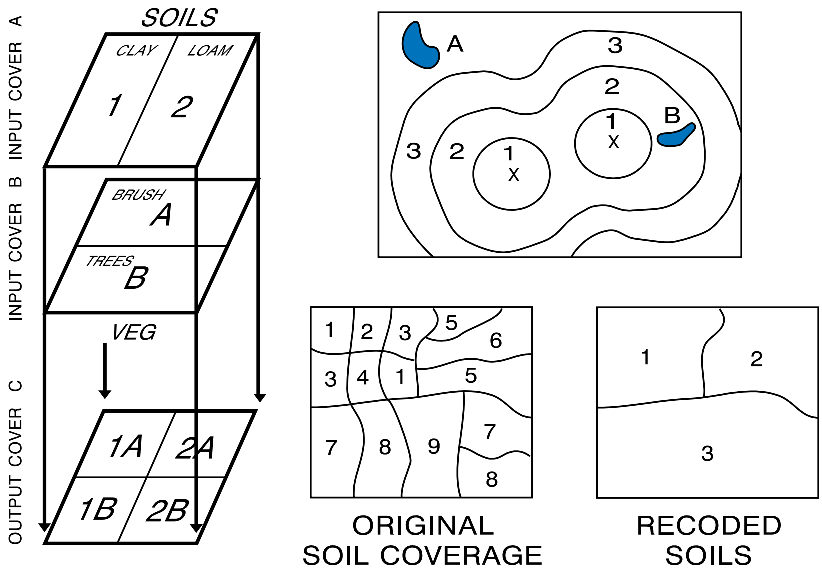
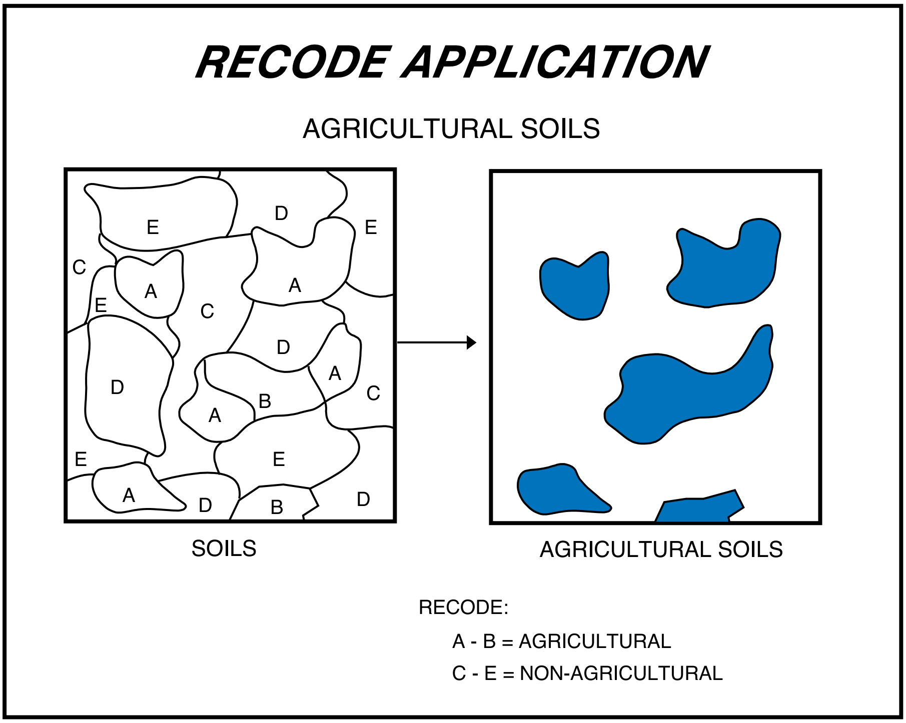
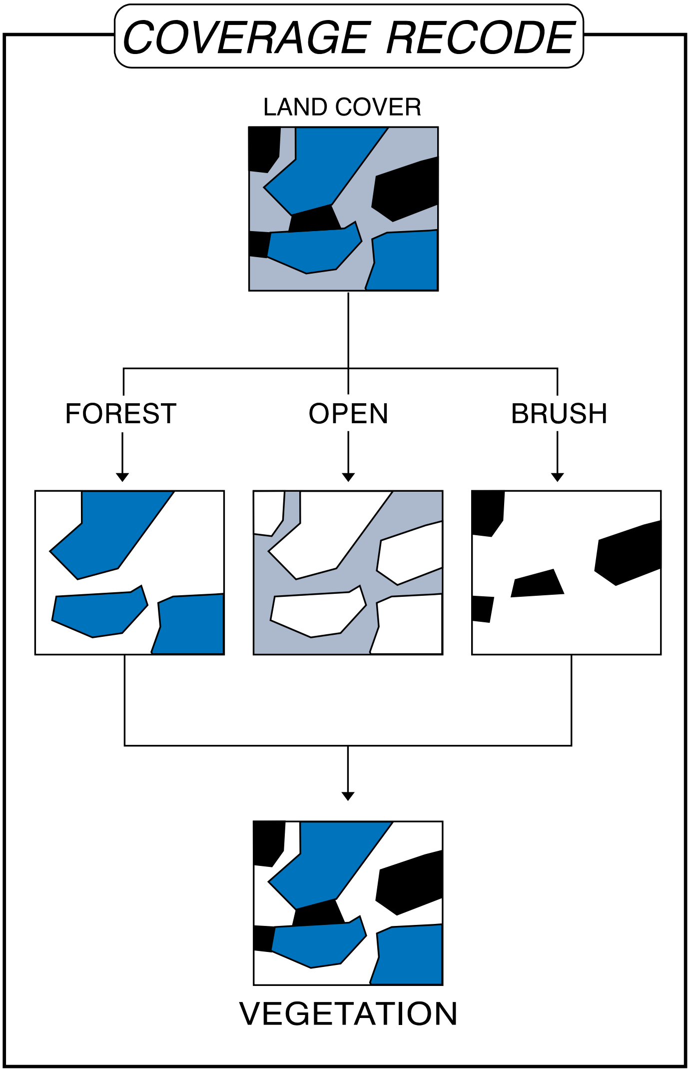
BASIC ANALYSIS

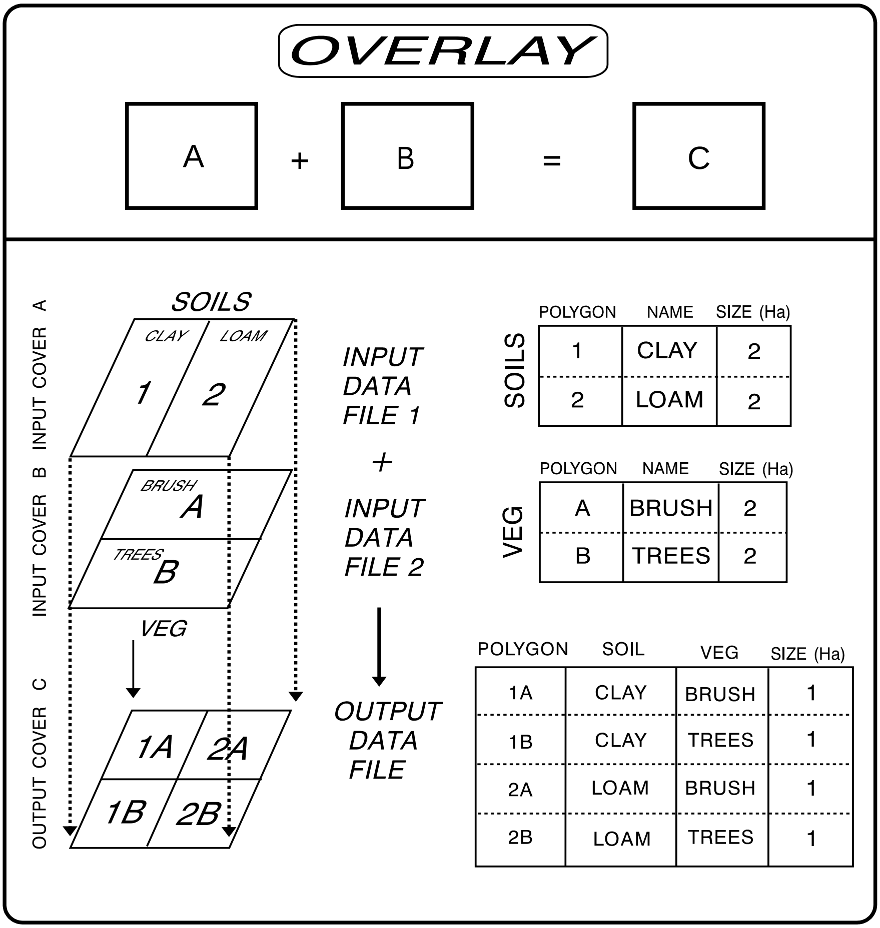
- OVERLAY
- GRAPHIC MANIPULATIONS
- BUFFER ZONES

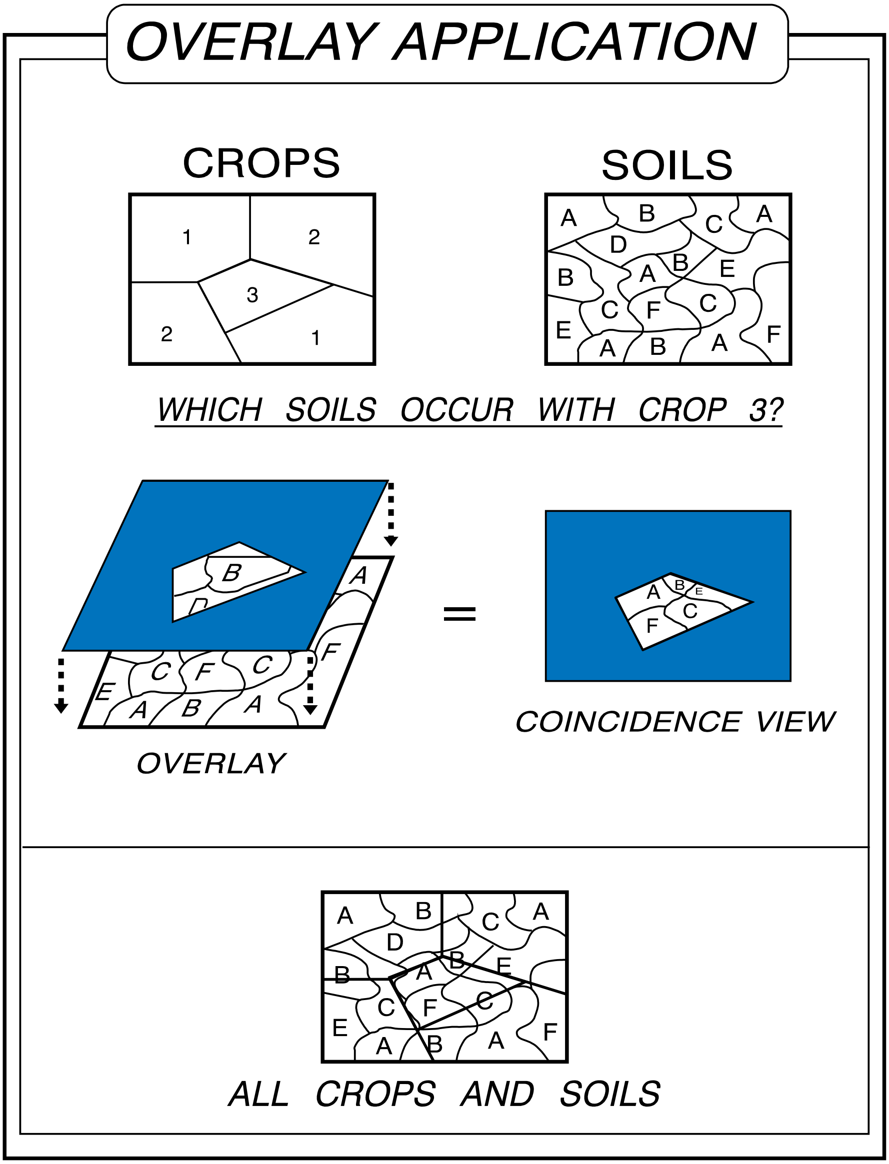


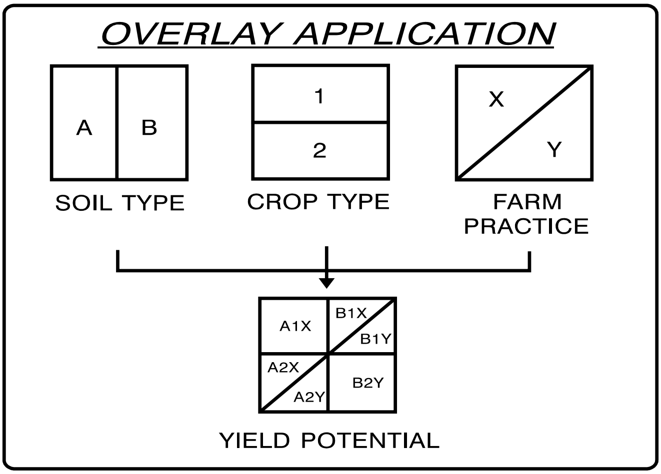


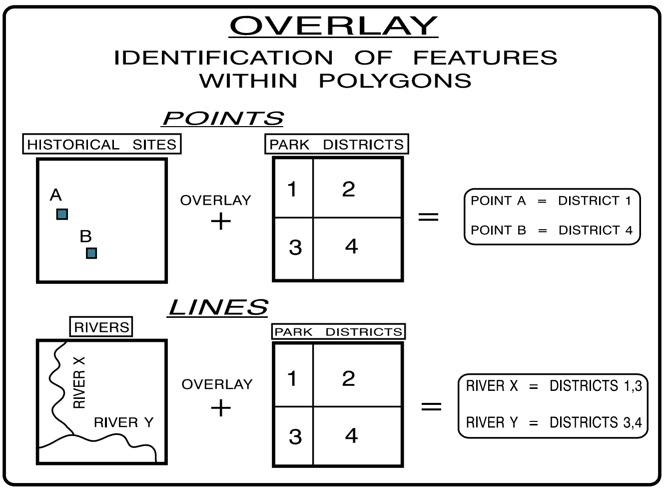
© 1996 Bruce Davis. Reprinted from *GIS: A Visual Approach*, p. 214 (OnWord Press).

