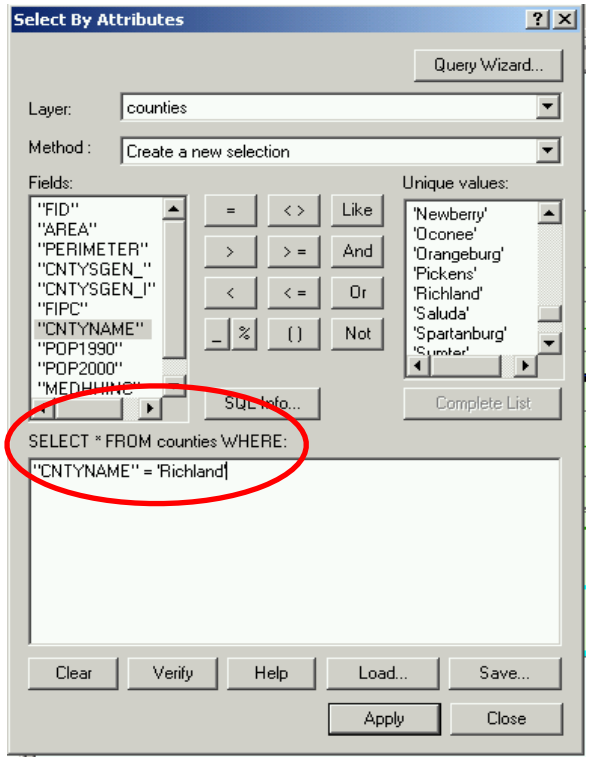
Vector Data Analysis

Topics

- Spatial query
- Spatial join
- Overlay analysis
- Proximity analysis
- Reading
  - Chapter 9

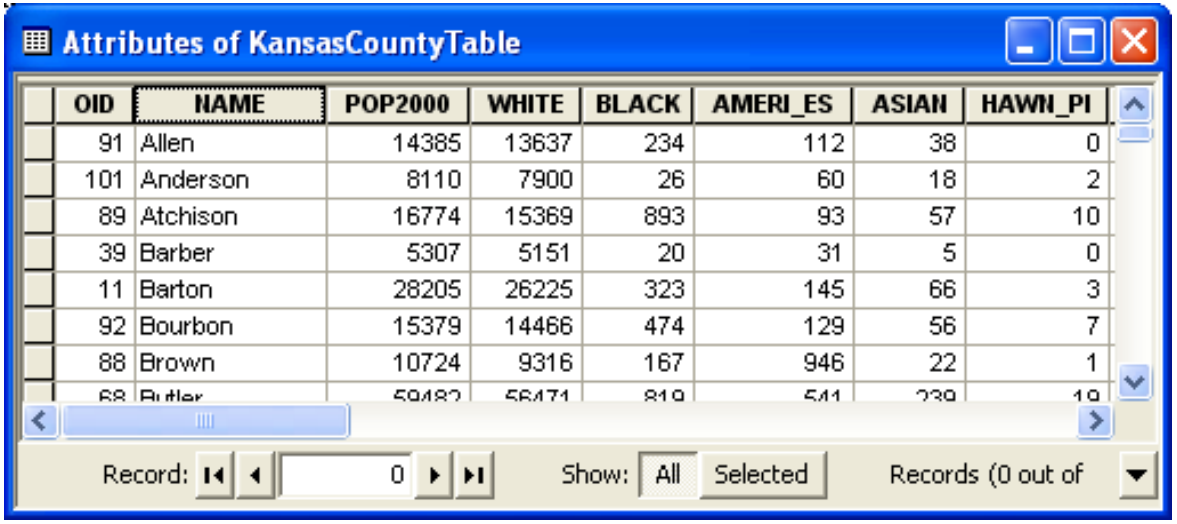
Query by Attributes

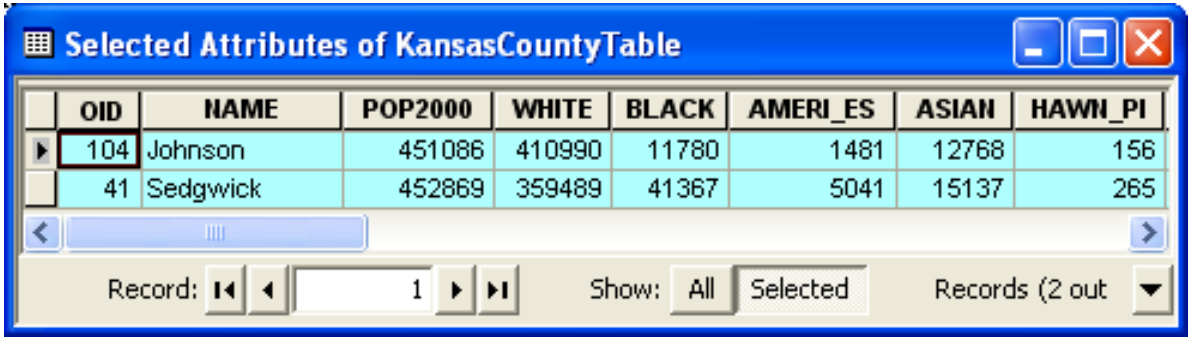
- Geospatial data have attributes and location
- Modern DBMS store both attributes and location in a database
- Structured Query Language (SQL) can be used to query data based on attributes



