Refining your plots

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Week 6, Class 1

Reviewing Lab 2

Data viz in Wild

Raleigh

Maggie

Ann–Marie and Murat on deck

Agenda

- Axes and aspect ratios
- Annotations
- Themes (a little bit)

What we won't get to

Each of the following are pretty fundamental to good data viz, but we won't have time to go over them today. Please make sure to read the corresponding chapters:

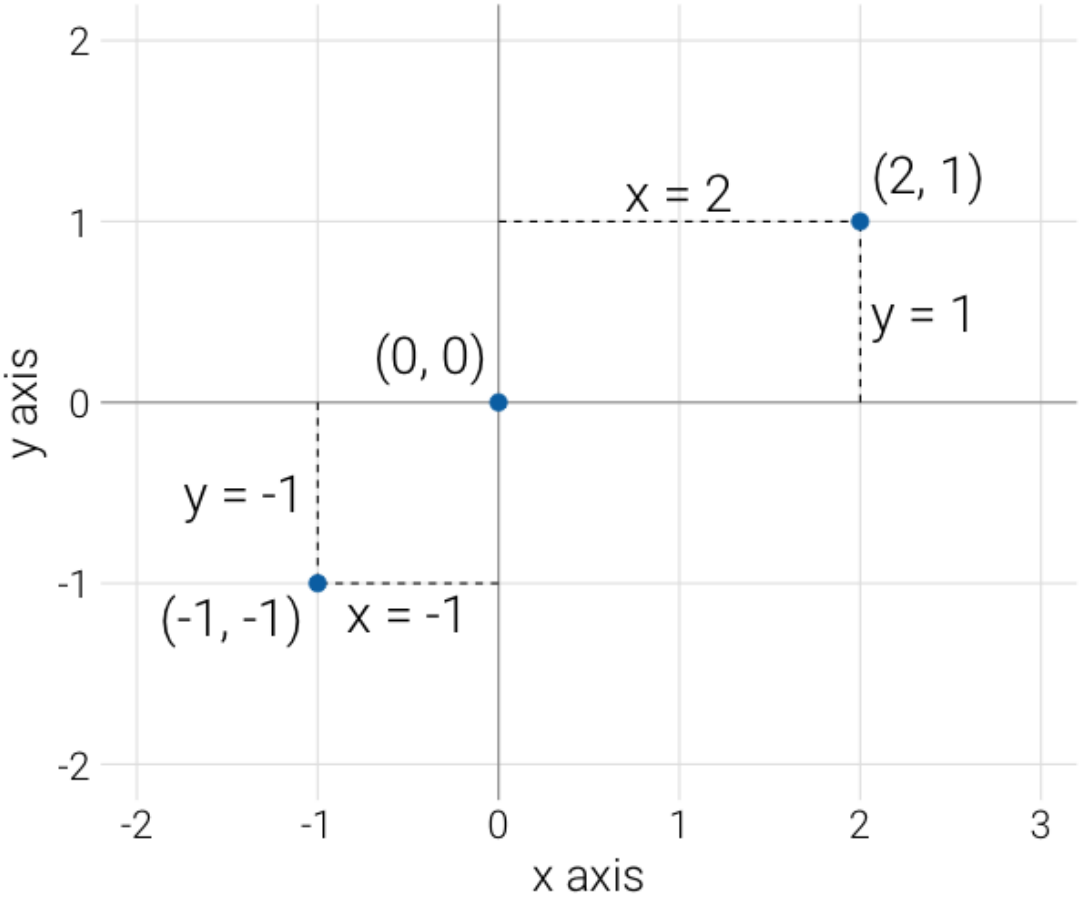
- Handling high data density (lots of overlapping points)
- Compound figures
  - See {patchwork} and {cowplot}
- Exporting figures

Learning Objectives

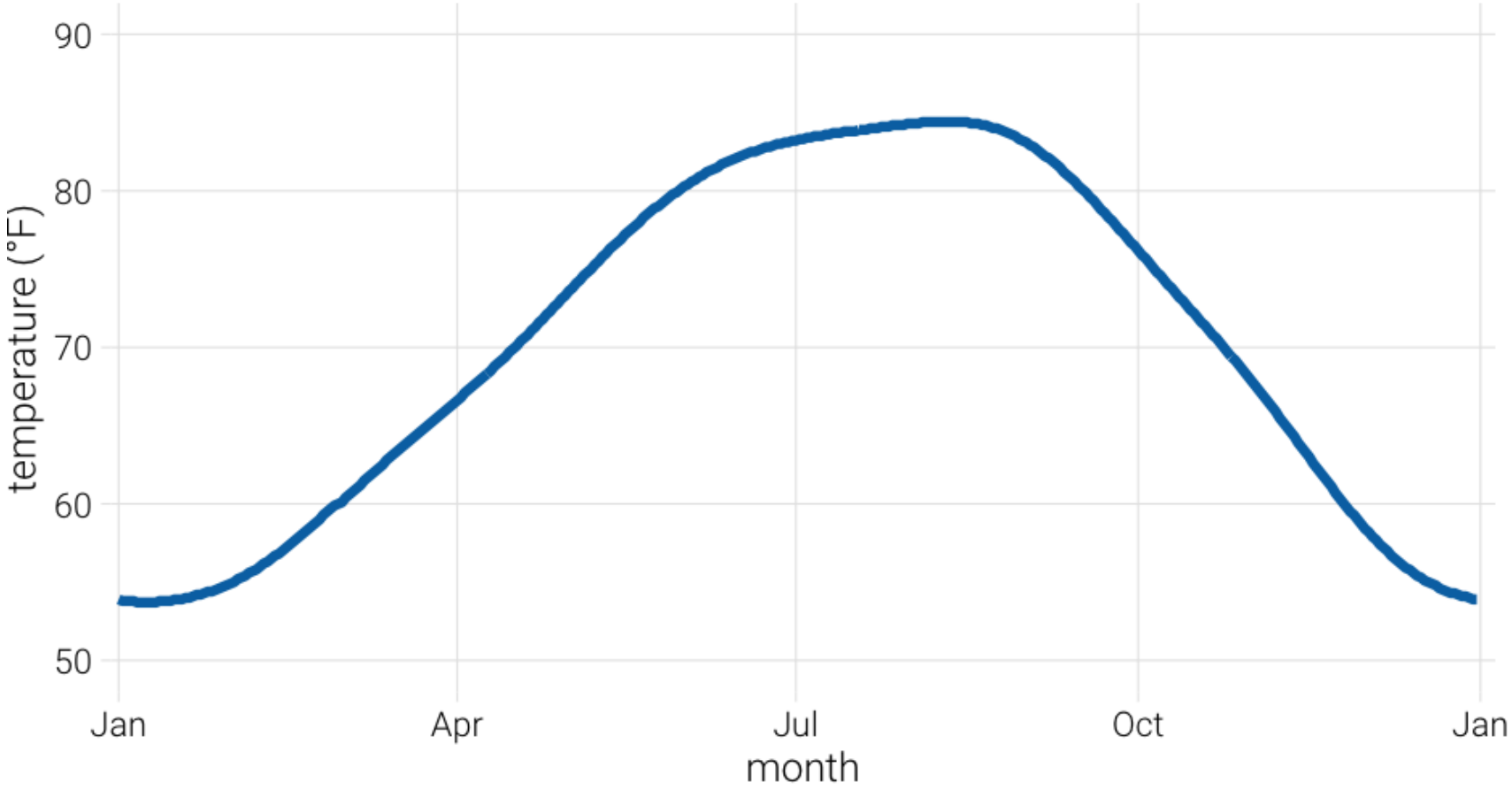
- Understand how to make a wide variety of tweaks to ggplot to essentially make it look however you want it to.
- Understand common modifications to plots to make them more clear and reduce cognitive load

Axes

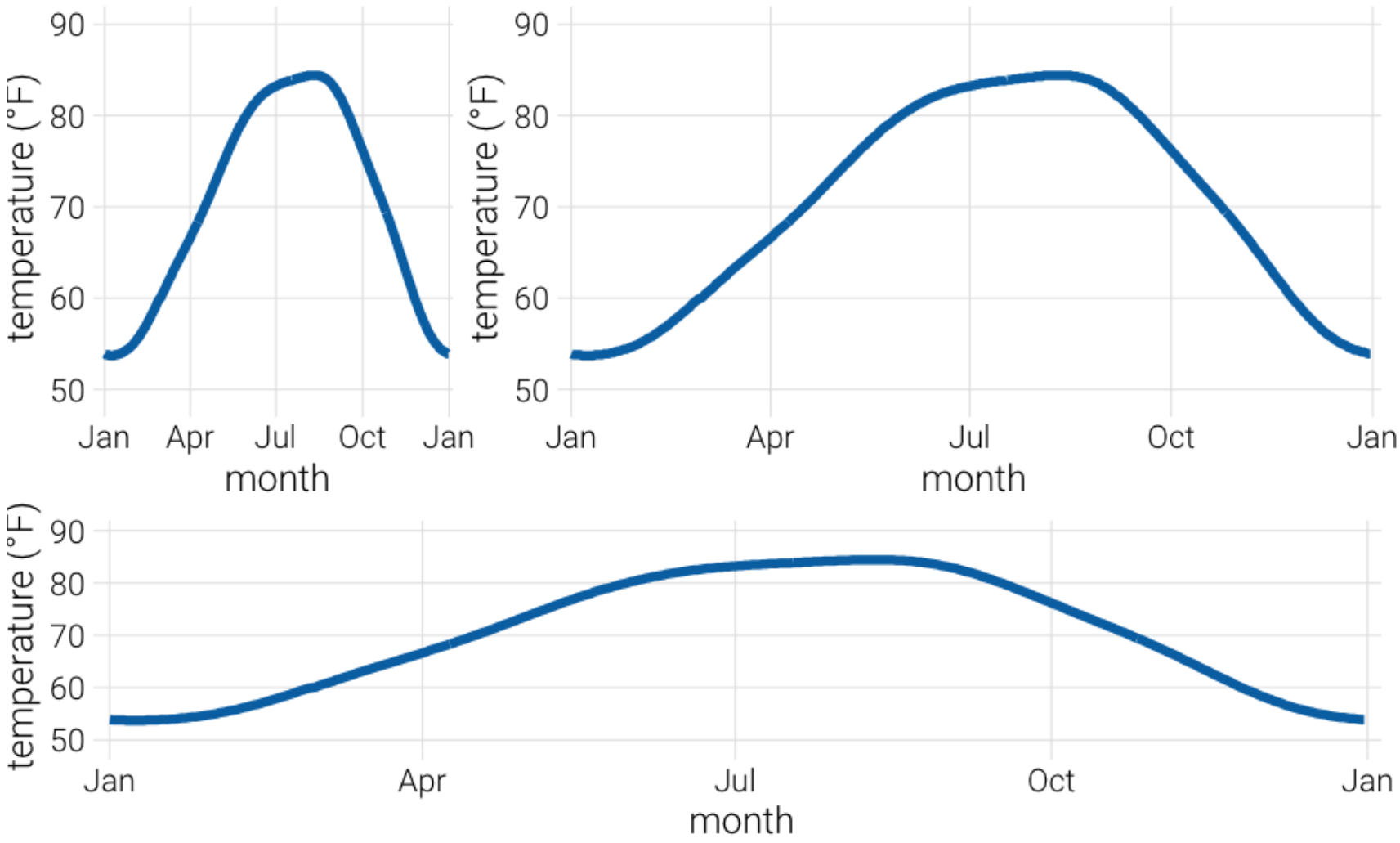
- Cartesian coordinates – what we generally use

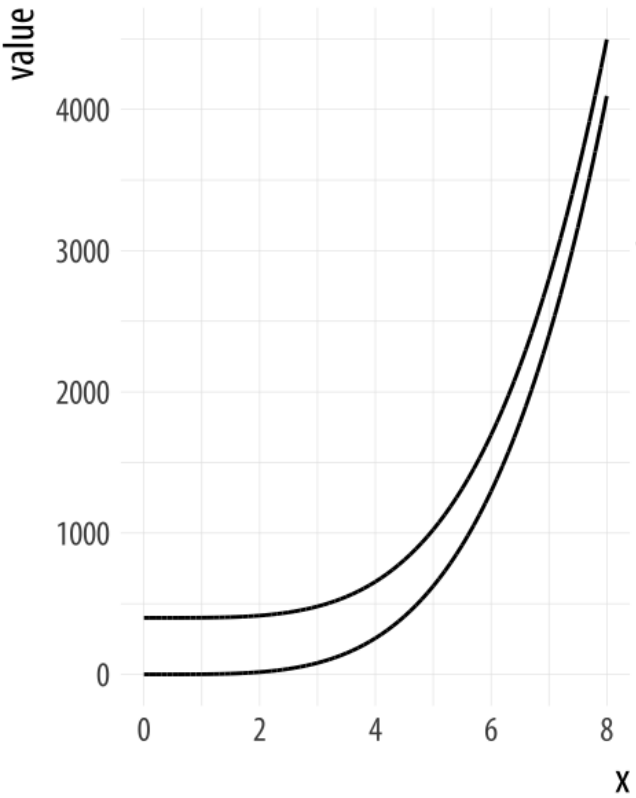


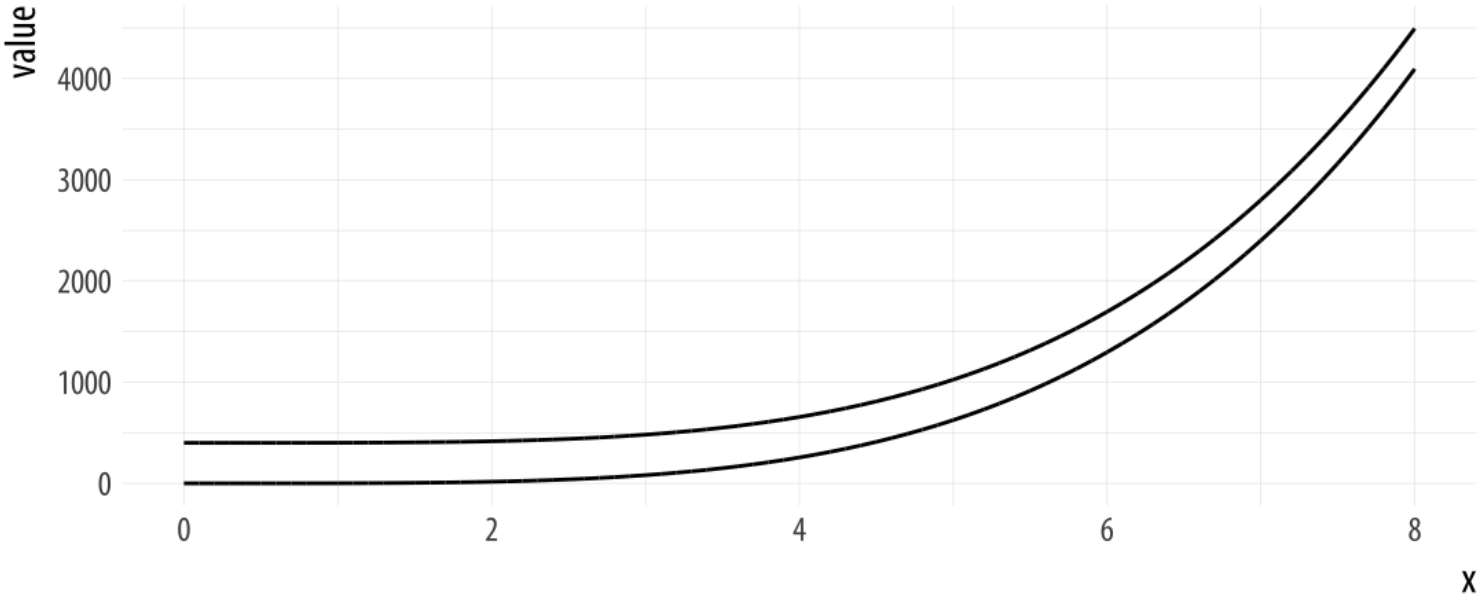
Different units



Aspect ratio

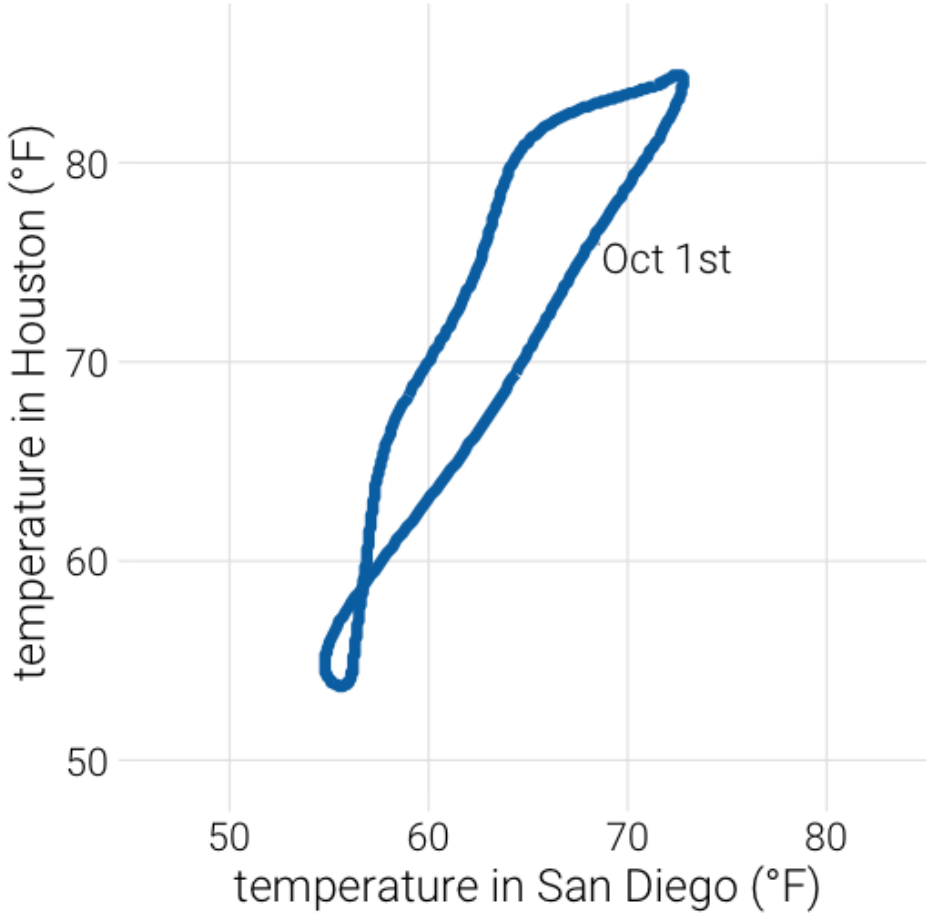



value
4000
3000
2000
1000
0
0
2
4
6
8
x


value
4000
3000
2000
1000
0
0
2
4
6
8
x

Same scales

Use `coord_fixed()`



Changing aspect ratio

- Explore how your plot will look in its final size
- No hard/fast rules (if on different scales)
- Not even really rules of thumb
- Keep visual perception in mind
- Try your best to be truthful – show the trend/relation, but don't exaggerate/hide it

Handy function

(from an apparently deleted tweet from @tjmahr)

> here's my favorite helper #rstats function. preview ggsave() output
>
> ggpreview <- function (..., device = "png") {
> fname <- tempfile(fileext = paste0(".", device))
> ggplot2::ggsave(filename = fname, device = device, ...)
> system2("open", fname)
> invisible(NULL)
> }
>
> — tj mahr 🍕🍍 (@tjmahr)

Gist

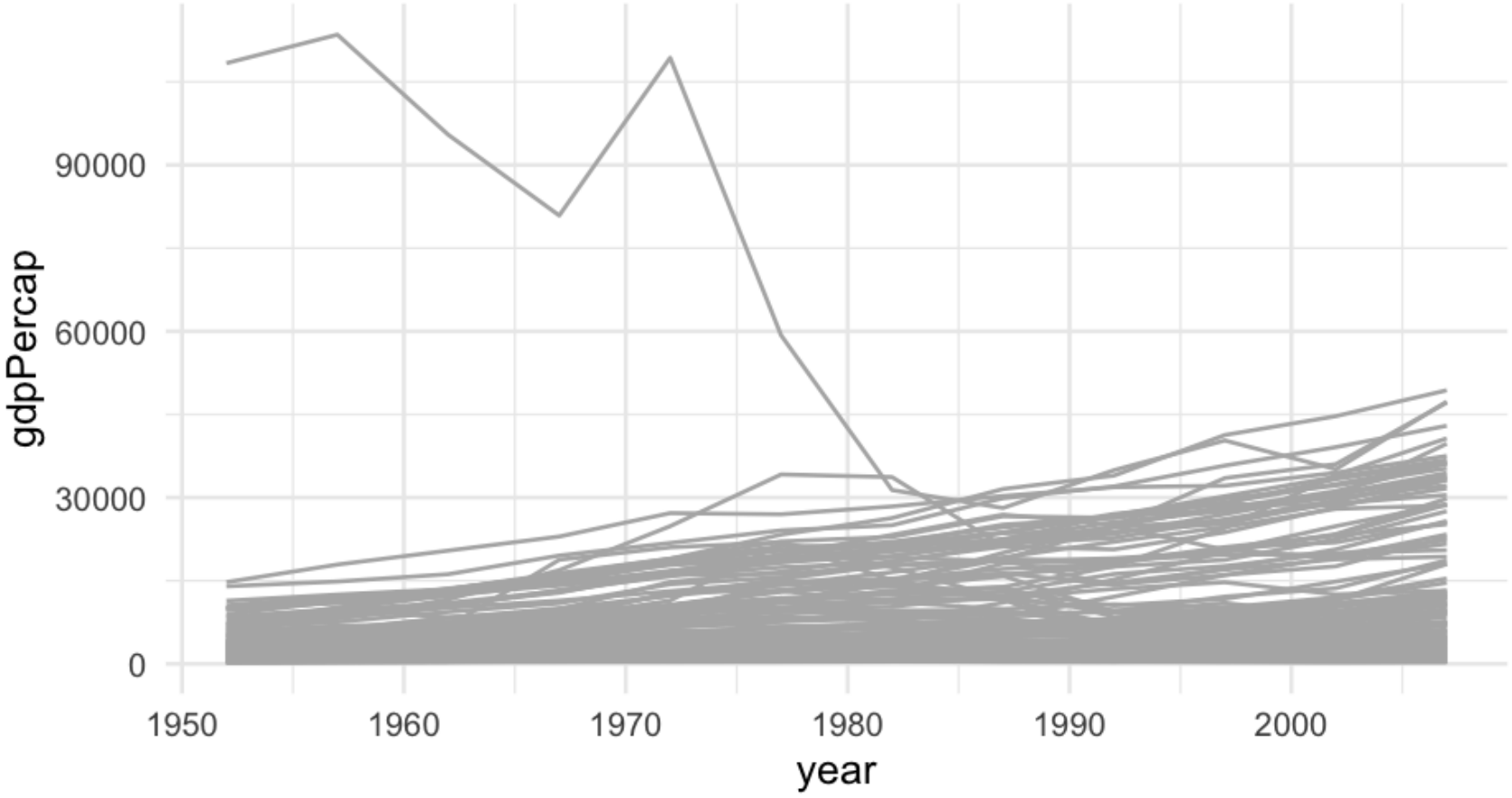
(side note: gists are a good way to share things)

- See the full code/example here
- Let's take 5 minutes to play around:
  - Create a plot (could even be the example in the gist)
  - Try different aspect ratios by changing the width/length

Scale transformations

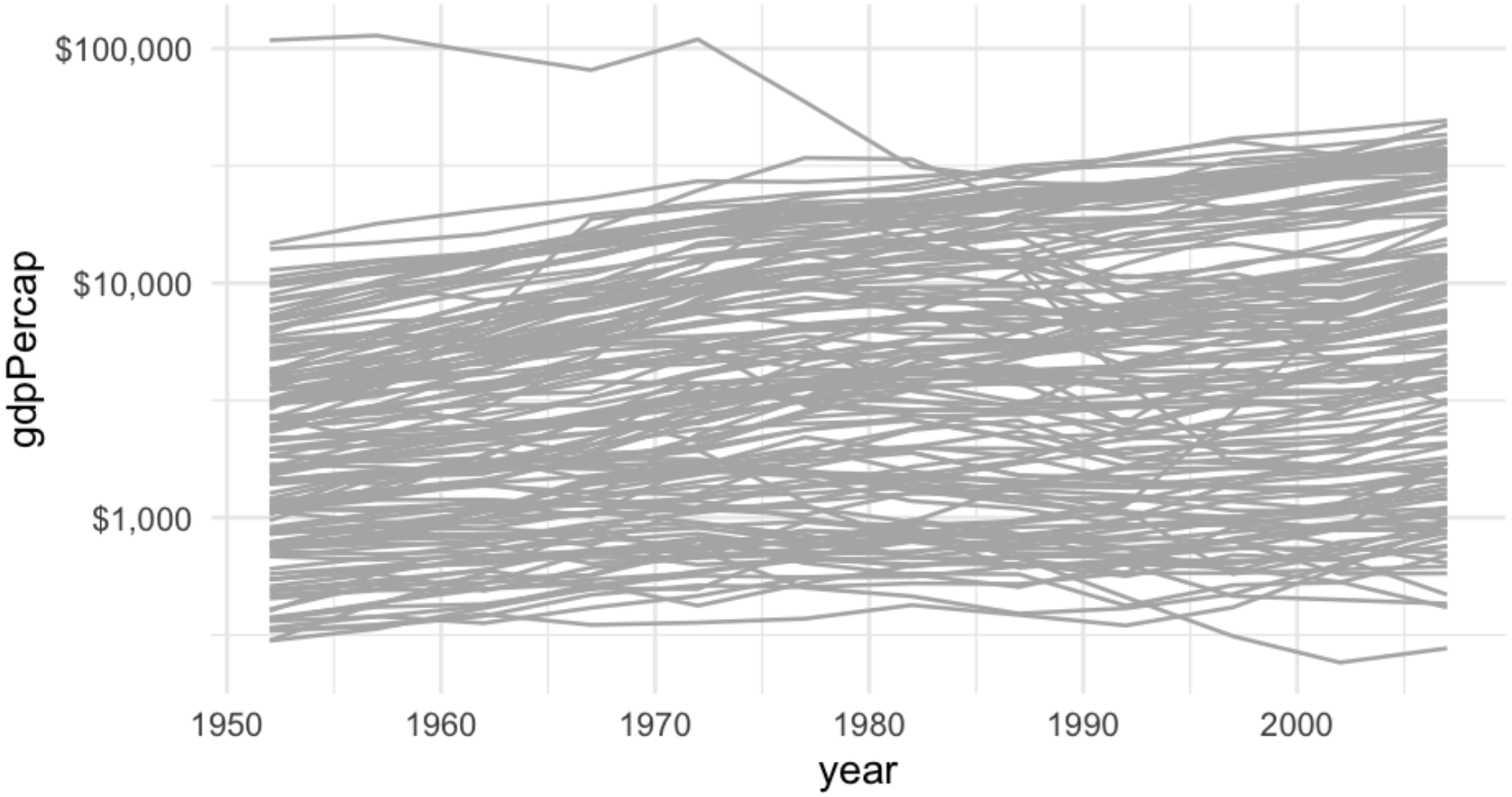
Raw scale

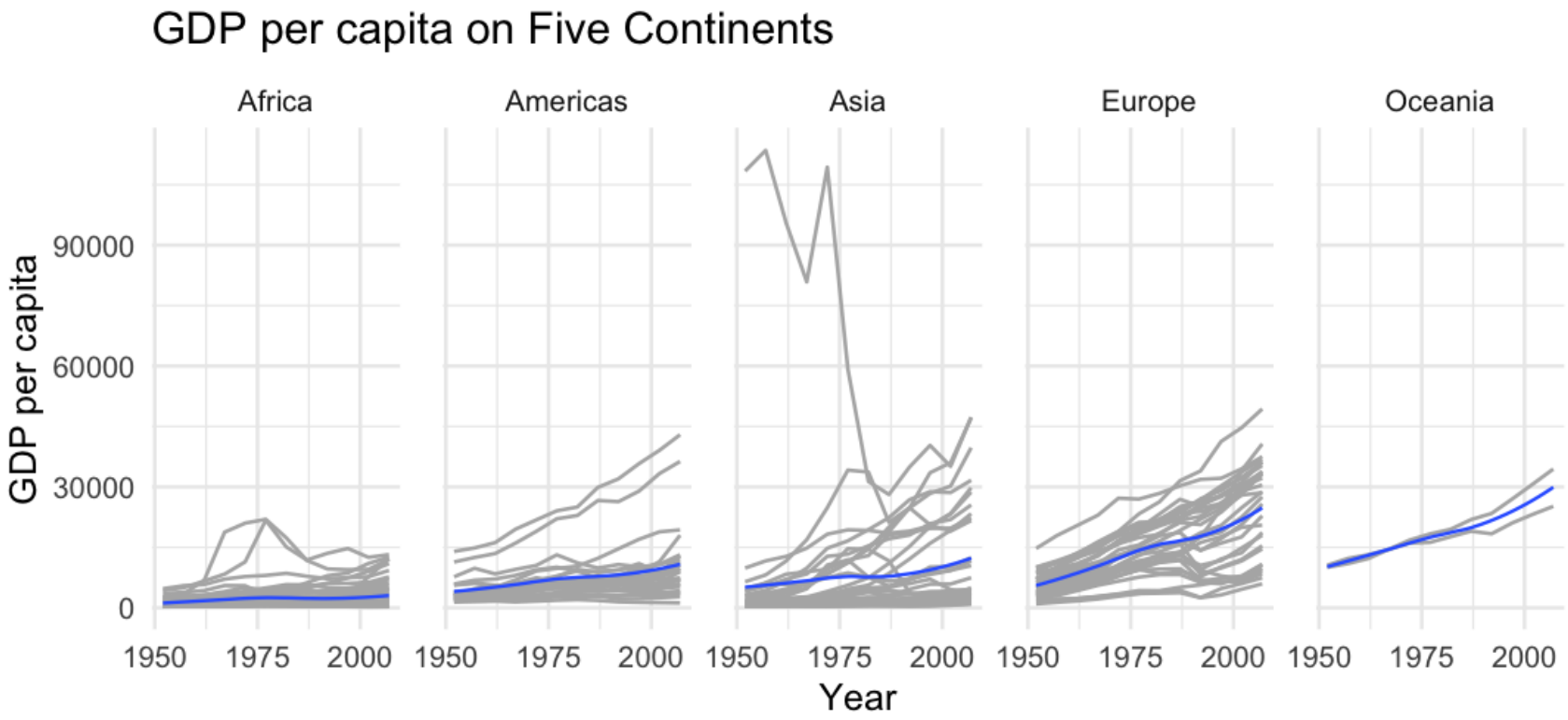
```
library(gapminder)
ggplot(gapminder, aes(year, gdpPercap)) +
  geom_line(aes(group = country),
            color = "gray70")
```

