

# Data Analytics

## CS301

### Exploratory, Visualization and Transformations

Week 4: 14 September  
Fall 2021

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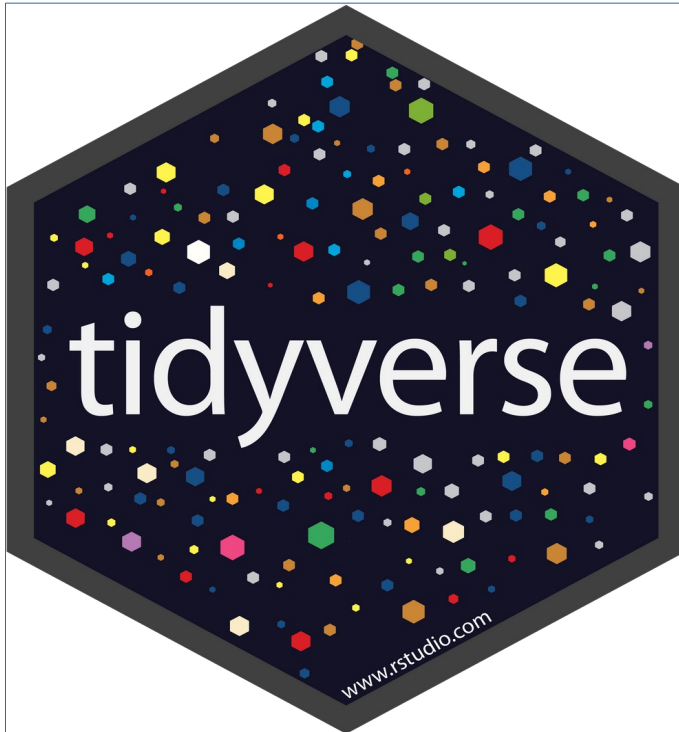


# Getting, Printing User Input

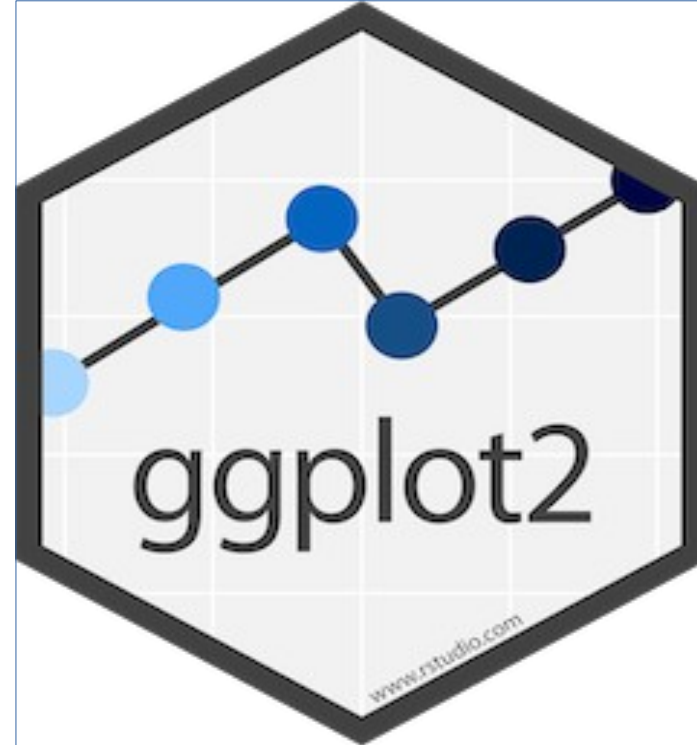
- Get some user input:
  - `myVar = readline(prompt = "Enter something :")`
- Print the input
  - `cat("You entered : ", myVar, "\n")` #print the output, *then drop a line.*
- Find out what kind of data is stored in the variable
  - `typeof(myVar)`

*Typically, many of the inputs are hard-coded into scripts*

# Tidyverse and Ggplot



<https://tidyverse.tidyverse.org/>



<https://ggplot2.tidyverse.org/>

```
# Try loading the tidyverse library  
library(tidyverse)
```

```
#If errors or not working, then try the following instead  
library(ggplot2)
```



# Ask Data about Mileage

Ask: *What classes of cars  
(i.e.,. suv's, trucks, etc.)  
get the best city and  
highway mileage?*

I know! I will use some MPG data  
from the Tidyverse library and  
see what the data says!!



```
library(tidyverse) #not working? Try library(ggplot2)
# check the data
View(mpg) # note the capital 'V'
# run simple plot
ggplot(data = mpg) +
  geom_point(mapping = aes(x = mpg$displ, y = mpg$hwy ))
```

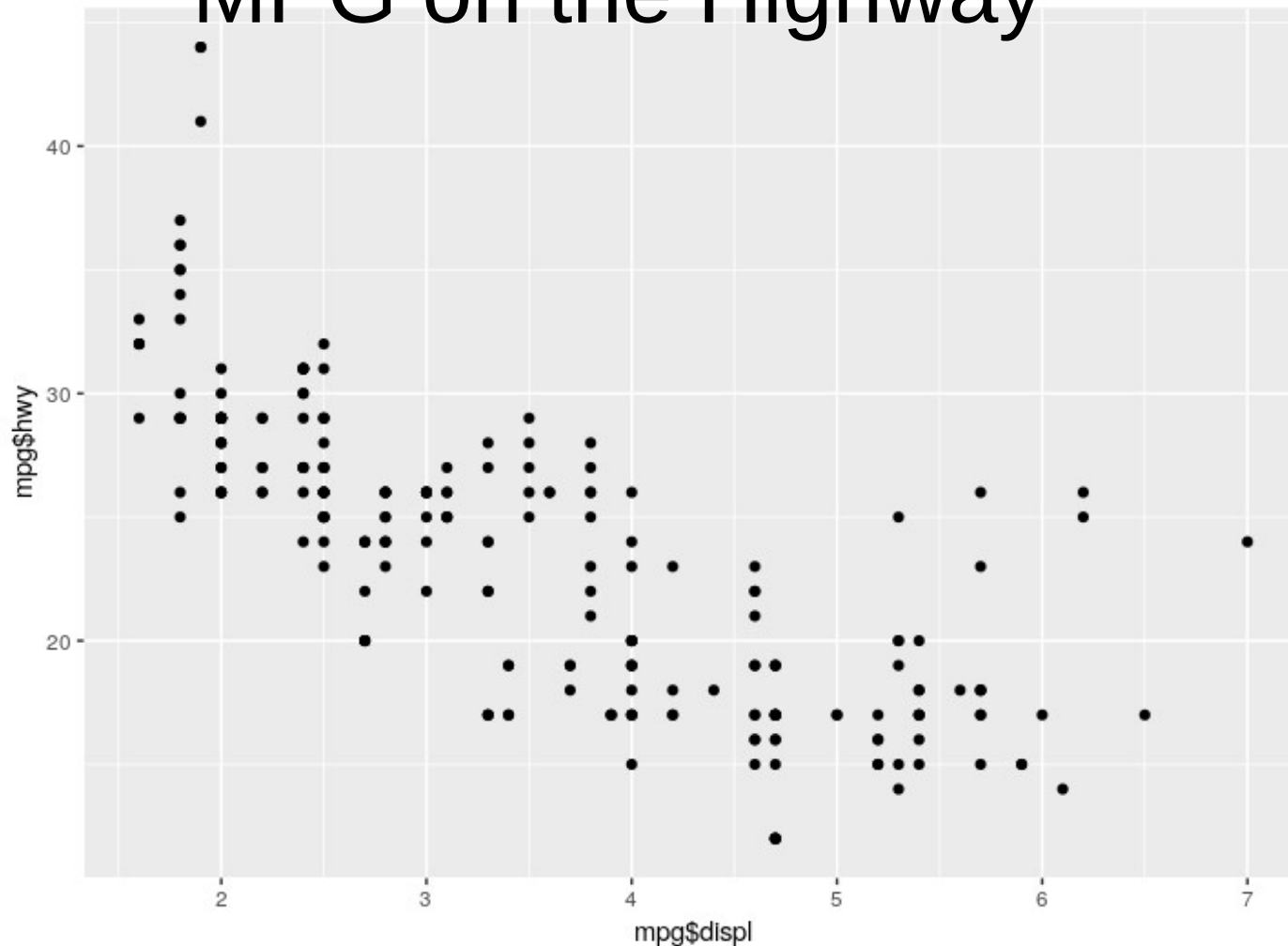


# From Last Time: Code for a Simple GGPlot

- `ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy))`
- Establish the *canvas* (where the plot is shown)
- `ggplot()`
- Link to the data (set is called, 'mpg')
  - `ggplot(data = mpg)`
- Compute the geometry of point placement on canvas
  - `geom_point(mapping = ... )`
- Compute the aesthetics of the plot (titles, color, point type, etc)
  - `aes(x = displ, y = hwy)`



# Displacement (Car Weight) by MPG on the Highway

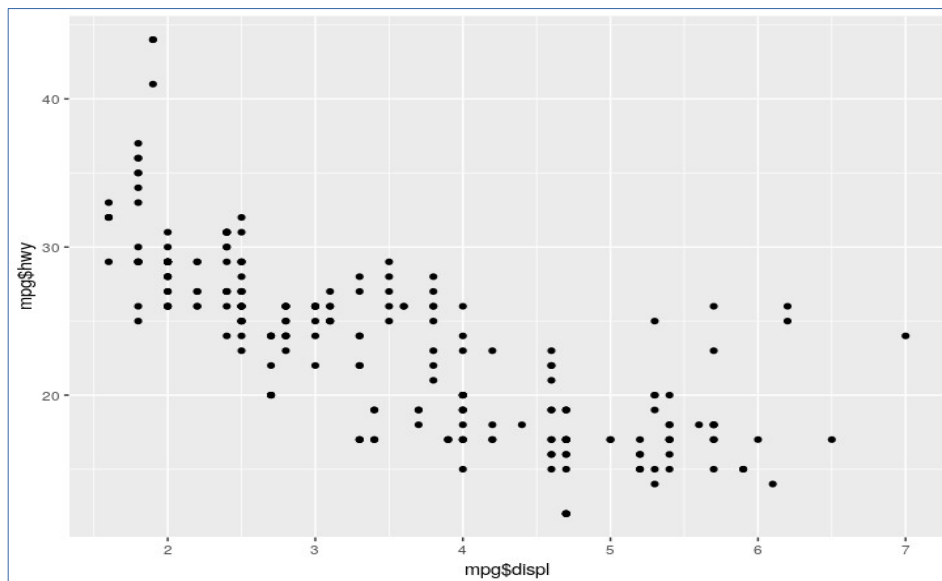


```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy ))
```

# Displacement (Car Weight) by MPG on the Highway

Is there more to  
learn from this data?

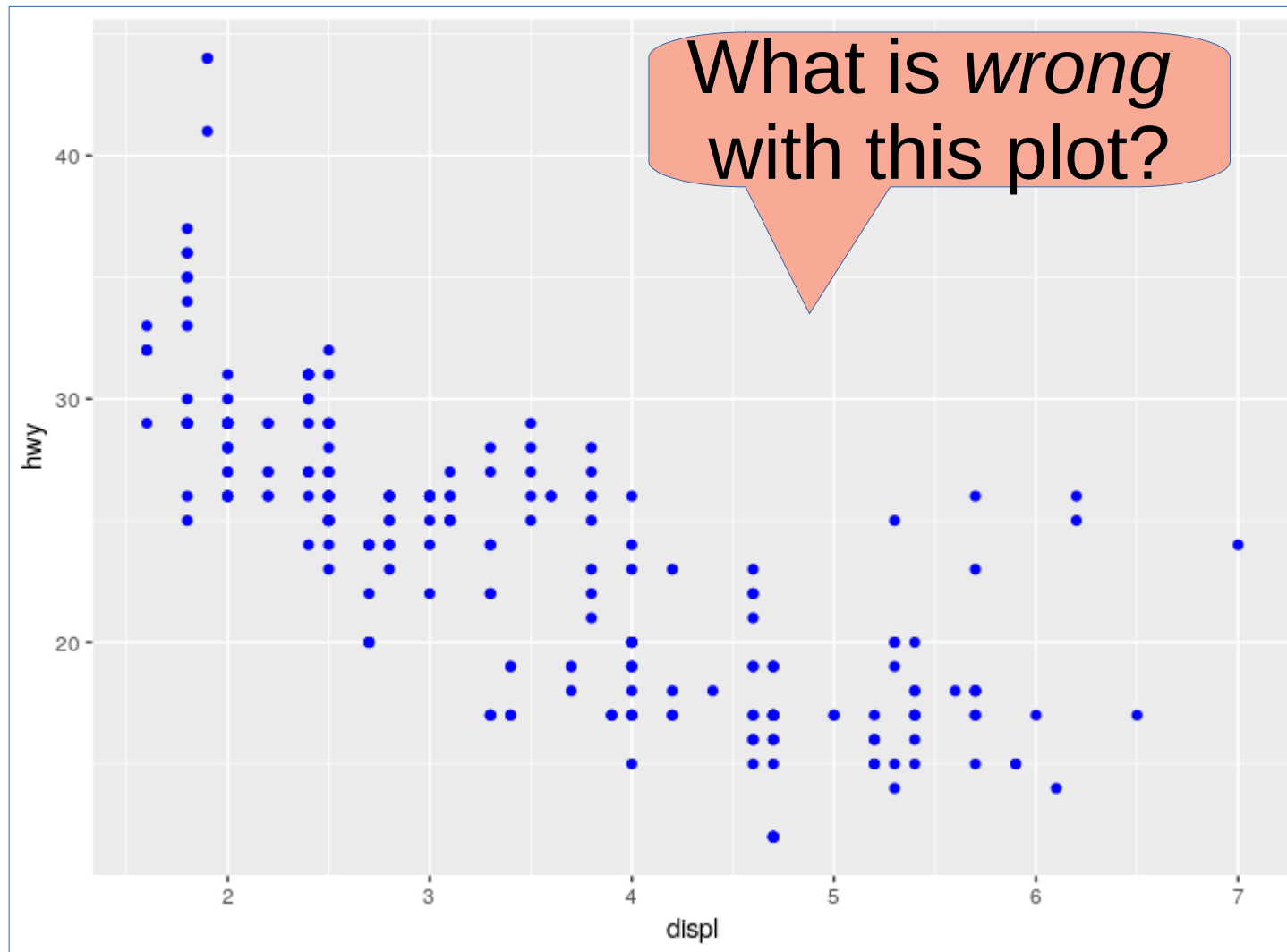
What is *wrong* with  
this the previous plot?