Attribute Query

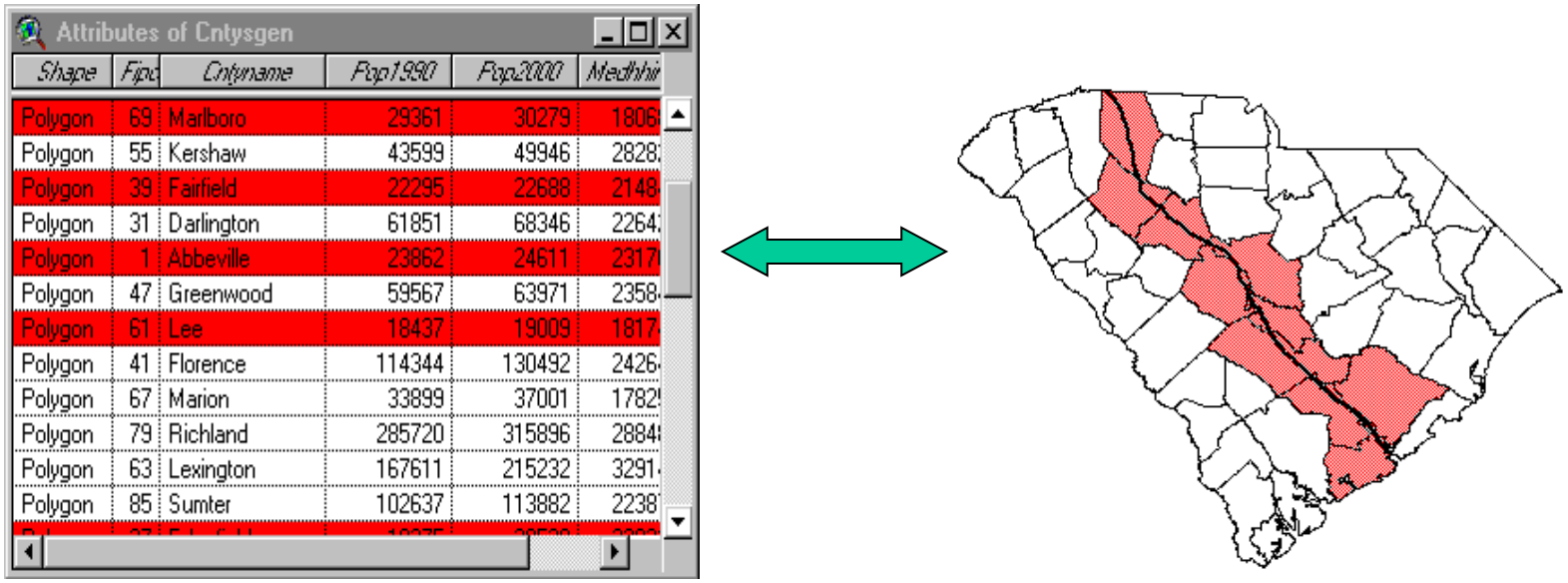
- SELECT * FROM KansasCountyTable WHERE POP2000 > 200000





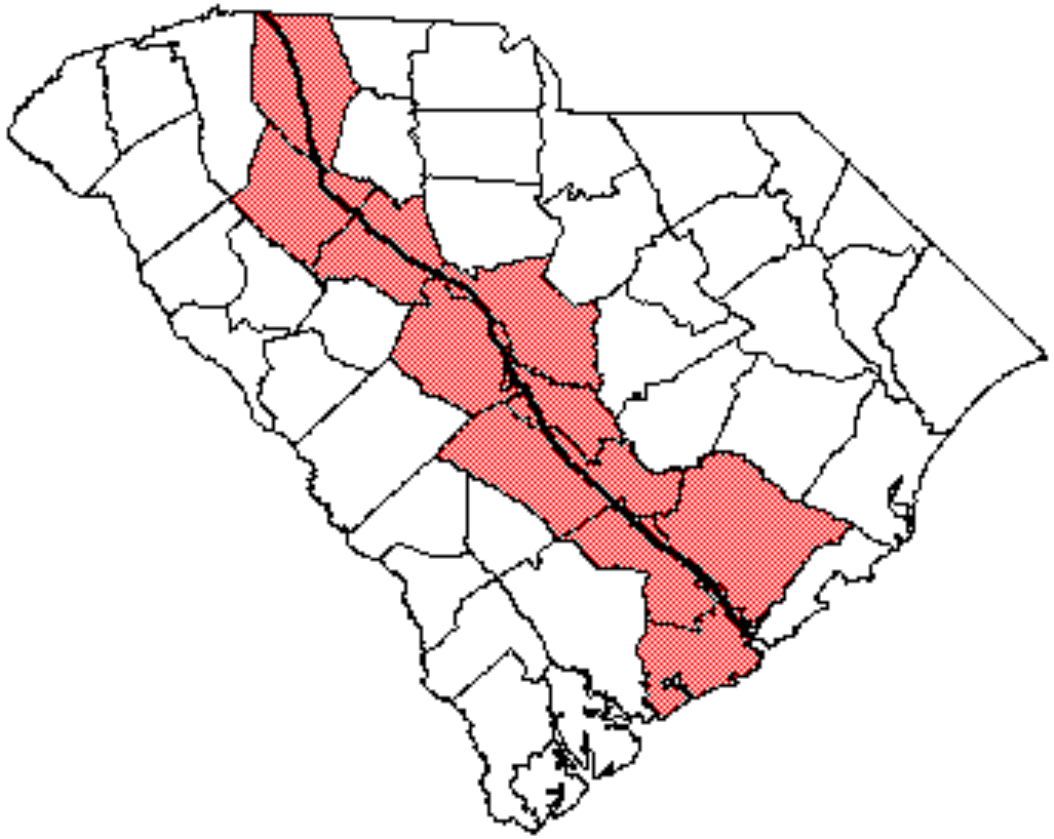
Spatial Query

- Spatial queries use spatial relationships among features as the conditions
- Features are highlighted on maps **and** in tables after queries



