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. Be sure to **answer the questions** in this assignment document.
5. When you have completed the assignment, **Knit** the text and code into a single PDF file.
6. After Knitting, submit the completed exercise (PDF file) to the dropbox in Sakai.

The completed exercise is due on Sept 30th.

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 include the subcommand to read strings in as factors.

```
# 1. Set up working directory
setwd("E:/ENV872/EDA-Fall2022/")
getwd()
```

```
## [1] "E:/ENV872/EDA-Fall2022"
```

```
# 2. Load packages
library(tidyverse)

# 3. Import datasets
Neonics.data <- read.csv("./Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv", stringsAsFactors = TRUE)
Litter.data <- read.csv("./Data/Raw/NEON_NIWO_Litter_massdata_2018-08_raw.csv", stringsAsFactors = TRUE)

#View(Neonics and Litter)
View(Neonics.data)
View(Litter.data)
```

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: We might be interested because the neonicotinoids insecticides especially to bees are the most economically essential and prominent group of pollinators recently in the world. It has a significant solution for crop protection against piercing-sucking pests, and a highly effective way in controlling flea on dogs and cats.

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 become a particular connection between tree canopy and the soils beneath that could influence the forrest productivity and tree growth. It is important to study them sinct it has a significant factor in driving a more sustainable ecological system within the forest.

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 has a limited access during winter months, this situation may be paused for up to 6 months during the dormant season. 2. Spatial sampling design has strictly provisions to comply with. 3. Temporal sampling should be conducted in various site according to what kind of vegetation such as frequent sampling (1x every 2weeks) in deciduous forest sites during senescence, and infrequent year-round sampling (1x every 1-2 months) at evergreen sites.

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim.data.frame(Neonics.data)
```

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

```
dim(Neonics.data)
```

```
## [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?

```
summary(Neonics.data$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
```

```
summary(Neonics.data)
```

```
##    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
##
##  Purity: Ê NR - NR | Organism Age: Ê NR - NR Not reported | Conc 1 (Author): Ê Active ingredient NR/
##  Purity: Ê NR - NR | Organism Age: Ê NR - NR Not reported | Conc 1 (Author): Ê Active ingredient NR +
##  Purity: Ê NR - NR | Organism Age: Ê NR - NR Not reported | Conc 1 (Author): Ê Active ingredient NR +
##  Purity: Ê NR - NR | Organism Age: Ê NR - NR Not reported | Conc 1 (Author): Ê Active ingredient NR/
##  Purity: Ê NR - NR | Organism Age: Ê NR - NR Not reported | Conc 1 (Author): Ê Active ingredient NR +
##  Purity: Ê NR - NR | Organism Age: Ê NR - NR Not reported | Conc 1 (Author): Ê Formulation NR - NR ml
##  (Other)
```

Answer: The most common effects in more than 1000 times are mortality (1493) and population (1803)

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.

```
summary(Neonics.data$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
```

Answer: Six most commonly studied species are Honey Bee (667), Parasitic Wasp (285), Buff Tailed Bumblebee (183), Carniolan Honey Bee (152), Bumble Bee (140), and Italian Honeybee (113). What do these species have in common, and why might they be of interest over other insects?

