Landscape Lighting Techniques for Cartography Using ArcGIS

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Context:

- **Cartographic Realism Movement**

  – **Greater understanding in the mind of the reader if you express the landscape more realistically**

  – **Uses Iconic similar to real-world images as seen from an airplane**

  – **Borrows Heavily from 3d graphics**

Examples

From Tom Patterson, Nation Park Service

From this year's ESRI Map Book

Enlargement of raw image

Lighting as a Cartographic Concept

A.   The MAP is now a "Scene" portrayed in a "Map View" of reality

B.   Every landscape and map object requires lighting and lighting definitions.

C.   Maps are painted digitally taking into account light, shadow, color, and texture of the landscape and its components

D.   Cartographers carefully weave the "message of the map" by adjusting the relative visibility of each object.

ArcGIS Capabilities

- **DREAM IT!** You should visualize what your map will be showing. What is the "message in the map"?

- ArcGIS has a really GREAT Hillshade function! It portrays accurately landscape lighting, shadows, cast shadows values for a given Altitude, Azimuth.

- ESRI's Spatial Analyst provides the "math engine" needed to add other lighting characteristics to a scene.

- ArcGIS desktop has image controls for transparency, color, brightness and other capabilities to fine tune your presentation.

- Use these capabilities to develop a "light map" for each type of light in a scene.

- **Blend these and additional themes into a single image for the map.**

ArcGIS Effects Menu
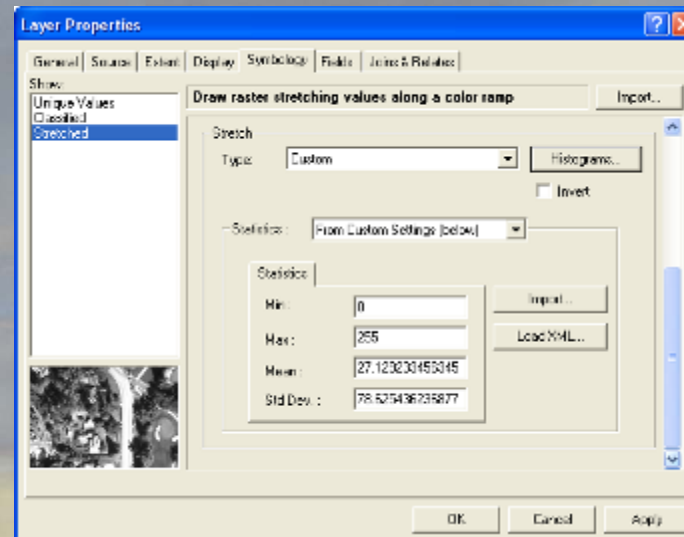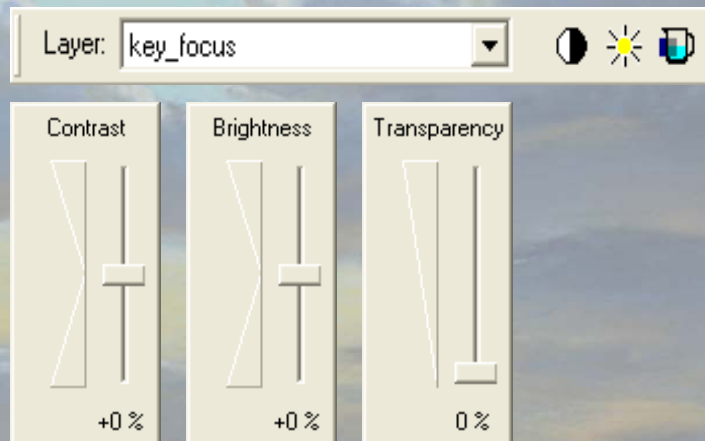
- The Effects menu is a good place to explore simulating light in a cartographic context.

- You can also experiment with histograms and color mixes in the under symbology in the layer properties menu.

Light Basics:

A.   Types of light:
Ambient Light – Non-directional scattered light
Point Light - Single omni-directional light
Spot Light – Cone shaped directional light
Directional light - parallel directional light

B.   Standard Light Nomenclature:
Set Light – Principle light source (Directional Light)
Fill Light – Background lighting (Ambient Light)
Back Light – Separates subject from background (point, spot, or directional light)
Key Light – Focused on subject (Spot light)

C.   Lights can be any color

D.   Lights are affected by atmospheric factors (fog, dust, distance,etc)

E.   An object's Surface Material affect how it reacts to light

F.   You should use multiple lights

General Cartographic Light application:

A.   Types of light:

Ambient Light – Overall Scene light level (use math in Raster Calculator)
Point Light - Single omni-directional light (function not available)
Spot Light – Cone shaped directional light (function not available)
Directional light - parallel directional light (Hillshade)

B.   Standard Light Nomenclature:

Set Light – Principle light source (hillshade)
Key Light – Focused on subject (Raster Calculator)
Fill Light – Background lighting (use math in Raster Calculator)
Back Light – Separates subject from background (inverse hillshade)

In landscape mapping – Ambient and Directional Lights are the primary sources of light. Use Raster calculator to blend multiple light maps to create the scene.

Lighting a landscape example

Given a elevation grid, imagery and an idea for a map:

1. Establish Set light characteristics:
    1. Time of Day, Color, Intensity
    2. Using Spatial Analyst "Hillshade" function, create "setlight" grid

2. Establish Backlight Characterics:
    1. Relationship to "Setlight", Color, Intensity
    2. Using Spatial Analyst, create "Inverse hillshade" grid

3. Establish Fill Light characteristics
    1. Level of Light, Color, Intensity, take into account other lights
    2. Using Spatial Analyst, create "constant Value" grid or vertical hillshade

4. Establish Key Light characteristics:
    1. Color, Intensity, take into account other lights
    2. Use Spatial Analyst Con Function to add to image

5. Determine what "contribution" themes such as imagery will make in the overall color balance of the image.

Plan your lights--

Type of Light	Red	Green	Blue
Set Light	255	128	1
Back Light	50	130	100
Fill Light – will discuss	255	255	255
Key Light – will discuss	?	?	?
Imagery – will discuss	?	?	?

Set Light (hillshade)
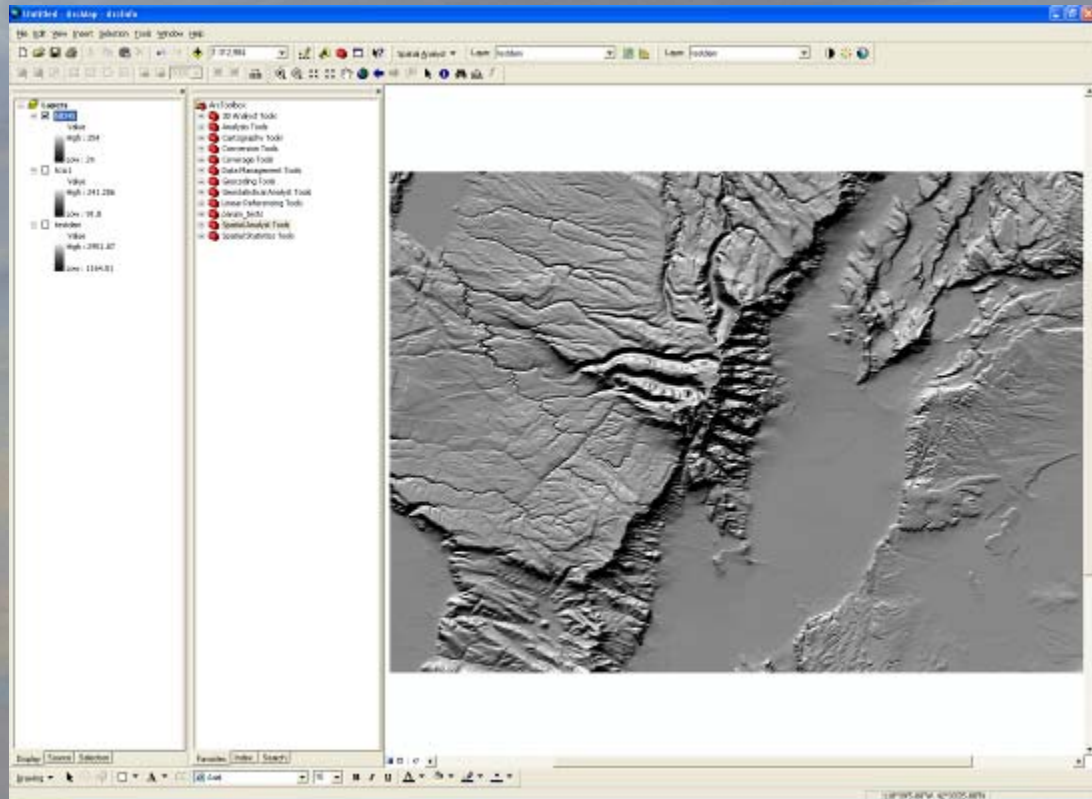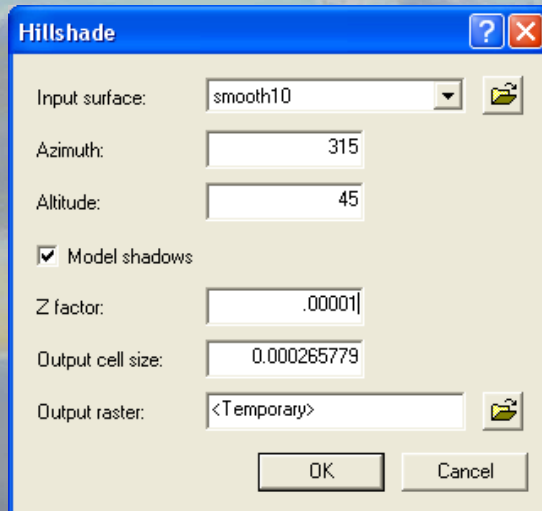
Formula
Hillshade(your dem, azimuth,angle, all,zfact)

