



United States Department of Agriculture

# Introduction to Spatial Analyst



Forest Service

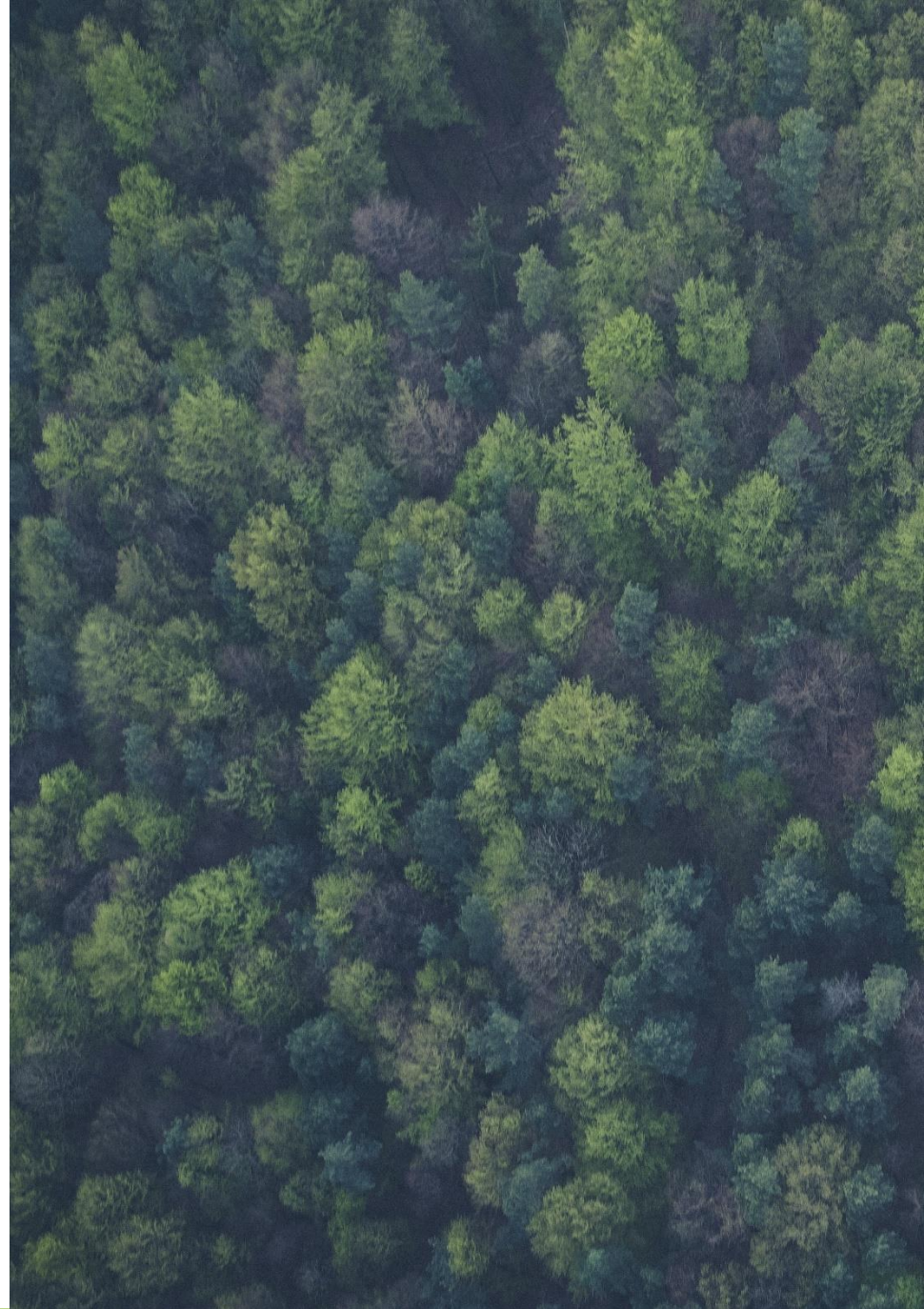


Geospatial Technology  
and Applications Center  
Mapping Our Future Together



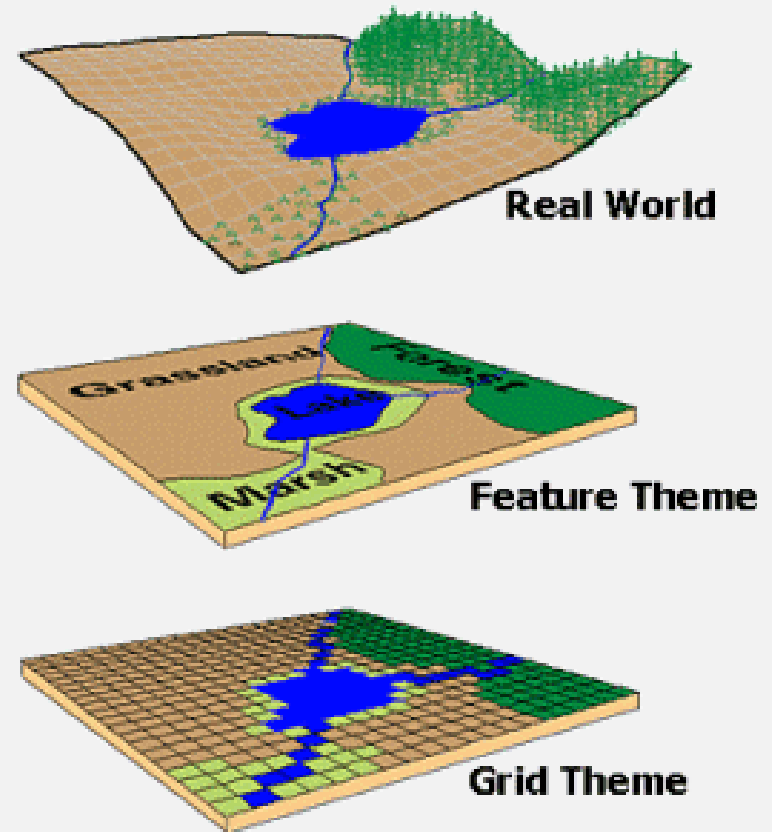
# Overview

- Raster data
  - Description of a raster dataset
  - Cell values / attributes
  - Layer properties
- Using Spatial Analyst in ArcGIS
- Setting up the Analysis Environment
- Performing analysis with the Raster Calculator



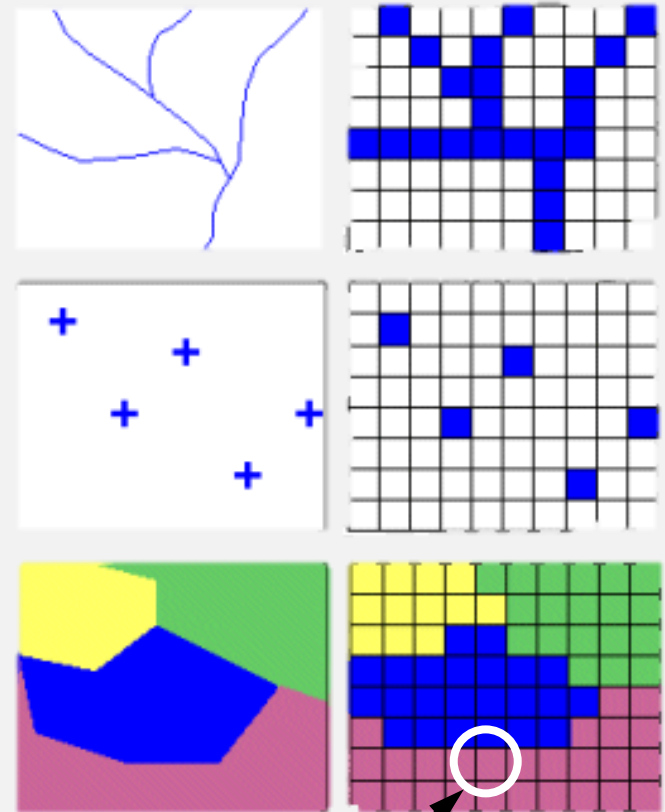
# Introduction to Spatial Analyst

- Licensed extension from ESRI
- Designed to work with cell-based data (i.e., rasters)
- Used for spatial analysis and modeling



# Vector data versus raster data

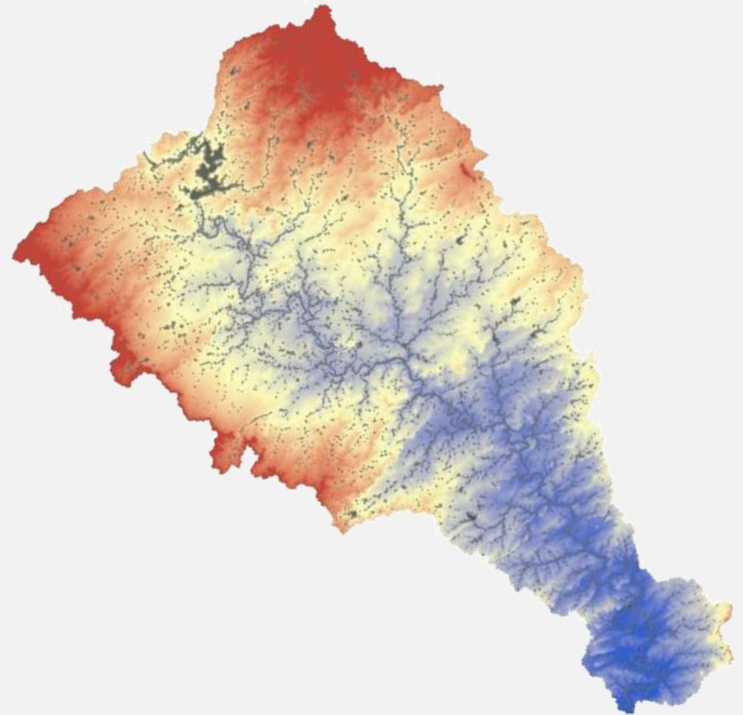
- Vector data
  - Collection of spatial coordinates
  - Points, lines, polygons
- Raster data
  - Matrix of square cells
  - Cells store a numeric value
- Types of raster data
  - Imagery
  - GRIDs
  - DEM & DRG
  - Graphics (BMP, JPEG, ...)



