ENVI®

ENVI Tutorials

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Acknowledgments

Tutorial 1:
Introduction to ENVI

The following topics are covered in this tutorial:

Overview of This Tutorial

This tutorial provides basic information about ENVI and some suggestions for your initial investigations of the software. It is designed to introduce first-time ENVI users to the basic concepts of the package and to explore some of its key features. It assumes that you are already familiar with general image-processing concepts.

Files Used in This Tutorial

CD-ROM: *ENVI Tutorial and Data CD No. 2*

Path: `envidata/can_tm`

File	Description
`can_tmr.img`	Cañon City, CO TM Data
`can_tmr.hdr`	ENVI Header for Above

Working with ENVI

ENVI uses a graphical user interface (GUI) to provide point-and-click access to image processing functions. You select menu choices and functions using a three-button mouse.

Note

If you are using *ENVI for Windows* with a two-button mouse, you can simulate a middle mouse button press by holding down the Control key and pressing the left mouse button. If you are using *ENVI for Macintosh*, hold down the Option key while pressing the mouse button to simulate a middle mouse button press, or hold down the Command key while pressing the mouse button to simulate a right mouse button press.

When you start ENVI, the **ENVI** main menu appears as a menu bar. Clicking with the left mouse button on any of the **ENVI** main menu topics brings up a menu of options, which may in turn contain submenus with further options. The choices selected from these submenus will often bring up dialog boxes that allow you to enter information or set parameters relating to the ENVI function you have selected.

ENVI File Formats

ENVI uses a generalized raster data format consisting of a simple flat binary file and a small associated ASCII (text) header file. This file format permits ENVI to use nearly any image file, including those that contain their own embedded header information.

Generalized raster data is stored as a binary stream of bytes in either Band Sequential (BSQ), Band Interleaved by Pixel (BIP), or Band Interleaved by Line (BIL) format.

- BSQ is the simplest format, with each line of data followed immediately by the next line of the same spectral band. BSQ format is optimal for spatial (X, Y) access to any part of a single spectral band.
- BIP format provides optimal spectral processing performance. Images stored in BIP format have the first pixel for all bands in sequential order, followed by the second pixel for all bands, followed by the third pixel for all bands, etc., interleaved up to the number of pixels. This format provides optimum performance for spectral (Z) access of the image data.
- BIL format provides a compromise in performance between spatial and spectral processing and is the recommended file format for most ENVI processing tasks. Images stored in BIL format have the first line of the first

band followed by the first line of the second band, followed by the first line of the third band, interleaved up to the number of bands. Subsequent lines for each band are interleaved in similar fashion.

ENVI supports a variety of data types: byte, integer, long integer, floating-point, double-precision floating-point, complex, and double-precision complex.

The separate text header file provides information to ENVI about the dimensions of the image, any embedded header that may be present, the data format, and other pertinent information. The header file is normally created (with your input) the first time a particular data file is read by ENVI. You can view and edit it at a later time by selecting **File → Edit ENVI Header** from the ENVI menu bar. You can also generate ENVI header files outside ENVI, using a text editor.

ENVI Windows and Displays

As you work with ENVI, a number of different windows and dialog boxes will appear on your screen. These allow you to manipulate and analyze your image. The most important of these displays is a group of three windows that display your image, allow you to move around in it, and allow you to magnify different areas. This group of windows is collectively referred to as the *Display group* (Figure 1-1). The Display group consists of:

- **The *Main Image Window*** – This window is where all or part of your image is displayed at full resolution (one screen pixel is one data pixel).
- **The *Scroll Window*** – If your entire image does not fit in the Main Image window, the Scroll window will appear. The Scroll window displays a subsampled reduced-size version of the entire image, which allows you to select the portion that is displayed in the Main Image window. A colored box in the Scroll window indicates the spatial location and coverage of the full-resolution Main Image display window. A number in the title bar of the Scroll window tells you what reduction factor has been applied to the image to display the full spatial extent within the Scroll window.
- **The *Zoom Window*** – This window displays an enlarged version of a selected portion of the Main Image window. A colored box in the Main Image display indicates the spatial location and coverage of the Zoom window. A number in the title bar of the Zoom window tells you what zoom factor has been applied to the image.

You may have any number of displays open on the screen at any time. There are a wide variety of other types of ENVI windows with which you may work, including scatter plots, spectral profiles, spectral plots, and vector windows.

Figure 1-1: An ENVI Display group: the Main Image, Scroll, and Zoom windows.

