# Intro to R - ggplot2

## INFO 550

Steve Pittard wsp@emory.edu

March 1, 2018

# Multiple Graphics Packages

There are Four Major Graphics Packages in R

- Base Graphics - Oldest and Most Well Known
- lattice - Second Oldest and Supports Grouping and Panels
- ggplot - Third Oldest and Supports Grouping and facets (similar to Panels)
- grid - This is a low level library that all the other graphic packages use

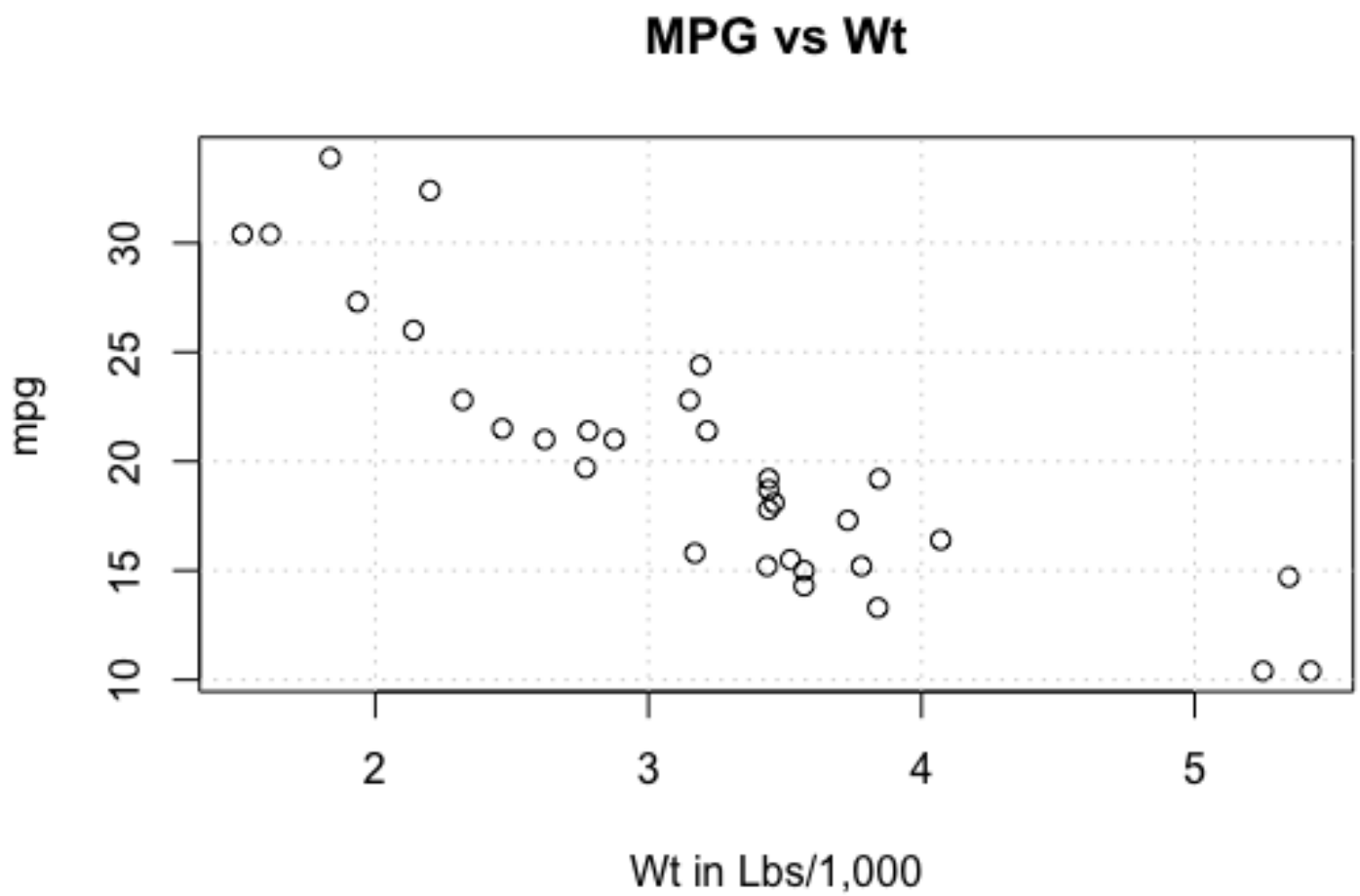
# Base Graphics

Base Graphics is the Oldest

- Has both low and high level commands
- You can draw polygons and lines
- Or you can call functions like **host boxplot**, etc
- You can reproduce any graphic you encounter
- Frequently need to build a plot in stages - layer by layer
- Uses "pen on paper" approach
- If you mess up then just start all over

# Base Graphics

```
data(mtcars)
xlab <- "Wt in Lbs/1,000"
main <- "MPG vs Wt"
plot(mpg~wt,data=mtcars,main=main,xlab=xlab)
grid()
```



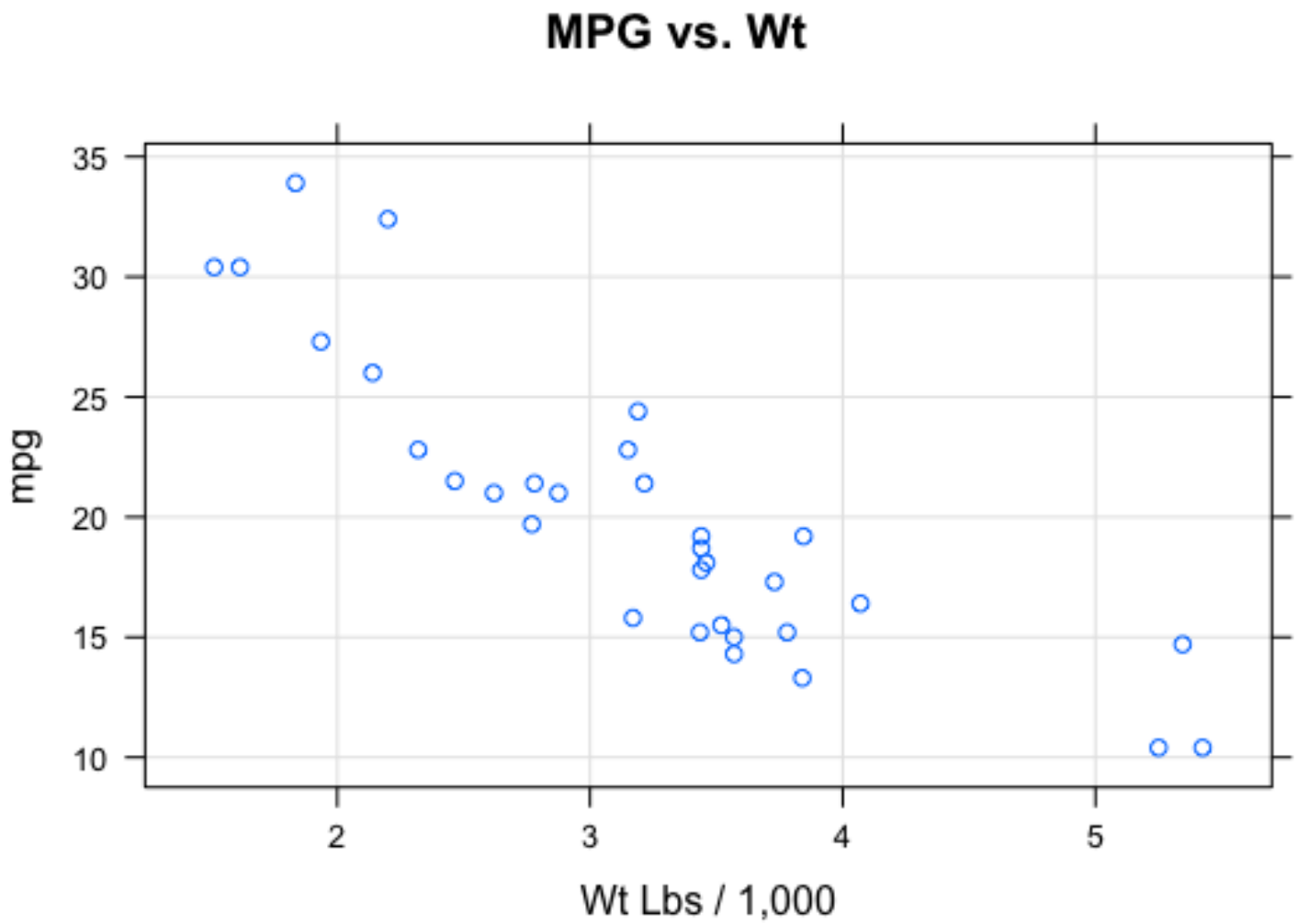
# Lattice Graphics

Lattice was written to provide grouping and paneling

- Consistent look and feel
- Great for multivariate data
- Takes care of lots of things for you
- Has a formula interface
- Lots of examples and support on Google
- See `http://lmdvr.r-forge.r-project.org/figures/figures.html`
- Picks useful defaults for you

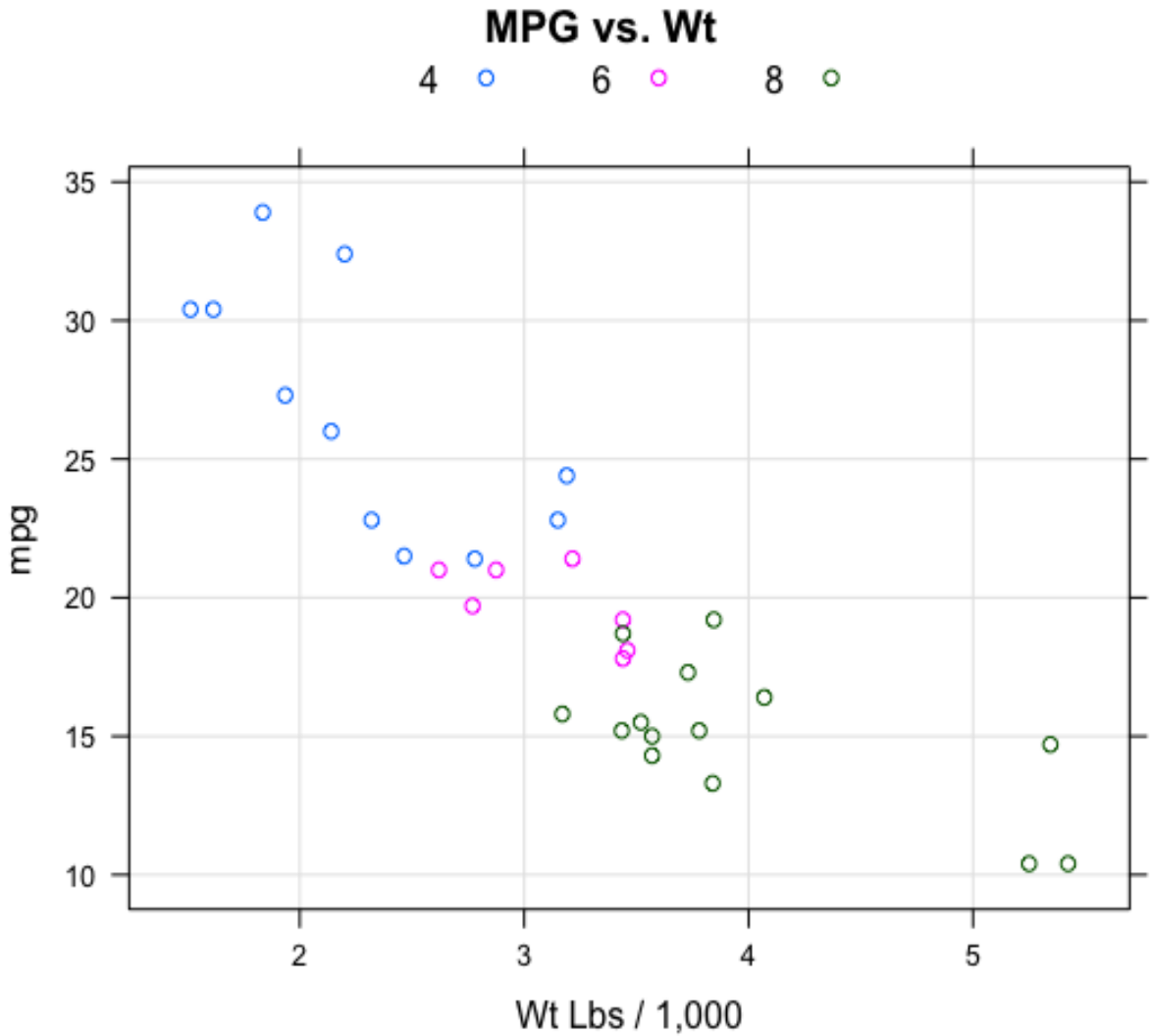
# Lattice Graphics

```
library(lattice)
xlab <- "Wt Lbs / 1,000"
main <- "MPG vs. Wt"
xyplot(mpg~wt,data=mtcars,main=main,xlab=xlab,type=c("p","g"))
```



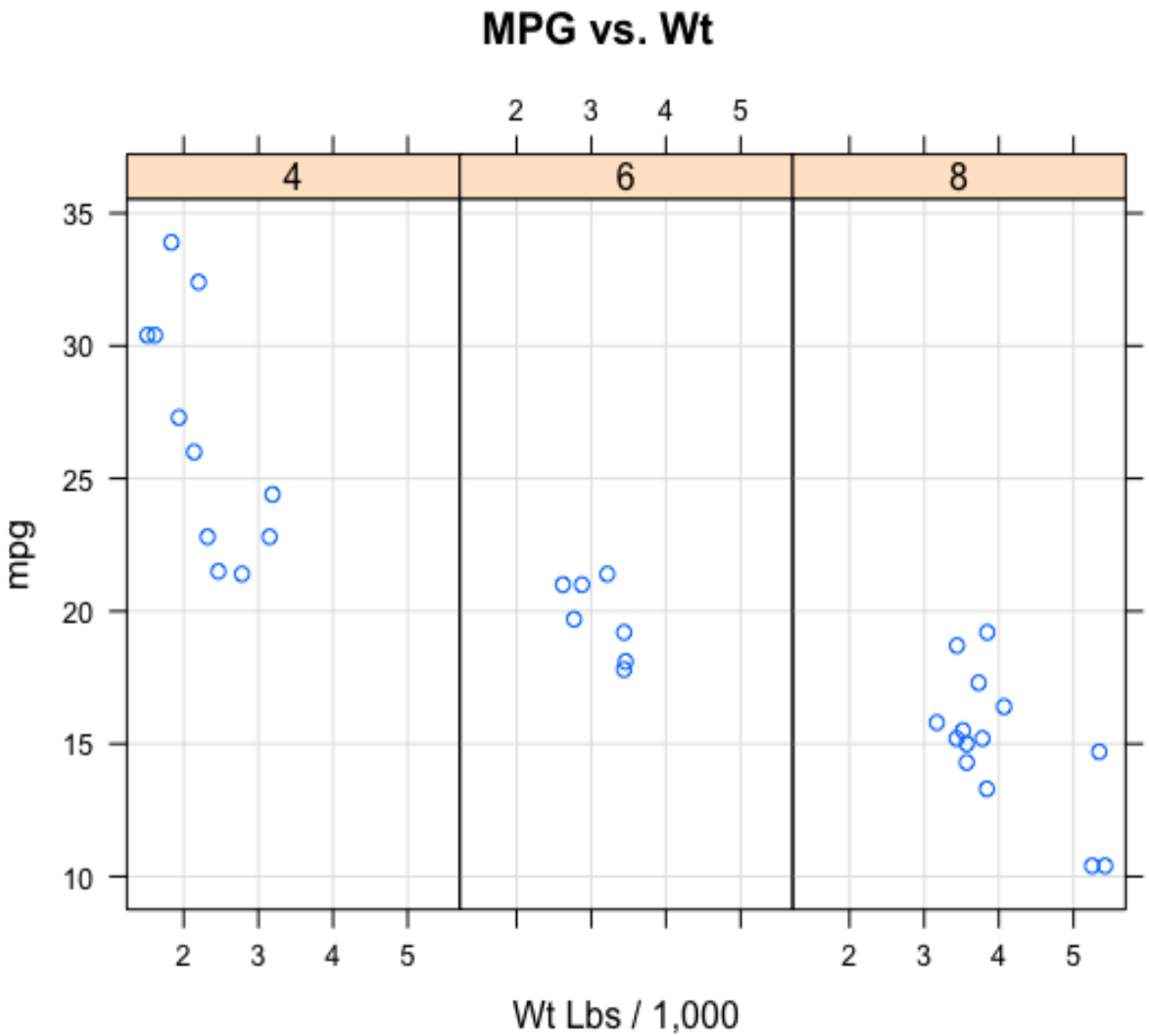
# Lattice Graphics - Grouping

```
library(lattice)
xlab <- "Wt Lbs / 1,000"; main <- "MPG vs. Wt"
xyplot(mpg~wt,groups=factor(cyl),data=mtcars,main=main,xlab=xlab,
                type=c("p","g"),auto.key=list(columns=3))
```



# Lattice Graphics - Panels

```
library(lattice)
xlab <- "Wt Lbs / 1,000"; main <- "MPG vs. Wt"
xyplot(mpg~wt|factor(cyl),data=mtcars,main=main,xlab=xlab,
       type=c("p","g"),layout=c(3,1))
```



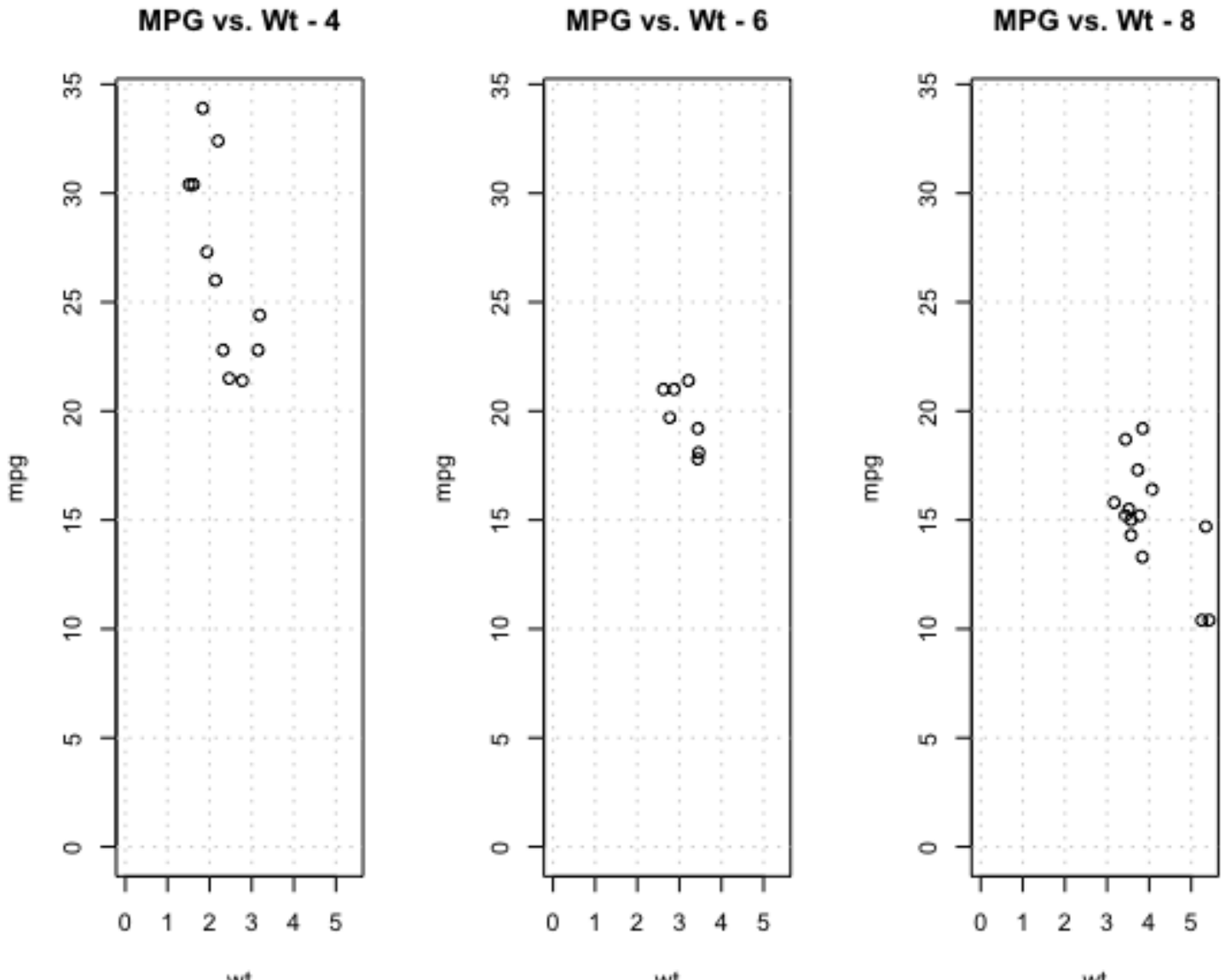
# Lattice Graphics - Panels

Doing Panels in Base Graphics is a Manual Process. This can be Powerful but very tedious

```
xlab <- "Wt Lbs / 1,000"; main <- "MPG vs. Wt"
par(mfrow=c(1,3))
maxmpg <- max(mtcars$mpg)
maxwt  <- max(mtcars$wt)
mydf <- split(mtcars,mtcars$cyl)
for (ii in 1:length(mydf)) {
  tmpdf <- mydf[[ii]]
  main <- paste("MPG vs. Wt",names(mydf)[ii],sep=" - ")
  plot(mpg~wt,data=tmpdf,main=main,
                         xlim=c(0,maxwt),
                         ylim=c(0,maxmpg))
  grid()
}
```

# Lattice Graphics - Panels

## Doing Panels in Base Graphics is a Manual Process



# Two Modes

We usually operate in one of two modes: Exploratory and Publication

- Use exploratory for early attempts at understanding the data
- It does not need not be pretty or elegant
- Look for relationships
- Can add annotations later
- Usually just for yourself and other team members

# Two Modes

Independently of the graphics packages we operate in two modes: Exploratory and Publication

- Publication mode is for, well, publication and sharing
- This is for journals
- Graphs are usually stsandard types but combined in interesting ways
- Comparisons across panels and facets
- Axes, legends, titles, colors, groups are ususally present
- ggplot makes it easy to create good default graphics

# Intro

ggolpt2 is a relative newcomer to R

- Written according to a "Grammar of Graphics" (Wilkinson, 2005)
- Discuss the visualization of data using an accepted vocabulary
- Flexibly explore the data using a number of vizualizations (or combinations thereof)
- No need to "commit" to specific chart types
- Specify plots in abstract terms using the aforementioned grammar
- Rapidly becoming the default R graphics package
- Attempts to leverage the good parts of lattice and Base graphics

See home page for ggplot at `http://ggplot2.org/`

# Intro

Some helpful resources:

- Presentation - ggplot2.org/resources/2007-past-present-future.pdf
- Book - ggplot2: Elegant Graphics for Data Analysis (check Amazon)
- Vanderbilt Workshop - ggplot2.org/resources/2007-vanderbilt.pdf
- Mailing List - groups.google.com/forum/?fromgroups#!forum/ggplot2
- Documentation - ggplot2.tidyverse.org/reference/
- R for Data Science Online Book - r4ds.had.co.nz/
- Cheat Sheet - www.rstudio.com/wp-content/uploads/2015/03/ggplot2-cheatsheet.pdf
- R Graphics Cookbook - www.cookbook-r.com/Graphs/index.html

# tidyverse

ggplot is part of the "tidyverse"

- A collection of R packages that share common philosphies to work well together
- Home page for project is at - `http://tidyverse.org/`
- Main packages are: ggplot2, tibblr, tidyr, readr, purrr, and dplyr
- Can install from within R Studio just like any other package
- The name of the package is simply **tidyverse**

# qplot

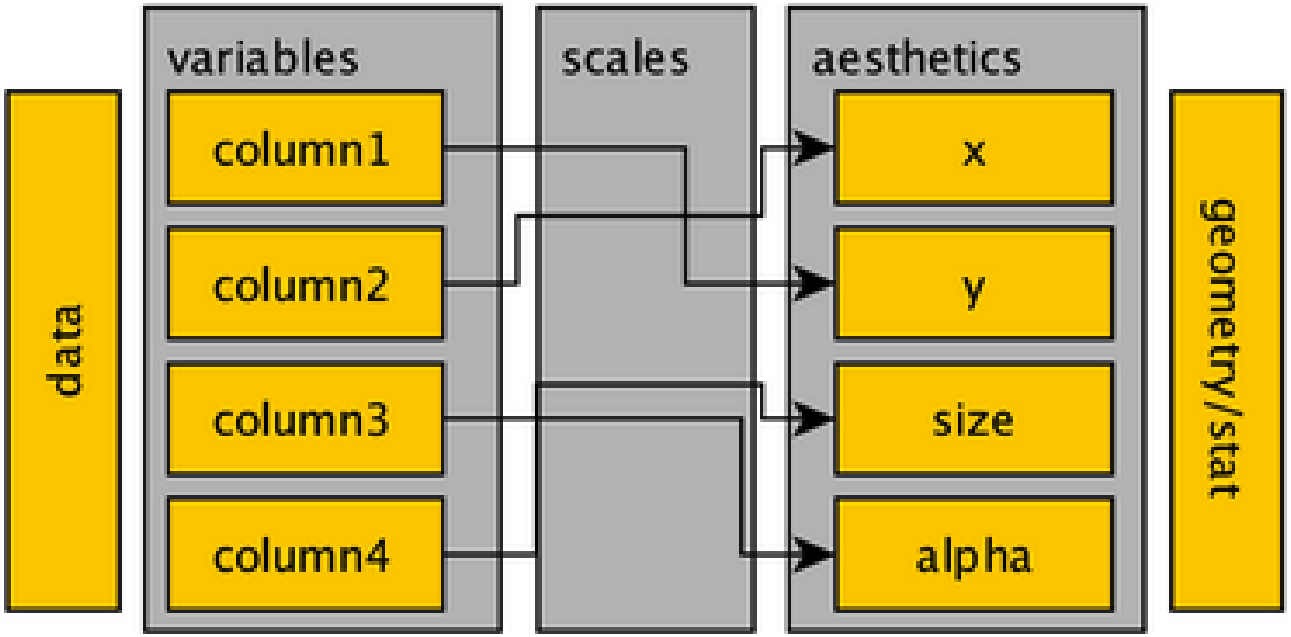
**qplot** is a command in ggplot that offers a "training wheels" like capability:

- The "q" in **qplot** stands for "quick"
- Is supposed to be an analog of the Base graphics **plot** command
- Useful if you already know Base Graphics really well
- Convenient wrapper for qucikly creating a number of different types of plots
- However it's not really demonstrative of the power of grammar of graphics
- Not commonly used in "serious" ggplot projects

# Key Ideas

There are some essential terms and concepts for using ggplot:

- Data - The actual data frame under consideration
- Aesthetics - Visual elements mapped to the data (axis, lines, colors, bars, etc)
- Scales - Transformations you might want to apply (e.g. logarithm, polar coordinates)
- Geometries - The shape mapped to the aesthetic(s)



# Key Ideas

These ideas come from the **Grammar of Graphics**

- Understanding these ideas will help you define a plot in general terms that can then be implemented using ggplot commands
- Data - The actual data frame under consideration
- Aesthetics - Visual elements mapped to the data (axis, lines, colors, bars, etc)
- Scales - Transformations you might want to apply (e.g. logarithm, polar coordinates)
- Geometries - The shape mapped to the aesthetic(s)

# Aesthetics

Here are some of the aesthetics that help make a plot:

- x and y position
- size of the elements
- shape
- color

We use geometries to view the data:

- lines and vsrisations (dashed, segements, etc)
- bars, histograms
- text labels
- points
- `http://ggplot2.tidyverse.org/reference/#section-layer-geoms`

# mtcars

We'll first use the built-in mtcars data frame to explore these ideas since mtcars is an easy data frame to understand:

```
The data was extracted from the 1974 Motor Trend US magazine,
and comprises fuel consumption and 10 aspects of automobile design
and performance for 32 automobiles (1973-74 models).

    A data frame with 32 observations on 11 variables.

      [, 1]  mpg   Miles/(US) gallon
      [, 2]  cyl   Number of cylinders
      [, 3]  disp  Displacement (cu.in.)
      [, 4]  hp    Gross horsepower
      [, 5]  drat  Rear axle ratio
      [, 6]  wt    Weight (1000 lbs)
      [, 7]  qsec  1/4 mile time
      [, 8]  vs    V/S
      [, 9]  am    Transmission (0 = automatic, 1 = manual)
      [,10]  gear  Number of forward gears
      [,11]  carb  Number of carburetors
```

# mtcars

- What are the categories/factors in this data ?
- What are the continuous quantitites ?

```
str(mtcars)
```

```
'data.frame': 32 obs. of  11 variables:
 $ mpg : num  21 21 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 ...
 $ cyl : num  6 6 4 6 8 6 8 4 4 6 ...
 $ disp: num  160 160 108 258 360 ...
 $ hp  : num  110 110 93 110 175 105 245 62 95 123 ...
 $ drat: num  3.9 3.9 3.85 3.08 3.15 2.76 3.21 3.69 3.92 3.92 ...
 $ wt  : num  2.62 2.88 2.32 3.21 3.44 ...
 $ qsec: num  16.5 17 18.6 19.4 17 ...
 $ vs  : num  0 0 1 1 0 1 0 1 1 1 ...
 $ am  : num  1 1 1 0 0 0 0 0 0 0 ...
 $ gear: num  4 4 4 3 3 3 3 4 4 4 ...
 $ carb: num  4 4 1 1 2 1 4 2 2 4 ...
```

# mtcars

- What are the categories/factors in this data ?
- What are the continuous quantitites ?
- Here is a "recipe" you can use with most any data frame

```
sapply(mtcars, function(x) length(unique(x)))
 mpg  cyl disp   hp drat   wt qsec   vs   am gear carb
  25    3   27   22   22   29   30    2    2    3    6
```

- Variables taking on a limited number of unique values are probably factors
- Variables taking on many different unique values are probably continuous
- We generally seek to summarize and/or compare continuous information in terms of (or across) categories

# mtcars

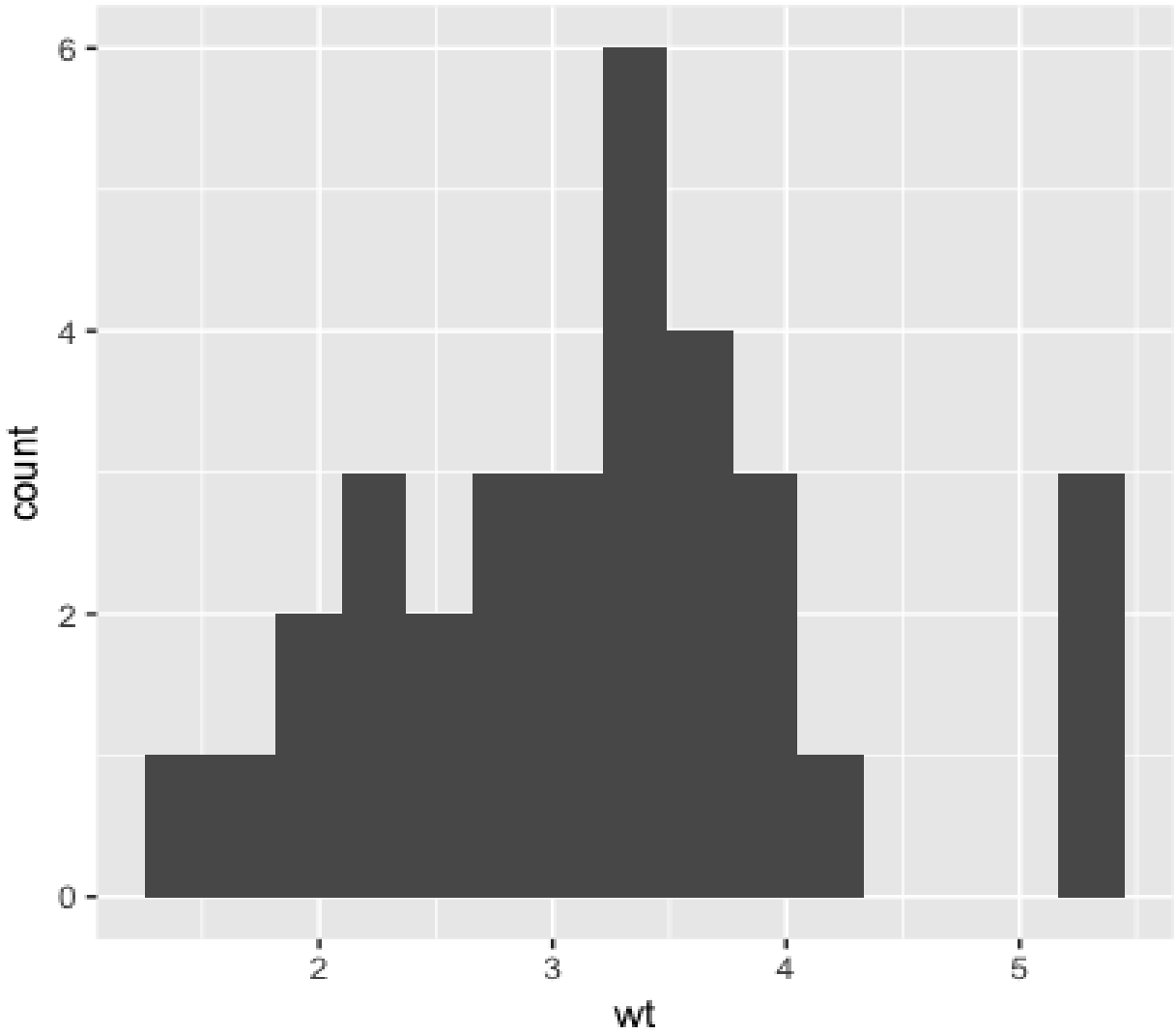
Some driving questions might be:

- What does the distribution of **wt** values look like ?
- Is there a relationship between **mpg** vs **wt** ?
- Does **mpg** appear to be different over individual cylinder groups ?
- Is there a relationship between **mpg** and **wt** that is effected by cylinder group ?
- Does **mpg** appear to be different over different transmission types ?
- What are the counts of transmission types and cylinder groups ?

# mtcars

What does the distribution of **wt** values look like ?

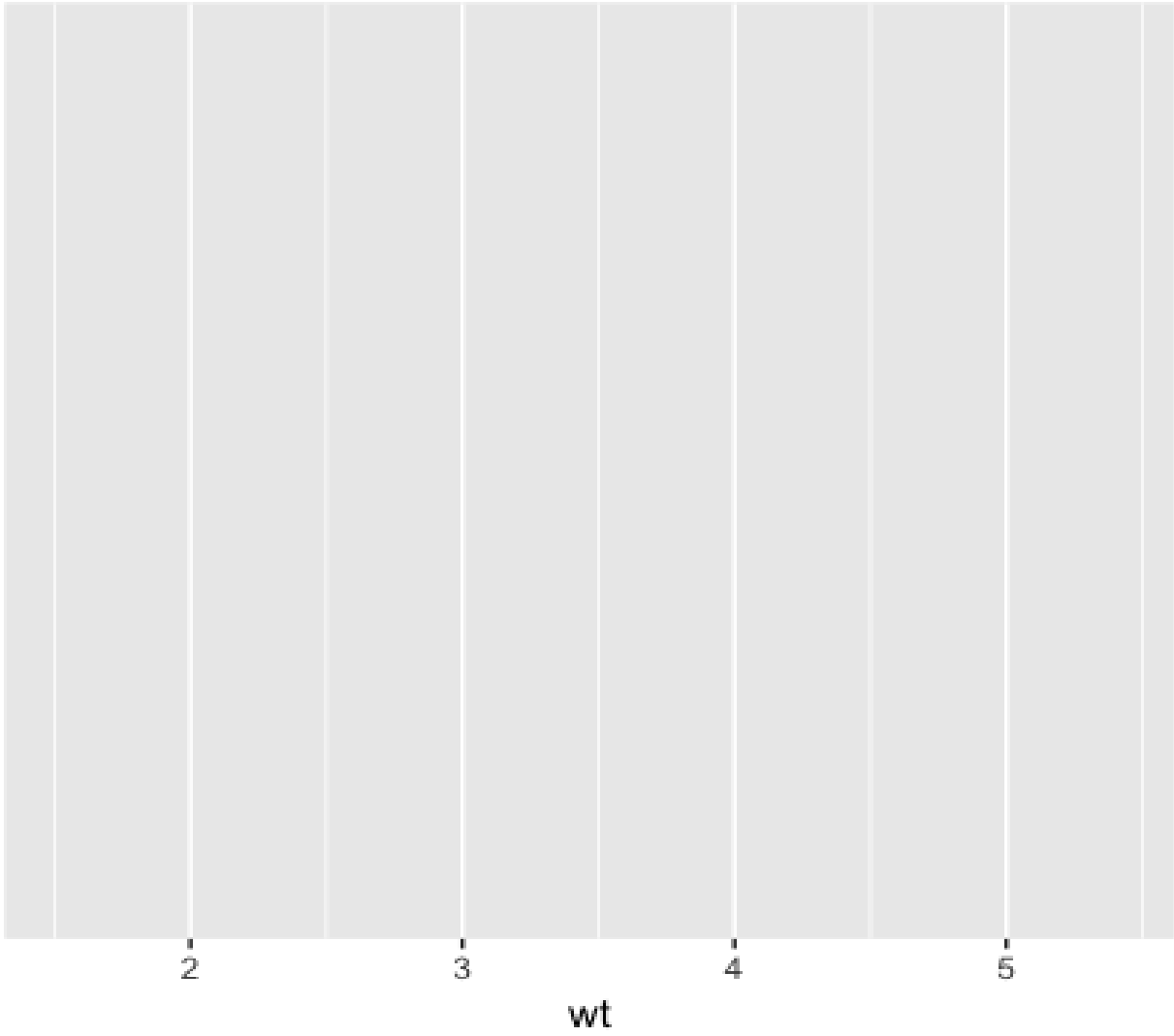
```
ggplot(mtcars,aes(x=wt)) + geom_histogram(bins=15)
```



# mtcars

What if we don't supply a **geometry** ?

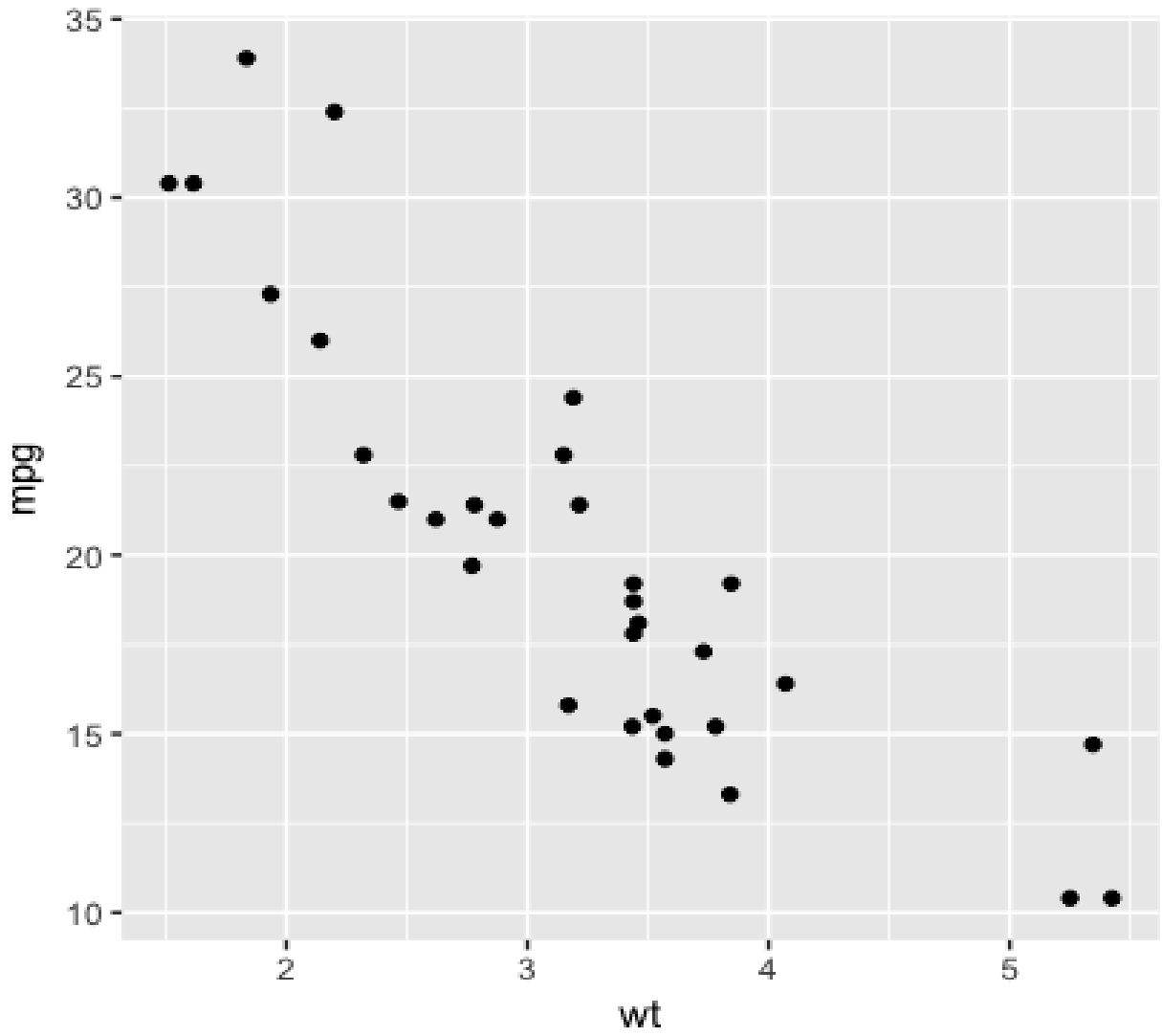
```
ggplot(mtcars,aes(x=wt))
```



# mtcars

Is there a relationship between **mpg** vs **wt** ?

```
ggplot(mtcars,aes(x=wt)) + geom_point(aes(y=mpg))
```

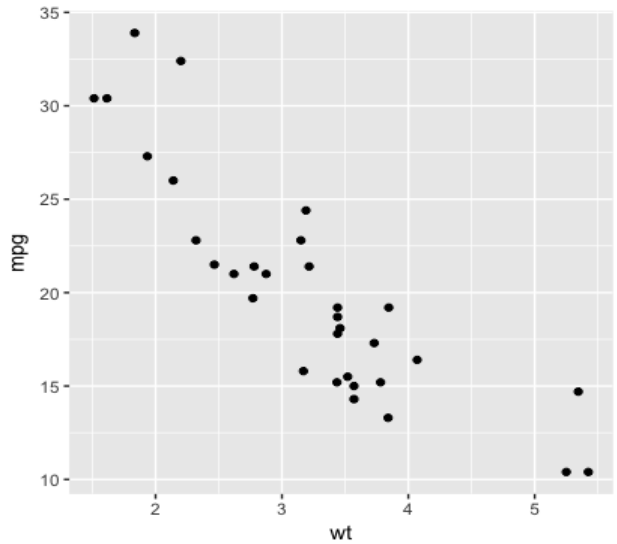


# mtcars

Is there a relationship between **mpg** vs **wt** ?

Note how we added a new geometry on an existing aesthetic mapping then added another aesthetic mapping - we mapped the y-axis to the **mpg** variable

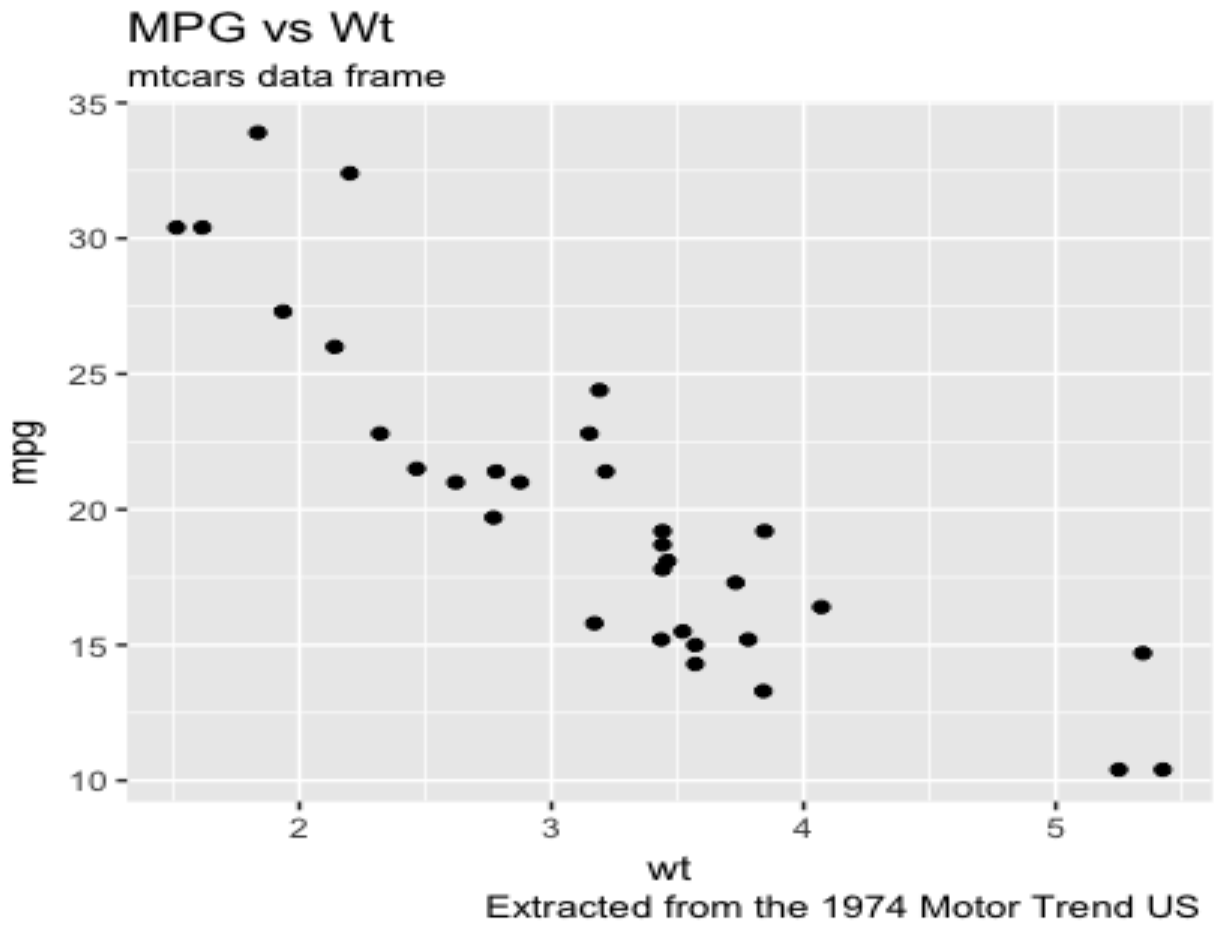
```
ggplot(mtcars,aes(x=wt)) + geom_point(aes(y=mpg))

# Could have also started over - see how flexible ggplot can be

ggplot(mtcars,aes(x=wt,y=mpg)) + geom_point()
```



# mtcars

Is there a relationship between **mpg** vs **wt** ? We can add titles, labels, and captions

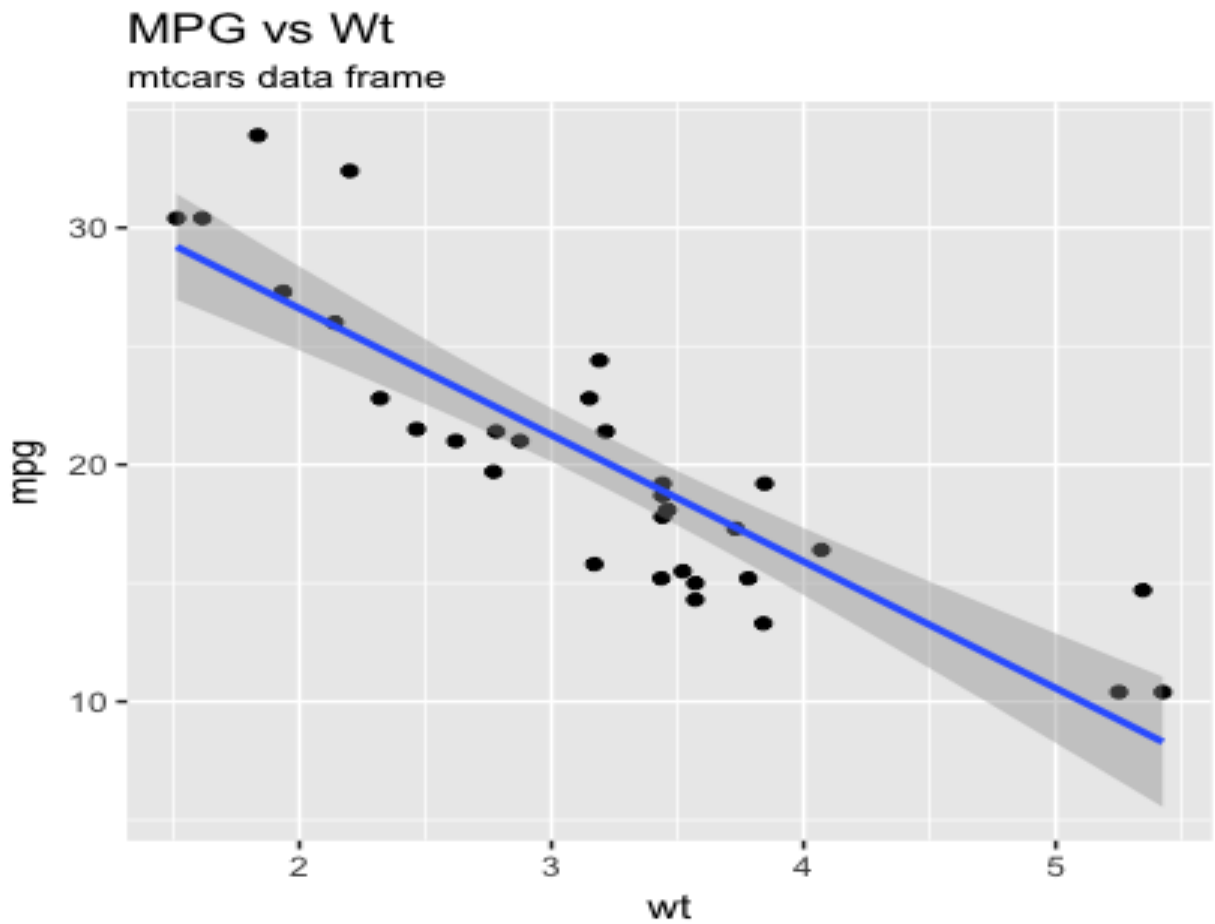
```
ggplot(mtcars,aes(x=wt,y=mpg)) + geom_point()   +
       ggtitle("MPG vs Wt","mtcars data frame") +
       labs(caption="Extracted from 1974 Motor Trend US")
```



# mtcars

We can add another geometry. In this case a regression line with confidence intervals:

```
ggplot(mtcars,aes(x=wt,y=mpg)) + geom_point() +
                ggtitle("MPG vs Wt","mtcars data frame") +
                geom_smooth(method="lm")
```



# mtcars

- Does **mpg** appear to be different over individual cylinder groups ?

