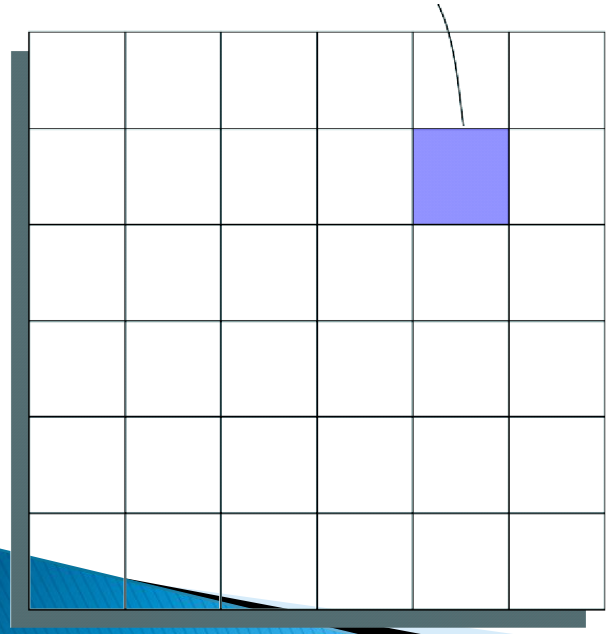
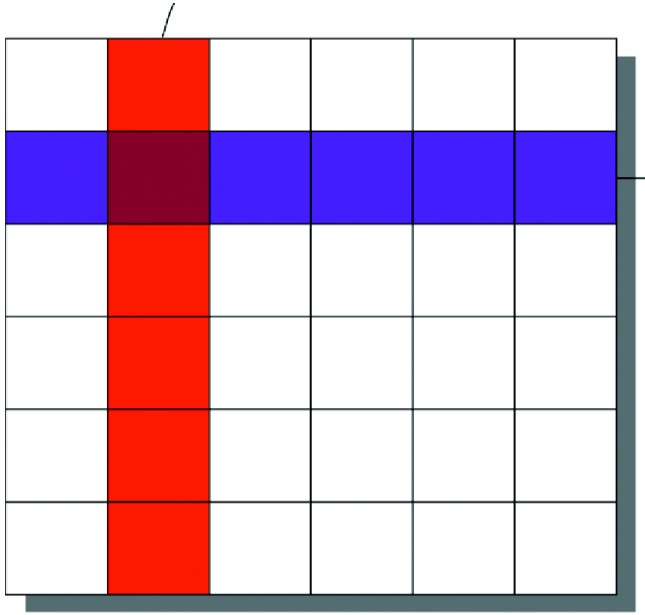
Intro to Raster GIS

