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.

```
#getting working directory
getwd()
```

```
## [1] "/Users/yekhaungoo/Library/CloudStorage/OneDrive-Personal/EDA Class"
```

```
#loading packages
library(tidyverse)
library(lubridate)

#importing dataset
```

```r
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)
#View(Neonics)
#View(Litter)
```

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: Neonicotinoids are considered systemic pesticides and kill all insects indiscrimately. Insects such as bees and butterflies are crucial for the ecosystem maintaining healthy soil, recycling nutrients and pollinating flowers. Without the insects, our food security is severely threatened.

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: Litter and woody debris help decompose organic materials, sending nutrients back into the food chain. Litter and woody debris are also a source of energy for aquatic ecosystems, and help release carbon dioxide slowly into the atmosphere.

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 - executed at terrestrial NEON sites that contain woody vegetation >2m tall. 2. Temporal Sampling Design - ground traps sampled once every year. Elevated traps varies by vegetation present at site. 3. Users are advised to leverage data from vegetation structure to provide context to litter data.

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```r
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?

```r
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: Most common effects observed are population and mortality.These effects are critical to understand the population change in insect groups since insects have profound ecological significance in terrestrial ecosystems.

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
specs_sum <- summary(Neonics$Species.Common.Name)
sorted_specs_sum <- sort(specs_sum, decreasing = TRUE)
sorted_specs_sum
```

```
##                             (Other)                           Honey Bee
##                                 670                                 667
##                      Parasitic Wasp               Buff Tailed Bumblebee
##                                 285                                 183
##                 Carniolan Honey Bee                          Bumble Bee
##                                 152                                 140
##                    Italian Honeybee                     Japanese Beetle
##                                 113                                  94
##                   Asian Lady Beetle                     Euonymus Scale
##                                  76                                  75
##                            Wireworm                  European Dark Bee
##                                  69                                  66
##                   Minute Pirate Bug                 Asian Citrus Psyllid
##                                  62                                  60
##                      Parastic Wasp               Colorado Potato Beetle
##                                  58                                  57
##                     Parasitoid Wasp                  Erythrina Gall Wasp
##                                  51                                  49
##                       Beetle Order       Snout Beetle Family, Weevil
##                                  47                                  47
##              Sevenspotted Lady Beetle                       True Bug Order
##                                  46                                  45
##                 Buff-tailed Bumblebee                        Aphid Family
##                                  39                                  38
##                      Cabbage Looper                 Sweetpotato Whitefly
##                                  38                                  37
```

```
##                  Braconid Wasp                      Cotton Aphid
##                             33                                33
##                 Predatory Mite           Ladybird Beetle Family
##                             33                                30
##                    Parasitoid                     Scarab Beetle
##                             30                                29
##                  Spring Tiphia                      Thrip Order
##                             29                                29
##           Ground Beetle Family                Rove Beetle Family
##                             27                                27
##                  Tobacco Aphid                      Chalcid Wasp
##                             27                                25
##        Convergent Lady Beetle                     Stingless Bee
##                             25                                25
##             Spider/Mite Class               Tobacco Flea Beetle
##                             24                                24
##              Citrus Leafminer                   Ladybird Beetle
##                             23                                23
##                     Mason Bee                          Mosquito
##                             22                                22
##                 Argentine Ant                            Beetle
##                             21                                21
##     Flatheaded Appletree Borer              Horned Oak Gall Wasp
##                             20                                20
##             Leaf Beetle Family                 Potato Leafhopper
##                             20                                20
##     Tooth-necked Fungus Beetle                      Codling Moth
##                             20                                19
##      Black-spotted Lady Beetle                      Calico Scale
##                             18                                18
##           Fairyfly Parasitoid                       Lady Beetle
##                             18                                18
##        Minute Parasitic Wasps                         Mirid Bug
##                             18                                18
##              Mulberry Pyralid                          Silkworm
##                             18                                18
##                Vedalia Beetle             Araneoid Spider Order
##                             18                                17
##                     Bee Order                    Egg Parasitoid
##                             17                                17
##                  Insect Class           Moth And Butterfly Order
##                             17                                17
## Oystershell Scale Parasitoid Hemlock Woolly Adelgid Lady Beetle
##                             17                                16
##          Hemlock Wooly Adelgid                              Mite
##                             16                                16
##                   Onion Thrip             Western Flower Thrips
##                             16                                15
##                  Corn Earworm                 Green Peach Aphid
##                             14                                14
##                     House Fly                         Ox Beetle
##                             14                                14
##             Red Scale Parasite                Spined Soldier Bug
##                             14                                14
```

```
##                Armoured Scale Family                        Diamondback Moth
##                                   13                                      13
##                        Eulophid Wasp                       Monarch Butterfly
##                                   13                                      13
##                        Predatory Bug                   Yellow Fever Mosquito
##                                   13                                      13
##                   Braconid Parasitoid                           Common Thrip
##                                   12                                      12
##       Eastern Subterranean Termite                                    Jassid
##                                   12                                      12
##                           Mite Order                               Pea Aphid
##                                   12                                      12
##                     Pond Wolf Spider                Spotless Ladybird Beetle
##                                   12                                      11
##               Glasshouse Potato Wasp                                Lacewing
##                                   10                                      10
##              Southern House Mosquito                Two Spotted Lady Beetle
##                                   10                                      10
##                           Ant Family                            Apple Maggot
##                                    9                                       9
```

