

# GEOG 204

## LECTURE 4

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Lit Review  
Tutorial 4 outcomes needed

This week:  
Spatial Analysis

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## Spatial Analysis

- In a GIS,
  - Data are usually grouped into layers (or themes).
  - The analysis functions of a GIS use the spatial and non-spatial data
  - Analysis functions are used
    - for maintenance of the data
    - Computing new information from the data
- Spatial Analysis can be viewed as:
  - Operations that use spatial data to derive new spatial information.
  - The most distinguishing purpose of a GIS

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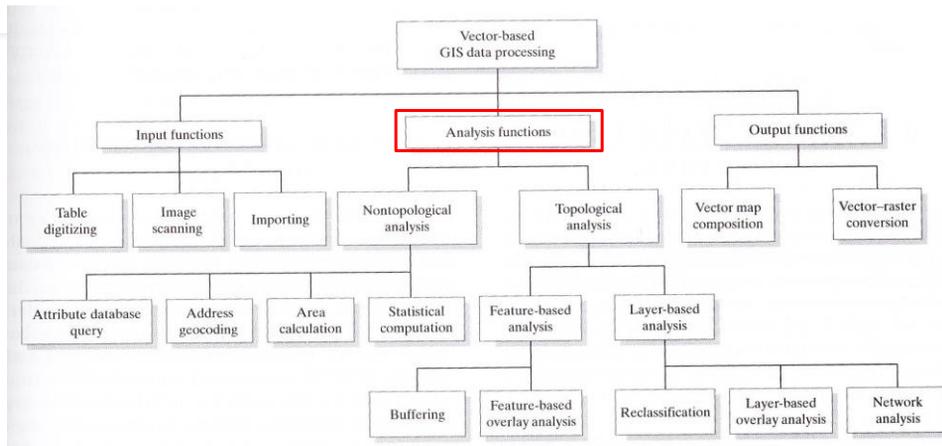
## Spatial Analysis

- Analysis occurs using either:
  - **Spatial location** e.g. wetlands near a pipeline; houses within 5km
    - Distinguishes GIS from a non-spatial analysis
  - **Data attributes** e.g. wetlands with black spruce; houses in a given price range
    - Distinguishes GIS from 'non-GIS' mapping software
  - **Comparative spatial statistics**
    - e.g. trees are clustered.
    - e.g. wetlands clustered at local scale, uniform at regional scale
    - Statistical Spatial Data Analysis with ArcGIS, QGIS,....

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# Spatial Analysis



Source: C.P. Lo, A.K.W. Yeung (2007) Concepts and Techniques of Geographic Information Systems

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# Spatial Analysis

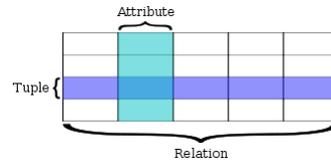
- Analysis functions
  - Non-topological functions
    - Attribute values of spatial data
  - Topological functions
    - Individual data objects
      - Feature-based
        - individual data objects
      - Layer-based
        - all objects in a layer

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# Nontopological Analysis

- SQL: Structured Query Language
- Goal: select only the features with (or without) particular values
- Relational table



