02 Class Activity

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# In-class Activity 2: Data Visualization

## Recap from Activity 1

* Collected pine needle samples from windward and leeward sides of trees
* Identified independent variable (wind exposure) and dependent variable (needle length)
* Measured needle lengths and recorded data
* Created basic visualizations
* Saved our data for further analysis

## Today’s Objectives

1. Implement data pipeline best practices
2. Apply controlled vocabulary and naming conventions
3. Create effective tables and visualizations
4. Customize plots for publication quality
5. Combine multiple plots into composite figures

# Part 1: Setting Up Your Environment

1. What data do we have
   1. what is the controlled vocabulary?
   2. are there units?
2. What is the directory structure?
3. Do we have a metadata file?
4. Is the data entered in a tidy format?
5. What are we missing?

# Now lets create a new quarto file

* note I usually use this sort of system in an r\_projects directory
* I have redone it for the class to organize all of the terms data
* you should try making some of your own projects



## In RStudio:

1. click file - open project and select the 2025\_UMD\_BioStats\_Student\_Code.Rproj file or double click on it in the finder or data explorer.
2. your screen will now change as RStudio knows where home is



1. Note that in the upper right you will see 2025\_UMD\_BioStats\_Student\_Code so you know you are in the right spot
2. Now click File - New File - Quarto File



1. Create a file that starts with 02\_ and then something that will help you know what is going on like 02\_class\_activity\_in\_class.qmd
2. Now this file thinks this is home.
3. So I usually copy stuff for the header from another file as its just too hard to remember all this…

---  
title: "Title of your file" # Title of the file  
author: "Your Name" # who you are  
execute:  
 freeze: auto  
 cache: true  
 echo: true  
 keep-md: true # retains the images when you start again  
 fig-height: 3  
 fig-width: 3  
 paged-print: false  
format:  
 html:  
 freeze: false  
 toc: false  
 output-file: "02\_02\_class\_activity.html"  
 default: true  
 embed-resources: true  
 self-contained: true  
 css: ../../css/activity.css  
 docx:  
 default: true  
 toc: false  
 toc-depth: 3  
 number-sections: false  
 highlight-style: github  
 reference-doc: ../../ms\_templates/custom-reference.docx  
 css: msword.css  
 embed-resources: true  
---

## Exercise 1: Now to load the libraries

# install packages -----  
# install.packages("readxl")  
# install.packages("tidyverse")  
  
# # we will install a few new libraries  
# install.packages("skimr")

Each script you run from then on you will load the libraries from within the package.

# Load the libraries ----  
library(readxl) # allows to read in excel files  
library(tidyverse) # provides utilities seen in console

── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──  
✔ dplyr 1.1.4 ✔ readr 2.1.5  
✔ forcats 1.0.0 ✔ stringr 1.5.1  
✔ ggplot2 3.5.2 ✔ tibble 3.2.1  
✔ lubridate 1.9.4 ✔ tidyr 1.3.1  
✔ purrr 1.0.4   
── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
✖ dplyr::filter() masks stats::filter()  
✖ dplyr::lag() masks stats::lag()  
ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(skimr) # provide summary stats  
library(janitor) # it cleans ; )

Attaching package: 'janitor'  
  
The following objects are masked from 'package:stats':  
  
 chisq.test, fisher.test

library(patchwork)

## Exercise 2: Loading and Examining Data

Now like we did before with x and y we will do this with a spreadsheet from a CSV file or excel file

We are going to work with the same data we did in the last class.

## Exercise 3: Examining Data

# Load the pine needle data  
pine\_df <- read\_csv("data/pine\_needles.csv", na = "NA")

Rows: 48 Columns: 6  
── Column specification ────────────────────────────────────────────────────────  
Delimiter: ","  
chr (4): date, group, n\_s, wind  
dbl (2): tree\_no, length\_mm  
  
ℹ Use `spec()` to retrieve the full column specification for this data.  
ℹ Specify the column types or set `show\_col\_types = FALSE` to quiet this message.

