Assignment 3: Data Exploration

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OVERVIEW

This exercise accompanies the lessons in Environmental Data Analytics on Data Exploration.

Directions

1. Change "Student Name, Section #" on line 3 (above) with your name and section number.
2. Work through the steps, **creating code and output** that fulfill each instruction.
3. Be sure to **answer the questions** in this assignment document.
4. When you have completed the assignment, **Knit** the text and code into a single PDF file.
5. After Knitting, submit the completed exercise (PDF file) to the dropbox in Sakai. Add your last name into the file name (e.g., "FirstLast_A03_DataExploration.Rmd") prior to submission.

The completed exercise is due on <>.

Set up your R session

1. Check your working directory, load necessary packages (tidyverse), and upload two datasets: the ECOTOX neonicotinoid dataset (ECOTOX_Neonicotinoids_Insects_raw.csv) and the Niwot Ridge NEON dataset for litter and woody debris (NEON_NIWO_Litter_massdata_2018-08_raw.csv). Name these datasets "Neonics" and "Litter", respectively. **Be sure to add the `stringsAsFactors = TRUE` parameter to the function when reading in the CSV files.**

```
library(tidyverse)

# load data
Neonics <- read.csv("../Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv",
                    stringsAsFactors = TRUE)
Litter <- read.csv("../Data/Raw/NEON_NIWO_Litter_massdata_2018-08_raw.csv",
                   stringsAsFactors = TRUE)
```

Learn about your system

2. The neonicotinoid dataset was collected from the Environmental Protection Agency's ECOTOX Knowledgebase, a database for ecotoxicology research. Neonicotinoids are a class of insecticides used widely in agriculture. The dataset that has been pulled includes all studies published on insects. Why might we be interested in the ecotoxicology of neonicotinoids on insects? Feel free to do a brief internet search if you feel you need more background information.

Answer: Neonicotinoids are a type of pesticide that was developed and released in the 1990s to serve as an effective alternative to contemporary pesticides. The benefit of neonicotinoids over competing pesticides is that they are safe for human consumption. While effective in killing the targeted insect agricultural pests, neonicotinoids spread far beyond the farm into neighboring ecosystems. Neonicotinoid dust from agricultural operations easily spreads by the wind into other locales. In addition, its spread was (and is) aided by its solubility in water which allows for contamination of waterways and subterranean insect larvae. The cumulative effect of the spread of this pesticide is largescale devastation for insect populations anywhere near - or connected by wind currents or waterways - neonicotinoids are spread. To make matters worse, neonicotinoids have long lifetimes (between several months to a couple of years). This is undoubtedly bad news for ecosystem function in affected areas as insects play invaluable roles as a food source and for their role in pollination.

3. The Niwot Ridge litter and woody debris dataset was collected from the National Ecological Observatory Network, which collectively includes 81 aquatic and terrestrial sites across 20 ecoclimatic domains. 32 of these sites sample forest litter and woody debris, and we will focus on the Niwot Ridge long-term ecological research (LTER) station in Colorado. Why might we be interested in studying litter and woody debris that falls to the ground in forests? Feel free to do a brief internet search if you feel you need more background information.

   Answer: A better question is why WOODN'T we be interested in litter and woody debris! Woody debris is important for understanding productivity, nutrient fluxes and carbon storage in forest ecosystems. Woody debris and litter also serves as some of the prime nutrient inputs for river and stream ecosystems. If we are to connect this dataset thematically to the neonicotinoids dataset, woody debris and litter are habitat for the insects that we are concerned about being affected by neonicotinoids!

4. How is litter and woody debris sampled as part of the NEON network? Read the NEON_Litterfall_UserGuide.pdf document to learn more. List three pieces of salient information about the sampling methods here:

   Answer: * Litter trap pairs consist of one elevated trap and one groudn trap. They are spaced such that one pair exists for every 400m^2 plot area which totals 1-4 traps per plot. * Depending on the vegetation of a given site, litter trap placement can either be targeted or randomized. * Ground traps are sampled once per year while elevated traps are checked more frequently based on the type of forest and differences in litter-fall that arise from phenophases (e.g., senescence in temperate forests during Fall).

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim(Neonics)
```

```
## [1] 4623   30
```

```
# 4623 rows, 30 columns
```

6. Using the `summary` function on the "Effect" column, determine the most common effects that are studied. Why might these effects specifically be of interest?

