VECTOR ANALYSIS

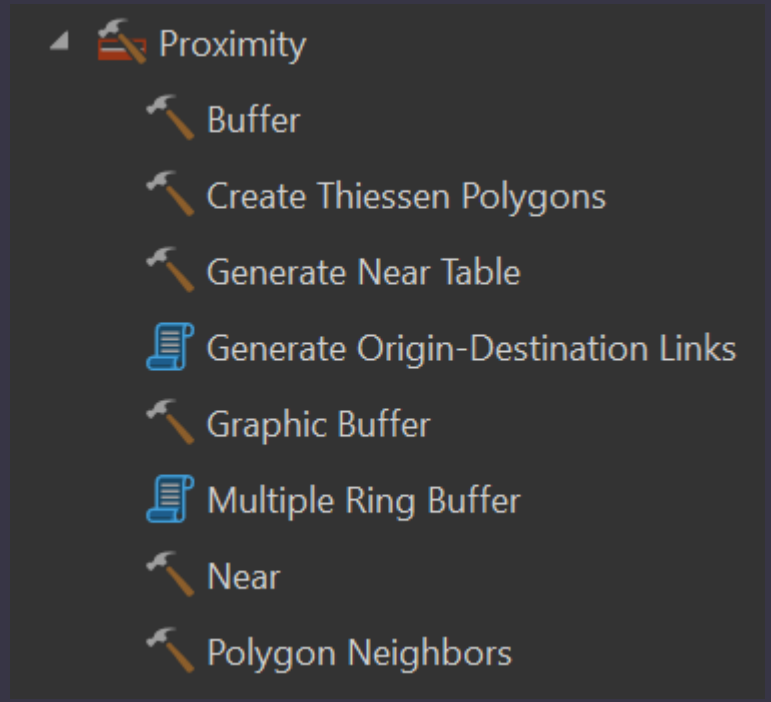
Sandeep Talasila, GISP

PROXIMITY

What's near what?

PROXIMITY TOOLS

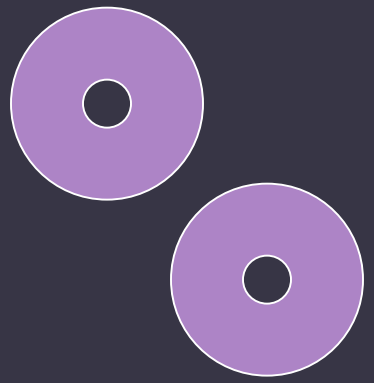
- To determine the proximity of features within one or more feature classes or between two feature classes.
- Tools in ArcGIS
  - Buffer
  - Create Thiessen Polygons
  - Generate Near Table
  - Generate Origin-Destination Links
  - Graphic Buffer
  - Multiple Ring Buffer
  - Near
  - Polygon Neighbors



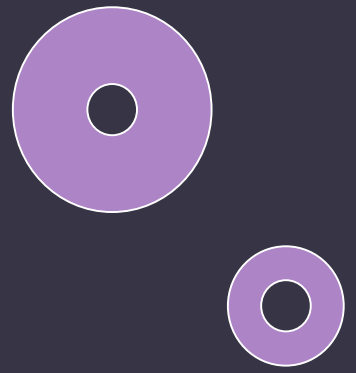
BUFFER

- Creates buffer polygons around input features to a specified distance.

Constant distance

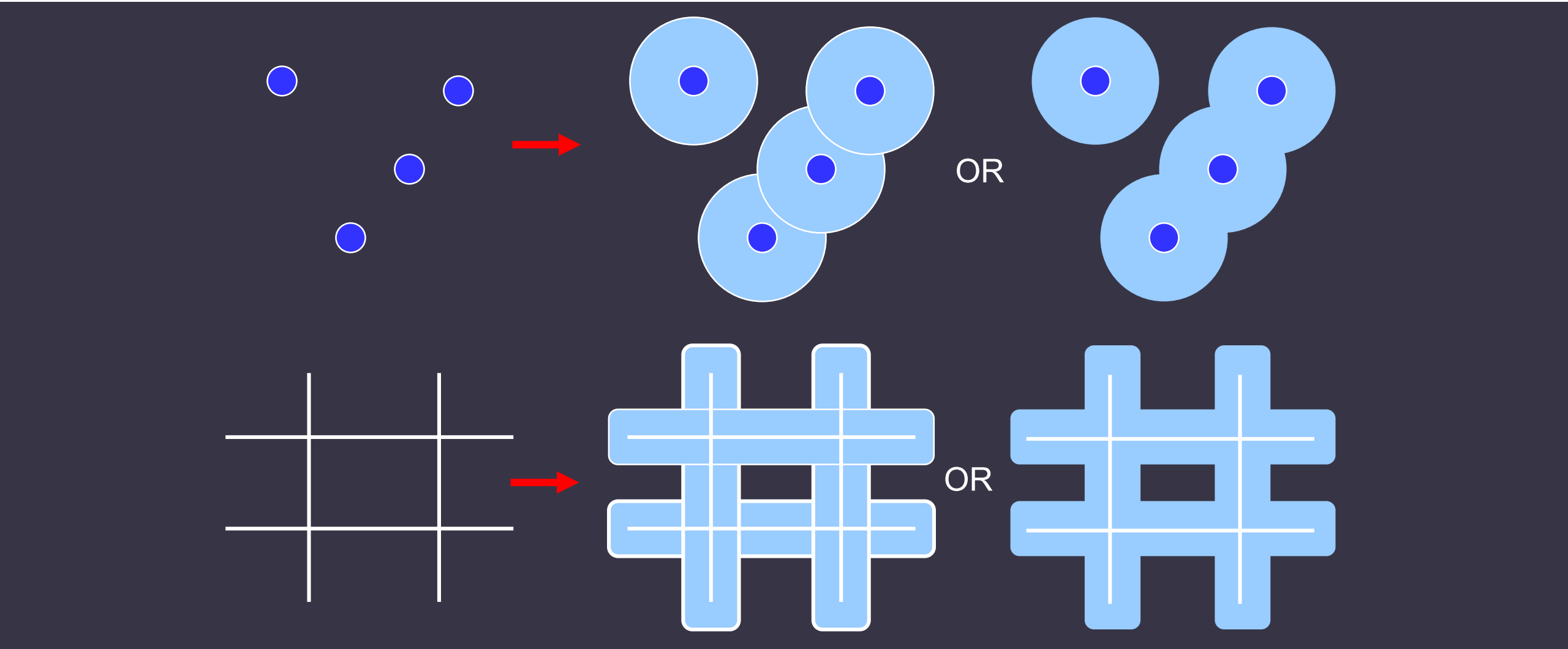


Variable distance



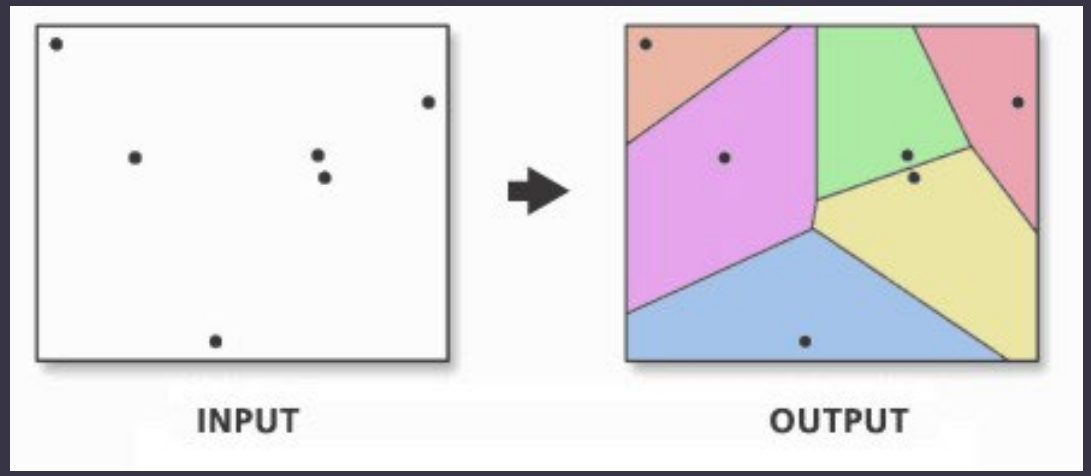
Multiple buffers

COALESCING BUFFERS



THIESSEN POLYGONS

- Proximal Zones
- 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.



