Before we start

- Lab 4 is due on Tuesday.
- EEGS Open House

Geographic Information Science and Technology

Lecture 6: Attribute Data & Queries

Instructor: Dr. Yao Li

Queries & Vector Analysis

- Relational Database
- Queries
- Vector Analysis (Basic analysis)

Relational Database

- Collection of tabular **relations** (tables), each having a set of attributes.
- Data are structured as a set of **rows** (tuples)
- **Attribute** has a **domain** from which its values are drawn.

Table 1 Tuples from the Country relation.

Name	*Population (millions)*	*Land area (thousand sq. miles)*	*Capital*
Austria	8	32	Vienna
Germany	81	138	Berlin
Italy	58	116	Rome
France	58	210	Paris
Switzerland	7	16	Bern

Table 2 Tuples from the City relation.

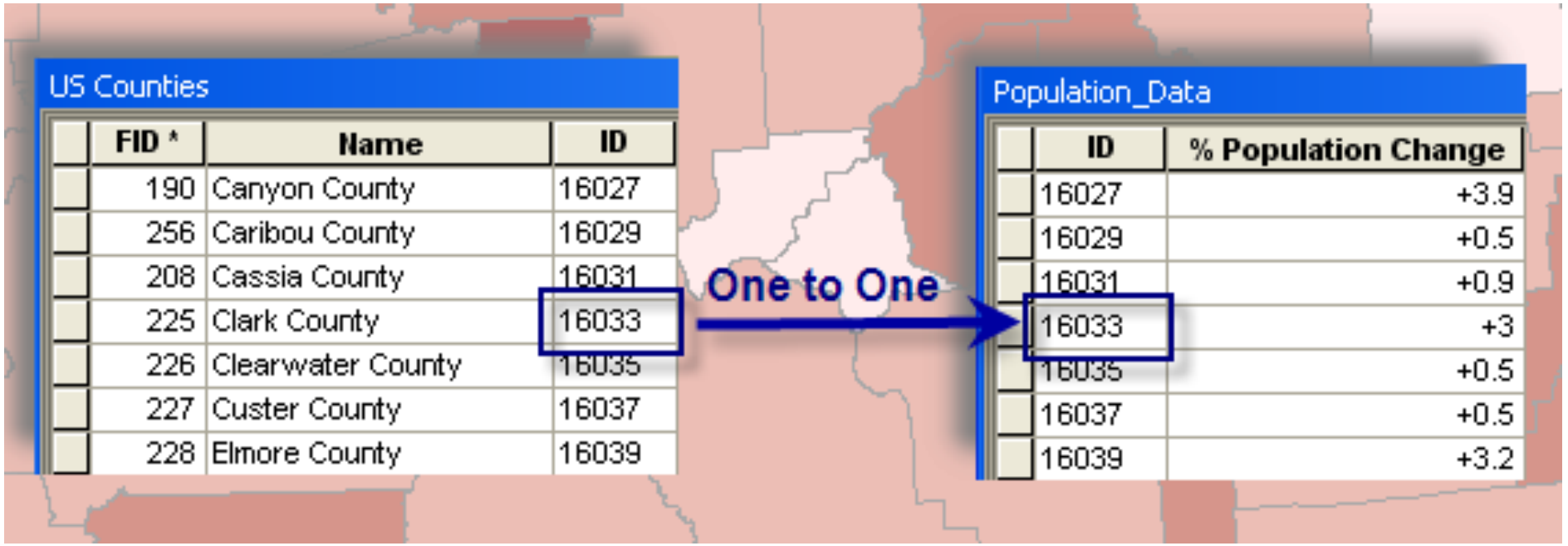
Name	*Country*	*Population (thousands)*
Vienna	Austria	1500
Berlin	Germany	3400
Hamburg	Germany	1600
Rome	Italy	2800
Milan	Italy	1400
Paris	France	2100
Zurich	Switzerland	300
Bern	Switzerland	100

https://www.geos.ed.ac.uk/~gisteac/gis_book_abridged/files/ch26.pdf

Linking Tables

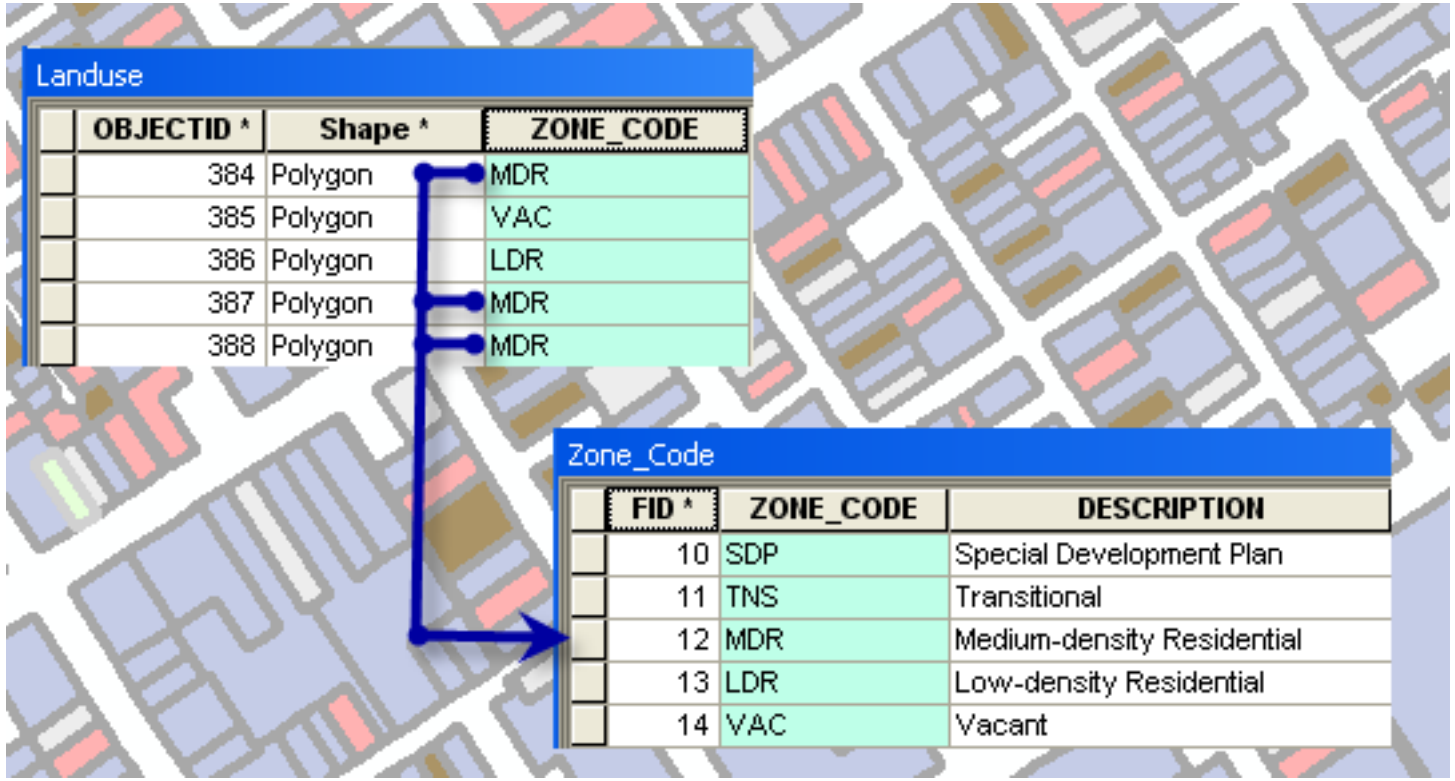
- Need a **KEY** – an attribute that uniquely defines a record (tuple)
  - Must be unique to that row (e.g. ssn)
- To Join one table to another need a **FOREIGN KEY**
- They have to match exactly! Be of the same data **TYPE** (e.g. string/Integer/decimal)

Types of Relationships



https://desktop.arcgis.com/en/arcmap/latest/manage-data/tables/about-joining-and-relating-tables.htm

Types of Relationships



Many-to-One

https://desktop.arcgis.com/en/arcmap/latest/manage-data/tables/about-joining-and-relating-tables.htm

Types of Relationships

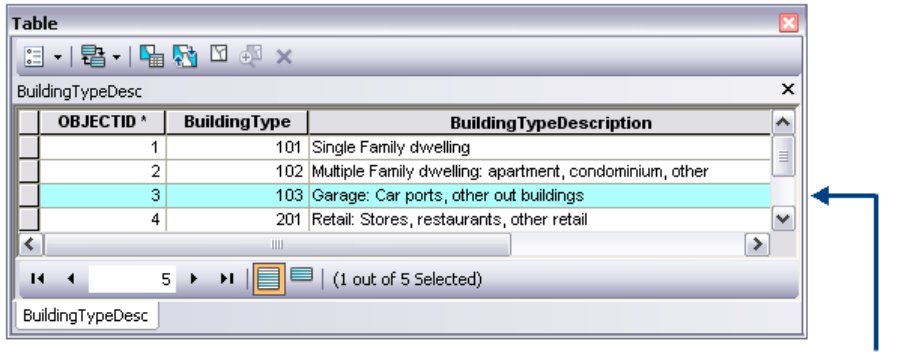
One-To-Many & Many-To-Many

FID	Shape	binomial
0	Polygon	Felis margarita
1	Polygon	Gulo gulo
2	Polygon	Herpestes fuscus
3	Polygon	Martes foina

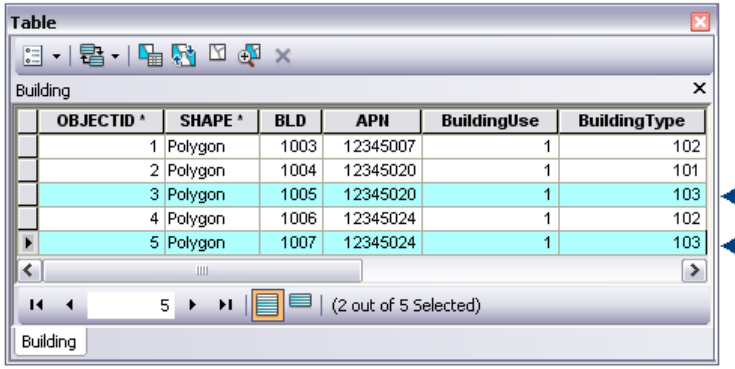
Spp	Disease
Felis margarita	rabies
Felis margarita	lyme
Felis margarita	plague
Felis margarita	giardiasis
Gulo gulo	rabies
Herpestes fuscus	brucellosis
Herpestes fuscus	lyme
Martes foina	rabies
Martes foina	lyme

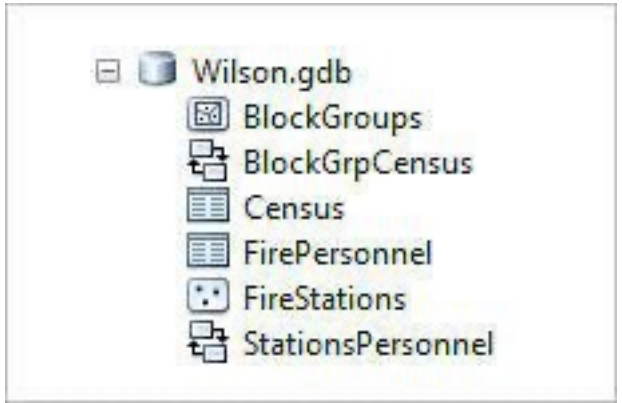
Join VS. Relate

- Join – appends all columns from one table to another (Lives in map)
- Relate – creates a new temporary table so when you select one record, the corresponding related records are shown. (Lives in a map)
  - Relationship Class is Super Useful!
  - Lives inside of a geodatabase.