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

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

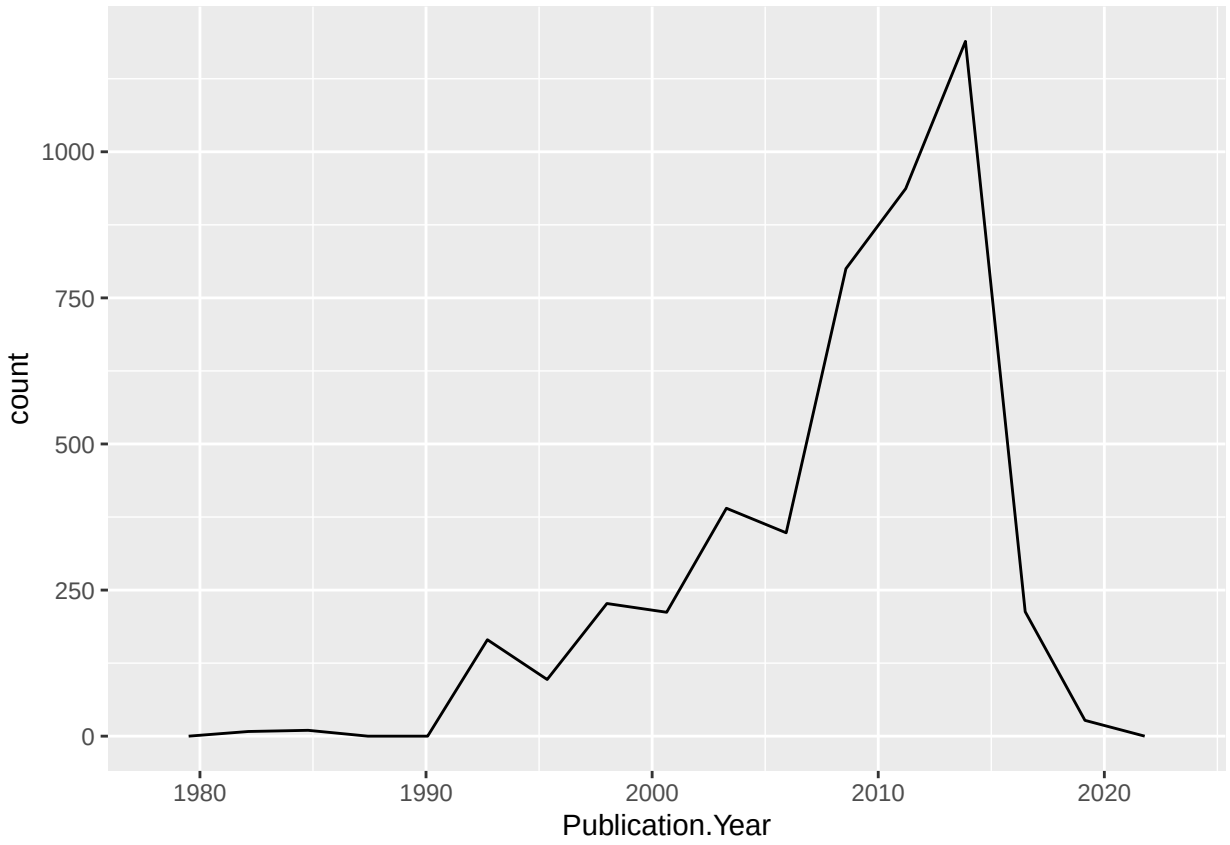
```
## [1] "factor"
```

Answer: The class of Conc.1..Author. in the dataset is a factor because it comprises in leveling according to data of author.