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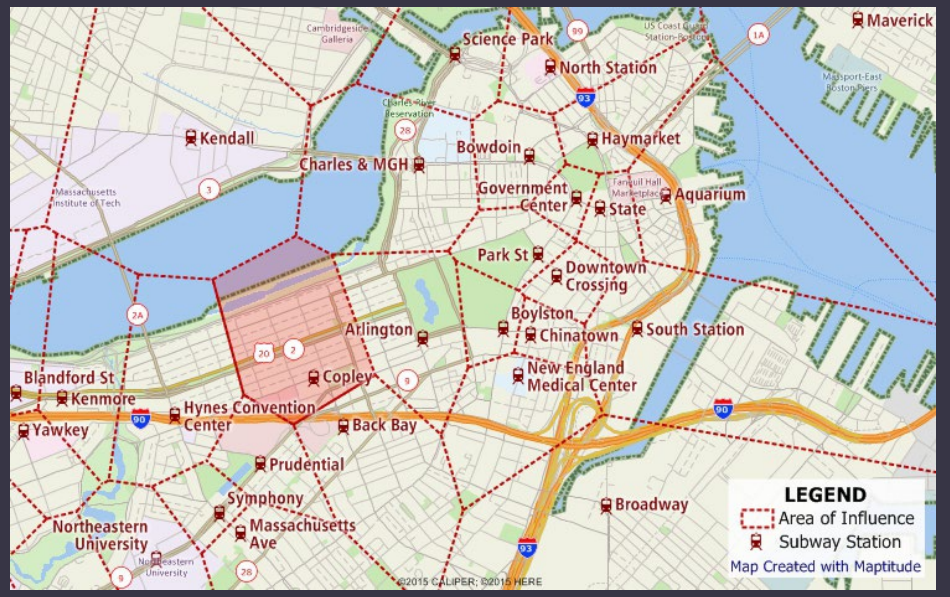

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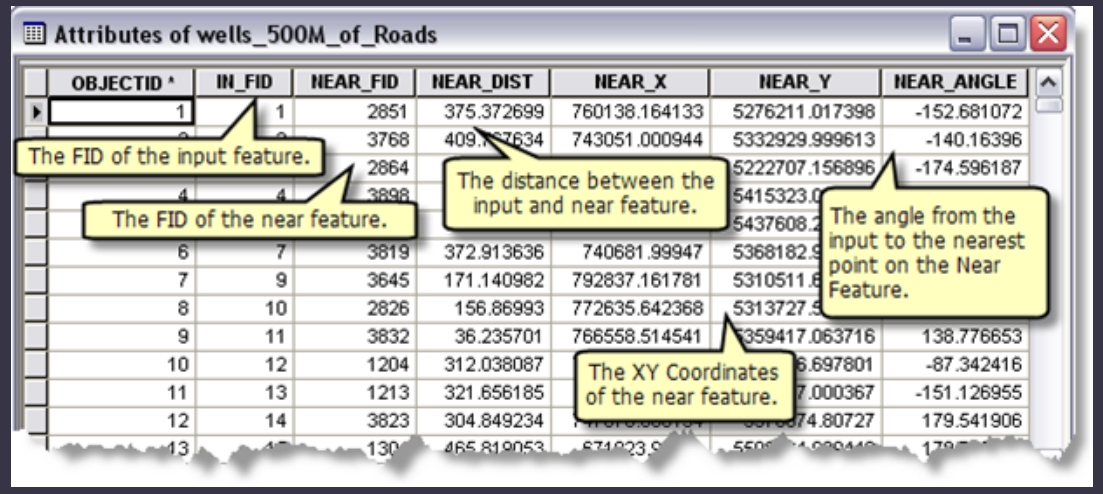
https://www.esri.com/arcgis-blog/products/arcgis-living-atlas/mapping/where-is-the-nearest-national-park/

GENERATE NEAR TABLE

- Calculates distances and other proximity information between features in one or more feature class or layer.
- Creates an output table.



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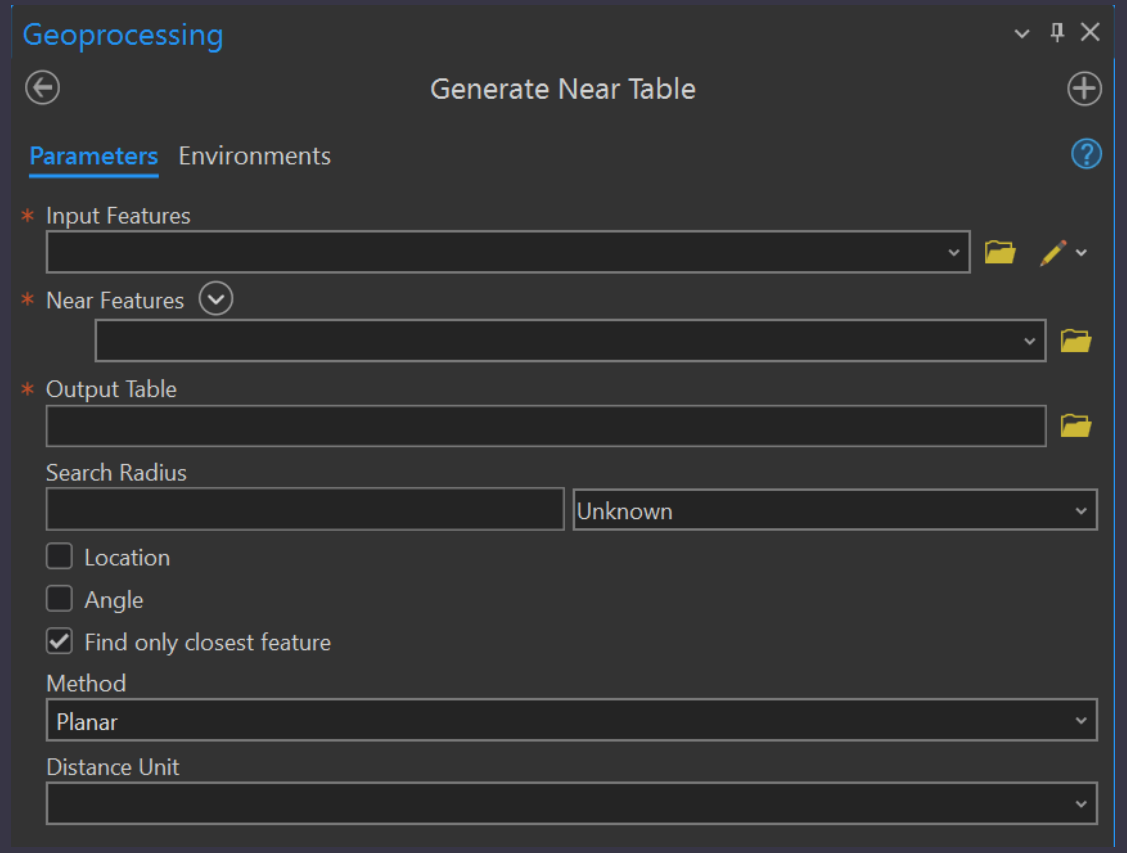
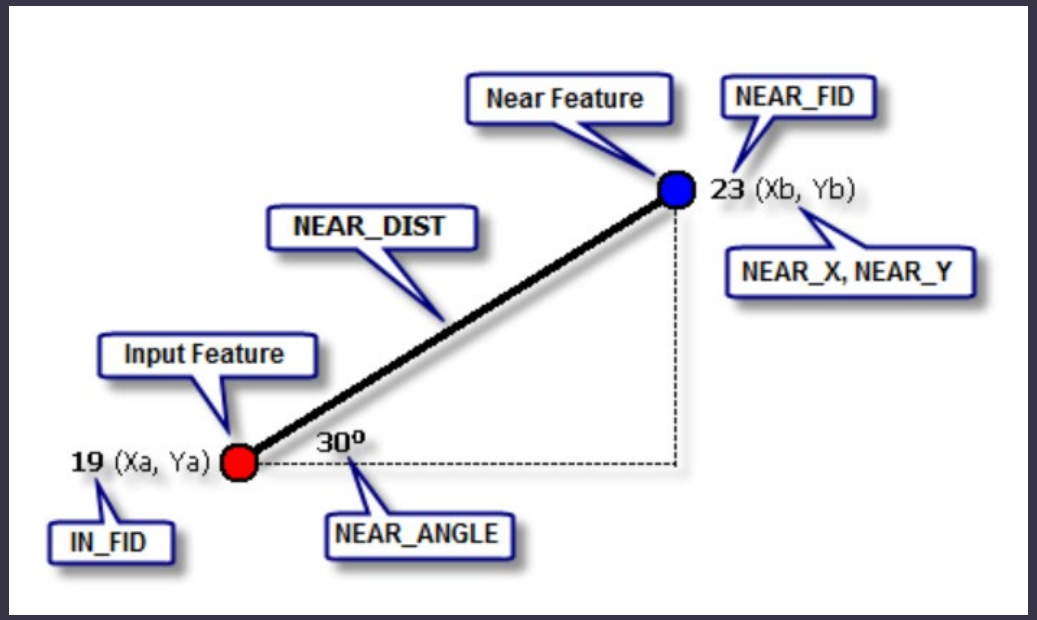
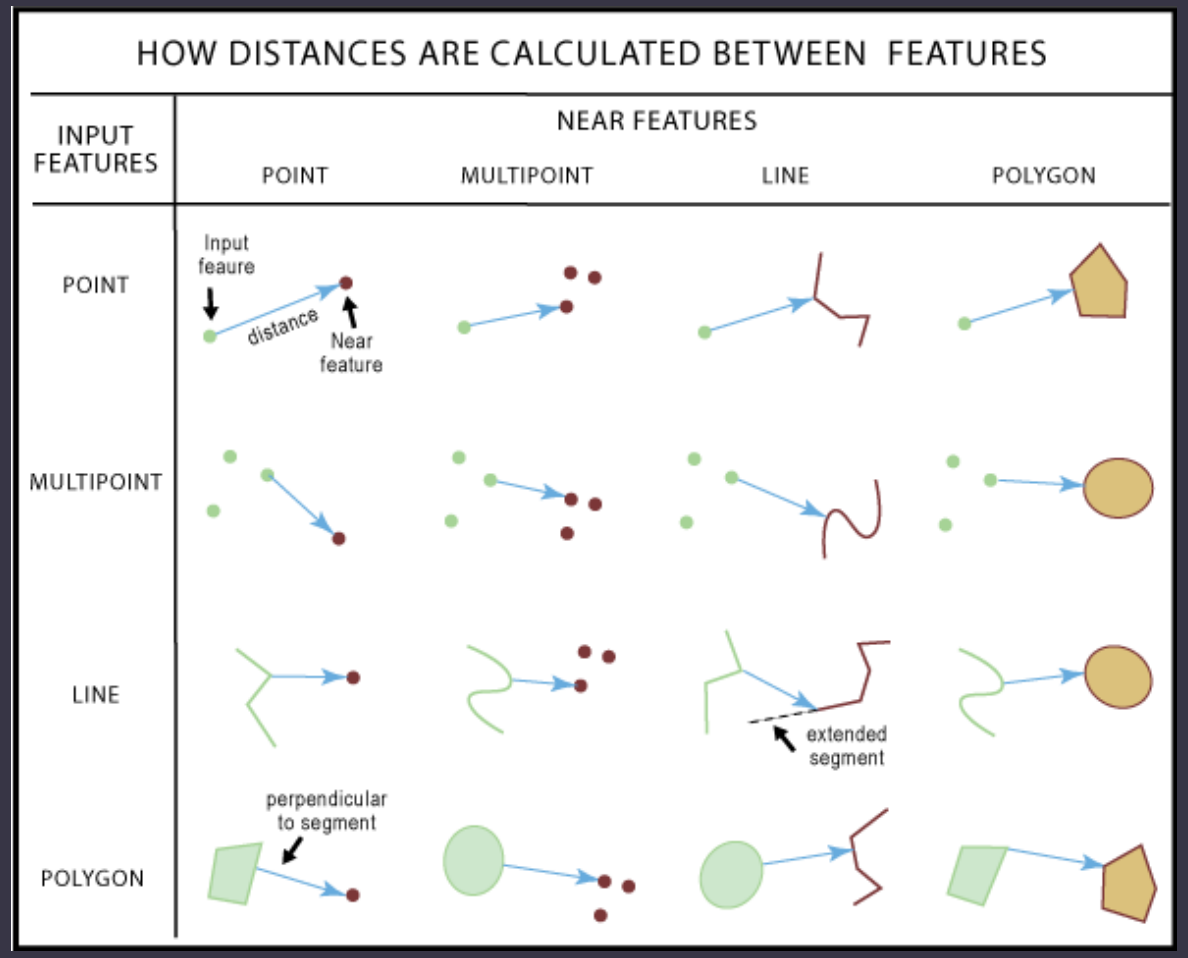


