# SamanthaSedar_A03_DataExploration.Rmd

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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.

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## 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.

```
#On-startup code, uploading packages, ensuring R can read files

getwd()
```

```
## [1] "/home/guest/EDE_Fall2023"
```

```
library(tidyverse)
library(lubridate)

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

## 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: According to Hladik, Main, and Goulson, neonicotinoids are known to have adverse impacts on pollinators and negatively impact aquatic insects and ecosystems. Given the importance of pollinators to our ecosystems and the environment more broadly, it is prudent to study the ecotoxicology of neonicotinoids on insects. Source: nviron. Sci. Technol. 2018, 52, 6, 3329–3335 Publication Date:February 26, 2018 https://doi.org/10.1021/acs.est.7b06388 y.

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: According to Scheungrab, Trettin, Lea, and Jurgensen, woody debris is important to study due to its role in carbon budgets and nutrient cycling in addition to influencing water flows and sediment transport. Source: In: Gen. Tech. Rep. SRS-38. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. p. 47-48.

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. Spatial sampling design: Tower plots are randomly selected within the 90% flux footprint of primary/secondary airsheds 2. Spatial sampling design: Plot edges must be separated by a distance 150% of one edge of the plot 3. Temporal sampling design: Sampling frequency varies between biweekly and bimonthly depending on vegetation while ground traps are sampled annually

## Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
#Printing dimensions (observations and variables) of the data set, reflecting 4623 observations and 30

print(dim(Neonics))
```

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

```
help("dim")
```

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?

```r
#Sorting the summary function to easily see the most common effects that are studied

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

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

> Answer: The most common effects that are studied are by far population and mortality at 1803 and 1493, respectively. These effects are likely the most commonly studied because they are the most definite/important to overall research, they are tightly related to each other and also each of the other effects.

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...]

```r
#Sorting the summary function to determine the six most studied species

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

```
##                         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 six most commonly studied species are: 1. Honey Bee-667; 2. Parasitic Wasp-285; 3. Buff Tailed Bumblebee-183; 4. Carniolan Honey Bee-152; 5. Bumble Bee-140; 6. Italian Honeybee-113. The commonality here is that they are all bees, and as indicated in answer #2, neonicotinoids are known to have adverse impacts on pollinators, so it is in-line with expectations that bees (primary pollinators) would be the insects of most interest.

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?

