Introduction to GIS for Social and Environmental Analysis (CITY201)

Lab 5: Vector Operations, Part A

Learning Objective: To introduce vector operations, including buffer, map dissolve, and overlay operations. Note that this lab uses a variety of data layers, in a somewhat random way, to point out where in the ArcGIS interface these operations can be accessed.

Additional Help: Links to the following video tutorials are on our class Moodle page:

- ArcGIS Pro Analysis – Buffer & Intersect (5 min)
- Performing a Spatial Join in ArcGIS Pro (11 min)
- ArcGIS Pro Clip Tool (3 min)

1. Get Your Data

Start by creating a folder for lab 5 on your storage device or drive. Using Catalog, copy the following shapefiles from our Cities 201 course data folder over to your workspace:

Tiger/counties
Tiger/railroads
Tiger/zipcodes
Tiger/tracts
Tiger/educ_utm

Transform the counties, railroads, zipcodes, and tracts shapefiles into UTM. Call the new shapefiles counties_utm, railroads_utm, zipcodes_utm, and tracts_utm respectively. The educ_utm shapefile is already in UTM. If you have previously converted one of these layers to UTM and know that your projected file is good, you can use that previously projected file.

Open a new ArcGIS map and add the railroads_utm shapefile. **Make sure that when you start a new map ArcGIS file that the FIRST data layer you add is projected in the proper projection.** If you are not sure, close your ArcGIS file and start with a clean blank file OR check the projection of your Map View.

2. Retrieve Line Length and Polygon Area Measurements

Here, you will learn how to use ArcGIS to **calculate line length and polygon area and encode these values in an attribute table**.

Open the attribute table and find the field 'LENGTH'. This is the length of each individual line segment. It is in decimal degrees – not a very intuitive nor practical spatial unit.

Here, we will add a new field and populate the field with new length values in meters.
Add a new field and call it 'Length_m'. Make it a float, and press OK.

Right click on the name of the field at the top of the column and go to Calculate Geometry. In the Calculate Geometry dialog box choose the Property for the Field as "Length" and make sure the Unit Length: reads Meters. Leave the Coordinate System Field blank. Click OK.

You should see the new length values appear in the new field.

Add the zipcodes_utm shapefile to ArcGIS and open its attribute table.

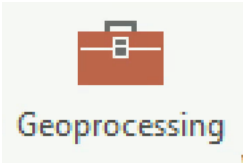
Find the AREA field. This field encodes the area of each zip code but it is in square decimal degrees. Create a new field called Area_m and calculate its value to be the area in square meters. Follow the same procedures as for the railroads but choose to calculate Area in square meters.

3. Buffer Operation

Here, you will learn how to use ArcGIS to **perform a buffer operation on points and lines**.

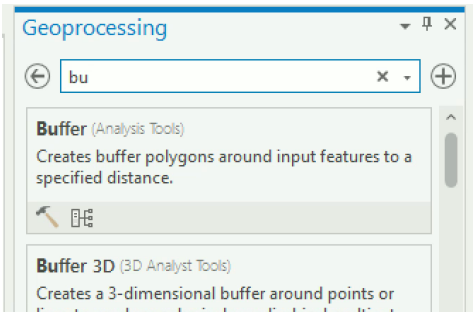
Add the educ_utm shapefile to ArcGIS.

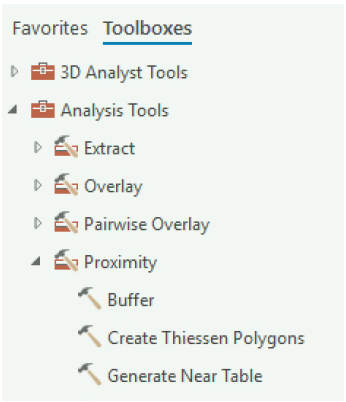
Click on the Geoprocessing Toolbox to open the Geoprocessing Pane. Remember you can get to the Toolbox from multiple locations, including the Insert, Analysis, and View toolbars.



