# Assignment 5: Data Visualization

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## Fall 2025

## 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, 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
#load tidyverse, here & cowplot packages
library(tidyverse)
```

```
## -- 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
```

```r
library(here)
```

```
## here() starts at /home/guest/R/EDE_Fall2025
```

```r
library(cowplot)
```

```
##
## Attaching package: 'cowplot'
##
## The following object is masked from 'package:lubridate':
##
##      stamp
```

```r
#verify home directory
here()
```

```
## [1] "/home/guest/R/EDE_Fall2025"
```

```r
#output [1] "/home/guest/R/EDE_Fall2025"

#Assign a variable to the processed data folder location
processed_data = here("Data/Processed_KEY")

#Read in data
PeterPaul.chem.nutrients <- read.csv(
  here
  (processed_data,"NTL-LTER_Lake_Chemistry_Nutrients_PeterPaul_Processed.csv"),
  stringsAsFactors = TRUE)

Niwot.litter<- read.csv(
  here(processed_data,"NEON_NIWO_Litter_mass_trap_Processed.csv"),
  stringsAsFactors = TRUE)

#2
#switch date data from factor to date
PeterPaul.chem.nutrients$sampledate <- ymd(PeterPaul.chem.nutrients$sampledate)
Niwot.litter$collectDate <- ymd(Niwot.litter$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
#define my theme, customize panel background,
#customize axis labels and axis text
mytheme <- theme_minimal(base_size = 14) +
  theme(panel.background = element_rect(fill = "#ead1dc"),
        axis.title.x = element_text(color = "#0964BD", face = "bold"),
        axis.title.y = element_text(color = "#0964BD", face = "bold"),
        axis.text = element_text(color = "#0964BD"))
#         plot.title.x = element_blank(),
#         plot.title.y = element_blank())

theme_set(mytheme)

