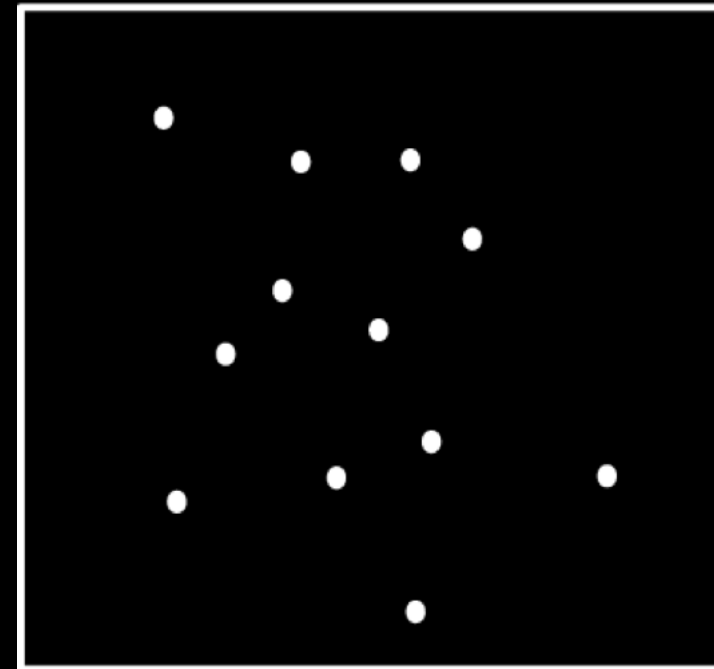


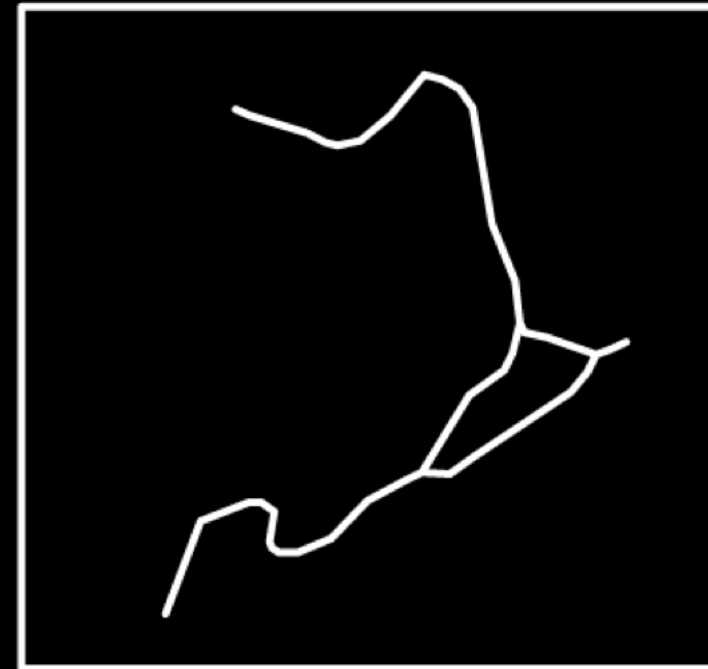
Why Vector Data?

- Recall: features vs fields
 - features: discrete entities with specific locations
 - fields: continuous functions of (x, y)
- “Vector” is GIS-speak for feature representations
 - dimensionality: point, line, area
 - topology: preserve/ignore connectivity
 - simple vs. composite

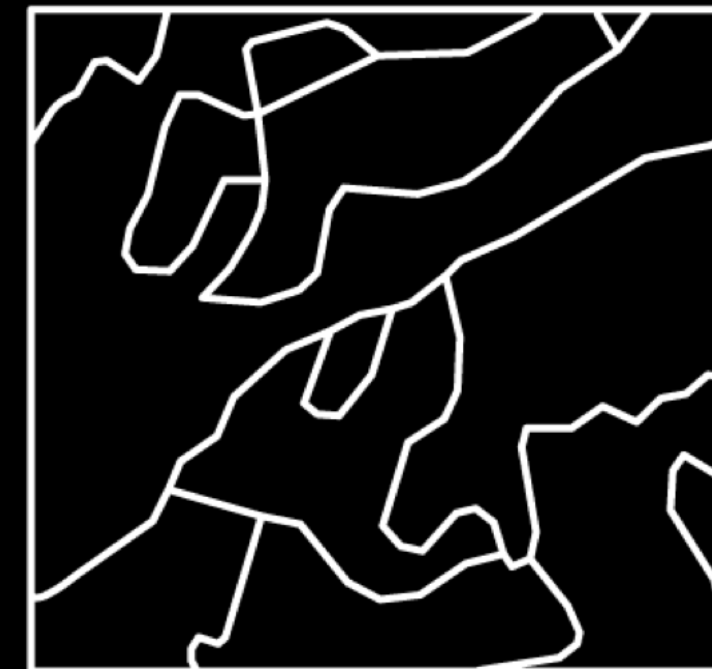
Simple Features



Point Feature



Line Feature



Area Feature

- Dimensionality

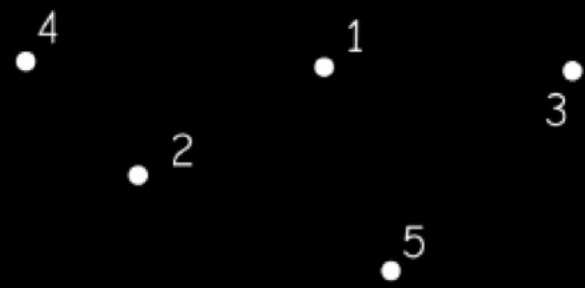
- 0: point
- 1: line
- 2: area

- Composition

- line: sequence of points
 - implicitly connected
- area: sequence of lines
 - boundary
 - implicit or explicit closure

Georelational Data Model

Points



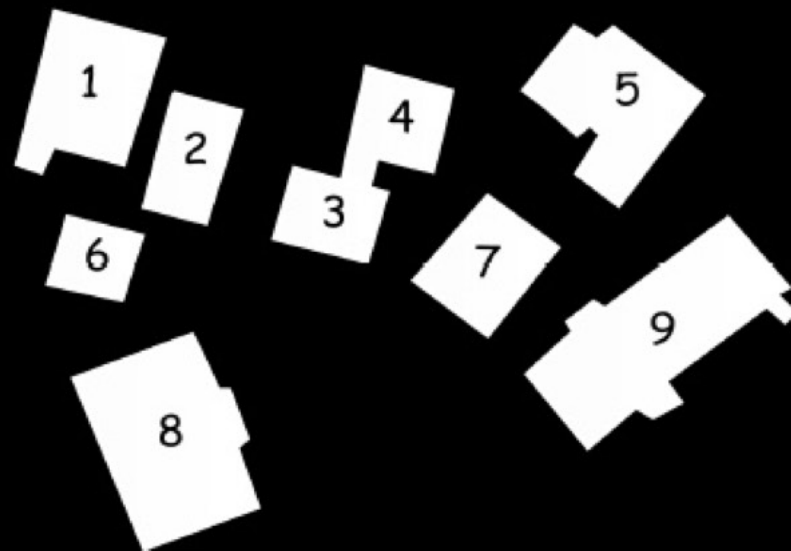
ID	Tower Name	Height	Format
1	WKRP	101.0	Pop
2	WYOU	55.5	Oldies
3	TPT	486.0	Public TV
4	WQXR	99.5	Classical
5	BBC	212.1	News

Lines



ID	Name
1	Tuckaseegee River
2	Pigeon Branch
3	Poplar Run
4	Shope Fork
5	Mel's Brook
6	Merdesansrame Creek
7	Longue Arm
8	Arroyo Grande

Polygons



ID	Building Name	Floors	Roof Type
1	Hodson Hall	6.0	flat, sealed tar
2	Borlaug Hall	5.5	pitched 9/12, tile
3	Guilford Technology Bldg.	4.0	flat, gasket
4	Shop Annex	2.5	flat, sealed tar
5	Animal Sciences Bldg.	1.0	pitched 12/12, tile
6	Administration Bldg.	14.0	pitched 6/12, metal
7	Climate Sciences Center	6.0	flat, sealed tar
8	Grantham Tower	1.0	pitched 9/12, tile
9	Biological Sciences Bldg.	9.0	pitched 12/12, tile

- Separation of **geometry** and **attributes**
 - related by feature ID
- May or may not represent **topology** (connectivity)
 - explicit topology: **coverage** (obsolete, but still used)
 - no topology: **shapefile**

Non-Topological Vector Data

- Lists of simple features
 - no explicit connectivity
 - features that share geometry, duplicate the geometry
- Advantages
 - easier to draw/display
 - don't have to look up arcs
 - simpler file formats
 - easier to extract subsets of features
- Disadvantages
 - can't tell if duplicate geometry is shared geometry
 - editing features with shared geometry can introduce inconsistencies
 - e.g. boundary between counties

Shapefile

- **foo.shp**
 - geometry
 - feature ID: coordinate list
- **foo.shx**
 - geometry index
 - feature ID: offset in bytes
 - from beginning of foo.shp
- **foo.dbf**
 - attributes
 - feature ID: attributes...
- **foo.prj**
 - coordinate system
 - geographic
 - projected
- **foo.xml**
 - metadata
- **foo.{anything else}:**
 - (probably ESRI-specific)

