Assignment 3: Data Exploration

Karina Leung

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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.

```
library(tidyverse)
library(lubridate)
```

```
getwd()
```

```
## [1] "C:/Users/ktlro/OneDrive/Documents/EDA-Spring2023"
```

```
ECOTOX.Neonic.data <- read.csv("./Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv")
NEON.Litter.data <- read.csv("./Data/Raw/NIWO_Litter/NEON_NIWO_Litter_massdata_2018-08_raw.csv")
```

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 a class of insecticide chemicals that are persistent in the environment and meant to remove pests from crops. However, bees and other pollinators are susceptible to the effects of neonicotinoids which can ultimately disrupt agricultural productivity and potentially travel up the food chain to birds and other animals that consume the insects that contain neonicotinoids.

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: Leaf litter and woody debris play a role in the soil quality and health of an ecosystem through nutrient cycling, prevention of soil erosion, water retention in soil, etc. It can also affect the growth of the forest by either impeding or helping germination of some seeds in 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. One aspect of the spatial sampling design is that litter and fine woody debris were sampled at NEON sites that contain woody vegetation greater than 2 meters tall. 2. Another aspect is that the trap placement used to obtain the litter and fine woody debris could either be targeted or randomized depending on the surrounding vegetation (e.g., sites with more than 50% aerial cover of woody vegetation that's greater than 2 meters in height, the placement of the traps is random). 3. Ground traps were sampled once per year, but target sampling for elevated traps was once every two weeks.

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim(ECOTOX.Neonic.data)
```

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

   Answer: The dimensions are 4623 rows and 30 columns.

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(ECOTOX.Neonic.data$Effect)
```

```
##    Length     Class      Mode
##      4623 character character
```

```
table(ECOTOX.Neonic.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
```

Answer: The "Effect" column is a character class, so it does not show what the common effects are. However, we can use the table() function to show the frequency each effect shows up. From the table() output, Population is the most common effect followed by Mortality. These might specifically be of interest since neonicotinoids act as an insecticide and could have an effect on population of insects, or insect deaths for crop/agricultural purposes.

