

Spatial Modelling and Analysis

1

Lecture 7

Raster Statistics Analysis

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Lecture Outline

1. Introduction to Raster Operation/Raster Statistics
2. Local Operation
3. Introduction to Neighborhood (focal) Operations/Statistics
4. Zonal Operations/Statistics
5. References

1. Introduction to Raster Operation/Raster Statistics

3

Local, Neighborhood and Zonal Analysis are raster statistical processes that are executed to solve geographical problems

Local: Operations performed on a cell by cell basis

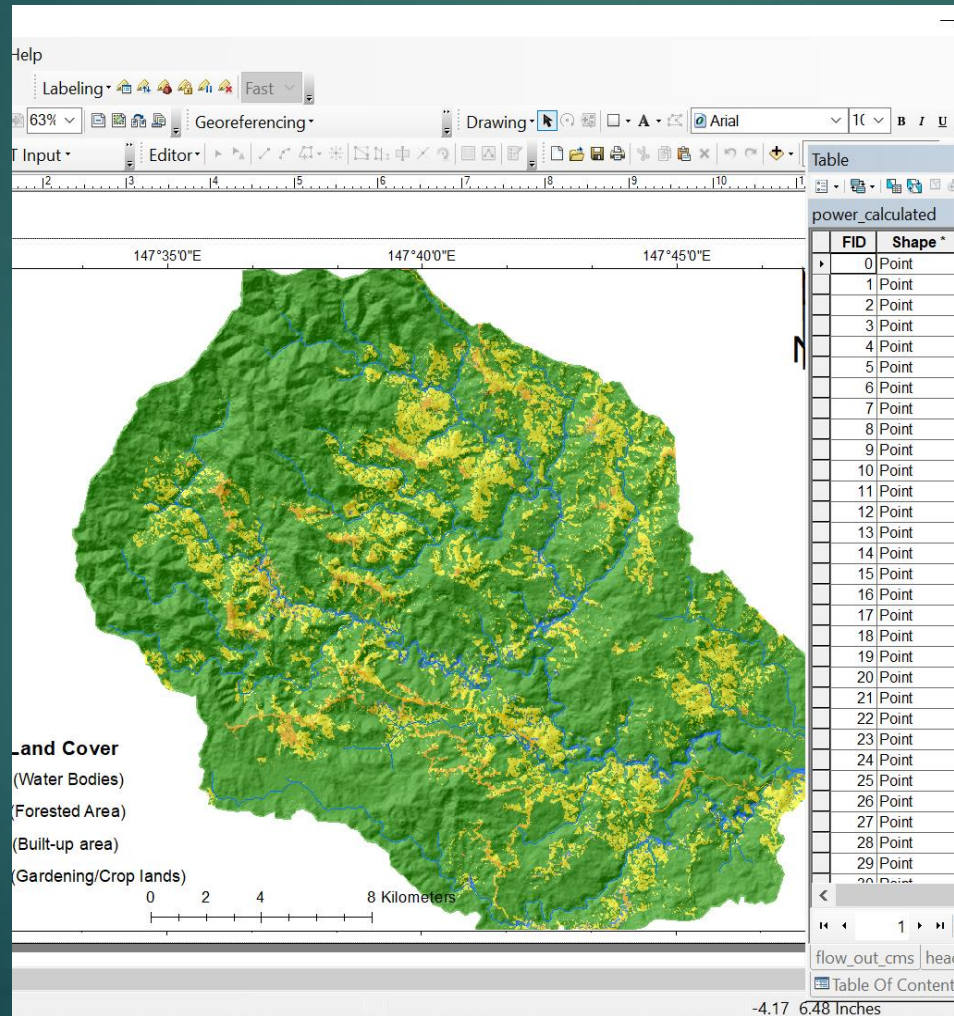
Neighborhood: Operations performed using a moving group of cells

Zonal: Operations performed using zones (groups of cells having the same value)

2. Local Operation

4

Given a single raster as the input, a local operation computes each cell value in the output raster as a mathematical function of the cell value in the input raster.



