Lecture 5: Advanced R Visualizations.

STAT GR5206 *Statistical Computing & Introduction to Data Science*

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Course Notes

- Exam corrections for up to 1/2 points back.
- Example: 50% on Exam 1, then you can get up to a 50%+27.5%=77.5%.
- Example: 97% on Exam 1, then you can get up to a 98%+4%=101%.
- Must knit a pdf (or html).
- Corrections due by Friday 11:59pm.
- Homework 3 & Lab 5 due Thursday 11:59pm.

Last Time

Base R Graphics

Some More Plotting with Base R

Basics of Plotting

Recall,

- Visualization variation (of a single variable):
  - `hist()` – Histograms. – quantitative
  - `barplot()` – Bargraphs. – categorical
- Visualizing covariation (of multiple variables):
  - `plot()` – Scatterplots.
  - `boxplot()` – Boxplots (box-and-whisker plots).

Basics of Plotting

The `plot()` function.

- The foundation of many of `R`'s graphics functions.
- Often one builds up the graph in stages with `plot()` as a base.
- Each call to `plot()` begins a new graph window.
- Takes arguments, called *graphical parameters*, to change various aspects of the plot. (`?par`)

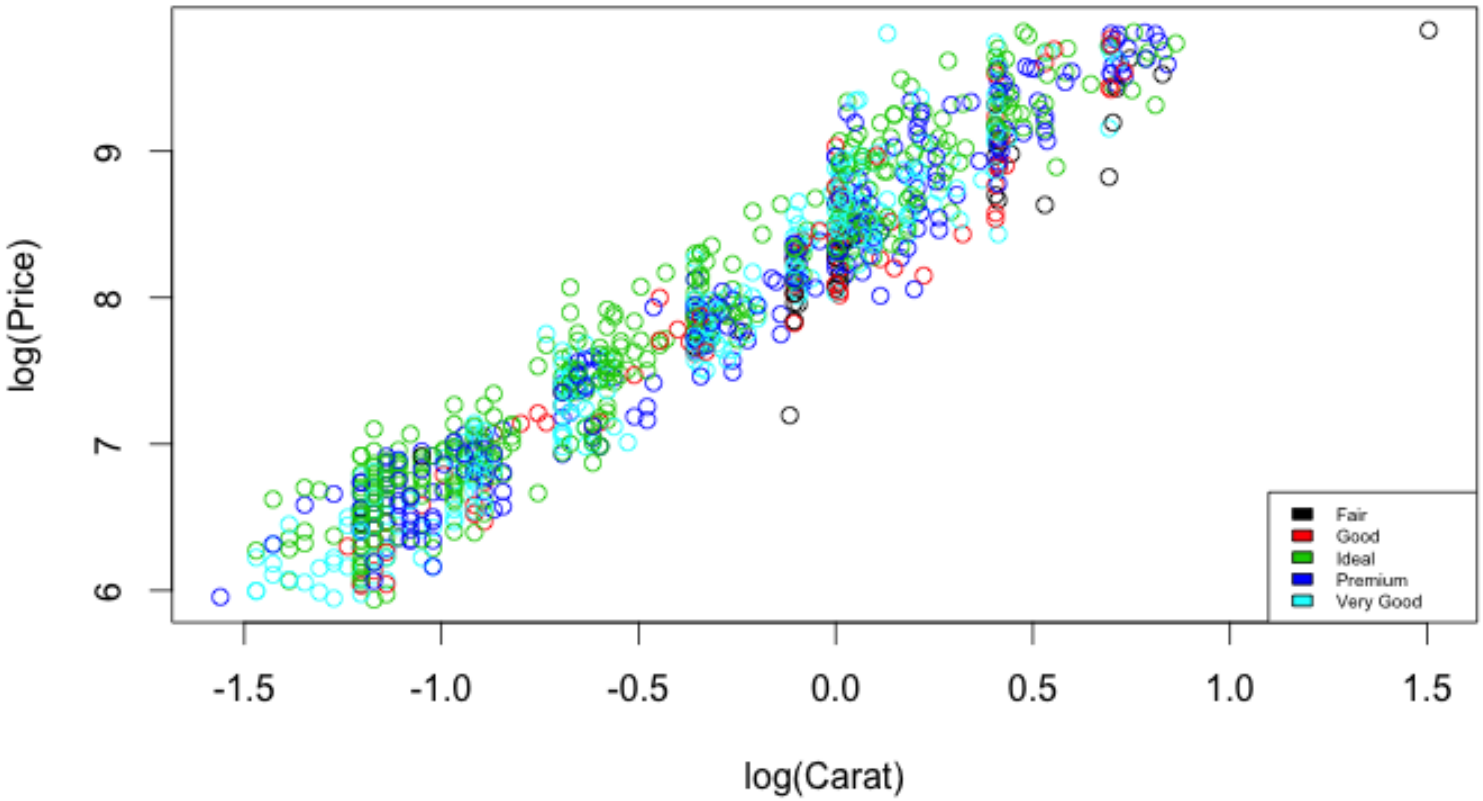
Diamonds Dataset

- Recall the diamonds data set. (`diamonds.csv`)
- Run `diamonds <- read.csv("diamonds.csv", as.is = TRUE)`.

```
> diamonds          <- read.csv("diamonds.csv", as.is = T)
> diamonds$cut      <- factor(diamonds$cut)
> diamonds$color    <- factor(diamonds$color)
> diamonds$clarity <- factor(diamonds$clarity)
> set.seed(1)
> rows <- dim(diamonds)[1]
> diam <- diamonds[sample(1:rows, 1000), ]
```

Building a Visualization: An Example

```
> plot(log(diam$carat), log(diam$price), col = diam$cut)
> legend("bottomright", legend = levels(diam$cut),
+        fill = 1:length(levels(diam$cut)), cex = .5)
```



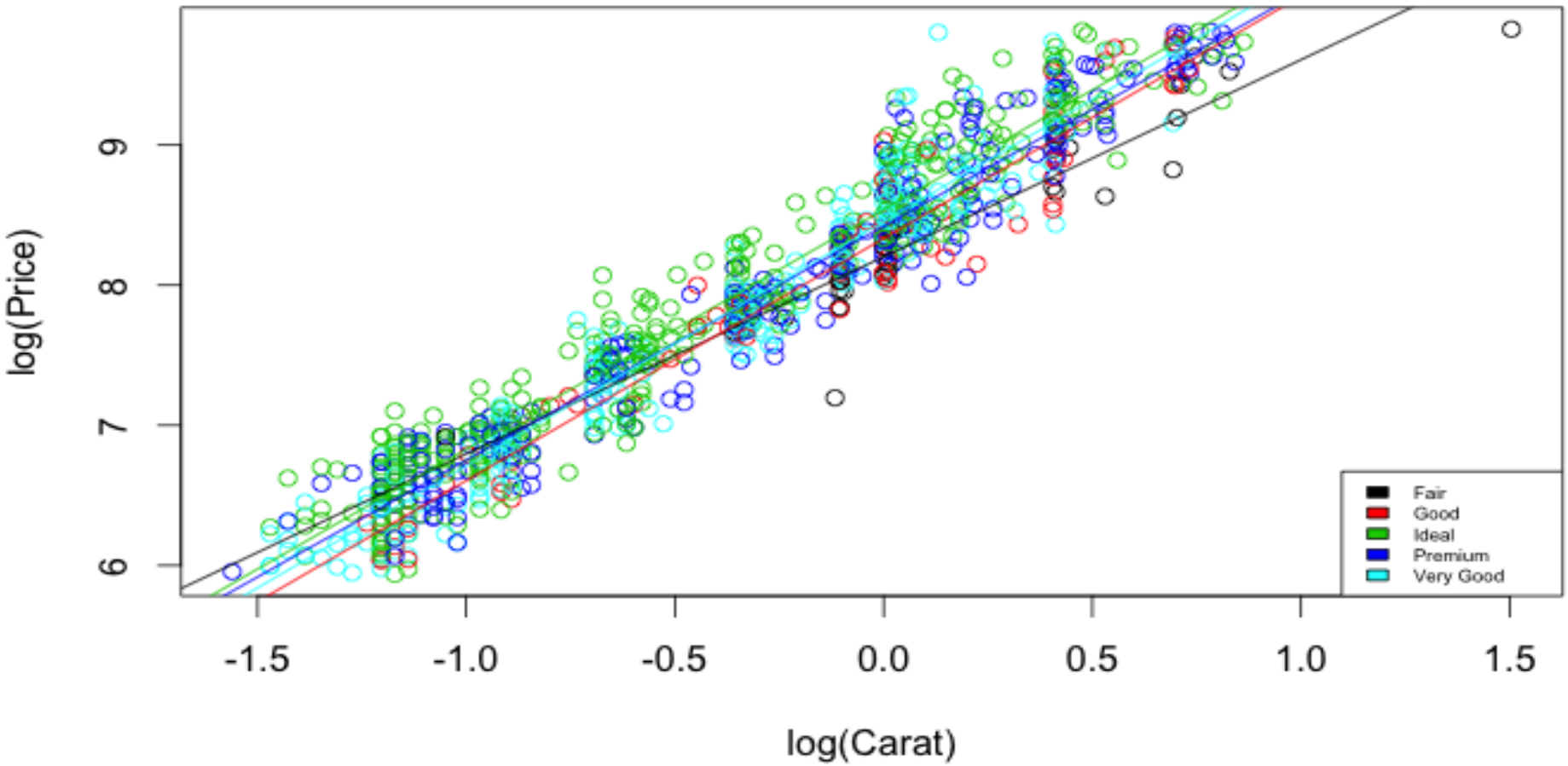
3 variables
Price
Carat
Quality

Building a Visualization: An Example

Let's instead plot a regression line for each cut separately.

```
> cuts        <- levels(diam$cut)
> col_counter <- 1
> for (i in cuts) {
+   this_cut    <- diam$cut == i
+   this_data   <- diam[this_cut, ]
+   this_lm     <- lm(log(this_data$price)
+                     ~ log(this_data$carat))
+   abline(this_lm, col = col_counter)
+   col_counter <- col_counter + 1
+ }
```

Building a Visualization: An Example



Check Yourself

Exercise:

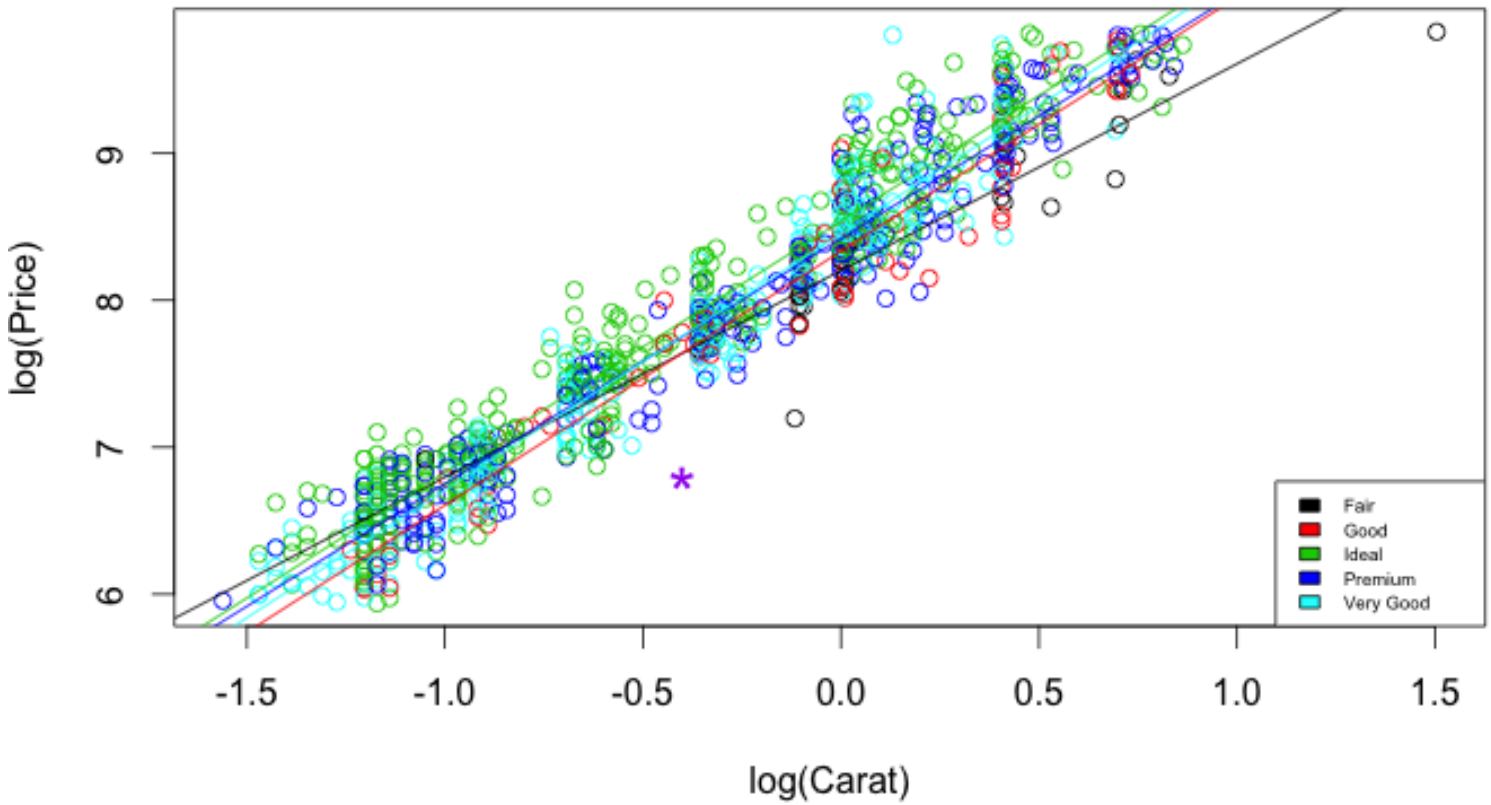
Use the built-in `iris` dataset.

- Create a new column `Setosa` that takes a 1 if the iris is a setosa and a 0 otherwise.
- Plot iris `Sepal.Width` on the x-axis and `Sepal.Length` on the y-axis. Color the points according to whether the iris is a setosa or not.
- Plot two regression lines on the plot, one for the setosa iris and one for non-setosa iris.

Building a Visualization: An Example

We add a new point for a diamond that is \$898 and 0.67 carats.

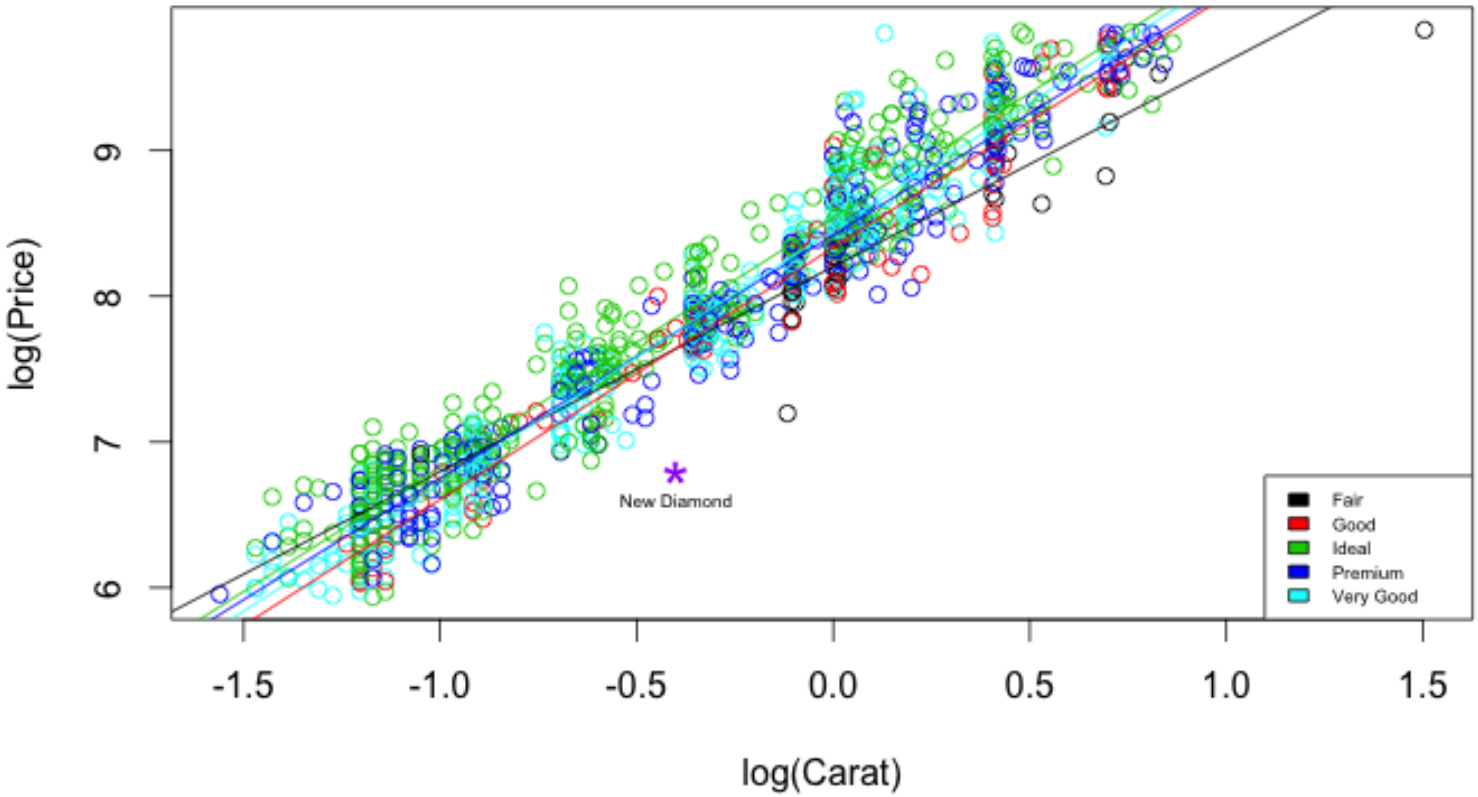
```
> points(-0.4, 6.8,  pch = "*", col = "purple")
```



Building a Visualization: An Example

We add text to the new point we just added.

```
> text(-0.4, 6.8 - .2, "New Diamond", cex = .5)
```



Useful Graphical Parameters

The table below lists a selection of R's graphical parameters. More info at `http://www.statmethods.net/advgraphs/parameters.html` or using `?par`.

Parameter	Description
`pch`	*Point Character*. Character of the points in the plot.
`main`	Title of the plot.
`xlab, ylab`	Axes labels.
`lty`	*Line Type*. E.g. 'dashed', 'dotted', etc.
`lwd`	*Line Width*. Line width relative to default $= 1$.
`cex`	*Character Expand*. Character size relative to default $= 1$.
`xlim, ylim`	The limits of the axes.
`mfrow`	Plot figures in an array (e.g. next to each other).
`col`	Plotting color.