#visualizing to edit theme output
#Rough.Plot <- ggplot(PeterPaul.chem.nutrients) +
#  geom_point(aes(x = sampledate, y = temperature_C)) +
#  mytheme
#print(Rough.Plot)
```

## 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
PeterPaul.P.by.PO4 <- PeterPaul.chem.nutrients %>%
  ggplot(
    mapping = aes(
      x = tp_ug,
      y = po4,
      color = lakename)
    )+
  geom_point() +
  geom_smooth(method = lm) +
  xlim(0,150) +
  ylim(0,75)
  mytheme
```

```
## List of 136
##  $ line                          :List of 6
##   ..$ colour      : chr "black"
##   ..$ linewidth   : num 0.636
##   ..$ linetype    : num 1
##   ..$ lineend     : chr "butt"
##   ..$ arrow       : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_line" "element"
##  $ rect                          :List of 5
```

```
##   ..$ fill        : chr "white"
##   ..$ colour      : chr "black"
##   ..$ linewidth   : num 0.636
##   ..$ linetype    : num 1
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text                       :List of 11
##   ..$ family      : chr ""
##   ..$ face        : chr "plain"
##   ..$ colour      : chr "black"
##   ..$ size        : num 14
##   ..$ hjust       : num 0.5
##   ..$ vjust       : num 0.5
##   ..$ angle       : num 0
##   ..$ lineheight  : num 0.9
##   ..$ margin      : 'margin' num [1:4] 0points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title                      : NULL
## $ aspect.ratio               : NULL
## $ axis.title                 : NULL
## $ axis.title.x               :List of 11
##   ..$ family      : NULL
##   ..$ face        : chr "bold"
##   ..$ colour      : chr "#0964BD"
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 3.5points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi FALSE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top           :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 0
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 0points 3.5points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom        : NULL
## $ axis.title.y               :List of 11
##   ..$ family      : NULL
```

```
##   ..$ face        : chr "bold"
##   ..$ colour      : chr "#0964BD"
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : num 90
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 3.5points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi FALSE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.title.y.left            : NULL
##  $ axis.title.y.right           :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : num -90
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 0points 0points 3.5points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.text                    :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : chr "#0964BD"
##   ..$ size        : 'rel' num 0.8
##   ..$ hjust       : NULL
##   ..$ vjust       : NULL
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : NULL
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi FALSE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.text.x                  :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 2.8points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
```

```
##  $ axis.text.x.top                    :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : NULL
##   ..$ vjust        : num 0
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 0points 0points 2.8points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.text.x.bottom               : NULL
##  $ axis.text.y                      :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : num 1
##   ..$ vjust        : NULL
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 0points 2.8points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.text.y.left                 : NULL
##  $ axis.text.y.right                :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : num 0
##   ..$ vjust        : NULL
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : 'margin' num [1:4] 0points 0points 0points 2.8points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.text.theta                  : NULL
##  $ axis.text.r                      :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : num 0.5
##   ..$ vjust        : NULL
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
```

```