Databases

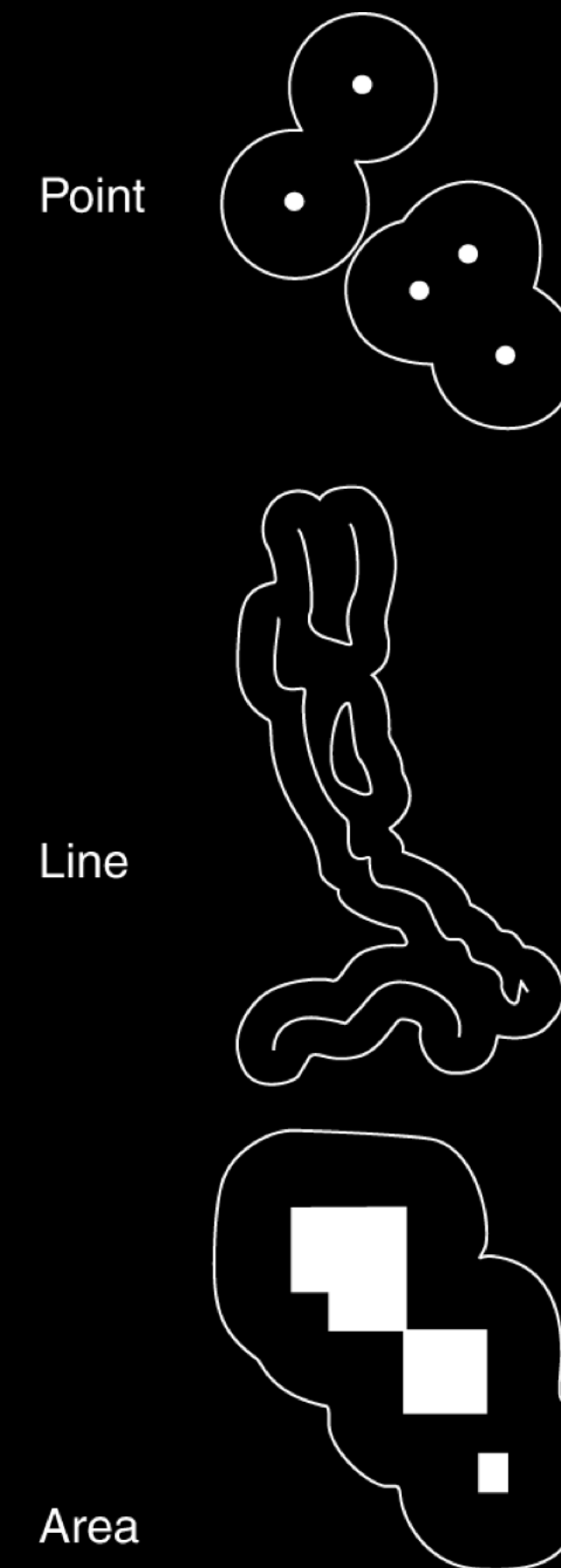
- Layers = database tables
 - geometry stored directly in the database
- GeoPackage
 - file containing SQLite database
 - ".gpkg" filename extension
 - open standard: anyone can implement it
- Geodatabase
 - folder containing database tables as files
 - ".gdb" folder name extension
 - ESRI proprietary
 - file format / database schema not documented
 - QGIS can read (sometimes) but not write

Vector Data Operations

- Buffering
- Overlay
- Editing

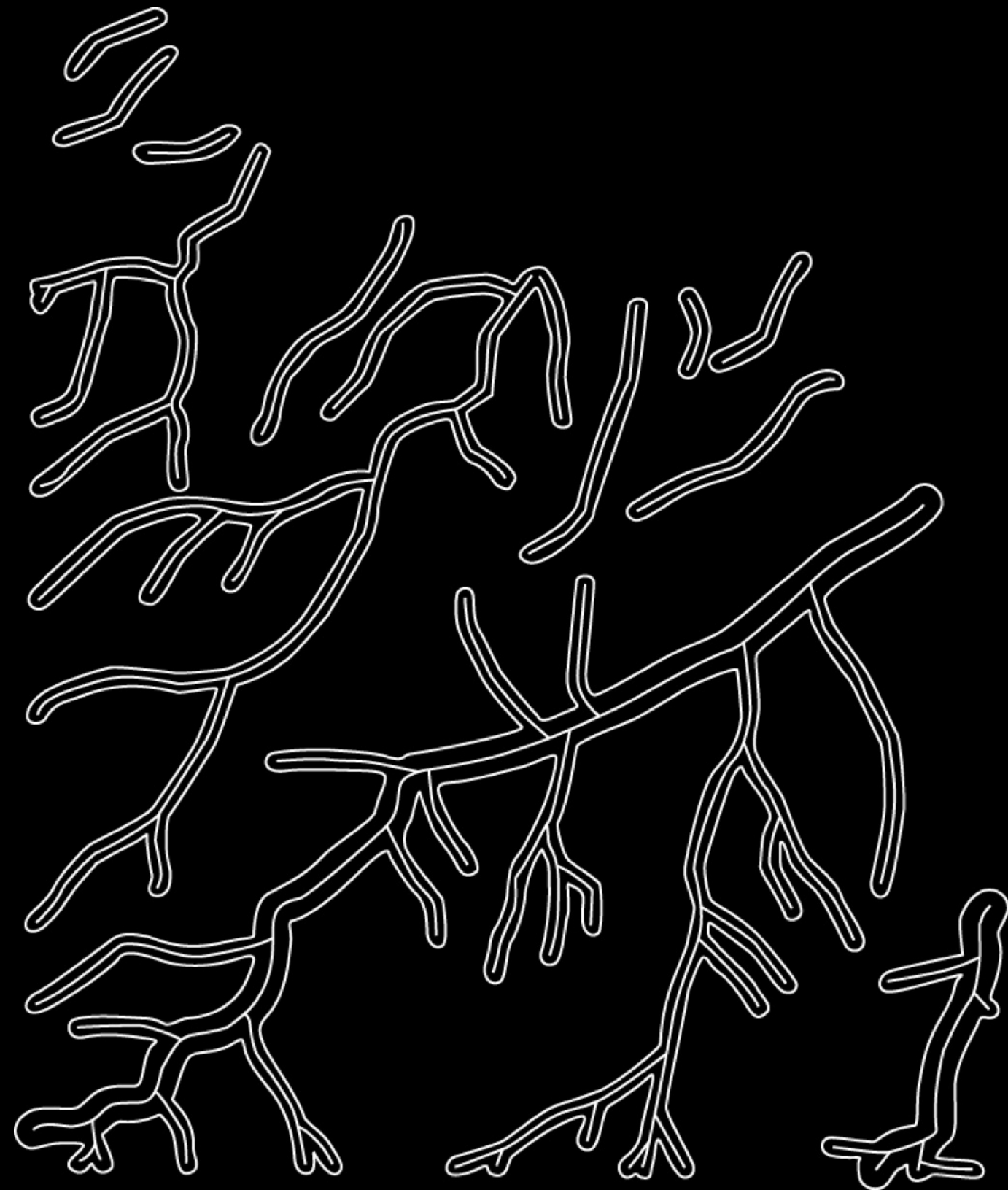
Proximity

- Buffering
 - feature of interest + distance D
 - ↓
 - buffer**
 - ↓
 - region w/in $D \leftrightarrow$ region beyond D
 - w/in distance D ?
 - ⇓
 - w/in buffer?
- Ubiquitous in GIS
 - exclusion zone
 - impact area
 - uncertainty
 - etc...

