Spatial Modelling and Analysis

Lecture 10

Proximity and Vector Overlay Analysis

Lecturer: Dr. Tingneyuc Sekac B.Sc., M.Phil., Ph.D.
PNG University of Technology, 2022

Lecture Outline

1. Vector Analysis Methods
2. Buffering Operation
3. Introduction to Near Tool
4. Vector Overlay Analysis
5. Feature Manipulation
6. References

1. Vector Analysis Methods

- Proximity (Buffer analysis)
- Overlay Analysis
- Other feature manipulation analysis/tools
    - Dissolve
    - Union
    - Intersection
    - clip
    - Erase
    - other

1.1. Introduction to Proximity Analysis – Questions Ask

The Questions ask to solve the real world problem:

- How close is this well to a landfill?
- Do any roads pass within 1,000 meters of a stream?
- What is the distance between two locations?
- What is the nearest or farthest feature from something?
- What is the distance between each feature in a layer and the features in another layer?
- What is the shortest street network route from some location to another?

1.2. Proximity Analysis – Vector Base

Proximity tools can be divided into two categories depending on the type of input the tool accepts:

Features/Vector base
Raster Base.

Vector Base:

1. Buffer operations/tool:

uses points, lines, polygon - creates zone within the specific distance of select features.

2. The Near tool:

adds a distance measurement attribute to the input features.

1.3. Proximity Analysis – Raster Base

Raster Base.

1. The raster-based Euclidean distance tools:

measure distances from the center of source cells to the center of destination cells.

2. Cost-distance tools:

accumulate the cost of each cell traversed between sources and destinations.

2. Buffering Operation

Buffering is a GIS operation that creates zone with in the specific distance of select features.

Buffer a region at specific distance interval

Buffer can be:

- Point Buffer
- Line Buffer
- Polygon Buffer

Buffering technique is use to examine proximity constraints.

Source: Institute of Space Technology (IST), Pakistan, 2002

2.1. Buffering Operation Example

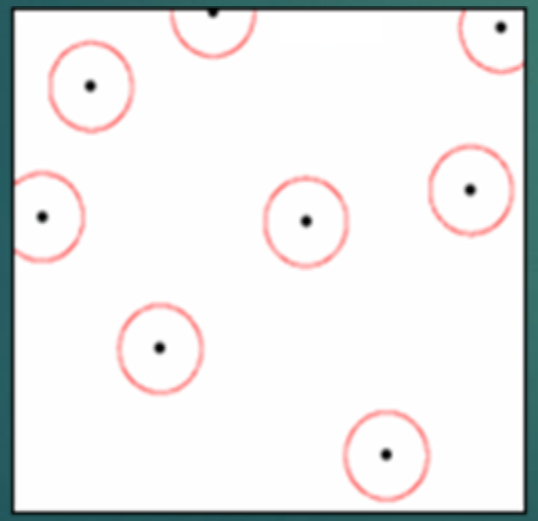
1. Identify communities located 20 km away from flood prone zones
2. Identify potential customers within 3km of store
3. Identify parks within 10km of Islamabad Highway
4. Identify schools within 5 km of industrial zone
5. Other

Source: Institute of Space Technology (IST), Pakistan, 2002

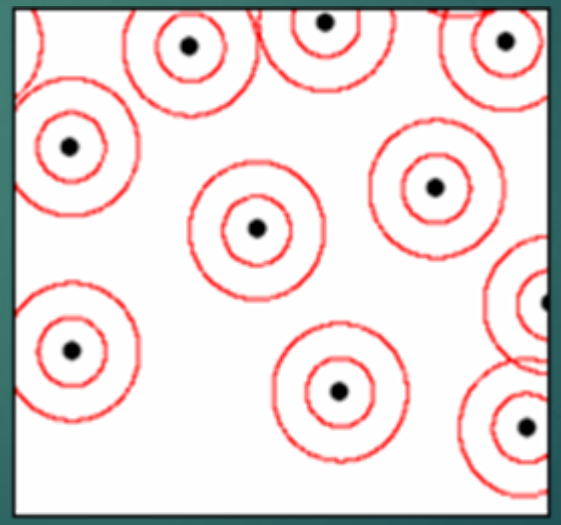
2.2. Point Buffer

Buffer around a point creates a circular buffer zone.

For example, you might buffer a school by one mile and use the buffer to select all of the students that live more than one mile from the school in order to plan for their transportation to and from school.