Yes!

No??

# New Blue Plot?

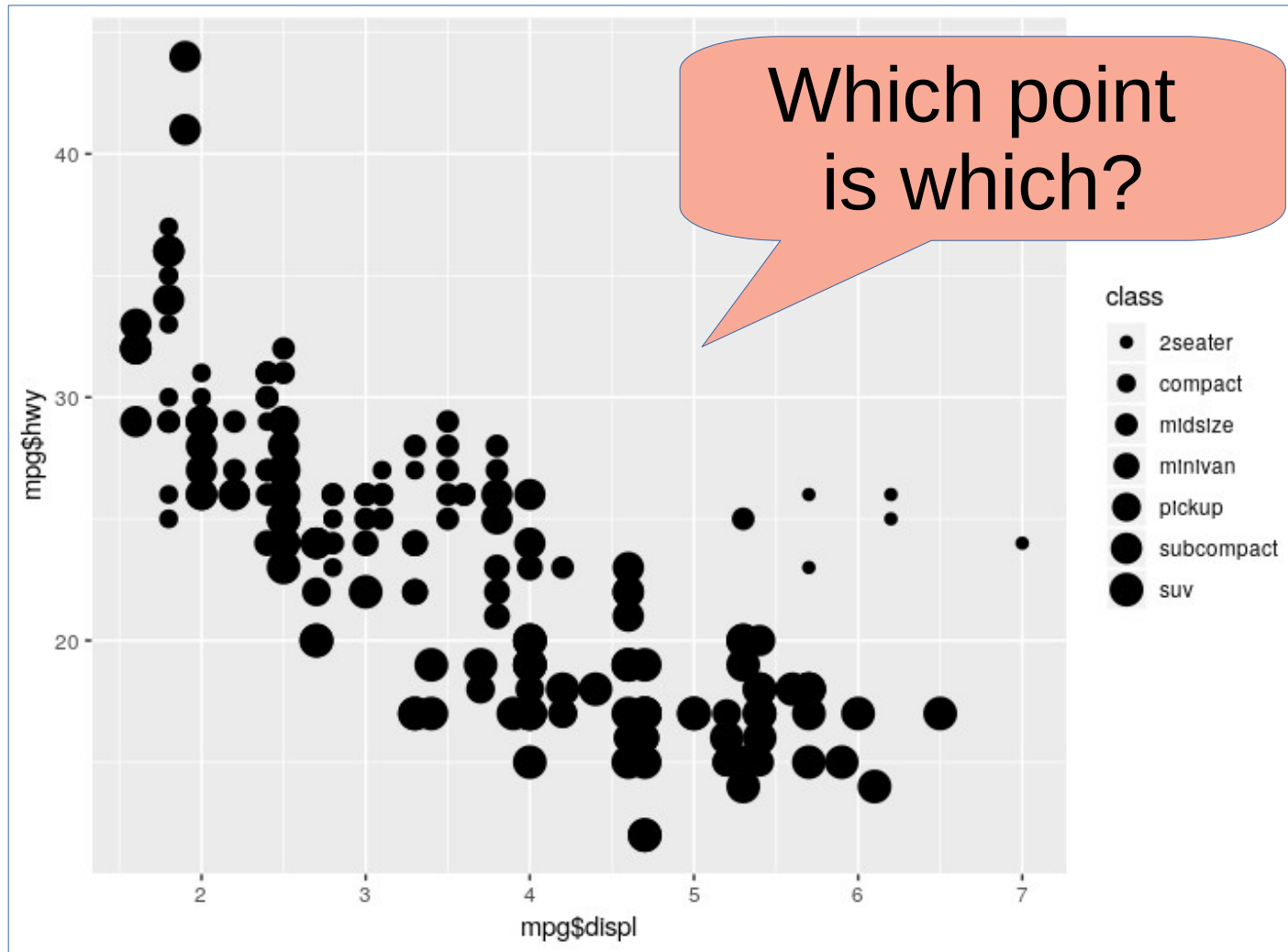


```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy), color = "blue")
```





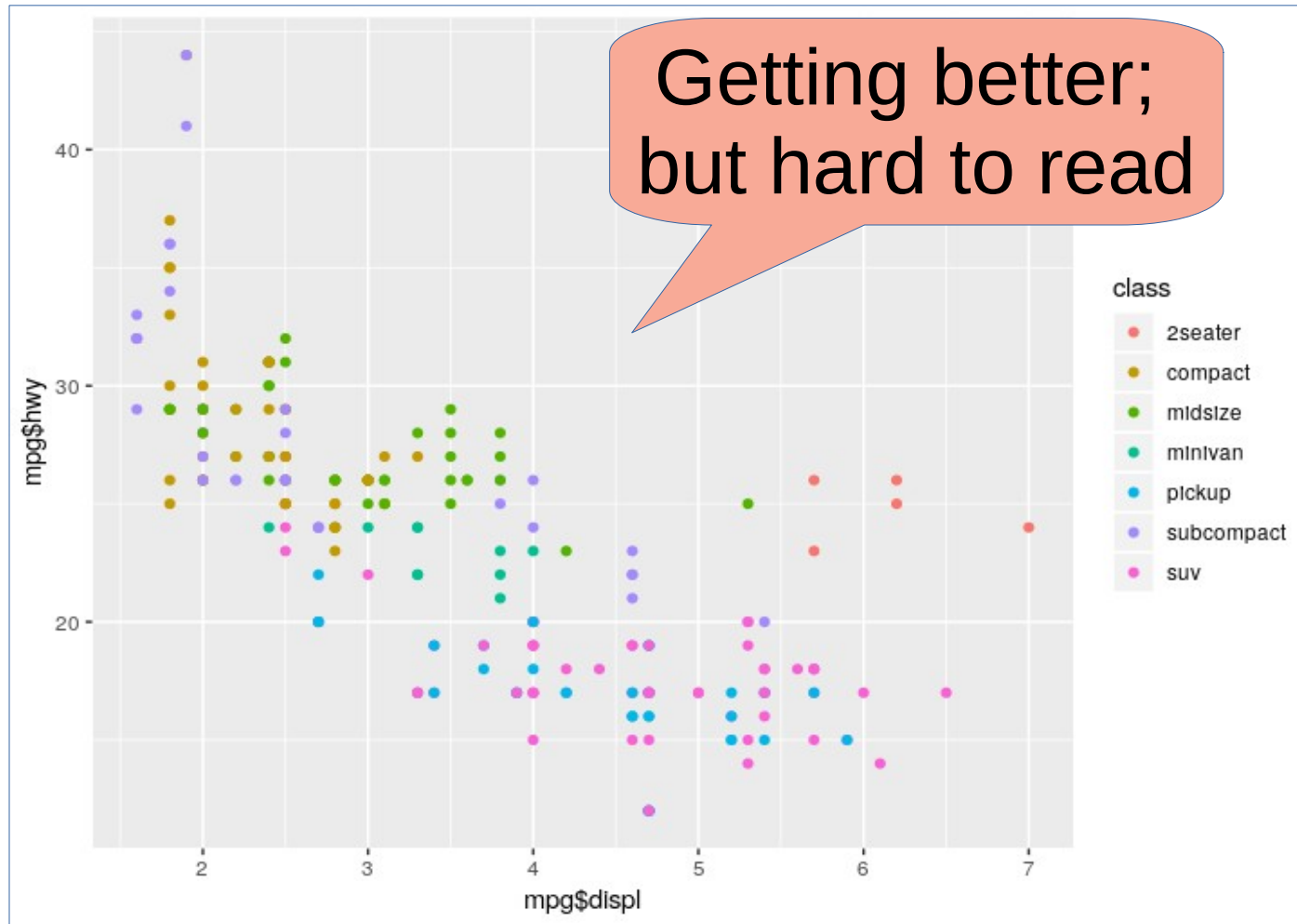
# Try Sizing the points for Dimension



```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy, size = class))
```

