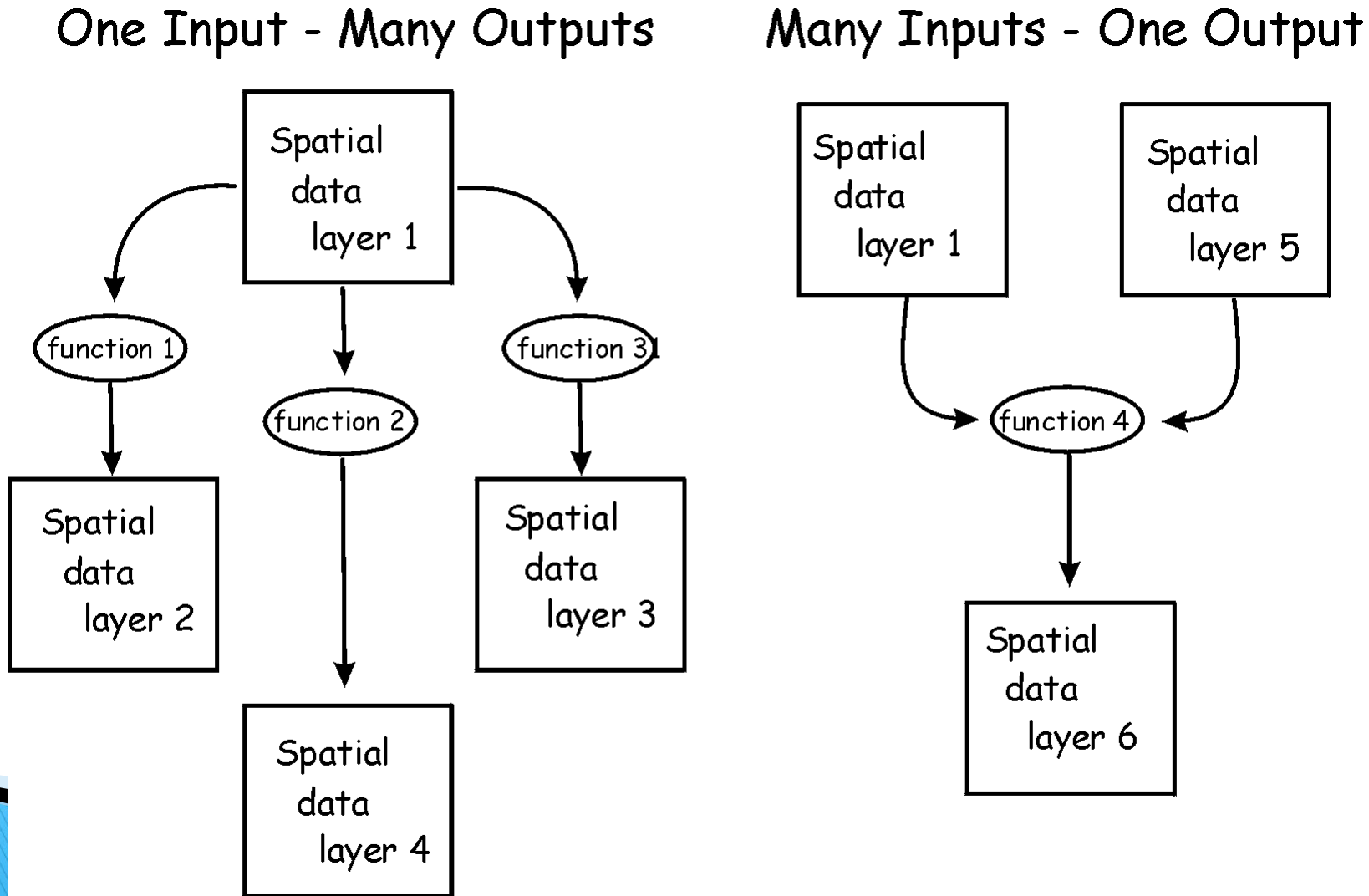
Spatial analysis in GIS

Spatial data analysis

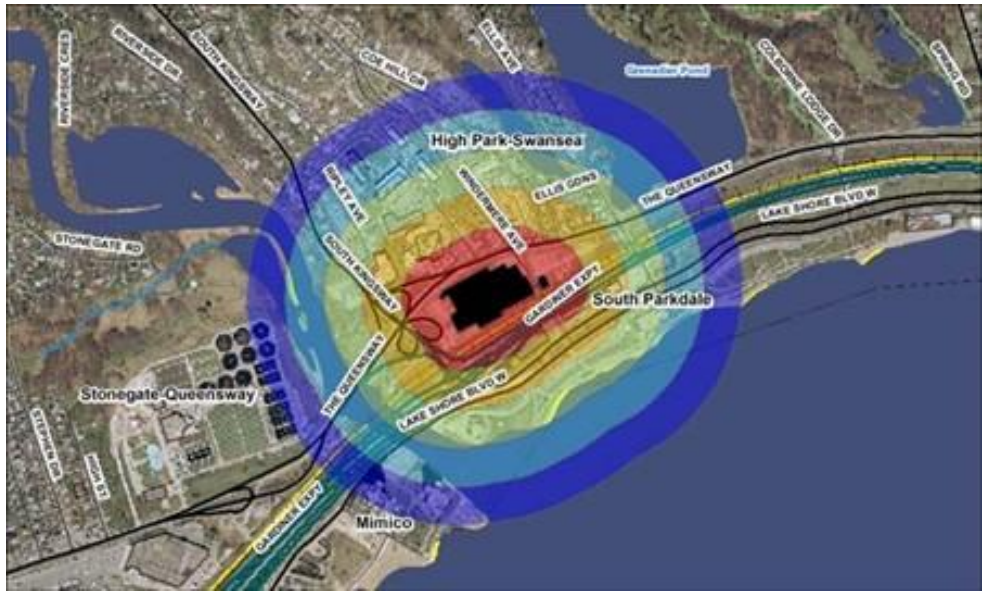
Input -> *spatial operation* -> output



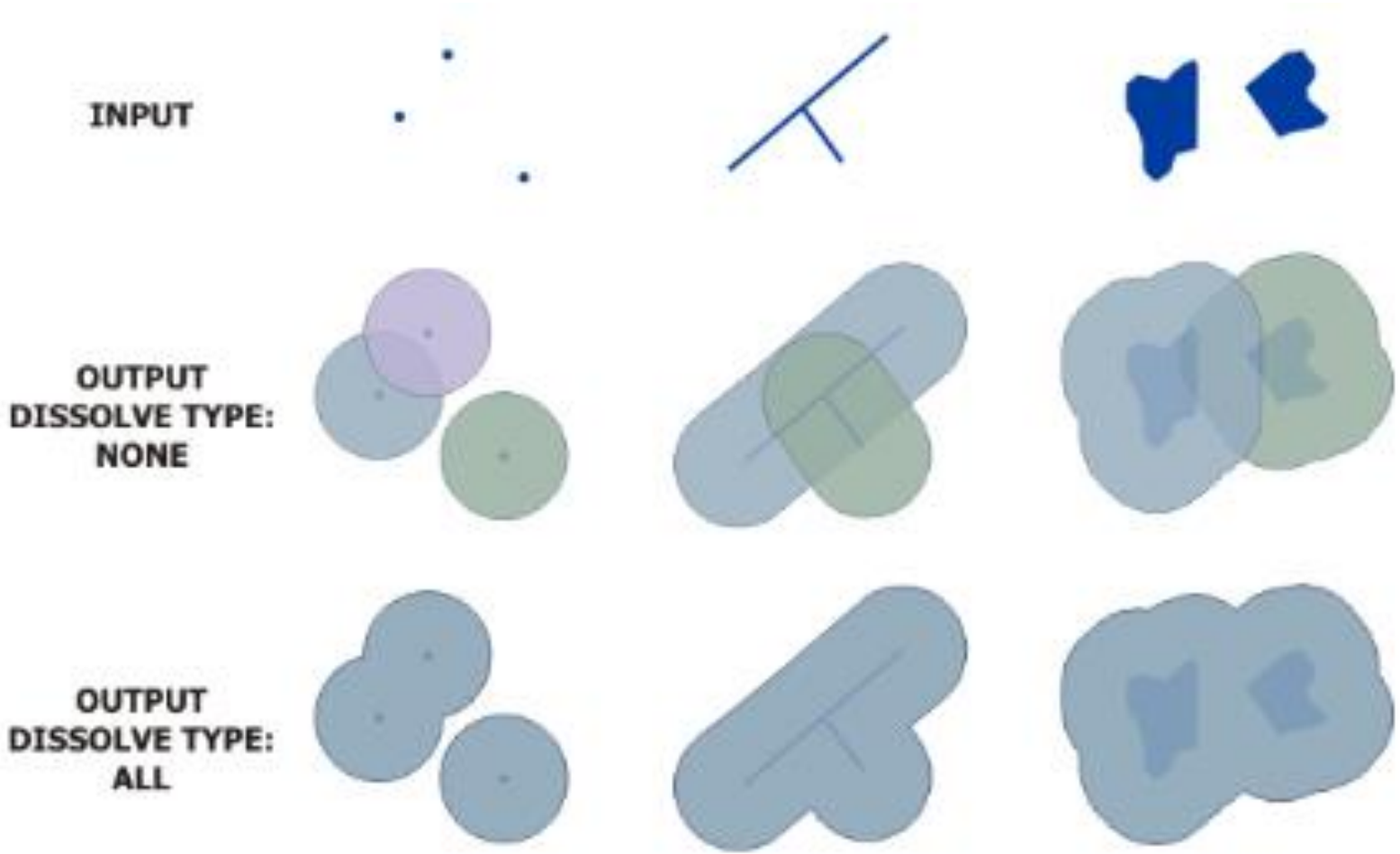
Buffers

Buffers

- A buffer creates polygons around input features to a specified distance.



Vector Buffers



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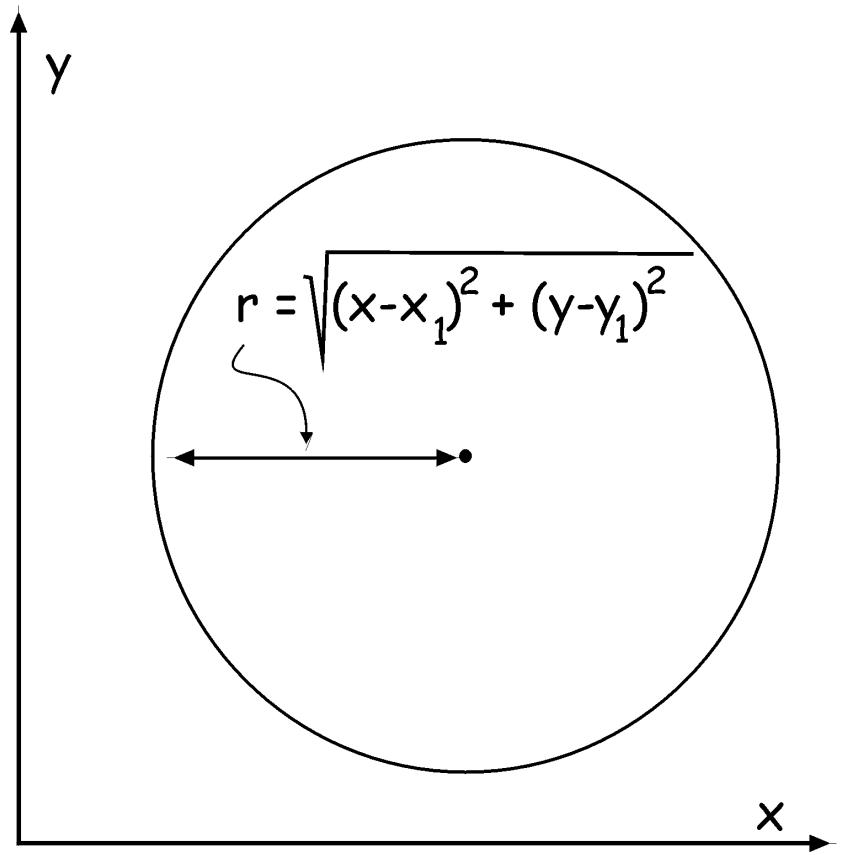
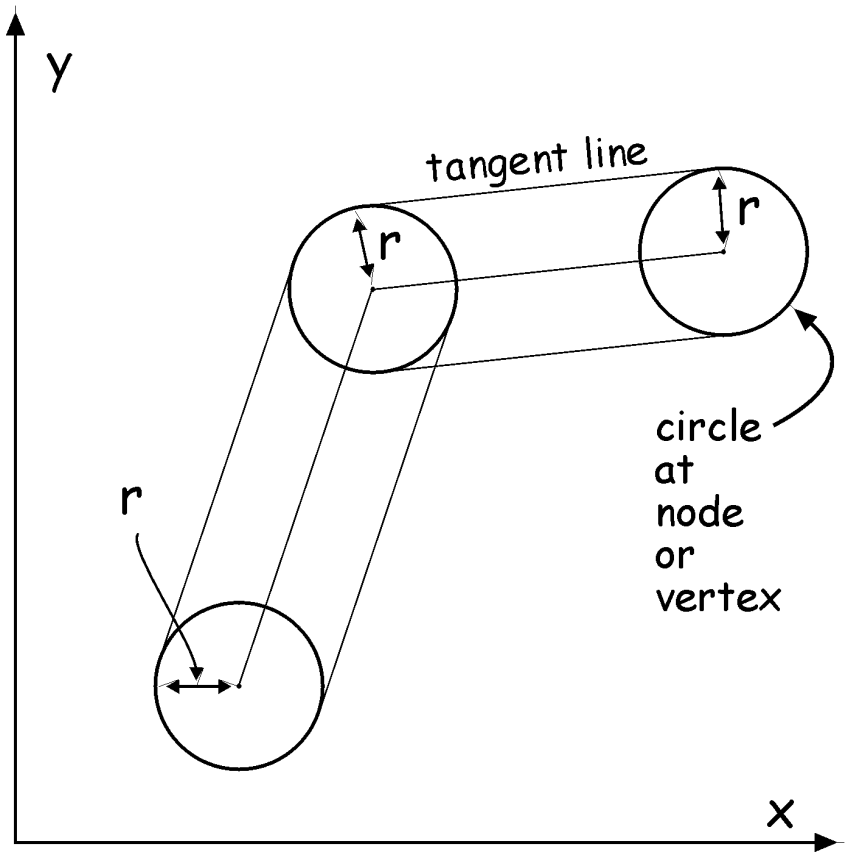
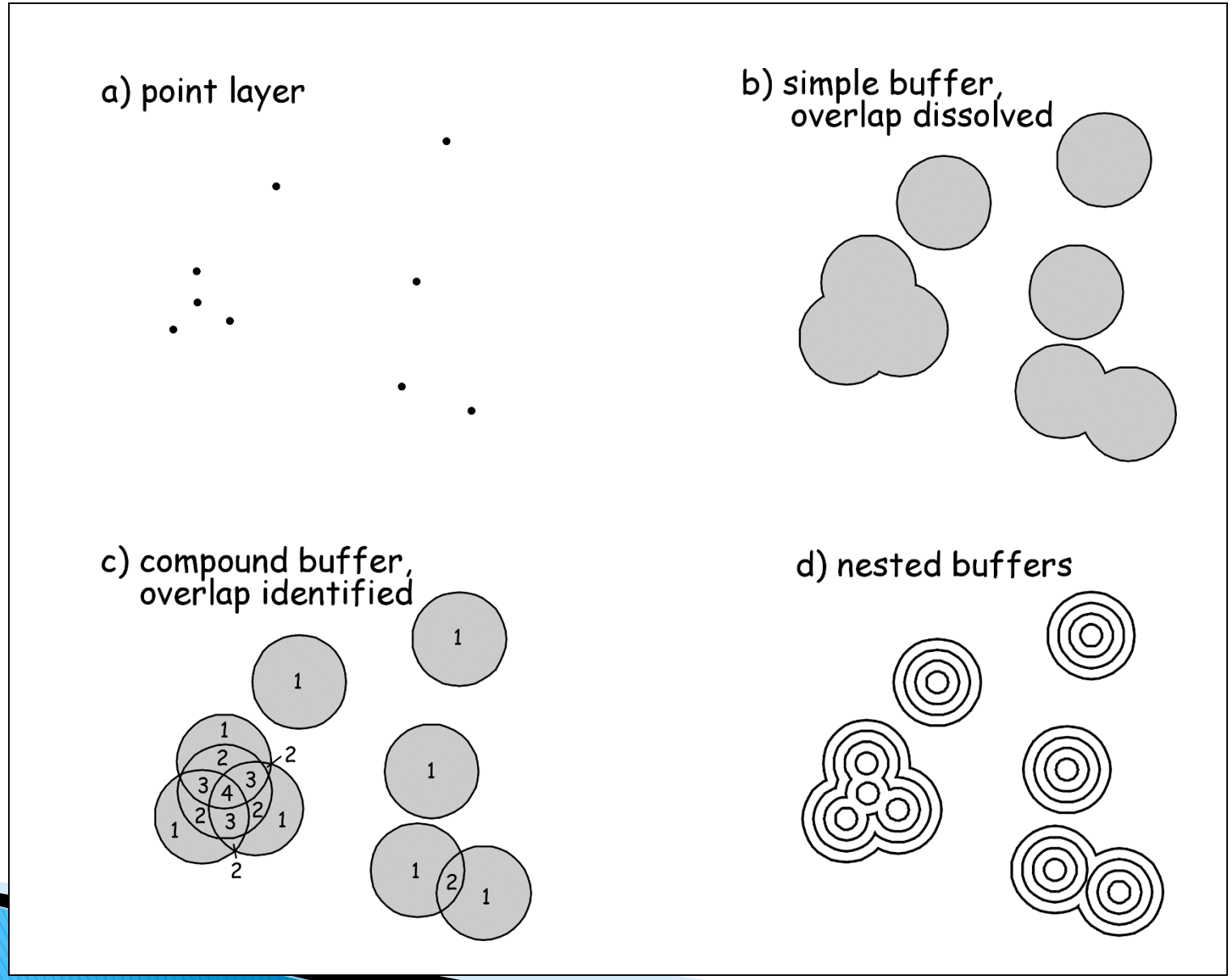
Mechanics of Point and Line Buffering