Answer: Six most commonly studied species are honey bee, parasitic wasp, buff tailed bumblebee, carniolan honey bee and bumble bee. Bees are important pollinators contributing directly to food security. UN Environment Program stated bees are responsible for 75 percent of our food chain. Parasitic wasp helps control agricultural pests.

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?

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

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

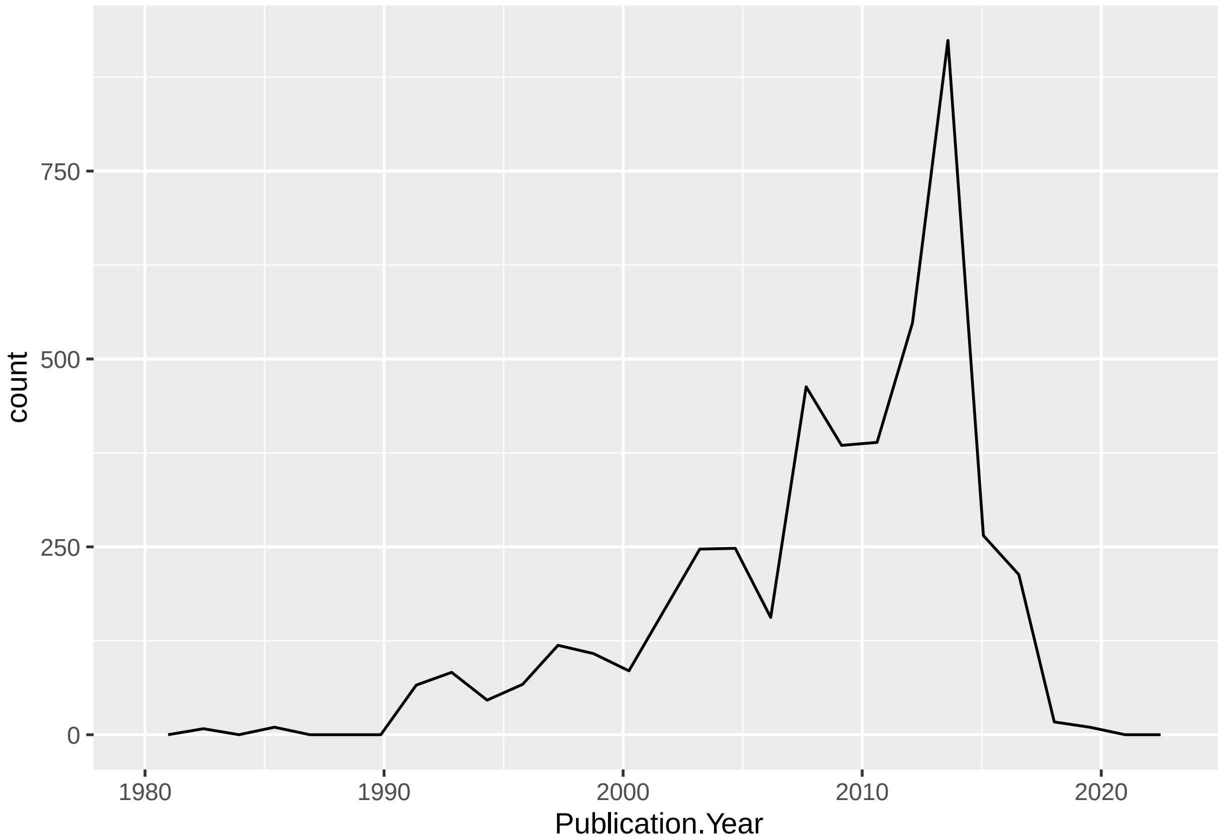
Answer: `Conc.1..Author.` column returns 'factor' class. It is not numeric because of the symbols such as '/' and '<'.