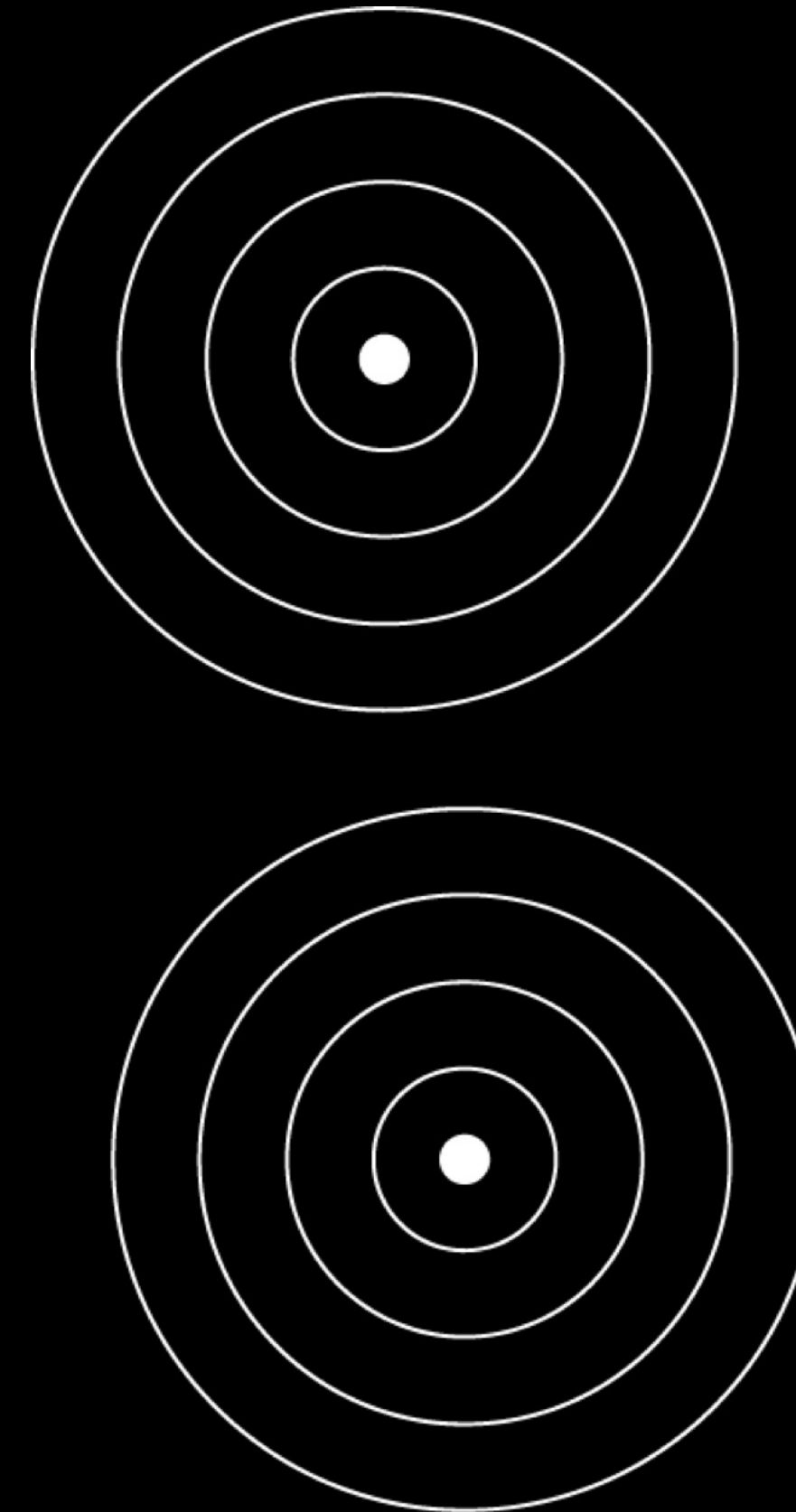


Buffering

- Variable-D buffers
 - e.g. stream gradient

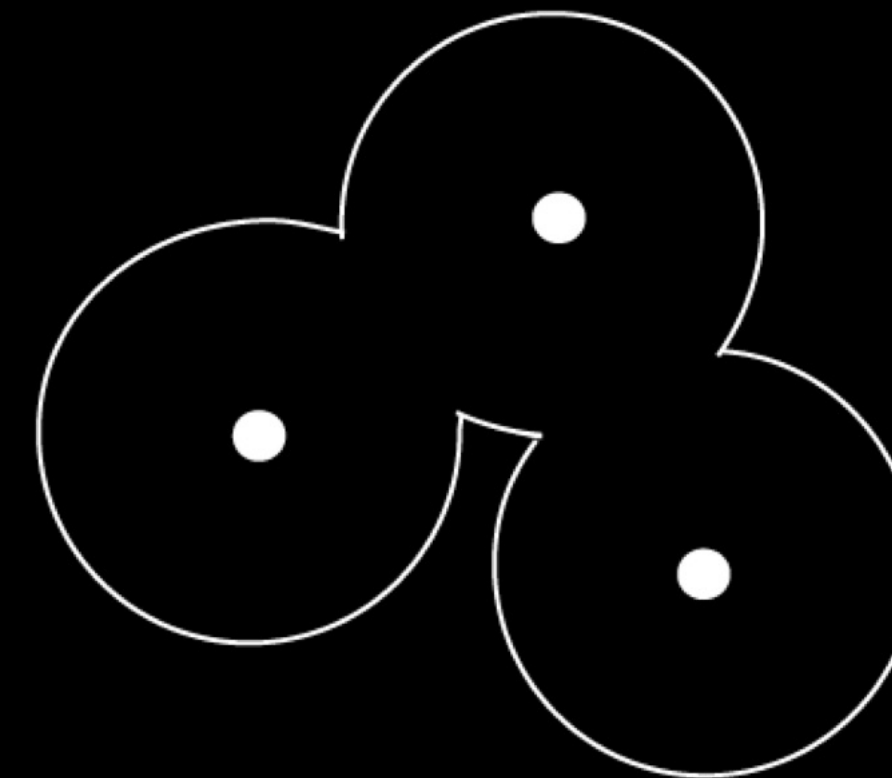
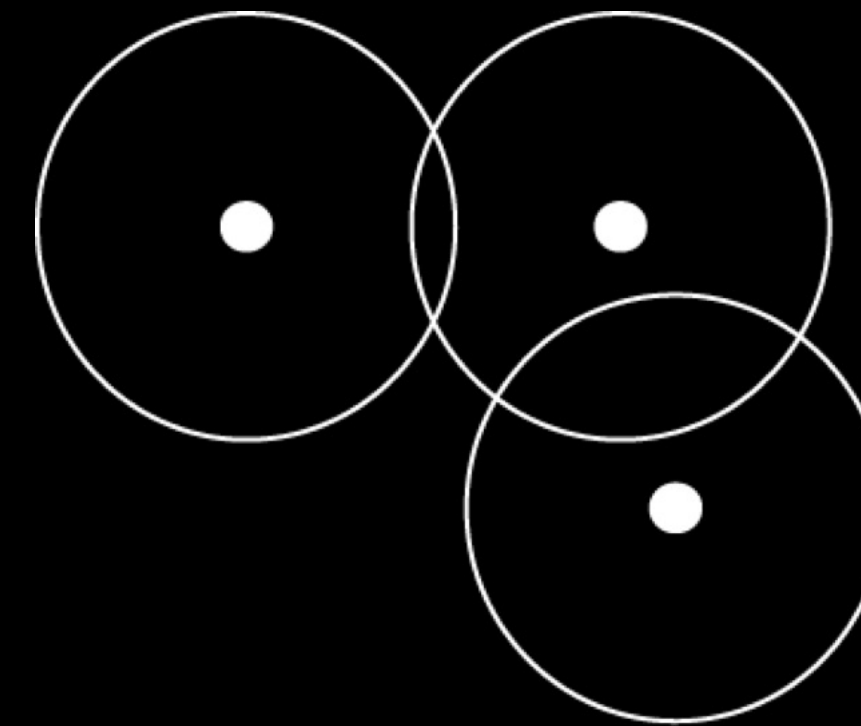


- Concentric buffers
 - e.g. distance from well



Buffering with Dissolve

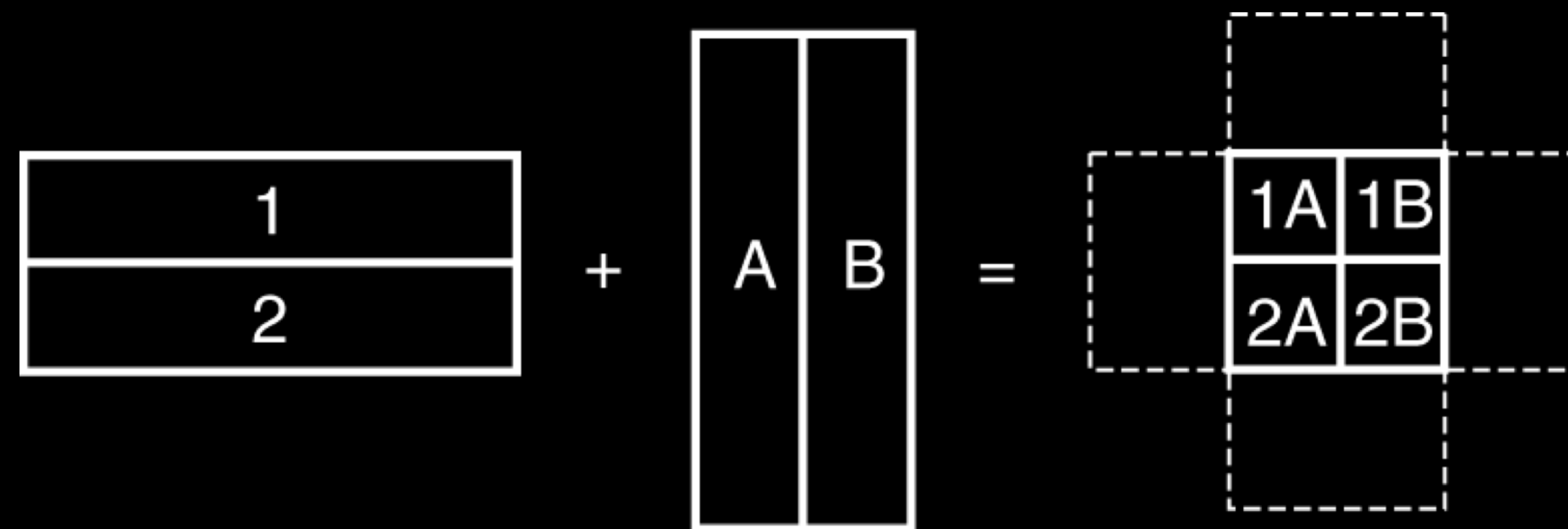
- Dissolve = remove overlap
 - Useful if same process governs creation of all the buffers
 - turns “each area” into “all areas”
 - e.g. “drug-free school zone”
 - “No drugs here”
more important than
“no drugs near school X”