```
#Using class to determine how the `Conc.1..Author` column is coded

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

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

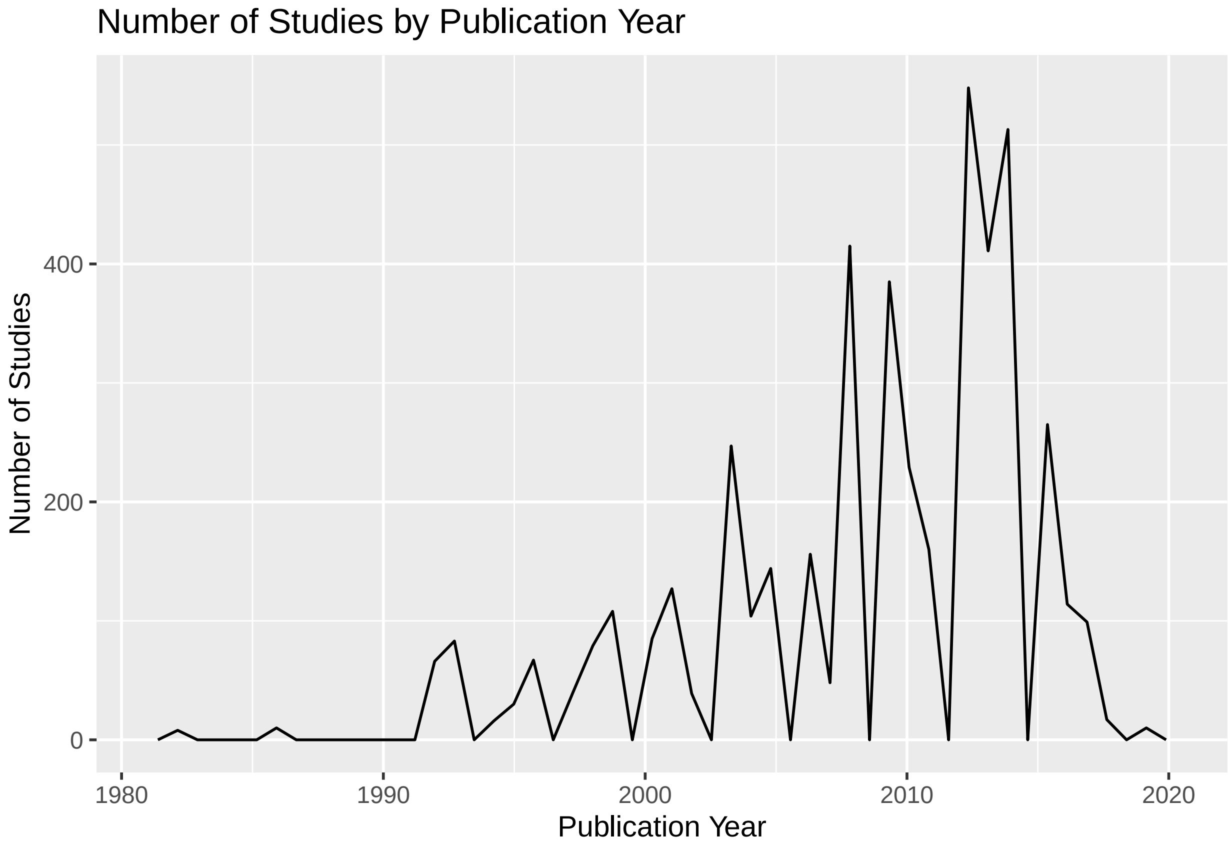
Answer: The concentration records, 'Conc.1..Author.' is a factor and not numeric beause the column contains several non-numeric values. In order to convert an entire column to numberic, each value would need to have a numeric value.

## Explore your data graphically (Neonics)

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

```
#Telling R we are starting a graph using the ggplot function, and specifying the dataframe. Then specif

ggplot(Neonics) +
  geom_freqpoly(aes(x= Publication.Year), bins=50) +
  labs(title = "Number of Studies by Publication Year",
        x= "Publication Year",
        y = "Number of Studies")
```