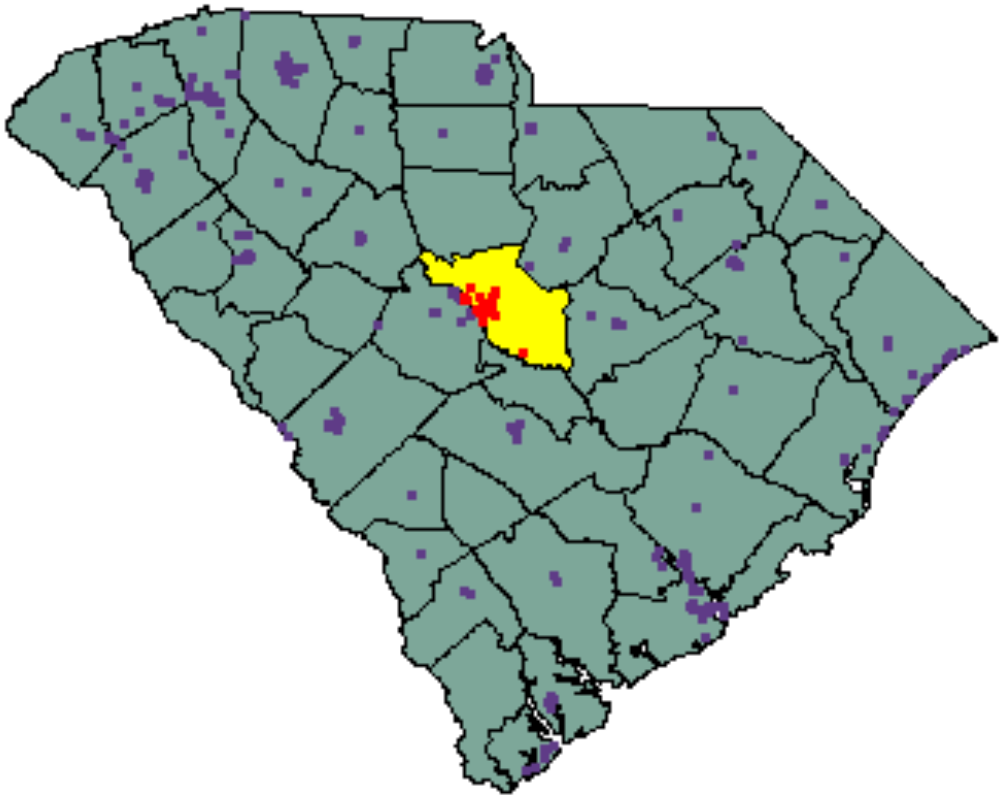
Spatial Query--Intersection

- Find the counties in South Carolina that I-26 **passes through**.



