Effective Graphs with `ggplot2`

ASA Short course, Kansas City
September 19, 2025

Joyce Robbins
Dept. of Statistics, Columbia University
jtr13@columbia.edu

Introduction

slides/01_introduction.pdf

Workshop schedule

github.com/jtr13/kc2025/

9:05 - 10:15	Introduction, grammar of graphics,
	Data layers 1: histograms and density curves
	Data layers 2: boxplots and scatterplots
		`slides/01_introduction.pdf`
		`02_datalayer1.pdf`
		`03_datalayer2.pdf`

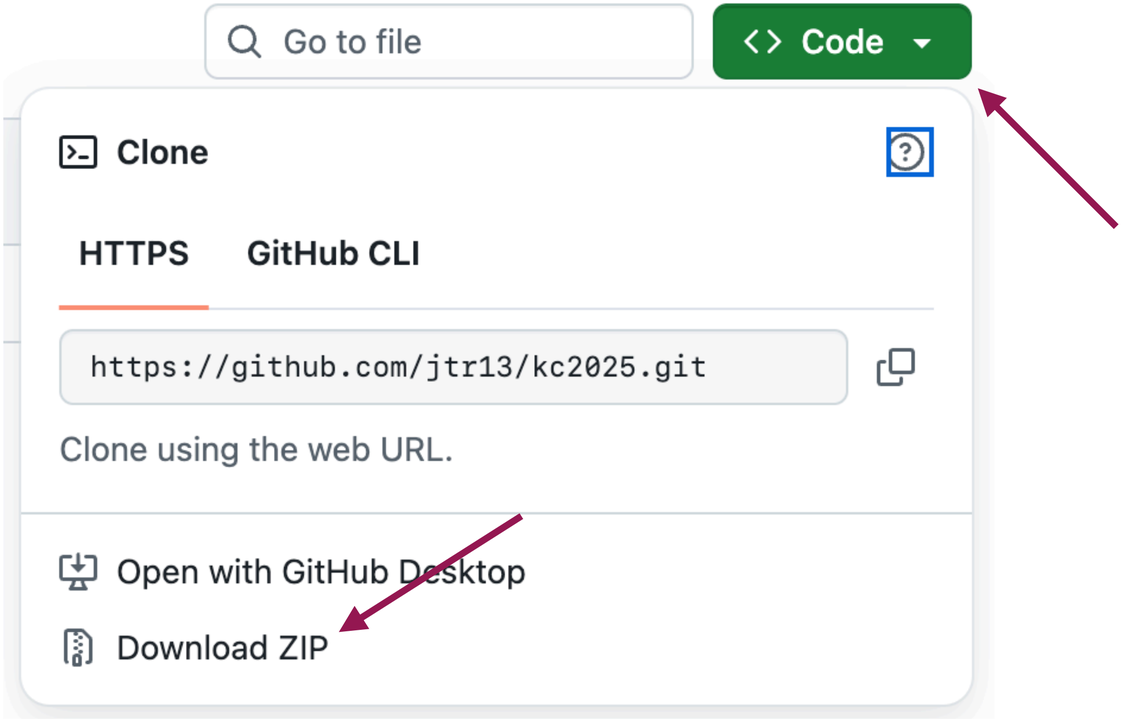
10:15 - 10:45	LAB + BREAK ☕	
10:45 - 12:00	Scales, Categorical data: bar charts and Cleveland dot plots	`slides/04_scales.pdf` `05_categorical.pdf`
12:00 - 1:00	Lunch	
1:00 - 2:00	Faceting: why and how, Presentation ready charts	`slides/06_faceting.pdf` `07_present.pdf`

What to expect

- Combination of the philosophy of the grammar of graphics, ggplot2 syntax, best practices for effective graphs
- Emphasis on common mistakes
- Flexibility

Slides and code

www.github.com/jtr13/kc2025



Labs

github.com/jtr13/kc2025/

```
labs/
  histogram.Rmd
  density.Rmd
  boxplots.Rmd
  scatterplots.Rmd
  barchart.Rmd
  dotplot.Rmd
  facets.Rmd
```

Why R for graphics?

