Geographic Information System (GIS)

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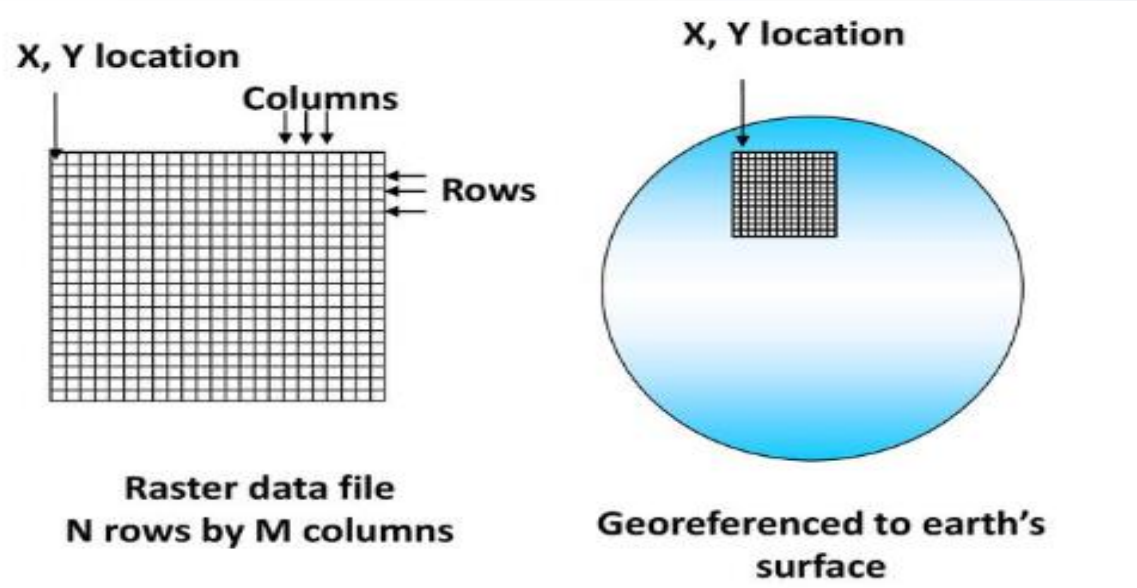
Outlines

- Raster Data
- Raster analysis techniques
  - Map algebra and Boolean Overlay
  - Other functions

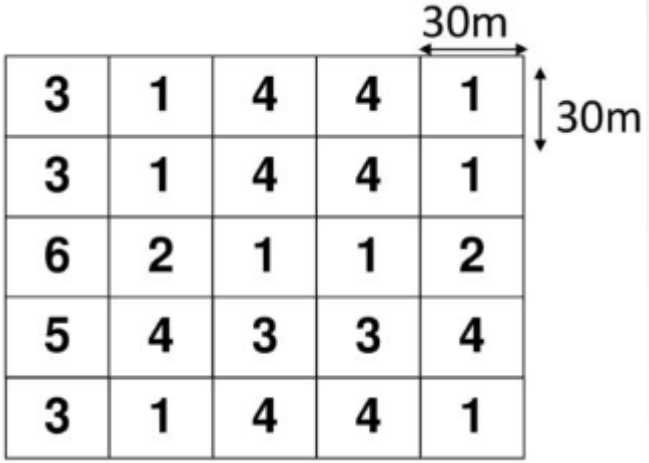
Raster Data

- A data set composed of an array of numeric values, each of which represents a condition in a square element of ground.



Pixels or Cells

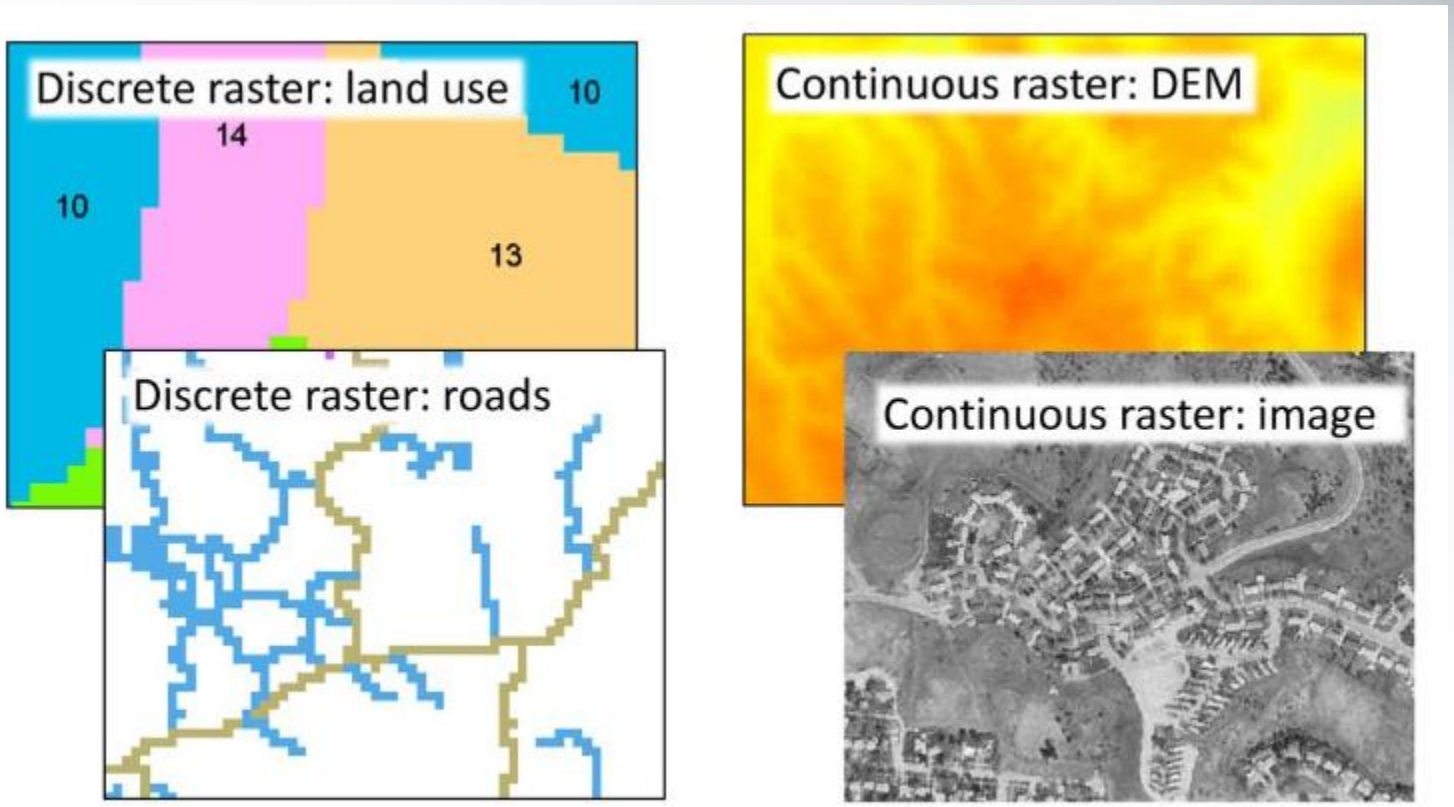
- Each pixel contains one numeric value
- Dimension of a pixel varies (resolution)
- Value represents some property of that pixel area, e.g. elevation or rainfall.
- Values may be integers or floating point numbers.
- Unlike a polygon, each cell has only ONE attribute: its value.