# Examine the data structure  
glimpse(pine\_df)

Rows: 48  
Columns: 6  
$ date <chr> "3/20/25", "3/20/25", "3/20/25", "3/20/25", "3/20/25", "3/20…  
$ group <chr> "cephalopods", "cephalopods", "cephalopods", "cephalopods", …  
$ n\_s <chr> "n", "n", "n", "n", "n", "n", "s", "s", "s", "s", "s", "s", …  
$ wind <chr> "lee", "lee", "lee", "lee", "lee", "lee", "wind", "wind", "w…  
$ tree\_no <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, …  
$ length\_mm <dbl> 20, 21, 23, 25, 21, 16, 15, 16, 14, 17, 13, 15, 19, 18, 20, …

# View the first few rows  
head(pine\_df)

# A tibble: 6 × 6  
 date group n\_s wind tree\_no length\_mm  
 <chr> <chr> <chr> <chr> <dbl> <dbl>  
1 3/20/25 cephalopods n lee 1 20  
2 3/20/25 cephalopods n lee 1 21  
3 3/20/25 cephalopods n lee 1 23  
4 3/20/25 cephalopods n lee 1 25  
5 3/20/25 cephalopods n lee 1 21  
6 3/20/25 cephalopods n lee 1 16

# Get a statistical summary  
summary(pine\_df)

date group n\_s wind   
 Length:48 Length:48 Length:48 Length:48   
 Class :character Class :character Class :character Class :character   
 Mode :character Mode :character Mode :character Mode :character   
   
   
   
 tree\_no length\_mm   
 Min. :1.00 Min. :12.00   
 1st Qu.:1.75 1st Qu.:15.00   
 Median :2.50 Median :17.50   
 Mean :2.50 Mean :17.67   
 3rd Qu.:3.25 3rd Qu.:20.25   
 Max. :4.00 Max. :25.00

### Questions to Consider:

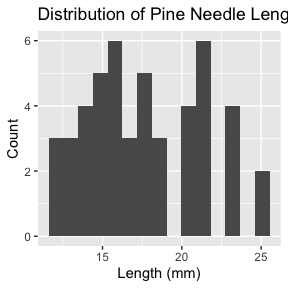
1. What variables are in our dataset?
2. What are their data types?
3. Are there any missing values?
4. Do the variable names follow consistent conventions?
5. How might we improve the data organization?

# Part 2: Basic Data Visualization

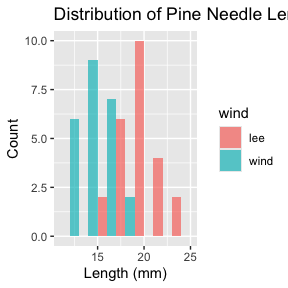
Let’s create some simple visualizations to explore our data:

### Exercise 2: Creating a Histogram

# Create a basic histogram  
pine\_df %>%  
 ggplot(aes(x = length\_mm)) +  
 geom\_histogram(bins = 15) +  
 labs(title = "Distribution of Pine Needle Lengths",  
 x = "Length (mm)",  
 y = "Count")



# Create a histogram with color grouping  
pine\_df %>%  
 ggplot(aes(x = length\_mm, fill = wind)) +  
 geom\_histogram(binwidth = 2, alpha = 0.7, position = "dodge") +  
 labs(title = "Distribution of Pine Needle Lengths by Wind Exposure",  
 x = "Length (mm)",  
 y = "Count")



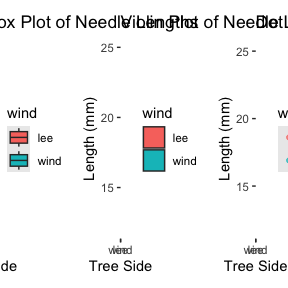
### Key Insights from Histograms:

The histogram helps us understand: - The overall distribution of needle lengths - Potential differences between windward and leeward needles - Presence of any unusual values or outliers

### Exercise 3: Creating Multiple Plot Types

Let’s explore different ways to visualize the same data:

# Box plot  
box\_plot <- pine\_df %>%  
 ggplot(aes(x = wind, y = length\_mm, fill = wind)) +  
 geom\_boxplot() +  
 labs(title = "Box Plot of Needle Lengths",  
 x = "Tree Side",  
 y = "Length (mm)")  
  
