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 Canvas.

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. Load necessary packages (tidyverse, lubridate, here), check your current working directory 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.

```r
#Noting down codes to install packages
#install.packages("tidyverse");
#install.packages("lubridate");
#install.packages("here")

#Loading necessary packages (tidyverse, lubridate, here)
library (tidyverse)
library (lubridate)
library (here)
```

```
## Warning: package 'here' was built under R version 4.3.3
```

```r
#Checking working directory is the project folder
here ()
```

```
## [1] "/Users/xuchunyi/Desktop/EDA_Spring2025/EDA_Spring2025"
```

```r
#Uploading the ECOTOX neonicotinoid dataset
Neonics <- read.csv(
  file = here("./Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv"),
  stringsAsFactors = TRUE)

#Uploading the Niwot Ridge NEON dataset for litter and woody debris
Litter <- read.csv(
  file = here("./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:The ecotoxicology of neonicotinoids on insects helps us better understand their ecological impacts. Although neonicotinoid insecticides were introduced because their relatively lower toxicity than other older insecticides, recent research has indicated that their environmental impact may also be devastating. Neonicotinoid can have harmful consequences for benefical insects, pollinator, and aquatic invertebrates. Source: https://www.xerces.org/pesticides/understanding-neonicotinoids#:~:text=While%20they%20were%20initially%20introduced,beneficial%20insects%2C%20and%20aquati

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 are essential components of forest and stream ecosystems. They are involved in the nutrient cycling and carbon budgets process, serving as a source of energy for aquatic ecosystems and providing habitat for aquatic and terrestrial organisms. They also influence the ecosystem's structure and roughness and could potentially change sediment transport and water flows. Source: https://research.fs.usda.gov/treesearch/20001

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 woody debris is sampled at terrestrial NEON sites that contain woody vegetation >2m tall. 2.The sampling plot's centers should be 50m from buildings and other non-NEON infrastructure. 3. The placement of litter traps within the plots may be either targeted or randomized, depending on the vegetation. For example, in sites with more than 50% aerial cover of woody vegetation >2m in height, the trap placement is randomized. In sites with less than 50% cover of woody vegetation and distributed vegetation, the placement is targeted.

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
#Checking the dimensions of the dataset Neonics. It has 4623 rows and 30 columns.
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? [Tip: The `sort()` command is useful for listing the values in order of magnitude...]

```
# Creating a new dataframe "Effect_Summary" for the summary of the "Effect" column
Effect_Summary <- summary (Neonics$Effect)
# Viewing the new dataframe "Effect_Summary"
print (Effect_Summary)
```

```
##     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
```

```
# Sorting the new dataframe "Effect_Summary" in order of magnitude
sort (Effect_Summary)
```

```
##       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 top six effects that are studied are Population, Mortality, Behavior, Feeding behavior, Reproduction, and Development. These effects are studied because they have a more significant impact on the biodiversity of an ecosystem than other impacts. For example, population is essential to maintaining habitat diversity, sustaining the balance of the food chain, and controlling the carbon cycle. However, studies have found that the use of neonicotinoids leads to increased population extinction rates. Therefore, mortality is worth investigating, too, as it is closely linked to the population of a species. Animal behavior, including feeding behavior, can potentially change ecosystem dynamics, so this topic becomes specifically of interest, too. Animal behavior is critical to delivering ecosystem services, which determine the material benefits people receive, such as food and fuel, and the regulating benefits, such as climate regulation and flood control. Source: https://www.noble.org/regenerative-agriculture/wildlife/top-5-considerations-for-increasing-wildlife-diversity/ https://environment.yale.edu/news/article/protecting-wildlife-populations-can-enhance-natural-capture-capture https://www.sciencedirect.com/science/article/abs/pii/S0169534722002762 https://aithor.com/essay-examples/an-analysis-of-the-impact-of-feeding-habits-on-animal-behavior-and-ecosystems#3-the-ecological-consequences-of-feeding-habits

