# 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.**

```
getwd()
```

```
## [1] "/Users/jessicacitrola/Documents/ENV872/Environmental_Data_Analytics_2022/Assignments"
```

```
library(tidyverse)
Neonics <- read.csv("/Users/jessicacitrola/Documents/ENV872/Environmental_Data_Analytics_2022/Data/Raw/
Litter <- read.csv("/Users/jessicacitrola/Documents/ENV872/Environmental_Data_Analytics_2022/Data/Raw/N
```

## 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 ecotoxicologoy of neonicotinoids on insects? Feel free to do a brief internet search if you feel you need more background information.

Answer: Neoticotinoids' ecotoxicology data is useful to evaluate the effectivess of application for food production. This dataset could also be helpful for understanding the effects of insecticides on pollinators. A decline in pollinators such as honeybees has been linked to extensive use of insecticides. Measuring hazardous and lethal toxicity as well as potential side effects for various pollinators could be utilized for research or management recommendations.

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: Primary production in a forest ecosystem depends on various factors, including litter and woody debris. Litterfall returns nutrients to the forest floor, while woody debris contribute to organic matter and nutrient cycling. Studying litter and woody debris can evaluate decomposition, nutrient release, carbon cycling, forest productivity, and plant functional groups.

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: In a spatial sampling design, sampling occurs in tower plots that have contain woody vegetation greater than 2m tall. Tower plots are randomly selected, where forested tower airsheds sampling takes place in 20 40m x 40m, while in low saturated vegetation sampling occurs in 4 40m x 40m plots plus 26 20m x 20m plots. One litter trap pair is deployed for every 400m2 plot area. Placement of litter traps is random in sites with greater than 50% aerial cover of woody vegetation greater than 2m in height. Trap placement is placed in areas beneath qualifying vegetation in sites with less than 50% cover of woody vegetation. In a temporal sampling design, ground traps are sampled once a year and sampling for elevated traps varies by vegetation at the site. *

## Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim(Neonics)
```

```
## [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$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 common effects studied are population and mortality. Pesticides are widely known to be linked to both of these effects. Honey bees and other pollinators exposed to the toxins in neonicotinoids typically interfere with their nervous system and eventually causing death.

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 species are the Honey bee, parasitic wasp, Buff Tailed Bumblebee, Carniolan Honey Bee, Bumble Bee, and Italian Honeybee. All of these species feed on nectar and are beneficial for crops. Parasitic wasps control pest populations while the five bee species are important pollinators. As a result, they could be an interest for studies as they provide ecosystem services and are valuable to agriculture. In addition, these species are all likely to be directly negatively affected by neonicotinoids.

