CPSC 260
Spring 2022

Instructions: This assignment will give you a chance to practice what you have learned about graphing using the ggplot2 package. You will also get more practice with extracting items from a data frame.

For each problem copy and paste your R code from the R script file window AND your output – either from the Console window or the Plots tab – into this Word document. Please use a color other than black for your R code. Graphs MUST be made using ggplot2 functions, unless otherwise specified.

You will also be asked to interpret/describe what you learned from many of the graphs that you make. You will upload this Word document to Bb when finished.

Use Beginning R by Gardener as a resource. See HW #2 for a list of sections in the text that may be helpful. Also see chapter 3 of R for Data Science by Wickham and Grolemund.

PART ONE:

1. Download the .csv file posted with this assignment on Bb. Then read the *house-and-land-values.csv* file into R. View the first few rows of the data set using the *head()* function. [Use the link provided on Bb to learn about the data.]

```
House_Land<-read.csv(file=file.choose())
> head(House_Land)

  State region    Date Home.Value
1    AK   West 2010.25     224952
2    AK   West 2010.50     225511
3    AK   West 2009.75     225820
4    AK   West 2010.00     224994
5    AK   West 2008.00     234590
6    AK   West 2008.25     233714
  Structure.Cost Land.Value
1         160599      64352
2         160252      65259
3         163791      62029
4         161787      63207
5         155400      79190
6         157458      76256
  Land.Share..Pct. Home.Price.Index
1             28.6            1.481
2             28.9            1.484
3             27.5            1.486
4             28.1            1.481
5             33.8            1.544
6             32.6            1.538
  Land.Price.Index Year Qrtr
1            1.552 2010    1
2            1.576 2010    2
3            1.494 2009    3
4            1.524 2009    4
5            1.885 2007    4
6            1.817 2008    1
```

2. In preparation for this assignment, create several subsets from the *house-and-land-values* data set, as described below. You will create a new object in R, with a descriptive name,

for each. After the subset of data is created, view the first and last few rows using the *head()* and *tail()* functions.

- Subset #1: Just the data for Iowa

```
Iowa_data = House_Land[c(1684:1836), (1:11)]
> Iowa_data

     State  region    Date Home.Value Structure.Cost Land.Value Land.Sh
are..Pct. Home.Price.Index
1684    IA Midwest 1975.25      25285          21948       3337
     13.2              0.255
1685    IA Midwest 1975.50      26335          22277       4058
     15.4              0.265
Land.Price.Index Year Qtr
1684            0.000 1975    1
1685            0.000 1975    2

head(Iowa_data)
     State  region    Date Home.Value Structure.Cost Land.Value Land.Sh
are..Pct. Home.Price.Index
1684    IA Midwest 1975.25      25285          21948       3337
     13.2              0.255
1685    IA Midwest 1975.50      26335          22277       4058
     15.4              0.265
1686    IA Midwest 1975.75      27304          22568       4736
     17.3              0.275
1687    IA Midwest 1976.00      28210          22831       5379
     19.1              0.284
1688    IA Midwest 1976.25      29080          23119       5961
     20.5              0.293
1689    IA Midwest 1976.50      29957          23404       6553
     21.9              0.302
     Land.Price.Index Year Qtr
1684                0 1975    1
1685                0 1975    2
1686                0 1975    3
1687                0 1975    4
1688                0 1976    1
1689                0 1976    2

tail(Iowa_data)
     State  region    Date Home.Value Structure.Cost Land.Value Land.Sh
are..Pct. Home.Price.Index
1831    IA Midwest 2012.00     145969         137439       8530
      5.8              1.471
1832    IA Midwest 2012.25     147404         137443       9961
      6.8              1.486
1833    IA Midwest 2012.50     148820         137448      11372
      7.6              1.500
1834    IA Midwest 2012.75     150213         137454      12759
      8.5              1.514
1835    IA Midwest 2013.00     151571         137462      14109
      9.3              1.528
1836    IA Midwest 2013.25     152897         137471      15427
     10.1              1.541
     Land.Price.Index Year Qtr
1831            0.082 2011    4
1832            0.096 2012    1
1833            0.110 2012    2
1834            0.123 2012    3
1835            0.136 2012    4
1836            0.149 2013    1
```

- Subset #2: Just the data from California, starting at 1985.

```
Cali_1985_Pres = House_Land[which((House_Land$State == "CA") & (House_Land$Year >=
1985)),]
Cali_1985_Pres

State region    Date Home.Value Structure.Cost Land.Value Land.Share..P
ct. Home.Price.Index
613    CA   West 2005.75     727221         158500     568721
   78.2            2.423
614    CA   West 2006.25     755981         163639     592343
   78.4            2.519
  Land.Price.Index Year Qtr
613            3.189 2005    3
614            3.324 2006    1

head(Cali_1985_Pres)
    State region    Date Home.Value Structure.Cost Land.Value Land.Shar
e..Pct. Home.Price.Index
613    CA   West 2005.75     727221         158500     568721
   78.2            2.423
614    CA   West 2006.25     755981         163639     592343
   78.4            2.519
615    CA   West 2006.50     758233         166587     591646
   78.0            2.526
616    CA   West 2006.75     752963         169478     583485
   77.5            2.509
617    CA   West 2006.00     745594         161194     584400
   78.4            2.484
621    CA   West 1985.25     131885          63217      68668
   52.1            0.439
    Land.Price.Index Year Qtr
613            3.189 2005    3
614            3.324 2006    1
615            3.323 2006    2
616            3.281 2006    3
617            3.279 2005    4
621            0.305 1985    1

tail(Cali_1985_Pres)
    State region    Date Home.Value Structure.Cost Land.Value Land.Shar
e..Pct. Home.Price.Index
728    CA   West 2012.00     422384         215423     206961
   49.0            1.407
729    CA   West 2012.25     428610         215800     212810
   49.7            1.428
730    CA   West 2012.50     438735         216195     222540
   50.7            1.462
731    CA   West 2012.75     452037         216611     235426
   52.1            1.506
732    CA   West 2013.00     467720         217053     250667
   53.6            1.558
733    CA   West 2013.25     484516         217521     266995
   55.1            1.614
    Land.Price.Index Year Qtr
728            1.195 2011    4
729            1.231 2012    1
730            1.290 2012    2
731            1.367 2012    3
```

```
732            1.458 2012    4
733            1.555 2013    1
```

- Subset #3: Data for just the following states: Iowa, California, Massachusetts, and Texas.

#Data is shortened

```
problem_2c
    State region    Date Home.Value Structure.Cost
613    CA   West 2005.75     727221          158500
614    CA   West 2006.25     755981          163639
Land.Value Land.Share..Pct. Home.Price.Index
613     568721             78.2             2.423
614     592343             78.4             2.519

head(problem_2c)
    State region    Date Home.Value Structure.Cost
613    CA   West 2005.75     727221          158500
614    CA   West 2006.25     755981          163639
615    CA   West 2006.50     758233          166587
616    CA   West 2006.75     752963          169478
617    CA   West 2006.00     745594          161194
618    CA   West 1984.50     126847           60879
    Land.Value Land.Share..Pct. Home.Price.Index
613     568721             78.2             2.423
614     592343             78.4             2.519
615     591646             78.0             2.526
616     583485             77.5             2.509
617     584400             78.4             2.484
618      65968             52.0             0.423
    Land.Price.Index Year Qrtr
613            3.189 2005    3
614            3.324 2006    1
615            3.323 2006    2
616            3.281 2006    3
617            3.279 2005    4
618            0.289 1984    2

tail(problem_2c)
     State region    Date Home.Value Structure.Cost
6574    TX  South 2012.00     164926          155156
6575    TX  South 2012.25     167094          155180
6576    TX  South 2012.50     169654          155213
6577    TX  South 2012.75     172431          155258
6578    TX  South 2013.00     175302          155314
6579    TX  South 2013.25     178180          155380
     Land.Value Land.Share..Pct. Home.Price.Index
6574       9769              5.9             1.457
6575      11914              7.1             1.476
6576      14441              8.5             1.498
6577      17173             10.0             1.523
6578      19988             11.4             1.548
6579      22800             12.8             1.574
     Land.Price.Index Year Qrtr
6574            0.058 2011    4
6575            0.071 2012    1
6576            0.086 2012    2
6577            0.102 2012    3
6578            0.119 2012    4
6579            0.136 2013    1
```