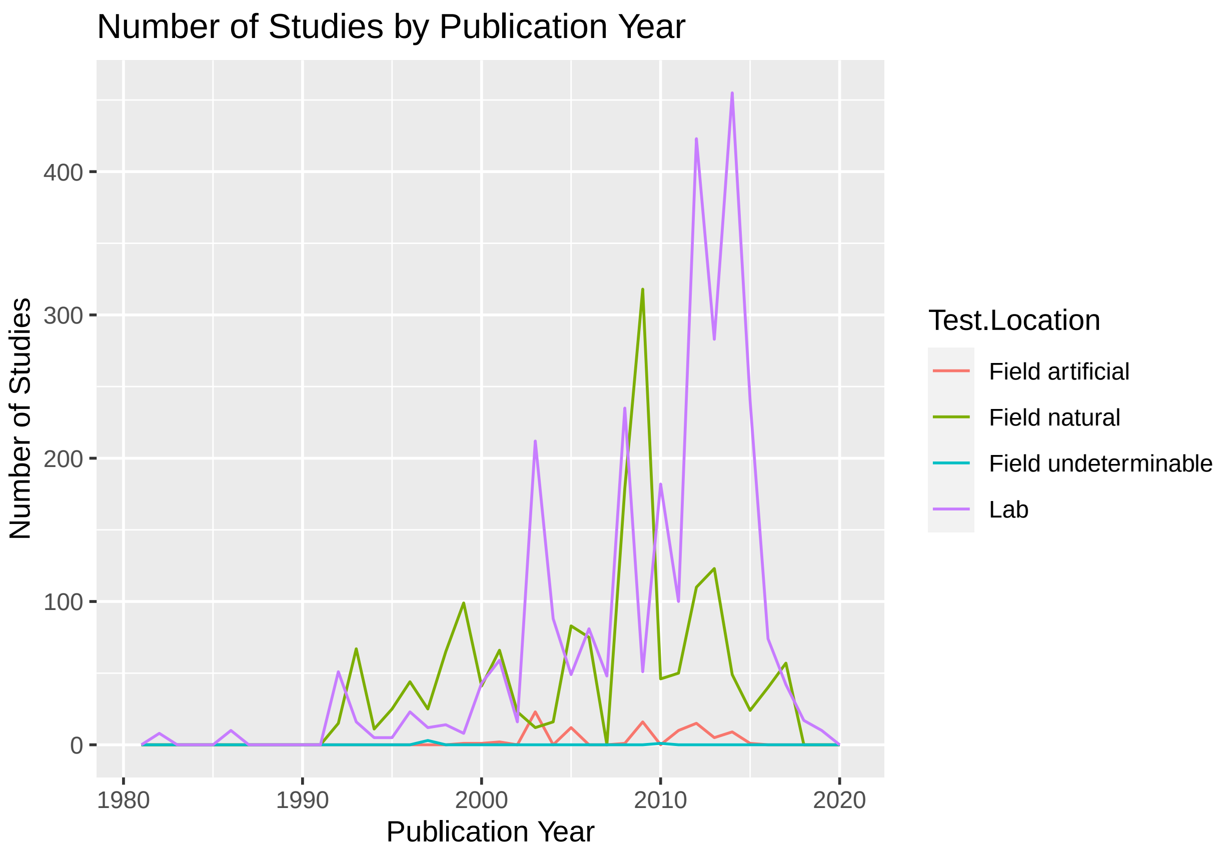


10. Reproduce the same graph but now add a color aesthetic so that different Test.Location are displayed as different colors.

#standard syntax + adding color=test.location to make the locations display as different colors

```
#Telling R we are starting a graph using the ggplot function, and specifying the dataframe. Then specif

ggplot(Neonics, aes(x=Publication.Year, color = Test.Location)) +
  geom_freqpoly(binwidth=1) +
  labs(title = "Number of Studies by Publication Year",
        x= "Publication Year",
        y = "Number of Studies")
```



