# Introduction to R, R Studio, and `ggplot2`

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# Contents

# R and RStudio

- RStudio is a user-friendly graphical interface for R
- Open source, packages for almost everything (data processing, cleaning, visualization, etc.)
- For help, click here.

# Downloading R and RStudio

- Downloading R
  - R for Windows: https://cran.r-project.org/bin/windows/base/
  - R for macOS: https://cran.r-project.org/bin/macosx/
- Downloading R Studio
  - RStudio: https://posit.co/downloads/
- Open the downloaded file (check your Downloads folder), click yes through all of the prompts to install like any other program

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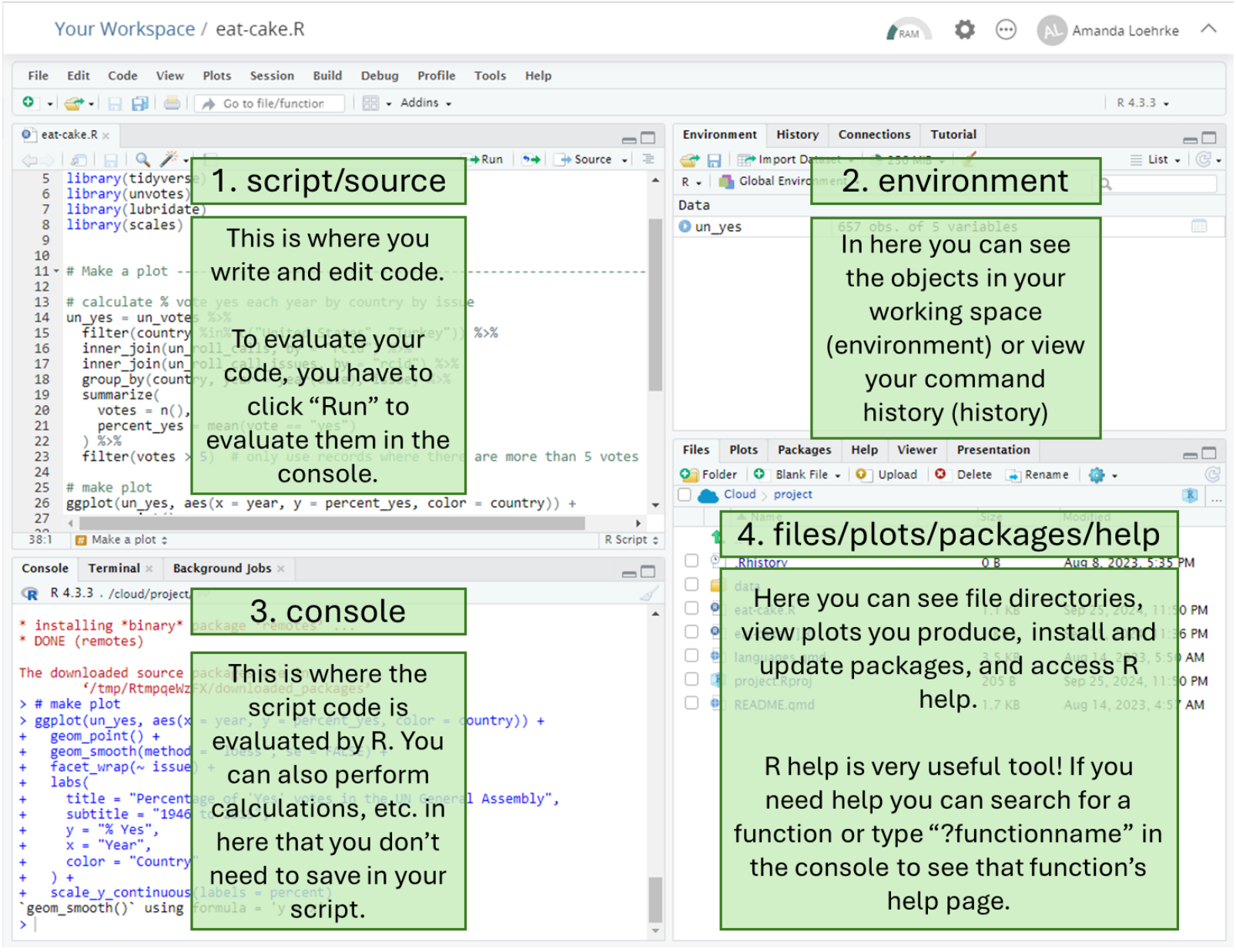
- *If* your computer is an older model, or you are using an iPad or similar, you can access RStudio online:
  - Go to https://posit.cloud/
  - Create an account using your UC Davis email
  - Click on "New Project" and select "New Project from Template"
  - Select "Data Analysis in R with the Tidyverse and click "OK"