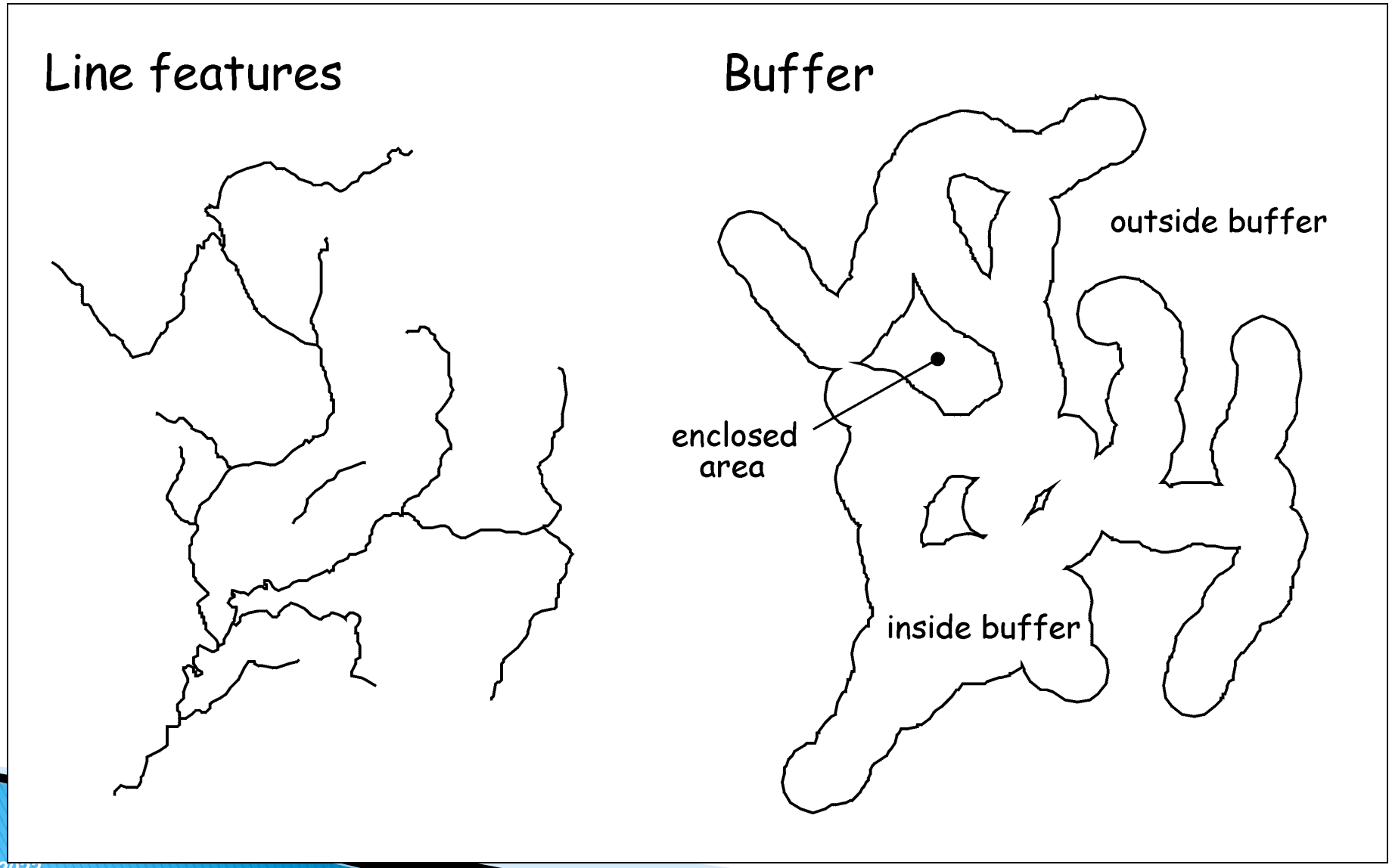
Buffering Variants: point buffer examples



Variable-distance buffer: a line buffer is shown with a variable buffer distance, 100 km from main stem of the Mississippi River, 75 km from larger tributaries, and 50 km from remaining tributaries.

river_identifier	buffdist
mississippi	100
missouri	50
arkansas	50
ohio	75
tennessee	75

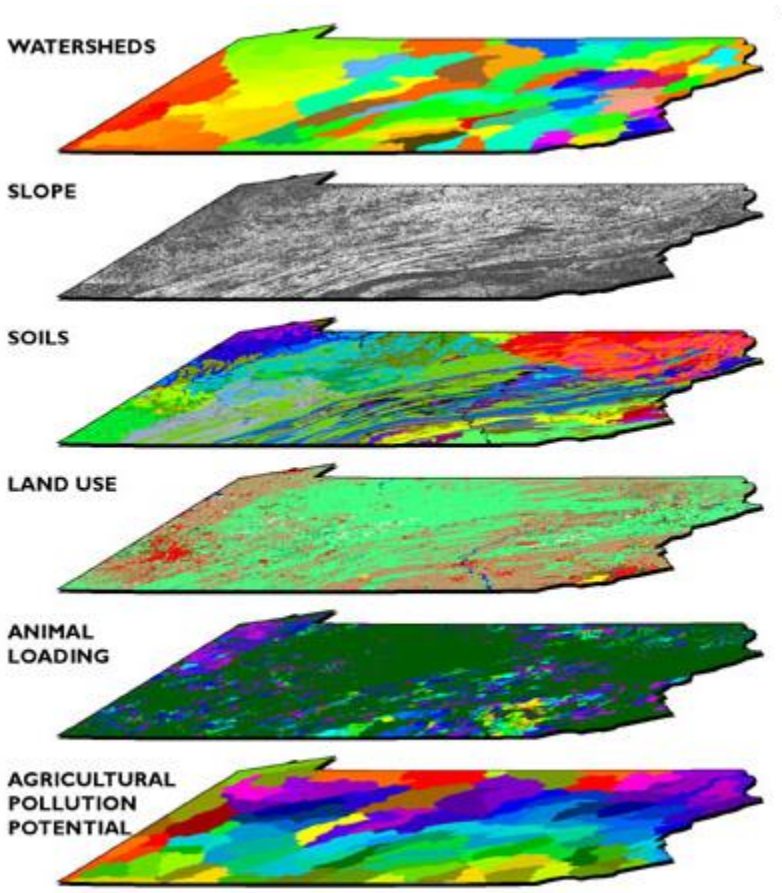
Regions in Buffering – inside, outside, enclosed

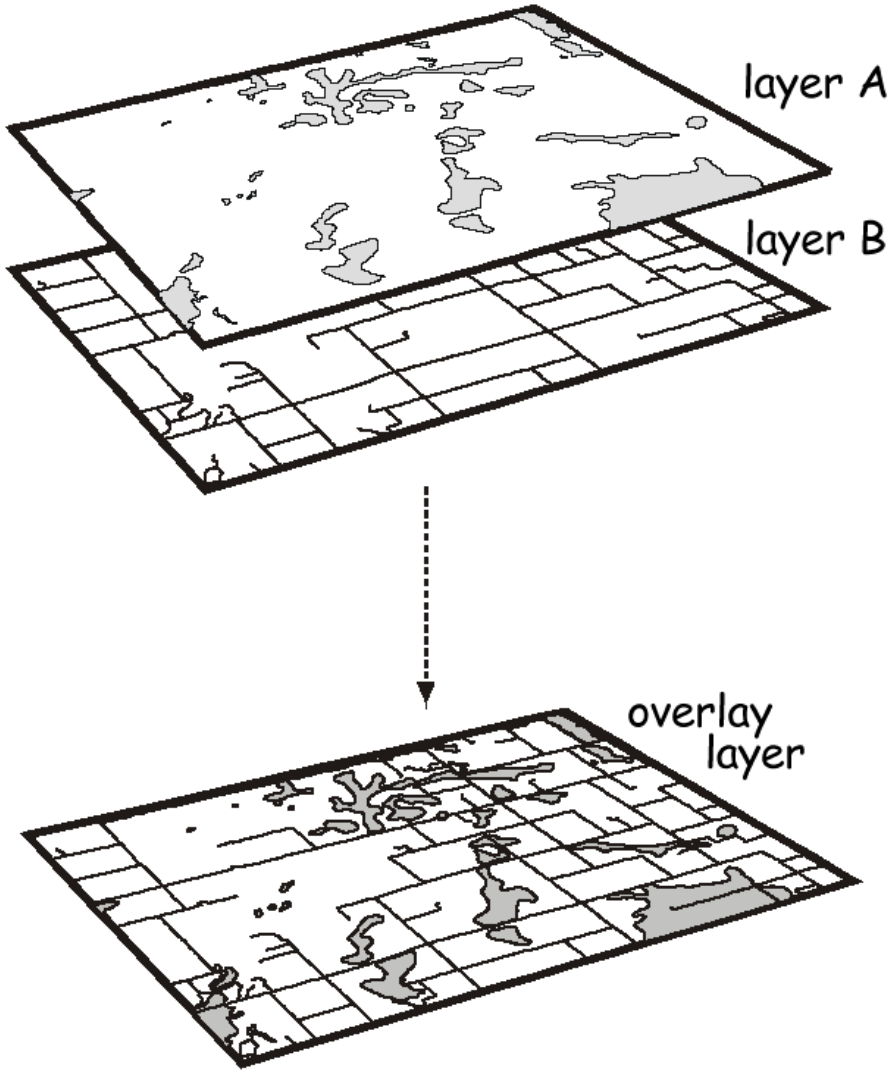


Overlay Analysis

Overlay Analysis

- Combination of different data layers
- Both spatial and attribute data is combined
- Requires that data layers use a common coordinate system
- A new data layer is created

