

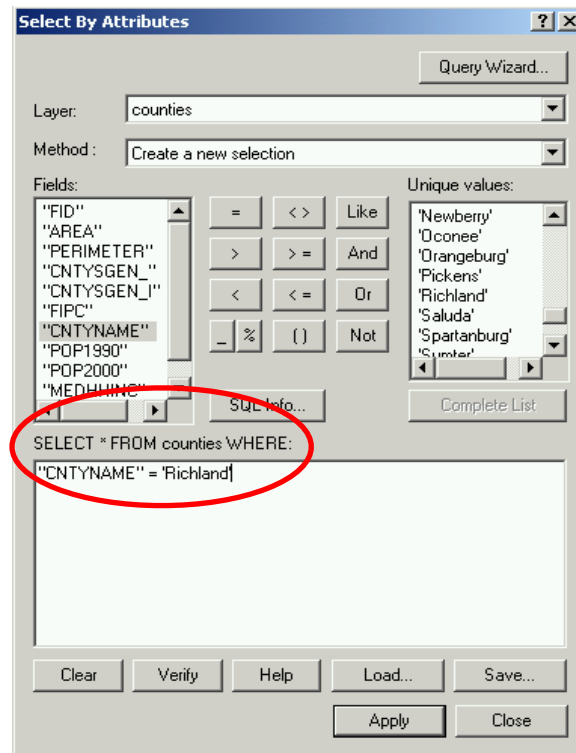
Vector Data Analysis

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

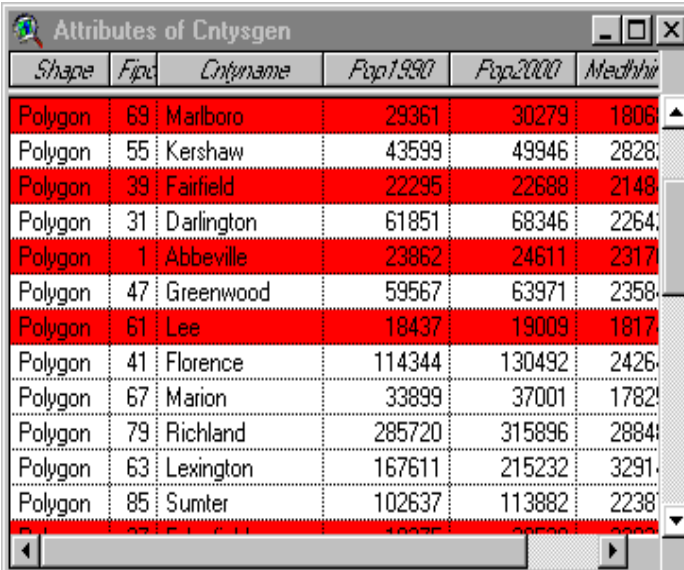
- `SELECT * FROM KansasCountyTable WHERE POP2000 > 200000`

OID	NAME	POP2000	WHITE	BLACK	AMERI_ES	ASIAN	HAWN_PI
91	Allen	14385	13637	234	112	38	0
101	Anderson	8110	7900	26	60	18	2
89	Atchison	16774	15369	893	93	57	10
39	Barber	5307	5151	20	31	5	0
11	Barton	28205	26225	323	145	66	3
92	Bourbon	15379	14466	474	129	56	7
88	Brown	10724	9316	167	946	22	1
68	Butler	59482	56474	819	541	239	19

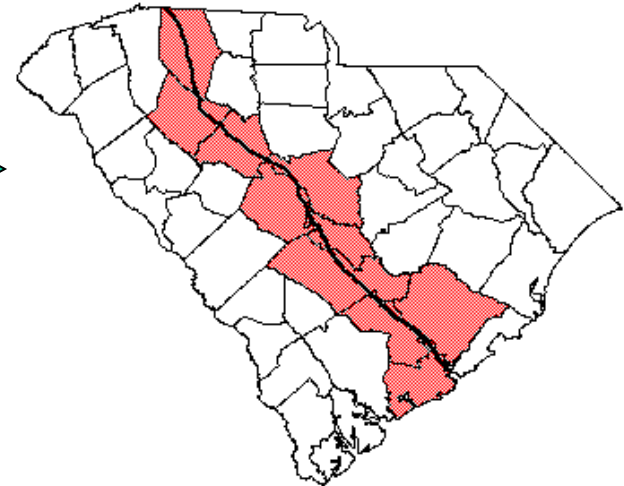
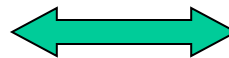
OID	NAME	POP2000	WHITE	BLACK	AMERI_ES	ASIAN	HAWN_PI
104	Johnson	451086	410990	11780	1481	12768	156
41	Sedgwick	452869	359489	41367	5041	15137	265