##   ..$ margin      : 'margin' num [1:4] 0points 2.8points 0points 2.8points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.ticks                   : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.ticks.x                 : NULL
## $ axis.ticks.x.top             : NULL
## $ axis.ticks.x.bottom          : NULL
## $ axis.ticks.y                 : NULL
## $ axis.ticks.y.left            : NULL
## $ axis.ticks.y.right           : NULL
## $ axis.ticks.theta             : NULL
## $ axis.ticks.r                 : NULL
## $ axis.minor.ticks.x.top       : NULL
## $ axis.minor.ticks.x.bottom    : NULL
## $ axis.minor.ticks.y.left      : NULL
## $ axis.minor.ticks.y.right     : NULL
## $ axis.minor.ticks.theta       : NULL
## $ axis.minor.ticks.r           : NULL
## $ axis.ticks.length            : 'simpleUnit' num 3.5points
##   ..- attr(*, "unit")= int 8
## $ axis.ticks.length.x          : NULL
## $ axis.ticks.length.x.top      : NULL
## $ axis.ticks.length.x.bottom   : NULL
## $ axis.ticks.length.y          : NULL
## $ axis.ticks.length.y.left     : NULL
## $ axis.ticks.length.y.right    : NULL
## $ axis.ticks.length.theta      : NULL
## $ axis.ticks.length.r          : NULL
## $ axis.minor.ticks.length      : 'rel' num 0.75
## $ axis.minor.ticks.length.x    : NULL
## $ axis.minor.ticks.length.x.top   : NULL
## $ axis.minor.ticks.length.x.bottom: NULL
## $ axis.minor.ticks.length.y       : NULL
## $ axis.minor.ticks.length.y.left  : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta   : NULL
## $ axis.minor.ticks.length.r       : NULL
## $ axis.line                    : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x                  : NULL
## $ axis.line.x.top              : NULL
## $ axis.line.x.bottom           : NULL
## $ axis.line.y                  : NULL
## $ axis.line.y.left             : NULL
## $ axis.line.y.right            : NULL
## $ axis.line.theta              : NULL
## $ axis.line.r                  : NULL
## $ legend.background            : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.margin                : 'margin' num [1:4] 7points 7points 7points 7points
##   ..- attr(*, "unit")= int 8
```

```
##  $ legend.spacing                   : 'simpleUnit' num 14points
##   ..- attr(*, "unit")= int 8
##  $ legend.spacing.x                 : NULL
##  $ legend.spacing.y                 : NULL
##  $ legend.key                       : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
##  $ legend.key.size                  : 'simpleUnit' num 1.2lines
##   ..- attr(*, "unit")= int 3
##  $ legend.key.height                : NULL
##  $ legend.key.width                 : NULL
##  $ legend.key.spacing               : 'simpleUnit' num 7points
##   ..- attr(*, "unit")= int 8
##  $ legend.key.spacing.x             : NULL
##  $ legend.key.spacing.y             : NULL
##  $ legend.frame                     : NULL
##  $ legend.ticks                     : NULL
##  $ legend.ticks.length              : 'rel' num 0.2
##  $ legend.axis.line                 : NULL
##  $ legend.text                      :List of 11
##   ..$ family     : NULL
##   ..$ face       : NULL
##   ..$ colour     : NULL
##   ..$ size       : 'rel' num 0.8
##   ..$ hjust      : NULL
##   ..$ vjust      : NULL
##   ..$ angle      : NULL
##   ..$ lineheight : NULL
##   ..$ margin     : NULL
##   ..$ debug      : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ legend.text.position             : NULL
##  $ legend.title                     :List of 11
##   ..$ family     : NULL
##   ..$ face       : NULL
##   ..$ colour     : NULL
##   ..$ size       : NULL
##   ..$ hjust      : num 0
##   ..$ vjust      : NULL
##   ..$ angle      : NULL
##   ..$ lineheight : NULL
##   ..$ margin     : NULL
##   ..$ debug      : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ legend.title.position            : NULL
##  $ legend.position                  : chr "right"
##  $ legend.position.inside           : NULL
##  $ legend.direction                 : NULL
##  $ legend.byrow                     : NULL
##  $ legend.justification             : chr "center"
##  $ legend.justification.top         : NULL
##  $ legend.justification.bottom      : NULL
##  $ legend.justification.left        : NULL
```

```
##  $ legend.justification.right    : NULL
##  $ legend.justification.inside   : NULL
##  $ legend.location               : NULL
##  $ legend.box                    : NULL
##  $ legend.box.just               : NULL
##  $ legend.box.margin             : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   ..- attr(*, "unit")= int 1
##  $ legend.box.background          : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
##  $ legend.box.spacing            : 'simpleUnit' num 14points
##   ..- attr(*, "unit")= int 8
##   [list output truncated]
##  - attr(*, "class")= chr [1:2] "theme" "gg"
##  - attr(*, "complete")= logi TRUE
##  - attr(*, "validate")= logi TRUE
```
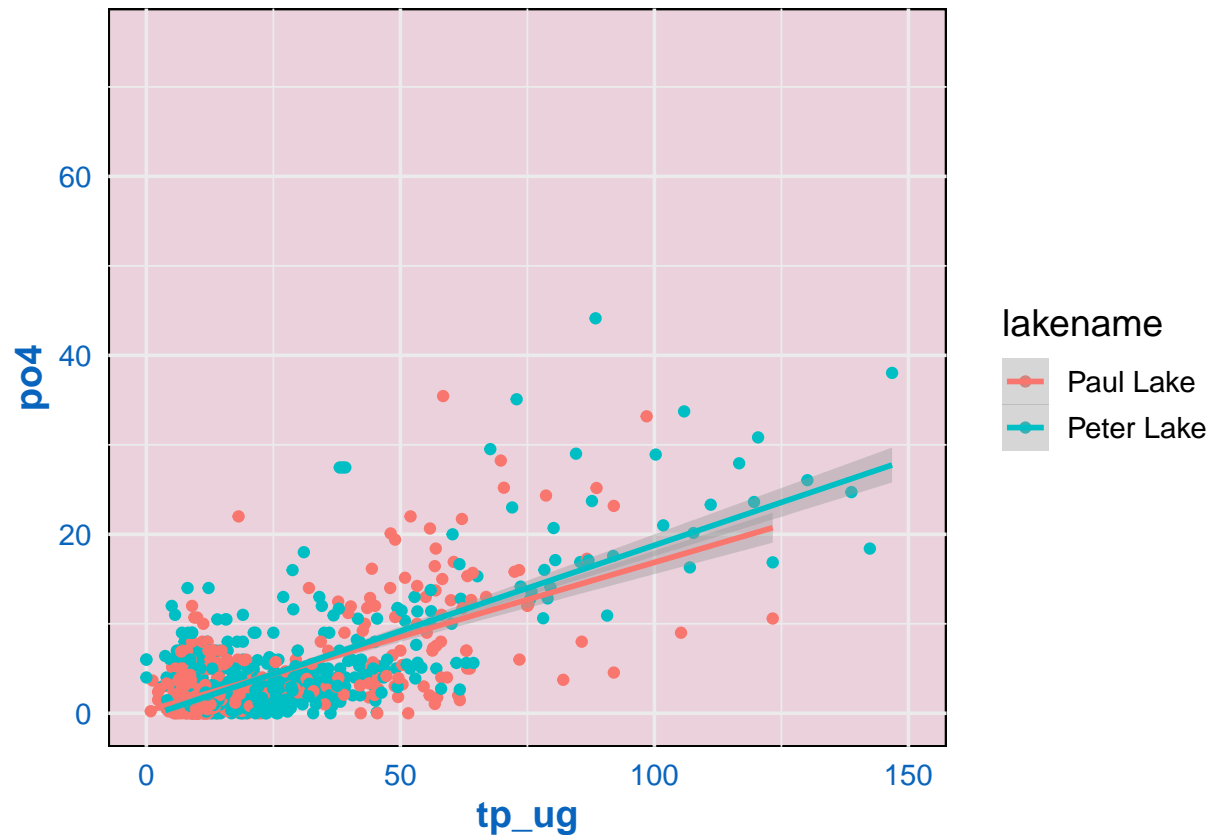
```r
print(PeterPaul.P.by.PO4)
```

```
## 'geom_smooth()' using formula = 'y ~ x'
```