```
summary(Neonics$Effect)
```

```
##     Accumulation        Avoidance         Behavior     Biochemistry
##               12              102              360               11
##          Cell(s)      Development        Enzyme(s) Feeding behavior
##                9              136               62              255
##         Genetics           Growth        Histology       Hormone(s)
##               82               38                5                1
##    Immunological     Intoxication       Morphology        Mortality
##               16               12               22             1493
##       Physiology       Population     Reproduction
##                7             1803              197
```

Answer: The four most common studied effects of neonicotinoids on insects are population (1803), Mortality (1493), Behavior (360), and Feeding behavior (255). These effects are specifically of interest to ecotoxicologists because they want to understand how this agricultural pesticide - released into neighboring ecosystems - affects population dynamics of insects (population, mortality). With respect to behavior and feeding behavior, I suspect they would want to know how feeding behavior - and behavior in general - exposes them to neonicotinoids.

7. Using the `summary` function, determine the six most commonly studied species in the dataset (common name). What do these species have in common, and why might they be of interest over other insects? Feel free to do a brief internet search for more information if needed.

```
summary(Neonics$Species.Common.Name)
```

```
##                          Honey Bee                       Parasitic Wasp
##                                667                                 285
##               Buff Tailed Bumblebee                  Carniolan Honey Bee
##                                183                                 152
##                         Bumble Bee                     Italian Honeybee
##                                140                                 113
##                    Japanese Beetle                   Asian Lady Beetle
##                                 94                                  76
##                     Euonymus Scale                            Wireworm
##                                 75                                  69
##                  European Dark Bee                   Minute Pirate Bug
##                                 66                                  62
##                Asian Citrus Psyllid                      Parastic Wasp
##                                 60                                  58
##             Colorado Potato Beetle                     Parasitoid Wasp
##                                 57                                  51
##                Erythrina Gall Wasp                       Beetle Order
##                                 49                                  47
##        Snout Beetle Family, Weevil           Sevenspotted Lady Beetle
##                                 47                                  46
##                     True Bug Order                Buff-tailed Bumblebee
##                                 45                                  39
##                       Aphid Family                      Cabbage Looper
##                                 38                                  38
##                Sweetpotato Whitefly                      Braconid Wasp
##                                 37                                  33
```

```
##                      Cotton Aphid                     Predatory Mite
##                                33                                33
##             Ladybird Beetle Family                        Parasitoid
##                                30                                30
##                     Scarab Beetle                    Spring Tiphia
##                                29                                29
##                       Thrip Order                Ground Beetle Family
##                                29                                27
##                Rove Beetle Family                    Tobacco Aphid
##                                27                                27
##                     Chalcid Wasp              Convergent Lady Beetle
##                                25                                25
##                     Stingless Bee                  Spider/Mite Class
##                                25                                24
##                Tobacco Flea Beetle                  Citrus Leafminer
##                                24                                23
##                   Ladybird Beetle                         Mason Bee
##                                23                                22
##                          Mosquito                    Argentine Ant
##                                22                                21
##                            Beetle          Flatheaded Appletree Borer
##                                21                                20
##               Horned Oak Gall Wasp                 Leaf Beetle Family
##                                20                                20
##                  Potato Leafhopper          Tooth-necked Fungus Beetle
##                                20                                20
##                      Codling Moth           Black-spotted Lady Beetle
##                                19                                18
##                      Calico Scale                 Fairyfly Parasitoid
##                                18                                18
##                       Lady Beetle              Minute Parasitic Wasps
##                                18                                18
##                         Mirid Bug                 Mulberry Pyralid
##                                18                                18
##                          Silkworm                    Vedalia Beetle
##                                18                                18
##               Araneoid Spider Order                         Bee Order
##                                17                                17
##                     Egg Parasitoid                      Insect Class
##                                17                                17
##           Moth And Butterfly Order       Oystershell Scale Parasitoid
##                                17                                17
## Hemlock Woolly Adelgid Lady Beetle              Hemlock Wooly Adelgid
##                                16                                16
##                              Mite                       Onion Thrip
##                                16                                16
##               Western Flower Thrips                     Corn Earworm
##                                15                                14
##                  Green Peach Aphid                        House Fly
##                                14                                14
##                         Ox Beetle                 Red Scale Parasite
##                                14                                14
##                 Spined Soldier Bug               Armoured Scale Family
##                                14                                13
```

