

vector analysis

foundations of geospatial analysis

2026.09.30

**vector analysis is
a kind of
geospatial
analysis**

**its built on spatial
operations that
work on vector
data models**

quick vector data recap

vector

uses points, lines, and polygons to distinguish features

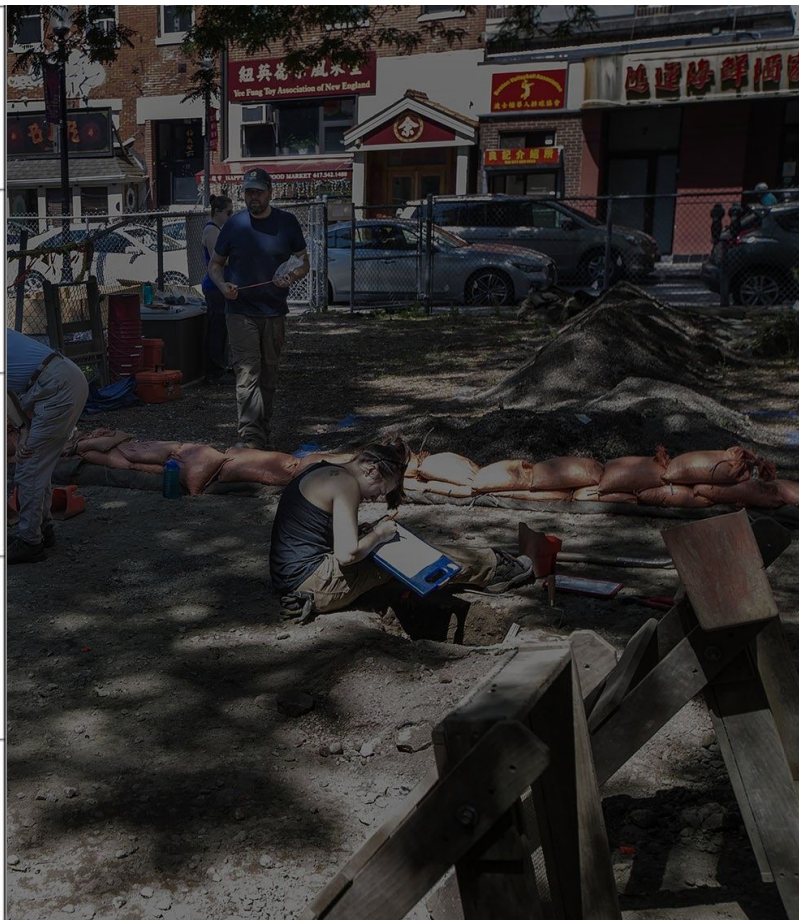
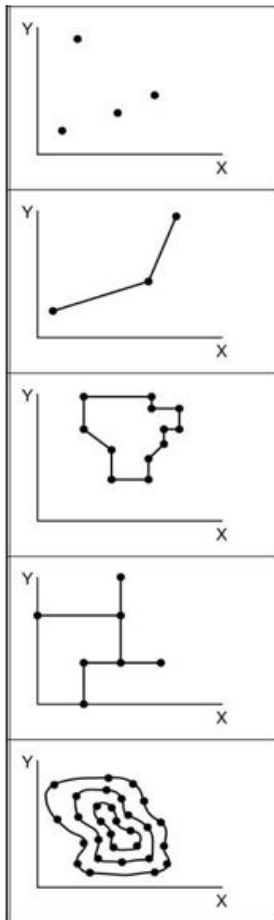
why vector?

good for discrete features
with distinct boundaries

plays well with attribute
table

examples:

- neighborhoods
- lighthouses
- canals



vector

uses points, lines, and polygons to distinguish features

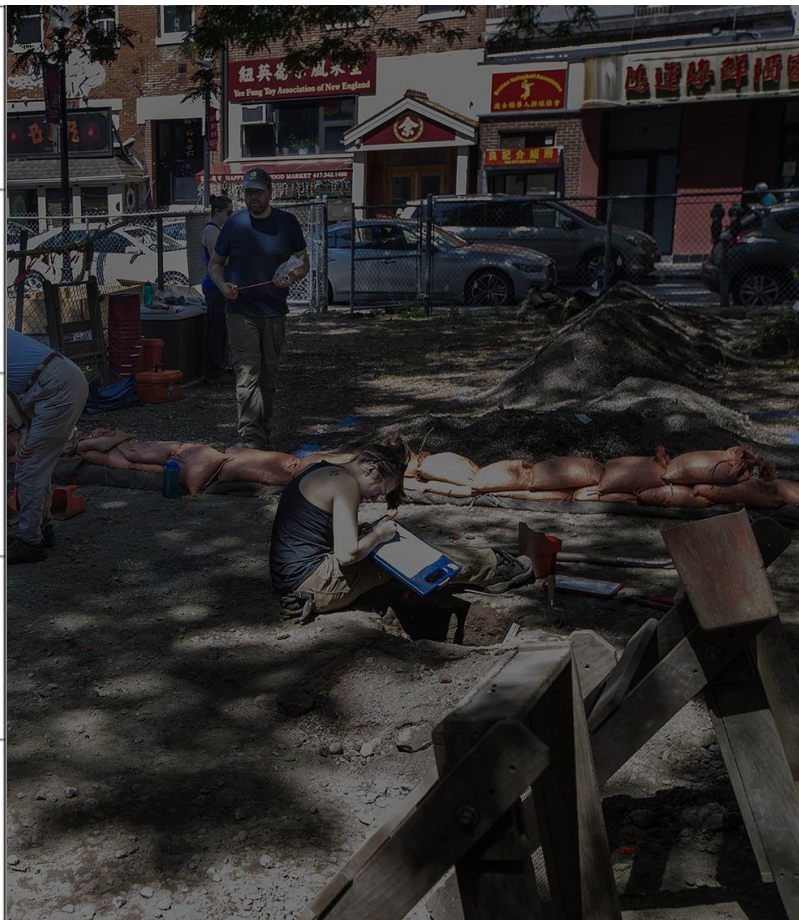
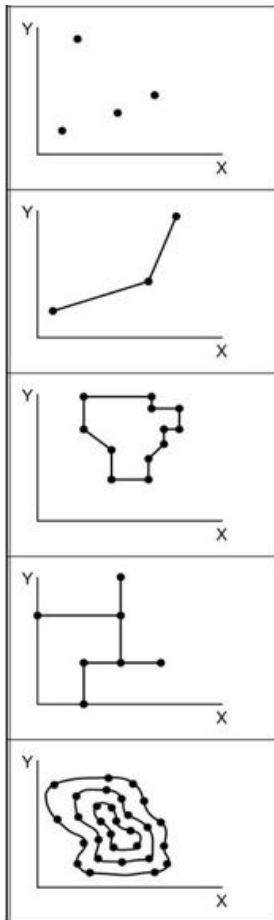
why vector?