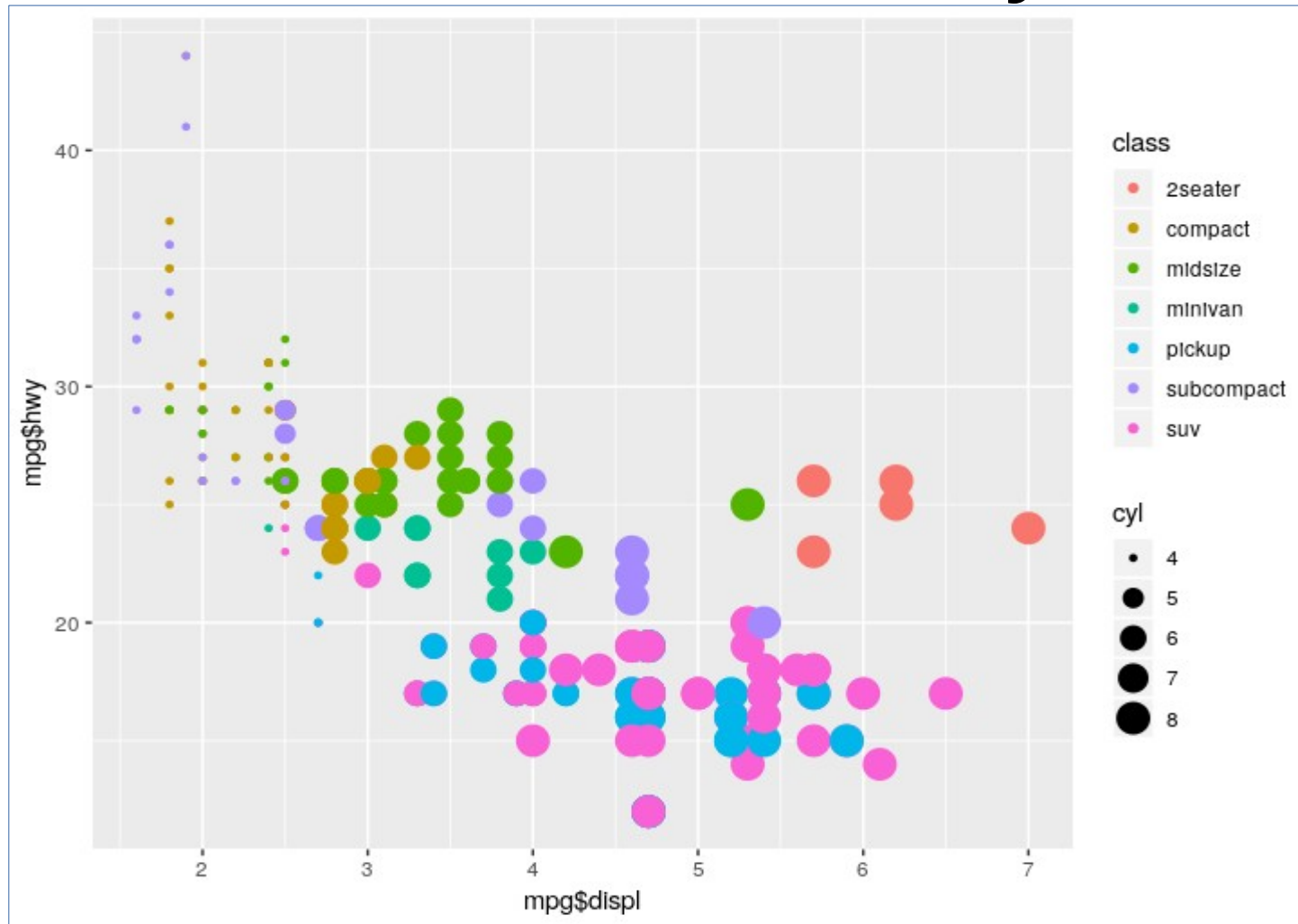


# Try Coloring for Dimension



```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy, color = class))
```

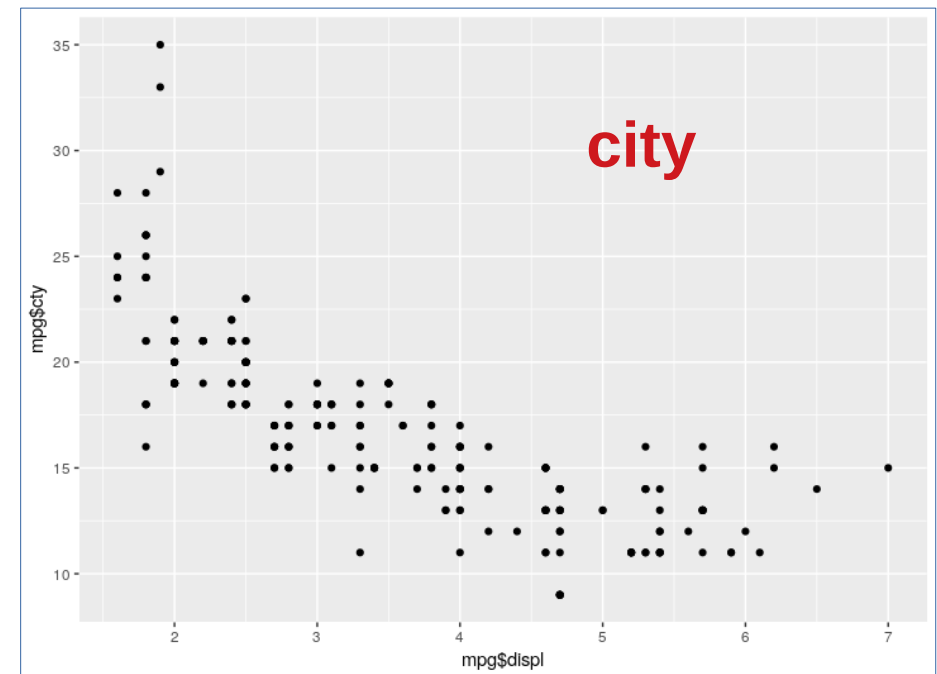
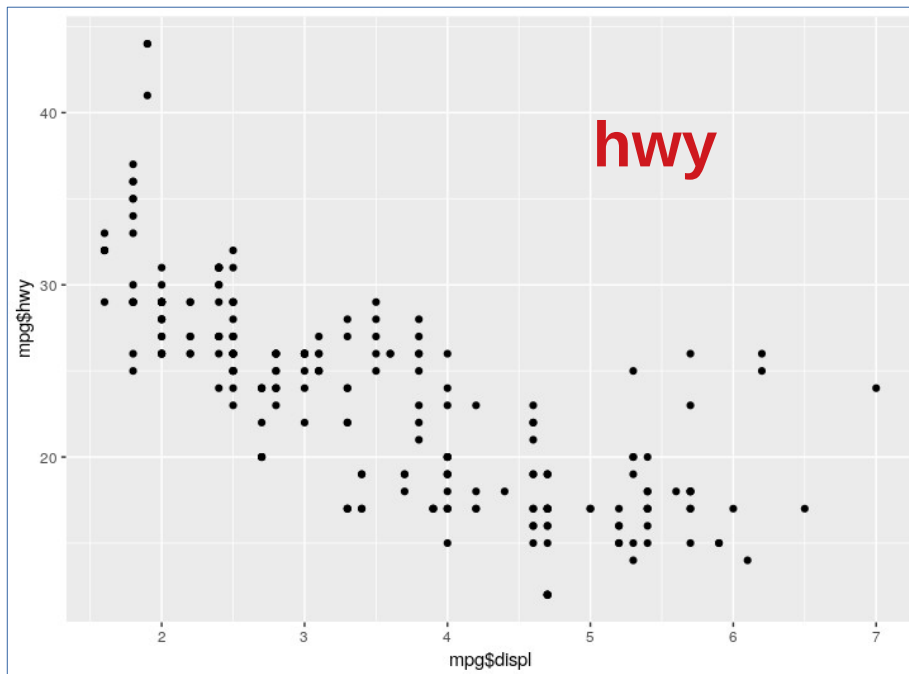
# Combine Color, Sized Points and Cycle



```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy, color = class, size = cyl))
```



# Comparing Hwy and City Mileage



# **hwy** mileage

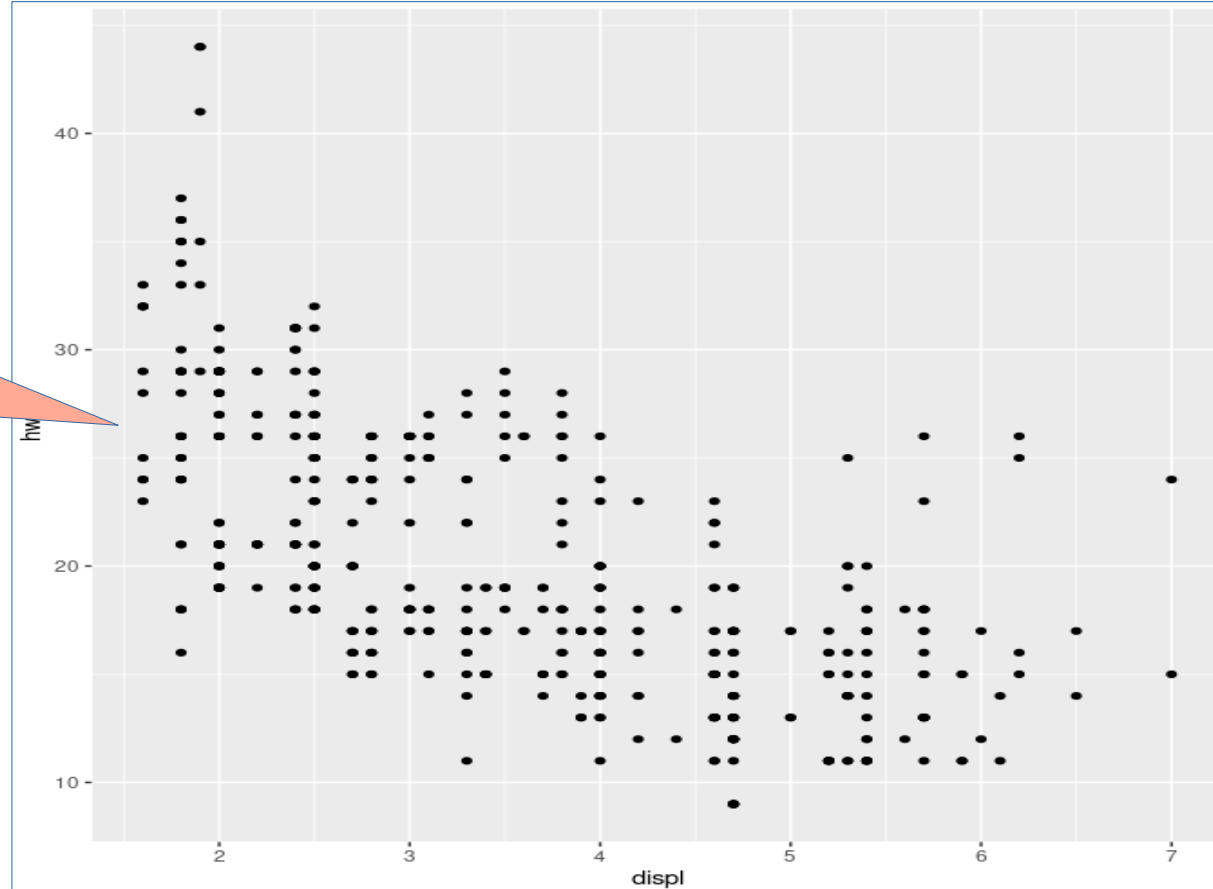
```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy ))
```

# **city** mileage

```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = city ))
```



# Comparing Hwy and City Mileage

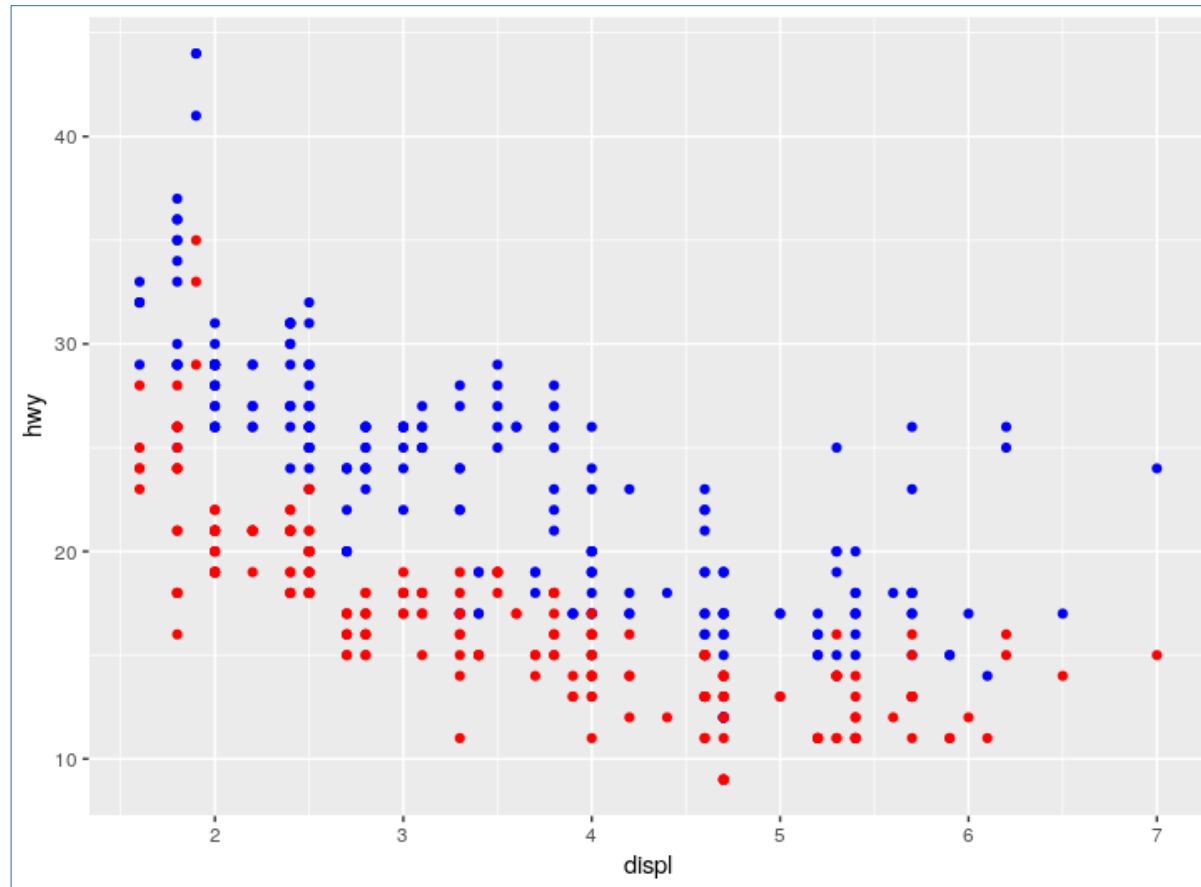


Which  
Is  
which?

```
#Place hwy and cty mileage together in same plot  
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy), ) +  
geom_point(mapping = aes(x = displ, y = cty))
```