```
##                   Diamondback Moth                       Eulophid Wasp
##                                 13                                  13
##                  Monarch Butterfly                     Predatory Bug
##                                 13                                  13
##              Yellow Fever Mosquito               Braconid Parasitoid
##                                 13                                  12
##                        Common Thrip       Eastern Subterranean Termite
##                                 12                                  12
##                              Jassid                         Mite Order
##                                 12                                  12
##                           Pea Aphid                  Pond Wolf Spider
##                                 12                                  12
##           Spotless Ladybird Beetle             Glasshouse Potato Wasp
##                                 11                                  10
##                            Lacewing            Southern House Mosquito
##                                 10                                  10
##            Two Spotted Lady Beetle                       Ant Family
##                                 10                                   9
##                       Apple Maggot                          (Other)
##                                  9                                 670
```

Answer: The six most commonly studied insects in this dataset are the Honey Bee (667), the Parasitic Wasp (285), the Buff Tailed Honey Bee (183), the Carniolan Honey Bee (152), the Bumble Bee (140), and the Italian Honeybee (113). All of these species are in the hymenoptera order of insects and are prolific - and charismatic - pollinators. As for why they might be of more interest than other species of insects, I believe their prowess in pollination and overall charisma make them the worthy subjects of this focus and research.

8. Concentrations are always a numeric value. What is the class of Conc.1..Author. in the dataset, and why is it not numeric?

