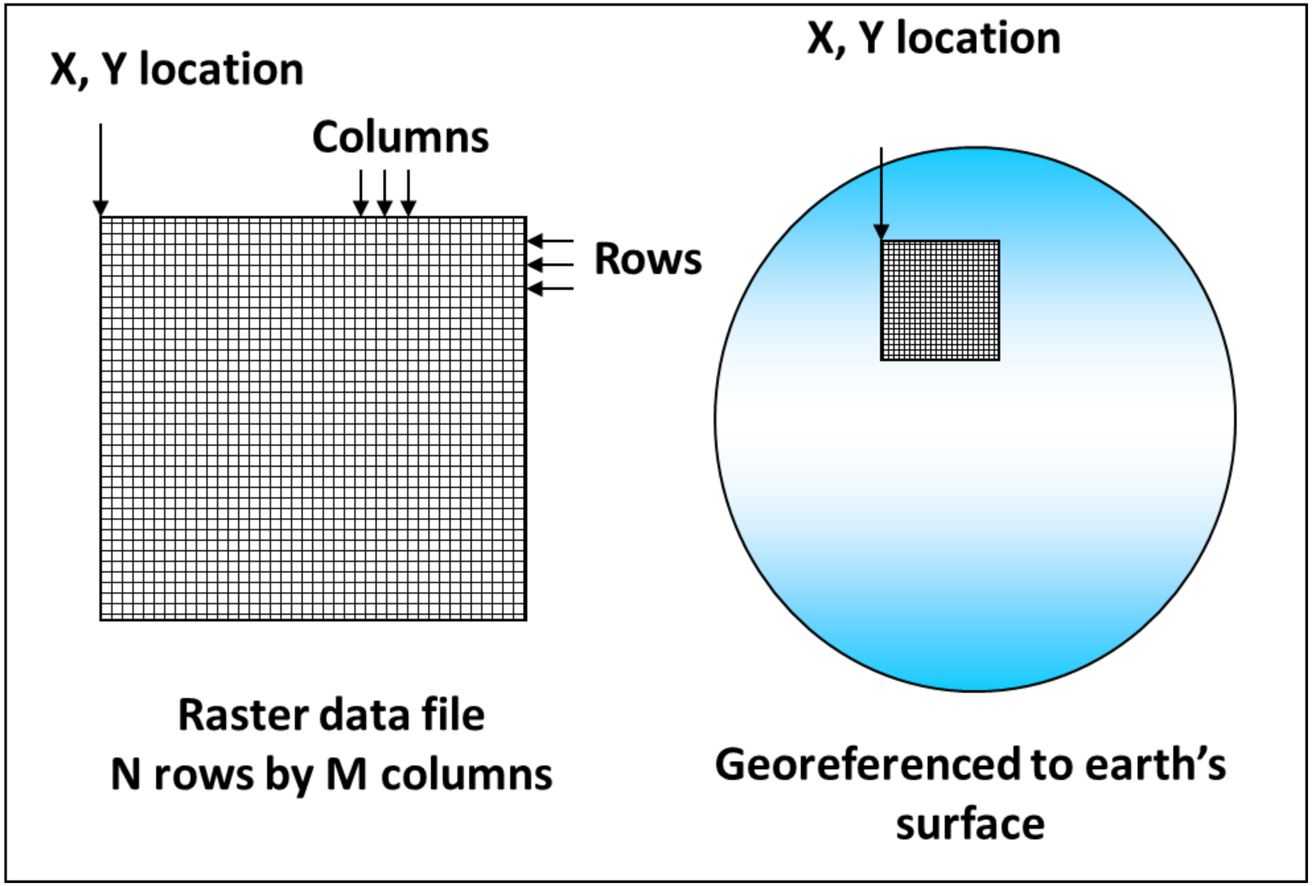
Raster Datasets

Today's Agenda

- Hand back and review exam
- Rasters
- Map algebra and Boolean overlay
- Other functions
- Intro to Sand Table Project

The raster data model



Raster Data Model: A method for representing instances of a field by dividing a space into cells.

- Raster data models use a set of cells arranged in a grid pattern
- Concepts or phenomena that vary over space

The raster data model

4 key parts:

- Number of columns
- Number of rows
- Origin (easting, northing)
- Grid cell size (in ground units)

If you know one cell, you can get the location of any other feature

Pixels or Cells

30m

30m

3	1	4	4	1
3	1	4	4	1
6	2	1	1	2
5	4	3	3	4
3	1	4	4	1

Each pixel contains one numeric value

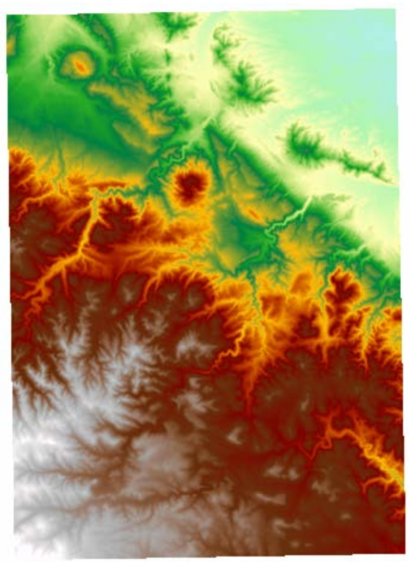
Dimension of a pixel varies (resolution)

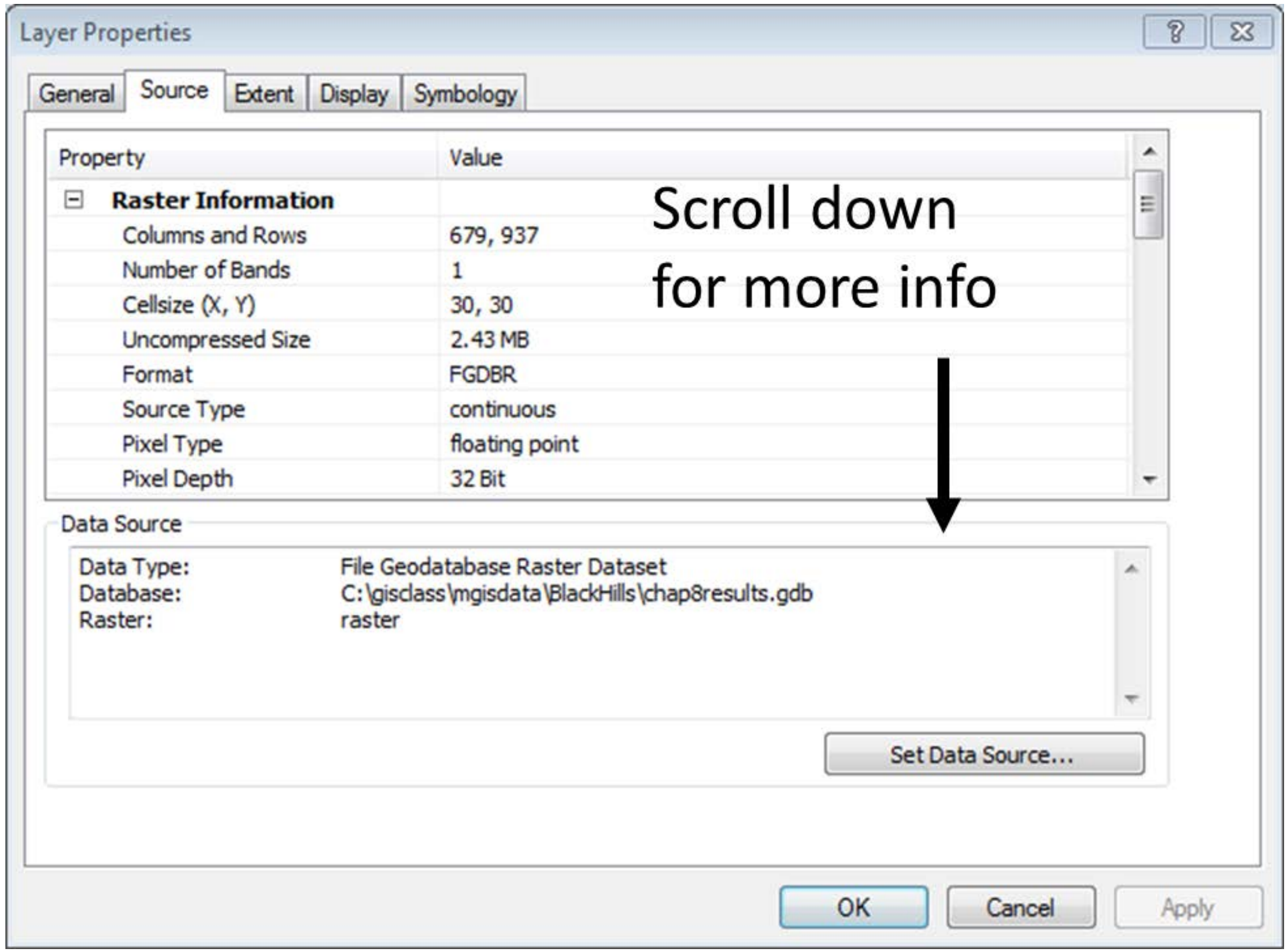
Value represents some property of that pixel area, for example, elevation or rainfall

Unlike a polygon, each cell has only ONE attribute: its value.

Storing multiple values means storing multiple rasters.

Raster Properties

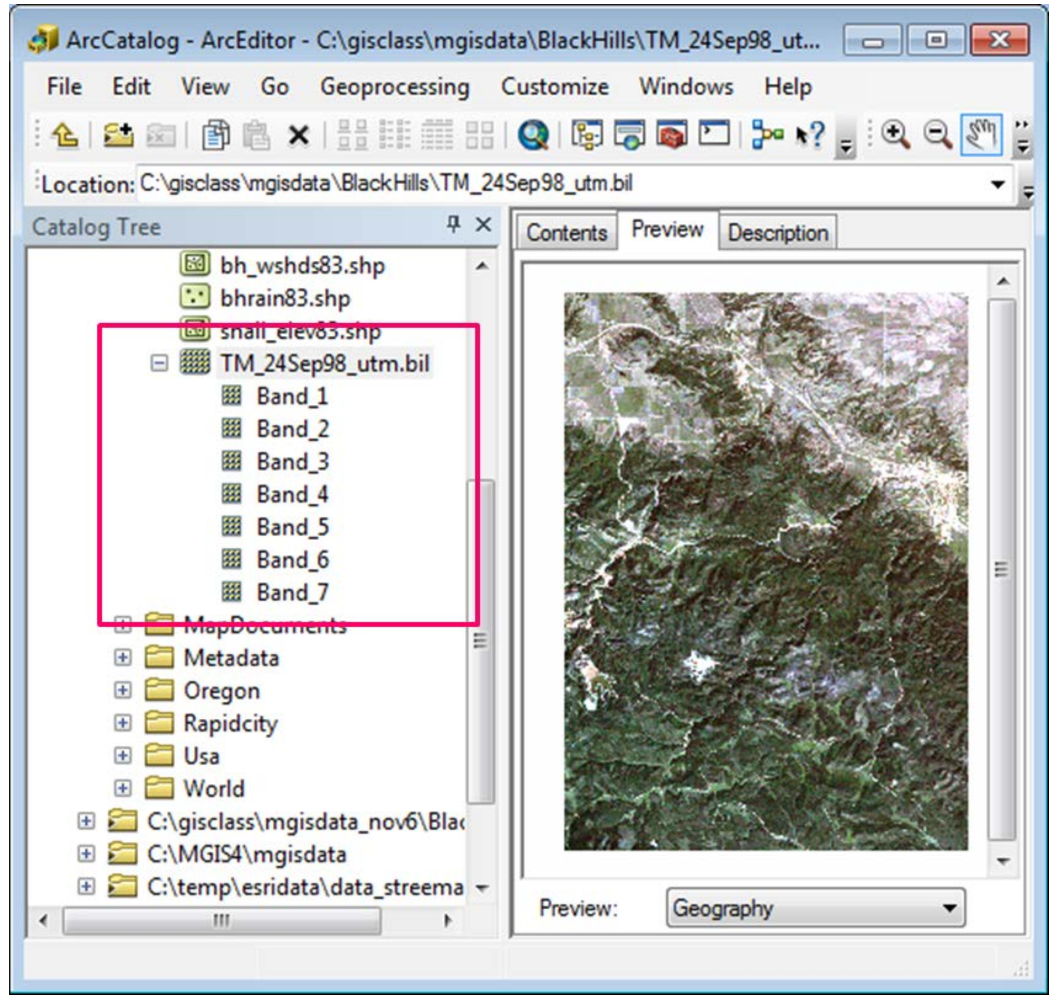




Bands

A single raster may include multiple arrays

Most often used to store color images and satellite images

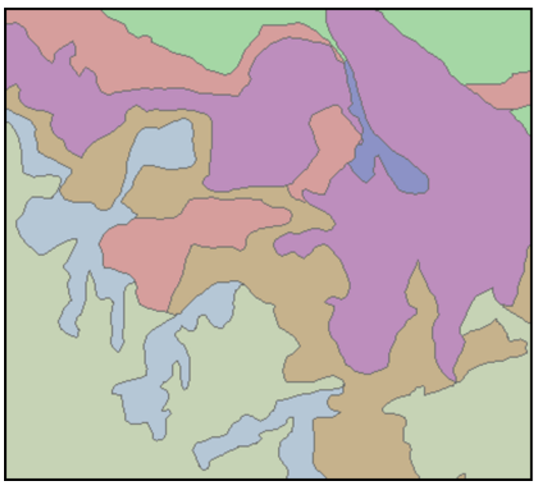


7-band Landsat satellite image

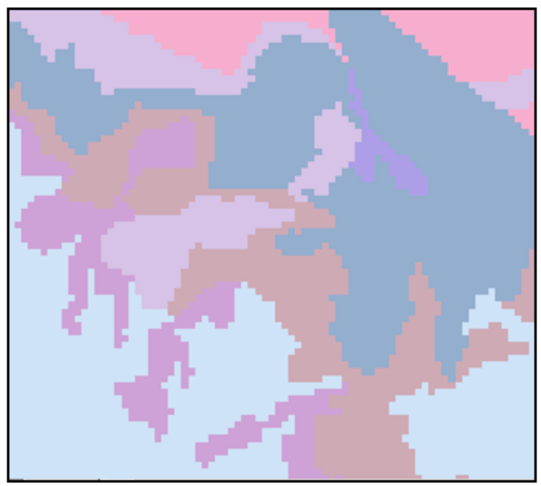
Raster resolution

Measured by cell size dimensions

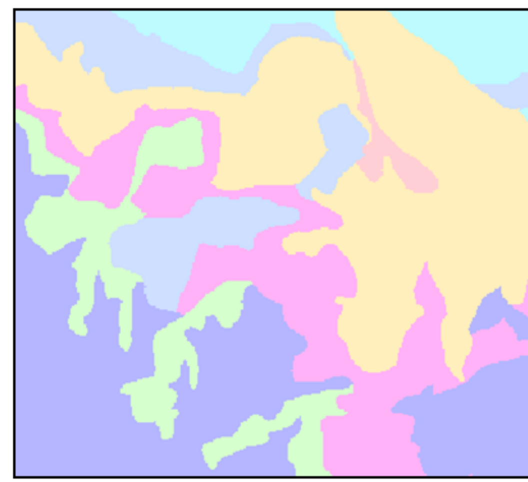
Storage space increases as the square of the resolution



