Assignment 5: Data Visualization

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OVERVIEW

This exercise accompanies the lessons in Environmental Data Analytics on Data Visualization

Directions

1. Rename this file `<FirstLast>_A05_DataVisualization.Rmd` (replacing `<FirstLast>` with your first and last name).
2. Change "Student Name" on line 3 (above) with your name.
3. Work through the steps, **creating code and output** that fulfill each instruction.
4. Be sure your code is tidy; use line breaks to ensure your code fits in the knitted output.
5. Be sure to **answer the questions** in this assignment document.
6. When you have completed the assignment, **Knit** the text and code into a single PDF file.

Set up your session

1. Set up your session. Load the tidyverse, lubridate, here & cowplot packages, and verify your home directory. Read in the NTL-LTER processed data files for nutrients and chemistry/physics for Peter and Paul Lakes (use the tidy `NTL-LTER_Lake_Chemistry_Nutrients_PeterPaul_Processed.csv` version in the Processed_KEY folder) and the processed data file for the Niwot Ridge litter dataset (use the `NEON_NIWO_Litter_mass_trap_Processed.csv` version, again from the Processed_KEY folder).

2. Make sure R is reading dates as date format; if not change the format to date.

```
#1 setting up

# loading libraries
library(tidyverse); library(lubridate); library(here); library(cowplot)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.1     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
```

```
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
## here() starts at /home/guest/ENV872/EDE_Fall2024
##
##
## Attaching package: 'cowplot'
##
##
## The following object is masked from 'package:lubridate':
##
##     stamp
```

```
# verifying home directory
here()
```

```
## [1] "/home/guest/ENV872/EDE_Fall2024"
```

```
# loading datasets
peterPaul.chem.nutrients <-
  read.csv(
    here(
      "Data/Processed_KEY/NTL-LTER_Lake_Chemistry_Nutrients_PeterPaul_Processed.csv"
      ), stringsAsFactors = T)

litter.mass.trap <-
  read.csv(here("Data/Processed_KEY/NEON_NIWO_Litter_mass_trap_Processed.csv"),
           stringsAsFactors = T)

#2 changing dates to date format

# checking data types
glimpse(peterPaul.chem.nutrients)
```

```
## Rows: 23,008
## Columns: 15
## $ lakename        <fct> Paul Lake, Paul Lake, Paul Lake, Paul Lake, Paul Lake,~
## $ year4           <int> 1984, 1984, 1984, 1984, 1984, 1984, 1984, 1984, 1984, ~
## $ daynum          <int> 148, 148, 148, 148, 148, 148, 148, 148, 148, 148, 148,~
## $ month           <int> 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, ~
## $ sampledate      <fct> 1984-05-27, 1984-05-27, 1984-05-27, 1984-05-27, 1984-0~
## $ depth           <dbl> 0.00, 0.25, 0.50, 0.75, 1.00, 1.50, 2.00, 3.00, 4.00, ~
## $ temperature_C   <dbl> 14.5, NA, NA, NA, 14.5, NA, 14.2, 11.0, 7.0, 6.1, 5.5,~
## $ dissolvedOxygen <dbl> 9.5, NA, NA, NA, 8.8, NA, 8.6, 11.5, 11.9, 2.5, 1.6, 0~
## $ irradianceWater <dbl> 1750.0, 1550.0, 1150.0, 975.0, 870.0, 610.0, 420.0, 22~
## $ irradianceDeck  <dbl> 1620, 1620, 1620, 1620, 1620, 1620, 1620, 1620, 1620, ~
## $ tn_ug           <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA~
## $ tp_ug           <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA~
## $ nh34            <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA~
## $ no23            <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA~
## $ po4             <dbl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA~
```

```
glimpse(litter.mass.trap)
```

```
## Rows: 1,692
## Columns: 13
## $ plotID           <fct> NIWO_062, NIWO_061, NIWO_062, NIWO_064, NIWO_058, NIW~
## $ trapID           <fct> NIWO_062_050, NIWO_061_169, NIWO_062_050, NIWO_064_10~
## $ collectDate      <fct> 2016-06-16, 2016-06-16, 2016-06-16, 2016-06-16, 2016-~
## $ functionalGroup  <fct> Seeds, Other, Woody material, Seeds, Needles, Leaves,~
## $ dryMass          <dbl> 0.000, 0.270, 0.120, 0.000, 1.110, 0.000, 0.000, 0.00~
## $ qaDryMass        <fct> N, N, N, N, Y, N, N, N, N, N, N, Y, N, N, N, N, N, Y,~
## $ subplotID        <int> 31, 41, 31, 32, 32, 32, 40, 40, 40, 40, 40, 31, 31, 3~
## $ decimalLatitude  <dbl> 40.05114, 40.04762, 40.05114, 40.04737, 40.04872, 40.~
## $ decimalLongitude <dbl> -105.5858, -105.5861, -105.5858, -105.5840, -105.5872~
## $ elevation        <dbl> 3477.0, 3413.4, 3477.0, 3373.2, 3446.4, 3446.4, 3509.~
## $ nlcdClass        <fct> shrubScrub, evergreenForest, shrubScrub, evergreenFor~
## $ plotType         <fct> tower, tower, tower, tower, tower, tower, tower, towe~
## $ geodeticDatum    <fct> WGS84, WGS84, WGS84, WGS84, WGS84, WGS84, WGS84, WGS8~
```

```
# we can see that the collection date for both datasets are factors

# converting dates to date format
peterPaul.chem.nutrients$sampledate <- ymd(peterPaul.chem.nutrients$sampledate)
litter.mass.trap$collectDate <- ymd(litter.mass.trap$collectDate)
```

