Labs

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Contents

Chapter 1

Prerequisites

This is a *sample* book written in **Markdown**. You can use anything that Pandoc's Markdown supports, e.g., a math equation $a^2 + b^2 = c^2$.

For now, you have to install the development versions of **bookdown** from Github:

Remember each Rmd file contains one and only one chapter, and a chapter is defined by the first-level heading `#`.

To compile this example to PDF, you need to install XeLaTeX.

Chapter 2

Loading data into R, data transformation, and summary statistics

Due: Monday, Sept. 18

Value: 30 points

Overview:

This lab is intended to assess your ability to use R to load data and to generate basic descriptive statistics. You'll be using monthly weather data from the Daymet climate database (http://daymet.ornl.gov) for all counties in the United States over a 10 year period (2005-2015). These data are available on the Github repo for our course. The following variables are provided:

- gisjn_cty: Code for joining to census data
- year: Year of observation
- month: Month of observation
- dayl: Mean length of daylight (in seconds)
- srad: Mean solar radiation per day
- tmax: Mean maximum recorded temperature (Celsius)
- tmin: Mean minimum recorded temperature (Celsius)
- vap_pres: Mean vapor pressure (indicative of humidity)
- prcp: Total recorded prcpitation (mm)
- cty_name: Name of the county
- state: state of the county
- region: Census region (map: https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf)
- division: Census division
- lon: Longitude of the point
- lat: Latitude of the point

These labs are meant to be done collaboratively, but your final submission should demonstrate your own original thought (don't just copy your classmate's work or turn in identical assignments). Your answers to the lab questions should be typed in the provided RMarkdown template and turned in using the Assignment Dropbox on the ELC site.

2.1 Procedure:

Load the tidyverse package and import the data from GitHub:

```
library(tidyverse)
Daymet_Cty_Summary_2005_2015 <- read_csv("https://github.com/jshannon75/geog4300/raw/master/Labs/Lab%20
```

```
## Parsed with column specification:
## cols(
##   gisjn_cty = col_character(),
##   year = col_integer(),
##   month = col_character(),
##   dayl = col_double(),
##   srad = col_double(),
##   tmax = col_double(),
##   tmin = col_double(),
##   vap_pres = col_double(),
##   prcp = col_integer(),
##   CTY_NAME = col_character(),
##   State = col_character(),
##   Region = col_character(),
##   Division = col_character(),
##   Lon = col_double(),
##   Lat = col_double()
## )
```

After loading the file into R, closely examine each variable.

Question 1 task (4 points): *Provide an example of nominal, ordinal, interval, and ratio data within this dataset. Explain why each fits in the level of measurement you chose in a sentence or two . If you cannot find an example for one of these four data types (no nominal variables, for example), given an example of climate data that would fit this type.*

2.2 Question 2

There are a lot of observations here, 413,820 to be exact. To get a better grasp on it, we can use group_by and summarise in the tidyverse package. Here's an example.

```
Daymet_Cty_Summary_2005_2015 %>%
  group_by(Region) %>%
  summarise(mean_srad=mean(srad))
```

```
## # A tibble: 4 x 2
##             Region mean_srad
##              <chr>     <dbl>
## 1   Midwest Region  319.4705
## 2 Northeast Region  312.1818
## 3     South Region  344.1628
## 4      West Region  342.4914
```

This command returns the mean value of solar radiation received by counties in each census region during our study period. You could replace "mean" with "sd" to get a similar summary of standard deviation. You may want to change the new variable name ("mean_srad") above as well.