Overlay

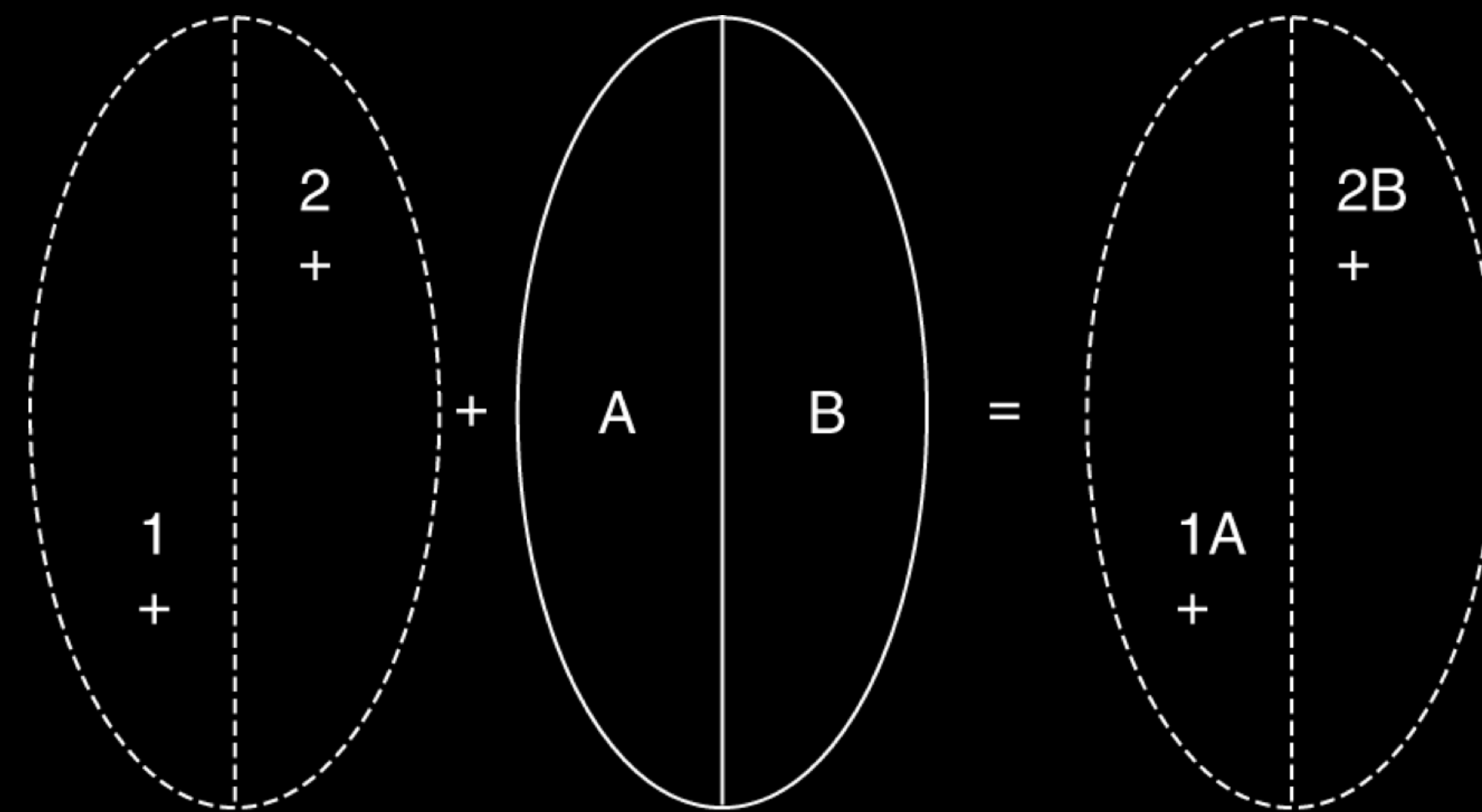
Combine feature layers

- $\text{New_Layer} = \text{Layer_1} \{ \text{op} \} \text{Layer_2}$
 - new **geometry** based on intersection of old geometries
 - old **attributes** distributed over new geometry
- Example: polygon AND polygon



Overlay: Point-in-Polygon

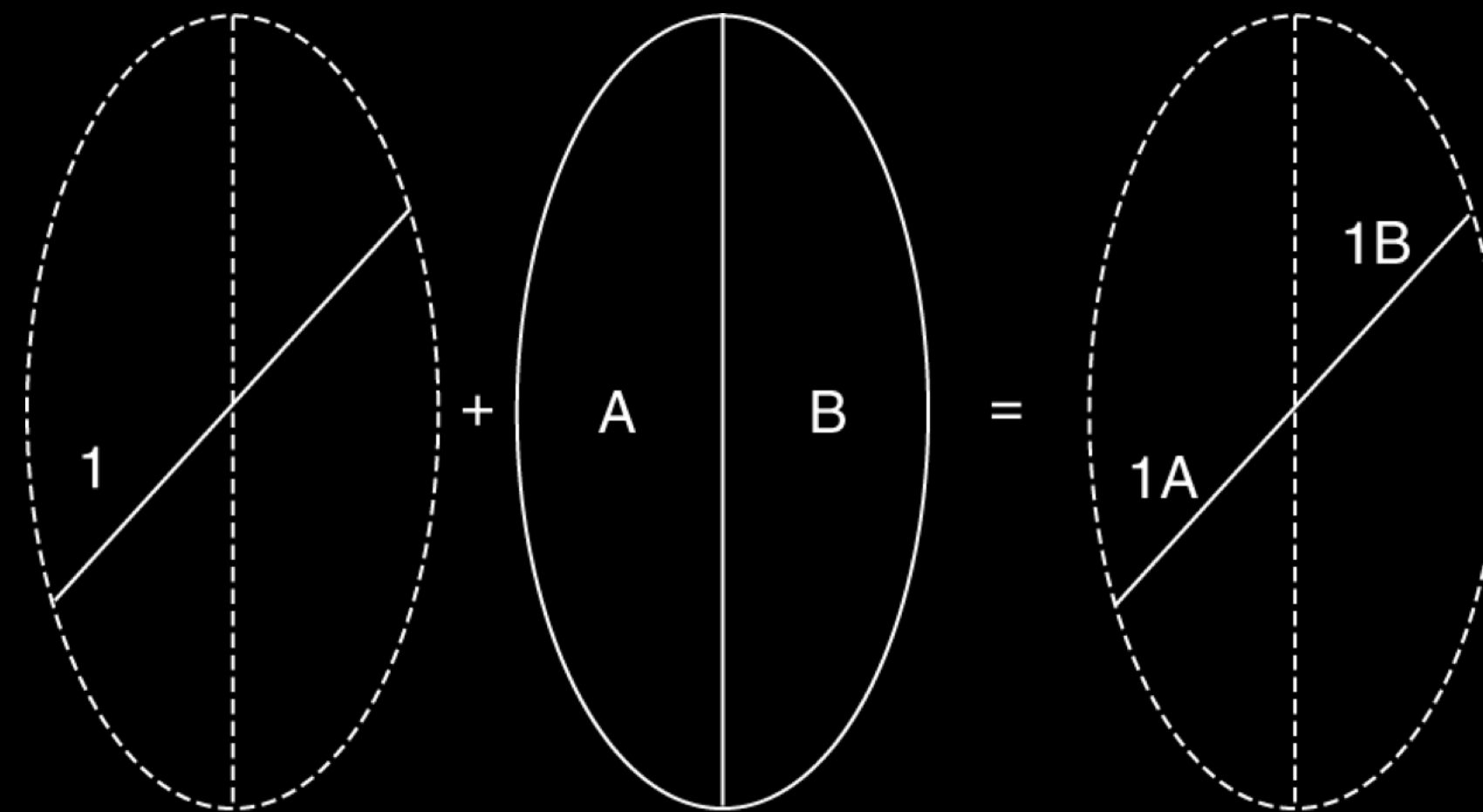
- Points receive attributes of containing polygon



- ... not the reverse: why?
 - hint: what if >1 point in a polygon...

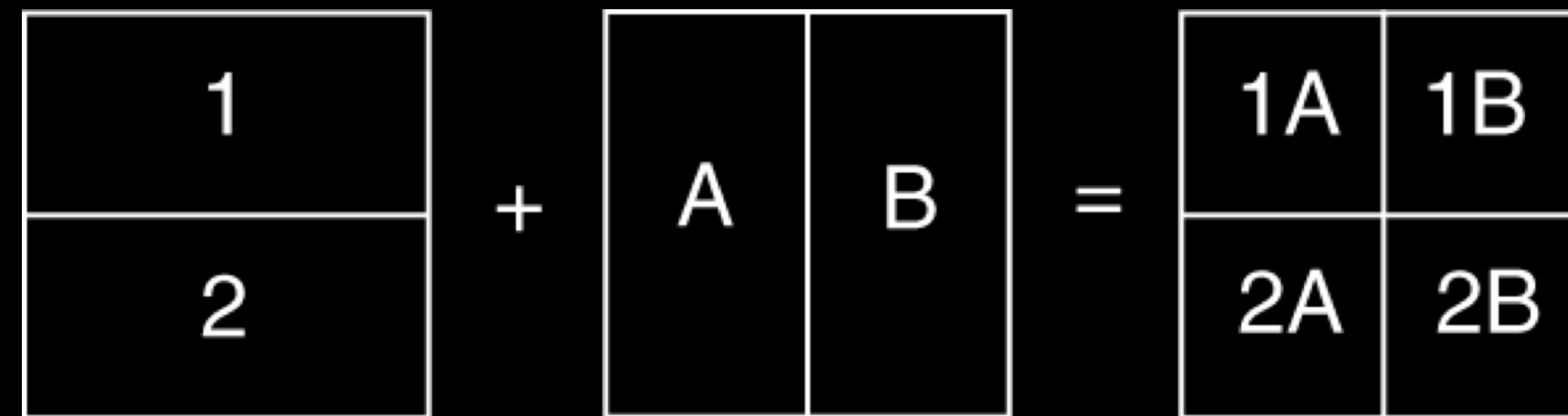
Overlay: Line-in-Polygon

- Old line \rightarrow 2 new lines
 - 1 per polygon
- New lines receive attributes of containing polygon