07/04/05 03:05 043.7 00.0

This movie was created with a script that utilized the Solar positions from the US Navy website.

http://aa.usno.navy.mil/data/docs/RS_OneDay.html

Backlight
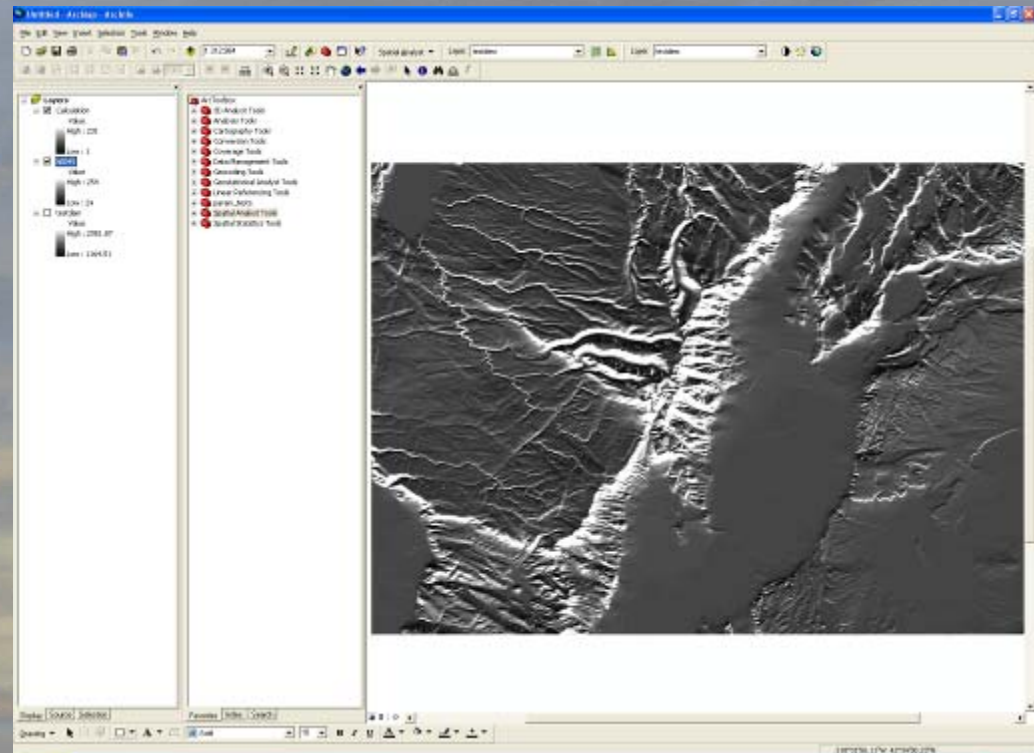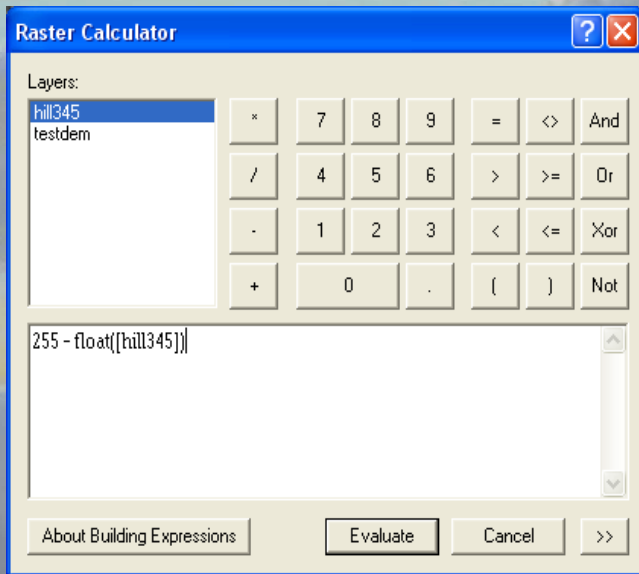
Formula
255 – float([setlight hillshade])

Fill Light
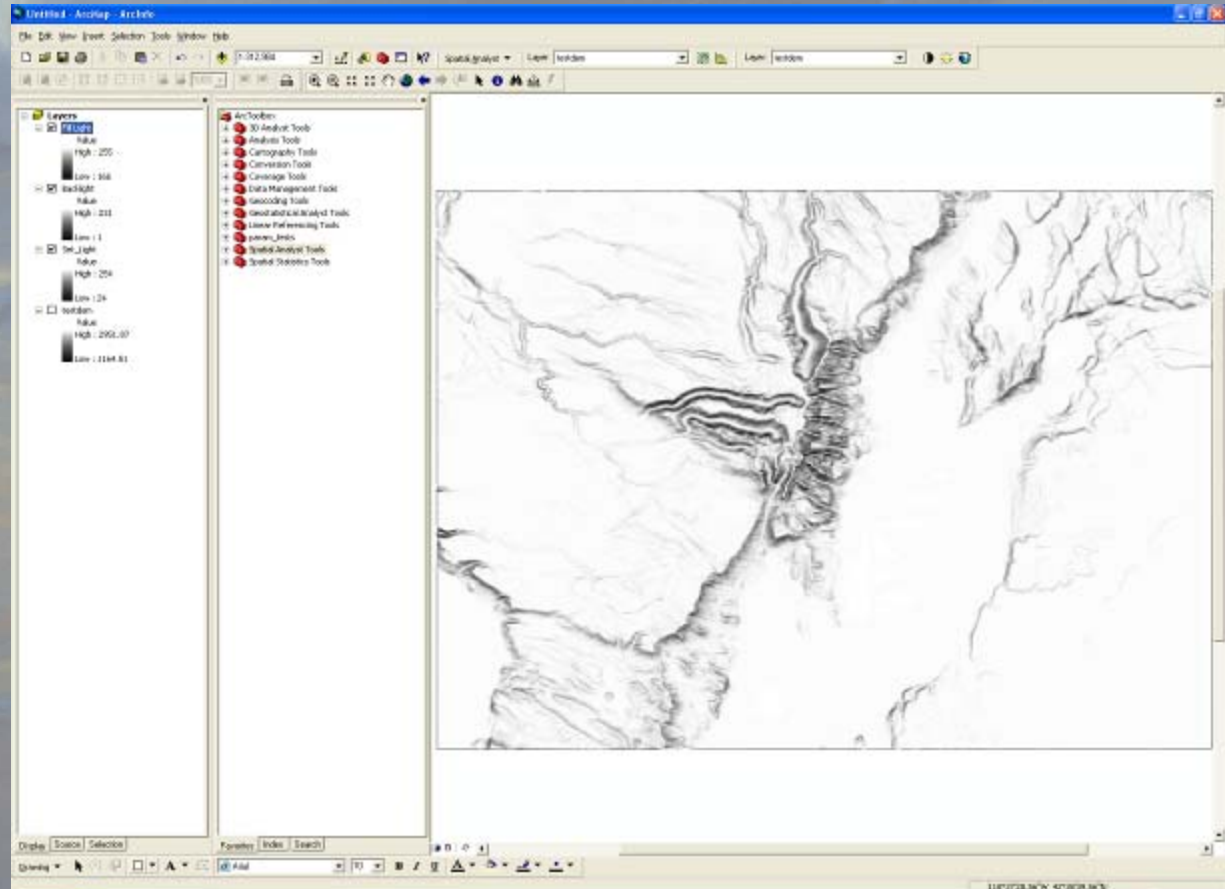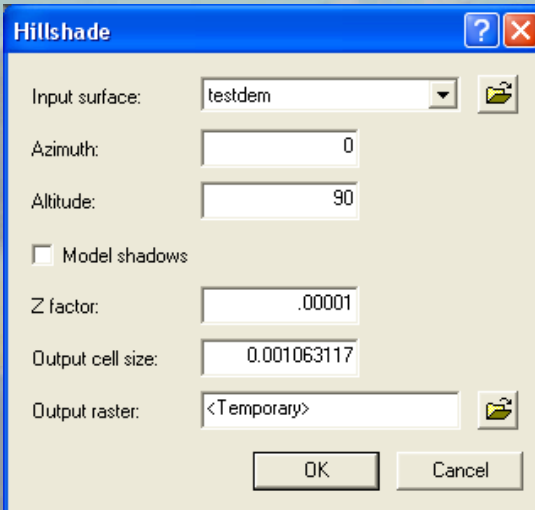
Use hillshade with 0 degrees Azimuth and 90 degree Altitude

