GEOG653 – Spatial Analysis

Lecture 3

1

Jianguo (Jack) Ma

Department of Geographical Sciences
University of Maryland at College Park

Outline

- Announcements and Updates
- Vector Analysis
  - Spatial Query
  - Spatial Join
  - Overlay Operations
  - Buffering
- Demos

Outline

- Announcements and Updates
  - Lab1
    - Due 9/16/2020
  - Exercises
  - ArcGIS Pro License

Overview

- The fundamental questions that spatial analysis tries to address:
  - Adjacency/Distance
    - What is near what?
    - Tobler's 1st law of geography: "Everything is related to everything else, but near things are more related than distant things."
  - Containment
    - What is in what?
- It is all about spatial relationships.

Overview

- Vector analysis is one of the most basic analytical functions.
- Methods:
  - Spatial Query
  - Spatial Join
  - Overlay Operations
  - Buffering

Overview

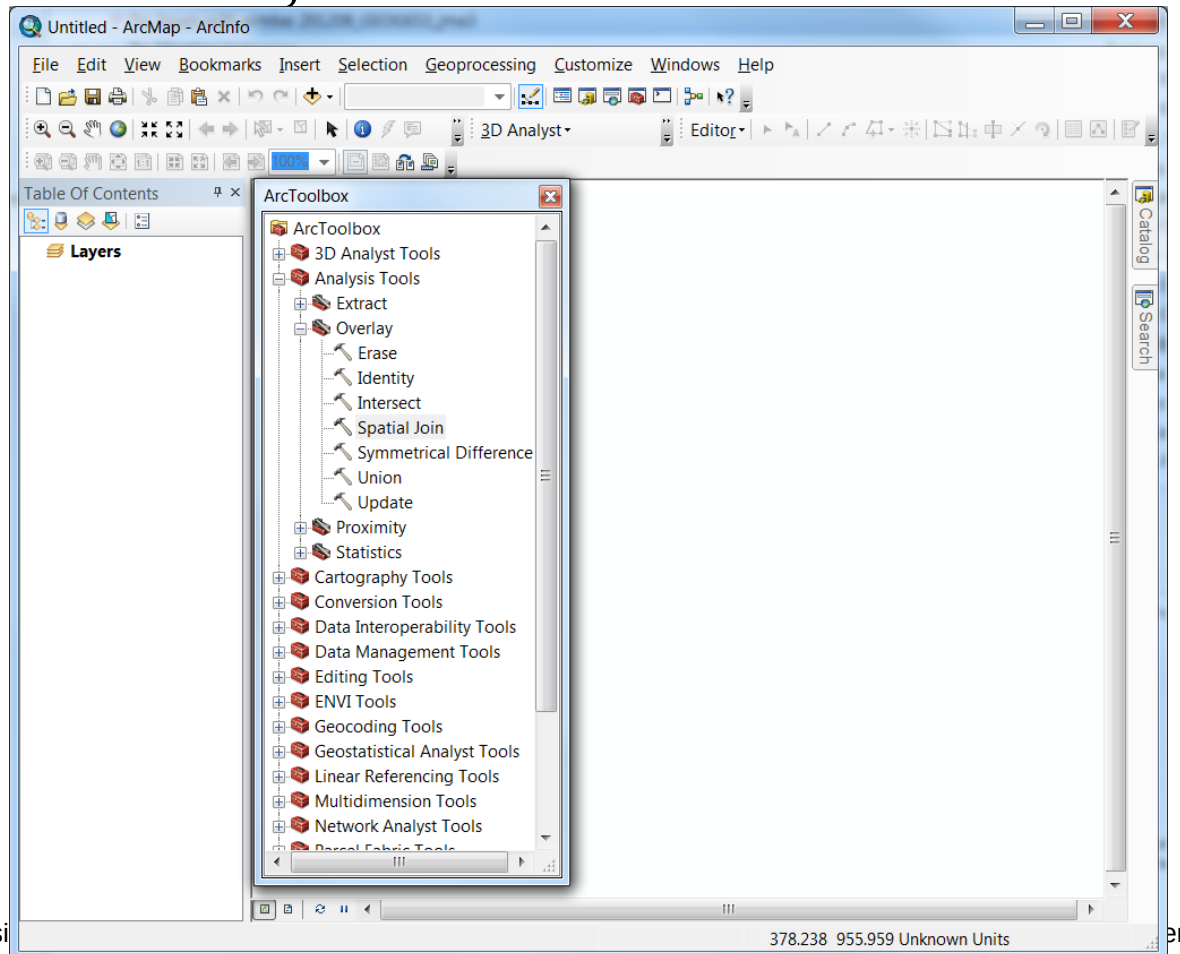
- Spatial Query and Spatial Join are vector analysis methods.
  - They can help locate features in one layer based on the location of other features in the same layer or in another layer.
  - This type of relationship is based on the spatial properties of the layers, including the spatial extent and location of features within layers, as well as the feature type of the layers.

Overview

- Spatial Query is one of vector analysis methods.
  - Examples:
    - Which cities lie within Hillsborough county?
    - How many counties is passed through by Hillsborough River? And what counties are they?
    - What are those counties that share borders with Hillsborough County? Show me a map of them.
    - Where are the WalMart stores within 1 mile of Fletcher Ave.?

Overview

- Spatial Join is also part of vector analysis.
  - Based on spatial information such as distance, intersection, or containment.



Overview

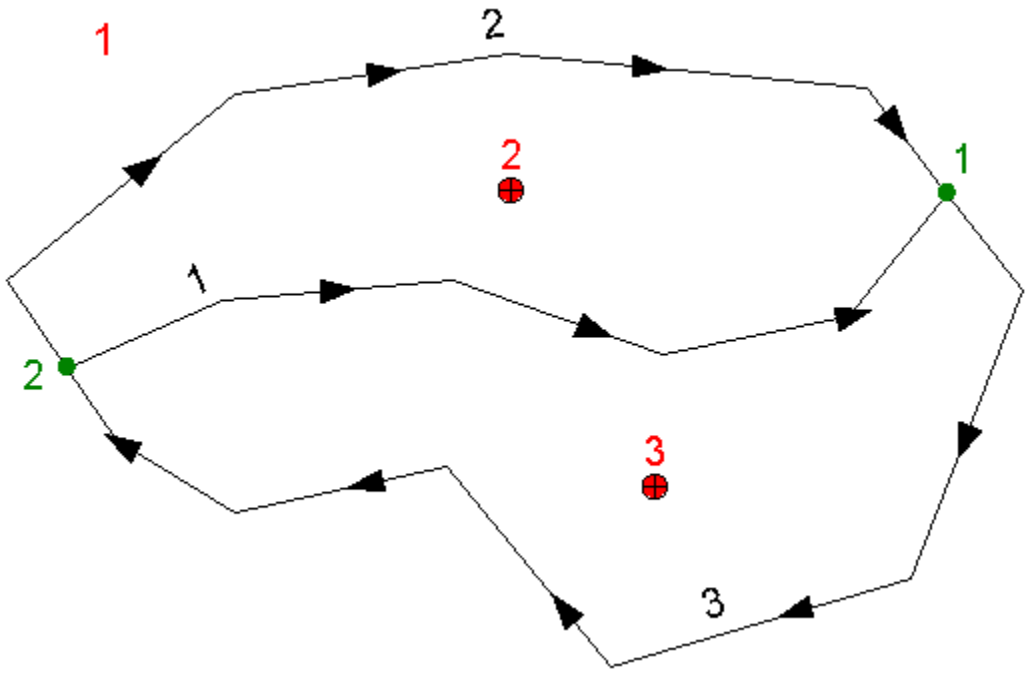
- Overlay Operations
  - Core functions of ArcGIS Toolbox.
    - That's what GIS software was designed to do initially.
  - Provide much more powerful analytical capabilities than Spatial Query and Spatial Join.
    - Example: Where are the best habitat areas in Tampa Bay Watershed for the endangered Nine-Banded Armadillo, that are on the public lands and 100-meter away from major roads? And what is their percentage of area with respect to the entire watershed.

Overview

- Overlay Operations vs. Spatial Query
  - Spatial Query will create a new selected set within one of the two layers that have features overlapped. During this process, no new datasets are created and the attribute tables are not updated, either.
  - During the Overlay Operations process, new data layers will be created. The geometry and/or attribute tables are modified.

Overview

- "Overlay Operations" is sometime called "Topological Operations"
  - Because the overlay operations will rebuild/modify the topological relationships that make layers function.



Vector Analysis

- Spatial Query
  - The process of retrieving data from a map by working with map features, instead of tables.
  - One of the most basic analytical tasks in GIS:
    - locating features in one layer based on the location of other features in the same layer or in another layer.

Vector Analysis

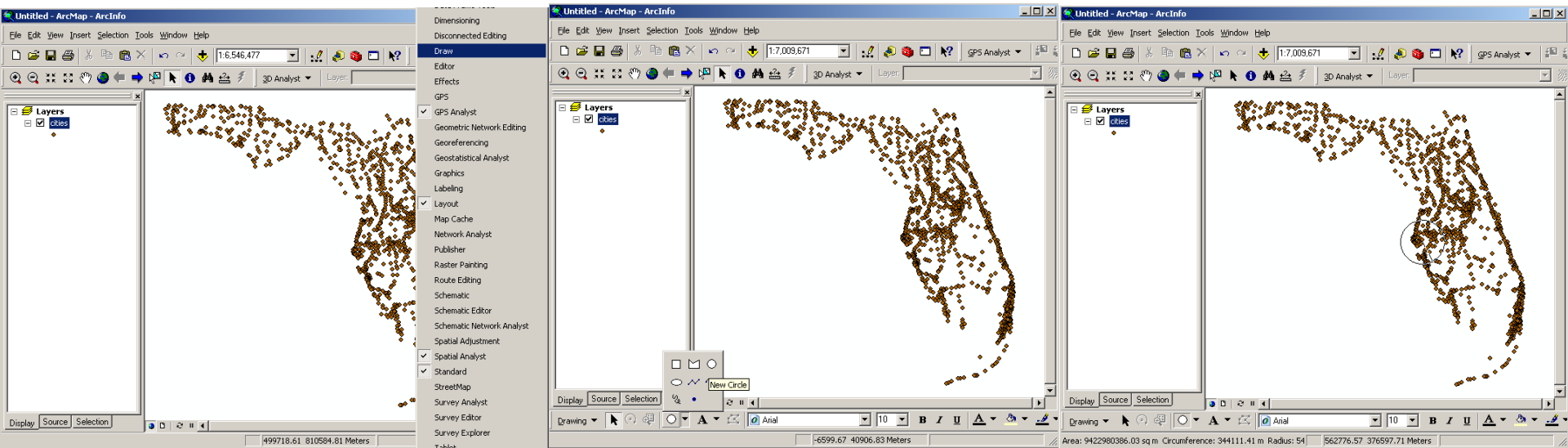
- Spatial Query
  - What is Spatial Query?
    - A spatial query is a query expression used to select features based on their spatial relationships to other features.
  - Usually features from one layer are selected using features from another.
  - A spatial query requires that you construct a statement about how the selection will occur.
  - The result of a spatial query is a selection of features within a layer.

Vector Analysis

- Spatial Query
  - Selecting Features by Graphics
    - You can create, move and delete graphics.
    - Graphics can be points, lines, or circles.
    - You can also change the size, color, shape, and position of the graphics.
    - Select graphics with the Select Elements tool - 

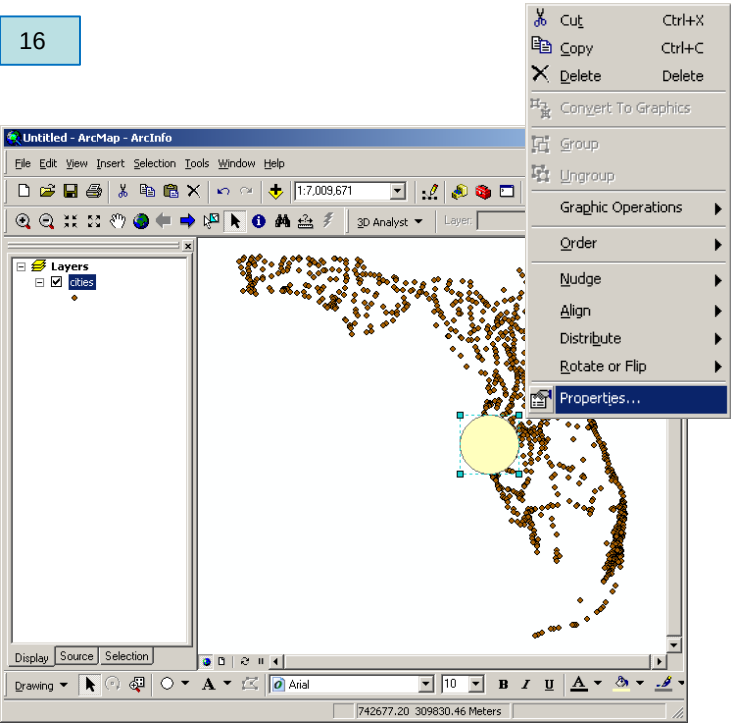
Vector Analysis

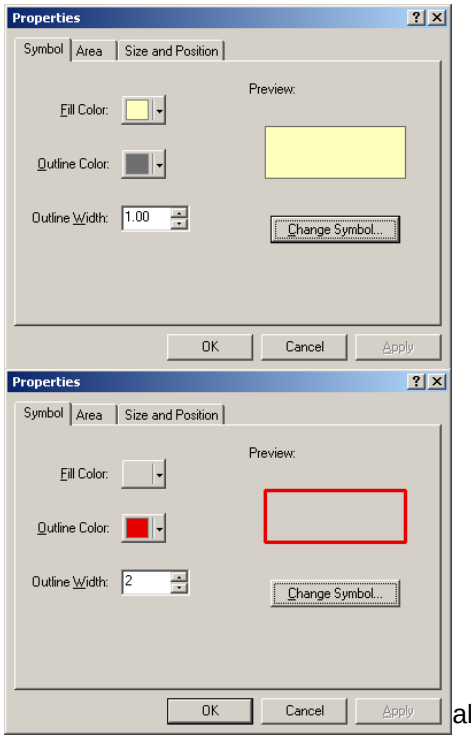
- Spatial Query
  - Selecting Features by Graphics
    - To be able to select features by graphics, firstly you need to create graphics.
      - Turn on Draw tool bar
      - Draw a graphics

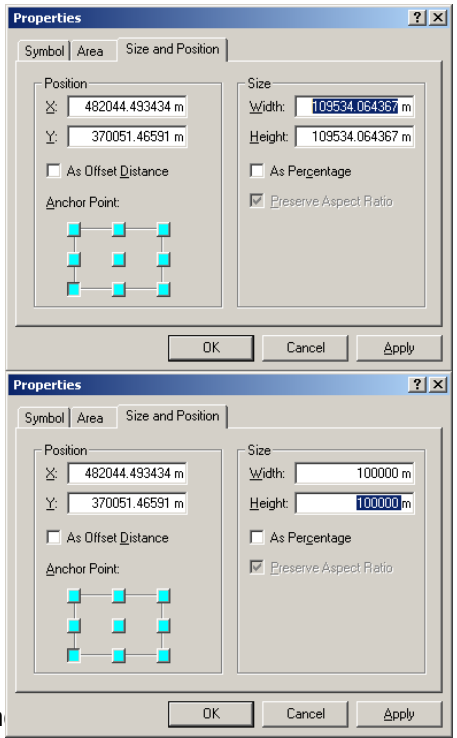


Vector Analysis

- Spatial Query
  - Selecting Features by Graphics
    - To be able to select features by graphics, firstly you need to create graphics.
      - After a graphics is created, you can customize it.

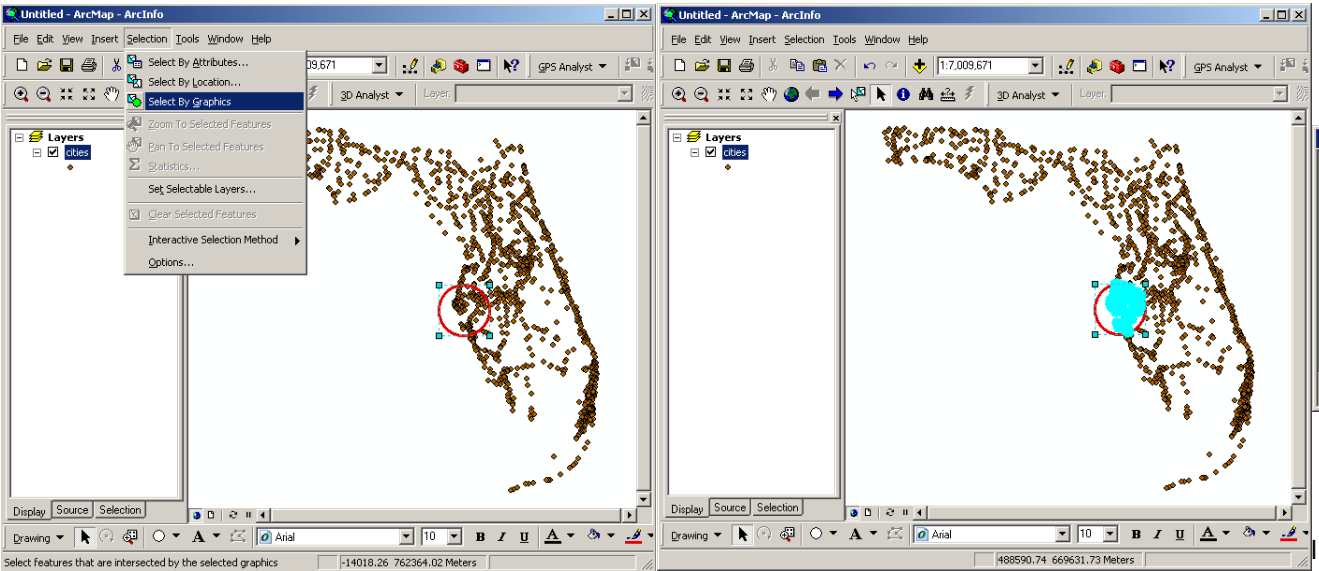


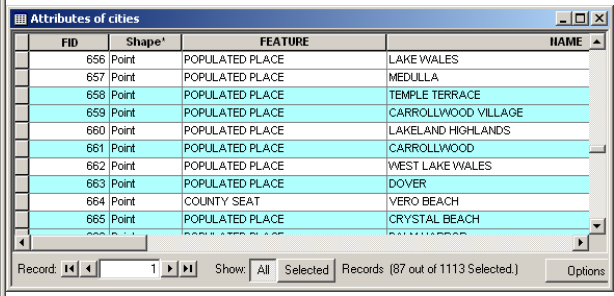




Vector Analysis

- Spatial Query
  - Selecting Features by Graphics
    - The **Select by Graphics** allows you to select features that intersect a graphic element from selectable layers.
    - This can be used with most graphics element except those containing text or curves.





Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship
    - Used to select features in one or more data layers on the spatial relationship to another layer. For example:
      - Which cities lie within Hillsborough county?
      - How many counties is passed through by Hillsborough River? And what counties are they?
      - What are those counties that share borders with Hillsborough County? Show me a map of them.
      - Where are the WalMart stores within 1 mile of Fletcher Ave.?

Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship
    - The layers used in Select by Location are called **Target Layer(s)** and **Source Layer**.
      - The target layer(s) contain the features that we are interested in and will be selected.
      - The source layer contains features that are known and will be used to select features from the target layer.

Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship

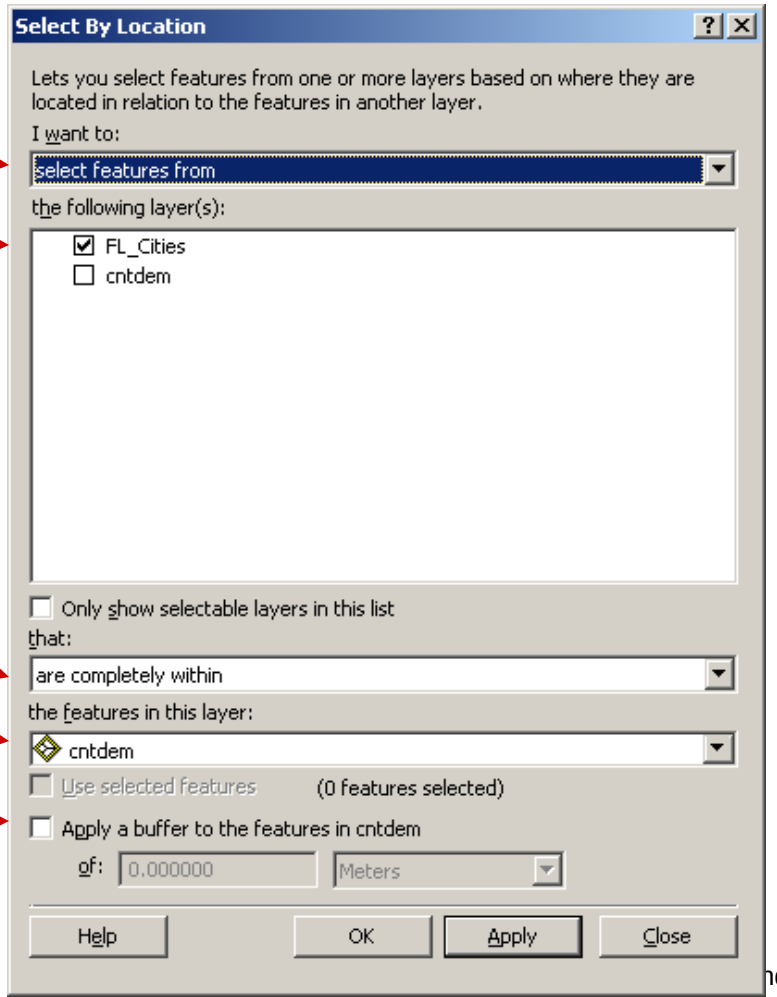
Selection Method

Target Layer

Spatial Relationship

Source Layer

Distance Buffer



Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship
    - Four types of spatial relationship
      - Distance
        - » Example: select points within a distance of a feature
      - Containment
        - » Example: select points contained by a polygon
      - Intersection
        - » Example: select lines that intersect a feature
      - Adjacency
        - » Example: select polygons adjacent to a feature

Vector Analysis

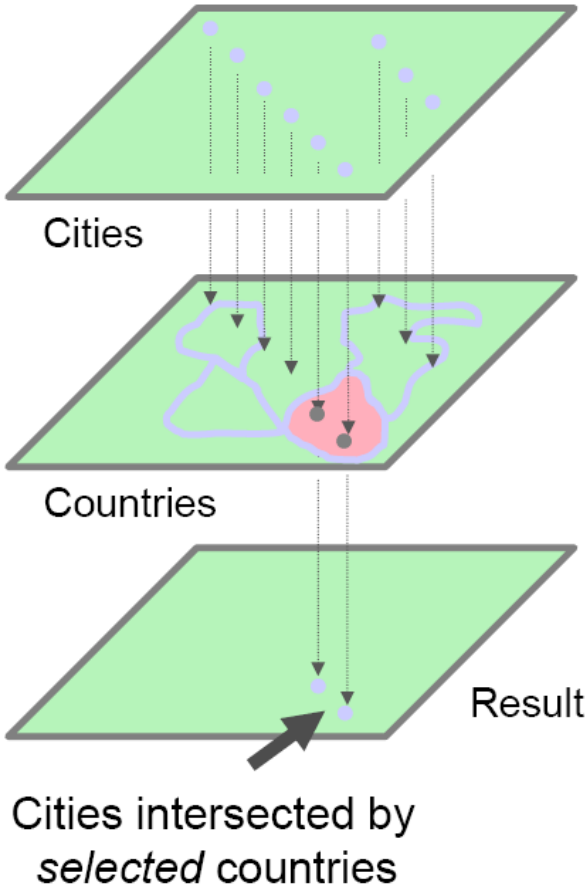
- Spatial Query
  - Selecting Feature by Spatial Relationship
    - ArcGIS defines eleven specific spatial relationships
      - Containment
        - » “are completely within”
        - » “completely contain”
        - » “have their center in”
        - » “contain”
        - » “are contained by”

Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship
    - ArcGIS defines eleven specific spatial relationships
      - Intersection
        - » “intersect”
        - » “are crossed by the outline of”
      - Distance/Adjacency
        - » “are within a distance of”
        - » “share a line segment with”
        - » “touch the boundary of”
        - » “are identical to”

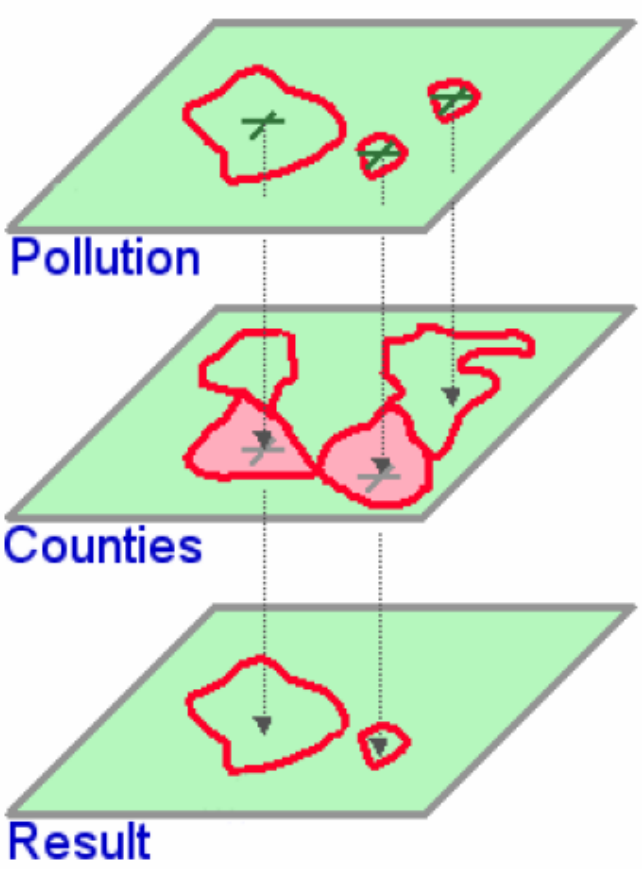
Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship
    - Example: intersection



Vector Analysis

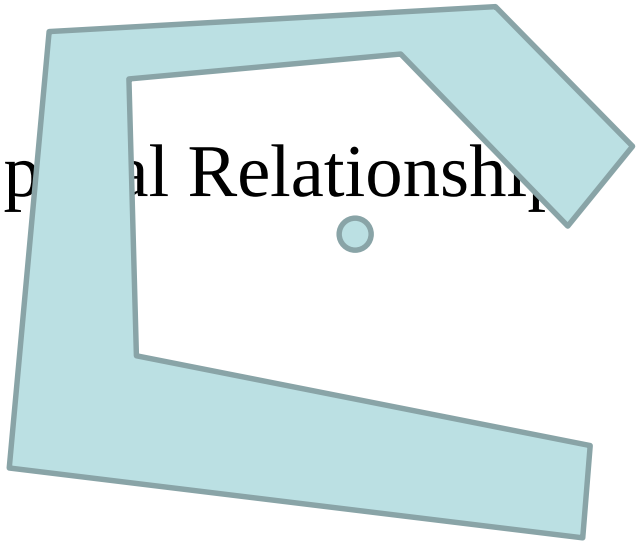
- Spatial Query
  - Selecting Feature by Spatial Relationship
    - Example: containment

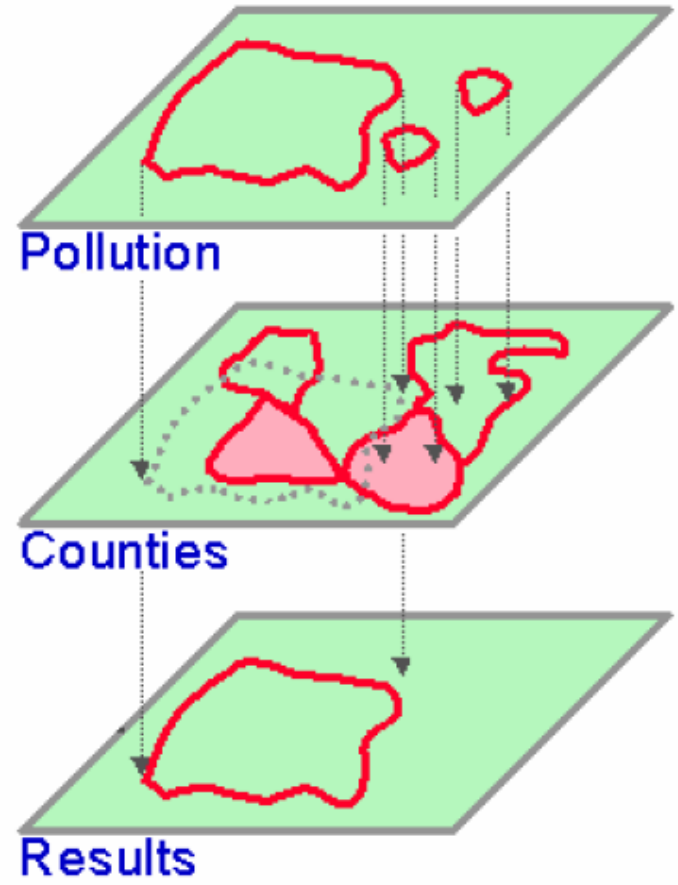


In this example, features in the Pollution dataset are selected if their centers fall inside the selected features in the Counties dataset.

Vector Analysis

- Spatial Query
  - Selecting Feature by Sp al Relationshi
    - Example: containment

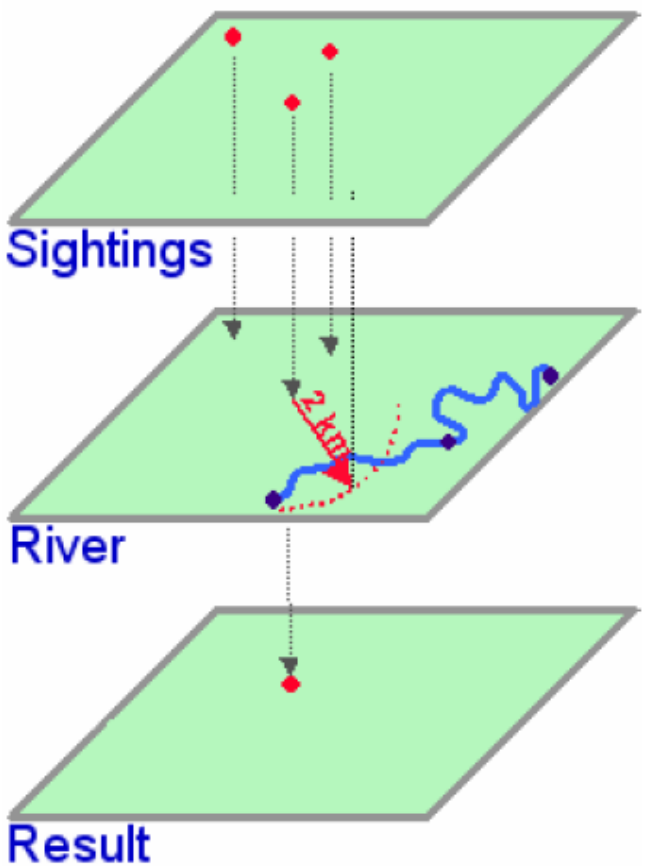




In this example, features in the Pollution dataset are selected if any selected features in the Counties dataset lie completely inside their boundaries.

Vector Analysis

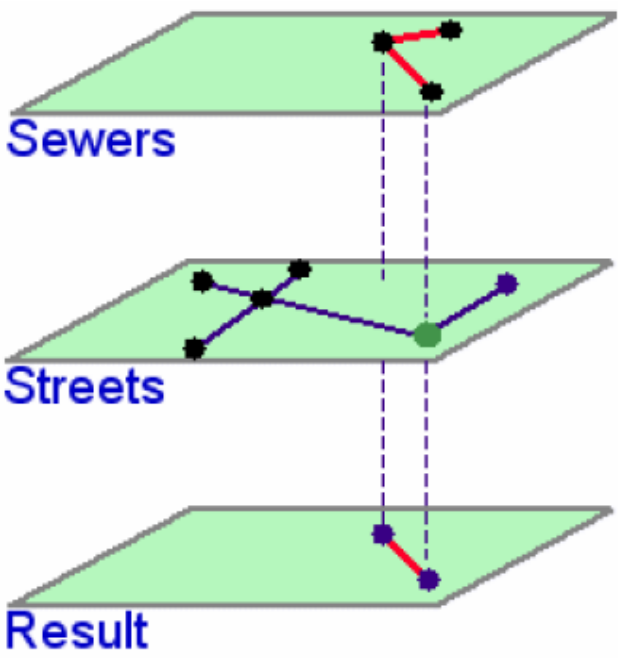
- Spatial Query
  - Selecting Feature by Spatial Relationship
    - Example: distance



In this example, the locations where animals have been sighted are selected if they are within 2 kilometers of the features in the River dataset.

Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship
    - Example: distance/adjacency



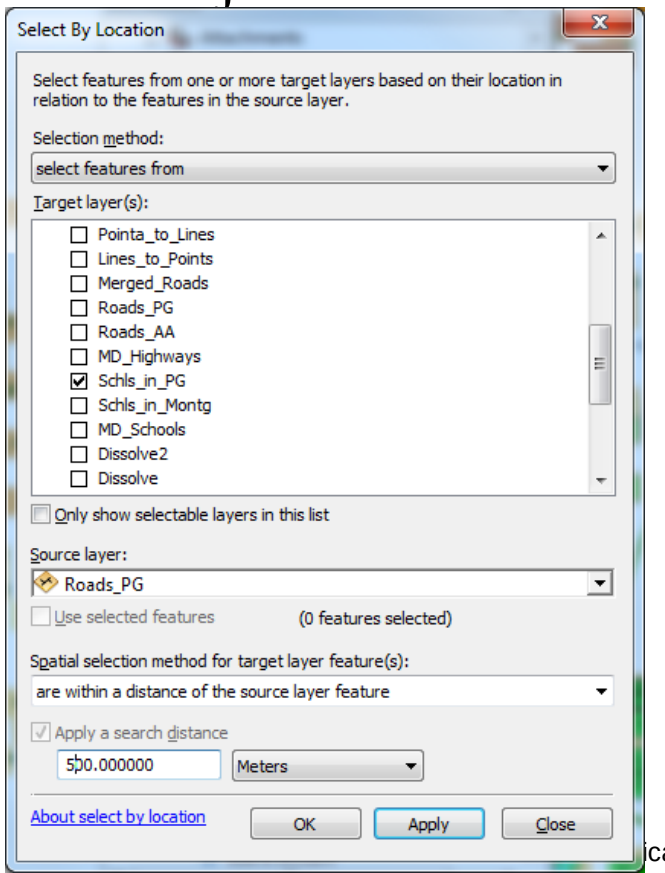
In this example, features in the Sewers dataset are selected if they share a point with features in the Streets dataset.

Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship
    - "**Select By Location**" dialog window
    - It is often useful to combine Attribute Query and Spatial Data Query.

