

Starting DataViz using R: ggplot2

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What is ggplot2?

- A second (and final) iteration of the ggplot
- Implementation of Wilkerson's Grammar of Graphics in R
- Conceptually, a way to layer different elements onto a canvas to create a data visualization
- Started as Dr. Hadley Wickham's PhD thesis (with Dr. Dianne Cook)
- Won the John M. Chambers Statistical Software Award in 2006
- Mimicked in other software platforms
 - ggplot and seaborn in Python
 - Translated in plotly

ggplot2 uses the grammar of graphics

A grammar ...

- compose and re-use small parts
- build complex structures from simpler units

of graphics ...

- Think of yourself as a painter
- Build a visualization using layers on a canvas
- Draw layers on top of each other

A dataset

```
library(tidyverse) # do this once per session
beaches <- read_csv('data/sydneybeaches3.csv')
```

```
#> # A tibble: 344 x 12
#>   date      year month   day season rainfall temperature enterococci
#>   <date>    <dbl> <dbl> <dbl> <dbl>    <dbl>      <dbl>      <dbl>
#> 1 2013-01-02 2013     1     2     1         0        23.4         6.7
#> 2 2013-01-06 2013     1     6     1         0        30.3          2
#> 3 2013-01-12 2013     1    12     1         0        31.4        69.1
#> 4 2013-01-18 2013     1    18     1         0        46.4          9
#> 5 2013-01-24 2013     1    24     1         0        27.5        33.9
#> 6 2013-01-30 2013     1    30     1        0.6        26.6        26.5
#> 7 2013-02-05 2013     2     5     1        0.1        25.7        66.9
#> 8 2013-02-11 2013     2    11     1         8        22.2       118.
#> 9 2013-02-17 2013     2    17     1       13.6        26.3        75
#> 10 2013-02-23 2013     2    23     1        7.2        24.8       311.
#> # ... with 334 more rows, and 4 more variables: day_num <dbl>,
#> #   month_num <dbl>, month_name <chr>, season_name <chr>
```

Credit: D. J. Navarro

Building a graph

Start with a blank canvas

```
ggplot()
```



Add a data set

```
ggplot(  
  data = beaches  
)
```

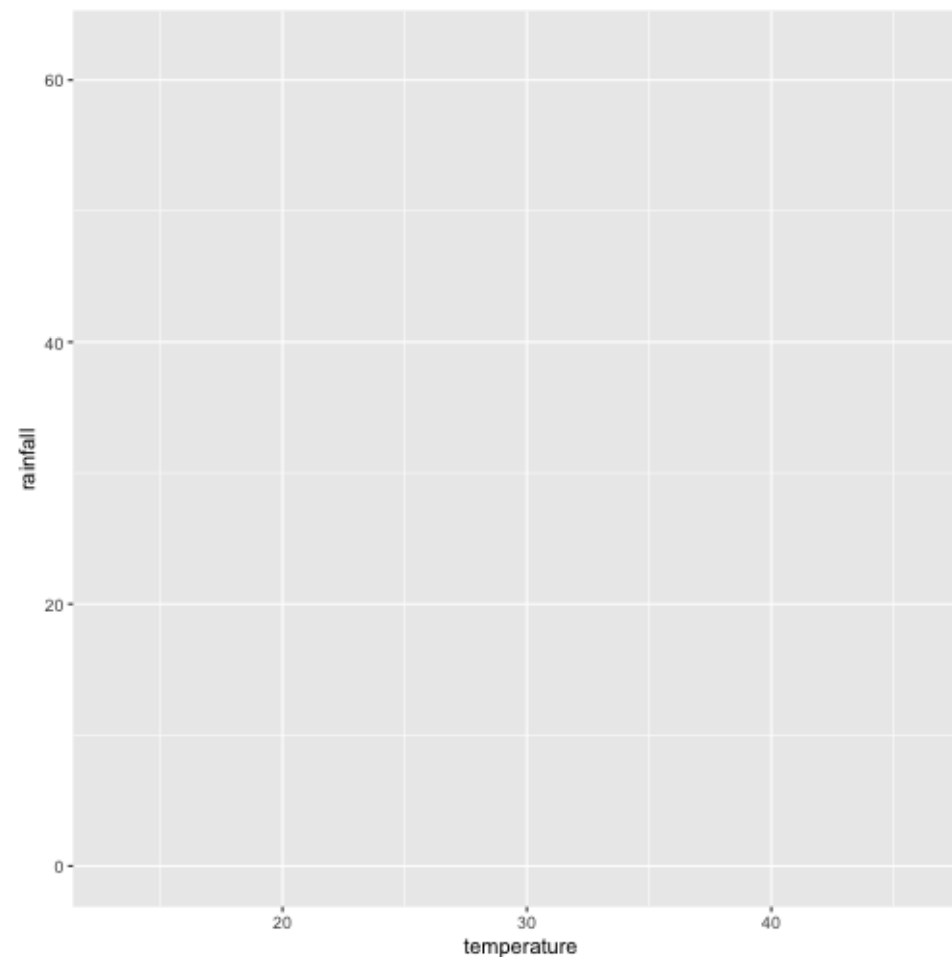


Add a mapping from data to elements

```
ggplot(  
  data = beaches,  
  mapping = aes(  
    x = temperature,  
    y = rainfall  
  )  
)
```

What goes in

- the x and y axes
- the color of markers
- the shape of markers

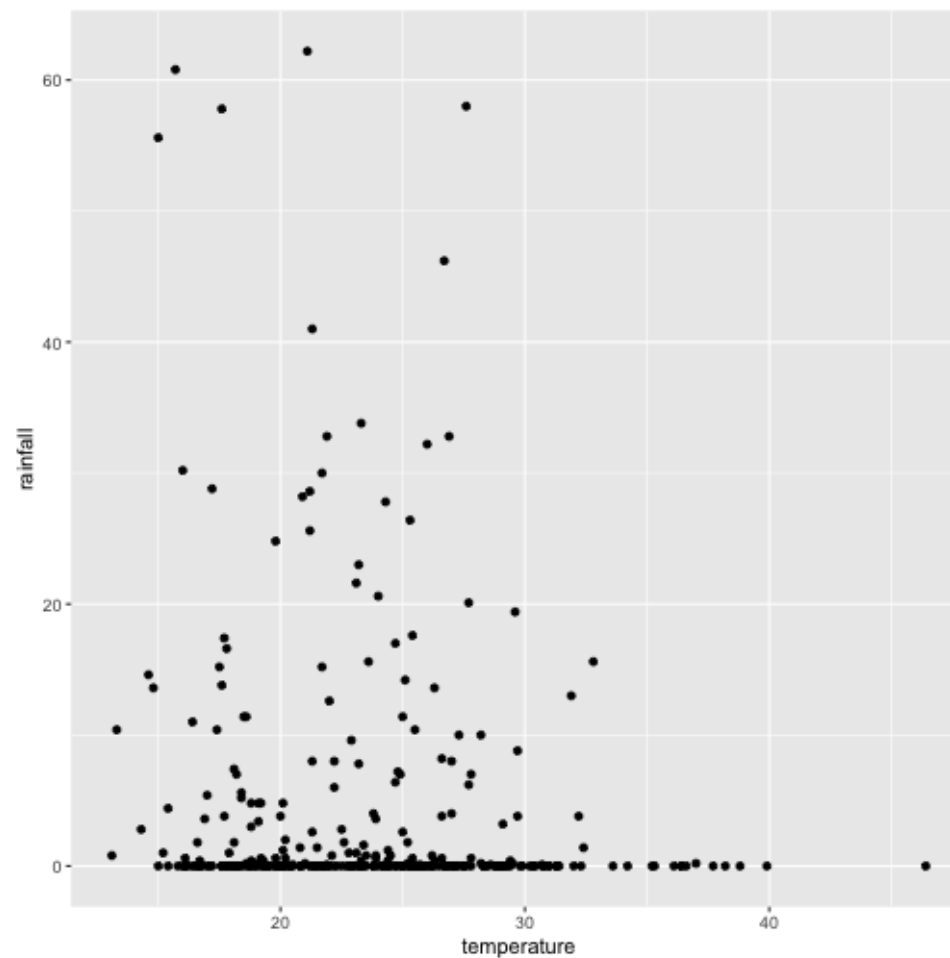


Add a geometry to draw

```
ggplot(  
  data = beaches,  
  mapping = aes(  
    x = temperature,  
    y = rainfall  
  )  
) +  
  geom_point()
```

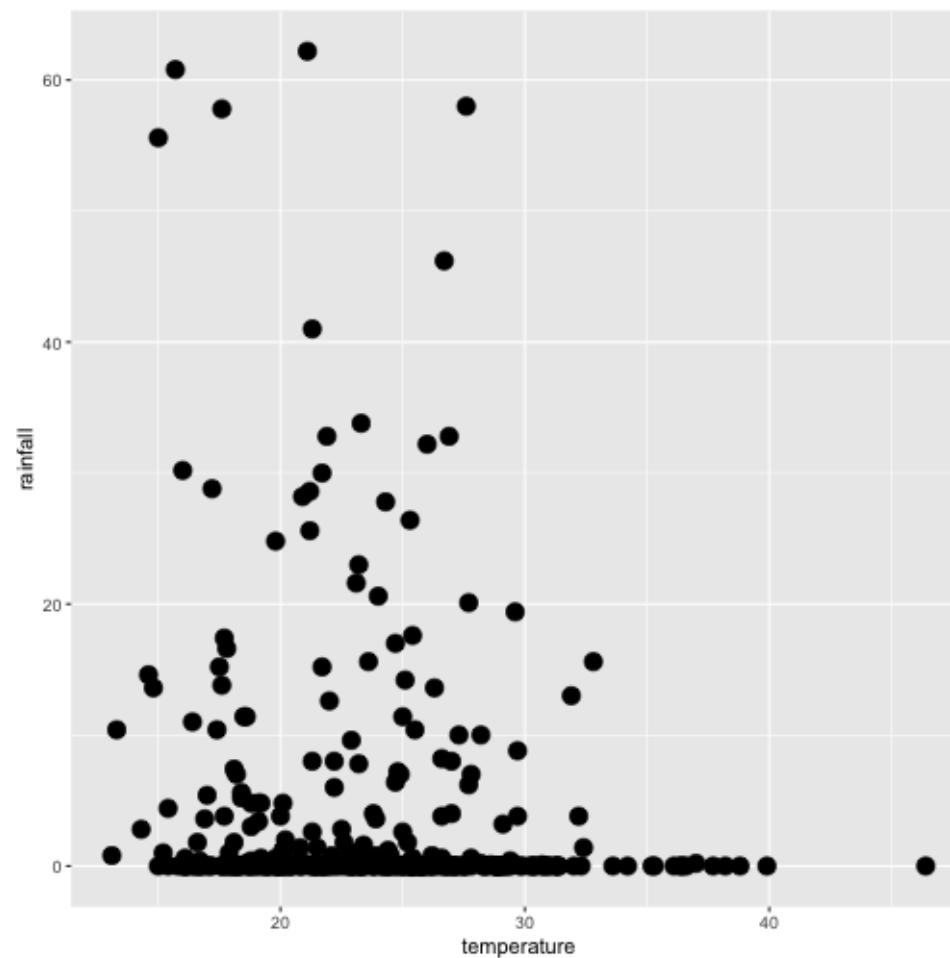
What to draw:

- Points, lines
- histogram, bars, pies



Add options for the geom

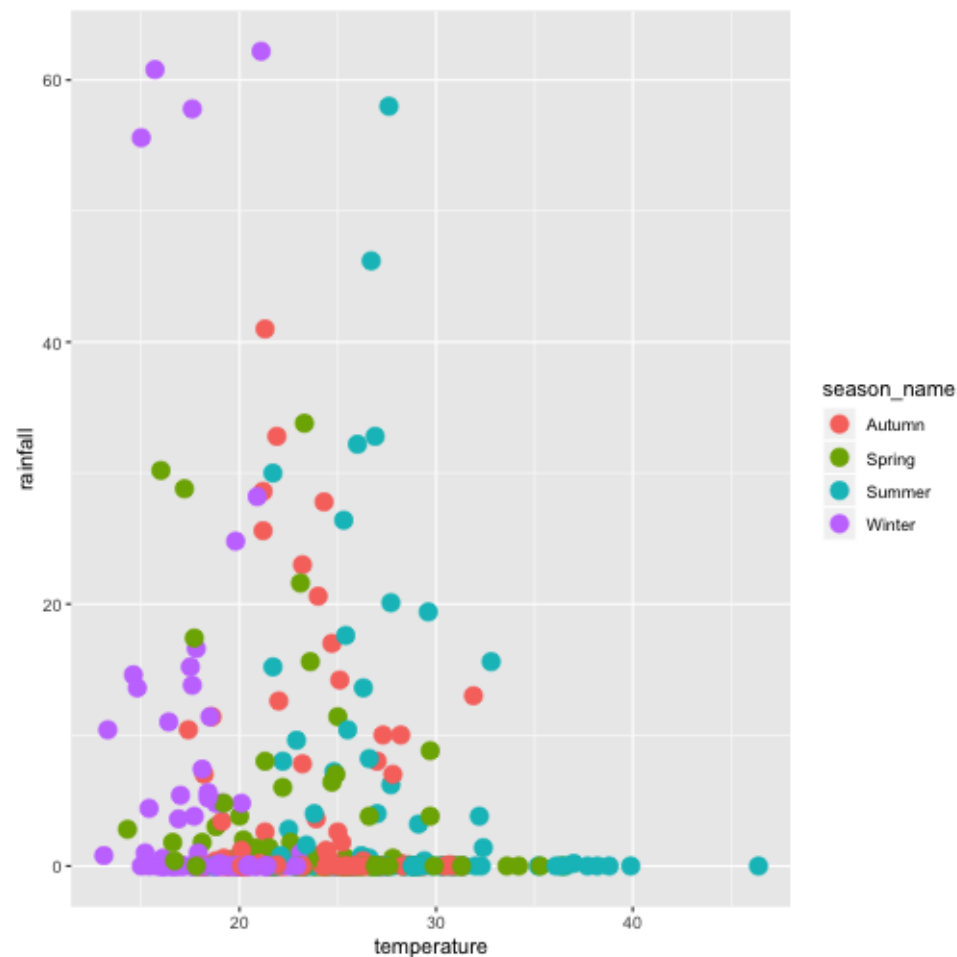
```
ggplot(  
  data = beaches,  
  mapping = aes(  
    x = temperature,  
    y = rainfall  
  )  
) +  
  geom_point(size = 4)
```



Add a mapping to modify the geom

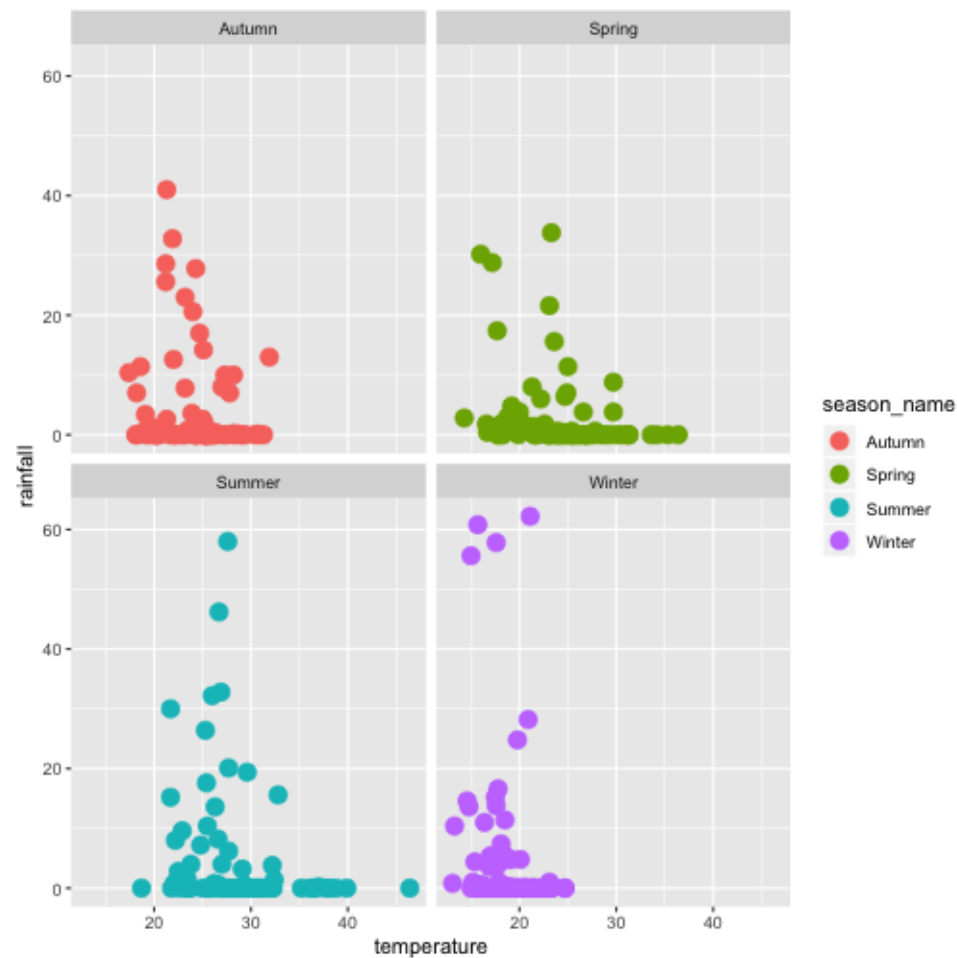
```
ggplot(  
  data = beaches,  
  mapping = aes(  
    x = temperature,  
    y = rainfall  
  )  
) +  
  geom_point(  
    mapping = aes(color = season_name),  
    size = 4  
  )
```

Anything data-driven has to be a mapping, driven by the aes function



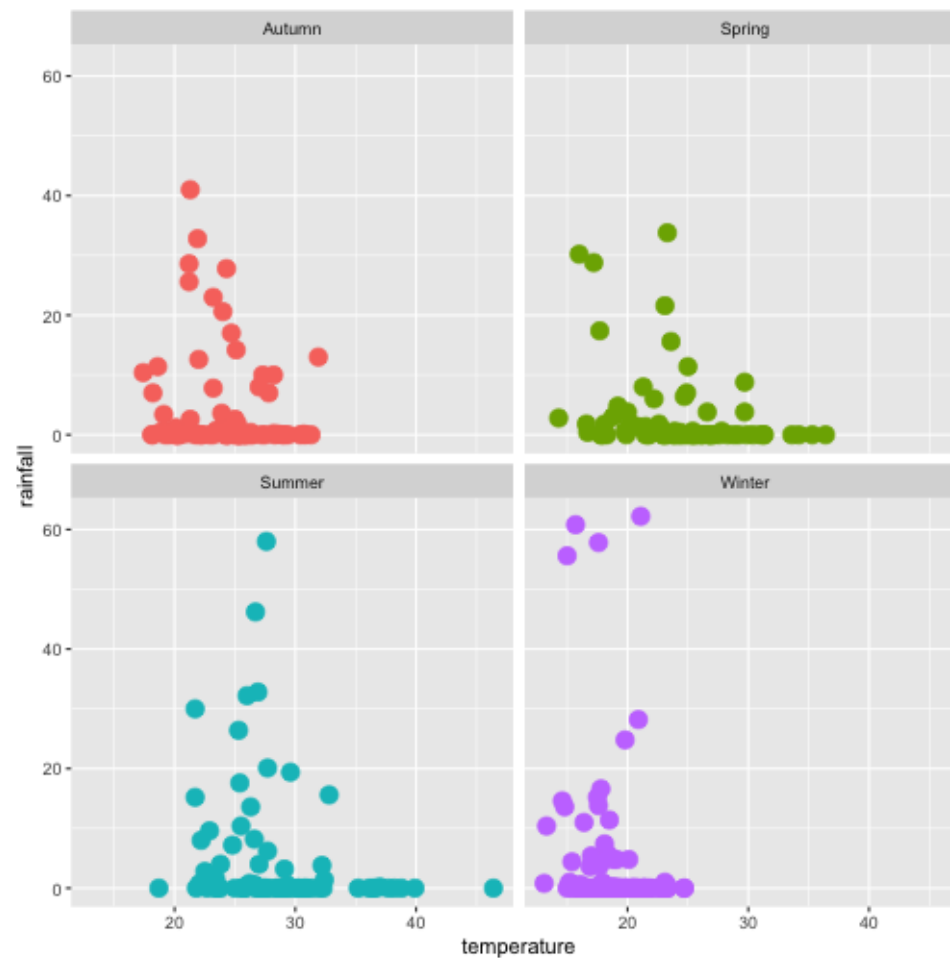
Split into facets

```
ggplot(  
  data = beaches,  
  mapping = aes(  
    x = temperature,  
    y = rainfall  
  )  
) +  
  geom_point(  
    mapping = aes(color = season_name),  
    size = 4  
  ) +  
  facet_wrap(~ season_name)
```



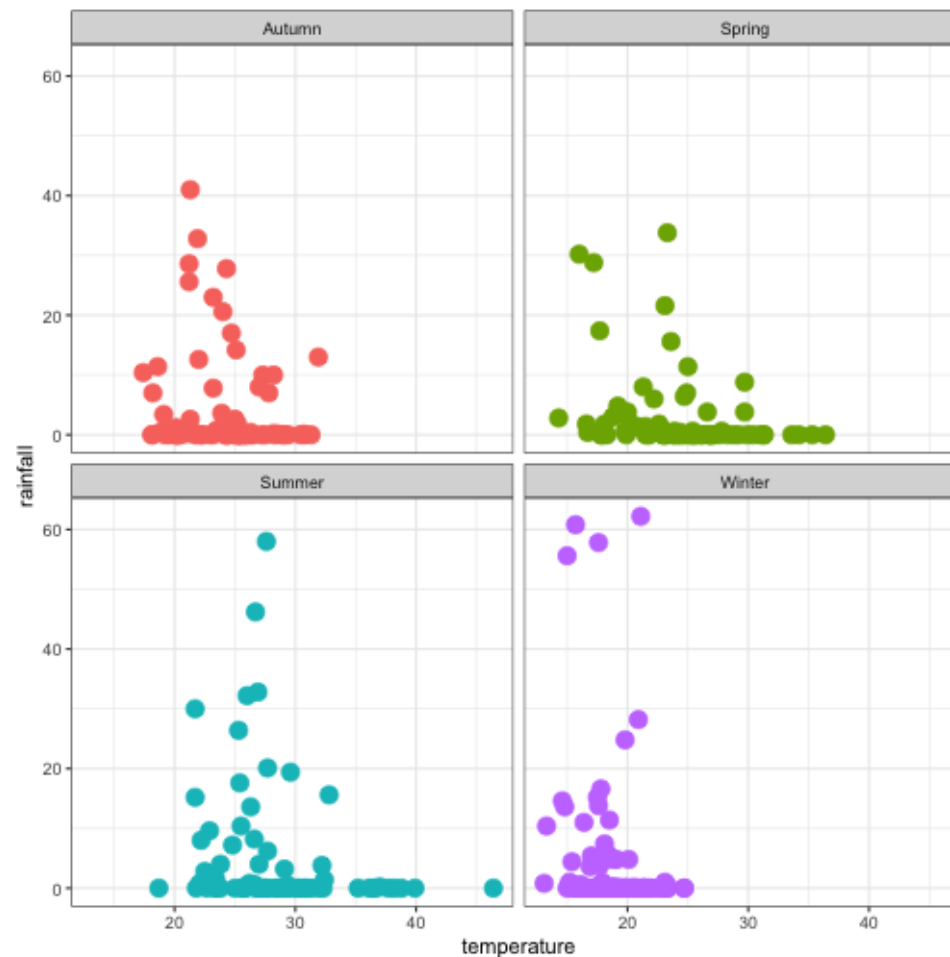
Remove the legend

```
ggplot(  
  data = beaches,  
  mapping = aes(  
    x = temperature,  
    y = rainfall  
  )  
) +  
  geom_point(  
    mapping = aes(color = season_name),  
    size = 4,  
    show.legend = FALSE  
  ) +  
  facet_wrap( ~ season_name)
```



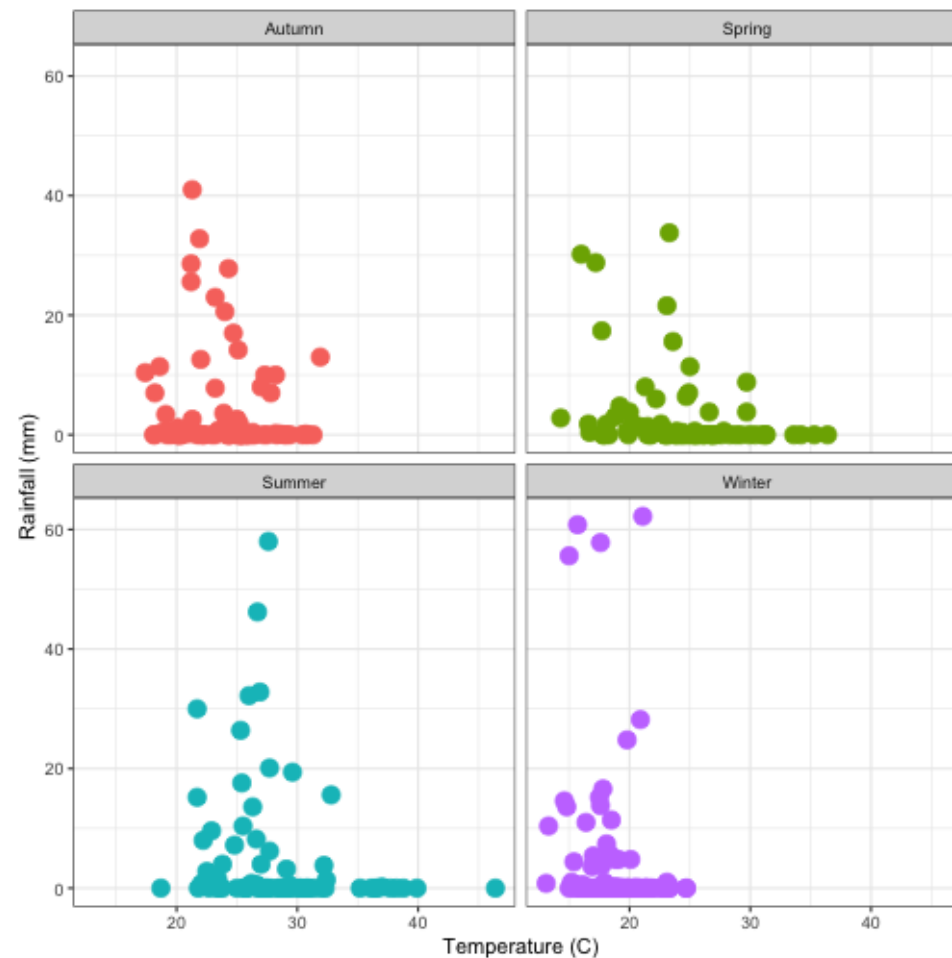
Change the background

```
ggplot(  
  data = beaches,  
  mapping = aes(  
    x = temperature,  
    y = rainfall  
  )  
) +  
  geom_point(  
    mapping = aes(color = season_name),  
    size = 4,  
    show.legend = FALSE  
  ) +  
  facet_wrap( ~ season_name) +  
  theme_bw()
```



