Assignment 3: Data Exploration

Sara Diamond, Section #2

OVERVIEW

This exercise accompanies the lessons in Environmental Data Analytics on Data Exploration.

Directions

1. Change "Student Name, Section #" on line 3 (above) with your name and section number.
2. Work through the steps, **creating code and output** that fulfill each instruction.
3. Be sure to **answer the questions** in this assignment document.
4. When you have completed the assignment, **Knit** the text and code into a single PDF file.
5. After Knitting, submit the completed exercise (PDF file) to the dropbox in Sakai. Add your last name into the file name (e.g., "FirstLast_A03_DataExploration.Rmd") prior to submission.

The completed exercise is due on <>.

Set up your R session

1. Check your working directory, load necessary packages (tidyverse), and upload two datasets: the ECOTOX neonicotinoid dataset (ECOTOX_Neonicotinoids_Insects_raw.csv) and the Niwot Ridge NEON dataset for litter and woody debris (NEON_NIWO_Litter_massdata_2018-08_raw.csv). Name these datasets "Neonics" and "Litter", respectively. **Be sure to add the `stringsAsFactors = TRUE` parameter to the function when reading in the CSV files.**

```
getwd() # looking at WD
```

```
## [1] "/Users/saradiamond/Documents/Environmental_Data_Analytics_2022"
```

```
setwd("/Users/saradiamond/Documents/Environmental_Data_Analytics_2022") #setting correct WD
library(tidyverse) # loading packages
library(ggplot2) #loading packages
Neonics <- read.csv("./Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv", stringsAsFactors = TRUE)
#reading in data ecotox file
Litter <- read.csv("./Data/Raw/NEON_NIWO_Litter_massdata_2018-08_raw.csv", stringsAsFactors = TRUE)
#loading in data for litter and woody debris
```

Learn about your system

2. The neonicotinoid dataset was collected from the Environmental Protection Agency's ECOTOX Knowledgebase, a database for ecotoxicology research. Neonicotinoids are a class of insecticides used widely in agriculture. The dataset that has been pulled includes all studies published on insects. Why might we be interested in the ecotoxicologoy of neonicotinoids on insects? Feel free to do a brief internet search if you feel you need more background information.

   Answer:

According to Cornell University's College of Agriculture and Life Sciences, Neonicotinoids are a commonly used insecticide and are very popular in agricultural practices. While they can be less toxic to vertebrates than other insecticides, there is some worry of the effects they might have on pollinators like bees, which are crucial to every ecosystem. It would be important to know the ecotoxicology in order to determine the impacts they might have on these insects and how we can lessen them.

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:

It is important to understand woody debris and litter because it is adds nutrients to the soil of a forest ecosystem as well as plays a role in moisture retention. It can also provide habitats for smaller terrestrial species.

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: * The litter and debris were collected from elevated ground traps * sampling takes place where there woody vegetation >2m tall * Ground traps were sampled one time per year

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
summary(Neonics)
```

```
##    CAS.Number
##  Min.   : 58842209
##  1st Qu.:138261413
##  Median :138261413
##  Mean   :147651982
##  3rd Qu.:153719234
##  Max.   :210880925
##
##                                                                                Chemical.Name
##  (2E)-1-[(6-Chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine                    :2658
##  3-[(2-Chloro-5-thiazolyl)methyl]tetrahydro-5-methyl-N-nitro-4H-1,3,5-oxadiazin-4-imine: 686
##  [C(E)]-N-[(2-Chloro-5-thiazolyl)methyl]-N'-methyl-N''-nitroguanidine                 : 452
##  (1E)-N-[(6-Chloro-3-pyridinyl)methyl]-N'-cyano-N-methylethanimidamide                : 420
##  N''-Methyl-N-nitro-N'-[(tetrahydro-3-furanyl)methyl]guanidine                        : 218
##  [N(Z)]-N-[3-[(6-Chloro-3-pyridinyl)methyl]-2-thiazolidinylidene]cyanamide            : 128
##  (Other)                                                                              :  61
##                                                        Chemical.Grade
##  Not reported                                                :3989
##  Technical grade, technical product, technical formulation: 422
##  Pestanal grade                                              :  93
##  Not coded                                                   :  53
##  Commercial grade                                            :  27
##  Analytical grade                                            :  15
##  (Other)                                                     :  24
##                                                     Chemical.Analysis.Method
##  Measured                                                       : 230
##  Not coded                                                      :  51
##  Not reported                                                   :   5
```