Key Light
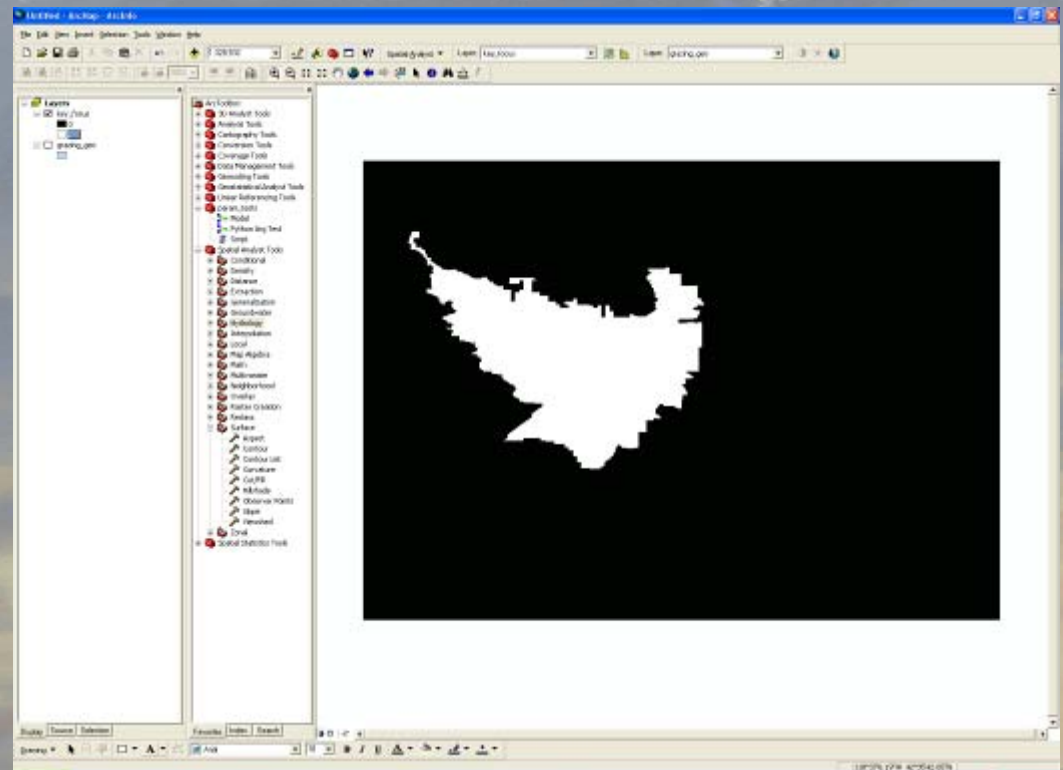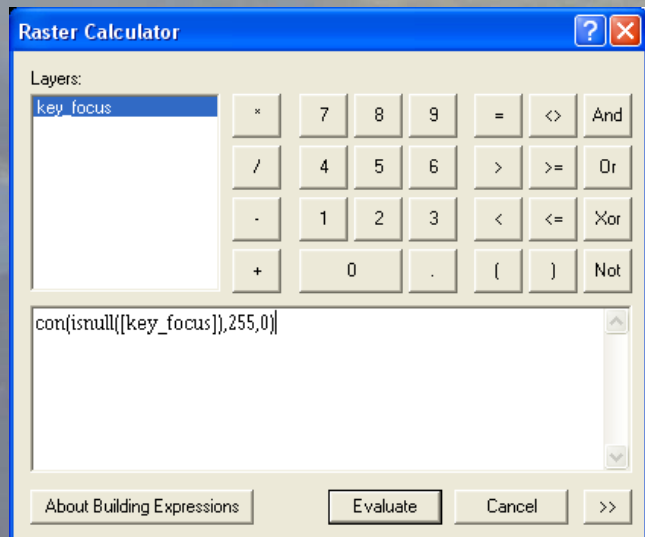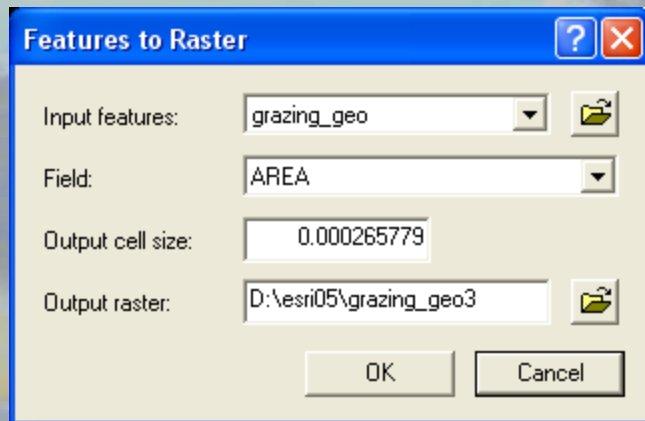
Data set to emphasize area of interest:
Convert to raster, then to a 0, 255 value grid

So Far…
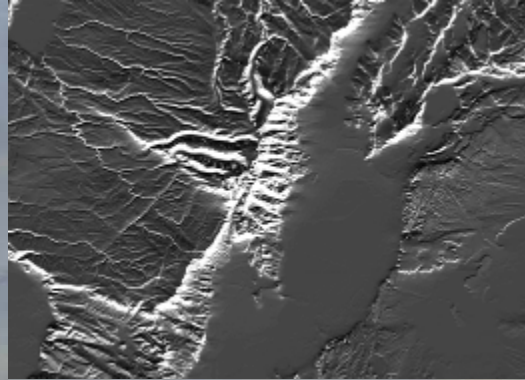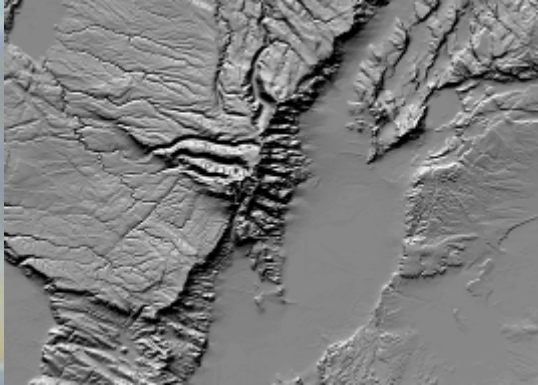
- Set Light
- Back Light
- Fill Light
- Key Light

Now Add Color to each light.
If desired…

For Example:

Set Light – Orange
Back Light – Dark Blue
Key Light – No Adjustment, White
Fill Light - No Adjustment, White

Compute (RGB) Color for the Set Light (Orange)
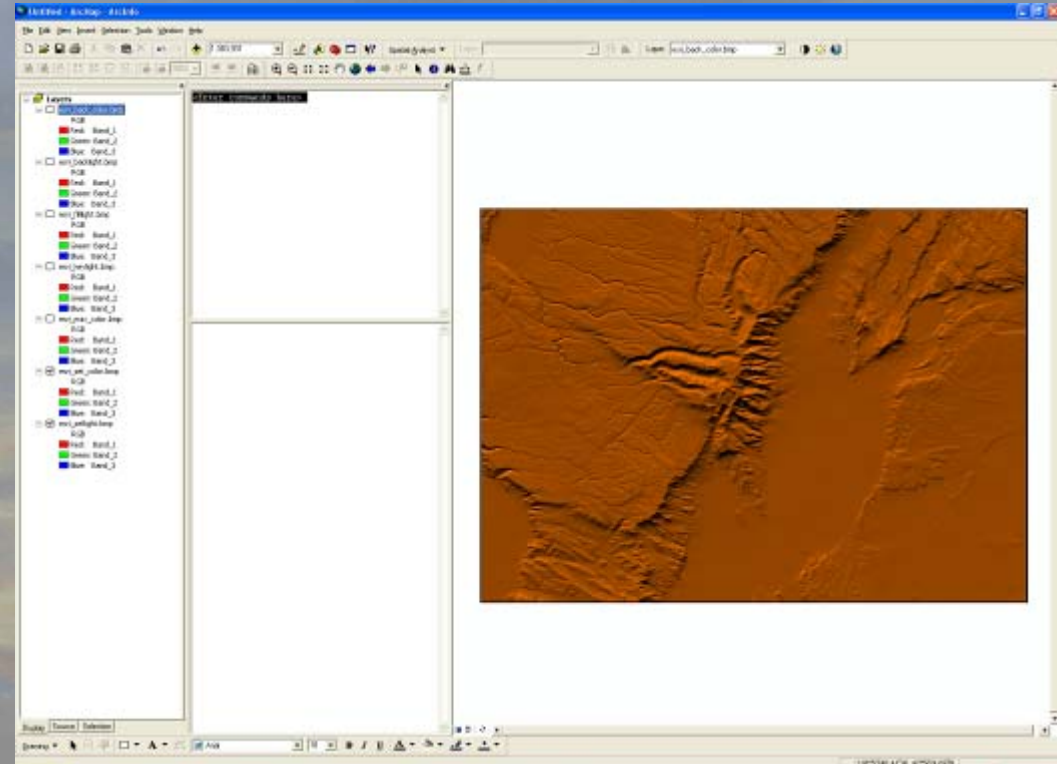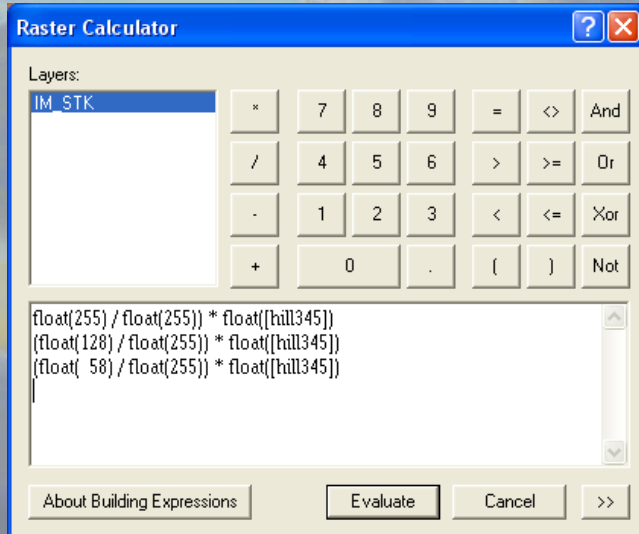
(float(255) / float(255)) * float([hill345])
(float(128) / float(255)) * float([hill345])
(float(58) / float(255)) * float([hill345])