Vector format



200 m raster



50 m raster

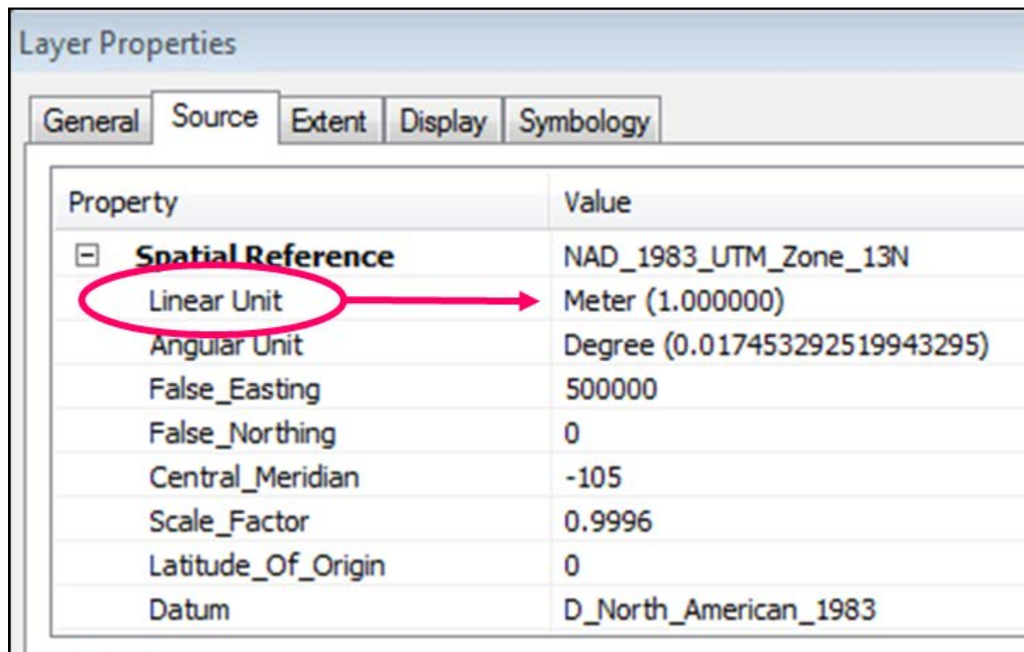
16x bigger!

Cell size units

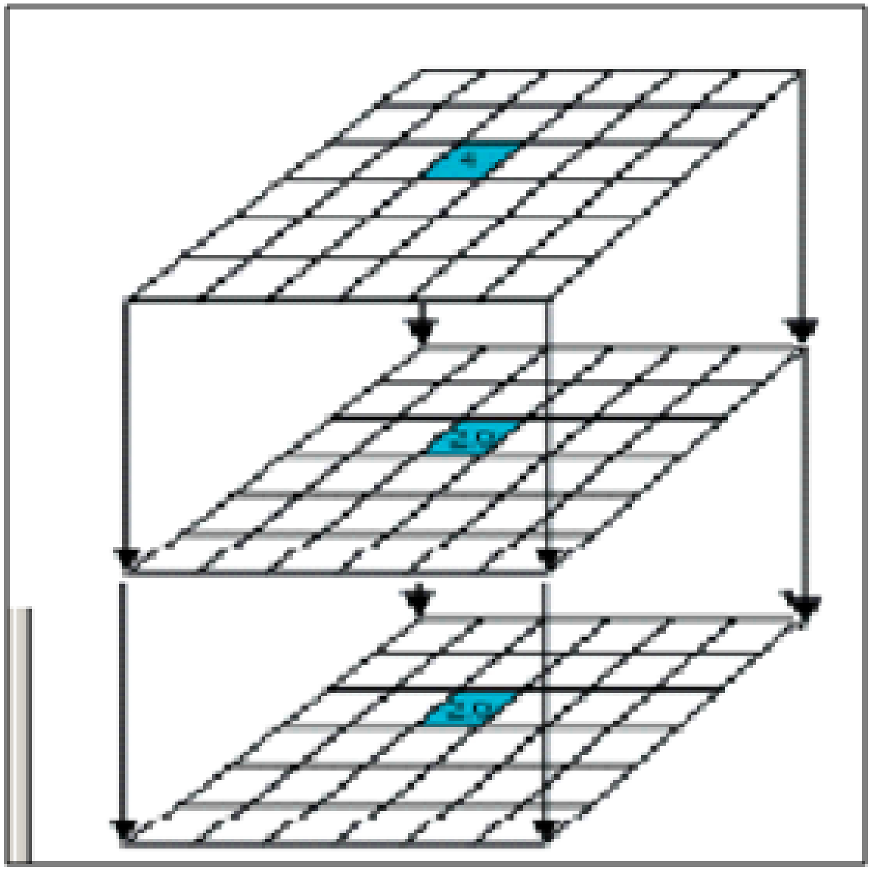
Cell x-y resolution units are based on the raster's coordinate system definition

- 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



Raster analysis uses cell-by-cell functions on one or more input grids.

Cells must be the same size and line up spatially.

Raster analysis techniques

Map algebra and Boolean overlay

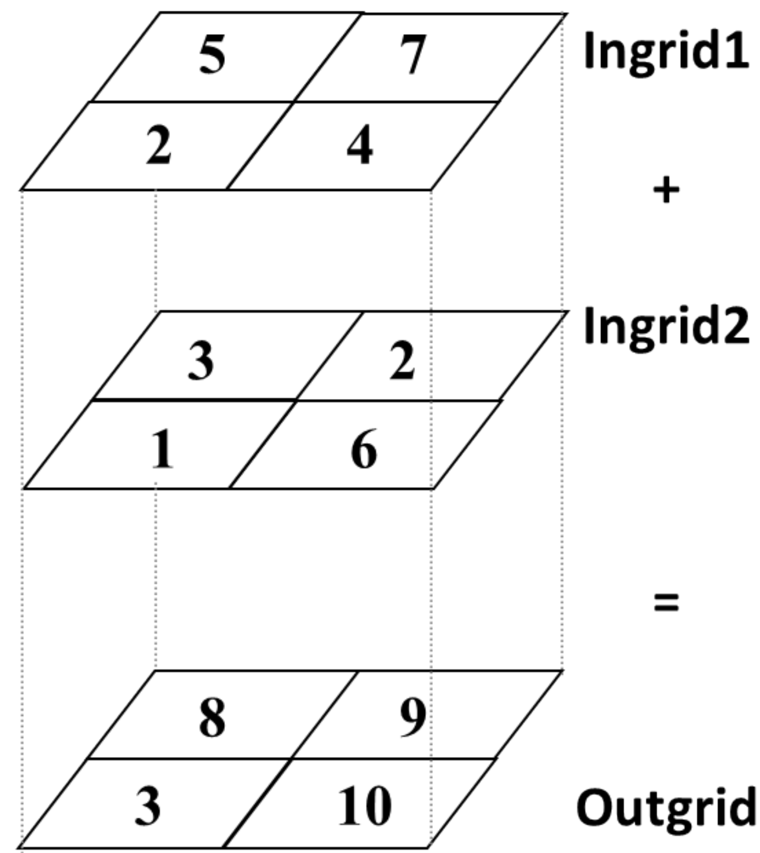
Other functions

Map Algebra

Rasters are arrays of numbers

Can be added, subtracted, etc.

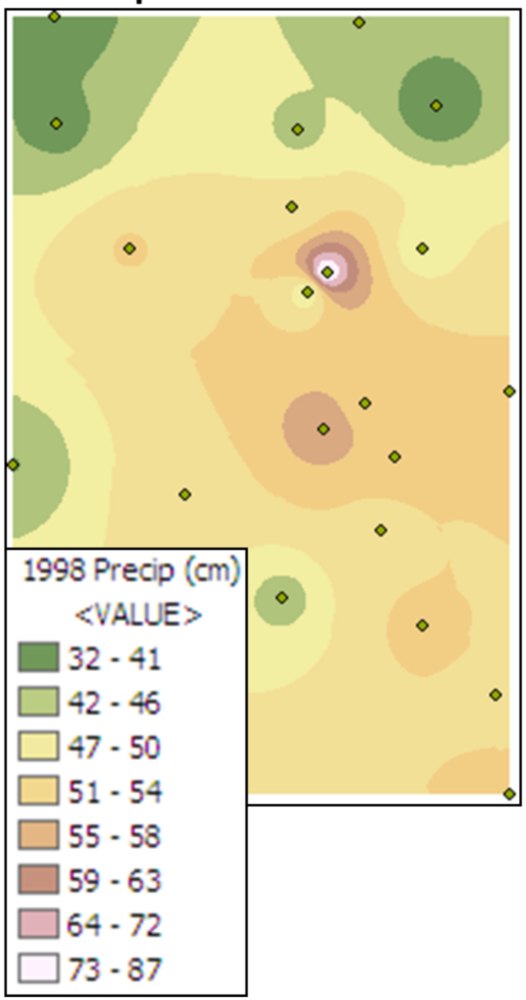
Line up matching cells vertically



Map algebra

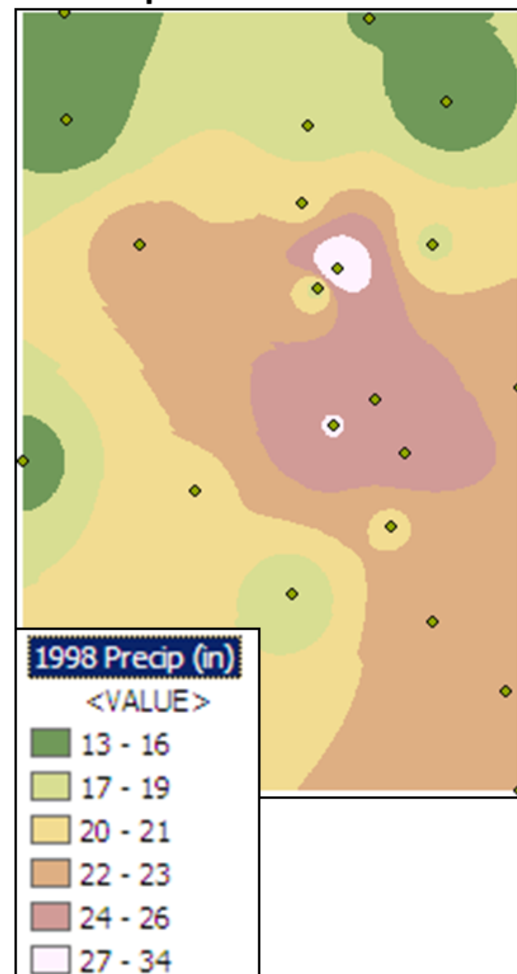
Map Algebra: Conversions

Precip in cm



[Precip_cm] / 2.54

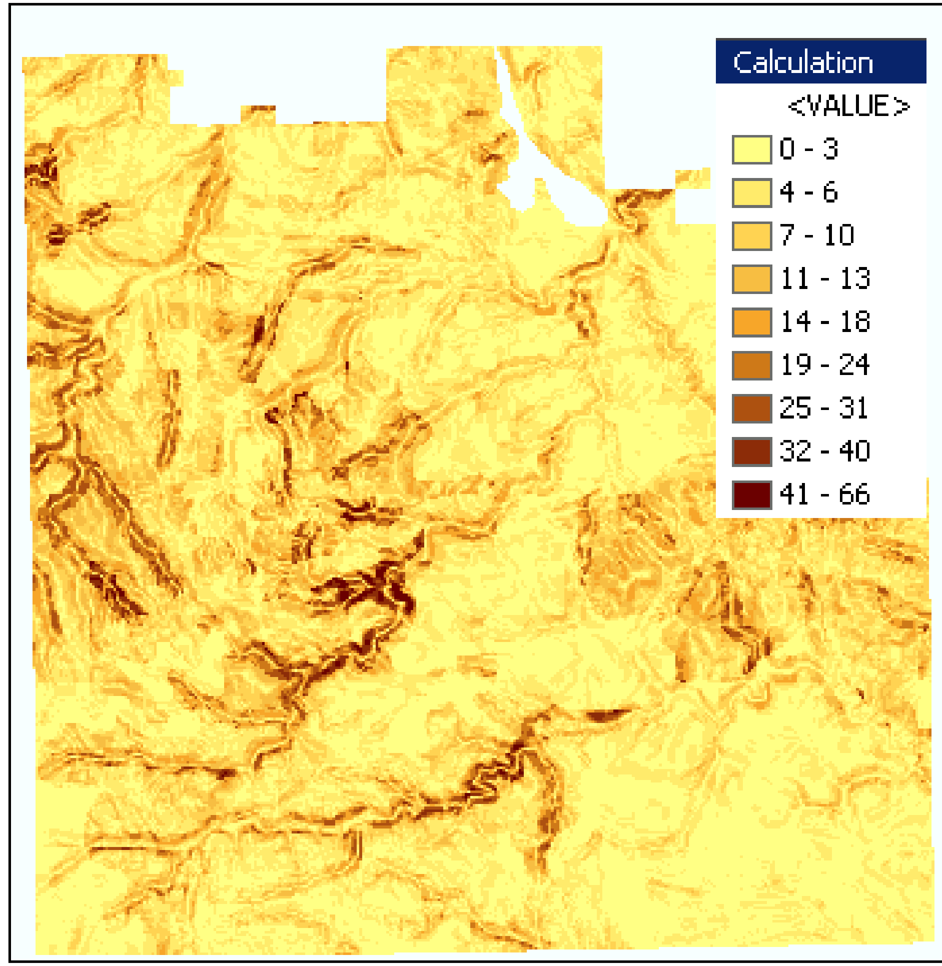
Precip in inches



Map Algebra: identify probable locations

Complex expressions with multiple inputs to calcuate **risk** or **hazard index**.