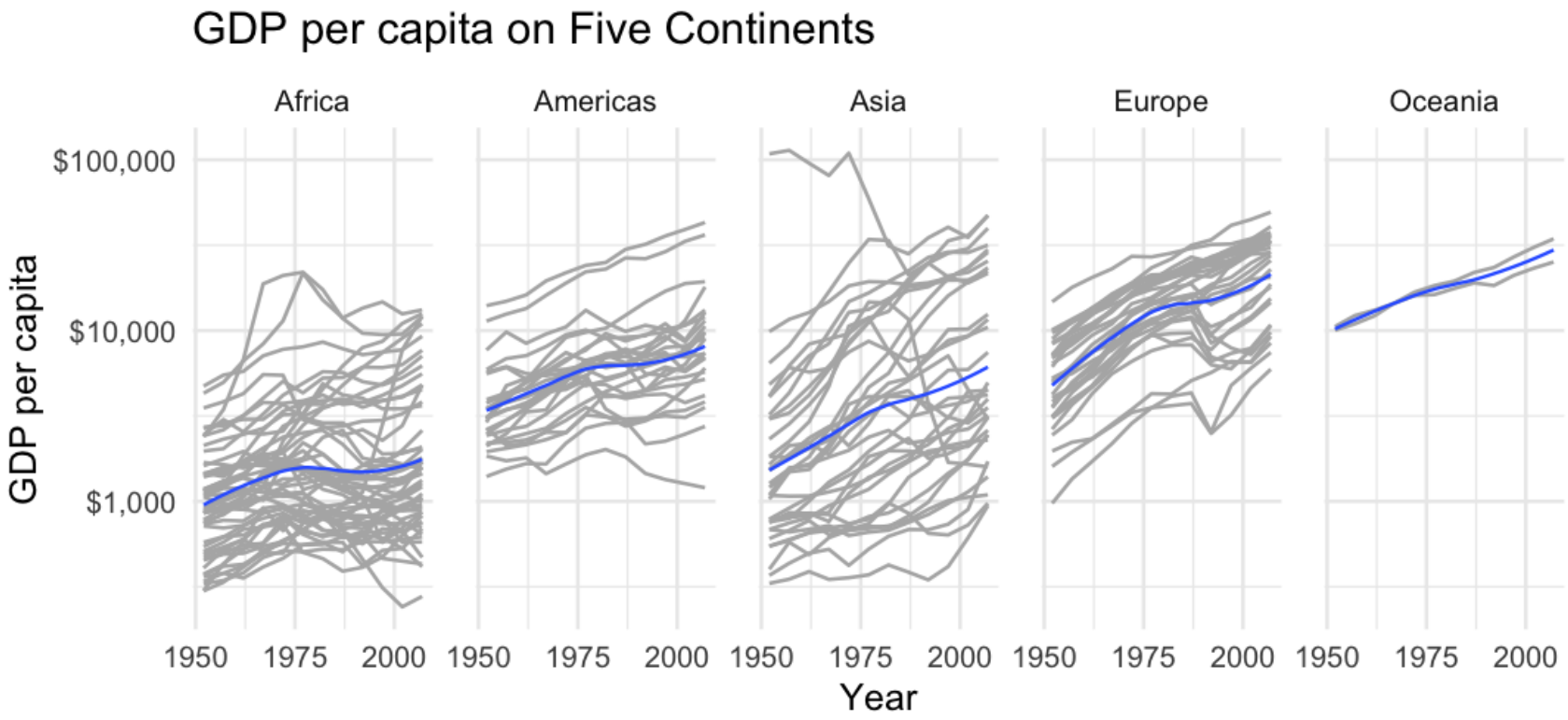


Log10 scale

```
ggplot(gapminder, aes(year, gdpPercap)) +
  geom_line(aes(group = country),
            color = "gray70") +
  scale_y_log10(labels = scales::dollar)
```



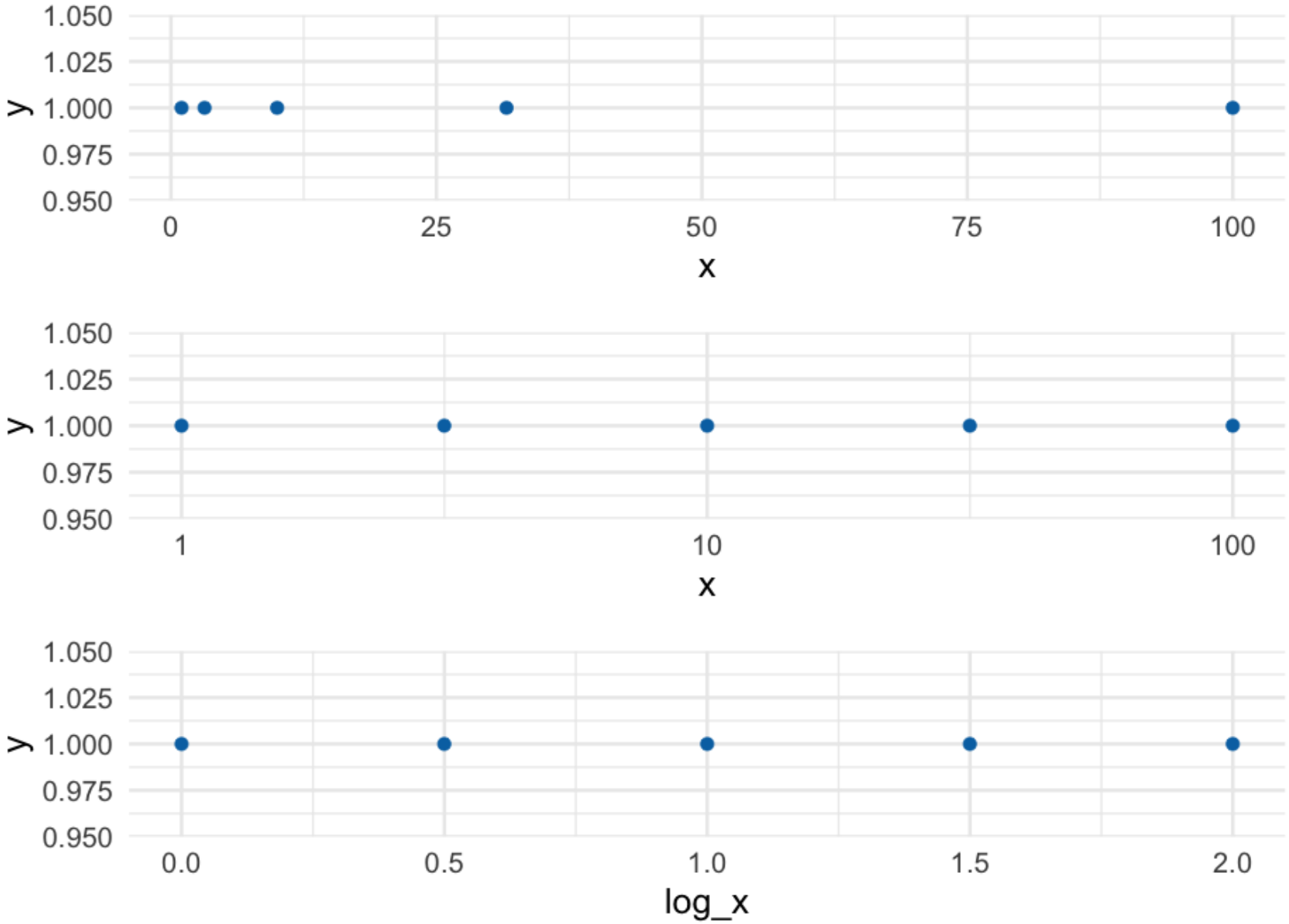

GDP per capita on Five Continents
Africa
Americas
Asia
Europe
Oceania
GDP per capita
90000
60000
30000
0
1950
1975
2000
Year


GDP per capita on Five Continents
Africa
Americas
Asia
Europe
Oceania
$100,000
$10,000
$1,000
GDP per capita
1950
1975
2000
Year

Scales

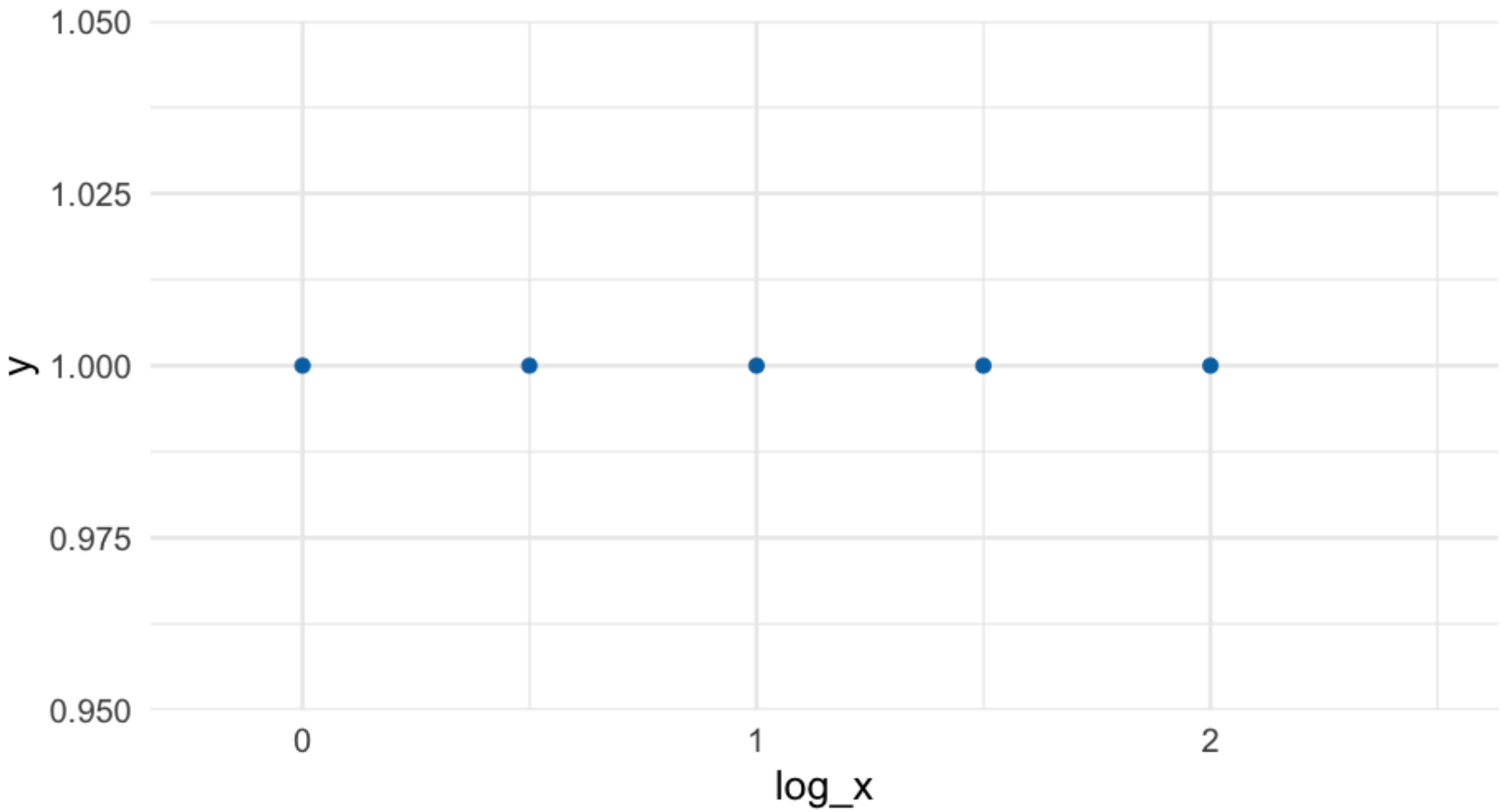
```
d <- tibble(x = c(1, 3.16, 10, 31.6, 100),
            log_x = log10(x))

ggplot(d, aes(x, 1)) +
  geom_point(color = "#0072B2")

ggplot(d, aes(x, 1)) +
  geom_point(color = "#0072B2") +
  scale_x_log10()

ggplot(d, aes(log_x, 1)) +
  geom_point(color = "#0072B2")
```

Scales


1.050
1.025
1.000
0.975
0.950
y
0
25
50
75
100
x
1.050
1.025
1.000
0.975
0.950
y
1
10
100
x
1.050
1.025
1.000
0.975
0.950
y
0.0
0.5
1.0
1.5
2.0
log_x

Don't transform twice

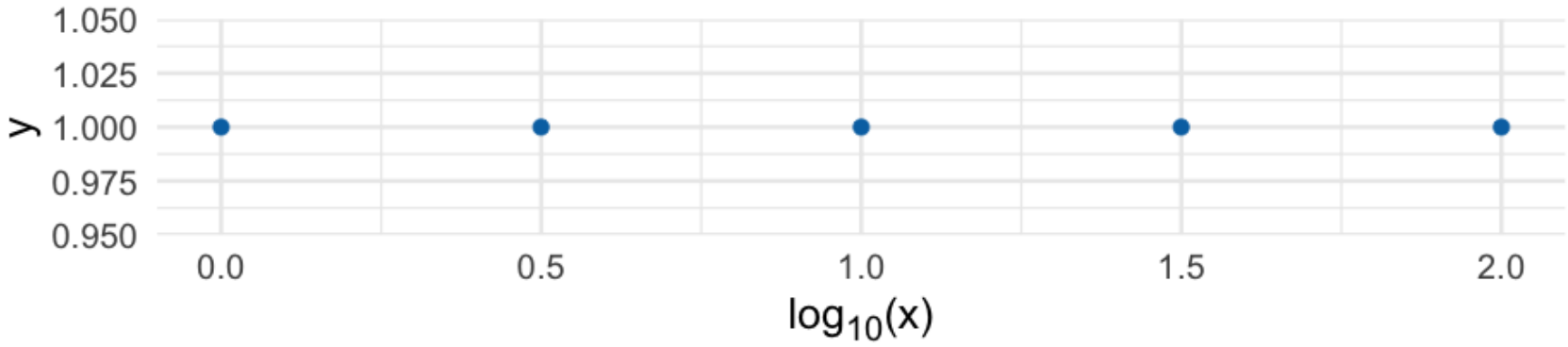
```
ggplot(d, aes(log_x, 1)) +
  geom_point(color = "#0072B2") +
  scale_x_log10() +
  xlim(-0.2, 2.5)
```



Careful with labeling

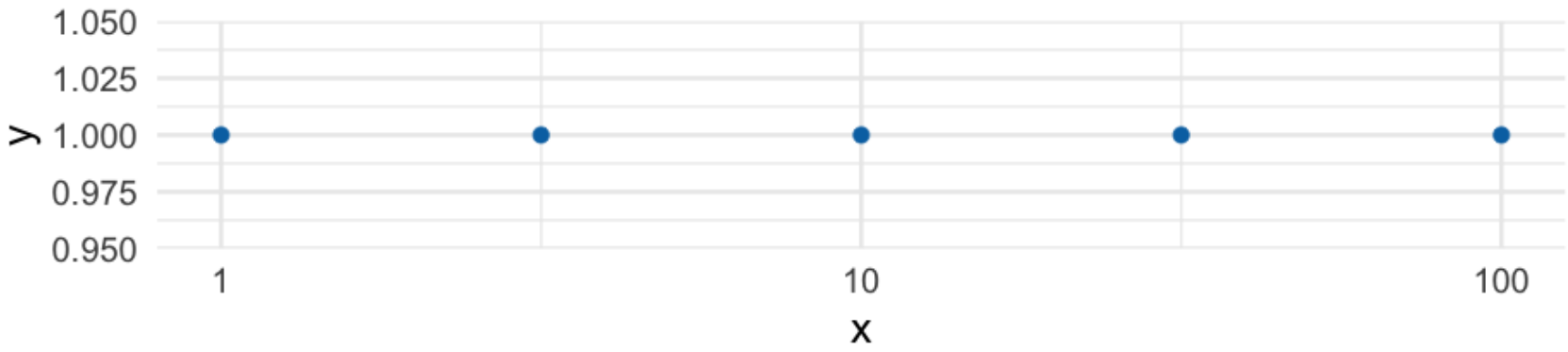
- Has the scale or the data been log transformed?
- Specify the base

```
library(ggtext)
ggplot(d, aes(log_x, 1)) +
  geom_point(color = "#0072B2") +
  labs(x = "log<sub>10</sub>(x)") +
  theme(axis.title.x = element_markdown())
```



Labels should denote the data, not the scale of the axis

```
ggplot(d, aes(x, 1)) +
  geom_point(color = "#0072B2") +
  scale_x_log10()
```



Labeling the above with $log_{10}(x)$ would be ambiguous and confusing

Labels and captions

Disclaimer

- APA style requires the labels be made in specific ways
- Much of the following discussion still applies
- Our book (Wilke) uses a similar style throughout

Title

What is the point of your figure?

What are you trying to communicate

- Figures should have only one title
- Use integrated title/subtitles for sharing with a broad audience
  - Blog posts
  - Social media
  - Reports to stakeholders
- Keep figures in subtext when there's a designated format you must adhere to
- Make sure your figure has a title
  - Should not start with "This figure displays/shows..."

Caption

Consider stating the data source

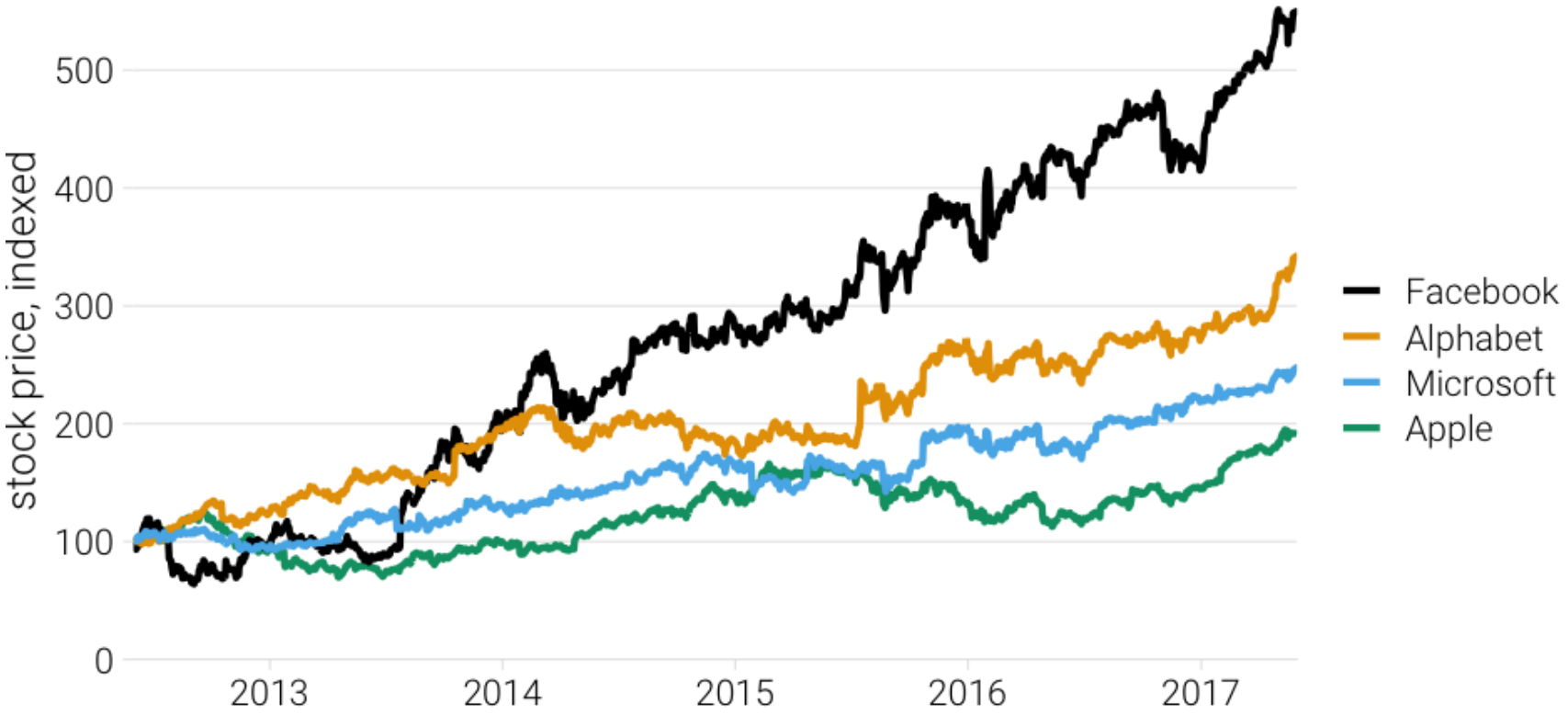
Other details relevant to the figure but not important enough for a subtitle

Axis labels

- The title for the axis
- Critical for communication
- **Never** use variable names (very common and very poor practice)
- State the measure and the unit (if quantitative)
    - e.g., "Brain Mass (grams)", "Support for Measure (millions of people)", "Dollars spent"
    - Categorical variable likely will not need to the measurement unit

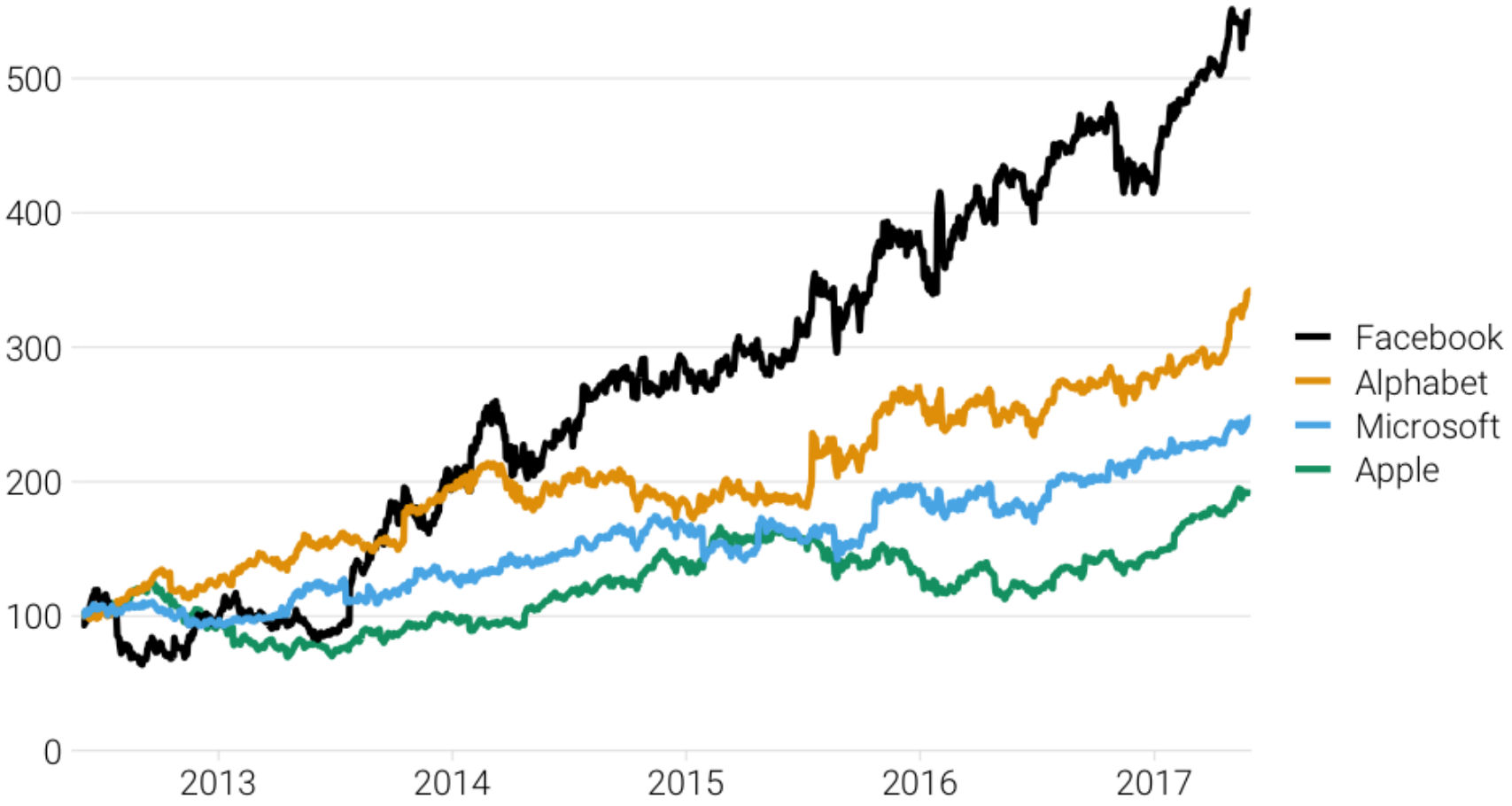
Omission

- Consider omitting obvious or redundant labels
  - Use `labs(x = NULL)` or `labs(x = "")`
  - If already using `scale_x/y_*()` just supply the `name` argument

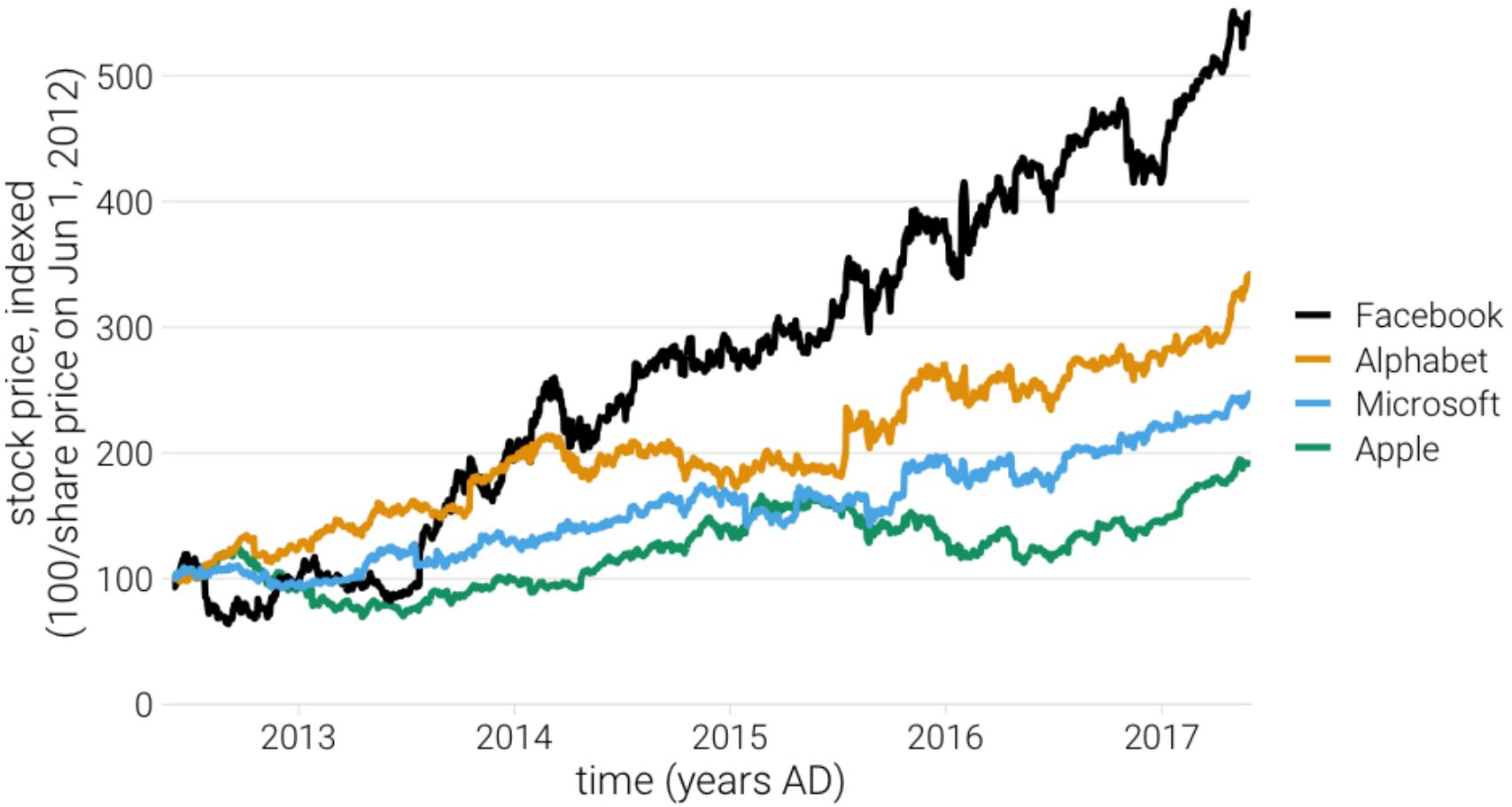


Omission

- Do not omit axis titles that are not obvious



Don't overdo it



Annotations

Among the most effective

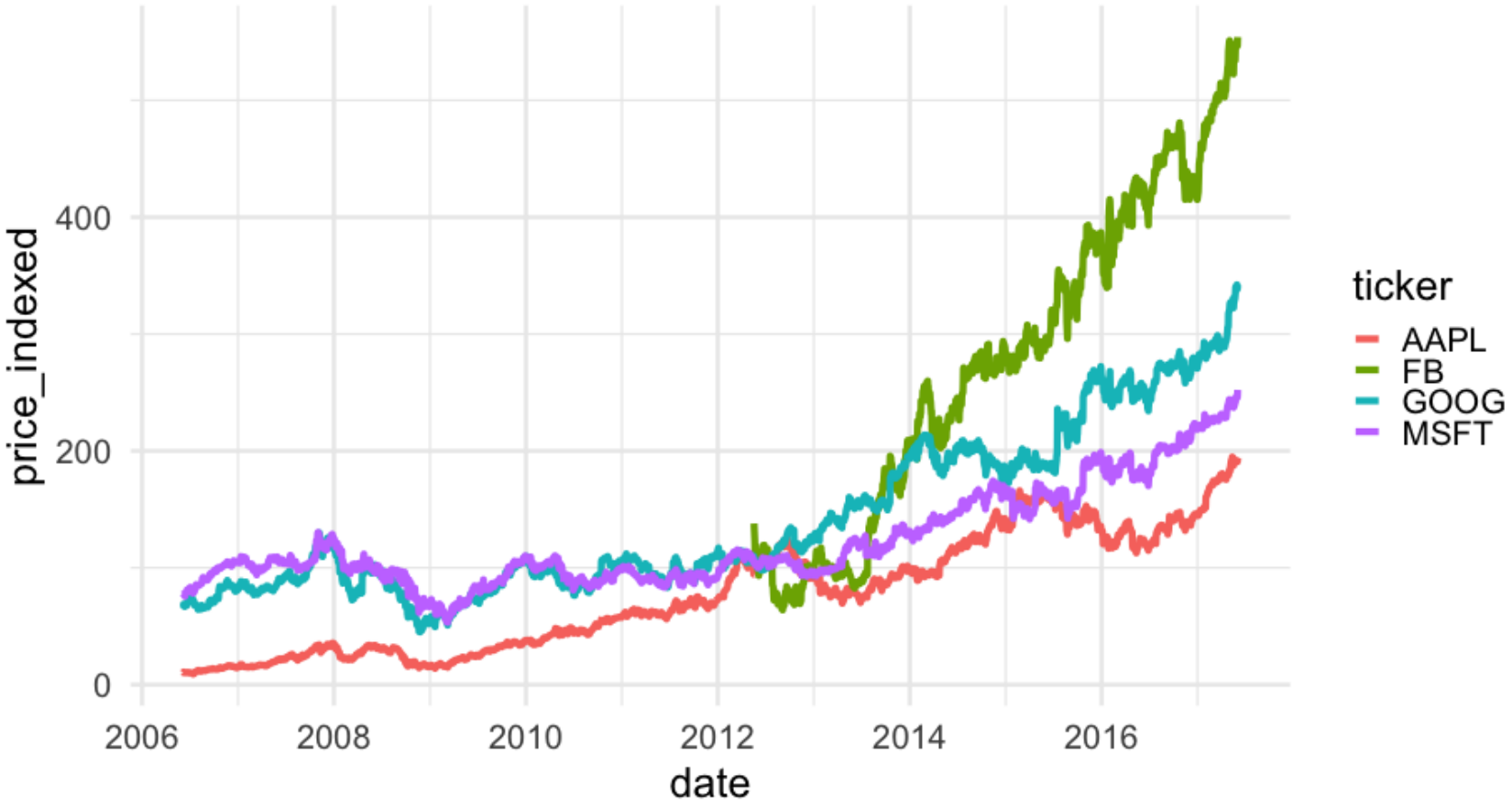
- If possible, try to remove legends, and just include annotations