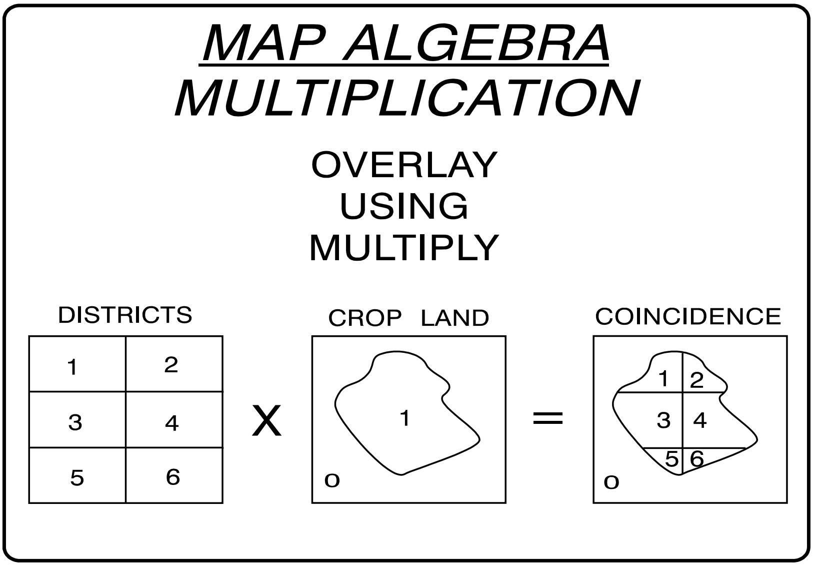

COVERAGE RECODE
LAND COVER
FOREST
OPEN
BRUSH
VEGETATION

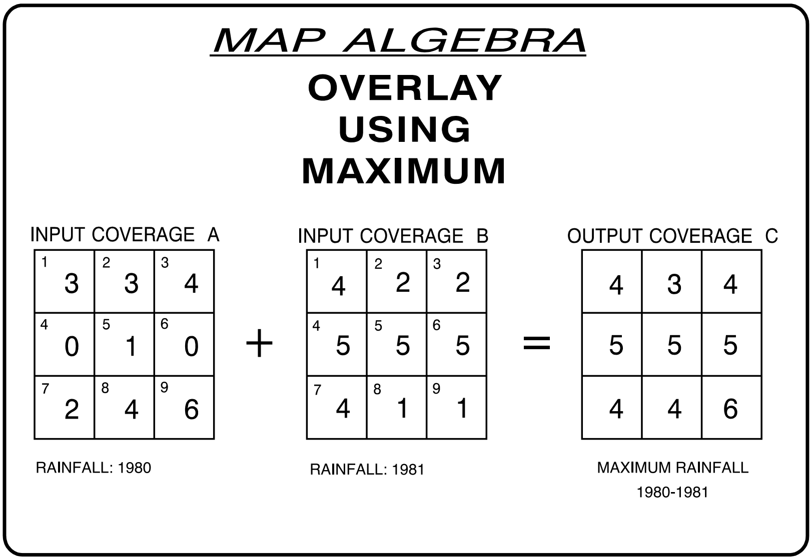

OVERLAY
A
+
B
=
C
SOILS
CLAY
LOAM
1
2
INPUT COVER A
BRUSH
A
TREES
B
INPUT COVER B
VEG
1A
2A
1B
2B
OUTPUT COVER C
INPUT DATA FILE 1
+
INPUT DATA FILE 2
OUTPUT DATA FILE
SOILS
POLYGON NAME SIZE (Ha)
1 CLAY 2
2 LOAM 2
VEG
POLYGON NAME SIZE (Ha)
A BRUSH 2
B TREES 2
POLYGON SOIL VEG SIZE (Ha)
1A CLAY BRUSH 1
1B CLAY TREES 1
2A LOAM BRUSH 1
2B LOAM TREES 1

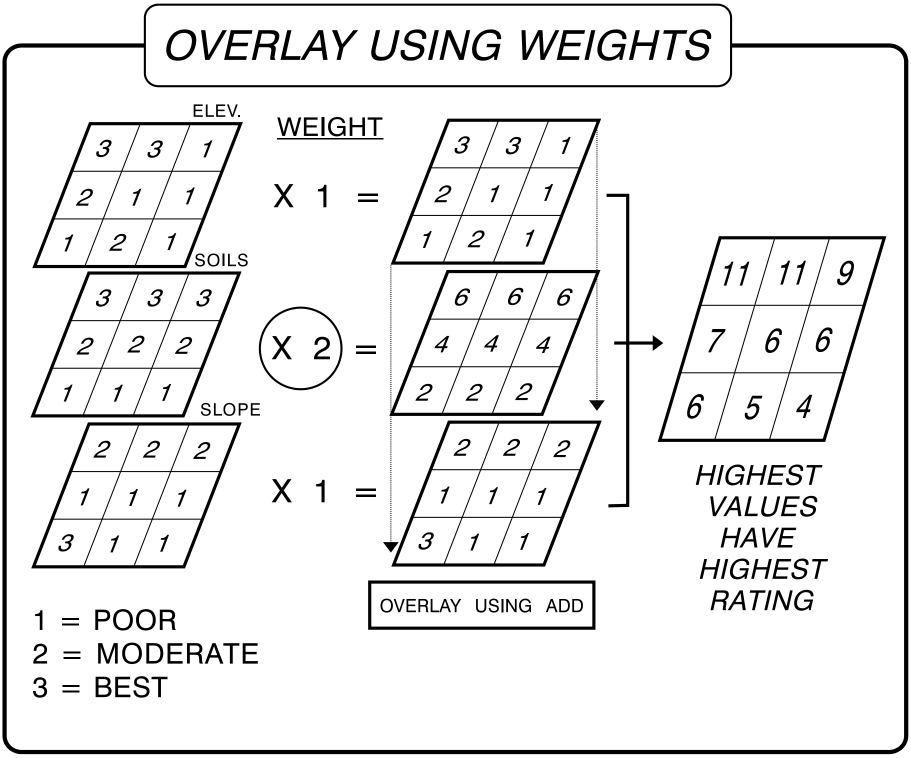

OVERLAY APPLICATION
CROPS
1
2
3
2
1
SOILS
A
B
C
A
D
B
A
B
E
C
F
C
E
A
B
A
F
WHICH SOILS OCCUR WITH CROP 3?
B
D
A
F
C
F
C
E
A
B
A
OVERLAY
=
A
B
E
C
F
COINCIDENCE VIEW
A
B
C
A
D
B
A
B
E
C
F
C
E
A
B
A
F
ALL CROPS AND SOILS


OVERLAY APPLICATION
A
B
SOIL TYPE
1
2
CROP TYPE
X
Y
FARM PRACTICE
A1X
B1X
B1Y
A2X
A2Y
B2Y
YIELD POTENTIAL

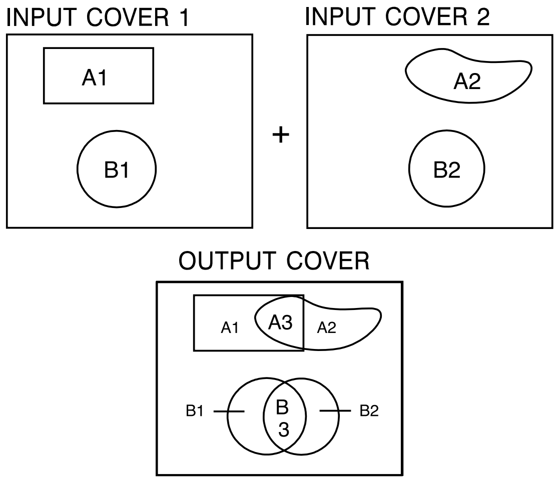

OVERLAY
IDENTIFICATION OF FEATURES WITHIN POLYGONS
POINTS
HISTORICAL SITES
A
B
OVERLAY
+
PARK DISTRICTS
1
2
3
4
=
POINT A = DISTRICT 1
POINT B = DISTRICT 4
LINES
RIVERS
RIVER X
RIVER Y
OVERLAY
+
PARK DISTRICTS
1
2
3
4
=
RIVER X = DISTRICTS 1,3
RIVER Y = DISTRICTS 3,4


MAP ALGEBRA
MULTIPLICATION
OVERLAY
USING
MULTIPLY
DISTRICTS
1
2
3
4
5
6
X
CROP LAND
1
0
=
COINCIDENCE
1
2
3
4
5
6
0


MAP ALGEBRA
OVERLAY
USING
MAXIMUM
INPUT COVERAGE A
1 3
2 3
3 4
4 0
5 1
6 0
7 2
8 4
9 6
RAINFALL: 1980
+
INPUT COVERAGE B
1 4
2 2
3 2
4 5
5 5
6 5
7 4
8 1
9 1
RAINFALL: 1981
=
OUTPUT COVERAGE C
4
3
4
5
5
5
4
4
6
MAXIMUM RAINFALL
1980-1981


OVERLAY USING WEIGHTS
ELEV.
3 3 1
2 1 1
1 2 1
SOILS
3 3 3
2 2 2
1 1 1
SLOPE
2 2 2
1 1 1
3 1 1
WEIGHT
X 1 =
3 3 1
2 1 1
1 2 1
X 2 =
6 6 6
4 4 4
2 2 2
X 1 =
2 2 2
1 1 1
3 1 1
OVERLAY USING ADD
11 11 9
7 6 6
6 5 4
HIGHEST VALUES HAVE HIGHEST RATING
1 = POOR
2 = MODERATE
3 = BEST