Menus in ENVI Windows

The Main Image display window has its own internal menus, which provide access to interactive display and analysis functions (Figure 1-2). These menus appear as a standard menu bar at the top of each Main Image display window. You can select options from it as you do from any other ENVI menu.

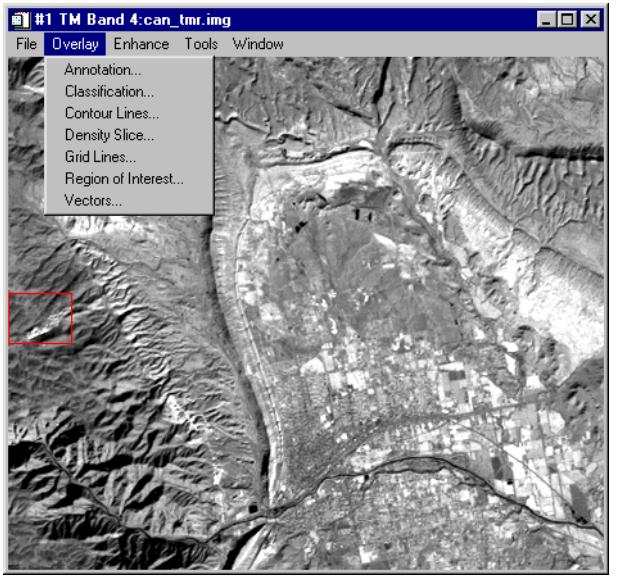

Figure 1-2: The Overlay menu in the Main Image window

The Available Bands List

ENVI provides access to both image files and to the individual spectral bands in those files. The **Available Bands List** is a special ENVI dialog that contains a list of all the available image bands in all open files (Figure 1-3).

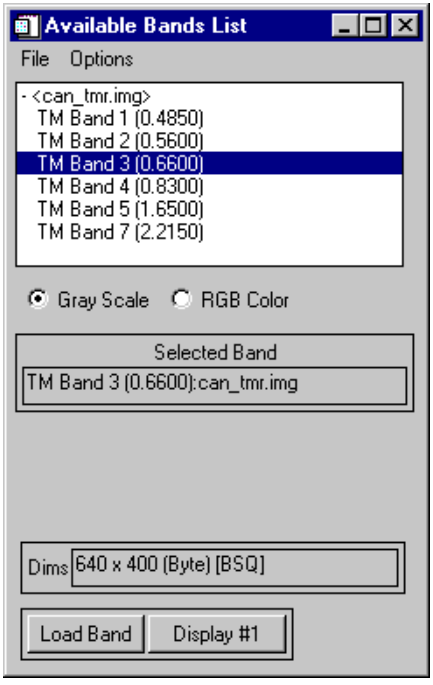

Figure 1-3: The Available Bands List dialog

Use the **Available Bands List** to load both color and gray scale images into a display by starting a new display or selecting the display number from the pull-down list of displays, clicking on the appropriate radio button, then selecting the desired bands from the list by clicking on the band name(s).

The File pull-down menu at the top of the **Available Bands List** dialog provides access to file opening and closing, file information, and the **Cancel** button. The **Options** menu provides a function to find the band closest to a specific wavelength, show the currently displayed bands, allows toggling between full and shortened band names in the list, and the capability to fold all of the bands in a single open image into just the image name. Folding and unfolding the bands into single image names or lists

of bands can also be accomplished by clicking on the + (plus) or – (minus) symbols to the left of the file name in the **Available Bands List** dialog.

Basic ENVI Functions

This section of the tutorial takes you on a step-by-step tour of ENVI's basic functions.

Start ENVI

Before attempting to start the program, ensure that ENVI is properly installed as described in the installation guide.

- To open ENVI in UNIX, enter `envi` at the UNIX command line.
- To open ENVI from a Windows or Macintosh system, double-click on the ENVI icon.

The ENVI main menu appears when the program has successfully loaded and executed.

Open an Image File

To open an image file:

1. Select **File** → **Open Image File**.

   Note that on some platforms you must hold the left mouse button down to display the submenus from the Main Menu.

   An **Enter Input Data File** file selection dialog appears.

2. Navigate to the `CAN_TM` subdirectory of the `envidata` directory on the ENVI *ENVI Tutorial and Data CD No. 2* just as you would in any other application and select the file `can_tmr.img` from the list and click **OK**.

   The **Available Bands List** dialog appears on your screen (Figure 1-3). This list allows you to select spectral bands for display and processing.

   You now have the choice of loading either a gray scale or an RGB color image.