CELL

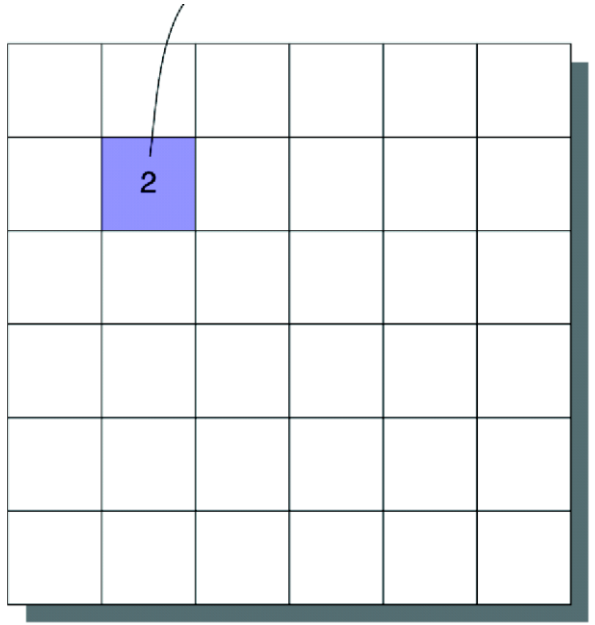


COLUMN

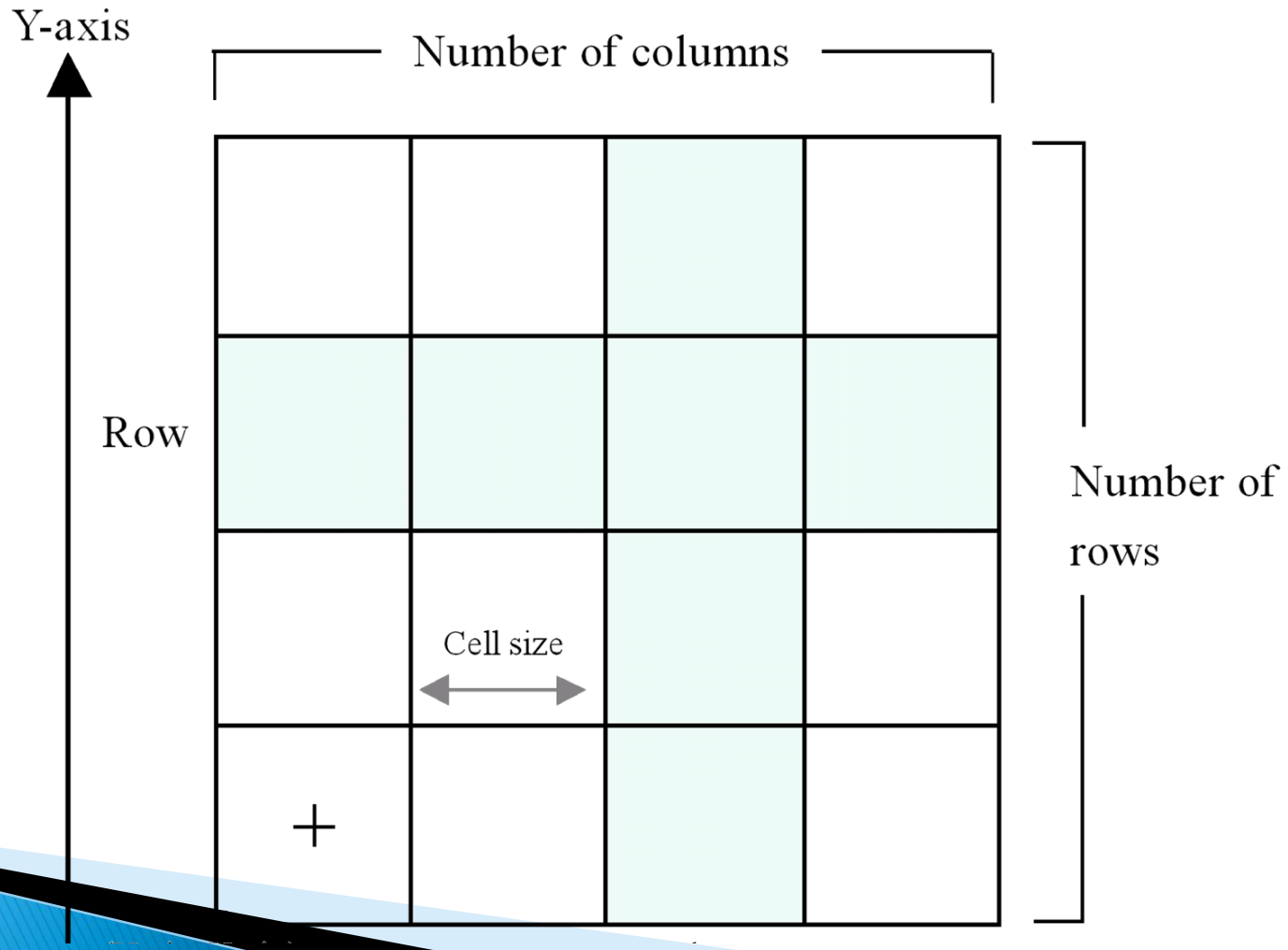


ROW

CELL with VALUE



Coordinate Space and the Raster Dataset



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

Zone with value 1

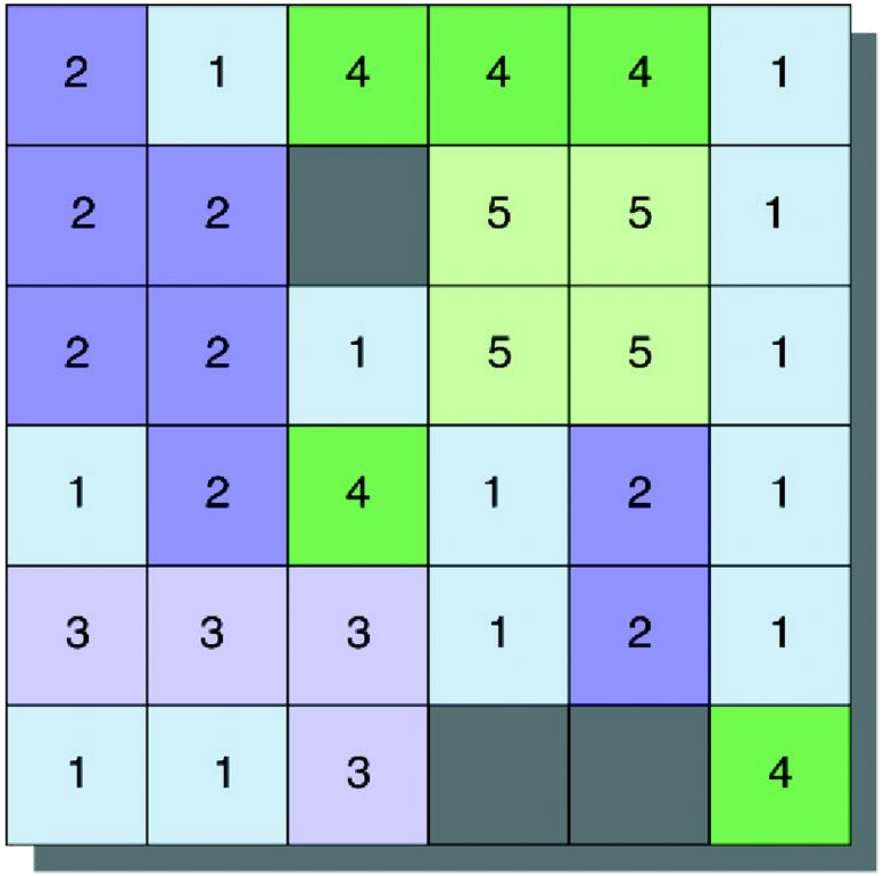
Zone with value 2

Zone with value 3

Zone with value 4

Zone with value 5

NO DATA



Zone with value 1

Zone with value 2

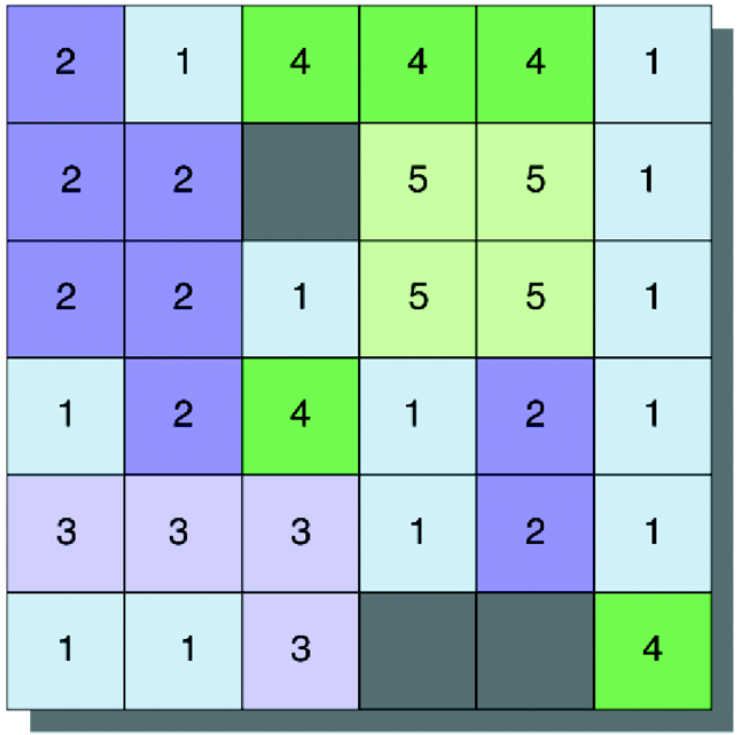
Zone with value 3

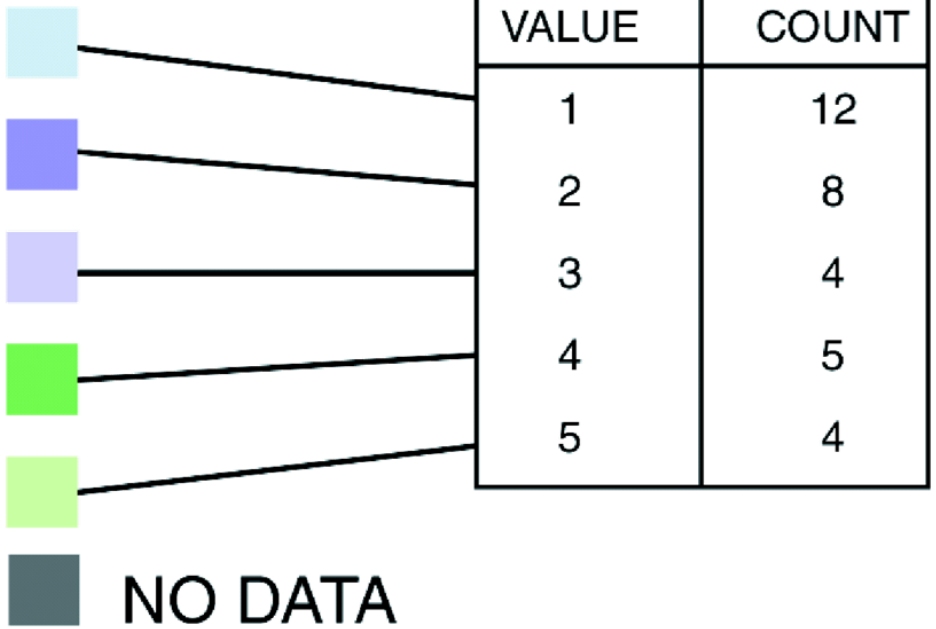
Zone with value 4

Zone with value 5

NO DATA

Raster Attribute Table



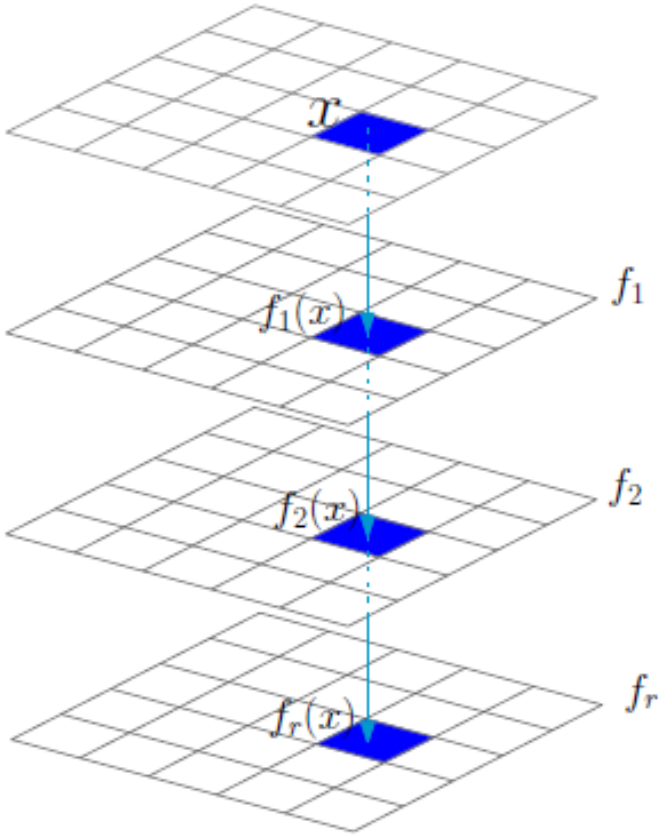


VAT	
VALUE	COUNT
1	12
2	8
3	4
4	5
5	4

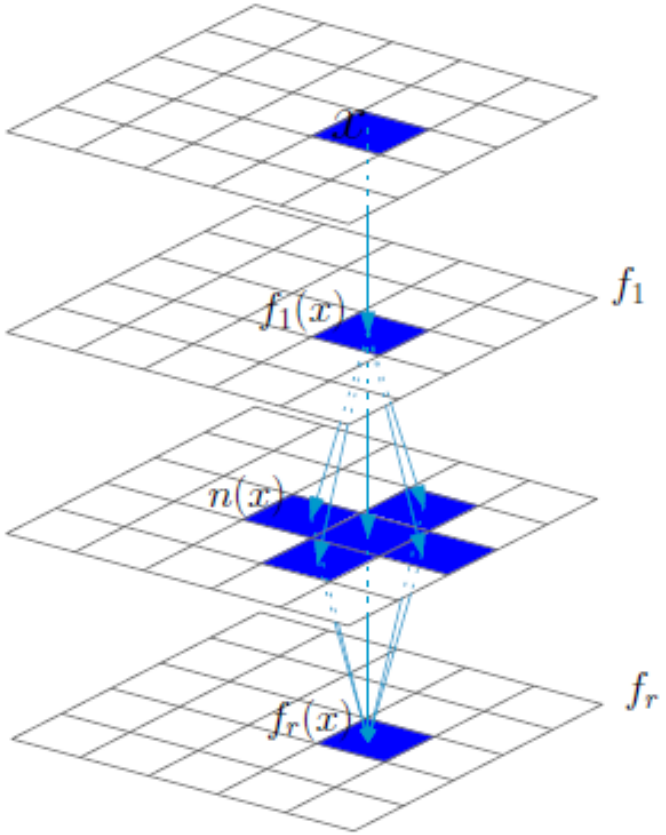
Map Algebra

Map Algebra

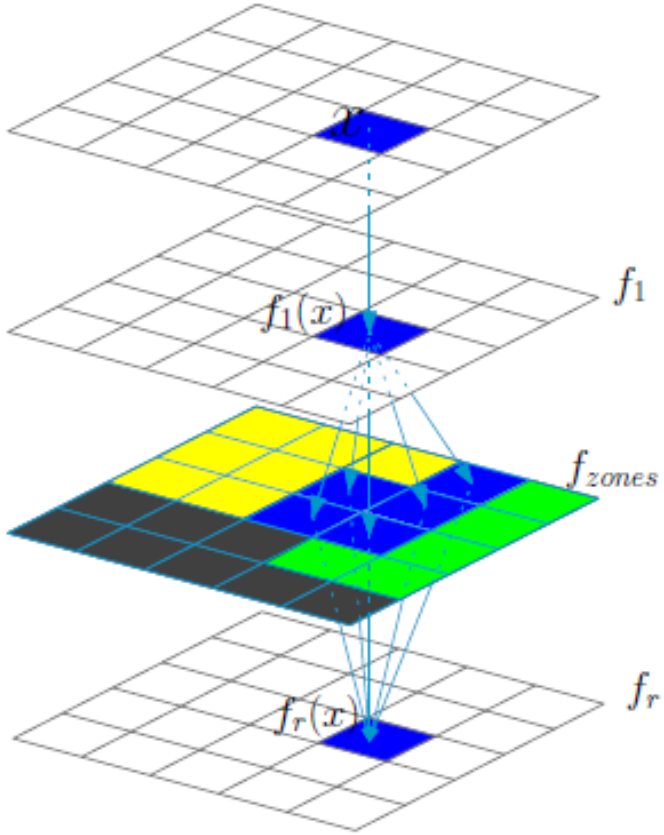
- Mathematical combinations of layers
- Several types of functions:
  - Local
  - Focal
  - Zonal
  - Global
- Functions can be applied to one or more layers