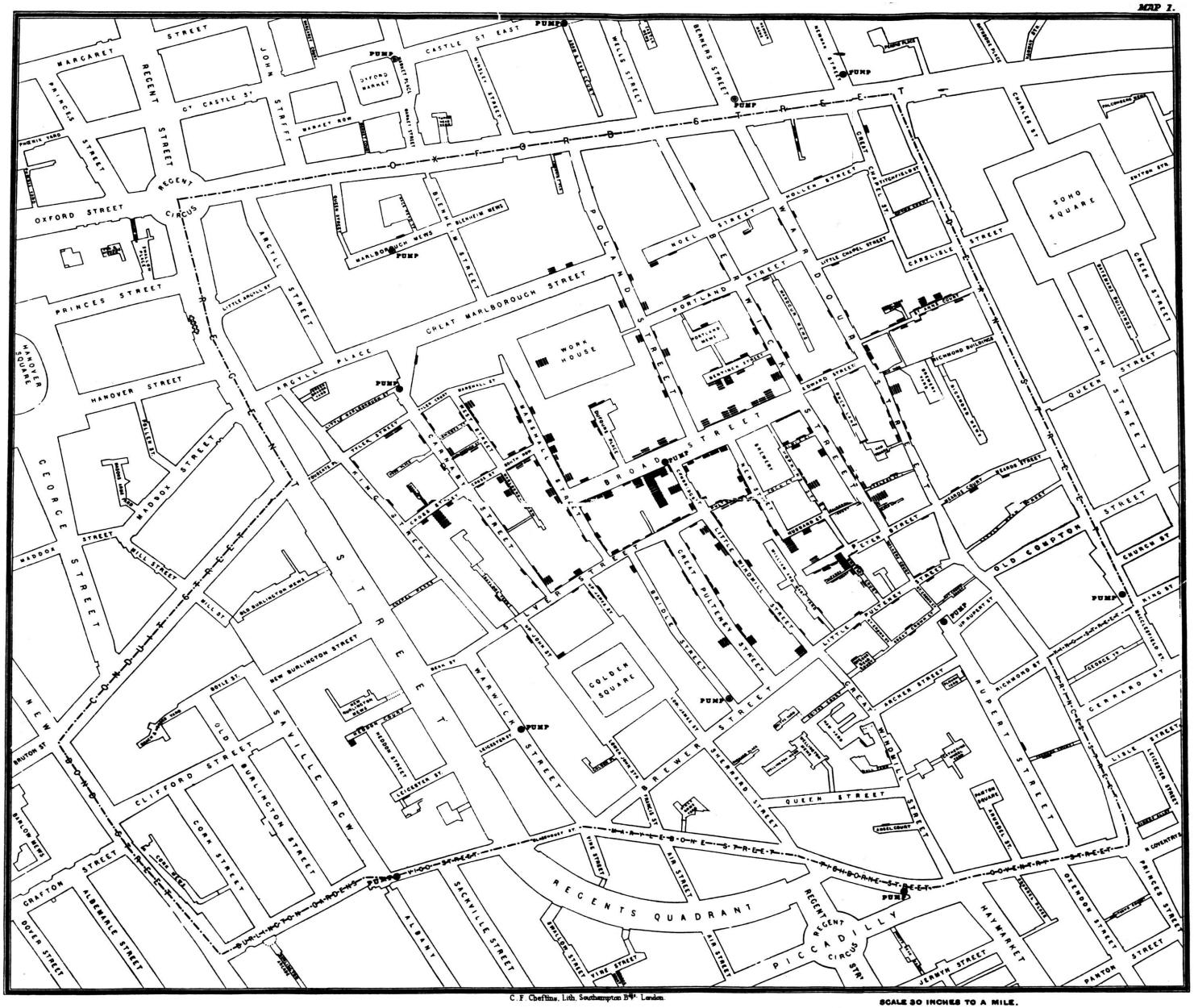
Data Visualization

Section II

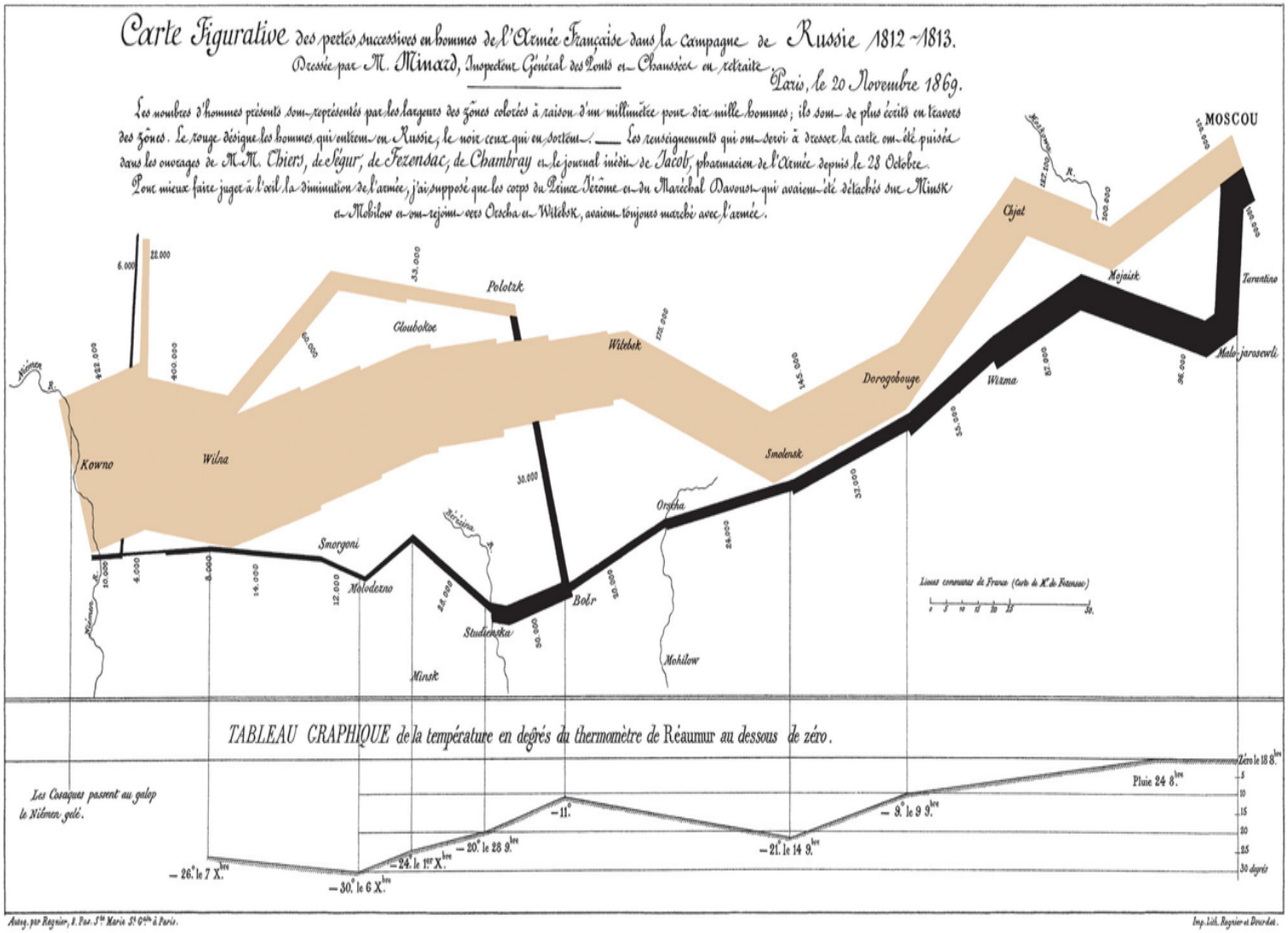
Good Visualizations

In data science, good visualizations should give you more information than you can see in just the data table itself.

Good Visualizations - John Snow 1854 (Wikipedia)



Good Visualizations - Charles Joseph Minard 1896 (Wikipedia)



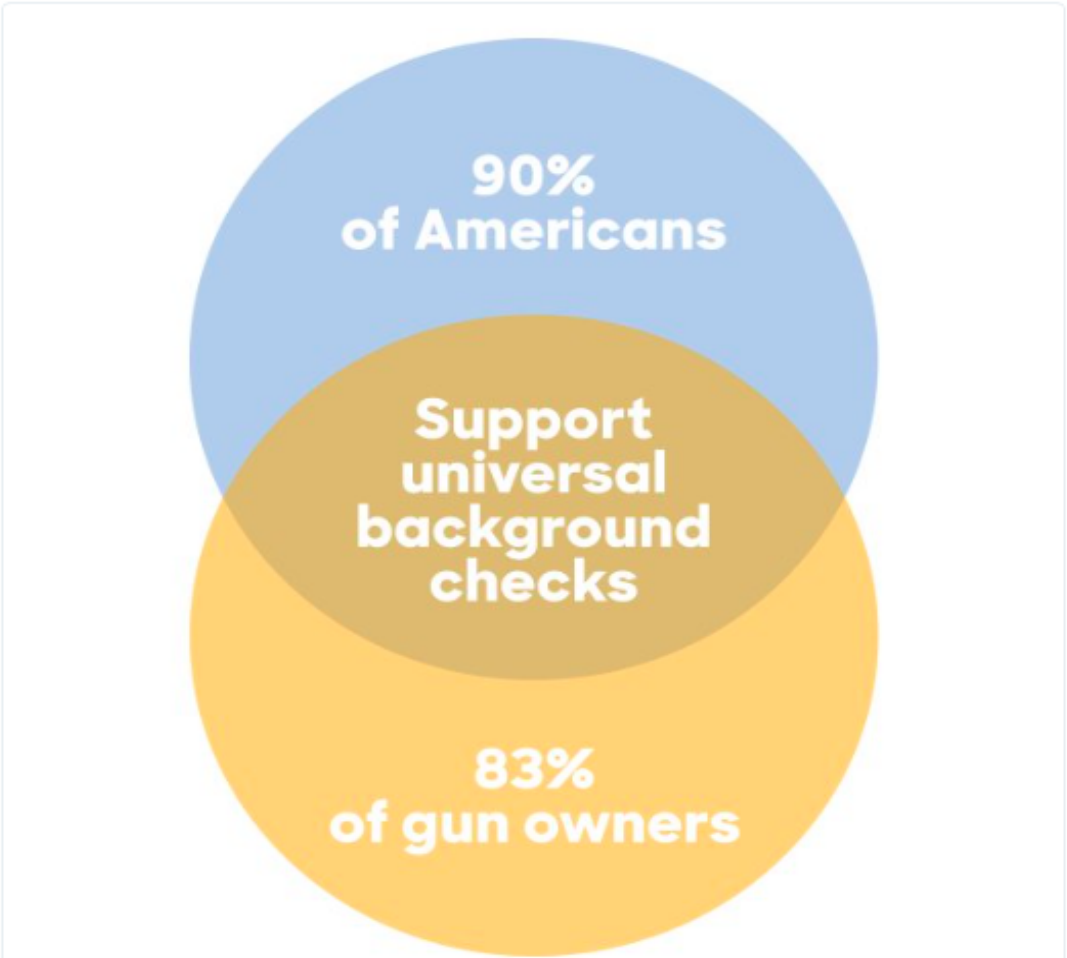
Good Visualizations - Charles Joseph Minard 1896 (Wikipedia)

Minard Graph

Minard shows six variables:

- Number of soldiers,
- Direction of the march,
- Location coordinates,
- Temperature on the return journey,
- Location on dates in November and December.

Bad Visualizations - Hillary Clinton



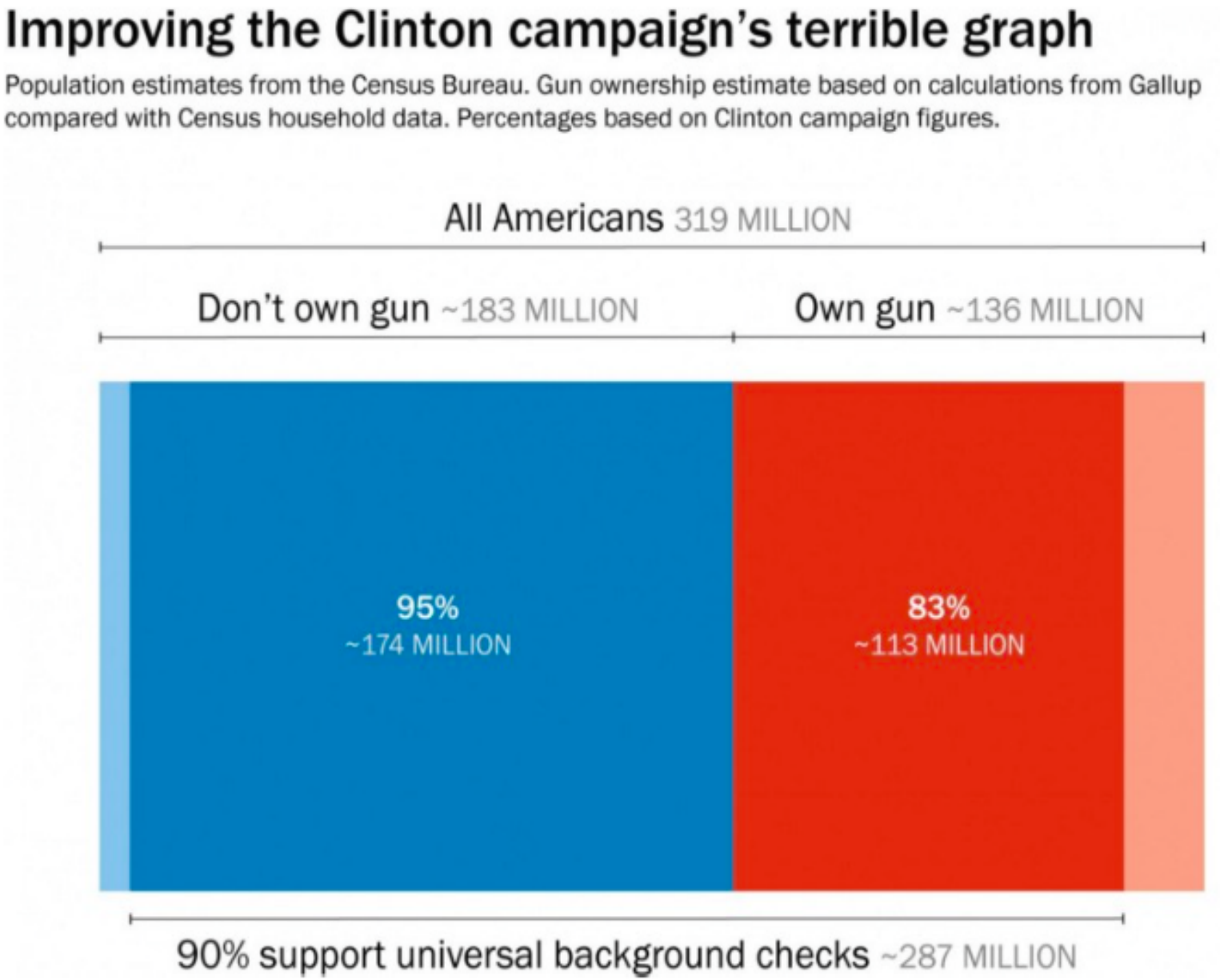
Hillary Clinton
@HillaryClinton

Follow

Dear Congress,

Let's get this done.