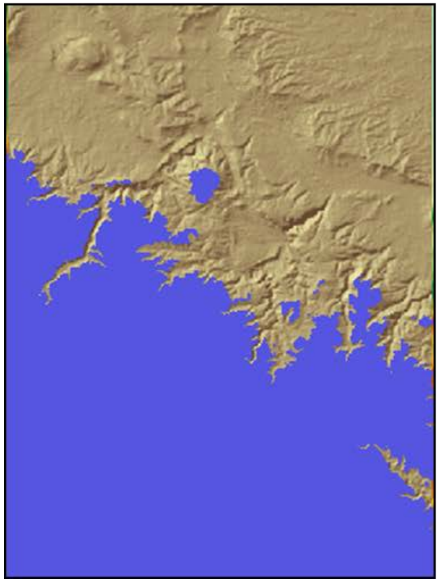
Runoff in cm based on four input grids: precip, slope, soil infiltration, and vegetation cover.



[Precip] * 2 + [Slope] * 4 / ([Erode] – [Vegcover]

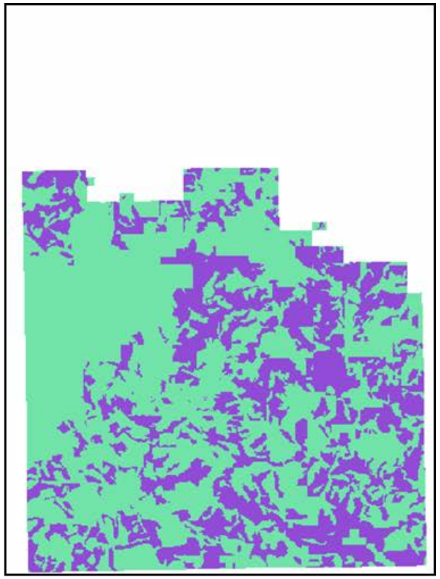
Map Algebra: logical operators

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



[Elevation] > 1200

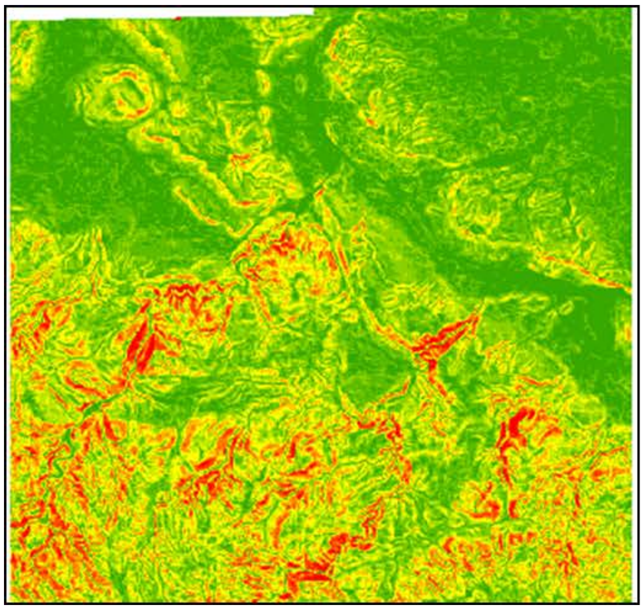
[Slope] < 10

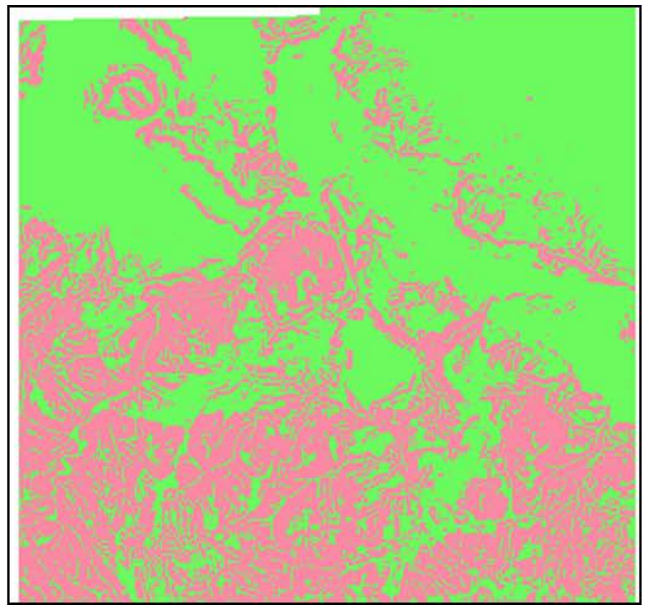


[crowncov] < 70 AND [crowncov] > 40

Boolean rasters

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



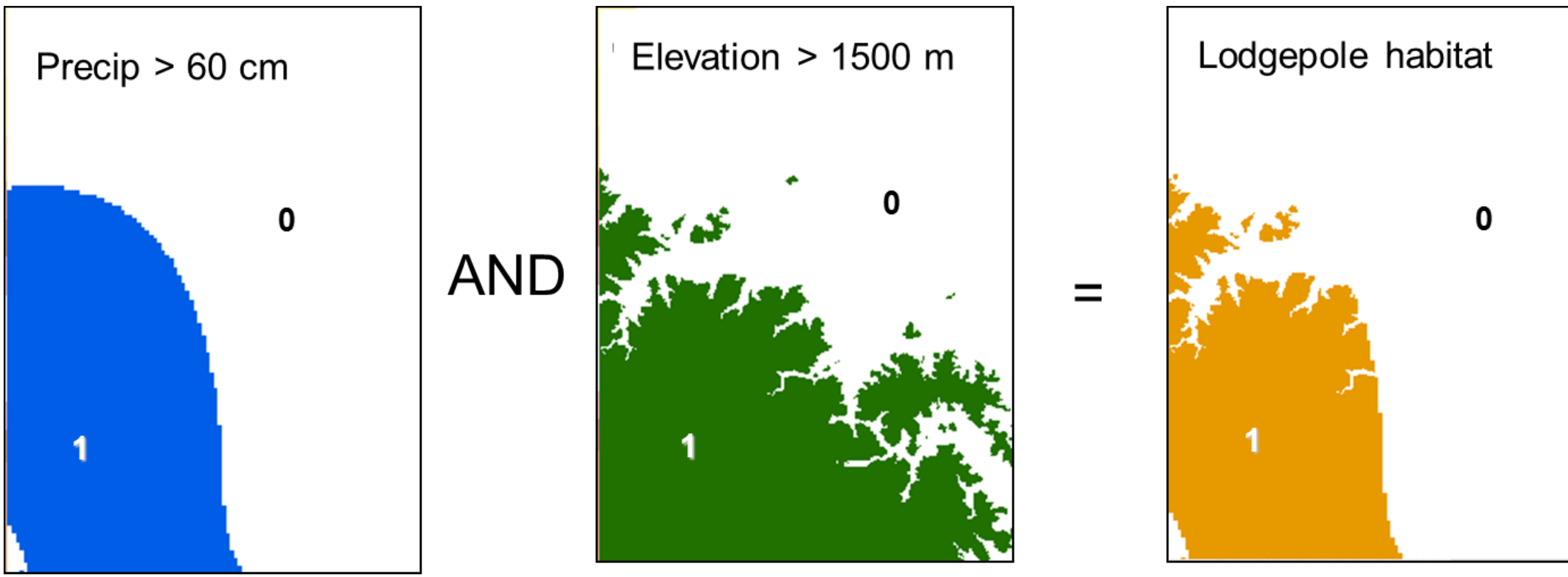


1 = True

0 = False

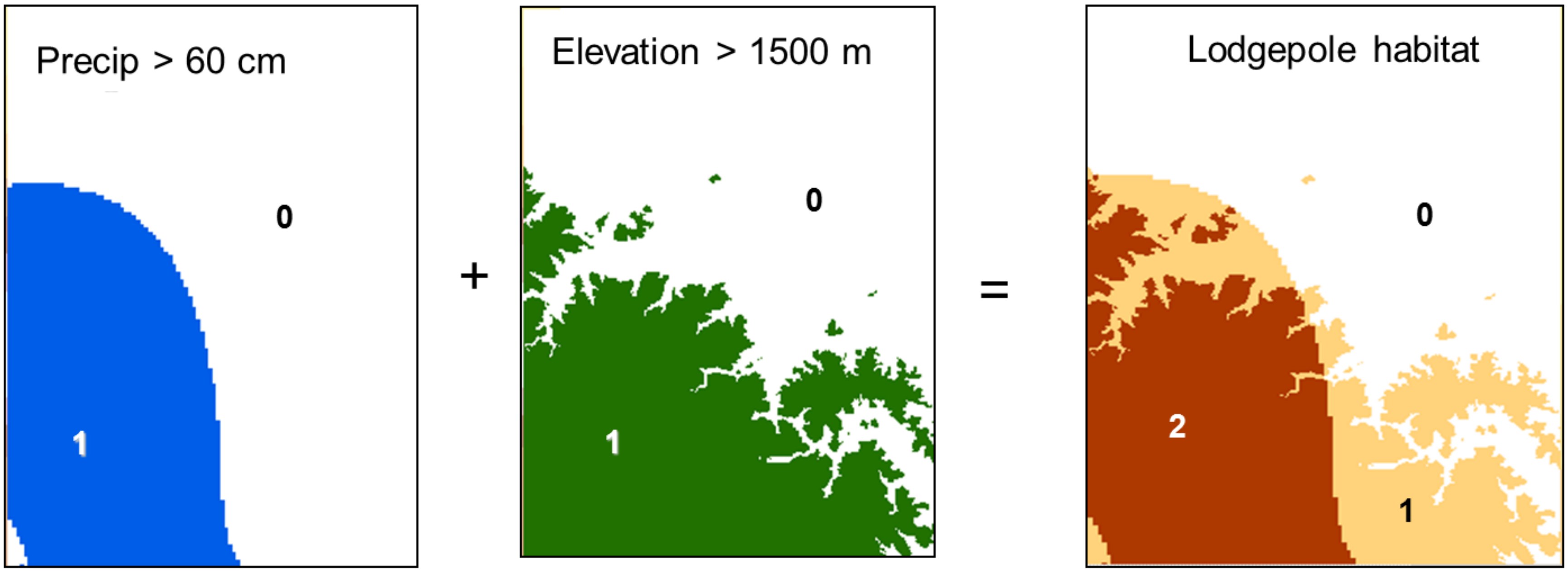
Slope < 10 degrees?

Boolean overlay (AND)



[PrecipGT60] AND [ElevGT1500]

Additive Boolean overlay



ADD the layers together to create a ranked result.

Raster analysis example

Siting a landfill

Landfill raster model

Problem: Find potential locations for a new landfill using these criteria

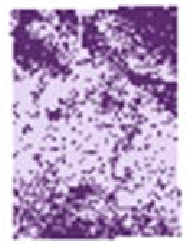
- On flat terrain <= 10 degrees slope
- No more than 1 km from an existing road
- At least 500 meters from a stream
- Meadow or low-density forest

Develop a Boolean raster for each condition with 1 = desirable area, 0 = not desirable area

Landfill suitability index (LSI)