- Subset #4: Just the data for the States that have a specified region, i.e. remove any rows that have *NA* values for region

```
remove.NA_values = is.na(House_Land$region)
> House_Land[-remove.NA_values,]
   State region    Date Home.Value Structure.Cost
2     AK   West 2010.50     225511         160252
3     AK   West 2009.75     225820         163791

Land.Value Land.Share..Pct. Home.Price.Index
2       65259             28.9            1.484
3       62029             27.5            1.486

Land.Price.Index Year Qrtr
2             1.576 2010    2
3             1.494 2009    3


head(NA_values)
[1] FALSE FALSE FALSE FALSE FALSE FALSE
> tail(NA_values)
[1] TRUE TRUE TRUE TRUE TRUE TRUE
```

- Subset #5: Data for just the first quarter of 2013 (this is the most recent data available in the data set)

#didn't paste all the shown data

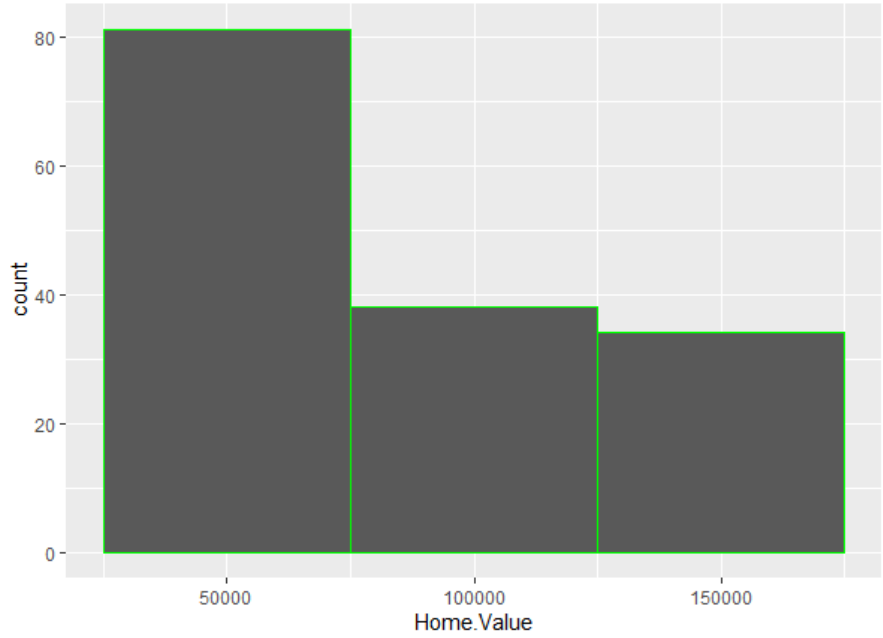
```
first_q_2013 = House_Land[which((House_Land$Year >= 2013)), (1:11)]
> first_q_2013
     State  region    Date Home.Value Structure.Cost
40      AK    West 2013.25     231891         181592
304     AL   South 2013.25     172864         146343
428     AR   South 2013.25     164279         140514

Land.Value Land.Share..Pct. Home.Price.Index
40        50299             21.7            1.526
304       26521             15.3            1.547
428       23765             14.5            1.701

Land.Price.Index Year Qrtr
40              1.248 2013    1
304             1.054 2013    1
428             1.661 2013    1

head(first_q_2013)
    State region    Date Home.Value Structure.Cost
40     AK   West 2013.25     231891         181592
304    AL  South 2013.25     172864         146343
428    AR  South 2013.25     164279         140514
580    AZ   West 2013.25     238430         179759
733    CA   West 2013.25     484516         217521
887    CO   West 2013.25     297928         167566
    Land.Value Land.Share..Pct. Home.Price.Index
40       50299             21.7            1.526
```

```
304      26521             15.3            1.547
428      23765             14.5            1.701
580      58671             24.6            1.482
733     266995             55.1            1.614
887     130362             43.8            1.411
    Land.Price.Index Year Qrtr
40             1.248 2013    1
304            1.054 2013    1
428            1.661 2013    1
580            1.000 2013    1
733            1.555 2013    1
887            1.221 2013    1

tail(first_q_2013)
     State  region    Date Home.Value Structure.Cost
7038    VT N. East 2013.25     234747          220074
7191    WA    West 2013.25     338871          270429
7344    WI Midwest 2013.25     184707          172796
7497    WV   South 2013.25     151494          134263
7650    WY    West 2013.25     254408          208384
7773    DC    <NA> 2013.25     757154          172015
     Land.Value Land.Share..Pct. Home.Price.Index
7038      14673              6.3             1.604
7191      68442             20.2             1.582
7344      11912              6.4             1.380
7497      17232             11.4             1.705
7650      46024             18.1             1.903
7773     585140             77.3             2.893
     Land.Price.Index Year Qrtr
7038            0.781 2013    1
7191            1.332 2013    1
7344            0.029 2013    1
7497            1.769 2013    1
7650            4.703 2013    1
7773            3.505 2013    1
```

3. Make a histogram displaying the distribution of home values in Iowa between 1975 and the beginning of 2013. [Use the first subset you created.] Set the *binwidth to $50,000*, and to make readability easier, add the argument *color= "green"* outside of *aes()*. You may choose a color other than green, if you wish.

What have you learned about home values in Iowa? Write at least 2 sentences.

```
ggplot(data=Iowa_data)+
  geom_histogram(mapping=aes(x=Home.Value), color = "green", binwidth=50000)
```

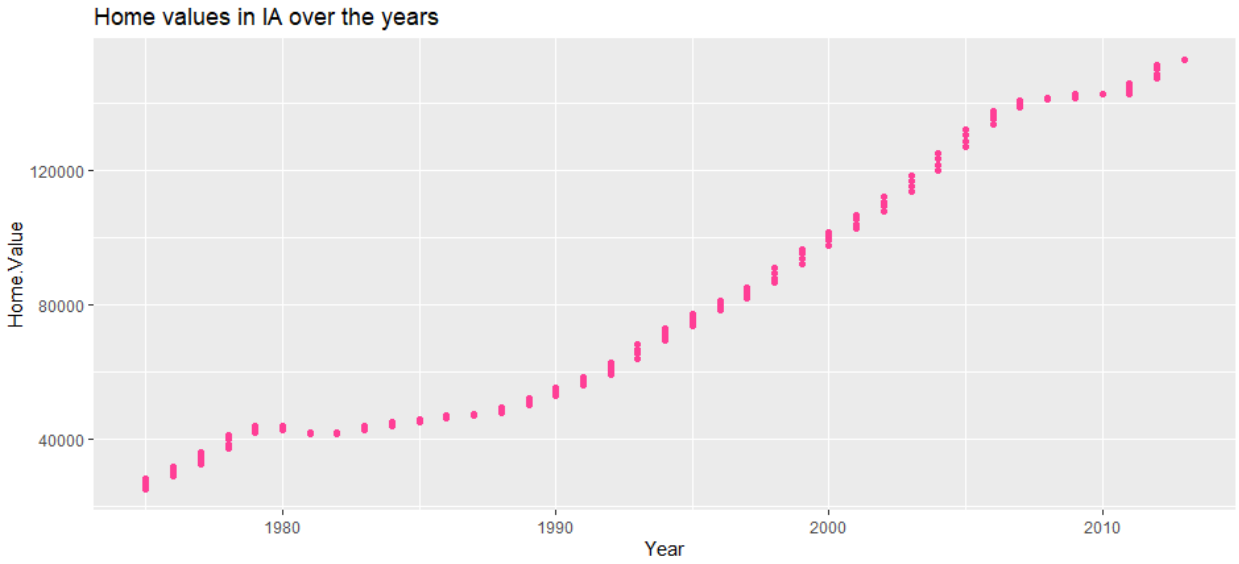


As the years go on, the value of home prices in Iowa continues to Increase. The amount of homes has decreased as price has gone up.