# Comparing Hwy and City Mileage



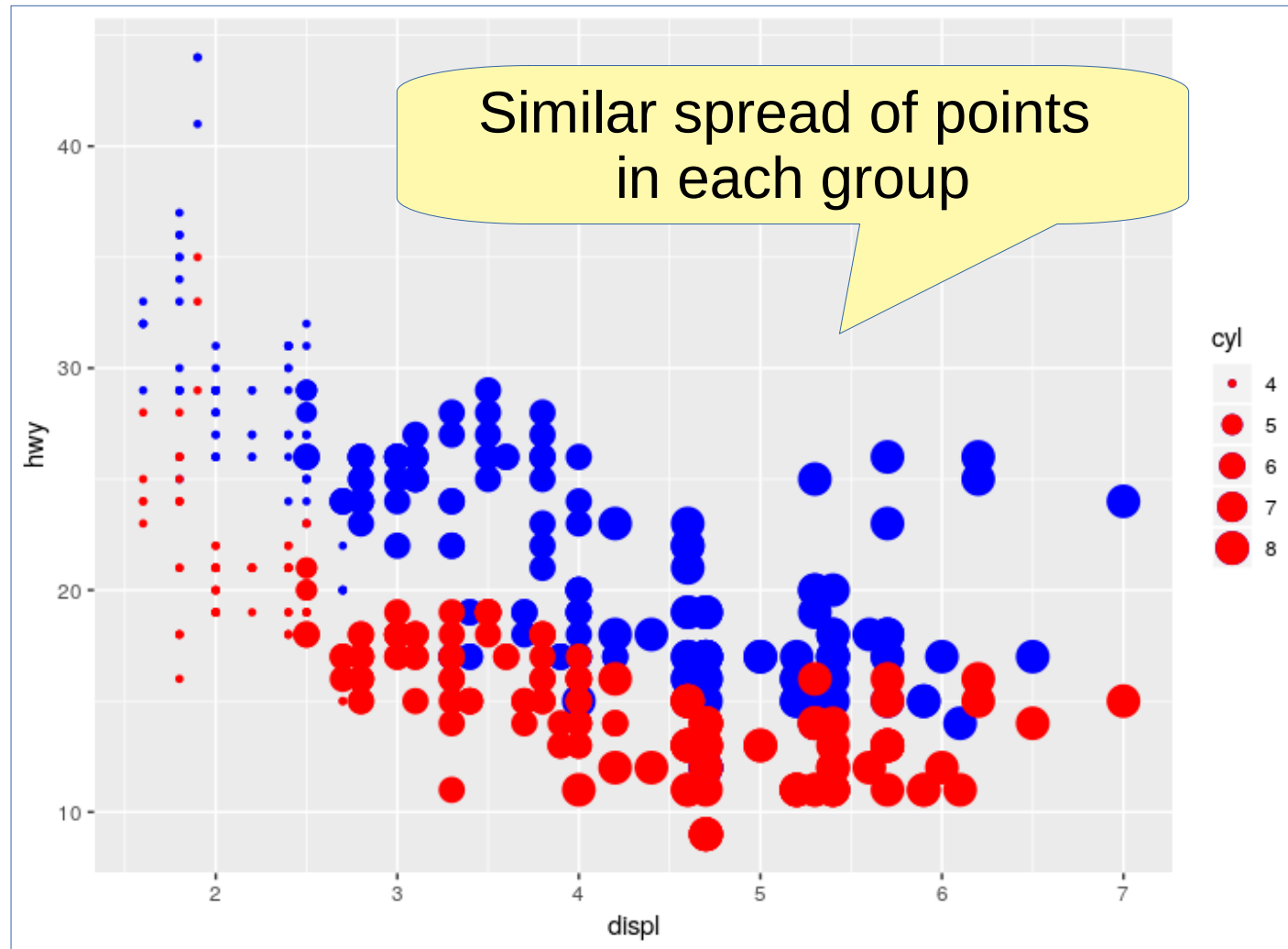
#Place **hwy** and **cty** mileage together in same plot

```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy), color = "blue") +  
geom_point(mapping = aes(x = displ, y = cty), color="red")
```

# Add Sized Points

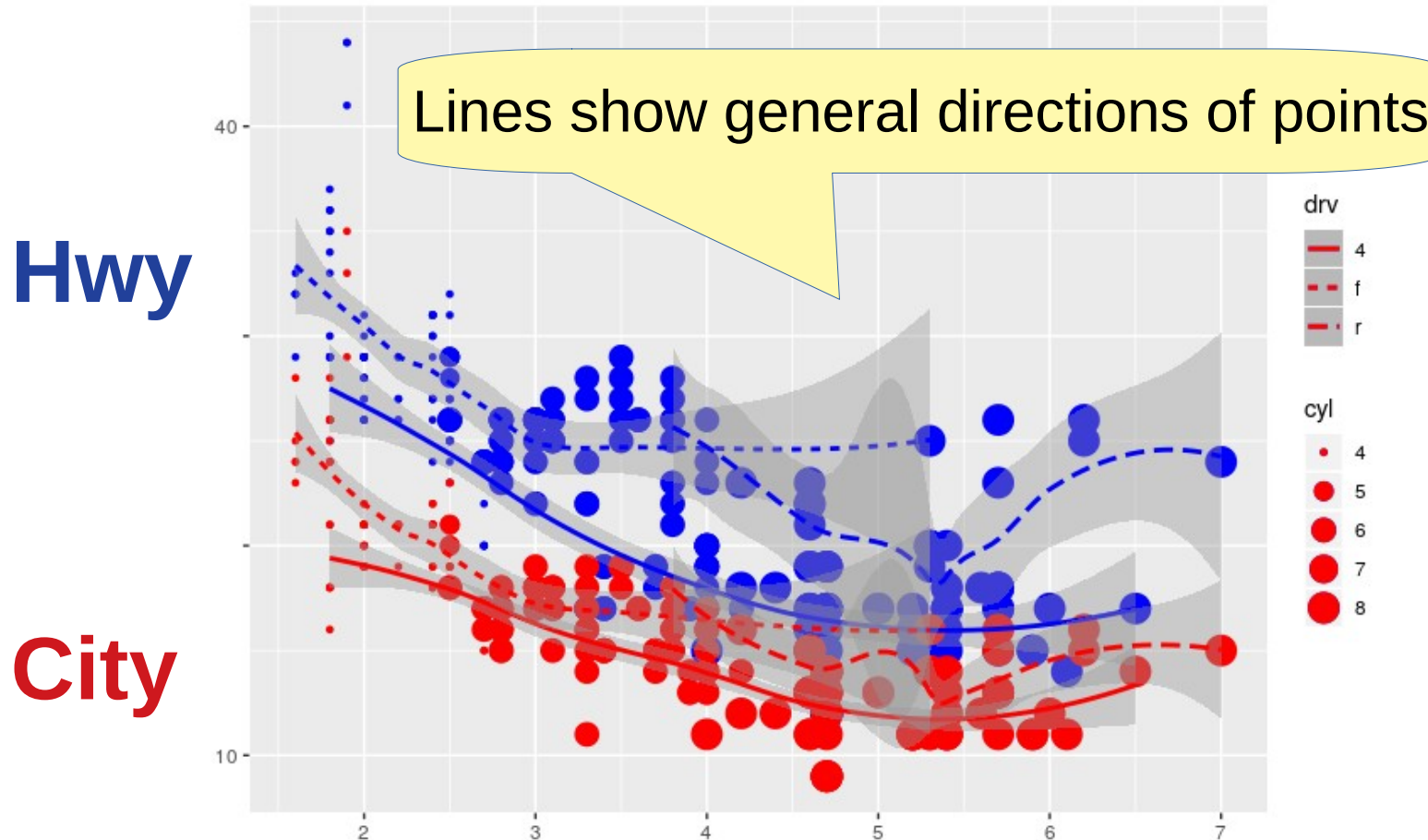
Hwy

City



```
ggplot(data = mpg) + geom_point(mapping = aes(x = displ, y = hwy,  
size = cyl), color = "blue") + geom_point(mapping = aes(x = displ, y  
= cty, size = cyl), color="red")
```

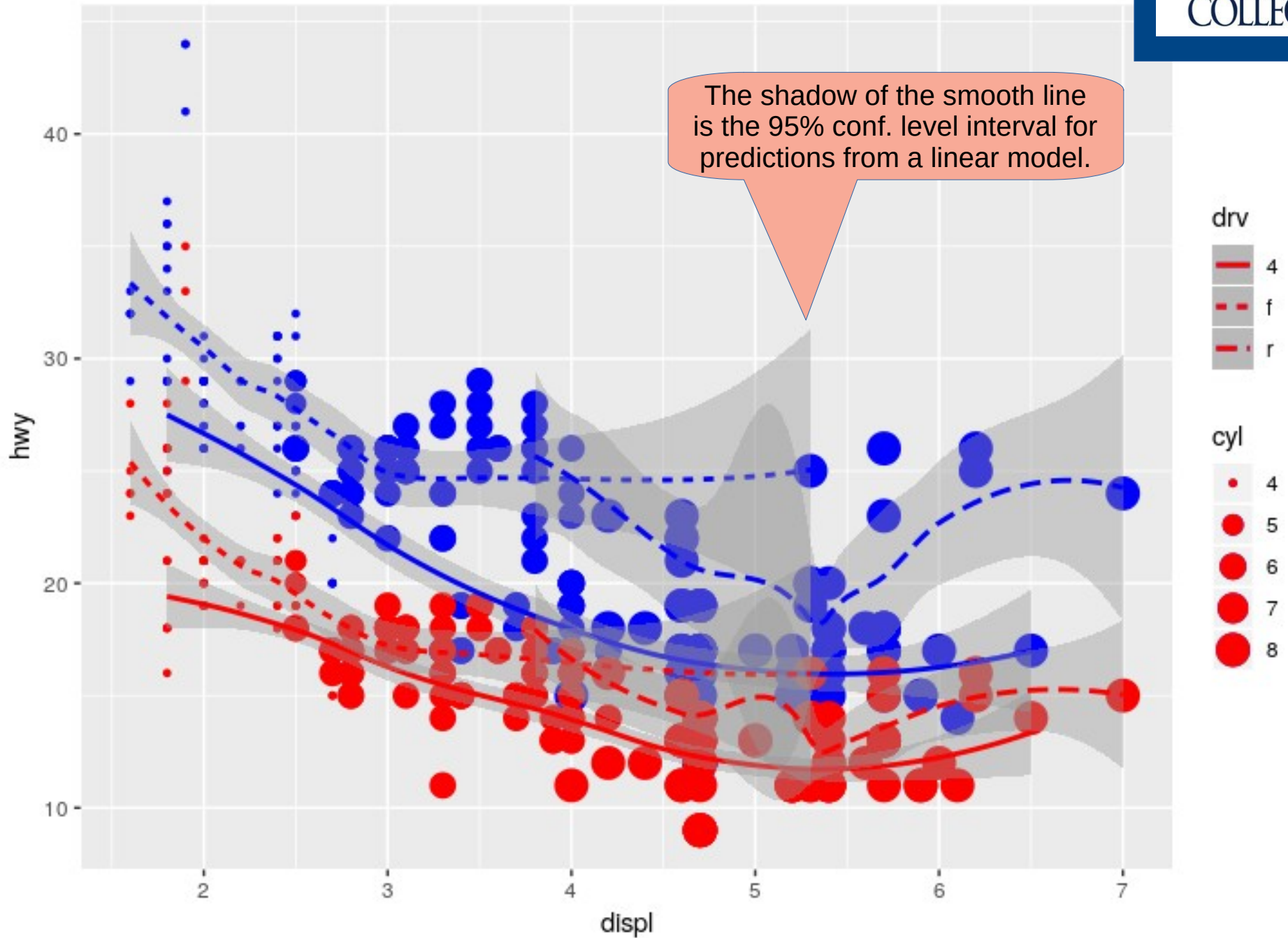
# Add a *Smooth-Line*



```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy, size = cyl), color = "blue") +
  geom_point(mapping = aes(x = displ, y = cty, size = cyl), color="red") +
  geom_smooth(mapping = aes(x = displ, y = hwy, linetype = drv), color = "blue") +
  geom_smooth(mapping = aes(x = displ, y = cty, linetype = drv), color = "red")
```