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

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

```
## Warning: Removed 2 rows containing missing values or values outside the scale range
## ('geom_smooth()').
```

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
# boxplot 1 by temp
bp1 <- PeterPaul.chem.nutrients %>%
  ggplot(
  mapping = aes(
      x = month,
      y = temperature_C,
      color = lakename)
  )+
  geom_boxplot() +
  xlim(5,12) +
  mytheme +
  theme(
    axis.title.x = element_blank(),
    legend.position = "none")
```

```r
#      axis.title.x = element_blank(),
#      axis.title.y = element_blank()

# boxplot 2 by TP
bp2 <- PeterPaul.chem.nutrients %>%
  ggplot(
    mapping = aes(
      x = month,
      y = tp_ug,
      color = lakename)
  )+
  geom_boxplot() +
  xlim(5,12) +
  mytheme +
  theme(
    axis.title.x = element_blank())


# boxplot 3 by TN
bp3 <- PeterPaul.chem.nutrients %>%
  ggplot(
    mapping = aes(
      x = month,
      y = tn_ug,
      color = lakename)
  )+
  geom_boxplot() +
  xlim(5,12) +
  mytheme +
  theme(
    legend.position = "none")

#plot three plots in one column
plot_grid(bp1, bp2, bp3, ncol = 1, align = "v")
```

```
## Warning: Removed 16 rows containing missing values or values outside the scale range
## ('stat_boxplot()').

