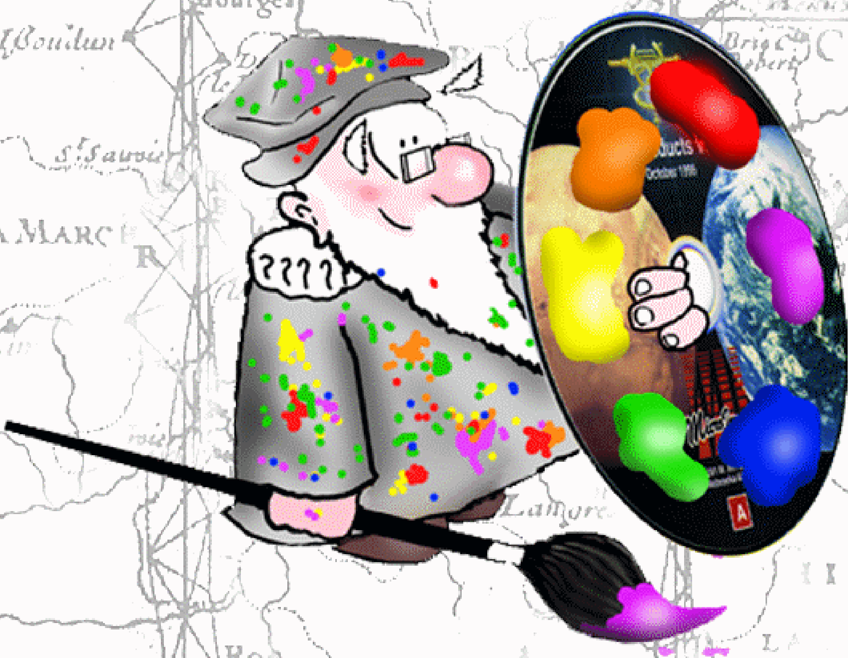
Getting Good Color



with

TNTmips®
TNTedit™
TNTview®

Before Getting Started

Color is an important element that helps you visualize the information contained in raster images that you display or print with TNTmips®. The exercises in this booklet introduce you to the many tools provided in TNTmips for manipulating and enhancing image color in screen displays, and for adjusting color translation to the printed page.

Prerequisite Skills This booklet assumes that you have completed the exercises in *Getting Started: Displaying Geospatial Data* and *Getting Started: Navigating*. Those exercises introduce essential skills and basic techniques that are not covered again here. Please consult those booklets and the TNTmips reference manual for any review you need.

Sample Data The exercises presented in this booklet use sample data that is distributed with the TNT products. If you do not have access to a TNT products CD, you can download the data from MicroImages' web site. In particular, this booklet uses sample files in the COLOR data collection. Make a read-write copy of these files on your hard drive; you may encounter problems if you work directly with the read-only sample data on the CD-ROM.

More Documentation This booklet is intended only as an introduction to Getting Good Color. The Display volume of the TNTmips reference manual contains more detailed information on most of the topics covered here. You can find additional information about the Raster Color Conversion process in the Prepare volume of the reference manual.

TNTmips and TNTlite® TNTmips comes in two versions: the professional version and the free TNTlite version. This booklet refers to both versions as "TNTmips." If you did not purchase the professional version (which requires a hardware key), TNTmips operates in TNTlite mode, which limits object size and does not allow export.

The display color enhancement tools described here are available in all TNT products. Color conversion is not available in TNTedit, TNTview, or TNTatlas. Printing using the Hardcopy Layout tools is also not available in TNTatlas. All of the exercises can be completed in TNTlite using the sample geodata provided.

Randall B. Smith, Ph.D., 17 September 2001

It may be difficult to identify the important points in some illustrations without a color copy of this booklet. You can print or read this booklet in color from MicroImages' web site. The web site is also your source for the newest Getting Started booklets on other topics. You can download an installation guide, sample data, and the latest version of TNTlite.

http://www.microimages.com

Welcome to Getting Good Color

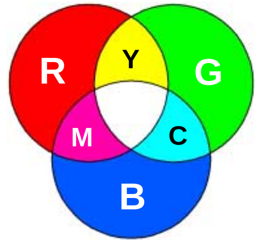
Color is an important characteristic of many raster images, scanned maps, and other forms of spatial data that you may work with using TNTmips. Good color quality makes it easier to understand and interpret the data, both for you and for the final users of your project results. Achieving good color requires subjective judgement, and in some cases you can manipulate color to emphasize particular features in an image.

This booklet is intended to help you enhance the color content of images that you display on your computer screen or print on a hardcopy output device. We will discuss how color is created on the computer screen, the ways in which color information can be stored in Project Files, and how colors are created when you print.

To begin, let's review two basic color models. Both models use sets of three primary colors that can be mixed in varying proportions to produce a wide spectrum of colors. The RGB model applies when light of different colors is mixed, as in your computer monitor. When two of the three primary colors (red, green, and blue) are mixed, the wavelengths contributed by each add together to produce intermediate colors. Examples are yellow (red + green), cyan (green + blue), and magenta (blue + red). An equal mixture of all three additive primaries produces white light.

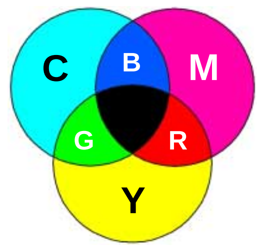
The CMY model (for cyan, magenta, and yellow) applies to color produced by mixing or overlaying translucent inks, dyes, or glass filters. When one of these materials is illuminated by white light, certain wavelengths are absorbed (subtracted from white), and the remaining reflected wavelengths determine the color. Pairs of subtractive primaries can be mixed to produce blue, red, and green. An equal mixture of all three yields black. The CMY color model is applicable to the printing process.

RGB Model



Additive mixing: computer display

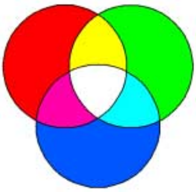
CMY Model



Subtractive mixing: printing

The exercises on pages 4-19 introduce you to the manipulation of color in screen displays. Topics covered include contrast enhancement for RGB displays, use of color composite rasters, working with color palettes, color transparency for raster and vector objects, and RGBI display. Page 20 is an overview of the Raster Color Conversion process. Color adjustments in the printing process are discussed on pages 21-27, including color balancing, adjusting gamma contrast, and printing test strips.

Color on Your Computer Screen



STEPS
- ☑ launch TNTmips
- ☑ select Display / Spatial Data from the main menu
- ☑ click the New 2D Group icon button on the Display Spatial Data toolbar.

The colors on your color computer screen are specified using the additive RGB color model. Each picture element (or pixel) in a desktop monitor or laptop display is actually made up of separate light-emitting elements for red, green, and blue light. The amount of light emitted can be varied individually for each of the color elements making up a pixel. In the simplest case, with each color element either fully on or off, this system could produce the eight basic colors: red, green, blue, cyan, magenta, yellow, white (all three color elements on), and black (all three color elements off). In reality, modern color displays can produce 256 intensity levels for each color element, which in combination can produce over 16 million colors.

New 2D Group

The trio of intensity settings for each screen pixel are stored in the memory module on your system's graphics display card. Providing the full color range described above (sometimes called "true color") requires 24 bits of memory per pixel (8 bits = 2^8 = 256 levels per color element). Most cards offer several additional display modes that require less display memory but provide more restricted color ranges. In 16-bit mode, only 32 intensity levels (5 bits) are discriminated per color element, providing over 32,000 colors. In 8-bit mode, display colors are selected from a palette of 256 colors supplied by the operating system or by the currently running software (such as the TNTmips Display process).

For best color rendition, choose 24-bit display mode. You may find that your choice of color settings is limited by your current screen size setting, depending on the amount of memory available for your display card. If so, decreasing the screen size (and resolution) may enable you to increase the display color depth.

NOTE: Adjusting the global brightness and contrast settings on your monitor has a major effect on the appearance of color images on your screen, independent of color adjustments made in the TNTmips Display process.

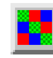
Three-Raster RGB Display

A color screen image can be created from several types of raster objects or sets of raster objects. You have the greatest flexibility to adjust color when you use the RGB raster display option. Each of the three selected raster objects is used to control the intensity of one of the display color components. In most cases the component rasters will be 8-bit grayscale objects, but you can also use 16-bit or floating-point rasters as RGB display components.