Building up a plot

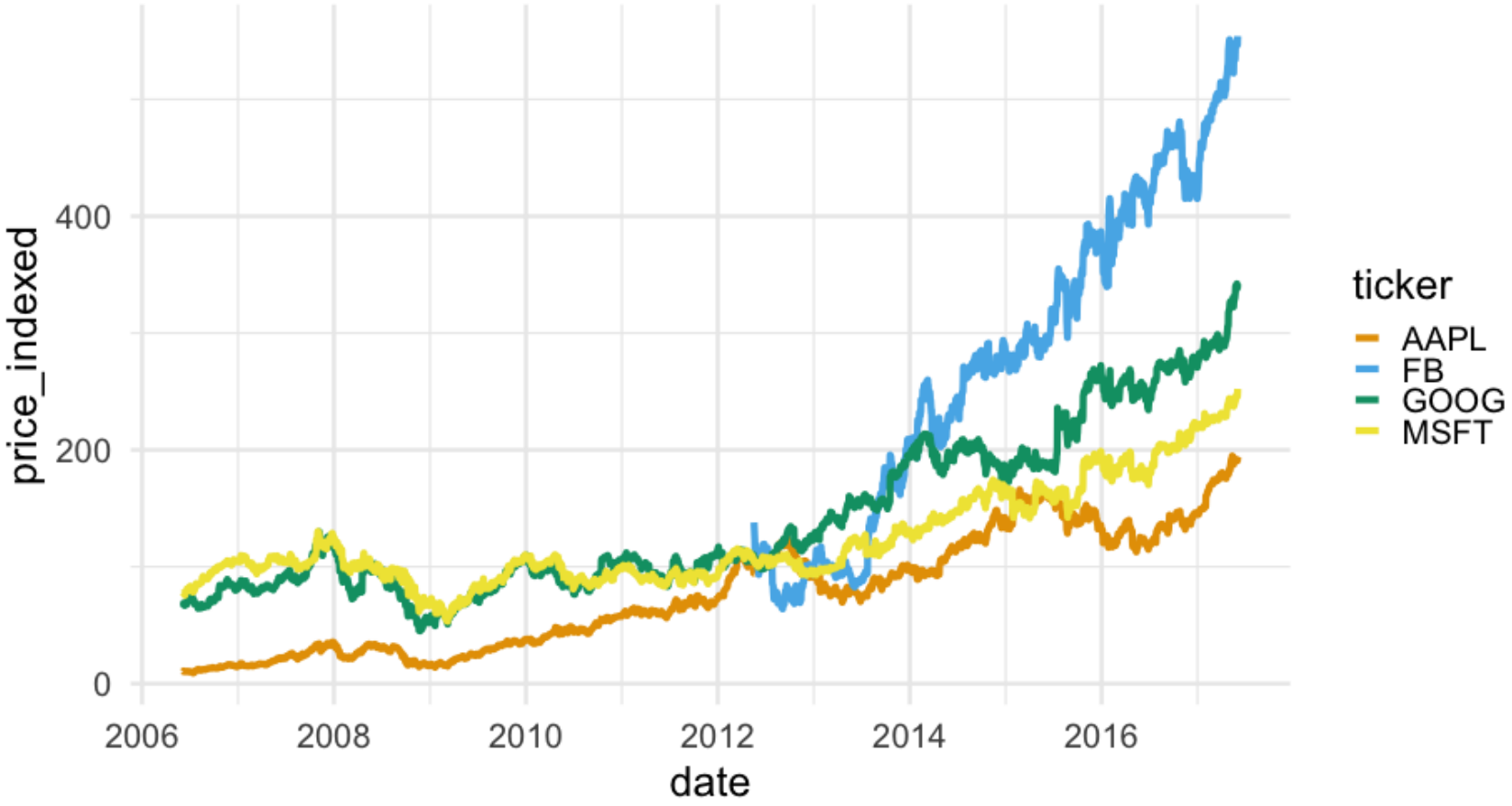
```
remotes::install_github("clauswilke/dviz.supp")
head(tech_stocks)
```

```
## # A tibble: 6 x 6
##   company  ticker date        price index_price price_indexed
##   <chr>    <chr>  <date>      <dbl>       <dbl>          <dbl>
## 1 Alphabet GOOG   2017-06-02 975.6        285.2      342.0757
## 2 Alphabet GOOG   2017-06-01 966.95       285.2      339.0428
## 3 Alphabet GOOG   2017-05-31 964.86       285.2      338.3100
## 4 Alphabet GOOG   2017-05-30 975.88       285.2      342.1739
## 5 Alphabet GOOG   2017-05-26 971.47       285.2      340.6276
## 6 Alphabet GOOG   2017-05-25 969.54       285.2      339.9509
```

```
ggplot(tech_stocks, aes(date, price_indexed, color = ticker)) +
  geom_line()
```

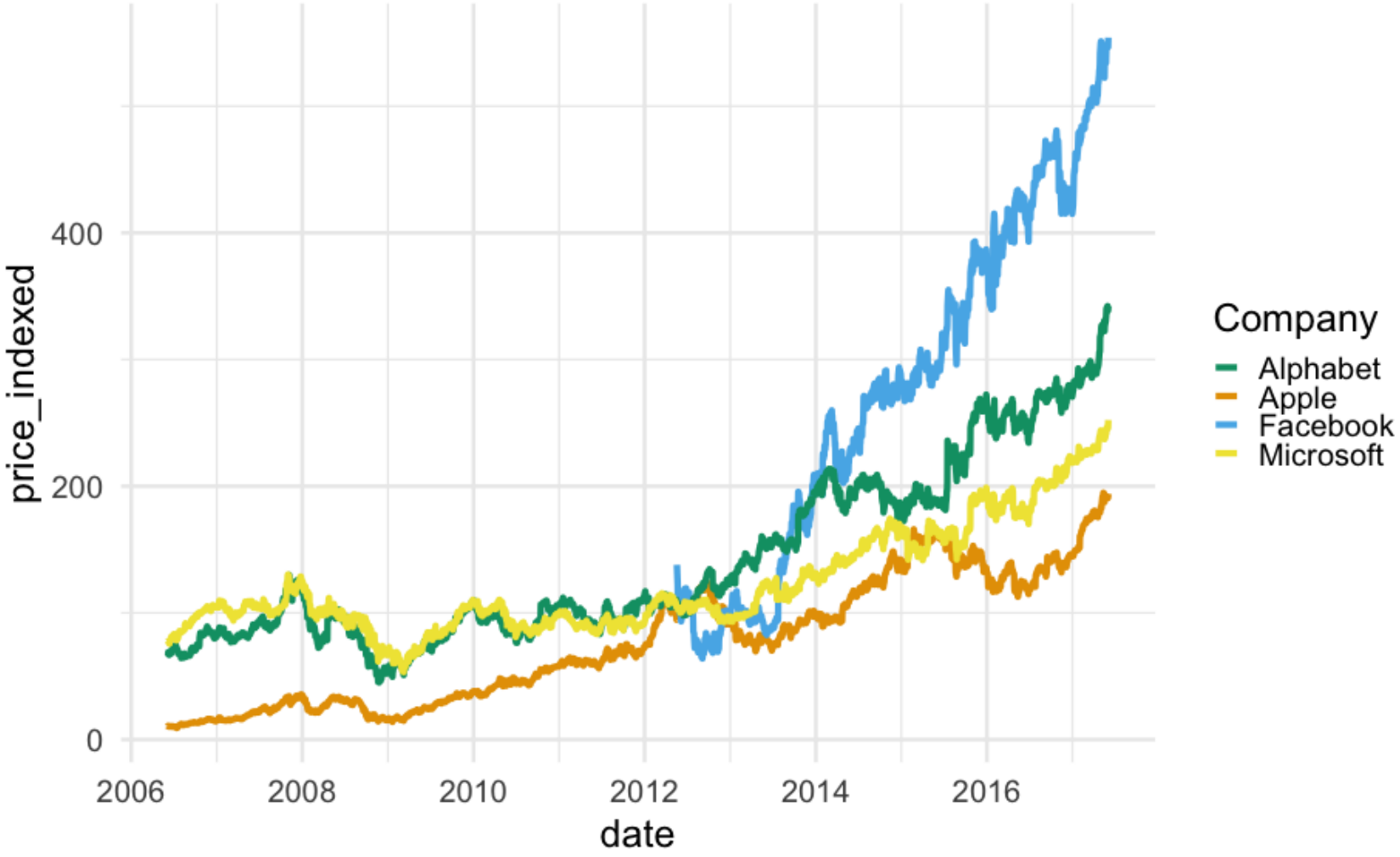


```
ggplot(tech_stocks, aes(date, price_indexed, color = ticker)) +
  geom_line() +
  scale_color_OkabeIto()
```



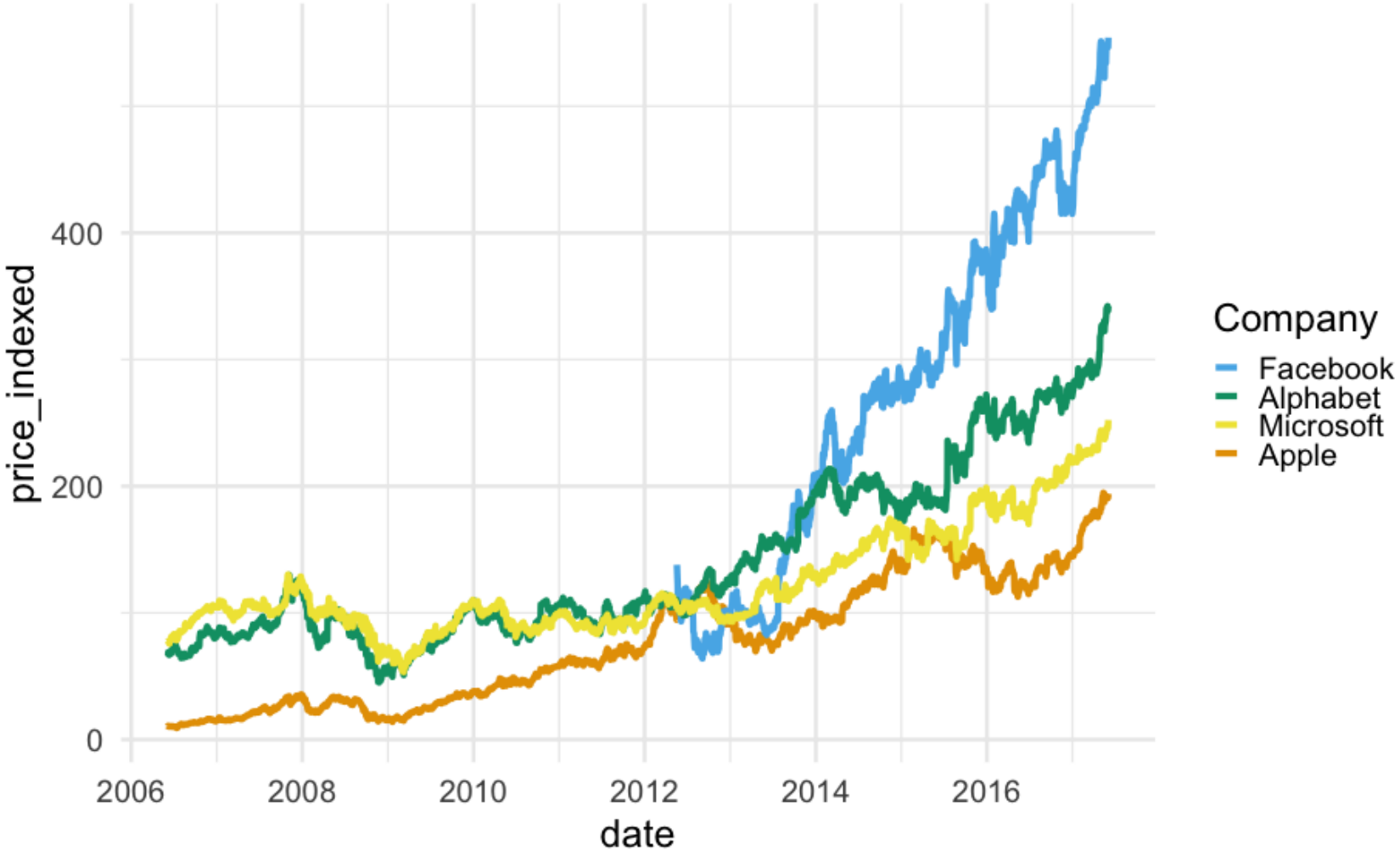
```
ggplot(tech_stocks, aes(date, price_indexed, color = ticker)) +
  geom_line() +
  scale_color_OkabeIto(name = "Company",
                       breaks = c("GOOG", "AAPL", "FB", "MSFT"),
                       labels = c("Alphabet", "Apple", "Facebook", "Microsoft"
```

Bad

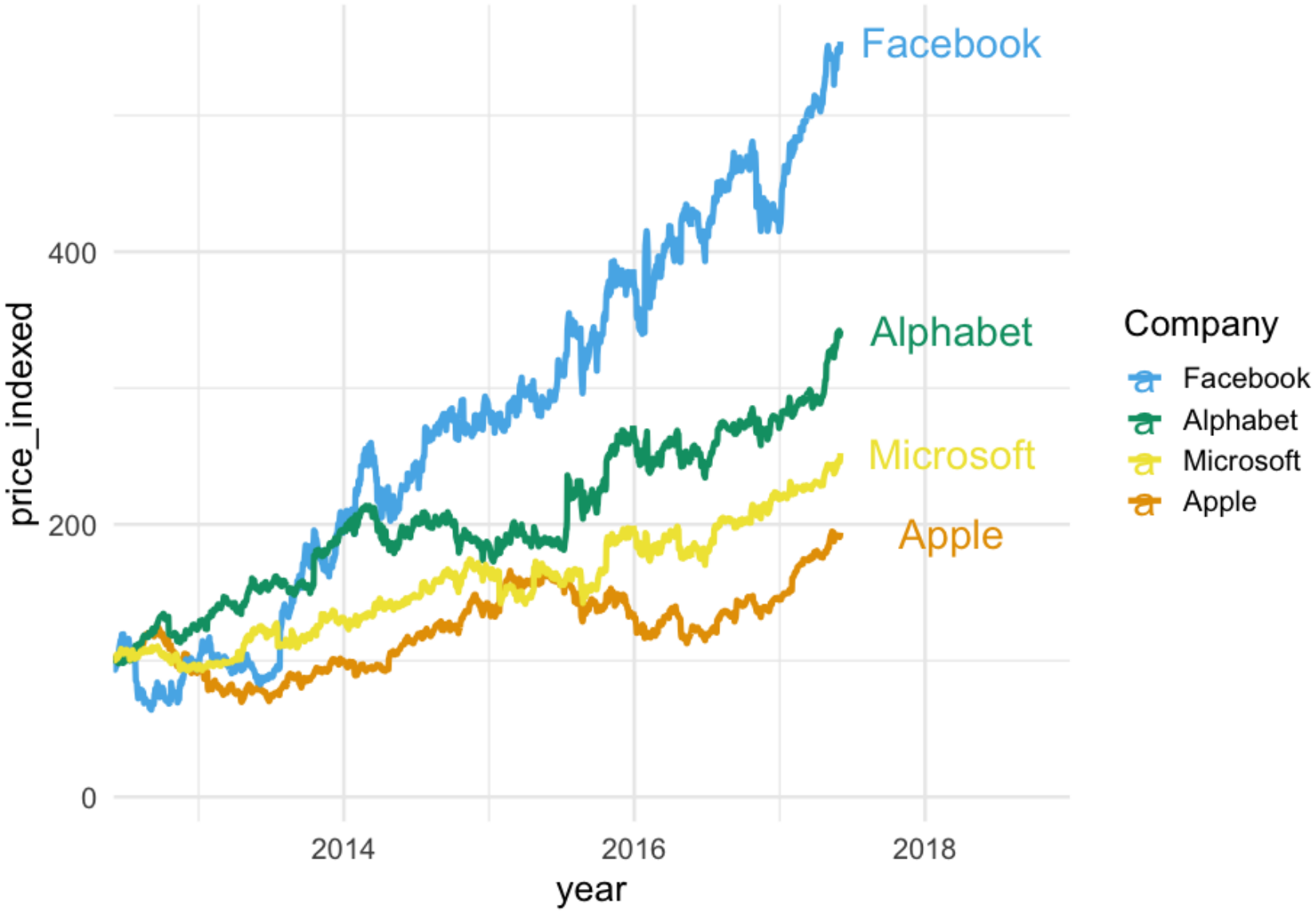

price_indexed
400
200
0
2006
2008
2010
2012
2014
2016
date
Company
Alphabet
Apple
Facebook
Microsoft

```
ggplot(tech_stocks, aes(date, price_indexed, color = ticker)) +
  geom_line() +
  scale_color_OkabeIto(name = "Company",
                       breaks = c("FB", "GOOG", "MSFT", "AAPL"),
                       labels = c("Facebook", "Alphabet", "Microsoft", "Apple"
```

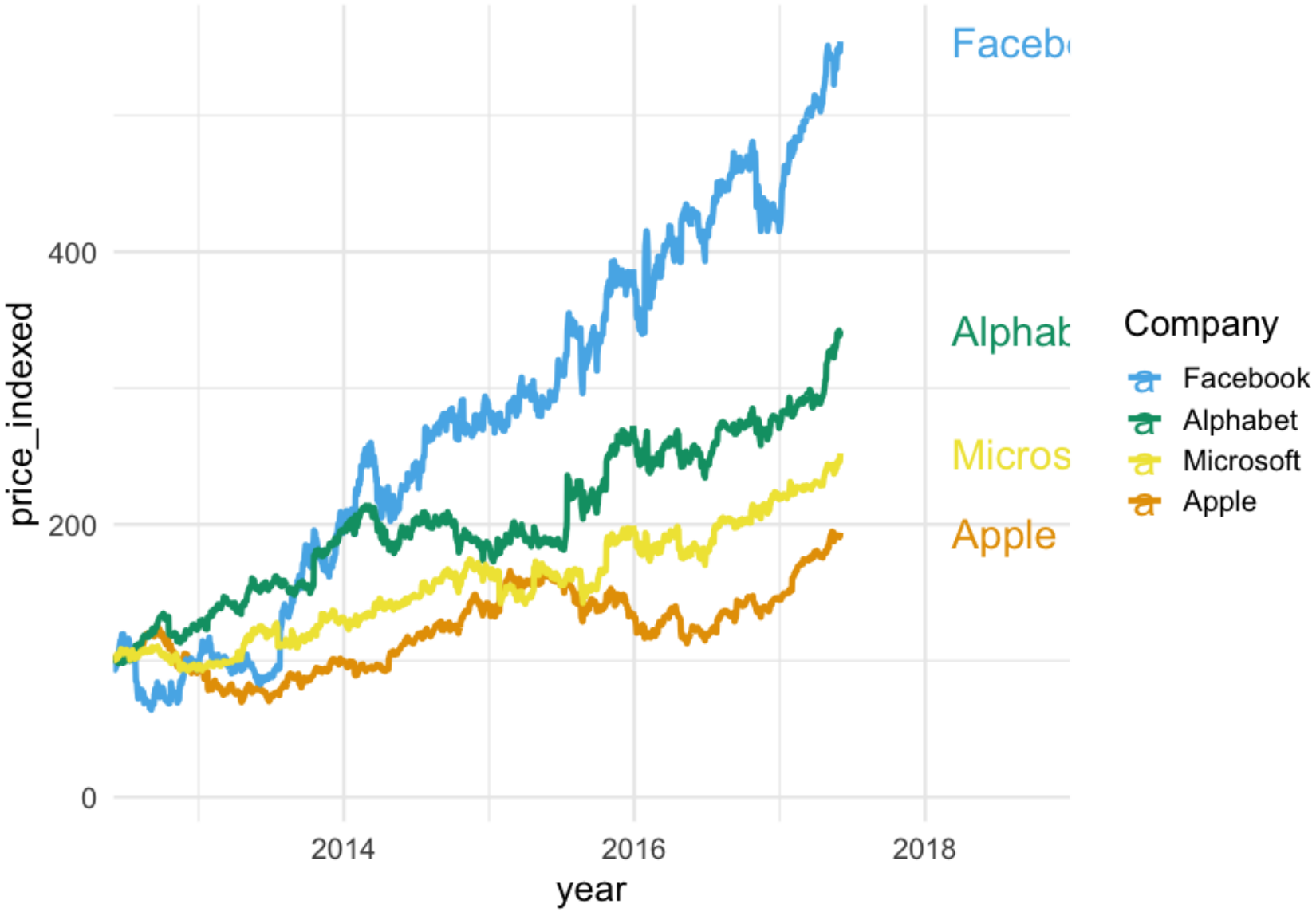
Good


price_indexed
400
200
0
2006
2008
2010
2012
2014
2016
date
Company
Facebook
Alphabet
Microsoft
Apple

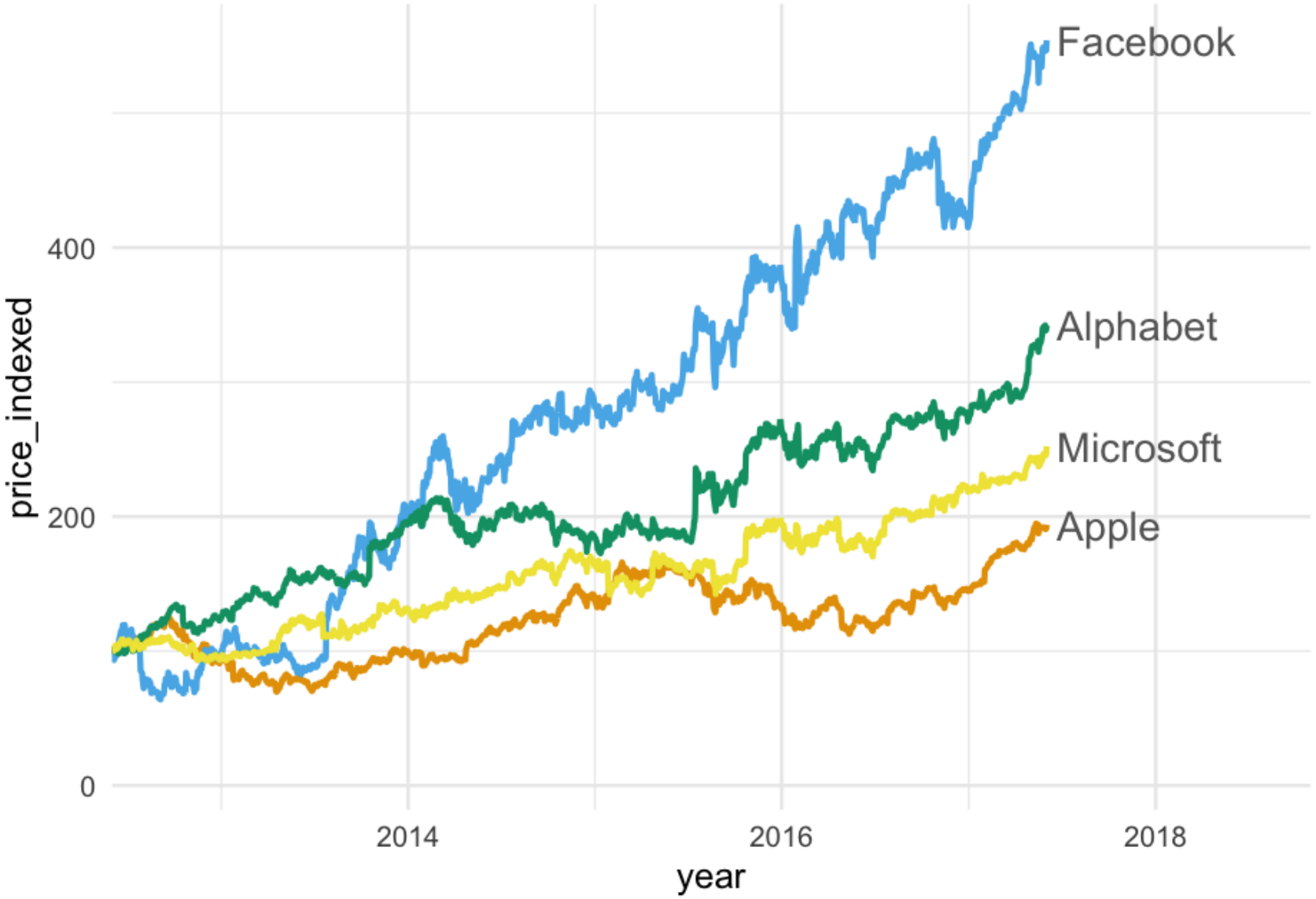
```
ggplot(tech_stocks, aes(date, price_indexed, color = ticker)) +
  geom_line() +
  scale_color_OkabeIto(name = "Company",
                       breaks = c("FB", "GOOG", "MSFT", "AAPL"),
                       labels = c("Facebook", "Alphabet", "Microsoft", "Apple"
  scale_x_date(name = "year",
               limits = c(ymd("2012-06-01"), ymd("2018-12-31")),
               expand = c(0,0)) +
  geom_text(data = filter(tech_stocks, date == "2017-06-02"),
            aes(y = price_indexed, label = company),
            nudge_x = 280)
```


Facebook
Alphabet
Microsoft
Apple
400
200
0
price_indexed
2014
2016
2018
year
Company
Facebook
Alphabet
Microsoft
Apple