Spatial Query

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

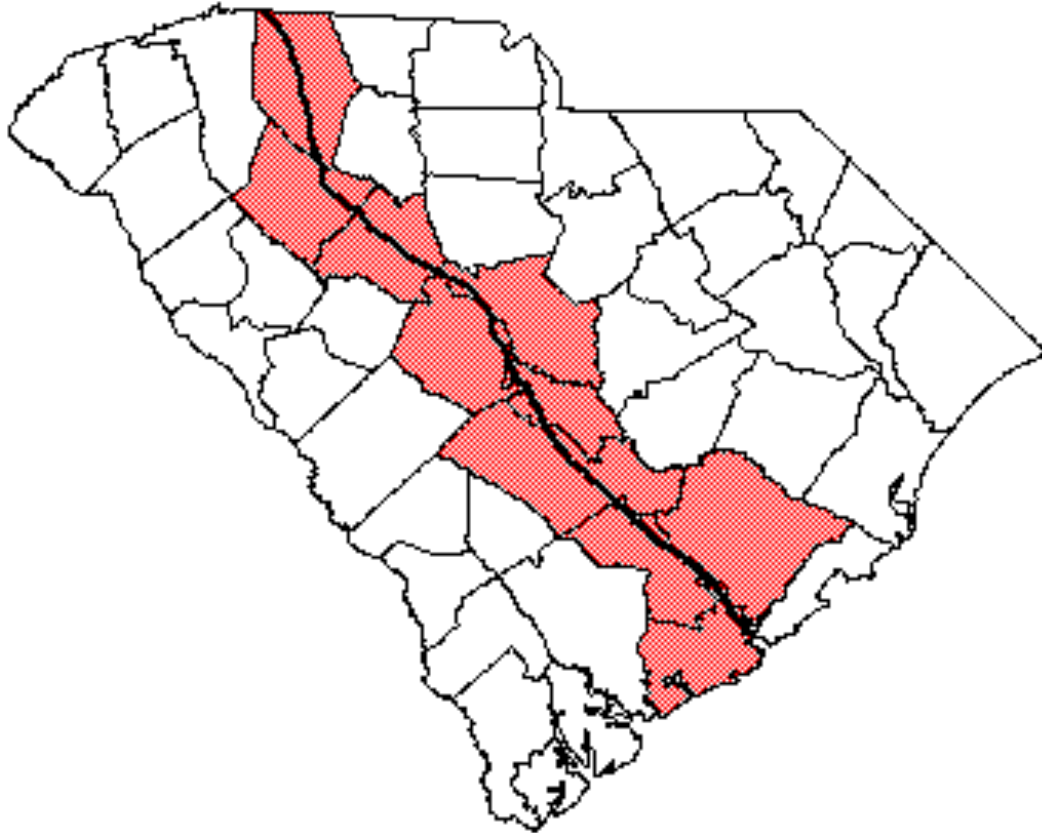


Shape	Fips	Cntyname	Pop1990	Pop2000	Medhhi
Polygon	69	Marlboro	29361	30279	1806
Polygon	55	Kershaw	43599	49946	2828
Polygon	39	Fairfield	22295	22688	2148
Polygon	31	Darlington	61851	68346	2264
Polygon	1	Abbeville	23862	24611	2317
Polygon	47	Greenwood	59567	63971	2358
Polygon	61	Lee	18437	19009	1817
Polygon	41	Florence	114344	130492	2426
Polygon	67	Marion	33899	37001	1782
Polygon	79	Richland	285720	315896	2884
Polygon	63	Lexington	167611	215232	3291
Polygon	85	Sumter	102637	113882	2238