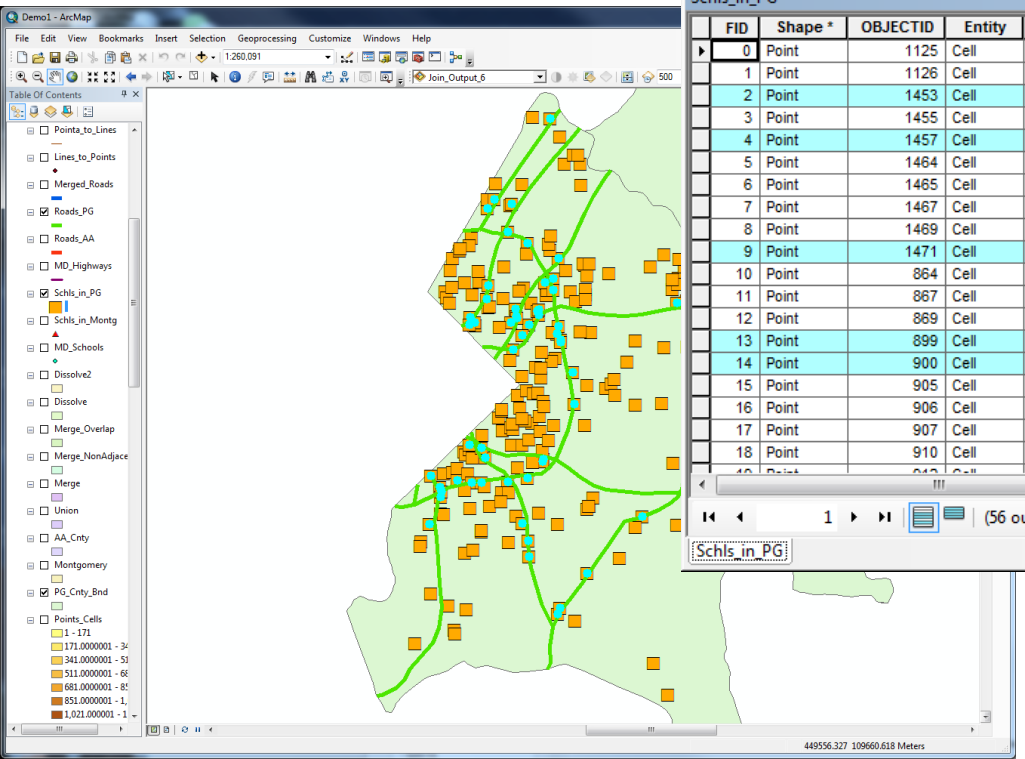
Vector Analysis

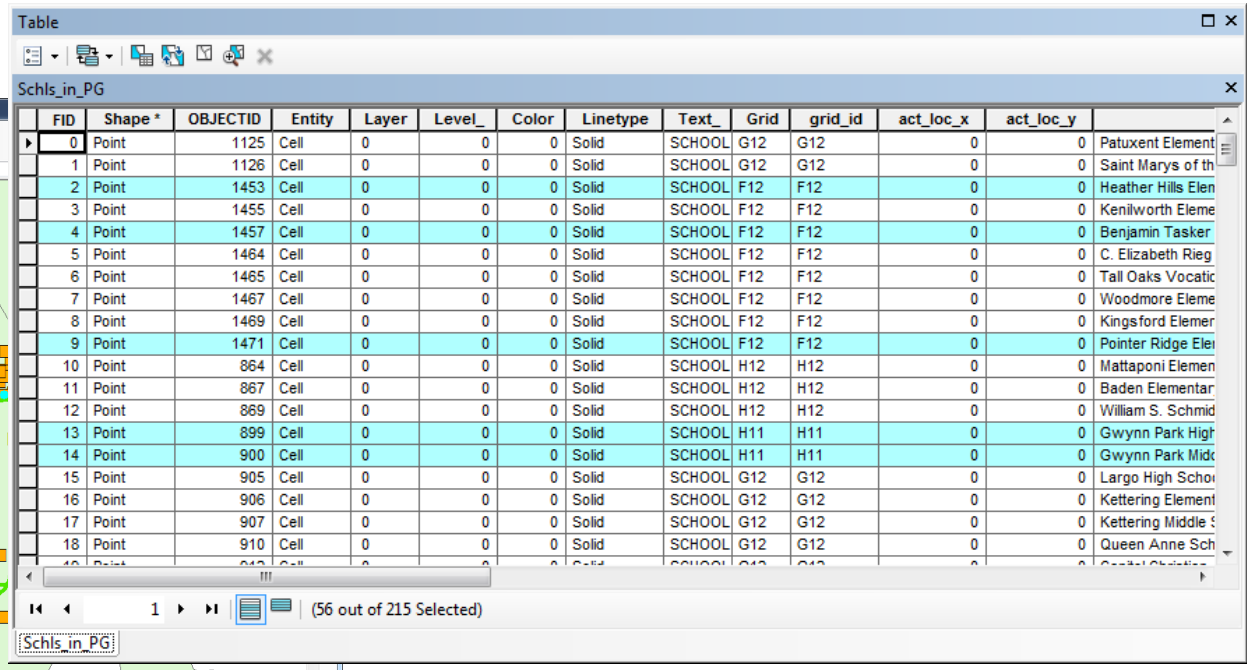
- Spatial Query
  - Selecting Feature by Spatial Relationship
    - Example: select all those schools that are within 500 meters from the major roads in Prince George's County.



Vector Analysis

- Spatial Query
  - Selecting Feature by Spatial Relationship
    - Example: select all those schools that are within 500 meters from the major roads in Prince George's County.





FID	Shape *	OBJECTID	Entity	Layer	Level_	Color	Linetype	Text_	Grid	grid_id	act_loc_x	act_loc_y	
0	Point	1125	Cell	0	0	0	Solid	SCHOOL	G12	G12	0	0	Patuxent Element
1	Point	1126	Cell	0	0	0	Solid	SCHOOL	G12	G12	0	0	Saint Marys of th
2	Point	1453	Cell	0	0	0	Solid	SCHOOL	F12	F12	0	0	Heather Hills Elen
3	Point	1455	Cell	0	0	0	Solid	SCHOOL	F12	F12	0	0	Kenilworth Eleme
4	Point	1457	Cell	0	0	0	Solid	SCHOOL	F12	F12	0	0	Benjamin Tasker
5	Point	1464	Cell	0	0	0	Solid	SCHOOL	F12	F12	0	0	C. Elizabeth Rieg
6	Point	1465	Cell	0	0	0	Solid	SCHOOL	F12	F12	0	0	Tall Oaks Vocatic
7	Point	1467	Cell	0	0	0	Solid	SCHOOL	F12	F12	0	0	Woodmore Eleme
8	Point	1469	Cell	0	0	0	Solid	SCHOOL	F12	F12	0	0	Kingsford Elemer
9	Point	1471	Cell	0	0	0	Solid	SCHOOL	F12	F12	0	0	Pointer Ridge Ele
10	Point	864	Cell	0	0	0	Solid	SCHOOL	H12	H12	0	0	Mattaponi Elemen
11	Point	867	Cell	0	0	0	Solid	SCHOOL	H12	H12	0	0	Baden Elementar
12	Point	869	Cell	0	0	0	Solid	SCHOOL	H12	H12	0	0	William S. Schmid
13	Point	899	Cell	0	0	0	Solid	SCHOOL	H11	H11	0	0	Gwynn Park High
14	Point	900	Cell	0	0	0	Solid	SCHOOL	H11	H11	0	0	Gwynn Park Midd
15	Point	905	Cell	0	0	0	Solid	SCHOOL	G12	G12	0	0	Largo High Schoo
16	Point	906	Cell	0	0	0	Solid	SCHOOL	G12	G12	0	0	Kettering Element
17	Point	907	Cell	0	0	0	Solid	SCHOOL	G12	G12	0	0	Kettering Middle S
18	Point	910	Cell	0	0	0	Solid	SCHOOL	G12	G12	0	0	Queen Anne Sch

Vector Analysis

- Spatial Join
  - Overview
    - A Spatial Join joins attributes from one layer to another based on feature location.
    - Spatial Join is a special case of tabular join. It uses the location of features, instead of a common field, to match the records in attribute tables.
    - Like tabular joins, spatial join will also append fields from a source table to the destination table.
    - It is based on spatial information such as distance, intersection, or containment.

Vector Analysis

- Spatial Join
  - Overview
    - There are two types of spatial relationship used to compare the locations of the features in the joined layers:
      - Proximity
      - Containment
    - The type of spatial join is dependent on the layer feature type.

Vector Analysis

- Spatial Join
  - Overview
    - Three different types:
      - Inside:
        - » Moves attributes of one theme to features of another based on location (one theme must be a polygon theme)
        - » Example: how many earthquakes fall within each county
      - Nearest:
        - » Determines the distance to the nearest feature of another theme (point/point, point/line)
        - » Example: which earthquake is the closest to each city
      - Intersect:
        - » Determines which features in another layer intersect the feature of another layer and summarizes the attributes of those features (line/line, line/polygon)
        - » Example: how many & which roads cross each river

Vector Analysis

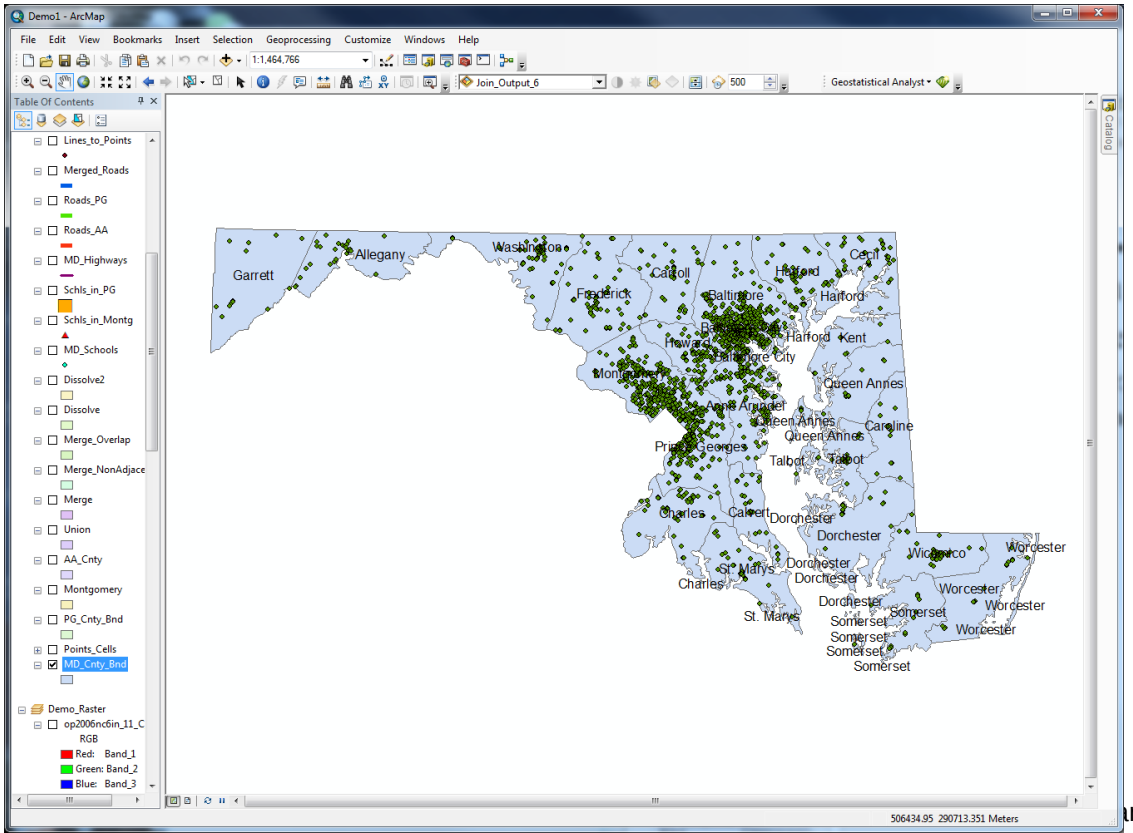
- Spatial Join
  - Overview
    - The join feature class is the layer to make a selection on.
    - The source layer contains features that to be used for defining the selection on the destination layer.
    - In the proximity relationship, the record for the feature in the source table has the greatest proximity to the record for the feature in the join table is appended to the record in the destination table.

Vector Analysis

- Spatial Join
  - Overview
    - In the containment relationship, the record for the polygon (source) completely containing the line or point (destination) is appended to the destination table's record.

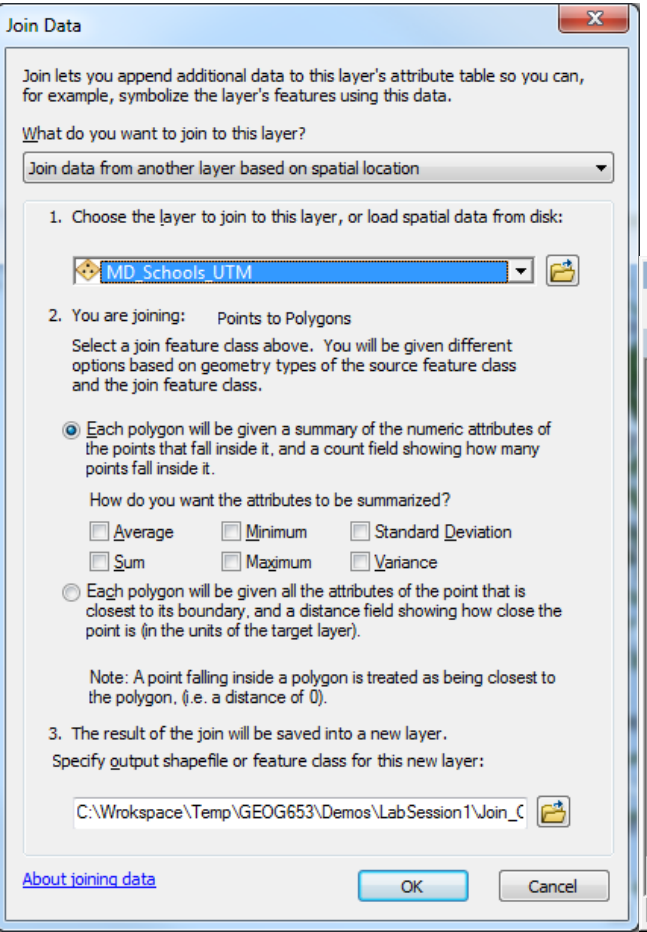
Vector Analysis

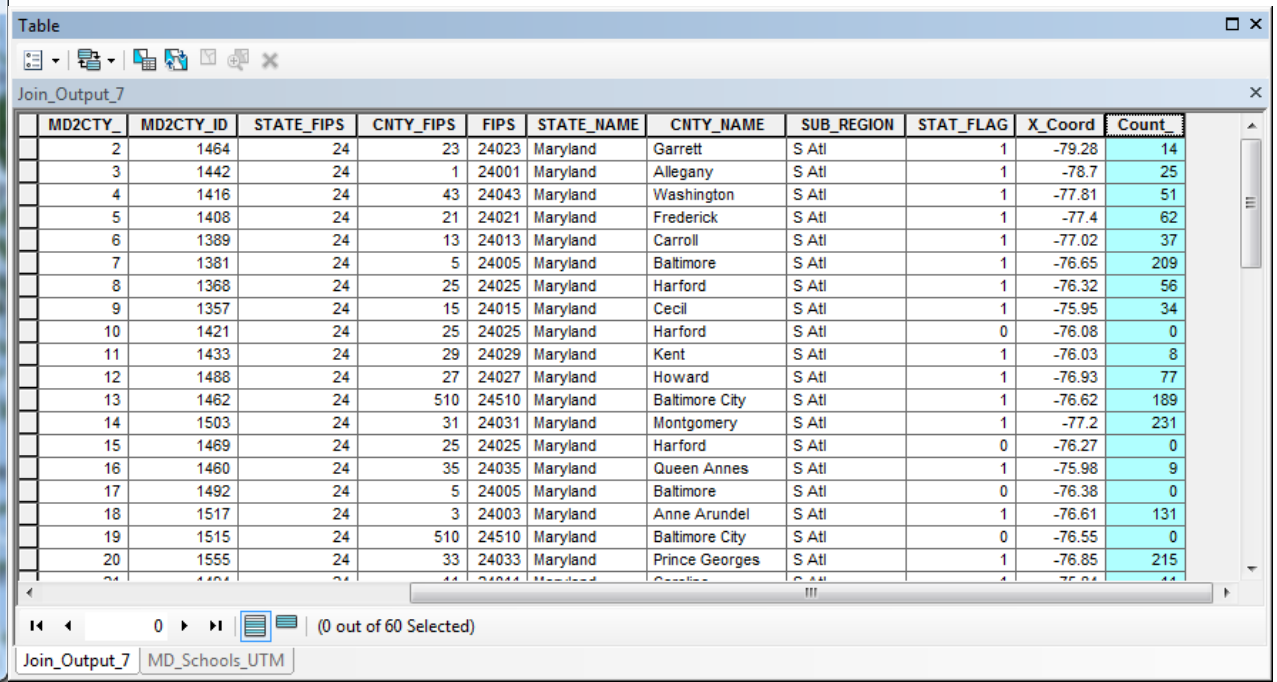
- Spatial Join
  - Containment
    - Example 1:
      - Append points to polygons.



Vector Analysis

- Spatial Join
  - Containment
    - Example 1: ('continued)

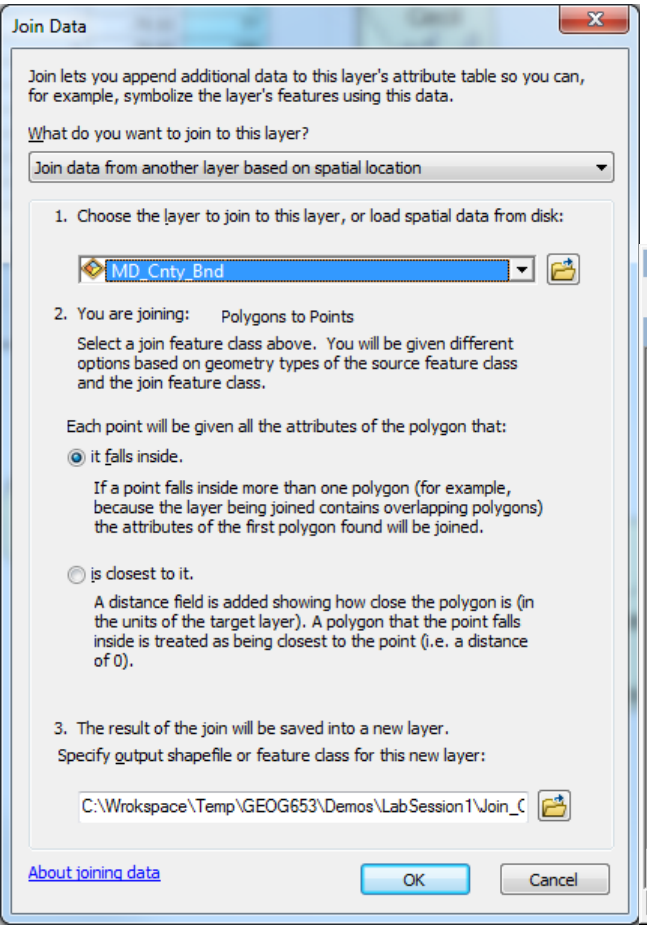


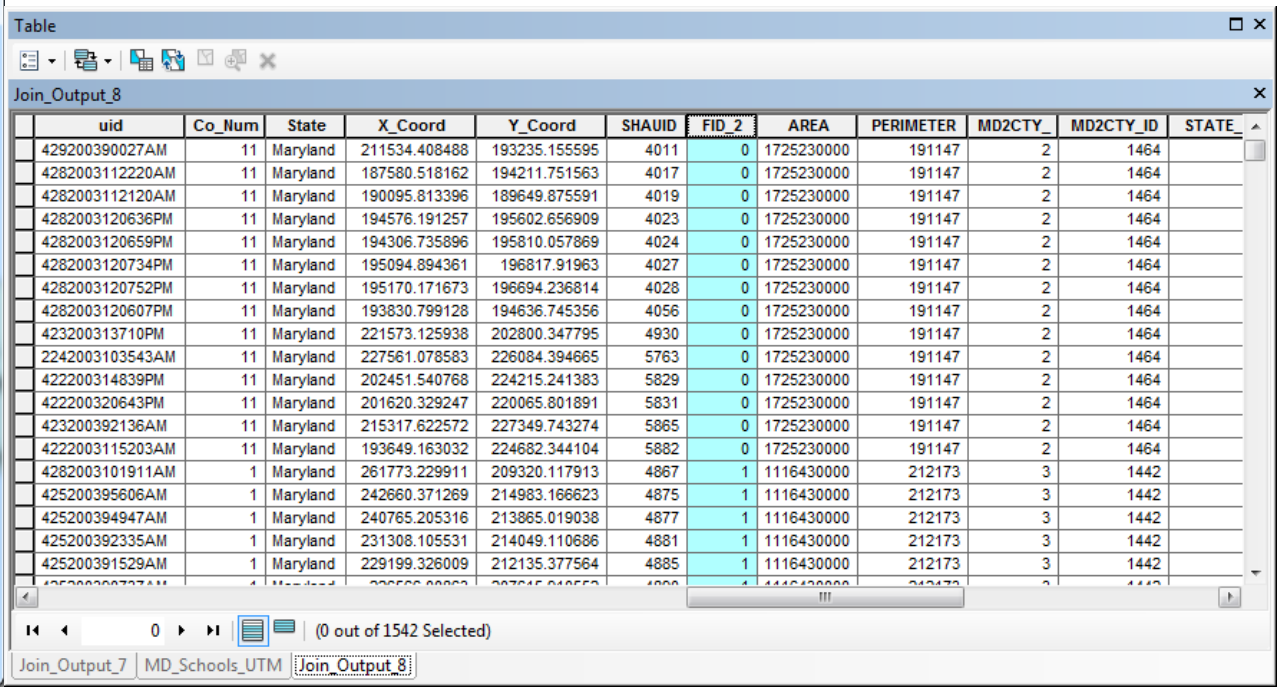


MD2CTY_	MD2CTY_ID	STATE_FIPS	CNTY_FIPS	FIPS	STATE_NAME	CNTY_NAME	SUB_REGION	STAT_FLAG	X_Coord	Count_
2	1464	24	23	24023	Maryland	Garrett	S Atl	1	-79.28	14
3	1442	24	1	24001	Maryland	Allegany	S Atl	1	-78.7	25
4	1416	24	43	24043	Maryland	Washington	S Atl	1	-77.81	51
5	1408	24	21	24021	Maryland	Frederick	S Atl	1	-77.4	62
6	1389	24	13	24013	Maryland	Carroll	S Atl	1	-77.02	37
7	1381	24	5	24005	Maryland	Baltimore	S Atl	1	-76.65	209
8	1368	24	25	24025	Maryland	Harford	S Atl	1	-76.32	56
9	1357	24	15	24015	Maryland	Cecil	S Atl	1	-75.95	34
10	1421	24	25	24025	Maryland	Harford	S Atl	0	-76.08	0
11	1433	24	29	24029	Maryland	Kent	S Atl	1	-76.03	8
12	1488	24	27	24027	Maryland	Howard	S Atl	1	-76.93	77
13	1462	24	510	24510	Maryland	Baltimore City	S Atl	1	-76.62	189
14	1503	24	31	24031	Maryland	Montgomery	S Atl	1	-77.2	231
15	1469	24	25	24025	Maryland	Harford	S Atl	0	-76.27	0
16	1460	24	35	24035	Maryland	Queen Annes	S Atl	1	-75.98	9
17	1492	24	5	24005	Maryland	Baltimore	S Atl	0	-76.38	0
18	1517	24	3	24003	Maryland	Anne Arundel	S Atl	1	-76.61	131
19	1515	24	510	24510	Maryland	Baltimore City	S Atl	0	-76.55	0
20	1555	24	33	24033	Maryland	Prince Georges	S Atl	1	-76.85	215

Vector Analysis

- Spatial Join
  - Containment
    - Example 2: Append polygons to points.

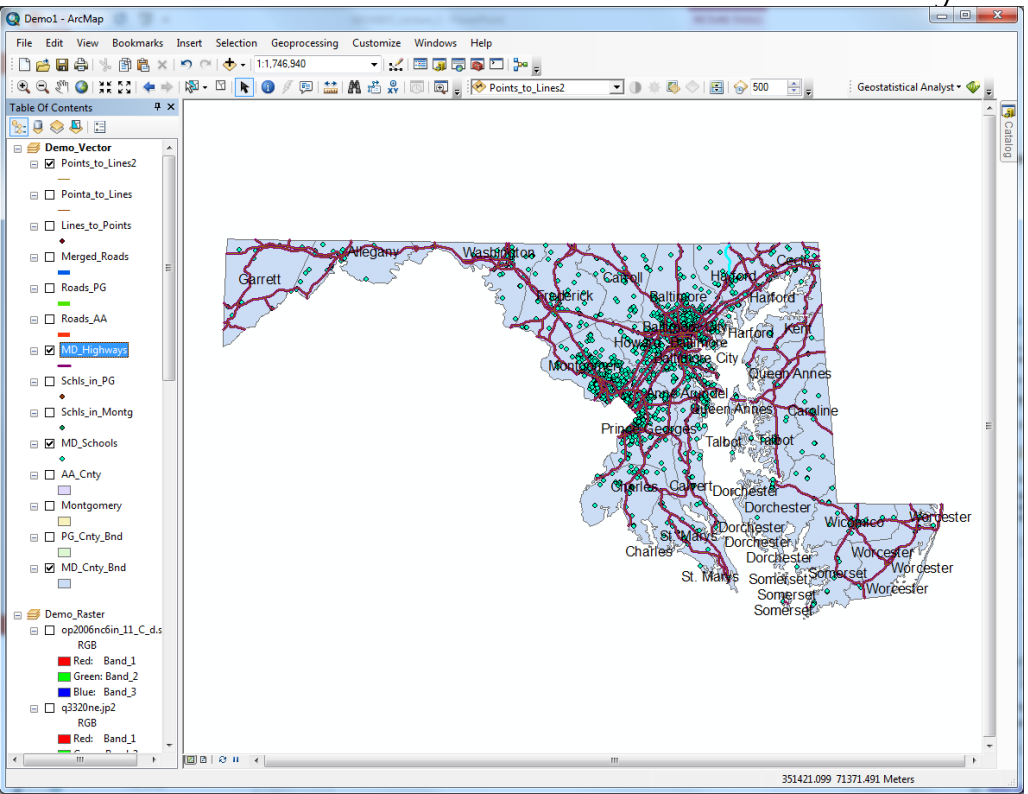


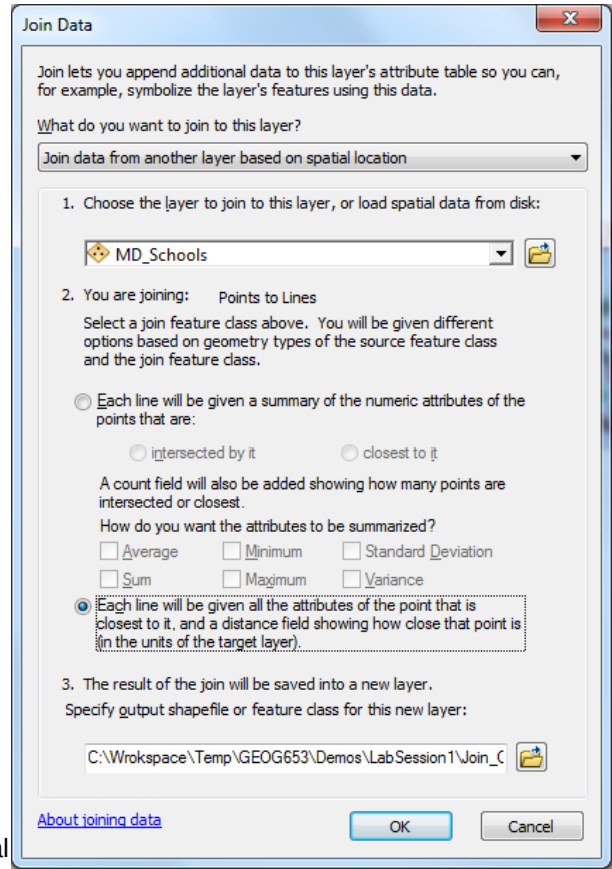


uid	Co_Num	State	X_Coord	Y_Coord	SHAUID	FID_2	AREA	PERIMETER	MD2CTY_	MD2CTY_ID	STATE_
429200390027AM	11	Maryland	211534.408488	193235.155595	4011	0	1725230000	191147	2	1464	
4282003112220AM	11	Maryland	187580.518162	194211.751563	4017	0	1725230000	191147	2	1464	
4282003112120AM	11	Maryland	190095.813396	189649.875591	4019	0	1725230000	191147	2	1464	
4282003120636PM	11	Maryland	194576.191257	195602.656909	4023	0	1725230000	191147	2	1464	
4282003120659PM	11	Maryland	194306.735896	195810.057869	4024	0	1725230000	191147	2	1464	
4282003120734PM	11	Maryland	195094.894361	196817.91963	4027	0	1725230000	191147	2	1464	
4282003120752PM	11	Maryland	195170.171673	196694.236814	4028	0	1725230000	191147	2	1464	
4282003120607PM	11	Maryland	193830.799128	194636.745356	4056	0	1725230000	191147	2	1464	
423200313710PM	11	Maryland	221573.125938	202800.347795	4930	0	1725230000	191147	2	1464	
2242003103543AM	11	Maryland	227561.078583	226084.394665	5763	0	1725230000	191147	2	1464	
422200314839PM	11	Maryland	202451.540768	224215.241383	5829	0	1725230000	191147	2	1464	
422200320643PM	11	Maryland	201620.329247	220065.801891	5831	0	1725230000	191147	2	1464	
423200392136AM	11	Maryland	215317.622572	227349.743274	5865	0	1725230000	191147	2	1464	
4222003115203AM	11	Maryland	193649.163032	224682.344104	5882	0	1725230000	191147	2	1464	
4282003101911AM	1	Maryland	261773.229911	209320.117913	4867	1	1116430000	212173	3	1442	
425200395606AM	1	Maryland	242660.371269	214983.166623	4875	1	1116430000	212173	3	1442	
425200394947AM	1	Maryland	240765.205316	213865.019038	4877	1	1116430000	212173	3	1442	
425200392335AM	1	Maryland	231308.105531	214049.110686	4881	1	1116430000	212173	3	1442	
425200391529AM	1	Maryland	229199.326009	212135.377564	4885	1	1116430000	212173	3	1442	

Vector Analysis

- Spatial Join
  - Proximity
    - Example 3:
      - Source feature class: Maryland major roads
      - Join feature class: Maryland schools





Vector Analysis

- Spatial Join
  - Proximity
    - Example 3: (‘continued)
      - The source table attributes will be appended to the destination table.
      - In addition, a field called “Distance” will be automatically added to the table, representing the distance between the source (roads) and the join (cities) features.

Table

MD_Highways

FID	Shape *	FNODE_	TNODE_	LPOLY_	RPOLY_	LENGTH	MD2RDS_	MD2RDS_ID	ESRI_CLASS	ROAD_CLASS	CLASS
0	Polyline	2	1	2	2	10520.3	1	10395	5	State secondary highway	2
1	Polyline	3	4	2	2	250.62	2	10399	8	Parallel highway	1
2	Polyline	7	8	2	2	2385.74	3	10458	1	Interstate	
3	Polyline	8	6	2	2	3272.27	4	10459	8	Parallel highway	2
4	Polyline	10	9	2	2	686.288	5	10476	5	State secondary highway	2
5	Polyline	11	4	2	2	13022.3	6	10511	8	Parallel highway	2
6	Polyline	5	11	2	2	6248.67	7	10512	3	Other U.S. highway	1
7	Polyline	13	11	2	2	1574.12	8	10568	8	Parallel highway	2
8	Polyline	14	12	2	2	4569.81	9	10591	8	Parallel highway	2

1 (0 out of 296 Selected)

Table

Points_to_Lines2

source	operator_i	updated_da	progress	uid	Co_Num	State	X_Coord	Y_Coord	SHAUID	Distance
16	ibarnes	3/18/2003	Complete	3182003104623AM	17	Maryland	470480.838682	144060.957277	1434	8780.440286
16	ibarnes	4/21/2003	Complete	4212003100041AM	10	Maryland	359578.357682	182850.559617	2969	6578.068387
16	ibarnes	3/21/2003	Complete	3212003111942AM	23	Maryland	565354.01381	77159.280158	358	6500.980578
16	ibarnes	4/11/2003	Complete	411200393016AM	18	Maryland	444701.255682	64483.587603	232	6311.0155
16	ibarnes	4/11/2003	Complete	411200393016AM	18	Maryland	444701.255682	64483.587603	232	6311.0155
16	ibarnes	3/21/2003	Complete	3212003111942AM	23	Maryland	565354.01381	77159.280158	358	6250.580281
16	ibarnes	3/21/2003	Complete	3212003111942AM	23	Maryland	565354.01381	77159.280158	358	6237.597624
16	ibarnes	3/11/2003	Complete	311200315018PM	12	Maryland	451420.072968	223224.93815	5980	6201.59477
16	ibarnes	3/21/2003	Complete	3212003111942AM	23	Maryland	565354.01381	77159.280158	358	5898.033102

0 (0 out of 296 Selected)

MD_Highways | Points_to_Lines2

Vector Analysis

- Overlay Operations
  - One of the original functions when GIS was designed
  - Geoprocessing is a broader term.
  - Geoprocessing essentially deals with automating GIS tasks, modeling and analysis.
    - More than overlaying
    - Manipulating tables
    - Changing projections

Vector Analysis

- Overlay Operations
  - Most common tools
    - Extract
    - Overlay
    - Proximity
    - Data Management

Vector Analysis

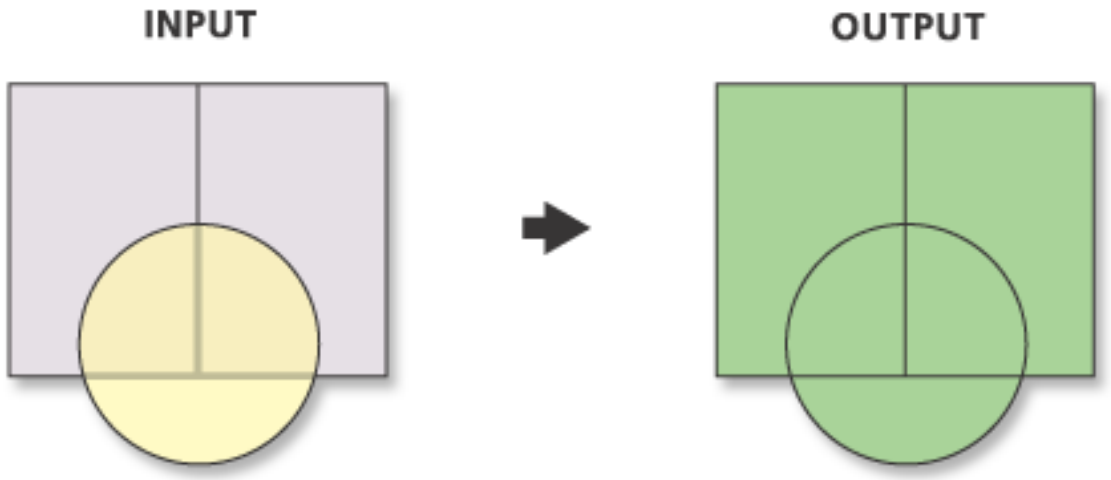
- Overlay Operations
  - Know what they are
    - Major characteristics
    - Restrictions
  - Know how to use
    - Geometry
    - Table attributes
  - Know when to use
    - Pay attention to the subtle differences between some similar operations
    - Integrate different tools

Vector Analysis

- Overlay Operations
  - Union
    - Combines two or more feature layers into a single new feature layer. All features and the attributes are written to the output feature class.
    - It is the Boolean operation: OR
    - In the vector analysis it allows to extend the boundary of any single layer.