If your input image is a scanned photograph or map, assigning each of the red, green, and blue component rasters to its corresponding display channel produces a screen display that can closely replicate the colors of the original. However, you can also choose a set of bands from a multispectral image source, such as a 7-band Landsat Thematic Mapper image, SPOT image, or multipolarization radar image. The resulting false-color images can be used to analyze and interpret the characteristics of different image areas.

The RGB raster set for this exercise represents a natural-color photograph acquired in 1994 by the crew of NASA's Space Shuttle over Mount Saint Helens volcano in southwestern Washington, USA. If your computer is in 24-bit display mode, you will see a true 24-bit color image. If your computer is in 16-bit or 8-bit display mode, the display process automatically produces a reduced range of colors that provides an optimal representation of the 24-bit color range provided by the RGB raster objects.

STEPS

- ☑ click the Add Raster icon button on the Group Controls window 
- ☑ choose Quick-Add RGB from the resulting option menu
- ☑ use the standard File / Object Selection procedure to select rasters RED, GREEN, and BLUE from the STHELENS Project File in the COLOR data collection

The dark forested slopes in the lower part of image contrast with the barren, ash-covered area devastated by the 1980 eruption of the volcano.

NOTE: To produce valid results in the RGB display process, each component raster must be a **grayscale** raster object. This means that the order of raster values must have some numerical significance, such as recording increasing brightness for a measured wavelength band of light. **Categorical rasters**, in which raster values are merely arbitrary labels for different classes or groups, should not be used as RGB display components.

Raster Contrast Enhancement Window

STEPS

☑ click the Tools icon button in the layer icon row of the Group Controls window 

☑ choose Enhance Contrast from the dropdown menu

☑ in the Raster Contrast Enhancement window, open the Options menu and turn on the Envelope option (toggle button in)

☑ examine the input and display histograms for the Red component (shown by default)

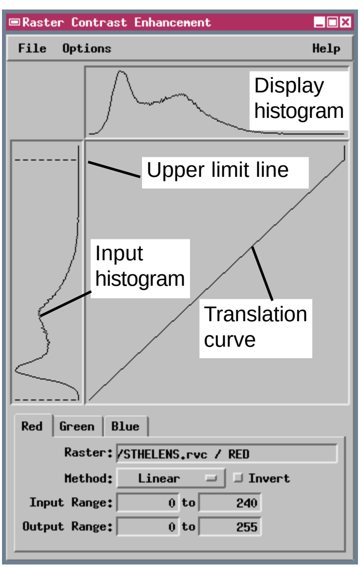
☑ click the tab for the Green component to view its histograms

☑ repeat for the Blue component

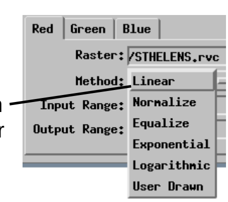
You can adjust the display of each RGB component raster individually using the Contrast Enhancement process. The raw values in each input raster can be translated to a new set of display values to enhance brightness and contrast for each band. In RGB display mode these individual adjustments can be used to improve the overall brightness, contrast, and color balance of the image. A look-up table of input and adjusted values can be saved as a Contrast Table subobject for each input raster. These tables are then used automatically by the Display process to determine the screen display values.

When you display an RGB raster set, the Raster Contrast Enhancement window displays Input and Display histograms for one color component at a time. Choose the color component you wish to adjust by clicking the corresponding tab in the lower part of the window. The tabbed panel for each component also displays the current upper and lower limit settings for the input and output, and includes an option button that allows you to choose an enhancement method.

The input histogram is shown vertically along the left edge of the window, and the display histogram horizontally across the top. You can choose to show the display histogram as a filled bar graph, or as a curve (envelope). The translation curve shows the graphic form of the function used to convert input raster values to display values. Some enhancement methods allow you to directly manipulate the shape of the translation curve. (This exercise continues on the next page).



Keep the Raster Contrast Enhancement window open and continue to the next page.



The Method option button on each tabbed panel lets you choose an enhancement method for that display color.

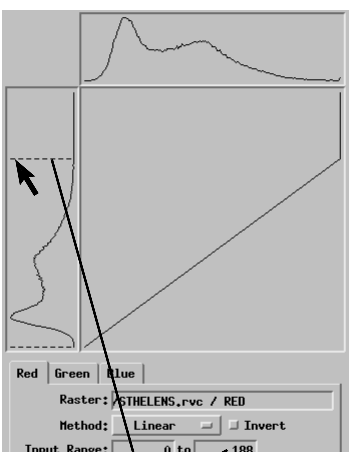
Adjust Linear Image Contrast

Each of the three raster components of the Mount Saint Helens image already has a stored Linear contrast table that maps input raster values to display values using a simple linear function. These tables were selected by default when you displayed the image. The image shows good color balance, but is somewhat dark and has low contrast.

The input histograms show that most cell values in the three rasters fall in the lower part of the 8-bit data range, and none of them has a significant number of cells with high values. We can therefore improve the image appearance by lowering the maximum input limit for each color component. Lowering these limits by roughly similar amounts shifts the display means to higher values, which brightens the image without adversely affecting the color balance. It also spreads the remaining set of input values over a wider range of display values, increasing the contrast. Cells with input values above the upper limit in all three rasters display as white. These cells correspond to the area of snow around the summit of the mountain, which of course should appear white.

STEPS

- ☑ click the tab for the Red component
- ☑ use the mouse cursor to drag the upper limit line for the Red input histogram down until the upper Input Limit value is 188
- ☑ click the tab for the Green component and change its upper input limit to 171
- ☑ repeat for the Blue component, setting an upper input limit of 151
- ☑ click the Redraw icon button on the Group View window 
- ☑ choose Save All from the File menu on the Raster Contrast Enhancement window to save changes for all three contrast tables



You can change input limits by moving the limit lines manually, or by typing a new value in the corresponding text box.

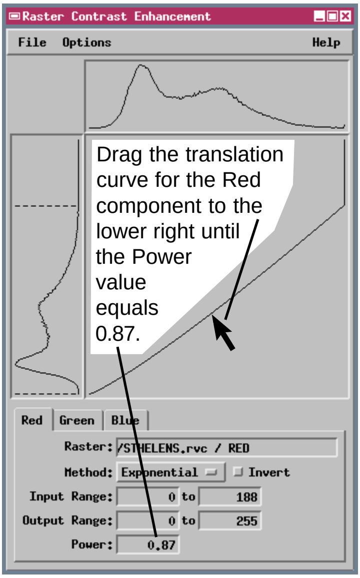
Keep the Raster Contrast Enhancement window open and continue to the next exercise.

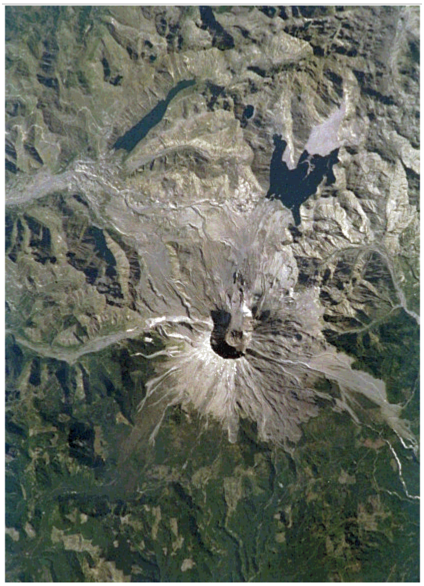
Adjust Exponential Image Contrast

STEPS

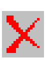
- ☑ click the tab for the Red component and select Exponential from the Method option menu
- ☑ use the mouse cursor to drag the translation curve toward the lower right until the Power value is 0.87
- ☑ choose Save As from the File menu and save a new contrast table for Red with the default name Exponential
- ☑ repeat the last two steps for the Green component, setting a Power value of 0.90
- ☑ click the Redraw icon button on the Group View window

After the contrast adjustments you made in the previous exercise, the brighter, nonvegetated areas in the Mount Saint Helens image show good contrast. The forested areas, however, are still somewhat dark and lacking in detail. We can preferentially improve the brightness and contrast of the forested areas by using Exponential contrast enhancement. In this method, display brightness is an exponential function of the input value. You can vary the function graphically by manipulating the translation curve, or enter an exponent value in the Power text field. The default power value is 1.00, corresponding to a simple linear enhancement. Power values less than 1.00 increase the mean output brightness, but preferentially increase the brightness and contrast of the lower range of input values. Power values greater than 1.00 lower the mean brightness, but preserve contrast over the upper range of input values.





