Week 11: *Data Visualization*

EMSE 4571: Intro to Programming for Analytics

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April 07, 2022

Quiz 6

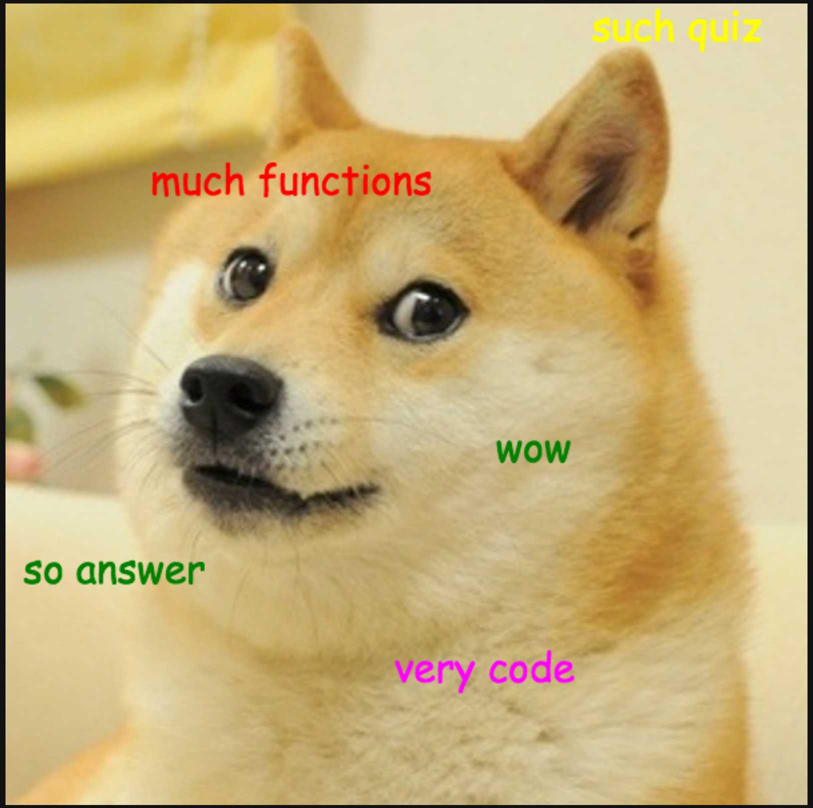
05:00

Go to `#class` channel in Slack for quiz link

Open RStudio first!

Rules:

- You may use your notes and RStudio
- You may **not** use any other resources (e.g. the internet, your classmates, etc.)



Before we start

Make sure you have the "tidyverse" installed and loaded, and import these two data frames

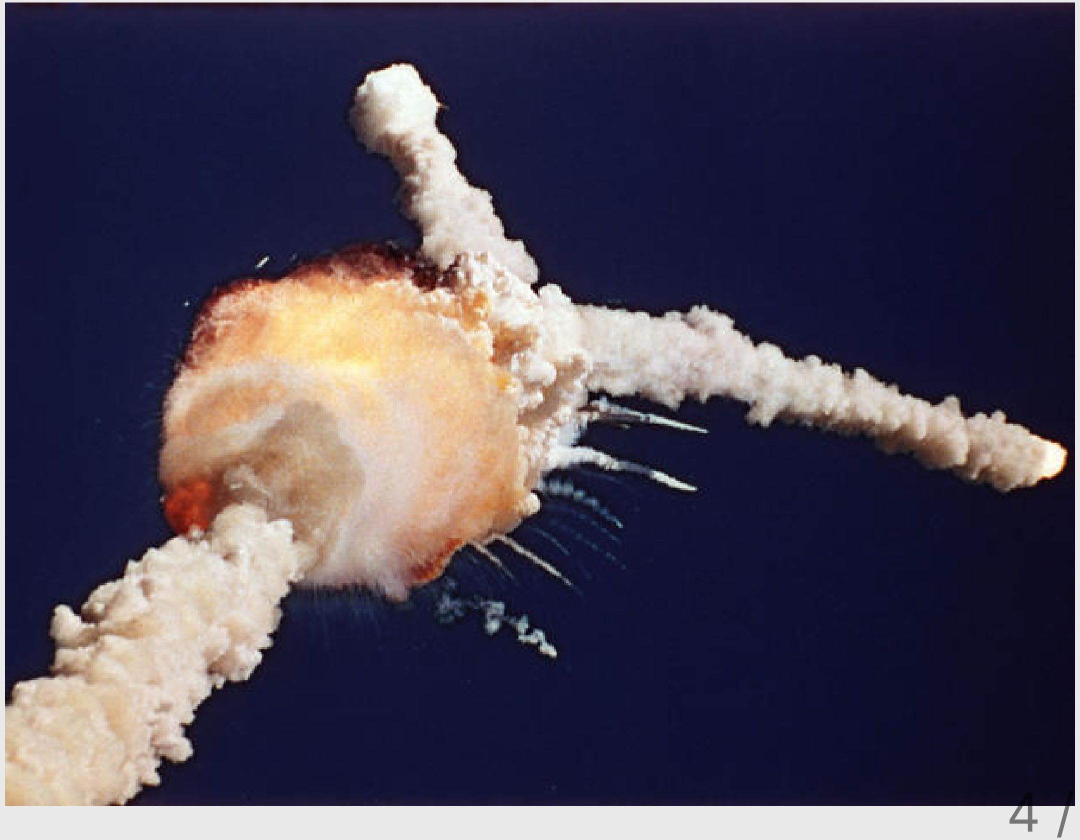
```r
library(tidyverse)
library(here)

birds <- read_csv(here('data', 'wildlife_impacts.csv'))
bears <- read_csv(here('data', 'bear_killings.csv'))
```

(this is at the top of the `notes-blank.R` file)

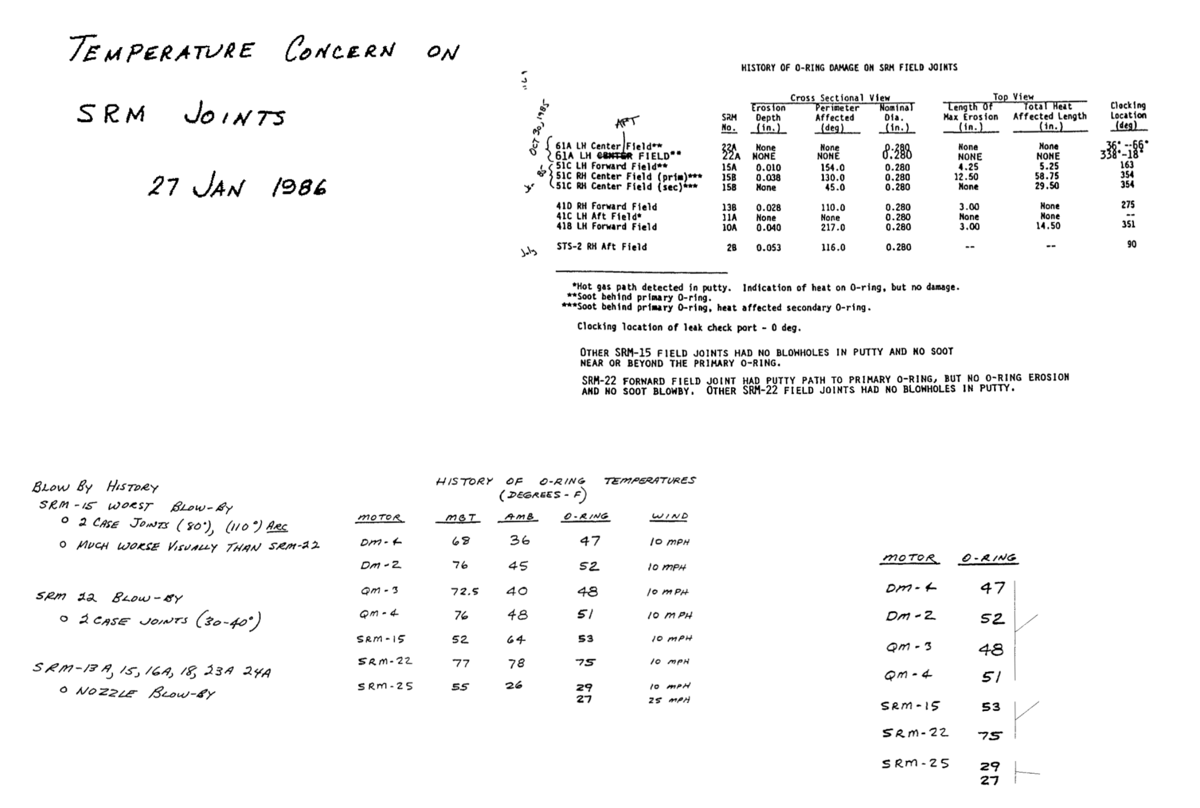
The Challenger disaster

On January 28, 1986 the space shuttle Challenger exploded



The Challenger disaster

NASA Engineers had the data on temperature & o-ring failure



TEMPERATURE CONCERN ON

SRM JOINTS

27 JAN 1986

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

			Cross Sectional View			Top View		
		SRM No.	Erosion Depth (in.)	Perimeter Affected (deg)	Nominal Dia. (in.)	Length Of Max Erosion (in.)	Total Heat Affected Length (in.)	Clocking Location (deg)
OCT 30, 1985	61A LH Center Field**	22A	None	None	0.280	None	None	36° - 66°
	61A LH ~~CENTER~~ AFT FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338° - 18°
85	51C LH Forward Field**	15A	0.010	154.0	0.280	4.25	5.25	163
	51C RH Center Field (prim)***	15B	0.038	130.0	0.280	12.50	58.75	354
	51C RH Center Field (sec)***	15B	None	45.0	0.280	None	29.50	354
	41D RH Forward Field	13B	0.028	110.0	0.280	3.00	None	275
	41C LH Aft Field*	11A	None	None	0.280	None	None	--
	41B LH Forward Field	10A	0.040	217.0	0.280	3.00	14.50	351
July	STS-2 RH Aft Field	2B	0.053	116.0	0.280	--	--	90

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

BLOW BY HISTORY

SRM-15 WORST BLOW-BY

- 2 CASE JOINTS (80°), (110°) ARC
- MUCH WORSE VISUALLY THAN SRM-22

SRM 22 BLOW-BY

- 2 CASE JOINTS (30-40°)

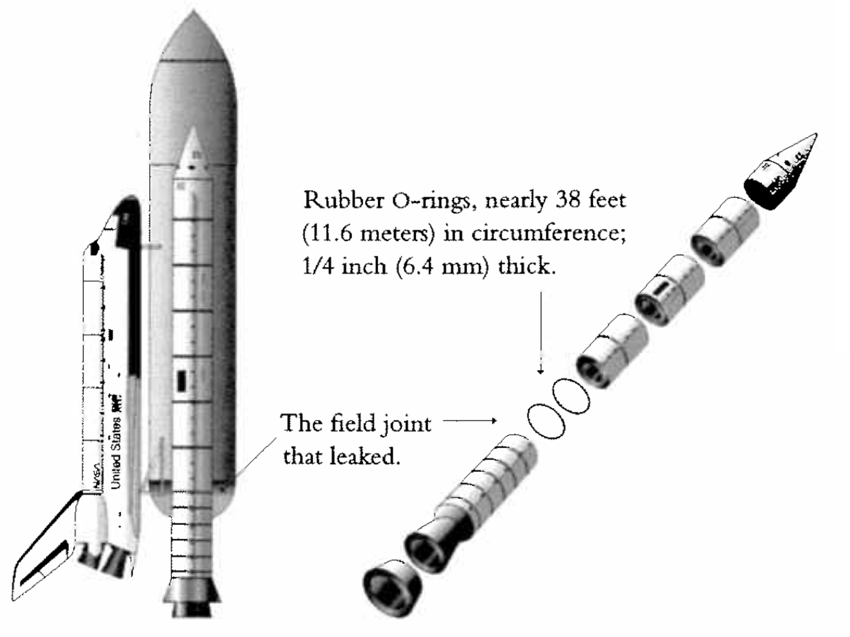
SRM-13A, 15, 16A, 18, 23A 24A

- NOZZLE BLOW-BY

HISTORY OF O-RING TEMPERATURES
(DEGREES - F)

MOTOR	MBT	AMB	O-RING	WIND
DM-4	68	36	47	10 MPH
DM-2	76	45	52	10 MPH
QM-3	72.5	40	48	10 MPH
QM-4	76	48	51	10 MPH
SRM-15	52	64	53	10 MPH
SRM-22	77	78	75	10 MPH
SRM-25	55	26	29 27	10 MPH 25 MPH

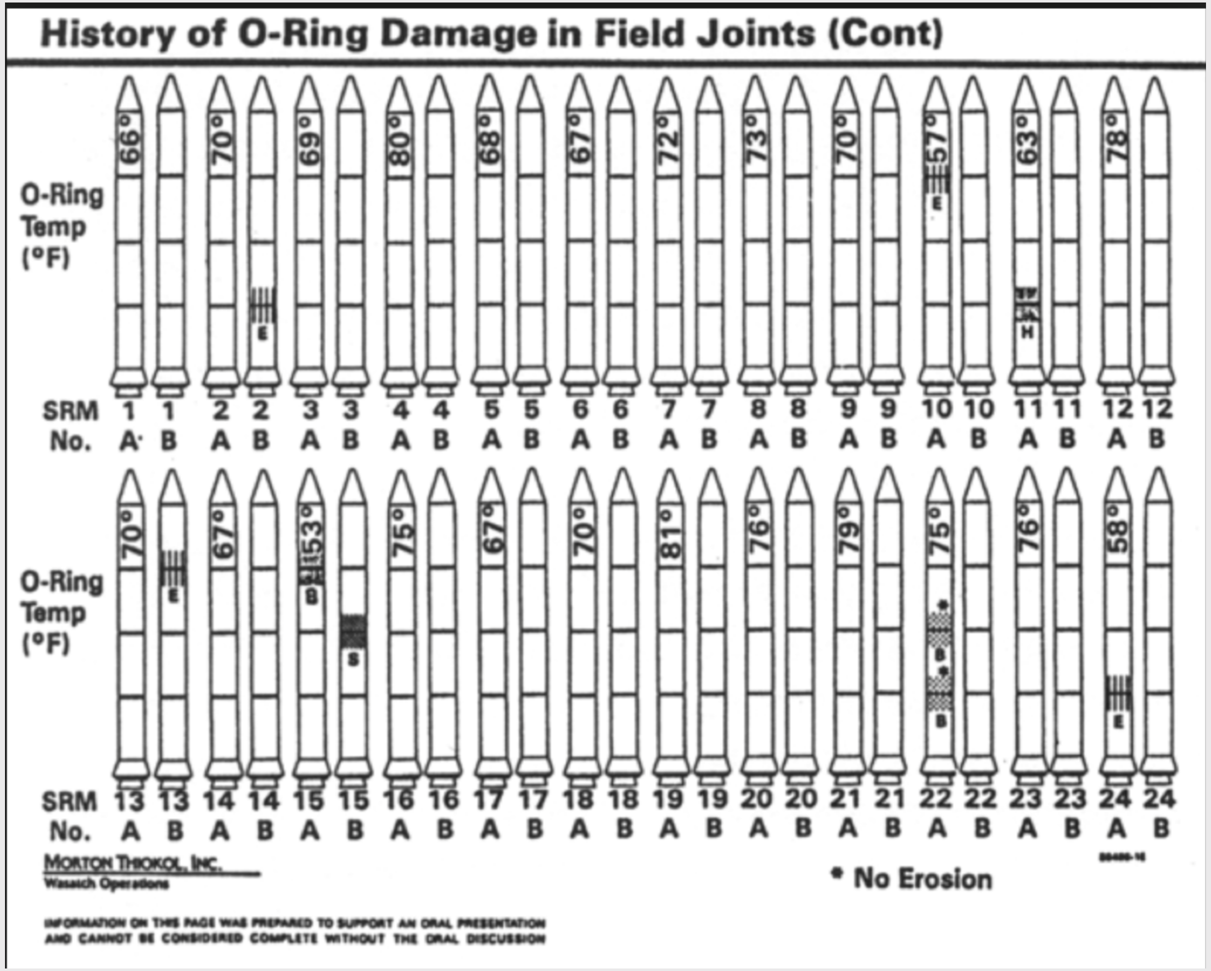
MOTOR	O-RING
DM-4	47
DM-2	52
QM-3	48
QM-4	51
SRM-15	53
SRM-22	75
SRM-25	29 27



Rubber O-rings, nearly 38 feet (11.6 meters) in circumference; 1/4 inch (6.4 mm) thick.