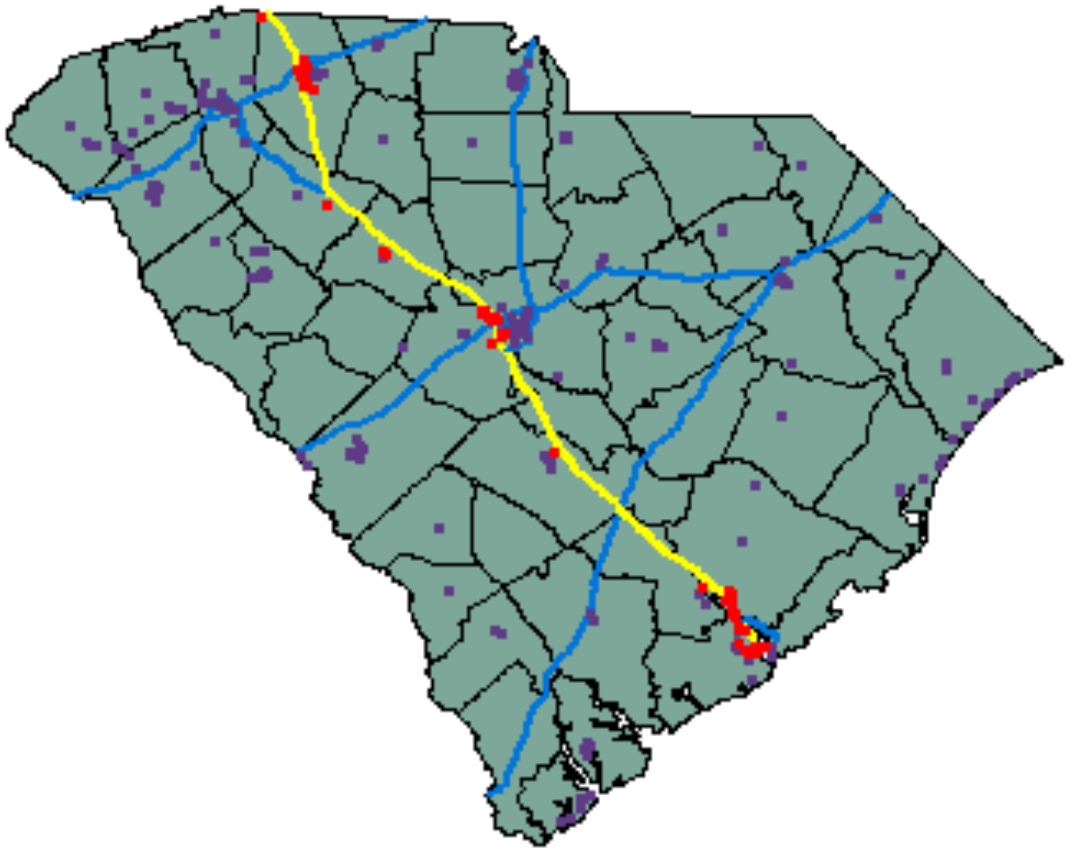
Spatial Query--Containment

Find the BBQ restaurants that are **inside** the Richland County, SC



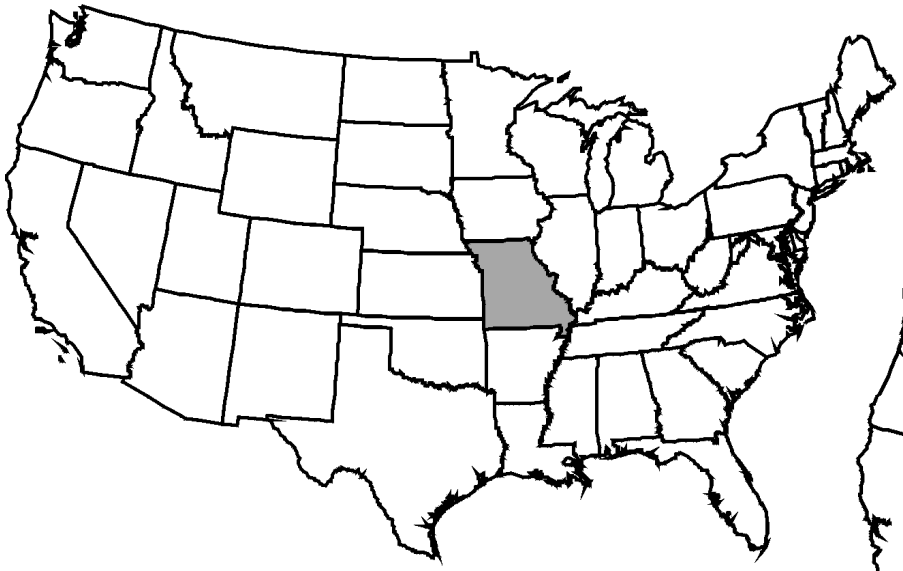
Spatial Query--Proximity

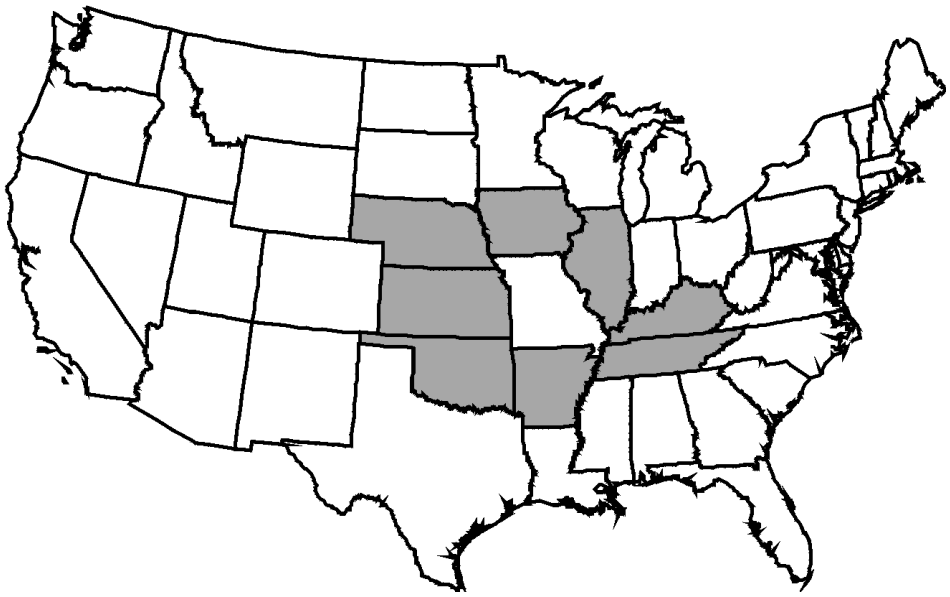
Find the BBQ restaurants that are **within 5 km** of I-26



Spatial Query—Adjacency

Find states that are adjacent to Missouri.





Simple and Complex Expressions

- Conditions are formed as expressions in the WHERE clause in SQL in attribute queries
- A simple expression consists of two operands and one logical operator
  - [Operand] [Logical Operator] [Operand]
  - An operand can be a field/column or a constant
  - A logical operator can be any of the followings
    - =, >, <, <>, >=, <=, like
- A complex expression is a set of expressions connected by Boolean connectors
  - Boolean connectors are AND, OR and NOT

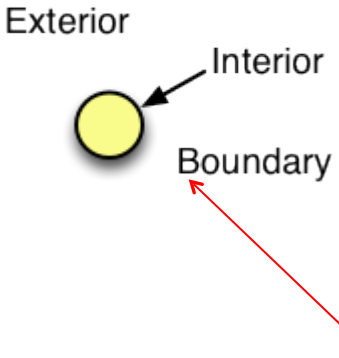
How To Specify Spatial Relationships

- Many different kinds of spatial relationships may exist
- Many of them are hard to define precisely in English
  - intersect, overlap, and cross can mean the same or slightly different relationships
- Spatial relationships depend on the type of features involved
  - Points can not contain polygons
- Some common spatial relationships are supported by most GIS systems
  - intersection, containment, and proximity
- The 9-intersect model ***precisely*** describes spatial relationships

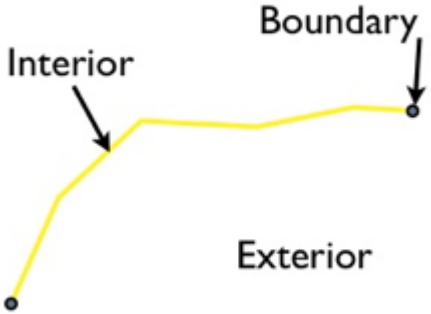
The 9-Intersection Model (9IM)

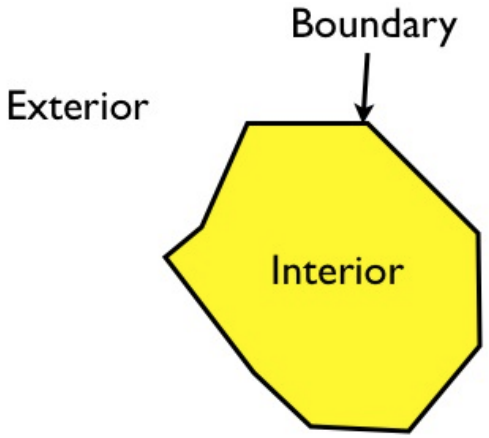
- Decompose a feature into Interior (A°), Boundary (∂A), and Exterior (A^{-}) components
  - Point, line and polygon
- Define spatial relationships between features based on the intersection of those components
  - 3 * 3 = 9 → 9-intersection model

		Feature B		
		Interior	Boundary	Exterior
Feature A	Interior	T/F	T/F	T/F
	Boundary	T/F	T/F	T/F
	Exterior	T/F	T/F	T/F



The boundary of point is empty





9IM

- 3-by-3 binary matrix
  - Each cell can be either True or False
  - $2^9 = 512$ possible relationships
- Define common spatial relationships
  - Aggregate several matrices as one named relationship
  - T, F, * (don't care as long as the Ts and Fs are there)

Intersects	$\begin{bmatrix} T & * & * \\ * & * & * \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} * & T & * \\ * & * & * \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} * & * & * \\ T & * & * \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} * & * & * \\ * & T & * \\ * & * & * \end{bmatrix}$
	T********	*T*******	***T*****	****T****
Within (inside)	$\begin{bmatrix} T & * & F \\ * & * & F \\ * & * & * \end{bmatrix}$			
	T*F**F***			
CoveredBy	$\begin{bmatrix} T & * & F \\ * & * & F \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} * & T & F \\ * & * & F \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} * & * & F \\ T & * & F \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} * & * & F \\ * & T & F \\ * & * & * \end{bmatrix}$
	T*F**F***	*TF**F***	**FT*F***	**F*TF***

DE-9IM

- Dimensionally Extended 9-Intersection Model (DE-9IM)

