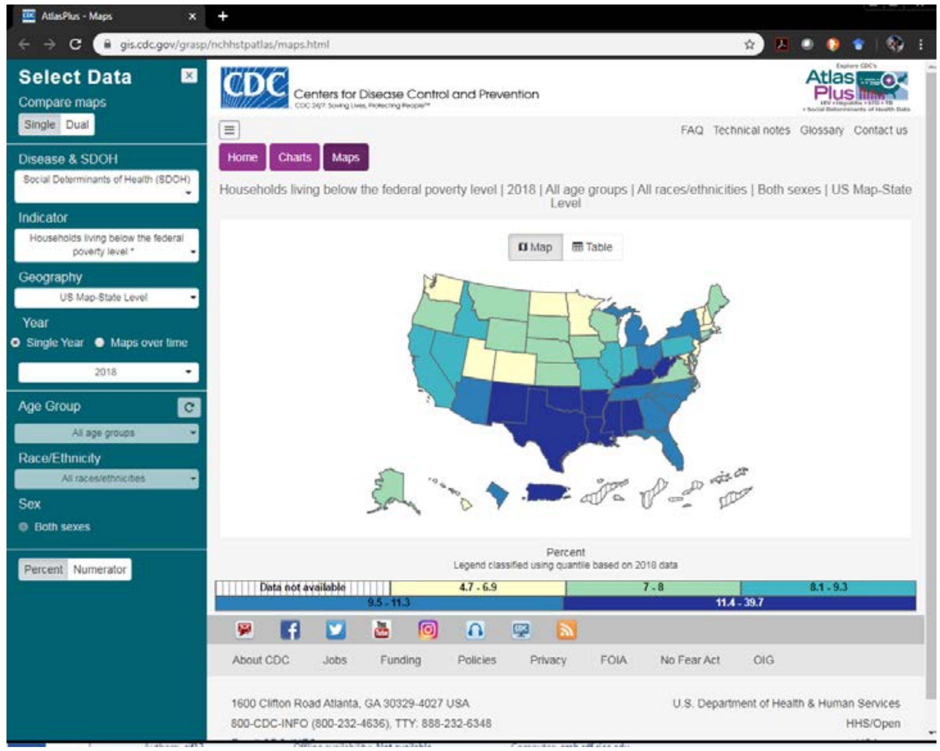
Leveraging the what and where of spatial data

Learning objectives

- Explore GIS methods that leverage the what and where of your data
  - Understand tabular attribute structure and common table operations
  - Apply spatial relationships to organize and connect your datasets



You have learned how to join tables to connect attribute data to spatial data.
Perhaps you are interested in creating your own attribute fields based on existing or new information?

Are you interested in the relationships between these layers?
How many hospitals are located within a selected geography?
Where is the closest hospital with a primary stroke center classification?
What are the underlying demographics for a selected Hospital Service area?

Consider some useful tools:
Use field calculator to generate new data from existing tables
Use attributes to create selections
Spatial Selection
Spatial Join

Review: spatial data?

Components

- Attributes (what?)
    - *Tabular data*
    - *Describes an object*
- Spatial (where?)
    - *Geometry or shape of an object*
    - *Where it is located*

OWNER_ST	LANDUSE_DE	PHYS_ADD	CONSTTYP	YEARBUILT	R
MD	VAC AG/ 10 ACRES OR >	0 OLD OXFORD RD		0	
NC	VAC AG/ 10 ACRES OR >	0 RED MOUNTAIN RD		0	
NC	PRESENT-USE/AGRICULTUR	0 COUNTY LINE RD		0	
NC	VAC AG/ TMBR 20 ACRES & >	0 COUNTY LINE RD		0	
NC	RES/ RURAL RES W/ ACREAG	811 COUNTY LINE RD	R/SD/CL-D/SH-2/AV	1985	
NC	RES/ RURAL RES W/ ACREAG	721 COUNTY LINE RD	R/SD/CL-D BV/SH-2/AV	1985	