Local operation



Focal operation

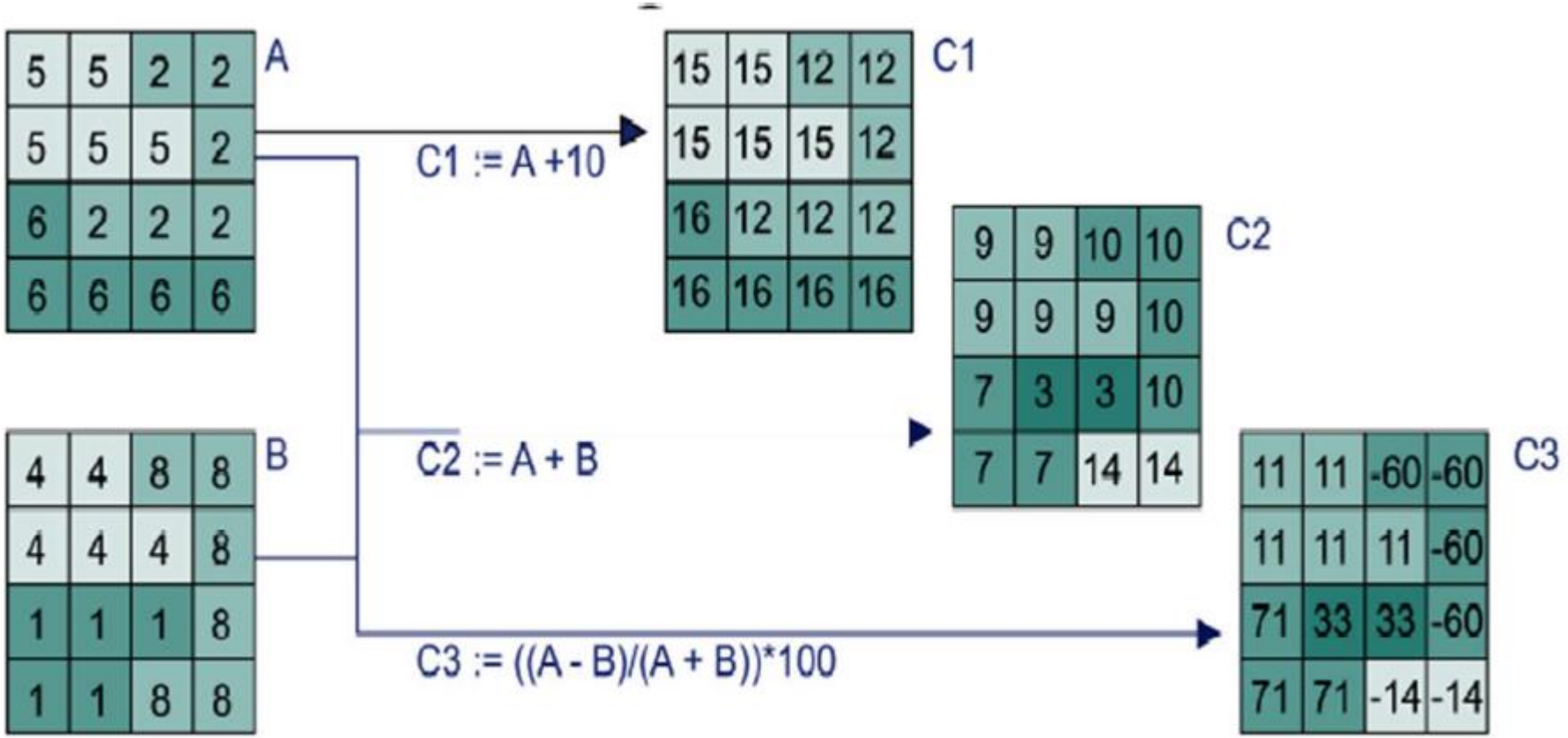


Zonal operation

Local Functions

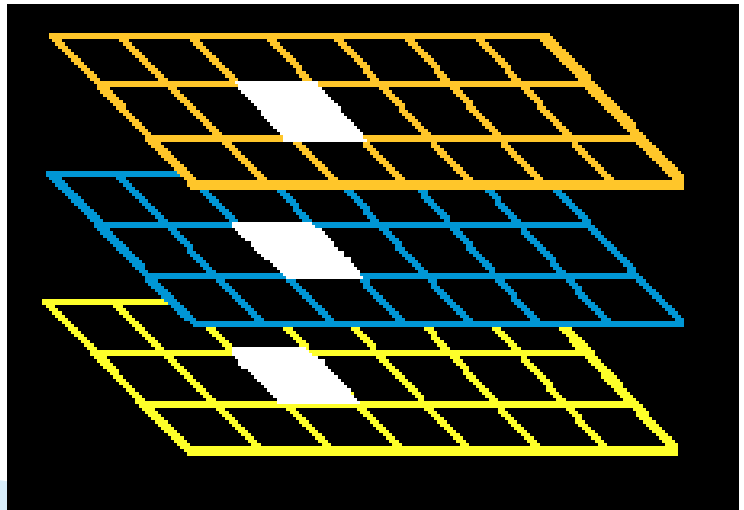
Local Functions

- Sometimes called layer functions
- Work on every single cell in a raster layer
- Cells are processed without reference to surrounding cells
- Operations can be arithmetic, trigonometric, exponential, logical or logarithmic functions
- As we are dealing with numbers, we can use a plethora of mathematical computations.


A
5 5 2 2
5 5 5 2
6 2 2 2
6 6 6 6
C1 := A +10
C1
15 15 12 12
15 15 15 12
16 12 12 12
16 16 16 16
B
4 4 8 8
4 4 4 8
1 1 1 8
1 1 8 8
C2 := A + B
C2
9 9 10 10
9 9 9 10
7 3 3 10
7 7 14 14
C3 := ((A - B)/(A + B))*100
C3
11 11 -60 -60
11 11 11 -60
71 33 33 -60
71 71 -14 -14

Local Functions

- new layer is a function of two or more input layers
- output value for each cell is a function of the values of the corresponding cells in the input layers
- neighboring or distant cells have no effect



Local Function Examples

- Multiply cells by a constant value

2	0	1	1
2	3	0	4
4		2	3
1	1		2

X 3 =

6	0	3	3
6	9	0	12
12		6	9
3	3		6

Use a multiplier grid

2	0	1	1
2	3	0	4
4		2	3
1	1		2

x

6	0	3	3
6	9	0	12
12		6	9
3	3		6

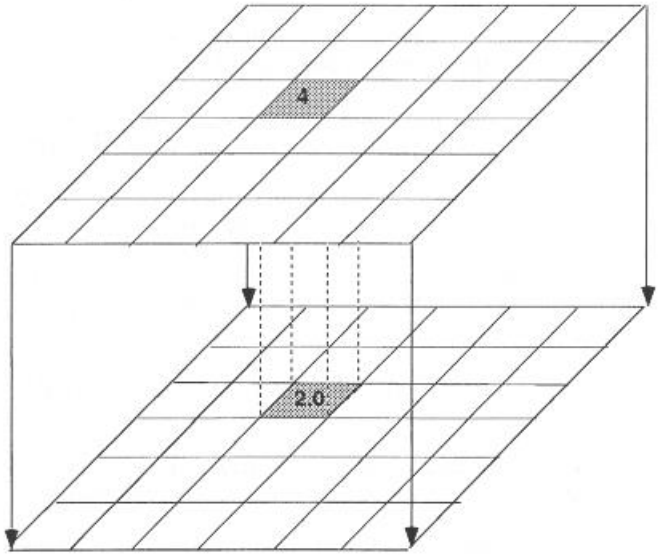
=

12	0	3	3
12	27	0	48
48		12	27
3	3		12

We can use a range of arithmetic functions

Local Operations

- Compute a new raster layer.
- The value for each cell on the output layer is a function of one or more cell values at the ***same location*** on the input layer(s).



Local Operations

- Arithmetic operations

  +, -, *, /, Abs, …

- Relational operators

  >, <, …

- Statistic operations

  Min, Max, Mean, Majority, …

- Trigonometric operations

  Sine, Cosine, Tan, Arcsine, Arccosine, …

- Exponential and logarithmic operations

  Sqr, sqrt, exp, exp2, …

Local Operation--Examples

9	9	7
9	8	5
6	3	0

+

0	0	2
0	0	1
0	0	0

=

9	9	9
9	8	6
6	3	0

9	9	7
9	8	5
6	3	0

/

0	0	2
0	0	1
0	0	0

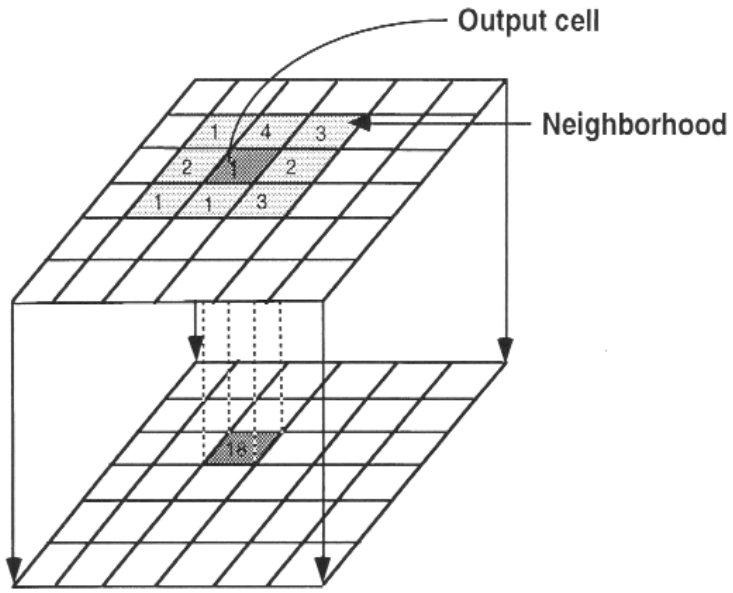
=

N	N	3.5
N	N	5
N	N	N

Focal Functions

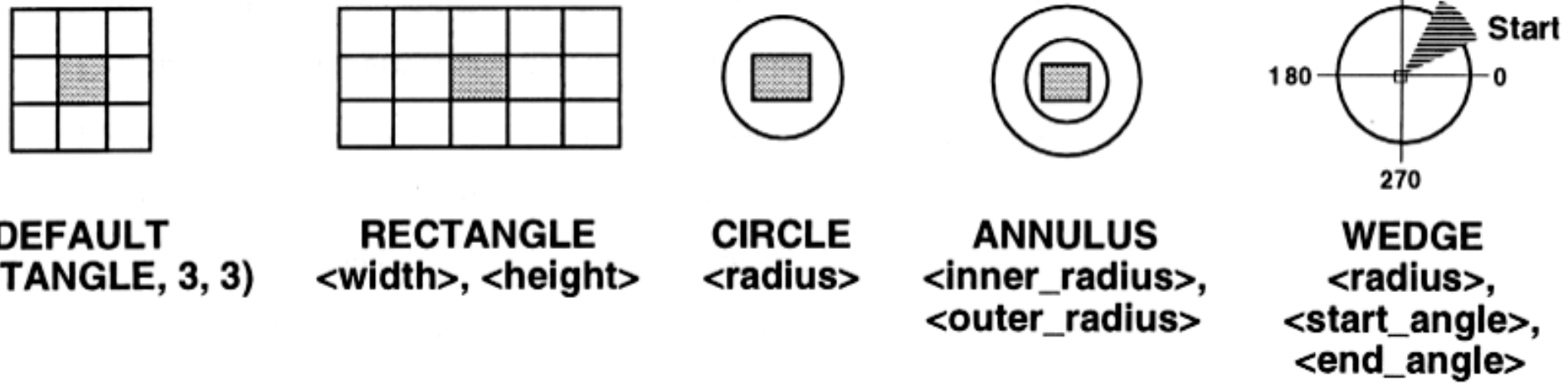
Focal Operations

- Compute an output value for each cell as a function of the cells that are within its neighborhood
- Widely used in image processing with different names
  - Convolution, filtering, kernel or moving window
- Focal operations are spatial in nature



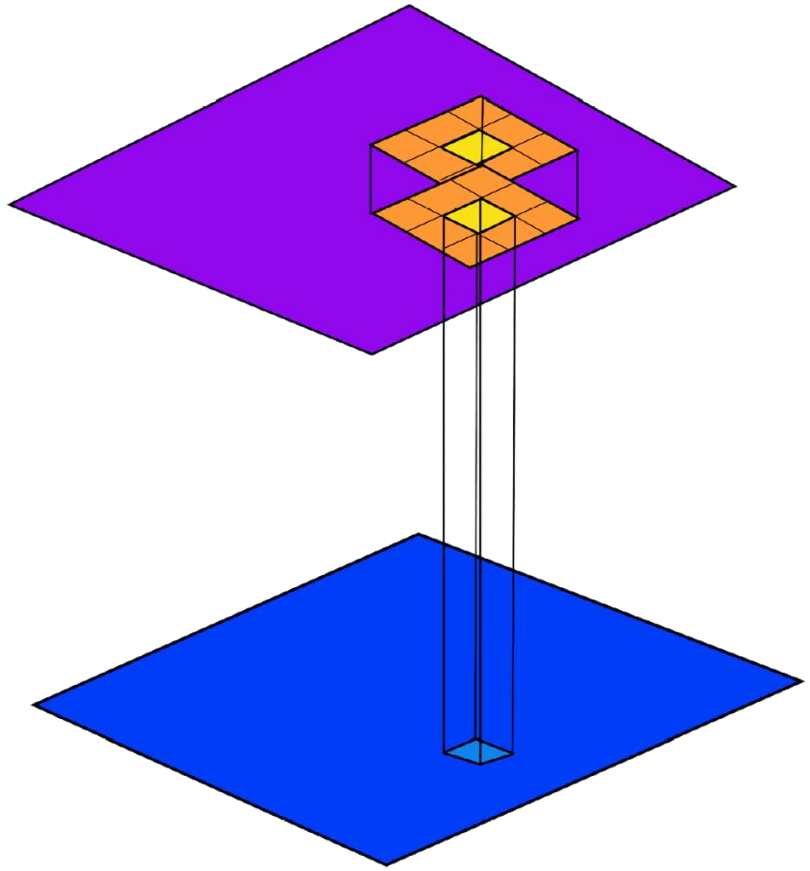
Neighborhoods

- The simplest and most common neighborhood is a 3 by 3 rectangle window
- Other possible neighborhoods
  - a rectangle, a circle, an annulus (a donut) or a wedge



