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 statics **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 *Ctr + Enter*
- Source the whole script with *Ctrl + Shift + Enter*

Listing 1 `dartpoints.r`

```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")
```

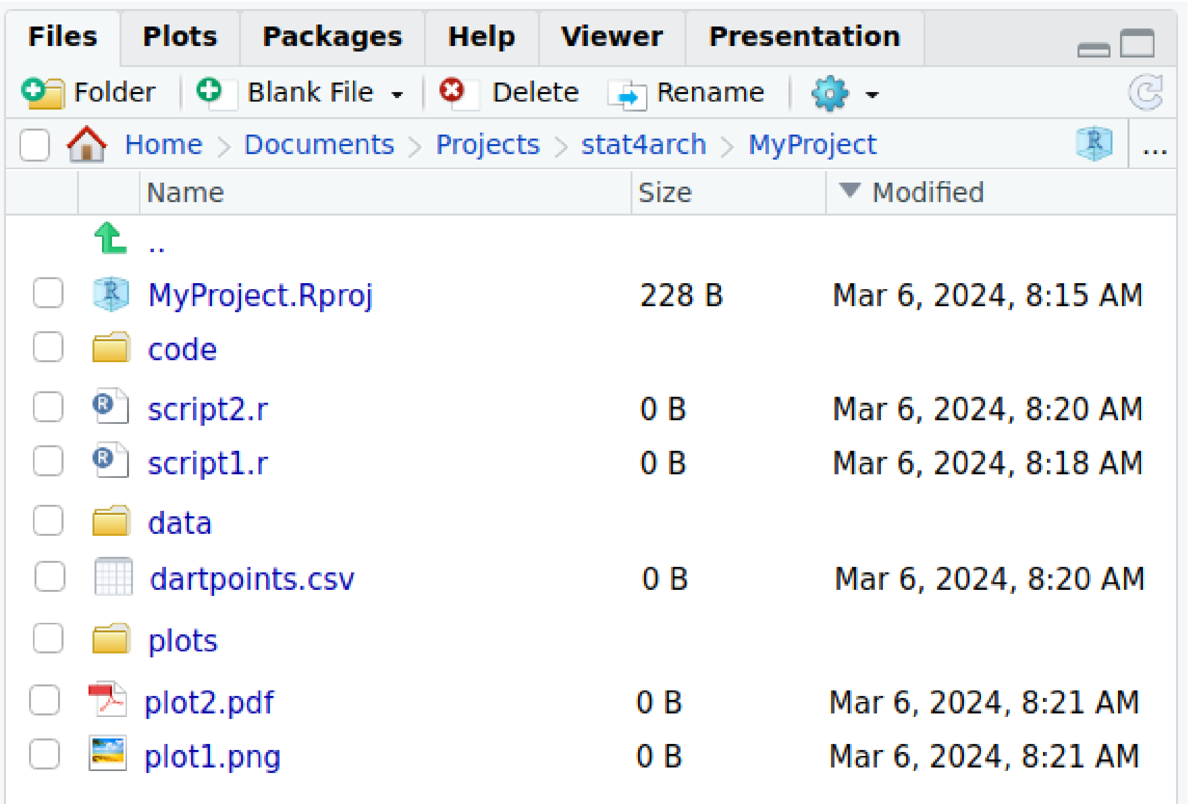
Organize your work in projects

- 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*



	Name	Size	Modified
	..		
□	MyProject.Rproj	228 B	Mar 6, 2024, 8:15 AM
□	code		
□	script2.r	0 B	Mar 6, 2024, 8:20 AM
□	script1.r	0 B	Mar 6, 2024, 8:18 AM
□	data		
□	dartpoints.csv	0 B	Mar 6, 2024, 8:20 AM
□	plots		
□	plot2.pdf	0 B	Mar 6, 2024, 8:21 AM
□	plot1.png	0 B	Mar 6, 2024, 8:21 AM

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)`

$$\overline{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{1}{n}(\sum_{i=1}^{n} x_i)$$

Median (*medián*)

`median(x)`
- **Robust**, minimizes influence of outliers.

What are outliers? (*odlehlé hodnoty*)

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

Characterizing centrality

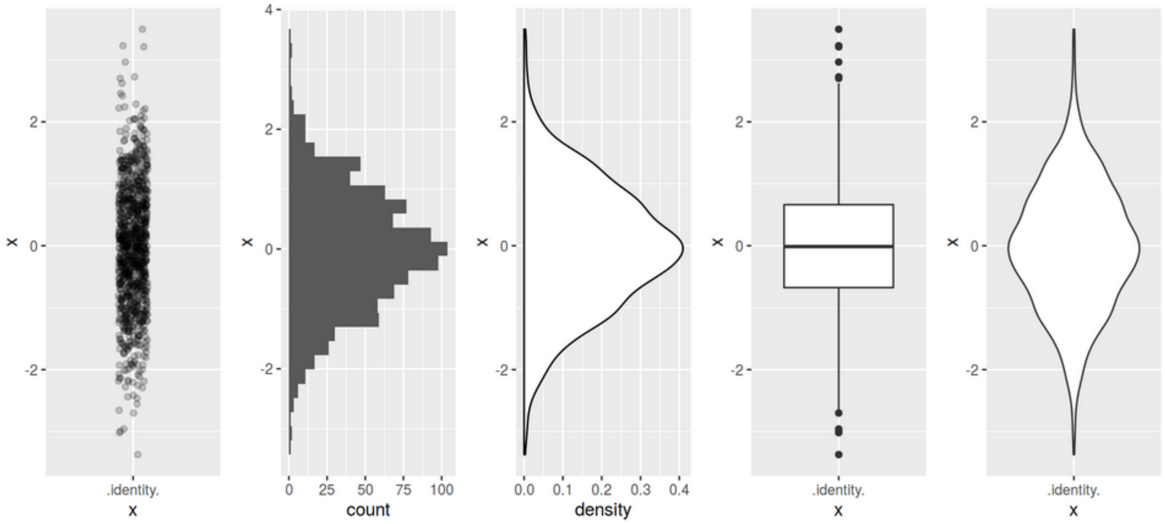


Figure 1: Various plots of a normal distribution

Characterizing dispersion and/or spread

Range (*rozpětí*)

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

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

`sd(x)`

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

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

`IQR(x)`
- **Robust**, minimizes influence of outliers.

Characterizing dispersion and/or spread

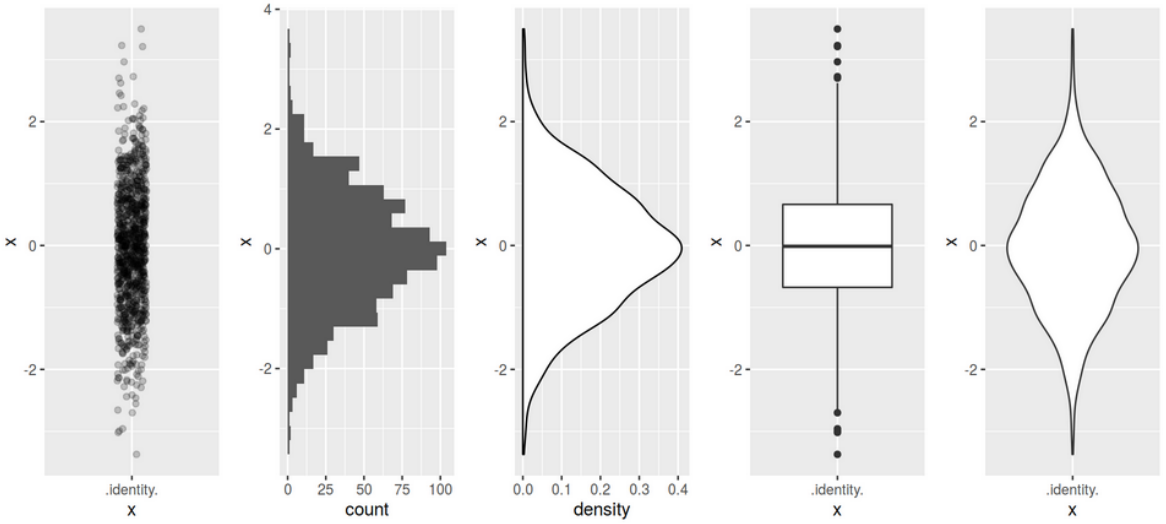


Figure 2: Various plots of a normal distribution

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

```r
# 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"  
```

```r
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
```