Pixel depth

- The number of bytes used for each pixel Integer values
- More bytes = larger numbers = more space
- Integer values
  - 8-bit pixel (one byte) stores 0-255
  - 16-bit pixel (two bytes) stores 0-65,565
  - 24-bit pixel (three bytes) stores 0-16.7 million
- Floating point values
  - Required for decimal number storage
  - 32-bit pixel (four bytes)

Types of Raster Data



Why use raster?

- Better at storing certain kinds of data.
- Better at analyzing certain kinds of data.
- Often faster analysis than vectors.
- Imagery desirable for certain maps.
- BUT
  - Coordinate precision generally lower.
  - High precision has high storage costs.
  - Cannot store multiple attributes.

Raster resolution

- Measured by cell size dimensions
- Storage space increases as the square of the resolution

Vector format

200 m raster

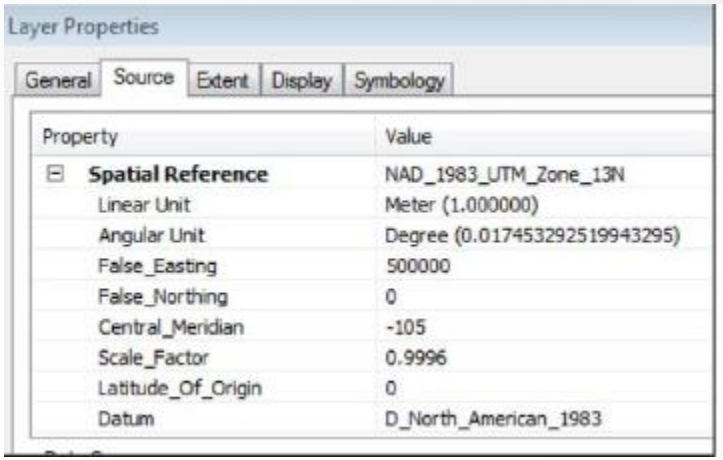
50 m raster

16X bigger!

Cell size units

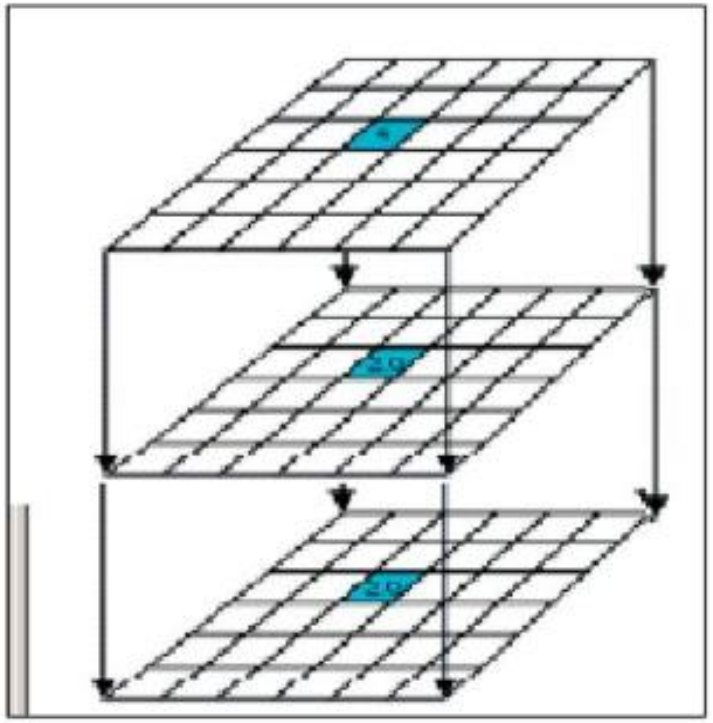
- Cell x-y resolution units are based on the raster's coordinate system definition
  - Decimal degrees*
  - Meters
  - Feet

*Because distances and areas are fundamental to raster analysis, it is best to use projected coordinate systems for rasters.



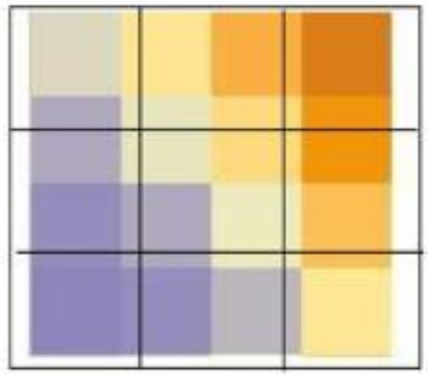
Raster analysis techniques

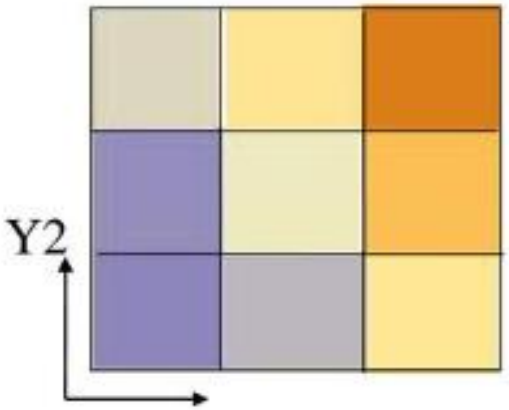
- Raster analysis uses cell-by-cell functions on one or more input grids.
- Cells must be the same size and line up spatially.
- Older software required the user to ensure that all input rasters had exactly the same size, shape, and aligned cell sizes.



