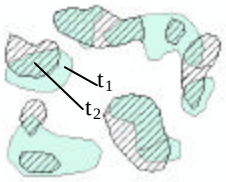
Analysis of Change in Polygon Distribution



These instructions enable you to analyze the change in polygon distribution between two time periods using ArcGIS 8.1 (*ArcInfo licensed*) software. The GIS processing used here is based on the following publication:

SADAHIRO, Yukio and Mitsuru UMEMURA (2001). "A Computational Approach for the Analysis of Changes in Polygon Distributions." *Journal of Geographical Systems*, to appear [CSIS Discussion Paper Series, 25, Center for Spatial Information Science, University of Tokyo]. http://okabe.t.u-tokyo.ac.jp/okabelab/sada/docs/pdf-e.html

In the publication, the change in polygon distribution is broken down into a combination of ***primitive events***:

1) generation, 2) disappearance, 3) expansion, 4) shrinkage, 5) union, 6) division

These events are categorized according to topological relationships of the polygons between the two time periods. Using the resulting attribute tables, change can then be computed in a spreadsheet according to formulae presented in the publication.

The following sample files are used:

ORIGINAL DATA THEMES

Set1.shp	shapefile of single-class polygons at time 1 (t_1)
Set2.shp	shapefile of single-class polygons at time 2 (t_2)

CREATED DATA THEME

Union	polygon coverage resulting from the conversion and union overlay of the original shapefiles

Start the map document:

1. Open ARCMAP
2. ADD DATA: ***Set1.shp*** and ***Set2.shp***
3. Choose VIEW → DATA FRAME PROPERTIES…
4. Set the Map and Display units under the GENERAL tab as appropriate
5. Click OK

Add unique identification fields to each shapefile attribute table.

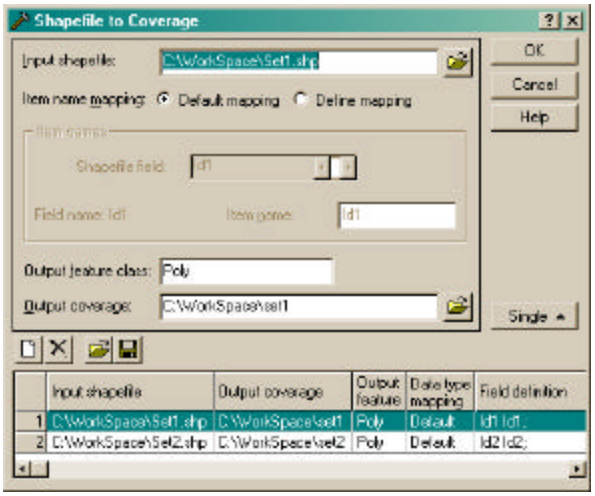
6. In the table of contents, right-click on ***Set1.shp***
7. Choose OPEN ATTRIBUTE TABLE
8. Click on the OPTIONS button
9. Choose ADD FIELD
10. Specify **[ID1]** as the name and Short Integer with a precision of 0 as the type

11. Right-click on the heading [ID1]
12. Choose CALCULATE VALUES
13. Enter the expression: **`1 & [FID]`**
14. Repeat steps 6 through 13 for ***Set2.shp***, except specify **[ID2]** as the name and use the expression: **`2 & [FID]`** to calculate values
15. Save the map document, e.g. **C:\Workspace\PolyDIst.mxd**
16. Close ArcMap

Convert to coverages, build topology, and overlay union:

1. Open ARCTOOLBOX

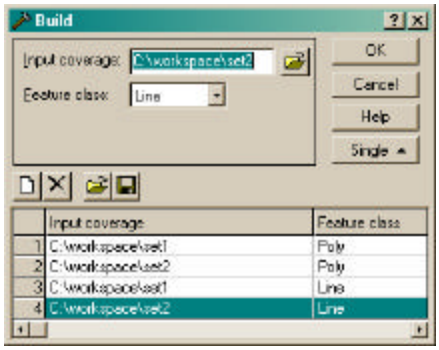
Import the shapefiles to polygon coverages.