3. Select one of the bands listed at the top of the dialog by clicking on the band with the left mouse button.

   The band you have chosen is displayed in the field marked **Selected Band:**.

4. Click the **Load Band** button to load the image into a new display.

   Note

   The Main Image window has a menu bar (Figure 1-2).

Familiarize Yourself with the Displays

When the image loads, an ENVI image display appears on your screen. The display consists of a Main Image window, a Scroll window, and a Zoom window (See Figure 1-1). These three windows are intimately linked; changes to one window are mirrored in the others. To get a feel for how the display windows interact, try the following:

Drag the Zoom Indicator Box

- Note the small red box in the center of the Main Image window. This box indicates the area of the image displayed in the Zoom window. You can drag the box from place to place in the Main Image window by clicking inside the box with the left mouse button and dragging it to a new position. The Zoom window is updated automatically to show the new area when you release the mouse button
- You can also reposition the zoom indicator box by placing the crosshair cursor in the Main Image window and clicking the left mouse button. The zoom region will be centered around the position you have chosen.
- Finally, if you click outside the zoom indicator box with the middle mouse button and hold and drag the box to a new position, the Zoom window is updated as you move the box.
- You can close either the Zoom and/or Scroll windows if you don't want to display them. They can again be displayed by selecting **Window** → **Show Scroll Window** or **Window** → **Show Zoom Window** from the Main Image window menu bar.

Zoom In and Out and Pan the Zoom Window

- Move the mouse cursor in the Zoom window and click the left mouse button to reposition the magnified area by centering the zoomed area on the selected pixel.
- Clicking and holding the left mouse button in the Zoom window while dragging causes the Zoom window to pan within the Main Image display.
- Click the right mouse button in the Zoom window to toggle the menu graphic on or off. The menu graphic is made up of three icons in the lower left corner of the Zoom window.
- Clicking the left mouse button on the – (minus) graphic zooms down by a factor of 1. Clicking the middle mouse button on this graphic zooms down by a factor of 2. Clicking the right mouse button on the graphic returns the Zoom window to the default zoom factor.

- Clicking the left mouse button on the + (plus) graphic zooms up by a factor of 1. Clicking the middle mouse button on this graphic zooms doubles the Zoom factor. Clicking the right mouse button on the graphic returns the Zoom window to the default zoom factor.
- Click the left mouse button on the right (third) graphics box to toggle the Zoom window crosshair cursor. Click the middle mouse button on this graphic to toggle the Main Image crosshair cursor. Click the right mouse button on this graphic to toggle the zoom box in the Main Image window on or off.
- Double-click the left mouse button on the right (third) graphics box to toggle interpolation in the Zoom window. Double-click the right mouse button in this graphic to toggle scroll bars on the Main Image window.

Scroll the Image

A red box in the Scroll window indicates what portion of the entire image is currently displayed in the Main Image window. You can move the selected area by clicking inside the scroll indicator box with the left mouse button and dragging the box to a new position. The displays in the Main Image and Zoom windows are updated when you release the mouse button. You can also reposition the scroll indicator box by clicking at the desired location outside of the box using the left mouse button (as for the Zoom window box above). If you click, hold and drag the left mouse button in this fashion, the Main Image window is updated as you drag (the speed depends on your computer resources).

Resize the Windows

You can resize the display windows the same way you would resize windows in other applications, by dragging any of the corners. Note, however, that you cannot make the Main Image window larger than the image size. When the Main Image window is large enough to display the entire image, the Scroll window is unnecessary and is automatically removed from your screen. The Scroll window reappears if the Main Image window is resized smaller than the full image.

Scroll Bars

The Main Image window can also have optional scroll bars, which provide an alternate method for moving through the Scroll image, allowing you to select which portion of the image appears in the Image window. To add scroll bars, select **File** → **Preferences** from the Main Image window menu bar. Click on the arrow toggle button next to the Scroll Bars text field in the dialog to toggle scroll bars on, then click **OK** at the bottom of the dialog. The portion of the image displayed in the Main Image window can now be controlled by clicking and dragging the scroll bars

using the left mouse button. Scroll bars can be turned on by default for all images from the ENVI menu bar by selecting **File** → **Preferences** → **Display Defaults** and clicking on the toggle button for the **Image window scroll bars** as described above.

Use the Mouse Button Descriptions

ENVI has many interactive functions, and the mouse button combinations and actions are different for each one. The **Mouse Button Descriptions** dialog is provided to tell you what the mouse buttons do in each graphics window.

- To start the **Mouse Button Descriptions** dialog, select **Window** → **Mouse Button Descriptions** from either the Main Image window menu bar, or from the ENVI main menu bar.