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examples:

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**in attribute
tables, you are
forced to define
field types**

**field data types
are different from
spatial data types**

hover your cursor over one of these field names

tractsIncome_firesDamsCentersCSMO

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

	OBJECTID *	Shape *	GEOID	GEOIDFQ	ALAND	AWATER	total households	medianIncome	meanIncome	fires_burned acres	fires_total wildfires	dams_HazardRank	dams_count
1	96	Polygon	51167030201	1400000US51167030201	202363915	2039256	1067	27527	47763	2072.3	89	4	10
2	372	Polygon	51051040200	1400000US51051040200	125624229	2762314	1171	45573	57503	508.2	64	2	3
3	374	Polygon	51051040100	1400000US51051040100	186522111	3149348	1492	50192	61974	5112.82	167	2	4
4	1480	Polygon	51027010300	1400000US51027010300	122301390	278045	1121	46845	56404	3908.65	83	2	3
5	1810	Polygon	51195931400	1400000US51195931400	102883586	599357	2162	54324	75171	346.01	44	6	5
6	1831	Polygon	51195931100	1400000US51195931100	161727594	491545	959	37932	48315	1401.9	44	2	6
7	1832	Polygon	51195930800	1400000US51195930800	118247026	751313	710	47250	62993	452.86	22	4	3
8	1838	Polygon	51195931600	1400000US51195931600	85155788	507548	990	42717	59289	340.8	52	1	2
9	2091	Polygon	51105950100	1400000US51105950100	210906854	1448711	1058	32175	42806	4552.7	121	2	4
10	151	Polygon	51107611028	1400000US51107611028	24012316	1651866	1778	<Null>	321457	0.2	2	3	4
11	297	Polygon	51185020301	1400000US51185020301	131017855	141730	998	53194	76234	218.6	23	2	4

0 of 2,198 selected

Filters: 100%

and you'll see a "Type"

tractsIncome_firesDamsCentersCSMO

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

	OBJECTID *	Shape *	GEOID	GEOIDFQ	ALAND	AWATER	total households	medianIncome	meanIncome	fires_burned acres	fires_total wildfires	dams_HazardRank	dams_count	
1	96	Polygon	511670	GEOID	0000US51167030201	202363915	2039256	1067	27527	47763	2072.3	89	4	10
2	372	Polygon	510510	Type: Text (11) Default: <Null> Read-Only: No Nullable: Yes Indexed: No Required: No	0000US51051040200	125624229	2762314	1171	45573	57503	508.2	64	2	3
3	374	Polygon	510510		0000US51051040100	186522111	3149348	1492	50192	61974	5112.82	167	2	4
4	1480	Polygon	510270		0000US51027010300	122301390	278045	1121	46845	56404	3908.65	83	2	3
5	1810	Polygon	511959		0000US51195931400	102883586	599357	2162	54324	75171	346.01	44	6	5
6	1831	Polygon	51195931100		1400000US51195931100	161727594	491545	959	37932	48315	1401.9	44	2	6
7	1832	Polygon	51195930800		1400000US51195930800	118247026	751313	710	47250	62993	452.86	22	4	3
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0 of 2,198 selected

Filters: 100%

these are "Field types"

(also visible when adding fields to attribute table)

The screenshot displays a GIS application interface. On the left, a table titled 'tractsIncome_firesDamsCentersCSMO' is shown. The table has columns: OBJECTID, Shape, GEOID, GEOIDFQ, and ALA. The GEOID column is highlighted with a red box. A dropdown menu is open for the GEOID field, showing the following properties:

- Type: Text (11)
- Default: <Null>
- Read-Only: No
- Nullable: Yes
- Indexed: No
- Required: No

In the center, a 'Geoprocessing' dialog box is open, showing the 'Add Field' tab. The 'Input Table' is set to 'Earthquakes'. The 'Field Name' is 'Date'. The 'Field Type' dropdown menu is open, showing the following options:

- Short (16-bit integer)
- Long (32-bit integer)
- Big integer (64-bit integer)
- Float (32-bit floating point)
- Double (64-bit floating point)
- Text
- Date
- Date only
- Time only
- Timestamp offset
- Blob (binary data)
- GUID (globally unique identifier)
- Raster

On the right, a table titled 'meanIncome_fires_burned acres_fires_total wildfires_dams_HazardRank_dams_count' is shown. The table has columns: meanIncome, fires_burned acres, fires_total wildfires, dams_HazardRank, and dams_count. The table contains 10 rows of data.