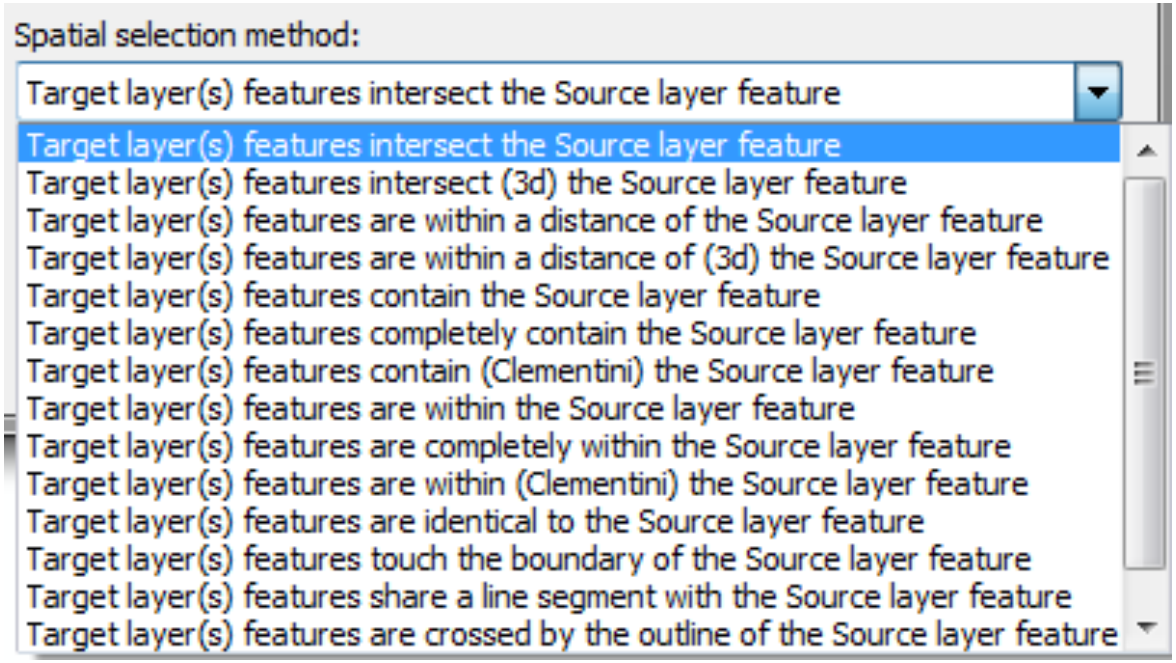
$$\mathrm{DE9IM}(a,b) = \begin{bmatrix} \dim(I(a) \cap I(b)) & \dim(I(a) \cap B(b)) & \dim(I(a) \cap E(b)) \\ \dim(B(a) \cap I(b)) & \dim(B(a) \cap B(b)) & \dim(B(a) \cap E(b)) \\ \dim(E(a) \cap I(b)) & \dim(E(a) \cap B(b)) & \dim(E(a) \cap E(b)) \end{bmatrix}$$

  - Based on the *dimensionality* of the intersection of the 3 components
  - -1 (empty), 0 (point), 1 (line), 2 (area)
- 9-intersection model (9IM) is a special case
  - Convert intersection dimension into True/False
  - -1 (empty) → False
  - 0 (point), 1 (line), 2 (area) → True

DE-9IM Example

	Interior	Boundary	Exterior
Interior	 $\dim[I(a)\cap I(b)] = 2$	 $\dim[I(a)\cap B(b)] = 1$	 $\dim[I(a)\cap E(b)] = 2$
Boundary	 $\dim[B(a)\cap I(b)] = 1$	 $\dim[B(a)\cap B(b)] = 0$	 $\dim[B(a)\cap E(b)] = 1$
Exterior	 $\dim[E(a)\cap I(b)] = 2$	 $\dim[E(a)\cap B(b)] = 1$	 $\dim[E(a)\cap E(b)] = 2$

Named Spatial Relationships in ArcGIS



“target layer/input feature” is the layer from which features are selected

“source layer/selecting feature” is the reference layer used to select features from “target layer”