2. Open CONVERSION TOOLS → IMPORT TO COVERAGE → SHAPEFILE TO COVERAGE
3. Select ***Set1.shp*** as the input shapefile
4. Accept Default mapping and Poly as the Output feature class
5. Specify **set1** as the output coverage name
6. Click on the BATCH button
7. Click on the ADD ROW button
8. Select ***Set2.shp*** as the input and specify **set2** as the output
9. Click OK

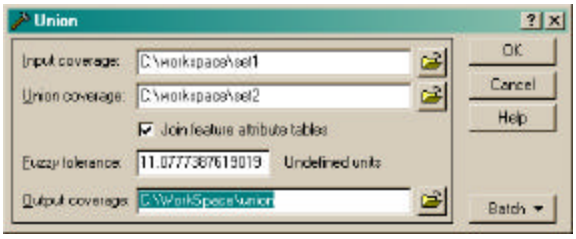
Build polygon and line topology for the new coverages.

10. Open DATA MANAGEMENT → TOPOLOGY → BUILD
11. Select ***set1*** as the input coverage and *Poly* as the feature class
12. Click on the BATCH button
13. Click on the ADD ROW button
14. Select ***set2*** as the input coverage and *Poly* as the feature class
15. Repeat steps 13 and 14 twice but select *Line* as the feature class for both coverages
16. Click OK



Perform a union overlay to combine the two sets.

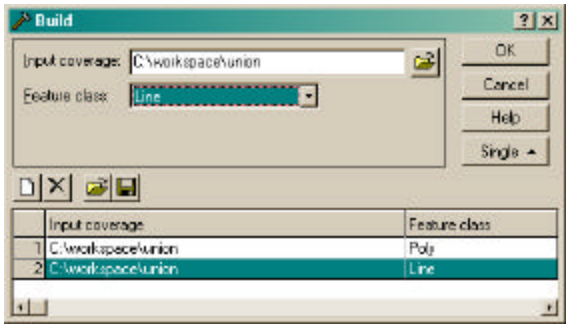
17. Open ANALYSIS TOOLS → OVERLAY → UNION



18. Select ***set1*** as the input coverage and ***set2*** as the union coverage
19. Accept defaults (or choose not to join tables modify the tolerance value)
20. Specify **union** as the output
21. Click OK

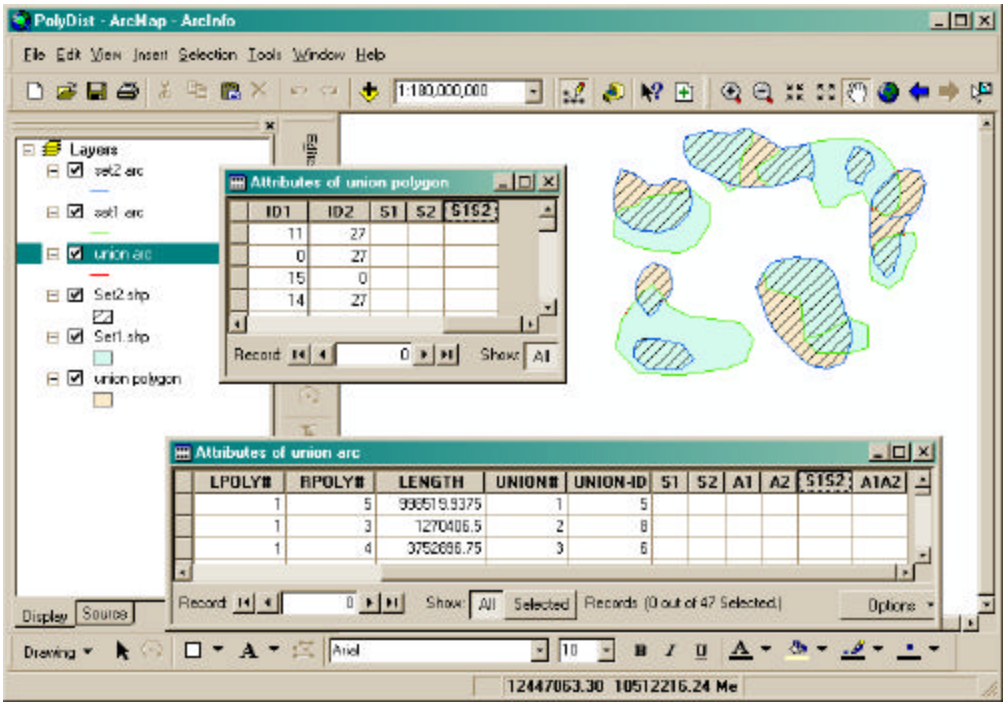
Build topology for the union coverage using the same tool as above.