Suitability (1 – N) **Weight**

Slope (deg)
0 – 10 = 3
10 – 20 = 2
> 20 = 1
0.1

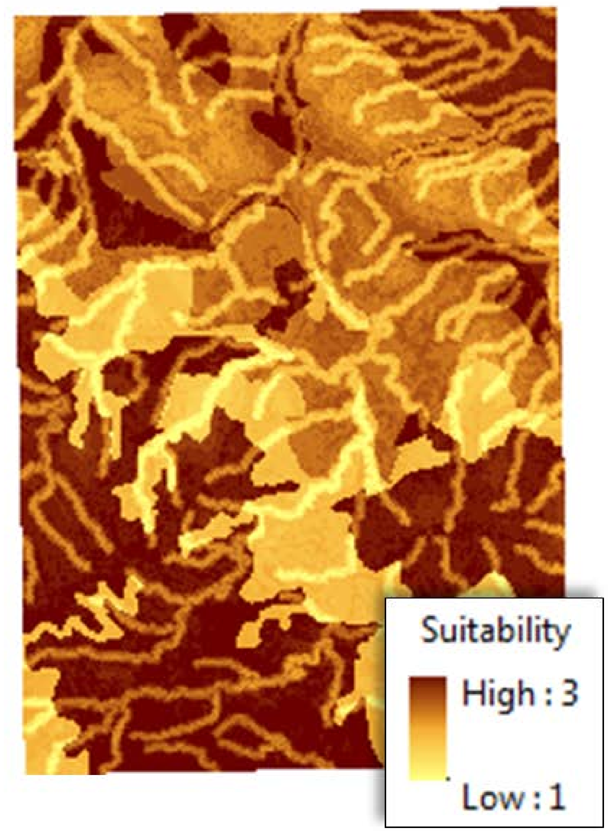


Infiltration (class)
Low = 3
Medium = 2
High = 1
0.4

Dist to Roads (m)
0 – 500 = 3
500 – 1000 = 2
> 1000 = 1
0.2

Dist to Streams (m)
0 – 100 = 1
100 – 200 = 2
> 200 = 3
0.3

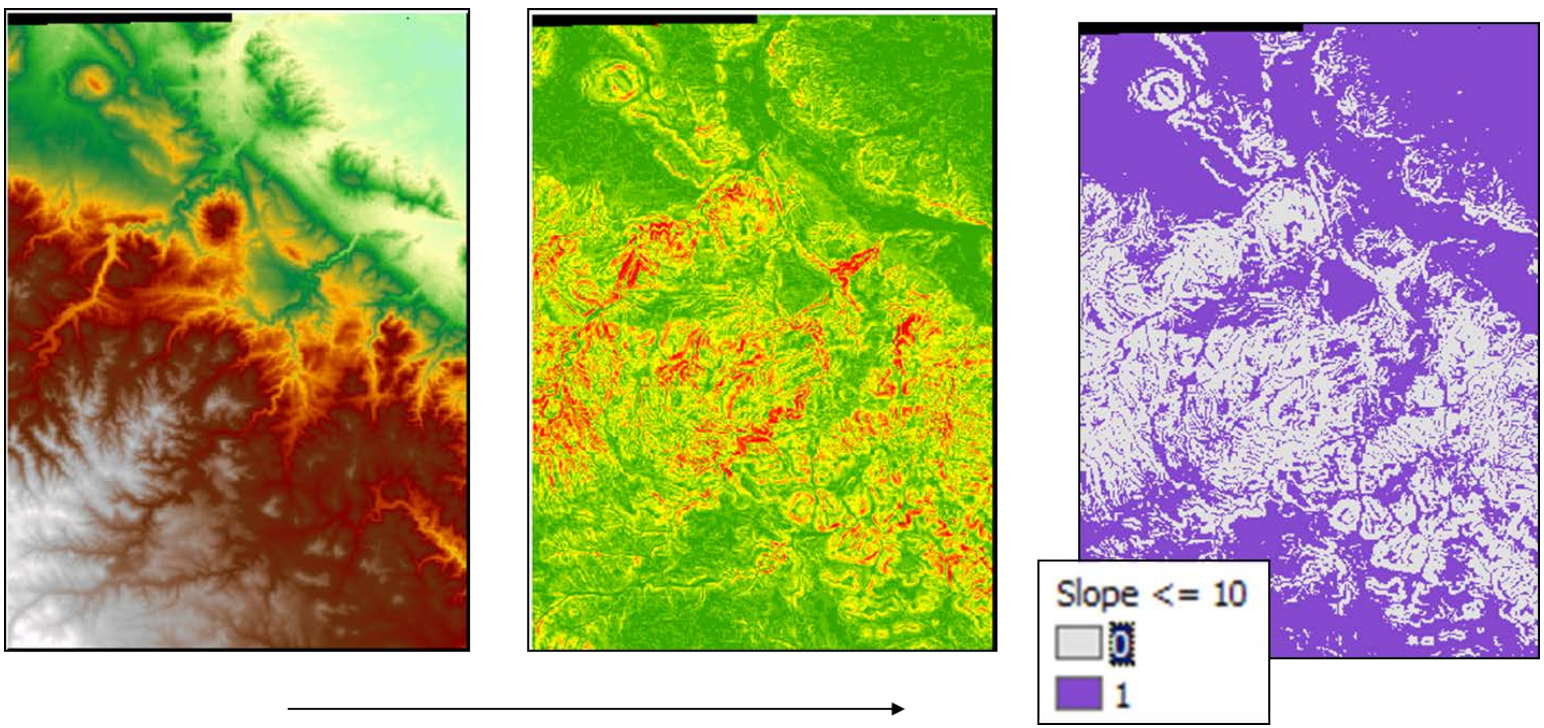
Landfill suitability index (LSI)



LSI = 0.1*slope + 0.4*infil + 0.2*roaddist + 0.3*streamdist

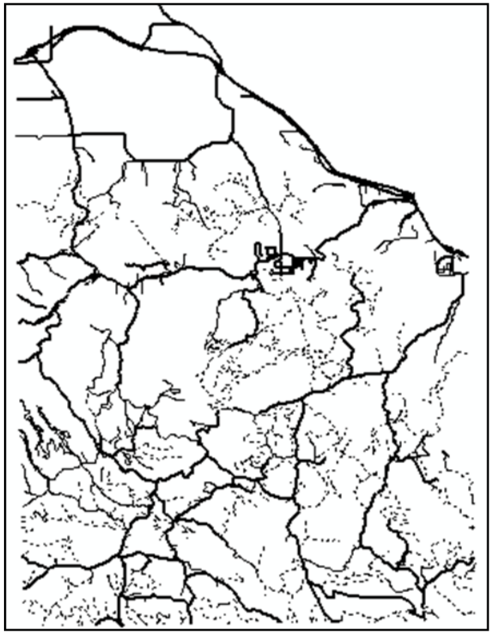
Slope condition

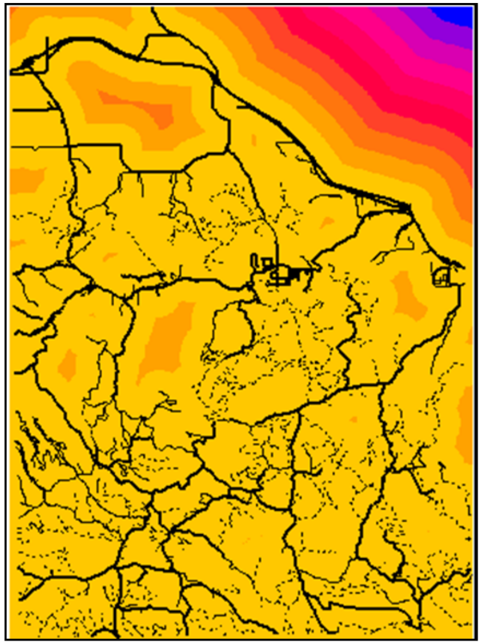
1. Use slope function on elevation raster.
2. Use map algebra logical operator to produce Boolean map of slope <= 10 degrees.

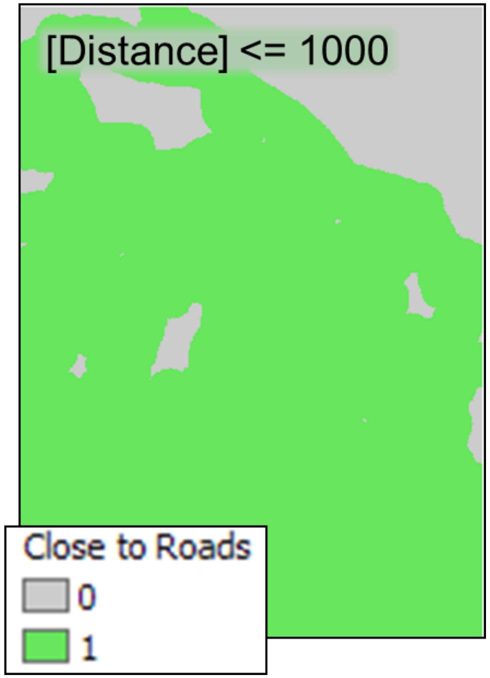


Road distance condition

1. Use distance function to create raster of distance from roads.
2. Use logical operator in map algebra to create Boolean raster of areas within 1000 meters of a road.

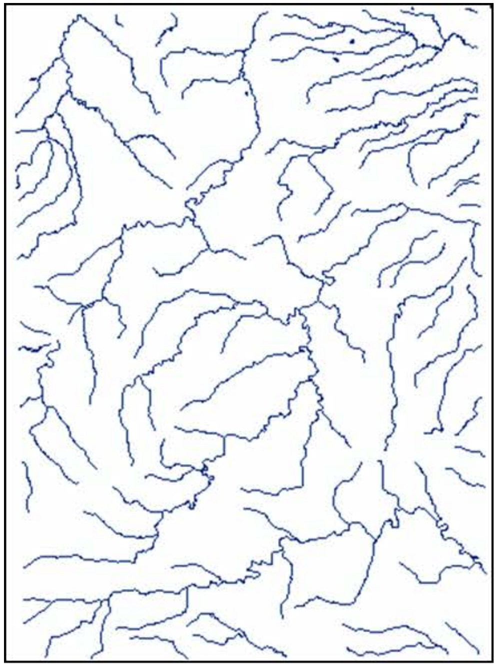


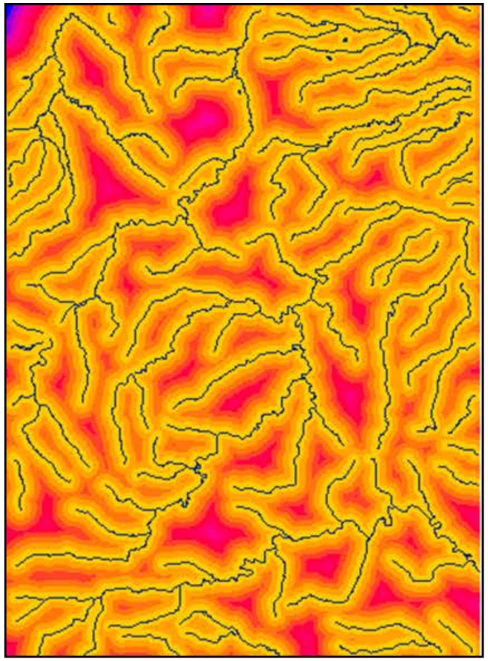


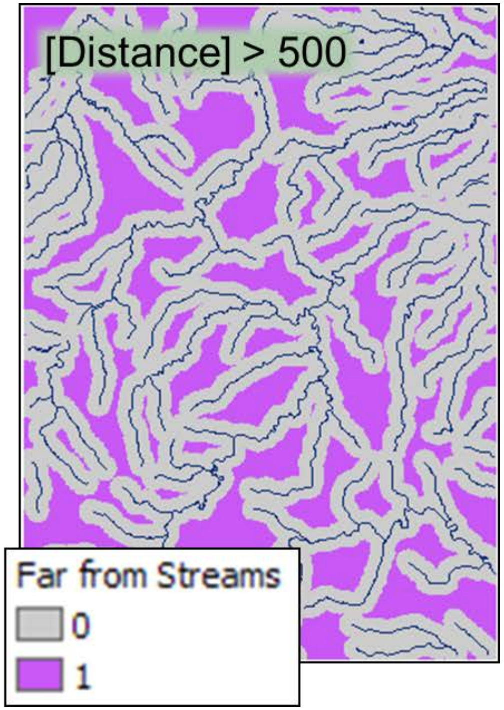


Stream distance condition

1. Use distance function to create raster of distance from streams.
2. Use a logical operator in map algebra to create a Boolean map of areas more than 500 meters from a stream.

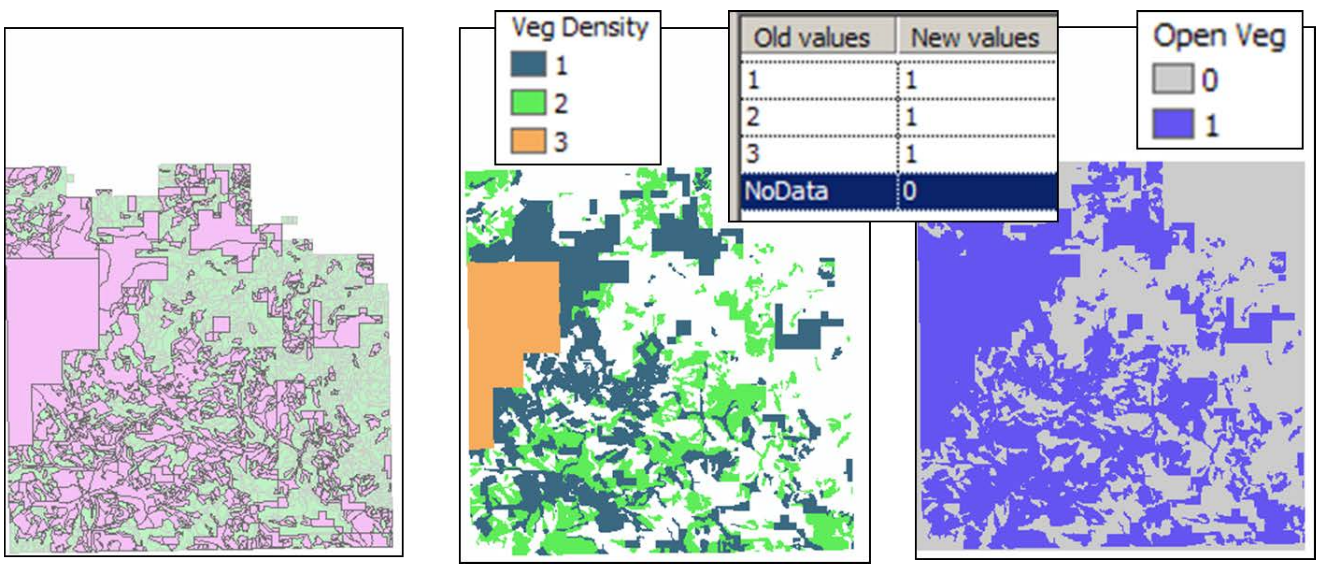






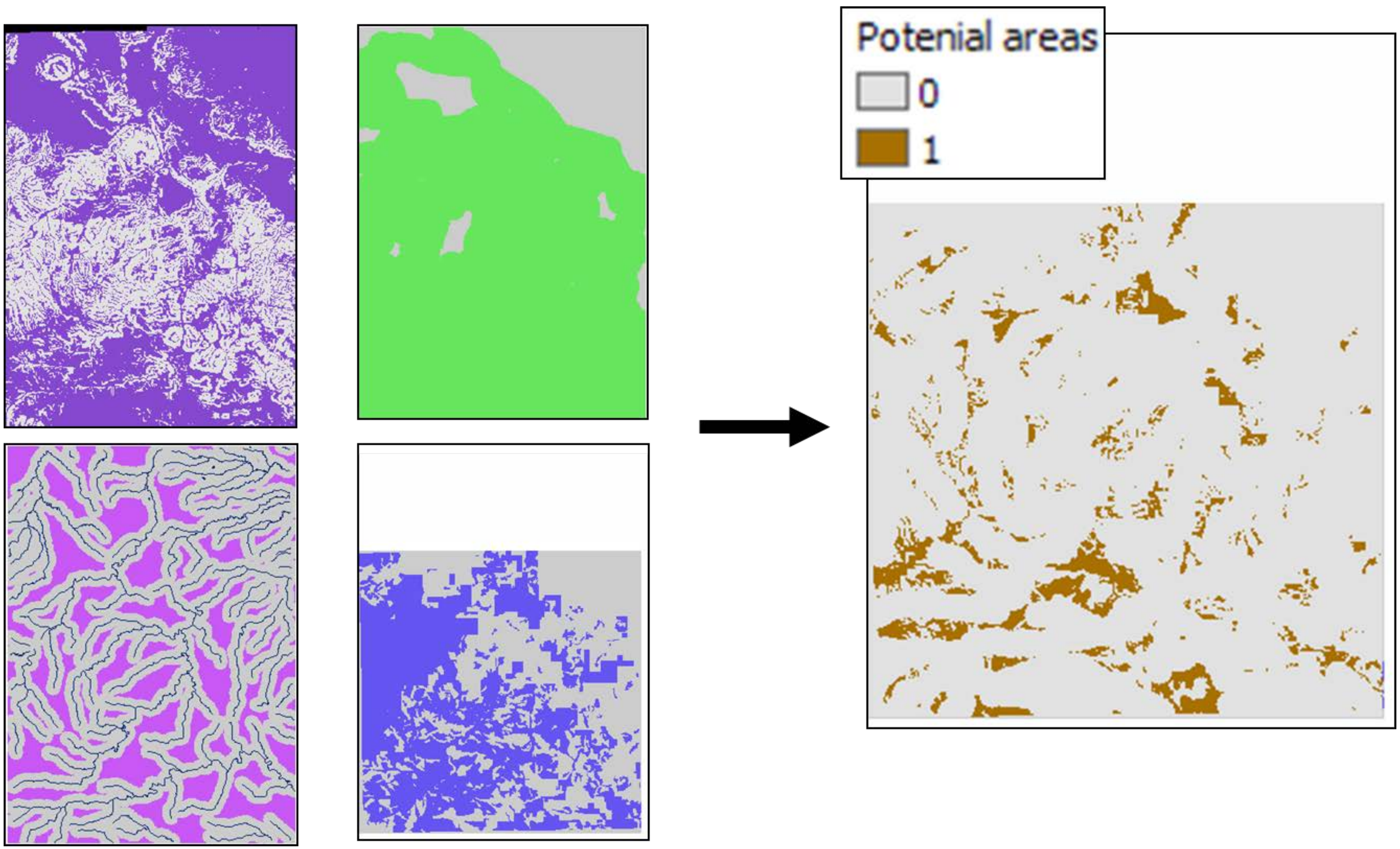
Vegetation condition

1. Select suitable vegetation density and create a layer from the selected polygons.
2. Convert the selected vegetation layer to a raster using the density attribute.
3. Reclassify the three density values all to 1 and the NoData areas to 0.