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: Explore the help on the `summary()` function, in particular the `maxsum` argument…]

```
# Creating a new dataframe "Effect_Species.Common.Name" for the summary of the "Effect" column
Effect_Species.Common.Name <- summary (Neonics$Species.Common.Name)
# Viewing the new dataframe "Effect_Species.Common.Name"
print (Effect_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
```

```
# Sorting the new dataframe "Effect_Species.Common.Name" in order of occurrence
sort (Effect_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 in the dataset are Honey Bee, Parasitic Wasp, Buff Tailed Bumblebee, Carniolan Honey Bee, Bumble Bee, and Italian Honeybee. These species are all bees. Bees are the primary pollinators in the ecosystem. They play important roles in maintaining and improving biodiversity by transporting flower pollen and fertilizing plants and have an impact on other insects, animals, and plants. Therefore, they are vital in sustaining the global food supply and a healthy ecosystem. However, a significant amount of studies indicate that neonics usage is a leading cause of massive bee die-offs around the world. Source: https://greenly.earth/en-us/blog/ecology-news/why-are-bees-so-important-for-people-and-the-environment https://www.nrdc.org/stories/neonicotinoids-101-effects-humans-and-bees

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? [Tip: Viewing the dataframe may be helpful…]

```r
#Figuring out the class of "Conc.1..Author", and the class is "factor"
class (Neonics$Conc.1..Author)
```

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

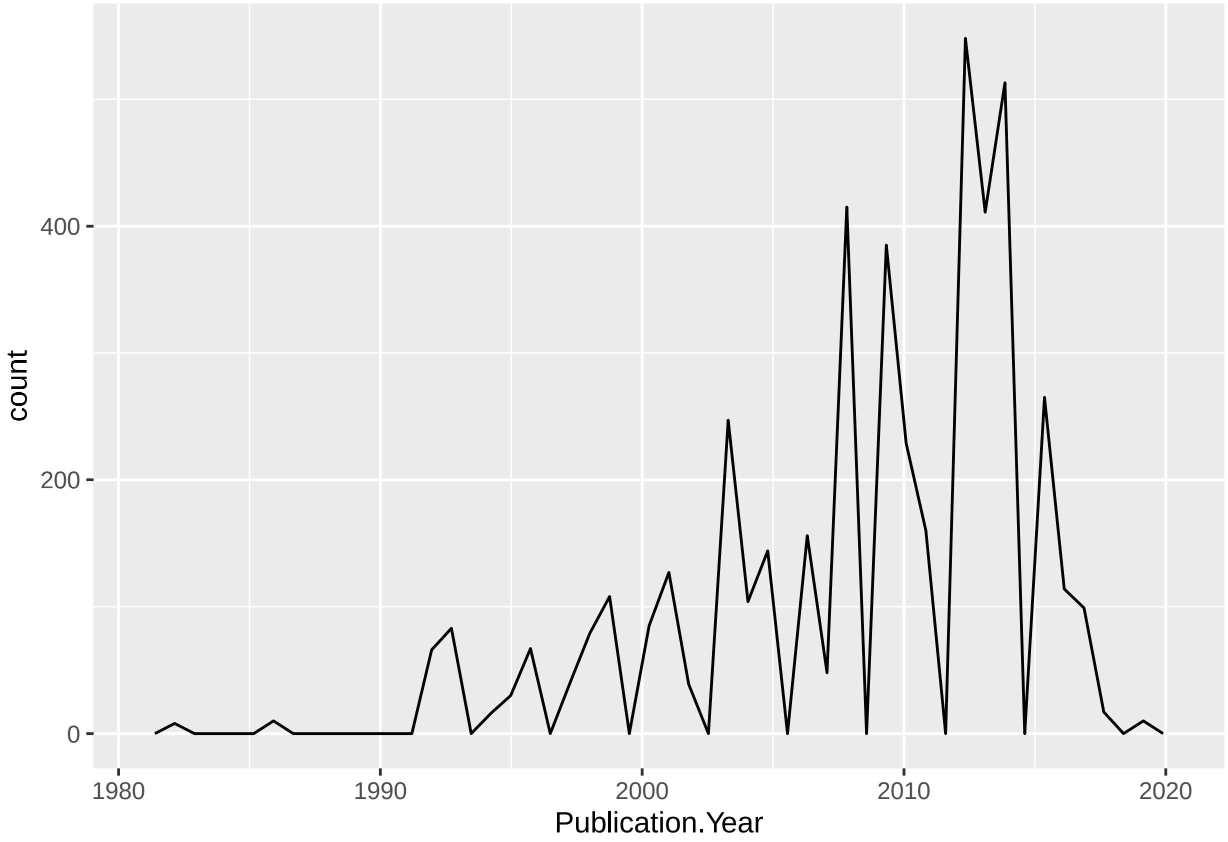
```r
#Viewing the dataframe
#View (Neonics)
#View(Neonics$Conc.1..Author)
```

> Answer: The class of 'Conc.1..Author' is factor. By viewing the entire dataframe Neonics, the entries in the column "Conc.1..Author" includes both values and symbols "/," becoming string variables. When we uploaded the dataset, we read strings variables in as factors. Therefore, the column "Conc.1..Author" is classified as factor. Meanwhile, by viewing the column "Conc.1..Author" separately, the result also shows that the value for "Conc.1..Author" are non-numeric but are factors with 1006 levels <0.0004 <0.025 <0.088 <0.5 <1.5 <10/ <2.5/ <4.00 <5.00 <8.79 … NR/.

Explore your data graphically (Neonics)

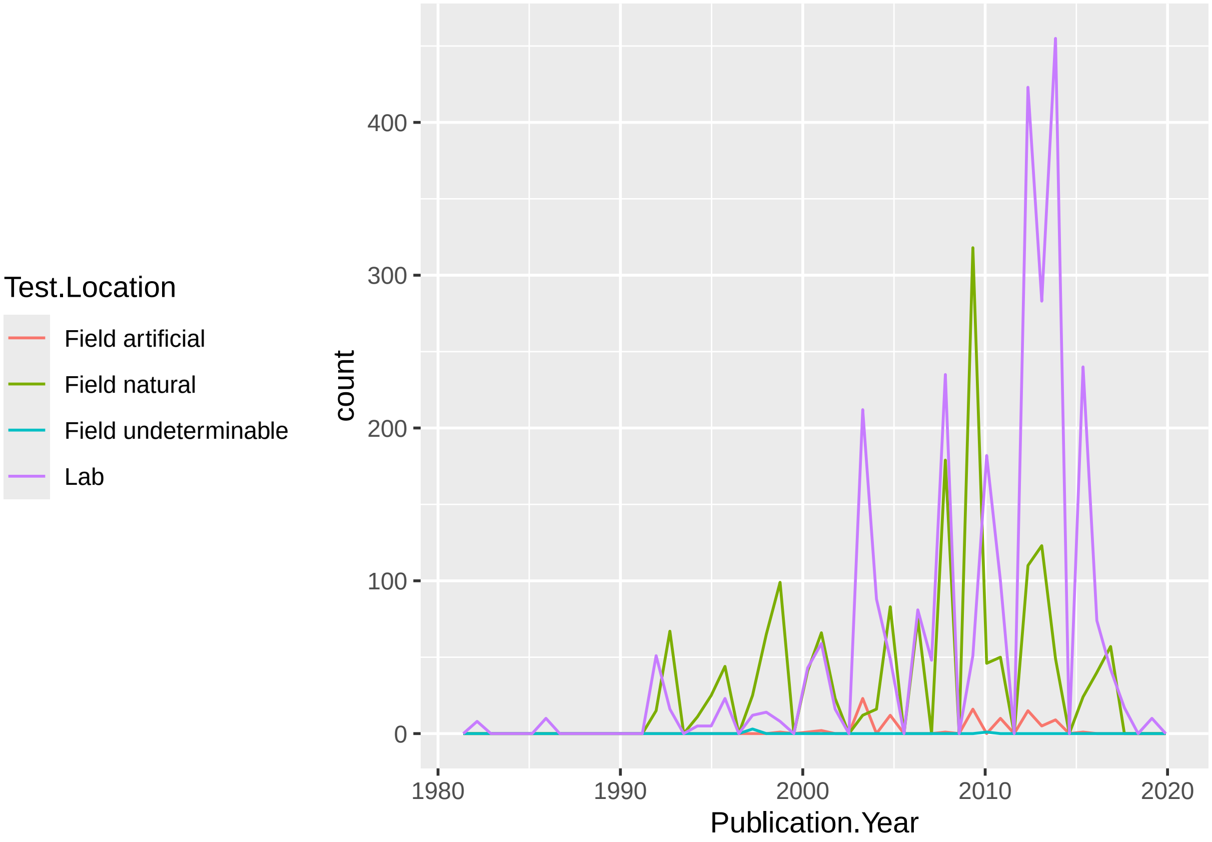
9. Using `geom_freqpoly`, generate a plot of the number of studies conducted by publication year.