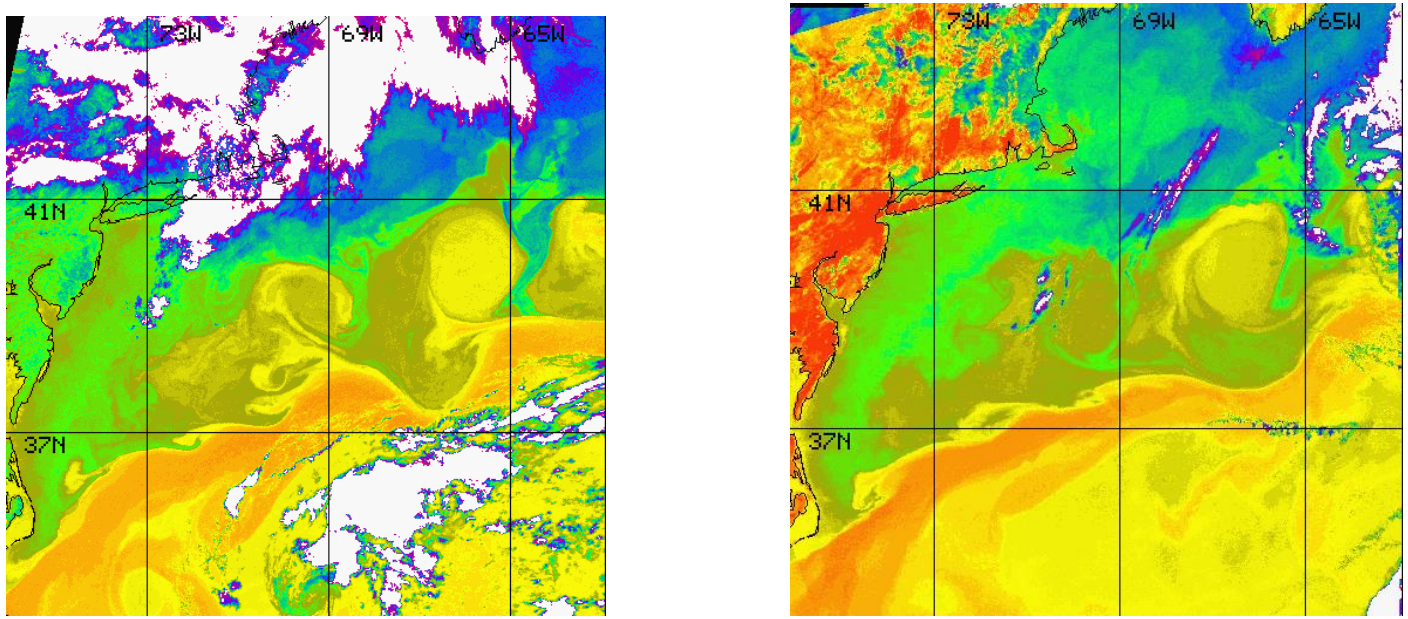
Neighborhood Operations (focal)

- output cell value is a function of a group of neighboring cells in the input raster
- operations could be
  - average (focalmean)
  - sum (focalsum)
  - variance (focalvar)
  - …..



Removing Clouds Using a Local Operation

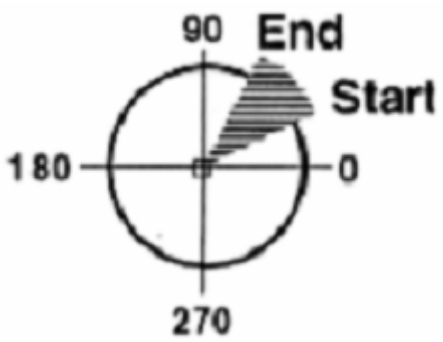
- Two consecutive ocean surface temperature raster layers for the same area (measured at a slightly different time).

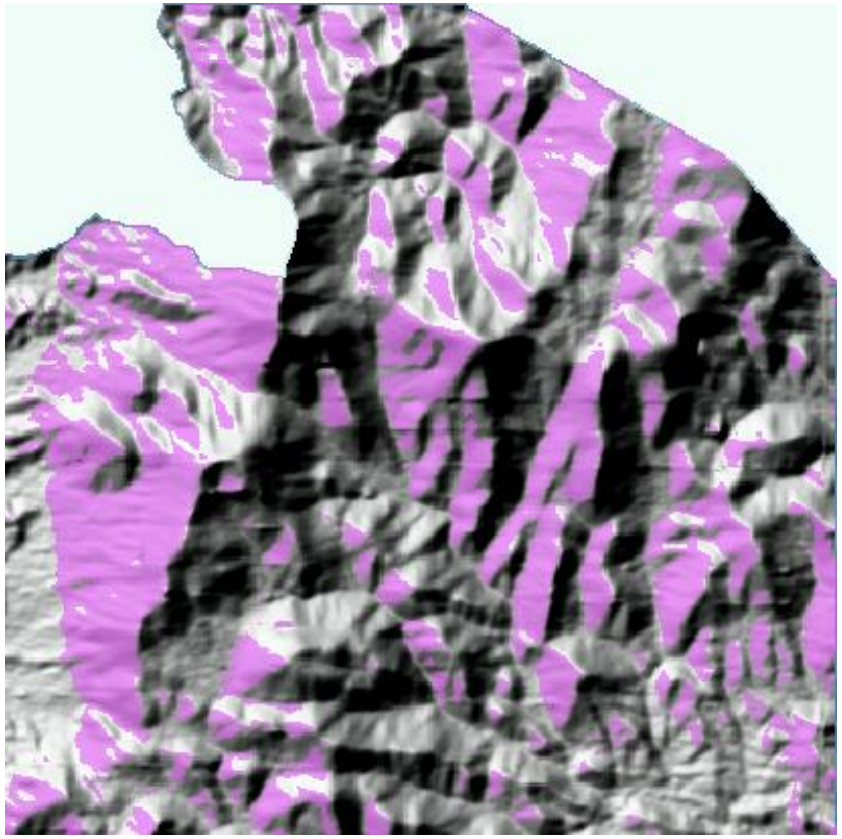


Images are from: http://rs.gso.uri.edu/amy/avhrr.html

Finding Appropriate Wind Farm Sites

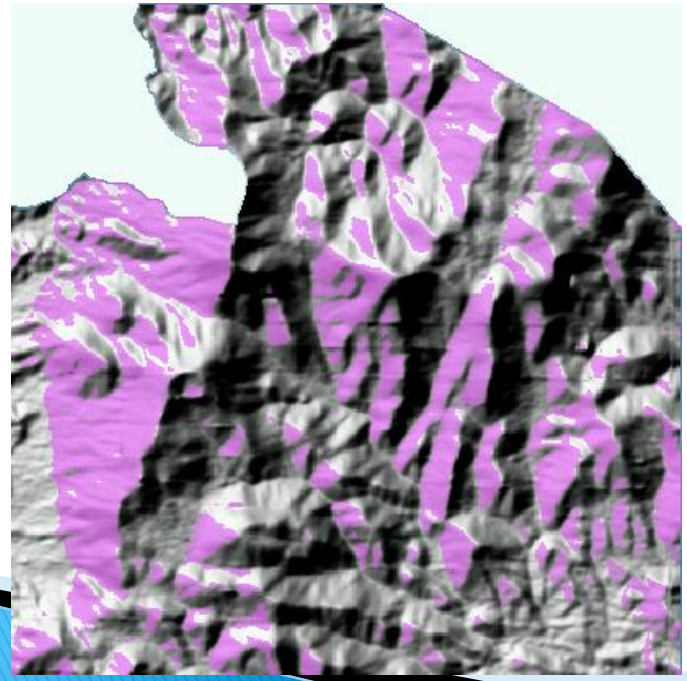
- Wind speed
  - Higher elevation higher speed
  - Elevation (>= 1000m)
- Aspect
  - facing prevailing wind direction
- Wind exposure
  - Not blocked by nearby hills in the prevailing wind direction
- Data
  - Prevailing wind direction
    - 225 ° to 315°
  - DEM
- Wedge neighborhood
  - 0 degree is East, counterclockwise (135—225)

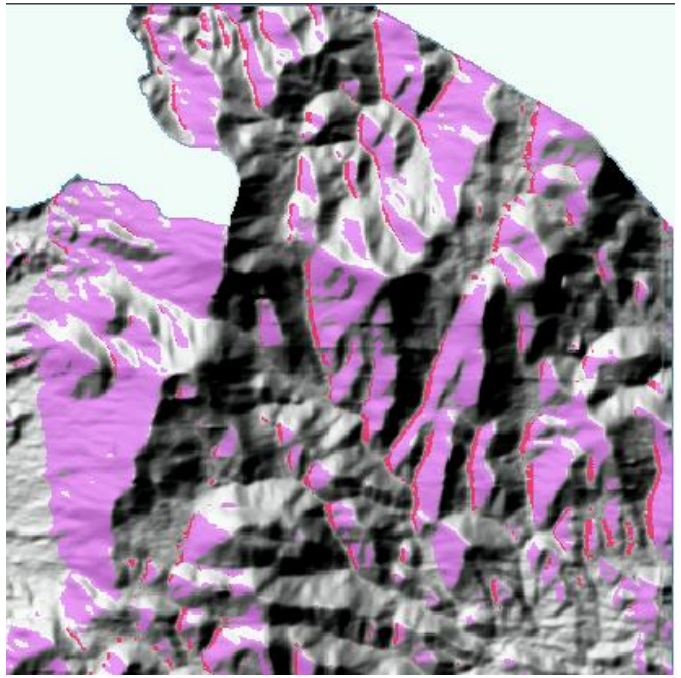




Wind Exposure Analysis

- Find max elevation in the prevailing wind direction
  - FocalMax with a wedge neighborhood
- Find cells not blocked by hills in the neighborhood
  - DEM > FocalMax





Focal Functions

- Focal functions process cell data depending on the values of neighboring cells
- We define a ‘kernel’ to use as the neighborhood
  - for example, 2x2, 3x3, 4x4 cells
- Sometimes in spatial analysis we use shapes to define the focal neighborhood
- Around edges a reduced kernel size is used
- Types of focal functions might be:
  - focal sum, focal mean, focal max, focal min, focal range

Focal Function Examples

- Focal Sum (sums the value of a neighborhood)

2	0	1	1
2	3	0	4
4	2	2	3
1	1	3	2

=

7	8	9	6
13	16	16	11
13	18	20	14
8	13	13	10

- Focal Mean (computes the moving average of a neighborhood)