```
class(Neonics$Conc.1..Author.)
```

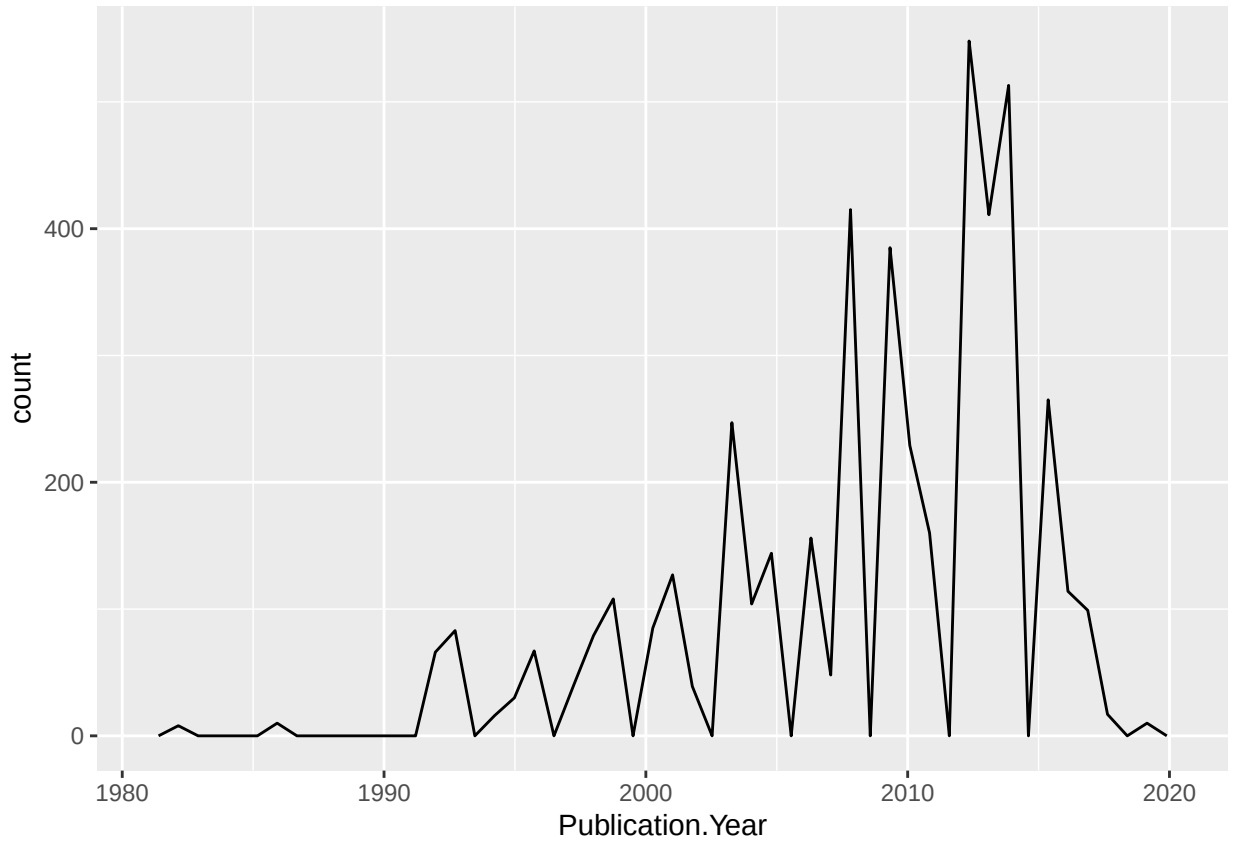
```
## [1] "factor"
```

Answer: The Conc.1..Author column holds factor data. In most cases, this column would be numeric except that it holds more than numbers. Throughout the column are '/' to indicate approximate doses as well as 'NR' values which likely stand for not recorded. Since there is a mixture of numeric, grammatical, and alphabetical characters, R interprets this column as a string. Finally, because we included the command stringsAsFactors = TRUE when we imported the .csv file, it reads as a factor.

Explore your data graphically (Neonics)

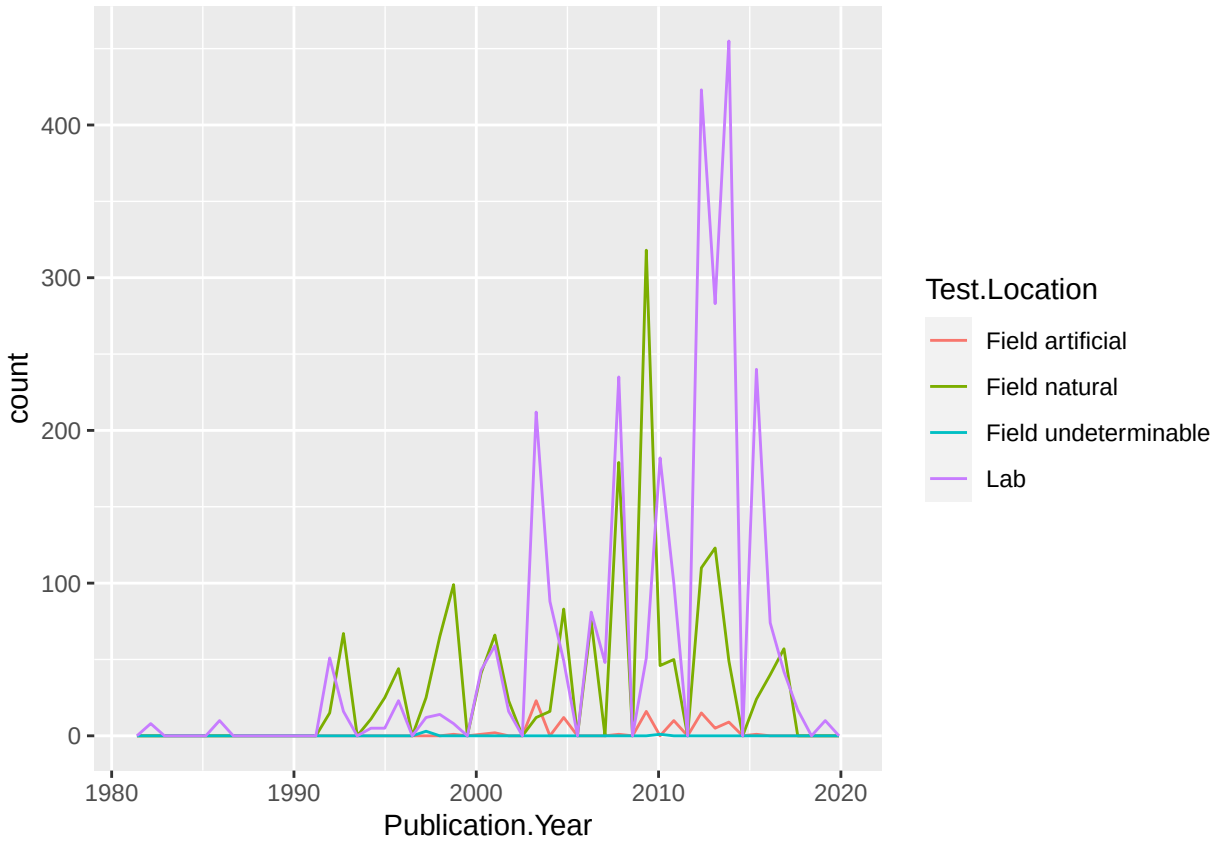
9. Using `geom_freqpoly`, generate a plot of the number of studies conducted by publication year.

```
ggplot(Neonics) +
  geom_freqpoly(aes(x = Publication.Year), bins = 50)
```



10. Reproduce the same graph but now add a color aesthetic so that different Test.Location are displayed as different colors.

