Assignment 3: Data Exploration

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OVERVIEW

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

Directions

1. Rename this file `<FirstLast>_A03_DataExploration.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. Assign a useful **name to each code chunk** and include ample **comments** with your code.
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.
7. After Knitting, submit the completed exercise (PDF file) to the dropbox in Sakai.

TIP: If your code extends past the page when knit, tidy your code by manually inserting line breaks.

TIP: If your code fails to knit, check that no `install.packages()` or `View()` commands exist in your code.

Set up your R session

1. Check your working directory, load necessary packages (tidyverse, lubridate), 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 include the subcommand to read strings in as factors.

```
# confirming that working directory is my ENV872 folder using getwd()
getwd() # output: "/Users/aditijackson/ENV872 Setup (local)"
```

```
## [1] "/Users/aditijackson/ENV872 Setup (local)"
```

```
# installing packages
# install.packages("dplyr") # helps with data manipulation
# install.packages("ggplot2") # helps with data visualization
# install.packages("tidyverse") # helps with data manipulation and visualization
# install.packages("lubridate") # helps with manipulating date objects
```

```r
# loading packages
library("dplyr")
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

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

```r
library("ggplot2")
library("tidyverse")
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v forcats   1.0.0     v stringr   1.5.0
## v lubridate 1.9.2     v tibble    3.2.1
## v purrr     1.0.2     v tidyr     1.3.0
## v readr     2.1.4

## -- 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("lubridate")
```

```r
# Importing data sets
Neonics <- read.csv("./Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv",stringsAsFactors = TRUE)
# ECOTOX neonicotinoid dataset

Litter <- read.csv("./Data/Raw/NEON_NIWO_Litter_massdata_2018-08_raw.csv",stringsAsFactors = TRUE)
# Niwot Ridge NEON dataset
```

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: Given that neonicotinoids are widely uses in agriculture, they likely have a huge impact on insect populations and ecosystem health more broadly. Given that insects play a critical role in most ecosytems, a decline in or disrupiton to insect populations could have negative environmental knock-on effects. Studying this data set could help us identify and better understand environmental externalities of using neonictoinoids.

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 may be interested in studying litter and woody debris for a variety of different reasons, including gaining insight into forest biodiversity or conducting fire risk assessments. Overall this data could help inform better forest management practices.

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: 1. Litter and debris sampling is executed at sites that conitan woody vegetation greater than 2 meters tall; samples are collected using a collected of ground and elevated traps 2. Sampling only occurs in tower plots which are randomly selected 3. Ground traps are sampled once a year while elevated traps are samples one time every two weeks

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim(Neonics) # dim() gives use the number of rows and columns in data set
```

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

```
# Neonics has 4623 rows and 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$Effect) # the "$" allows us to pull a specific column of the Neonics dataset
```

```
##     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 studdied effects include Population and Mortality. Population is likely of interest to researchers b/c it can help them better understand the effects of neonicotinoids on current and histroical insect populations and identify trends. Similarly, researchers are likely interested in studying the effects of neonicotinoids on mortality to identify the effectivites of insecticdes.

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.[TIP: The `sort()` command can sort the output of the summary command. . .]

```
Summary_CommonName <- summary(Neonics$Species.Common.Name) # summarizing common names column
sort(Summary_CommonName) # sorting Summary_CommonName, output is in lowest to highest order
```