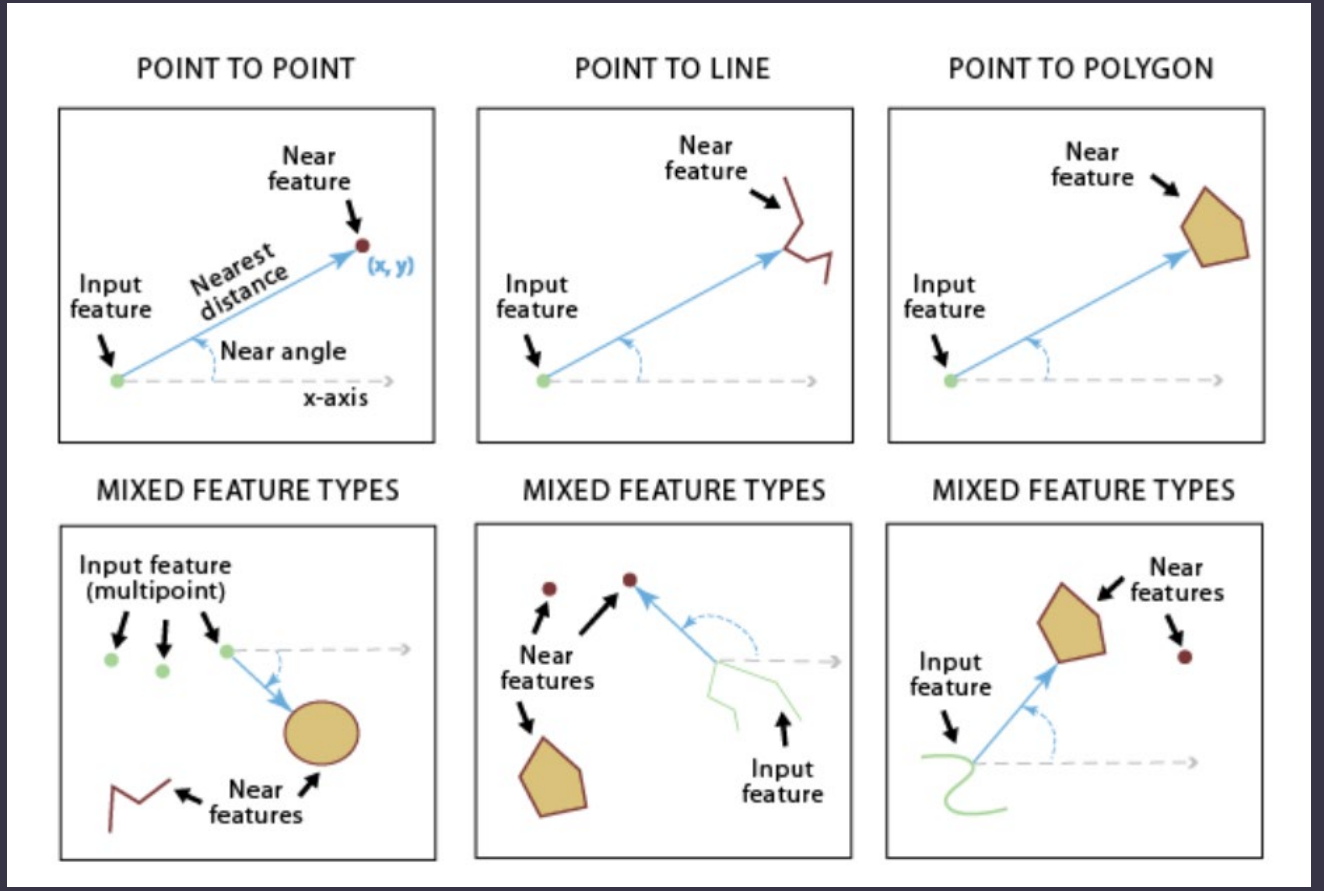
HOW ARE DISTANCES CALCULATED?





NEAR

Calculates distance and additional proximity information between the input features and the closest feature in another layer or feature class.



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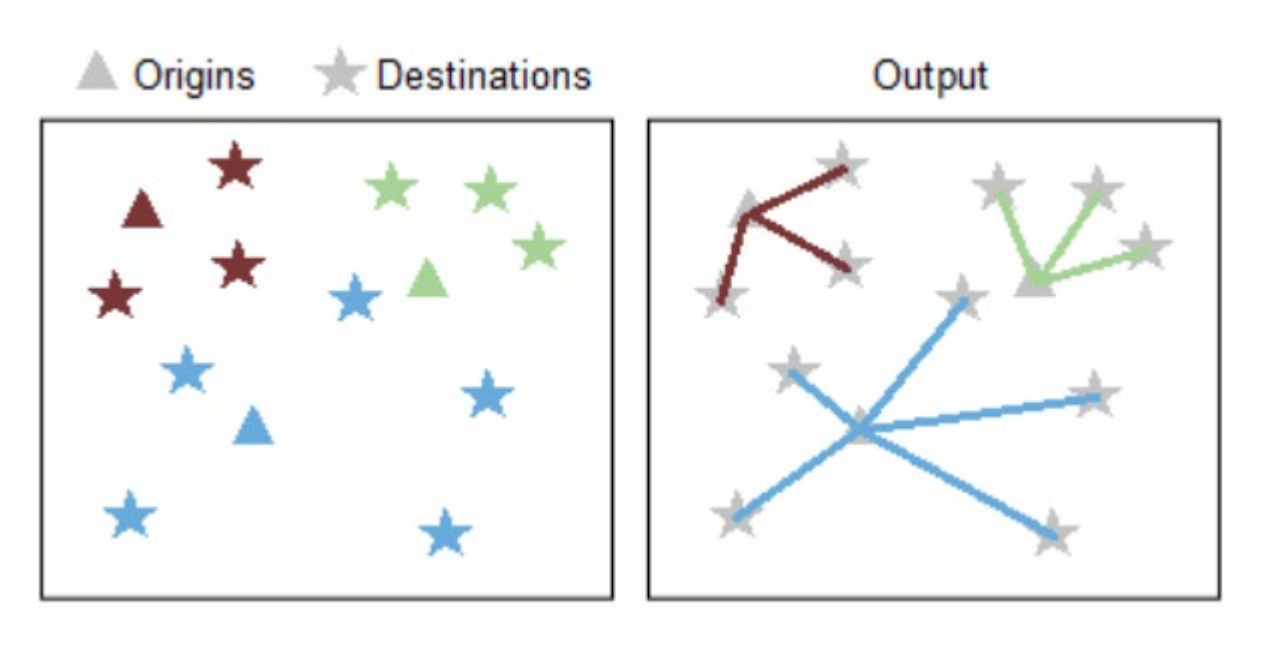
GENERATE ORIGIN-DESTINATION LINKS

- Generates connecting lines from origin features to destination features
- When origin or destination features are lines or polygons, feature centroids are used for generating links
- Can be used for both one-to-one and one-to-many relationships
- Referred as spider diagram



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POLYGON NEIGHBORS

- Creates a table with statistics based on polygon contiguity (overlaps, coincident edges, or nodes).