Mount Saint Helens image after exponential contrast enhancement of Red and Green. Forested areas are brighter and have better contrast; nonvegetated areas are more brown.



Remove the RGB layer for the next exercise

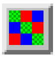
Automatic Contrast Enhancement

The Contrast option buttons on the Raster Layer Controls window allow you to choose a contrast table to use for each input raster. The default choice is the table last used to display the object. You can also choose to use one of several automatic contrast enhancement methods, or choose None to use raw raster values as display values. The automatic methods use default settings to stretch the range of input values to the full range of display values (for 8-bit rasters).

If no contrast table has been saved for an object, as is the case for the raster objects used in this exercise, the Auto Normalize contrast option is the default selection for 8-bit rasters. This method attempts to rescale the input values to fit a normal (symmetrical bell-shaped) distribution of display values. The median of the normalized distribution is set to the middle of the output range (128).

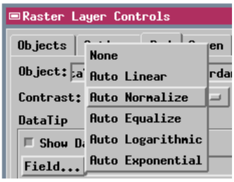
STEPS

☑ select Add RGB Rasters from the Add Raster icon button menu



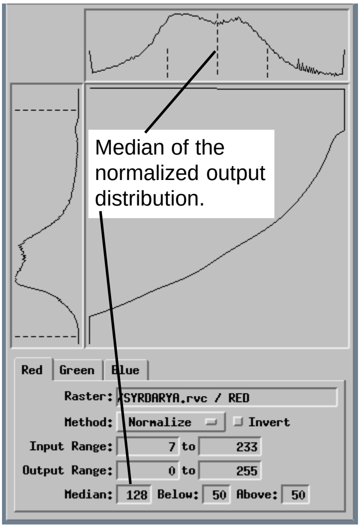
☑ select rasters RED, GREEN, and BLUE from the SYRDARYA Project File

☑ in the Raster Layer Controls window, note the default choices for Contrast for the Red component, then click [OK]



☑ select Enhance Contrast from the Tools icon button menu

Space Shuttle photograph of the semiarid Syr-Darya River region of Tajikistan, Kyrgyzstan, and Uzbekistan, displayed with auto-normalized contrast enhancement. Irrigated fields of the river valley are seen in the upper left.



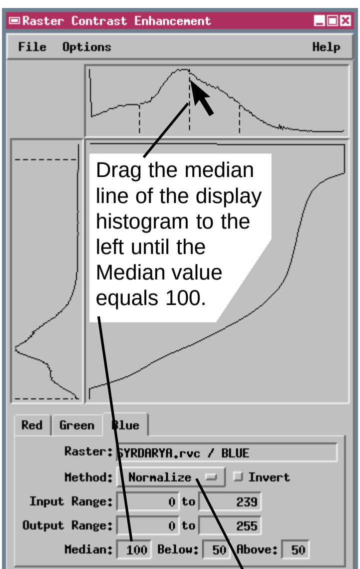
Keep the Raster Contrast Enhancement window open and continue to the next page.

Adjust Normalized Image Contrast

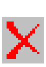
STEPS
- ☑ click the tab for the Blue color component
- ☑ click on the middle dashed line in the Display histogram and drag the line to the left until M=100
- ☑ redraw the display in the View window 
- ☑ select Save All from the File menu on the Raster Contrast Enhancement window and name each of the three new contrast tables
- ☑ choose Close from the File menu

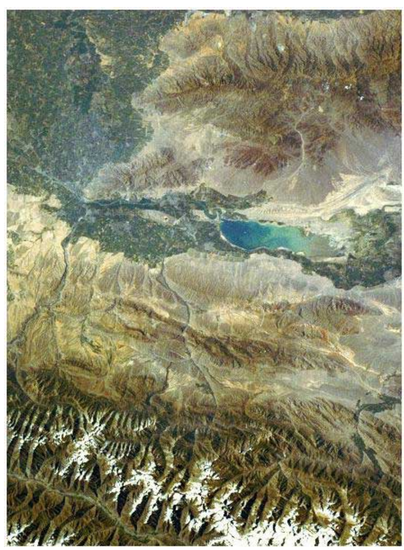
The auto-normalized display of the Syr-Darya shuttle image has a hazy appearance in some areas, and an overall bluish tint. Because the automatic contrast enhancement methods stretch each color component independently, they can over-stretch one or more of the components and thus not produce an appropriate color balance in the RGB display. In this exercise you reduce the brightness of the blue component of the image and save a new set of contrast tables.

You can change the position and shape of the normalized display histogram by moving the vertical dashed lines. Moving the middle line (representing the median brightness) to the left shifts the histogram toward lower values, reducing the overall brightness for that component. You can also move the flanking deviation lines to increase (stretch) or reduce (compress) the contrast for the upper or lower parts of the input range.



The default choice on each contrast method option button is the method currently used to display that color component.

 *Remove the RGB layer for the next exercise*



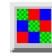
Syr-Darya image after adjusting the auto-normalized contrast for the blue color component.

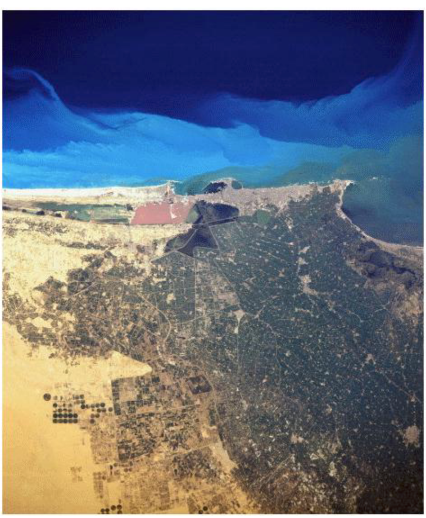
Single-Raster Composite Color

Color information can also be stored in a single **composite color** raster object. TNTmips supports several types of composite color objects. The first object used in this exercise is a 24-bit color composite, which can reproduce any color created by an RGB display of three 8-bit raster objects. A 24-bit composite raster stores three values for each cell (one for each display color), with an 8-bit data range for each value. A 16-bit composite raster has a similar three-value format, but uses only a 5-bit data range (32 brightness values) for each display color. You will probably see no discernible loss in color quality between the 24-bit and 16-bit composite versions of most images.

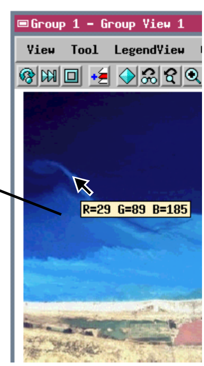
When you display a 24-bit or 16-bit composite color object, no interactive contrast enhancement is available. You can use the Color Conversion process (discussed subsequently) to create a fixed, composite color object from a contrast-enhanced RGB raster set.

STEPS

- ☑ select Quick-Add Single from the Add Raster icon button menu 
- ☑ select raster object COMP24 from the COLOR Project File
- ☑ select Setup Datatips from the layer Tools icon button menu 
- ☑ in the Spatial DataTip Selection window, make sure that the Show DataTip toggle button on the Raster Cells panel is turned on
- ☑ place the cursor over any part of the displayed image until the datatip appears, and note the values
- ☑ remove the COMP24 raster layer 
- ☑ repeat the first two steps, selecting the COMP16 object from the COLOR Project File



NASA Space Shuttle photograph of Alexandria, on the Mediterranean coast of Egypt. The green vegetation of the Nile River delta in the lower right contrasts with the barren sands of the Western Desert in the lower left.

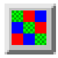


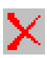
24-bit and 16-bit composite color rasters store separate Red, Green, and Blue values for each raster cell.