Now try a VERY simple model of climate change. Let's say that 100 years from now, temperatures in these cities will be warmer by exactly 2 degrees Celsius. You can create a new variable showing the projected new minimum temperatures. The command below uses the mutate function from the tidyverse to create a new variable (tmin_new) with values two degrees higher than the old one (tmin). It then uses select to get just our variables of interest.

```
daymet_climatechg<-Daymet_Cty_Summary_2005_2015 %>%
  mutate(tmin_new=tmin+2) %>%
  select(Region,tmin,tmin_new)
daymet_climatechg
```

```
## # A tibble: 413,820 x 3
##          Region       tmin  tmin_new
##           <chr>      <dbl>     <dbl>
##  1 South Region  9.4666667 11.466667
##  2 South Region 22.0322581 24.032258
##  3 South Region  0.1774194  2.177419
##  4 South Region  5.4107143  7.410714
##  5 South Region  3.5483871  5.548387
##  6 South Region 22.0483871 24.048387
##  7 South Region 19.7500000 21.750000
##  8 South Region  5.5645161  7.564516
##  9 South Region 13.6129032 15.612903
## 10 South Region  6.8666667  8.866667
## # ... with 413,810 more rows
```

***Question 2 task (3 points):** Calculate the mean and standard deviation for the original minimum temperature variable and a new one two degrees higher, grouping these by each census region as shown above. How do these compare? Explain any similarities or differences you find.

2.3 Question 3

You can also create a table showing summary statistics for each variable. For example, if you wanted to know the mean, median, standard deviation coefficient of variation (CV), and IQR for the tmax variable, you can use group_by and summarise:

```
daymet_summarystats<-Daymet_Cty_Summary_2005_2015 %>%
  group_by(Region) %>%
  summarise(tmax_mean=mean(tmax),
            tmax_med=median(tmax),
            tmax_sd=sd(tmax),
            tmax_cv=tmax_sd/tmax_mean,
            tmax_iqr=IQR(tmax))
daymet_summarystats
```

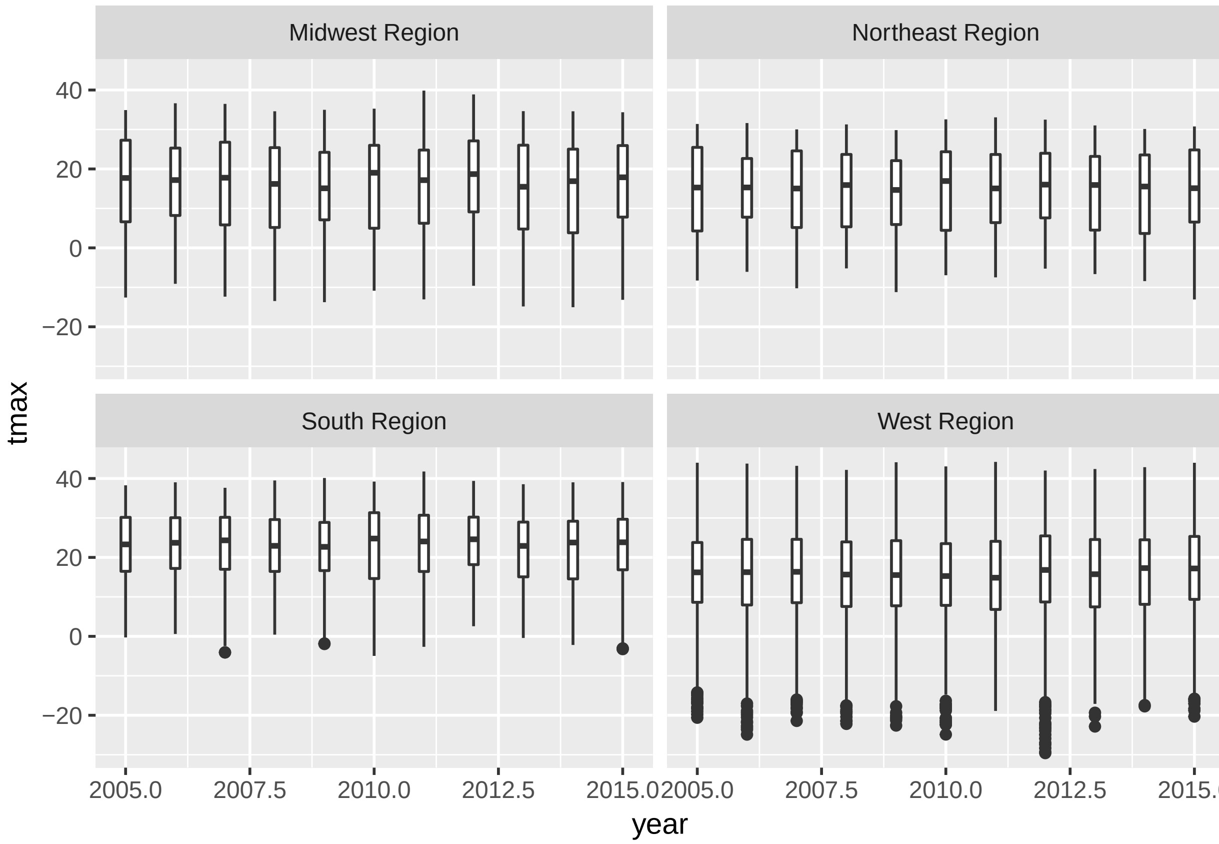
```
## # A tibble: 4 x 6
##             Region tmax_mean tmax_med   tmax_sd   tmax_cv tmax_iqr
##              <chr>     <dbl>    <dbl>     <dbl>     <dbl>    <dbl>
## 1   Midwest Region  15.74354 17.26667 11.236738 0.7137364 19.37500
## 2 Northeast Region  14.64101 15.51613  9.991482 0.6824312 18.10000
## 3     South Region  22.78074 23.75806  8.338996 0.3660547 13.48387
## 4      West Region  16.11225 16.12500 10.504552 0.6519604 16.38602
```