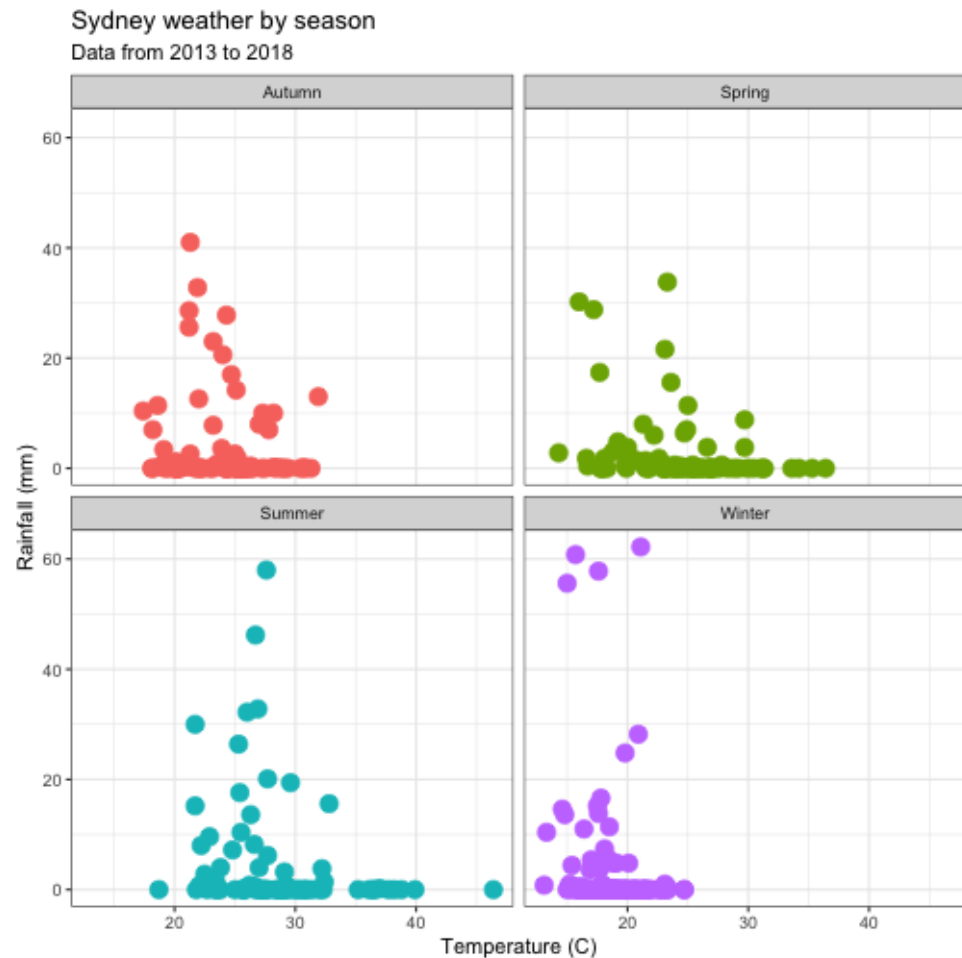
Update the labels

```
ggplot(
  data = beaches,
  mapping = aes(
    x = temperature,
    y = rainfall
  )
) +
  geom_point(
    mapping = aes(color = season_name),
    size = 4,
    show.legend = FALSE
  ) +
  facet_wrap( ~ season_name) +
  theme_bw() +
  labs(x = 'Temperature (C)', y = 'Rainfall (mm)')
```



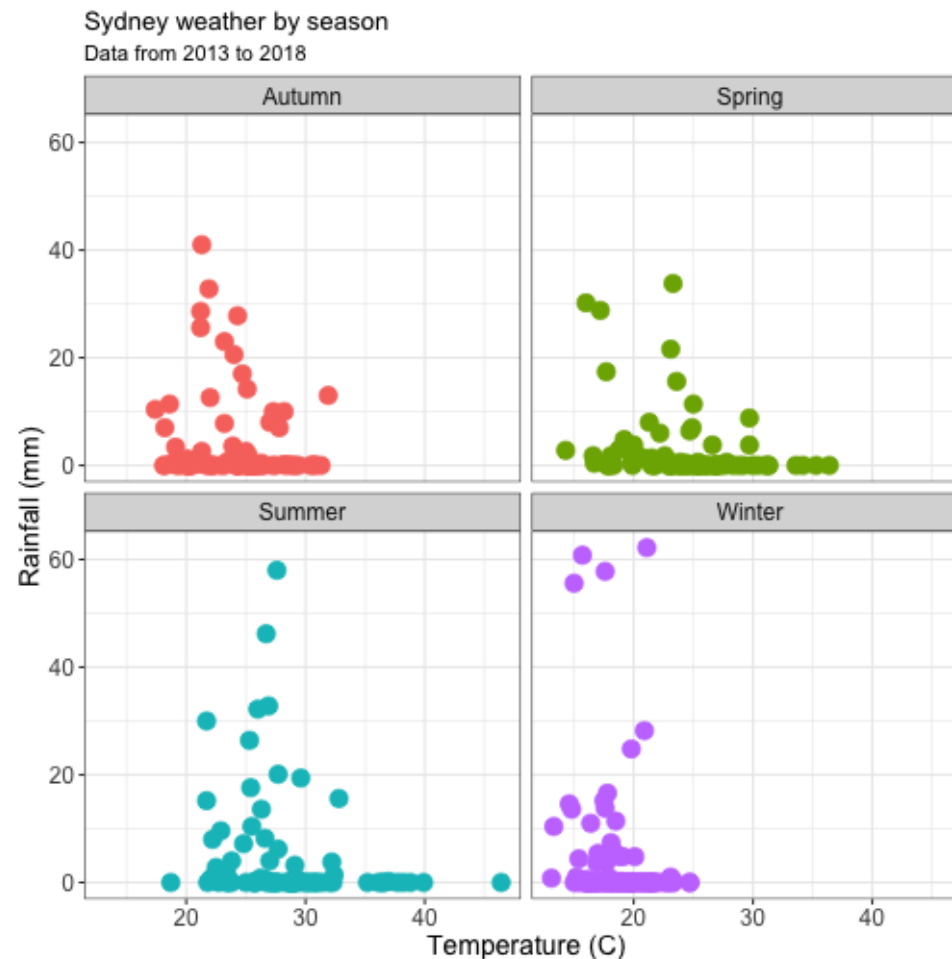
Add titles

```
ggplot(
  data = beaches,
  mapping = aes(
    x = temperature,
    y = rainfall
  )
) +
  geom_point(
    mapping = aes(color = season_name),
    size = 4,
    show.legend = FALSE
  ) +
  facet_wrap( ~ season_name) +
  theme_bw() +
  labs(x = 'Temperature (C)',
       y = 'Rainfall (mm)',
       title = 'Sydney weather by season',
       subtitle = "Data from 2013 to 2018")
```



Customize

```
ggplot(
  data = beaches,
  mapping = aes(
    x = temperature,
    y = rainfall
  )
) +
  geom_point(
    mapping = aes(color = season_name),
    size = 4,
    show.legend = FALSE
  ) +
  facet_wrap( ~ season_name) +
  theme_bw() +
  labs(x = 'Temperature (C)',
       y = 'Rainfall (mm)',
       title = 'Sydney weather by season',
       subtitle = "Data from 2013 to 2018") +
  theme(axis.title = element_text(size = 14),
        axis.text = element_text(size = 12),
        strip.text = element_text(size = 12))
```



The grammar

- Data
- Aesthetics (or aesthetic mappings)
- Geometries (as layers)
- Facets
- Themes
- (Coordinates)
- (Scales)

Exercise 1

Peeking under the hood

If I write...

```
ggplot(  
  data = beaches,  
  aes(x = temperature,  
      y = rainfall)  
) +  
  geom_point()
```

what's really run is ...

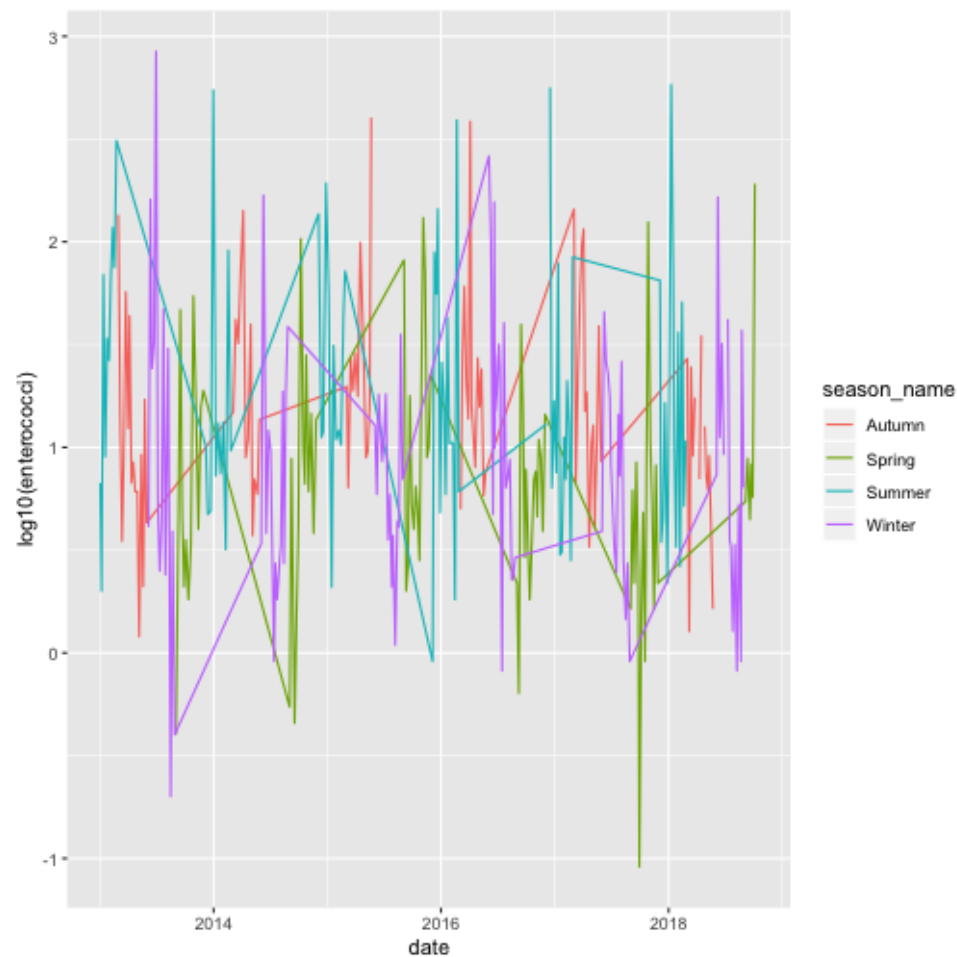
```
ggplot(  
  data = beaches,  
  mapping = aes(  
    x = temperature, y = rainfall)) +  
  layer(  
    geom = "point",  
    stat = "identity",  
    position = "identity") +  
  facet_null() +  
  theme_grey() +  
  coord_cartesian() +  
  scale_x_continuous() +  
  scale_y_continuous()
```

Each element can be adapted and tweaked to create graphs

Exploring aesthetics

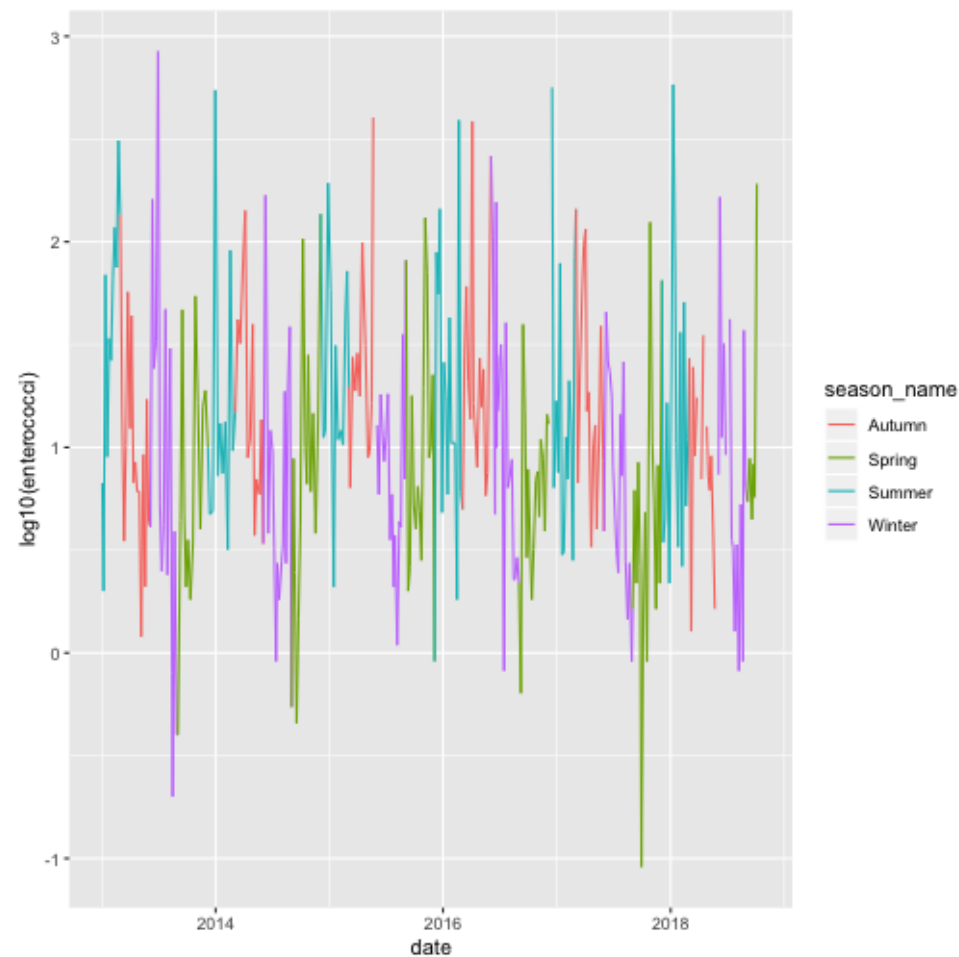
Mapping color

```
ggplot(  
  data=beaches,  
  aes(x = date,  
      y = log10(enterococci),  
      color = season_name)  
) +  
  geom_line()
```



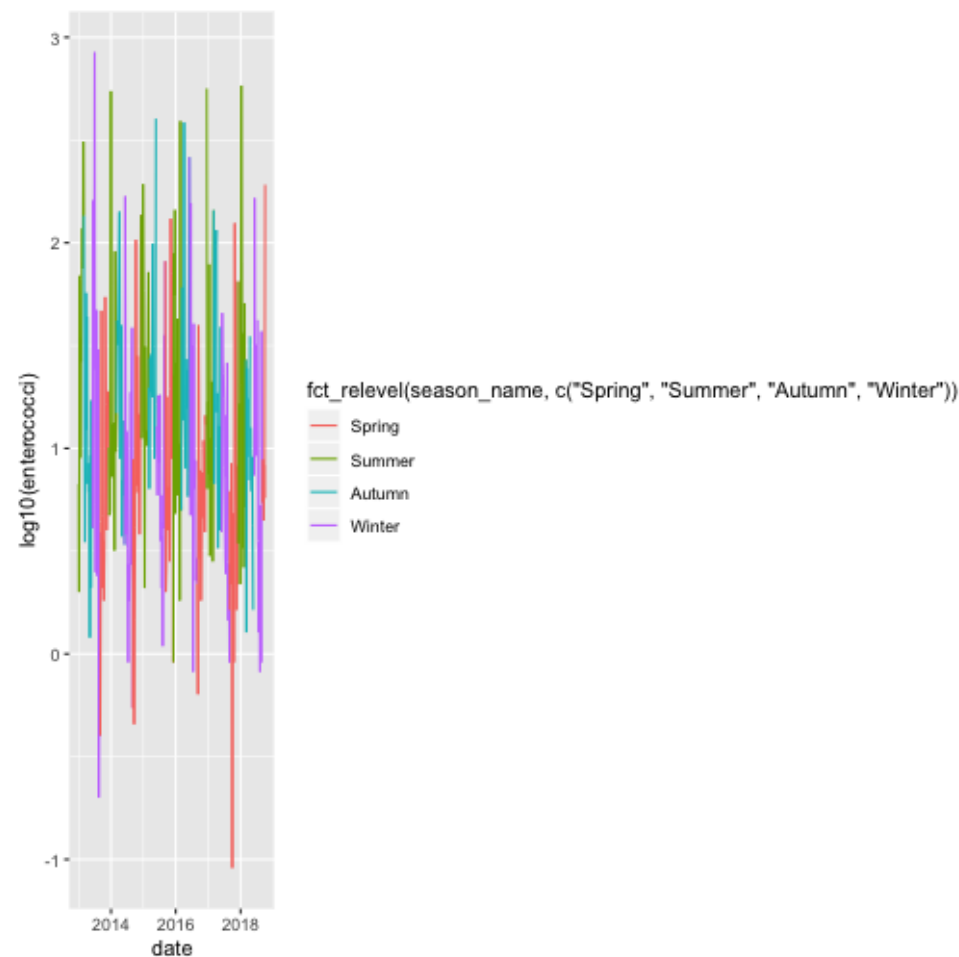
Adding groups to the mapping

```
ggplot(  
  data=beaches,  
  aes(x = date,  
      y = log10(enterococci),  
      color = season_name,  
      group = 1)  
) +  
  geom_line()
```



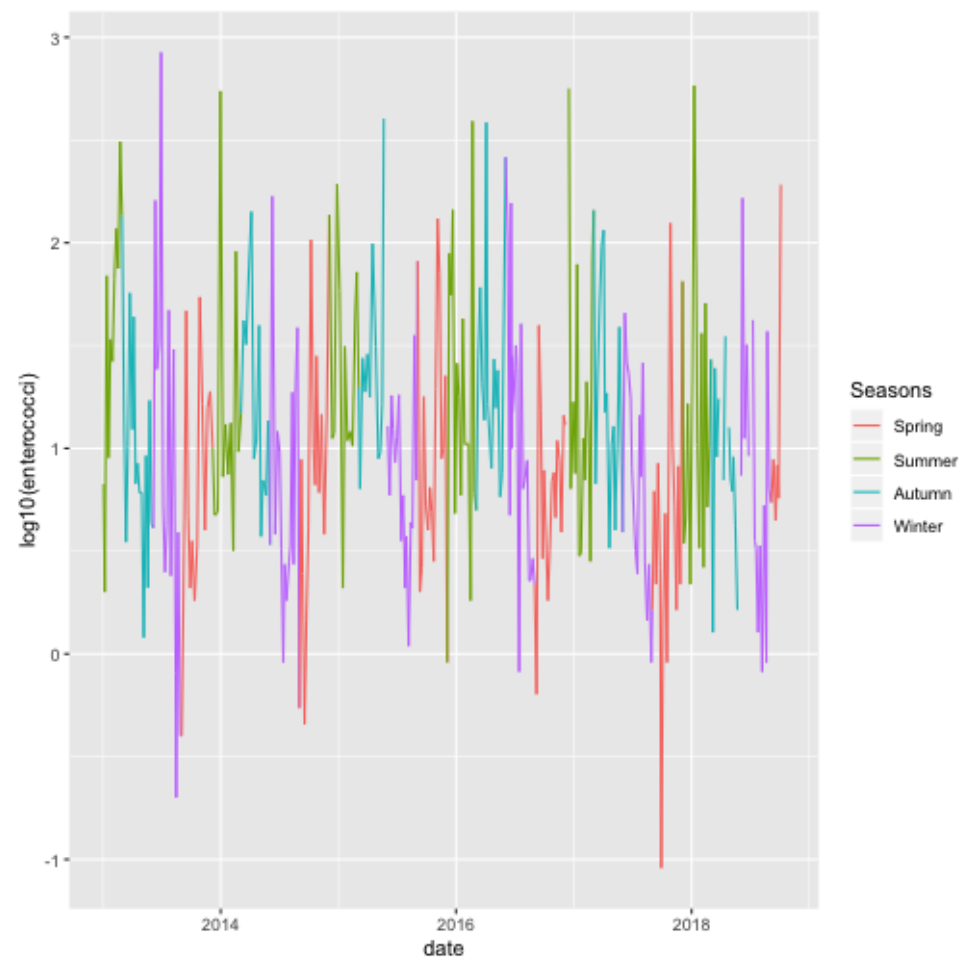
Fixing the legend ordering

```
ggplot(
  data=beaches,
  aes(x = date,
      y = log10(enterococci),
      color = fct_relevel(season_name, c('Spring', 'Summer', 'Autumn', 'Winter')),
      group = 1)
) +
  geom_line()
```



Fixing the legend ordering

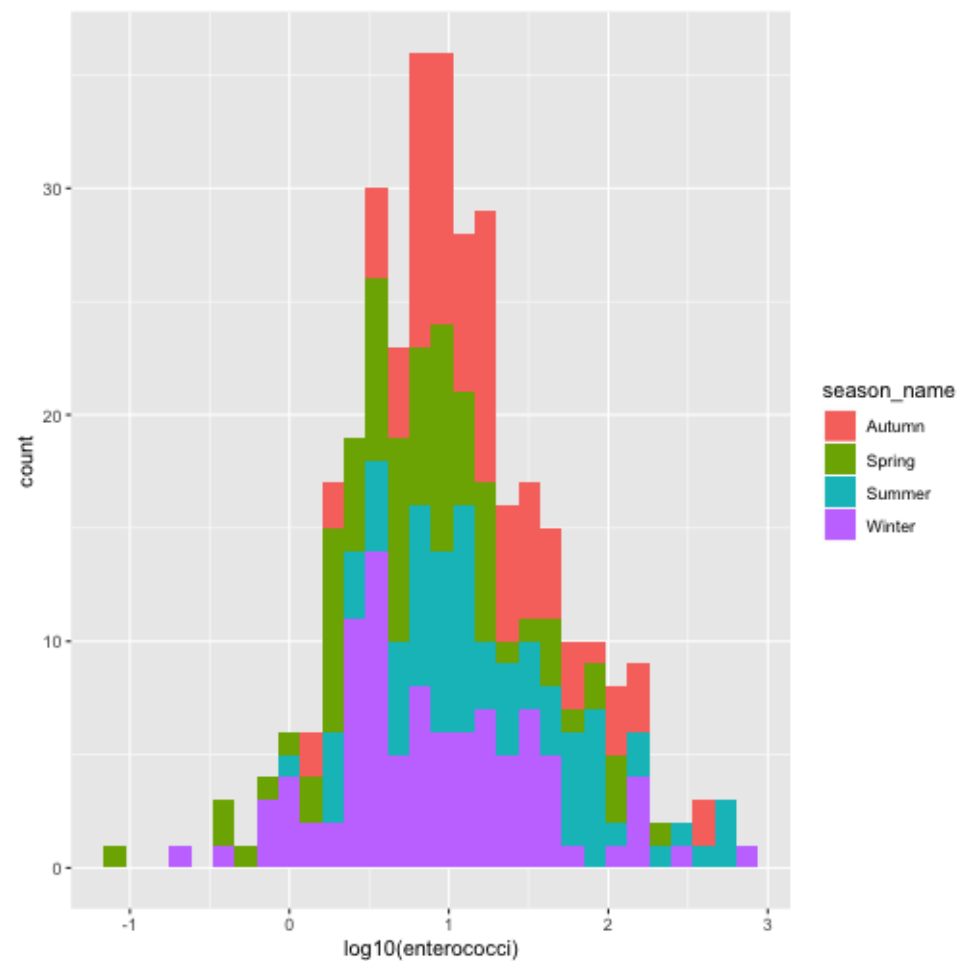
```
ggplot(  
  data=beaches,  
  aes(x = date,  
      y = log10(enterococci),  
      color = fct_relevel(season_name, c('Spring', 'Su  
      group = 1)  
) +  
  geom_line()+  
  labs(color = 'Seasons')
```



You can also fill based on data

```
ggplot(  
  data=beaches,  
  aes(x = log10(enterococci),  
      fill = season_name)) +  
  geom_histogram()
```