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

```
[1] 7.642857
```

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

```
[1] 6.8
```

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

```
[1] 26.5
```

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

```
[1] 4.207088
```

```r
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?

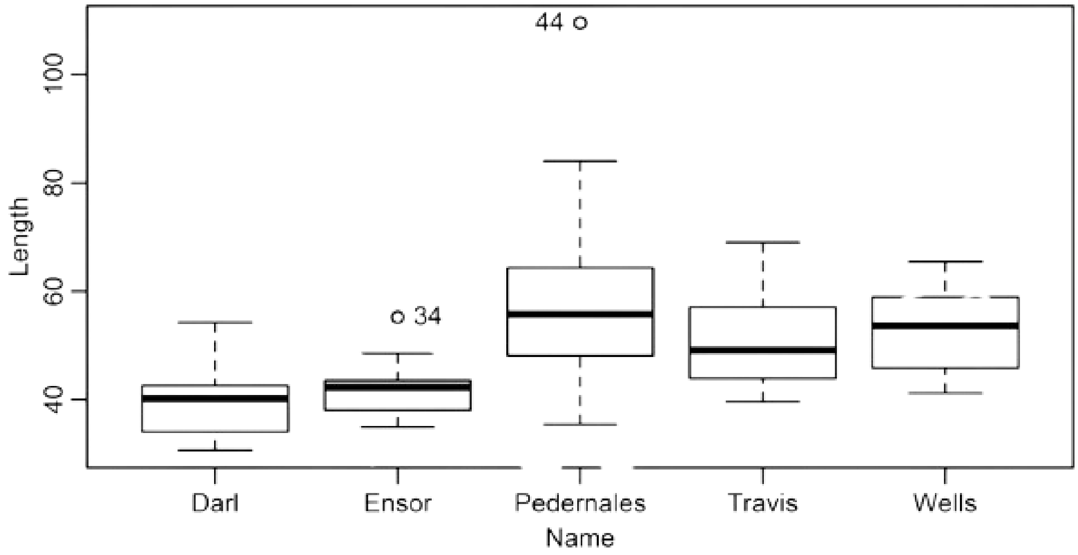


FIGURE 15 Box-and-whiskers plots for dart point lengths.

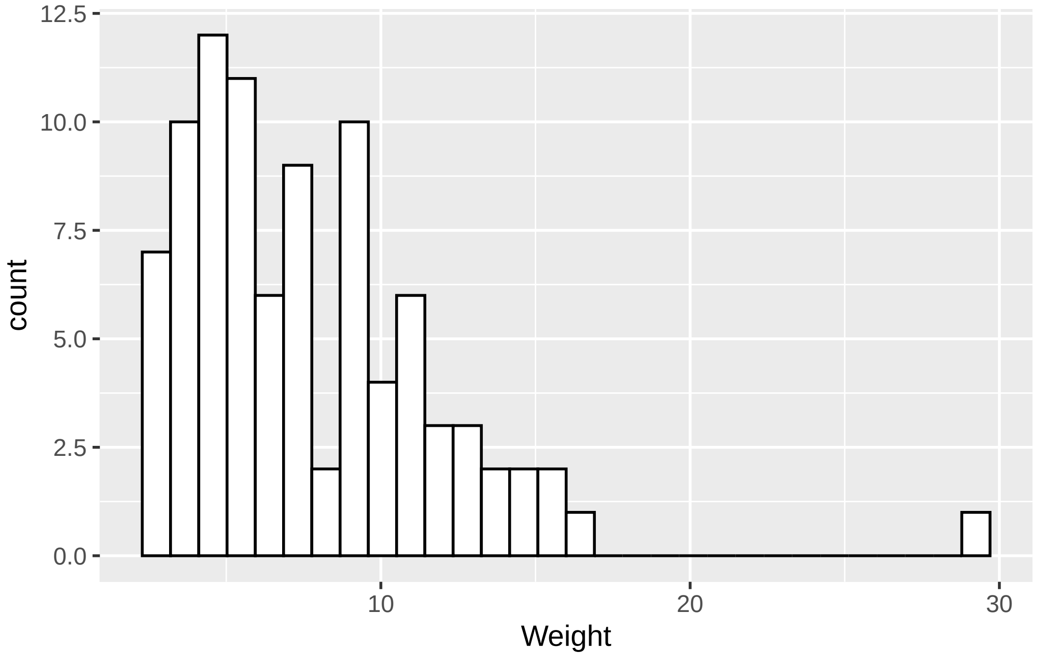
Figure 3: Boxplots from Carlson 2017

Plots for one variable

Histogram

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

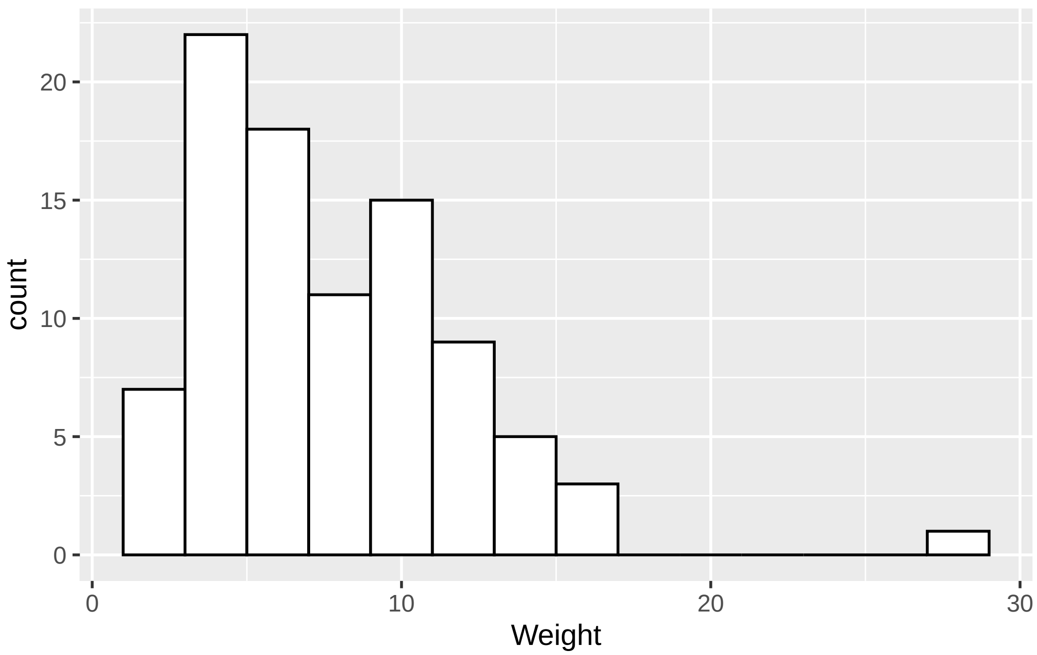
Distribution of dart point weights.



Histogram

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

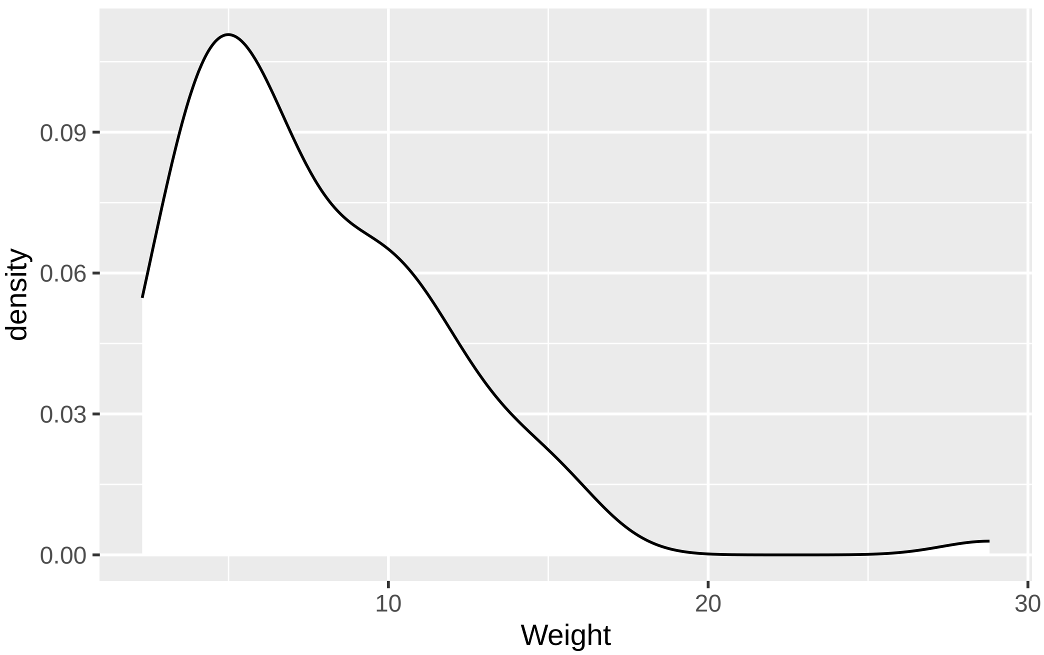
Distribution of dart point weights, one column (*bin*) equals 2 g.



Density plot

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

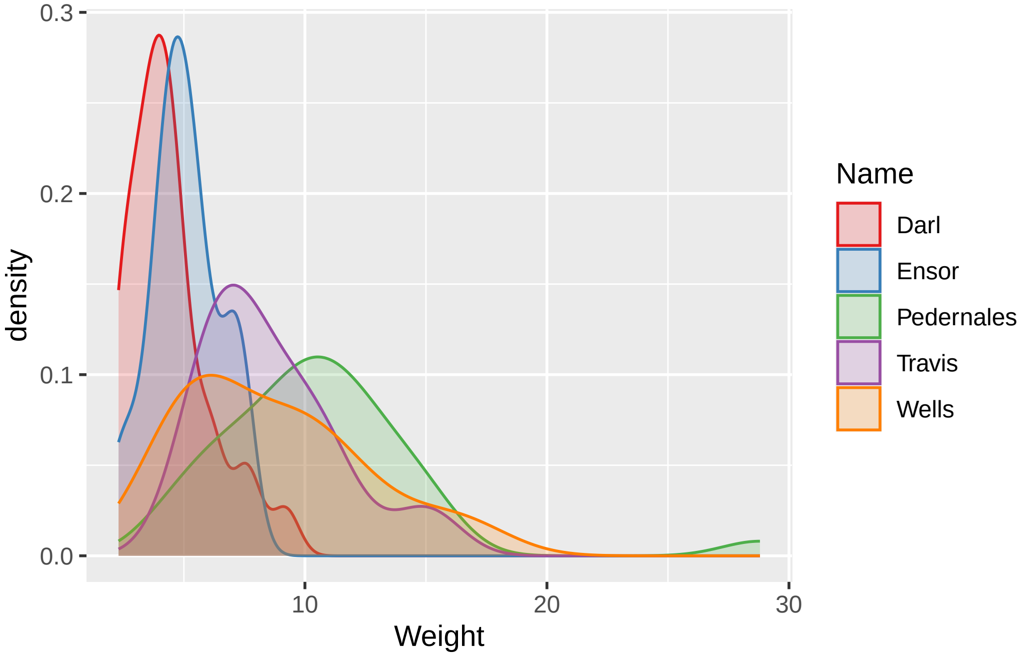
Distribution of dart point weights.



Density plot

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

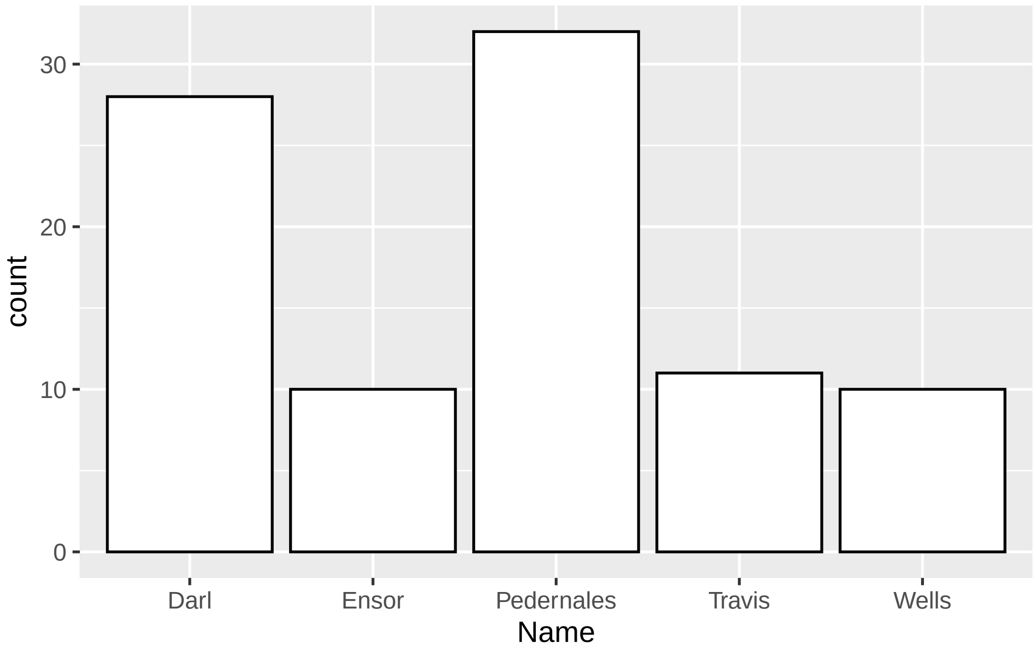
Distribution of different types of dart points by weight.



Bar chart

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

Distribution of types of dart points.



Plots in ggplot2 package