Define your theme

3. Build a theme and set it as your default theme. Customize the look of at least two of the following:

- Plot background
- Plot title
- Axis labels
- Axis ticks/gridlines
- Legend

```
#3 building a theme

mytheme <- theme_classic(base_size = 10) +
  theme(
    # plot background
    plot.background = element_rect(fill = "lightgrey", color = NA),
    # plot title
    plot.title = element_text(size = 8, face = "bold", hjust = 0.5),
    # axes labels
    axis.title.x = element_text(size = 10, face = "bold", color = "black"),
    axis.title.y = element_text(size = 10, face = "bold", color = "black"),
    # axis ticks and lines
    axis.ticks = element_line(color = "black"),
    axis.line = element_line(color = "black"),
    # gridlines
    panel.grid.major = element_line(color = "grey90", size = 0.5),
    # legend
```

```
    legend.position = "right",
    legend.box.size = unit(1, "cm")
  )
```

```
## Warning: The ‘size‘ argument of ‘element_line()‘ is deprecated as of ggplot2 3.4.0.
## i Please use the ‘linewidth‘ argument instead.
## This warning is displayed once every 8 hours.
## Call ‘lifecycle::last_lifecycle_warnings()‘ to see where this warning was
## generated.
```

Create graphs

For numbers 4-7, create ggplot graphs and adjust aesthetics to follow best practices for data visualization. Ensure your theme, color palettes, axes, and additional aesthetics are edited accordingly.

4. [NTL-LTER] Plot total phosphorus (`tp_ug`) by phosphate (`po4`), with separate aesthetics for Peter and Paul lakes. Add line(s) of best fit using the `lm` method. Adjust your axes to hide extreme values (hint: change the limits using `xlim()` and/or `ylim()`).