This is not a great plot. We'll refine this idea later



Exercise 2

Exploring geometries

Univariate plots

Histograms

```
library(tidyverse)
library(rio)
dat_spine <- import('data/Dataset_spine.csv',
                    check.names = T)

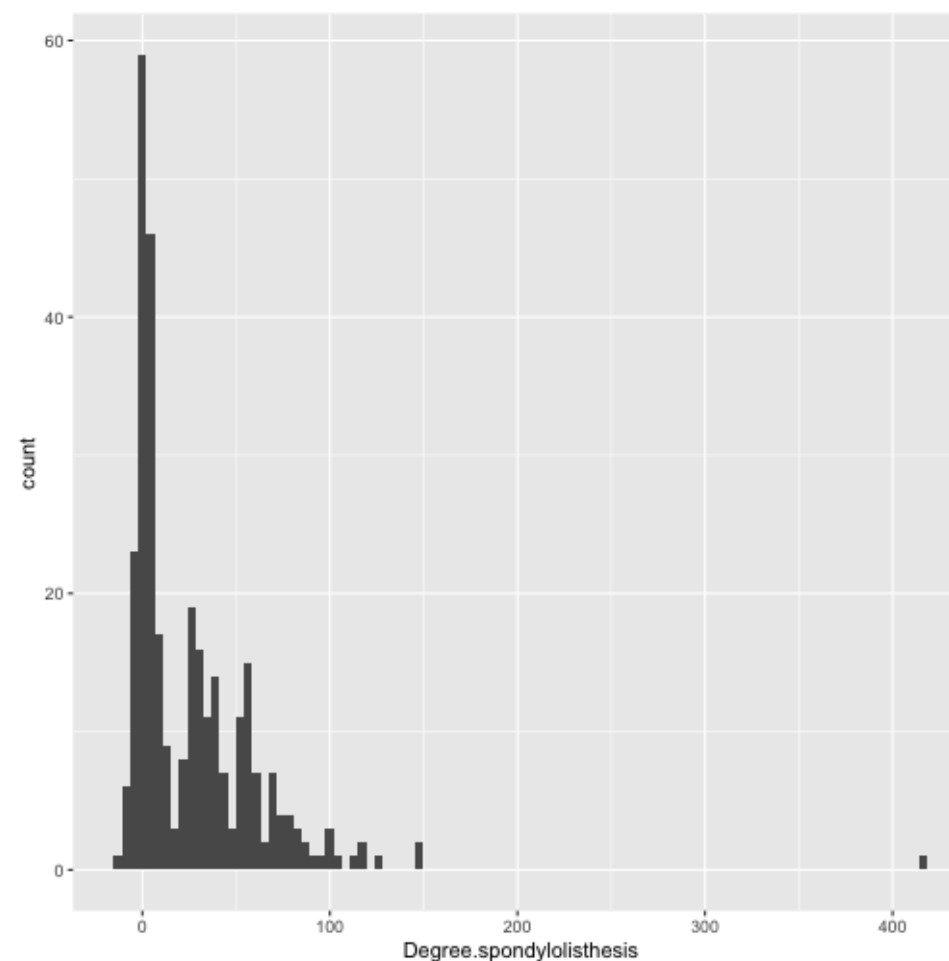
ggplot(
  data=dat_spine,
  aes(x = Degree.spondylolisthesis))+
  geom_histogram()
```

```
#> `stat_bin()` using `bins = 30`. Pick better value
```

Histograms

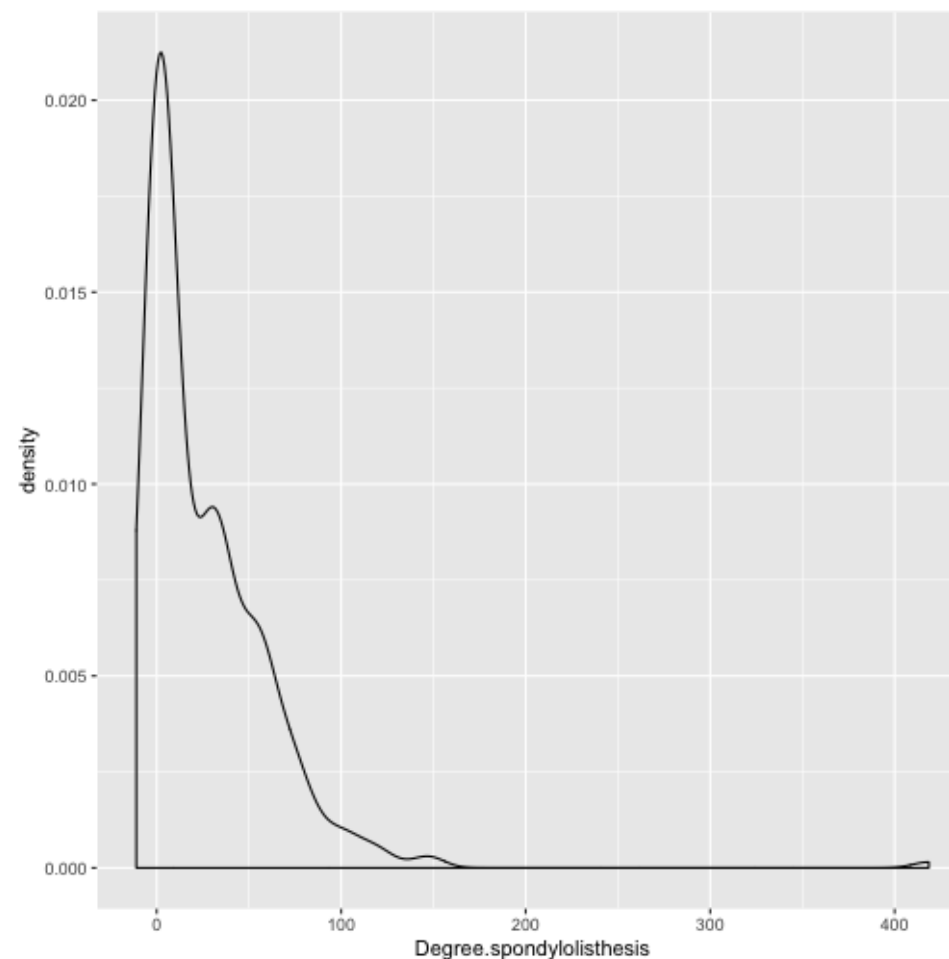
```
ggplot(  
  data=dat_spine,  
  aes(x = Degree.spondylolisthesis))+  
  geom_histogram(bins = 100)
```

This gives a very different view of the data



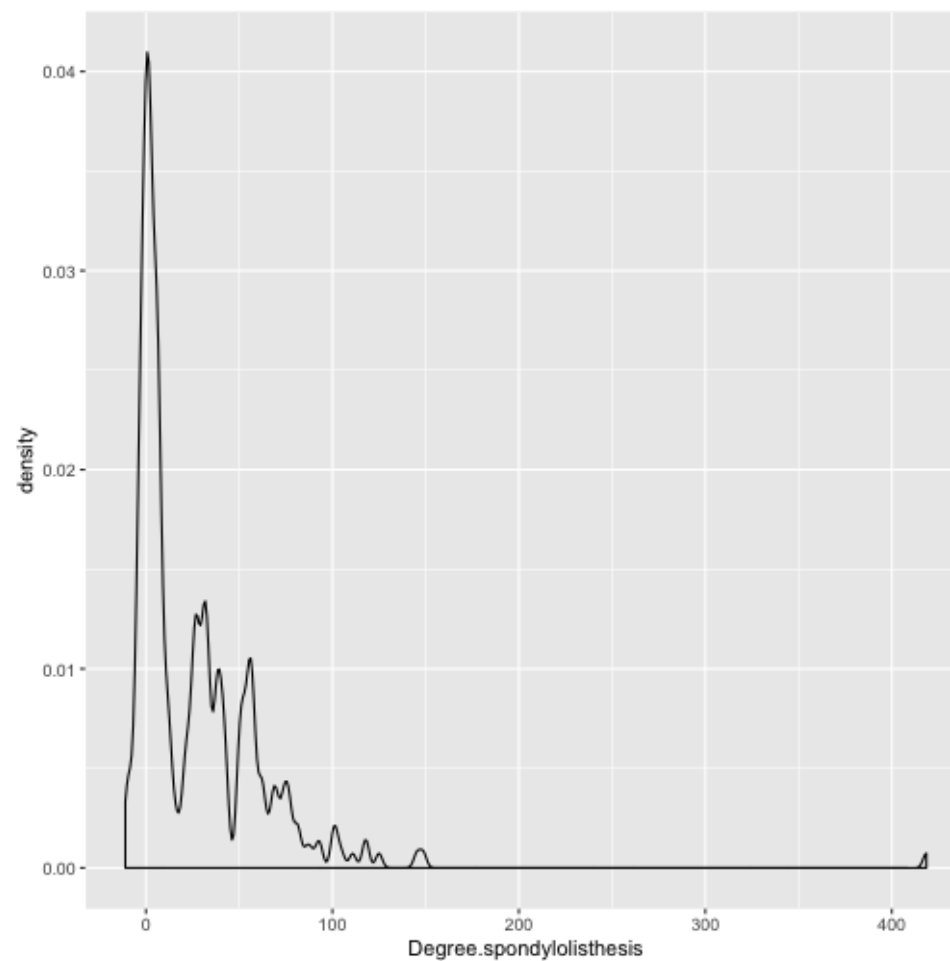
Density plots

```
ggplot(  
  data=dat_spine,  
  aes(x = Degree.spondylolisthesis))+  
  geom_density()
```



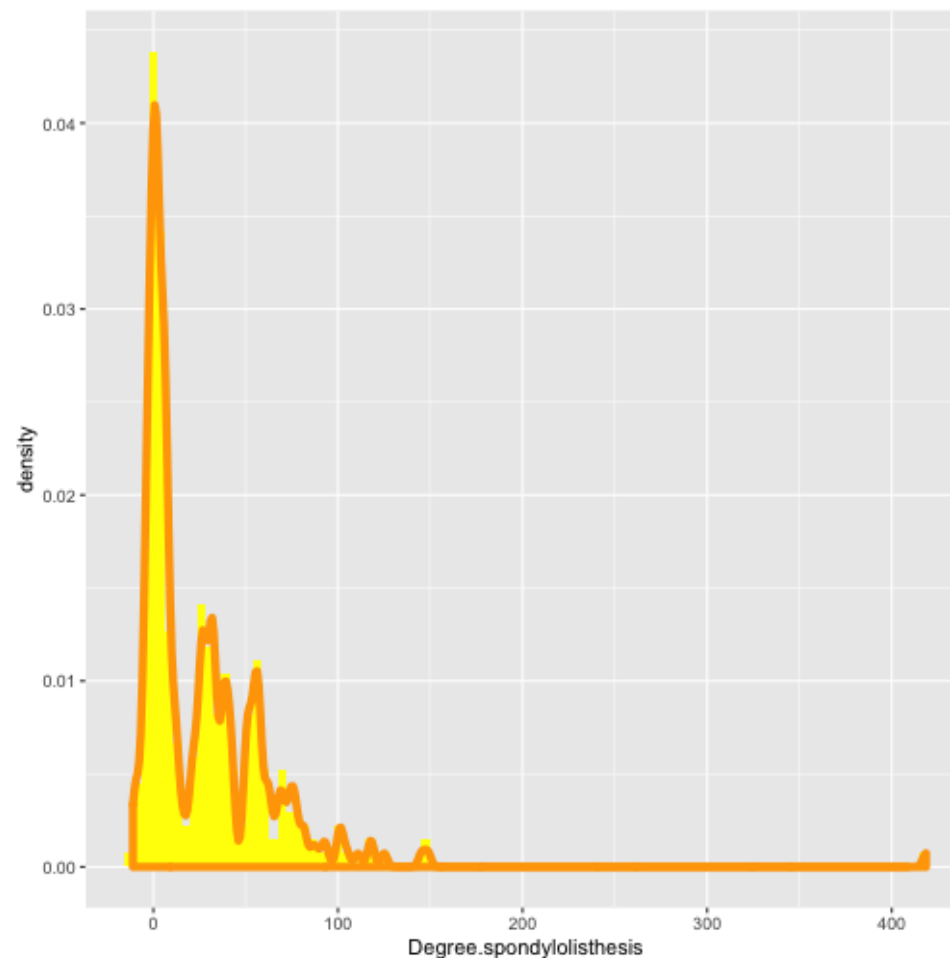
Density plots

```
ggplot(  
  data=dat_spine,  
  aes(x = Degree.spondylolisthesis))+  
  geom_density(adjust = 1/5) # Use 1/5 the bandwidth
```



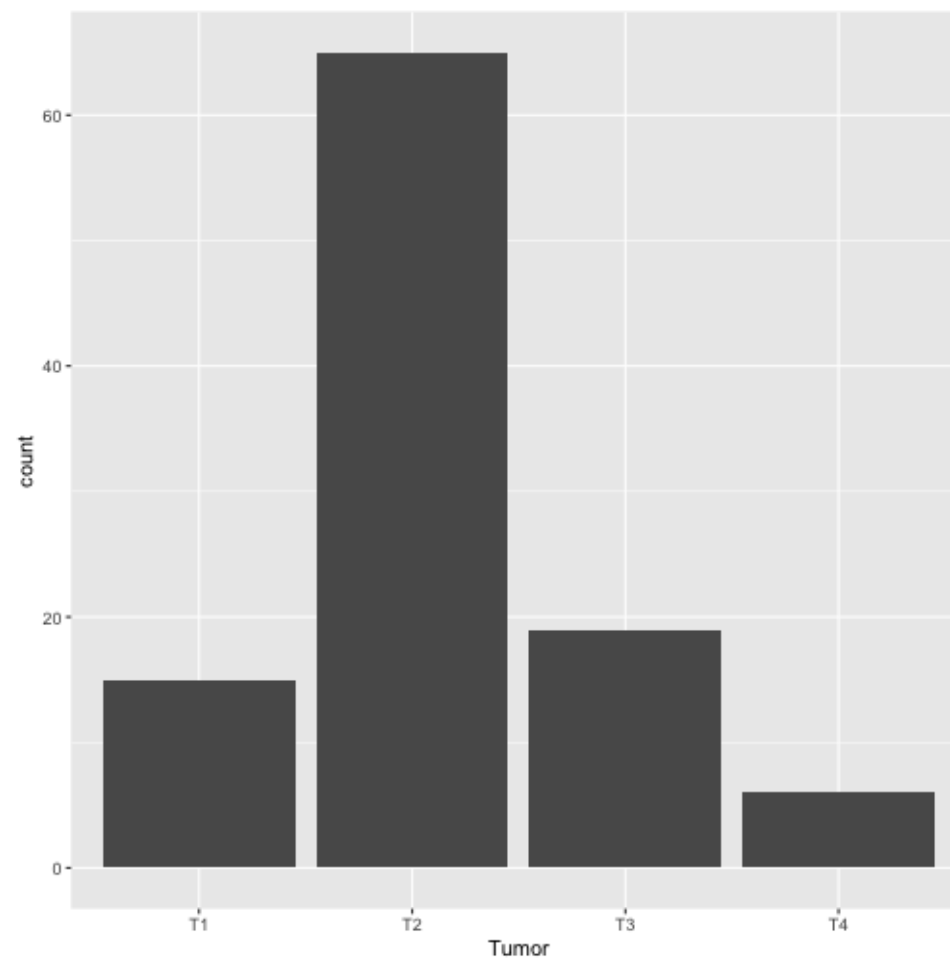
Layering geometries

```
ggplot(  
  data=dat_spine,  
  aes(x = Degree.spondylolisthesis,  
      y = stat(density)))+ # Re-scales histogram  
  geom_histogram(bins = 100, fill='yellow') +  
  geom_density(adjust = 1/5, color = 'orange', size =
```



Bar plots (categorical variable)

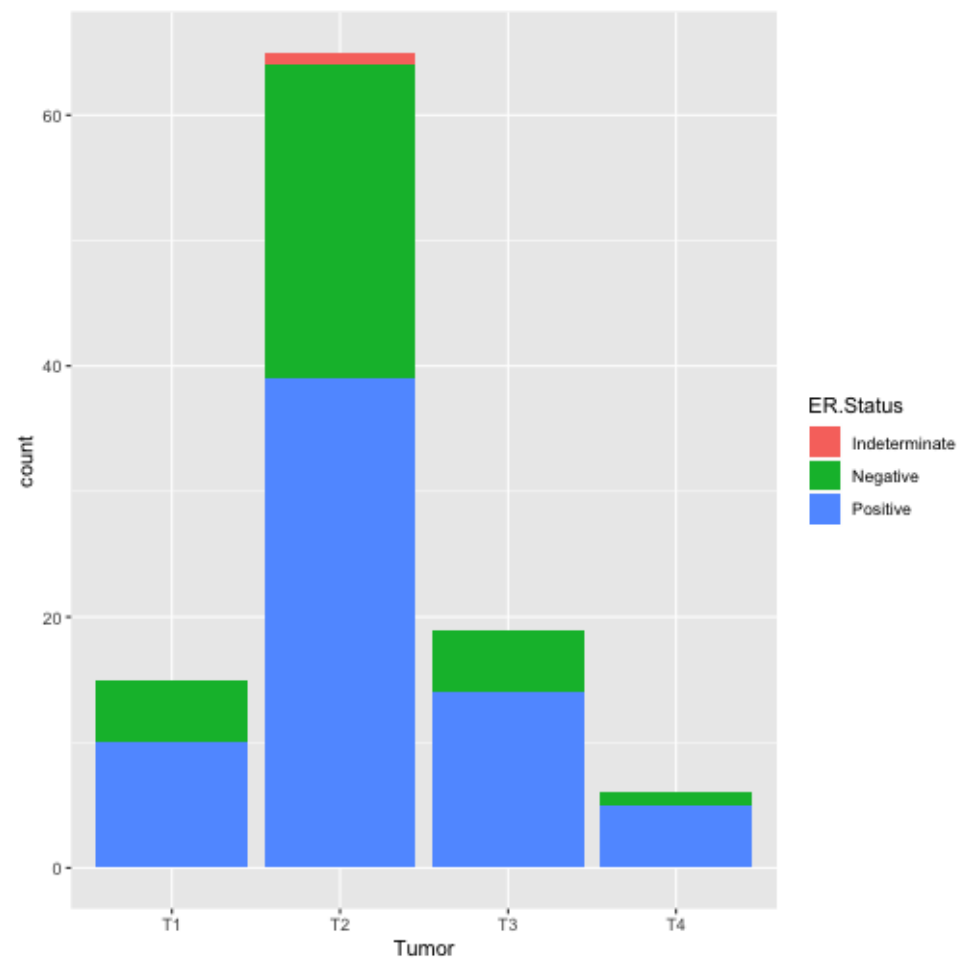
```
dat_brca <- rio::import('data/clinical_data_breast_ca',  
                        check.names = T)  
ggplot(  
  data=dat_brca,  
  aes(x = Tumor)) +  
  geom_bar()
```



Bar plots (categorical variable)

```
dat_brca <- import('data/clinical_data_breast_cancer_  
                    check.names = T')  
ggplot(  
  data=dat_brca,  
  aes(x = Tumor,  
      fill = ER.Status)) +  
  geom_bar()
```

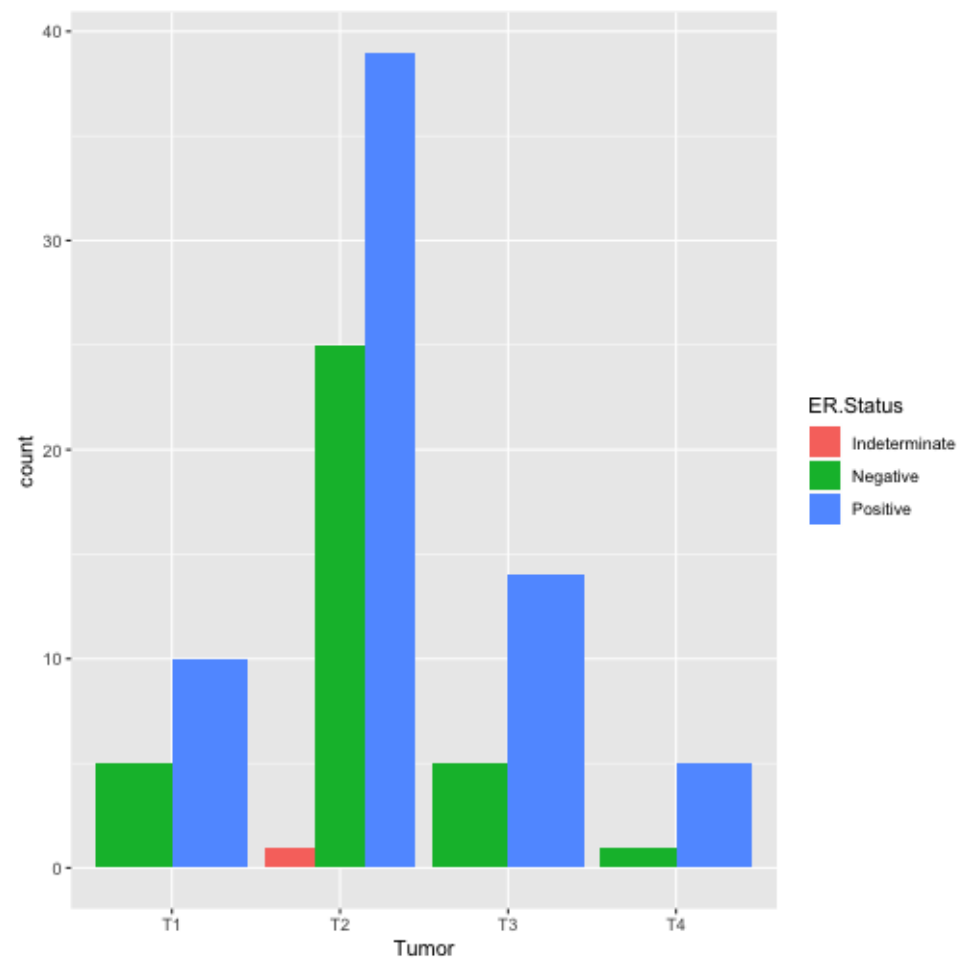
Add additional information via mapping



Bar plots (categorical variable)

```
dat_brca <- import('data/clinical_data_breast_cancer_
                    check.names = T)
ggplot(
  data=dat_brca,
  aes(x = Tumor,
      fill = ER.Status))+
  geom_bar(position = 'dodge')
  # Default is position = "stack"
```

Change the nature of the geometry



Graphing tabulated data

```
tabulated <- dat_brca %>% count(Tumor)
tabulated
```

```
#> # A tibble: 4 x 2
#>   Tumor      n
#>   <chr> <int>
#> 1 T1      15
#> 2 T2      65
#> 3 T3      19
#> 4 T4       6
```

```
ggplot(
  data = tabulated,
  aes(x = Tumor, y = n)) +
  geom_bar()
```

```
#> Error: stat_count() must not be used with a y aes
```

Graphing tabulated data

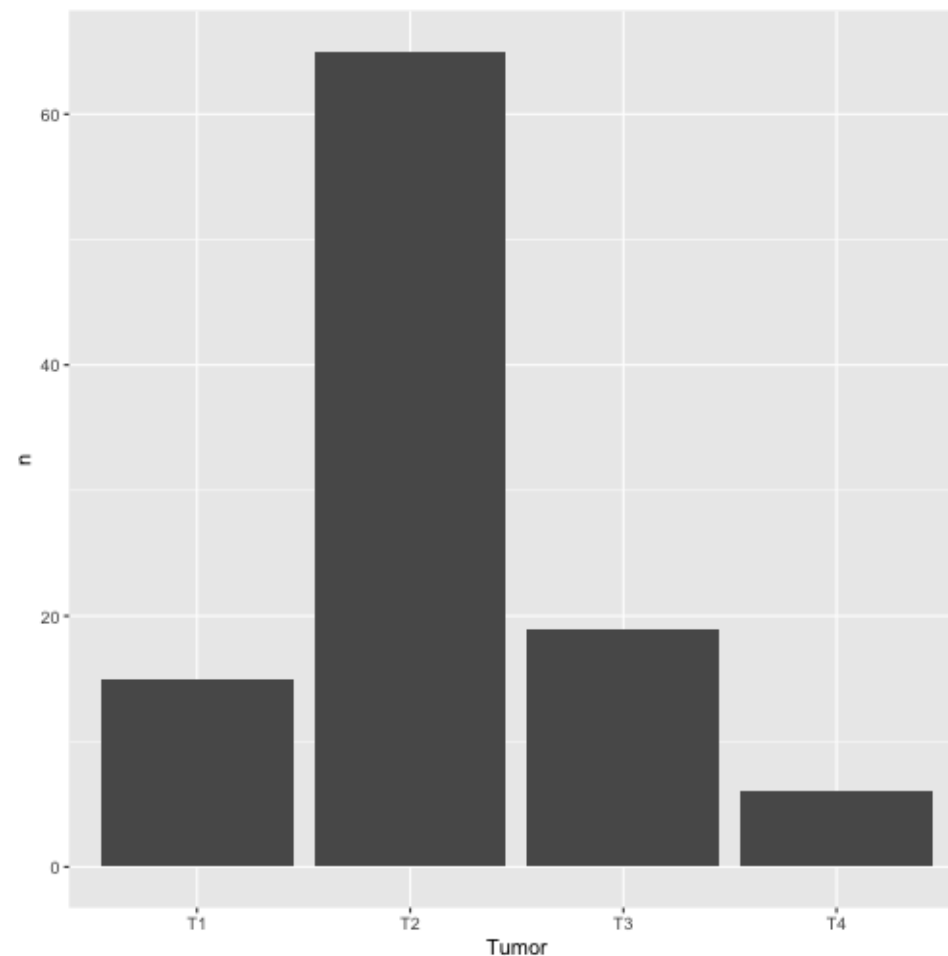
```
tabulated <- dat_brca %>% count(Tumor)
tabulated
```

```
ggplot(
  data = tabulated,
  aes(x = Tumor, y = n)) +
  geom_bar(stat = 'identity')
```

Here we need to change the default computation

The barplot usually computes the counts
(stat_count)

We suppress that here since we have already
done the computation



Peeking under the hood

```
plt <- ggplot(  
  data = tabulated,  
  aes(x = Tumor, y = n)) +  
  geom_bar()
```

```
plt$layers
```

```
#> [[1]]  
#> geom_bar: width = NULL, na.rm = FALSE  
#> stat_count: width = NULL, na.rm = FALSE  
#> position_stack
```

```
plt <- ggplot(  
  data = tabulated,  
  aes(x = Tumor, y = n)) +  
  geom_bar(stat = 'identity')
```

```
plt$layers
```

