# 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 January 31, 2022.

### 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.**

```
getwd() #check working directory
```

```
## [1] "Z:/ENV872/Environmental_Data_Analytics_2022/Assignments"
```

```
library(tidyverse) #load packages
library(ggplot2)
library(lubridate)

Neonics.data <- read.csv("../Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv",
                         stringsAsFactors = TRUE)
Litter.data <- 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: We might be interested in the exotoxicology of neonicotinoids on insects to understand the degree to which the insecticides affect both species and ecosystem function in certain locations.Further, having an understanding of the impacts of neonicotinoids on certain species and ecosystems could allow for more advanced development of regulations and standards on where the insecticide is applied and appropriate concentrations to use.

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: We might be interested in studying litter and woody debris in forests to understand the distribution and functions of certain types of debris, such as roles in decomposition and habitat. This also includes the types of species and ecosystem services that are tied to such debris. However, tying it to the other Neonics dataset, it may help us identify how insectides impact species and habitat function around debris.

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: *Sampling is only conducted at sites in which woody vegetation is > 2 m tall.* Trap placement is targeted or randomized depending on vegetation cover and height. *Ground traps are only sampled once per year, while sampling frequency for elevated traps varies by deciduous (1x per 2 weeks) versus evergreen forests (1x per 1-2 months).

## Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim(Neonics.data)
```

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

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.data$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 most commonly studied effects include, mortality, behavior, and population. These effects would be of interest because they help to explain how the insecticide directly influences changes to species abundance as well as its larger presence and function within a given ecosystem.

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.data$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 species include the honey bee, parasitic wasp, Buff Tailed Bumblebee, Carniolan Honey Bee, Bumble Bee, and Italian Honeybee. In addition to being closely related, all of these species serve as significant pollinators. This function may cause them to be of greater interest in the role that pollination plays for both plant diversity and general ecosystem composition.