Overlay: Polygon-on-Polygon

- Polygons broken up as needed so attributes distribute correctly

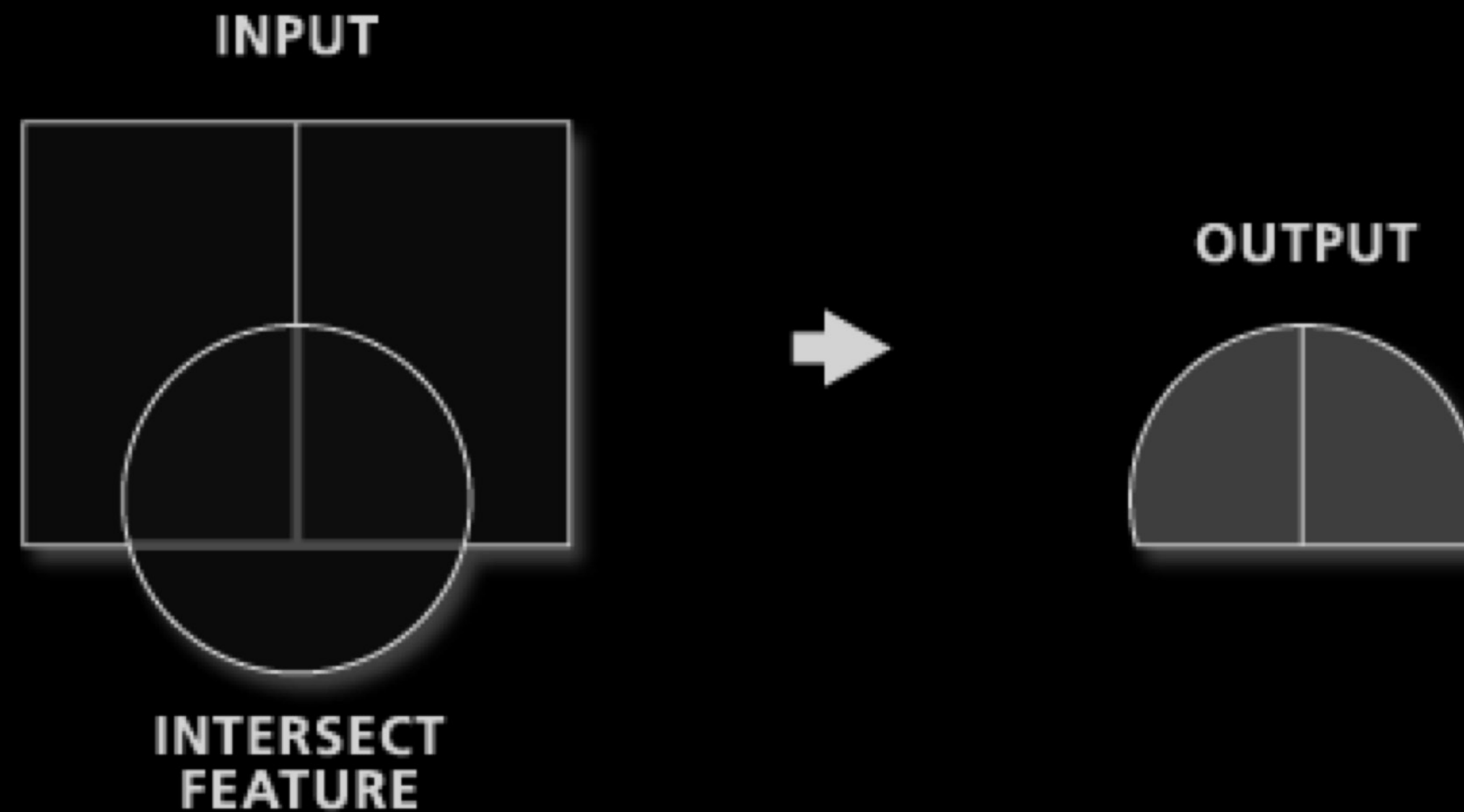


Overlay Operations

- Intersection
- Union
- Symmetrical Difference
- Difference
- Identity
- Update

Intersection (AND)

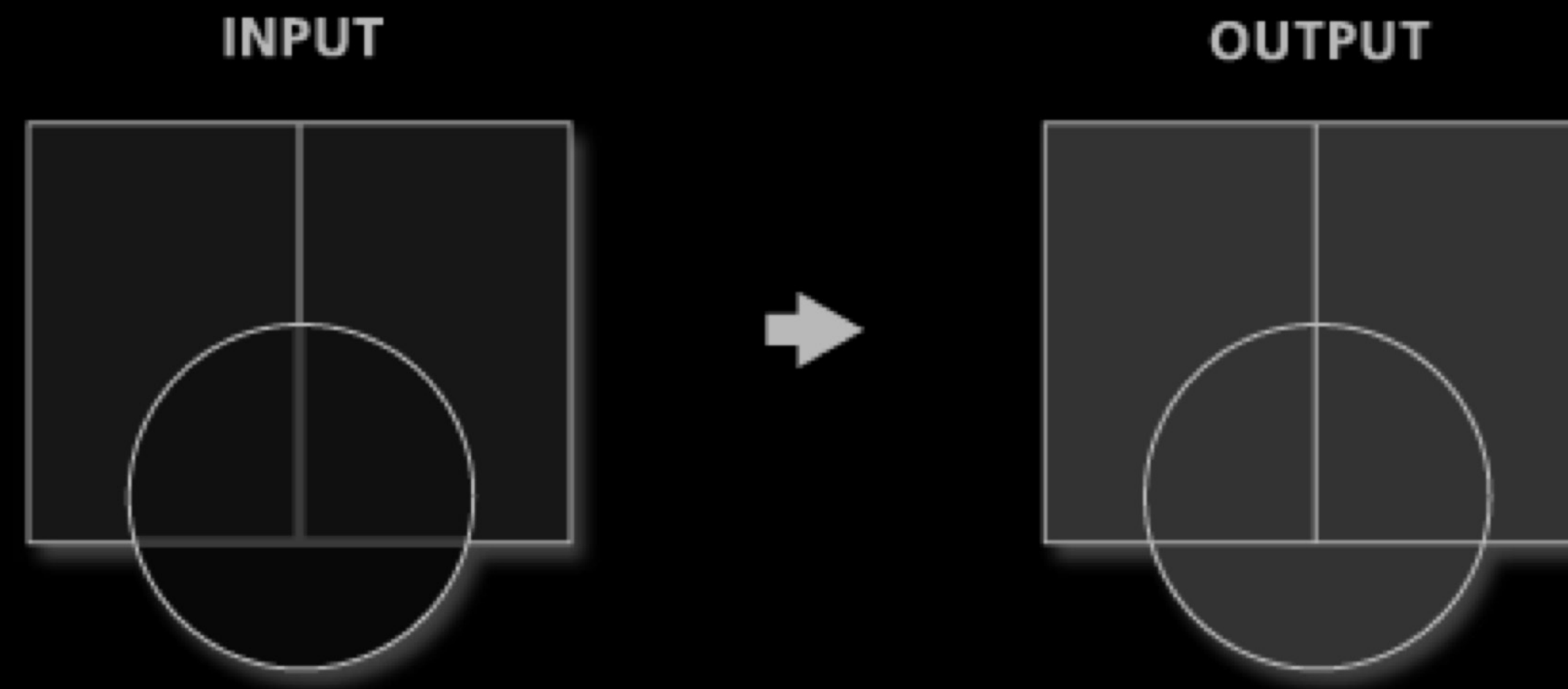
- only areas common to both input layers



- output = input AND intersect

Union (OR)

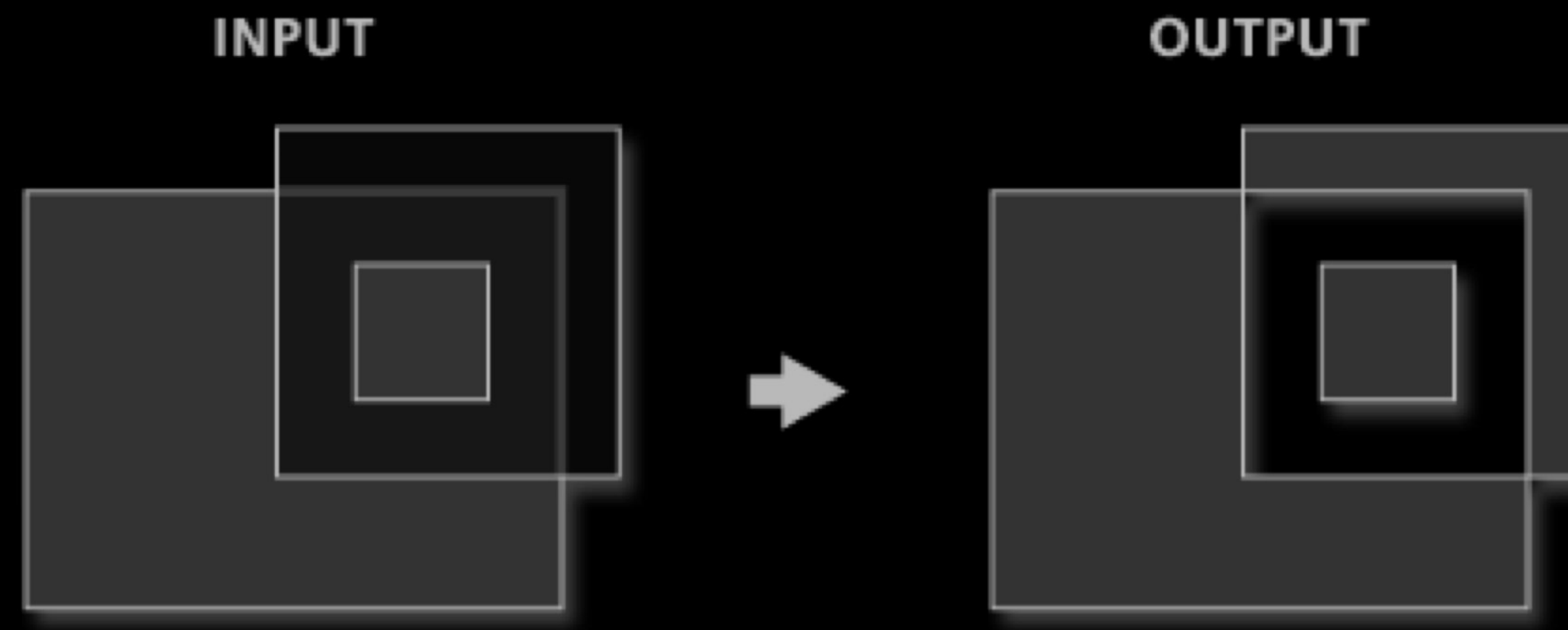
- All areas from both input layers



- $\text{output} = \text{input}_1 \text{ OR } \text{input}_2$
 - OR: inclusive “or”
 - 1 or 2 or both

Symmetrical Difference (XOR)