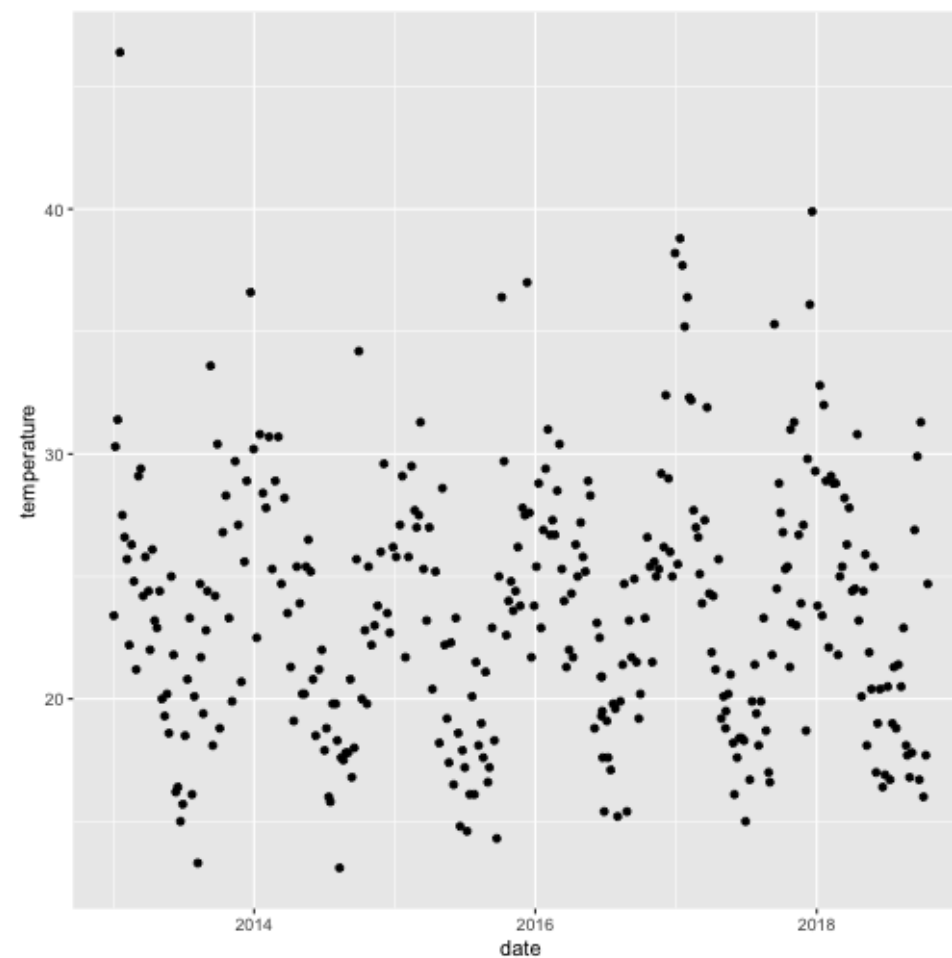
```
#> [[1]]  
#> geom_bar: width = NULL, na.rm = FALSE  
#> stat_identity: na.rm = FALSE  
#> position_stack
```

Each layer has a geometry, statistic and position associated with it

Bivariate plots

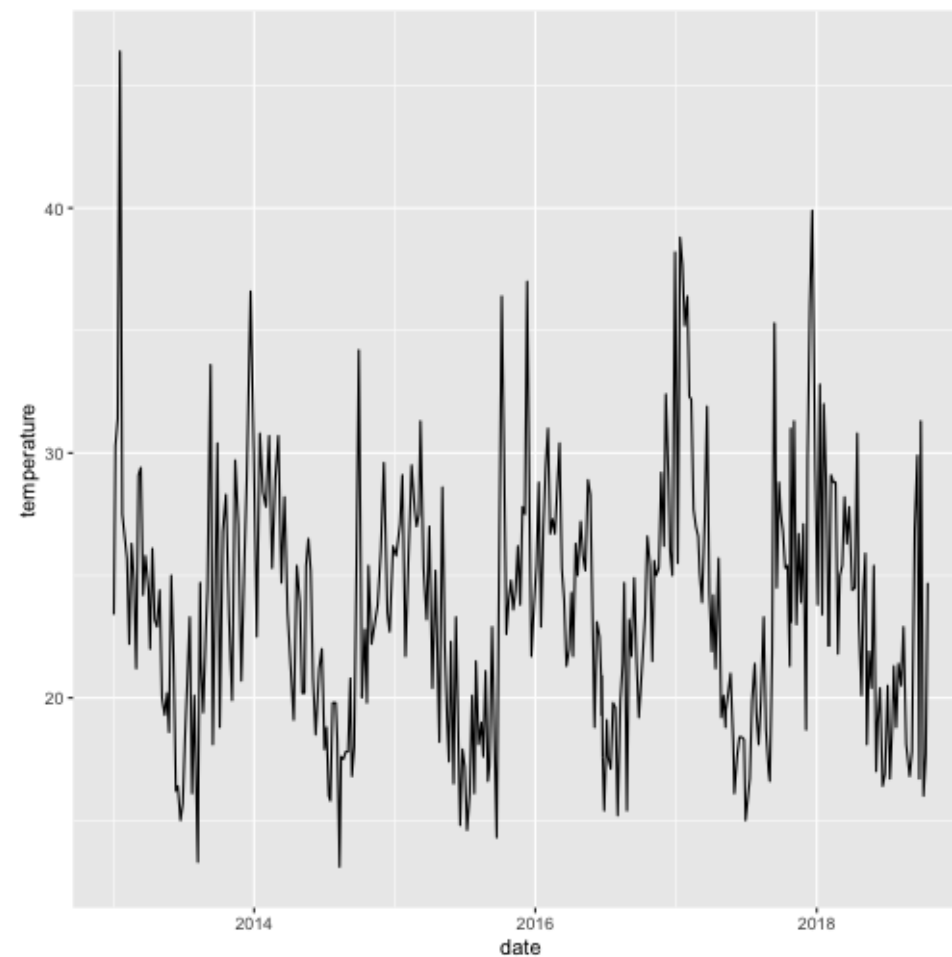
Scatter plots

```
ggplot(  
  data = beaches,  
  aes(x = date, y = temperature)) +  
  geom_point()
```



Scatter plots

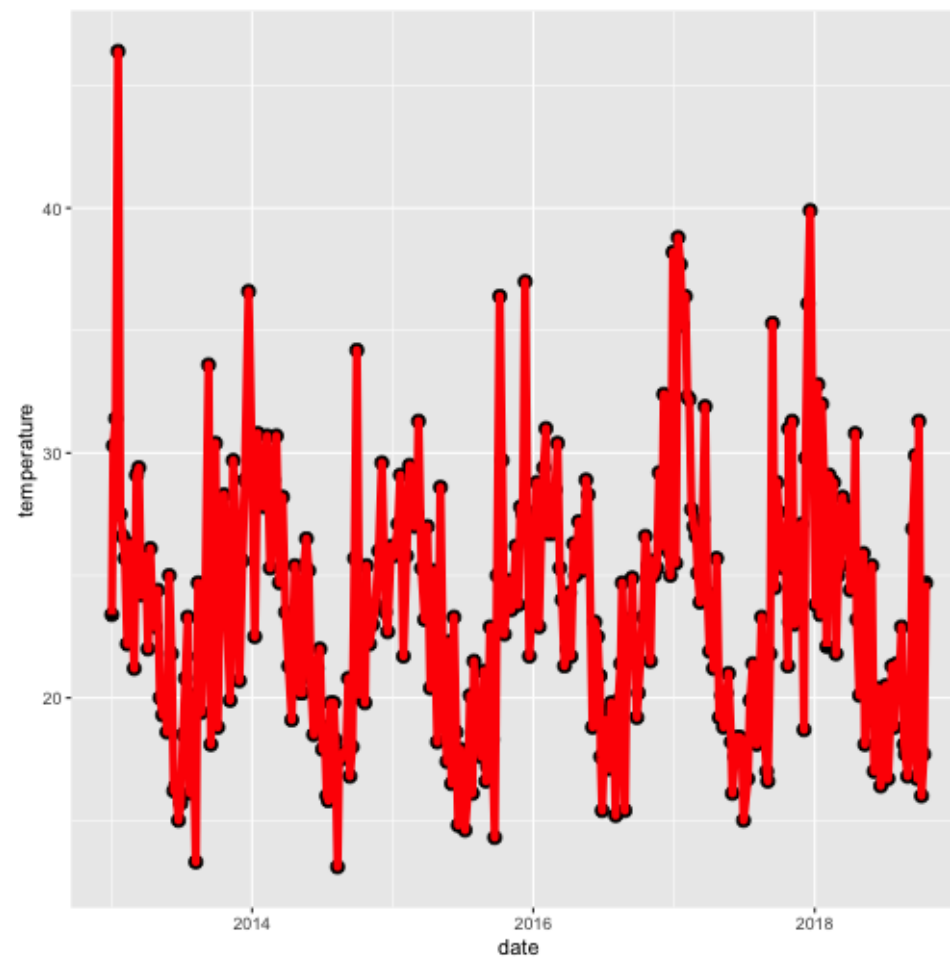
```
ggplot(  
  data = beaches,  
  aes(x = date, y = temperature)) +  
  geom_line()
```



Scatter plots

```
ggplot(  
  data = beaches,  
  aes(x = date, y = temperature)) +  
  geom_point(color='black', size = 3) +  
  geom_line(color='red', size=2)
```

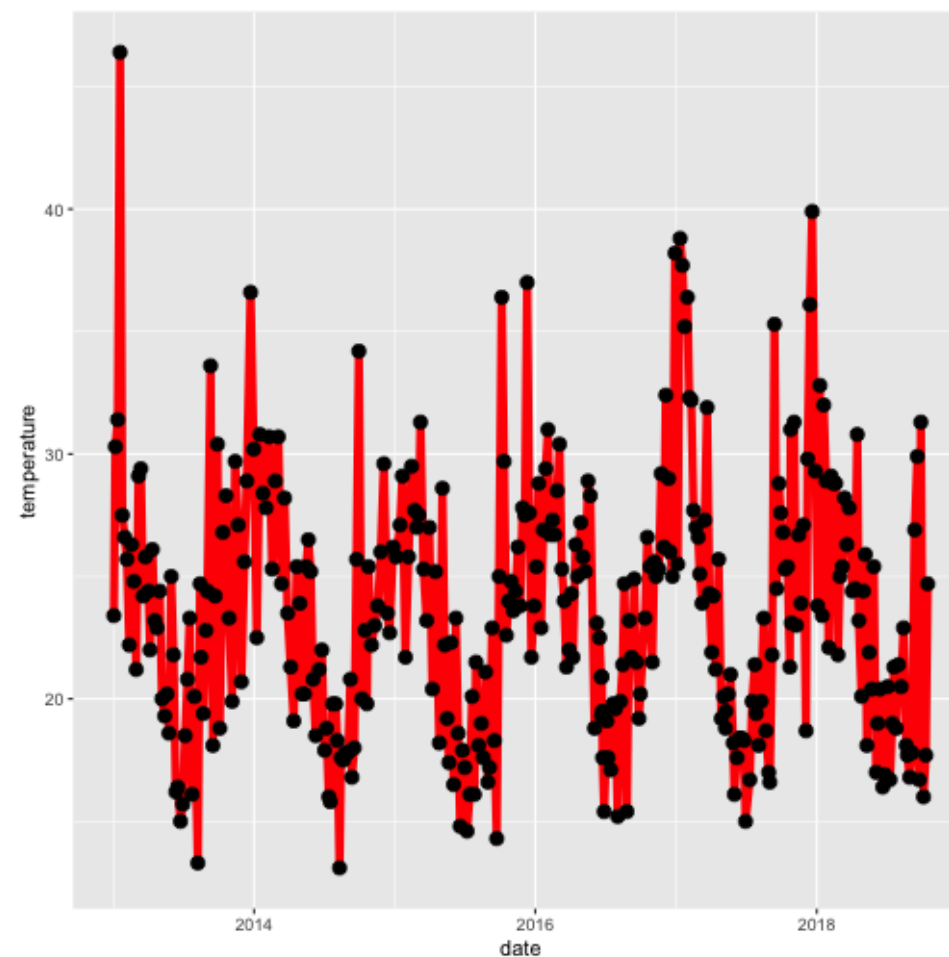
Layer points and lines



Scatter plots

```
ggplot(
  data = beaches,
  aes(x = date, y = temperature)) +
  geom_line(color='red',size=2) +
  geom_point(color='black', size = 3)
```

Order of laying down geometries matters



Doing some computations

```
ggplot(  
  data = beaches,  
  aes(x = date, y = temperature)) +  
  geom_point() +  
  geom_smooth()
```

```
#> `geom_smooth()` using method = 'loess' and formula
```

Averages over 75% of the data

Doing some computations

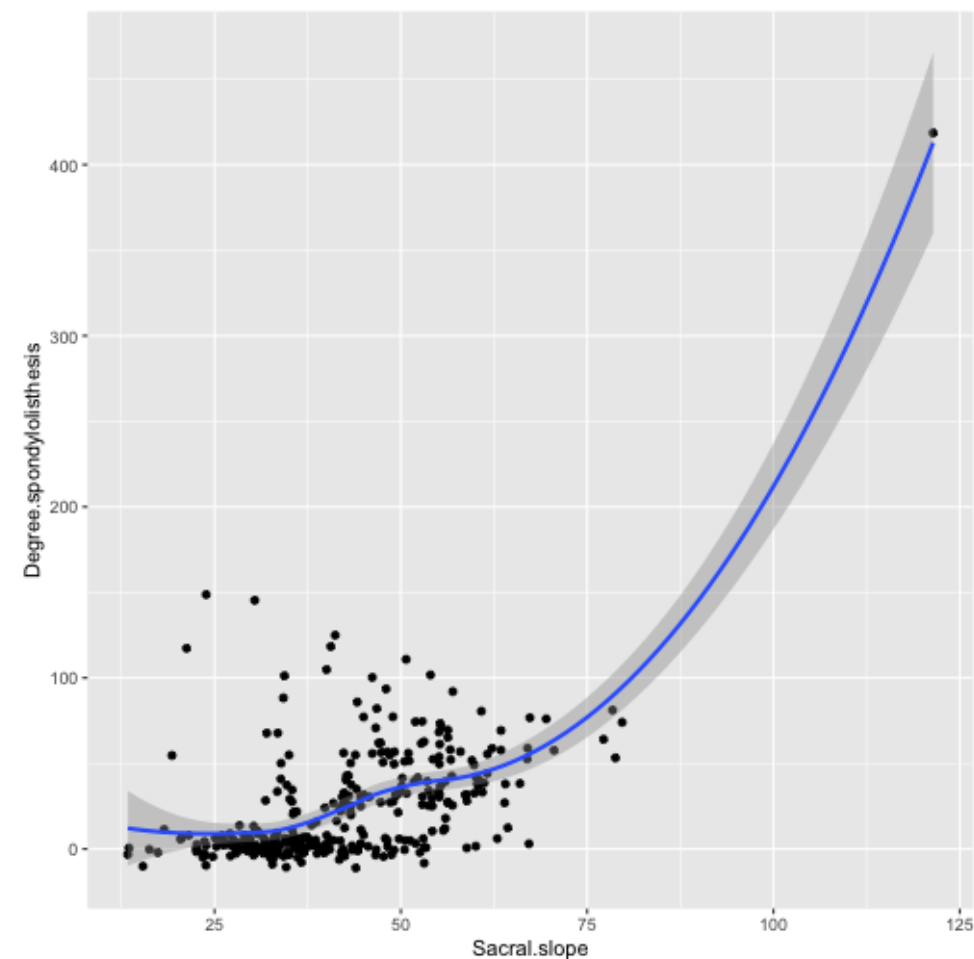
```
ggplot(  
  data = beaches,  
  aes(x = date, y = temperature)) +  
  geom_point() +  
  geom_smooth(span = 0.1)
```

```
#> `geom_smooth()` using method = 'loess' and formula
```

Averages over 10% of the data

Computations over groups

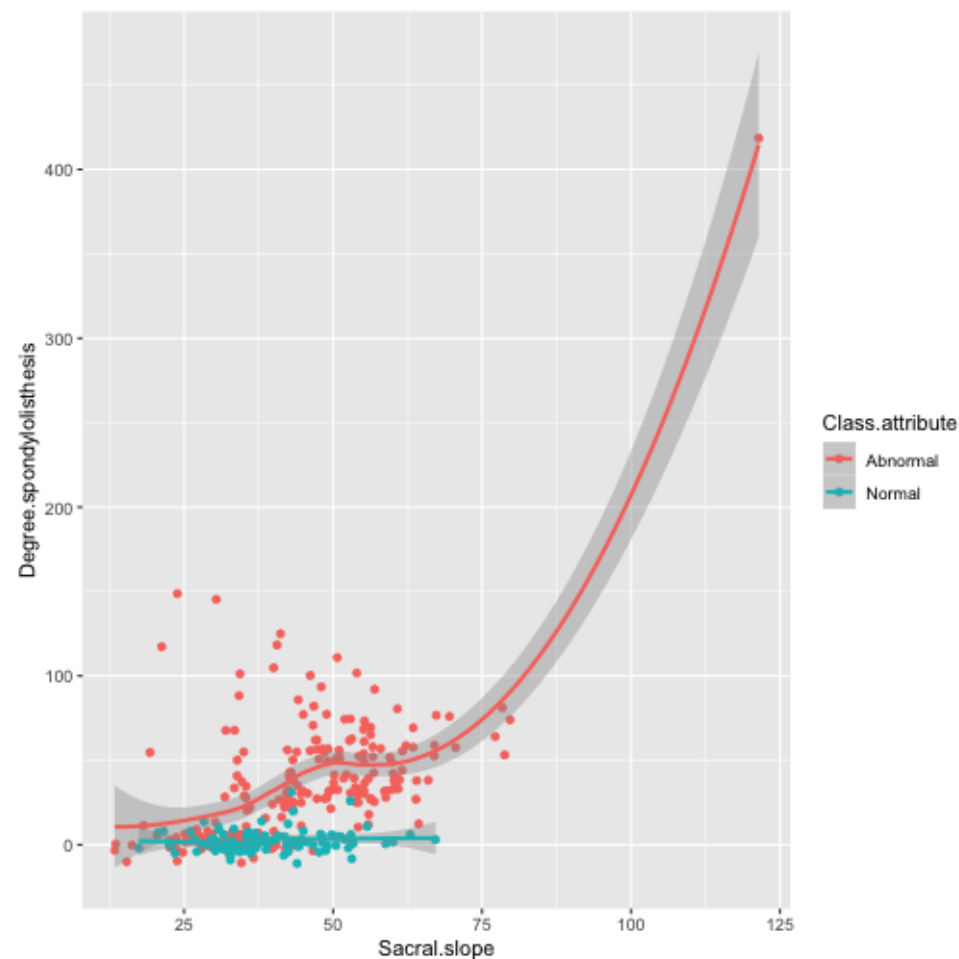
```
ggplot(  
  data = dat_spine,  
  aes(x = Sacral.slope,  
      y = Degree.spondylolisthesis)) +  
  geom_point() +  
  geom_smooth()
```



Computations over groups

```
ggplot(  
  data = dat_spine,  
  aes(x = Sacral.slope,  
      y = Degree.spondylolisthesis,  
      color = Class.attribute)) +  
  geom_point() +  
  geom_smooth()
```

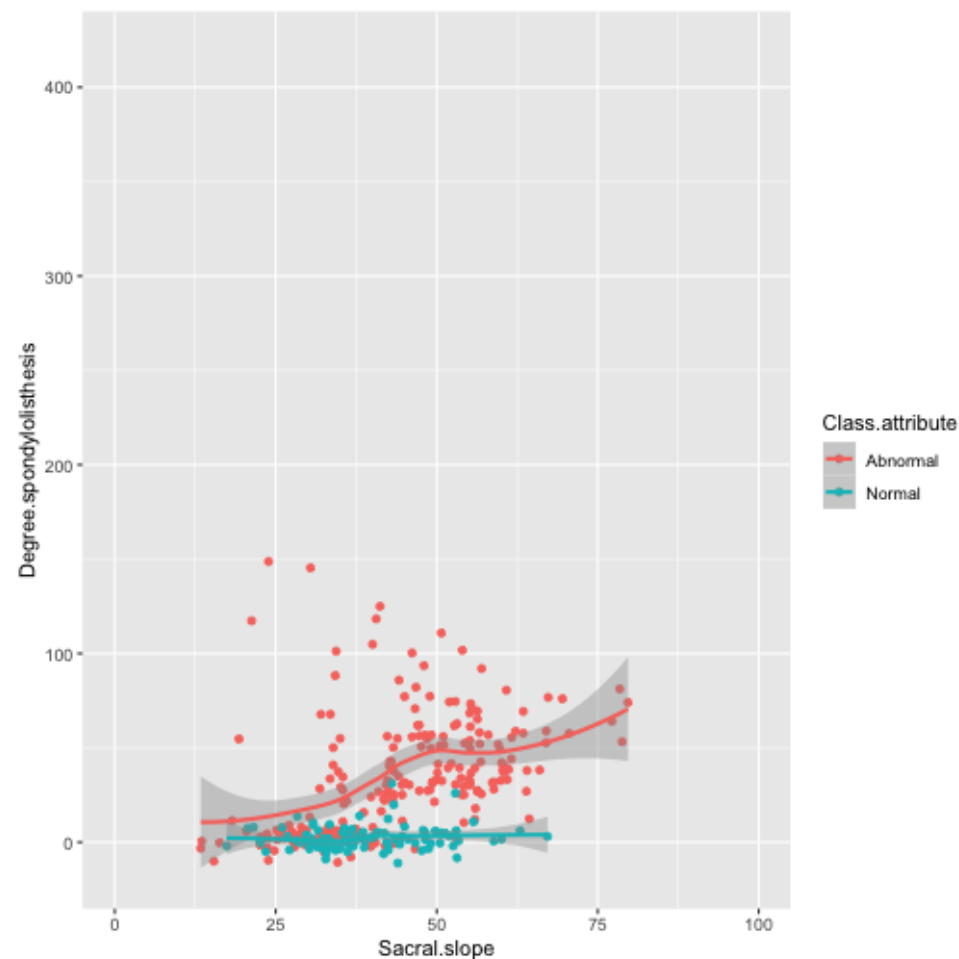
Computation is done by groups



Computations over groups

```
ggplot(  
  data = dat_spine,  
  aes(x = Sacral.slope,  
      y = Degree.spondylolisthesis,  
      color = Class.attribute)) +  
  geom_point() +  
  geom_smooth() +  
  xlim(0, 100)
```

Ignore the outlier for now

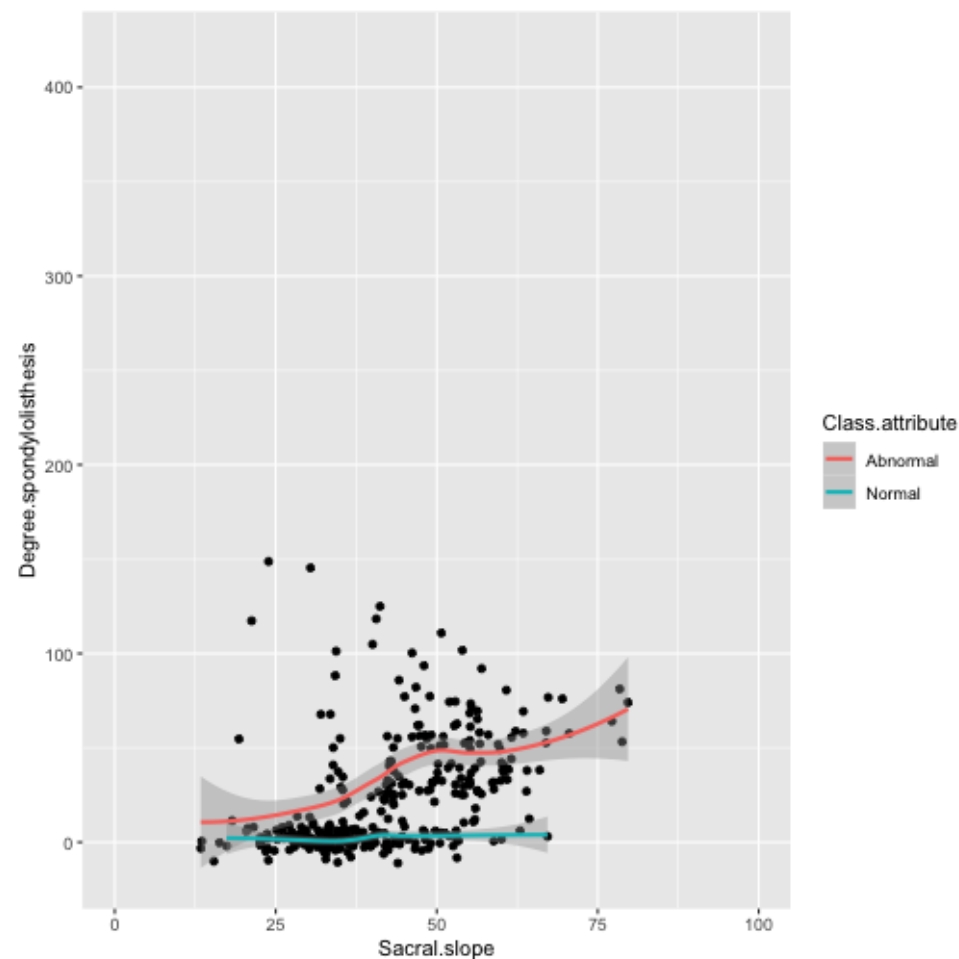


Computations over groups

```
ggplot(  
  data = dat_spine,  
  aes(x = Sacral.slope,  
      y = Degree.spondylolisthesis)) +  
  geom_point() +  
  geom_smooth(aes(color = Class.attribute)) +  
  xlim(0, 100)
```