Resampling

- If input grids do not match, then one must be resampled to match the other. Resampling can degrade the accuracy of a raster even if the difference in cell size and location is small.
- The new cell grid is determined, and the old cell values must be fit into the new structure somehow.
- Several methods are used for resampling.





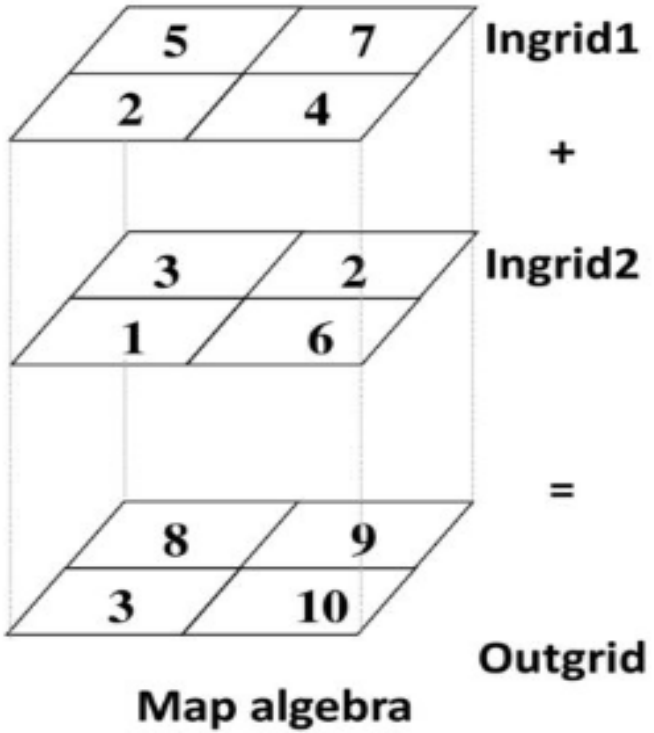
Resampling (warning)

- ArcGIS automatically resamples rasters for analysis if needed, without warning the user.
- Because resampling can degrade raster quality, users should be aware that this may be happening.
- Best practices:
  - Strive to create and keep analysis data in aligned rasters with common extents and cell sizes.
  - Use environment settings to enforce common grids for newly created raster
  - Use the available resampling functions to prepare data, so that YOU can control how resampling happens rather than having the software do it automatically.

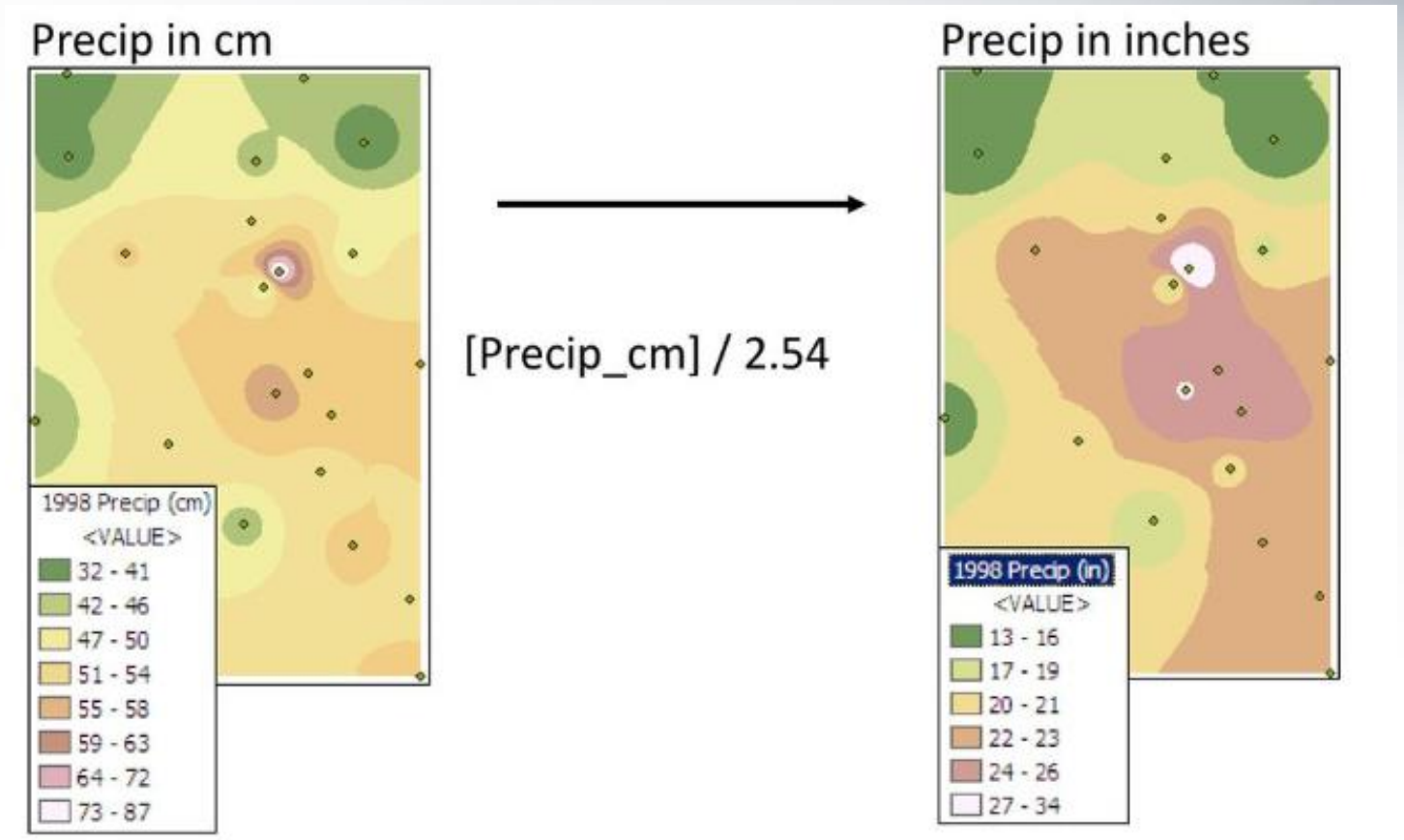
Map algebra and Boolean overlay

Map Algebra

- Rasters are essentially arrays of numbers
- Can be added, subtracted, etc
- Line up matching cells vertically



Map Algebra: Conversions

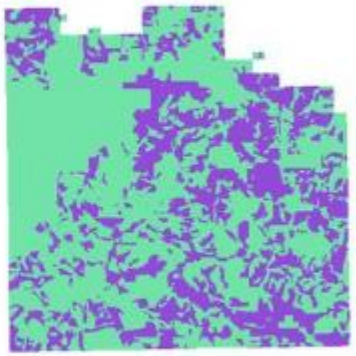


Map Algebra: logical operators

- Logical operators produce either TRUE (1) or FALSE (0) values in the output grid, based on whether a cell meets the condition.