```
install.packages("ggplot2")                                        ①

library(ggplot2)                                                   ②

ggplot(data = <your data frame>) +                                 ③
  aes(x = <variable to be mapped to axis x>) +                     ④
  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 Functons with `geom_` prefix are *geometries*, ie. types of plots to draw.

Geoms for one variable:

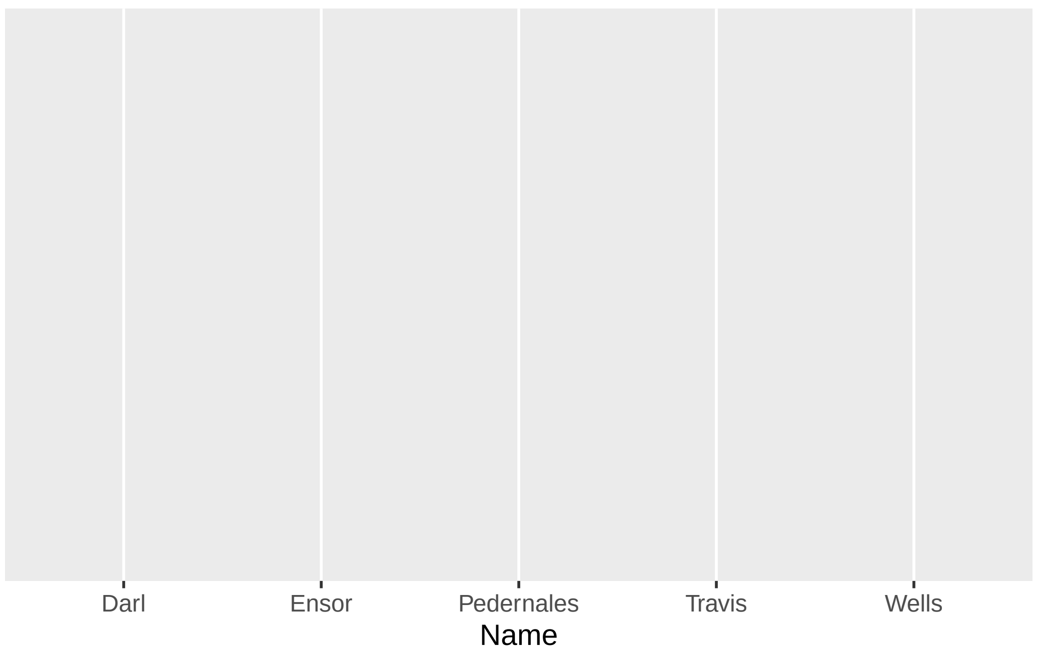
- `geom_histogram()`
- `geom_density()`
- `geom_bar()`