```r
#Generating a plot for the number of studies conducted by publication year by using the dataset Neonics
ggplot(Neonics) +
geom_freqpoly(aes(x = Publication.Year), bins = 50)
```



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

```
# Reproducing the same graph but adding a color aesthetic according to the variable Test.Location
ggplot(Neonics) +
geom_freqpoly(aes(x = Publication.Year, color = Test.Location), bins = 50) +
theme(legend.position = "left")
```



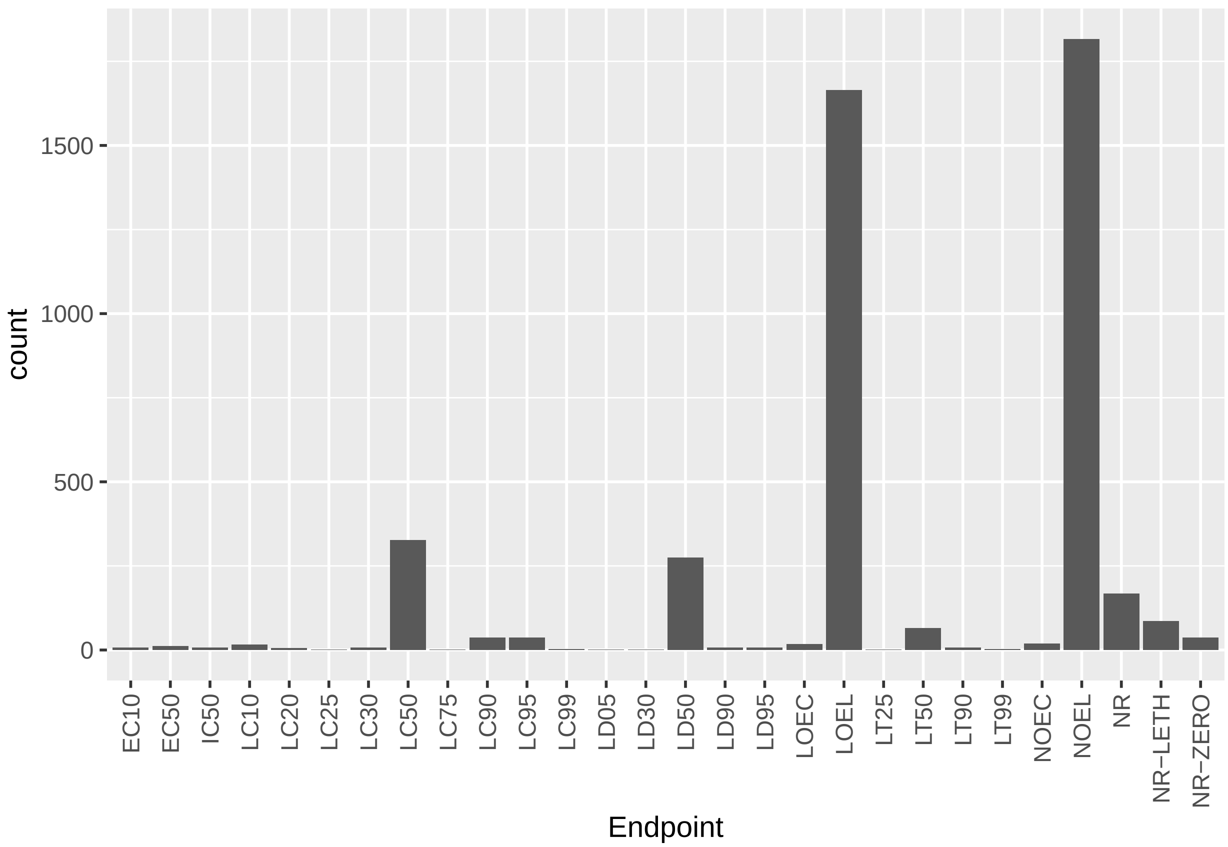
Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer:The most common test location is the Lab. The second common test location is Field Natural. They differ over time. For example, from around 1993 to 2000, and from around 2007 to 2010, Field Nature was a more common test location than Lab. However, from around 2003 to 2005, and from around 2012 to 2020, Lab has become a more common test location than Field Natural. From 2000 to around 2003, both locations were equally common.

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…]

```r
# Creating a bar graph of Endpoint counts and adjusting the X-axis labels
ggplot(Neonics)+
geom_bar(aes(x = Endpoint))+
theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```



Answer: The two most common end points are NOEL and LOEL. LOEL is for the terrestrial database usage. It means lowest-observable-effect-level: lowest dose (concentration) producing effects that were significantly different (as reported by authors) from responses of controls (LOEAL/LOEC). NOEL is for terrestrial database usage too. It means 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).