[Elevation] > 1200

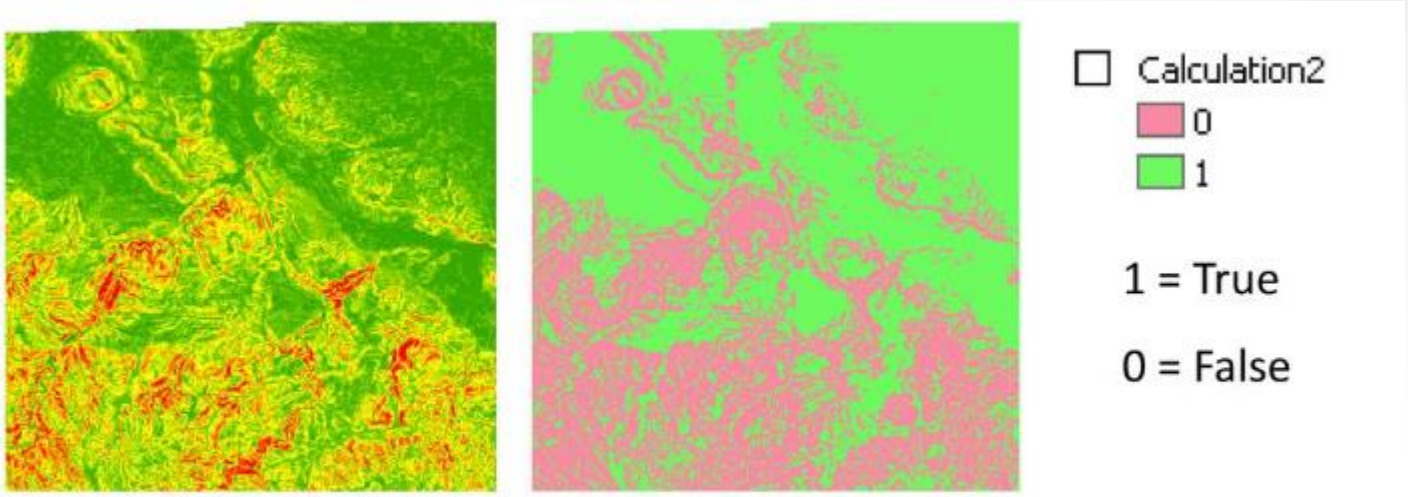
[Slope] < 10



[crowncov] < 70 AND
[crowncov] > 40

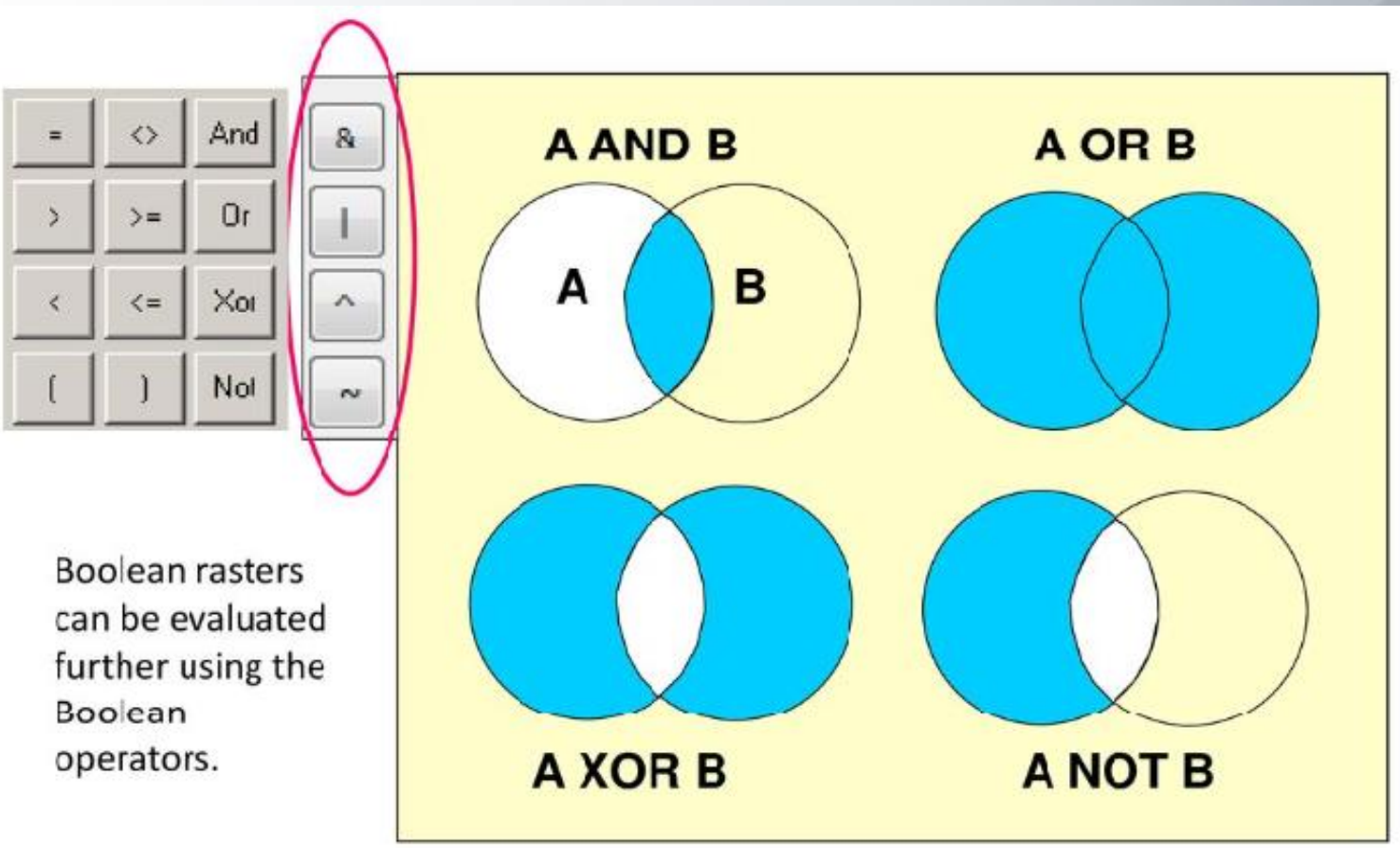
Boolean rasters

- Boolean rasters represent maps of True/False states for a particular condition.



Slope < 10 degrees?

Boolean operators

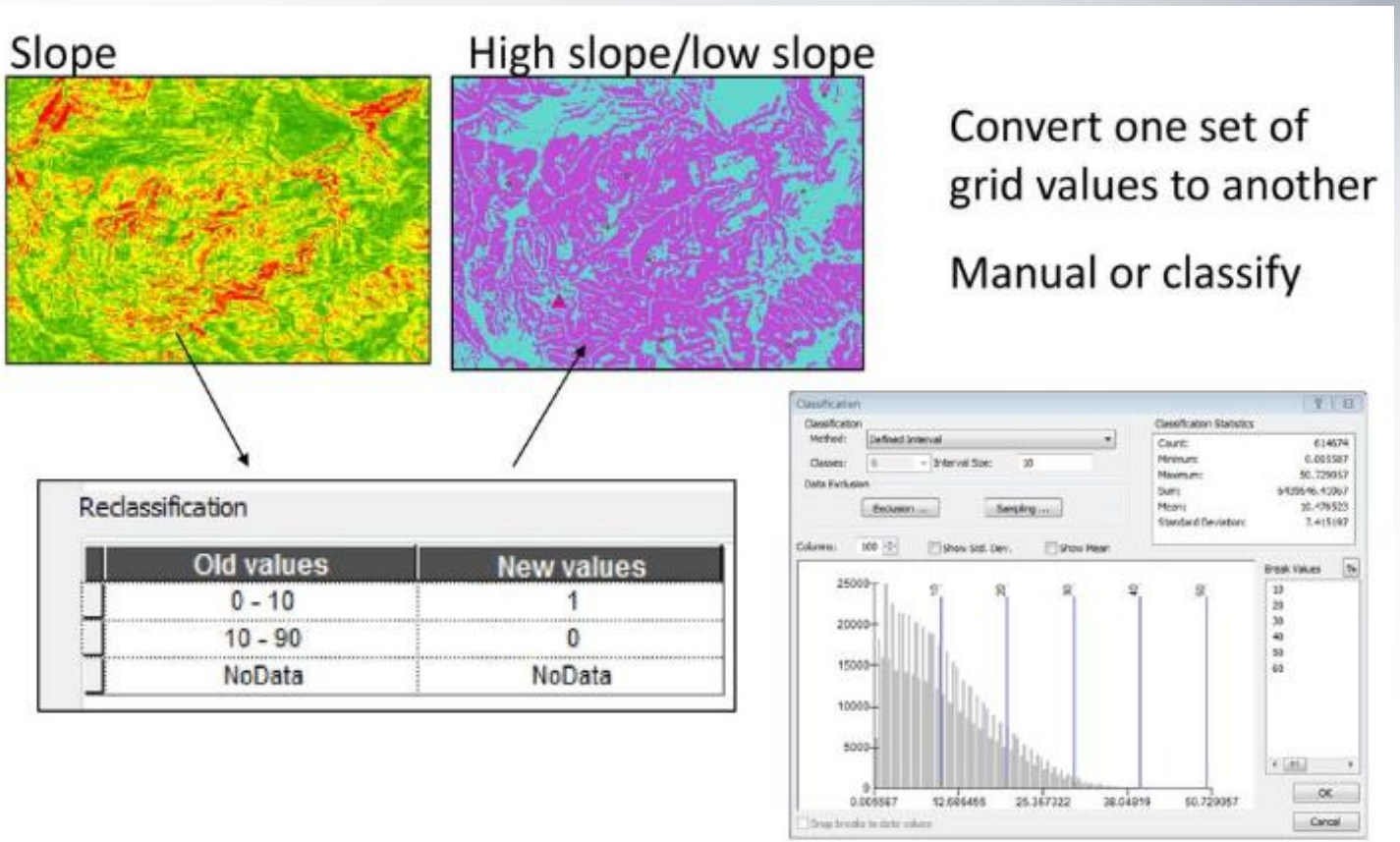