Remove the COMP16 layer for the next exercise

Composite Color with Color Palette

STEPS

- ☑ select Quick-Add Single from the Add Raster icon button menu 
- ☑ select raster object COMP8 from the COLOR Project File
- ☑ select Edit Colors from the layer Tools icon button menu 
- ☑ after you have examined the color palette, select Close from the File menu

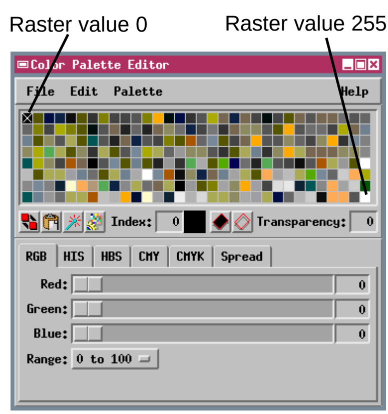


Remove the COMP8 layer for the next exercise

A final option for color composite images is an 8-bit composite color raster. This type of raster object can include up to 256 unique colors. The numeric values in the raster are arbitrary, and serve merely to assign display colors from a **color palette** (or **color map**) stored as a subobject of the raster. The color palette records a set of RGB values for each of the raster values in the 8-bit data range (0 to 255). A color map subobject is created automatically when you import an 8-bit color composite image, or when you use the Color Conversion process to create an 8-bit composite color raster from an RGB raster set or 24- or 16-bit composite raster.

The Color Palette Editor displays the array of assigned colors for the current composite raster object. Assignment of colors to particular raster values is arbitrary, so there is no obvious order to the color palette for a composite color raster. Likewise, displaying the raster without the color map does not produce a meaningful grayscale image.

Natural color image of South America from data acquired by the SeaWiFS satellite. The most cloud-free parts of images acquired over a 15-day period (18 September to 3 October 1997) were assembled to produce the final image.

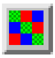


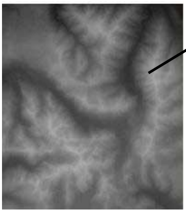
The Color Palette Editor window shows the color assigned to each possible raster value, from 0 in the upper left to 255 in the lower right. (Raster values are ordered from left to right, then from top to bottom in the sample array).

Grayscale Raster with Color Palette

A color palette can also be used to create a pseudocolor display from a grayscale raster object. When the raster values represent a smoothly varying surface, you can create a color palette with a similarly smooth gradation of colors to emphasize the characteristics of the surface. A color map can be used with any type of grayscale raster object, but no more than 256 colors can be included in the color palette. When you use a color map with a 16-bit or floating-point raster object, the display process automatically partitions the range of raster values into 256 bins for purposes of color assignment. If you select a contrast option other than None, the contrast enhancement is applied before the color assignments are made from the color palette.

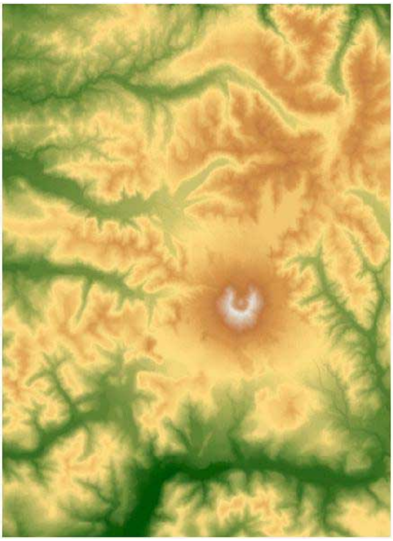
STEPS

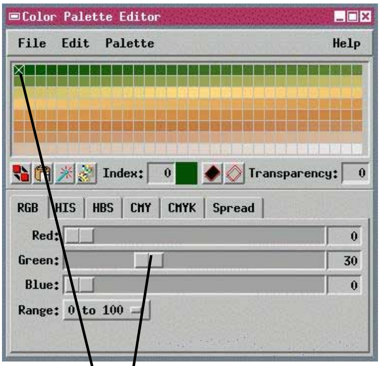
- ☑ select Add Single Raster from the Add Raster icon button menu 
- ☑ select raster object DEM16 from the COLOR Project File
- ☑ in the Raster Layer Display Controls window, make sure that ColorMap is selected on the Color Palette option button, then click [OK]
- ☑ select Edit Colors from the layer Tools icon button menu 



Upper right portion of the DEM (a 16-bit raster) displayed without the color map. Displaying the DEM with the color map creates a more lively and interesting display, and brings out more detail.

Digital elevation model of Mount Saint Helens, Washington. The color map portrays low elevations in green, grades up through yellow to brown, and shows the mountain summit in very light gray.



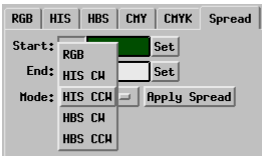


You can edit any color in the color palette by clicking on its tile and manipulating the sliders for Red, Green, and Blue. (Sliders for the HIS, HBS, CMY, and CMYK color systems are found on their respective tabbed panels). The X symbol marks the selected color.

Keep the Color Palette Editor window open and continue to the next page.

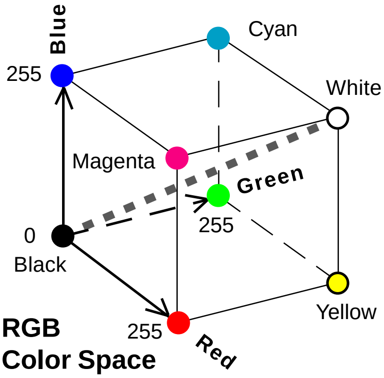
Color Spaces and Color Spreads

☑ click on the Spread tab in the Color Palette Editor, then click on the Mode option button to reveal the selection of available color spread models



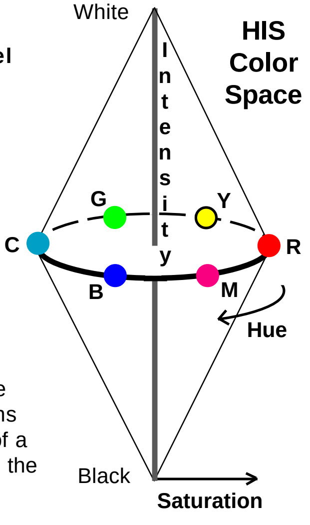
You can create a color palette with smooth color gradations by applying a **color spread** to all or part of the palette. You first assign a color for the low and high ends of the selected value range; applying the spread creates a gradual color variation across the range of intervening values.

Several color spread modes are available. Each mode uses a particular color model to represent ranges of colors. These color models are most easily understood if they are represented graphically as three-dimensional **color spaces**.



The **RGB color model** represents colors within a cubic volume defined by orthogonal Red, Green, and Blue axes. Black is at the origin of the coordinate system (R=G=B=0), and white is at the opposite corner of the cube (R=G=B=255). The diagonal connecting the black and white corners (gray dashed line) contains the range of neutral gray levels. Complementary colors (such as blue and yellow) lie at opposite corners of the cube. An R-G-B color spread includes colors found on a straight line connecting the two end-member colors (for example, the edge connecting red and yellow).

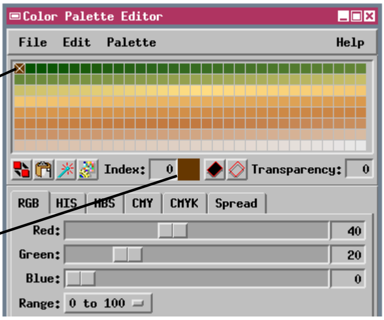
The **Hue-Intensity-Saturation (HIS) color model** represents colors within a double-cone space. The vertical axis is intensity, which represents variations in the lightness and darkness of a color. The 0 intensity level is black; full intensity is white. HIS values elsewhere along the intensity axis represent different levels of gray. On any horizontal slice through the model space, the hue (or “color” of the color) varies around the slice, and the saturation (the purity of the color) increases radially outward from the central intensity axis. Maximum saturation in this model is at the midpoint of the intensity range. (The closely-related HBS model uses a single-cone color space with maximum saturation at full brightness.) You can apply an HIS spread in either the clockwise (CW) or counterclockwise (CCW) directions around the cone. (The directions are defined in terms of a view upward along the intensity axis; the arrow shows the counterclockwise direction).



Creating a Color Spread

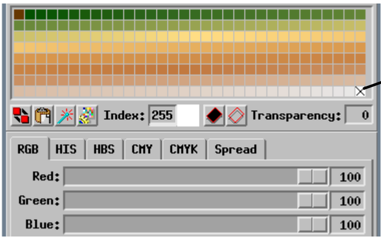
Now let's try creating a clockwise HBS color spread from brown (for the 0 palette index) to white (for 255). This produces a smooth gradation from brown to green, gray, and white.

Use the Red and Green sliders to change the color for palette index 0 to brown. The color tile next to the Index field shows the color for the current index value.