## Warning: Removed 3550 rows containing non-finite outside the scale range
## ('stat_boxplot()').

## Warning: Removed 16 rows containing missing values or values outside the scale range
## ('stat_boxplot()').

## Warning: Removed 20713 rows containing non-finite outside the scale range
## ('stat_boxplot()').

## Warning: Removed 16 rows containing missing values or values outside the scale range
## ('stat_boxplot()').

## Warning: Removed 21567 rows containing non-finite outside the scale range
## ('stat_boxplot()').
```
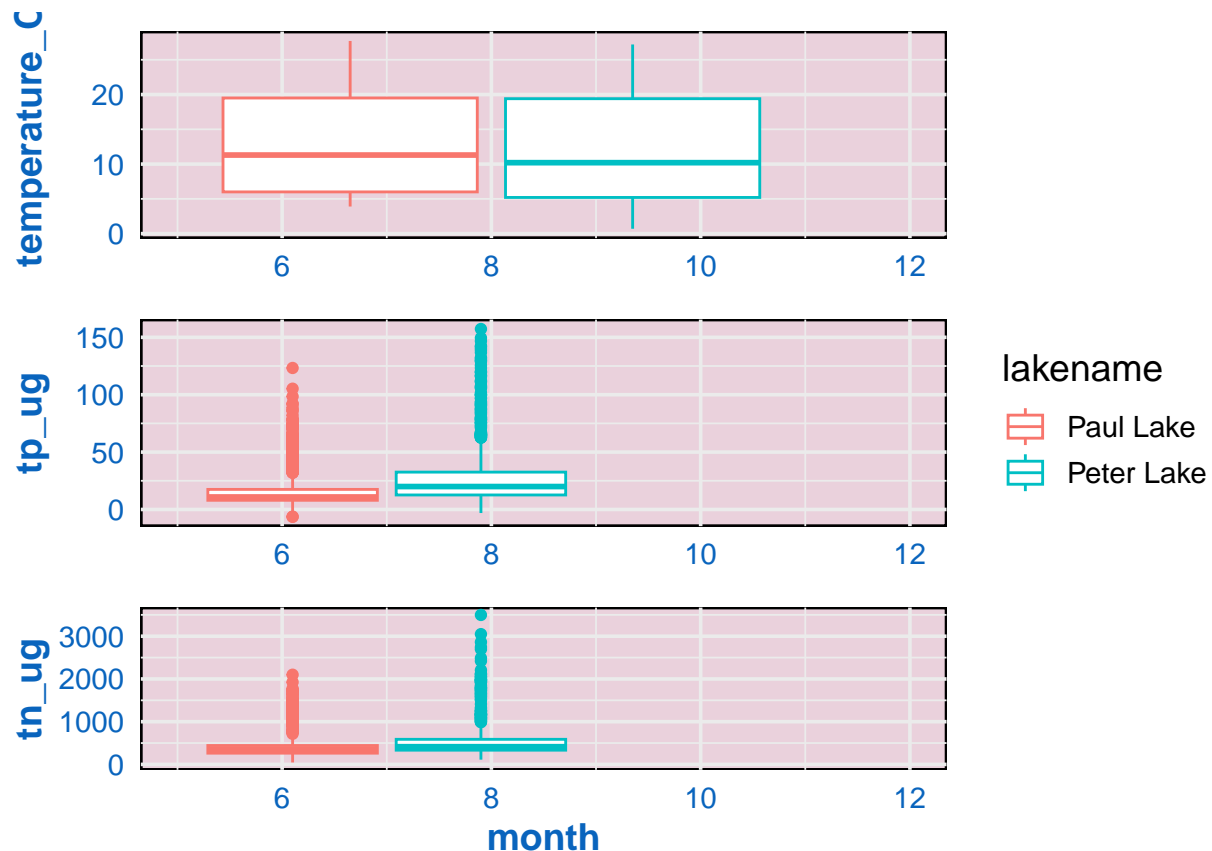
Question: What do you observe about the variables of interest over seasons and between lakes?

Answer: For all three plots, data is collected only part of the year, from about March through September for nutrients. So during the winter, it looks like samples are not collected. Peter lake has higher nitrogen and phosphorus levels.

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
#Use Niwot Ridge dataset make a scatterplot of dry mass of needle
#litter by date, separate NLCD class by color
Niwot.plot1 <- Niwot.litter %>%
  filter(functionalGroup == "Needles") %>%
  ggplot(
    mapping = aes(
      x = collectDate,
      y = dryMass,
      color = nlcdClass)
  )+
  geom_point()+
  mytheme
```

```
print(Niwot.plot1)
```
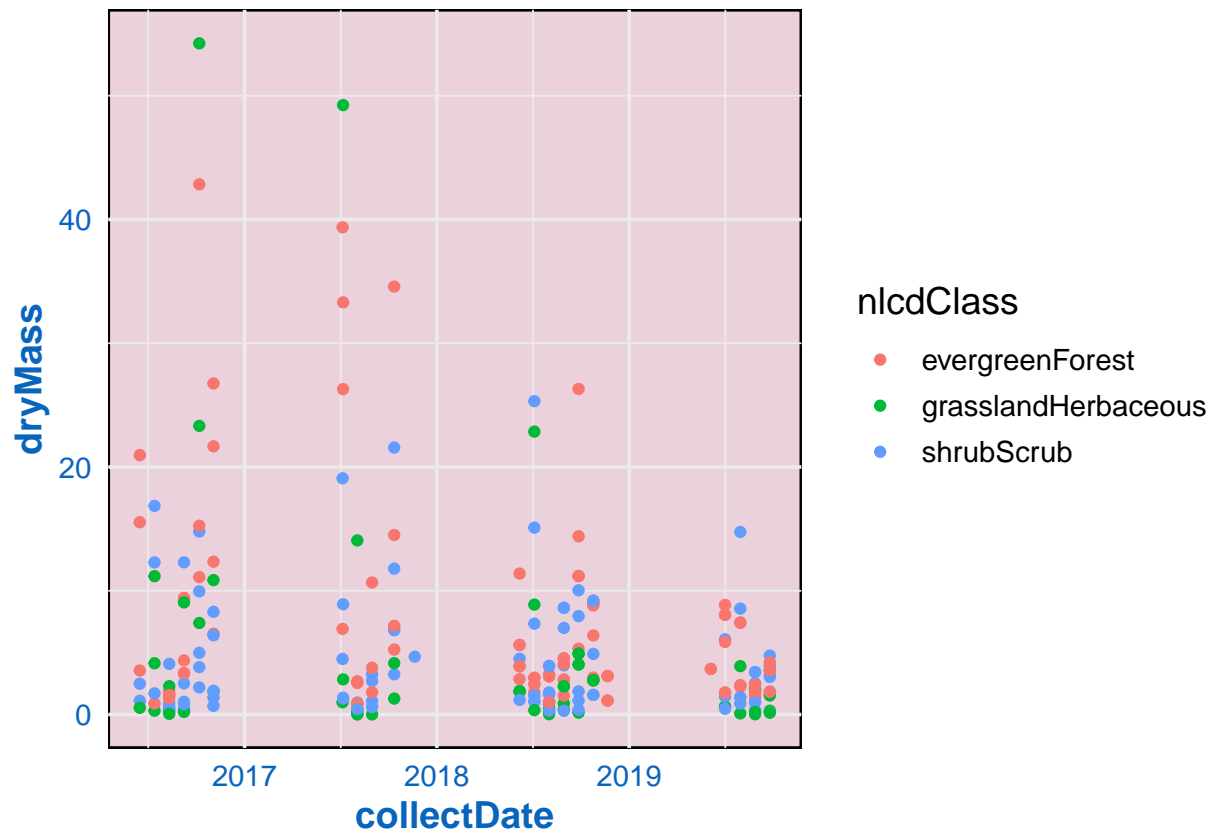


```
#7
#Use Niwot Ridge dataset make a scatterplot of dry mass of needle
#litter by date, but this time separate NLCD classes by facet
Niwot.plot2 <- Niwot.litter %>%
  filter(functionalGroup == "Needles") %>%
  ggplot(
    mapping = aes(
      x = collectDate,
      y = dryMass)
  )+
  geom_point()+
  facet_wrap(vars(nlcdClass))
  mytheme
```

```
## List of 136
##  $ line                      :List of 6
##   ..$ colour      : chr "black"
##   ..$ linewidth   : num 0.636
##   ..$ linetype    : num 1
##   ..$ lineend     : chr "butt"
##   ..$ arrow       : logi FALSE
##   ..$ inherit.blank: logi TRUE
```

```
##    ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect                          :List of 5
##   ..$ fill       : chr "white"
##   ..$ colour     : chr "black"
##   ..$ linewidth  : num 0.636
##   ..$ linetype   : num 1
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text                          :List of 11
##   ..$ family     : chr ""
##   ..$ face       : chr "plain"
##   ..$ colour     : chr "black"
##   ..$ size       : num 14
##   ..$ hjust      : num 0.5
##   ..$ vjust      : num 0.5
##   ..$ angle      : num 0
##   ..$ lineheight : num 0.9
##   ..$ margin     : 'margin' num [1:4] 0points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug      : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ title                         : NULL
## $ aspect.ratio                  : NULL
## $ axis.title                    : NULL
## $ axis.title.x                  :List of 11
##   ..$ family     : NULL
##   ..$ face       : chr "bold"
##   ..$ colour     : chr "#0964BD"
##   ..$ size       : NULL
##   ..$ hjust      : NULL
##   ..$ vjust      : num 1
##   ..$ angle      : NULL
##   ..