Find landfill areas with Boolean AND

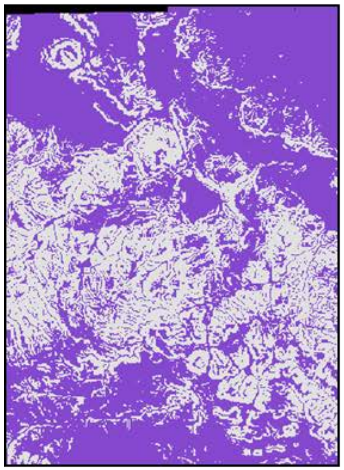
[Slope] AND [Roads] AND [Streams] AND [Vegetation]

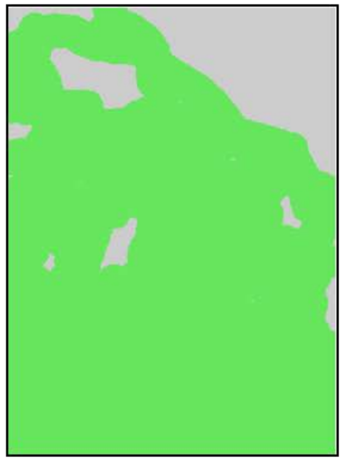


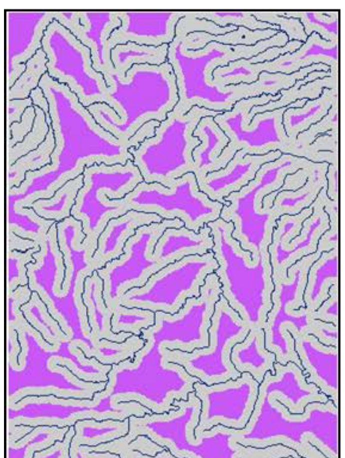
[Return to Outline](#)

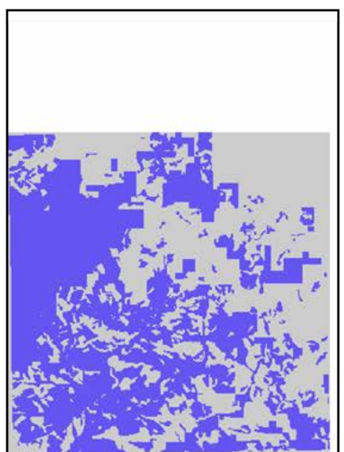
Additive model

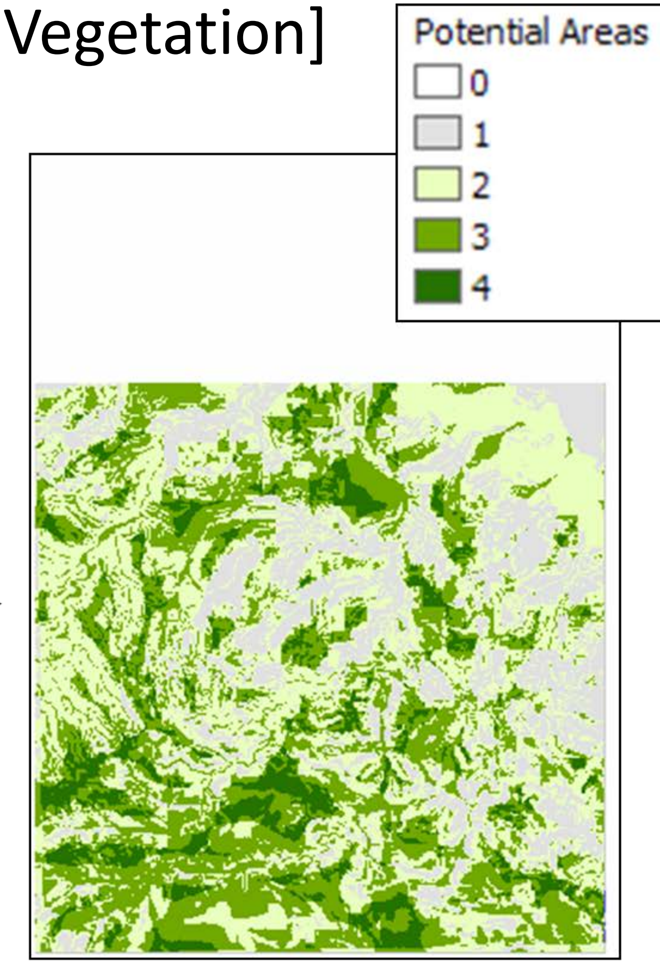
[Slope] + [Roads] + [Streams] + [Vegetation]



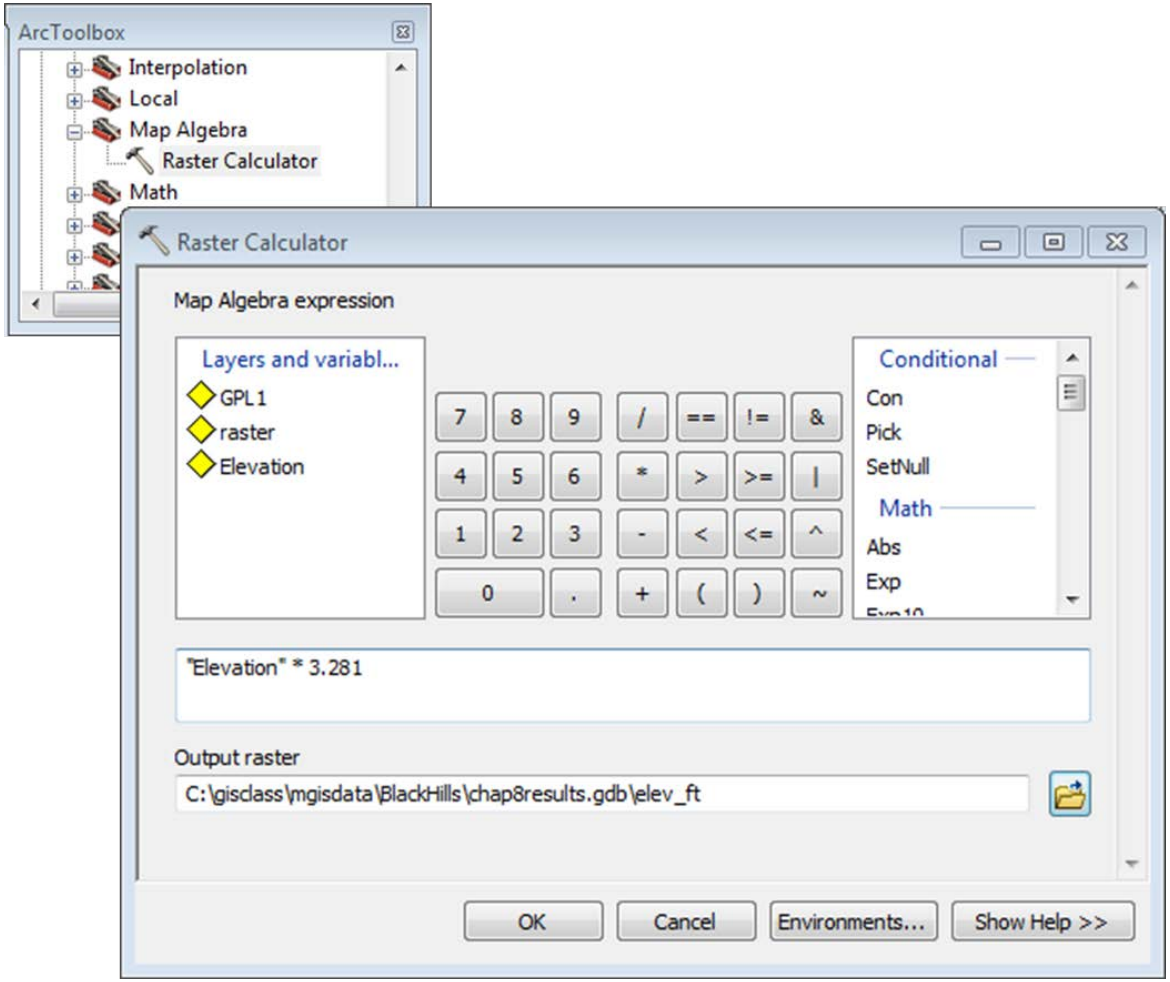








Where do we do these calculations? Raster Calculator



Numeric formulas

Mathematical functions (sin, exp, cos, etc)

Logical operators

Boolean operators

Raster analysis techniques

Other raster analysis techniques

Reclassification

Surface functions

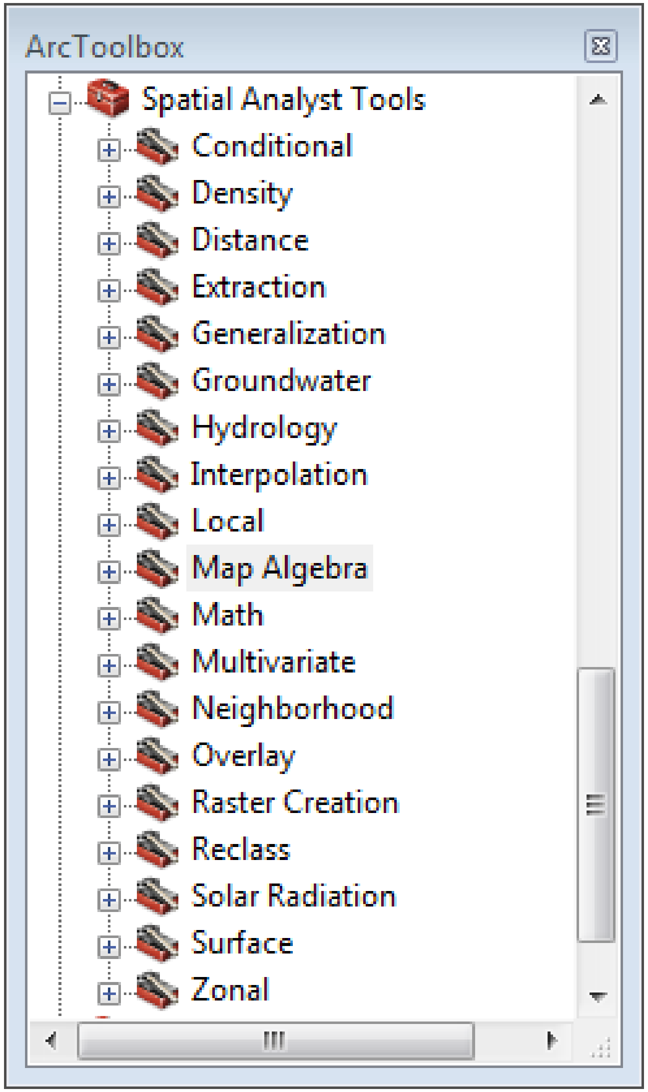
Distance functions

Density functions

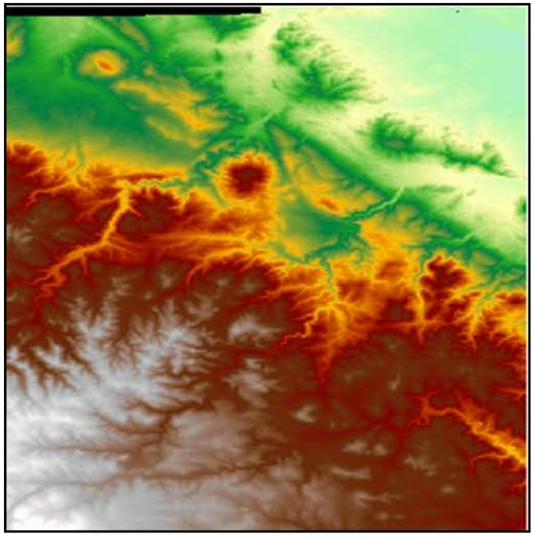
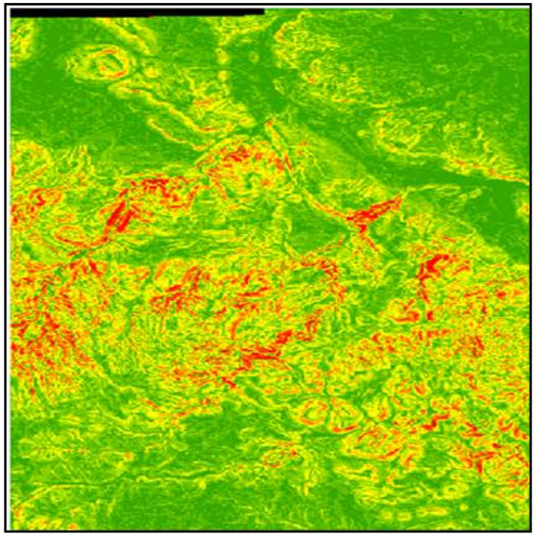
Interpolation