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

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

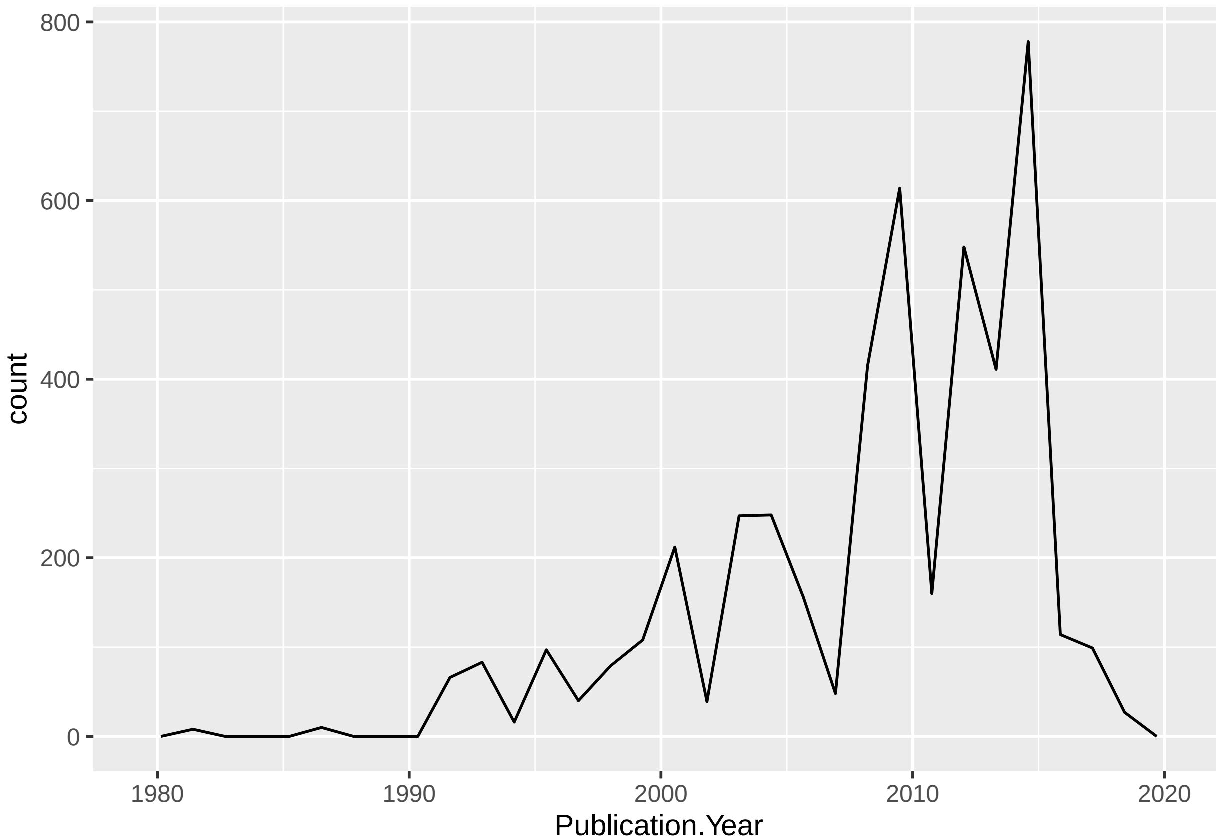
```
## [1] "factor"
```

> Answer: The class is a "factor". This is because they actually represent categorical data that can be numeric and/or a string based on the concentration type.

## Explore your data graphically (Neonics)

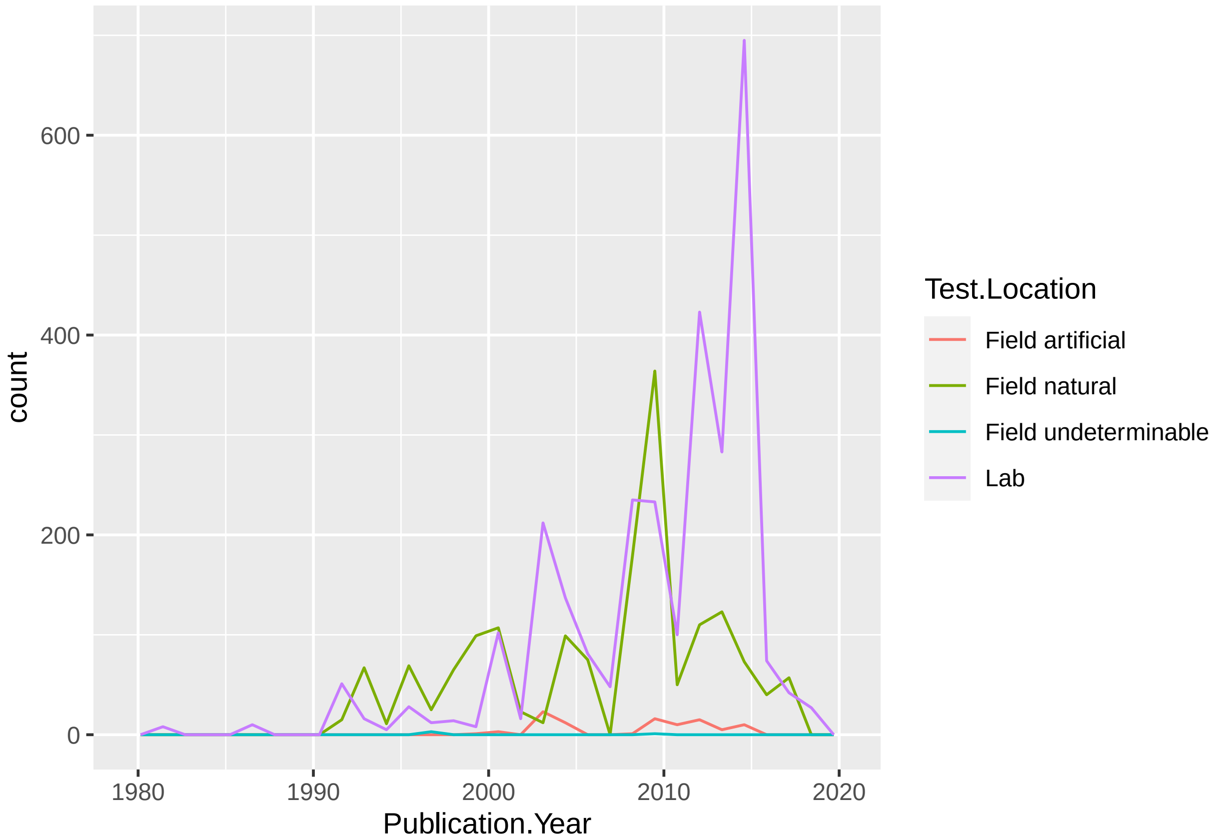
9. Using `geom_freqpoly`, generate a plot of the number of studies conducted by publication year.

```r
ggplot(Neonics.data) + geom_freqpoly(aes(x = Publication.Year), bins = 30)
```