Only color-code the smoothers

You can change the plot based on where you map the aesthetic

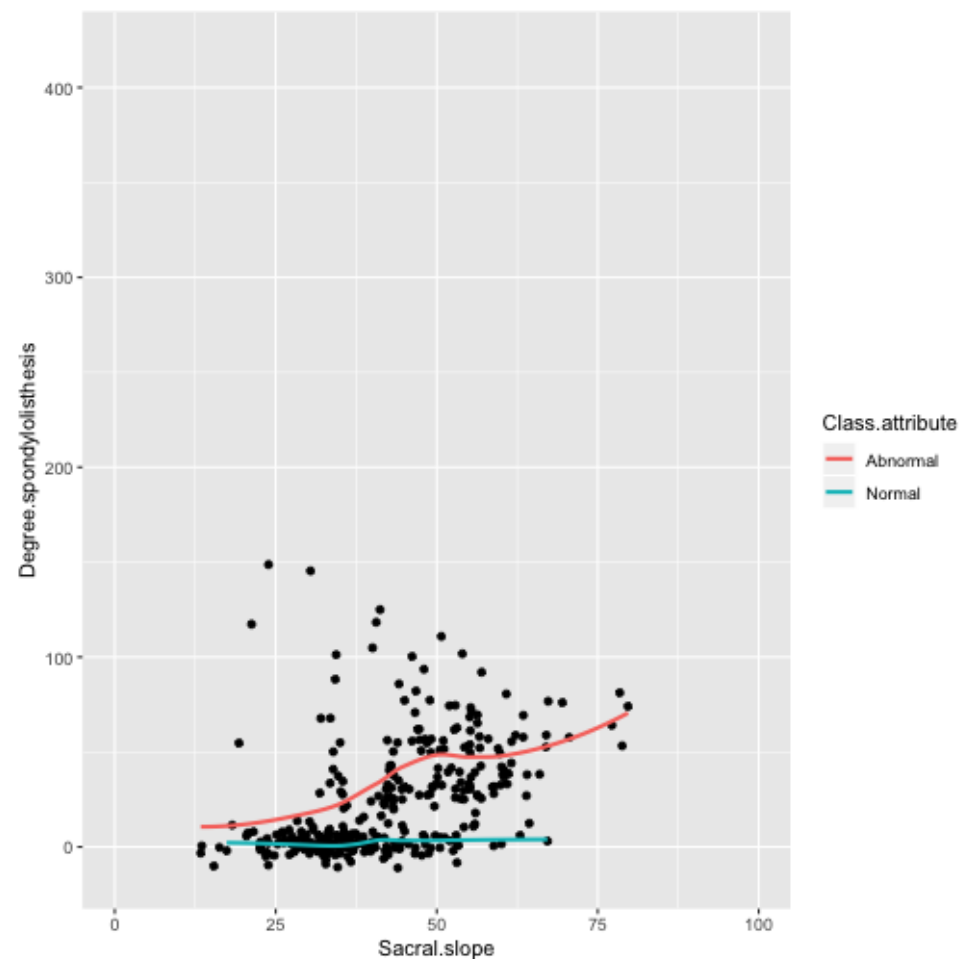


Computations over groups

```
ggplot(  
  data = dat_spine,  
  aes(x = Sacral.slope,  
      y = Degree.spondylolisthesis)) +  
  geom_point() +  
  geom_smooth(aes(color = Class.attribute),  
             se = F) +  
  xlim(0, 100)
```

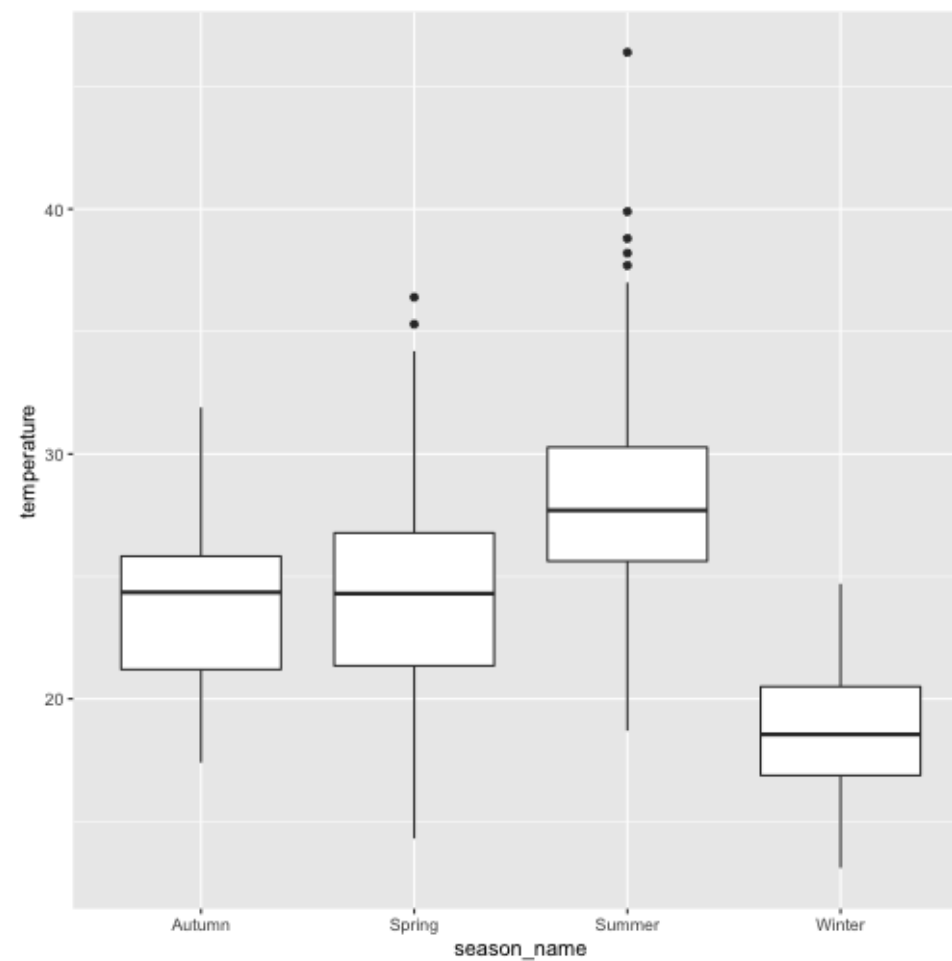
Remove the confidence bands

Maybe a cleaner look



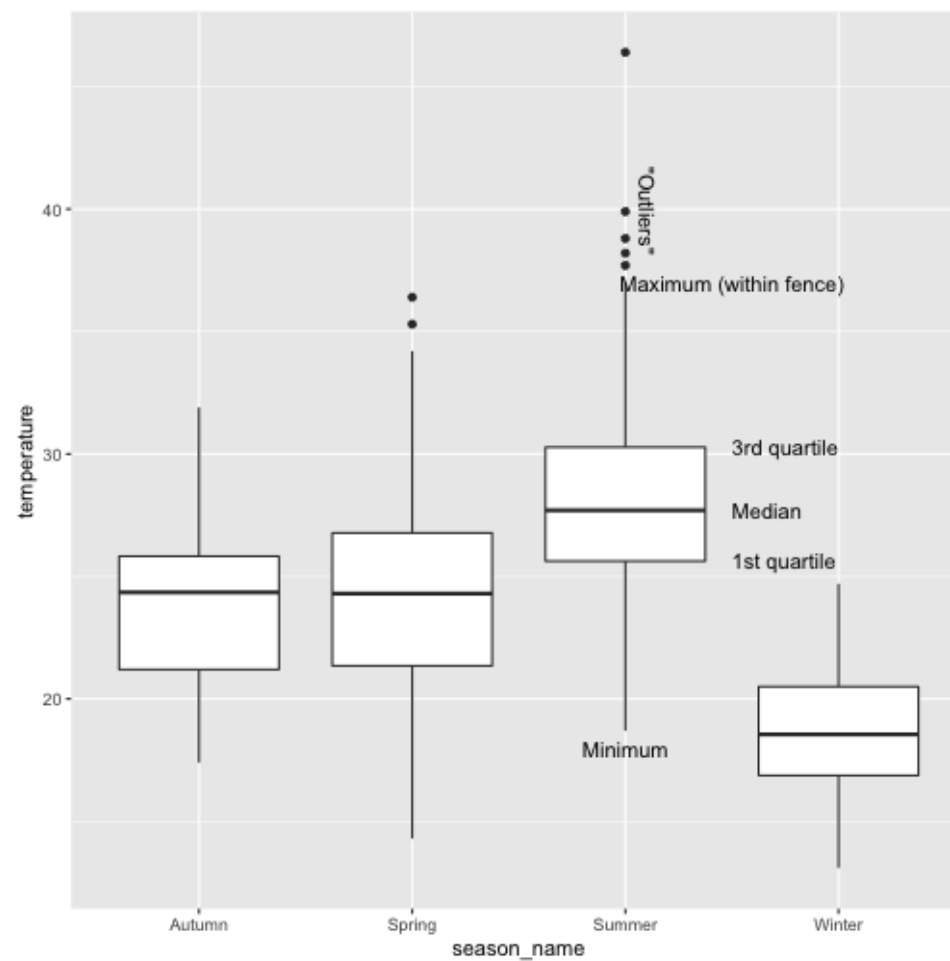
Box Plots

```
ggplot(  
  data = beaches,  
  aes(x = season_name,  
      y = temperature)) +  
  geom_boxplot()
```



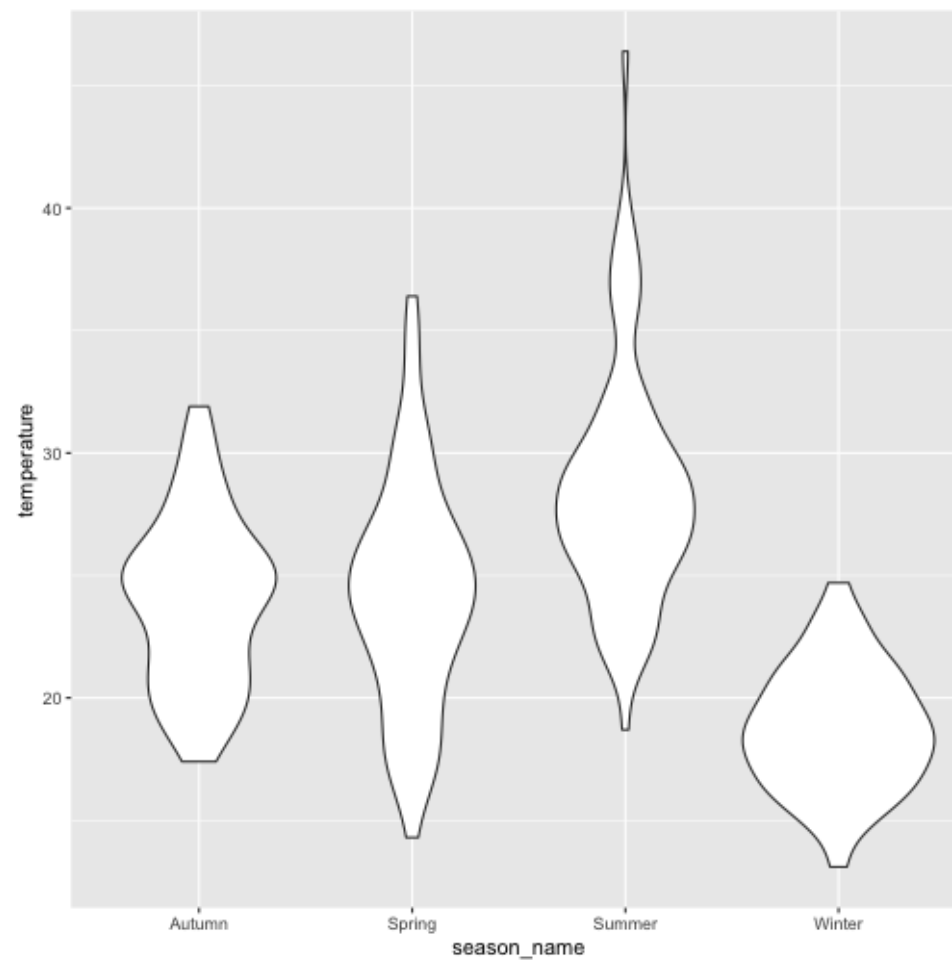
Box Plots

```
ggplot(  
  data = beaches,  
  aes(x = season_name,  
      y = temperature)) +  
  geom_boxplot()
```



Violin plots

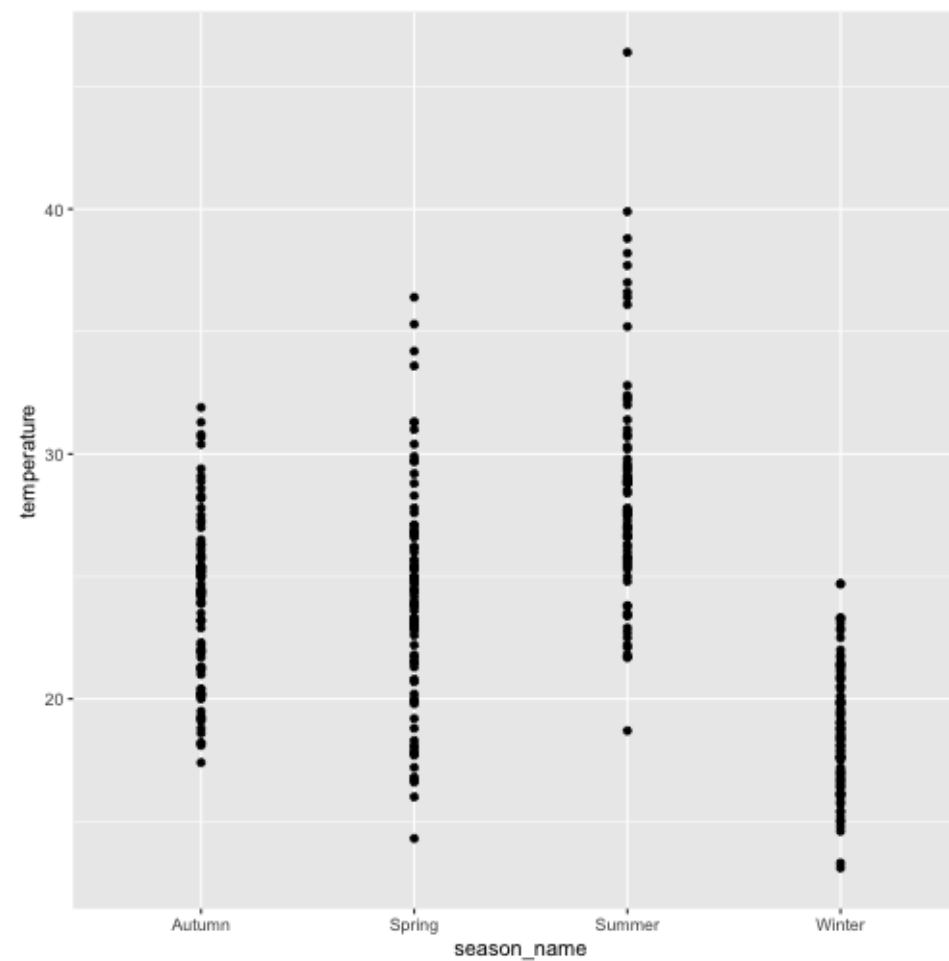
```
ggplot(  
  data = beaches,  
  aes(x = season_name,  
      y = temperature)) +  
  geom_violin()
```



Strip plots

```
ggplot(  
  data = beaches,  
  aes(x = season_name,  
      y = temperature)) +  
  geom_point()
```

Points are overlaid on each other

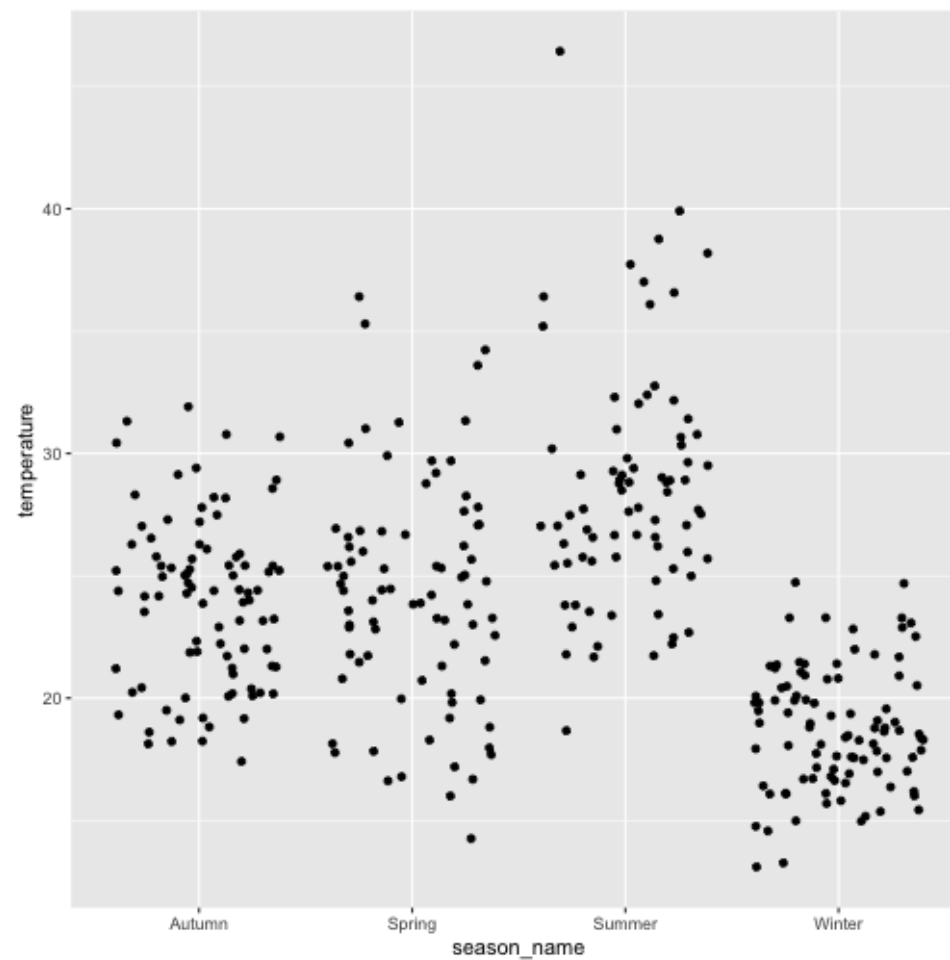


Strip plots

```
ggplot(  
  data = beaches,  
  aes(x = season_name,  
      y = temperature)) +  
  geom_jitter()
```

Jittering allows all points to be seen

Maybe too much

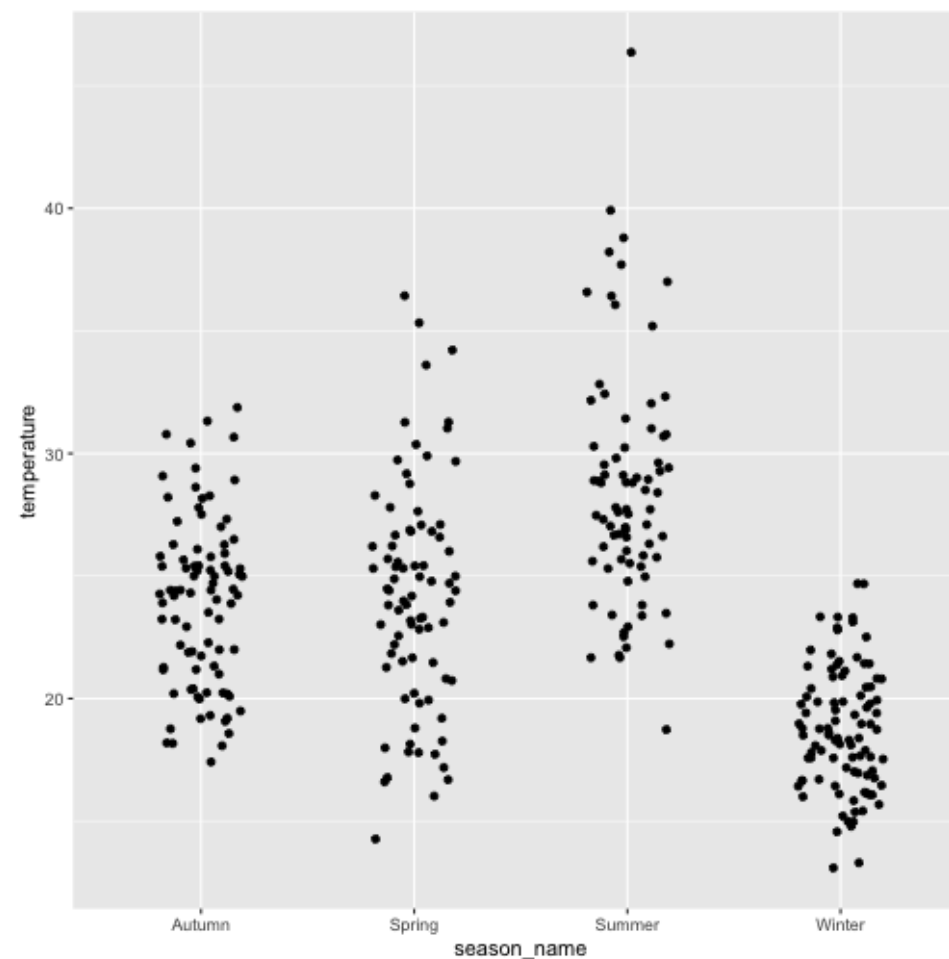


Strip plots

```
ggplot(  
  data = beaches,  
  aes(x = season_name,  
      y = temperature)) +  
  geom_jitter(width = 0.2)
```

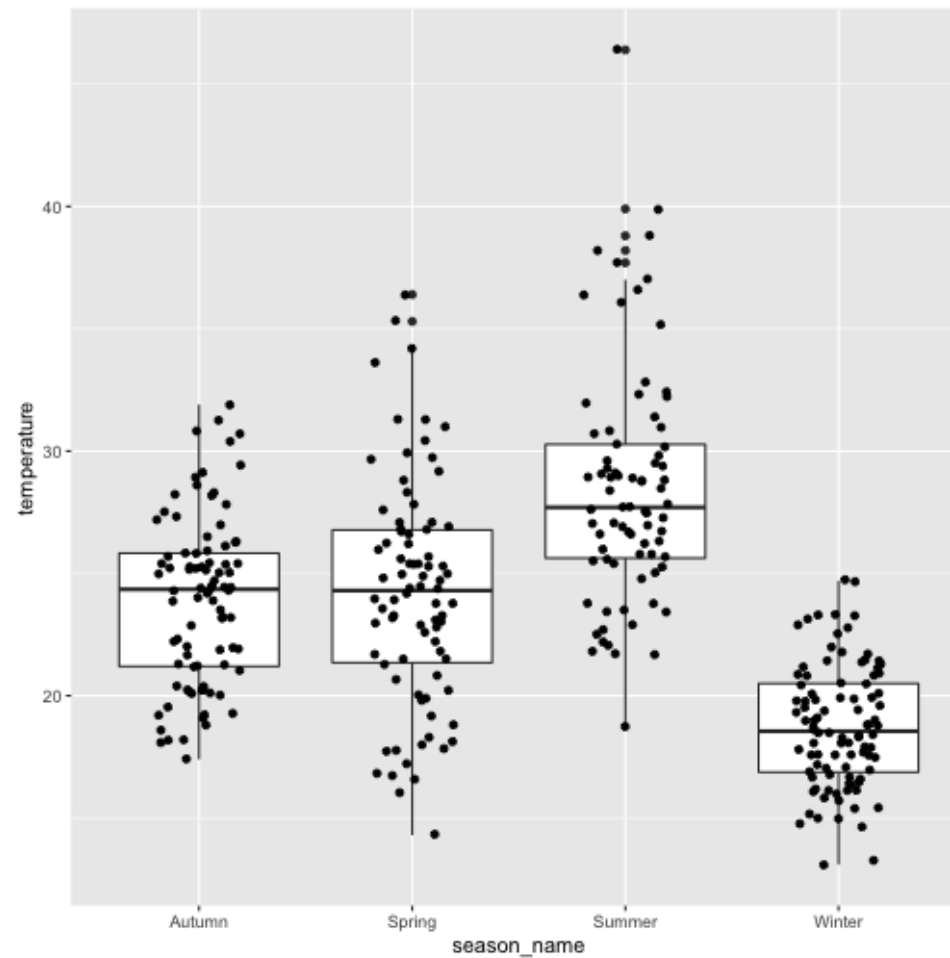
Jittering allows all points to be seen

Maybe too much



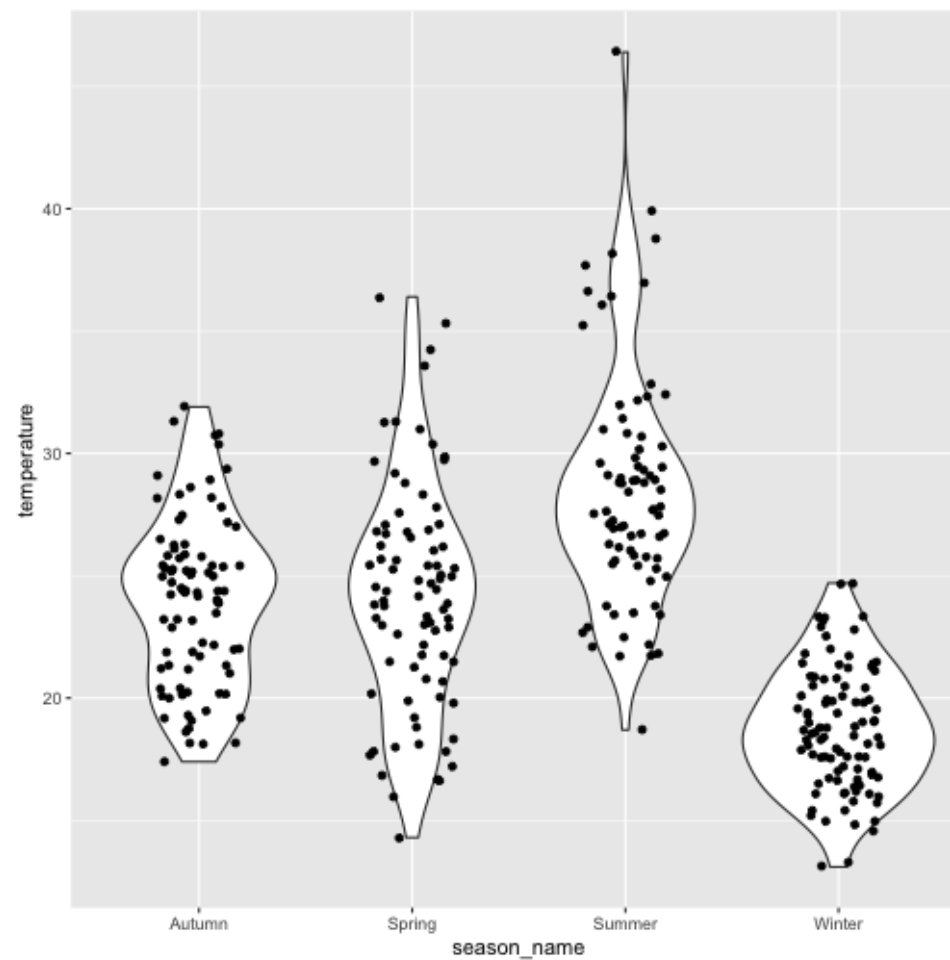
Layers, again

```
ggplot(  
  data = beaches,  
  aes(x = season_name,  
      y = temperature)) +  
  geom_boxplot() +  
  geom_jitter(width = 0.2)
```



Layers, again

```
ggplot(  
  data = beaches,  
  aes(x = season_name,  
      y = temperature)) +  
  geom_violin() +  
  geom_jitter(width = 0.2)
```