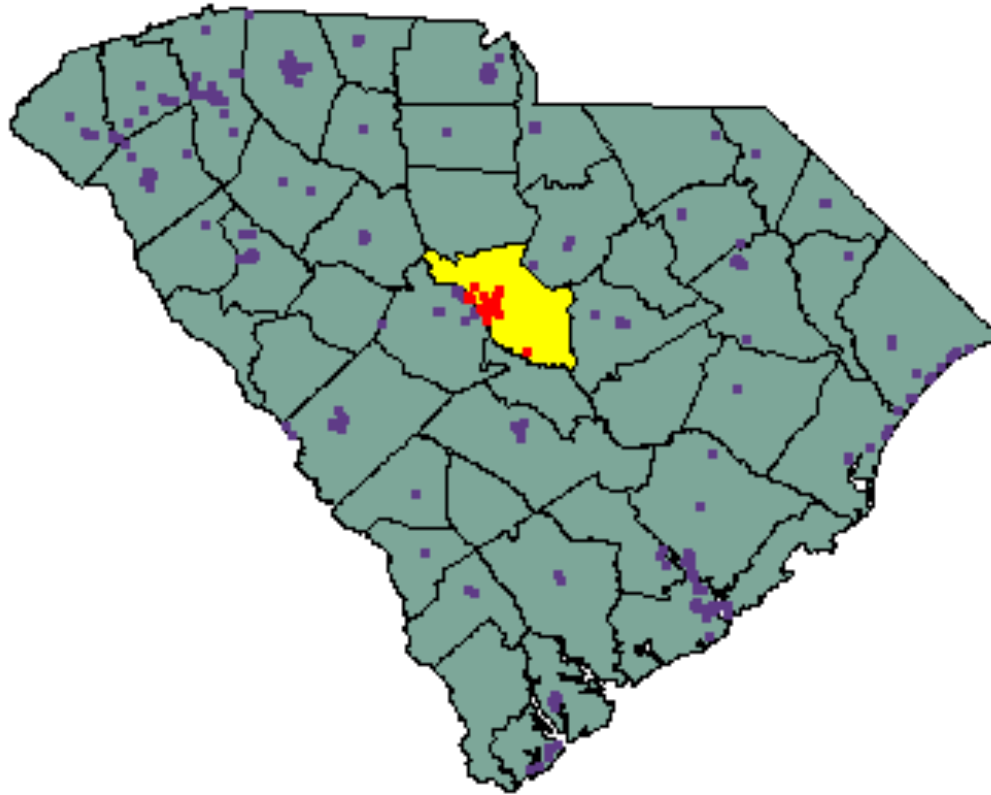
Spatial Query--Intersection

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



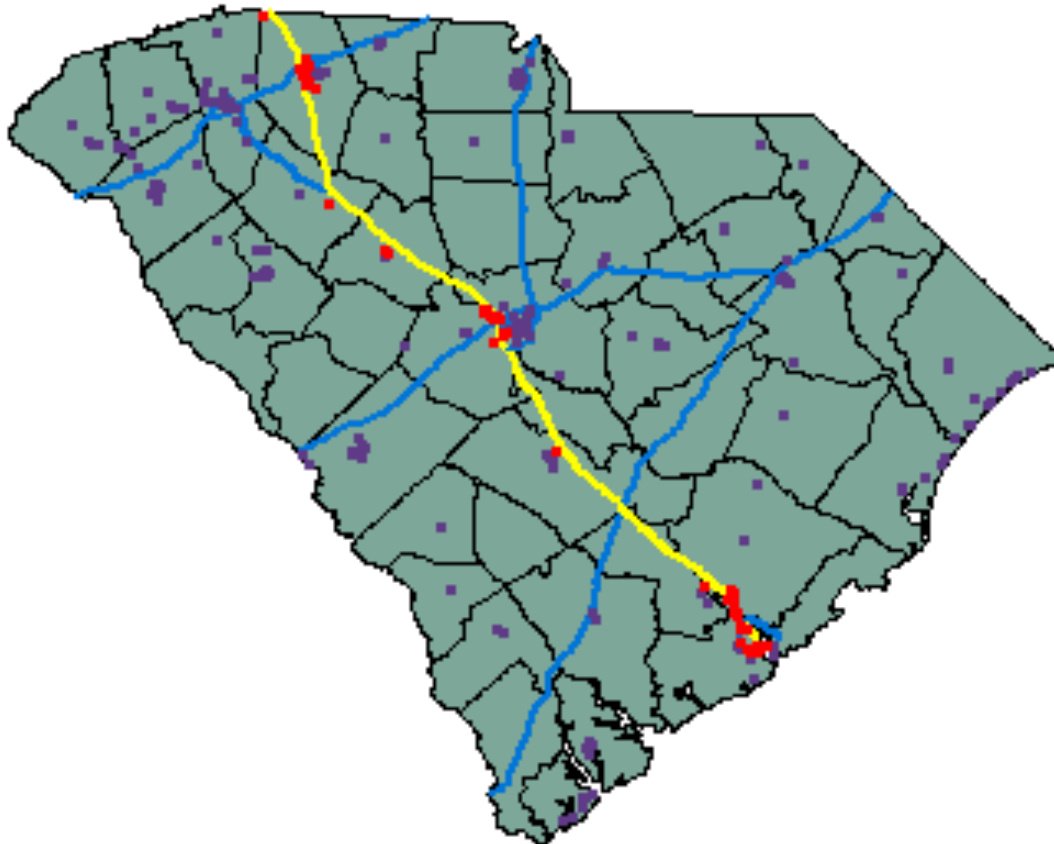
Spatial Query--Containment

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



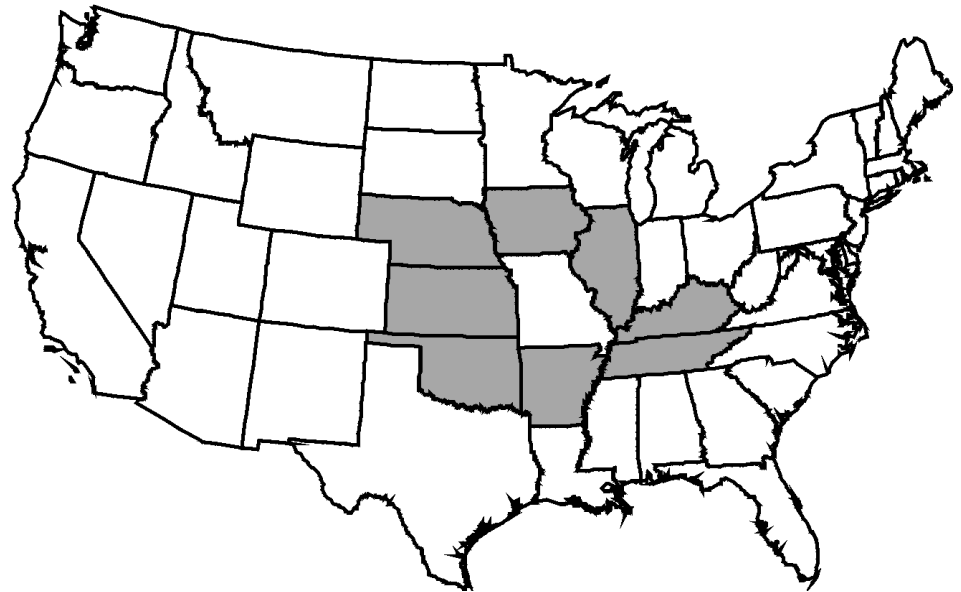
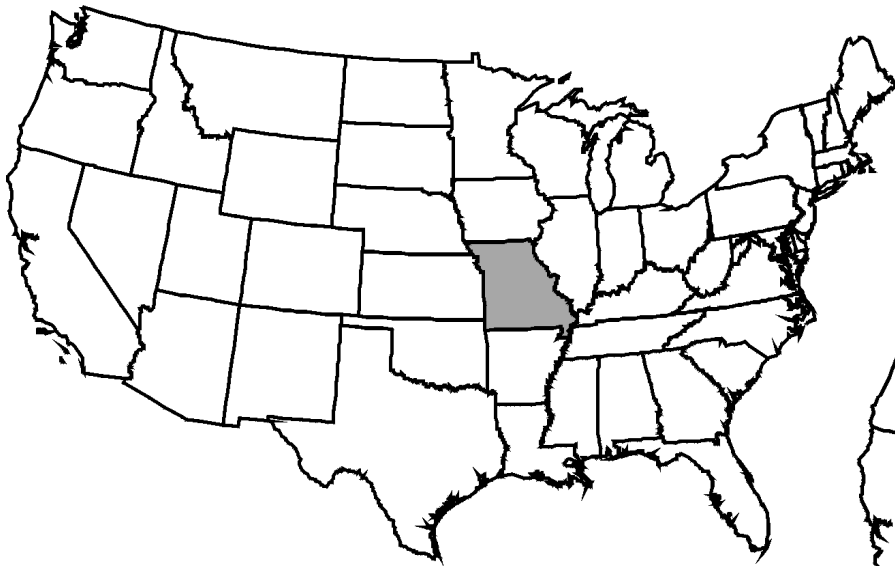
Spatial Query--Proximity