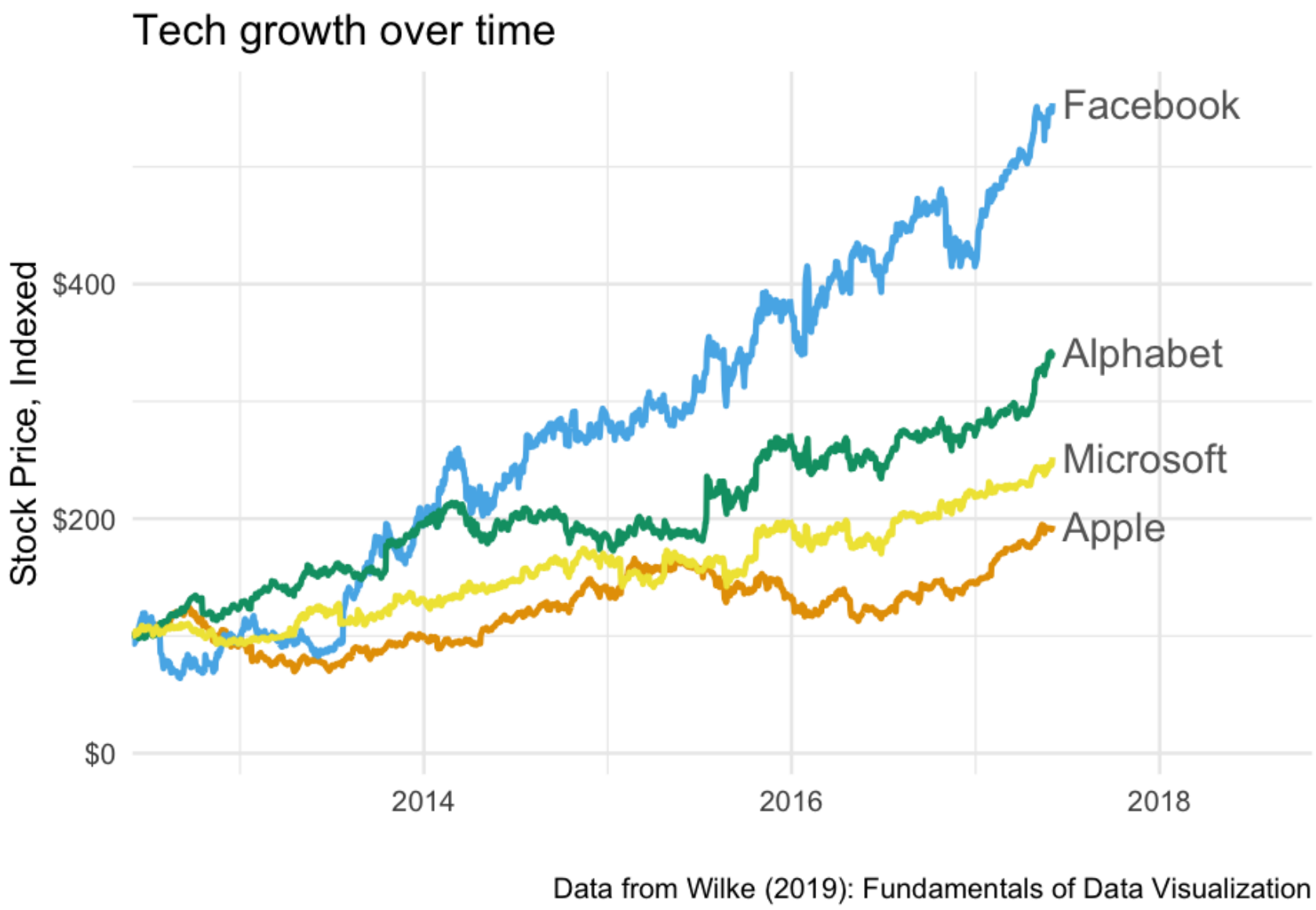
```
ggplot(tech_stocks, aes(date, price_indexed, color = ticker)) +
  geom_line() +
  scale_color_OkabeIto(name = "Company",
                       breaks = c("FB", "GOOG", "MSFT", "AAPL"),
                       labels = c("Facebook", "Alphabet", "Microsoft", "Apple"
  scale_x_date(name = "year",
               limits = c(ymd("2012-06-01"), ymd("2018-12-31")),
               expand = c(0,0)) +
  geom_text(data = filter(tech_stocks, date == "2017-06-02"),
            aes(y = price_indexed, label = company),
            nudge_x = 280,
            hjust = 0)
```


Faceb
Alphab
Micros
Apple
Company
Facebook
Alphabet
Microsoft
Apple
price_indexed
400
200
0
2014
2016
2018
year

```
ggplot(tech_stocks, aes(date, price_indexed, color = ticker)) +
  geom_line() +
  scale_color_OkabeIto(name = "Company",
                       breaks = c("FB", "GOOG", "MSFT", "AAPL"),
                       labels = c("Facebook", "Alphabet", "Microsoft", "Apple"
  scale_x_date(name = "year",
               limits = c(ymd("2012-06-01"), ymd("2018-10-31")),
               expand = c(0,0)) +
  geom_text(data = filter(tech_stocks, date == "2017-06-02"),
            aes(y = price_indexed, label = company),
            color = "gray40",
            nudge_x = 20,
            hjust = 0) +
  guides(color = "none")
```


Facebook
Alphabet
Microsoft
Apple
400
200
0
price_indexed
2014
2016
2018
year

```
ggplot(tech_stocks, aes(date, price_indexed, color = ticker)) +
  geom_line() +
  scale_color_OkabeIto(name = "Company",
                       breaks = c("FB", "GOOG", "MSFT", "AAPL"),
                       labels = c("Facebook", "Alphabet", "Microsoft", "Apple"
  scale_x_date(name = "",
               limits = c(ymd("2012-06-01"), ymd("2018-10-31")),
               expand = c(0,0)) +
  scale_y_continuous(name = "Stock Price, Indexed",
                     labels = scales::dollar) +
  geom_text(data = filter(tech_stocks, date == "2017-06-02"),
            aes(y = price_indexed, label = company),
            color = "gray40",
            nudge_x = 20,
            hjust = 0,
            size = 10) +
  guides(color = "none") +
  labs(title = "Tech growth over time",
       caption = "Data from Wilke (2019): Fundamentals of Data Visualization")
```


Tech growth over time
Stock Price, Indexed
$400
$200
$0
2014
2016
2018
Facebook
Alphabet
Microsoft
Apple
Data from Wilke (2019): Fundamentals of Data Visualization

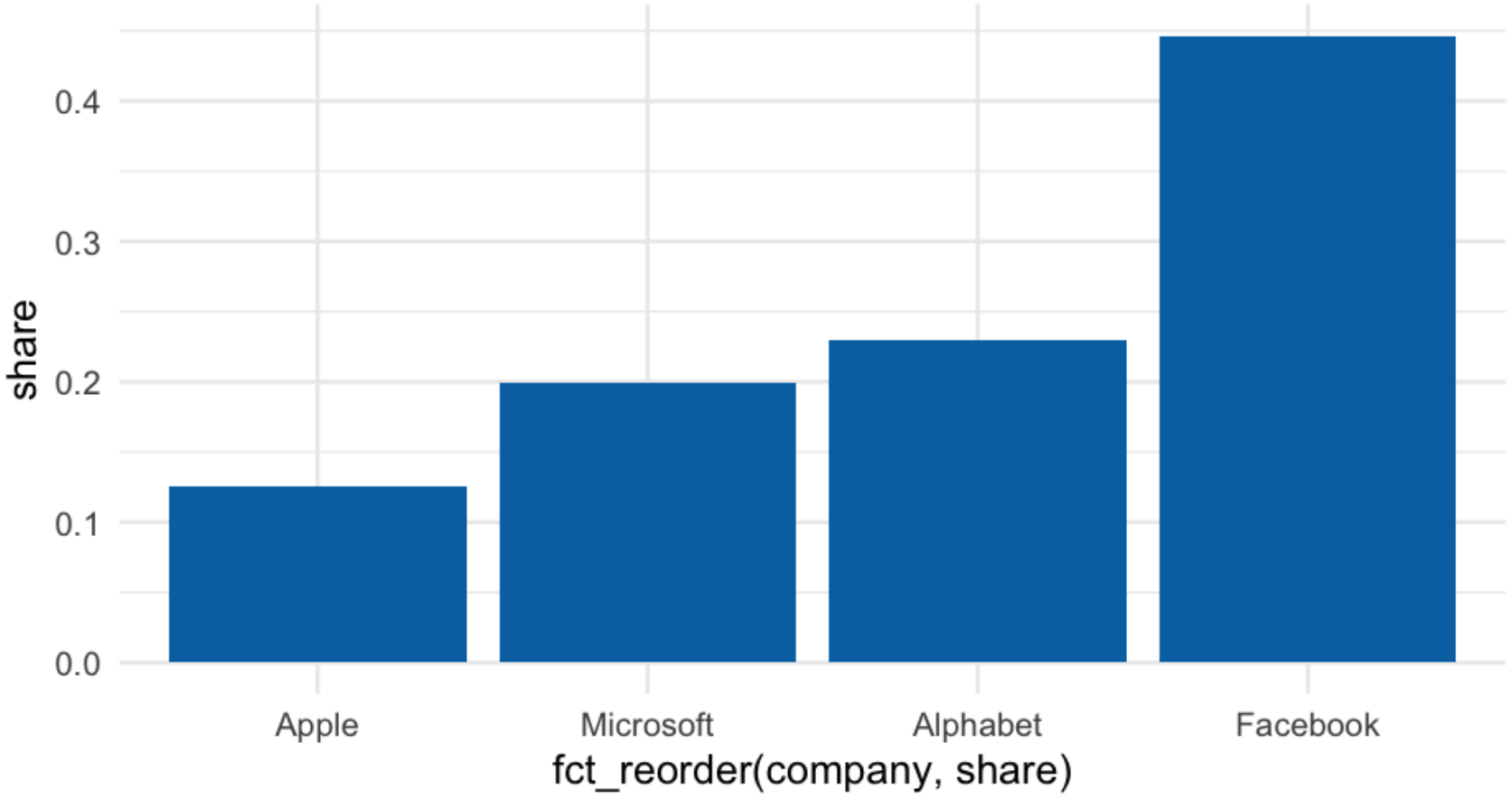
Labeling bars

```
avs <- tech_stocks %>%
  group_by(company) %>%
  summarize(stock_av = mean(price_indexed)) %>%
  ungroup() %>%
  mutate(share = stock_av / sum(stock_av))
avs
```

```
## # A tibble: 4 x 3
##   company    stock_av     share
## * <chr>         <dbl>     <dbl>
## 1 Alphabet  141.0205  0.2292441
## 2 Apple      77.08241 0.1253058
## 3 Facebook  274.7427  0.4466240
## 4 Microsoft 122.3088  0.1988261
```

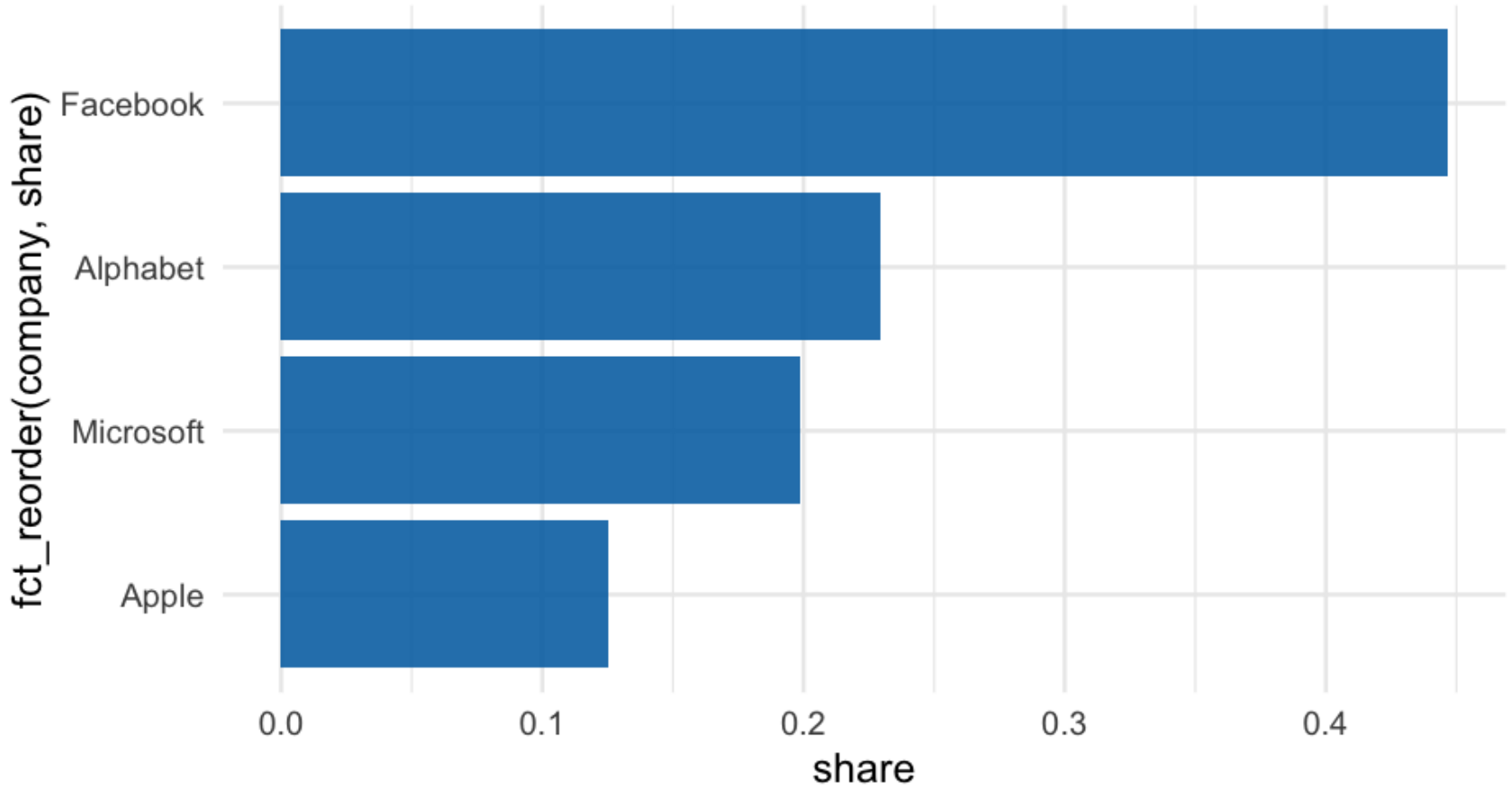
Bar plot

```
ggplot(avs, aes(fct_reorder(company, share), share)) +
  geom_col(fill = "#0072B2")
```

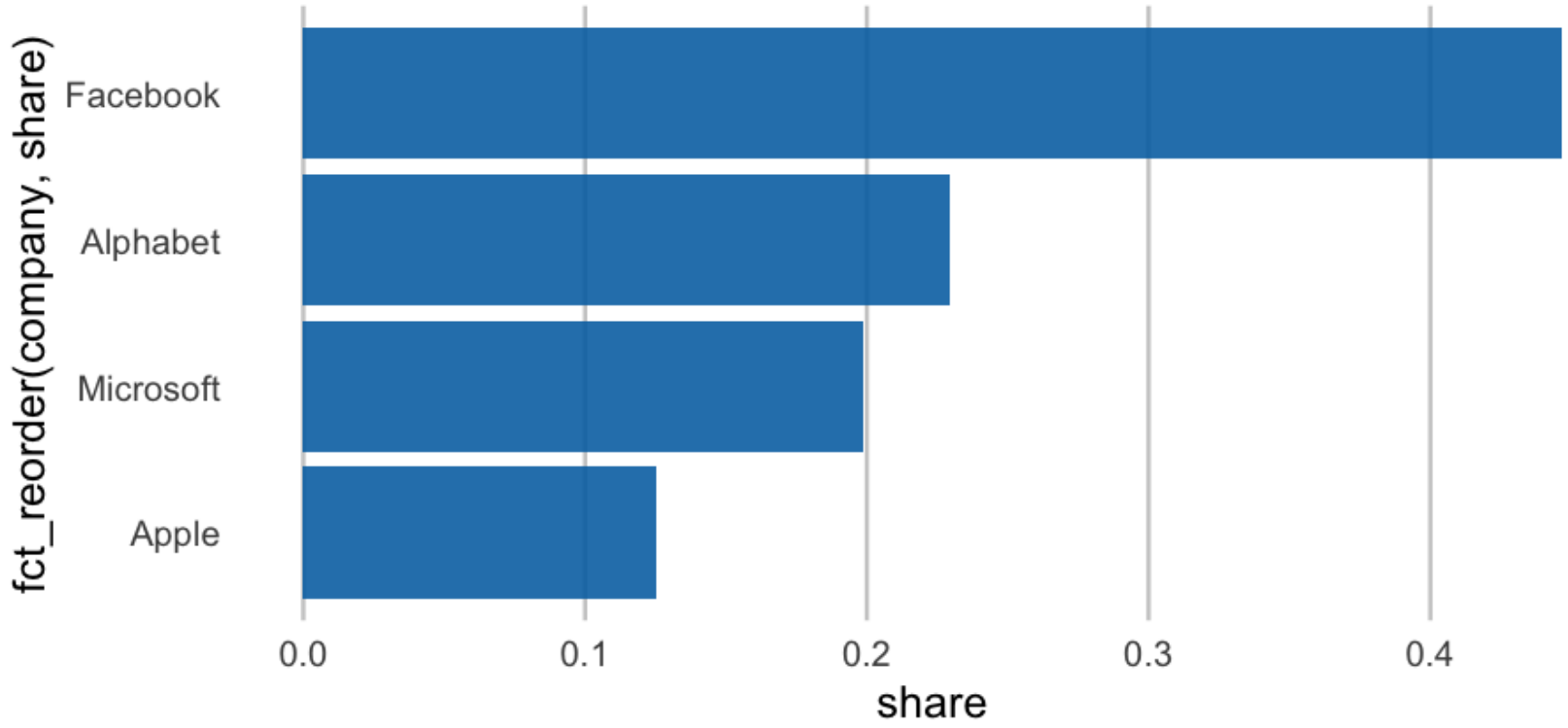


Horizontal

```
ggplot(avs, aes(share, fct_reorder(company, share))) +
  geom_col(fill = "#0072B2",
           alpha = 0.9)
```



```
ggplot(avs, aes(fct_reorder(company, share), share)) +
  geom_col(fill = "#0072B2",
           alpha = 0.9) +
  coord_flip() +
  theme(panel.grid.major.y = element_blank(),
        panel.grid.minor.x = element_blank(),
        panel.grid.major.x = element_line(color = "gray80"))
```

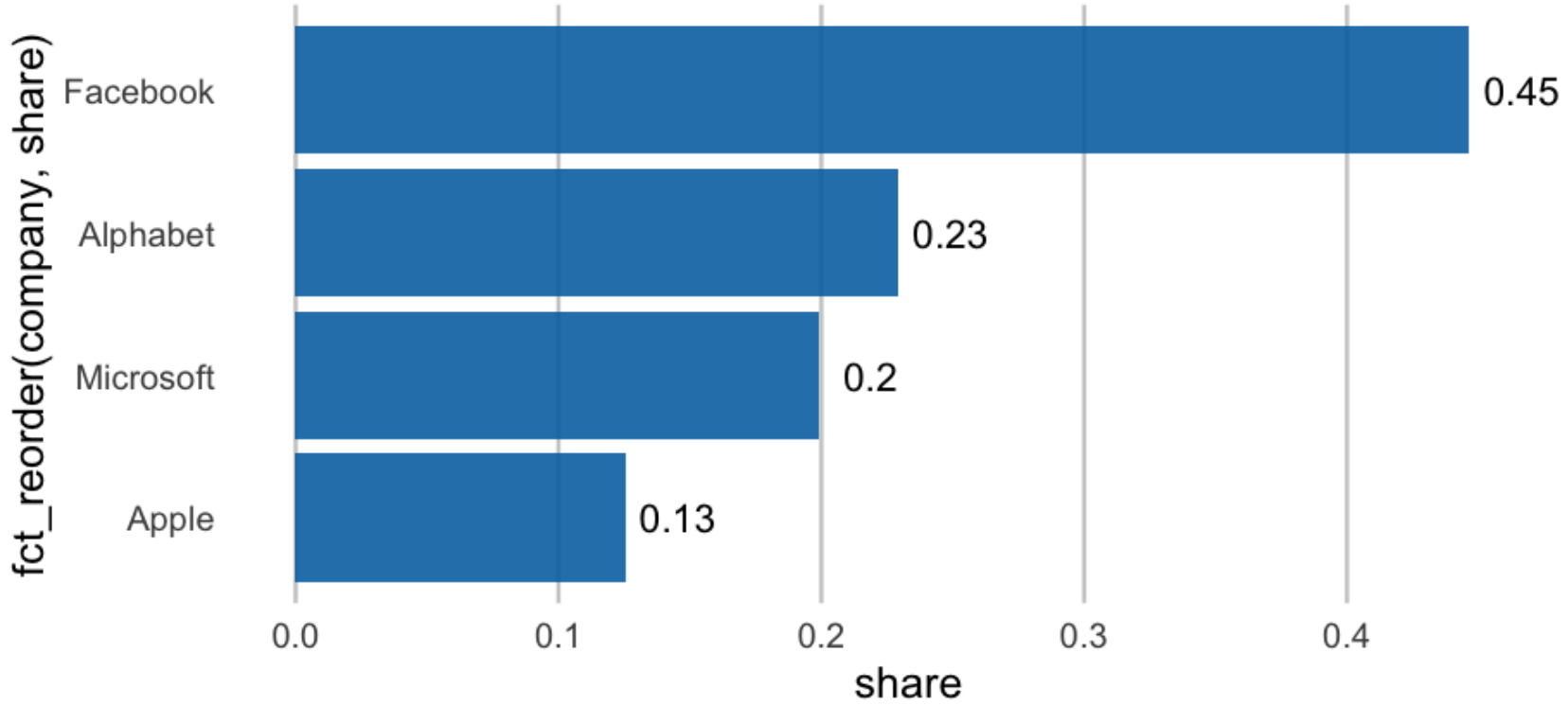


Quick aside

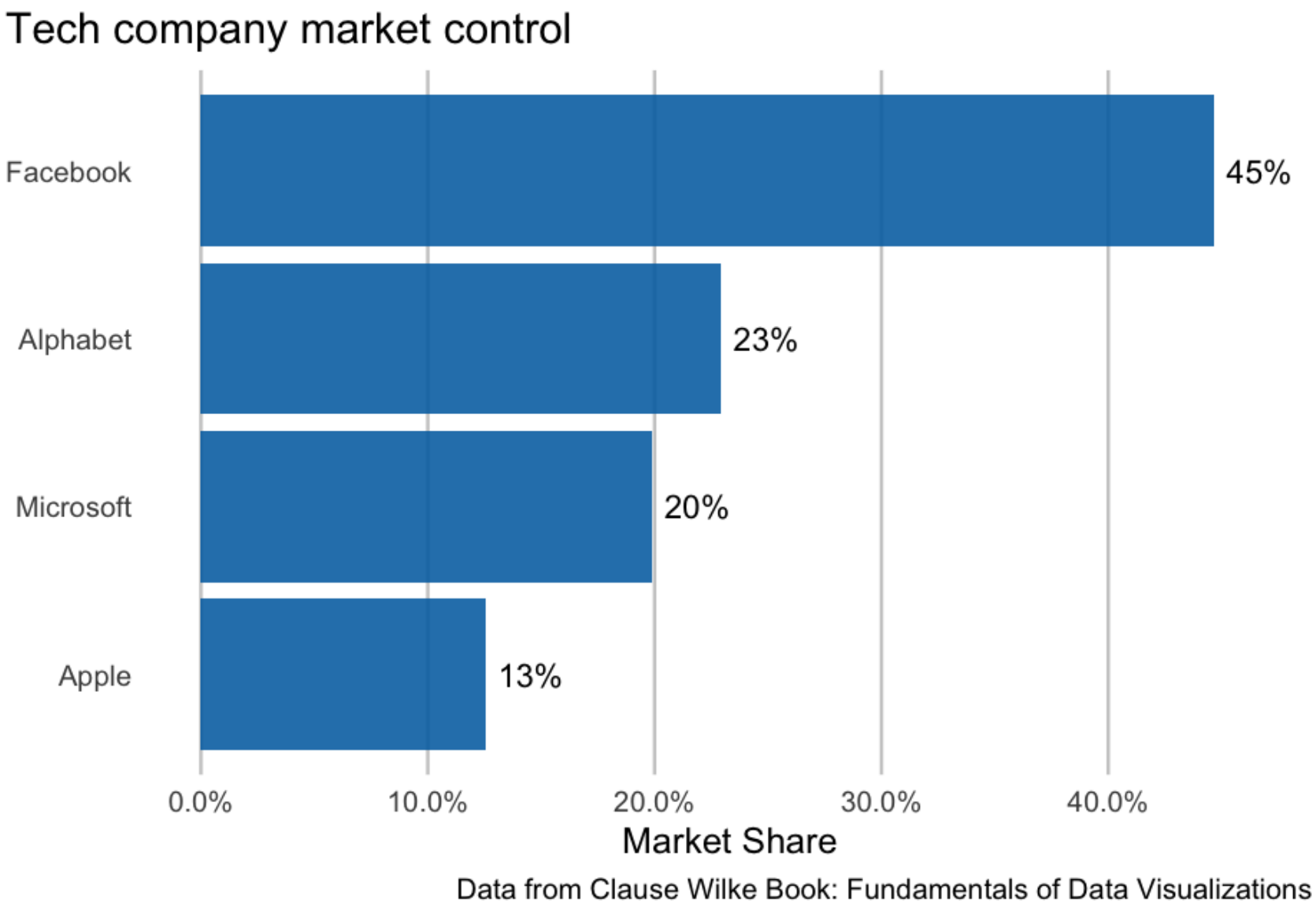
Let's actually make a bar plot theme

```
bp_theme <- function(...) {
  theme_minimal(...) +
    theme(panel.grid.major.y = element_blank(),
          panel.grid.minor.x = element_blank(),
          panel.grid.major.x = element_line(color = "gray80"),
          plot.title.position = "plot")
}
```

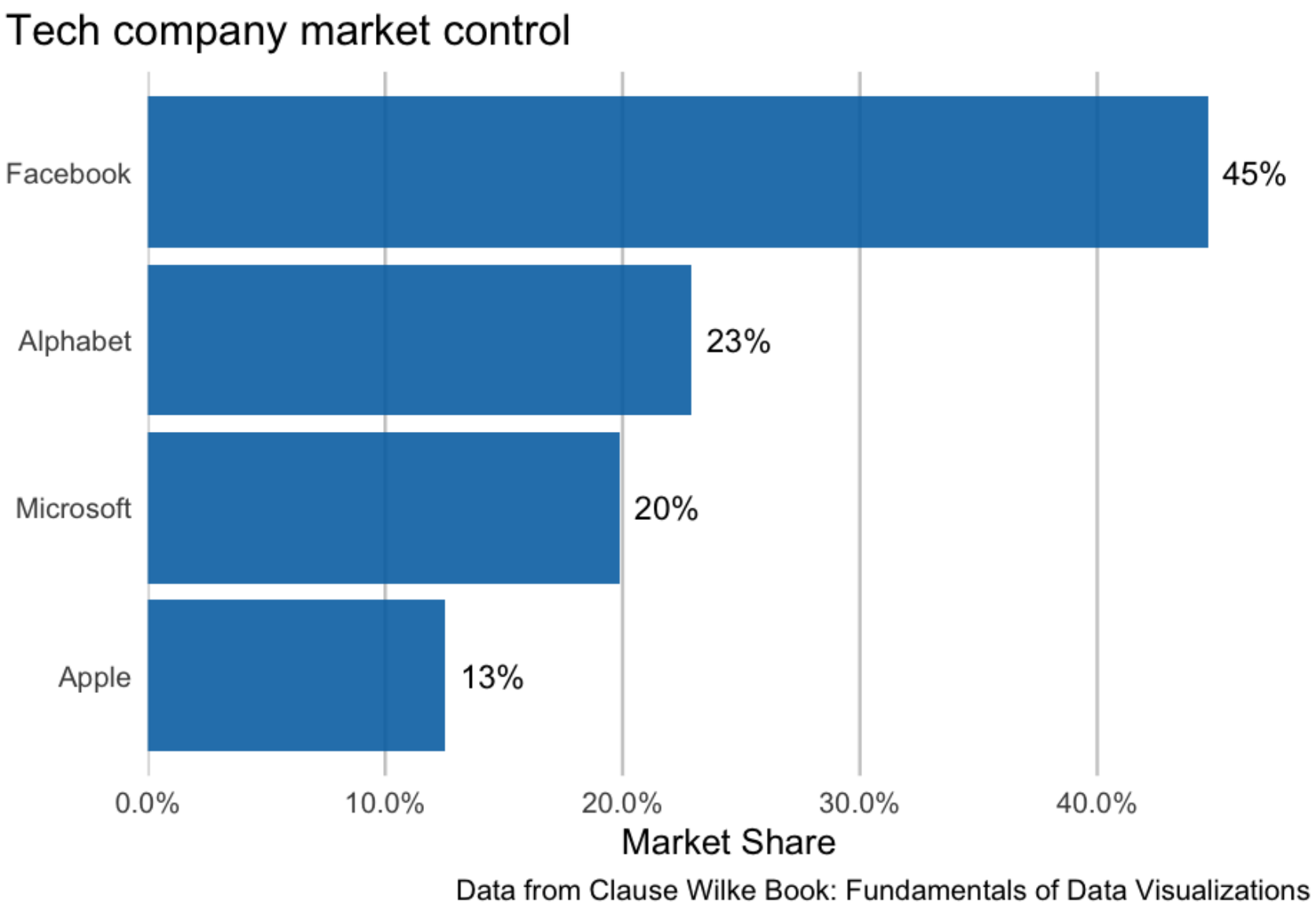
```
ggplot(avs, aes(fct_reorder(company, share), share)) +
  geom_col(fill = "#0072B2",
           alpha = 0.9) +
  geom_text(aes(company, share, label = round(share, 2)),
            nudge_y = 0.02,
            size = 8) +
  coord_flip() +
  bp_theme(base_size = 25)
```



```
ggplot(avs, aes(fct_reorder(company, share), share)) +
  geom_col(fill = "#0072B2",
           alpha = 0.9) +
  geom_text(aes(company, share, label = paste0(round(share*100), "%")),
            nudge_y = 0.02,
            size = 8) +
  coord_flip() +
  scale_y_continuous("Market Share", labels = scales::percent) +
  labs(x = NULL,
       title = "Tech company market control",
       caption = "Data from Clause Wilke Book: Fundamentals of Data Visualizat
  bp_theme(base_size = 25)
```