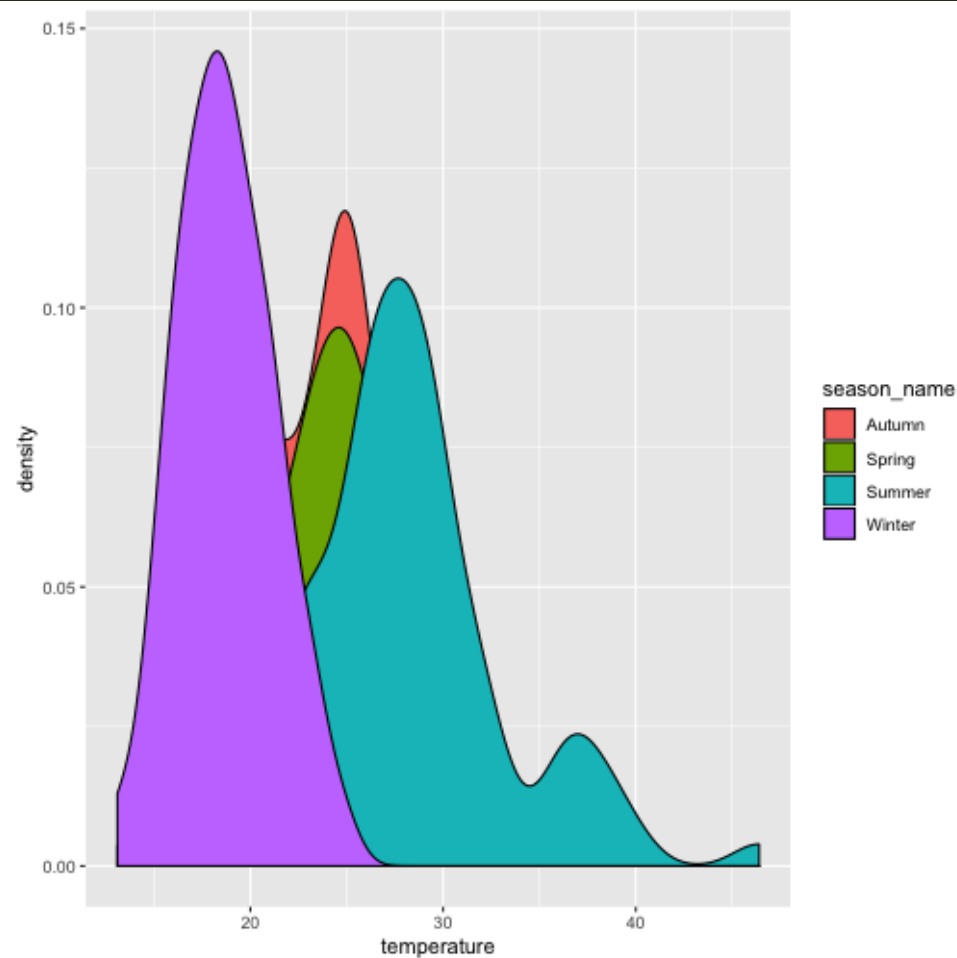


Exploring grouped data

Let's start here

```
ggplot(  
  data = beaches,  
  aes(x = temperature,  
       fill = season_name)) +  
  geom_density()
```

Not very useful

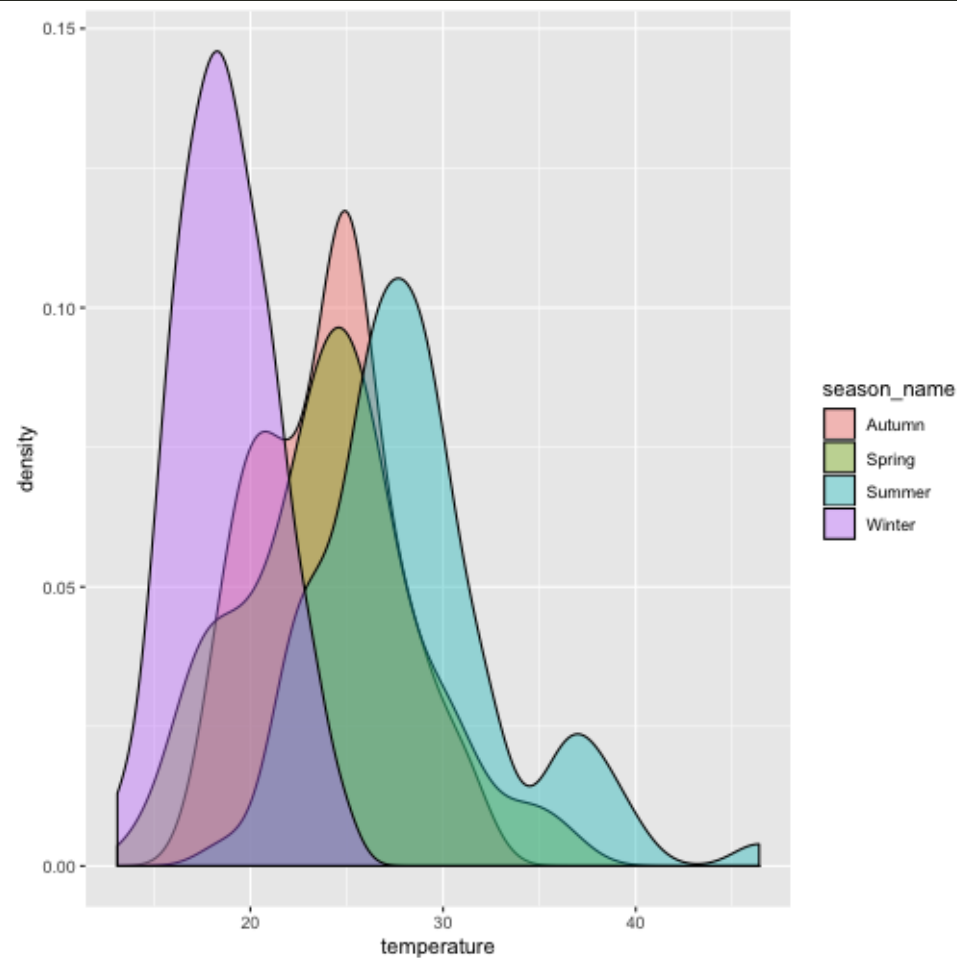


Overlaying graphs

```
ggplot(  
  data = beaches,  
  aes(x = temperature,  
      fill = season_name)) +  
  geom_density(alpha = 0.4)
```

Make graphs more transparent

Still pretty cluttered

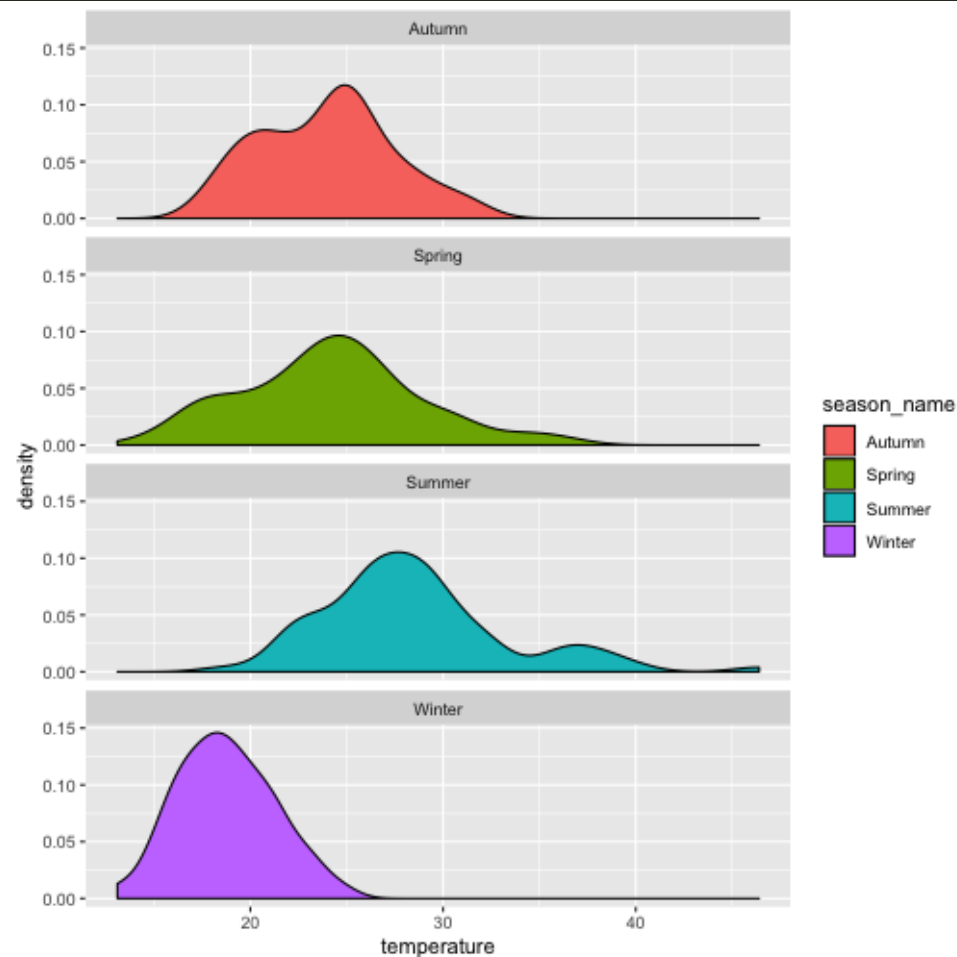


Exploding graphs

```
ggplot(  
  data = beaches,  
  aes(x = temperature,  
      fill = season_name)) +  
  geom_density() +  
  facet_wrap(~ season_name, ncol = 1)
```

Let's explode these out

This is called "small multiples" (Tufte) or "trellis graphics" (Cleveland)

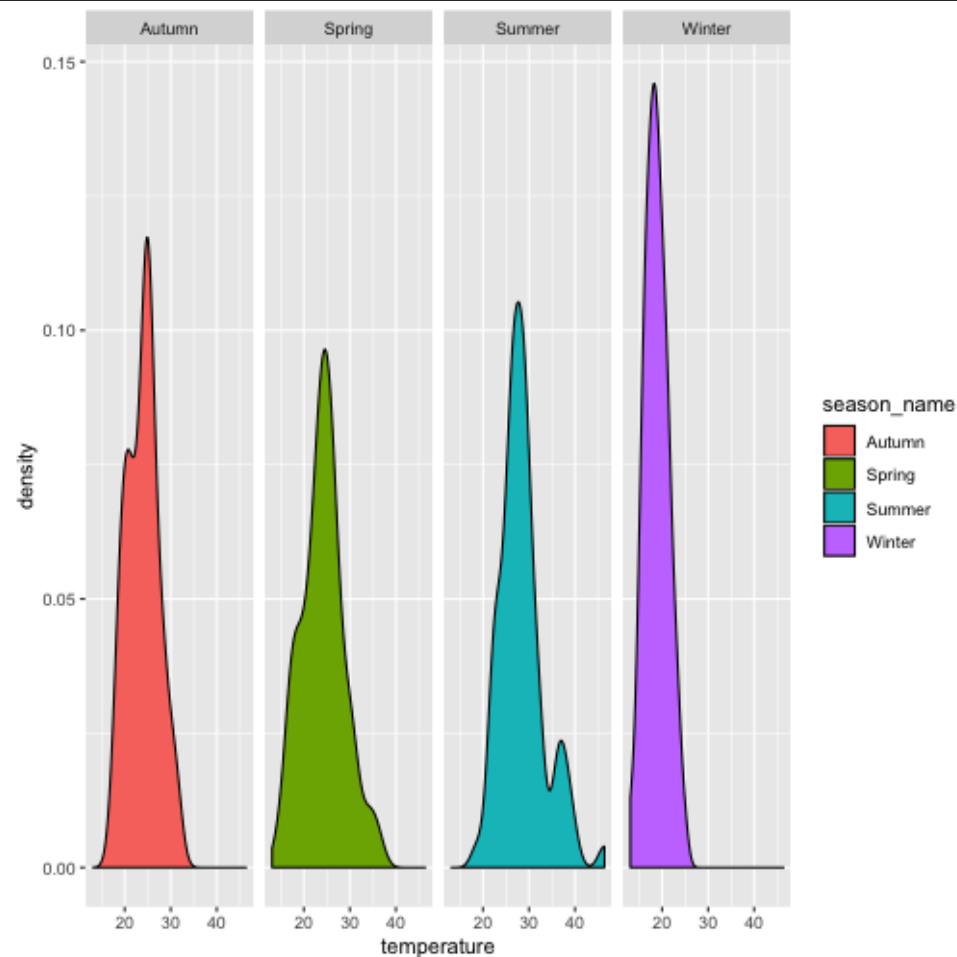


Notice that all the graphs have the same x-axis. This is a good thing

Exploding graphs

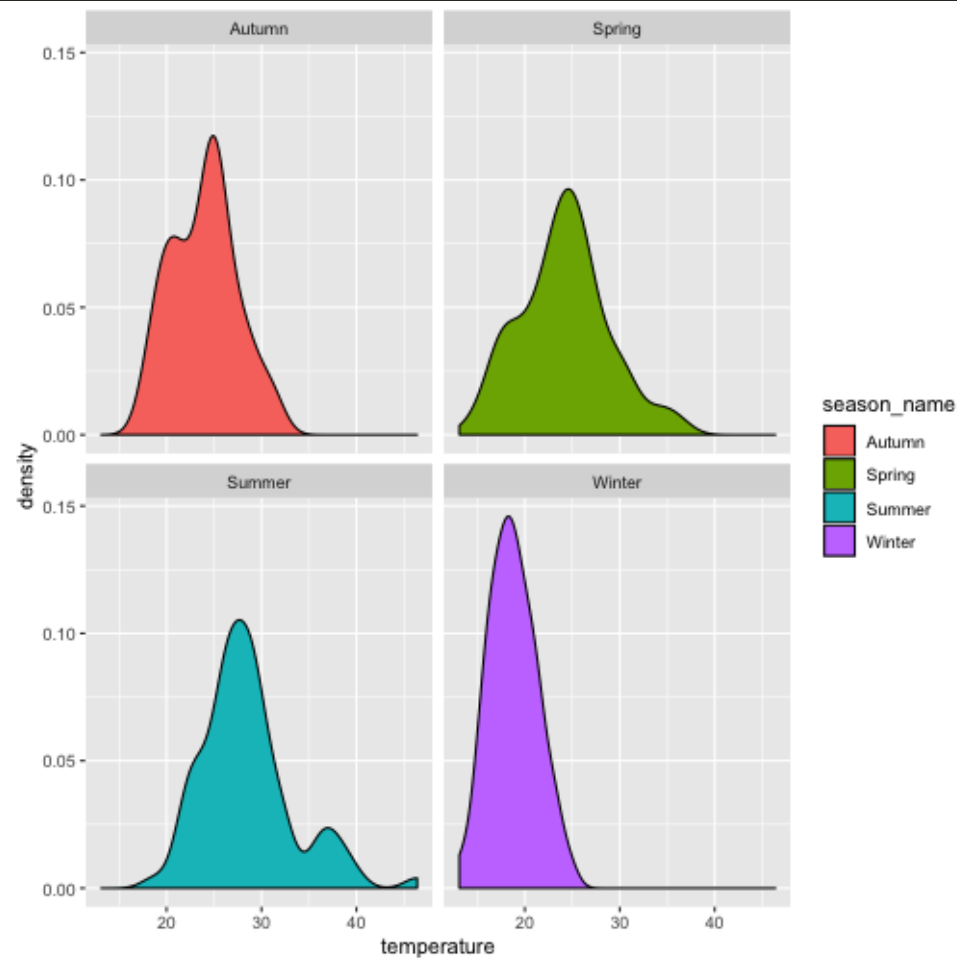
```
ggplot(  
  data = beaches,  
  aes(x = temperature,  
      fill = season_name)) +  
  geom_density() +  
  facet_wrap(~ season_name, nrow = 1)
```

We can arrange them the other way too



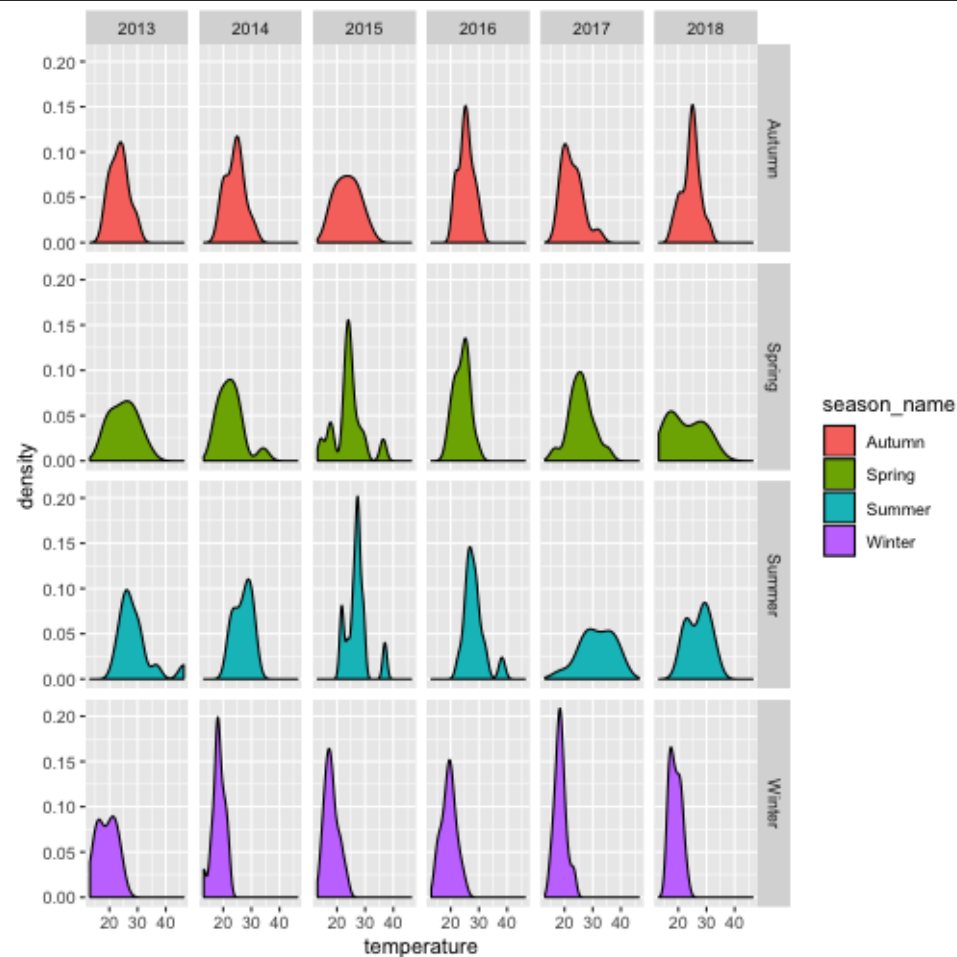
Re-arranging graphs

```
ggplot(  
  data = beaches,  
  aes(x = temperature,  
       fill = season_name)) +  
  geom_density() +  
  facet_wrap(~season_name, ncol = 2)
```



Creating a grid of graphs

```
ggplot(  
  data = beaches,  
  aes(x = temperature)) +  
  geom_density(aes(fill = season_name)) +  
  facet_grid(rows = vars(season_name),  
             cols = vars(year))
```



Grids of graphs

Start with a blank slate

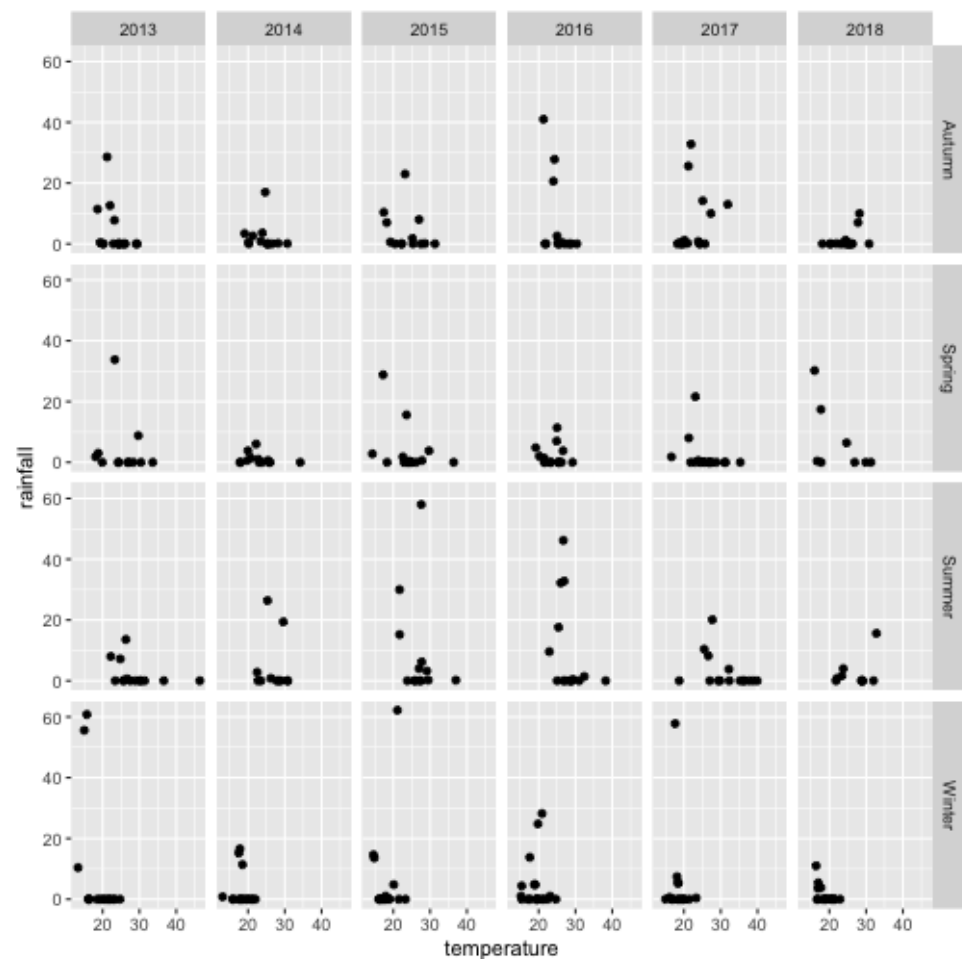
```
ggplot(  
  data = beaches) +  
  facet_grid(rows = vars(season_name),  
             cols = vars(year))
```



Grids of graphs

Create geoms you want

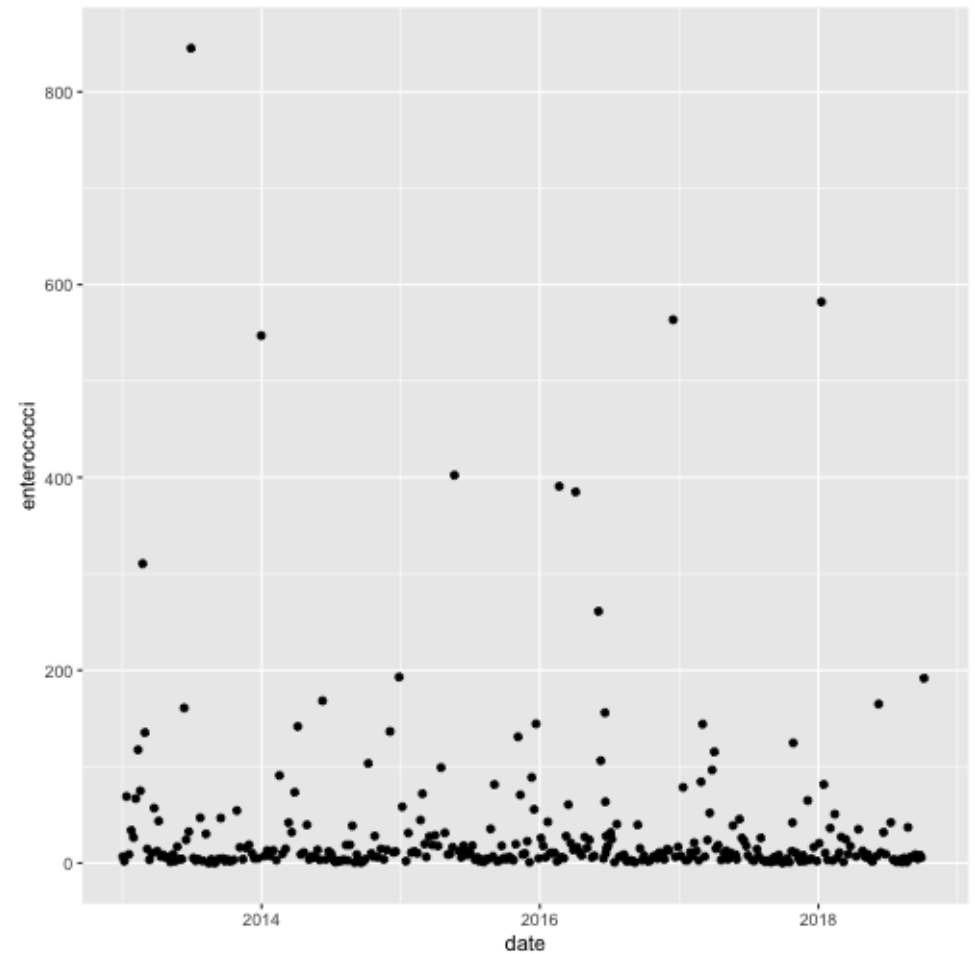
```
ggplot(  
  data = beaches) +  
  facet_grid(rows = vars(season_name),  
             cols = vars(year))+  
  geom_point(aes(x = temperature, y = rainfall))
```



