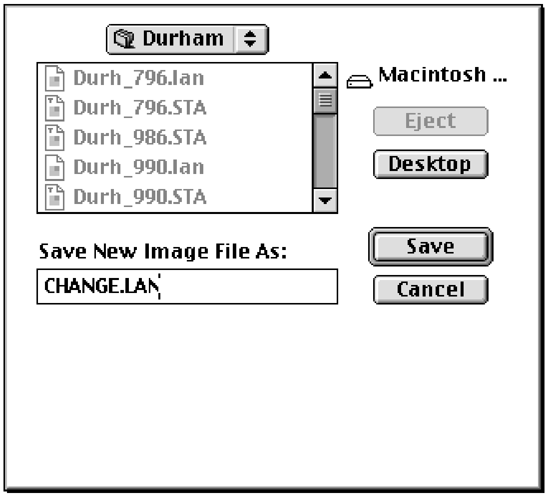


- Click **OK**.
- The following screen appears. Note at the top of the dialog box the number of channels is listed as “10.” Our image now contains five channels from each image.



- Click **OK**.

- The next screen is the standard file saving screen. Name your file **change.lan**, as shown in the diagram below, and click the **Save** button.



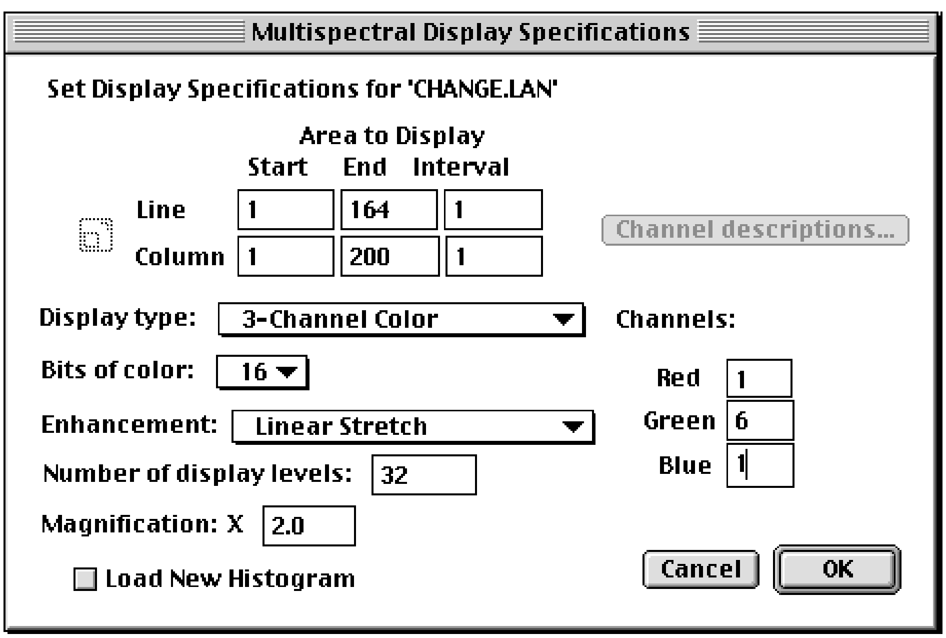
- Close the current image either by clicking the **Close** box or selecting **Close Window** from the **File** menu.

Opening the New Composite Image

- From the **File** menu, select **Open Image**.
- Select your **Change.lan** image, and click **Open**.