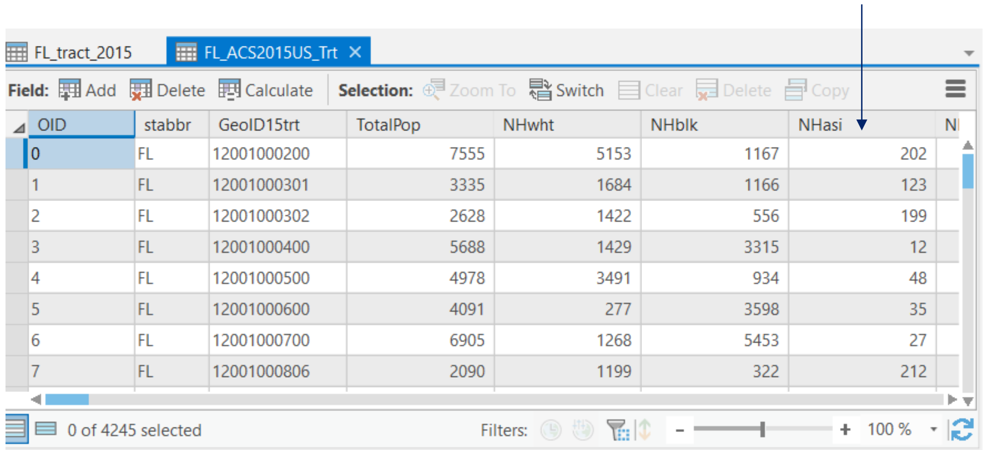
Topology (relationships)

Coordinate system

Table components

Attribute Fields (columns)

Records (rows)



OID	stabbr	GeoID15trt	TotalPop	NHwht	NHblk	NHasi	NI
0	FL	12001000200	7555	5153	1167	202	
1	FL	12001000301	3335	1684	1166	123	
2	FL	12001000302	2628	1422	556	199	
3	FL	12001000400	5688	1429	3315	12	
4	FL	12001000500	4978	3491	934	48	
5	FL	12001000600	4091	277	3598	35	
6	FL	12001000700	6905	1268	5453	27	
7	FL	12001000806	2090	1199	322	212	

The one-to-one relationship between geometry and attributes is based on record number (OID)

dbf columns

•Must have unique names

•Can contain different data type (text, numeric, date)

•Column names limited to 10 characters

• Allowable column characters: all lower and uppercase alpha, all numeric digits, and the underscore '_' character

Geodatabase columns

•Must have unique names- supports use of aliases

•Can contain different data type (text, numeric, date)

•Column names limited to 64 characters

• Allowable column characters: all lower and uppercase alpha, all numeric digits, and the underscore '_' character

A closer look at attribute fields

- Data Types:
  - Integer
    - Short Integer – -32k to 32k
    - Long Integer – -2 billion to 2 billion
  - Decimal number
    - Float – 6 digits of precision
    - Double – 15 digits of precision
  - Text
  - Date

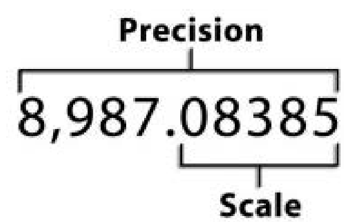
- Field Properties:
  - Length – text field length
  - Precision – numeric field length
  - Scale – decimal places

Map | Fields: tl_2015_us_county

Current Layer: tl_2015_us_county

Visible	Read Only	Field Name	Alias	Data Type	Allow NULL	Highlight	Number Format	Default	Precision	Scale	Length
☑	☐	GEOID	GEOID	Text	☐	☐			0	0	5
☑	☐	NAME	NAME	Text	☐	☐			0	0	100
☑	☐	NAMELSAD	NAMELSAD	Text	☐	☐			0	0	100
☑	☐	LSAD	LSAD	Text	☐	☐			0	0	2
☑	☐	CLASSFP	CLASSFP	Text	☐	☐			0	0	2
☑	☐	MTFCC	MTFCC	Text	☐	☐			0	0	5
☑	☐	CSAFP	CSAFP	Text	☐	☐			0	0	3
☑	☐	CBSAFP	CBSAFP	Text	☐	☐			0	0	5
☑	☐	METDIVFP	METDIVFP	Text	☐	☐			0	0	5
☑	☐	FUNCSTAT	FUNCSTAT	Text	☐	☐			0	0	1
☑	☐	ALAND	ALAND	Double	☐	☐	Numeric		14	0	
☑	☐	AWATER	AWATER	Double	☐	☐	Numeric		14	0	
☑	☐	INTPTLAT	INTPTLAT	Text	☐	☐			0	0	11
☑	☐	INTPTLON	INTPTLON	Text	☐	☐			0	0	12

Click here to add a new field.



