The Two-Step Floating Catchment Area Model: Patterns of Pharmacy Access

Introduction:

The two-step floating catchment area model is a method designed to generate an index of the spatial accessibility of services, first developed in relation to healthcare facilities. The model has become popular because it can be readily implemented with a GIS. In this exercise, we will show how the model can be implemented within ArcGIS, using the example of spatial accessibility of pharmacies within England.

Data:

Data from this exercise are drawn from two sources, namely:

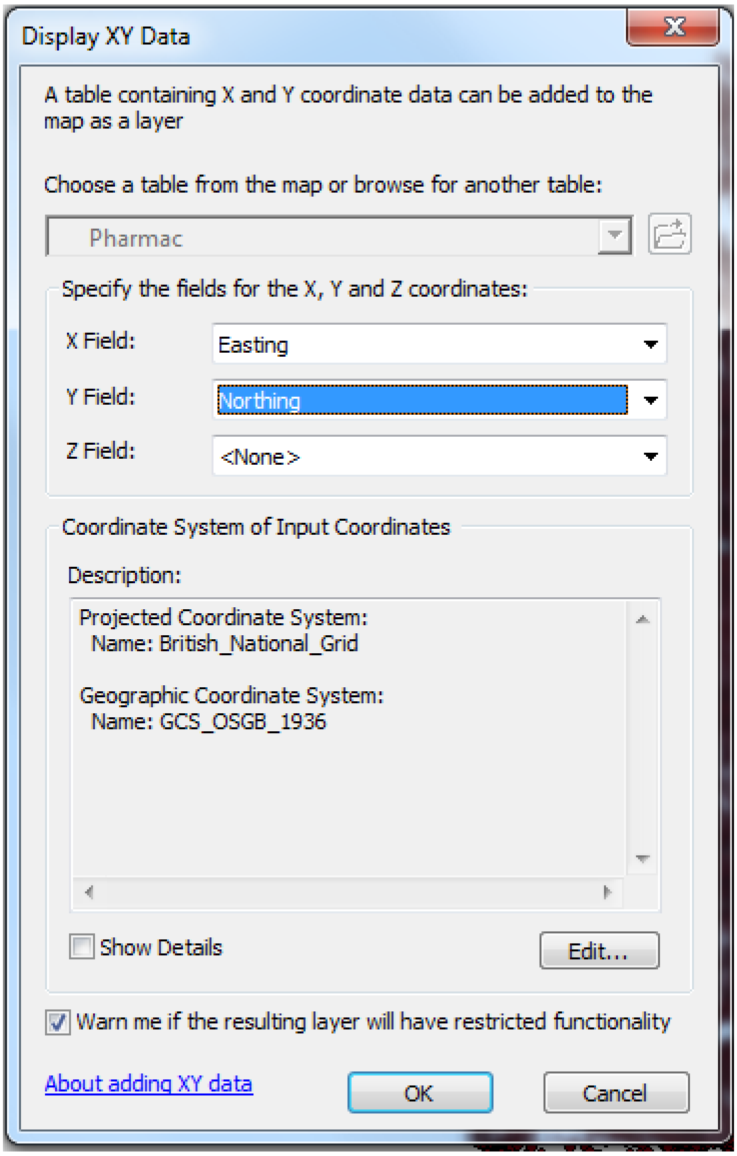
- **OA_2011_EW_PWC**: Office for National Statistics data identifying the population-weighted centroids of output areas (OAs), as of 2011. Note that output areas are the most detailed 'building blocks' of census geography in England and Wales. A typical output area will contain a population of around 400 people. The centroid's location is calculated from the distribution of population within the output area, so is not the same as the centroid of the polygon representing the OA boundary. More details are included in the file (see http://www.ons.gov.uk/ons/guide-method/geography/products/census/spatial/centroids/index.html). Note that we could repeat this exercise using Workplace Zones data from this source, which would reflect the daytime distribution of the employed population at their places of work.
- **PharmaciesDownload04_csv**: Locations of pharmacies are taken from an open access data set available here: http://www.ons.gov.uk/ons/guide-method/geography/products/census/spatial/centroids/index.html