# Violin plot  
violin\_plot <- pine\_df %>%  
 ggplot(aes(x = wind, y = length\_mm, fill = wind)) +  
 geom\_violin() +  
 labs(title = "Violin Plot of Needle Lengths",  
 x = "Tree Side",  
 y = "Length (mm)")  
  
# Dot plot  
dot\_plot <- pine\_df %>%  
 ggplot(aes(x = wind, y = length\_mm, color = wind)) +  
 geom\_jitter(width = 0.2, alpha = 0.7) +  
 labs(title = "Dot Plot of Needle Lengths",  
 x = "Tree Side",  
 y = "Length (mm)")  
  
# Display all plots using patchwork  
box\_plot | violin\_plot | dot\_plot



### Questions to Consider:

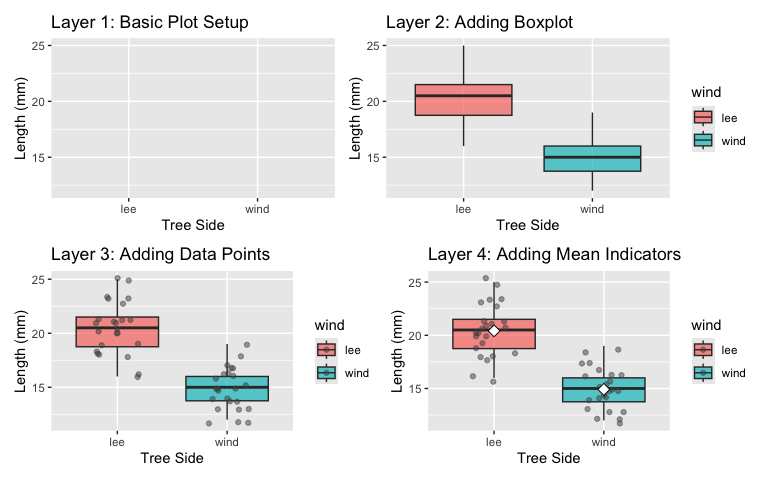
1. Which plot type best reveals patterns in our data?
2. What are the advantages and disadvantages of each plot type?
3. How might we combine elements from different plot types?

## Part 3: Building Complex Visualizations Layer by Layer

Now let’s build more sophisticated visualizations by adding layers one at a time:

### Exercise 4: Building a Layered Plot

# Start with a basic plot  
p1 <- pine\_df %>%  
 ggplot(aes(x = wind, y = length\_mm, fill = wind)) +  
 labs(title = "Layer 1: Basic Plot Setup",  
 x = "Tree Side",   
 y = "Length (mm)")  
  
# Add boxplot layer  
p2 <- p1 +  
 geom\_boxplot(alpha = 0.7) +  
 labs(title = "Layer 2: Adding Boxplot")  
  
# Add individual data points  
p3 <- p2 +  
 geom\_jitter(width = 0.2, alpha = 0.5, color = "gray30") +  
 labs(title = "Layer 3: Adding Data Points")  
  
# Add mean indicators  
p4 <- p3 +  
 stat\_summary(fun = mean, geom = "point", shape = 23, size = 3, fill = "white") +  
 labs(title = "Layer 4: Adding Mean Indicators")  
  
# Create a 2x2 grid of the progressive plot building  
(p1 | p2) / (p3 | p4)



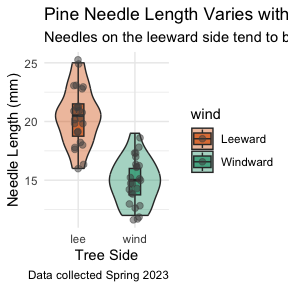
### Discussion Points:

* How does each layer contribute to the story our data is telling?
* Why might we want to show individual data points alongside summary statistics?
* How does transparency (alpha) help when overlaying multiple elements?

