Session 3: Querying Attribute Data and Spatial Selection

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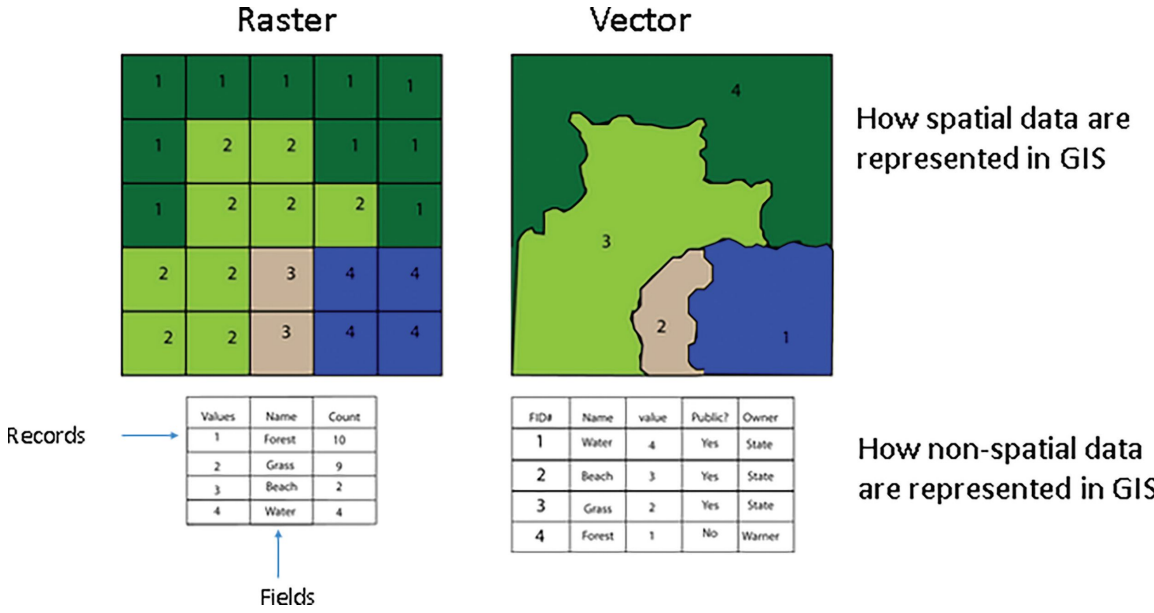
Class Schedule

Monday	Tuesday	Wednesday	Thursday	Friday
08/05/19 **Introduction to Geographical Information Systems** 10:45 am–12:15 am	08/06/19 **Cartography and Spatial Data Display** 8:30am – 11:00pm	08/07/19 **Querying Data for Spatial & Attribute Selections** 8:30am – 11:00pm	08/08/19 **Data Formats for GIS** 8:30am – 11:00pm	08/09/19 **Map Projections and Coordinate Systems** 8:30am – 11:00pm
08/12/19 **Editing and Storing Spatial and Attribute Data** 8:30am – 11:00pm	08/13/19 **Spatial Data Analysis Tools** 8:30am – 9:30 am **Scripps Institute of Oceanography** 10:30am – 1:30pm	08/14/19 **Analysis Tools/Online Map Creation** 8:30am – 11:00pm	08/15/19 **Map Creation/ Geocoding** 8:30am – 11:00pm	08/16/19 **Geocoding/ Wrap up** 8:30am – 11:30am **Closing Ceremony and Certificates** 12:00pm – 2:00pm

Outline: Querying Attribute Data and Spatial Selection

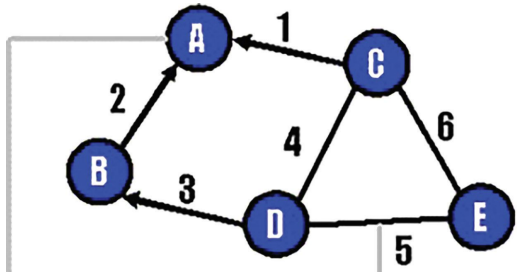
- Introduction
- Attribute tables
- Making queries
- Spatial selection
- Demonstration
- Project



Source: GIS - An Introduction (McHaffie, 2019)

Introduction

- Attribute tables
  - What are attribute tables?
  - How do we use them?
- Making queries
  - Query = Selection
- Spatial selection and proximity
  - Selecting spatial features
  - What is proximity?



Nodes		
ID	Long	Lat
A	40.42345	-75.1245
B	40.31021	-75.2510
C	40.41882	-74.9124
D	40.25908	-75.0031
E	40.28990	-74.7893

Links			
ID	From	To	One_Way
1	C	A	Yes
2	B	A	Yes
3	D	B	Yes
4	D	C	No
5	D	E	No
6	C	E	No

Source: GIS - An Introduction (McHaffie, 2019)

Attribute Tables

Spatial data represented in a GIS is often split into two components:

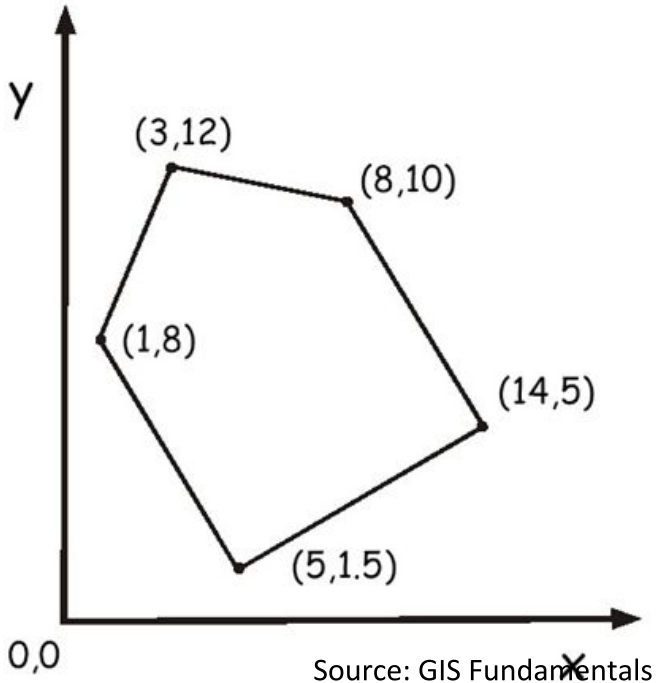
- **Coordinate information** (i.e. features) describing spatial geometry
- **Attribute information** (i.e. tabular data) representing the (mostly) non-spatial properties of object being mapped.