The field joint that leaked.

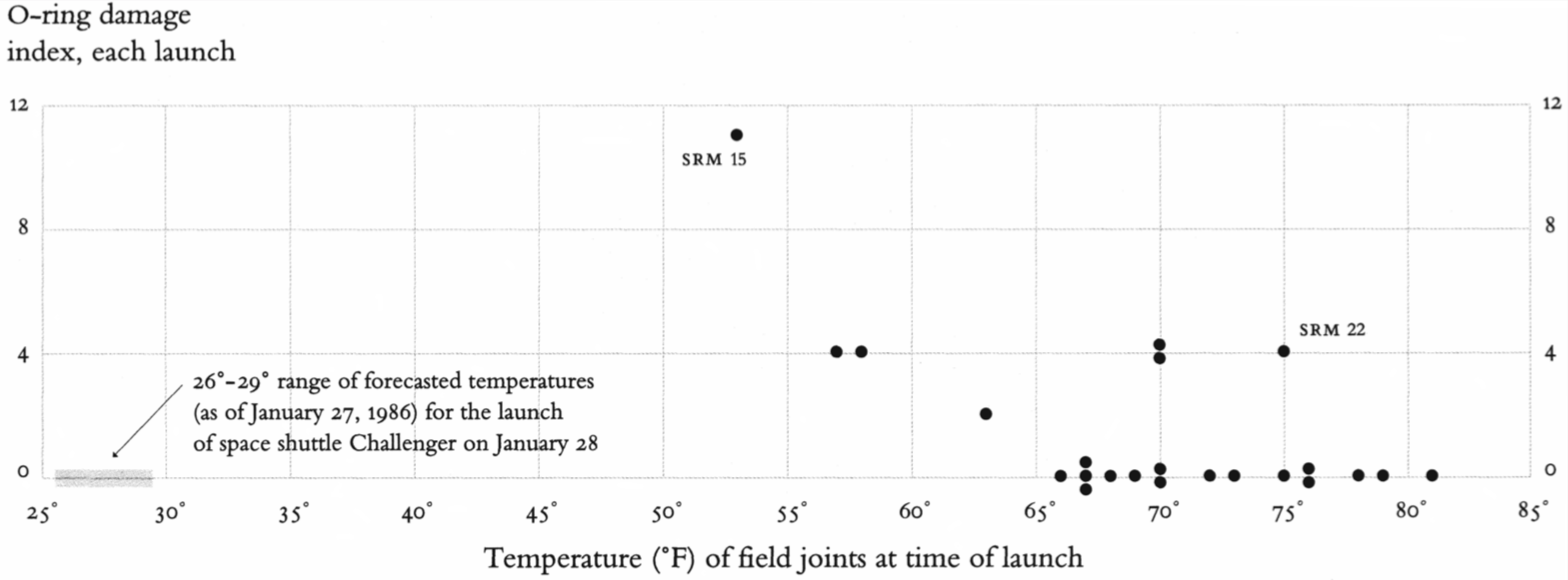
What NASA was shown



INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

Tufte, Edward R. (1997) *Visual Explanations: Images and Quantities, Evidence and Narrative*, Graphics Press, Cheshire, Connecticut.

What NASA *should* have been shown



Tufte, Edward R. (1997) *Visual Explanations: Images and Quantities, Evidence and Narrative*, Graphics Press, Cheshire, Connecticut.

Week 11: *Data Visualization*

1. Plotting with Base R

2. Plotting with ggplot2: Part 1

BREAK

3. Plotting with ggplot2: Part 2

4. Tweaking your ggplot

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Today's data:

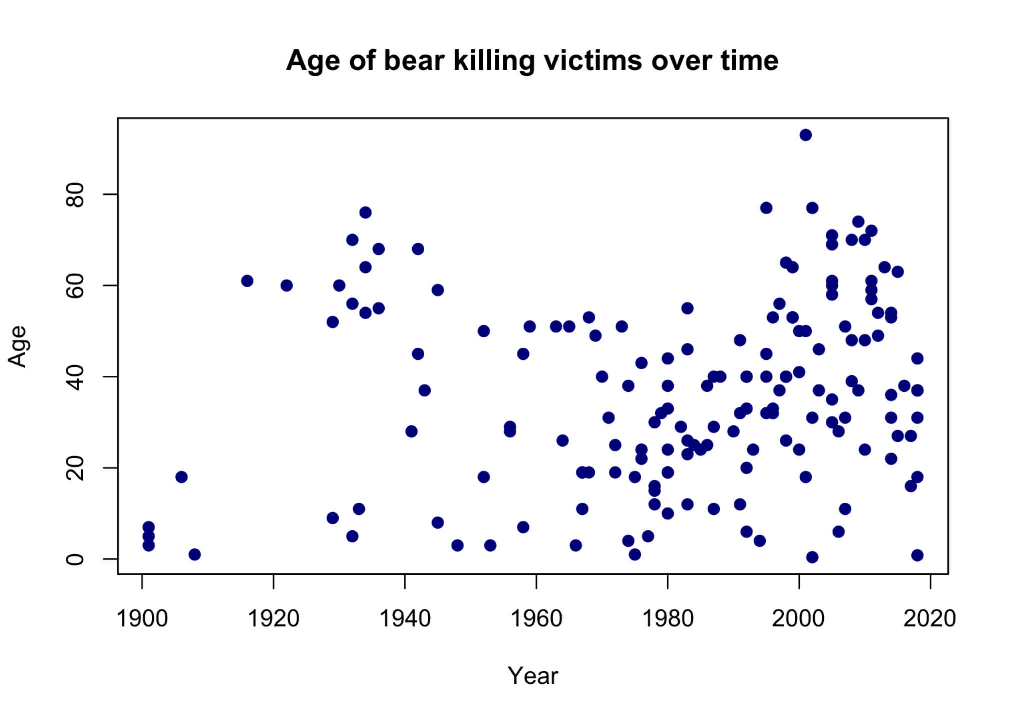
Bear attacks in North America

Explore the `bears` data frame:

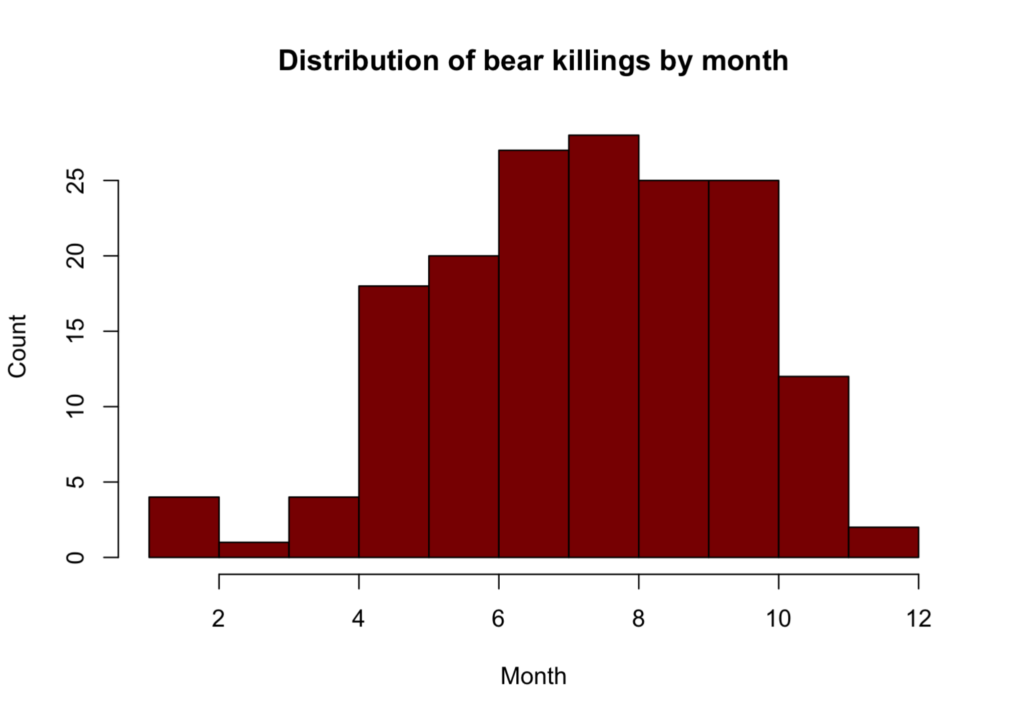
```
glimpse(bears)
head(bears)
```

Two basic plots in R

Scatterplots



Histograms



Scatterplots with `plot()`

Plot relationship between two variables

General syntax:

```
plot(x = x_vector, y = y_vector)
```

Scatterplots with `plot()`

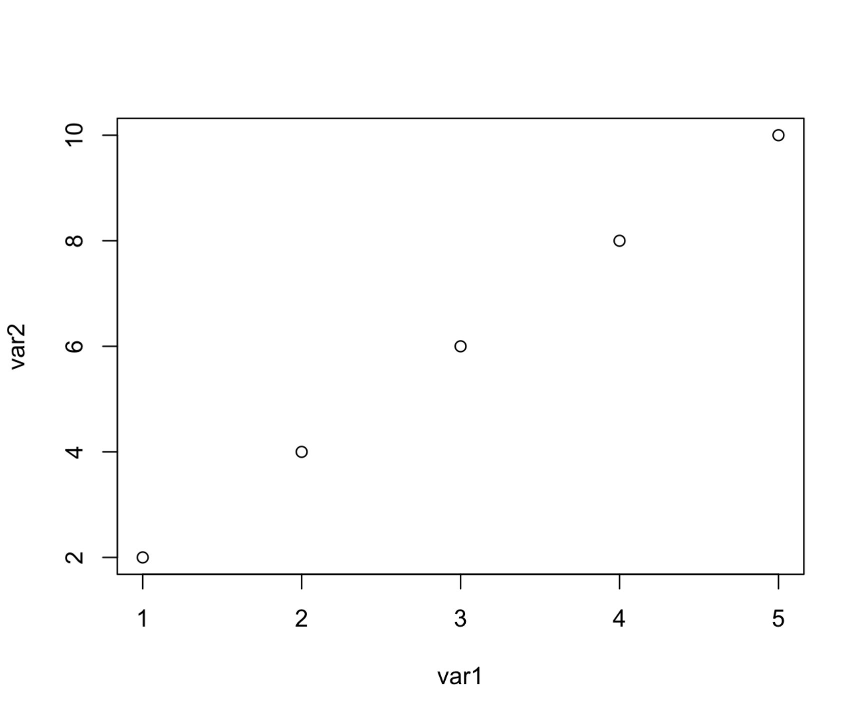
Plot relationship between two variables

General syntax:

```
plot(x = x_vector, y = y_vector)
```

Example:

```
var1 <- seq(1, 5)
var2 <- 2*var1
plot(x = var1, y = var2)
```



Scatterplots with plot()

x and y must have the same length!

```
var2 <- var2[-1]
```

```
length(var1) == length(var2)
```

```
#> [1] FALSE
```

```
plot(x = var1, y = var2)
```

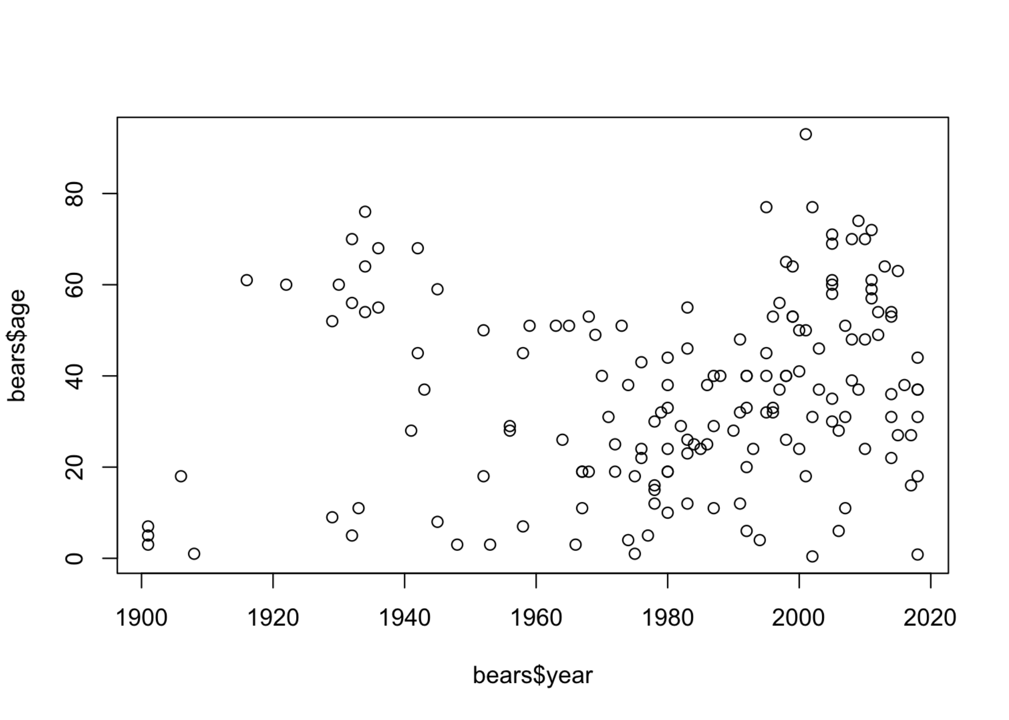
```
#> Error in xy.coords(x, y, xlabel, ylabel, log): 'x' and 'y' lengths differ
```