Explore your data graphically (Neonics)

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

```r
ggplot(Neonics) +
  geom_freqpoly(aes(x=Publication.Year),bins=30) +
  scale_x_continuous(limits = c(1980,2023))
```

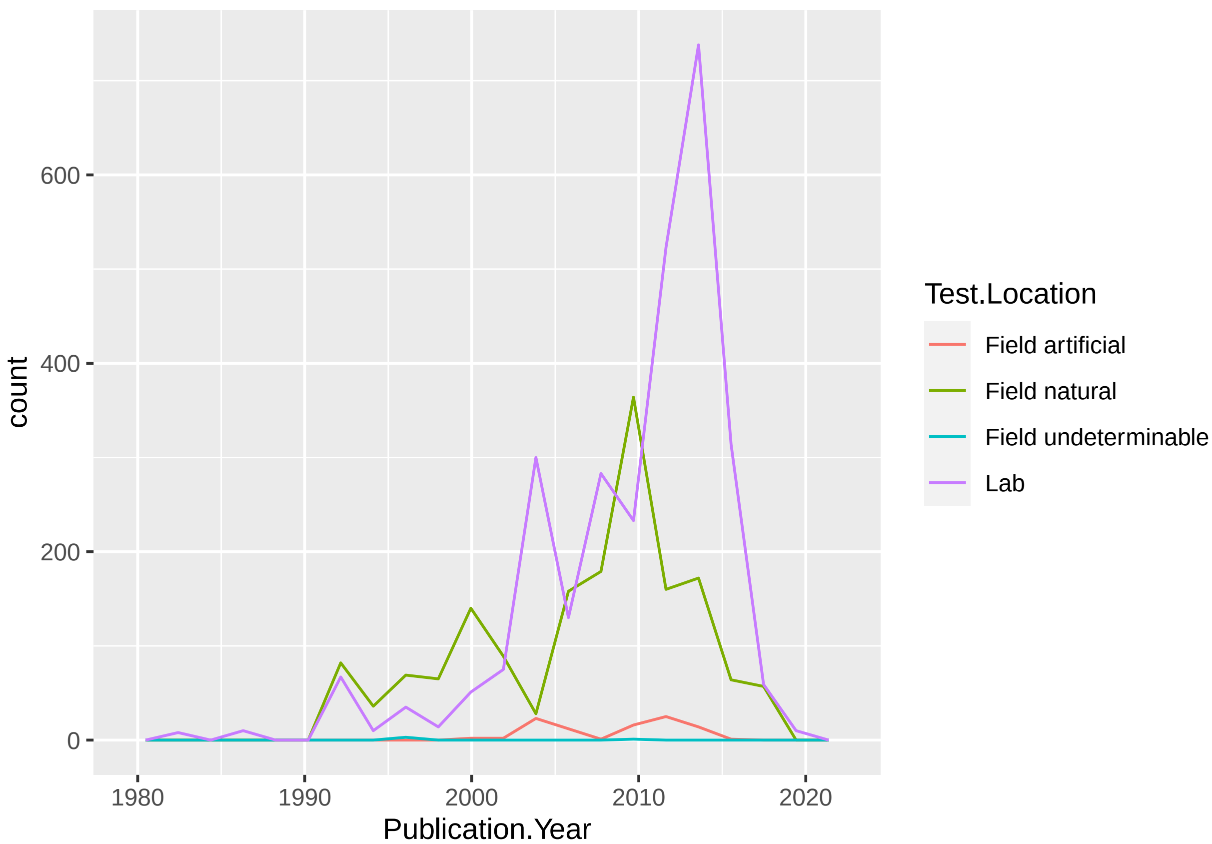
```
## Warning: Removed 3 rows containing missing values ('geom_path()').
```