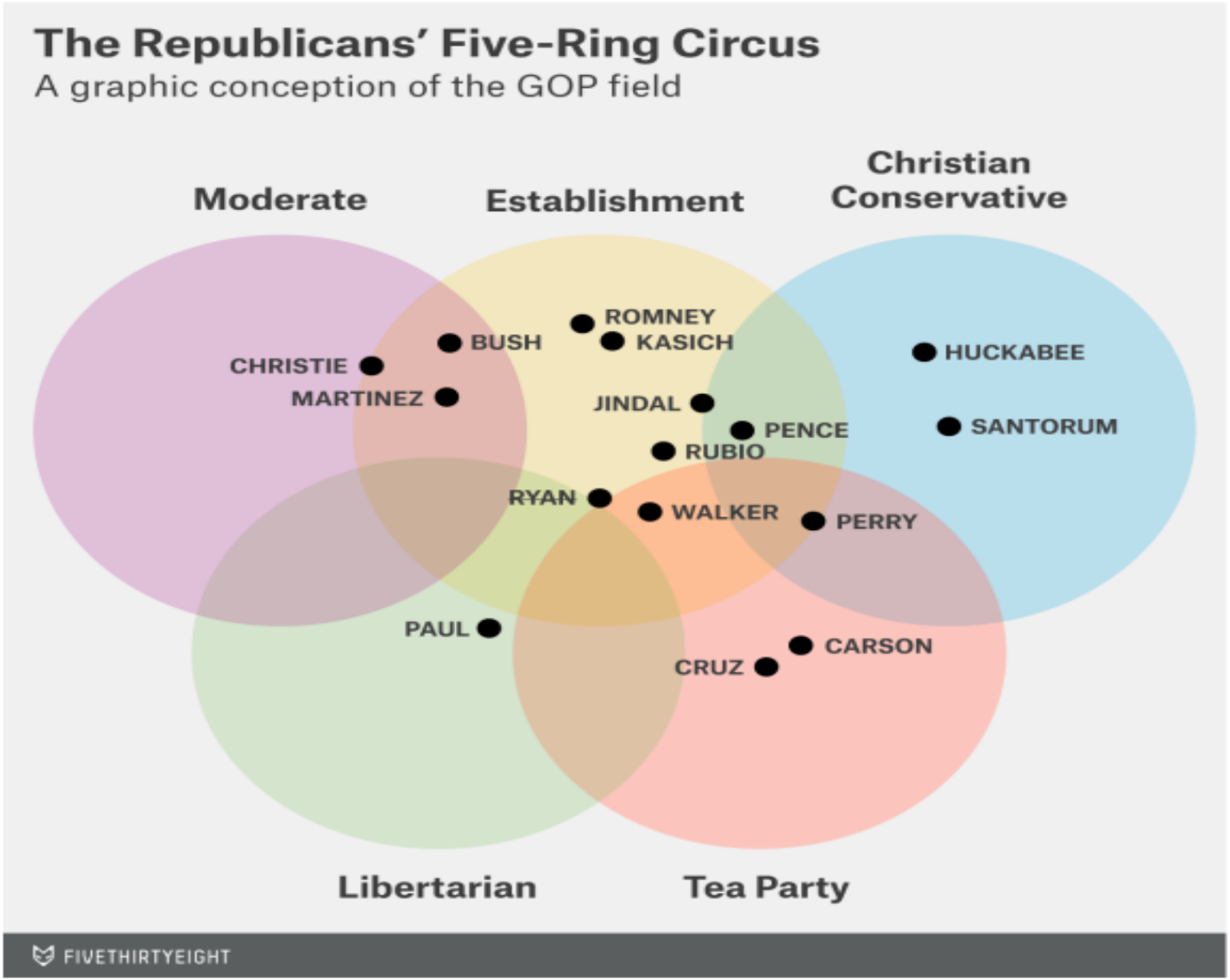
Good Visualizations - Washington Post



Bad Visualizations

Even statisticians are sometimes bad at making visualizations!

Bad Visualizations - Nate Silver



Bad Visualizations - Nate Silver

Candidate	Moderate	Establishment	Christian Conservative	Libertarian	Tea Party
Bush	X	X			
Carson					X
Christie	X	X			
Cruz					X
Huckabee			X		
Jindal		X	X		
Kasich		X			
Martinez	X	X			
Paul				X	
Pence		X	X		
Perry		X	X		X
Romney		X			
Rubio		X			
Ryan		X			
Santorum			X		
Walker		X			X

Check Yourself – Good or Bad?

National Household Survey (NHS)

Search NHS

By topic

By geography

Products

Analytical products

Data products

Reference products

Other links

NHS corrections/updates

Accessing my NHS information

Census

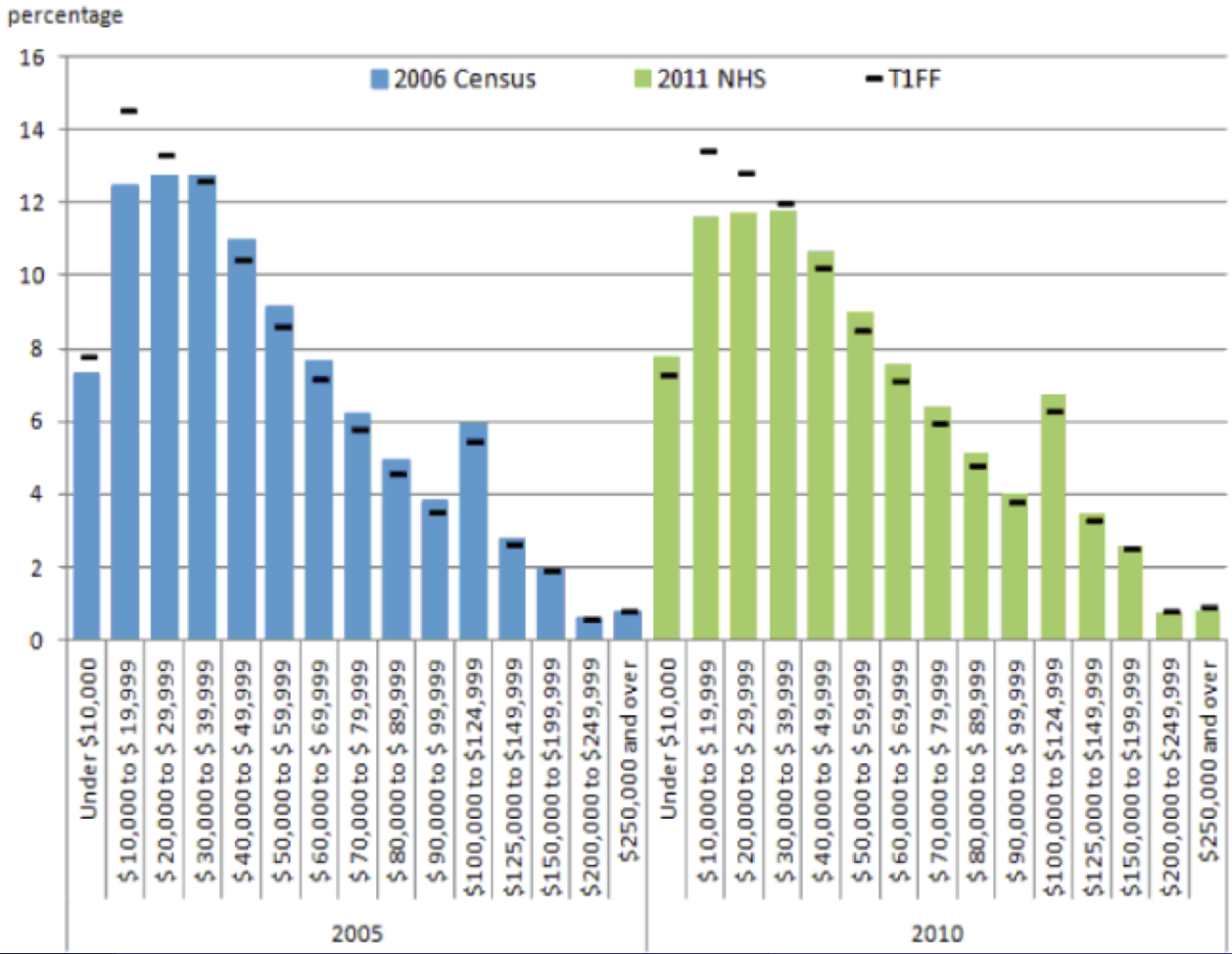
Geography

Open data

Figure 2

Distribution of after-tax income of census family units for Canada, 2005 and 2010

Description for figure 2



Bad Visualizations

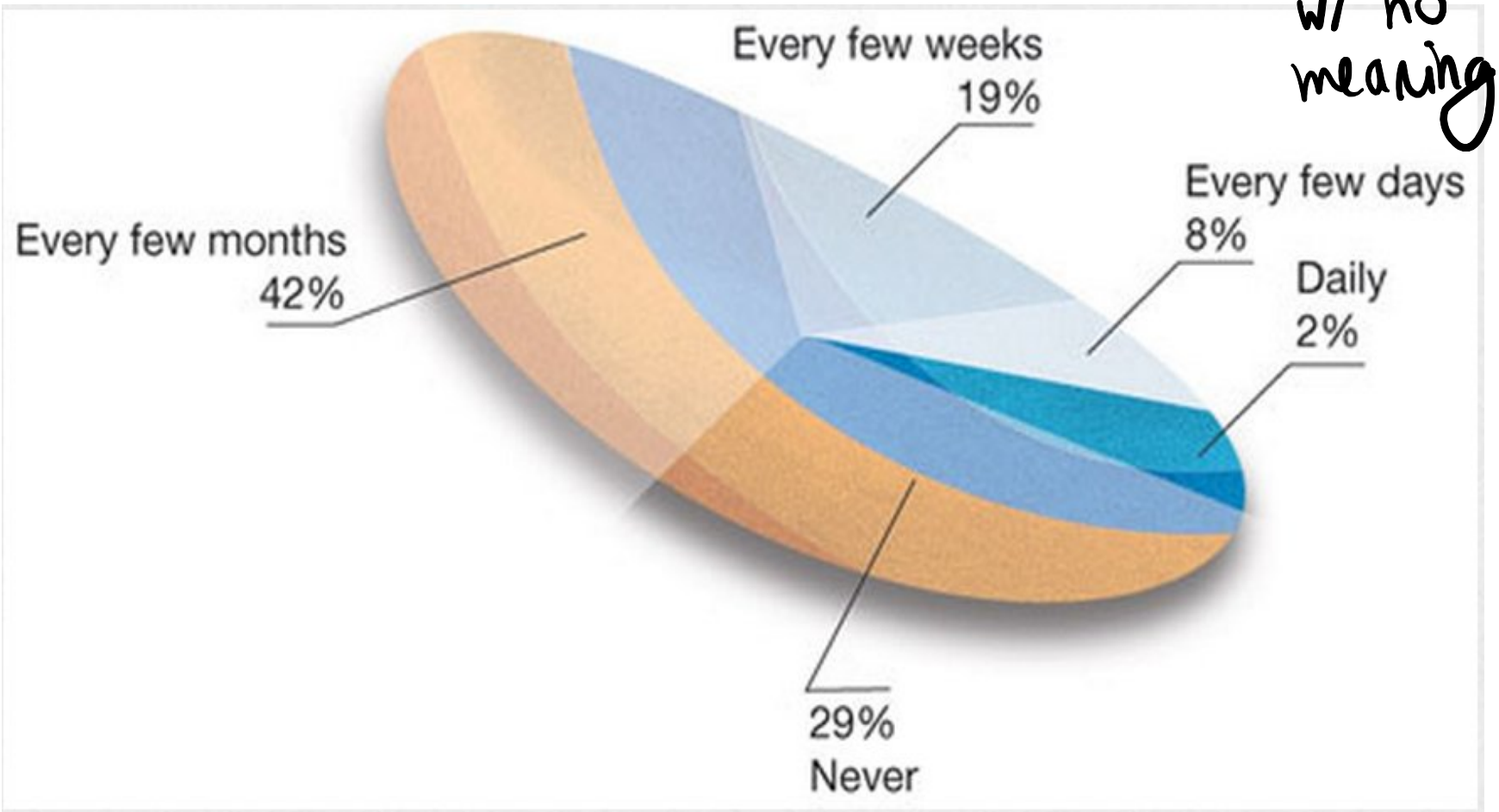
Pie charts are a poor way to illustrate information.