Two methods of Combining multiple rasters:
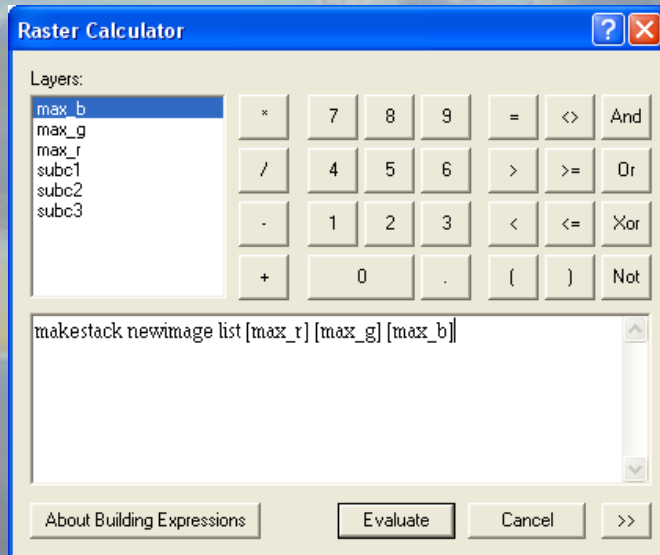
Makestack in Raster Calculator
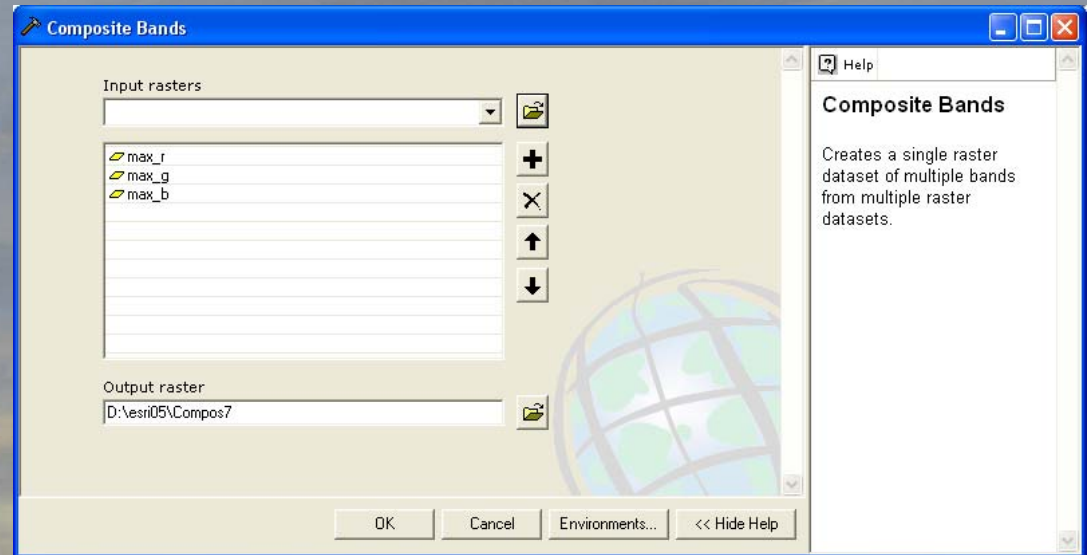
Composite Bands Tool in Toolbox

**You may have to use the "Custom Settings"
RGB Composite Symbology editor
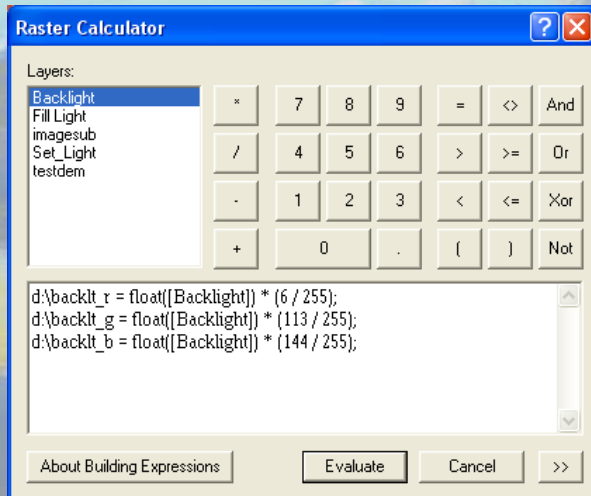and re-enter 0 -255 min and max settings:**
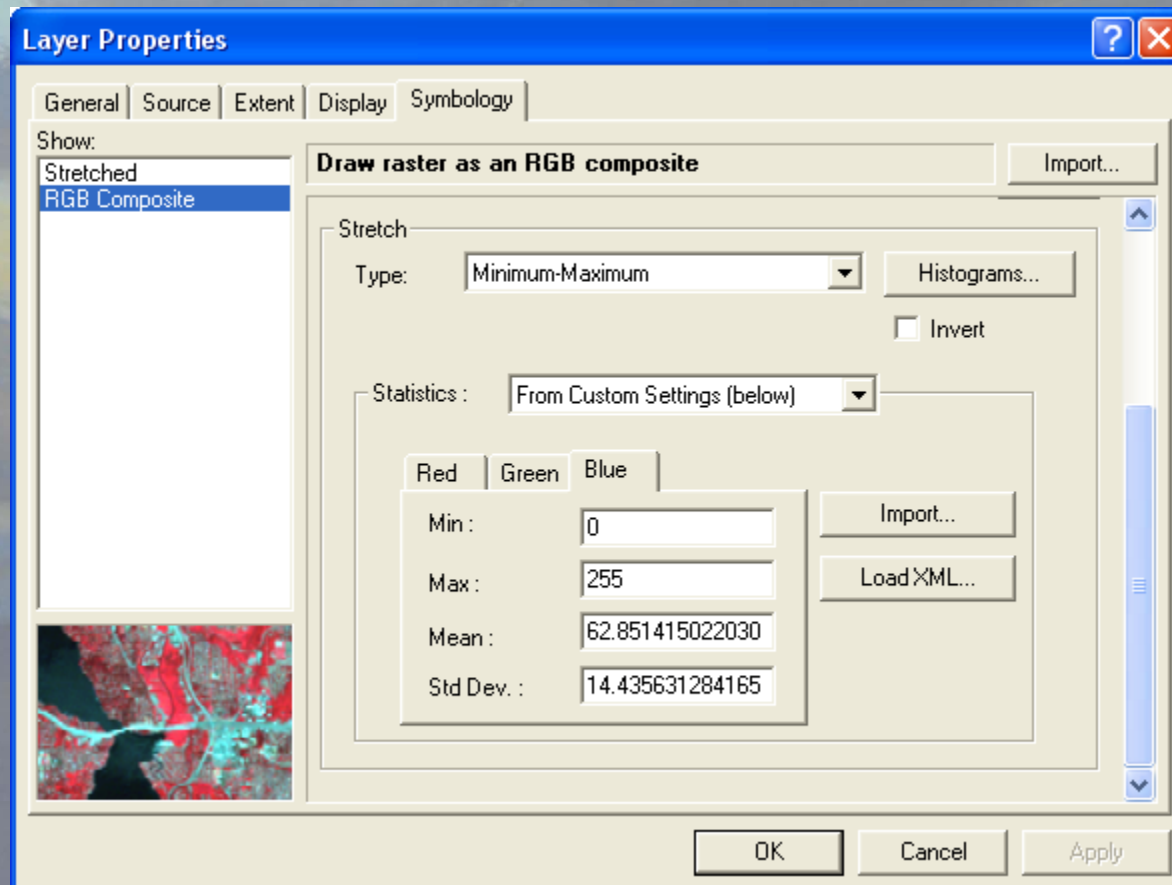
Set Light
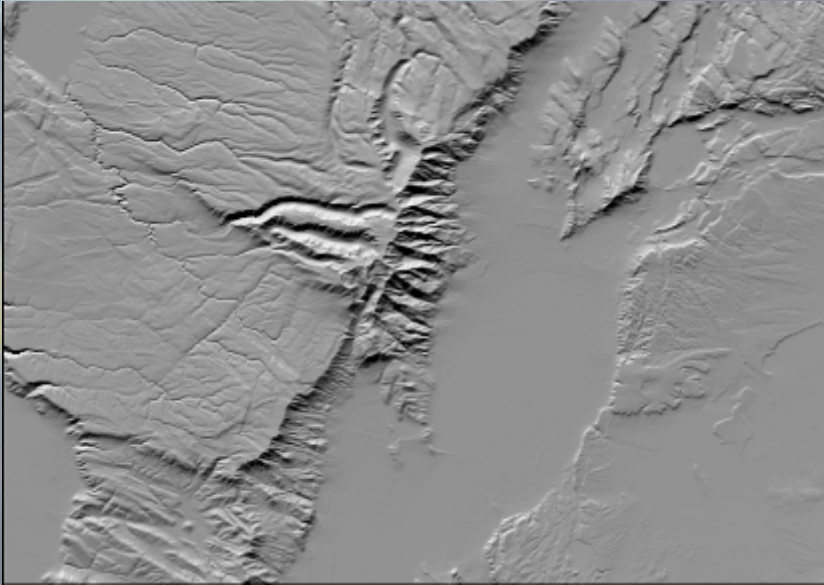
Set Light hillshade
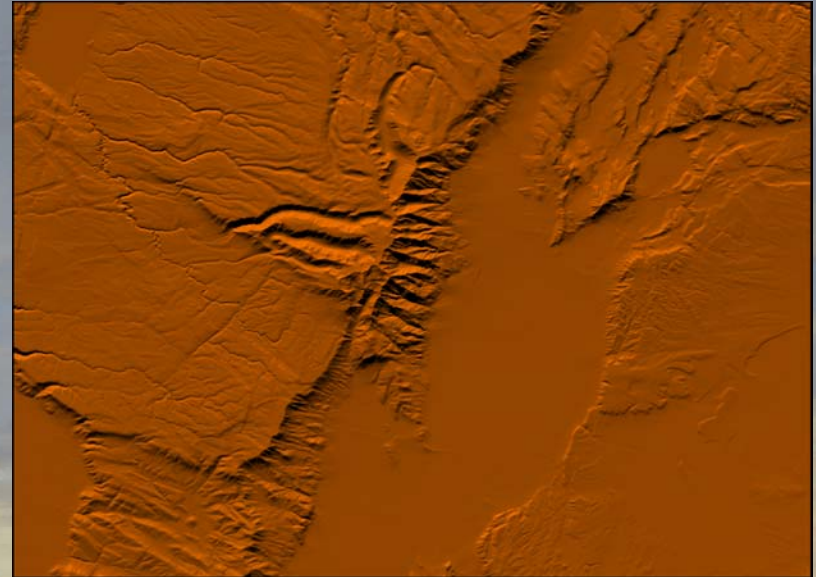
Set Light with Orange color

