Assignment 3: Data Exploration

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Spring 2023

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.

```
#Check working directory
getwd()
```

```
## [1] "/Users/yaoyao/Desktop/ENV872/EDA-Spring2023"
```

```
#Load the two packages
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
## v ggplot2 3.3.6      v purrr   0.3.4
## v tibble  3.1.8      v dplyr   1.0.10
## v tidyr   1.2.1      v stringr 1.4.1
## v readr   2.1.2      v forcats 0.5.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(lubridate)
```

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

```
#Upload two datasets and name the datasets

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:Neonicotinoid is a kind of pesticides that permanently binds to the nerve cells of insects, overstimulating and destroying the insects. It is commonly used to help agriculture and cultivate crops.When the insects are degraded in the soil or eaten by other organisms, it will pose toxical effects on other organisms and contaminate the environment close by.Neonicotioid will also toxic bees (they can help the pollination process) and other insects that have important economic and ecological values. Thus, it is important to important to research on this chemical and its effects on insects population, like bees.

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: Forest littler and woody debris are important components of healthy soil. The decomposition of them release essential nutrients into the soil and also helps the soil to keep moist. They are also essential materials for nesting, hiding and protected spots for animals. It is important to research on them to learn about the soil and environmental quality in general.

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. Temporal Sampling Design: The sampling frequency varies by the kind of vegetration that is on different sites. For deciduous foret furing senescence, the frequency is 1x every 2weeks. For everygreen sites, the frequncy is 1x every 1-2 months. 2. Spatial Sampling Design: The litter sampling took place in 20 40m x 40m plots for sites that have forested tower airsheds.On the other hand, for sites that have low-statured vegetation over the twoer airsheds, the sampling took place in 4 40m x 40m tower plots plus 26 20m x 20m plots. 3. Spatial Sampling Design: Locations of tower plots are selected randomly within the 90% flux footprint of the primary and secondary airsheds and the litter and woody debris are sampled at terrestial NEON sites that have woody vegetation >2m tall.

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
#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?

```
#Effect columns
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 that are studied include mortality, population, behavior and feeding behavior. Mortality is directly related to the research of toxicity of neonicotinoid to insects. By seeing the fluctuation of population when neonicotinoid is given, the effect of neonicotinoid on insects can also be discovered. Behavior and feeding behavior may be important factors that closely related to how neonicotinoid is taken by the insects and how much are taken in, affecting insects' survival.