Simple Buffer



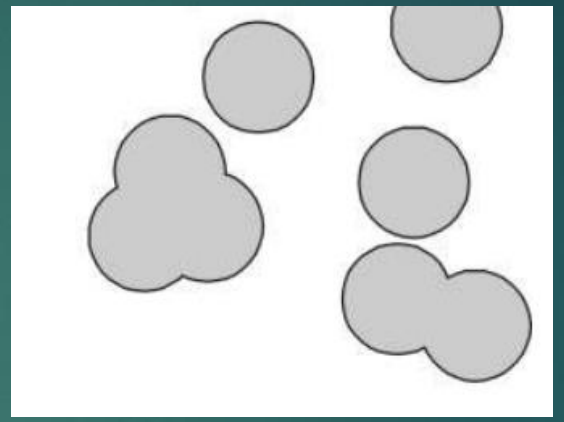
Multiple ring Buffer

Source: ESRI, 2021

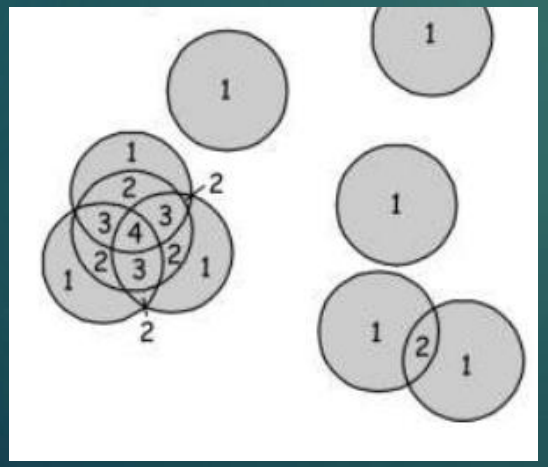
2.2.1. Buffering Variations

Point layer

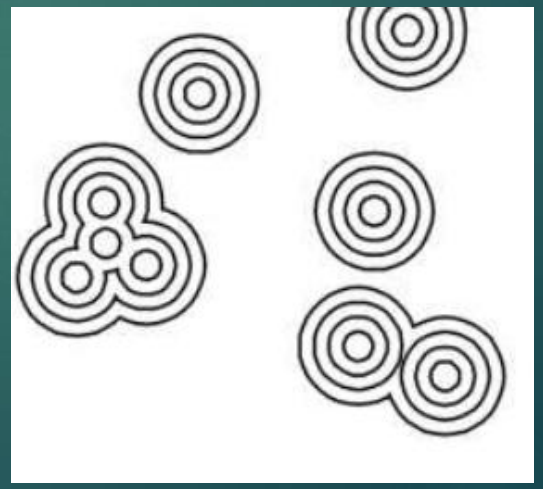
Simple Buffer
Overlap dissolve



Compound buffer identification



Nested buffer/multiple ring buffer



Source: Institute of Space Technology (IST), Pakistan, 2002

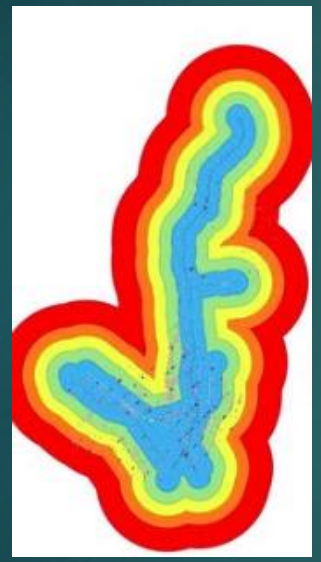
2.3. Line Buffer

Buffer around a line creates a elongated buffer zone.

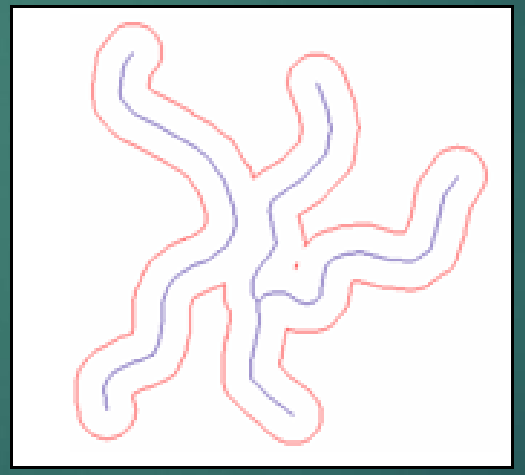
Example-

- Govt. regulation may set-2 Km buffer zone along streams to minimize sedimentation from logging operation.

- To know how far away are the rural residential area from maid roads



Multi-ring buffer analysis of the main roads



study area clipped to a buffer area

Source: Xuesong, Z et al (2018) and ESRI, 2021

2.4. Polygon Buffer

Buffer around a polygon creates a buffer zone, extending outward the polygon boundary

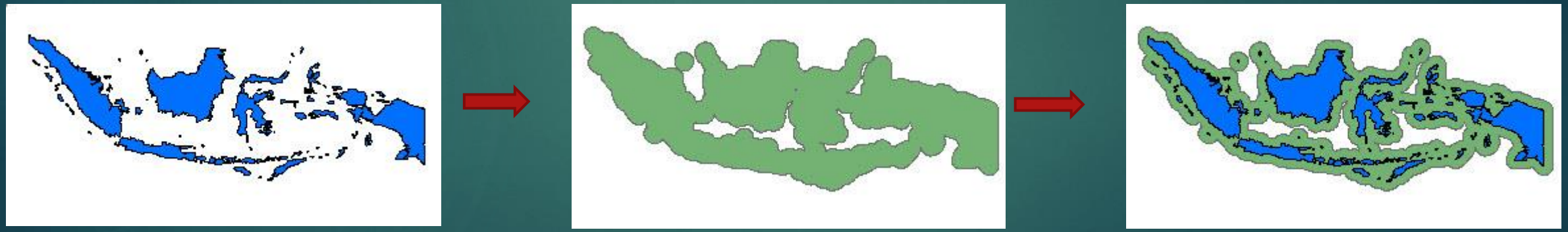
Input Polygon layer

Output Polygon Buffer

Create buffers from much more complicated geometries.

For example, consider the input geometry shown below which represents Indonesia.

This multipart polygon has 137 parts and 9,164 vertices.



Input Geometry

Buffer Polygon layer

Output Result

Source: http://esri.github.io/geometry-api-java/doc/Buffer.html

Source: ESRI, 2021

3. Introduction to Near Tool

The Near tool calculates the distance from each point in one feature class to the nearest point or line feature in another feature class.

Example:

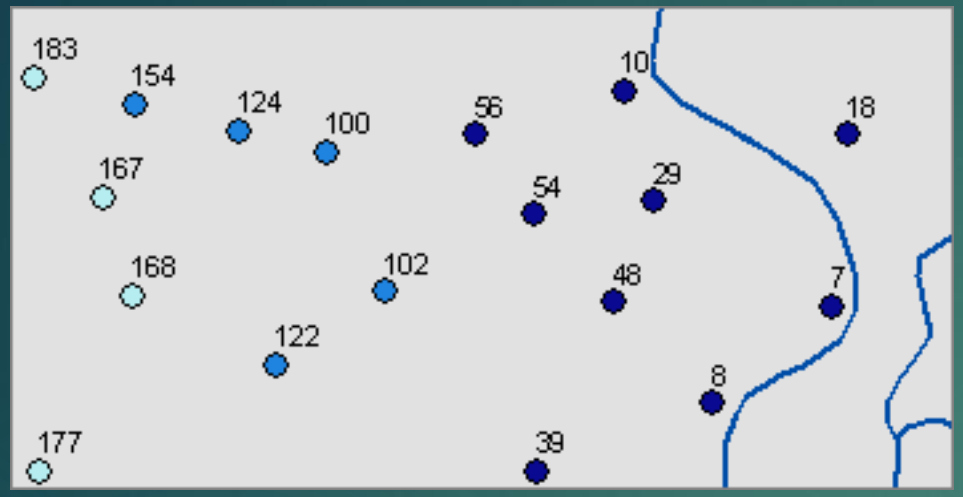
- find the closest stream for a set of wildlife observations
- the closest bus stops to a set of tourist destinations.