4. Make a scatter plot showing how home values have changed over time in Iowa. Make all points in the scatter plot a *color* other than black (your choice) and add an appropriate title to the graph using *labs()*. You may use either *Year* or *Date* for the x-axis.

Refer to problem 1 ~ What additional information have you learned about home values in Iowa through your scatterplot? Write at least 2 sentences.

```
ggplot(data=Iowa_data)+
  geom_point(mapping = aes(x=Year, y = Home.Value), color = "violetred1")+
  labs(title = "Home values in IA over the years")
```

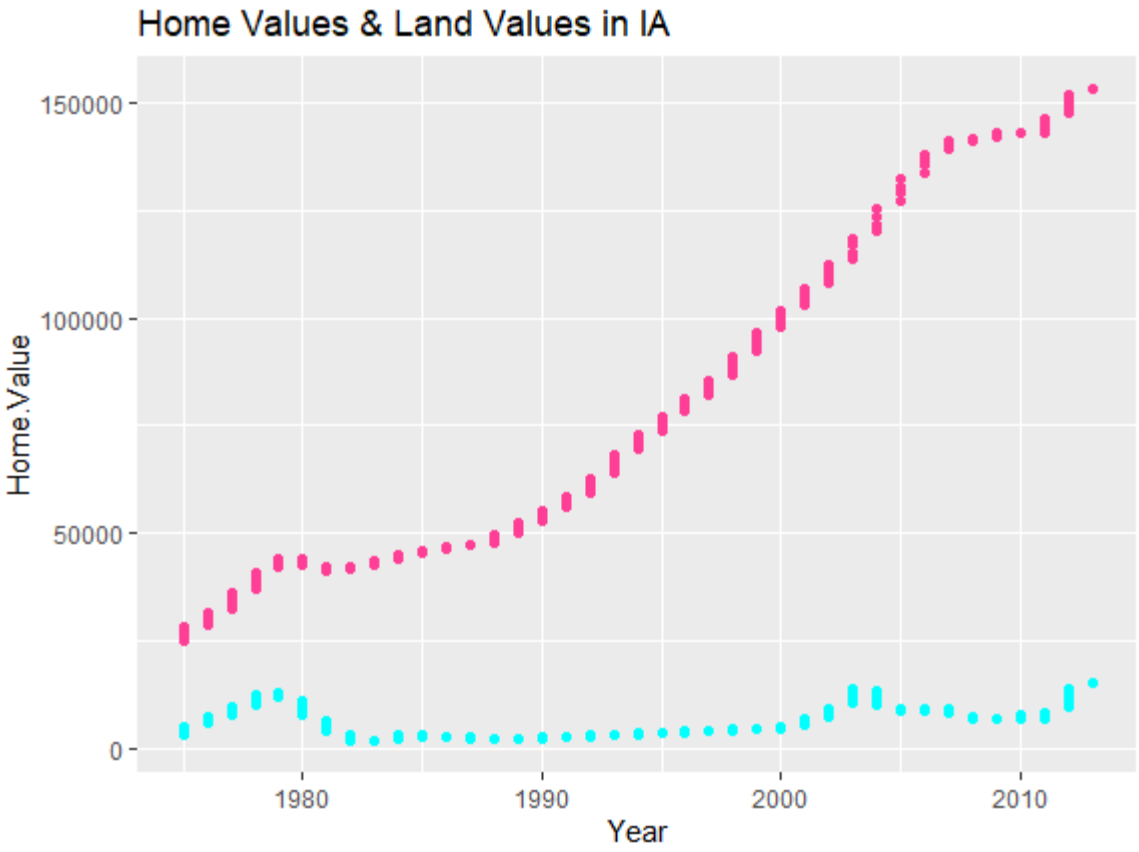


The values of houses between 1980 and 1990 rises at a slow rate then after 1990 the value of houses skyrockets and continues to go up.

5. Add another layer to the scatterplot that you made in problem 4; include how land values have changed over time in Iowa. You may need to adjust your title and y-axis label.

What have you learned about land values in Iowa? Write at least 2 sentences. Also write a couple of sentences relating home values to land values.

```
ggplot(data=Iowa_data)+
  geom_point(mapping = aes(x=Year, y = Home.Value), color = "violetred1")+
  geom_point(mapping = aes(x=Year, y=Land.Value), color="cyan")+
  labs(title = "Home Values & Land Values in IA")
```



Land values in IA have not really changed as time has gone on. There seems to be a correlation between land value and house value though as the highest bump at land value also has a similar one in the house value

6. Make another adjustment to your graph from problems 4 & 5. Add a legend to the graph by doing the following:

- Create a vector containing the two colors that you would like to use for home and land values. Call the vector: *Graph.Colors*

Graph.colors = c("violetred1", "cyan")

- Rather than specify a color for the home value scatterplot outside of the *aes()* function, put *color= "Home.Value"* inside *aes()*. The quotes are important!

geom_point(mapping = aes(x=Year, y = Home.Value, color = "Home.Value"))+

- Do the same for the land value layer: put *color= "Land.Value"* inside the *aes()* function.

geom_point(mapping = aes(x=Year, y=Land.Value, color="Land.Value"))+

- Add *color= "Legend"* to the *labs()* layer.

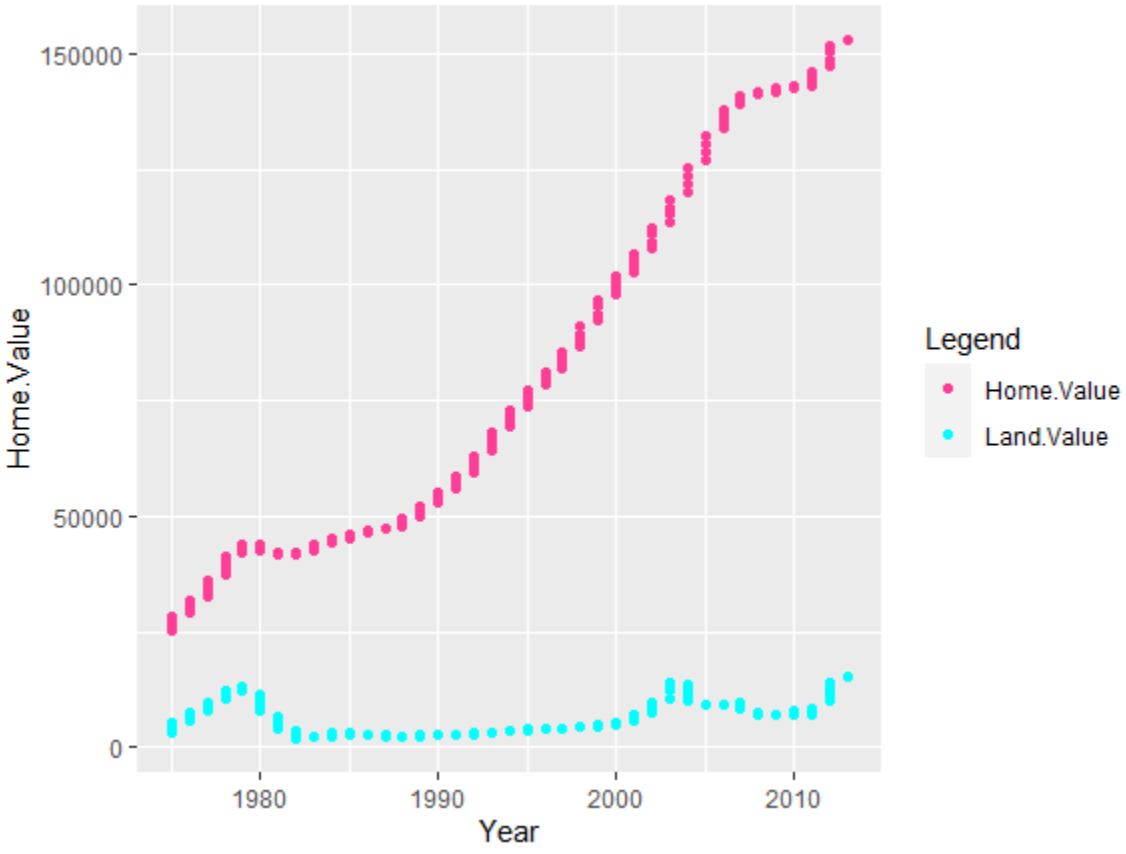
```
labs((title = "Home Values & Land Values in IA"), color="Legend")
```