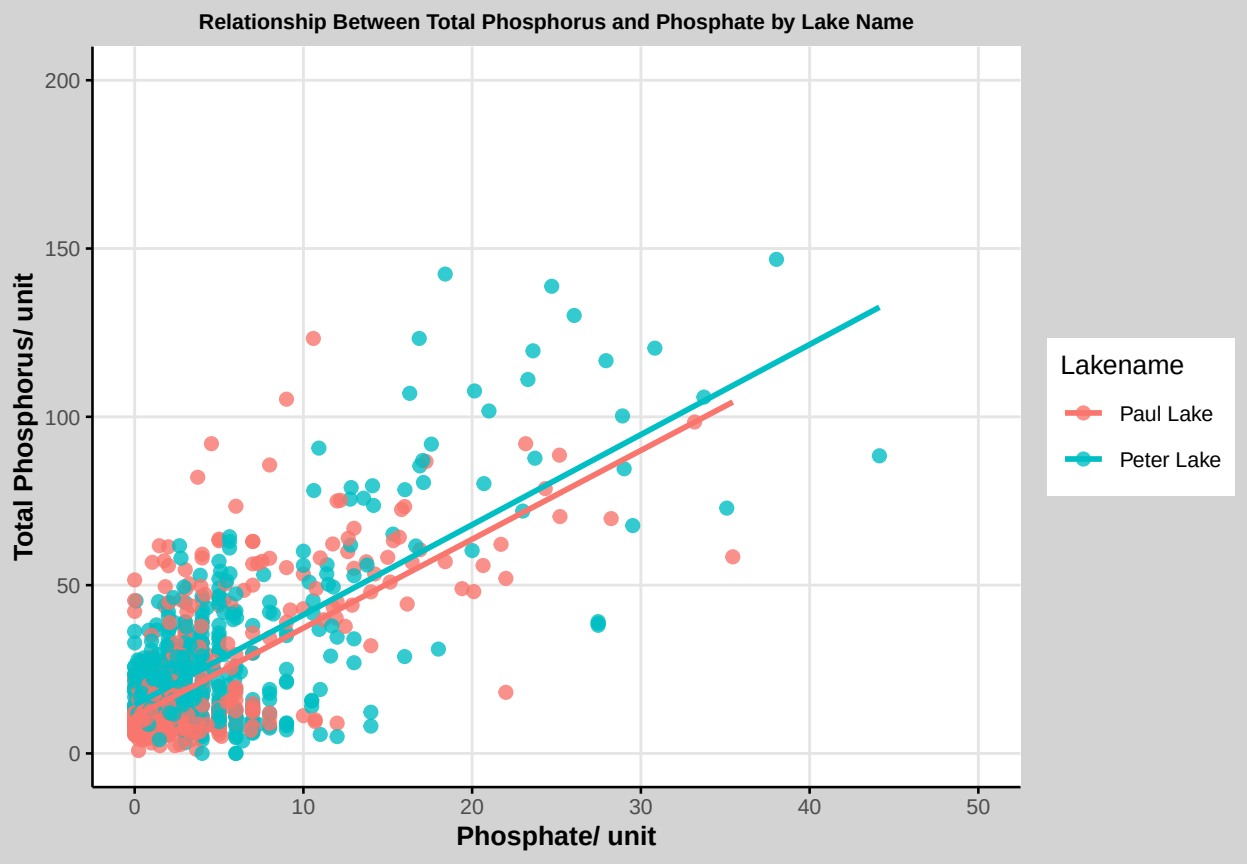
```
#4 Scatter plot with best fit line

# plotting total phosphorus by phosphate, separated by lake
ggplot(peterPaul.chem.nutrients, aes(x = po4, y = tp_ug, color = lakename)) +
  geom_point(size = 2, alpha = 0.8) +
  # best fit line
  geom_smooth(method = "lm", se = FALSE) +
  # hide extreme values
  xlim(0, 50) +
  ylim(0, 200) +
  labs(
    title = "Relationship Between Total Phosphorus and Phosphate by Lake Name",
    x = "Phosphate/ unit",
    y = "Total Phosphorus/ unit",
    color = "Lakename"
  ) +
  mytheme
```

```
## ‘geom_smooth()‘ using formula = ’y ~ x’
```

```
## Warning: Removed 21948 rows containing non-finite outside the scale range
## (‘stat_smooth()‘).
```

```
## Warning in plot_theme(plot): The ‘legend.box.size‘ theme element is not defined
## in the element hierarchy.
```

```
## Warning: Removed 21948 rows containing missing values or values outside the scale range
## (‘geom_point()‘).
```



5. [NTL-LTER] Make three separate boxplots of (a) temperature, (b) TP, and (c) TN, with month as the x axis and lake as a color aesthetic. Then, create a cowplot that combines the three graphs. Make sure that only one legend is present and that graph axes are aligned.