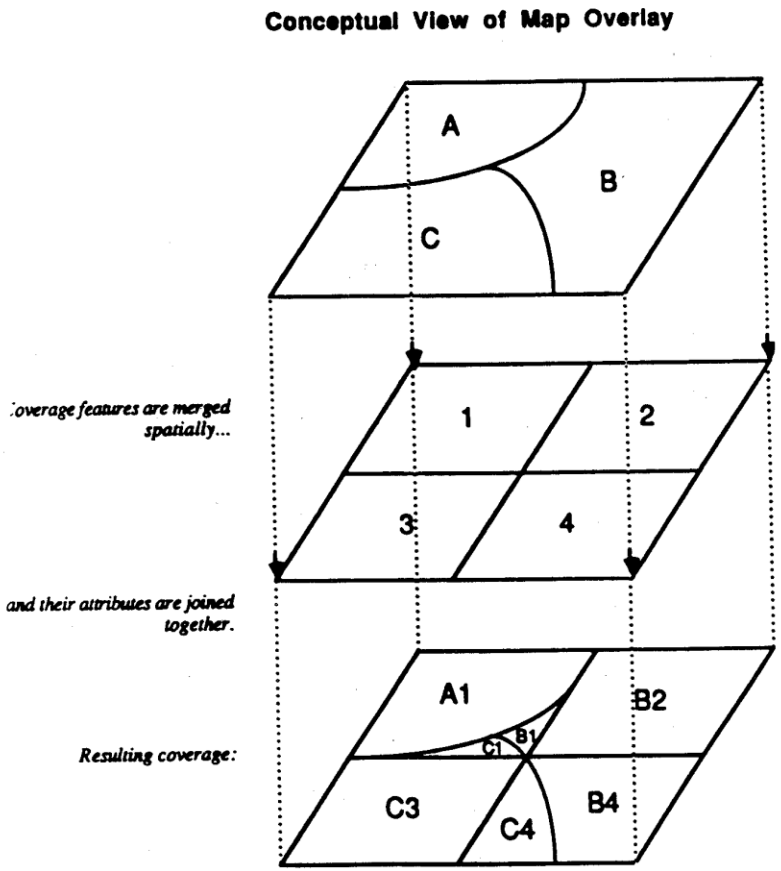


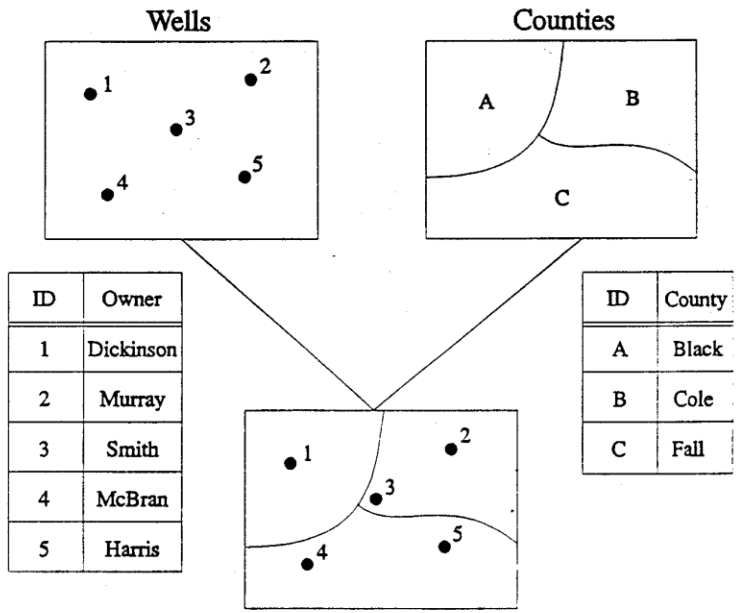


attributes for layer A

attributes for layer B

overlay attributes, combined attributes for layers A & B





ID	Owner
1	Dickinson
2	Murray
3	Smith
4	McBran
5	Harris

ID	County
A	Black
B	Cole
C	Fall

ID	County	Owner
1	Black	Dickinson
2	Cole	Murray
3	Cole	Smith
4	Fall	McBran
5	Fall	Harris

Overlay - Point in Polygon

Vector Overlay

- Topology is likely to be different
- Vector overlays often identify line intersection points automatically.
- Intersecting lines are split and a node placed at the intersection point
- Topology must be recreated for later processing
- Any type of vector may be overlain with any other type
- Output typically takes the lowest dimension of the inputs
- For example: Point on Polygon results in a point

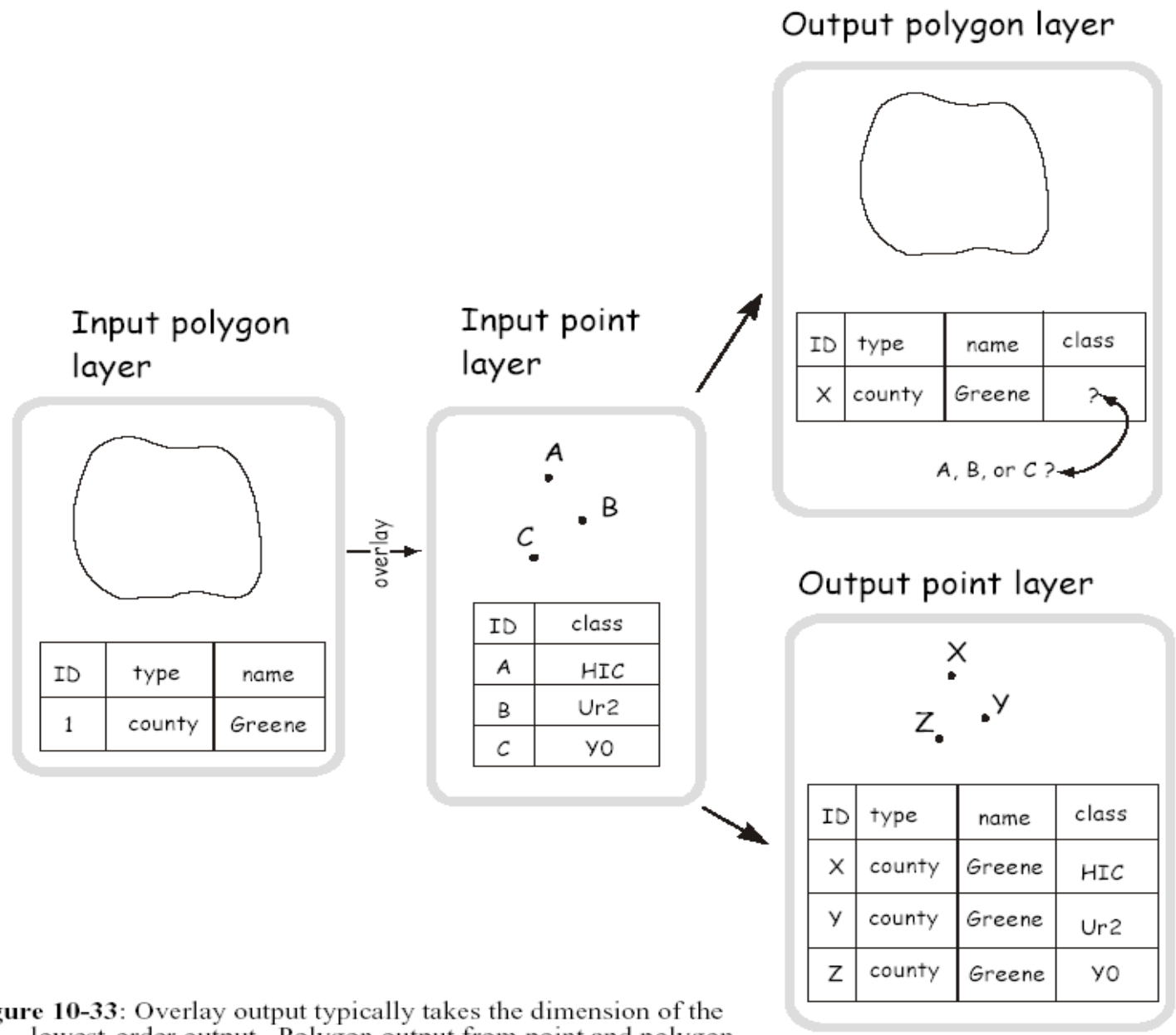


Figure 10-33: Overlay output typically takes the dimension of the lowest-order output. Polygon output from point and polygon overlay (right, top) results in uncertainty regarding the source for combined attribute data because there may be multiple points corresponding to each output polygon. Point output is unambiguous.

Ambiguous result

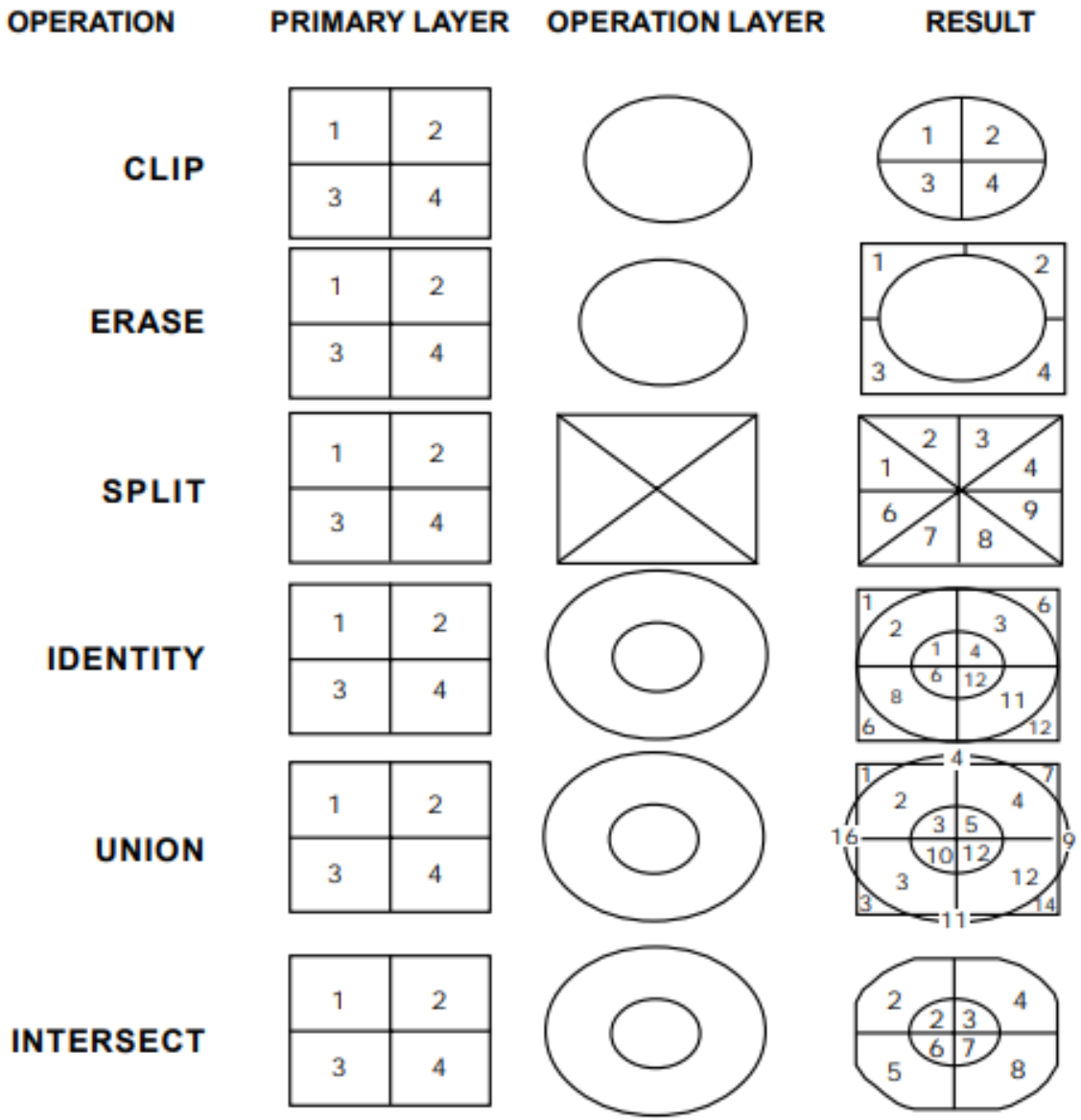
Un-ambiguous result

Vector Overlay - Most common ways applied, but there are other methods.