2	0	1	1
2	3	0	4
4	2	2	3
1	1	3	2

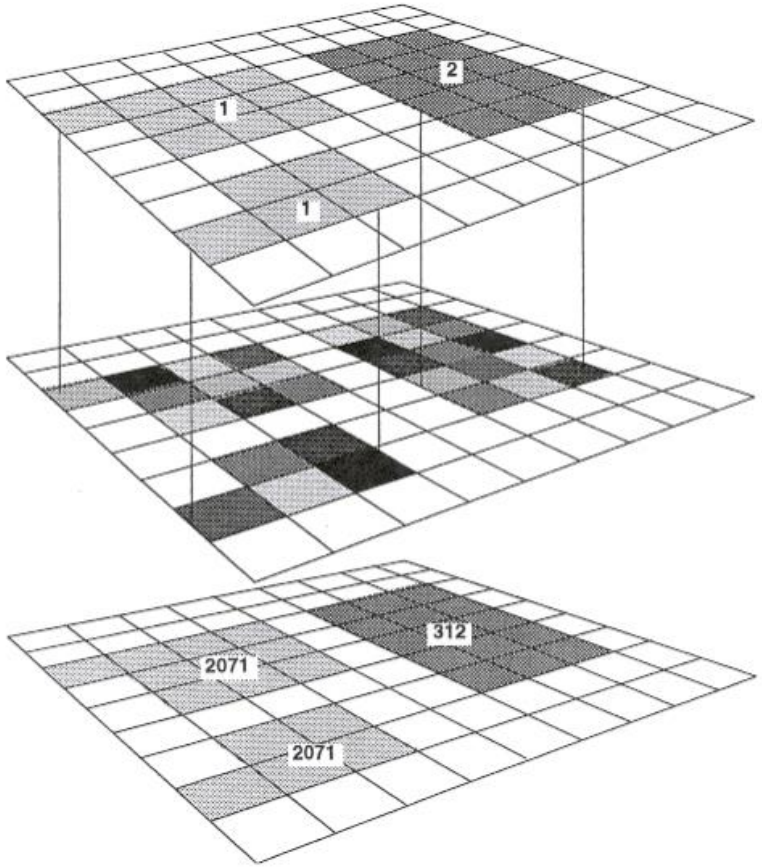
=

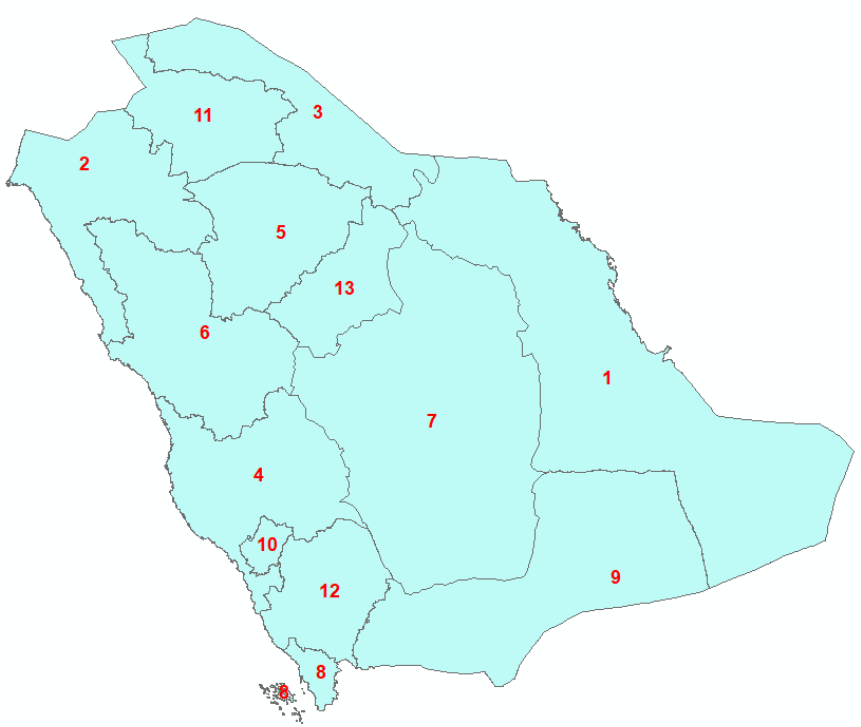
1.8	1.3	1.5	1.5
2.2	2.0	1.8	1.8
2.2	2.0	2.2	2.3
2.0	2.2	2.2	2.5

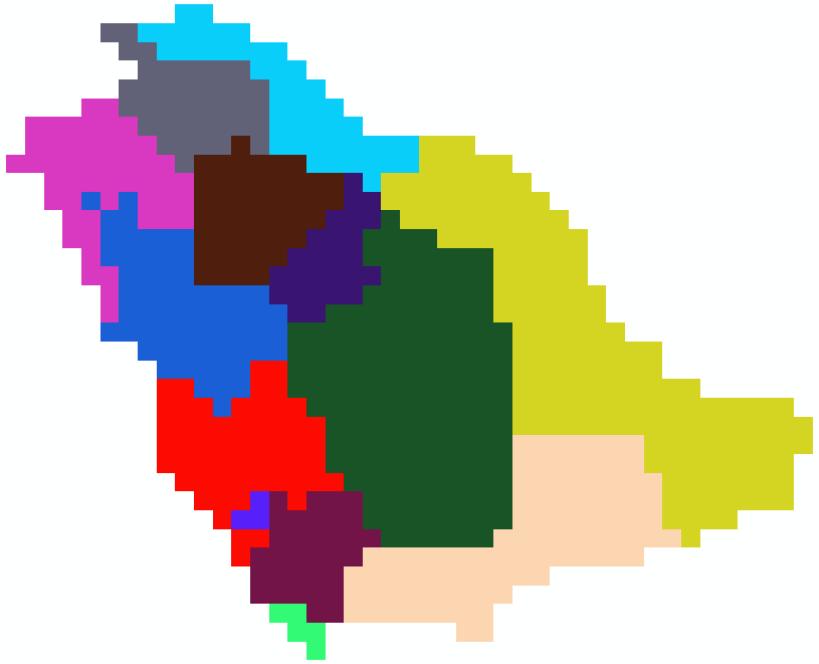
Zonal Functions

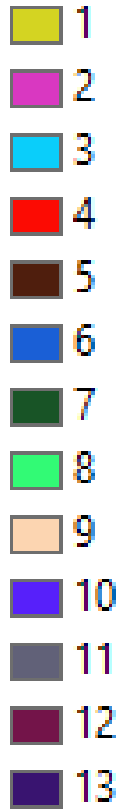
Zonal Operations

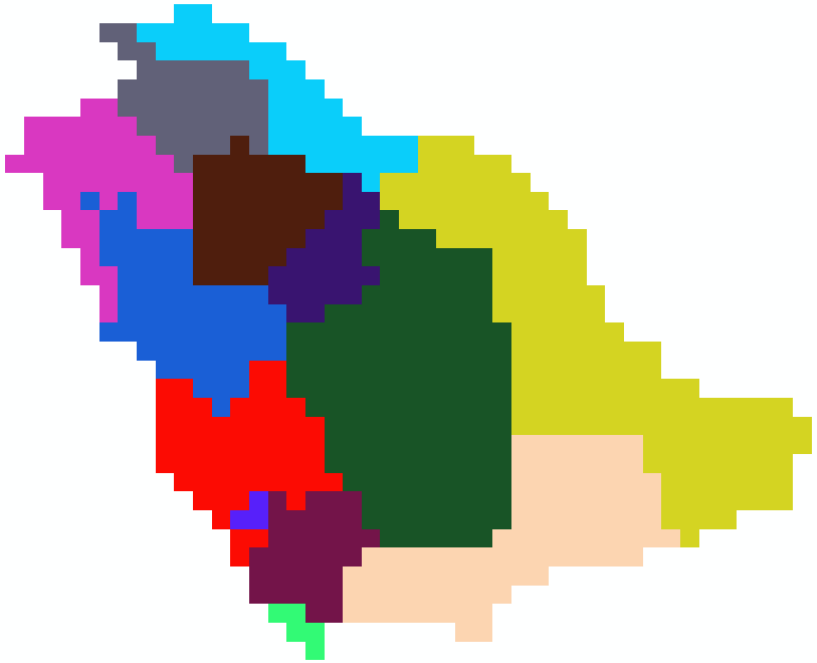
- Compute a new value for each cell as a function of the cell values within a zone containing the cell
- Zone layer
  - defines zones
- Value layer
  - contains input cell values




11
3
2
5
13
6
1
7
4
10
12
9
8

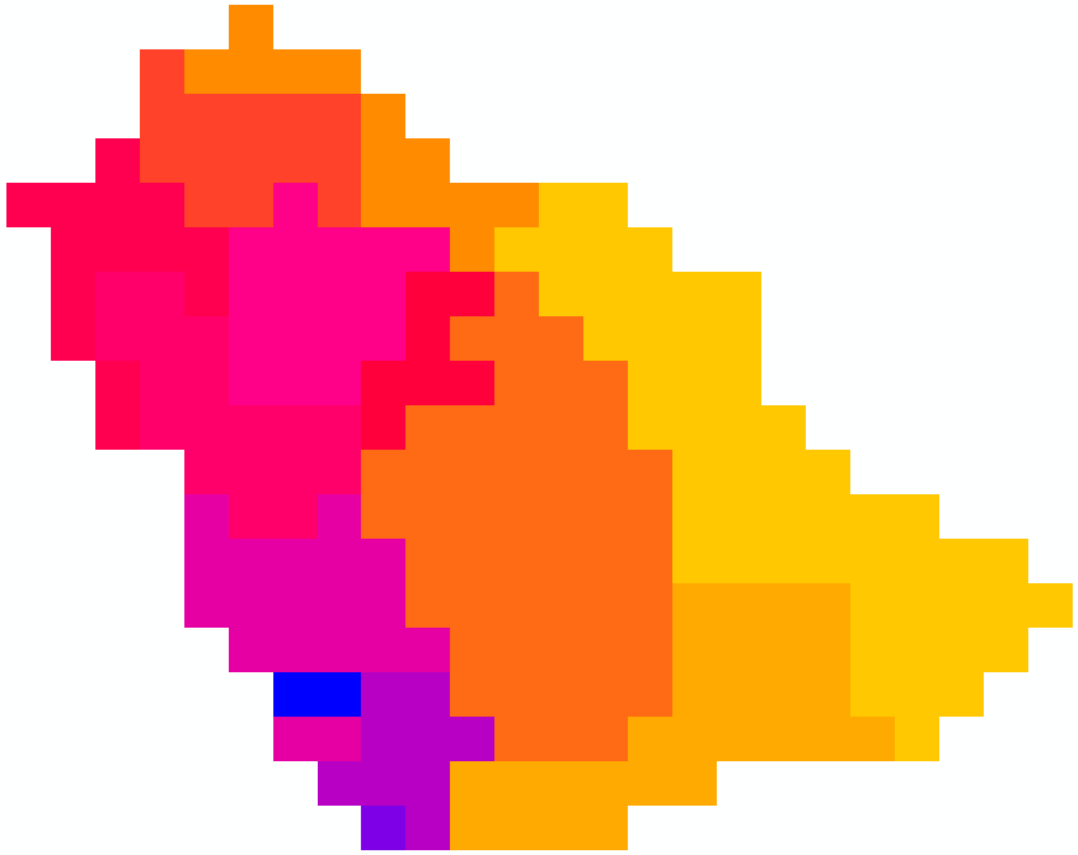



1
2
3
4
5
6
7
8
9
10
11
12
13



Zone Grid (Province)

Value Grid (DEM)



198.5283051
441.5714417
585.1538696
691
726.8571167
748.2857056
766.5
800.388916
915.1176758
1,038.473633
1,349.666626
1,384
1,849.5