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

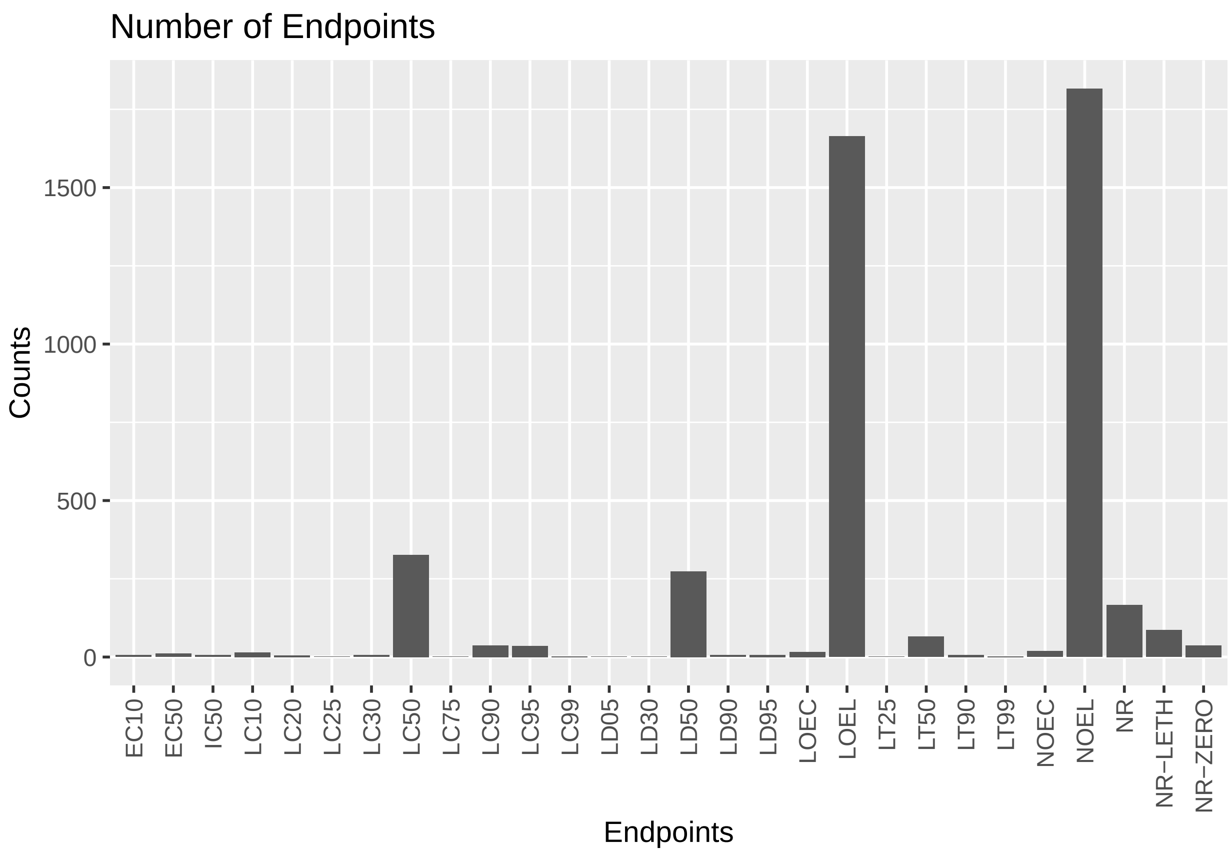
> Answer: The most common test locations differ over time. However, based on this graph, we can see that ‘field artificial’ is the least common and the most common is ‘lab.’ This is likely due to the accessability and realiability of a lab, as compared to the remaining options.

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...]

```
#Telling R we are starting a graph using the ggplot function, and specifying the dataframe. Then specif

ggplot(Neonics, aes(x = Endpoint)) +
  geom_bar() + theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))  +
  labs(title = "Number of Endpoints",
        x= "Endpoints",
        y = "Counts")
```



Answer: The two most common endpoints are: 1. NOEL-Terrestrial: 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) 2. LOEL-Terrestrial: Lowest-observable-effect-level: lowest dose (concentration) producing effects that were significantly different (as reported by authors) from responses of controls (LOEAL/LOEC)

### 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.

```
#After determining that collectDate is a date, telling R to reformat using the as.Date function and ens
#Then reformatting the dates to only include month/year and isolate 8/18 using the unique function, spe

class(Litter$collectDate)
```

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

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

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

```r
unique_dates_aug_2018 <- unique(Litter$collectDate[format(Litter$collectDate, "%Y-%m") == "2018-08"])
print(unique_dates_aug_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`?

```r
#Using the length function in addition to the unique and summary functions in order to obtain usable re