2.1. Local Operation/Statistics - Basic

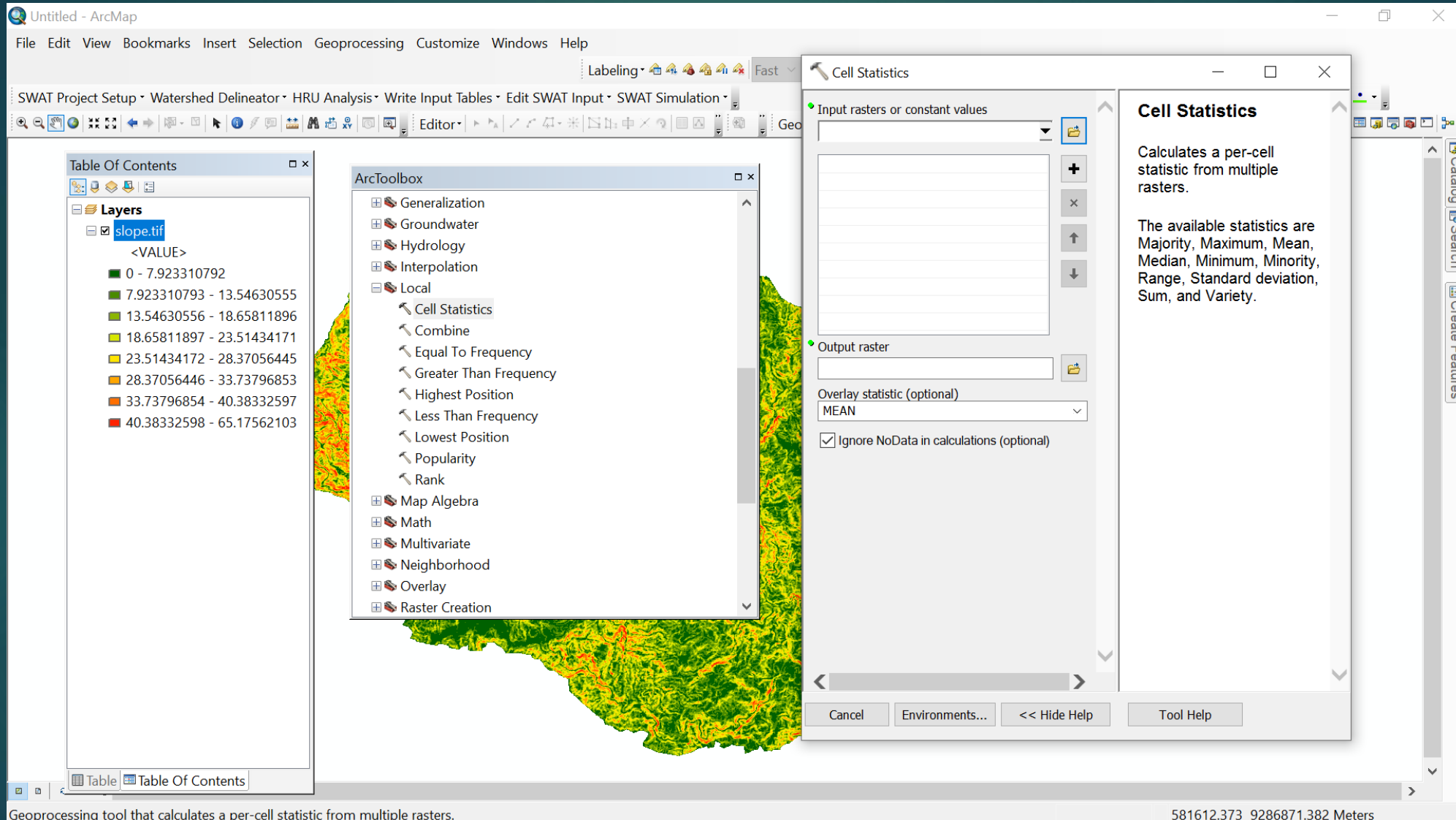
- Cell by cell operations/statistics
- Computes output cell values as a function of the input cell values
- Can be done using single or multiple rasters.

Example for using multiple Raster is;

- use the tools to analyze a certain phenomenon over time to determine the yearly mean or minimum rainfall for a 25-year period for allocating agricultural aid money or to calculate the range of temperatures between years to understand global warming.

- Common uses: **reclassification and overlays**

2.2. Local ArcMap tool



Geoprocessing tool that calculates a per-cell statistic from multiple rasters.

581612.373 9286871.382 Meters

2.3. The Common Local tool

Cell Statistics:

Calculates a per-cell statistic from multiple rasters.

Majority,
Maximum,
Mean, Median,
Minimum,
Minority,
Range,
Standard deviation,
Sum,
Variety.

Combine:

Combines multiple rasters so that a unique output value is assigned to each unique combination of input values.

2.4. The Common Local tool - Frequency

Greater Than, Less Than and Equal to Frequency

Evaluates on a cell-by-cell basis the number of times a set of rasters is greater than another raster.

Evaluates on a cell-by-cell basis the number of times a set of rasters is less than another raster.

Evaluates on a cell-by-cell basis the number of times the values in a set of rasters are equal to another raster.

2.5. Local Operations – Reclassification with single raster

One-to-one change – input raster cell value is replaced with new value in the output raster (integer rasters only)

Re-classification

Input Raster

3	3	19	1	6	6
20	3	19	17	1	5
20	15	15	6	11	14
12	7	15	8	8	10
13	4	18	18		10
16	4	18	7		9



Old Values	New Values
1-1	5
2-2	5
3-3	7
4-4	8
5-5	10
6-6	12
7-7	3
8-8	20
9-9	11
10-10	2
11-11	19
12-12	1
13-13	9
14-14	9
15-15	4
16-16	13
17-17	6
18-18	14
19-19	13
20-20	14



Output Raster

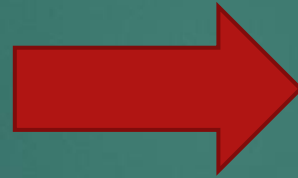
7	7	13	5	12	12
14	7	13	6	5	10
14	4	4	12	19	9
1	3	4	20	20	2
9	8	14	14		2
13	8	14	3		11

2.6. Local Operations – Slope Calculation with Single Raster

10

A local operation can convert a slope raster from percent (a) to degrees (b).

15.2	16.0	18.5
17.8	18.3	19.6
18.0	19.1	20.2



8.64	9.09	10.48
10.09	10.37	11.09
10.20	10.81	11.42

2.7. Local Operations – Multiple Rasters

- **Operation:** add raster 1 and raster 2 cell values to produce an output raster with the summed cell values

In put Raster 1

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



In put Raster 2

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



Out put Raster

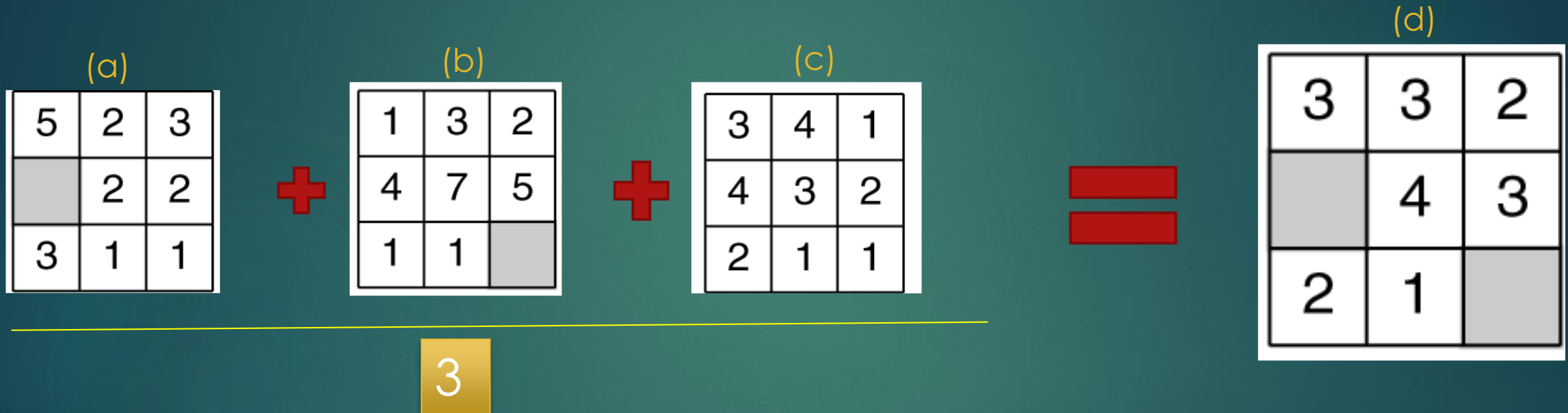
4	4	3	4	4
5	4	4	5	5
5	7	5	7	5
5	4	5	5	8
4	4	3	2	5

