Spatial Data and Analysis

Discussion 4

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Outline

Display text

- Until now, we have been using the command `disp('Hi')` to display text in the command window
- However, this command does not interact in a great way with numbers. This is a major disadvantage, specially when we are trying to compress the output of our code
- Sometimes you might want to display actual calculations. To achieve more control over the display we will use the command `fprintf`

Display text — `fprintf`

- The command `fprintf` has the following structure:

```
fprintf('Number %f displayed', x)
```

- The symbol % tells MATLAB that there is a number in that position. The letter after % specifies the format

- For example, the following would produce the mean of 100 draws from a normal distribution with 2 decimal numbers:

```
fprintf('The mean is %.2f', mean(randn(100,1)))
```

Display text — useful commands

`%d`	:	integer
`%s`	:	string
`%f`	:	number with decimals
`%.1f`	:	number with 1 decimal
`n`	:	print a new line
`t`	:	print a tab

Interactive screening

- Draw N numbers from a normal distribution. Repeat this S times and answer the following questions:
  1. What is the mean of the distribution of minimums?
  2. Plot the distribution of minimums

Interactive screening

- Draw N numbers from a normal distribution. Repeat this S times and answer the following questions:
  1. What is the mean of the distribution of minimums?
  2. Plot the distribution of minimums
- Write a program that does the following:
  1. Allows a random user to select N and S
  2. Prints output in a friendly way

Interactive screening — example

- Show m-file with written program
- You can download it from the bCourse website in the `Files/Resources` folder

Polygons, structures and shapefiles

- Theoretically, a polygon is a closed shape where the first and last vertex are the same:

$$\widetilde{P} \;=\; \{\vec{X}, \vec{Y}\} \qquad \text{where } \vec{X} = \begin{bmatrix} x_1 \\ \vdots \\ x_N \end{bmatrix} \text{ and } \vec{Y} = \begin{bmatrix} y_1 \\ \vdots \\ y_N \end{bmatrix}$$

  i.e., $x_1 = x_N$ and $y_1 = y_N$

- However, in reality many units of interest are composed by multiple polygons (e.g., Hawaii)

Polygons, structures and shapefiles

- In that case, multiple polygons are separated by a missing value. Example of two polygons defining a state:

$$\widetilde{P} = \{\vec{X}, \vec{Y}\} \quad \text{where } \vec{X} = \begin{bmatrix} x_{11} \\ \vdots \\ x_{1N} \\ . \\ x_{21} \\ \vdots \\ x_{2N} \end{bmatrix} \text{ and } \vec{Y} = \begin{bmatrix} y_{11} \\ \vdots \\ y_{1N} \\ . \\ y_{21} \\ \vdots \\ y_{2N} \end{bmatrix}$$

in which case, $x_{11} = x_{1N}$, $x_{21} = x_{2N}$, and $y_{11} = y_{1N}$, $y_{21} = y_{2N}$

Shapefiles

- A shapefile is a set of four files that define structures (`s`) and attributes (`a`):
  1. `NAME.shp` → two vectors defining polygons
  2. `NAME.dbf` → attributes
  3. `NAME.shx`
  4. `NAME.prj`

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- 3 types of shapefiles: points, lines, and polygons
- A structure is a set of polygons (e.g., U.S. is a structure composed by states)
- An attribute is a characteristic of a structure (e.g., population)

Shapefiles — lat lon variables

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- Two variables in `NAME.shp` define polygons:
  1. Latitude
  2. Longitude
- Latitude and longitude are nothing more than numbers in a vector, separated by missing values (`NaN`) that define the end of a closed polygon
- How to open a shapefile:

```
[s,a] = shaperead('NAME.shp','UseGeoCoords',true);
```

Shapefiles — lat lon variables

- Let's count the number of closed polygons in a structure:

```
1       disp('Number of closed polygons:')
2       disp(sum(isnan(s(1).Lon)))
```