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

```
## [1] 12
```

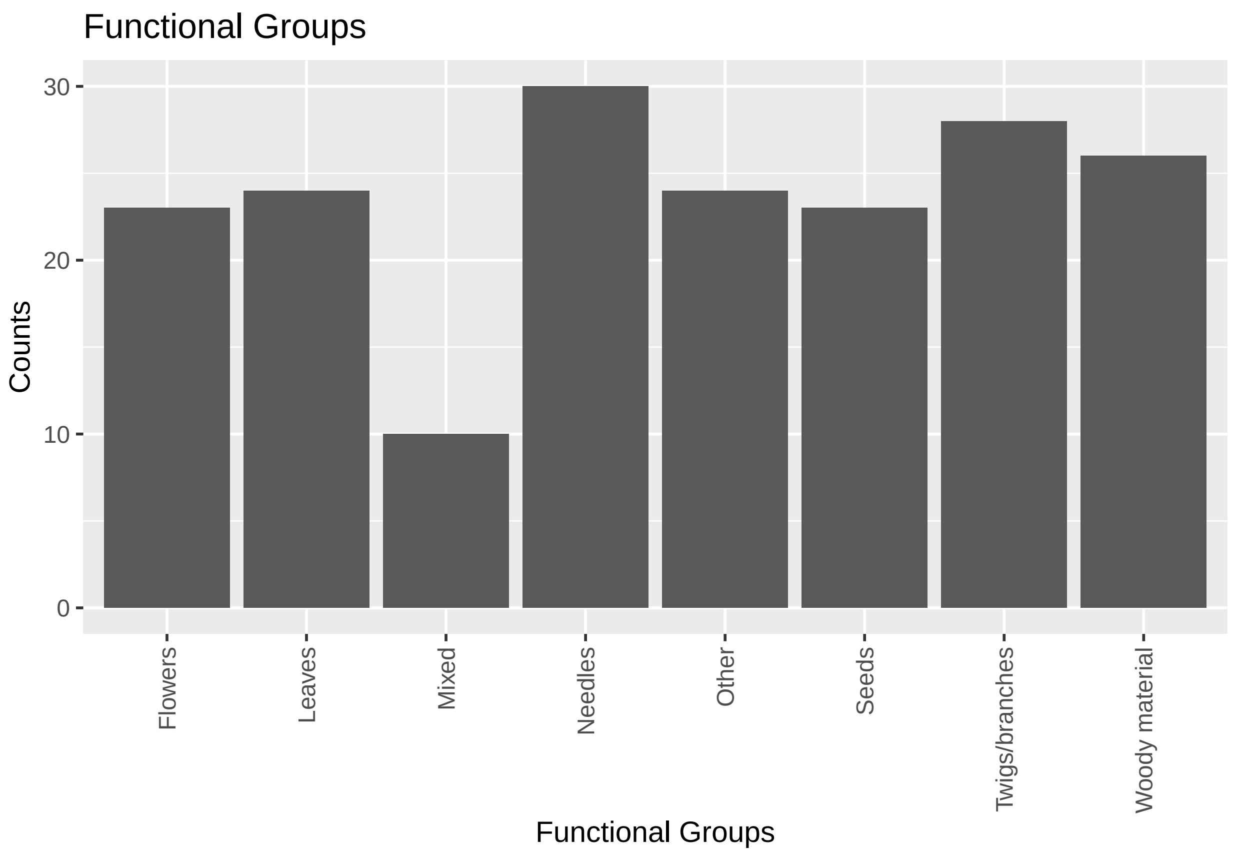
```r
length(summary(Litter$plotID))
```

```
## [1] 12
```

> Answer: The information obtained using the unique function along with the length function result in the same information obtained from using summary. This is necause the plotID is a factor, therefore there are no other summary statistics that can be generated.

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.