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.

```
# Determining the class of collectDate, and the result shows that it is not a date.
# It is "factor" instead.
class (Litter$collectDate)
```

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

```
#Changing collectDate to a date
Litter$collectDate <- as.Date(Litter$collectDate, format = "%Y-%m-%d")

#Confirming the new class of collectDate is date
class (Litter$collectDate)
```

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

```
# Determining which dates litter was sampled in August 2018
# The result shows that 2018-08-02 and 2018-08-30 were two dates litter was sampled
unique (Litter$collectDate)
```

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

13. Using the `unique` function, determine how many different plots were sampled at Niwot Ridge. How is the information obtained from `unique` different from that obtained from `summary`?

```
#Using the unique function to determine how many different plots were sampled at Niwot Ridge (NIWO)
# The result is 12
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
```

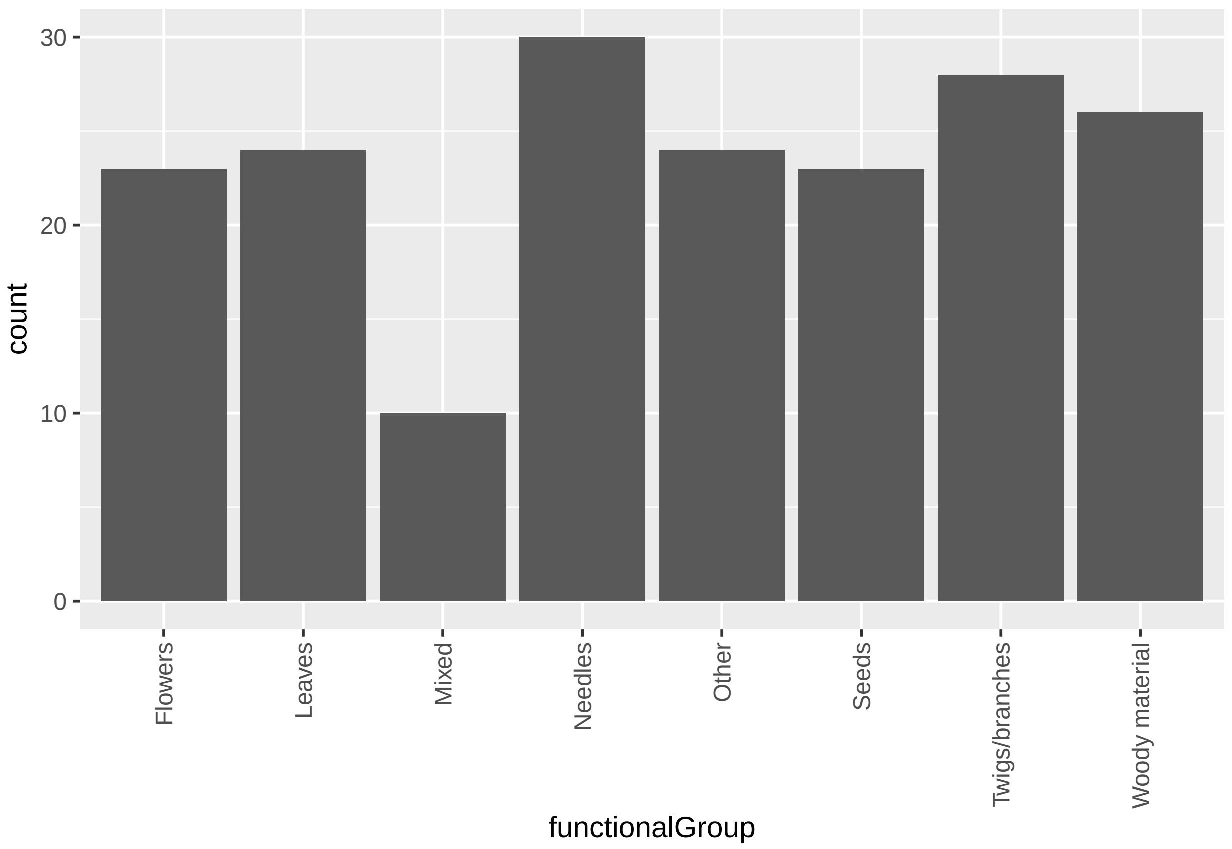
```
# Comparing the result given by the unique function and the summary function
summary (Litter$plotID)
```

```
## 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: There are 12 different plots were sampled at the Niwot Ridge, since there 12 levels in the plotID column. While the information obtained from 'unique' only shows the unique values that one factor can take, the information obtained from 'summary' gives the detailed counts of each unique value.

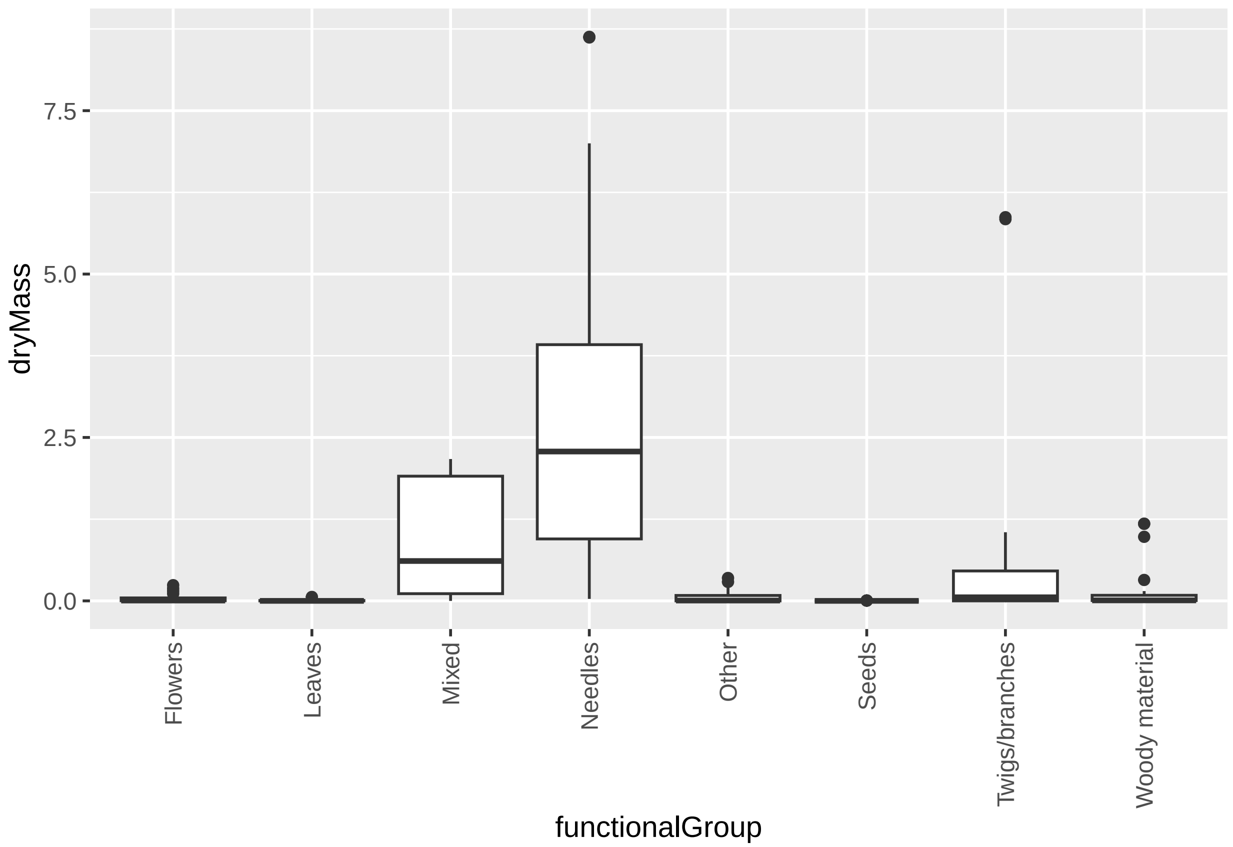
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
# Creating a bar graph of functionalGroup counts and adjusting the X-axis labels
ggplot(Litter)+
geom_bar(aes(x = functionalGroup))+
theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```

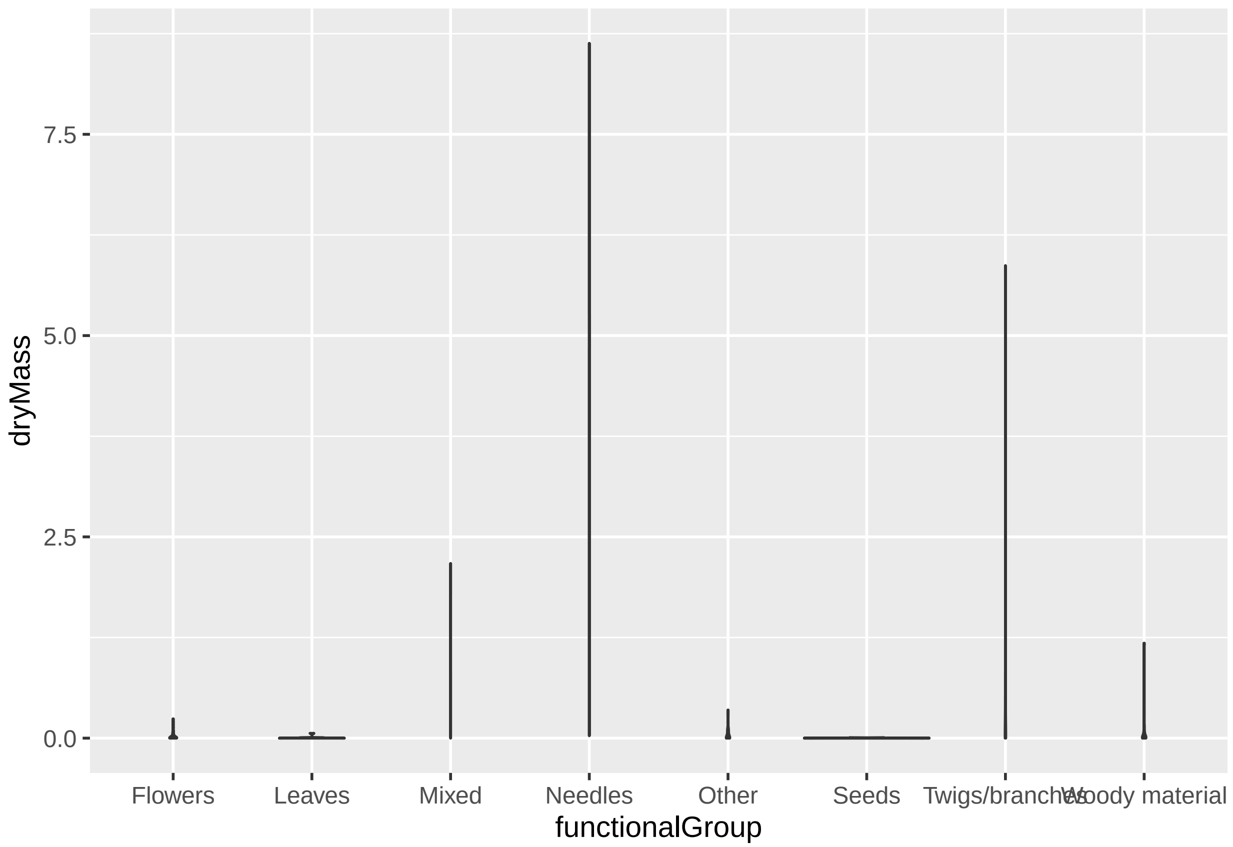


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```
#Creating a boxplot of dryMass by functionalGroup and adjusting the X-axis labels
ggplot(Litter) +
geom_boxplot(aes(x = functionalGroup, y = dryMass))+
theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```



```
#Creating a violin plot of dryMass by functionalGroup and adjusting the X-axis labels
ggplot(Litter) +
geom_violin(aes(x = functionalGroup, y = dryMass),
draw_quantiles = c(0.25, 0.5, 0.75))
```



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

> Answer: The width of the violin plot is proportional to the number of entries in a column, making the plot look like a frequency poly at the same time. However, in this violin plot, the number of entries for the dryMass by functionalGroup is not enough to generate a violin plot with the evident distribution. Therefore, the violin plot is not informative and cannot showcase the median and the interquartile range. However, the boxplot can still showcase all helpful information, such as the median and the interquartile range, regardless of the distribution.

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

> Answer: The Needles and Mixed types of litter tend to have the highest biomass at these sites. This is because they have higher median and higher interquartile range.