```
##                         Ant Family                         Apple Maggot
##                                  9                                    9
##              Glasshouse Potato Wasp                            Lacewing
##                                 10                                   10
##             Southern House Mosquito             Two Spotted Lady Beetle
##                                 10                                   10
##            Spotless Ladybird Beetle                 Braconid Parasitoid
##                                 11                                   12
##                       Common Thrip        Eastern Subterranean Termite
##                                 12                                   12
##                             Jassid                           Mite Order
##                                 12                                   12
##                          Pea Aphid                   Pond Wolf Spider
##                                 12                                   12
##               Armoured Scale Family                   Diamondback Moth
##                                 13                                   13
##                       Eulophid Wasp                   Monarch Butterfly
##                                 13                                   13
##                       Predatory Bug                Yellow Fever Mosquito
##                                 13                                   13
##                        Corn Earworm                   Green Peach Aphid
##                                 14                                   14
##                           House Fly                           Ox Beetle
##                                 14                                   14
##                  Red Scale Parasite                  Spined Soldier Bug
##                                 14                                   14
##              Western Flower Thrips Hemlock Woolly Adelgid Lady Beetle
##                                 15                                   16
##              Hemlock Wooly Adelgid                                Mite
##                                 16                                   16
##                        Onion Thrip               Araneoid Spider Order
##                                 16                                   17
##                          Bee Order                     Egg Parasitoid
##                                 17                                   17
##                       Insect Class            Moth And Butterfly Order
##                                 17                                   17
##       Oystershell Scale Parasitoid          Black-spotted Lady Beetle
##                                 17                                   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
```

```
##                   Codling Moth         Flatheaded Appletree Borer
##                             19                                 20
##              Horned Oak Gall Wasp                 Leaf Beetle Family
##                             20                                 20
##                 Potato Leafhopper        Tooth-necked Fungus Beetle
##                             20                                 20
##                  Argentine Ant                             Beetle
##                             21                                 21
##                     Mason Bee                            Mosquito
##                             22                                 22
##                Citrus Leafminer                    Ladybird Beetle
##                             23                                 23
##                Spider/Mite Class                 Tobacco Flea Beetle
##                             24                                 24
##                     Chalcid Wasp              Convergent Lady Beetle
##                             25                                 25
##                   Stingless Bee               Ground Beetle Family
##                             25                                 27
##                Rove Beetle Family                      Tobacco Aphid
##                             27                                 27
##                   Scarab Beetle                      Spring Tiphia
##                             29                                 29
##                     Thrip Order               Ladybird Beetle Family
##                             29                                 30
##                     Parasitoid                      Braconid Wasp
##                             30                                 33
##                   Cotton Aphid                     Predatory Mite
##                             33                                 33
##              Sweetpotato Whitefly                       Aphid Family
##                             37                                 38
##                  Cabbage Looper                Buff-tailed Bumblebee
##                             38                                 39
##                  True Bug Order             Sevenspotted Lady Beetle
##                             45                                 46
##                    Beetle Order       Snout Beetle Family, Weevil
##                             47                                 47
##                Erythrina Gall Wasp                  Parasitoid Wasp
##                             49                                 51
##              Colorado Potato Beetle                   Parastic Wasp
##                             57                                 58
##                Asian Citrus Psyllid                 Minute Pirate Bug
##                             60                                 62
##                  European Dark Bee                          Wireworm
##                             66                                 69
##                   Euonymus Scale                 Asian Lady Beetle
##                             75                                 76
##                  Japanese Beetle                  Italian Honeybee
##                             94                                113
##                     Bumble Bee                Carniolan Honey Bee
##                            140                                152
##               Buff Tailed Bumblebee                   Parasitic Wasp
##                            183                                285
##                     Honey Bee                            (Other)
##                            667                                670
```

Answer: The most commonly studied species are the Honey Bee, the Parasitic Wasp, the Buff Tailed Bumblebee, the Carniolan Honey Bee, the Bumble Bee, and the Italian Honeybee. All six belong to the Hymenoptera order of insectrs (according to Google) and play a crucial role in polinating agricultural crops. They are likely of higher interest than other insectrs given they are crucial to the health of plant ecosystems.

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