Pixel

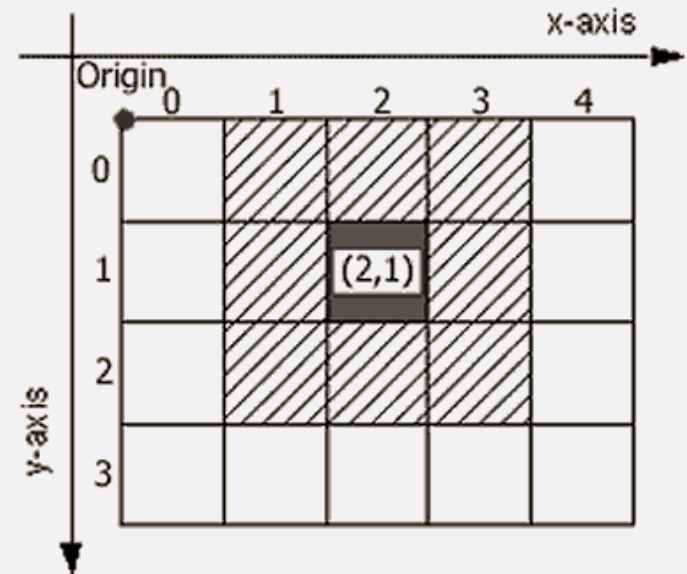
# RASTER DATA

- Raster data represents geographic phenomena
- Advantages over vector data
  - Better represents continuous surfaces
  - Allows for spatial analysis of flows, trends, and surfaces
  - Uniform data structure
- Formats usable in ArcGIS



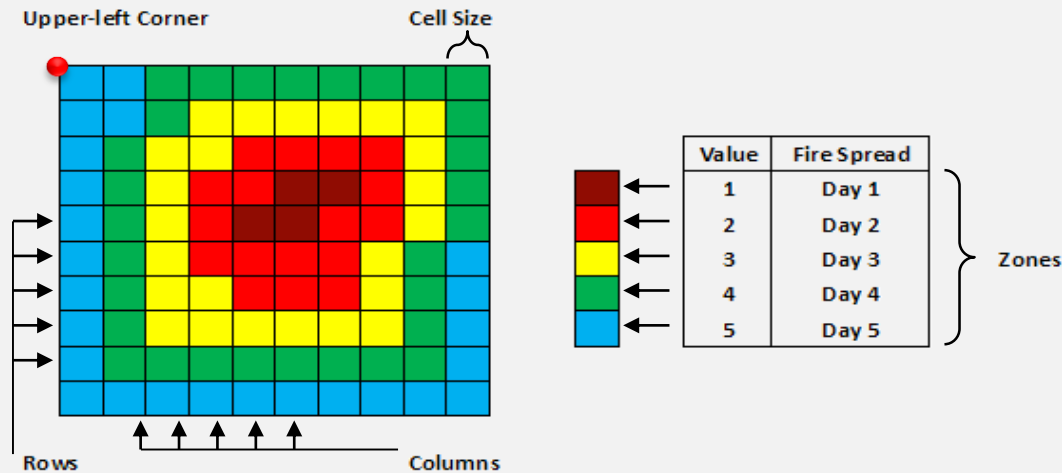
# GRID cells, rows, and columns

- All cells are rectangular and are the same size
  - Cell size dictates GRID resolution (e.g., 10 meters)
  - Improving resolution increases file size and decreases software performance
- Cells are organized into rows and columns
- Each cell has a unique index number
  - Top left cell is at the (0,0) position



# Cell value assignment

- Cells store a single numeric value
- Coded values represent geographic features
- Cells with the same value make up a zone



# Cell value: pixel (data) type

- Integer = whole numbers
- Floating point = decimal numbers
- No Data = non-numeric

**Integer**

2	1	1	1
NO DATA	1	2	2
NO DATA	1	2	2
1	1	2	2

1 = Forest    2 = Water

**Floating Point**

1.112	3.822	3.755	3.432
0.257	1.829	2.867	2.993
0	0.923	0.712	0.448
0	0.181	NO DATA	NO DATA

Continually Changing Values



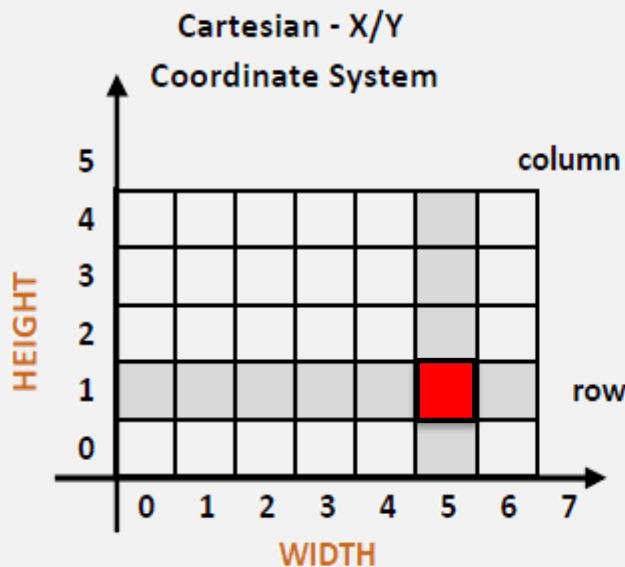
# Cell value: source type

- Discrete (Qualitative)
  - Integer = whole numbers
    - Thematic / Categorical with distinct boundaries
    - Landuse, Vegetation, Roads, Lakes, Streams, etc...
- Continuous (Quantitative)
  - Floating point = decimal numbers
    - Continuously changing data values with no identifiable boundaries
    - Remotely Sensed Images - Satellite Imagery, Aerial Photography
    - Rainfall, Elevations, Slope, Temperature, etc...
- In between (e.g., soil types, forest edges)
  - Continuous integer values
- NoData = non-numeric
  - Do not use the number 0

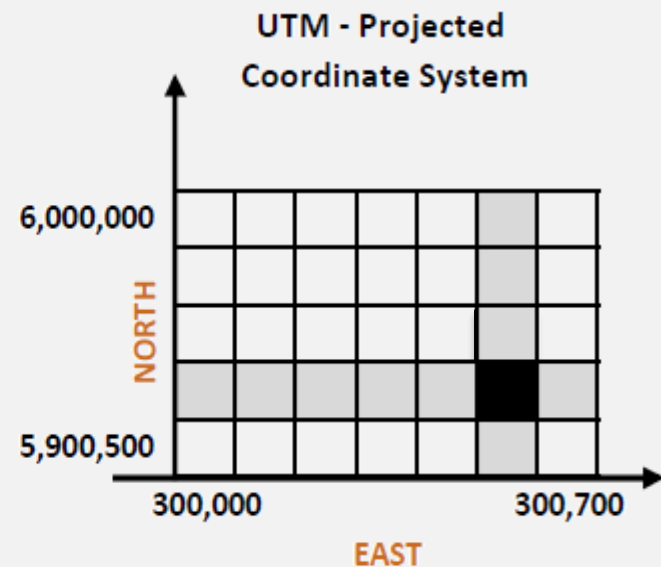


# A GRID's spatial reference

- GRIDs can be spatially referenced to real-world locations
- All input/output datasets should use same spatial reference with same datum
- Each cell's location is referenced by an X,Y coordinate