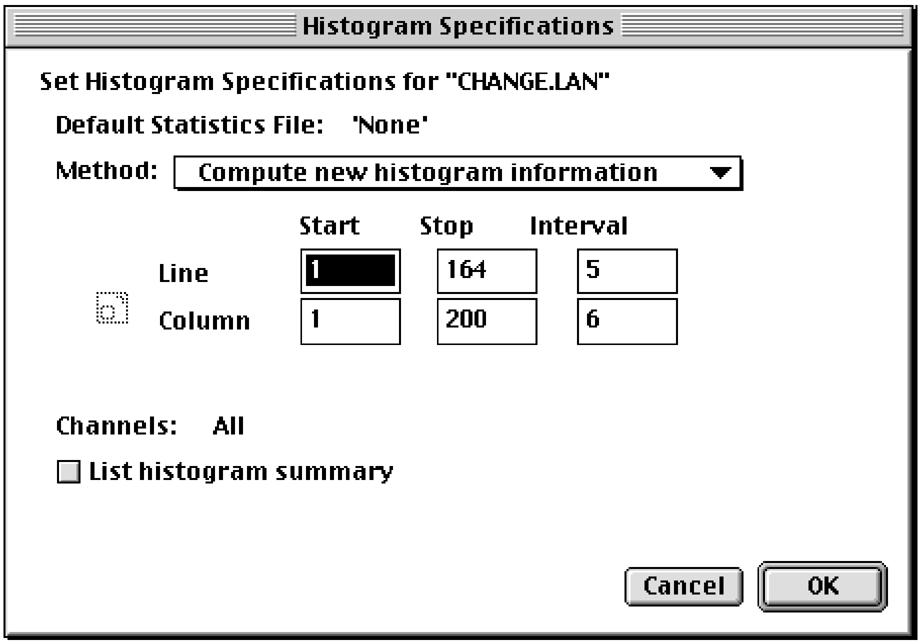
To look for change in cultural features or human developed areas, use any of the visible channels since cultural features are bright across the visible bands. This tutorial demonstrates how to use channel 1, the Blue visible channel.

- In the **Set Thematic Display Specifications** window, enter the channel combination shown below.

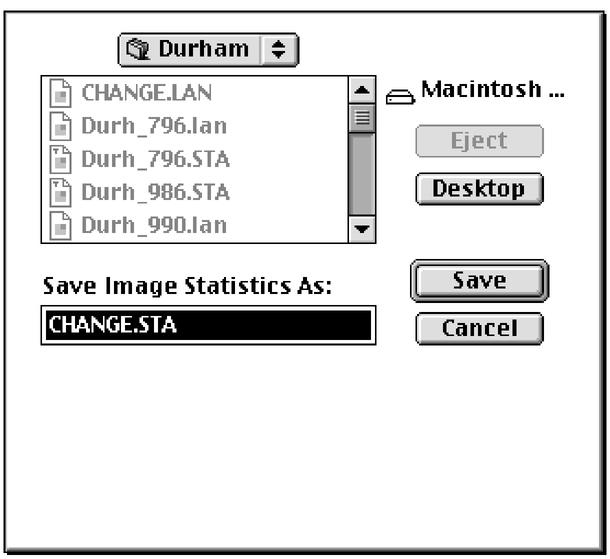


- Click **OK**.

- Since this is a new image, MultiSpec must make a “statistics (.sta)” file for the image. The following screen appears.



- Click **OK**.
- At the **Save Image Statistics** window, shown below, click **Save**.



The new image opens.

In this image, areas showing as green have a higher reflectance in channel 1 in the 1996 image than in the 1990 image. Since strong visible reflectance is often associated with exposed mineral materials (urban development, rocks, bare ground), we might infer that these green areas have undergone an increase in urban development.

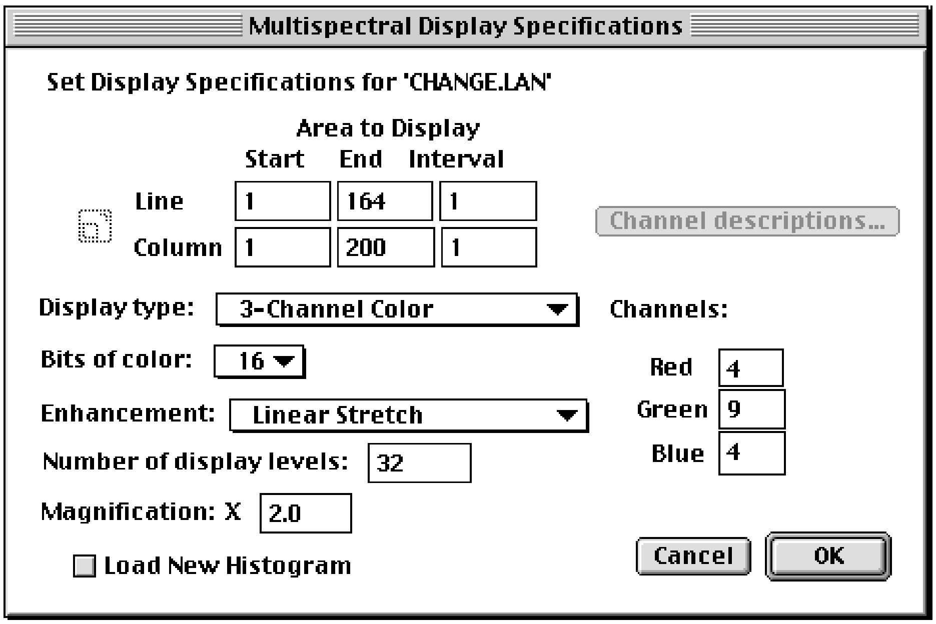
How do we check?