Important feature of Near tool:

The Near tool will also add the Feature Identifier and, optionally, coordinates of and the angle toward the nearest feature.

Source: ESRI, 2021

3.1. Near Tool Example



Example showing points near river features.

The points are symbolized using graduated colors based on distance to a river, and they're labeled with the distance.

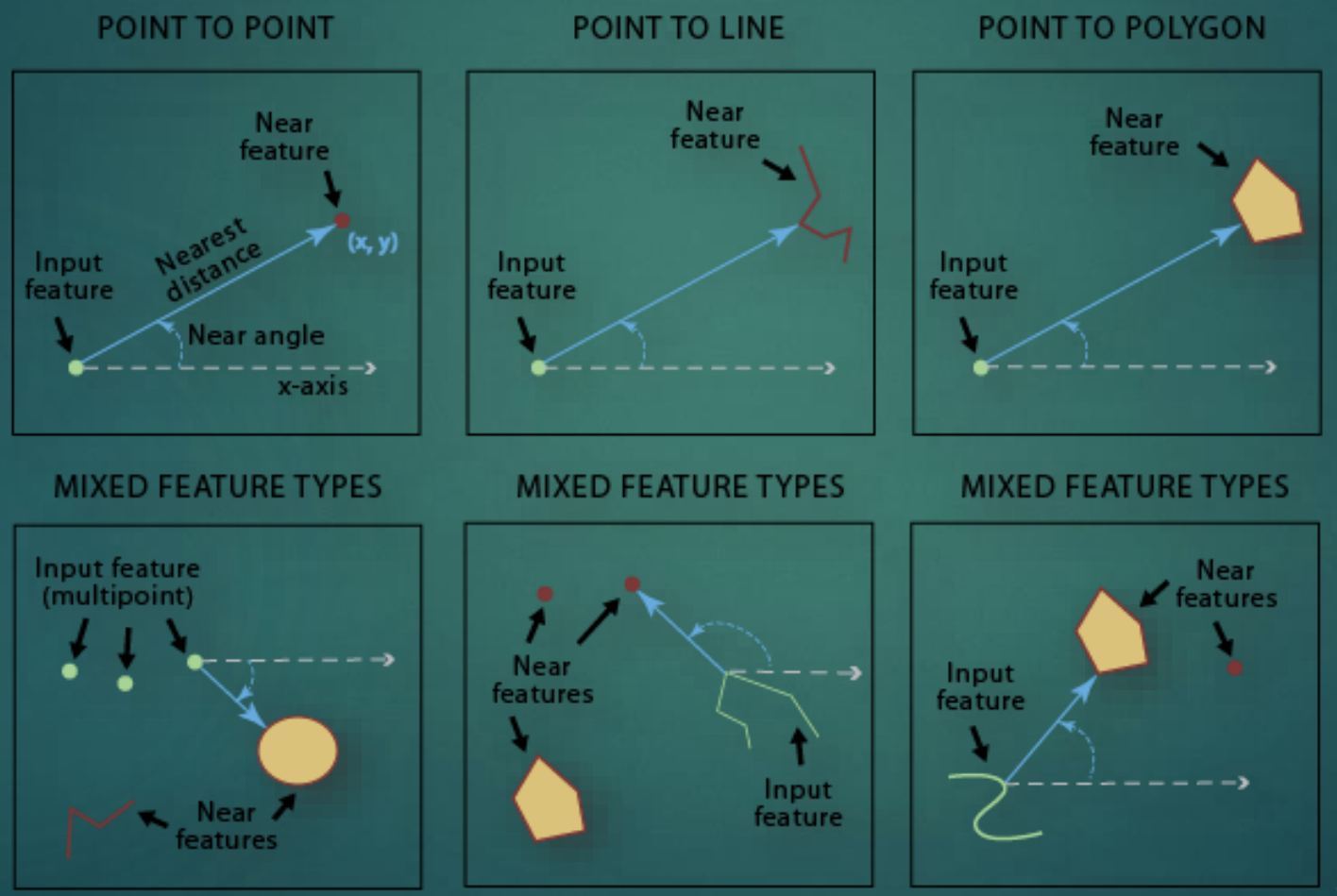
	FeatureID	NearDist	NearAngle
	0	56	18.394009
	1	122	-31.848772
	2	195	-2.41069
	3	48	-35.72168
	4	105	-13.856518
	5	177	-10.703785
	6	75	-23.185714

Part of the attribute table of the points, showing the distance to the nearest river feature:

Source: ESRI, 2021

3.2. Near Tool concept

The Near tool will compare two layers and create a new output layer, complete with a new field in the attribute table expressing the exact distance between features



Source: https://vector.geospatial.science/textbook/section-three-proximity-analysis

4. Vector Overlay Analysis

An overlay operation combines the geometries and attributes of two feature layers to create the output.

Each feature on the output contains a combination of attributes from the input layers, and this combination differs from its neighbors.

Source: McGraw-Hill Companies, Inc.
https://csm.fresnostate.edu/ees/documents/facstaff/wang/gis200/lecture-notes/gis/chap11.pdf

4.1. Common vector Overlay operations

The four overlay operations in common that are always use in GIS vector analysis:

1. Area on area (Polygon overlay on polygon)
2. Line in area (Line overlay on polygon)
3. Point in area (point overlay on polygon)
4. Weighted overlay

4.2. Polygon on Polygon Overlay Analysis

Add new intersections and create polygon for new topology.

The overlay of 2 layers of polygon will produce large number of polygons and increase the number of intersections zone and arcs.