```
## Unmeasured                                                   :4321
## Unmeasured values (some measured values reported in article):  16
##
##
## Chemical.Purity                 Species.Scientific.Name
## NR     :2502   Apis mellifera               : 667
## 25     : 244   Bombus terrestris            : 183
## 50     : 200   Apis mellifera ssp. carnica  : 152
## 20     : 189   Bombus impatiens             : 140
## 70     : 112   Apis mellifera ssp. ligustica: 113
## 75     :  89   Popillia japonica            :  94
## (Other):1287   (Other)                      :3274
##            Species.Common.Name
## Honey Bee            : 667
## Parasitic Wasp       : 285
## Buff Tailed Bumblebee: 183
## Carniolan Honey Bee  : 152
## Bumble Bee           : 140
## Italian Honeybee     : 113
## (Other)              :3083
##                                                       Species.Group
## Insects/Spiders                                              :3569
## Insects/Spiders; Standard Test Species                       :  27
## Insects/Spiders; Standard Test Species; U.S. Invasive Species: 667
## Insects/Spiders; U.S. Invasive Species                       : 360
##
##
##
##    Organism.Lifestage  Organism.Age            Organism.Age.Units
## Not reported:2271     NR     :3851   Not reported        :3515
## Adult       :1222     2      : 111   Day(s)              : 327
## Larva       : 437     3      : 105   Instar              : 255
## Multiple    : 285     <24    :  81   Hour(s)             : 241
## Egg         : 128     4      :  81   Hours post-emergence:  99
## Pupa        :  69     1      :  59   Year(s)             :  64
## (Other)     : 211     (Other): 335   (Other)             : 122
##                   Exposure.Type        Media.Type
## Environmental, unspecified:1599   No substrate:2934
## Food                      :1124   Not reported: 663
## Spray                     : 393   Natural soil: 393
## Topical, general          : 254   Litter      : 264
## Ground granular           : 249   Filter paper: 230
## Hand spray                : 210   Not coded   :  51
## (Other)                   : 794   (Other)     :  88
##               Test.Location  Number.of.Doses       Conc.1.Type..Author.
## Field artificial    :  96   2      :2441    Active ingredient:3161
## Field natural       :1663   3      : 499    Formulation      :1420
## Field undeterminable:   4   5      : 314    Not coded        :  42
## Lab                 :2860   6      : 230
##                             4      : 221
##                             NR     : 217
##                             (Other): 701
## Conc.1..Author. Conc.1.Units..Author.             Effect
## 0.37/  : 208    AI kg/ha  : 575       Population      :1803
```

```
##  10/    : 127    AI mg/L   : 298       Mortality       :1493
##  NR/    : 108    AI lb/acre: 277       Behavior        : 360
##  NR     :  94    AI g/ha   : 241       Feeding behavior: 255
##  1      :  82    ng/org    : 231       Reproduction    : 197
##  1023   :  80    ppm       : 180       Development     : 136
##  (Other):3924    (Other)   :2821       (Other)         : 379
##              Effect.Measurement    Endpoint                 Response.Site
##  Abundance             :1699     NOEL   :1816   Not reported          :4349
##  Mortality             :1294     LOEL   :1664   Midgut or midgut gland:  63
##  Survival              : 133     LC50   : 327   Not coded             :  51
##  Progeny counts/numbers: 120     LD50   : 274   Whole organism        :  41
##  Food consumption      : 103     NR     : 167   Hypopharyngeal gland  :  27
##  Emergence             :  98     NR-LETH:  86   Head                  :  23
##  (Other)               :1176     (Other): 289   (Other)               :  69
##  Observed.Duration..Days.      Observed.Duration.Units..Days.
##  1      : 713            Day(s)              :4394
##  2      : 383            Emergence           :  70
##  NR     : 355            Growing season      :  48
##  7      : 207            Day(s) post-hatch   :  20
##  3      : 183            Day(s) post-emergence:  17
##  0.0417 : 133            Tiller stage        :  15
##  (Other):2649            (Other)             :  59
##                                                                          Author
##  Peck,D.C.                                                                 : 208
##  Frank,S.D.                                                                : 100
##  El Hassani,A.K., M. Dacher, V. Gary, M. Lambin, M. Gauthier, and C. Armengaud:  96
##  Williamson,S.M., S.J. Willis, and G.A. Wright                             :  93
##  Laurino,D., A. Manino, A. Patetta, and M. Porporato                       :  88
##  Scholer,J., and V. Krischik                                               :  82
##  (Other)                                                                   :3956
##  Reference.Number
##  Min.   :   344
##  1st Qu.:108459
##  Median :165559
##  Mean   :142189
##  3rd Qu.:168998
##  Max.   :180410
##
##
##  Long-Term Effects of Imidacloprid on the Abundance of Surface- and Soil-Active Nontarget Fauna in Tu
##  Reduced Risk Insecticides to Control Scale Insects and Protect Natural Enemies in the Production and
##  Effects of Sublethal Doses of Acetamiprid and Thiamethoxam on the Behavior of the Honeybee (Apis mel
##  Exposure to Neonicotinoids Influences the Motor Function of Adult Worker Honeybees
##  Toxicity of Neonicotinoid Insecticides on Different Honey Bee Genotypes
##  Chronic Exposure of Imidacloprid and Clothianidin Reduce Queen Survival, Foraging, and Nectar Storin
##  (Other)
##                                           Source     Publication.Year
##  Agric. For. Entomol.11(4): 405-419          : 200   Min.   :1982
##  Environ. Entomol.41(2): 377-386             : 100   1st Qu.:2005
##  Arch. Environ. Contam. Toxicol.54(4): 653-661:  96   Median :2010
##  Ecotoxicology23:1409-1418                   :  93   Mean   :2008
##  Bull. Insectol.66(1): 119-126               :  88   3rd Qu.:2013
##  PLoS One9(3): 14 p.                         :  82   Max.   :2019
##  (Other)                                     :3964
```

