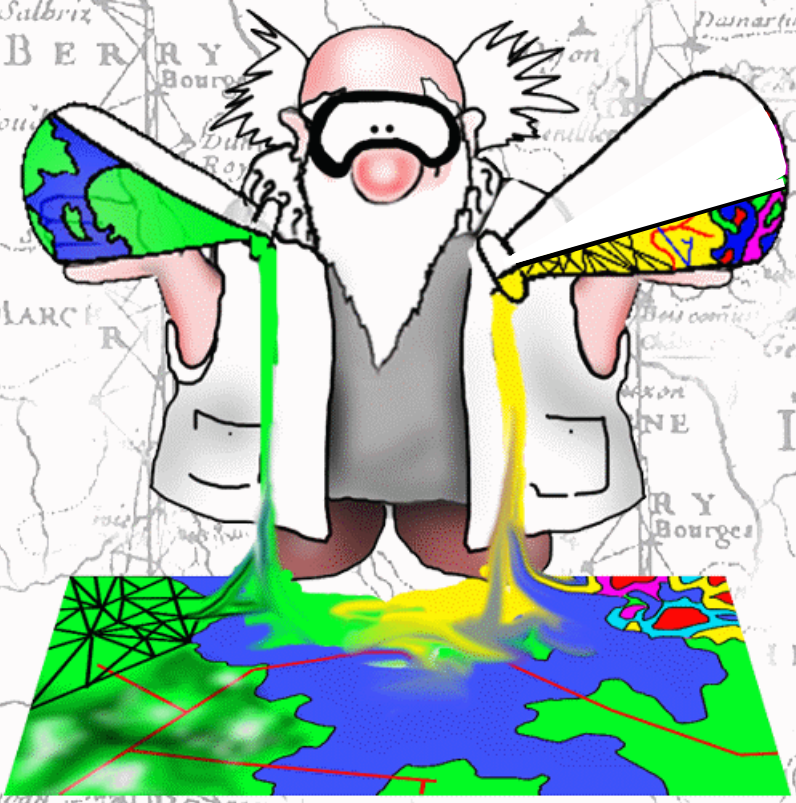
GEOFORMULAS

Tutorial

Using Geospatial Formulas



in

TNTmips®

TNTedit™

TNTview®

Before Getting Started

This booklet introduces techniques for using GeoFormulas™ in TNTmips®, TNTedit™, and TNTview®. Geospatial objects from TNT Project Files can be combined dynamically in the display process to achieve "data fusion" effects in a virtual display layer or new raster object. This booklet introduces you to the basic GeoFormula tools in the Main / Display and Script / GeoFormula processes.

Prerequisite Skills This booklet assumes that you have completed the exercises in the tutorials *Displaying Geospatial Data* and *TNT Product Concepts*. The exercises in those booklets present basic skills and techniques for selecting and viewing objects stored in Project Files and getting around in TNTmips. Please consult those booklets and the TNTmips reference manual for any review you need. You will also find it helpful to complete the exercises in the *Writing Scripts with SML* tutorial, since GeoFormula constructions use SML syntax.

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 DVD, you can download the data from MicroImages' web site. In particular, this booklet uses objects in the CB_DATA and GEOFRMLA data collections.

More Documentation This booklet is intended only as an introduction to data fusion with GeoFormulas. Search for additional materials available on MicroImages' website or locally installed documentation for more information.

TNTmips® Pro and TNTmips Free TNTmips (the Map and Image Processing System) comes in three versions: the professional version of TNTmips (TNTmips Pro), the low cost TNTmips Basic version, and the TNTmips Free version. All versions run exactly the same code from the TNT products DVD and have exactly the same features. If you did not purchase the professional version (which requires a software license key) or TNTmips Basic, then TNTmips operates in TNTmips Free mode.

The GeoFormula feature is also available in TNTedit and TNTview. The exercises can be completed in TNTmips Free using the sample geodata provided.

Keith Ghormley and Merri P. Skrdla, Ph.D., 3 January 2011

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 tutorial booklets on other topics. You can download an installation guide, sample data, and the latest version of TNTmips Free:

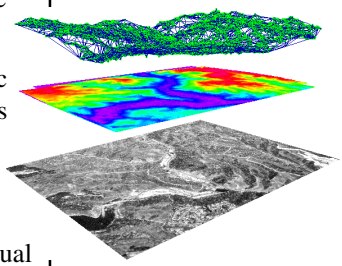
http://www.microimages.com

Introducing Geospatial Formulas

A GeoFormula is a script that uses one or more input objects to derive a new result. Use a GeoFormula layer in the Display process to combine objects "on the fly" to create a virtual layer rather than running a separate process to prepare output objects. Alternatively, run the standalone GeoFormula process (Script / GeoFormula) to create saved output raster objects for other uses. A GeoFormula script can be saved in Display or the standalone process as a small, reusable file that can be run with the same or new input objects.

One or more layers in a display may be dynamically computed from a **GeoFormula** that refers to one or more input objects.

The GeoFormula feature provided for dynamic visualization tasks in Display is the primary focus of this booklet. However, the same scripts can be run in the standalone process if you want to save the ouput to a raster (see pages 18–19).



A GeoFormula layer in Display contains a "virtual object." A GeoFormula layer does not create an output object in a Project File. Instead, it creates a display layer that releases all its system resources (such as disk space and memory) when you are finished with it. A GeoFormula layer can be combined with any number of other geospatial layers in TNT's Display process to create a complex visualization.

GeoFormula display layers perform file access and multi-object processing on the fly. Thus you may notice that this processing overhead results in slower display times that may seem sluggish compared to other display layers. The Preview tab offers a small, quicker rendering.

Grayscale GeoFormula layers created in the Display process are assumed to have a range of values from 0–255. Values that fall outside this range are assigned to the nearest extreme (e.g., 0 if less than 0). Results of a GeoFormula that evaluate as not a number (e.g., divide by 0) or as imaginery numbers [e.g., square root of (–*x*)] are treated as null.

Simple one-object GeoFormulas are introduced on pages 4 and 5. Pages 6-12 present a number of multi-raster scripts. The exercises on pages 13-15 show how to combine both raster and vector objects in a single GeoFormula. Pages 16–19 describe DataTips, scripting issues, use of the GeoFormula Creation Wizard, and saving output.

When running the standalone GeoFormula process, whether you are opening an existing script, using the GeoFormula Creation Wizard to assist you with a new script, or a creating a new script without wizard assistance, it is important that you check the Output panel to ensure the raster type selected can contain the possible range of output values.