Neighborhood functions

Zonal functions



Surface analysis

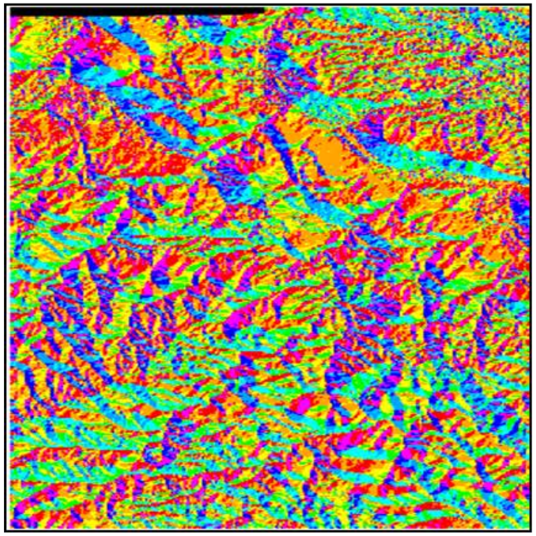
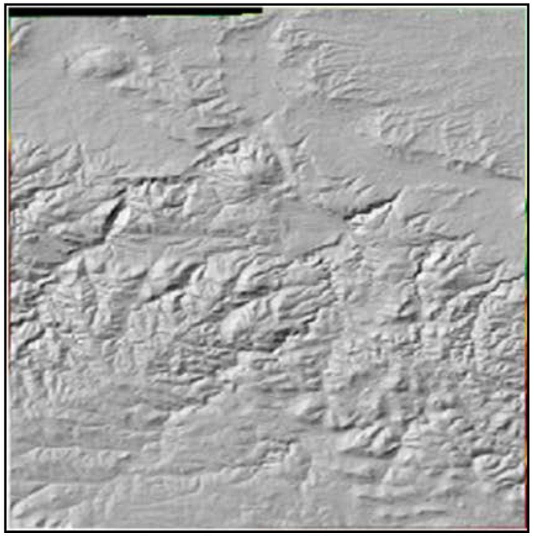
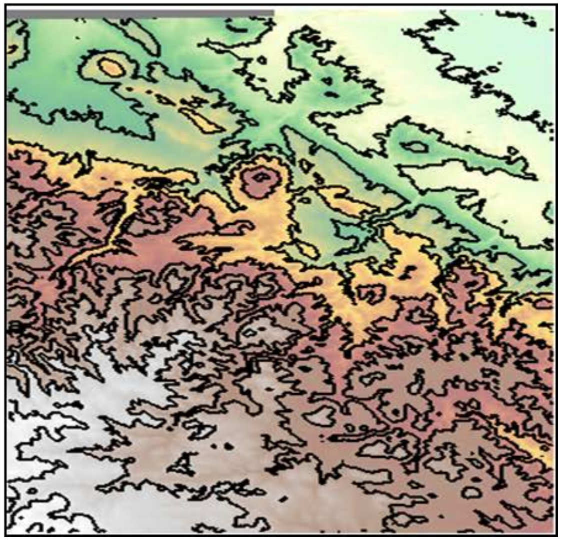
DEM

Slope

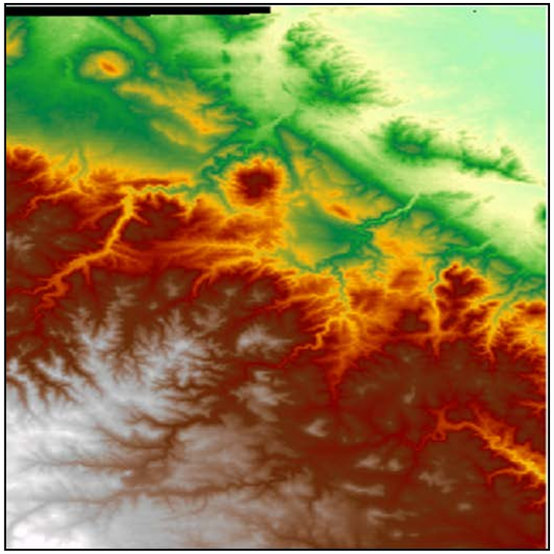
Aspect

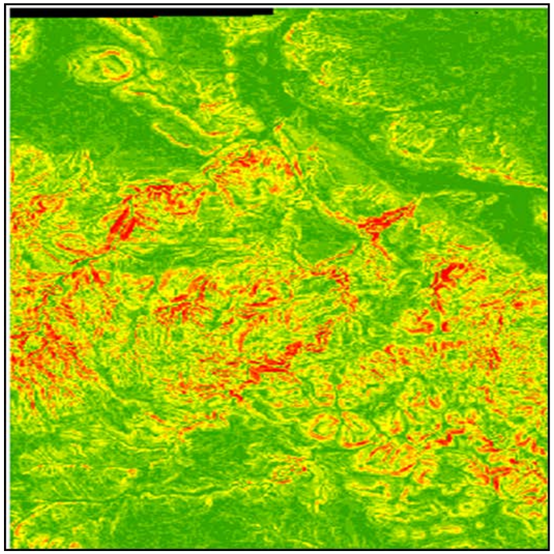
Hillshade

Contouring

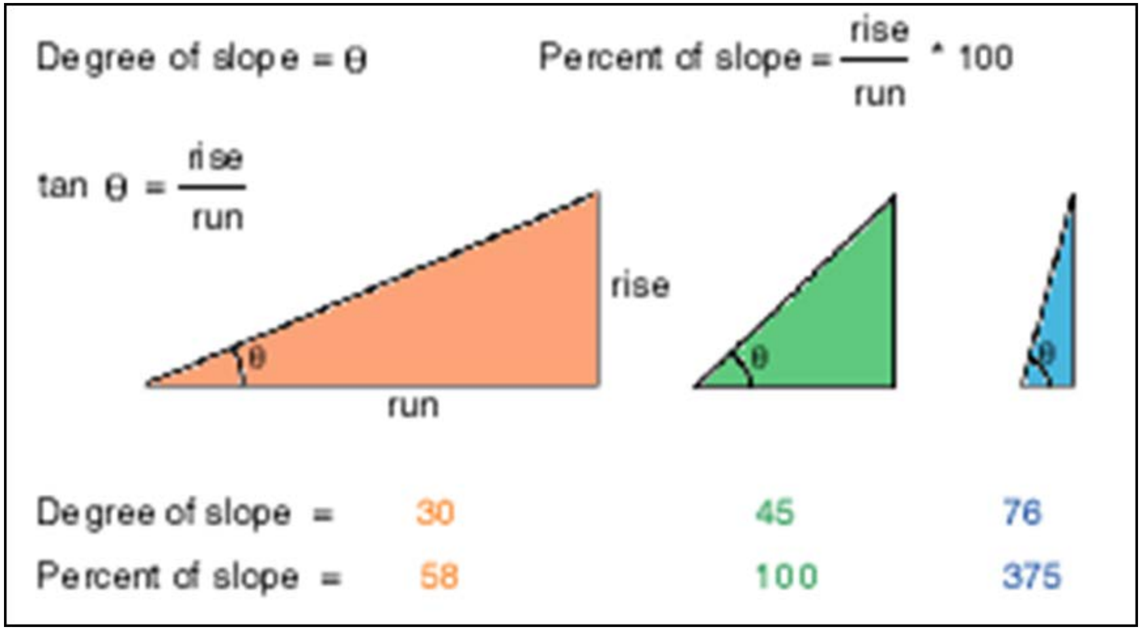
Slope function



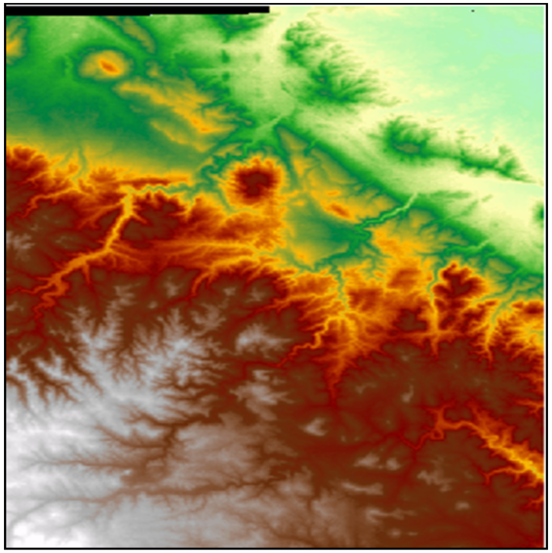


Calculates slope of the surface based on surrounding cells. Can be expressed in degrees or percent.

What areas are suitable for a ski resort?

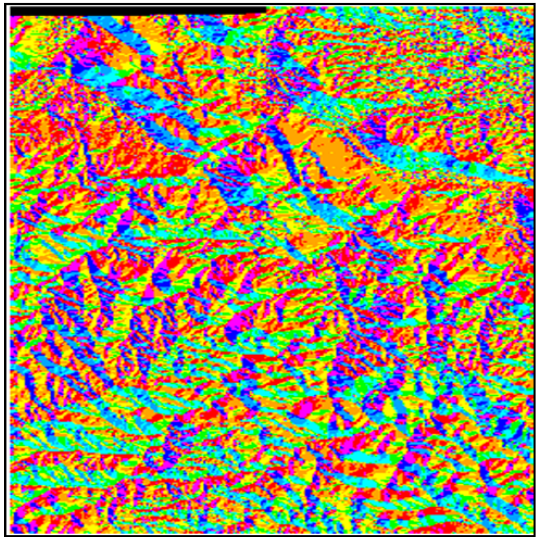


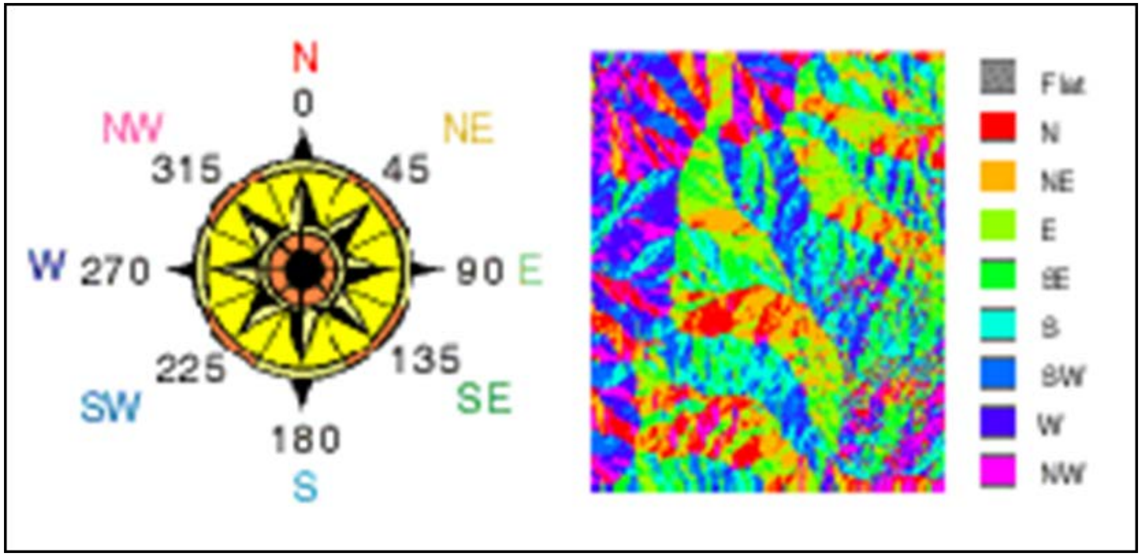
Aspect function



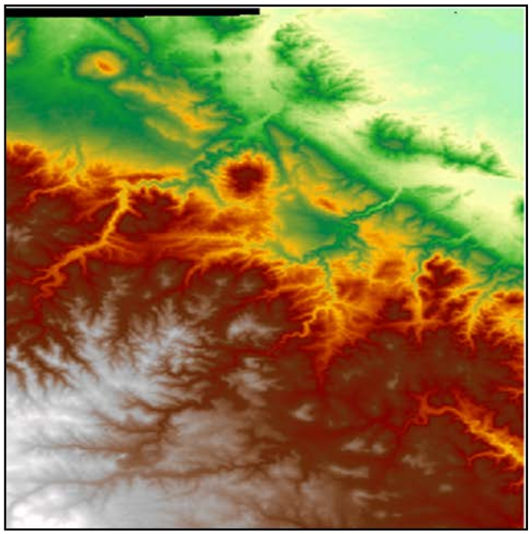
Calculates direction of steepest slope, e.g. which way the slope “faces”. Value represents direction from 0-360 where 0/360 is North. Flat areas are assigned a -1 value.

Where should we install solar panels?



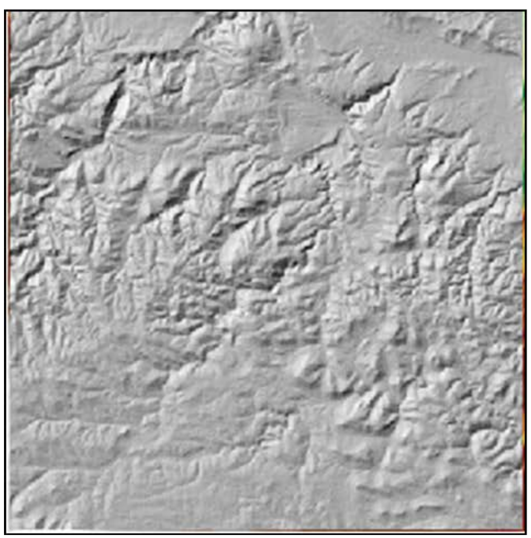


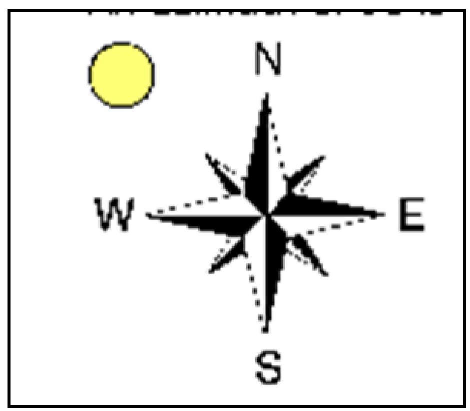
Hillshade



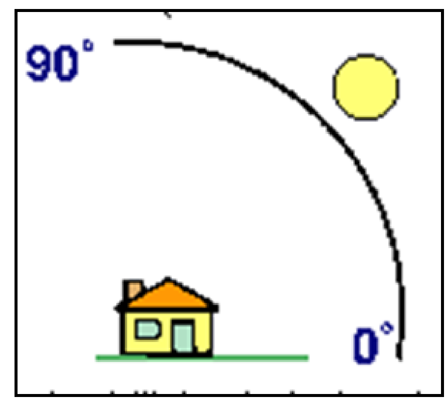
Calculates the brightness or illumination of a surface from a specified light source.