You are looking for the Buffer tool. There are 2 ways to find tools: you can search in the search bar or you can navigate through the Toolbox Tree.

Find Analysis Tools->Proximity->Buffer.





Drag educ_utm into the input features box.

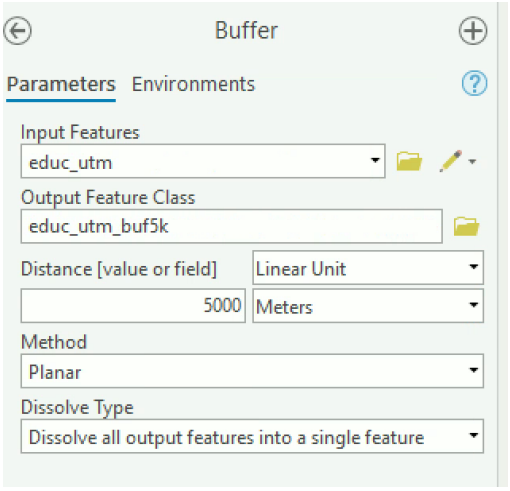
Call the output features class educ_utm_buf5k and make sure it will save in your lab5 folder.

For the Distance box, enter 5000 then under Linear Unit enter Meters.

Click on the ⓘ information symbol next to the Method box to read about the two buffer methods. Leave this field set to the default: Planar

For Dissolve Type choose 'Dissolve all output features into a single feature'.

Press Run.



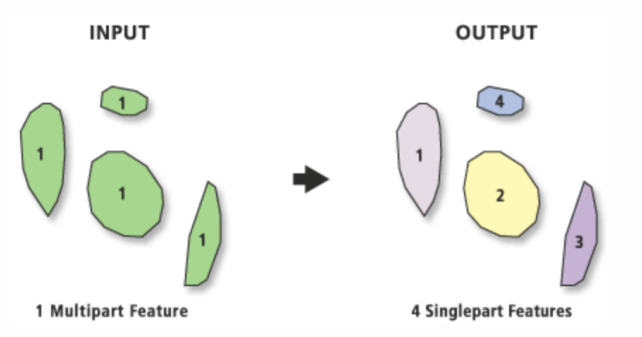
View the new educ_utm_buf5k layer in ArcGIS. Zoom in to where there are clusters of schools to see how the buffers merge together (i.e. are dissolved as single polygons in these locations). Notice that other than an object ID field, there is very little information in the buffer Attribute Table.

Repeat the buffer operation with the educ_utm shapefile, experimenting with different settings in the Buffer tool (e.g. the distance in the Linear Unit option and the dissolve option)

Note that the operation can take a bit of processing time given certain settings. These types of operations can require significant processing power.

4. Features Toolset: Multipart to Singlepart

Here, you will learn how to use ArcGIS to **convert multipart polygons (where there is just one record for multiple polygons) to singlepart polygons (where there is a separate record for each shape)**.



Open the attribute table for educ_utm_buf5k. Note that although there are multiple polygons displayed on screen, there is only a single record in the attribute table. This is because in a shapefile or geodatabase feature layer (ESRI's implementation of the spaghetti vector data model), multiple features can be associated with a single record. Multipart polygons are common for features that have a single identity but are not contiguous in space, such as island chains. But sometimes you see a polygon with multipart features when what you really want is separate polygons with a single record for each feature (this problem can happen when ArcGIS performs the Union operation, which you will do later in the lab).

To make this conversion, where each polygon is represented as a single record in the attribute table, go to ArcToolbox->Data Management Tools->Features->Multipart to Singlepart and input edu_utm_buf5k and name the output edu_utm_buf5k_single. Open the output table from the resulting shapefile and confirm that it has multiple records – one for each feature.

5. Map Dissolve

Here, you will learn how to use ArcGIS to **generalize a data layer by dissolving adjacent polygons with identical values**.