A Simple GeoFormula

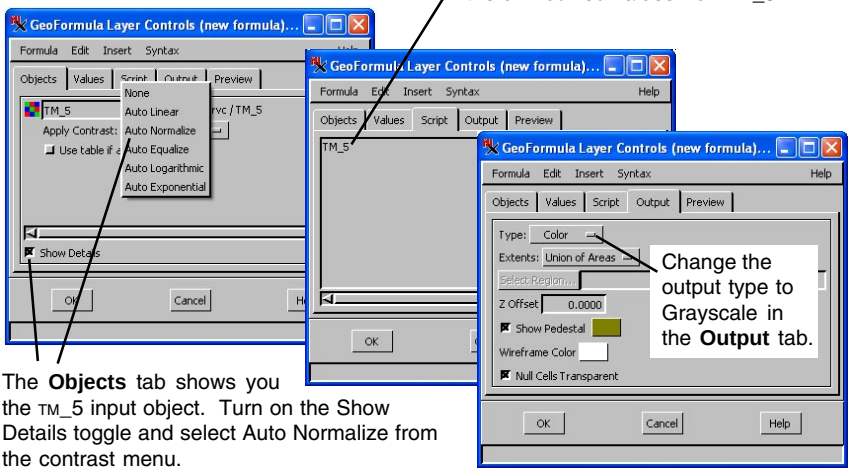
STEPS

- ☑ choose Main / Display, click on the New icon, and choose Empty 2D
- ☑ from the Display Manager menu choose Add/Layer/GeoFormula/ Add GeoFormula Layer
- ☑ select Formula / New in the GeoFormula Layer Controls dialog
- ☑ select CB_DATA / CB_TM / TM_5 in the Select Objects dialog
- ☑ click the Show Details toggle on the Objects panel and select Auto Normalize for contrast
- ☑ select the Script tab and type in "TM_5"
- ☑ select the Output tab and change the Type to Grayscale
- ☑ click [OK] to close the GeoFormula Layer Controls dialog
- ☑ click [No] in the Question dialog that asks if you want to save changes

GeoFormula layers are added to an already open view (either empty or containing other layers) from the Add menu in the Display Manager. You can choose either Quick-Add GeoFormula, which prompts you to select a saved GeoFormula file (*.gsf) and then prompts for the objects to use, or Add GeoFormula Layer, which opens the GeoFormula Layer Controls. You can create a new GeoFormula or open an existing one in the GeoFormula Layer Controls. You can also save any GeoFormula you create in it. Since a GeoFormula must refer to at least one georeferenced object, the process prompts you to select one or more input objects in the standard Select Objects dialog.

For this script, we will simply display the unmodified values of the TM_5 raster object in grayscale. Select the Object, Script, and Output tabs in turn and make the changes illustrated below. When you click [OK] after making the last change, the process closes the GeoFormula Layer Controls dialog and displays the GeoFormula layer.

On the **Script** tabbed panel, a very simple GeoFormula expression uses the unmodified values from TM_5.

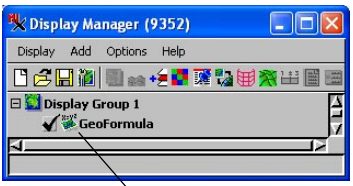


The **Objects** tab shows you the TM_5 input object. Turn on the Show Details toggle and select Auto Normalize from the contrast menu.

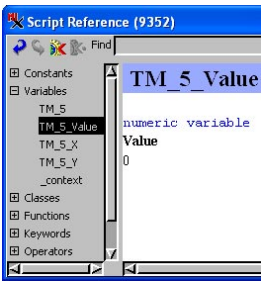
Change the output type to Grayscale in the **Output** tab.

Using Insert Symbol

For our next look at the GeoFormula controls, we will create a slightly more complex script. When you open the Layer Controls for an existing GeoFormula, all of the settings are as you left them for the original GeoFormula Layer. If you choose Formula / New, you are first prompted to select new input objects, then you have to change any default settings you want changed. In this exercise you can simply delete the original script and enter the new one, and the input object and settings from the previous exercise are retained.



When you choose Symbol from the Insert menu and expand the Variables, the process automatically lists the variables available for the TM_5 input object. The type of variable and other information about it are shown at the right of the window.



You do not need to close the Script Reference window to continue modifying the script shown in the GeoFormula Layer Controls. Your complete GeoFormula should be as shown in the box below.

STEPS

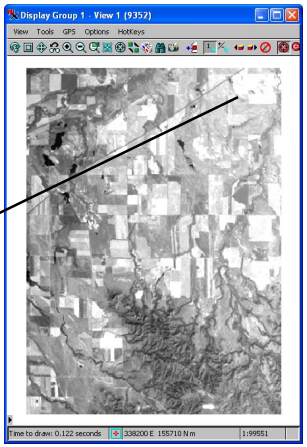
- ☑ click on the Layer Controls icon for the GeoFormula layer, and delete the text on the Script tabbed panel
- ☑ select Insert / Symbol
- ☑ expand the Variables group in the Script Reference window, select TM_5_Value, and click on the Insert icon 
- ☑ select TM_5_X from the symbol list and edit the script manually to complete the expression shown below left in the box
- ☑ click [OK] then [No] and view the results

Type in these three parts of the script.

```
return  TM_5_Value  +  TM_5_X  /  4;
```

Use the Insert icon in the Script Reference window to insert these two numeric variables.

Adding TM_5_X / 4 to the output value increases display intensities as the X coordinate value increases.



The TM_5_Value variable is a "processed" value: the cell value adjusted for display by the selected contrast table. The TM_5 value (used in the previous exercise) is a "raw" input cell value that is not affected by the selected contrast table.

A Two-Band Vegetation Index

A .**gsf** file contains the parameters and definitions used in a GeoFormula. It prompts to save any changes you make when you close the GeoFormula Layer Controls dialog.

STEPS

- ☑ click on the Layer Controls icon and choose Formula / Open*
- ☑ select GEOFRMLA / TVI.GSF
- ☑ select PHOTO_IR and RED from the CB_TM Project File in that order
- ☑ turn on the Show Details option and set contrast to Auto Equalize for both rasters, then click [OK]
- ☑ return to the GeoFormula Layer Controls and comment out or delete the first three lines of the script, then click [OK]

* If you do not already have a GeoFormula layer in a display group, you can choose Add/Layer/GeoFormula/Quick-Add GeoFormula, which skips the GeoFormula Layer Controls.