Now whenever your cursor is in an ENVI display or graphics window, the mouse button assignments will be listed in this dialog. MB1 is the left mouse button, MB2 is the middle mouse button, and MB3 is the right mouse button.

Display the Cursor Location

- To display the cursor location and value, select **Window** → **Cursor Location/Value** from the ENVI main menu or the Main Image window menu bar.

  The **Cursor Location / Value** dialog box appears displaying the location of the cursor in the Main Image, Scroll, or Zoom windows (Figure 1-4). The dialog also displays the screen value (color) and the actual data value of the pixel underneath the crosshair cursor.
- To dismiss the dialog, select **Cancel** from the pull-down **File** menu at the top of the **Cursor Location /Value** dialog.
- The **Cursor Location/Value** dialog can also be started/stopped by double-clicking using the left mouse button in the Main Image window.

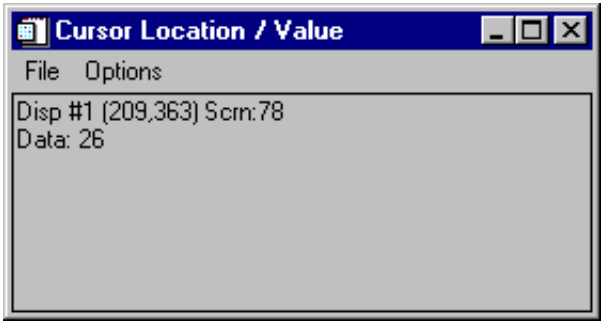

Figure 1-4: The Cursor Location/Value dialog displays the screen and data values of the selected pixel.

Display Image Profiles

X (horizontal), Y (vertical), and Z (spectral) profile plots can be selected and displayed interactively. These profiles show the data values across an image line (X), column (Y), or spectral bands (Z).

1. Select **Tools** → **Profiles** → **X Profile** from the Main Image display menu bar to display a window plotting data values versus sample number for a selected line in the image (Figure 1-5).
2. Repeat the process, selecting **Y Profile** to display a plot of data value versus line number, and selecting **Z Profile** to display a spectral plot (Figure 1-5).

Note

The **Mouse Button Descriptions** dialog contains the descriptions of the mouse button actions in the Profile displays.

3. Position the Profile plot windows so you can see all three at once.

   A red crosshair extends to the top and bottom and to the sides of the Main Image window. The red lines indicate the line or sample locations for the vertical or horizontal profiles.
4. Move the crosshair around the image (just as you move the zoom indicator box) to see how the three image profile plots are updated to display data on the new location.

5. Close the profile plots by selecting **File** → **Cancel** from within each plot window.

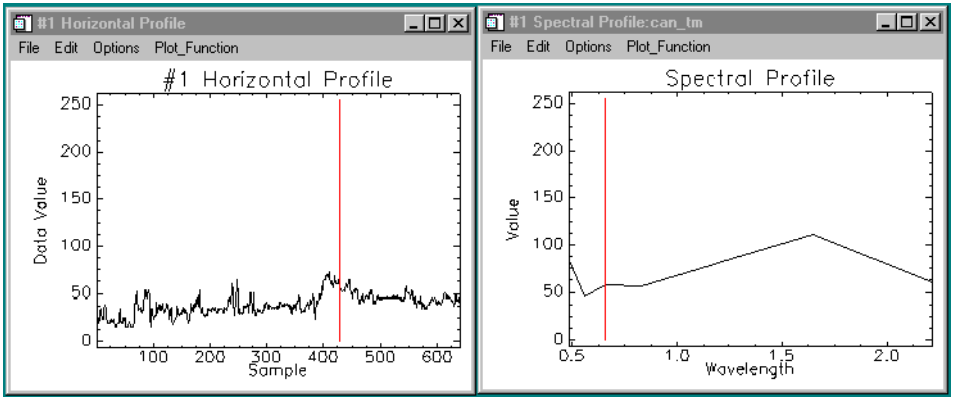

Figure 1-5: The Horizontal (X) Profile (left) and Spectral (Z) Profile (right) plots.

Perform Quick Contrast Stretching

You can perform quick contrast stretches using default parameters and data from either the Main Image window, the Zoom window, or the Scroll window. Using the **Enhance** menu from the Main Image window menu bar, you can apply various contrast stretches (Linear, Linear 0-255, Linear 2%, Gaussian, Equalization, and Square Root).