That these green areas may represent an increase in urban development is only an inference, or hypothesis. For our conclusion to be valid, we must develop some evidence. We can visit this area and, using maps and GPS units, verify that the green regions do represent urban development. But, are they *recent* development? To answer this question we would have to make use of records, photos, interviews, etc. to determine what was present in these areas at the time the older image was acquired.

Examining Changes in Vegetation

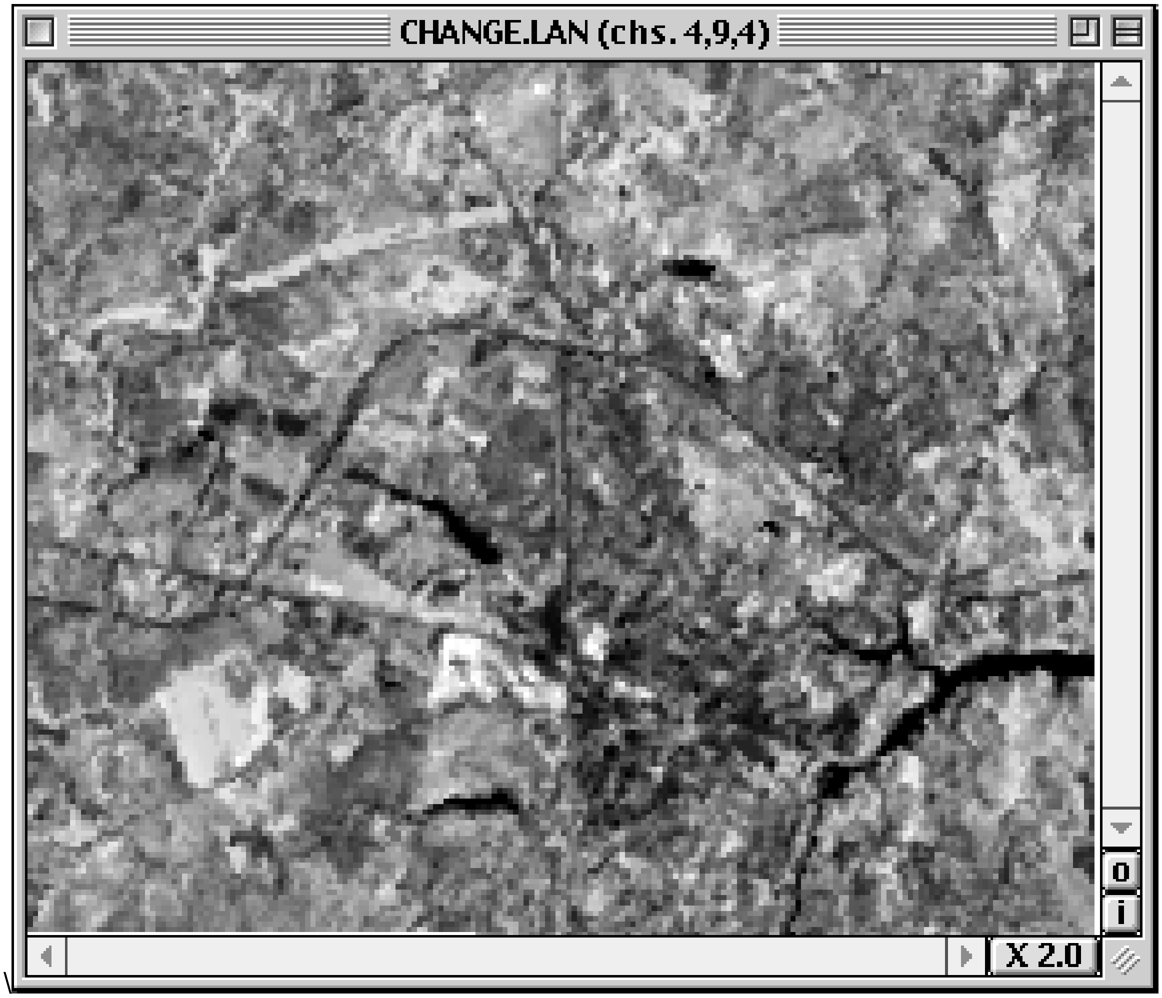
Reflectance in Landsat channel 4, the near infrared, is most strongly influenced by biomass, or the amount of available chlorophyll-containing plant structures. By examining this channel, we can infer changes in vegetated cover over the time period.