**XY = 5,1**



**300,500 E**  
**5,900,600 N**

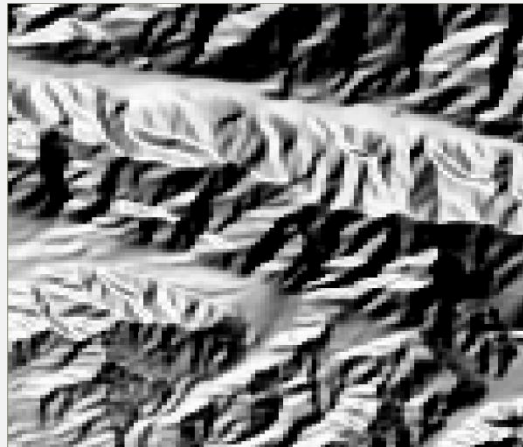
# Raster Resolution

- Spatial Resolution
  - Level of detail within an individual pixel or cell

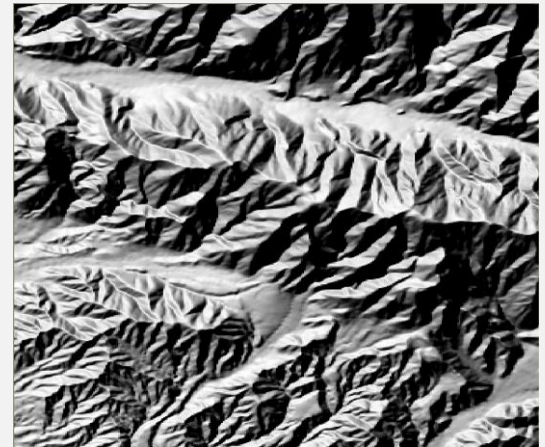
**270 Meter**



**90 Meter**



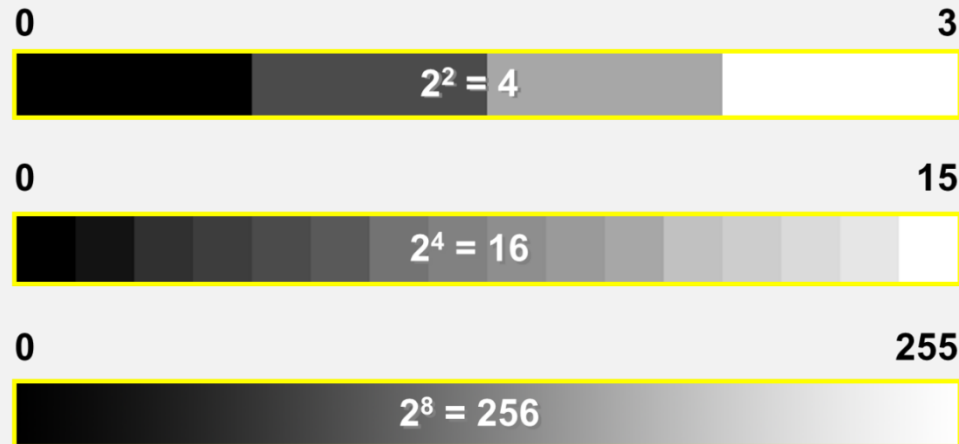
**30 Meter**



# Raster Resolution

- Radiometric Resolution

- Bit depth- number of possible values in each band
- Signed - allows positive and negative values
- Unsigned - only positive values are allowed

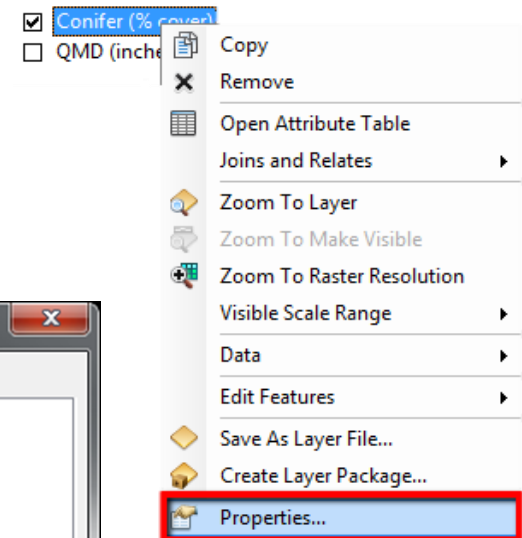
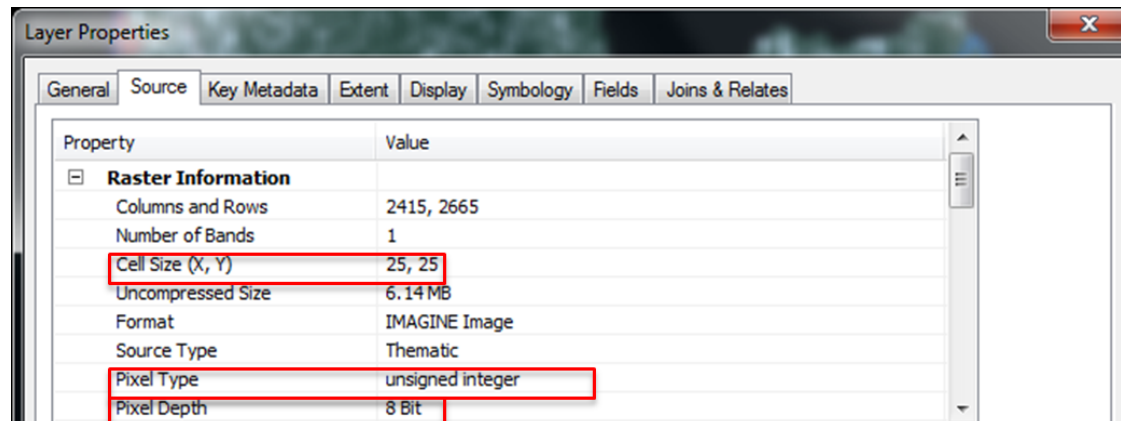


Exception: An ESRI GRID is always stored as 32 bit. ArcMap displays a GRID with the most appropriate bit depth with respect to it's cell values



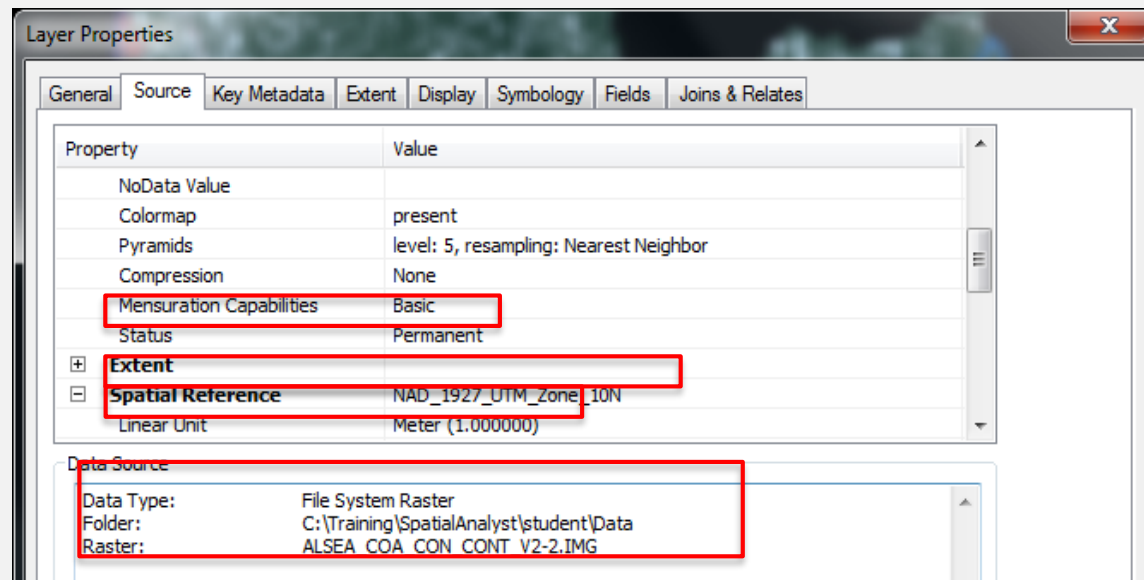
# Layer Properties for a raster

- Right-click | Properties
- Cell Size = spatial resolution
- Pixel Type = integer vs. floating point
- Pixel Depth = the number of possible values



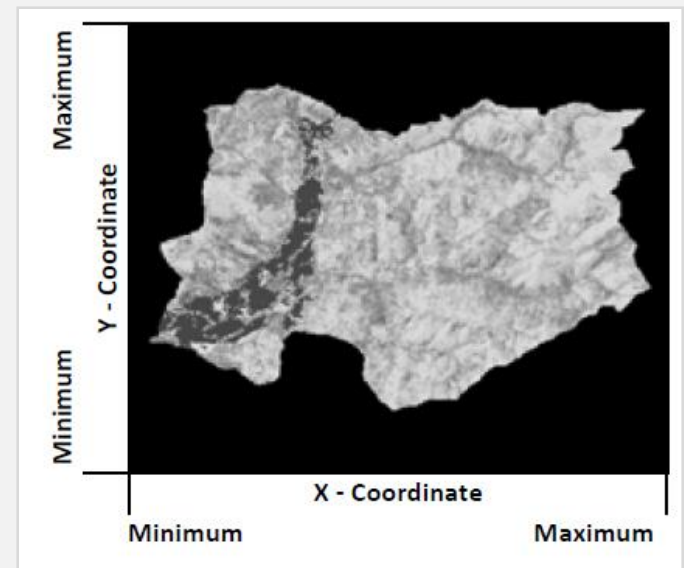
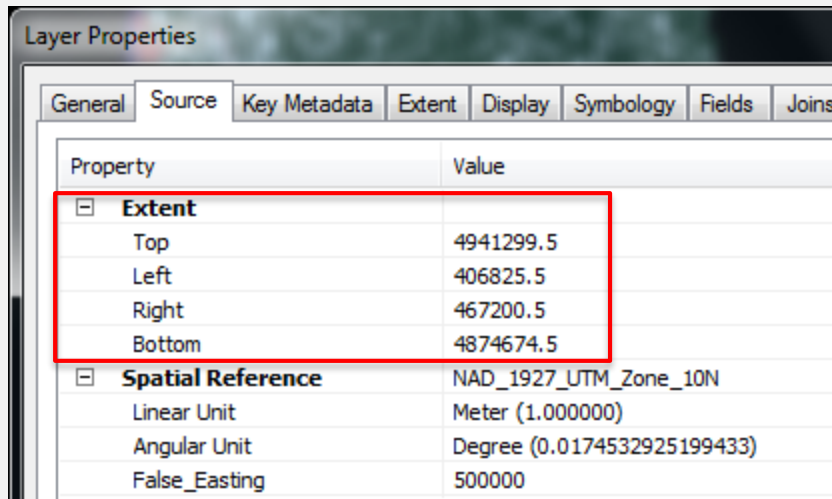
# Layer Properties for a raster