**field types control
how the values in a
field are encoded,
which impacts what
you can do with
them**

LAB 04

Counting people

5. This is the most important step:

1. Select all of the columns that contain data you want to map, click into the “Home” group, and change the data type of everything to “Number”

2. Then, “Save As” > save the spreadsheet in `.xlsx` format, with a shorter title like `data_numeric`

6. Save the spreadsheet and quit Excel

Warning

Step #5 is very important because if you try to load a `.csv` into ArcGIS Pro, it is harder to enforce data types on a field-by-field basis. ArcGIS and Excel play nicely together. Arc understands when something is a number in Excel, but if you loaded the plain `.csv` into Arc, everything would probably get interpreted as a `text` field, which is not compatible for choropleth mapping.

two biggest things to remember

1. join fields need to be of the same data type

Add Join ? x

Input Table
tl_2024_51_tract

Input Field
GEOIDFQ

Join Table
'ACSST5Y2024#S1901-Data\$'

Join Field
GEO_ID

2. you can't numerically sort or do math on text

S1901_C01_001E	S1901_C01_002E	S1901_C01_003E	S1901_C01_004E
849	39.6		12.5
533	38.3		10.1
1405	31.7		7.2
1023	31.4		9
628	31.2		13.9
435	29.7		5.5
842	29.1	1.7	15.2
2036	27.8	6.5	4.9
789	27.5	19.1	10
670	27.2	3.6	27.6
1161	26.5	10.9	5.7

S1901_C01_002E
Type: Double
Default: <Null>
Read-Only: No
Nullable: Yes
Indexed: No
Required: No

here are the numeric types in ArcGIS Pro

Data type	Storable range	Size	Application
Short integer	-32,768 to 32,767	16 bits	Numbers without decimals
Long integer	-2,147,483,648 to 2,147,483,647	32 bits	Large numbers without decimals
Big integer	-9,007,199,254,740,991 to 9,007,199,254,740,991	64 bits	BIG numbers without decimals
Float	Approximately -3.4E38 to 1.2E38	32 bits	Numbers with decimals
Double	Approximately -2.2E308 to 1.8E308	64 bits	Numbers with BIG decimals

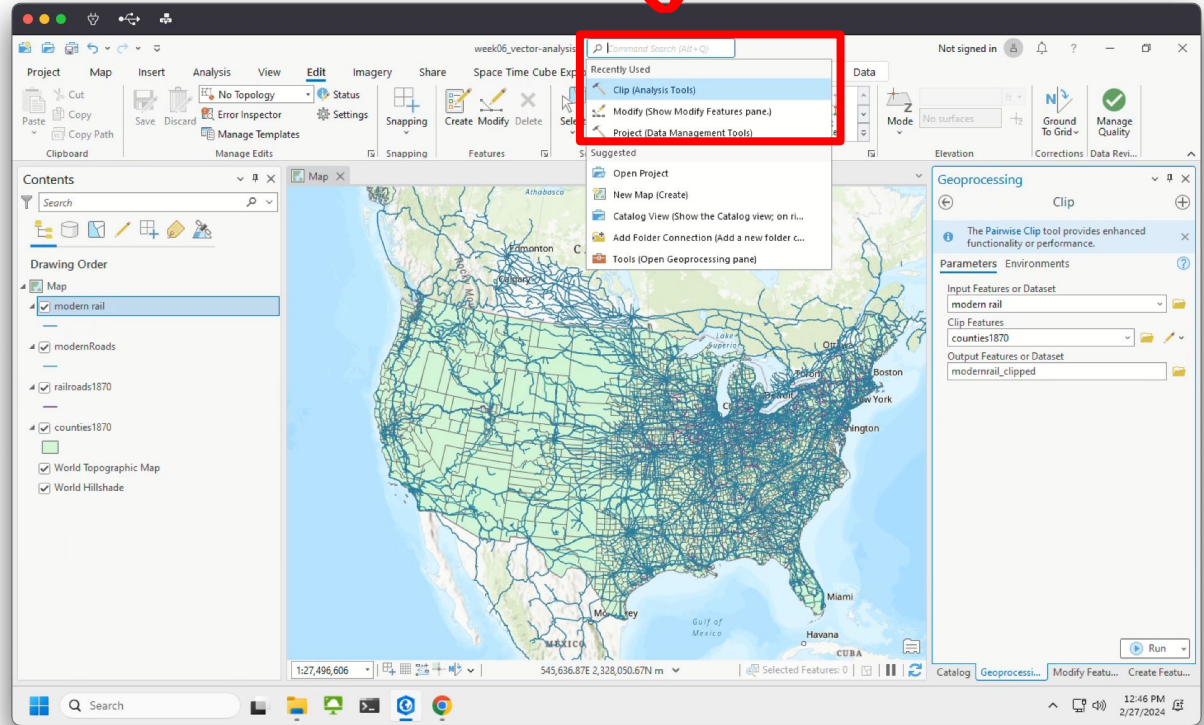
you can also have these:

- text
- BLOBS (binary large-objects), such as image or document attachments
- date and time
- global/object identifiers

vector operations and analysis

vector analysis

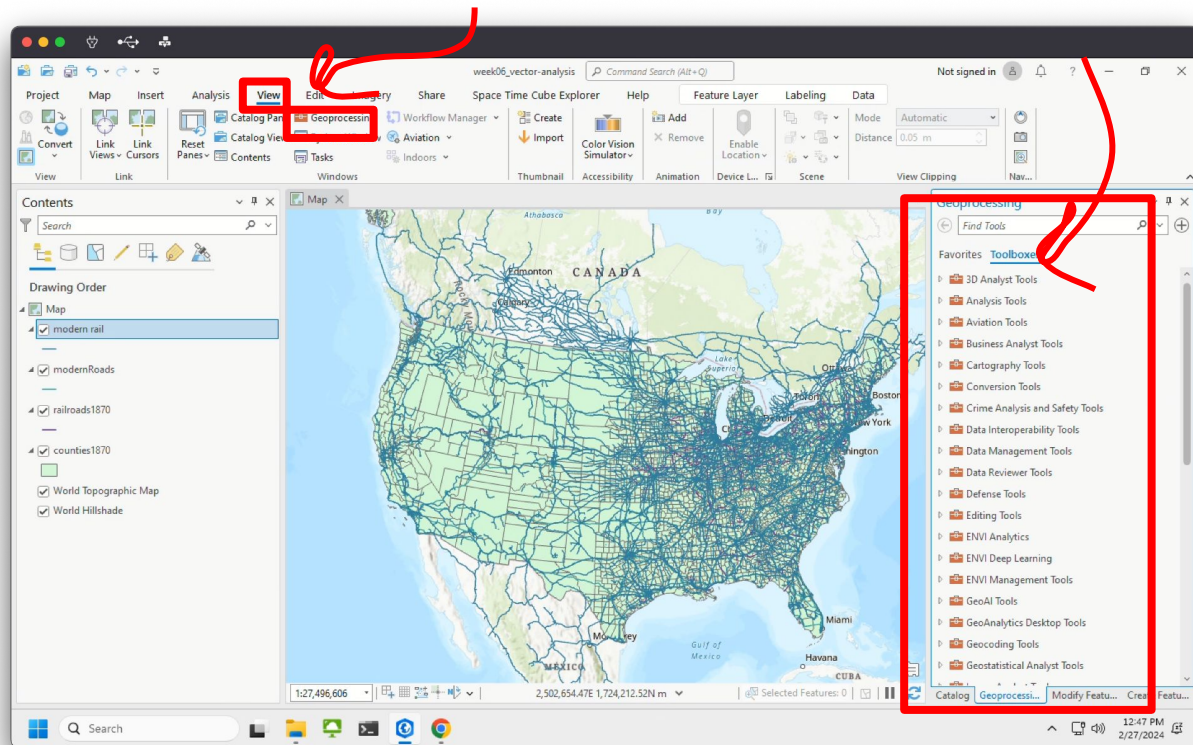
you can search for tools here



vector analysis

or, in “view” tab, open “geoprocessing”...

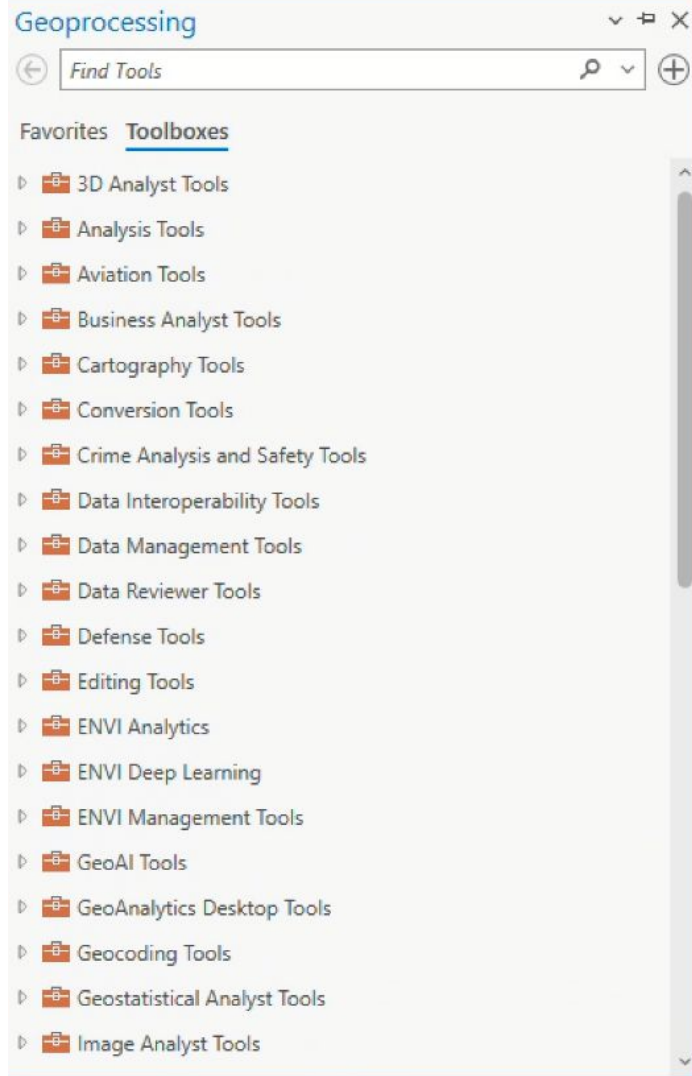
... then “toolboxes”