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. . .]

```
summary(ECOTOX.Neonic.data$Species.Common.Name)
```

```
##    Length     Class      Mode
##      4623 character character
```

```
table(ECOTOX.Neonic.data$Species.Common.Name) %>%
    sort(ECOTOX.Neonic.data$Species.Common.Name, decreasing = TRUE)
```

```
## Warning in order(c(8L, 2L, 2L, 3L, 6L, 4L, 9L, 1L, 2L, 38L, 6L, 5L, 9L, : NAs
## introduced by coercion
```

```
##
##                          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                 Asiatic Honey Bee
##                                  9                                  9
##                Eulophid Parasitoid                  Lacewing Family
##                                  9                                  9
##                Mealybug Destroyer           Alfalfa Leafcutter Bee
##                                  9                                  8
##                                Bee                          Bumblebee
##                                  8                                  8
##             Chilean Predatory Mite                  Dwarf Honey Bee
##                                  8                                  8
##           Neotropical Stingless Bee            Parasitic Wasp Family
##                                  8                                  8
##                Spiralling Whitefly                Beetle Mite Family
##                                  8                                  7
##                         Chinch Bug              Macedonian Honey Bee
##                                  7                                  7
##                               Moth                   Potato Tuberworm
##                                  7                                  7
```

```
##               Russian Wheat Aphid                   Soldier Beetle
##                                 7                                 7
##         Southern One-Year Canegrub              Tarnished Plant Bug
##                                 7                                 7
##                  Ambrosia Beetle                       Aphid Wasp
##                                 6                                 6
##                Black Vine Weevil                Childers Canegrub
##                                 6                                 6
##              Coconut Leaf Beetle      Elevenspotted Ladybird Beetle
##                                 6                                 6
##                   Encyrtid Wasp               European Red Mite
##                                 6                                 6
##                   Fall Armyworm                       Fruit Fly
##                                 6                                 6
##                      Hover Fly         Oblique Banded Leaf Roller
##                                 6                                 6
##                Obscure Mealybug           Oribatid Mite Suborder
##                                 6                                 6
##                Pistachio Psyllid           Redbay Ambrosia Beetle
##                                 6                                 6
##               Silverleaf Whitefly                   Soybean Aphid
##                                 6                                 6
##              Subterranean Termite                           Thrip
##                                 6                                 6
##            Two-Spotted Spider Mite                     Apple Aphid
##                                 6                                 5
##                Brown Planthopper                           Earwig
##                                 5                                 5
##                Green June Beetle                    Hornfaced Bee
##                                 5                                 5
##          Long Horned Beetle Family                    Plum Curculio
##                                 5                                 5
##                     Rove Beetle                   San Jose Scale
##                                 5                                 5
##                   Scelionid Wasp             Speckled Cutworm Moth
##                                 5                                 5
##                    Thrip Family                               Ant
##                                 5                                 4
##             Cabbage Seedpod Weevil             Common Green Lacewing
##                                 4                                 4
##              Eucalyptus Gall Wasp             European Apple Sawfly
##                                 4                                 4
##                European Honey Bee       European Tarnished Plant Bug
##                                 4                                 4
##                 Garden Symphylan                 Linyphiid Spider
##                                 4                                 4
##                    Onion Maggot                  Oriental Beetle
##                                 4                                 4
##                Parsnip Seed Wasp               Pea And Bean Weevil
##                                 4                                 4
##                     Pear Sucker             Red Imported Fire Ant
##                                 4                                 4
##            Striped Cucumber Beetle                 Sugarcane Beetle
##                                 4                                 4
```

```
##                            Wasp                Wolf Spider Family
##                               4                                 4
##            Yellow-faced Bumblebee             Ambrosia Bark Beetle
##                               4                                 3
##             Asian Ambrosia Beetle                   Beetle Family
##                               3                                 3
##                  Birch Leafminer                Black Twig Borer
##                               3                                 3
##          Braconid Parasitoid Wasp            California Red Scale
##                               3                                 3
##              Crucifer Flea Beetle                         Cutworm
##                               3                                 3
##             Delphacid Planthopper          Egyptian Cotton Leafworm
##                               3                                 3
##               Encyrtid Parasitoid          Fly/Mosquito/Midge Order
##                               3                                 3
##     Formosan Subterranean Termite          Fruit-tree Pinhole Borer
##                               3                                 3
##             Green Rice Leafhopper                    Ground Beetle
##                               3                                 3
##                 Ichneumonid Wasp     Large-Jawed Orb Weaver Family
##                               3                                 3
##                 Leaf Cutting Ant           Mediterranean Fruit Fly
##                               3                                 3
##                 Minute Flour Bug                     Mite Family
##                               3                                 3
##                      Moth Family                Negatoria Canegrub
##                               3                                 3
##                Sap Beetle Family                Scale Insect Order
##                               3                                 3
##             Scarab