Pre-processing

Before we use the pharmacy data file in ArcGIS, we will first need to tidy up the spreadsheet containing pharmacy coordinates. Open up the spreadsheet in Excel and delete the first four rows, so that the first row containers the headers for each column of information. Next, edit the headers in that first row and make sure that there are no spaces in these names, e.g. 'name of pharmacy' should be replaced with 'pharmacyname' so the file can be imported into ArcGIS without difficulty. Finally, scroll down to the very end of the data file and be sure to delete the footnote that appears at the very end of the data file. When you have done all this, choose file and 'save as' and save your edited file with a new name as a comma separated values (.csv) file.

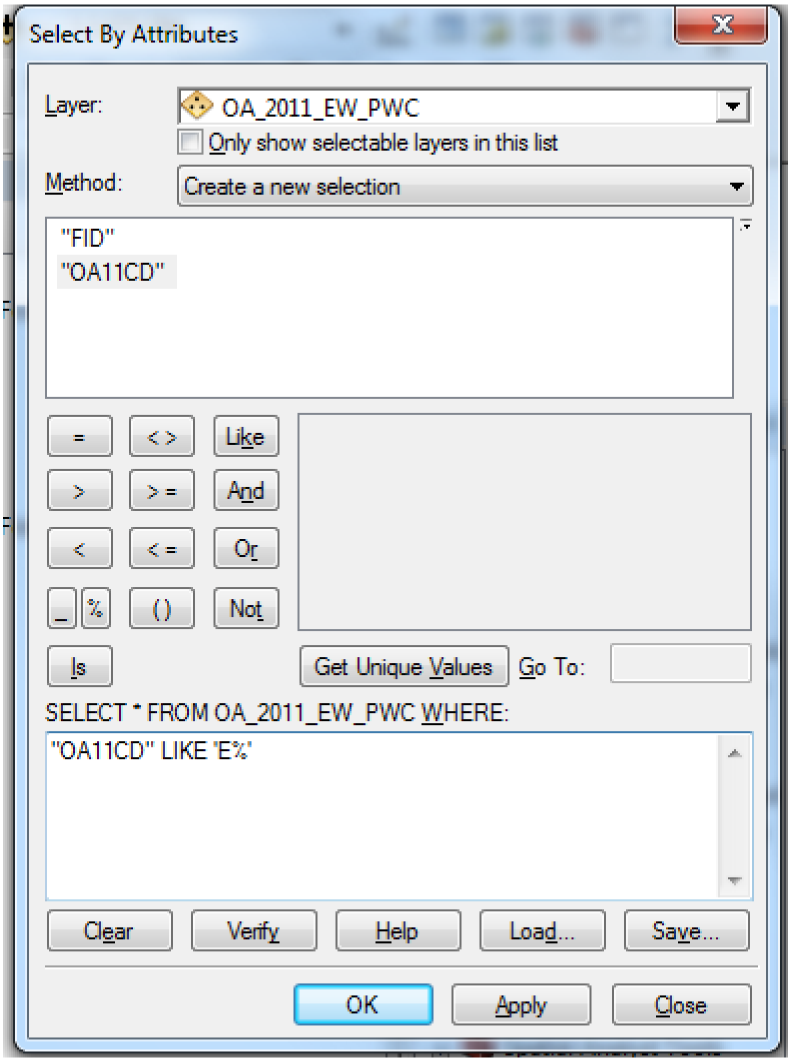
Now start up ArcMap and open up the **OA_2011_EW_PWC** shape file. Open up the .csv file you have just created as well and right-click and choose *open* – have a quick look at the table to make sure it has imported correctly. Next, close down the table and then right-click on it in the left-hand table of contents, select *data* then *export* and save a version of it as a .dbf file (or in a geodatabase if you prefer).