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

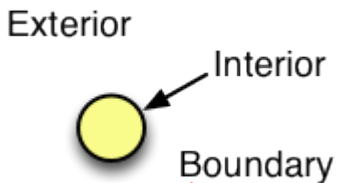
How To Specify Spatial Relationships

- 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

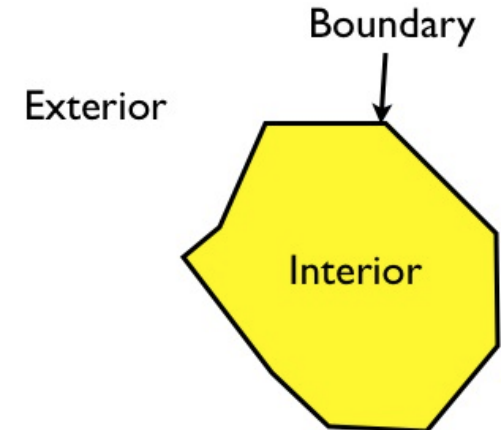
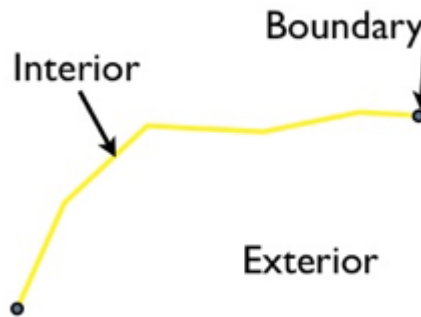
The 9-Intersection Model (9IM)

- 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
 - $3 * 3 = 9 \rightarrow$ 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***