- S developed in the 1970s at Bell Labs as a system "for organizing, visualizing, and analyzing data"
- Main goal: to create an interactive environment for statisticians using the most advanced analytical tools
- Influenced by John Tukey's work on exploratory data analysis, William Cleveland's work on human perception
- Importance of statistical perspective / graphics research is still a defining feature of R today

R help example

pie {graphics} R Documentation

Pie Charts

Description

Draw a pie chart.

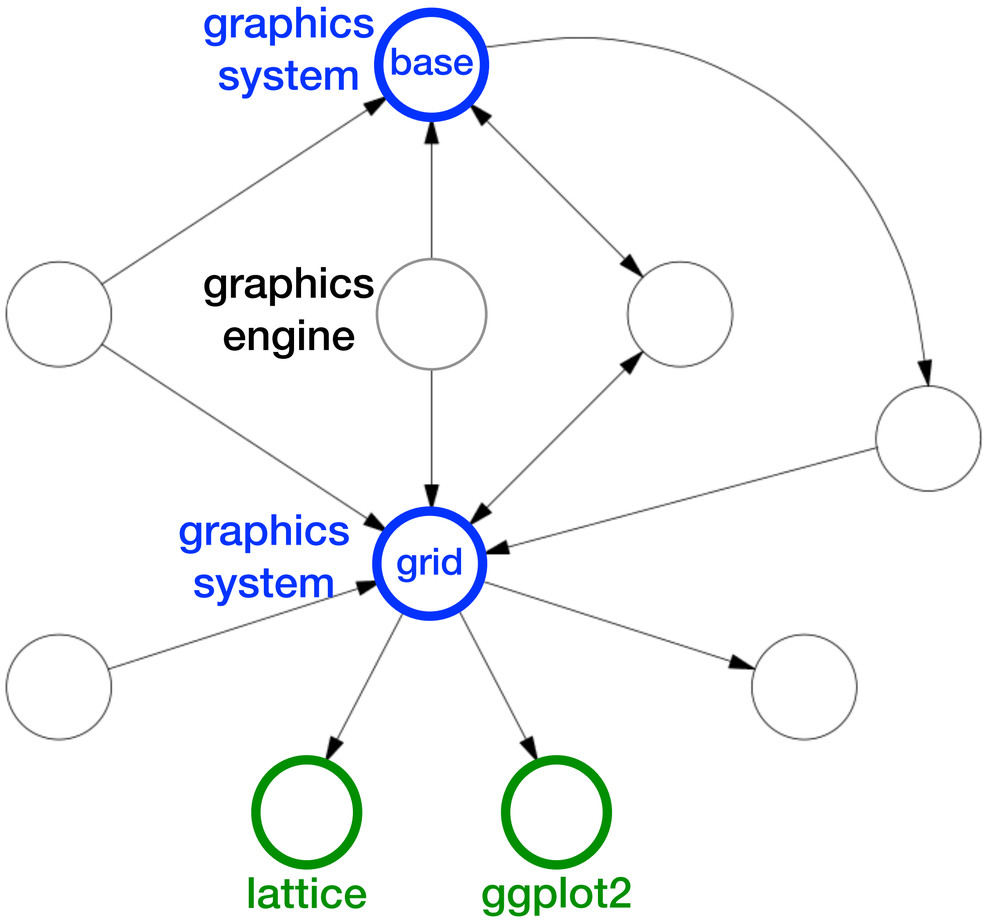
Usage

```
pie(x, labels = names(x), edges = 200, radius = 0.8,
    clockwise = FALSE, init.angle = if(clockwise) 90 else 0,
    density = NULL, angle = 45, col = NULL, border = NULL,
    lty = NULL, main = NULL, ...)
```

Arguments

`x`	a vector of non-negative numerical quantities. The values in `x` are displayed as the areas of pie slices.
`labels`	one or more expressions or character strings giving names for the slices. Other objects are coerced by `as.graphicsAnnot`. For empty or `NA` (after coercion to character) labels, no label nor pointing line is drawn.
`edges`	the circular outline of the pie is approximated by a polygon with this many edges.
`radius`	the pie is drawn centered in a square box whose sides range from *-1* to *1*. If the character strings labeling the slices are long it may be necessary to use a smaller radius.
`clockwise`	logical indicating if slices are drawn clockwise or counter clockwise (i.e., mathematically positive direction), the latter is default.
`init.angle`	number specifying the *starting angle* (in degrees) for the slices. Defaults to 0 (i.e., '3 o'clock') unless `clockwise` is true where `init.angle` defaults to 90 (degrees), (i.e., '12 o'clock').
`density`	the density of shading lines, in lines per inch. The default value of `NULL` means that no shading lines are drawn.