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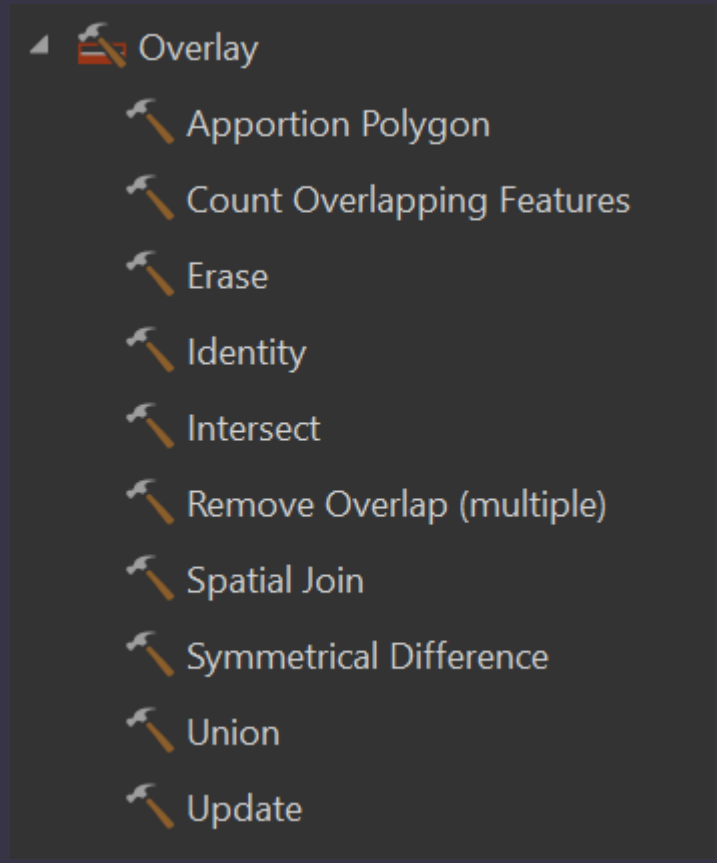
OVERLAY

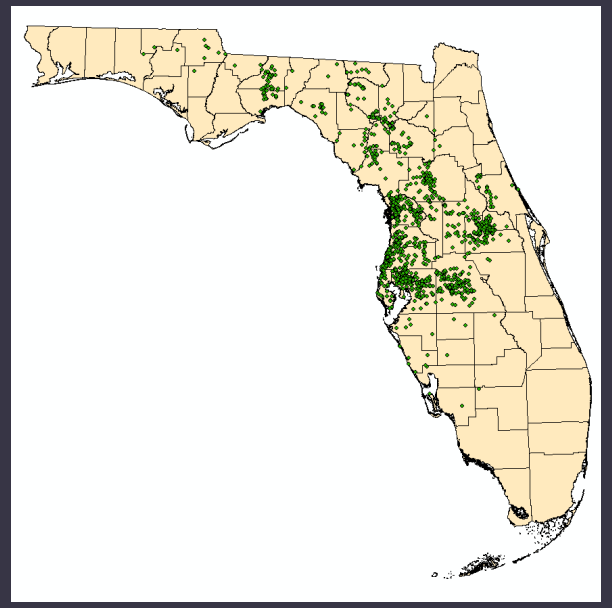
What's on top of what?

OVERLAY TOOLS

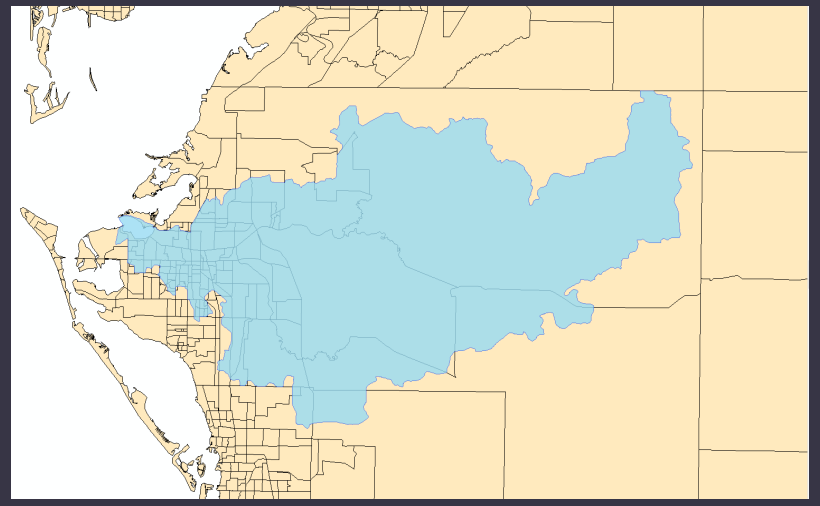
- To overlay multiple feature classes to combine, erase, modify, or update spatial features, resulting in a new feature class.
- Tools in ArcGIS
  - Apportion Polygon
  - Count Overlapping Features
  - Erase
  - Identity
  - Intersect
  - Remove Overlap
  - Union
  - Spatial Join
  - Symmetrical Difference
  - Update



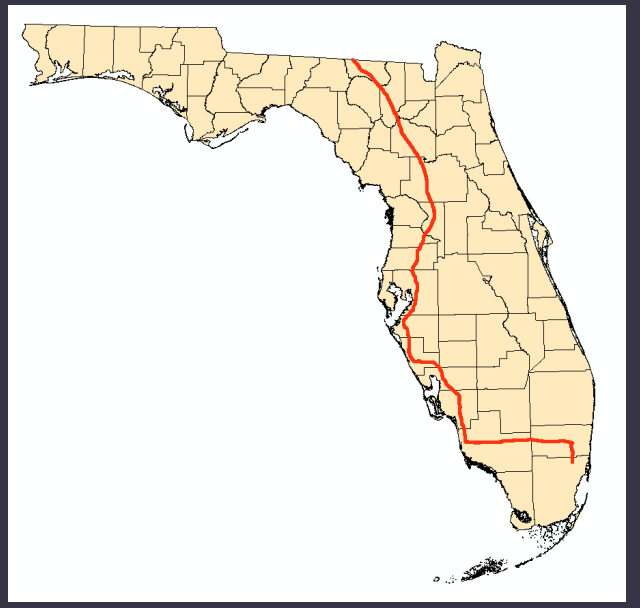
OVERLAY EXAMPLES



Point/Polygon



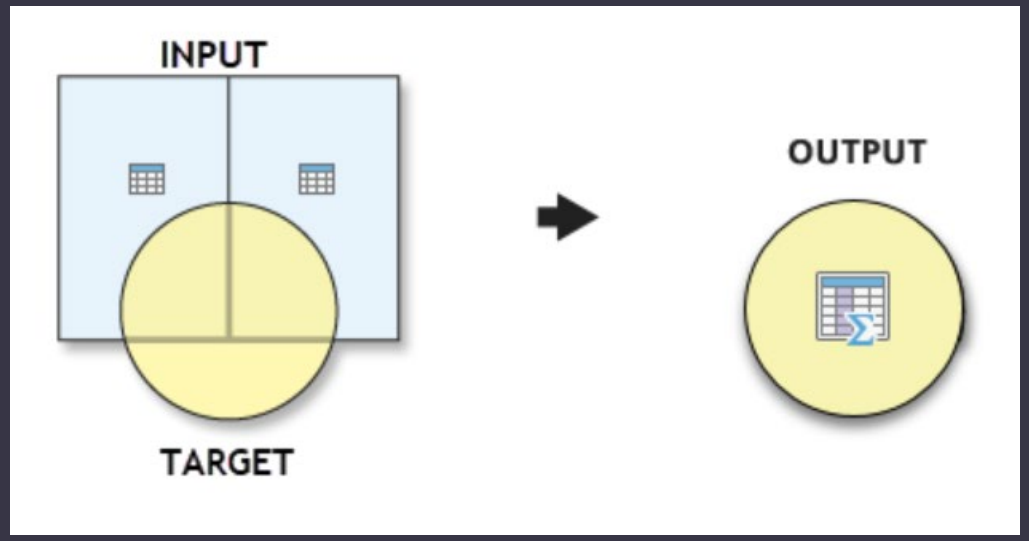
Polygon/Polygon



Polyline/Polygon

APPORTION POLYGON

- Summarizes the attributes of an input polygon layer based on the spatial overlay of a target polygon layer and assigns the summarized attributes to the target polygons.
- Example: estimate population of one feature based on the percentage of that feature that overlays another feature with a known population



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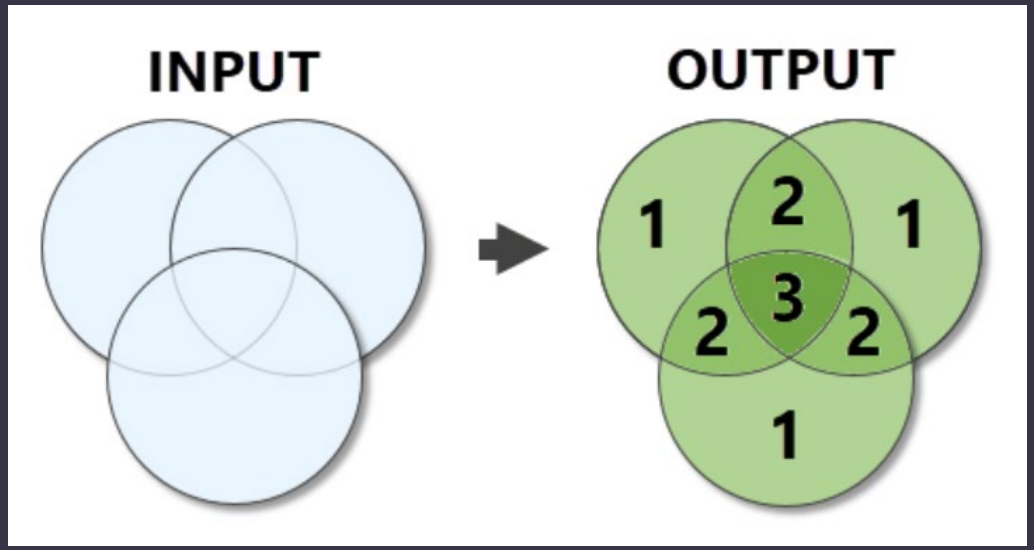
COUNT OVERLAPPING FEATURES

- Generates planarized overlapping features from the input features.
- Geometry type of the output is same as the input, with exception of point geometry
- For points, the output will be multi-point feature class if there are multiple input feature classes



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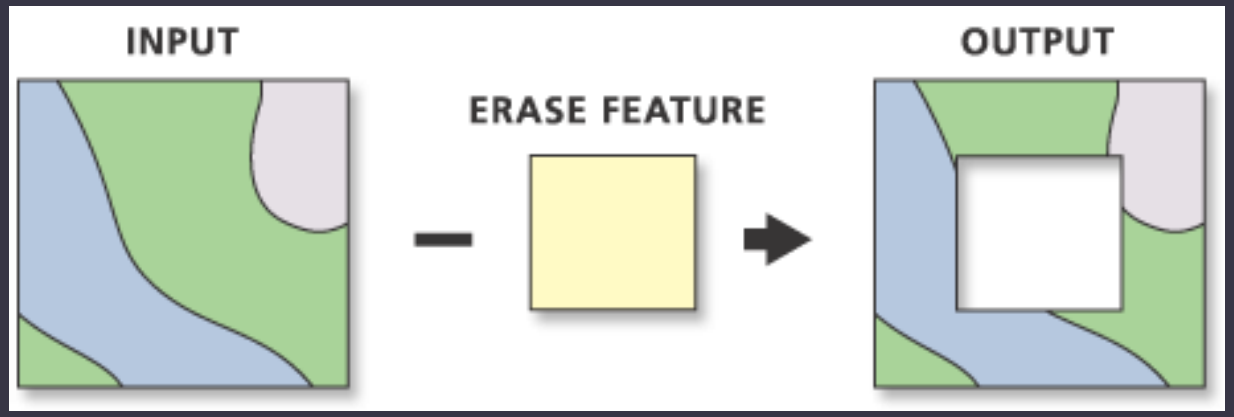
ERASE

- Creates a feature class by overlaying the Input Features with the polygons of the Erase Features.