- Status = temporary or permanent
- Spatial Reference = projection / coordinate system
- Linear Unit = unit of measure (meters, feet)
- Data Source = name, file type, and location



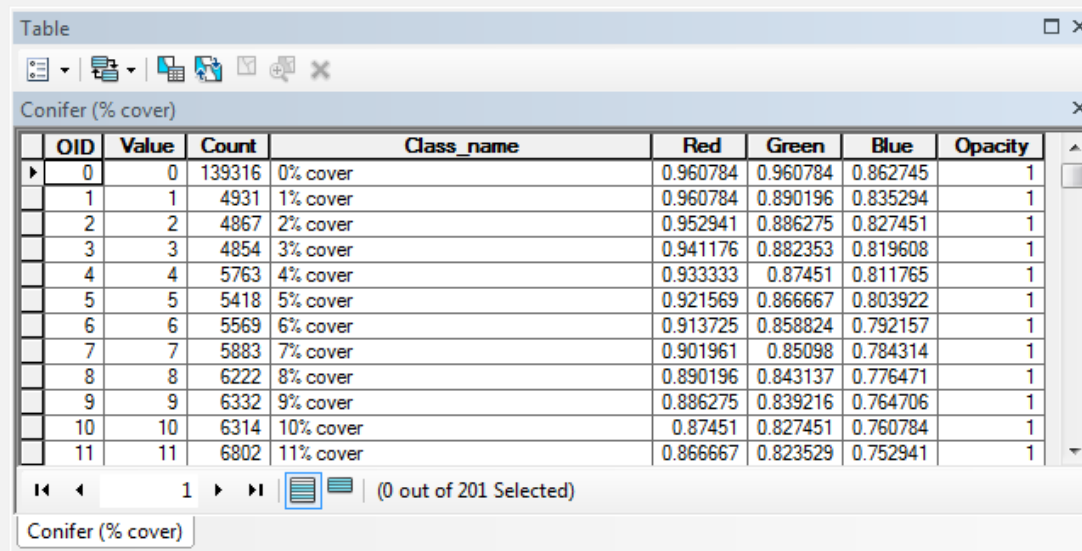
# Layer Properties for a raster

- Extent = dataset's rectangular boundary
  - Includes areas of NoData



# Value Attribute Table (VAT)

- Only an integer raster can display a VAT
  - Count field stores the number of cells per zone
  - One record for each unique value
  - VAT's store one record per zone
  - Never edit Value or Count fields



Table

Conifer (% cover)

OID	Value	Count	Class_name	Red	Green	Blue	Opacity
0	0	139316	0% cover	0.960784	0.960784	0.862745	1
1	1	4931	1% cover	0.960784	0.890196	0.835294	1
2	2	4867	2% cover	0.952941	0.886275	0.827451	1
3	3	4854	3% cover	0.941176	0.882353	0.819608	1
4	4	5763	4% cover	0.933333	0.87451	0.811765	1
5	5	5418	5% cover	0.921569	0.866667	0.803922	1
6	6	5569	6% cover	0.913725	0.858824	0.792157	1
7	7	5883	7% cover	0.901961	0.85098	0.784314	1
8	8	6222	8% cover	0.890196	0.843137	0.776471	1
9	9	6332	9% cover	0.886275	0.839216	0.764706	1
10	10	6314	10% cover	0.87451	0.827451	0.760784	1
11	11	6802	11% cover	0.866667	0.823529	0.752941	1

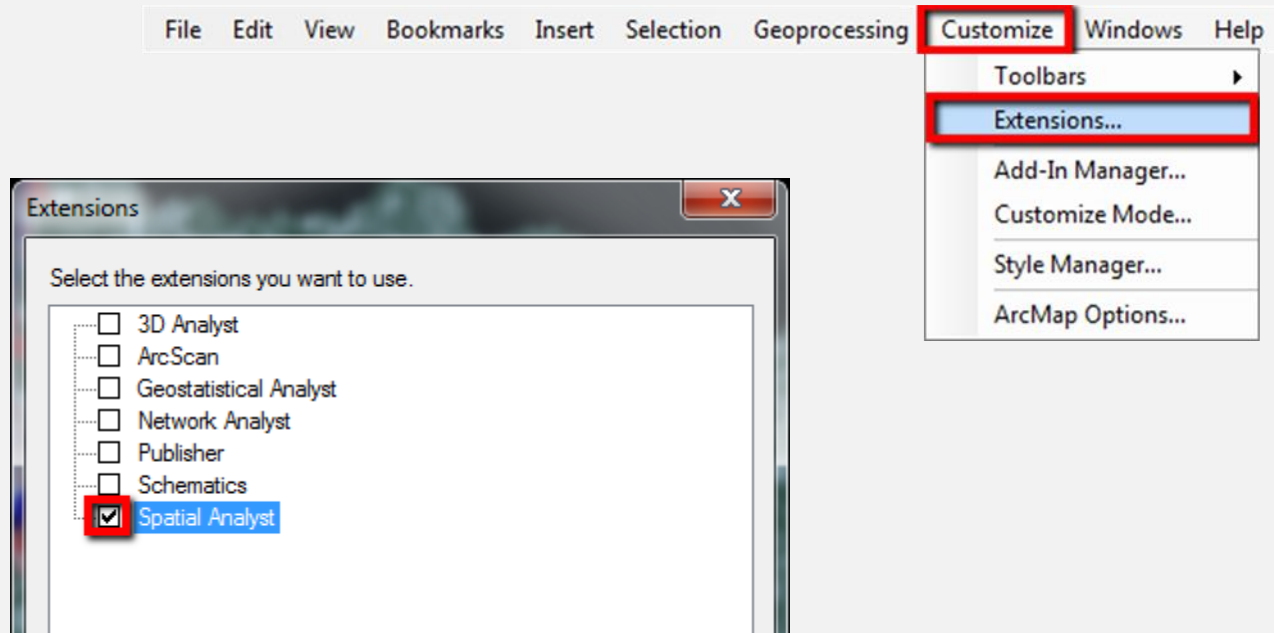
1 (0 out of 201 Selected)

Conifer (% cover)



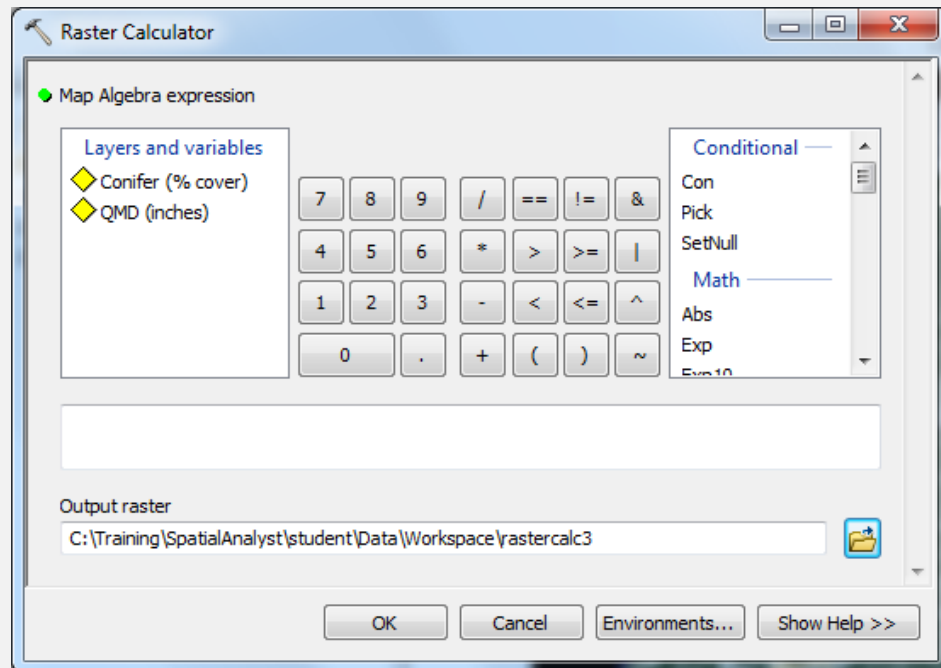
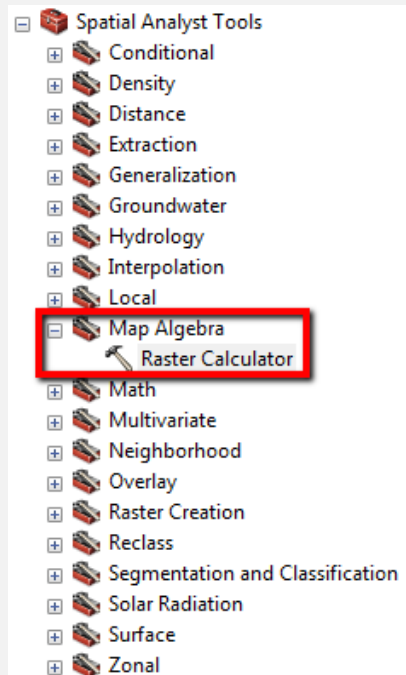
# ArcGIS's Spatial Analyst Tools