- From the **Processor** menu, select **Display Image**.
- Make the channel selections shown below.



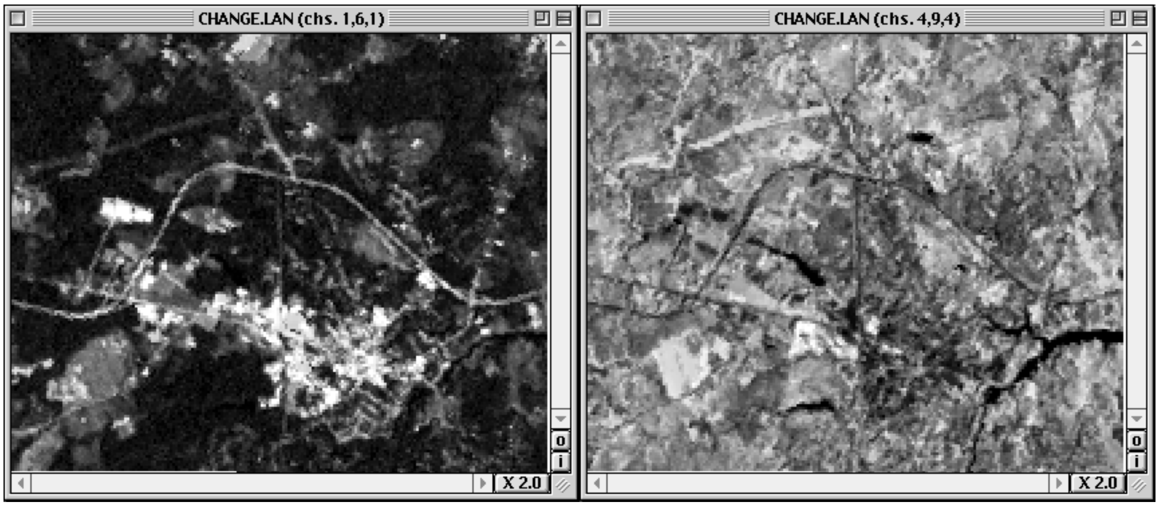
- Press **OK**.

The following image opens.