Explore your data graphically (Neonics)

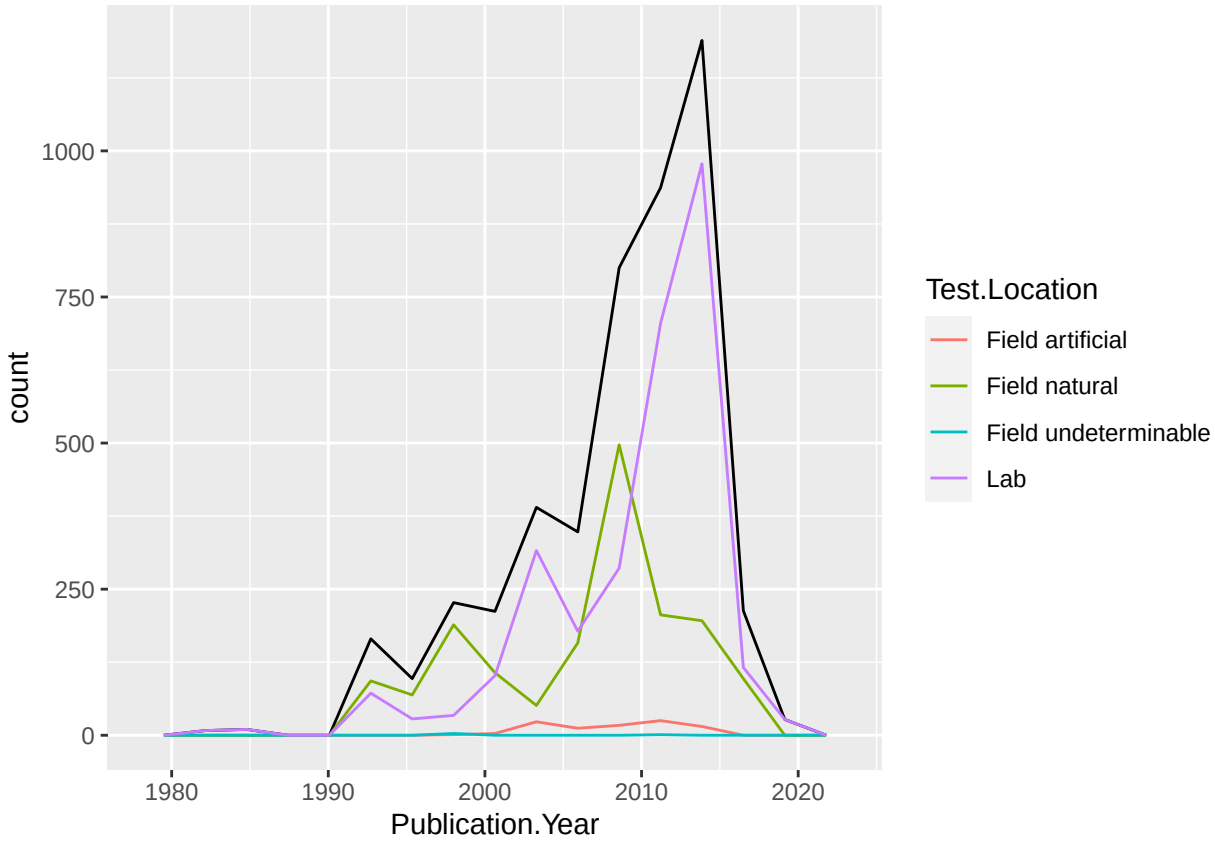
9. Using `geom_freqpoly`, generate a plot of the number of studies conducted by publication year.

```
ggplot(Neonics.data) + geom_freqpoly(aes(x = Publication.Year), bins = 15)
```