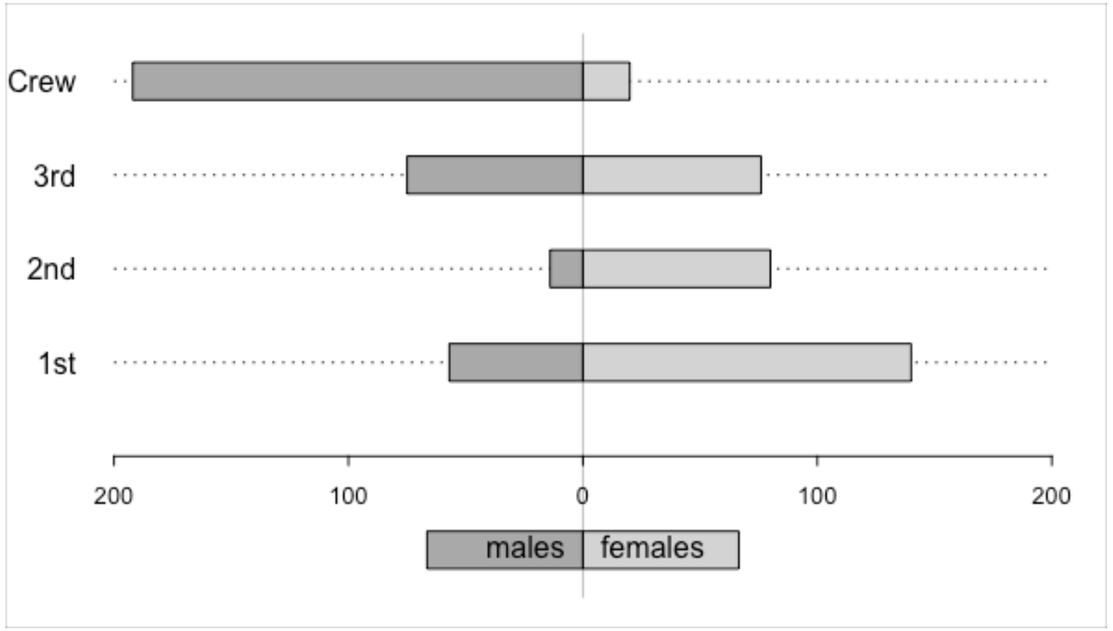
R graphics



Based on https://www.stat.auckland.ac.nz/~paul/RG3e/organisation-graphicslevels.png