```
##  Summary.of.Additional.Parameters
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingre
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingre
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingre
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingre
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingre
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Formulation 
##  (Other)
```

```r
#summary of the entire dataset
dim(Neonics)
```

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

```r
#finding the number of rows and columns
```

Answer:

There are 4623 rows and 30 columns in this dataset.

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
```

```r
#looking specifically at the effects column
```

Answer:

The most common effects are population, mortality, behavior, feeding behavior, and reproduction. These might be the most interesting to look at because some are major parts of life stages and if they are having negative effects then it also may be having impacts on other areas as well and on other animal and plant species besides pollinators.

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.

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

```
##                            Honey Bee                       Parasitic Wasp 
##                                  667                                  285 
##                 Buff Tailed Bumblebee                  Carniolan Honey Bee 
##                                  183                                  152 
##                           Bumble Bee                    Italian Honeybee 
##                                  140                                  113 
##                       Japanese Beetle                    Asian Lady Beetle 
##                                   94                                   76 
##                       Euonymus Scale                             Wireworm
```

```
##                               75                                69 
##                 European Dark Bee                 Minute Pirate Bug 
##                               66                                62 
##              Asian Citrus Psyllid                     Parastic Wasp 
##                               60                                58 
##            Colorado Potato Beetle                   Parasitoid Wasp 
##                               57                                51 
##               Erythrina Gall Wasp                      Beetle Order 
##                               49                                47 
##      Snout Beetle Family, Weevil        Sevenspotted Lady Beetle 
##                               47                                46 
##                   True Bug Order             Buff-tailed Bumblebee 
##                               45                                39 
##                     Aphid Family                    Cabbage Looper 
##                               38                                38 
##              Sweetpotato Whitefly                     Braconid Wasp 
##                               37                                33 
##                     Cotton Aphid                    Predatory Mite 
##                               33                                33 
##            Ladybird Beetle Family                        Parasitoid 
##                               30                                30 
##                     Scarab Beetle                     Spring Tiphia 
##                               29                                29 
##                       Thrip Order              Ground Beetle Family 
##                               29                                27 
##                Rove Beetle Family                     Tobacco Aphid 
##                               27                                27 
##                      Chalcid Wasp          Convergent Lady Beetle 
##                               25                                25 
##                     Stingless Bee                Spider/Mite Class 
##                               25                                24 
##               Tobacco Flea Beetle                 Citrus Leafminer 
##                               24                                23 
##                   Ladybird Beetle                         Mason Bee 
##                               23                                22 
##                          Mosquito                     Argentine Ant 
##                               22                                21 
##                            Beetle      Flatheaded Appletree Borer 
##                               21                                20 
##               Horned Oak Gall Wasp               Leaf Beetle Family 
##                               20                                20 
##                Potato Leafhopper      Tooth-necked Fungus Beetle 
##                               20                                20 
##                      Codling Moth        Black-spotted Lady Beetle 
##                               19                                18 
##                      Calico Scale              Fairyfly Parasitoid 
##                               18                                18 
##                       Lady Beetle          Minute Parasitic Wasps 
##                               18                                18 
##                         Mirid Bug                 Mulberry Pyralid 
##                               18                                18 
##                          Silkworm                    Vedalia Beetle 
##                               18                                18 
##              Araneoid Spider Order                         Bee Order 
```

```
##                               17                             17
##                    Egg Parasitoid                   Insect Class
##                               17                             17
##          Moth And Butterfly Order    Oystershell Scale Parasitoid
##                               17                             17
## Hemlock Woolly Adelgid Lady Beetle        Hemlock Wooly Adelgid
##                               16                             16
##                              Mite                   Onion Thrip
##                               16                             16
##             Western Flower Thrips                  Corn Earworm
##                               15                             14
##                 Green Peach Aphid                     House Fly
##                               14                             14
##                         Ox Beetle            Red Scale Parasite
##                               14                             14
##                Spined Soldier Bug         Armoured Scale Family
##                               14                             13
##                  Diamondback Moth                 Eulophid Wasp
##                               13                             13
##                 Monarch Butterfly                 Predatory Bug
##                               13                             13
##             Yellow Fever Mosquito           Braconid Parasitoid
##                               13                             12
##                      Common Thrip   Eastern Subterranean Termite
##                               12                             12
##                            Jassid                    Mite Order
##                               12                             12
##                         Pea Aphid               Pond Wolf Spider
##                               12                             12
##          Spotless Ladybird Beetle        Glasshouse Potato Wasp
##                               11                             10
##                          Lacewing       Southern House Mosquito
##                               10                             10
##            Two Spotted Lady Beetle                   Ant Family
##                               10                              9
##                      Apple Maggot                       (Other)
##                                9                            670
```

```r
#summary of the species
```