Before answering this question I think that it is a good time to introduce the idea of "grouping":

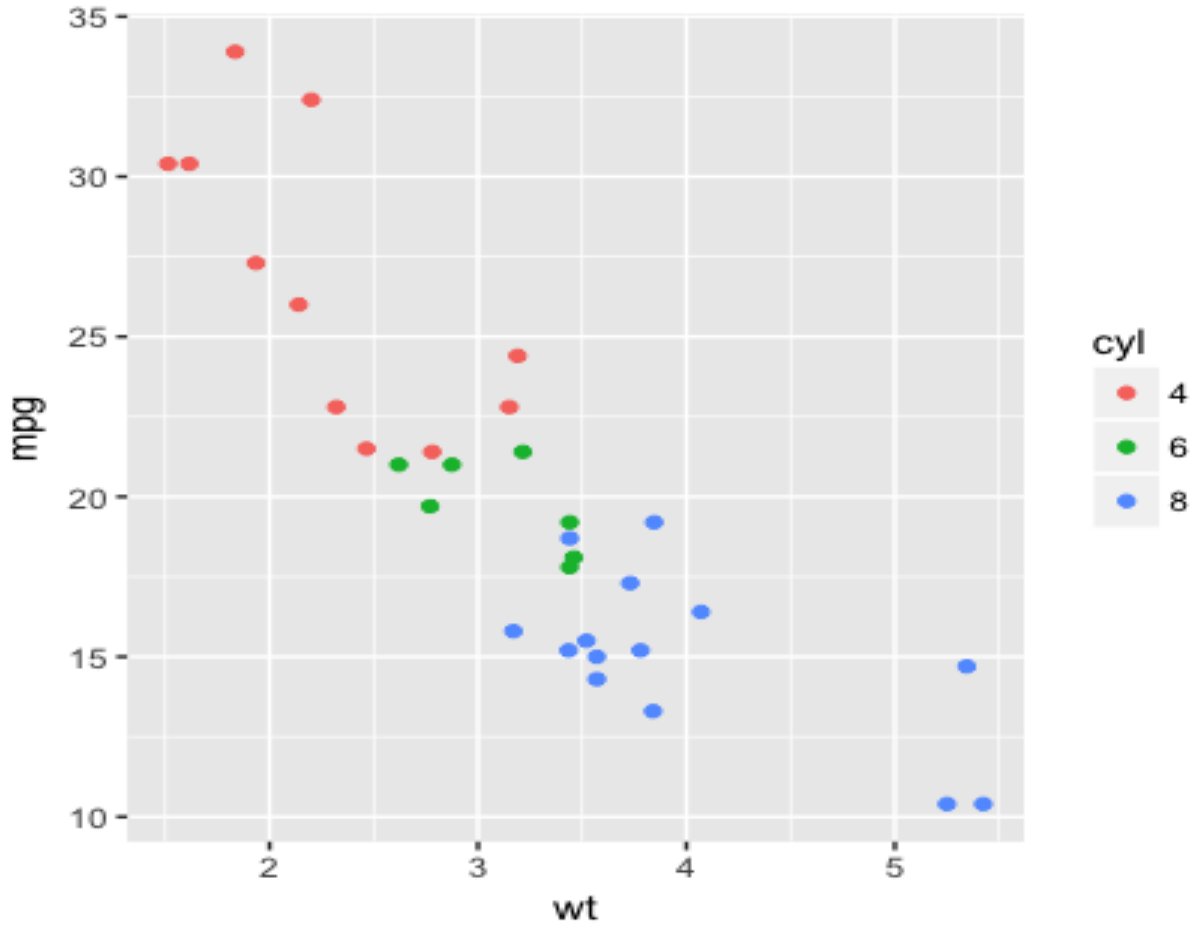
- For each unique value of a factor or category we can see how it impacts the plot
- We can use color, shapes, and size to accomplish this
- In ggplot we use and "aesthetic mapping" to do this
- Note that the **cyl** variable assumes only three unique values

```
unique(mtcars$cyl)
[1] 6 4 8

# Let's make cyl and "official" factor
mtcars$cyl <- factor(mtcars$cyl)
```

# mtcars

- Does **mpg** appear to be different over individual cylinder groups ?

```
ggplot(mtcars,aes(x=wt,y=mpg,color=cyl)) + geom_point()
```

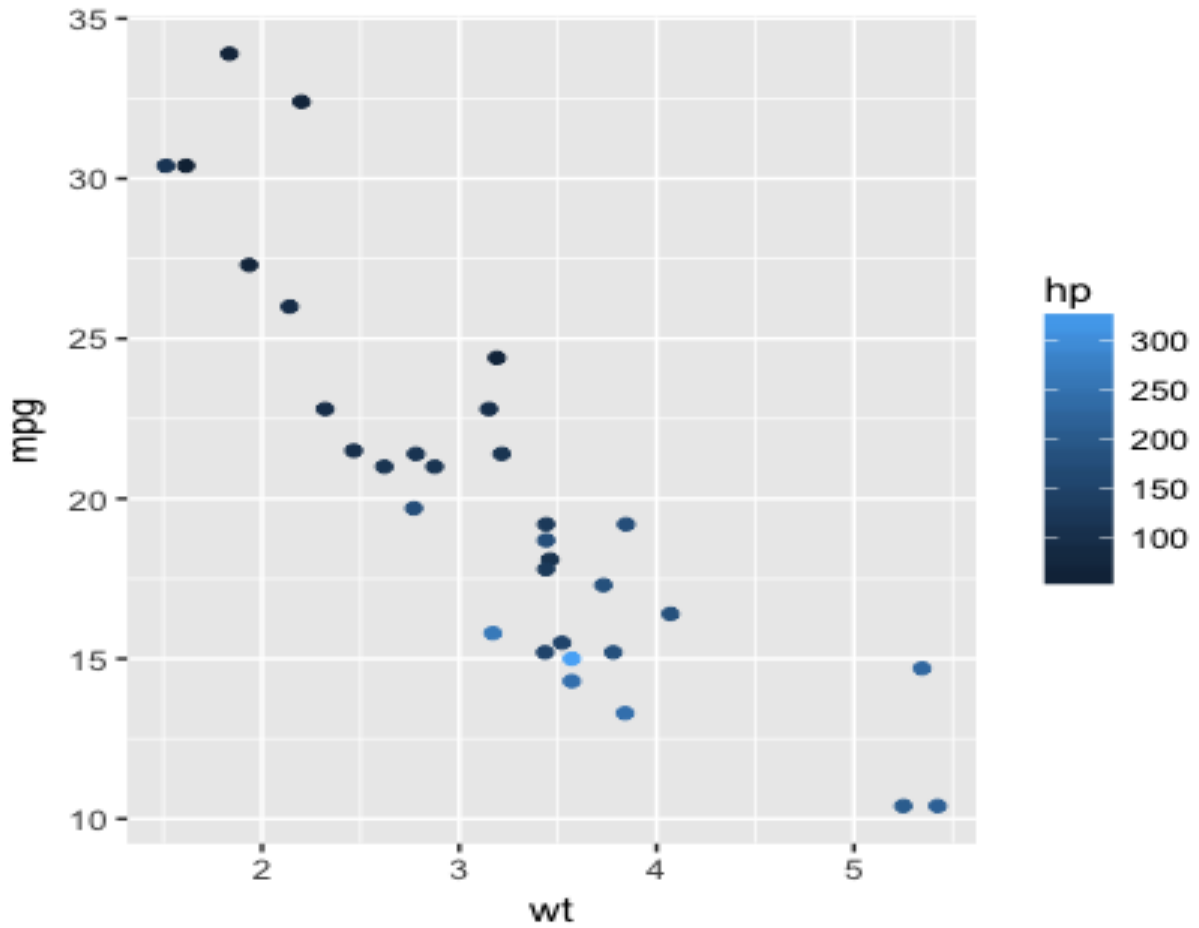


# mtcars

- Does **mpg** appear to be different over individual cylinder groups ?

What happens if we use a continuous quantity as a color aesthetic ? Like **hp** ?

```
ggplot(mtcars,aes(x=wt,y=mpg,color=hp)) + geom_point()
```

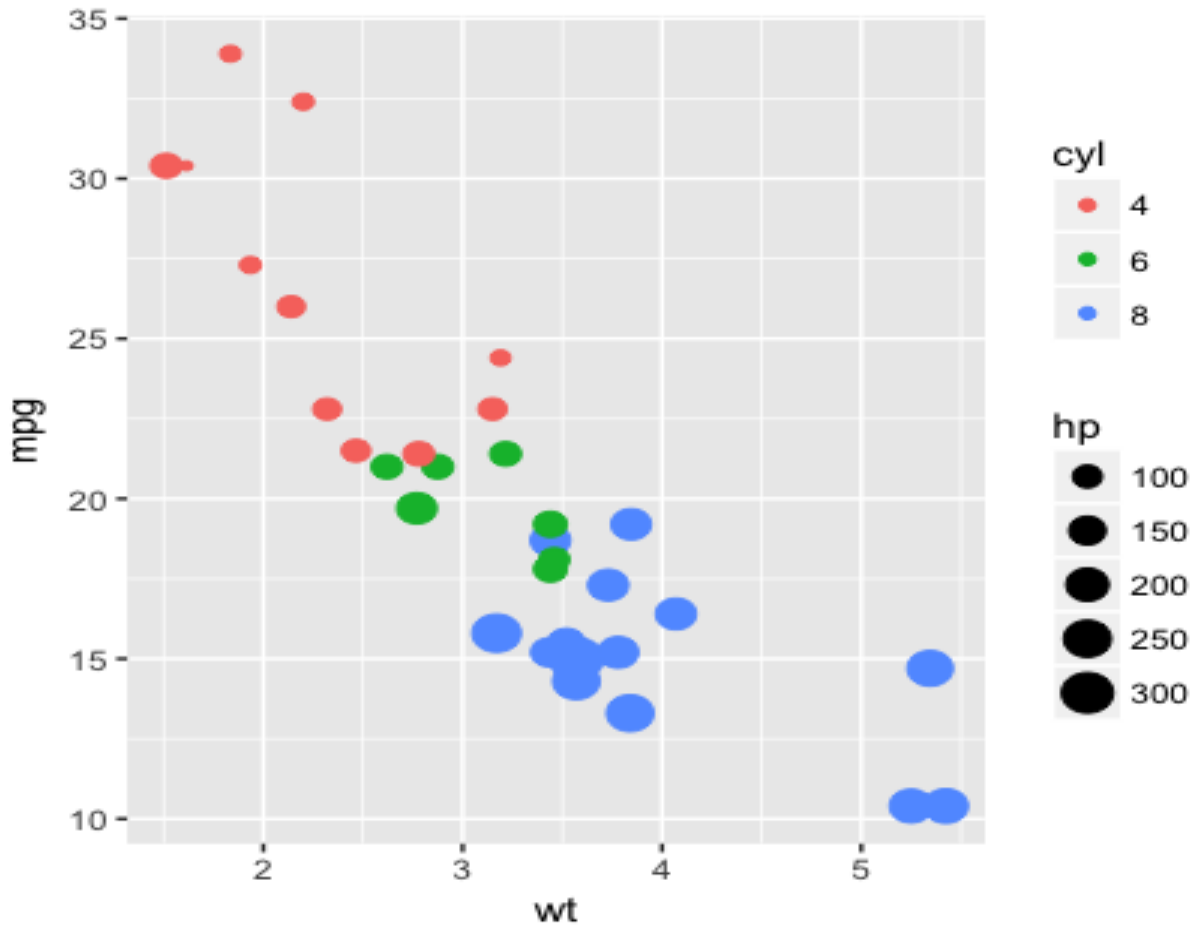


# mtcars

- Does **mpg** appear to be different over individual cylinder groups ?

We can use multiple variables for grouping

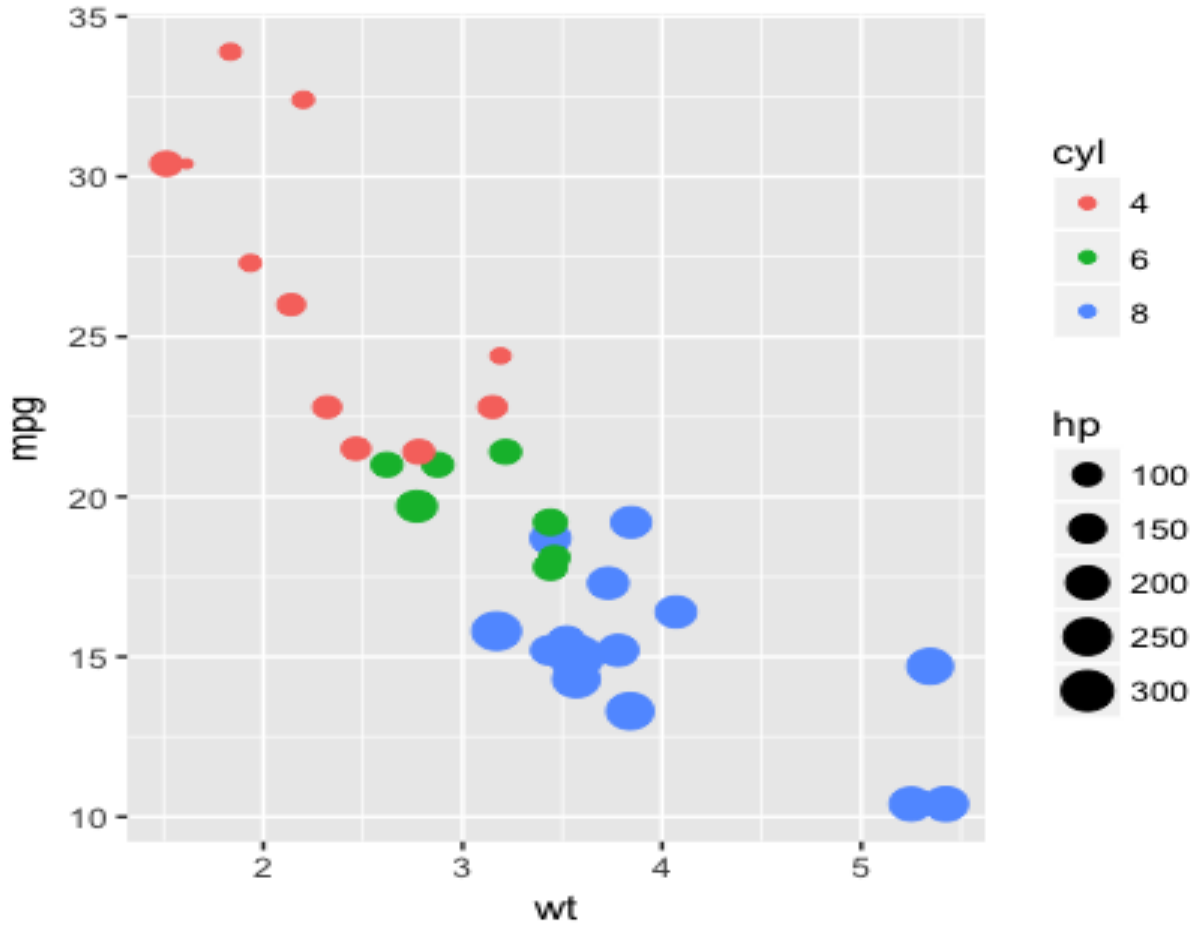
```
ggplot(mtcars,aes(x=wt,y=mpg,size=hp,color=cyl)) + geom_point()
```



# mtcars

Maybe better to put aesthetic assignments in the associated **geom** layer. This gives us flexibility

```
ggplot(mtcars) +  geom_point(aes(x=wt,y=mpg,size=hp,color=cyl))
```

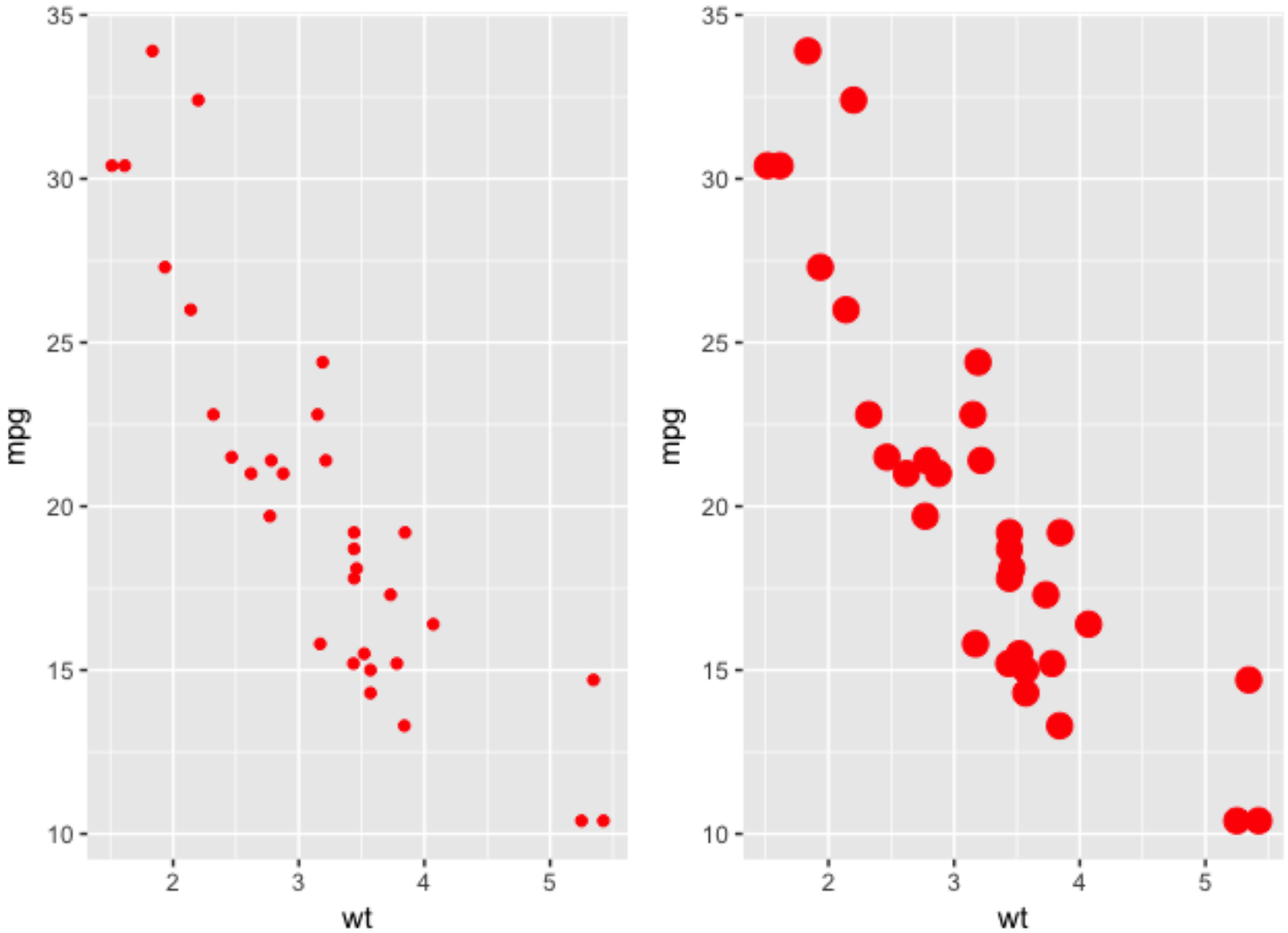


# mtcars

- Note that there is a difference between **mappings** and **settings** with the former usually being a function of some variable in the data
- **Settings** are for altering appearance in a fixed, "set" way

```
library(ggplot2)
library(gridExtra)

p1 <- ggplot(mtcars,aes(x=wt,y=mpg)) + geom_point(color="red")

p2 <- ggplot(mtcars,aes(x=wt,y=mpg)) + geom_point(color="red",size=4)

grid.arrange(p1, p2, nrow=1, ncol=2)
```

# mtcars



# diamonds

A dataset containing the prices and other attributes of almost 54,000 diamonds. The columns/variables are as follows:

price - price in US dollars ($326 - $18,823)

carat - weight of the diamond (0.2 - 5.01)

cut - quality of the cut (Fair, Good, Very Good, Premium, Ideal)

color - diamond colour, from J (worst) to D (best)

clarity - how clear the diamond is
(I1 (worst), SI1, SI2, VS1,
VS2, VVS1, VVS2, IF (best))

x - length in mm (0 - 10.74)
y - width in mm (0 - 8.9)
z - depth in mm (0 - 31.8)

depth - total depth percentage
table - width of top of diamond relative to widest point (43 - 95)

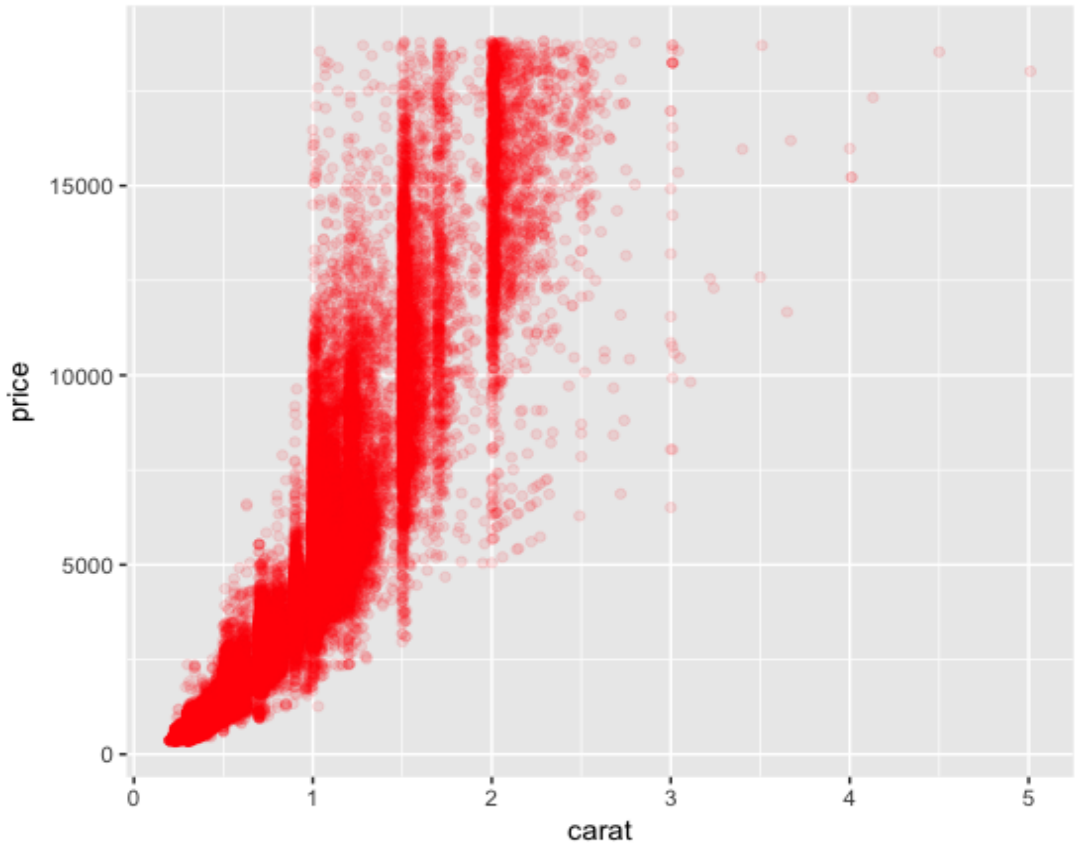
# diamonds

```
> str(diamonds)
Classes tbl_df, tbl and data.frame: 53940 obs. of  10 variables:
 $ carat  : num  0.23 0.21 0.23 0.29 0.31 0.24 0.24 0.26 0.22 0.23 ...
 $ cut    : Ord.factor w/ 5 levels "Fair"<"Good"<..: 5 4 2 4 2 3 3 3 1 3 ...
 $ color  : Ord.factor w/ 7 levels "D"<"E"<"F"<"G"<..: 2 2 2 6 7 7 6 5 2 5 ...
 $ clarity: Ord.factor w/ 8 levels "I1"<"SI2"<"SI1"<..: 2 3 5 4 2 6 7 3 4 5 ...
 $ depth  : num  61.5 59.8 56.9 62.4 63.3 62.8 62.3 61.9 65.1 59.4 ...
 $ table  : num  55 61 65 58 58 57 57 55 61 61 ...
 $ price  : int  326 326 327 334 335 336 336 337 337 338 ...
 $ x      : num  3.95 3.89 4.05 4.2 4.34 3.94 3.95 4.07 3.87 4 ...
 $ y      : num  3.98 3.84 4.07 4.23 4.35 3.96 3.98 4.11 3.78 4.05 ...
 $ z      : num  2.43 2.31 2.31 2.63 2.75 2.48 2.47 2.53 2.49 2.39 ...
```

# diamonds

Let's look at a more "dense" data set. Using a fixed color setting along with a transparency factor can make obvious certain groups in the data.

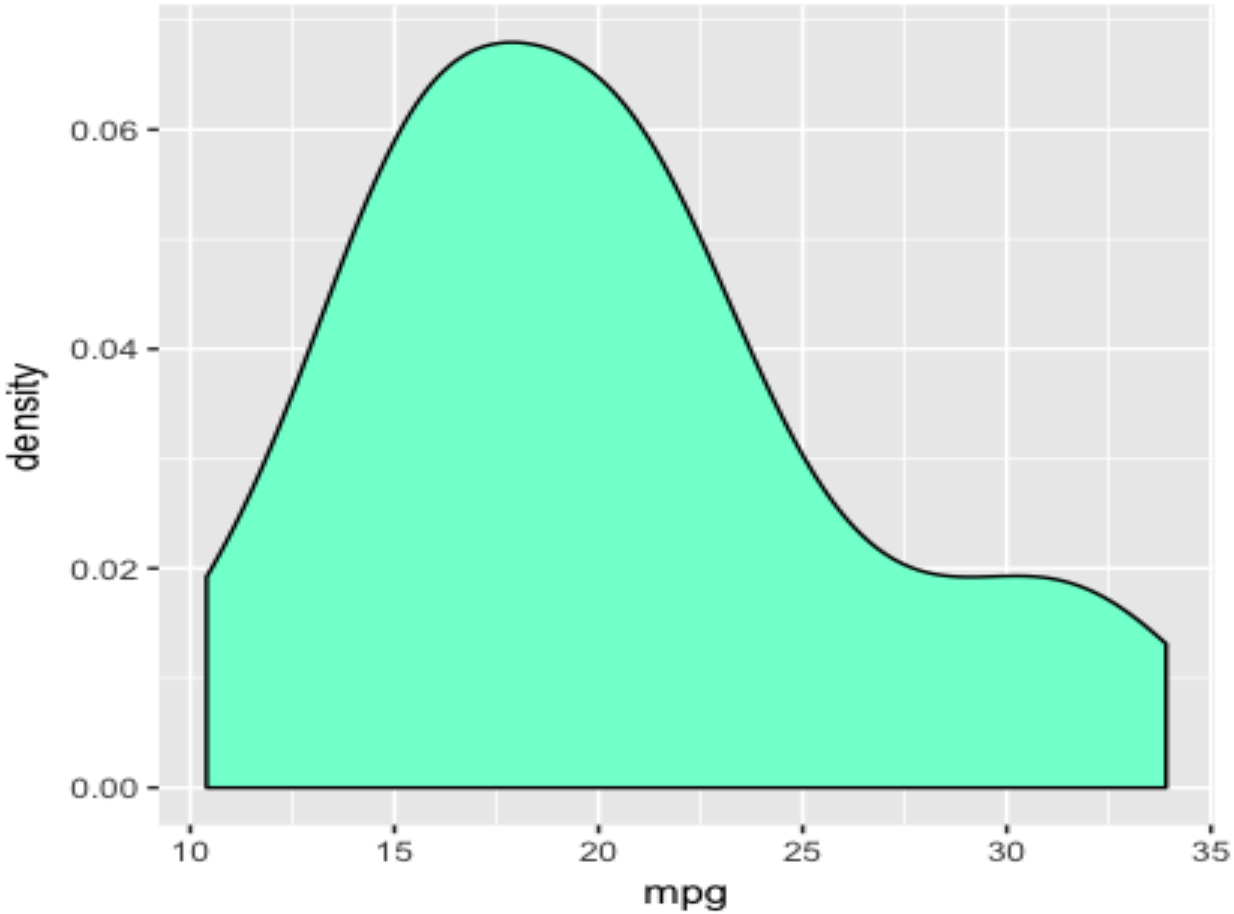
```
data(diamonds)
ggplot(diamonds,aes(x=carat,y=price)) +
                    geom_point(color="red",alpha=0.1)
```



# mtcars

In general anything you wish to set to a static value should be set **outside** of the **aes** function