Question 3 task (6 points): *Adapting the script above, create a data frame that shows the mean, median, standard deviation, CV, and IQR for the* **prcp** *variable. Based on these data, are these data skewed or roughly normal in distribution? Which measures of central tendency and dispersion should you use as a result?*

2.4 Questions 4-6

We can also look at variables over time. For instance, we can use facet_wrap with boxplot to see how the distribution of maximum temperatures varies by region:

```
ggplot(Daymet_Cty_Summary_2005_2015, aes(x=year,y=tmax,group=year))+
  geom_boxplot()+
  facet_wrap(~Region)
```



Suppose we are just interested in the median. We would then want to create a dataset where the value of tmax is summarized by each year for each census division. You can do so using the combination of group_by and summarise, similar to the command above.

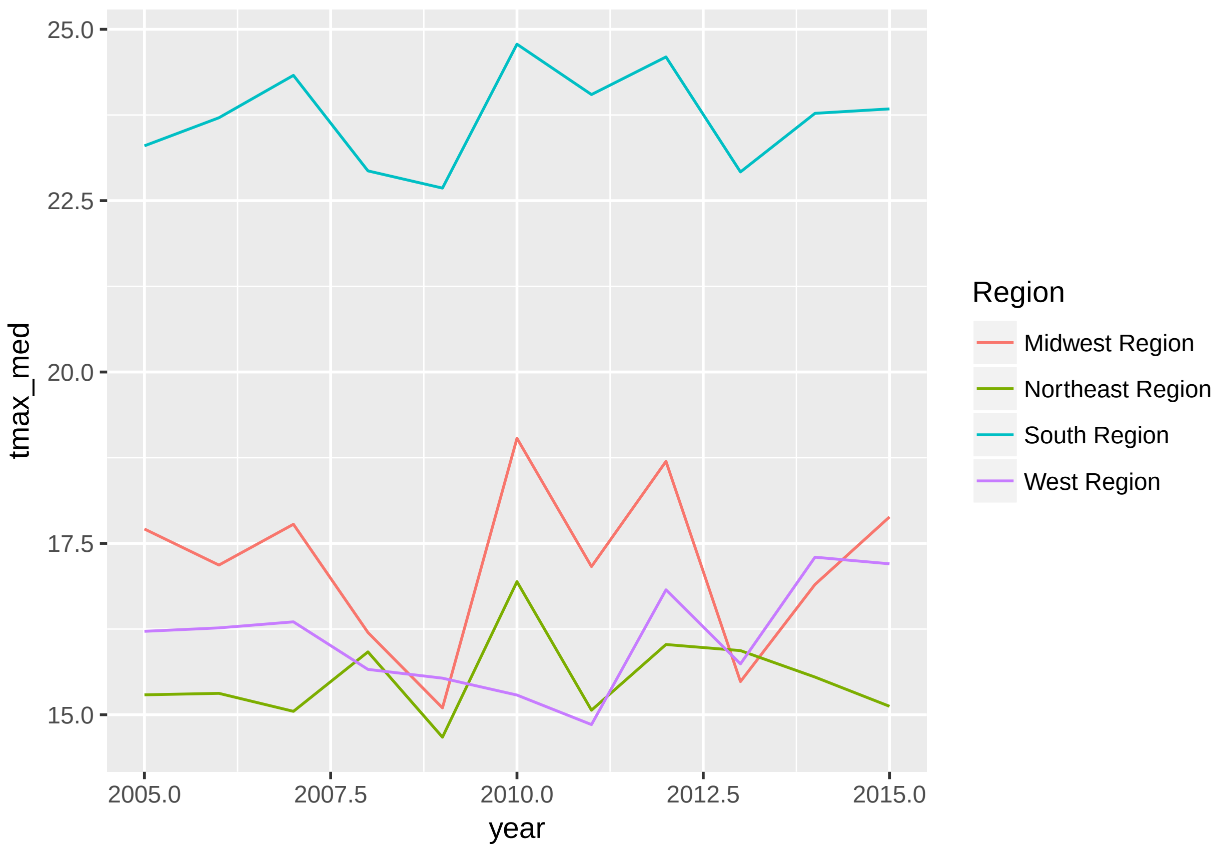
```
daymet_summary_region<-Daymet_Cty_Summary_2005_2015 %>%
  group_by(Region, year) %>%
  summarise(tmax_med=median(tmax))
daymet_summary_region
```

```
## # A tibble: 44 x 3
## # Groups:   Region [?]
##            Region  year tmax_med
##             <chr> <int>    <dbl>
##  1 Midwest Region  2005 17.70968
##  2 Midwest Region  2006 17.18333
##  3 Midwest Region  2007 17.77876
##  4 Midwest Region  2008 16.20000
##  5 Midwest Region  2009 15.10000
```

```
##   6 Midwest Region  2010 19.03333
##   7 Midwest Region  2011 17.16129
##   8 Midwest Region  2012 18.69677
##   9 Midwest Region  2013 15.48333
##  10 Midwest Region  2014 16.90000
## # ... with 34 more rows
```

Notice how much smaller this dataset is already. Plot it out using ggplot:

```
ggplot(daymet_summary_region, aes(x=year,y=tmax_med, group=Region, colour=Region))+
  geom_line()
```



Suppose you wanted to see the distribution of the average maximum temperatures of all counties by region. You can summarise that in this way:

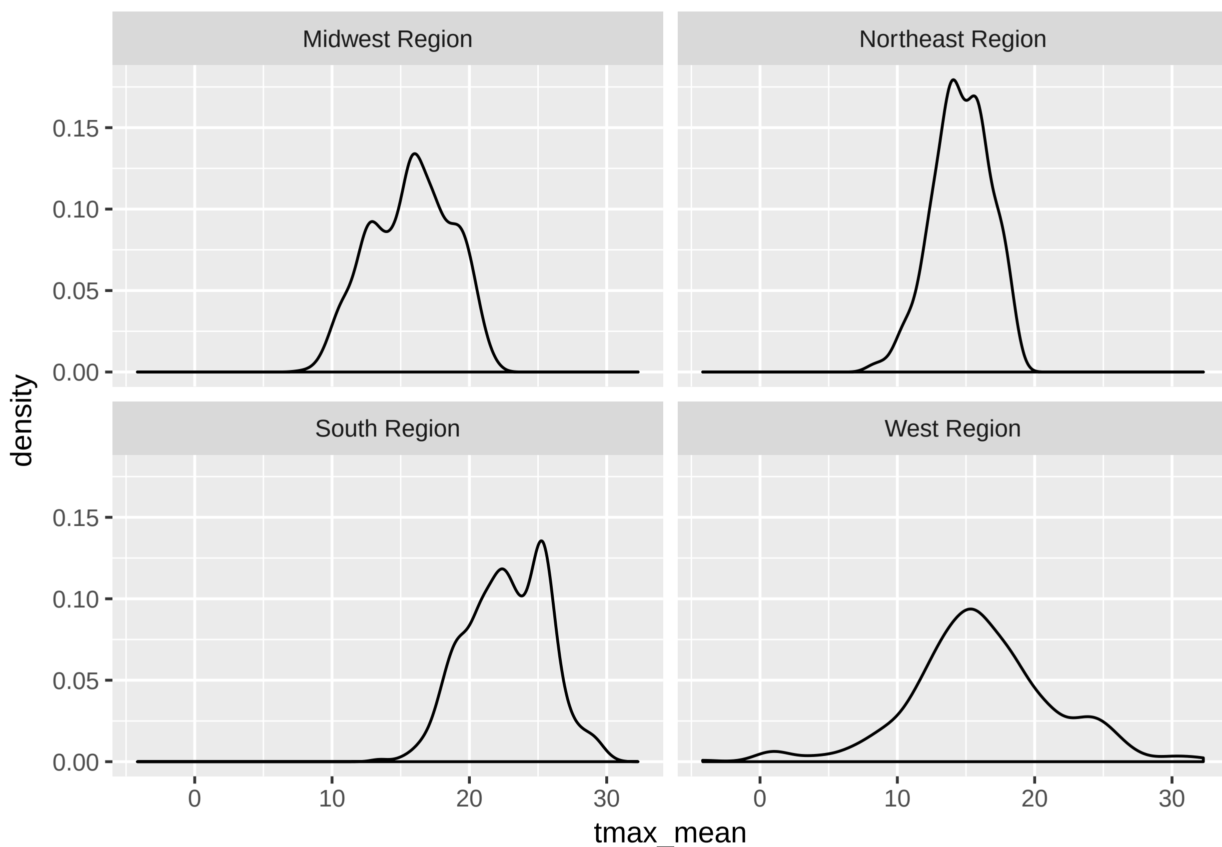
```
daymet_summary_county <- Daymet_Cty_Summary_2005_2015 %>%
  group_by(Region,gisjn_cty) %>%
  summarise(tmax_mean=mean(tmax))
daymet_summary_county
```

```
## # A tibble: 3,135 x 3
## # Groups:   Region [?]
##            Region gisjn_cty tmax_mean
##             <chr>     <chr>     <dbl>
##  1 Midwest Region    G17001  17.10559
##  2 Midwest Region    G17003  20.22032
##  3 Midwest Region    G17005  18.53646
##  4 Midwest Region    G17007  14.33828
```

```
##  5 Midwest Region    G17009  17.15056
##  6 Midwest Region    G17011  15.60495
##  7 Midwest Region    G17013  18.11706
##  8 Midwest Region    G17015  14.95555
##  9 Midwest Region    G17017  17.20915
## 10 Midwest Region    G17019  16.70861
## # ... with 3,125 more rows
```

You can then create a density plot of these mean values by region, again using facet_wrap to separate them.

```
ggplot(daymet_summary_county, aes(x=tmax_mean))+geom_density()+facet_wrap(~Region)
```