Answer:

The six most commonly studied species are the Honey Bee, the Parasitic Wasp, the Buff Tailed Bumblebee, the Carniolan Honey Bee, the Bumble Bee and the Italian Honeybee. All 6 of these species are pollinators. As stated previously, neonicotinoids are of concern because of the major impacts they have specifically on pollinator species. Pollinators serve a crucial role in the production of plants and without them, it would be disastrous. It is important to study these species because then you could have an opportunity to make management decisions that would have positive impacts for pollinations.

8. Concentrations are always a numeric value. What is the class of Conc.1..Author. in the dataset, and why is it not numeric?

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

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

```
#determining the class of the Conc.1..Author column in the dataset.
```

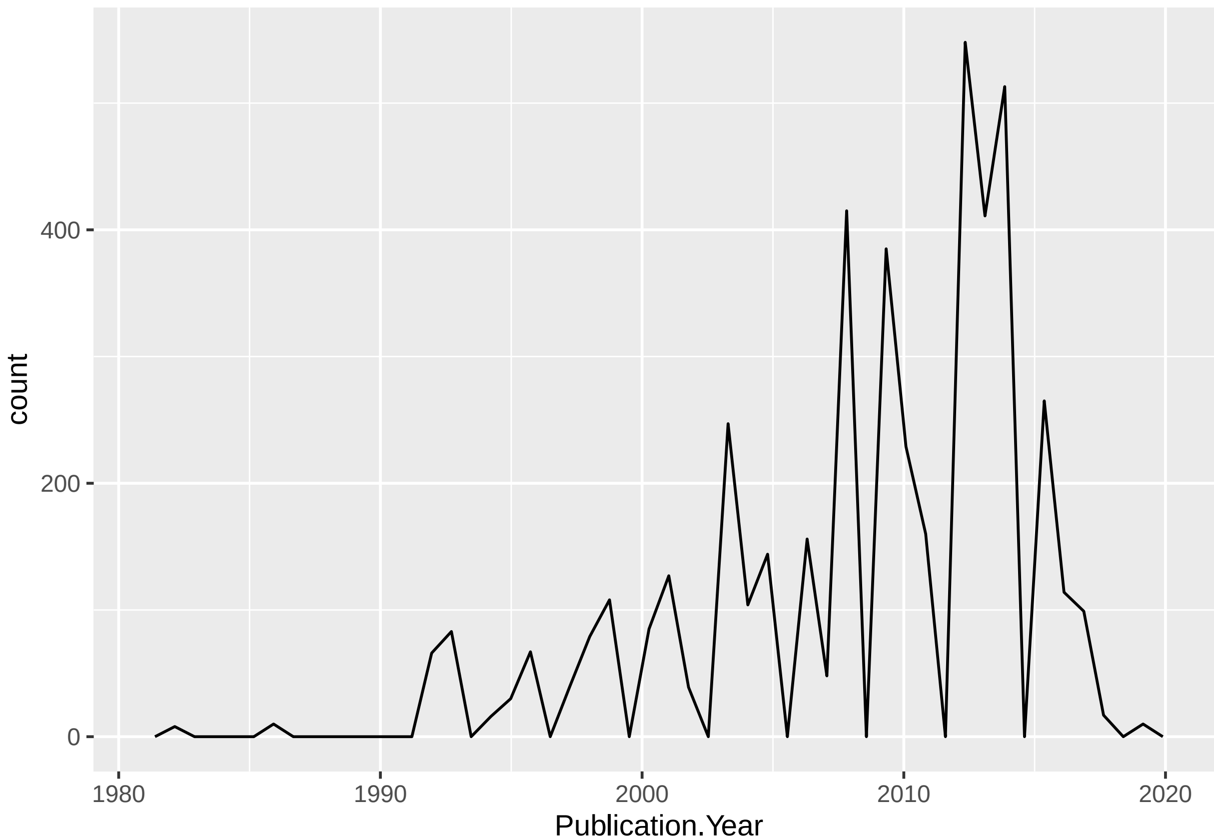
Answer:

The class of the Conc.1..Author column is a factor. It is not numeric because even thought the column contains number, some of the entries has slashes, symbols or letters, which makes R think that this is not a numeric class. If all the entries were numbers without any other symbols or letters then it would be classified as a numeric class.