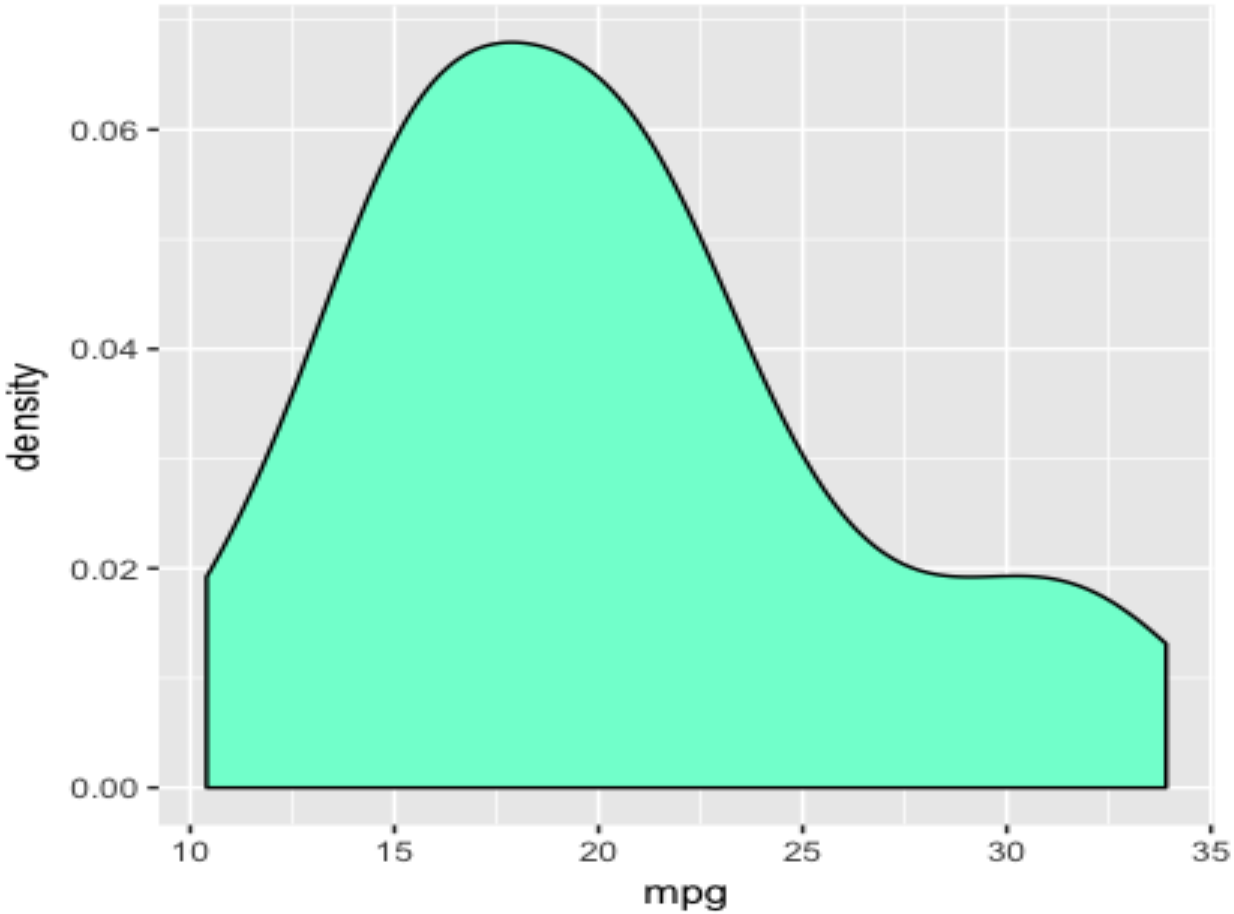
```
ggplot(mtcars) + geom_density(aes(x=mpg),fill="aquamarine")
```



# mtcars

Here we create a density plot of MPG. Note with a static color assignment we place it **outside** of the **aes**

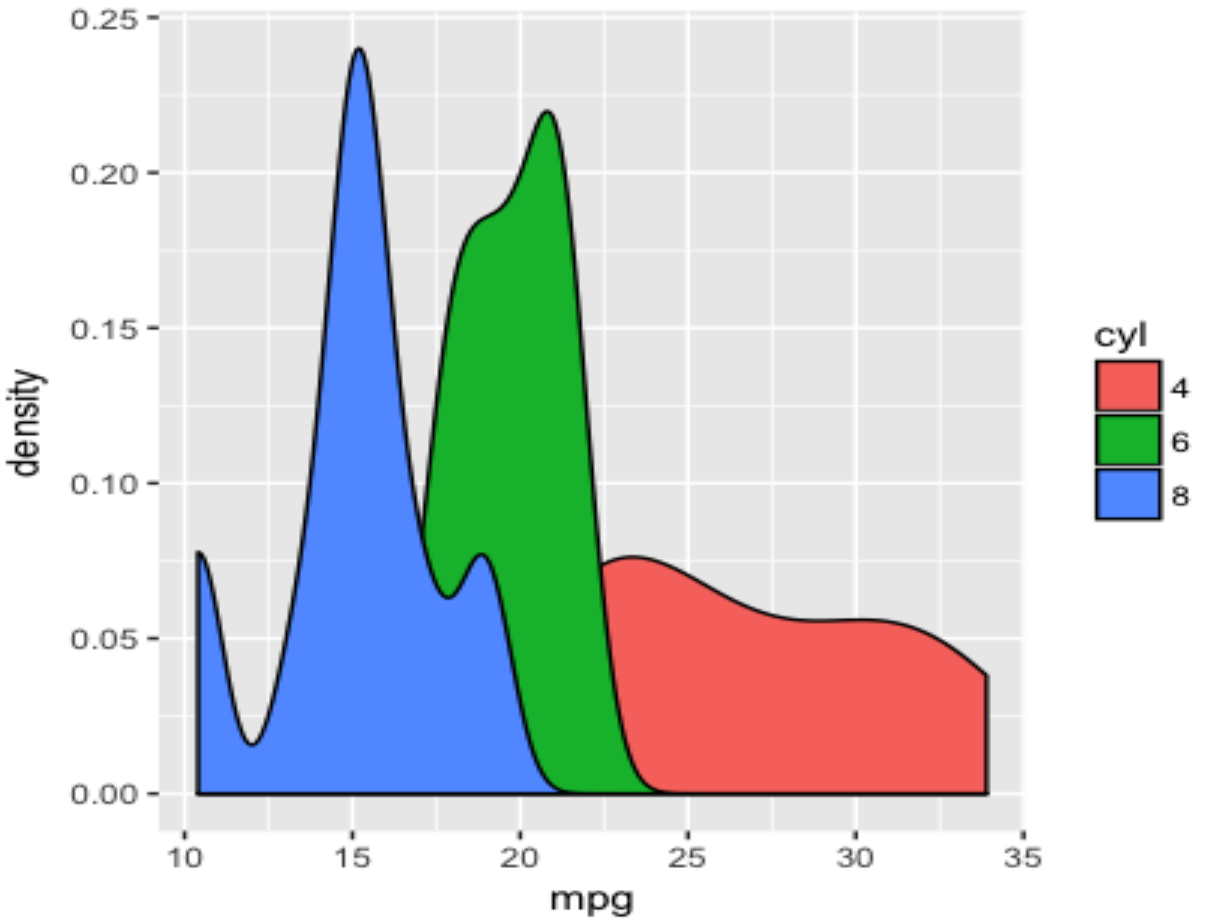
```
ggplot(mtcars) + geom_density(aes(x=mpg),fill="aquamarine")
```



# mtcars

Here we create a density plot of MPG. We can group the density by **cyl**

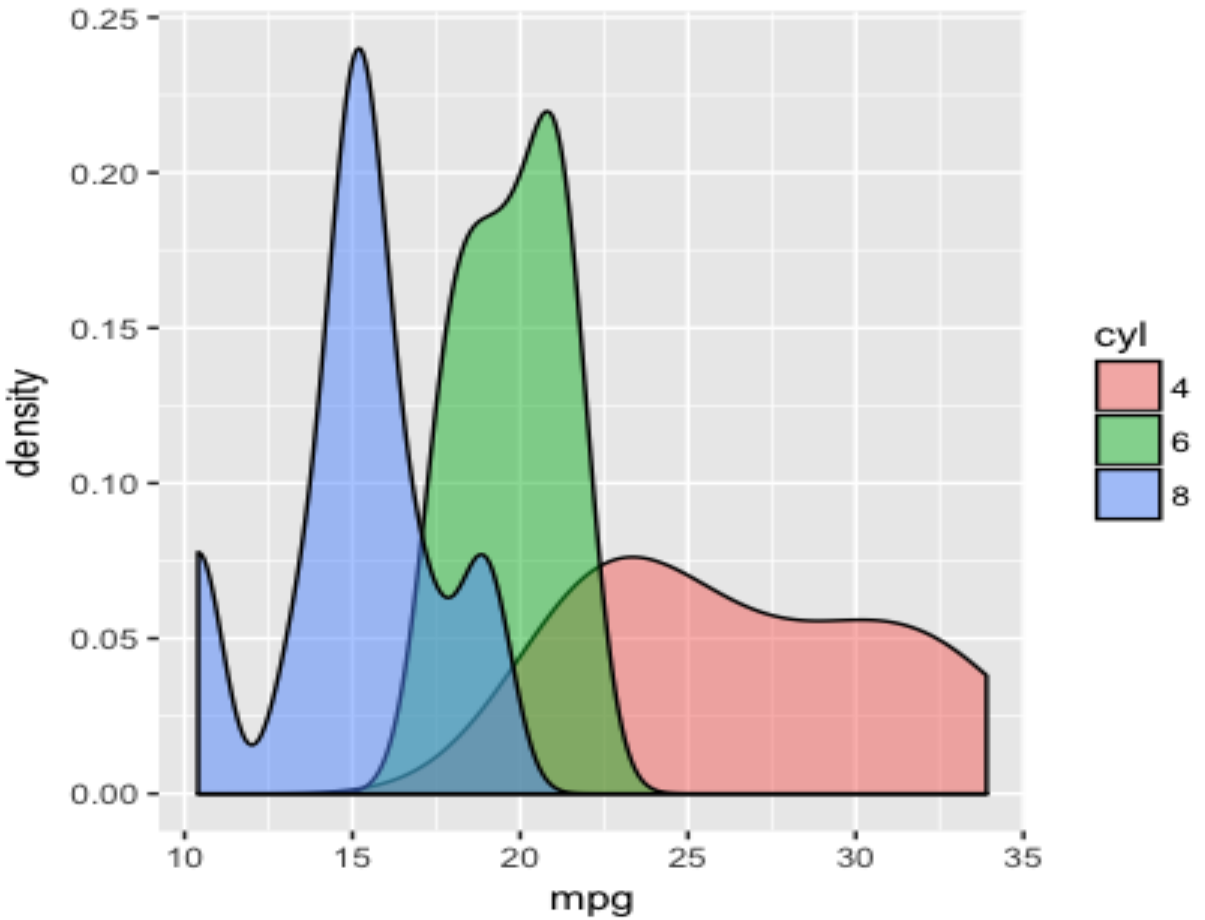
```
ggplot(mtcars) + geom_density(aes(x=mpg,fill=cyl))
```



# mtcars

What about looking at a boxplot of **mpg** across cylinder groups ?

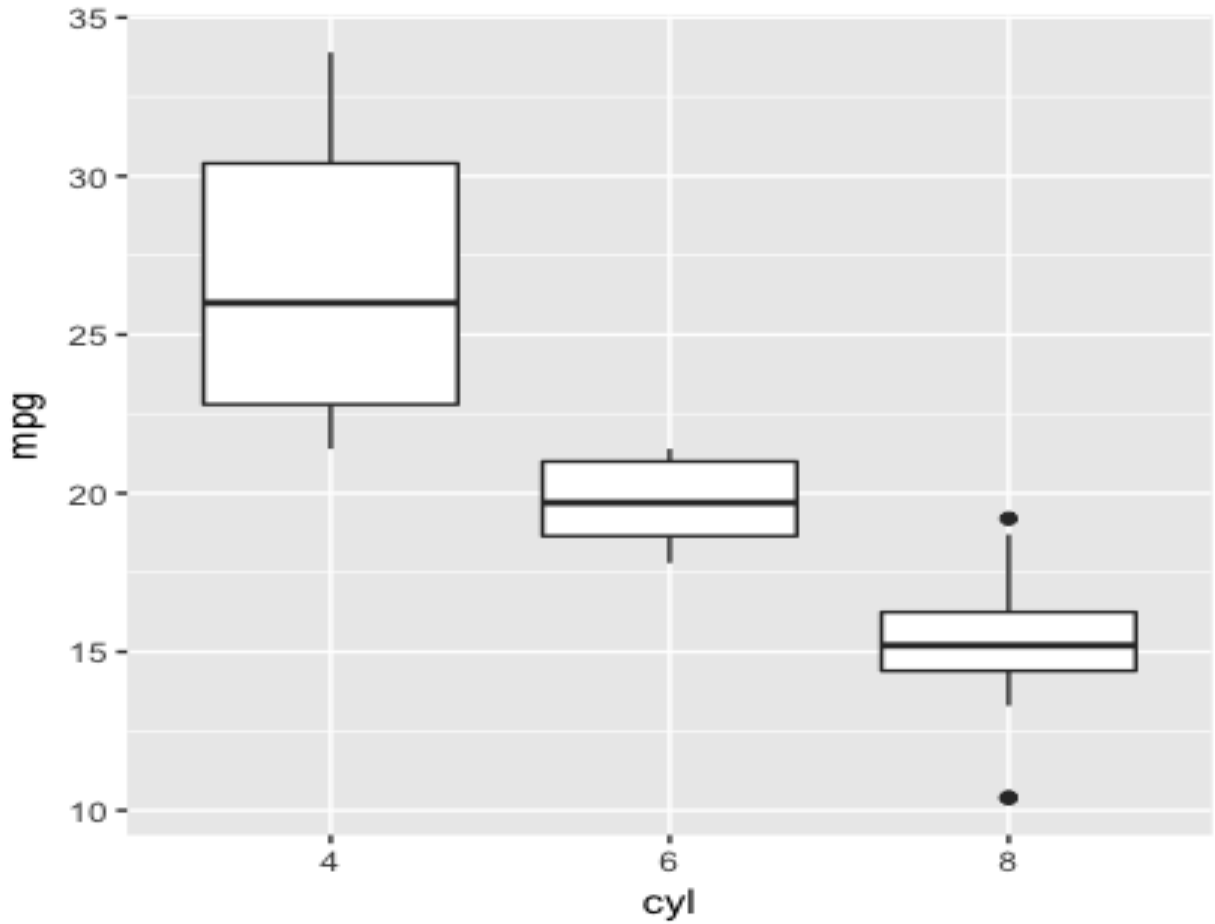
```
ggplot(mtcars) + geom_boxplot(aes(x=cyl,y=mpg),alpha=0.5)
```



# mtcars

What about looking at a boxplot of **mpg** across cylinder groups ?

```
ggplot(mtcars) + geom_boxplot(aes(x=cyl,y=mpg))
```

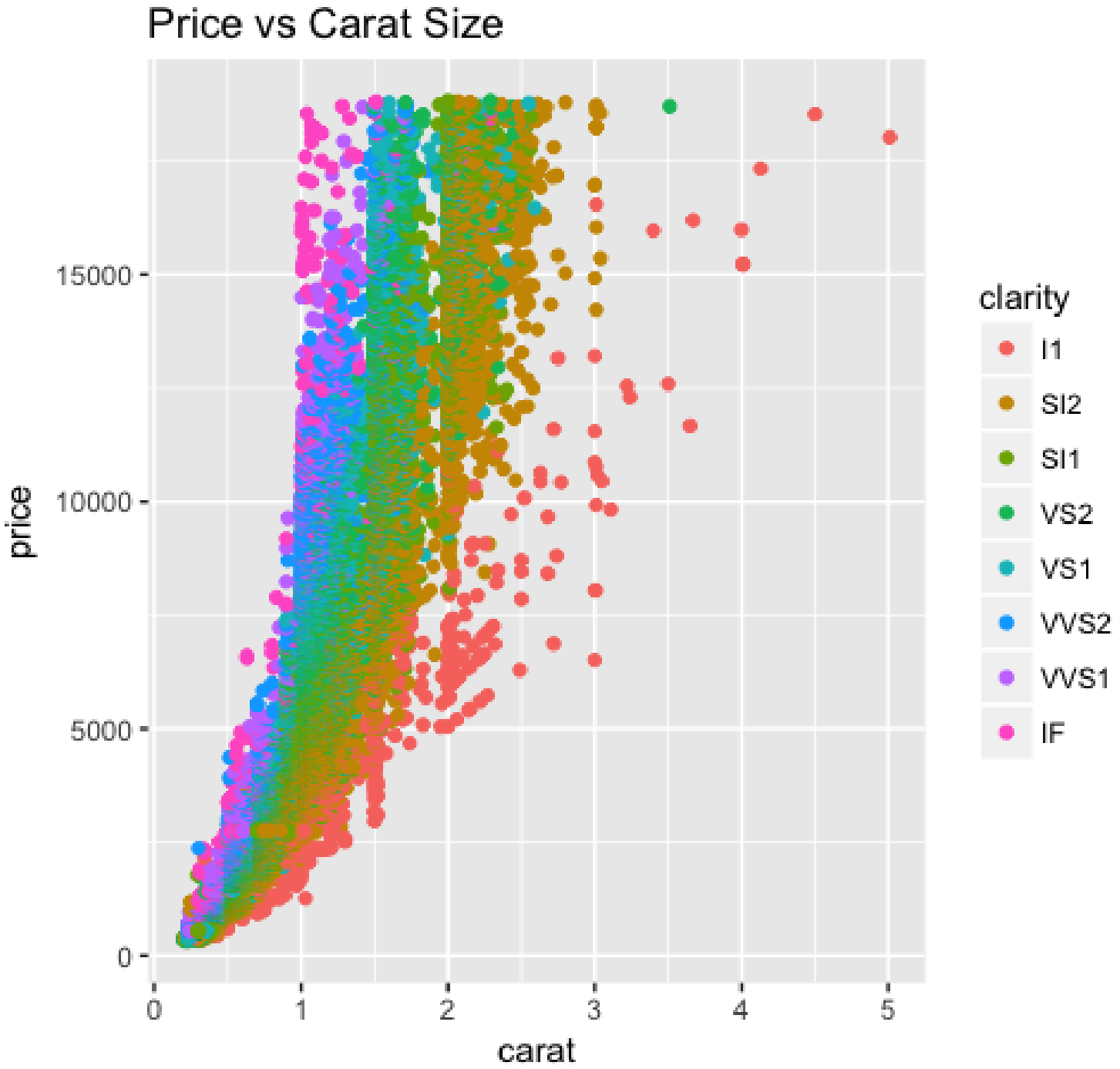


# Facets

Facets allow us to display data within panels to facilitate easy comparisons

- In lattice graphics this is called panelling or conditioning
- In Base graphics you have to do panelling or faceting manually - it's a pain
- Consider the following grouping graph:

```
ggplot(diamonds,aes(x=carat,y=price)) +
                  geom_point(aes(color=clarity)) +
                  ggtitle("Price vs Carat Size")
```

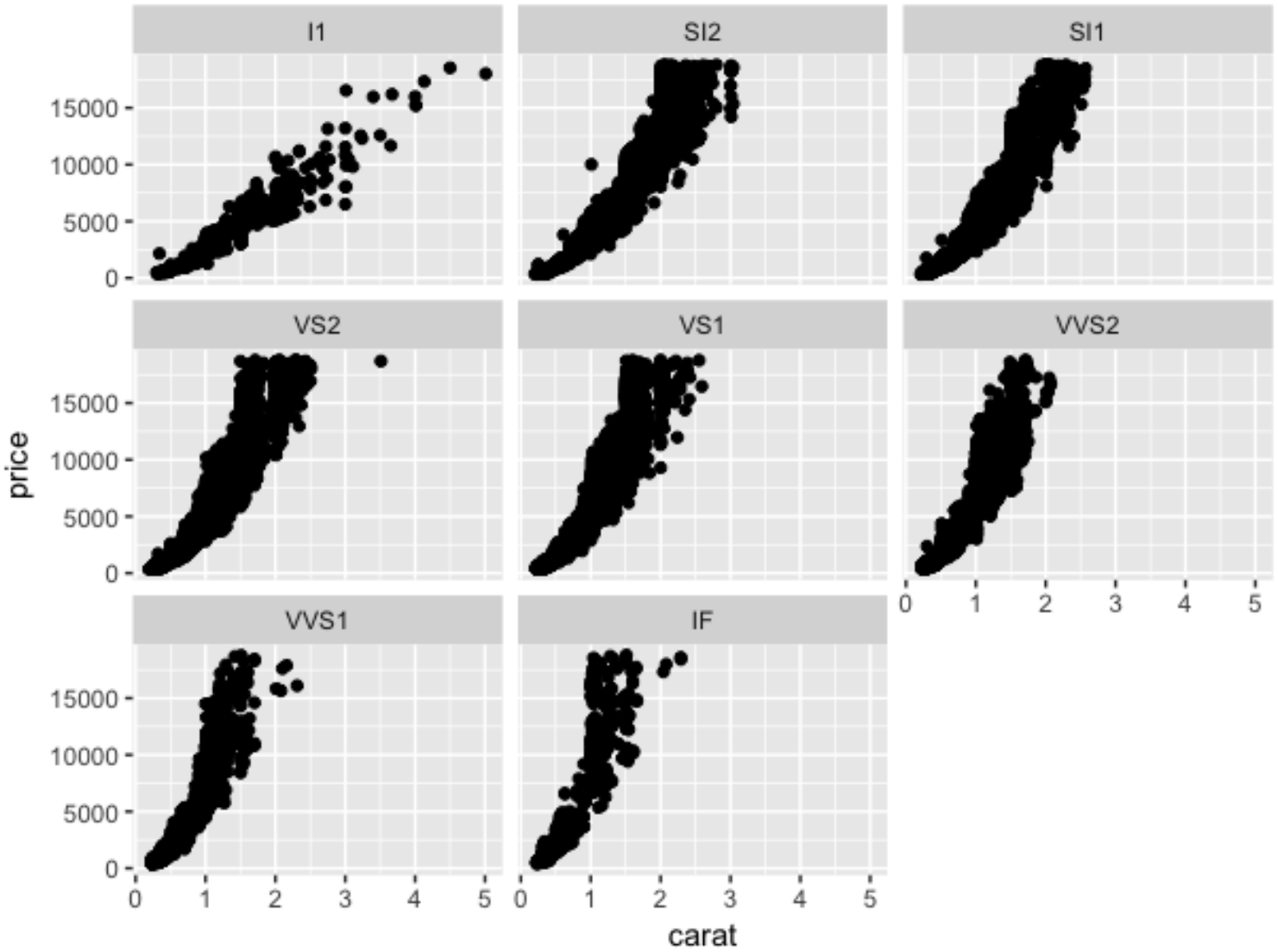

Price vs Carat Size
price
15000
10000
5000
0
0
1
2
3
4
5
carat
clarity
I1
SI2
SI1
VS2
VS1
VVS2
VVS1
IF

# Facets

Here we will plot the same data that was formerly grouped. By splitting the data into separate panels corresponding to each value of the clarity variable we might be able to see interesting trends more easily.

```
ggplot(diamonds,aes(x=carat,y=price)) +
                  geom_point() +
                  facet_wrap(~clarity)
```

# Facets

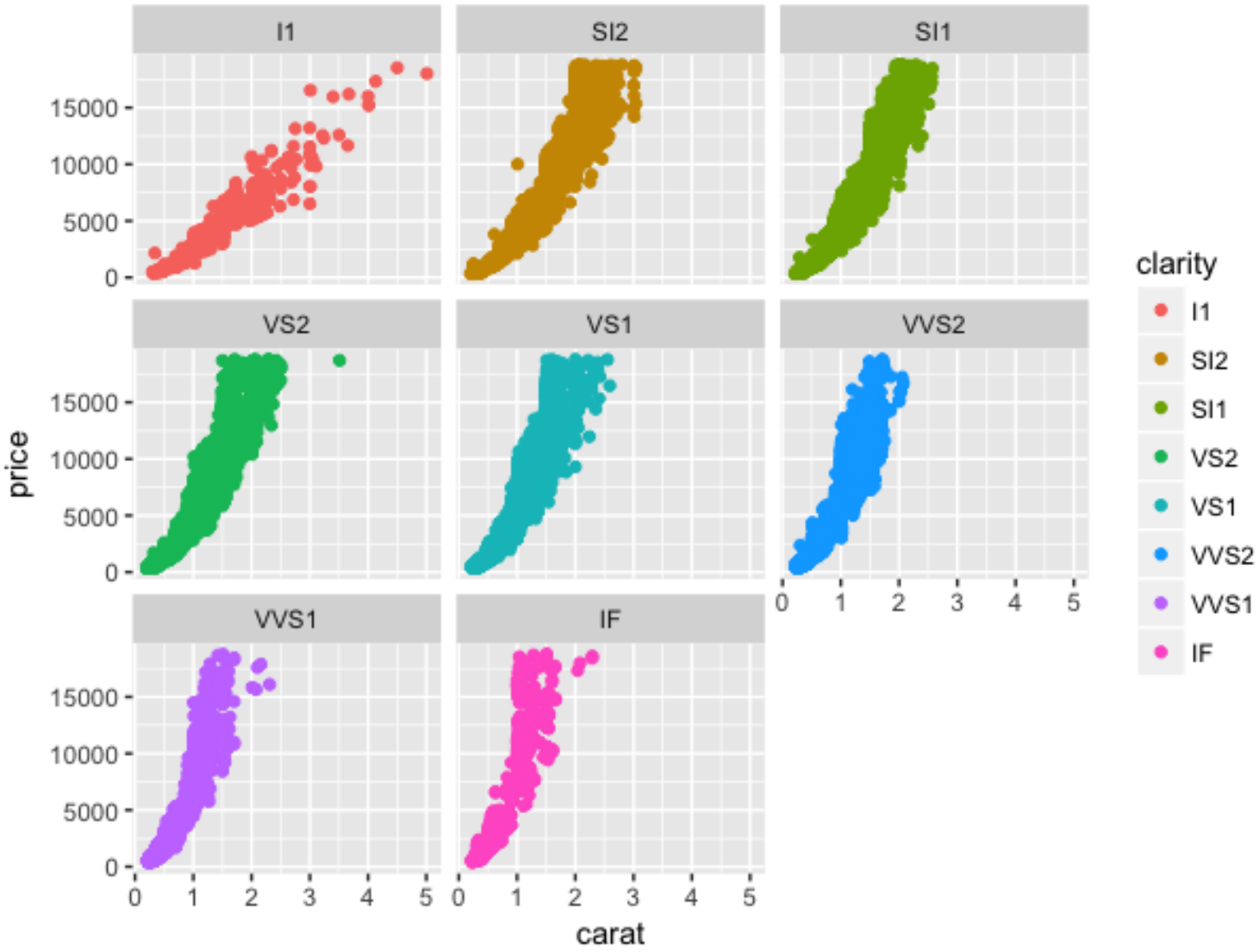

I1
SI2
SI1
VS2
VS1
VVS2
VVS1
IF
price
carat
0
5000
10000
15000
0
1
2
3
4
5

# Facets

Here we will plot the same data that was formerly grouped. However we will still preserve the grouping colors. While this isn't essential it might be helpful

```
ggplot(diamonds,aes(x=carat,y=price)) +
                  geom_point(aes(color=clarity)) +
                  facet_wrap(~clarity)
```