# Bigger Image of the Previous Plot



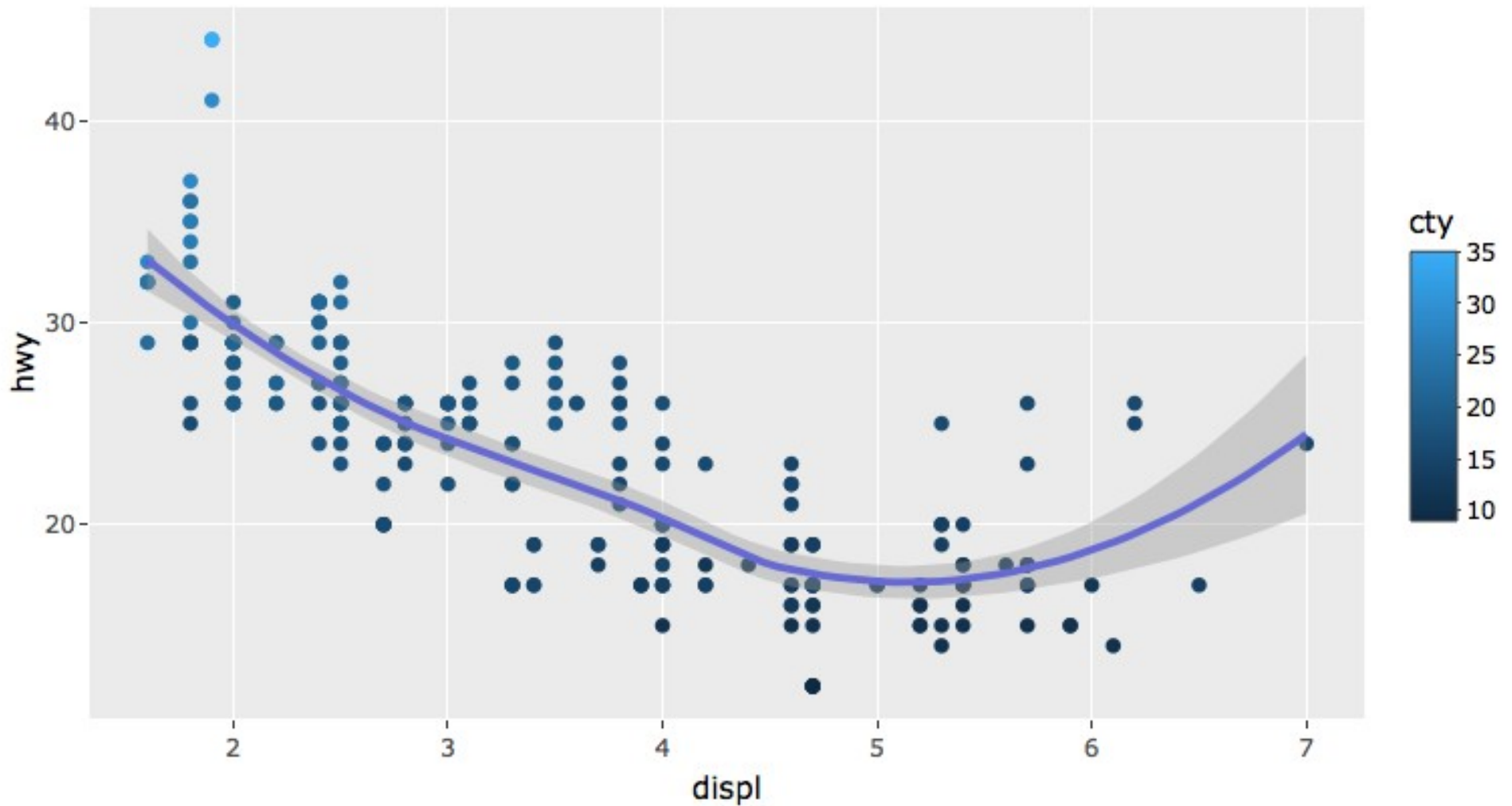
# Add Plotly For Interaction

```
# ref: https://plot.ly/ggplot2/stat\_smooth/  
#install.packages("plotly")  
  
library(plotly)  
  
p <- ggplot(mpg, aes(displ, hwy, color = cty))  
p <- p + geom_point() + stat_smooth()  
  
p <- ggplotly(p)  
  
p
```





# Interact With Plots



# Add Plotly For Interaction

```
# ref: https://plot.ly/ggplot2/stat\_smooth/  
#install.packages("plotly")
```

```
library(plotly)
```

```
p <- ggplot(mpg, aes(displ, hwy, color = cty, size = displ))  
p <- p + geom_point() + stat_smooth()
```

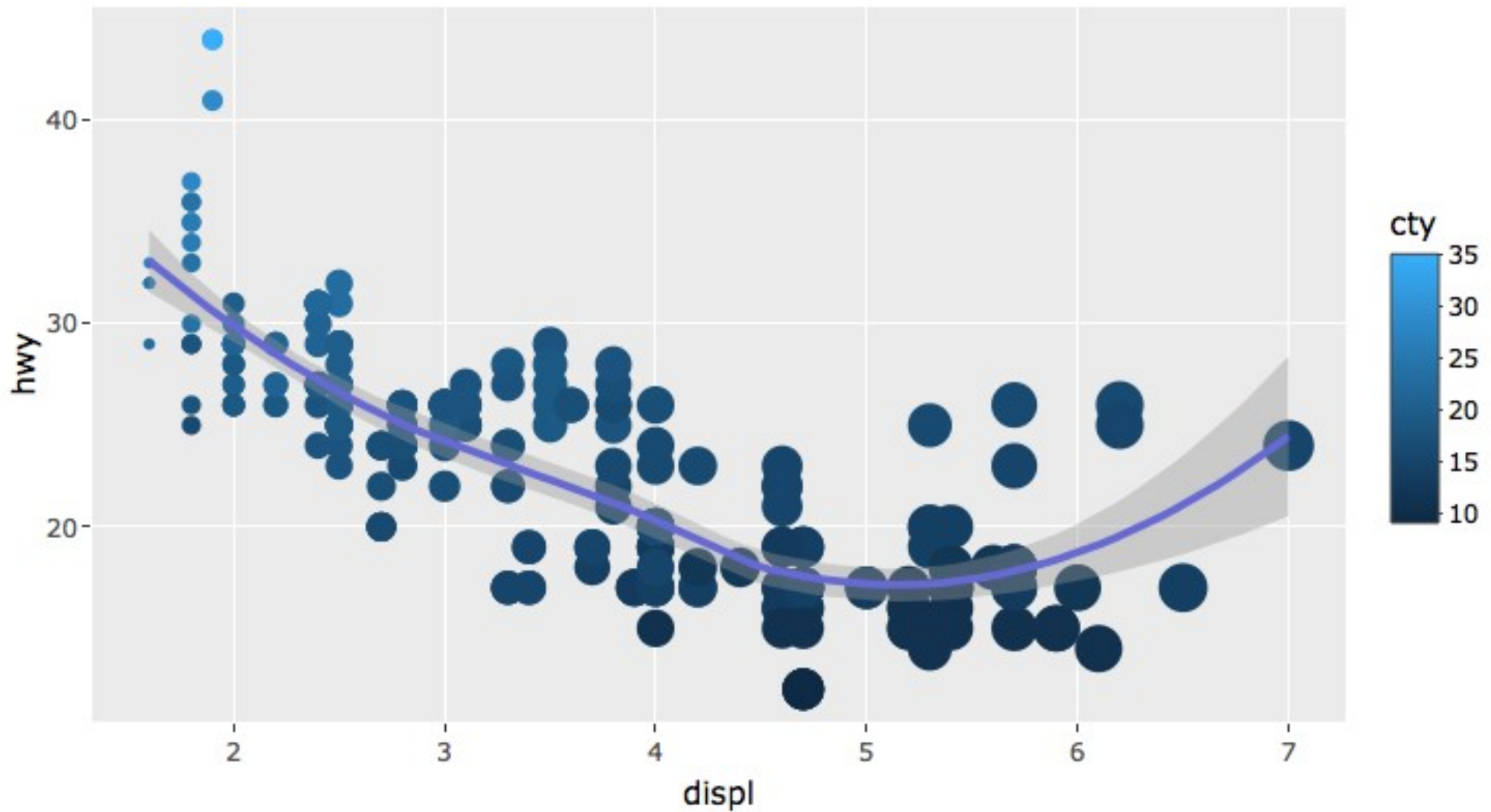
```
p <- ggplotly(p)
```

```
p
```



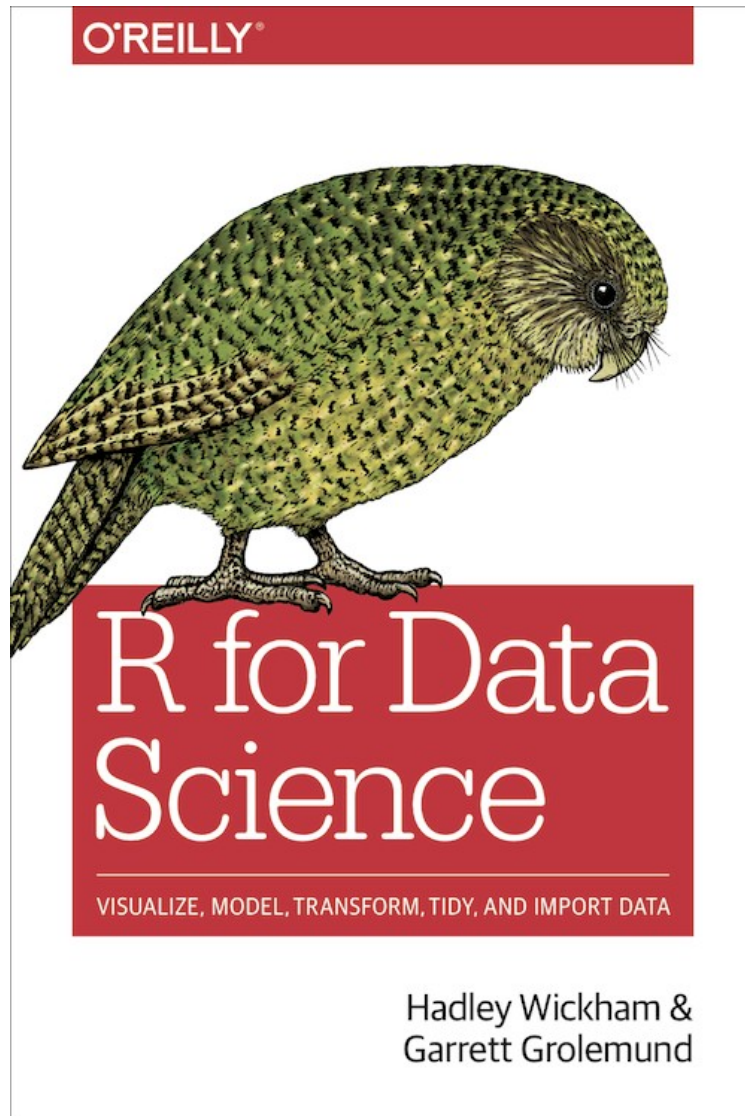


# Interact With Plots



# Where in the Web?

## Where in the Book?



- Note the chapter differences!
- Book:
  - Chap 3: Data Transformation with dplyr
  - Pages 43 - 73
- Web:
  - Chap 5: Data Transformation with dplyr
  - <http://r4ds.had.co.nz/transform.html>



# Transformation?



- What you want to show is in the data
- Unfortunately: To begin to show this is complicated.
  - Too much noise
  - Clutter
  - Unrelated pieces of data in the way

# Filters

- Filters allow us to keep part of the whole while removing what we do not want







# *Filters* to Transform Data?

## Dictionary

transformation



trans·for·ma·tion

/,tran(t)sfər'māSH(ə)n/

*noun*

a thorough or dramatic change in form or appearance.

"its landscape has undergone a radical transformation"

*synonyms:* [change](#), [alteration](#), [mutation](#), [conversion](#), [metamorphosis](#), [transfiguration](#), [transmutation](#),  
[sea change](#); [More](#)

- a metamorphosis during the life cycle of an animal.

- **PHYSICS**

the induced or spontaneous change of one element into another by a nuclear process.

# Data Transformation

- Filter out the unwanted stuff to leave the “good” stuff
- Easier to work with and visualize
- **Data transformation:** the process of converting data or information from one format to another,
- Usually from the format of a source system into the required format of a new destination system.





# Let the Transformation Begin!!

- # Install the library containing the data (if necessary)  
install.packages("nycflights13")  
library(nycflights13)  
library(tidyverse)
- # check that the data is found in the library  
nycflights13::flights
- View(flights)



# What is the Data?

- # assign this data to an object.  
flights <- nycflights13::flights
- # View the table's columns  
names(nycflights13::flights)
- #Or, run,  
names(flights)

What does your data say about the  
types of questions that you can ask?!