1. Try the various stretches using the Main Image, Zoom, and Scroll as the stretch data source.
2. Compare the effects of the various Linear, Gaussian, Equalization, and Square Root stretches in the Display group windows.

Display Interactive Scatter Plots

You can plot the data values of two selected image bands versus each other in a scatter plot to graphically display the overlapping values.

1. Select **Tools** → **2D Scatter Plots** from the Main Image window menu bar.

   The **Scatter Plot Band Choice** dialog appears, in which you choose the two image bands to compare.

2. Select one band for the X axis and another band for the Y axis and click **OK**.

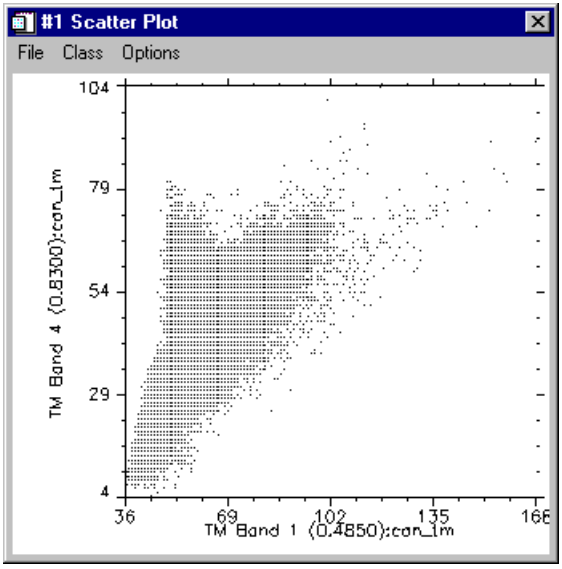

Figure 1-6: An Interactive Scatter Plot comparing band 1 values to band 4 values.

It may take a few seconds for ENVI to extract and tabulate the data values.

3. Once the scatter plot has appeared (Figure 1-6), position the mouse cursor anywhere in the Main Image window and drag with the left mouse button pressed.

   Pixel values contained in a ten-pixel by ten-pixel box surrounding the crosshair will be highlighted in red on the scatter plot.

Note

The **Mouse Button Descriptions** dialog tells you the functions of the different mouse button actions when applied in the **Scatter Plot** display.

4. Move the cursor around in the Main Image window to observe the *dancing pixels* effect.

5. You can also use the scatter plot to highlight specific data values in the Main Image window. Place the mouse cursor in the scatter plot window and click and drag with the middle mouse button.

A ten-pixel-square box will appear in red on the plot. Pixels with the values contained in the box are highlighted on the image in the Main Image window and appear to *dance*, as you drag the cursor in the **Scatter Plot** display moving the 10-by-10 pixel area.

6. From the Scatter Plot menu bar, select **File** → **Cancel** to close the **Scatter Plot** window.

Load a Color Image

1. If the **Available Bands List** dialog is not already on your screen, call it up again from the ENVI Main menu bar by selecting **Window** → **Available Bands List** (Figure 1-3).
2. Set up to load a color image in a second display by clicking on the radio button labelled **RGB Color** in the **Available Bands List** dialog.
3. Select a band for each color (red, green, blue) from the list by clicking on the band name. The radio buttons for assigning the R, G, and B colors automatically advance when you click on a band name in the list.
4. When all three colors have band names associated with them, click the **Display #1** menu button to open a **New Display** from the pull-down menu.
5. Now, click on the **Load RGB** button to load the image in the new display.

Link Two Displays

Link the two displays together for comparison. When you link two displays, any action you perform on one display (scrolling, zooming, etc.) is echoed in the linked display. To link the two displays you have on screen now do the following.

1. From either of the two Main Image menu bars, select **Tools** → **Link** → **Link Displays**. This opens the **Link Displays** dialog box.
2. Click **OK** in the **Link Displays** dialog to establish the link.
3. Now try scrolling or zooming in one display group and observe as your changes are mirrored in the second display.

Dynamic Overlays

ENVI's multiple Dynamic Overlay feature allows you to dynamically superimpose parts of one or more linked images onto the other image. Dynamic overlays are turned on automatically when you link two displays, and may appear in either the Main Image window or the Zoom window.

1. To start, click the left mouse button to see both displays completely overlaid on one another.
2. To create a smaller overlay area, position the mouse cursor anywhere in either Main Image window (or either Zoom window) and hold down and drag with the middle mouse button. Upon button release, the smaller overlay area is set and a small portion of the linked image will be superimposed on the current image window.
3. Now click the left mouse button and drag the small overlay window around the image to see the overlay effects.
4. You can resize the overlay area at any time by clicking and dragging the middle mouse button until the overlay area is the desired size.