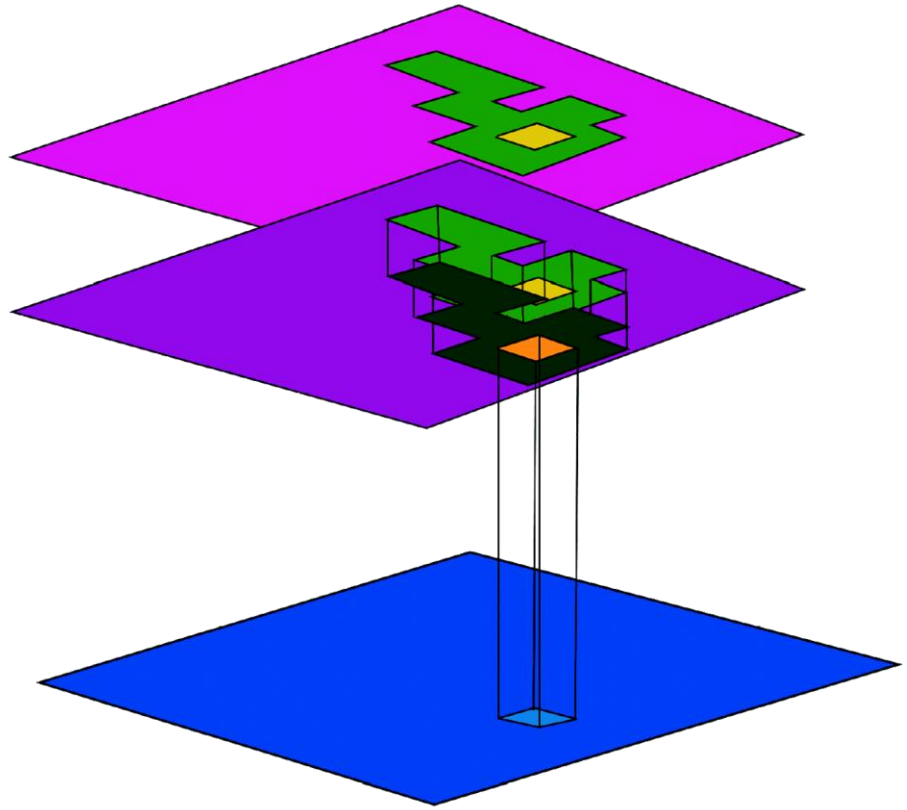
Mean

Zonal Statistical Operations

- Calculate statistics for each cell by using all the cell values within a zone
- Zonal statistical operations:
  - ZonalMean, ZonalMedian, ZonalSum, ZonalMinimum, ZonalMaximum, ZonalRange, ZonalMajority, ZonalVariety, ….

Zonal Functions

- Process and analyze cells on the basis of ‘zones’
- Zones define cells that share a common characteristic
- Cells in the same zone don’t have to be contiguous



Zonal Functions

- A typical zonal function requires two grids
  - a zone grid which defines the size, shape and location of each zone
  - a value grid which is to be processed
- Typical zonal functions include zonal mean, zonal max, zonal sum, zonal variety
- also: sum of the values in different raster that fall into the same zone (e.g., mean district elevation)
- results could be assigned to each cell in that zone, or written to a summary table

Zonal Function Example

- Zonal maximum – identify the maximum in each zone

Zone Grid

2	2	1	1
2	3	3	1
	3	2	
1	1	2	2

Value Grid

1	2	3	4
5	6	7	8
1	2	3	4
5	5	5	5

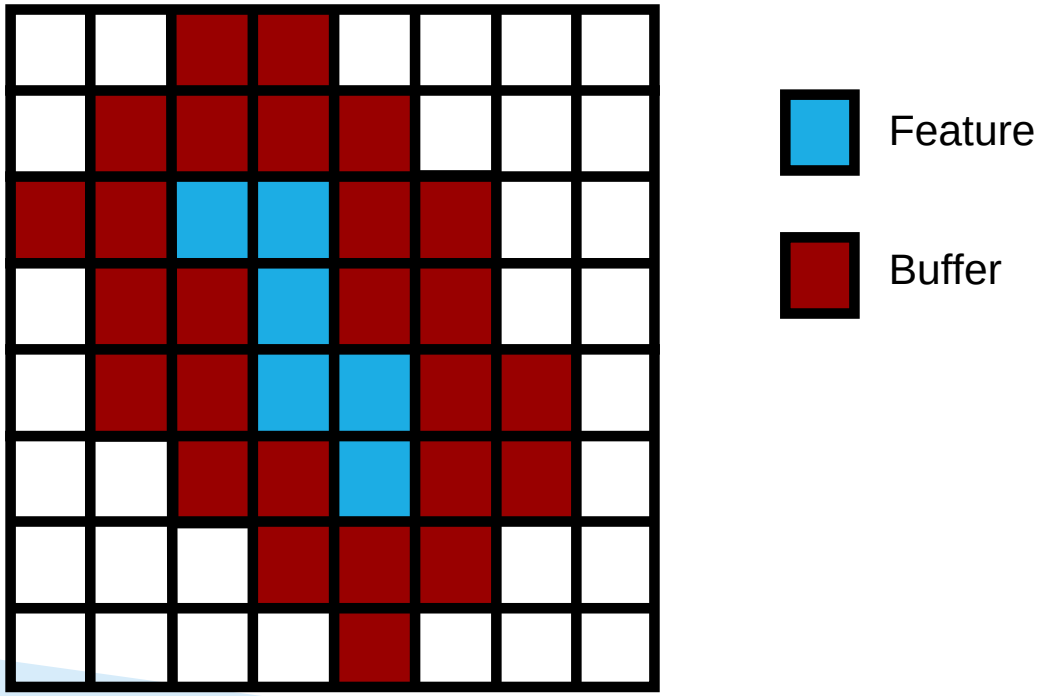
=

5	5	8	8
5	7	7	8
	7	5	
8	8	5	5

- Useful when we have some regions to classify with
  - for example, different forest types

Buffer as a Zonal Function

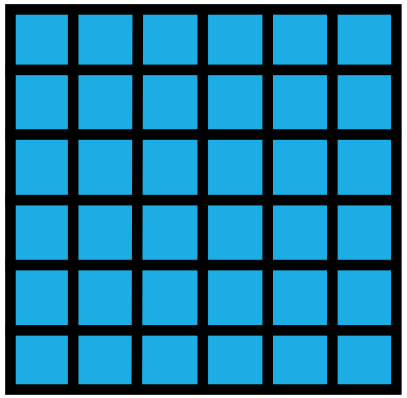
- Can be thought of as spreading a feature by a given distance

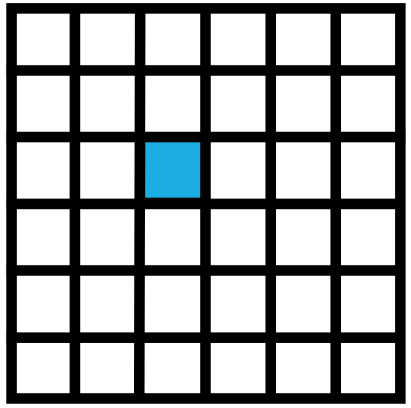


Global Functions

Global Functions

- The output value of each cell is a function of the entire grid
- Typical global functions are distance measures, flow directions, or weighting measures.
- Useful when we want to work out how cells ‘relate’ to each other





Global Function Examples

- Distance measures
  - Euclidean distance computes distance based on cell size

		1	1
			1
	2		

=

2	1	0	0
1.4	1	1	0
1	0	1	1
1.4	1	1.4	2

- Use a ‘cost’ grid to weight functions

		1	1
			1
	2		

Cost Grid

1	1	1	1
1	1	1	1
3	3	3	3
3	3	3	3

=

2	1	0	0
1.4	1	1	0
3	0	3	3
4.2	3	4.2	6

Map Algebra on Multiple Layers

- outgrid = zonalsum(zonegrid, valuegrid)
- outgrid = focalsum(ingrid1, rectangle, 3, 3)
- outgrid = (ingrid1 div ingrid2) * ingrid3
- Map algebra can also be used for multivariate and regression analysis

Application Functions

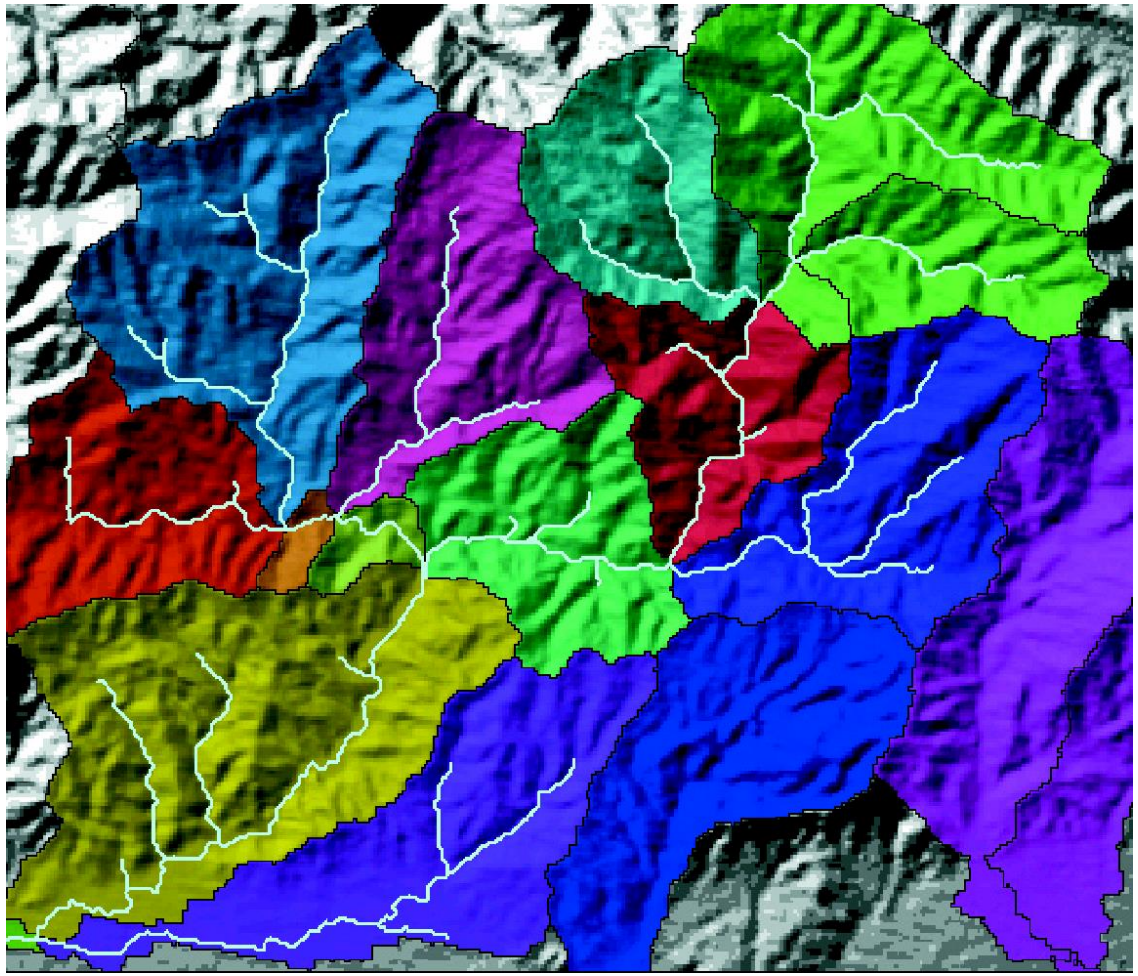
- Surface Analysis
- Hydrologic Analysis
- Geometric Transformation
- Generalization

