# Lab 5: Mapping Boston Zoning Variances

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**Purpose:**

ArcView allows access to Oracle tables on our database server. In this exercise, we'll learn how to access Oracle tables from ArcView and use this capability to create a 'pin-map' showing the location of zoning variances on the Boston maps that we used earlier in the semester.

**Needed Info:**

- Clark Broida's database of Boston Zoning variances (stored in the ZONING* table on the Oracle server)
- Assorted Boston maps described in the web page of CRL-supported datasets.

## (1) Preparing the ZONING data

In class, we explained how the table **lonlat4** contained 'geocoding' information about the location of each zoning variance --namely, the longitude and latitude of the corresponding parcel. However, the longitude values needed to be multiplied by -1 to represent values in the Western Hemisphere. We used the following Oracle query to create a 'view' that made this change:

```
CREATE VIEW lonlat5 AS
  SELECT casenumber, -1 * longitude longitude, latitude,
         streetname, quality
    FROM lonlat4;
```

Use SQL*Plus to connect to Oracle and create your own view, **lonlat5**, to convert the longitudes.

## (2) Connecting ArcView to Oracle

The SQL connection from ArcView to Oracle can be made from the **SQL Connect** option of the **Project** menu. The SQL dialogue window that pops up allows you to run a single SQL command that extracts a table from Oracle and makes it available as an ordinary ArcView table (that can be linked or joined with other ArcView tables). (Note that, however small or large the resulting SQL table, ArcView will bring over the **entire** table right away. Don't use this method to access directly the entire parcel database for Boston!)

Open ArcView and use this method to grab a copy of the **lonlat5**view that you just created. Name the table 'lonlat5' in the SQL dialogue window so that you remember from whence it came.

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* Kindly refer to Lecture Notes section

# (3) Mapping the Zoning Variances

To map the zoning variances, you'll need to convert the latitude/longitude values in the **lonlat5** table into 'points' on your map. Since all the Boston area maps we've been using are in Massachusetts State Plane coordinates (not latitude/longitude), we'll have to worry about map projections.

**(a)** Open a View window and use the **View > Add Event Theme** menu item to convert the latitude/longitude values in your **lonlat5** table into 'pin-map' points on your ArcView map. Enough zoning variances have been georeferenced for the general envelope of Boston to be visible around all the dots. HOWEVER, the coordinates are expressed in lat/lon -- not the state plane coordinates we have used when drawing maps of Boston and vicinity last month. If you were to add, say, the Massachusetts town boundary map in **/mit/massgis/2000/state/towns (polygon)** to your view, the lonlat locations of the zoning variances won't line up with the town boundaries (which are in Massachusetts State Plane Coordinates, Mainland Zone, NAD83, meters).

**(b)** Open a second View window and add the Massachusetts town boundaries as a theme in this view. Once we've projected the latitude/longitude of the zoning variances, we will be able to add them to this view.

**(c)** Now, let's project the variances from latitude/longitude to state plane coordinates. Highlight the first View window (showing only the zoning variances from **lonlat5** mapped in latitude/longitude 'geographic' coordinates). Choose **View > Properties** from the menus and set the Map Units to 'decimal degrees' (to indicate that the coordinates read in from disk are geographic coordinates expressing latitude/longitude location in decimal degrees). Next, click the 'Projection...' button and set the coordinate system to be used by this View window to be 'State Plane - 1983' with type set to 'Massachusetts, Mainland'. Note that, when you click OK and return to the View Properties dialogue box, the map units have been reset to meters (in accordance with the projected state plane parameters for the projected view you are about to see). You may set the distance units to the units of your choice. When you click 'OK' the zoning variances will now be displayed in Massachusetts state plane coordinates -- but they still are saved on disk in latitude/longitude. Highlight the projected zoning variance theme in your View window and choose **Theme > Convert to Shapefile** from the menus to save the projected zoning variances in the projected units -- i.e., Massachusetts state plane coordinates. As usual, be careful to select (and remember) an appropriate directory in which to store the projected shapefile. Once you've save the projected zoning variances to disk, you can add them to the other View (with the Massachusetts town boundaries).

***Alternate strategy for projecting zoning variances***

To project the zoning variance latitude/longitude values to Massachusetts State Plane, you can follow a slightly different procedure from the one we used in class. This method uses the **Projector!** extension. This procedure, when it works, is a bit more streamlined than that outlined above. However, in some cases, obscure permission problems have prevented students from using the Projector! button to do the coordinate transformation. Depending on what ArcView operations you have done, ArcView may refuse to save the projected coverage because it does not have write permission for the MassGIS towns shapefile. In such cases you can use the original method demonstrated in class instead of the Projector! extension.