three main kinds of vector operations

given a geographic feature...

- what are its *subsets*?
- what *overlaps* it?
- what's it *nearby*?



three main kinds of vector operations

given a geographic feature...

- what are its *subsets*?
- what *overlaps* it?
- what's it *nearby*?



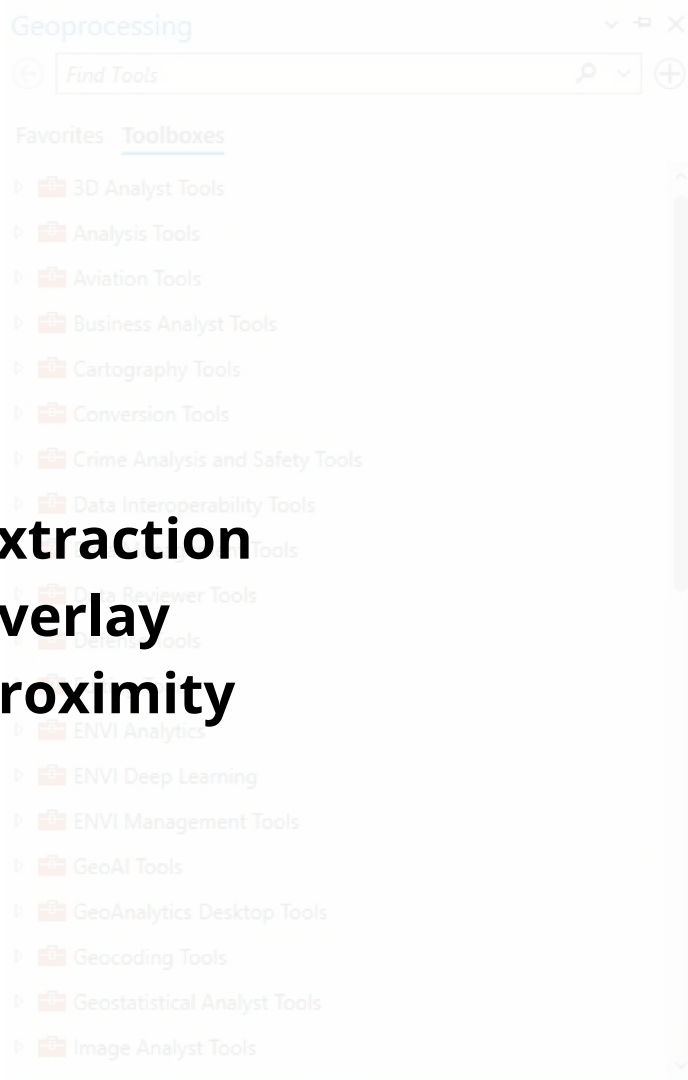
extraction



overlay

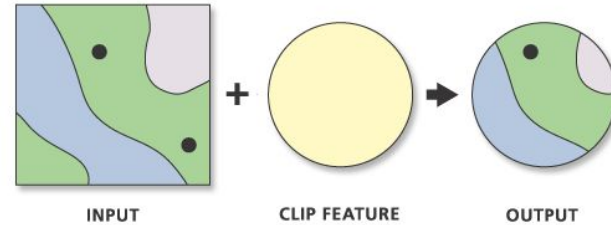


proximity



clip

Use this tool to cut out a piece of one dataset using one or more of the features in another dataset as a cookie cutter



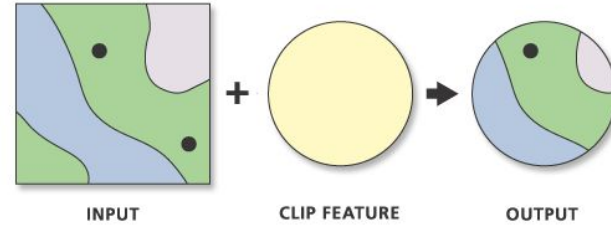
extraction

overlay

proximity

clip

*example: what roads
are inside of Henrico
County?*



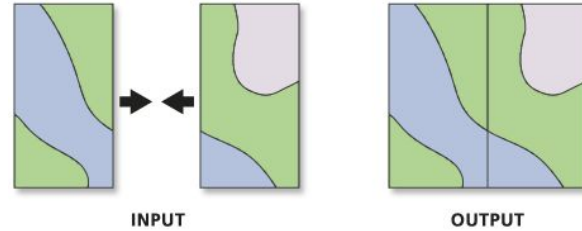
extraction

overlay

proximity

merge

combines multiple input datasets into a single, new output dataset. can combine point, line, polygons, or tables