Vector Analysis

- Overlay Operations
  - Union

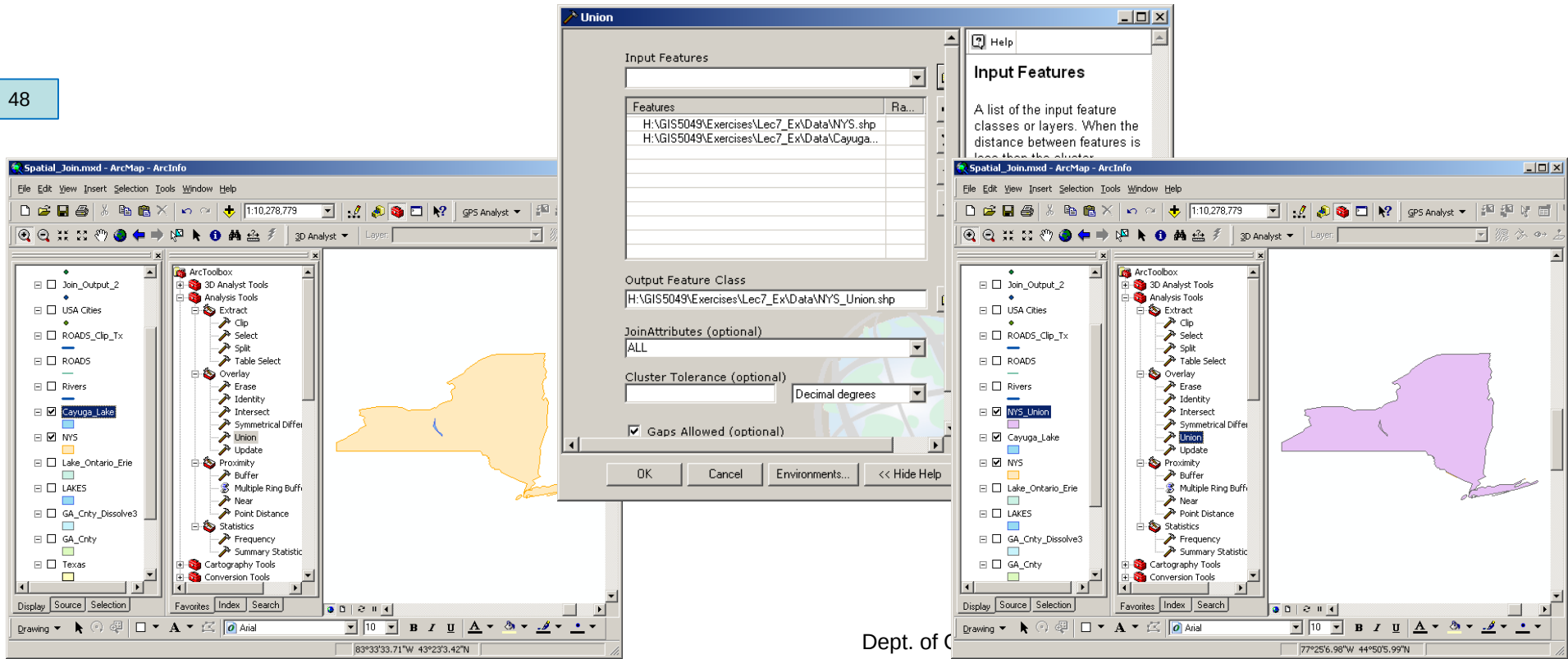


Vector Analysis

- Overlay Operations
  - Union
    - Characteristics of Union:
      - All inputs must be of polygon feature type.
      - The output features will have the attributes of all the input features that they overlap.
      - Multiple polygon feature layer and feature layers can be unioned together at a time.
      - The sequence of adding inputs does not matter.

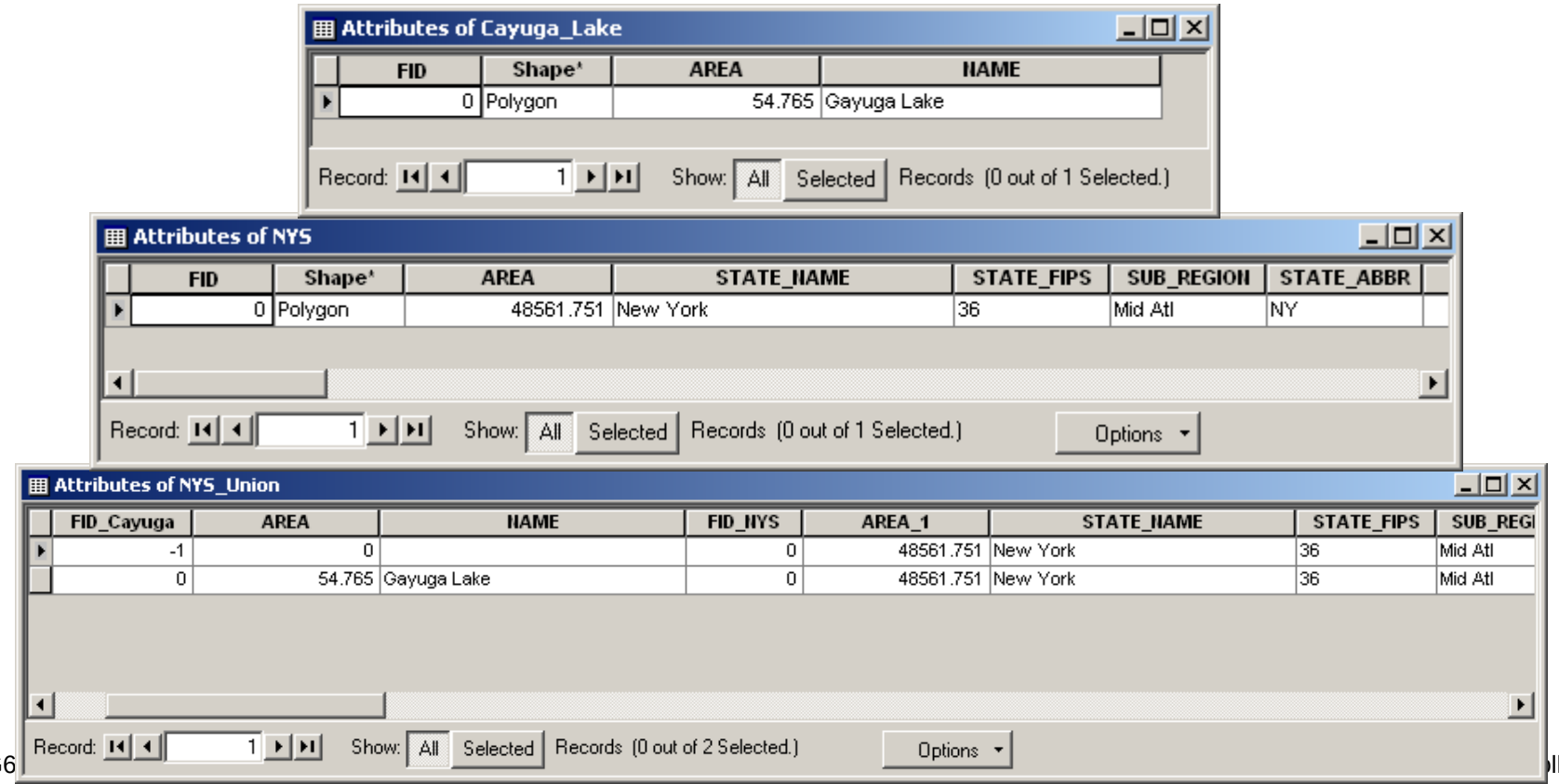
Vector Analysis

- Overlay Operations
  - Union (ArcMap)
    - Example: (one input feature is inside the other one)
      - Question: What will be the number of records in the output attribute table?



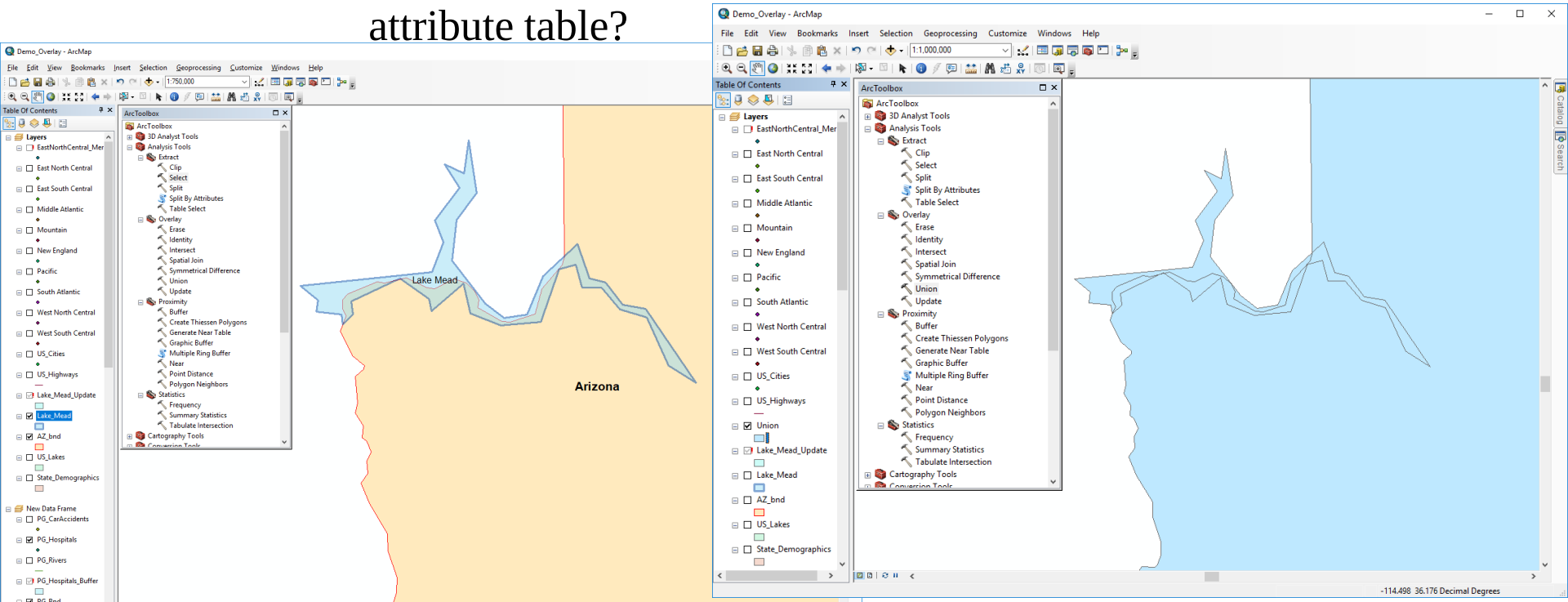
Vector Analysis

- Overlay Operations
  - Union (ArcMap)
    - Example: (‘continued)
      - All attributes from the input layers are included in the output.



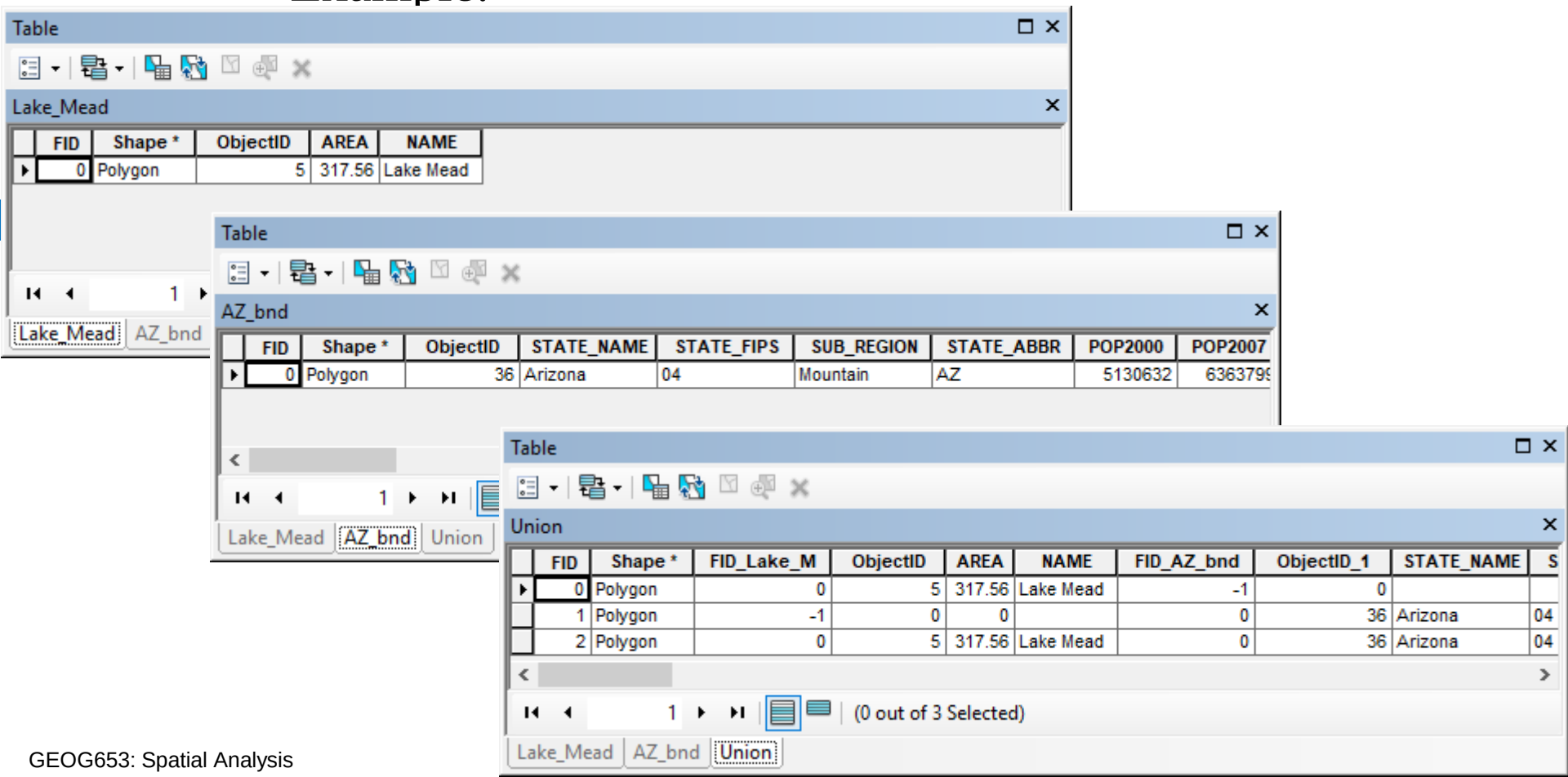
Vector Analysis

- Overlay Operations
  - Union (ArcGIS Pro)
    - Example: (one input feature is partially overlapped with the other one)
      - Question: What will be the number of records in the output attribute table?



Vector Analysis

- Overlay Operations
  - Union (ArcGIS Pro)
    - Example:

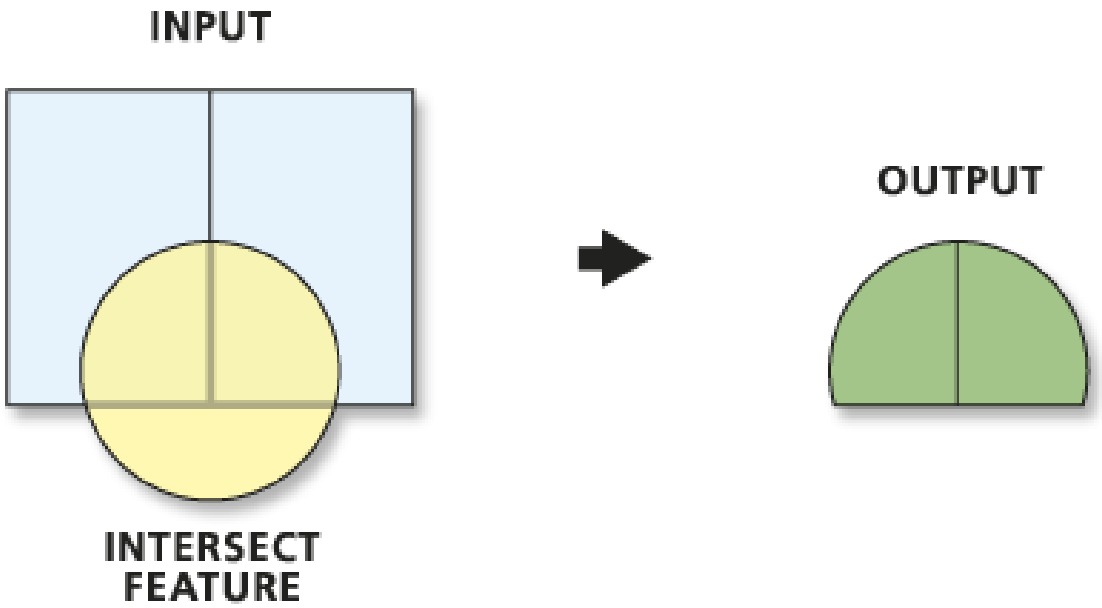


Vector Analysis

- Overlay Operations
  - Intersect
    - Computes a geometric intersection of the input features.
    - Features or portion of features common to all layers will be written to the output layer.
    - It is the Boolean operation: AND
    - In vector analysis it allows to narrow down the boundary of interest.

Vector Analysis

- Overlay Operations
  - Intersect

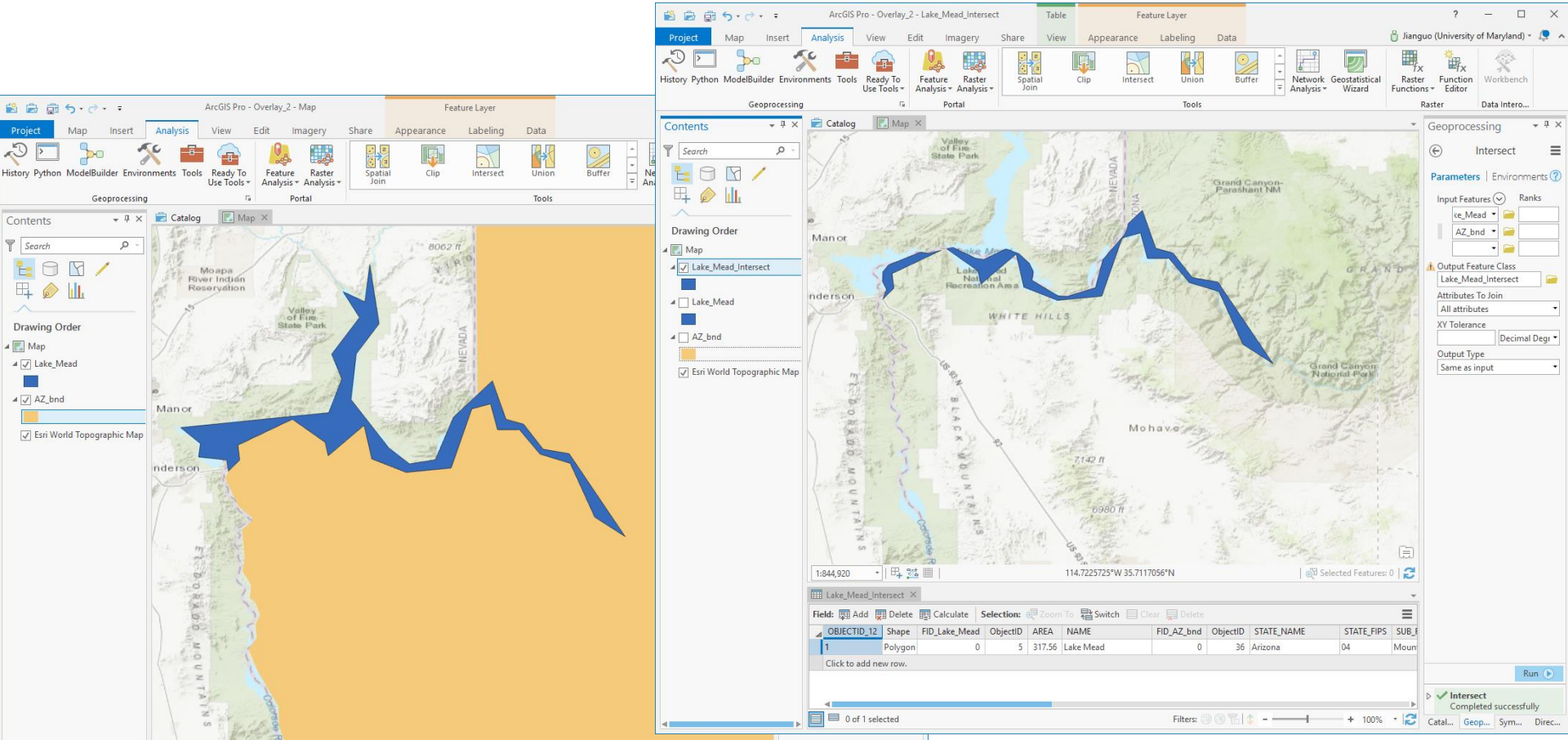


Vector Analysis

- Overlay Operations
  - Intersect
    - Characteristics of Intersect
      - The inputs can be any combination of feature types (point, multipoint, line, polygon).
        - » They cannot be complex features such as annotation features, dimension features, or network features.
      - The attribute table of the output feature layer will contain attribute information from both input features.
      - The output geometry type can only be of the same geometry or a geometry of lower dimension as the input feature layer with the lowest dimension geometry.
      - The sequence of adding inputs does not matter.

Vector Analysis

- Overlay Operations
  - Intersect (ArcGIS Pro)



Vector Analysis

- Overlay Operations
  - Clip
    - This operation will extract input features that overlay the clip features.
    - The output feature will be a portion of the input feature.
    - The attributes of the output feature layer are the same as those of the input feature layer.

Vector Analysis

- Overlay Operations
  - Clip
    - Characteristics of Clip:
      - The input feature layer can be any feature type: points, lines, or polygons.
      - The clip feature restrictions have changed.
        - » It must be a polygon before V10.0.
        - » Starting from 10.0, the clip feature can be points, lines, and polygons, depending on the feature types of the input.

Vector Analysis

- Overlay Operations
  - Clip
    - Characteristics of Clip:
      - The clip feature restrictions have changed. (since 10.0)
        - » When the Input Features are polygons, the Clip Features must also be polygons.
        - » When the Input Features are lines, the Clip Features can be lines or polygons. When clipping line features with line features, only the coincident lines or line segments are written to the output, as shown in the graphic below.
        - » When the Input Features are points, the Clip Features can be points, lines, or polygons. When clipping point features with point features, only the coincident points are written to the output. When clipping point features with line features, only the points that are coincident with the line features are written to the output.

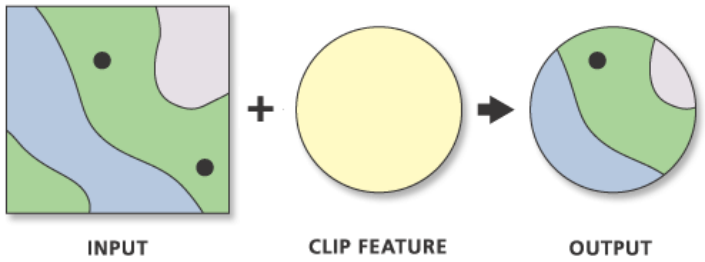
Vector Analysis

- Overlay Operations
  - Clip
    - Characteristics of Clip:
      - The output feature layer will be have the same coordinate system as the input feature layer.
      - Particularly useful for creating a new feature layer that contains a geographic subset of the features in another, larger feature layer.

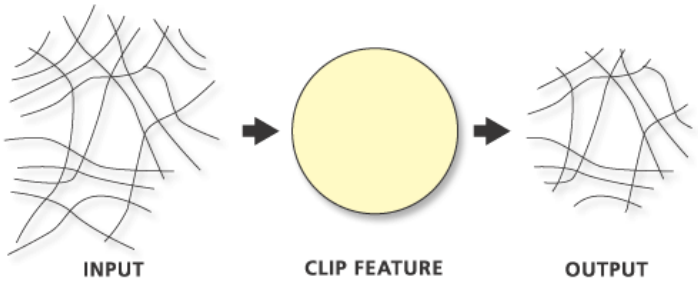
Vector Analysis

- Overlay Operations
  - Clip

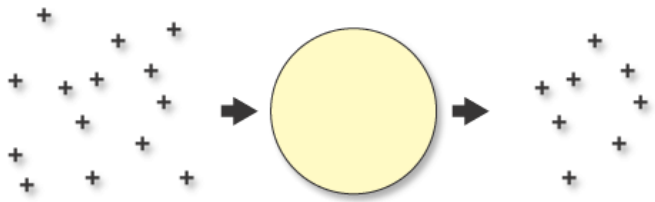
- Polygon features clipped by polygon features



- Line features clipped by polygon features



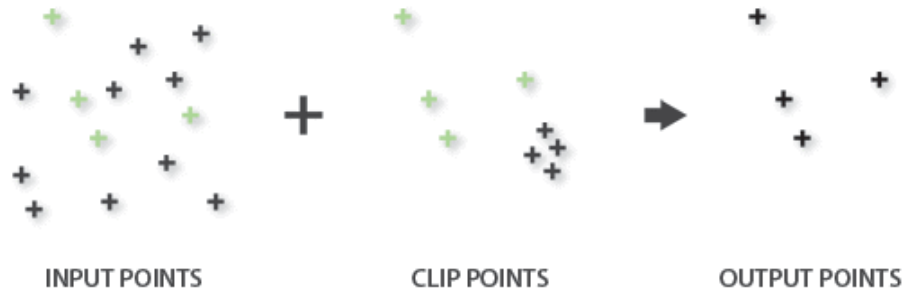
- Point features clipped by polygon features



Vector Analysis

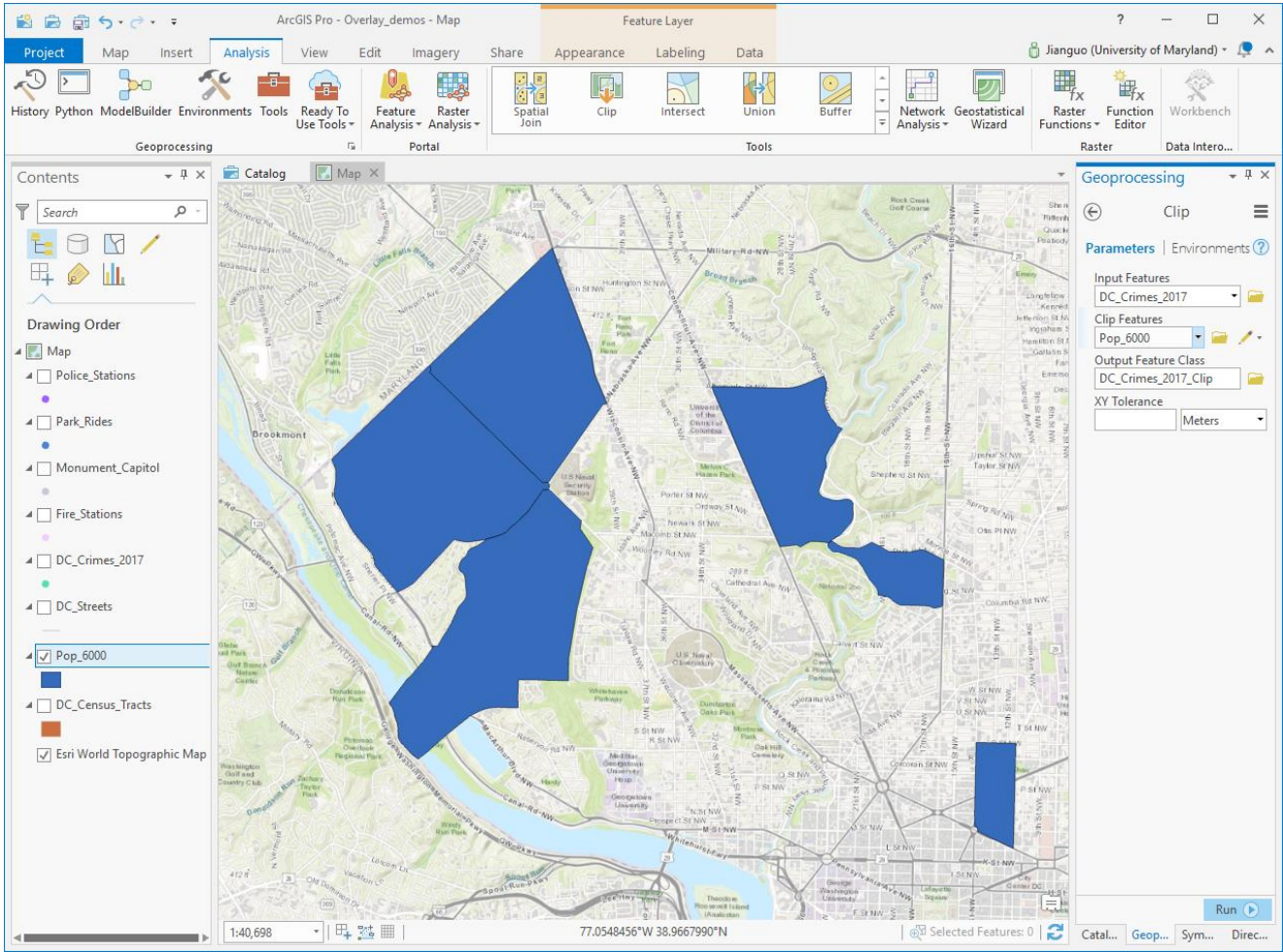
- Overlay Operations
  - Clip
    - Both the input and clip features are lines.

    - Both the input and clip features are points.



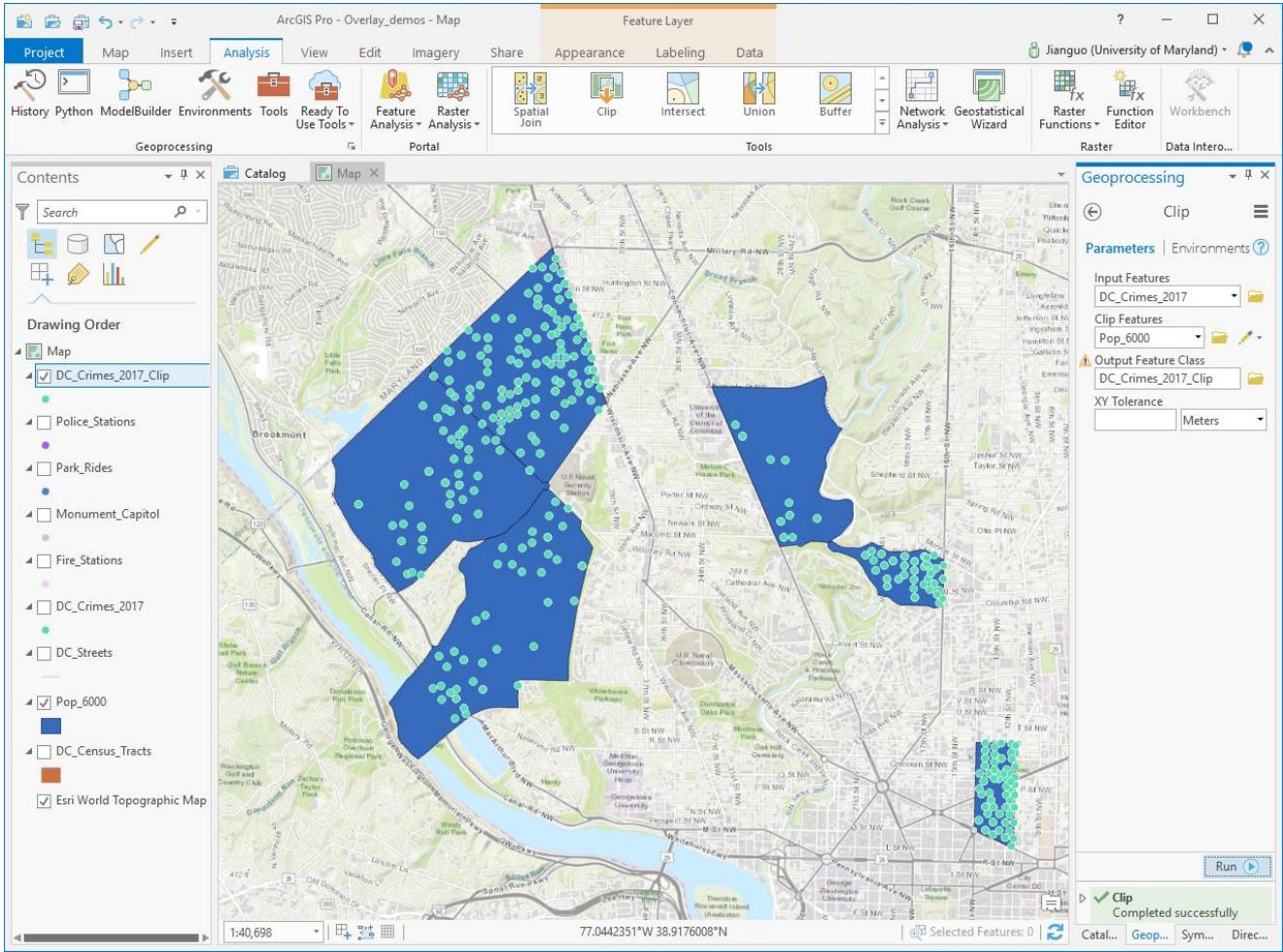
Vector Analysis

- Overlay Operations
  - Clip (ArcGIS Pro)
    - Example:



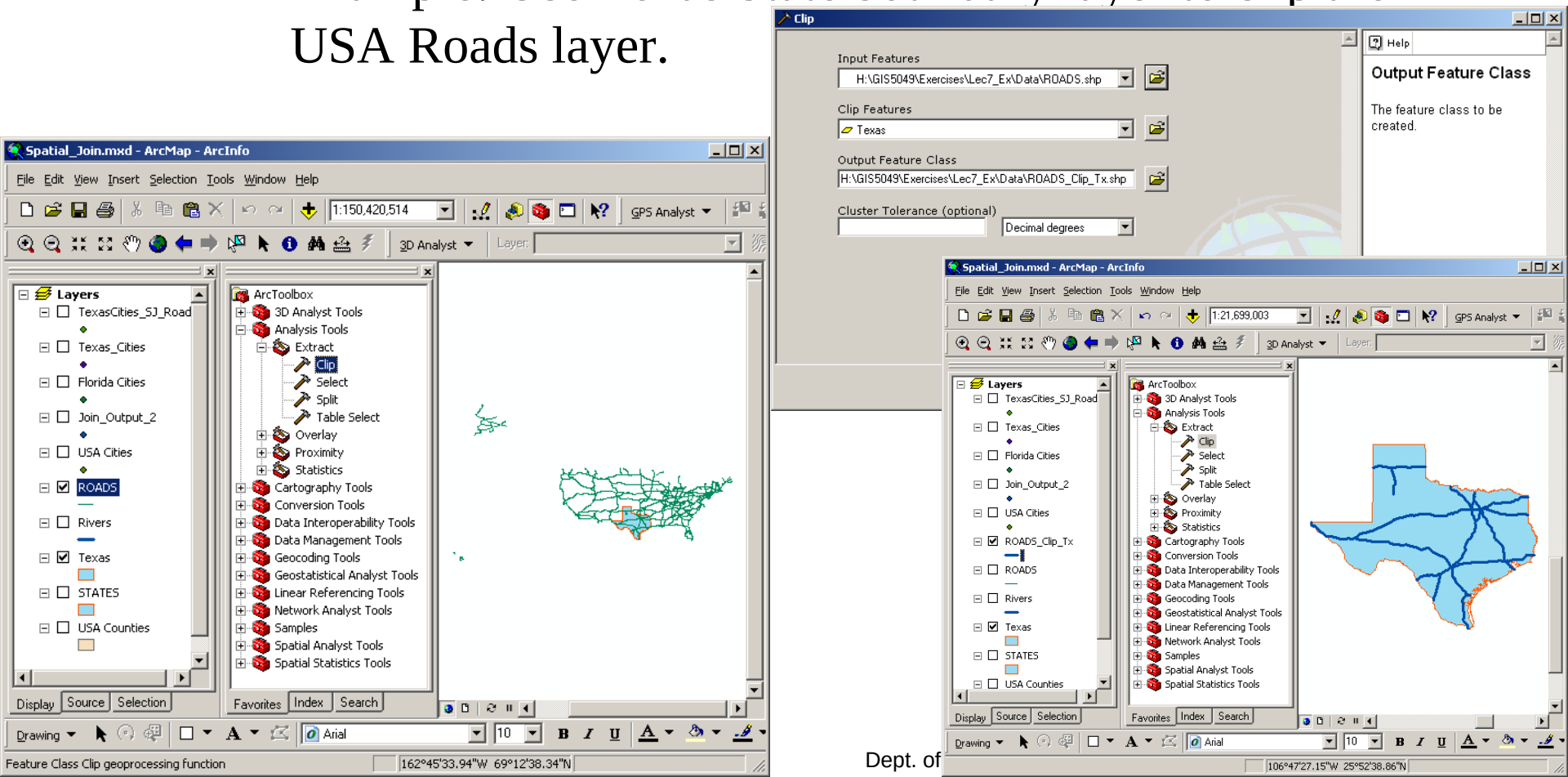
Vector Analysis

- Overlay Operations
  - Clip (ArcGIS Pro)
    - Example:



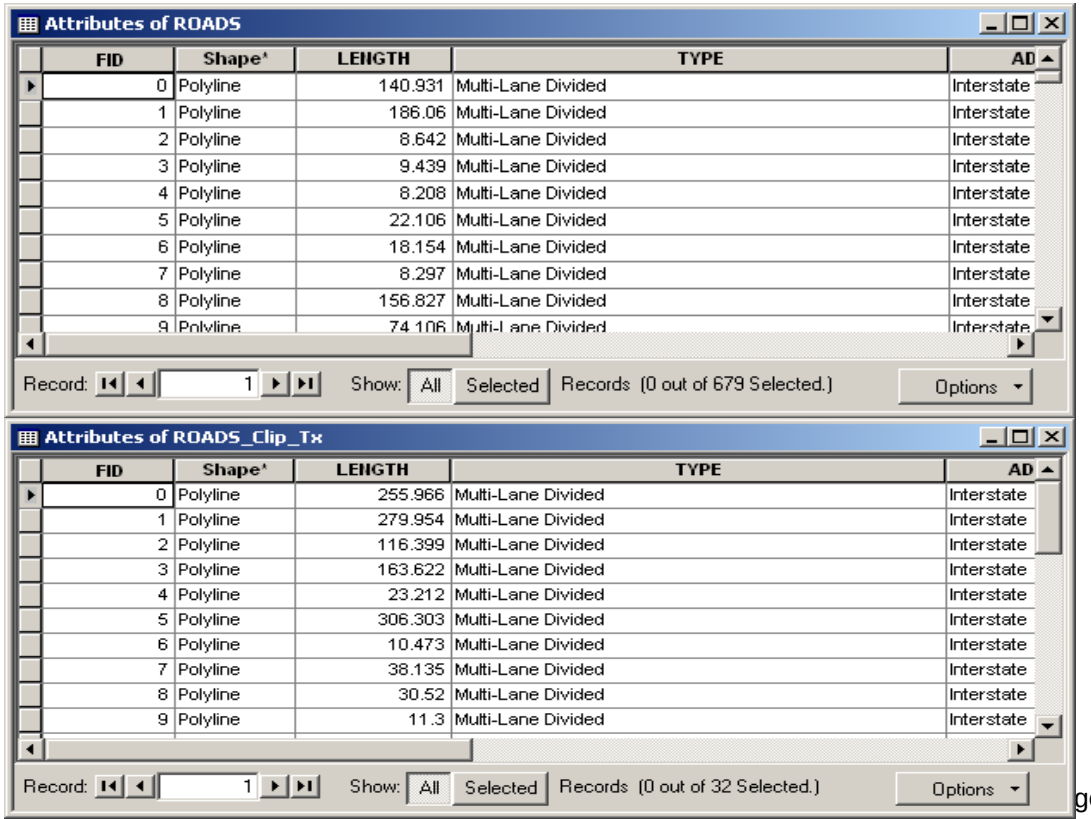
Vector Analysis

- Overlay Operations
  - Clip (ArcMap)
    - Example: Use Texas State boundary layer to clip the USA Roads layer.