Be aware of field data type (field type) when you are running geoprocessing tools. type of fields can prevent the tool from running properly.

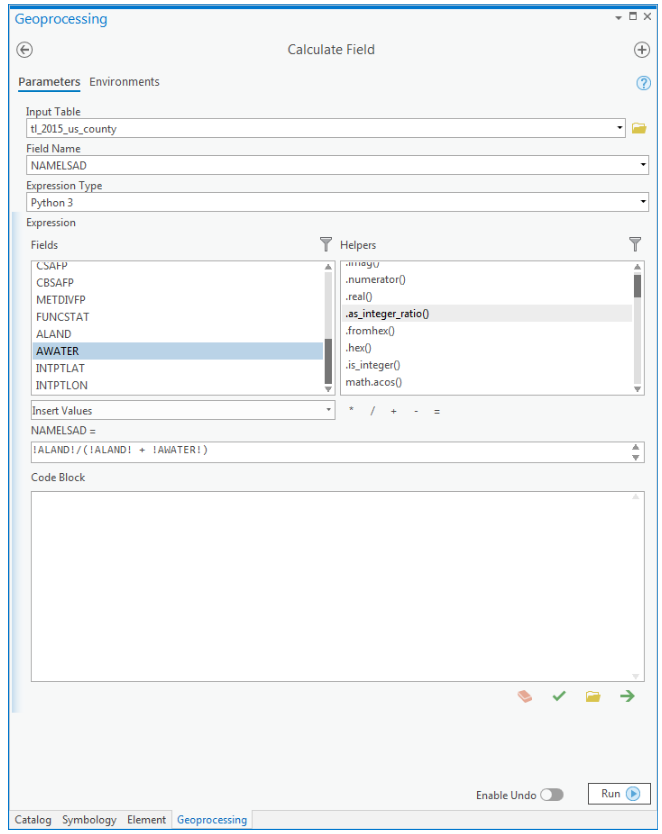
Leaving field properties options as 0 will not create any restrictions – this is the default

Introducing the field calculator

- Create an expression to perform simple or complex operations on field values in a table

- Field calculations work on string, number, and date fields, and automatically calculate selected records if the layer or table has a selection set present

- Calculations can be performed using Python, SQL and Arcade



Python for the field calculator

- Numbers and characters are different in computer.
- e.g. 0 ≠ ‘0’ , 5 ≠ ‘5’

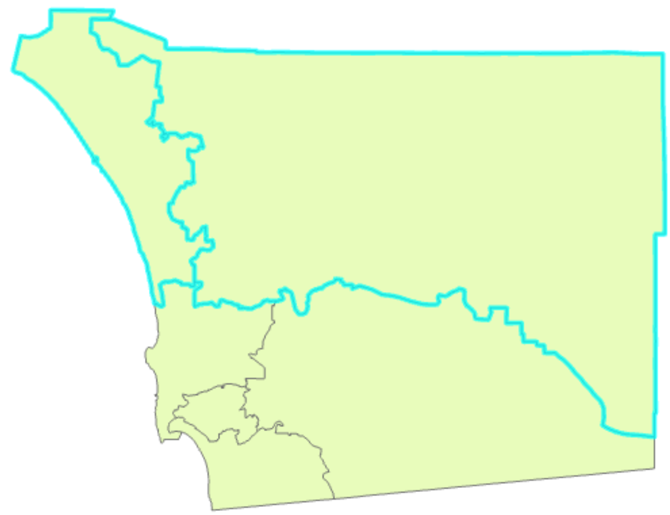
- Concatenate Text
- Convert Types
- Substring
- Split Text
- Convert Case

‘Python’ + ‘ ’ + ‘Cheat’ = ‘Python Cheat’ str(50) = ‘50’,
str(11.5) = ‘11.5’
“Python”[2:4] = “th”
“Python_Cheat”.split(“_”)[0] = “Python”
“Python”.lower() = “python”

More examples here:
https://pro.arcgis.com/en/pro-app/tool-reference/data-management/calculate-field-examples.htm

Tabular selection

- Selections will appear both in the table and on the map
- Selected features will be highlighted with
- Select features that meet a criteria
- Operations will only work on selected features (export data, batch edit data, and analysis)