- Add a layer to the graph that allows you to manually select the colors that you use: *scale_color_manual(values = Graph.Colors)*

```
scale_color_manual(values=Graph.Colors)
```

No graph interpretation required. Note that a legend is only generated when you map a variable to an aesthetic, and we did NOT do that in problem 5.

```
Graph.Colors = c("violetred1", "cyan")

ggplot(data=Iowa_data)+
  geom_point(mapping = aes(x=Year, y = Home.Value, color = "Home.Value"))+
  geom_point(mapping = aes(x=Year, y=Land.Value, color="Land.Value"))+
  labs((title = "Home Values & Land Values in IA"), color="Legend")+
  scale_color_manual(values=Graph.Colors)
```

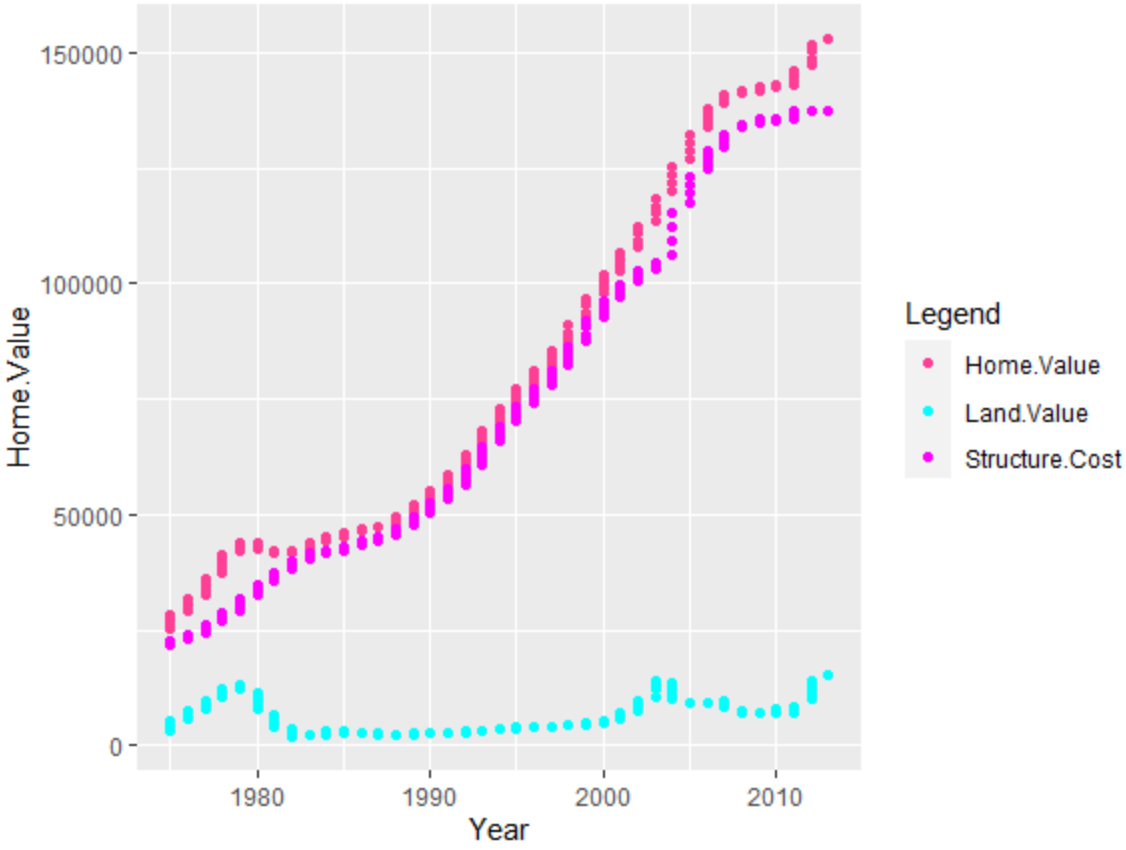


7. Morris A. Davis is an assistant professor of Real Estate and Urban Land Economics at the Wisconsin School of Business and a fellow at the Lincoln Institute of Land Policy, who created the data sets. Dr. Davis wrote,

> *"Price indices and values of land inform the analysis of trends and cycles in house prices. If housing were simply a manufactured good, and location or land had no value, then the price of housing would be determined by construction costs, and housing prices would increase at roughly the same rate as the price of other goods in the US economy.*
>
> *But housing is on land with a specific location, and good locations are often scarce and valuable. If construction costs rise slowly over time and desirable locations are in limited supply, increases in the demand for housing can translate directly to increases in the price of good locations – the land – and in house prices."*

For the most part, home values in Iowa are based on the structural cost of the home. To see this, add a layer containing the structure cost to your graph from problem 6. Make sure the legend on the graph works appropriately. No graph interpretation required.

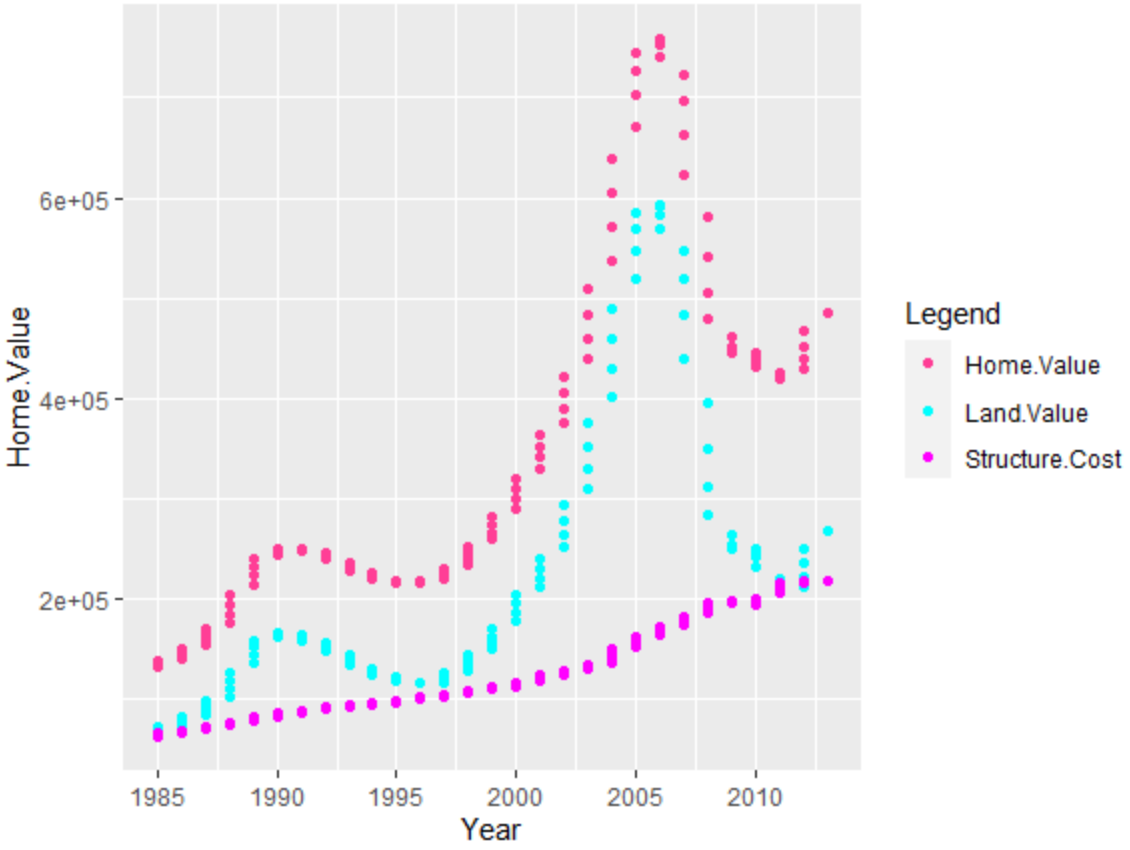
```
Graph.Colors2 = c("violetred1", "cyan", "magenta1")

ggplot(data=Iowa_data)+
  geom_point(mapping = aes(x=Year, y = Home.Value, color = "Home.Value"))+
  geom_point(mapping = aes(x=Year, y=Land.Value, color="Land.Value"))+
  geom_point(mapping = aes(x=Year, y=Structure.Cost, color="Structure.Cost"))+
  labs((title = "Data of homes in IA"), color="Legend")+
  scale_color_manual(values=Graph.Colors2)
```