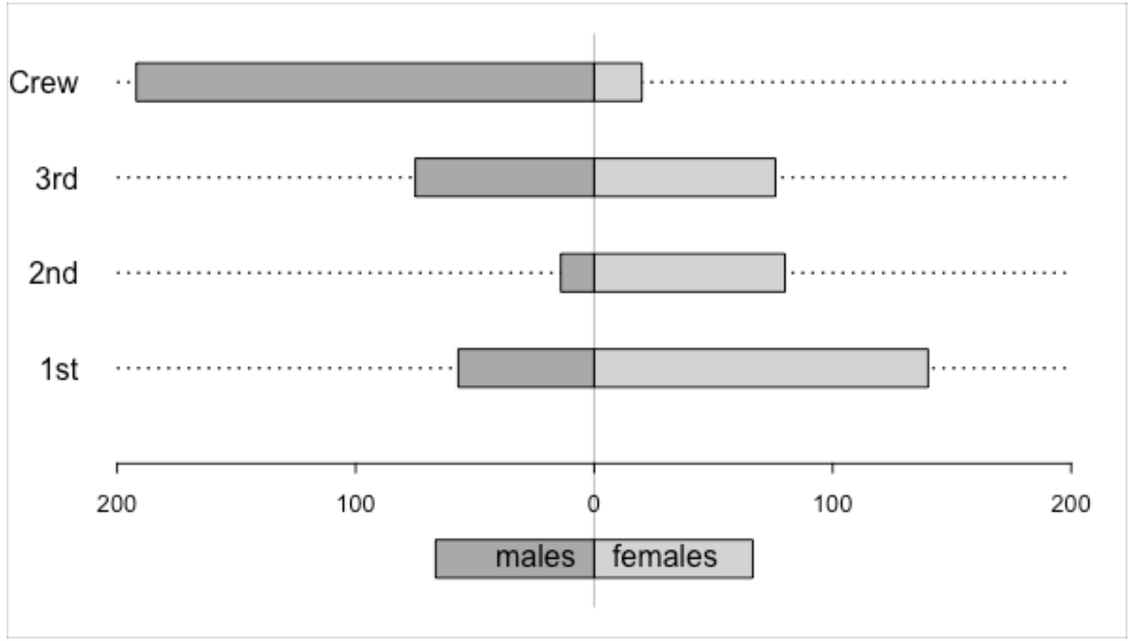
Low level base R graphics functions

```
groups <- dimnames(Titanic)[[1]]
males <- Titanic[, 1, 2, 2]
females <- Titanic[, 2, 2, 2]
par(mar=c(0.5, 4, 0.5, 1))
plot.new()
plot.window(xlim=c(-200, 200), ylim=c(-1.5, 4.5))
ticks <- seq(-200, 200, 100); y <- 1:4; h <- 0.2
lines(rep(0, 2), c(-1.5, 4.5), col="gray")
segments(-200, y, 200, y, lty="dotted")
rect(-males, y-h, 0, y+h, col="dark gray")
rect(0, y-h, females, y+h, col="light gray")
mtext(groups, at=y, adj=1, side=2, las=2)
par(cex.axis=0.8, mex=0.5)
axis(1, at=ticks, labels=abs(ticks), pos=0)
tw <- 1.5*strwidth("females")
rect(-tw, -1-h, 0, -1+h, col="dark gray")
rect(0, -1-h, tw, -1+h, col="light gray")
text(0, -1, "males", pos=2)
text(0, -1, "females", pos=4)
box("inner", col="gray")
```



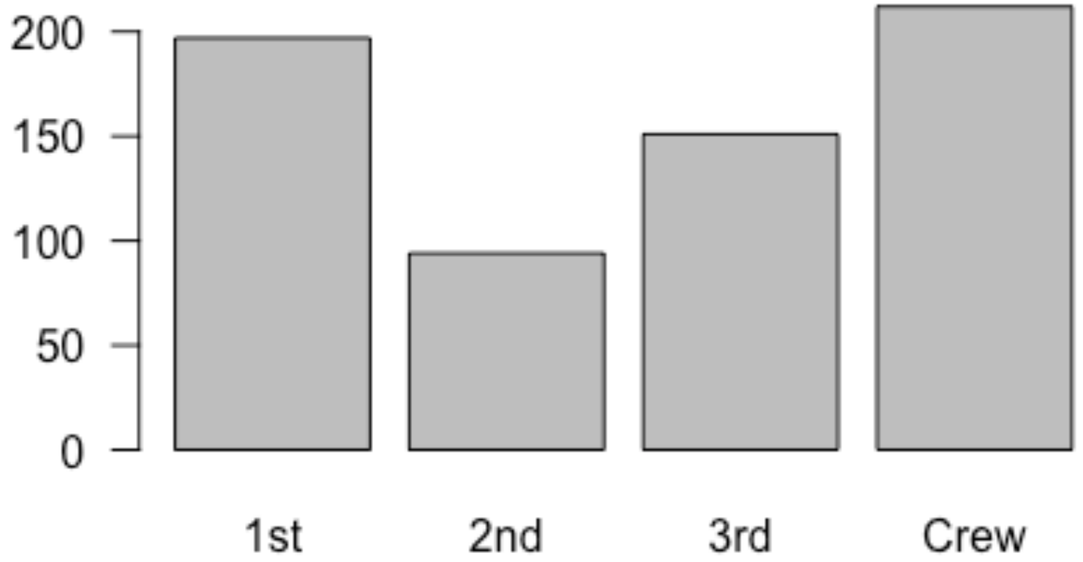
https://www.stat.auckland.ac.nz/~paul/RG3e/custombase-xmastree.R

Base R graphics



High level base R graphics functions

```
crew_counts <- rowSums(Titanic[,1:2,2,2])
barplot(crew_counts, las = 1)
```