Source: GIS Fundamentals by P. Bolstad, 2015

Coordinates & Attributes

REPRESENTATION AND DATA STRUCTURES

Coordinates and Attributes



Coordinates:
1,8
3,12
8,10
14,5
5,1.5
1,8

Attributes:
Lot # :1347
Street: Willow Lane
Town: Hopkins

Source: GIS Fundamentals by P. Bolstad, 2015

Spatial Attributes

One-to-one relationship between:

- Geographic features (point, line, or polygon)
- Records in a table

Name	FIPS	Pop90	Area	PopDn
Whatcom	53073	128	2170	59
Skagit	53057	80	1765	45
Clallam	53009	56	1779	32
Snohomish	53061	466	2102	222
Island	53029	60	231	261
Jefferson	53031	20	1773	11
Kitsap	53035	190	391	485
King	53033	1507	2164	696
Mason	53045	38	904	42
Gray Harbor	53027	64	1917	33
Pierce	53053	586	1651	355
Thurston	53067	161	698	231
Pacific	53049	19	945	20
Lewis	53041	59	2479	24

Source: GIS Fundamentals by P. Bolstad, 2015

Attribute Data Types

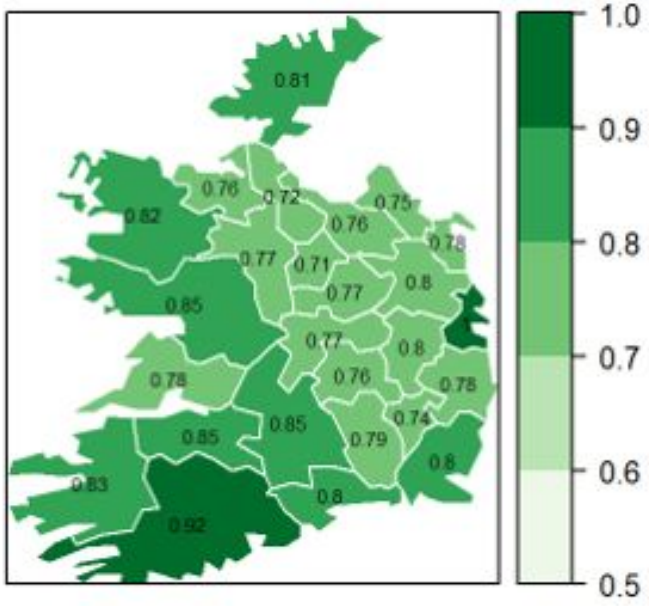
Data types:

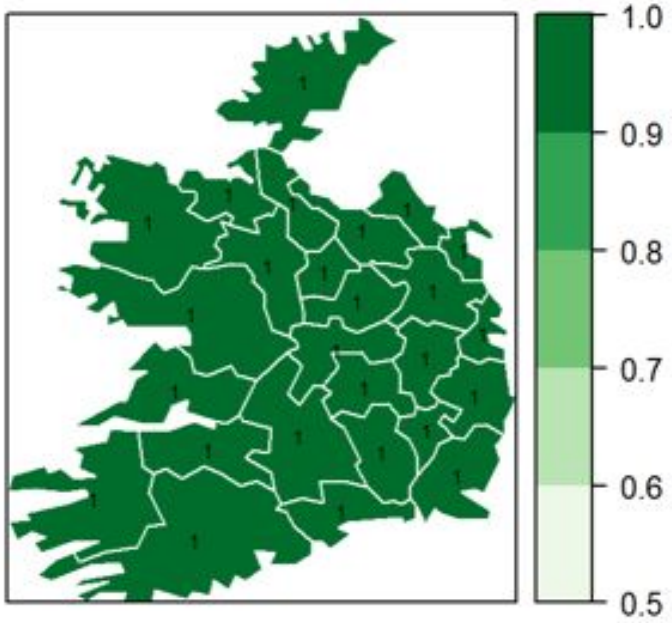
- Integer
- Float
- Double
- Text

Type	Stored values	Note
Short integer	-32,768 to 32,768	Whole numbers
Long integer	-2,147,483,648 to 2,147,483,648	Whole numbers
Float	-3.4 * E-38 to 1.2 E38	Real numbers
Double	-2.2*E-308 to 1.8* E308	Real numbers
Text	Up to 64,000 characters	Letters and words

Source: GIS Fundamentals by P. Bolstad, 2015

Choosing A Data Type





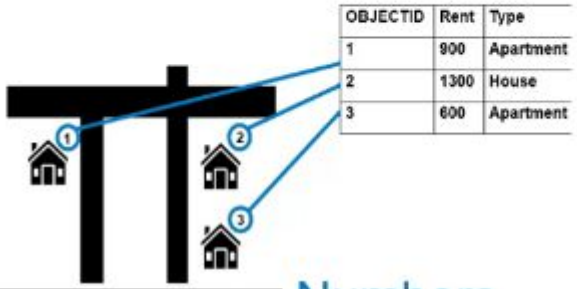
Source: https://mgimond.github.io/Spatial/introGIS.html

Data Types: Example

Table of Houses in Neighborhood

OBJECTID	Rent	Type	Year_Built
1	900	Apartment	2011
2	1300	House	1956
3	600	Apartment	1989
4	2000	House	2000
5	2500	House	1998
6	1200	House	1964

Object identifiers



Dates

Numbers

Text

Attribute Query

Query: a selection of a subset of records based on the values of specified attributes.

Querying Data

Example: Housing facilities

OBJECTID	Rent	Type
1	900	Apartment
2	1300	House
3	600	Apartment
4	2000	House
5	2500	House
6	1200	House

You can use the attributes to learn more about the features.

Here, the selected feature is a house that costs $1,300 a month in rent.

Attribute Tables

Attribute Field

OBJECTID	Rent	Type	Year built
1	900	Apartment	2011
2	1300	House	1956
3	600	Apartment	1989
4	2000	House	2000
5	2500	House	1998
6	700	House	1964

Type Is Equal To Apartment

Attribute Value

OBJECTID	Rent	Type	Year built
1	900	Apartment	2011
2	1300	House	1956
3	600	Apartment	1989
4	2000	House	2000
5	2500	House	1998
6	700	House	1964

Type Is Equal To Apartment

Operator

OBJECTID	Rent	Type	Year built
1	900	Apartment	2011
2	1300	House	1956
3	600	Apartment	1989
4	2000	House	2000
5	2500	House	1998
6	700	House	1964

Type Is Equal To Apartment

Query Features

A Query requires 3 things:

1. Attribute Field
2. Operator
3. Attribute Value

** A Query is called a "Clause" in ArcGIS Pro

Attribute Field: Type Operator: Is Equal To Attribute Value: Hospitals

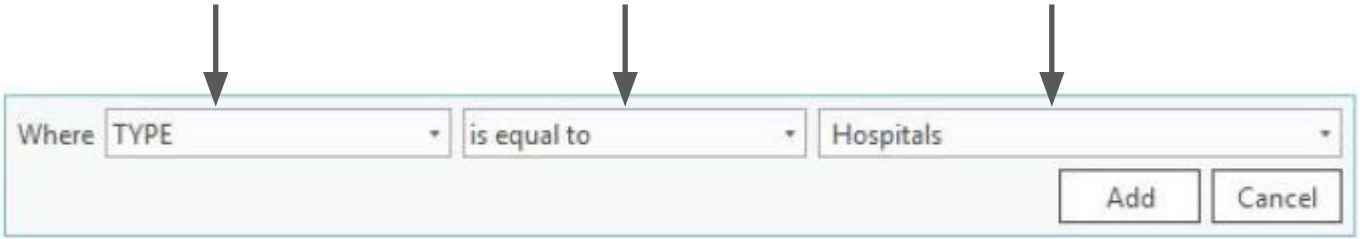


Table Operations (1-4)