Boolean rasters can be evaluated further using the Boolean operators.

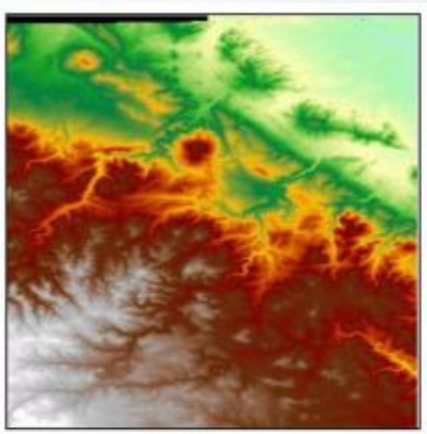
Other raster analysis techniques

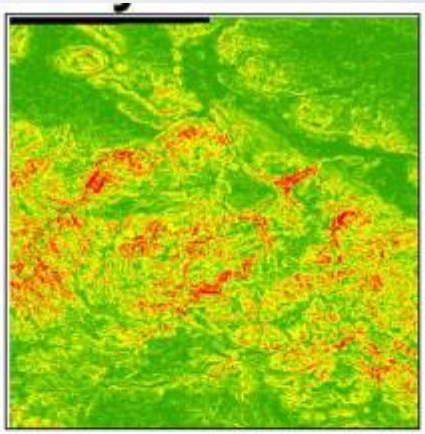
- Reclassification
- Surface functions
- Distance functions
- Density functions
- Interpolation
- Neighborhood functions
- Zonal functions