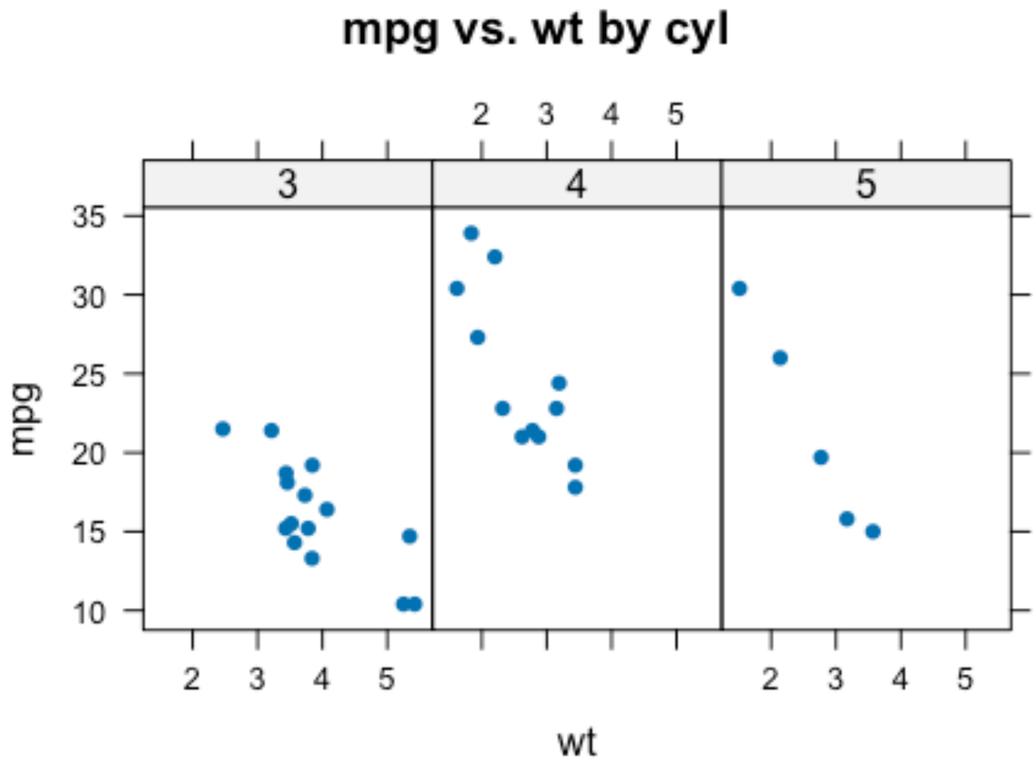


High level base R graphics functions

```
barplot()
boxplot()
cdplot()
contour()
coplot()
dotplot()
fourfoldplot()
hist()
matplot()
mosaicplot()
pairs()
pie()
plot()
smoothScatter()
spineplot()
stars()
stem()
stripchart()
sunflowerplot()
```

lattice package

```
library(lattice)
xyplot(mpg~wt|factor(cyl), data = mtcars,
       main="mpg vs. wt by cyl", pch = 16)
```



Higher level lattice graphing functions

```
xyplot()
splom()
cloud()
stripplot()
bwplot()
dotplot()
barchart()
histogram()
densityplot
qqmath()
qq()
contourplot()
levelplot()
parallel()
wireframe()
```

http://www.sthda.com/english/wiki/lattice-graphs

Why ggplot2?