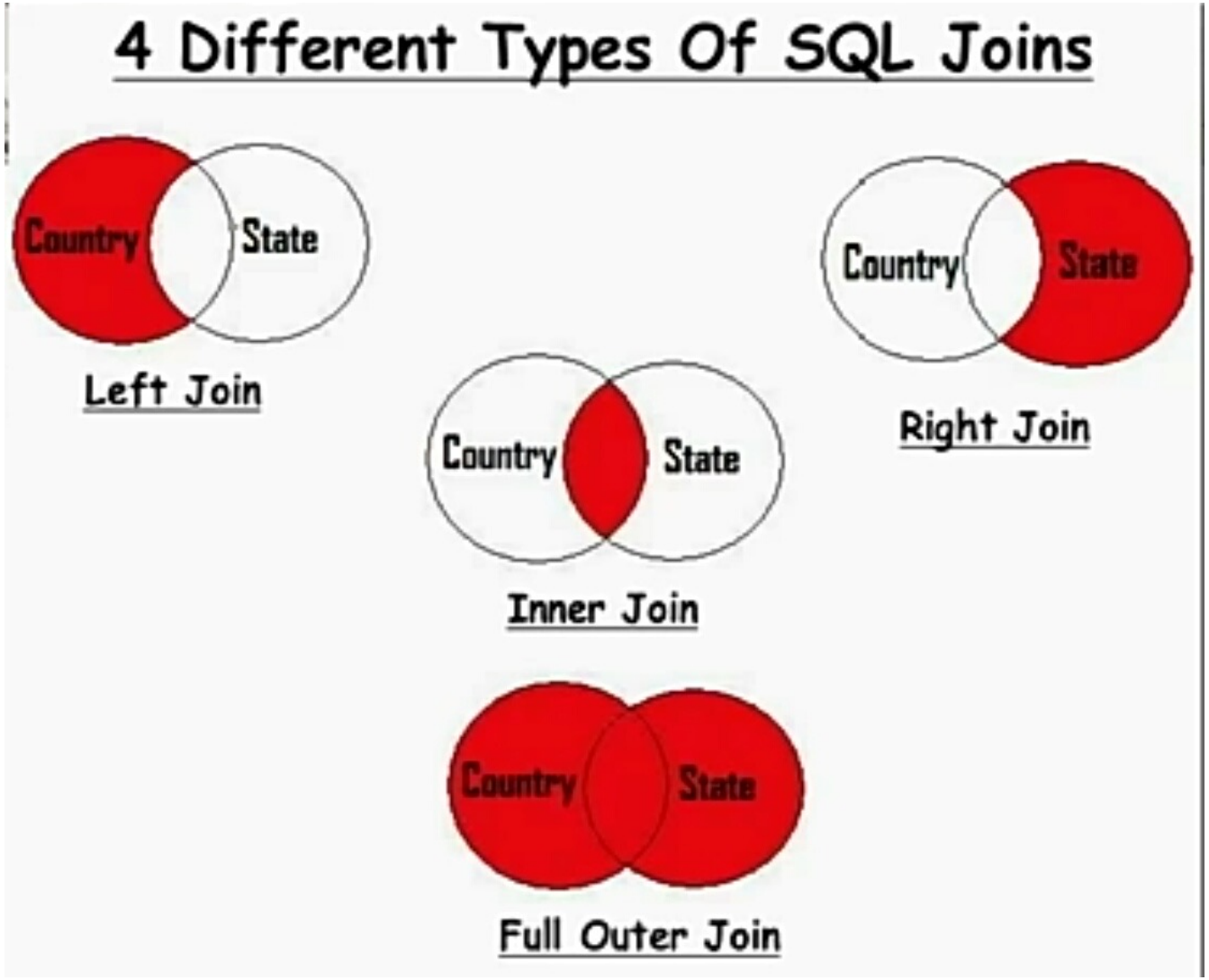


BuildingTypeToBuilding





Types of Joins



Queries: The Basics

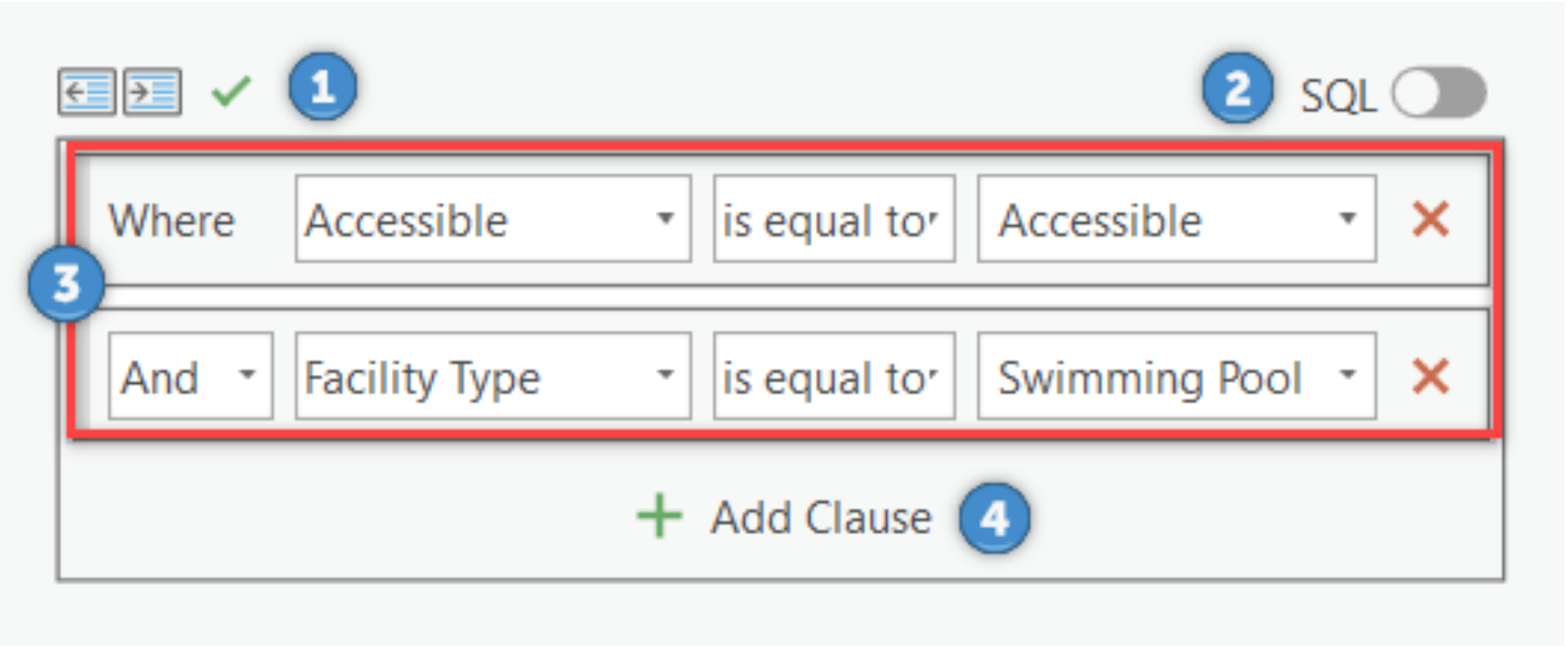
- Searching a database to obtain some specific information about one or more attributes that satisfy a set of criteria.

Structured Query Language

- *de facto* query language for relational databases
- Developed by IBM in the 1970s
- Basic syntax is as follows:
  - SELECT <attribute list>
  - FROM <relation>
  - WHERE <condition>

Ways to Query in ArcGIS Pro

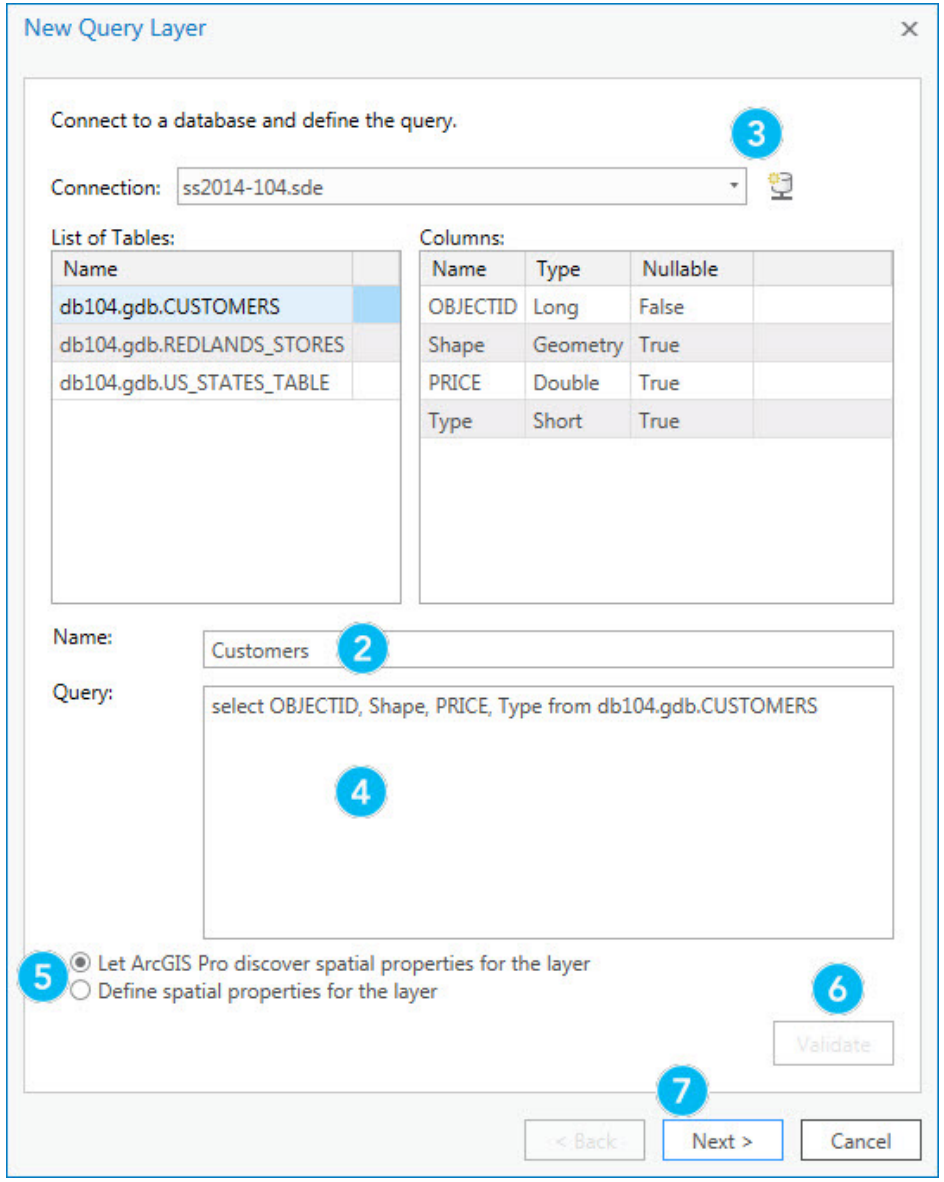
- Query Builder (training wheels)