Reclassify

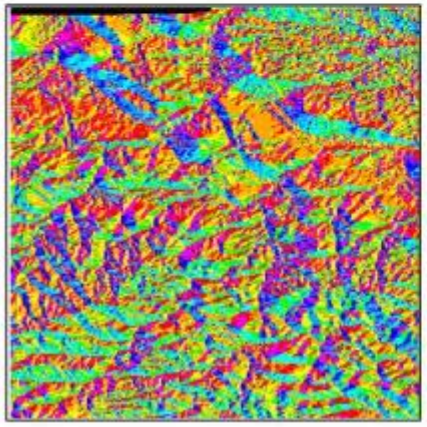

Slope
High slope/low slope
Convert one set of grid values to another
Manual or classify
Reclassification
Old values
New values
0 - 10
1
10 - 90
0
NoData
NoData

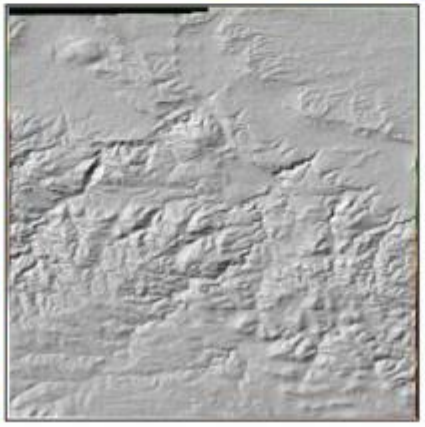
Surface analysis

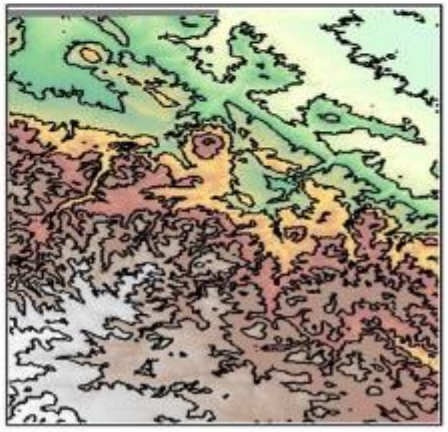




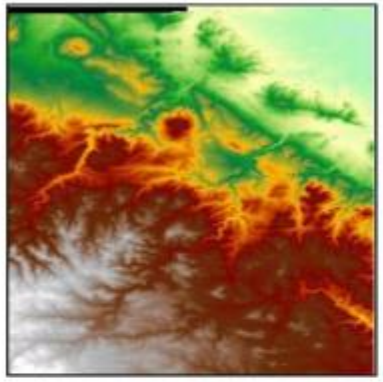
DEM
Slope
Aspect
Hillshade
Contouring

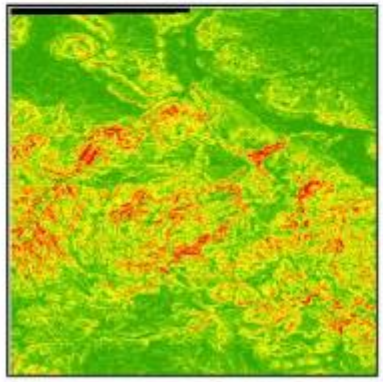






Slope function



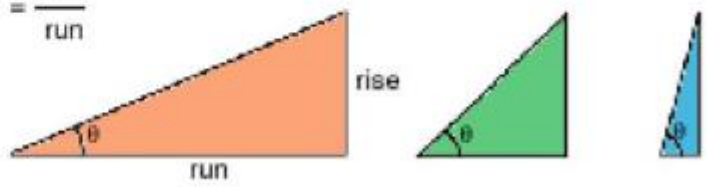


Calculates slope of the surface based on surrounding cells. Can be expressed in degrees or percent.

Degree of slope = θ

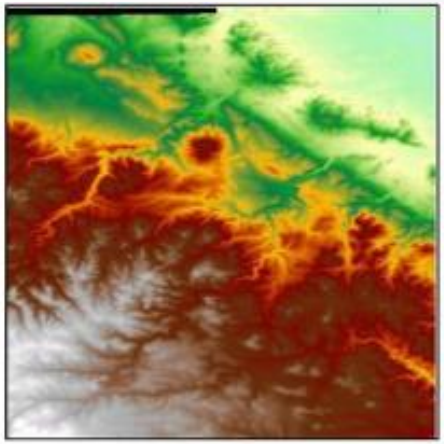
Percent of slope = $\frac{\text{rise}}{\text{run}} * 100$

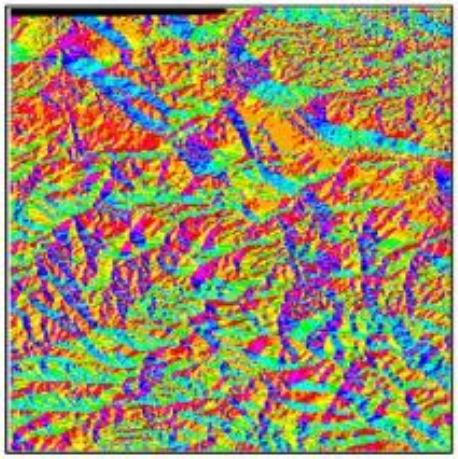
$\tan \theta = \frac{\text{rise}}{\text{run}}$



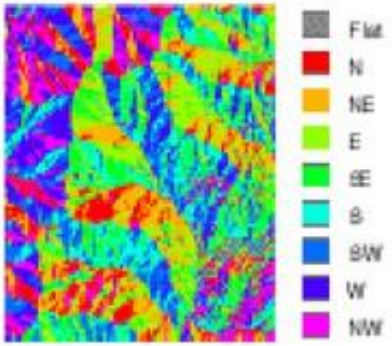
Degree of slope =	30	45	76
Percent of slope =	58	100	375

Aspect function

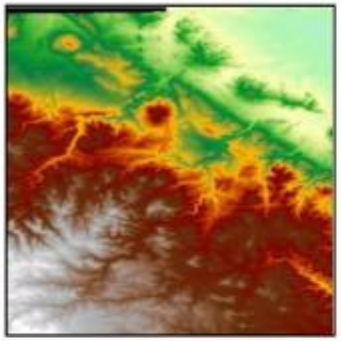




Calculates direction of steepest slope, e.g. which way the slope "faces". Value represents direction from 0-360 where 0/360 is North. Flat areas are assigned a -1 value.