2.8. Local Operations – Multiple Rasters-mean

12

The cell value in (d) is the mean calculated from three input rasters (a, b, and c) in a local operation.

The shaded cells have no data.



2.9. Local Operations – Multiple Raster

Examples of operations that can be done using multiple rasters:

- Mathematical functions
- Summary statistics
- Combine operation (Combines rasters by assigning a unique output value to each unique combination of input values).

Applications: change detection studies; predicting habitats favorable for wildlife species

3. Introduction to Neighborhood (focal) Operations/Statistics

14

- Uses values for the cells within the neighborhood to calculate the value for the focal cell
- Focal cell moves from cell to cell
- Applies to single rasters
- Can produce summary statistics
- “No data” cells not included in analysis
- Common shapes used for neighborhood analysis:

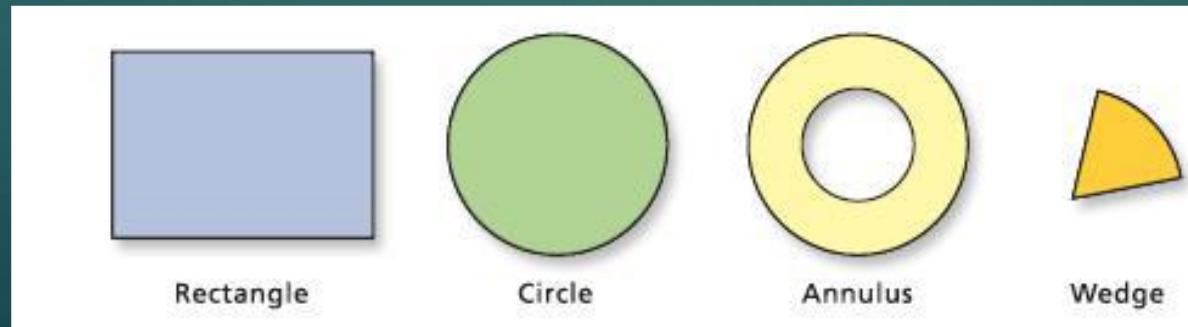
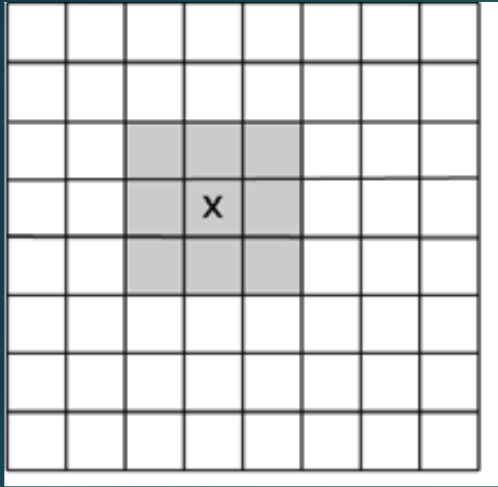


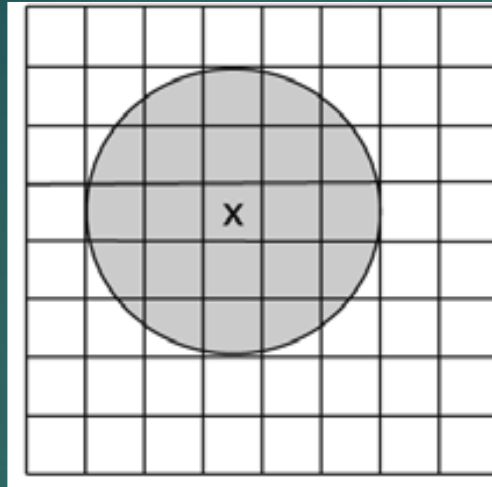
Diagram from ESRI ArcGIS 9.3 Help Desk
Source: McLain, R. Geography 575 Fall 2009

3.1 Neighborhood Type - Shapes

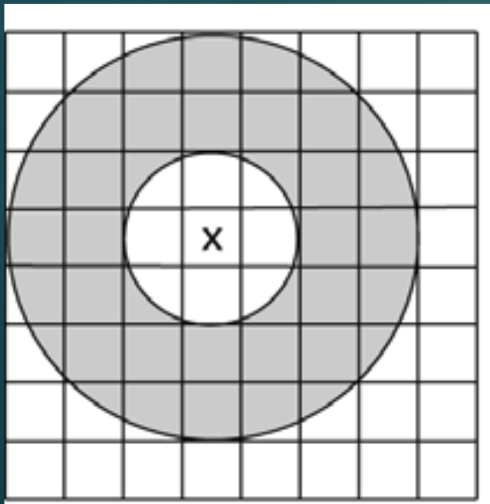
15



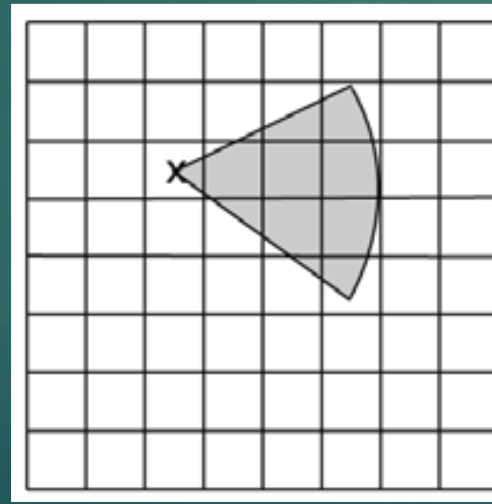
(a)



(b)



(c)



(d)

Neighborhood types:

rectangle (a),
circle (b),
annulus (c),
and wedge (d).