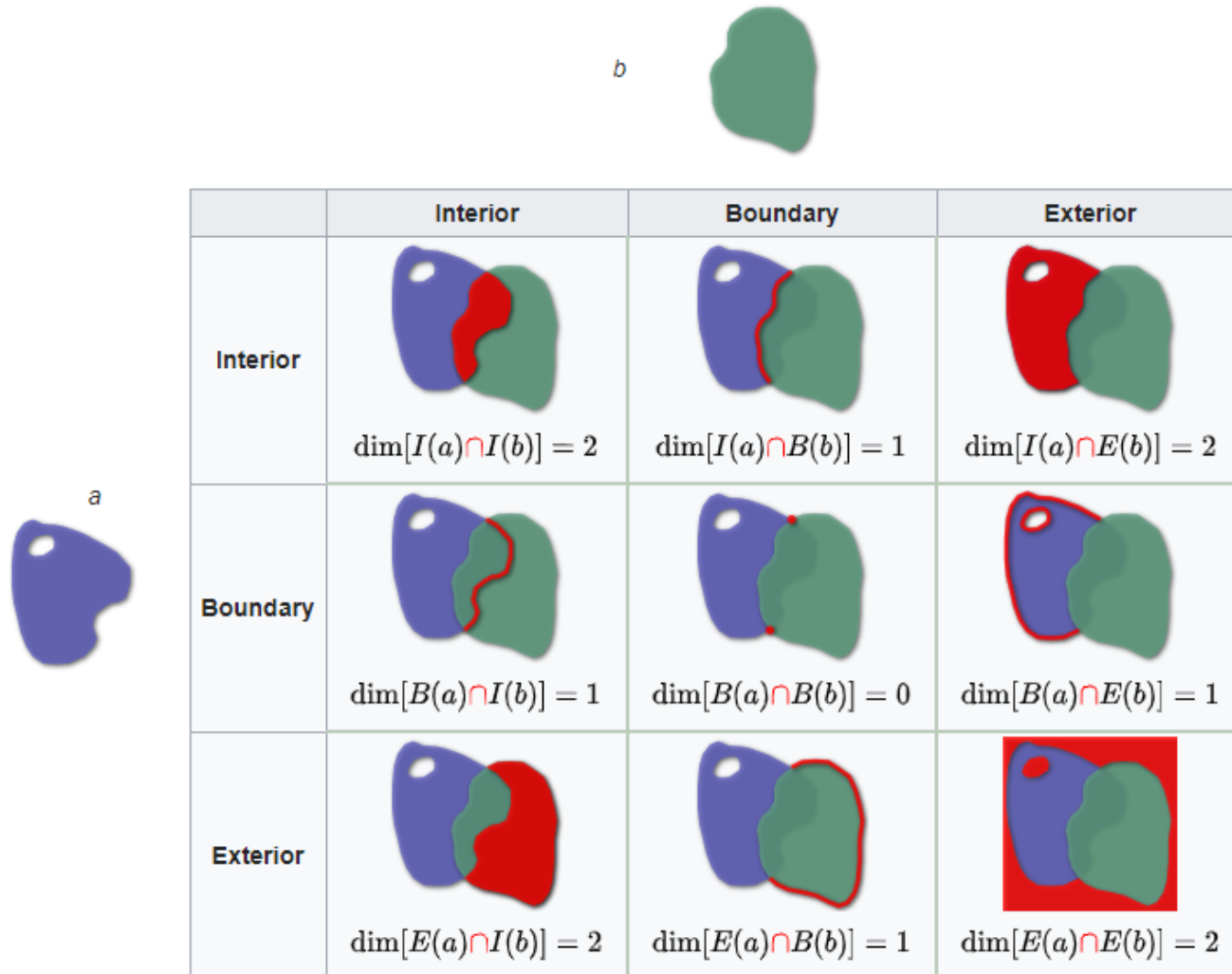
DE-9IM

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

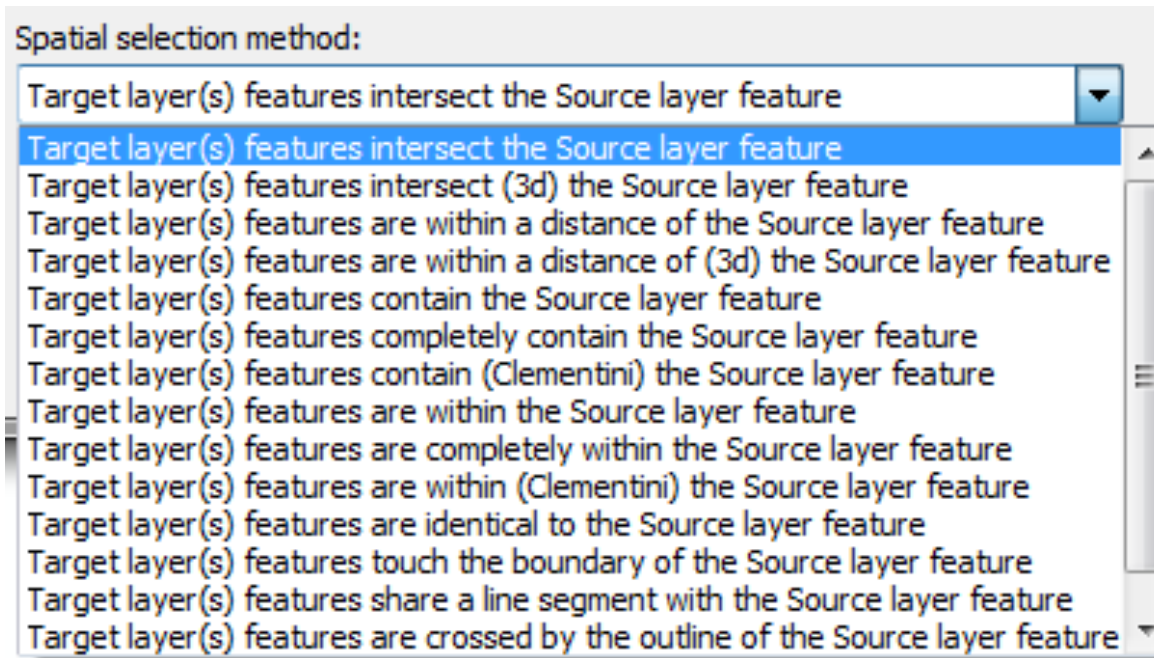
$$\text{DE9IM}(a, b) = \begin{bmatrix} \dim(I(a) \cap I(b)) & \dim(I(a) \cap B(b)) & \dim(I(a) \cap E(b)) \\ \dim(B(a) \cap I(b)) & \dim(B(a) \cap B(b)) & \dim(B(a) \cap E(b)) \\ \dim(E(a) \cap I(b)) & \dim(E(a) \cap B(b)) & \dim(E(a) \cap E(b)) \end{bmatrix}$$

- 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) \rightarrow False
 - 0 (point), 1 (line), 2 (area) \rightarrow True

DE-9IM Example



Named Spatial Relationships in ArcGIS

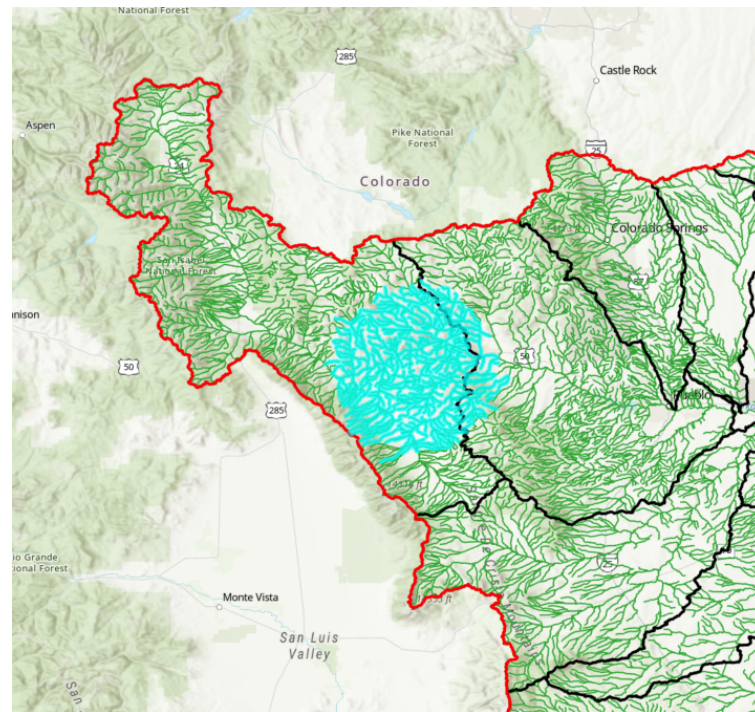
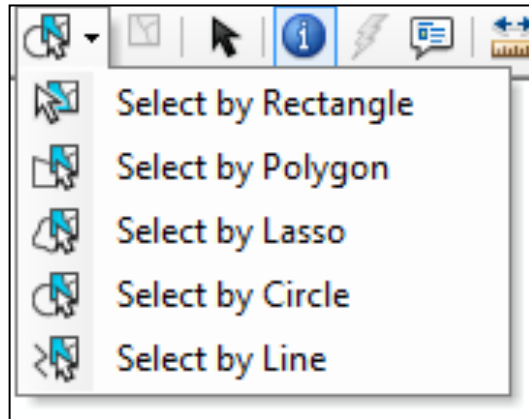
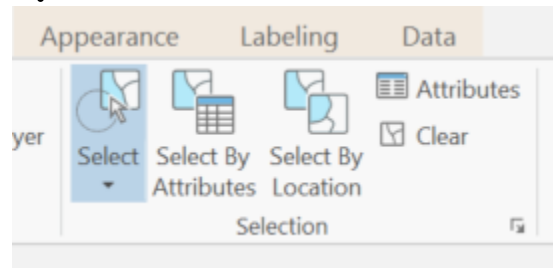