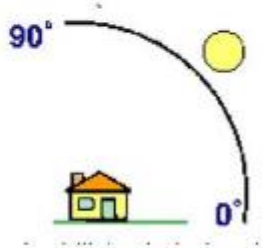
Hillshade



Calculates the brightness or illumination of a surface from a specified light source.

Applications include terrain display and modeling satellite reflectance.

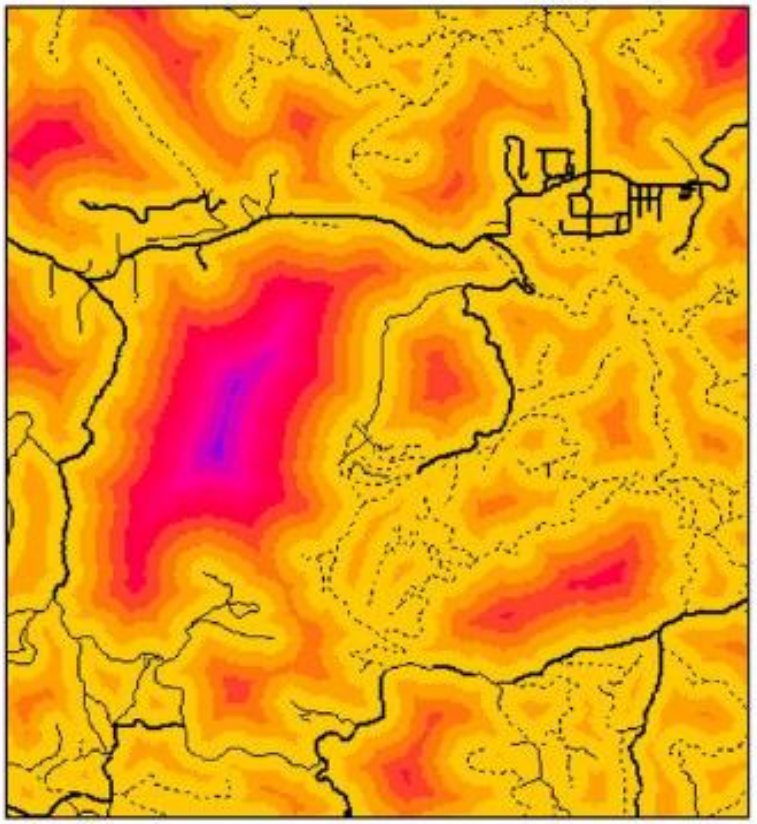
Azimuth is direction of illumination source (315 by default)



Altitude is the angle of the source above the horizon (45 deg)

Euclidean distance

- Starts from a set of features (points, lines, polygons).
- Creates a grid where each cell represents distance to the closest of the features.
- Distances are given in coordinate system map units

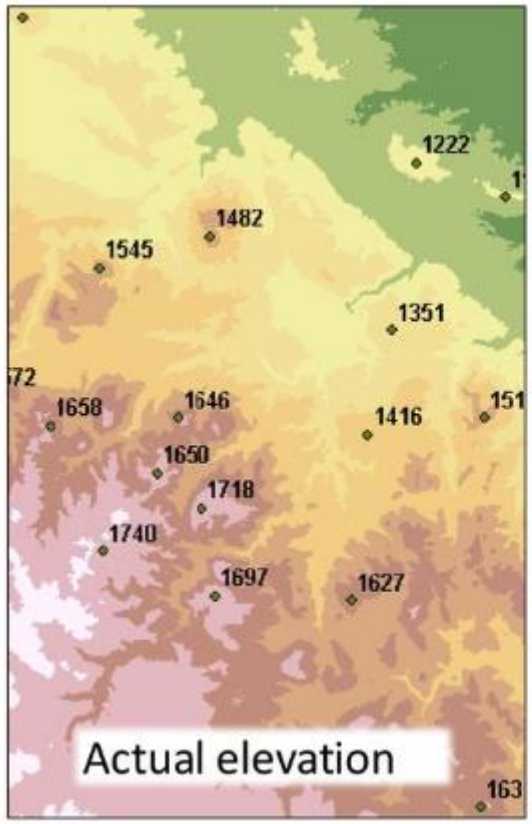


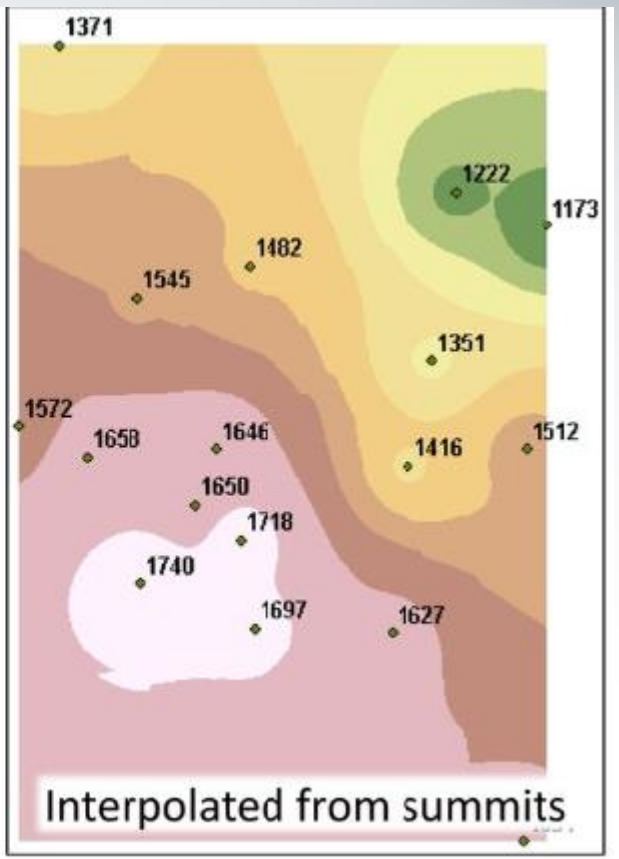
Distance to roads (meters)

What is interpolation?

