

# Summaries and visualization of distributions

## Reflection on the last week

### Objectives

At the end of the lecture, you will know how to..

- Organize your **code in scripts**.
- Organize your **work in projects**.
- Count and interpret descriptive statistics **characterizing central tendency** of a numeric variable.
- **Describe spread** of a numeric variable.
- **Read plots** for one variable.
- **Create plots** displaying one variable in ggplot2 package.
- **Understand** what type of **variation occurs within** your variables.

### Organize your work in scripts

#### In RStudio...

- Create a new script with *Ctrl + Shift + n*
- Put some basic info on what are you doing at the top.  
Use **comments #** (*Ctrl + Shift + c*) to write notes.  
Comment on the **why**, not the **what**.
- **Divide the code** into sections with *Ctrl + Shift + r*  
# Section name ----
- Load the packages you use at the top of the script.
- RStudio will give you **hints**, hit *Tab* to autocomplete function calls.
- **Execute the current line** with *Ctrl + Enter*
- Source the whole script with *Ctrl + Shift + Enter*

---

**Listing 1** dartpoints.r

---

```
# Analysis of dartpoints data set
# 6. 3. 2024

library(ggplot2)

# data -----
# read data from CSV
# url: https://petrpajdla.github.io/stat4arch/lect/w02/data/dartpoints.csv
dartpoints <- read.csv("dartpoints2.csv")

# structure -----
colnames(dartpoints)
nrow(dartpoints)
ncol(dartpoints)
str(dartpoints)

mean(dartpoints$Length)

# plots -----
ggplot(data = dartpoints) +
  aes(x = Length) +
  geom_histogram() +
  labs(x = "Length (cm)", y = "Count")
```