Compute (RGB) Color for the Back Light (BLUE)
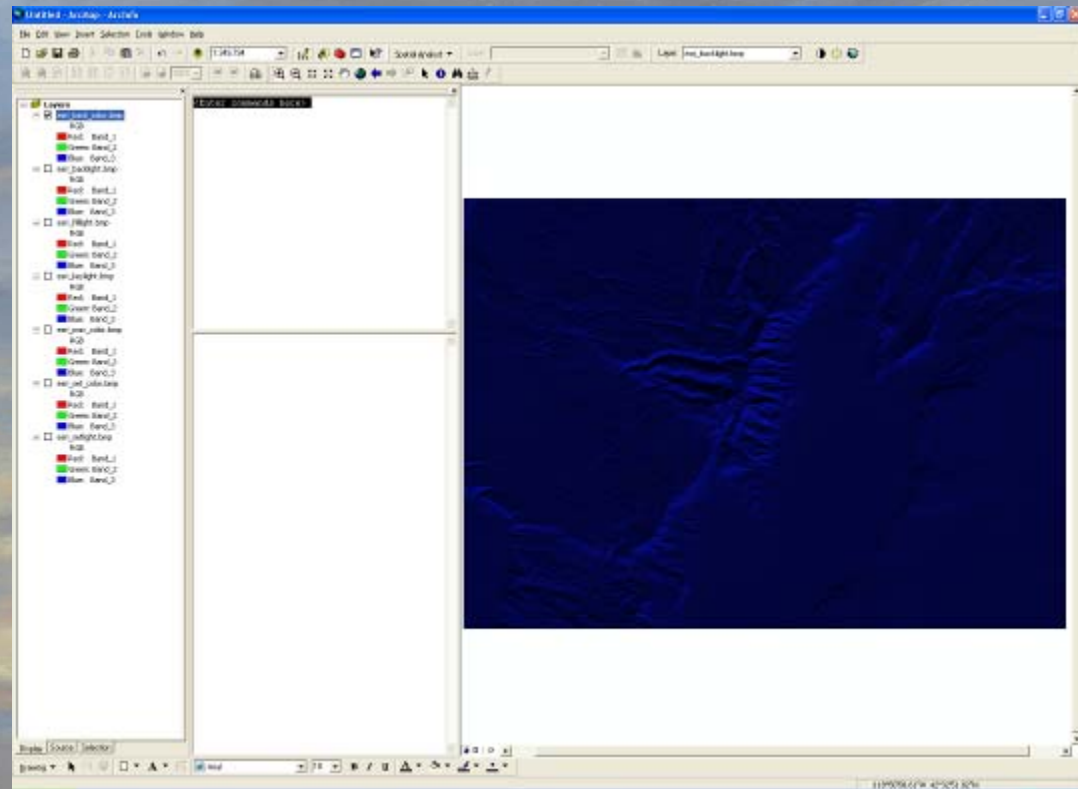
float([backlight]) * (float(6) / float(255))
float([backlight]) * (float(113) / float(255))
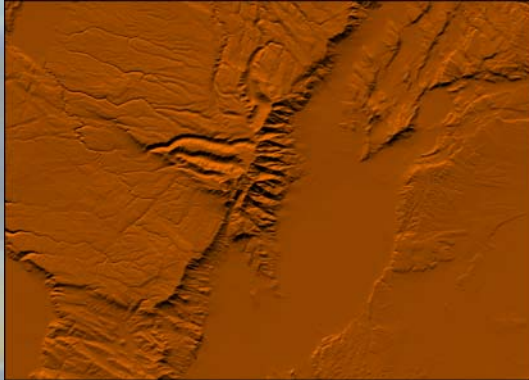float([backlight]) * (float(144) / float(255))

Back Light
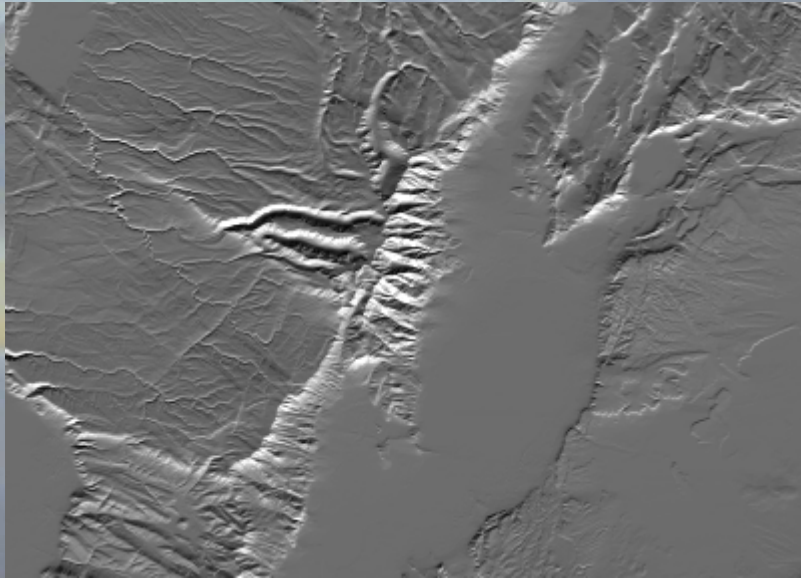
Back Light hillshade
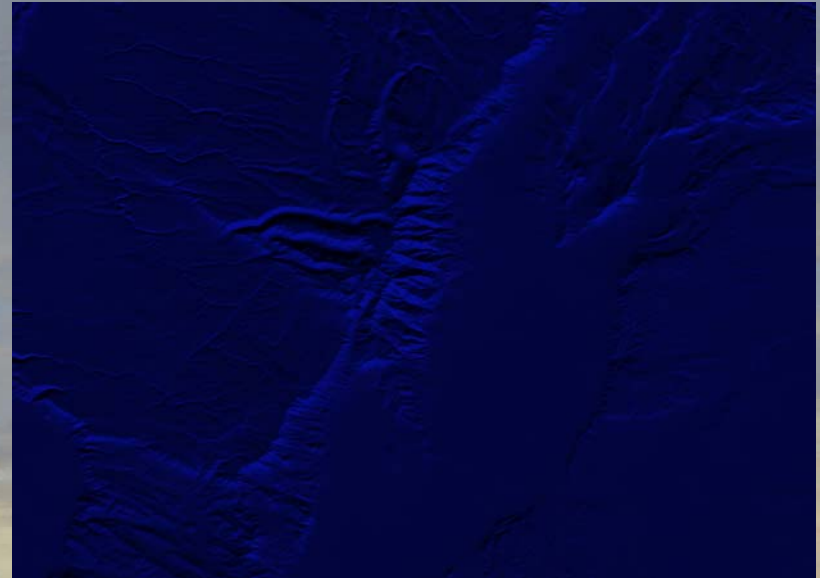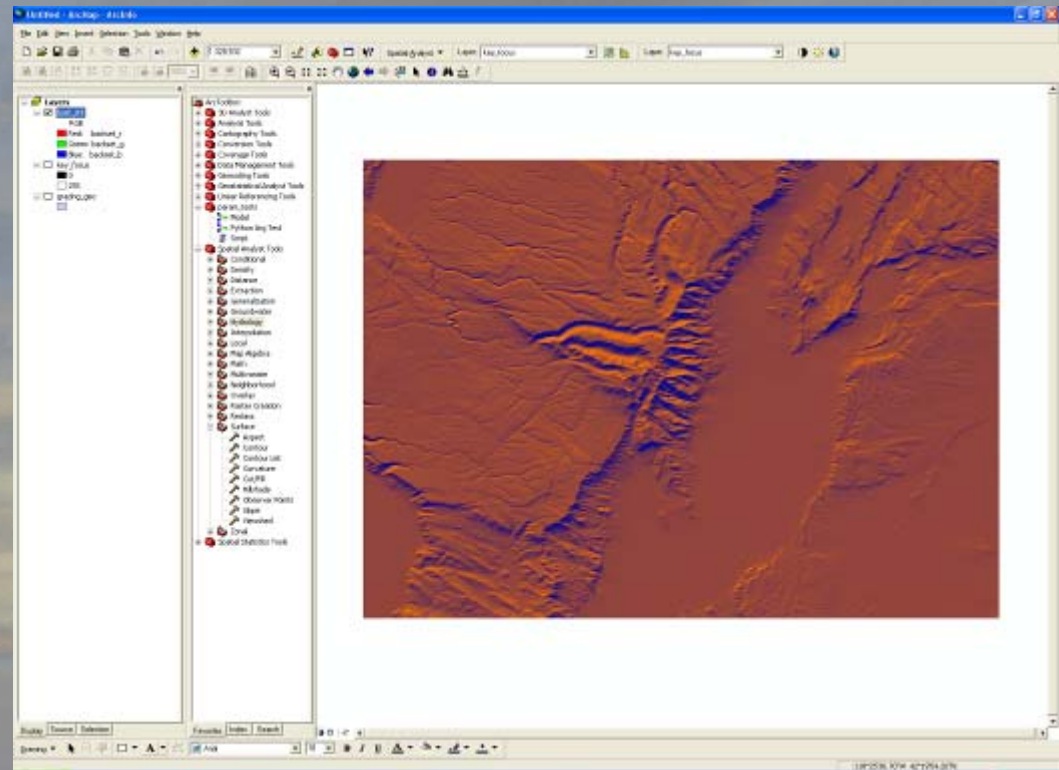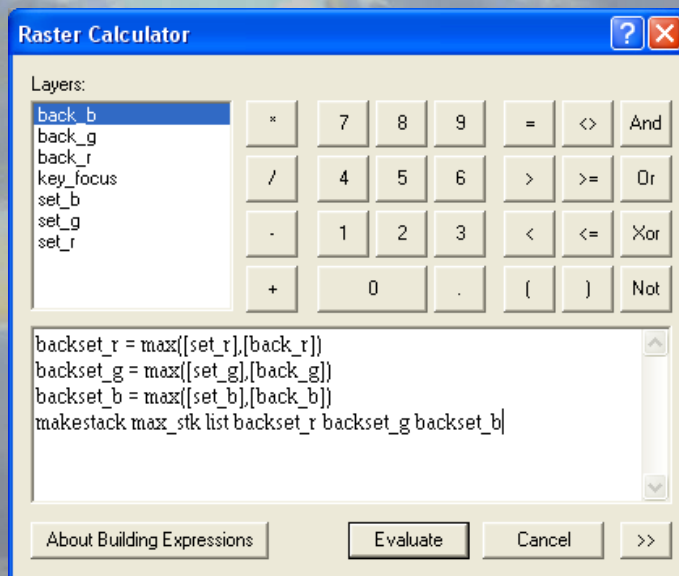