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"
```

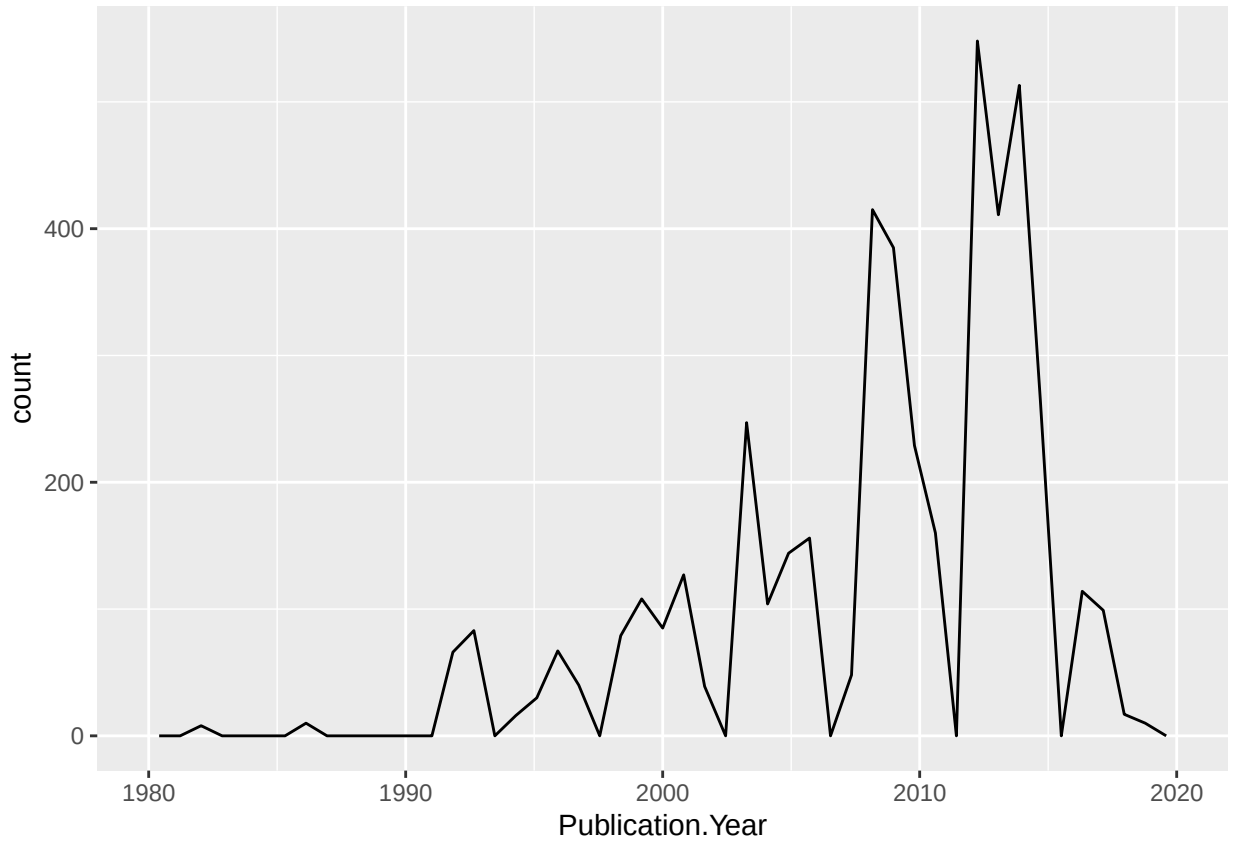
Answer: The class of Conc.1.Author is a factor. It is listed as a factor because the data is not soley numeric. Many entries contain other text (eg. /, ~, >, and NR). Although mostly numberic, this data cannot be stored as a number since it contains various other text as well. Each unique factor is stored once, and storing the data as a factor ensures that functions will treat the data correctly.

## 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) +
  scale_x_continuous(limits = c(1980, 2020))
```

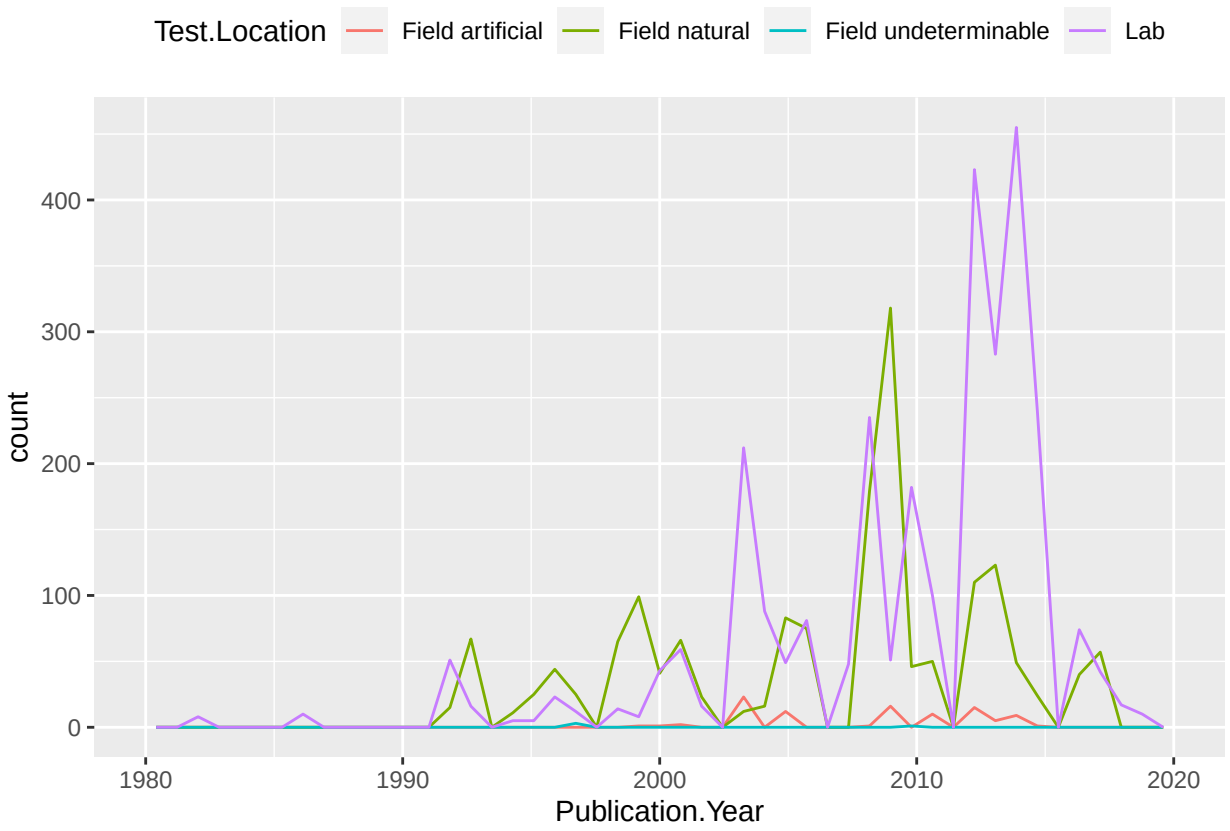
```
## Warning: Removed 2 row(s) containing missing values (geom_path).
```