Bad Visualizations

Pie charts are a poor way to illustrate information.

Especially this one:

a lot of dimensions w/ no meaning



Task

Identify what the following function does.

Code

```
> pie.chart <- function(data) {
+ print("I suck")
+ }
```

Task

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Code

```
> pie.chart <- function(data) {
+ print("I suck")
+ }
```

The pie.chart function prints "I suck"

```
> pie.chart(c("Red","Red","Blue"))

[1] "I suck"
```

Good Visualizations

- Keep things simple in terms of color and presentation!
- Try not adding non-needed dimensions to a plot, i.e., 3D bar chart describing one categorical variable.
- Showing more dimensions on lower a dimensional plot is encouraged, i.e, diamond price versus carat split by cut.
- Barcharts are a better way to summarize categorical data compared to piecharts.

Advanced Visualization Techniques

ggplot2

- R has several systems for making graphs (we've looked at the base R functions).
- ggplot2 is one of the most elegant and flexible.
- ggplot2 uses a coherent system (or 'grammar') for describing and building graphs.

↳ part of tidyverse

ggplot2

- R has several systems for making graphs (we've looked at the base R functions).
- ggplot2 is one of the most elegant and flexible.
- ggplot2 uses a coherent system (or 'grammar') for describing and building graphs.

Need to run `install.packages("ggplot2")` now and `library("ggplot2")` every time you want to use it!

ggplot2

We study `ggplot2` using the `mpg` dataset. Let's try to answer the question: do cars with bigger engines use more fuel than cars with small engines?

ggplot2

We study ggplot2 using the mpg dataset. Let's try to answer the question: do cars with bigger engines use more fuel than cars with small engines?

Read about the data using ?mpg.

```
> dim(mpg)

[1] 234  11

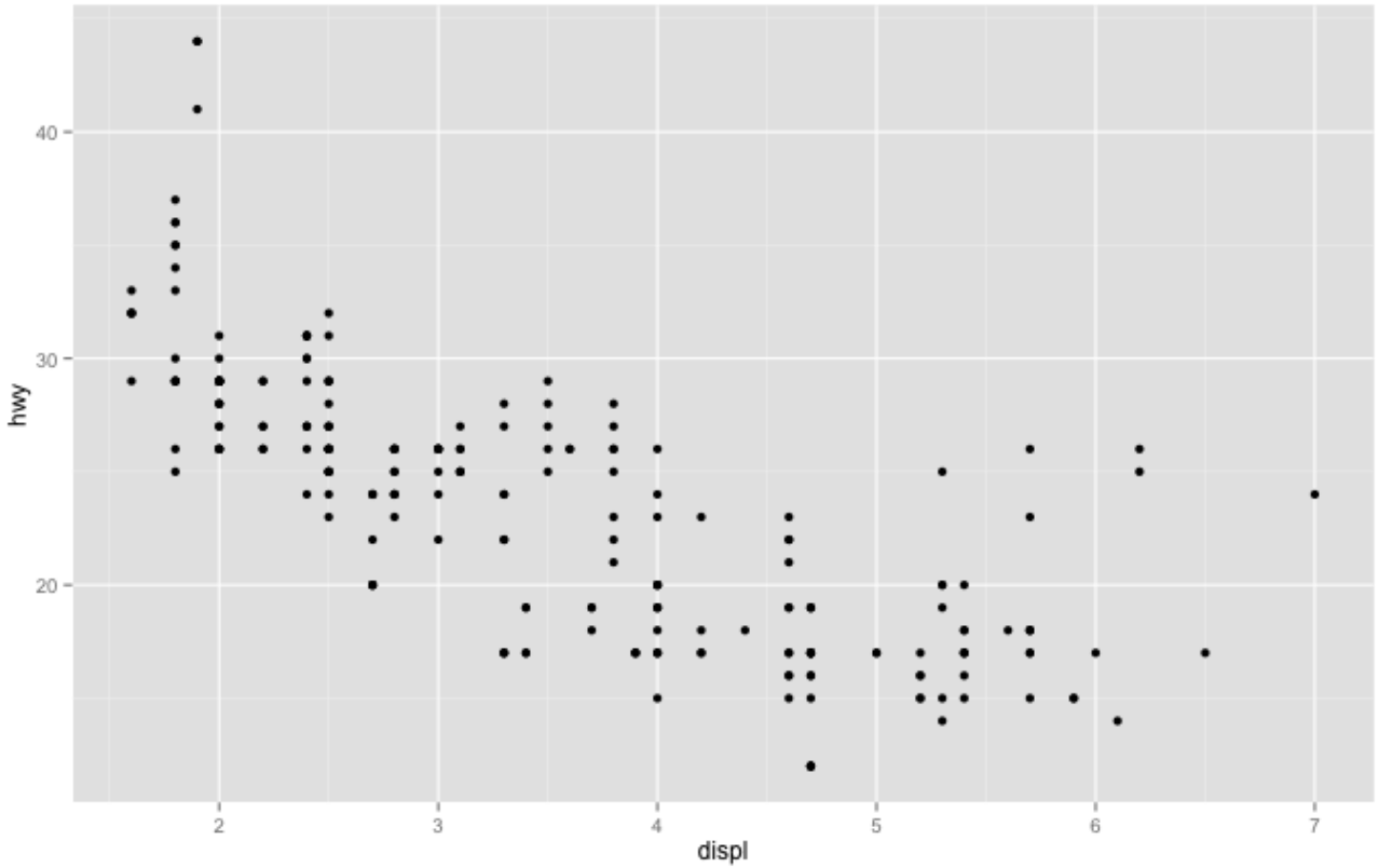
> head(mpg, 3)

  manufacturer model displ year cyl      trans drv cty hwy
1         audi    a4   1.8 1999   4   auto(l5)   f  18  29
2         audi    a4   1.8 1999   4 manual(m5)   f  21  29
3         audi    a4   2.0 2008   4 manual(m6)   f  20  31
  fl   class
1  p compact
2  p compact
3  p compact
```

A First Plot

↳ reference dataframe

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



A First Plot

Let's break apart the code:

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy))
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  - It creates the coordinate axis that you add to.
  - The first argument is the dataset

A First Plot

Let's break apart the code:

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

1. Begin a plot with `ggplot()`.
   - It creates the coordinate axis that you add to.
   - The first argument is the dataset
2. Next you want to add layers to the plot. → putting layer on dataframe
   - In our example: `geom_point()` adds a layer of points.
   - Lots of different `geom` functions doing different things.

A First Plot

Let's break apart the code:

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

- Begin a plot with `ggplot()`.
  - It creates the coordinate axis that you add to.
  - The first argument is the dataset
- Next you want to add layers to the plot.
  - In our example: `geom_point()` adds a layer of points.
  - Lots of different `geom` functions doing different things.
- `geom` functions take `mapping` arguments.
  - Defines how variables in your dataset are mapped to visual properties.
  - Always paired with `aes()`. aesthetic
  - The `x` and `y` arguments specify which variables to map to the axes.

A First Plot

General structure:

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

To create a plot, replace the bracketed sections in the code above with a datatset, a `geom` function, and a set of mappings.

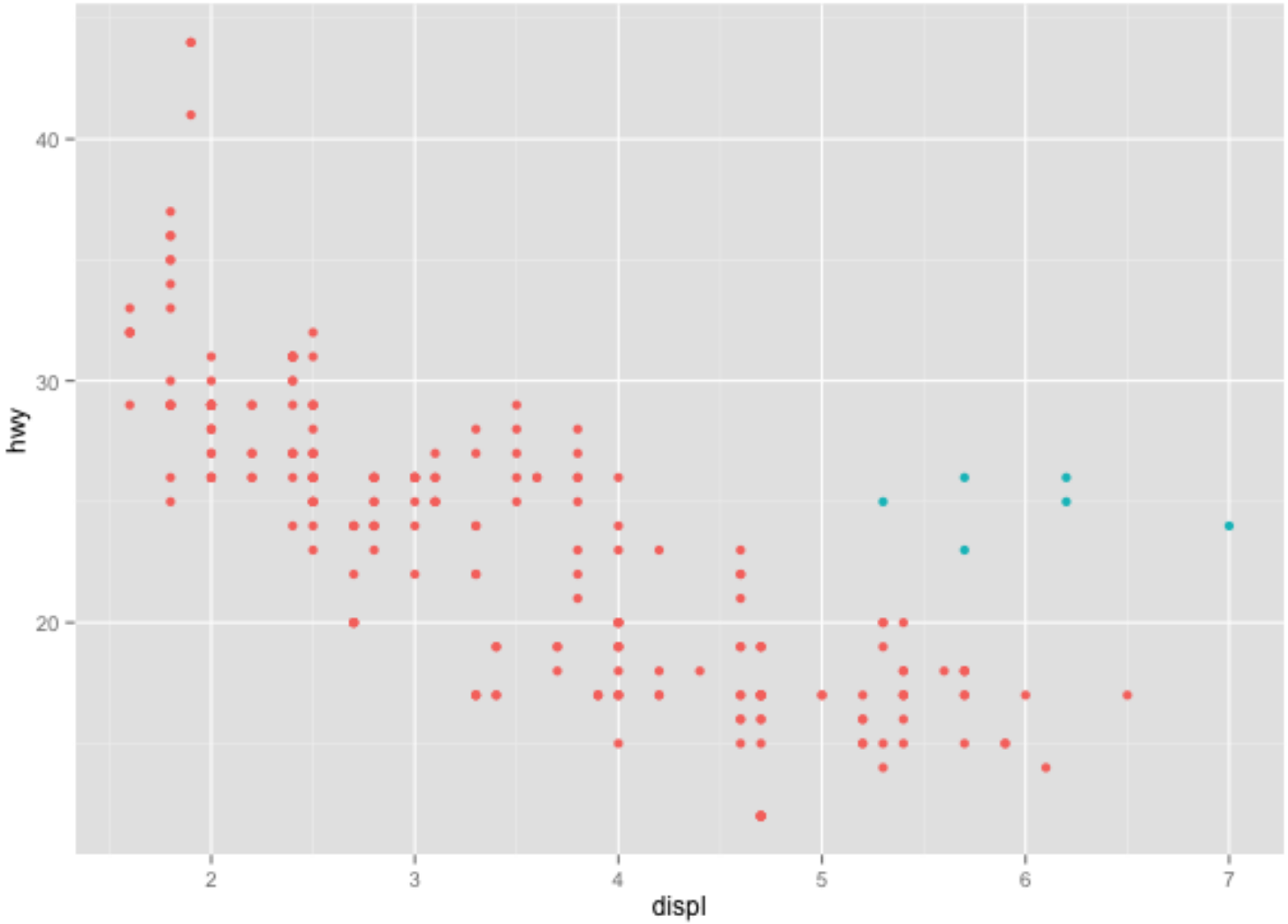
From this template, we can make many different kinds of graphs using `ggplot`.