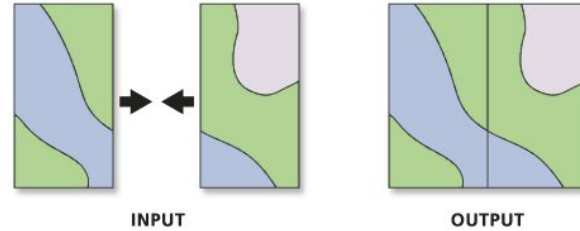
extraction

overlay

proximity

merge

*example: i need to combine
different block group
shapefiles across New
England*



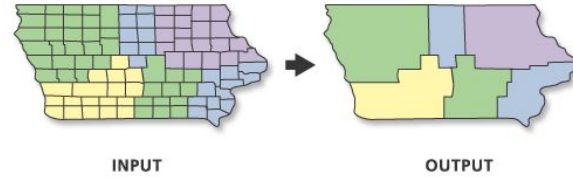
extraction

overlay

proximity

dissolve

aggregates features
based on specified
attributes (or based
on no attribute)



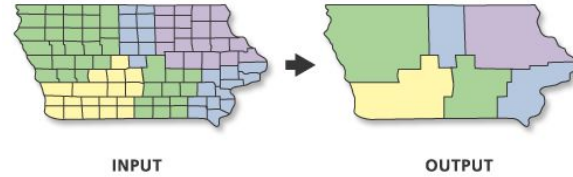
extraction

overlay

proximity

dissolve

*example: i need to
aggregate census
blocks up to block
groups*



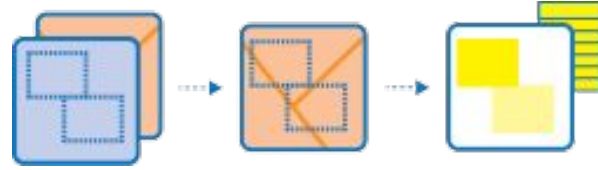
extraction

overlay

proximity

summarize within

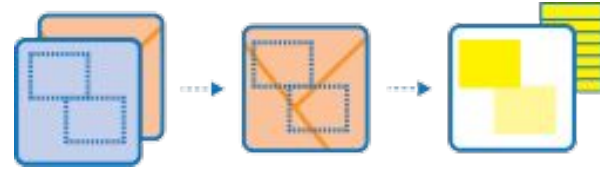
a fancy “spatial join,”
this overlays a
polygon layer with
another layer,
producing a count
field and other
summary statistics



extraction
overlay
proximity

summarize within

*example: how many
coal mines are
located in Virginia?*

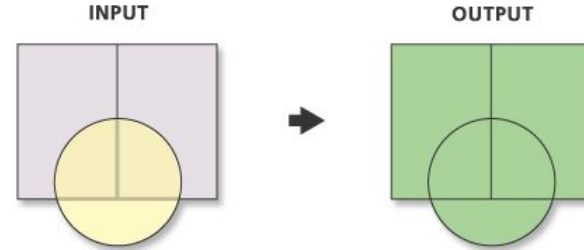


extraction
overlay
proximity

union

spatial “OR” query

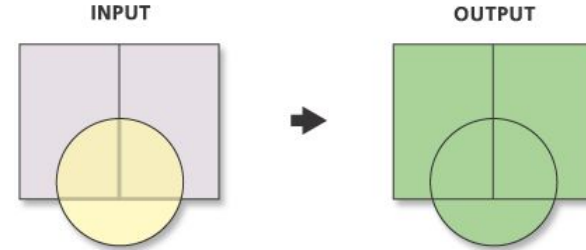
intersects two
features, then writes
a new feature
retaining their
original geometry
and where they
overlap



extraction
overlay
proximity

union

*example: which soil
types overlap with
flood inundation
zones?*

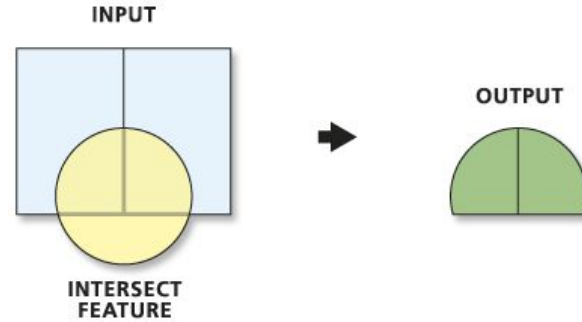


extraction
overlay
proximity

intersect

spatial “AND” query

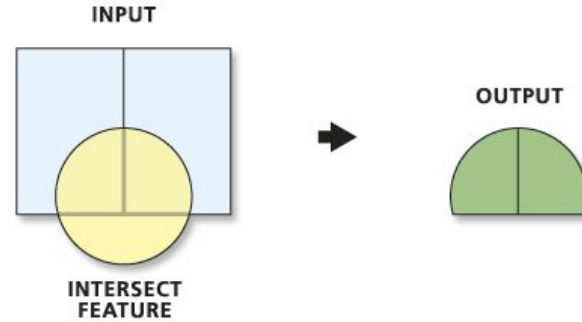
intersects two
features, then writes
a new feature
retaining *only* where
they overlap