Highlight the first View window (with the mapped zoning variances from **lonlat5**). Choose the **File > Extensions** menu option and load the 'Projector!' option. Notice the new 'projection' button at the far right of the toolbar. Click it to see if we can figure out how to convert the zoning variances. When you do this ArcView will complain if you haven't set any map units yet -- we need to tell ArcView that the coordinates of our mapped zoning variances are expressed in decimal degrees. Use the **View > Properties** dialogue box to set the map units to decimal degrees. Now click the projection button once again, accept the default choice of 'meters' for displaying the projected results, and then (in the next popup window) set the projection to be 'State Plane - 1983' so that it uses the 1983 North American Datum. The 'type' will reset automatically to Massachusetts Mainland (a fine choice...). Click 'OK' to accept the projection and then 'Yes' again when asked whether to recompute lengths/areas in meters. Now, click 'Yes' and 'OK' when asked whether to add the resulting shapefile as a theme in one of your View windows. Add the projected zoning variances to your second View (with the Massachusetts town boundaries) and, when prompted, specify a path and filename in which to save the projected theme as a shapefile (and then load it into your View window).

Now you have 'pin map' of the projected zoning variances showing up within the town boundaries of Boston where they belong. (Compared with the projection method used in class, this way is a little more direct in projecting, saving, and adding the zoning variances to the Massachusetts Town view.)

# (4) Analyzing Spatial Patterns of the Zoning Variances

Let's examine and map various subsets of the zoning variance cases -- for example, all approved variances. We're not quite ready to do this since the**lonlat5** table has none of the zoning variance characteristics -- we'll have to join it to the ZONING table* using 'casenumber'. We can do this in Oracle or we can move the entire zoning table into ArcView and do all the queries (and joins) there. Since the ZONING table isn't that big, bringing the whole table into ArcView is manageable. However, for other situations -- such as the landuse owner categorization exercise that we did earlier, we might want to run the queries in Oracle, store the results in a SQL 'view' and pull the view over to ArcView.

**(d)** Now let's add a few other coverages to give more meaning to the zoning variance map. Add the **msa5_tr90** and **bostnbrd** coverages (showing Eastern Mass 1990 census tracts and Boston neighborhood boundaries). On CRL machines you can enter the

* Kindly refer to Lecture Notes section

environment variable $BOSTON_METRO into the 'add theme' dialogue box. These environment variables are described on the CRL metadata help page http://gis.mit.edu/metadata and retain the same names even if the data are moved to another CRL locker.) Finally, if you want to get more exotic, add the MIT OrthoServer extension so that you can slip orthophoto imagery under your maps as demonstrated in class.

**(e)** After joining the zoning data to your projected-and-mapped**lonlat5** data, generate a pin-map showing the location of all variances (that were geo-referenced) which proposed to convert vacant land to housing. Your map should be zoomed in to just fit Boston onscreen and should show city boundaries and census tracts as well as the zoning variance locations.

**(f)** Now change the symbols used to draw the Part (e) variances (involving vacant land converted to housing) so that a different symbol is used for those which were APPROVED (code 1 or 2). You will also want to exclude the missing value cases so the two symbols apply only to approved/not-approved variances. Once again, there is more than one way to do this. For example, you can use the 'hammer' query tool  associated with the theme properties of your zoning variance theme. Select only those variances that are vacant-to-housing and have a known Board decision. Then set the symbols to be displayed based on the Board decision. Alternatively, you could write an Oracle query that creates a view with a WHERE clause limiting the variances -- and then pull the resulting table over to ArcView. The former option is easier here. But, if you wanted to, say, tag the zoning variances with some of their 1980 census characteristics[*] (which are stored, by sub-neighborhood, in the Oracle table called CENSUS), then it would be easier to generate the desired table in Oracle before pulling it across.

**(g)** Next let's examine whether the approval rate of vacant-land-to-housing variances appears to be different across parts of Boston that have high/medium/low housing value - - as measured by the 1990 census data. Selected 1990 Census tract data are stored in an INFO table called **msa5_tr90.dat** stored together with the **msa5_tr90** census tract coverage mentioned earlier. The data table is stored in an INFO database (this is the 'info' part of the software called ArcInfo.) Add this table to your ArcView project -- just remember to set the table type to 'INFO' and to look in the sub-directory called 'info' in the $BOSTON_METRO directory (N:\meters83\massmaps\boston). You will have to join (or link) this data table to the **msa5_tr90** theme in order to map the census data. The column names in the **msa5_tr90.dat** table are the official Census Bureau names. As explained in Tom Grayson's Census notes in lecture no. 3 of 11.208, the technical documentation for STF3 census data contains the data dictionary for these variables. But we'll save you some time: the H061A001 variable contains the median value of owner-occupied housing units. Use this variable to generate a thematic map of the housing values across the Boston census tracts. Now zoom in a bit on a part of town of particular

[*] Kindly refer to the Lecture Notes section

interest to you and fiddle with the map so that the Part (f) variances (with approved/not-approved symbols) are readable on top of your thematic map.

**(h)** Finally, let's ask some questions about the zoning variances that fall within high/medium/low value tracts. How many vacant-to-housing variances are in above-average value tracts (1990)? What fractions are approved? From the map, we can see which variances fall within the high/medium/low value tracts. But we can't easily compute the counts and fraction-approved because the zoning variances aren't 'tagged' with the number of the census tract that contains them. Here's an opportunity to use some of the spatial data processing capabilities of our GIS. We can do a spatial join -- in this case a so-called 'point-in-polygon' operation -- to find out which zoning variances (points) are contained within which census tracts (polygons). There are several ways to do this. (You may also want to refer to one of last Fall's 11.520 lab exercises for more information. We'll use the method that involves a 'spatial' join of the **lonlat5** attribute table to the **msa5_tr90** attribute table.