https://pro.arcgis.com/en/pro-app/latest/help/mapping/navigation/write-a-query-in-the-query-builder.htm

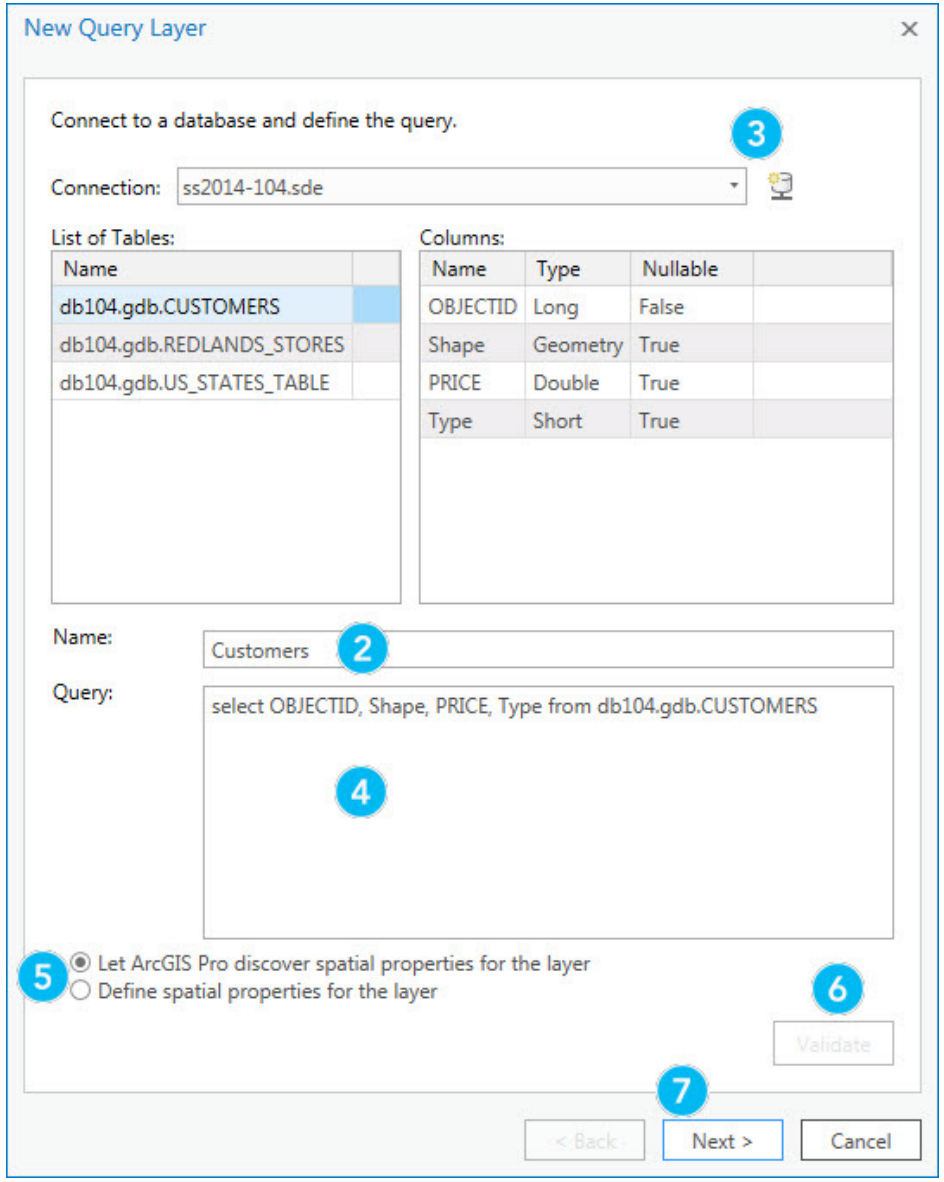
Make Query Table\Layer

- Create temporary layer with the results of your query (in database land we would call this a VIEW)



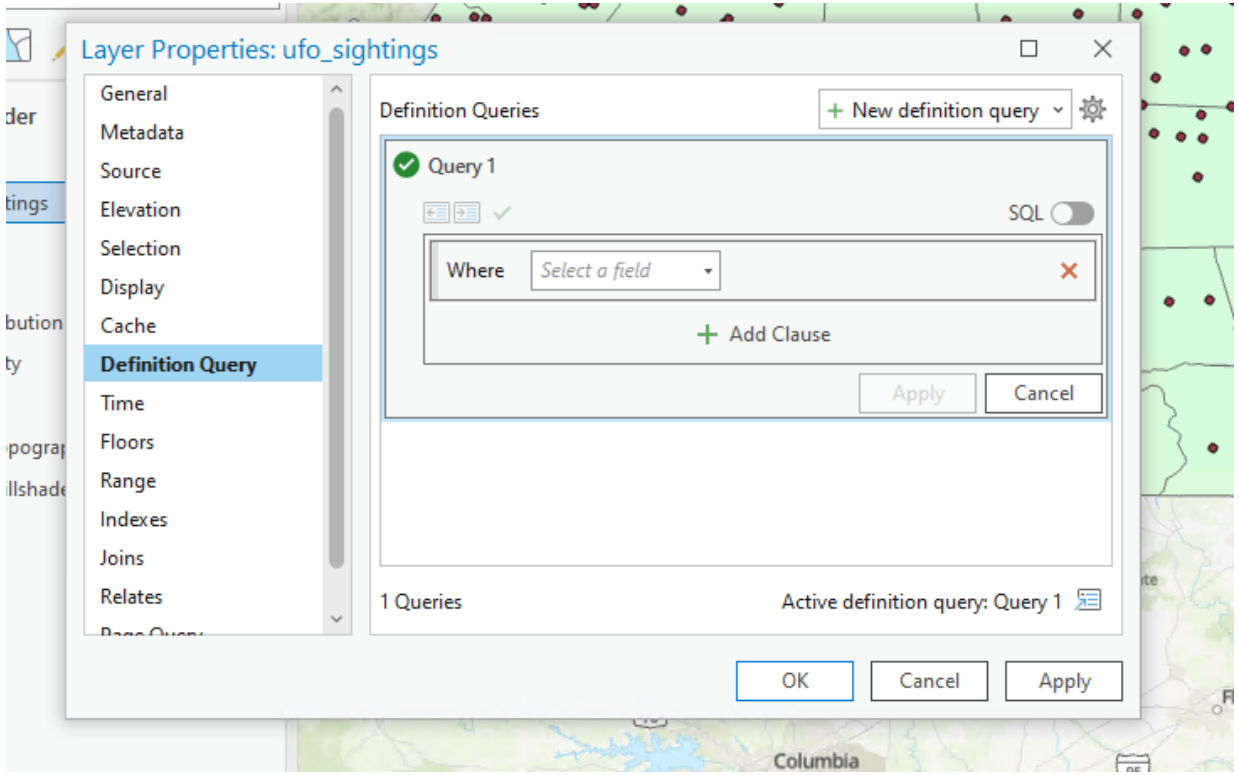
Make Query Table\Layer

- Create temporary layer with the results of your query (in database land we would call this a VIEW)



Ways to Query in ArcGIS Pro

- Definition query



https://pro.arcgis.com/en/pro-app/latest/help/mapping/navigation/write-a-query-in-the-query-builder.htm

‘Group BY’ → Summarize Field

ObjectID	Designation	Count	Count_VO2	Sum_VO2	Min_VO2	Max_VO2	N
1	Amateur	3	3	116.3	30.7	50.2	
2	Professional	3	2	65.1	28	37.1	

Mean_VO2	Range_VO2	Sd_VO2	Var_VO2	Count_Rating	Any_Rating
38.76667	19.5	8.309165	69.04222	3	Good
32.55	9.1	4.55	20.7025	2	Fair

ObjectID	Designation	AgeGroup	VO2	Rating
1	Amateur	20-29 year old	50.2	Superior
2	Amateur	20-29 year old	35.4	Good
3	Amateur	30-39 year old	30.7	Good
4	Professional	20-29 year old	37.1	Superior
5	Professional	30-39 year old	28	Fair
6	Professional	30-39 year old		

Vector analysis

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

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.

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.