extraction
overlay
proximity

intersect

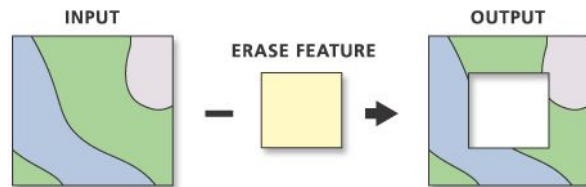
*example: given a few
input layers, what are
ideal habitat zones
for wild horses?*



extraction
overlay
proximity

erase

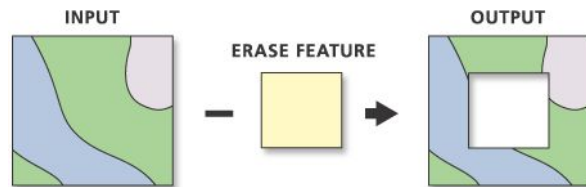
intersects two
features, then
subtracts the “erase”
from the “input.” this
is the donut maker



extraction
overlay
proximity

erase

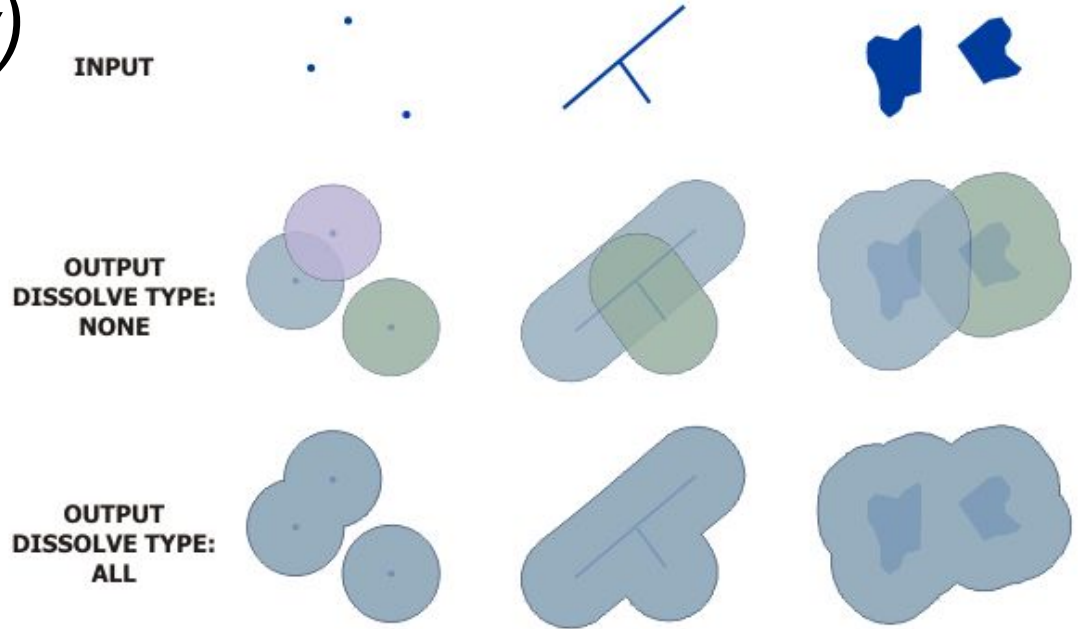
*example: i need to
remove all water
features from census
tracts in Richmond*



extraction
overlay
proximity

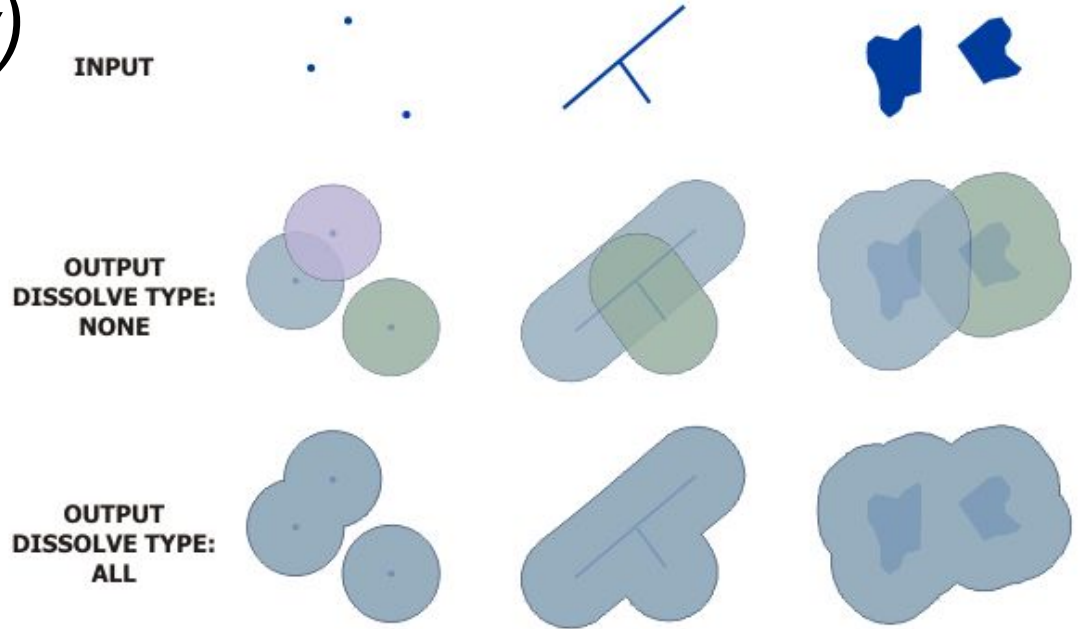
buffer (*proximity*)

creates buffer
polygons around
input features to a
specified distance
(can do multi-rings,
can dissolve output)



buffer (*proximity*)