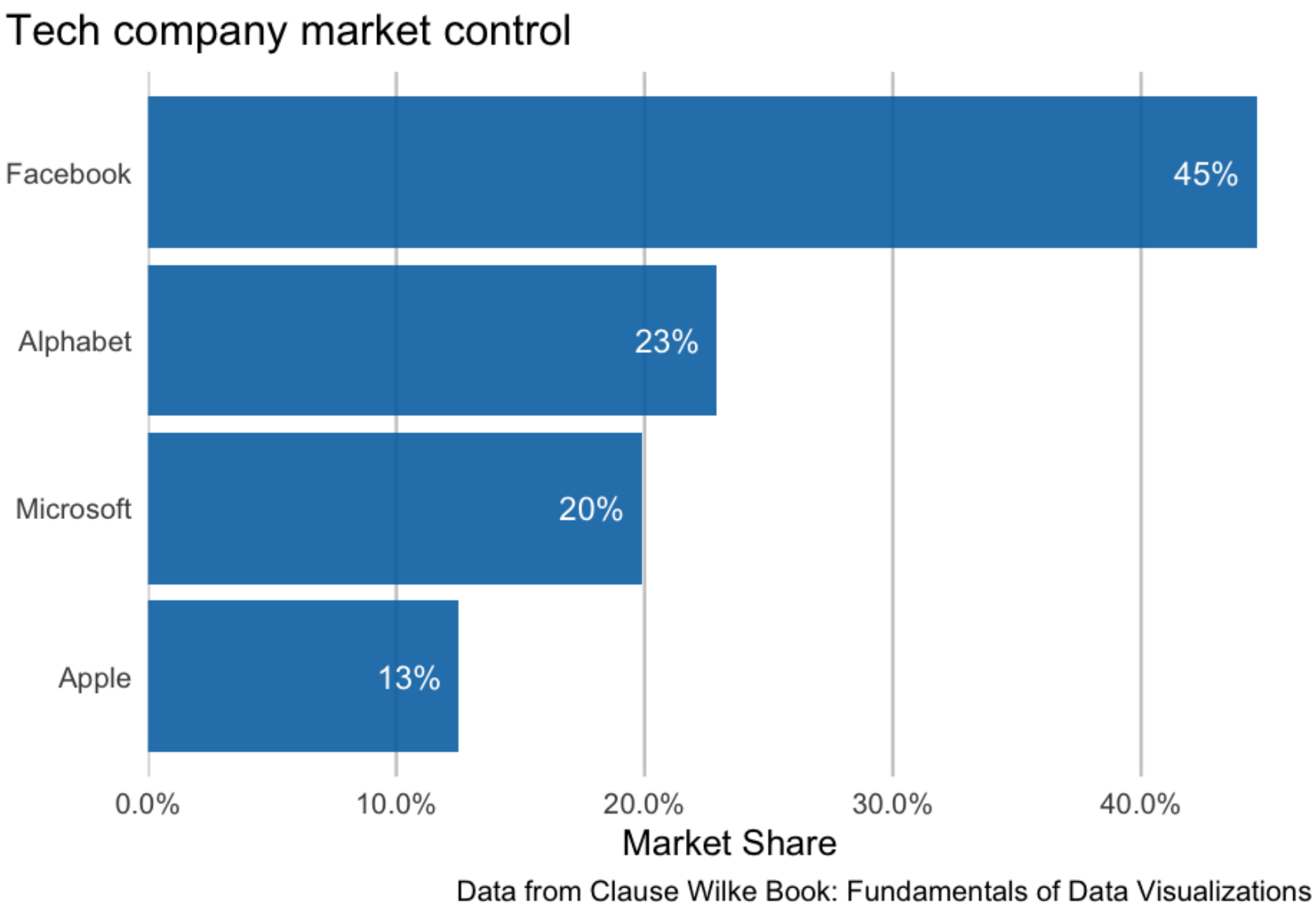

Tech company market control
Facebook
Alphabet
Microsoft
Apple
45%
23%
20%
13%
0.0%
10.0%
20.0%
30.0%
40.0%
Market Share
Data from Clause Wilke Book: Fundamentals of Data Visualizations

```
ggplot(avs, aes(fct_reorder(company, share), share)) +
  geom_col(fill = "#0072B2",
           alpha = 0.9) +
  geom_text(aes(company, share, label = paste0(round(share*100), "%")),
            nudge_y = 0.02,
            size = 8) +
  coord_flip() +
  scale_y_continuous("Market Share",
                     labels = scales::percent,
                     expand = c(0, 0, 0.05, 0)) +
  labs(x = NULL,
       title = "Tech company market control",
       caption = "Data from Clause Wilke Book: Fundamentals of Data Visualizat
  bp_theme(base_size = 25)
```


Tech company market control
Facebook
Alphabet
Microsoft
Apple
45%
23%
20%
13%
0.0%
10.0%
20.0%
30.0%
40.0%
Market Share
Data from Clause Wilke Book: Fundamentals of Data Visualizations

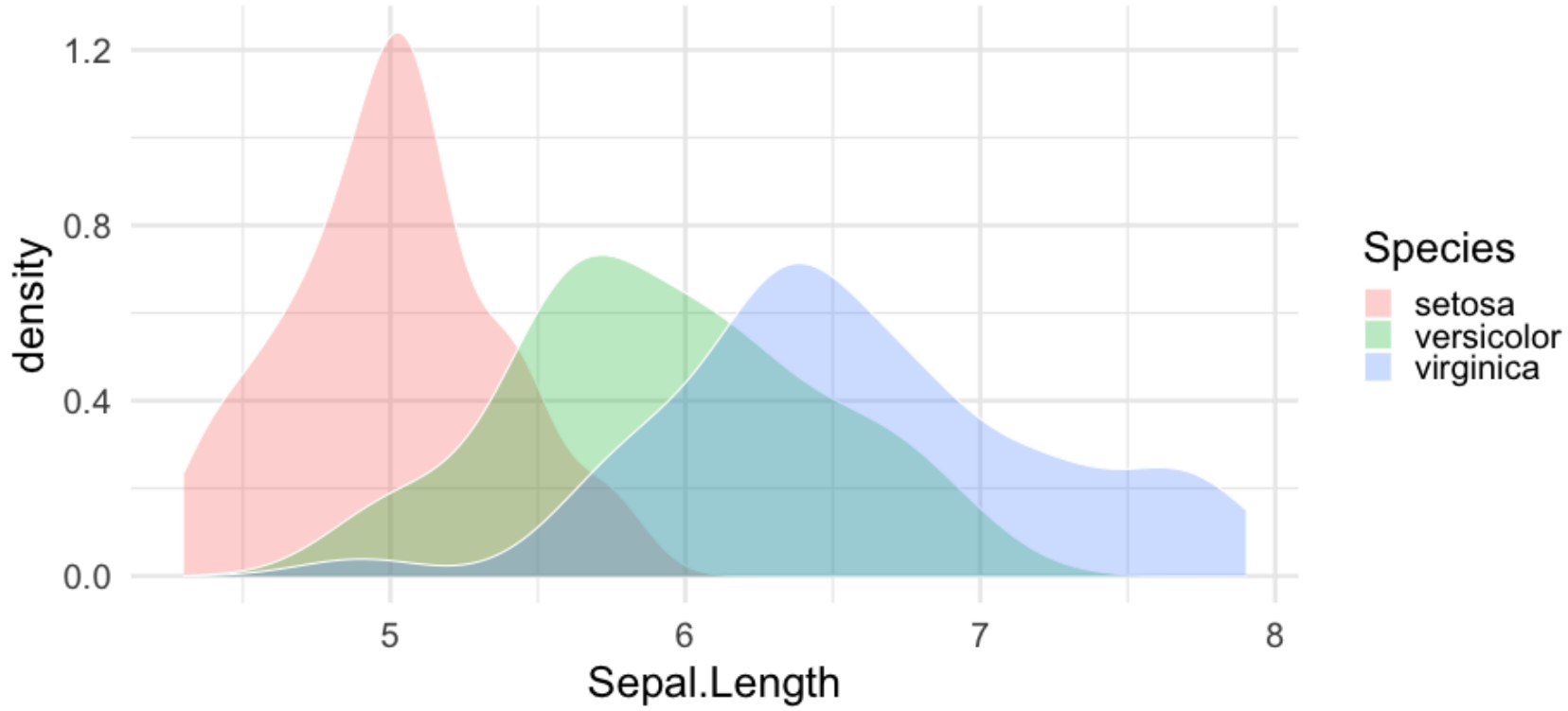
Last alternative

```
ggplot(avs, aes(fct_reorder(company, share), share)) +
  geom_col(fill = "#0072B2",
           alpha = 0.9) +
  geom_text(aes(company, share, label = paste0(round(share*100), "%")),
            nudge_y = -0.02,
            size = 8,
            color = "white") +
  coord_flip() +
  scale_y_continuous("Market Share",
                     labels = scales::percent,
                     expand = c(0, 0, 0.05, 0)) +
  labs(x = NULL,
       title = "Tech company market control",
       caption = "Data from Clause Wilke Book: Fundamentals of Data Visualizat
  bp_theme(base_size = 25)
```

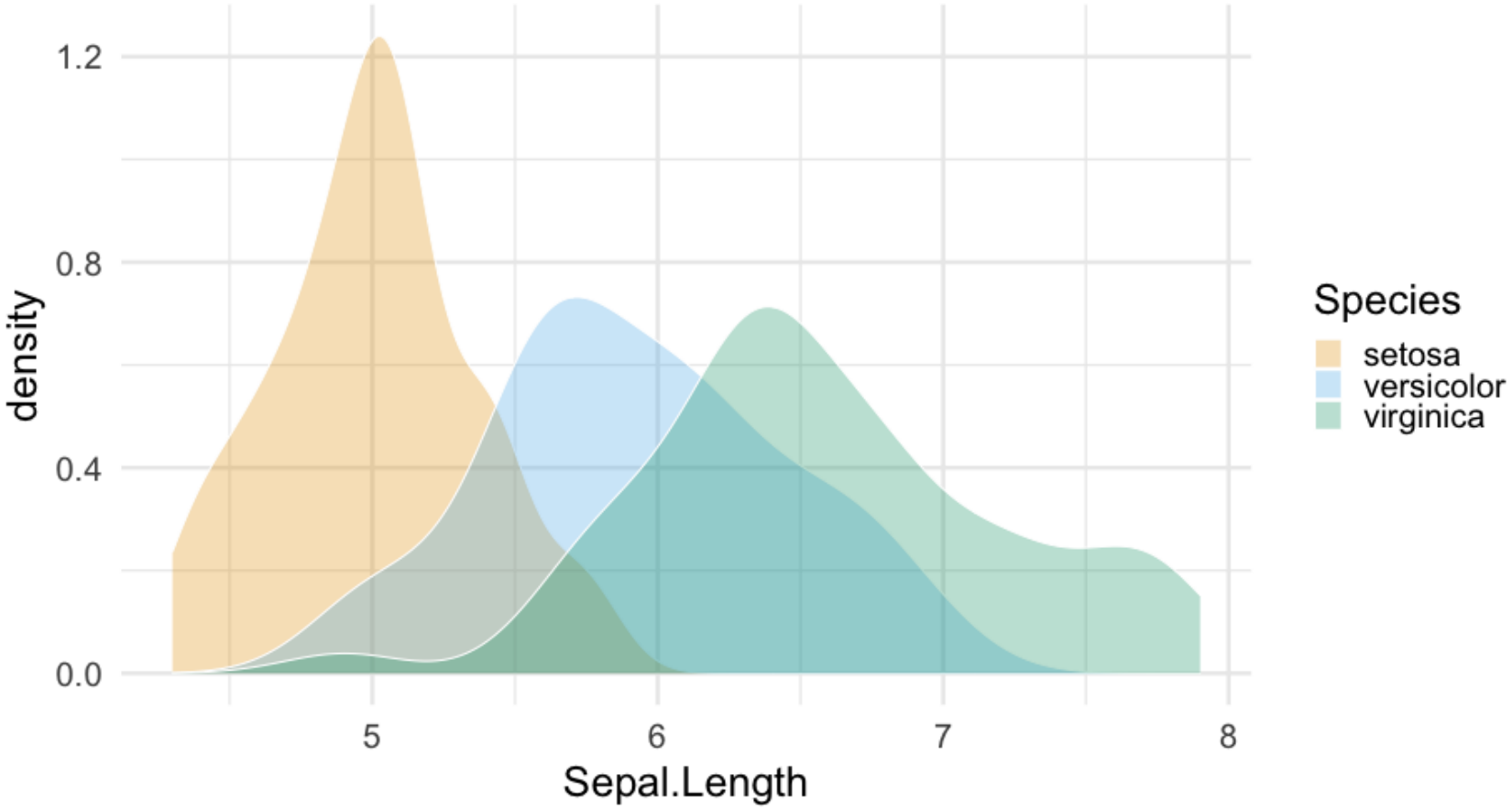

Tech company market control
Facebook
Alphabet
Microsoft
Apple
45%
23%
20%
13%
0.0%
10.0%
20.0%
30.0%
40.0%
Market Share
Data from Clause Wilke Book: Fundamentals of Data Visualizations

Distributions

```
ggplot(iris, aes(Sepal.Length, fill = Species)) +
  geom_density(alpha = 0.3,
               color = "white")
```



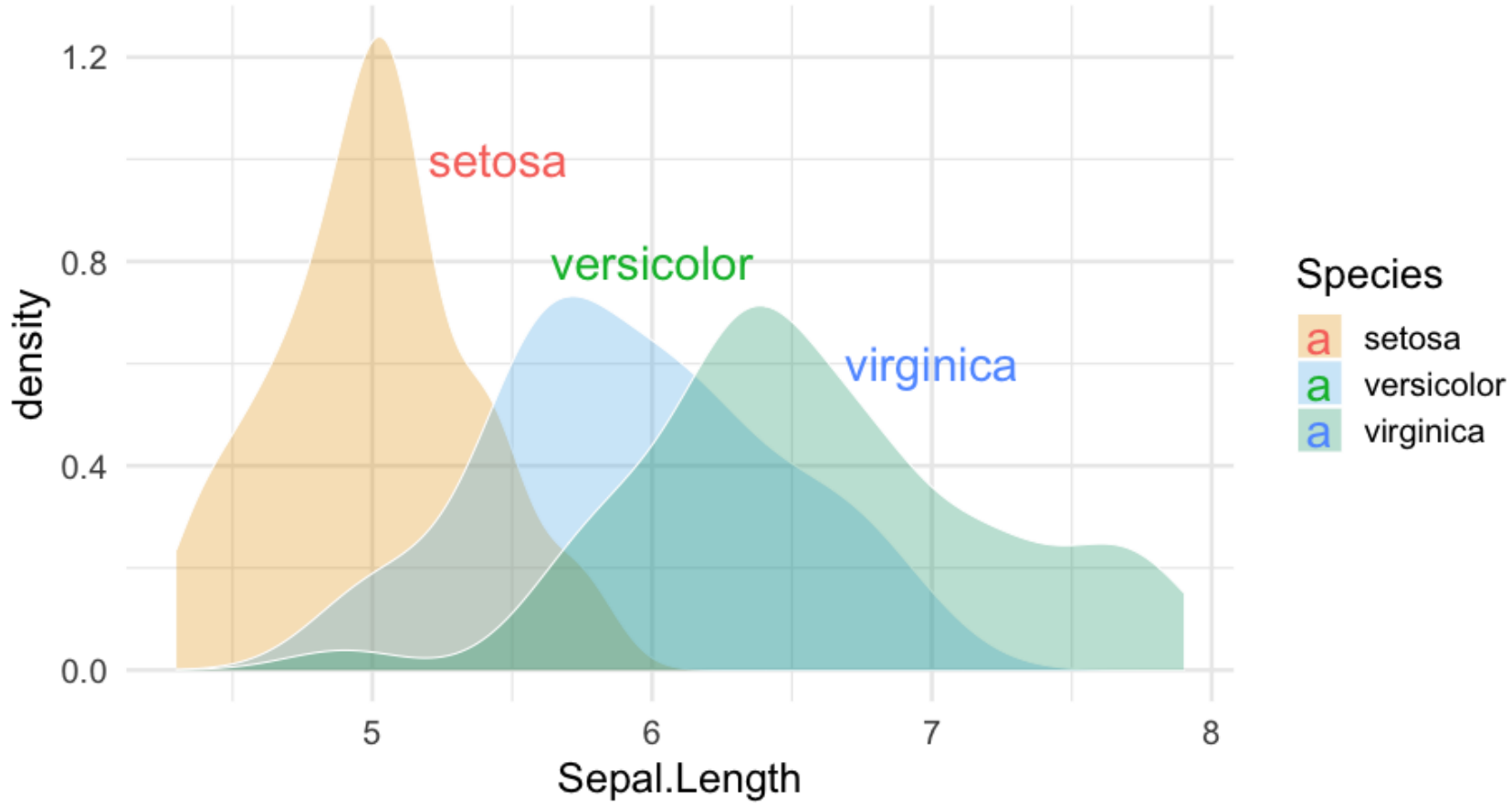
```
ggplot(iris, aes(Sepal.Length, fill = Species)) +
  geom_density(alpha = 0.3,
               color = "white") +
  scale_fill_OkabeIto()
```



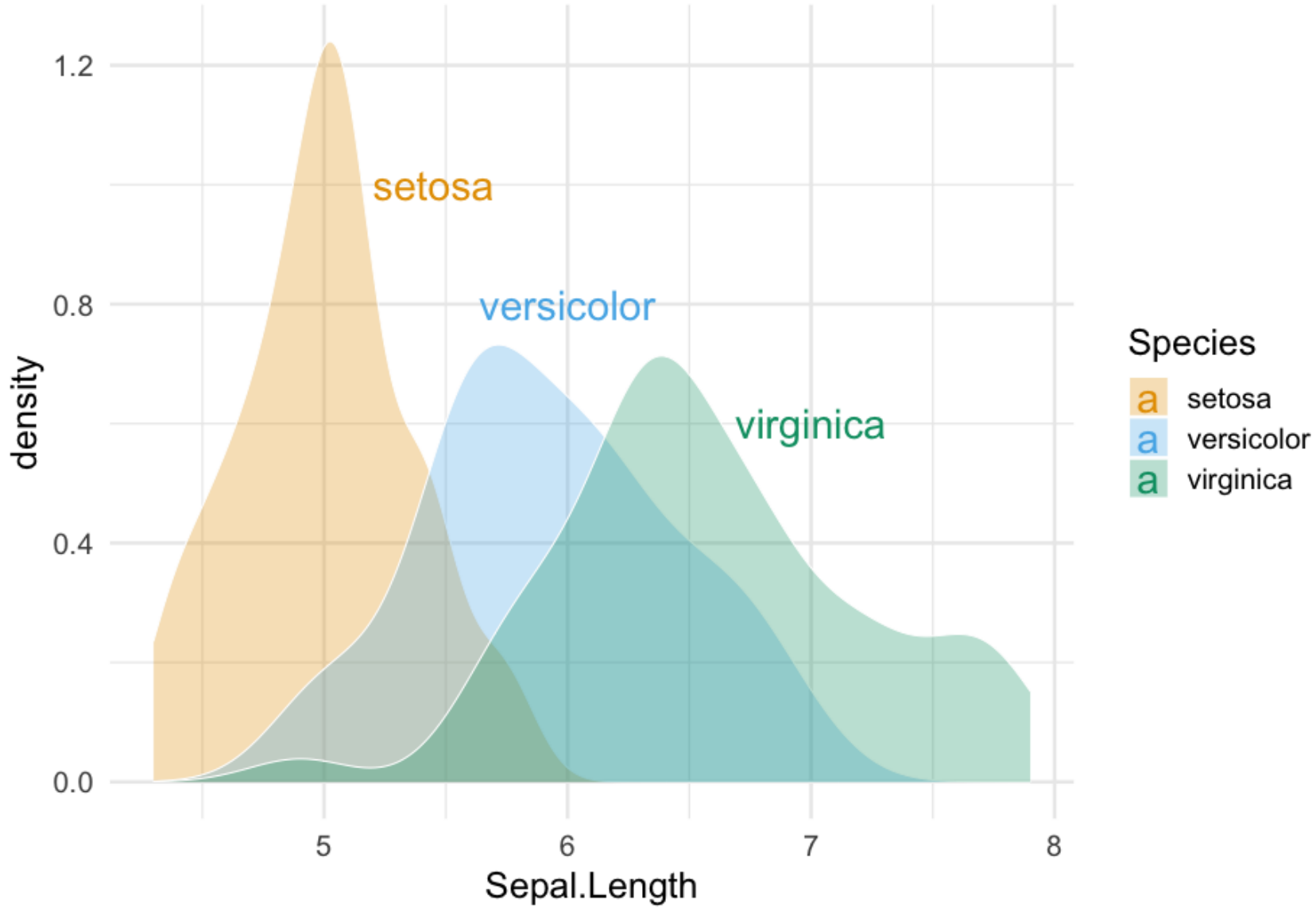
Labeling

One method

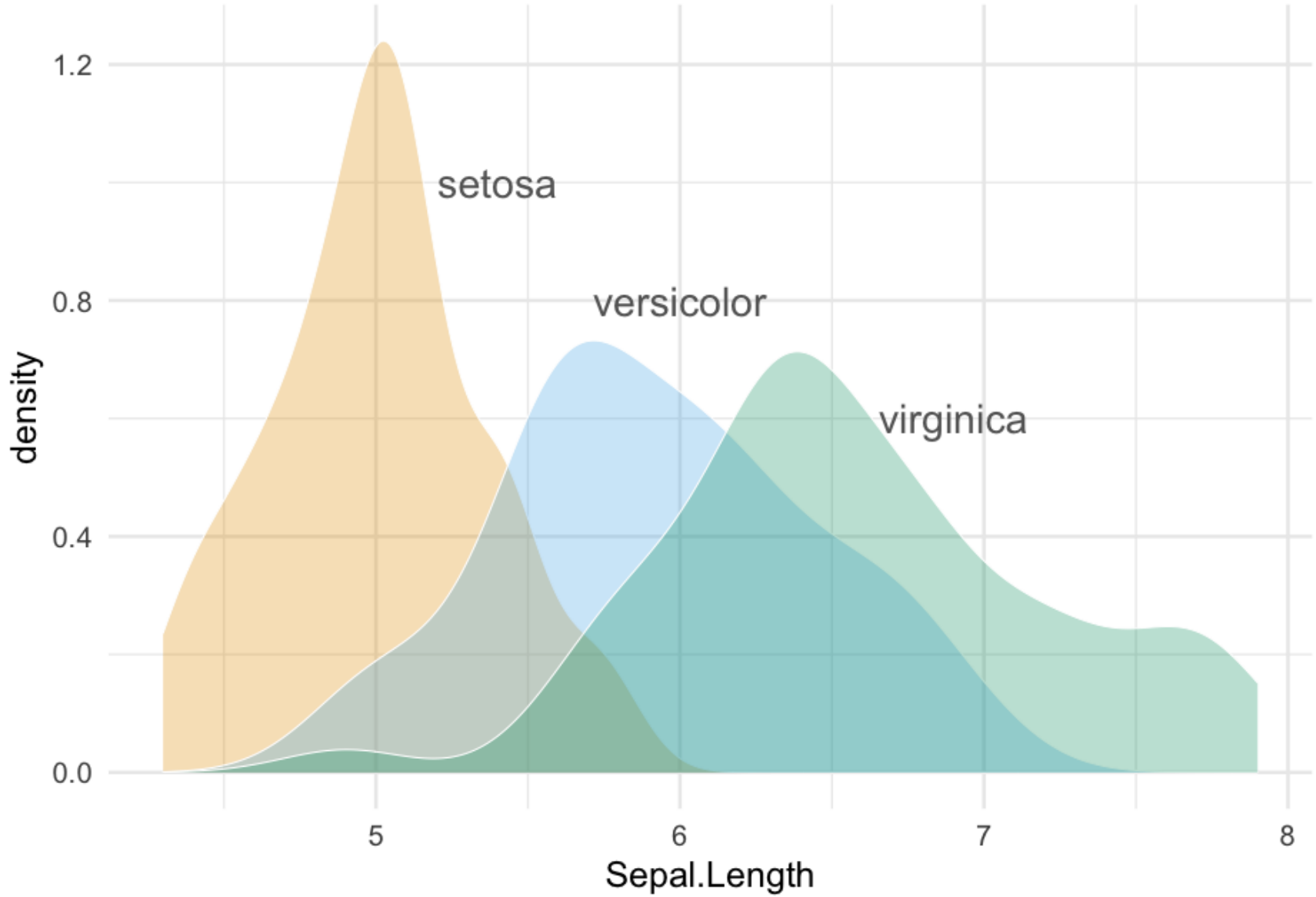
```
label_locs <- tibble(Sepal.Length = c(5.45, 6, 7),
                     density = c(1, 0.8, 0.6),
                     Species = c("setosa", "versicolor", "virginica"))

ggplot(iris, aes(Sepal.Length, fill = Species)) +
  geom_density(alpha = 0.3,
               color = "white") +
  scale_fill_OkabeIto() +
  geom_text(aes(label = Species, y = density, color = Species),
            data = label_locs)
```


1.2
0.8
0.4
0.0
density
setosa
versicolor
virginica
5
6
7
8
Sepal.Length
Species
a setosa
a versicolor
a virginica

```
ggplot(iris, aes(Sepal.Length, fill = Species)) +
  geom_density(alpha = 0.3,
               color = "white") +
  scale_fill_OkabeIto() +
  scale_color_OkabeIto() +
  geom_text(aes(label = Species, y = density, color = Species),
            data = label_locs) +
  guides(color = "none",
         fill = "none")
```


1.2
0.8
0.4
0.0
density
setosa
versicolor
virginica
5
6
7
8
Sepal.Length
Species
a setosa
a versicolor
a virginica

```r
label_locs <- tibble(Sepal.Length = c(5.4, 6, 6.9),
                     density = c(1, 0.75, 0.6),
                     Species = c("setosa", "versicolor", "virginica"))

ggplot(iris, aes(Sepal.Length, fill = Species)) +
  geom_density(alpha = 0.3,
               color = "white") +
  scale_fill_OkabeIto() +
  scale_color_OkabeIto() +
  geom_text(aes(label = Species, y = density),
            color = "gray40",
            data = label_locs) +
  guides(fill = "none")
```

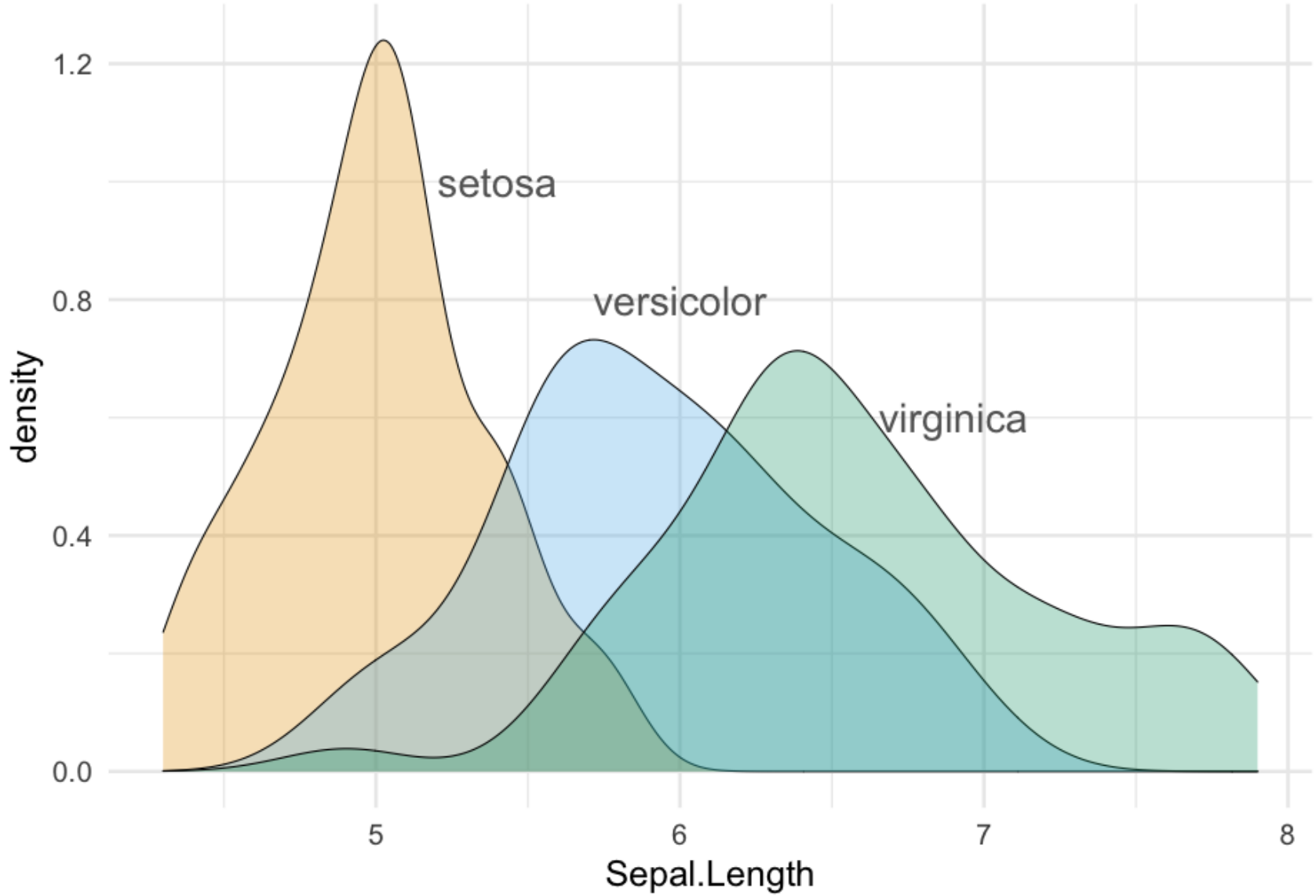

1.2
0.8
0.4
0.0
density
setosa
versicolor
virginica
5
6
7
8
Sepal.Length

Other options

- Rather than using a new data frame, you could use multiple calls to `annotate`.
- One is not necessarily better than the other, but I prefer the data frame method
- Keep in mind you can always use multiple data sources within a single plot
    - Each layer can have its own data source
    - Common in geographic data in particular