FID	Shape	Name	Code	Author	Northing	Easting	MedDev	CuDet	FIRE_YEAR	FIRE_CAUSE	SIZE_AK	MAT_TPM1_0	MAP_01_90	Mean_dstr	SG	Ts_count	Elevation
9	Point ZN	Fuzzy	FUZ	Neil Thompson					1940	Person	6089.2	23	467	0	0	0	1068 NT
10	Point ZN	Tulla Lake	TL	Jodi Axelsson					1961	Person	2828.3	23	429	11	4	2	0 JA
11	Point ZN	Bull Canyon	BC	Jodi Axelsson					2010	Person	177.2	39	325	8	7	2	374 JA
12	Point ZN	Bull Canyon	BCA	Neil Thompson					2010	Person	177.2	39	325	0	0	0	935 NT
13	Point ZN	Alexa North	ALE	Neil Thompson					2010	Lightning	11638.6	30	334	0	0	0	959 NT
14	Point ZN	CM	CM	Jodi Axelsson					0	0	41	342	9	4	1	1058 JA	
15	Point ZN	Big Bar	BKG	Neil Thompson					0	0	31	430	0	0	0	0	1261 NT
16	Point ZN	HL	HL	Jodi Axelsson					0	0	26	429	9	7	2	2	1207 JA
17	Point ZN	Dog Creek Bluffs	DCB	Neil Thompson					0	0	46	422	6	0	0	0	847 NT
18	Point ZN	Epicenter South	ERI	Neil Thompson					0	0	26	474	0	0	0	0	1262 NT
19	Point ZN	Snag Lake	SS	Lori Daniels					0	0	33	490	7	5	1	1	1083 LD
20	Point ZN	Jolly TK	JRY	Neil Thompson					0	0	29	509	6	0	0	0	1136 NT
21	Point ZN	Caenden Lake	CAE	Neil Thompson					0	0	33	480	0	0	0	0	1087 NT
22	Point ZN	Chimney Lake D	SZ	Lori Daniels					0	0	33	563	9	3	1	1	992 LD
23	Point ZN	Hayfield Bluffs	HAB	Neil Thompson					0	0	37	452	6	0	0	0	945 NT
24	Point ZN	Chimney Lake	CHI	Neil Thompson					0	0	38	484	0	0	0	0	906 NT
25	Point ZN	Lee's Corner	LEE	Neil Thompson					0	0	33	375	0	0	0	0	1031 NT
26	Point ZN	Hancock North	HAN	Neil Thompson					0	0	17	459	0	0	0	0	1329 NT
27	Point ZN	Risk Creek	RS	Neil Thompson					0	0	21	404	0	0	0	0	1259 NT
28	Point ZN	FR	FR	Jodi Axelsson					0	0	47	417	11	9	2	2	556 JA
29	Point ZN	Enterprise Bluffs	ENT	Neil Thompson					0	0	35	473	6	0	0	0	910 NT
30	Point ZN	Lee's Corner North	LEN	Neil Thompson					0	0	17	431	0	0	0	0	1268 NT
31	Point ZN	Pyper Lake	PYP	Neil Thompson					0	0	25	375	0	0	0	0	1107 NT

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# Nontopological Analysis

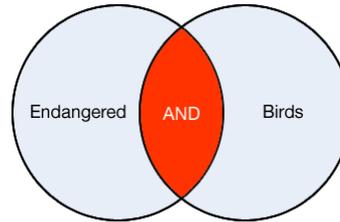
- Attribute Database Query Operations
  - **SELECT:** Extract data items in specified rows of a table  
 $SELECT <attribute\_name> FROM <table> WHERE <condition\_statement>$
  - **JOIN (RELATIONAL JOIN):** Merges two tables based on the values in the columns of the tables  
 $[a \text{ select statement}] <table\_1> JOIN <table\_2> ON table\_1.attribute = table\_2.attribute$   
 $[a \text{ condition statement}]$

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# Nontopological Analysis

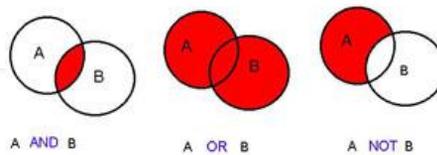
- **Boolean Logic** (after George Boole, a 19th century mathematician)
  - "Create an expression reducible to a true or false condition".
- **SQL can use:**
  - **Boolean Operators**
    - **And** (narrows the selection)
    - **Or** (expands the selection)
    - **Not** (excludes/reduces results)
    - **XOR** (A or B, but not both)
    - **Like (Similarity)**
      - **% is wildcard**
  - Relational Operators (=, >, <, >=, <=)
  - Arithmetic Operators (+, -, \*, /)



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## Boolean Operators (to combine conditions)

BOOLEAN OPERATORS



### Selection by attribute

type = pine AND age > 100

... selects all old growth pine

type = pine OR age > 100

selects all pine and any type older than 100

*These may require the use of brackets to avoid ambiguity in complex queries e.g.*

type = pine OR type = fir AND age > 100    selects any pine plus old growth fir

type = (pine OR type = fir) AND age > 100    selects old growth (pine and fir)

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## Nontopological Analysis

- Statistical Computation
  - Extension of attribute data query
  - Conventional statistical measures such as:
    - mean, maximum, minimum, range, standard deviation, frequency
    - Note: These are aspatial statistics
    - Note: Can't do statistics on text field.