Check Yourself

Tasks

- Plot just `ggplot(data = mpg)`. What do you get?
- Make a scatterplot of `hwy` vs. `cyl`.
- Make a scatterplot of `class` vs. `drv`. Why is this plot not useful?

Aesthetic Mappings



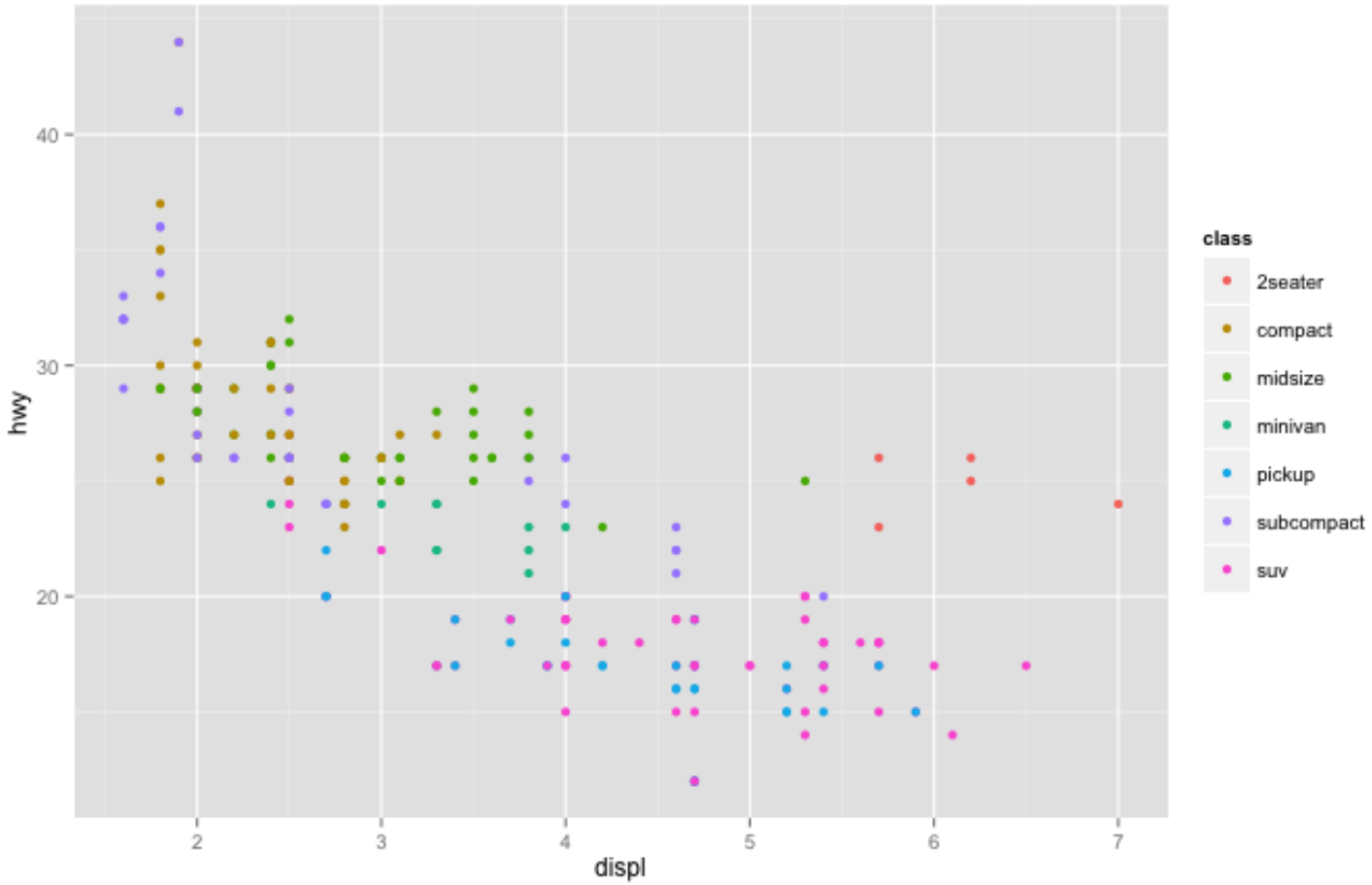
The blue points seem to have a different trend than the rest – possibly hybrids? We study car `class` to find out.

Aesthetic Mappings

- We can add a third variable to a scatterplot by mapping it to an **aesthetic**.
- An **aesthetic** is a visual property of the objects in the plot.
- Things like size, color, shape of points.

Mapping Aesthetics

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



Check Yourself

Tasks

- Instead of mapping `class` to the `color` aesthetic, map it to the `alpha` aesthetic or the `size` aesthetic.
- Instead of mapping `class` to the `color` aesthetic, map it to the `shape` aesthetic. Note that `ggplot()` will only use 6 shapes at a time. What does this mean for our plot?
- What does the following code do?

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

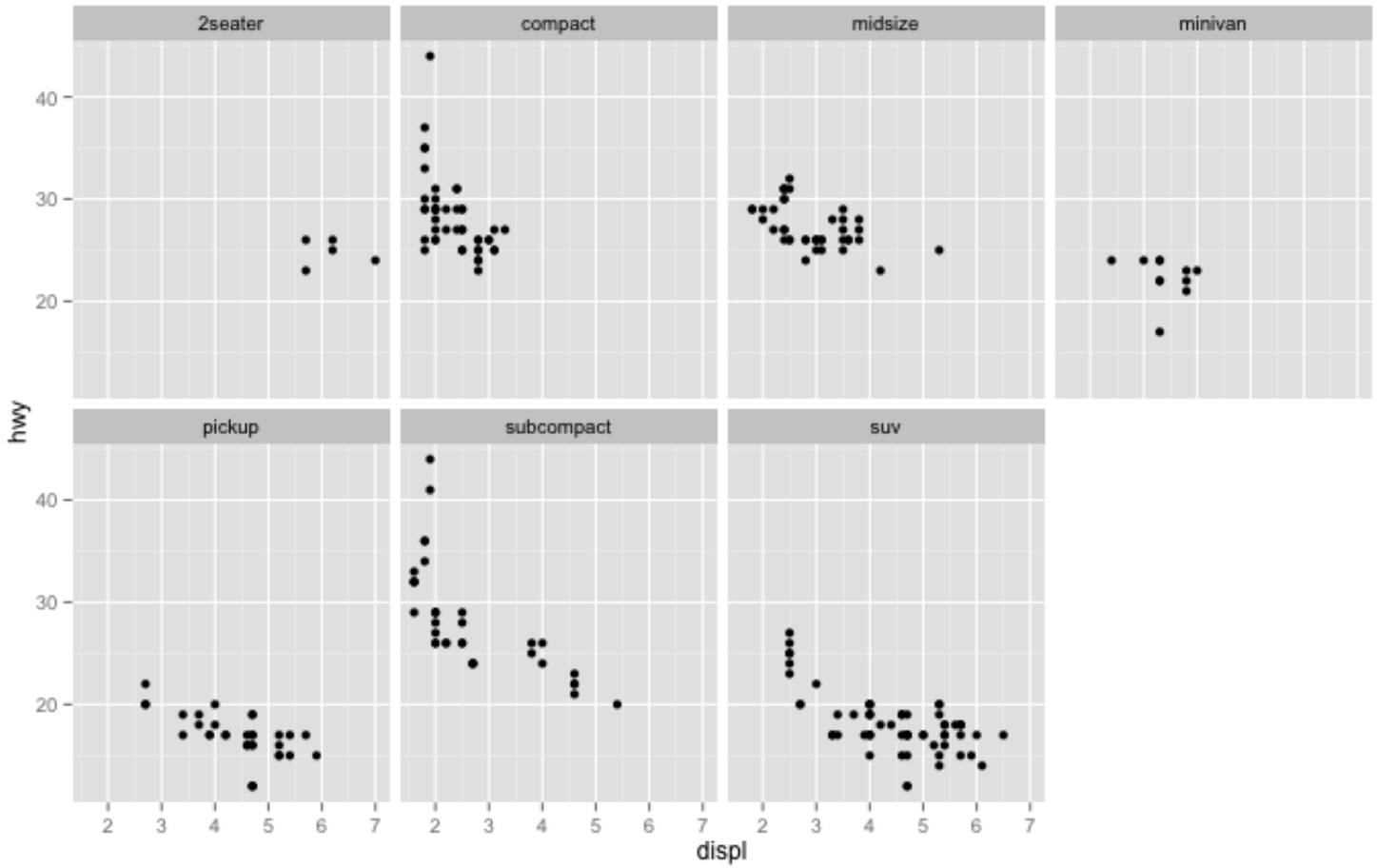
- Map a continuous variable in the `mpg` dataset, like `cty`, to the `alpha`, `shape`, and `size` aesthetics. What does this do?

Facets

- We saw we could add categorical variables to plots using aesthetics.
- Can also do this by splitting the plot into **facets**, which are subplots that each display one subset of the data.
- Use the ~~`fact_wrap()`~~ facet_wrap() command to facet a plot by a single variable.
- The argument is a formula created with ~ followed by a variable name.