The cell marked with an x is the focal cell.

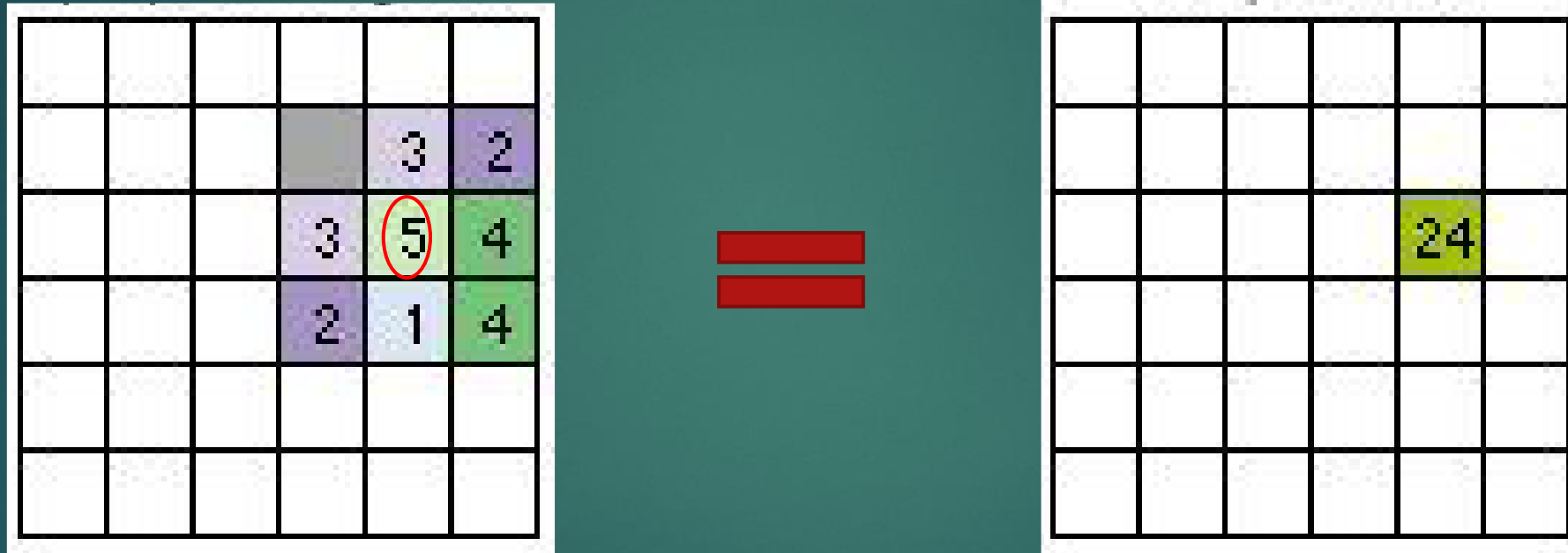
3.2. Neighborhood Out Put

Neighbourhood functions create output values for each cell location based on the value for that location and the values identified in a neighbourhood specified by the user.

The statistics calculated for the neighbourhood act as a moving window that scans across the data.

3.3. Neighborhood Operations – Single Raster

Operation: Summation (including value of focal cell)
Neighborhood size: 3 x 3 rectangle; red circle = focal cell
Gray square = no data for that cell's value



3.4. Neighborhood Operations - Summation

18

Operation: Summation (including value of focal cell) Neighborhood size: 3 x 3 rectangle; red circle = focal cell Gray square = no data for that cell's value

4	0	1	2	3	0
2	5	0	Gray	3	2
1	1	2	3	5	4
1	5	3	2	1	4
5	Gray	1	3	3	0
1	1	2	3	4	3

=

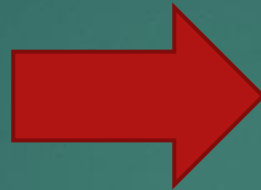
11	12	8	9	10	8
13	16	14	19	22	17
15	20	21	19	24	19
13	19	20	23	25	17
13	19	20	22	23	15
7	10	10	16	16	10

3.5. Neighborhood Operations - Mean

19

(a)