Scatterplots with `plot()`

Plotting variables from a data frame:

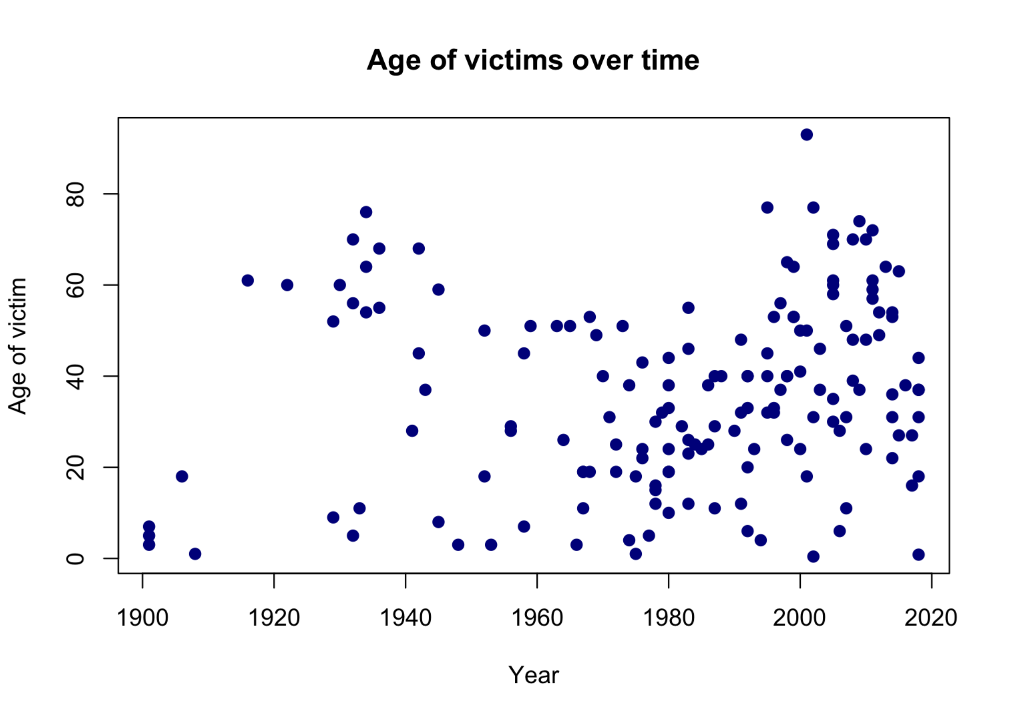
Plot `year` vs. `age`:

```
plot(x = bears$year, y = bears$age)
```



Making `plot()` pretty

```
plot(
  x    = bears$year,
  y    = bears$age,
  col  = 'darkblue', # Point color
  pch  = 19, # Point shape
  main = "Age of victims over time",
  xlab = "Year",
  ylab = "Age of victim"
)
```



Your turn: `plot()`

10:00

Does the annual number of bird impacts appear to be changing over time?

Make a plot using the `birds` data frame to justify your answer.

Hint: You may need to create a summary data frame to answer this question!

Bonus: Make your plot pretty!

Histograms with `hist()`

Plot the *distribution* of a single variable

General syntax:

```
hist(x = x_vector)
```

Histograms with `hist()`

Plot the *distribution* of a single variable

General syntax:

```
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```
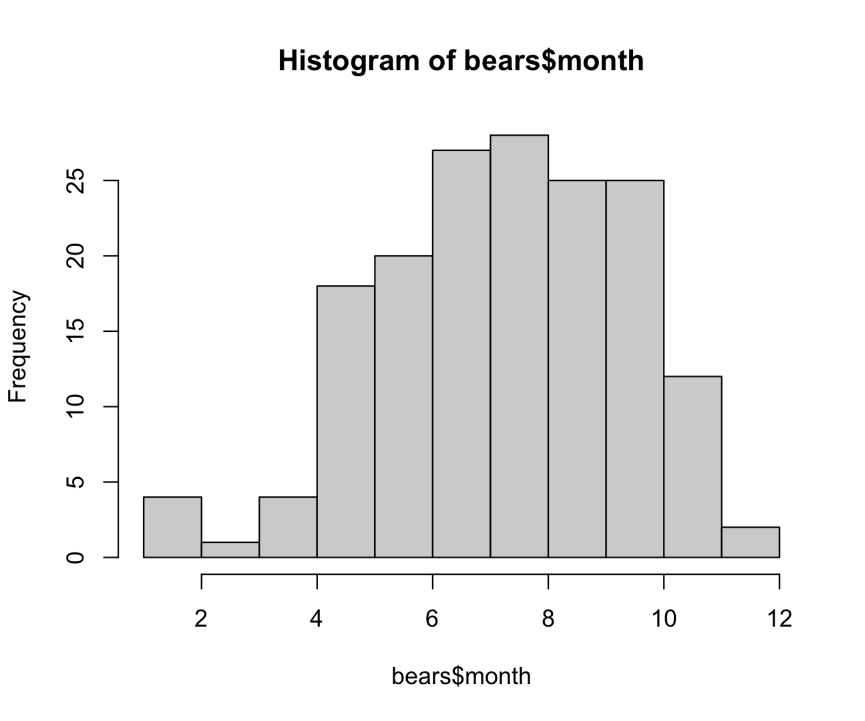
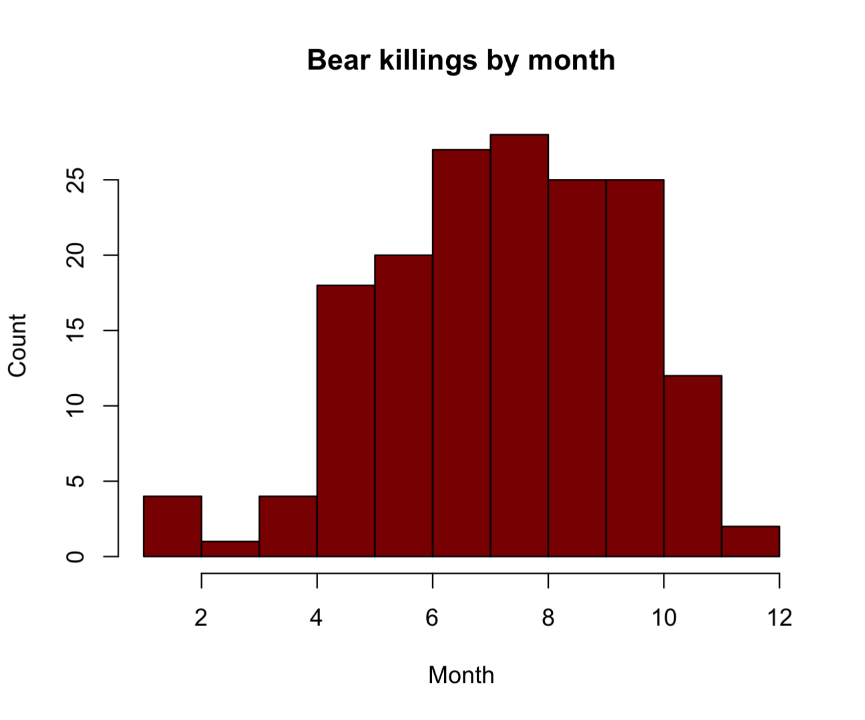

Example:

```
hist(bears$month)
```



Making hist() pretty

```
hist(
  x      = bears$month,
  breaks = 12,
  col    = 'darkred',
  main   = "Bear killings by month",
  xlab   = "Month",
  ylab   = "Count"
)
```



Your turn: `hist()`

10:00

Make plots using the `birds` data frame to answer these questions

1. Which months have the highest and lowest number of bird impacts in the dataset?
2. Which aircrafts experience more impacts: 2-engine, 3-engine, or 4-engine?
3. At what height do most impacts occur?

Bonus: Make your plots pretty!

Week 11: *Data Visualization*

1. Plotting with Base R

2. Plotting with ggplot2: Part 1

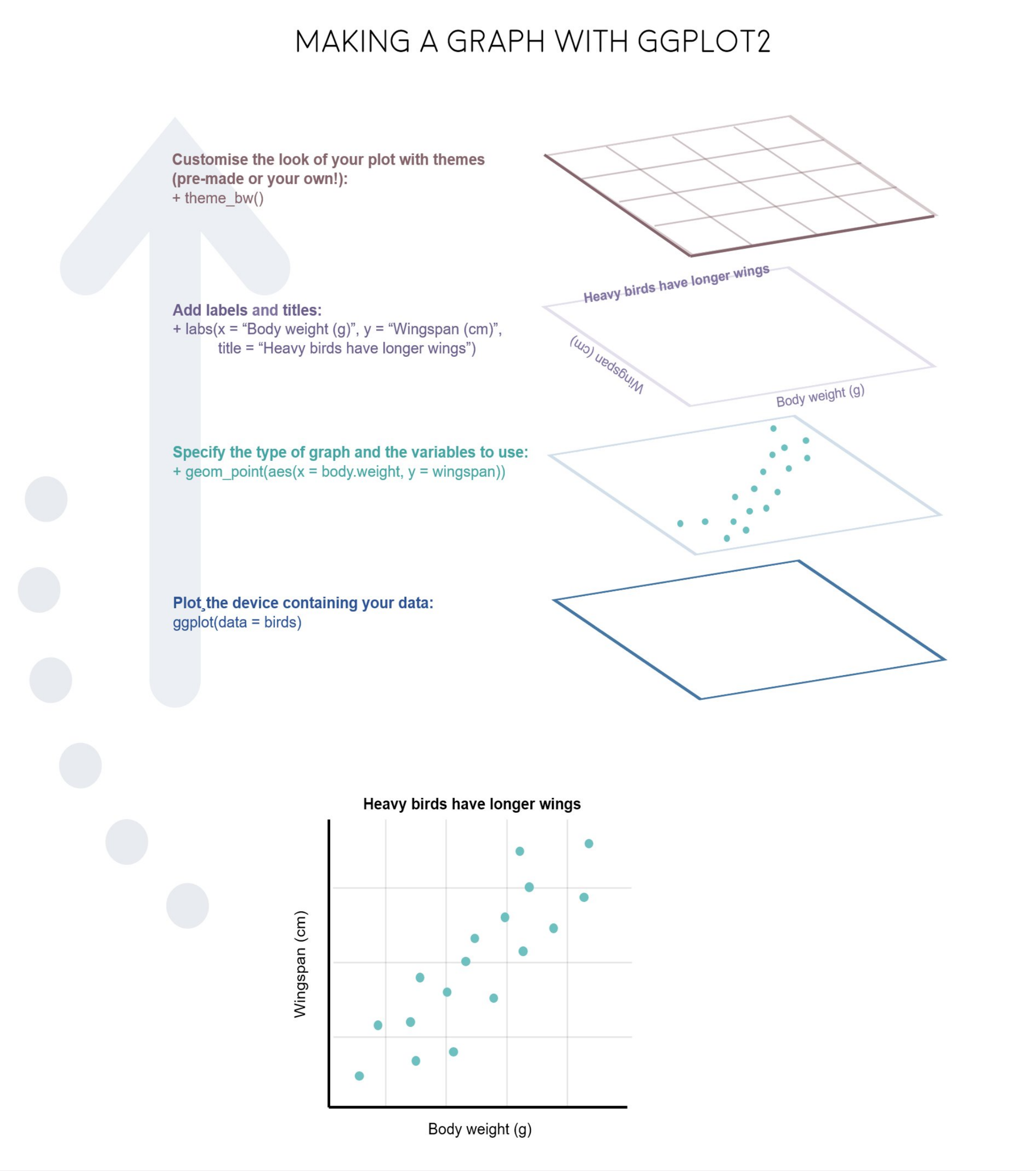
BREAK

3. Plotting with ggplot2: Part 2

4. Tweaking your ggplot

Advanced figures with `ggplot2`

Art by Allison Horst



MAKING A GRAPH WITH GGPLOT2

Customise the look of your plot with themes (pre-made or your own!):
+ theme_bw()

Add labels and titles:
+ labs(x = “Body weight (g)”, y = “Wingspan (cm)”,
          title = “Heavy birds have longer wings”)

Specify the type of graph and the variables to use:
+ geom_point(aes(x = body.weight, y = wingspan))

Plot the device containing your data:
ggplot(data = birds)

"Grammar of Graphics"

Concept developed by Leland Wilkinson (1999)

ggplot2 package developed by Hadley Wickham (2005)

Making plot layers with ggplot2

1. The data (we'll use `bears`)

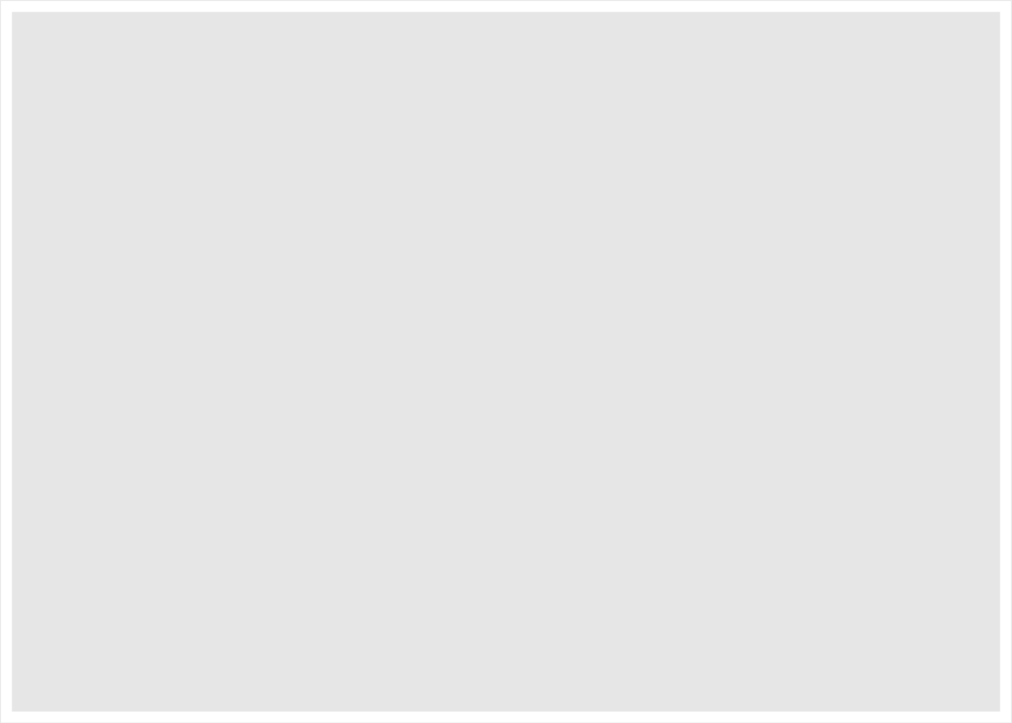
2. The aesthetic mapping (what goes on the axes?)

3. The geometries (points? bars? etc.)

Layer 1: The data

The `ggplot()` function initializes the plot with whatever data you're using

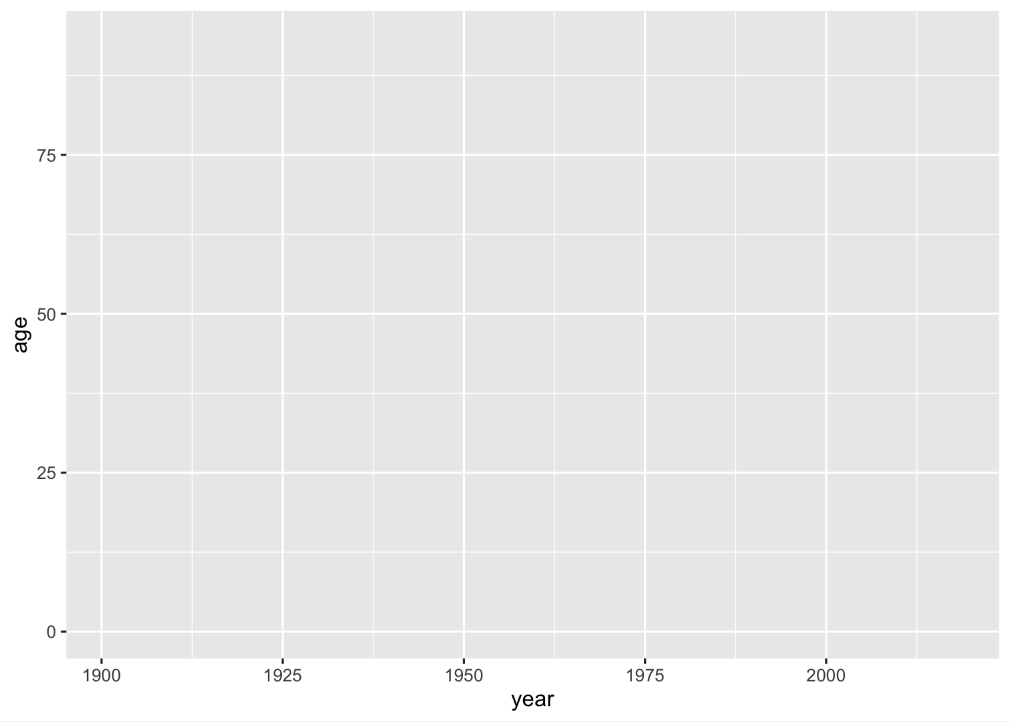
```
ggplot(data = bears)
```



Layer 2: The aesthetic mapping

The `aes()` function determines which variables will be *mapped* to the geometries (e.g. the axes)

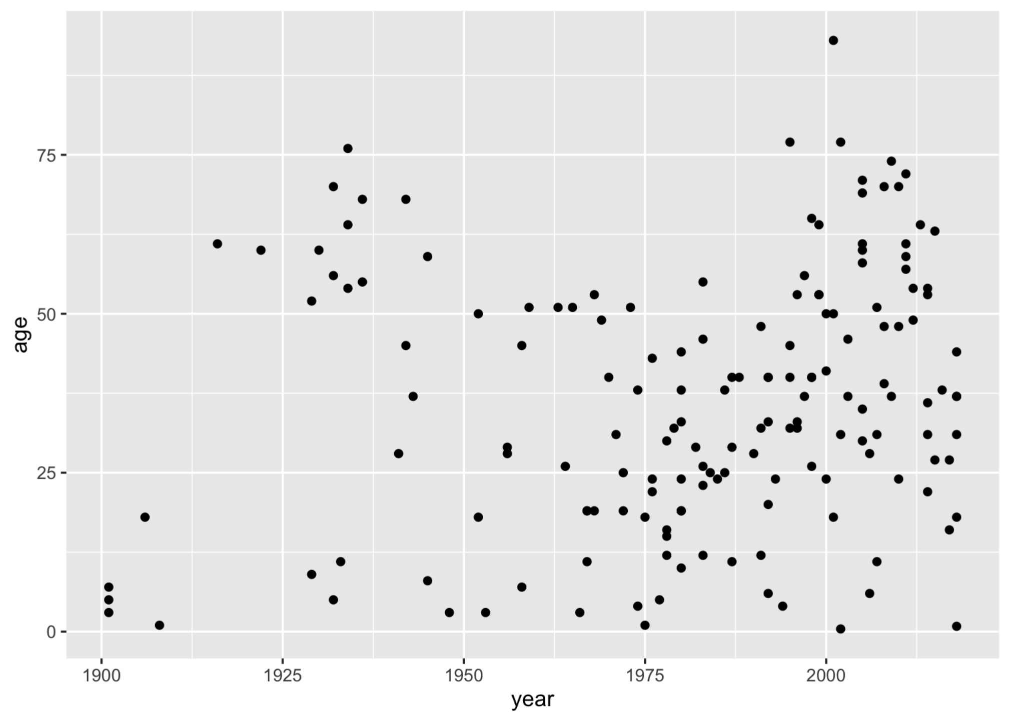
```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age))
```



Layer 3: The geometries

Use + to add geometries (e.g. points)