We can use the filter command to further specify things, selecting only a single month for comparison over this timeframe.

```
daymet_july<-Daymet_Cty_Summary_2005_2015 %>%
     filter(month=="July")
daymet_july
```

```
## # A tibble: 34,485 x 15
##    gisjn_cty  year month     dayl     srad     tmax     tmin vap_pres
##        <chr> <int> <chr>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>
##  1    G01001  2005  July 50045.13 350.2452 31.37097 22.04839 2649.032
##  2    G01001  2006  July 50045.13 386.4774 34.29032 21.54839 2567.742
##  3    G01001  2007  July 50045.13 378.6323 31.96774 21.00000 2122.581
##  4    G01001  2008  July 50045.13 387.9226 33.01613 20.53226 2427.097
##  5    G01001  2009  July 50045.13 370.8903 31.45161 20.03226 2352.258
##  6    G01001  2010  July 50045.13 382.7613 34.37097 22.40323 2710.968
```

```
## 7    G01001  2011  July 50045.13 349.2129 33.25806 21.88710 2600.000
## 8    G01001  2012  July 50045.13 370.0645 33.83871 21.51613 2565.161
## 9    G01001  2013  July 50045.13 337.9613 30.04839 20.80645 2454.194
## 10   G01001  2014  July 50045.13 398.9677 31.70968 20.29032 2393.548
## # ... with 34,475 more rows, and 7 more variables: prcp <int>,
## #   CTY_NAME <chr>, State <chr>, Region <chr>, Division <chr>, Lon <dbl>,
## #   Lat <dbl>
```

Question 4 task (3 points): *Adapt the above command to create a new data frame, changing "July" to a month of your choosing and using tmin (rather than tmax) as your variable of interest. You should also be sure to keep the region and year variables for use in question 5. You'll need two commands–one to create the data frame and another to "call" it, just like you see above.*

Question 5 task (9 points): *With your subsetted data, create the three graphs below using the graphs listed earlier as a guide. You may need to further transform the data in order to make each graph.*

- *Create a box plot showing the value distribution for tmin in each of the four regions over all 10 years.*
- *Create a line chart showing the median value of tmin for each region over all 10 years.*
- *Create a faceted density plot like the one above showing the distribution of median minimum temperatures for all regions.*

Don't worry about things like column names or customization for now—these will be addressed in lab 2.

Question 6 task (5 points): *Each of the three graphics you created above tells a particular story about the data. What does each of these graphics tell us about the data? How do they differ from one another in what they communicate? Use details to illustrate your points.*

Chapter 3

Spatial statistics and probability distributions

Due: Wednesday, Oct. 4

Value: 30 points

Overview: This lab has four main sections: mapping point patterns, calculating rates and location quotients, quadrat analysis, and probability distributions. Your answers to the lab questions should be typed in the response template and turned in using the Assignment Dropbox on the ELC site.

3.1 Part 1: mapping the data and its distribution

The lab folder on Google Drive has three files related to crime data for Spokane, Washington.

- "Spokane_crimes_all" has data for every crime committed in from 2000-2015.
- "SpokanePrecincts_data" has precinct boundaries, crime counts, the 2010 population of blocks in those precincts. Note: this is saved as a geojson file, which similar to a shapefile but more compact.