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

```r
ggplot(Neonics.data) + geom_freqpoly(aes(x = Publication.Year,
                                         color = Test.Location), bins = 30)
```

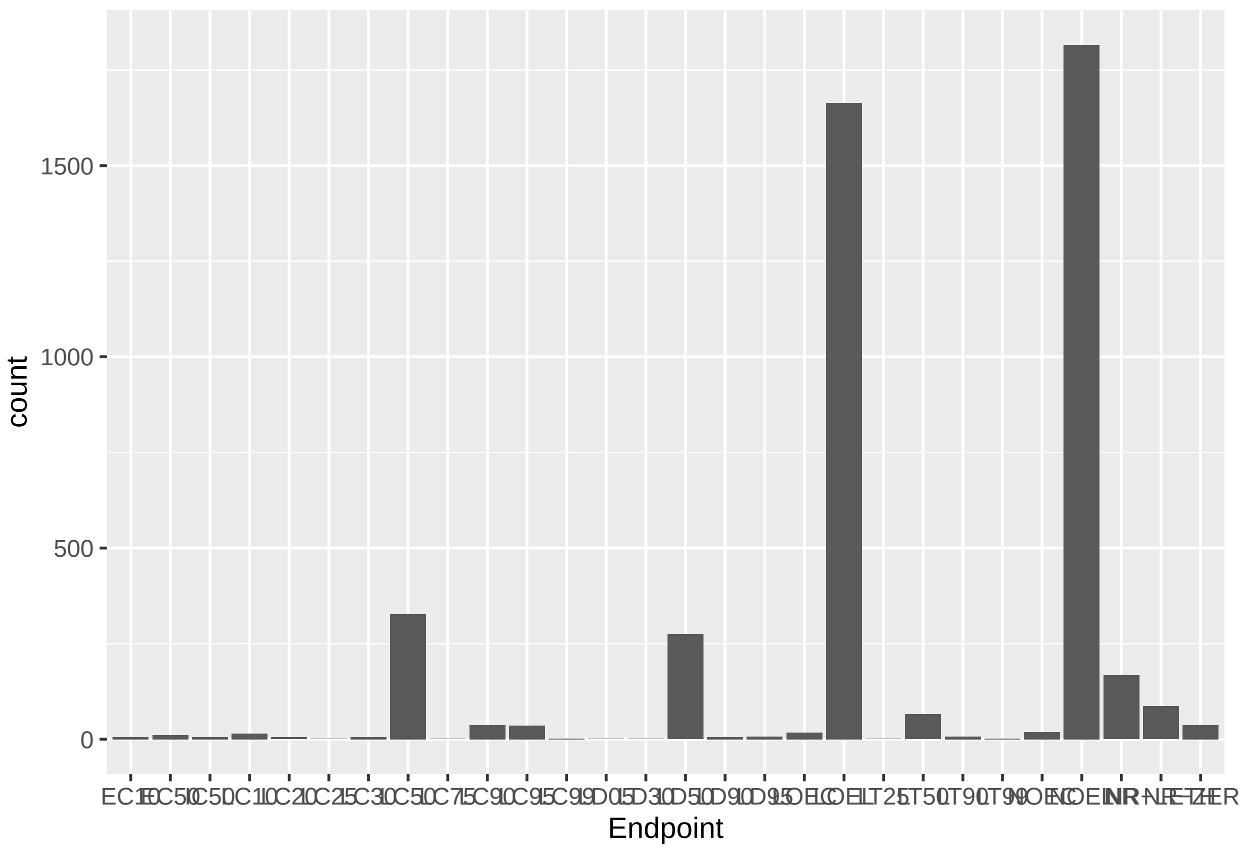



Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer: The most common test locations are either "field natural" or "Lab". Although field natural has historically been the more common location, laboratory testing has become more frequently used in the past decade. This may be due to a variety of reasons ranging from access to new technologies to types of sampling/research performed.