Right-click on the name of the new file you have just created in the left-hand table of contents and select *display x y data.* Enter in the **eastings** and **northings** fields as the ones that contain the coordinates for each pharmacy, as shown below:



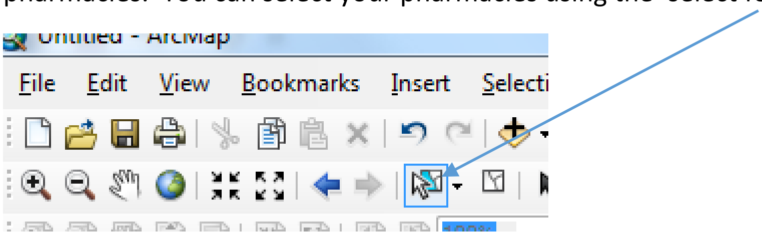
This should enable you to plot out the locations of all the pharmacies. To make sure that any subsequent ArcToolBox commands perform as expected, let us now save this as a shape file (Or in a geodatabase if you prefer). Right-click on your map layer representing pharmacy 'events' (i.e. the pharmacy points), select *data* then *export data* and save this as a new file, displaying it in your current ArcMap window.

You will see that the pharmacy data relate to England only, whereas the output areas are for both England and Wales. Let us now remove the Welsh output areas therefore. To do this, head for the *selection* menu and choose *select by attributes*. English output areas have a unique ID code beginning with 'E…', whilst Welsh output areas have codes beginning with 'W…'. We can therefore use the 'like' function to pick out just the output areas whose ID codes start with 'E…' as follows:



Once again, to permanently save the English output areas as a new layer, right-click on the output areas layer in the left-hand table of contents, select *data* and then choose *export data* to create a new file.

We have a lot of data and to save the calculations becoming painfully slow, let us now restrict our analysis to a smaller part of England (e.g. I chose the area around the city of Bristol). You can pick any area you wish, but I would suggest restricting your study area to include no more than 500 pharmacies. You can select your pharmacies using the 'select features' tool:



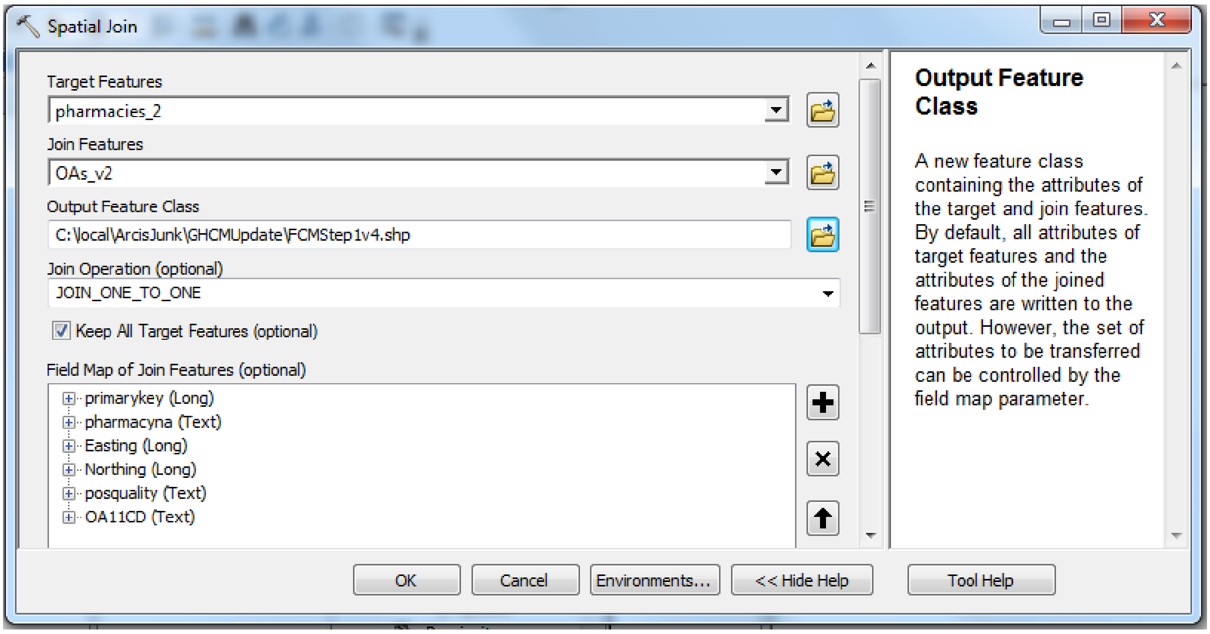
If you click and hold down the mouse button, you should be able to draw a box over your pharmacies and Arc will select all the pharmacies within that box. Once you are happy with your chosen pharmacies, right-click on the pharmacies layer, choose *data*, *export data* again and save your subset of pharmacies as a new map layer again.