VECTOR OVERLAY



DATABASE RESULTS

INPUT COVER 1

ID	AREA
A1	10
B1	8

+

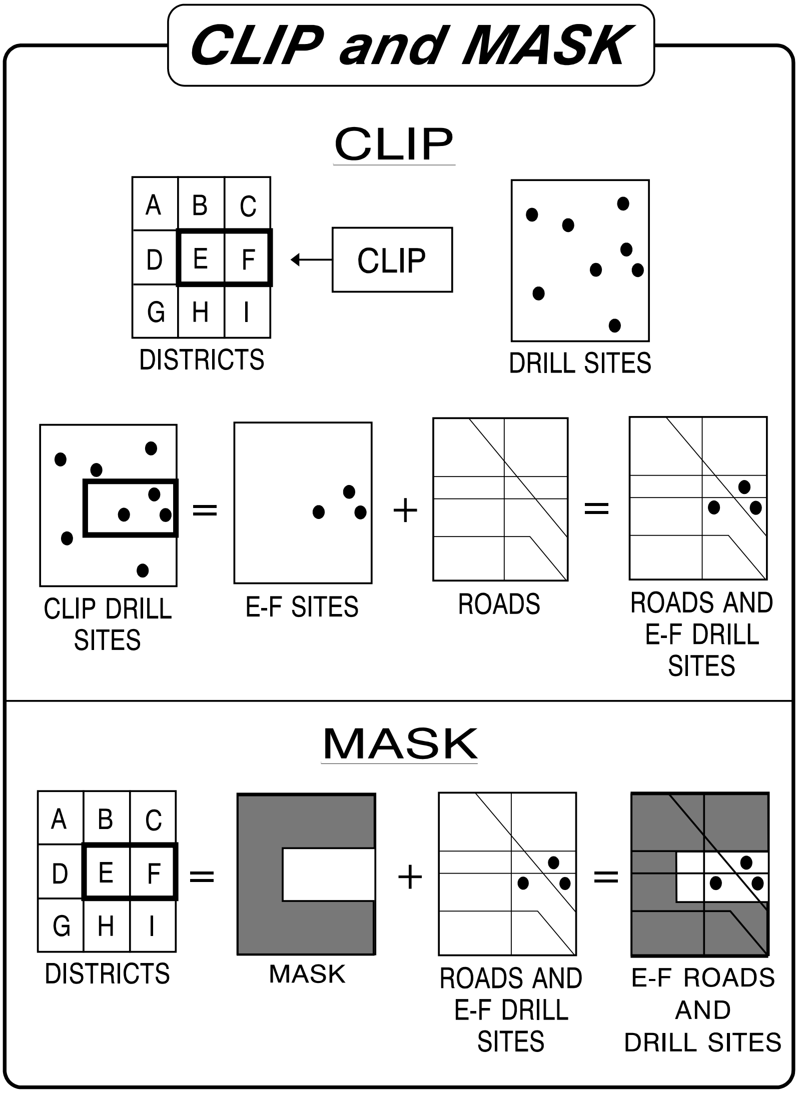
INPUT COVER 2

ID	AREA
A2	8
B2	8

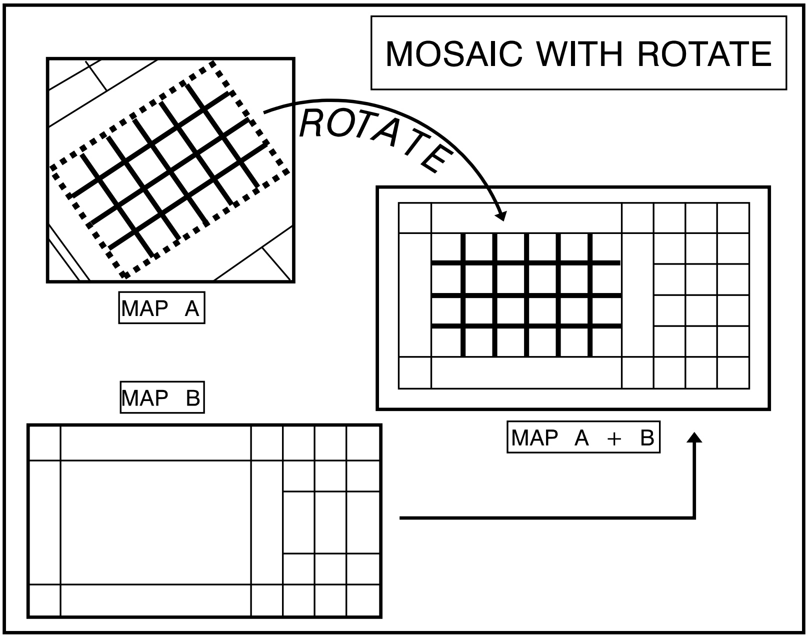
→

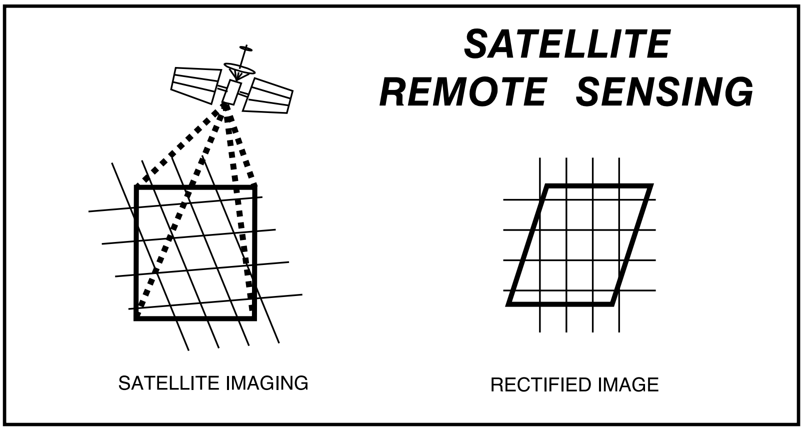
OUTPUT COVER

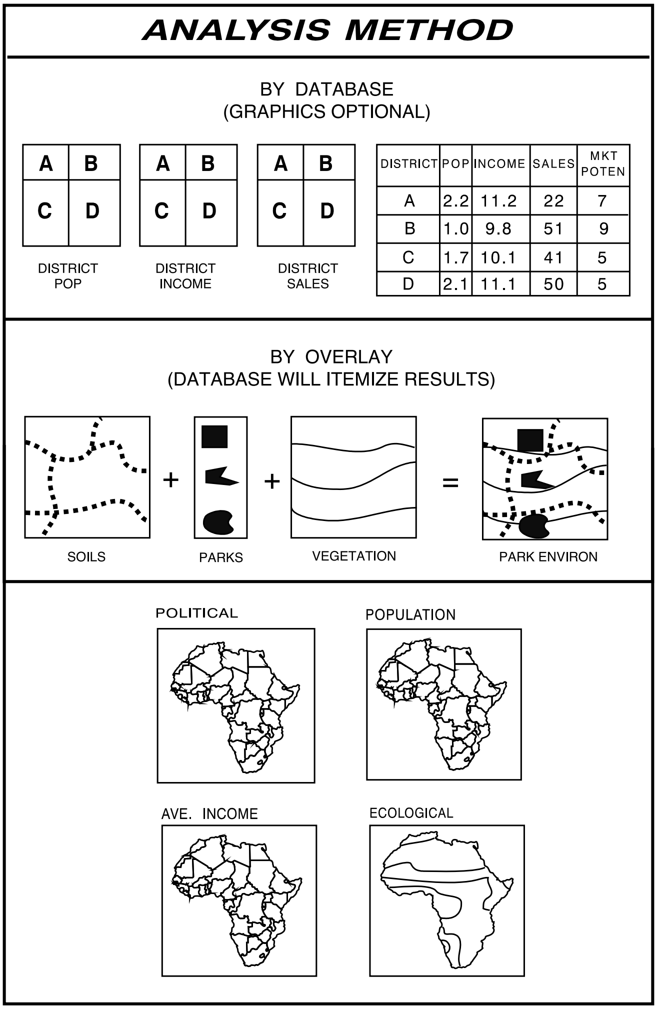
ID	AREA
A1	6
A2	4
A3	4
B1	5
B2	5
B3	4



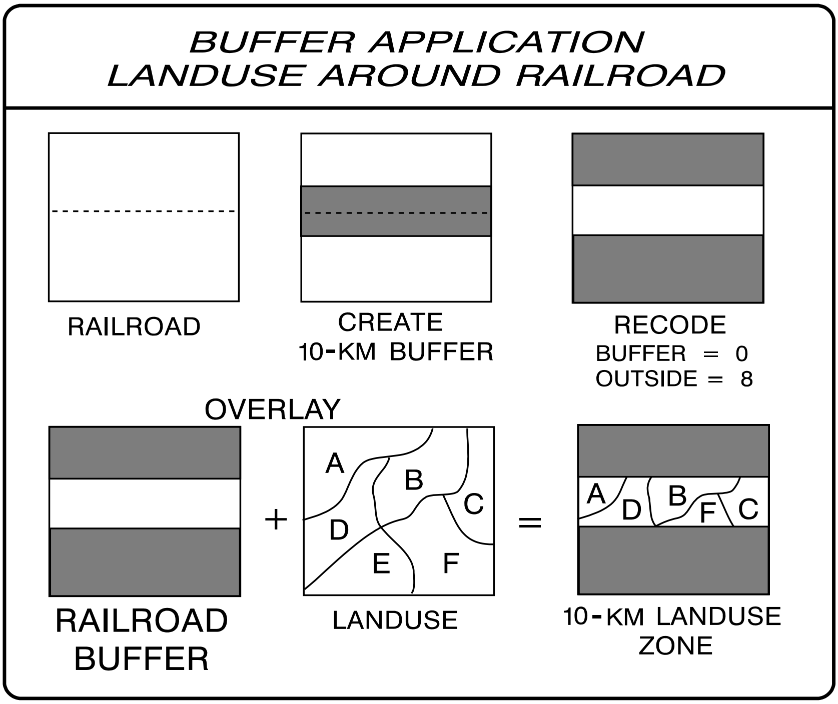
CLIP and MASK
CLIP
A
B
C
D
E
F
G
H
I
CLIP
DISTRICTS
DRILL SITES
CLIP DRILL SITES
E-F SITES
ROADS
ROADS AND E-F DRILL SITES
MASK
A
B
C
D
E
F
G
H
I
DISTRICTS
MASK
ROADS AND E-F DRILL SITES
E-F ROADS AND DRILL SITES

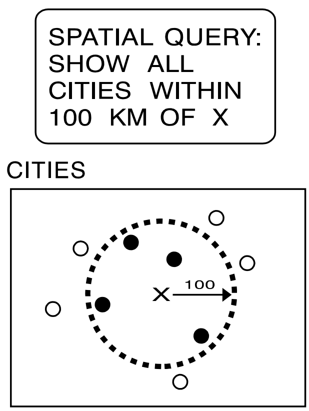

MOSAIC WITH ROTATE
ROTATE
MAP A
MAP B
MAP A + B


SATELLITE
REMOTE SENSING
SATELLITE IMAGING
RECTIFIED IMAGE



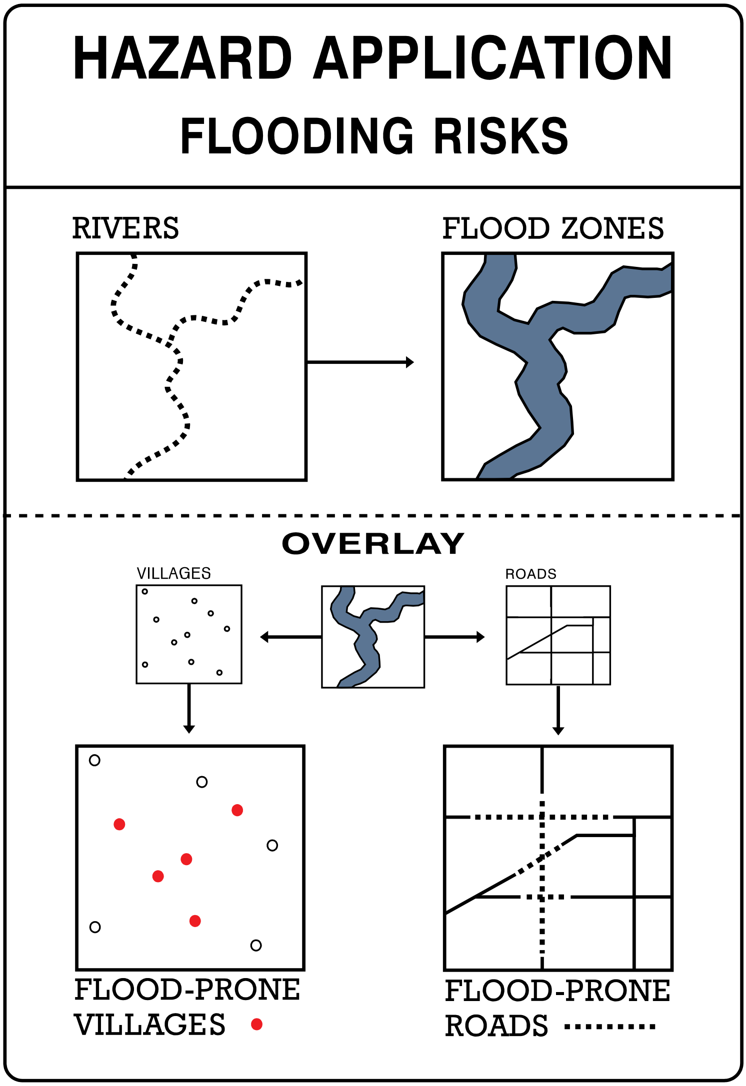
DISTRICT	POP	INCOME	SALES	MKT POTEN
A	2.2	11.2	22	7
B	1.0	9.8	51	9
C	1.7	10.1	41	5
D	2.1	11.1	50	5

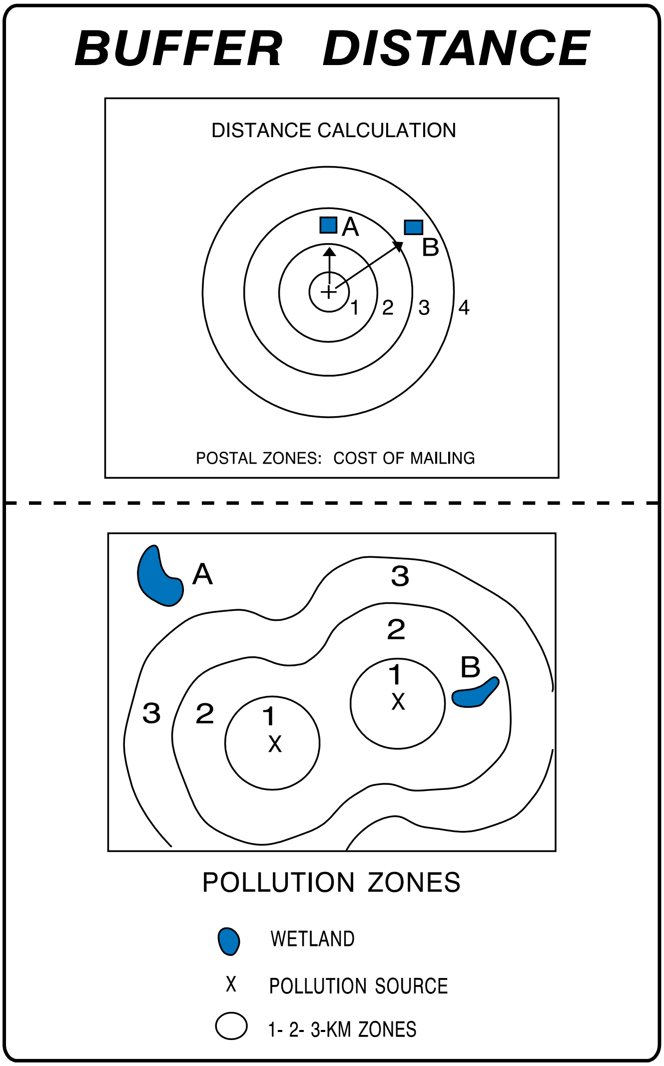




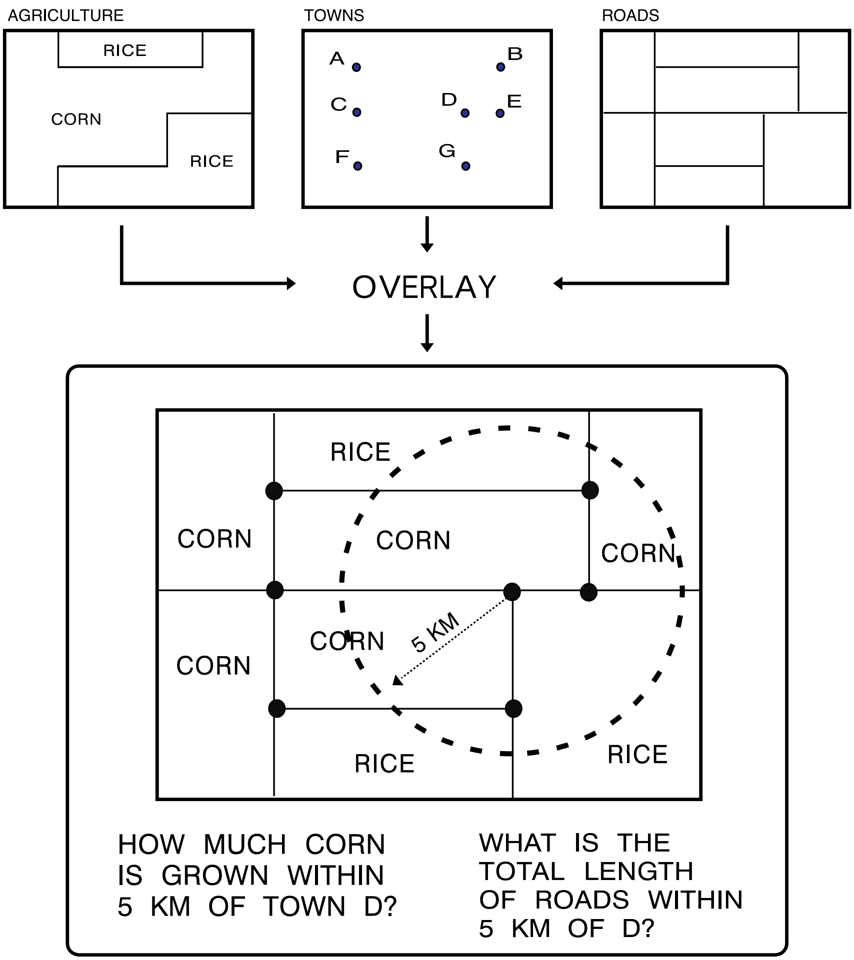
DISTANCE SELECTION

NAME	**POP**	**CLASS**
DUBOP	**12.5**	**A**
TRIMAN	**9.0**	**A**
TIBOO	**10.1**	**B**
POST	**11.4**	**C**
MANT	**7.1**	**A**
RATAP	**5.0**	**C**
FEENAN	**7.0**	**C**
JOST	**11.7**	**B**


HAZARD APPLICATION
FLOODING RISKS
RIVERS
FLOOD ZONES
OVERLAY
VILLAGES
ROADS
FLOOD-PRONE
VILLAGES
FLOOD-PRONE
ROADS


BUFFER DISTANCE
DISTANCE CALCULATION
A
B
1
2
3
4
POSTAL ZONES: COST OF MAILING
A
B
3
2
1
X
3
2
1
X
POLLUTION ZONES
WETLAND
X POLLUTION SOURCE
1- 2- 3-KM ZONES

SPATIAL ANALYSIS



Spatial Analysis and Modeling Resources

Special thanks to Ron Briggs, UT-Dallas

Analysis Components

- **analyses may be applied to (use as input):**
  - tabular attribute data
  - spatial data/layers
  - combination of spatial and tabular
- **results may be displayed as (produce as output):**
  - table subsets, table combinations, highlighted records (rows), new variables (columns)
  - charts
  - maps/map features:
    - highlights on existing themes
    - new themes/layers
  - combination

Availability of Analytical Capabilities:

- **Basic: Desktop GIS packages**
  - ArcView
  - Mapinfo
  - Geomedia
- **Advanced: Professional GIS systems**
  - ARC/INFO, MapInfo Pro, etc.
  - provide data editing plus more advanced analysis

  Provided now through extra cost Extensions or professional versions of desktop packages
- **Specialized: modeling and simulation**
  - via scripting/programming within GIS
    - » AMLs in Workstation ARC/INFO (v. 7)
    - » Avenue scripts in ArcView 3.2
    - » VB and ArcObjects in ArcGIS

    Write your own or download from ESRI Web site
  - via specialized packages and/or GISs
    - » 3-D Scientific Visualization packages
    - » transportation planning packages
    - » ERDAS, ER Mapper or similar package for raster

Capabilities move 'down the chain' over time.

In earlier generation GISes, use of advanced applications often required learning another package with a different user interface and operating system (usually UNIX).

Advanced and Specialized Applications:
in comparison to basic applications

Most ‘**basic**’ analyses are used to create ***descriptive*** *models* of the world, that is, representations of reality as it exists.