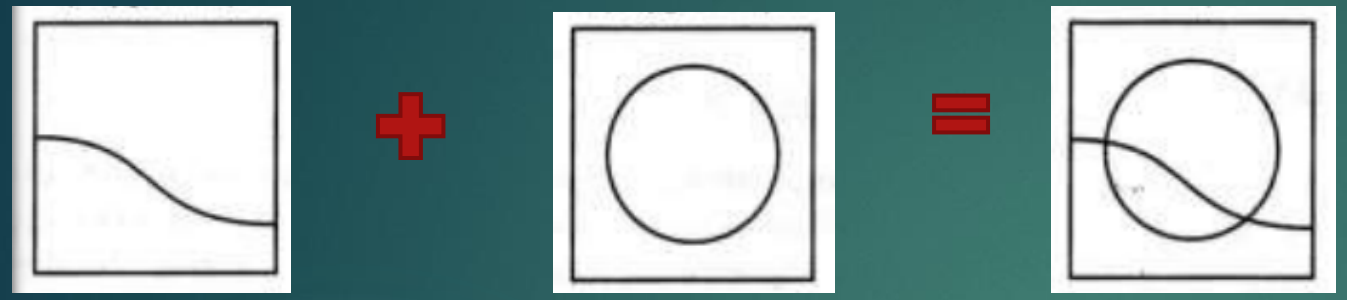
If the new polygon, arcs and set of nodes have been shaped then meaningful set of layer can be extract.

4.2.1. Polygon on Polygon Overlay Analysis

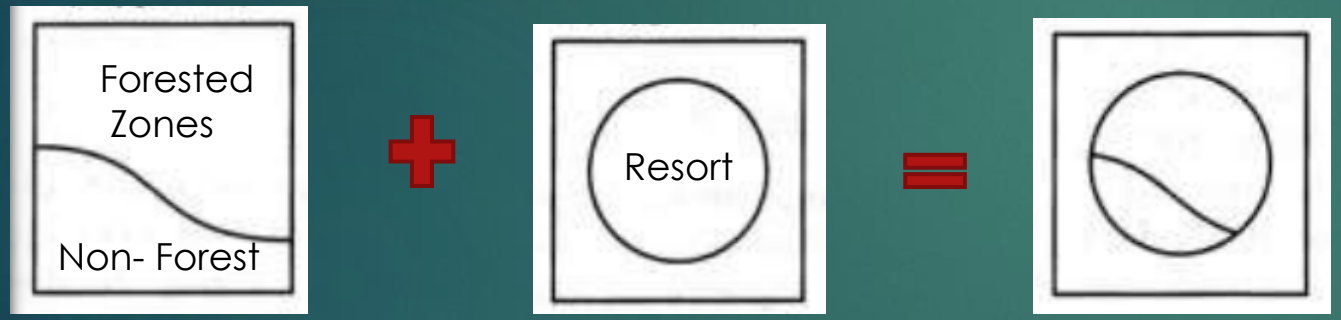
Forest Polygon Map

Resort Polygon Map

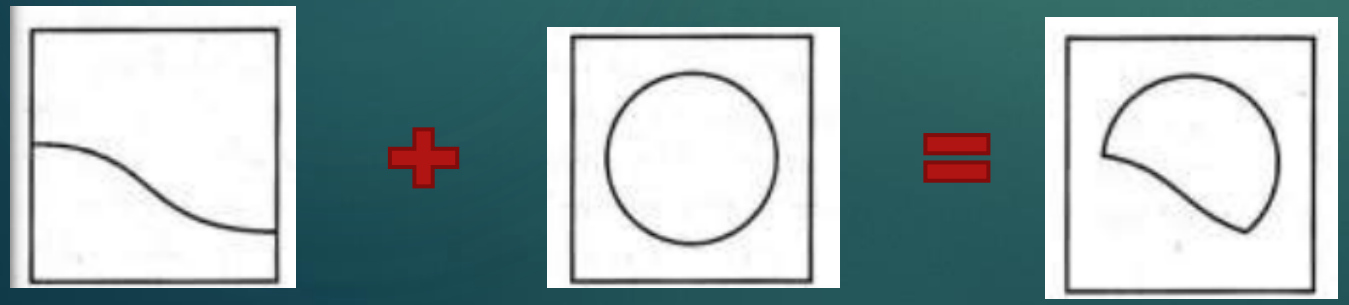
Polygon Map



Union Operation was performed



Erase operation

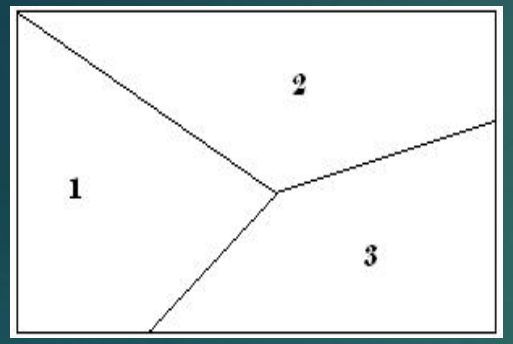


Intersect operation

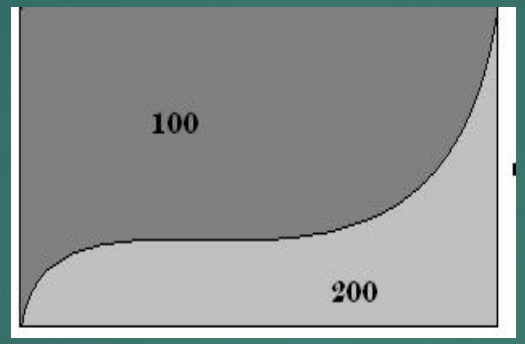
Source: Siddiqui, M.A, et al RS/GIS-24 course module

4.2.2. Polygon on Polygon Overlay Analysis with Attribute data

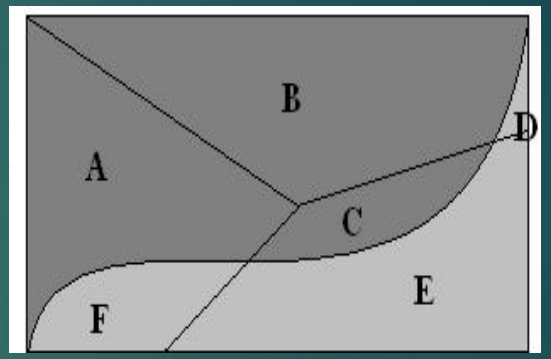
The out put combines the polygon boundaries from the inputs to create a new set of polygons and each new polygon carries attributes from the inputs.