Restrict (query) – subset by rows

Project – subset by columns

Product – all possible combinations

Divide – inverse of product

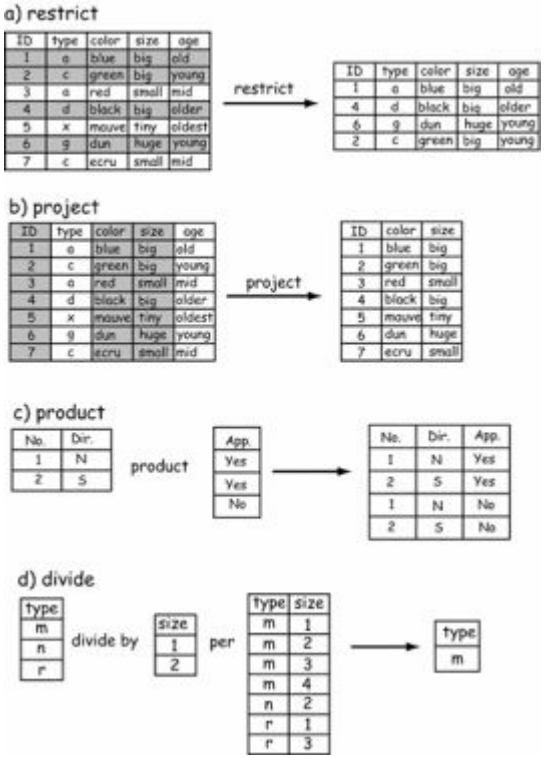


Table Operations (5-8)

Union – combine top to bottom

Intersect – row overlap

Difference – row non-- overlap

Join (relate) – combine by a key column

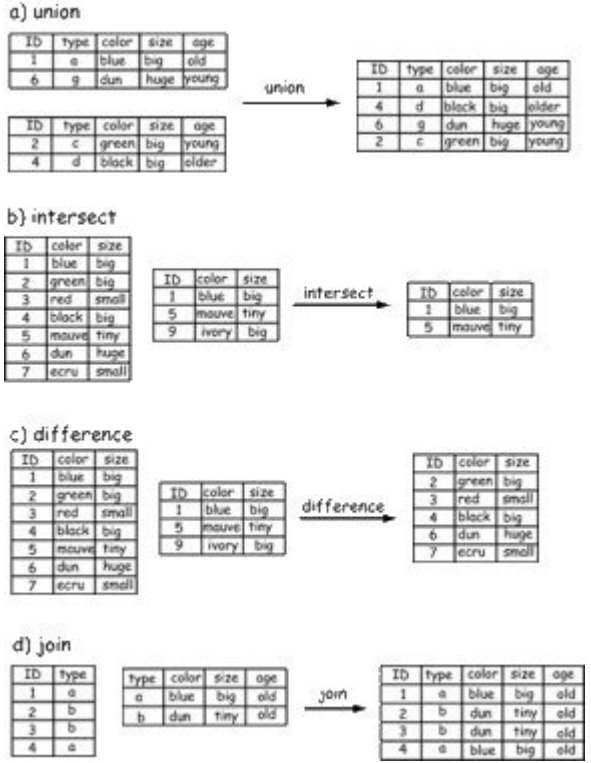


Table Join

- Joins a table to another table based on a common field.
- Appends attributes of a source table to the end of a target table

INPUT

OBJECT ID#	Landuse Code
1	2
2	0
3	1

Join Fields

+

Landuse Code	Landuse Type
0	Unclassified
1	shrub
2	water

OUTPUT

OBJECT ID#	Landuse Code	Join Table Landuse Code	Join Table Landuse Type
1	2	2	water
2	0	0	Unclassified
3	1	1	shrub

Source: ArcGIS Pro Documentation

Table Join Questions

Answering the following questions will help you use table join properly:

- Do the two tables share the same attribute values?
- Are those common attributes of the same data types?
- What is the relationship between the two tables?
- In what direction should you perform table join?

Table Join Exercise

- Presence of common attribute
- Data type of common key
- Relationship between tables
- Direction of table join

TRI

TRI_ID	Toxic	zipcode
1	25354	60001
2	3422	60001
3	253	60002
4	345	60002

Cancer

zipcode	cancerrt
60001	3.4
60002	1.4

TRI+Cancer if you join Cancer (one-side) to TRI (many-side)

TRI_ID	Toxic	zipcode	cancerrt
1	25354	60001	3.4
2	3422	60001	3.4
3	253	60002	1.4
4	345	60002	1.4

Cancer+TRI if you join TRI (many-side) to Cancer (one-side)

zipcode	cancerrt	TRI_ID	Toxic
60001	3.4	1? 2?	25354? 3422?
60002	1.4	3? 4?	253? 345?

Building Query Expressions

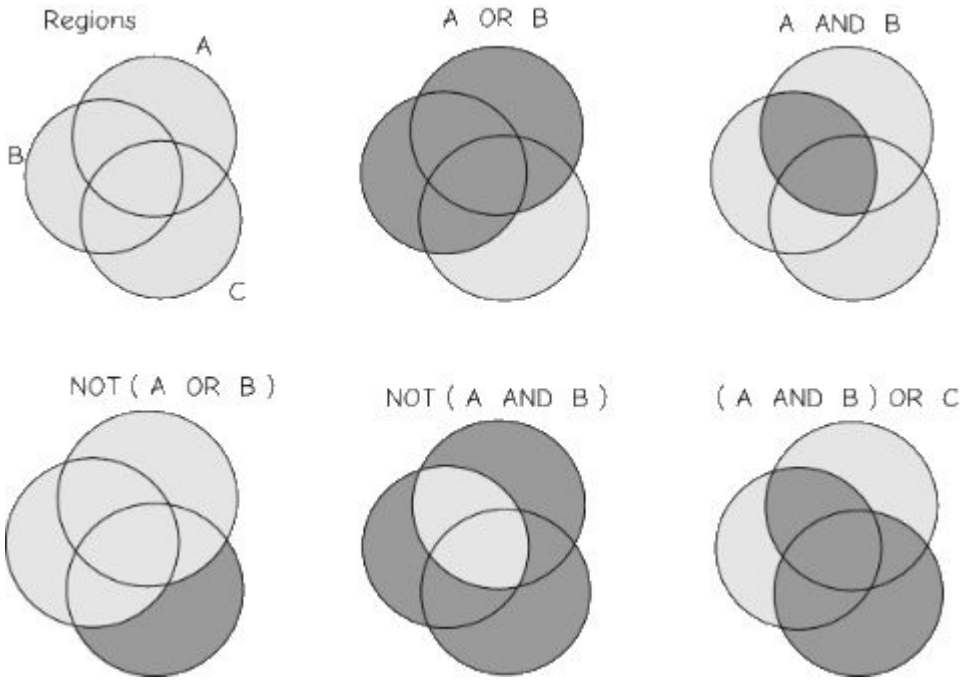
Set Algebra:

- Less than (<)
- Greater than (>)
- Equal to (=)
- Not Equal to (<>)

Boolean Operators:

- **AND** combinations decrease number of records in selected set
- **OR** combinations typically increase number of records
- **NOT** is negation operator meaning “select those records that do not meet the following condition”.

Boolean Algebra Schematic



Source: GIS Fundamentals by Bolstad, 2015.

Examples of Boolean Algebra combining the operators AND, OR, NOT.