Spatial Query

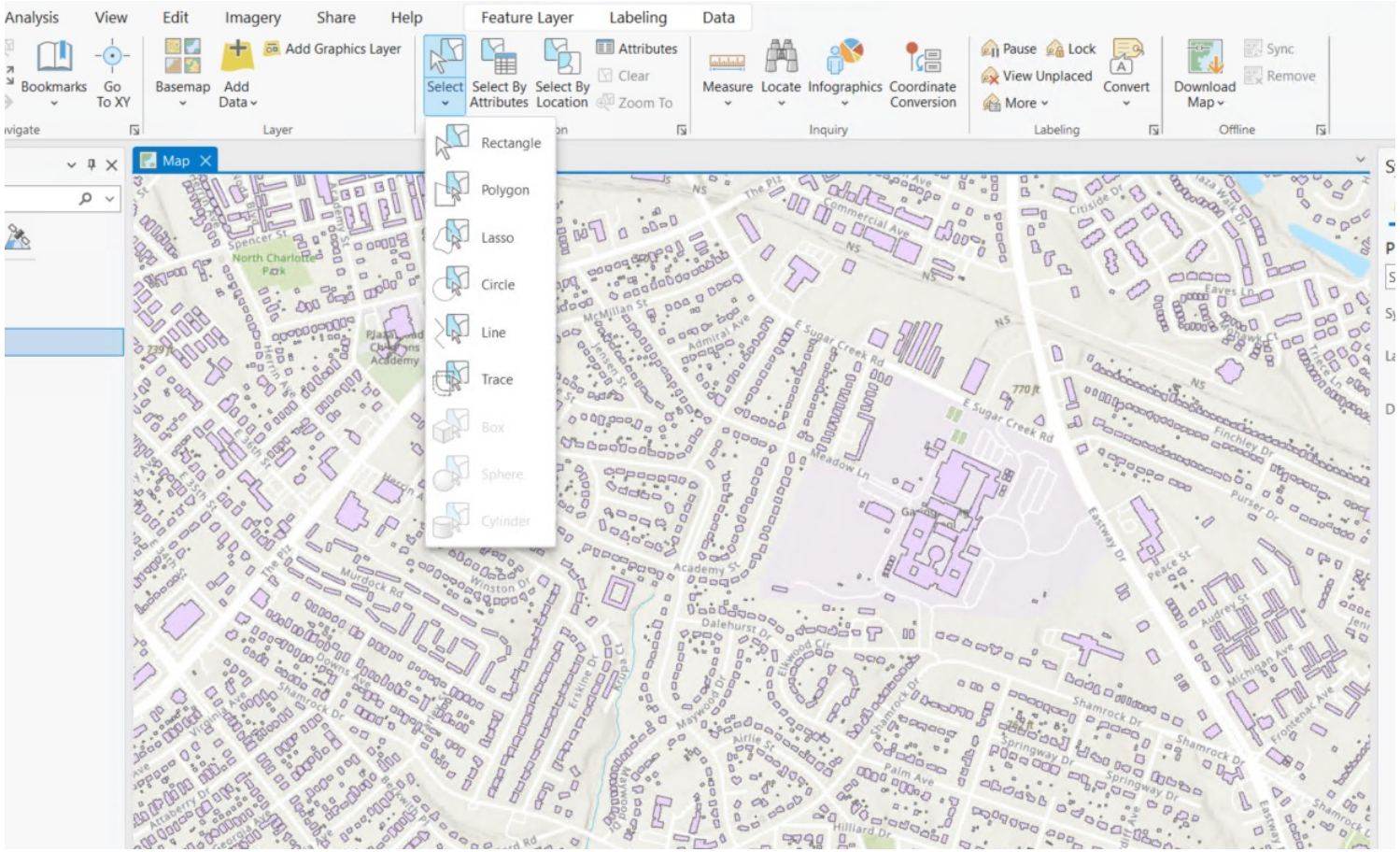
- Three methods of selecting features
  - Select Feature Button
  - Selecting Features by Graphics
  - Selecting Feature by Spatial Relationship

Selecting Features by Graphics

- You can create, move and delete graphics.
- Graphics can be points, lines, or circles.
- Select graphics with the Select Elements tool - 

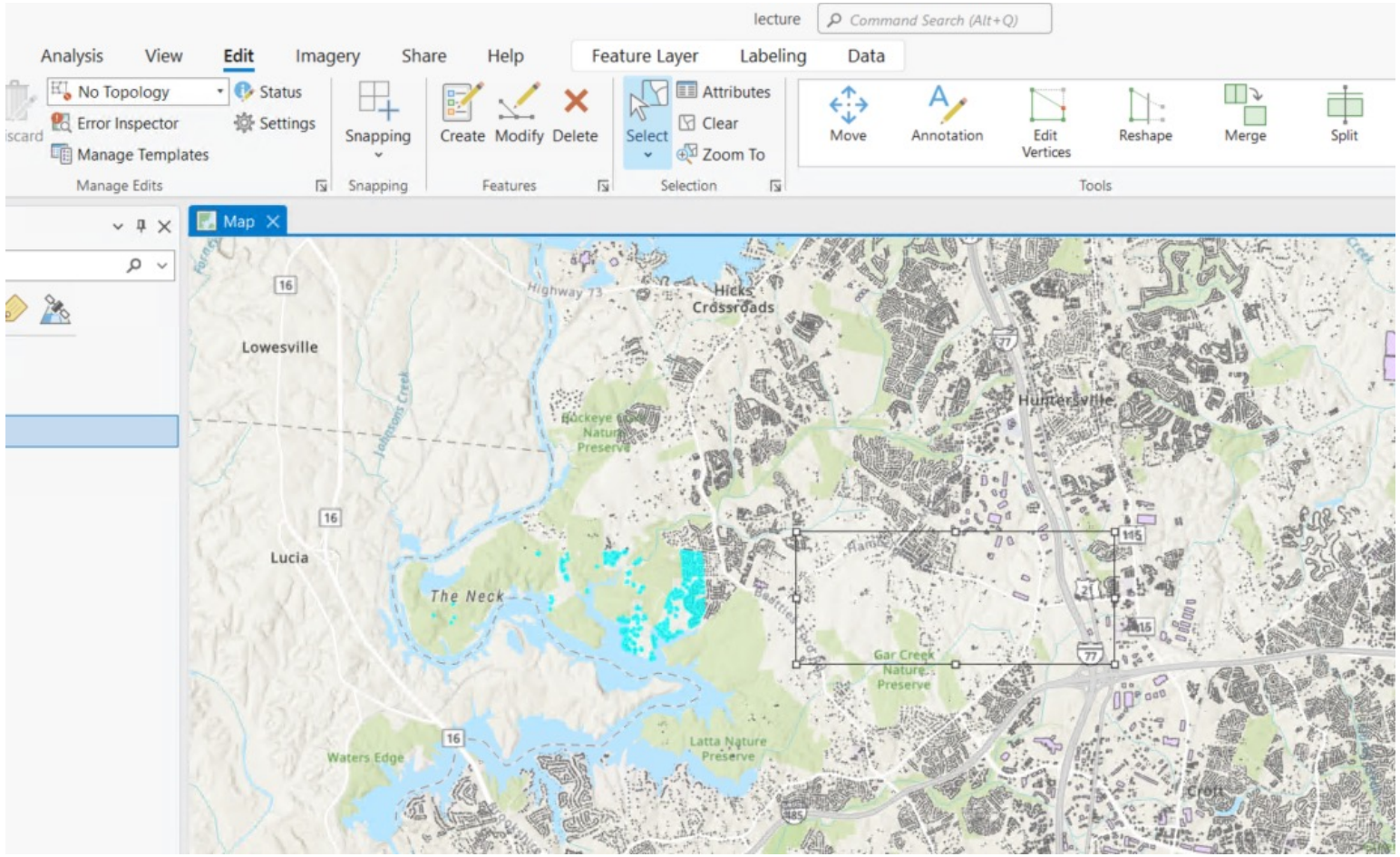
Selecting Features by Graphics

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



Selecting Features by Graphics

- To be able to select features by graphics, firstly you need to create graphics.
  - Move the selection



Selecting Features 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 Mecklenburg county?
  - How many counties is passed through by Chowan River? And what counties are they?
  - What are those counties that share borders with
  - Where are the Starbucks within 1 mile of McEniry?

Selecting Features 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.
- The source layer contains features that are known or selected.

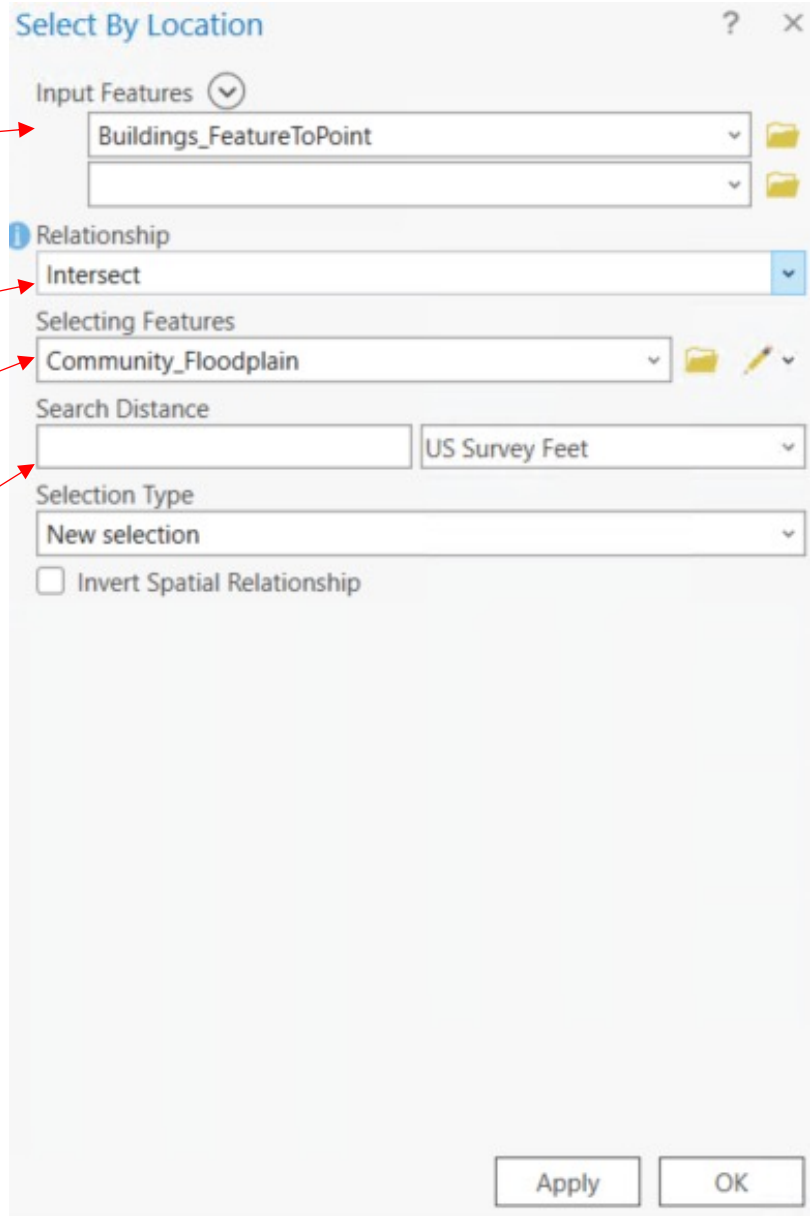
Selecting Features by Spatial Relationship