Vector Analysis

- Overlay Operations
  - Clip (ArcMap)
    - Example: (‘continued)
    - The output layer will have the same attributes as that of the input layer – “Roads”.



Attributes of ROADS

FID	Shape*	LENGTH	TYPE	AD
0	Polyline	140.931	Multi-Lane Divided	Interstate
1	Polyline	186.06	Multi-Lane Divided	Interstate
2	Polyline	8.642	Multi-Lane Divided	Interstate
3	Polyline	9.439	Multi-Lane Divided	Interstate
4	Polyline	8.208	Multi-Lane Divided	Interstate
5	Polyline	22.106	Multi-Lane Divided	Interstate
6	Polyline	18.154	Multi-Lane Divided	Interstate
7	Polyline	8.297	Multi-Lane Divided	Interstate
8	Polyline	156.827	Multi-Lane Divided	Interstate
9	Polyline	74.106	Multi-Lane Divided	Interstate

Record: 1 Show: All Selected Records (0 out of 679 Selected.) Options

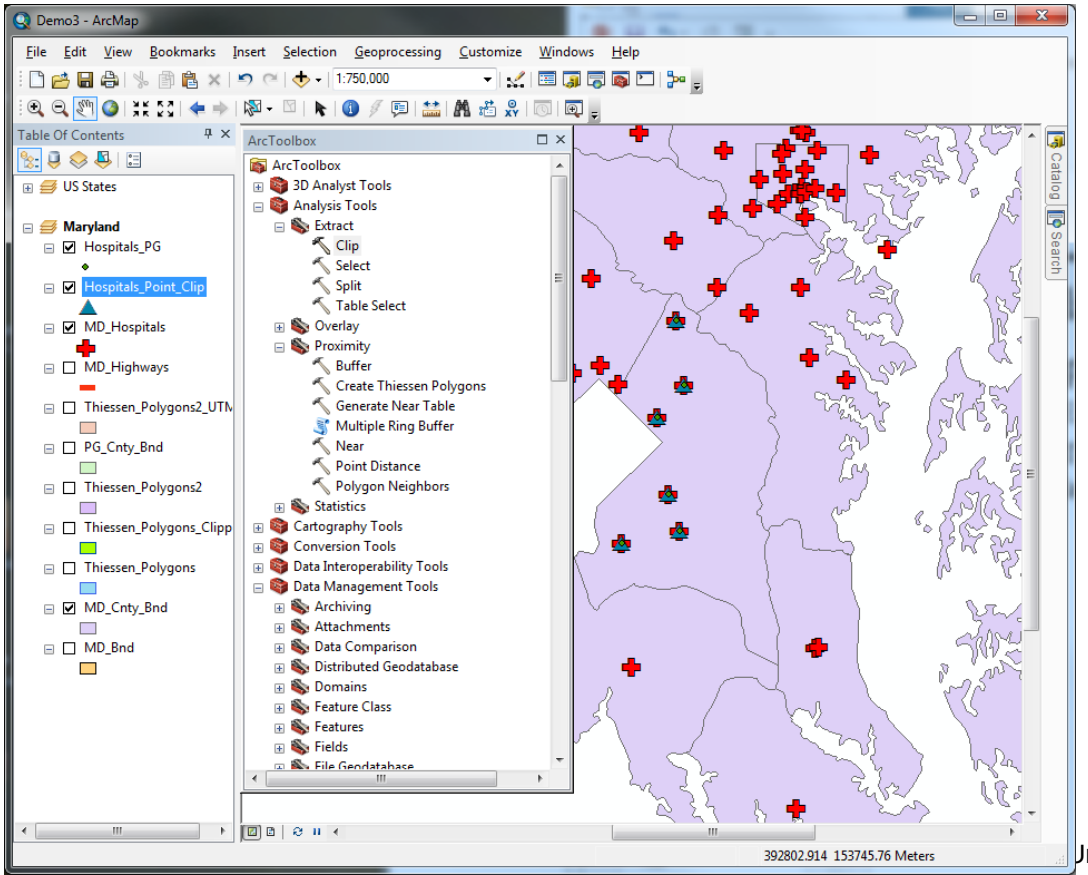
Attributes of ROADS_Clip_Tx

FID	Shape*	LENGTH	TYPE	AD
0	Polyline	255.966	Multi-Lane Divided	Interstate
1	Polyline	279.954	Multi-Lane Divided	Interstate
2	Polyline	116.399	Multi-Lane Divided	Interstate
3	Polyline	163.622	Multi-Lane Divided	Interstate
4	Polyline	23.212	Multi-Lane Divided	Interstate
5	Polyline	306.303	Multi-Lane Divided	Interstate
6	Polyline	10.473	Multi-Lane Divided	Interstate
7	Polyline	38.135	Multi-Lane Divided	Interstate
8	Polyline	30.52	Multi-Lane Divided	Interstate
9	Polyline	11.3	Multi-Lane Divided	Interstate

Record: 1 Show: All Selected Records (0 out of 32 Selected.) Options

Vector Analysis

- Overlay Operations
  - Clip (ArcMap)
    - Example: (both Input and Clip features are points)
      - Only the coincident points are written to the output.

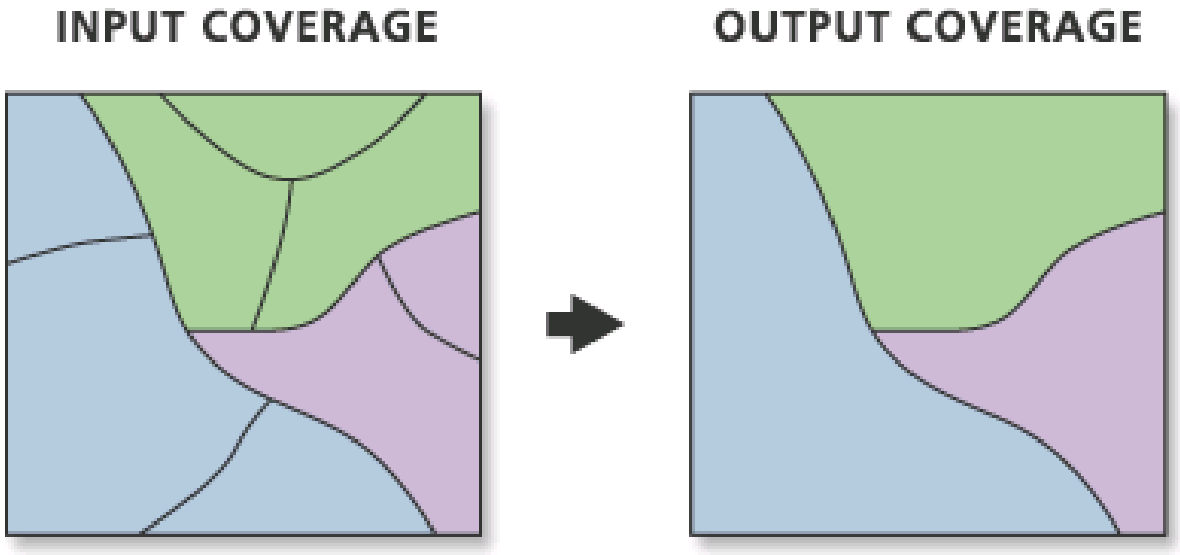


Vector Analysis

- Overlay Operations
  - Dissolve
    - Generalization toolset.
    - This operation aggregates features based on specified attributes.
    - It will create a new layer by merging layers that have the same value for a specified item.
    - It is often used to create a simplified coverage from one that is more complex.

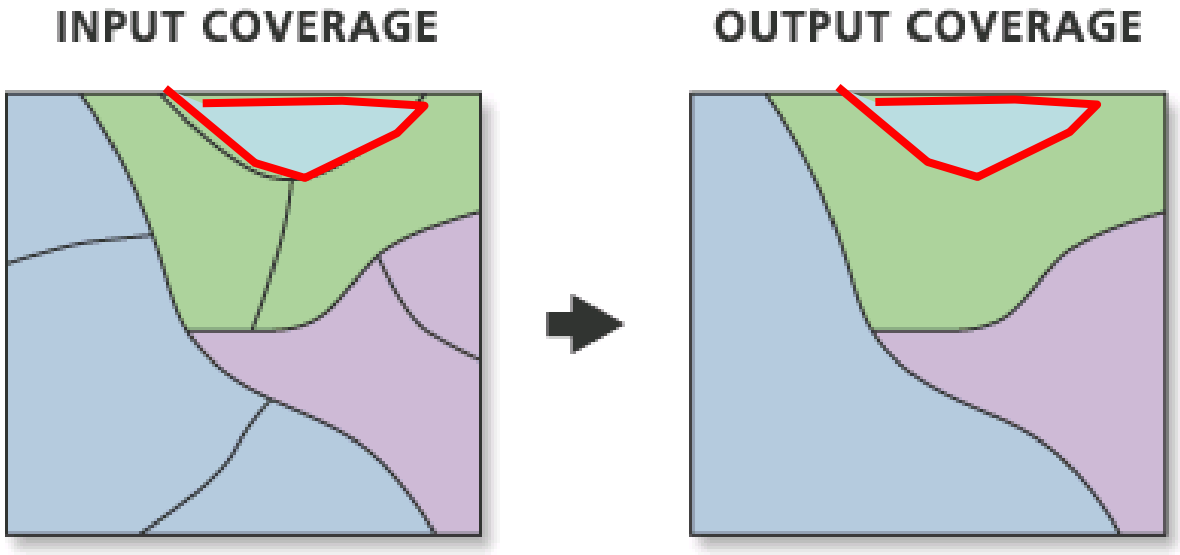
Vector Analysis

- Overlay Operations
  - Dissolve



Vector Analysis

- Overlay Operations
  - Dissolve
    - Defined by “zones” (attributes)



Vector Analysis

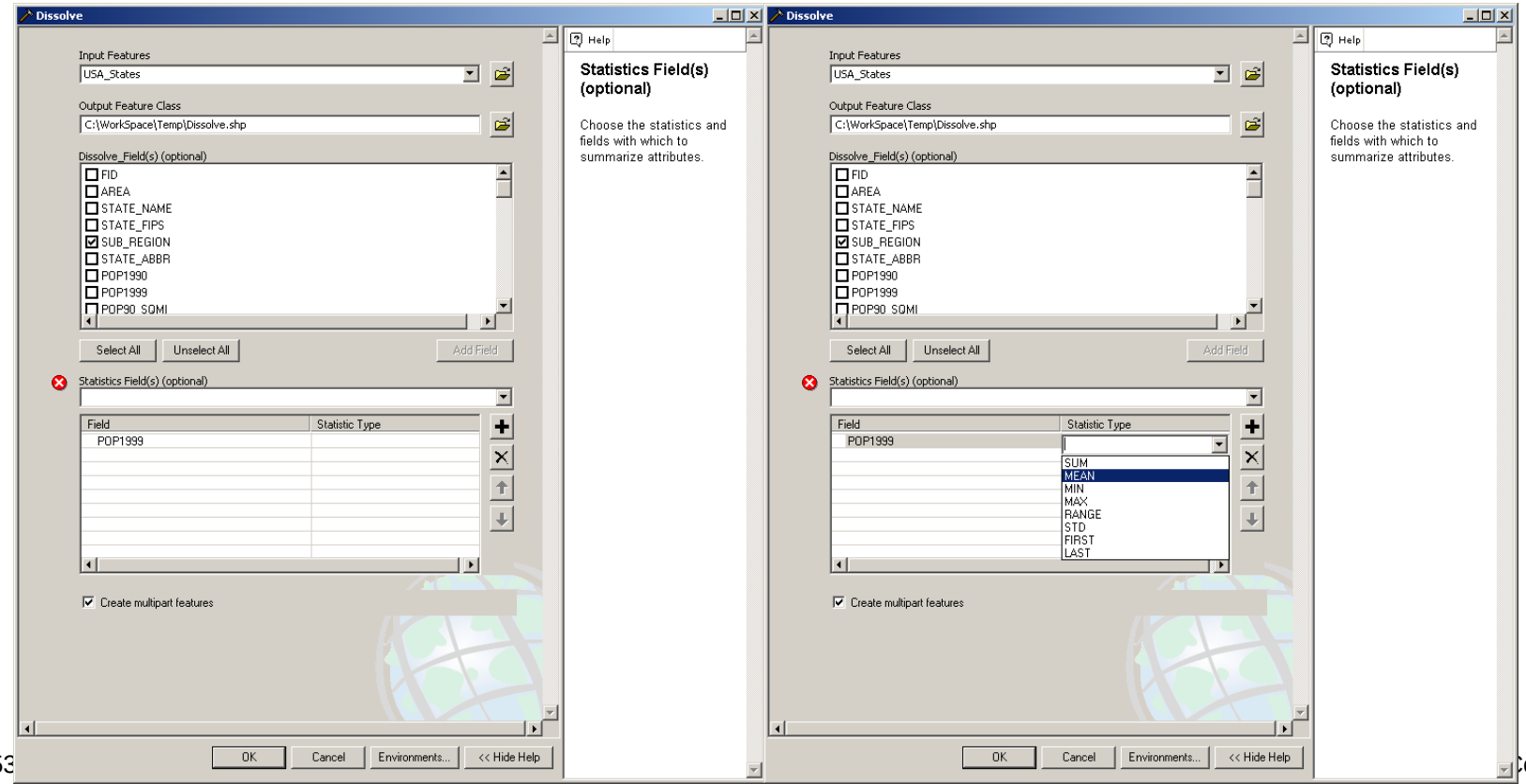
- Overlay Operations
  - Dissolve
    - Characteristics of Dissolve:
      - The input layer can be any feature types (point, line , or polygon).
      - A dissolve field must be identified/defined.
      - The features to be aggregated do NOT have to be adjacent to each other.
        - » "Zone" vs. "region"
        - » "Zone" is defined by attributes, not by location.

Vector Analysis

- Overlay Operations
  - Dissolve
    - The attributes of the aggregated features may be summarized using a statistic type.
    - Text attribute fields may be summarized using the statistics First or Last.
      - The record that is ranked as the first or last one with same value (based on dissolve field) of each group in the table.
    - Numeric attribute fields may be summarized using any statistic: Sum, Mean, Max, Min, Range, Std, First, or Last.

Vector Analysis

- Overlay Operations
  - Dissolve
    - The attributes of the aggregated features may be summarized using a statistic type.



Vector Analysis

- Overlay Operations
  - Dissolve
    - The statistic type used to summarize attributes is added to attribute table of the output feature as a field.

Attributes of Dissolve

FID	Shape *	SUB_REGION	MEAN_POP19
0	Polygon	E N Cen	8882006.4
1	Polygon	E S Cen	4153858.75
2	Polygon	Mid Atl	12787758.3333
3	Polygon	Mtn	2145487.25
4	Polygon	N Eng	2248007.5
5	Polygon	Pacific	8801677.4
6	Polygon	S Atl	5514351.44444
7	Polygon	W N Cen	2686266.71429
8	Polygon	W S Cen	7611667

Record: 1 Show: All

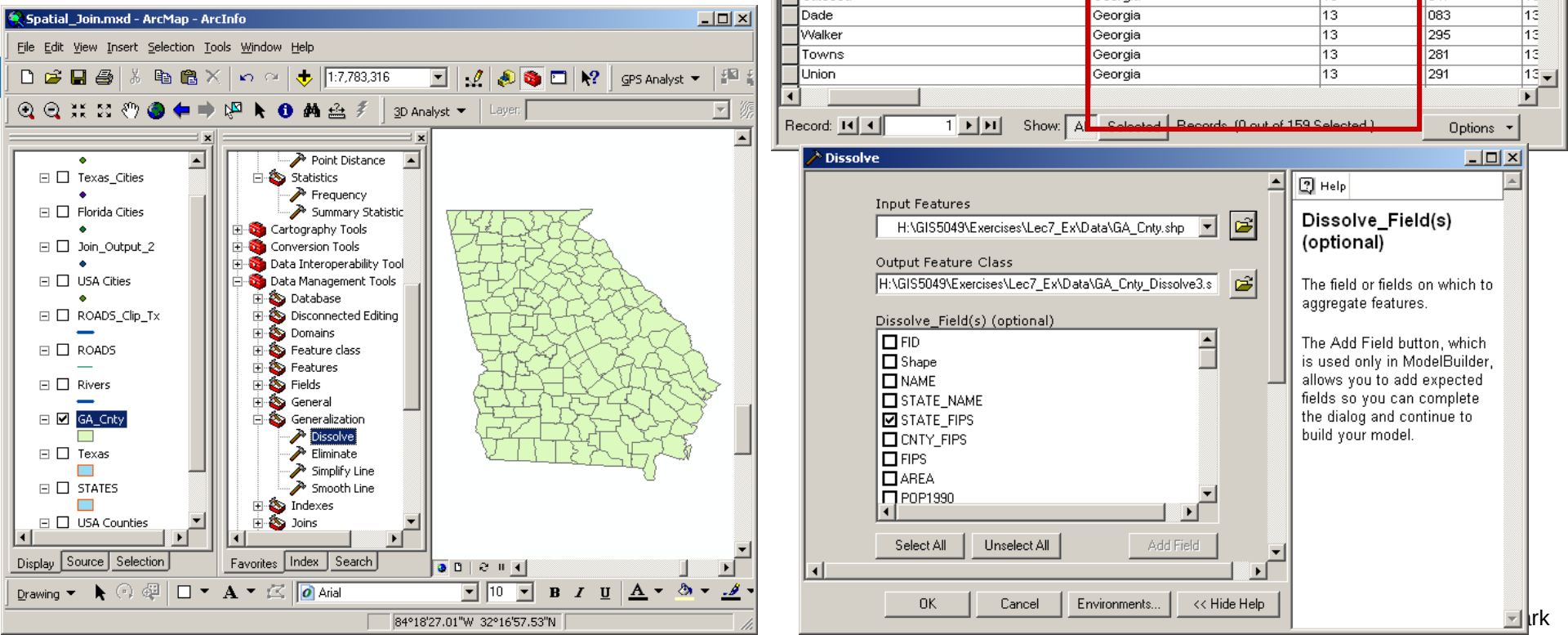
Attributes of Dissolve5

FID	Shape *	SUB_REGION	FIRST_STAT
0	Polygon	E N Cen	Wisconsin
1	Polygon	E S Cen	Kentucky
2	Polygon	Mid Atl	New York
3	Polygon	Mtn	Montana
4	Polygon	N Eng	Maine
5	Polygon	Pacific	Washington
6	Polygon	S Atl	District of Columbia
7	Polygon	W N Cen	North Dakota
8	Polygon	W S Cen	Oklahoma

Record: 1 Show: All

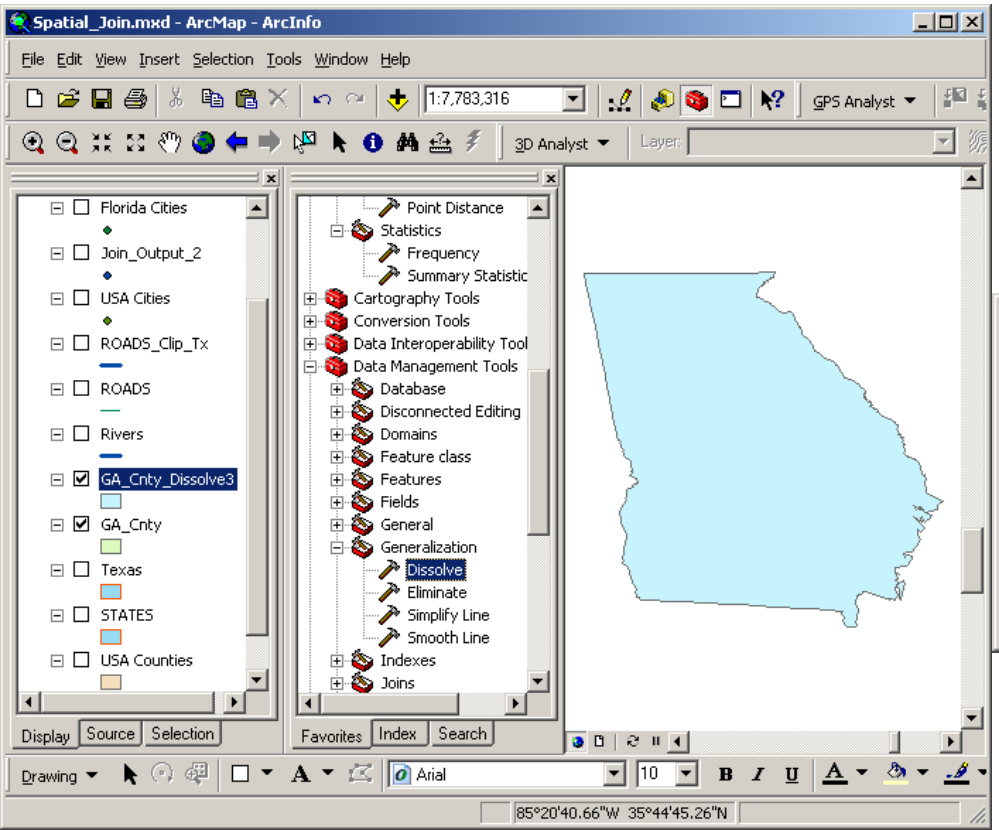
Vector Analysis

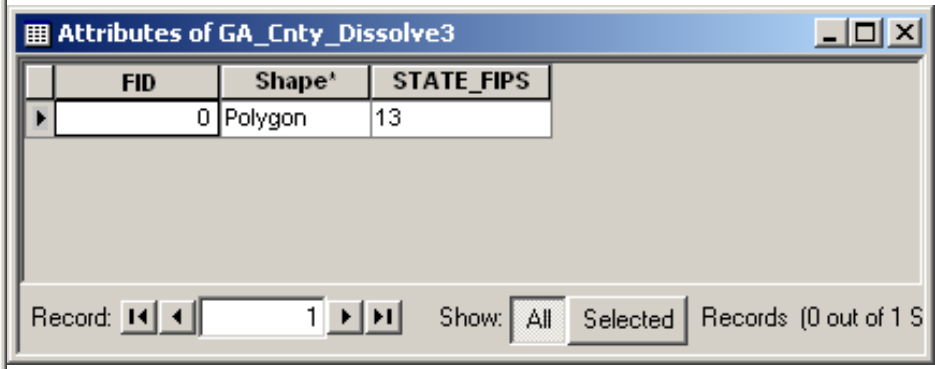
- Overlay Operations
  - Dissolve
    - Example: Dissolve the counties in Georgia to create a single polygon feature.



Vector Analysis

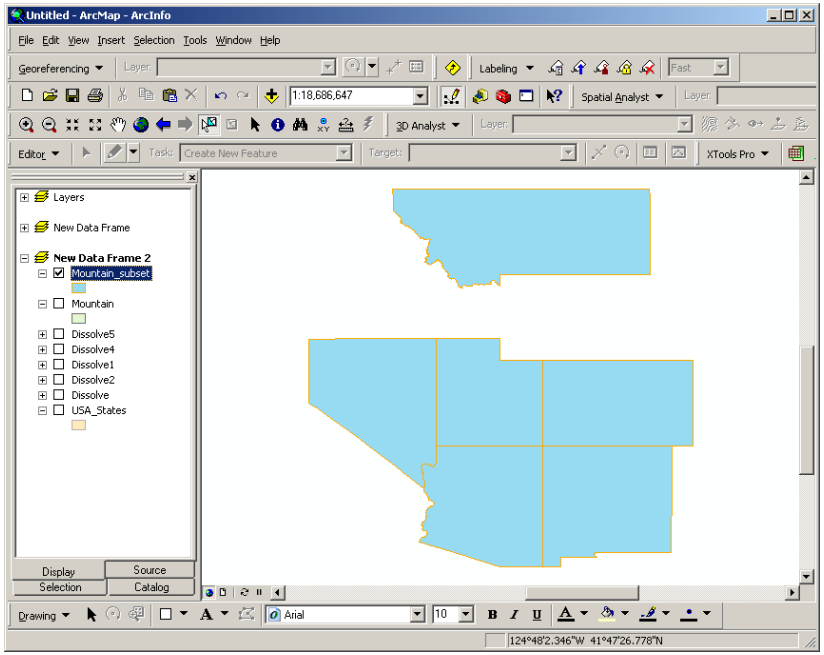
- Overlay Operations
  - Dissolve
    - Example: (‘continued)

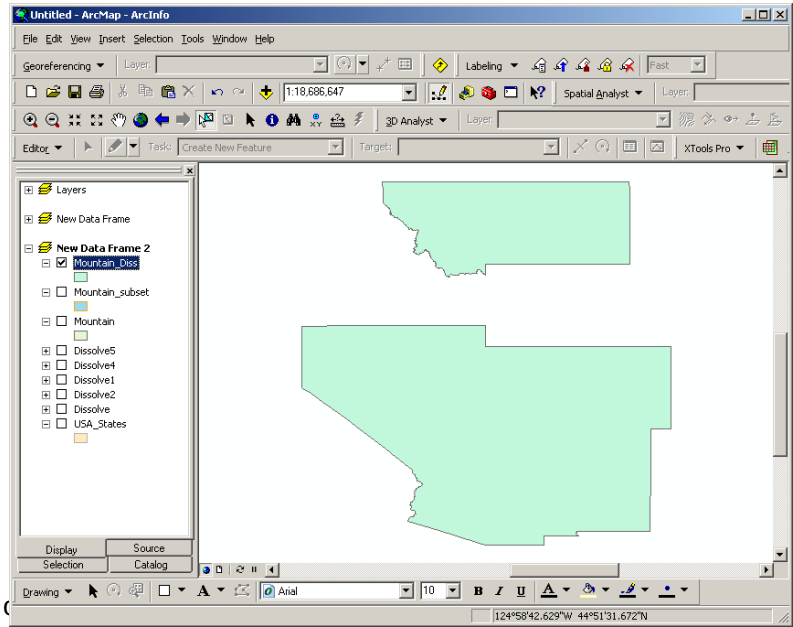




Vector Analysis

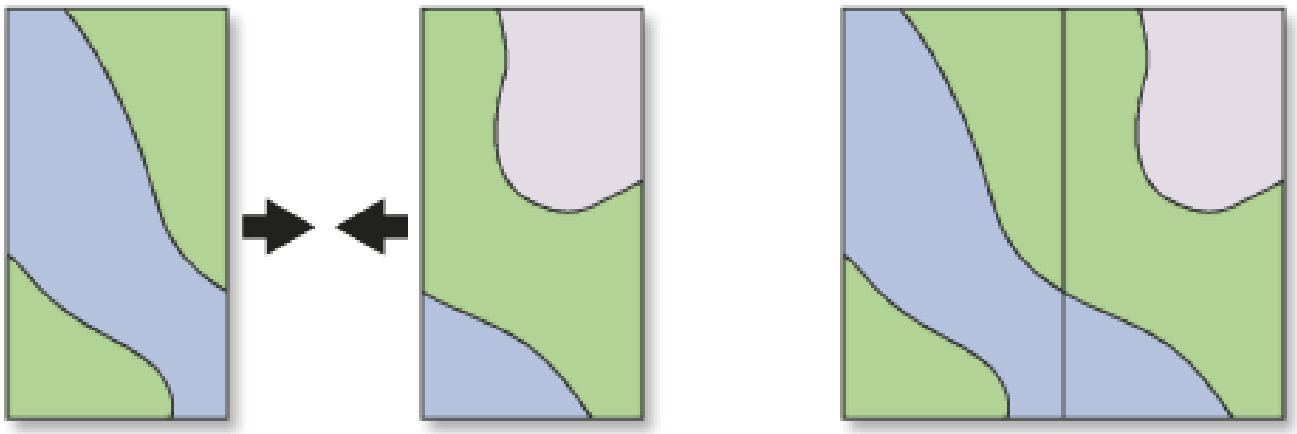
- Overlay Operations
  - Dissolve
    - Example: non-adjacent features





Vector Analysis

- Overlay Operations
  - Merge
    - Combines input features from multiple input sources (of the same data type) into a single, new, output feature layer.
    - ArcToolbox: Data Management Tools > General > Merge



Vector Analysis

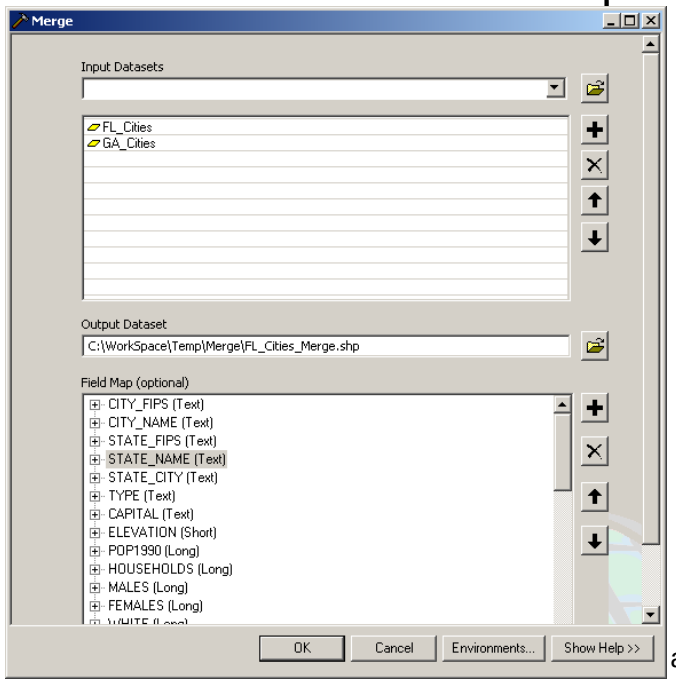
- Overlay Operations
  - Merge
    - Characteristics of Merge:
      - The input layer can be of any feature types (point, line, or polygon).
        - » However, given a specific operation, the input features must be the same type.
      - Input data sources need not be adjacent.
      - Overlap of the input layers is allowed.
      - Can merge multiple layers at a time.
      - Can't use multiple input layers of the same name.

Vector Analysis

- Overlay Operations
  - Merge
    - Characteristics of Merge: (‘continued)
      - This tool will not split or alter the geometries from the input datasets. All features from the input datasets will remain intact in the output dataset, even if the features overlap.
      - If no coordinate system is specified in the Environment Settings, the output feature class will be in the coordinate system of the first feature layer in the input features list.

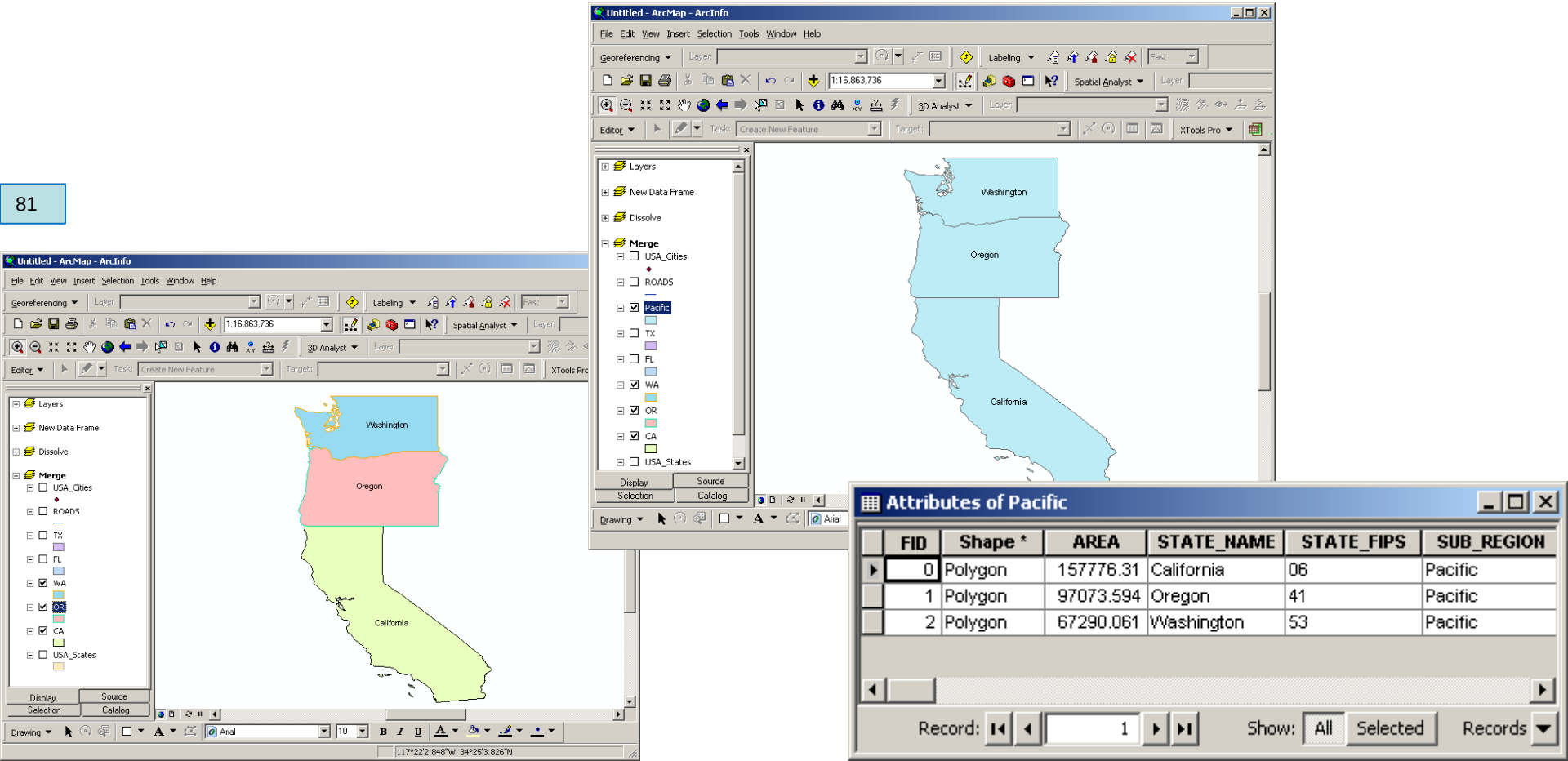
Vector Analysis

- Overlay Operations
  - Merge
    - Characteristics of Merge: (‘continued)
      - The order in which you select fields determines the order in which their values will be displayed in the output field. When joining several input fields into a single output field, the output fields' values will be generated based on the order the input fields were chosen.
      - The order can be modified.