# Facets


I1
SI2
SI1
VS2
VS1
VVS2
VVS1
IF
price
carat
clarity
I1
SI2
SI1
VS2
VS1
VVS2
VVS1
IF

# Facets

- Let's look at another example. Consider the built in **Indometh** data frame.
- We want to see the reduction in concentration of Indometh over time
- There are six subjects so let's plot six lines

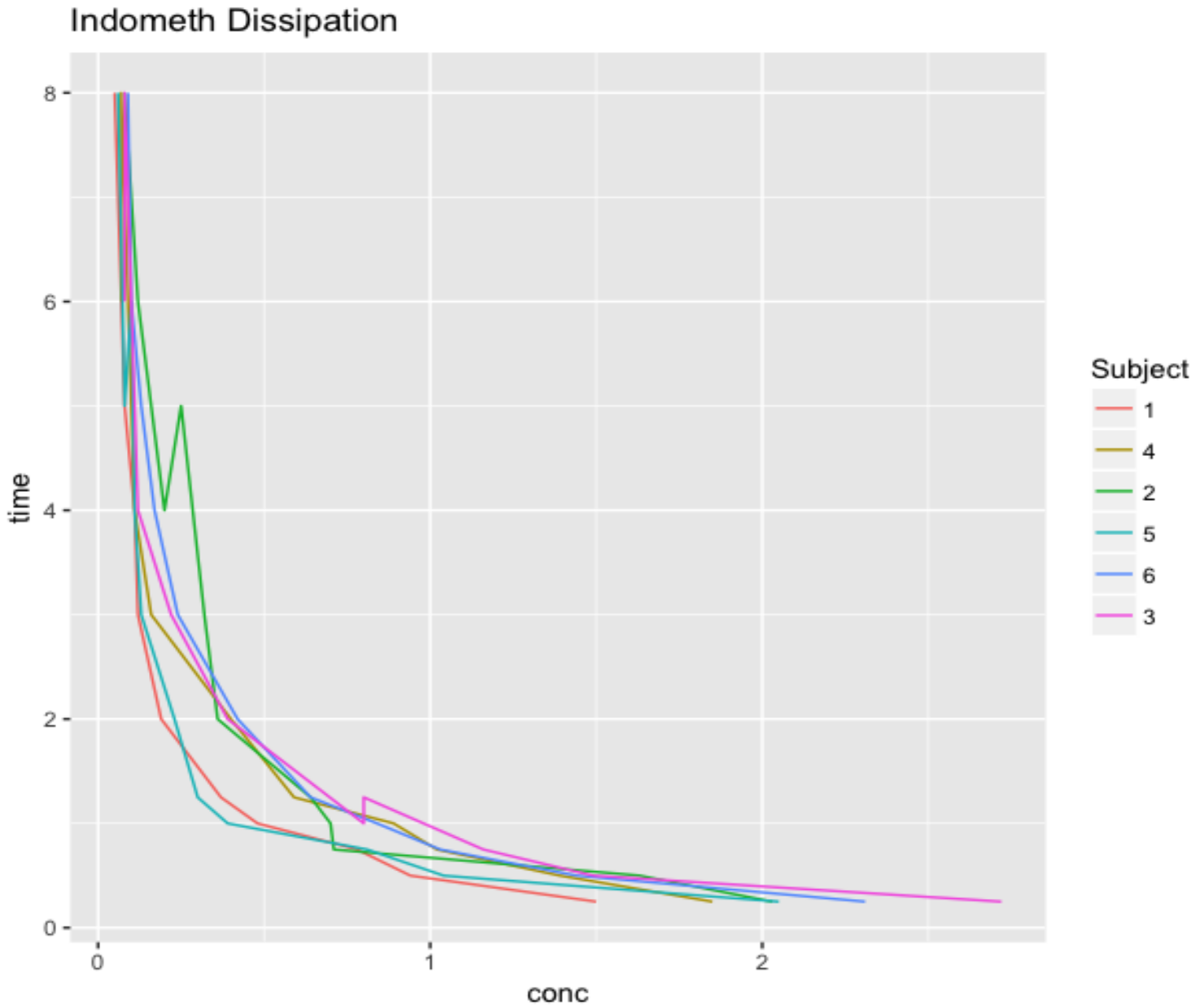
```
str(Indometh)
Classes : 66 obs. of  3 variables:
 $ Subject: Ord.factor w/ 6 levels "1"<"4"<"2"<"5"<..: 1 1 1 1 1 1 1 1 1 1 ...
 $ time   : num  0.25 0.5 0.75 1 1.25 2 3 4 5 6 ...
 $ conc   : num  1.5 0.94 0.78 0.48 0.37 0.19 0.12 0.11 0.08 0.07 ...
 - attr(*, "formula")=Class 'formula'  language conc ~ time | Subject
  .. ..- attr(*, ".Environment")=<environment: R_EmptyEnv>
 - attr(*, "labels")=List of 2
  ..$ x: chr "Time since drug administration"
  ..$ y: chr "Indomethacin concentration"
 - attr(*, "units")=List of 2
  ..$ x: chr "(hr)"
  ..$ y: chr "(mcg/ml)"
```

# Facets

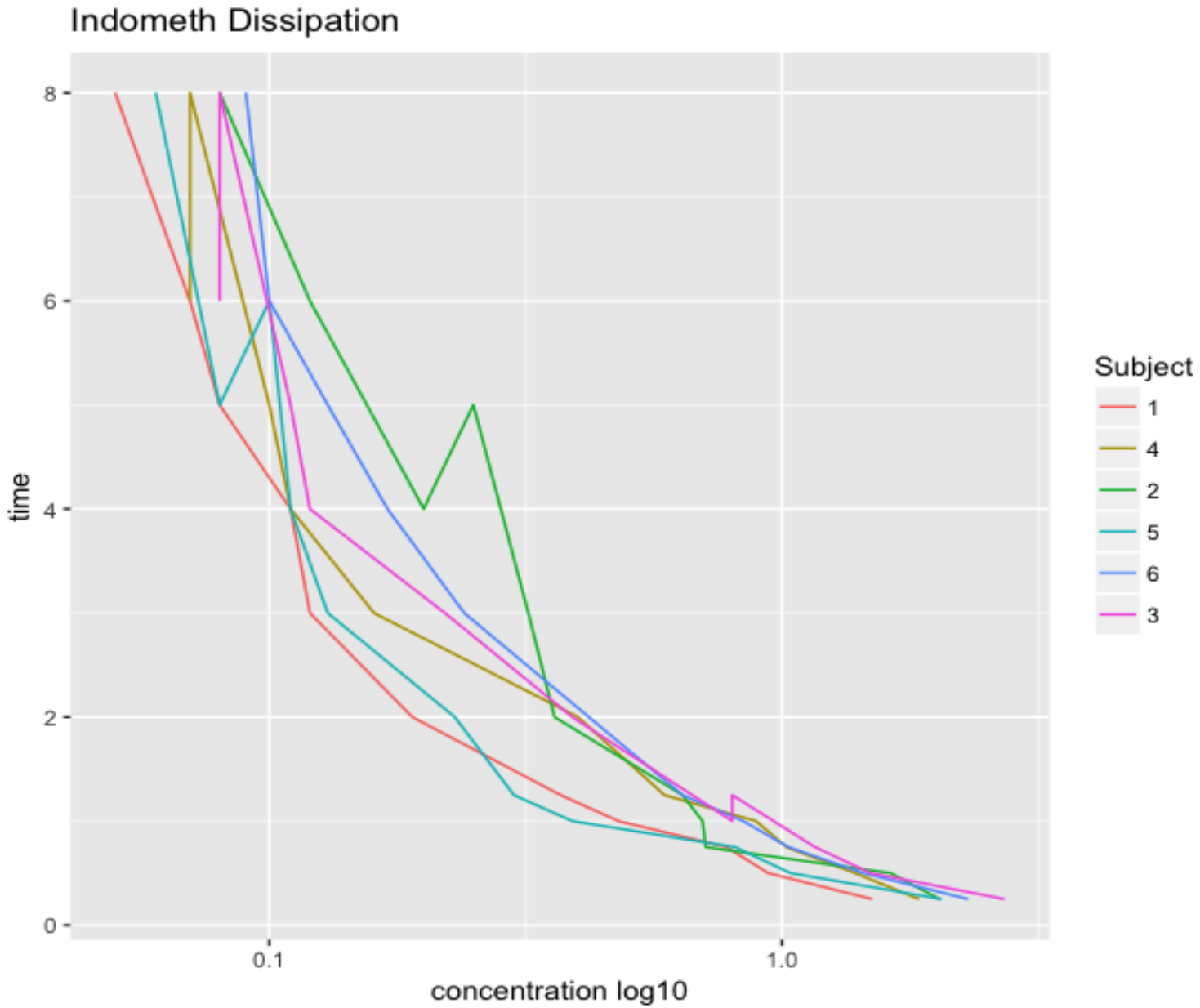
The first plot will be a little hard to read but we can replot it again using a log 10 transformation on the X Axis to improve interpretability.

```
ggplot(Indometh,aes(x=conc,y=time,color=Subject)) +
                  geom_line() +
                  ggtitle("Indometh Dissipation")

# Transform the X axis to improve readability

ggplot(Indometh,aes(x=conc,y=time,color=Subject)) +
                  geom_line() + scale_x_log10() +
                  ggtitle("Indometh Dissipation") +
                  xlab("concentration log10")
```

# Facets



# Facets

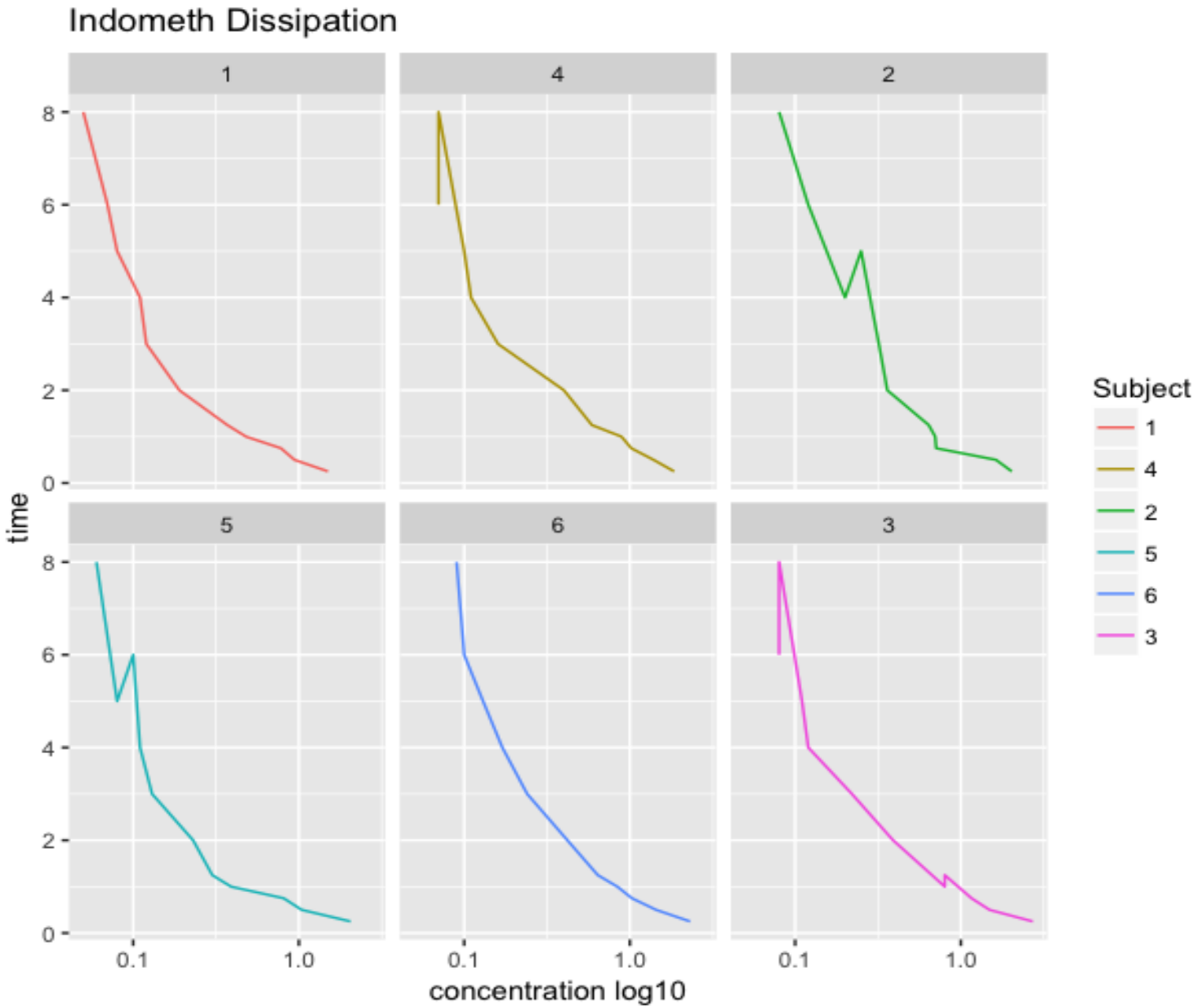

Indometh Dissipation
time
8
6
4
2
0
0.1
1.0
concentration log10
Subject
1
4
2
5
6
3

# Facets

But wait - Aren't we talking about Facets ?

```
ggplot(Indometh,aes(x=conc,y=time,color=Subject)) +
                    geom_line() +
                    ggtitle("Indometh Dissipation") +
                    scale_x_log10() +
                    xlab("concentration log10") +
                    facet_wrap(~Subject)
```

# Facets


Indometh Dissipation
1
4
2
5
6
3
time
0
2
4
6
8
0.1
1.0
concentration log10
Subject
1
4
2
5
6
3

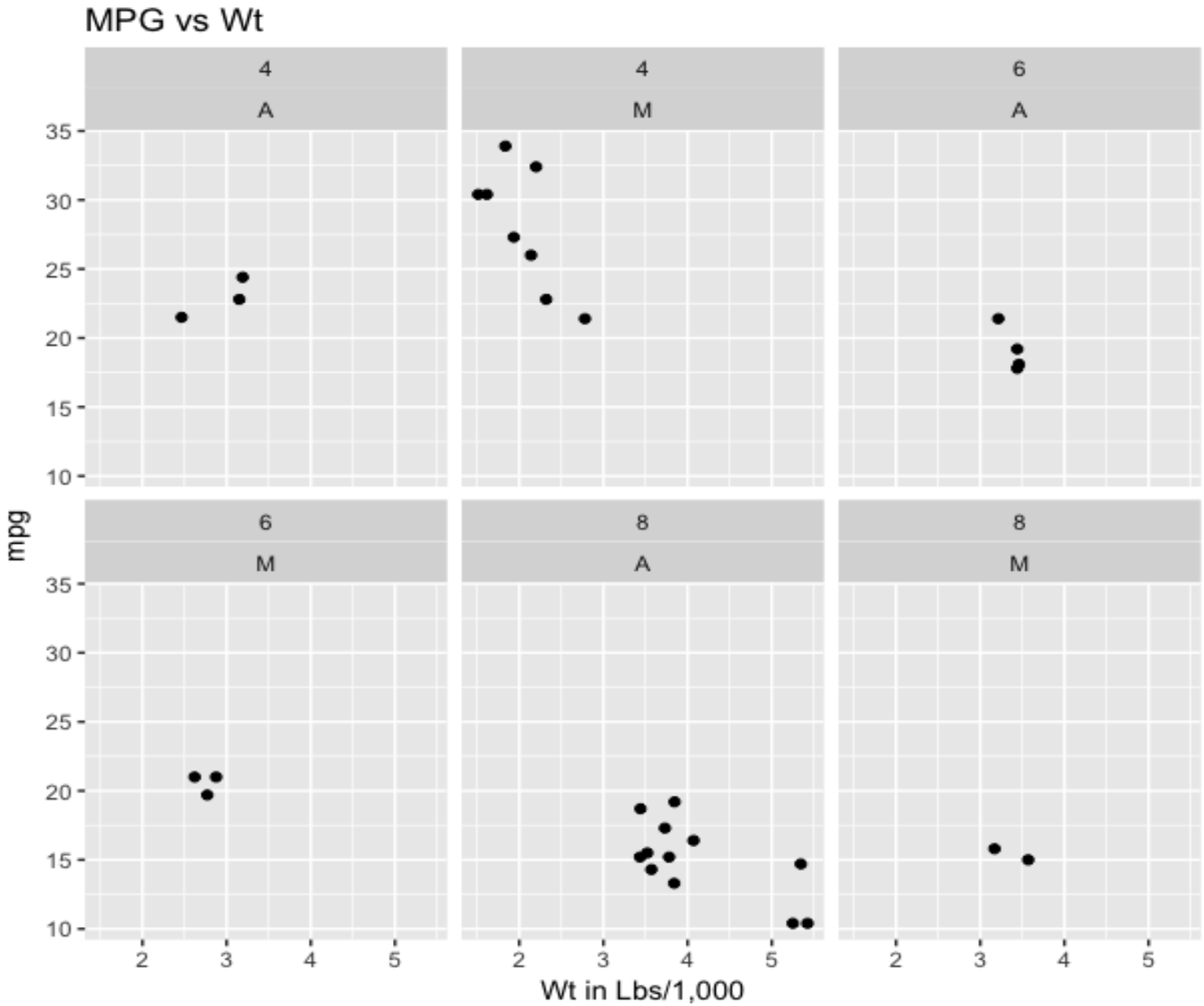
# Facets

Let's go back to mtcars

- plot mpg vs wt for all combinations of cylinder group and Transmission Type
- Let's make these variables into factors
- What combination gets the best MPG ?

```
mtcars <- transform(mtcars,am=factor(am,labels=c("A","M")),
                           cyl=factor(cyl))

ggplot(mtcars,aes(x=wt,y=mpg)) +
                              geom_point() +
                              facet_wrap(~cyl+am) +
                              ggtitle("MPG vs Wt") +
                              xlab("Wt in Lbs/1,000")
```

# Facets

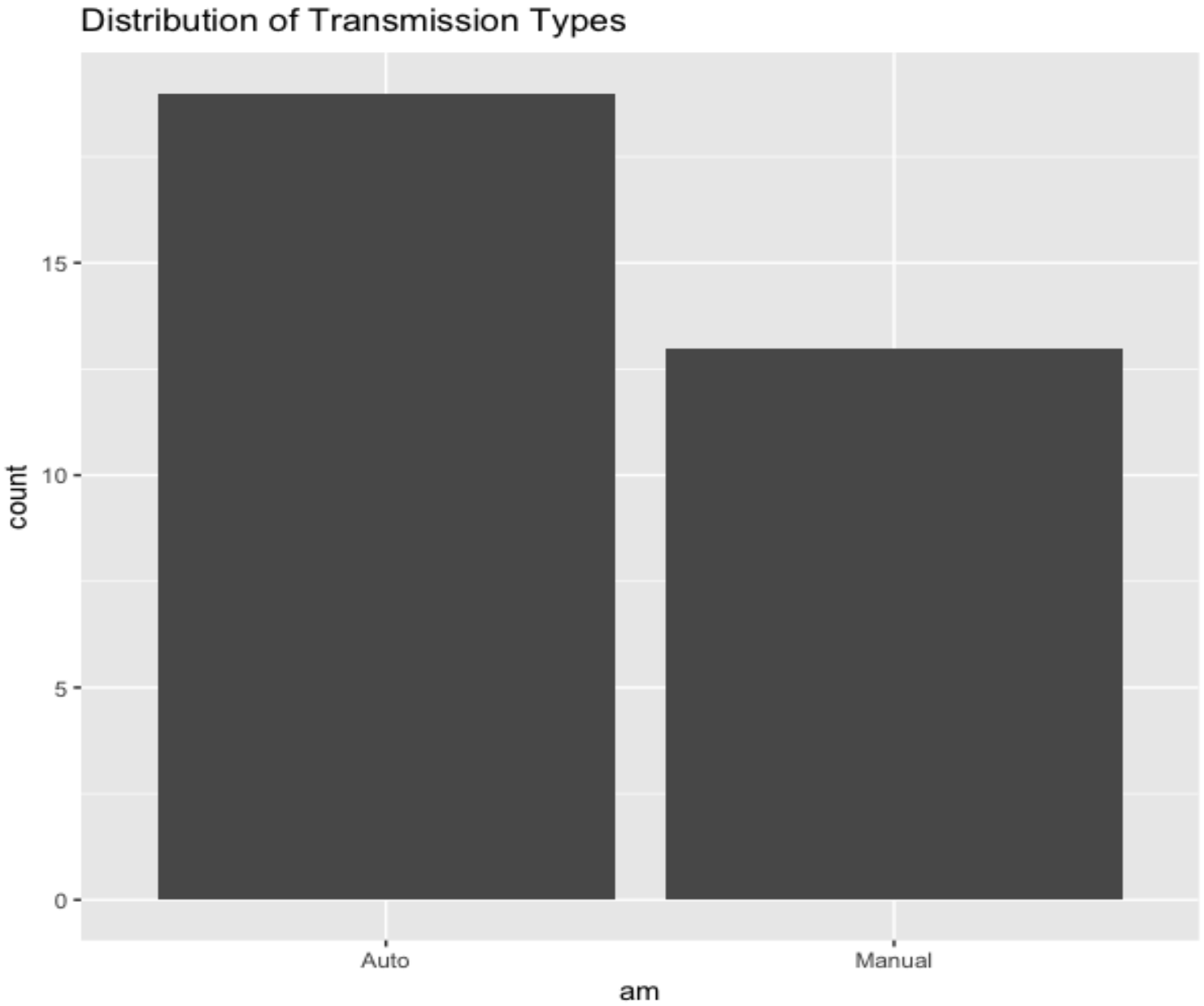


# Couint and Table

- What about tabular data ?
- ggplot ususally prefers data frames as input
- aggregation commands in R produce tables
- If you have the dataframe used to produce the table then use that
- Consider the following:

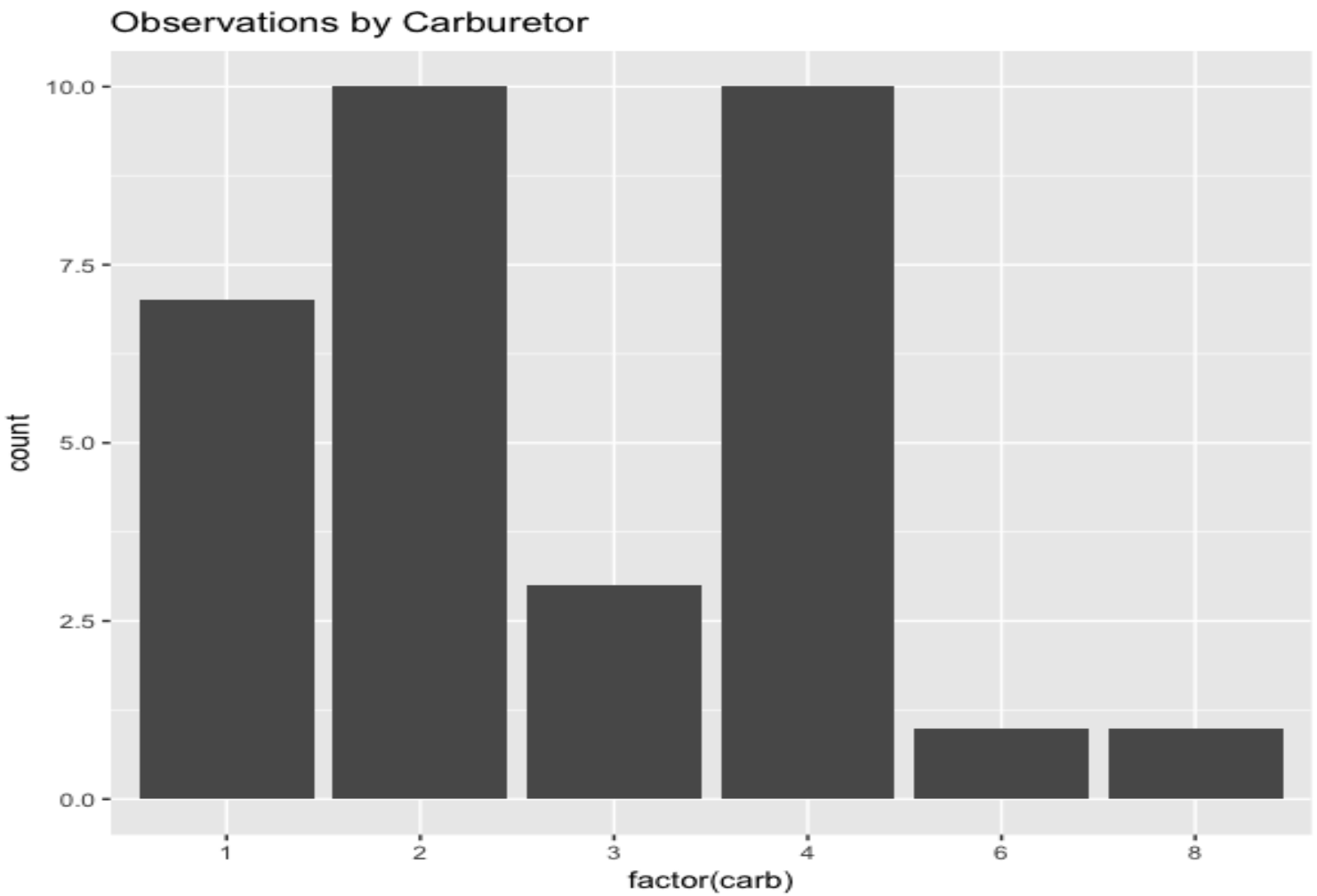
```
# A barplot of cars by Transmission Type

mtcars$am <- factor(mtcars$am, labels=c("Auto","Manual"))
ggplot(mtcars,aes(x=am)) + geom_bar() +
                           ggtitle("Distribution of Transmission Types")
```

# Count and Tabular Data



# Count and Tabular Data

```
ggplot(mtcars,aes(x=factor(carb))) + geom_bar() +
                                     ggtitle("Observations by Carburetor")
```



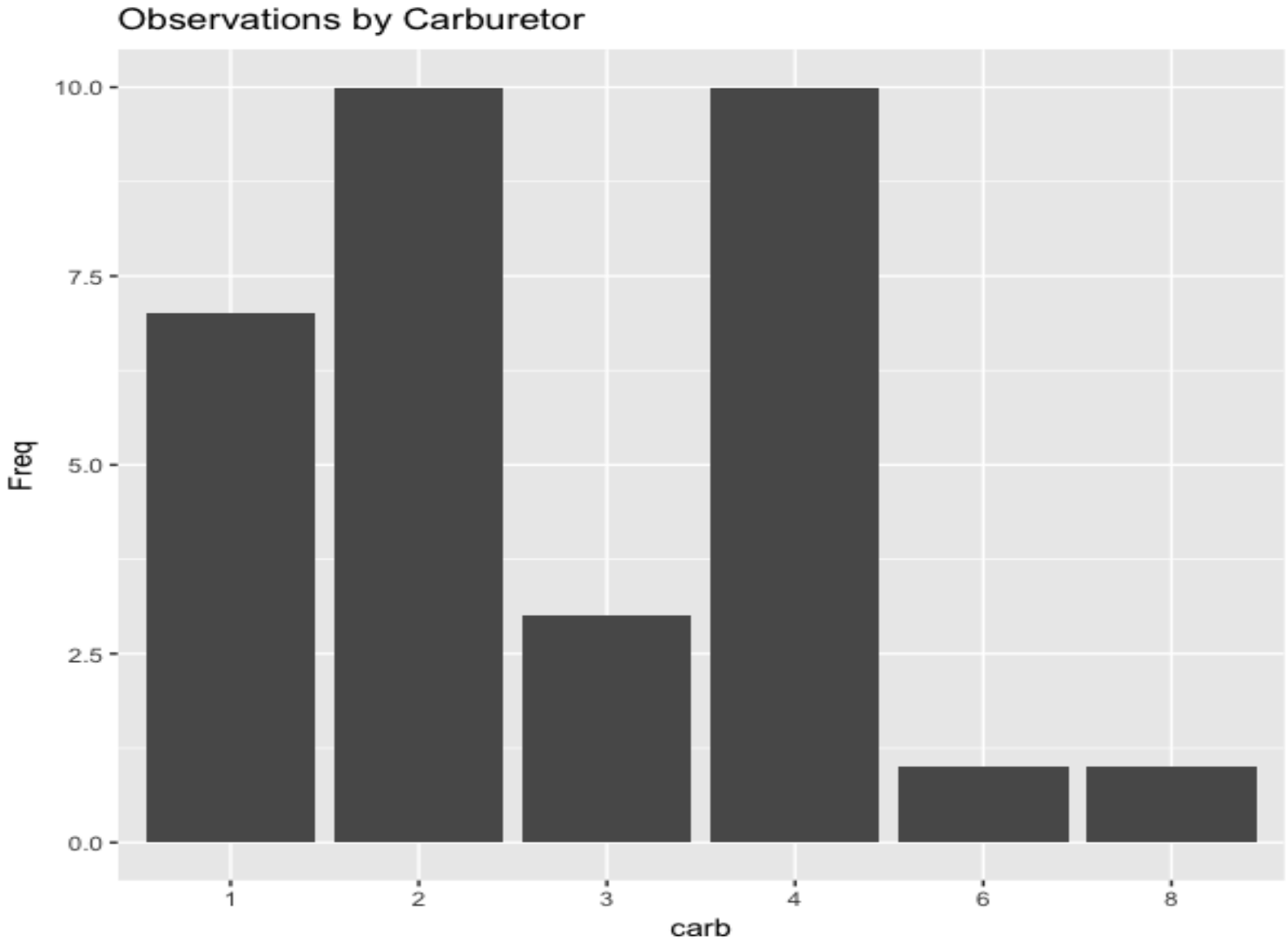
# Count and Tabular Data

What if you are starting with a table ?

```
(ctab <- table(carb=mtcars$carb))
carb
 1  2  3  4  6  8
 7 10  3 10  1  1

# Remember that ggplot wants a data frame

(df <- as.data.frame(ctab))

ggplot(df,aes(x=carb,y=Freq)) + geom_bar(stat="identity") +
                                    ggtitle("Observations by Carburetor")
```

# Count and Tabular Data

What if you are starting with a table ?