Field: Add Delete Calculate Selection: Zoom To Switch Clear Delete Copy

FID	Shape	NAME	OBJECTID	SHP_ID_ARE	SHP_ID_LEN
0	Polygon	CENTRAL	1	1535303291.31	263934.311085
1	Polygon	EAST	2	28996195963.700001	968586.194665
2	Polygon	NORTH CENTRAL	3	5533931462.35	524020.360024
3	Polygon	NORTH COASTAL	4	11036787477.5	804323.942146
4	Polygon	NORTH INLAND	5	67284697823.099998	1623568.03522
5	Polygon	SOUTH	6	4388876502.48	391667.510459

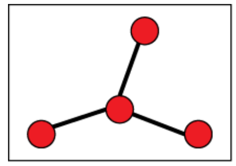
Click to add new row.

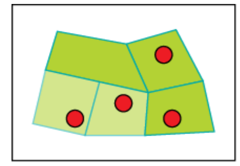
Topology: Defining relationships among objects

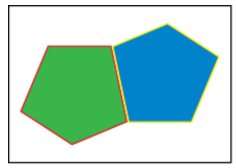
Connectivity
Connections between objects

Containment
Maintenance of boundaries and closed areas to define relationships with other objects

Adjacency
Relationships between objects that are next to each other







For the purposes of this discussion we will limit of definition of topology to: how points lines and polygons relate to each other.

Along with explicit spatial definition (i.e. coordinates) your geographic data includes topological information that helps define relationships to objects in space:

-What is connected to what?
-What is within what?
-What is beside what?

GIS software keeps track of this information allowing you to use it for a number of spatial operations and queries; indeed this very information allows for spatial join and spatial query functionality, which we will discuss in this module.

The arrangement that constrains how point, line, and polygon features share geometry.

For example, street centerlines and census blocks share geometry, and adjacent ZIP Code Tabulation Area (ZCTA) polygons share geometry.

Topology defines and enforces data integrity rules (for example, there should be no gaps between polygons).

It supports topological relationship queries and navigation (for example, navigating feature adjacency or connectivity), supports sophisticated editing tools, and allows feature construction from unstructured geometry (for example, constructing polygons from lines).

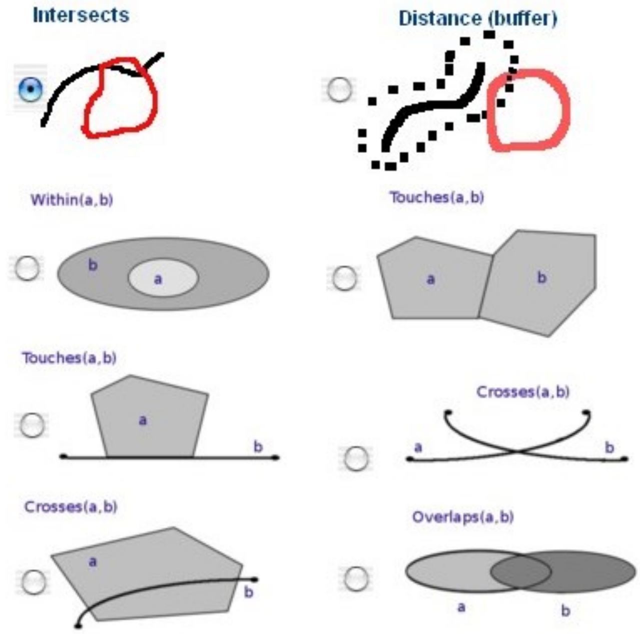
Unleashing spatial operations

Spatial selections/queries: Asking questions of your data

Select features in one or more layers based on relationship to other features

Spatial Joins: Connecting your data

Uses spatial associations between layers to append fields from one layer to another