Target Layer

Spatial Relationship

Source Layer

Distance Buffer

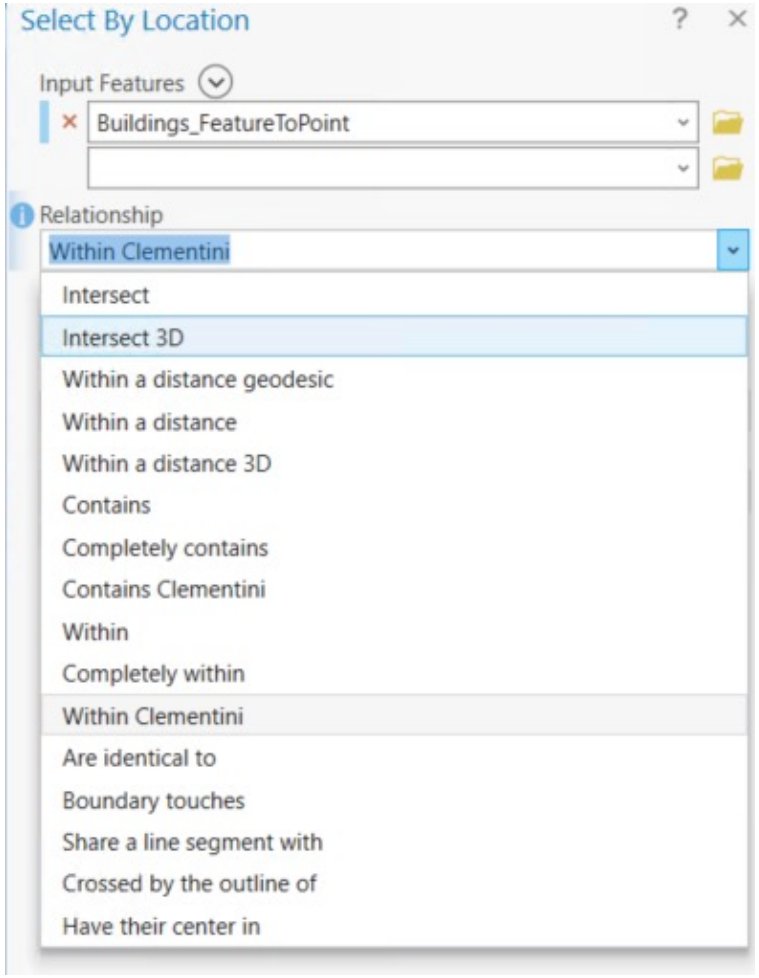


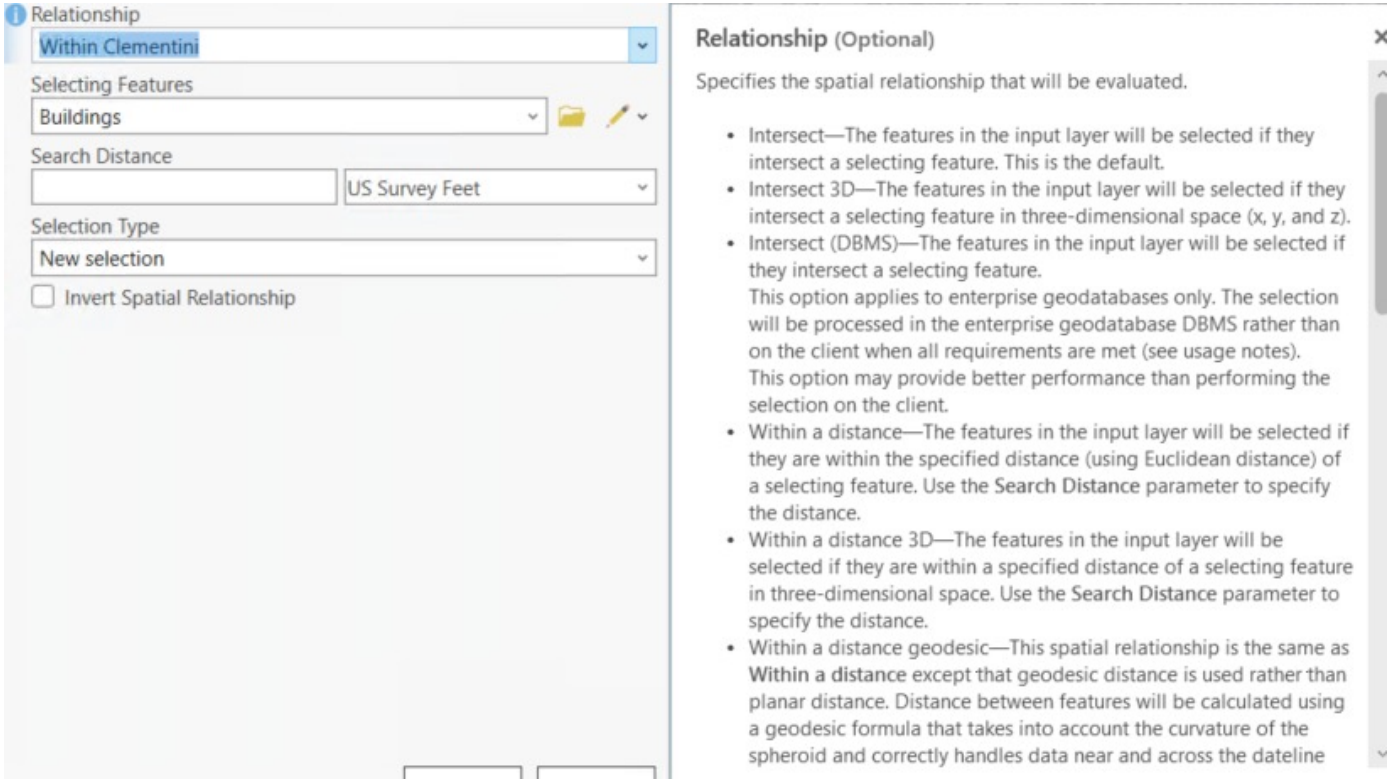
Selecting Features by Spatial Relationship

- Four typical 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

Selecting Features by Spatial Relationship

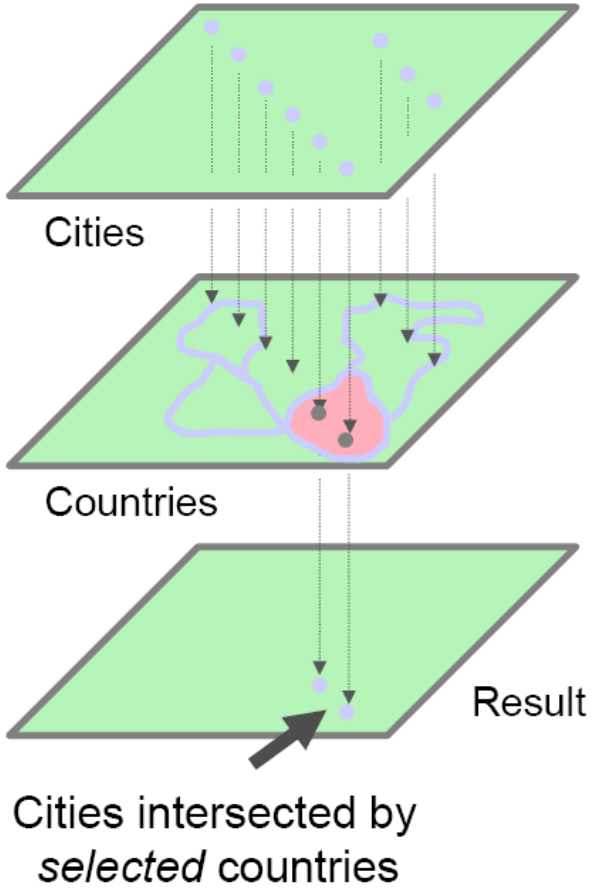
- ArcGIS defines over 17 specific spatial relationships





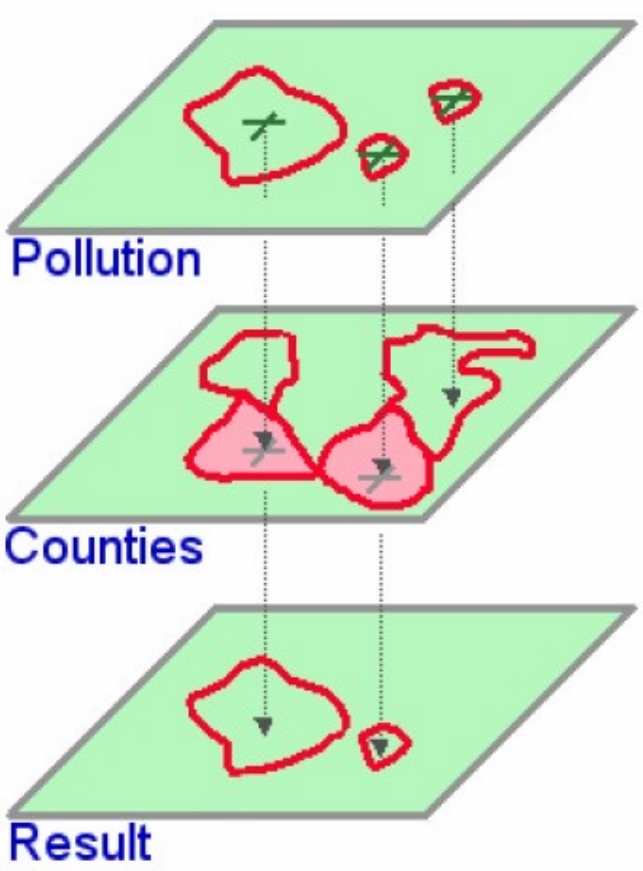
Selecting Features by Spatial Relationship