Layers of ggplot2

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

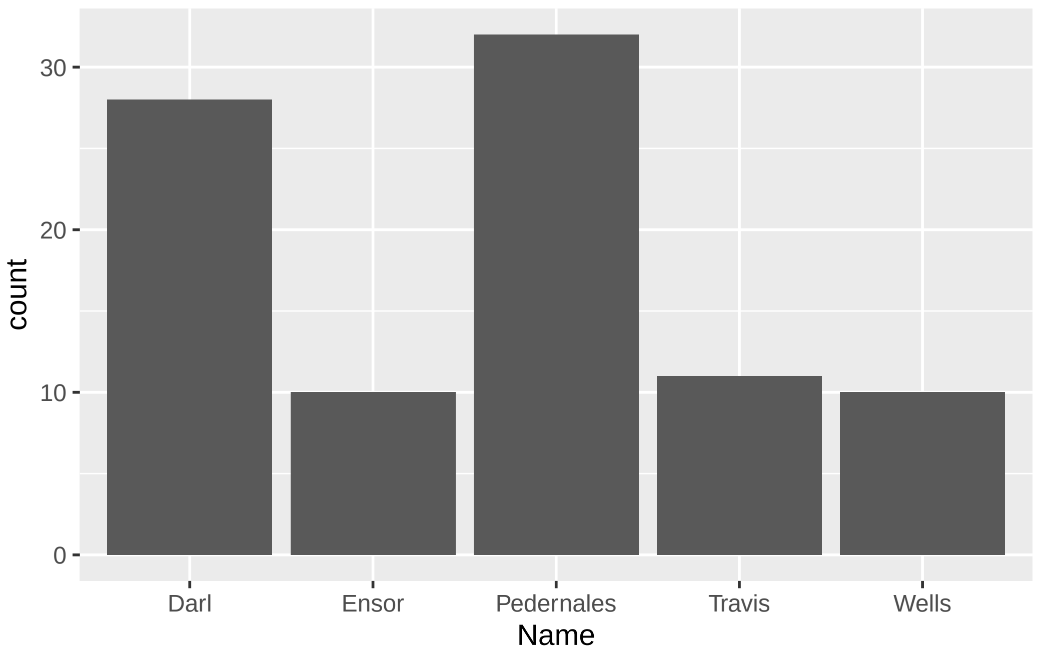
Layers of ggplot2

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



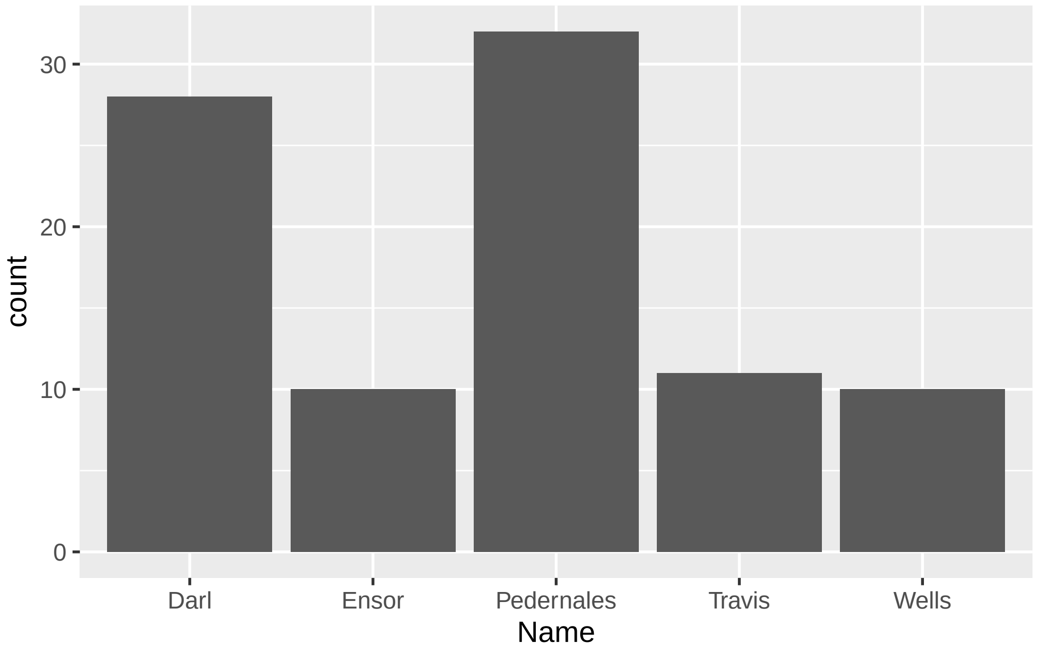
Layers of ggplot2

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



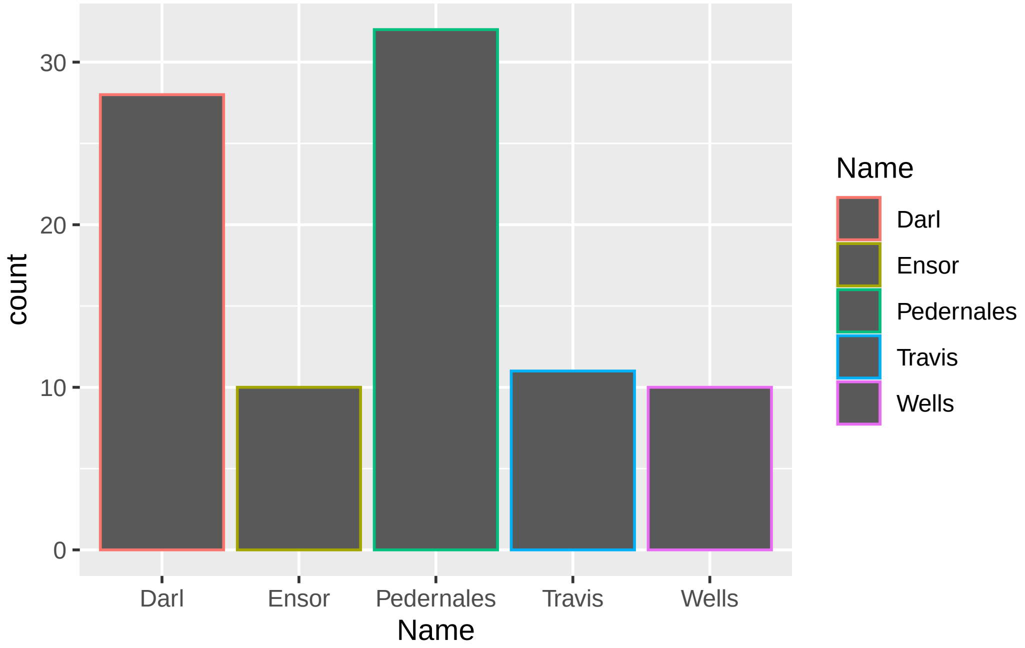
Bar chart

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