## Part 4: Customizing Plots for Publication

### Exercise 5: Adding customization

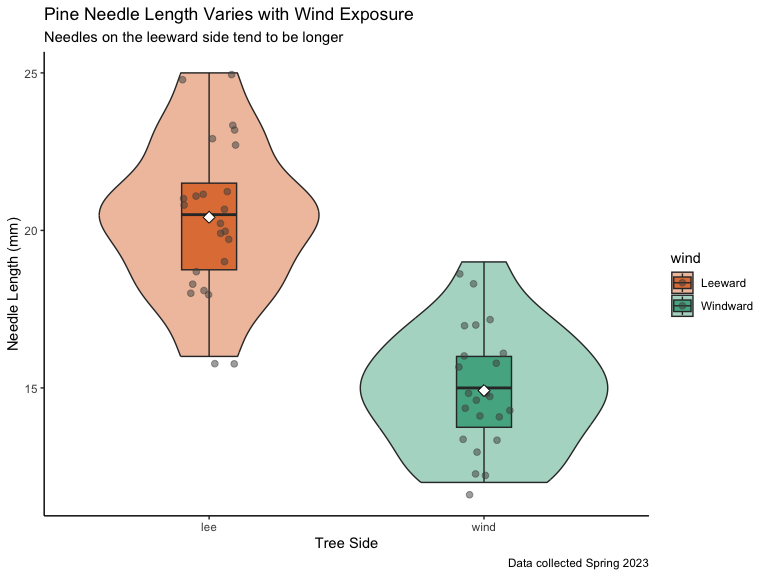
# Create a fully customized plot  
color\_plot <- pine\_df %>%  
 ggplot(aes(x = wind, y = length\_mm, fill = wind)) +  
 # Add violin plots for distribution  
 geom\_violin(alpha = 0.4) +  
 # Add boxplots for key statistics  
 geom\_boxplot(width = 0.2, alpha = 0.7, outlier.shape = NA) +  
 # Add individual data points  
 geom\_jitter(width = 0.1, alpha = 0.5, color = "gray30", size = 2) +  
 # Add mean points  
 labs(  
 title = "Pine Needle Length Varies with Wind Exposure",  
 subtitle = "Needles on the leeward side tend to be longer",  
 x = "Tree Side",   
 y = "Needle Length (mm)",  
 caption = "Data collected Spring 2023"  
 ) +  
 # Customize colors with a colorblind-friendly palette  
 scale\_fill\_manual(  
 values = c(  
 "wind" = "#1b9e77",  
 "lee" = "#d95f02"  
 ),  
 labels = c(  
 "wind" = "Windward",   
 "lee" = "Leeward"  
 )) +  
 # Apply a clean theme  
 theme\_minimal()   
  
  
# Display the publication-ready plot  
color\_plot



Let’s create a publication-quality figure by customizing colors, labels, and themes:

### Exercise 6: Creating a Publication-Ready Plot

# Create a fully customized plot  
publication\_plot <- pine\_df %>%  
 ggplot(aes(x = wind, y = length\_mm, fill = wind)) +  
 # Add violin plots for distribution  
 geom\_violin(alpha = 0.4) +  
 # Add boxplots for key statistics  
 geom\_boxplot(width = 0.2, alpha = 0.7, outlier.shape = NA) +  
 # Add individual data points  
 geom\_jitter(width = 0.1, alpha = 0.5, color = "gray30", size = 2) +  
 # Add mean points  
 stat\_summary(fun = mean, geom = "point", shape = 23, size = 3, fill = "white") +  
 # Add informative labels  
 labs(  
 title = "Pine Needle Length Varies with Wind Exposure",  
 subtitle = "Needles on the leeward side tend to be longer",  
 x = "Tree Side",   
 y = "Needle Length (mm)",  
 caption = "Data collected Spring 2023"  
 ) +  
 # Customize colors with a colorblind-friendly palette  
 scale\_fill\_manual(  
 values = c("wind" = "#1b9e77", "lee" = "#d95f02"),  
 labels = c("wind" = "Windward", "lee" = "Leeward")  
 ) +  
 # Apply a clean theme  
 theme\_classic()   
   