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...]

```
#Species common name
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: Except from the "Other" category, honey bee, parasitic wasp, buff tailed bumblebee, carniolan honey bee, bumble bee and italian honeybee are the top six most commonly studied species in the dataset.They are all very important to agriculture and crops and plants' growth.

Different kinds of bees are heavily researched upon, since they create important ecological and economic value in the ecosystem as crop pollinators and the use of pesticides will heavily affect their population. Parasitic wasphelp farmers and gardeners in naturally controlling crops by killing those insects that are harmful to the crops, so if neonicotinoid can threat their survivalship, they couldn't control the harmful insects anymore.

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

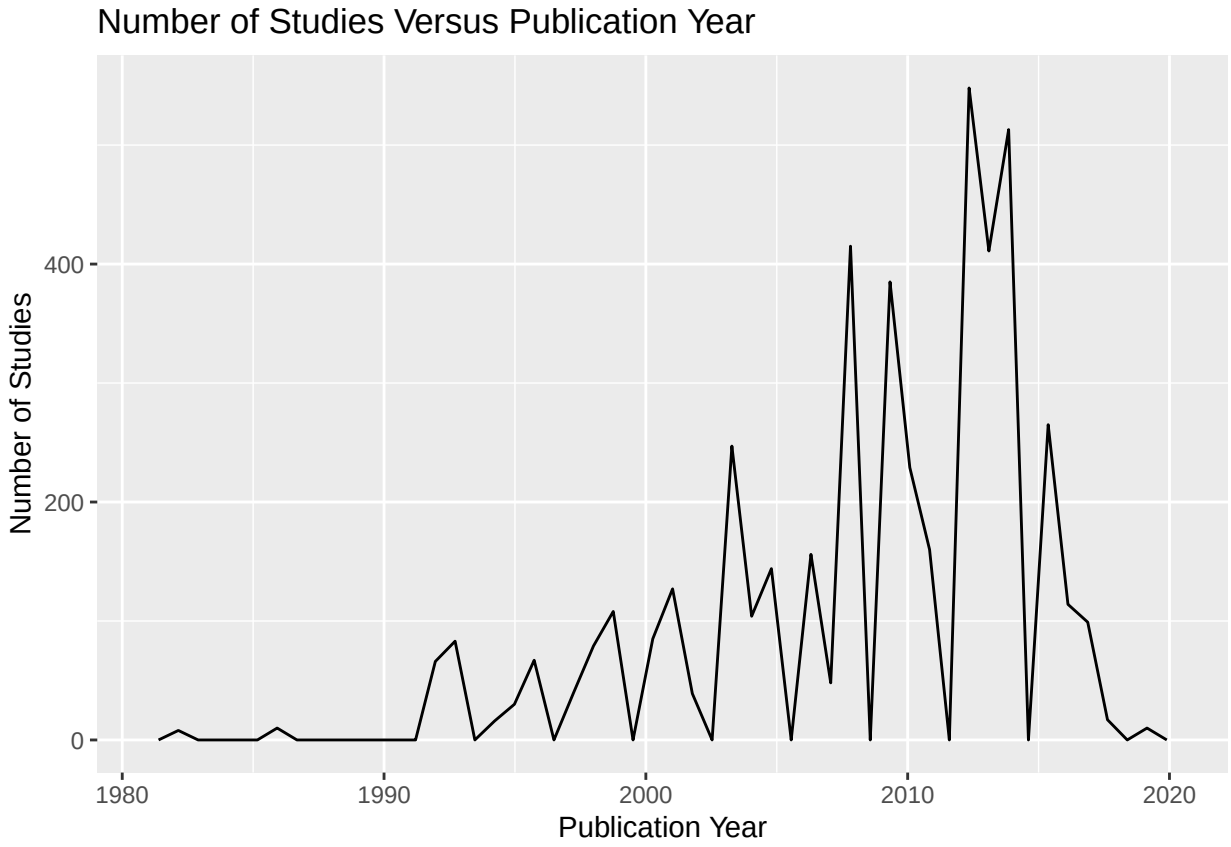
```
## [1] "factor"
```

Answer:It is a factor. By looking into the dataset, we can see that many entries are like "<0.025" which is a range rather than a specific number. In addition, there are also "NR" - not recorded data. As a resultmm the column can't be numeric.

Explore your data graphically (Neonics)

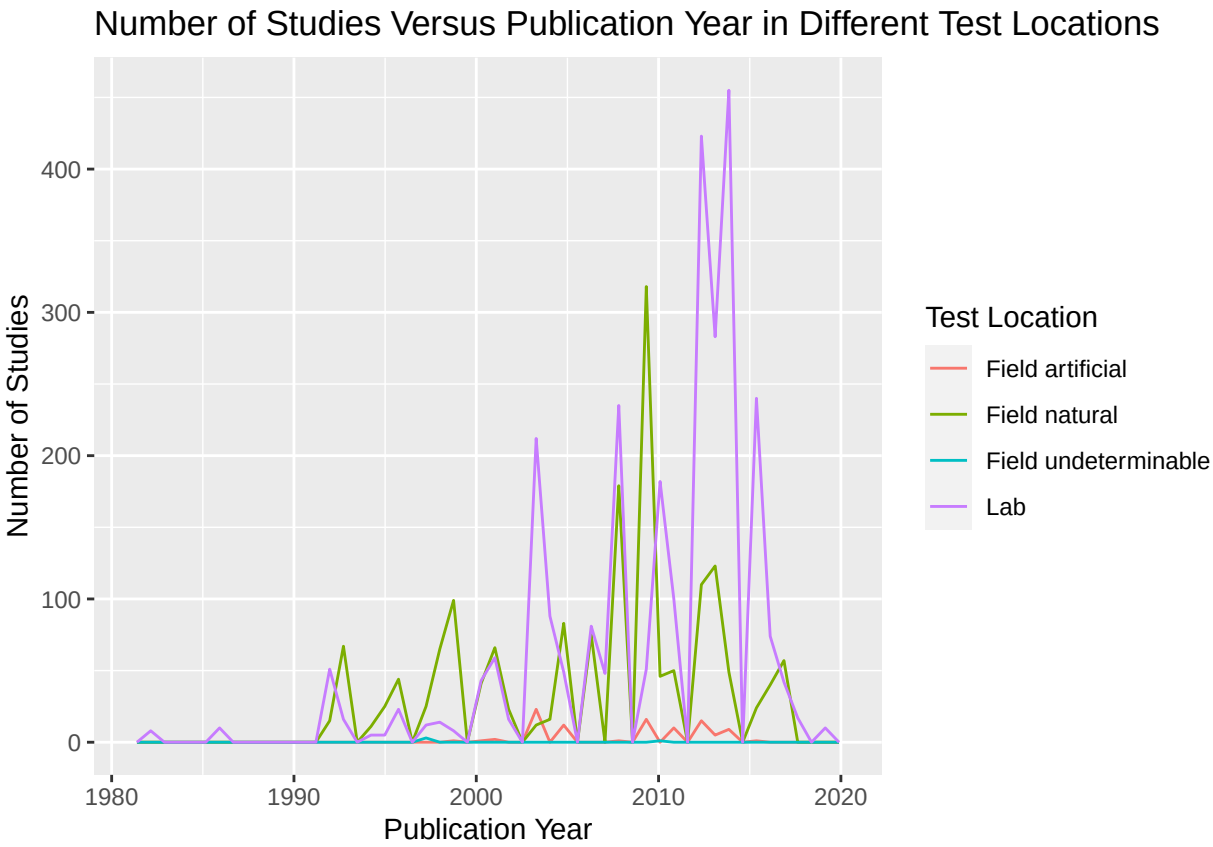
9. Using `geom_freqpoly`, generate a plot of the number of studies conducted by publication year.