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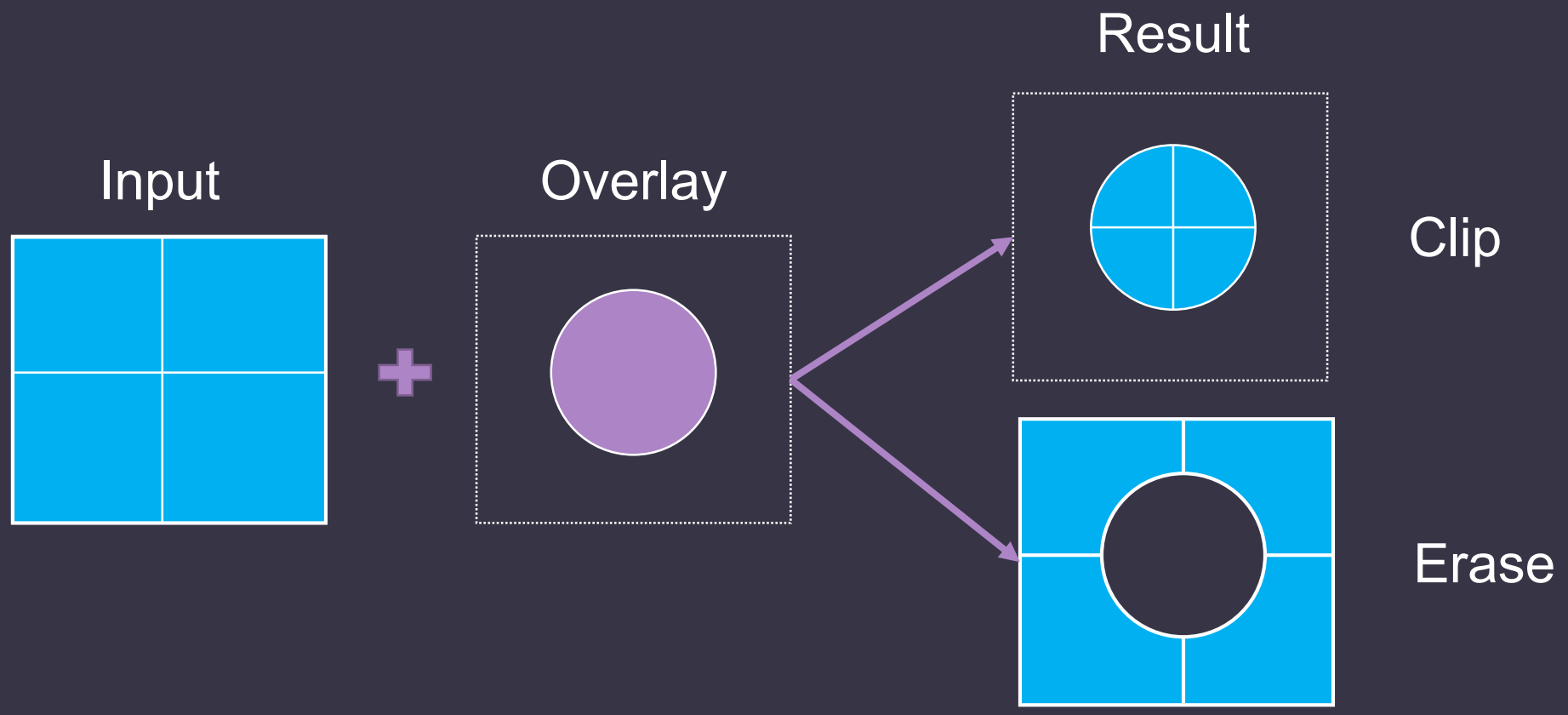
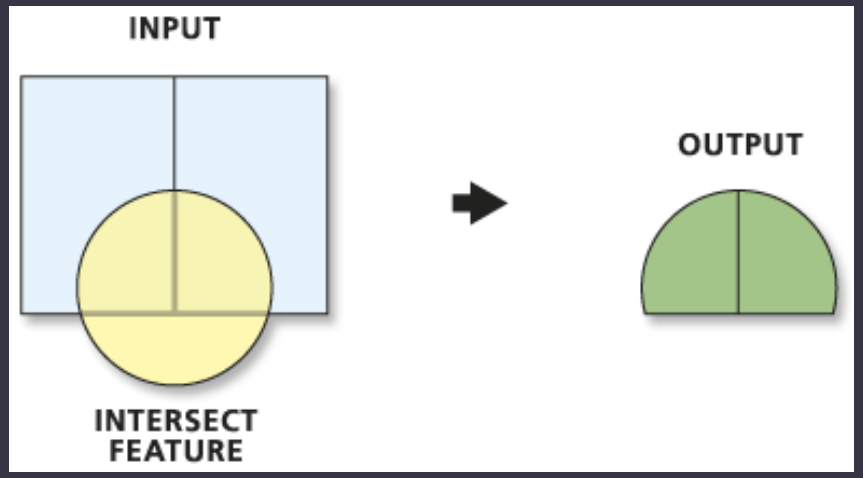
CLIP VS. ERASE



INTERSECT

- Computes a geometric intersection of the input features.
- Features or portions of features which overlap in all layers and/or feature classes will be written to the output feature class



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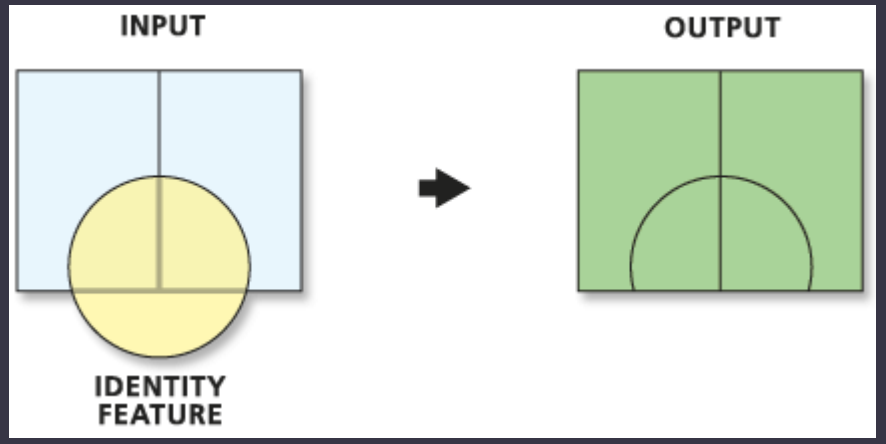
IDENTITY

- 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.
- Identity features must be polygons or have same geometry type as input.



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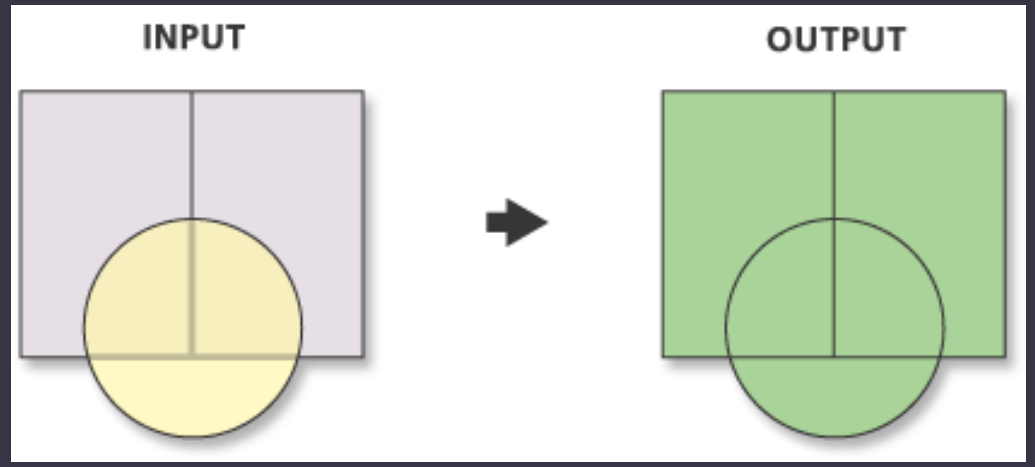
UNION

- Computes a geometric union of the input features.
- All features and their attributes will be written to the output feature class.