Most ‘**advanced**’ **analyses** involve creating a new conceptual *output* layer, or in some cases table(s) or chart(s), the values of which are some *transformation* of the values in the descriptive *input* layer.

e.g. slope or aspect layer

Most ‘**specialized**’ applications involve using GIS capabilities to create a ***predictive*** *model* of a real world process, that is, a model capable of reproducing processes and/or making predictions or projections as to how the world might appear.

e.g. fire spread model, traffic projections

Analysis Options: *Basic*

(Table of Contents)

- **Spatial Operations**

  Vector
  - centroid determination ⎤ geostatistics
  - spatial measurement
  - buffer analysis
  - spatial aggregation
    - » redistricting
    - » regionalization
    - » classification
  - Spatial overlays and joins

  Raster
  - neighborhood analysis/spatial filtering
  - Raster modeling

- **Attribute Operations**
  - record selection
    - » tabular via SQL
    - » 'information clicking' with cursor
  - variable recoding
  - record aggregation
  - general statistical analysis
  - table relates and joins

Analysis Options: *Advanced & Specialized*

Advanced

- **surface analysis**
  - cross section creation
  - visibility/viewshed
- **proximity analysis**
  - nearest neighbor layer
  - distance matrix layer
- **network analysis**
  - routing
    - » shortest path (2 points)
    - » travelling salesman (n points)
  - time districting
  - allocation
- **Thiessen Polygon creation**

Specialized

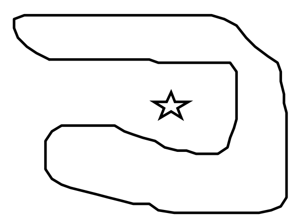
- Remote Sensing image processing and classification
- raster modeling
- 3-D surface modeling
- spatial statistics/statistical modeling
- functionally specialized
  - transportation modeling
  - land use modeling
  - hydrological modeling
  - etc.

Spatial operations:
Centroid or Mean Center

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}, \overline{Y} = \frac{\sum_{i=1}^{n} Y_i}{n}$$

- **balancing point for a spatial distribution**
  - point representation for a polygon--analogous to the mean
  - single point summary for a distribution (point or polygon)
  - can be weighted by 'magnitude' at each point (analogous to weighted mean)
  - minimizes squared distances to other points, thus 'distant' points have bigger influence than close points (Oregon births more impact than Kansas births!)
  - is not the point of "minimum aggregate travel"--this would minimize distances (not their square) and can only be identified by approximation.
- **useful for**
  - summarizing change over time in a distribution (e.g US pop. centroid every 10 years)
  - placing labels for polygons
- **for weird-shaped polygons,**
  centroid may not lie within polygon

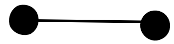
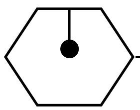
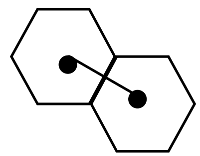
Note: many ArcView applications calculate only a "psuedo" centroid: the coordinates of the bounding box (the extent) of the polygon



centroid outside polygon

Spatial operations:
Spatial Measurement

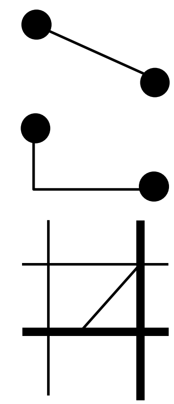
Spatial measurements:

- **distance measures**
  - between points 
  - from point or raster to polygon or zone boundary 
  - between polygon centroids 
- **polygon area**
- **polygon perimeter**
- **polygon shape**
- **volume calculation**
  - e.g. for earth moving, reservoirs
- **direction determination**
  - e.g. for smoke plumes

ArcGIS 8.1 geodatabases contain automatic variables:
shape.length: line length or polygon perimeter
shape.area: polygon area
(Much easier than AV 3.2—see appendix!)

Comments:

- **possible distance metrics:**
  - straight line/airline
  - city block/manhattan metric
  - distance thru network
  - time/friction thru network

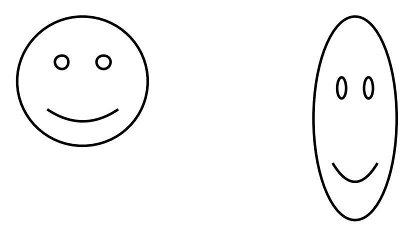


- **shape often measured by:**

$$\frac{\text{perimeter}}{\sqrt{\text{area}} \times 3.54}$$

= 1.0 for circle
= 1.13 for square
= large number for irregular polygon

- **Projection affects values!!!**



Perimeter to area ratio differs

Spatial operations:

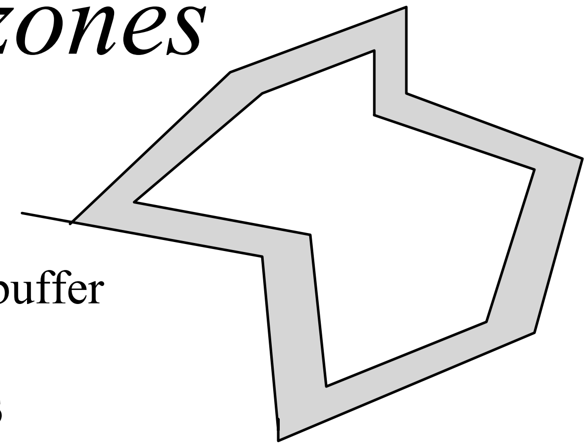
Spatial Measurement--example

SHAPE	AREA	PERIMETER	CNTY_	CNTY_ID	NAME	FIPS	Shape Index
Polygon	0.265	2.729	2605	2605	Anderson	48001	1.50
Polygon	0.368	2.564	2545	2545	Andrews	48003	1.19
Polygon	0.209	2.171	2680	2680	Angelina	48005	1.34
Polygon	0.072	2.642	2899	2899	Aransas	48007	2.78
Polygon	0.233	1.941	2335	2335	Archer	48009	1.14
Polygon	0.233	1.941	2103	2103	Armstrong	48011	1.14
Polygon	0.299	2.278	2870	2870	Atascosa	48013	1.18
Polygon							
Polygon	0.224	1.900	2471	2471	Dallas	48113	1.13
Polygon	0.222	1.889	2481	2481	Dawson	48115	1.13
Polygon	0.368	2.580	2106	2106	Deaf Smith	48117	1.20
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Shape Index can be calculated from area and perimeter measurements. These are available in *Attributes of* ..... file if source is a coverage or a geodatabase. If source is a shapefile, you need an *ArcScript* to calculate area and perimeter (or convert to geodatabase) (Note: “Shape index” is unrelated to “shapefile.”)

Spatial Operations: *buffer zones*

- region within ‘x’ distance units
- buffer any object: point, line or polygon
- use multiple buffers at progressively greater distances to show gradation
- may define a ‘friction’ or ‘cost’ layer so that spread is not linear with distance
- Implement in Arcview 3.2 with *Theme/Create buffers*
  in ArcGIS 8 with *Tools/Buffer Wizard*

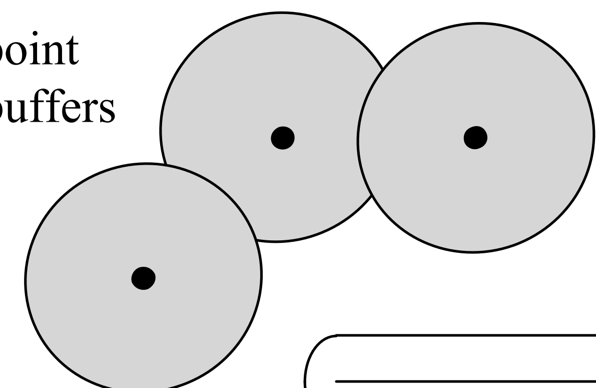


polygon buffer

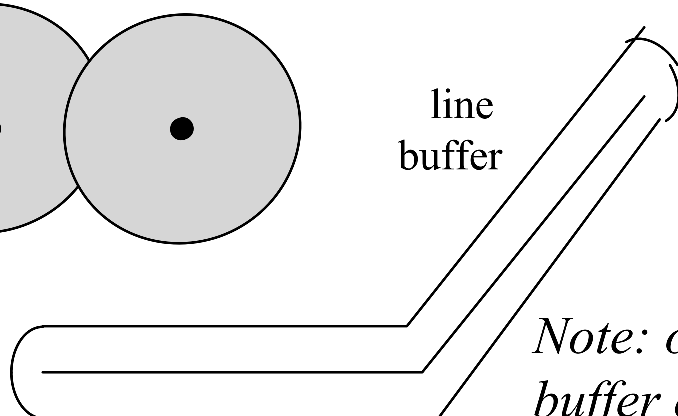
Examples

- 200 foot buffer around property where zoning change requested
- 100 ft buffer from stream center line limiting development
- 3 mile zone beyond city boundary showing ETJ (extra territorial jurisdiction)
- use to define (or exclude) areas as options (e.g for retail site) or for further analysis
- in conjunction with ‘friction layer’, simulate spread of fire

point buffers



line buffer



Note: only one layer is involved, but the buffer can be output as a new layer

Spatial Operations: *spatial aggregation*

Grouping/combining polygons—is applied to one polygon layer only.

- **districting/redistricting**
  - grouping *contiguous* polygons into *districts*
  - original polygons preserved
- **Regionalization (or dissolving)**
  - grouping polygons into contiguous regions
  - original polygon boundaries dissolved
- **classification**
  - grouping polygons into non-contiguous regions
  - original boundaries usually dissolved
  - usually 'formal' groupings

Implement in ArcView 8 thru Tools/Geoprocessing Wizard, using *dissolve features based on an attribute*

Criteria may be:

- formal (based on in situ characteristics) e.g. city neighborhoods
- functional (based on flows or links): e.g. commuting zones

Groupings may be:

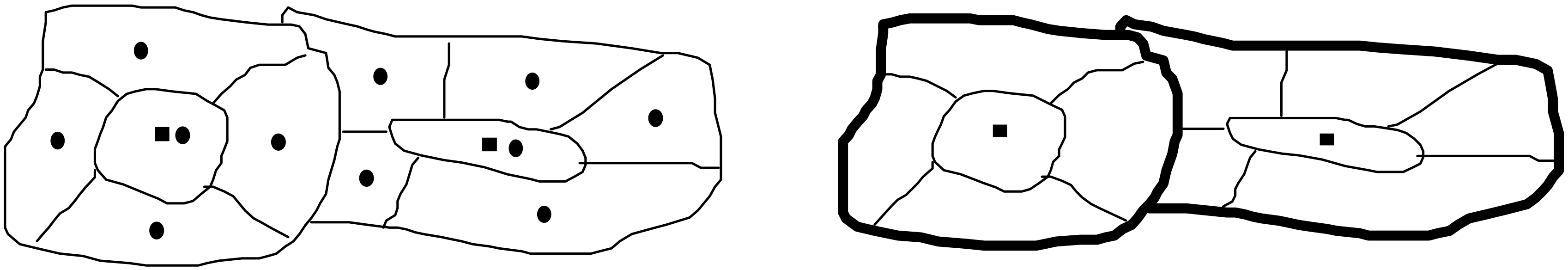
- contiguous
- non-contiguous

Boundaries for original polygons:

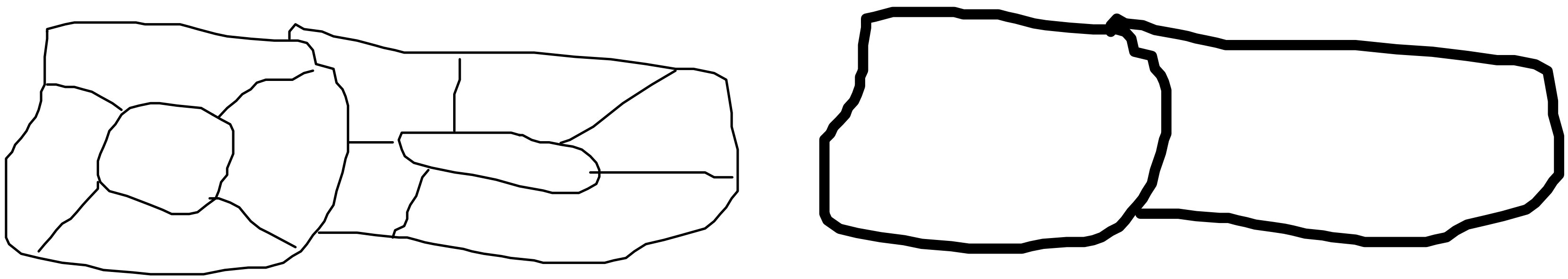
- may be preserved
- may be removed (called dissolving)

Examples:

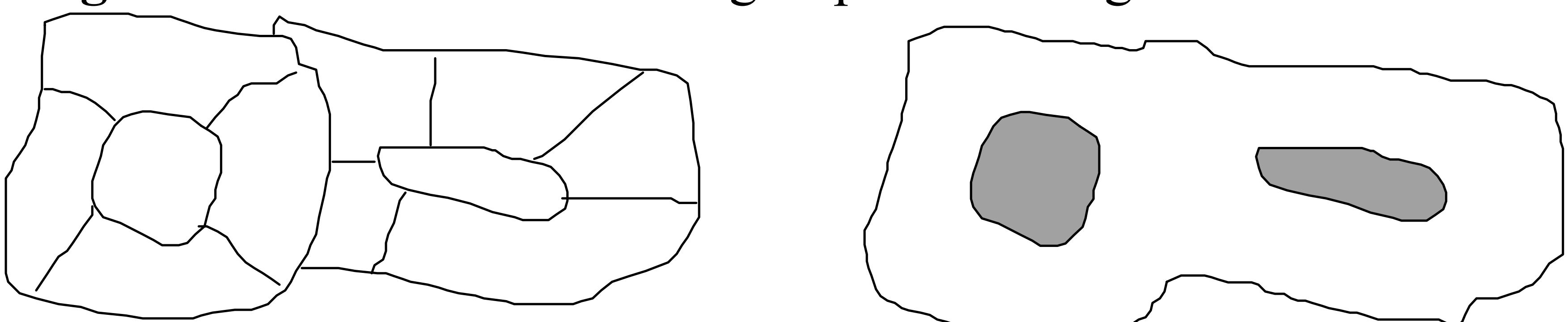
- elementary school zones to high school attendance zones (*functional districting*)
- election precincts (or city blocks) into legislative districts (*formal districting*)
- creating police precincts (*funct. reg*.)
- creating city neighborhood map (*form. reg.*)
- grouping census tracts into market segments--yuppies, nerds, etc (*class.*)
- creating soils or zoning map (*class*)



Districting: elementary school attendance zones grouped to form junior high zones.