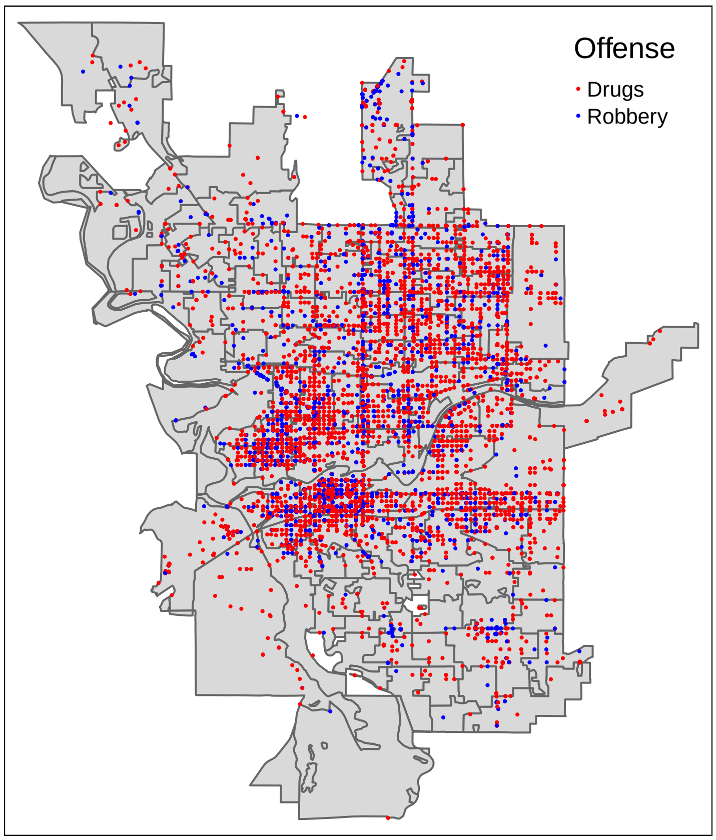
You can load each file using the commands below, using st_as_sf to convert the crimes to spatial data

```
library(tidyverse)
library(sf)
spokane_crimes_all<-read_csv("https://github.com/jshannon75/geog4300/raw/master/Labs/Lab%202_%20Point%2

spokane_crimes_sf<-st_as_sf(spokane_crimes_all,coords=c("Long","Lat"),crs=4326)

spokaneprecincts_data<-st_read("https://github.com/jshannon75/geog4300/raw/master/Labs/Lab%202_%20Point%
```

```
## Reading layer `SpokanePrecincts_data' from data source `https://github.com/jshannon75/geog4300/raw/ma
## Simple feature collection with 117 features and 14 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: -117.5215 ymin: 47.5871 xmax: -117.3039 ymax: 47.7588
## epsg (SRID):    4326
## proj4string:    +proj=longlat +datum=WGS84 +no_defs
```

Question 1 (3 points): *Using the Offense variable and working with the spokane_crimes_all data, select just murder as the offense type. Using tmap, create a map that shows the location of all reports in the this* *data frame and the precinct boundaries. See script 6-2 for a model to work from.*

```
library(tmap)
tmap_mode("plot")
sample_crimes<-spokane_crimes_sf %>% filter(Offense=="Drugs" | Offense=="Robbery")

tm_shape(spokaneprecincts_data)+
  tm_polygons()+
tm_shape(sample_crimes) +
  tm_dots("Offense",palette=c("red","blue"))
```



Question 2 (4 points): *Create a new data frame with the mean centers for each type of crime listed in the spokane_crime_sf data frame. Then map the mean centers you created using tmap. To do so, you'll need to use st_as_sf to convert your new data frame to sf format. Use tm_dots to show the points in different colors, as in the example above (though here you're showing only the mean centers). Also use tm_legend to make sure your legend is outside the bounding box as shown in class.*

Question 3 (2 points): *Explain the code you used in question 2 to calculate your mean centers. What does each line of the code do to the data?*

Question 4 (2 points) *Interpret how geographic differences between the mean centers you calculated are meaningful. What do they tell you about the locations of these crimes?*

Question 5 (2 points): *The nearest neighbor index for vehicle thefts in this dataset is 0.44 compared to 1.51 for murders. Explain what these two numbers tell you about the distribution of these two point datasets.*

3.2 Part 2: Crime rates

The precinct data frame has the number of crimes in each precinct. Crimes are commonly reported as crimes/100,000, so you should calculate the rate of any of these crimes rather than showing the raw counts. For this lab, we will focus on reported *burglary*. Calculate the assault rate by creating a new variable in the data, dividing the reported crimes by population and then multiplying by 100,000:

[new variable] <- [Burglary variable] / [population variable] * 100000

Use the mutate command from the tidyverse to create this variable.