```
class(Neonics$Conc.1..Author.) # class of Conc.1..Author. is a factor
```

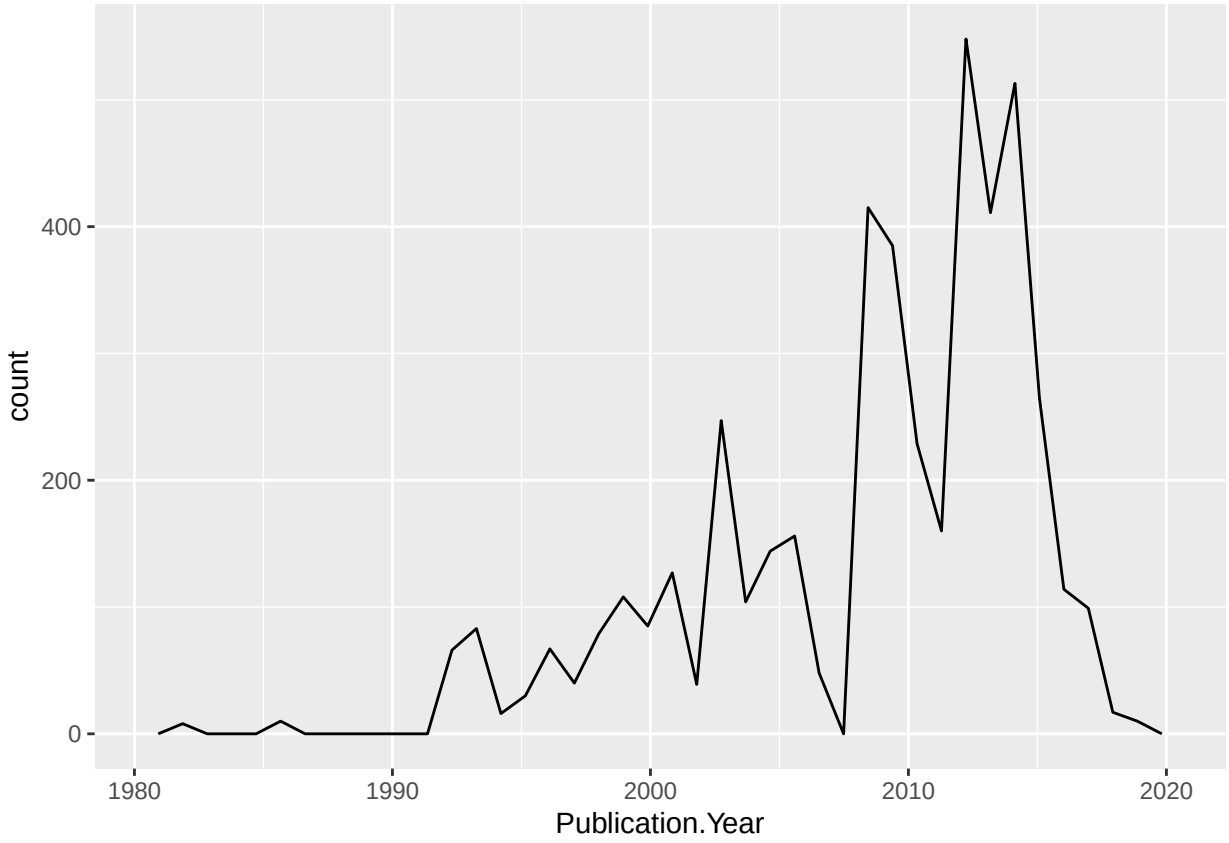
```
## [1] "factor"
```

Answer: The column above is a factor. It is likely not numeric because it is a form of nominal data - data used to categorize or classify entries (rather having quantitative significance). Also, since we told R to "import strings as factors," if