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) +
  scale_x_continuous(limits = c(1980, 2020)) +
  theme(legend.position = "top")
```

```
## Warning: Removed 8 row(s) containing missing values (geom_path).
```

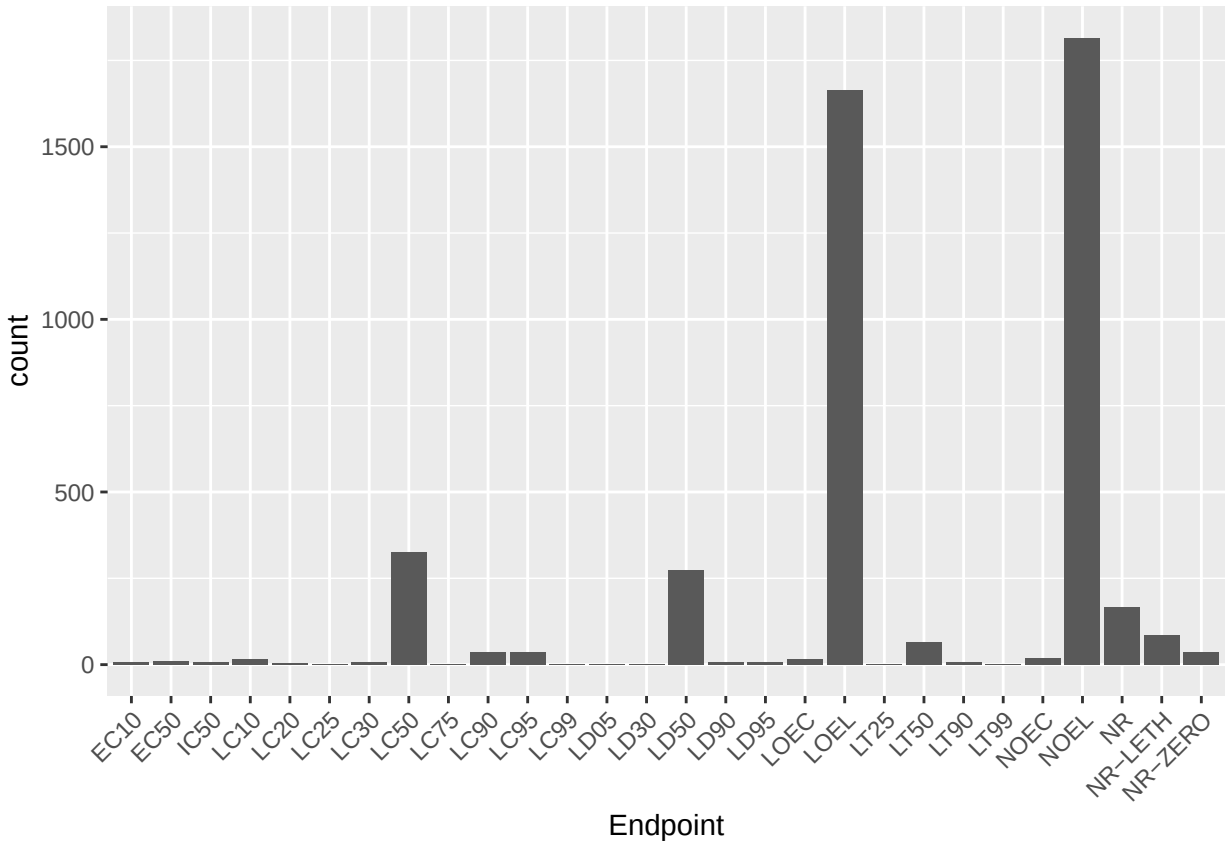



Interpret this graph. What are the most common test locations, and do they differ over time?

Answer: 'Lab' and 'field natural' are the most common test locations. The count of 'lab' test locations generally increase between approximately 1990 and 2015. The 'field natural' test locations fluctuated over time with a sharp increased around 2008.

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, aes(x = Endpoint)) +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  geom_bar()
```