- Enable the Spatial Analyst Extension
  - Customize > Extensions



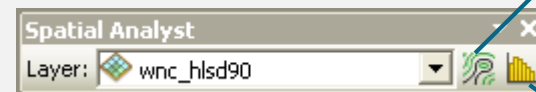
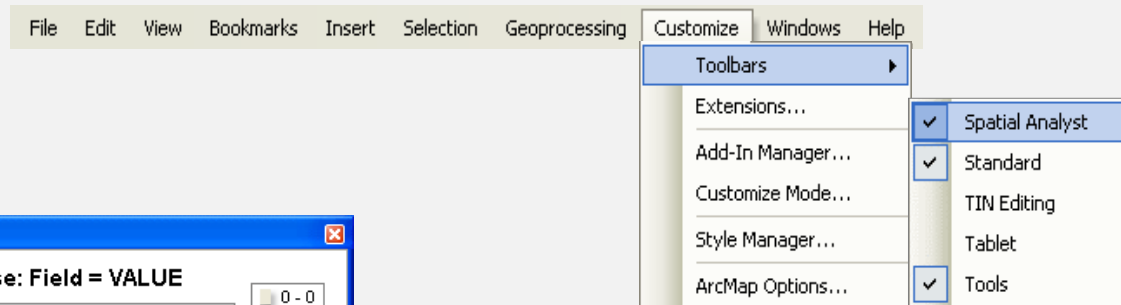
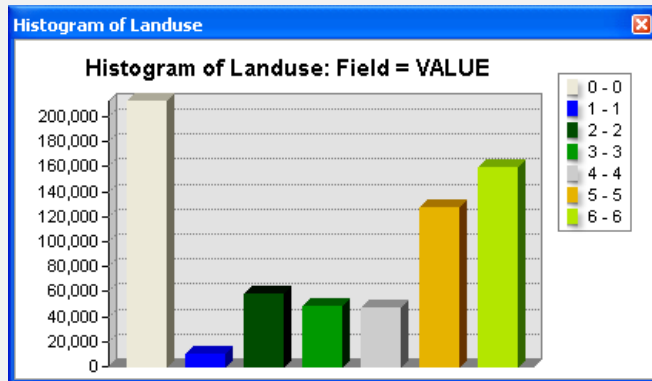
# ArcGIS's Spatial Analyst Tools

- Tools are organized into toolsets



# Spatial Analyst toolbar

- Enable the Spatial Analyst Toolbar
  - Customize > Toolbars > Spatial Analyst
  - Create Contour tool
  - Histogram tool

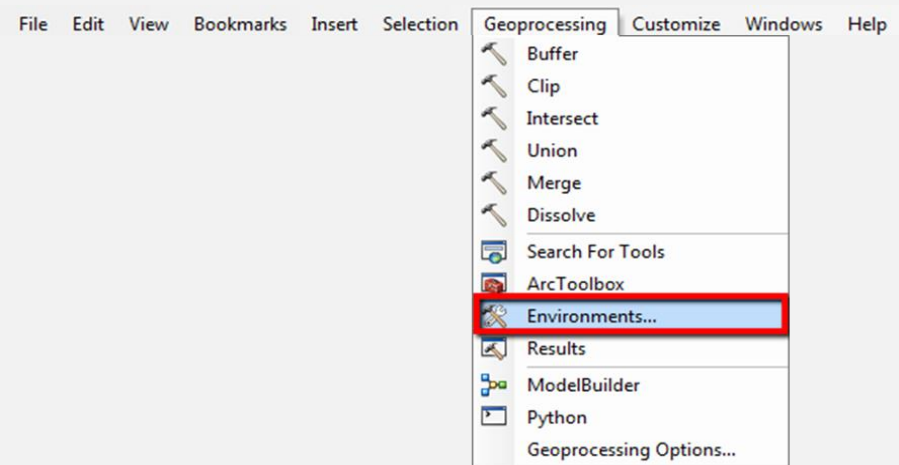


Create  
Contour

Histogram

# Environment Settings

- Set up your geoprocessing environment
  - Working directory
  - Processing Extent
  - Analysis mask: defines study area of analysis
  - Cell size
- 3 Levels
  - Advanced ArcMap settings – applies to all ESRI applications
  - Application – applies to all geoprocessing tools in an MXD
  - Within a tool – applies to a single use of the



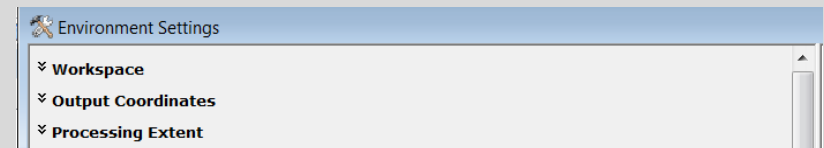


# Setting the analysis environment

- Working directory Default location:

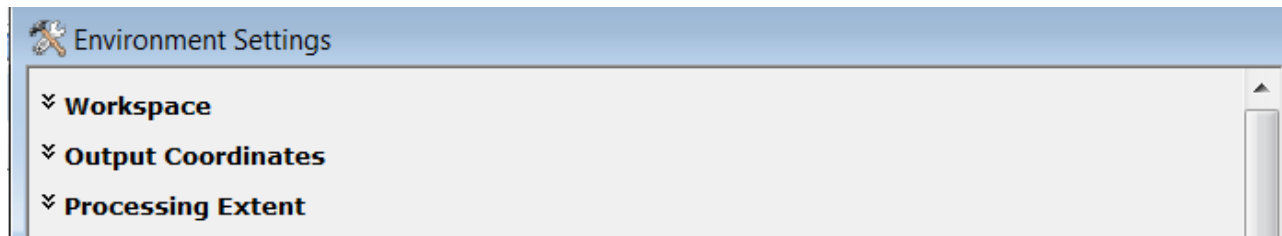
[C:\Documents and Settings\yourname\My Documents\ArcGIS\Default.gdb](#)

- Output Coordinates
  - defines the coordinate system (map projection) for any output data



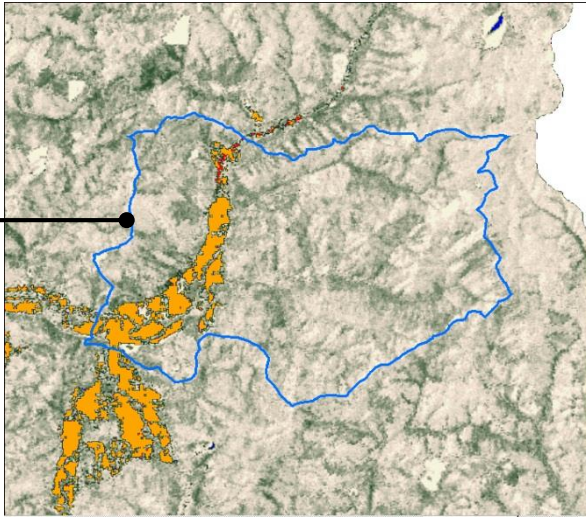
# Setting the analysis environment

- Cell size
  - Cell size or resolution for all output datasets
- Processing extent
  - Limits analysis to a specific geographic area
- Analysis mask
  - Processing will only occur on selected cells and all other cells will be assigned values of NoData

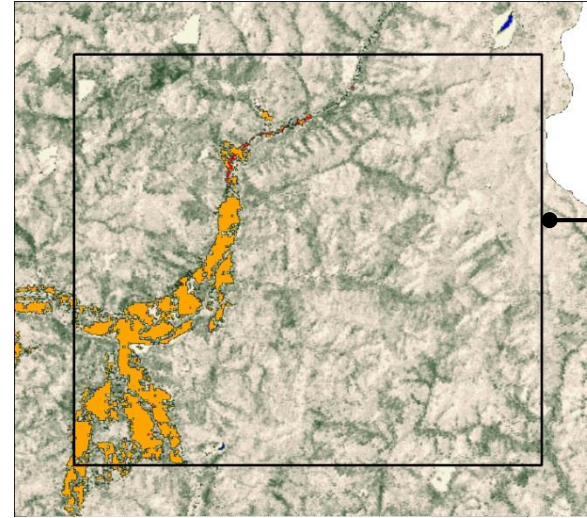


# Analysis mask vs. Processing extent

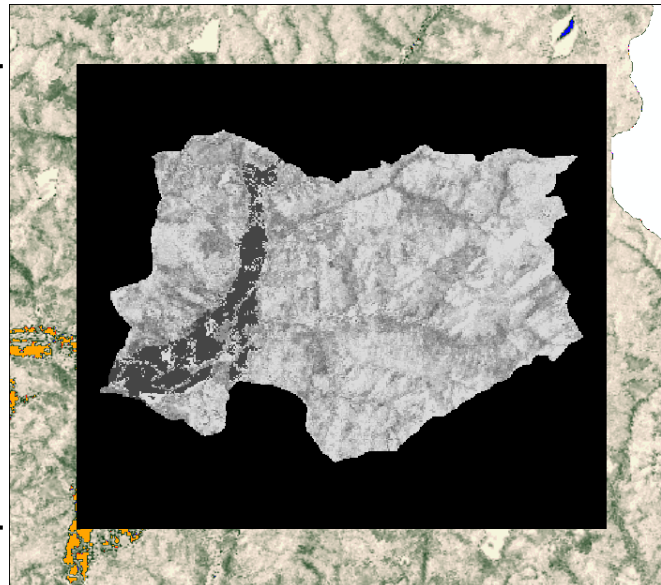
**Analysis  
Mask**  
(in blue)