Shapefiles — lat lon variables

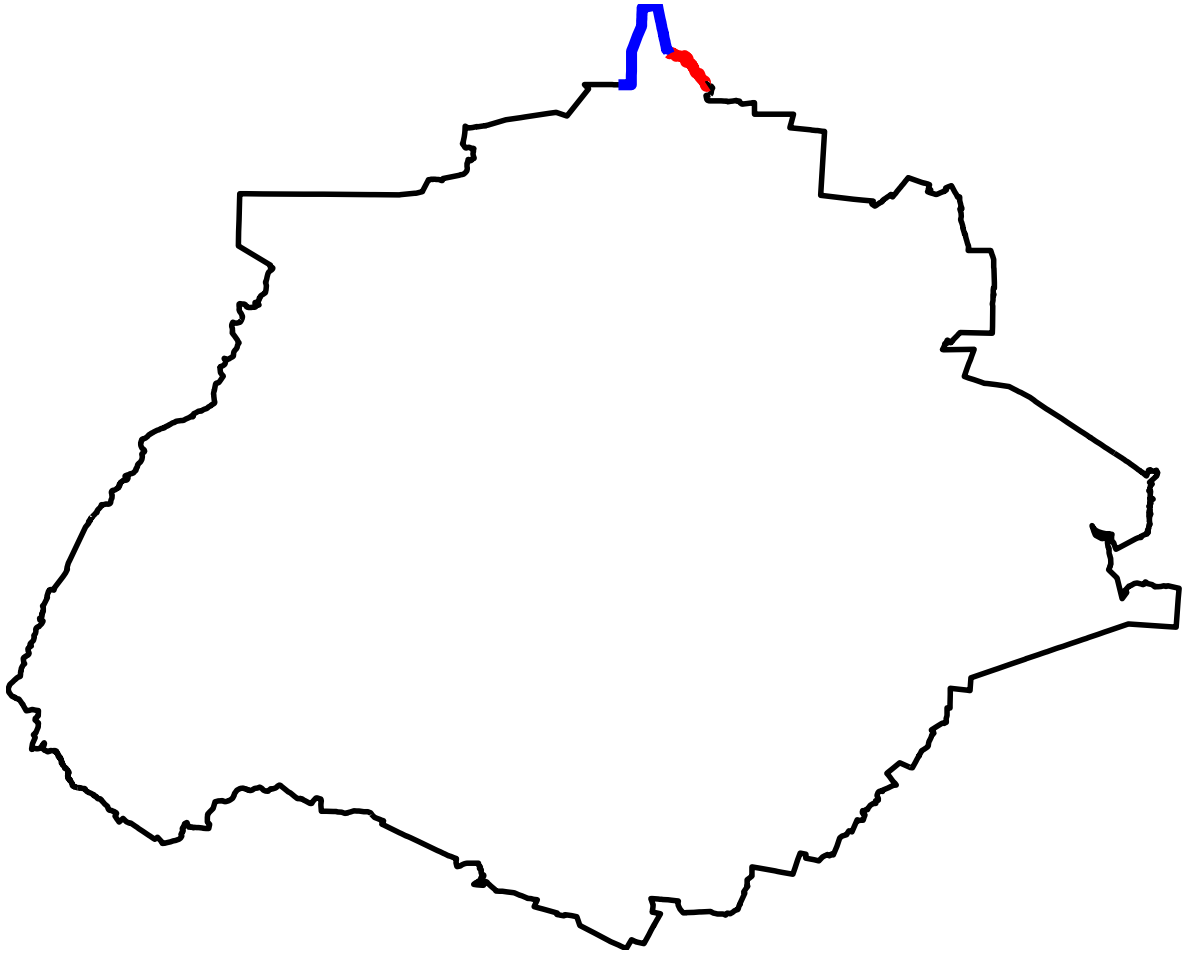
- Let's count the number of closed polygons in a structure:

```
disp('Number of closed polygons:')
disp(sum(isnan(s(1).Lon)))
```

- Now let's explore values in lat lon vectors:

```
x = 100;
hold on
plot(s(1).Lon, s(1).Lat, '-k', 'LineWidth',2)
plot(s(1).Lon(1,1:x), s(1).Lat(1,1:x),...
    '-r','LineWidth',4)
plot(s(1).Lon(1,end-x:end),...
     s(1).Lat(1,end-x:end),'-b','LineWidth',4)
hold off
```

Shapefiles — lat lon variables



Shapefiles — multiple polygons

- How do you plot multiple polygons into a single figure?