---

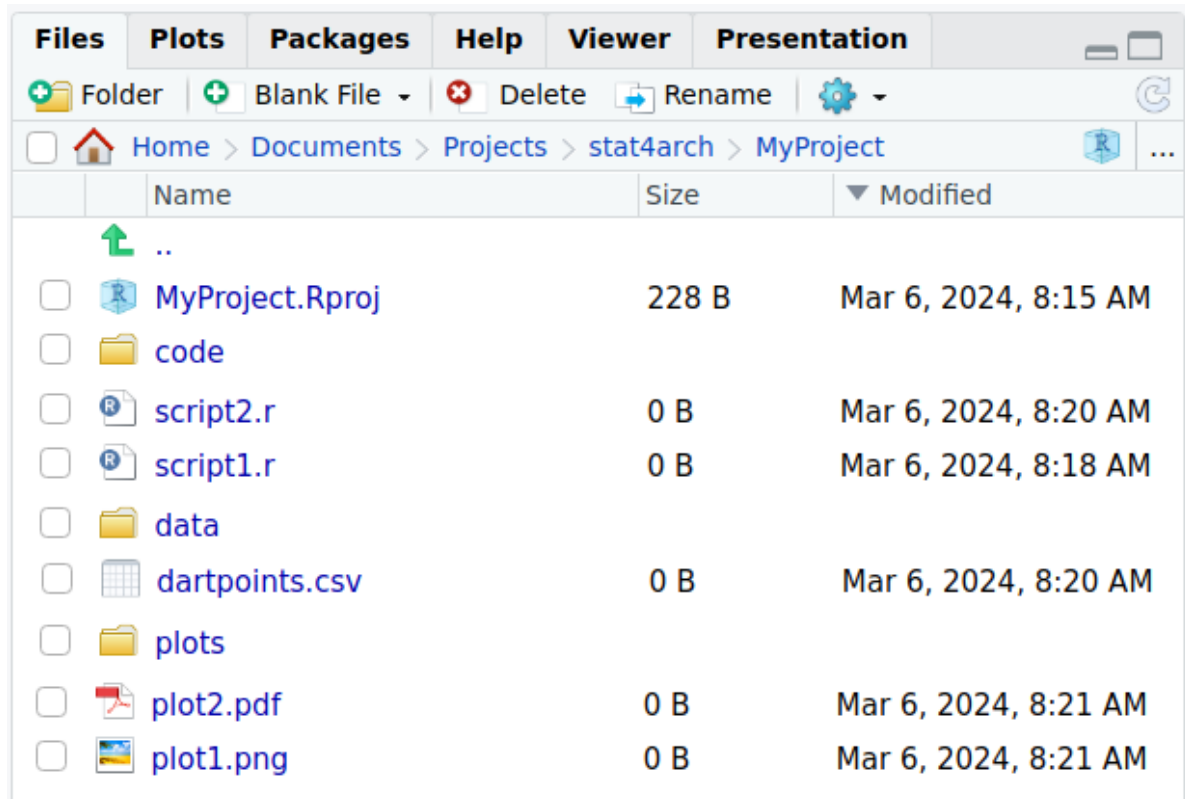
**Organize your work in projects**

- Each project is in a **separate directory**.
- There are **subdirectories** for different parts of the project.

```
MyProject/
  code/
    script1.R
    script2.R
  data/
    dartpoints.csv
  plots/
```

plot1.png  
plot2.pdf  
MyProject.Rproj

- In RStudio go to *Files > New Project*



## Paths

### Absolute file path

The file path is specific to a given user.

C:/Documents/MyProject/data/dartpoints.csv

### Relative file path

If I am currently in MyProject/ folder:

./data/dartpoints.csv

Package `here` is here to save the day!

- Do not forget to install the package first.
- Load it at the top of your script.

```
# install.packages("here")  
library(here)
```

- Function `here()` will know where the top directory is.

```
# read data ----  
dartpoints <- read_csv(here("data/dartpoints.csv"))
```

## Descriptive Statistics

### Characterizing centrality

#### Mean (*průměr*)

`mean(x)`

$$\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{n} = \frac{1}{n} \left( \sum_{i=1}^n x_i \right)$$

#### Median (*medián*)

`median(x)`

- **Robust**, minimizes influence of outliers.

#### What are outliers? (*odlehle hodnoty*)

- **Outliers** are data points that significantly differ from other observations.
- May indicate a measurement error, an exceptional observation, etc.

## Characterizing centrality

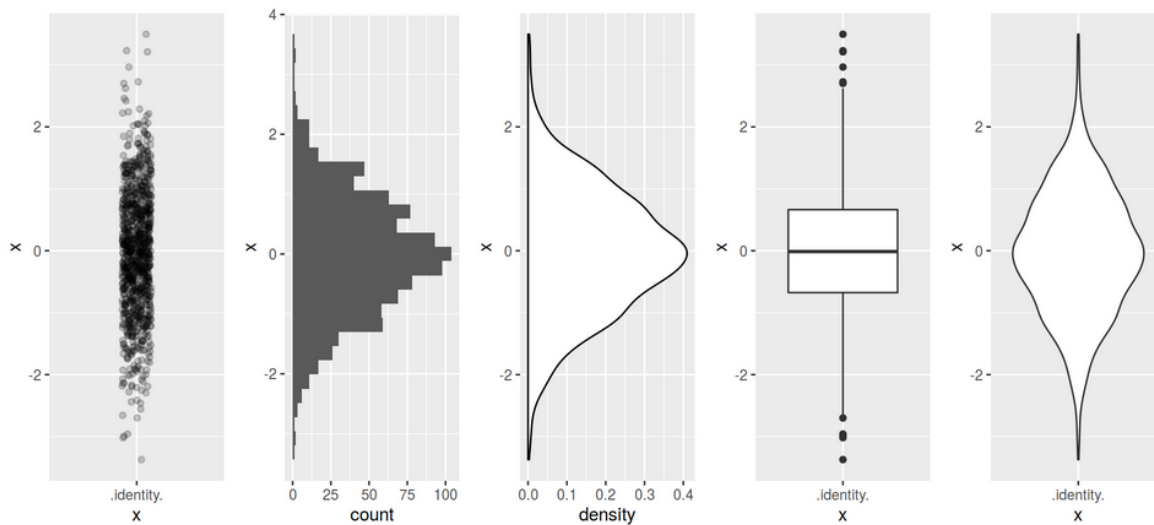


Figure 1: Various plots of a normal distribution

## Characterizing dispersion and/or spread

### Range (*rozpětí*)

`max(x) - min(x)` or `range(x)`

### Variance and Standard deviation (*rozptyl a směrodatná odchylka*)

`sd(x)`

$$\sigma = \sqrt{s^2} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$$

### Interquartile range (midspread, IQR, *kvantil, mezikvartilové rozpětí*)

`IQR(x)`

- **Robust**, minimizes influence of outliers.