- Example: intersection



Selecting Features by Spatial Relationship

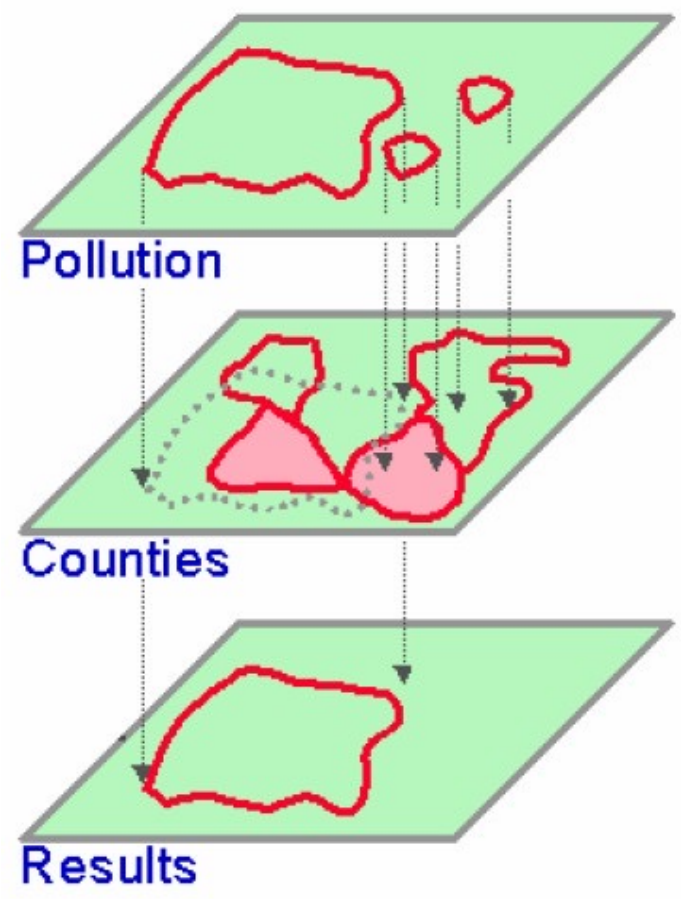
- Example: containment



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

Selecting Features by Spatial Relationship

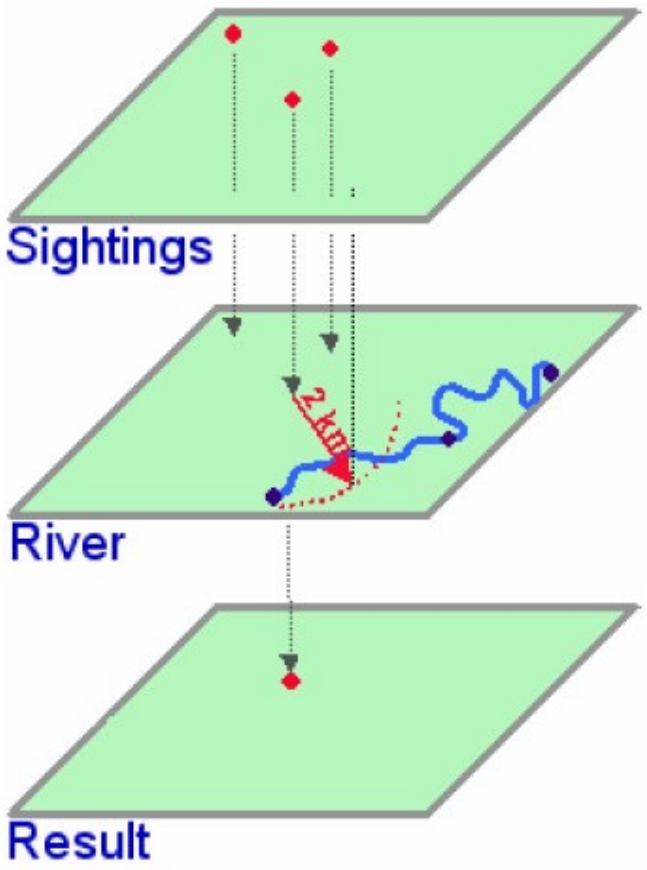
- Example: containment



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

Selecting Features by Spatial Relationship

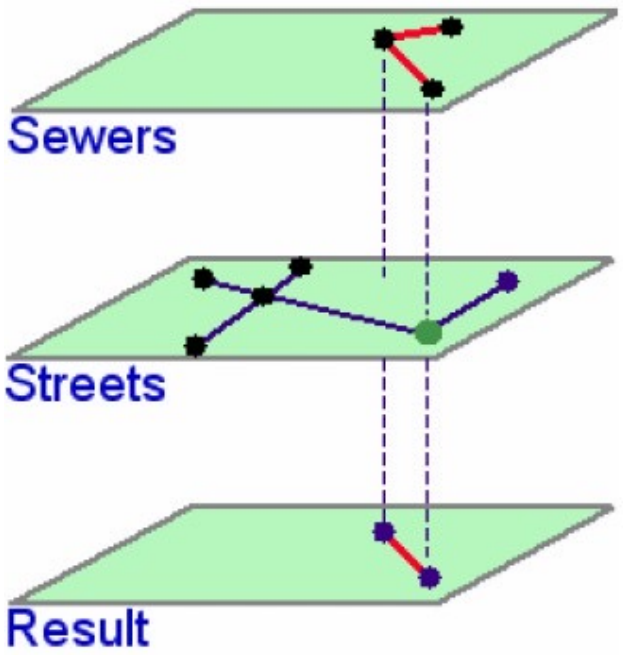
- Example: distance



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.

Selecting Features 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.

Selecting Features by Spatial Relationship

- “Select By Location” dialog window
- It is often useful to combine Attribute Query and Spatial Data Query.

Spatial Join

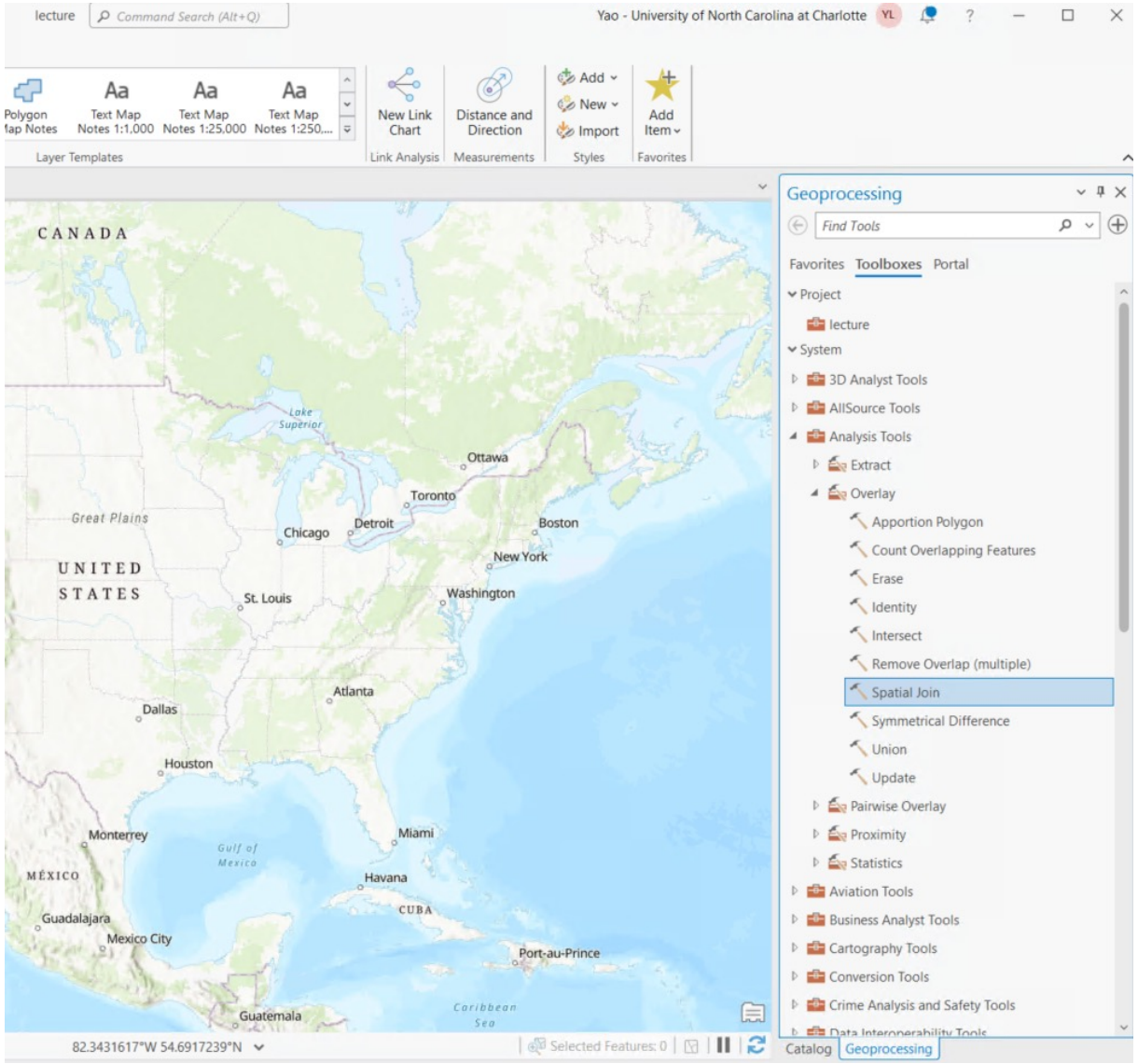
- A Spatial Join joins attributes from one layer to another based on feature location.
- Spatial Join is a special case of tabular join. It uses the location of features, instead of a common field, to match the records in attribute tables.
- Like tabular joins, spatial join will also append fields from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

Spatial Query & Spatial Join

- 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.

Spatial Join in ArcGIS Pro

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



Spatial Join

- 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.