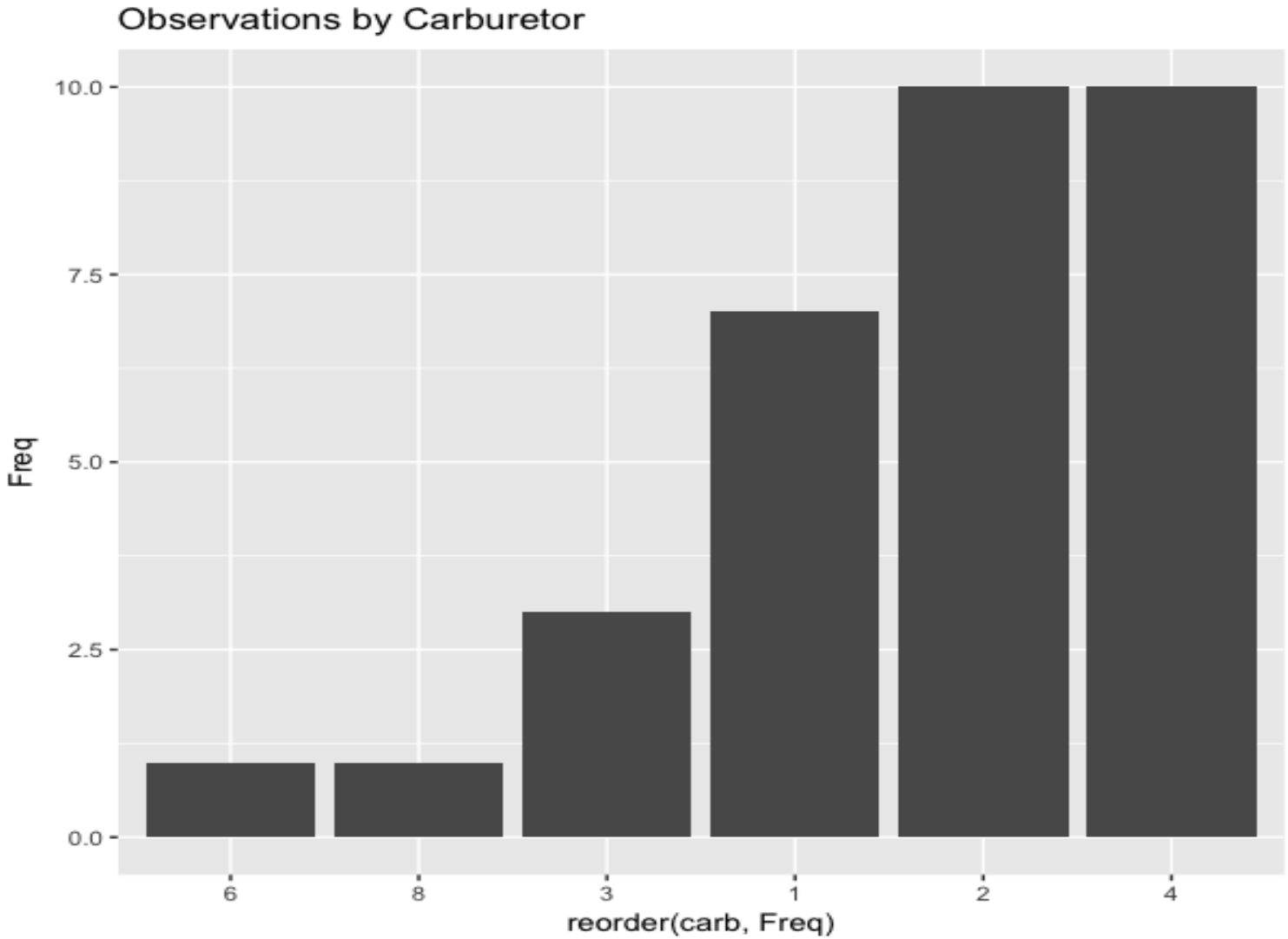
# Count and Tabular Data

What if you are starting with a table ? How to order the bars ?

```
(ctab <- table(carb=mtcars$carb))
carb
 1  2  3  4  6  8
 7 10  3 10  1  1

# Remember that ggplot wants a data frame. We also use a "stat" of
# "identity" since we are using a pre-existing table that already has
# count information.

# geom_bar uses "stat_count" by default which does the counting for you.
# But we already have the counts in our table !

(df <- as.data.frame(ctab))

ggplot(df,aes(x=reorder(carb,Freq),y=Freq)) + geom_bar(stat="identity") +
                                        ggtitle("Observations by Carburetor")
```

# Count and Tabular Data

What if you are starting with a table ? How to order the bars ?



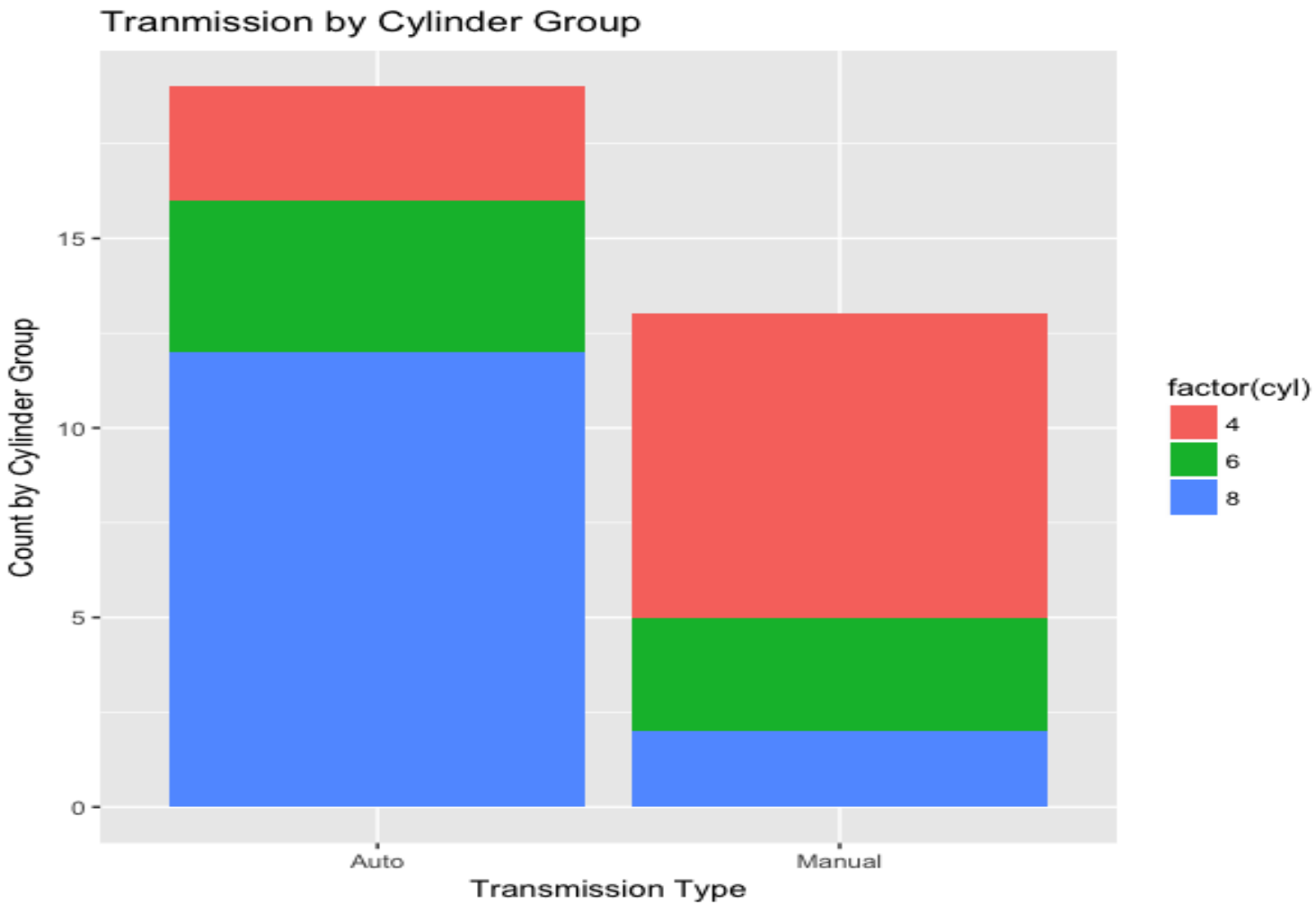
# Count and Tabular Data

- If you want to look at a 2-way count table then you can use the **fill** aesthetic.
- This is one of those things that actually winds up being easier in Base graphics
- Although once you learn the "grammar of graphics" this becomes easier
- This relates mostly to table and count data

```
ggplot(mtcars,aes(x=am)) + geom_bar(aes(fill=factor(cyl))) +
                           ggtitle("Tranmission by Cylinder Group") +
                           xlab("Transmission Type") +
                           ylab("Count by Cylinder Group")
```

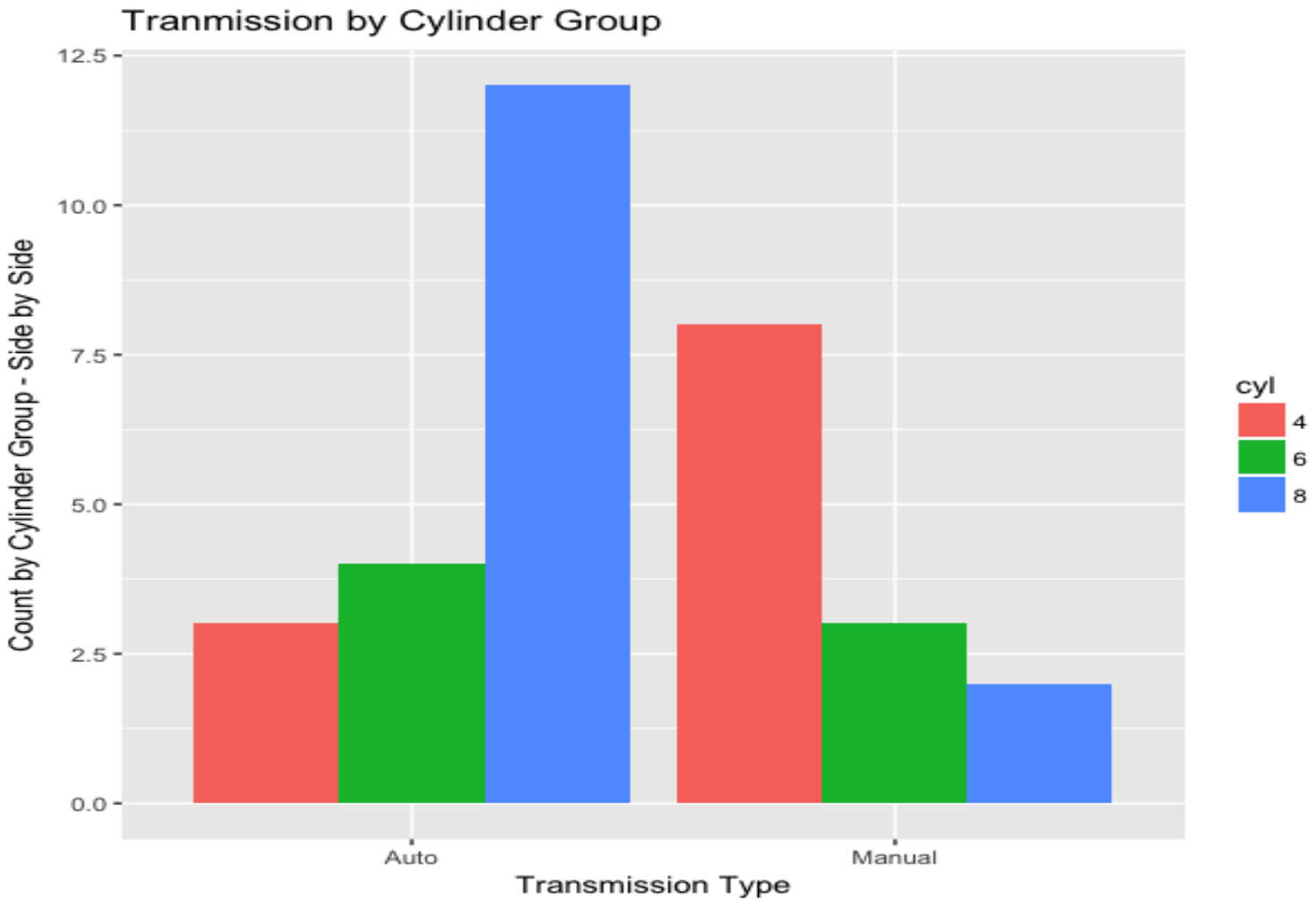
# Count and Tabular Data

```
ggplot(mtcars,aes(x=am)) + geom_bar(aes(fill=factor(cyl))) +
                           ggtitle("Tranmission by Cylinder Group") +
                           xlab("Transmission Type") +
                           ylab("Count by Cylinder Group")
```



# Count and Tabular Data

```
mtcars <- transform(mtcars,am=factor(am,labels=c("Auto","Manual")),cyl=factor(cyl))
ggplot(mtcars,aes(x=am)) + geom_bar(aes(fill=cyl),position="dodge") +
                           ggtitle("Tranmission by Cylinder Group") +
                           xlab("Transmission Type") +
                           ylab("Count by Cylinder Group - Side by Side")
```

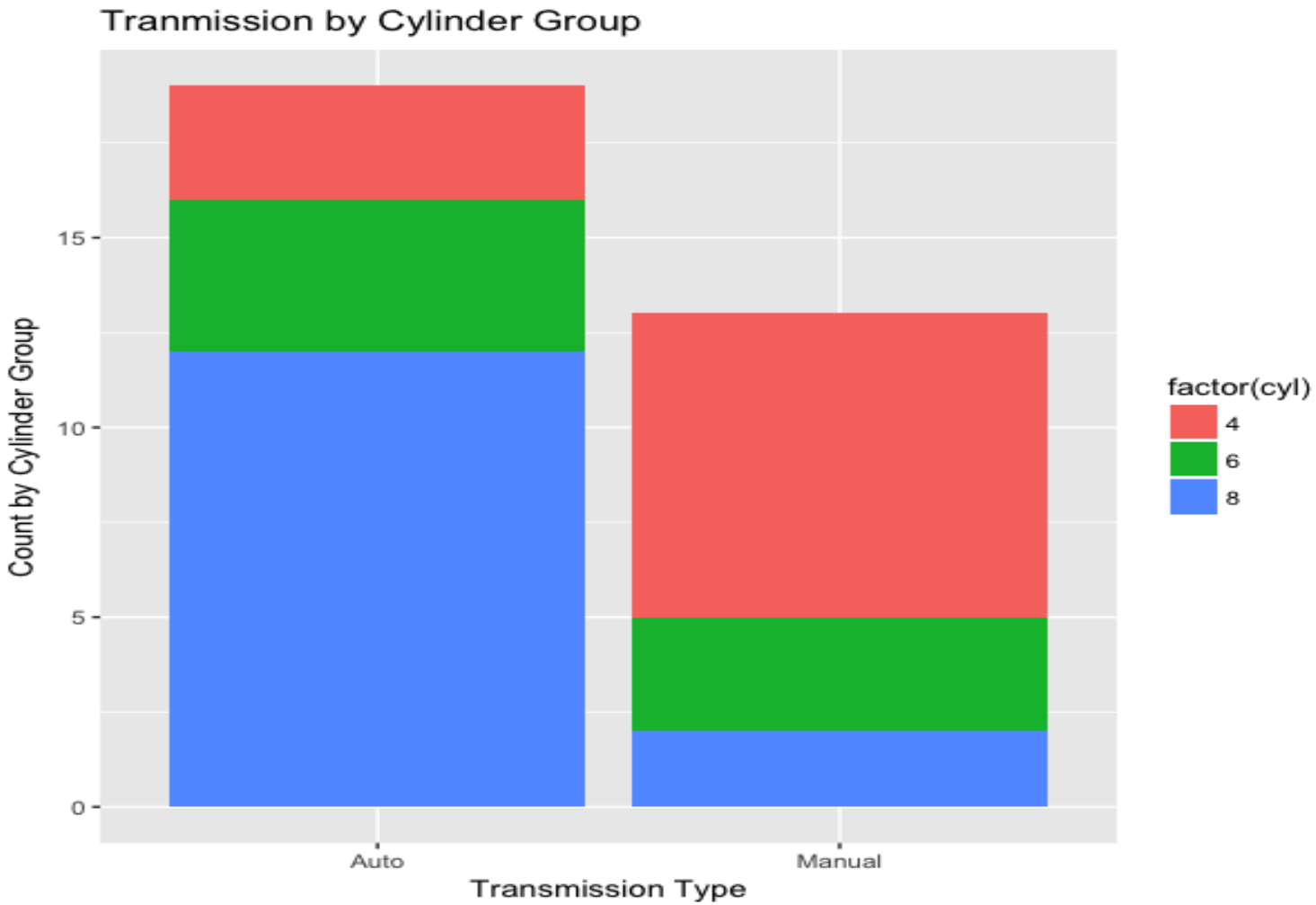


# Count and Tabular Data

But what if you have just the table without data from whence it came ?

```
sometable
             cyl
transmission  4  6  8
      Auto    3  4 12
      Manual  8  3  2

df <- as.data.frame(sometable)

ggplot(df,aes(transmission,Freq,fill=cyl)) +
                            geom_bar(stat="identity") +
                            ggtitle("Tranmission by Cylinder Group") +
                            xlab("Transmission Type") +
                            ylab("Count by Cylinder Group")
```

# Count and Tabular Data

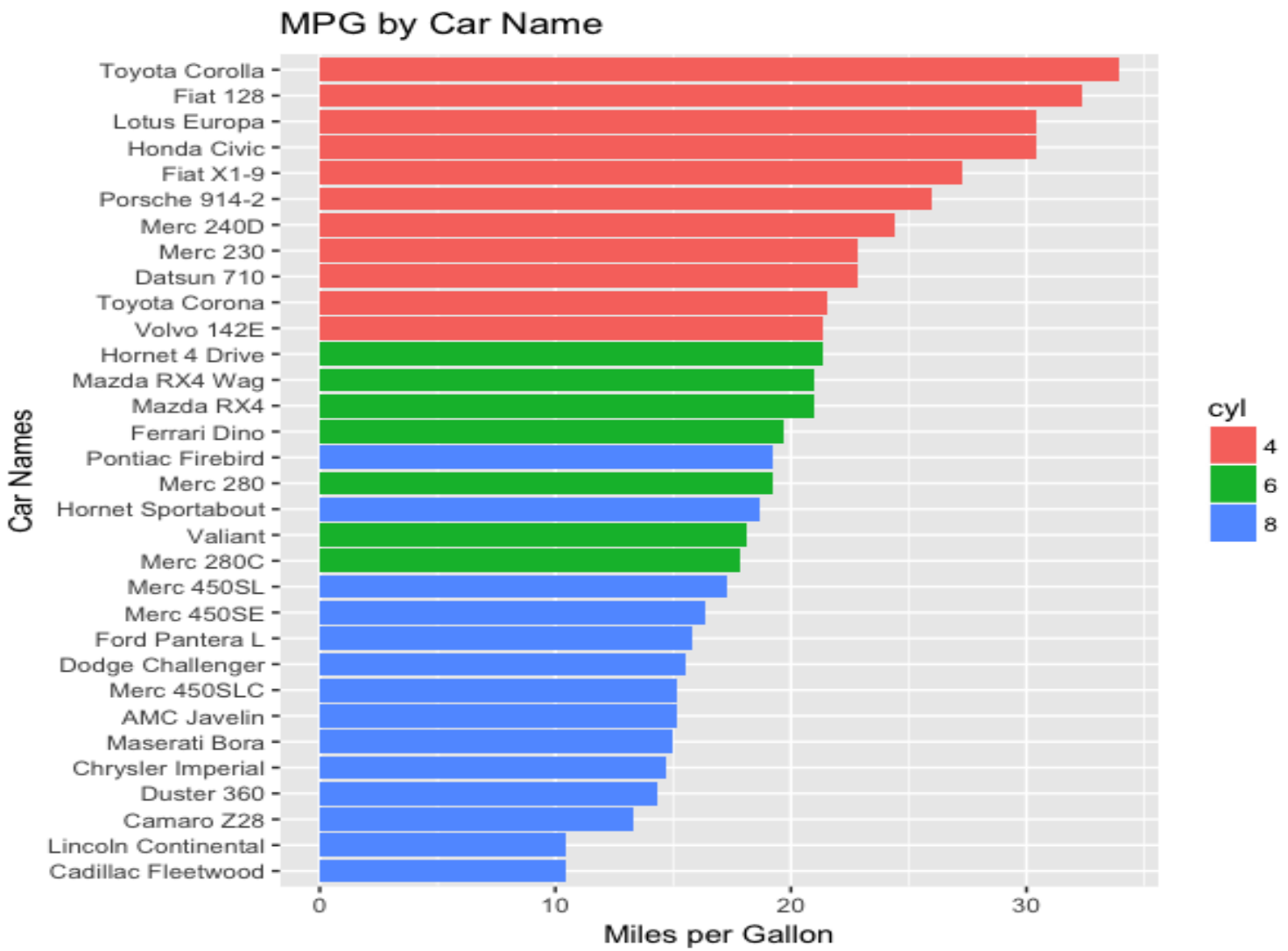


# Count and Tabular Data

Here is how to list the cars in mtcars by MPG from best to worst

```
# Make Cylinder into a factor

mtcars$cyl <- factor(mtcars$cyl,labels=seq(4,8,2))

# Use reorder to arrange the data from high MPG to low

ggplot(mtcars, aes(x = reorder(row.names(mtcars), mpg),
                   y = mpg)) +
  geom_bar(aes(fill = cyl),stat = "identity") +
  coord_flip() +
  xlab("Car Names") + ylab("Miles per Gallon") +
  ggtitle("MPG by Car Name")
```