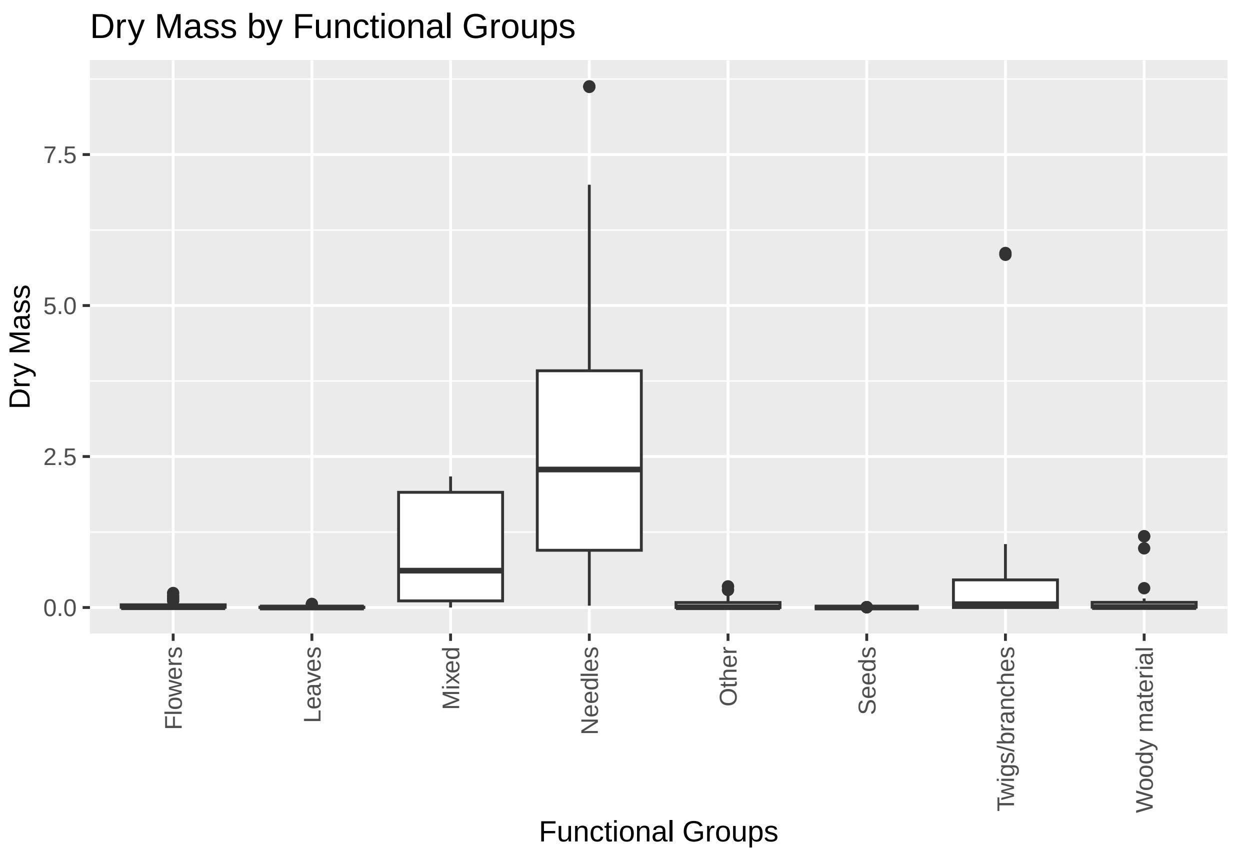
```r
ggplot(Litter, aes(x = functionalGroup)) +
  geom_bar() + theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) +
  labs(title = "Functional Groups",
        x= "Functional Groups",
        y = "Counts")
```