Applications include terrain display and modeling satellite reflectance.



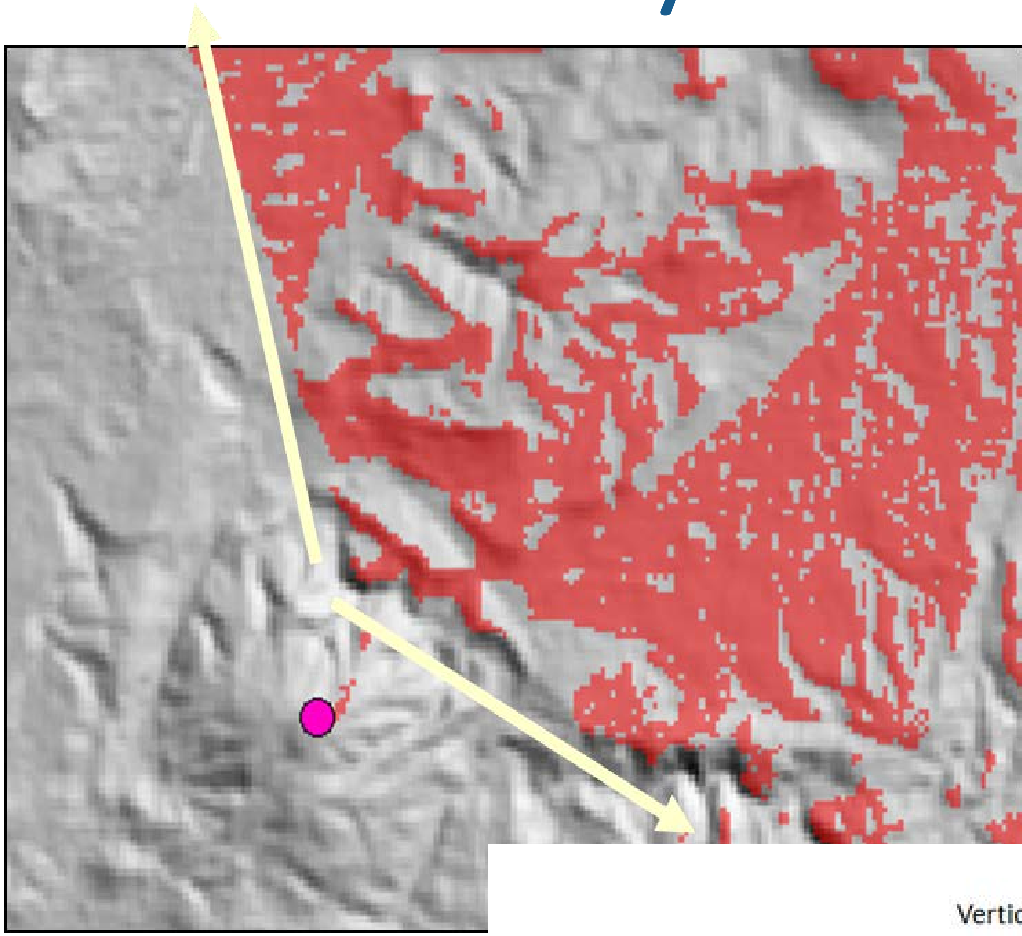


Azimuth is direction of illumination source (315 by default)



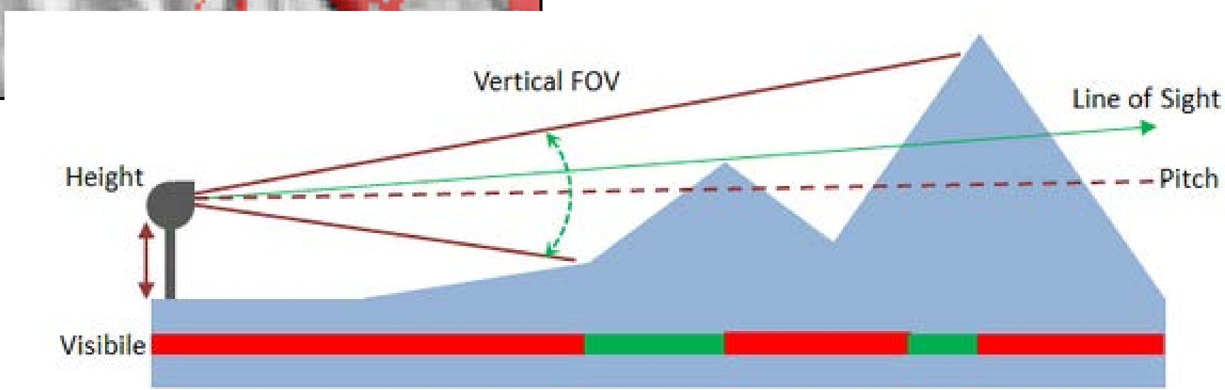
Altitude is the angle of the source above the horizon (45 deg)

Viewshed analysis

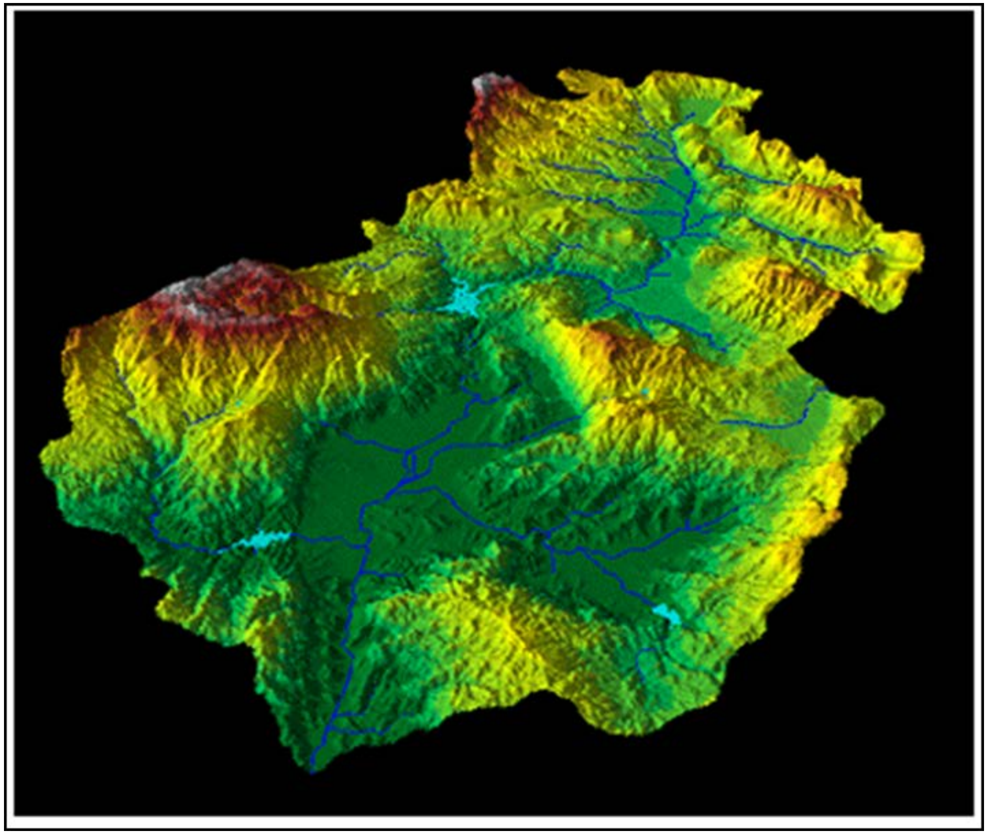


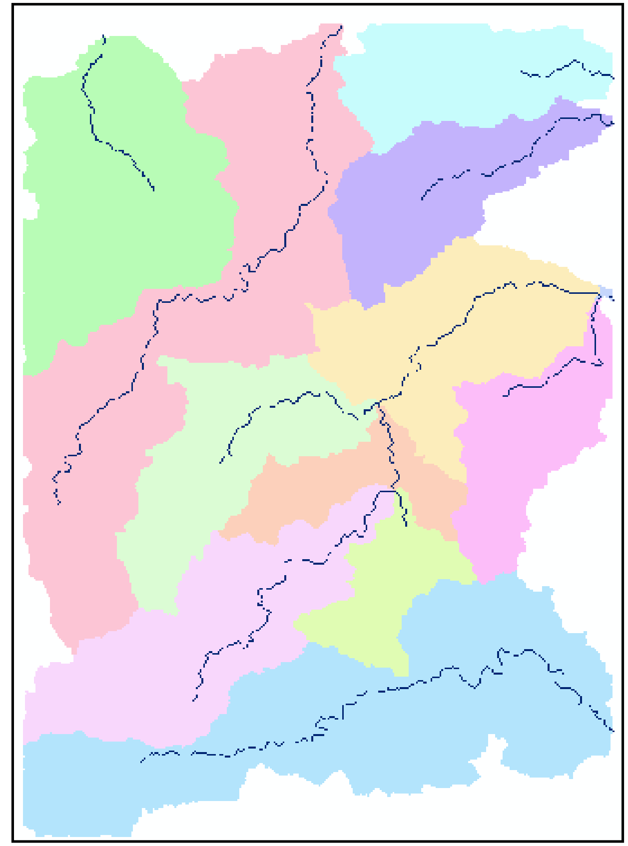
Calculate areas visible from a set of observation points

Why is it difficult to get cell phone reception in some areas?



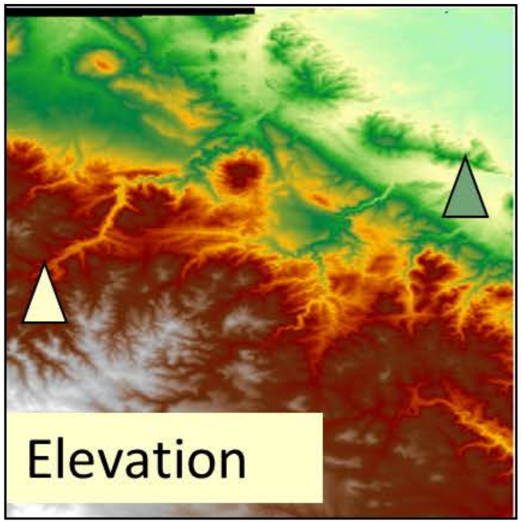
Hydrologic functions

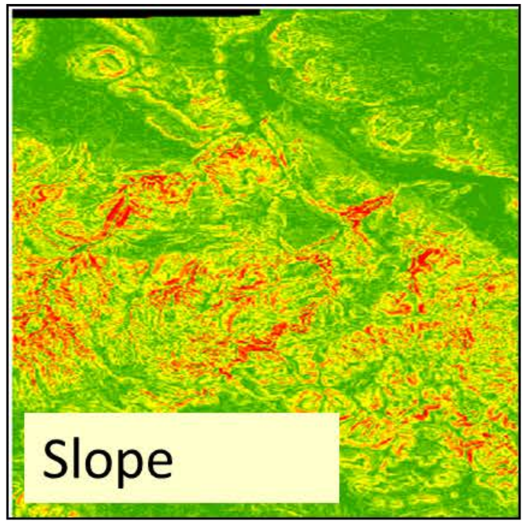


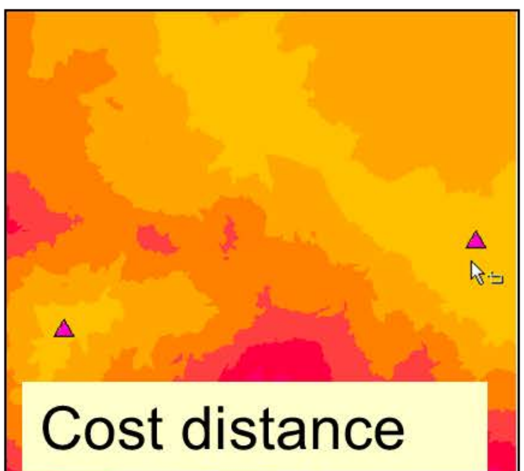


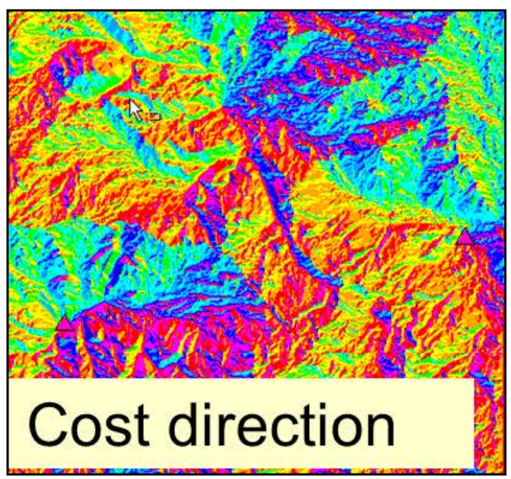
Derive streams, watersheds, and other hydrologic features based on analysis of a DEM.