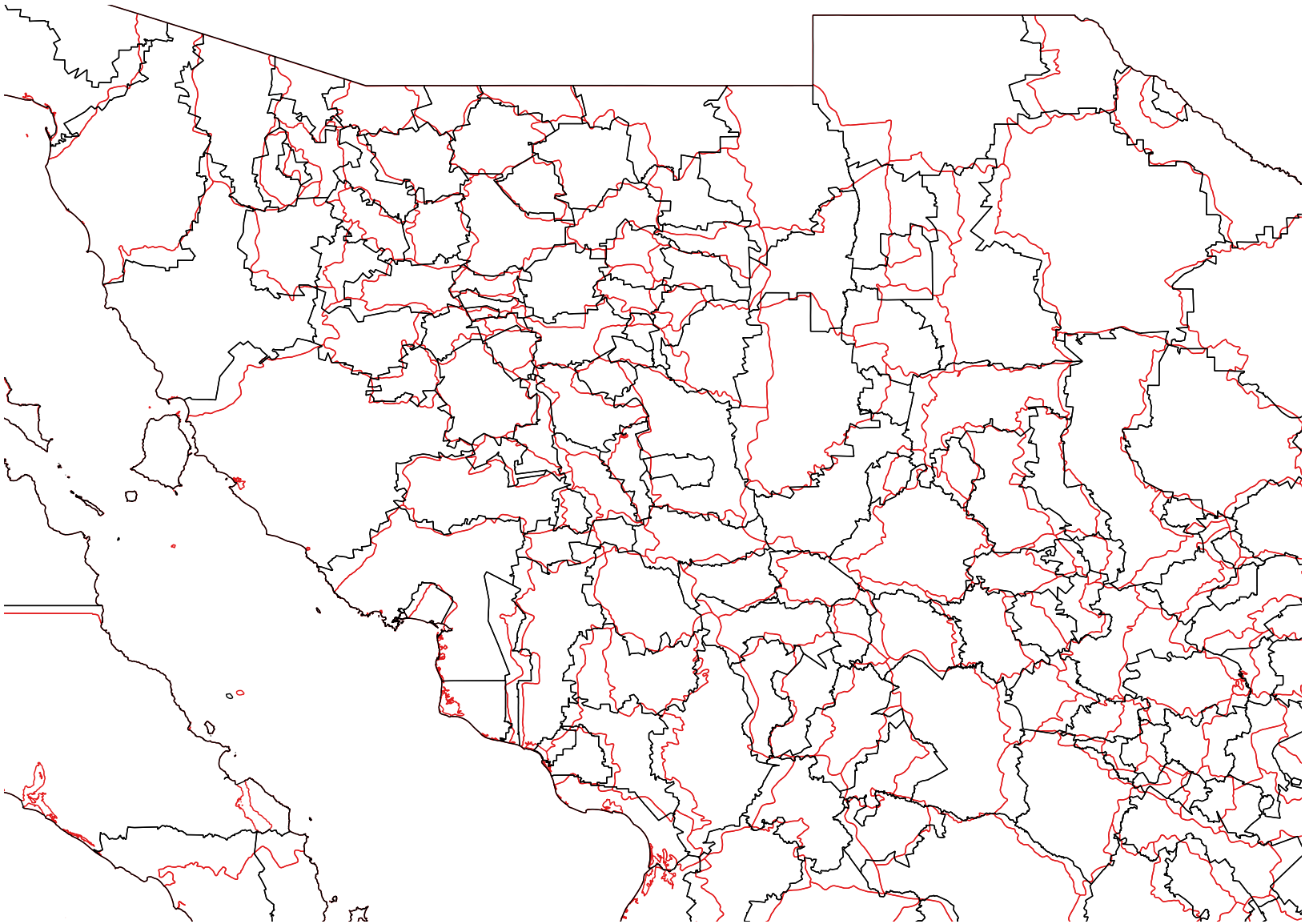
```
1       hold on
2       for i = 1:size(s,1)
3           plot(s(i).Lon, s(i).Lat, 'k')
4               set(gcf,'color','w')
5               box off
6               axis equal
7               axis off
8       end
9       hold off
```

Shapefiles — multiple polygons

Shapefiles — where to find them?

- There are multiple sources in the internet where you can get shapefiles for free. These are usually `.zip` files with previously discussed files (example: DIVA-GIS)
- However, careful is needed because of two different reasons:
  1. Not all shapefiles use the same projection
  2. Check shapefiles make sense (attributes and geometry)
- Official sources are always preferred

Official source and downloaded from website



Occupied zones

- In many cities there are zones in which the state does not have control. For simplicity we will call these "occupied zones"
- This means lots of people don't benefit from public programs and don't have access to basic infrastructure such as police stations, hospitals, schools, etc
- In the following application we will empirically analyze with MATLAB the real case of occupied zones in a large Latin American city

Occupied zones

- In particular, we are interested in two things when it comes to ocuppied zones and information about people living in there:

  1. How many people actually live in occupied zones?
     - This will be an estimate with a confidence interval

  2. How are aggregate statistics biased because of the existence of occupied zones that don't appear in surveys?
     - How to guess statistics of occupied zones?