# Flight Data

flights ✕

⏪

⏩

🔍

Filter

🔍

	year	month	day	dep_time	sched_dep_time	dep_delay	arr_time	sched_arr_time	arr_delay	carrier	flight	tailnum	origin	dest	air_time	distance	hour	minute	time_hour
1	2013	1	1	517	515	2	830	819	11	UA	1545	N14228	EWR	IAH	227	1400	5	15	2013-01-01 05:00
2	2013	1	1	533	529	4	850	830	20	UA	1714	N24211	LGA	IAH	227	1416	5	29	2013-01-01 05:00
3	2013	1	1	542	540	2	923	850	33	AA	1141	N619AA	JFK	MIA	160	1089	5	40	2013-01-01 05:00
4	2013	1	1	544	545	-1	1004	1022	-18	B6	725	N804JB	JFK	BQN	183	1576	5	45	2013-01-01 05:00
5	2013	1	1	554	600	-6	812	837	-25	DL	461	N668DN	LGA	ATL	116	762	6	0	2013-01-01 06:00
6	2013	1	1	554	558	-4	740	728	12	UA	1696	N39463	EWR	ORD	150	719	5	58	2013-01-01 05:00
7	2013	1	1	555	600	-5	913	854	19	B6	507	N516JB	EWR	FLL	158	1065	6	0	2013-01-01 06:00
8	2013	1	1	557	600	-3	709	723	-14	EV	5708	N829AS	LGA	IAD	53	229	6	0	2013-01-01 06:00
9	2013	1	1	557	600	-3	838	846	-8	B6	79	N593JB	JFK	MCO	140	944	6	0	2013-01-01 06:00
10	2013	1	1	558	600	-2	753	745	8	AA	301	N3ALAA	LGA	ORD	138	733	6	0	2013-01-01 06:00
11	2013	1	1	558	600	-2	849	851	-2	B6	49	N793JB	JFK	PBI	149	1028	6	0	2013-01-01 06:00
12	2013	1	1	558	600	-2	853	856	-3	B6	71	N657JB	JFK	TPA	158	1005	6	0	2013-01-01 06:00
13	2013	1	1	558	600	-2	924	917	7	UA	194	N29129	JFK	LAX	345	2475	6	0	2013-01-01 06:00

Showing 1 to 13 of 226 776 entries

```
> View(flights)
```

```
> names(nycflights13::flights)
```

```
[1] "year"          "month"         "day"           "dep_time"      "sched_dep_time" "dep_delay"
[7] "arr_time"      "sched_arr_time" "arr_delay"     "carrier"       "flight"         "tailnum"
[13] "origin"        "dest"          "air_time"      "distance"      "hour"           "minute"
[19] "time_hour"
```

- Get a summary of the flights data set

```

> summary(flights$)

```

- Ex: `summary(flights$arr time)`

```
> summary(flights$arr_time)
```

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
1	1104	1535	1502	1940	2400	8713



# Upon A Closer Inspection...

- This data frame contains all 336,776 flights that departed from New York City in 2013. The data comes from the US Bureau of Transportation Statistics, and is documented in ? flights.
- Flight numbers,
- Date, takeoff time and duration of flight
- Scheduled departure and arrival times
- Actual departure and arrival times (delays)
- Carrier
- Airports (origin and destination for a flight)
- Distance flown
- And more...



# What are the Elements?

- #show whole dataset  
View(flights)
- # show first and second row of data table  
flights[1:2,] #flights[rows, cols]
- # show first and second cols  
flights[,1:2]
- # show cols 1 and 5 (using a vector)  
flights[,c(1,5)]





# Data Types?

- #show the data types  
flights[1,]

```
> flights[1,]  
# A tibble: 1 x 19  
  year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time arr_delay  
  <int> <int> <int>   <int>         <int>      <dbl>   <int>         <int>      <dbl>  
1  2013     1     1     517           515         2     830           819        11  
# ... with 10 more variables: carrier <chr>, flight <int>, tailnum <chr>, origin <chr>,  
#   dest <chr>, air_time <dbl>, distance <dbl>, hour <dbl>, minute <dbl>, time_hour <dtm>
```

**Why should we care about the data type?**



# Just My Type!

- **int** stands for integers.
- **dbl** stands for doubles, or real numbers.
- **chr** stands for character vectors, or strings.
- **dtm** stands for date-times (a date + a time).
- #others
- **lgl** stands for logical, vectors that contain only TRUE or FALSE.
- **fctr** stands for factors, which R uses to represent categorical variables with fixed possible values.
- **date** stands for dates.



# dplyr Basics

- Five key dplyr functions
  - Pick observations by their values (**filter()**).
  - Reorder the rows (**arrange()**).
  - Pick variables by their names (**select()**).
  - Create new variables with functions of existing variables (**mutate()**).
  - Collapse many values down to a single summary (**summarise()**).
- Find help for each: ?keyword



# Filter()

- `#filter(object, column_header to consider)`  
`filter(flights, month == 1, day == 1)`  
`filter(flights, month == 1, dep_time == 554)`
- `#Assign a variable to this particular object`  
`dep_timeFlights554 <- filter(flights, month == 1,`  
`dep_time == 554)`
- `View(dep_timeFlights554)`



# Comparisons with Filter()

- R provides the standard suite:  $>$ ,  $>=$ ,  $<$ ,  $<=$ ,  $\neq$  (not equal), and  $=$  (equal).
- `# select * from flights where month == 1;`  
`filter(flights, month == 1)`
- **#What happens here?**  
`filter(flights, month >=11)`  
`filter(flights, month <=11)`



# De Morgan's Law with Filter()

- #De Morgan's law:  $!(x \ \& \ y)$  is the same as  $!x \ | \ !y$ ,  $!(x \ | \ y)$  is the same as  $!x \ \& \ !y$ .
- #For example, Use **OR** if you wanted to find flights that were not delayed (on arrival or departure) by more than two hours, you could use either of the following two filters:

```
filter(flights, !(arr_delay > 120 | dep_delay > 120))
```

```
filter(flights, arr_delay <= 120, dep_delay <= 120)
```



# Arrange()

`arrange()` works similarly to `filter()` except that instead of selecting rows, it changes their order.

- #Show rows and cols as ordered by a particular column.
- #`arrange(object, column_header)`
- #What happens here?

```
arrange(flights, minute)
```

```
filter(flights, day == 30, dep_time == 554)
```



# Arrange()

- #If you provide more than one column name, each additional column will be used to break ties in the values of preceding columns.

```
arrange(flights, year, month, day)
```

- #Use desc() to re-order by a column in **descending** order.

```
arrange(flights, desc(arr_delay))
```

```
arrange(flights, arr_delay)
```

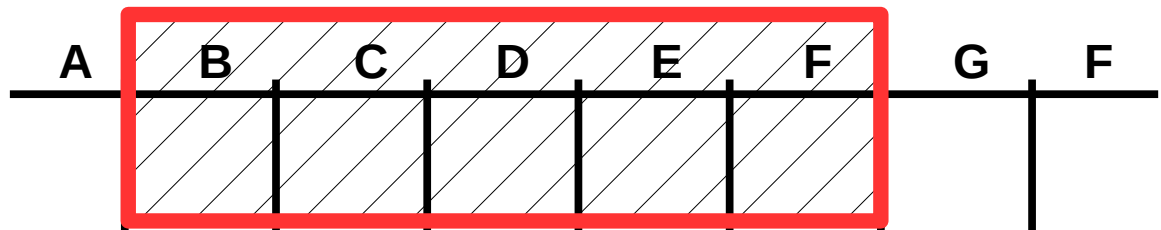




# Select()

- `#select()` allows you to rapidly zoom in on a useful subset using names of the variables as parameters  
`select(flights, year, month, day)`
- `#` Select all columns going across the headers found between year and day (inclusive)  
`select(flights, year:day)`
- `#` Select all columns except those from year to day (inclusive)  
`select(flights, -(year:day))`

Selecting(data, A:F)





# Mutate()

- #add new columns that are functions of existing columns
- #create a new object from flights having new cols.
- # xx and yy could be equations using existing data.
- `xy <- mutate(flights, xx = day, yy = month)`
- `View(xy)`



# Summarise()

- Collapse your data into a single subset
- Use with `group_by()` to organize data into groups to help you see results from that time.

```
# A tibble: 365 x 4
# Groups:   year, month [?]
   year month   day mean
  <int> <int> <int> <dbl>
1  2013     1     1  11.5
2  2013     1     2  13.9
3  2013     1     3  11.0
4  2013     1     4   8.95
5  2013     1     5   5.73
6  2013     1     6   7.15
7  2013     1     7   5.42
8  2013     1     8   2.55
```

```
by_day <- group_by(flights, year, month, day)
summarise(by_day, delay = mean(dep_delay, na.rm = TRUE))
```

# or, another way to enter the command using pipes...

```
flights %>%
  group_by(year, month, day) %>%
  summarise(mean = mean(dep_delay, na.rm = TRUE))
```



# Lets Work With Data

Load some libraries

```
library(ggplot2) or use install.packages(ggplot2)
```

- What data can we play with?

```
data()
```

- A good habit to define a variable for a data set

```
myData = diamonds
```

```
View(myData) # what do you see now?
```



# Diamonds in Data

	carat	cut	color	clarity	depth	table	price	x	y	z
1	0.23	Ideal	E	SI2	61.5	55.0	326	3.95	3.98	2.43
2	0.21	Premium	E	SI1	59.8	61.0	326	3.89	3.84	2.31
3	0.23	Good	E	VS1	56.9	65.0	327	4.05	4.07	2.31
4	0.29	Premium	I	VS2	62.4	58.0	334	4.20	4.23	2.63
5	0.31	Good	J	SI2	63.3	58.0	335	4.34	4.35	2.75
6	0.24	Very Good	J	VVS2	62.8	57.0	336	3.94	3.96	2.48
7	0.24	Very Good	I	VVS1	62.3	57.0	336	3.95	3.98	2.47
8	0.26	Very Good	H	SI1	61.9	55.0	337	4.07	4.11	2.53
9	0.22	Fair	E	VS2	65.1	61.0	337	3.87	3.78	2.49
10	0.23	Very Good	H	VS1	59.4	61.0	338	4.00	4.05	2.39

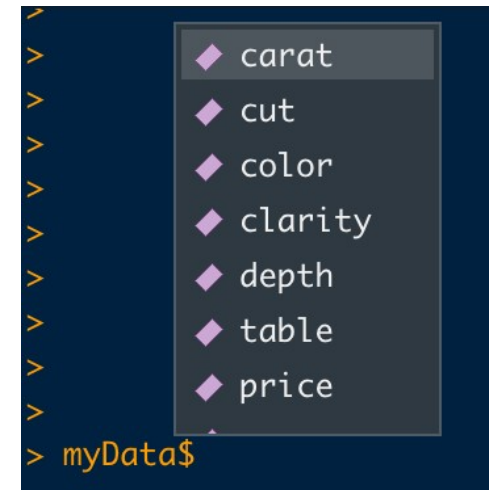
- What is this data?
- ? diamonds for help



# Ask: Diamonds in Data

- Let's ask about the carats and cuts relationship:
  - **carat**: weight of the diamond (0.2–5.01)
  - **cut**: quality of the cut (Fair, Good, Very Good, Premium, Ideal)

Dataset\$ColumnHeader



```
ggplot(data = myData) + geom_point(aes(x=myData$carat, y=myData$cut))
```