BackLight with Blue Color

Process So Far…
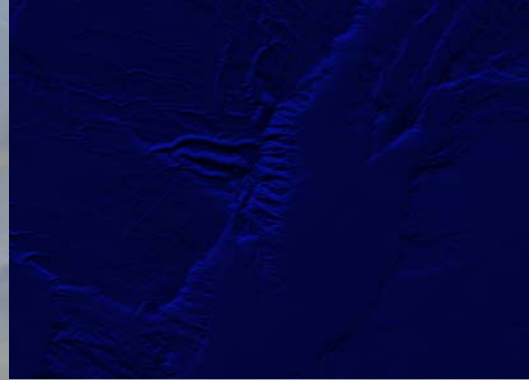
- Orange Set Light
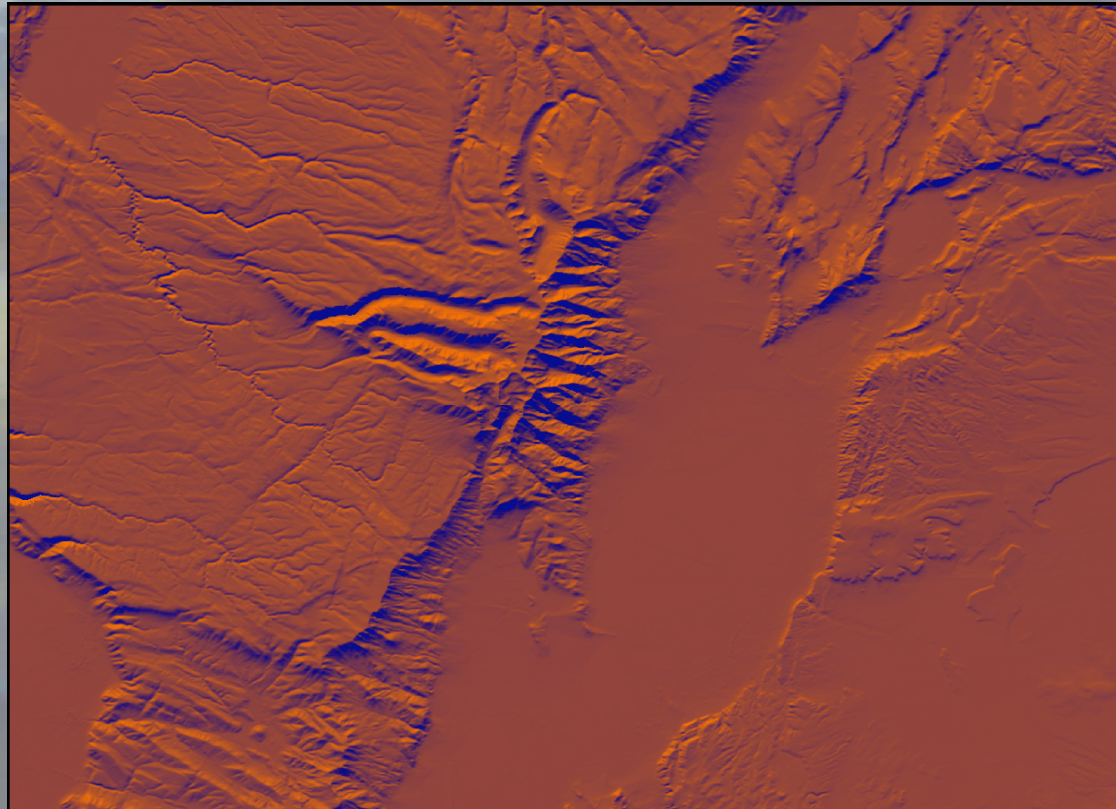- Blue Back Light
- White Fill Light
- White Key Light

Combine Set Light and Back Light
Using the Max Function

max_r = max(set_r,back_r)
max_g = max(set_g,back_g)
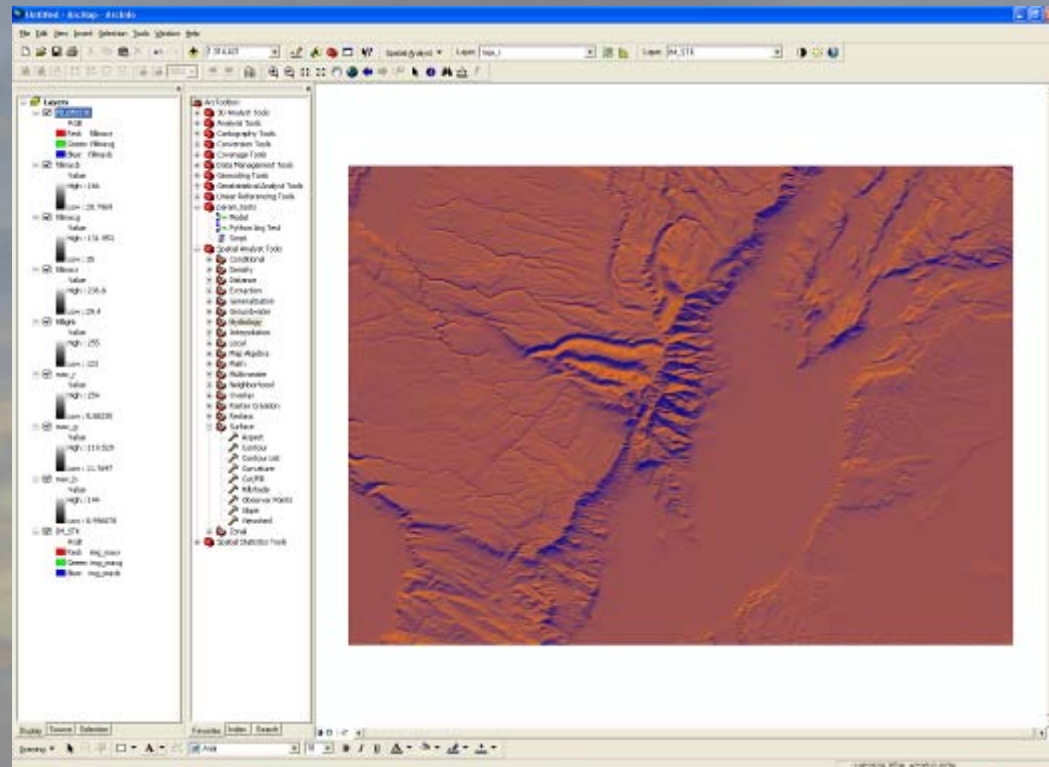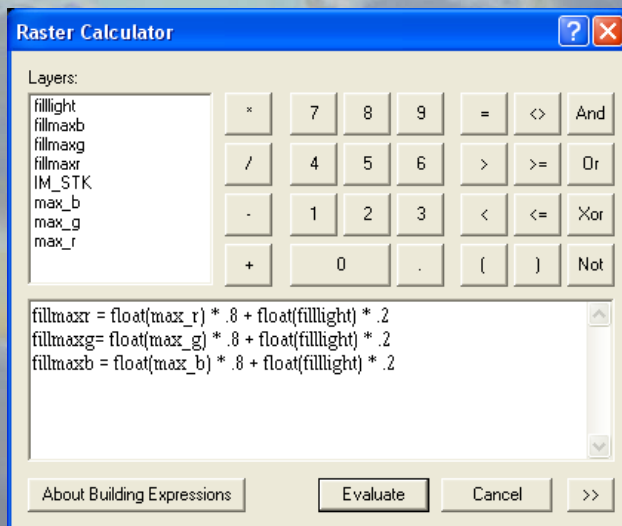max_b = max(set_b,back_b)
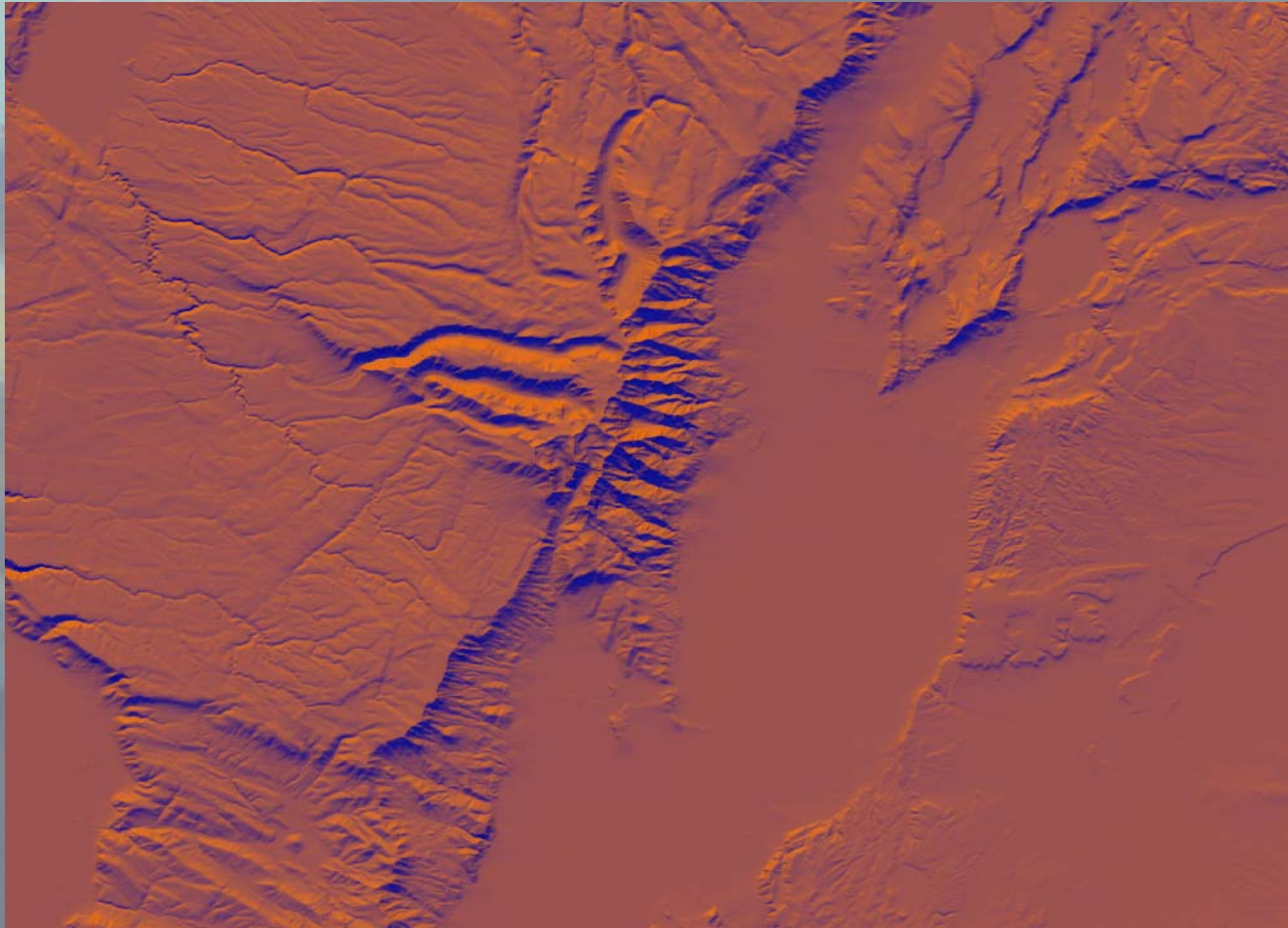makestack max_stk list max_r max_g max_b