Answer: The NOEL and LOEL are the most common end points. The LOEL is the lowest-observabe-effect-level,the lowest dose, or concentration, producing effects that were significantly different from responses of controls. The NOEL is the no-observable-effect-level, the highest dose, or concentration, producing effects not significantly different from responses of controls according to author's reposrted 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$collectDate)
```

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

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

class(Litter$collectDate)
```

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

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`?

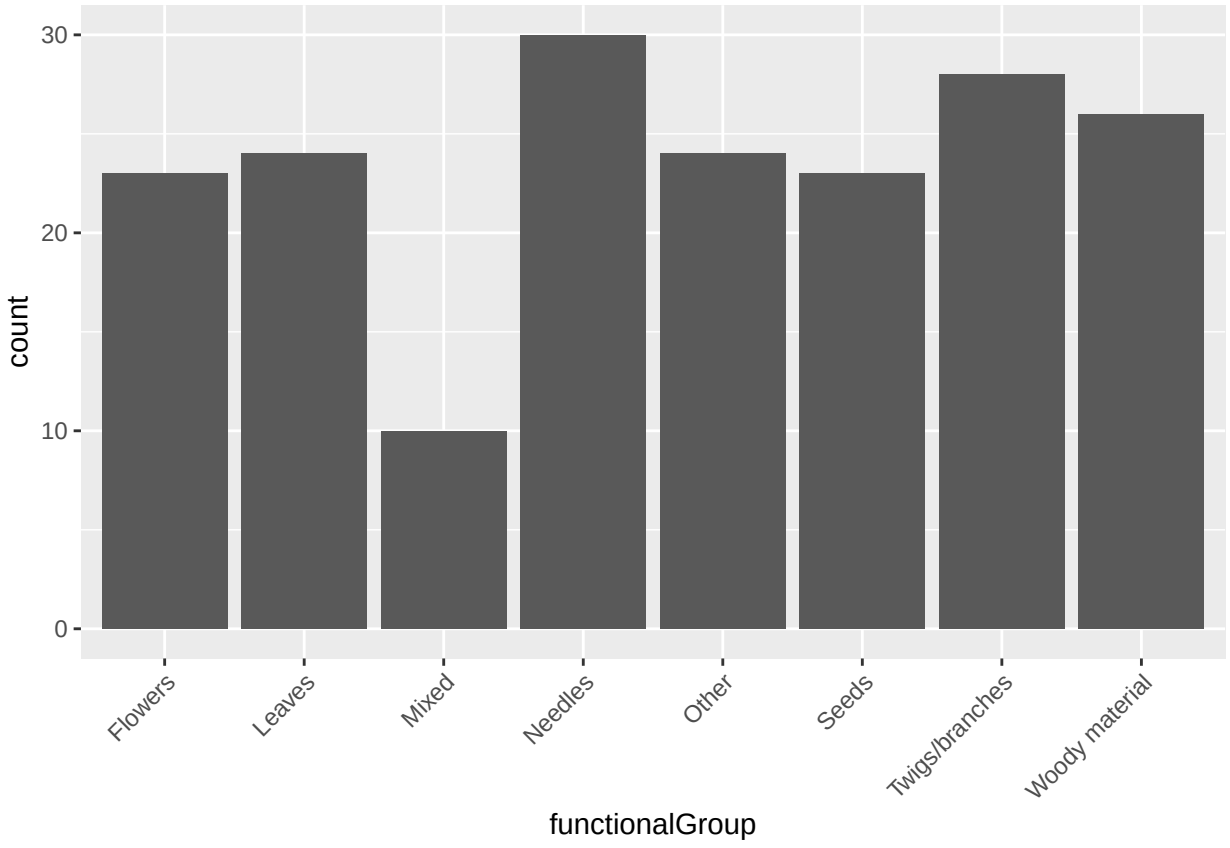
```
unique(Litter$plotID)
```

```
##  [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 were 12 plots sampled at Niwot Ridge. The unique function returns the unique values and removes duplicate values in the dataset. The summary function returns descriptive statistics of a dataset. It does not remove duplicate values.

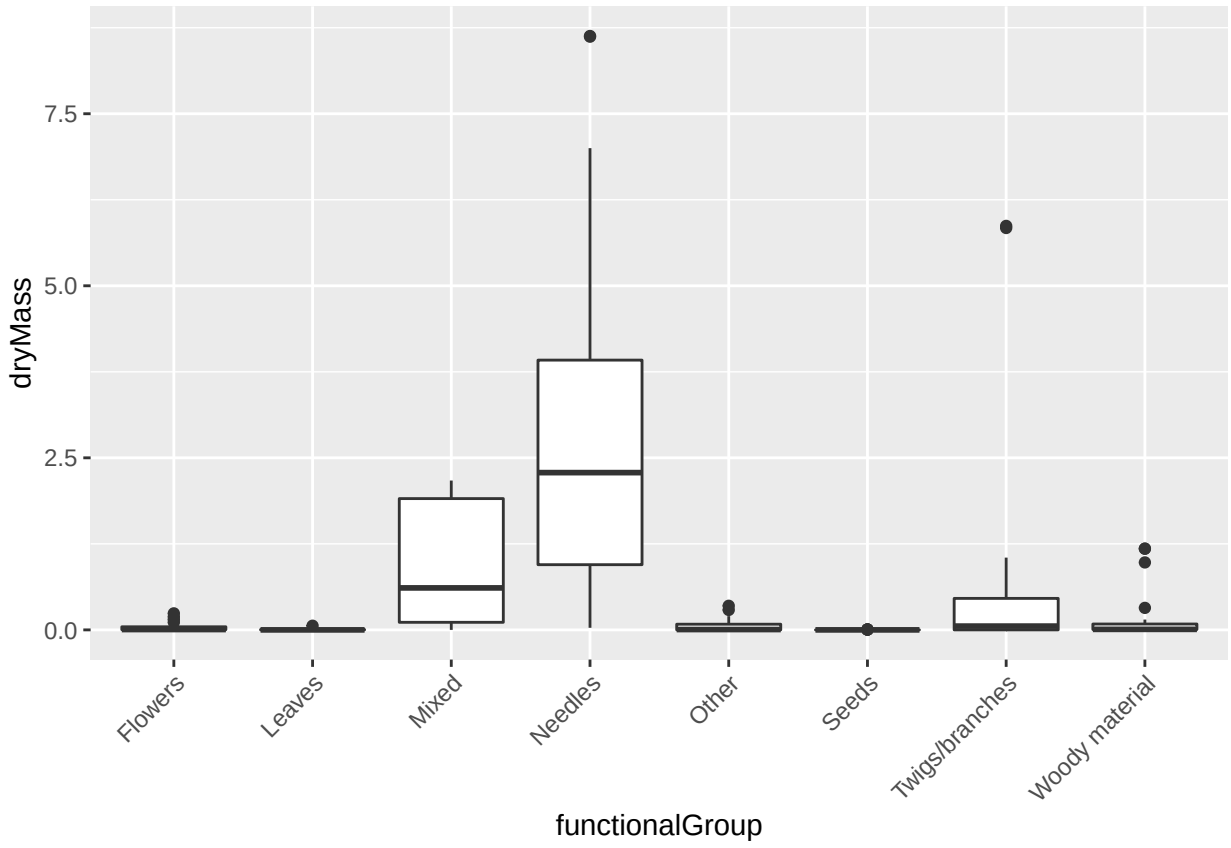
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
ggplot(Litter, aes(x = functionalGroup)) +
    theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  geom_bar()
```