Tips: * Recall the discussion on factors in the lab section as it may be helpful here. * Setting an axis title in your theme to `element_blank()` removes the axis title (useful when multiple, aligned plots use the same axis values) * Setting a legend's position to "none" will remove the legend from a plot. * Individual plots can have different sizes when combined using `cowplot`.

```
#5 box plots
library(grid)
library(gridExtra)
```

```
##
## Attaching package: 'gridExtra'
```

```
## The following object is masked from 'package:dplyr':
##
##     combine
```

```
peterPaul.chem.nutrients$month <- factor(peterPaul.chem.nutrients$month)
# (a) Boxplot for temperature by month
temp_plot <- ggplot(peterPaul.chem.nutrients,
                    aes(x = month, y = temperature_C, fill = lakename)) +
```

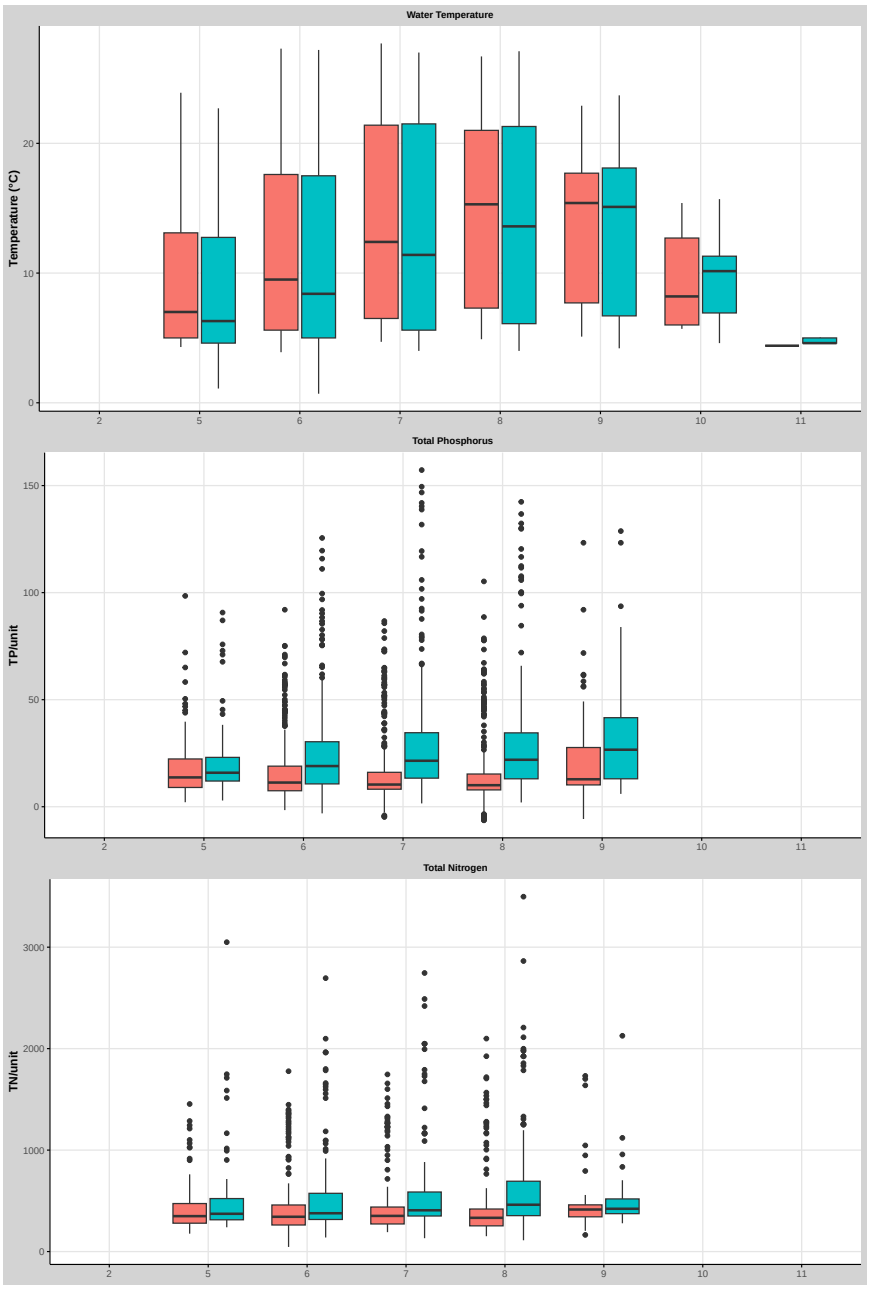
```
  geom_boxplot() +
  labs(title = "Water Temperature", y = "Temperature (°C)") +
  mytheme +
  theme(legend.position = "none", axis.title.x = element_blank())

# (b) Boxplot for total phosphorus by month
tp_plot <- ggplot(peterPaul.chem.nutrients,
                  aes(x = month, y = tp_ug, fill = lakename)) +
  geom_boxplot() +
  labs(title = "Total Phosphorus", y = "TP/unit") +
  mytheme +
  theme(legend.position = "none", axis.title.x = element_blank())

# (c) Boxplot for total nitrogen by month
tn_plot <- ggplot(peterPaul.chem.nutrients,
                  aes(x = month, y = tn_ug, fill = lakename)) +
  geom_boxplot() +