Now repeat this exercise for the output areas, using more or less the same area again.

The first step of the floating catchment area model

Now we have our data ready for analysis, we can apply the first step of the two-step floating catchment area model. To run this, go to the Arctoolbox and under *analysis tools*, select *overlay* and then *spatial join*:

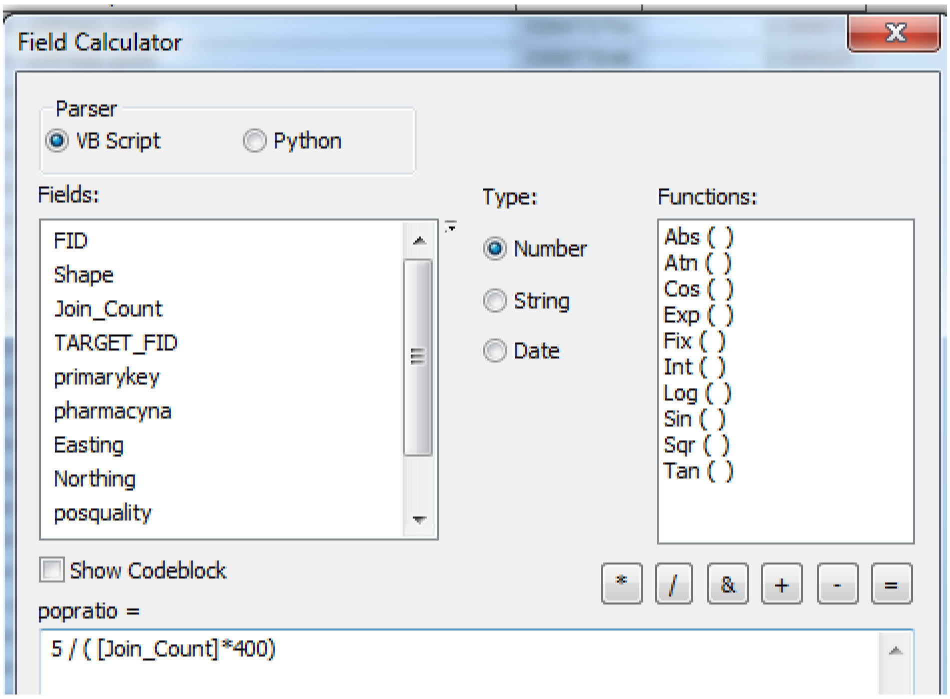
- Choose the pharmacies within your chosen small area as your *target features* and the output areas within your chosen small area as the *join features*.
- Leave the *join operation* set to JOIN_ONE_TO_ONE and select WITHIN_A_DISTANCE as the *match option*. WITHIN_A_DISTANCE enables ARcGIS to find all of the output areas within a given distance of each pharmacy, so corresponds to the floating catchment area method. If we had three output areas close to a pharmacy, JOIN_ONE_TO_ONE gives us a single output row of information with a summary of those three output areas' characteristics – this is what we need for the floating catchment area model. Choosing JOIN_ONE_TO_MANY gives us three separate output rows, one for each output area, which is not what we want here.
- A crucial decision in a two-step floating catchment model is the choice of search radius. A typical choice would be to use some policy statement about access, e.g. if there was a target to maximise the population within 10km of a health centre. We can set this via the *search radius*. For this exercise, we will make an arbitrary choice of 5000 metres, loosely based on walking distance.
- Choose a name for the *output feature class* - what this tool will do is to generate a new version of the pharmacies map layer that has additional attribute fields appended to each pharmacy, containing information about the surrounding output areas.