```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point()
```



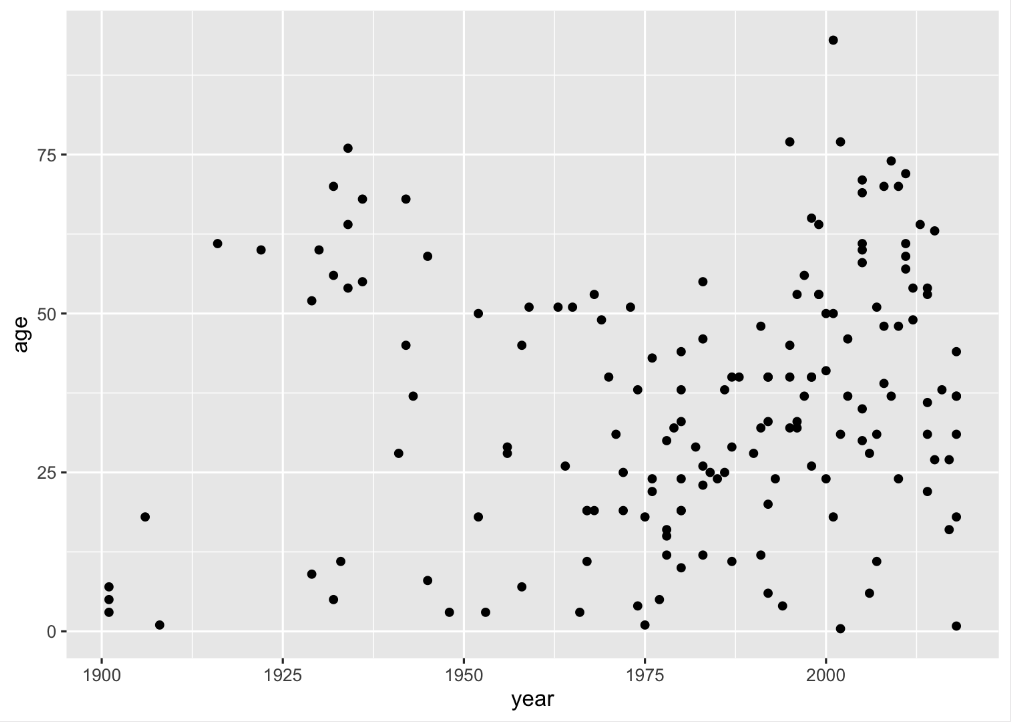
Other common geometries

- `geom_point()`: scatter plots
- `geom_line()`: lines connecting data points
- `geom_col()`: bar charts
- `geom_boxplot()`: boxes for boxplots

Scatterplots with `geom_point()`

Add points:

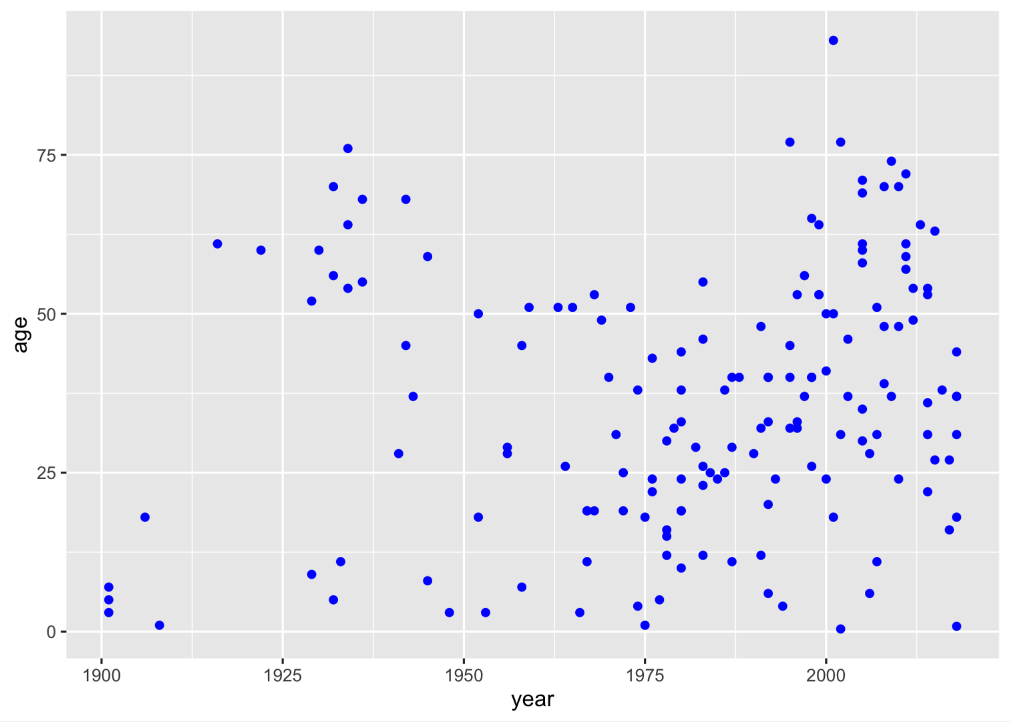
```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point()
```



Scatterplots with `geom_point()`

Change the color of all points:

```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point(color = 'blue')
```

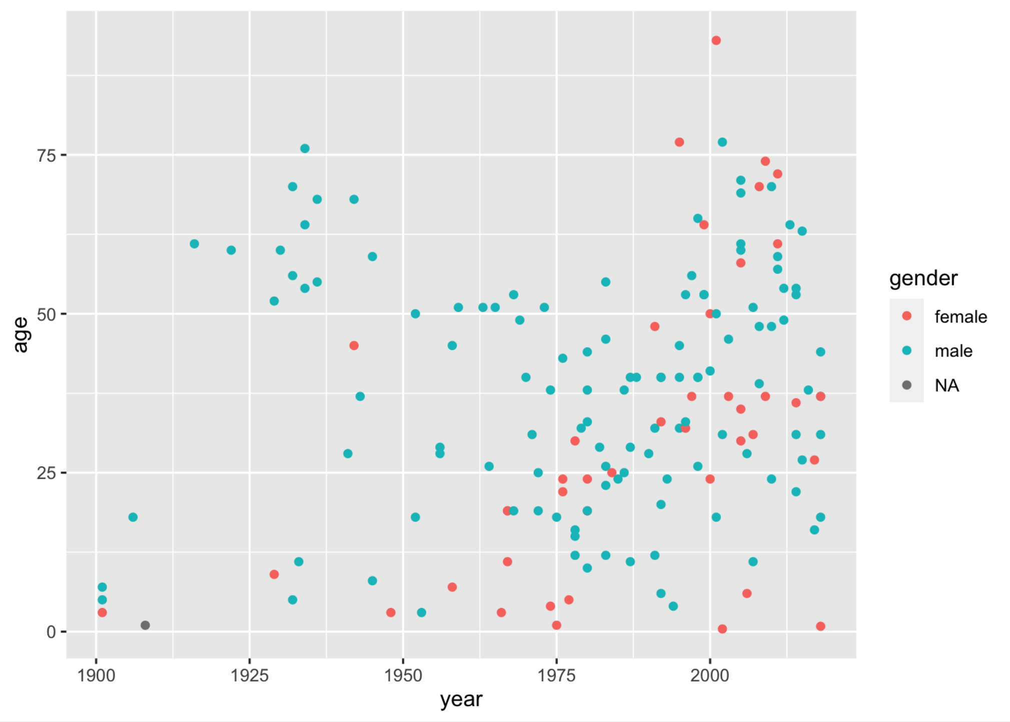


Scatterplots with `geom_point()`

Map the point color to a **variable**:

```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point(aes(color = gender))
```

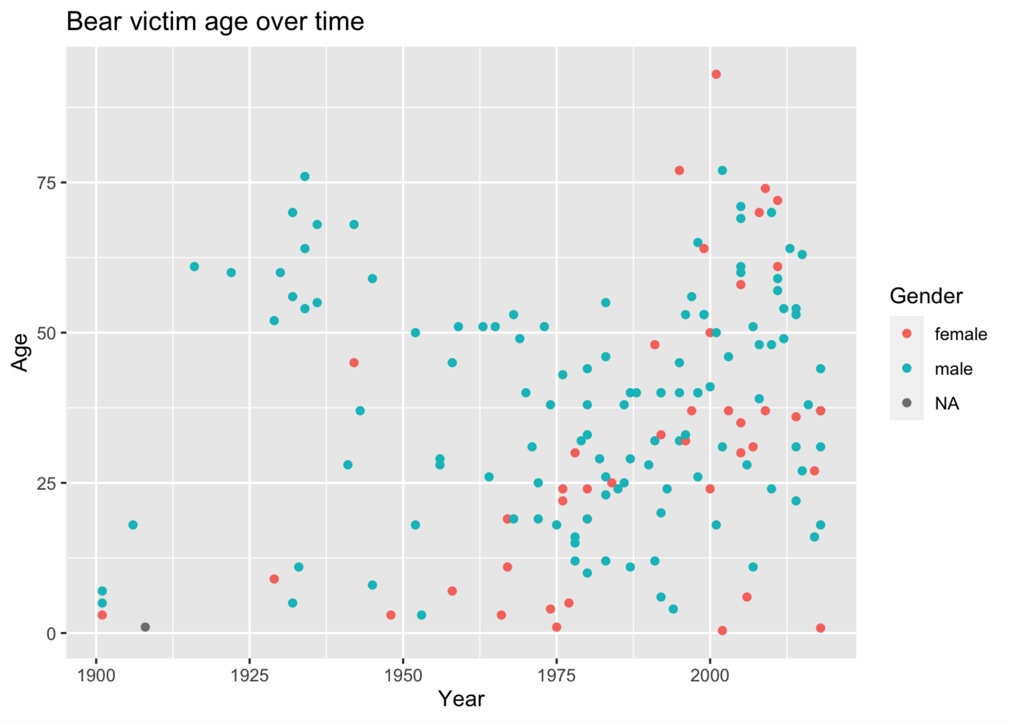
Note that `color = gender` is *inside* `aes()`



Scatterplots with `geom_point()`

Adjust labels with `labs()` layer:

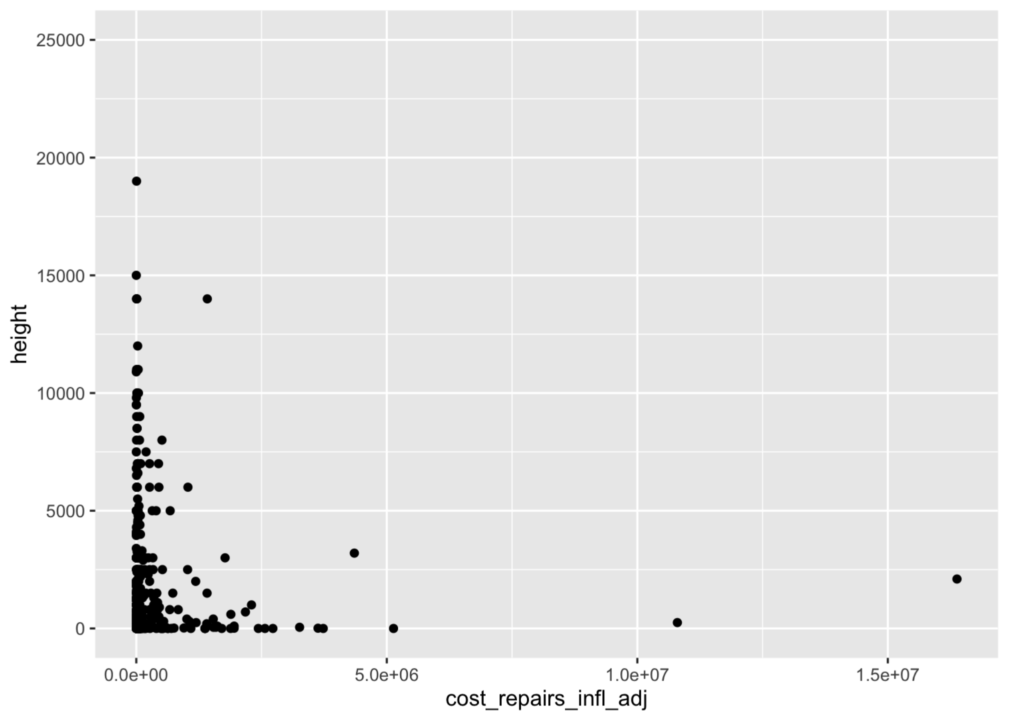
```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point(aes(color = gender)) +
  labs(
    x = "Year",
    y = "Age",
    title = "Bear victim age over time",
    color = "Gender")
```

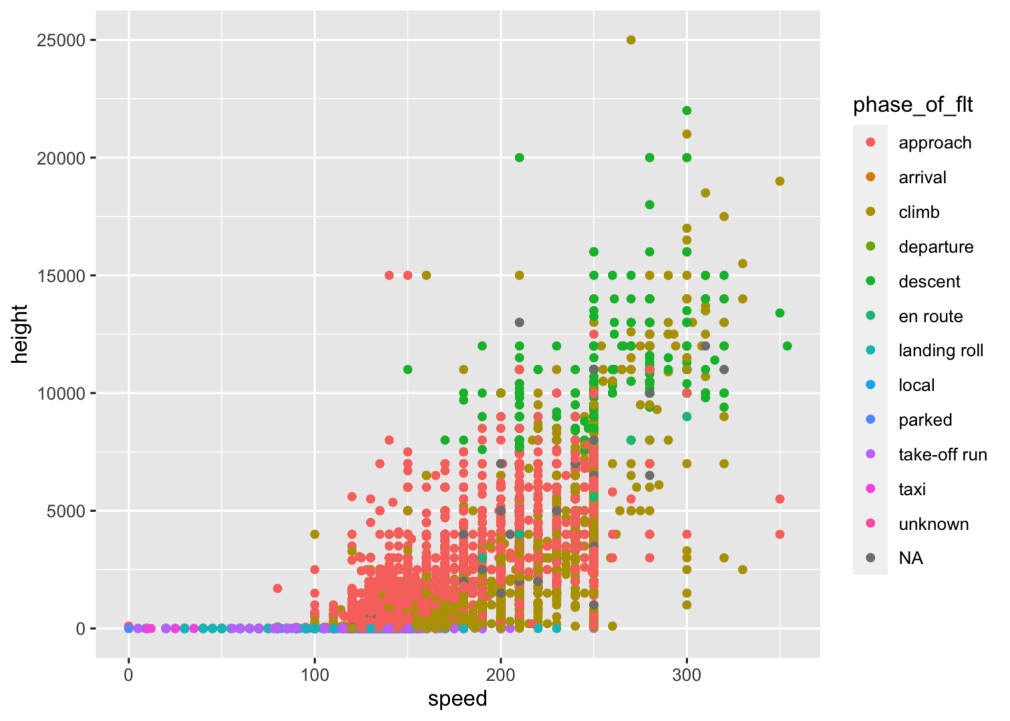


Your turn: geom_point()

10:00

Use the birds data frame to create the following plots





Break

05:00

Week 11: *Data Visualization*

1. Plotting with Base R

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4. Tweaking your ggplot

Make bar charts with `geom_col()`

With bar charts, you'll often need to create summary variables to plot

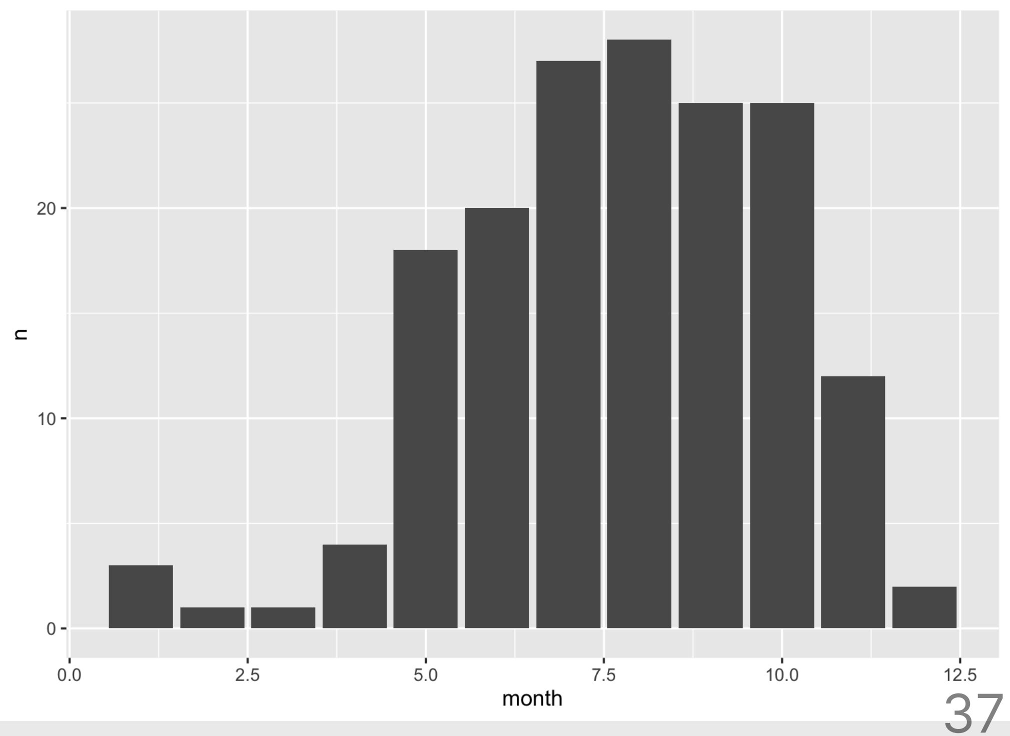
Step 1: Summarize the data

```
bear_months <- bears %>%
  count(month)
```

Step 2: Make the plot

```
ggplot(data = bear_months) +
  geom_col(aes(x = month, y = n))
```

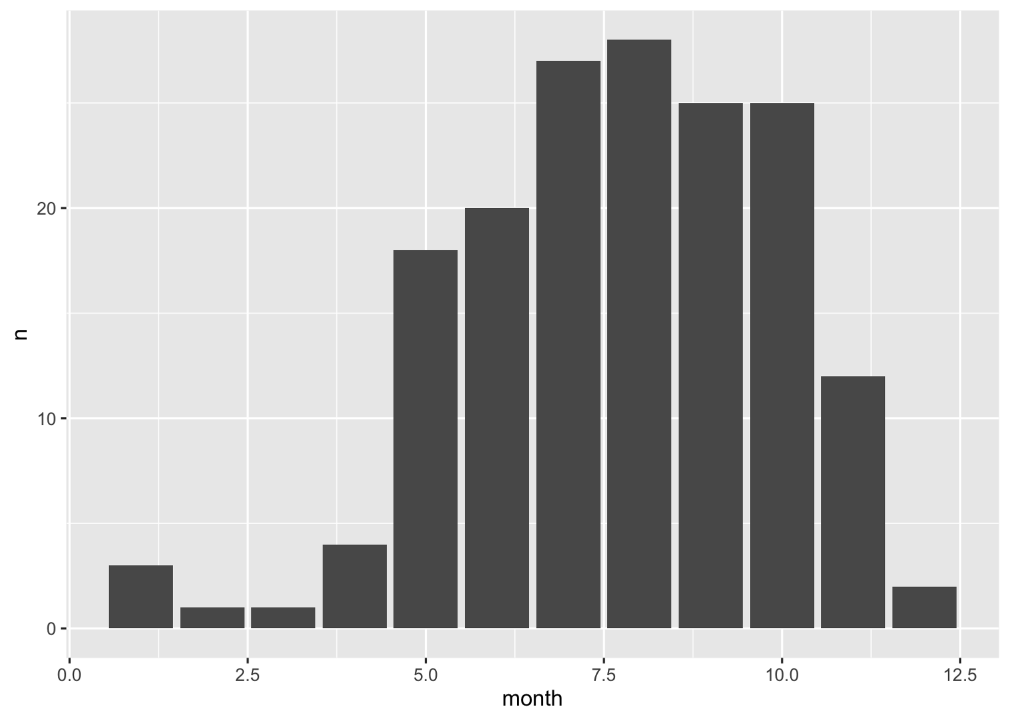
Example: count of attacks by month



Make bar charts with `geom_col()`

Alternative approach: piping directly into ggplot

```r
bears %>%
  count(month) %>%  # Pipe into ggplot
  ggplot() +
  geom_col(aes(x = month, y = n))
```

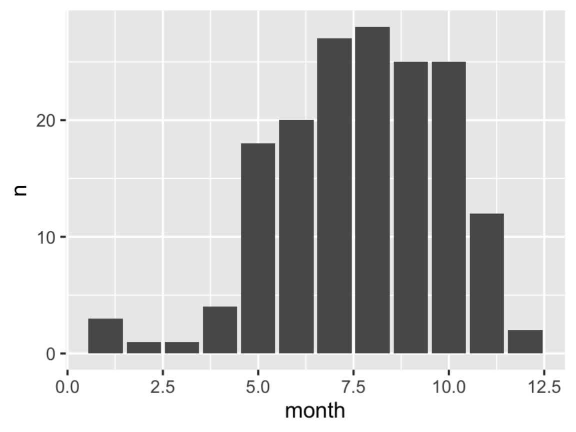


Be careful with `geom_col()` vs. `geom_bar()`

`geom_col()`

Map both `x` and `y`

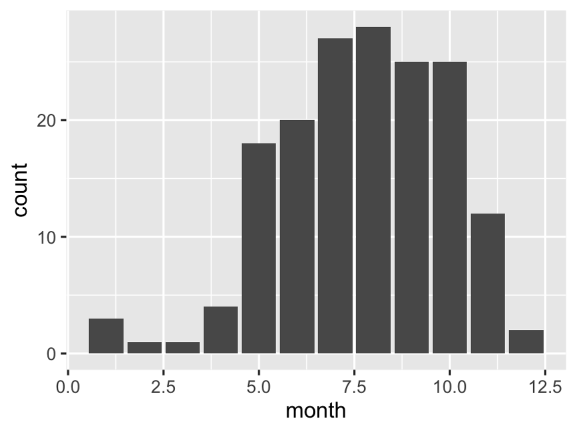
```
bears %>%
  count(month) %>%
  ggplot() +
  geom_col(aes(x = month, y = n))
```



`geom_bar()`

Only map `x` (`y` is computed)

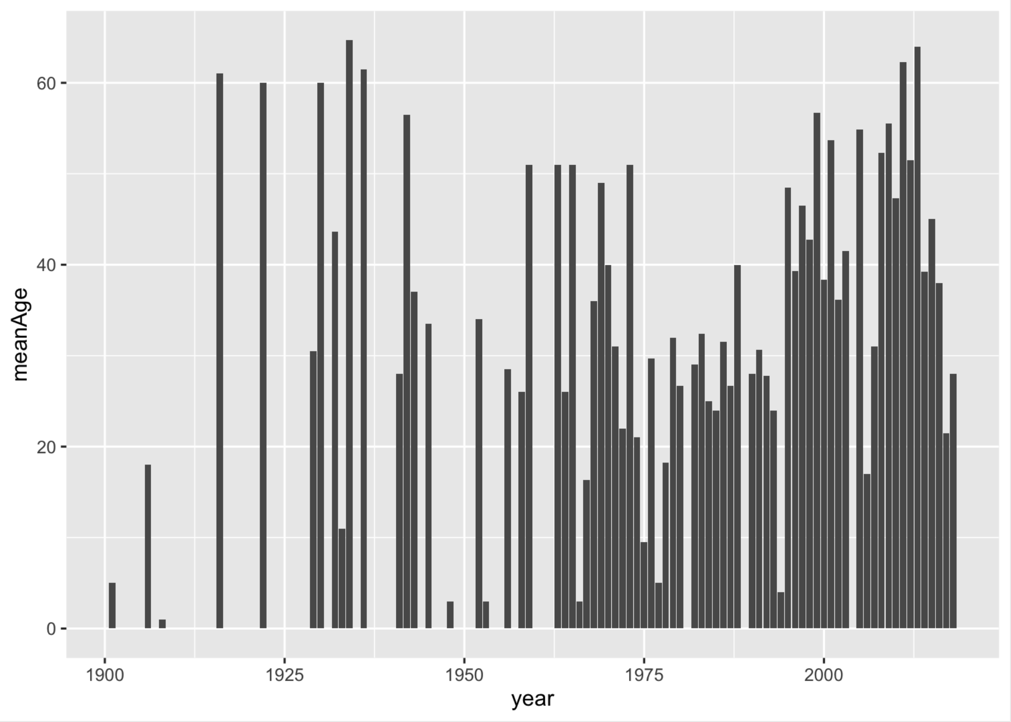
```
bears %>%
  ggplot() +
  geom_bar(aes(x = month))
```



Make bar charts with `geom_col()`

Another example:
Mean age of victim in each year