“target layer/input feature” is the layer from which features are selected

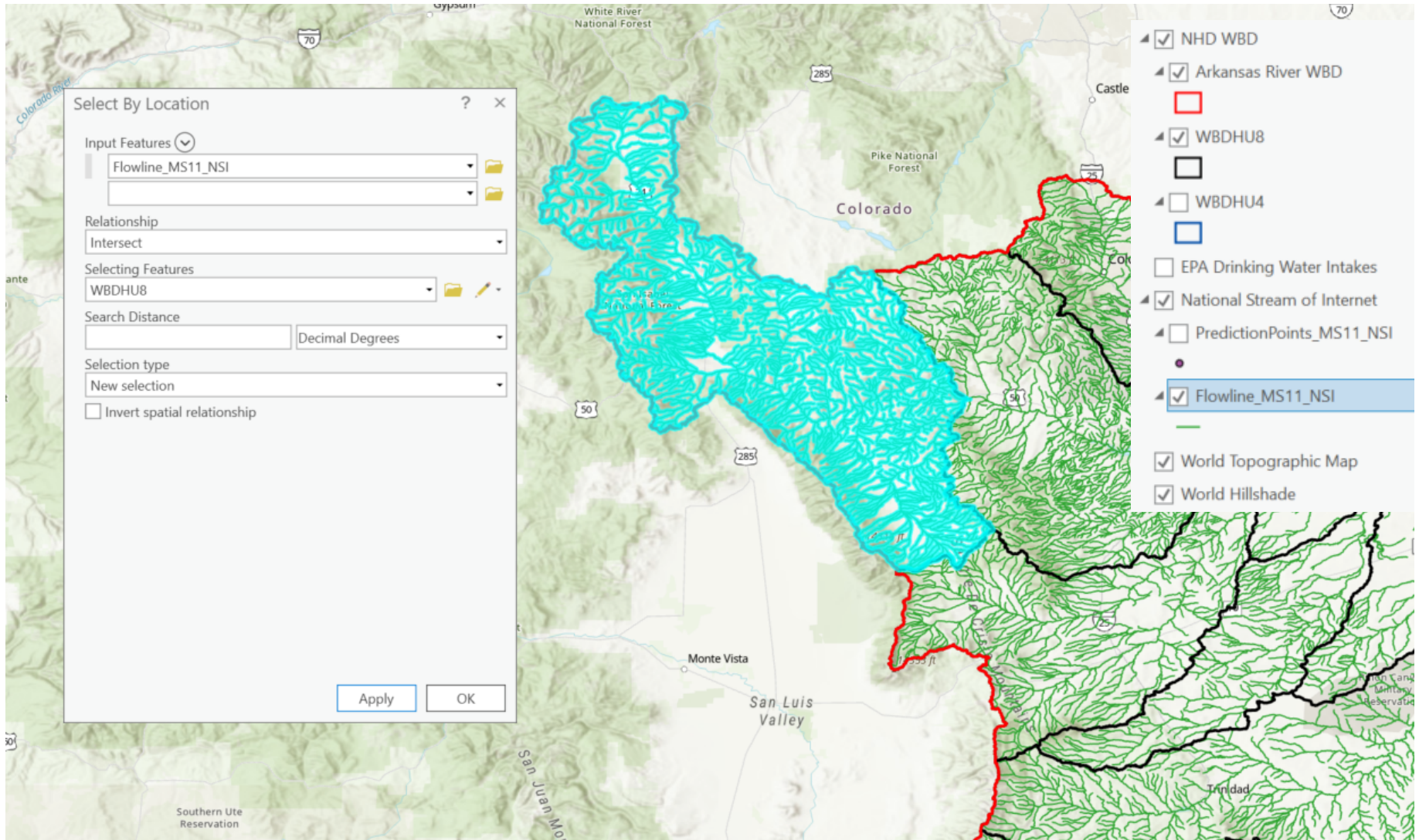
“source layer/selecting feature” is the reference layer used to select features from “target layer”