```
#Plot of the number of studies conducted by publication year
ggplot(Neonics) +
  geom_freqpoly(aes(x = Publication.Year), bins = 50) +
  labs(y= "Number of Studies", x = "Publication Year") +
  labs (title = "Number of Studies Versus Publication Year")
```



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

```
#Plot of the number of studies conducted by publication year at different test locations
ggplot(Neonics) +
  geom_freqpoly(aes(x = Publication.Year, color = Test.Location), bins = 50) +
 labs(y= "Number of Studies", x = "Publication Year") +
 labs(color="Test Location") +
 labs (title = "Number of Studies Versus Publication Year in Different Test Locations")
```



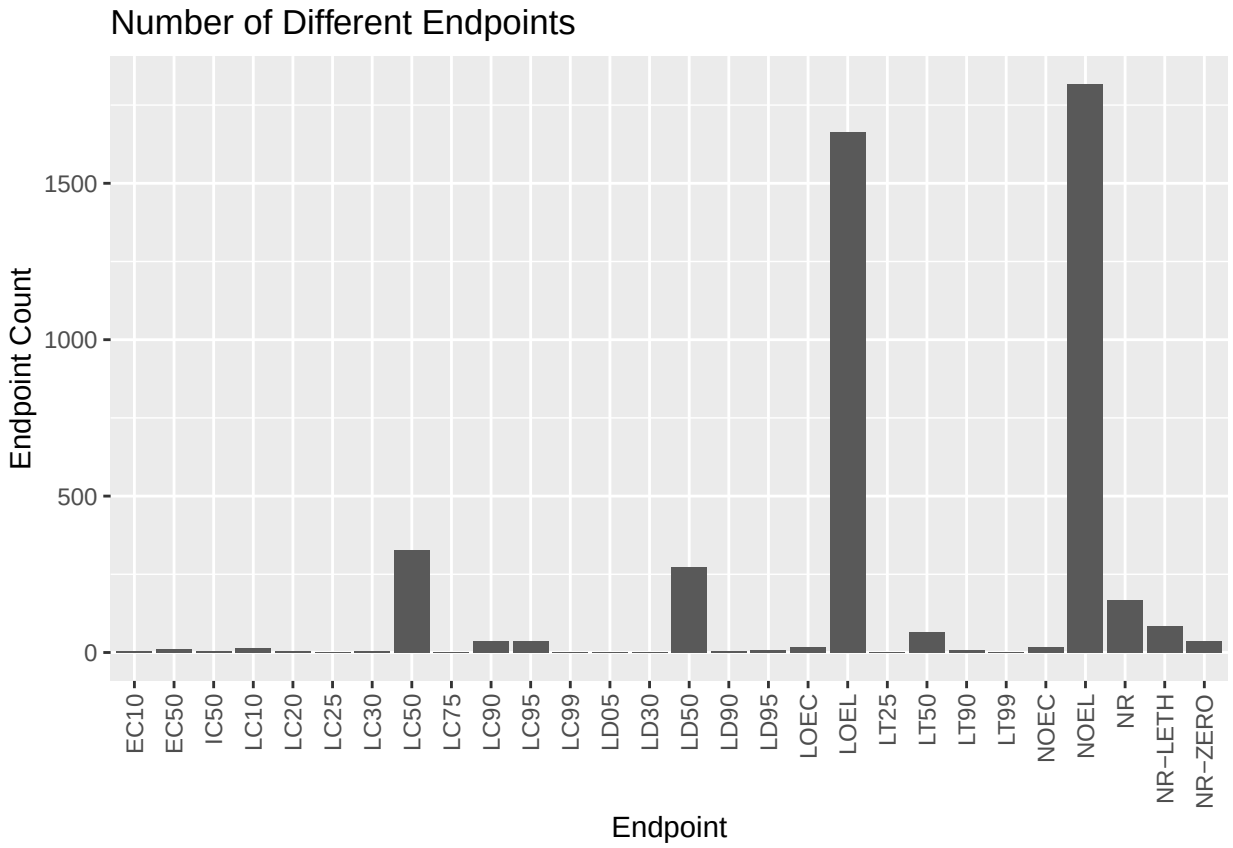
Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer:The most common test locations are lab and natural fields, since they have the most counts of publications throughout the year. There are fluctuations on the number of publications throughtout the year. Test in labs become very prevalent through 2010-2015 and went down from 2015-2020. Number of research on both locations increase gradually from 1980-2010 with a peak of number of publications conducted in natural field at around 2010. The number of publications in natural field then gradually went down after 2010.

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...]

```
#Plot of the number of different Endpoints
ggplot(Neonics, aes(x = Endpoint)) +
  geom_bar() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) +
   labs(y= "Endpoint Count") +
 labs (title = "Number of Different Endpoints")
```



Answer:NOEL and LOEL. NOEL is no-observable-effect-level. It means that dose with highest concentration produces effects that is not significantly different from responses of controls according to author's reported statistical test. LOEL is lowest-observable-effect-level. It means that dose with lowest concentration produces effects that is 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.

```
#Determine the class of collectDate
class(Litter$collectDate)
```

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

```
#It is a factor

#Change to date
Litter$collectDate <- as.Date(Litter$collectDate)
class(Litter$collectDate)
```

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

```
#Determine which dates litter was sampled in August 2018
unique(Litter$collectDate)
```

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

```
#It is 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`?

```
#Determine how many plots were sampled at Niwot Ridge
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
```