```
bears %>%
  filter(!is.na(age)) %>%
  group_by(year) %>%
  summarise(meanAge = mean(age)) %>%
  ggplot() +
  geom_col(aes(x = year, y = meanAge))
```

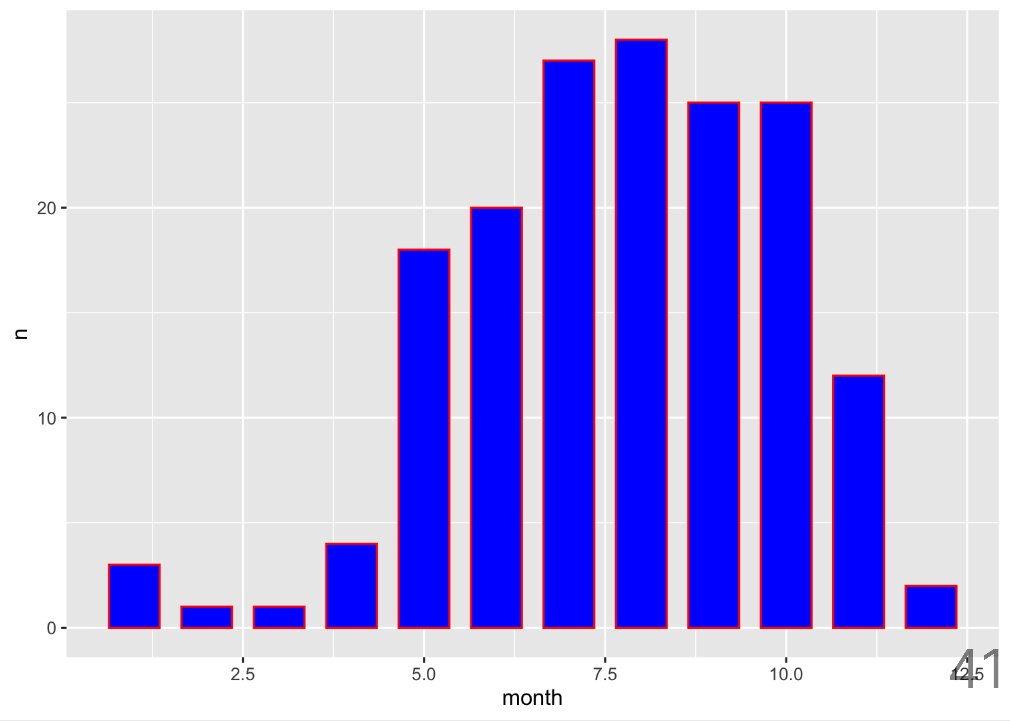


Change bar width: `width`

Change bar color: `fill`

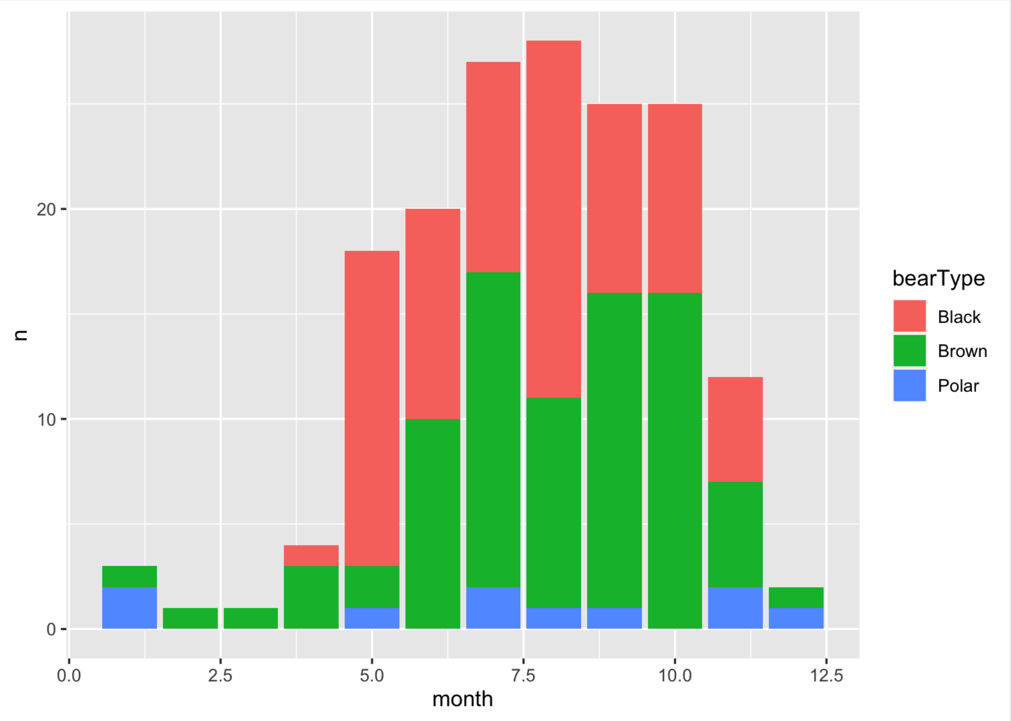
Change bar outline: `color`

```r
bears %>%
  count(month) %>%
  ggplot() +
  geom_col(
    mapping = aes(x = month, y = n),
    width = 0.7,
    fill = "blue",
    color = "red")
```



Map the fill to bearType

```
bears %>%
  count(month, bearType) %>%
  ggplot() +
  geom_col(
    mapping = aes(
      x = month, y = n, fill = bearType)
  )
```



Note that I had to summarize the count by both month and bearType

```
bears %>%
  count(month, bearType)
```

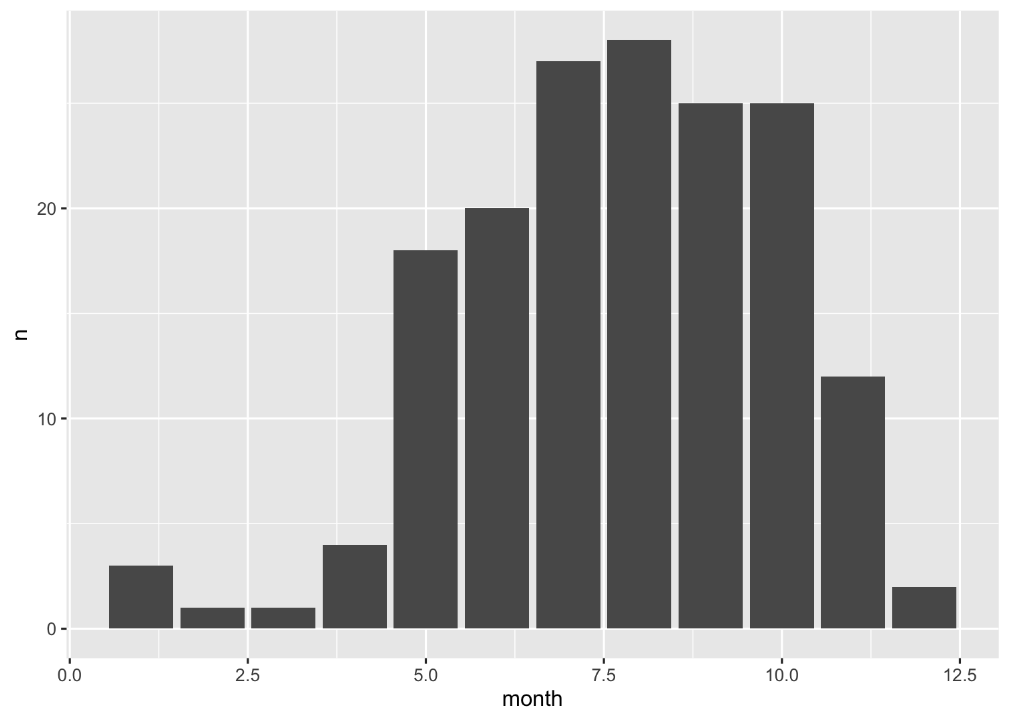
```
#> # A tibble: 27 × 3
#>    month bearType     n
#>    <dbl> <chr>    <int>
#>  1     1 Brown        1
#>  2     1 Polar        2
#>  3     2 Brown        1
#>  4     3 Brown        1
#>  5     4 Black        1
```

"Factors" = Categorical variables

By default, R makes numeric variables *continuous*

```
bears %>%
  count(month) %>%
  ggplot() +
  geom_col(aes(x = month, y = n))
```

The variable `month` is a *number*

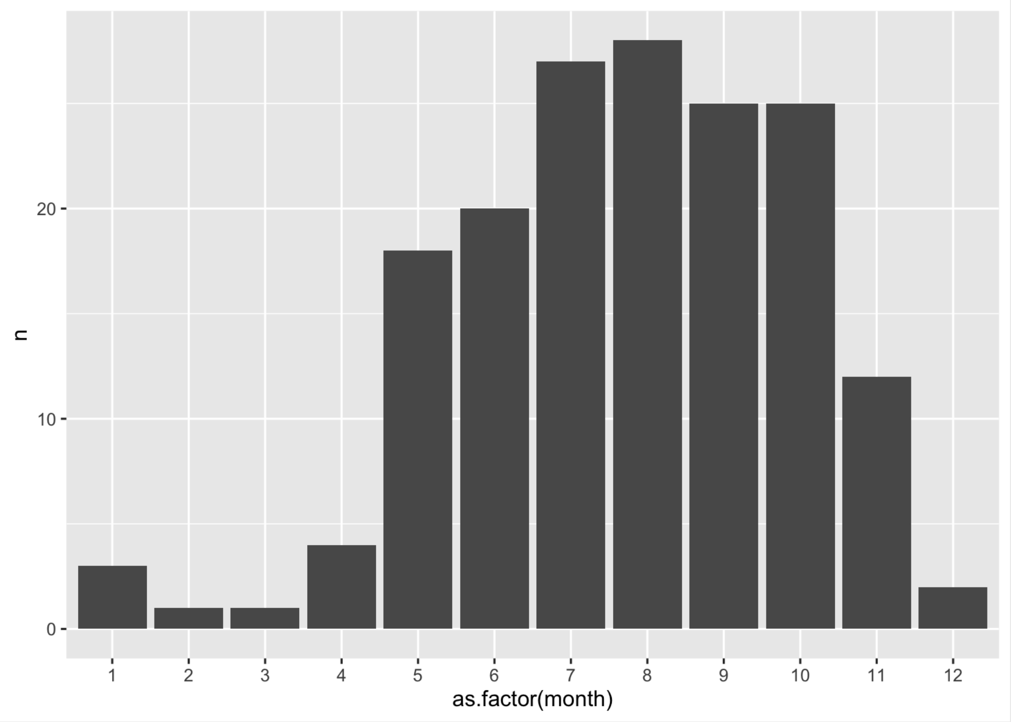


"Factors" = Categorical variables

You can make a continuous variable *categorical* using `as.factor()`