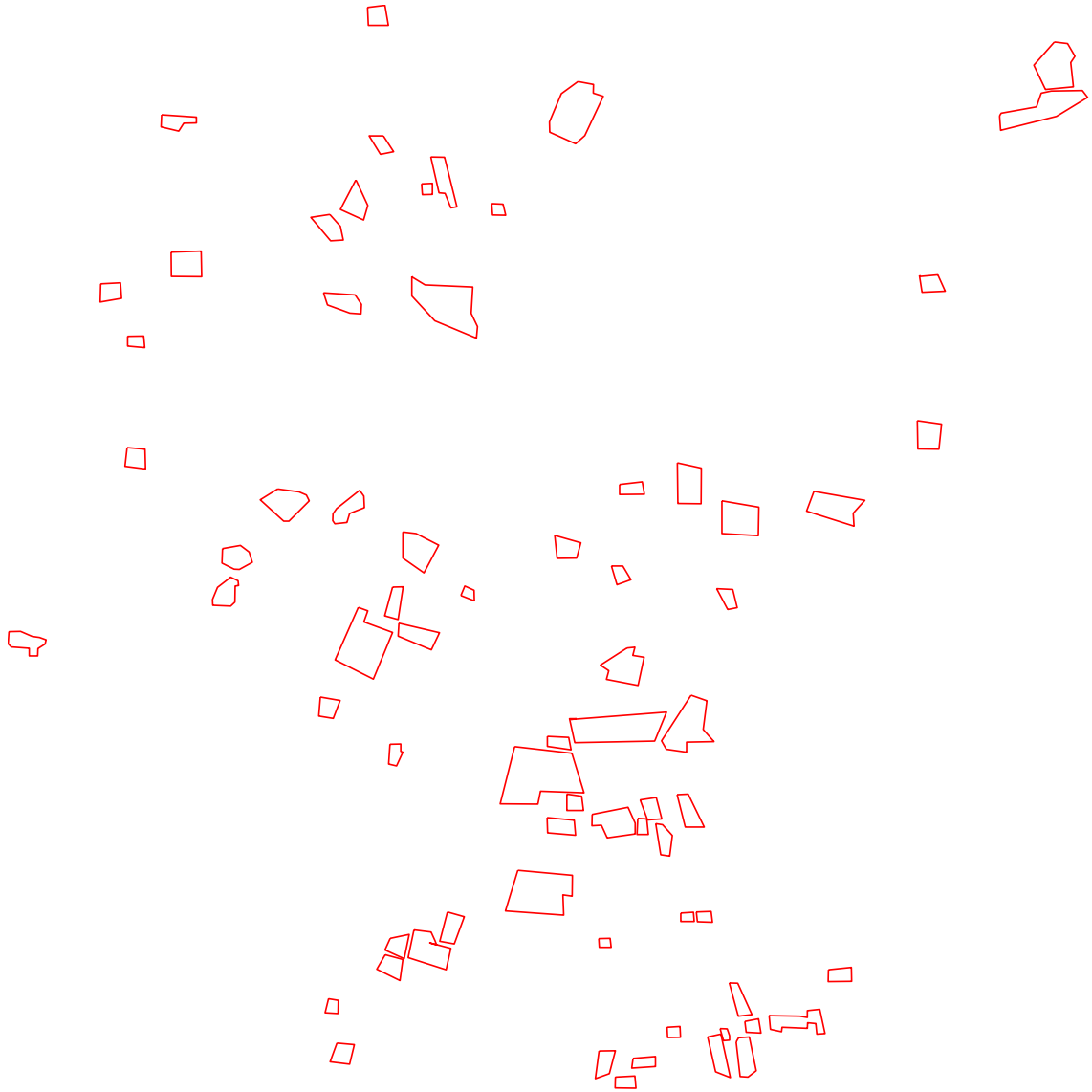
Occupied zones according to news story

Digitizing occupied zones

- Digitizing occupied zones in an image into a shapefile is easier in a different software which we will review in another discussion
- There are 71 polygons in the previous figure.
- Let's open that shapefile:

```
[z,b] = shaperead('Zonas Ocupadas.shp',...
                  'UseGeoCoords', true) ;
```