```
ggplot(Neonics) +
  geom_freqpoly(aes(x = Publication.Year, color = Test.Location), bins = 50)
```

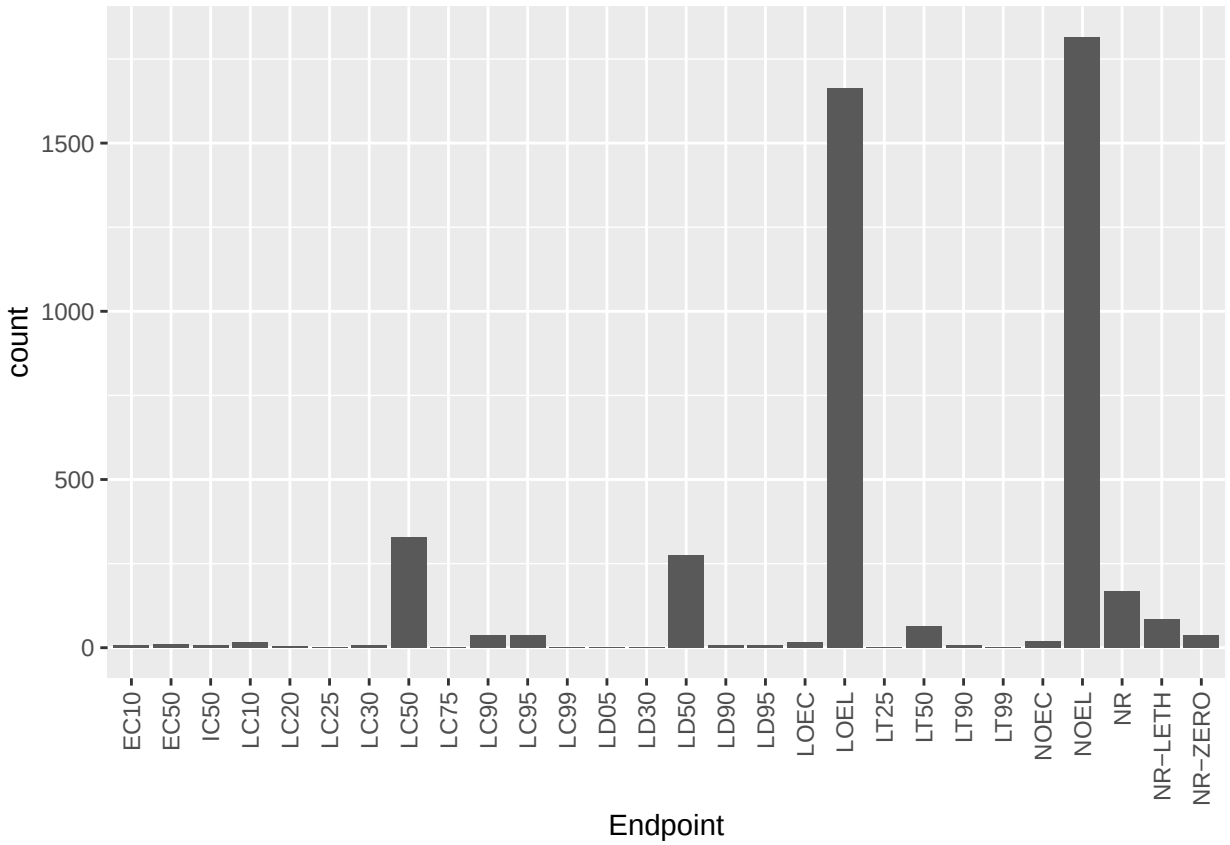


Interpret this graph. What are the most common test locations, and do they differ over time?

Answer: The most common test locations are the lab and the natural field. Field studies seemed to have peaked around 2009 meanwhile lab studies peaked (higher than field studies) around 2014.

11. Create a bar graph of Endpoint counts. What are the two most common end points, and how are they defined? Consult the ECOTOX_CodeAppendix for more information.

```
endpoints <- ggplot(data = Neonics, aes (x = Endpoint))
endpoints + geom_bar(stat = "count") +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```



Answer: The two most common endpoints are LOEL and NOEL. LOEL is defined in the ECOTOX_CodeAppendix as "Lowest-observable-effect-level: lowest dose (concentration) producing effects that were significantly different (as reported by authors) from responses of controls (LOEAL/LOEC)". Similarly, ECOTOX_CodeAppendix defines NOEL as "No-observable-effect-level: highest dose (concentration) producing effects not significantly different from responses of controls according to author's reported statistical test (NOEAL/NOEC)."