```
bears %>%
  count(month) %>%
  ggplot() +
  geom_col(
    mapping = aes(
      x = as.factor(month),
      y = n)
  )
```

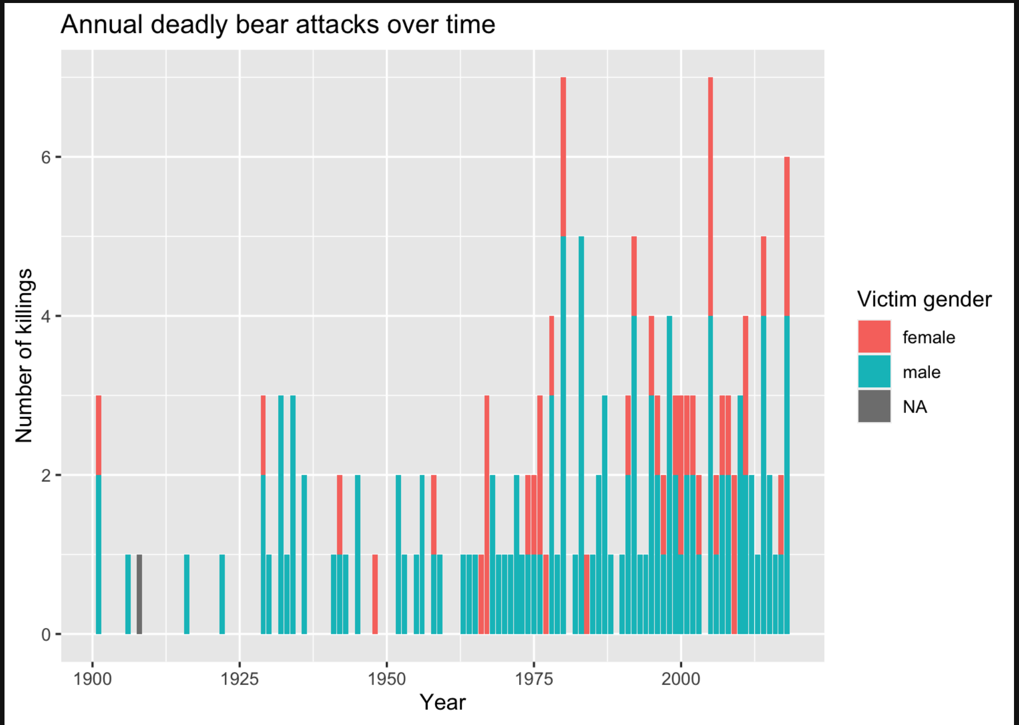
The variable `month` is a *factor*

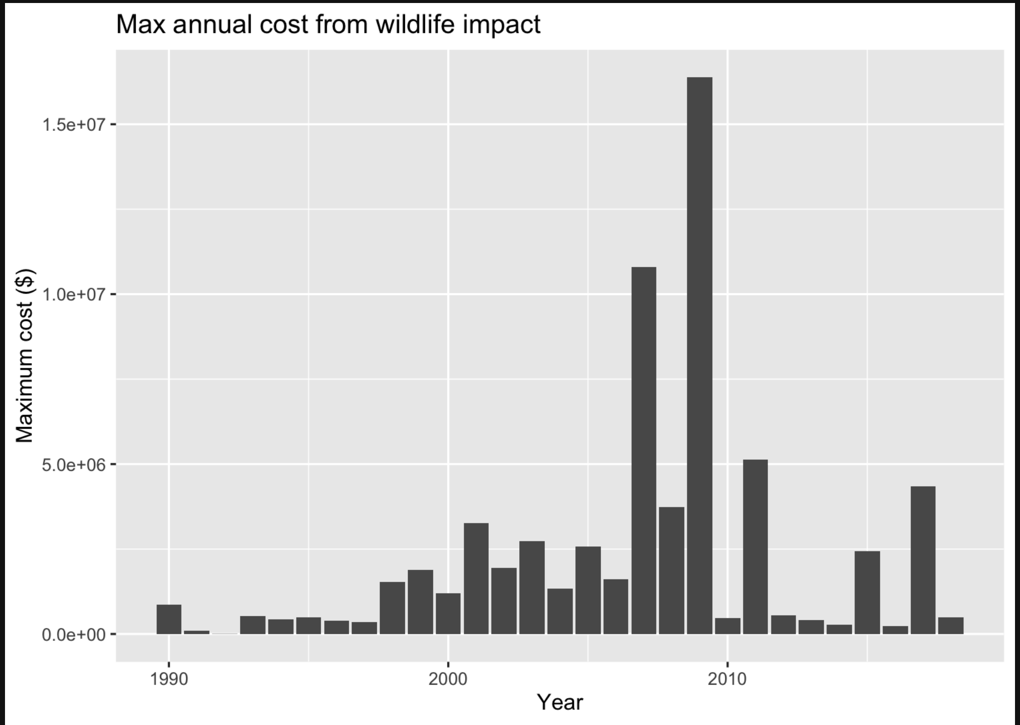


Your turn: geom_col()

15:00

Use the bears and birds data frame to create the following plots





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BREAK

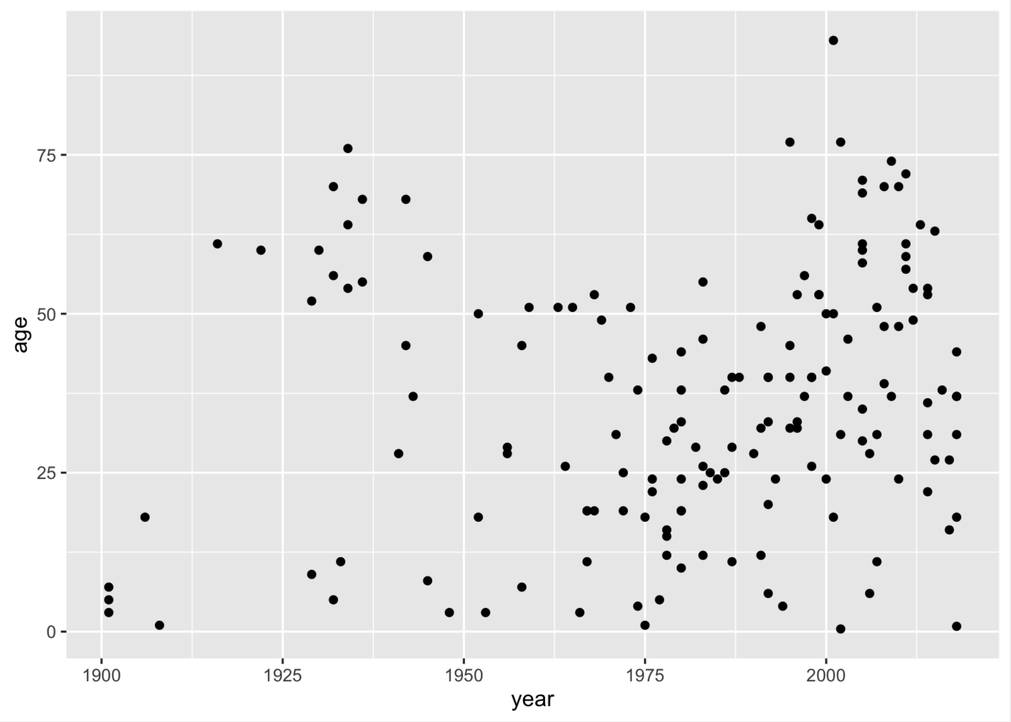
3. Plotting with ggplot2: Part 2

4. Tweaking your ggplot

Working with themes

Themes change *global* features of your plot, like the background color, grid lines, etc.

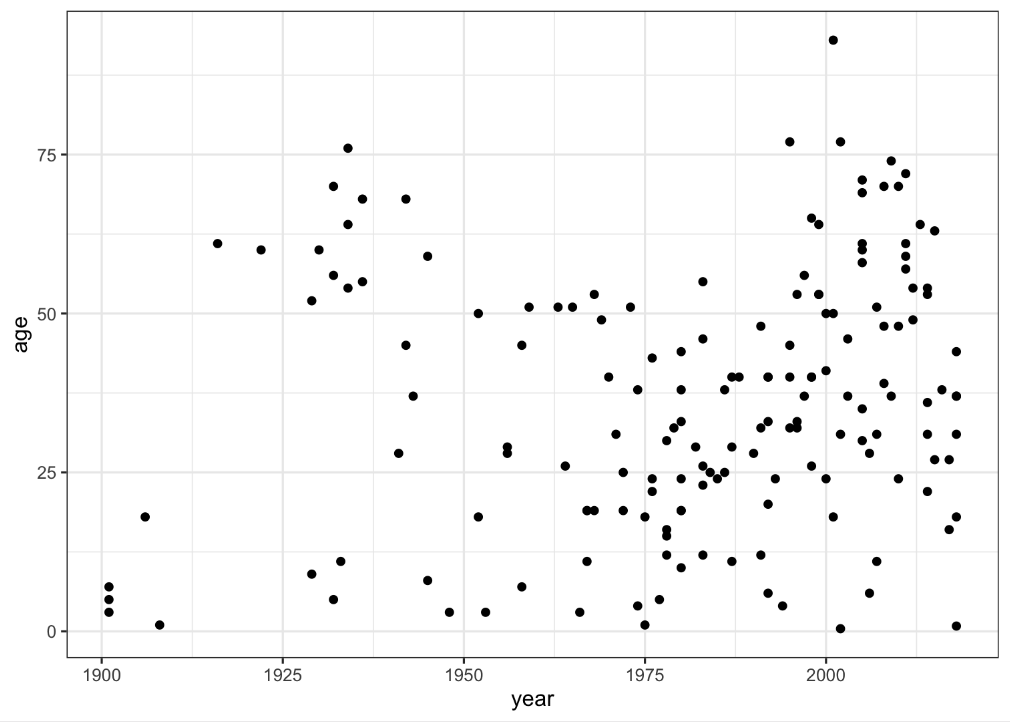
```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point()
```



Working with themes

Themes change *global* features of your plot, like the background color, grid lines, etc.

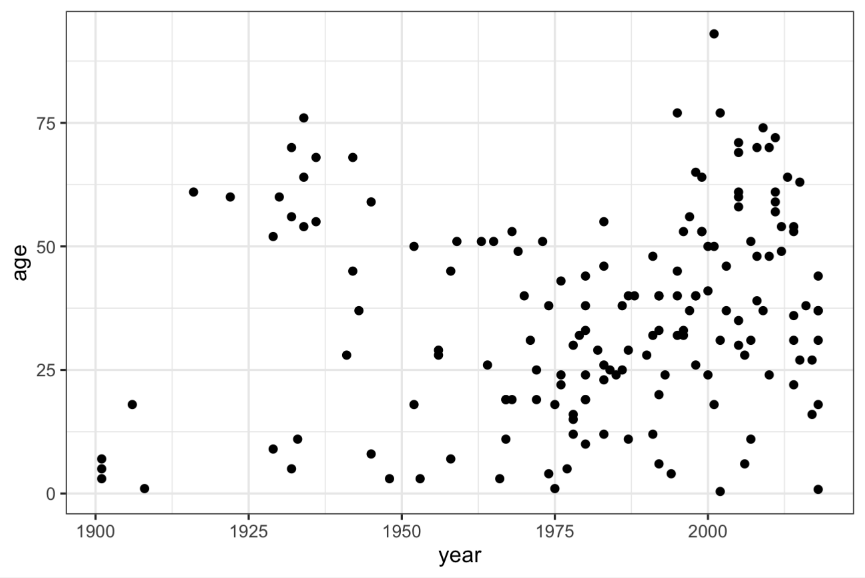
```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_bw()
```



Common themes

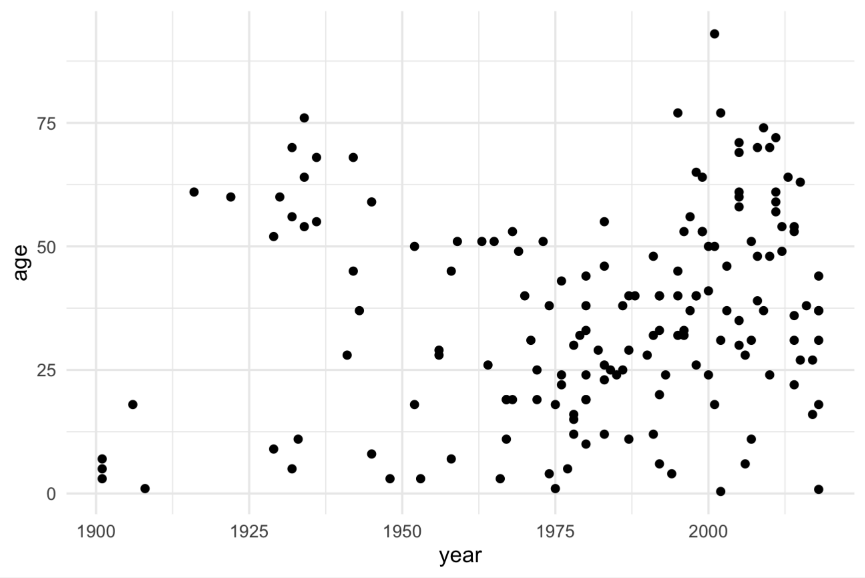
theme_bw()

```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_bw()
```



theme_minimal()

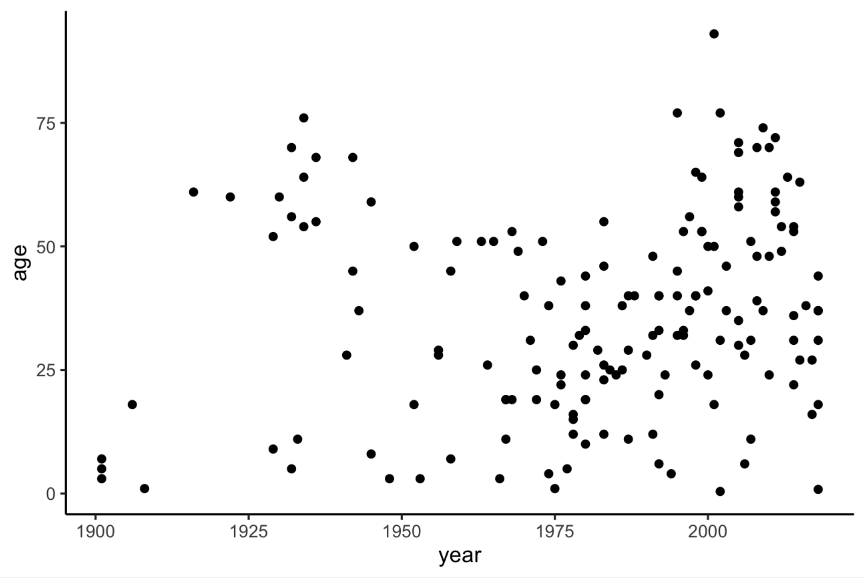
```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_minimal()
```



Common themes

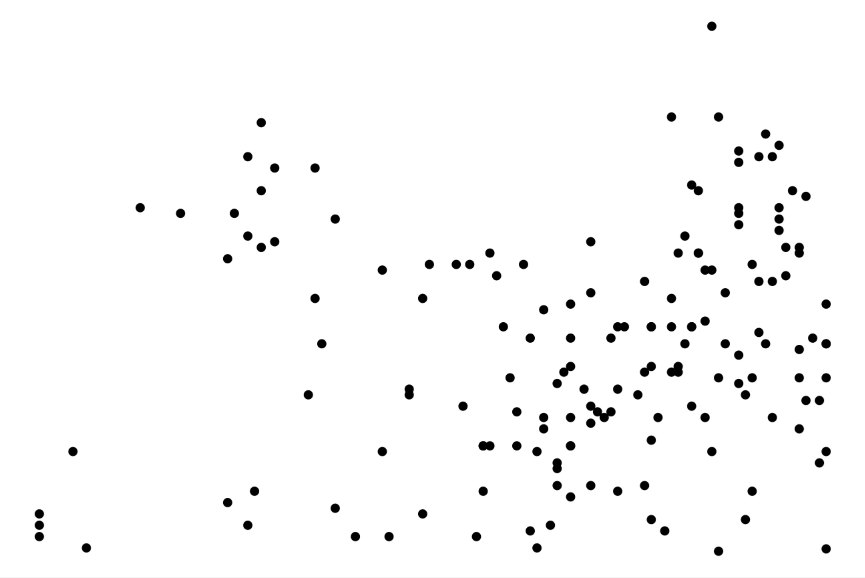
`theme_classic()`