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

```
#ggplot(Neonics, aes(x=Test.Location, fill=Test.Location)) +
  #geom_bar()

ggplot(Neonics, aes(x=Publication.Year, color=Test.Location)) +
  geom_freqpoly(bins=20)
```



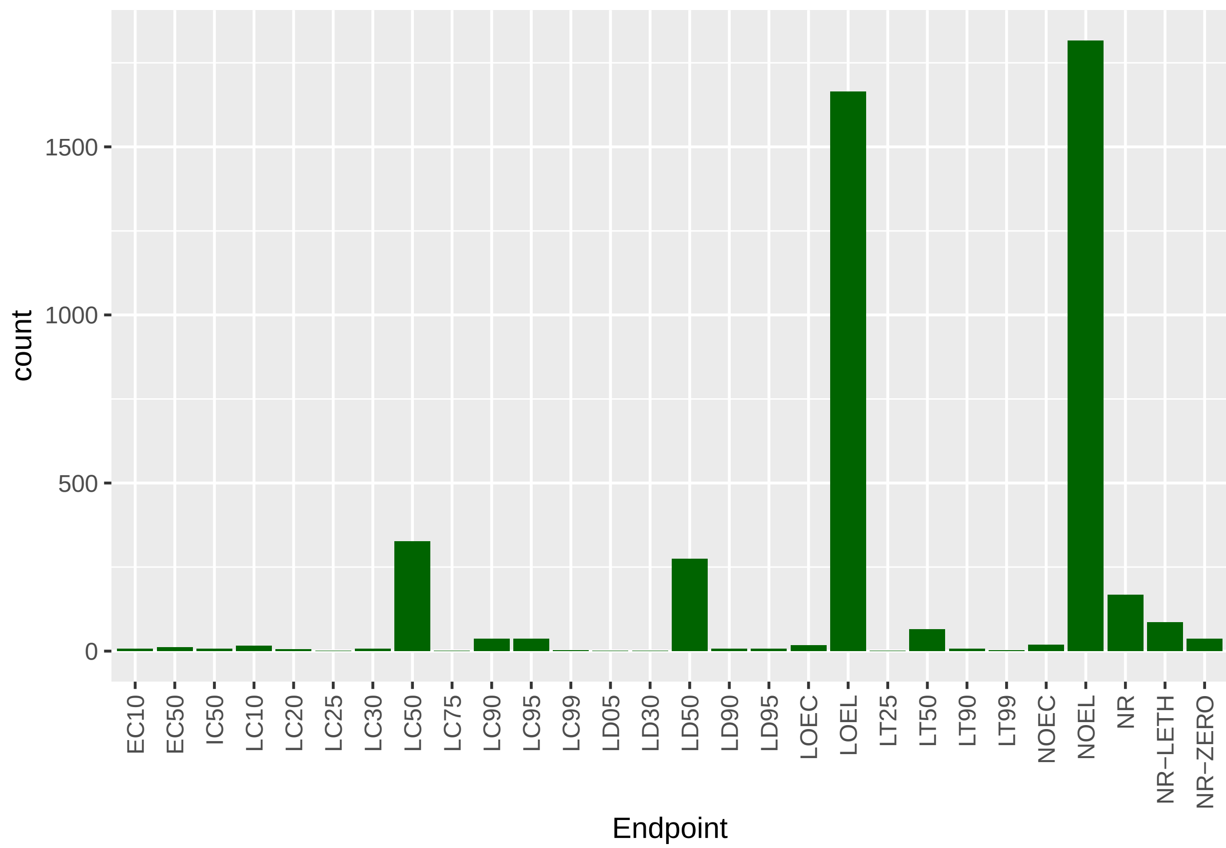
Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer: Most common test locations are Lab and Field Natural. Before the early 2000s, it seems like test locations used to be done on the natural fields. The lab environment must have been siginificantly improved with new technology after the early 2000s, and therefore most test locations have shifted to the lab.