Select Regions Of Interest

ENVI lets you define regions of interest (ROIs) in your images. ROIs are typically used to extract statistics for classification, masking, and other operations.

1. From the Main Image window menu bar, select **Overlay** → **Region of Interest**. The **ROI Tool** dialog for that Main Image display will appear (Figure 1-7).

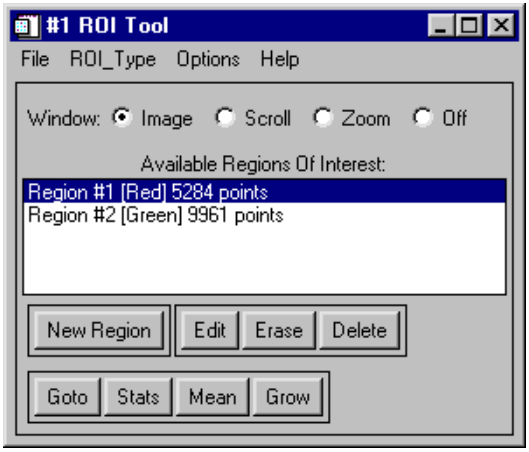

Figure 1-7: The ROI Tool dialog with two regions defined.

2. Draw a polygon that represents the region of interest.

- Click the left mouse button in the Main Image window to establish the first point of the ROI polygon.
- Select further border points in sequence by clicking the left button again, and close the polygon by clicking the right mouse button.The middle mouse button deletes the most recent point, or (if you have closed the polygon) the entire polygon. Click the right mouse button a second time to fix the polygon.
- ROIs can also be defined in the Zoom and Scroll windows by selecting the appropriate window radio button in the **ROI Tool** dialog.

When you have finished defining an ROI, it is shown in the dialog in the **Available Regions of Interest** list, with the name, region color, and number of pixels enclosed (Figure 1-7).

3. To define a new ROI, click the **New Region** button.
   - You can enter a name for the region and select the color and fill patterns for the region by clicking on the **Edit** button.

Other types of ROIs

ROIs can also be defined as polylines or as a collection of individual pixels by selecting the desired ROI type from the **ROI_Type** pull-down menu. See the *ENVI 3.5 User's Guide* or the hypertext online help for further discussion of these types of ROI.

Working with ROIs

You can define as many ROIs as you wish in any image (Figure 1-8).

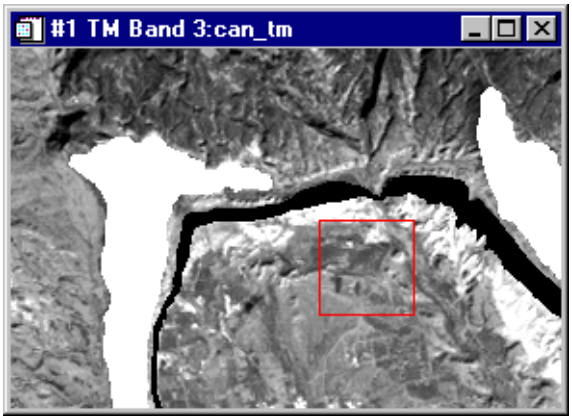

Figure 1-8: An image with two regions of interest (ROIs) defined.

1. Once you have created the ROI definitions, you can erase them from the display (leaving the definition in the list) by selecting the ROI from the **Available Regions of Interest** list and clicking on the **Erase** button.
2. Clicking on the **Stats** button allows you to view statistics about the ROI you select.
3. Clicking the **Delete** button permanently deletes the selected ROI definitions from the list.
4. The other buttons and options under the pull-down menus at the top of the **ROI Tool** dialog let you calculate ROI means, save your ROI definitions, load saved definitions, or display or delete all the definitions in the list.

Region of interest definitions are retained in memory after the **ROI Tool** dialog is closed, unless you explicitly delete them. This means the ROIs are available to other ENVI functions even if they are not displayed.

Annotate the Image

ENVI's flexible annotation features allow you to add text, polygons, color bars, and other symbols to your plots and images.

1. To annotate an image, select **Overlay** → **Annotation** from the Main Image menu bar. The **Annotation: Text** dialog for that Main Image window will appear (Figure 1-9).
2. To annotate plots, 3-D surfaces, and similar objects, select **Options** → **Annotation** from the plot window menu bar.