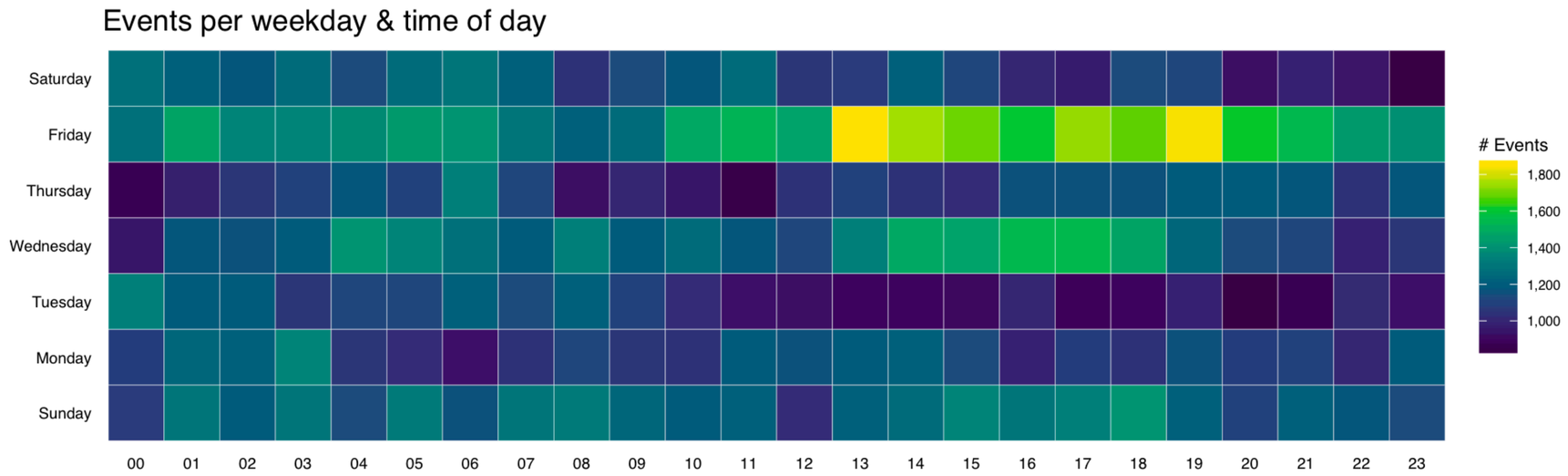
- **Many similarities to `lattice` (in constrast to base R):**
  - **automated legends and margins**
  - **easy to create panel plots***
  - **flexibility of `grid` system for manipulating graphics output**
  - **carefully chosen defaults**
- **BUT based on a grammar of graphics rather than a list of chart functions**

* also called trellis / lattice / small multiple / facet plots

Why ggplot2?

- Modular system allows low level control with ease of a relatively high level system
- Intentionally extendable -- hundreds of packages on CRAN that begin with "gg" + other extension packages
- Ability to create very professional, beautiful, publication ready plots
- Large, active community of users

Building block approach

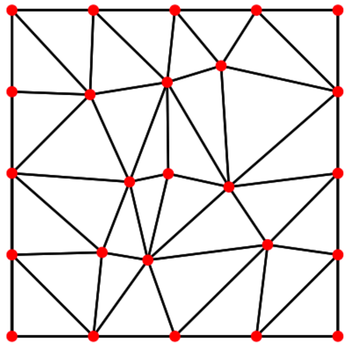


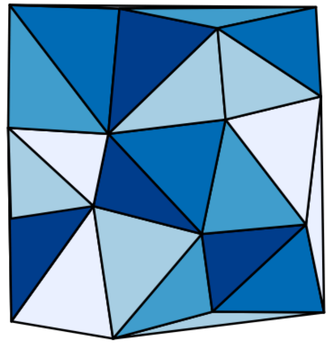
https://rud.is/b/2016/02/14/making-faceted-heatmaps-with-ggplot2/

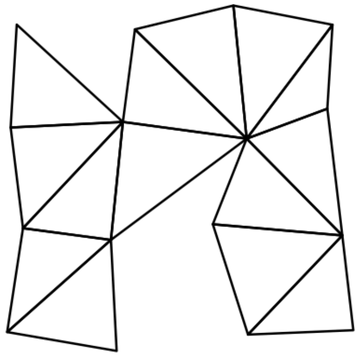
I still use base R graphics

- One dimensional data graphs (***vectors***):
  `hist(x), stem(x), boxplot(x), barplot(x)`