Regionalization: census tracts grouped into neighborhoods

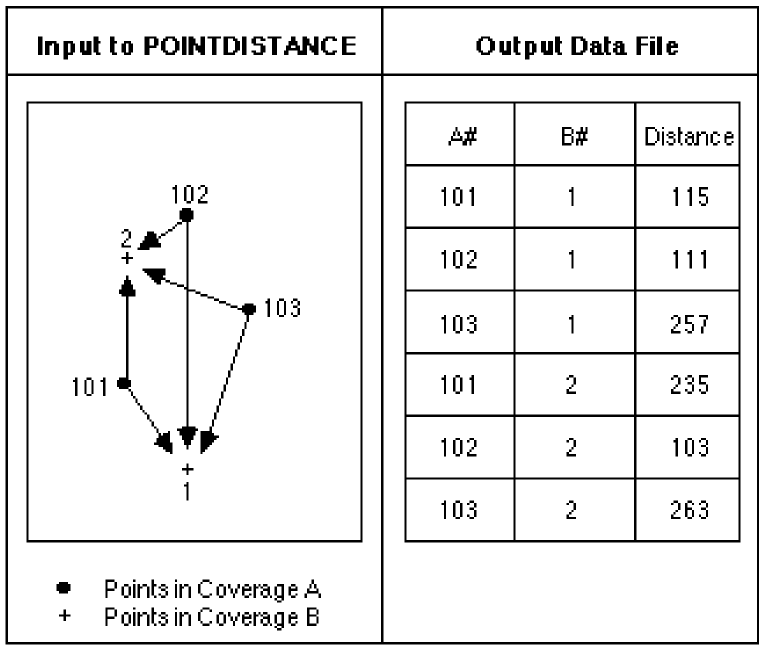


Classification: cities categorized as central city or suburbs
soils classified as igneous, sedimentary, metamorphic

Proximity Calculations

- POINTDISTANCE **computes the distances between point features in one coverage to all points in** … **re within the specified** …

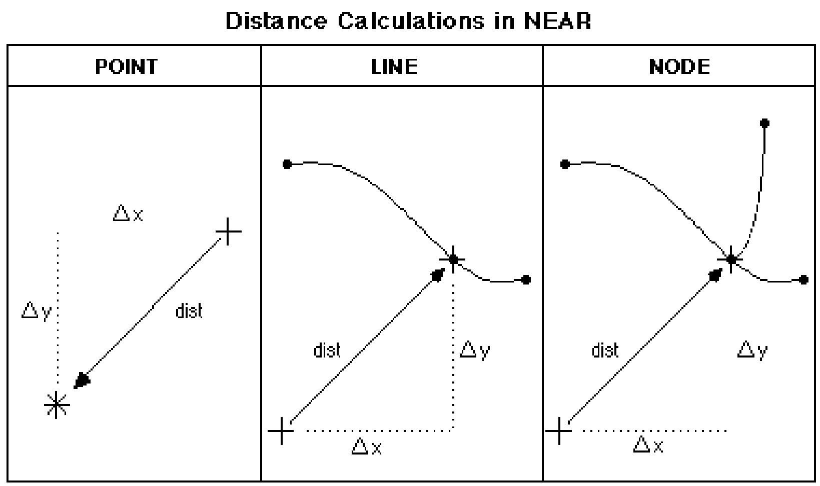
  POINTD … **<to_cover>**
  <out_inf …



A#	B#	Distance
101	1	115
102	1	111
103	1	257
101	2	235
102	2	103
103	2	263

Proximity Calculations, page 2

- NEAR **computes the distance from each point in a coverage to the nearest arc, point or node in anotl**



NEAR ‹ LINE | POINT {out_cover} {NOLO

Arc: r 0 wellstr location

The PAT of the output coverage will have two additional items: one to store the distance to the nearest feature in the near_cover, and a second to store the internal number of the nearest feature. LOCATION adds items for x and y coordinates.

Spatial Operations:

Spatial Matching: Spatial Joins and Overlays

- **combine <u>two (or more)</u> layers to:**
  - select features in one layer, &/or
  - create a new layer
- **used to integrate data having different spatial properties (point v. polygon), or different boundaries (e.g. zip codes and census tracts)**
- **can overlay polygons on:**
  - points (*point in polygon)*
  - lines (*line on polygon*)
  - other polygons *(polygon on polygon)*
  - many different Boolean logic combinations possible
    - » Union (A or B)
    - » Intersection (A and B)
    - » A and not B ; not (A and B)
- **can overlay points on:**
  - Points, which finds & calculates distance to nearest point in other theme
  - Lines, which calculates distance to nearest line

Examples

- assign environmental samples (points) to census tracts to estimate exposure per capita (point in polygon)
- identify tracts traversed by freeway for study of neighborhood blight (polygon on lines)
- integrate census data by block with sales data by zip code (polygon on polygon)
- Clip US roads coverage to just cover Texas (polygon on line)
- Join *capital city* theme to *all city* theme to calculate distance to nearest state capital (point on point)

POLYGON OVERLAY

- **POLYGON OVERLAY commands involve three coverages: an input coverage, an overlay coverage, and an output coverage created as a result of the overlay.**
- **Input coverage features can be polygons, lines, or points.**
- **The overlay coverage feature must be polygons.**
- **Output coverage features are of the same class as the input coverage features.**
  - polygon-on-polygon overlay - output is a polygon cover
  - line-on-polygon overlay - output is an arc coverage
  - point-on-polygon overlay - output is a point coverage

- **CLIP, ERASE, SPLIT, UPDATE, UNION, INTERSECT, IDENTITY**

No attribute merging | With attribute merging

CLIP

- CLIP **- extracts those features from an input coverage that overlap with a clip coverage. This is the most frequently used polygon overlay command to extract a portion of a coverage to create a new coverage.**

CLIP <in_cover> <clip_cover> <out_cover> {POLY | LINE | POINT | NET | LINK | RAW} {fuzzy_tolerance}

The <clip_cover> must have polygon topology.

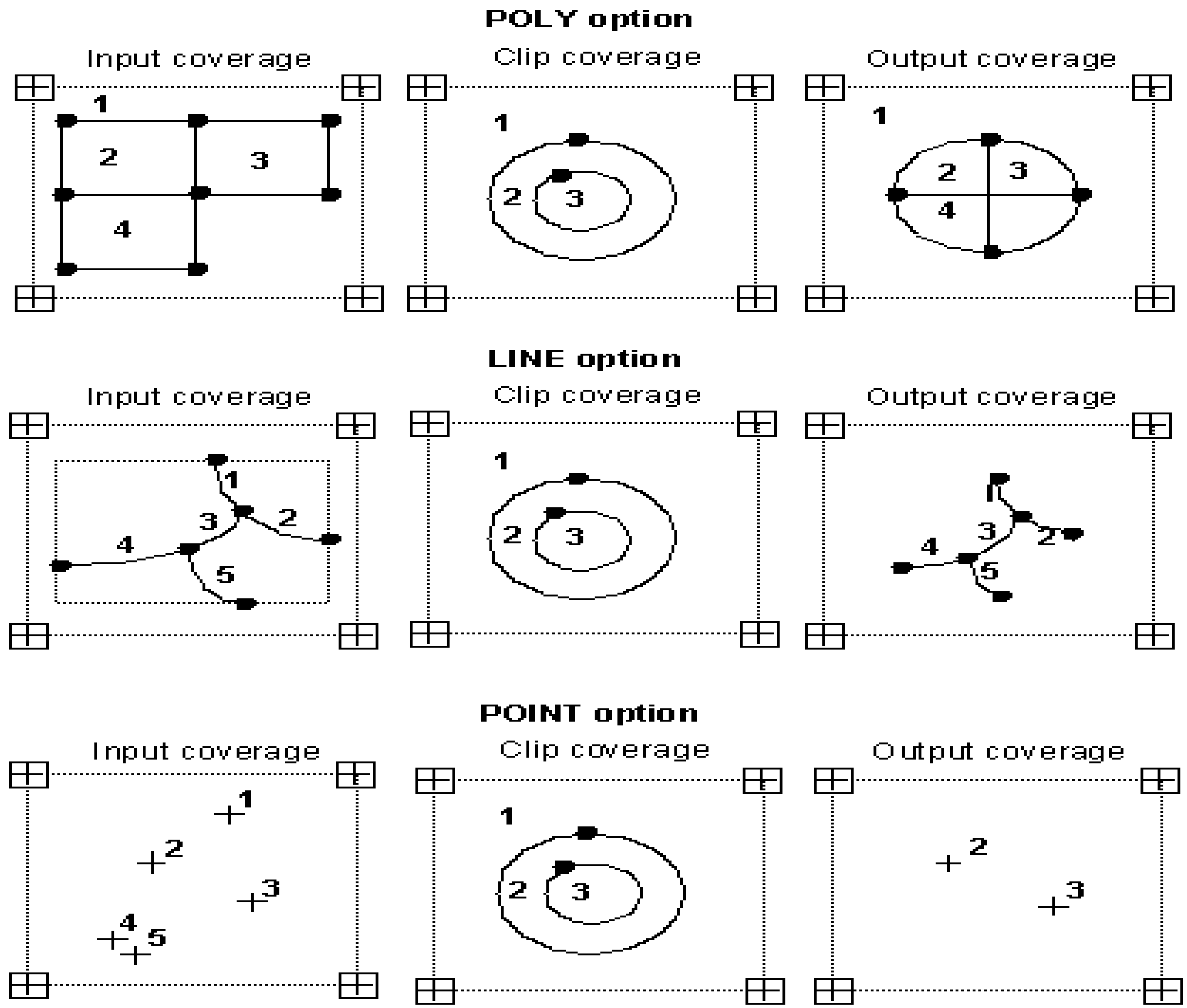
Boundaries of interior polygons in the <clip_cover> are not used in CLIP.

CLIP uses the clip coverage as a **cookie cutter**; only those input coverage features that are within the clip coverage are stored in the output coverage.

Topology is built for the output coverage.

Only the attributes of the in_cover are retained in the out_cover

CLIP, pg 2


POLY option
Input coverage
Clip coverage
Output coverage
LINE option
Input coverage
Clip coverage
Output coverage
POINT option
Input coverage
Clip coverage
Output coverage

Clipping an Image

- **Clipping of images is fundamentally different from clipping coverages. This is because images are a raster data format while coverages are a vector format. There are several ways to clip an image. The most straightforward way is given herein.**
- **Use the RECTIFY command, specifying a clip BOX or clip_cover on the command line. Note that the clip_cover area is defined by the BND of the coverage, not the polygon features in the coverage.**
- **An image is always rectangular, so it can only be clipped with a rectangular box or BND.**

ERASE

- ERASE **- erases the input coverage features that overlap with the erase coverage polygons.**

ERASE <in_cover> <erase_cover> <out_cover> {POLY | LINE | POINT | NET | LINK | RAW} {fuzzy_tolerance}

The <erase_cover> must have polygon topology.

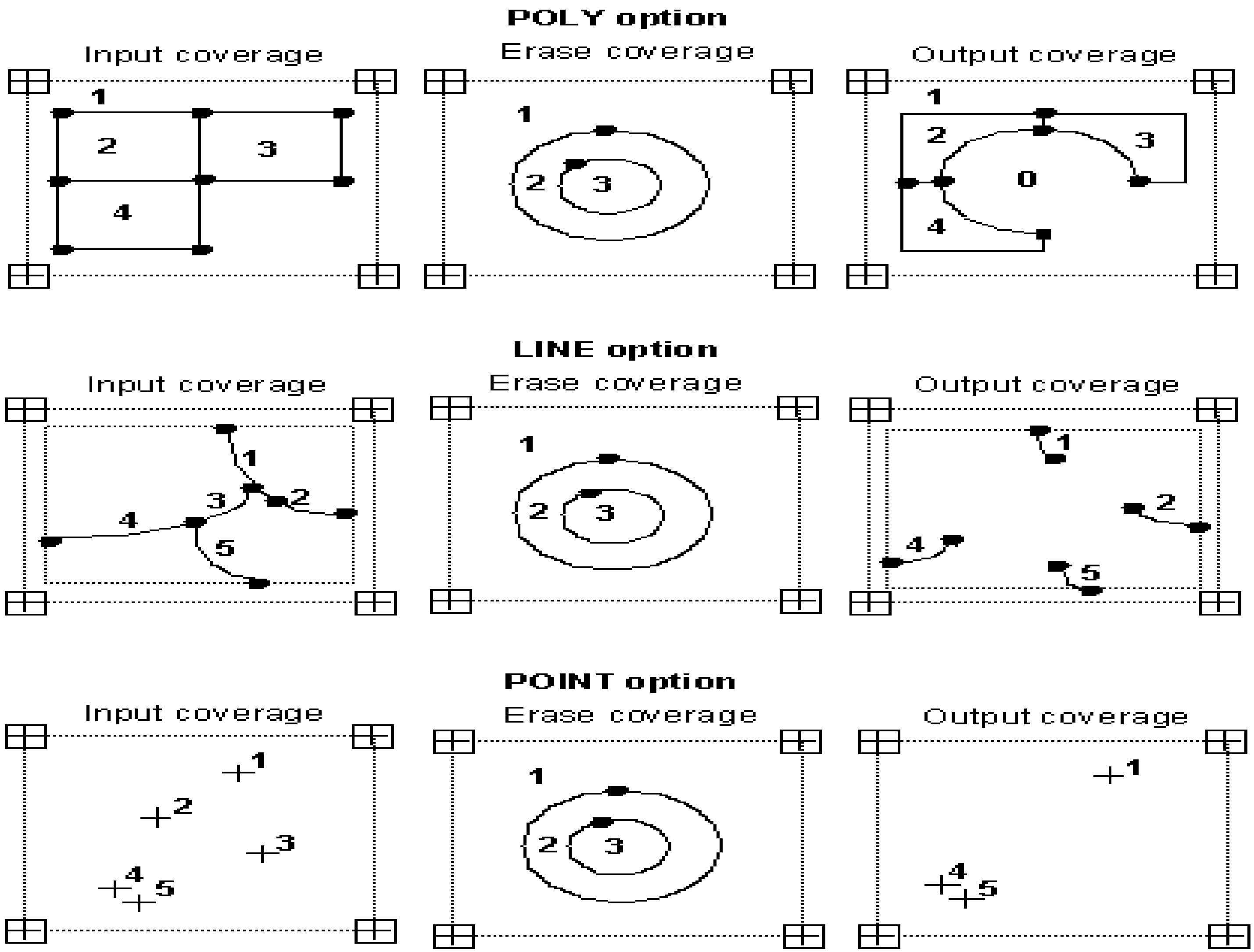
Boundaries of interior polygons in the <erase_cover> are not used in ERASE.

The polygons of the erase coverage define the erasing region. Input coverage features that are within the erasing region are removed. The output coverage contains only those input coverage features that are outside the erasing region.

Erase is the opposite of clip: it leaves you with “the left over dough”

Topology is rebuilt for the output coverage.

ERASE


POLY option
Input coverage
Erase coverage
Output coverage
LINE option
Input coverage
Erase coverage
Output coverage
POINT option
Input coverage
Erase coverage
Output coverage

SPLIT

- SPLIT **- breaks a single coverage into many coverages.**
  - SPLIT <in_cover> <split_cover> <split_item> {POLY | LINE | POINT | NET | LINK | RAW} {fuzzy_tolerance}
    - » <split_item> - the item in <split_cover> which will be used to split the <in_cover>.
    - » You will be prompted to enter the names of output coverages and <split_item> values
    - » Up to 50 output coverages can be specified.
    - » The <split_cover> must have polygon topology.

Arc: split maptile index tilename poly 1.0

When done entering coverages, type END or a blank line.