8. A better example of Dr. Davis' statement (see problem 7) comes from California. Recreate your graph from problem 7 using data from just California, starting at the Year 1985. [Use the second subset you created.]

Explain how Dr. Davis' statement is exemplified by your graph. Write at least three sentences.

```
ggplot(data=Cali_1985_Pres)+
geom_point(mapping = aes(x=Year, y = Home.Value, color = "Home.Value"))+
geom_point(mapping = aes(x=Year, y=Land.Value, color="Land.Value"))+
geom_point(mapping = aes(x=Year, y=Structure.Cost, color="Structure.Cost"))+
labs((title = "Data of homes in IA"), color="Legend")+
scale_color_manual(values=Graph.Colors2)
```



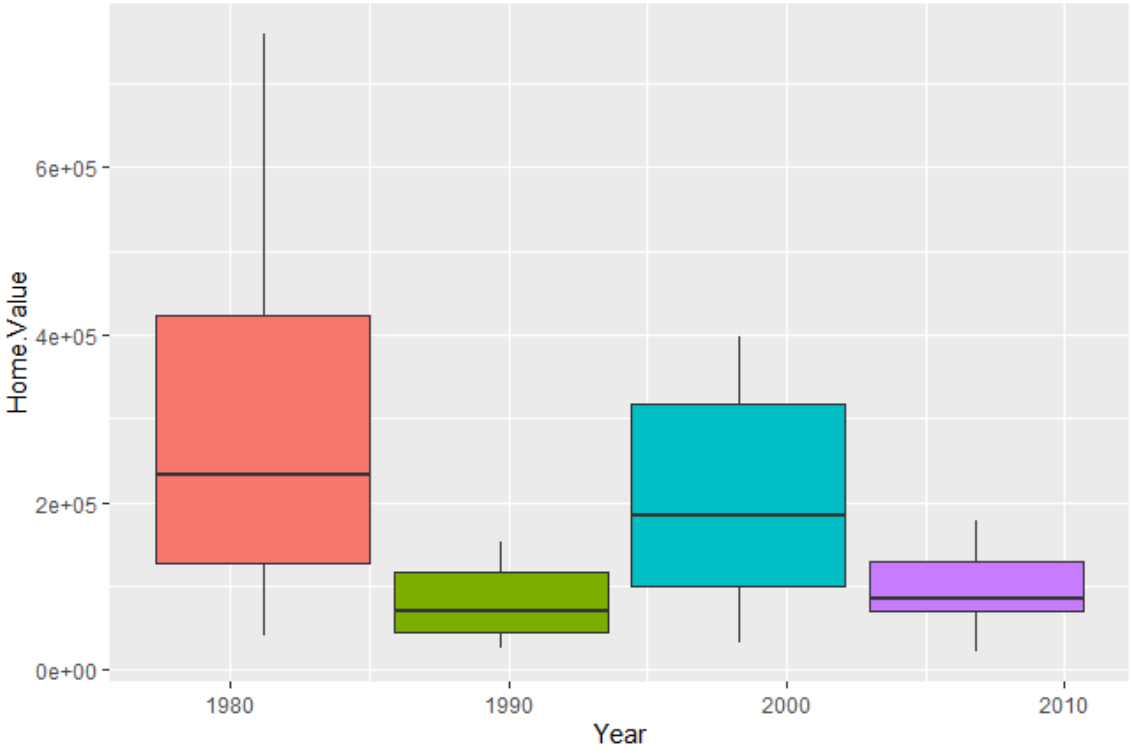
PART TWO:

9. You will now make comparisons across multiple states: Iowa, California, Massachusetts, and Texas. [Use the third subset you created.] Create one graph showing side-by-side boxplots comparing home values for the four states. Each boxplot should be a different color. You can do this by mapping a color to each state. Remove the automatically generated legend by adding *show.legend = FALSE* in your *geom_boxplot()*.

Describe how home values between 1975 and the beginning of 2013 compare across the four states. Write at least three sentences.

The median cost of home values in California in 1975 cost more than the most expensive home in Iowa. The median home value in California is more than the other 3 states. Iowa has the least expensive box plot with Texas being somewhat close.

```
problem_2c = House_Land[c(613:765, 1684:1836, 2755:2907, 6427:6579), c(1:11)] #Data for only Iowa, California, Massachusetts, and Texas. This is from part 1

ggplot(data=problem_2c)+
  geom_boxplot(mapping=aes(x=Year, y=Home.Value, fill = State), show.legend = F)
```



10. Now compare structure costs for Iowa, California, Massachusetts, and Texas. Create one graph showing side-by-side boxplots, but this time do the following to make a more customized graph:

- Make all boxplots the same color(s).
- Specify both the color for the outline of the boxplot and the filled in color. They can be the same color, or you can use different ones for this.
- Adjust the transparency of the fill color using: *alpha=0.5*.
- Also add *notch=TRUE*