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

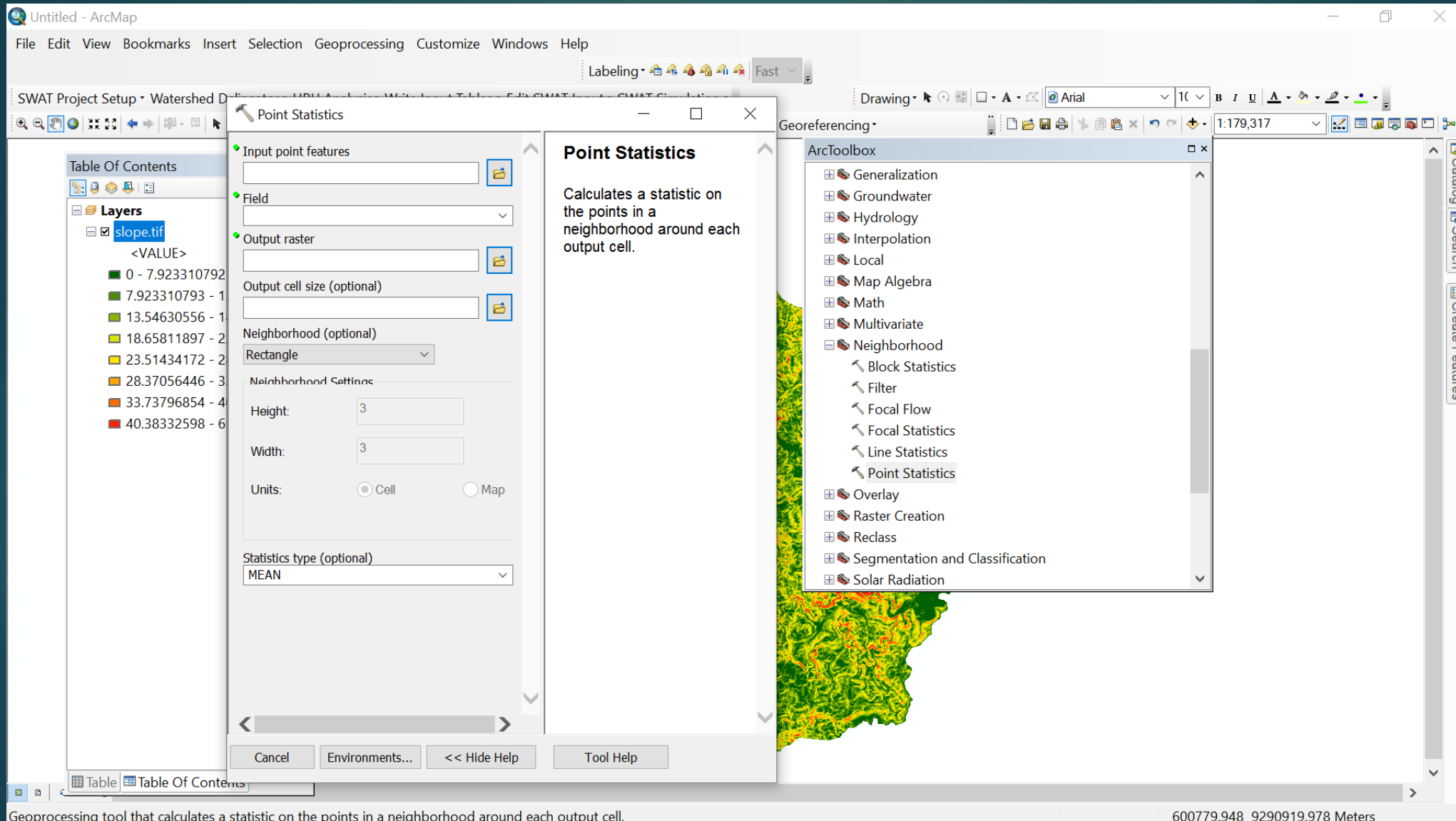


(b)

1.56	2.00	2.22
1.67	2.11	2.44
1.67	2.11	2.44

The cell values in (b) are the neighborhood means of the shaded cells in (a) using a 3 x 3 neighborhood. For example, 1.56 in the output raster is calculated from $(1 + 2 + 2 + 1 + 2 + 2 + 1 + 2 + 1) / 9$.

3.6. Neighborhood Operations – ArcMap Tools



Geoprocessing tool that calculates a statistic on the points in a neighborhood around each output cell.

600779.948 9290919.978 Meters

3.6.1 Tools

21

Block Statistics:

Partitions the input into non-overlapping blocks and calculates the statistic of the values within each block.

Filter:

Performs either a smoothing (Low pass) or edge-enhancing (High pass) filter on a raster.

Focal Flow:

Determines the flow of the values in the input raster within each cell's immediate neighborhood.

3.6.2. Common Tools

22

Focal Statistics:

Calculates for each input cell location a statistic of the values within a specified neighborhood around it.

Line Statistics:

Calculates a statistic on the attributes of lines in a circular neighborhood around each output cell.

Point Statistics:

Calculates a statistic on the points in a neighborhood around each output cell.

3.7. Neighborhood Operations - Common Applications

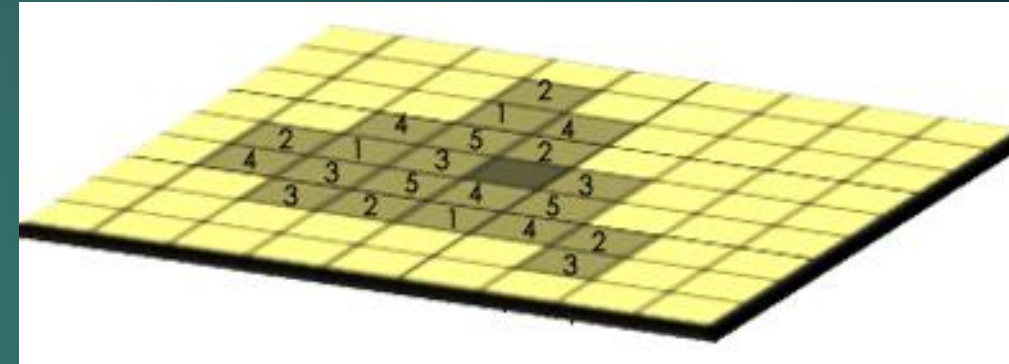
23

- Data simplification
- Terrain analysis
- Image processing
- Site selection

4. Zonal Operations/Statistics

24

- Zonal Statistics uses groupings to **calculate statistics** for **specified zones**.
- The **zonal extent** could include anything from country boundaries, watershed catchment areas, or property parcels as a vector or raster dataset.
- Can be used with a single raster or with two rasters



- Single raster zonal operations
 - Measures the geometry of each zone (area, perimeter, centroid, thickness, etc.)
- Two raster zonal operations
 - Involves an input raster and a zonal raster to produce a new raster that summarizes cell values in the input raster by zone

4.2. Zonal Statistics Examples

26

Zonal Statistics is a common [spatial analysis](#) procedure for raster data.