Explore your data (Litter)

12. Determine the class of collectDate. Is it a date? If not, change to a date and confirm the new class of the variable. Using the `unique` function, determine which dates litter was sampled in August 2018.

```
class(Litter$collectDate)
```

```
## [1] "factor"
```

```
# Not a date!
library(lubridate)
```

```
##
## Attaching package: 'lubridate'
```

```
## The following objects are masked from 'package:base':
##
##     date, intersect, setdiff, union
```

```
Litter$collectDate <- ymd(Litter$collectDate)
class(Litter$collectDate)
```

```
## [1] "Date"
```

```
# Hurray, it's a date!
unique_dates <- unique(Litter$collectDate)
unique_dates
```

```
## [1] "2018-08-02" "2018-08-30"
```

```
# Litter was sampled on 2018-08-02 and 2018-08-30
```

13. Using the `unique` function, determine how many plots were sampled at Niwot Ridge. How is the information obtained from `unique` different from that obtained from `summary`?

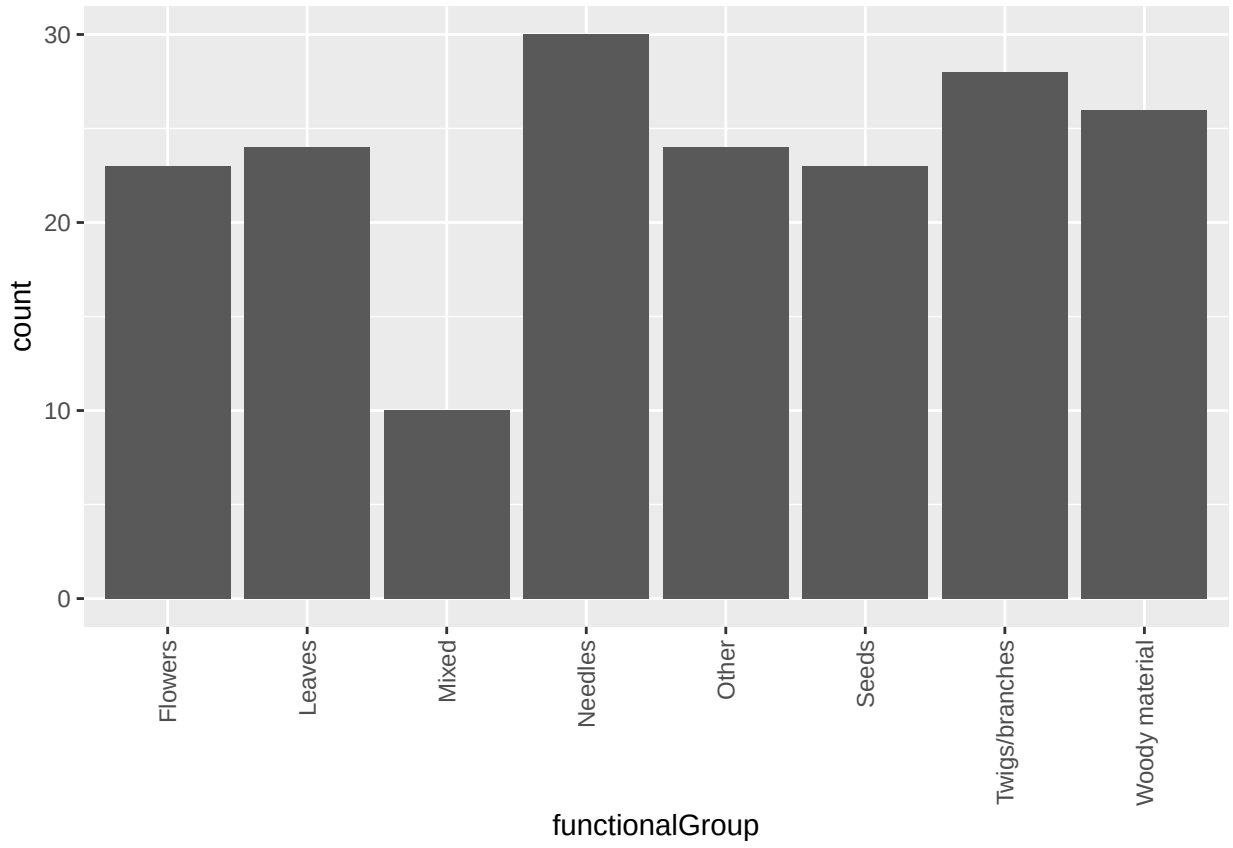
```
unique_plots <- unique(Litter$plotID)
unique_plots
```

```
##  [1] NIWO_061 NIWO_064 NIWO_067 NIWO_040 NIWO_041 NIWO_063 NIWO_047 NIWO_051
##  [9] NIWO_058 NIWO_046 NIWO_062 NIWO_057
## 12 Levels: NIWO_040 NIWO_041 NIWO_046 NIWO_047 NIWO_051 NIWO_057 ... NIWO_067
```