The strength of the GeoFormula feature in the Display process is that you can perform operations on multiple input objects "on the fly." For example, to view a Transformed Vegetation Index (TVI) result (showing vegetation vigor computed from near-infrared and red spectral bands), you could run Image /Combine/Predefined or Script/GeoFormula, select input objects, create an output raster, and subsequently view the result in the Display process. In contrast, the GeoFormula feature in Display lets you preview the results and modify the script while creating your dynamic "virtual object."

The TVI formula takes the square root of the difference between the infrared and red values. If this difference is less than zero, the square root cannot be calculated for integer output. The "classic" TVI calculation assigns such cells to zero, but assigning a null value to these areas is equally valid and ultimately more useful if you want to display over other imagery.

The first three lines of the script shown determine whether the GeoFormula layer appears as at the left (no null value, shown black) or at the right (with null value, shown white).

Objects | Values | Script | Outp

```
if ((TM4_Value - TM3_Value) < 0)
return 0;
else
return 100 *
(sqrt ((TM4_Value - TM3_Value)
/ (TM4_Value + TM3_Value))
+ 0.5);
```

Grayscale output type assumes an 8-bit data range (values 0-255). **Always adjust the expressions in your scripts to scale the display values** into an appropriate range for 8-bit grayscale display when creating a GeoFormula layer in Display. A multiplier of 100 is used in this script.

(TM4_Value - TM3_Value) < 0 assigned to 0 (not null)

(TM4_Value - TM3_Value) < 0 assigned to null

A First Look at Color

In the previous exercises, the GeoFormula scripts have been simple expressions that yield numeric values for grayscale display. When the output type is grayscale, the numeric expression is used directly for 8-bit grayscale display intensity. (Always scale grayscale GeoFormula values to the 0-255 range.*)

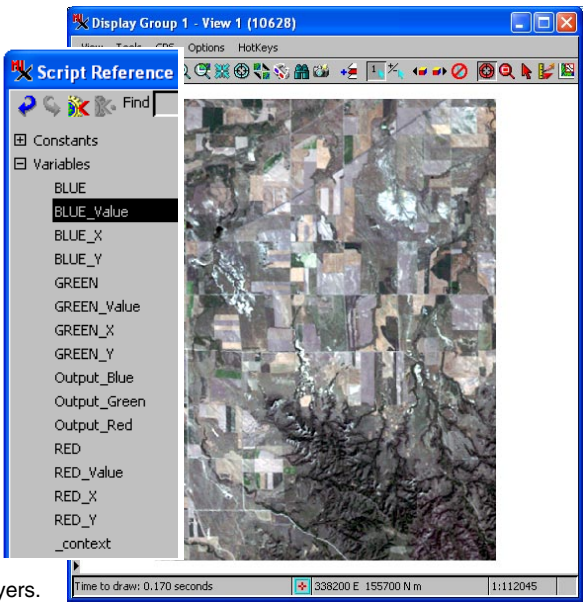
When you change the output type to color, the process automatically creates three color component variables: Output_Blue, Output_Green, and Output_Red. For color output, your script must assign 8-bit values to each of the output component variables.

The Script Reference window is an important resource when writing scripts of any kind. In a simple script like the one illustrated here, it keeps you from making spelling and capitalization errors for the inserted variables (yes, capitalization is important). In this example, you could create all parts of the script by inserting from the Script Reference window (= and all other operators are shown when you expand the Operators entry).

STEPS

- ☑ Open the GeoFormula Layer Controls dialog and select Formula / New
- ☑ select RED, GREEN, and BLUE from the CB_TM Project File
- ☑ on the Objects panel turn on Show Details if not on, and select Auto Normalize for the contrast of all three objects
- ☑ on the Output panel select Color for Type
- ☑ type in the script illustrated below inserting from the Variables list in the Script Reference window if desired (be careful to match case shown if typing)

The simple script illustrated here achieves the same display result as the direct RGB display option in the Display process.



*Scaling is necessary because you cannot apply contrast to GeoFormula layers.

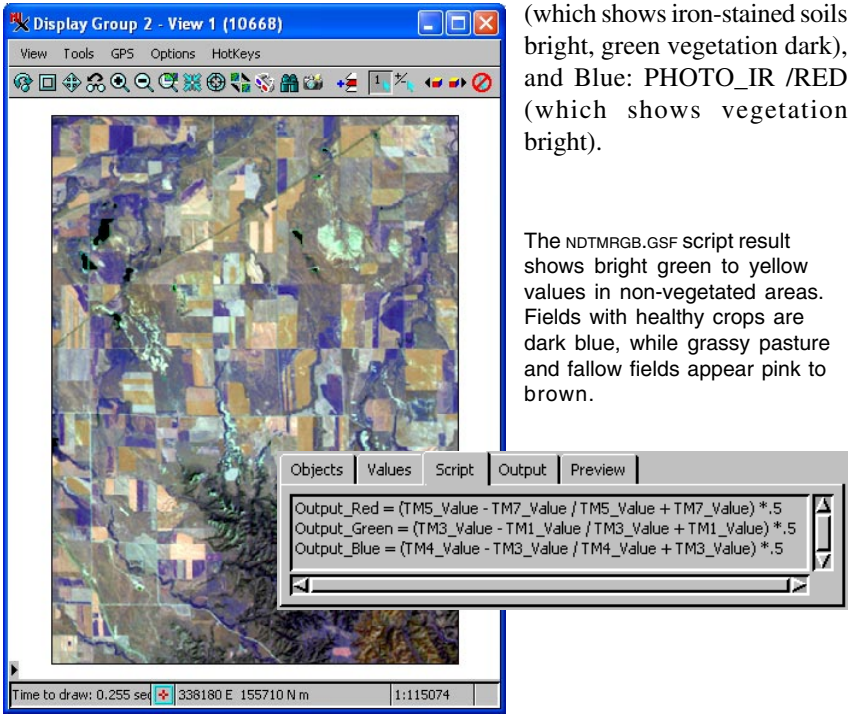
Band Ratios for Composite Color

STEPS

- ☑ open the GeoFormula Layer Controls dialog 
- ☑ select Formula / Open and select GEOFRMLA / NDTMRGB.GSF
- ☑ for input, select the CB_TM Project File
- ☑ select BLUE, RED, PHOTO_IR, TM_5, and TM_7 for the input objects in that order
- ☑ turn off the Null Cells Transparent toggle on the Output panel of the GeoFormula Layer Controls
- ☑ click [OK] to close the GeoFormula Layer Controls dialog

The previous exercise showed how simple input values and expressions can be assigned to RGB color components in a GeoFormula. For a slightly more complex example, we will use computed values for RGB color components.