Annotate example

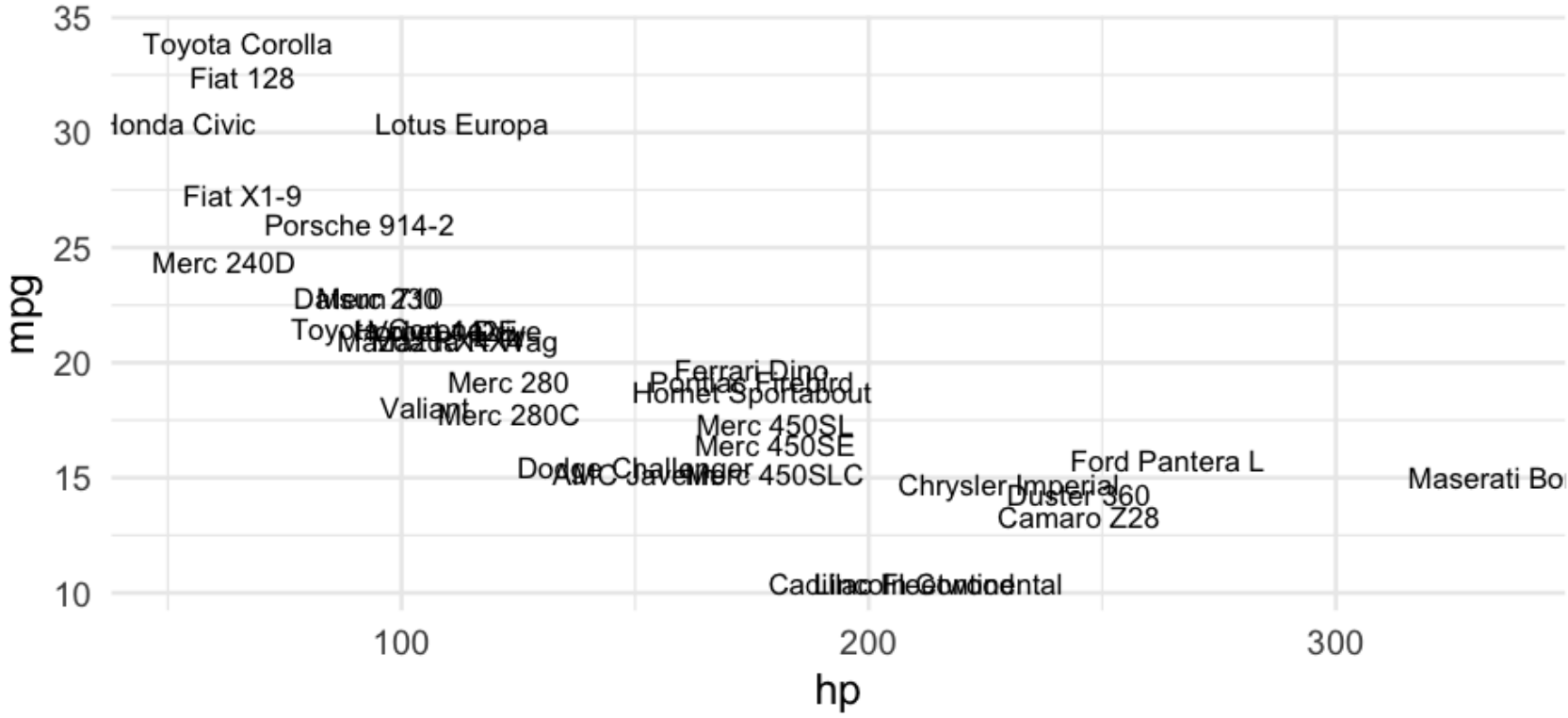
```
ggplot(iris, aes(Sepal.Length, fill = Species)) +
  geom_density(alpha = 0.3) +
  scale_fill_OkabeIto() +
  scale_color_OkabeIto() +
  annotate("text", label = "setosa", x = 5.45, y = 1, color = "gray40") +
  annotate("text", label = "versicolor", x = 6, y = 0.8, color = "gray40") +
  annotate("text", label = "virginica", x = 7, y = 0.6, color = "gray40") +
  guides(fill = "none")
```


1.2
0.8
0.4
0.0
density
setosa
versicolor
virginica
5
6
7
8
Sepal.Length

ggrepel

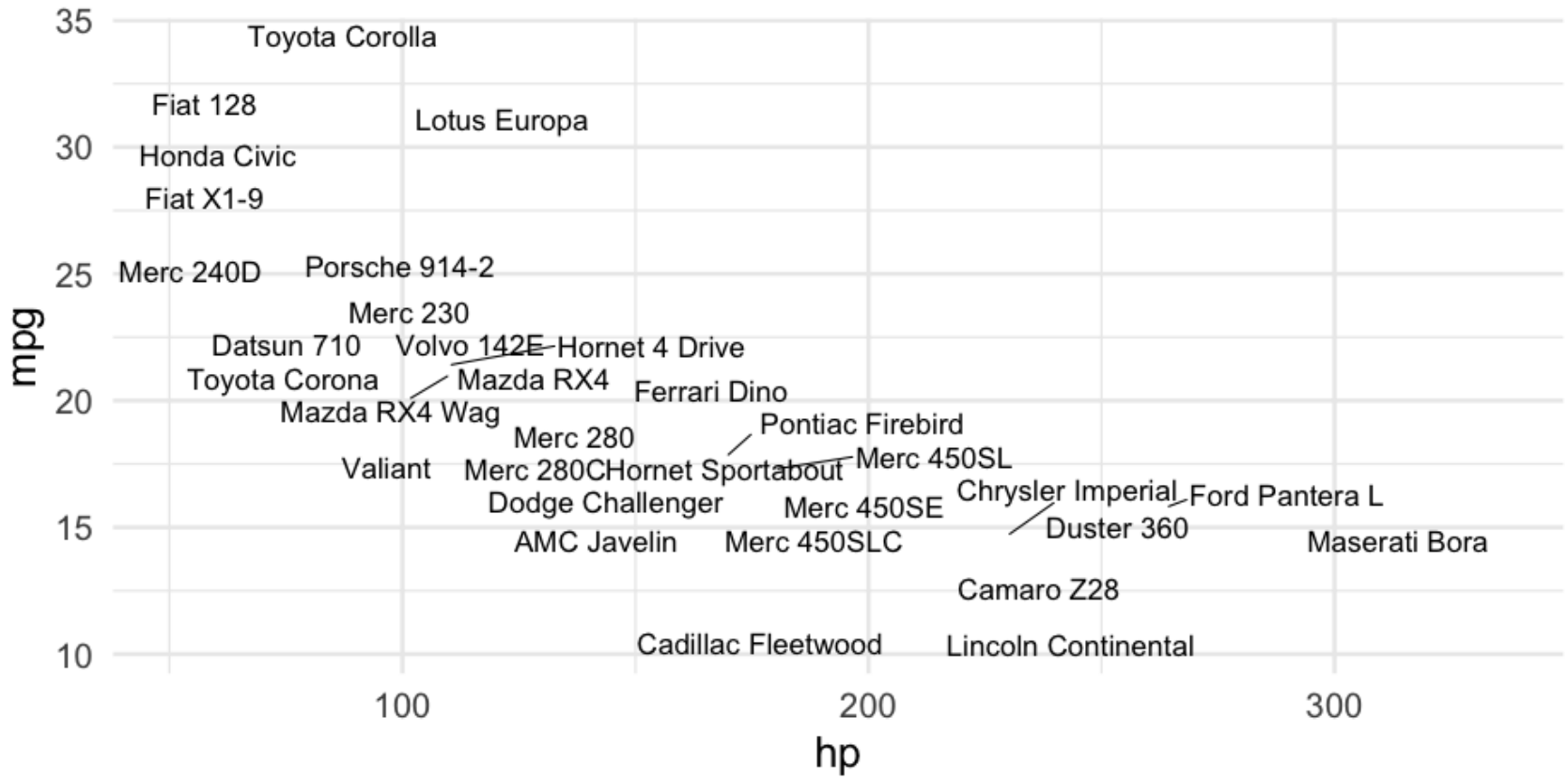
Plot text directly

```
cars <- rownames_to_column(mtcars)

ggplot(cars, aes(hp, mpg)) +
  geom_text(aes(label = rowname))
```



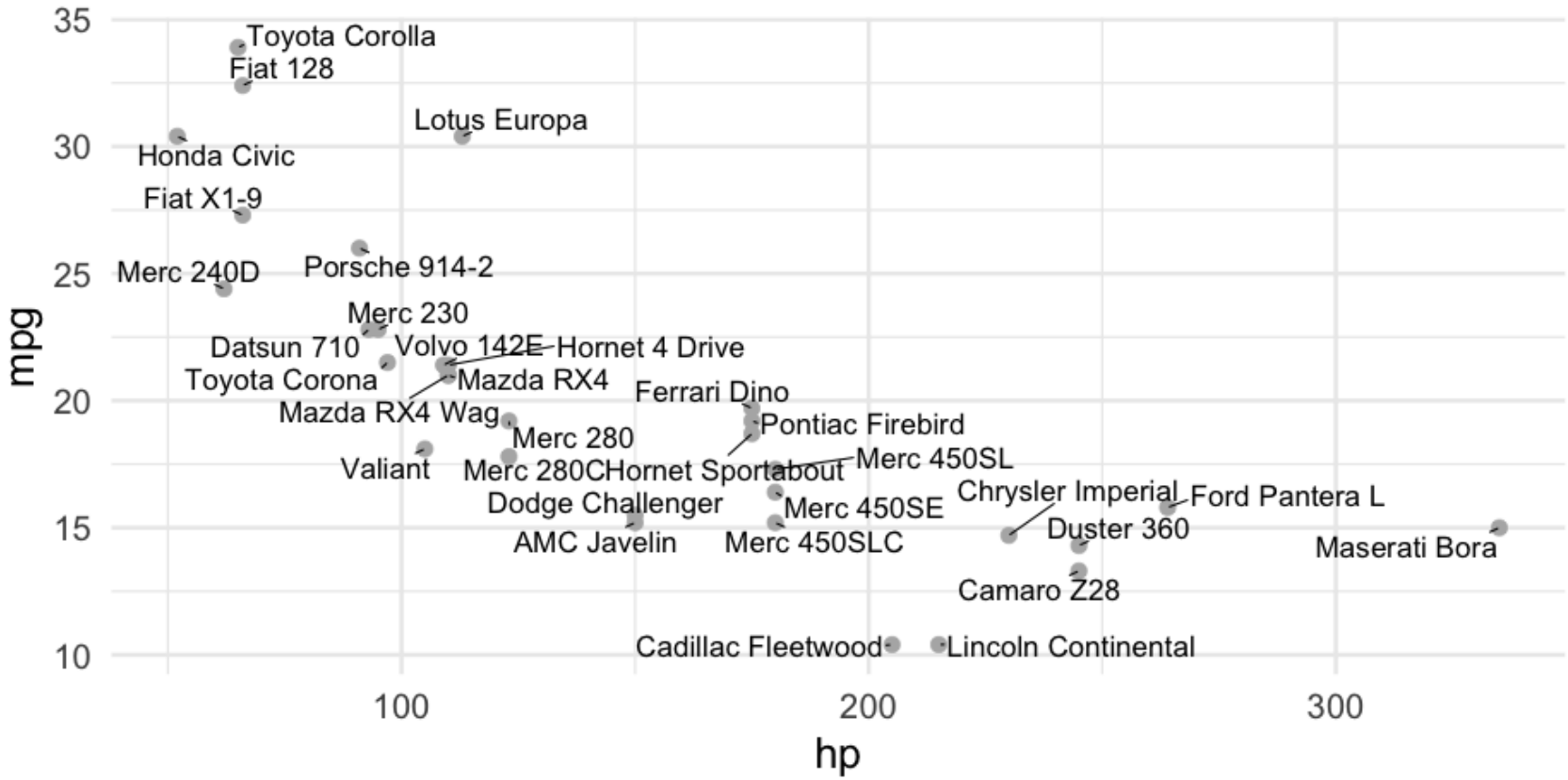
Repel text

```
library(ggrepel)
ggplot(cars, aes(hp, mpg)) +
  geom_text_repel(aes(label = rowname))
```



Slightly better

```
ggplot(cars, aes(hp, mpg)) +
  geom_point(color = "gray70") +
  geom_text_repel(aes(label = rowname),
                  min.segment.length = 0)
```



Common use cases

- Label some sample data that makes some theoretical sense (we've seen this before)
- Label outliers
- Label points from a specific group (e.g., similar to highlighting – can be used in conjunction)

Some new data

```
remotes::install_github("kjhealy/socviz")
library(socviz)
```

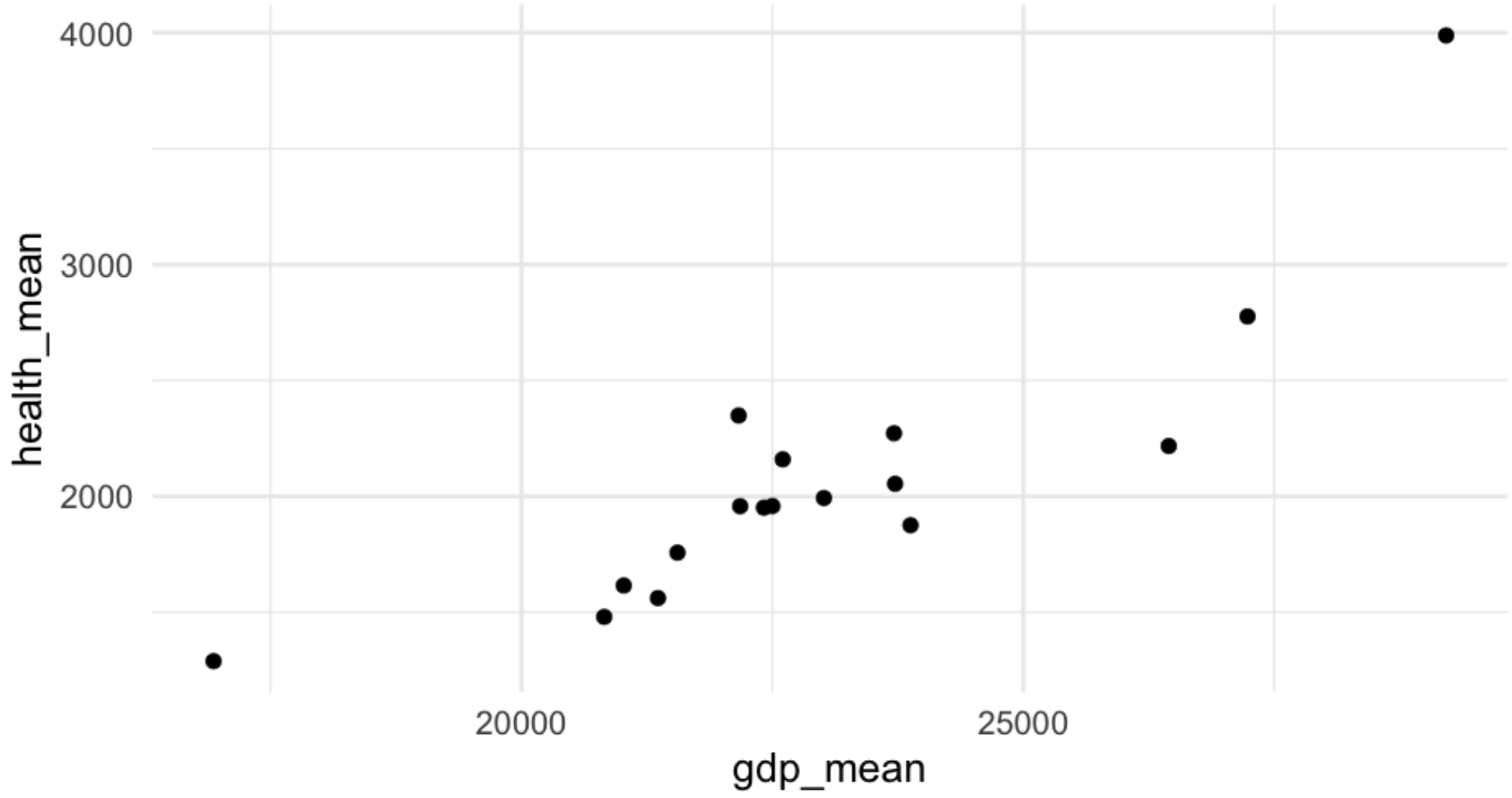
```
by_country <- organdata %>%
  group_by(consent_law, country) %>%
  summarize(donors_mean= mean(donors, na.rm = TRUE),
            donors_sd = sd(donors, na.rm = TRUE),
            gdp_mean = mean(gdp, na.rm = TRUE),
            health_mean = mean(health, na.rm = TRUE),
            roads_mean = mean(roads, na.rm = TRUE),
            cerebvas_mean = mean(cerebvas, na.rm = TRUE))
```

```
by_country
```

```
## # A tibble: 17 x 8
## # Groups:   consent_law [2]
##   consent_law country     donors_mean donors_sd gdp_mean health_mean roads_mean
##   <chr>       <chr>             <dbl>     <dbl>    <dbl>       <dbl>      <dbl>
## 1 Informed    Australia      10.635   1.142808  22178.54    1957.5    104.8757
## 2 Informed    Canada         13.96667 0.7511607 23711.08    2271.929  109.2601
## 3 Informed    Denmark        13.09167 1.468121  23722.31    2054.071  101.6363
## 4 Informed    Germany        13.04167 0.6111960 22163.23    2348.75   112.7887
## 5 Informed    Ireland        19.79167 2.478437  20824.38    1479.929  117.7742
## 6 Informed    Netherlands    13.65833 1.551807  23013.15    1992.786   76.09357
## # … with 11 more rows, and 1 more variable: cerebvas_mean <dbl>
```

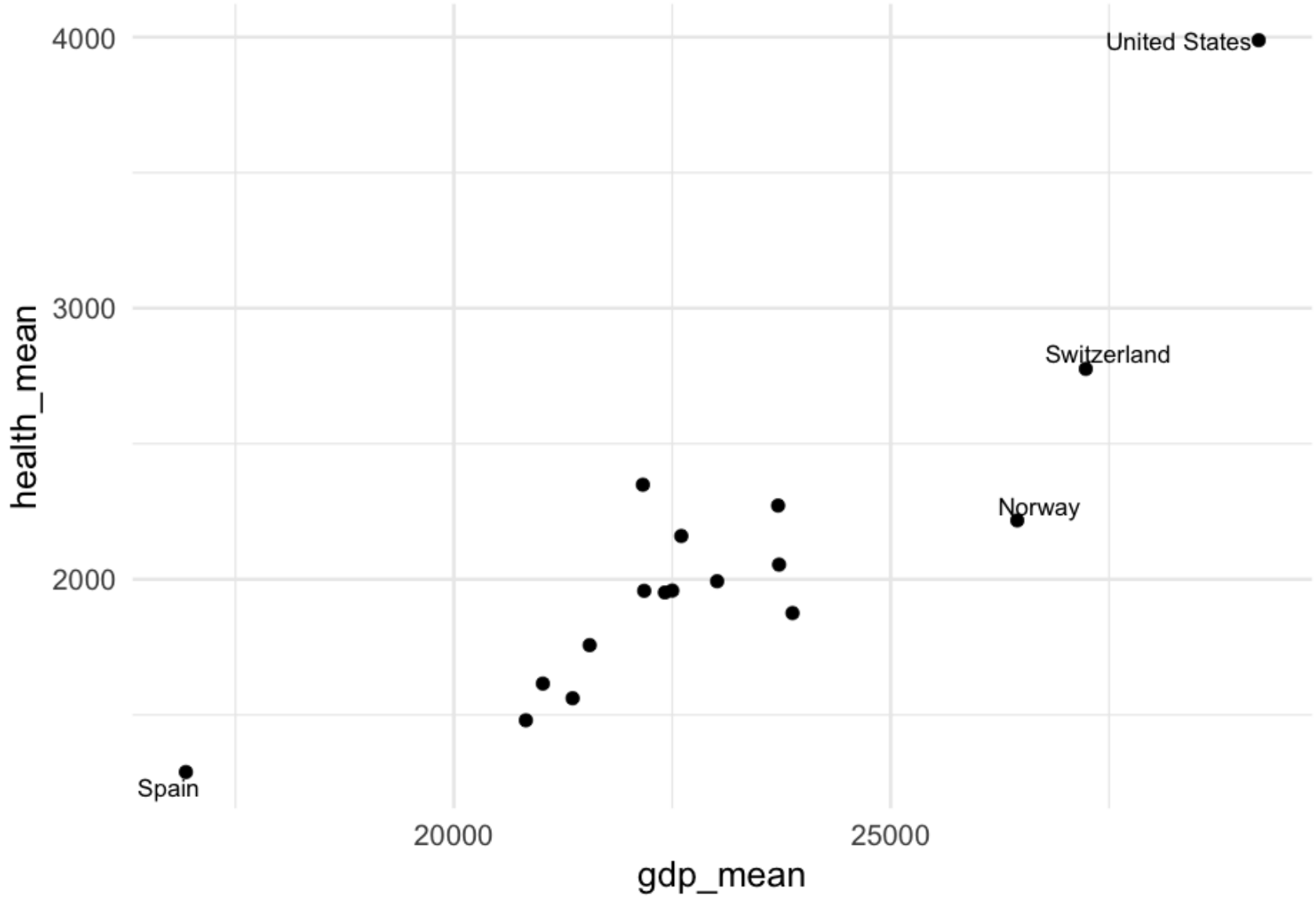
Scatterplot

```
ggplot(by_country, aes(gdp_mean, health_mean)) +
  geom_point()
```



Outliers

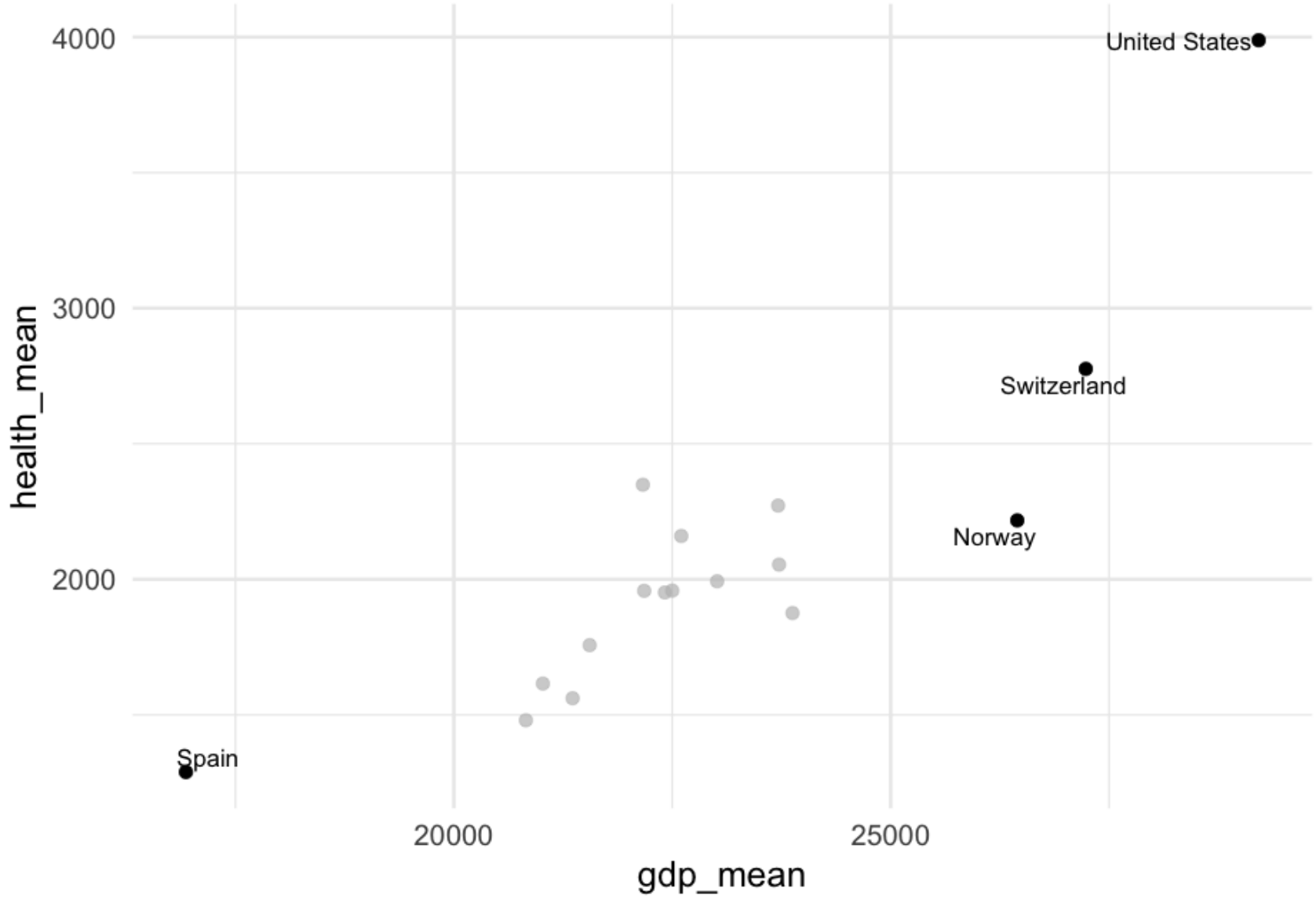
```
ggplot(by_country, aes(gdp_mean, health_mean)) +
  geom_point() +
  geom_text_repel(data = filter(by_country,
                                gdp_mean > 25000 |
                                gdp_mean < 20000),
                  aes(label = country))
```


4000
3000
2000
health_mean
United States
Switzerland
Norway
Spain
20000
25000
gdp_mean

Combine with highlighting

```
library(gghighlight)
ggplot(by_country, aes(gdp_mean, health_mean)) +
  geom_point() +
  gghighlight(gdp_mean > 25000 | gdp_mean < 20000) +
  geom_text_repel(aes(label = country))
```

- Notice you only have to specify the points to highlight and `geom_text_repel` will then only label those points

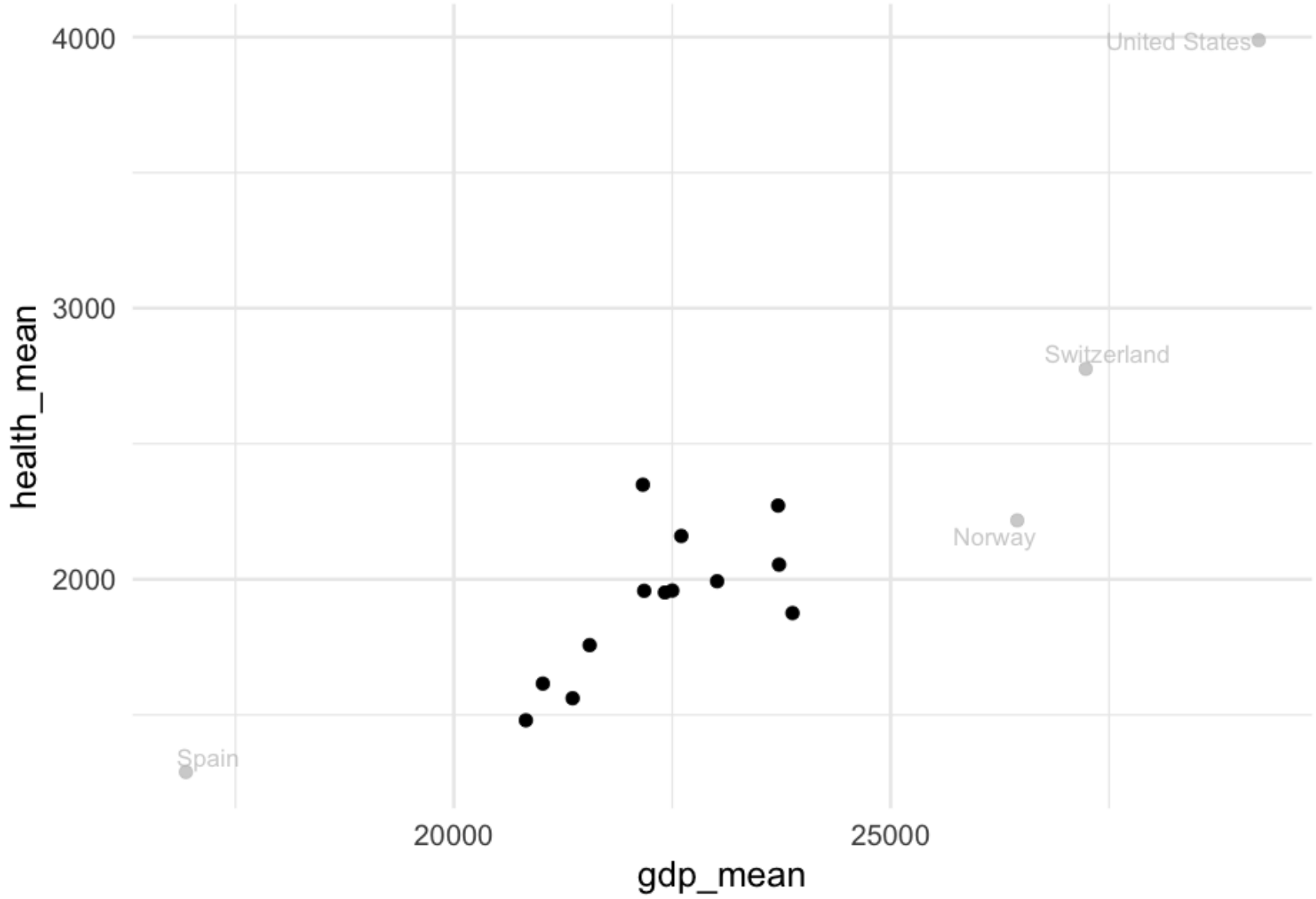

4000
3000
2000
health_mean
United States
Switzerland
Norway
Spain
20000
25000
gdp_mean