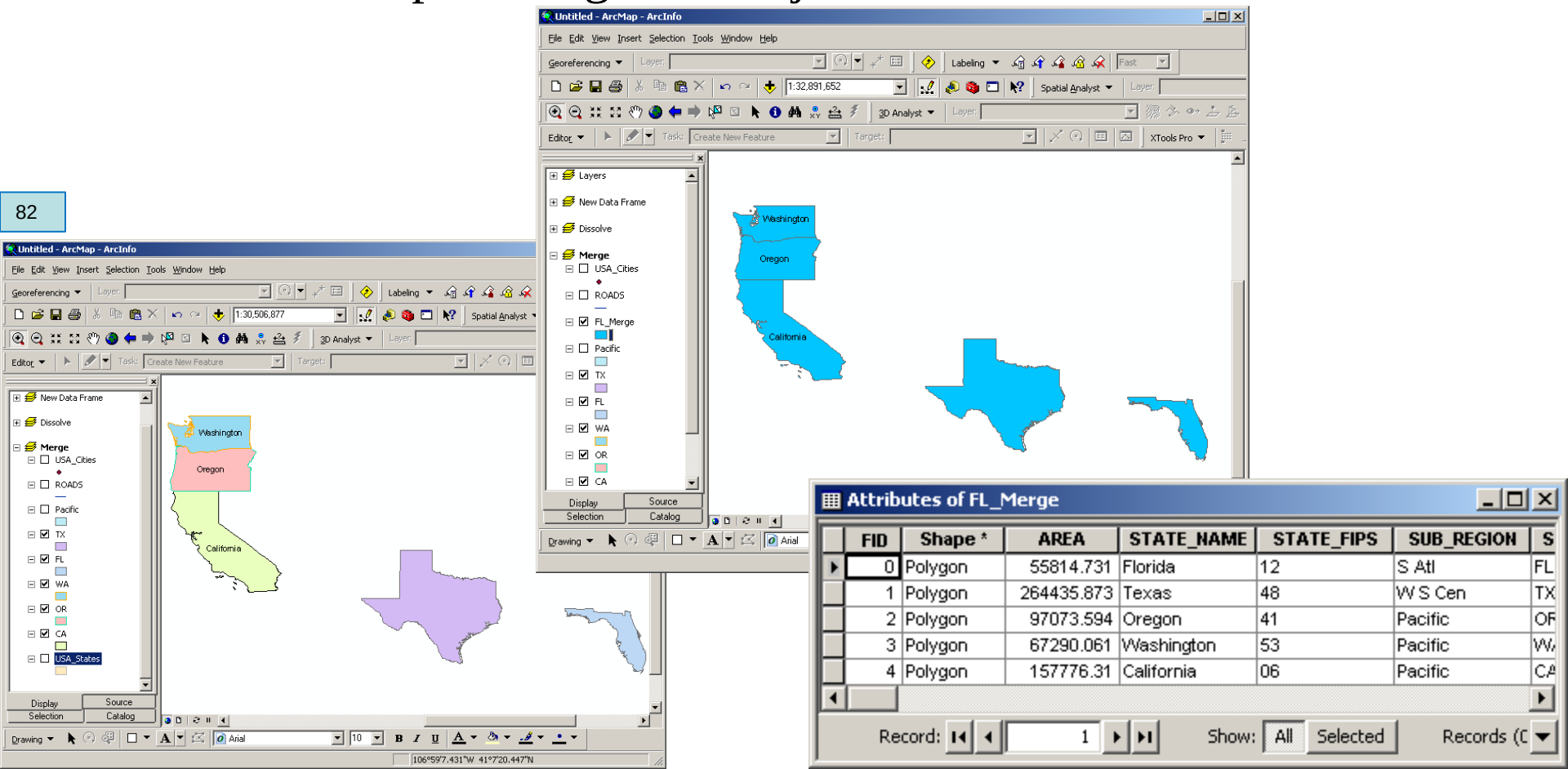
Vector Analysis

- Overlay Operations
  - Merge
    - Example: merge adjacent features



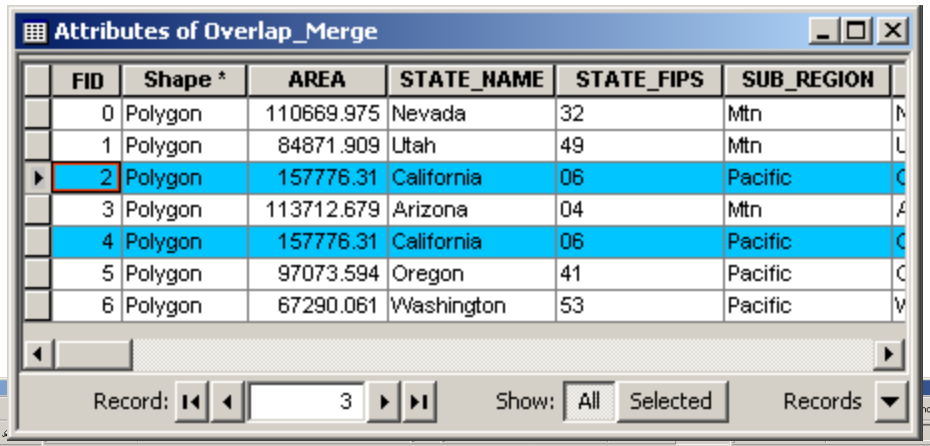
Vector Analysis

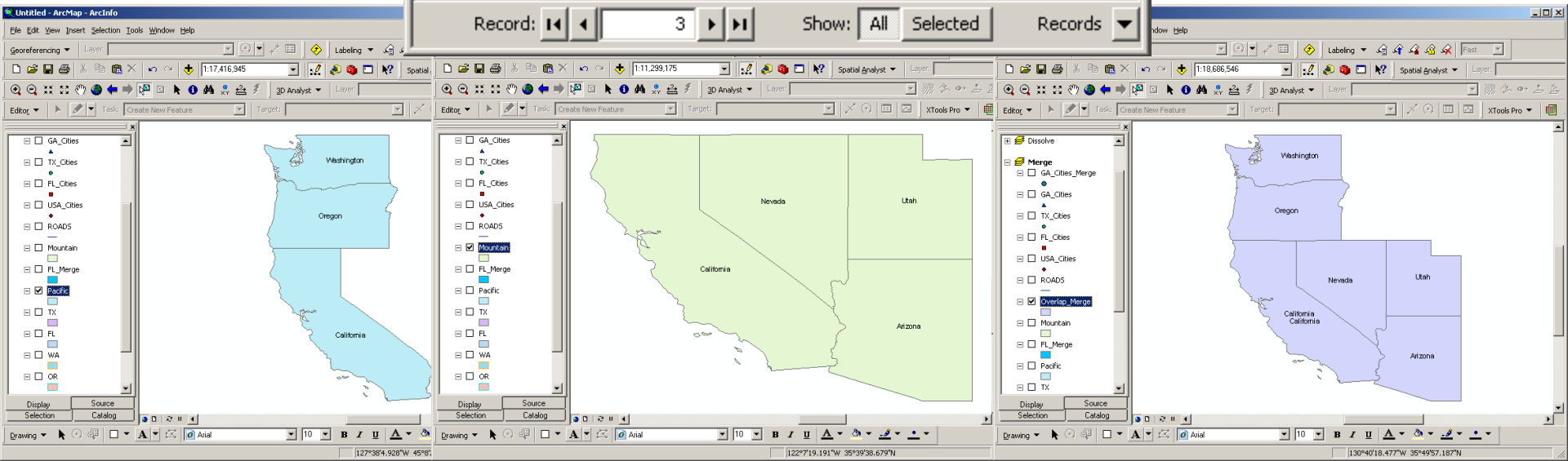
- Overlay Operations
  - Merge
    - Example: merge non-adjacent features



Vector Analysis

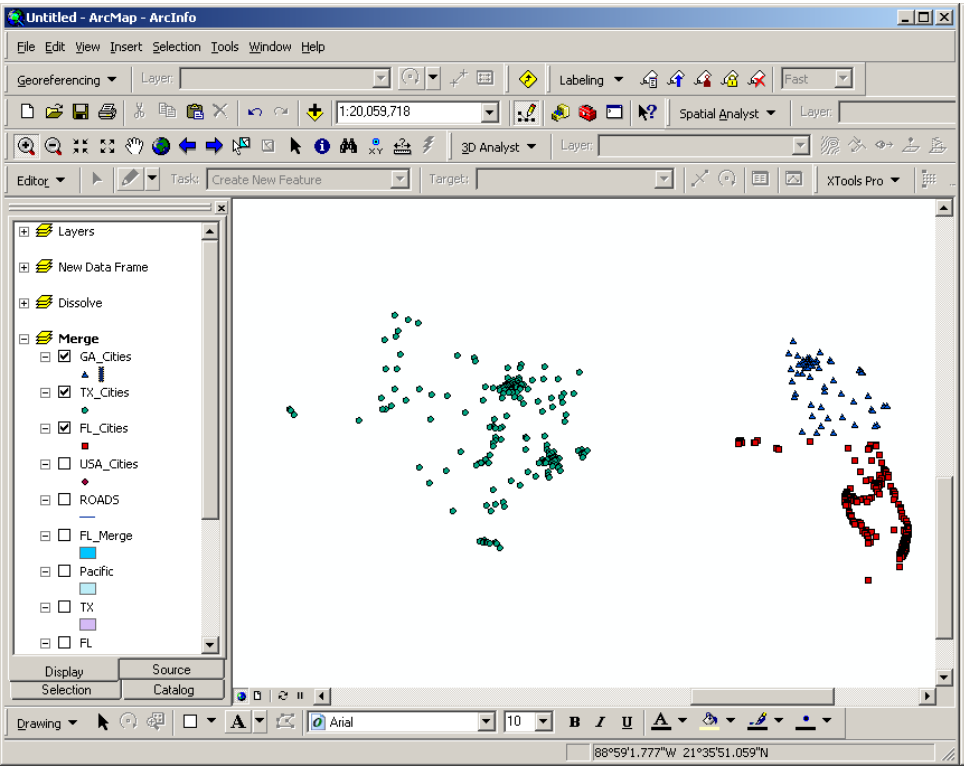
- Overlay Operations
  - Merge
    - Example: merge overlapped features

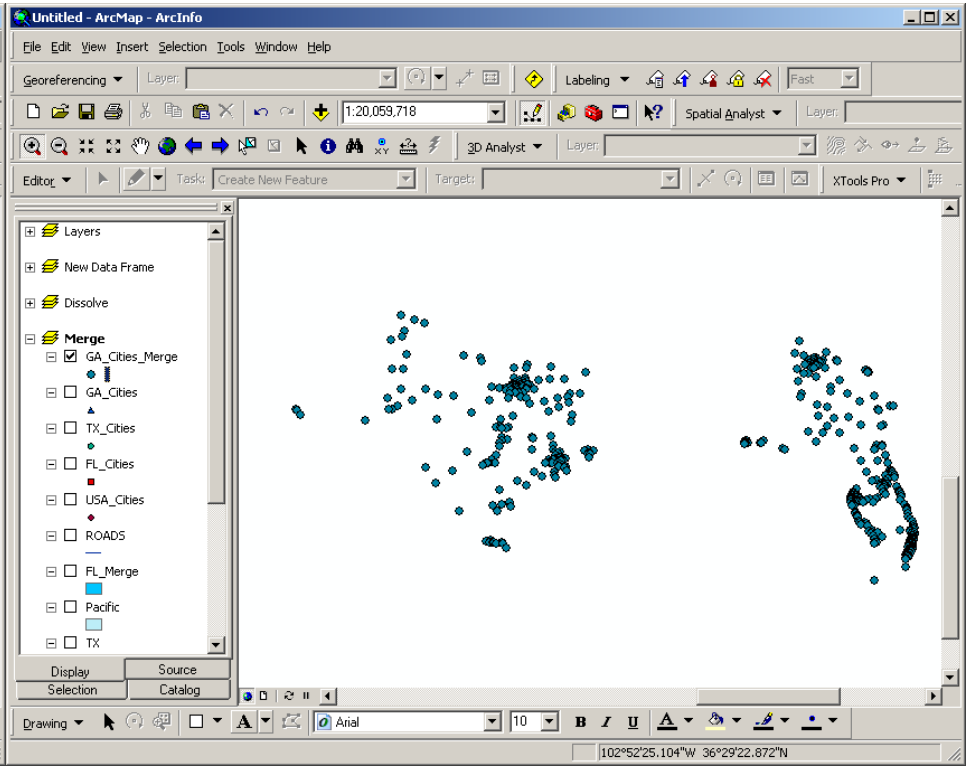




Vector Analysis

- Overlay Operations
  - Merge
    - Example: merge point features



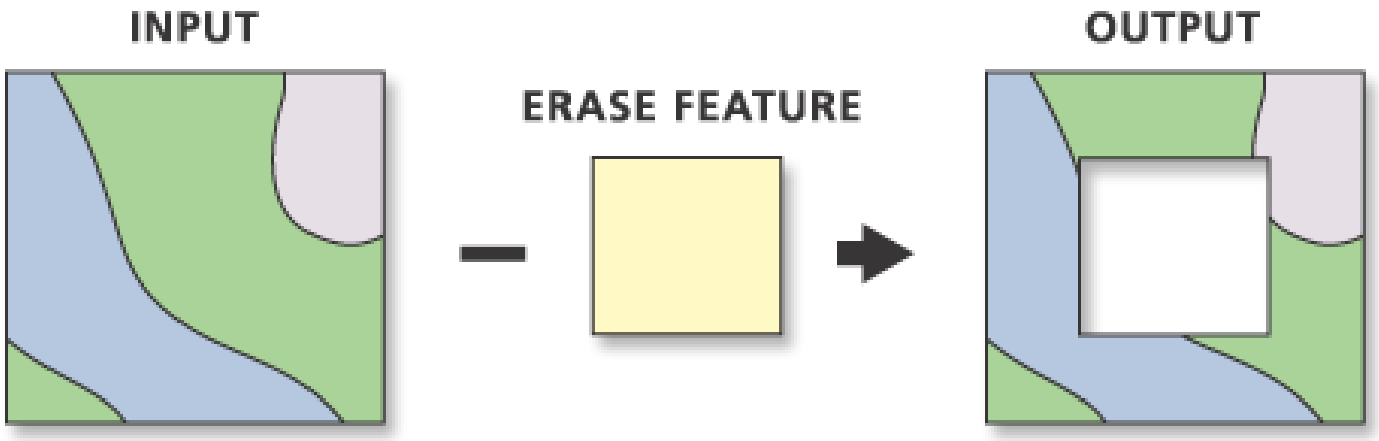


Vector Analysis

- Overlay Operations
  - Erase
    - Overlaying the Input Features with the Erase Feature which defines the erasing area.
    - Input features or portions of input features that do not overlap erase features are written to the output feature layer.
    - Input Features or portions of input features that overlap the Erase Features are not written to the output feature layer.
    - The output feature has the same attributes as that of the input feature.

Vector Analysis

- Overlay Operations
  - Erase
    - Just like a cookie cutter.



Vector Analysis

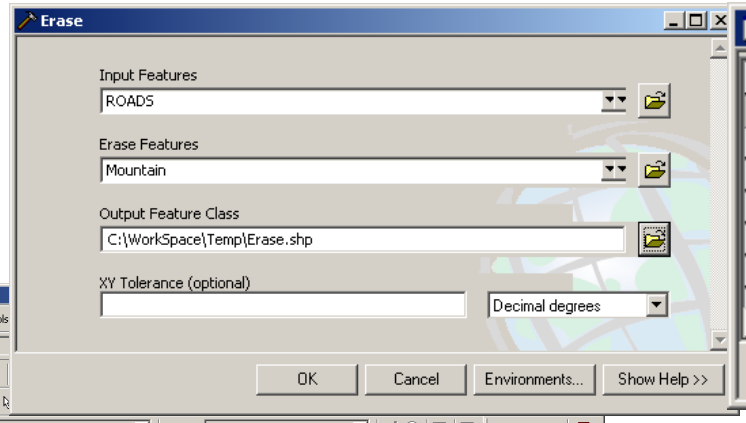
- Overlay Operations
  - Erase
    - Characteristics of Erase:
      - Input Features can be points, lines, or polygons.
      - Typically the Erase Feature is smaller than the Input Feature in terms of spatial extent.
      - The restrictions on the types of Erase Features have changed.
        - » Before 10.0, the Erase Features must be polygons.
        - » After 10.0, the Erase Features can be point, lines, and polygons.

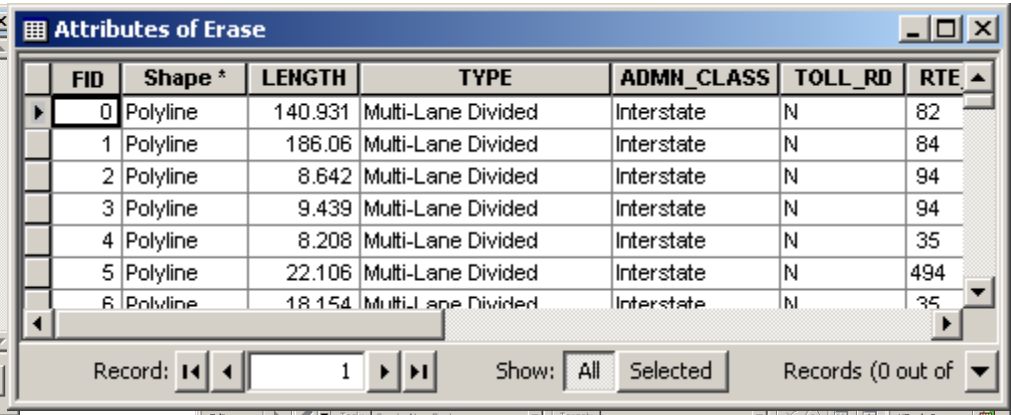
Vector Analysis

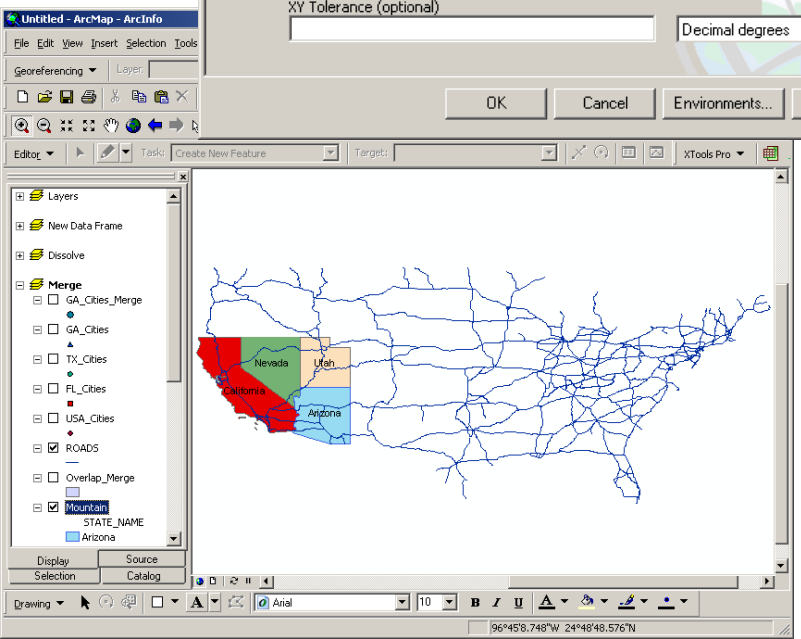
- Overlay Operations
  - Erase
    - Characteristics of Erase: (‘continued)
      - A polygon erase feature can be used to erase polygons, lines, or points from the input features
      - A line erase feature can be used to erase lines or points from the input features.
        - » **Exercise 1**: coincident vs. non-coincident?
        - » **Exercise 2**: Line Erase Feature + Point Input Feature?
      - A point erase feature can be used to erase points from the input features.
      - Output Features will be of the same geometry type as Input Features.
      - Input Feature polygons that are coincident with Erase Feature polygons will be removed.

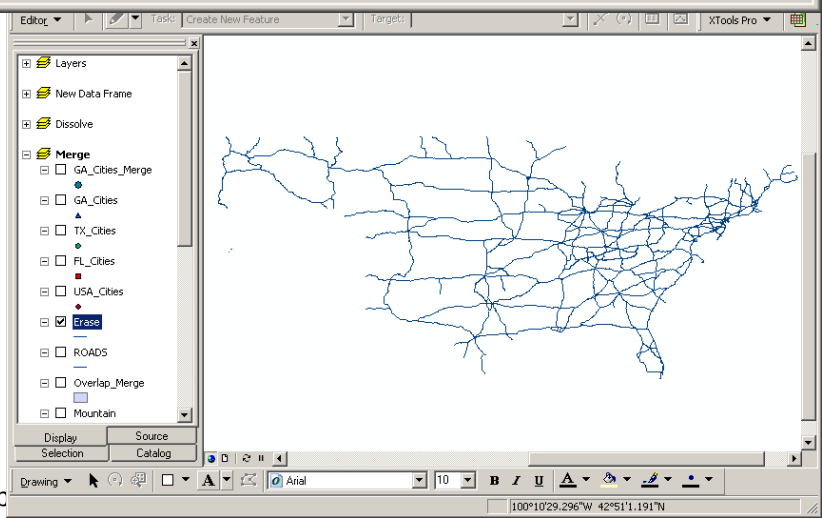
Vector Analysis

- Overlay Operations
  - Erase
    - Example:



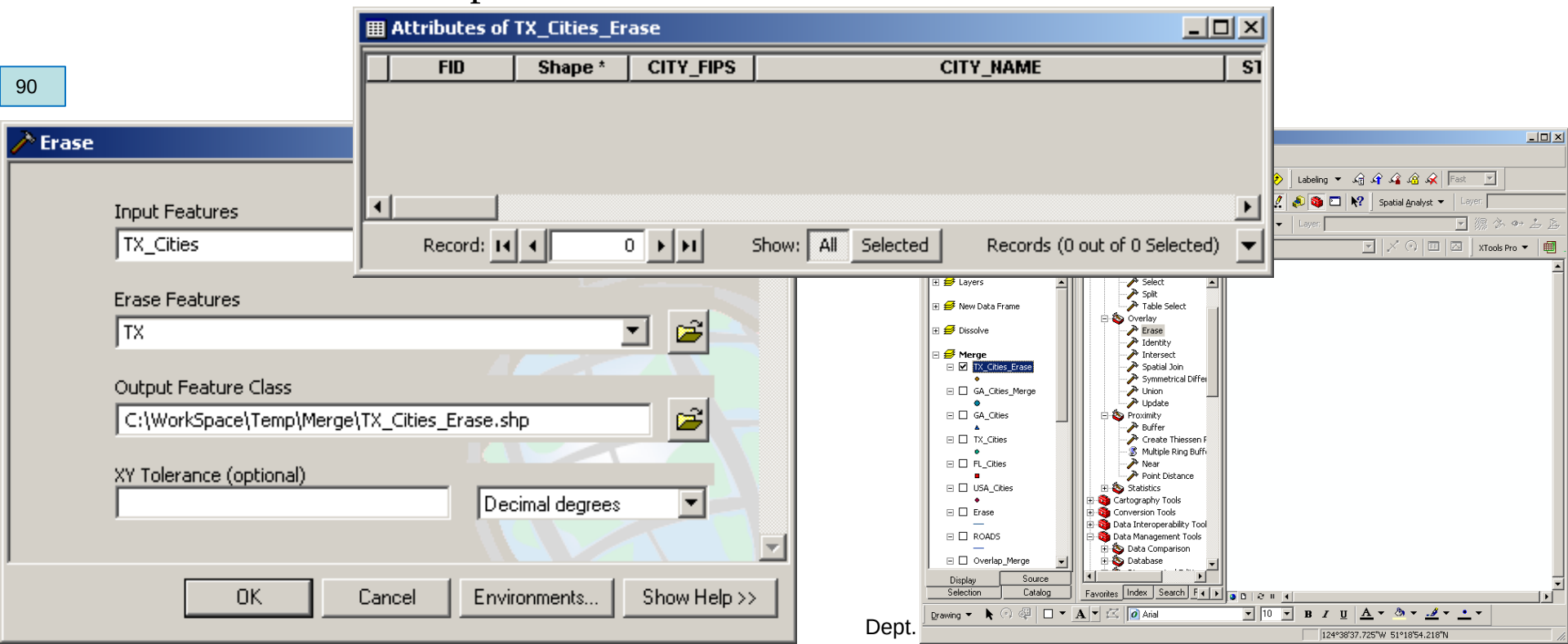






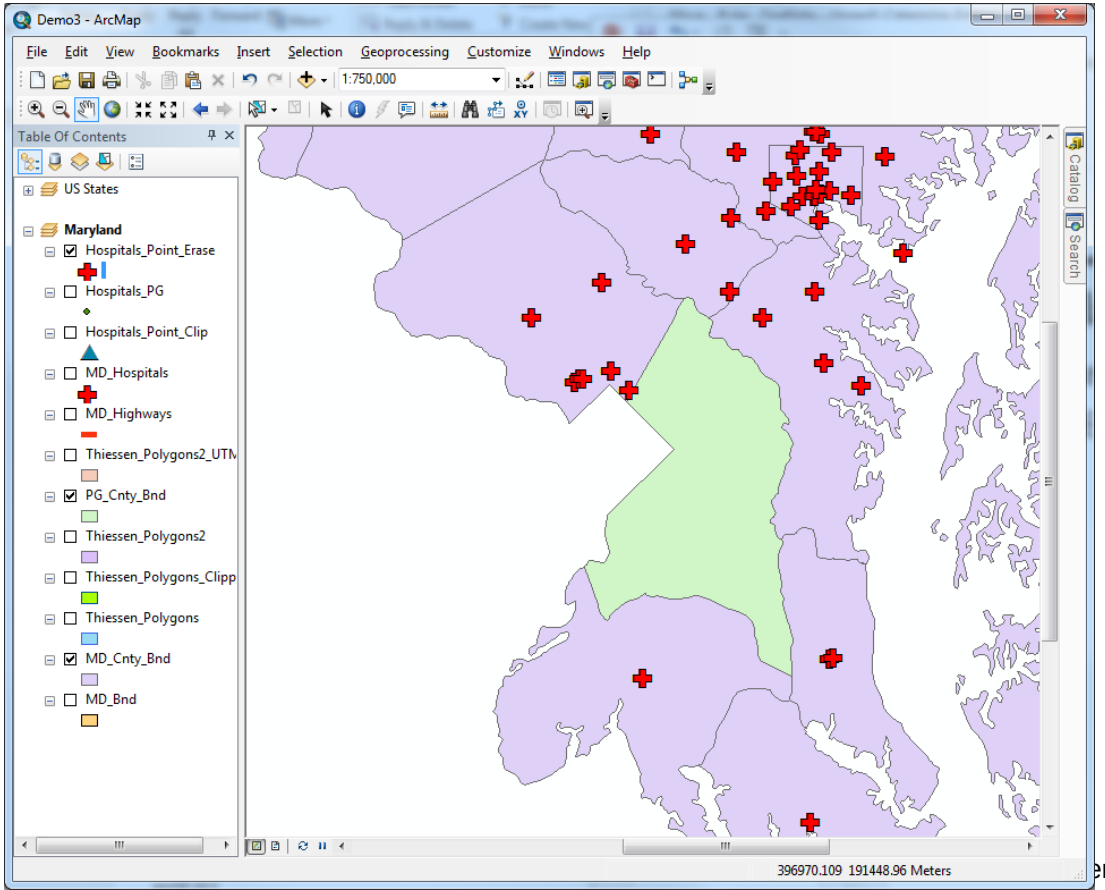
Vector Analysis

- Overlay Operations
  - Erase
    - What if the input layer is coincident with the erase feature?
      - Example:



Vector Analysis

- Overlay Operations
  - Erase
    - Example: (both the input and erase features are points)

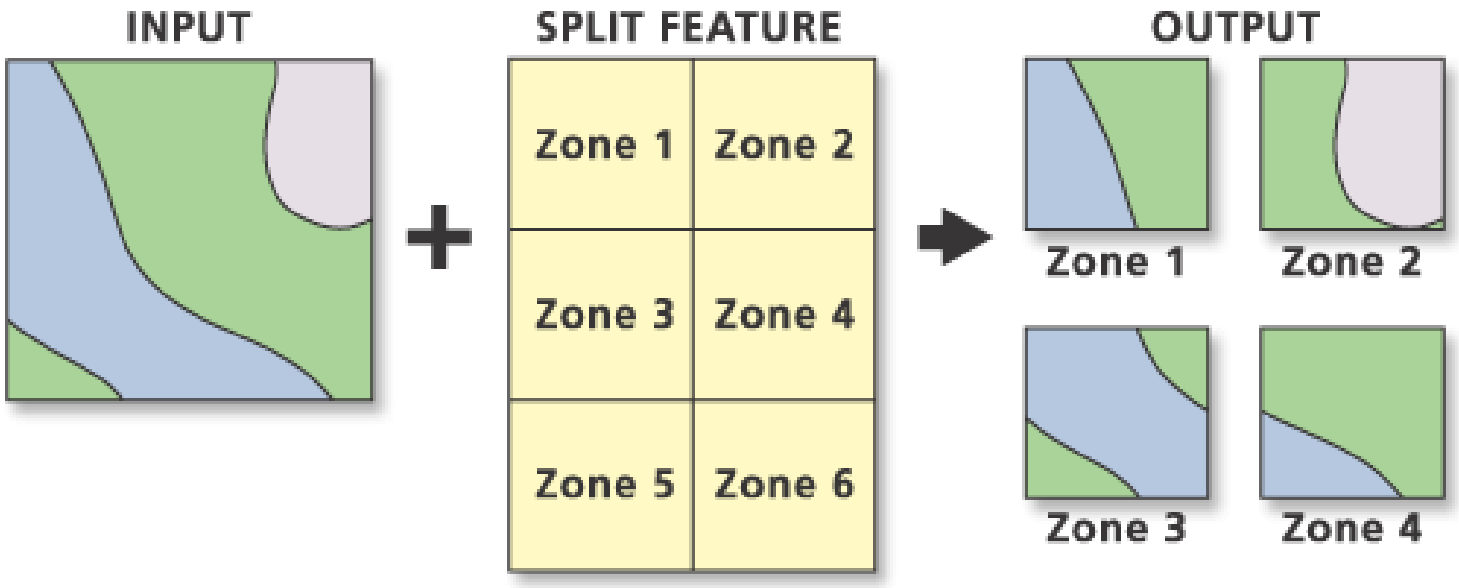


Vector Analysis

- Overlay Operations
  - Split
    - Breaks the Input Features into multiple output feature layers.
    - The boundary of each unique value in the Split Field is used to split the Input Features.
    - The feature attribute table for output feature layers contains the same items as the Input Features attribute table.

Vector Analysis

- Overlay Operations
  - Split



Vector Analysis

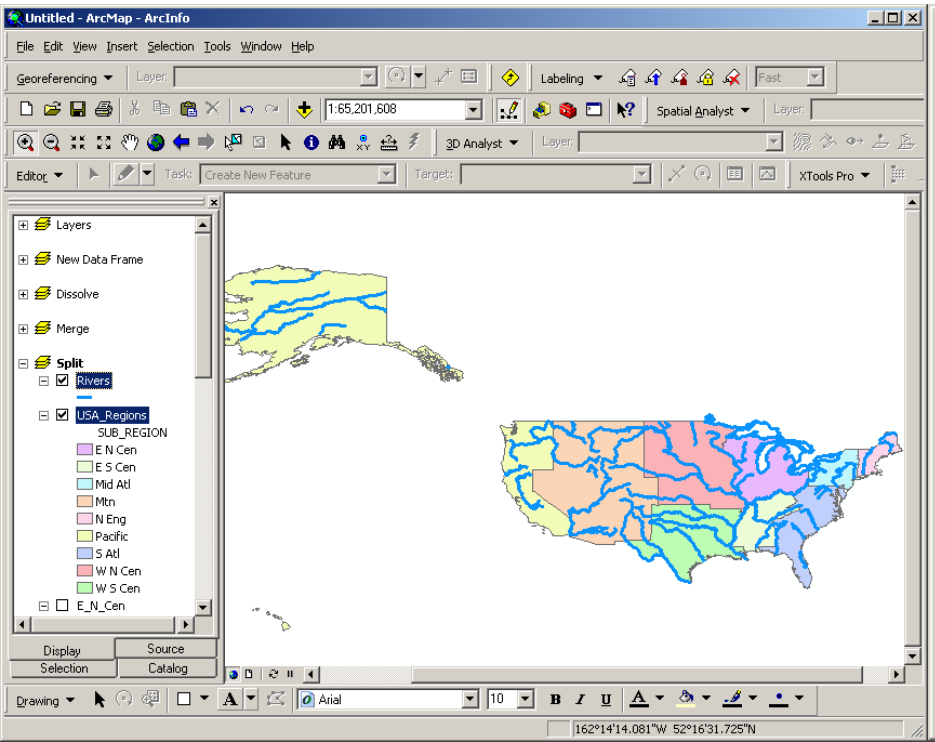
- Overlay Operations
  - Split
    - Characteristics of Split:
      - The Split Features must be polygons.
      - The Split Field data type must be character.
      - The output feature layers will be named for Split Field values.
      - The number of output feature layers equals the total number of unique values in the Split Field.
      - The Target Workspace must already exist.
      - The Target Workspace for saving those multiple output layers can not be overwritten.

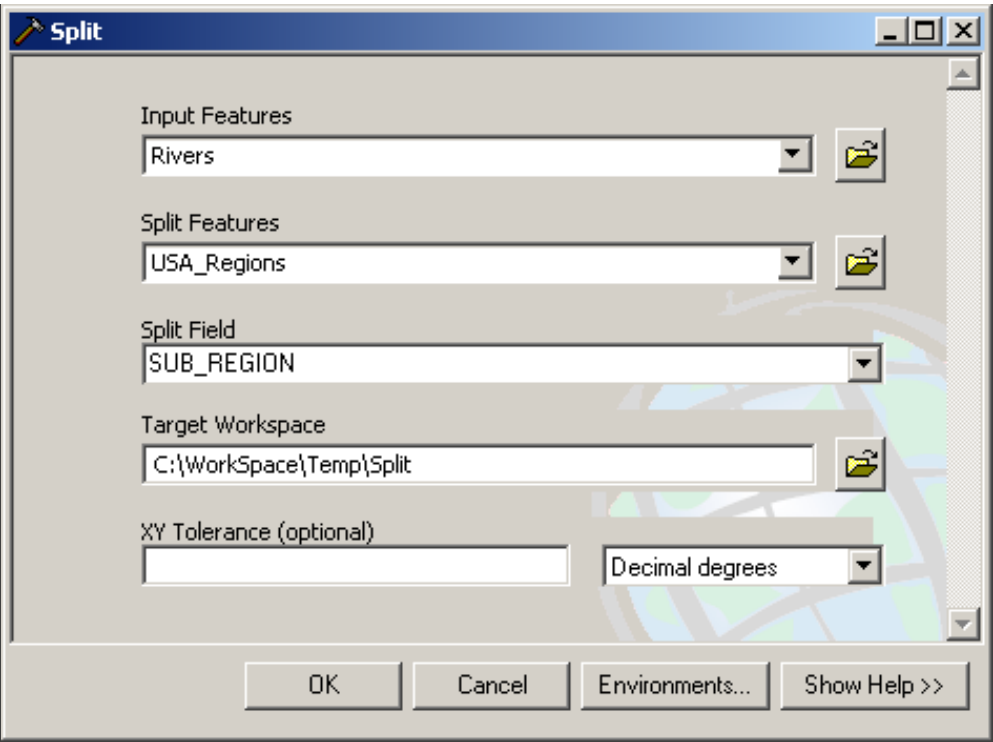
Vector Analysis

- Overlay Operations
  - Split
    - Characteristics of Split: (‘continued)
      - The split field's unique values must start with a valid character. If the target workspace is a file, personal, or ArcSDE geodatabase, the field's values must begin with a letter.
        - » Exception: Shapefile names can begin with a number, and a folder target workspace allows field values that begin with a number.
        - » Example: using State FIPs which are numbers but can be defined as text/string data type.
      - **Exercise**: use a dataset to test and verify these restrictions.