Set light and backlight image
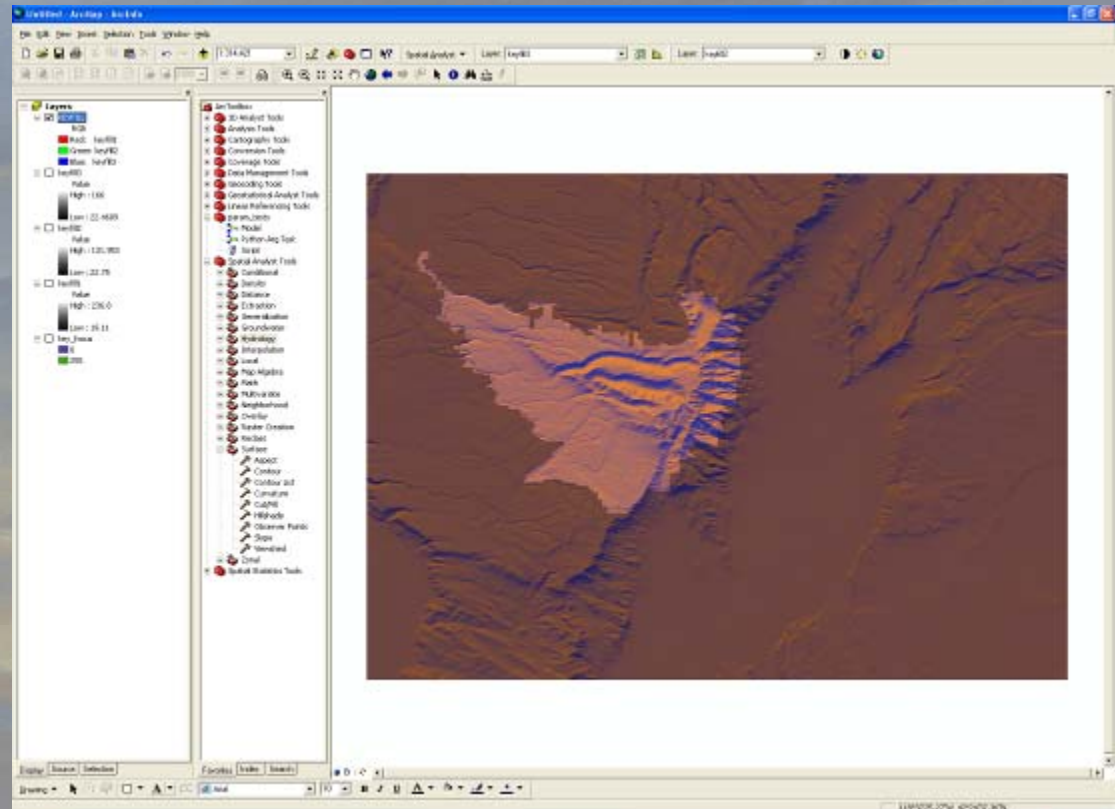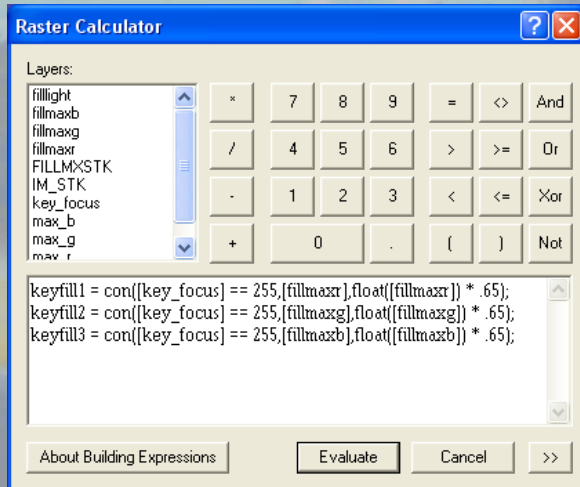
Add the Fill light
Using the weighted Overlay function

fillmaxr = float([max_r]) * .8 + float([filllight]) * .2
fillmaxg = float([max_g]) * .8 + float([filllight]) * .2
fillmaxb = float([max_b]) * .8 + float([filllight]) * .2
makestack fillmstk list [fillmaxr] [fillmaxg] [fillmaxb]
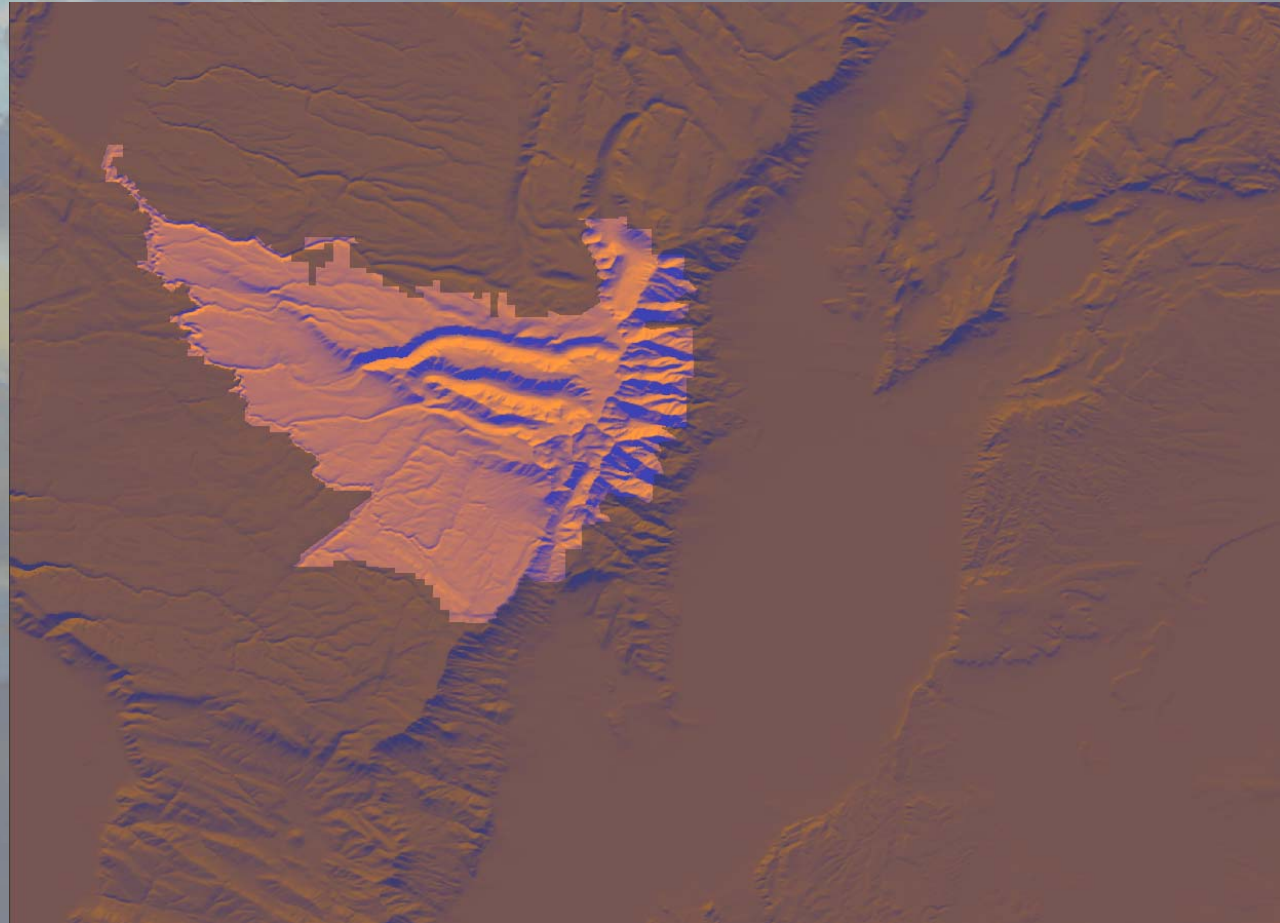
Set light, Back light, and Fill light
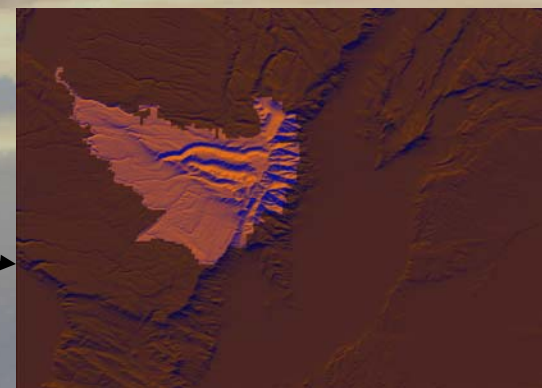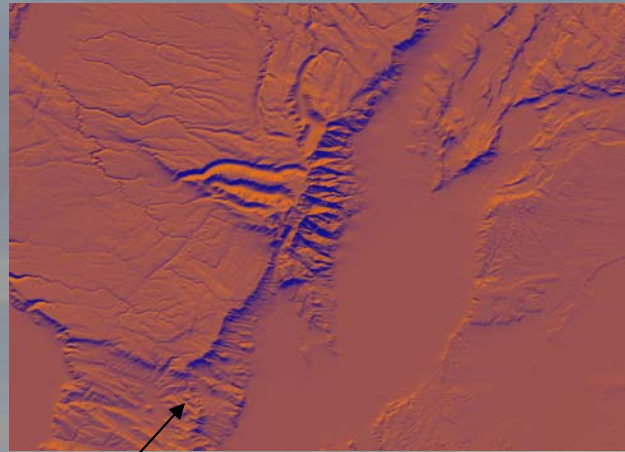
Add the Key light
Using the CON function