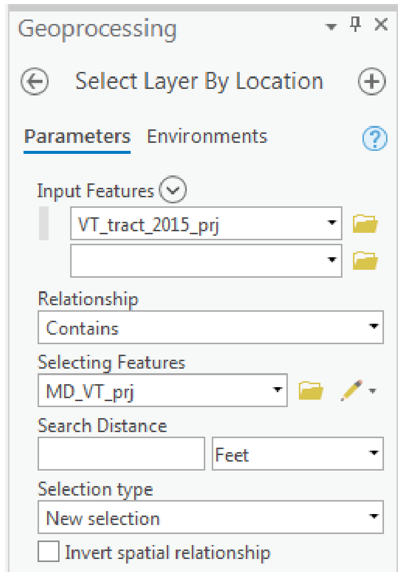


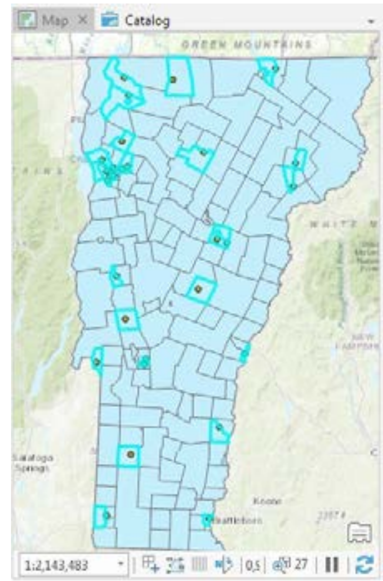
Spatial operations take advantage of the spatial information associated with your geographic data; they are one of the many things that make GIS pretty cool

Spatial selections

- Intersect
- Intersect 3D
- Within a distance geodesic
- Within a distance
- Within a distance 3D
- 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

Select features based on location relative to other features



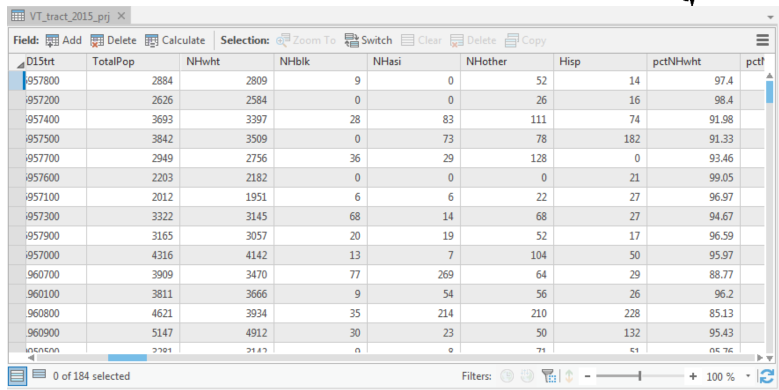


Spatial relationships covered:
+Geoprocessing tool
Selection\Select By Location...
INTERSECT Target layer(s) features intersect the Source layer feature
WITHIN_A_DISTANCE Target layer(s) features are within a distance of the Source layer feature
CONTAINS Target layer(s) features contains the Source layer feature
COMPLETELY_CONTAINS Target layer(s) features completely contains the Source layer feature
CONTAINS_CLEMENTINI Target layer(s) features contains (Clementini) the Source layer feature
WITHIN Target layer(s) features are within the Source layer feature
COMPLETELY_WITHIN Target layer(s) features are completely within the Source layer feature
WITHIN_CLEMENTINI Target layer(s) features are within (Clementini) the Source layer feature
ARE_IDENTICAL_TO Target layer(s) features are identical to the Source layer feature
BOUNDARY_TOUCHES Target layer(s) features touch the boundary of the Source layer feature
SHARE_A_LINE_SEGMENT_WITH Target layer(s) features share a line segment with the Source layer feature
CROSSED_BY_THE_OUTLINE_OF Target layer(s) features are crossed by the outline of the Source layer feature
HAVE_THEIR_CENTER_IN Target layer(s) features have their centroid in the Source layer feature

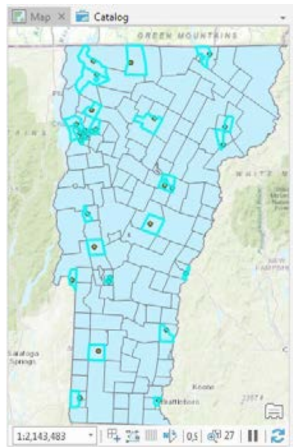
Spatial join

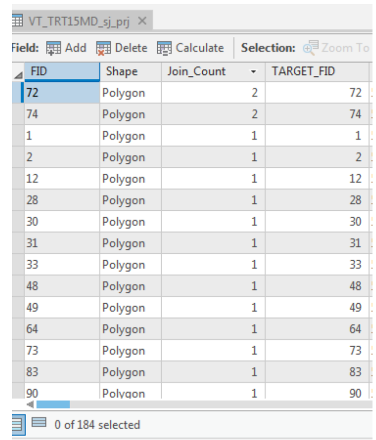
- **Join based on location of two layers**
  - **Creates new layer**
  - **Appends tables (join to target)**