```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_classic()
```



`theme_void()`

```
ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_void()
```



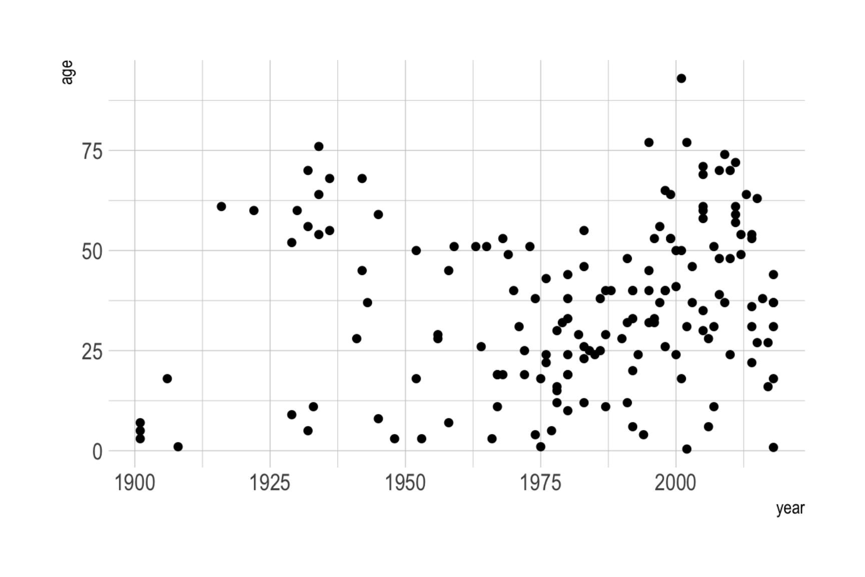
Other themes: hrbrthemes

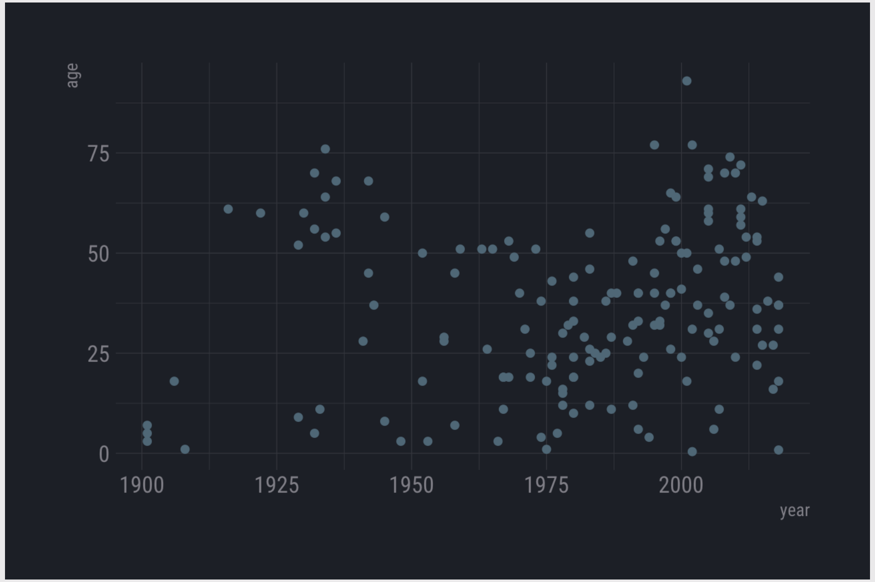
```
library(hrbrthemes)

ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_ipsum()
```

```
library(hrbrthemes)

ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_ft_rc()
```





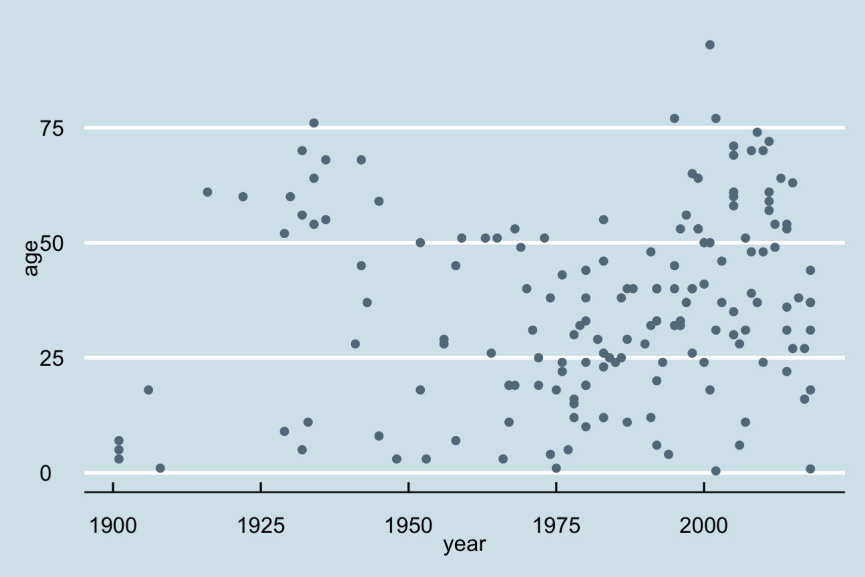
Other themes: **ggthemes**

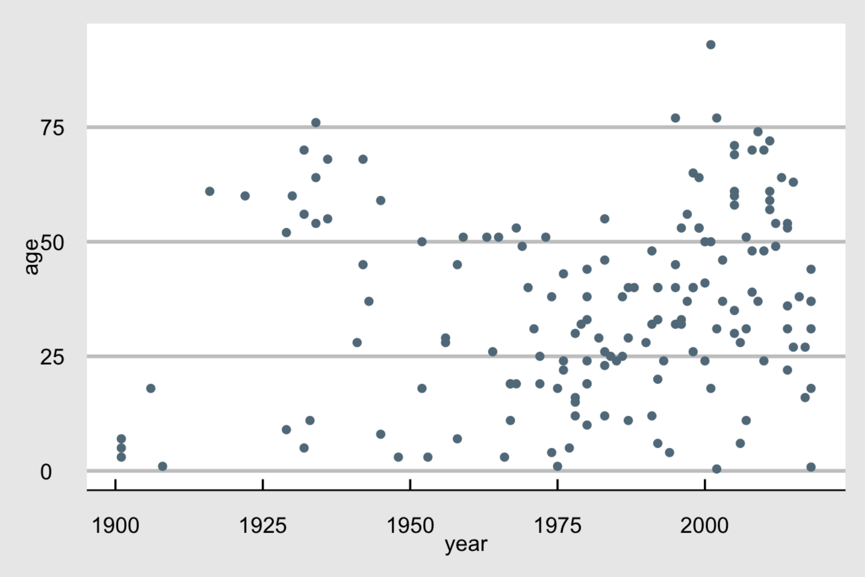
```r
library(ggthemes)

ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_economist()
```

```r
library(ggthemes)

ggplot(
  data = bears,
  mapping = aes(x = year, y = age)) +
  geom_point() +
  theme_economist_white()
```





Save figures with `ggsave()`

First, assign the plot to an object name:

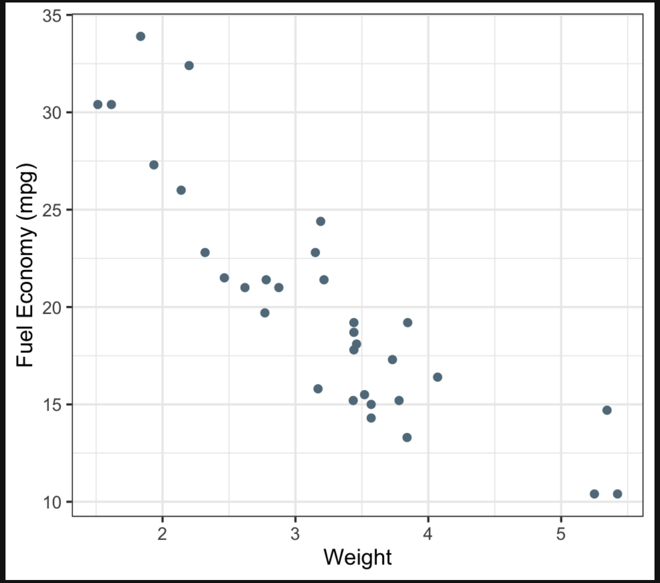
```r
scatterPlot <- ggplot(data = bears) +
    geom_point(aes(x = year, y = age))
```

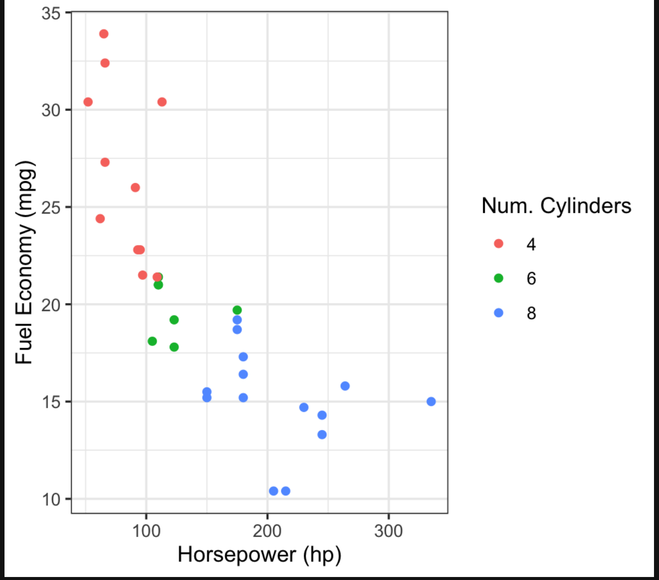
Then use `ggsave()` to save the plot:

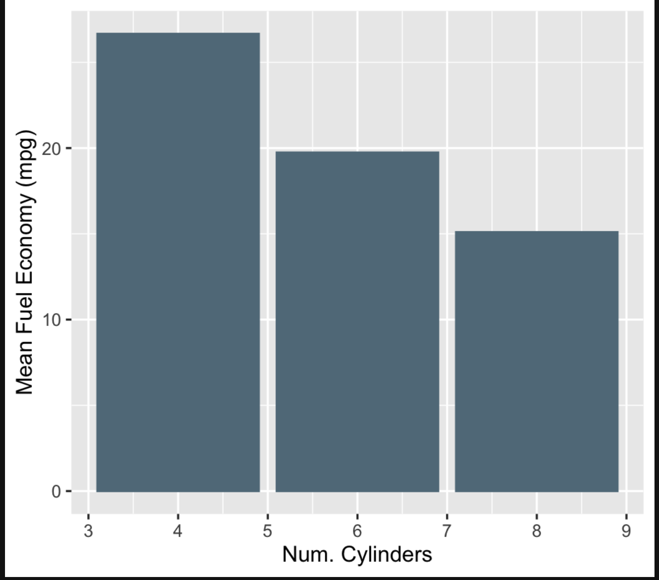
```r
ggsave(
    filename = here('plots', 'scatterPlot.png'),
    plot   = scatterPlot,
    width  = 6, # inches
    height = 4)
```

Extra practice 1

Use the `mtcars` data frame to create the following plots

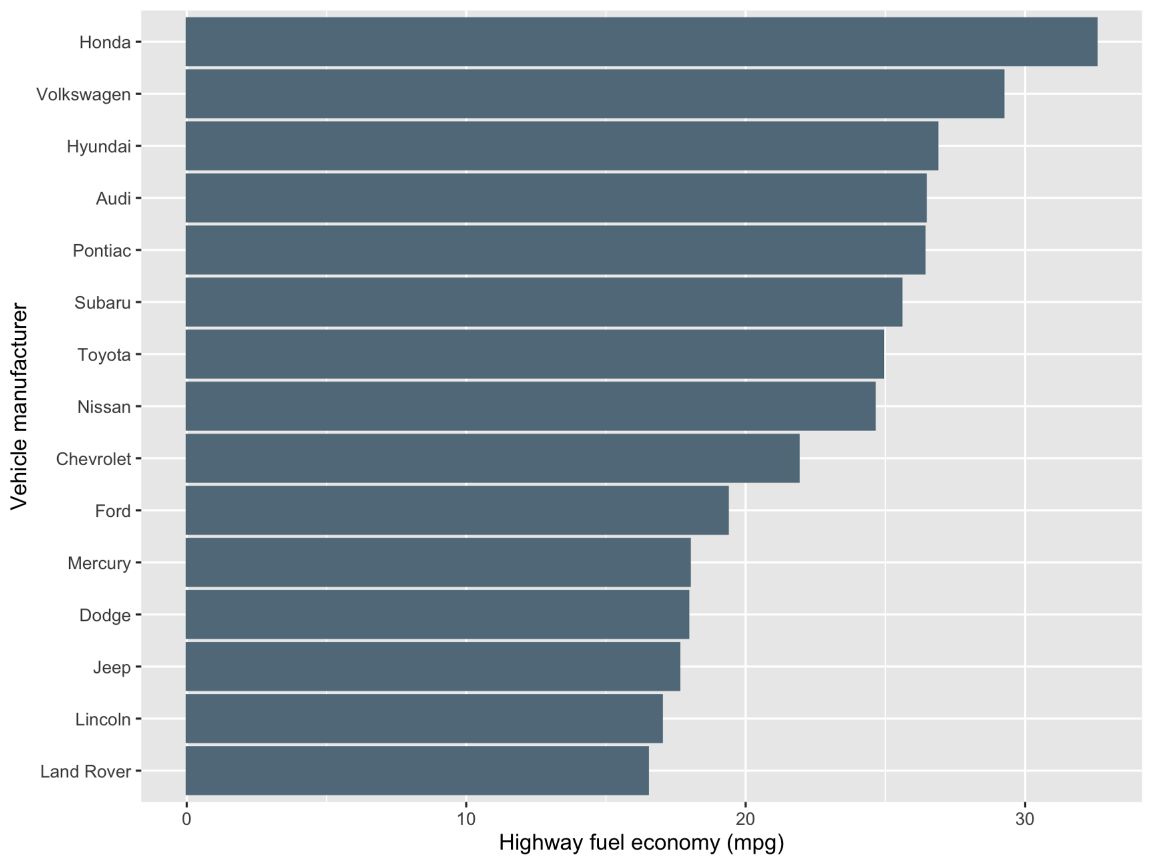






Extra practice 2

Use the `mpg` data frame to create the following plot


Honda
Volkswagen
Hyundai
Audi
Pontiac
Subaru
Toyota
Nissan
Chevrolet
Ford
Mercury
Dodge
Jeep
Lincoln
Land Rover
Vehicle manufacturer
Highway fuel economy (mpg)