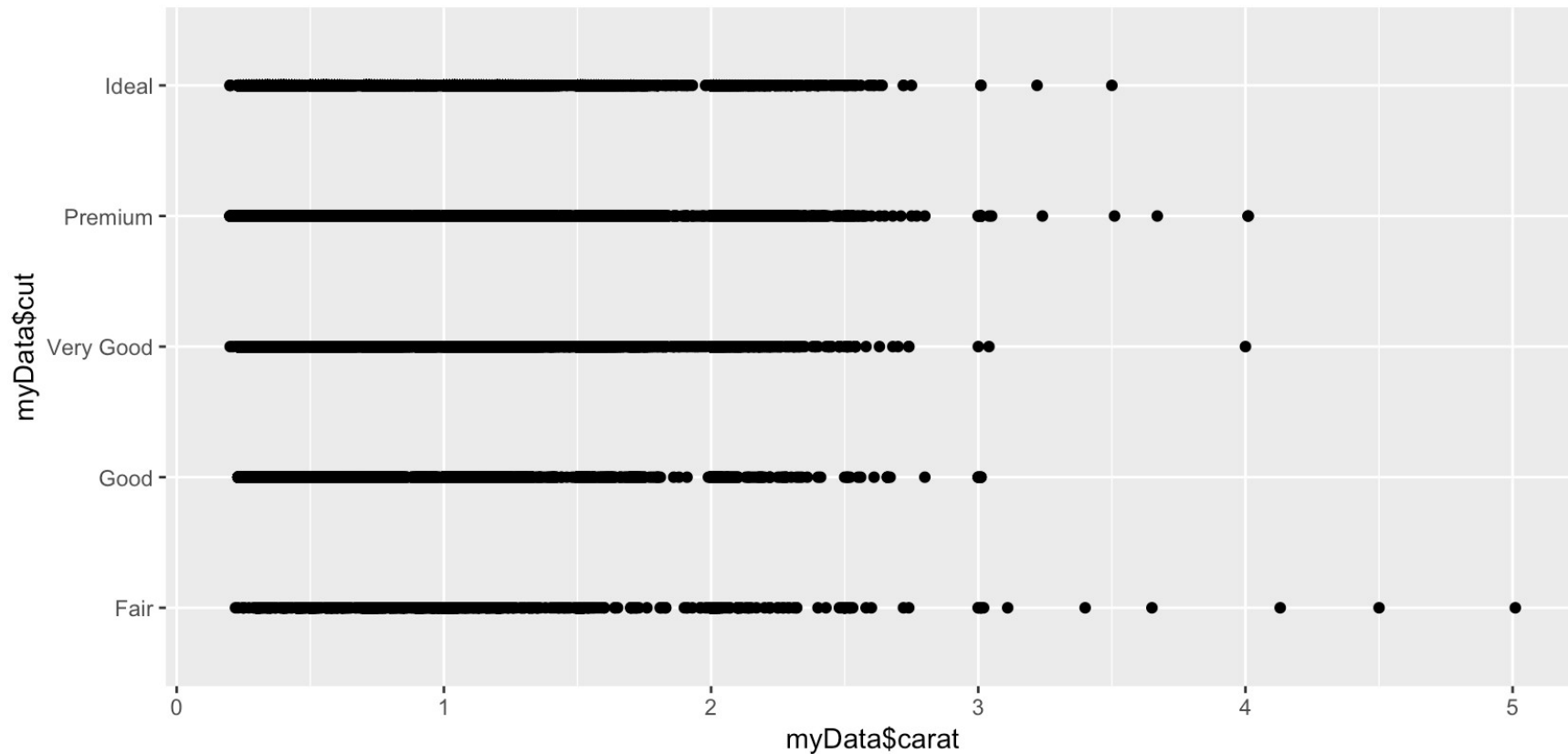
Better way to code:

```
ggplot(data = myData) + geom_point(aes(x=carat, y=cut))
```



# Ask: Diamonds in Data

```
ggplot(data = myData) + geom_point(aes(x=carat, y=cut))
```

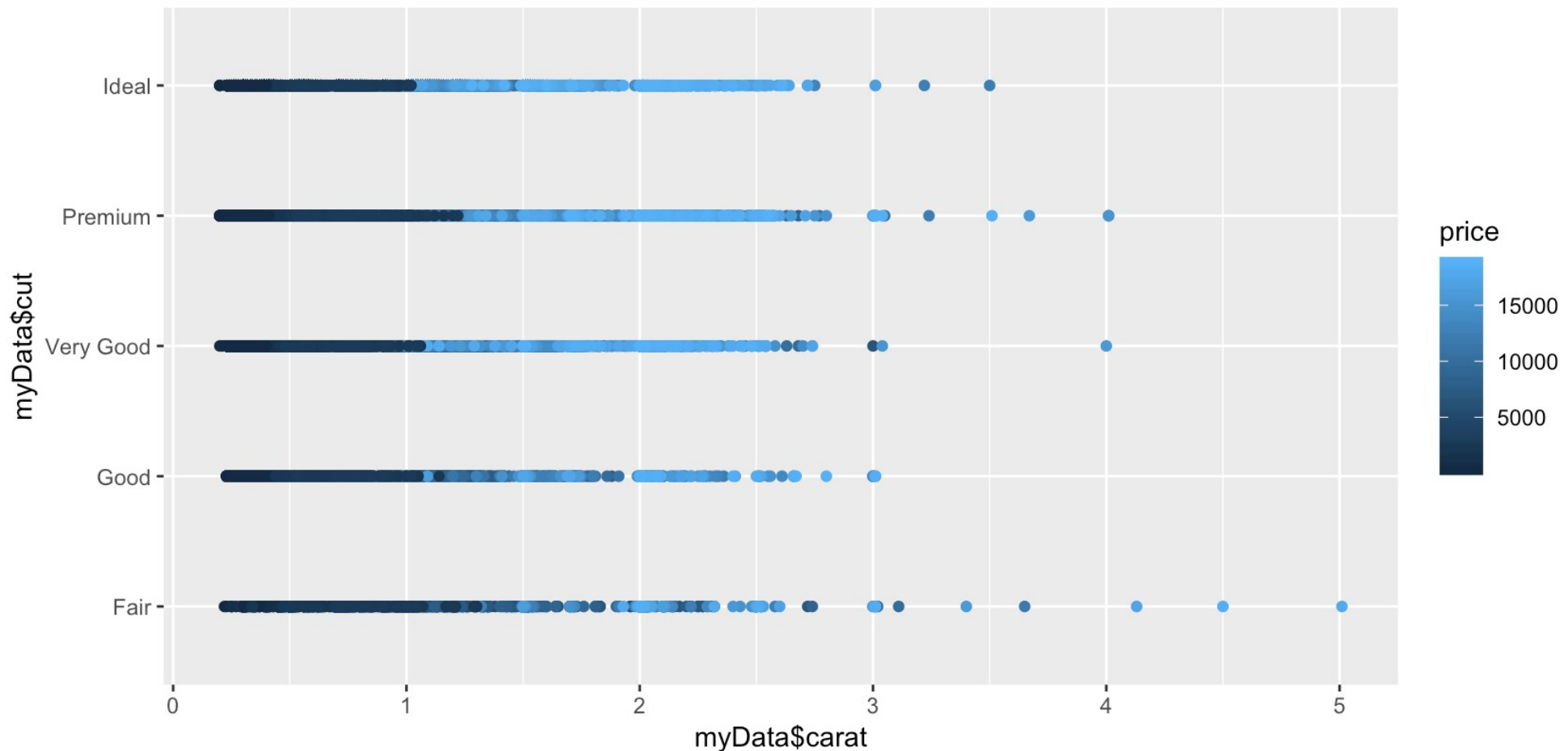


Do I understand what this plot is telling me?



# How Do The Prices Compare?

```
ggplot(data = myData) + geom_point(aes(x=carat, y=cut, color = price))
```

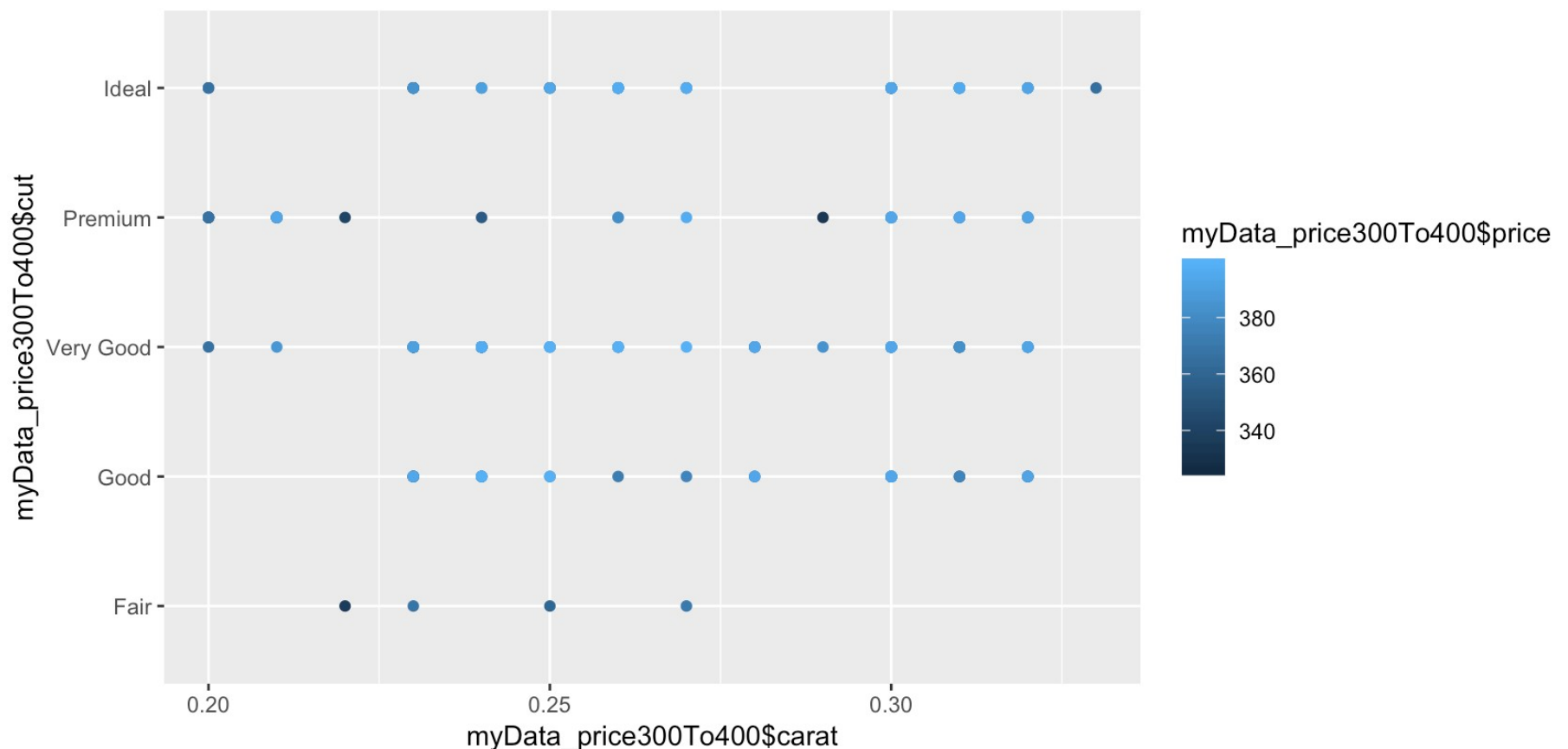




# Isolate Diamonds in Price Range: \$300 to \$400

```
myData_price300To400 <- filter(myData, price >= 300 & price < 400)
```

```
ggplot(data = myData_price300To400) + geom_point(aes(x=carat, y=cut, color = price))
```





ALLEGHENY  
COLLEGE

# Convert Price to Another Currency?





ALLEGHENY  
COLLEGE

# How about Pound Sterling?

1 United States Dollar equals

**0.76 Pound  
sterling**

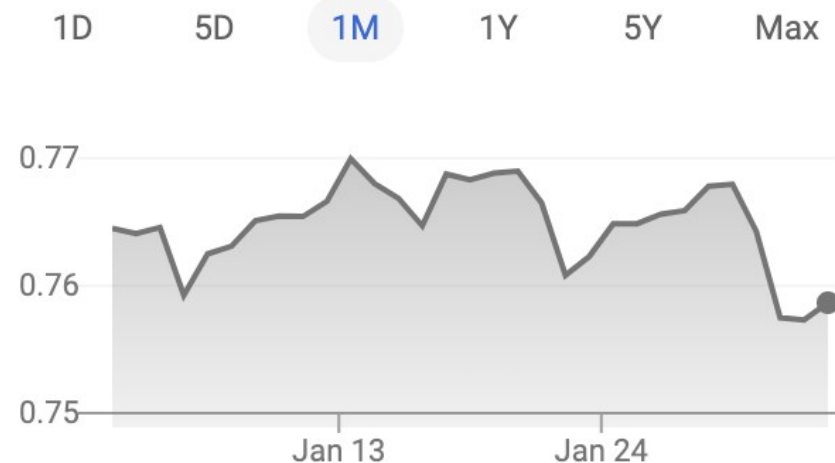
Feb 3, 2:56 AM UTC · Disclaimer

1

United States Dolla▼

0.76

Pound sterling ▼



Data provided by Morningstar for Currency and Coinbase for Cryptocurrency

Can we plot in pounds?!