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)) +
  geom_bar(fill="darkgreen") +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```



Answer: The two most common endpoints are NOEL and LOEL. NOEL is short for 'No-observable-effect-level' and LOEL is short for 'lowest-observable-effect-level'.

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"
```

```
Litter$collectDate
```

```
##   [1] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##   [6] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [11] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [16] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
```

```
##  [21] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [26] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [31] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [36] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [41] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [46] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [51] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [56] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [61] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [66] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [71] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [76] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [81] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [86] "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02" "2018-08-02"
##  [91] "2018-08-02" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
##  [96] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [101] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [106] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [111] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [116] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [121] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [126] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [131] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [136] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [141] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [146] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [151] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [156] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [161] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [166] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [171] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [176] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [181] "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30" "2018-08-30"
## [186] "2018-08-30" "2018-08-30" "2018-08-30"
```

```r
unique_dates <- unique(Litter$collectDate)
august_dates <- unique_dates[month(unique_dates) == 8 & year(unique_dates) == 2018]
august_dates
```

```
## [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_plots <- unique(Litter$plotID)
length(unique_plots)
```

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

```r
unique_plots
```

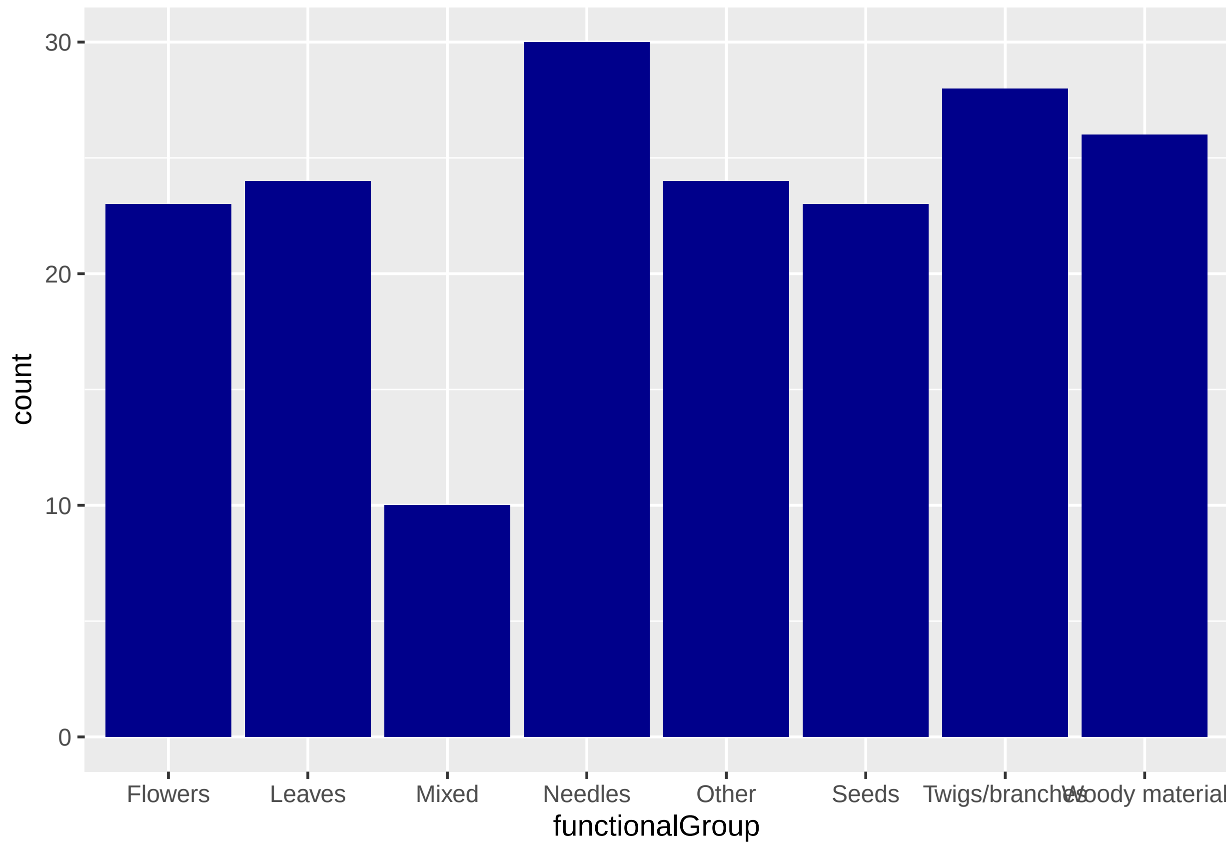
```
##  [1] NIWO_061 NIWO_064 NIWO_067 NIWO_040 NIWO_041 NIWO_063 NIWO_047 NIWO_051
```