Surface Analysis

- Slope
- Aspect
- Hill shade
- View shed
- Curvature
- Contour

Hydrologic Analysis

- Stream network
- Watershed
- Discharge



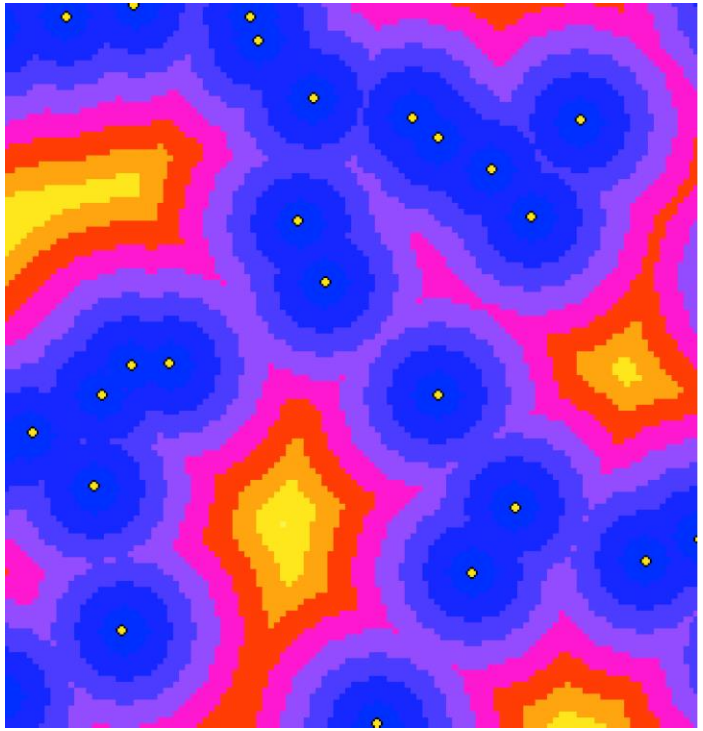
GIS-based Spatial Analysis

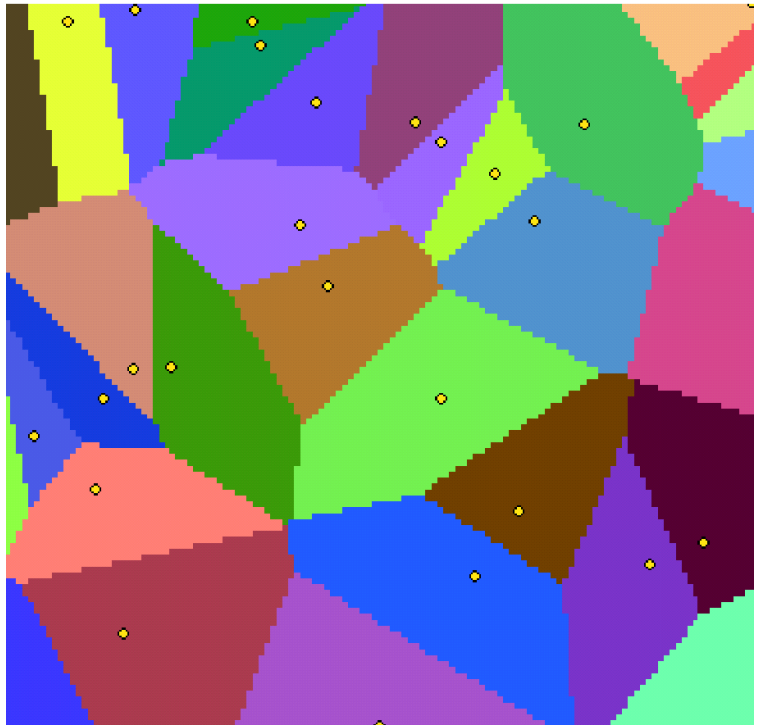
- Mapping distance
- Mapping density
- Interpolating to raster
- Surface analysis
- Neighborhood statistics

- Cell statistics
- Zonal statistics
- Reclassifying data
- Raster calculator

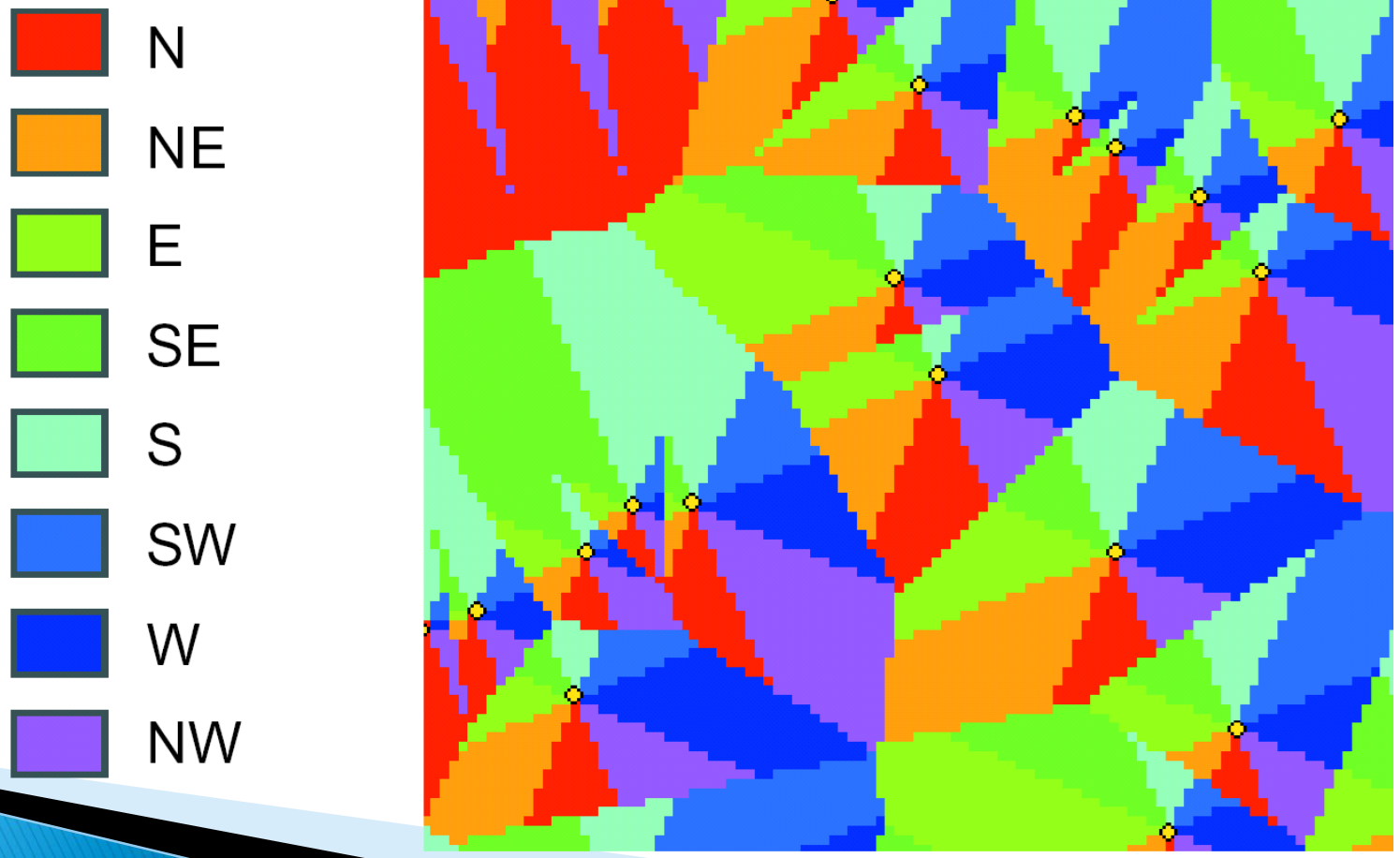
Mapping Distance

- Straight line distance (Thiessen/Voronoi)



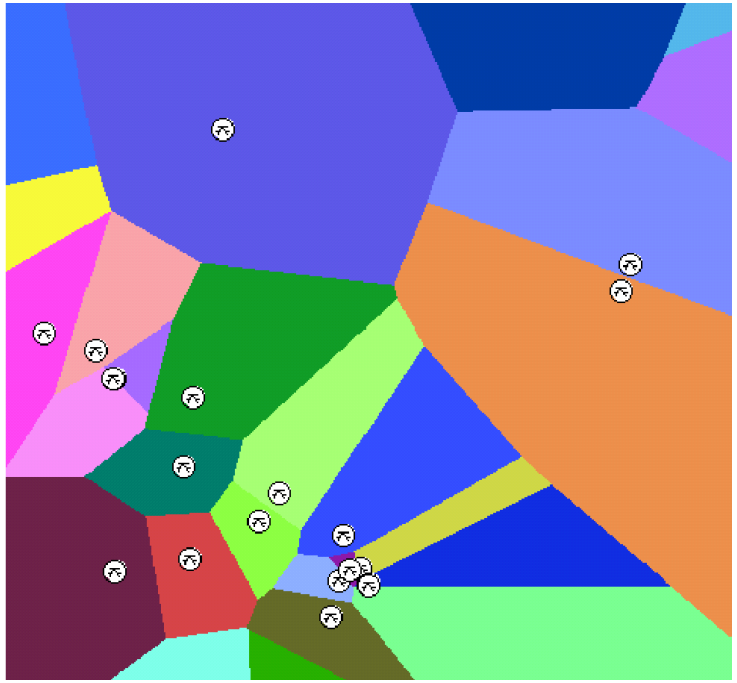


What Direction?



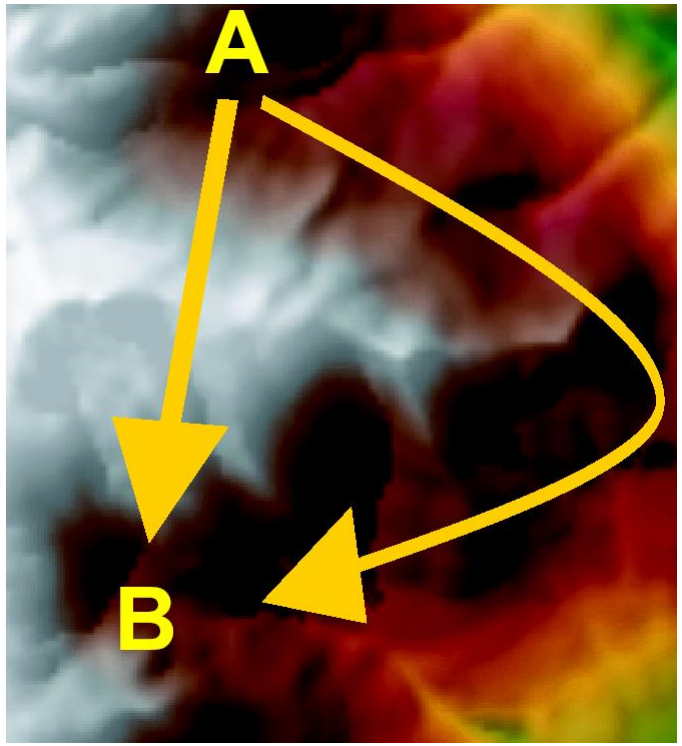
Allocation

- Identifying the customers served by a series of stores
- Finding out which hospital is the closest
- Finding areas with a shortage of fire hydrants
- Locating areas that are not served by a chain of supermarkets



