Week 12: Data Visualization

EMSE 6574 | John Paul Helveston | November 11, 2019

Getting started

1) Download the `week12notes.zip` file for class today (link in `slack/classroom`).

2) Make sure you have the "tidyverse" installed and loaded:

```
library(tidyverse)
```

3) Load two data frames:

```
birds
bears
```

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

	SRM No.	Cross Sectional View: Erosion Depth (in.)	Cross Sectional View: Perimeter Affected (deg)	Cross Sectional View: Nominal Dia. (in.)	Top View: Length Of Max Erosion (in.)	Top View: Total Heat Affected Length (in.)	Clocking Location (deg)
61A LH Center Field**	22A	None	None	0.280	None	None	36°-66°
61A LH CENTER FIELD**	22A	NONE	NONE	0.280	NONE	NONE	338°-18°
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
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

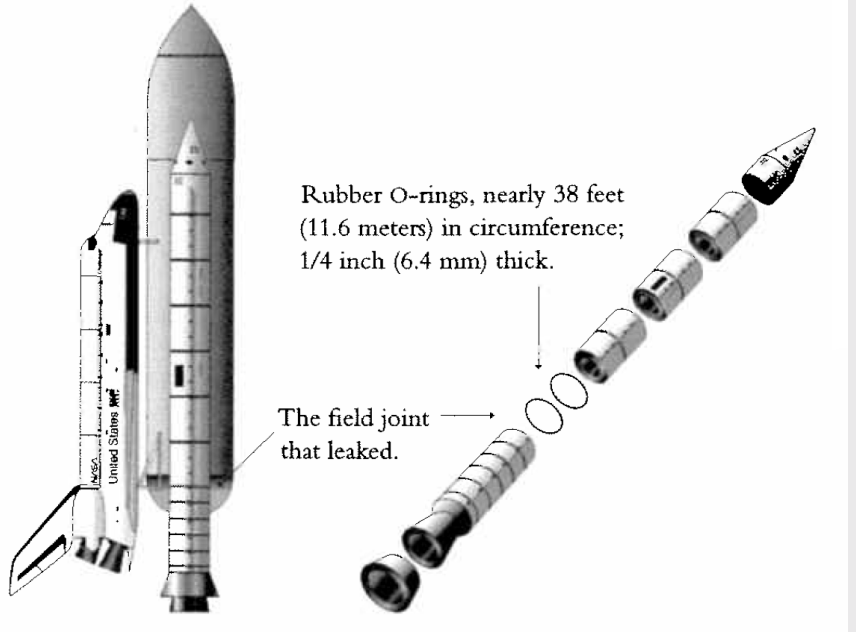
SRM 22 BLOW-BY
- 2 CASE JOINTS (30-40°)

SRM-13A, 15, 16A, 18, 23A 24A
- NOZZLE BLOW-BY

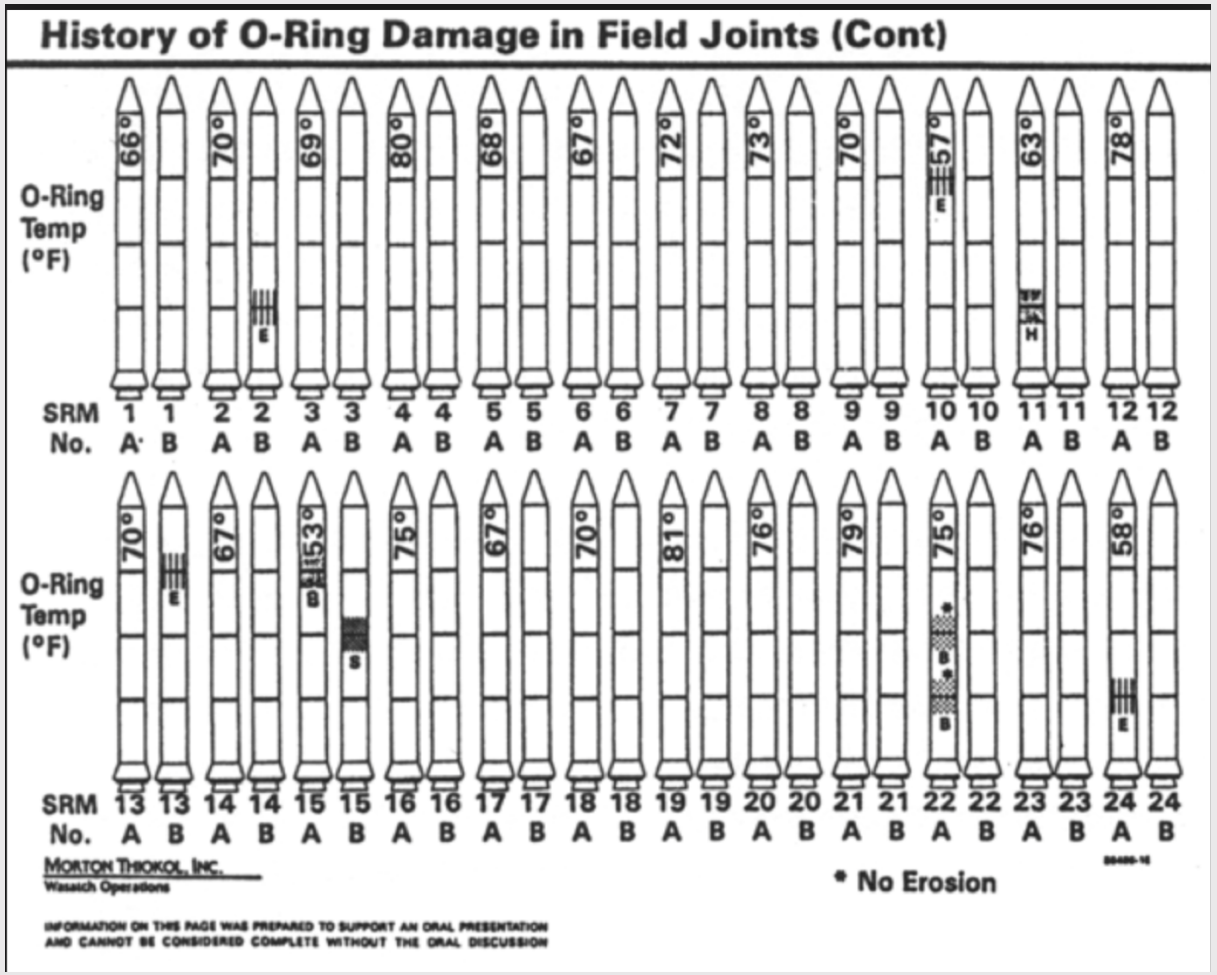
HISTORY OF O-RING TEMPERATURES (DEGREES-F)

MOTOR	M&T	AMB	O-RING	WIND
DM-1	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-1	47
DM-2	52
QM-3	48
QM-4	51
SRM-15	53
SRM-22	75
SRM-25	29 27

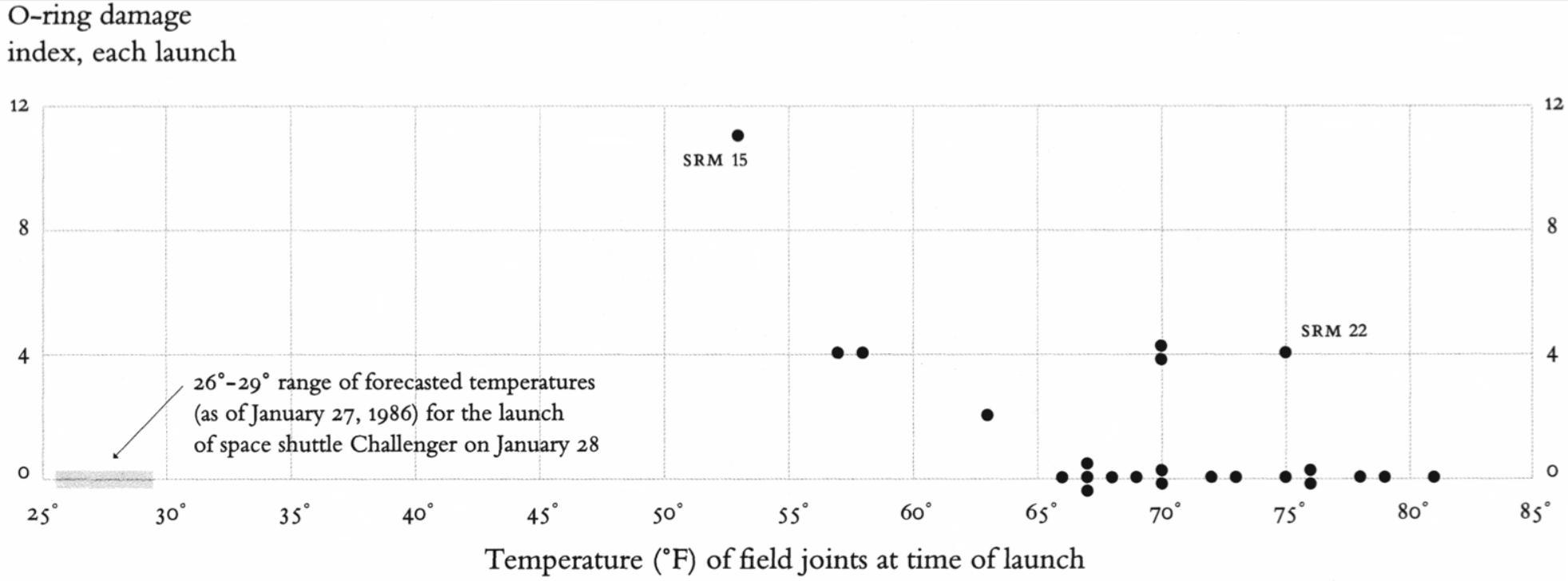


What NASA was shown



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.

