

GIS AND PUBLIC HEALTH EXERCISE 7 – DEFINING NEIGHBORHOODS (ArcGIS 9.3.1)

PREPARATION

Download the **exer7** folder you will need for this exercise from the online supplement.

All of the databases and files used in the exercise will be stored in various subfolders within the folder called **exer7**. The following instructions are written for this folder to be located on the **c:** drive. If the folder is located on another drive, the path names shown below should be modified accordingly. Some of the folders are empty. They have been included because you may need to save the results of an operation to one of these folders.

The map documents created using ArcGIS 9.3.1 reference the spatial databases and tables in the application based on the directories and paths where the data are stored. Changing the locations of databases in the system can prevent a GIS application from working properly.

Connecting to the Exercise Folder

Go to **Start ⇒ Programs ⇒ ArcGIS ⇒ ArcCatalog** to start ArcCatalog.

Find the button labeled **Connect to Folder** and click the button. Navigate to **c:\exer7** then click OK and look at the Catalog tree in the left window to see that the folder has been added.

Within the data folder, data can be organized in folders identifying the agency that produced the data and then by the format of the data. For these exercises, you will consider yourself to be working for the organization called “agency” that is creating the GIS.

As you work through the exercises, you will be retrieving data from and saving data to specific folders. Please make sure you understand the System Design for the exercises.

Use the **File ⇒ Exit** menu to close ArcCatalog.

PREPARING TO DEFINE NEIGHBORHOODS

Go to **Start ⇒ Programs ⇒ ArcGIS ⇒ ArcMap** to start ArcMap.

In the “ArcMap Start using ArcMap with” window, click the radio button labeled “A new empty map” and then click OK.

Rename the Layers data frame by right clicking the word Layers and selecting the **Properties** item in the menu. Then select the **General** tab and enter the name Neighborhoods. Click OK. The name of the Data Frame in the Table of Contents window should now appear as Neighborhoods.

Add a Database of County Subdivisions

To begin, add a database of county subdivisions in New Hampshire. The database was downloaded from the U.S. Census Bureau TIGER® web site. Initially, a shapefile of New Hampshire county subdivisions from the 2010 TIGER database was downloaded. Two county subdivisions along the coast covering water areas were deleted. Then, the data were projected using NAD_1983_StatePlane_New_Hampshire_FIPS_2800 coordinates. Map units are meters.

County subdivisions are the primary divisions of counties and equivalent features for the reporting of Census Bureau data. This feature includes the primary governmental or administrative divisions of a county and other independent places. In New Hampshire, towns are the primary governmental divisions of a county. Townships, grants, locations, and purchases in New Hampshire are county subdivisions which are not part of any town and have limited or no self-government. Many of these entities are uninhabited. There are 259 county subdivisions in New Hampshire.

A table of data was prepared from data downloaded from the Census Bureau's American FactFinder web site for the purposes of this exercise. The data are from the 2010 Redistricting Data Summary File (P.L. 94-171), among the first data released from the 2010 census. The data in this table provide information on the total population within different racial groups by county subdivision. These data were joined to the shapefile of county subdivisions.

Find the button labeled **Add Data** and click the button. You should find the **c:\lexer7** folder in your catalog. If not, please connect to the folder using the **Connect to Folder** button. Navigate to **c:\lexer7\data\agency\shapes** and add the **tl_2010_33_cousub10_Project_Pop.shp** shapefile.

Right-click the **tl_2010_33_cousub10_Project_Pop** data layer and select **Open Attribute Table** from the menu. Scroll to the right and explore the data fields. The state FIPS code for New Hampshire is 33. Each county also has a FIPS code. FIPS and ANSI county subdivision codes are also provided. The GEOID10 field concatenates the state, county, and county subdivision FIPS codes. Note that this is a text field.

The table also contains fields (ALAND10 and AWATER10) with data on the surface land and surface water areas in each county subdivision in square meters.

For the 2010 Census, individuals could identify themselves with one or more of six racial groups: White, Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, or Other. For this exercise, we will be using data on the total population (D001), the total population identifying themselves as being of one race alone (D002 through D008), and the total population identifying themselves as two or more races (D009). The values in D002 and D009 sum to the value in D001.