- Interpolation is the prediction of values in between measured points.
- Sampling of points may be uniform, random, or based on a sampling scheme.
- Numerous methods are used which have different mathematical models and make different assumptions about the data.
- Best application of interpolation relies on substantial study of models and assumptions.

Interpolation is NOT truth!

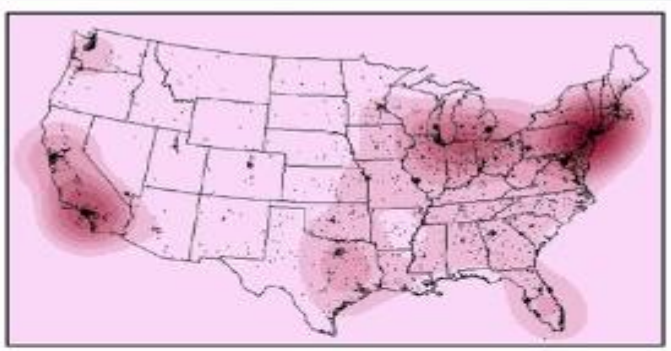




Density functions

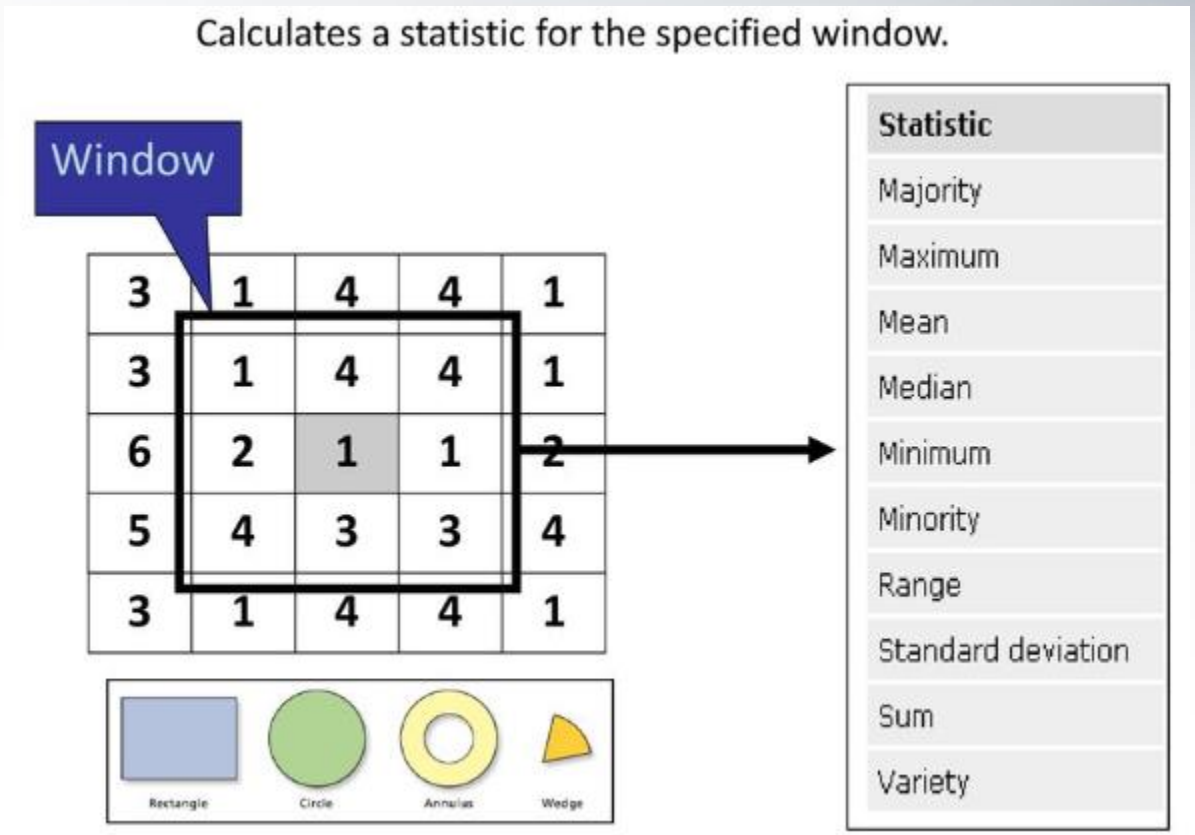
- Appear similar to interpolation, but are calculated differently
  - Interpolation predicts values between points using a variety of mathematical methods
  - Density functions count occurrences within a given radius and divide by the area

Density functions



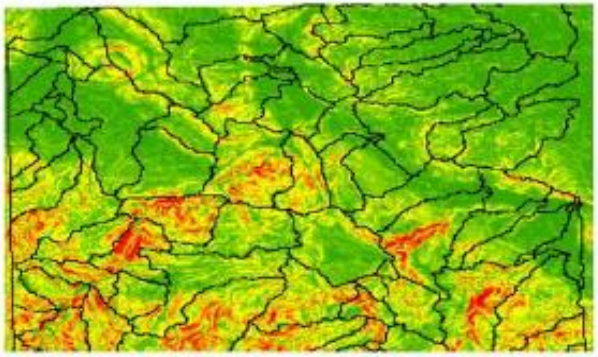
Occurrences may be features or attributes of features (number of cities versus city population).

Neighborhood statistics

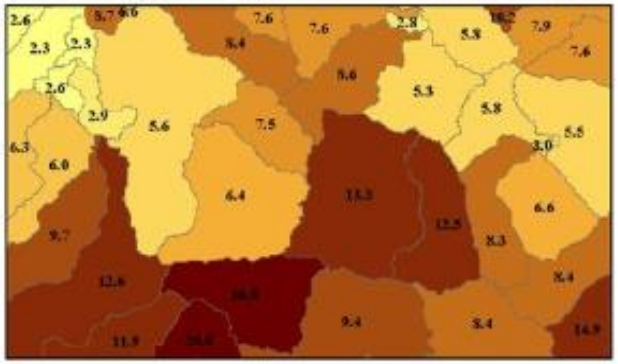


Zonal statistics

Watersheds and slope



Average slope in watershed



- Zones defined by the zone layer (watersheds)
- Generates statistics for each zone from the value grid (slope)
- Output is either a raster, or a table

Thank You

Questions ??