Conc.1..Author was a string in the CSV file it would've been converted to a factor upon running the command.

Explore your data graphically (Neonics)

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

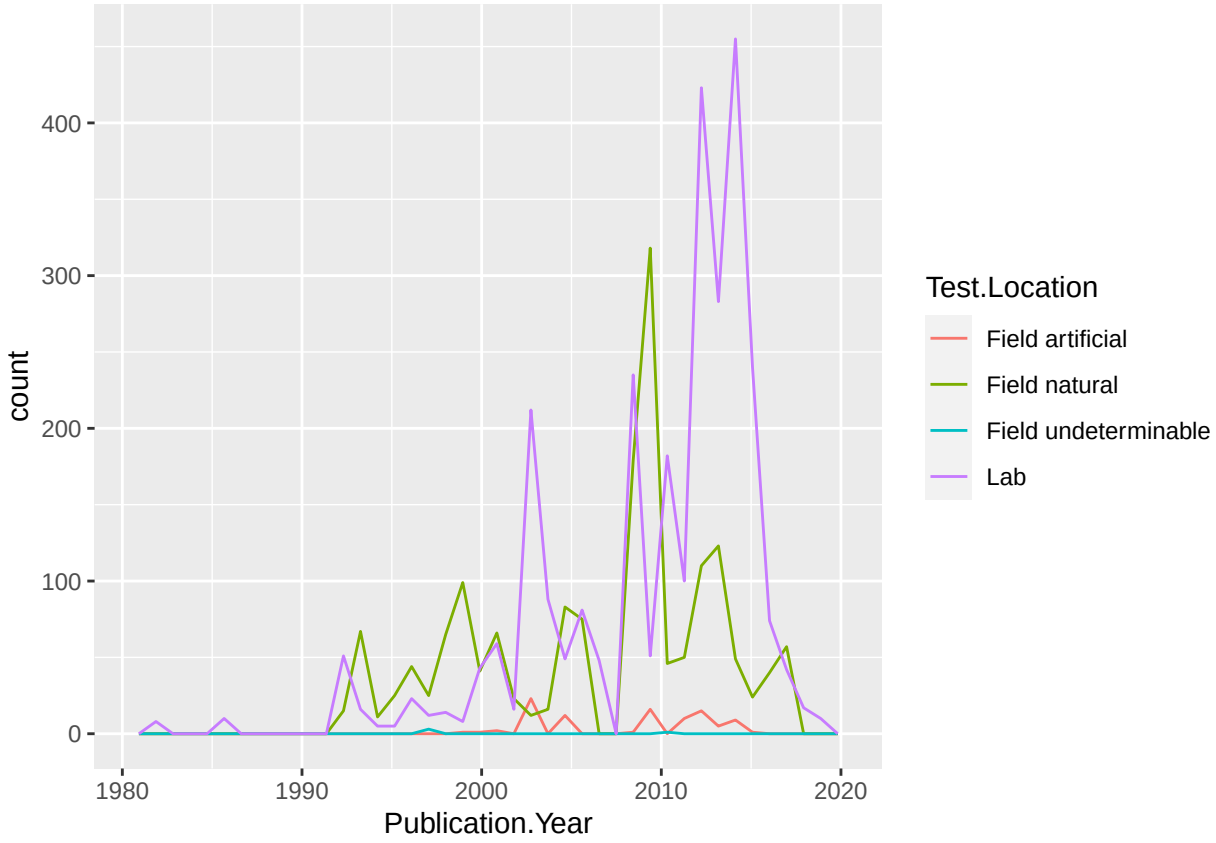
```
ggplot(Neonics) +
# using the ggplot package on the Neonics data set
  geom_freqpoly(aes(x = Publication.Year), bins=40)
```