# *A New Header is Afoot*

Add a new column “poundsSterling” to  
**myData\_price300To400**

```
# create new col, overwrite old dataset  
myData_price300To400 <- mutate(myData, poundsSterling  
= price * 0.76)
```

```
# check data for new col  
View(myData_price300To400)
```

```
# colourise by pounds sterling  
ggplot(data = myData_price300To400) +  
geom_point(aes(x=carat, y=cut, color = poundsSterling))
```





# *Price Vs poundsSterling*

```
ggplot(data = myData_price300To400) +  
  geom_point(mapping = aes(x=carat, y=price, color = price), color = "Blue") +  
  geom_point(mapping = aes(x=carat, y=poundsSterling, color = poundsSterling), color = "Red") +  
  geom_smooth(mapping = aes(x=carat, y=price), color = "Blue") +  
  geom_smooth(mapping = aes(x=carat, y=poundsSterling), color = "Red") +  
  ggtitle("Dollars (Blue) and Pound Sterling (Red)")
```



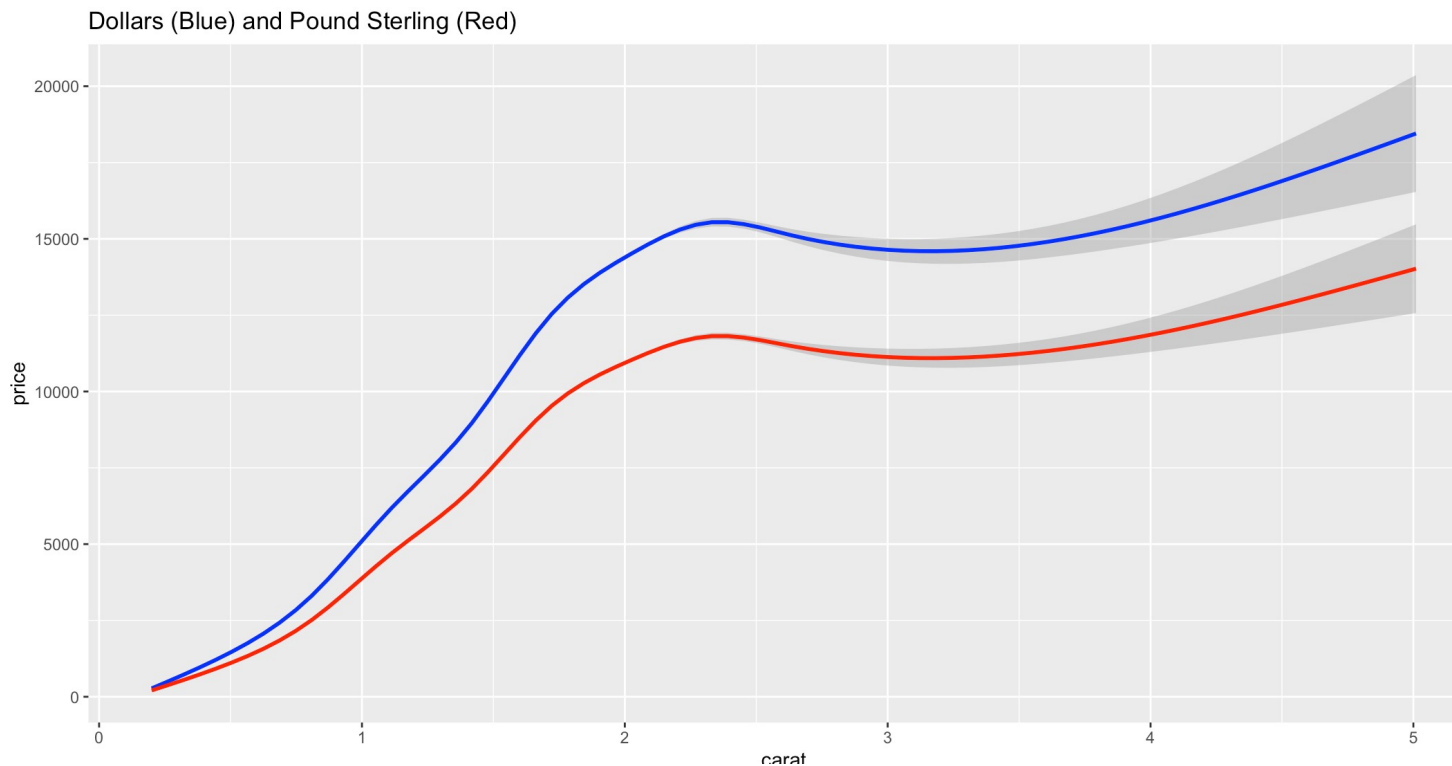
See all points:  
dollars and  
pounds sterling





# *Price Vs poundsSterling*

```
ggplot(data = myData_price300To400) +  
  geom_smooth(mapping = aes(x=carat, y=price), color = "Blue") +  
  geom_smooth(mapping = aes(x=carat, y=poundsSterling), color = "Red") +  
  ggtitle("Dollars (Blue) and Pound Sterling (Red)")
```



Use smooth  
lines to view  
the data

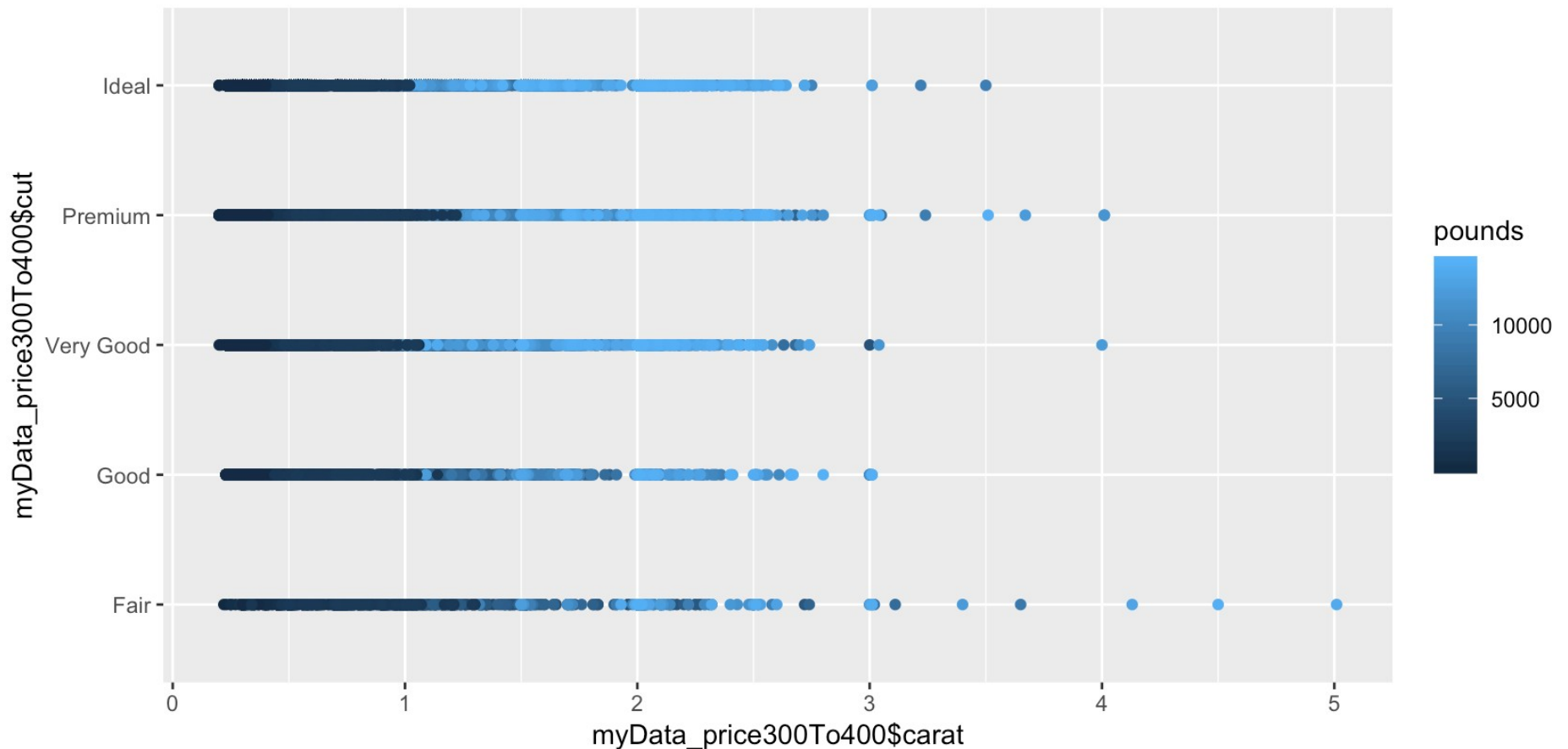






# Add Pounds Currency

```
ggplot(data = myData_price300To400) +  
  geom_point(aes(x=carat, y=cut, color = pounds))
```

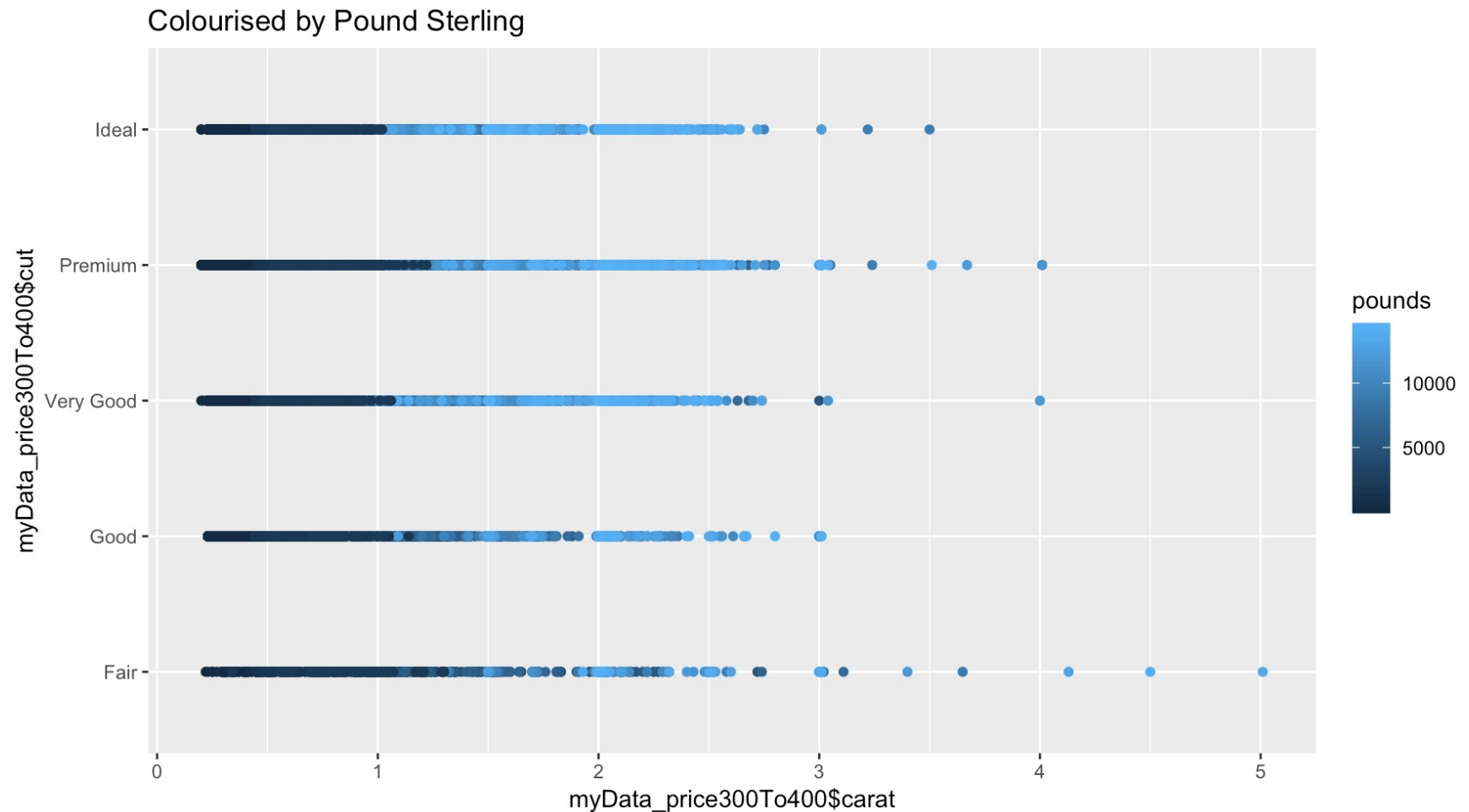






# *Add a Title to the Plot*

```
ggplot(data = myData_price300To400) +  
  geom_point(aes(x=carat, y=cut, color = poundsSterling)) +  
  ggtitle("Colourised by Pound Sterling")
```





# Try Out On Another Dataset?

- **iris** data set gives the measurements in centimeters of the variables sepal length, sepal width, petal length and petal width, respectively, for 50 flowers from each of 3 species of iris. The species are *Iris setosa*, *versicolor*, and *virginica*.
- **ToothGrowth** data set contains the result from an experiment studying the effect of vitamin C on tooth growth in 60 Guinea pigs. Each animal received one of three dose levels of vitamin C (0.5, 1, and 2 mg/day) by one of two delivery methods, (orange juice or ascorbic acid (a form of vitamin C and coded as VC)).
- **PlantGrowth**: Results obtained from an experiment to compare yields (as measured by dried weight of plants) obtained under a control and two different treatment condition.
- **USArrests**: This data set contains statistics about violent crime rates by us state.
- *Data()* # to see more sets in R