Query - AND Example

Simple selection:

records with Area > 20.0

ID	Area	Landuse	Municip
1	10.5	Urban	City
2	330.3	Farm	County
3	2.4	Suburban	Township
4	96.0	Suburban	County
5	22.1	Urban	City
6	30.2	Farm	Township
7	4.4	Urban	County

AND selection:

records with (Landuse = Urban) AND (Municip = City)

ID	Area	Landuse	Municip
1	10.5	Urban	City
2	330.3	Farm	County
3	2.4	Suburban	Township
4	96.0	Suburban	County
5	22.1	Urban	City
6	30.2	Farm	Township
7	4.4	Urban	County

Query – OR & NOT Example

OR selection:
records with (Area > 20.0)
OR (Municip = City)

ID	Area	Landuse	Municip
1	10.5	Urban	City
2	330.3	Farm	County
3	2.4	Suburban	Township
4	96.0	Suburban	County
5	22.1	Urban	City
6	30.2	Farm	Township
7	4.4	Urban	County

NOT selection:
records with
Landuse NOT Urban

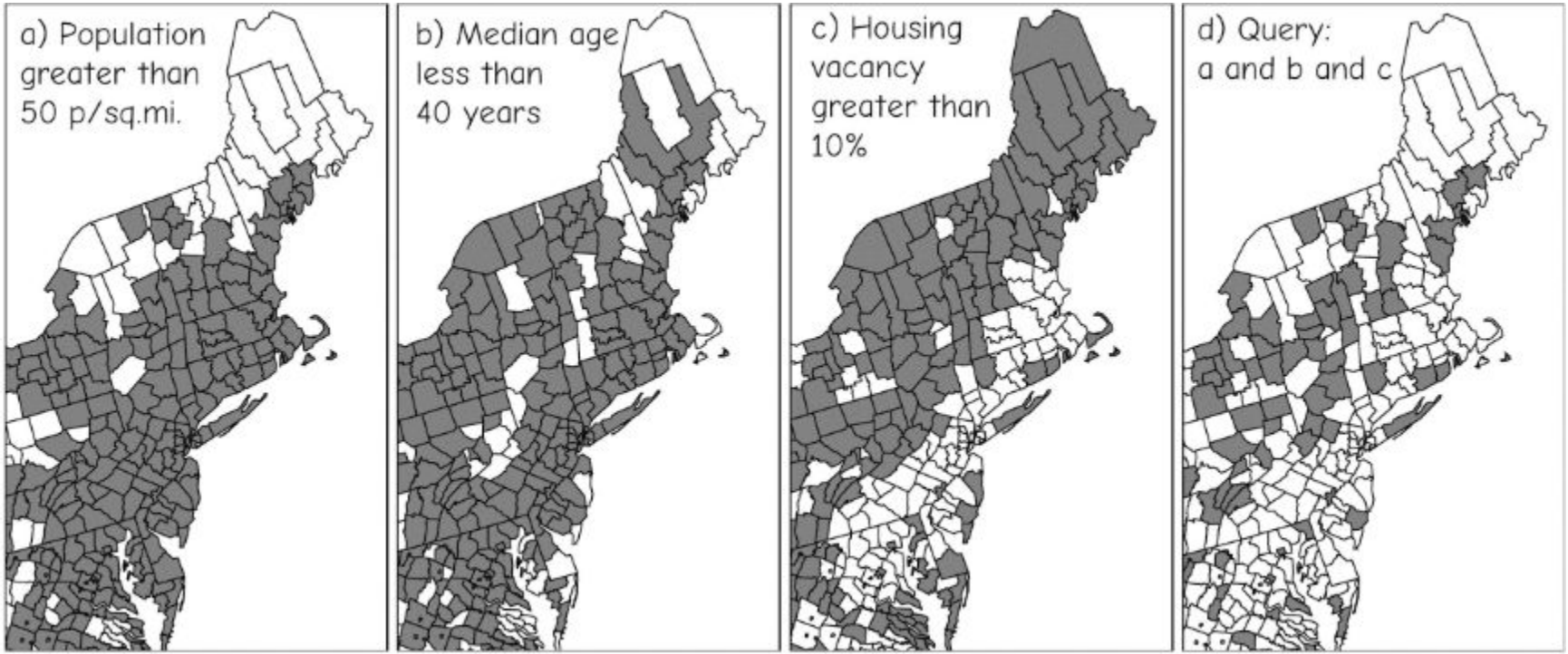
ID	Area	Landuse	Municip
1	10.5	Urban	City
2	330.3	Farm	County
3	2.4	Suburban	Township
4	96.0	Suburban	County
5	22.1	Urban	City
6	30.2	Farm	Township
7	4.4	Urban	County

Query - Complex Selection

Complex selection:
records with [(Landuse = Urban) AND (Mill Rate = B)] OR
{NOT(Municip = City) AND (Density > 200)}

ID	Area	Landuse	Municip	Density	Mill Rate
1	10.5	Urban	City	1,112.2	A
2	330.3	Farm	County	1.9	C
3	2.4	Suburban	Township	237.5	C
4	96.0	Suburban	County	98.1	A
5	22.1	Urban	City	916.2	B
6	30.2	Farm	Township	3.7	A
7	4.4	Urban	County	153.8	D