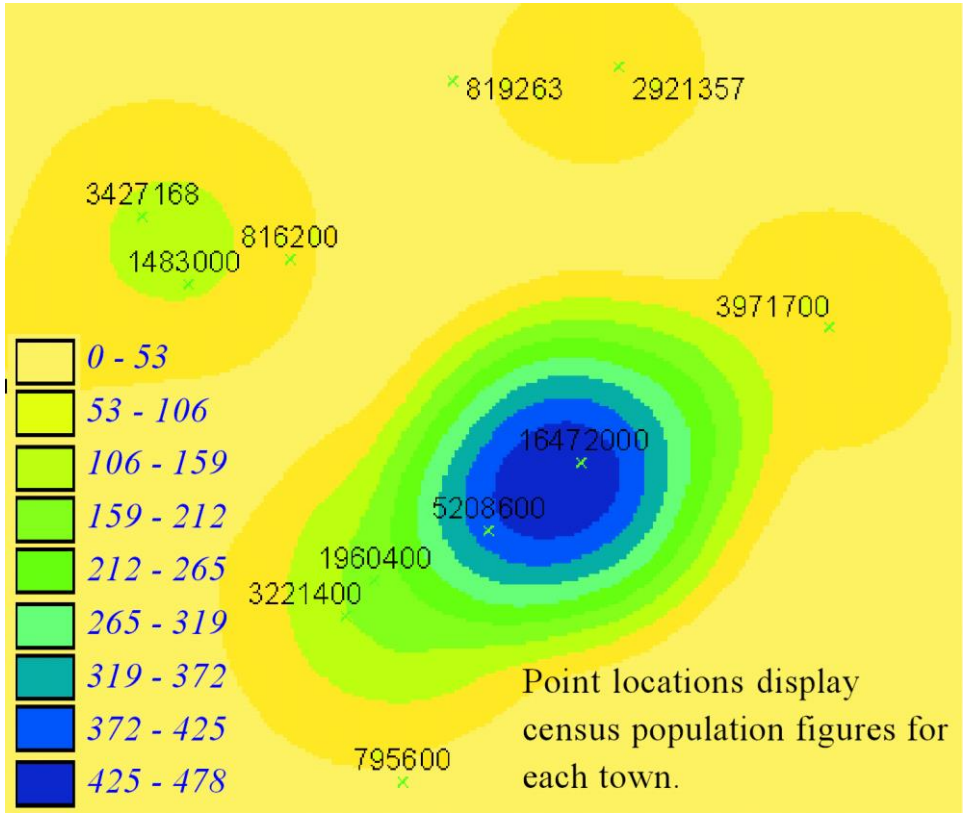
Cost-weighted Distance

- Cost can be money, time, or preference
- Two input grids
  - One regular distance grid
  - One friction surface
- Reclassifying your datasets to a common scale
- Weighting datasets according to percent influence



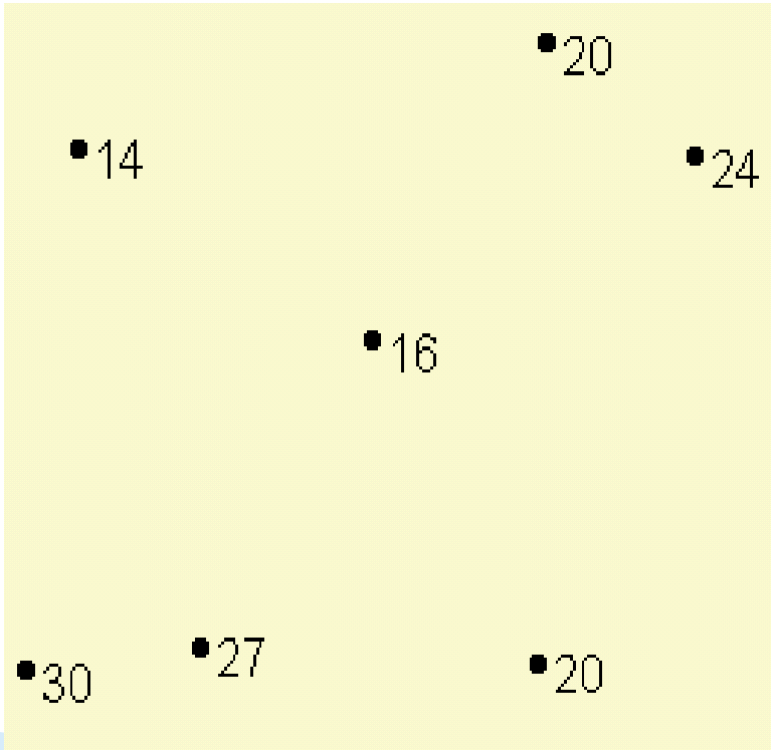
Density Mapping

- In a simple density calculation, points or lines that fall within the search area are summed and then divided by the search area size to get each cell's density value.



Interpolation

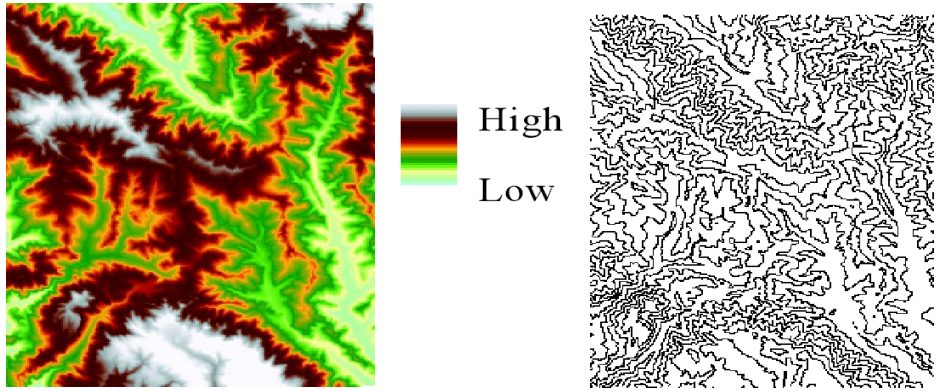
- e.g. precipitation

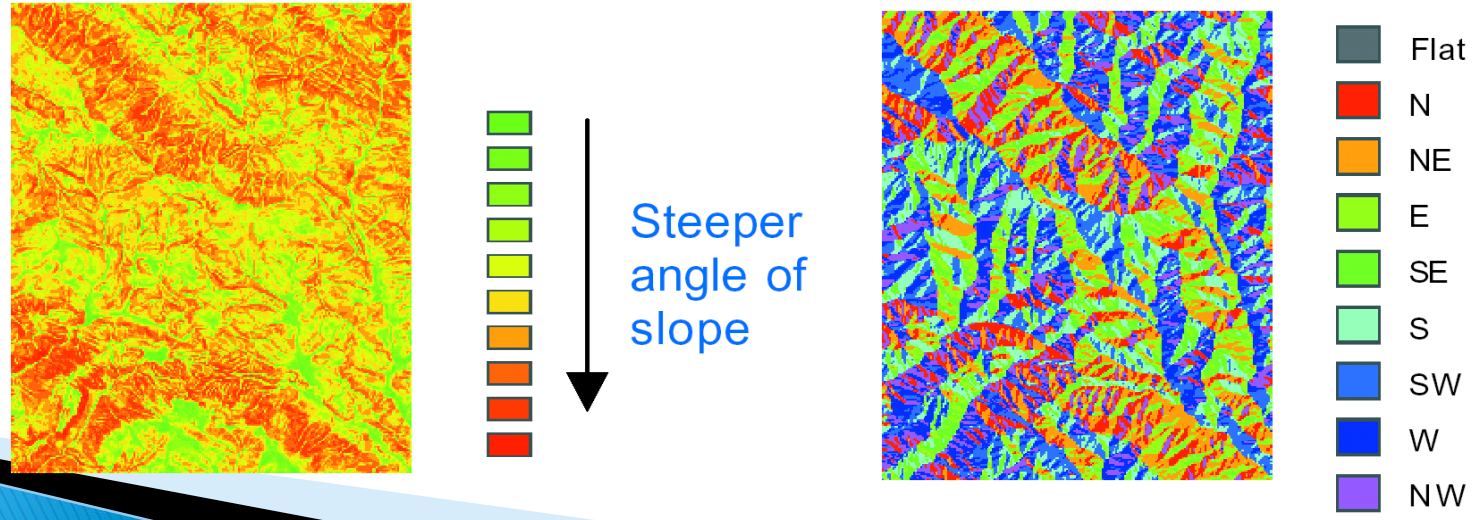


13	14	16	20	23
14	14	16	19	24
18	16	16	18	22
24	22	19	19	21
30	27	23	20	20

Surface Analysis

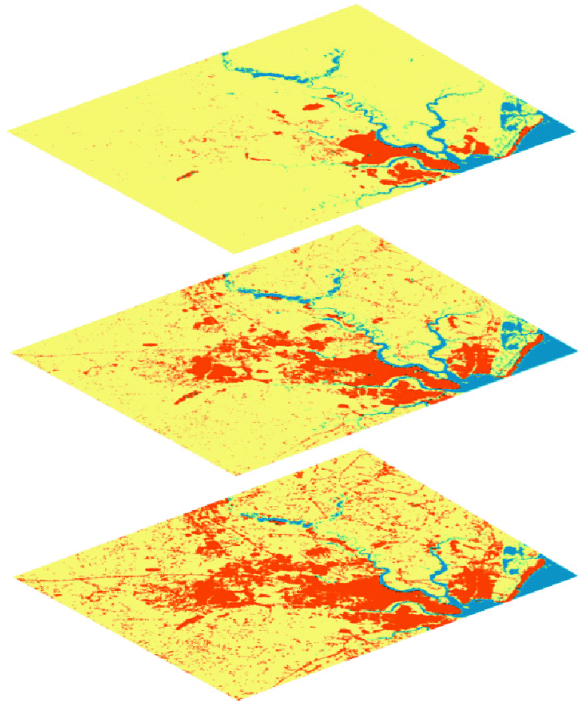
- Contours
- Slope, aspect
- Viewshed

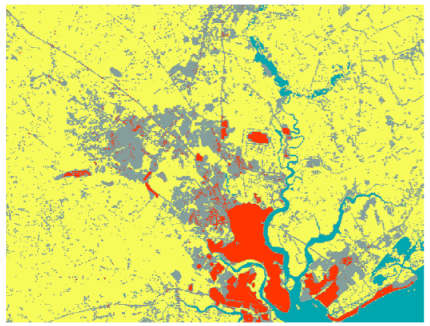




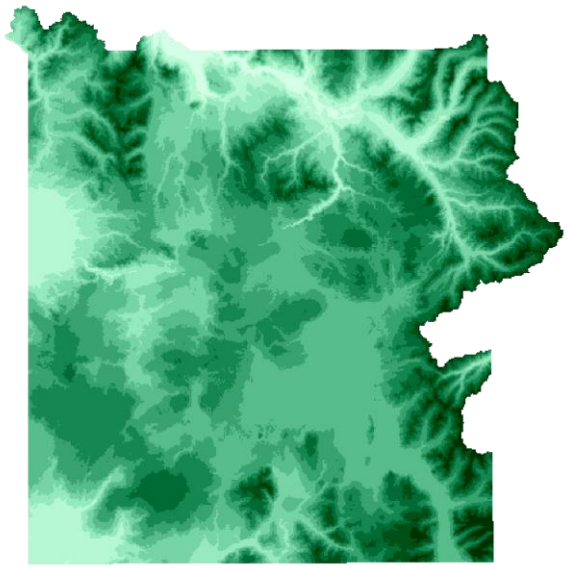
Cell Statistics

- Majority
- Maximum
- Mean
- Median
- Minimum
- Minority
- Range
- Standard deviation
- Sum
- Variety





Zonal Statistics



Attributes of Zones

VALUE	VARIETY
1547	13
1773	28
1999	41
2226	47
2452	50
2679	43
2905	26
3132	14
3358	3

Record: 0