Today's data:

Bear attacks in North America

Explore the `bears` data frame:

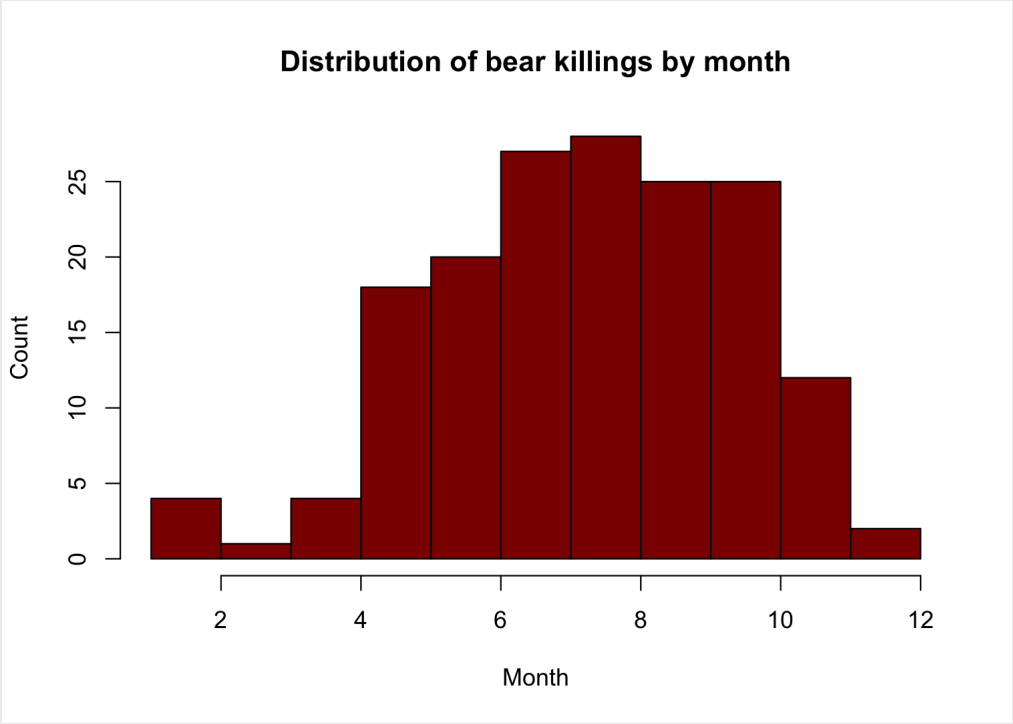
```
glimpse(bears)
head(bears)
```

Two basic plots in R

(there are others)

Scatterplots

Histograms



Scatterplots with `plot()`

Plot relationship between two variables

General syntax:

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

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General syntax:

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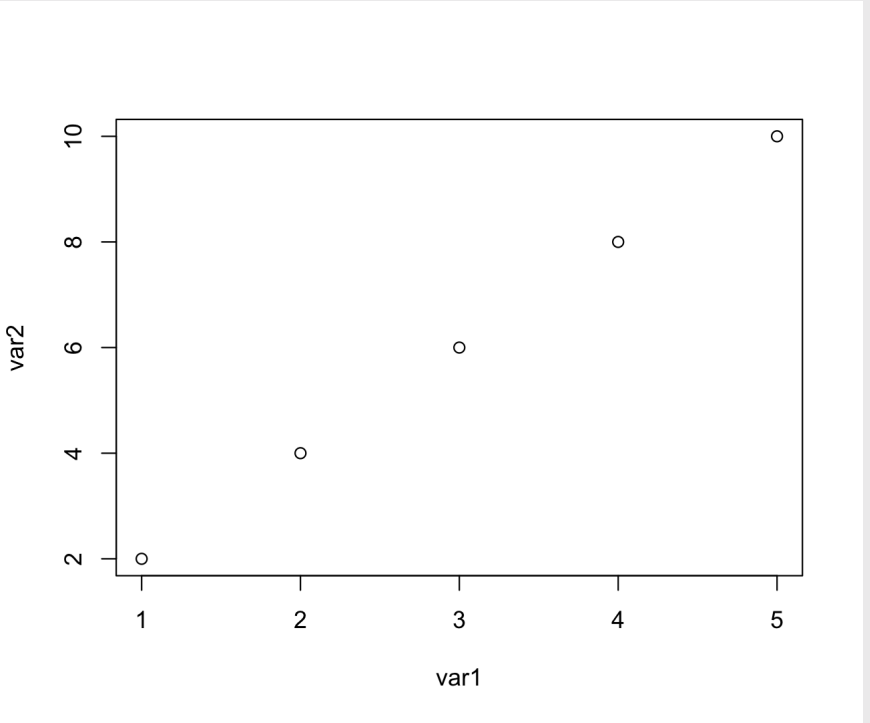
```

Example:

```
var1 <- 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)
```

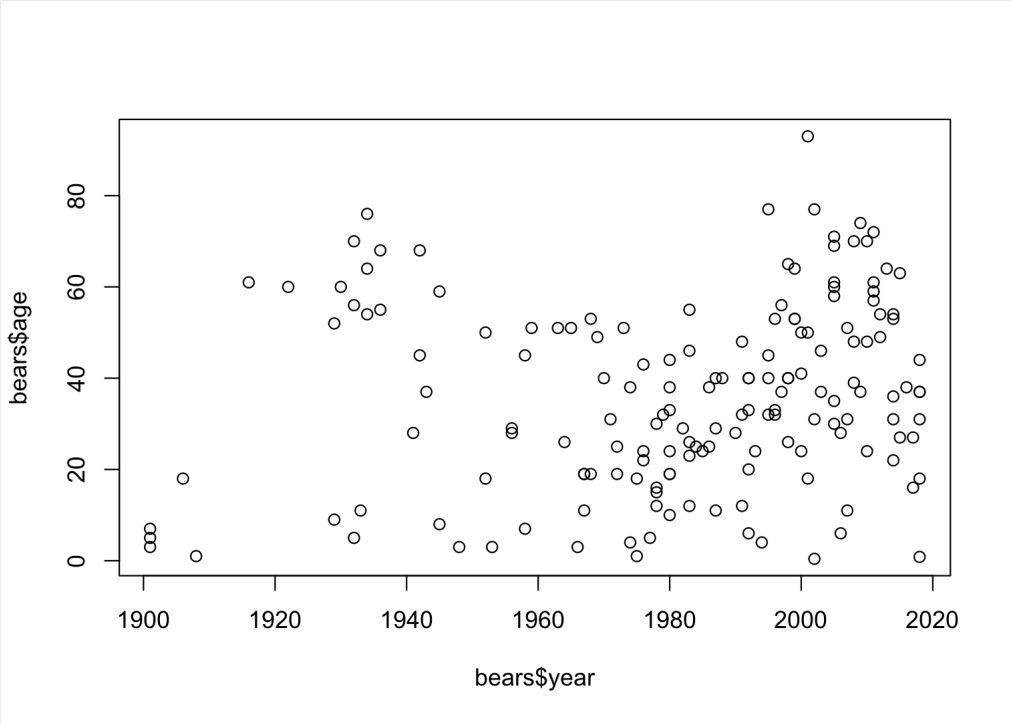
```
## Error in xy.coords(x, y, xlabel, ylabel, log): 'x' and 'y' lengths differ
```

Scatterplots with `plot()`

Plotting variables from a data frame:

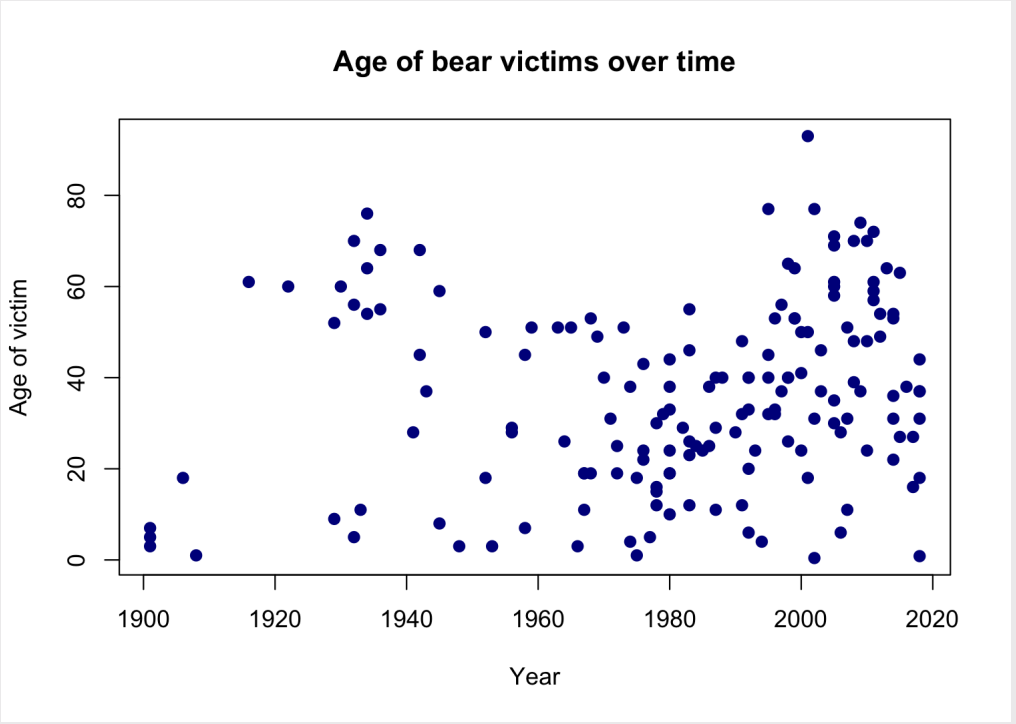
Plot `year` vs. `age`:

```
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 bear victims over time",
     xlab = "Year",
     ylab = "Age of victim")
```

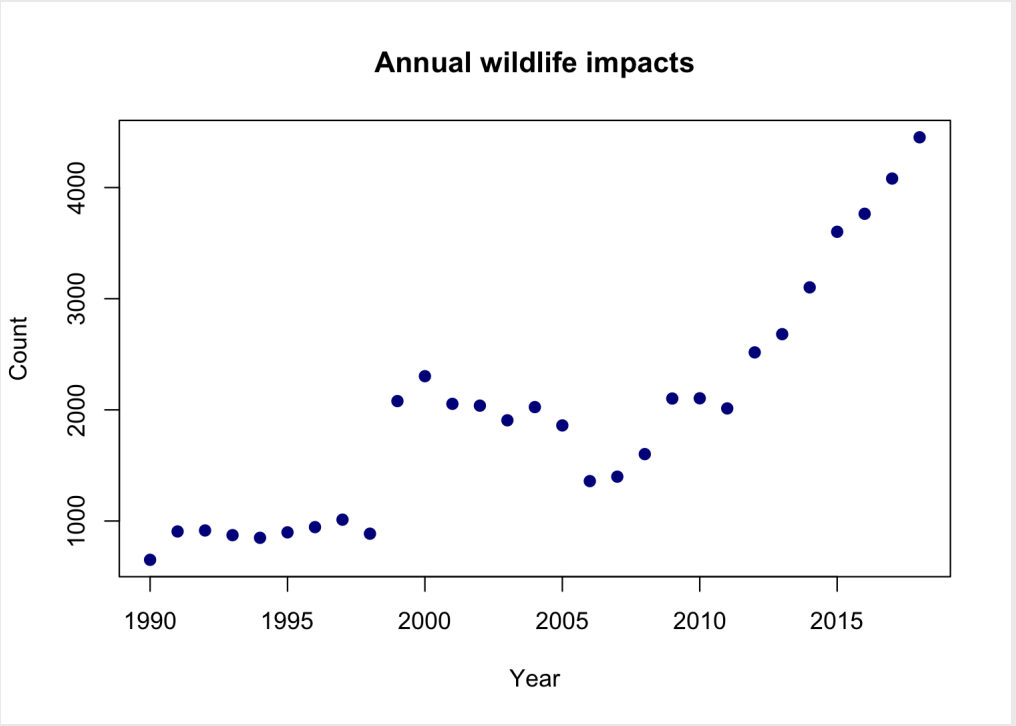


Practice: `plot()`

Does the annual number of bird impacts appear to be changing over time? (use the `birds` data frame)

```
annualCount <- birds %>%
    count(incident_year)

plot(
  x = annualCount$incident_year,
  y = annualCount$n,
  col  = "darkblue",
  pch = 19,
  main = "Annual wildlife impacts",
  xlab = "Year",
  ylab = "Count")
```



Histograms with `hist()`

Plot the *distribution* of a single variable

General syntax:

```
hist(x = <x_vector>)
```

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```
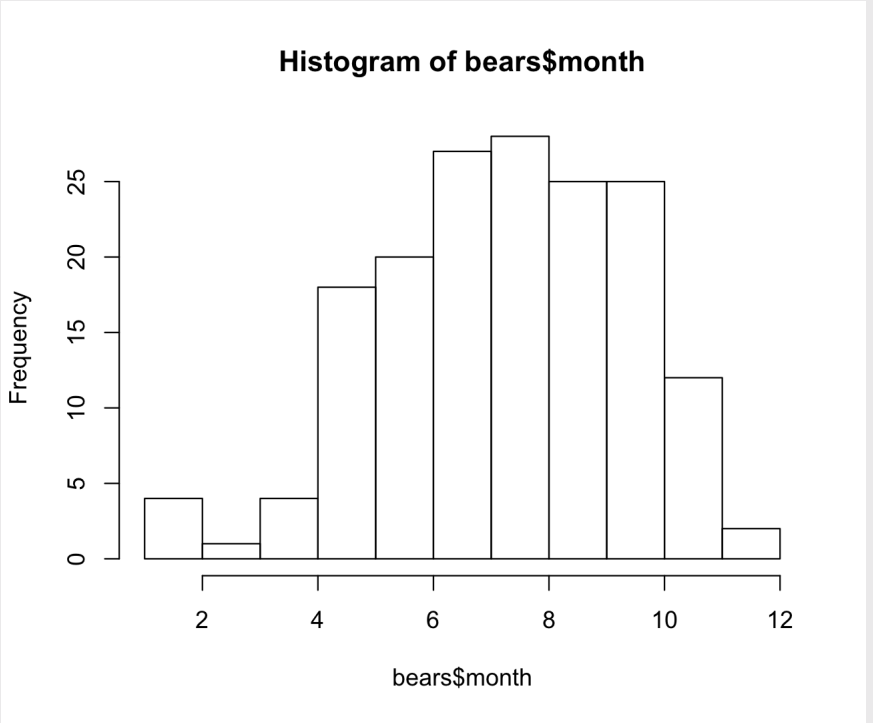
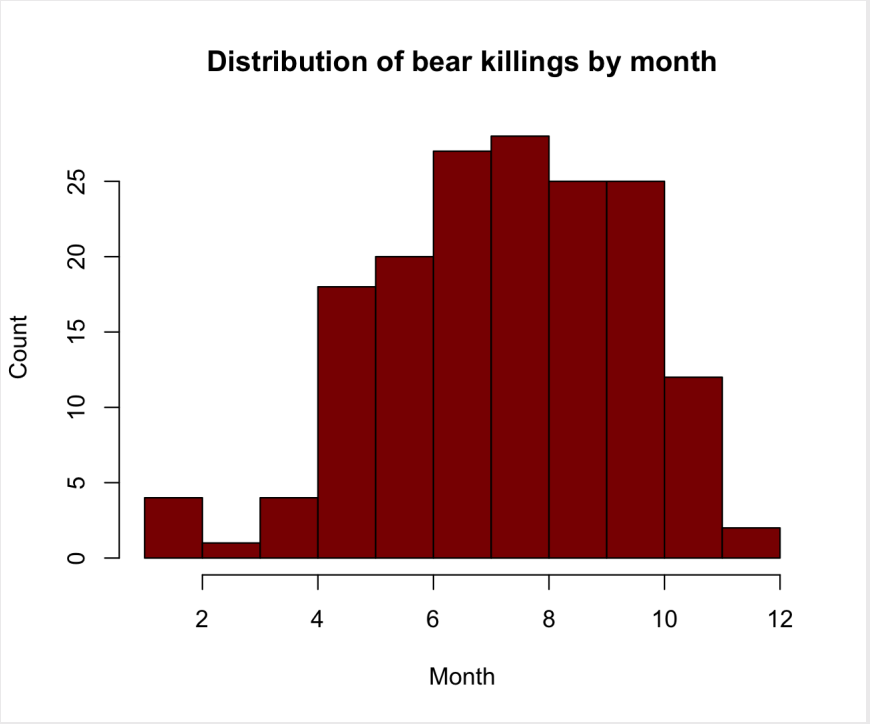

Example:

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



Making `hist()` pretty

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



Practice: `hist()`

Answer the following questions by visually examining the `birds` data frame:

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

Advanced figures with `ggplot2`

"Grammar of Graphics" (gg)

Concept developed by Leland Wilkinson, 1999

ggplot2 package developed by Hadley Wickham, 2005

Layer 1: The data

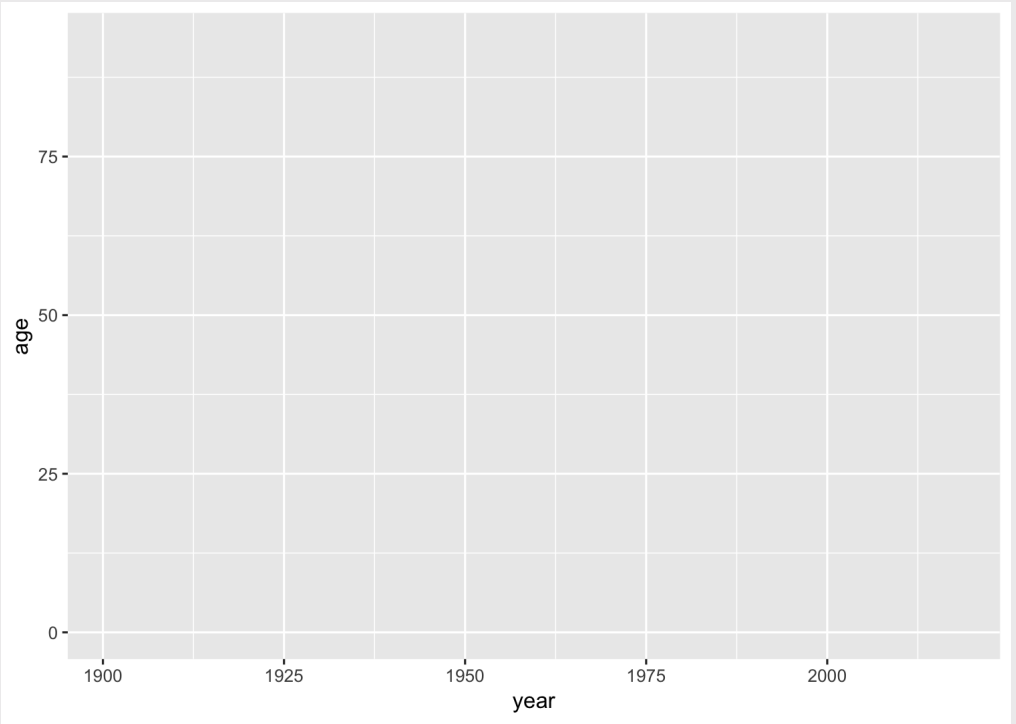
The `ggplot()` function initializes the plot:

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

Layer 2: The aesthetics

The `aes()` function determines which variables will be *mapped* to the axes:

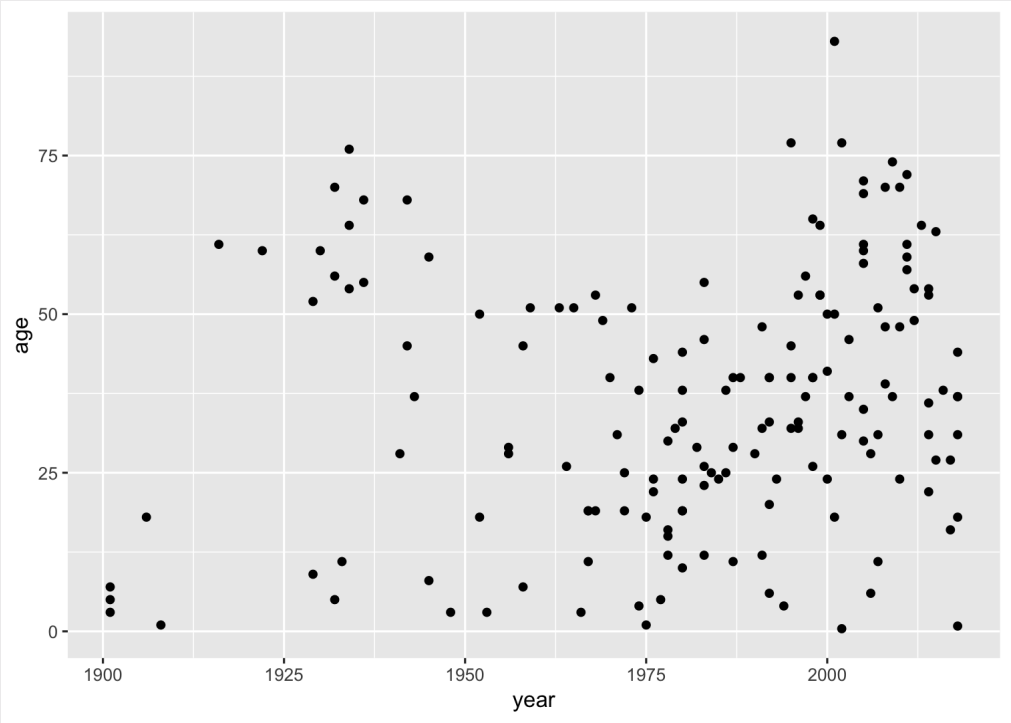
```
ggplot(data = bears, aes(x = year, y = age))