# Getting Started With RStudio

- Create a POL 114 folder on your computer
  - This is where you will store your R files, download data to use in R, etc.
- Open R Studio
  - Create a new R script and save to POL 114 folder
  - Set working directory to your POL 114 folder in R script
    - ★ It will look something like this:

      ```
      setwd("C:/Desktop/POL 114")
      getwd()
      ```
- For a helpful RStudio tutorial, click here.

# More on R Studio



# The ggplot2 package

- "Grammar of graphics"
- Think about grammer in language: it is a set of rules that govern how language is structured (words, phrases, clauses)
- Used to produce layered, statistical graphics
- Uses a "grammar" to build graphs layer-by-layer
- For more package information, click here.

# Grammar of graphics - the basics

- **Data**: what information to map
- **Aesthetics**: which data is on your x-axis? y-axis? color? size? fill?
- **Geometries**: the type of plot you want to create (scatterplot, bar plot, time series, etc.)
- **Scales**: mappings of aesthetic values to data values
- **Stats**: transformations with statistics to summarize data
- **Faceting**: splitting data to create multiple variations of the same graph

# Using `ggplot()`

- All graphics begin with the `ggplot()` function
- In this function, we specify the dataset and variables to map to the aesthetics - `aes()`

```
ggplot(data, aes(x = variable1, y = variable2)
```

- **Data**: name of the data frame that holds the variables we want to plot
- **X and Y**: aesthetics that position objects on the graph
- We would specify then variable1 and variable2
- Running this will produce a plot with x and y axes, no data will be plotted

# Aesthetics

- Commonly used aesthetics:
  - **x**: positioning on the x-axis
  - **y**: positioning on the y-axis
  - **color**: color of the objects
  - **fill**: fill color of objects
  - **linetype**: solid, dashed, dotted, etc.
  - **shape**: circle, square, solid, etc.
  - **size**: how large objects appear
  - **alpha**: transparency of objects

# Using `ggplot()` + `geom_*`

- We add layers with + and our next layer will be the geometry

  ```
  ggplot(data, aes(x)) + geom_*()
  ```

- You'll specify the type of geometry you want, based on the type of plot you want to create (scatterplot, histogram, barplot, etc.)
- The geometry will take the mapping from `ggplot()` but can also be overwritten in `geom_*(aes(variable))`

# Geometries

- *There are many geometries available, some common ones are:
  - `geom_histogram()`
  - `geom_density()`
  - `geom_boxplot()`
  - `geom_bar()`
  - `geom_point()`: scatter plot
  - `geom_line()`

# Using the stats layer

- Can map on statistical functions to transform adata
- Each stat function is associated with a geometry, so they can be used without specifying a geometry
- Ex) `stat_summary()` will give a point for the mean and error bars
- Many ways to use this layer depending on what you are trying to do

# Using the scales layer

- Scales define which aesthetic values are mapped to the data values
- This layer is added to `ggplot()` and the geometry layer

```
ggplot(data, aes(x)) +
    geom_bar() +
    scale_*()
```