Query: Visual Check

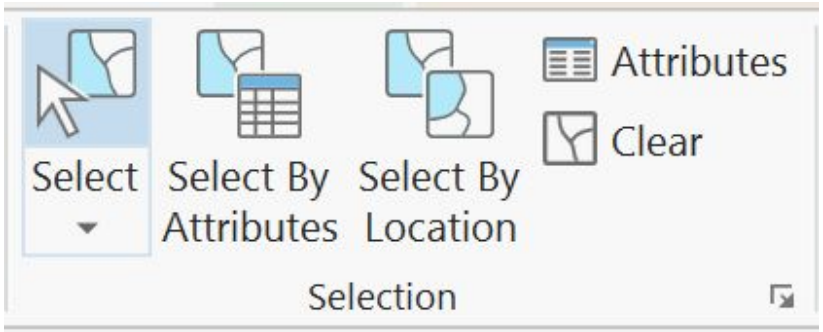


Selection/Query in ArcGIS Pro

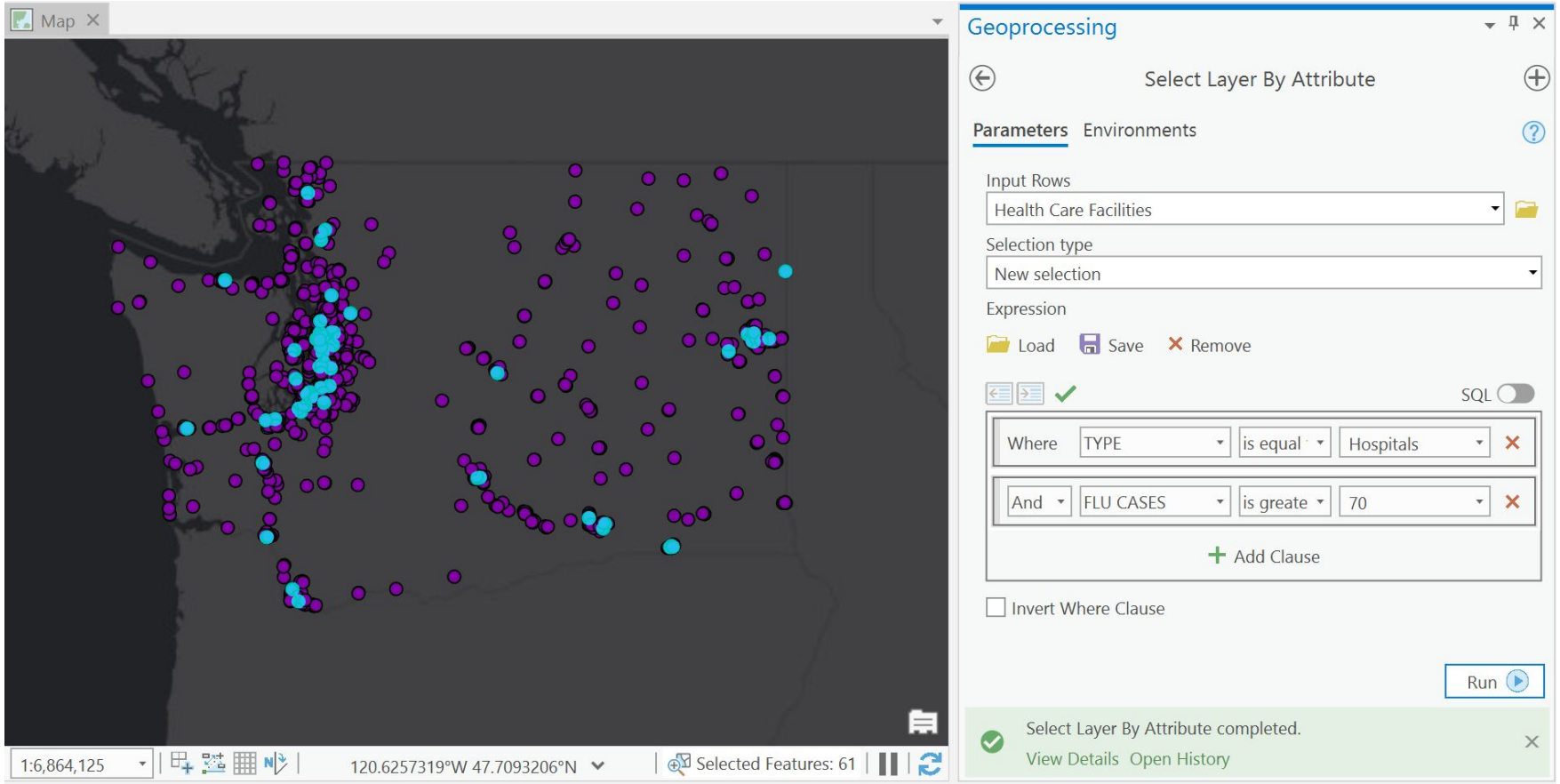
Two main tools:

1. Select Layer By Attribute

2. Select Layer By Location



Select Layer By Attribute

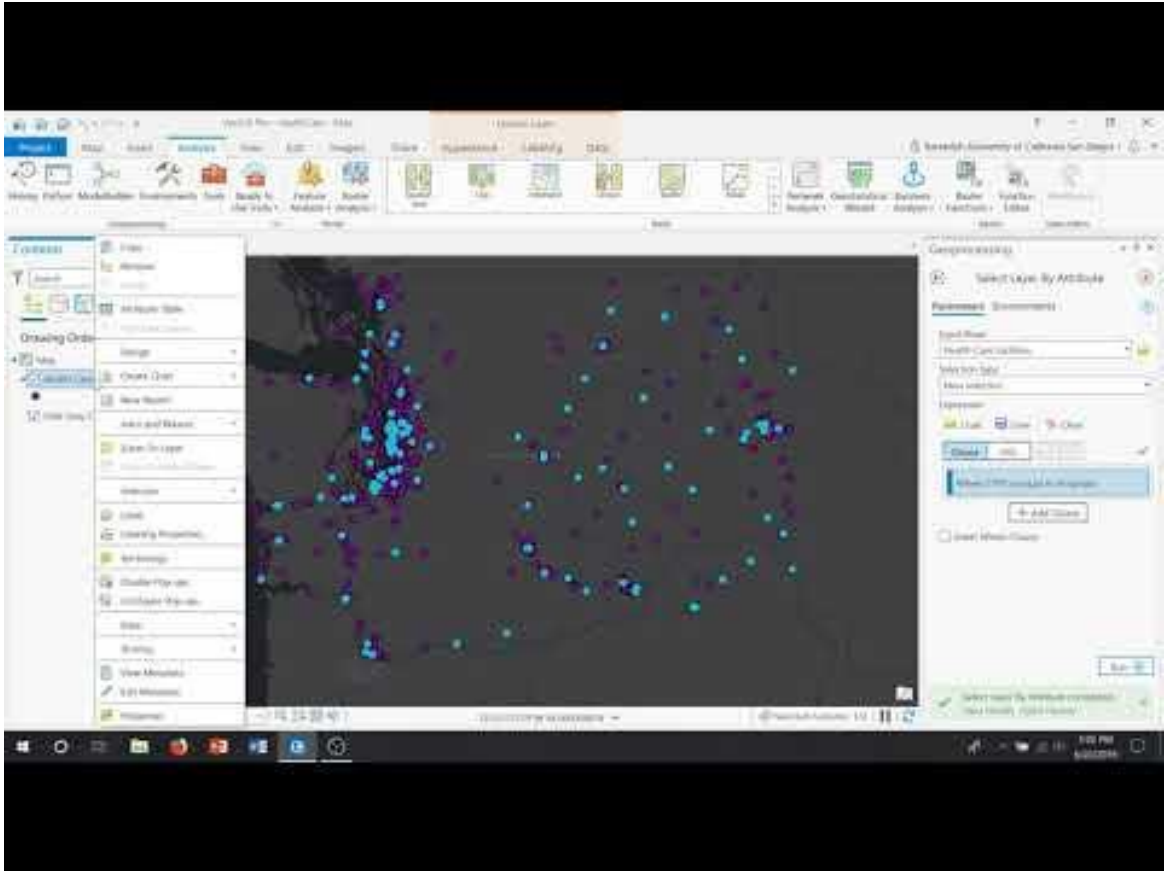


Video: Select By Attributes

Please check out the video by Paul Bolstad:

Select By Attributes

Demo: Select By Attributes



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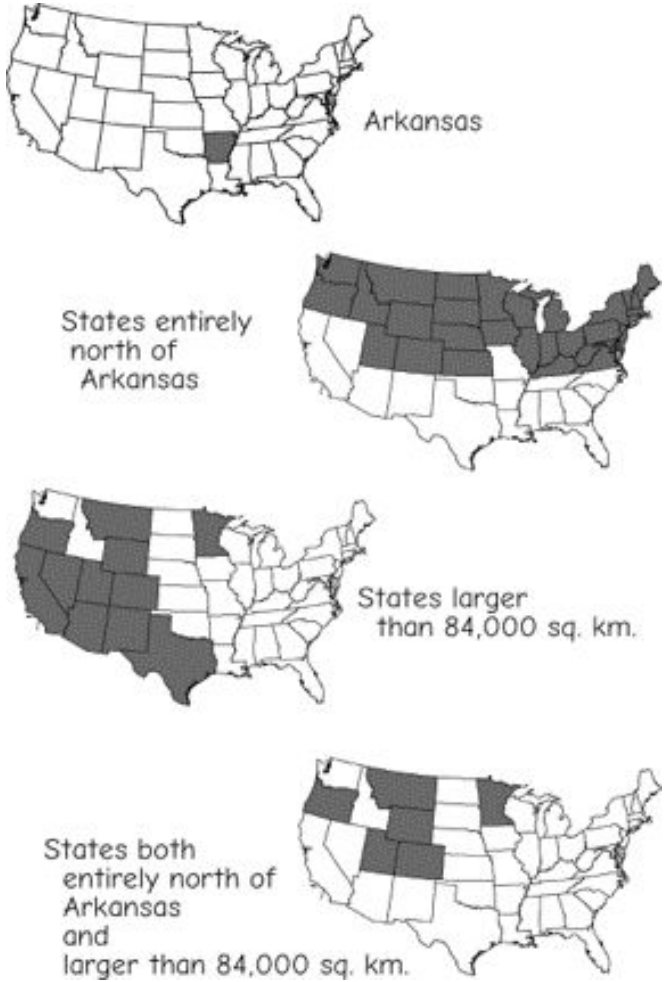
Source: GIS - An Introduction (McHaffie, 2019)