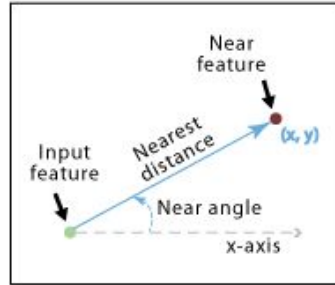
*example: how many
polluters fall within
200 and 400 feet of
tributaries?*



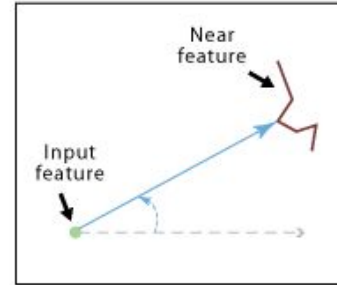
near (*proximity*)

calculates distance
and proximity
information between
the input features
and the closest
feature in another
layer or feature class

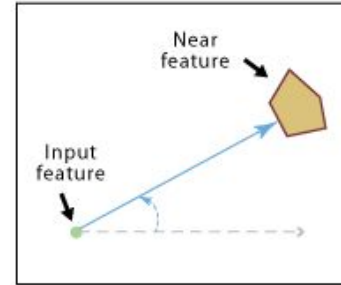
POINT TO POINT



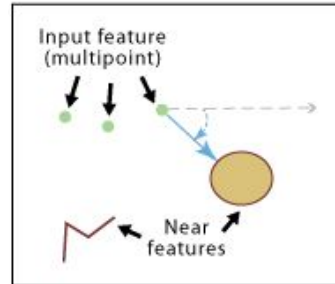
POINT TO LINE



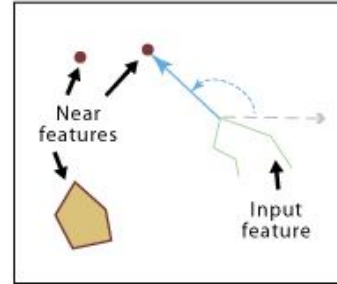
POINT TO POLYGON



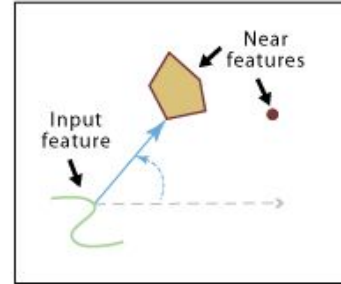
MIXED FEATURE TYPES



MIXED FEATURE TYPES



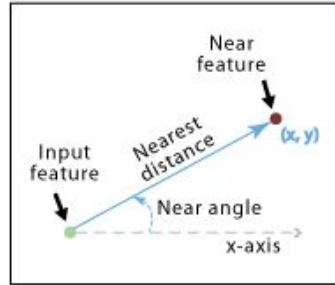
MIXED FEATURE TYPES



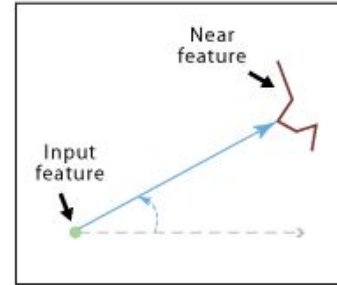
near (*proximity*)

example: what's the average distance of every polluter from their closest tributaries?

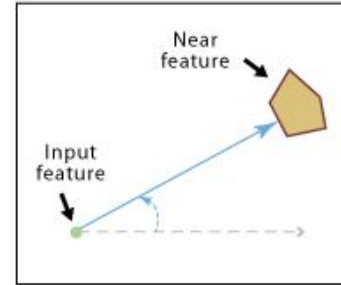
POINT TO POINT



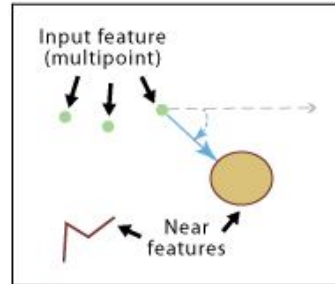
POINT TO LINE



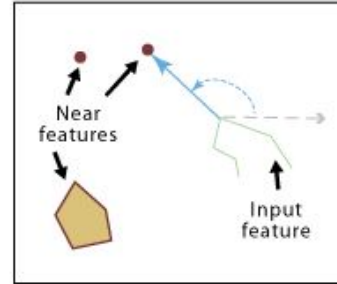
POINT TO POLYGON



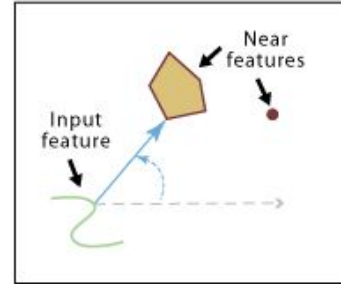
MIXED FEATURE TYPES



MIXED FEATURE TYPES



MIXED FEATURE TYPES



**there are dozens
more tools like
this**