Vector Analysis

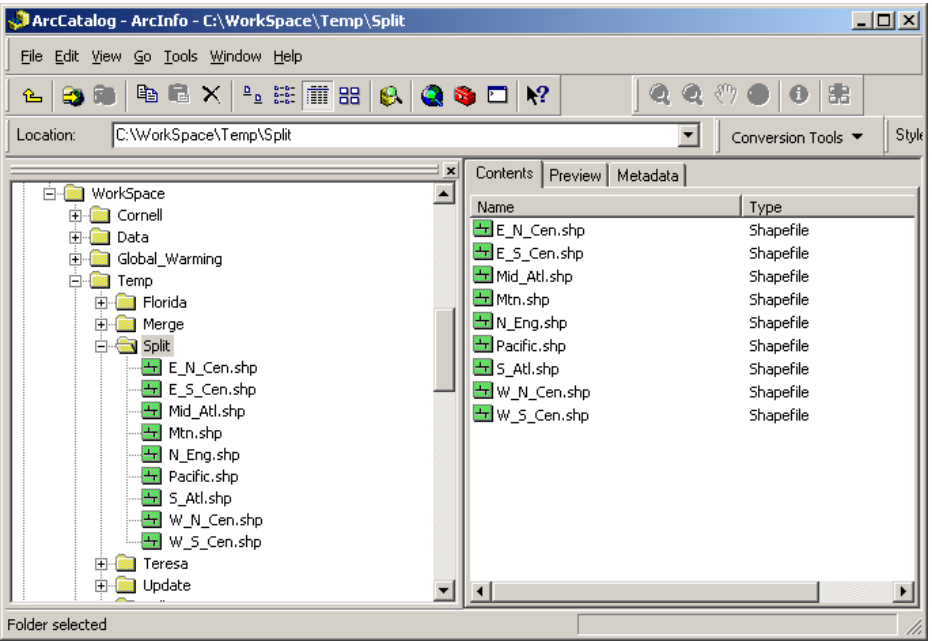
- Overlay Operations
  - Split
    - Example:

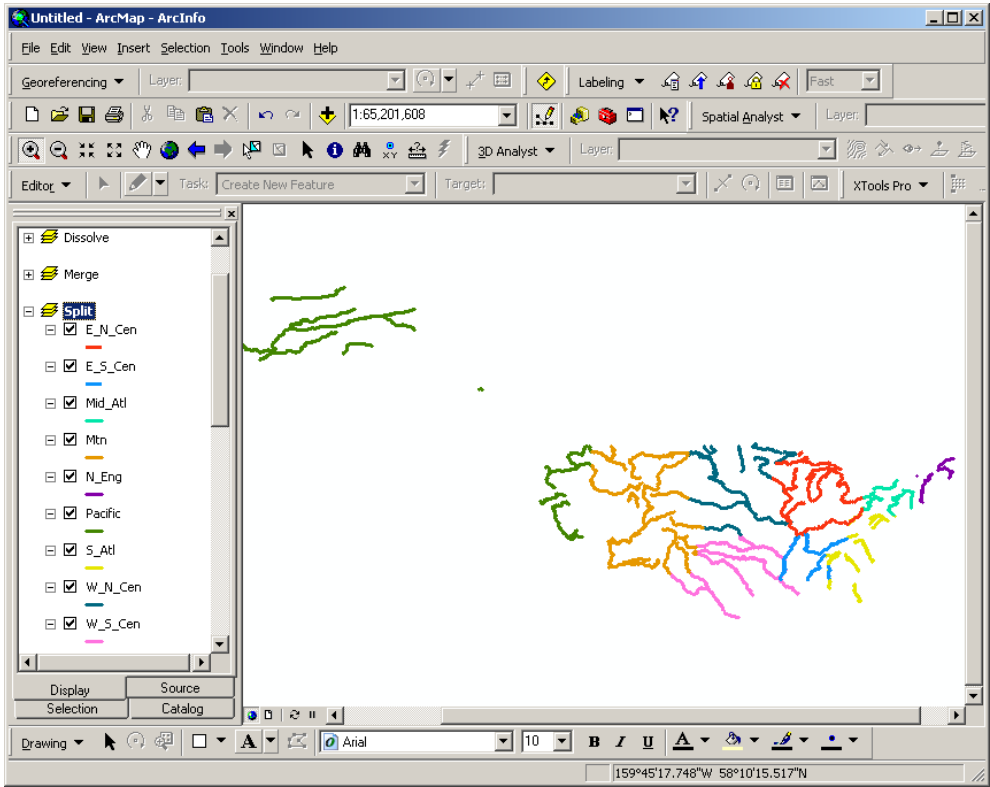




Vector Analysis

- Overlay Operations
  - Split
    - Example: (‘continued)



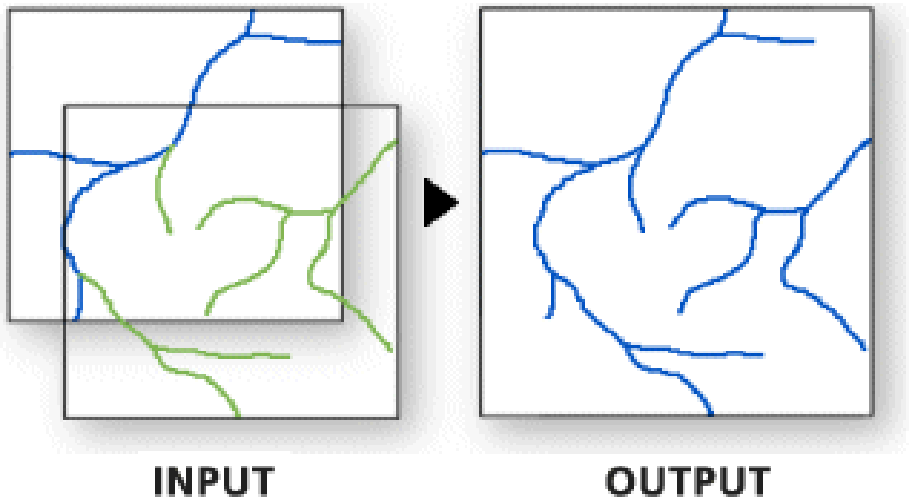


Vector Analysis

- Overlay Operations
  - Append
    - Appends multiple input dataset into an already existing target dataset.
    - Input datasets can be point, line or polygon feature classes, tables, rasters or raster catalogs.

Vector Analysis

- Overlay Operations
  - Append

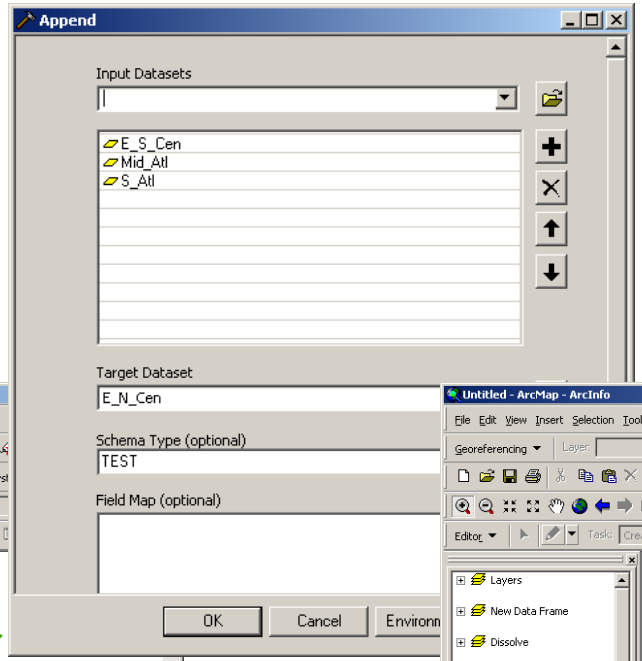


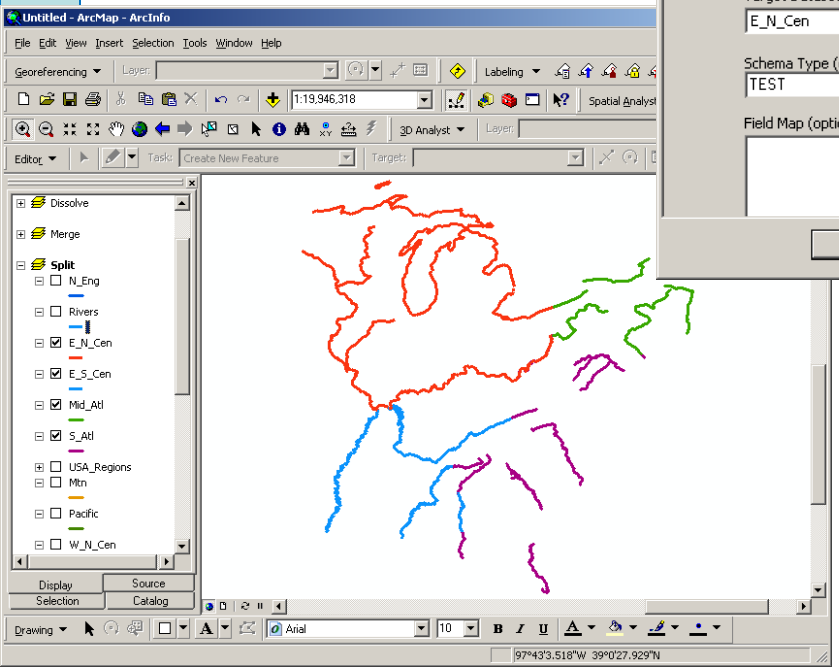
Vector Analysis

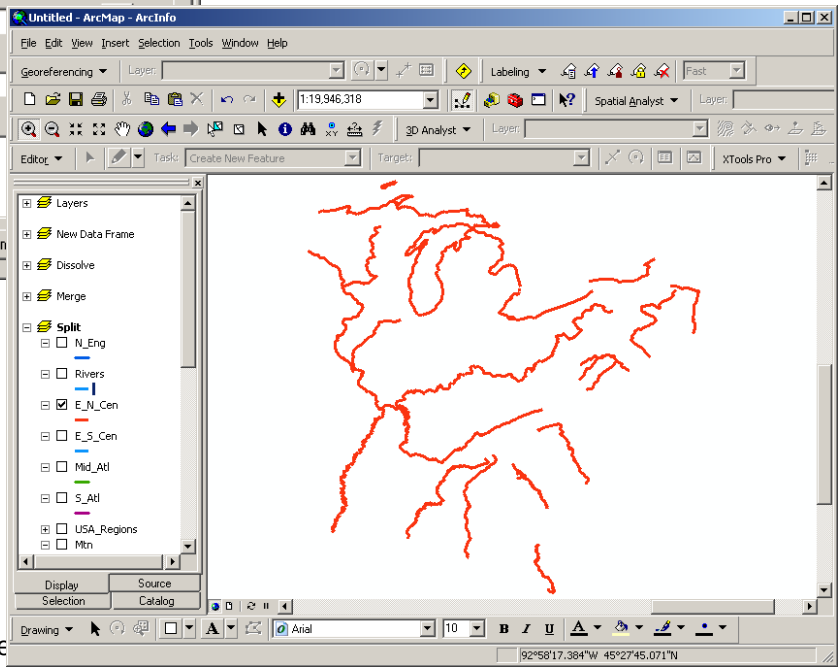
- Overlay Operations
  - Append
    - Characteristics of Append:
      - When the inputs are features, all input features must be of the same feature type as the features of the target dataset.
        - » For example, if the target feature class contains polygon features, the input features types must be polygon as well.
      - Input datasets may overlap one another and/or the target dataset.
      - All features from both the input feature class and the target feature class will remain intact after the append, even if the features overlap.
      - Input datasets in a different coordinate system from the target feature class will be projected into the coordinate system of the target feature class.

Vector Analysis

- Overlay Operations
  - Append
    - Example:

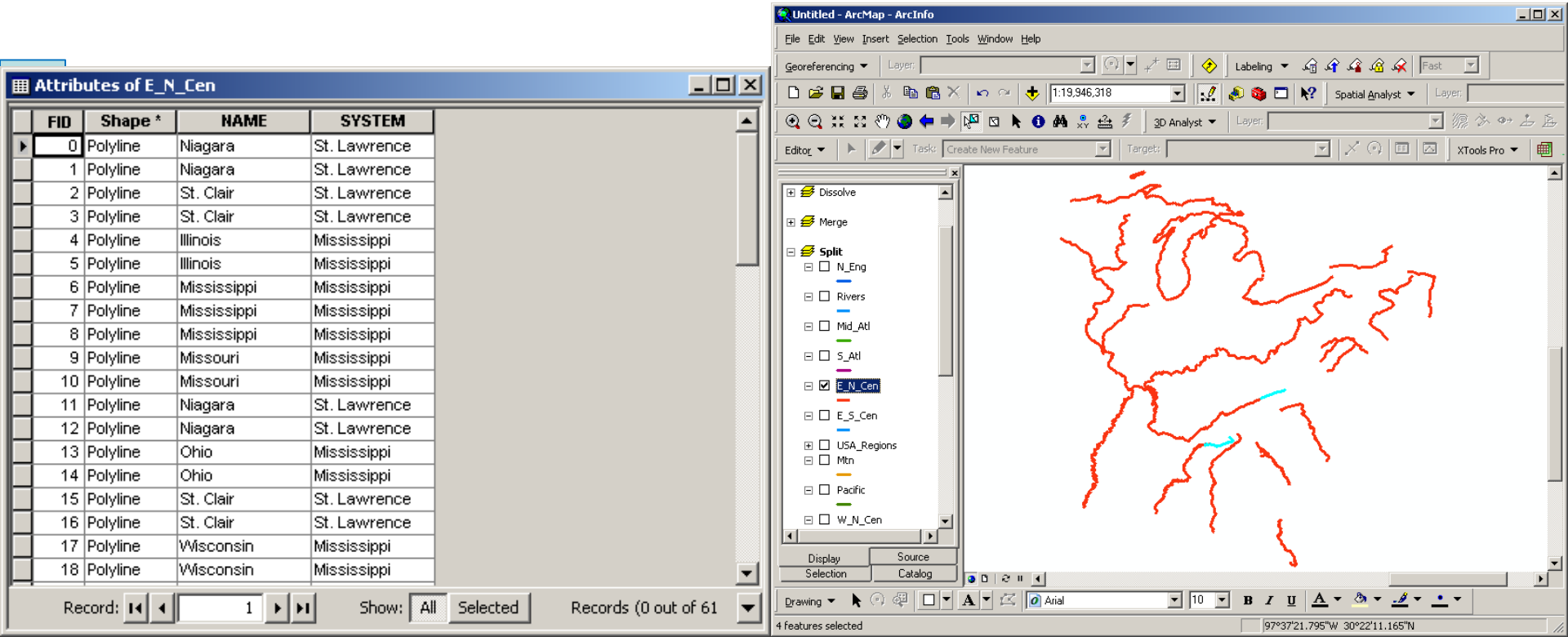






Vector Analysis

- Overlay Operations
  - Append
    - Example:
      - Input features from all the input feature classes remain intact in the target feature class, i.e. not planarized.

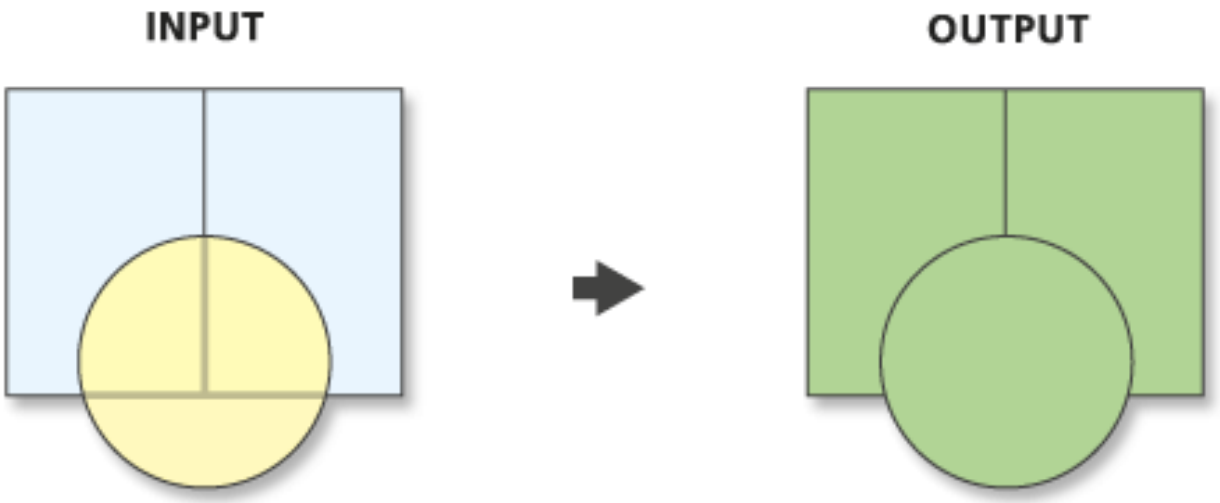


Vector Analysis

- Overlay Operations
  - Update
    - It computes a geometric intersection of the Input Features and Update Features.
    - The attributes and geometry of the Input Features are updated by the Update Features.
      - The Input Features or portions of input features that do not overlap Update Features will be written to the Output Feature Class.
      - The Input Features or portions of Input Features that overlap update features **will be erased**, and the update features will be written to the Output Feature Class.

Vector Analysis

- Overlay Operations
  - Update



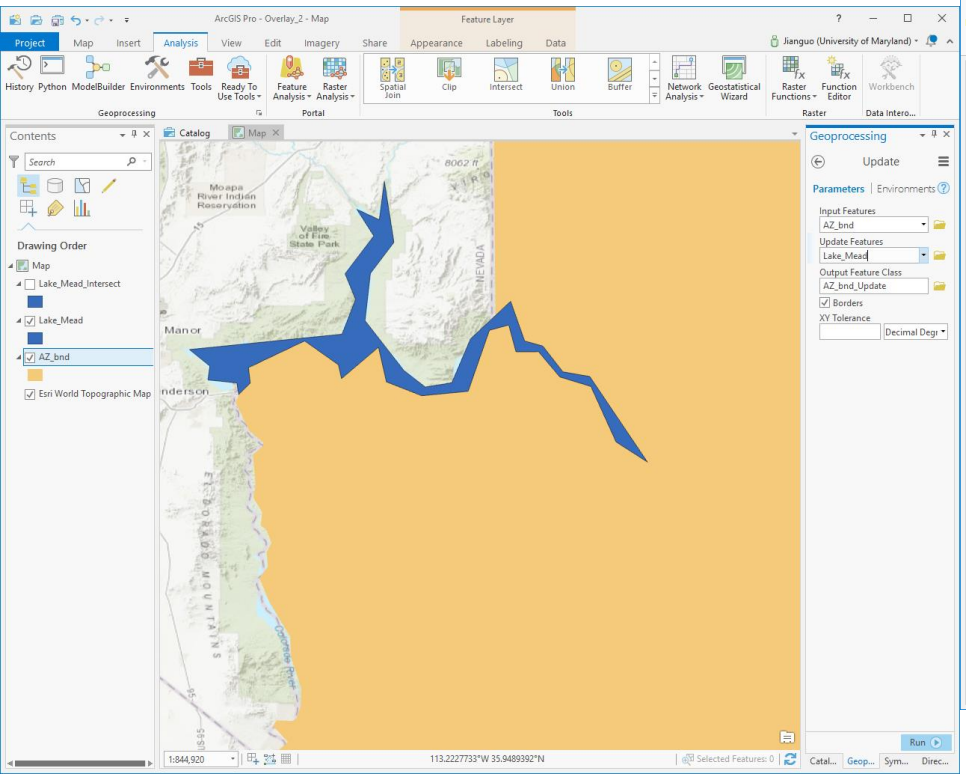
Vector Analysis

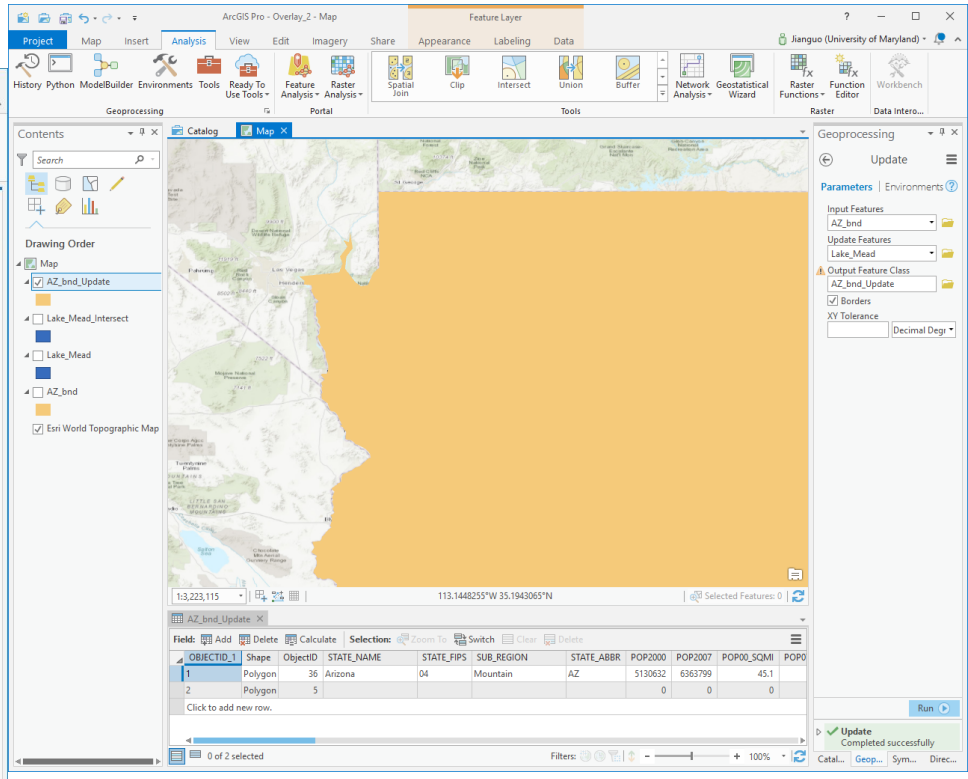
- Overlay Operations
  - Update
    - Characteristics of Update:
      - The original input will not be modified by this operation.
      - The Input Features and Update Features must be polygon.
      - The Input Features and Update Features field names must match.
        - » If the update feature class is missing one (or many) of the fields that are present in the input feature class, the input feature class field value for the missing fields will be removed from the output feature class.

Vector Analysis

- Overlay Operations
  - Update
    - Example: (ArcGIS Pro)
      - Input Features: AZ; Update Feature: Lake Mead

The Input Features or portions of input features that do not overlap Update Features will be written to the Output Feature Class.
The Input Features or portions of Input Features that overlap update features will be erased, and the update features will be written to the Output Feature Class.

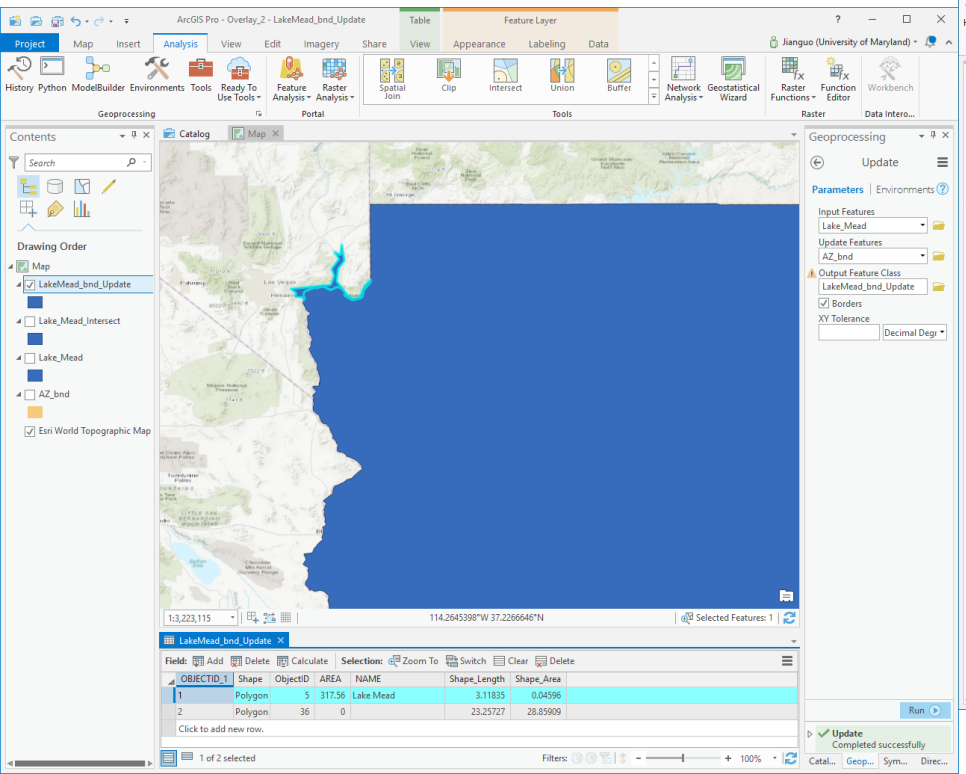


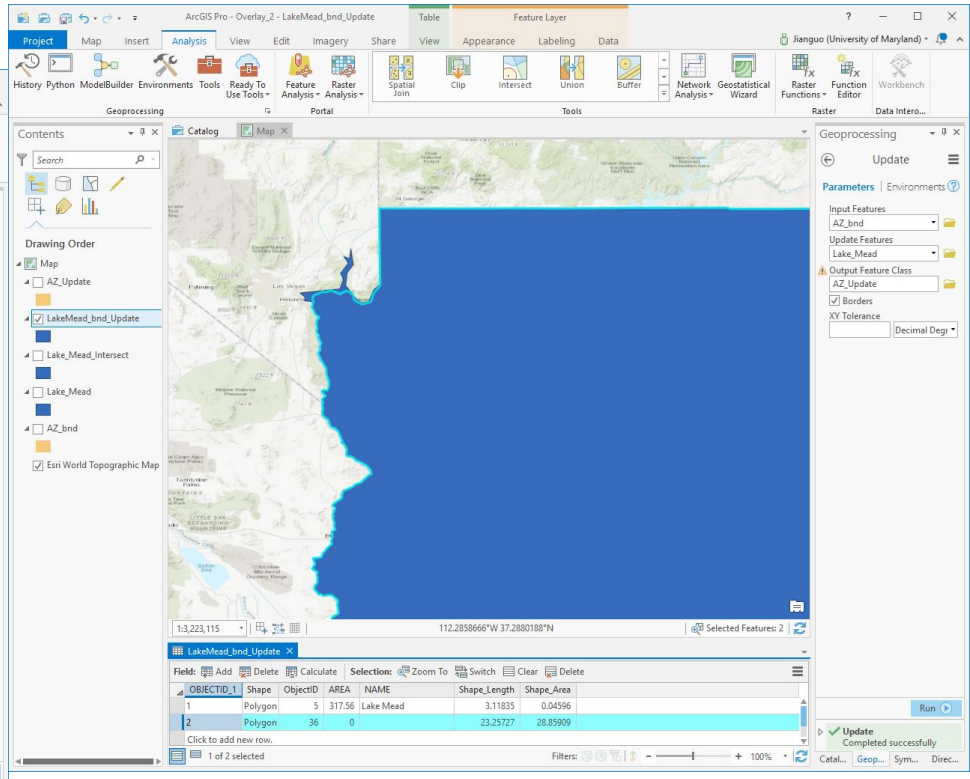


Vector Analysis

- Overlay Operations
  - Update
    - Example: (ArcGIS Pro)
      - Input Features: Lake Mead; Update Feature: AZ

The Input Features or portions of input features that do not overlap Update Features will be written to the Output Feature Class.
The Input Features or portions of Input Features that overlap update features will be erased, and the update features will be written to the Output Feature Class.



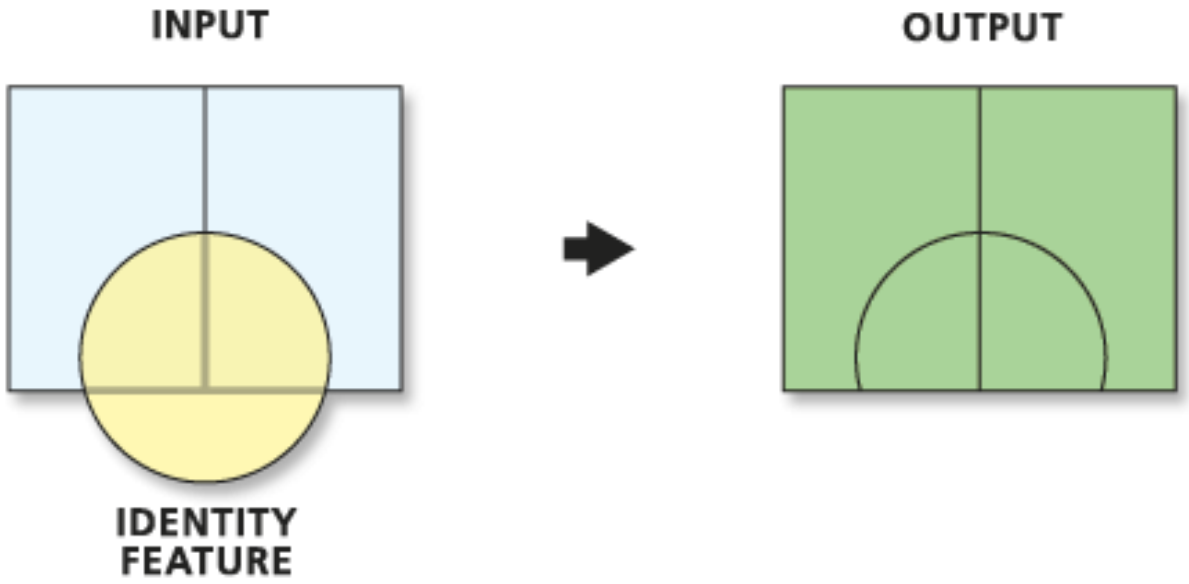


Vector Analysis

- Overlay Operations
  - Identity
    - Computes a geometric intersection of the Input Features and Identity Features.
    - Input Features or portions of Input Features that do not overlap Identity Features are written to the output.
    - Input features or portions of Input Features that overlap Identity Features get the attribute information from the Identity Feature and are written to the output.

Vector Analysis

- Overlay Operations
  - Identity



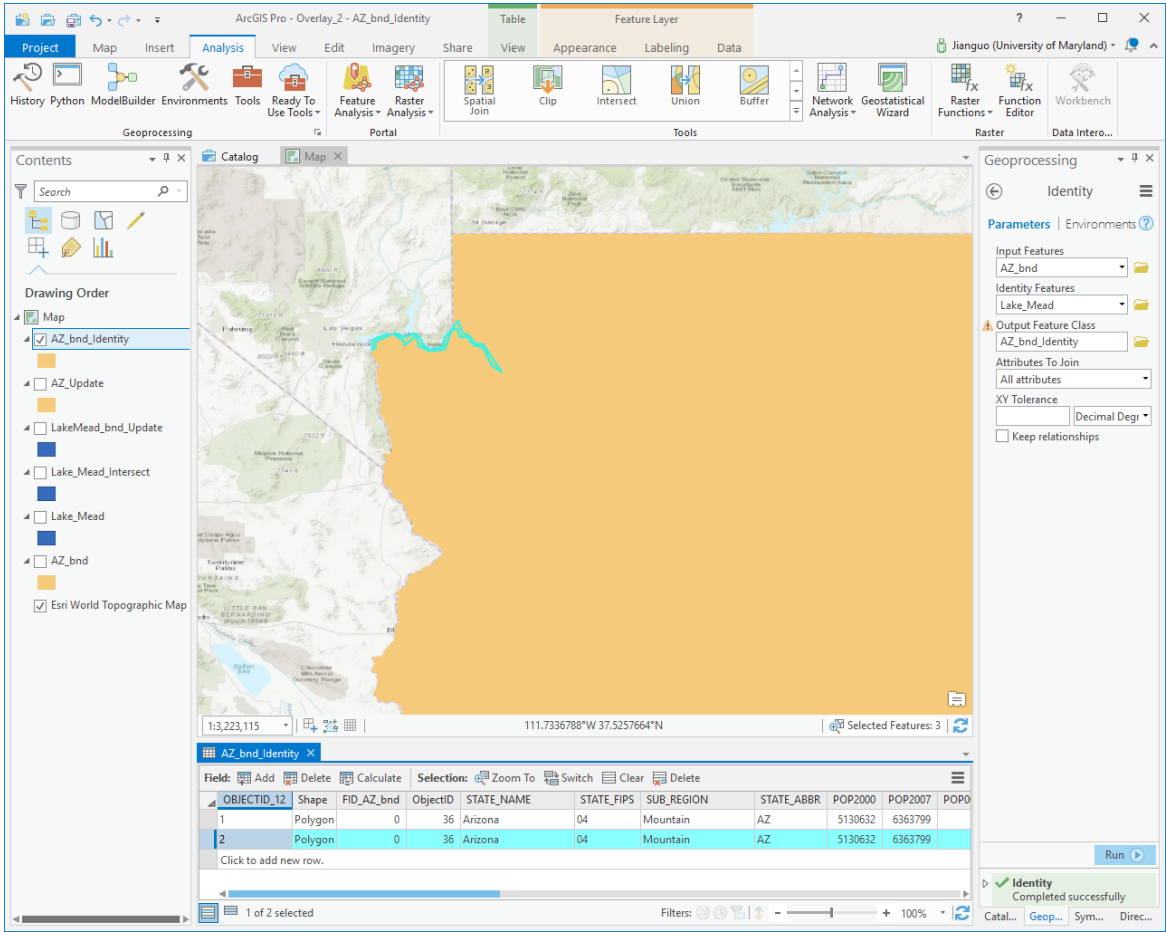
Vector Analysis

- Overlay Operations
  - Identity
    - Characteristics of Identity:
      - The input features can be points, lines or polygons.
      - The inputs cannot be annotation features, dimension features, or network features.
      - The Identity Features must be polygons or have the same geometry type as the Input Features.
        - » Before 10.0, the Identity Features must be polygons.

Vector Analysis

- Overlay Operations
  - Identity
    - Example: Input: AZ; Identity Feature: Lake Mead

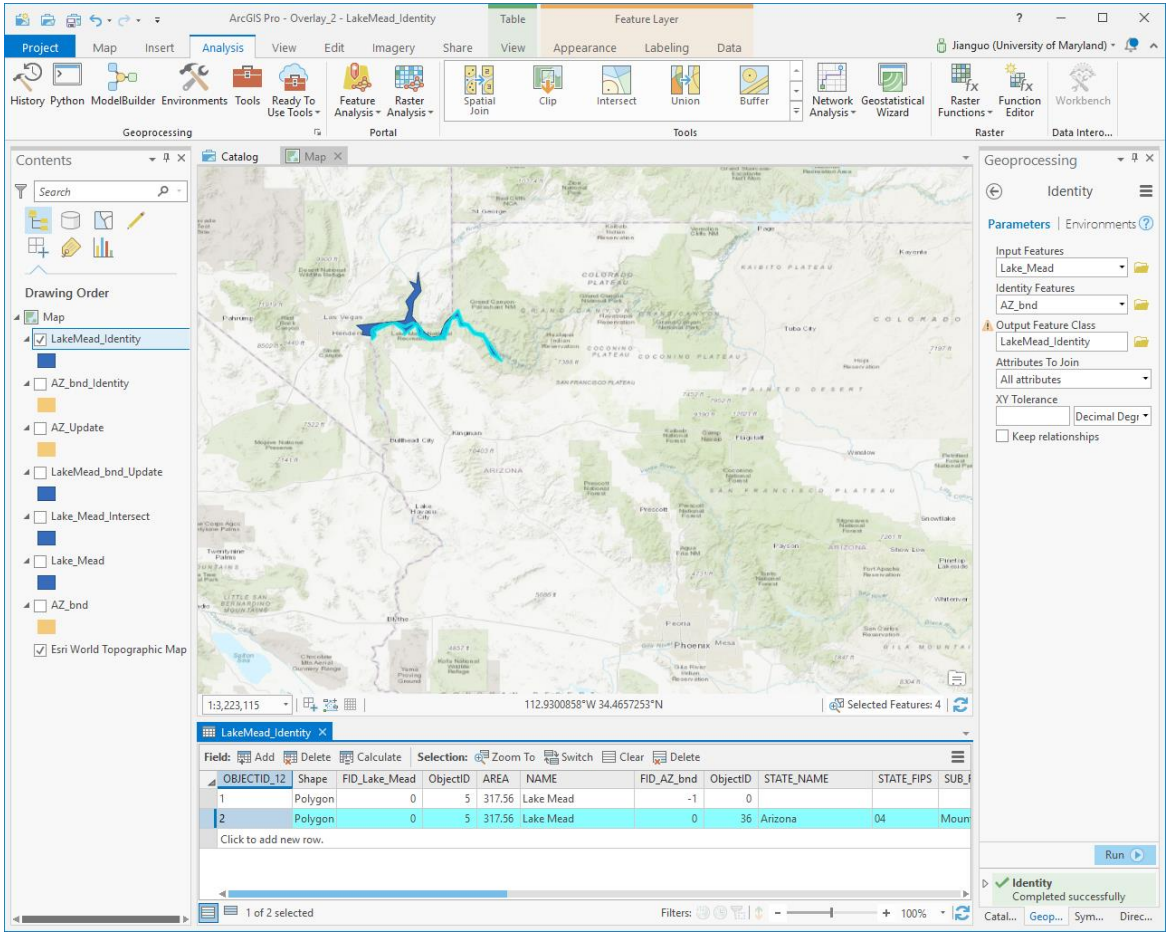
Input Features or portions of Input Features that do not overlap Identity Features are written to the output. Input features or portions of Input Features that overlap Identity Features get the attribute information from the Identity Feature and are written to the output.