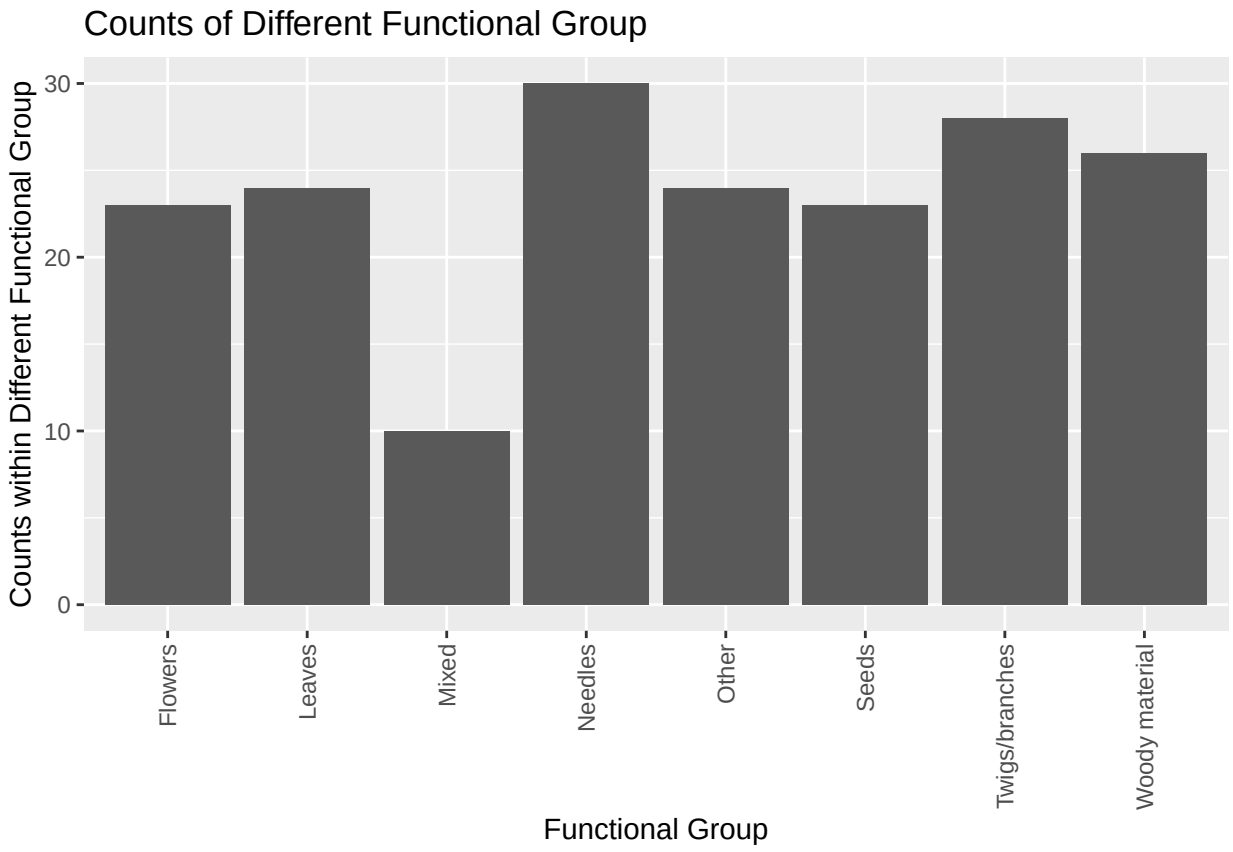
```
summary(Litter$plotID)
```

```
## 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: 12 plots were sampled. Unique function gives you the number of unique values and what they are. Summary function gives use the unique vlaues with the number count of each value in the dataset.

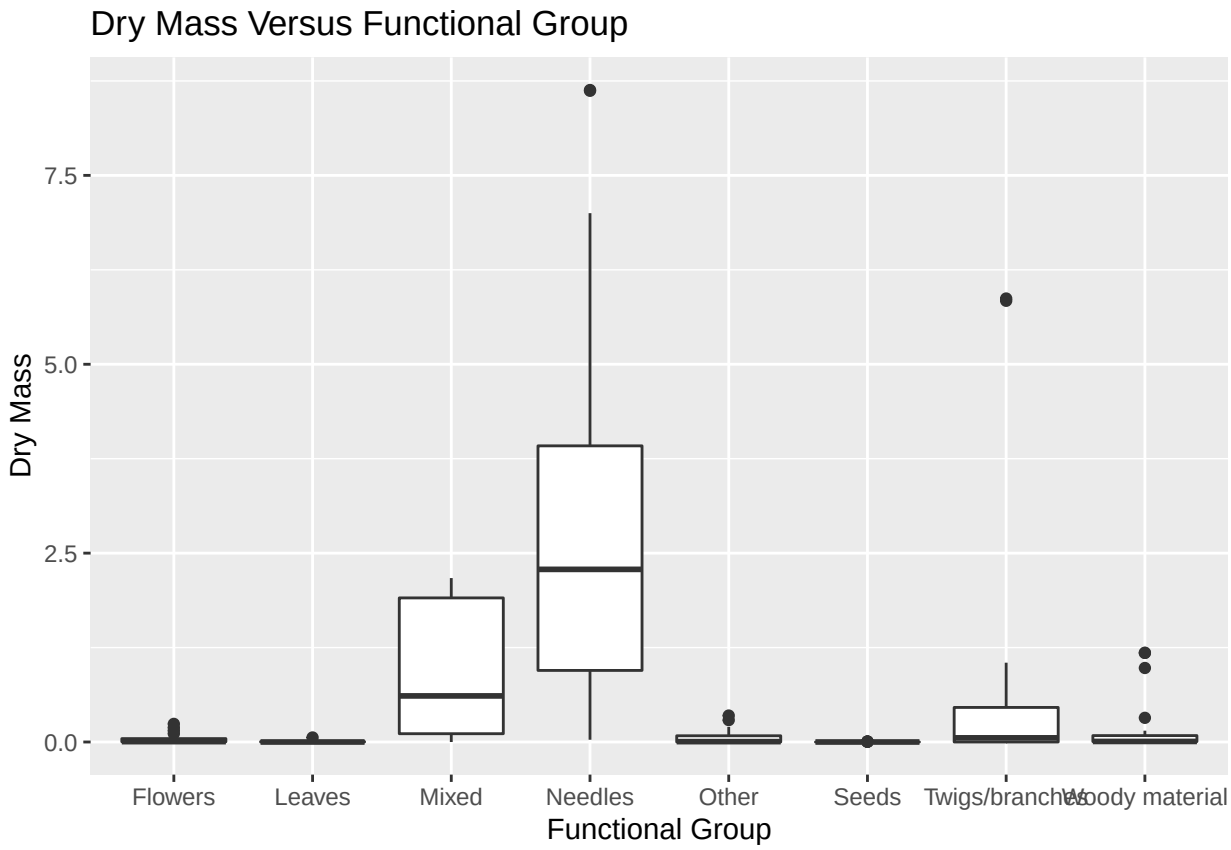
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
#Bar graph of functionalGroup
ggplot(Litter, aes(x = functionalGroup)) +
  geom_bar() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) +
  labs(y= "Counts within Different Functional Group", x = "Functional Group") +
  labs (title = "Counts of Different Functional Group")
```