  labs(title = "Total Nitrogen", y = "TN/unit") +
  mytheme +
  theme(legend.position = "none", axis.title.x = element_blank())

legend <- get_legend(tn_plot + theme(legend.position = "right"))
```

```
## Warning: Removed 21583 rows containing non-finite outside the scale range
## (‘stat_boxplot()‘).

## Warning in plot_theme(plot): The ‘legend.box.size‘ theme element is not defined
## in the element hierarchy.

## Warning in get_plot_component(plot, "guide-box"): Multiple components found;
## returning the first one. To return all, use ‘return_all = TRUE‘.
```

```
# combining plots
combined_plot <- plot_grid(temp_plot, tp_plot, tn_plot, legend, nrow = 4)
```

```
## Warning: Removed 3566 rows containing non-finite outside the scale range
## (‘stat_boxplot()‘).

## Warning in plot_theme(plot): The ‘legend.box.size‘ theme element is not defined
## in the element hierarchy.

## Warning: Removed 20729 rows containing non-finite outside the scale range
## (‘stat_boxplot()‘).

## Warning in plot_theme(plot): The ‘legend.box.size‘ theme element is not defined
## in the element hierarchy.

## Warning: Removed 21583 rows containing non-finite outside the scale range
## (‘stat_boxplot()‘).

## Warning in plot_theme(plot): The ‘legend.box.size‘ theme element is not defined
## in the element hierarchy.
```

```r
# adding common x-axis
x.grob <- textGrob("Month",
                   gp=gpar(fontface="bold", fontsize=15))
grid.arrange(arrangeGrob(combined_plot, bottom = x.grob))
```