```
# plotting Publication.Year with bin width of 40
```

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

```
ggplot(Neonics) +
# using the ggplot package on the Neonics data set
  geom_freqpoly(aes(x = Publication.Year,color=Test.Location), bins=40)
```




```
# plotting Publication.Year with bin width of 40; adding Test.Location and
  ## displaying in different colors
```

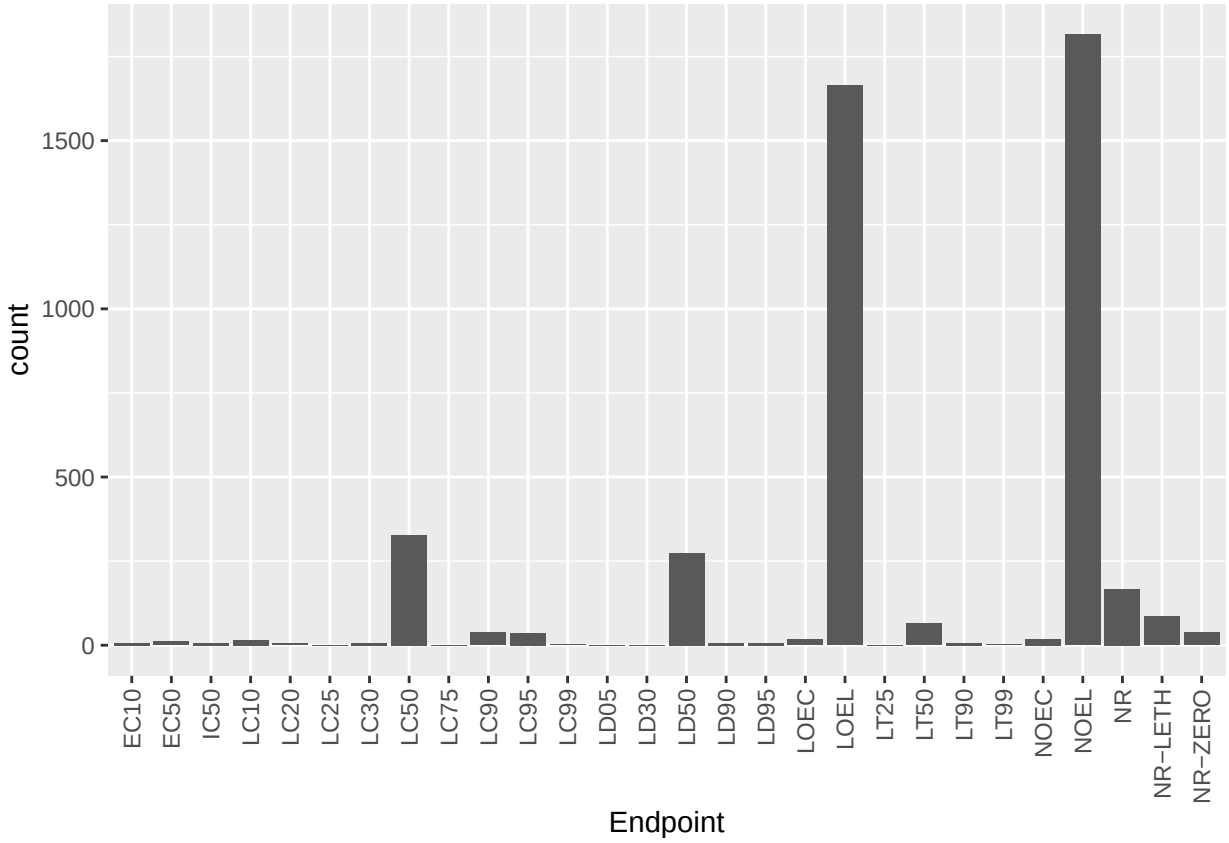
Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer: The most common test locations are "Lab" and "Field natural." They differ a bit over time, but "Lab" has been the most common for approximately the last decade.

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.

[**TIP**: Add `theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))` to the end of your plot command to rotate and align the X-axis labels...]

```
ggplot(Neonics, aes(x = Endpoint)) + # using ggplot to specify data set and column
  geom_bar() + # specifying type of graph as bargraph
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) # rotating
```




```
  ## x-axis labels for easier viewing
```

Answer: The most common end points are NOEL and LOEL. Per the appendix, NOEL is defined as "No-observable-effect-level" and represents :the highest dose (concentration) producing effects not significantly different from responses of controls according to author's reported statistical test". LOEL is defined as the "lowest-observable-effect-level" and represents the "lowest dose (concentration) producing effects that were significantly different (as reported by authors) from responses of controls."

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) # class of collectDate is a factor
```

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

```
Litter$collectDate <- as.Date(Litter$collectDate, format = "%Y-%m-%d")
# converting collectDate column from factor to date using as.Date() function

class(Litter$collectDate) # column is now classified as date
```

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

```
unique(Litter$collectDate) # identifying unique dates sampled in August 2018
```

```
## [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`?