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

```
#Boxplot of dryMass by functionalGroup
ggplot(Litter) +
  geom_boxplot(aes(x = functionalGroup, y = dryMass)) +
  labs(y= "Dry Mass", x = "Functional Group") +
  labs (title = "Dry Mass Versus Functional Group")
```

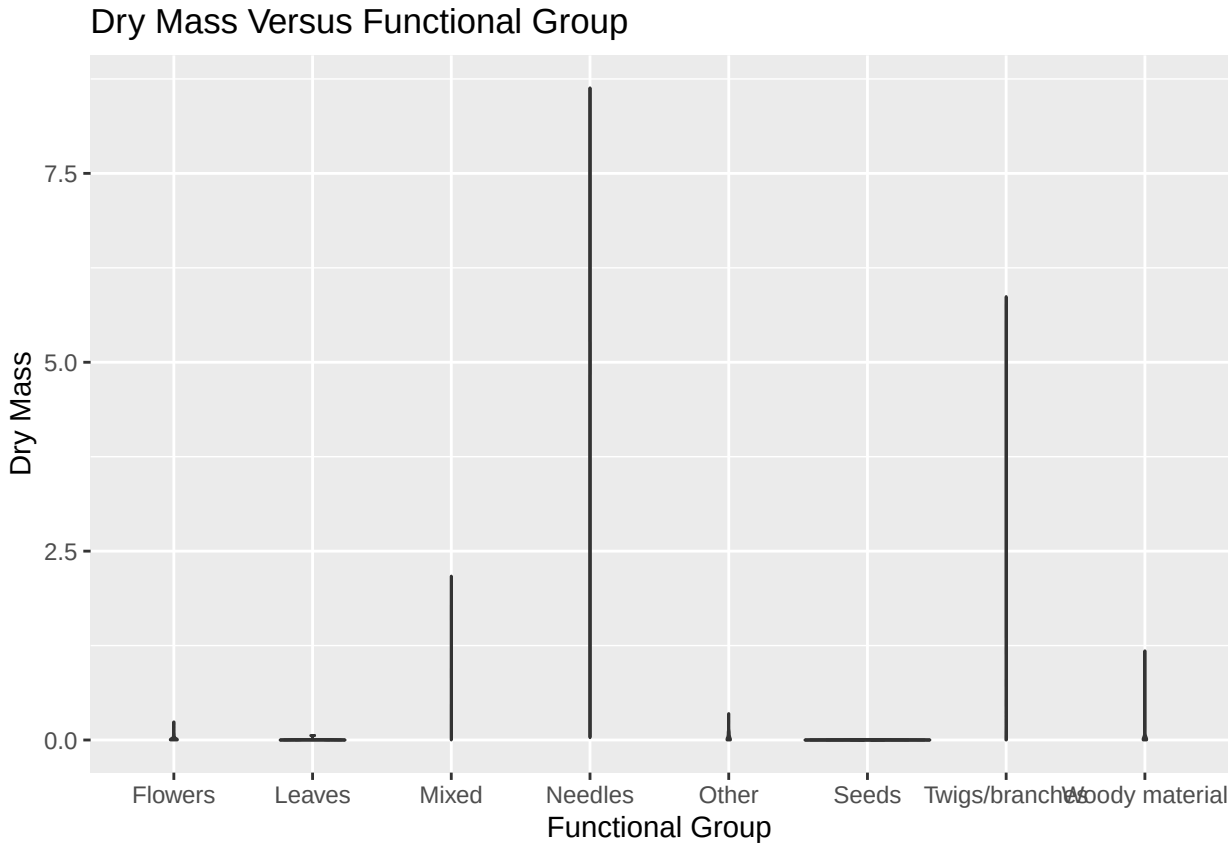



```
#Violin plot of dryMass by functionalGroup
ggplot(Litter) +
  geom_violin(aes(x = functionalGroup, y = dryMass),
              draw_quantiles = c(0.25, 0.5, 0.75)) +
  labs(y= "Dry Mass", x = "Functional Group") +
  labs (title = "Dry Mass Versus Functional Group")
```

```
## Warning in regularize.values(x, y, ties, missing(ties), na.rm = na.rm):
## collapsing to unique 'x' values

## Warning in regularize.values(x, y, ties, missing(ties), na.rm = na.rm):
## collapsing to unique 'x' values

## Warning in regularize.values(x, y, ties, missing(ties), na.rm = na.rm):
## collapsing to unique 'x' values
```



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

> Answer:The data in each category is either very concentrated at a certain value or very distributed (the values are spread out and not repeating), so the width of the violin plot is either very thin or very wild. Thus, we can not extract effective information from the width of the violin plot. The boxplot on the other hand doesn't use the width to show the number of datapoints. It shows the IQR, median, the range and outliers of the data, which gives the audience a better sense of the actual distribution of the data.

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

> Answer: Needles, mixed, and twigs/branches.