Spatial Selection

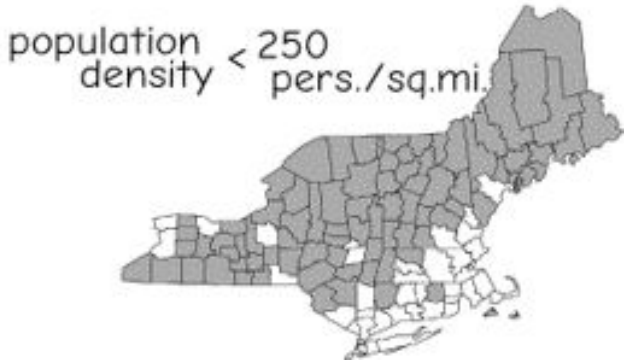
- **Spatial Query**: Identifying features based on spatial criteria.
- Results are either highlighted on screen or written to new data layer
- Criteria include: **Adjacency** or **Containment**



Source: GIS Fundamentals by Bolstad, 2015.

Spatial Set Algebra

Attribute query resulting in: spatial selections (shaded features)

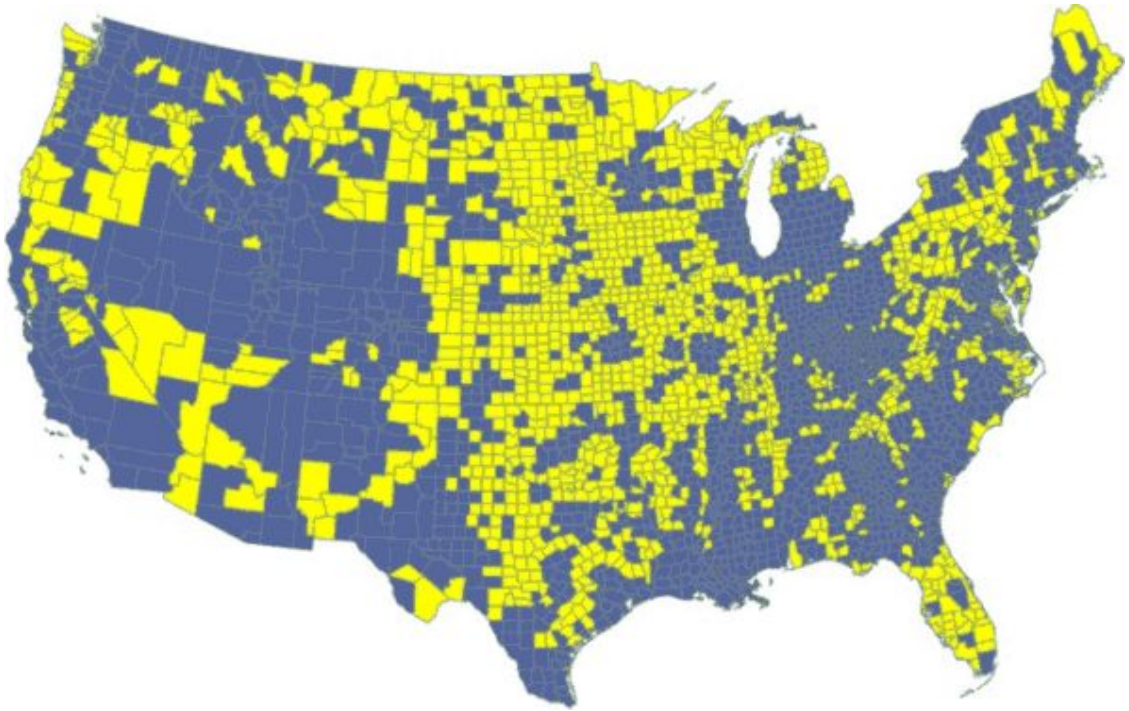


Source: GIS Fundamentals by Bolstad, 2015.

Selection: Boolean and Set Algebra

Select counties with large senior citizen population

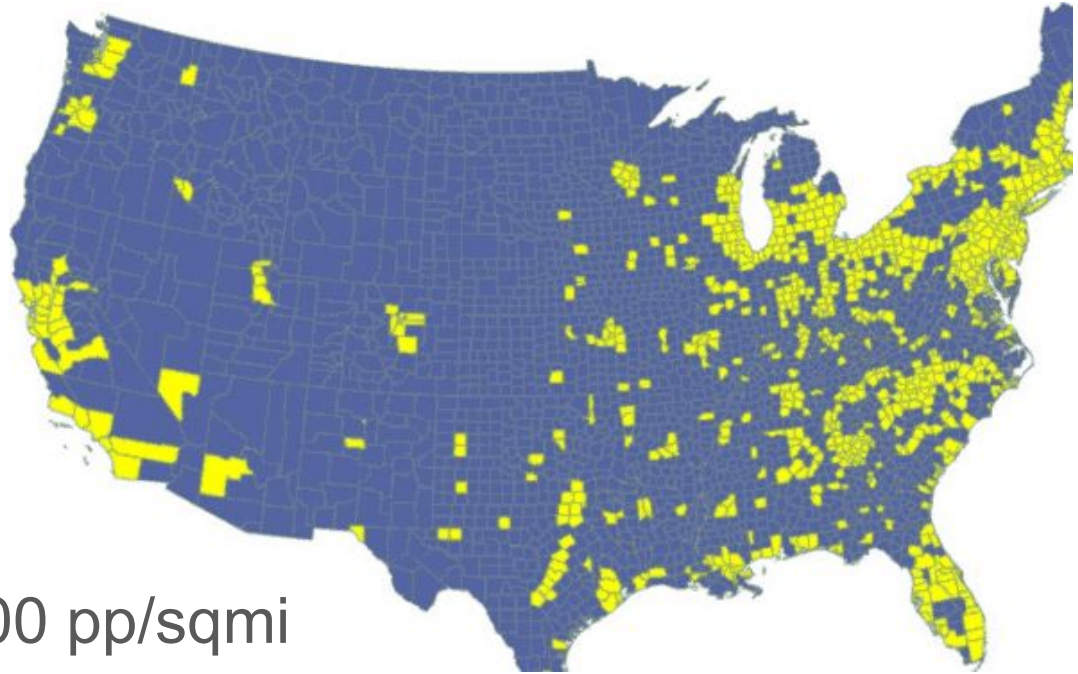
population 65+ > 15%



Source: GIS Fundamentals by Bolstad, 2015.