Explore your data graphically (Neonics)

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

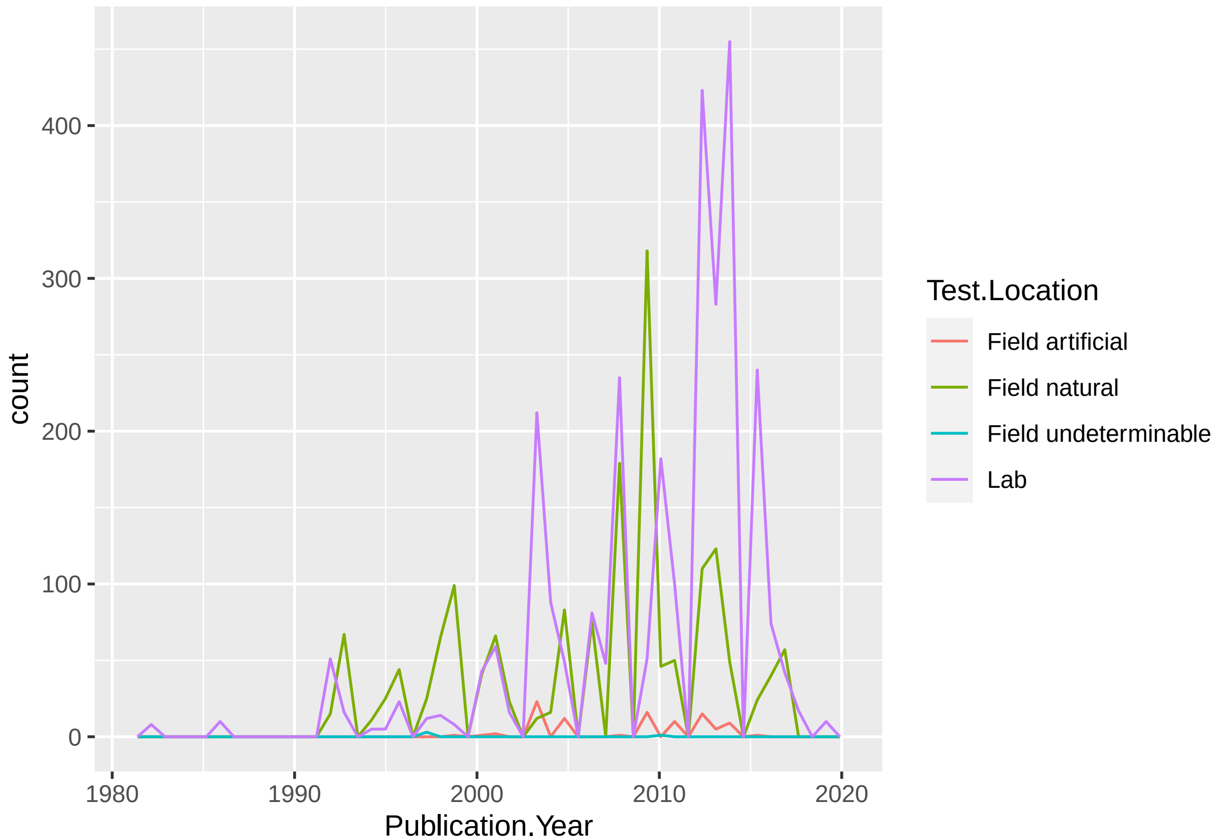
```
ggplot(Neonics) +
  geom_freqpoly(aes(x = Publication.Year), bins = 50)
```




```
#creating a frequency plot of the number of publications per year
```

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

```
ggplot(Neonics) +
  geom_freqpoly(aes(x = Publication.Year, color = Test.Location)
                , bins = 50) #making the same graph but now denoting colors to specific test locations
```