Parcel type



Soil Type



Output

Parcel ID	Parcel No
1	10
2	20
3	30

Soil ID	Character
100	Good
200	Bad

Out Put	ID	P No	S ID	Character
A	1	10	100	Good
B	2	20	100	Good
C	3	30	100	Good
D	2	20	200	Bad
E	3	30	200	Bad
F	1	10	200	Bad

Source: RGS 606 Course Module

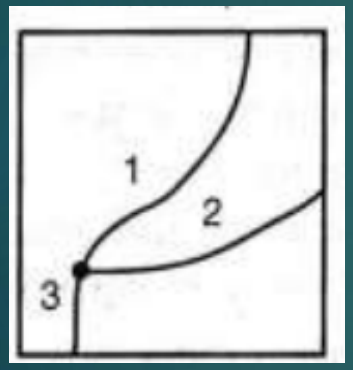
4.3. Line in Polygon Overlay Analysis

Line in area polygon operations need to check linear object or attribute which will combine or merge with area layer.

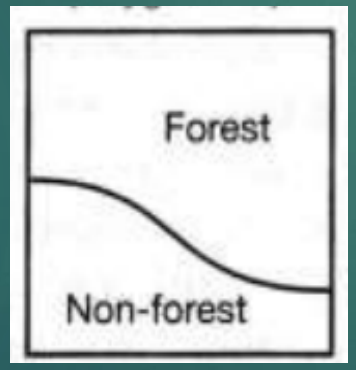
Ex. To know about which road is going in forest are or non- forest.

Simply overlay the line layer on polygon, remaining extracted layer will be result.

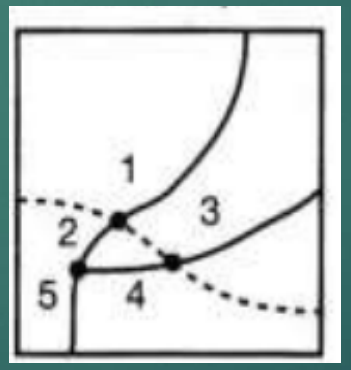
Road polyline Map



Forest Polygon Map



Road polyline Map



Road Attribute Table

Old ID	New ID	Land use
1	1	Forest
1	2	Non-Forest
2	3	Forest
2	4	Non-Forest
3	5	Non-Forest

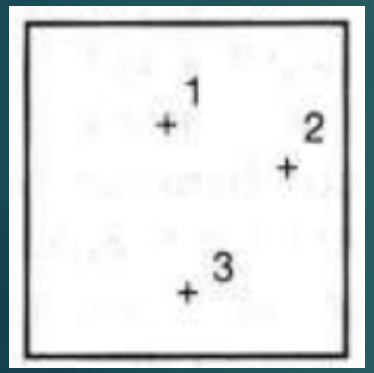
Source: Siddiqui, M.A, et al RS/GIS-24 course module

4.4. Point in Polygon Overlay Analysis

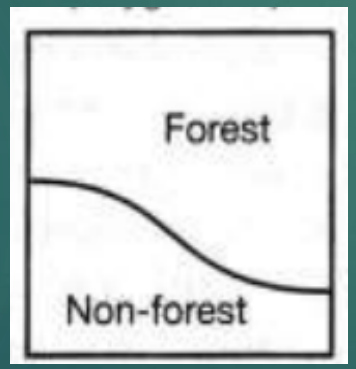
To see the point attribute or object that superimpose on area.

Ex: To know the location of met station in forest or non-forest area. It is simply done by overlaying the point layer on area layer