Selection: Boolean and Set Algebra

Select counties with large population density

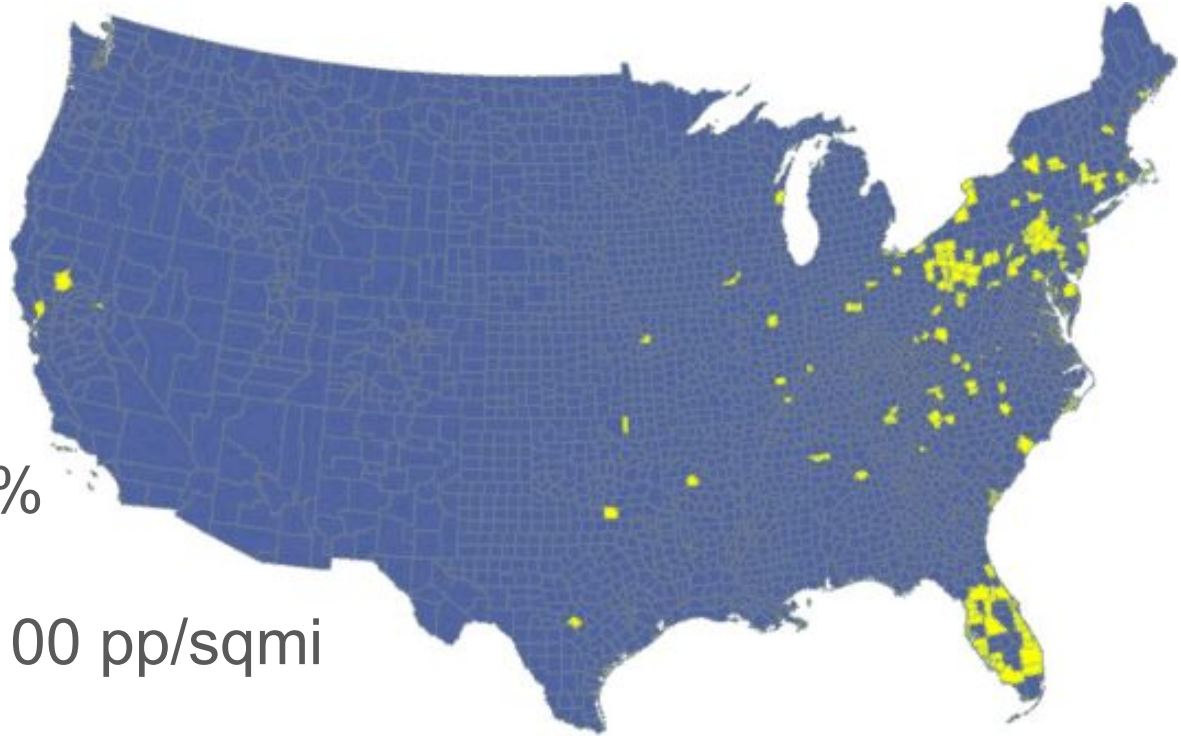


population density > 100 pp/sqmi

Source: GIS Fundamentals by Bolstad, 2015.

Selection: Boolean and Set Algebra

Where are the most senior citizens in the country?



population 65+ > 15%
AND
population density > 100 pp/sqmi

Source: GIS Fundamentals by Bolstad, 2015.

Proximity Analysis

- **Proximity analysis** compares, calculates,and shows distances between features
- Proximity tools:
  - Locate nearest features
  - Calculate distances between features
  - Generate distance buffers
- Located in Proximity toolset

Spatial Selection: Adjacency

How do we define "**Adjacency**"?

- A feature is adjacent if it shares a border.
- How you define a shared border is important.

Source: GIS Fundamentals by Bolstad, 2015.

Adjacency Example

Example of 4 Corners USA:

- Is Colorado Adjacent to Arizona?

Source: GIS Fundamentals by Bolstad, 2015.

Spatial Selection: Containment

- **Containment** Selection identifies all features that contain or surround a set of target features.

- Example: Which states contain some portion of the Mississippi River?

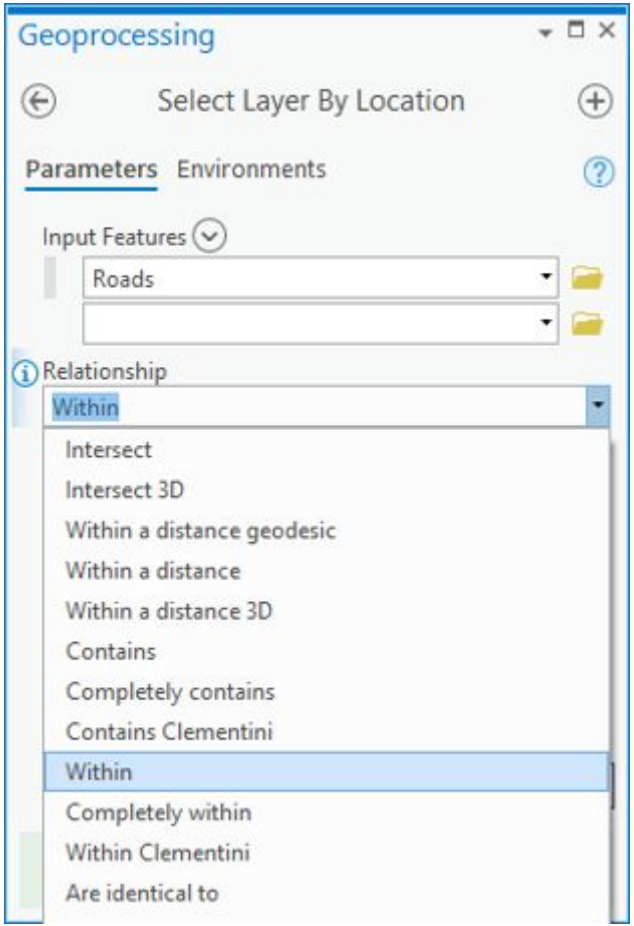
Source: GIS Fundamentals by Bolstad, 2015.

Select Layer By Location

Many Options:

- Intersect
- Within a distance
- Contains
- Within

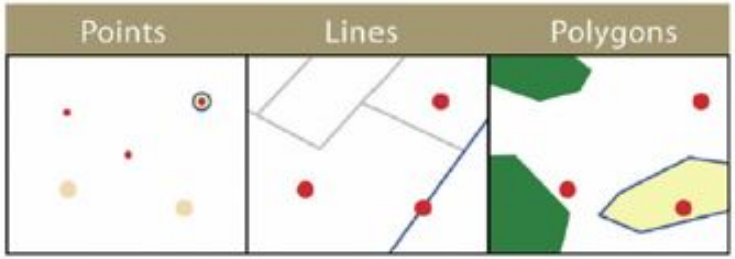
Refer to ArcGIS Documentation



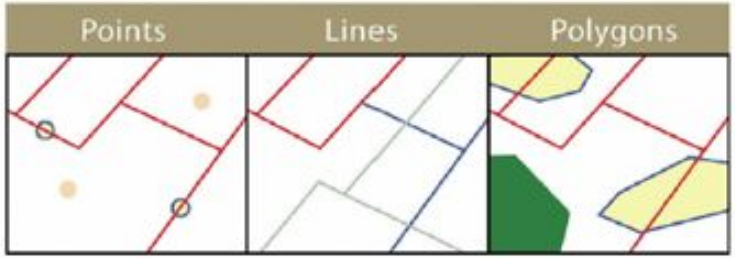
Intersection

- Select features that overlap or touch source layer
- Point, Line, or Polygon

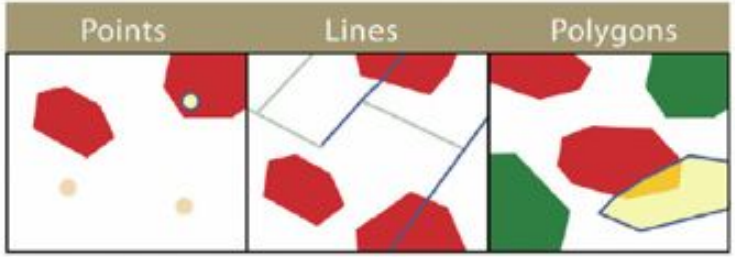
When finding features that intersect with point features