Once spatial join has run, right-click on the new layer it creates and select *Open attributes*. Take a look at the **join_count** field in particular. This field should contain a count of the number of output areas within a 5km (5000 metre) radius of the pharmacy – that is the key information we need to use.

Now let us convert this into a ratio of provision to demand. A typical calculation here would be to calculate the ratio of medical staff to population within the search radius. As we do not have information about the number of staff at each pharmacy here, let us for simplicity assume we have 5 staff in each facility. With a bit of further work, we could track down data on the resident population in each output area and then join these data to our population-weighted centroids for output areas. However, again for simplicity, let us assume that each output area has a typical population size of 400 people.

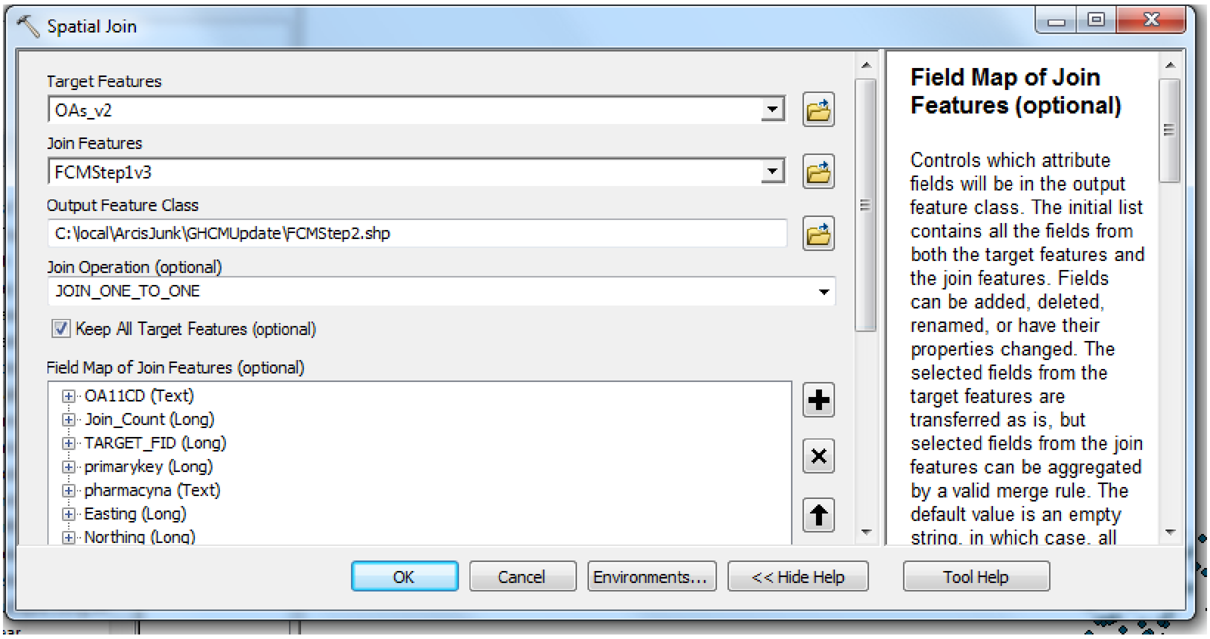
Now let us work out a provision to demand ratio based on these assumptions. To do this, head up to the top-left corner of your table of attributes and click to bring up the drop-down menu there, then select *add field*. Create a new field of type float called **popratio.** Next, right-click on the header of your new field **popratio** and select *Field calculator*. Say *yes* to any warning message you receive at this point. If we assume each pharmacy has 5 staff and each output area has 400 people, we can calculate a ratio of staff to population as follows (see bottom box):