Answer: There are 12 unique plots being sampled at Niwot Ridge. Summary returns three values: length, class, and mode but does not give the number of unique values in the column. Summary also tries to compute summary statistics like minimum, median, mean, max as well as the first and third quartile values. Given that these are factor data, no such statistics can be computed.

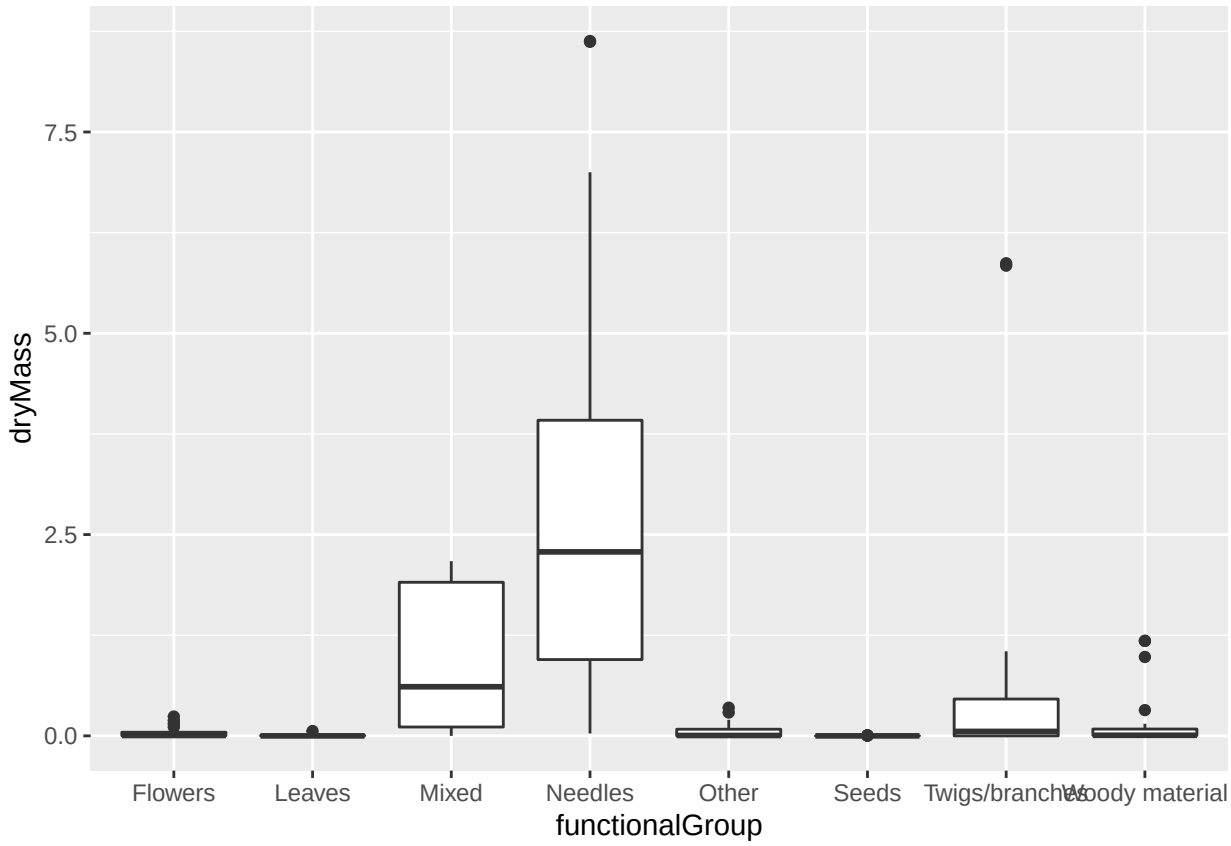
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
funcGroupCounts <- ggplot(data = Litter, aes (x = functionalGroup))
funcGroupCounts + geom_bar(stat = "count") +
    theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```