Field Name	Field Type	Description
D001	Numeric	Total population
D002	Numeric	Total: Population of one race
D003	Numeric	Total: Population of one race: White alone
D004	Numeric	Total: Population of one race: Black or African American alone
D005	Numeric	Total: Population of one race: American Indian and Alaska Native alone
D006	Numeric	Total: Population of one race: Asian alone
D007	Numeric	Total: Population of one race: Native Hawaiian and Other Pacific Islander alone
D008	Numeric	Total: Population of one race: Some Other Race alone
D009	Numeric	Total: Two or More races

Close the table.

Use the **Save** button or go to **File ⇒ Save** to save your map document. Navigate to **c:\lexer7\mapdocs** and save the file as **exer7.mxd**.

Add a Shapefile of Air Quality Monitoring Station Locations

Next, add a shapefile of air quality monitoring stations for ozone in New Hampshire. This database was developed from data on criteria pollutant networks downloadable from the Map

Monitoring Sites page of the U.S. EPA's AirExplorer site. The active sites in New Hampshire in the ozone monitoring network were selected for this exercise.

Use the **Add Data** button and navigate to **c:\lexer7\data\agency\shapes** to add the **nhaqsites_Project.shp** shapefile.

Right click the shapefile and select **Open Attribute Table** from the menu. Explore the fields. In addition to AQSID, the air quality station identifier, there is a field for the name of the station, the county and the town where the station is located, the datum, the longitude, the latitude, the elevation in meters, and the year established.

Close the table.

Use the **Save** button to save the map document.

Defining neighborhoods and using them in spatial analyses are important GIS functions. Next, you will define neighborhoods around the air quality monitoring stations using two different methods. First, you will define neighborhoods using buffers. Second, you will define neighborhoods using Thiessen polygons.

Once the neighborhoods have been defined, you will use the neighborhoods defined by buffering to interpolate the population within the neighborhood of each monitoring station using area interpolation methods.

DEFINING NEIGHBORHOODS

Defining Neighborhoods Using Buffers

Check to see that you have the **Tools ⇒ Buffer Wizard** control in the menu. If you do not, you can add it by using **Tools ⇒ Customize** to open the "Customize" window. Click on the **Commands** tab. Under "Categories:", scroll through the list until you find Tools and highlight Tools. In the "Commands:" window to the right, you will see the **Buffer Wizard**.

Click on Buffer Wizard to highlight it and, holding down on the Buffer Wizard, drag the item to the **Tools** menu in the main interface and hover over Tools until the menu drops down. Then, drop the Buffer Wizard into a position where you want it on the drop-down menu. Close the "Customize" window.

Save the map document.

Use the **Tools ⇒ Buffer Wizard** menu to open the "Buffer Wizard." Under "What do you want to buffer?", select the radio button for "The features of a layer" and select the nhaqsites_Project layer from the pull-down list of layers. The number of features to be buffered should be 12. Click the Next> button.

Under "How do you want to create buffers?", select the "At a specified distance" radio button and select 25 as the number of distance units. Make sure the units are set to kilometers. If not, use the pull-down list under "Buffer distance" below to set the units to Kilometers. Click the Next> button.

Under "Buffer output type: Dissolve barrier between", select the "Yes" radio button to union any overlapping buffer areas into a single neighborhood.

Under "Where do you want the layers to be saved?", select the "In a new layer. Specify output shapefile or feature class:" button. Save the new shapefile as:

c:\lexer7\data\agency\shapes\Buffer_of_nhaqsites_Project.shp

and click the Finish button.

The new shapefile of buffer areas will be added to the Data Frame automatically. Although there were 12 air quality monitoring stations, you should see only 4 buffer areas because you chose to dissolve the barriers between overlapping buffer zones. Right click the **Buffer_of_nhaqsites_Project.shp** layer and select **Open Attribute Table** to verify this.

The table has 2 attribute fields: Id and BufferDist.

Edit the attribute table to assign unique identifiers to each buffer zone. Use the **View ⇒ Toolbars** menu to open the list of Toolbars and check the **Editor** toolbar if it has not already been checked. This will add the **Editor** toolbar to the interface.

Select **Editor ⇒ Start Editing** to open an editing session.

Make sure that the “Target:” is **Buffer_of_nhaqsites_Project** in the pull-down list so that you are editing the correct layer.

Right click the **Buffer_of_nhaqsites_Project** layer and select **Open Attribute Table** from the menu to open the attribute table.

Click in the Id field for the first record in table (the record with FID or Feature Id of 0), and edit the Id to be 1. Then click any place in another record to register the edit.