Open ArcGIS and add the tracts_utm shapefile. Open the attribute table and find the field 'FIPSSTCO'. This field is an identifier for each individual state (42) and county (e.g. 091 for Montgomery County). Of course, many individual tracts share the same value for this field. It is thus possible to perform a map dissolve operation on the tracts_utm shapefile, using the FIPSSTCO field as the dissolve field.

Go to ArcToolbox->Data Management Tools->Generalization->Dissolve.
Drag the tracts_utm layer into the input box.
Name the output layer tracts_utm_diss.
Under the Dissolve Field option click FIPSSTCO.
Leave the statistics field blank.
Press Run.

View the resulting layer in ArcGIS. It should appear just as the counties layer does.

6. Spatial Join: Point IN Polygon Overlay

Here, you will learn how to use ArcGIS to perform a point in polygon overlay **to join data from a polygon layer onto a point layer**.

Point in polygon overlay is accomplished using a spatial join operation. You have already done a point in polygon overlay in the previous lab when combining the TRI facility and zip code data.

Right click the educ_utm shapefile and choose Joins and Relates->Spatial Join.

For Join Features, choose zipcodes_utm.

For Output Feature Class, choose a name for your new layer.

For Join Operation, leave as Join one to one

For Match Option, you are given a choice of how to associate each polygon with a given point. Here, choose 'Within', meaning it falls inside.

Click OK

View the new layer and confirm that its table contains attributes of both the educ_utm and zipcodes_utm layers.

7. Spatial Join: Point TO Polygon Overlay

You can also **join data from points to polygons**. The problem, however, is that many points can fall within a single polygon. Since we cannot store multiple values of a single attribute for a single polygon (a violation of first normal form), the software provides a few options for transforming potentially multiple point values to a single value for each polygon.

Right click on zipcodes and choose Joins and Relates->Spatial Join.

For Join Feature, choose educ_utm.

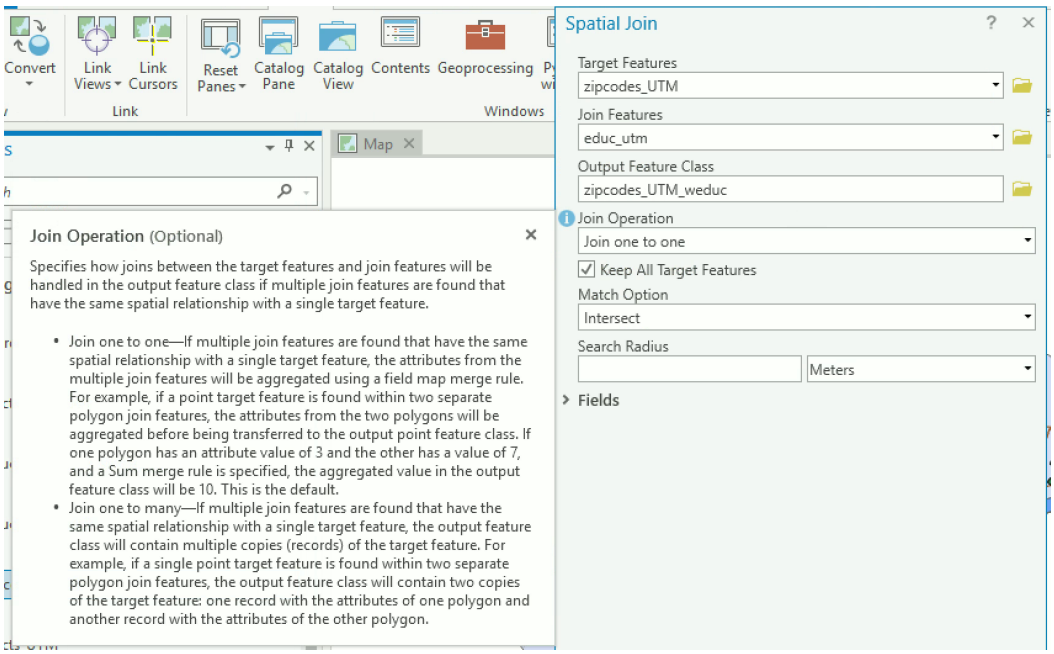
Give a name for your new Output Feature Class.