Here are some examples when you would use this operation in GIS:

1. Summarizing Rain in a Watershed:

If you want to find out how much rain is in a watershed, you can use a zonal operation like this one. By using a precipitation raster as your value field, you can set your zone as the watersheds with a sum function.

2. Highest Elevation in Country:

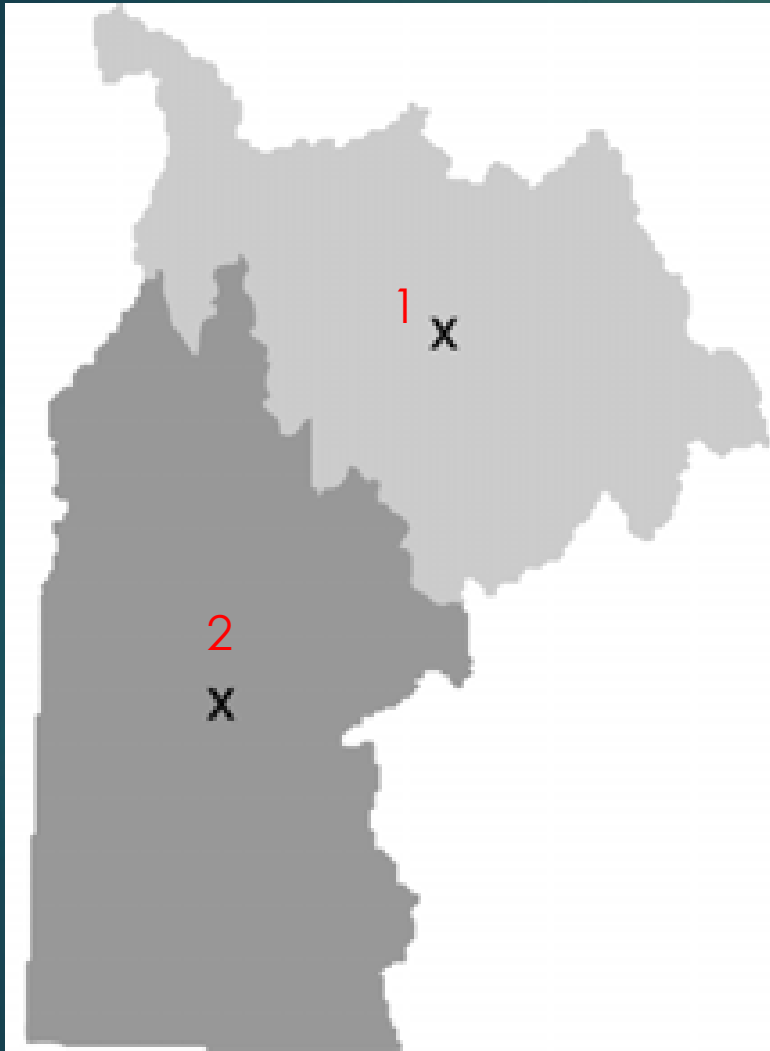
If you have an elevation raster dataset, you can run Zonal Statistics to find out its highest peak by using the maximum function.

3. Adding Tree Cover in an Ecozone:

To find the tree cover area in an ecozone, you can run Zonal Statistics to sum a raster land cover dataset.

4.3. Zonal Operations – Thickness and Centroid

27



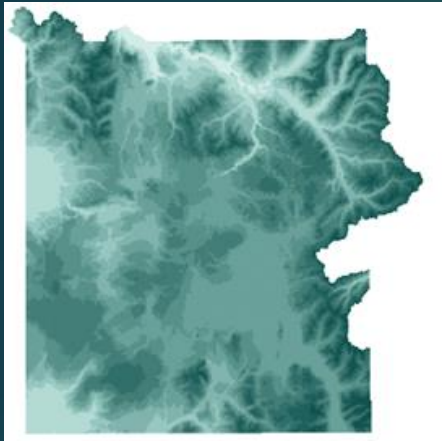
Thickness and centroid for two large watersheds (zones).

Area is measured in square kilometers, and perimeter and thickness are measured in kilometers.

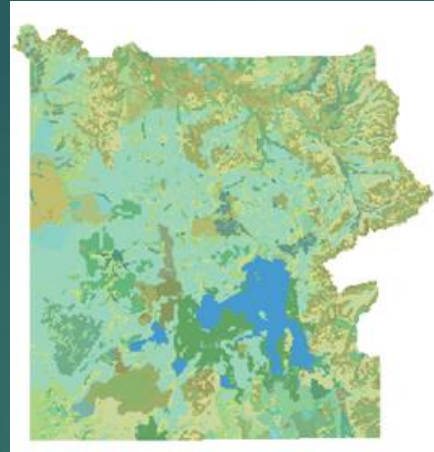
The centroid of each zone is marked with an x.

Zone	Area	Perimeter	Thickness
1	36,224	1,708	77.6
2	48,268	1,464	77.4

4.4. Zonal Operation –Two Raster Example



Input zone datasets:
Elevation zones
Elevation range from
1,547 to 3,358



Input Value Raster :
Vegetation type

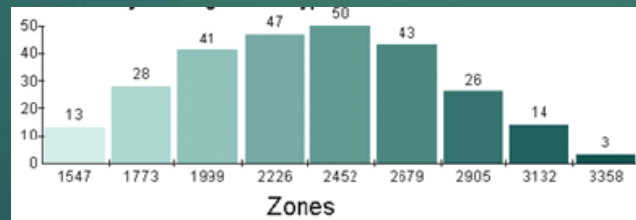


VALUE	VARIETY
1547	13
1773	28
1999	41
2226	47
2452	50
2679	43
2905	26
3132	14
3358	3

Output Table



Variety of Vegetation type within zones of Elevation



Output Chart

Practical Example:

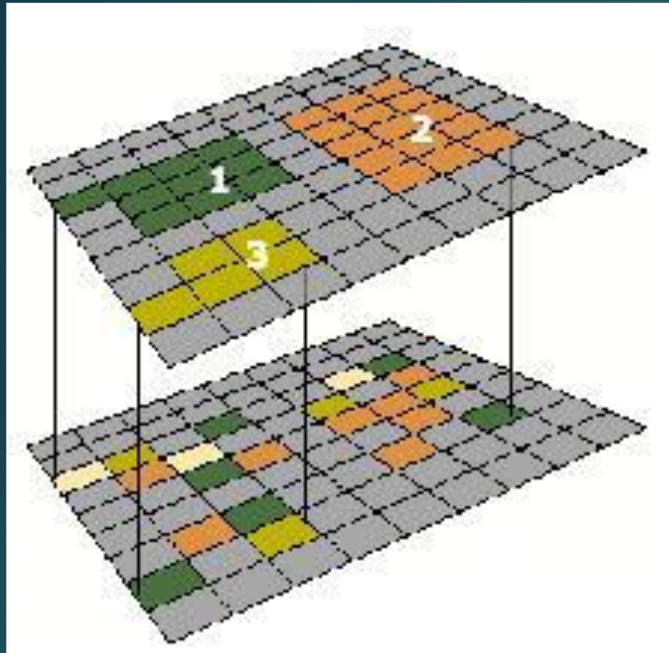
The diagram show an example of the inputs from the Zonal Statistics function.

The variety of vegetation species per elevation zone is displayed in the output table and chart.

The most variety of species occurs at elevation levels of approximately 2,500 meters.

4.4.1. Zonal Operation –Two Raster Example

29



Zone Layer:

Defines the zones
(Shape, Values, and
Locations).

Value Layer:

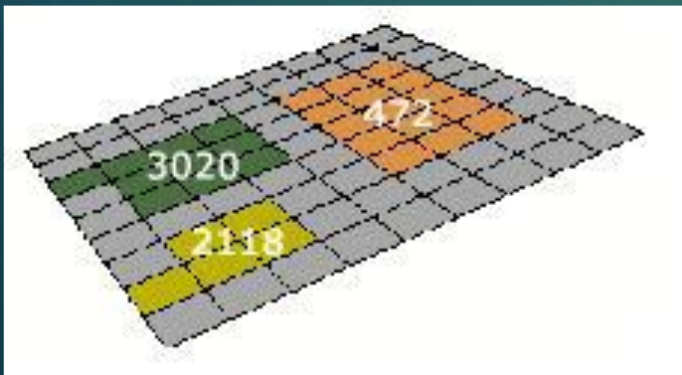
Contains the input
Values used in calculating
The output for each zone

Example application:

Zone layer – soil type

Value layer – vegetation type

Output table – Number of
vegetation types associated with
each soil type



The output table
Can be joined to the
Zone layer to display
A static per zone.