Occupied zones in a shapefile

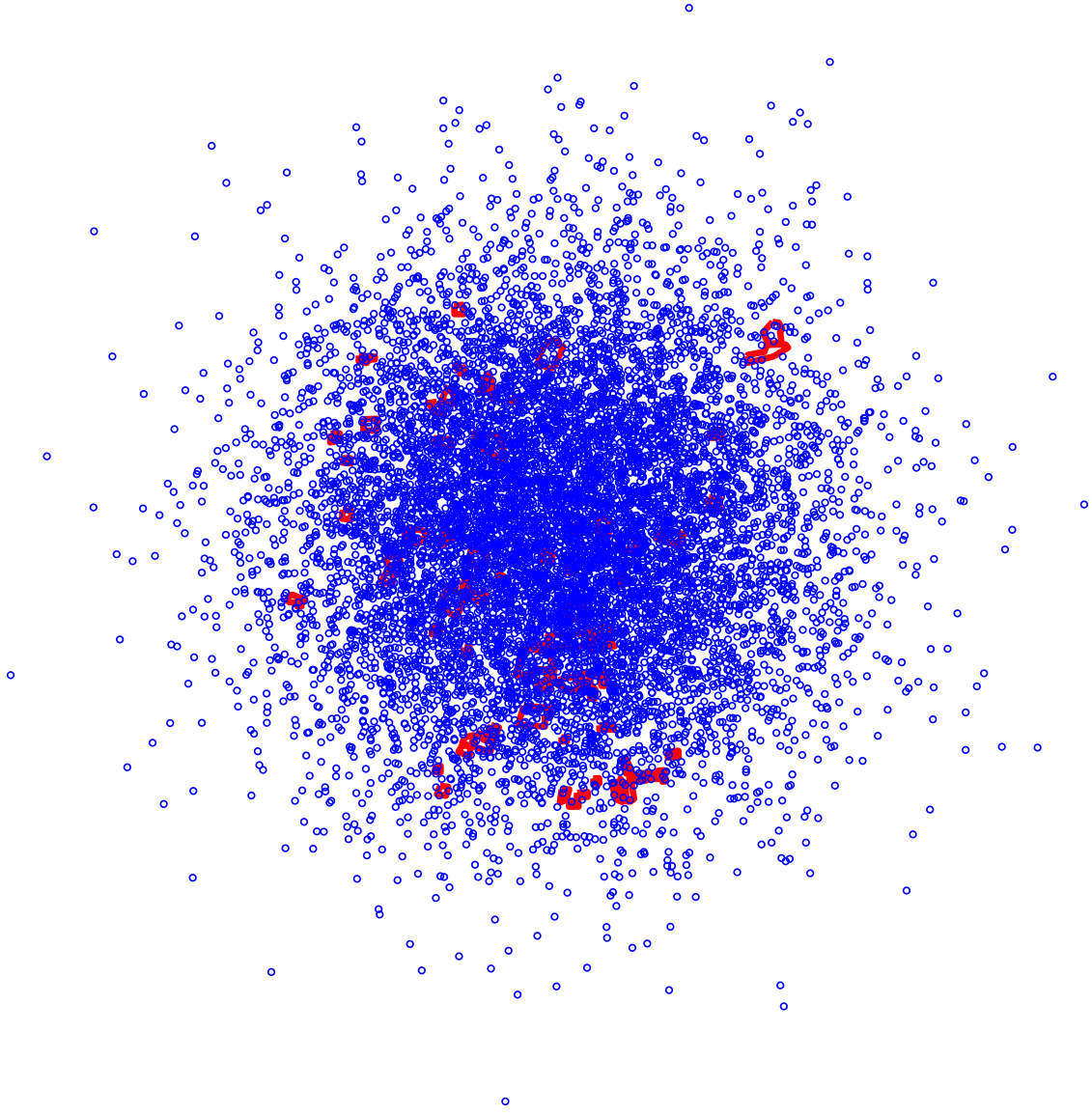


Random locations in the city

```
% Random locations in Santiago
    clear ; clc
    rng(1234)

% Generates 'N' random locations in Santiago
    N     = 10000                          ;
    loc_x = -70.63 + .08 * randn(N, 1) ;
    loc_y = -33.47 + .08 * randn(N, 1) ;
```

Simulating 10,000 random locations in the city



Inside and outside occupy zones

```
% Loop over 71 occupied zones
IN = NaN(N, 71);
     for i = 1:71
         IN(:,i) = inpolygon(loc_x, loc_y,...
                   z(i).Lon', z(i).Lat');
     end
disp('Number of individuals living in occupy zones:')
disp(sum(sum(IN)))
```