Scales

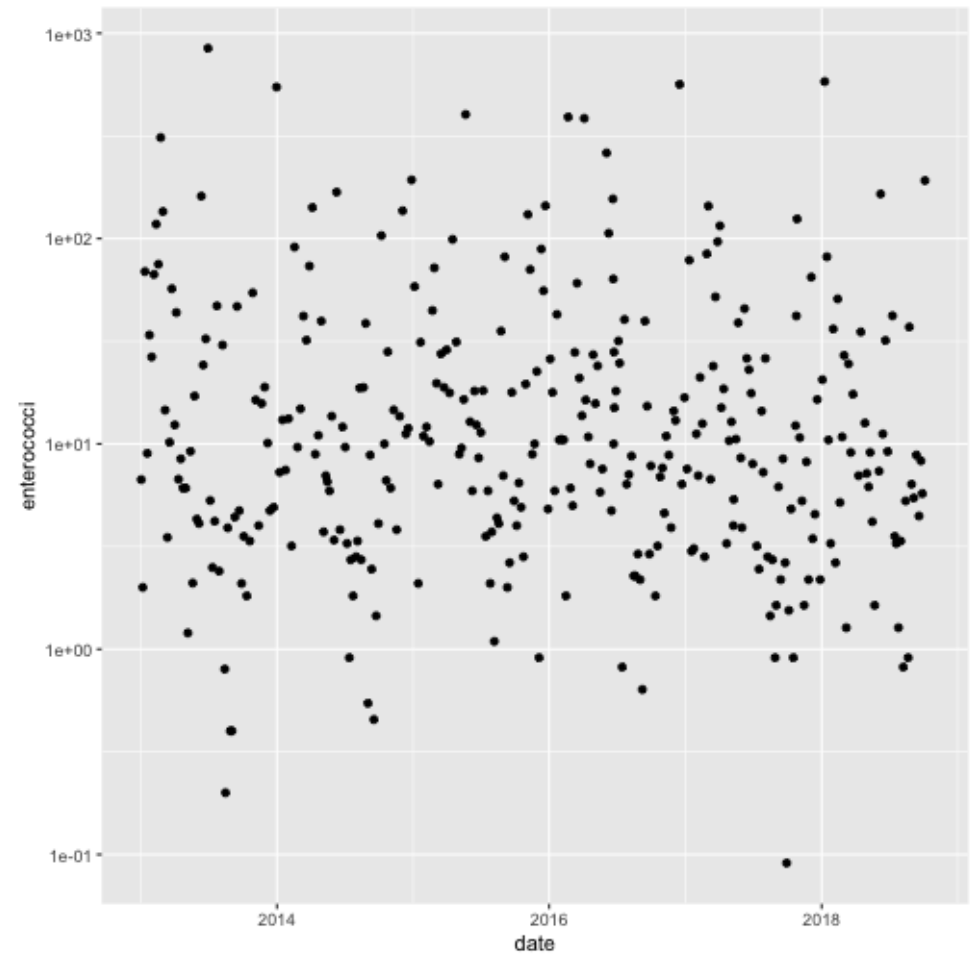
```
ggplot(
  data = beaches,
  aes(x = date, y = enterococci)) +
  geom_point()
```

All the action is happening in the bottom bit



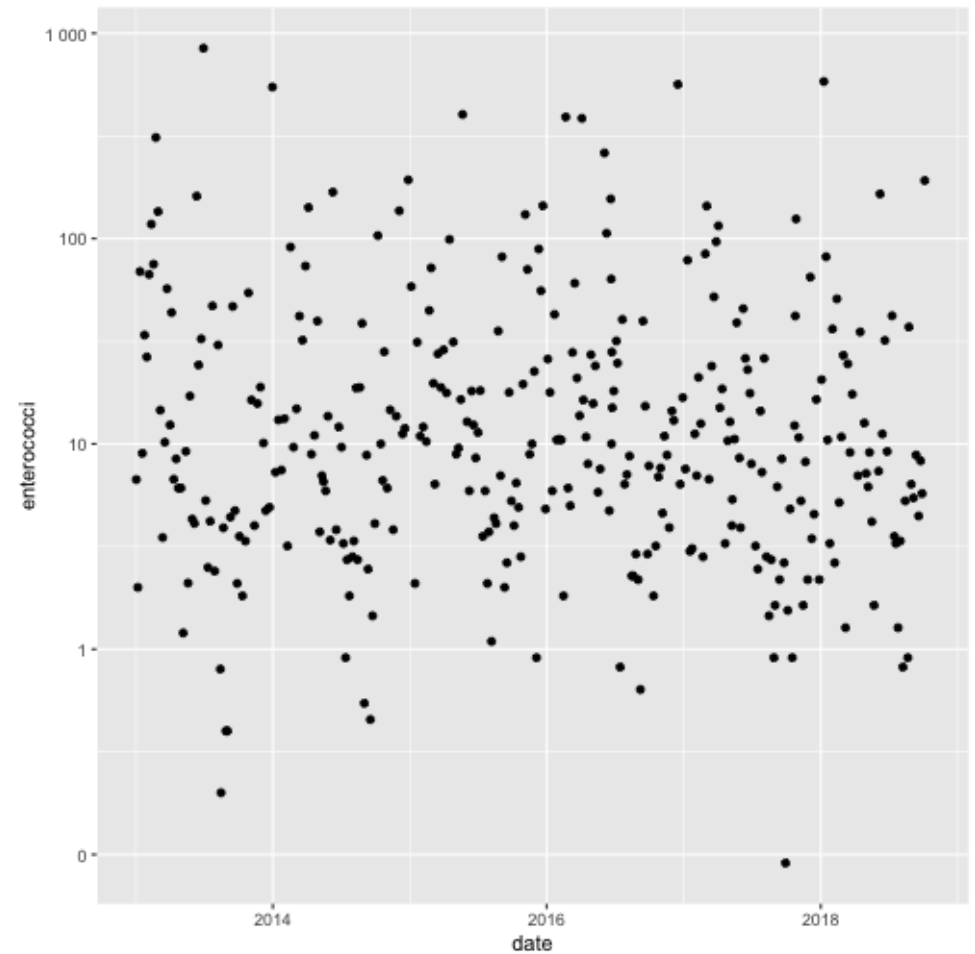

```
ggplot(  
  data = beaches,  
  aes(x = date, y = enterococci)) +  
  geom_point() +  
  scale_y_log10()
```

Log-transforming an axis can make things easier to see



```
ggplot(
  data = beaches,
  aes(x = date, y = enterococci)) +
  geom_point() +
  scale_y_log10(
    labels = scales::number_format(digits=3))
```

Making the labels a bit easier to read



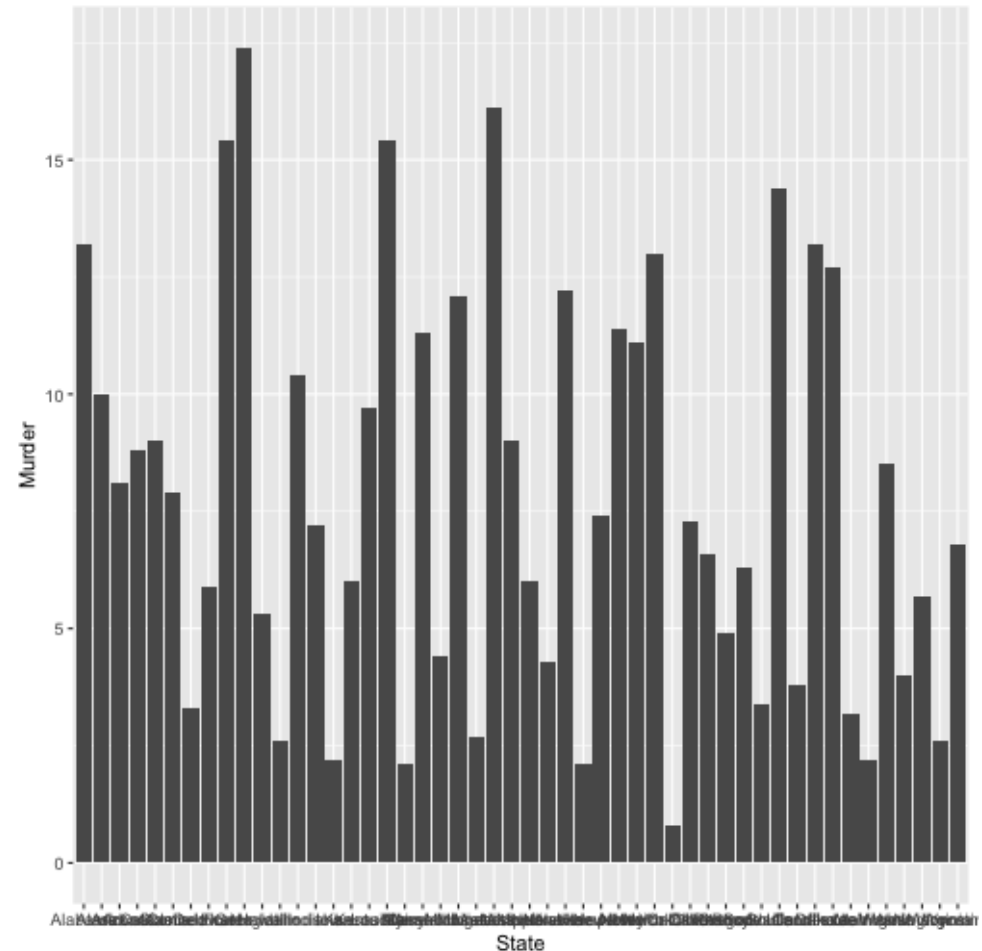
Order and orientation

Arrests in the USA in 1973

```
arrests <- import('data/USArrests.csv')
ggplot(
  data = arrests,
  aes(x = State,
      y = Murder)) +
  geom_bar(stat = 'identity')
```

This plot is very hard to read

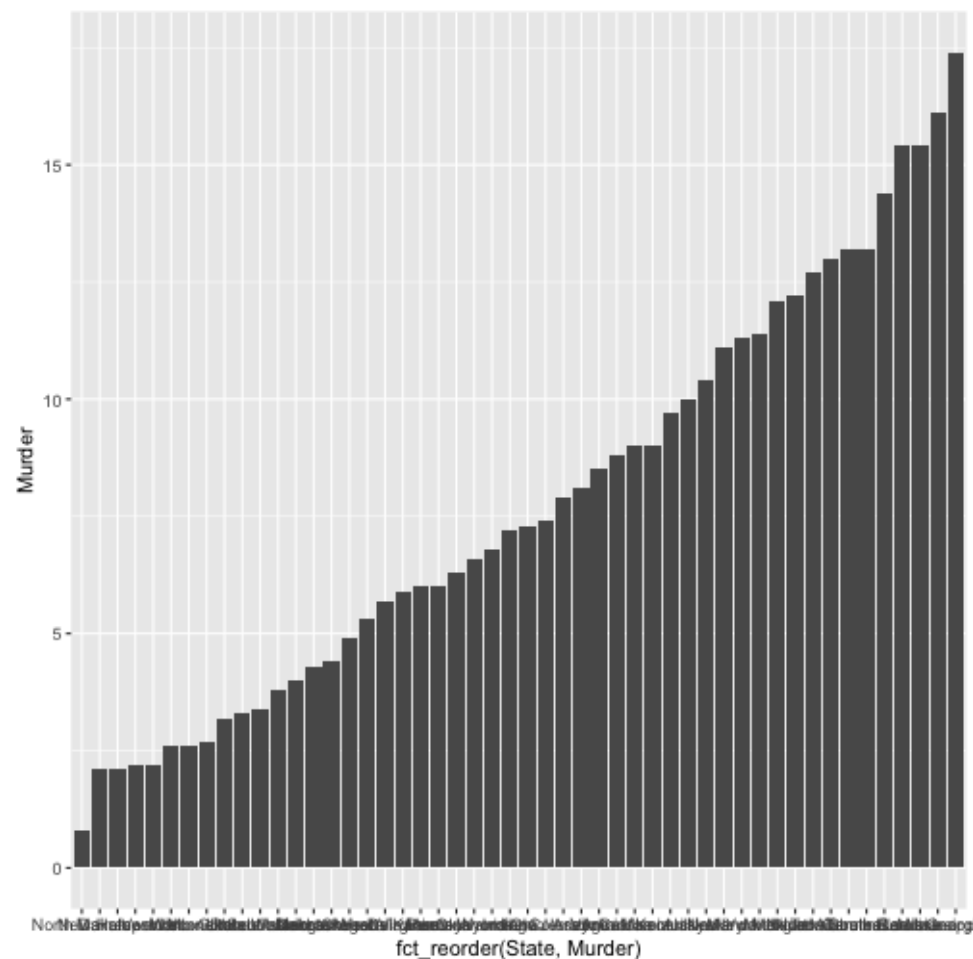
There is no ordering, and states can't be read



Arrests in the USA in 1973

```
arrests <- import('data/USArrests.csv')
ggplot(
  data = arrests,
  aes(x = fct_reorder(State, Murder), # Order by murder
    y = Murder)) +
  geom_bar(stat = 'identity')
```

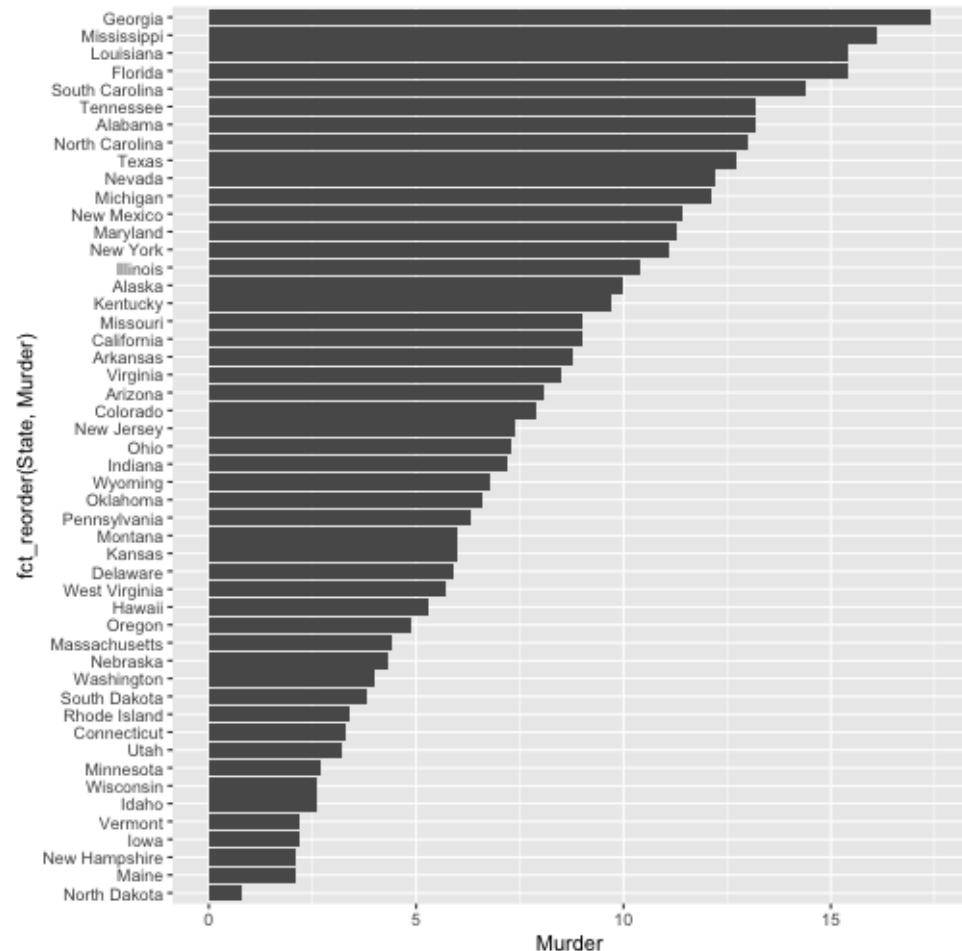
We see the pattern, but its still unreadable



Arrests in the USA in 1973

```
arrests <- import('data/USArrests.csv')
ggplot(
  data = arrests,
  aes(x = fct_reorder(State, Murder), # Order by murder
      y = Murder)) +
  geom_bar(stat = 'identity') +
  coord_flip()
```

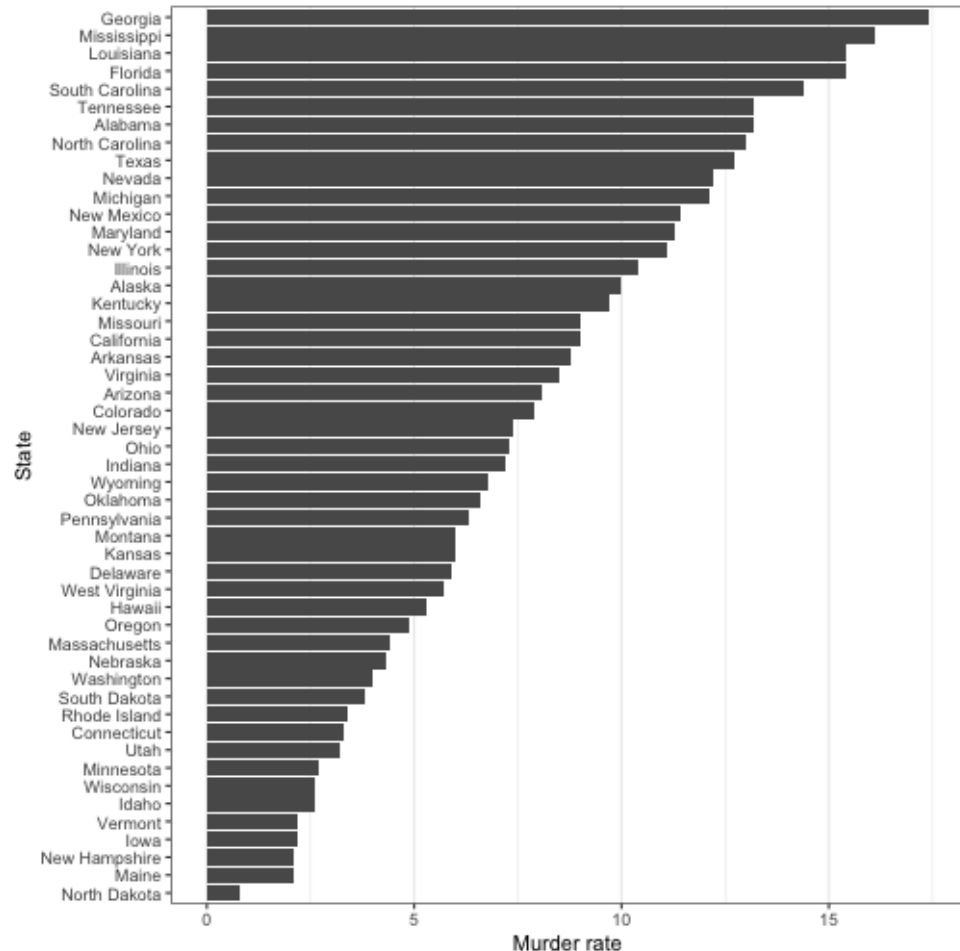
Flipping the axes makes the states readable



Arrests in the USA in 1973

```
arrests <- import('data/USArrests.csv')
ggplot(
  data = arrests,
  aes(x = fct_reorder(State, Murder), # Order by murder rate
      y = Murder)) +
  geom_bar(stat = 'identity') +
  labs(x = 'State', y = 'Murder rate') +
  theme_bw() +
  theme(panel.grid.major.y = element_blank(),
        panel.grid.minor.y = element_blank()) +
  coord_flip()
```

Cleaning it up a little



Themes

Color schemes

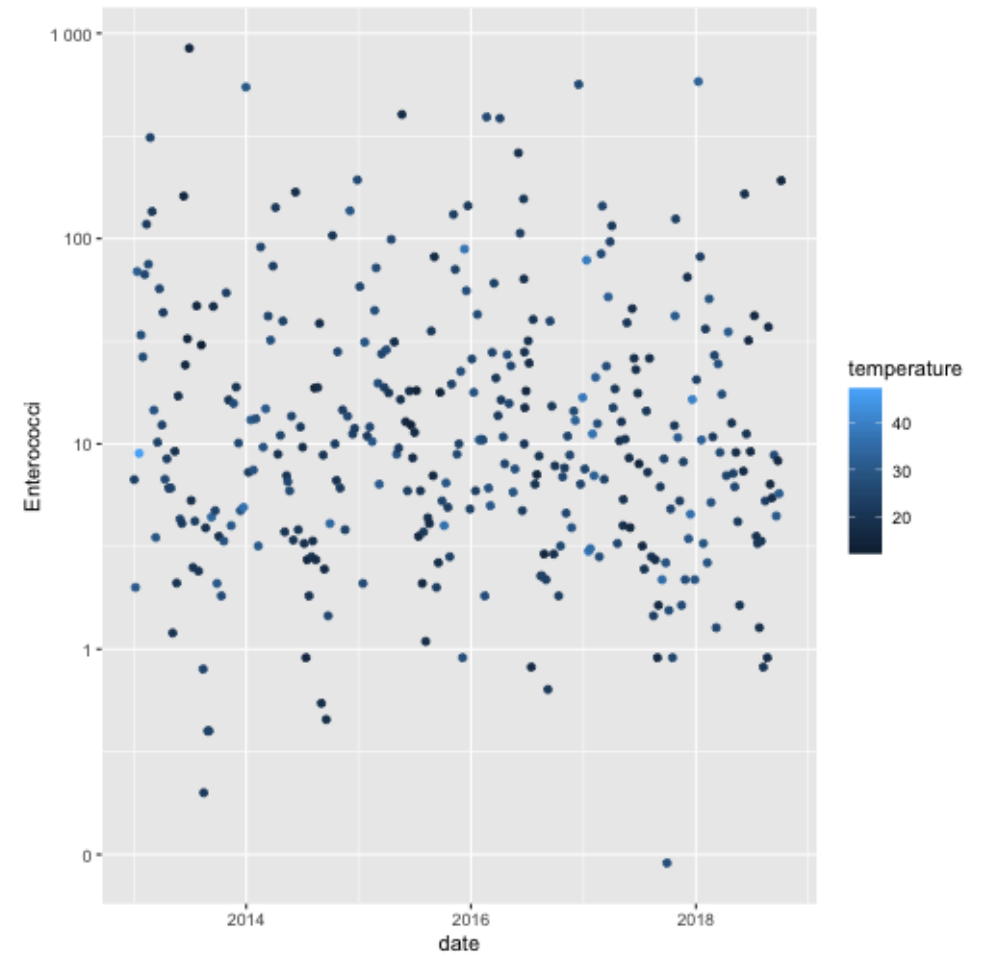
ggplot comes with a default color scheme. There are several other schemes available

- `scale*_brewer` uses the [ColorBrewer](#) palettes
- `scale*_gradient` uses gradients
- `scale*_distill` uses the ColorBrewer palettes, for continuous outcomes

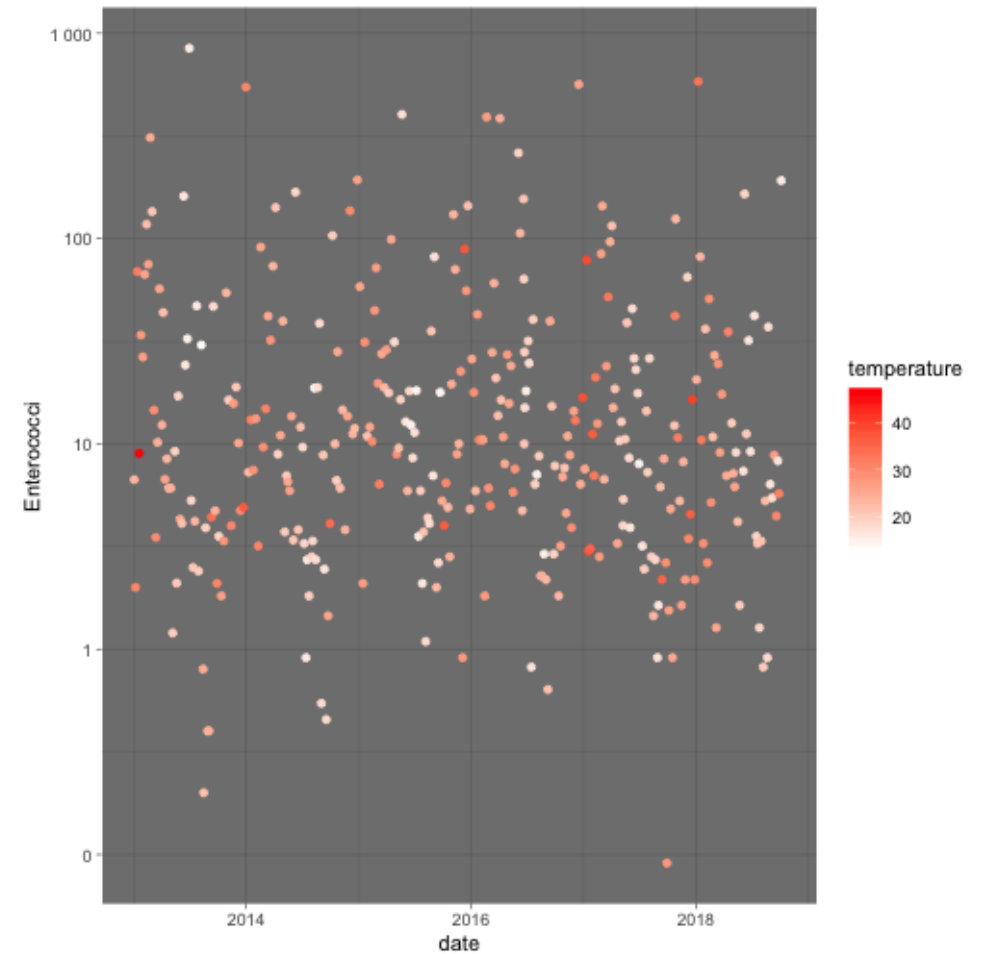
Here `*` can be `color` or `fill`, depending on what you want to color