4.5. Zonal Operation Tools

30

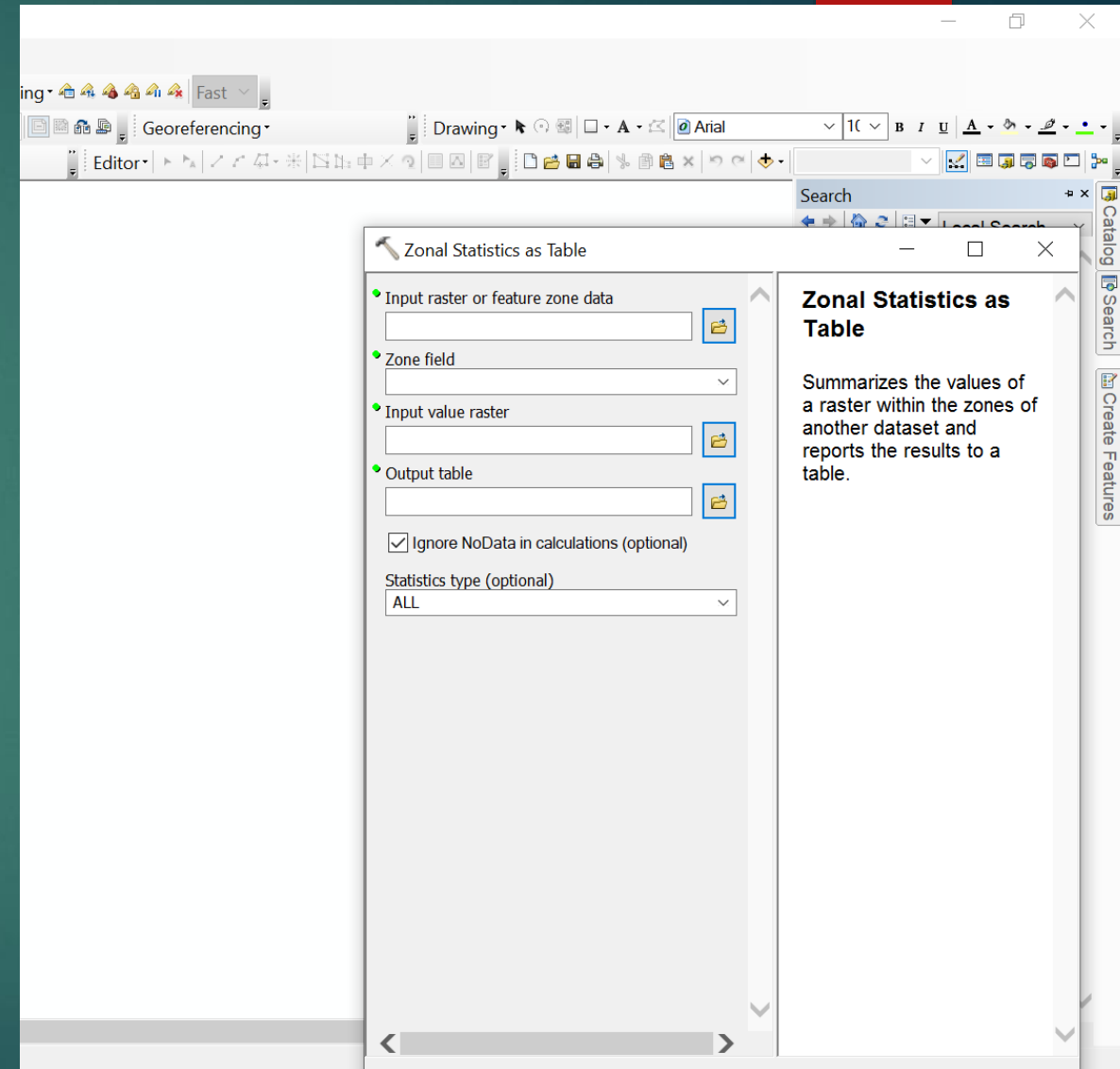
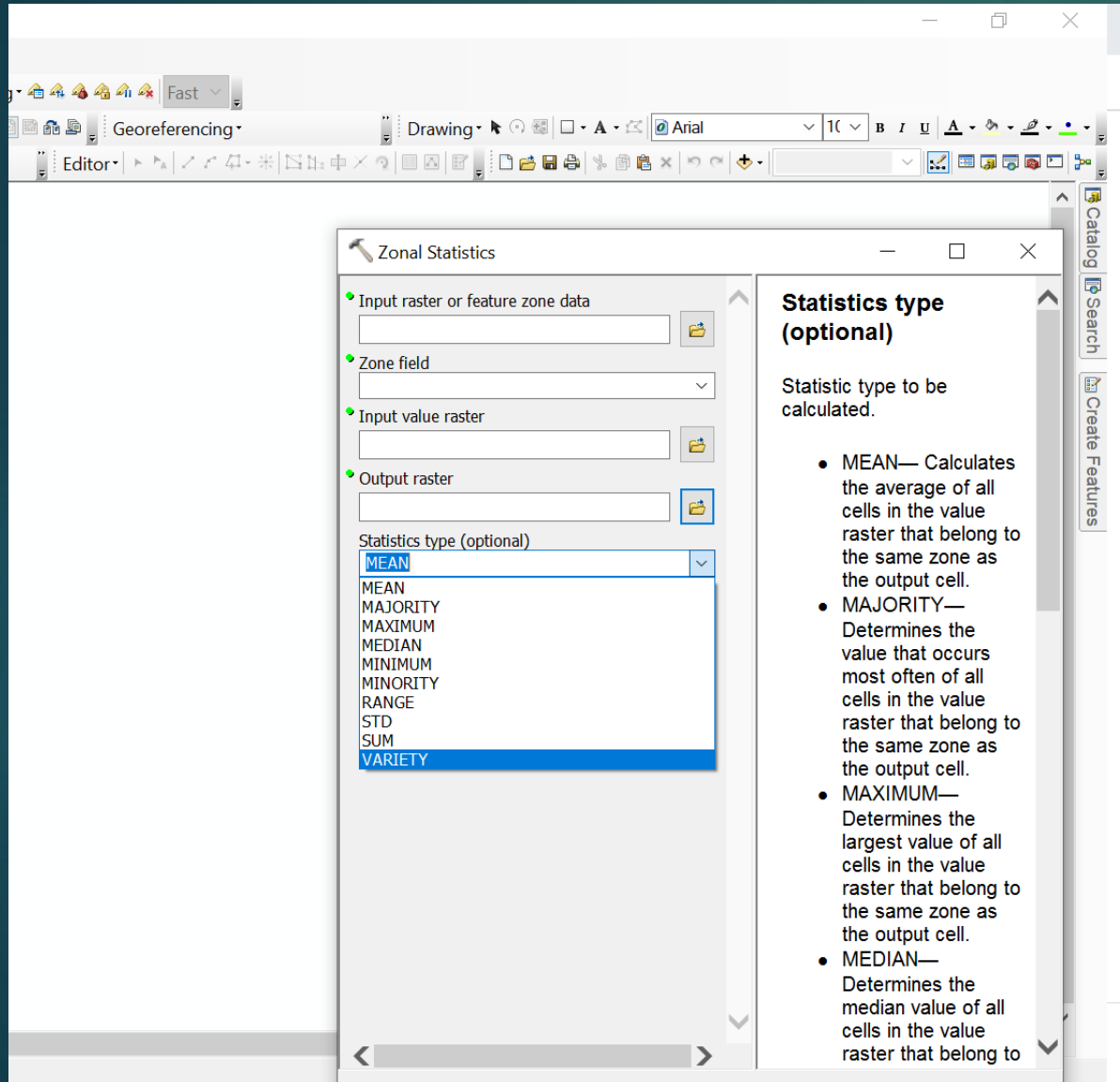
In ArcGIS, there are two main tools to run this process:

Zonal Statistics – Outputs a raster defined by your zones and input value raster.

Zonal Statistics as Table – Generates a summary table based on the specified input value raster, statistical function, and zonal extents.

To add the output table back into your input zones, you will have to first use the [join table operation](#). Then, you can copy the statistical field over by matching it with the same zone field.

4.5.1. Zonal Operation –ArcMap Tools



4.6. Other Zonal Application

- You might calculate the mean elevation for each forest zone.
- Number of accidents along each of the roads in a town.
- Alternatively, you might want to know how many different types of vegetation there are in each elevation zone (variety).
- Vegetation at Each Soil Zone
- Landscape ecology analyses

5. References

Chang, K. 2009. Raster data analysis. In: Introduction to geographic information systems. McGrawHill. New York, NY. Pp. 248267.

ESRI. 2002. Using ArcGIS spatial analysis. Redlands, CA. Pp. 164189.

ESRI ArcGIS 9.3 Help Desk. <http://webhelp.esri.com/arcgisdesktop/9.3/> (Accessed 102309).

McLain, R. (2009). Raster Operation - Local, Neighborhood, and Zonal Approaches - Geography 575 (PPT Slide).

GISGeography (2022). How To Use Zonal Statistics. Retrieve from: <https://gisgeography.com/zonal-statistics/>