Water Temperature
Temperature (°C)
0
10
20
2
5
6
7
8
9
10
11
Total Phosphorus
TP/unit
0
50
100
150
Total Nitrogen
TN/unit
0
1000
2000
3000
lakename
Paul Lake
Peter Lake
Month

Question: What do you observe about the variables of interest over seasons and between lakes?

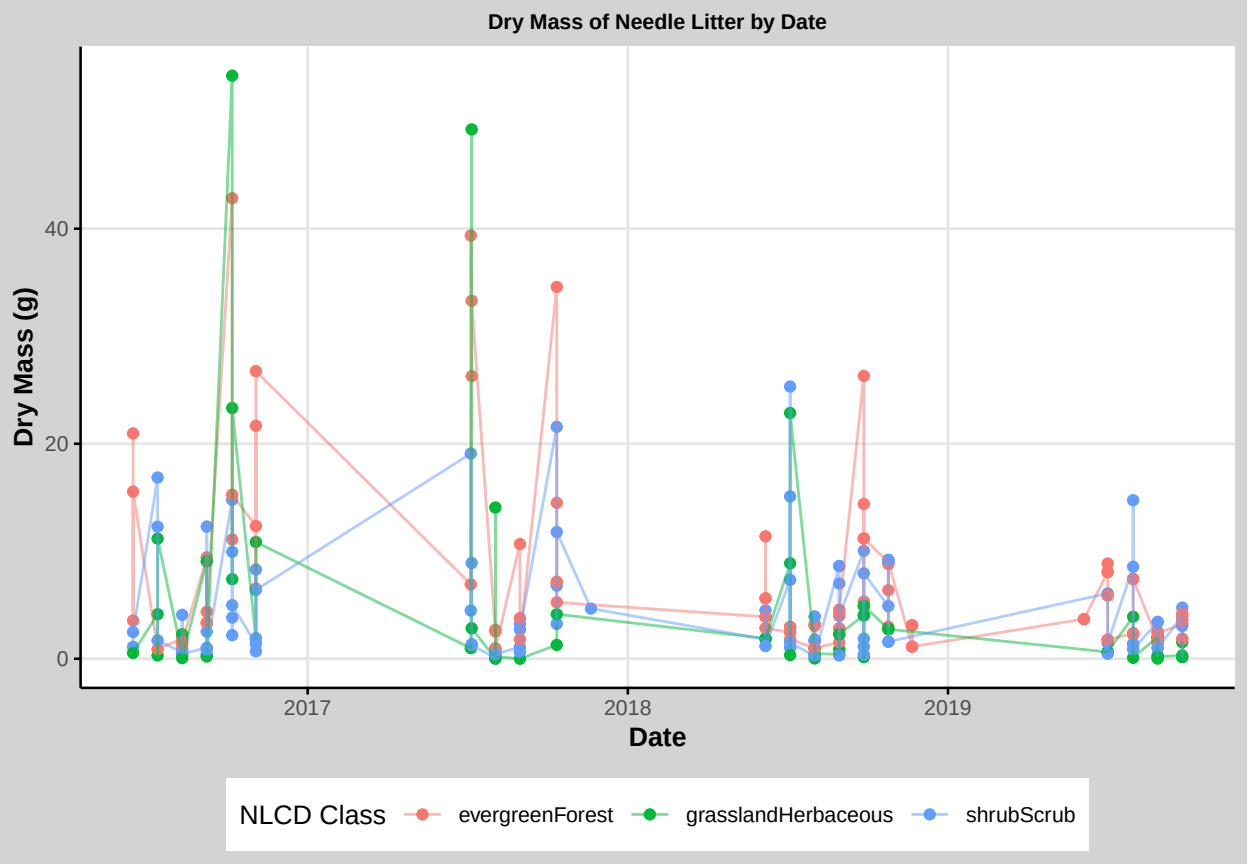
> Answer: The variable across lakes are not very different in terms of temperature. But the phosphorus and nitrogen content is higher in peter lake. Moreover, the water temperature is highest in summer months (July and August), and is low in May, October and November. The phosphorus and nitrogen content does not vary much across months

6. [Niwot Ridge] Plot a subset of the litter dataset by displaying only the "Needles" functional group. Plot the dry mass of needle litter by date and separate by NLCD class with a color aesthetic. (no need to adjust the name of each land use)

7. [Niwot Ridge] Now, plot the same plot but with NLCD classes separated into three facets rather than separated by color.