```
unique(Litter$plotID) # unique values in the plotID column. There were 12 unique plots 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
```

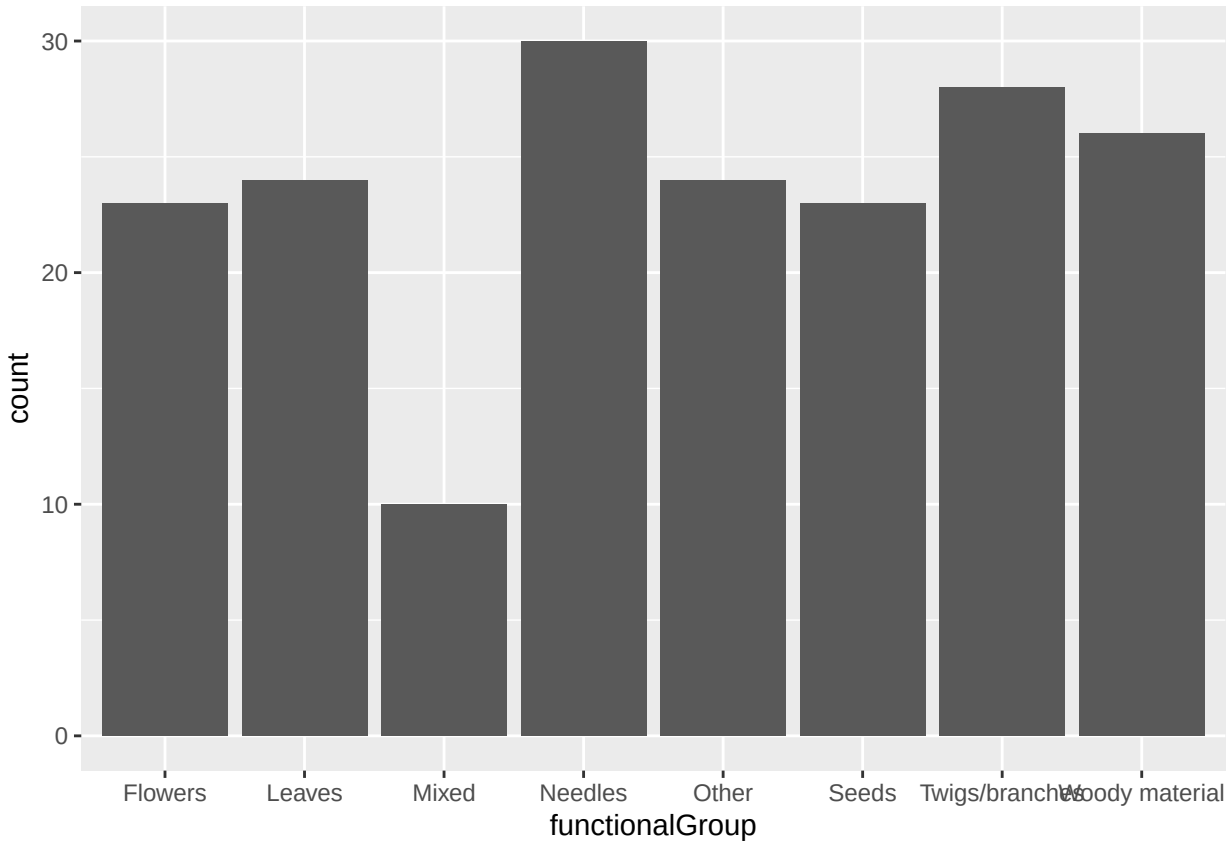
```
summary(Litter$plotID) # summary of values in the plotID column
```