```



Layer 3: The geometries

Use `+` to add geometries (e.g. points) to the plot:

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



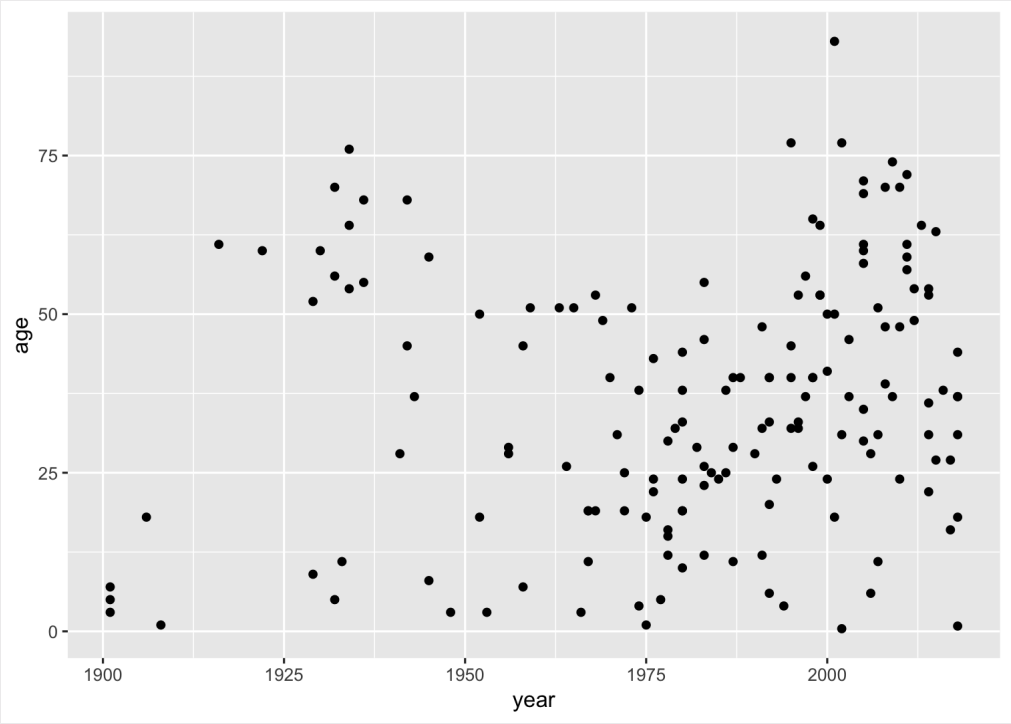
Other common geometries

- `geom_point()`: makes a scatter plot
- `geom_line()`: lines connecting data points
- `geom_bar()`: adds bars for bar charts and histograms
- `geom_boxplot()`: adds boxes for boxplots

Scatterplots with `geom_point()`

Example:

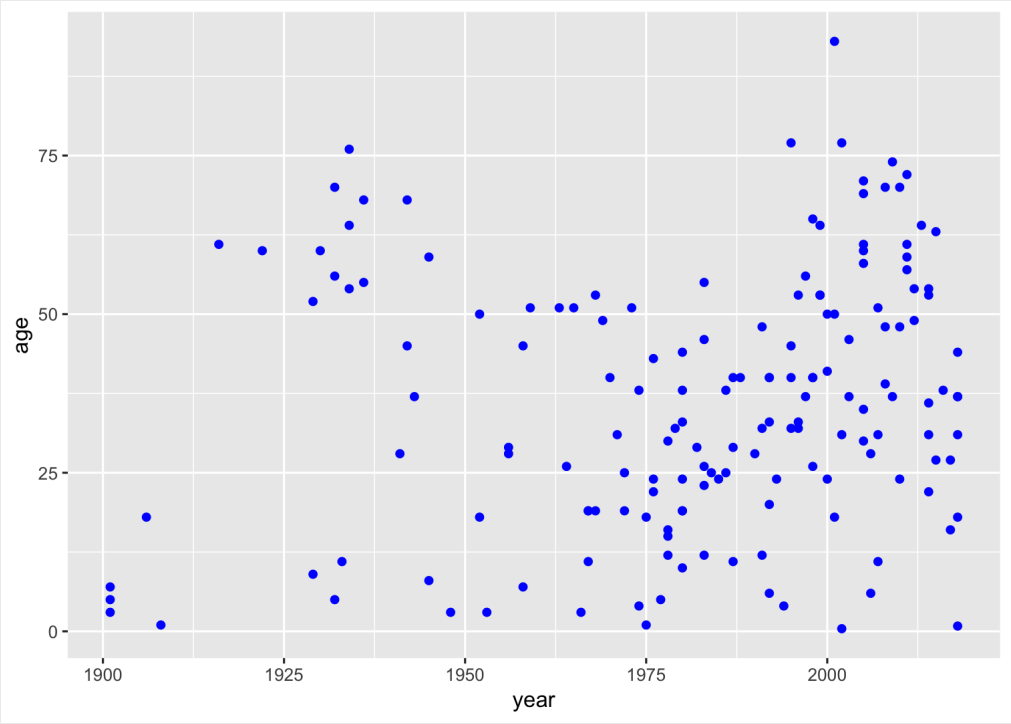
```
ggplot(data = bears, aes(x = year, y = age)) +
    geom_point()
```



Scatterplots with `geom_point()`

Change the point color:

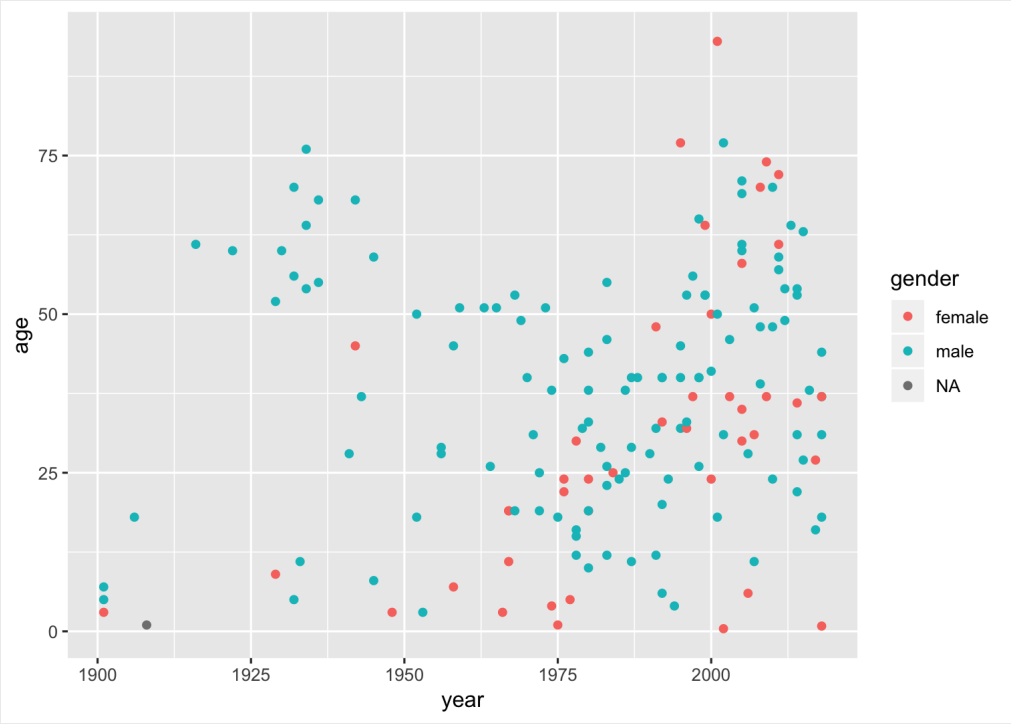
```
ggplot(data = bears, aes(x = year, y = age)) +
    geom_point(color = 'blue')
```



Scatterplots with `geom_point()`

Change the point color **based on another variable**:

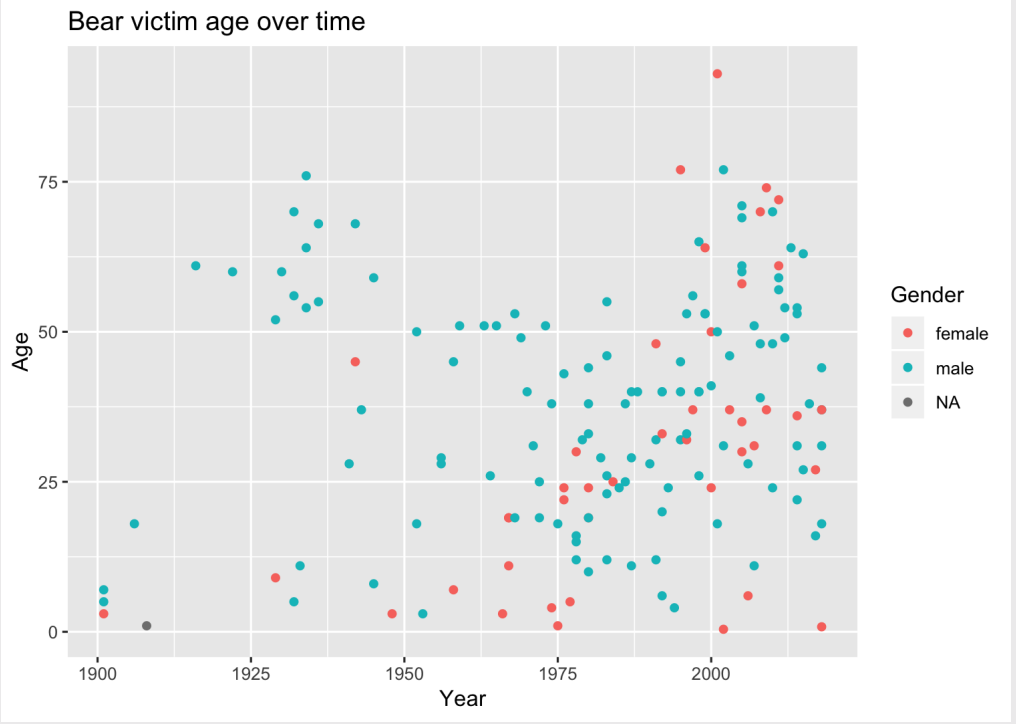
```
ggplot(data = bears, aes(x = year, y = age)) +
    geom_point(aes(color = gender))
```