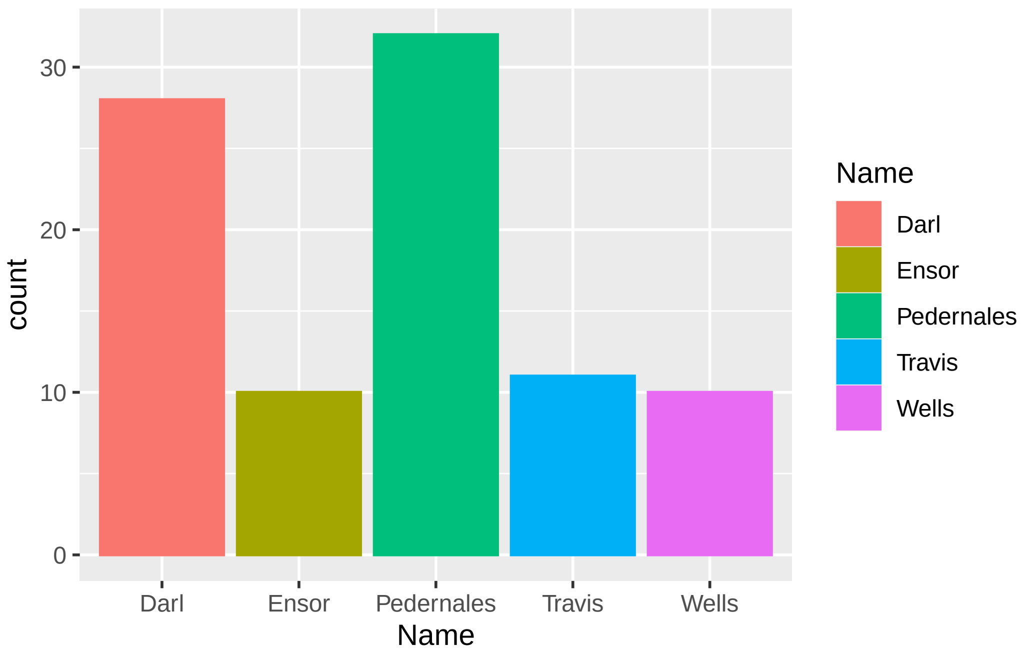
Bar chart

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



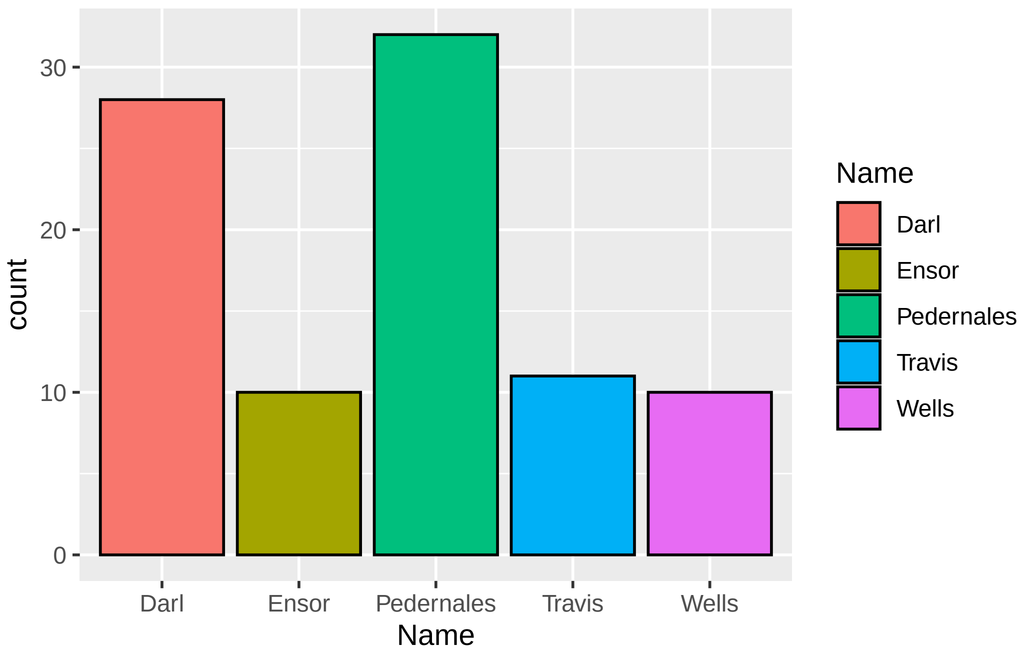
Bar chart

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



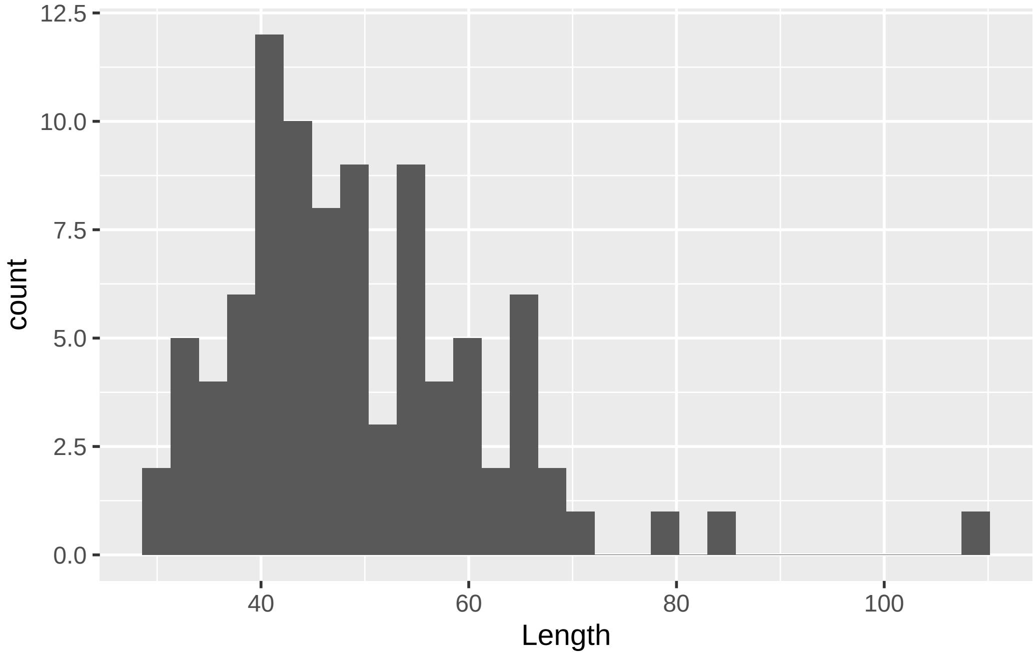
Bar chart

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



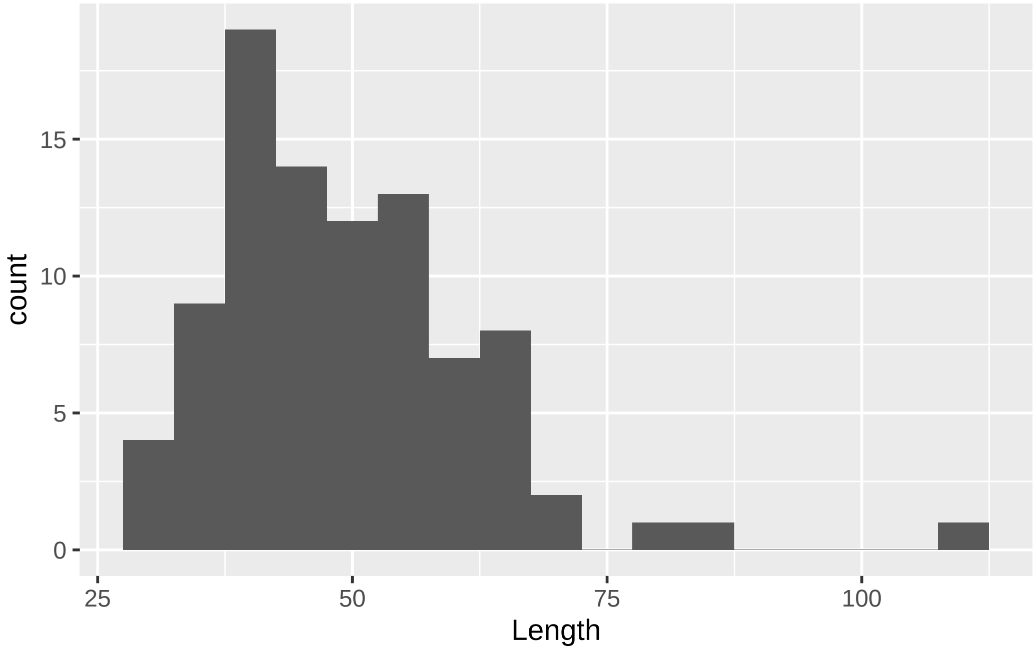
Histogram

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