Answer: with random geographic sampling there are $\sim$4% of individuals living inside occupied zones. A Montecarlo exercise in the 'appropriate dimension' can give you a sense of uncertainty

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Bias in aggregate statistics

- How are aggregate statistics biased because of the existence of occupied zones that don't appear in surveys?
- The key to answer this question is to find a similar group of individuals and assign their observables to people living inside occupied zones
- One alternative is to use observables of people living in areas closed to occupied zones. Let's define 'close' as approximately 1 kilometer

Buffer zones for occupied zones

In order to find people living close to ocuppied zones we will create buffer zones around occupied zones

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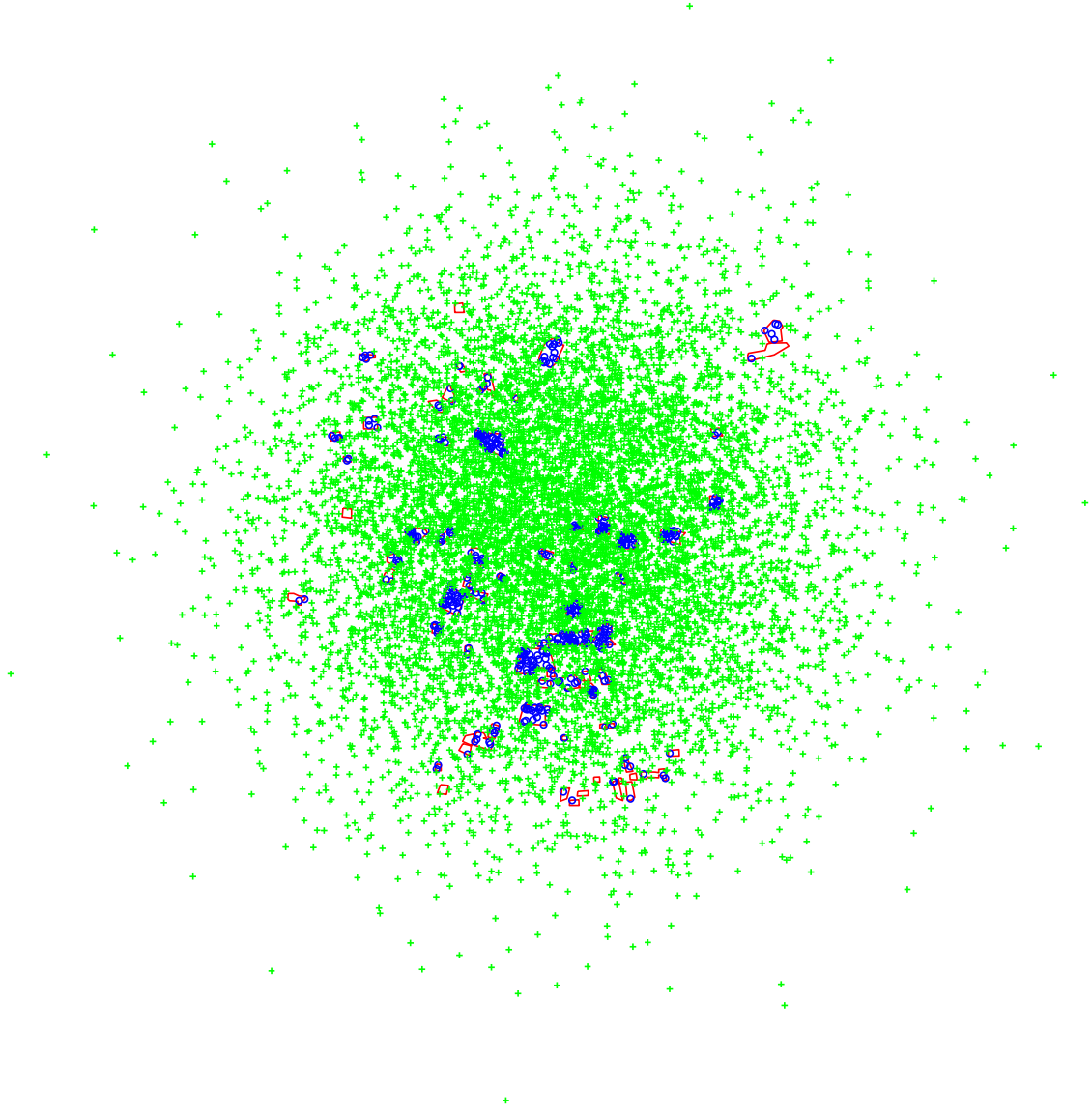
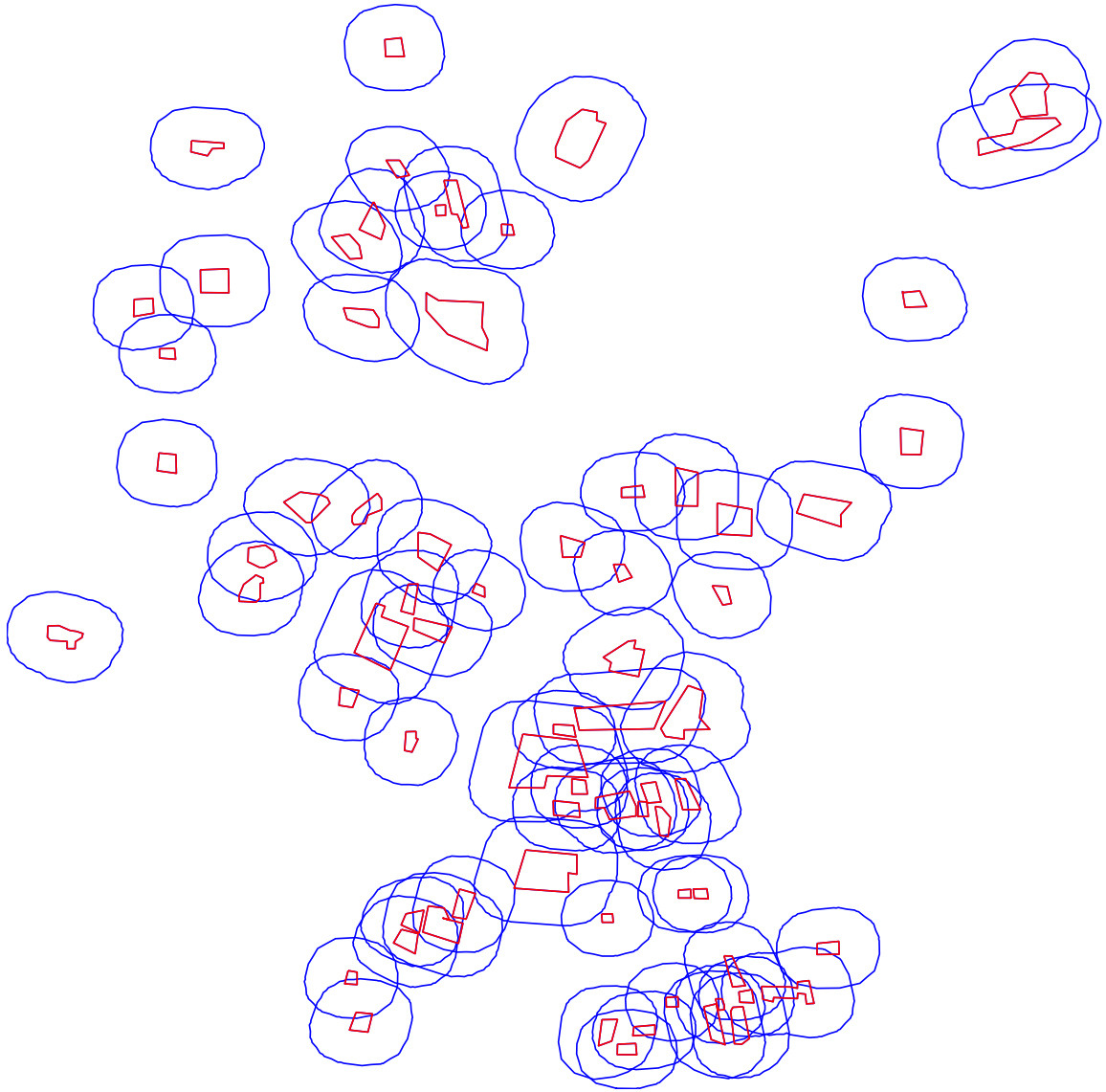
```
1       B(71).Lon = '' ;
2       B(71).Lat = '' ;
3       disp('Generates structure with buffers:')
4       for i = 1 : 71
5           [buff_lat, buff_lon] = bufferm(z(i).Lat',...
6                                          z(i).Lon',.01);
7           B(i) = struct('Lon', {buff_lon},...
8                  'Lat', {buff_lat}) ;
9           disp(i)
10      end
```