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## Nontopological Analysis

- Spatial Calculation
  - Spatial calculation of position, area, perimeter, distance, proximity
    - Algorithms are well known
  - An intermediate step to obtain new attribute data to support specific spatial analyses
  - Be sure that data are preprocessed
    - projection, coordinate transformation, measurement unit conversion

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The image shows two screenshots from ArcMap. The left screenshot displays the Field Calculator dialog box. The 'Parser' is set to 'VB Script', and the 'Type' is 'Number'. The 'Fields' list includes 'Cause\_CD', and the 'Functions' list includes 'Abs', 'Atn', 'Cos', 'Exp', 'Fix', 'Log', 'Sin', 'Sqr', and 'Tan'. The 'Show Codeblock' checkbox is checked, and the code block contains 'Cause\_CD = 1'. The right screenshot shows the Statistics tool interface. The 'Field' is set to 'Cause\_CD', and the 'Statistics' section displays the following values: Count: 33, Minimum: 0, Maximum: 1, Sum: 24, Mean: 0.727273, Standard Deviation: 0.445362, and Nulls: 0.

Statistics and the Field Calculator

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## Selection in ArcMap

- Manual selection
- By Location
- By Attributes
- Show attributes from
  - All layers
  - Selected layer
  - Visible layers
  - Top-most layer

Once you have selected something, the selection will be all ArcGIS sees by default.

CAUTION when you export, analyze, compare

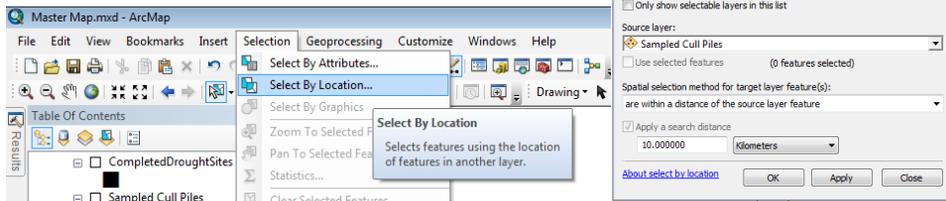
The image shows the Identify tool interface in ArcMap. The 'Identify from' dropdown is set to '< All layers >'. The 'Location' is 1,208,780.185 992,281.186 Meters. The 'Field Value' table shows the following data:

Field	Value
AREA	889292390801
FID	0
Shape	Polygon
Shape_Area	889292390803
Shape_Leng	12171344.3133

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## Select by Location

- Selects features from one data set based on their spatial relationship with another layer e.g.
  - Are within a distance of
  - Are within
  - Are completely within
  - Share a line segment with
  - Intersect

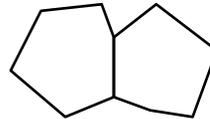


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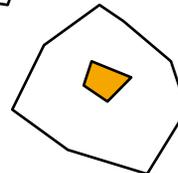
## Topological Functions

- Topology: spatial relationship between entities

- Adjacency (polygons)



- Containment (e.g. points in polygons)



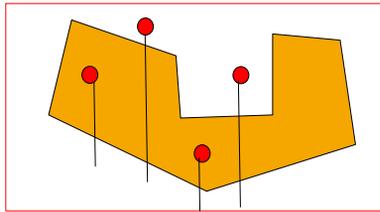
- Connectivity (lines)



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# Topological Functions

- Feature-Based Analysis: Find relationships between features of one layer and those of another
  - Common functions: Point in polygon, adjacency, connectivity, buffering
    - Point in polygon matching: whether a given point feature falls inside a polygon