**Processing  
extent**



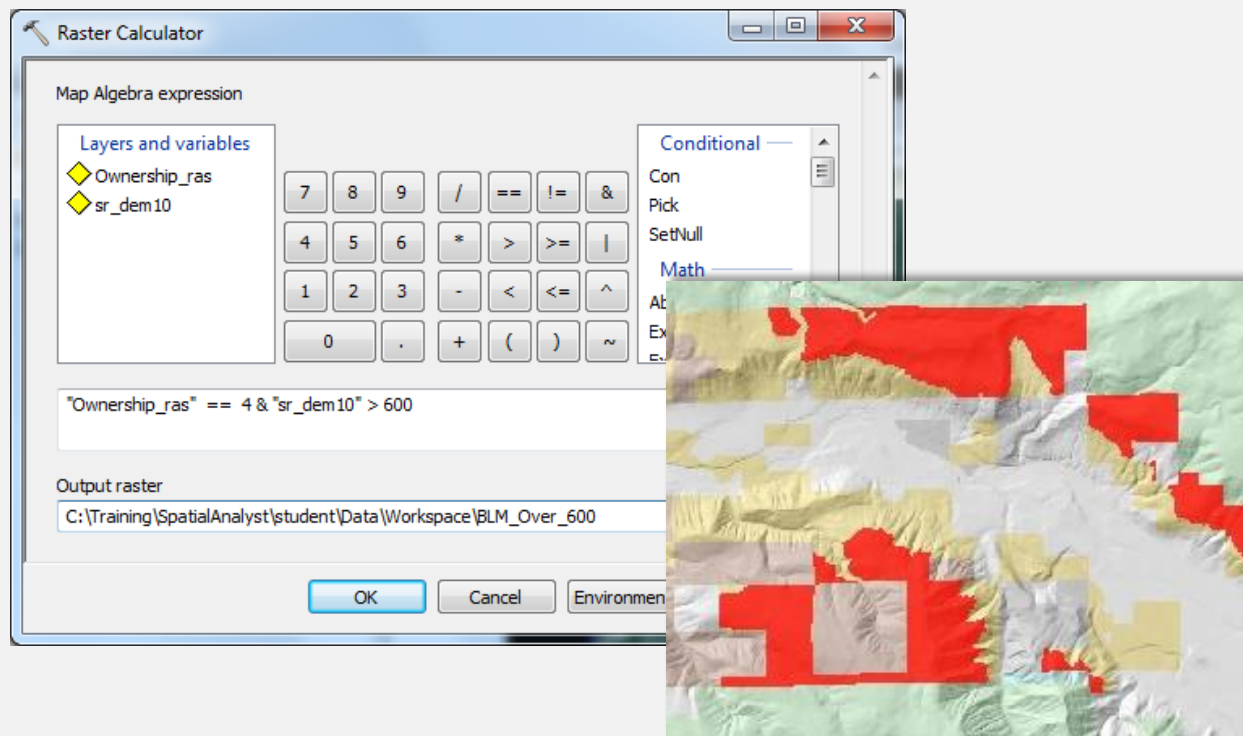
**Output GRID from  
a Spatial Analyst  
operation**



**Cells outside analysis  
mask assigned NO DATA  
(shaded in black)**

# Raster Calculator

- Used to select raster information via query or mathematical operators (Map Algebra)
- Types of operations: Arithmetic, Boolean, Relational



# Old File Types

## **Caution when using Grids, Images, and other old raster layers**

- Path to the file must be less than 129 characters long with no spaces.
- File name must be 10 characters or less.
- Use a File Geodatabase to avoid the errors caused by the old file type.
- Add your image to a Geodatabase.

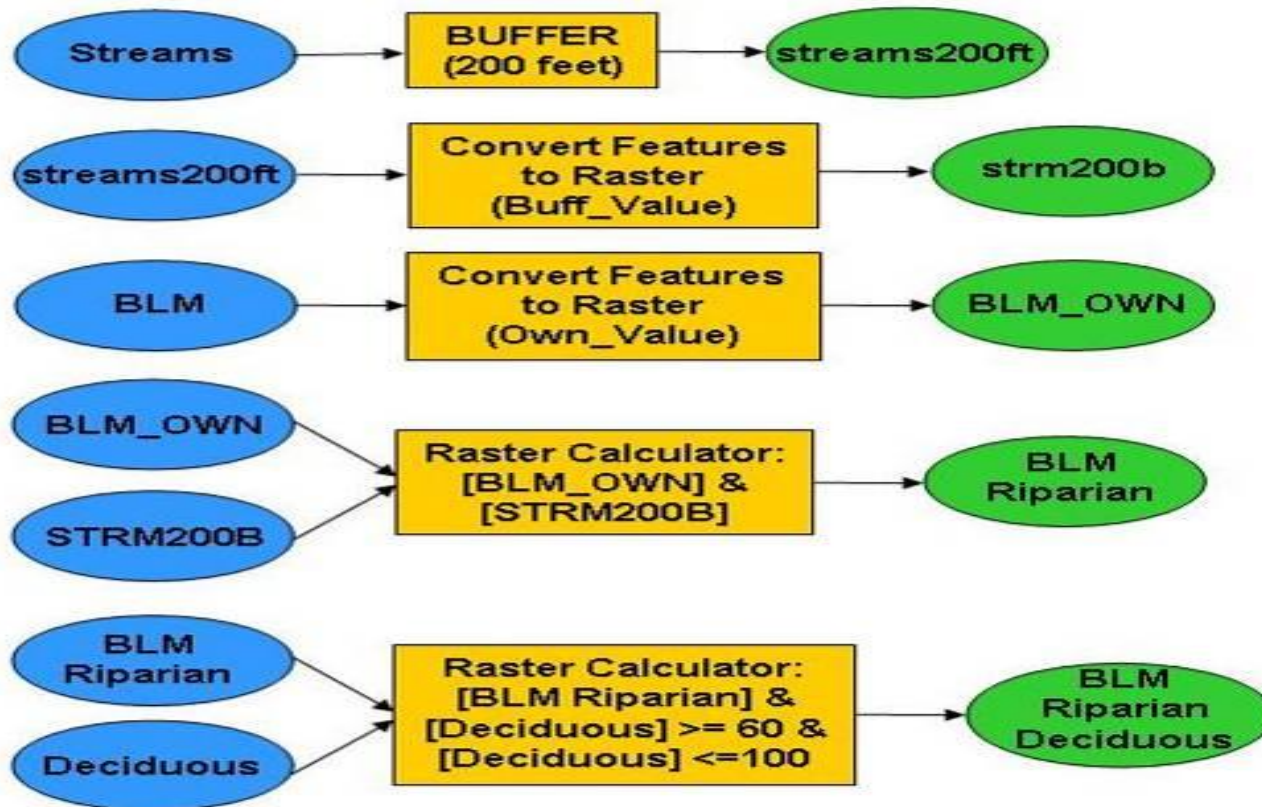




# Demonstration







# Demonstration





# Surface Analyses



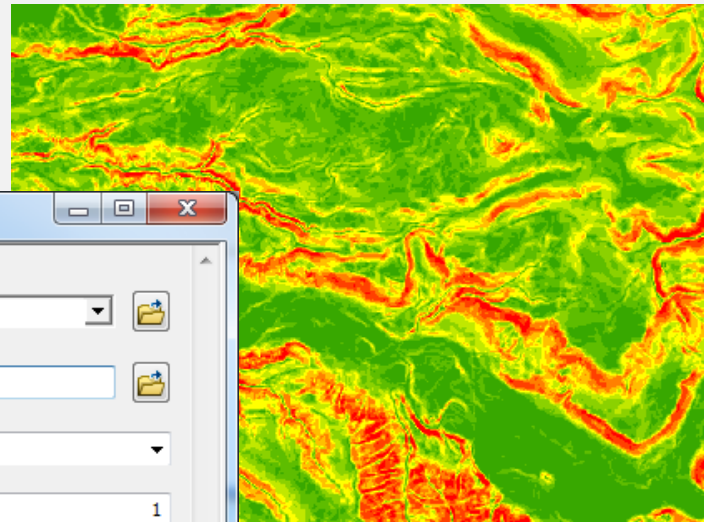
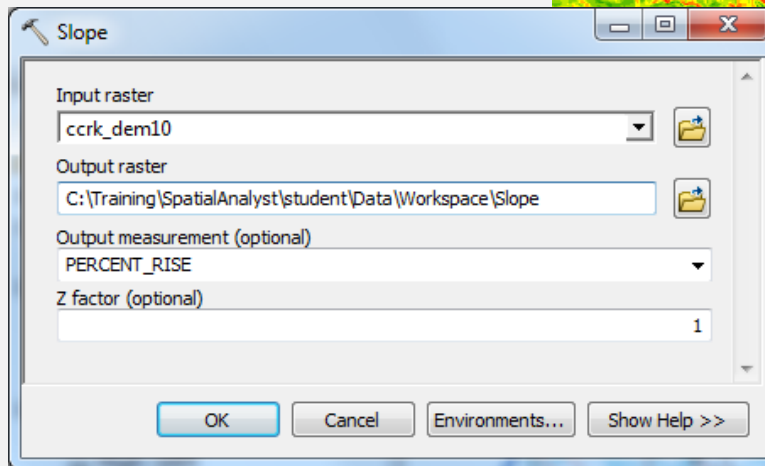
# Slope, Aspect, and Contour maps