Click in the Id field for the second record in the table (the record with FID or Feature Id of 1), and edit the Id to be 2. Then click any place in another record to register the edit.

Repeat the process for the remaining two records so that every record has a unique Id number. Remember to click anyplace in another record to register the edit.

Use the **Editor ⇒ Save Edits** menu to save your edits. When you see that the edits are correct, use the **Editor ⇒ Stop Editing** menu to stop editing.

Save the map document.

Defining Neighborhoods Using Thiessen Polygons

Next, define neighborhoods using Thiessen polygons. If you do not have the function for creating Thiessen polygons in your version of ArcGIS 9.3.1, read through this section until you find instructions for adding the **nhaqsites_Project_CreateThie** shapefile which has already been created for you.

Otherwise, click on the **Show/Hide ArcToolbox Window** button to open ArcToolbox.

Click on **Analysis Tools ⇒ Proximity** to show the various proximity tools available in ArcToolbox.

Double click **Create Thiessen Polygons** to open the “Create Thiessen Polygons” window.

Select the **nhaqsites_Project** layer from the pull-down menu under “Input Features” so that the Thiessen polygons will be formed around the monitoring station sites.

Under “Output Feature Class”, set the output shapefile to be:

c:\lexer7\data\agency\shapes\inhaqsites_Project_CreateThie.shp

Under “Output Fields (optional)” select “ALL” from the pull-down menu.

Click OK.

The shapefile of Thiessen polygons will be added to the Data Frame.

If you do not have the function for creating Thiessen polygons in your version of ArcGIS 9.3.1, navigate to **c:\lexer7\data\agency\thiessen** and add the **inhaqsites_Project_CreateThie** shapefile which has already been created for you.

Right click on the Thiessen polygon layer and select **Open Attribute Table** from the menu to open the attribute table. You should have 12 polygons, one for each monitoring station site. The attributes of the associated site have been used to describe each polygon.

The Thiessen polygon shows the area closer to a particular monitoring station site than to any other of the 12 sites.

Click the symbol in the legend for the Thiessen polygon layer in the Table of Contents to open the “Symbol Selector” window. Set the fill to Hollow and click OK. This will allow you to see how the county subdivisions are arranged in relation to the Thiessen neighborhoods. Then turn off the visibility of the Thiessen polygon layer.

Save the map document.

ESTIMATING THE POPULATION IN A NEIGHBORHOOD USING AREAL INTERPOLATION

Performing an Intersect Operation

Click on the **Show/Hide ArcToolbox Window** button to open ArcToolbox.

Click on **Analysis Tools** ⇒ **Overlay** to show the various overlay tools available in ArcToolbox. We will be using the Intersect operation in this polygon overlay analysis.

Click on **Intersect** to open the “Intersect” window.

Click on the **Buffer_of_inhaqsites_Project** layer and then click on the **tl_2010_33_cousub10_Project_Pop** layer in the pull-down menu to add them as the input layers for intersection.

Edit the file path and name to save the result of the Intersect operation as:

c:\lexer7\data\agency\shapes\Buffer_of_inhaqsites_Inters.shp.

Click OK.

After the result of the Intersect operation is added to the Data Frame, close the “Intersect” window and open the attribute table of the **Buffer_of_inhaqsites_Inters.shp** layer and check to see that you have 192 polygons in the intersection of the two layers. Note that the ALAND10 and AWATER10 of the county subdivisions shown for each record are not accurate areas for the records in the table. They describe the areas of the county subdivisions, not the areas of the part of the county subdivision in a buffer zone.

Close the table.

Then, turn off the visibility of the **Buffer_of_nhaqsites_Project** and **tl_2010_33_cousub10_Project_Pop** layers so that only the **Buffer_of_nhaqsites_Inters.shp** shapefile resulting from the Intersect operation is visible.

Save the map document.

Areal Interpolation by Area Weighting

In order to perform the areal interpolation of population from the county subdivision (source) zones to the air quality monitoring station buffers (target zones), we will need to add three fields to the **Buffer_of_nhaqsites_Inters.shp** data layer.

- **TOTAREA** will sum the land and water areas from the county subdivision layer.
- **INTER_SQM** will calculate the area of the polygon in square meters.
- **WEIGHT** will calculate the area of the polygon in square kilometers as a percent of the area of the county subdivision in square meters.
- **ESTPOP** will calculate the population of the polygon by multiplying the weight and population of the county subdivision.