key1 = con([key_focus] == 255,[max_r],float([max_r]) * .65)
key2 = con([key_focus] == 255,[max_g],float([max_g]) * .65)
key3 = con([key_focus] == 255,[max_b],float([max_b]) * .65)
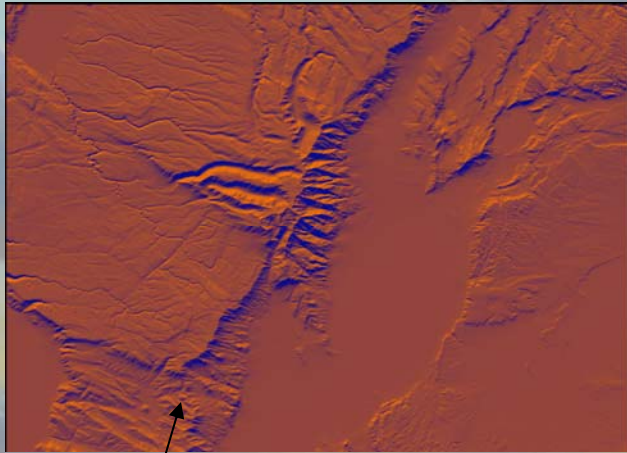makestack key_max list key1 key2 key3

Set Light, Back Light ,Fill Light and Key Light

Process So Far…

- Setlight and Backlight
- Set, Back and Fill light
- Set,Back,Fill and Key light

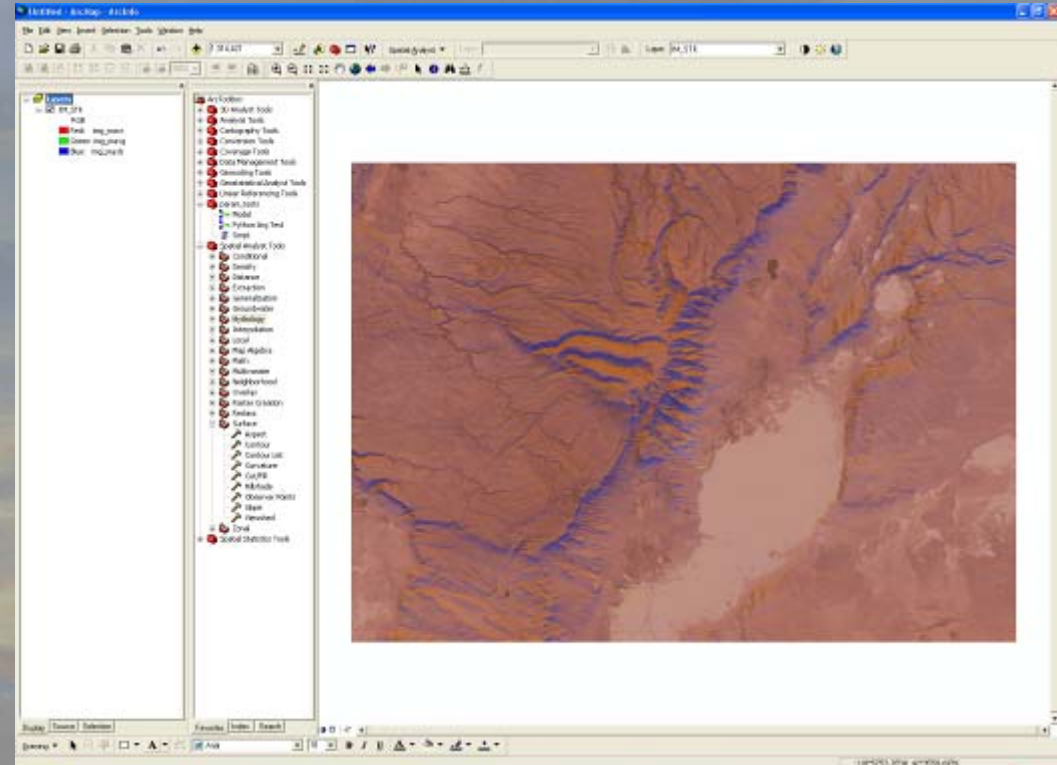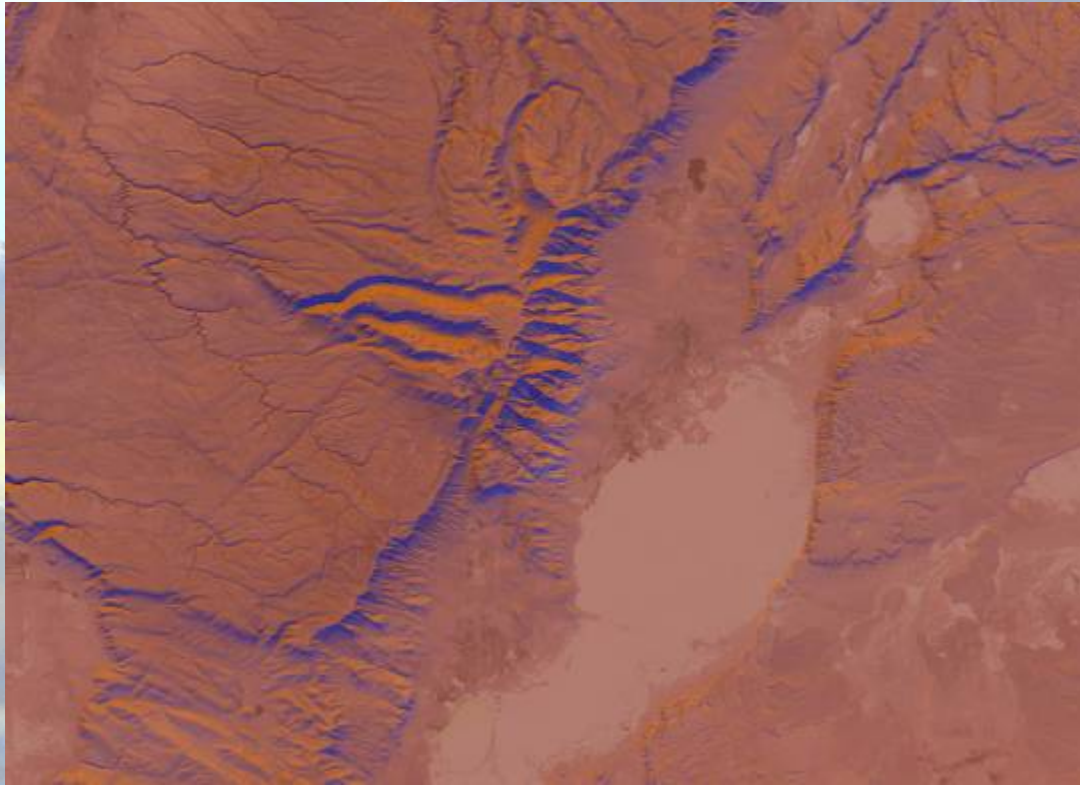# Use the Weighted Overlay to add Landsat Imagery or other Themes

img_maxr = float([max_r]) * .6 + float([subc1]) * .4
img_maxg = float([max_g]) * .6 + float([subc2]) * .4
img_maxb = float([max_b]) * .6 + float([subc3]) * .4
makestack im_stk list [img_maxr] [img_maxg] [img_maxb]

Final Color Landscape with Imagery added

Hill_img_r = max_r * .7 + img_c1 * .3
Hill_img_g = max_r * .7 + img_c2 * .3
Hill_img_b = max_r * .7 + img_c3 * .3

Final Image after color adjustments

Conclusions

- ArcGIS is capable of supporting a lighting methodology for Cartography

- ArcGIS needs point and spot light functions added to the hillshade function

- Lighting helps create dramatic eye-catching maps and graphics

QUESTIONS?

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