Facets

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy)) +
  facet_wrap(~ class, nrow = 2)
```



Check Yourself

Tasks

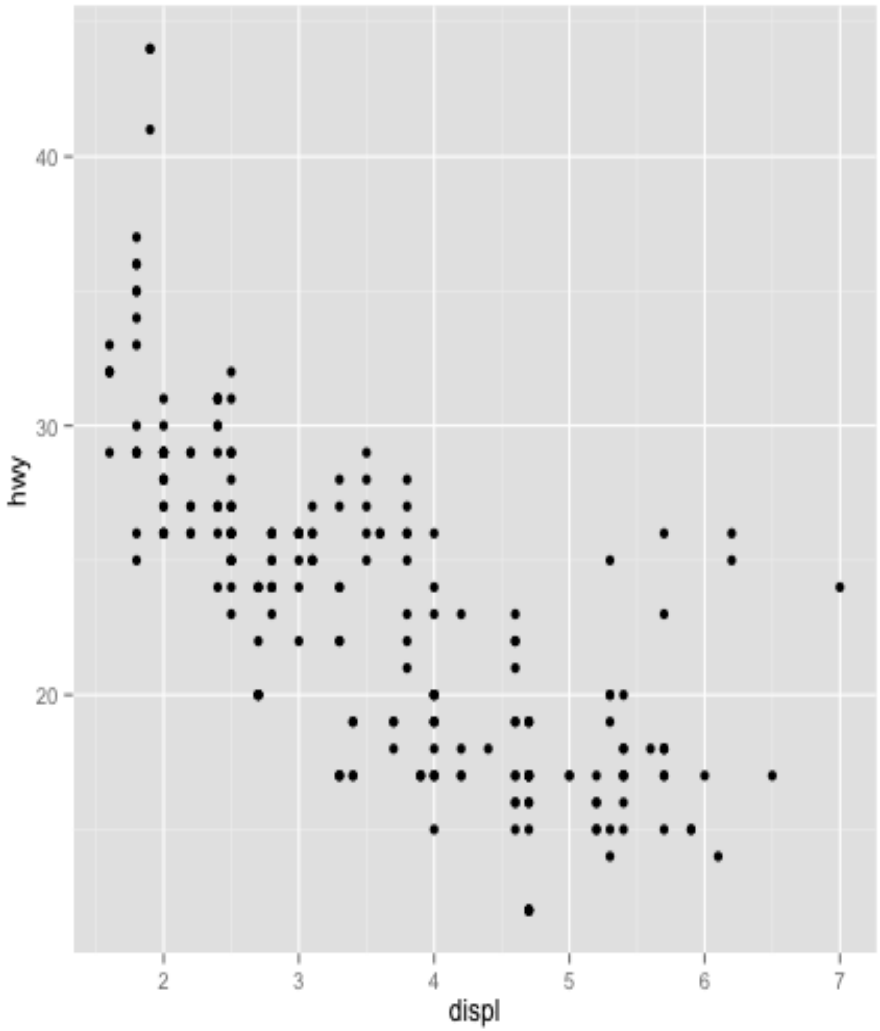
- Facet on two variables use the `facet_grid()` command. An example is the following:

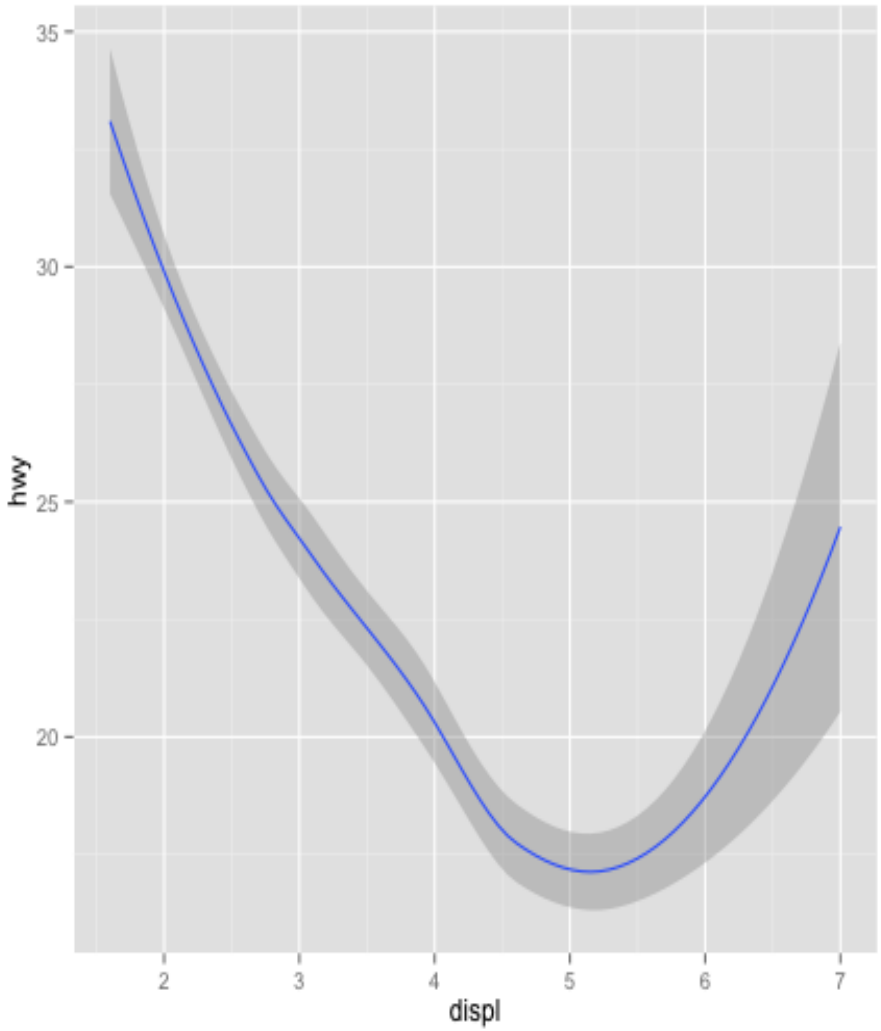
```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy)) +
  facet_grid(drv ~ class)
```

  What do the empty cells mean?

- Look at `?facet_wrap`. What do `nrow` and `ncol` do? Why doesn't `facet_grid()` have `nrow` and `ncol` arguments?
- What happens if you facet on a continuous variable?

Geometric Objects



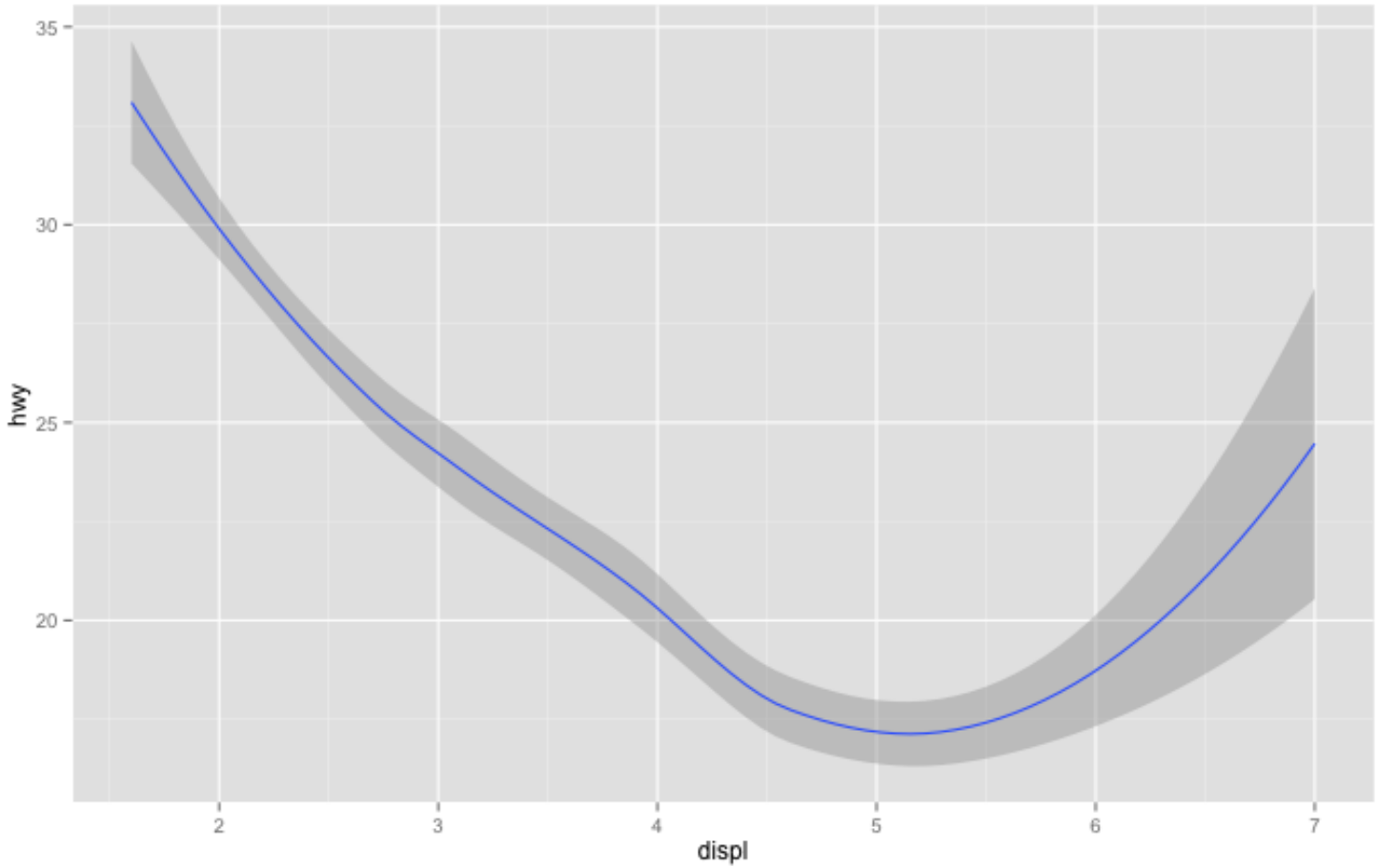


Geometric Objects

- In the previous slide, each plot used a different **visual object** to represent the data.
- Produce this by using different `geoms`.
- A `geom` is a geometrical object used to represent data in a plot.
- Often describe plots by the type of `geom` they use. For example, bar graphs use bar `geoms`.

Geometric Objects

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



Geometric Objects

- Every `geom` takes a `mapping` argument but not every aesthetic works with every `geom`.
  - E.g., you can set the `shape` of a point, but not a line. You can set the `linetype` of a line.
- `ggplot2` has around 30 different `geoms`.
- Can get help with `?geom_smooth`, for example.

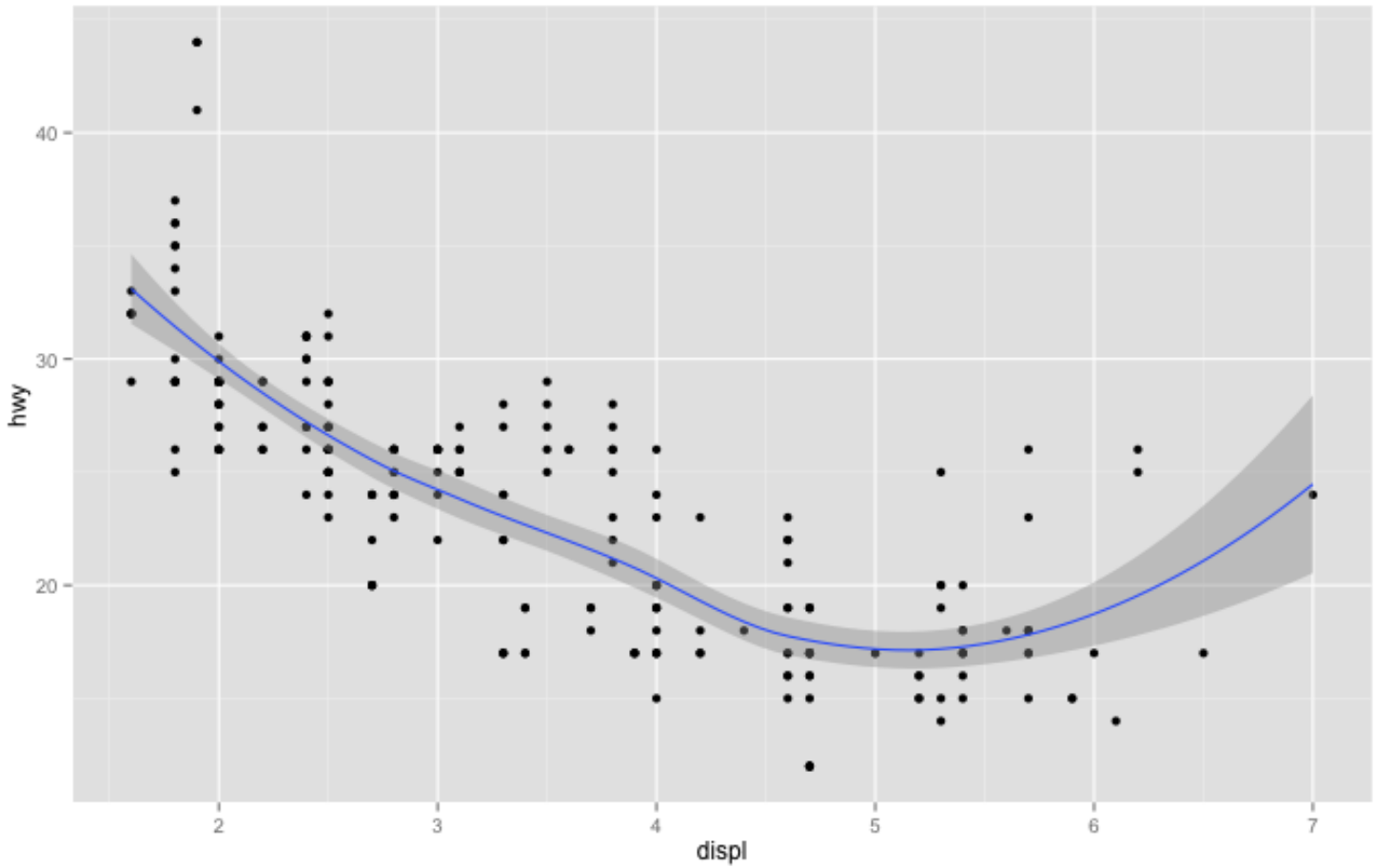