Spatial Query in ArcGIS

- Select a feature by click or by drawing a feature on map

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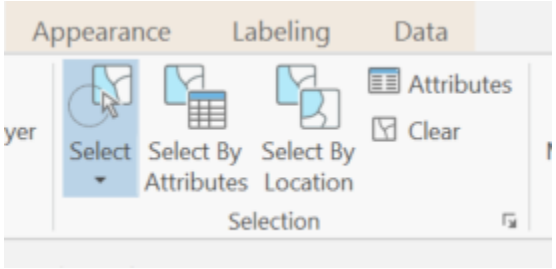
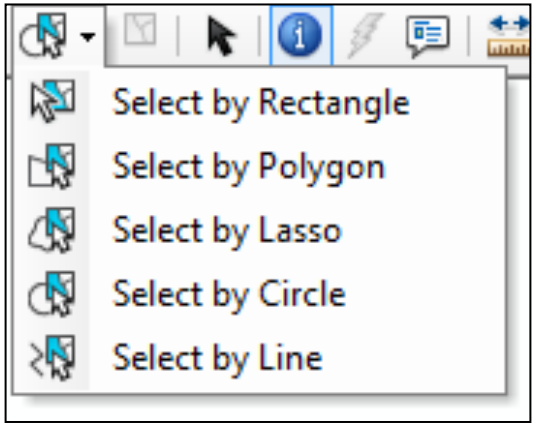
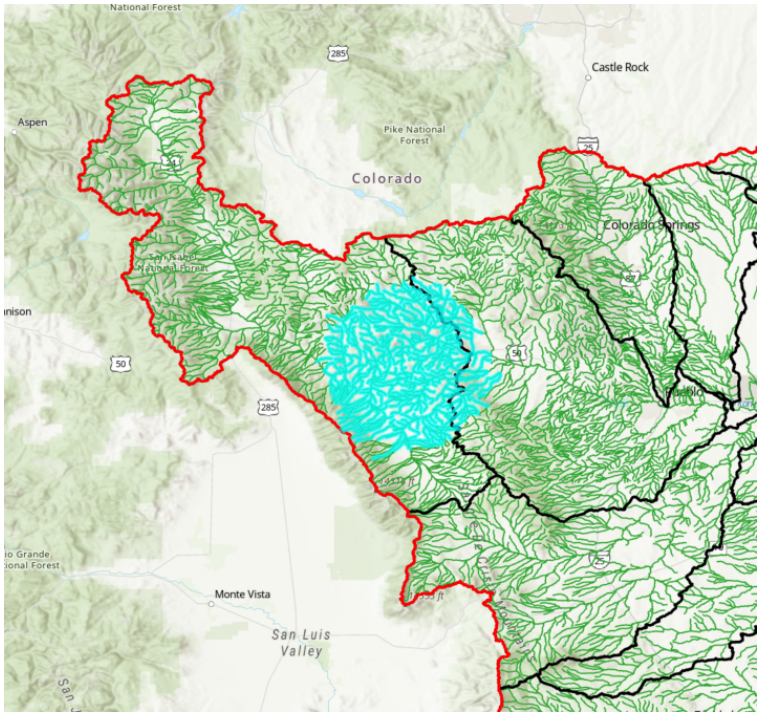
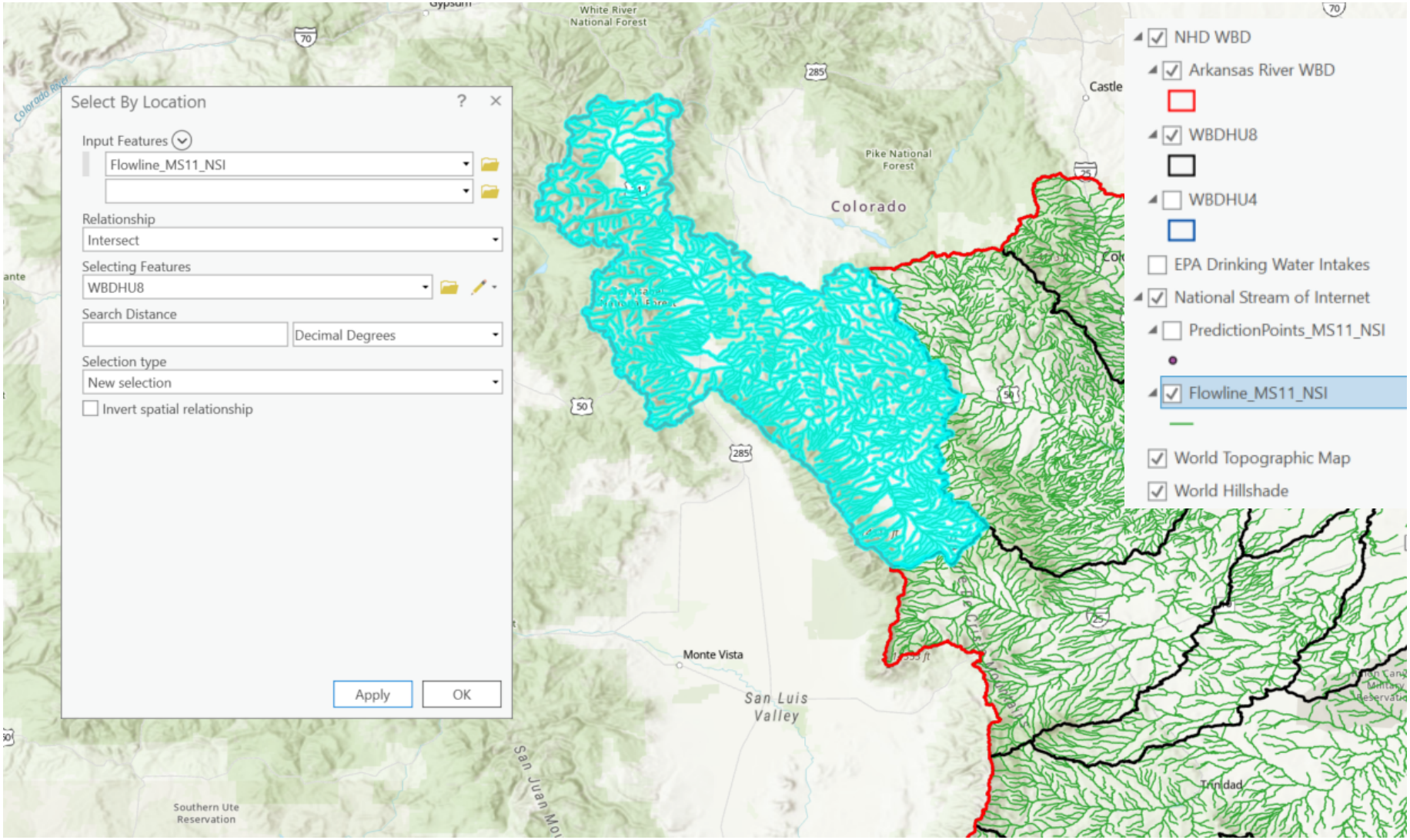