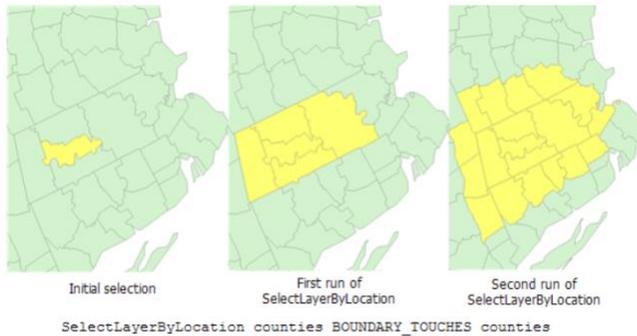
## **Plumb-line algorithm**

Odd number of intersections: **In**  
 Even number of intersections: **Out**

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**Touch =  
adjacency**



**Are  
connected  
with**



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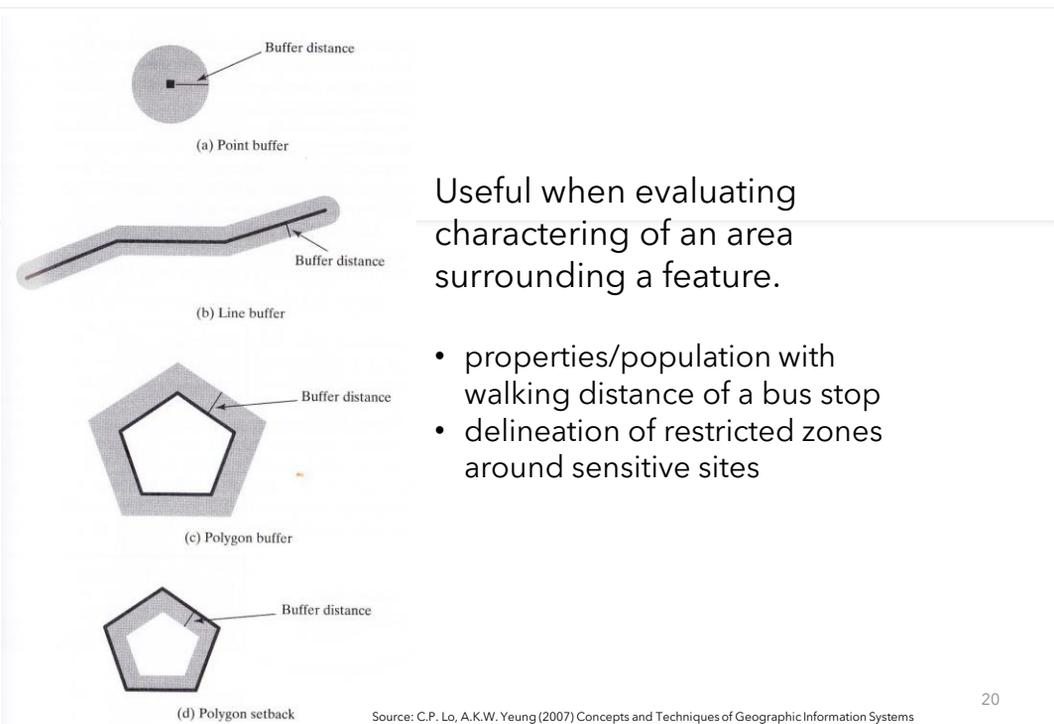
# Topological Functions

## • Buffering

- A buffer is a zone covering a specified distance around a spatial feature
  - Buffer zones are polygons.
  - Buffer distance is usually user defined
  - Boundaries of overlapping buffer zones are automatically dissolved to give a single coherent buffer polygon

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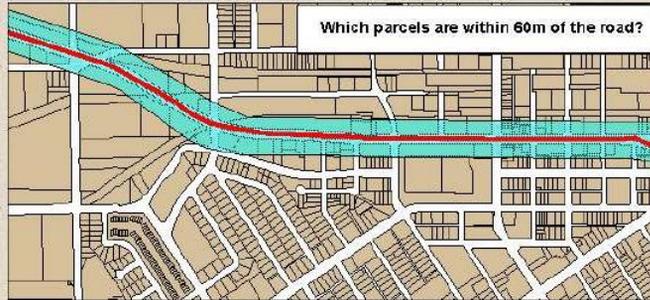
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### Applications of BUFFER

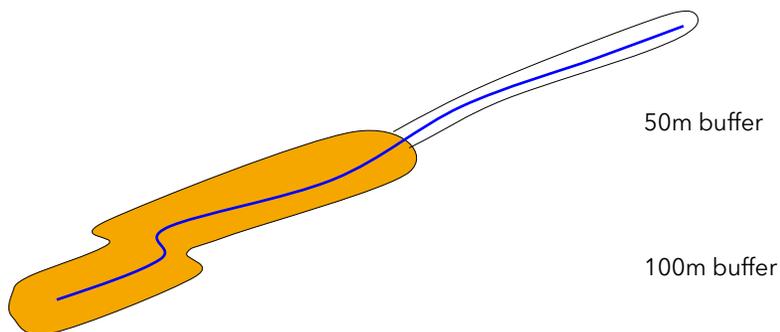


For example: consideration of widening of existing roadway, to identify parcels affected by underground utility line additions, etc.