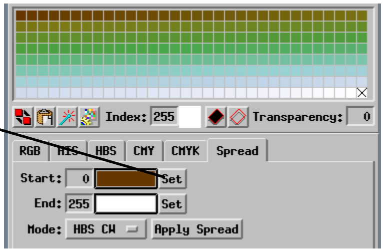
STEPS

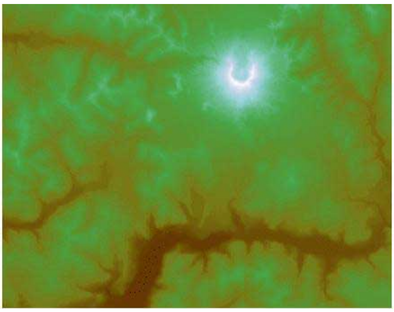
- ☑ on the RGB panel, move the Red slider Red to 40 and the Green slider to 20
- ☑ click on the color tile in the lower right corner of the color palette (index 255)
- ☑ move all three sliders all the way to the right to set index 255 to white
- ☑ on the Spread panel, select HBS CW from the Mode option menu
- ☑ press [Apply Spread]
- ☑ click the Redraw icon button on the Group View window 



Change the color for palette index 255 to white.

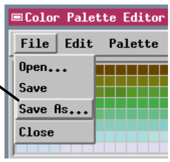
You can use the Set buttons to designate any selected palette index as the start or end of a color spread (0 and 255 are the default values). You can design complex color palettes by specifying a number of intermediate colors, then creating color spreads between them.





Lower part of the Mount Saint Helens DEM with the new color spread applied.

After you apply the spread you can choose Save As from the File menu to save the new color palette as a subobject of the current raster object.



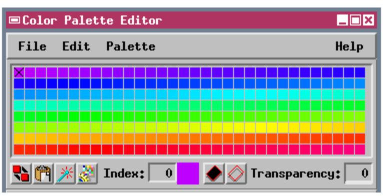
Keep the Color Palette Editor window open and continue to the next exercise.

Using Standard Color Palettes

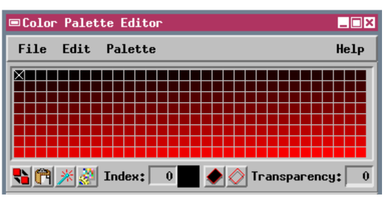
STEPS
- ☑ select Rainbow 1 from the Palette menu in the Color Palette Editor window
- ☑ click the Redraw icon button on the Group View window

The Display process also provides a number of standard color palettes that can be selected from the Palette menu for use with any raster object. The Rainbow palette mimics the range of colors in a rainbow, from purple (index 0) through blue, green, yellow, red, and pink (index 255). The Gray, Red, Green, and Blue Scale palettes each have index 0 set to black, then progress through increasing levels of the respective color. The Random color palette has colors assigned randomly to the palette index values.

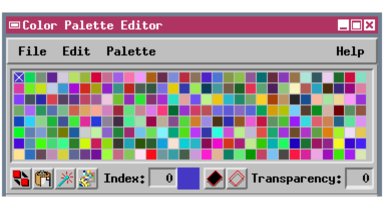
You can edit any standard palette to create a new color palette. After editing, you can choose Save As from the File menu to save the new palette as a subobject of the current raster. Alternatively, you can use the Save As option on the Palette menu to save the new palette as a standard palette. The new palette is added to the Palette menu, and so becomes available for use with any raster object.



Standard Rainbow 1 color palette.

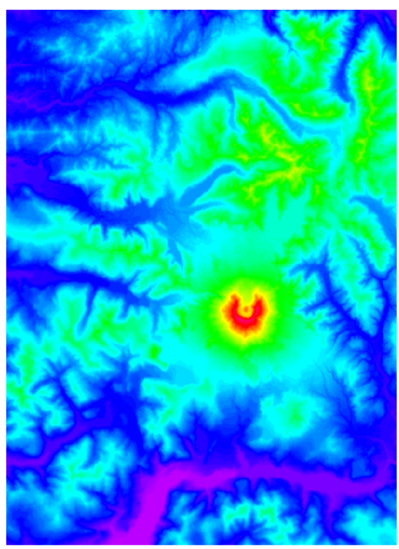


Standard Red Linear color palette.



Standard Random color palette.

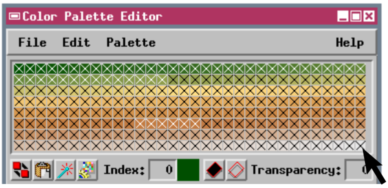
Close the Color Palette Editor window and close the current group for the next exercise.



Mount Saint Helens DEM displayed with the Rainbow color palette.

Using Transparent Raster Colors

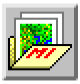
The Color Palette Editor also allows you to set a transparency percentage value for any or all colors in the palette, from 0 (completely opaque) to 100 (completely transparent). The color-mapped raster can then be displayed over other layers to add information without obscuring the underlying objects. The two-layer display of a DEM in this exercise combines elevation-keyed colors with the visual effect of shaded relief.



Holding down the Shift key while clicking on a color tile selects the entire color range from the previously selected tile (in this case, index 0) to the new tile (index 255).

STEPS

- ☑ click the Open icon button on the Display Spatial Data toolbar and choose Open Group

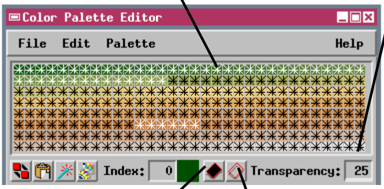


- ☑ select DEMGROUP from the COLOR Project File
- ☑ click the Tools icon button on the upper layer controls icon row and select Edit Colors from the menu

- ☑ in the Color Palette Editor window, hold down the Shift key while clicking on the lower right color tile (index 255) to select the all palette colors
- ☑ enter 25 in the Transparency text box
- ☑ redraw the display in the View window

A cross symbol marks the tiles for colors that have a non-zero transparency value.

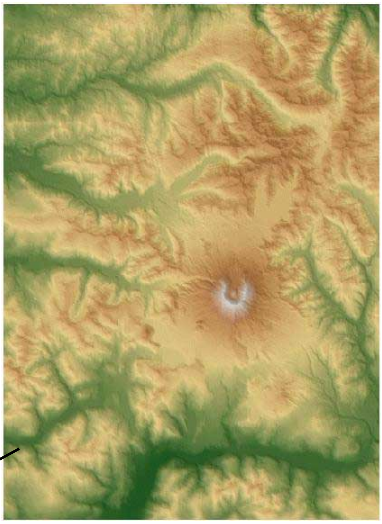
Enter transparency percentage values in the Transparency text box.



Set Selected Opaque (0 Transparency)

Set Selected Transparent (100% Transparency)

These icon buttons provide a quick means to set selected colors completely opaque or completely transparent.

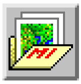


Mount Saint Helens DEM displayed in two layers: color-mapped with each color 25% transparent in the upper layer, and in shaded relief in the lower layer. A saved transparent color map is stored with the DEM16 raster as subobject TransColor.

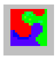
Close the Color Palette Editor window and close the current group for the next exercise.

Vector Polygon Fill Transparency

STEPS

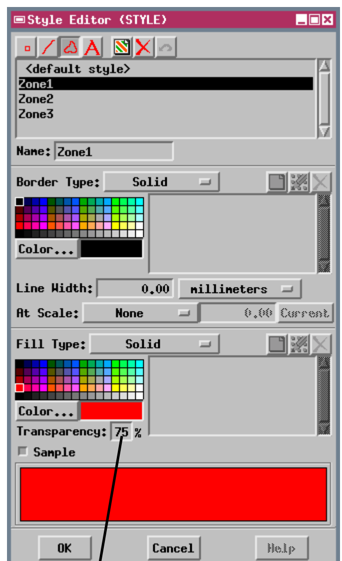


- ☑ click the Open icon button on the Display Spatial Data toolbar and choose Open Group
- ☑ select HAZGROUP from the COLOR Project File

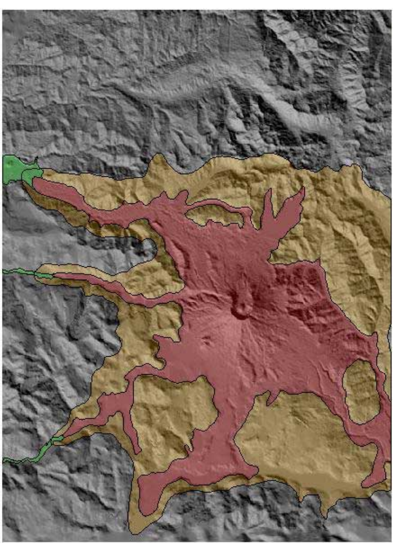


- ☑ click the Vector icon button in the COLOR / HazZones layer icon row
- ☑ click the Polygons tab in the Vector Layer Controls window, then click [Specify...] for Style: By Attribute
- ☑ on the Style Assignment window that opens, press [Edit]

Solid color fill styles that you create for vector or CAD polygons or for TIN triangles also can be displayed with varying degrees of transparency. The object with transparent fills can then be displayed over another object (such as a raster image), and the information conveyed by both layers is easily visible. Once you have set a transparency value as part of the definition of a fill style, the transparency effect is used automatically in both the standard display process (in both 2D and 3D views) and when you print. For more information on vector display styles, consult *Getting Started: Creating and Using Styles*.