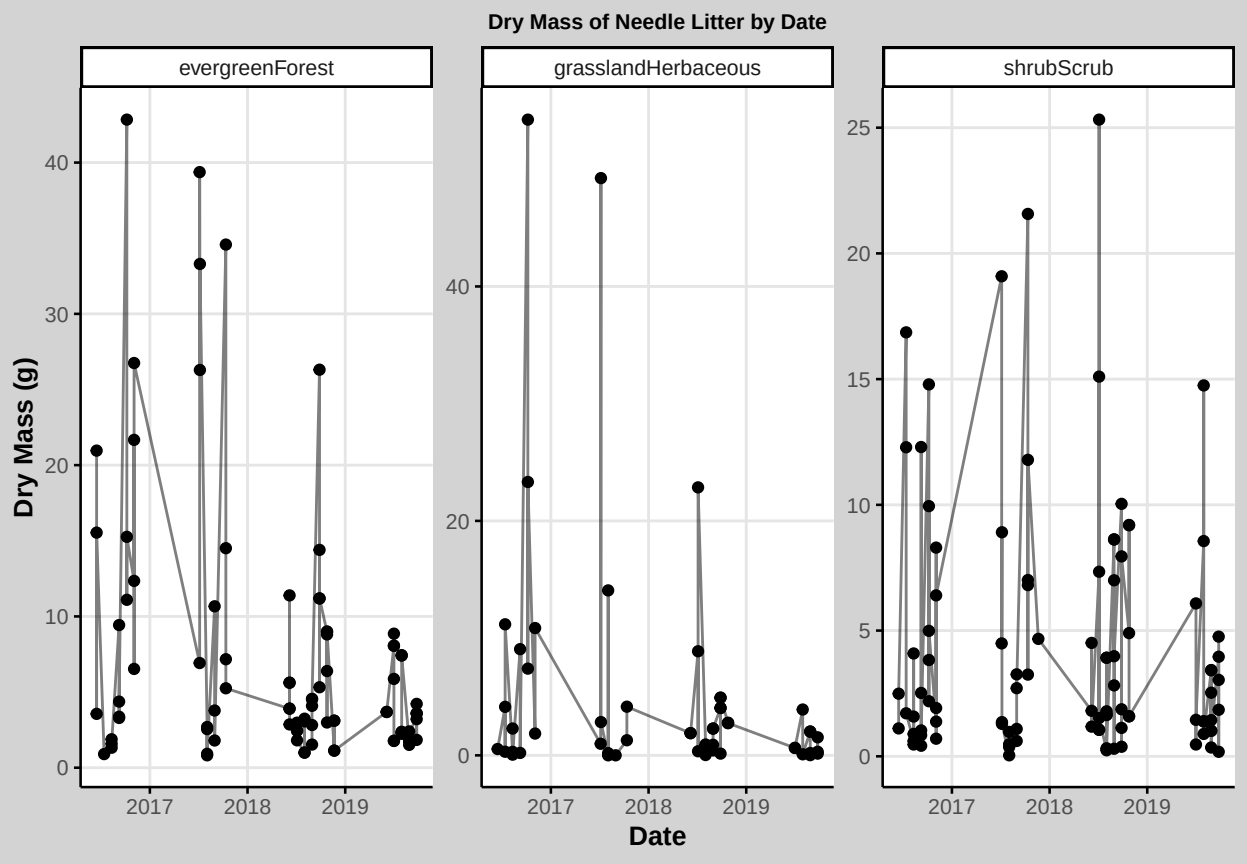
```
#6 Needle plot

# filtering out data
needles_data <- litter.mass.trap %>%
  filter(functionalGroup == "Needles")

# creating needle plot
needle_plot <- ggplot(needles_data,
                      aes(x = collectDate, y = dryMass, color = nlcdClass)) +
  geom_point() +
  geom_line(aes(group = nlcdClass), alpha = 0.5) +
  labs(title = "Dry Mass of Needle Litter by Date",
       x = "Date",
       y = "Dry Mass (g)",
       color = "NLCD Class") +
  mytheme +
  theme(legend.position = "bottom")  # move legend to the bottom

needle_plot
```

```
## Warning in plot_theme(plot): The ‘legend.box.size‘ theme element is not defined
## in the element hierarchy.
```




```
#7 creating 3 facets

# creating faceted plot
needle_plot_facet <- ggplot(needles_data,
                      aes(x = collectDate, y = dryMass)) +
  geom_point() +
  geom_line(aes(group = nlcdClass), alpha = 0.5) +
  labs(title = "Dry Mass of Needle Litter by Date",
       x = "Date",
       y = "Dry Mass (g)") +
  mytheme +
  theme(legend.position = "none") +
  facet_wrap(~ nlcdClass, scales = "free_y")

needle_plot_facet
```

```
## Warning in plot_theme(plot): The 'legend.box.size' theme element is not defined
## in the element hierarchy.
```



Question: Which of these plots (6 vs. 7) do you think is more effective, and why?

Answer: The plot in Q6 is more effective, because it can compare the different facets more directly by observing the patterns of different colors. It allows a direct comparison and is better due to its simplicity.