- CLIP
- INTERSECTION
- UNION

Overlay operations

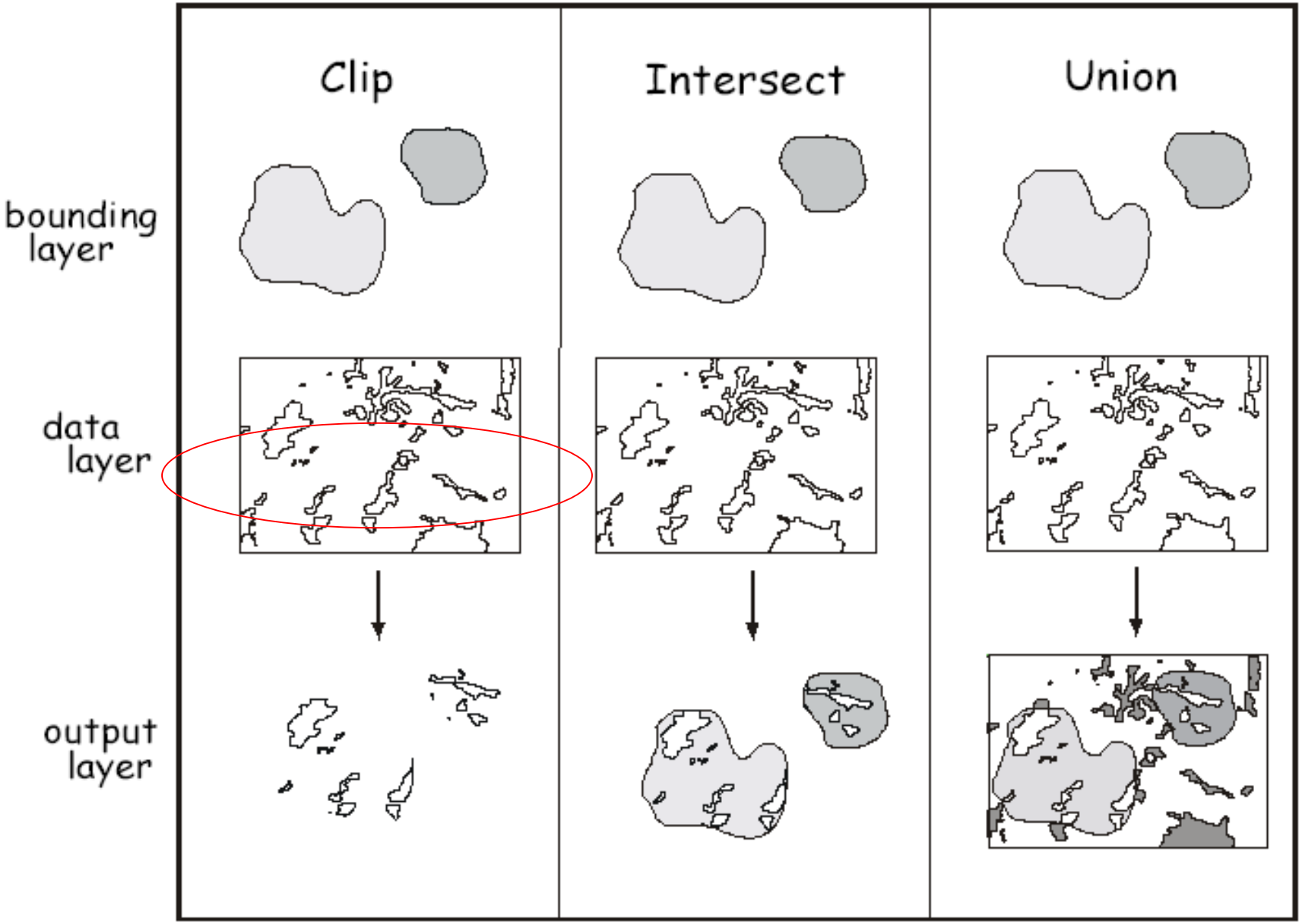
جامعة الملك سعود
King Saud University



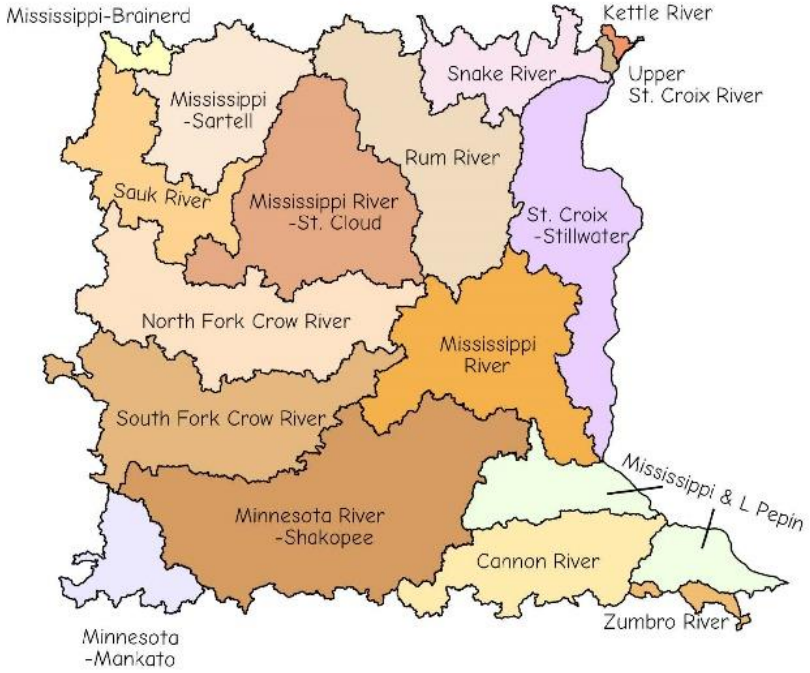
CLIP

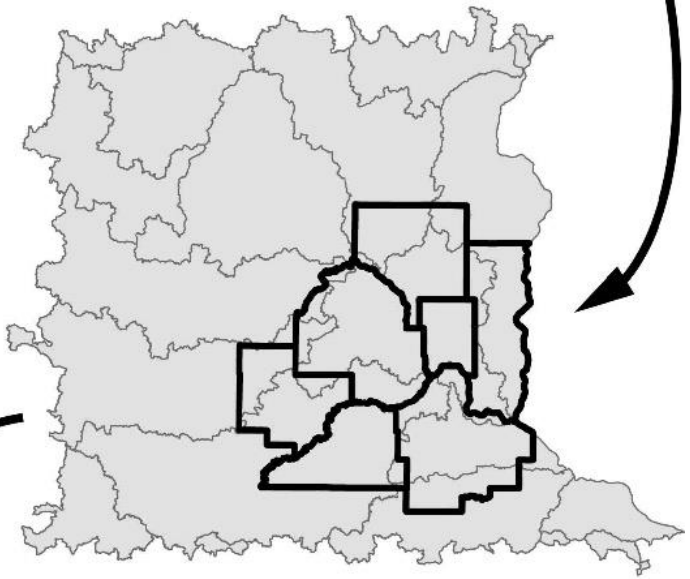
CLIP

- Cookie cutter approach
- Bounding polygon defines the clipped second layer
- Neither the bounding polygon attributes nor geographic (spatial data) are included in the output layer


Clip
Intersect
Union
bounding layer
data layer
output layer

Clip Catchments by Counties





Yields

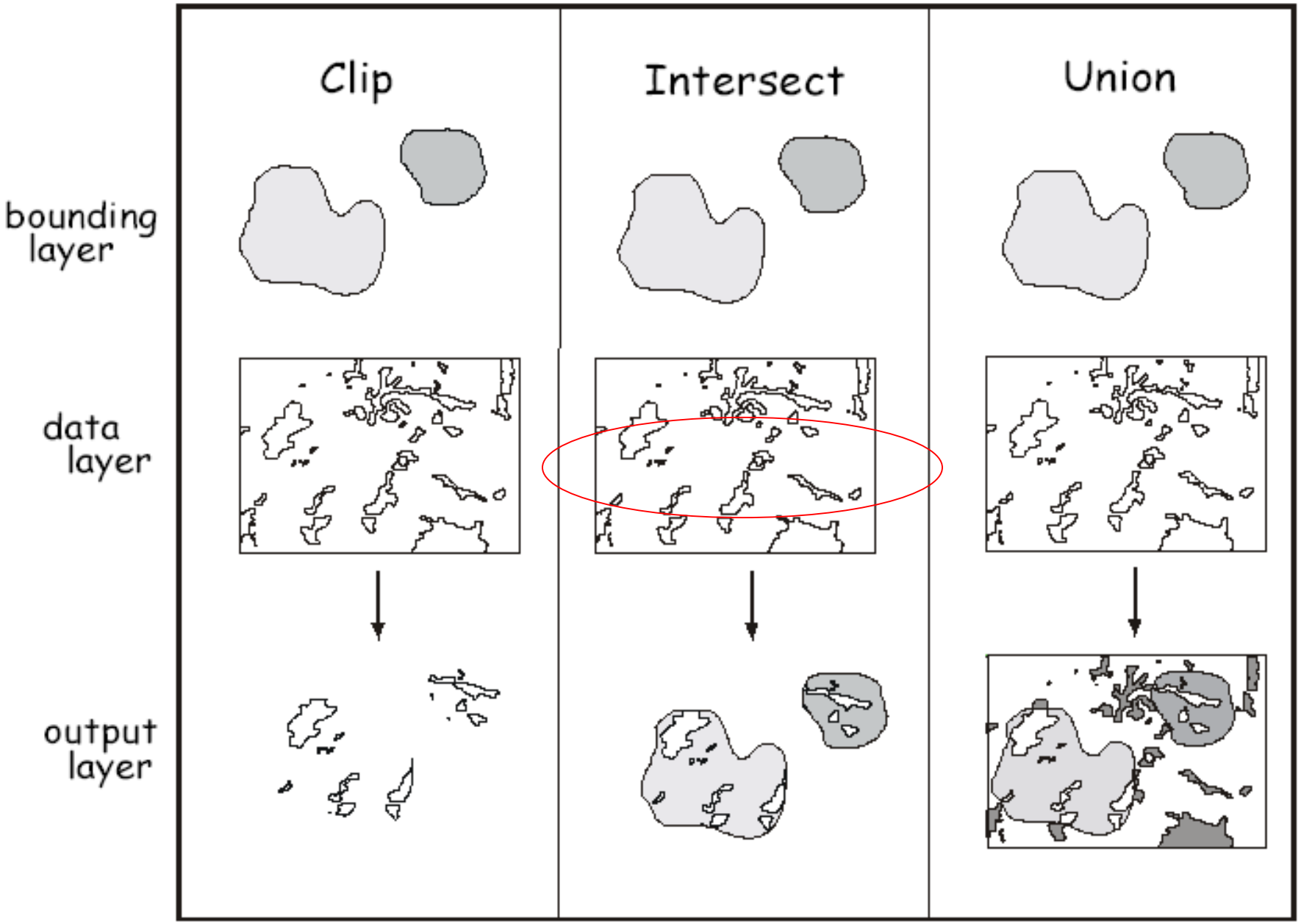
Extent of the clipping layer, the boundaries and attributes of only the clipped layer

INTERSECTION

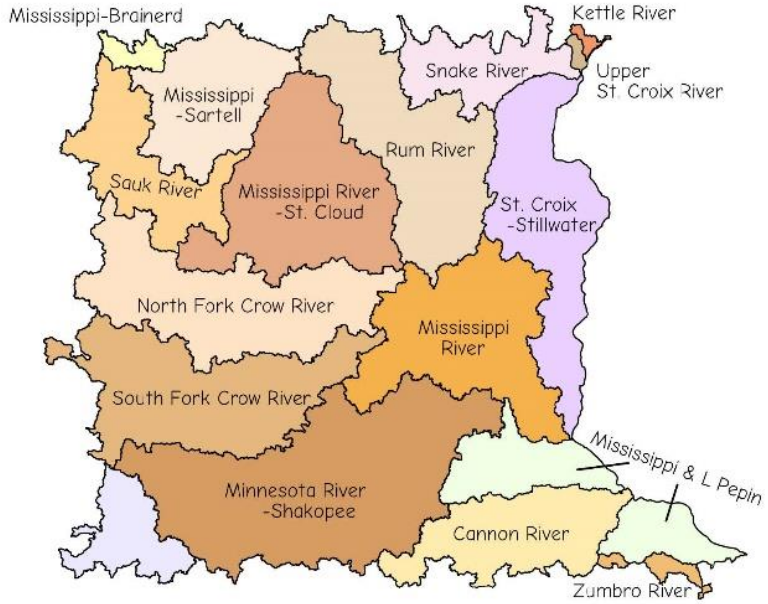
INTERSECTION

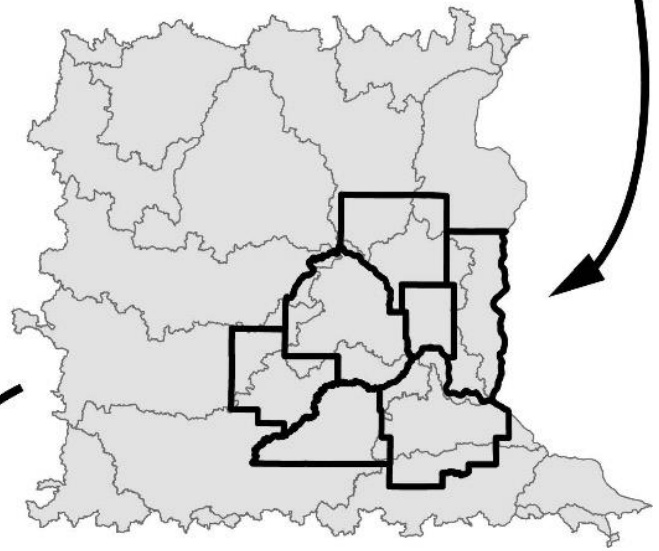
- Combines data from both layers but only for the bounding area

  (Bounding polygon also defines the output layer
  Data from both layers are combined
  Data outside the bounding layer (1st layer) is discarded)


Clip
Intersect
Union
bounding layer
data layer
output layer

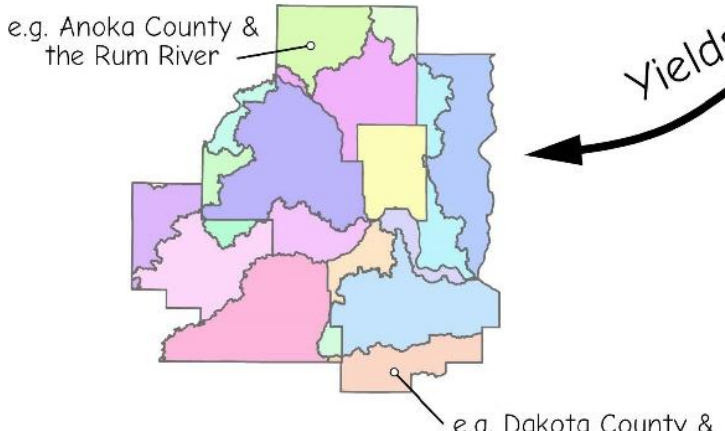
Intersect Catchments and Counties





Yields

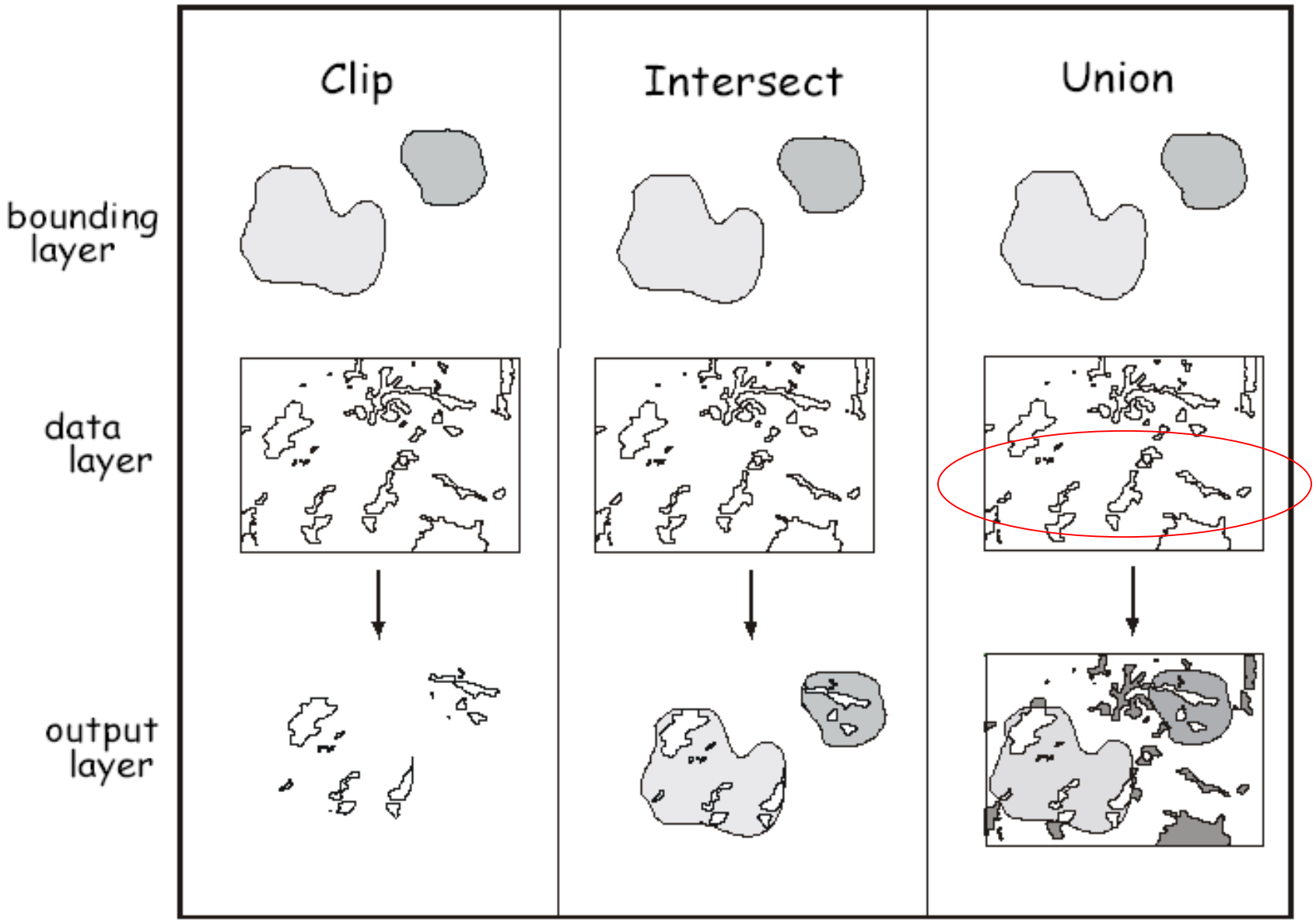
Extent of the clipping layer, boundaries and attributes of both layers