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.

```
ggplot(Neonics.data, aes(x = Endpoint)) +
  geom_bar()
```




Answer: The two most common endpoints are "NOEL" and "LOEL". LOEL is defined as "Lowest-observable-effect-level: lowest dose (concentration) producing effects that were significantly different (as reportedby authors) from responses of controls".
NOEL is defined as "No-observable-effect-level: highest dose (concentration) producing effects not significantly different from responses of controls according to author's reported statistical test".

## 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.data$collectDate) #Determined that class is a factor
```

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

```
Litter.data$collectDate <- as.Date(Litter.data$collectDate, format = "%Y-%m-%d")

class(Litter.data$collectDate)
```

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

```
#after running the class function again it returned date instead of factor

unique(Litter.data$collectDate) #Determining dates that litter samples were collected
```

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

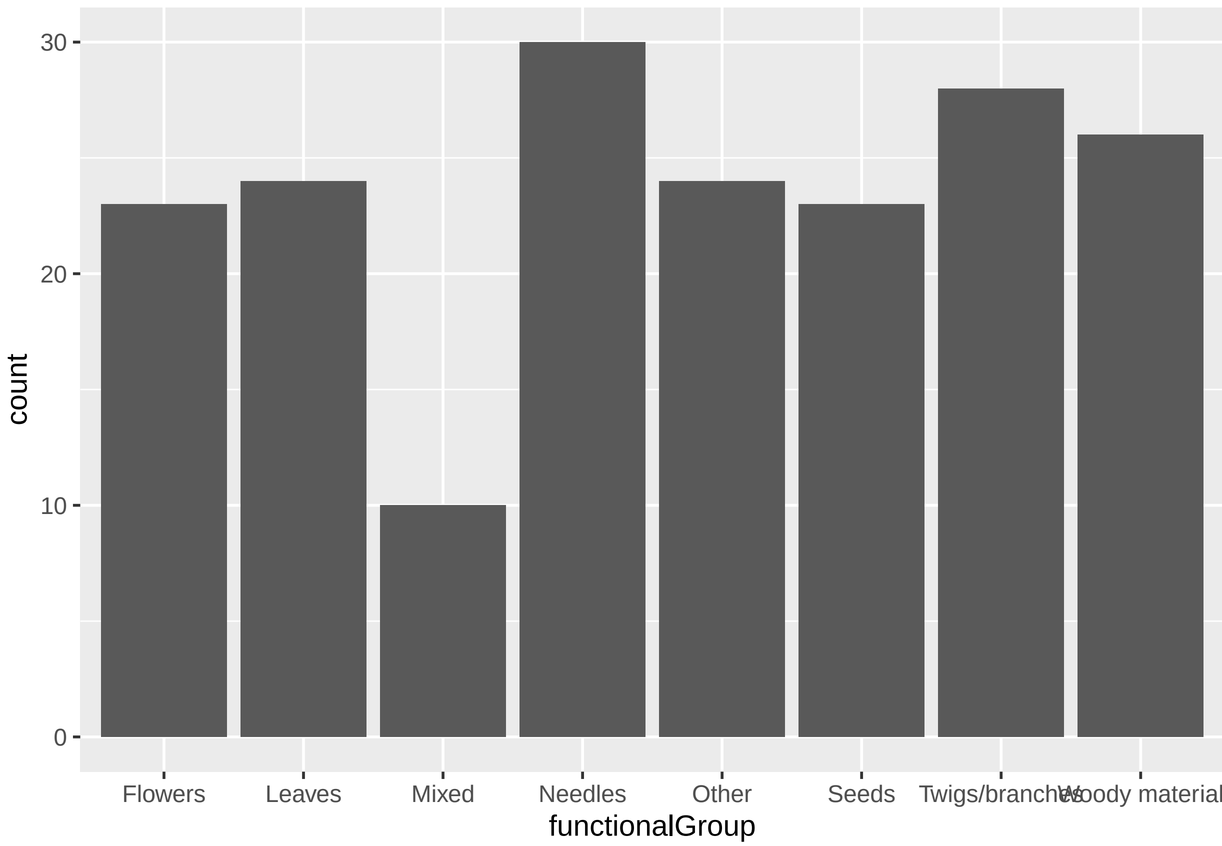
```r
unique(Litter.data$plotID) #12 plots total were sampled
```