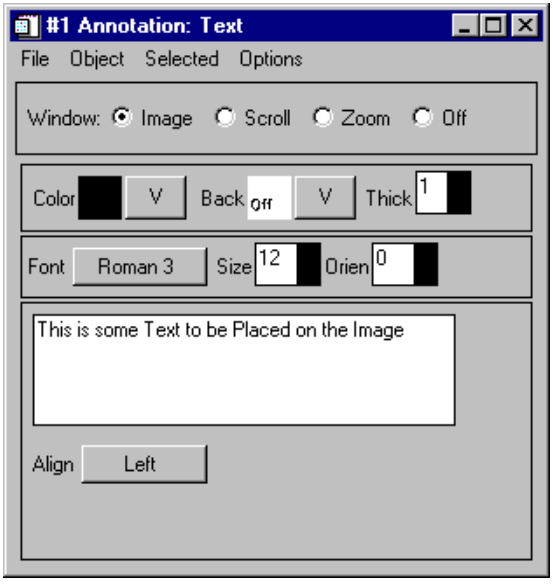

Figure 1-9: The Annotation dialog, in Text mode.

Annotation Types

The **Annotation: Text** dialog allows you to choose from a variety of annotation types. Different types are selected from the **Object** menu and include Text, Symbols, Rectangles, Ellipses, Polygons, Polylines, Arrows, Map Scale Bars and Declination Diagrams, Map Keys, Color Table Ramps, and Images. By default, the Annotation dialog starts up with *Text* selected. Other fields in the dialog let you control the size, color, placement, and angle of the annotation text. When you select different

annotation types from the *Object* menu, the fields in the dialog change to display options appropriate to the new type.

Placing Annotation

Try placing a text annotation in your Main Image window:

1. Type some text in the text field of the **Annotation: Text** dialog.
2. Select a font, color, and size from the appropriate menus and parameters in the dialog, then position the mouse pointer in the Main Image window and press the left mouse button.

Note

The **Mouse Button Description** dialog describes the mouse button interactions within annotation.

Your text is displayed in the window at the point you chose (Figure 1-10).

3. Drag the handle using the left mouse button to position the text in the window.
   - You can continue to change the annotation's properties and position by changing the fields in the dialog box or dragging the text or symbol while holding down the left mouse button.
4. When you are satisfied with the annotation, press the right mouse button to fix the annotation in position.

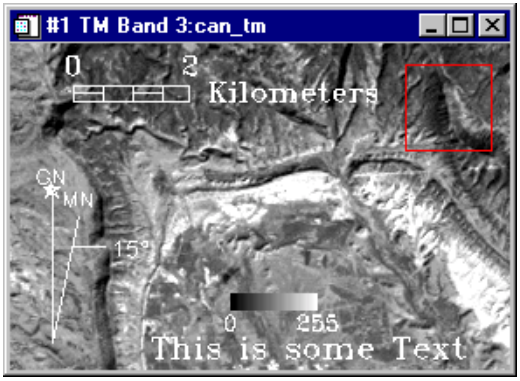

Figure 1-10: An annotated image.

Saving and Restoring Annotation

1. You can save your image annotation by selecting **File** → **Save Annotation** from the **Annotation: Text** dialog menu bar.
2. This opens the **Output Annotation Filename** dialog in which you specify a path and filename with a `.ann` extension for the saved annotation.

Note

If you do not save your annotation in a file, it will be lost when you close the **Annotation: Text** dialog (you will be prompted to save the annotation if you close without first saving).

3. You can also restore saved annotation files by selecting **File** → **Restore Annotation** in the **Annotation: Text** dialog.

Editing Previously Placed Annotation

To edit an annotation element that has already been set in the image, do the following.

1. Select **Object** → **Selection/Edit** in the **Annotation: Text** dialog.
2. Draw a box around the annotation you wish to edit by clicking and dragging with the left mouse button.
3. When the handle reappears, Click and drag the handle and annotation to move and configure the item just as you would a new annotation.

Suspending the Annotation Function Temporarily

1. To suspend annotation operations and return to normal ENVI functionality temporarily, select the **Off** radio button at the top of the **Annotation: Text** dialog.

   This allows you to use the scroll and zoom features in your display without losing your annotations.
2. To return to the annotation function, select the radio button in the **Annotation: Text** dialog for the window you are annotating.

Leave your annotation on the Main Image window as you complete this tutorial.

Add Grid Lines

Try adding a grid (Figure 1-11) to your image.

1. To overlay grid lines on your image, select **Overlay** → **Grid Lines** in the Main Image window. This brings up the **Grid Line Parameters** dialog box.

Note

An image border is automatically added when you overlay grid lines.