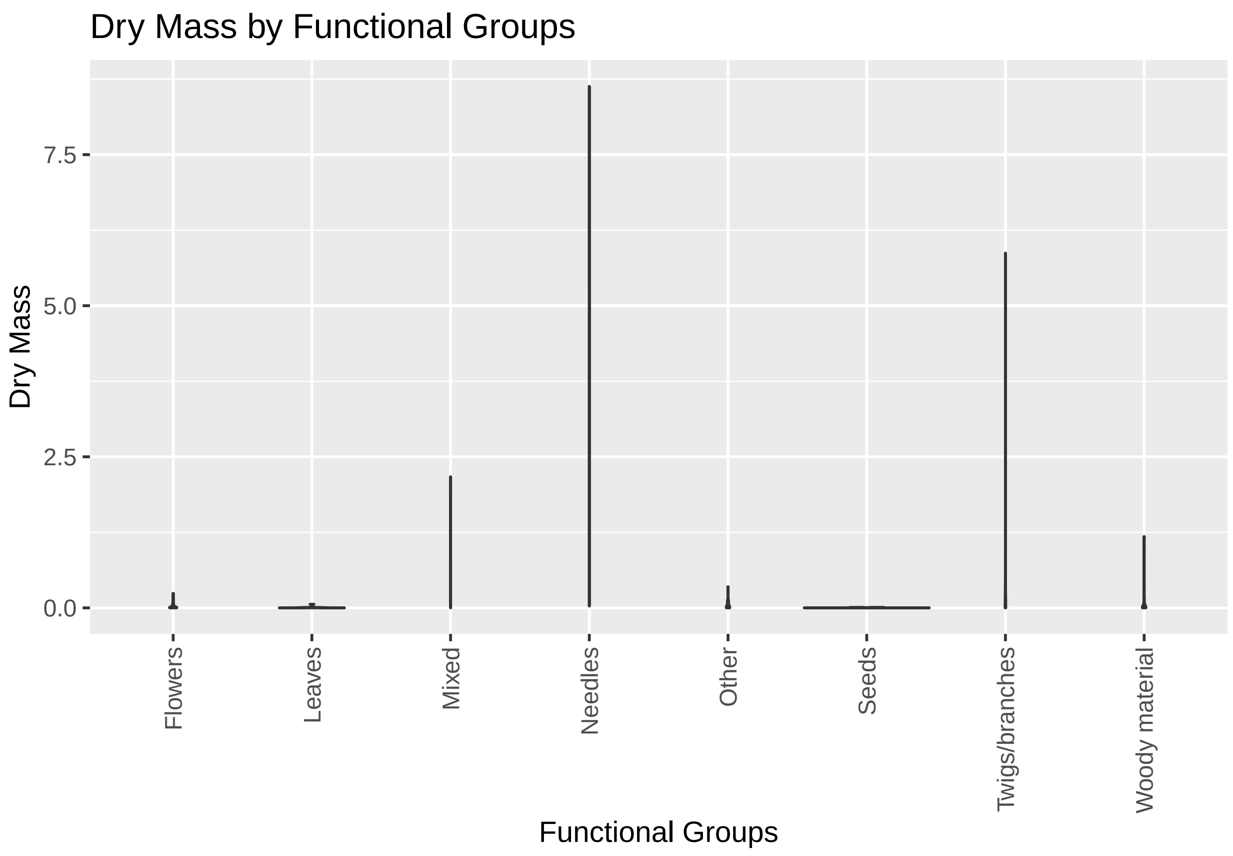
15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```
#Similar process to number 11 using geom_boxplot and geom_violin. To confirm hypothesis that there isn'

ggplot(Litter) +
  geom_boxplot(aes(x = functionalGroup, y = dryMass)) + theme(
    axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) +
  labs(title = "Dry Mass by Functional Groups",
        x= "Functional Groups",
        y = "Dry Mass")
```



```
ggplot(Litter) +
  geom_violin(aes(x = functionalGroup, y = dryMass))+ theme(
    axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))  +
  labs(title = "Dry Mass by Functional Groups",
        x= "Functional Groups",
        y = "Dry Mass")
```



```
length(summary(Litter$Flowers))
```

```
## [1] 3
```

```
length(summary(Litter$Leaves))
```

```
## [1] 3
```

```
length(summary(Litter$Mixed))
```

```
## [1] 3
```

```
length(summary(Litter$Needles))
```

```
## [1] 3
```

```
length(summary(Litter$Other))
```

```
## [1] 3
```

```r
length(summary(Litter$Seeds))
```

```
## [1] 3
```

```r
length(summary(Litter$"Twings/branches"))
```

```
## [1] 3
```

```r
length(summary(Litter$"Woody material"))
```

```
## [1] 3
```

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

> Answer: A violin plot is an effective way to show density distributions. For this data, the boxplot is more effective than the violin plot because there is not enough data to depict a trend. Indeed, each functional group only has three datapoints.

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

> Answer: Needles tend to have the highest biomass at these sites.