Set a Transparency percentage for solid polygon fills in the Style Editor window (0% = completely opaque fill, while 100% = fully transparent = no color fill).



Mount Saint Helens DEM displayed with relief shading, overlaid by a vector hazard zonation map. The polygon fills are solid colors with 75% transparency, so the underlying terrain remains visible.

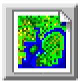
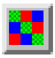
Close the Style Editor, Style Assignment, and Vector Object Display Controls windows, then close the current group for the next exercise.

RGBI Raster Display

The RGBI raster display mode uses four raster objects to produce an enhanced RGB display. The three rasters selected as Red, Green, and Blue components are first converted to the HIS color space. The designated Intensity object is then substituted for the calculated intensity, and the rasters are converted back to the RGB color space for display. All selected objects must have the same cell size and extents.

The RGBI display mode is useful for merging visual information obtained by different sensors. For example, an RGBI display might use three bands from a multispectral optical sensor (such as Landsat TM or SPOT XS) to determine hue and saturation, and a grayscale radar image to set the intensity. This exercise shows another example, in which a high-resolution panchromatic image is used as the intensity component to enhance the spatial resolution of the multispectral bands.

STEPS

- ☑ click the New Group icon button on the Display Spatial Data toolbar 
- ☑ select Quick-Add RGBI from the Add Raster icon button menu 
- ☑ from the RGBI Project File, select raster object TM5R for Red, TM4R for Green, TM3R for Blue, and SPOTPAN for Intensity

Close the current group for the next exercise.

RGB display of objects TM5R, TM4R, and TM3R. (These objects were produced by resampling to the 10-m cell size and extent of the SPOT panchromatic image.)

RGBI display of the same three TM rasters with object SPOTPAN as Intensity. The resulting display combines the high spatial resolution of the SPOT panchromatic image with the spectral content of the TM bands.

Color Conversion Process

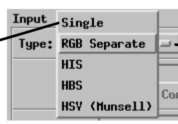
STEPS

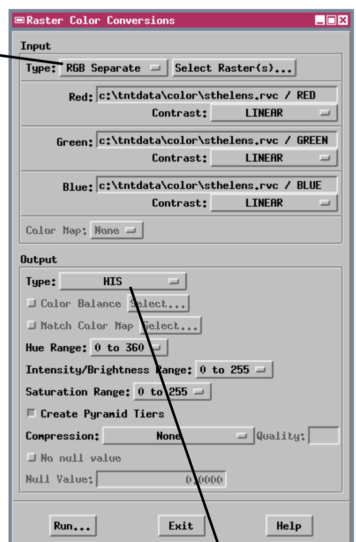
- ☑ select Process / Raster / Combine / Convert Color from the TNTmips main menu
- ☑ select RGB Separate from the Input Type option button
- ☑ click [Select Raster(s)...] and select rasters RED, GREEN, and BLUE from the STHELENS Project File
- ☑ select HIS from the Output Type option button
- ☑ click [Run]
- ☑ use the standard File / Object Selection procedure to name a new Project File and the output raster objects

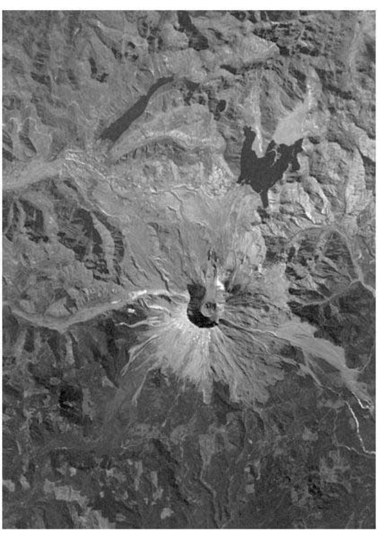
The Color Conversion process allows you to change the storage mode or color space of any color image. You can convert from or to a single color composite raster, an RGB raster set, or Hue-Intensity-Saturation (or related variant) raster set. With RGB input rasters you can select contrast tables or automatic contrast enhancements to be applied during conversion.

When you have an RGB image which is dark but has good color balance, conversion to the HIS color space can provide an easy means of enhancing the color. You can display the output Intensity raster, adjust its brightness and contrast, and select the resulting contrast table for use during the reconversion from HIS to RGB. The resulting RGB raster set will show improved brightness and contrast while retaining its original hues.

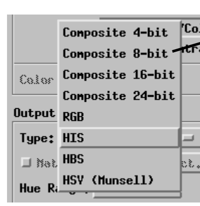
Choose the Single option to select a color composite raster for conversion.







Intensity raster created from RED, GREEN, and BLUE color component rasters, displayed with auto-normalized contrast enhancement.



Output type options.

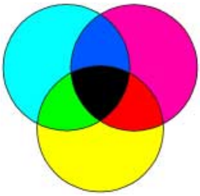
Click Exit to close the Raster Color Conversions window.

In a Dither about Printing

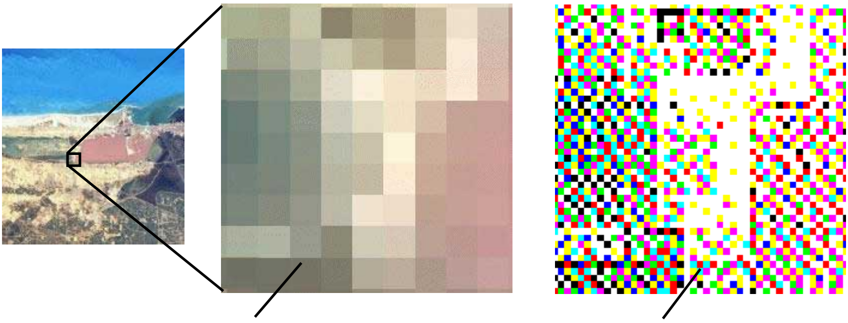
Now that we have covered the basics of producing good colors when displaying images, we turn to the realm of printing color images. Let's begin by considering how printers reproduce colors. Most digital printers apply tiny dots of cyan, magenta, and yellow ink to the page. For most common printers (such as ink-jet and solid-ink types), these dots have a fixed size, and each ink color is either fully "on" or fully "off" for each dot. By overlaying the translucent inks on a single dot, these printers can also produce blue, green, red, and black dots. If no ink is applied for a dot position, it remains white.

Printers use these eight basic colors to simulate a much wider range of image colors. This is possible because of the printer's high spatial resolution. In other words, the ink dots are very tiny and very close together, which has two important consequences. First, a single image pixel is commonly represented by an array of ink dots. Second, we can't distinguish the individual dot colors, but instead perceive a blended color produced by groups of nearby dots. By varying the colors and placement of printer dots for each image cell (a process called **dithering**), the printer can produce the visual effect of the original colors in the image.

Low end printers use only cyan, magenta, and yellow inks. Four-color (CMYK) printers include a separate black ink supply (K) to produce pure black tones and reduce the use of the colored inks. Some new desktop printers now offer six or seven inks, including lighter hues of the primary ink colors.



Printer resolution is measured in dots per inch, abbreviated **dpi**. Typical desktop printers have print resolutions of 300 to 720 dpi. High-end printers used by graphics service bureaus may have resolutions of 1200 or 2400 dpi.