22. Open DATA MANAGEMENT → TOPOLOGY → BUILD
23. Select union as the input coverage and Poly as the feature class
24. Batch and add row to repeat building for the Line feature class
25. Click OK
26. Close ArcToolbox



Add fields, make selections, and calculate inferred variables:

1. Open ARCMAP and specify to open with the ***PolyDist.mxd*** map document
2. ADD DATA: Union polygon, Union arc, Set1 arc, and Set2 arc
3. Modify the symbology and change the drawing order of layers to make the various layers easier to interpret (see example below)



*Add new fields to the **union** polygon and arc attribute tables.*

4. Right-click on union polygon, OPEN ATTRIBUTE TABLE, and ADD FIELDS:
   - [S1] – Text type of Width 2
   - [S2] – Text type of Width 2
   - [S1S2] – Text type of Width 4
5. Right-click on union arc, OPEN ATTRIBUTE TABLE, and ADD FIELDS:
   - [S1] – Text type of Width 2
   - [S2] – Text type of Width 2
   - [S1S2] – Text type of Width 4
   - [A1] – Text type of Width 2

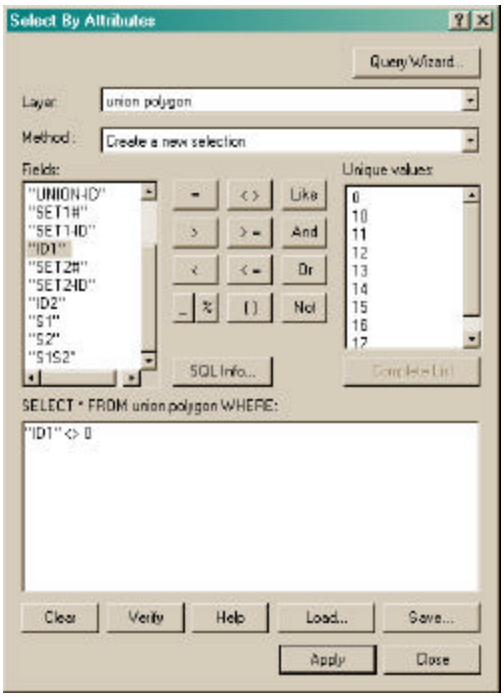
- [A2] – Text type of Width 2
- [A1A2] – Text type of Width 4

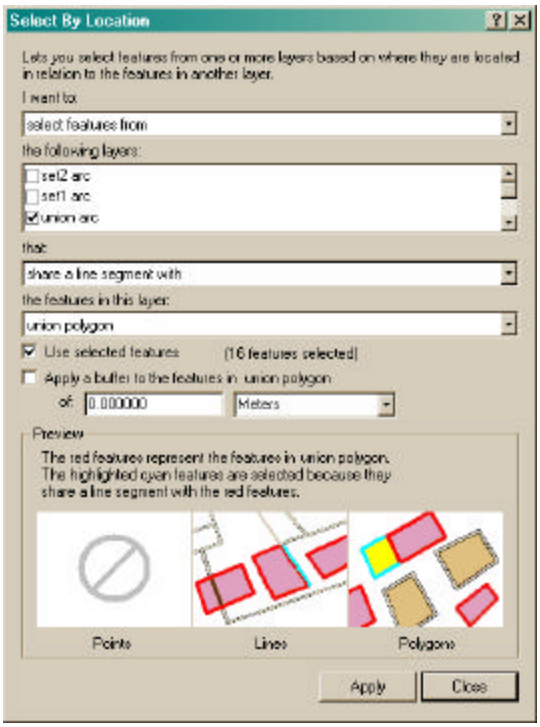
Select by attributes and by location to calculate new values in the order presented:

6. Choose SELECT → SELECT BY ATTRIBUTES
7. Select Union polygon as the layer
8. Enter the first "Where:" expression from the table below
9. Click APPLY
10. Right-click on the appropriate heading and CALCULATE VALUE as specified
11. Click OK
12. Repeat steps 6 through 11 until you are finished with Table 1

Table 1. *Union polygon*: SELECT BY ATTRIBUTES

Select * from Layer	Where:	Calculate values for	Value
Union polygon	"ID1" <> 0	S1	E
	"ID1" = 0 (OPTIONS → SWITCH SELECTION)		O
Union polygon	"ID2" <> 0	S2	E
	"ID2" = 0 (OPTIONS → SWITCH SELECTION)		O





13. For Table 2, you must first choose to select by attributes according to the SELECT BY ATTRIBUTES expressions and layers indicated by **(A)**.
14. Choose SELECT → SELECT BY ATTRIBUTES
15. Select Union polygon (or one of the set arcs) as the layer
16. Enter the "SELECT BY ATTRIBUTES (A)" expression
17. Click APPLY
18. Then choose SELECT → SELECT BY LOCATION
19. Complete the selection expression according to Table 2 for each value

20. Right-click on the appropriate field heading and calculate the corresponding values for the selection
21. Repeat until you are finished with Table 2

Table 2. *Union arc*: SELECT BY LOCATION

Select features from	That	The features in this layer (A)	Use selected features	SELECT BY ATTRIBUTES (A)	Calculate values for	Value
Union arc	Share a line segment with	Union polygon	Y	"ID1" <> 0	S1	E
Union arc	Share a line segment with	Union polygon	Y	"ID2" <> 0	S2	E
Union arc	Share a line segment with	Set1 arc	N	"LPOLY#" <> 1	A1	B
			Y		A1	P
Union arc	Share a line segment with	Set2 arc	N	"LPOLY#" <> 1	A2	B
			Y		A2	P

22. According to Table 3, make selections and calculate using the same methods as for the first table

Table 3. *Union arc*: SELECT BY ATTRIBUTES

Select * from Layer	Where:	Calculate values for	Value
Union arc	"S1" = ' '	S1	O
		A1	O
Union arc	"S2" = ' '	S2	O
		A2	O
Union arc	"A1" = ' '	A1	I
Union arc	"A2" = ' '	A2	I

Calculate the final variables for [S1S2] in both tables and [A1A2] in the arc table.

23. Right-click on the appropriate table heading and choose CALCULATE VALUES
24. Enter the expression that correspond with the heading you clicked:
    - **`[S1S2] = Trim ([S1] & [S2])`**, or
    - **`[A1A2] = Trim ([A1] & [A2])`**
25. Click OK
26. Visually inspect and manually recode if ***[A1A2] = "II"***

This error may be due to the fuzzy tolerance used when building topology.

27. Export the union arc and polygon attribute tables to dBase for use in a spreadsheet by clicking OPTIONS → EXPORT…

Refer to the Sadahiro and Umemura (2001) publication to:

- ***categorize primitive events as defined by [S1S2] and [A1A2]***
- ***compute change using the formulae***

KEY to the VARIABLE Values:

Inferred *Polygon* Variables

S1S2	S1 = state at t_1	E = existing
	S2 = state at t_2	O = not-existing

Inferred *Arc* Variables

S1S2	S1 = state at t_1	E = existing
	S2 = state at t_2	O = not-existing
A1A2	A1 = value at t_1	B = boundary
	A2 = value at t_2	P = partition
		I = interior
		O = absent