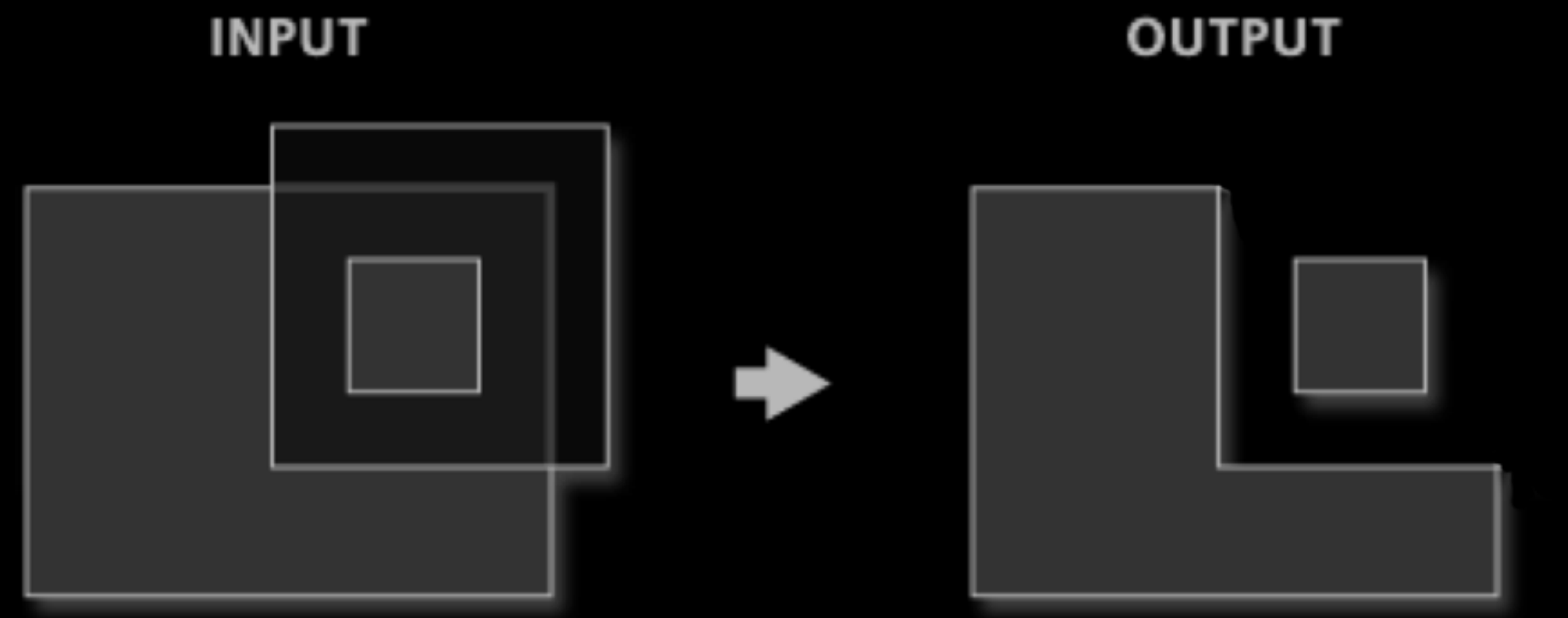
- Only areas unique to 1 input layer



- $\text{output} = \text{input}_1 \text{ XOR } \text{input}_2$
 - XOR: exclusive “or”
 - 1 or 2 but not both

Difference

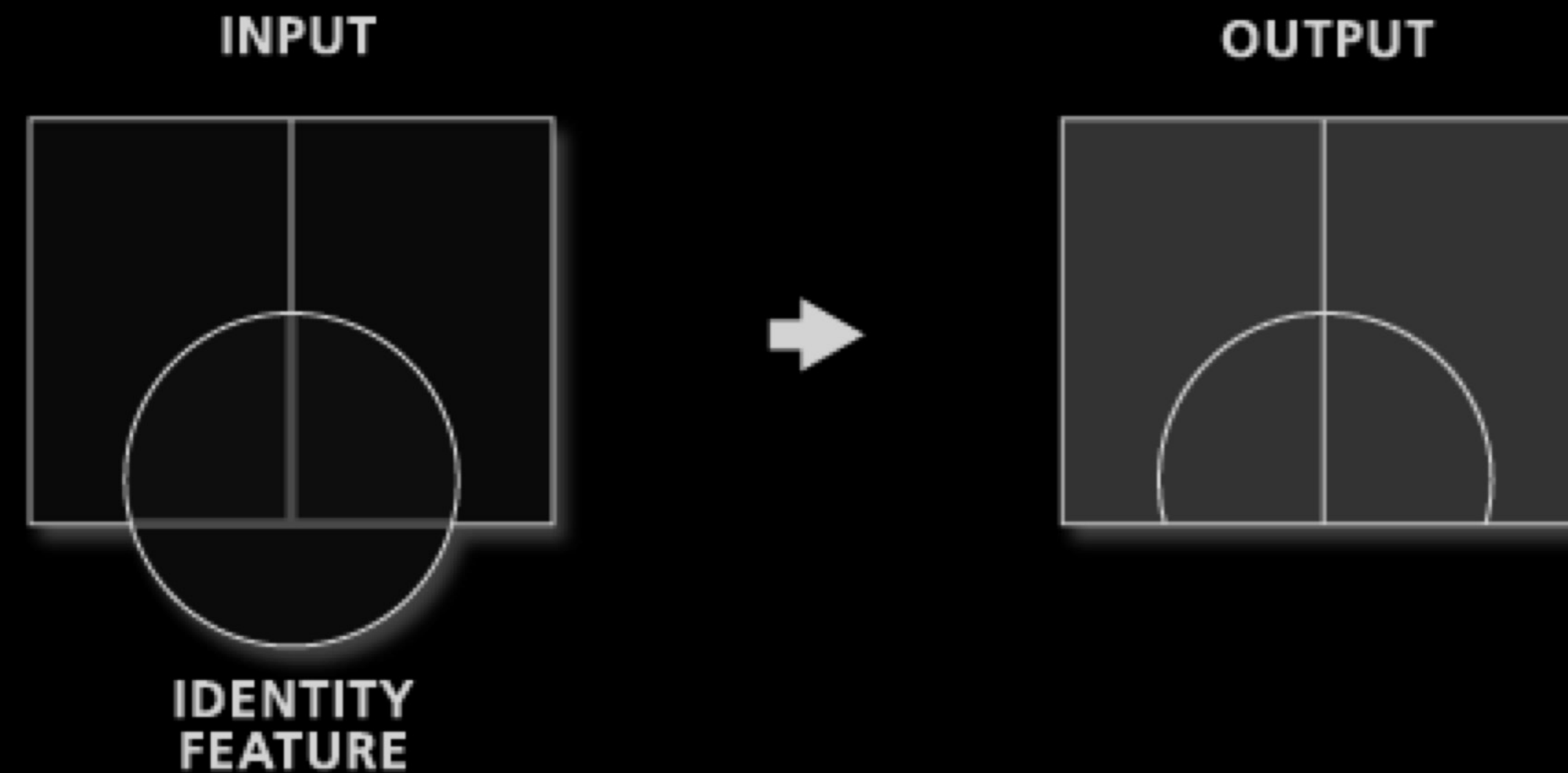
- Like symmetrical difference, but only keeps input layer



- $\text{output} = (\text{input XOR erase}) \text{ AND input}$

Identity

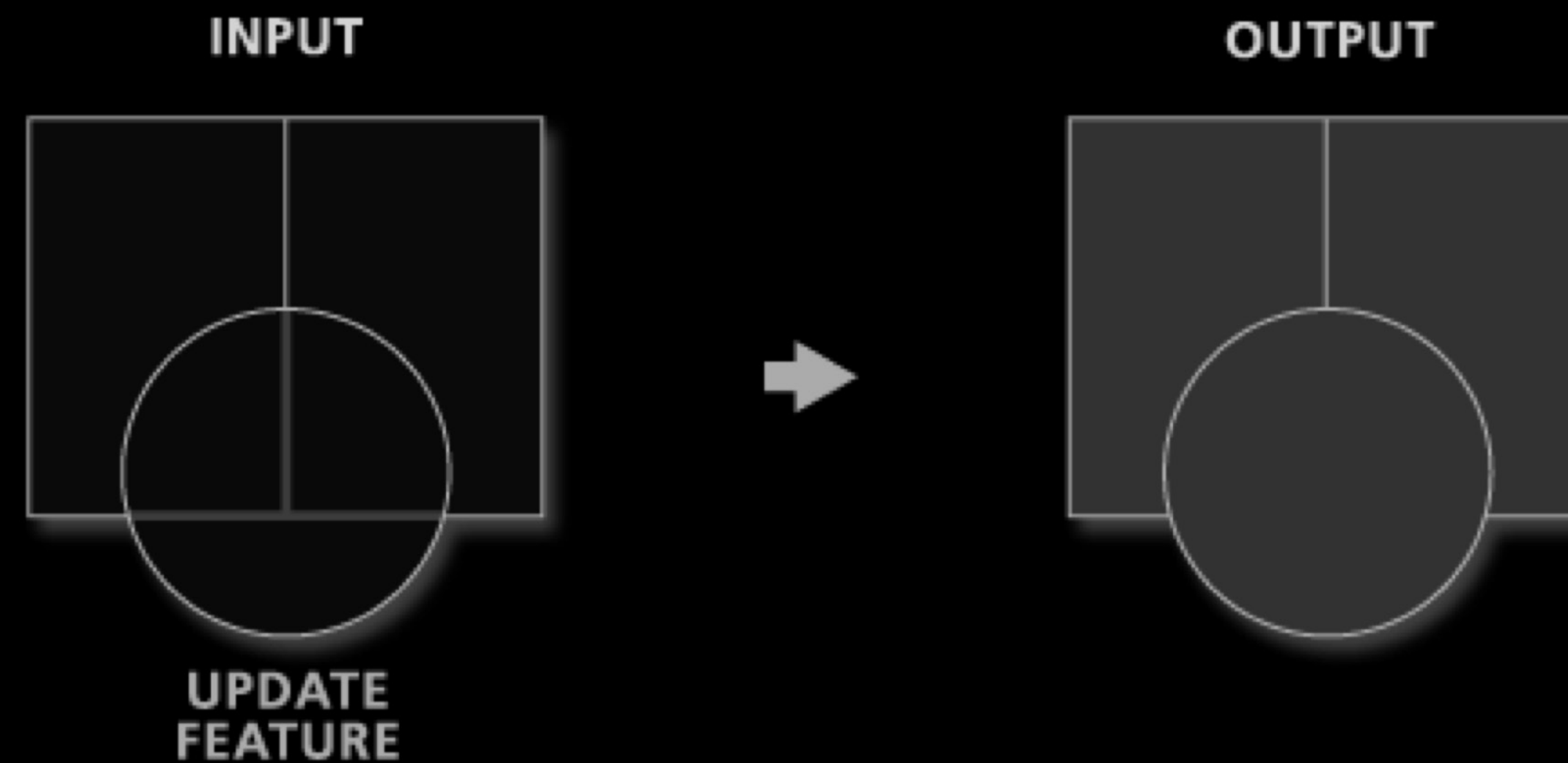
- Like intersect, but keeps all of 1st input layer