You may be familiar with the Normalized Difference band ratio from an introductory image processing course. (Also refer to the tutorial booklet *Combining Rasters* for a brief introduction to Normalized Difference ratios.) A Normalized Difference ratio of two bands can supply a value that can be used for grayscale display, just as the TVI example did on page 6. In this exercise, we use 6 bands in 3 ratios to produce values for RGB component display. The TM imagery in the CB_TM Project File can be combined for: Red: TM_5/TM_7 (which shows bare soils bright, green vegetation dark), Green: RED/BLUE (which shows iron-stained soils bright, green vegetation dark), and Blue: PHOTO_IR /RED (which shows vegetation bright).



The NDTMRGB.GSF script result shows bright green to yellow values in non-vegetated areas. Fields with healthy crops are dark blue, while grassy pasture and fallow fields appear pink to brown.

Open the Brovey GeoFormula

A more complex use of GeoFormulas implements the Brovey transform to enhance low resolution color imagery using high resolution grayscale imagery. Similar effects are obtained by choosing the Red-Green-Blue-Intensity option from the Add Raster icon or the Add/Layer/Raster menu cascade in the Display Manager.

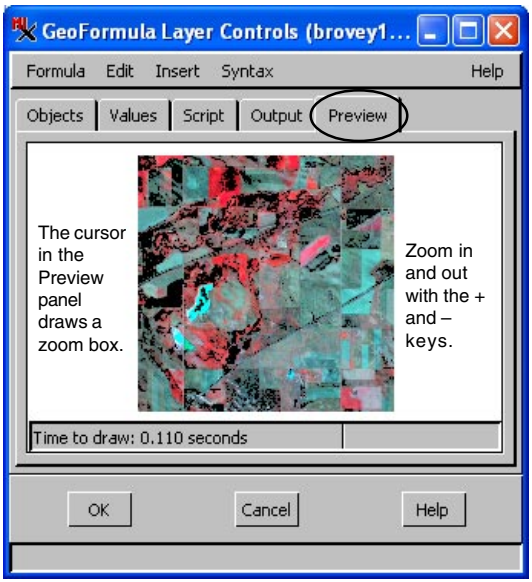
BROVEY1.GSF enhances the display of three color component bands of low resolution imagery by using one band of high resolution grayscale imagery. The sample data in the CB_TM Project File offers 7 bands of 30-meter TM imagery, while the CB_SPOT Project File contains 1 band of 10-meter SPOT imagery. The GeoFormula can combine TM with SPOT to provide a synthetic 10-meter resolution for the color TM data.

By default, the GeoFormula process treats only the overlap area of input objects that have different spatial extents. Thus, the display confines the extents to the smaller area of SPOT_PAN_LITE and does not show the whole area of the CB_TM bands.

STEPS

- ☑ open the GeoFormula Layer Controls window 
- ☑ select Formula / Open in the GeoFormula Layer Controls window
- ☑ select GEOFRMLA / BROVEY1.GSF
- ☑ for input, select the CB_TM Project File and PHOTO_IR, RED, and GREEN* for the input objects in that order (note that [OK] is not yet active), then select CB_SPOT / SPOT_PAN _LITE for the HIGHRES input object, and click [OK]
- ☑ select the Preview tab to see a quick rendering

* Note that this band combination produces a color-infrared image.



The Preview panel lets you quickly see the image that results from your GeoFormula and see the effects of modifications to the script without having to close the Geoformula Layer Controls.

The Brovey GeoFormula Results

The Brovey formula is quite simple. Assume an RGB display of bands B4, B3, B2 (such as the TM bands 4, 3, 2) being sharpened with band S1 (such as SPOT). The formula is:

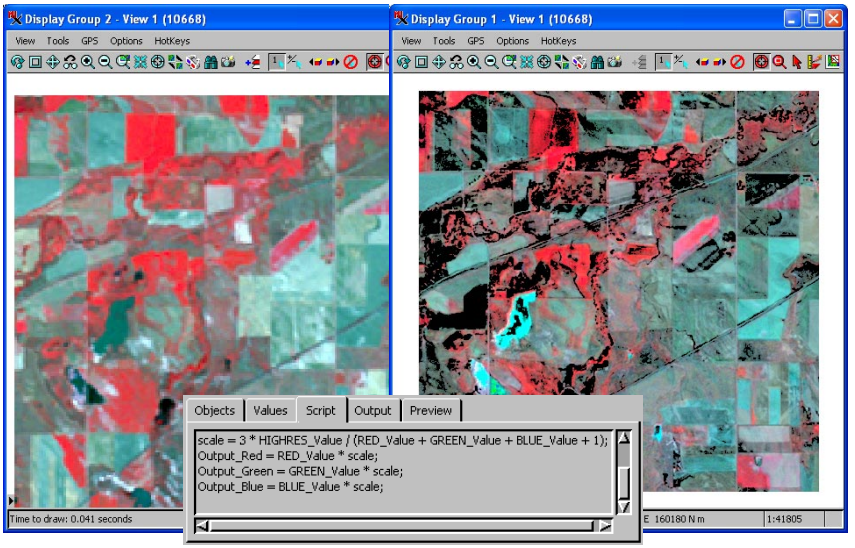
R = B4 / (B4+B3+B2) * S1
G = B3 / (B4+B3+B2) * S1
B = B2 / (B4+B3+B2) * S1

Some simple algebraic equivalence manipulations and the introduction of a scale factor (to improve display intensity) can be observed in the form of the BROVEY1 script illustrated below.

The Display process renders the BROVEY1.GSF GeoFormula layer in the Group View window. Use the standard zoom and position tools to examine the display image. Open a second group view and add the same three TM input images as an RGB raster layer to compare the display results. As illustrated below, the Brovey GeoFormula (right) shows greatly enhanced feature detail compared to the straight TM RGB image (left).

The Brovey transform does two things. First, it normalizes the data by dividing the band being displayed by the summation of all bands being displayed. Second, it sharpens the image by multiplying the normalized result by the high resolution data. The implementation in the TNTmips GeoFormula also multiplies by a scale factor to increase display intensity.

The Brovey GeoFormula takes color information from the low-resolution TM images and feature detail from the high-resolution SPOT image and automatically presents a color image with simulated high resolution. The image on the left (three TM bands) is zoomed to the same map scale as that at the right (Brovey transform).