For Join Operation, the ⓘ information symbol next to the Join Operation box to read about the two join methods. Leave this field set to the default: Join one to one.

For Match Option, choose 'Intersect'.

Press OK.

View the new shapefile and open its attribute table. You should see a new field called 'Join-Count' that contains the number of educational points that fall within each polygon. The other data that came from the points layer is just from the first record ArcGIS reached in the join process.



8. Spatial Join: Line IN Polygon Overlay

Here, you will learn how to use ArcGIS to perform a line in polygon overlay to **join data from polygons to lines**.

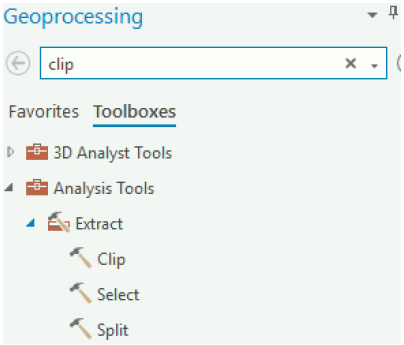
You can also do a line in polygon overlay in a manner analogous to the point in polygon overlay demonstrated above. Here, however, multiple lines can fall within a single polygon, and multiple polygons can fall across a single line. Thus, the user must supply the method of summarizing multiple values for both spatial joins from polygon onto line layers and from line onto polygon layers – different options will give you different results.

Use the railroads_utm and zipcodes_utm shapefiles in ArcGIS to play around doing a spatial join with different line in polygon overlay choices.

9. Polygon Overlay: Clip

Here, you will learn how to use ArcGIS to **perform a clip operation to use one layer like a cookie cutter to clip another layer** to the 'cookie cutter' layer boundaries.

For instance, say you were interested in the railroads of Montgomery County only. Add the counties_utm and railroads_utm shapefiles to ArcGIS. Create a new shapefile that represents only Montgomery County. You can do this by performing a manual selection or by using a Select by Attributes operation. After only Montgomery County is selected, export the selected features to a new shapefile called montco.



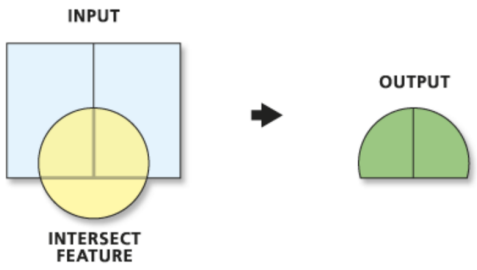
Go to ArcToolbox->Analysis Tools->Extract->Clip.

Drag railroad_utm into the input features box.
Drag montco into the clip features box.
Name the output layer rail_clip.

View the new layer. It should encode only those railroads within the boundaries of Montgomery County.

10. Polygon Overlay: Intersection

Here, you will learn how to use ArcGIS to **perform an intersection overlay operation to create a new data layer from the area that spatially coincides with the input polygon data layers**.



Use zipcodes_utm and the educ_buf5k and that you

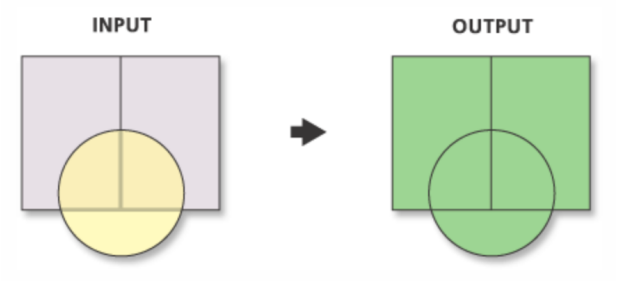
created earlier. Say you were interested in finding the zipcodes of the areas within 5 km of a school

Go to ArcToolbox->Analysis Tools->Overlay->Intersect.