- Many different scaling layers depending on what you are trying to accomplish

# Scales

- Specify that you are using scale, then name the primary aesthetic (x, y, color, etc.), then name the scale you want to use (continuous, discrete, etc.)
- Some common scale specifications
  - `scale_x_continuous()`
  - `scale_y_continuous()`
  - `scale_color_manual()`
- Axis scales specify the breaks, labels, and names

# More on axes, limits, and labeling

- Can also control the limits and titles of the axes using shortcut functions instead of scaling
- Some examples:
  - `lims()`: set axis limits
  - `xlim()`: set x axis limit
  - `ylim()`: set y axis limit
  - `xlab()`: label x axis
  - `ylab()`: label y axis
  - `ggtitle()`: label title
  - Or, use `lab()` to specify each axis label, title, subtitle, etc.

# Faceting

- Used to split plots into multiple panels
- `facet_wrap()` and `facet_grid()`

# Themes and colors

- Themes control the parts of the graph not related to the data (background color, font size, gridlines, label colors, etc.)
- Can set one theme for the entire plot (complete themes)
- Can modify specific components of a theme (modify components)
- There are various default colors in R, for a full list, click here

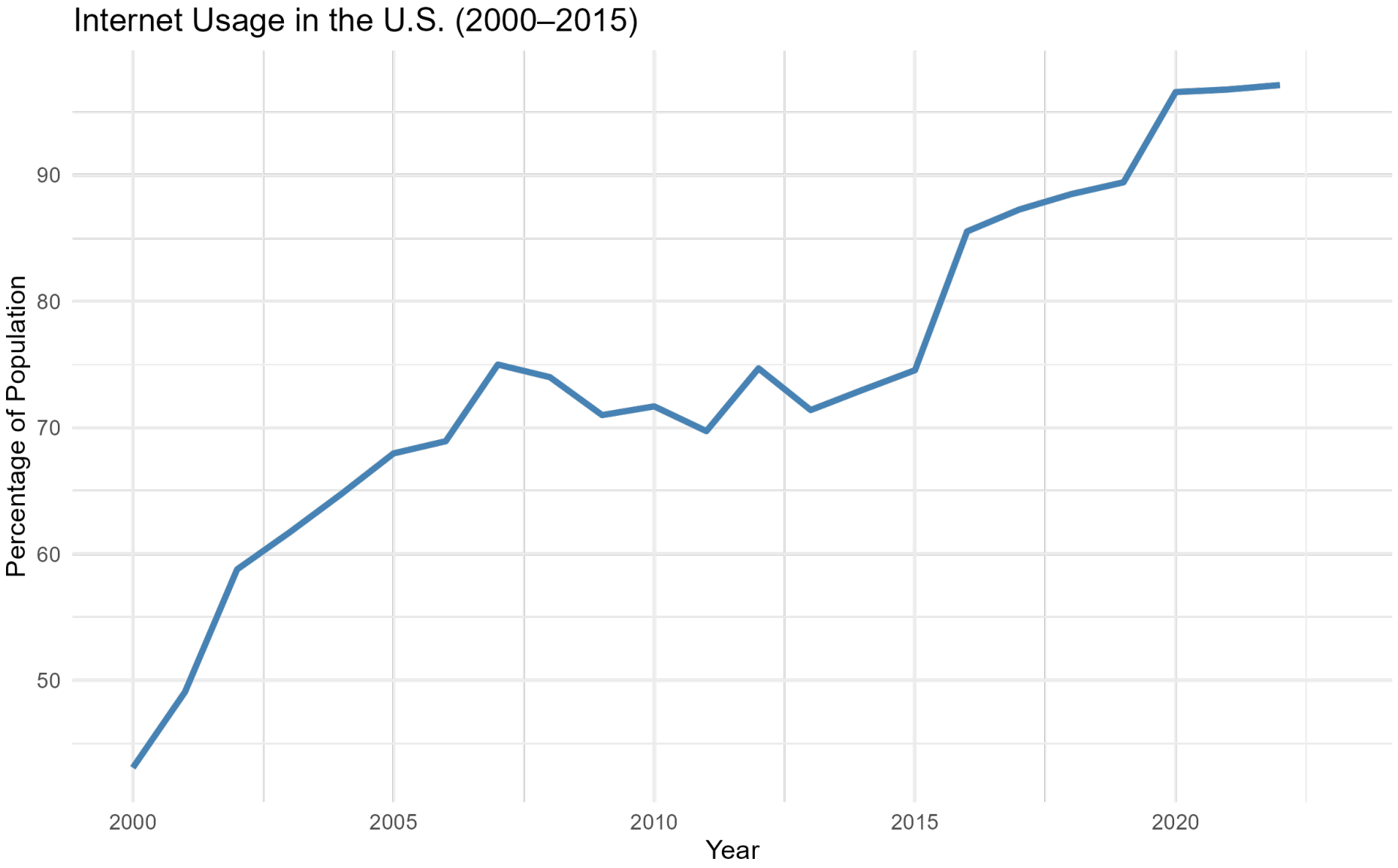
# Saving plots to files

- A few ways to save a plot
- You can export from the Plots tab in R Studio (default is the bottom right panel, Plots tab)
- Can right click on an image and save it
- Can use `ggsave()` in your code to save the plot object
  - Easy to specify width, height, name of file

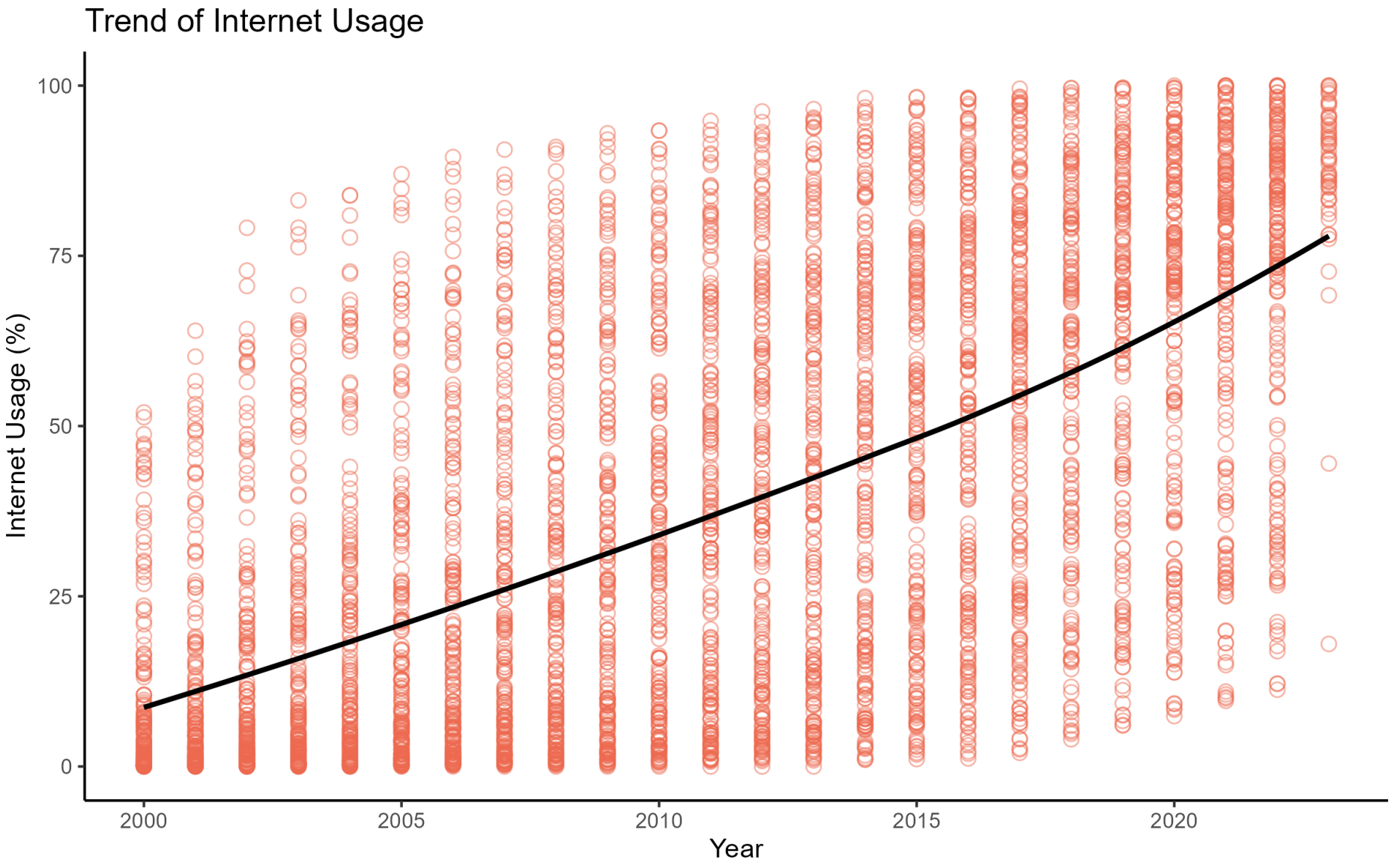
```
myplot <- ggplot(data, aes(x) + geom_bar()
ggsave("myplot.png", plot = myplot)
```