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

```
ggplot(Neonics.data) + geom_freqpoly(aes(x = Publication.Year), bins = 15) + geom_freqpoly(aes(x = Publi
```

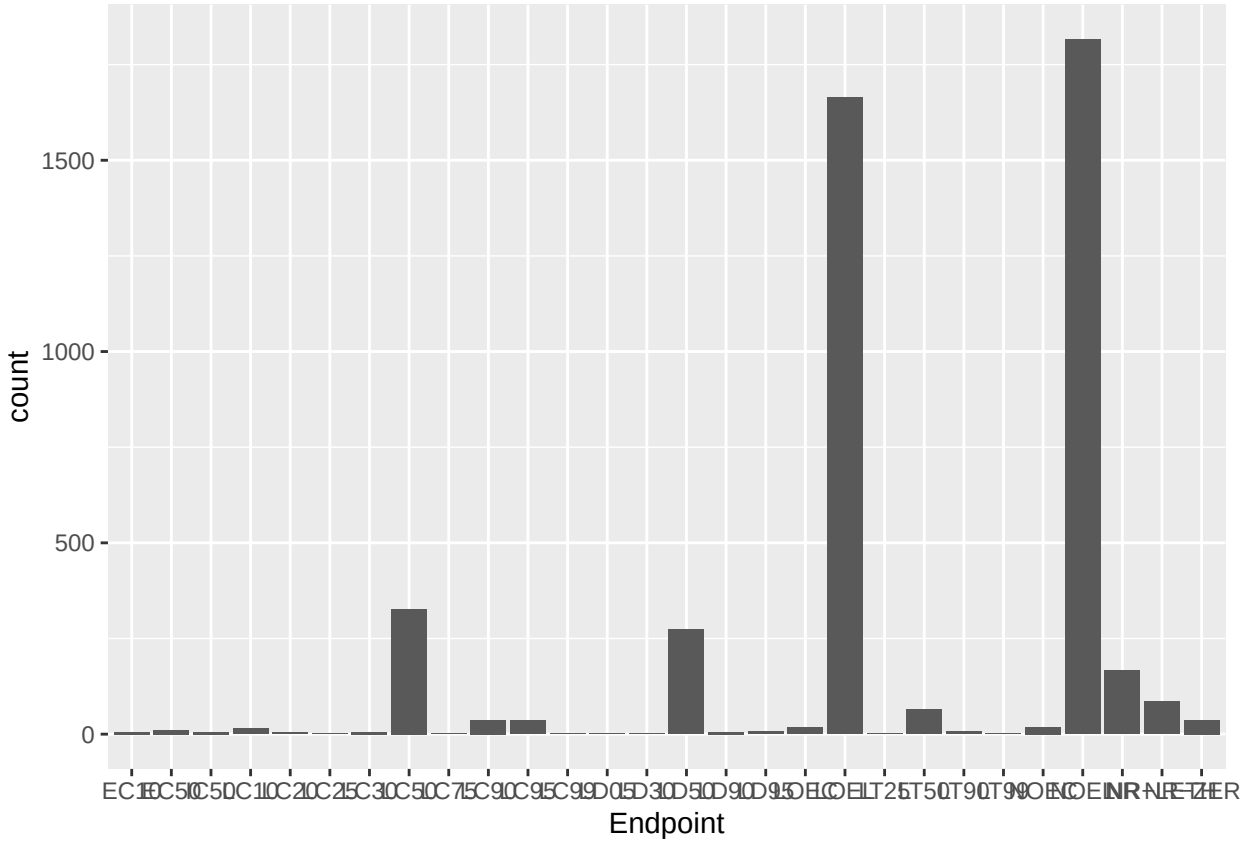


Interpret this graph. What are the most common test locations, and do they differ over time?

Answer: The most common test location is Lab with an increasing number over the years

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.data, aes(x = Endpoint)) + geom_bar()
```




```
summary(Neonics.data$Endpoint)
```

```
##     EC10     EC50     IC50     LC10     LC20     LC25     LC30     LC50     LC75     LC90
##        6       11        6       15        5        1        6      327        1       37
##     LC95     LC99     LD05     LD30     LD50     LD90     LD95     LOEC     LOEL     LT25
##       36        2        1        1      274        6        7       17     1664        1
##     LT50     LT90     LT99     NOEC     NOEL       NR  NR-LETH  NR-ZERO
##       65        7        2       19     1816      167       86       37
```

Answer: Two most common end point: 1. NOEL (1816 endpoints) is No-observable-effect-level or the highest dose (concentration) producing effects not significantly different from responses of controls according to author's reported statistical test (NOEAL/NOEC) and; 2. LOEL or Lowest-observable-effect-level with 1664 endpoint number that describing the lowest dose (concentration) producing effects that were significantly different (as reported by authors) from responses of controls (LOEAL/LOEC)

Explore your data (Litter)

12. Determine the class of collectDate. Is it a date? If not, change to a date and confirm the new class of the variable. Using the `unique` function, determine which dates litter was sampled in August 2018.

```
class(Litter.data$collectDate)
```

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

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

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

```
unique(Litter.data$collectDate)
```

```
## [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`?

```
unique(Litter.data$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
```