Households inside and outside of occupied zones



Buffer zones of .01 degrees ($\approx$ 1 km.) around each zone



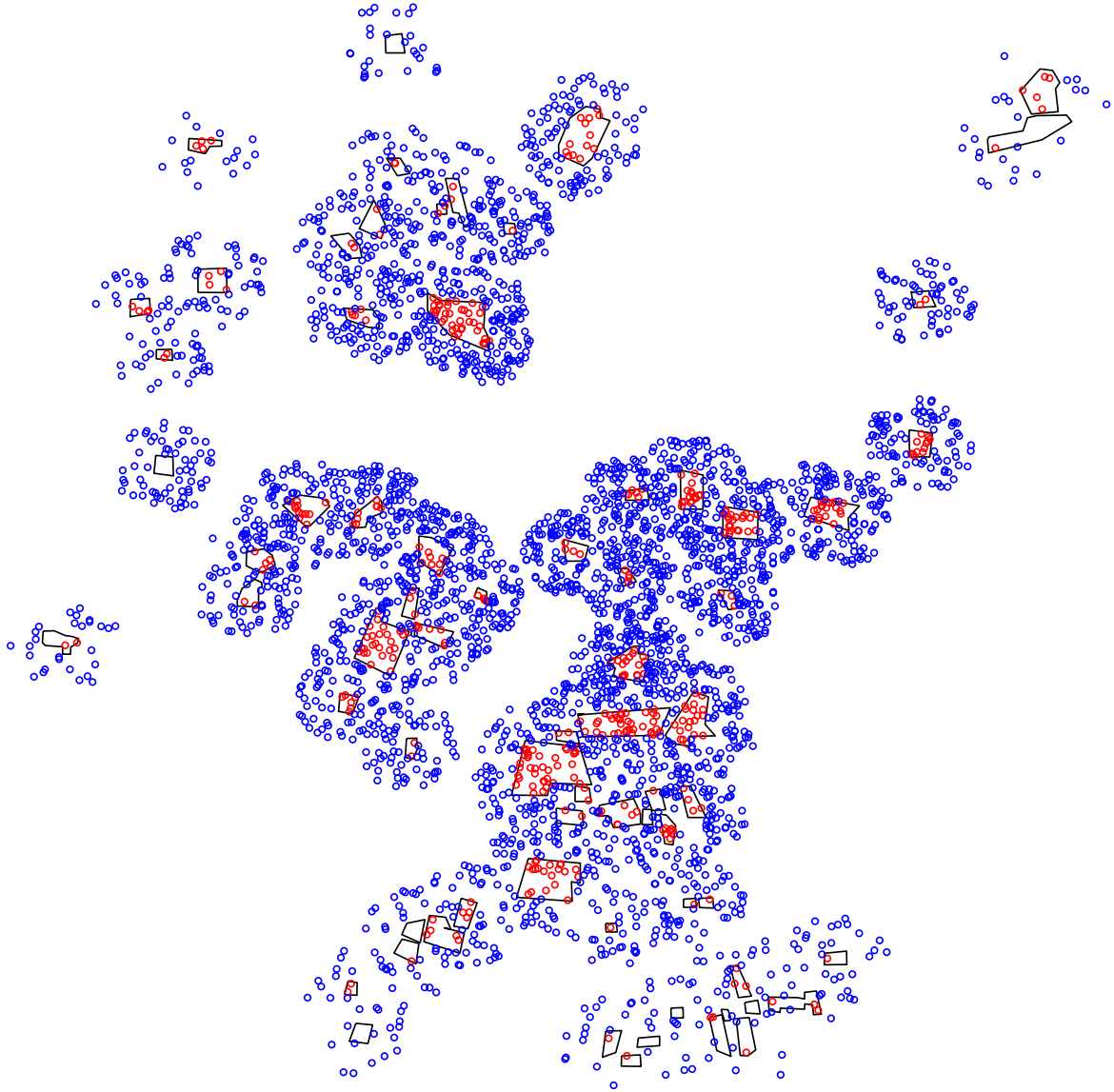
Group of interest

```
% Living in buffers outside occupy zones
% Loop over 71 occupy locations
Control = NaN(N, 71);
    for i = 1:71
        Control(:,i) = inpolygon(loc_x, loc_y, B(i).Lon'
    end

% Individuals can be located in more than 1 buffer
A   = sum(Control, 2)  ;
OUT = (A > 0 & IN == 0);

% Group of interest
    disp('Number of individuals living in buffers:')
    disp(sum(sum(OUT)))
```

Inside and outside households



Additional resources

- Where to download shapefiles:
  - DIVA-GIS
- Check some MATLAB code at Prof. Hsiang's website