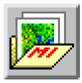


Highly magnified portion of the Alexandria Space Shuttle photo. A 24-bit color image includes very subtle cell-to-cell color variations.

Same area dithered for printing. At this layout scale, each input raster cell is represented by a 5 x 5 array of printer dots. The dithering process uses different patterns of the available print colors to recreate the wide range of colors in the original image.

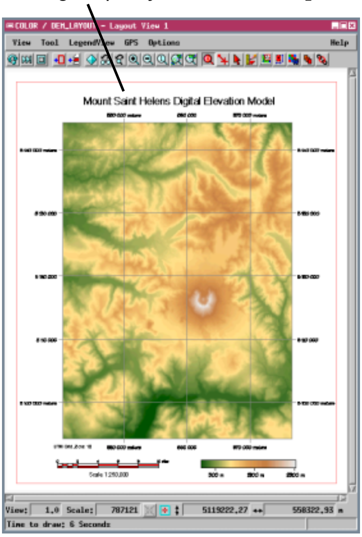
Page Setup Window

STEPS



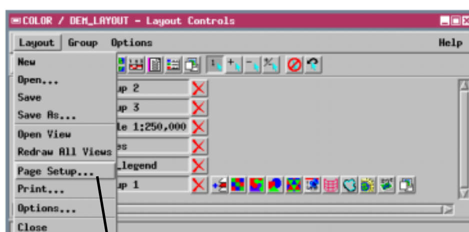
- ☑ click the Open icon button on the Display Spatial Data toolbar and choose Open Layout
- ☑ select DEM_LAYOUT from the COLOR Project File
- ☑ choose Page Setup from the Layout menu on the Layout Controls window

The layout used in this exercise was created using standard tools available in the Hardcopy Layout process. For an introduction to the use of the layout tools, consult the Getting Started booklet *Making Map Layouts*.



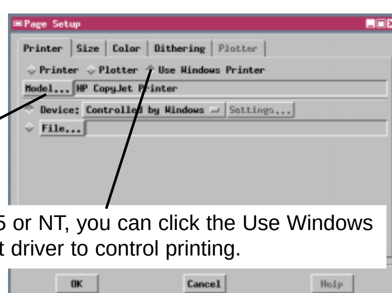
To illustrate the color adjustments available during printing, we will work with a sample hardcopy layout designed for printing to an 8.5" x 11" page in portrait orientation. You can print layouts up to 11" x 17" in size with TNTlite, TNTview, or TNTedit. The professional version of TNTmips supports printing to a variety of page sizes (up to 44" rolls) and printing over multiple pages.

You make color adjustments for printing using the Page Setup window, which comes in two versions. When you choose Page Setup from the Layout menu on the Layout Controls window (or choose Support / Setup / Printers from the TNTmips main menu), you can set up basic print parameters and save them by pressing the OK button without actually initiating printing. When you select Print from the Layout menu, the Page Setup window opens with a Run button in place of OK, but the remaining controls are identical. Pressing the Run button starts the printing process and closes the window.



Select Page Setup from the Layout menu.

You should already have a printer set up from the Print exercise in *Getting Started: Displaying Geospatial Data*. If not, use the controls on the Printer tabbed panel to select one.

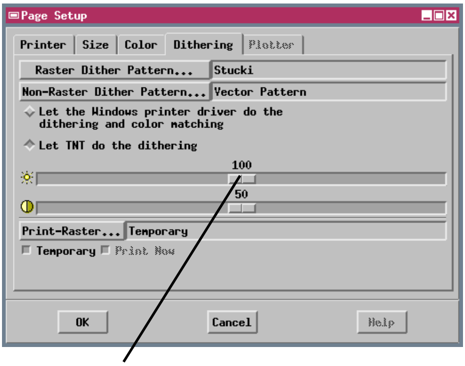


If you are running TNTmips under Windows95 or NT, you can click the Use Windows Printer radio button to use your Windows print driver to control printing.

Choosing Dither Patterns

The controls on the Dithering tabbed panel allow you to choose dither patterns for both raster and nonraster components of your print layout. The Floyd-Steinberg, Jarvis-Judice-Ninke, Stucki, and Ordered Dither patterns usually provide good results for color images on most printers, and the choice between them is a matter of personal preference. The sample in the lower part of the Dither Pattern window gives you some idea of how the pattern looks for different colors. The Stucki (enhanced gray) pattern provides the best results when you print a grayscale raster image. The default Vector pattern for nonraster components insures continuity of thin lines in vector, CAD, or TIN overlays, and those in map grids, scale bars, and legends.

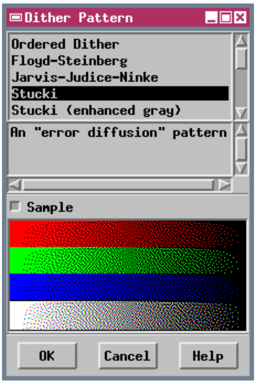
The print drivers supplied with many printers now have built-in dithering capability. If you are printing to a Windows printer using the Windows print driver, you have the choice of letting either TNTmips or the Windows print driver do the dithering. The latter choice typically requires more processing time than using the TNTmips dithering process.



The two sliders on the Dithering panel can be used to adjust the overall brightness (upper slider) and contrast (lower slider) for the print output. Moving a slider to the right increases its respective property in the print. But for better and more predictable results, you should use the Intensity and Saturation sliders on the Color panel (described subsequently).

STEPS

☑ click the tab for the Dithering panel, and press [Raster Dither Pattern...]
☑ from the list in the Dither Pattern window that opens, select Stucki
☑ click [OK] to close the Dither Pattern window
☑ click [OK] on the Page Setup window
☑ click the Print icon button on the Layer Controls window to print the layout



Dye sublimation printers and film recorders are not limited to the eight basic dot colors produced by most printers. They are able to continuously vary the level of each color component used to reproduce the image pixels, resulting in true continuous-color output. Dithering is not required when you print to one of these devices, so the dither pattern controls are inactive.

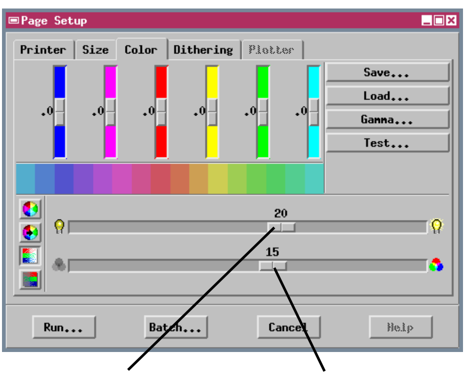
Adjusting Intensity and Saturation

STEPS

- ☑ select Print from the Layout menu
- ☑ click the Color tab on the Page Setup window
- ☑ slide the Intensity slider back and forth and note the effect on the color sample bar above it
- ☑ repeat with the Saturation slider
- ☑ set the Intensity level to 20 and the Saturation level to 15
- ☑ press [Run...] to print the layout and close the Page Setup window

Using dithering, a printer can produce a range of colors comparable to that of a computer monitor. But dithering doesn't ensure that a particular color generated by the printer will look the same as the corresponding color on the display screen. Because of the different ways in which the colors are created, there is usually a significant shift in colors between the screen display of a raster image and the printed version, and some display colors may be outside the printer's available range of colors.

The Color panel of the Page Setup window provides a number of controls that allow you to alter the manner in which image colors are translated to the printer. Using these controls you can adjust the colors produced in the print without altering the contrast tables or color palette you have created to provide screen colors.



Intensity slider

Saturation slider

The colors produced by inkjet printers are often darker and less saturated than the corresponding screen colors. The lower part of the Color panel includes two horizontal sliders that use the HIS color model to modify all of the colors in the print image simultaneously. Moving the upper slider to the right increases the intensity (brightness) of all colors. Moving the lower slider to the right increases the saturation of each hue at the expense of intervening pastel shades. The color sample bar above these sliders changes as you move the sliders, giving you a preview of their overall effects. Many natural color images benefit from modest increases in intensity and saturation during the print process. However, if part of the image is already very bright, increasing the overall intensity may "wash out" the color in this part, resulting in a local loss of detail.

The intensity and saturation slider settings are not saved between print jobs, or when you press [OK] on the nonprinting Page Setup window. If you are using slider settings other than the default 0 values, you must reset the sliders each time you print.