TM 4,3,2 input

Brovey result

Brovey Enhancements to Band Ratios

Our last exercise in this progression shows some of the powerful complexity of the GeoFormula layer by combining the band ratio computations from the exercise on page 8 with the Brovey resolution enhancement (pages 9 and 10).

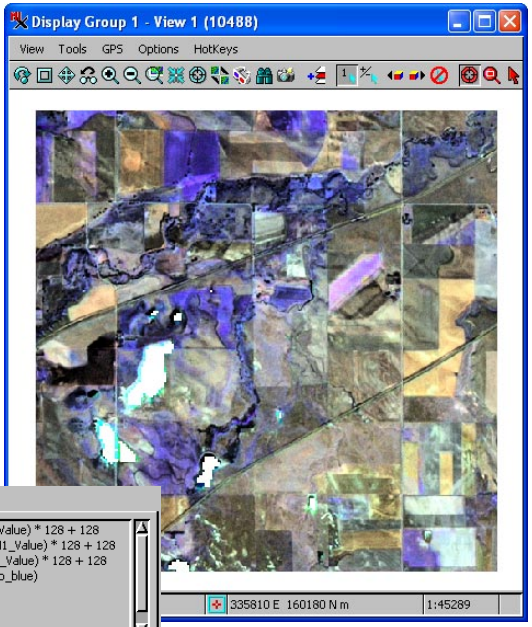
The script in this exercise applies the TM5 / TM7, TM3 / TM1, and TM4 / TM3 ratios to the low resolution TM bands, and then multiplies the result by the SPOT image to get the high resolution enhancement.

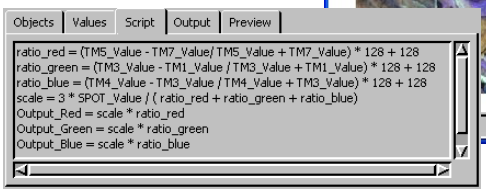
Look at the scripts for the basic Brovey GeoFormula (page 10) and for the band ratio GeoFormula (page 8) and observe how the two were combined for this script. The first three lines come with only slight modification from NDRGB.GSF, while the last four lines come from BROVEY1.GSF. In the same way, many complex GeoFormulas can be built from simpler scripts, and the wise user will develop and test GeoFormula components in simple scripts before using them in complex scripts.

STEPS

- ☑ open the GeoFormula Layer Controls dialog 
- ☑ select Formula / Open and select GEOFRMLA / NDRATBRV.GSF
- ☑ Select BLUE, RED, PHOTO_IR, TM_5, and TM_7 in that order from the CB_TM Project File in that order, then select SPOT_PAN_LITE from the CB_SPOT Project File

The NDRATBRV.GSF script combines the Normalized Difference ratio computations on lower resolution TM bands with the Brovey resolution enhancement from the higher resolution SPOT image. The result shows the spectral information from TM sharpened by the resolution information from SPOT.



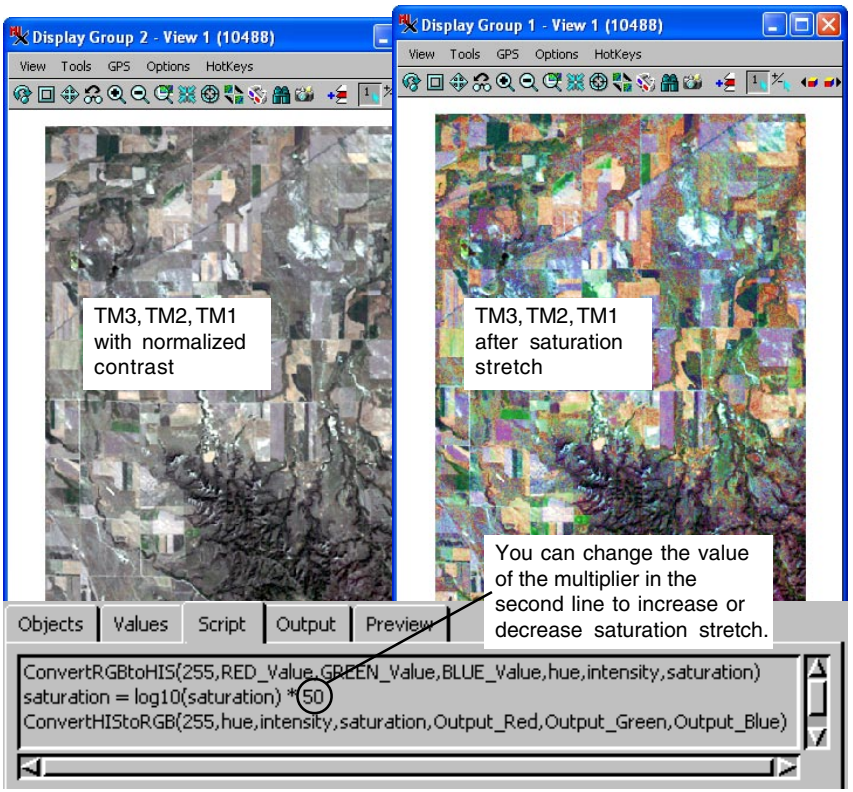


A Saturation Stretch

STEPS

- ☑ open the GeoFormula Layer Controls dialog 
- ☑ select Formula / Open and select GEOFRMLA / STRETCH2.GSF
- ☑ for input, select RED, GREEN, and BLUE in that order from CB_TM

A GeoFormula layer can be used to apply color conversion manipulations. In this example, RGB input components are converted to the equivalent HIS (Hue-Intensity-Saturation) values. Then a logarithmic stretch is applied to saturation values and the HIS components are converted back to RGB values for display. The new RGB set has brighter, more vivid colors than the subdued colors in the original. An HIS saturation stretch has an advantage over alternative RGB manipulations. When RGB manipulations are used, they often create problems of color drift (such as red hues drifting toward orange). By way of contrast, HIS manipulations make it easier to brighten colors without changing their hue.