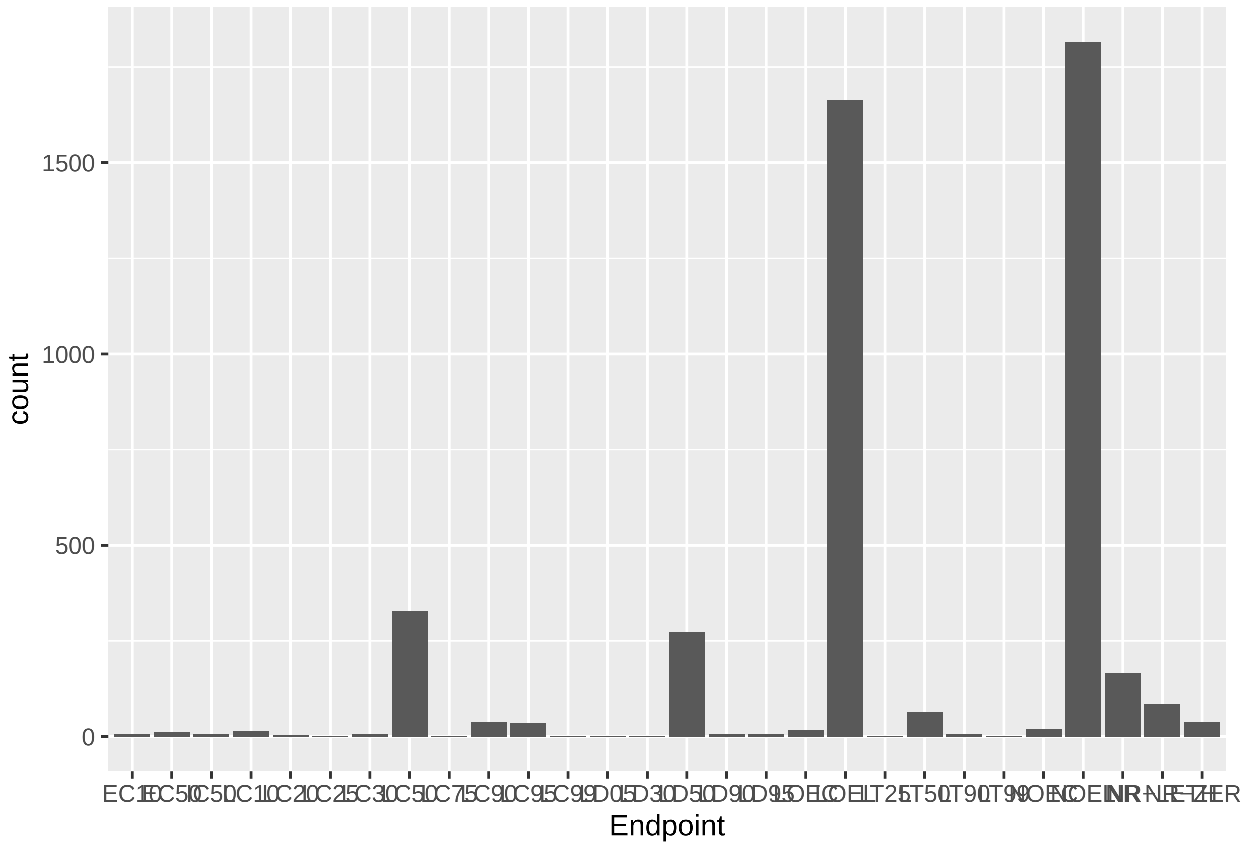
Interpret this graph. What are the most common test locations, and do they differ over time?

Answer:

Based on the graph, it seems the most common testing locations were in the lab, with a greenhouse and indoor pots, followed by field natural, which means the "test system and the stressor are naturally derived."

11. Create a bar graph of Endpoint counts. What are the two most common end points, and how are they defined? Consult the ECOTOX_CodeAppendix for more information.

```
ggplot(Neonics, aes(x = Endpoint)) +
  geom_bar() #creating bar graph of the enpoint column to show counts
```



Answer:

The two most common endpoint counts are NOEL and LOEL. NOEL is defined as no observable effect level, which means that the highest dose is not creating effects that are significantly different from the different responses of the controls. LOEL is defined as lowest observable effect level, which means the lowest dose that had effects were significantly different than that of the controls used.

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"
```

```
#checking the class of date column and it is a factor

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

class(Litter$collectDate)
```

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

```
#checking to make sure it is now a date class

unique(Litter$collectDate)
```

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

```
#determining which dates in August 2018 were data collected - August 2, 2018 and August 30, 2018
```

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

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

```
##  [1] NIWO_061 NIWO_064 NIWO_067 NIWO_040 NIWO_041 NIWO_063 NIWO_047 NIWO_051
##  [9] NIWO_058 NIWO_046 NIWO_062 NIWO_057
## 12 Levels: NIWO_040 NIWO_041 NIWO_046 NIWO_047 NIWO_051 NIWO_057 ... NIWO_067
```