- $\text{output} = (\text{input AND identity}) \text{ OR input}$

Update

- Like difference, but keeps update layer



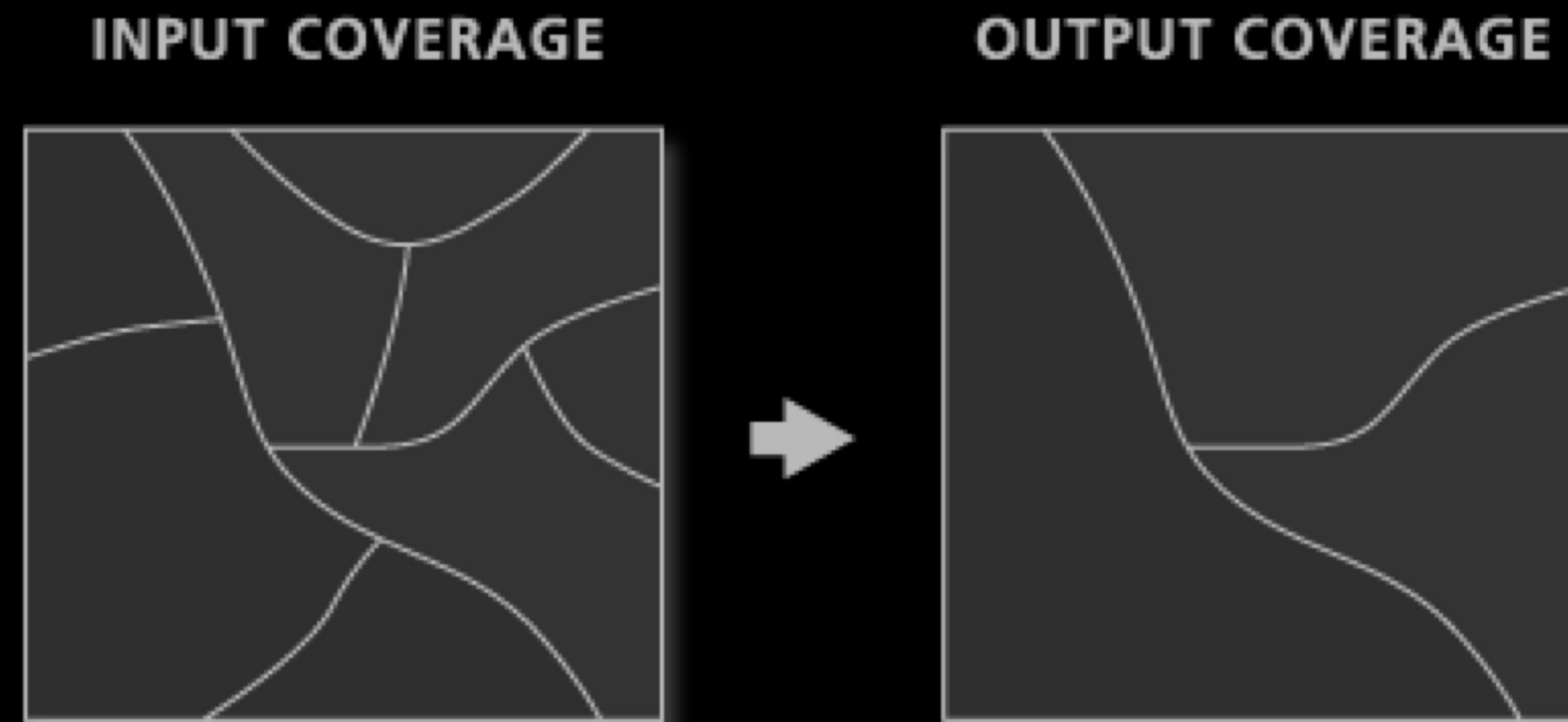
- $output = ((input \text{ XOR } update) \text{ AND } input) \text{ OR } update$

Vector Editing Operations

- Apply combinations of ...
 - overlay operators
 - attribute queries
 - ... to create new feature layers
-
- Dissolve
 - Clip
 - Merge
 - Select
 - Eliminate

Dissolve

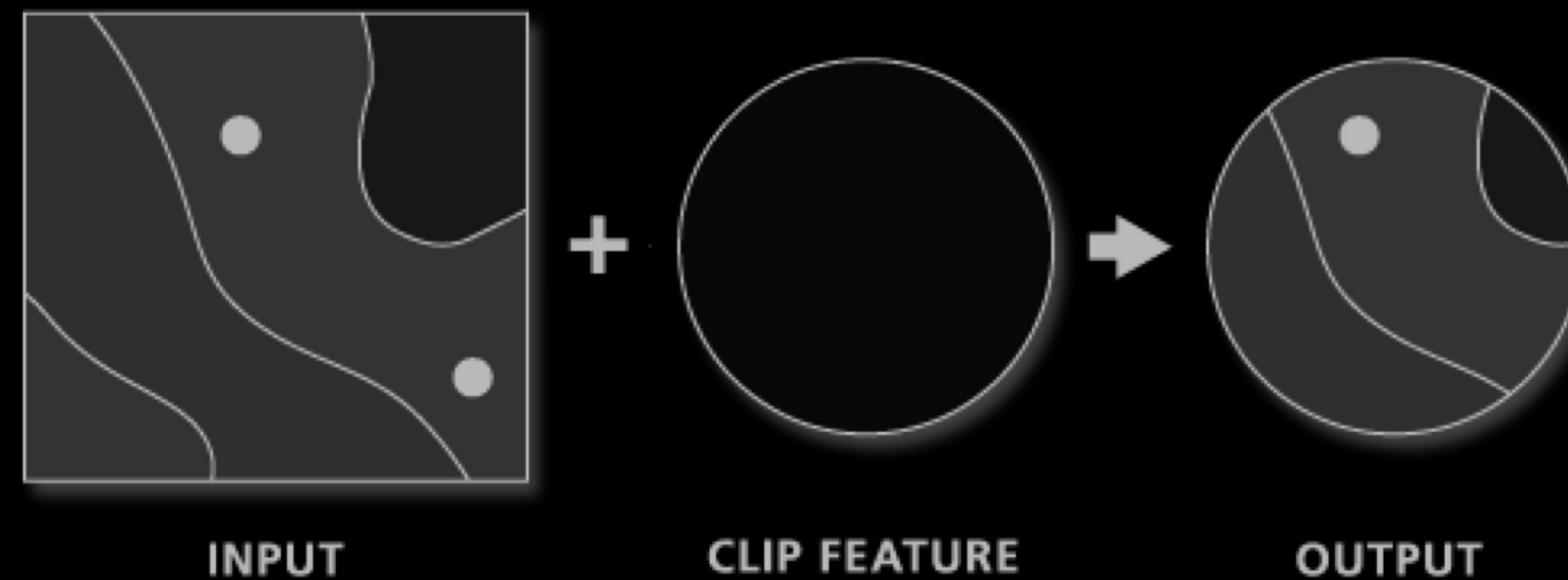
- Combine adjacent polygons based on shared attribute value