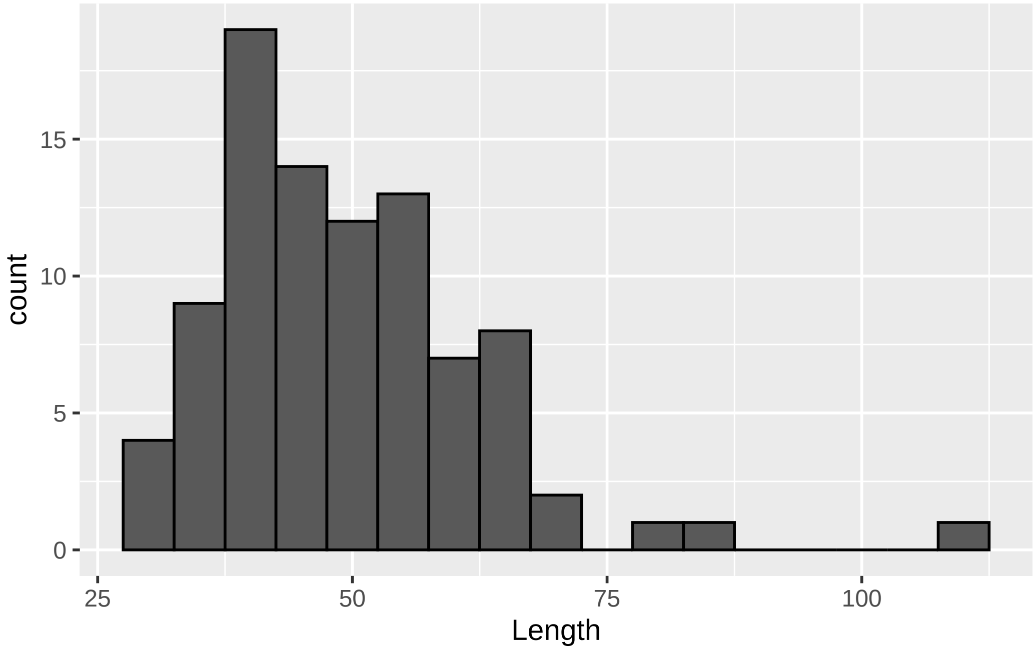
Histogram

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



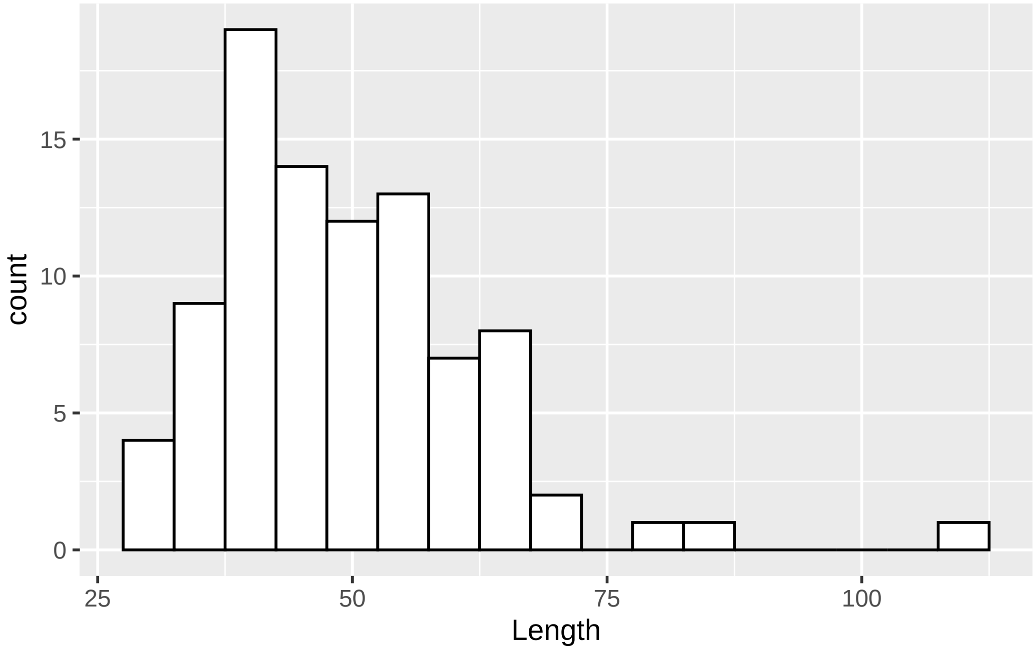
Histogram

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



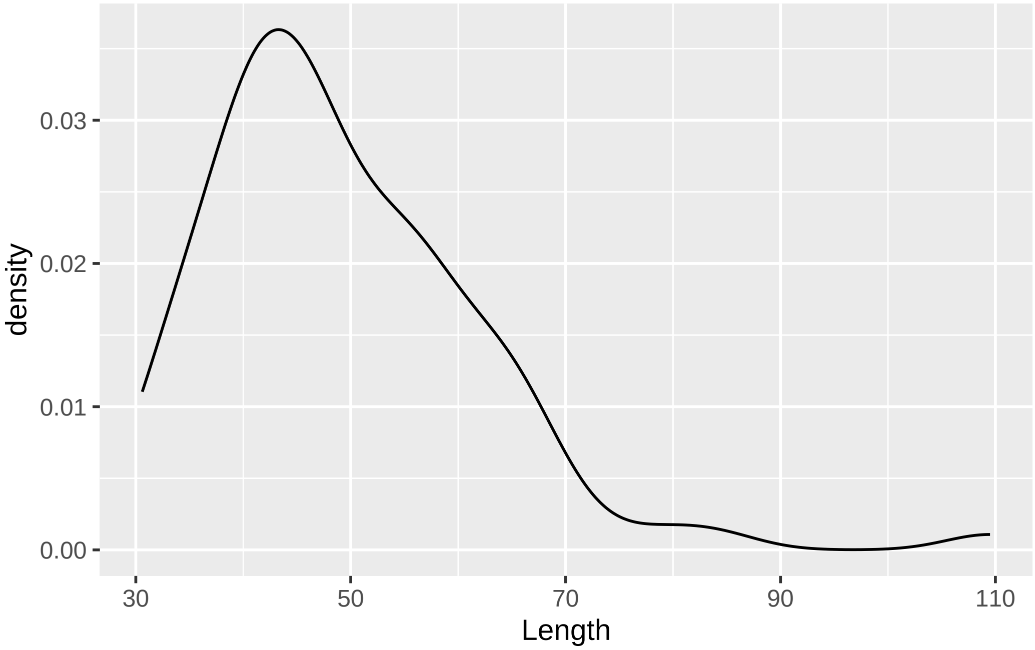
Histogram

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



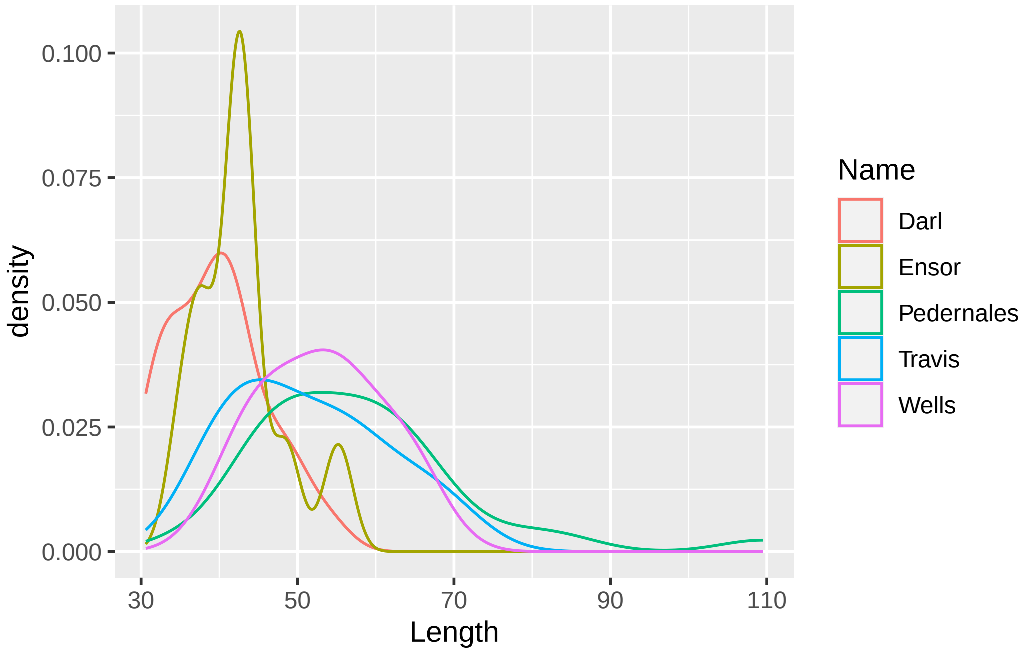
Density plot

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