2. You can adjust the grid line attributes by setting the line thickness and color and the grid spacing using the **Options** → **Edit Pixel Grid Attributes** pull-down menu from the **Grid Lines Parameters** dialog. This selection brings up the **Edit Pixel Attributes** dialog box.
3. In the **Edit Pixel Attributes** dialog, you can change the color, thickness and grid spacing for the labels, lines, box and corners of the grid. When the attributes are set up to your satisfaction, click **OK** in the **Edit Pixel Attributes** dialog to apply the changes to the grid on the images.
4. When you have added a satisfactory grid, click **Apply** in the **Grid Line Parameters** dialog.

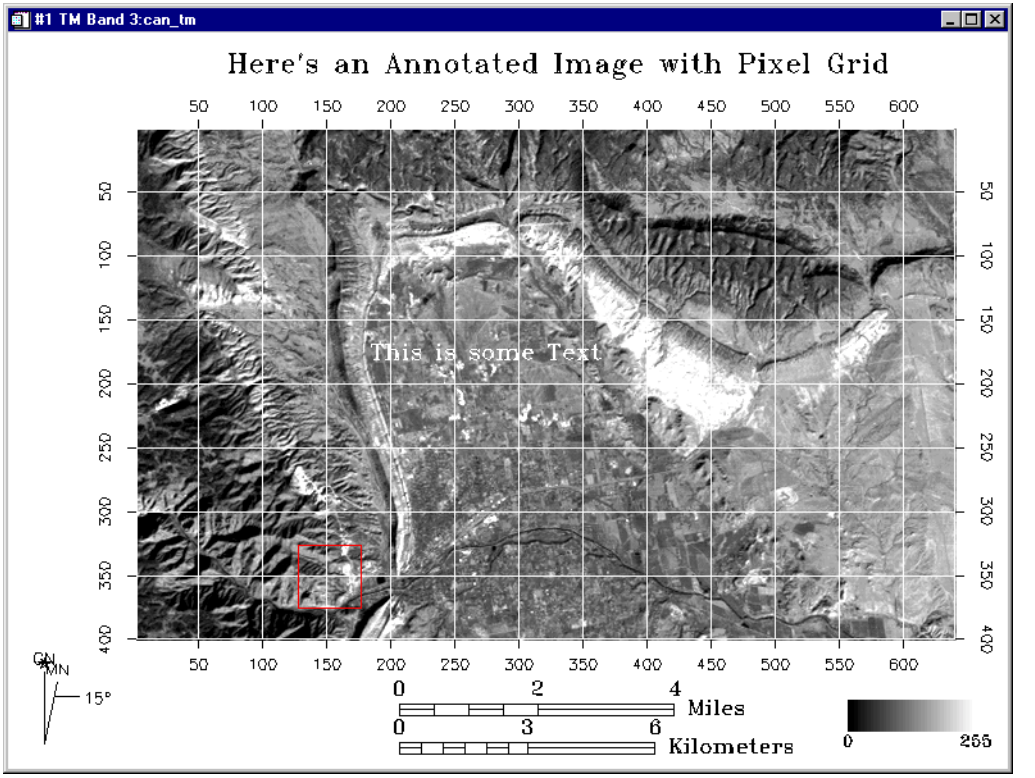

Figure 1-11: An annotated image with a grid overlaid.

Save and Output an Image

ENVI gives you several options for saving and outputting your filtered, annotated, gridded images. You can save your work in ENVI's image file format, or in several popular graphics formats (including Postscript) for printing or importing into other software packages. You can also output directly to a printer.

Saving your Image in ENVI Image Format

To save your work in ENVI's native format (as an RGB file):

1. From the Main Image window menu bar, select **File** → **Save Image As** → **Image File**. The **Output Display to Image File** dialog appears.

2. Select 24-Bit color or 8-Bit gray scale output, graphics options (including annotation and gridlines), and borders.

   If you have left your annotated and gridded color image on the display, both the annotation and grid lines will be automatically listed in the graphics options.

   You can also select other annotation files to be applied to the output image.

3. Select output to **Memory** or **File** using the desired radio button.

   - If output to **File** is selected, enter an output filename.

   Note

   If you select other graphics file formats from the **Output File Type** button which, by default is set to **ENVI**, your choices will be slightly different.

4. Click **OK** to save the image.

   Note

   This process saves the current display values for the image, not the actual data values.

End the ENVI Session

You can quit your ENVI session by selecting **File** → **Exit** (**Quit** on UNIX) on the ENVI main menu, then click **OK** to terminate ENVI when prompted.