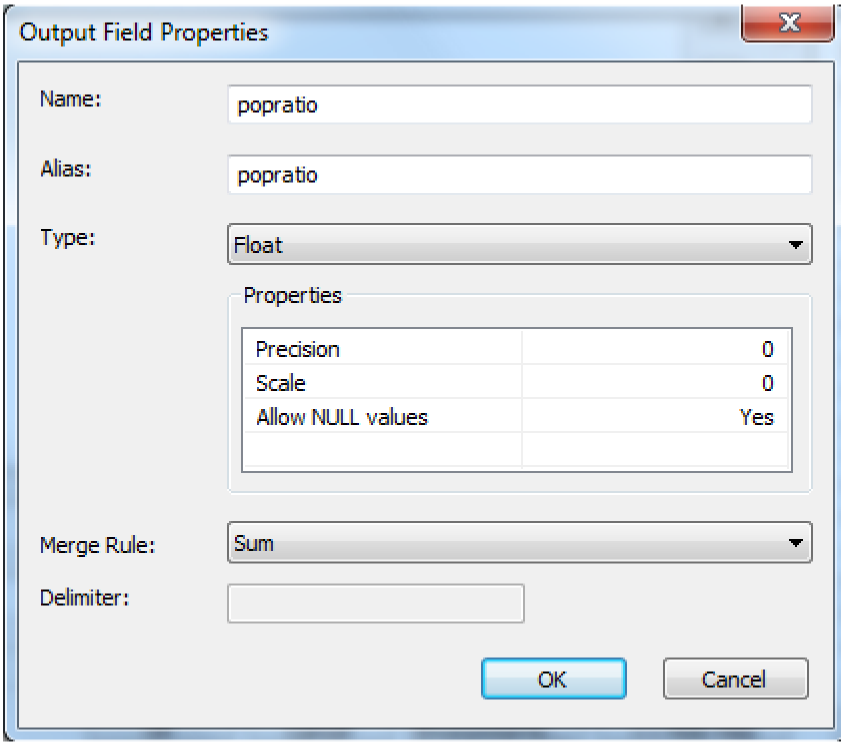
Those numbers complete the first step of the model, so we can close our table down now.

Second step of the Floating Catchment Area method

Now for the second step: head back to the *spatial join* tool in the ArcToolBox for a second time. This time, select your output areas for your small study area as your *target features* and use your output shape file from the first step of the calculation (i.e. with the **popratio** field added) as the *join features*. Enter in an appropriate name for the new layer to be created, and once again, stick with the JOIN_ONE_TO_ONE and WITHIN_A_DISTANCE options, plus the same *search radius* of 5,000 metres.



We will however need to do a little further work under the *field map of join features*. In this area right-click on our new **popratio** field and select *properties.* Set *merge rule* to be **sum.** What this means is that ArcGIS will add up all of the provision to demand ratio figures for all the pharmacies within a given radius of each output area – which is what happens in the second step of a floating catchment area model:



Now run *spatial join* and take a look at its output. If you right-click on the output layer, on the *symbology* tab, you can use *quantities / graduated colours* to visualise the pharmacy accessibility index that you just produced, under *fields* setting *value* = **popratio** to colour each output area according to its accessibility index value. Explore the values of the two-step floating catchment access index – do they make sense?