Vector Objects in GeoFormulas

Vector objects can be used in a GeoFormula. When you select a vector object as input, you can access the object coordinate values in the form `object_x` and `object_y`. You can also access values from associated attribute tables in the form

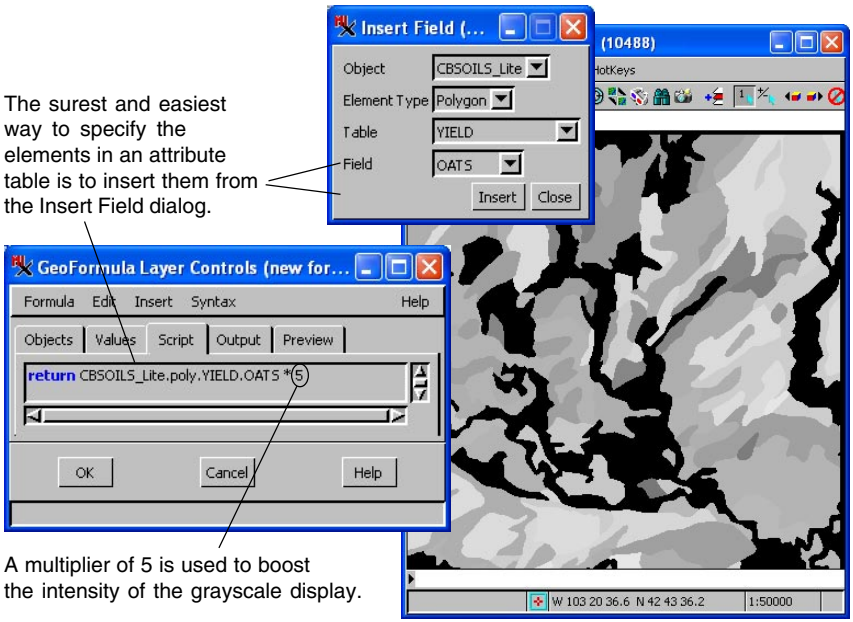
OBJECT.poly.TABLE.FIELD,
OBJECT.line.TABLE.FIELD, and
OBJECT.node.TABLE.FIELD.

Note: precise use of upper and lowercase is essential. If a table is named in uppercase characters, as in "YIELD," then the process will not find it if you use lowercase characters, "yield." Likewise, the element type keywords must be entered in lowercase: "poly," "line," and "node."

The oat yield values range from 0 to 46, which leaves room for a scale factor to improve the intensity of the 8-bit grayscale display. You need to be familiar with your data to determine an appropriate scale factor.

STEPS

- ☑ open the GeoFormula Layer Controls dialog 
- ☑ select Formula / New and select CB_DATA / CB_SOILS / CBSOILS_LITE as the single input object
- ☑ select the Script tab in the GeoFormula Layer Controls dialog and type in the expression illustrated (use the Insert Field dialog to pick the field name)
- ☑ select the Output tab and change the output type to Grayscale



The surest and easiest way to specify the elements in an attribute table is to insert them from the Insert Field dialog.

A multiplier of 5 is used to boost the intensity of the grayscale display.

Using Both Vectors and Rasters

STEPS

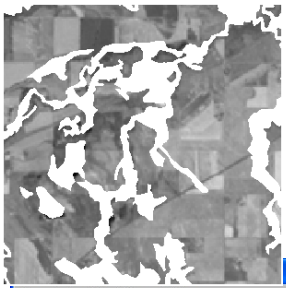
- ☑ open the GeoFormula Layer Controls dialog 
- ☑ select Formula / New and select CBSOILS_LITE and TM_5 as input
- ☑ type in the three-line script illustrated
- ☑ change the output type to grayscale, turn on the Null Cells Transparent toggle, and view the result
- ☑ select Formula / Open and select YIELD431.GSF with CB_TM and CBSOILS_LITE inputs

The GeoFormula feature offers a great deal of potential for complex combinations of different types of objects. You can construct an endless number of expressions and statements that reference attributes and values from a variety of input objects of different types.

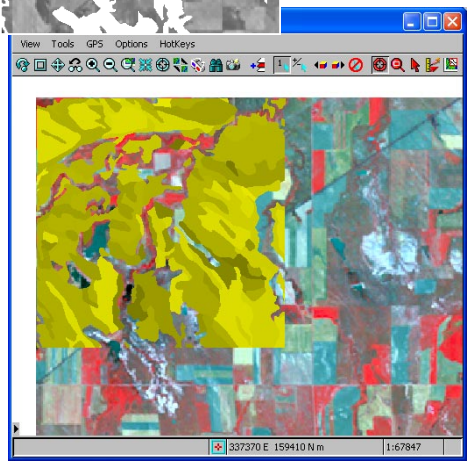
In this exercise the CBSOILS_LITE vector object is combined with one band of the TM imagery from CB_TM. The vector expression is similar to the expression in the previous exercise, with the addition of a conditional structure. Make a new GeoFormula for grayscale output, select TM_5 and CBSOILS_LITE for input, and type in the expression

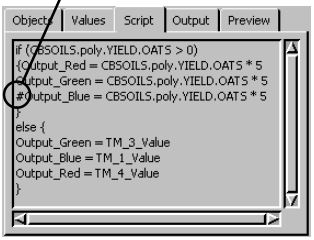
```
if (CBSOILS_Lite.poly.YIELD.OATS > 0)
return TM_5_Value;
else return 255;
```

This expression works like a mask, taking the display value from TM_5 except where the YIELD.OATS value is zero. For a more complex GeoFormula, open YIELD431.GSF which displays the YIELD_OATS.OATS values where they are larger than 0, and the composite color TM_4, TM_3, and TM_1 bands elsewhere.



The # character marks a line as a comment, which makes the process ignore it.





The color composite image of Crow Butte TM bands 431 is visible where YIELD_OATS.OATS has no value. The color spread is achieved by assigning the same value to the red and green output color components. Modify the script to remove a different color component and view the effect.

Universal Soil Loss Equation (USLE)

The Universal Soil Loss Equation is used to create a soil erosion map from data that include conservation practices, soil types, surface slope, and rainfall amounts. The basic form of the equation is:

$$A = R * K * LS * C * P$$

A GeoFormula script (USLE.GSF) implements the Universal Soil Loss Equation for the Crow Butte map quadrangle. It uses the CBSOILS_LITE vector object to access soil erodibility (K = LAYER.kfact) and slope-length factor (LS = COMPON.slopel). It uses three raster objects for the remaining inputs: RAINFALL (R), MANAGEMENT (C), and CONSERVATION (P), all found in the CB_DATA / LANDUSE Project File.

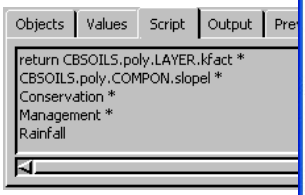
The resulting display layer is a grayscale map of erosion effects. Darker areas indicate lower erosion, and bright areas show higher soil loss.