# Examples

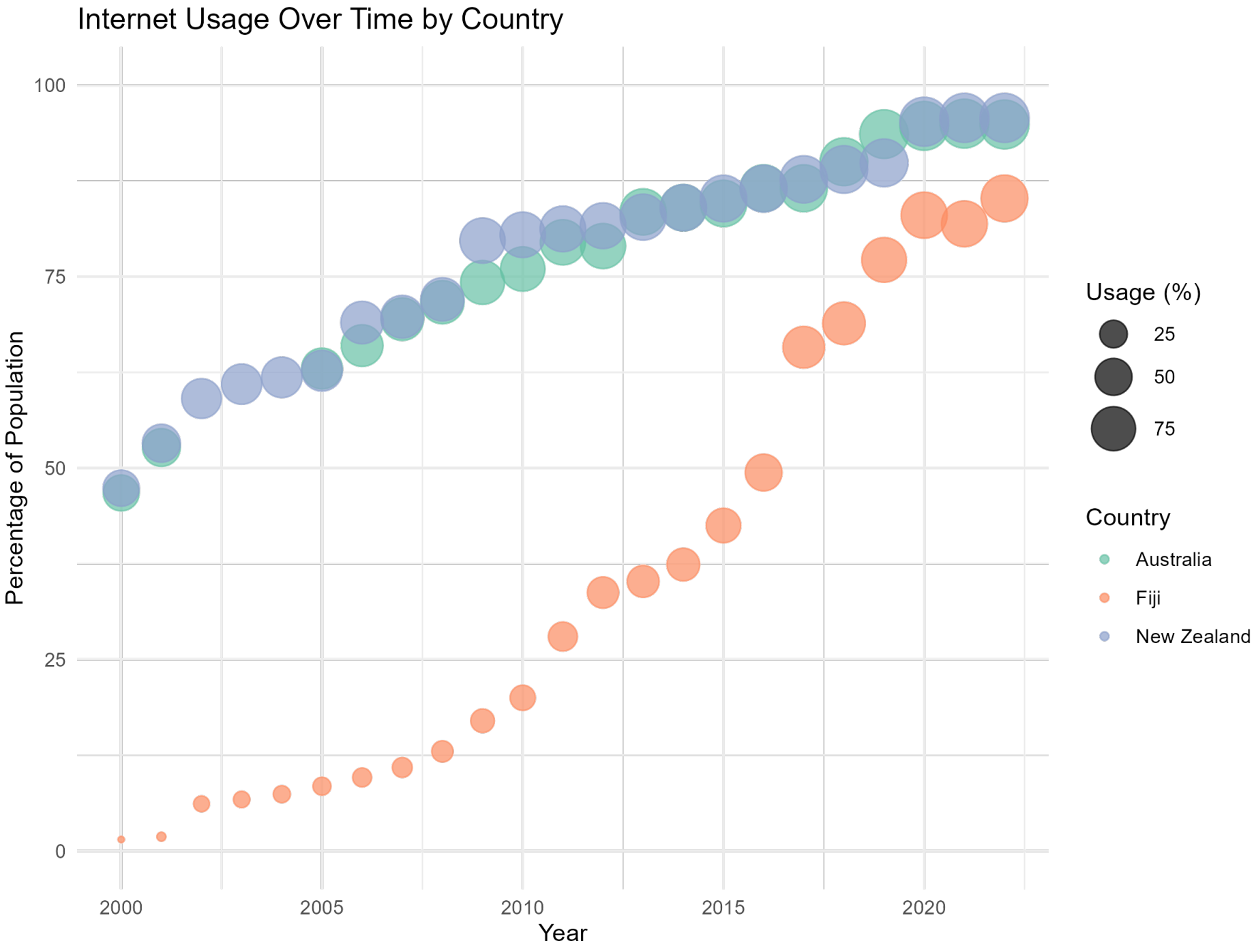
```r
# Time series for US internet usage
us <- df %>% filter(Country.Name == "United States")

timeseries <- ggplot(us, aes(x = Year, y = Percentage)) +
  geom_line(color = "steelblue", size = 1.2) +
  labs(
    title = "Internet Usage in the U.S. (2000-2015)",
    x = "Year",
    y = "Percentage of Population"
  ) +
  theme_minimal()

timeseries

ggsave("timeseries.png", width = 8, height = 5, plot = timeseries)
```