```
#seeing how many plots at Niwot Ridge

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
```

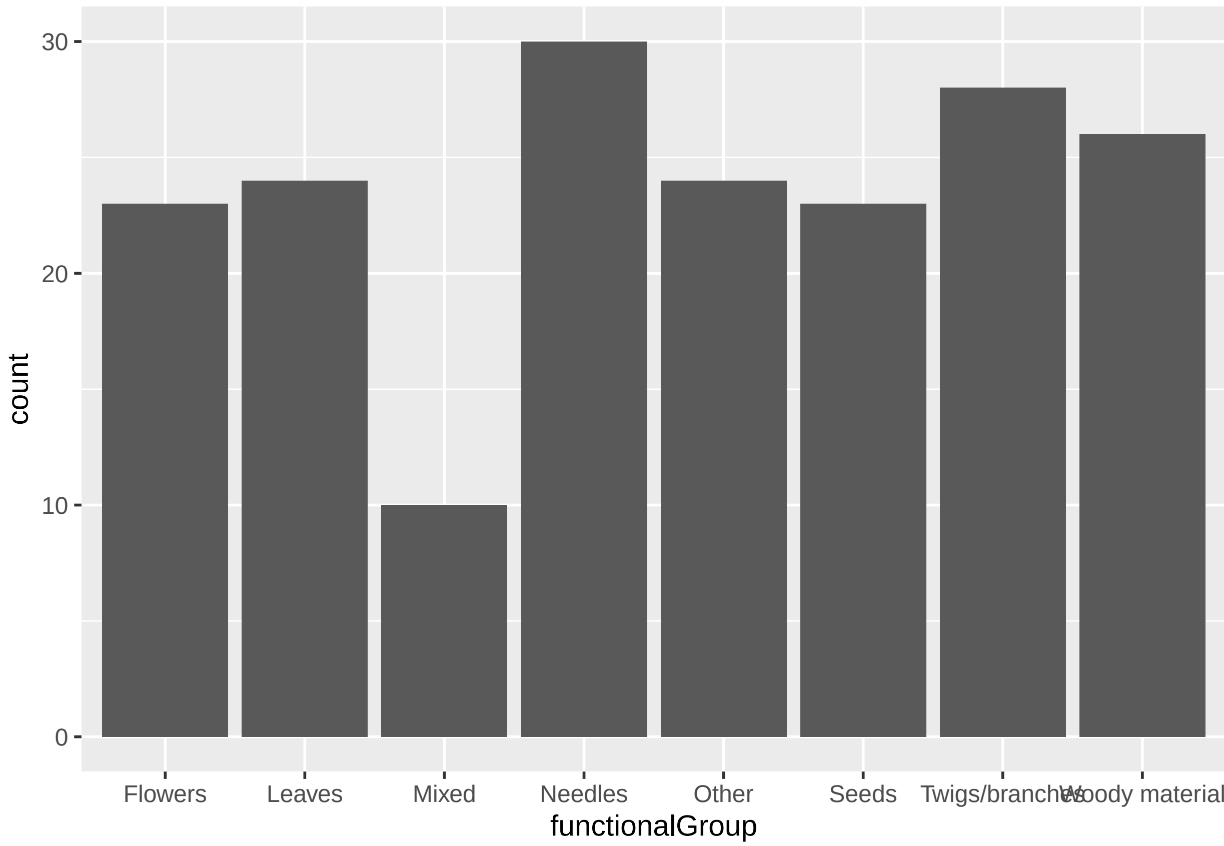
```
#using summary tool for comparison
```

Answer:

The unique tool shows the different categories within that one column whereas the summary tool shows the categories and the numbers of each. This shows that there were 12 different plots sampled at Niwot Ridge and eahc one was sampled a speicifc amount of times.

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.

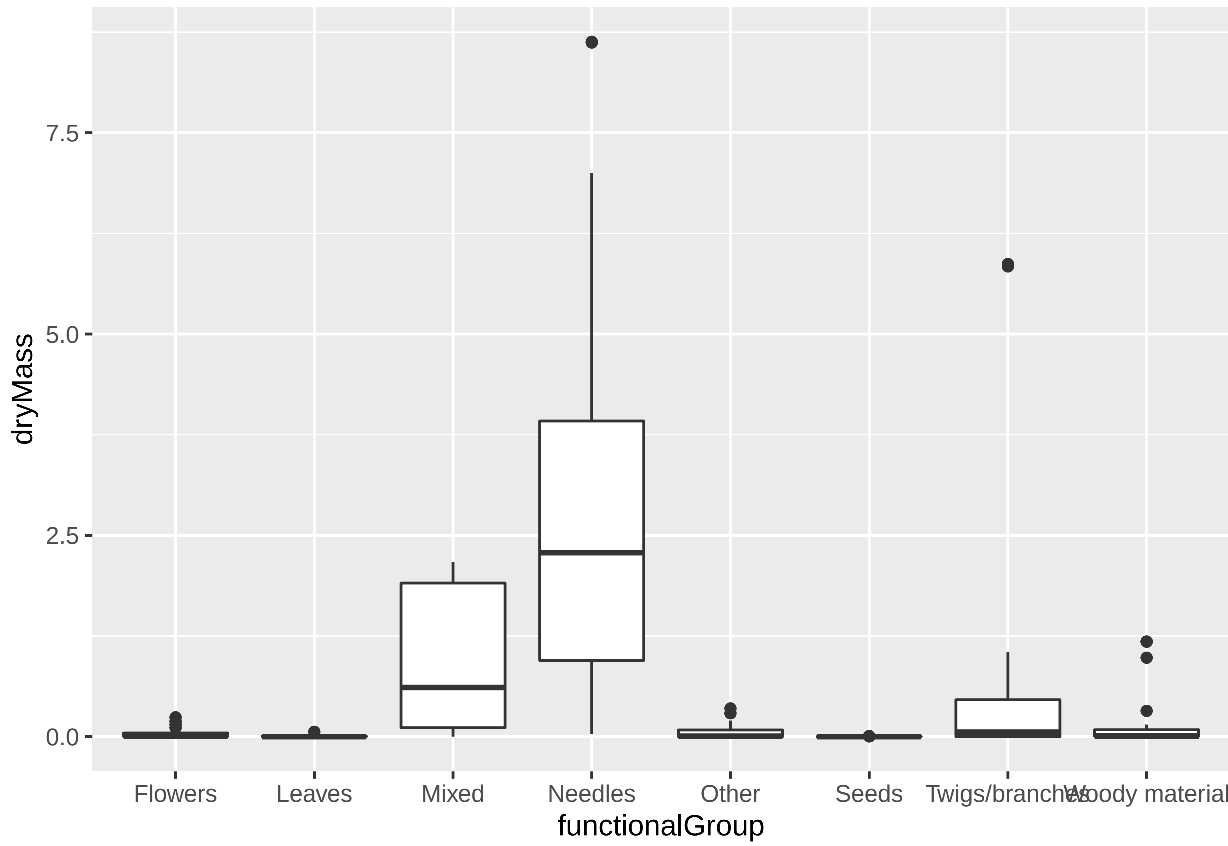
```
ggplot(Litter, aes(x = functionalGroup)) +
  geom_bar()
```