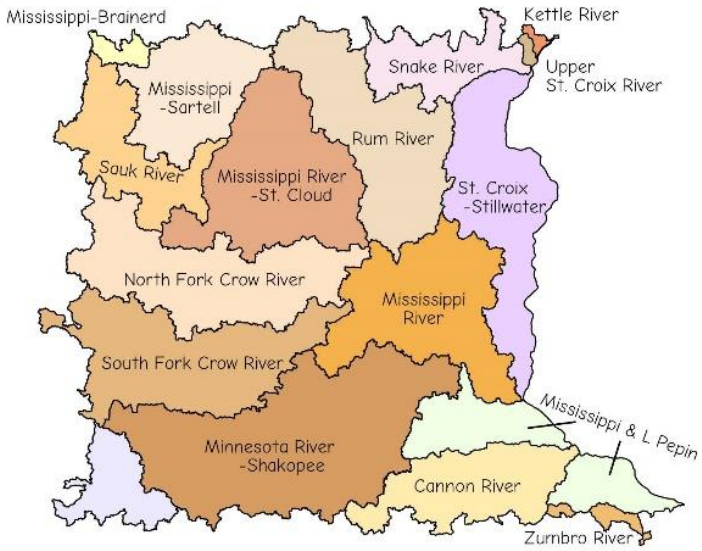
UNION

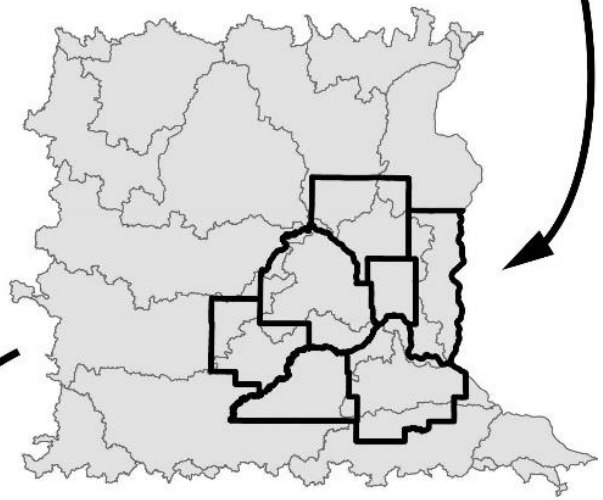
UNION

- Includes all data from both the bounding and data layers
- New polygons are formed by the combinations of the coordinate data from each layer


Clip
Intersect
Union
bounding layer
data layer
output layer

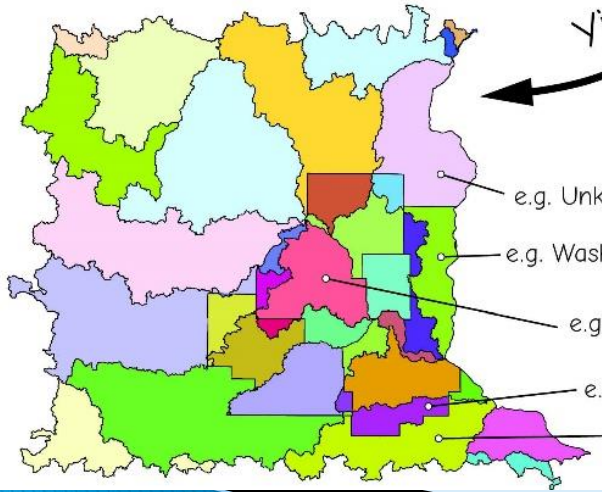
Union Catchments and Counties





Extent of both layers,boundaries and attributes of both layers, but note "unknown" or null values in non-overlapping regions

Yields



e.g. Unknown county & St. Croix-Stillwater River

e.g. Washington County & St. Croix-Stillwater River

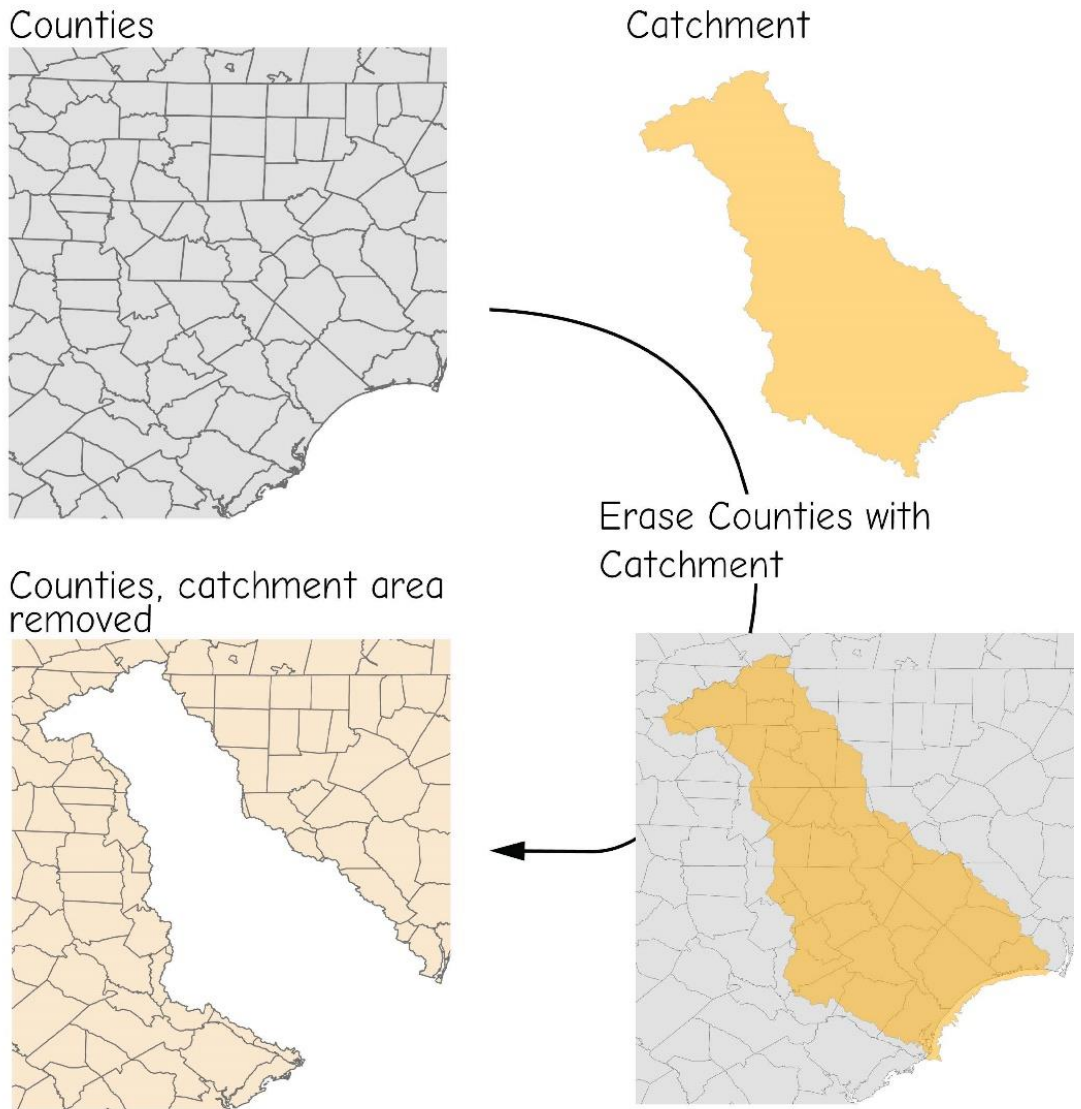
e.g. Hennepin County & Mississippi River

e.g. Dakota County & Cannon River

e.g. Unknown County & Cannon River

Erase

Erase


Counties
Catchment
Erase Counties with Catchment
Counties, catchment area removed

Merge

Merge

- New parcels can be created by merging existing parcels in the parcel fabric. Adjacent parcels can be merged to create a single parcel, and disjoint parcels can be merged to create multipart parcels. Parcels being merged can be saved as historic parcels, kept current, or deleted.

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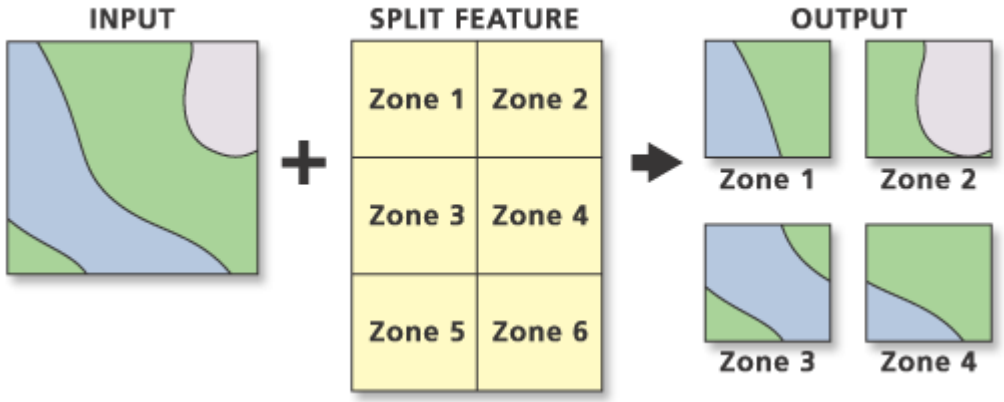
Split

Split

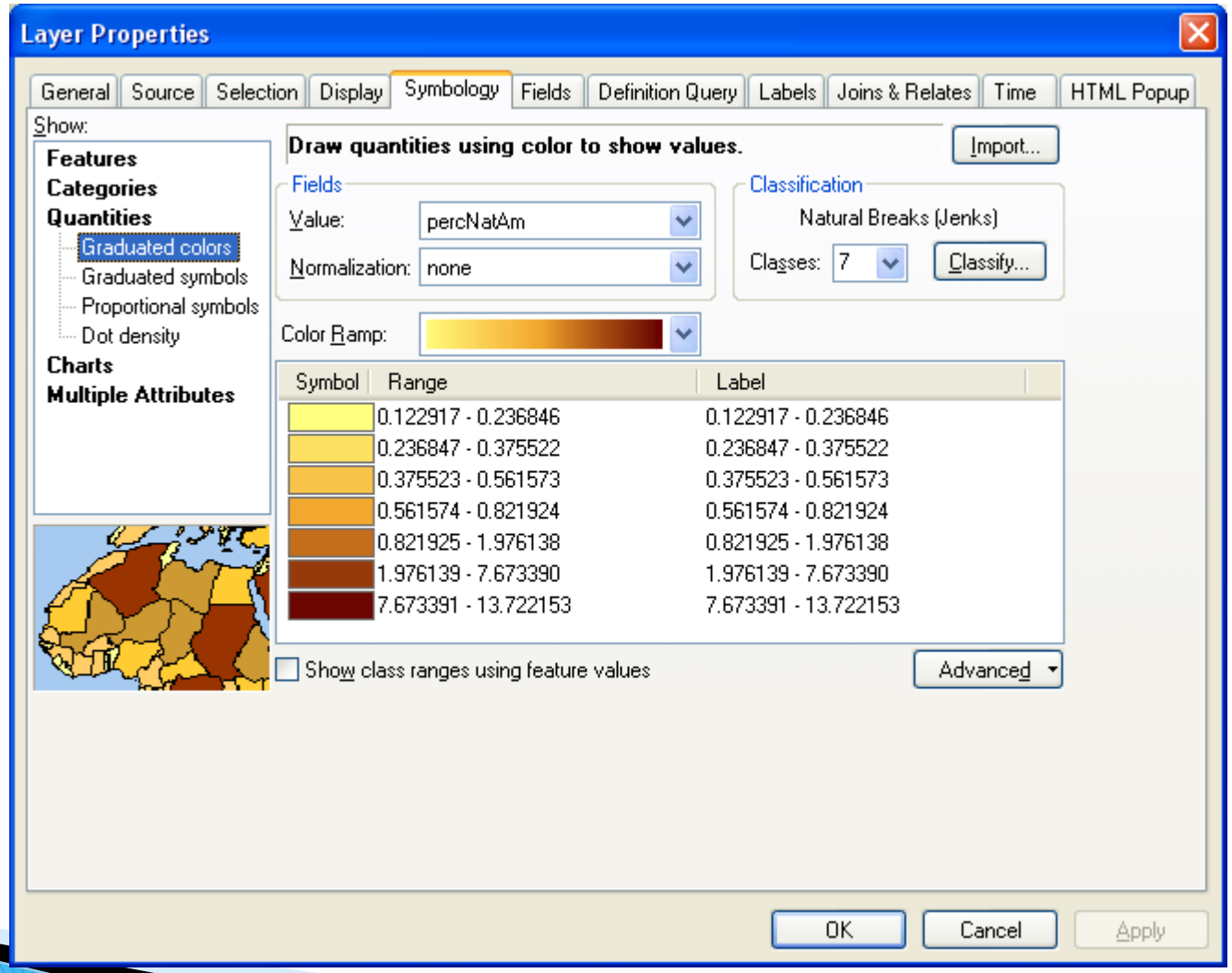
- Splitting the Input Features creates a subset of multiple output feature classes.
- The Split Field's unique values form the names of the output feature classes. These are saved in the target workspace.