Spatial Join

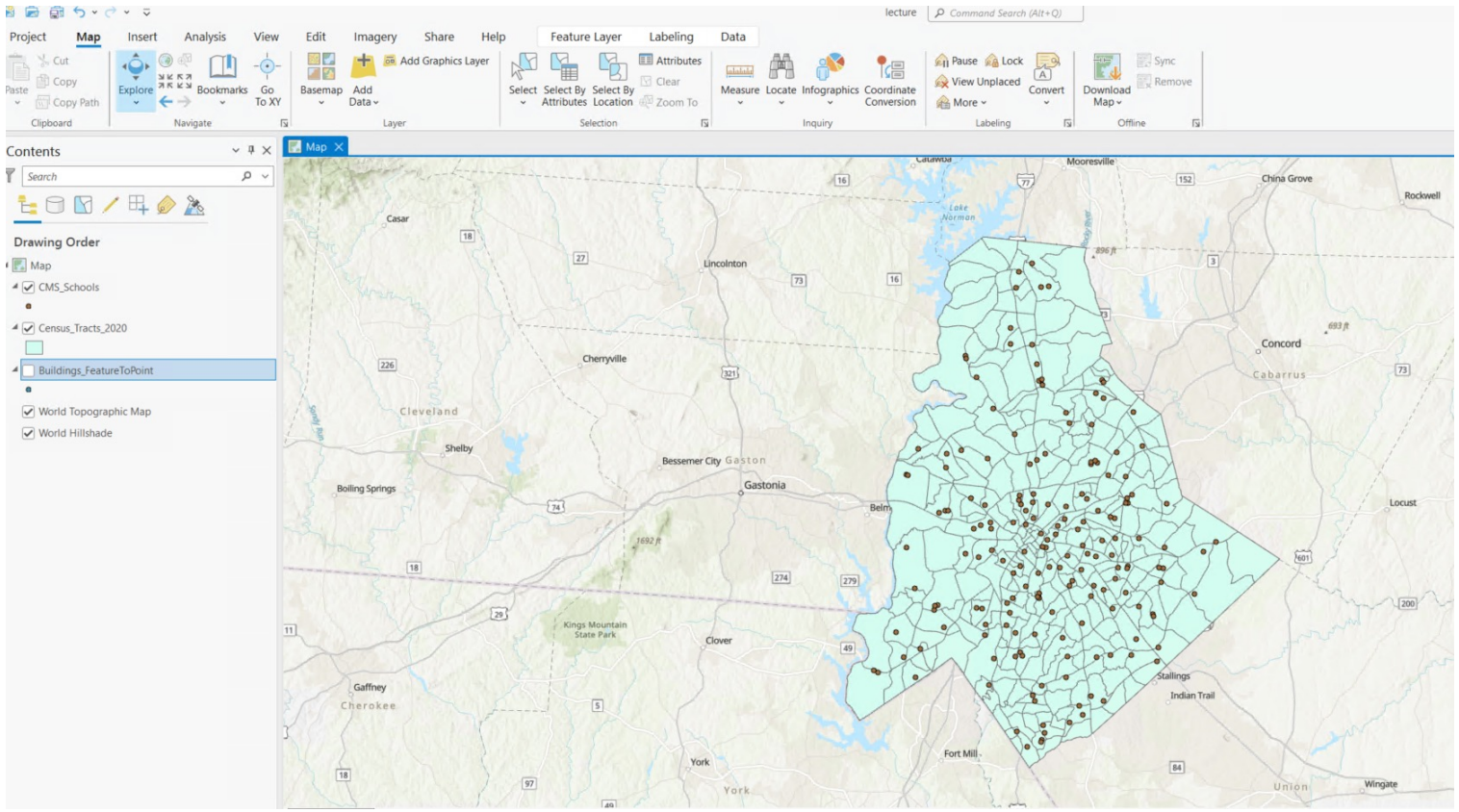
- Three typical types:
  - Inside:
    - Moves attributes of one theme to features of another based on location (one theme must be a polygon theme)
    - Example: how many earthquakes fall within each county
  - Nearest:
    - Determines the distance to the nearest feature of another theme (point/point, point/line)
    - Example: which earthquake location 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

Spatial Join

- The **destination layer** 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 destination table and is appended to the record in the destination table.

Spatial Join

- Example 1:
  - Append points to polygons.



Spatial Join

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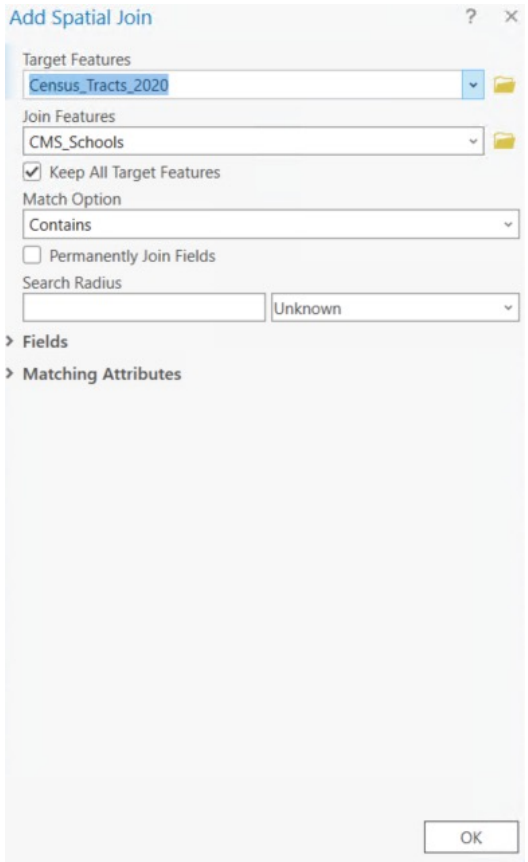
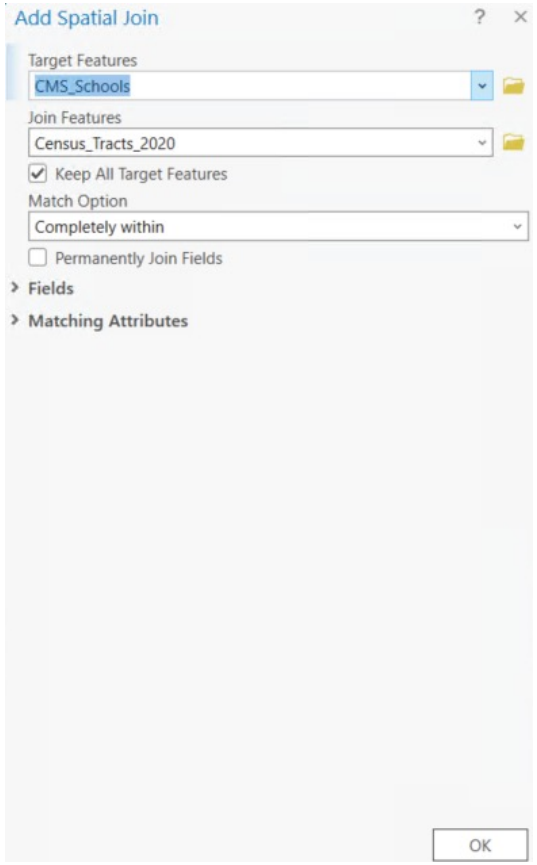


ER20	INTPTLAT20	INTPTLON20	OBJECTID *	Join_Count	TARGET_FID	school_num	school	schoo
7571	+35.3920017	-080.8391093	147	5	146	4442	BLYTHE	ELEM
7946	+35.2334149	-080.9112968	275	5	274	4311	ASHLEY PARK PRE K-8	MIDD
2166	+35.2984939	-080.7730234	41	4	40	5428	JAMES MARTIN	MIDD
0	+35.2615509	-080.8610607	167	4	166	8482	NORTHWEST SCHOOL...	HIGH
1366	+35.2624641	-080.8268574	170	4	169	4374	DRUID HILLS ACADEMY	MIDD
9663	+35.2642786	-080.7079907	244	4	243	7334	CATO MIDDLE COLLEGE	HIGH
7563	+35.0537552	-080.7838289	271	4	270	5431	JAY M. ROBINSON	MIDD
3230	+35.3015004	-080.9174186	33	3	32	4462	MOUNTAIN ISLAND LA...	MIDD
7709	+35.2541287	-080.9453076	42	3	41	4583	J.W. WILSON	MIDD
7068	+35.1947247	-080.9912816	63	3	62	4369	BEREWICK	ELEM
7353	+35.1723424	-080.9492420	68	3	67	5434	KENNEDY	MIDD
1323	+35.1604255	-080.8316285	98	3	97	5399	ALEXANDER GRAHAM	MIDD
4754	+35.1506787	-080.9060583	110	3	109	4471	NATIONS FORD	ELEM
0	+35.2574751	-080.8492145	169	3	168	4488	OAKLAWN LANGUAGE...	MIDD
6864	+35.2507947	-080.7397811	245	3	244	5341	COCHRANE COLLEGIA...	MIDD
1149	+35.3040262	-080.7390968	270	3	269	7567	CHARLOTTE ENGINEERI...	HIGH

Spatial Join

- Example 2:
  - Append polygons to points.



CMS_Schools

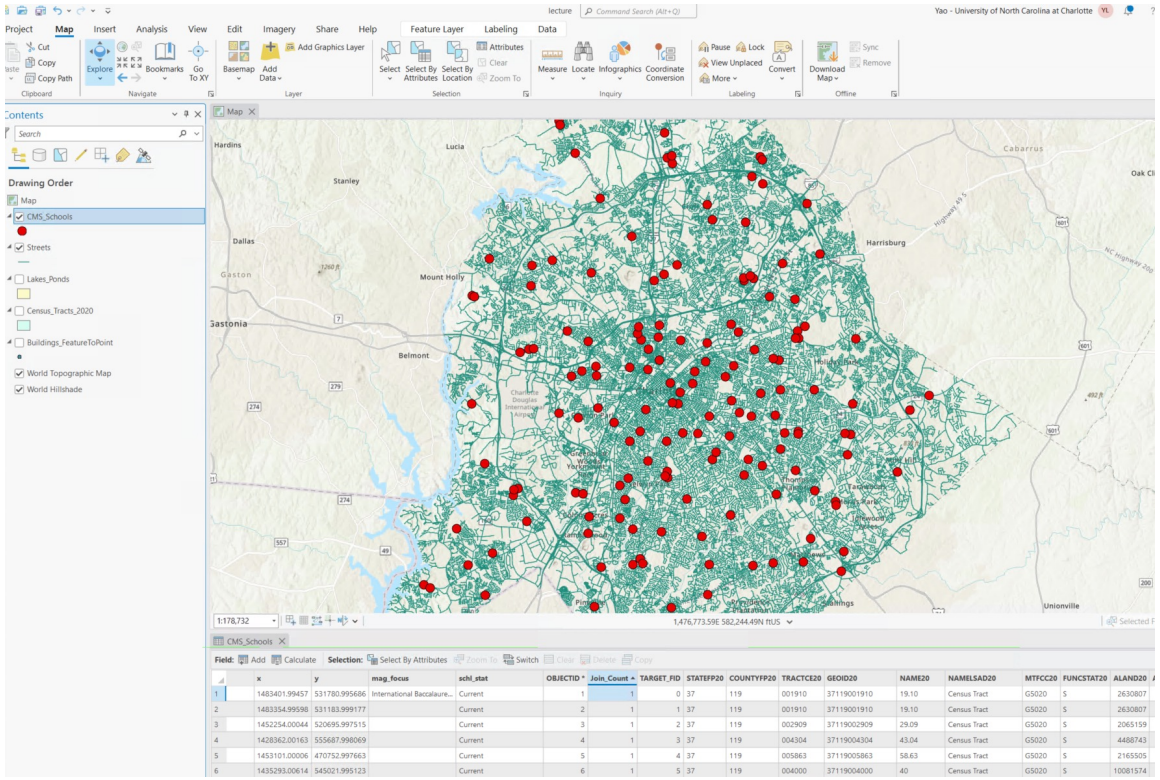
Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear Delete Copy