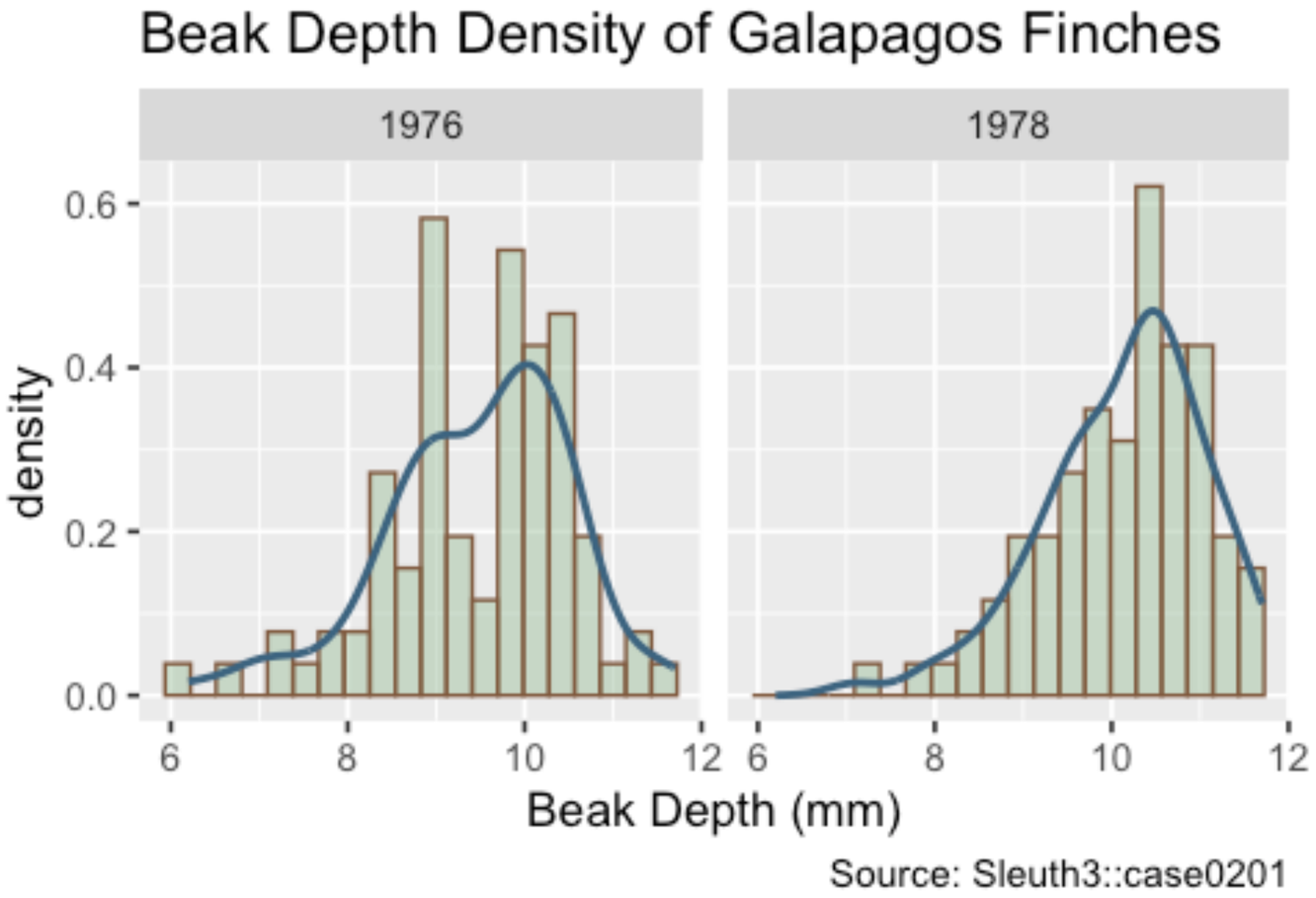
- Graphics without real data







ggplot2 example



ggplot2 example code

```
library(ggplot2)
finches <- Sleuth3::case0201
ggplot(finches, aes(x = Depth, y = after_stat(density))) +
  geom_histogram(bins = 20, color = "#80593D",
                 fill = "#9FC29F", alpha = .5) +
  geom_density(color = "#3D6480", lwd = 1) +
  facet_wrap(~Year) +
  labs(title = "Beak Depth Density of Galapagos Finches",
       x = "Beak Depth (mm)",
       caption = "Source: Sleuth3::case0201") +
  theme_grey(13)
```

Tidyverse

R packages for data science

The tidyverse is an opinionated **collection of R packages** designed for data science. All packages share an underlying design philosophy, grammar, and data structures.

Install the complete tidyverse with:

```
install.packages("tidyverse")
```

tidyverse.org