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## Topological Functions

- *Variable buffer distances* (assigned by attribute)
  - Different buffer size depending on stream attribute
  - e.g. stream protection status



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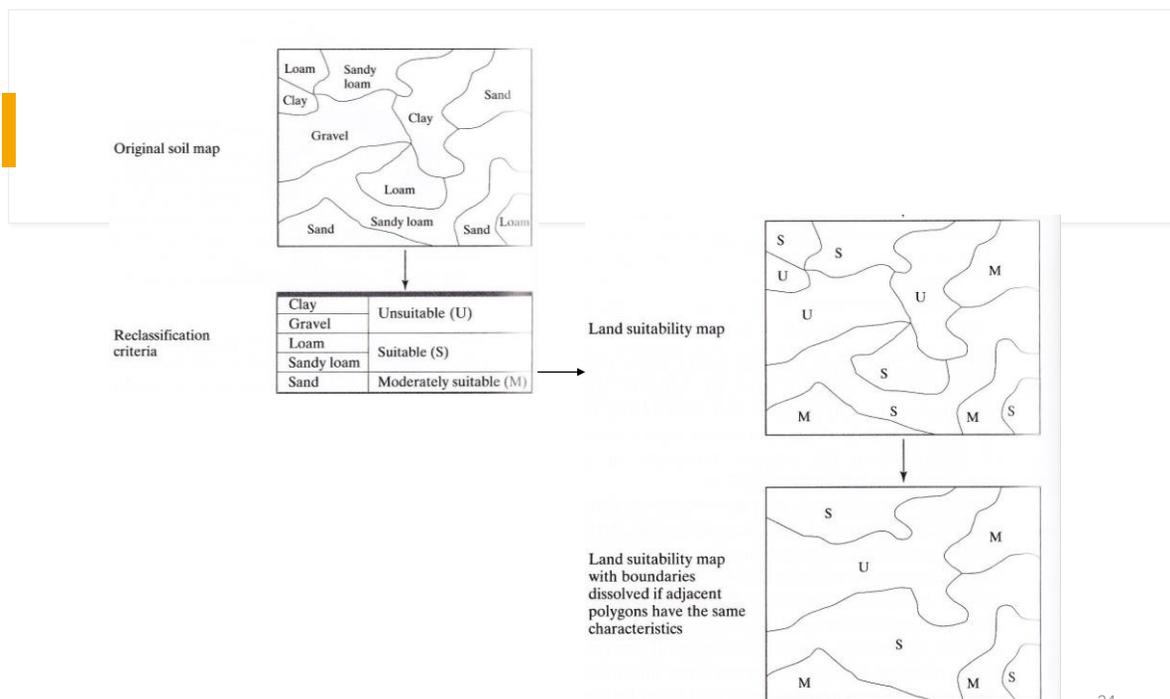
# Topological Functions

## • Reclassification

- Database simplification process
  - reduces (modifies) the categories in attribute data
- Two step process
  - Nontopological: select attribute e.g. a range of values and assign them a new class
  - Topological: dissolve according to new classification scheme

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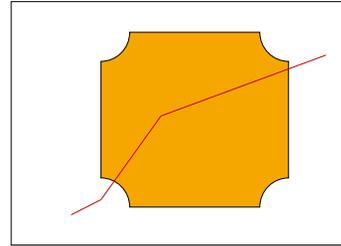
Source: C.P. Lo, A.K.W. Yeung (2007) Concepts and Techniques of Geographic Information Systems

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## The Concept of GIS Overlay