Geometric Objects

Some Commonly-used geoms

geom Name	Used to...	Aesthetics
geom_histogram	Visualize a Continuous Variable	x .
geom_bar	Visualize a Discrete Variable	x.
geom_point	Visualize a Two Continuous Variables	x, y.
geom_text	Add Labels to a Plot	x, y, label.
geom_boxplot	Visualize Continuous and Discrete Variables	x, y.
geom_jitter	Visualize a Two Variables	x, y.
many more ...		

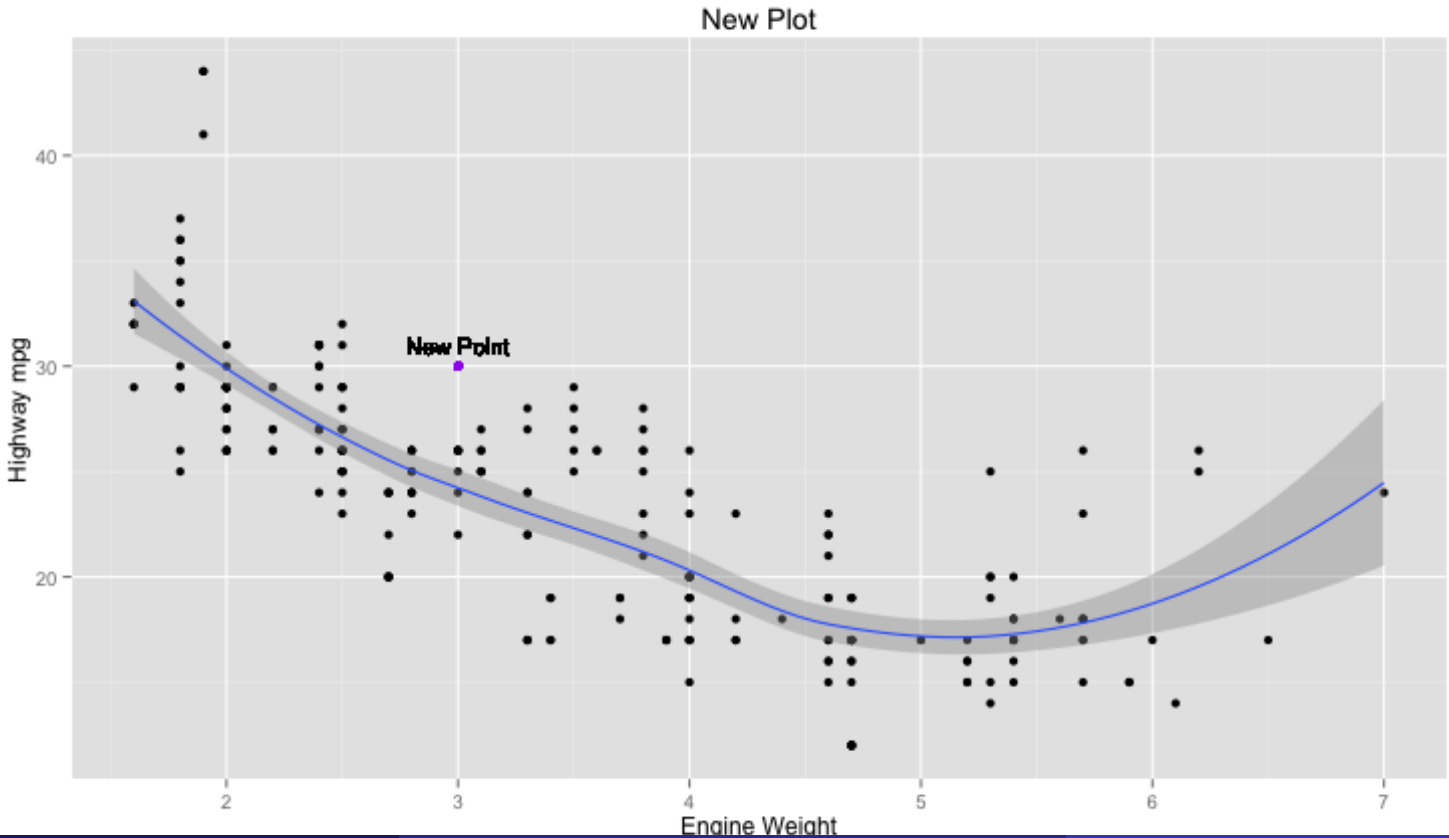
Layering geoms

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



Adding Axis Labels

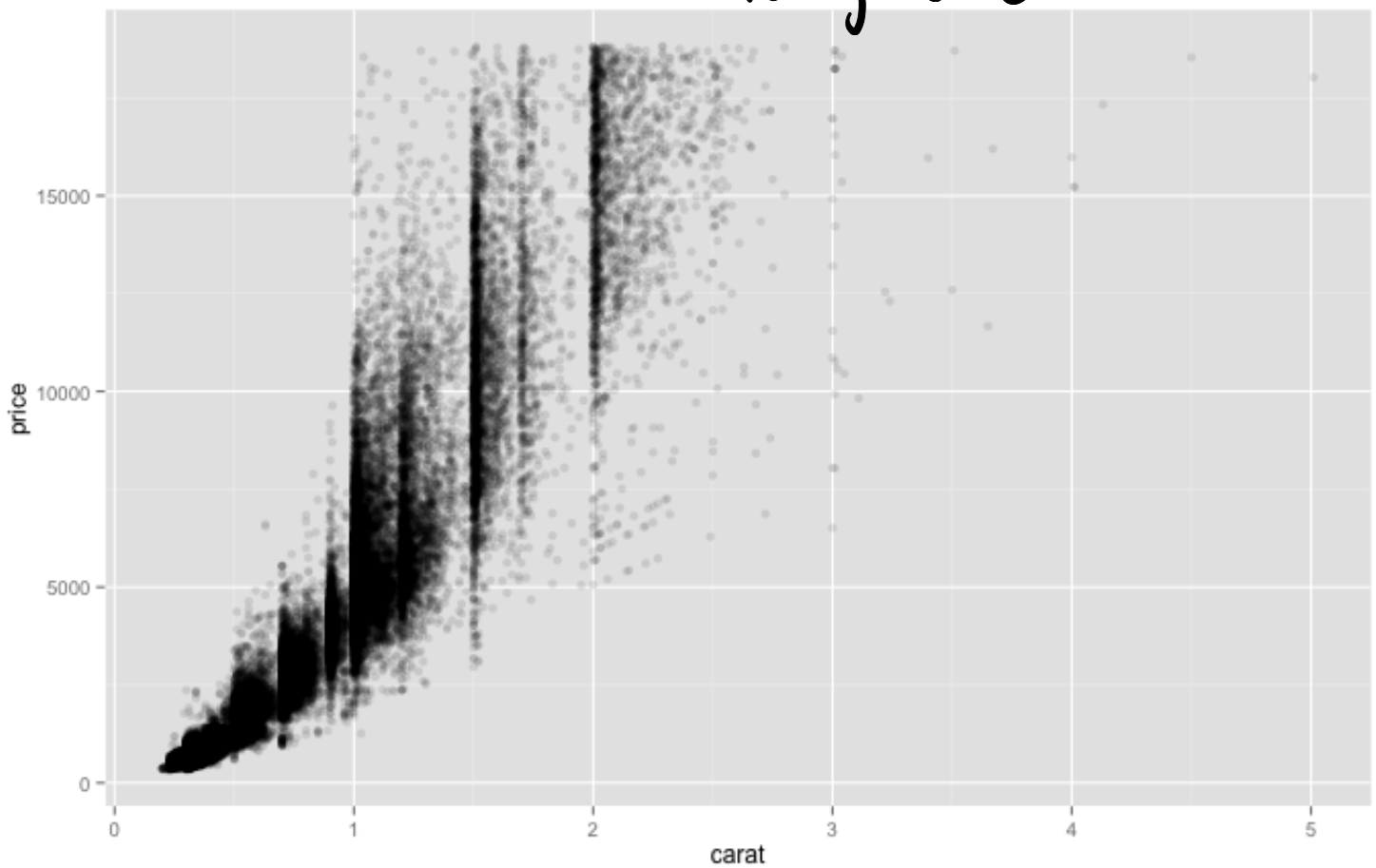
```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy)) +
  geom_smooth(mapping = aes(x = displ, y = hwy)) +
  geom_point(mapping = aes(x=3, y=30), color = "purple") +
  geom_text(mapping = aes(x=3, y=31, label = "New Point"), size=4)+
  labs(title = "New Plot", x = "Engine Weight", y = "Highway mpg")
```



Layering geoms

```
> ggplot(data = diamonds) +
+   geom_point(mapping = aes(x = carat, y = price),
+              alpha = 1/10)
```

really dense dataset? change the alpha!



Check Yourself

Exercise:

Use the built-in `iris` dataset.

- Plot iris `Sepal.Width` on the x-axis and `Sepal.Length` on the y-axis. Color the points according to whether the iris is a setosa or not.
- Plot two regression lines on the plot, one for the setosa iris and one for non-setosa iris. Hint: Use `geom_abline(intercept, slope)`.