$ lineheight : NULL
##   ..$ margin     : 'margin' num [1:4] 3.5points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug      : NULL
##   ..$ inherit.blank: logi FALSE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top              :List of 11
##   ..$ family     : NULL
##   ..$ face       : NULL
##   ..$ colour     : NULL
##   ..$ size       : NULL
##   ..$ hjust      : NULL
##   ..$ vjust      : num 0
##   ..$ angle      : NULL
##   ..$ lineheight : NULL
##   ..$ margin     : 'margin' num [1:4] 0points 0points 3.5points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug      : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.bottom           : NULL
```

```
##  $ axis.title.y                      :List of 11
##   ..$ family      : NULL
##   ..$ face        : chr "bold"
##   ..$ colour      : chr "#0964BD"
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : num 90
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 3.5points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi FALSE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.title.y.left              : NULL
##  $ axis.title.y.right             :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : num -90
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 0points 0points 3.5points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.text                      :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : chr "#0964BD"
##   ..$ size        : 'rel' num 0.8
##   ..$ hjust       : NULL
##   ..$ vjust       : NULL
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : NULL
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi FALSE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ axis.text.x                    :List of 11
##   ..$ family      : NULL
##   ..$ face        : NULL
##   ..$ colour      : NULL
##   ..$ size        : NULL
##   ..$ hjust       : NULL
##   ..$ vjust       : num 1
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 2.8points 0points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
```

```
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top              :List of 11
##   ..$ family     : NULL
##   ..$ face       : NULL
##   ..$ colour     : NULL
##   ..$ size       : NULL
##   ..$ hjust      : NULL
##   ..$ vjust      : num 0
##   ..$ angle      : NULL
##   ..$ lineheight : NULL
##   ..$ margin     : 'margin' num [1:4] 0points 0points 2.8points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug      : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.bottom           : NULL
## $ axis.text.y                  :List of 11
##   ..$ family     : NULL
##   ..$ face       : NULL
##   ..$ colour     : NULL
##   ..$ size       : NULL
##   ..$ hjust      : num 1
##   ..$ vjust      : NULL
##   ..$ angle      : NULL
##   ..$ lineheight : NULL
##   ..$ margin     : 'margin' num [1:4] 0points 2.8points 0points 0points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug      : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.y.left             : NULL
## $ axis.text.y.right            :List of 11
##   ..