Vector Analysis

- Overlay Operations
  - Identity
    - Example: Input: Lake Mead; Identity Feature: AZ

Input Features or portions of Input Features that do not overlap Identity Features are written to the output. Input features or portions of Input Features that overlap Identity Features get the attribute information from the Identity Feature and are written to the output.

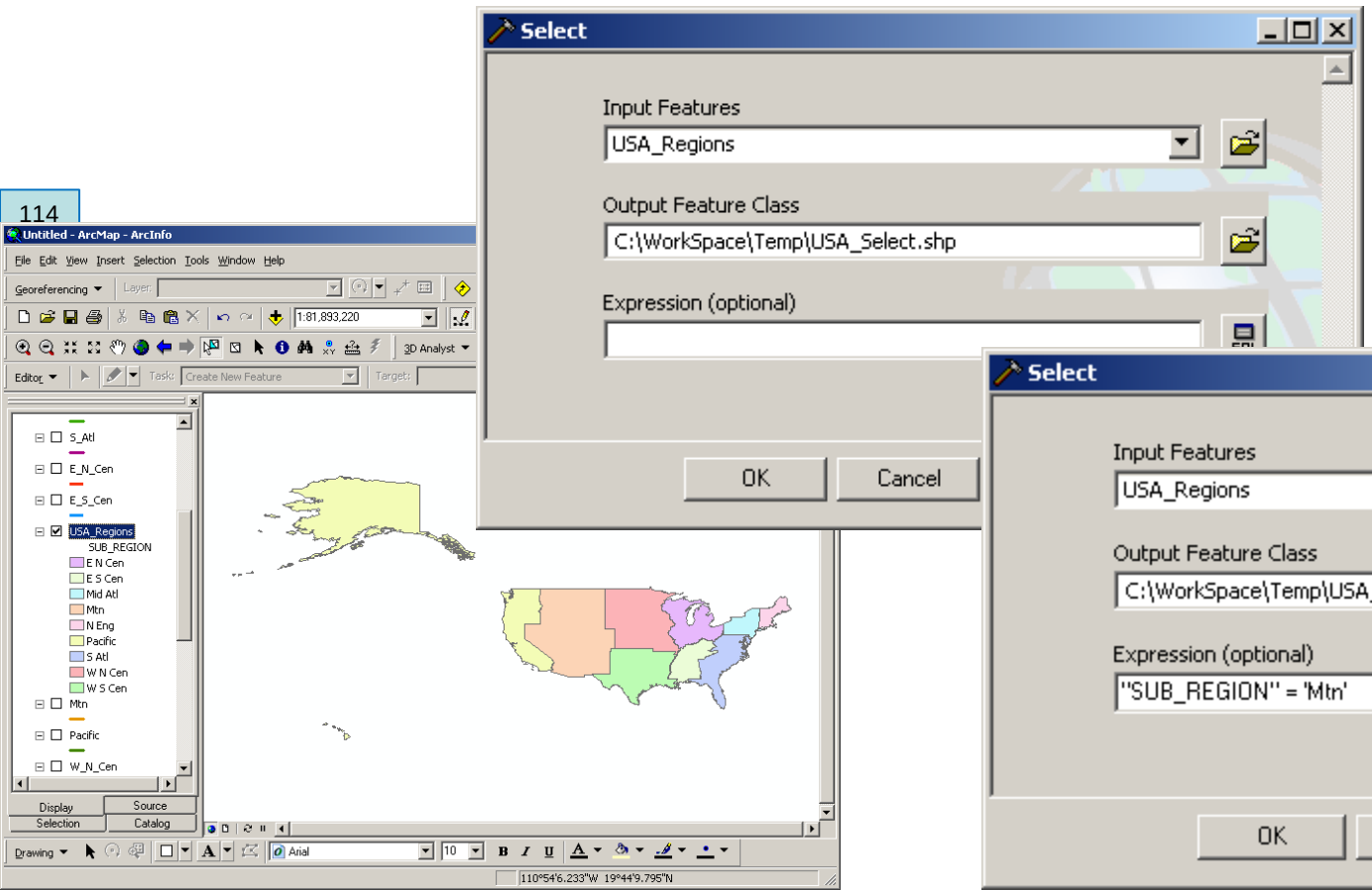


Vector Analysis

- Overlay Operations
  - Select
    - Extracts features from an input feature class or input feature layer and stores them in a new output feature class.
    - The output feature class may be created with a subset of features based on a Structured Query Language (SQL) expression.
      - If no SQL expression is included, then all features will be included in the output feature class.
      - If a SQL expression is used but returns nothing, the output feature class will be empty.

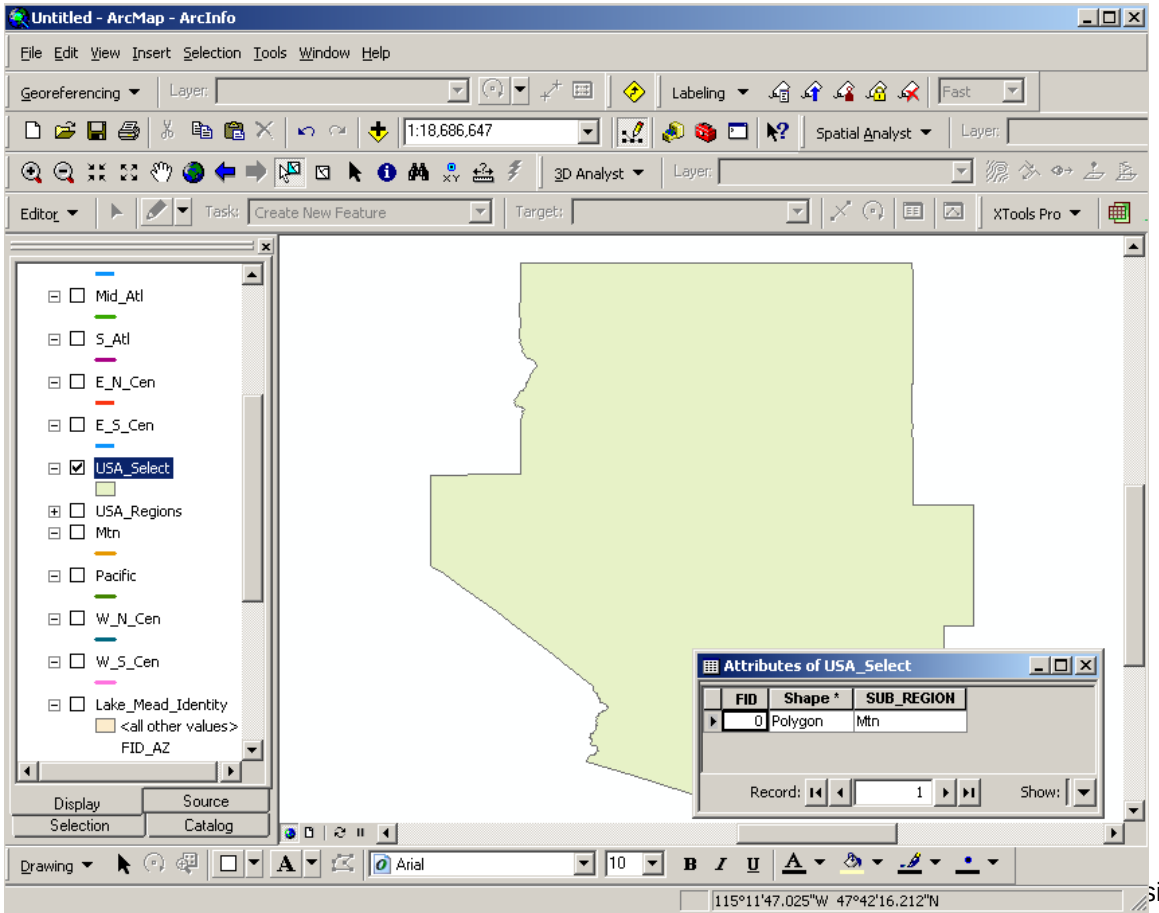
Vector Analysis

- Overlay Operations
  - Select
    - Example:



Vector Analysis

- Overlay Operations
  - Select
    - Example:

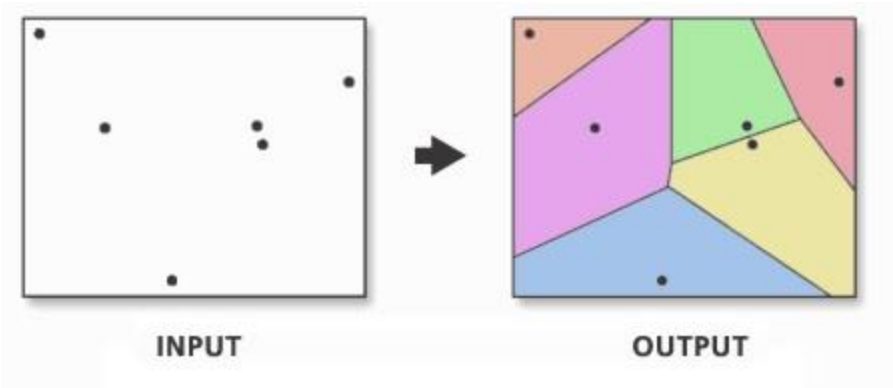


Vector Analysis

- Overlay Operations
  - Create Thiessen Polygons
    - This tool creates Thiessen polygons from point input features.
    - Each Thiessen polygon contains only a single point input feature. Any location within a Thiessen polygon is closer to its associated point than to any other point input feature.

Vector Analysis

- Overlay Operations
  - Create Thiessen Polygons
    - This tool is used to divide the area covered by the point input features into Thiessen or proximal zones. These zones represent full areas where any location within the zone is closer to its associated input point than to any other input point.

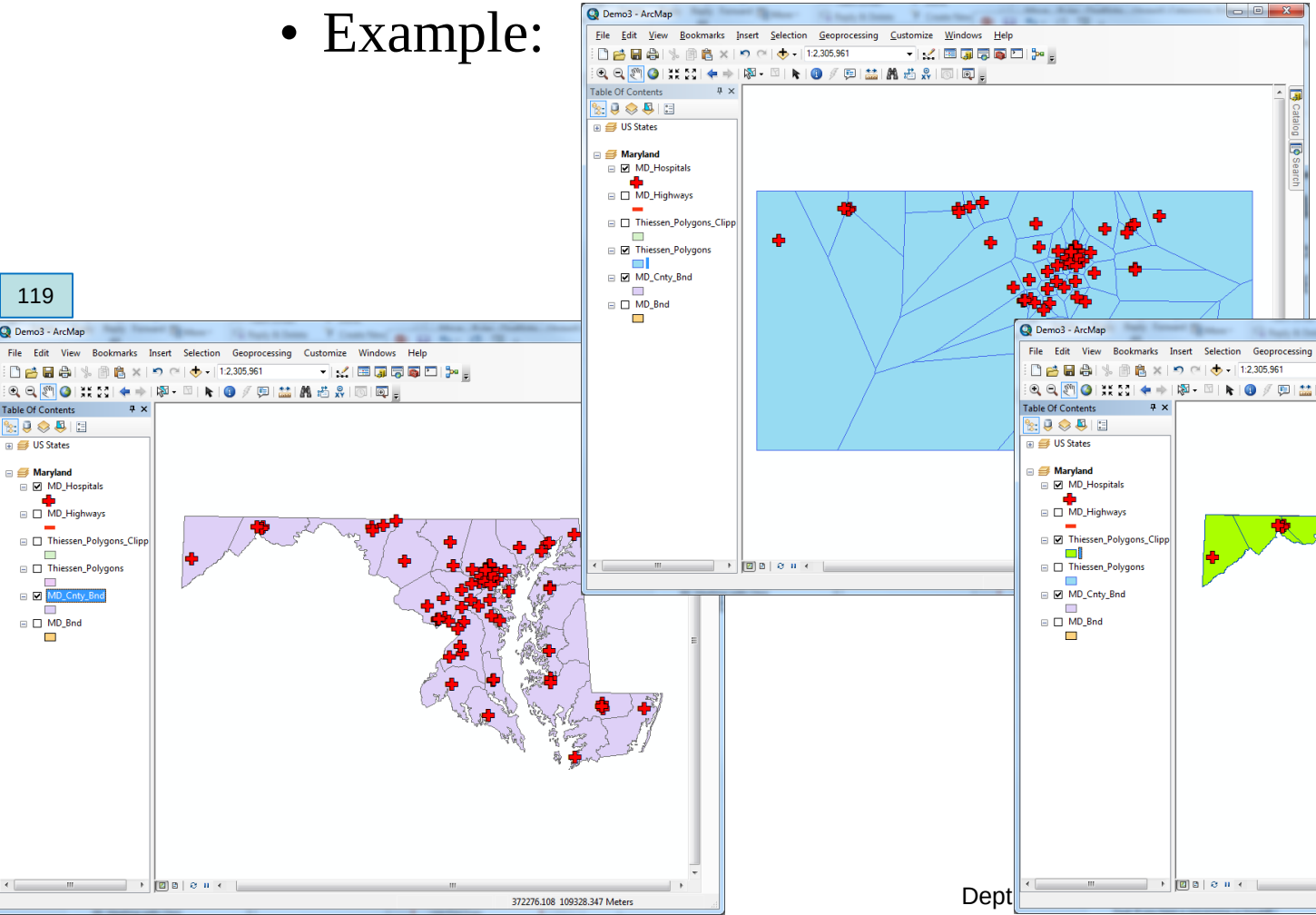


Vector Analysis

- Overlay Operations
  - Create Thiessen Polygons
    - Characteristics:
      - The outside boundary of the output Thiessen polygon feature class is the extent of the point input features plus an additional 10%. If the Extent environment is set to a specific extent window, this tool will use the environment setting to set its outside boundary.
        - » **Exercise:** Use a dataset to verify it. (Make sure the data is projected and that the spatial extents are compared based on the same coordinate system.)
      - This tool may produce unexpected results with data in a geographic coordinate system since the Delaunay triangulation method used by the tool works best with data in a projected coordinate system.

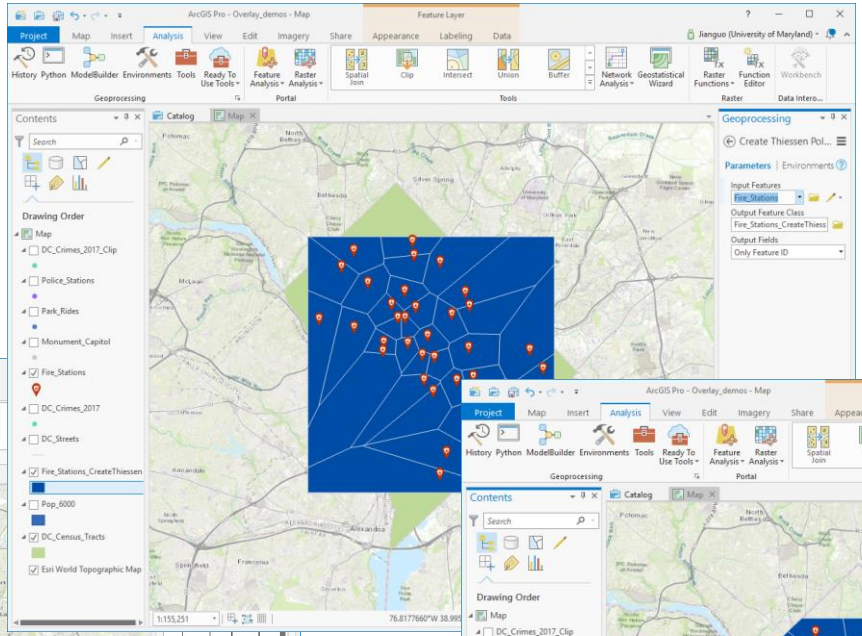
Vector Analysis

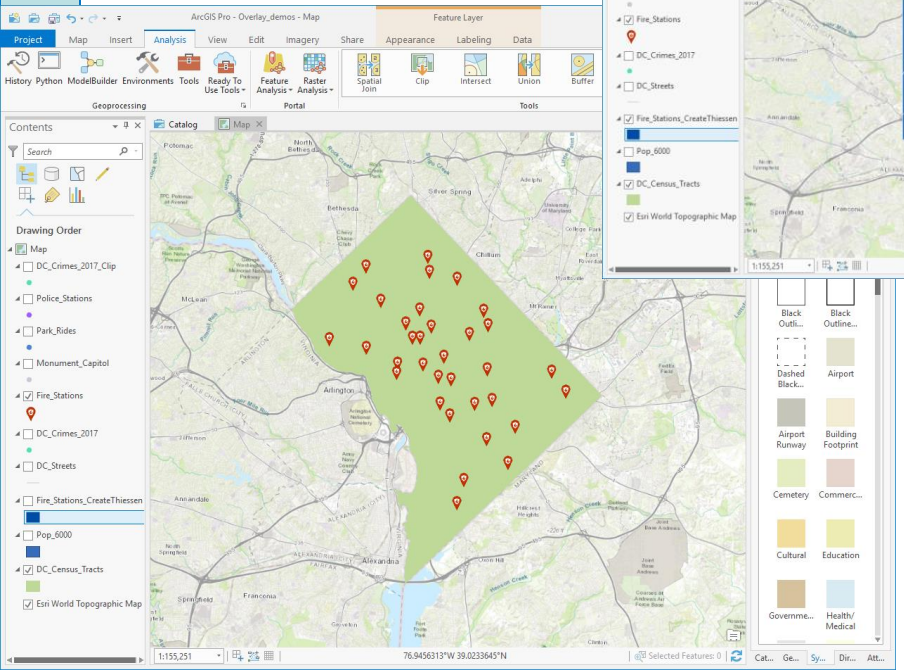
- Overlay Operations
  - Create Thiessen Polygons
    - Example:

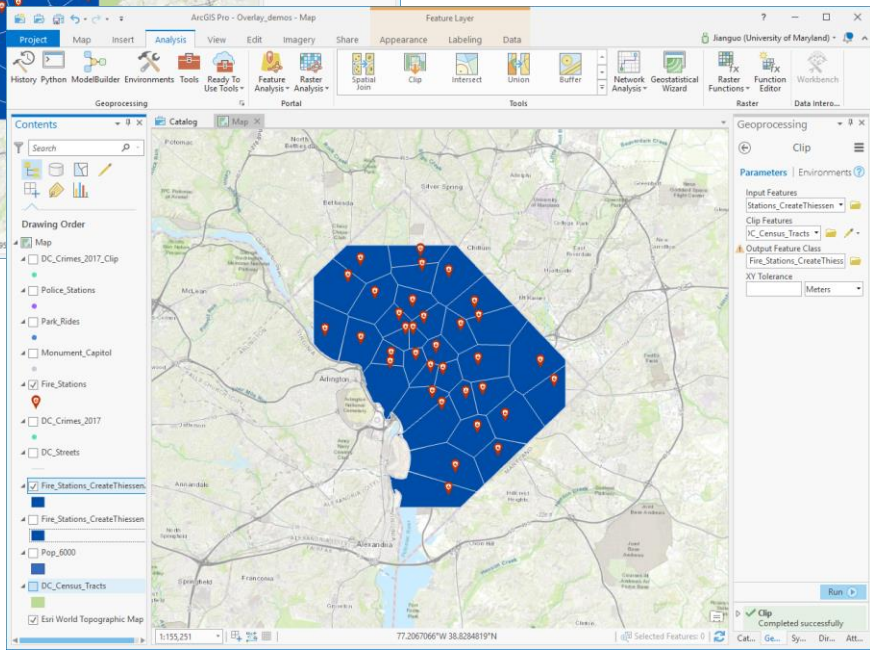


Vector Analysis

- Overlay Operations
  - Create Thiessen Polygons
    - Example:







Vector Analysis

- Overlay Operations
  - Overlay tools that accept polygons only:
    - Union
    - Update
  - All other overlay tools accept a variety of geometry types.

Vector Analysis

- Overlay Operations
  - Merge vs. Append
    - Similarities:
      - They both will create a single output feature layer from multiple input layers.
      - Two or more of the input layers can not have the same name.
      - The input features do not have to be adjacent to each other.
      - Input features from all the input feature classes remain intact in the output layer or the target layer.
    - Differences:
      - For Append, the target feature must already exist.
        - » This target layer will be modified.
        - » This target layer will define the geometry type, attribute structure, and coordinate system.
      - For Merge, all the input layers are equal in terms of priority.

Vector Analysis

- Overlay Operations
  - Union vs. Append
    - Similarities
      - Both methods will expand the extent of any individual input layer.
    - Differences:
      - Unlike the Union function, Append does not planarize the input features into a single output.
        - » Input features from all the input feature classes remain intact in the target feature class.

123

Vector Analysis

- Overlay Operations
  - Clip vs. Erase
    - Similarities:
      - They both will define a new boundary (often smaller) for the input layers.
      - The output layer will have the same attribute structure and feature type as that of the input layer.
    - Differences:
      - For Clip, the input features that overlap with the clipping feature are preserved instead of erased.

Vector Analysis

- Overlay Operations
  - Clip vs. Intersect
    - Similarities:
      - They both will define a new boundary (often smaller) for the input layers.
    - Differences:
      - For Intersect, the output layer will have the attributes from all input layers. Also the feature type of the output will be determined by the lowest dimension of the input layer.
      - For Clip, the output layer will have the same attribute structure and feature type as that of the input layer.

Vector Analysis

- Overlay Operations
  - Overlaying large datasets is CPU and RAM intensive.
    - Schedule large overlays accordingly.
    - Shut down all other applications.
    - Use powerful computers with lots of memory.
  - Use file geodatabases for outputs
    - Result dataset may be too large for shapefiles or personal geodatabases.

Vector Analysis

- Buffering
  - Proximity is always one of the most basic GIS questions.
  - Buffering will identify or define an area within a specified distance around a feature.
    - Input features can be polygons, lines, or points.
  - Buffers are usually used to delineate protected zones around features or to show areas of influence.

Vector Analysis

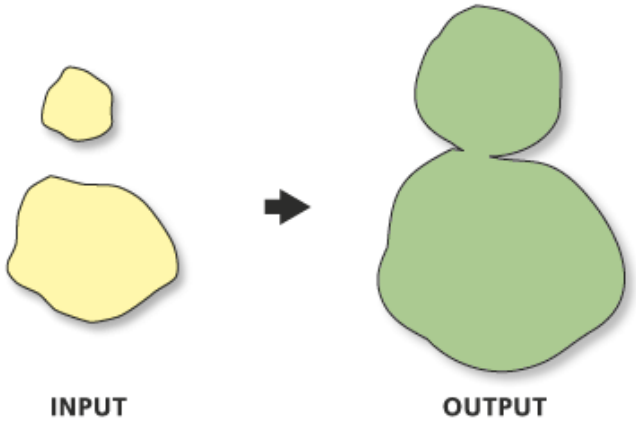
- Buffering
  - Three types of buffers:
    - Buffers based on constant distance
    - Buffers based on variable distance
    - Multiple Ring Buffers

Vector Analysis

- Buffering
  - Buffers based on constant distance
    - Buffering around points creates circular zones.
    - Buffering around lines creates a series of elongated zones.
    - Buffering around polygons creates buffer zones extending outward from the polygon boundaries.

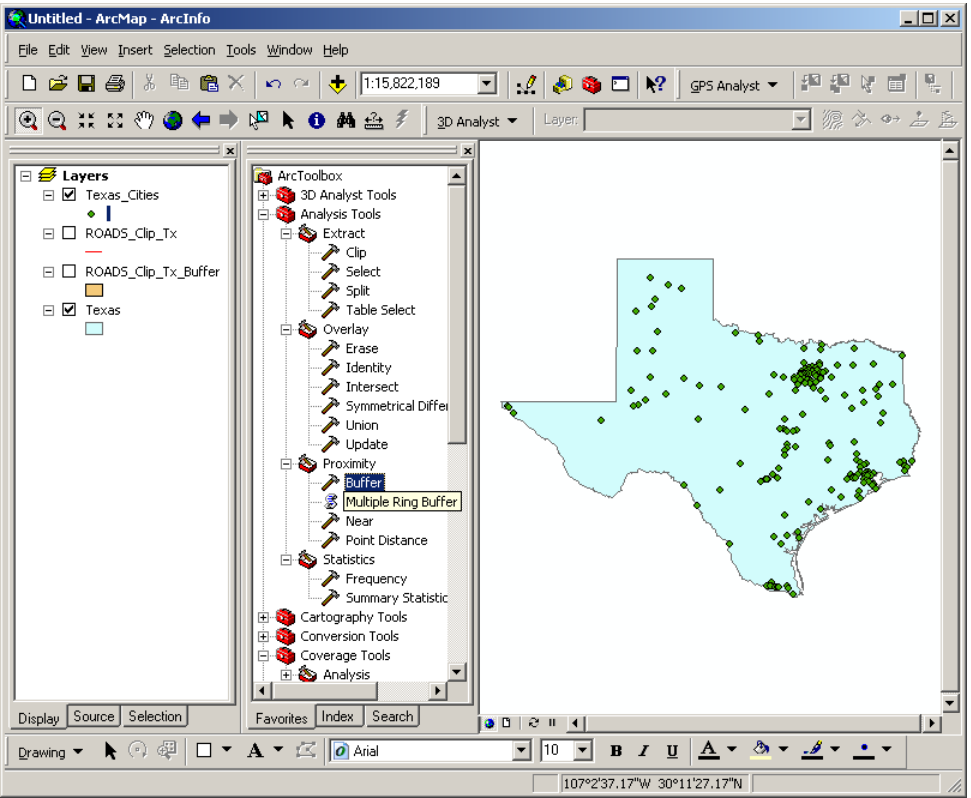
Buffering a point

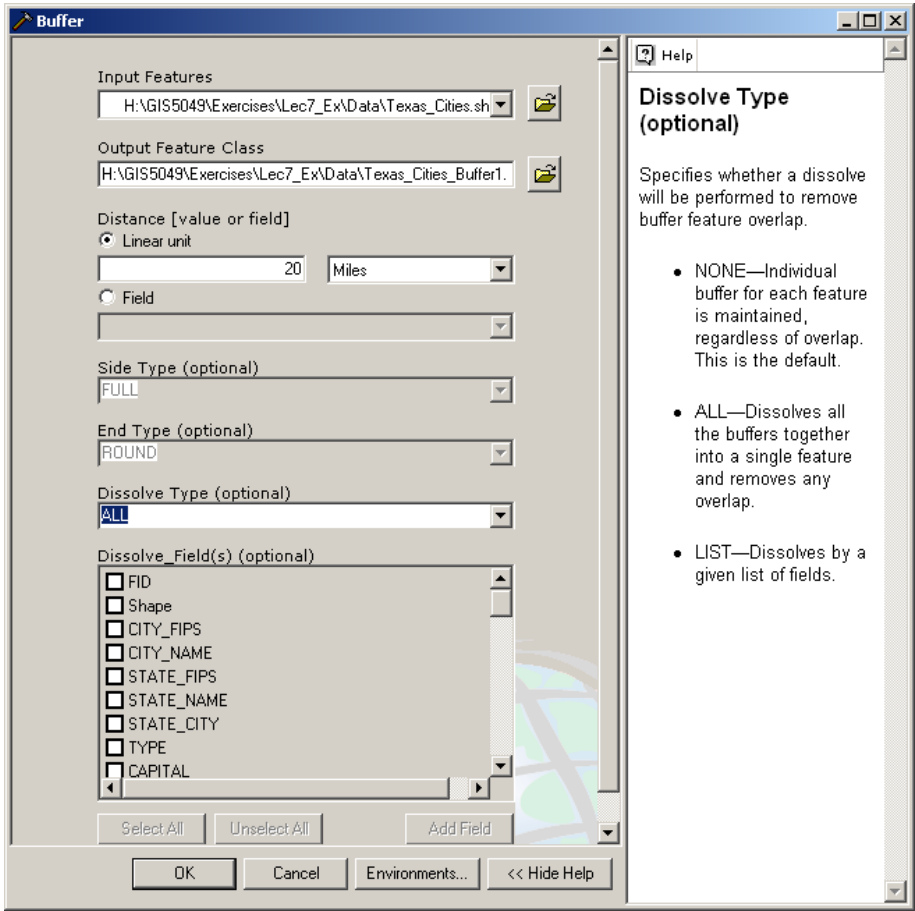
Buffering a linestring



Vector Analysis

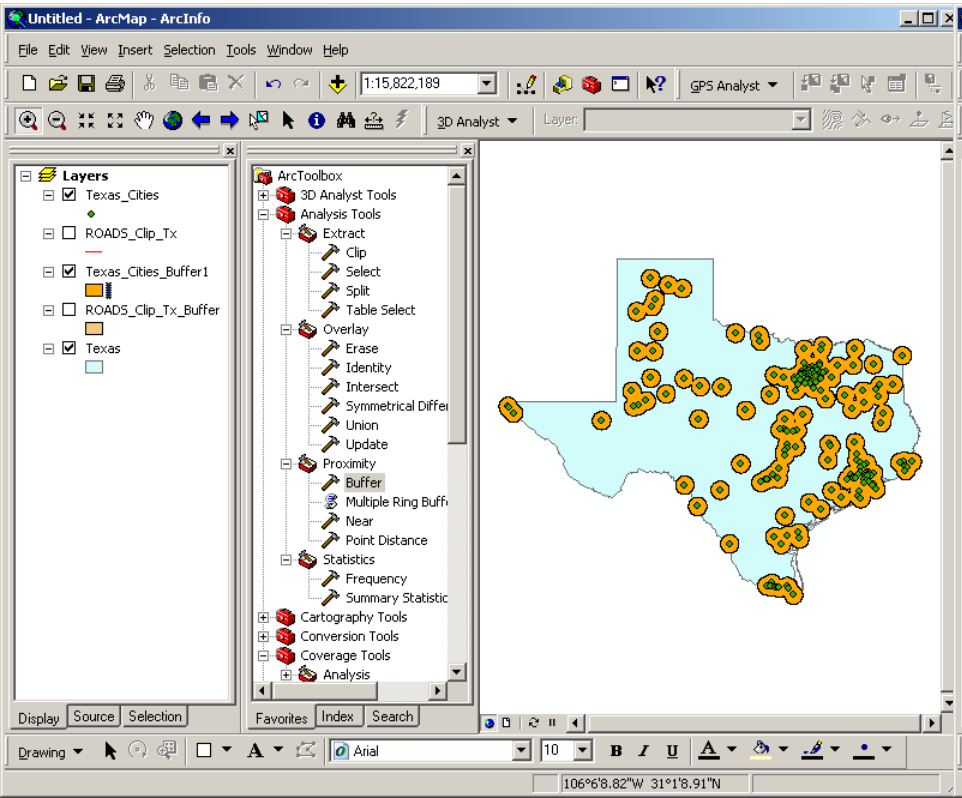
- Buffering
  - Buffers based on constant distance
    - Example: make a 20-mile buffer zone around cities in Texas.