```
## NIWO_040 NIWO_041 NIWO_046 NIWO_047 NIWO_051 NIWO_057 NIWO_058 NIWO_061
##       20       19       18       15       14        8       16       17
## NIWO_062 NIWO_063 NIWO_064 NIWO_067
##       14       14       16       17
```

Answer: Unique tells you the number of unique objects in the column while summary tells you how many of each unique object is in the column.

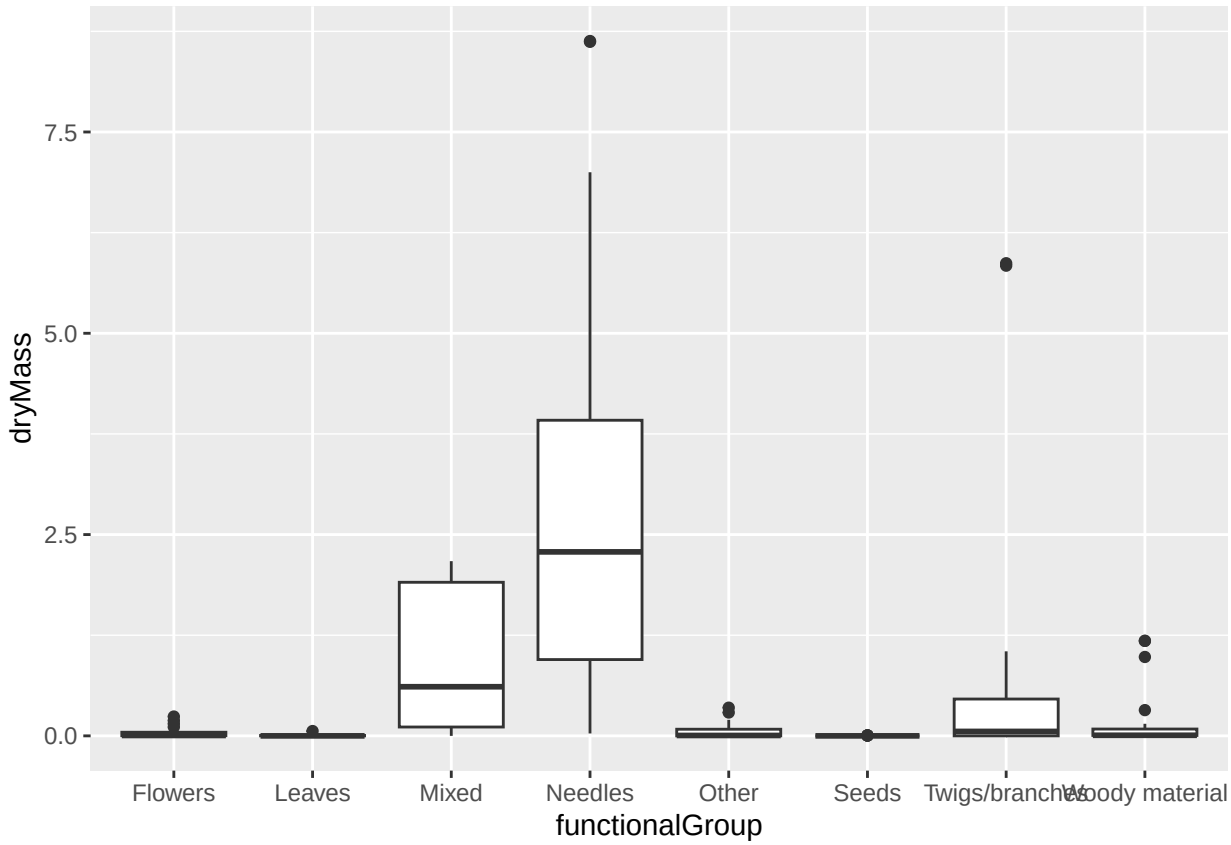
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
ggplot(Litter, aes(x = functionalGroup)) + # using ggplot to specify data set and column
  geom_bar() # specifying type of graph as bar graph
```