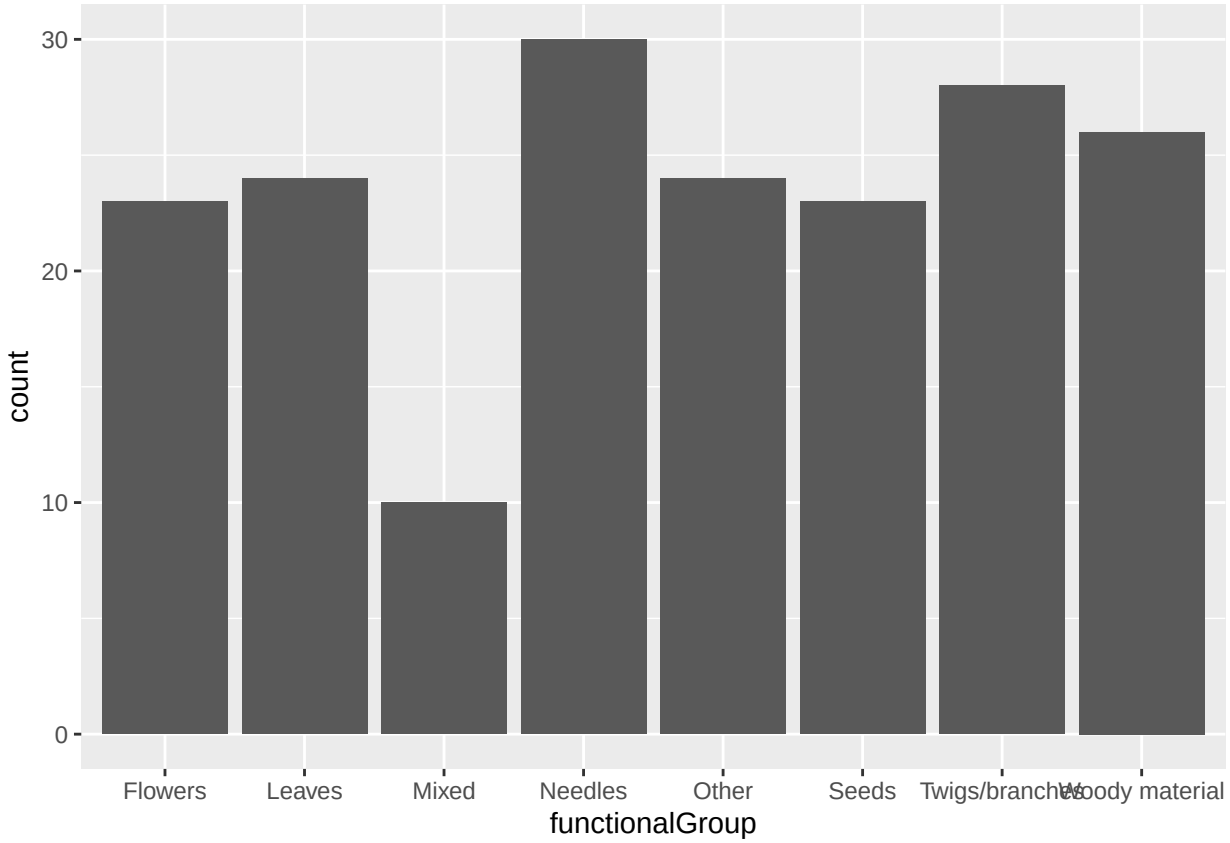
```
summary(Litter.data$plotID)
```

```
## 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: The function of "unique" will shows the plotID and eliminating the data duplication in the vectors, while summary shows all the plot ID without any elimination process. This process of unique function will also work on other ype of data in matrix and dataframe.

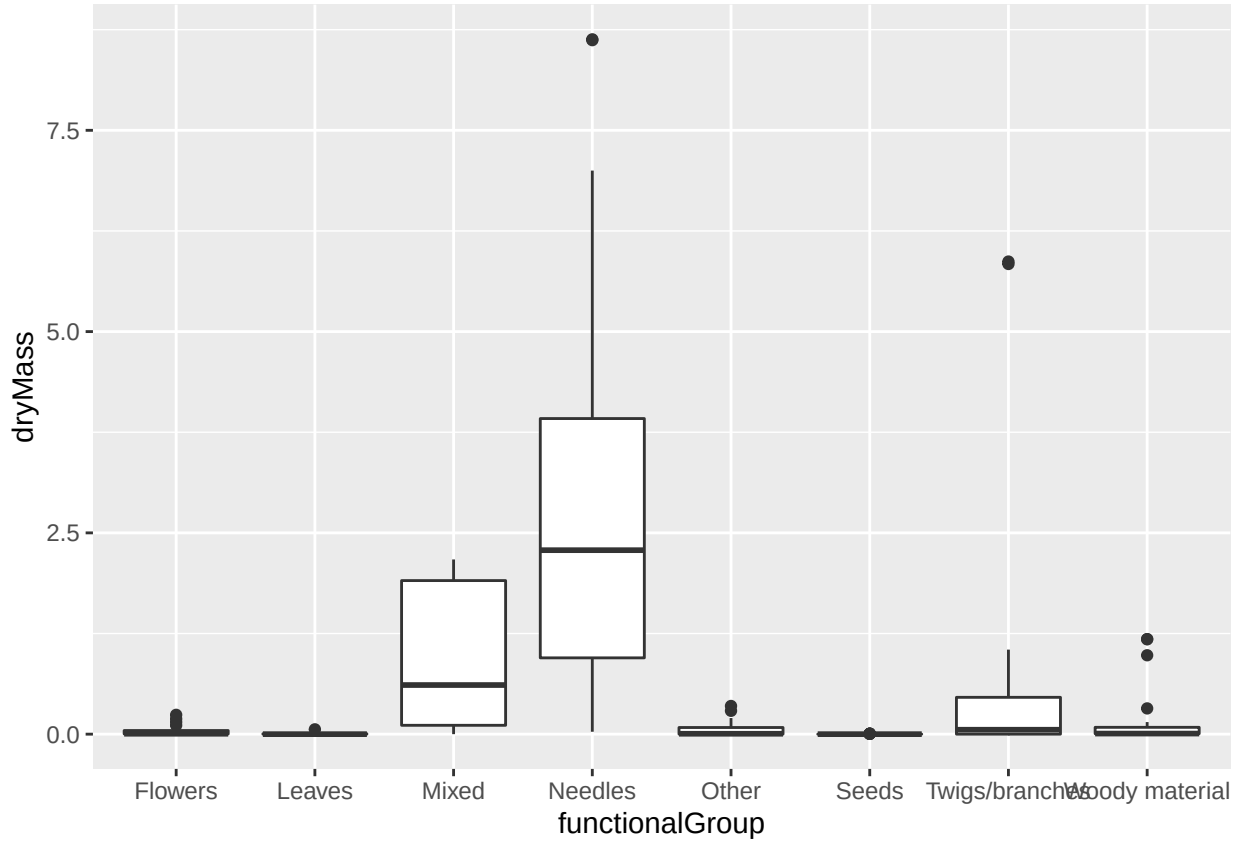
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

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