Internet Usage in the U.S. (2000–2015)
Percentage of Population
90
80
70
60
50
2000
2005
2010
2015
2020
Year

```r
# Scatterplot with trendline
scatter <- ggplot(df, aes(x = Year, y = Percentage)) +
  geom_point(color = "coral2", size = 2.5, shape = 1, alpha = 0.5) +
  geom_smooth(method = "loess", color = "black", se = FALSE) +
  labs(
    title = "Trend of Internet Usage",
    x = "Year",
    y = "Internet Usage (%)"
  ) +
  theme_classic()

scatter

ggsave("scatter.png", width = 8, height = 5, plot = scatter)
```


Trend of Internet Usage
Internet Usage (%)
100
75
50
25
0
2000
2005
2010
2015
2020
Year

```r
# Bubble plot for usage over time, three countries
clean <- df %>%
  filter(Country.Name %in% c("Australia", "New Zealand", "Fiji")) %>%
  na.omit()

bubble <- ggplot(clean, aes(x = Year, y = Percentage,
                            color = Country.Name, size = Percentage)) +
  geom_point(alpha = 0.7) +
  scale_size(range = c(1, 10), name = "Usage (%)") +
  scale_x_continuous(by = 5) +
  scale_color_brewer(palette = "Set2") +
labs(
    title = "Internet Usage Over Time by Country",
    x = "Year",
    y = "Percentage of Population",
    color = "Country"
  ) +
  theme_minimal()

bubble

ggsave("bubble.png", width = 8, height = 6, plot = bubble)
```


Internet Usage Over Time by Country
Percentage of Population
100
75
50
25
0
2000
2005
2010
2015
2020
Year
Usage (%)
25
50
75
Country
Australia
Fiji
New Zealand

# Final thoughts

- When in doubt, ask questions! There are endless resources online about on plotting with ggplot2. Talk to your professor, TA, or classmates.
- Don't get overwhelmed!
- Think:
  - What dataset am I plotting from?
  - What variables do I want to visualize?
  - What type of plot do I want to create?
  - What I can do to make the plot look nicer?
    - Labels, colors, scaling, etc.
- Try different styles and layers until you produce a clear, professional-style plot that presents the data accurately & meaningfully