```
##  [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: While the unique function presents each unique value within a row (i.e. eliminates duplicates of a certain value), the summarize function provides the summary statistics for each value depending on the class. For instance, for a factor class such as plotID, the unique function returns the 12 unique values in the row, while the summary function also provides the frequency of each value.

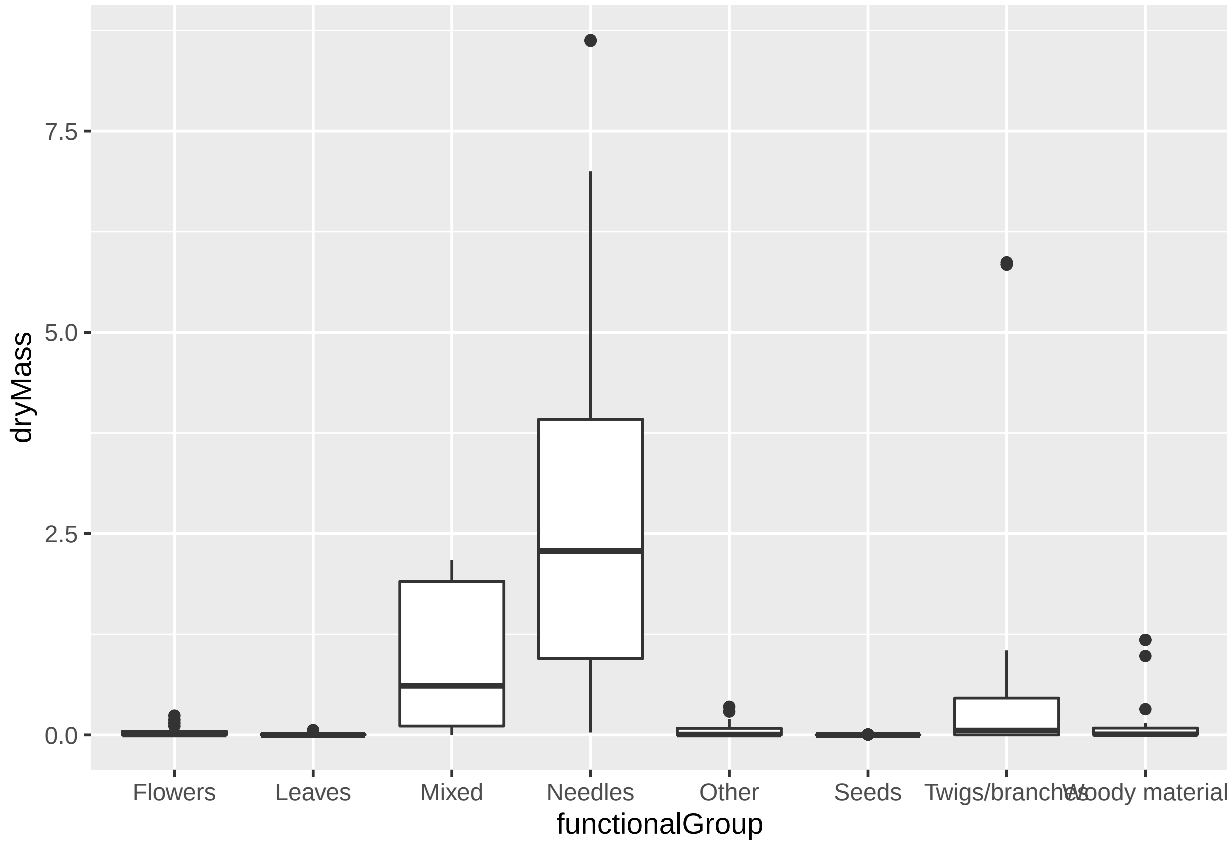
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```r
ggplot(Litter.data, aes(x = functionalGroup)) +
  geom_bar()
```

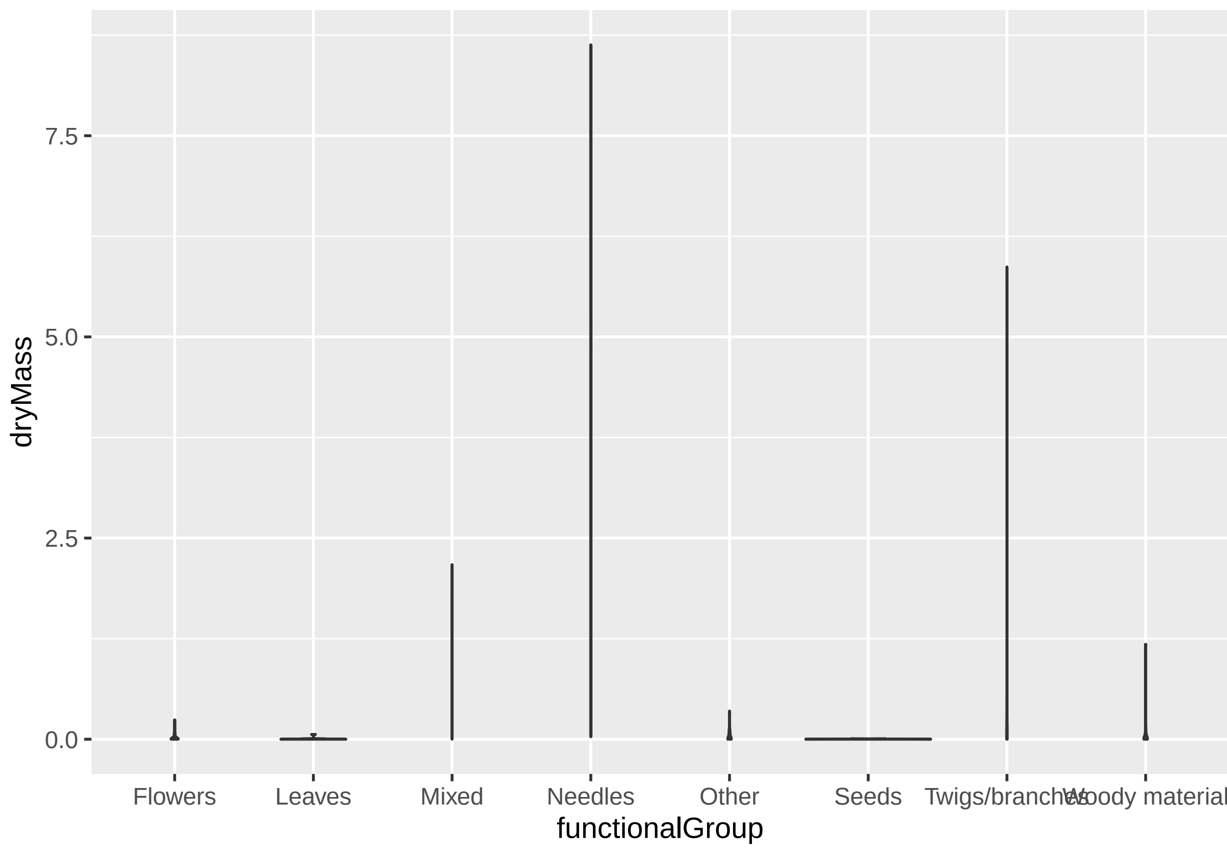



15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```r
ggplot(Litter.data) +
  geom_boxplot(aes(x = functionalGroup, y = dryMass)) #Boxplot of dryMass x functionalGroup
```




```
ggplot(Litter.data) +
  geom_violin(aes(x = functionalGroup, y = dryMass)) #Violin of drymass x functional group
```




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

> Answer: Because dryMass has outliers, the violin plot becomes skewed when representing the full distribution of density. On the other hand, the box plot is able to highlight the outliers as separate points while still effectively showing the statistical distribution of dryMass values (i.e. median and IQR) in the boxes.

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

> Answer: "Needles" followed by "mixed" (unsorted material) tend to have the highest biomass at these sites.