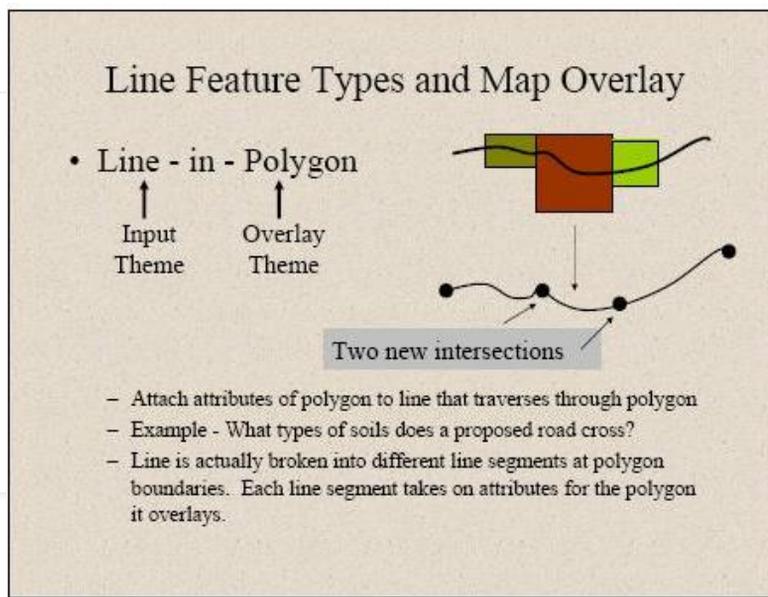
- Overlay addresses the relationship of the overlap between spatial features.
- Overlay **combines** the spatial *and* attribute data of two input themes.



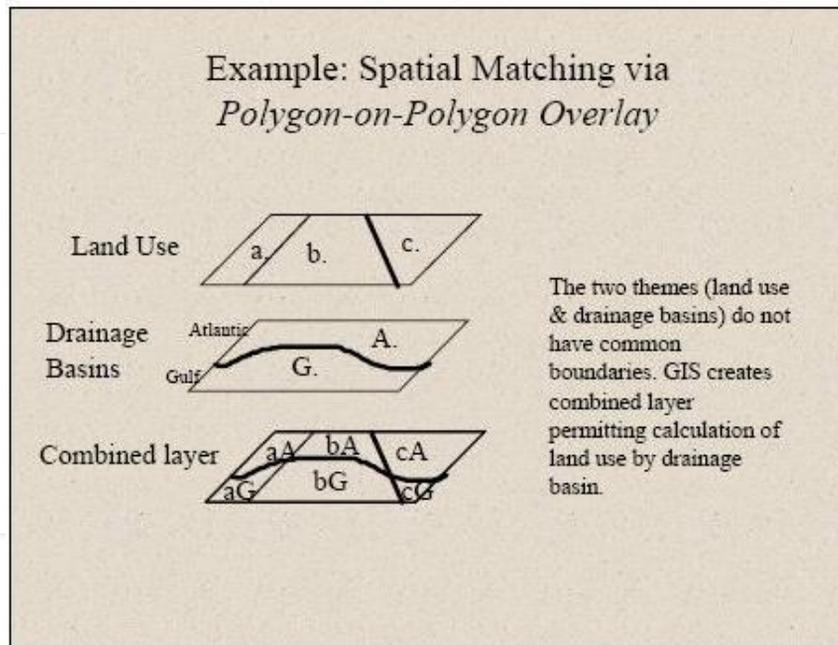
Three input feature types, overlay cover is always polygon:

- 1) point-in-polygon,  $\longrightarrow$  points are output
- 2) line-in-polygon,  $\longrightarrow$  lines are output
- 3) polygon-in-polygon  $\longrightarrow$  polygons are output

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## Topological Functions

### • Topological Overlay Operators

- UNION: Overlays polygons and keeps all areas in both layers. Never clips data
- INTERSECT: Keeps portions of the first input layer that fall within the second input layer
- IDENTITY: Overlays polygons and keeps all input features
- CLIP: Cuts out the first input layer using the second input layer as a cookie cutter
- ERASE: Erases part of the first input layer using the second input layer
- SPLIT: Divide the polygons in the first input layer into a number of smaller polygons based on the second input layer

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