Scatterplots with `geom_point()`

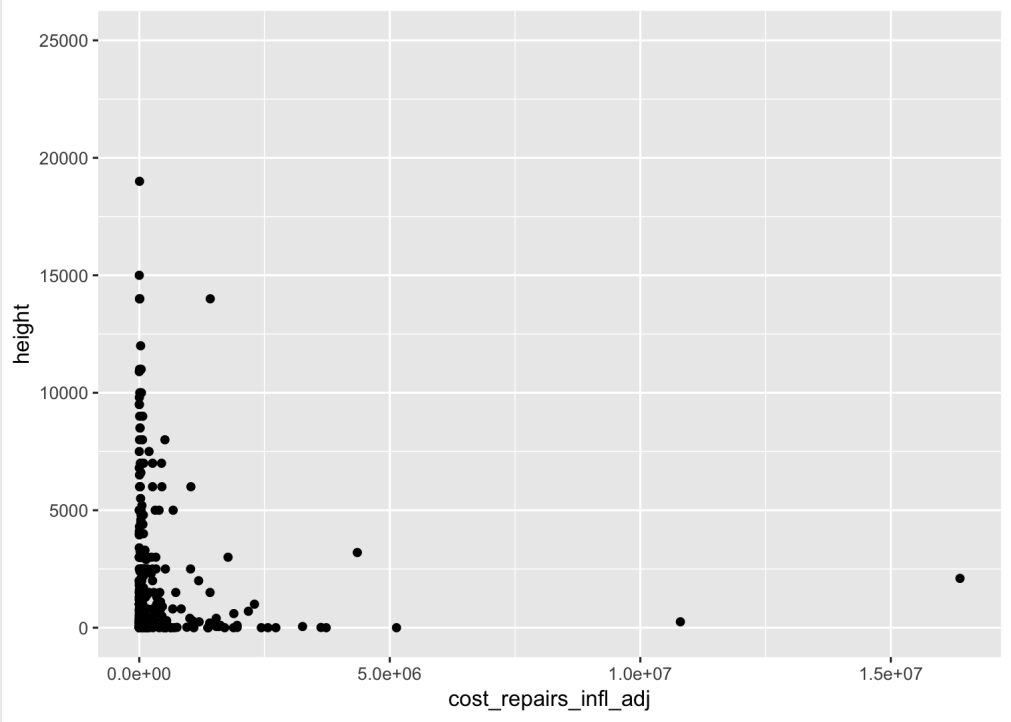
Adjust labels with `labs()` layer:

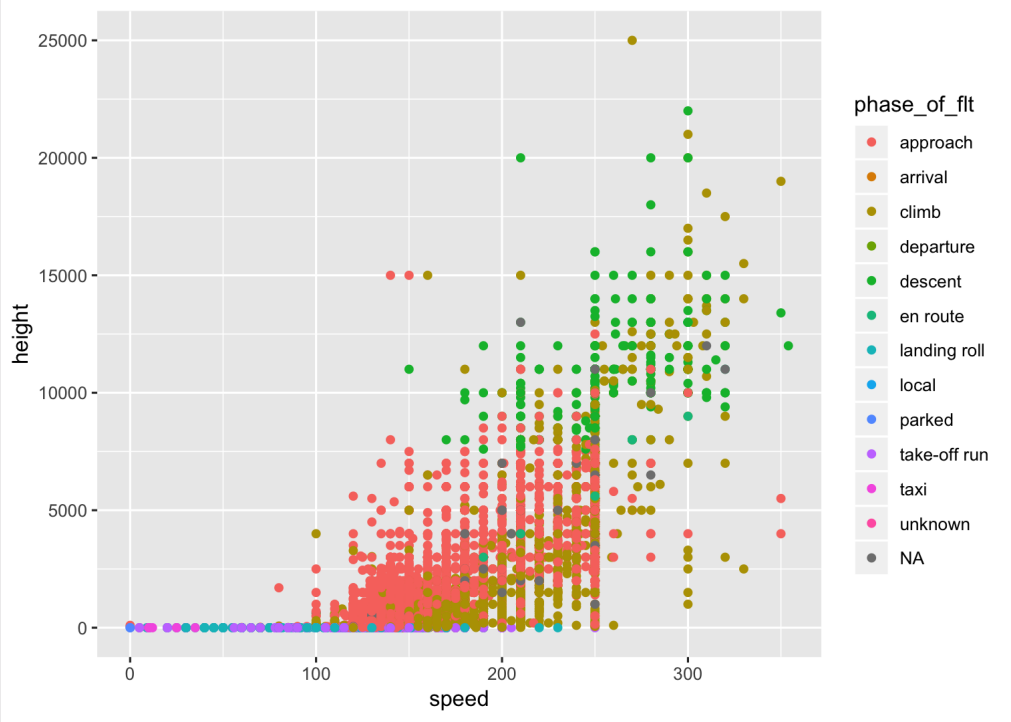
```
ggplot(data = bears, aes(x = year, y = age)) +
    geom_point(aes(color = gender)) +
    labs(x = "Year",
         y = "Age",
         title = "Bear victim age over time",
         color = "Gender")
```



Practice: `geom_point()`

Use the `birds` data frame and `geom_point()` to create the following plots





5 minute break!

Stand up

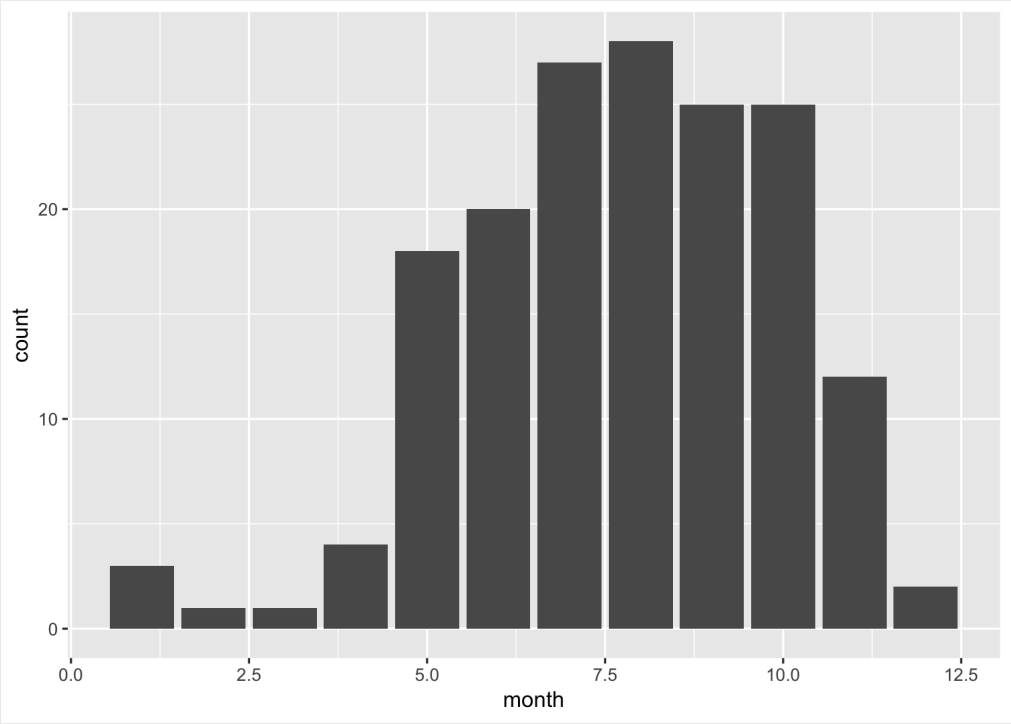
Move around

Stretch!

Histograms with `geom_bar()`

Example:

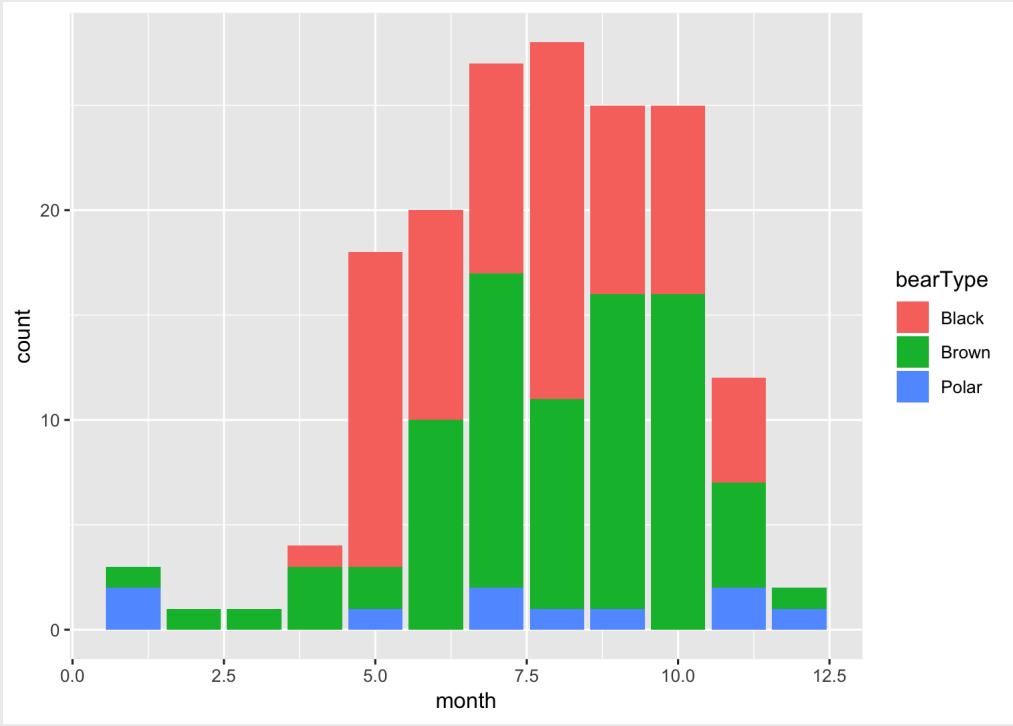
```
ggplot(data = bears, aes(x = month)) +
    geom_bar()
```



Histograms with `geom_bar()`

Use `fill` (not `color`) to change the color of the bars:

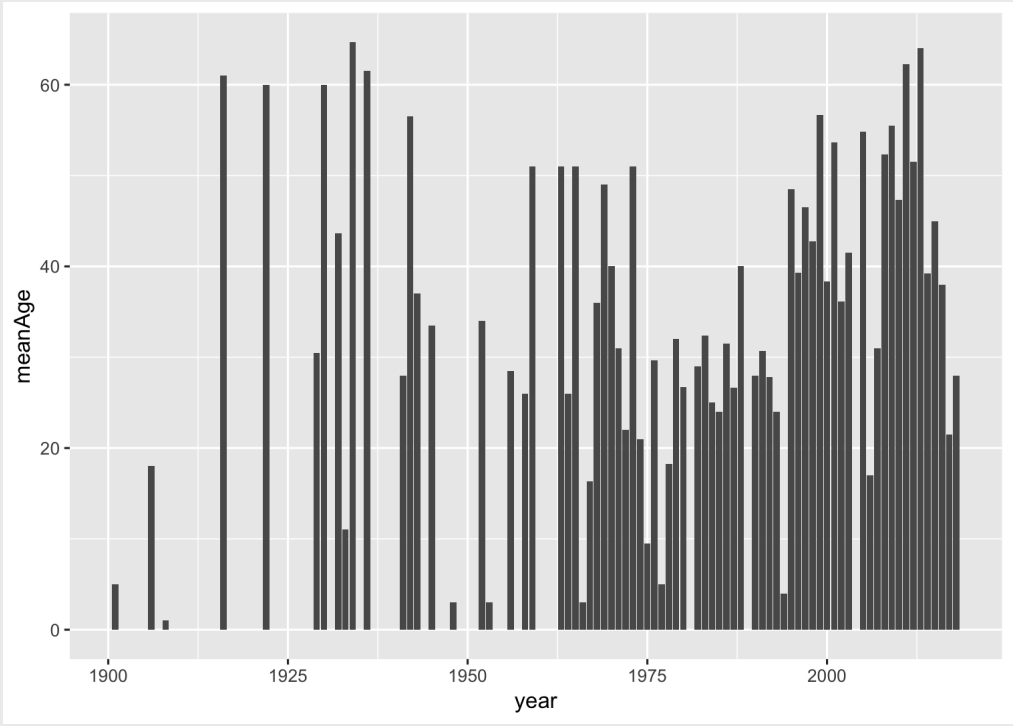
```
ggplot(data = bears, aes(x = month)) +
    geom_bar(aes(fill = bearType))
```



Bar chars with `geom_bar()`

Use both `x` and `y` variables:

```
meanAgeAnnual <- bears %>%
  filter(!is.na(age)) %>%
  group_by(year) %>%
  summarise(meanAge = mean(age))

ggplot(data=meanAgeAnnual, aes(x=year, y=meanAge)
    geom_bar(stat = 'identity')
```

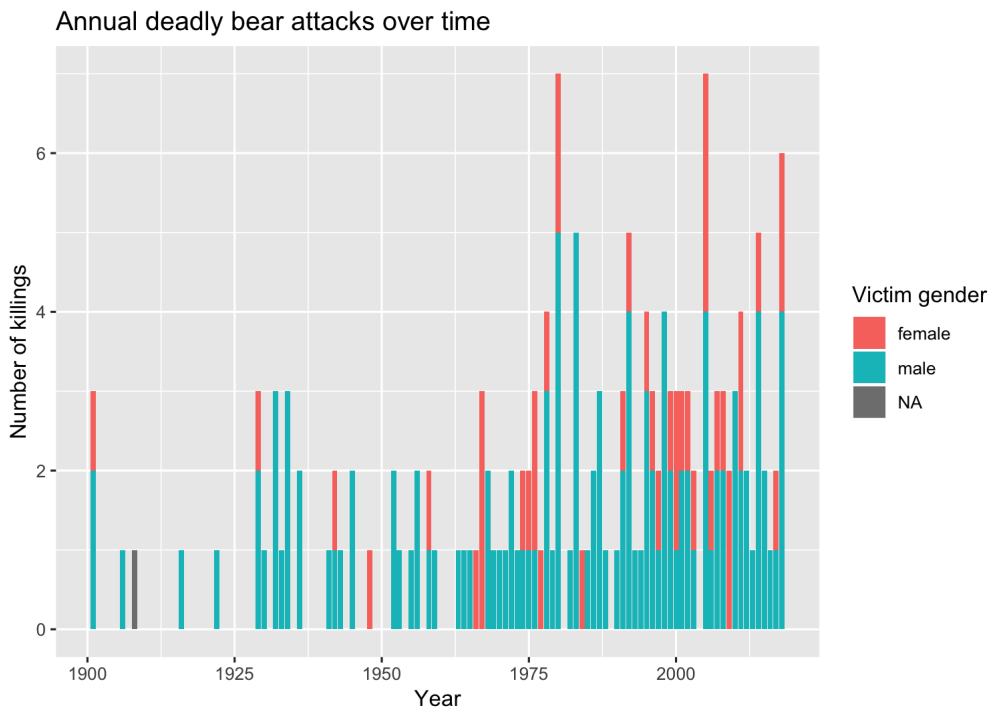


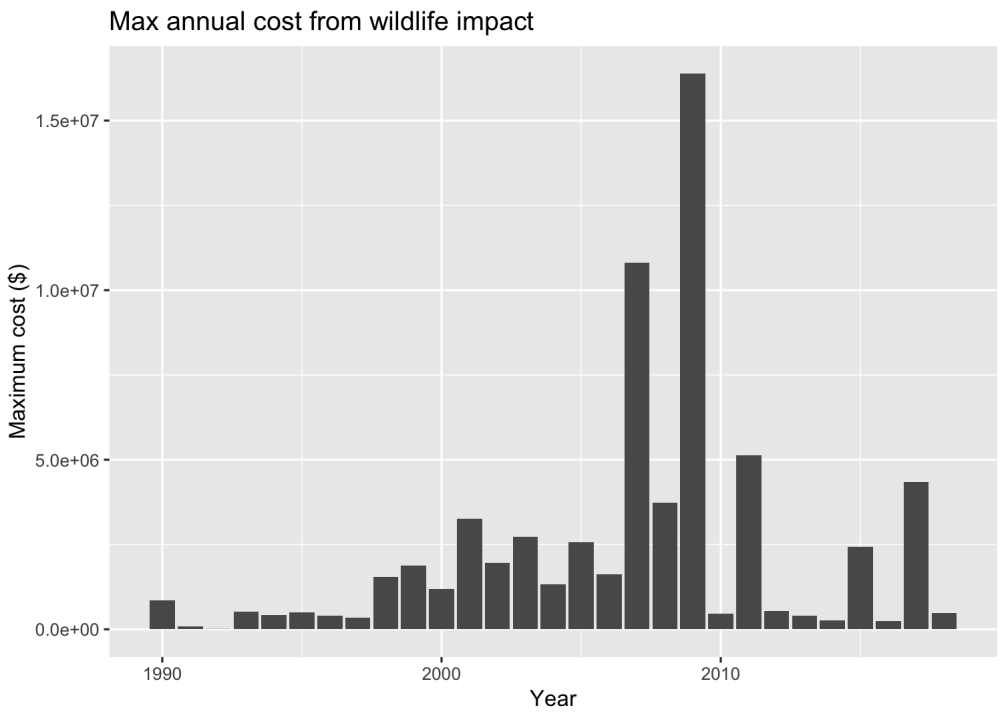
Note addition of `stat = 'identity'`

(Default "stat" is `count`)

Practice: `geom_bar()`

Use the `bears` and `birds` data frames with `geom_bar()` to create the following plots

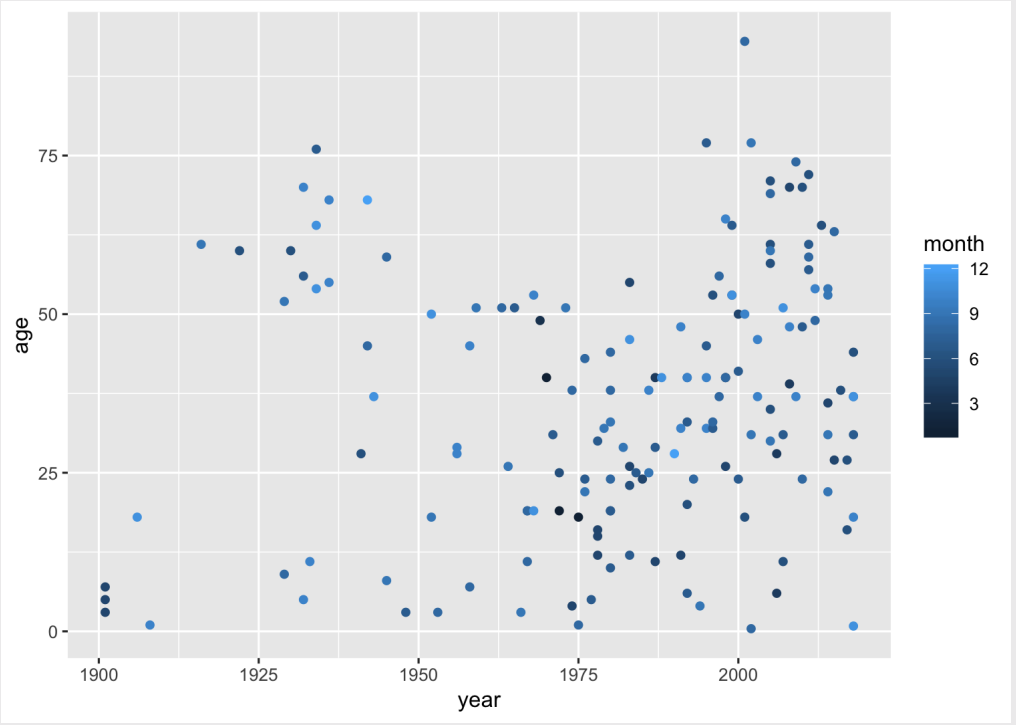




"Factors" = Categorical variables

By default, R makes numeric variables *continuous*

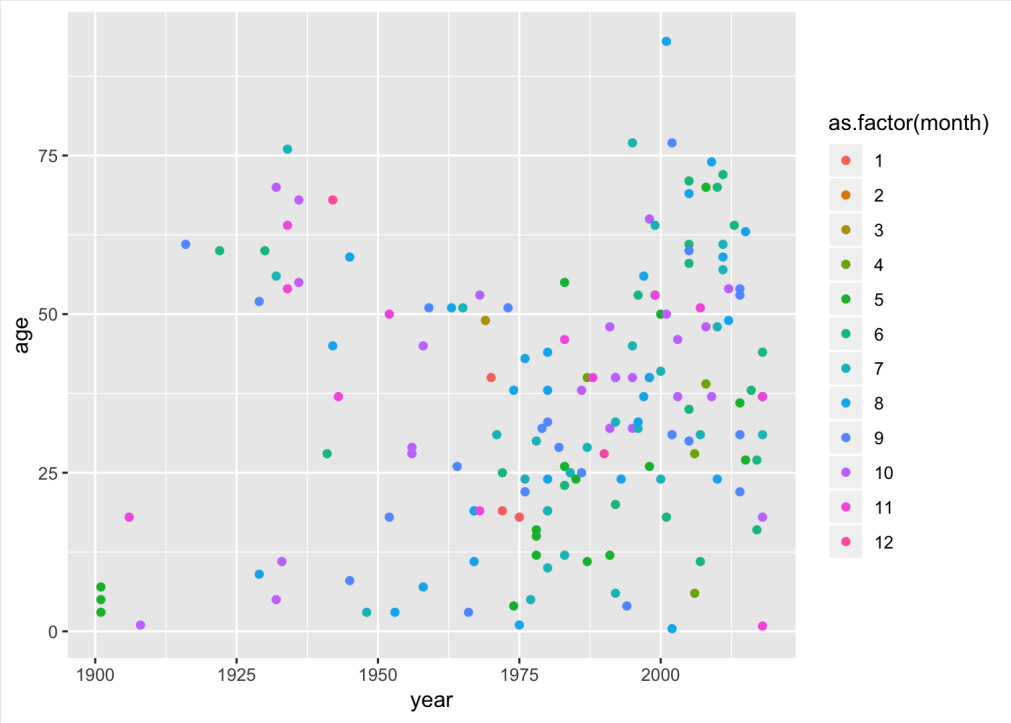
```
ggplot(bears, aes(x=year, y=age)) +
    geom_point(aes(color=month))
```



"Factors" = Categorical variables

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

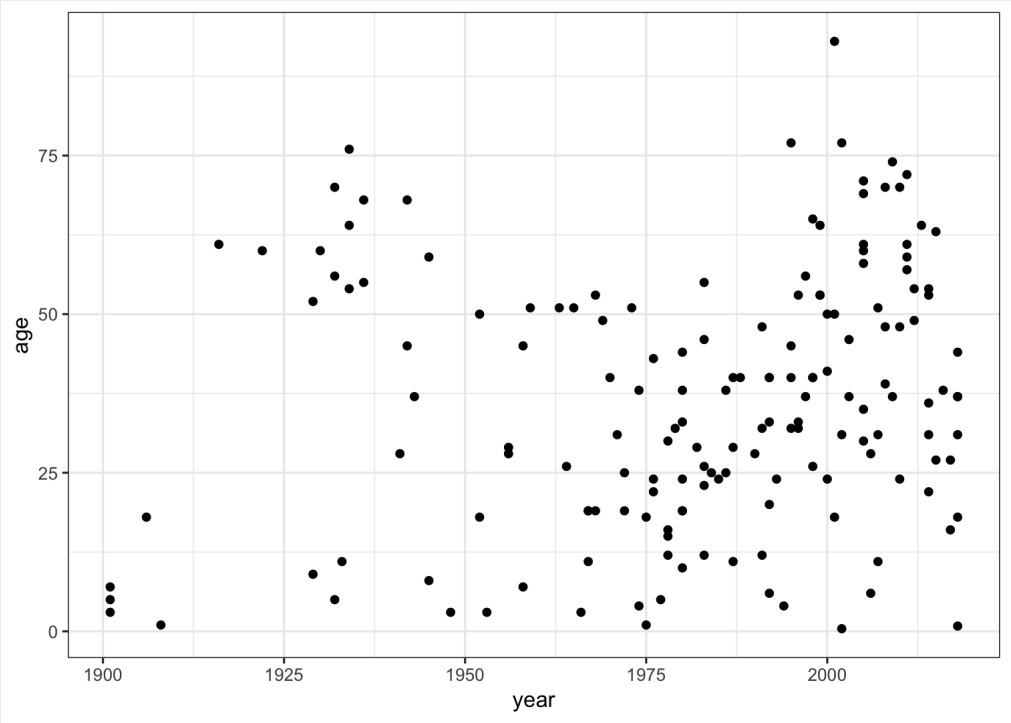
```
ggplot(bears, aes(x=year, y=age)) +
    geom_point(aes(color=as.factor(month)))
```



Working with themes

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

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



Some common themes

Very commonly used:

- `theme_bw`: **My personal default**
- `theme_minimal`: Another simple, minimal theme
- `theme_classic`: Classic R plotting style
- `theme_void`: Completely blank

Others:

- `theme_light`
- `theme_dark`
- `theme_grey`
- `theme_gray`
- `theme_linedraw`
- `theme_test`

Getting some gg-assistance