Follow the steps listed on this page and run the USLE script. You can modify the script to brighten the grayscale display by adding a multiplier after the Rainfall factor.

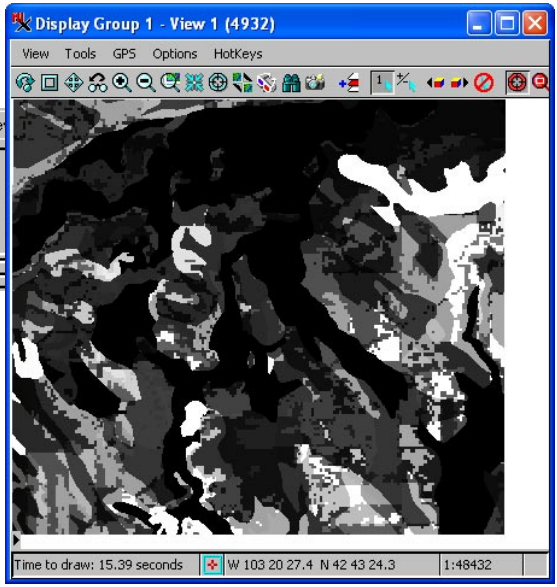
STEPS

- ☑ open the GeoFormula Layer Controls dialog
- ☑ select Formula / Open and select GEOFRMLA / USLE.GSF
- ☑ select input rasters CB_DATA / LANDUSE / MANAGEMENT, CONSERVATION, and RAINFALL
- ☑ select input vector object CB_DATA / CB_SOILS / CBSOILS_LITE

Remove the USLE GeoFormula layer before going on to the next exercise.



USLE.GSF is a good candidate for use in the stand-alone GeoFormula process (Script / GeoFormula). You can examine the output raster object to quantify erosion estimates, and create color maps for display.



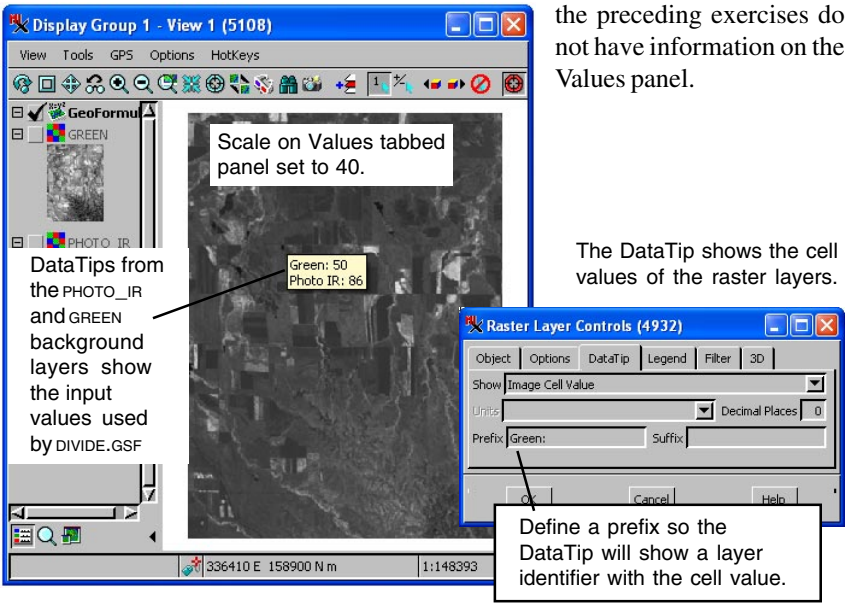
Background Layers and DataTips

STEPS

- ☑ add PHOTO_IR and GREEN as background 
- ☑ open the Raster Layer Display Controls dialog and define DataTips for both background layers
- ☑ deselect the Hide/Show checkbox in the LegendView for both background layers
- ☑ turn on DataTips for all layers with Options / DataTips / Maximum
- ☑ click Add / Layer / GeoFormula / Add GeoFormula Layer  and select DIVIDE.GSF with PHOTO_IR (A) and GREEN (B) as input
- ☑ click on the Values tab and increase the Scale value for a brighter display

The TNTmips Raster Combinations process (Image / Combine / Predefined) offers a number of standard "raster algebra" manipulations. These include algebraic, logical, statistics, enhancement, indices, and sensor specific combinations. GeoFormulas have been prepared to duplicate many of these combinations. You can enhance your use of GeoFormulas by using DataTips with background layers or multiple Views to examine the input values for the GeoFormula.

For this exercise, we will display a simple grayscale band ratio (refer to the tutorial *Combining Rasters*, page 9). This script includes a Scale variable that appears on the Values tabbed panel of the GeoFormula Layer Controls. Rather than editing the script to change the scale factor, you can change the scale by entering a new value on the Values panel. The initial scale set for the GeoFormula layer is 20. If you turn on the Show Details toggle, the default value is shown on the Values panel. Most of the preceding exercises do not have information on the Values panel.



Speeding Up GeoFormula Display

GeoFormula display layers perform file access and multi-object processing on the fly. This processing overhead results in slower display times that may seem sluggish compared to other display layers. This exercise introduces some standard programming techniques that help reduce display times.

Display times vary with the complexity of the GeoFormula and the size and number of input objects. The comparison times listed below show only sample speed improvements.

Use the Preview Panel. The Preview panel in the GeoFormula Layer Controls window presents a small preview image quickly. Use the Preview panel especially as you compare the effects of different variable values and other script changes during development.

Preview panel: 1 second
View window: 3 seconds

Reduce the View Window Size. Just as the small image in the Preview panel displays quickly, so does a small View window. The GeoFormula process samples its input objects according to the size of the View window, so a small View results in less input data to process.

Small View: 2 seconds
Large View: 9 seconds

Calculate Values Once. Find ways to optimize your script. See if you can precalculate a value so that it is derived once rather than repeatedly. For example, in BROVEY1.GSF (see p. 9), a **scale** variable is calculated once rather than with each output statement.

```
scale = 3 * HIGHRES_Value / (RED_Value +
   GREEN_Value + BLUE_Value + 1);
Output_Red = RED_Value * scale;
Output_Green = GREEN_Value * scale;
Output_Blue = BLUE_Value * scale
```

BROVEY1.GSF computes the **scale** value once at the beginning rather than in each output statement.