```
#creating a bar graph of the types of litter collected at the sites
```

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

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



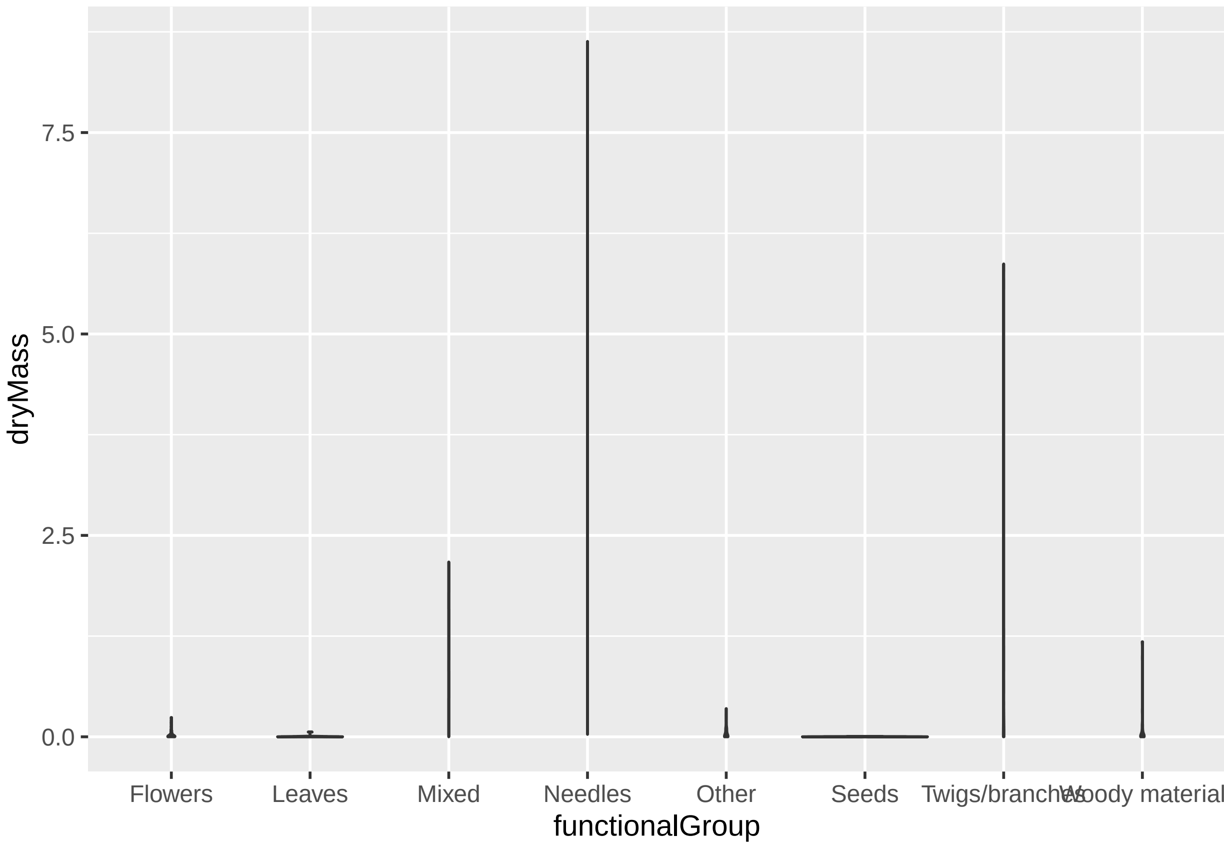

```
#box plot of the mass according to the litter types

ggplot(Litter) +
  geom_violin(aes(x = functionalGroup, y = dryMass),
              draw_quantiles = c(0.25, 0.5, 0.75))
```

```
## 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
```




```
#creating violin plot of same data
```

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

> Answer:

The boxplot shows the distribution of the continuous values of dry mass in this case while the violin plot shows the density of the values. In this case, the box plot might be better because we are simply just interested in some summary statistics of the data rather than the entire distribution of the data.

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

> Answer:

Based on the plots, the needles and the mixed litter categories tend to have the highest biomass. This makes sense here because the Niwot Ridge LTER is located in the Rocky Mountains in a higher elevation forest, which consists of trees mostly with needles.