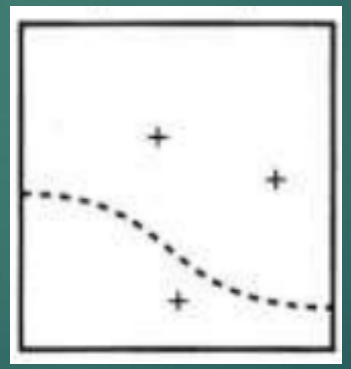
Met Station Point Map



Forest Polygon Map



Met Station Point Map



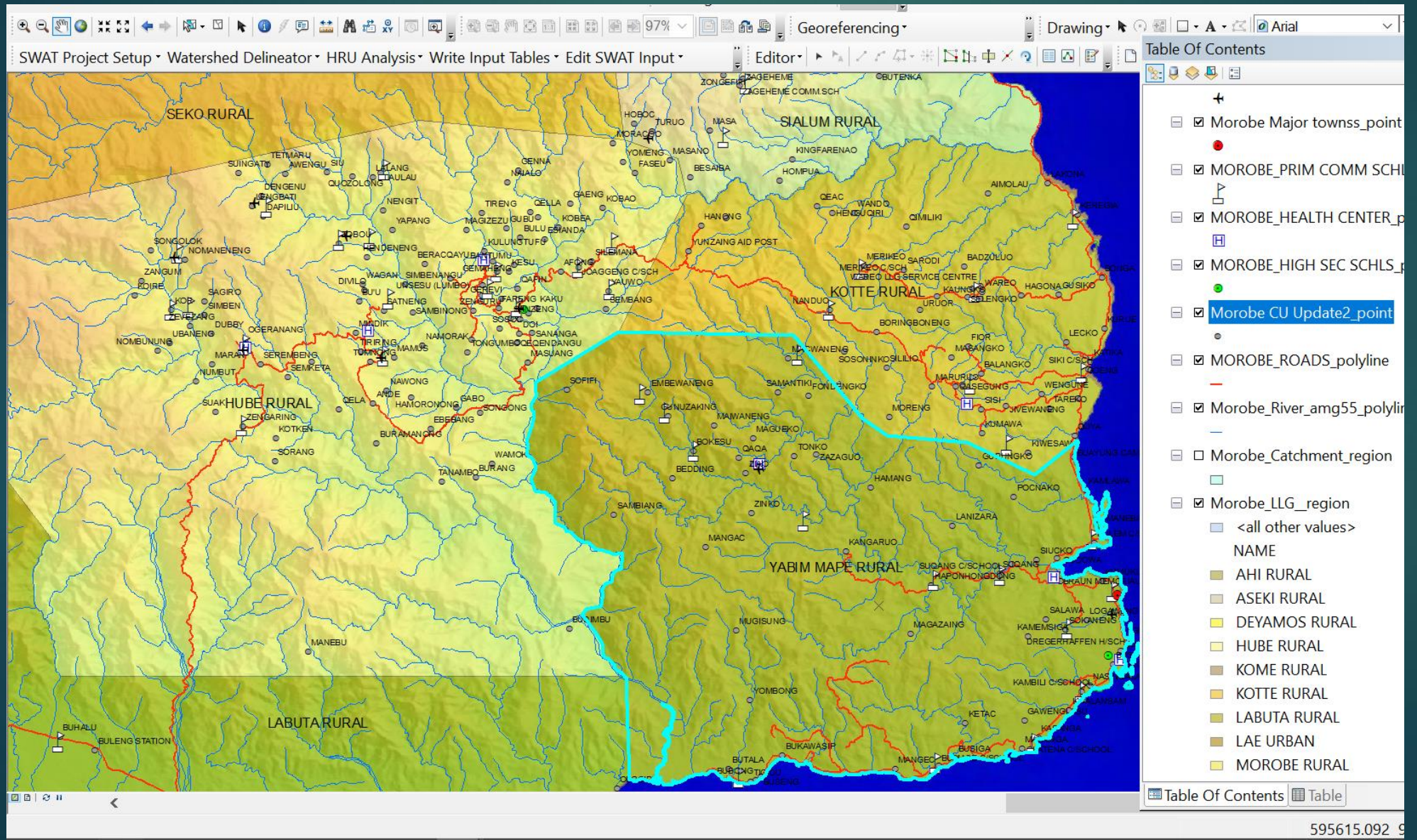
Met Station Attribute table

Point ID	Land use
1	Forest
2	Non-Forest
3	Forest
4	Non-Forest
5	Non-Forest

Source: Siddiqui, M.A, et al RS/GIS-24 course module

4.5. Vector Layer Overlay

Points, Line, Polygons



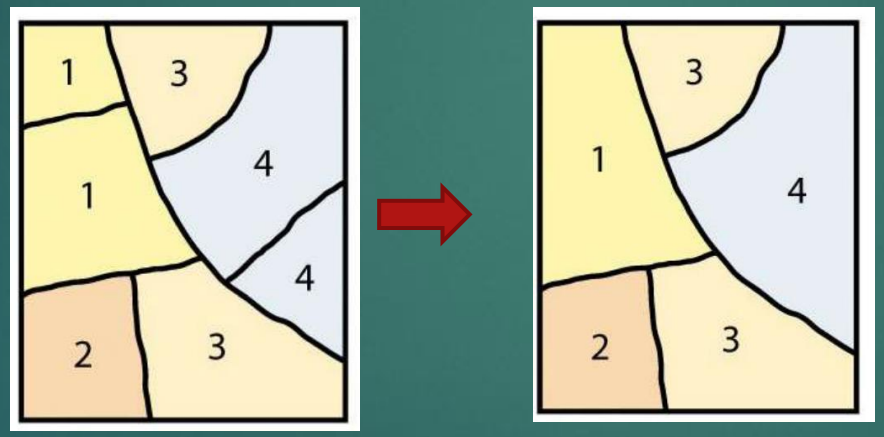
Source: T.Sekac, 2022

5. Feature Manipulation

5.1. Dissolve

Dissolve analysis aggregates features based on specified attributes. Features with the same value combinations for the specified fields will be aggregated (dissolved) into a single feature.

Dissolve operation

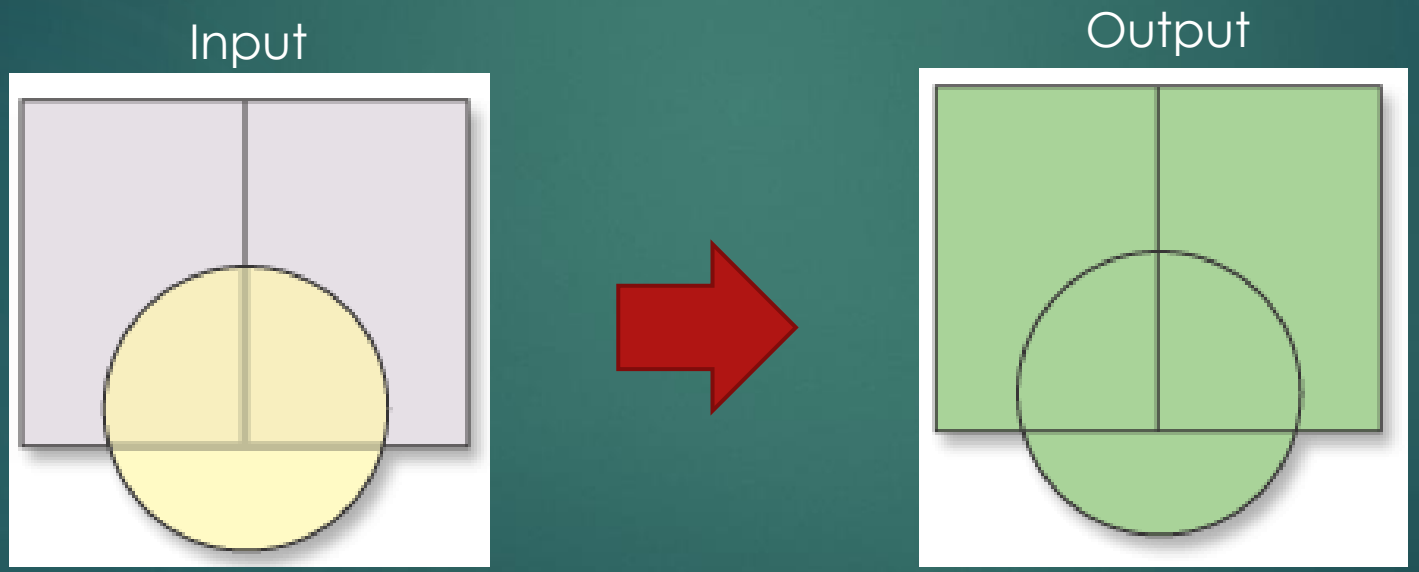


(a) (b)

Source: Institute of Space Technology (IST), Pakistan, 2002

5.2. Union

Union analysis computes a geometric intersection of the Input Features. All features will be written to the Output Feature Class with the attributes from the Input Features, which it overlaps.