Question 6 (4 points) *Select just the precinct number and burglary rate from the precincts data frame. Then create a new variable for this rate using the formula above. Then do the following: 1) Call your dataset once you've created it to show your results. 2) Create a histogram using ggplot showing the distribution of these data. 3) Map the rates using tmap.*

Question 7 (3 points) *The burglary rate for the city of Spokane in this dataset is 10,639 per 100,000 residents. Using this figure, calculate the location quotient for burglary in each precinct within the city. Use the min and max functions to identify the minimum and maximum values for the location quotient. Then explain what each of these values tell you about the pattern of burglary in those two precincts compared to the city as a whole.*

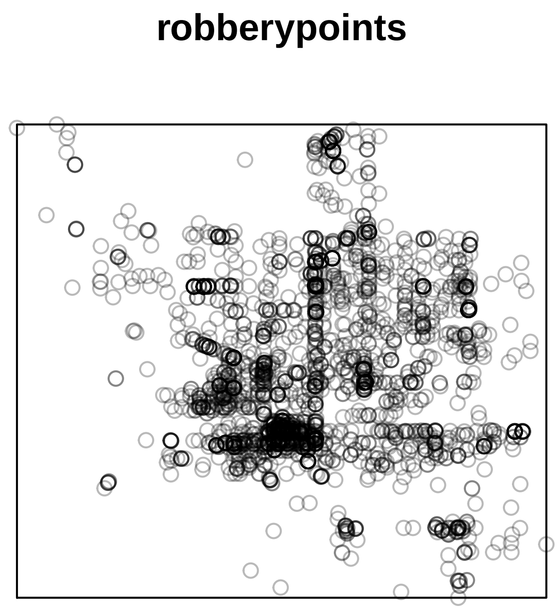
3.3 Part 3: Quadrat analysis

You can also use the spatstat package to create a ppp object for your robbery data.

```
library(spatstat)
robberies<-spokane_crimes_all %>% filter(Offense=="Robbery")

long_bounds<-c(min(robberies$Long),max(robberies$Long))
lat_bounds<-c(min(robberies$Lat),max(robberies$Lat))

robberypoints<-ppp(robberies$Long,robberies$Lat,long_bounds,lat_bounds)
```

```
## Warning: data contain duplicated points
```

```
plot(robberypoints)
```



Question 8 (2 points) *Using the script from week 7 in class as a guide, combine the kernel density map and appropriately sized quadrat grid for robberies in Spokane during the study period. You'll need to include "add=TRUE" for the quadratcount function to layer it and change the text color to white as we did in class.*

Question 9 (3 points) *Based on your analysis in the questions 6 through 8, describe two notable patterns you see in the statistical and geographic distribution of burglary in the city of Spokane.*

Question 10 (2 points) *In this lab, you have used mean center, calculated rates, location quotients, kernel density mapping, and quadrat analysis to analyze the distribution of crime in Spokane. Pick **two** of these and compare what they tell you about this dataset. How are they similar and/or different?*

3.4 Part 4: Probability

The number of persons in each camping party that reserves a campsite at Dawgsville National Park is assumed to be distributed as a Poisson distribution. The maximum number of persons in a camping party is 6. The mean number of persons in a camping party is 2.43.

Question 11 (2 points): *Calculate the probability of observing each possible count of persons in a camping party for each reservation (including no shows).*

For the past 100 years, a stream close to Athens has been measured at a gauging station. The station measures the volume passing a point in a minute, so the values obtained are in units of cubic feet per minute (or CFM). A USGS scientist has crunched these numbers and determined that the results are normally distributed, with a mean of 35.26 CFM and a standard deviation of 4.61 CFM

Question 12 (2 points): *Calculate the probabilities the stream flow in a given year will exceed 42 and 48 CFM.*