# Count and Tabular Data



# ggmaps - Maps

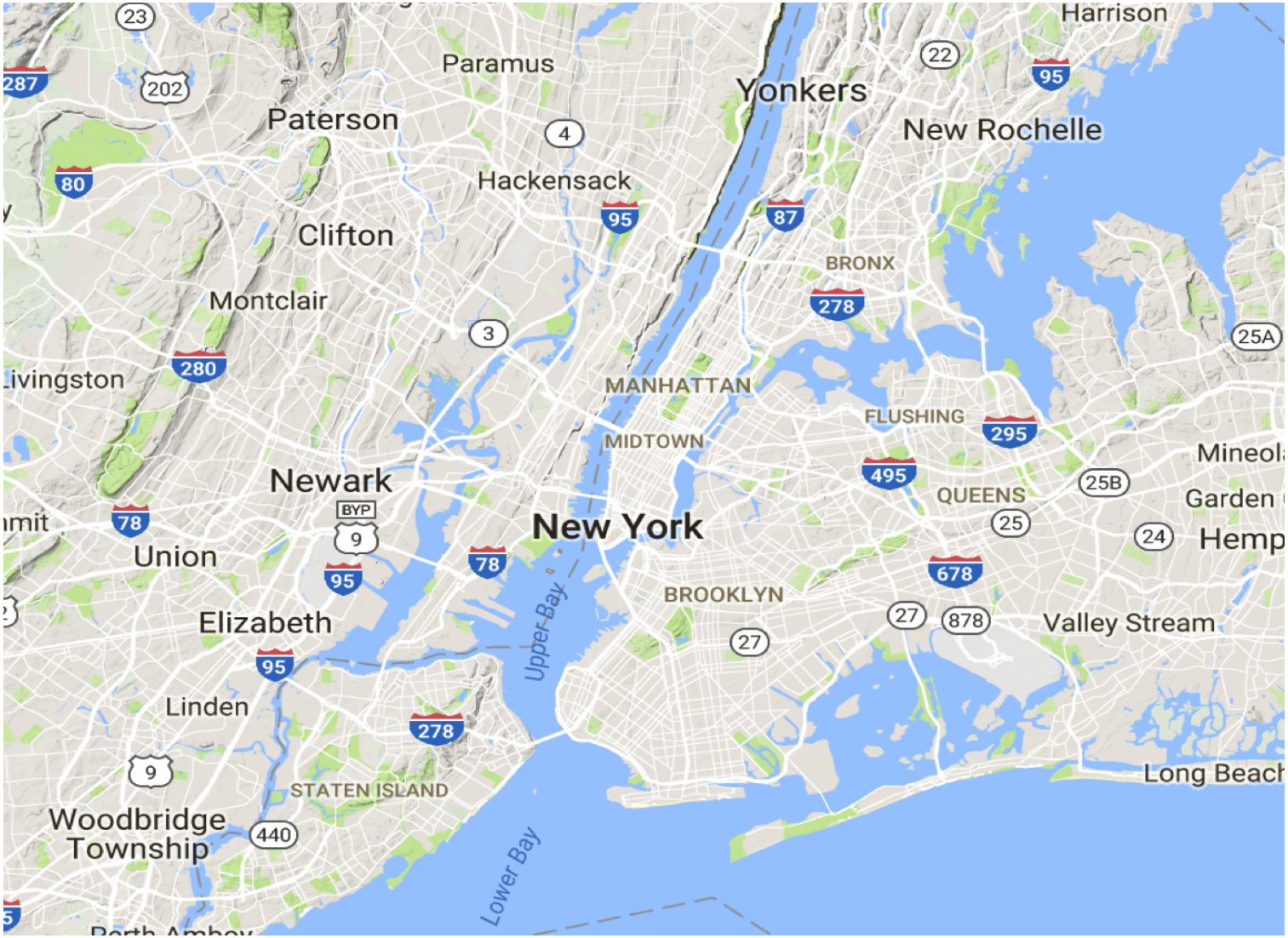
The following material adopted from Data Camp course on Spatial Data

# ggmaps - Maps

ggplot has a companion package called ggmap which helps us with maps. It conforms to the philosphy adhered to in the ggplot package

```
# Get the Lat / Lon pair
nyc <- c(lon = -74.0059, lat = 40.7128)

# Get the Map and set a zoom leve
nyc_map <- get_map(location = nyc, zoom = 10)

# Actually display the map
ggmap(nyc_map)
```

# ggmap

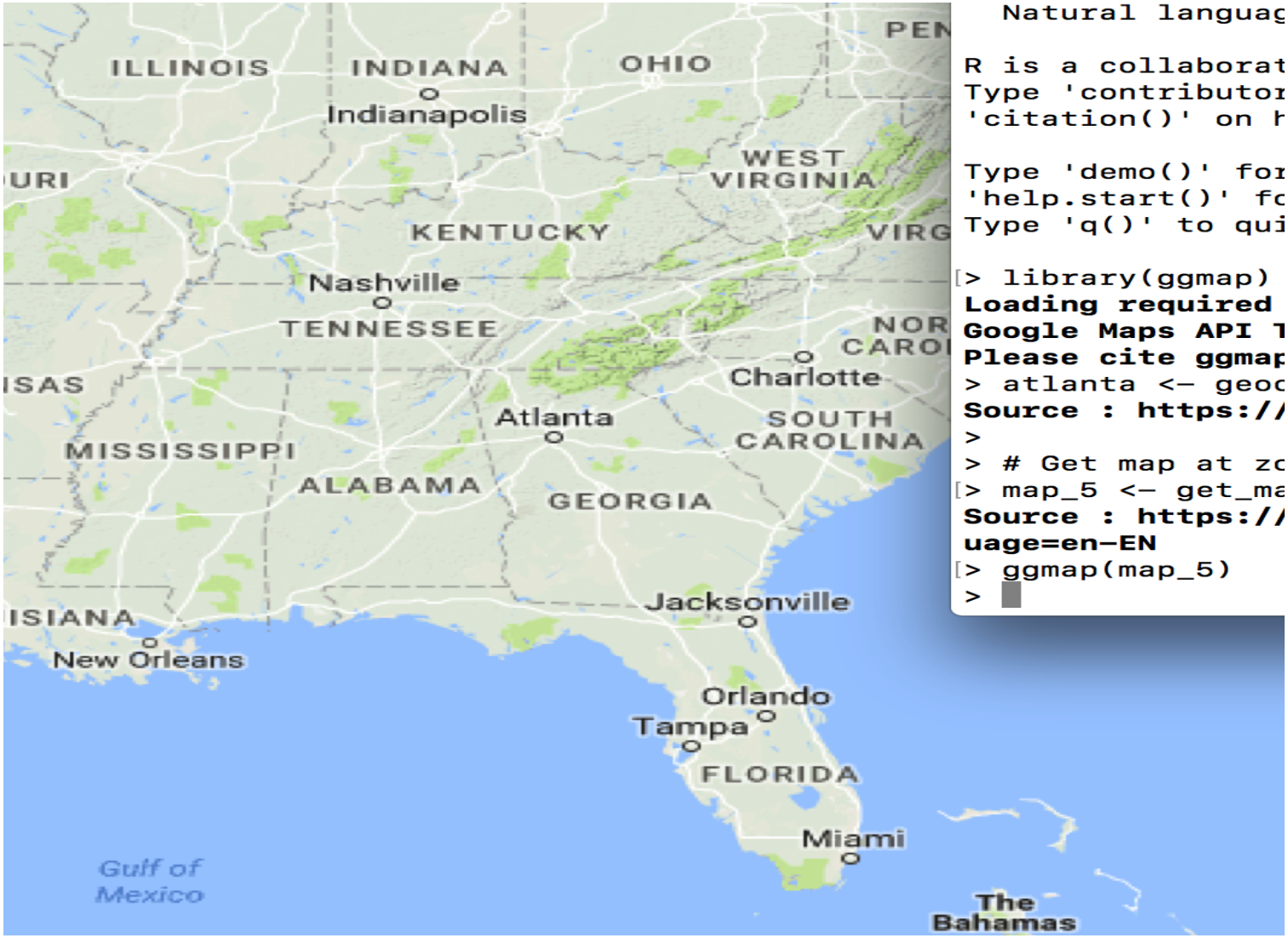

Harrison
Paramus
Yonkers
New Rochelle
Paterson
Hackensack
Clifton
Montclair
BRONX
MANHATTAN
FLUSHING
MIDTOWN
Newark
New York
QUEENS
Union
BROOKLYN
Elizabeth
Upper Bay
Valley Stream
Linden
STATEN ISLAND
Woodbridge Township
Lower Bay
Long Beach
Garden
Hemp
Mineol
23
202
287
80
4
95
87
22
278
3
280
25A
25B
495
295
78
BYP
9
678
27
878
440

# ggmaps - Maps

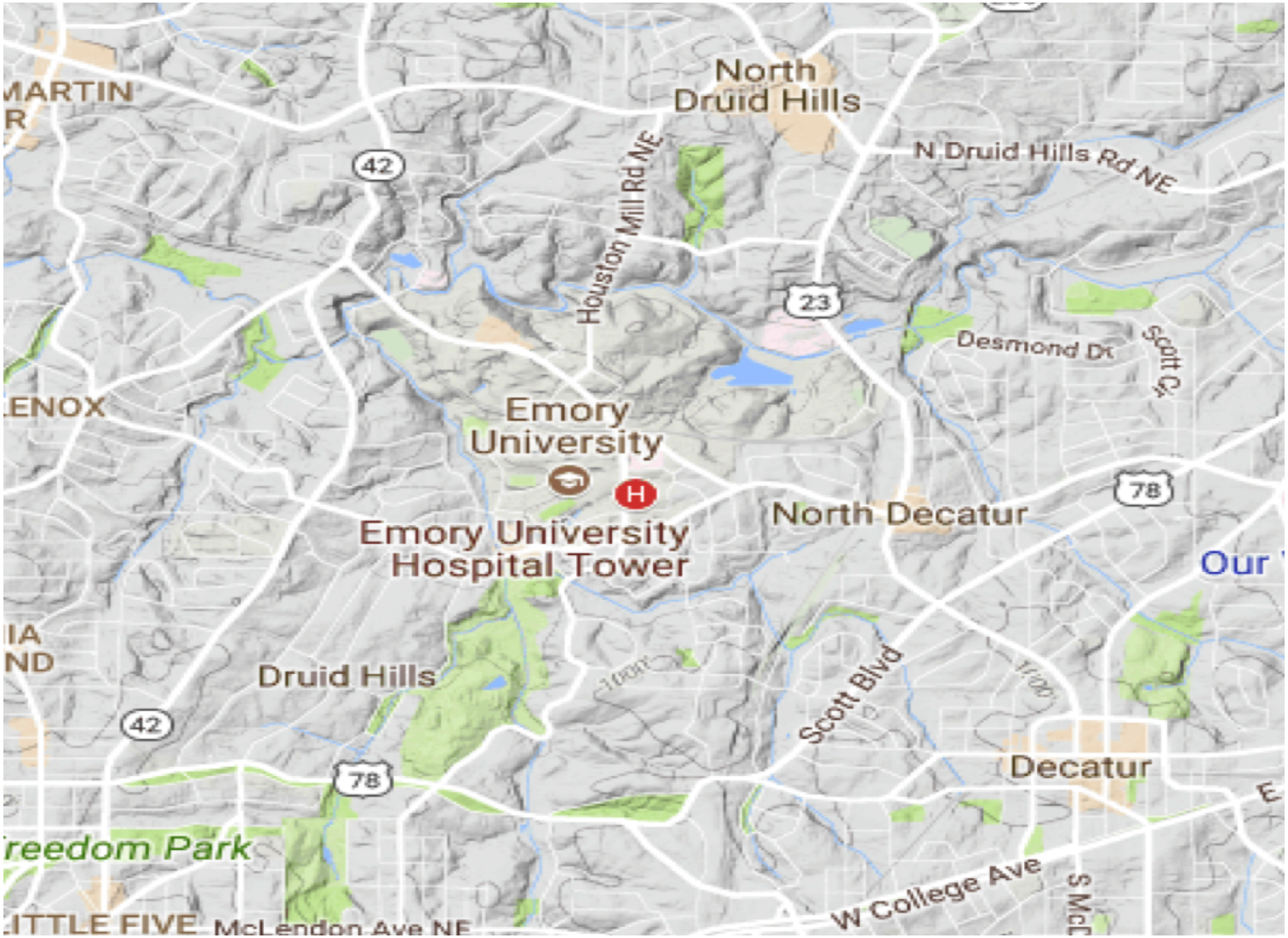
ggplot has a companion package called ggmap which helps us with maps. It conforms to the philosphy adhered to in the ggplot package

```
atlanta <- geocode("1510 Clifton Rd Atlanta, GA 30322")

# Get map at zoom level 5: map_5
map_5 <- get_map(atlanta, zoom = 5, scale = 1)

# Plot map at zoom level 5
ggmap(map_5)

# Get map at zoom level 13: atlanta_map
atlanta_map <- get_map(atlanta, zoom = 13, scale = 1)

# Plot map at zoom level 13
ggmap(atlanta_map)
```

# ggmap


ILLINOIS
INDIANA
Indianapolis
OHIO
WEST VIRGINIA
KENTUCKY
Nashville
TENNESSEE
Charlotte
Atlanta
SOUTH CAROLINA
MISSISSIPPI
ALABAMA
GEORGIA
Jacksonville
New Orleans
Orlando
Tampa
FLORIDA
Miami
Gulf of Mexico
The Bahamas
Natural languag
R is a collaborat
Type 'contributor
'citation()' on h
Type 'demo()' for
'help.start()' fo
Type 'q()' to qui
> library(ggmap)
Loading required
Google Maps API T
Please cite ggmap
> atlanta <- geoc
Source : https://
>
> # Get map at zo
> map_5 <- get_ma
Source : https://
uage=en-EN
> ggmap(map_5)
>

# ggmap

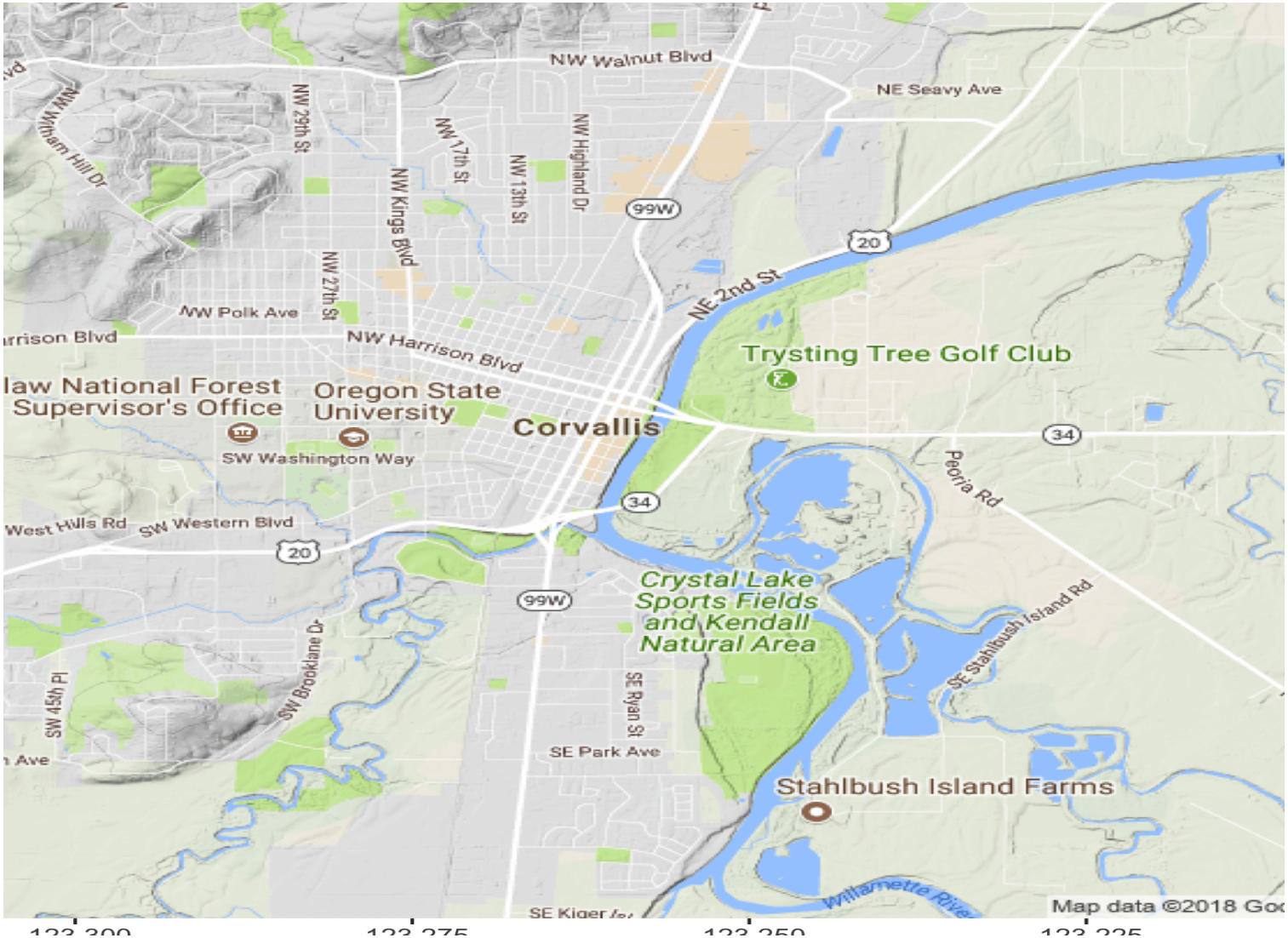

North
Druid Hills
N Druid Hills Rd NE
Houston Mill Rd NE
42
23
Desmond Dr
Emory
University
H
Emory University
Hospital Tower
North Decatur
78
Druid Hills
Scott Blvd
Decatur
42
78
W College Ave
McLendon Ave NE

# ggmaps - Maps

ggplot has a companion package called ggmap which helps us with maps. It conforms to the philosphy adhered to in the ggplot package

```
corvallis <- c(lon = -123.2620, lat = 44.5646)

# Get map at zoom level 5: map_5
map_5 <- get_map(corvallis, zoom = 5, scale = 1)

# Plot map at zoom level 5
ggmap(map_5)

# Get map at zoom level 13: corvallis_map
corvallis_map <- get_map(corvallis, zoom = 13, scale = 1)

# Plot map at zoom level 13
ggmap(corvallis_map)
```

# ggmap


NW Walnut Blvd
NE Seavy Ave
NW Wilham Hill Dr
NW 25th St
NW Kings Blvd
NW 17th St
NW 13th St
NW Highland Dr
99W
20
NE 2nd St
NW 27th St
NW Polk Ave
NW Harrison Blvd
Trysting Tree Golf Club
law National Forest
Supervisor's Office
Oregon State
University
Corvallis
SW Washington Way
34
Peoria Rd
West Hills Rd
SW Western Blvd
20
99W
Crystal Lake
Sports Fields
and Kendall
Natural Area
SW 45th Pl
SW Brooklane Dr
SE Ryan St
SE Park Ave
SE Stahlbush Island Rd
Stahlbush Island Farms
Willamette River
Map data ©2018 Goo

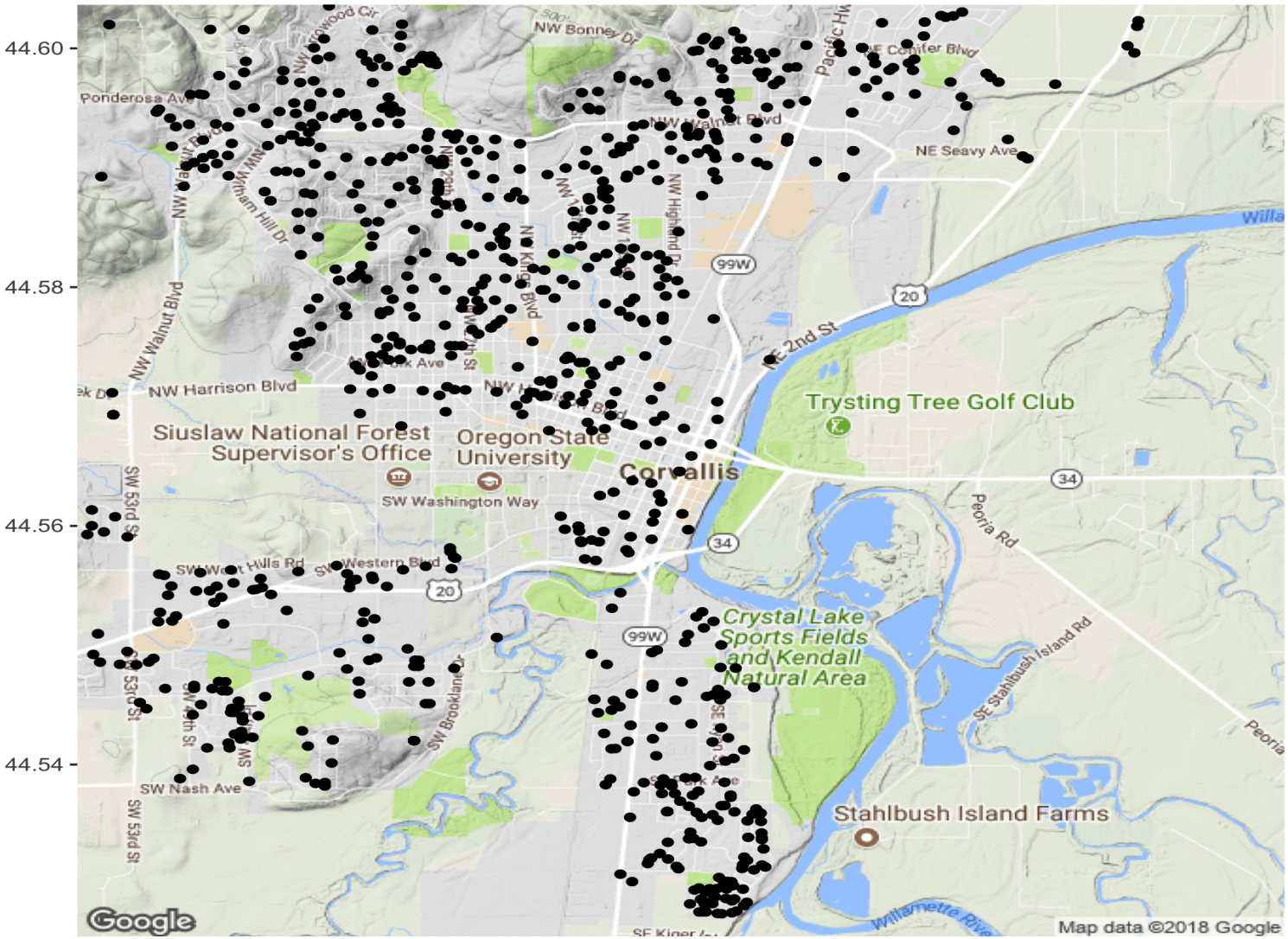
# ggmaps - Maps

We can put points on top of this map:

```
url <- "https://assets.datacamp.com/production/course_1816/datasets/01_corv_sales.rds","corv_sales.rds"
```

```
if (!file.exists("corv_sales.rds")) {
  download.file(url,"corv_sales.rds")
}

sales <- readRDS("corv_sales.rds")
head(sales)

# Swap out call to ggplot() with call to ggmap()

ggmap(corvallis_map) +
  geom_point(aes(lon, lat), data = sales)
```

# ggmap


44.60
44.58
44.56
44.54
Ponderosa Ave
NW Bonney Dr
NW Walnut Blvd
NE Seavy Ave
NW Harrison Blvd
Siuslaw National Forest
Supervisor's Office
Oregon State
University
Corvallis
SW Washington Way
Trysting Tree Golf Club
NE 2nd St
Peoria Rd
Crystal Lake
Sports Fields
and Kendall
Natural Area
SE Stahlbush Island Rd
Stahlbush Island Farms
SW Nash Ave
SW 53rd St
99W
20
34
Google
Map data ©2018 Google

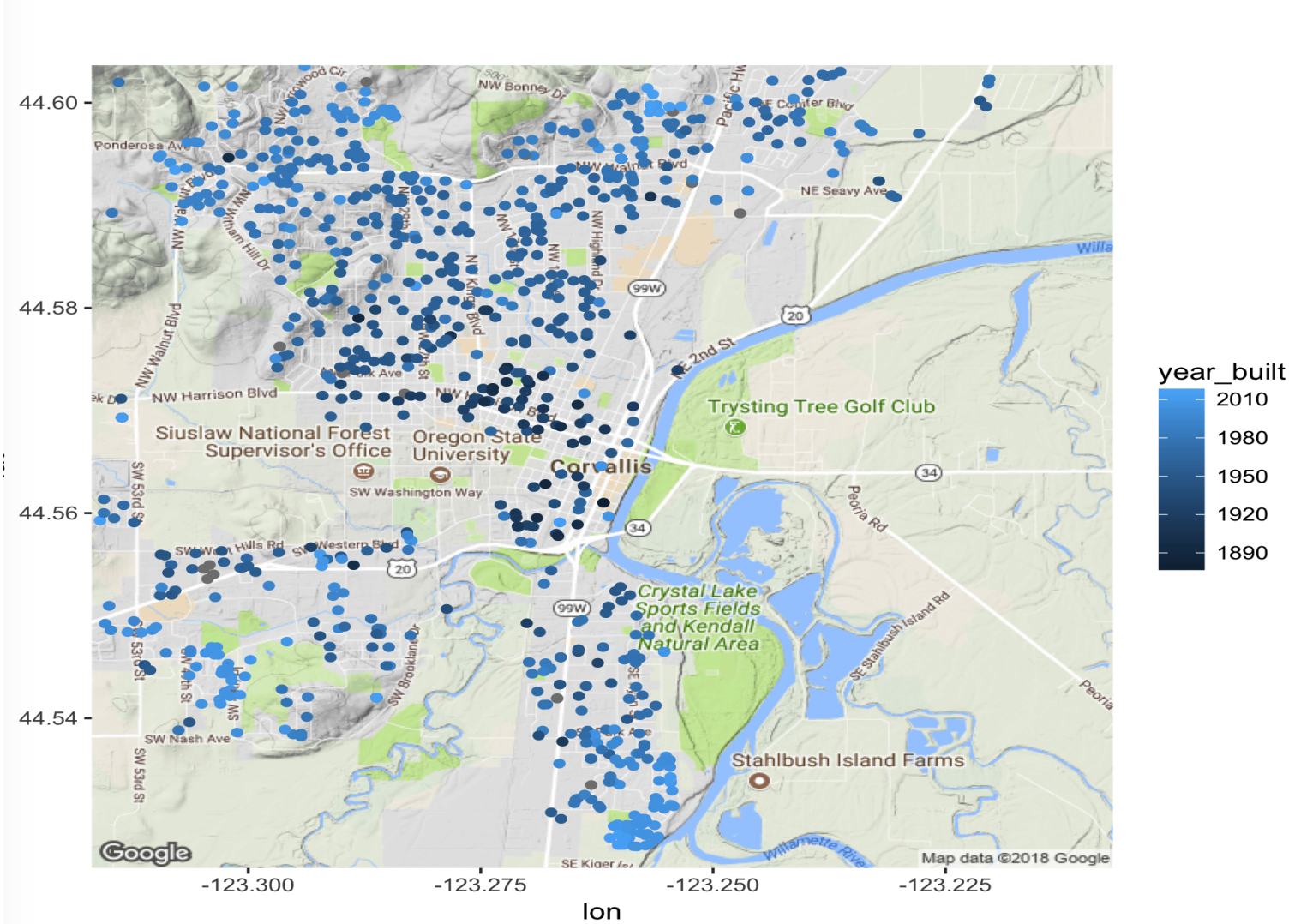
# ggmaps - Maps

- Map the color of the points to year built.
- Map the size of the points to bedrooms.
- Map the color of the points to price per squarefoot
- That is the price / finished_squarefeet).
- Are there areas with better "value" than others?