$ family     : NULL
##   ..$ face       : NULL
##   ..$ colour     : NULL
##   ..$ size       : NULL
##   ..$ hjust      : num 0
##   ..$ vjust      : NULL
##   ..$ angle      : NULL
##   ..$ lineheight : NULL
##   ..$ margin     : 'margin' num [1:4] 0points 0points 0points 2.8points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug      : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.theta              : NULL
## $ axis.text.r                  :List of 11
##   ..$ family     : NULL
##   ..$ face       : NULL
##   ..$ colour     : NULL
##   ..$ size       : NULL
##   ..$ hjust      : num 0.5
##   ..$ vjust      : NULL
```

```
##   ..$ angle       : NULL
##   ..$ lineheight  : NULL
##   ..$ margin      : 'margin' num [1:4] 0points 2.8points 0points 2.8points
##   .. ..- attr(*, "unit")= int 8
##   ..$ debug       : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.ticks                  : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.ticks.x                : NULL
## $ axis.ticks.x.top            : NULL
## $ axis.ticks.x.bottom         : NULL
## $ axis.ticks.y                : NULL
## $ axis.ticks.y.left           : NULL
## $ axis.ticks.y.right          : NULL
## $ axis.ticks.theta            : NULL
## $ axis.ticks.r                : NULL
## $ axis.minor.ticks.x.top      : NULL
## $ axis.minor.ticks.x.bottom   : NULL
## $ axis.minor.ticks.y.left     : NULL
## $ axis.minor.ticks.y.right    : NULL
## $ axis.minor.ticks.theta      : NULL
## $ axis.minor.ticks.r          : NULL
## $ axis.ticks.length           : 'simpleUnit' num 3.5points
##   ..- attr(*, "unit")= int 8
## $ axis.ticks.length.x         : NULL
## $ axis.ticks.length.x.top     : NULL
## $ axis.ticks.length.x.bottom  : NULL
## $ axis.ticks.length.y         : NULL
## $ axis.ticks.length.y.left    : NULL
## $ axis.ticks.length.y.right   : NULL
## $ axis.ticks.length.theta     : NULL
## $ axis.ticks.length.r         : NULL
## $ axis.minor.ticks.length     : 'rel' num 0.75
## $ axis.minor.ticks.length.x   : NULL
## $ axis.minor.ticks.length.x.top   : NULL
## $ axis.minor.ticks.length.x.bottom: NULL
## $ axis.minor.ticks.length.y       : NULL
## $ axis.minor.ticks.length.y.left  : NULL
## $ axis.minor.ticks.length.y.right : NULL
## $ axis.minor.ticks.length.theta   : NULL
## $ axis.minor.ticks.length.r       : NULL
## $ axis.line                   : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x                 : NULL
## $ axis.line.x.top             : NULL
## $ axis.line.x.bottom          : NULL
## $ axis.line.y                 : NULL
## $ axis.line.y.left            : NULL
## $ axis.line.y.right           : NULL
## $ axis.line.theta             : NULL
## $ axis.line.r                 : NULL
## $ legend.background           : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
```

```