Spatial Query in ArcGIS

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

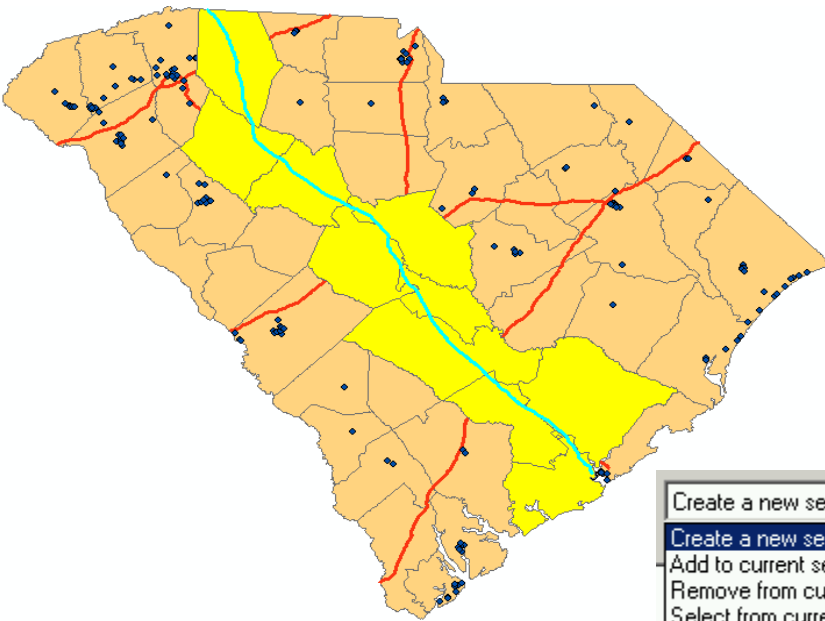


Spatial Query in ArcGIS

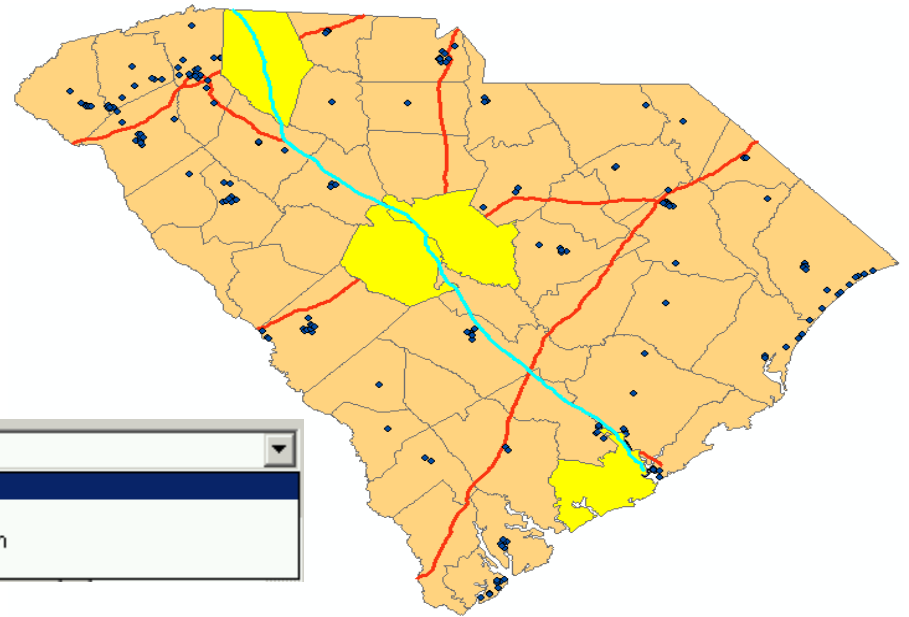


Compound Queries

- 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 \geq
200,000

Join Attribute Tables

Attributes of DouglasCensusTracts

FID	Shape*	ID	FIPSSTCO	TRT2000	STFID
0	Polygon	1	20045	000100	20045000100
1	Polygon	2	20045	000200	20045000200
2	Polygon	3	20045	000300	20045000300
3	Polygon	4	20045	000400	20045000400
4	Polygon	5	20045	000501	20045000501
5	Polygon	6	20045	000502	20045000502
6	Polygon	7	20045	000601	20045000601
7	Polygon	8	20045	000602	20045000602
8	Polygon	9	20045	000701	20045000701
9	Polygon	10	20045	000702	20045000702
10	Polygon	11	20045	000797	20045000797
11	Polygon	12	20045	000801	20045000801
12	Polygon	13	20045	000802	20045000802
13	Polvonn	14	20045	000901	20045000901

Record: 1 Show: All Selected Records (0 out of 22 Selected.)

Attributes of population

OID	STFID	POP2000	WHITE	BLACK
0	20045000100	2547	2190	142
1	20045000200	6497	5083	609
2	20045000300	6746	6017	151
3	20045000400	5952	4437	459
4	20045000501	3626	2883	333
5	20045000502	5556	4974	160
6	20045000601	7707	6810	362
7	20045000602	1166	1076	38
8	20045000701	3939	3486	159
9	20045000702	6283	5363	302
10	20045000797	4940	4440	120

Record: 1 Show: All Selected Records (0 out of 22 Selected.)

Attributes of DouglasCensusTracts

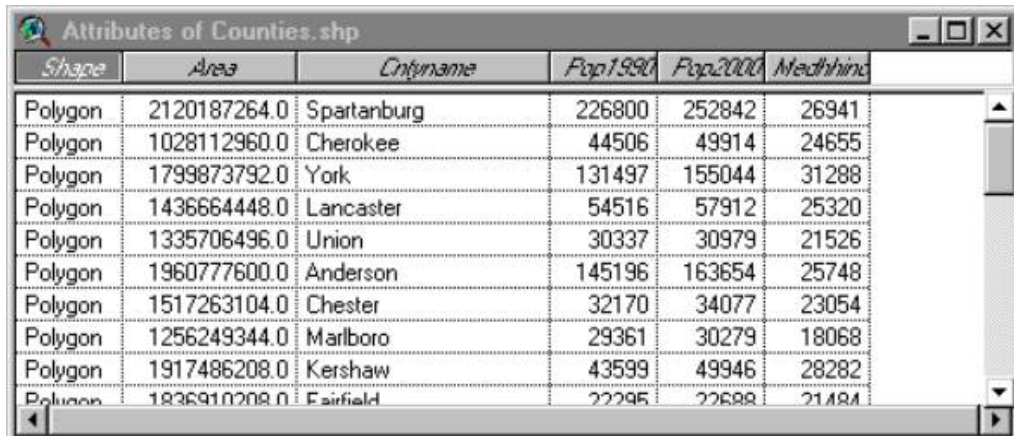
DouglasCensusTracts.MinPer	population.OID	population.STFID	population.POP2000	population.WHITE	population.BLACK
14.02	0	20045000100	2547	2190	142
21.76	1	20045000200	6497	5083	609
10.81	2	20045000300	6746	6017	151
25.45	3	20045000400	5952	4437	459
20.49	4	20045000501	3626	2883	333
10.48	5	20045000502	5556	4974	160
11.64	6	20045000601	7707	6810	362
7.72	7	20045000602	1166	1076	38
11.5	8	20045000701	3939	3486	159

Record: 1 Show: All Selected Records (0 out of 22 Selected.) Options

- Common field
- Equality relationship
- Attributes are copied.