ArcGIS Desktop Help

Reclassify

Reclassify in ArcGIS

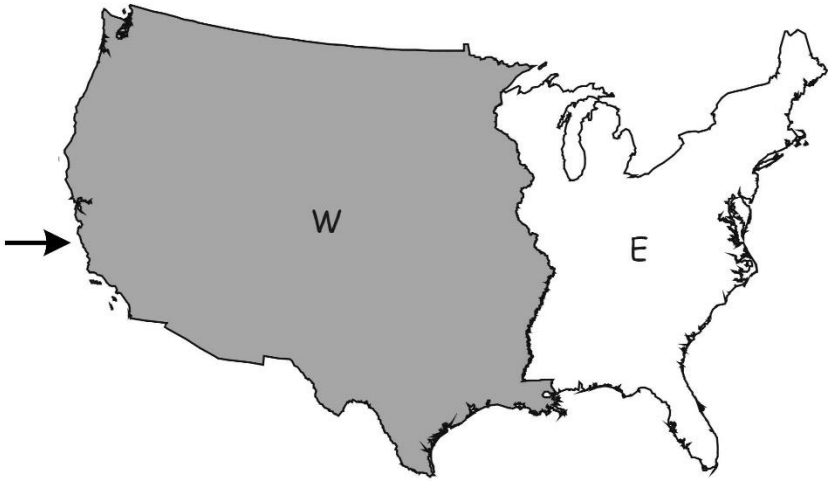


Dissolve

Dissolve operation

Dissolve table

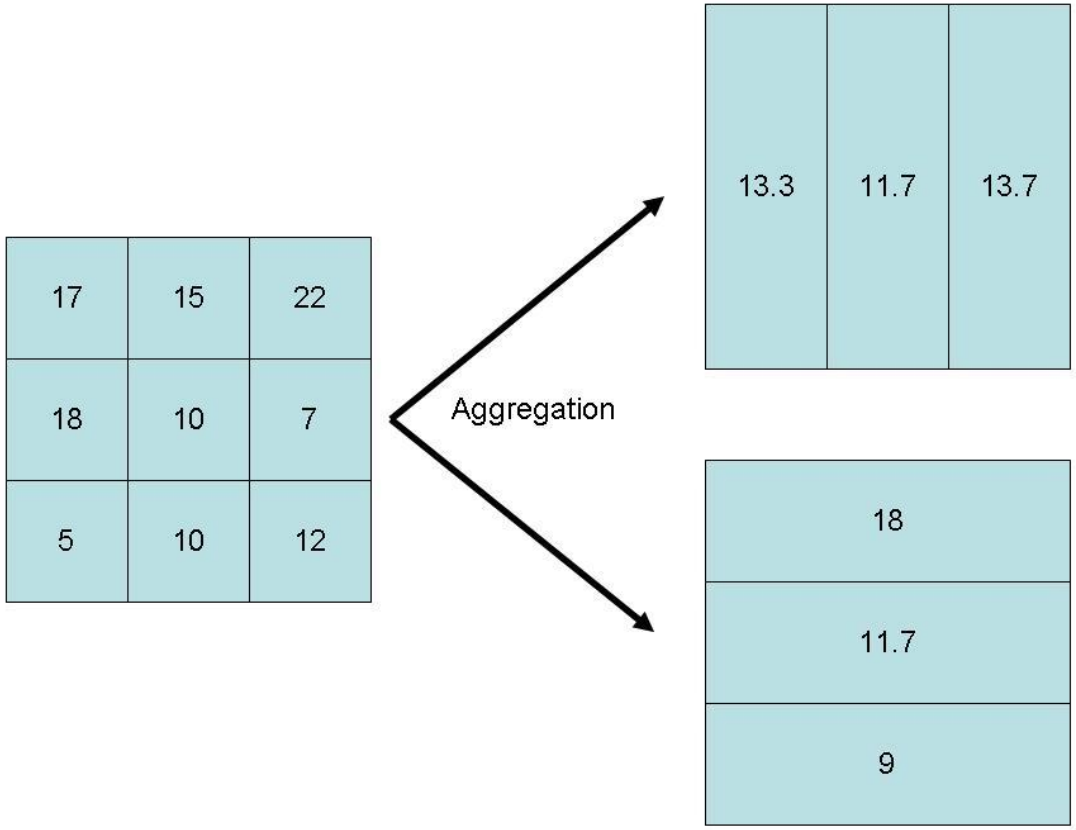
state name	is_west	dissolve value
Alabama	0	E
Arizona	1	W
Arkansas	1	W
Colorado	1	W
Connecticut	0	E
....	....	....
Wyoming	1	W



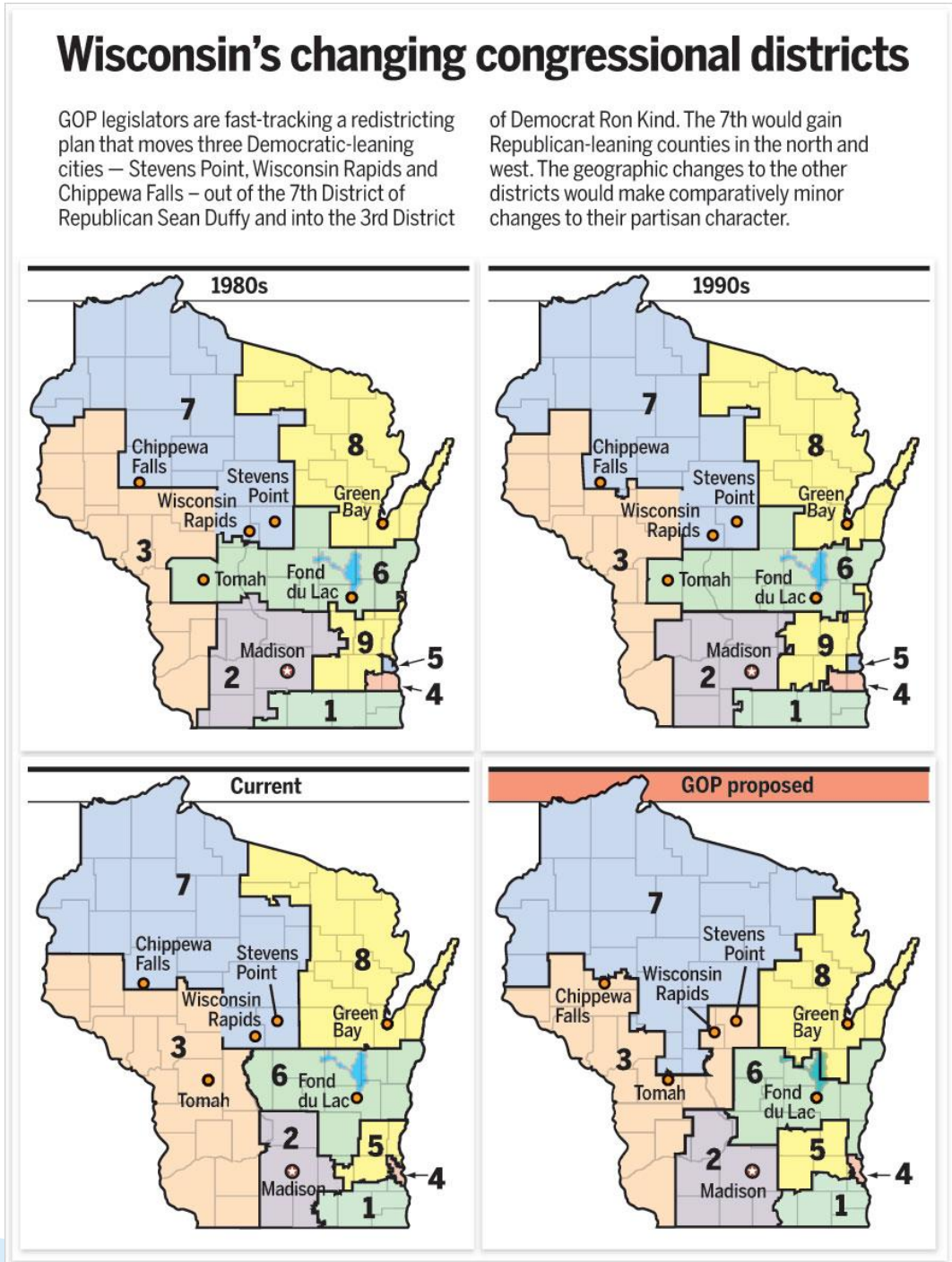
The Modifiable Areal Unit Problem (MAUP)

- The results of data analysis are influenced by the number and sizes of the zones used to organize the data. The Modifiable Area Unit
- Problem has at least three aspects:
  - The number of ways in which fine-scale zones can be aggregated into larger units is often great.
  - The number, sizes, and shapes of zones affect the results of analysis.
  - There are usually no objective criteria for choosing one zoning scheme over another.

MAUP Example



A Real World Example



A Real World Example

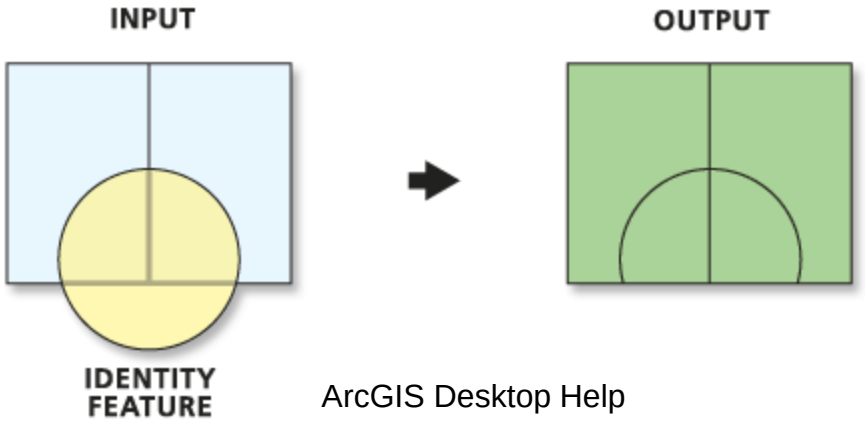
- The Supreme Court heard arguments on Tuesday in Gill v. Whitford, a gerrymandering case which many say will be the most important opinion of the term.
- The Republican-run Wisconsin legislature, it's claimed, created a redistricting plan so partisan that it guarantees their party stays in power even when they don't get a majority of the vote.

- The Supreme Court has been here before. In Vieth v. Jubelirer (2004) they declared that since there was no workable standard to resolve the issue, courts should stay out of the business of fixing alleged partisan gerrymandering.

http://www.foxnews.com/opinion/2017/10/05/supreme-court-takes-on-gerrymandering-but-does-it-even-work.html

Identity Analysis

- Computes a geometric intersection of the Input Features and Identity Features.
- The Input Features or portions thereof that overlap Identity Features will get the attributes of those Identity Features.



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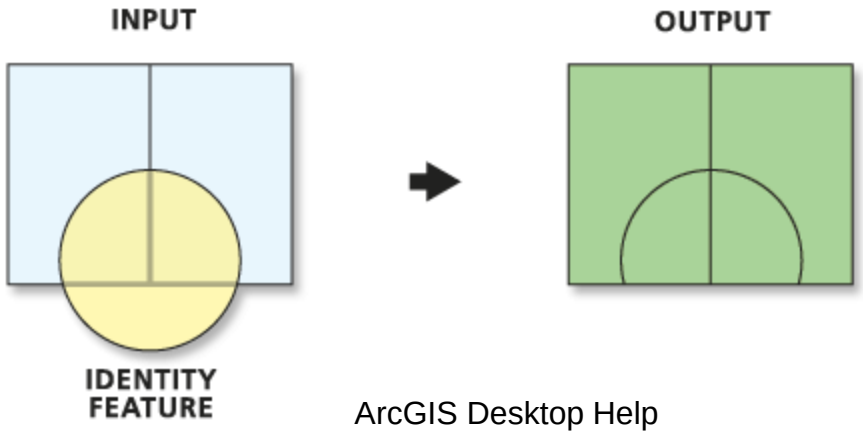
Identity Analysis

- The Input Features must be point, multipoint, line, or polygon. The Identity Features must be polygons.
- Output may be multipart. If multipart features are not desired, use the Multipart to Singlepart tool on the output.



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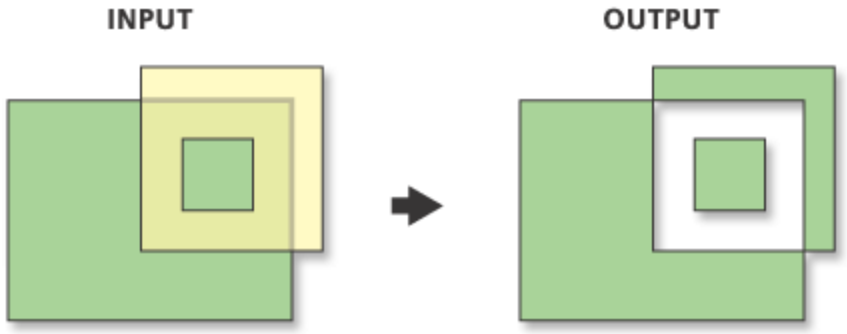
Symmetrical Difference

- Computes a geometric intersection of the input and update features. Features or portions of features in the input and update features which do not overlap will be written to the Output Feature Class.