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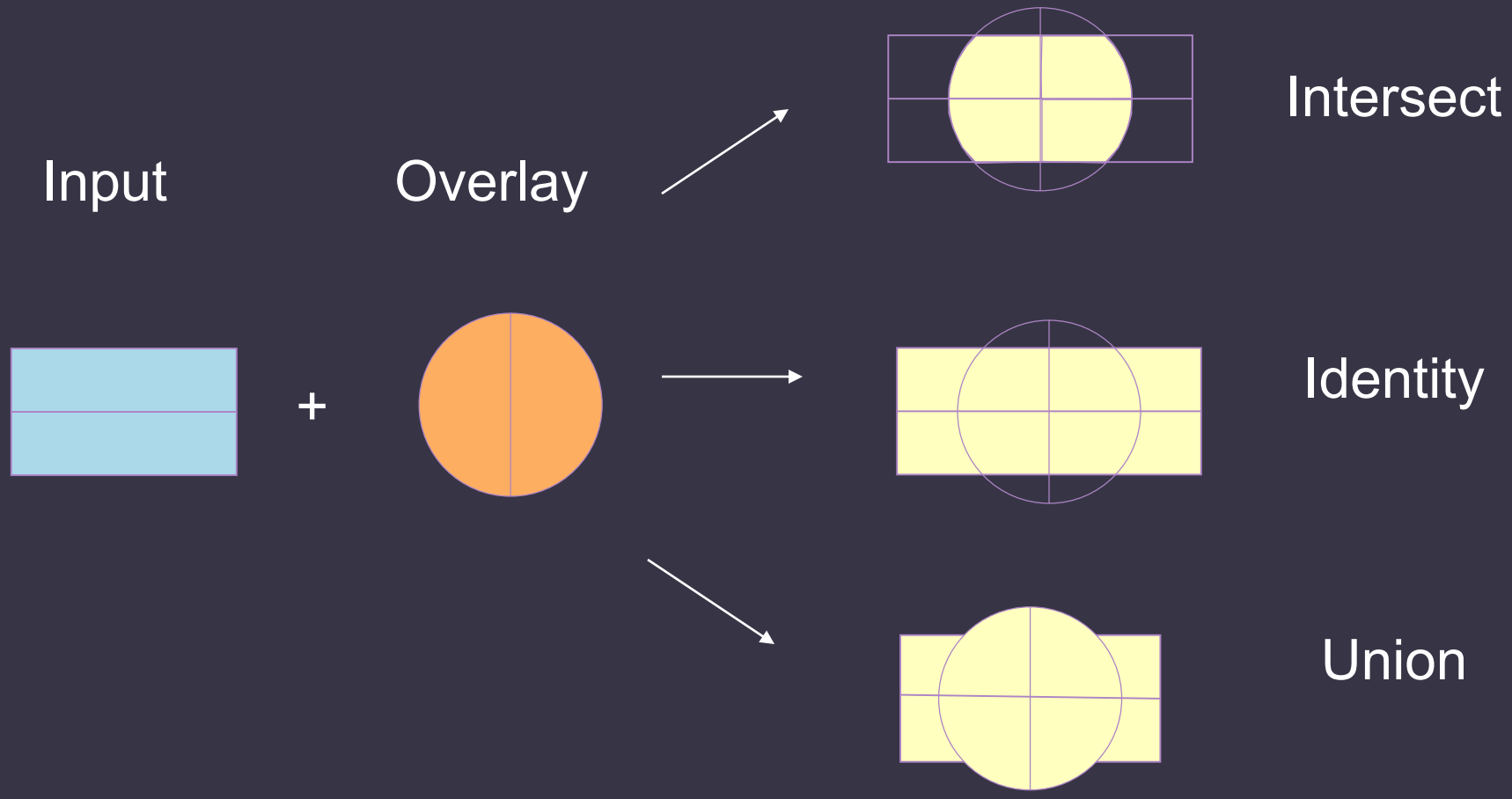
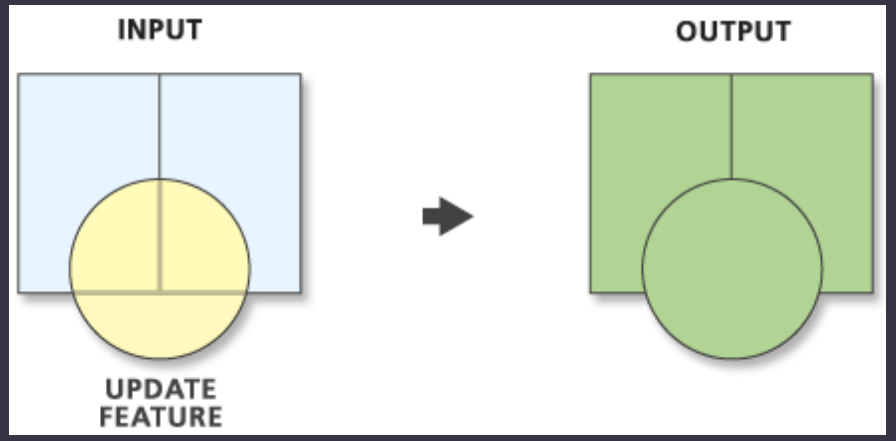
INTERSECT, IDENTITY, UNION



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.
- Input and Update features must be polygons
- Creates multipart features



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SPATIAL JOIN

- A spatial join involves matching rows from the Join Features to the Target Features based on their relative spatial locations.
- INTERSECT, WITHIN_A_DISTANCE, and CLOSEST are valid for any combination of geometry type

Target Features	Join Features	CONTAINS	COMPLETELY_CONTAINS	CONTAINS_CLEMENTINI	WITHIN	COMPLETELY_WITHIN	WITHIN_CLEMENTINI	ARE_IDENTICAL_TO	BOUNDARY_TOUCHES	SHARE_A_LINE_SEGMENT_WITH	CROSSED_BY_THE_OUTLINE_OF	HAVE_THEIR_CENTER_IN
Point	Point	√		√	√		√	√				√
Point	Line				√	√	√					√
Point	Polygon				√	√	√					√
Line	Point	√	√	√								√
Line	Line	√	√	√	√	√	√	√	√	√	√	√
Line	Polygon				√	√	√		√	√	√	√
Polygon	Point	√	√	√								√
Polygon	Line	√	√	√					√	√	√	√
Polygon	Polygon	√	√	√	√	√	√	√	√	√	√	√

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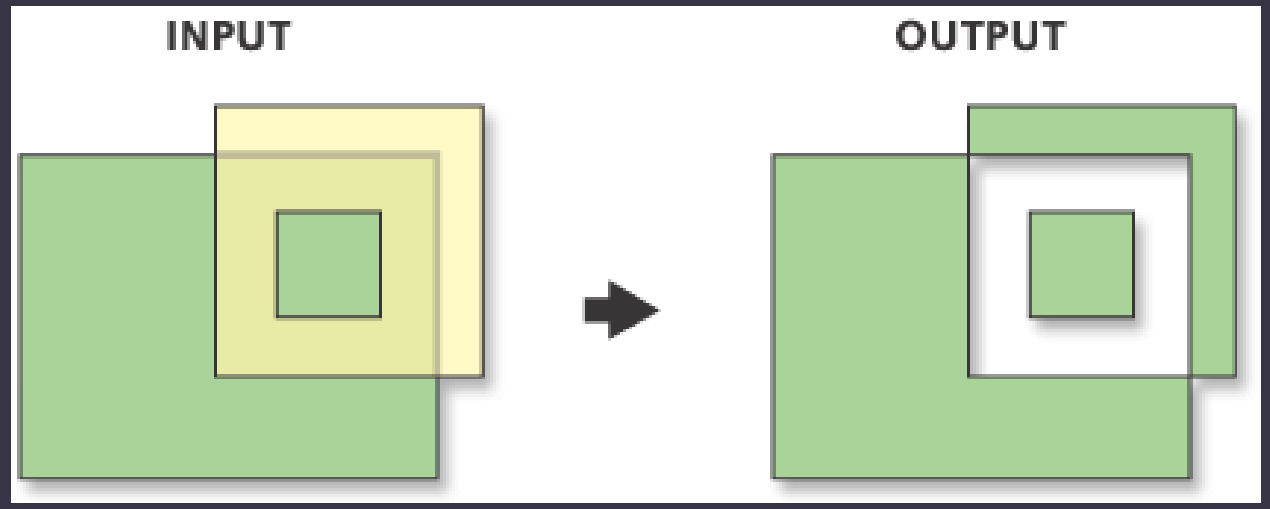
SYMMETRICAL DIFFERENCE

- Features or portions of features in the input and update features that do not overlap will be written to the output feature class.
- The input and update feature class or feature layer must be of the same geometry type.



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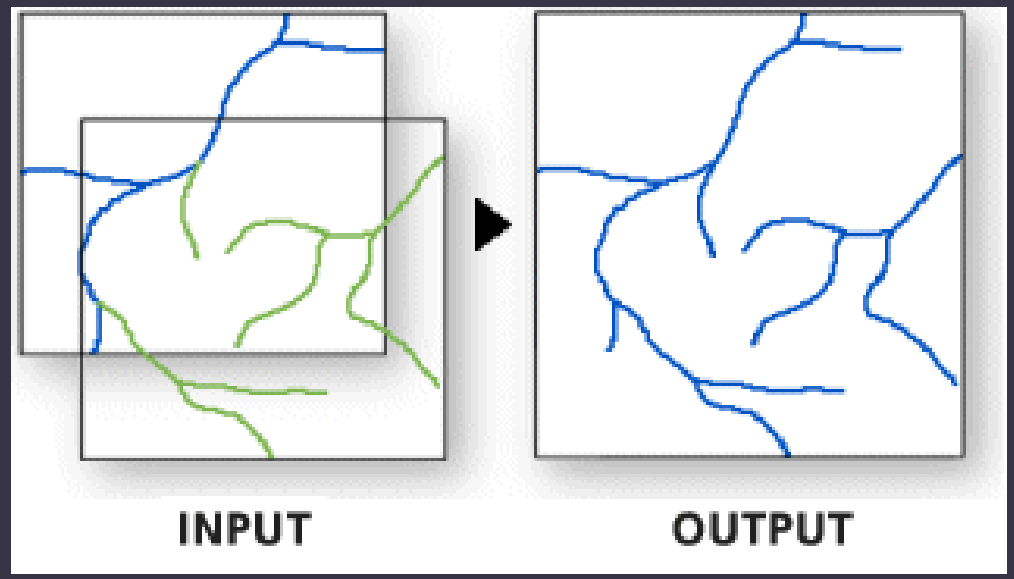
PAIRWISE OVERLAY TOOLS