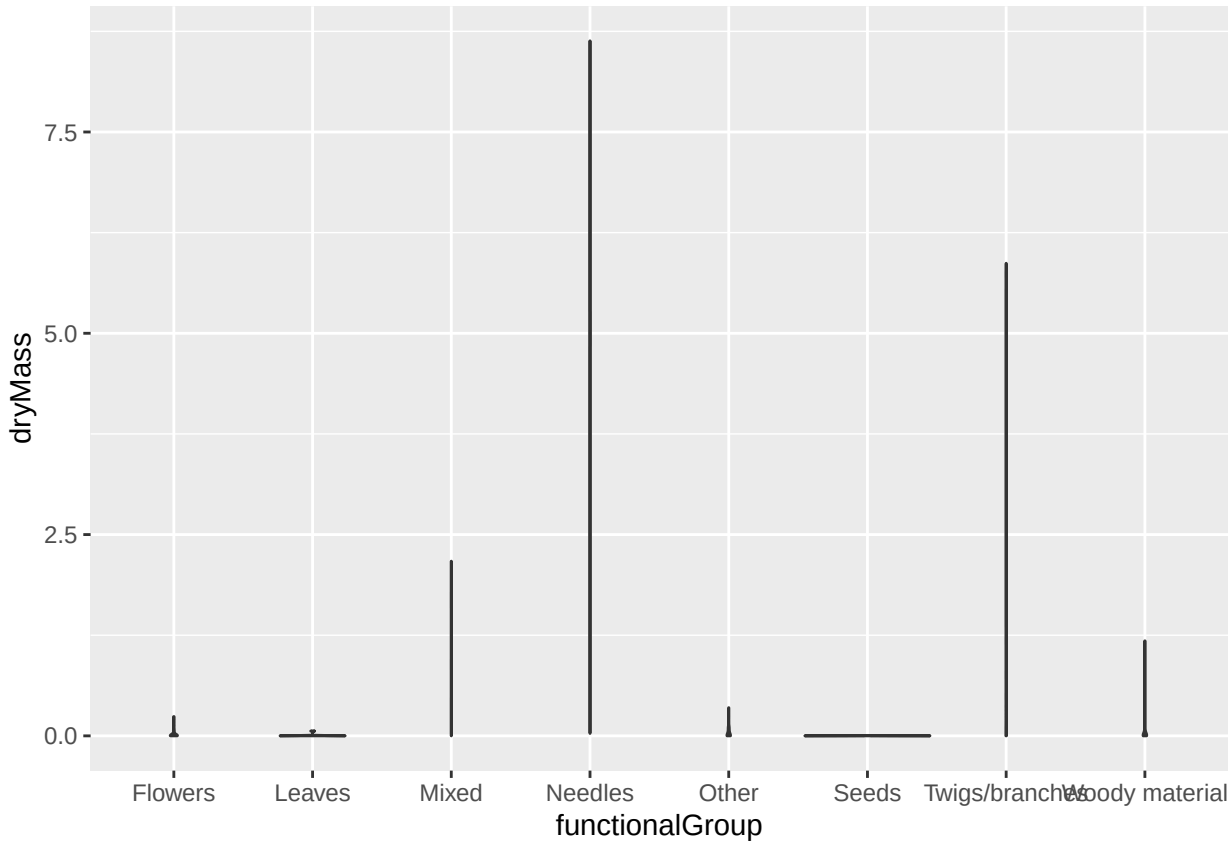


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```
ggplot(Litter, aes(x = functionalGroup, y = dryMass)) + # inputs to ggplot
  geom_boxplot() # specifying type of graph as boxplot
```




```
ggplot(Litter, aes(x = functionalGroup, y = dryMass)) + # inputs to ggplot
  geom_violin() # specifying type of grpah as violin
```



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

> Answer: The boxplot is a more effective option because the values in the data are very close together, so we are better able to see the distribution of data within a small range using the box plot. Since there is not a huge spread, it's difficult to discern anything meaningful about the data from the violin plot.

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

> Answer: Needles tend to have the highest biomass as we can see from the boxplot.