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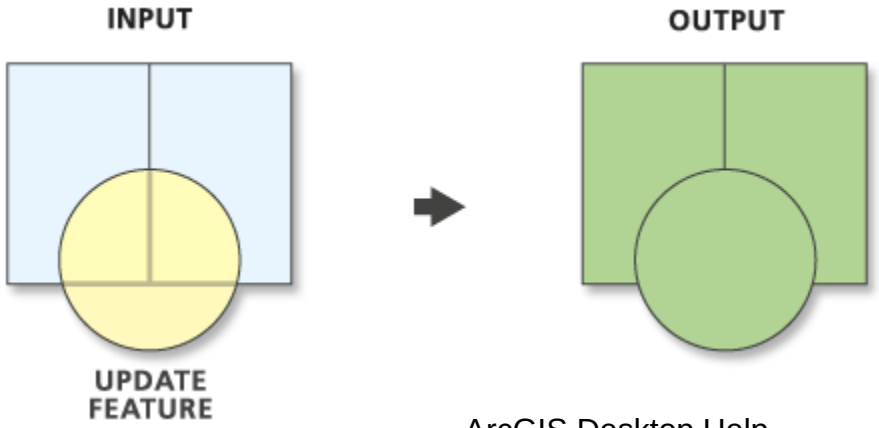
- The input and difference feature class and feature layer must have polygon geometry.
- Output may be multipart.

Update

- 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 in the output feature class.



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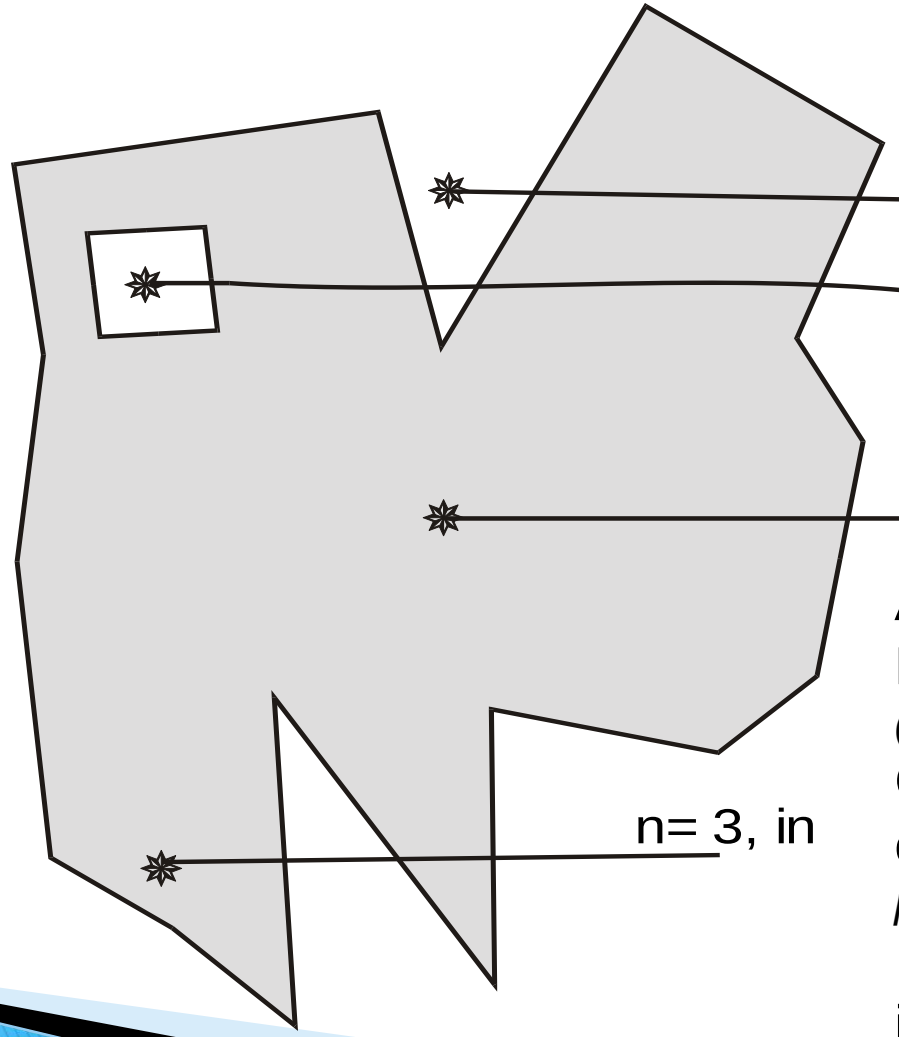
The input must be a polygon.

Why do buffering and vector overlay often take so long?

Because a time consuming line intersection test must be performed for all lines in the data layers

Then, inside vs. outside regions must be identified for all new polygons

Finding the interior: Is a point inside a polygon *(shaded)*?



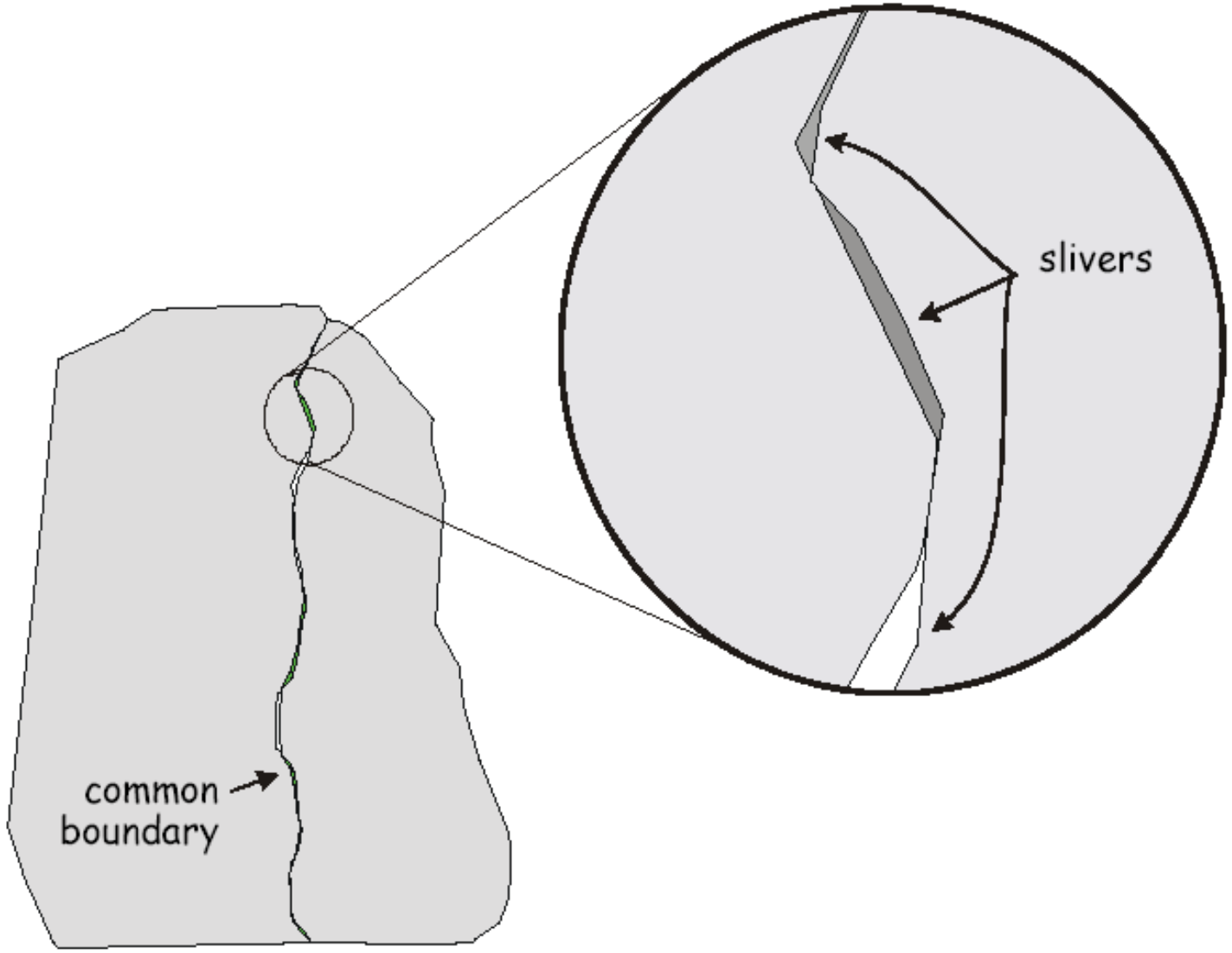
Potential point

Algorithm:
Pick a direction
(East (right) in the example)
Count line crossings to the outside of convex hull *(shaded polygon)*
If odd number then the point is inside
If even, the point is outside

Vector Overlay

Common features in Vector overlays create “Slivers” or “Sliver polygons”

A common feature in both layers. The problem is that each definition is very subtly different *(different time, source, materials)* so the polygons don’t line up. They can only be seen a very large display scale but can represent over half the output polygons. They take very little space but affect analytical results.

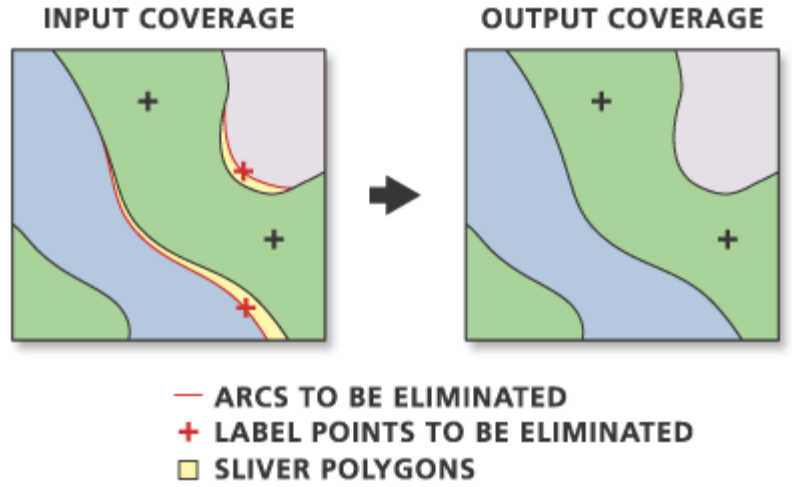

slivers
common
boundary

Methods to reduce/remove slivers:

- Redefine the common boundaries with highest coordinate accuracy and replace them in all layers before overlay
- Manually identify and remove
- Use snap distance during overlay

Eliminate

Eliminate is often used to remove sliver polygons created during polygon overlay or buffering. With the LINE option, Eliminate merges selected arcs separated by pseudo nodes into single arcs.



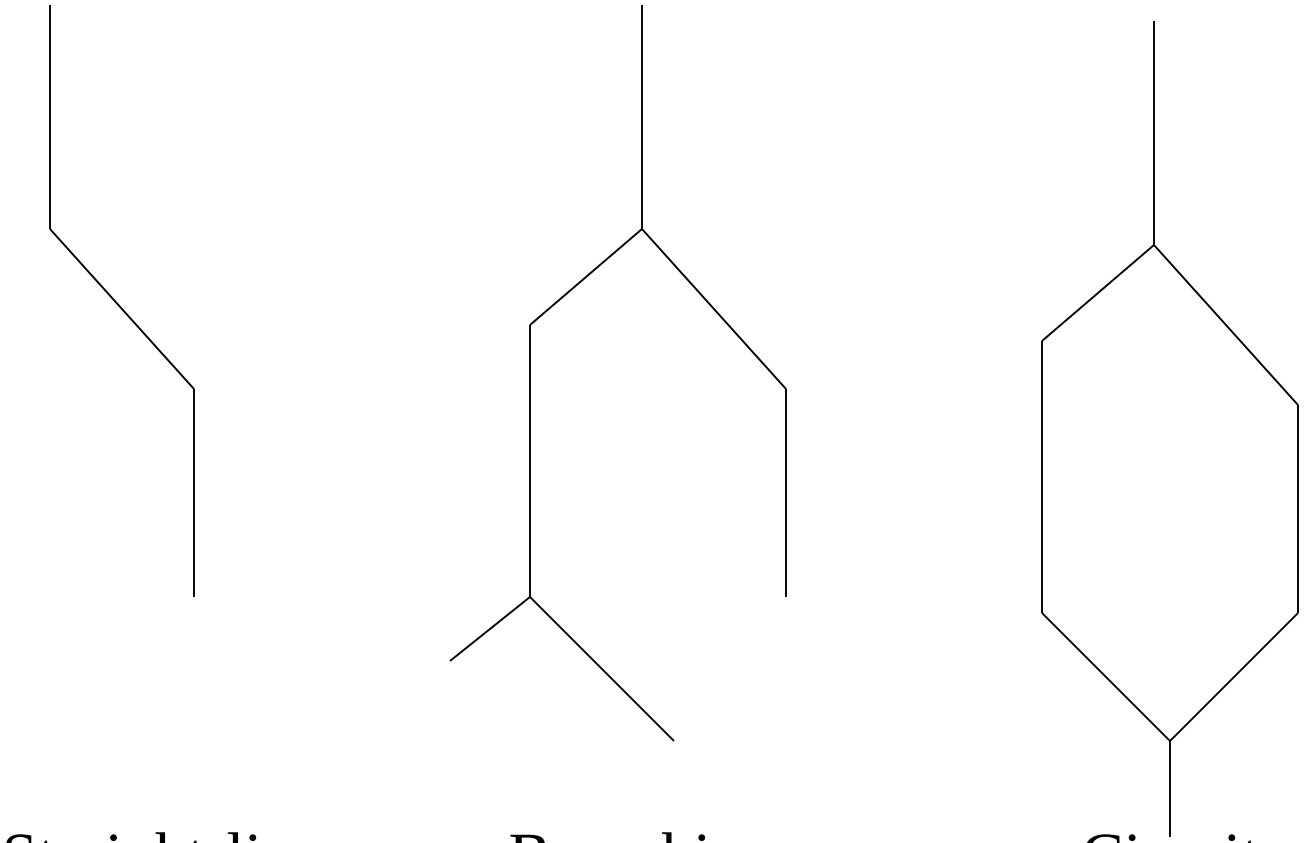
ArcGIS Desktop Help

Networks

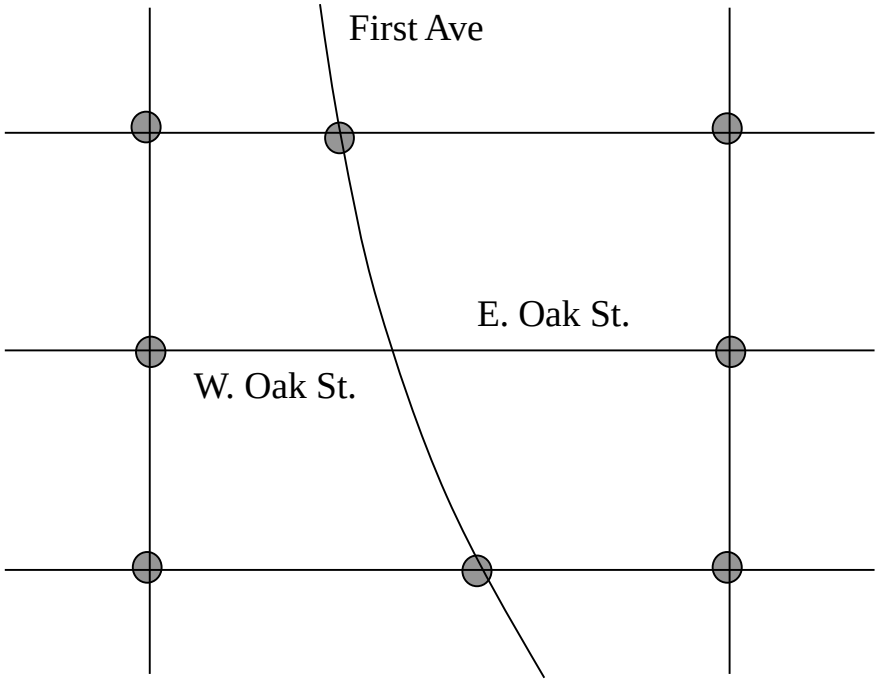
Networks

- A set of interconnected line entities.
  - Roads or railroads.
  - Streams
- Network analysis is based on graph theory, specifically directed acyclic graphs (DAGs).
- Allow us to model flow
- Find the shortest route