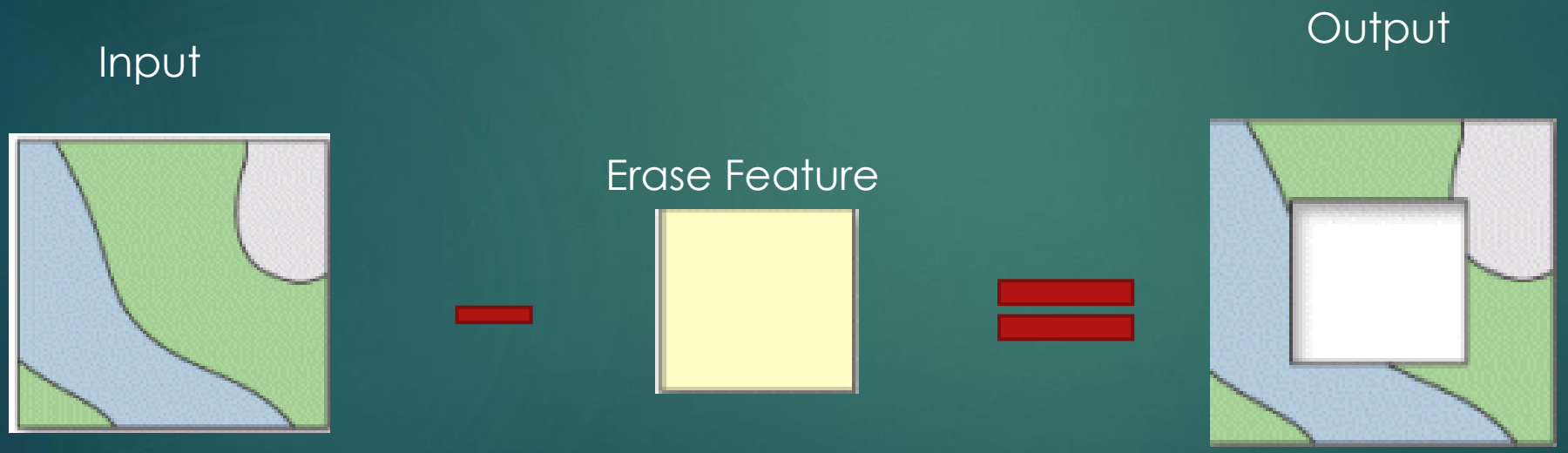


Source: ESRI
https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/an-overview-of-the-overlay-toolset.htm

5.3. Erase

Creates a feature class by overlaying the input features with the erase features.

Only those portions of the input features falling outside the erase features are copied to the output feature class.



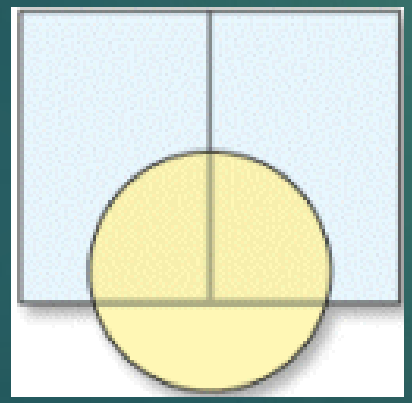
Source: ESRI
https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/an-overview-of-the-overlay-toolset.htm

5.4. Intersect

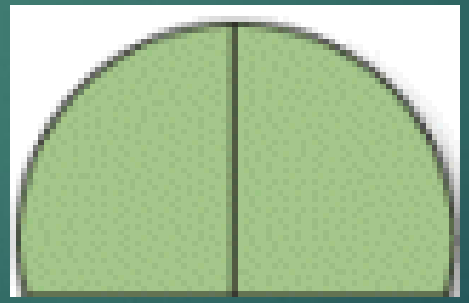
Computes a geometric intersection of the input features.

Features or portions of features that overlap in all layers or feature classes will be written to the output feature class.

Input



Output

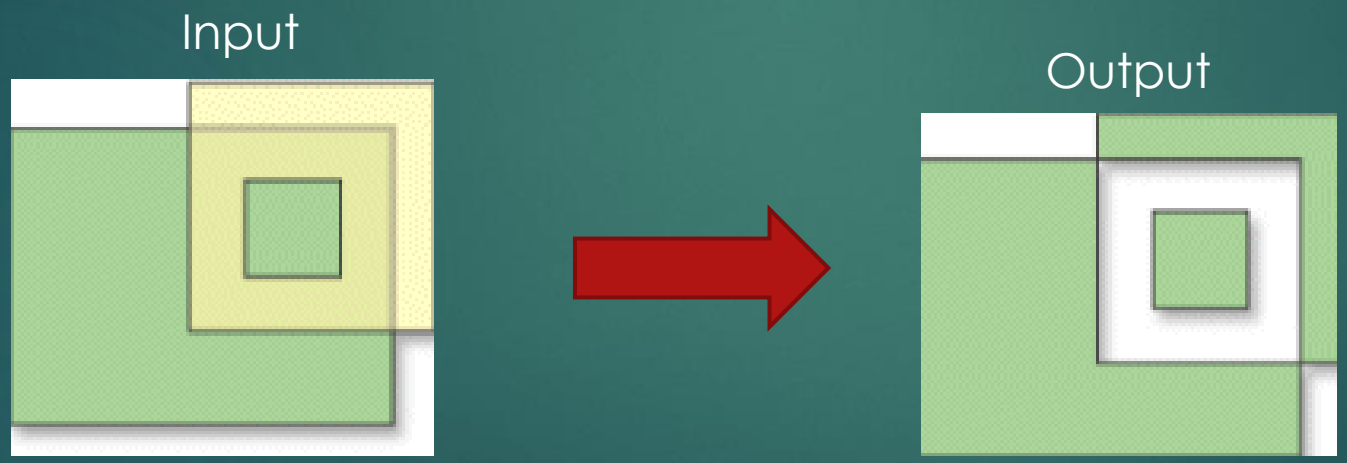


Source: ESRI
https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/an-overview-of-the-overlay-toolset.htm

5.5. Symmetrical Difference

Computes a geometric intersection of the input and update features, returning the input features and update features that do not overlap.