- Alternate to the classic overlay tools
- Designed to maximize performance and accuracy of analysis when processing very large and complex datasets
- Use parallel processing by default

APPEND

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



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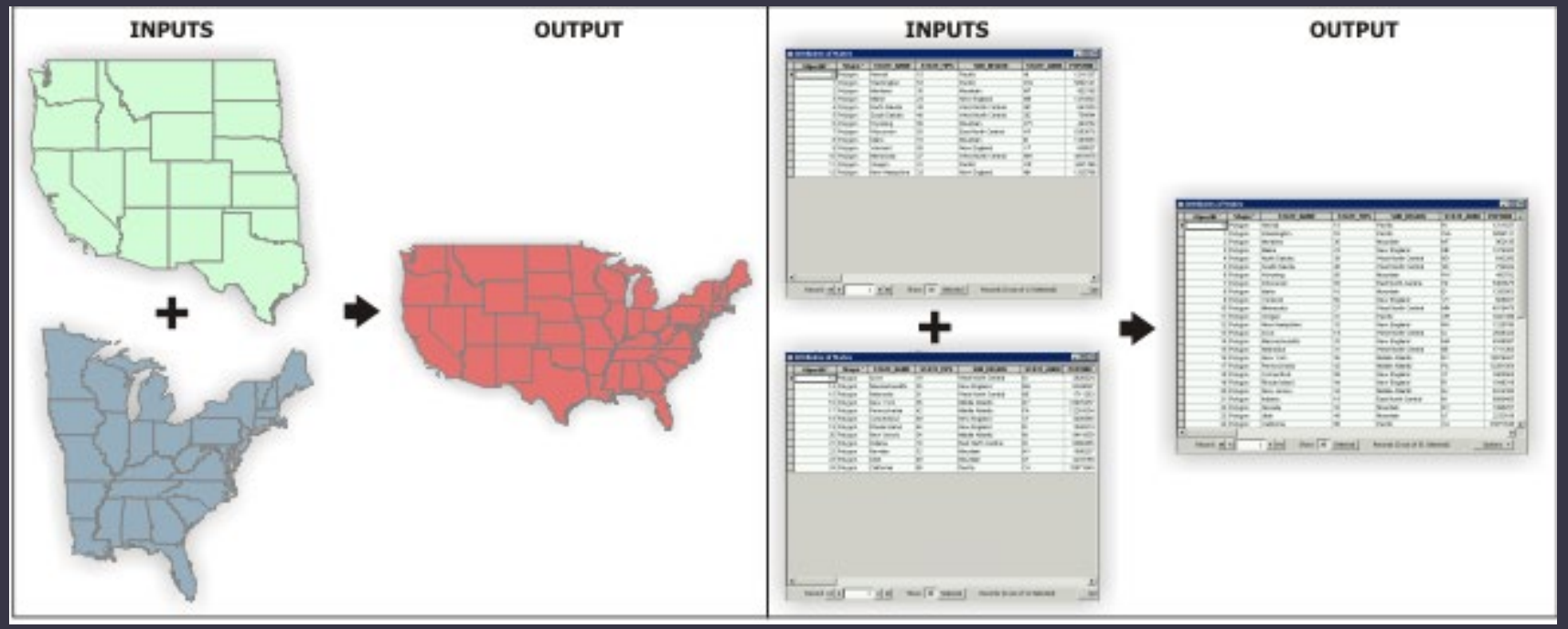
APPEND

- The Append tool's Field Map Control can be used to control how the attribute information from the input dataset fields is transferred to the target dataset.
- If the spatial references of an input and target feature class do not match, the Append tool will project the features in the input feature class to the coordinate system used by the target feature class.
- Field Matching Type
  - Input field must match target fields
  - Use the field map to reconcile field differences
  - Skip and warn if schema does not match

MERGE

- Combines multiple input datasets of the same data type into a single, new output dataset. This tool can combine point, line, or polygon feature classes or tables. All input datasets must be of the same type



SPATIAL STATISTICS

Identifying and understanding geographic patterns

SPATIAL STATISTICS TOOLS

- Compare patterns for different data distributions or time periods
- Summarize the key characteristics of a distribution
- Identify statistically significant spatial clusters (hot spots/cold spots) and spatial outliers
- Assess overall patterns of clustering or dispersion

- Toolsets in ArcGIS
  - Analyzing Patterns
  - Assessing Sensitivity
  - Mapping Clusters
  - Measuring Geographic Distributions
  - Modeling Spatial Relationships
  - Spatial Component Utilities
  - Utilities

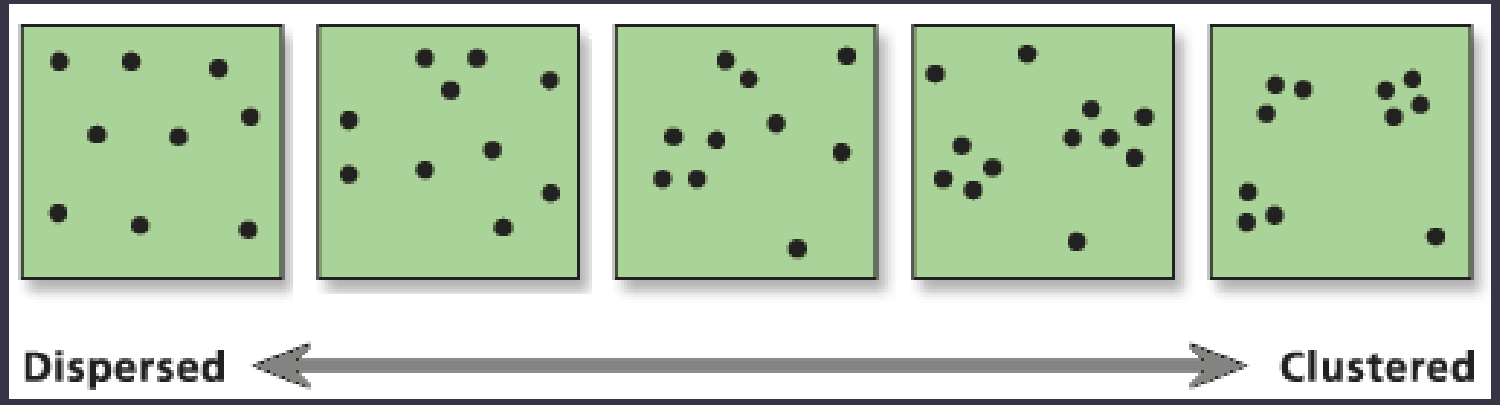
https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/an-overview-of-the-spatial-statistics-toolbox.htm

ANALYZING PATTERNS

- Average Nearest Neighbor
- High/Low Clustering
- Incremental Spatial Autocorrelation
- Multi-Distance Spatial Cluster Analysis
- Spatial Autocorrelation

AVERAGE NEAREST NEIGHBOR

- Calculates a nearest neighbor index based on the average distance from each feature to its nearest neighboring feature.
- If the nearest neighbor index is less than 1, the pattern exhibits clustering.
- If the index is greater than 1, the trend is toward dispersion.



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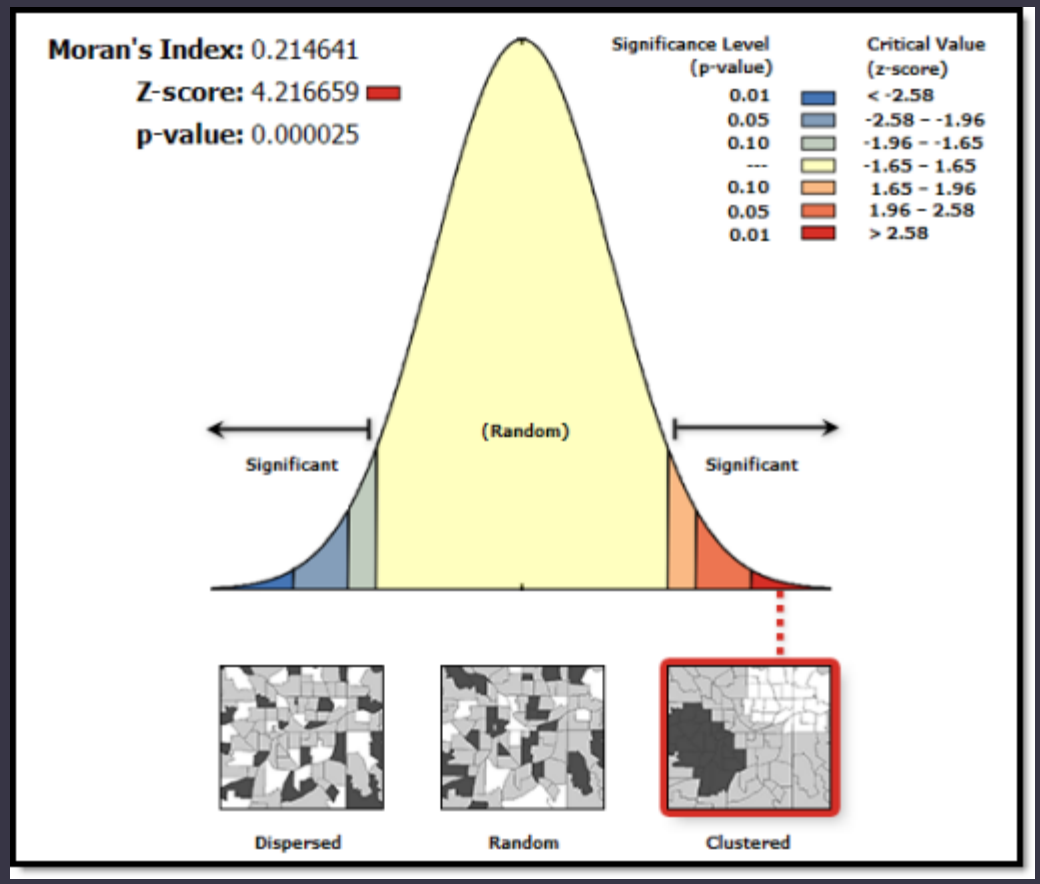
SPATIAL AUTOCORRELATION

- Helps to understand the degree to which one object is similar to other nearby objects.
- Tool measures spatial autocorrelation based on both feature locations and feature values simultaneously.
- P-value is statistically significant and z-score is positive – clustering.
- P-value is statistically significant and z-score is negative – dispersed.