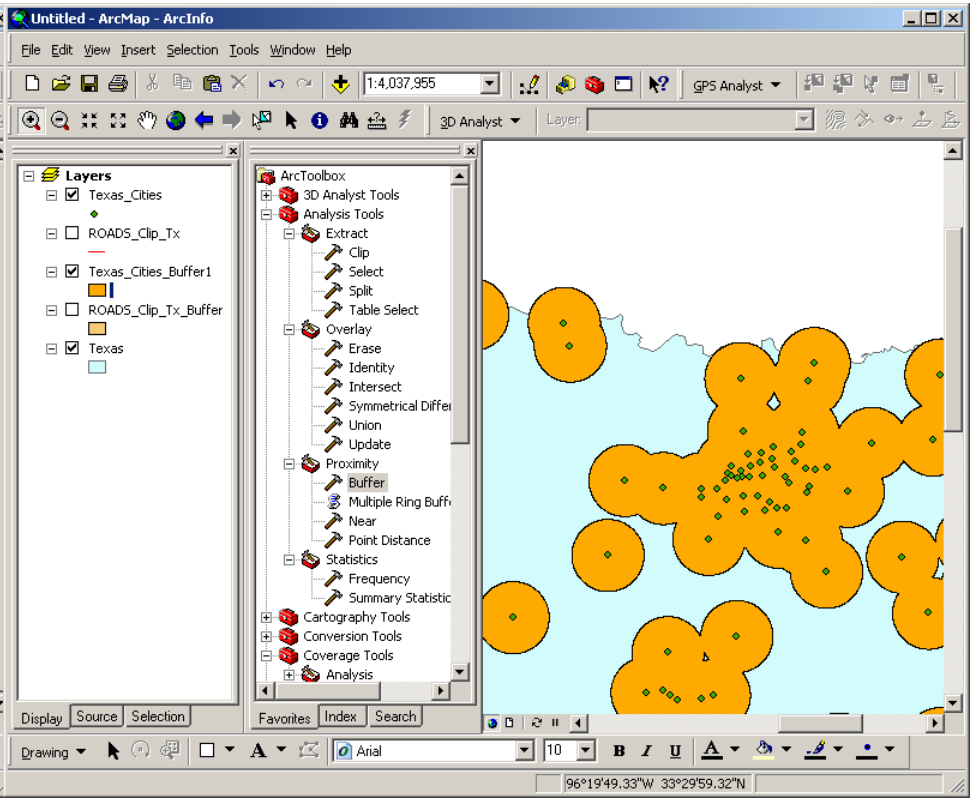




Vector Analysis

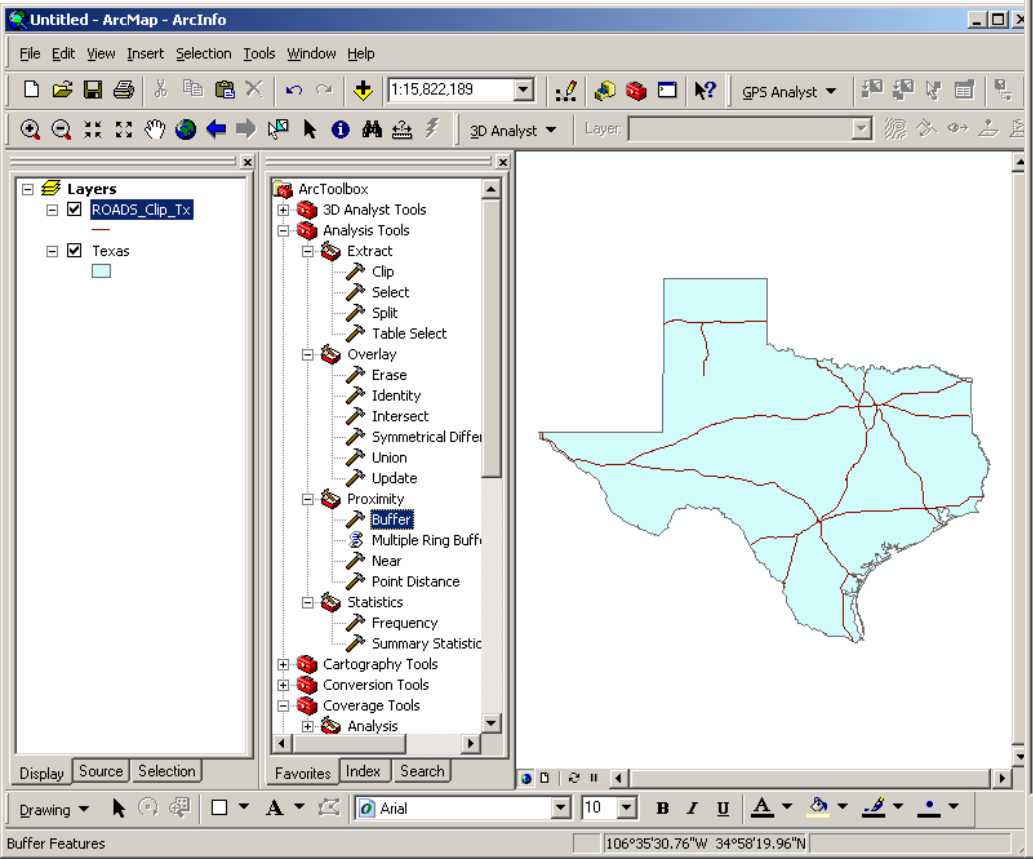
- Buffering
  - Buffers based on constant distance
    - Example: (‘continued)

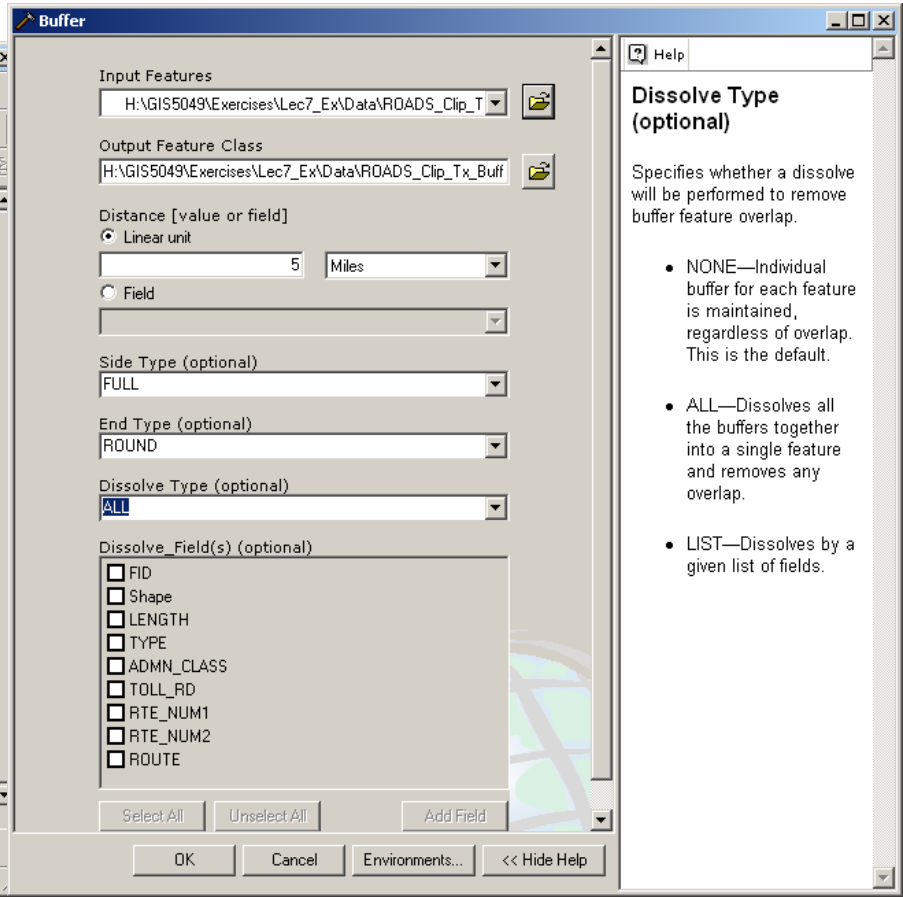




Vector Analysis

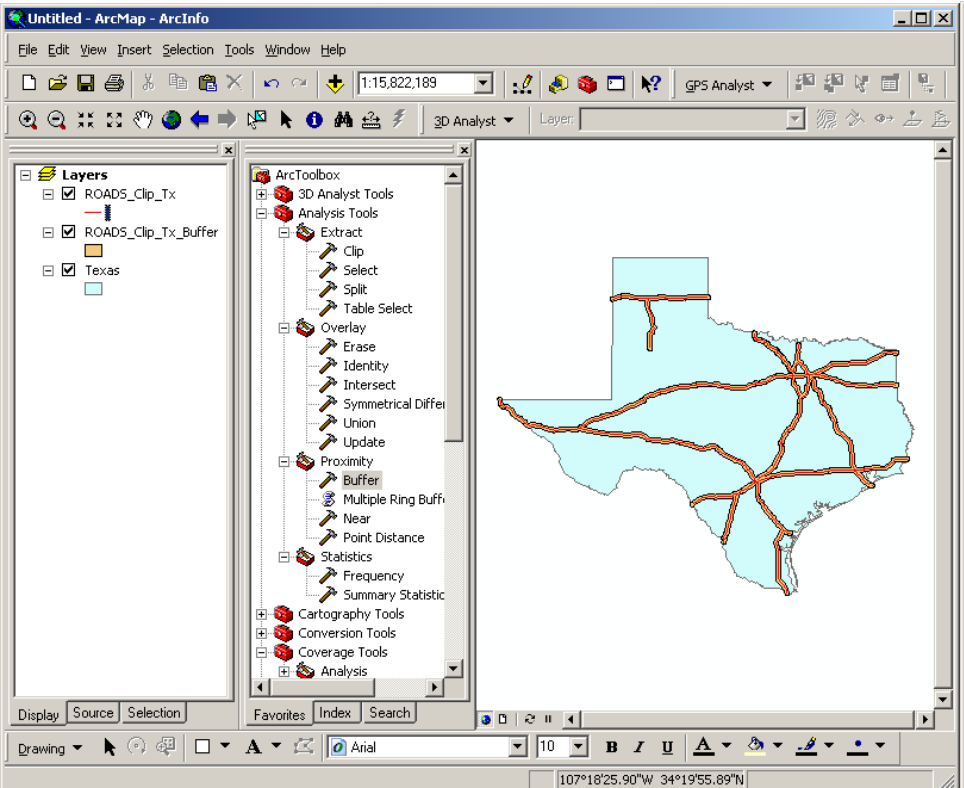
- Buffering
  - Buffers based on constant distance
    - Example: Make a 5-mile buffer zone around the major roads in Texas.

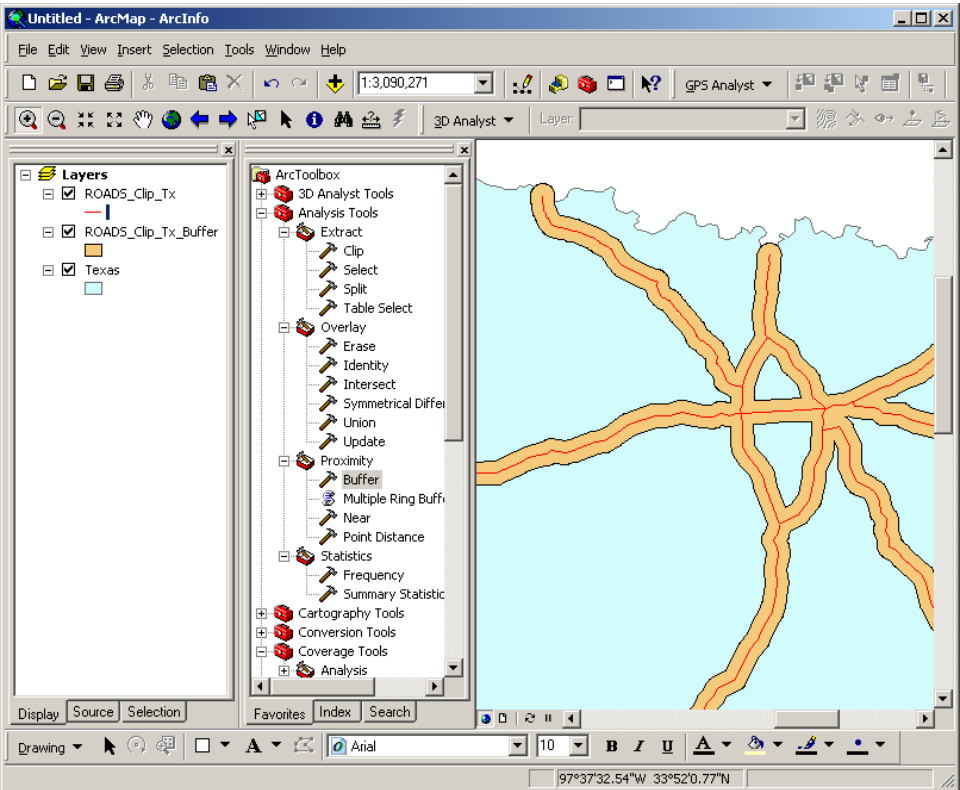




Vector Analysis

- Buffering
  - Buffers based on constant distance
    - Example (‘continued)



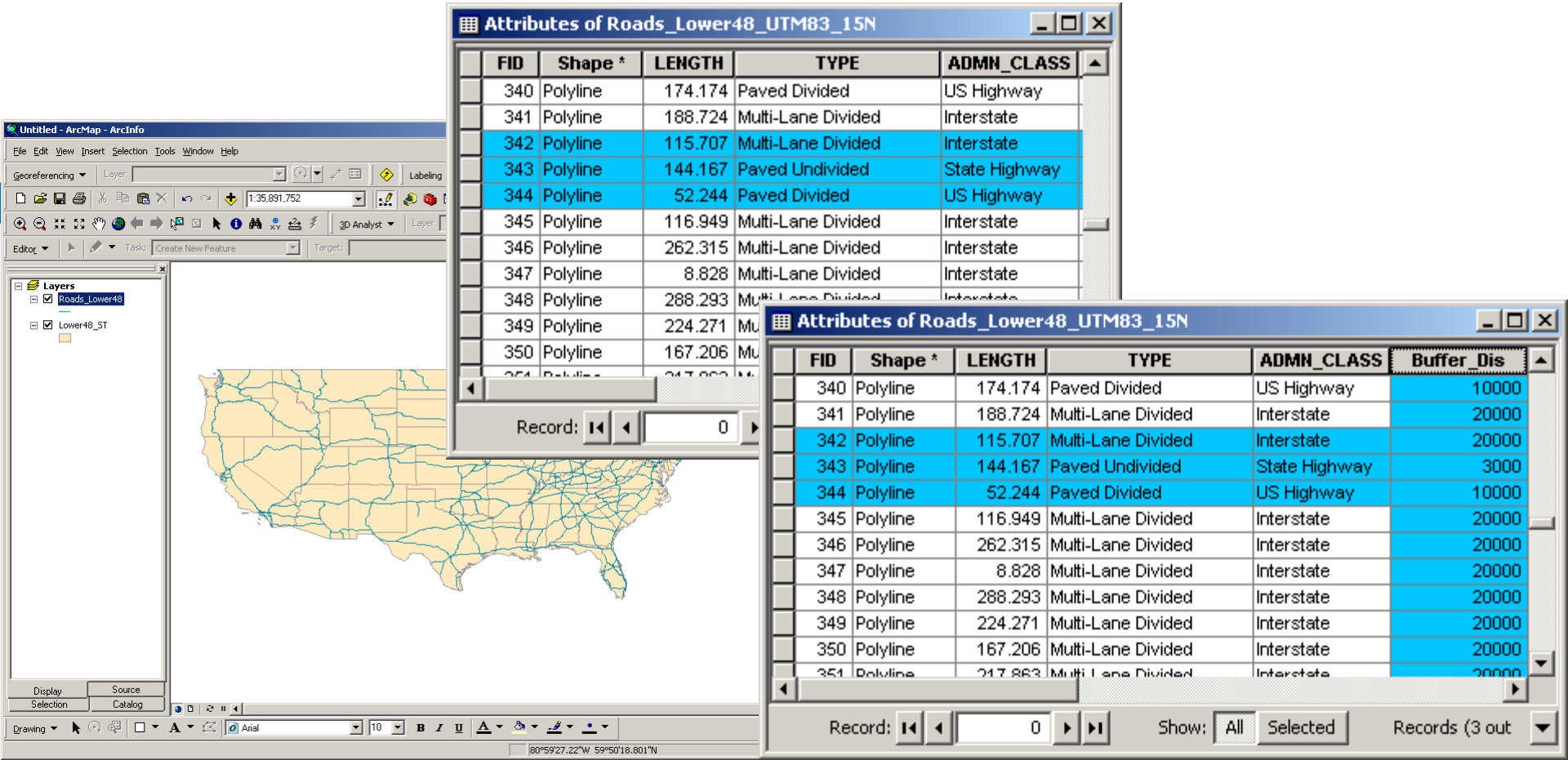


Vector Analysis

- Buffering
  - Buffers based on variable distance
    - You can create buffers of various distances depending on the types of objects in the feature class.
      - Example: For the single dataset of turtle habitats in Florida, you can create larger buffers for those most endangered turtle species while creating smaller buffer zones for those less endangered turtle species.
    - Needs a new field which stores the variable distance in the attribute table of the input layer.

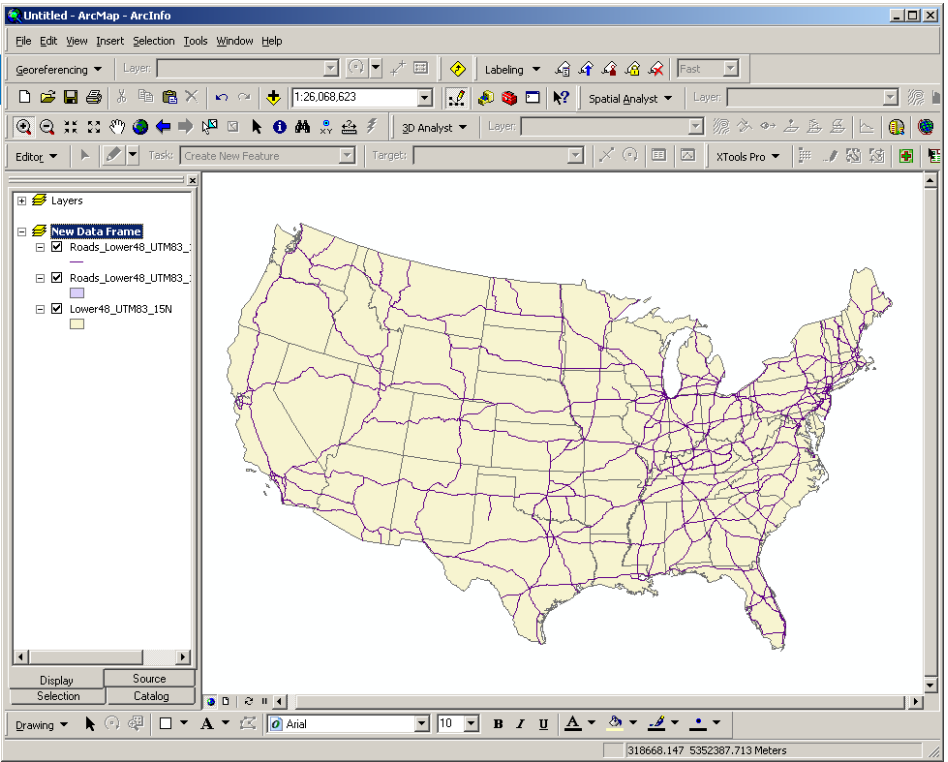
Vector Analysis

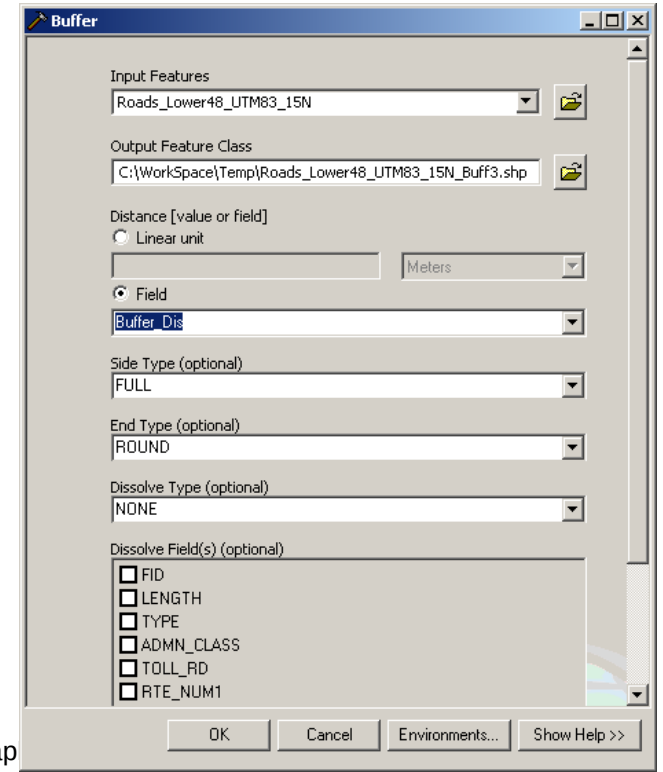
- Buffering
  - Buffers based on variable distance
    - Needs a new field which stores the variable distance



Vector Analysis

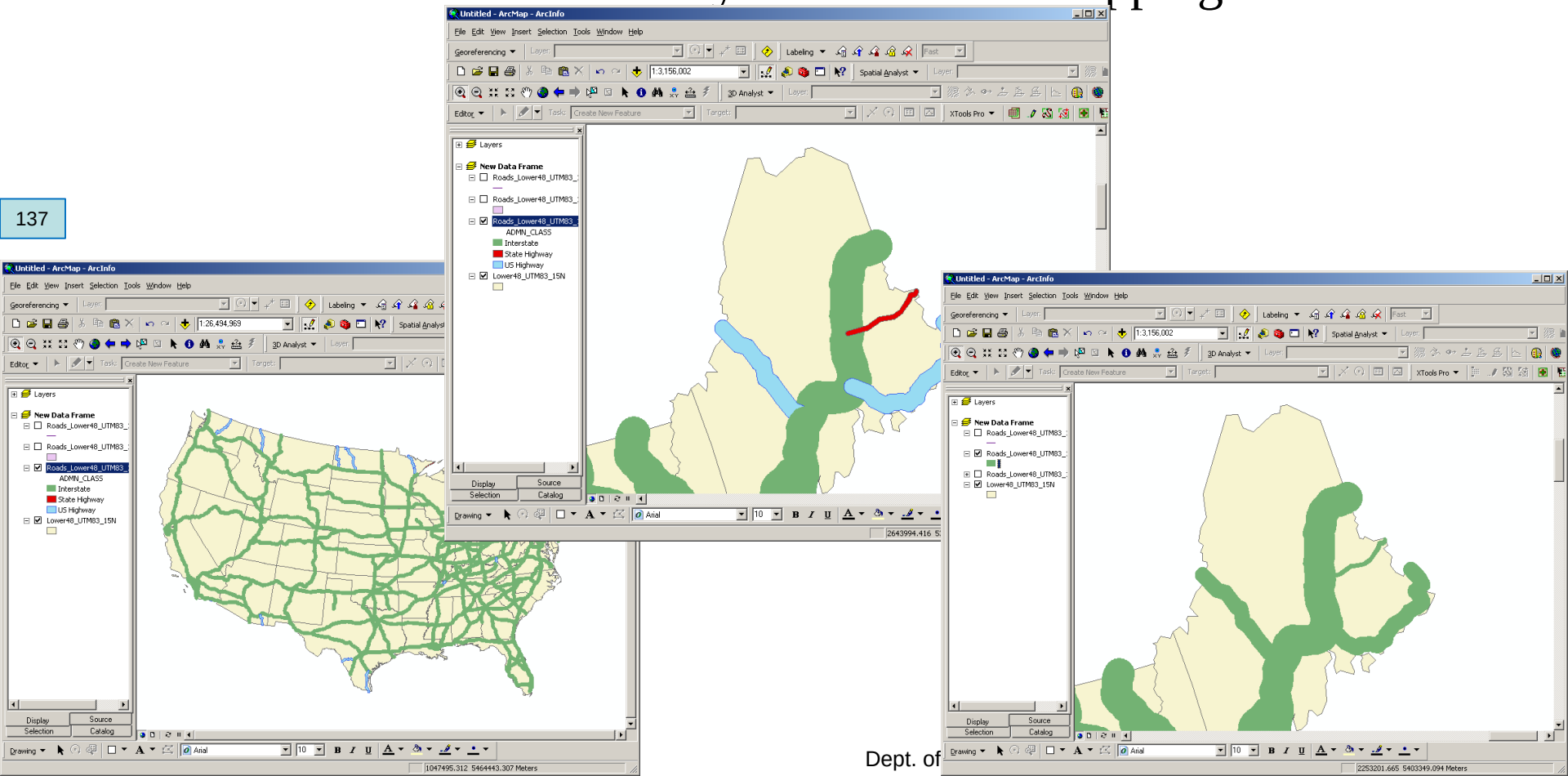
- Buffering
  - Buffers based on variable distance
    - Note: The unit of distance is very important.
      - Re-project the datasets.
      - Changing the coordinate system of data frame does not work.





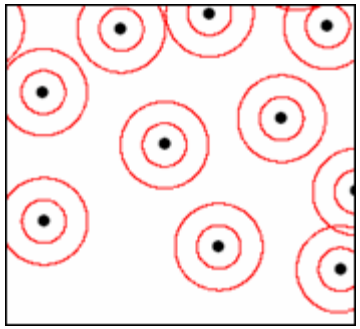
Vector Analysis

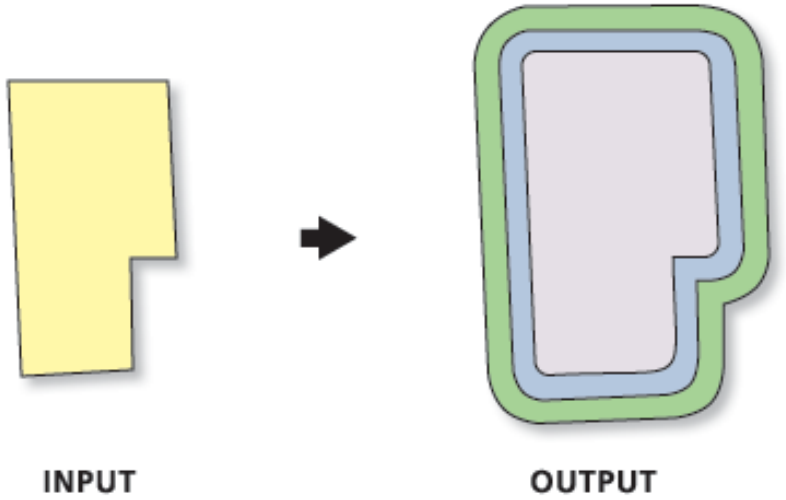
- Buffering
  - Buffers based on variable distance
    - Dissolve is necessary to remove overlapping buffers.



Vector Analysis

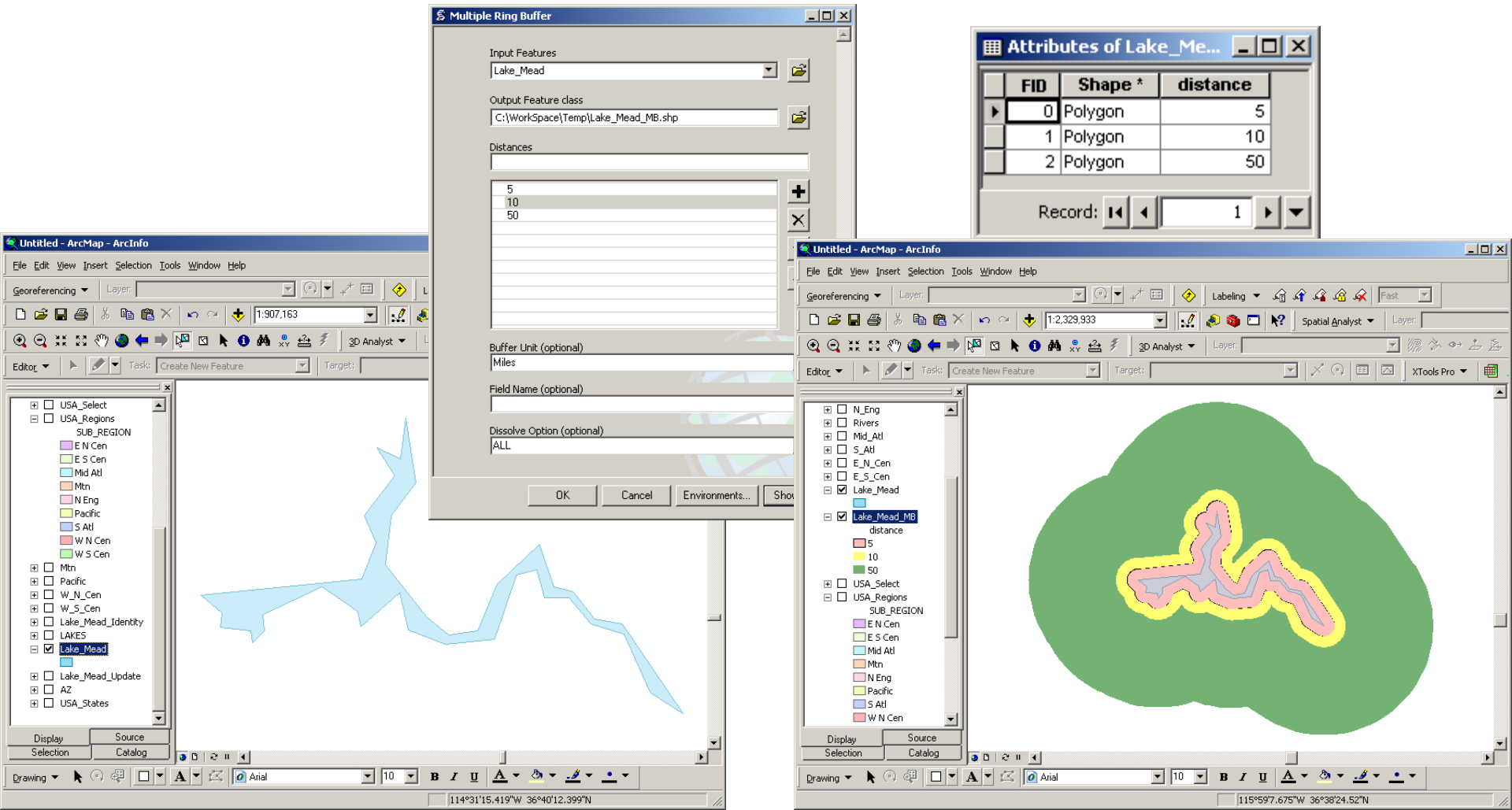
- Buffering
  - Multiple Ring Buffer
    - Creates a new feature class of buffer features using a set of buffer distances.
    - You could use the multi-ring buffer tool to classify the areas around a feature into near, moderate distance, and long distance classes for an analysis.





Vector Analysis

- Buffering
  - Multiple Ring Buffer

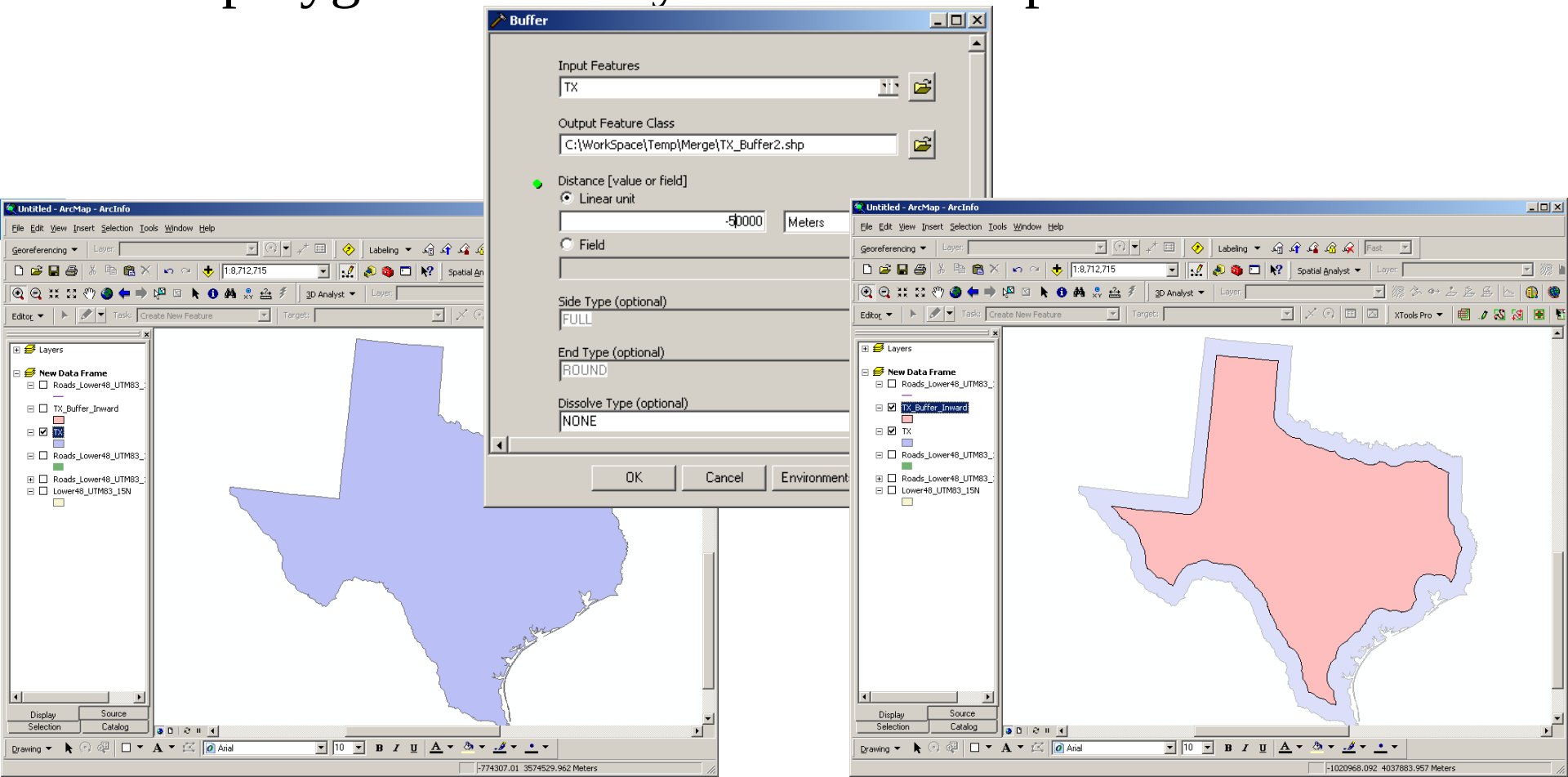


Vector Analysis

- Buffering
  - Features will not be buffered if their buffer distance is zero.
  - Negative distances can be used when buffering polygon features, to create buffers on the inside of the polygon features.
    - Using a negative value will shrink the output polygon feature by the distance specified.

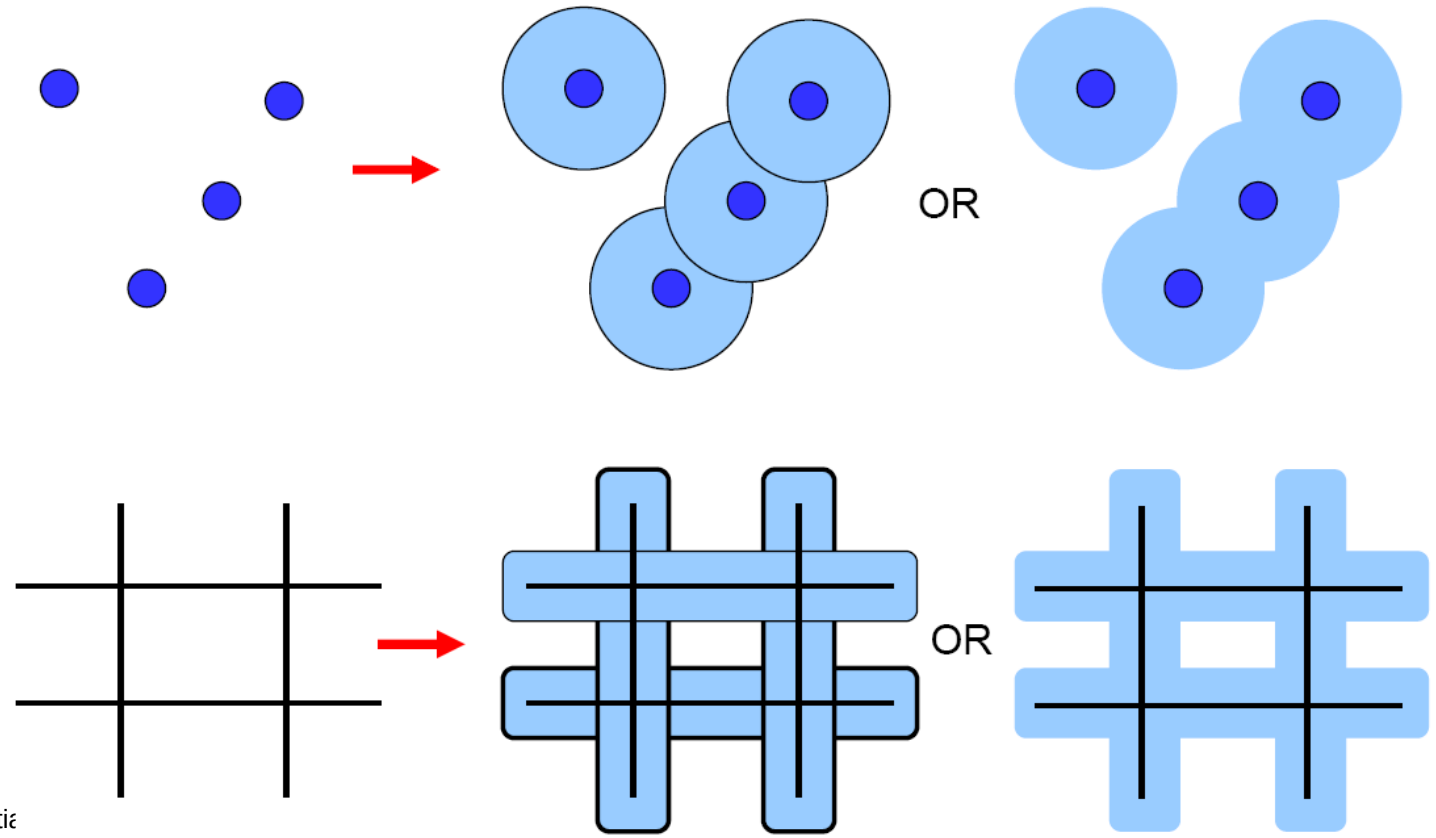
Vector Analysis

- Buffering
  - Using a negative value will shrink the output polygon feature by the distance specified.



Vector Analysis

- Buffering
  - An optional dissolve is often performed to remove overlapping buffers. It is called “coalescing”.



Vector Analysis

- Buffering
  - Coalescing can be important.
    - When using the results of Buffer as input to an overlay operation such as Union or Intersect, it is recommended that Buffer output be dissolved in order to reduce the number of features and overlap.
      - This will reduce the number of spatial relationships between the input features being processed, thereby reducing the amount of memory the tool requires and the amount of time required for processing.

Vector Analysis

- Buffering
  - Buffer with overlay will provide portions of features within a distance.
  - Spatial Join and Select Layer By Location all capable of selecting within a distance, but not portions of features.

Vector Analysis

- Demos

  - Union
  - Intersect
  - Dissolve
  - Split
  - Clip
  - Erase
  - Merge
  - Append
  - Update
  - Identity
  - Create Thiessen Polygons
  - Selection

  - Buffer based on constant distance
  - Buffering based on variable distance
  - Multiple Ring Buffer
  - Spatial Query
  - Spatial Join

THE END