Note `color` refers to the outline, and `fill` refers to the inside

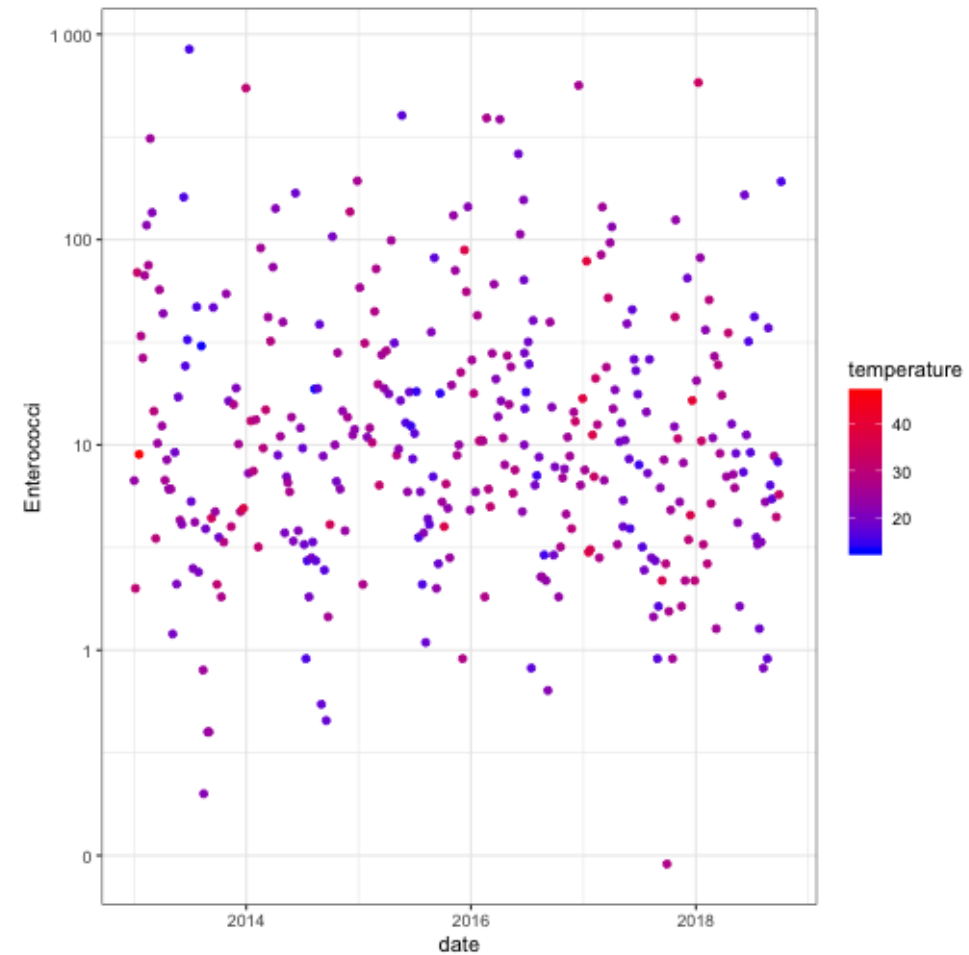
```
ggplot(
  data = beaches,
  aes(x = date, y = enterococci,
      color = temperature)) +
  geom_point() +
  scale_y_log10(name = 'Enterococci',
               label = scales::number_format(digits=
```



```
ggplot(
  data = beaches,
  aes(x = date, y = enterococci,
      color = temperature)) +
  geom_point() +
  scale_y_log10(name = 'Enterococci',
               label = scales::number_format(digits=
  scale_color_gradient(low = 'white', high='red') +
  theme_dark()
```

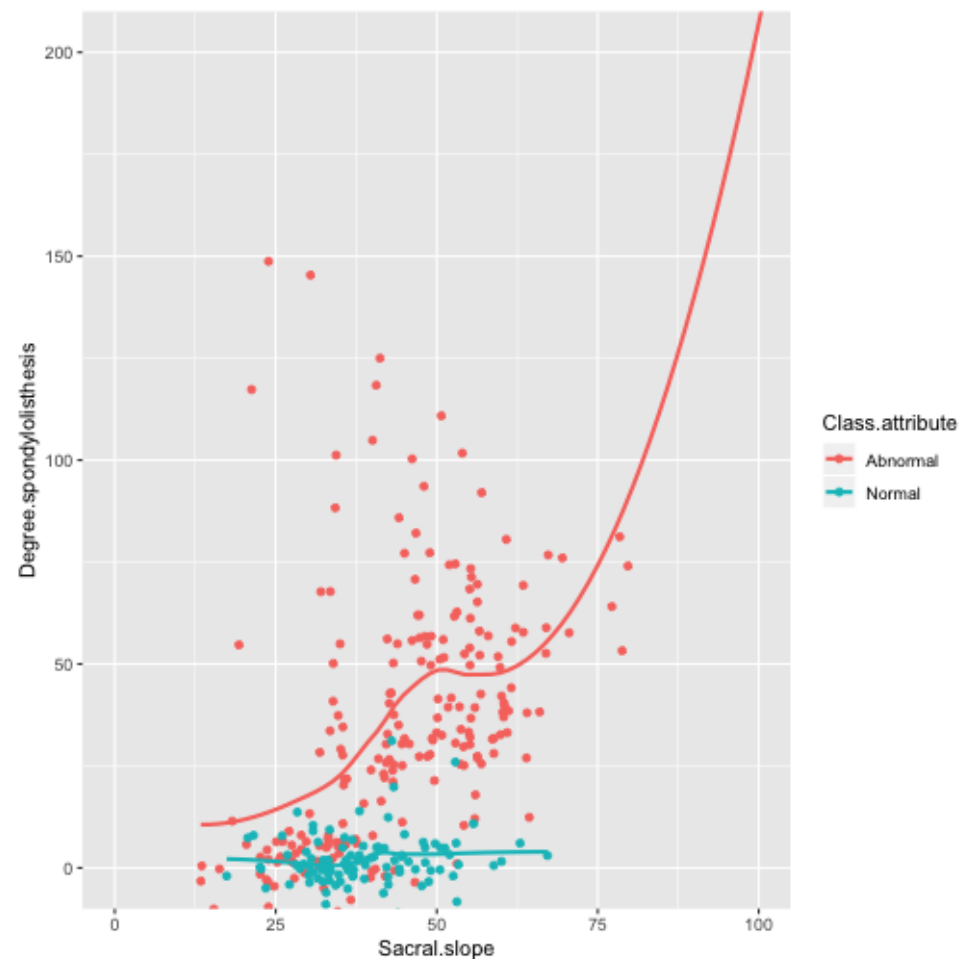


```
ggplot(
  data = beaches,
  aes(x = date, y = enterococci,
      color = temperature)) +
  geom_point() +
  scale_y_log10(name = 'Enterococci',
               label = scales::number_format(digits=
  scale_color_gradient(low = 'blue', high='red') +
  theme_bw()
```



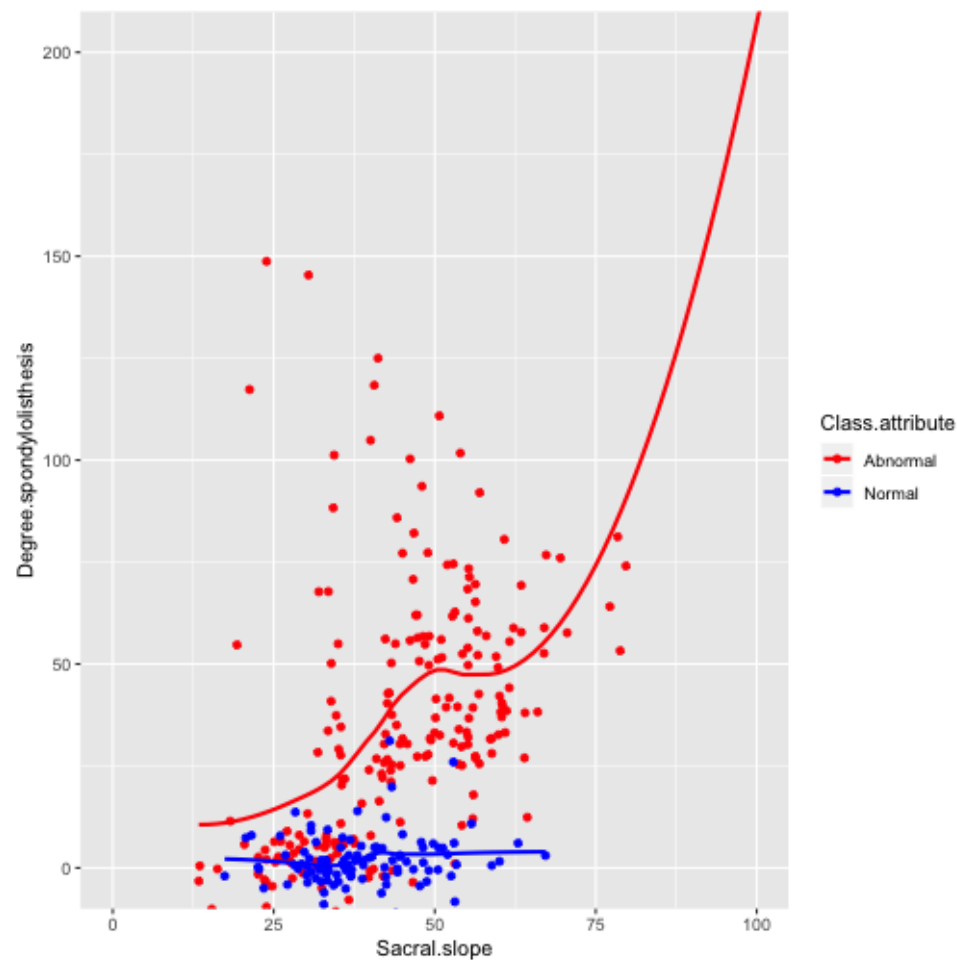
Specifying colors

```
ggplot(  
  data = dat_spine,  
  aes(x = Sacral.slope, y = Degree.spondylolisthesis,  
      color = Class.attribute)) +  
  geom_point() +  
  geom_smooth(se = F) +  
  coord_cartesian(xlim = c(0, 100), ylim = c(0, 200))
```



Specifying colors

```
ggplot(
  data = dat_spine,
  aes(x = Sacral.slope, y = Degree.spondylolisthesis,
      color = Class.attribute)) +
  geom_point() +
  geom_smooth(se = F) +
  coord_cartesian(xlim = c(0, 100), ylim = c(0, 200))
  scale_color_manual(values = c("Normal"="blue", 'Abn
```



Themes

You can create your own custom themes to keep a unified look to your graphs

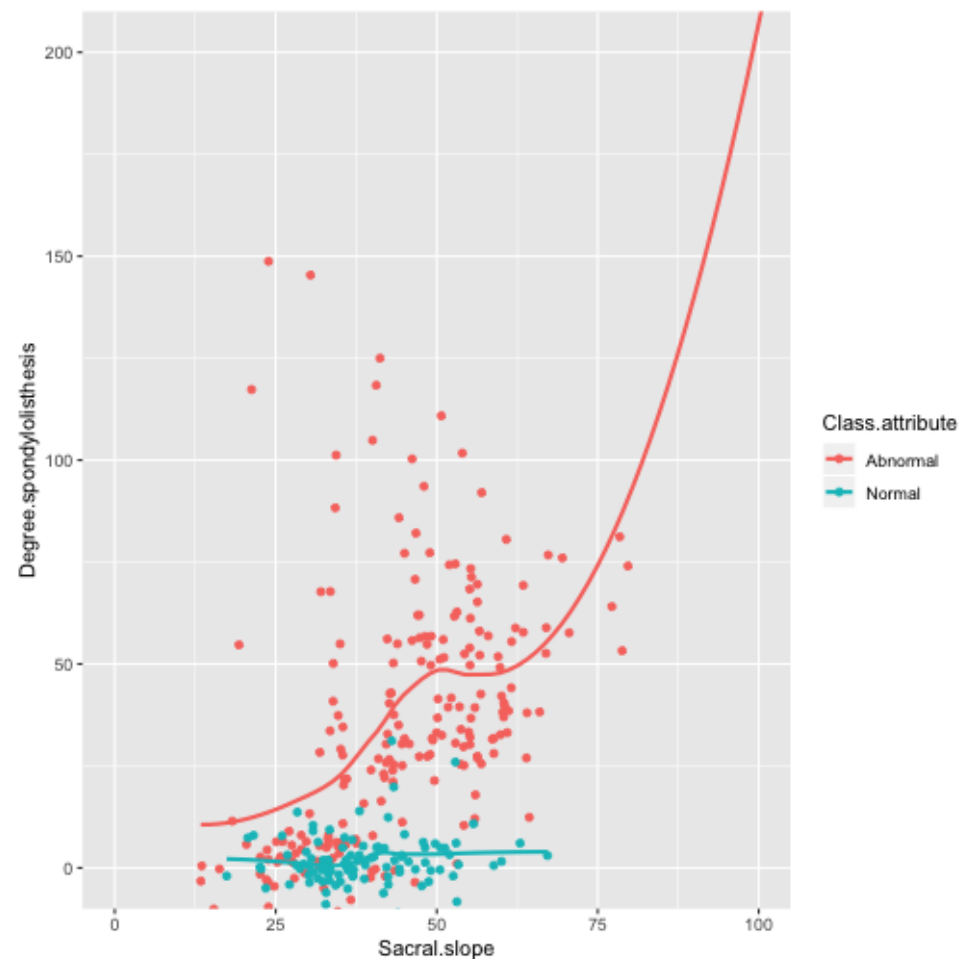
ggplot comes with

- `theme_classic`
- `theme_bw`
- `theme_void`
- `theme_dark`
- `theme_gray`
- `theme_light`
- `theme_minimal`

Themes

Create your own

```
ggplot(  
  data = dat_spine,  
  aes(x = Sacral.slope, y = Degree.spondylolisthesis,  
      color = Class.attribute)) +  
  geom_point() +  
  geom_smooth(se = F) +  
  coord_cartesian(xlim = c(0, 100),  
                  ylim = c(0, 200))
```

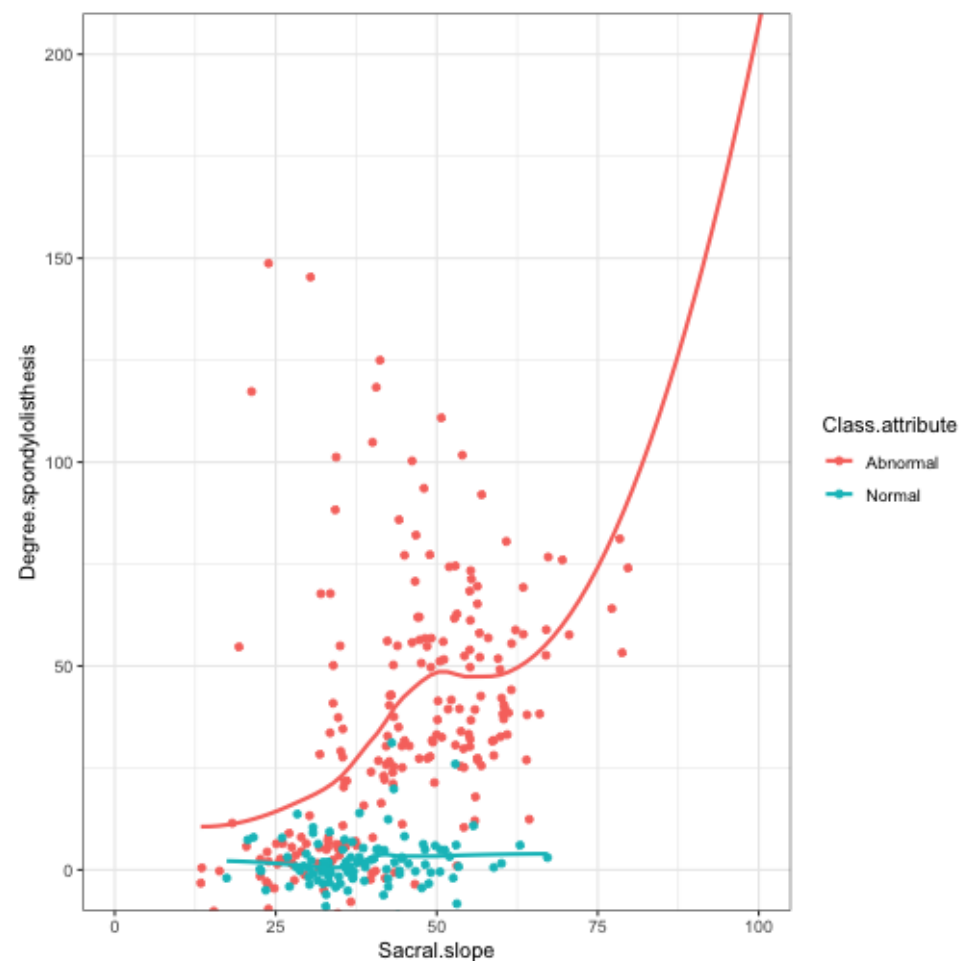


Themes

Create your own

```
my_theme <- function(){
  theme_bw()
}

ggplot(
  data = dat_spine,
  aes(x = Sacral.slope, y = Degree.spondylolisthesis,
      color = Class.attribute)) +
  geom_point() +
  geom_smooth(se = F) +
  coord_cartesian(xlim = c(0, 100),
                  ylim = c(0, 200)) +
  my_theme()
```

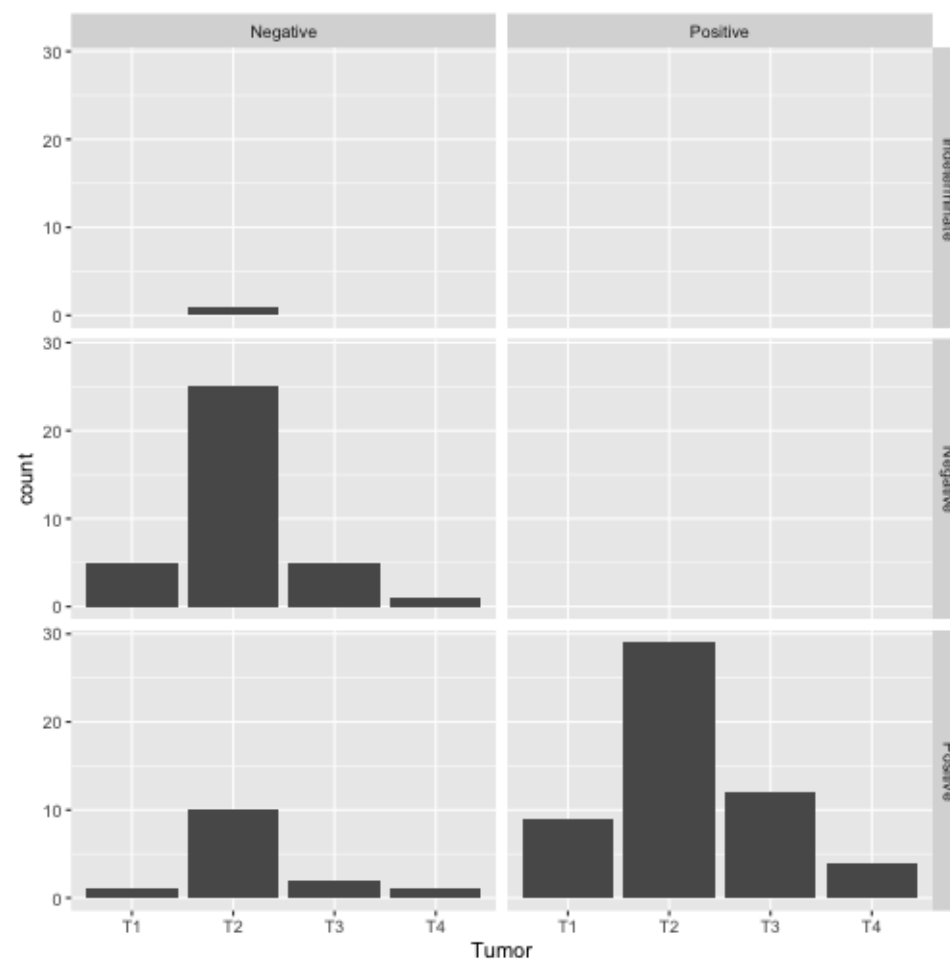


Themes

Create your own

```
my_theme <- function(){
  theme_bw() +
    theme(axis.text = element_text(size = 14),
          axis.title = element_text(size = 16),
          panel.grid.minor = element_blank(),
          strip.text = element_text(size=14),
          strip.background = element_blank())
}

ggplot(
  data = dat_brca,
  aes(x = Tumor)) +
  geom_bar() +
  facet_grid(rows = vars(ER.Status),
            cols = vars(PR.Status))
```

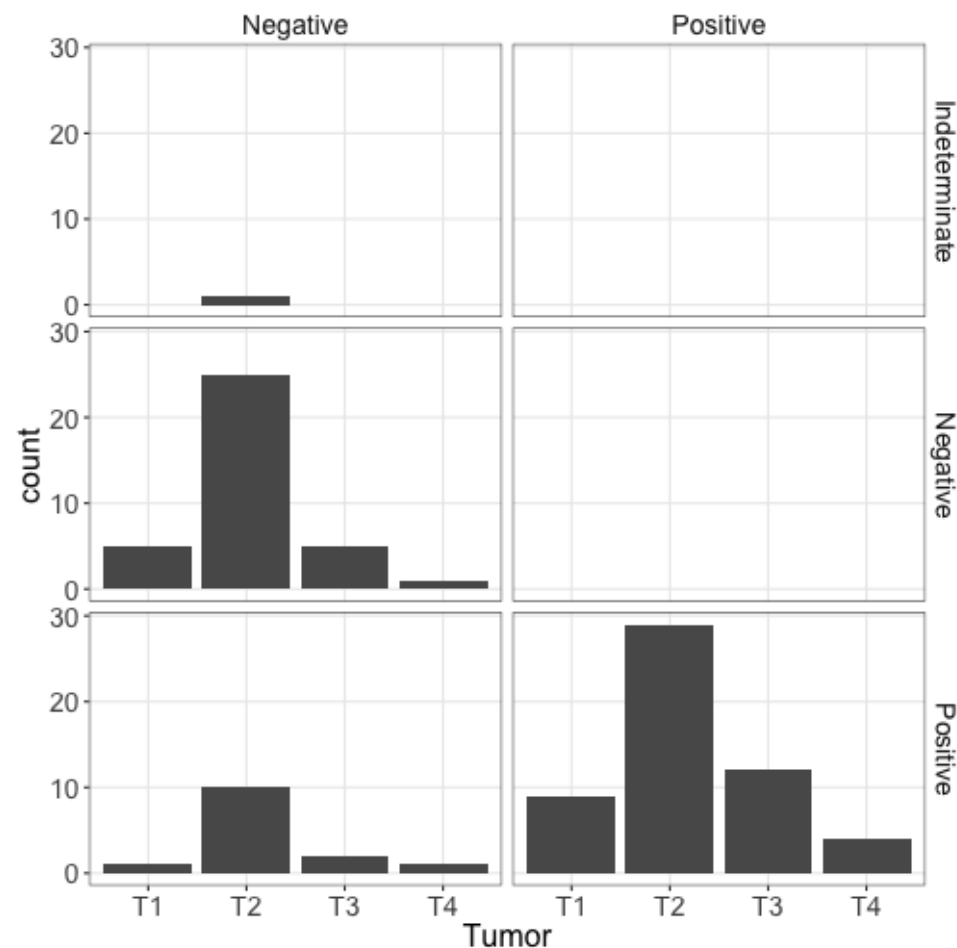


Themes

Create your own

```
my_theme <- function(){
  theme_bw() +
    theme(axis.text = element_text(size = 14),
          axis.title = element_text(size = 16),
          panel.grid.minor = element_blank(),
          strip.text = element_text(size=14),
          strip.background = element_blank())
}

ggplot(
  data = dat_brca,
  aes(x = Tumor)) +
  geom_bar() +
  facet_grid(rows = vars(ER.Status),
            cols = vars(PR.Status)) +
  my_theme()
```



Animations

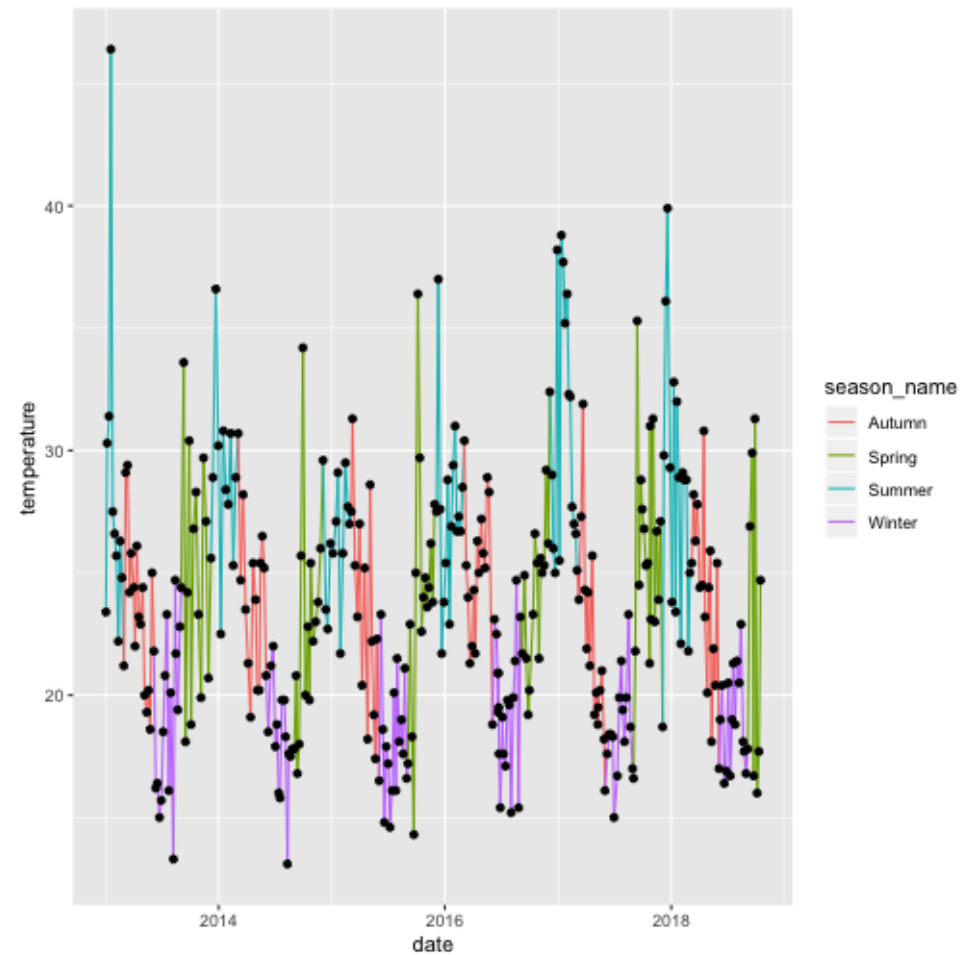
gganimate

The new `gganimate` package has made it very easy to create animations

It's literally a few lines

```
library(gganimate)
plt <- ggplot(beaches,
              aes(date, temperature))+
  geom_path(aes(color = season_name, group = 1))+
  geom_point()

plt
```



```
library(gganimate)
plt <- ggplot(beaches,
              aes(date, temperature))+
  geom_path(aes(color = season_name, group = 1))+
  geom_point()

plt + transition_reveal(date)
```