Enter the 1st coverage: tilesplit1

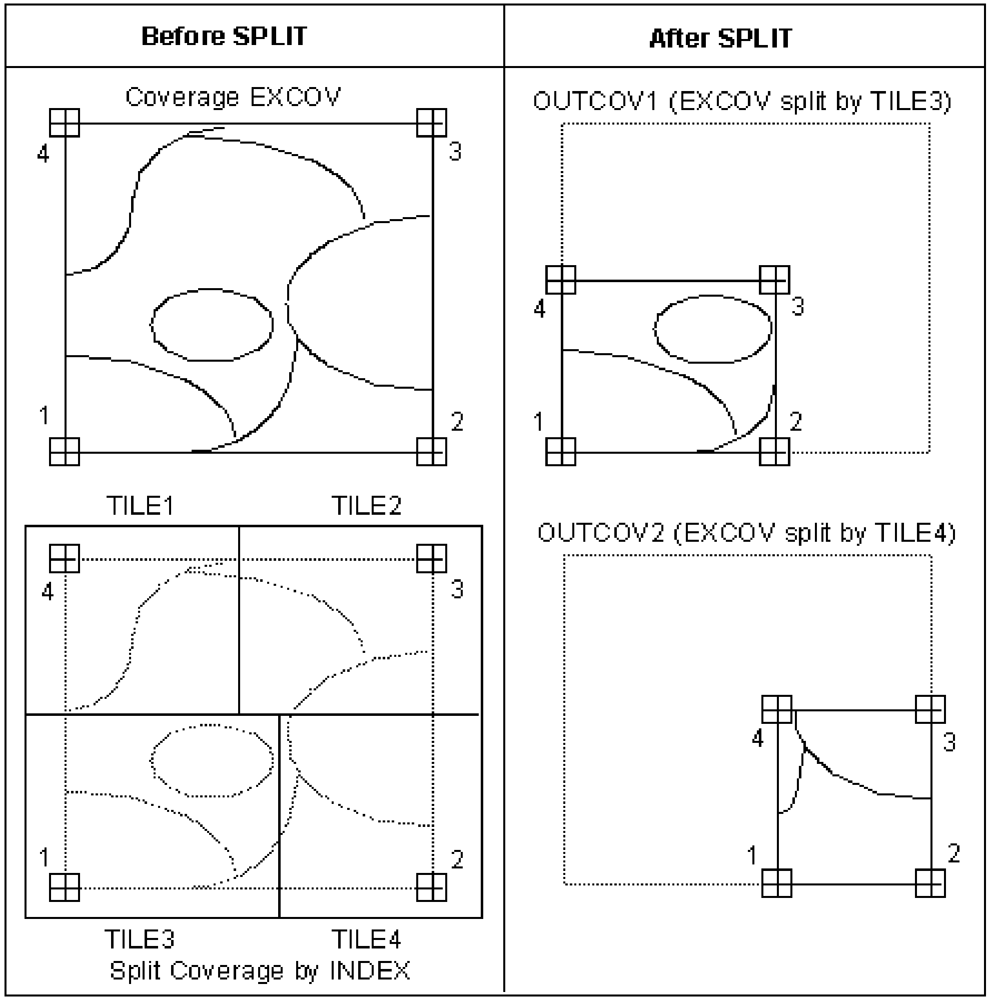
Enter item value: tile3

Enter the 2nd coverage: tilesplit2

Enter item value: tile4

Enter the 3rd coverage: end

SPLIT, page 2

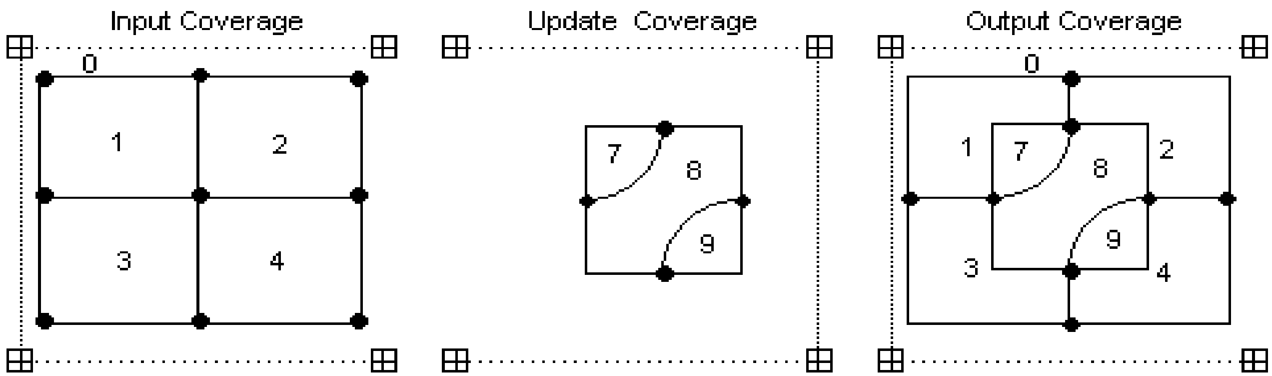

Before SPLIT
After SPLIT
Coverage EXCOV
4
3
1
2
TILE1
TILE2
4
3
1
2
TILE3
TILE4
Split Coverage by INDEX
OUTCOV1 (EXCOV split by TILE3)
4
3
1
2
OUTCOV2 (EXCOV split by TILE4)
4
3
1
2

UPDATE

- UPDATE **- replaces the input coverage areas with the update coverage polygons using a cut-and-paste operation.**
  - UPDATE <in_cover> <update_cover> <out_cover> {POLY | NET} {fuzzy_tolerance} {KEEPBORDER | DROPBORDER}
    - » {KEEPBORDER | DROPBORDER} - specifies whether or not the outside border of the <update_coverage> will be kept after it is inserted into the <in_cover>.
  - UPDATE uses the updating extent in a '**cut-and-paste'** operation; update coverage features replace the area they overlap in the input coverage. The result is stored in the output coverage.
  - Both the input and update coverages must have polygon topology.
  - Topology is rebuilt for the output coverage.
  - Attributes are also updated. Items in the PAT are merged using the old internal number of each polygon.

UPDATE, page 2

KEEPBORDER option



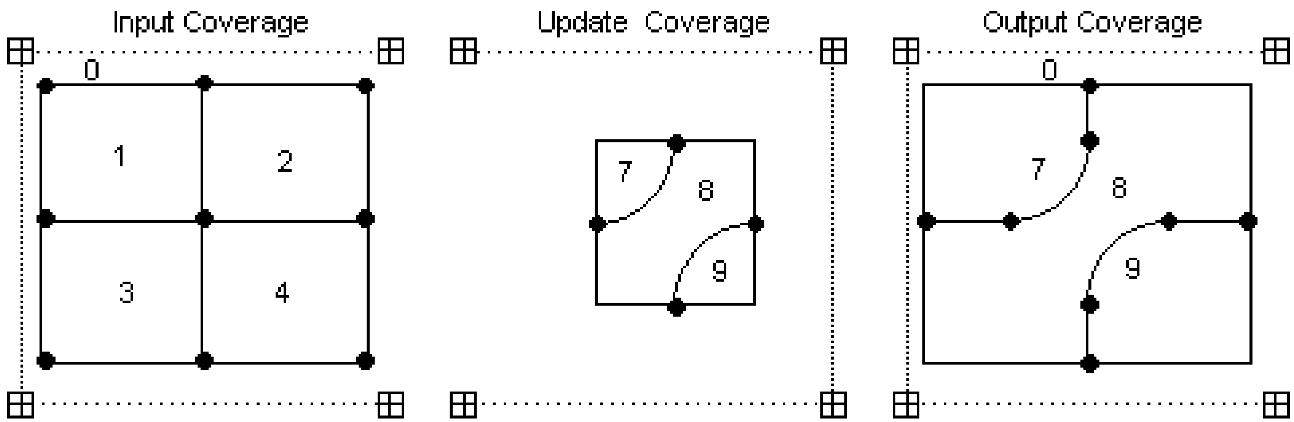
ID	ATTRIBUTE
0	
1	A
2	B
3	C
4	D

ID	ATTRIBUTE
7	A
8	E
9	D

ID	ATTRIBUTE
0	
1	A
2	B
7	A
8	E
9	D
3	C
4	D

UPDATE, page 3

DROPBORDER option



ID	ATTRIBUTE
0	
1	A
2	B
3	C
4	D

ID	ATTRIBUTE
7	A
8	E
9	D

ID	ATTRIBUTE
0	
7	A
8	E
9	D

Polygon Overlay with Attribute Merging

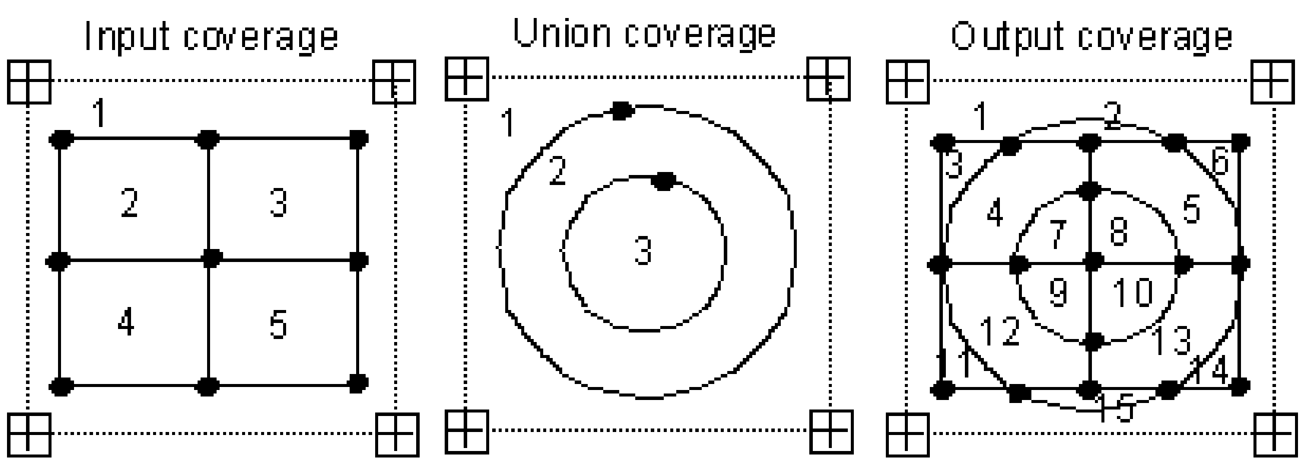
- **There are three commands that perform polygon overlay that merge attribute data:** UNION, INTERSECT**, and** IDENTITY

- UNION **combines all the features of both coverages**
- INTERSECT **Only those features in the area common to both coverages will be preserved in the output coverage. Any data that lie outside the common area are deleted (clipped) from the output coverage.**
- IDENTITY **All features of the input coverage, as well as those features of the identity coverage that overlap the input coverage, are preserved in the output coverage.**

Union

- UNION **- computes the geometric intersection of two** polygon **coverages. All polygons from both coverages will be split at their intersections and** preserved **in the output coverage.**

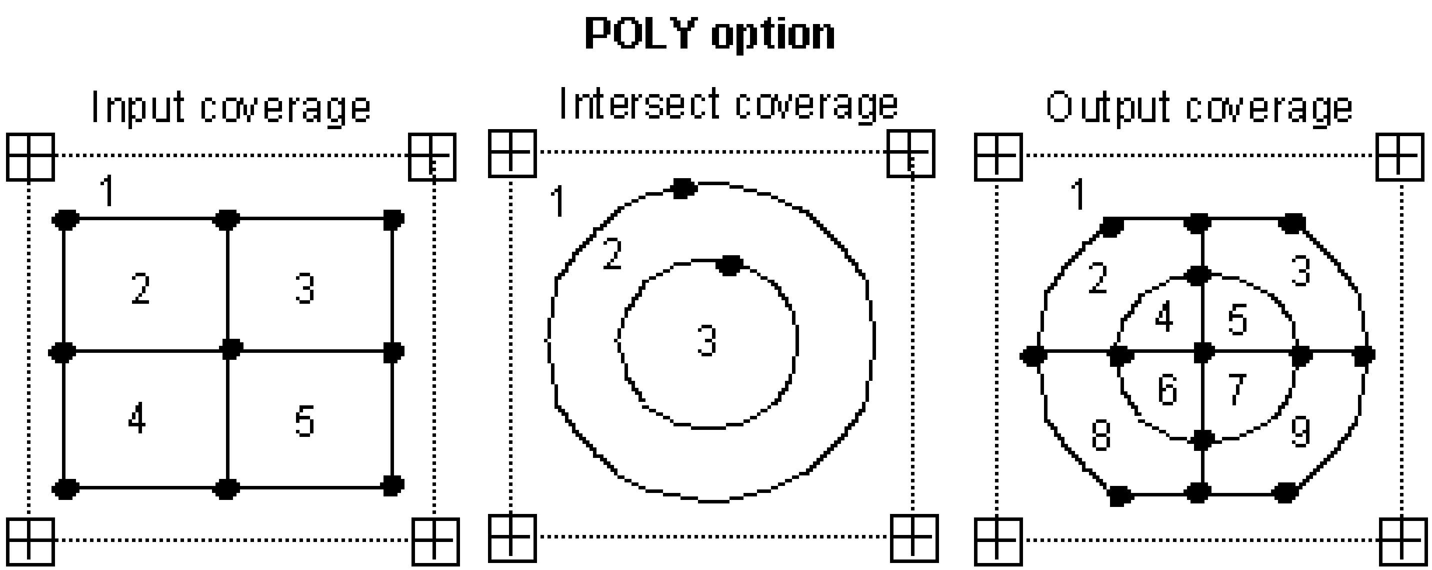
- **UNION <in_cover> <union_cover> <out_cover> {fuzzy_tolerance} {JOIN | NOJOIN}**
  - {JOIN | NOJOIN} - specifies whether all items in both the <in_cover> PAT and <union_cover> PAT will be joined into the output coverage PAT.