Distance functions: Lowest cost path

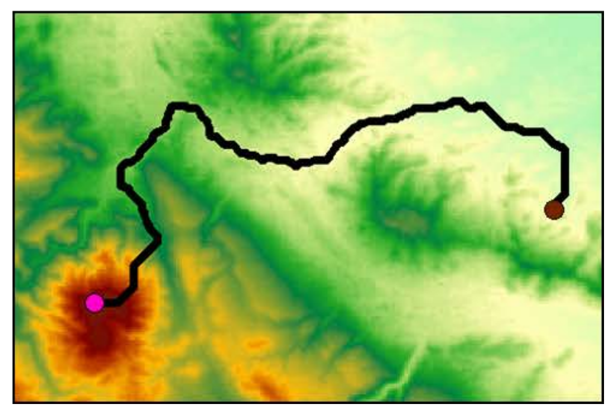




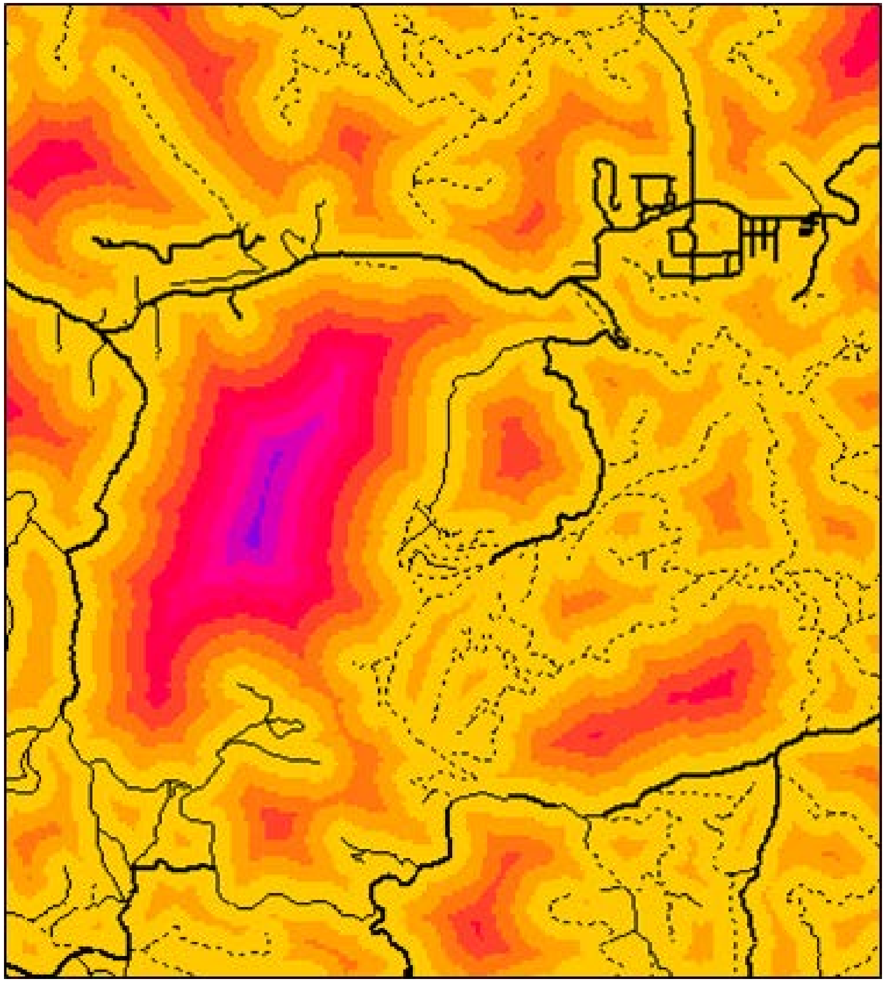




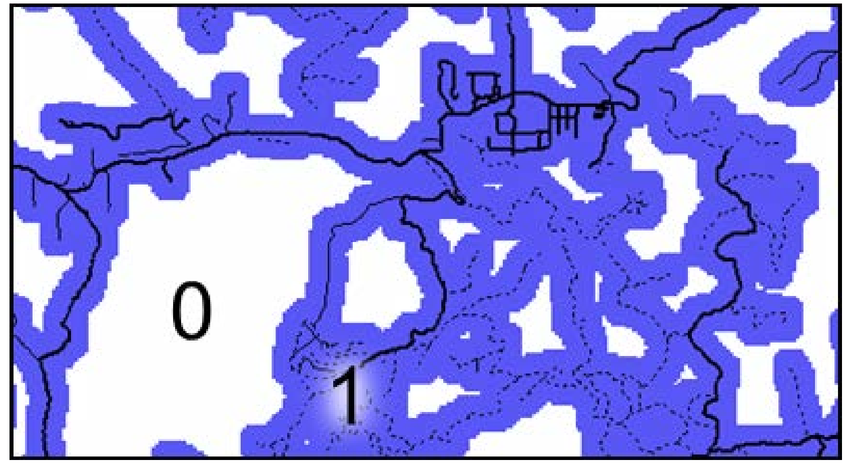
1. Create start/stop shapefiles
2. Create cost grid
3. Calculate cost distance grid and cost direction grid
4. Find lowest cost path



Distance functions: Buffers



Roaddist < 500



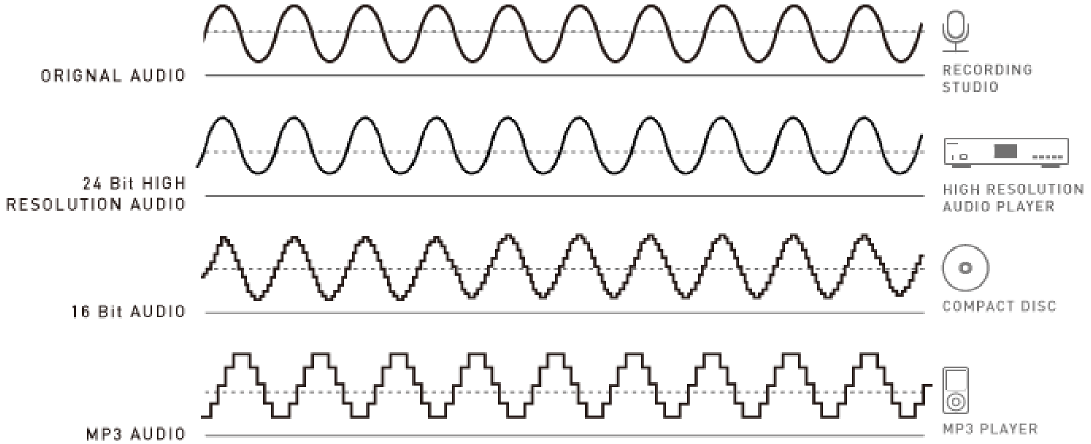
Logical expressions easily create Boolean rasters representing buffers from distance rasters.

How do we create a raster of the real-world from scratch?

Sampling

What is sampling? A finite number of observations selected from a larger population

- The earth and everything on it is comprised of an infinite number of points
- It is impossible to capture every aspect of the earth – or even a small landscape – because we cannot take an infinite number of measurements
- Therefore, we must measure only what is essential, or practical, or what we can afford



Source: Technics

Geospatial Sampling

- Sampled locations should be spaced so the “net” can capture important features
- A **spatial sampling interval** is the average distance between sampled locations
  - Short interval – more points and more detail
  - Large interval – fewer points and less detail
  - *The sample interval should be no larger than ½ the size of the smallest detail to be mapped*

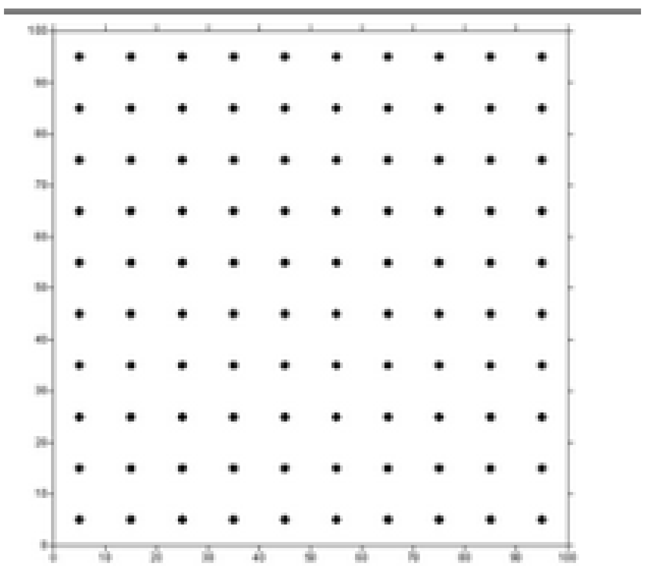
Geospatial Sampling

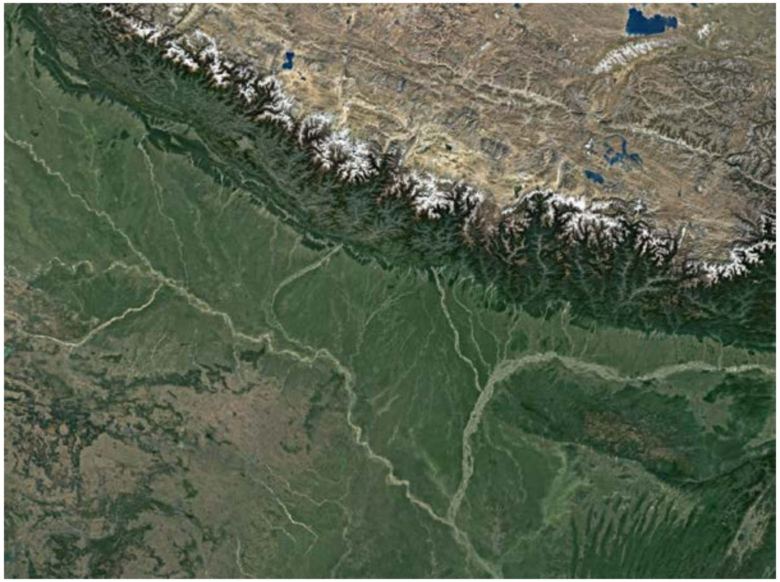
We can control 2 main aspects of the sampling process

1) Choose location of samples
2) Choose number of samples

<u>Systematic sampling pattern</u>

- Usually the simplest pattern but it is not always the most efficient. One size does not always fit all.
- Works best for homogeneous landscapes

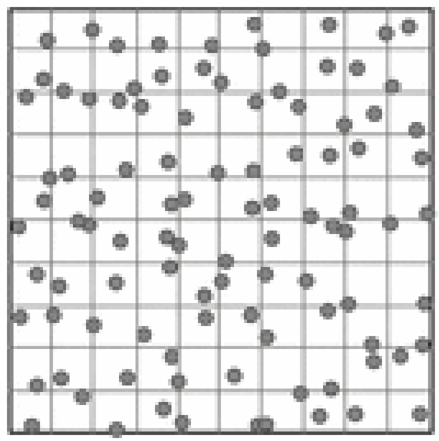




Geospatial Sampling

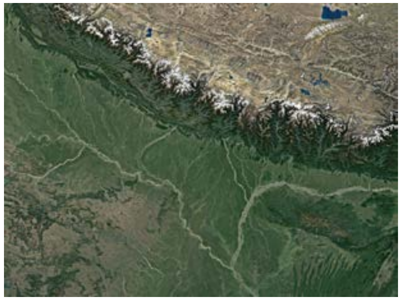
<u>Systematic random sampling pattern</u>

- Random within each grid cell



<u>Sample methods to exploit known natural patterns or features</u>

- Cluster of samples can be focused on possible hotspots



- <u>Cluster sampling</u> – clusters focused on interest areas
- <u>Adaptive sampling</u> – Sample location dependent on landscape (requires knowledge of landscape

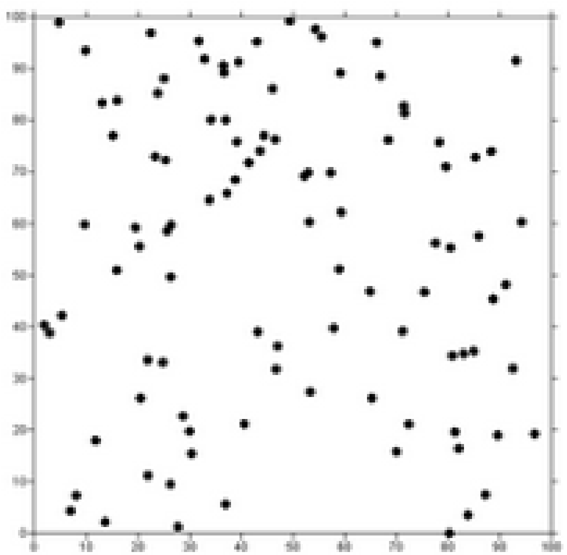
Geospatial Sampling

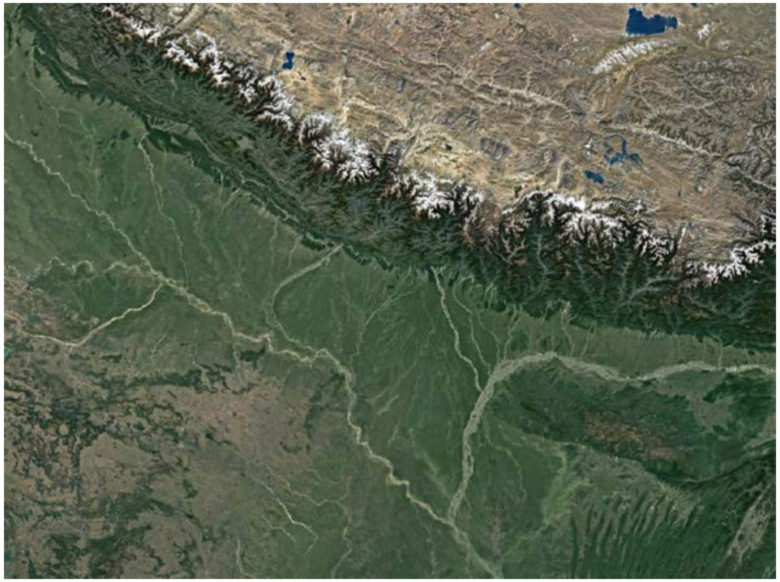
We can control 2 main aspects of the sampling process

1) Choose location of samples
2) Choose number of samples

<u>Random sampling pattern</u>

- Grounded in statistical theory, but ignores geography
- Rarely used because it is difficult to follow random pattern





Geospatial Sampling

We can control 2 main aspects of the sampling process

1) Choose location of samples
2) Choose number of samples

Exploit your knowledge of the landscape to sample more efficiently.

If you have information about the processes that govern the landscape, then you can use that knowledge to help you design a spatial sampling pattern

Also, different layers can be built using different sampling patterns (different layers can be sampled differently)

Hybrid sampling patterns are possible