## Characterizing dispersion and/or spread



Figure 2: Various plots of a normal distribution

## Exercise

- Start *RStudio*.
- Create a new project, save it somewhere you can find it.
- Use dataset [dartpoints2.csv](#).
- Save it in your project directory.
- Load the data from the CSV file.
- What is the column separator?
- How are NAs represented?
- Explore the dataset.
- Count mean and median **weight**, how do they differ?
- What is the range of the weights?
- What is the standard deviation of weights? What does it mean?
- Count the IQR. Compare it with standard deviation.
- Hints: `read.csv2(path, na.strings)`, `str()`, `colnames()`, `mean()`, `median()`, `range()`, `sd()`, `IQR()`, `summary()`

## Solution

```
# dartpoints <- read.csv2(here::here("dartpoints2.csv"), na.strings = "-")
colnames(dartpoints)
```

```
[1] "Name"      "Catalog"   "TARL"      "Quad"      "Length"    "Width"
[7] "Thickness" "B.Width"   "J.Width"   "H.Length"  "Weight"    "Blade.Sh"
[13] "Base.Sh"   "Should.Sh" "Should.Or" "Haft.Sh"   "Haft.Or"
```

```
dartpoints$Weight
```

```
[1] 3.6 4.5 3.6 4.0 2.3 3.0 3.9 6.2 5.1 2.8 2.5 4.8 3.2 3.8 4.5
[16] 4.4 2.5 2.3 4.2 3.3 3.6 7.4 5.6 4.8 7.8 9.2 6.2 4.3 4.6 5.4
[31] 5.9 5.1 4.7 7.2 2.5 3.9 4.1 7.2 10.7 12.5 13.4 11.1 7.2 28.8 13.9
[46] 9.4 5.3 7.9 7.3 12.2 9.3 11.1 14.8 10.7 11.1 12.3 13.1 6.1 9.2 9.4
[61] 6.7 15.3 15.1 4.6 4.3 11.6 10.5 6.8 9.1 9.4 9.5 10.4 7.5 8.7 6.9
[76] 15.0 11.4 6.3 7.5 5.9 5.4 9.5 5.4 7.1 9.7 12.6 10.5 5.6 4.9 5.2
[91] 16.3
```

```
mean(dartpoints$Weight)
```

```
[1] 7.642857
```

```
median(dartpoints$Weight)
```

```
[1] 6.8
```

```
max(dartpoints$Weight) - min(dartpoints$Weight) # or range(dartpoints$Weight)
```

```
[1] 26.5
```

```
sd(dartpoints$Weight)
```

```
[1] 4.207088
```

```
IQR(dartpoints$Weight)
```

```
[1] 5.5
```

```
summary(dartpoints$Weight)
```

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
2.300	4.550	6.800	7.643	10.050	28.800

## Brainstorming

- Why do we visualize data?
- What elements does a *good* graph contain?
- How are these elements called?



FIGURE 15 Box-and-whiskers plots for dart point lengths.

Figure 3: Boxplots from Carlson 2017

## Plots for one variable

### Histogram

- **Distribution** of values of a **quantitative** variable.