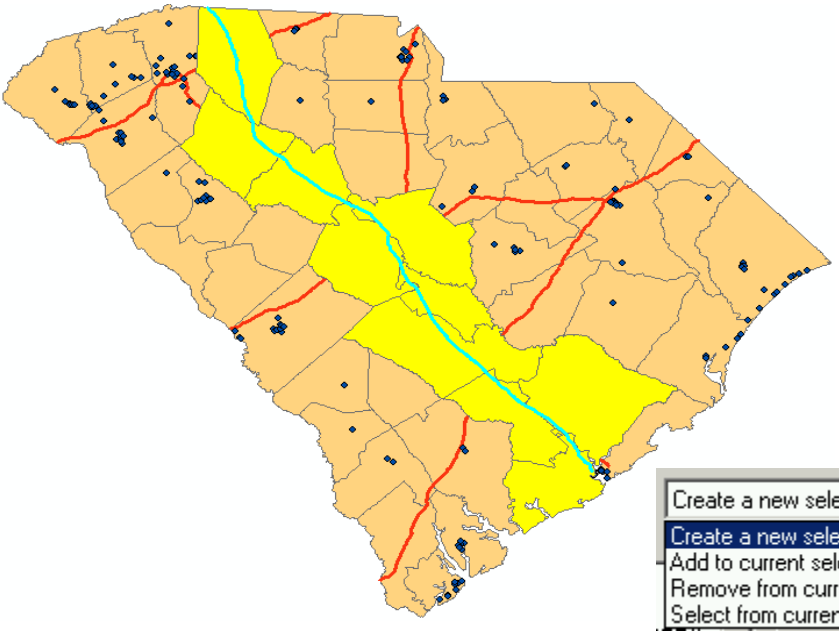


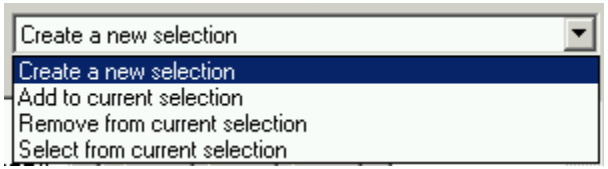
Spatial Query in ArcGIS

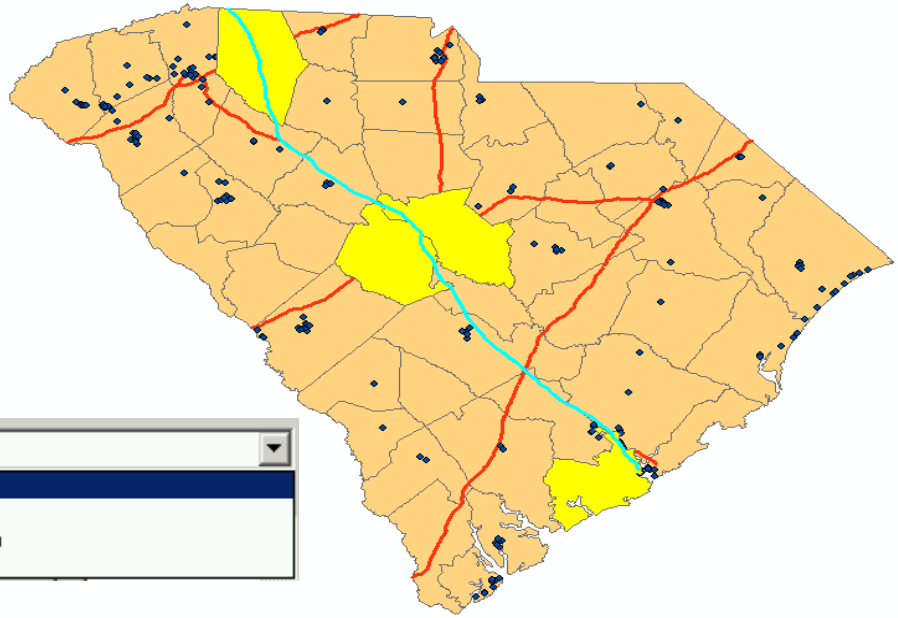


Compound Queries

- Queries that use both attribute and spatial conditions. Carry out in steps
- Find the counties in South Carolina that I-26 passes through and their population is greater than 200,000