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

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

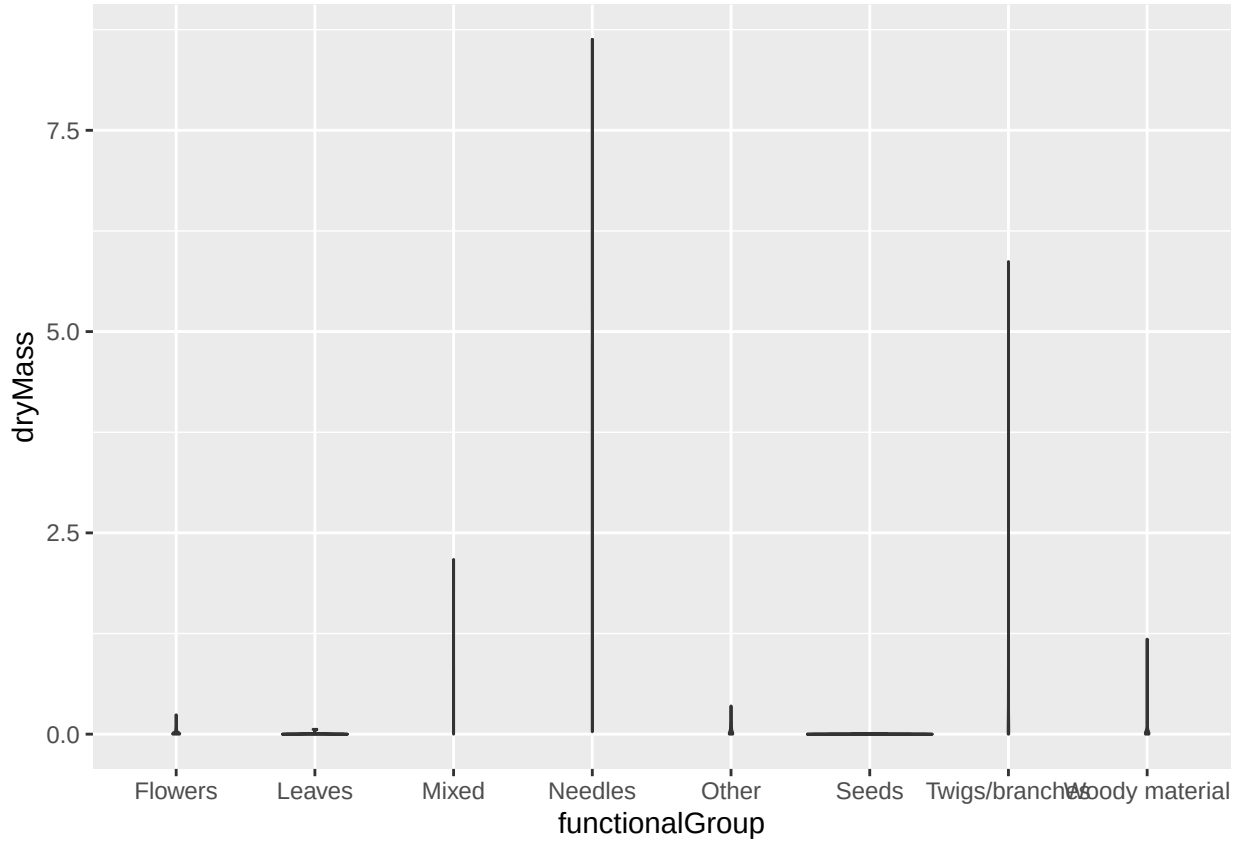



```
#
ggplot(Litter.data) + geom_violin(aes(x = functionalGroup, y = dryMass), draw_quantiles = c(0.25, 0.5, 0
```

```
## 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: It is more effective because boxplot visualize the data more clearly since the datatype is numerical.

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

> Answer: The needles has the highest biomass among the other type of litters.