- Ways to visualize surface relief
  - Slope
  - Aspect
  - Contours



# Determining Slope

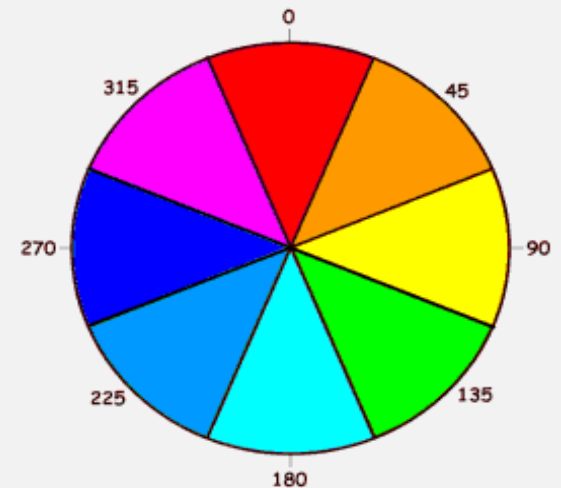
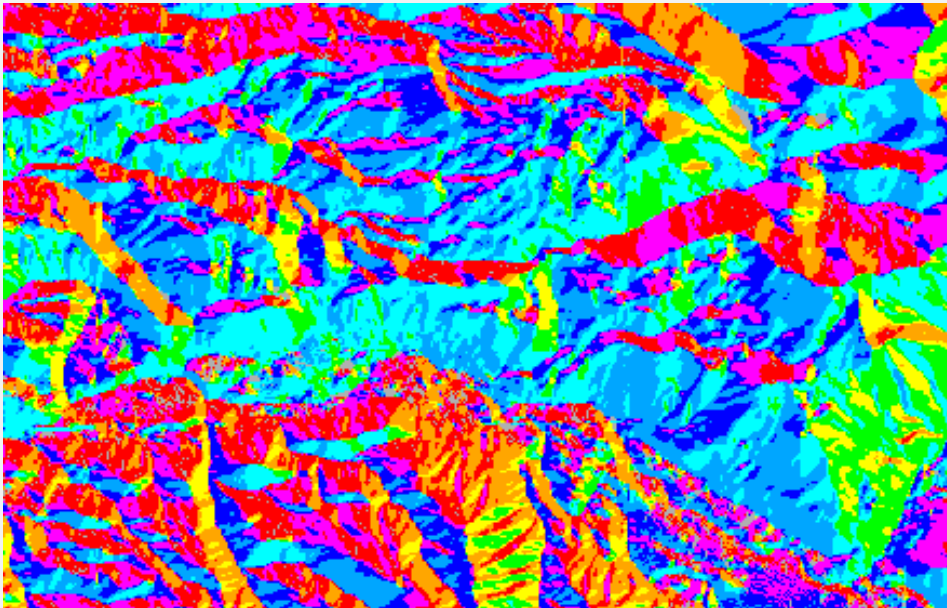
- Slope: maximum rate of change of surface
- Measured in degrees or percent (e.g.,  $5^\circ = 9\%$  slope)
  - Green shading = gentle slope
  - Red shading = steep slope





# Determining Aspect

- Aspect: identifies downslope direction of surface
- Measured in compass degrees (e.g.,  $0^\circ$  = North)
  - Every  $45^\circ$  has a unique color assignment
  - Zero slope has aspect of -1





# Creating Contours

- Contours

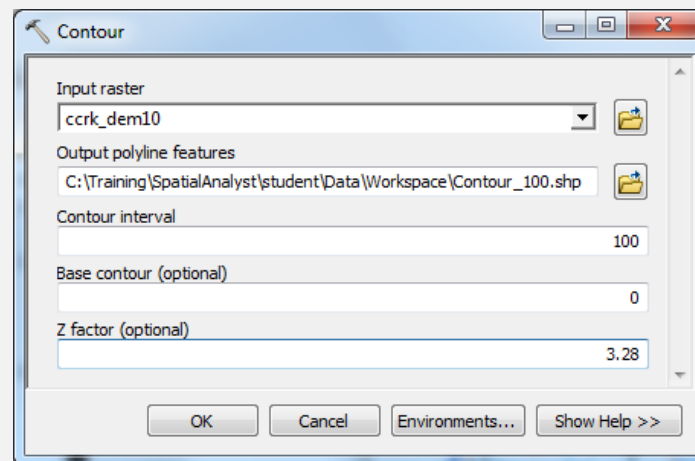
- Lines of equal elevation (a type of isoline)
- Examples: elevation, temperature, precipitation

- Contour creation settings

- Output is a vector dataset
- Contour interval
- Base contour
- Z factor

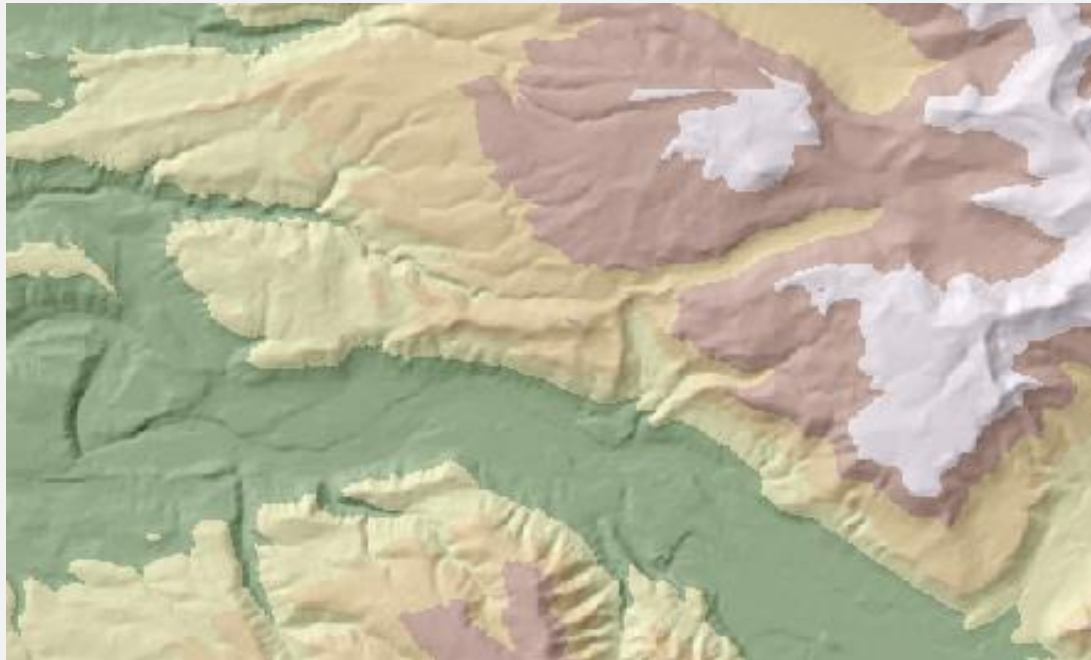
- To alter contour interval using definition Query in Layer Properties:

- $(([\text{Subj\_con}] \bmod \text{<interval \#>}) = 0) \text{ and } ([\text{Subj\_con}] < > 0).$
- For example, if the value of <interval #> equals 100, then the layer redraws contours every 100 units.



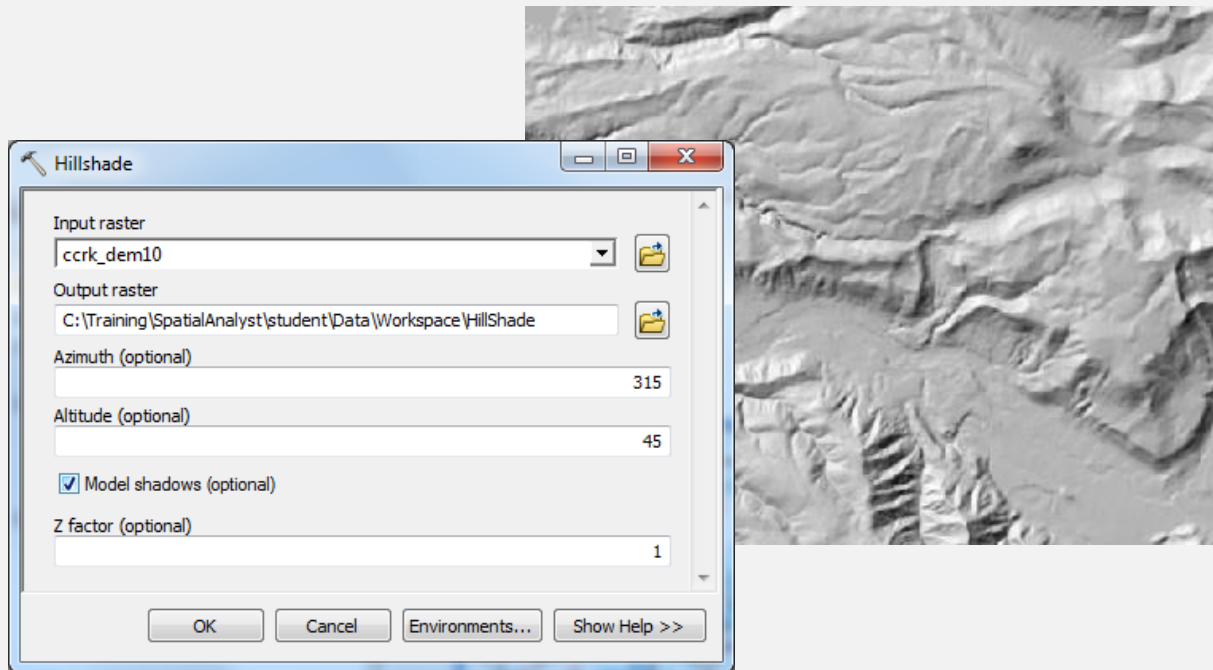
# Create hillshade; viewshed analysis

- Create a hillshade to improve a map's appearance
- Conduct a viewshed analysis to identify visible areas