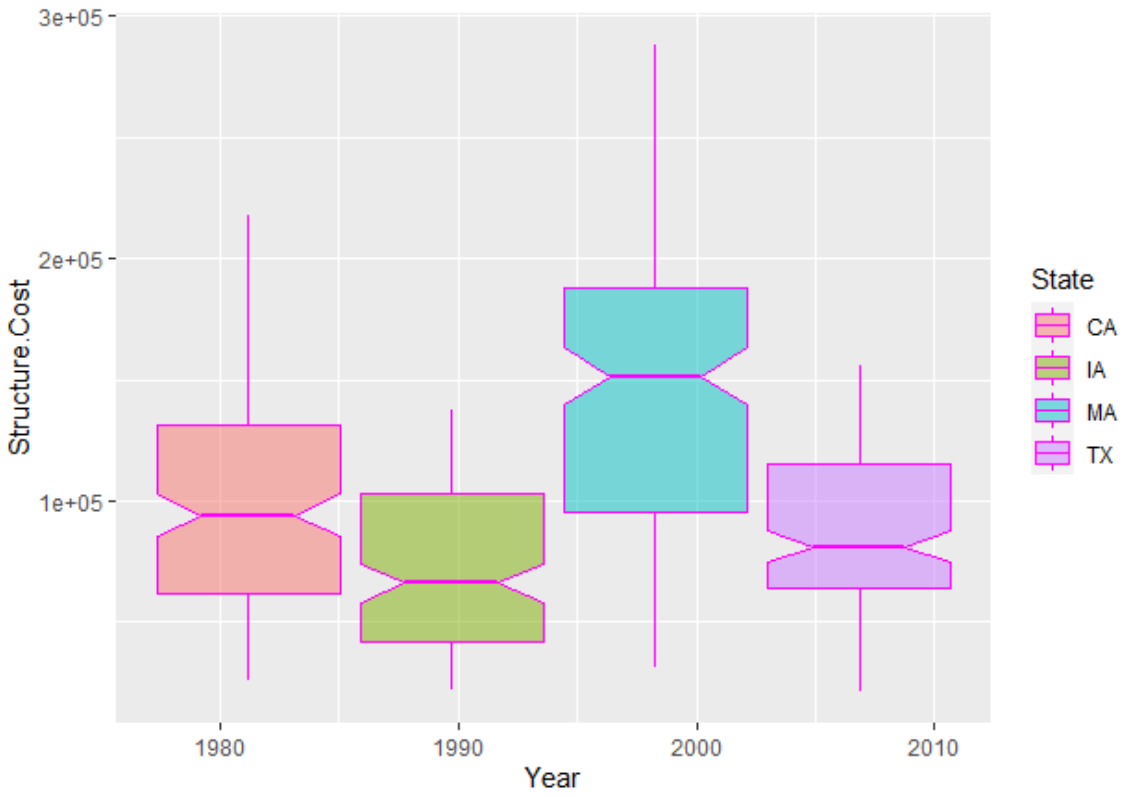
Describe how structure costs compare across the four states, and also compare this with home values from problem 9. Do you see the same pattern in the two graphs? Write at least four sentences.

When I tried to have both the outline and the filled in color, it would turn into one boxplot instead of side-by-side ones.

Structure costs in MA appear to be the highest while IA is again the lowest. IA and TX are about in the same spot for structure costs and home value costs. CA and MA swapped places for structure costs with MA being the highest of the four for structure costs.

```
ggplot(data=problem_2c, aes(x=Year, y=Structure.Cost, fill=State))+
  geom_boxplot(
    color = 'magenta',
    alpha = .5,
```

notch = T)

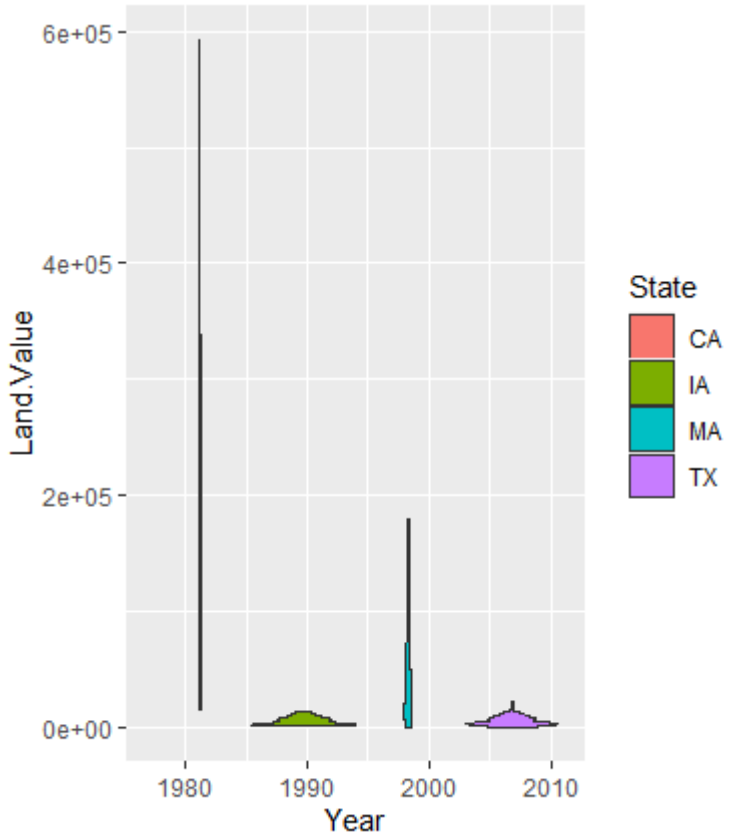


11. Last, compare land values for Iowa, California, Massachusetts, and Texas by making a violin plot. This is very similar to a box plot, but you will use *geom_violin()*. You may look at the example and code provided at the R graph gallery (link on Bb), if you need help.

Describe how land values compare across the four states, and also compare this with home values and structure costs from problems 9 and 10. Do you see the same pattern in the three graphs? Write at least four sentences.

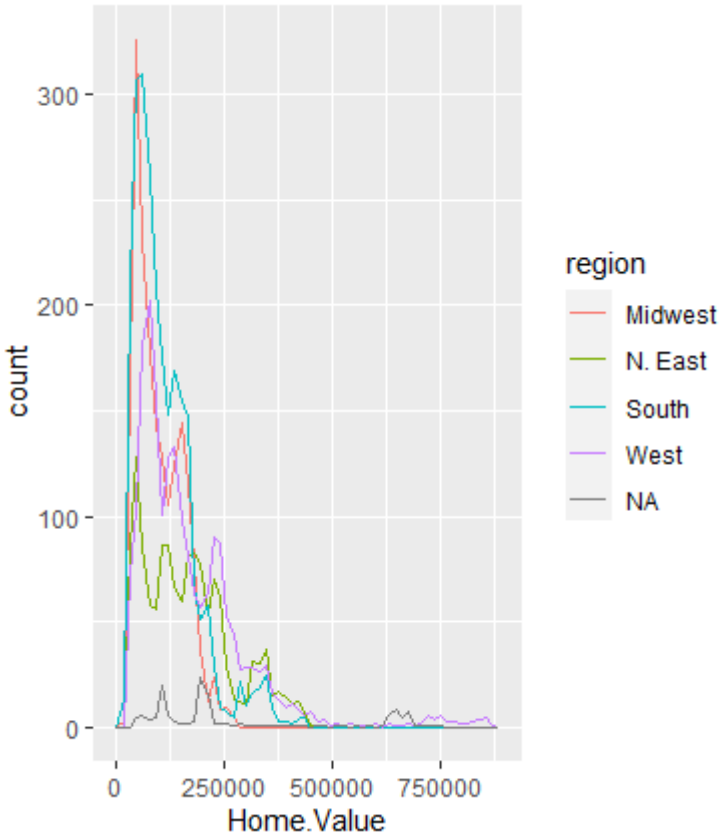
IA and TX have a little lower land value costs compared to structure and home values but they are still just about equal like the other two graphs. CA is through the roof on land value costs just like it was for home values. MA land value cost is lower than both previous graphs.

```
problem11 = ggplot(problem_2c, aes(x=Year, y = Land.Value, fill=State))+
  geom_violin()

problem11
```



12. Let's compare home values based on region. Using the full data set, create a plot showing a frequency polygon for each region: *geom_freqpoly()*. Use a bin width of 15,000$. No graph interpretation required.

```
ggplot(data=House_Land)+
  geom_freqpoly(mapping=aes(x=Home.Value, color=region), binwidth = 15000)
```