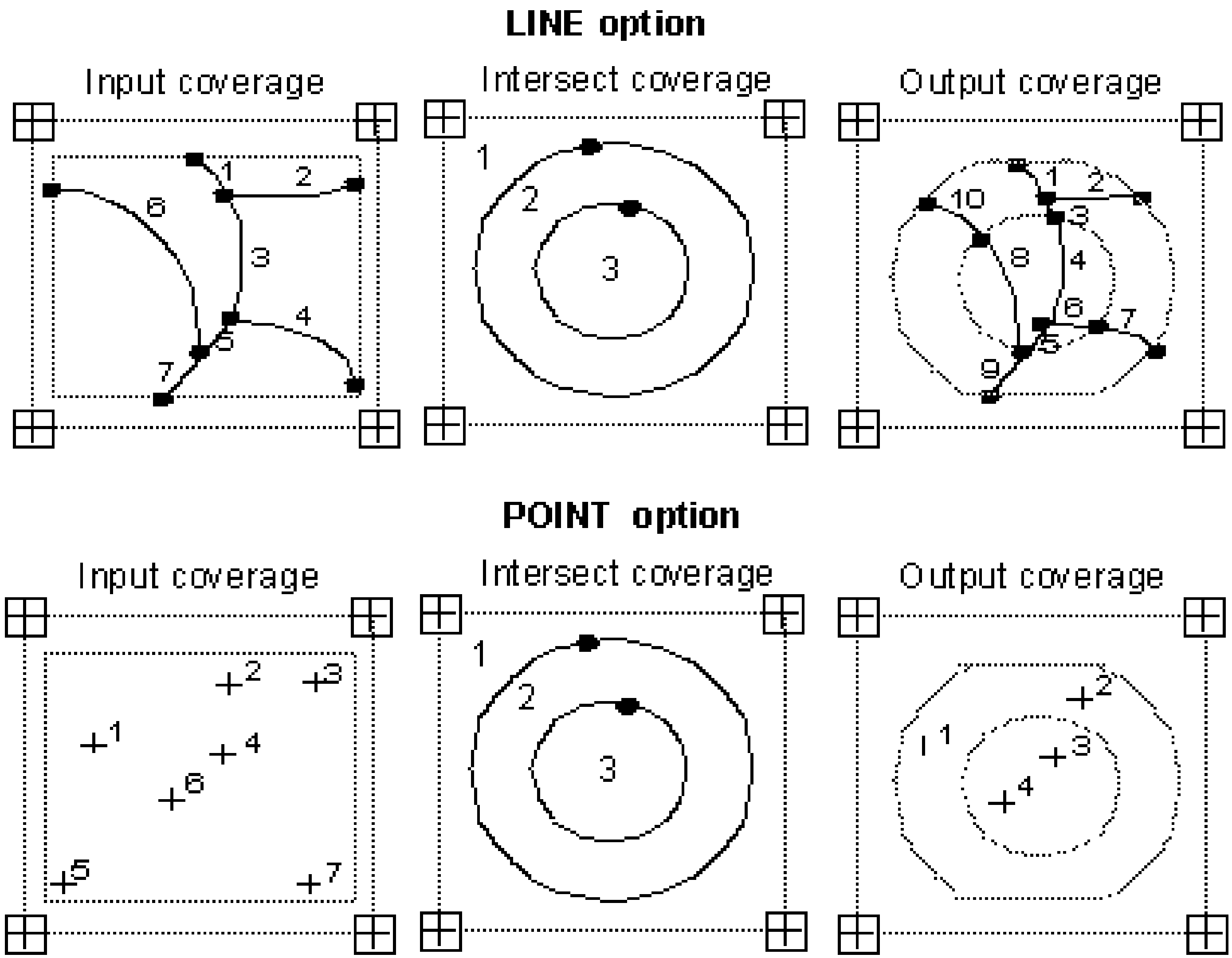
INTERSECT

- INTERSECT **- computes the geometric intersection of two coverages. Only those features in the area common to both coverages will be preserved in the output coverage.**

- **INTERSECT <in_cover> <intersect_cover> <out_cover> {POLY | LINE | POINT} {fuzzy_tolerance} {JOIN | NOJOIN}**



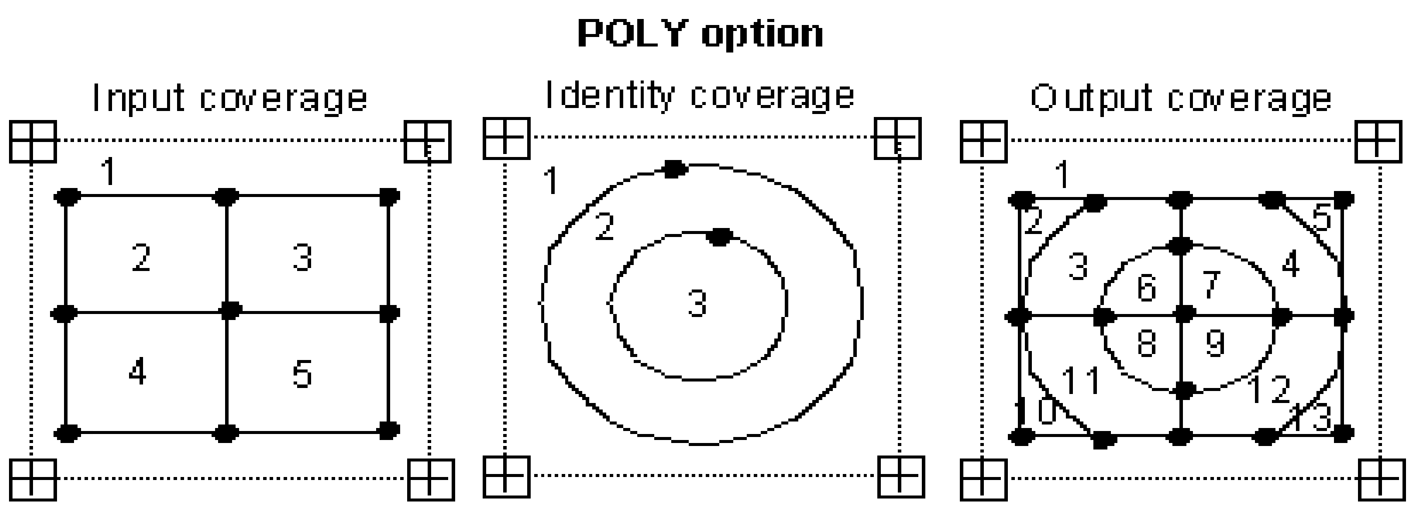
INTERSECT, page 2



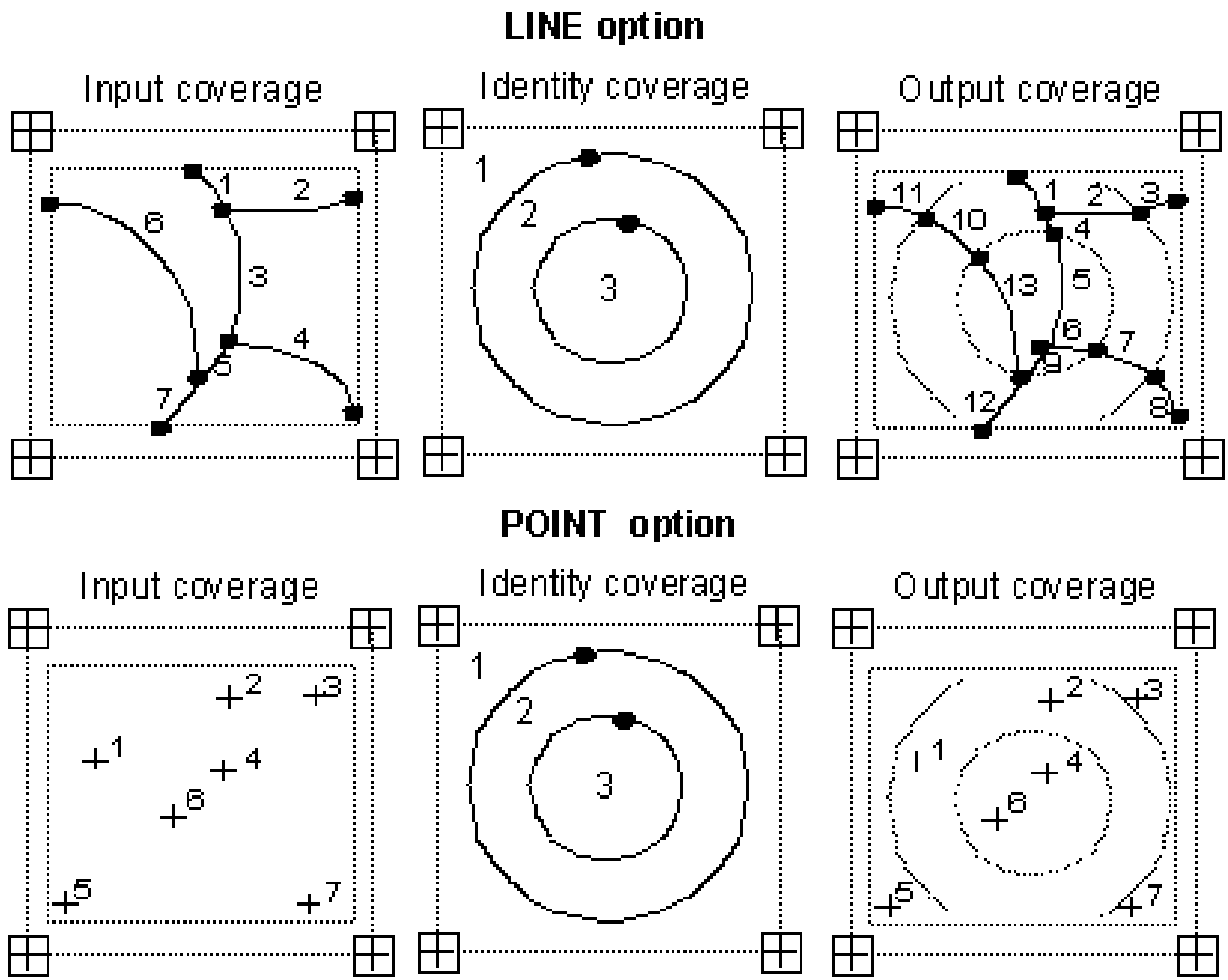
IDENTITY

- IDENTITY **- computes the geometric intersection of two coverages. All features of the input coverage, as well as those features of the identity coverage that overlap the input coverage, are preserved in the output coverage.**

- **IDENTITY <in_cover> <identity_cover> <out_cover> {POLY | LINE | POINT} {fuzzy_tolerance} {JOIN | NOJOIN}**



IDENTITY, Page 2



Solving Problems Through Spatial Analysis

- **Extract features from a coverage to create a new coverage**
- **Create zones around features**
- **Combine coverages to create new data relationships**
- **Develop models**
- **Identify trends**
- **Make better decisions**

Typical Steps in Spatial Analysis

- **Establish analysis objectives and criteria**
- **Prepare data for spatial operations**
- **Perform spatial operations**
- **Prepare derived data for tabular analysis**
- **Perform tabular analysis**
- **Evaluate and interpret results**
- **Refine the analysis as necessary**
- **Produce final maps and tabular reports of the results**

Spatial Analysis Example, page 1

- **Your firm has been contracted to identify sites that are suitable for a landfill. An ideal site would meet the following criteria:**
  - At least 1/4 mile from any local street
  - Soil suitable for landfill development
  - Zoned industrial or agricultural
  - Vacant or agricultural land use
  - Not prone to flooding
  - Not within a fault zone
  - Area greater than 1,400,000 square feet
- **Coverages available:**
  - 1. streets
  - 2. soil
  - 3. zoning
  - 4. landuse
  - 5. flood
  - 6. faultzone

Spatial Analysis Example, page 2

- **STEP 1: BUFFER streets for 1/4 mile (1320 feet)**
- **STEP 2: UNION the street buffer coverage with soils, flood, zoning, landuse, and faultzone (all polygon on polygon with join). Add an item to the final coverage called suitable.**
- **STEP 3: RESELECT (in Arcplot) from the resulting coverage, buffer item INSIDE = 1 (to select areas outside the buffer polygon), soiltype = clay, flood = outside, zone = industrial or zone = agricultural, landuse = vacant or landuse = agricultural, and faultzone = outside.**
- **STEP 4: Once the polygons are selected, calculate suitable to be equal to 1. Combine polygons for which suitable = 1 (dissolve on suitable). Reselect polygons with area>1400K**

Spatial Analysis Example #2

- **Identify suitable sites (from 6 possible locations) for a branch bank:**
  - more than 10,000 population within 2 miles
  - no other bank within 1 mile
  - on a parcel adjacent to a major thoroughfare

- **Available coverages:**
  - 6parcels
  - census
  - banks
  - roads

Spatial Analysis Example #3

- **Design a sensitive habitat preservation zone for the purple-throated tutsi bird (very rare), which needs:**
  - grassland, area over 1,000 acres
  - adjacent to forest, area over 500 acres
  - no major road within 5 miles.

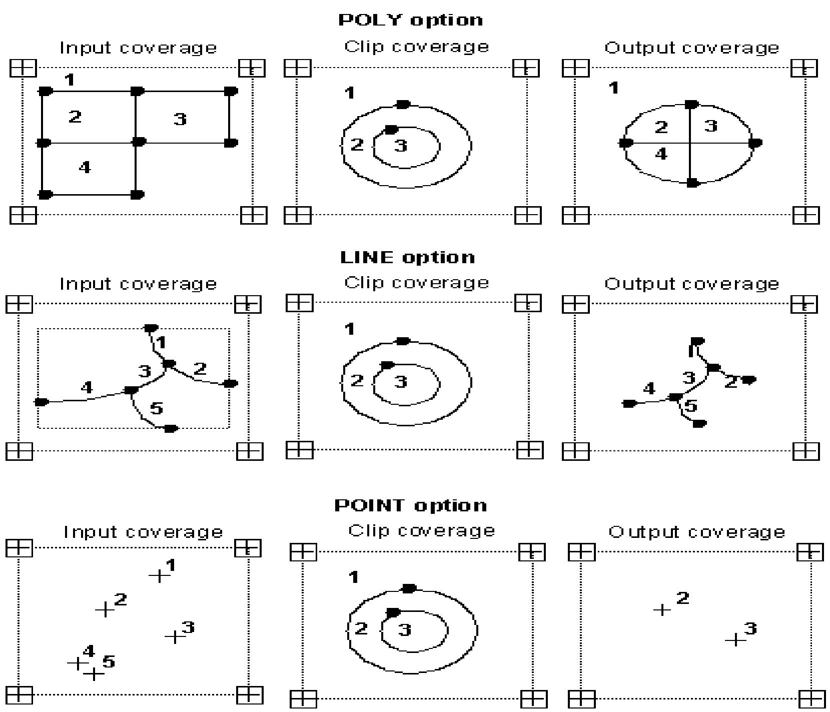
- **What data do I need?**

Spatial Matching:

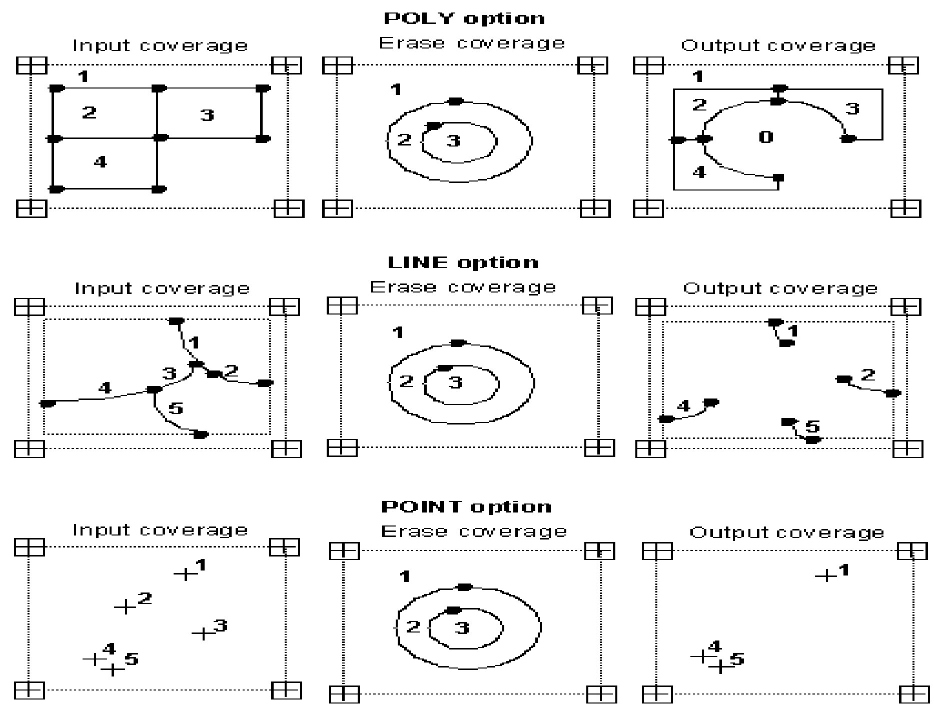
Clipping and Erasing

(sometimes referred to as *spatial extraction*)