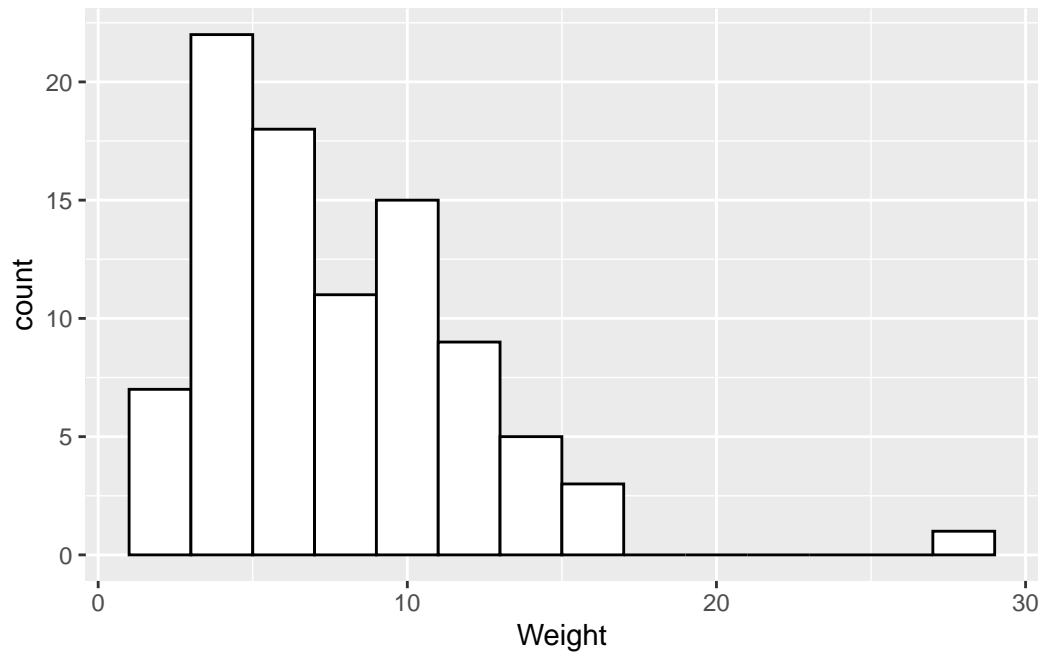
Distribution of dart point weights.



## Histogram

- **Distribution** of values of a **quantitative** variable.

Distribution of dart point weights, one column (*bin*) equals 2 g.



### Density plot

- **Distribution** of values of a **quantitative** variable.

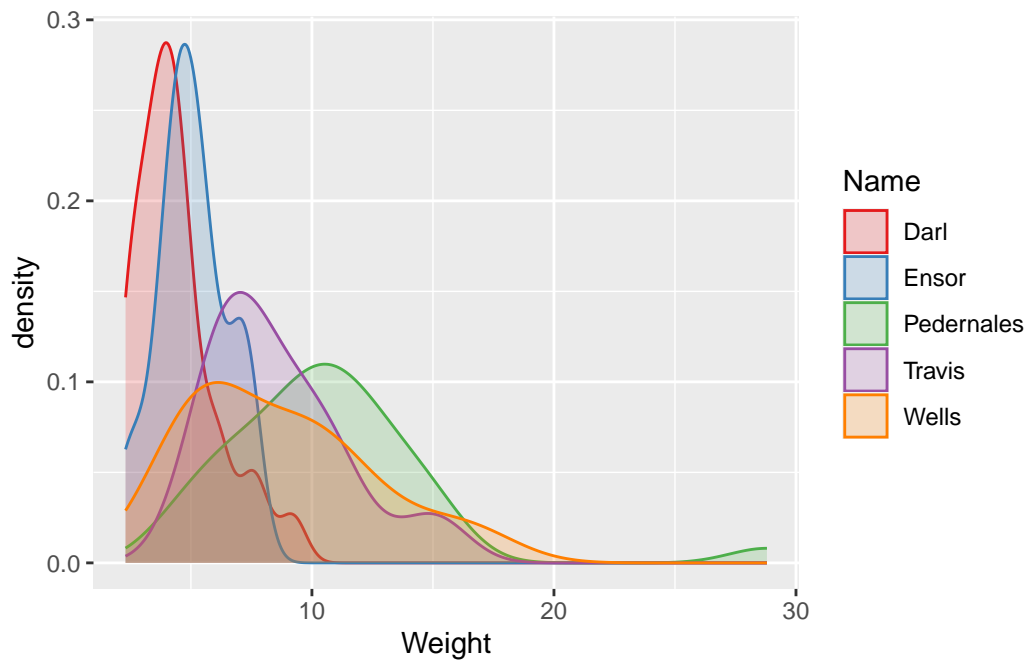
Distribution of dart point weights.



### Density plot

- **Distribution** of values of a **quantitative** variable, great for **comparisons**.