Combine with highlighting

Switch to make outliers grayed out and labeled

```
ggplot(by_country, aes(gdp_mean, health_mean)) +
  geom_point() +
  gghighlight(gdp_mean > 20000 & gdp_mean < 25000 ) +
  geom_text_repel(data = filter(by_country,
                                gdp_mean > 25000 |
                                gdp_mean < 20000),
                  aes(label = country),
                  color = "#BEBEBEB3")
```

Note I found the exact gray color by looking at the source code. Specifically, it is the output from `ggplot2::alpha("grey", 0.7)`

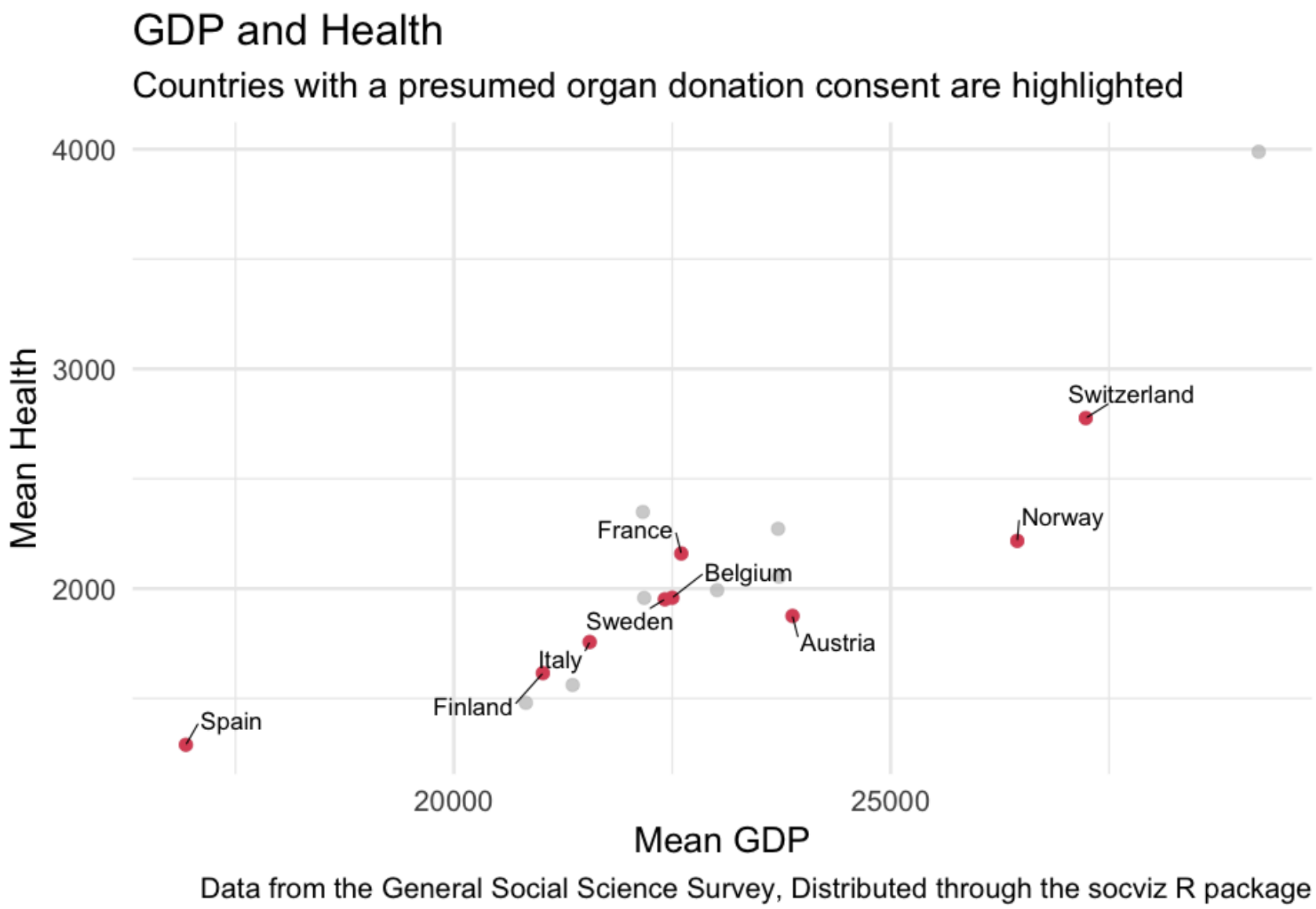

4000
3000
2000
health_mean
United States
Switzerland
Norway
Spain
20000
25000
gdp_mean

By group

```
ggplot(by_country, aes(gdp_mean, health_mean)) +
  geom_point() +
  geom_text_repel(data = filter(by_country,
                                consent_law == "Presumed"),
                  aes(label = country))
```

By group

```
ggplot(by_country, aes(gdp_mean, health_mean)) +
  geom_point(color = "#DC5265") +
  gghighlight(consent_law == "Presumed") +
  geom_text_repel(aes(label = country),
                  min.segment.length = 0,
                  box.padding = 0.75) +
  labs(title = "GDP and Health",
         subtitle = "Countries with a presumed organ donation consent are high
         caption = "Data from the General Social Science Survey, Distributed t
         x = "Mean GDP",
         y = "Mean Health")
```


GDP and Health
Countries with a presumed organ donation consent are highlighted
4000
3000
2000
Mean Health
Switzerland
Norway
France
Belgium
Sweden
Austria
Italy
Finland
Spain
20000
25000
Mean GDP
Data from the General Social Science Survey, Distributed through the socviz R package

ggforce

Quickly

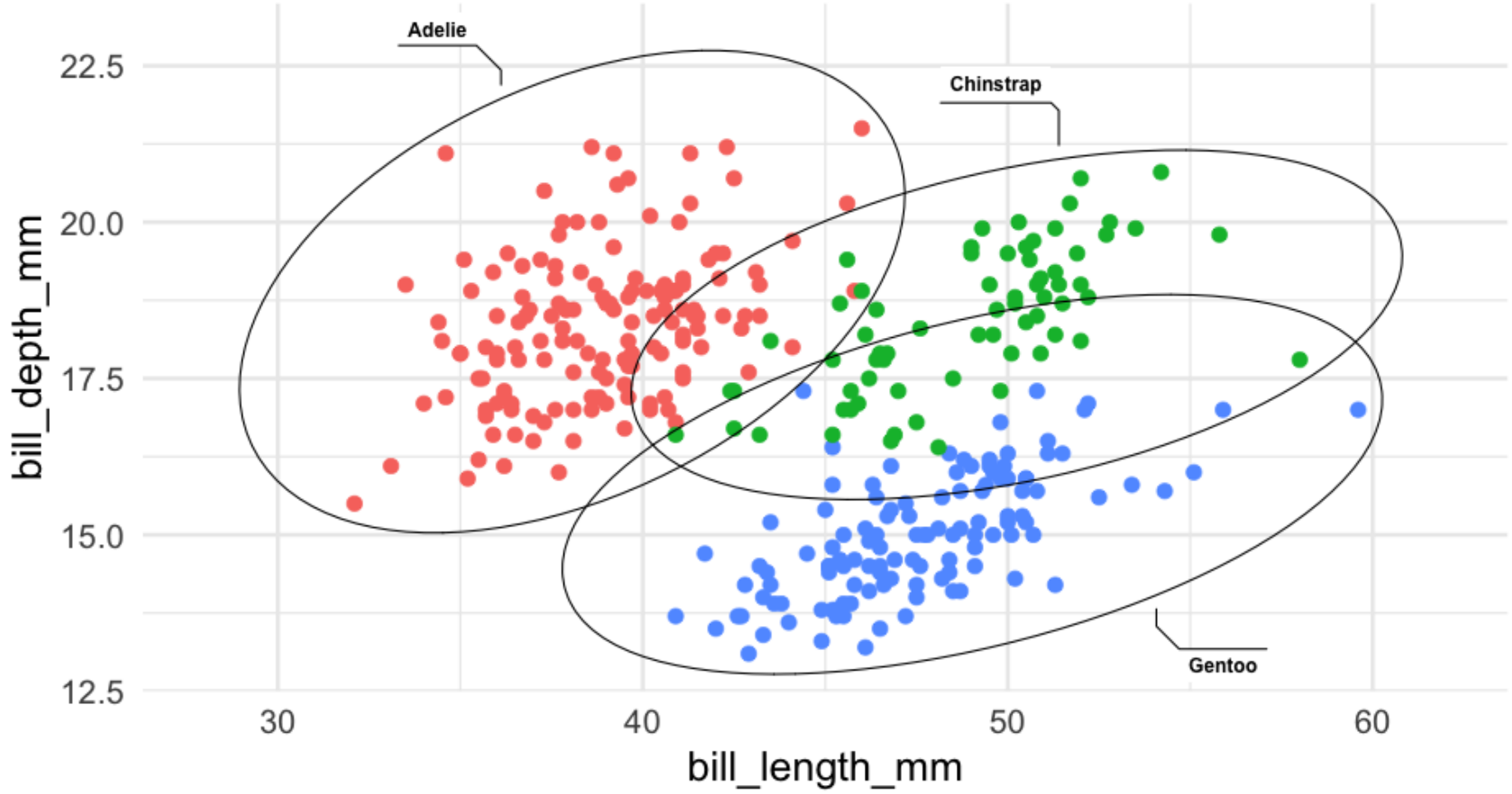
Annotating groups of points

Consider using any of the following from **ggforce** to annotate specific points

- `geom_mark_rect()`
- `geom_mark_circle()`
- `geom_mark_ellipse()`
- `geom_mark_hull()`

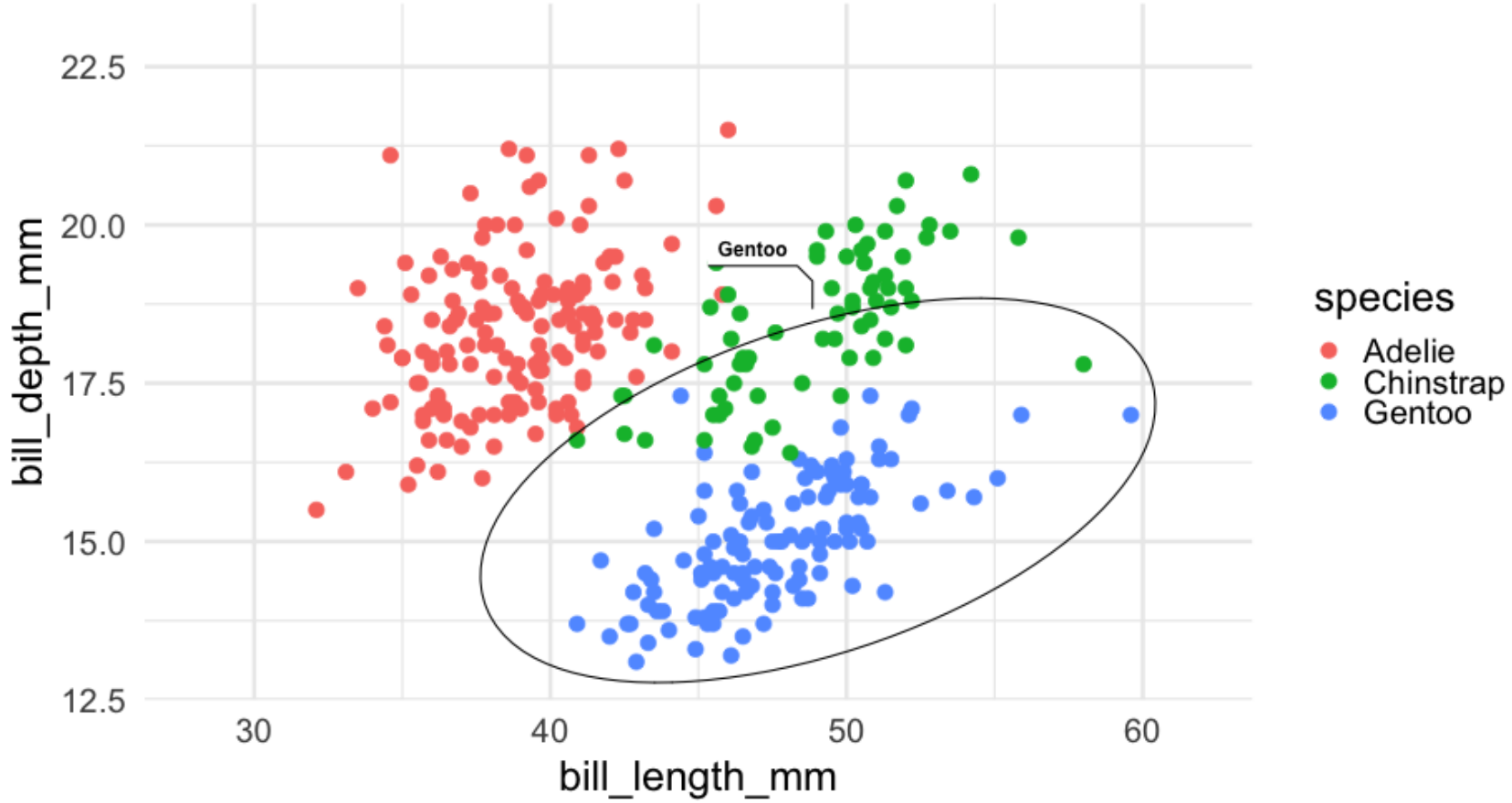
Examples

```
library(palmerpenguins)
library(ggforce)

penguins %>%
  drop_na() %>% # Can't take missing data
ggplot(aes(bill_length_mm, bill_depth_mm)) +
  geom_mark_ellipse(aes(group = species, label = species)) +
  geom_point(aes(color = species)) +
  coord_cartesian(xlim = c(28, 62), ylim = c(13, 23)) +
  guides(color = "none")
```


Adelie
Chinstrap
Gentoo
22.5
20.0
17.5
15.0
12.5
30
40
50
60
bill_depth_mm
bill_length_mm

Limit to a single group

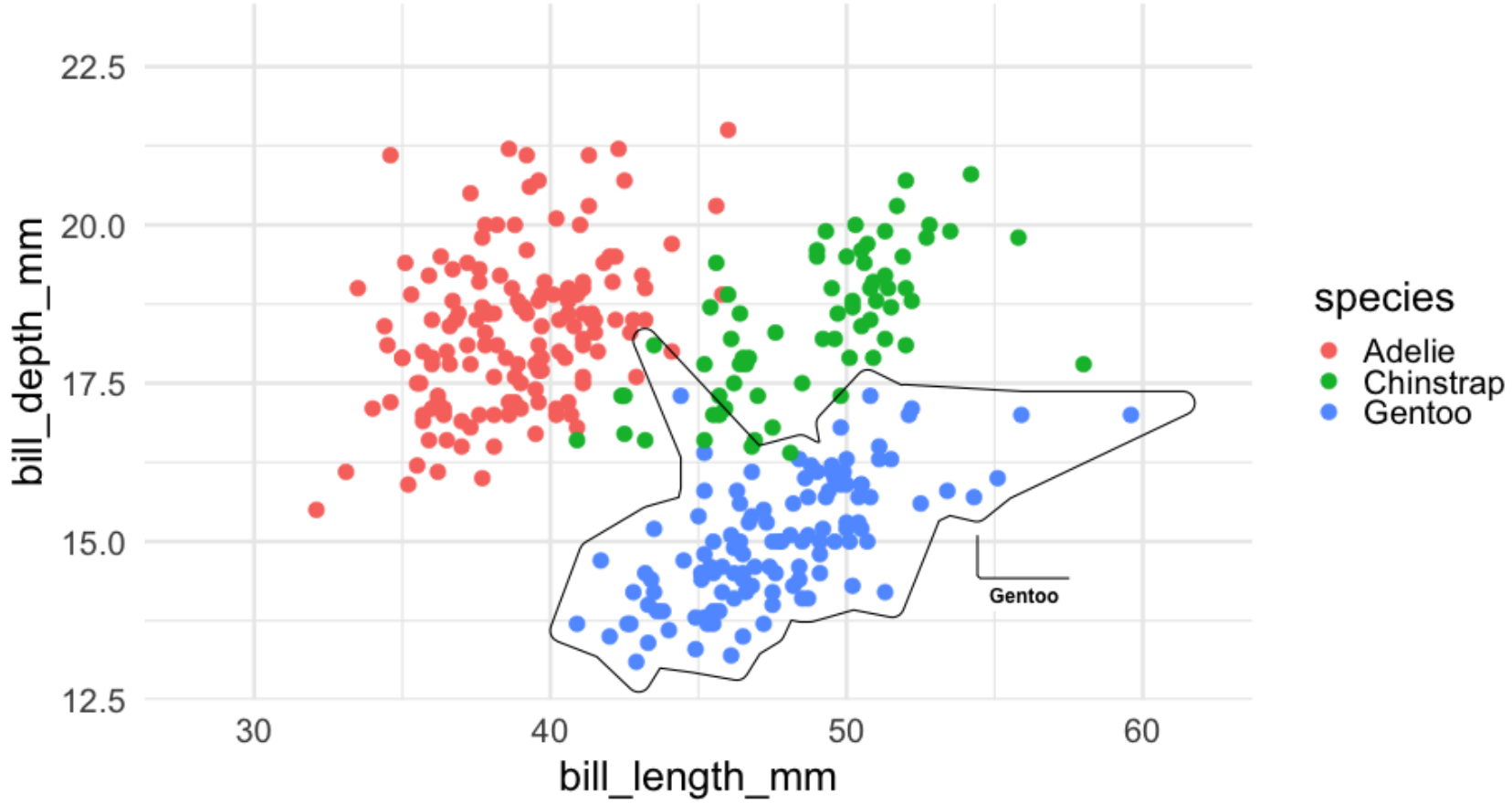
```
penguins %>%
  drop_na() %>%
ggplot(aes(bill_length_mm, bill_depth_mm)) +
  geom_point(aes(color = species)) +
  geom_mark_ellipse(aes(group = species, label = species),
                    data = filter(drop_na(penguins),
                                  species == "Gentoo")) +
  coord_cartesian(xlim = c(28, 62), ylim = c(13, 23))
```


22.5
20.0
17.5
15.0
12.5
bill_depth_mm
30
40
50
60
bill_length_mm
Gentoo
species
Adelie
Chinstrap
Gentoo

Switch to hull

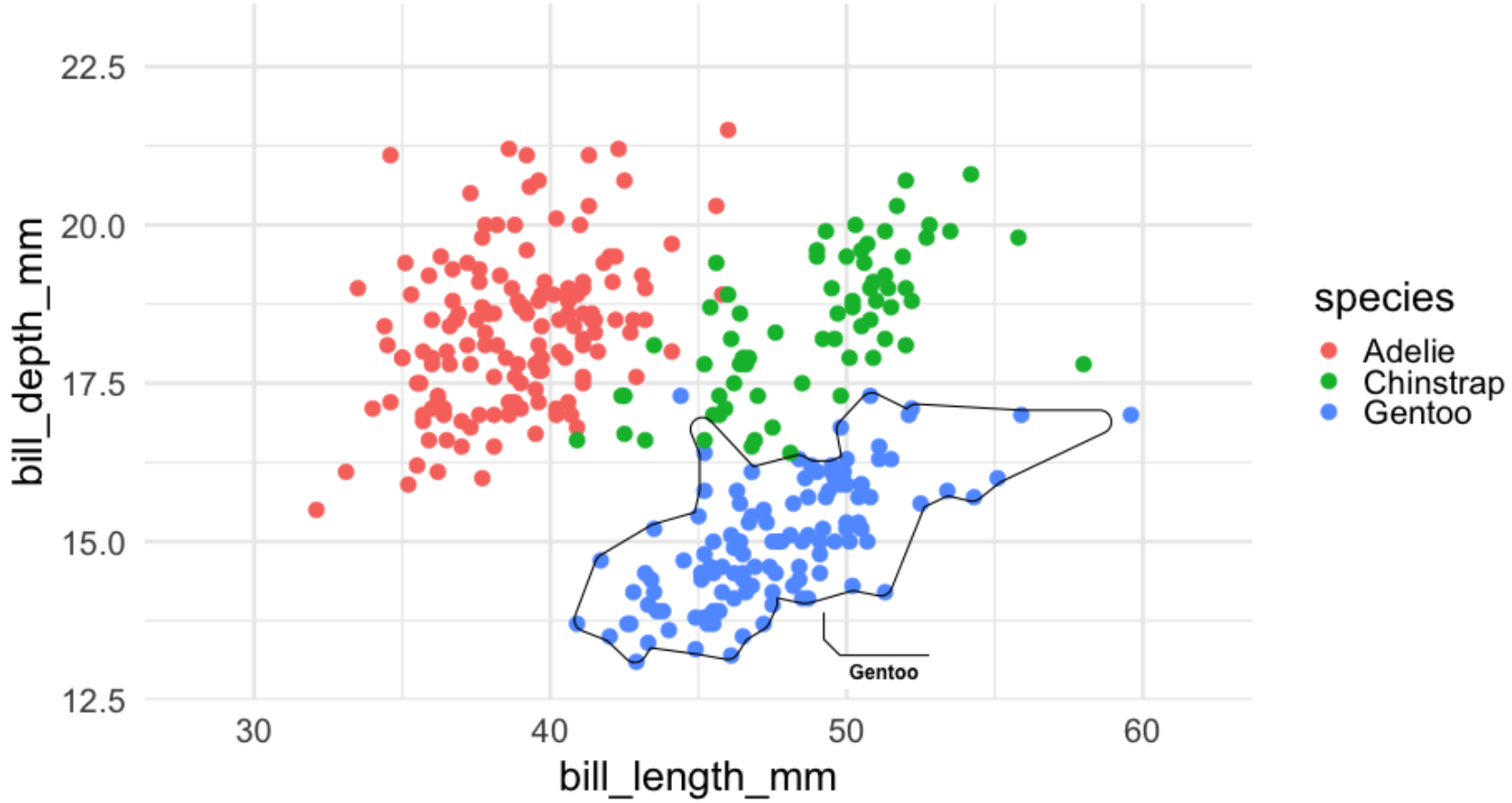
Note – requires the **concaveman** package be installed

```
penguins %>%
  drop_na() %>%
ggplot(aes(bill_length_mm, bill_depth_mm)) +
  geom_point(aes(color = species)) +
  geom_mark_hull(aes(group = species, label = species),
                 data = filter(drop_na(penguins),
                               species == "Gentoo")) +
  coord_cartesian(xlim = c(28, 62), ylim = c(13, 23))
```


22.5
20.0
17.5
15.0
12.5
bill_depth_mm
30
40
50
60
bill_length_mm
Gentoo
species
Adelie
Chinstrap
Gentoo

Change expand

```
penguins %>%
  drop_na() %>%
ggplot(aes(bill_length_mm, bill_depth_mm)) +
  geom_point(aes(color = species)) +
  geom_mark_hull(aes(group = species, label = species),
                 expand = unit(1, "mm"),
                 data = filter(drop_na(penguins),
                               species == "Gentoo")) +
  coord_cartesian(xlim = c(28, 62), ylim = c(13, 23))
```


22.5
20.0
17.5
15.0
12.5
bill_depth_mm
30
40
50
60
bill_length_mm
Gentoo
species
Adelie
Chinstrap
Gentoo

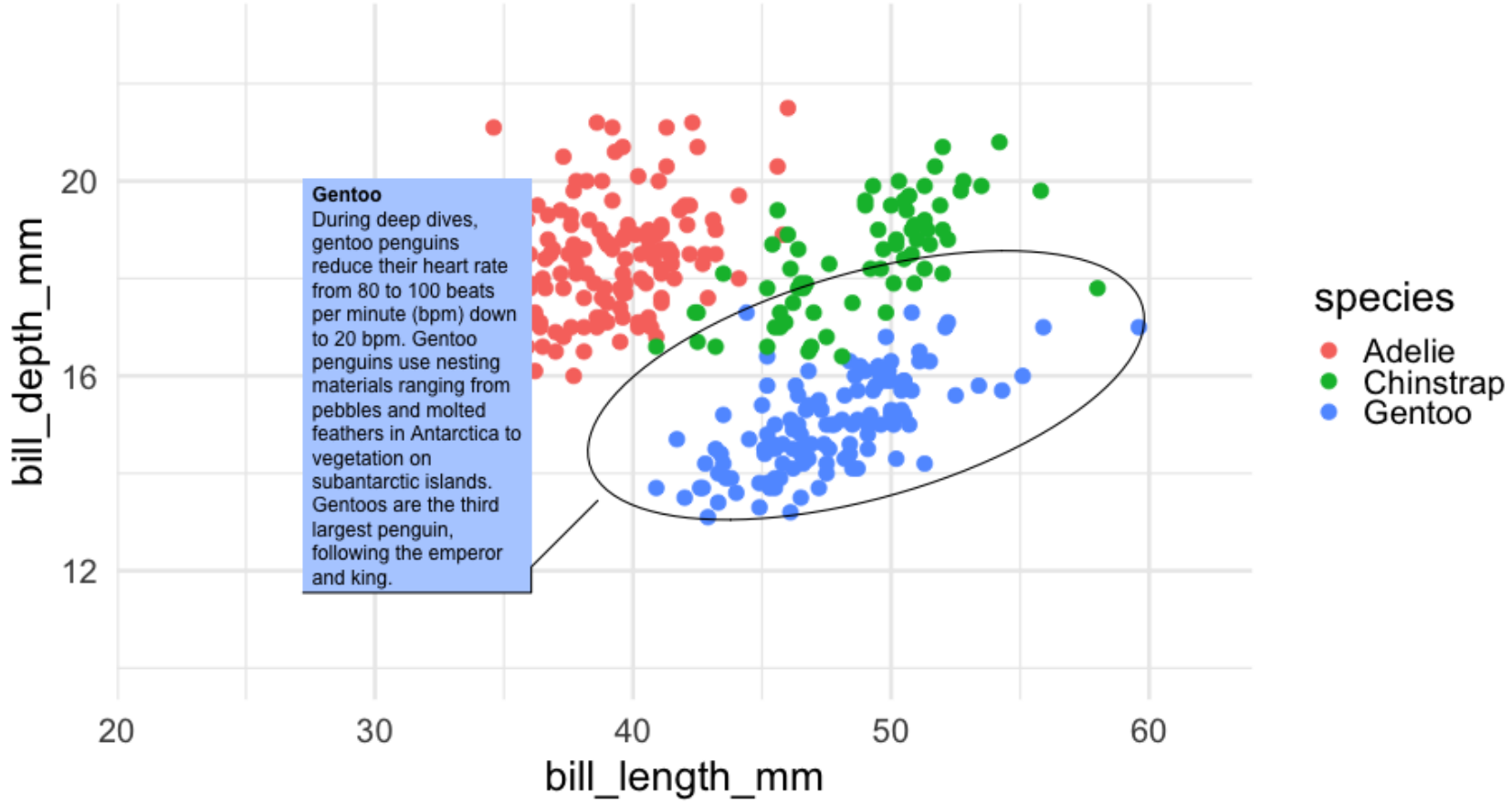
More in–depth annotations

First create a description

```
penguins <- penguins %>%
  mutate(desc = ifelse(species != "Gentoo", "", "During deep dives, gentoo pen
```

Now add as a description

```
penguins %>%
  drop_na() %>%
ggplot(aes(bill_length_mm, bill_depth_mm)) +
  geom_point(aes(color = species)) +
  geom_mark_ellipse(aes(group = species,
                        label = species,
                        description = desc),
                    data = filter(drop_na(penguins),
                                  species == "Gentoo"),
                    label.fill = "#b3cfff") +
  coord_cartesian(xlim = c(28, 62), ylim = c(13, 23))
```