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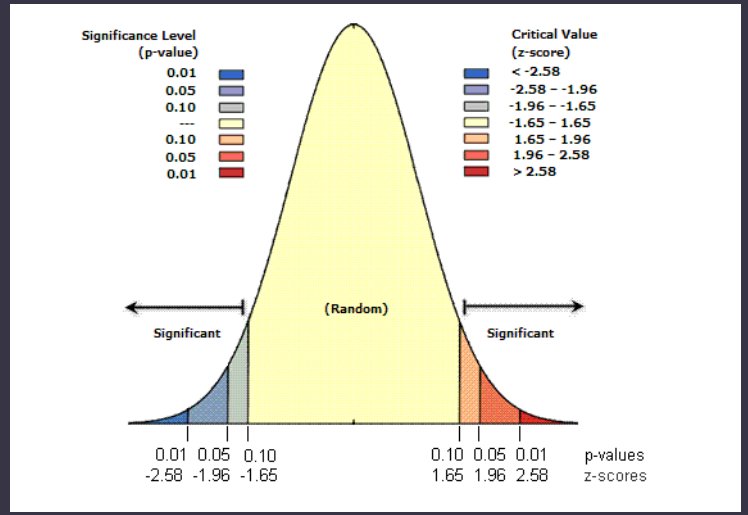
P-VALUE & Z-SCORE

- P-Value is a probability
- P-value is small means it's very unlikely that the observed spatial pattern is a result of random processes.
- Z-Scores are standard deviations
- Very high or very low (negative) z-scores, associated with very small p-values, are found in the tails of the normal distribution.



z-score (Standard Deviations)	p-value (Probability)	Confidence level
< -1.65 or > +1.65	< 0.10	90%
< -1.96 or > +1.96	< 0.05	95%
< -2.58 or > +2.58	< 0.01	99%

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HIGH/LOW CLUSTERING

- Concentration of high or low values for a given study area.
- Uses the Getis-Ord General G statistic.
- Most appropriate for a fairly even distribution of values and looking for unexpected spatial spikes of high values.
- High values = p-value is significant and z-score is positive
- Low values = p-values is significant and z-score is negative

SPATIAL RELATIONSHIPS

- Inverse Distance: Nearby neighboring features have a larger influence on the computations for a target feature than features that are far away.
- Fixed Distance Band: Each feature is analyzed within the context of neighboring features. Neighboring features inside the specified critical distance (Distance Band or Threshold Distance) receive a weight of one and exert influence on computations for the target feature. Neighboring features outside the critical distance receive a weight of zero and have no influence on a target feature's computations.
- Zone of Indifference: Features within the specified critical distance (Distance Band or Threshold Distance) of a target feature receive a weight of one and influence computations for that feature. Once the critical distance is exceeded, weights (and the influence a neighboring feature has on target feature computations) diminish with distance.

SPATIAL RELATIONSHIPS

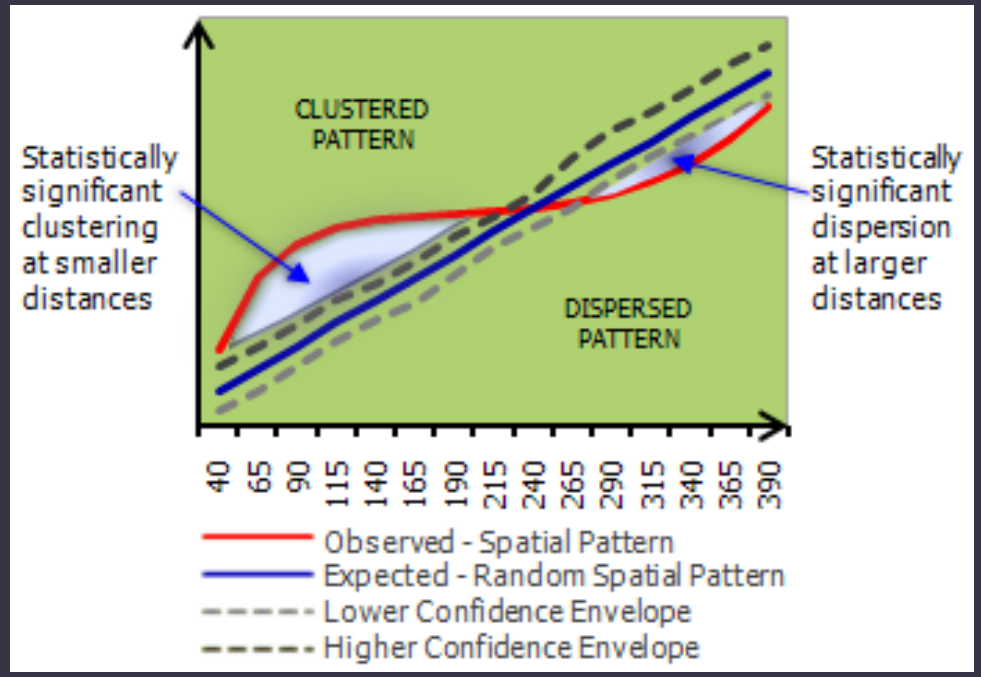
- Polygon Contiguity
  - Contiguity Edges Only: Only neighboring polygon features that share a boundary or overlap will influence computations for the target polygon feature.
  - Contiguity Edges Corners: Polygon features that share a boundary, share a node, or overlap will influence computations for the target polygon feature.

https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/modeling-spatial-relationships.htm

- K nearest neighbors: Neighbor relationships may also be constructed so that each feature is assessed within the spatial context of a specified number of its closest neighbors. If K (the number of neighbors) is 8, then the eight closest neighbors to the target feature will be included in computations for that feature.

MULTI-DISTANCE SPATIAL CLUSTERS

- Determines whether features, or the values associated with features, exhibit statistically significant clustering or dispersion over a range of distances.
- Uses Ripley's K-function
  - If observed K value is larger than the expected K value for a particular distance, the distribution is more clustered.
  - If the observed K value is smaller than the expected K value, the distribution is more dispersed.



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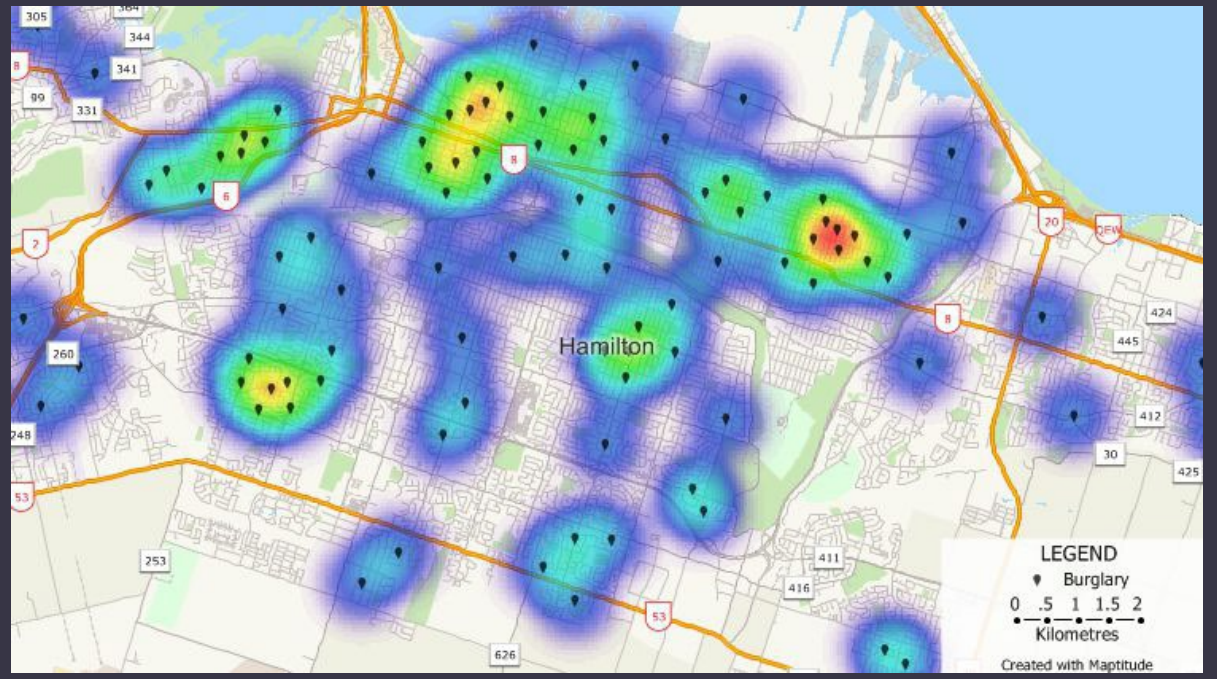
HOT SPOT ANALYSIS

- Given a set of weighted features, identifies statistically significant hot spots and cold spots using the Getis-Ord Gi* statistic.
- A feature with a high value is interesting but may not be a statistically significant hot spot. To be a statistically significant hot spot, a feature will have a high value and be surrounded by other features with high values as well.



Crime hotspots – caliper.com