```
##  [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: Unique function looks for duplicates and eliminates those to return unique values with particular counts. Summary function returns descriptive analysis such as mean, medium, mode, etc.

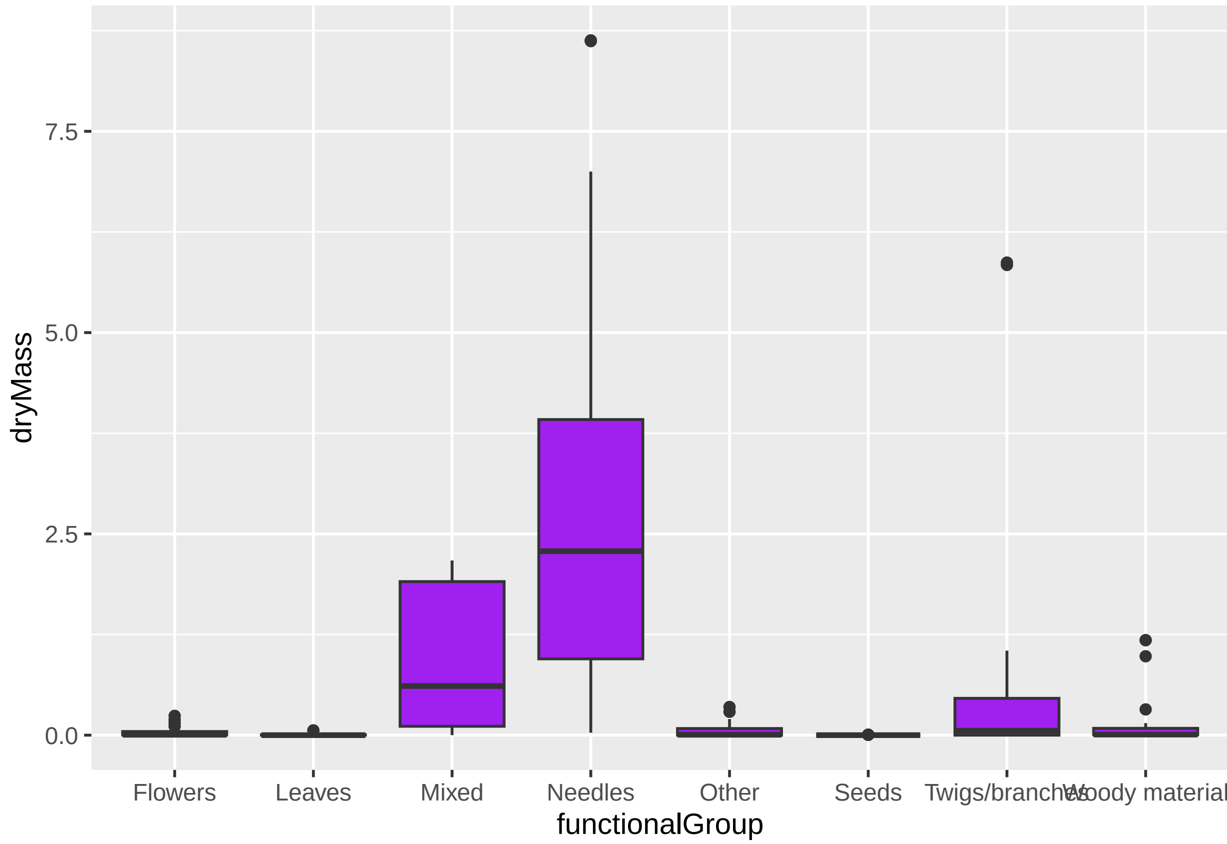
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
ggplot(Litter, aes(x=functionalGroup)) +
  geom_bar(fill="darkblue")
```

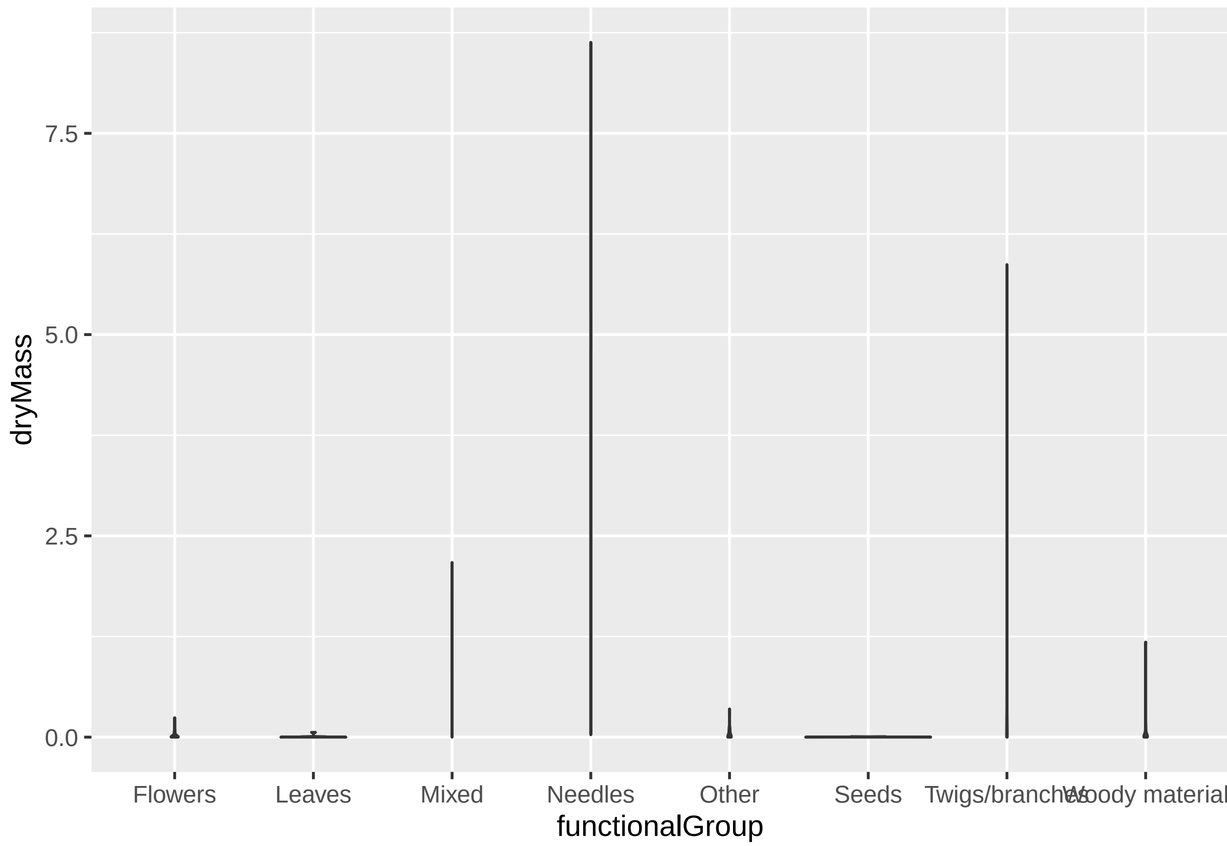


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```
ggplot(Litter, aes(x=functionalGroup, y=dryMass)) +
  geom_boxplot(fill="purple")
```




```
ggplot(Litter, aes(x=functionalGroup, y=dryMass)) +
  geom_violin(fill="orange")
```



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

> Answer: The dataset is small and therefore the violin plot is having difficulties showing the data distribution in each category.

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

> Answer: Needles tend to have the highest biomass.