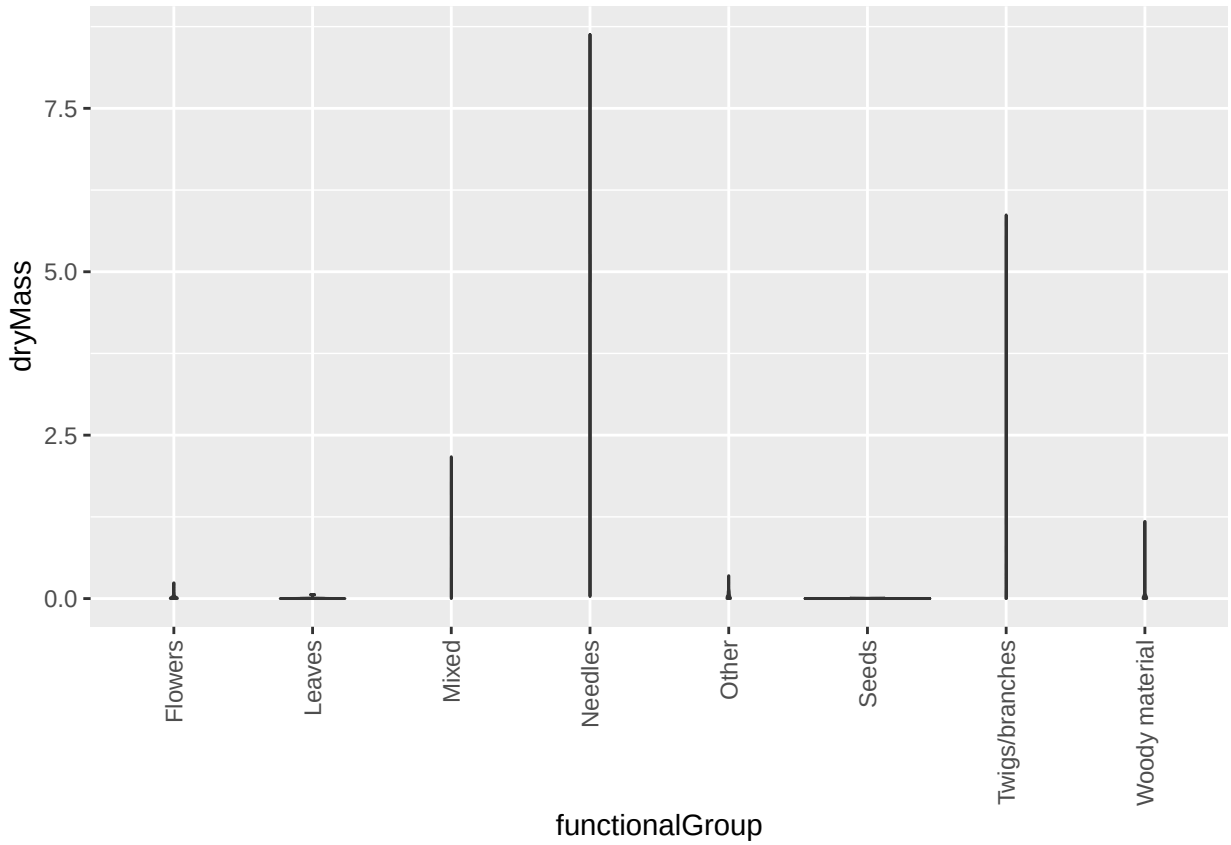


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```
ggplot(Litter) +
  geom_boxplot(aes(x = functionalGroup, y = dryMass))
```




```
ggplot(Litter) +
  geom_violin(aes(x = functionalGroup, y = dryMass)) +
    theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```



Why is the boxplot a more effective visualization option than the violin plot in this case?

> Answer: Boxplots show summary statistics like median, IQR, and outliers. Violin plots also show these but also show distribution of the data and are thus especially useful for multimodal datasets. However, when there are many unique values in a range, violin plots will have no width and appear as a straight line (as they do here). In this instance, the boxplots show the range far better and the mark of the median on the boxplot clearly shows the distribution of values.

What type(s) of litter tend to have the highest biomass at these sites?

> Answer: Needles! This makes sense because there's often an abundance of pine needles on evergreen forest floors above any other kind of woody debris and our research site is in such a forest. The next highest biomass functional group are twigs and branches - while less abundant than needles, they are certainly heavier when they do occur.