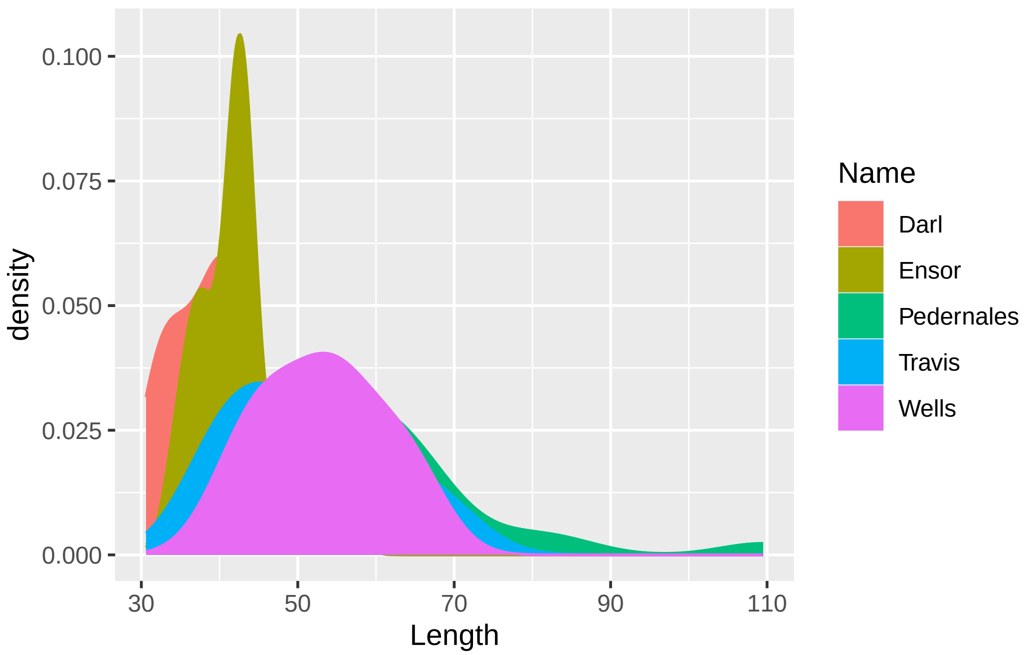
Density plot

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



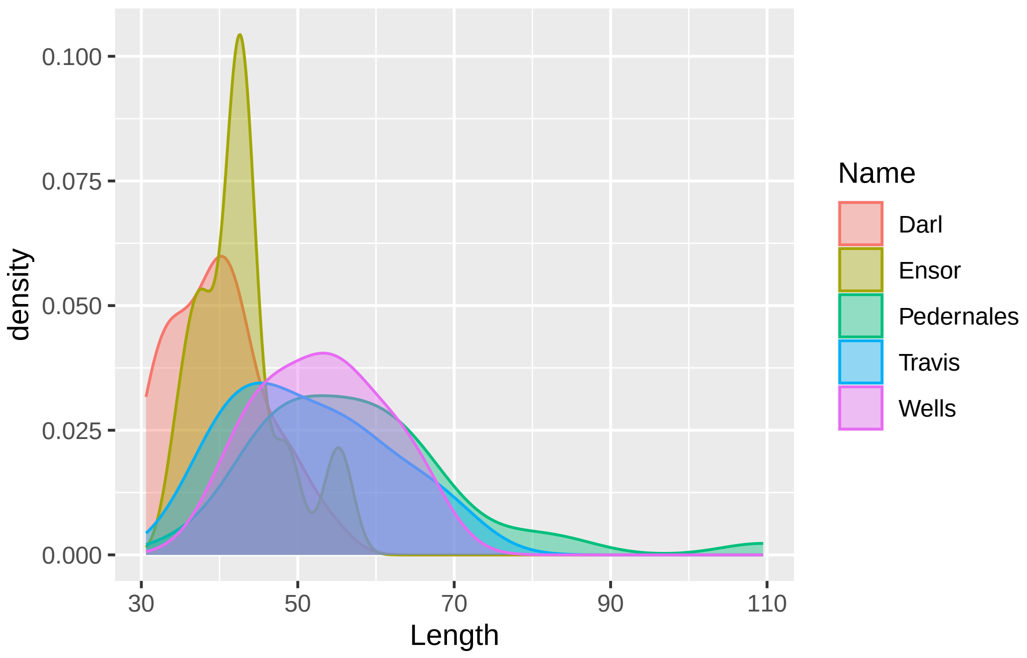
Density plot

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



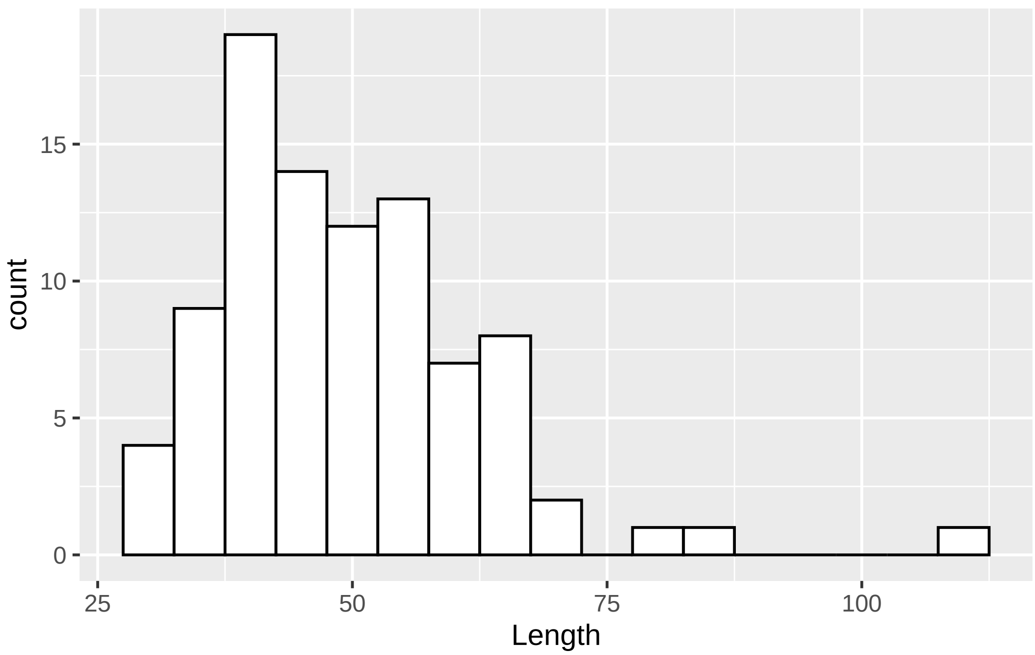
Density plot

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



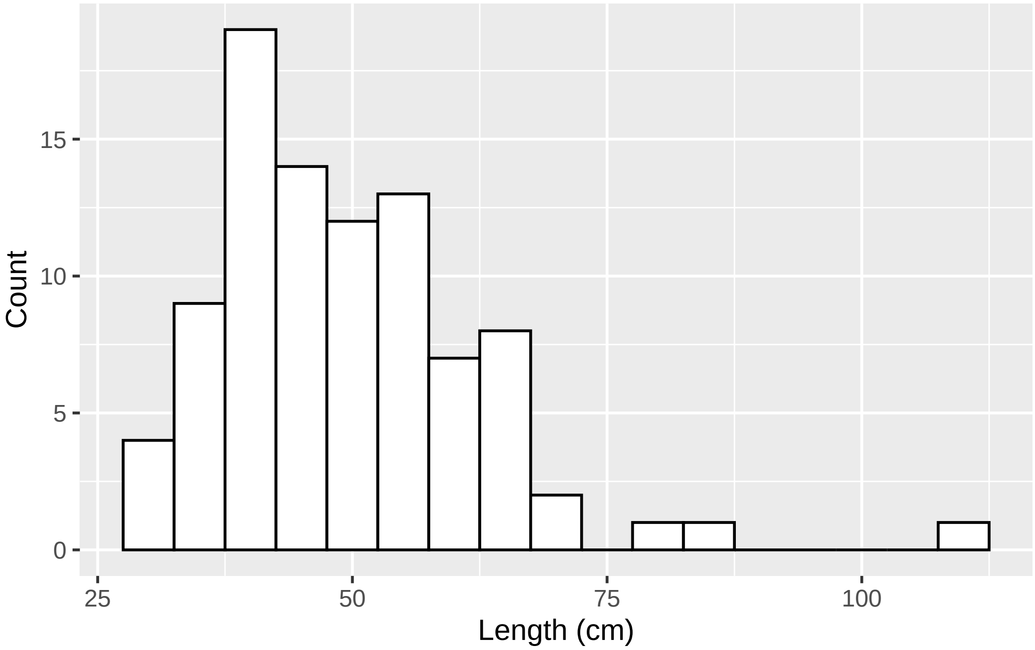
Labels