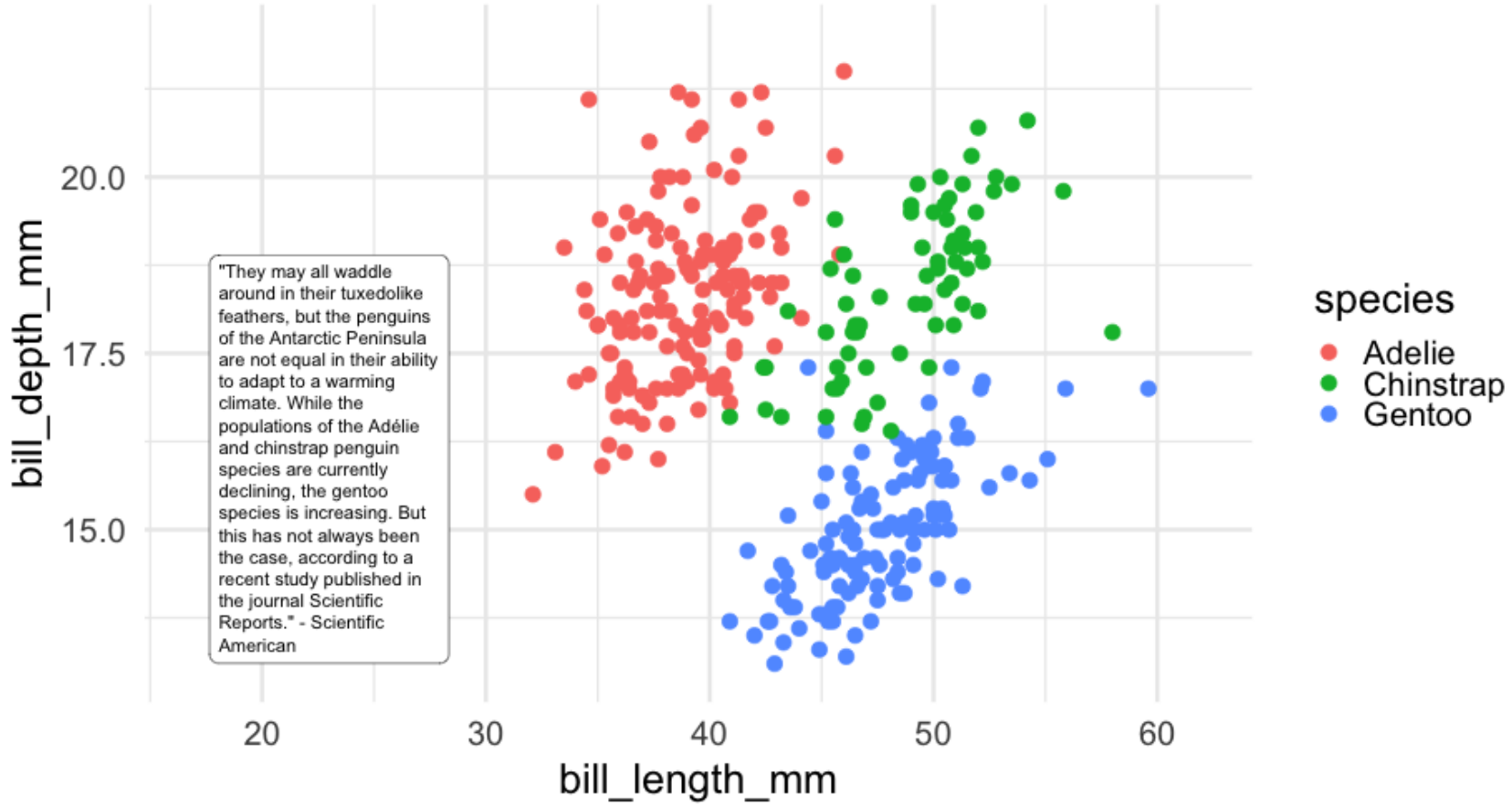

Gentoo
During deep dives, gentoo penguins reduce their heart rate from 80 to 100 beats per minute (bpm) down to 20 bpm. Gentoo penguins use nesting materials ranging from pebbles and molted feathers in Antarctica to vegetation on subantarctic islands. Gentoos are the third largest penguin, following the emperor and king.
bill_depth_mm
20
16
12
20
30
40
50
60
bill_length_mm
species
Adelie
Chinstrap
Gentoo

Similar

We can also just add a textbox through **{ggtext}**

```
txtbox <- tibble(
  bill_length_mm = 23,
  bill_depth_mm = 16,
  lab = '"They may all waddle around in their tuxedolike feathers, but the pen
)
```

```
penguins %>%
  drop_na() %>%
ggplot(aes(bill_length_mm, bill_depth_mm)) +
  geom_point(aes(color = species)) +
  ggtext::geom_textbox(aes(label = lab),
                       data = txtbox) +
  coord_cartesian(xlim = c(17, 62), ylim = c(13, 22))
```

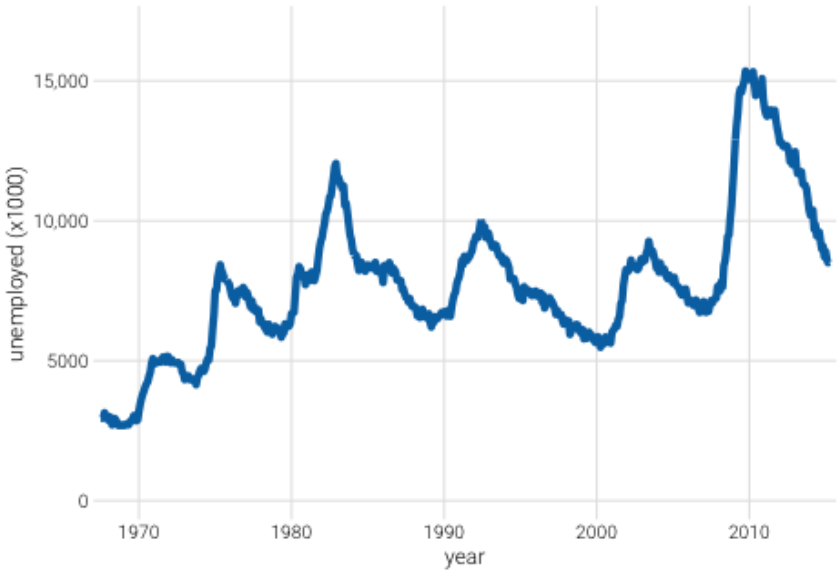


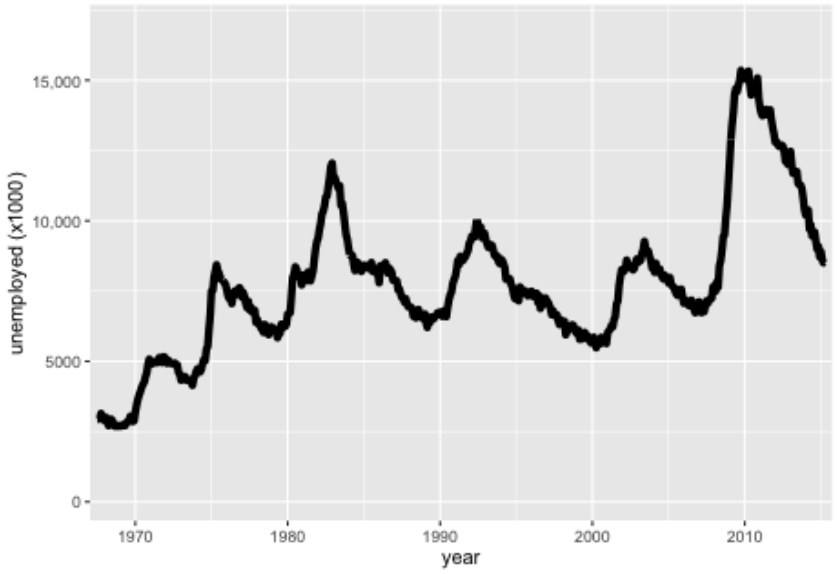
Last bit

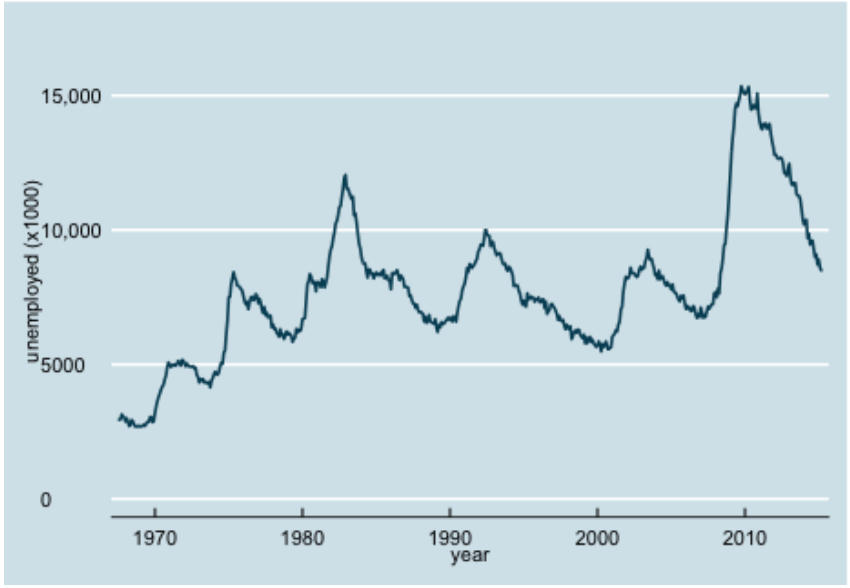
The **ggforce** package is well worth exploring more.

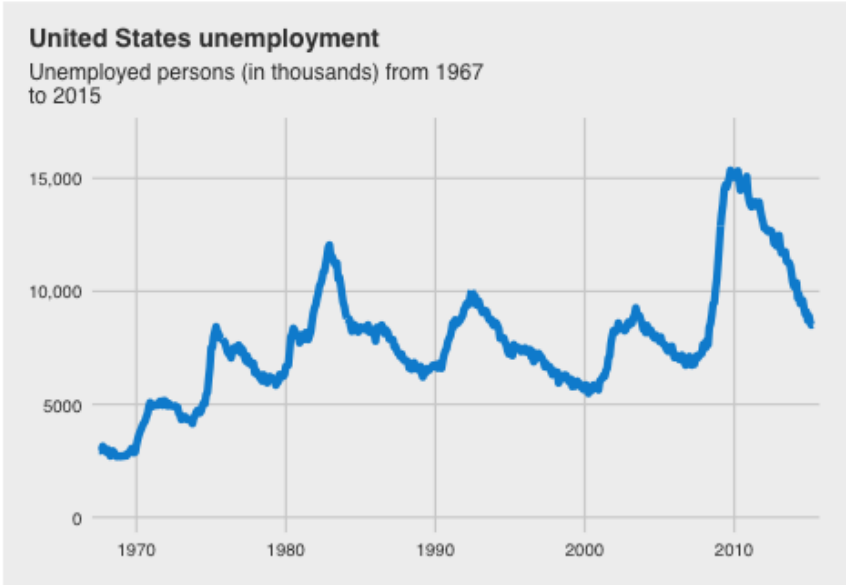
See here for a nice walkthrough that has good data viz and uses some of the **ggforce** functions (as well as illustrating a few other cool packages)

Themes (quickly)


15,000
10,000
5000
0
unemployed (x1000)
1970
1980
1990
2000
2010
year


15,000
10,000
5000
0
unemployed (x1000)
1970
1980
1990
2000
2010
year


15,000
10,000
5000
0
unemployed (x1000)
1970
1980
1990
2000
2010
year


United States unemployment
Unemployed persons (in thousands) from 1967 to 2015
15,000
10,000
5000
0
1970
1980
1990
2000
2010

ggthemes

- Good place to start. All sorts of themes.
- Includes color scales, etc., that align with themes
- You can even conform with other software
  - fit into an economics conference with `theme_stata`

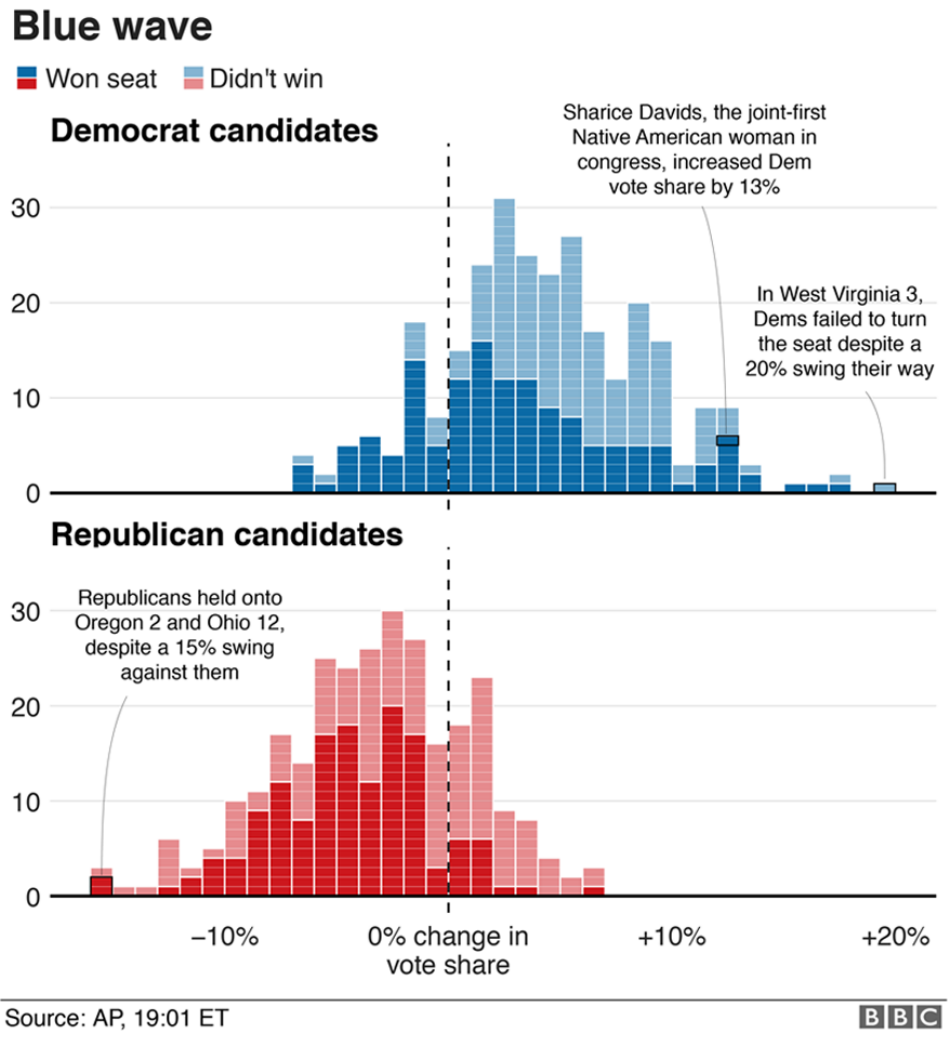
See the themes here

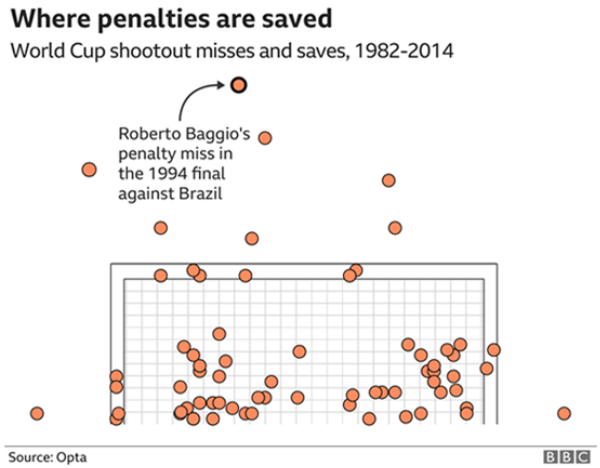
BBC

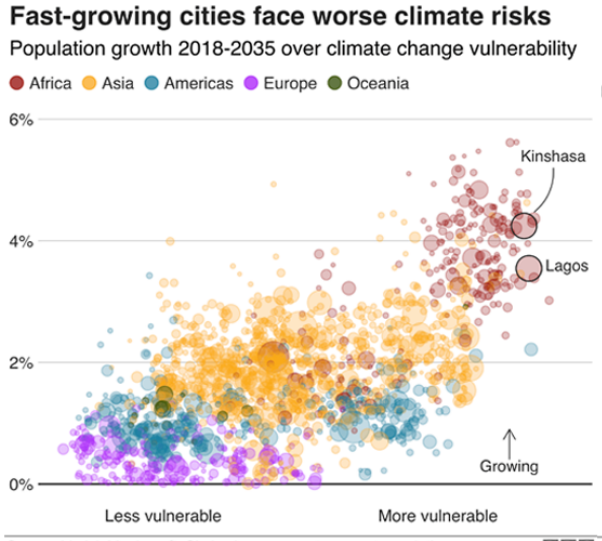
The BBC uses ggplot for most of its graphics. They've developed a package with a theme and some functions to help make it match their style more.

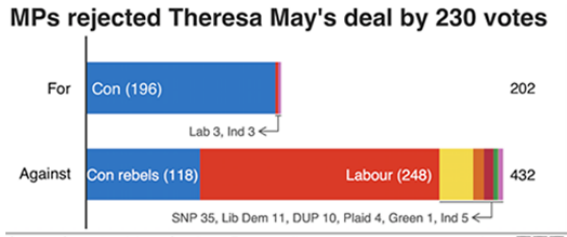
See the repo here

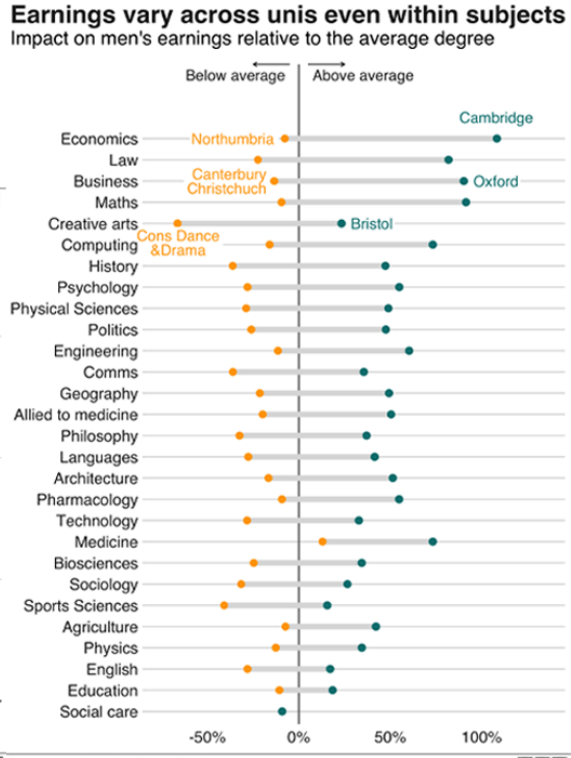
Their Journalism Cookbook is really nice too


Blue wave
Won seat
Didn't win
Democrat candidates
Sharice Davids, the joint-first Native American woman in congress, increased Dem vote share by 13%
In West Virginia 3, Dems failed to turn the seat despite a 20% swing their way
30
20
10
0
Republican candidates
Republicans held onto Oregon 2 and Ohio 12, despite a 15% swing against them
30
20
10
0
–10%
0% change in vote share
+10%
+20%
Source: AP, 19:01 ET
BBC


Where penalties are saved
World Cup shootout misses and saves, 1982-2014
Roberto Baggio's penalty miss in the 1994 final against Brazil
Source: Opta
BBC


Fast-growing cities face worse climate risks
Population growth 2018-2035 over climate change vulnerability
Africa
Asia
Americas
Europe
Oceania
6%
4%
2%
0%
Kinshasa
Lagos
Growing
Less vulnerable
More vulnerable
Source: Verisk Maplecroft. Circle size represents current population.
BBC


MPs rejected Theresa May's deal by 230 votes
For
Con (196)
202
Lab 3, Ind 3
Against
Con rebels (118)
Labour (248)
432
SNP 35, Lib Dem 11, DUP 10, Plaid 4, Green 1, Ind 5
Source: Commons Votes Services. Excludes 'tellers', the Speaker and deputies
BBC


Earnings vary across unis even within subjects
Impact on men's earnings relative to the average degree
Below average
Above average
Economics
Law
Business
Maths
Creative arts
Computing
History
Psychology
Physical Sciences
Politics
Engineering
Comms
Geography
Allied to medicine
Philosophy
Languages
Architecture
Pharmacology
Technology
Medicine
Biosciences
Sociology
Sports Sciences
Agriculture
Physics
English
Education
Social care
Cambridge
Northumbria
Canterbury Christchuch
Oxford
Bristol
Cons Dance &Drama
-50%
0%
50%
100%
Source: Institute for Fiscal Studies
BBC

ggthemeassist

- Another great place to start with making major modifications/creating your own custom theme
- Can't do everything, but can do a lot
- See here

[demo]

`theme()` for everything else

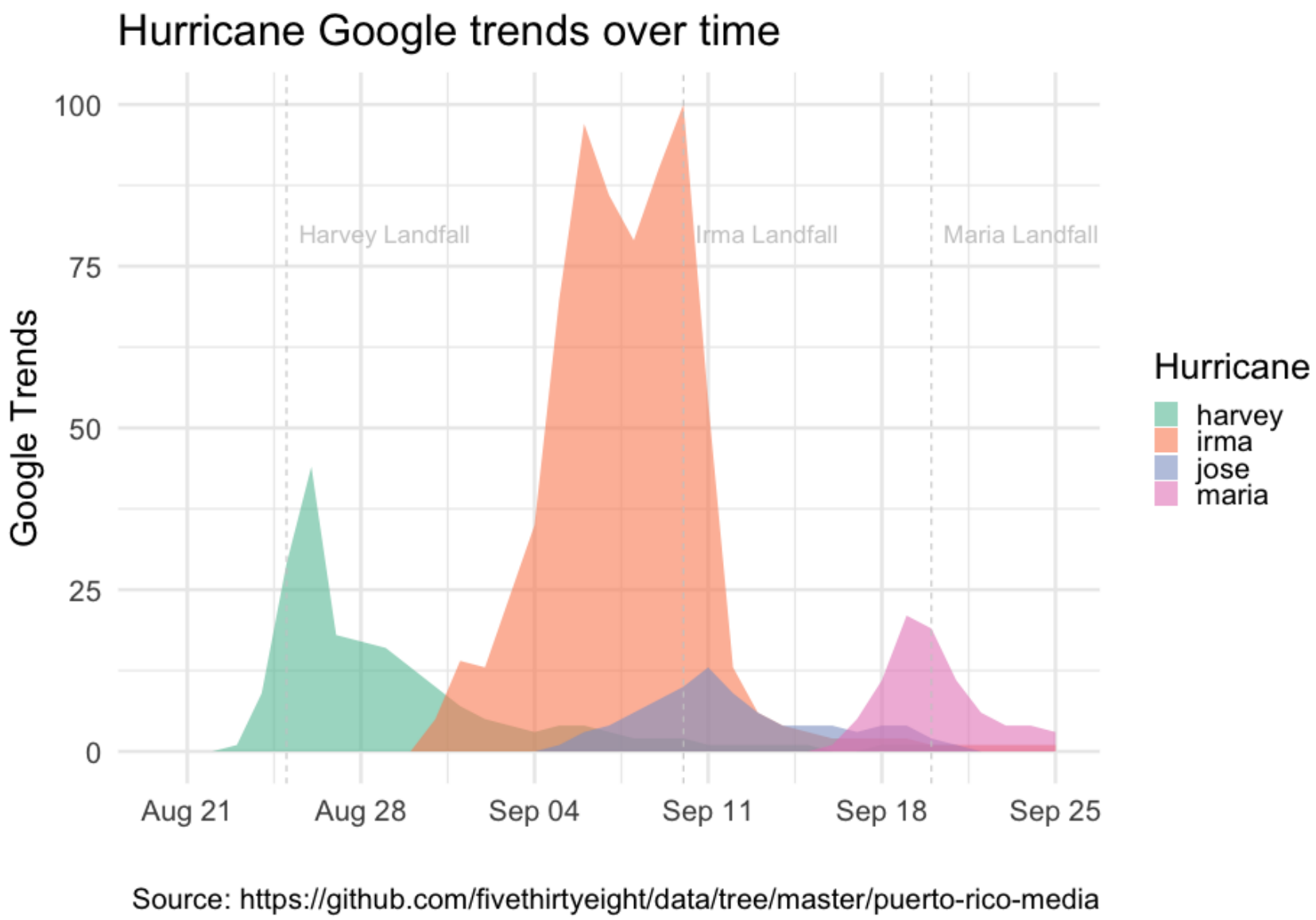
- You can basically change your plot to look however you want through `theme`
- Generally a bit more complicated
- I've used ggplot for *years* and only really now gaining fluency with it

Quick example

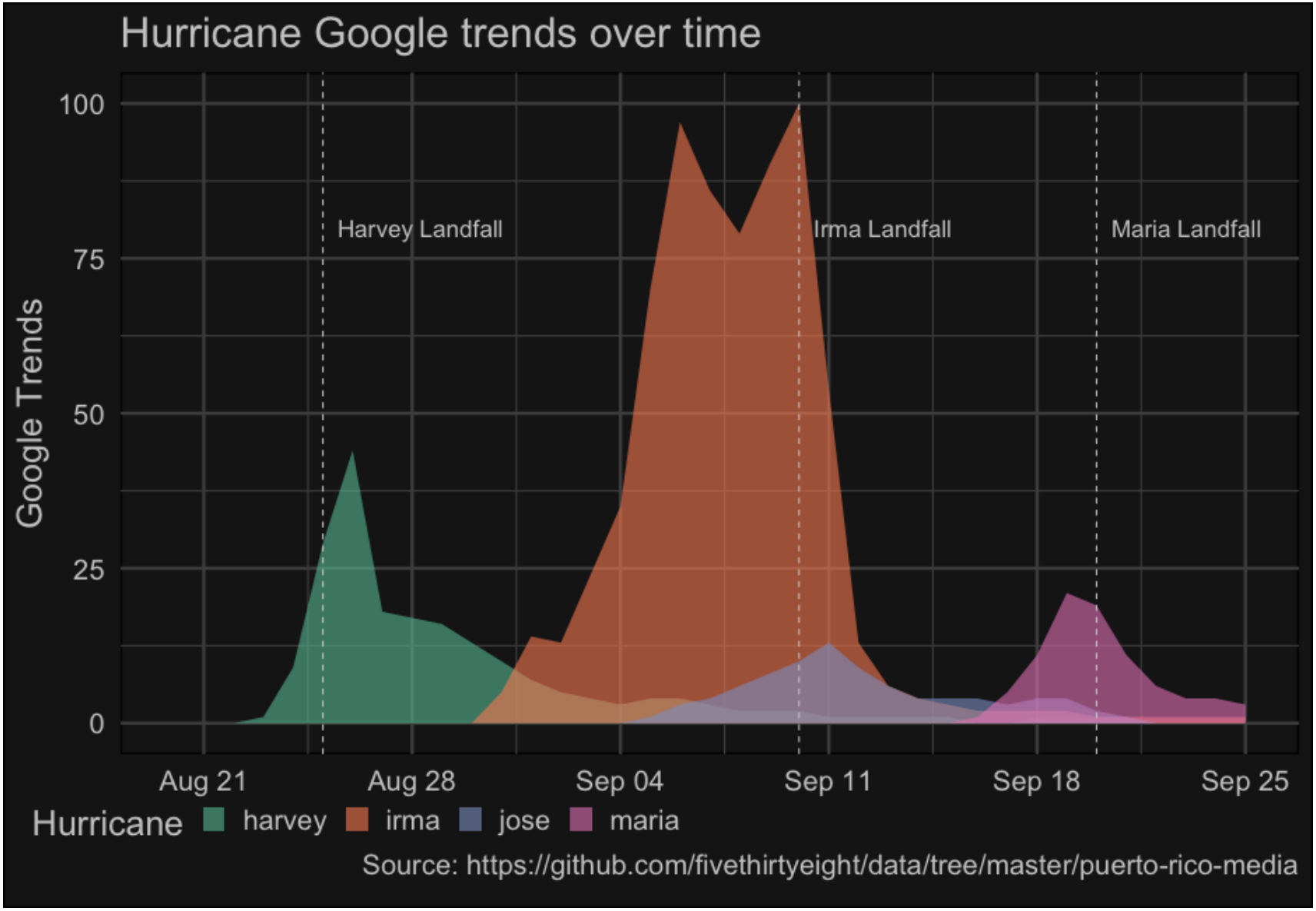
From Lab 3

```
library(fivethirtyeight)
g <- google_trends %>%
  pivot_longer(starts_with("hurricane"),
               names_to = "hurricane",
               values_to = "interest",
               names_pattern = "_(.+)_")

landfall <- tibble(date = lubridate::mdy(c("August 25, 2017",
                                           "September 10, 2017",
                                           "September 20, 2017")),
                   hurricane = c("Harvey Landfall",
                                 "Irma Landfall",
                                 "Maria Landfall"))
```

```
p <- ggplot(g, aes(date, interest)) +
  geom_ribbon(aes(fill = hurricane, ymin = 0, ymax = interest),
              alpha = 0.6) +
  geom_vline(aes(xintercept = date), landfall,
             color = "gray80",
             lty = "dashed") +
  geom_text(aes(x = date, y = 80, label = hurricane), landfall,
            color = "gray80",
            nudge_x = 0.5,
            hjust = 0) +
  labs(x = "",
       y = "Google Trends",
       title = "Hurricane Google trends over time",
       caption = "Source: https://github.com/fivethirtyeight/data/tree/master/
  scale_fill_brewer("Hurricane", palette = "Set2")
```


Hurricane Google trends over time
Google Trends
100
75
50
25
0
Harvey Landfall
Irma Landfall
Maria Landfall
Aug 21
Aug 28
Sep 04
Sep 11
Sep 18
Sep 25
Hurricane
harvey
irma
jose
maria
Source: https://github.com/fivethirtyeight/data/tree/master/puerto-rico-media

```
p + theme(panel.grid.major = element_line(colour = "gray30"),
          panel.grid.minor = element_line(colour = "gray30"),
          axis.text = element_text(colour = "gray80"),
          axis.text.x = element_text(colour = "gray80"),
          axis.text.y = element_text(colour = "gray80"),
          axis.title = element_text(colour = "gray80"),
          legend.text = element_text(colour = "gray80"),
          legend.title = element_text(colour = "gray80"),
          panel.background = element_rect(fill = "gray10"),
          plot.background = element_rect(fill = "gray10"),
          legend.background = element_rect(fill = NA, color = NA),
          legend.position = c(0.20, -0.1),
          legend.direction = "horizontal",
          plot.margin = margin(10, 10, b = 20, 10),
          plot.caption = element_text(colour = "gray80", vjust = 1),
          plot.title = element_text(colour = "gray80"))
```


Hurricane Google trends over time
100
75
50
25
0
Google Trends
Harvey Landfall
Irma Landfall
Maria Landfall
Aug 21
Aug 28
Sep 04
Sep 11
Sep 18
Sep 25
Hurricane
harvey
irma
jose
maria
Source: https://github.com/fivethirtyeight/data/tree/master/puerto-rico-media

Next time

Visualizing uncertainty

Homework 2 is also posted currently, but is technically assigned Wednesday