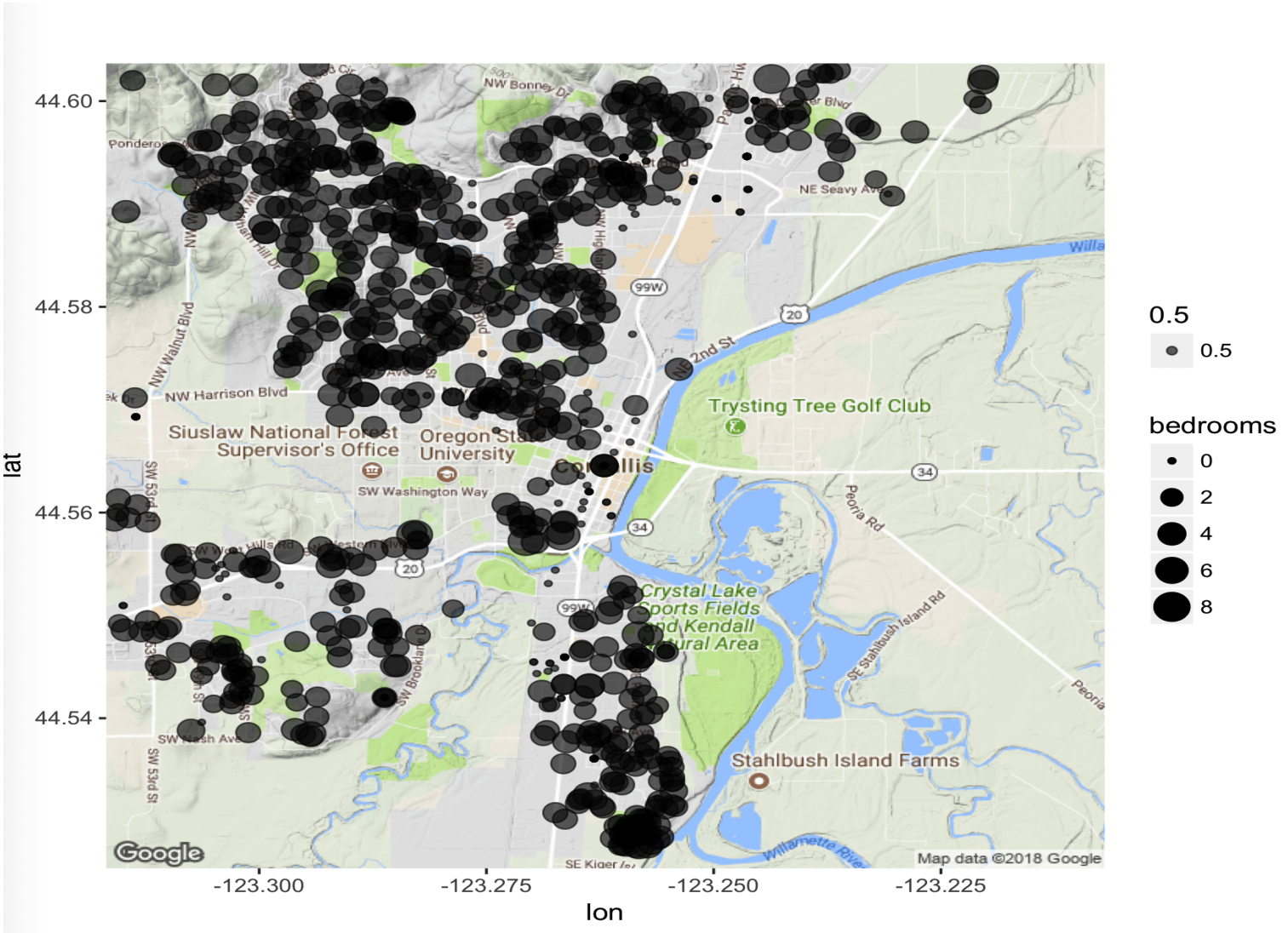
# ggmaps - Maps

```
# Map color to year_built
ggmap(corvallis_map) +
  geom_point(aes(lon, lat, color=year_built), data = sales)

# Map size to bedrooms
ggmap(corvallis_map) +
  geom_point(aes(lon, lat,size=bedrooms,alpha=.5), data = sales)

# Map color to price / finished_squarefeet
ggmap(corvallis_map) +
  geom_point(aes(lon, lat,color=price/finished_squarefeet),
             data = sales)
```

# ggmap


44.60
44.58
44.56
44.54
-123.300
-123.275
-123.250
-123.225
lon
year_built
2010
1980
1950
1920
1890
Trysting Tree Golf Club
Siuslaw National Forest Supervisor's Office
Oregon State University
Corvallis
Crystal Lake Sports Fields and Kendall Natural Area
Stahlbush Island Farms
NW Harrison Blvd
SW Washington Way
NW Walnut Blvd
NE Seavy Ave
SW Nash Ave
Google
Map data ©2018 Google

# ggmap

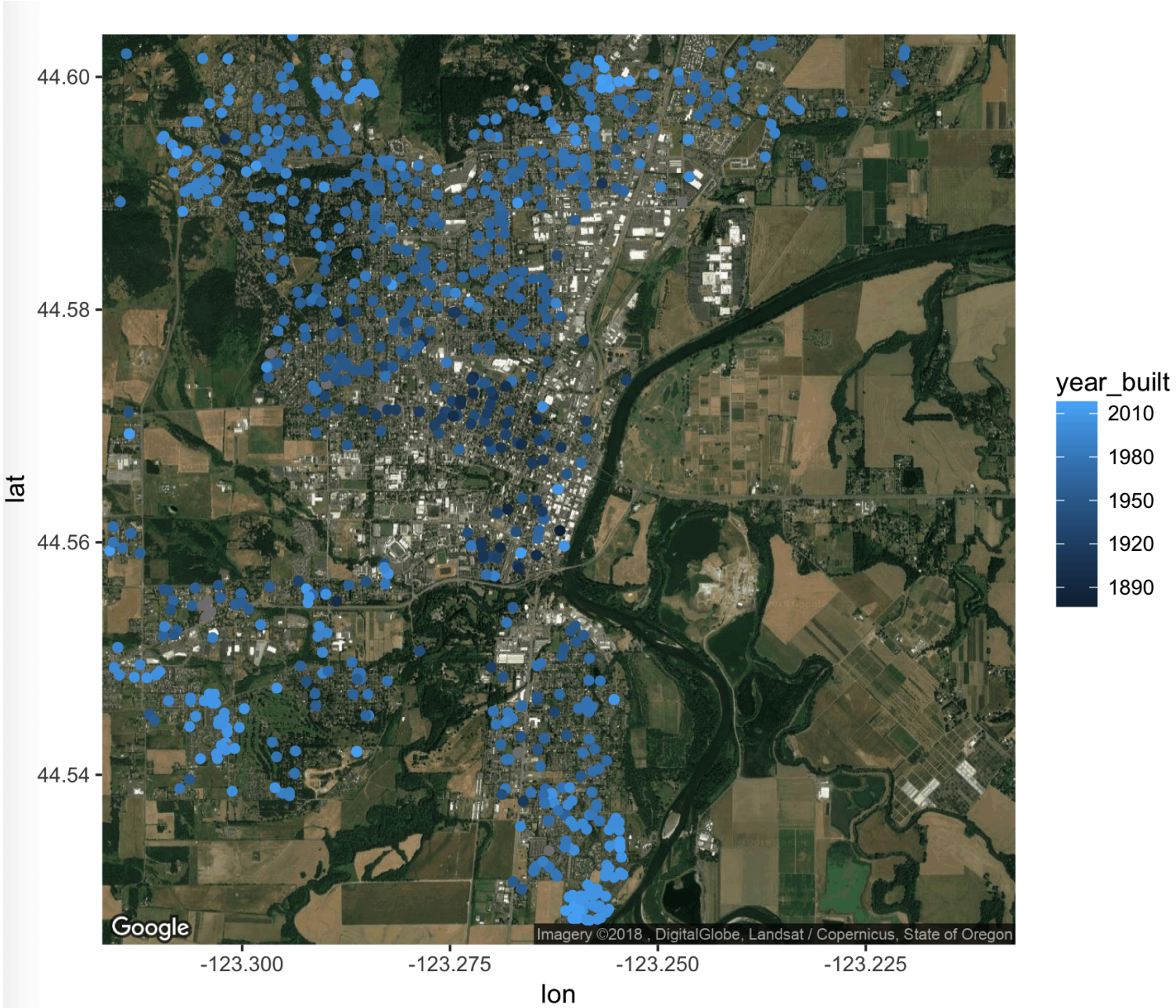

44.60
44.58
44.56
44.54
lat
-123.300
-123.275
-123.250
-123.225
lon
Trysting Tree Golf Club
Siuslaw National Forest Supervisor's Office
Oregon State University
Crystal Lake Sports Fields
Stahlbush Island Farms
NW Harrison Blvd
SW Washington Way
NW Walnut Blvd
NE Seavy Ave
2nd St
Peoria Rd
SE Stahlbush Island Rd
Google
Map data ©2018 Google
0.5
0.5
bedrooms
0
2
4
6
8

# ggmaps - Maps

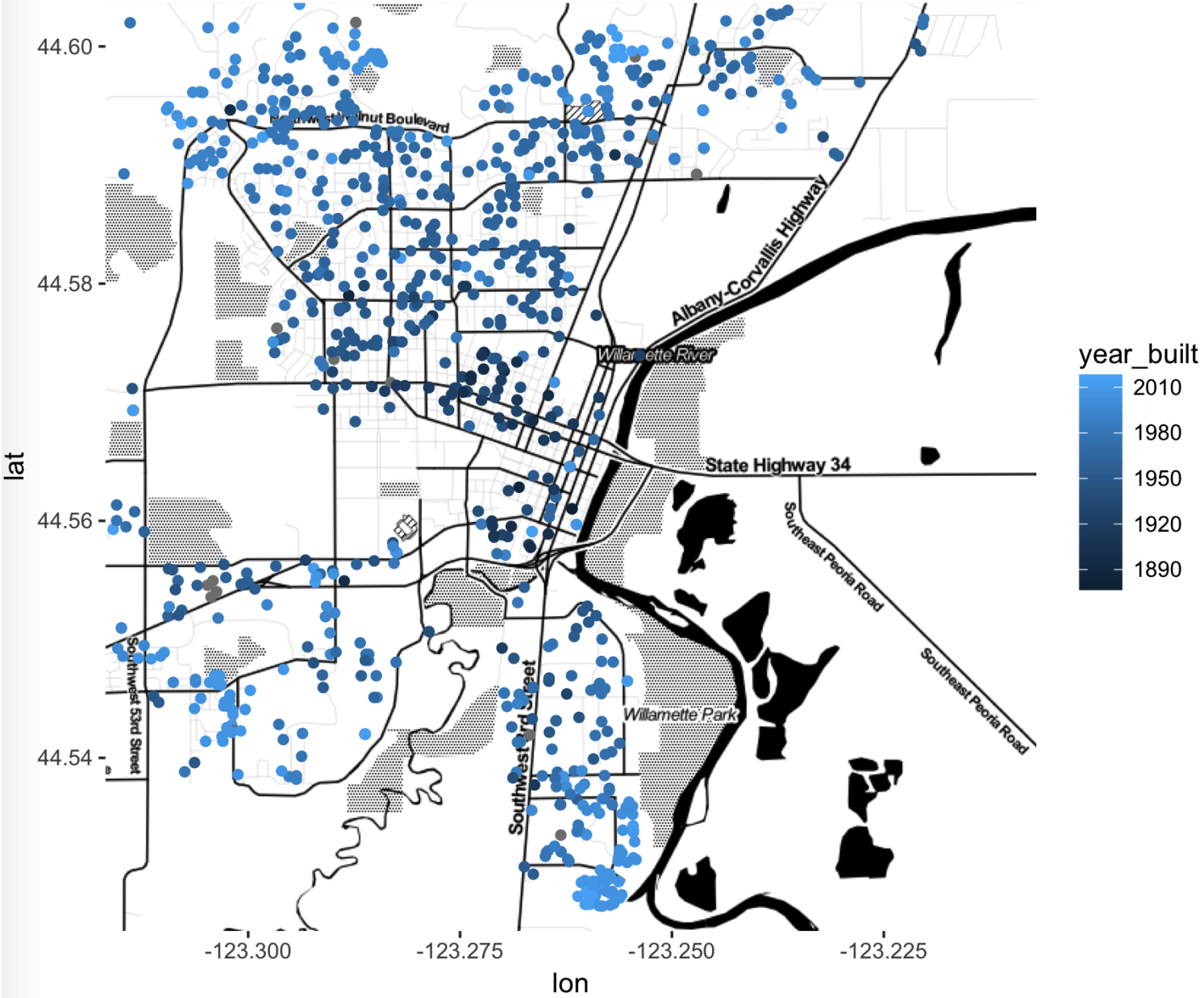
There are many different map types as well as sources

```
corvallis <- c(lon = -123.2620, lat = 44.5646)

# Add a maptype argument to get a satellite map
corvallis_map_sat <- get_map(corvallis, zoom = 13,
                             maptype = "satellite")

# Edit to display satellite map
ggmap(corvallis_map_sat) +
  geom_point(aes(lon, lat, color = year_built), data = sales)

# Add source and maptype to get toner map from Stamen Maps
corvallis_map_bw <- get_map(corvallis, zoom = 13,source="stamen",
                            maptype="toner")

# Edit to display toner map
ggmap(corvallis_map_bw) +
  geom_point(aes(lon, lat, color = year_built), data = sales)
```

# ggmap


44.60
44.58
44.56
44.54
lat
-123.300
-123.275
-123.250
-123.225
lon
Google
Imagery ©2018 , DigitalGlobe, Landsat / Copernicus, State of Oregon
year_built
2010
1980
1950
1920
1890

# ggmap


44.60
44.58
44.56
44.54
lat
-123.300
-123.275
-123.250
-123.225
lon
Albany-Corvallis Highway
Willamette River
State Highway 34
Southeast Peoria Road
Southeast Peoria Road
Southwest 53rd Street
Southwest 3rd Street
Willamette Park
year_built
2010
1980
1950
1920
1890

# ggmaps - Maps

Let's look at the San Francisco restaurant data

```
setwd("/Users/esteban/SF_RESTAURANTS")
businesses  <- read.csv("businesses_plus.csv",sep=",")
inspections <- read.csv("inspections_plus.csv",sep=",")

# Let's get the top 40 worst businesses in terms of
# insepction scores

top100worst <- inspections %>% arrange((Score)) %>% head(.,100)

# Join this with he businesses table to get addresses

top100worst <- left_join(top100worst,businesses) %>%
                          select(name,latitude,longitude,Score)

top100worst <- top100worst[complete.cases(top100worst),]
```

# ggmaps - Maps

Let's look at the San Francisco restaurant data

```
sf <- c(lon = -122.431297, lat = 37.773972)

# Get map at zoom level 5: map_5
map_5 <- get_map(sf, zoom = 13, scale = 1)

ggmap(map_5) + geom_point(aes(longitude, latitude,
                              alpha=0.5,size=-Score),
                          data = top100worst)
```

# ggmap

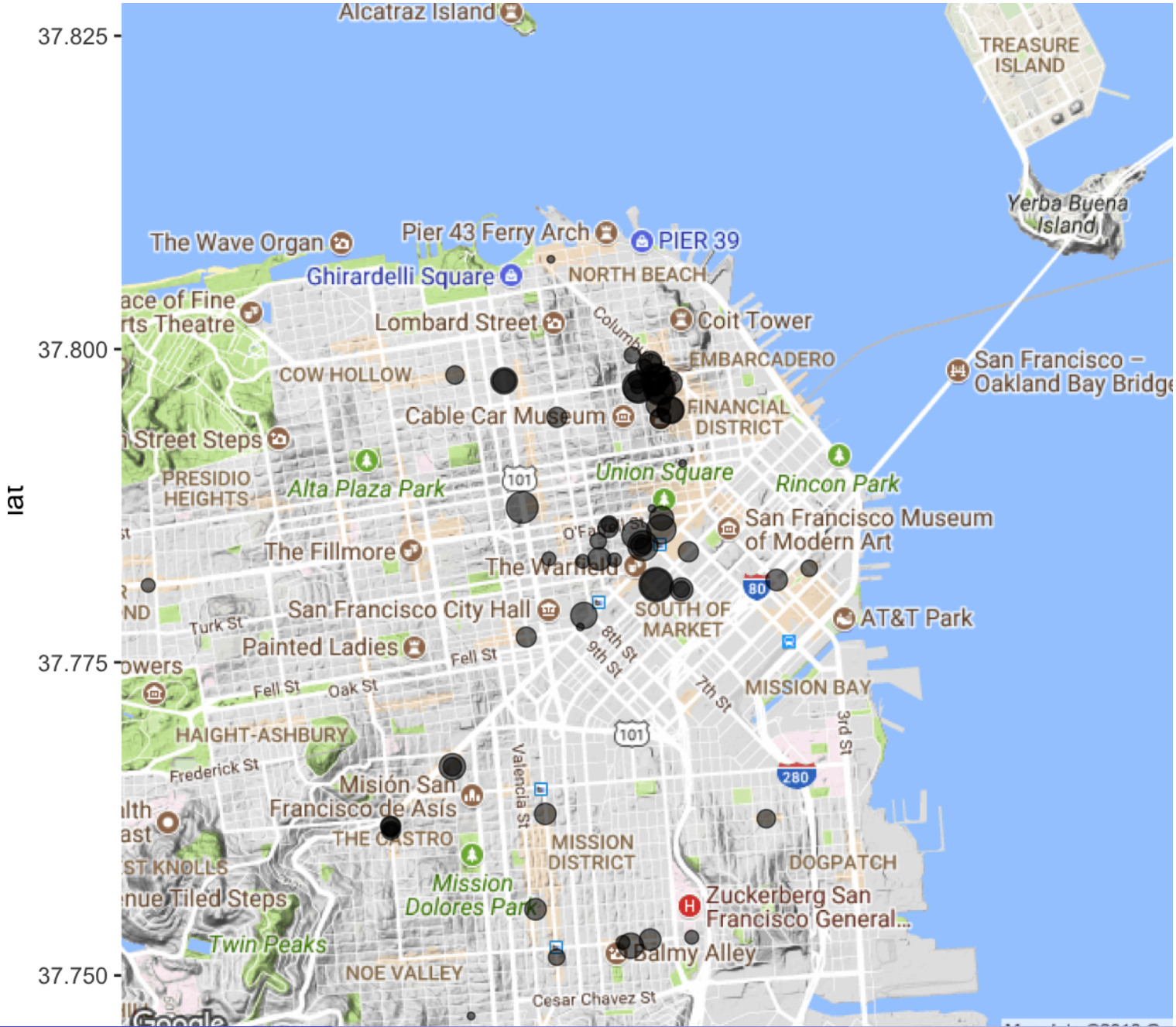

lat
37.800
37.775
37.750
-122.46
-122.43
-122.40
lon
-Score
-60
-55
-50
-45
0.5
0.5
The Wave Organ
Pier 43 Ferry Arch
PIER 39
Ghirardelli Square
NORTH BEACH
Palace of Fine Arts Theatre
Lombard Street
Coit Tower
PRESIDIO
COW HOLLOW
EMBARCADERO
Cable Car Museum
FINANCIAL DISTRICT
Lyon Street Steps
PRESIDIO HEIGHTS
Alta Plaza Park
Union Square
Rincon Park
San Francisco Museu of Modern Art
The Fillmore
The Warfield
RICHMOND DISTRICT
INNER RICHMOND
San Francisco City Hall
SOUTH OF MARKET
AT&T Park
Painted Ladies
Conservatory of Flowers
MISSION BAY
HAIGHT-ASHBURY
UCSF Health Sciences East
Misión San Francisco de Asís
THE CASTRO
MISSION DISTRICT
DOGPATCH
FOREST KNOLLS
16th Avenue Tiled Steps
Mission Dolores Park
Zuckerberg San Francisco General...
Twin Peaks
Balmy Alley
NOE VALLEY
FOREST HILL
Billy Goat Hill
WEST PORTAL
BERNAL HEIGHTS
GLEN PARK
Sigmund Stern Recreation Grove
City College of San
Google
Map data ©2018 Google

# ggmaps - Maps

Let's look at the San Francisco restaurant data

```
map_5 <- get_map(sf, zoom = 13, scale = 1)

ggmap(map_5) + geom_point(aes(longitude, latitude,
                              alpha=0.5,size=-Score),
                          data = top100worst)


sf <- c(lon = -122.4075, lat = 37.7880)

# Get map at zoom level 5: map_5
map_5 <- get_map(sf, zoom = 13, scale = 1)

ggmap(map_5) + geom_point(aes(longitude, latitude,
                              alpha=0.2,size=-Score),
                          data = top100worst)
```

# ggmap


37.825
37.800
37.775
37.750
lat
Alcatraz Island
TREASURE ISLAND
Yerba Buena Island
The Wave Organ
Pier 43 Ferry Arch
PIER 39
Ghirardelli Square
NORTH BEACH
Lombard Street
Coit Tower
COW HOLLOW
EMBARCADERO
San Francisco – Oakland Bay Bridge
Cable Car Museum
FINANCIAL DISTRICT
PRESIDIO HEIGHTS
Alta Plaza Park
Union Square
Rincon Park
San Francisco Museum of Modern Art
The Fillmore
The Warfield
San Francisco City Hall
SOUTH OF MARKET
AT&T Park
Painted Ladies
Turk St
Fell St
Oak St
8th St
9th St
7th St
MISSION BAY
3rd St
HAIGHT-ASHBURY
Frederick St
Misión San Francisco de Asís
Valencia St
THE CASTRO
MISSION DISTRICT
DOGPATCH
Mission Dolores Park
Zuckerberg San Francisco General...
Twin Peaks
Balmy Alley
NOE VALLEY
Cesar Chavez St
101
80
280

# ggmaps - Maps

Let's look at some of the Dialysis Data

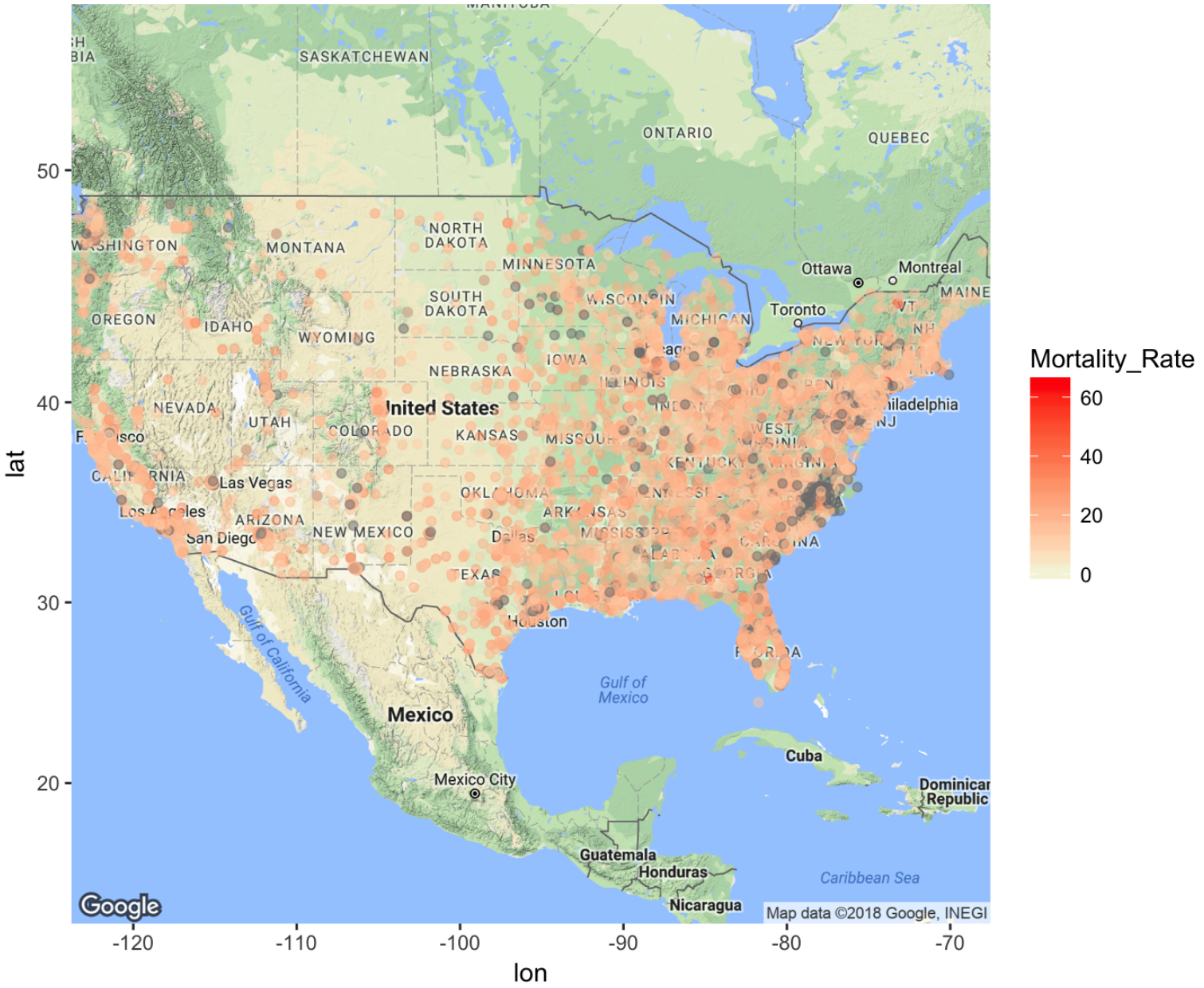
```
setwd("/Users/esteban/Downloads/dialysis")
dia <- read.csv("Dialysis_csv.csv",header=TRUE)
wordlist <- strsplit(as.character(dia$Location),"\\\n")
latlon <- sapply(wordlist,function(x) rev(x)[1])
latlon <- latlon %>% gsub("\\(|\\)","",.)
latlon %>% gsub(",","",.) -> latlon

lat <- vector()
lon <- vector()

for (ii in 1:length(latlon)) {
  lat[ii] <- as.numeric(strsplit(latlon[ii]," ")[[1]][1])
  lon[ii] <- as.numeric(strsplit(latlon[ii]," ")[[1]][2])
}
```

# ggmaps - Maps

Let's look at some of the Dialysis Data

```
loc_df <- data.frame(lat=lat,lon=lon,
                     Mortality_Rate=dia$"Mortality.Rate..Facility.")

map <- get_map(location='united states', zoom=4, maptype = "terrain'
               source='google',color='color')


ggmap(map) + geom_point(
  aes(x=lon, y=lat, color=Mortality_Rate),
  data=loc_df, alpha=.5, na.rm = T)  +
  scale_color_gradient(low="beige", high="red")
```

# ggmap


SASKATCHEWAN
ONTARIO
QUEBEC
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
OREGON
IDAHO
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
KANSAS
Las Vegas
ARIZONA
NEW MEXICO
Dallas
Houston
Ottawa
Montreal
Toronto
Mexico
Mexico City
Gulf of California
Gulf of Mexico
Cuba
Guatemala
Honduras
Nicaragua
Caribbean Sea
Google
Map data ©2018 Google, INEGI
lat
lon
50
40
30
20
-120
-110
-100
-90
-80
-70
Mortality_Rate
60
40
20
0