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



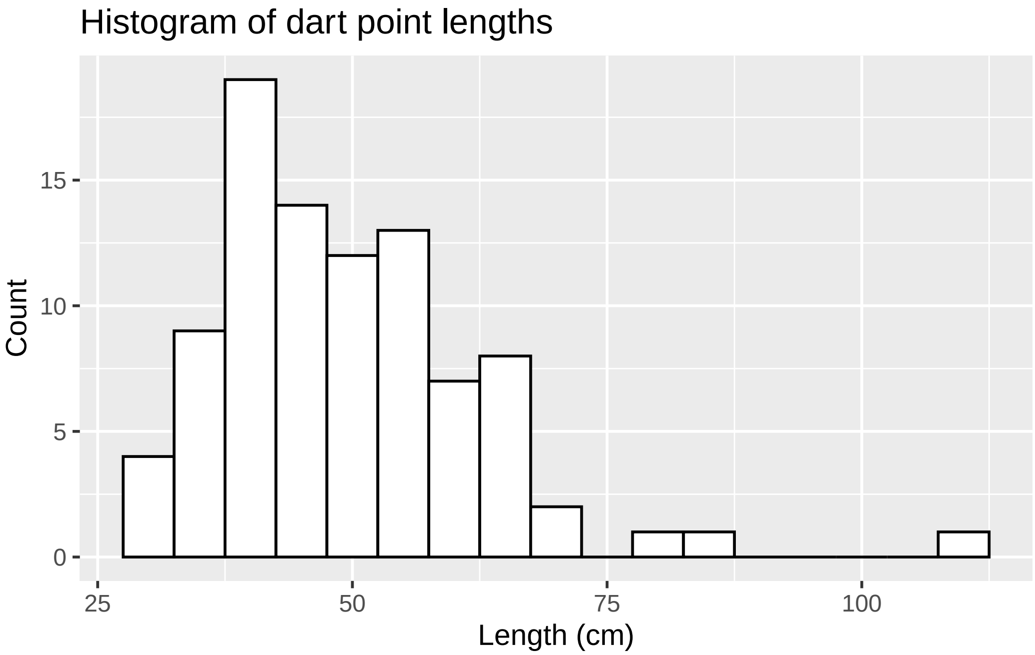
Labels

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



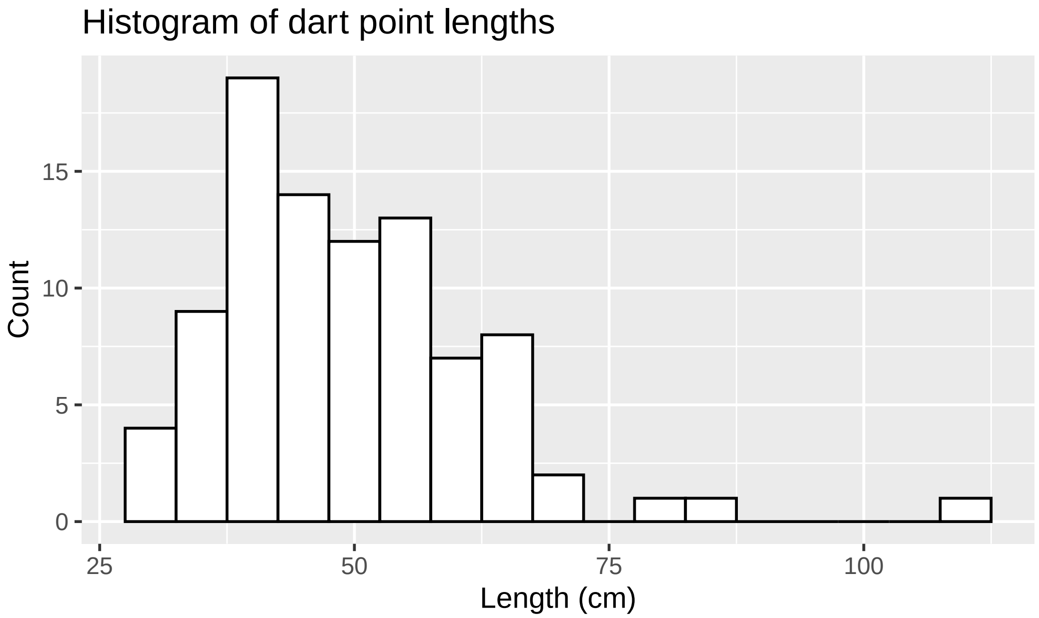
Labels

```
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")
```



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")
```



Histogram of dart point lengths

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.