Drag educ_buf5k and zipcodes_utm into the input features box.
Call the output educ_buf_zip_intersect.
Leave the other fields as the defaults.

View the resulting layer. It should include the area spatially coincident to both layers. Now view the attribute table. It should also contain attributes of both input layers.

11. Polygon Overlay: Union



Union **creates a new data layer from all of the areas in either of the input polygon data layers**.

Now use the Analysis Tools->Overlay->Union tool. Choose the educ_buf5k and zipcodes_utm layers again and view the result. The resulting layer should contain those areas that are within 5 km of a school **or** are in a zip code (i.e. all the area covered by both polygon data layers). The resulting attribute table should also contain attributes of both input layers.

In the attribute table, find the field that begins 'FID_educ..'. **The value of '-1' indicates the polygon is outside the educ_buf5k buffer.** This is how ArcGIS keeps track of what is inside or outside of a buffer. To demonstrate this, perform a selection selecting those polygons with a value of '-1' for this field. You should see polygons outside the education shapefile buffer selected. Switch selection to see the polygons inside the educational shapefile buffer selected.

ASSIGNMENT

Lab #3-6: Must do 1 Full Lab Report & 3 Slim Lab Reports – your choice which is which

Objective

The objective of this assignment is to identify an area in which to build a new high school in Abington School District. This new school must be in an area that meets ALL of these criteria:

1. not within 3000 meters of the existing high school
2. not within 1000 meters of a railroad
3. not within 500 meters of a river
4. within 50 meters of a street
5. with an area of at least 100,000 square meters

Deliverables

Turn in a lab report addressing this objective. Your report should include a map of the potential area(s) in which to build the high school. A second map or series of maps should be used to illuminate your methodology, such as the buffers generated in the course of the analysis. All maps should follow good design principles and include key map features on the map design checklist.

Tips:

- *Choose your clip boundaries carefully!*
- Think through what you think the series of steps (operations) will be. Then work through one at a time, saving interim layer files along the way.
- If you get stuck, think about the operations you learned in this lab – how can they help you?
- Remember, you may need to use operations from previous labs to complete the assignment. There are other operations we have not learned that could be used to complete this analysis, but you CAN complete this analysis using only operations that have been taught in Labs 1-5.

Lab 5 Summary of Operations

Operation	Briefly describe what this operation does	List the steps to complete this operation
Spatial Join for Point TO Polygon Overlay (join point table data to polygon table data)		
Spatial Join for Line in Polygon Overlay (join line table data to polygon table data)		
Dissolve		
Buffer		
Singlepart to multipart		
Polygon overlay: clip		
Polygon overlay: union		
Polygon overlay: intersect		

Lab 5 will be graded with the following criteria (see General Lab Report instructions for more detail):

FULL REPORT

	Pass	Good	Excellent
Objective			
Clear statement of GIS analysis objective			
Methods			
Correct steps & understanding of GIS operations			
Results			
Clear summary of results that describes the patterns seen			
Discussion			
Limitations			
Extensions			
Decisionmaker applications			
Tables & Figures			
Map has required analysis features			
Maps are in UTM projection			
Map 1 clearly shows potential areas to build the school			
Additional map(s) illustrate analysis methodology			
Symbology makes analysis steps clear			
Map layout displays qualities identified in Map Design Checklist			
GIS Operations Summary			
Table is completed			
Other Notes			
Notes (see tracked changes below for more)			
Grade			

SLIM REPORT

	Pass	Good	Excellent
Methods			
Correct steps & understanding of GIS operations			
Tables & Figures			
Map has required analysis features			
Maps are in UTM projection			
Map 1 clearly shows potential areas to build the school			
Additional map(s) illustrate analysis methodology			
Map design: overall composition			
Map design: required elements			
Map design: features included			
Map design: symbology choices			
GIS Operations Summary			
Table is completed			
Other Notes			
Notes (see tracked changes below for more)			
Grade			