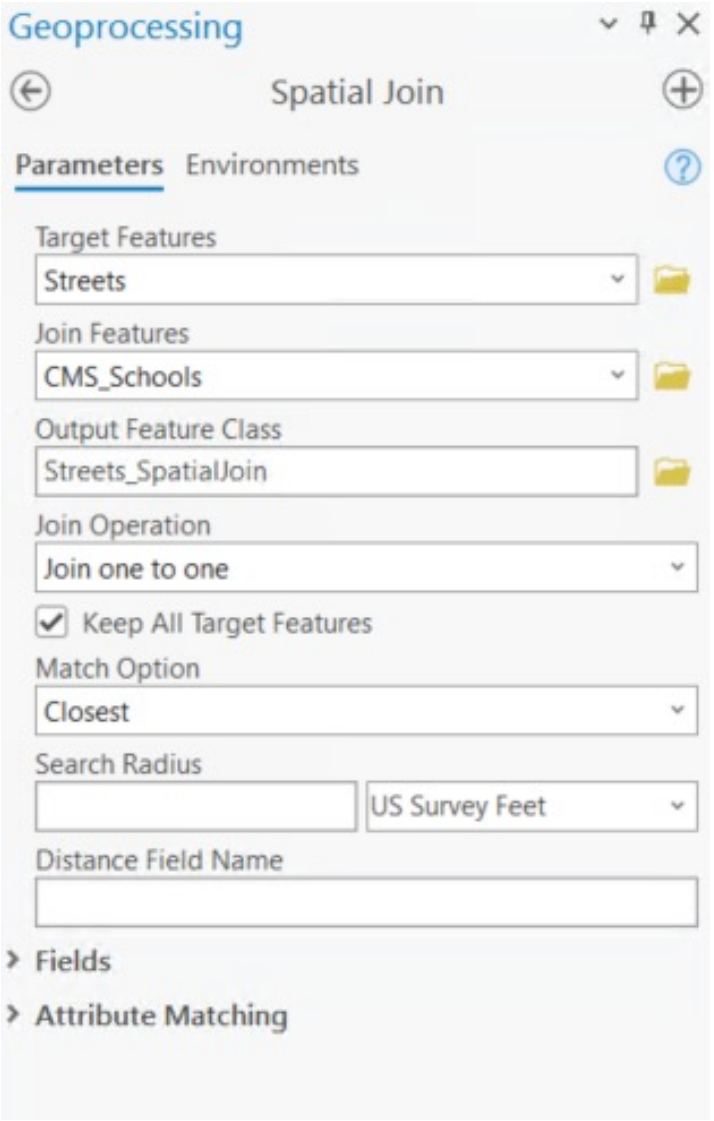
	OBJECTID *	Join_Count	TARGET_FID	STATEFP20	COUNTYFP20	TRACTCE20	GEOID20	NAME20	NAMELSAD20	MTFCC20
1	1	1	0	37	119	001910	37119001910	19.10	Census Tract	G5020
2	2	1	1	37	119	001910	37119001910	19.10	Census Tract	G5020
3	3	1	2	37	119	002909	37119002909	29.09	Census Tract	G5020
4	4	1	3	37	119	004304	37119004304	43.04	Census Tract	G5020
5	5	1	4	37	119	005863	37119005863	58.63	Census Tract	G5020
6	6	1	5	37	119	004000	37119004000	40	Census Tract	G5020
7	7	1	6	37	119	004000	37119004000	40	Census Tract	G5020
8	8	1	7	37	119	006409	37119006409	64.09	Census Tract	G5020
9	9	1	8	37	119	005714	37119005714	57.14	Census Tract	G5020
10	10	1	9	37	119	005858	37119005858	58.58	Census Tract	G5020
11	11	1	10	37	119	006222	37119006222	62.22	Census Tract	G5020
12	12	1	11	37	119	003902	37119003902	39.02	Census Tract	G5020
13	13	1	12	37	119	005920	37119005920	59.20	Census Tract	G5020
14	14	1	13	37	119	005920	37119005920	59.20	Census Tract	G5020
15	15	1	14	37	119	005920	37119005920	59.20	Census Tract	G5020
16	16	1	15	37	119	003006	37119003006	30.06	Census Tract	G5020

0 of 197 selected Filters: 100%

Spatial Join

- Example 3:
  - Proximity

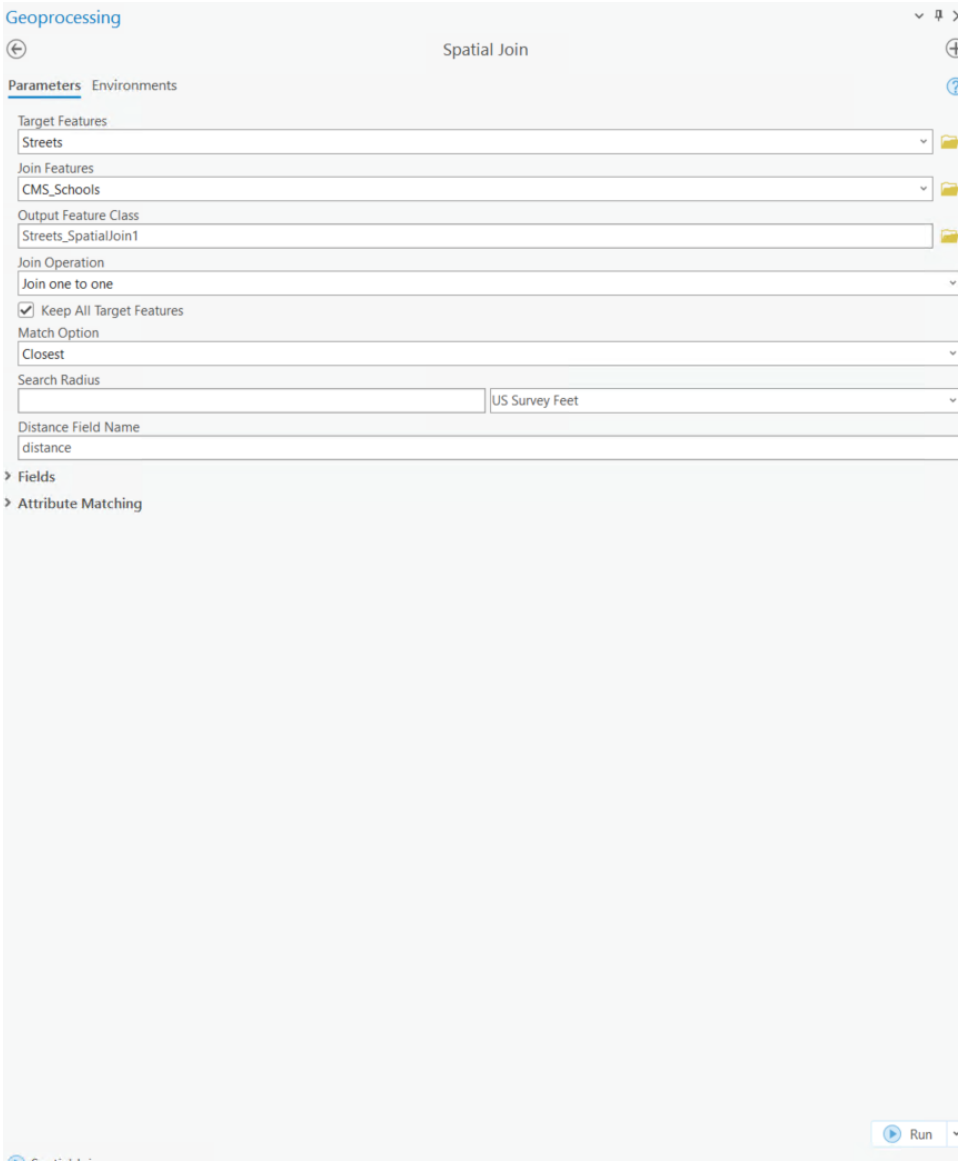




Spatial Join

- Example 3:
  - Proximity

OBJECTID_1 *	Shape *	Join_Count	distance	TARGET_FID	enabled	e911	lasteditda	dateadded	username	actiontype	prefixc
1	Polyline	1	6541.550933	57	0	6	5/5/2020	12/30/1999	SDE	AddressChange	
2	Polyline	1	5598.100289	57	0	7	5/5/2020	12/30/1999	SDE	AddressChange	
3	Polyline	1	7759.229046	57	0	16	8/22/2024	12/30/1999	WISMESE	AddressChange	
4	Polyline	1	12924.66361	69	0	22	5/5/2020	12/30/1999	SDE	New	
5	Polyline	1	10163.515691	10	0	37	5/5/2020	12/30/1999	SDE	New	
6	Polyline	1	5277.371036	69	0	38	5/5/2020	12/30/1999	SDE	New	
7	Polyline	1	8734.181779	7	0	39	1/25/2021	12/30/1999	AHRENN	Split	
8	Polyline	1	5552.064891	57	0	40	5/5/2020	12/30/1999	SDE	AddressChange	
9	Polyline	1	5988.435224	57	0	41	8/22/2024	12/30/1999	WISMESE	AddressChange	
10	Polyline	1	5598.100289	57	0	42	5/5/2020	12/30/1999	SDE	New	N
11	Polyline	1	5565.494524	57	0	43	6/12/2024	12/30/1999	SDE	New	S
12	Polyline	1	10697.085294	10	0	49	5/13/2020	12/30/1999	AHRENN	JurisChange	
13	Polyline	1	5773.159156	57	0	51	6/12/2024	12/30/1999	SDE	New	S
14	Polyline	1	11313.331697	57	0	52	5/5/2020	12/30/1999	SDE	New	
15	Polyline	1	13500.246883	69	0	53	8/22/2024	12/30/1999	WISMESE	New	
16	Polyline	1	9281.032053	110	0	308	7/20/2023	12/30/1999	SCASTONGIA	New	
17	Polyline	1	5565.494524	57	0	80	5/5/2020	12/30/1999	SDE	AddressChange	
18	Polyline	1	5627.070976	57	0	81	5/5/2020	12/30/1999	SDE	AddressChange	



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: identify green spaces near UNC Charlotte that are at risk of being developed based on proximity to new housing projects and existing zoning laws.

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.

“Overlay Operations” vs. “Buffering”

- **Buffering** is actually a separate topic from overlay operations.
- However, buffering is often used together with overlay operations.
  - The results of buffering are often used in subsequent overlay analysis to quantify the properties of the feature within a buffer area.

Thank you!