Color Balancing

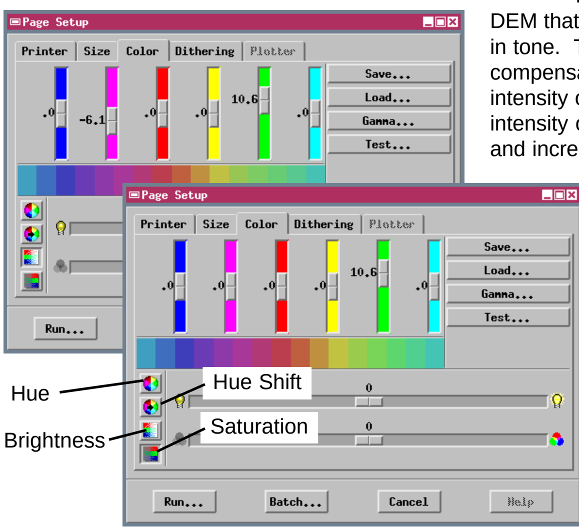
The controls you adjusted in the previous exercise influence all of the raster image colors in your print. However, all screen colors may not print equally well from a given layout. For example, green and blue typically print darker than other colors on inkjet printers, and deep blue colors on the screen often appear closer to purple when printed. You can use the vertical color sliders in the Color panel in conjunction with the four icon buttons in the lower left part of the panel to adjust individual output colors.

With the Brightness icon button turned on, moving a slider increases or decreases the intensity of its color. With the Saturation button turned on, move a slider up to increase the saturation (purity) of the color, or move the slider down to move the color toward gray. The color bar beneath the sliders previews the resulting effects. Slider positions are not automatically saved when you run the print process or click [OK] on the nonprinting Page Setup window. However, you can save these settings at any time in a color balance object by pressing the Save button, and recall saved settings using the Load button.

STEPS

- ☑ select Print from the Layout menu
- ☑ click the Color tab on the Page Setup window
- ☑ with the Brightness icon button selected (the default) move the Green slider upward to a value of 10.6 and the Magenta slider downward to a value of -6.1
- ☑ press the Saturation icon button, and move the Green slider upward to a value of 10.6
- ☑ press [Save], use the File / Object Selection window to navigate to the COLOR Project File, and name a new color balance object
- ☑ press [Run] to print the layout and close the Page Setup window

My printer produces greens in the Mount Saint Helens DEM that are too dark and too olive in tone. The settings in this exercise compensate by increasing the intensity of green, decreasing the intensity of its complement, magenta, and increasing the green saturation.



The color sliders can also be used in conjunction with the Hue and Hue shift icon buttons to modify selected hues, but this is a tricky procedure which may produce unexpected results. You should be able to achieve a good color balance using only the Brightness and Saturation settings.

Adjusting Gamma Contrast

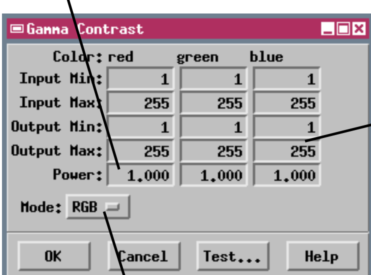
STEPS

- ☑ select Print from the Layout menu
- ☑ click the Color tab on the Page Setup window
- ☑ click [Gamma...]
- ☑ in the Gamma Contrast window, use the mouse to highlight the Power text box for Green, and type in the value 1.4
- ☑ change the Power value for Blue to 1.2
- ☑ click [OK] to accept the values and close the Gamma Contrast window
- ☑ press [Run] to print the layout and close the Page Setup window

The Gamma Contrast window provides an alternative means of selectively adjusting how screen colors are translated to print colors. The relationship between the brightness variation of a color in a print and the brightness variation of that color in a screen display is typically not a linear one. Instead, it is approximately a power function. That is, the print brightness equals the screen brightness raised to some exponential power. In computer graphics, the Greek letter "gamma" is the symbol used for the numerical exponent in the power function.

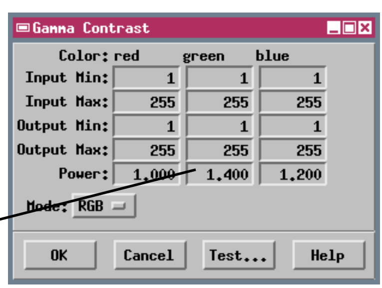
The Gamma Contrast window has a Power text box for each color component in which you can enter a value for the gamma exponent (the default is 1.00, which defines a linear brightness translation). The Mode option button allows you to choose between RGB (display color) or CMY (ink color) modes for specifying gamma values. Although color printing uses CMY, it is easier to visualize the results using RGB mode. Entering a gamma value greater than 1.0 for red, green, or blue brightens the low to middle intensity range of the color in the print; entering a value less than one has the opposite effect.

The Gamma Contrast window opens with default values for gamma of 1.00 for each color component.



You can also change the allowed minimum and maximum input and output values to adjust the brightness and contrast of the print.

RGB is the default color mode.



The gamma values used in this exercise are designed to brighten the green colors in the print without brightening red. Green areas should appear brighter in the print, and brown areas should contain less red.

Printing Test Strips

The settings on the Color panel affect the printing process and not the screen display, so you must print the layout to assess the results. It may take some trial and error to discover the best settings for your printer, and printing the entire layout for each change in settings would be time-consuming. To avoid this problem, you can print a set of test strips of a raster layer that use a sample area to show the results of a number of different color balance or gamma contrast settings.

STEPS

☑ select Print from the Layout menu

☑ click the Color tab on the Page Setup window

☑ set the horizontal Brightness slider to 20 and the Saturation slider to 10

☑ click [Test...]

☑ in the Test Strip Setup window, click [Add]

☑ with the Brightness icon button turned on, set the color sliders to the following values from left to right:

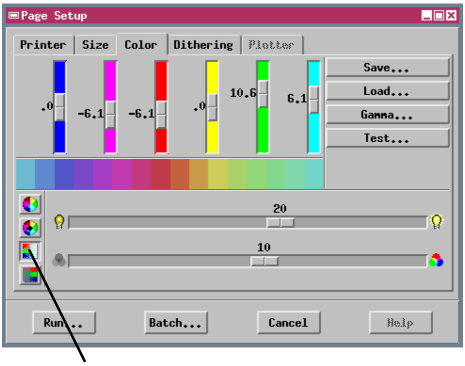
0.0, -4.5, -4.5, 0.0, 6.1, 3.0

☑ click Add again

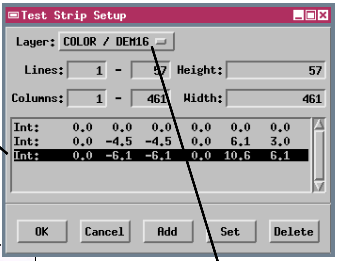
☑ repeat the last two steps with the following slider settings:

0.0, -6.1, -6.1, 0.0, 10.6, 6.1

☑ click [OK] on the Test Strip Setup window to print the test strips



You can adjust settings for any or all of the color balance parameters before adding a listing in the Test Strip Setup window. The listing shows the settings for whichever parameter is currently selected by a color balance icon button.



If there is more than one raster layer in your layout, use the Layer option button to choose which layer to test.

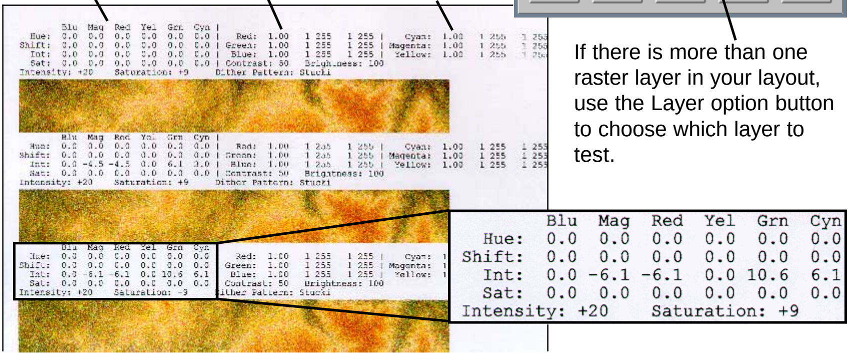
Each test strip is preceded by a listing of all settings:

Color Balance

Gamma Contrast:

RGB

CMY



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