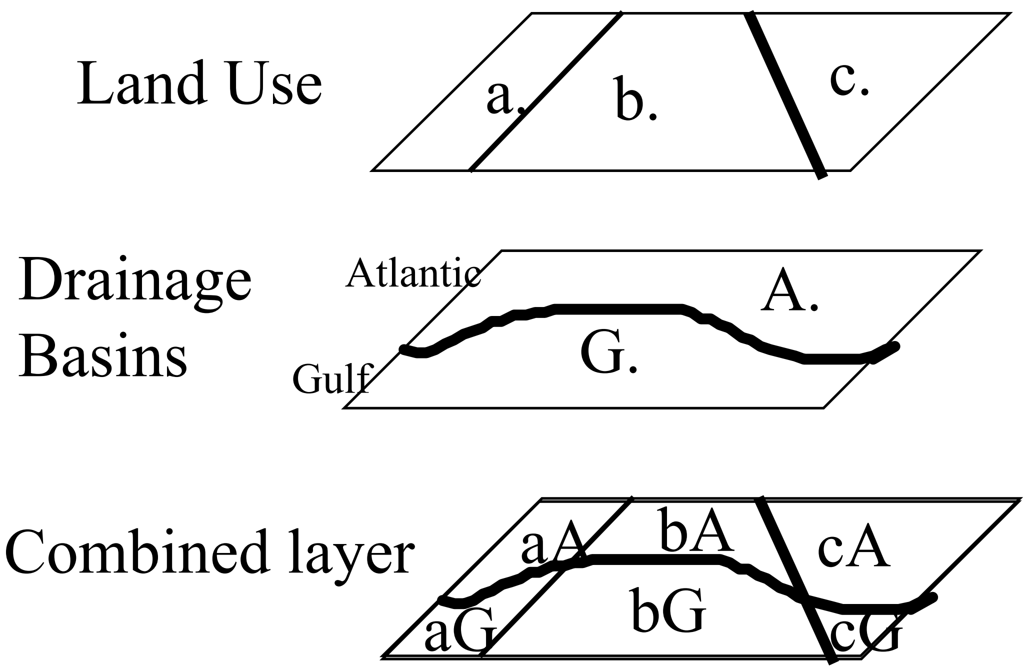
•**CLIP** - extracts those features from an input coverage that overlap with a clip coverage. This is the most frequently used polygon overlay command to extract a portion of a coverage to create a new coverage.



•**ERASE** - erases the input coverage features that overlap with the erase coverage polygons.



Example: Spatial Matching via *Polygon-on-Polygon Overlay: Union*



The two themes (land use & drainage basins) do not have common boundaries. GIS creates combined layer with all possible combinations, permitting calculation of land use by drainage basin.

Implementing Spatial Matching in ArcGIS 8

Available in three places

- via *Selection/Select by Location*
  - this selects features of one layer(s) which relate in some *specified spatial manner* to the features in another layer
  - if desired, selected features may be saved later to a new theme via *Data/Export Data*
- via *Spatial Join* (right click layer in T of C, select ***Join/****Joins and Relates*, then click down arrow in first line of **Join Data** window---see *Joining Data* in **Help** for details)
  - **Use for: points in polygon**
lines in polygon
points on lines (to calculate distance to nearest line)
points on points (to calculate distance to "nearest neighbor" point)
- via *Tools/Geoprocessing Wizard*
  - Creates a new layer (e.g. shape file) & combines attribute tables from 2 or more input themes
  - Five options available for different types of matching *(see below)*

Options in Geoprocessing Wizard

- *Dissolve features based on an attribute*
  - **Use for spatial aggregation/dissolving**
- *Merge layers together*
  - **Use for edge matching**
- *Clip one layer based on another*
  - **Use one theme to limit features in another theme** (e.g. limit a Texas road theme to Dallas county only)
- *Intersect two layers (extent limited to common area)*
  - **Use for polygon on polygon overlay**
- *Union two layers (covers full extent of both layers)*
  - **Use for polygon on polygon overlay**

--**Selection:** simply selects ("highlights") entire spatial features in the target layer, but doesn't modify these features
--**joins:** operate on tables and normally creates a new table with additional variables, but again does not modify spatial features themselves
--**geoprocessing wizard:** modifies geographic features thus creates new spatial file

Spatial Operations:

neighborhood analysis/spatial filtering

- **spatial convolution or filter**
  - applied to one raster layer
  - value of each cell replaced by some function of the values of itself and the cells (or polygons) surrounding it
  - can use ‘neighborhood’ or ‘window’ of any size
    - » 3x3 cells (8-connected)
    - » 5x5, 7x7, etc.
  - differentially weight the cells to produce different effects
  - **kernel** for 3x3 mean filter:

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

weights must sum to 1.0

- **low frequency (low pass) filter:**

mean filter

  - cell replaced by the mean for neighborhood
  - equivalent to weighting (mutiplying) each cell by 1/9 = .11 (in 3x3 case)
  - smooths the data
  - use larger window for greater smoothing

median filter

  - use median (middle value) instead of mean
  - smoothing, especially if data has extreme value outliers

Spatial Operations:

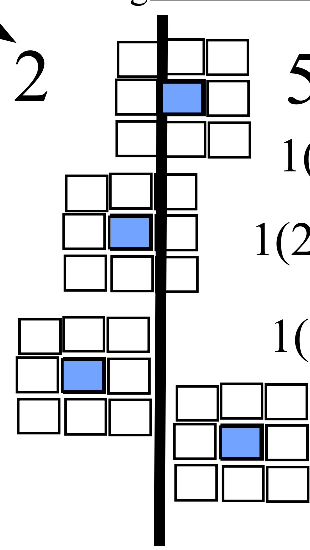
spatial filtering -- high pass filter

high frequency (high pass) filter

negative weight filter

- exagerates rather than smooths local detail
- used for edge detection

cell values (v_i) on each side of edge



filtered values for highlighted pixel

1(5)(9)+5(5)(-1)+3(2)(-1) = 14

1(2)(9)+5(2)(-1)+3(5)(-1) = -7

1(2)(9)+8(2)(-1) = 2

1(5)(9)+8(5)(-1) = 5

$f_i \bullet v_i \bullet w_i$

standard deviation filter (texture transform)

- calculate *standard deviation* of neighborhood raster values
- high SD=high texture/variability
- low SD=low texture/variability
- again used for edge matching
- neighorhoods spanning border have large SD 'cos of variability

–**kernel for example** (w_i)

-1	**-1**	**-1**
-1	**9**	**-1**
-1	**-1**	**-1**

Spatial Operations:
raster–based modelling

- **Relating multiple rasters**
- **Processes may be:**
  - Local: one cell only
  - Neighborhood: cells relating to each other in a defined manner
  - Zonal: cells in a given section
  - Global: all cells
- **ArcGIS implementation:**
  - All raster analyses require either the Spatial Analyst or 3-D Analyst extensions (extra cost)
  - Base ArcView can do no more than display an image (raster) data set

- **Suitability modelling**

soil + slope + for sale = Site options

- **Diffusion Modelling**

Incidence matrix × Probability mask = System at time t+1

- **Connectivity Modelling**

Initial State + Connectivity matrix = Resultant State

Attribute Operations:
record selection or extraction

Tabular (select by attributes)

- Independent selection by clicking table: *right click in TofC, select Open Attribute Table & click on grey selection box at start of row; hold ctrl key for multiple rows)*
- Create SQL query: *use Selection/Select by Attribute*
- use table relates /joins to select specific data

Graphic (select by location)

- with manual cursor on map *(use Select Features tool)*
  - at a point
  - within a rectangle
  - within a radius (circle) around a point
- By using another layer (spatial extraction)

Hot Link

- Click on map to 'hot link' to pictures, graphs, or other maps

Outputs may be:

- Simultaneously highlighted records in table, and features on map
- New tables and/or map layers

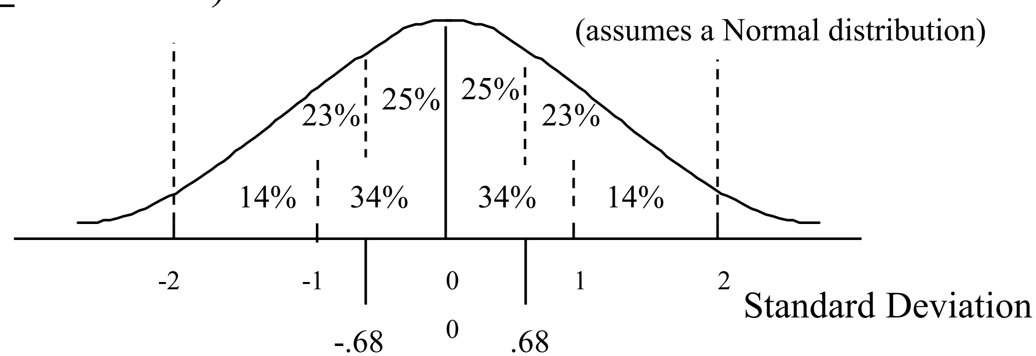
Examples

- Use SQL query to select all zip codes with median incomes above $50,000 (tabular)
- identify zip codes within 5 mile radius of several potential store sites and sum household income (graphic)
- show houses for sale on map, and click to obtain picture and additional data on a selected house (hot link)

Attribute Operations: *variable recoding*

- **establishing/modifying number of classes and/or their boundaries for continuous variable. Options for ArcGIS**
  - natural breaks (default)
    (finds inherent inherent groups via Jenks optimization which minimizes the variances within each of the classes).
  - quantile (classes contain equal number of records--or equal area under the frequency distribution)
  - equal interval (user selects # of classes)
    (equal width classes on variable)
  - Defined interval (user selects <u>width</u> of classes)
    (equal width classes on variable)
  - standard deviation
    (categories based on 1,2, etc, SDs above/below mean)
  - Manual (user defined)
    - » whole numbers (e.g. 2,000)
    - » meaningful to phenomena (e.g zero, 32^{o})
- **aggregating categories on a nominal (or ordinal) variable**
  - pine and fir into evergreen

Implement in ArcGIS via:
Right click in T of C, select *Properties*, then *Symbology* tab



<u>No change</u> in number of records (observations).

Attribute Operations:

record aggregation

- combining two or more records into one, based on common values on a key variable
- the attribute equivalent of regionalization or classification
- equivalent of PROC SUMMARY in SAS
- interval scale variables can be aggregated using mean, sum, max, min, standard deviation, etc. as appropriate
- ordinal and nominal require special consideration
- example: aggregate county data to states, or county to CMSA

Record count <u>decreases</u> (e.g. from 12 to 2)

Fips	PMSA_90	PMSA_93	Pop90	Pop95_est	Pop90-95%	MedInc89	Suburb	Name
48085	1920	1920	264036	346232	5.93	46020	1	Collin
48113	1920	1920	1852810	1959281	1.09	31605	0	Dallas
48121	1920	1920	273525	334070	4.22	36914	1	Denton
48139	1920	1920	85167	94223	2.03	30553	1	Ellis
48213		1920	58543	64293	1.87	20747	1	Henderson
48231		1920	64343	66972	0.78	25317	1	Hunt
48257	1920	1920	52220	60114	2.88	27280	1	Kaufman
48397	1920	1920	25604	32725	5.30	42417	1	Rockwall
48221		2800	28981	33384	2.89	31627	1	Hood
48251	2800	2800	97165	106181	1.77	30612	1	Johnson
48367	2800	2800	64785	73794	2.65	30592	1	Parker
48439	2800	2800	1170103	1278606	1.77	32335	0	Tarrant
Source: US Bureau of the Census								
MedInc=Median Household Income. Pop90 as of April 1. Pop95 as of July 1.								

Fips	PMSA_90	PMSA_93	Pop90	Pop95_est	Pop90-95%	MedInc89	Suburb	Name
		1920	2676248	2957910	2.00	32607	7	Dallas
		2800	1361034	1491965	1.83	31292	3	Fort Worth

Type of processing: sum (Pop90), sum (Pop95_est), re-calc. (Pop90-95%), ↑ average of medians! (MedInc89), count (Suburb)

Attribute Operations: *Joining and Relating Tables*

associating spatial layer to non-spatial table

<u>Join:</u> one to one, or one to many, relationship, appends attributes

Associate table of country capitals with country layer: only one capital for each country (one to one)

Country Code	Country
29	France
68	Saudi Arabia
106	Chad
248	Spain
199	Venezuela
9	UK
96	Philippines

Layer Attribute Table

Country Code	Capital
199	Caracas
96	Manila
68	Riyadh
29	Paris
106	N'Djamena
9	London
248	Madrid

NonSpatial Table

Country Code	Country	Capital
9	UK	London
29	France	Paris
68	Saudi Arabia	Riyadh
96	Philippines	Manila
106	Chad	N'Djamena
199	Venezuela	Caracas
248	Spain	Madrid

Layer Attribute Table after Join

Associate country layer with type of government: one gov. type assigned to many countries--but each country has only one gov. type (one to many)

Gov. Code	Country
20	France
30	Vietnam
15	UK
20	Argentina
10	Saidi Arabia
15	Sweden
45	Portugal

Layer Attribute Table

Gov. Code	Type
10	Absolute Monarchy
15	Const. Monarchy
20	Republic
30	Communist State
45	Parliamentary Democracy

NonSpatial Table

Gov. Code	Country	Type
20	France	Republic
30	Vietnam	Communist State
15	UK	Const. Monarchy
20	Argentina	Republic
10	Saudi Arabia	Absolute Monarchy
15	Sweden	Const. Monarchy
45	Portugal	Parliamentary Democracy

Layer Attribute Table after Join

Attribute Operations: *Joining and Relating Tables*

associating spatial layer to non-spatial table (contd.)

<u>Relate:</u> many to one relationship, attributes not appended

Associate country layer with its multiple cities (many to one)

Country Code	Country
29	France
68	Saudi Arabia
106	Chad
248	Spain
199	Venezuela
9	UK
96	Philippines

Layer Attribute Table

Country Code	City
129	Mombasa
129	Nairobi
29	Paris
29	Lyon
29	Marseille
60	Katmandu
248	Madrid
248	Barcelona
248	Valencia

NonSpatial Table

If <u>*joined*</u> Paris to France, for example, we lose Lyon and Marseille, therefore use *relate*

Note: if we flip these tables we can do a join since there is only one country for each city (one to many)

For both Joins and Relates:

- **Association exists only in the map document**
- **Underlying files not changed unless export data**