##  $ legend.margin                 : 'margin' num [1:4] 7points 7points 7points 7points
##   ..- attr(*, "unit")= int 8
##  $ legend.spacing                : 'simpleUnit' num 14points
##   ..- attr(*, "unit")= int 8
##  $ legend.spacing.x              : NULL
##  $ legend.spacing.y              : NULL
##  $ legend.key                    : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
##  $ legend.key.size               : 'simpleUnit' num 1.2lines
##   ..- attr(*, "unit")= int 3
##  $ legend.key.height             : NULL
##  $ legend.key.width              : NULL
##  $ legend.key.spacing            : 'simpleUnit' num 7points
##   ..- attr(*, "unit")= int 8
##  $ legend.key.spacing.x          : NULL
##  $ legend.key.spacing.y          : NULL
##  $ legend.frame                  : NULL
##  $ legend.ticks                  : NULL
##  $ legend.ticks.length           : 'rel' num 0.2
##  $ legend.axis.line              : NULL
##  $ legend.text                   :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : 'rel' num 0.8
##   ..$ hjust        : NULL
##   ..$ vjust        : NULL
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : NULL
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ legend.text.position          : NULL
##  $ legend.title                  :List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : num 0
##   ..$ vjust        : NULL
##   ..$ angle        : NULL
##   ..$ lineheight   : NULL
##   ..$ margin       : NULL
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  $ legend.title.position         : NULL
##  $ legend.position               : chr "right"
##  $ legend.position.inside        : NULL
##  $ legend.direction              : NULL
##  $ legend.byrow                  : NULL
##  $ legend.justification          : chr "center"
##  $ legend.justification.top      : NULL
```

```
##  $ legend.justification.bottom    : NULL
##  $ legend.justification.left      : NULL
##  $ legend.justification.right     : NULL
##  $ legend.justification.inside    : NULL
##  $ legend.location                : NULL
##  $ legend.box                     : NULL
##  $ legend.box.just                : NULL
##  $ legend.box.margin              : 'margin' num [1:4] 0cm 0cm 0cm 0cm
##   ..- attr(*, "unit")= int 1
##  $ legend.box.background          : list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
##  $ legend.box.spacing             : 'simpleUnit' num 14points
##   ..- attr(*, "unit")= int 8
##   [list output truncated]
##  - attr(*, "class")= chr [1:2] "theme" "gg"
##  - attr(*, "complete")= logi TRUE
##  - attr(*, "validate")= logi TRUE
```

```
print(Niwot.plot2)
```
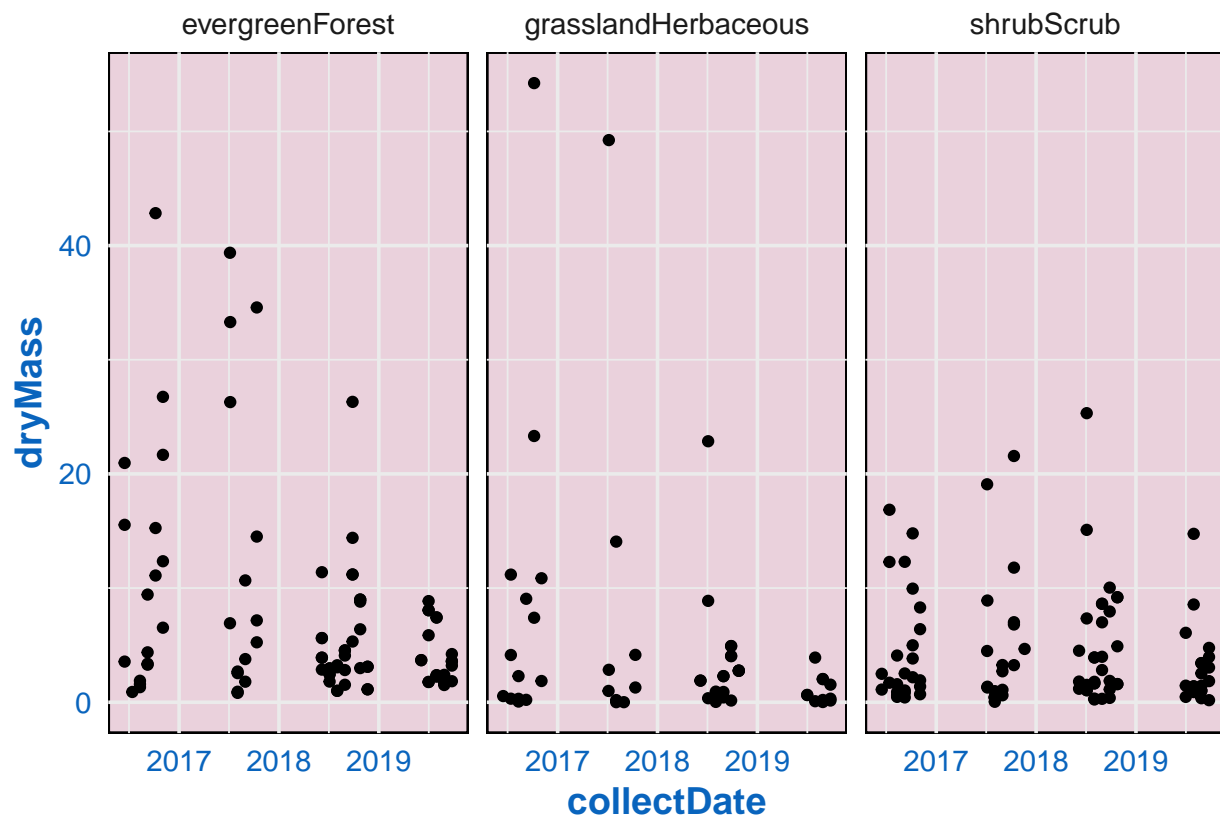


Question: Which of these plots (6 vs. 7) do you think is more effective, and why?

Answer:I think that 7, where NLCD classes are separated by facets instead of just colors on the same plot helps highlight the differences between the groups faster to the eye. In the faceted plot, I immediately see that grasslandHerbaceous has a few points with really high masses in 2017 and 2019, evergreenForest also has some higher range (relative to the rest of the data) masses

recorded, and shrubScrub has lower masses in general. I think it is easier to see the spread of the distribution of mass within each group as well.