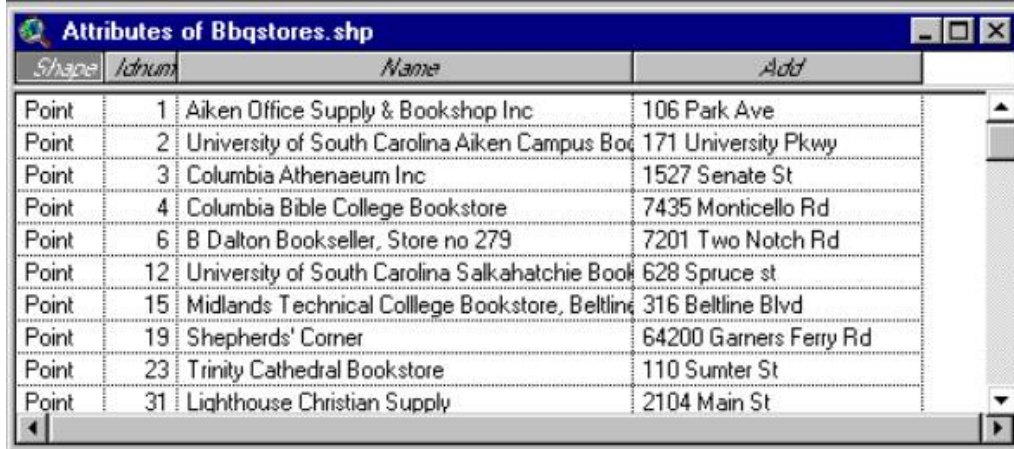
Spatial Join

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

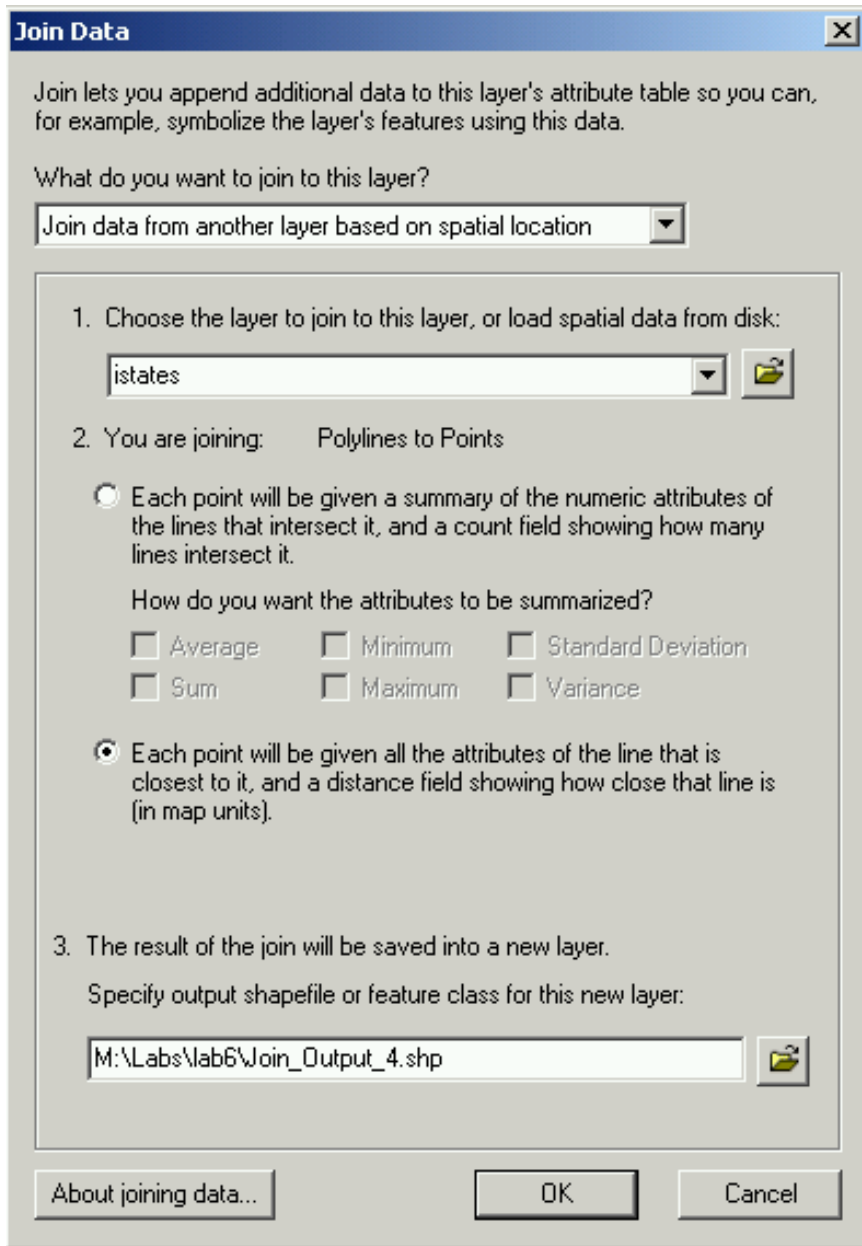


Shape	Area	Cntyname	Pop1990	Pop2000	Medthinc
Polygon	2120187264.0	Spartanburg	226800	252842	26941
Polygon	1028112960.0	Cherokee	44506	49914	24655
Polygon	1799873792.0	York	131497	155044	31288
Polygon	1436664448.0	Lancaster	54516	57912	25320
Polygon	1335706496.0	Union	30337	30979	21526
Polygon	1960777600.0	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	22688	21484

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



Shape	Idnum	Name	Addr
Point	1	Aiken Office Supply & Bookshop Inc	106 Park Ave
Point	2	University of South Carolina Aiken Campus Bo	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 College 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



Spatial Join Example

Join nearest interstates to book stores

	NAME	ROUTE	Distance
▶	The Map Shop	I-185	341.237231
	Reader's Market/ K Mart No 03240	I-185	6874.613874
	Southern Historical Press	I-185	361.416461
	The Book Shelf	I-185	4192.025308
	Whittershins Bookstore and Cafe	I-185	388.828790
	Burry Bookstore Inc	I-20	18670.016237
	Coker College Bookstore	I-20	18905.366324
	Reader's Market/ K Mart No 04873	I-20	2983.402827
	Saint Leo College Center	I-20	26580.983580
	Bookfinder's International	I-20	4576.711553
	Turn of the Page	I-20	5348.705087
	Rays	I-20	4567.469677

Record: 1 Show: All Selected Records (0 of 1)