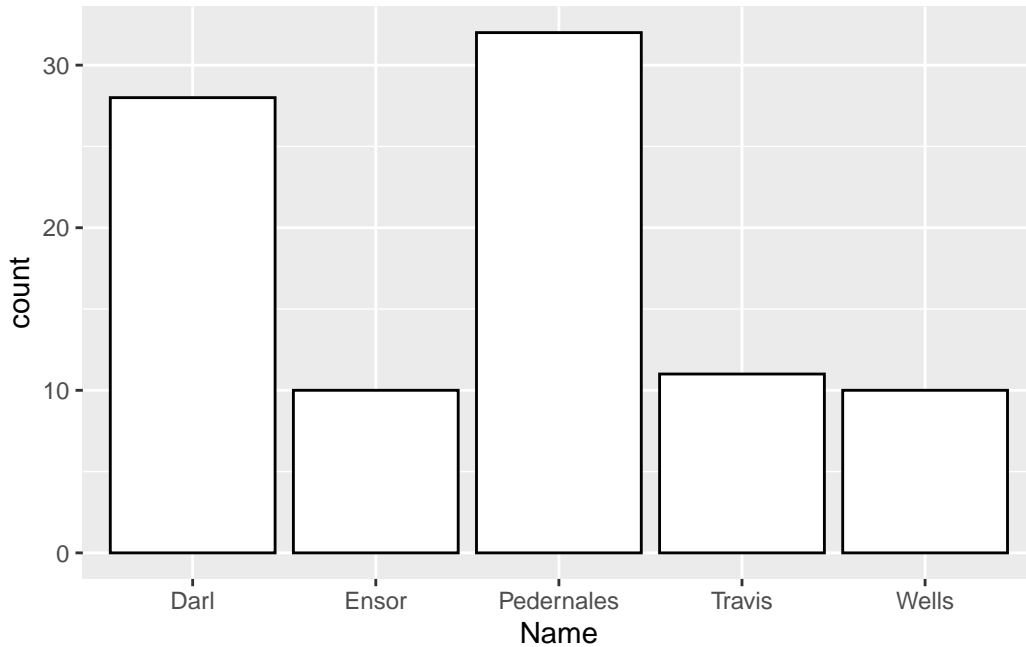
Distribution of different types of dart points by weight.



### Bar chart

- **Distribution** of values of a **qualitative** variable.

Distribution of types of dart points.



## Plots in ggplot2 package

```
1 install.packages("ggplot2") ①
2
3 library(ggplot2) ②
4
5 ggplot(data = <your data frame>) + ③
6   aes(x = <variable to be mapped to axis x>) + ④
7   geom_<geometry>() ⑤
```

- ① Install the package `ggplot2`, do this only once.
- ② Load the package from the library of installed packages, do this for every new script.  
(Calls to `library()` function are usually written at the top of the script.)
- ③ Function `ggplot()` takes the data frame as an argument.
- ④ Function `aes()` serves to map *aesthetics* (axis x and y, colors etc.) to different variables from your data frame.
- ⑤ Functions with `geom_` prefix are *geometries*, ie. types of plots to draw.

Geoms for one variable:

- `geom_histogram()`
- `geom_density()`
- `geom_bar()`

## Layers of ggplot2

```
ggplot(data = dartpoints)
```



## Layers of ggplot2

```
ggplot(data = dartpoints) +  
  aes(x = Name)
```



### Layers of ggplot2

```
ggplot(data = dartpoints) +  
  aes(x = Name) +  
  geom_bar()
```



### Bar chart

```
ggplot(data = dartpoints) +  
  aes(x = Name) +  
  geom_bar()
```





### Bar chart

```
ggplot(data = dartpoints) +  
  aes(x = Name, color = Name) +  
  geom_bar()
```



## Bar chart

```
ggplot(data = dartpoints) +  
  aes(x = Name, color = Name, fill = Name) +  
  geom_bar()
```



### Bar chart

```
ggplot(data = dartpoints) +  
  aes(x = Name, fill = Name) +  
  geom_bar(color = "black")
```



## Histogram

```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_histogram()
```



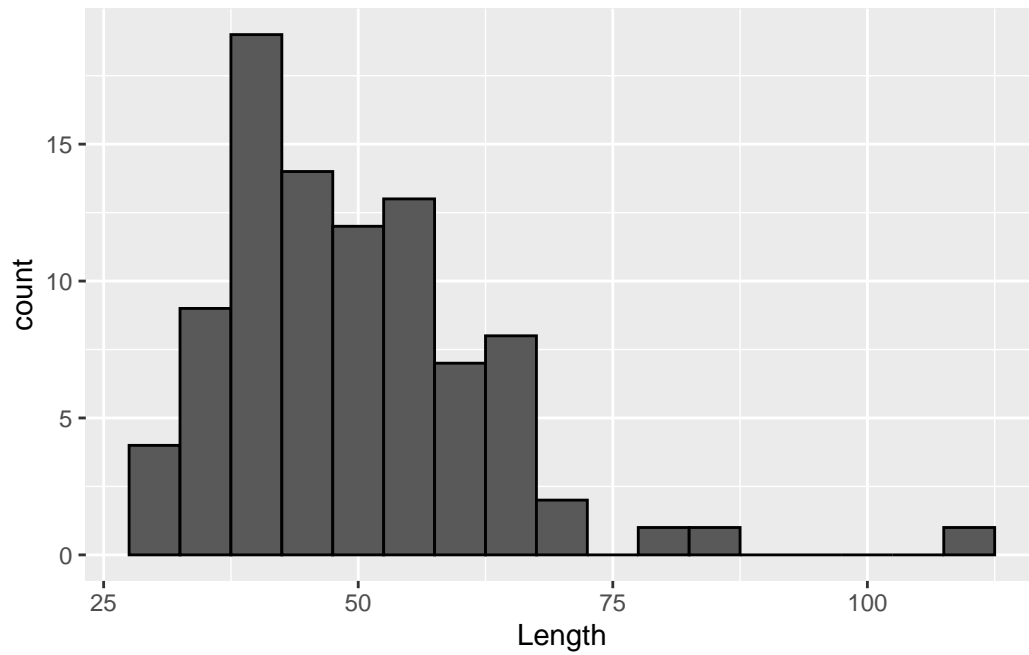
## Histogram

```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_histogram(binwidth = 5)
```



## Histogram

```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_histogram(binwidth = 5, color = "black")
```



## Histogram

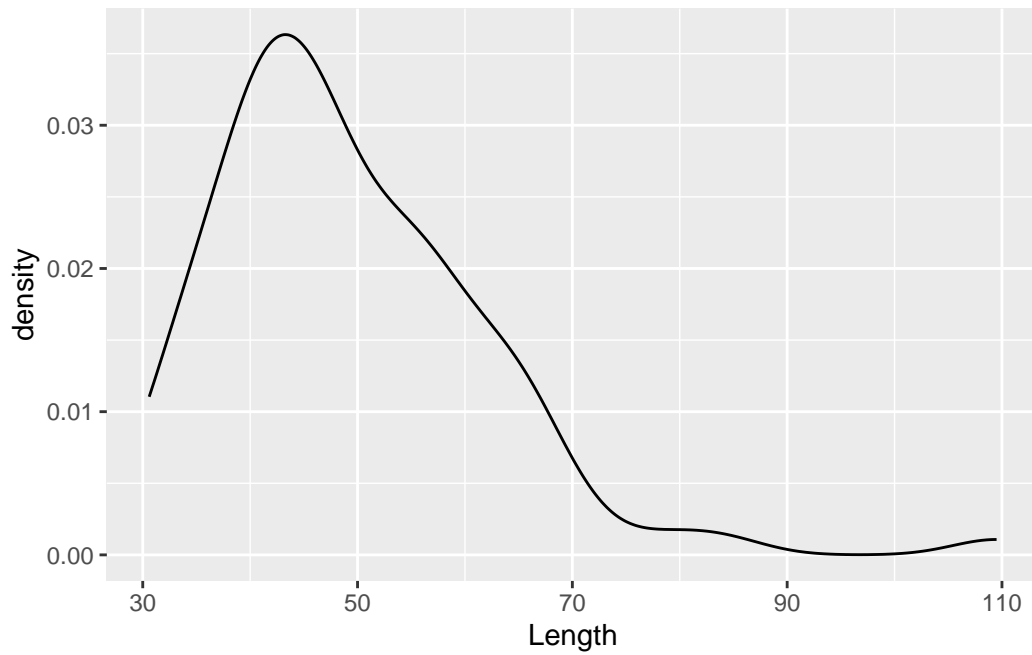
```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_histogram(binwidth = 5, color = "black", fill = "white")
```