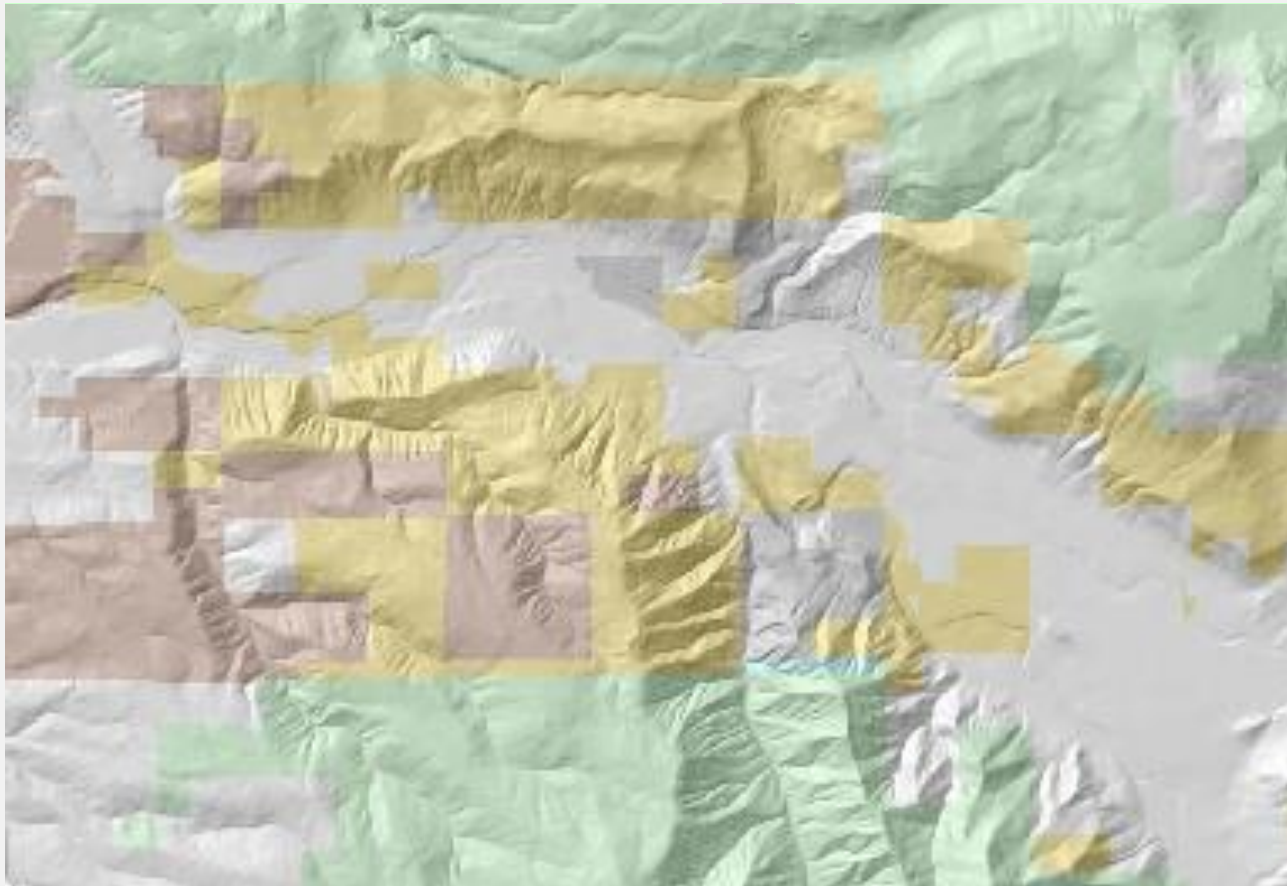
# Hillshading

- Casts shadows with an imaginary light source
- **Azimuth:** compass direction of the light source
- **Altitude:** angle of light source above the horizon



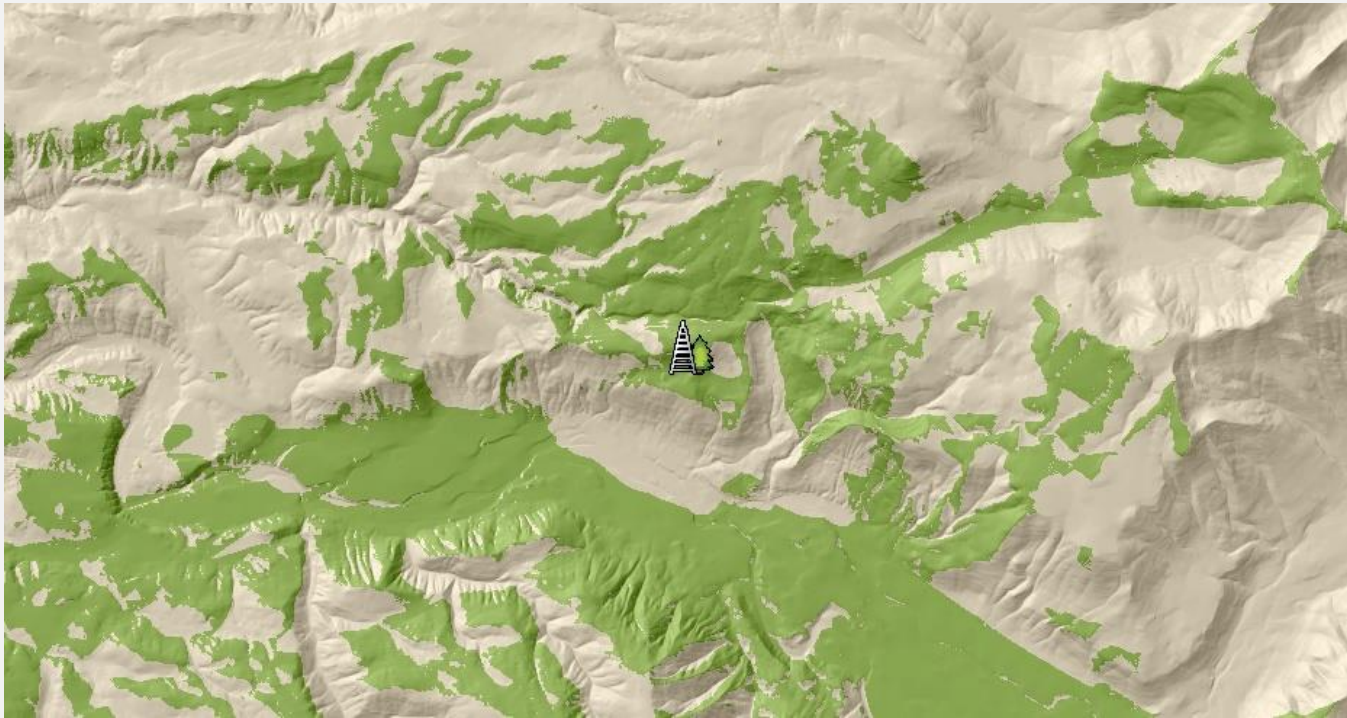
# Applying a hillshade to overlapping layers

- Open layer properties → adjust transparency

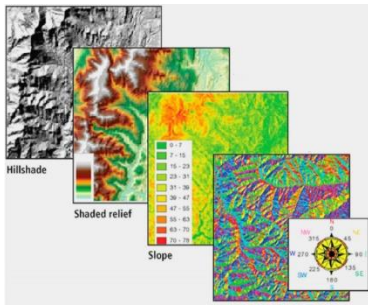


# Viewshed Analysis

- Computes visible areas from an observation point
- Output is a GRID showing visible areas



# Additional Training



## Introduction to Raster Geoprocessing (Self-Paced Tutorial)

- Foundations of Raster Analysis

## Lidar Derivatives: Processing and Analysis (2-Day Webinar)

- Canopy height, canopy cover, and DEMs
- Stand delineation, habitat suitability, road mapping and stream networks

## Introduction to Change Detection (2-Day Webinar)

- Change detection, best practices in image processing, case studies

## Introduction to Change Detection (Self-Paced Tutorial)

## Introduction to Random Forests (Self-Paced Tutorial)



# Demonstration