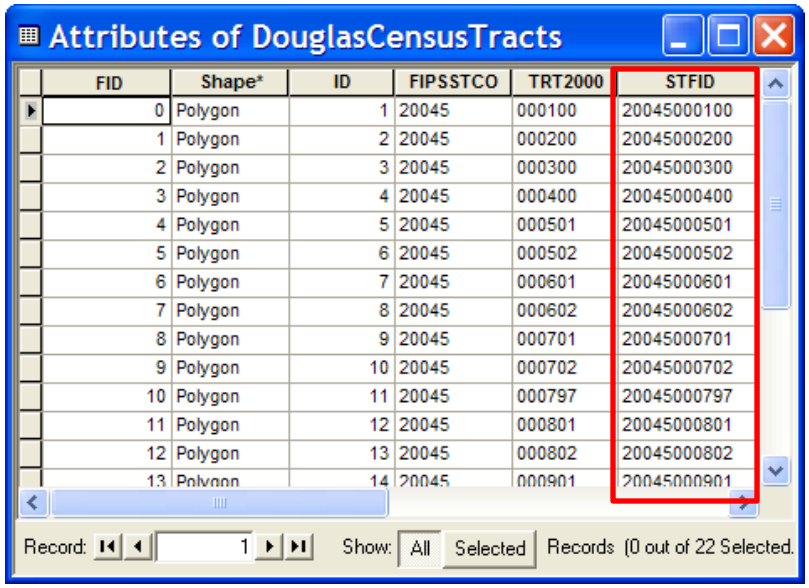


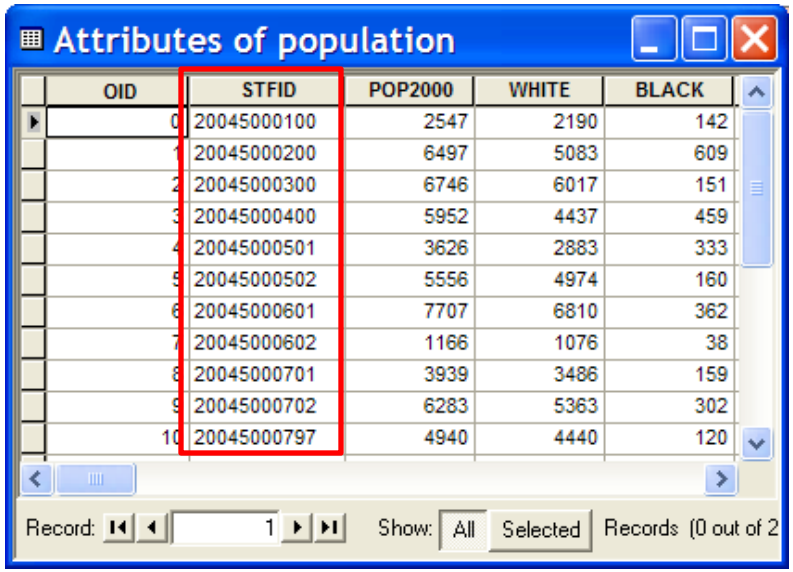


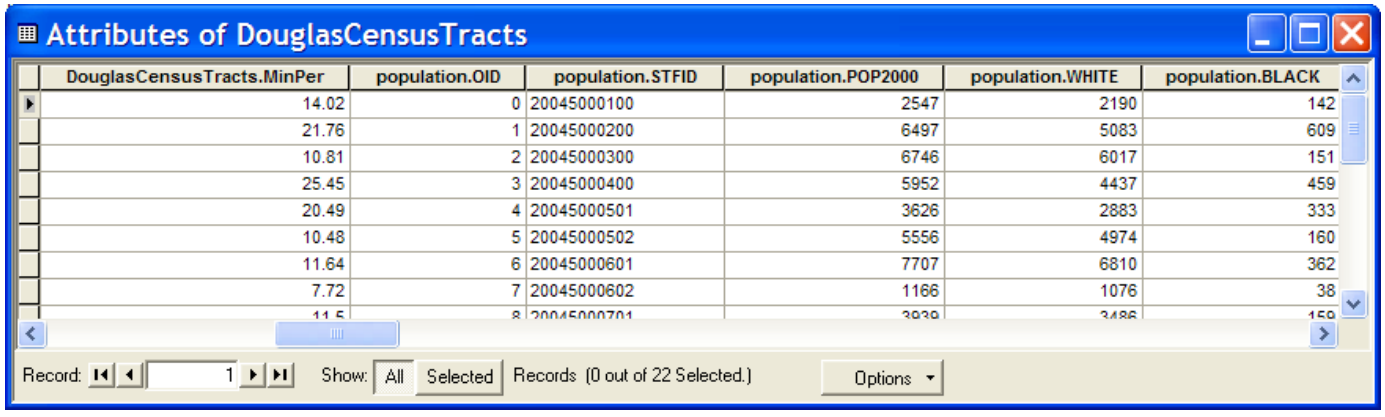
Counties intersect with interstate I-26

Counties intersect with interstate I-26 and 2000 population >= 200,000

Join Attribute Tables



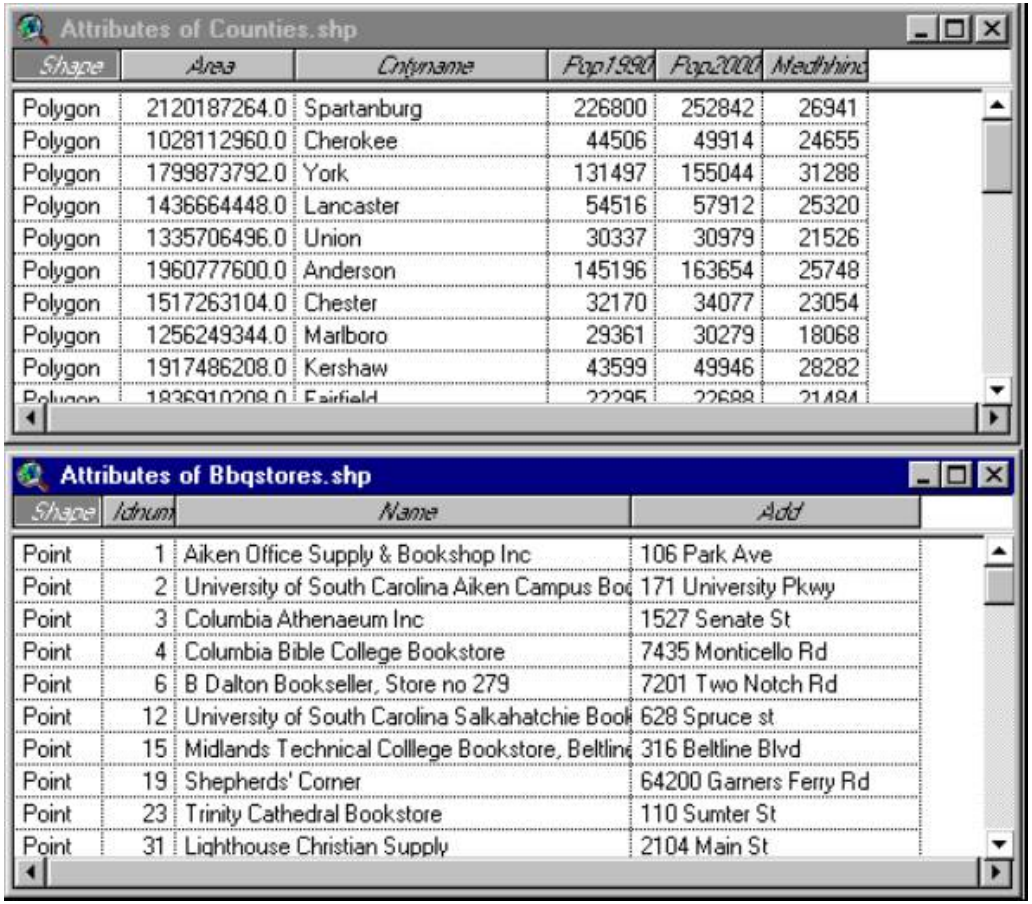




- Common field
- Equality relationship
- Attributes are copied.

Spatial Join

Join attributes based on the spatial relationships between features on two maps



Attributes of Counties.shp

Shape	Area	Cntyname	Pop1990	Pop2000	Medhhinc
Polygon	2120187264.0	Spartanburg	226800	252842	26941
Polygon	1028112960.0	Cherokee	44506	49914	24655
Polygon	1799873792.0	York	131497	155044	31288
Polygon	1436664448.0	Lancaster	54516	57912	25320
Polygon	1335706496.0	Union	30337	30979	21526
Polygon	1960777600.0	Anderson	145196	163654	25748
Polygon	1517263104.0	Chester	32170	34077	23054
Polygon	1256249344.0	Marlboro	29361	30279	18068
Polygon	1917486208.0	Kershaw	43599	49946	28282
Polygon	1836910208.0	Fairfield	22295	22689	21484

Attributes of Bbqstores.shp

Shape	Idnum	Name	Add
Point	1	Aiken Office Supply & Bookshop Inc	106 Park Ave
Point	2	University of South Carolina Aiken Campus Boo	171 University Pkwy
Point	3	Columbia Athenaeum Inc	1527 Senate St
Point	4	Columbia Bible College Bookstore	7435 Monticello Rd
Point	6	B Dalton Bookseller, Store no 279	7201 Two Notch Rd
Point	12	University of South Carolina Salkahatchie Book	628 Spruce st
Point	15	Midlands Technical Colllege Bookstore, Beltline	316 Beltline Blvd
Point	19	Shepherds' Corner	64200 Garners Ferry Rd
Point	23	Trinity Cathedral Bookstore	110 Sumter St
Point	31	Lighthouse Christian Supply	2104 Main St

- Geometry/location as the join fields
- Spatial relationship (instead of attribute relationship)

Spatial Join Example

Join nearest interstates to book stores