### Density plot

```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_density()
```





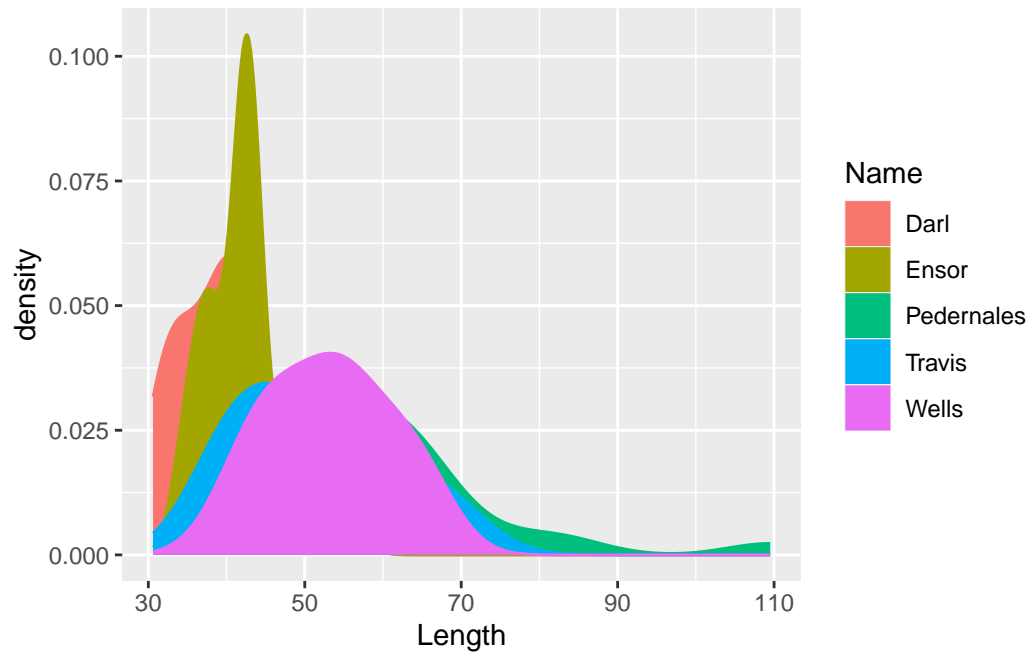
### Density plot

```
ggplot(dartpoints) +  
  aes(x = Length, color = Name) +  
  geom_density()
```



### Density plot

```
ggplot(dartpoints) +  
  aes(x = Length, color = Name, fill = Name) +  
  geom_density()
```



**Density plot**

```
ggplot(dartpoints) +  
  aes(x = Length, color = Name, fill = Name) +  
  geom_density(alpha = 0.4)
```



## Labels

```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_histogram(binwidth = 5, color = "black", fill = "white")
```



## Labels

```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_histogram(binwidth = 5, color = "black", fill = "white") +  
  labs(x = "Length (cm)", y = "Count")
```



## Labels

```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_histogram(binwidth = 5, color = "black", fill = "white") +  
  labs(x = "Length (cm)", y = "Count",  
       title = "Histogram of dart point lengths")
```

Histogram of dart point lengths



## Labels

```
ggplot(dartpoints) +  
  aes(x = Length) +  
  geom_histogram(binwidth = 5, color = "black", fill = "white") +  
  labs(x = "Length (cm)", y = "Count",  
        title = "Histogram of dart point lengths",  
        caption = "Data adapted from archdata R package, Carlson 2017")
```



## Exercises

## Assignments

- Read [Make a plot](#) chapter in *Data Visualization* book by K. J. Healy.

## Optional

- Go through *Visualize data* tutorials [here](#).