*With **scale**: 3 seconds*
*Without **scale**: 4 seconds*

Use Nested If/Else. Test multiple logical conditions with nested if/else statements, always putting the most likely cases first and the least likely cases last. When the script encounters a true condition, it skips the rest of the conditions. By contrast, if you use a simple sequence of if statements, the process tests every condition, every time.

```
if((SPOT_PAN>=36)and(SPOT_PAN<47))return(128);
elseif((SPOT_PAN>=32)and(SPOT_PAN<36))return(86);
elseif((SPOT_PAN>=47)and(SPOT_PAN<50))return(170);
elseif((SPOT_PAN>=19)and(SPOT_PAN<32))return(42);
elseif((SPOT_PAN>=50)and(SPOT_PAN<54))return(212);
else if(SPOT_PAN<19) return(0);
elseif(SPOT_PAN>=54)return(255);
```

NESTEDIF.GSF puts higher-probability conditions earlier.

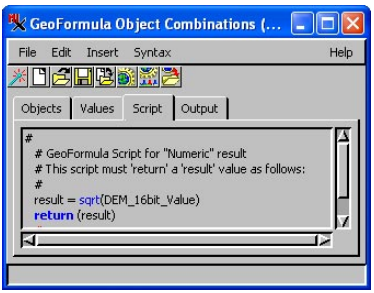
Likely first: 4 seconds
Likely last: 6 seconds

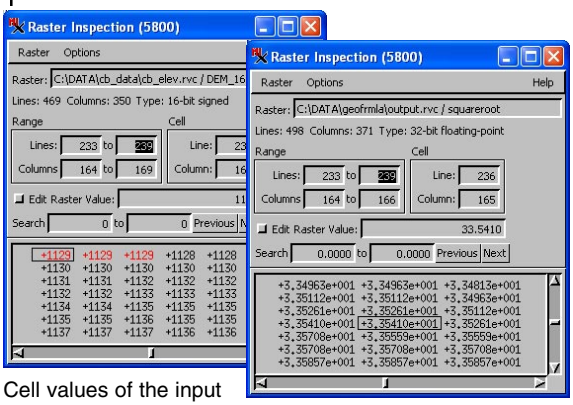
Standalone GeoFormula Process

STEPS

- ☑ choose Script / GeoFormula from the TNTmips menu
- ☑ choose Create new formula using wizard
- ☑ select DEM_16bit from the CB_ELEV Project File
- ☑ choose General with numeric result on the next wizard panel, and click Next then Finish
- ☑ remove the # before the lines that begin with *result* and *return*
- ☑ choose Insert / Function, expand the Functions list, then its Math list, and choose sqrt to replace the ... after result =, and click on Insert 
- ☑ next insert the cursor between the () following sqrt in the script, expand the Variables tree in the Script Reference window, choose DEM_16bit_Value, and click on Insert 
- ☑ click on the Run icon, and name your output object 
- ☑ launch Display and open a new display layout
- ☑ choose Add / Multiple groups and select the input and output rasters from this exercise
- ☑ right click on each layer and choose Examine Cell Values
- ☑ note that although the rasters appear similar, their cell values are quite different

In addition to creating temporary GeoFormula layers in the Display process, TNTmips provides a separate GeoFormula process that lets you save the result as a raster object and provides a wizard to assist you with your script if desired. You begin by specifying how you want to start and selecting the object(s) you want to process. You next specify what type of GeoFormula you want to create: General with numeric result, General with "color" result, or Multi-critreria analysis model. Your choice affects the default script provided. In order for the last choice to be active, you need to select more than one input object. The sample script that is provided consists of instructions and the selected script type. All of the lines of the sample script are commented out. You need to remove the # from the lines you want to include in your script.





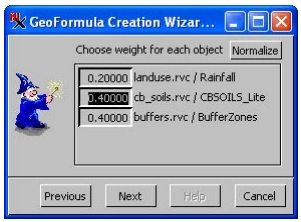
Cell values of the input (left) and result of the GeoFormula (right).

Multi-Criteria Decision Analysis

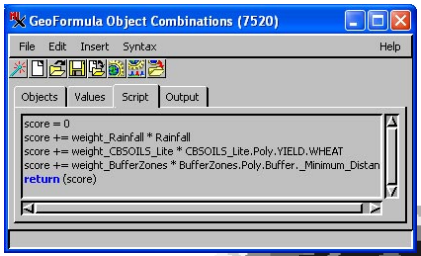
When you elect to use the wizard and you select more than one input object the *Multi-criteria analysis model* is the third active choice in the wizard's first panel. Multi-criteria Decision Analysis (MCDA) is a quantitative approach to evaluating decision problems that involve multiple variables (criteria). You can apply MCDA to a set of geospatial objects using the GeoFormula process. As with other GeoFormulas you can combine raster and geometric input to achieve the desired image/raster output.

STEPS

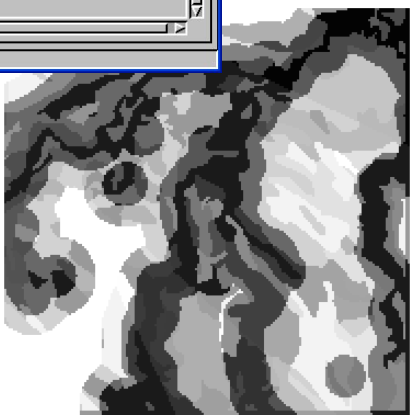
- ☑ choose Script / GeoFormula from the TNTmips menu
- ☑ choose Create new formula using wizard
- ☑ select RAINFALL from the LANDUSE Project File, CBSOILS_LITE, and the vector in the BUFFERS Project File
- ☑ choose Multi-criteria analysis model on the next wizard panel
- ☑ enter weights as shown at the left on the next panel
- ☑ choose INTERNAL.VALUE for RAINFALL, YIELD.WHEAT for CBSOILS, and BUFFER.MINIMUM DISTANCE
- ☑ change the Extents on the Output panel to Common Area
- ☑ look at the contents of the other panels
- ☑ click on Run and view the result in Display



The wizard uses a weighted, linear combination method to produce a script similar to the one illustrated below. You specify the weighting factor, which designates the relative importance of each selected input object for evaluation of the decsion problem and designate a database table and field to provide a value that contributes to the value for each output cell. You can use existing database values directly or generate a new table to provide "score" values for that location.



The script and output shown here are generated directly by the GeoFormula process without additional alterations after designating the weighting factor and the table and field to use. The GeoFormula process does not have an associated View window, so you need to take the result into the Display process to View it or simply use it as input to some other image-based process.



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