Open up the attribute table for **msa5_tr90** shapefile and click on the column heading marked 'Shape'. Next, open the attribute table for your **lonlat5** theme and click on its 'Shape' column. Now select the menu item **Table > Join**. The attributes for **msa5_tr90** will disappear. If you examine the attribute table for **lonlat5**, however, you should now see all the census tract columns appended to the **lonlat5** table. You've done an (outer) join of the census tract table to the **lonlat5** table using the spatial location of the zoning variances to relate each variance to the census tract that contains it. All the zoning variances within a census tract have the same (duplicated) census data brought over from **msa5_tr90**. The 'Shape' columns aren't true attributes; they serve as placeholders that remind us that each row of the attribute table is tagged with a hidden spatial object ID that associates it with the vector geometry of that object's boundary. That geometry is used to carry out the 'spatial join'.

We still have a ways to go to answer the part (h) questions because the original **msa5_tr90** attribute table had only the census tract identifiers -- and not the census variable that are in the **msa5_tr90.dat**table and have to be joined in. Once you have joined in the data table, use ArcView's query tools (and **Field > Statistics** options) to compute the desired numbers: the number of vacant-to-housing variances in above-average income (1990) tracts and the fraction of them that were approved. In addition to computing these two numbers, turn in a printout of a table showing the casenumber, board decision, 1980 nsa number, and 1990 census tract number for all vacant-to-housing variances that are within ROSLINDALE (i.e., NSA subnghbrd 49, 50 and 51).

If we could easily put ArcView tables back into Oracle, it might be easier to do these last few steps in Oracle. But ArcView can't easily update Oracle tables. Hence, we are stuck with the one-way path for moving portions of Oracle tables into ArcView before we do any spatial processing. There are tools around that facilitate moving tables from ArcView into Oracle, but we won't use them until the project portion of the course.

# Lab Assignment

The only parts of this exercise that you need turn in are:

**(a)** The two numbers (variance count and fraction approved) and the Roslindale table from Part (h), and

**(b)** A printed layout showing your two maps of Boston from Parts (f) and (g) with the location of the vacant-to-housing variances highlighted in various ways.

Be sure to put your name and Athena username on your sheet for part (a) and on your map layout for part (b).

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## OPTIONAL Question 1 (just for fun...)

For simple queries, it's easier to use ArcView's SQL tools to run the queries using the SQL connection -- or even to query *.dbf versions of the ZONING database* and lookup tables (rather than do the queries in Oracle and bring them over with the browser and addins). But, suppose you wanted to use the institutional categories of ownership that you developed in the last homework set. It took a while to develop these as you accumulated the SELECT and UPDATE SQL statements that built the cross-reference table. Hence, you'd like to leave all this on a network database server that could protect private data while letting you reach it quickly from any Athena or PC 'client' when you had a chance to work on it and map the results.

For all those variances whose board decision is known, what is the approval rate (code 1 or 2) broken down by your institutional categories? What fraction are in high income neighborhoods and tracts (as defined earlier) by each institutional category? What about for the vacant-to-housing subset? Map the locations of the variances in the various institutional categories. Do you see any patterns worth pursuing? Are they closer to major roads, downtown, more/less dense residential neighborhoods,...? Perhaps you are comparing apples and oranges -- the institutionally owned property might not be comparable to the one-, two-, and triple-deckers owned by individuals. Use the 'existzonin' variable to zero in on those variances on property that is zoned for single through 3-family structures and then redo some of these comparisons.

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## OPTIONAL Question 2 (just for more fun...)

Now let's do an exercise similar to Part (f) above that uses additional 1990 census data--viz. census data that aren't already included in the data tables for the ArcInfo census tract layer. We'll mount Massachusetts STF3A data online at CRL and pull off the needed STF3A data. In this case, let's find census data indicating the extent of auto ownership in

* Kindly refer to the Lecture Notes section

each Boston census tract and compare the incidence and approval rates of vacant-to-housing zoning variances within 1990 census tracts that are above/below average in your measure of auto ownership. As explained in the 11.208 Census notes, the technical documentation for STF3 census data has several variables related to vehicle usage. For example:

```
H38. AGGREGATE VEHICLES AVAILABLE(1) BY TENURE(2)
     Universe: Occupied housing units
     Total:
       Owner occupied
       Renter occupied
```

Use these variables (with appropriate normalization) to construct some measure of auto ownership that allows you to group Boston census tracts into above/below 'average' categories. Think about your reasoning and the specific census variables and formulae that you used to compute your measure. Generate a map (just as you did earlier) showing the location of all variances (that were geo-referenced) which proposed to convert vacant land to housing. Use color (or grayscale) again to distinguish approved/dis-approved variances but this time use thematic shading of the census tract map to indicate parts of town where auto ownership is high/medium/low.

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