- i.e. remove unnecessary boundaries
 - simplifies analysis
 - smaller dataset

Clip

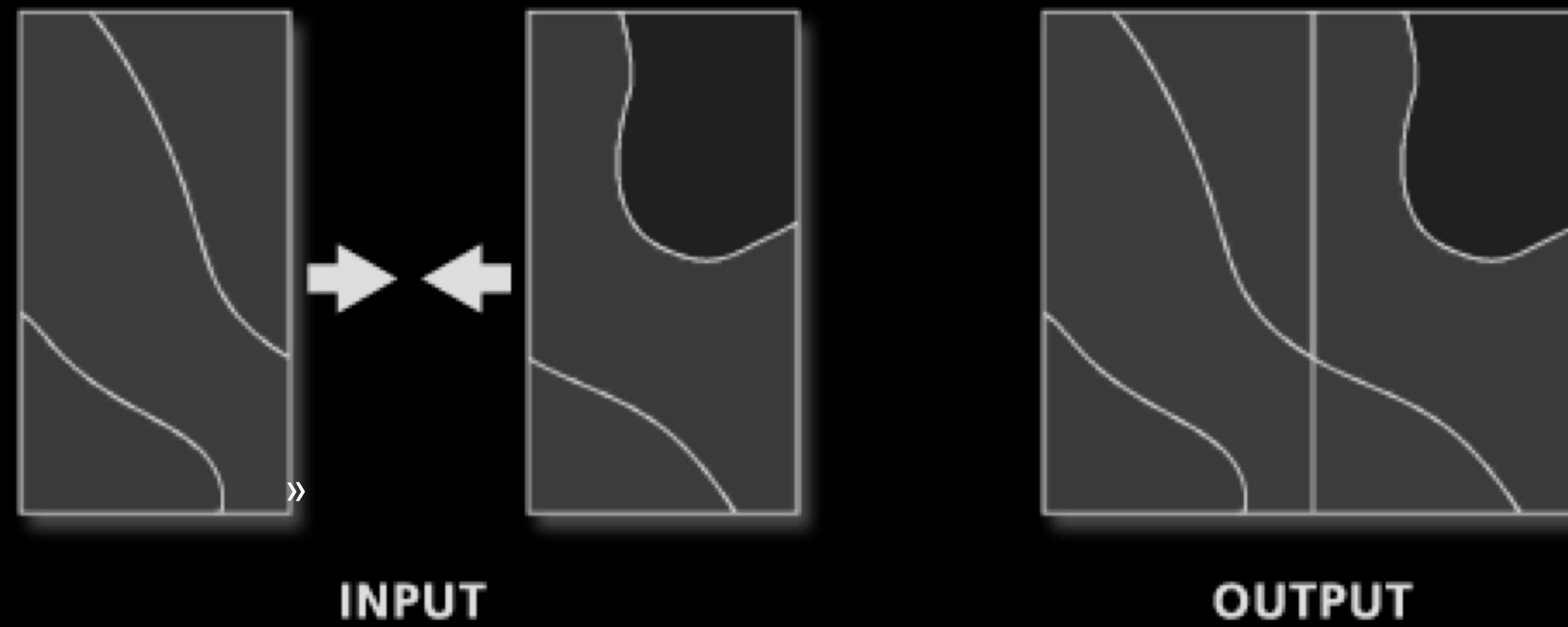
- “Cut out” input layer using feature(s) from clip layer



- Think “stencil” ...

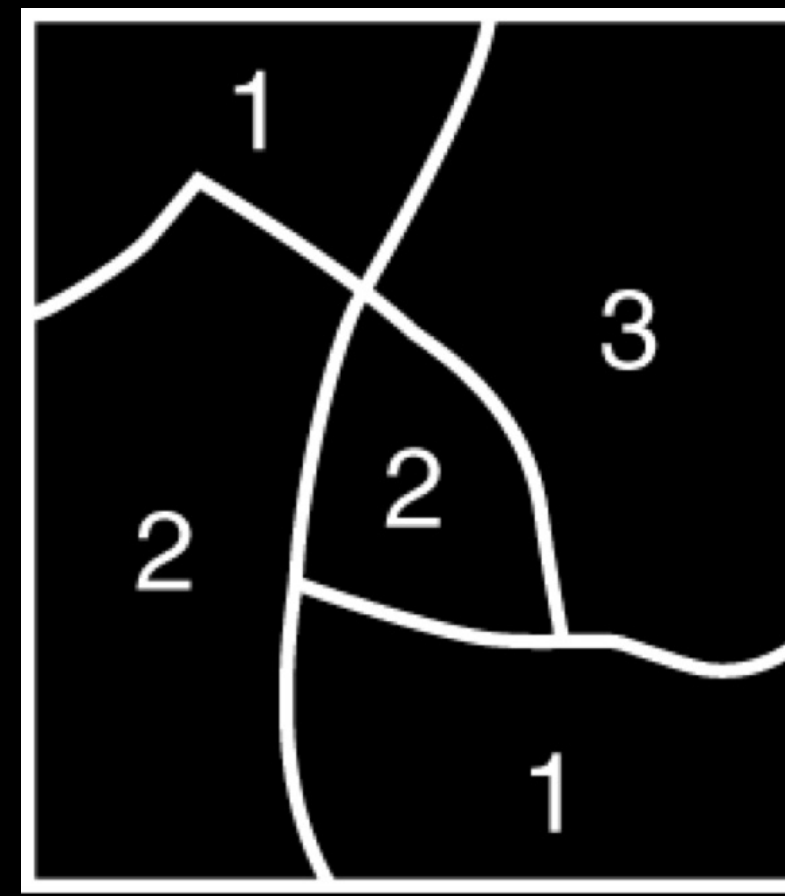
Merge

- Combine vector datasets

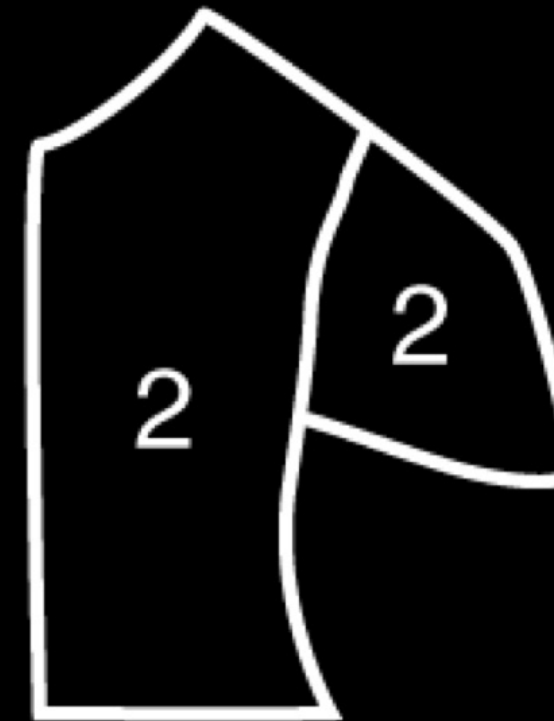


Select

- Extract selected features into new layer



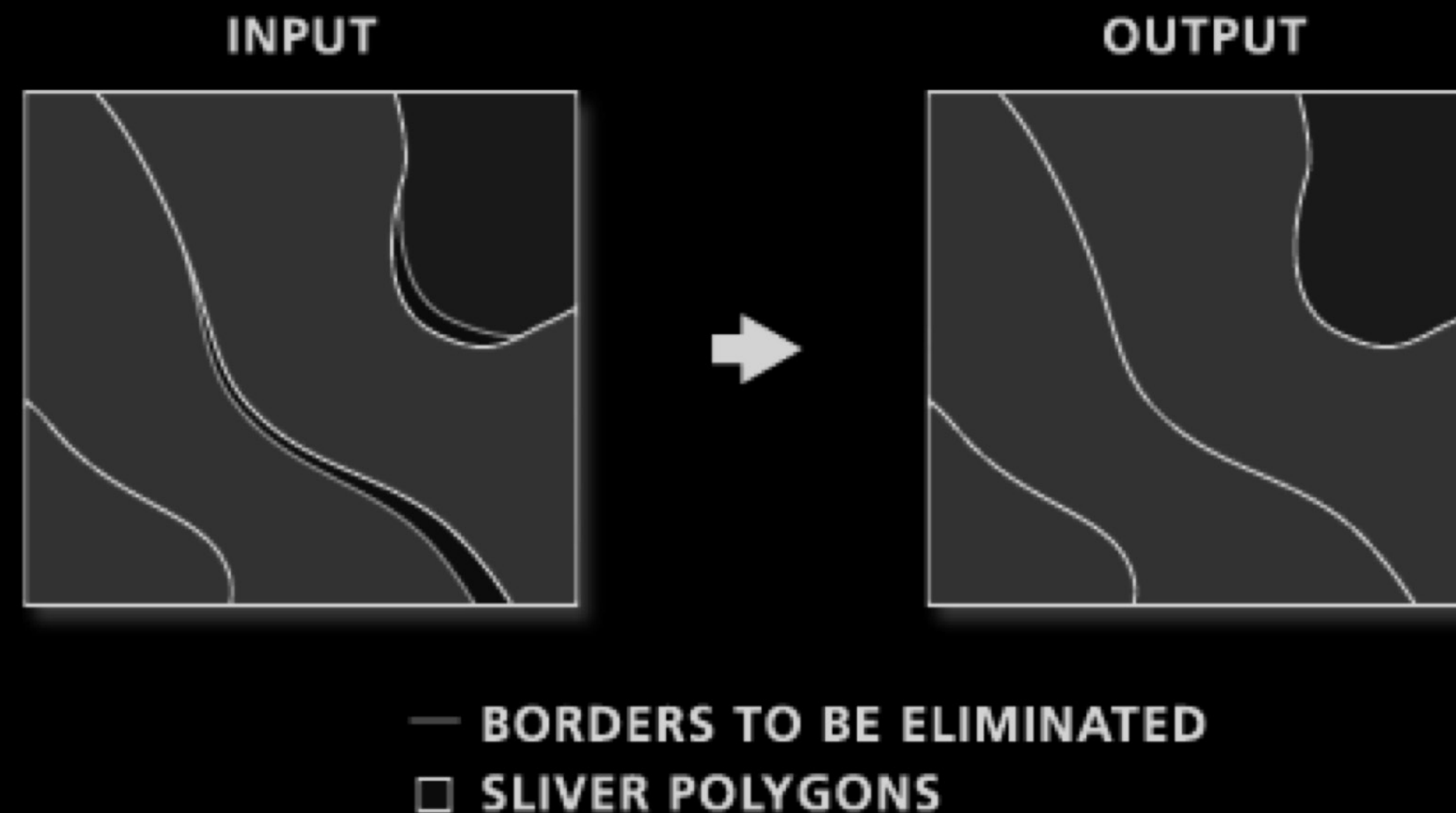
(a)



(b)

Eliminate

- Get rid of “spurious” polygons...
 - e.g. digitization errors
- ...by merging into neighbors
 - largest
 - longest common boundary



Graphics Credits

- Introduction to Geographic Information Systems, 5/e
- ArcMap Help
- GIS Fundamentals, 6/e