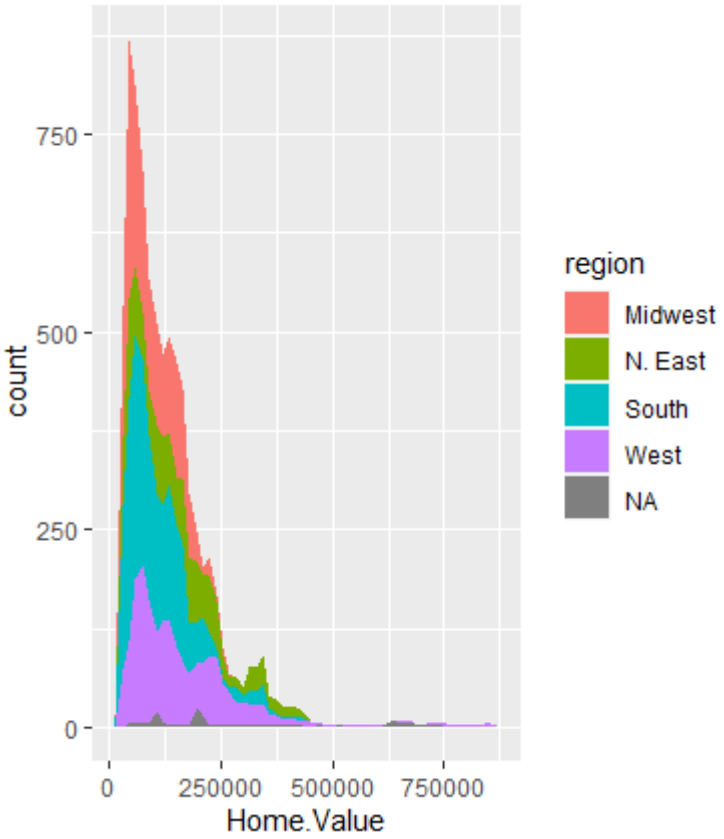


13. To make the graph from problem 12 easier to interpret, we can fill in the colors on the graph. Do this by:

- Replacing *geom_freqpoly()* with *geom_area()*
- Mapping region to fill
- And adding the argument: *stat="bin"*

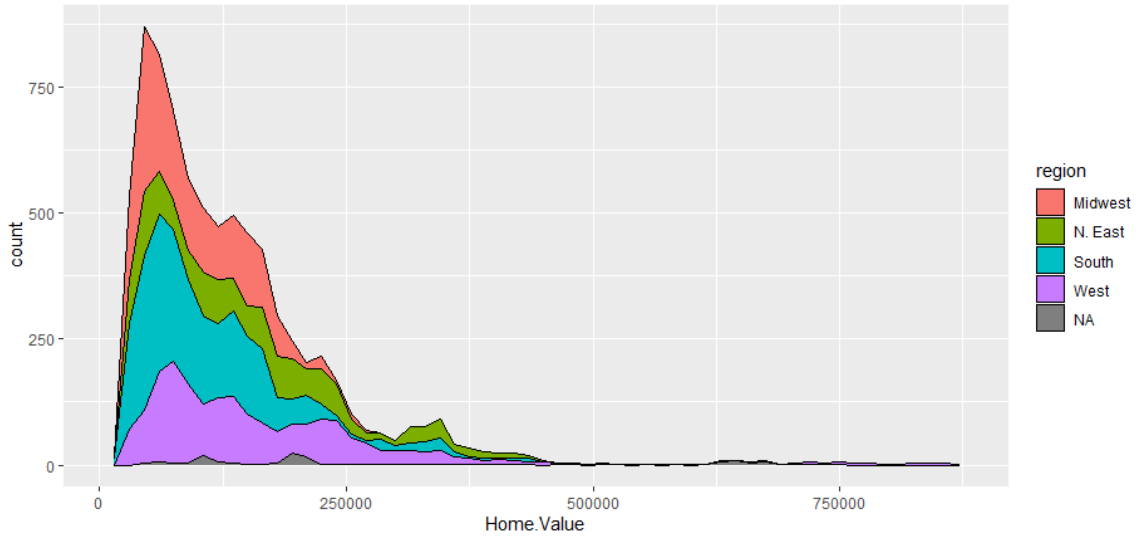
No graph interpretation required.

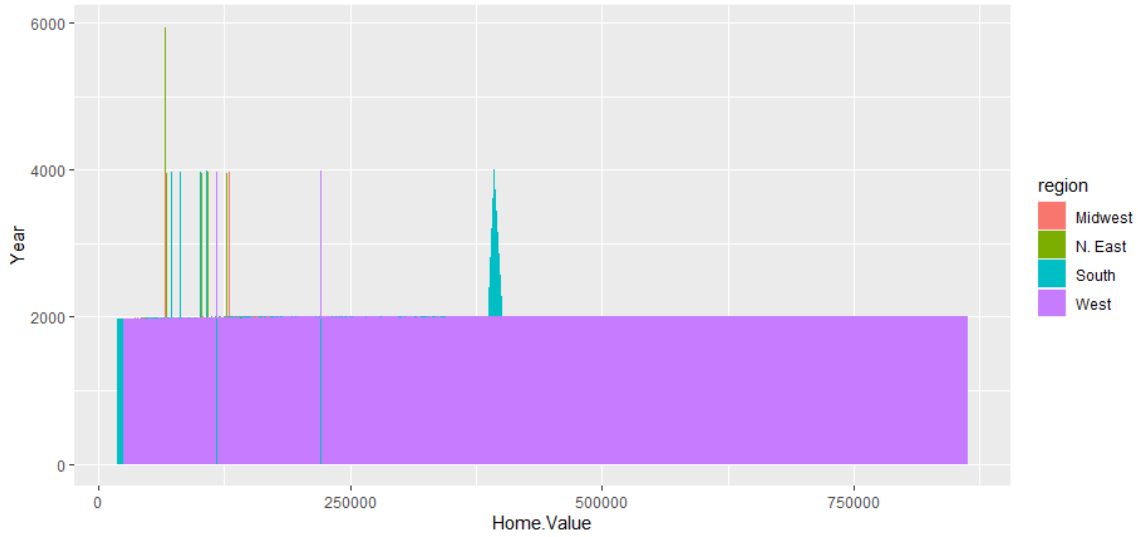
```
ggplot(data=House_Land)+
  geom_area(mapping=aes(x=Home.Value, fill=region), binwidth = 15000, stat="bin")
```



14. You can see on your graphs from problems 12 and 13 that some regions are labeled as NA. Recreate your graph from problem 13 after removing the rows containing NA values. [Use your fourth subset.] Improve the look of the graph by specifying *color= "black"* which will outline the area for each region.

How do home values between 1975 and the beginning of 2013 compare for the different regions of the U.S.? Write at least 2 sentences.





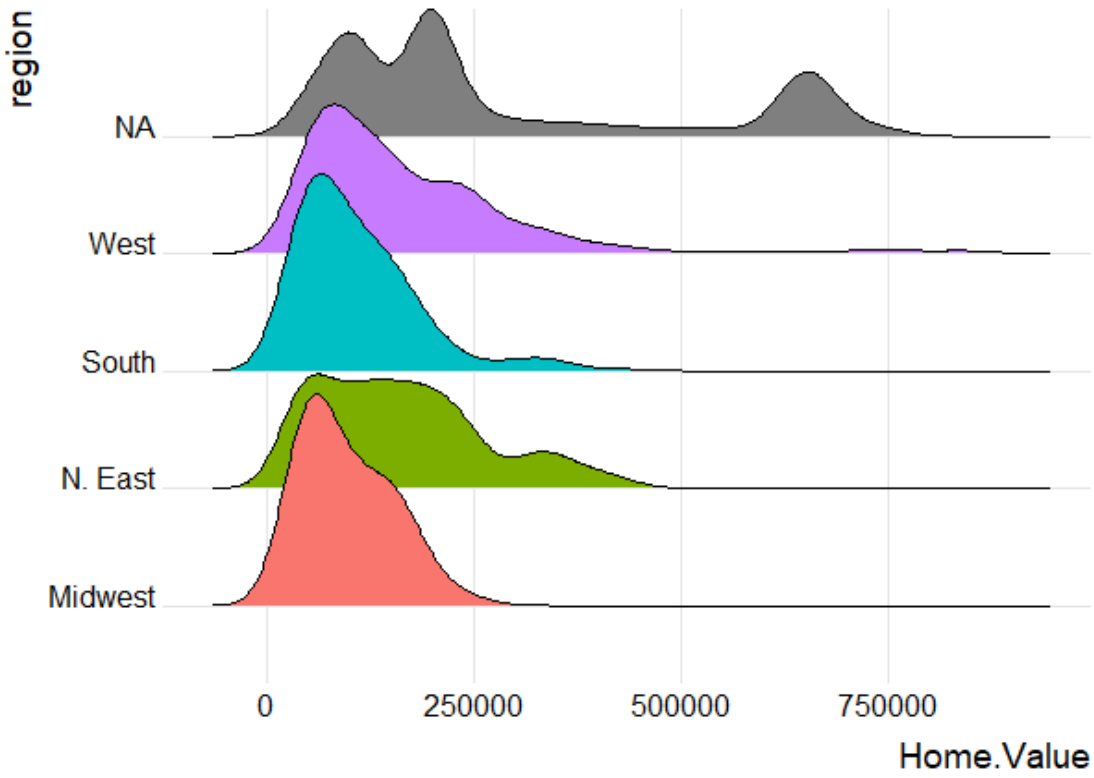
When trying to get rid of NA values, the second graph is the result. Not sure why. As time went on, the number of houses being sold went down as the prices continued to increase for each region.