- **Based on the relationship(s) between two participating layers**
  - **Intersection**
  - **Contain/Within**
  - **Closest**



D15trt	TotalPop	NHwht	NHblk	NHasi	NHother	Hisp	pctNHwht	pctN
957800	2884	2809	9	0	52	14	97.4	
957200	2626	2584	0	0	26	16	98.4	
957400	3693	3397	28	83	111	74	91.98	
957500	3842	3509	0	73	78	182	91.33	
957700	2949	2756	36	29	128	0	93.46	
957600	2203	2182	0	0	0	21	99.05	
957100	2012	1951	6	6	22	27	96.97	
957300	3322	3145	68	14	68	27	94.67	
957900	3165	3057	20	19	52	17	96.59	
957000	4316	4142	13	7	104	50	95.97	
960700	3909	3470	77	269	64	29	88.77	
960100	3811	3666	9	54	56	26	96.2	
960800	4621	3934	35	214	210	228	85.13	
960900	5147	4912	30	23	50	132	95.43	





FID	Shape	Join_Count	TARGET_FID
72	Polygon	2	72
74	Polygon	2	74
1	Polygon	1	1
2	Polygon	1	2
12	Polygon	1	12
28	Polygon	1	28
30	Polygon	1	30
31	Polygon	1	31
33	Polygon	1	33
48	Polygon	1	48
49	Polygon	1	49
64	Polygon	1	64
73	Polygon	1	73
83	Polygon	1	83
90	Polygon	1	90

https://pro.arcgis.com/en/pro-app/tool-reference/analysis/spatial-joins-by-feature-type.htm

A spatial join joins the attributes of two layers based on the location of the features in the layers.

A new layer is created Like joining two tables by matching attribute values in a field, a spatial join appends the attributes of one layer to another.

Match join options:

+Intersect-matches join features with intersect target features

+Contains-target feature contains a join feature (points cannot be set as target feature and polygons can only be set as join features when target feature is polygon)

+Is within-target features within join features matched (points cannot be set as join features and polygons may only be target features when join fields are also polygons

+Closest- target features matched to closest join feature

Wont' work with number leading on target for GDB

Join by location (spatial join)

Join by location or spatial join uses spatial associations between the layers involved to append fields from one layer to another. Spatial joins are different from attribute and relationship class joins in that they are not dynamic and require the results to be saved to a new output layer.

1. **Match each feature to the closest feature or features** - In this association, you can either append the attributes of the nearest feature or append an aggregate (i.e. min, max etc.) of the numeric attributes of the closest features.

2. **Match each feature to the feature that it is part of** - In this case, the attributes of the feature for which the current feature makes up a portion are appended.
3. **Match each feature to the feature or features that it intersects** - Like with the closest feature(s) association above, you can either append the attributes of a single intersecting feature or an aggregate of the numeric attributes of the intersecting features.

For each point, polygon and line combination, only the most commonly used of these associations are available in the join dialog. With VBA, however, it is possible to perform a join based on any association and with any combination of point, line or polygon feature layers.

For the best results, it is recommended that both layers have the same coordinate system. If the layers have different coordinate systems, the following rules apply:

- The spatial join will be calculated in the target layer's (the select layer in the table of contents) coordinate system.
- If the type of join performed involves adding a field to show the distance between joined features, the distance will be in a unit of measure associated with the target layer's coordinate system.
- If one of the layers has an unknown coordinate system and the other a defined coordinate system, an error message will appear. If both layers have an unknown coordinate system, the join will proceed and the resulting layer will have an unknown coordinate system.
- The coordinate system used to display data in ArcMap has no effect on how the data is joined. ArcMap allows data to be stored in one coordinate system and displayed in another. The analysis is always performed using the stored coordinate system.

Note: Use the Spatial Join geoprocessing tool in ArcToolbox (Analysis Tools > Overlay > Spatial Join tool) instead of this dialog if you are performing spatial join with large or complex datasets. The Spatial Join tool will in these cases give you dramatically better performance and reliability, and you can use the geoprocessing framework to easily automate repetitive or frequently performed joins with the tool as part of a model or script, or simply by entering the parameters for the tool in the geoprocessing command line. For example, you may wish to perform several similar spatial joins to compare the results.