Features or portions of features in the input and update features that do not overlap will be written to the output feature class.



Source: ESRI
https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/an-overview-of-the-overlay-toolset.htm

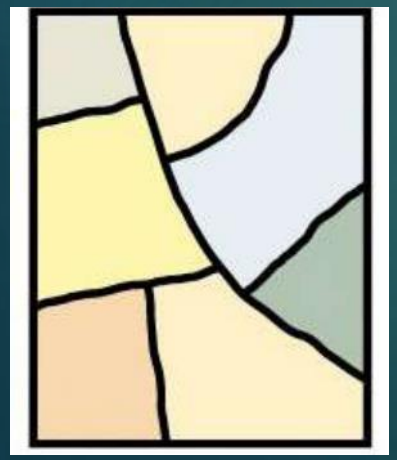
5.6. Clip

Clip is used to cut out a piece of one feature class using one or more of the features in another feature class.

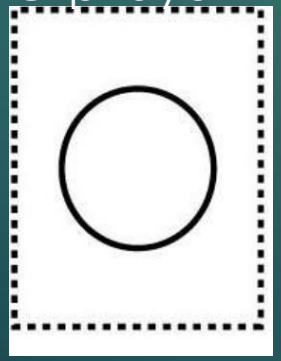
This is particularly useful for creating a new feature class that contains a geographic subset of the features in another, larger feature class.

Clip operation

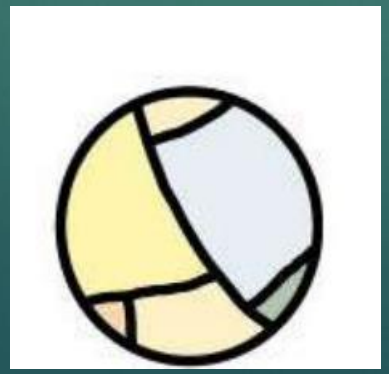
Input layer



Clip layer



Output result



Source: Institute of Space Technology (IST), Pakistan, 2002

5.7. Merge

Merge combines input features from multiple input sources (of the same data type) into a single, new, output feature class. The input data sources may be point, line, or polygon feature classes or tables.

Input layer

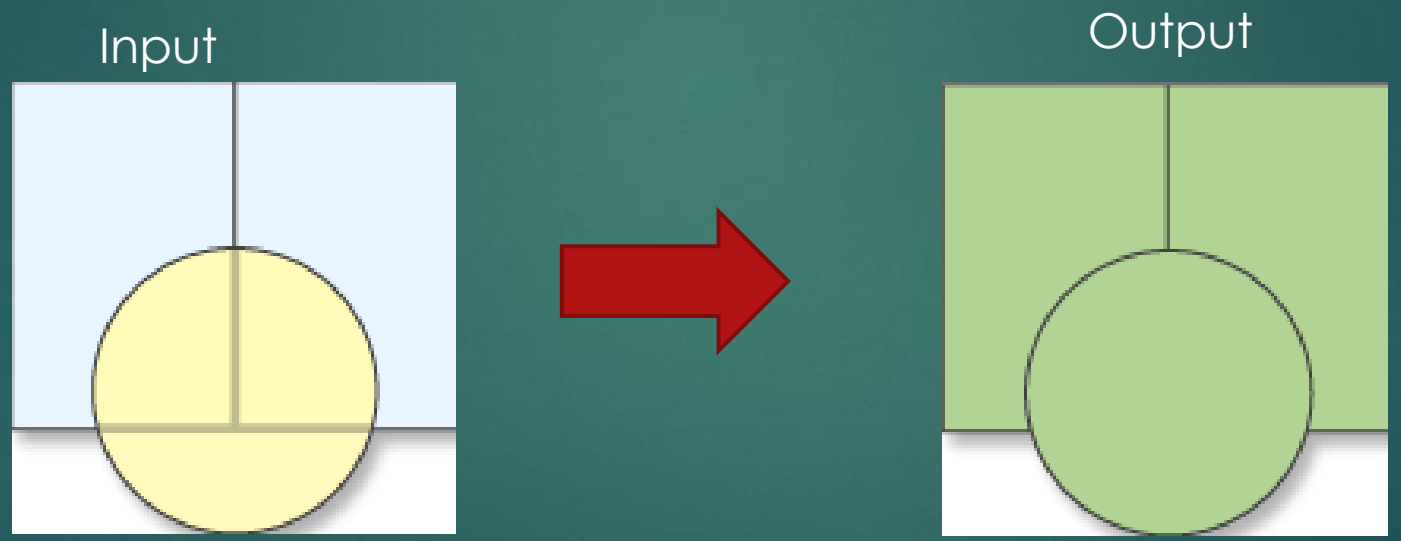
Output layer

Source: ESRI
https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/an-overview-of-the-overlay-toolset.htm

5.8. Update

Computes the geometric intersection of the **Input Features** and **Update Features**.

The attributes and geometry of the input features are updated by the update features in the output feature class.



Source: ESRI
https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/an-overview-of-the-overlay-toolset.htm

6. References

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

Shellito, B. A (2020) Introduction to Geospatial Technologies (Book – Fifth Edition).

Dempsey, C., (2015). What is shapefile. Retrieve from https://www.gislounge.com/what-is-a-shapefile/

Siddiqui, M.A and Islamia, J.M (_). GIS-06: Spatial Analysis (1) Overlay Operations & Analysis in GIS. RS/GIS-24 course module. Retrieve from: http://aditi.du.ac.in/uploads/econtent/SPATIALANALYSIS_overlay.pdf

IST, (_). Introduction to GIS Vector Data Analysis. Retrieve from: http://grel.ist.edu.pk/lms/pluginfile.php?file=%2F2168%2Fmod_resource%2Fcontent%2F0%2FLecture_04.pdf

ArcGIS 9.2 ArcCatalog Desktop Help: GIS Concepts and Examples of Their Use in This Analysis. Retrieve from: http://gisedu.colostate.edu/webcontent/nr505/nps07/team2/GISconcepts.html

ESRI, ArcGIS Pro: An overview of the Overlay toolset. Retrieve from: https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/an-overview-of-the-overlay-toolset.htm