15. Since there is so much overlap on the graph (see problems 13 and 14), a better choice to compare home values by region might be a *ridgeline* chart. Make this using the *ggridges* package. You may look at the example and code provided at the R graph gallery (link on Bb), if you need help. [We did look at this together in-class!]

Did you learn anything new about home values by looking at your ridgeline chart? Explain why this graph is easier to interpret. Write at least two sentences.

I think it's somewhat easy to see how much the regions differ based on how much they overlap each other. The Midwest almost going over the East shows that it has the lowest home values

```
library(ggridges)

ggplot(House_Land, aes(x=Home.Value, y = region, fill=region), binwidth = 15000,
stat='bin')+
  geom_density_ridges()+
  theme_ridges()+
  theme(legend.position="none")
```

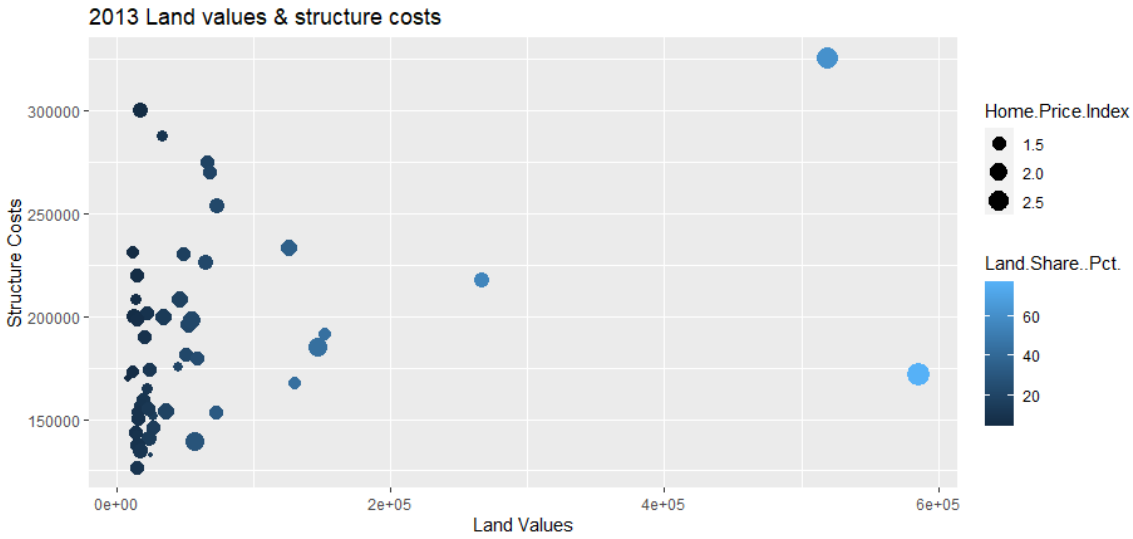


16. Focusing on just one time point, the first quarter of 2013, make a scatter plot that compares land value (x) and structure cost (y). [Use your fifth subset] Then find a way to also include the variables:

- *Land.Share..Pct.* ~ Land share percent = proportion of the home value attributed to the value of the land.
- *Home.Price.Index* ~ A home price index measures the price changes of residential housing as a percentage change from some specific reference date. [I do not know the reference date for our data.]

For example, you can do this by mapping them to various aesthetics. Recall: We've used color, shape, size, and alpha. Your final graph should be easy to read and have appropriate, descriptive axis labels and title. No graph interpretation required.

```
first_q_2013 = House_Land[which((House_Land$Year >= 2013)), (1:11)] #subset number 5.


ggplot(data=first_q_2013)+
  geom_point(mapping = aes(x=Land.Value, y = Structure.Cost, size = Home.Price.Index, color = Land.Share..Pct.))+
  labs(x="Land Values", y="Structure Costs", title = "2013 Land values & structure costs")
```



17. Adjust your graph from problem 16 by:

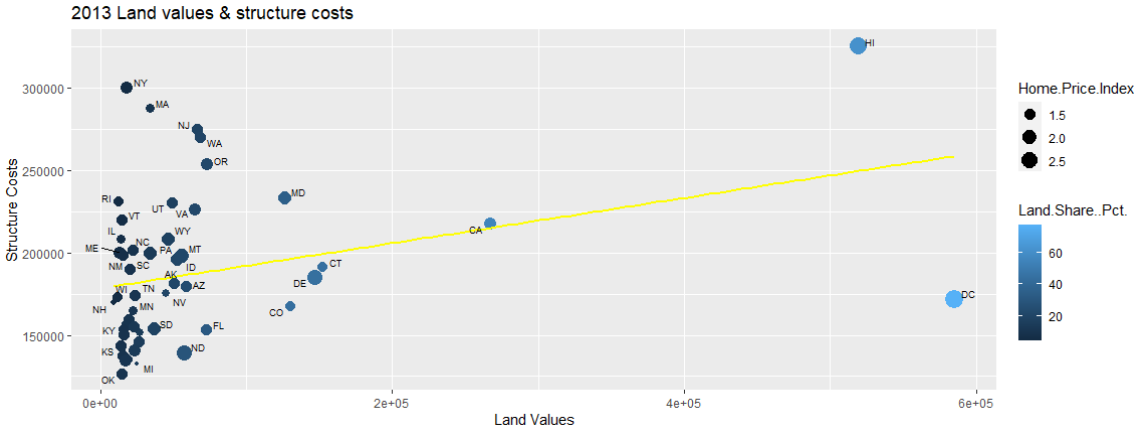
- Using the log of the land values: *x= log(Land.Value)*
- Labeling the points with their corresponding state names. [I suggest using *geom_text_repel()* from the *ggrepel* library.]
- Fitting a smooth line to the scatter plot. [Make sure the line is easy to see. You may need to change colors.]
- And mapping the line type of the smooth line to region.

You may need to adjust your axis labels and/or graph title.

Provide a complete interpretation of the graph, describing how the five variables are (or are not) related to each other. Write at least 6 sentences.

```
library(ggrepel)

problem17 = ggplot(data=first_q_2013, mapping=aes(x=Land.Value, y=Structure.Cost))+
        geom_point(mapping=aes(size = Home.Price.Index, color=Land.Share..Pct.))+
        geom_smooth(se=F, color='yellow', method='lm')+
        labs(x='Land Values', y='Structure Costs', title = "2013 Land values & structure costs")

problem17 + geom_text_repel(aes(label = State), size = 2.5)
```

CPSC 260
Spring 2022



The smaller dots indicating a lower home price index are more on the left side and they get bigger as it goes to the right. The dots shade of color also appears to be lighter and the size is bigger as it goes to the right. OK is the lowest below the regression line and NY seems to be the highest above it. DC has the priciest land values out of the 50 states and possibly NH has the cheapest. HI appears to have the most expensive structure costs while also having the 2nd highest land value, probably because property in Hawaii is limited and very nice having beach and ocean outside.