```
install.packages("ggThemeAssist")
```

Save figures with `ggsave()`

First, assign the plot to an object name:

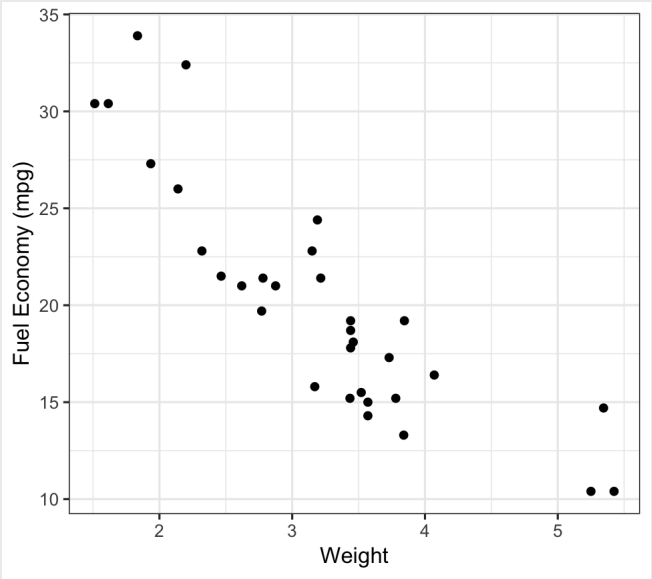
```
scatterPlot <- ggplot(data = bears) +
    geom_point(aes(x = year, y = age))
```

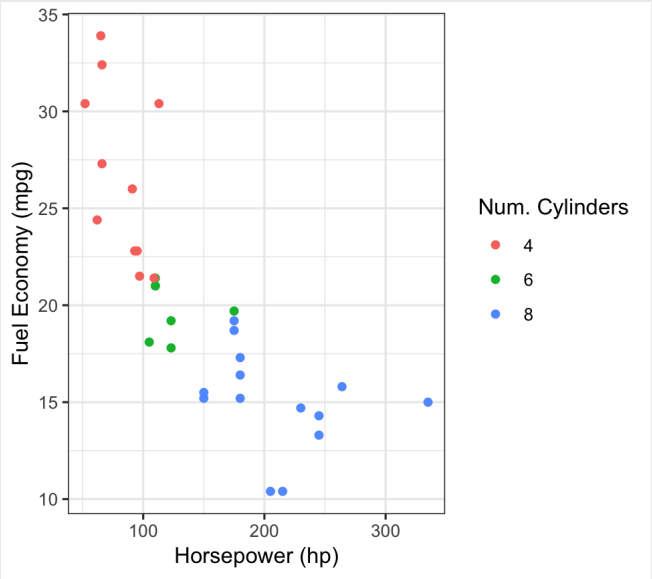
Then use `ggsave()` to save the plot:

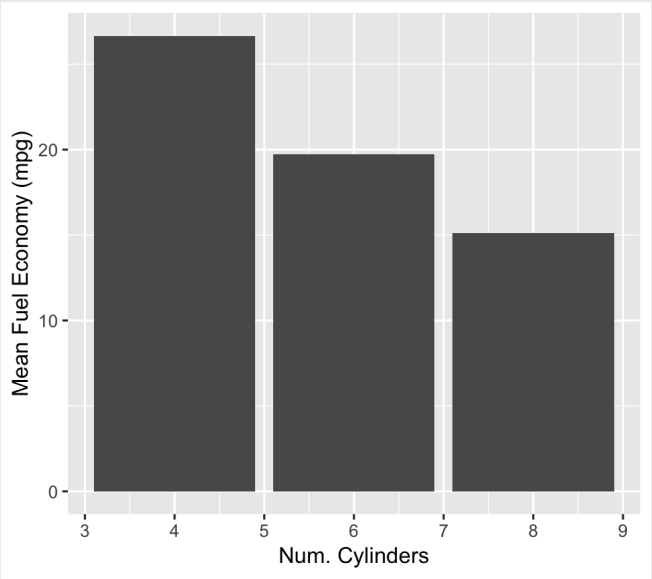
```
ggsave(filename = file.path('data', 'scatterPlot.pdf'),
       plot   = scatterPlot,
       width  = 6,
       height = 4)
```

Extra practice 1

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

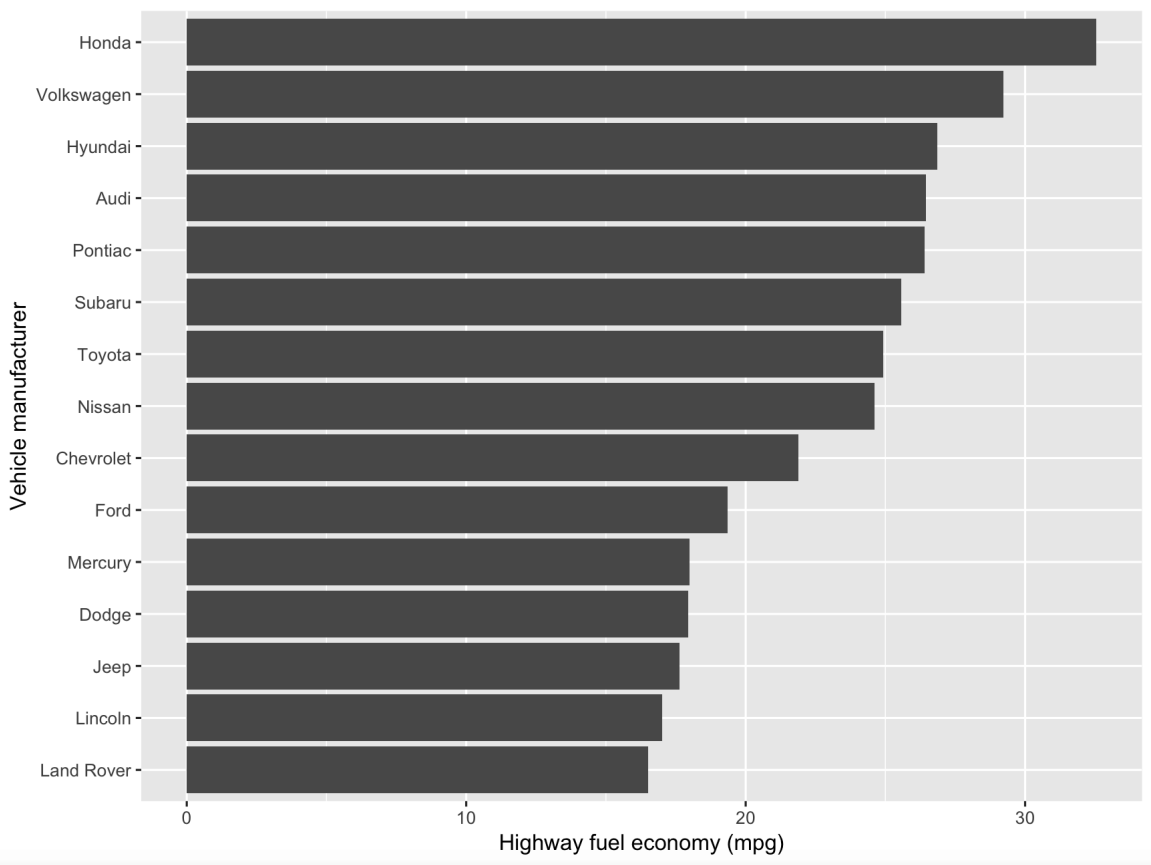






Extra practice 2

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



HW 6

Complete parts 1 - 3 by next week!