  
# Display the publication-ready plot  
publication\_plot



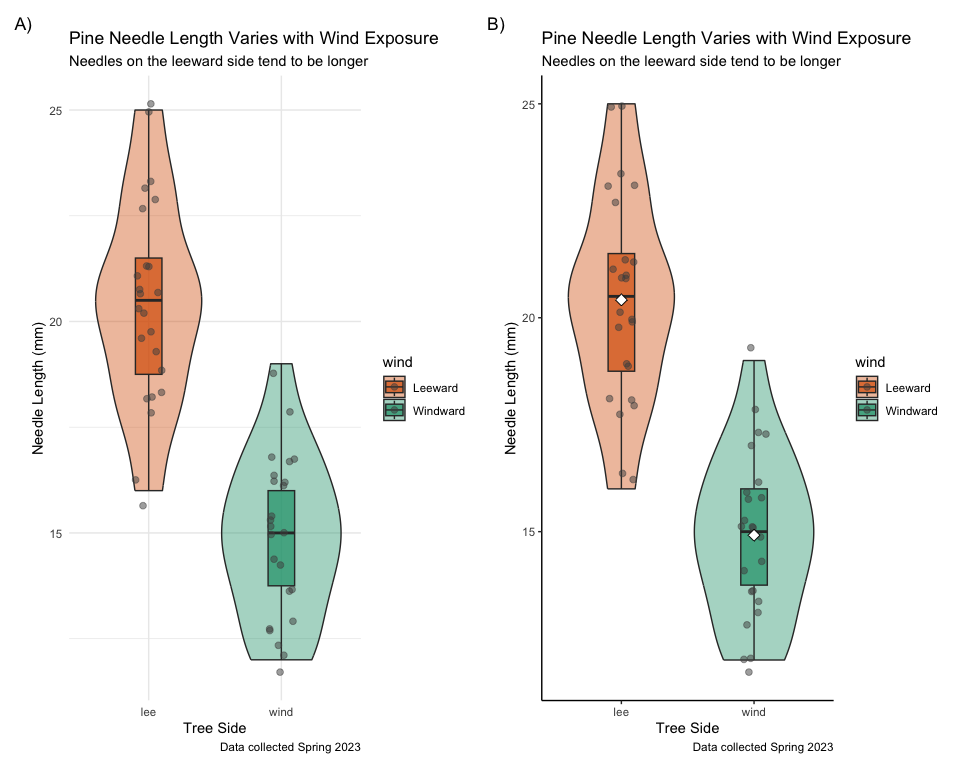
### Customization Elements:

1. **Plot Elements**:
   * Violin plots to show distribution
   * Boxplots to show quartiles and median
   * Individual points for transparency
   * Mean indicators for central tendency
2. **Visual Design**:
   * Colorblind-friendly color palette
   * Thoughtful use of transparency
   * Clear, informative title and subtitle
   * Professional typography and spacing
3. **Accessibility Considerations**:
   * Sufficient contrast
   * Redundant encoding (position and color)
   * Clear labels with units

## Part 5: Creating Complex Multi-Panel Figures

Finally, let’s create a publication-ready multi-panel figure:

color\_plot +  
   
 publication\_plot +   
 plot\_layout(ncol = 2) +   
 plot\_annotation(tag\_levels = "A", tag\_suffix = ")")



# we can add this to remove things  
# why do this?  
# + theme(  
# axis.text.y = element\_blank(), # Removes x-axis labels  
# axis.title.y = element\_blank() # Removes x-axis title

## Summary and Key Takeaways

In this activity, we’ve learned how to:

1. **Load and examine data** properly
2. **Create basic visualizations** to explore patterns
3. **Build complex plots layer by layer** using ggplot2’s grammar
4. **Customize plots** for clear communication and visual appeal
5. **Add statistical information** to support data interpretation
6. **Combine multiple plots** into publication-ready figures

### Best Practices for Data Visualization:

1. **Start simple**, then add complexity as needed
2. **Focus on the story** your data is telling
3. **Use appropriate plot types** for your data structure
4. **Minimize chart junk** and maximize data-ink ratio
5. **Create clear, informative labels**
6. **Use color purposefully** and with accessibility in mind
7. **Include both individual data points and summary statistics** when possible
8. **Consider your audience** when designing visualizations