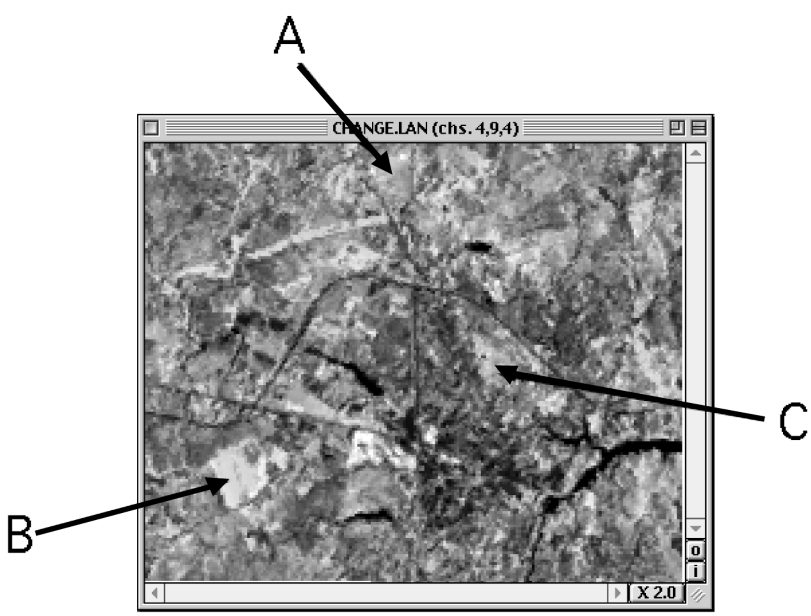
In this image, **green** areas represent an **increase in reflectance in channel 4** in 1996 compared to 1990. It would be tempting to infer that this increase is all due to an increase in vegetative growth. However, the 1990 image was acquired in September and the 1996 image in July. We are now faced with the problem of deciding how much of the change is real increase in vegetated area, and how much is due to seasonal variations.

This can be studied more effectively by examining both change images side by side. If you are unfamiliar with the process of displaying two images side-by-side, see the *Helpful Hints* on the next page.



The image on the left is the urban change image (channels 1, 6, 1), on the right is the vegetation image (channels 4, 9, 4.) Find locations that show an increase in vegetation in 1996 (they are green) and also a decrease in reflectance in 1990 (they are magenta). We might infer more strongly that these represent areas of real vegetation increase. Conversely, areas of magenta in the 1996 image that are green in the 1990 image could represent areas of vegetative decrease.

Some locations that meet this criteria are shown in the figure below.



Which of these locations suggest an increase in vegetation? Which suggest a decrease?

To verify this, we would have to perform ground verification by traveling to the site and using historical records to document real increases or decreases in vegetation at these locations.

(Position A suggests a decrease in vegetation, while B and C suggest increases.)

Helpful Hints

Viewing Two Images Side-by-Side

- **Launch** MultiSpec.
- From the **File** menu, select **Open Image**.
- Select the first image to be opened, and click **Open**.
- Select the band combination you desire, and click **OK**.
- **Click** on the image's **title bar** and **drag** to position the image in the upper left-hand corner of your screen.
- **Click** and **drag** the size of the image to cover half the screen horizontally.
- From the **File** menu, again select **Open Image**.
- **Select** the second image to open and click **Open**.
- **Assign** this image the same band combination as the first, and click **OK**.
- **Click** on this image's **title bar** and **drag** to position it just to the right of the first image.
- **Adjust the size** of this image window to the same size as the first image.

Implementation with Your Own School Image

Even before you acquire a new GLOBE Landsat image of your GLOBE Study Site, there are things you can do to prepare for implementing this change exercise.

Look at Your Original GLOBE Image

- Can you see areas that you know have experienced changes?
- Where are they?
- What kinds of changes have occurred?
- Have there been increases or decreases in the amount of land covered by agriculture? Urban development? Other types of land cover?

When You Receive a New Landsat Image

- Look at your new GLOBE Landsat image and compare it to your original image. Can you see any areas where there have been obvious changes in the time between these images?
- Do these visible changes accurately depict the changes you know have occurred?

Extensions

If you have access to images older than your current GLOBE image, you can perform the same analysis with these. This analysis, when coupled with changes you find in newer images, can give you a longer time line for estimating *rates* of change.

Note: In order to be used in this type of comparison, two images must be registered. Because of slight differences over times, two Landsat images, of exactly the same area, will not exactly match pixel-by-pixel. In the process of *registration*, a series of locations are matched from image to image. Identifying these ground control points allows a computer system to stretch one image to exactly match the other.

This process cannot be done with MultiSpec. It requires more sophisticated software not generally available in public school systems.

If you acquire other images and wish to use them for this protocol, you will have to arrange for registration. Remote Sensing and Image Processing facilities at local universities are ideal points of contact for having this done.