These estimated populations can then be summed by air quality monitoring station buffer zone to ascertain how many New Hampshire residents live in each zone.

Open the **Buffer_of_nhaqsites_Inters.shp** attribute table and use **Options ⇒ Add Field** and add a field called **TOTAREA** to the table. Make it a Double field with a precision of 12 and a scale of 0. The precision indicates the number of significant digits and the scale indicates the number of decimal places.

Right click on the **TOTAREA** field header and select **Field Calculator** from the menu. A window will open telling you that you are calculating the value of a field outside of an edit session and that you will not be able to undo the calculations. Click Yes to continue.

In the “Field Calculator” window, scroll down the list of variables under “Fields:” and double click the **[ALAND10]** field to add it to the window below under **TOTAREA=**. Then click the “+” button. Then double click the **[AWATER10]** field to add it to the string as shown below:

[ALAND10]+[AWATER10]

Then click OK. This will add the value of the land area of the county subdivision and the value of the water area of the county subdivision and populate the **TOTAREA** field with that value. When you are sure the values are correct, add the **INTER_SQM** field.

Open the **Buffer_of_nhaqsites_Inters.shp** attribute table and use **Options ⇒ Add Field** and add a field called **INTER_SQM** to the table. Make it a Double field with a precision of 12 and a scale of 0.

Right click on the **INTER_SQM** field header and select **Calculate Geometry**. A window will open telling you that you are calculating the value of a field outside of an edit session and that you will not be able to undo the calculations. Click Yes to continue.

In the “Calculate Geometry” window, select “Area” as the property from the pull-down menu and make sure the “Units:” are “Square Meters [sq m]”. Then click OK.

The field should be populated with values that describe the area in square meters of each polygon resulting from the Intersect operation.

Next, use **Options ⇒ Add Field** and add a field called **WEIGHT** to the table. Make it a Double field with a precision of 4 and a scale of 1.

Right click on the field header and select **Field Calculator**. When the window opens, make sure the **Advanced** box is **not** checked. Type the following statement in the box under “WEIGHT =” exactly as shown to calculate the percent of the county subdivision area that is in a particular air quality monitoring site buffer zone:

`[INTER_SQM]/[TOTAREA]*100`

Click OK.

The field should be populated with a value that shows the percent of the county subdivision area that is in a particular air quality monitoring site buffer zone. Some county subdivisions are completely within a buffer zone (100.0%) while others are only partially within a buffer zone.

Finally, use **Options ⇒ Add Field** and add a field called **ESTPOP** to the table. Make it a Double field with a precision of 7 and a scale of 0.

Right click on the field header and select **Field Calculator**. When the window opens, make sure the **Advanced** box is **not** checked. Then, type the following statement in the box under “ESTPOP=” exactly as shown to calculate the estimated population from a county subdivision that is in a particular air quality monitoring site neighborhood:

`[D001]*[WEIGHT]/100`

Click OK.

The field should be populated with a value that shows the estimated population of the county subdivision area that is in a particular air quality monitoring site neighborhood.

To obtain the total estimated New Hampshire population for each air quality monitoring site neighborhood, right click on the **Id** field and select **Summarize**. Select the **Id** field as the field to summarize under “1. Select a field to summarize.” Then, under “2. Choose one or more summary statistics to be included in the output table:” click on the plus sign in front of the **ESTPOP** field in the list and check **Sum** to obtain the sum of the **ESTPOP** fields for each buffer zone **Id** number. Direct the output dbase table to **c:\exer7\data\agency\dbase\buffernhpop.dbf** and click **OK**. Add the table to the Data Frame.

Right click on the data table and open it to see the sum of the estimated New Hampshire population in each buffer area. Because some buffer areas extend into other states, the analysis as you performed it yields only the total estimated New Hampshire population in each buffer area.

You should find that there 1,061,874 people living in New Hampshire who are within 25 km of an air quality monitoring site for ozone. The total population of all county subdivisions is 1,316,470 so about 80.7% of the state's population is within the 25 km neighborhood of an active site.

You could use the same techniques to estimate the number of people of different races within the different buffer zones or to estimate the number of people within neighborhoods defined as Thiessen polygons.

Use the **Save** button to save the map document and then use the **File ⇒ Exit** menu to close ArcMap.