When finding features that intersect with line features



When finding features that intersect with polygon features

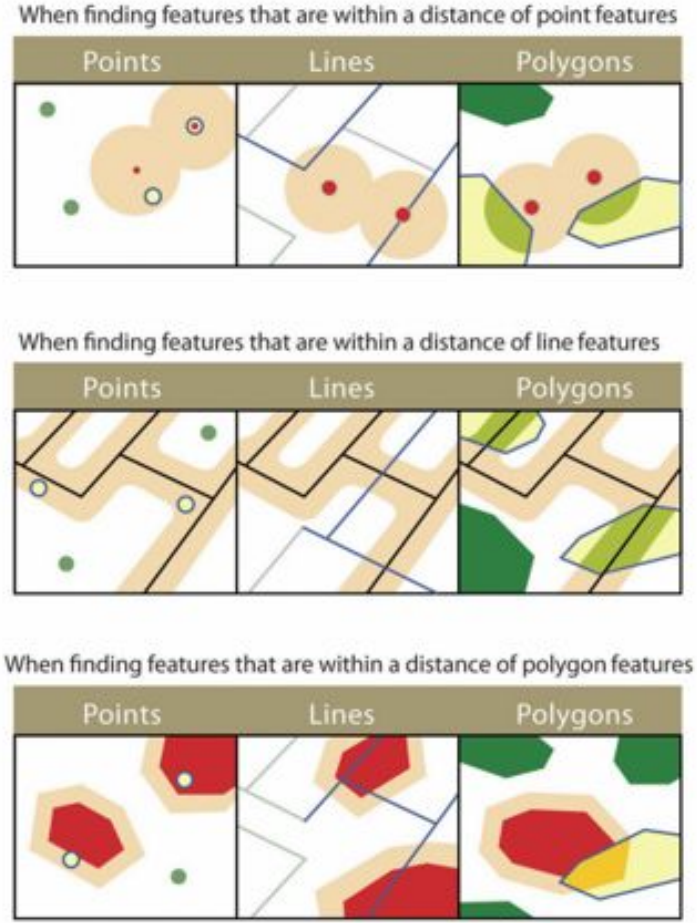


Source: Essentials of GIS by J. Cambell, 2011.

Within Distance Of

- Specify some distance value
- Source layer is buffered
- All features intersecting buffer are highlighted in target layer

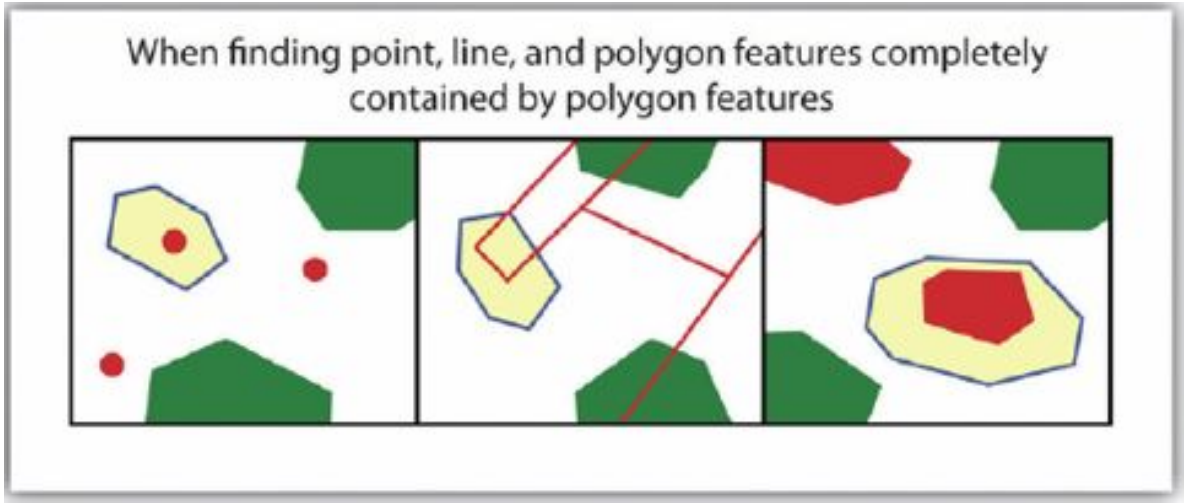
The highlighted blue and yellow features are selected because they **are within a distance of** the red features.



Source: Essentials of GIS by J. Cambell, 2011.

Completely Contain

- Select features that are entirely within the source layer
- Features with coincident boundaries are not selected

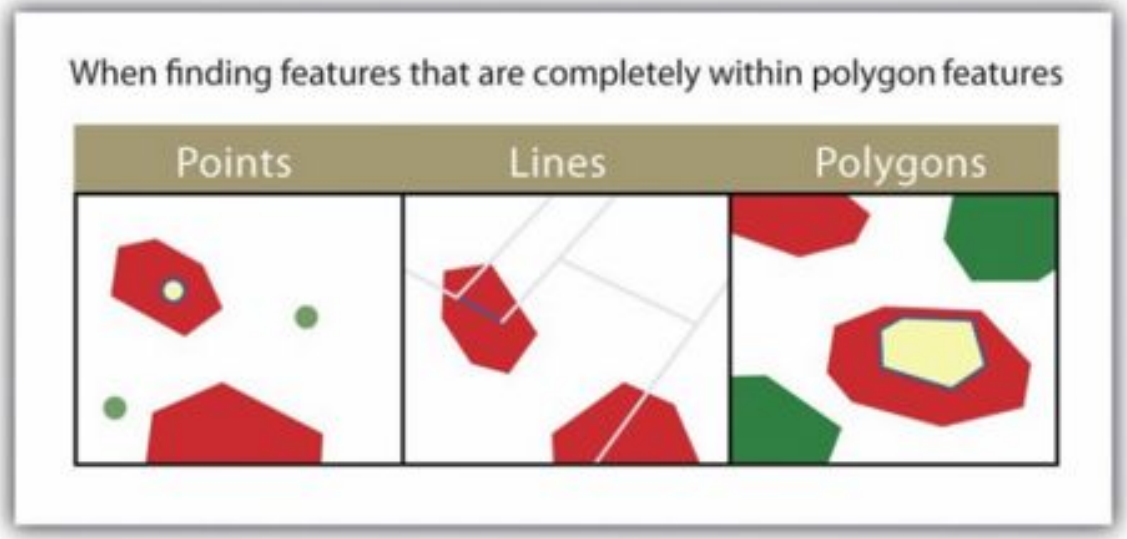


The highlighted blue and yellow features are selected because they **completely contain** the red features.

Source: Essentials of GIS by J. Cambell, 2011.

Completely Within

Select features in target layer whose entire spatial extent occurs within geometry of source layer



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