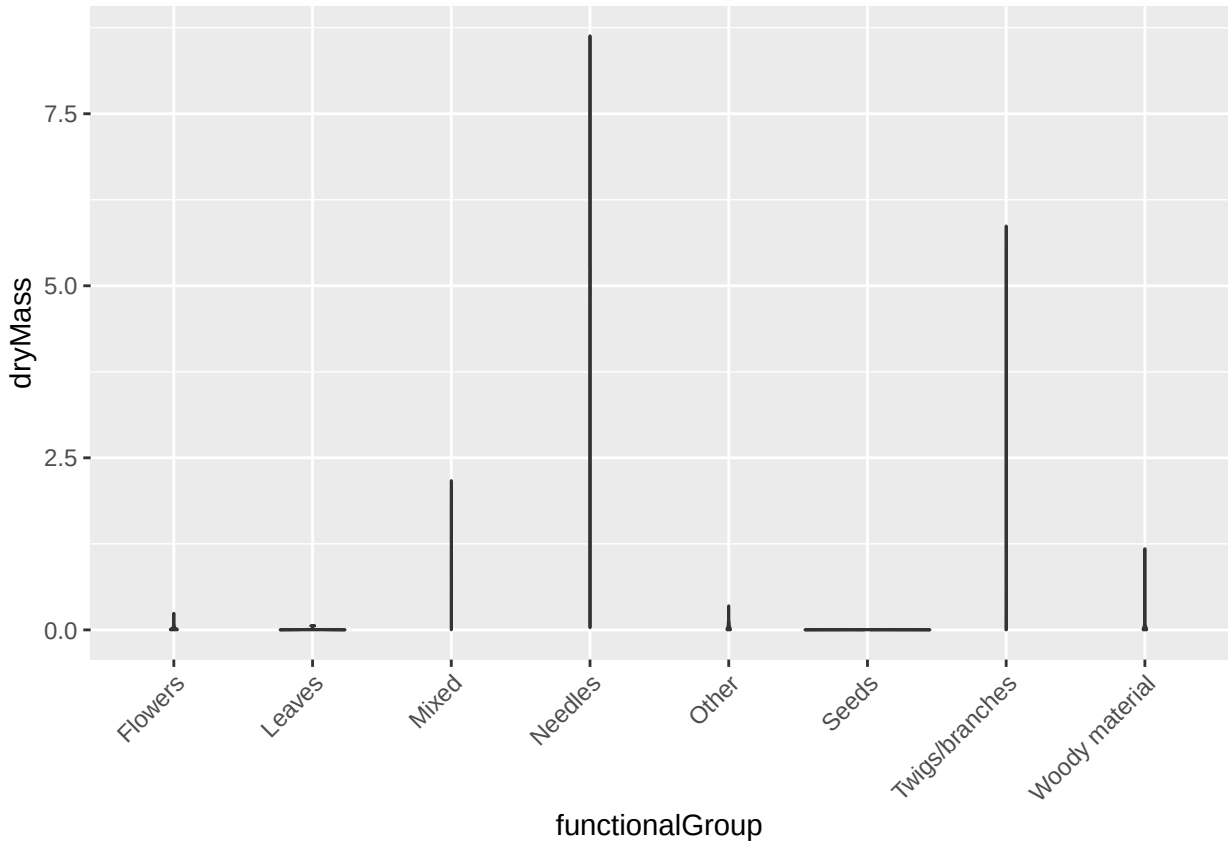



15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```
ggplot(Litter) +
  geom_boxplot(aes(x = functionalGroup, y = dryMass)) +
                theme(axis.text.x = element_text(angle = 45, hjust = 1))
```




```
ggplot(Litter) +
  geom_violin(aes(x = functionalGroup, y = dryMass)) +
        theme(axis.text.x = element_text(angle = 45, hjust = 1))
```




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

> Answer: Violin plots are able to provide more detail about the distribution, which isn't necessary with the litter types and dry mass as they are both not widely distributed. The box plot provides a more direct summarization of the data and an easier way to identify outliers in this dataset.

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

> Answer: Needles have the highest biomass at these sites. Twigs/branches also have a few dry mass readings that are much higher than the average.