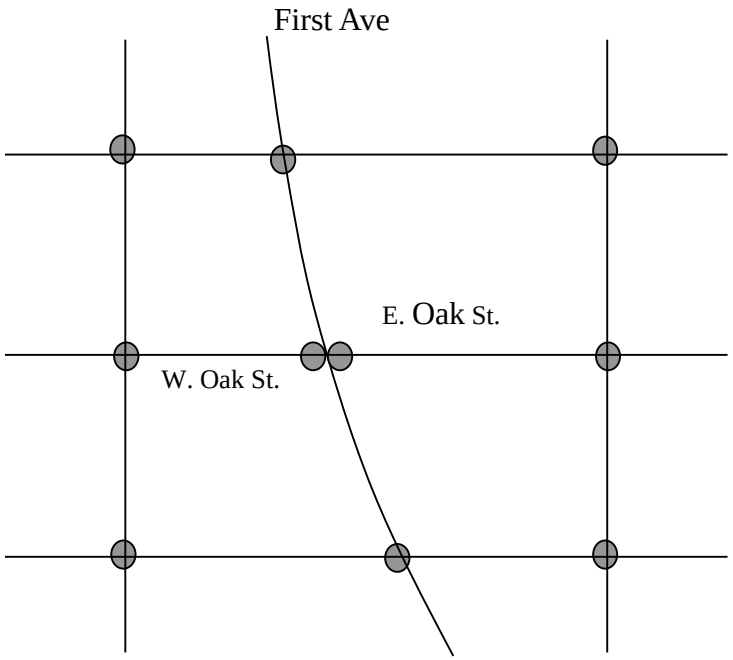
Types of Networks



Straight-line Branching Circuit

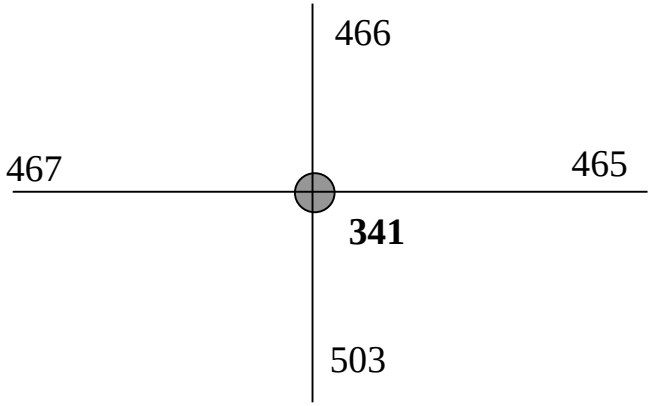


First Ave. crosses Oak St. with an overpass. A non-planar representation with no nodes is used at the intersection of Oak St. and First Ave., indicating an overpass or underpass.



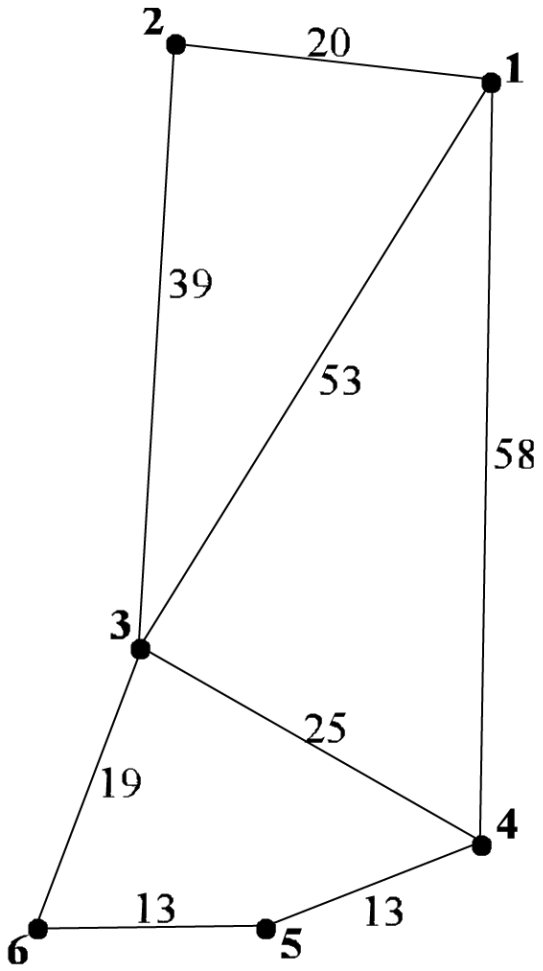
Street Name	F-elev	T-elev
First Ave	0	1
First Ave	1	0
W. Oak St.	0	0
E. Oak St.	0	0

First Ave crosses Oak St with an overpass. A planar representation with two nodes is used at the intersection: one for First Ave, and the other for Oak St. The elevation value of 1 shows that the overpass is along First Ave.

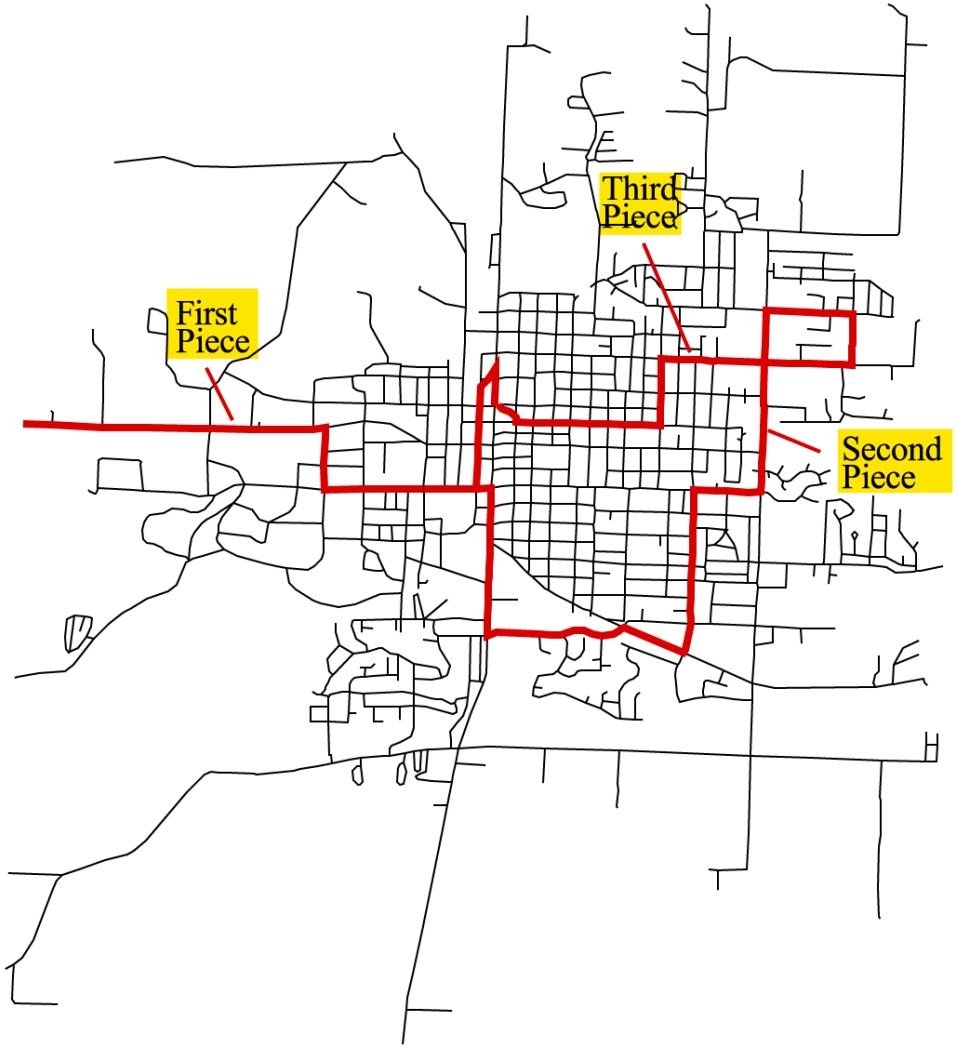


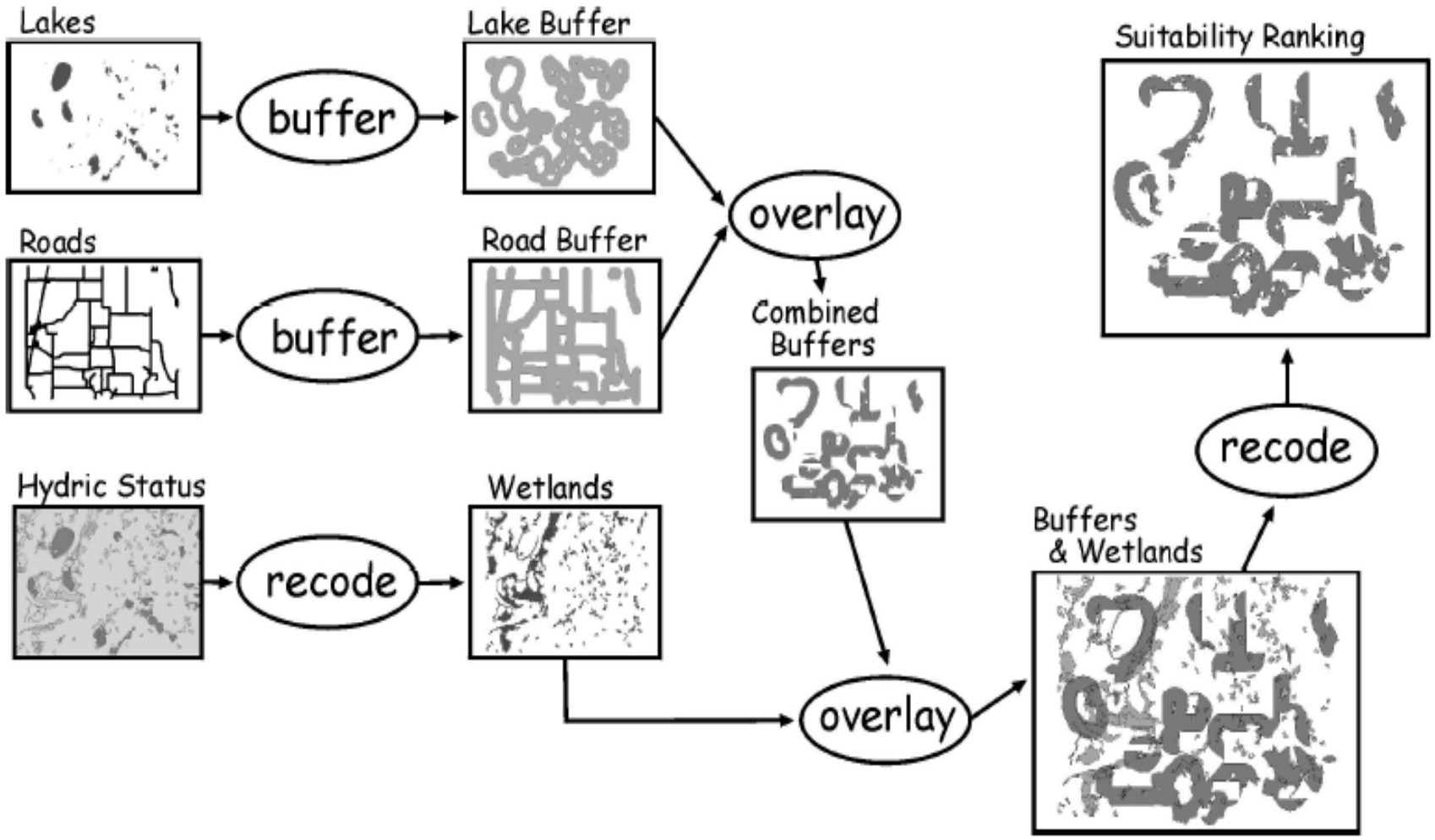
node#	arc1#	arc2#	angle	minutes
341	503	467	90	0.500
341	503	466	0	0.250
341	503	465	-90	0.250
341	467	503	-90	0.250
341	467	466	90	0.500
341	467	465	0	0.250
341	466	503	0	0.250
341	466	467	-90	0.250
341	466	465	90	0.500
341	465	503	90	0.500
341	465	467	0	0.250
341	465	466	-90	0.250

Possible turns at node 341



Six cities on a road network for shortest-path analysis



Because the bus route is a looping route, the route system is dissected into three sections.

Cartographic modeling