Beetle Family           Sheet-Web Weaver Family
##                               3                                 3
##                           Spider                   Sugarcane Grub
##                               3                                 3
##                Tenebrionid Beetle                 Alfalfa Plant Bug
##                               3                                 2
##                      Alkali Bee                             Aphid
##                               2                                 2
##                     Assassin Bug                  Azalea Lace Bug
##                               2                                 2
##                     Banana Aphid                      Brown Scale
##                               2                                 2
##                    Brown Stinkbug                          Budworm
##                               2                                 2
##                     Cabbage Aphid                    Cabbage White
##                               2                                 2
##                    Cardamom Thrip                    Carrot Weevil
##                               2                                 2
##                Celer Crab Spider                  Centipede Class
##                               2                                 2
##                   Citricola Scale                Clouded Plant Bug
##                               2                                 2
##                Coffee Bean Weevil                Cotton Fleahopper
##                               2                                 2
```

```
##            Egyptian Alfalfa Weevil                  Engraver Beetle
##                                  2                                2
##               Fig Longicorn Beetle         Glassy-winged Sharpshooter
##                                  2                                2
##                  Hawthorn Lace Bug               Hister Beetle Family
##                                  2                                2
##              Jumping Spider Family                 Lined Click Beetle
##                                  2                                2
##                  Maple Spider Mite                  Meshweaver Spider
##                                  2                                2
##           Minute Pirate Bug Family                     Predaceous Fly
##                                  2                                2
##               Pygmy Mangold Beetle                       Rose Sawfly
##                                  2                                2
##               Serpentine Leafminer              Spider Mite Destroyer
##                                  2                                2
##        Spotted Tentiform Leafminer                         Stink Bug
##                                  2                                2
##                 Tawny Mole Cricket            Tick/Chigger/Mite Order
##                                  2                                2
##                 Turf Running-spider                      Turnip Aphid
##                                  2                                2
##                 Western Bigeyed Bug                 Western Damsel Bug
##                                  2                                2
##                   Western Plant Bug           White-backed Planthopper
##                                  2                                2
##       White Apple Leafhopper Nymph             Whitemarked Fleahopper
##                                  2                                2
##               Antlike Flower Beetle   Banded Soft-winged Flower Beetle
##                                  1                                1
##               Banded Sunflower Moth                         Bee Family
##                                  1                                1
##                      Beet Armyworm                 Black Citrus Aphid
##                                  1                                1
##                  Blue Alfalfa Aphid                   Cabbage Root Fly
##                                  1                                1
##                  Cactus Lady Beetle                   Citrus Red Mite
##                                  1                                1
##               Cottony Cushion Sale                  Crapemyrtle Aphid
##                                  1                                1
##                  Damselbug Family                Ectoparasitoid Wasp
##                                  1                                1
##                 English Grain Aphid                         Fairyfly
##                                  1                                1
##                        Flea Beetle                        Gall Midge
##                                  1                                1
##   Grasshopper/Cricket/Locust Order                Greenhouse Whitefly
##                                  1                                1
##         Grey Sunflower Seed Weevil             Harvestman Spider Order
##                                  1                                1
##                 Hawthorn Leaf Miner      Longtailed Fruit Fly Parasite
##                                  1                                1
##                 Minute Lady Beetles                Painted Maple Aphid
##                                  1                                1
```

```
##                       Pepper Weevil                 Pine False Webworm
##                                   1                                  1
##                          Plant Bug                      Pollen Beetle
##                                   1                                  1
##                     Predacious Mite                       Predator Bug
##                                   1                                  1
##               Pseudocentipede Class              Pteromalid Wasp Family
##                                   1                                  1
##          Red Sunflower Seed Weevil               Rice Leaf Folder Moth
##                                   1                                  1
##                   Rose Grain Aphid                 Scale Picnic Beetle
##                                   1                                  1
##                 Shiny Spider Beetle                 Southern Army Worm
##                                   1                                  1
##                        Spirea Aphid      Spotted Sunflower Stem Weevil
##                                   1                                  1
##          Strawberry Blossom Weevil                     Sunflower Midge
##                                   1                                  1
##                      Sunflower Moth           Ten-spot Ladybird Beetle
##                                   1                                  1
##                       Tobacco Thrip           Twicestabbed Lady Beetle
##                                   1                                  1
##                         Wasp Family                            Weevil
##                                   1                                  1
##              Yellow Mealworm Beetle
##                                   1
```

Answer: The six most commonly studied species are the Honey bee, Parasitic wasp, Buff tailed bumblebee, Carniolan honey bee, bumble bee, and the Italian Honey bee

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

```
class(ECOTOX.Neonic.data$Conc.1..Author.)
```

```
## [1] "character"
```

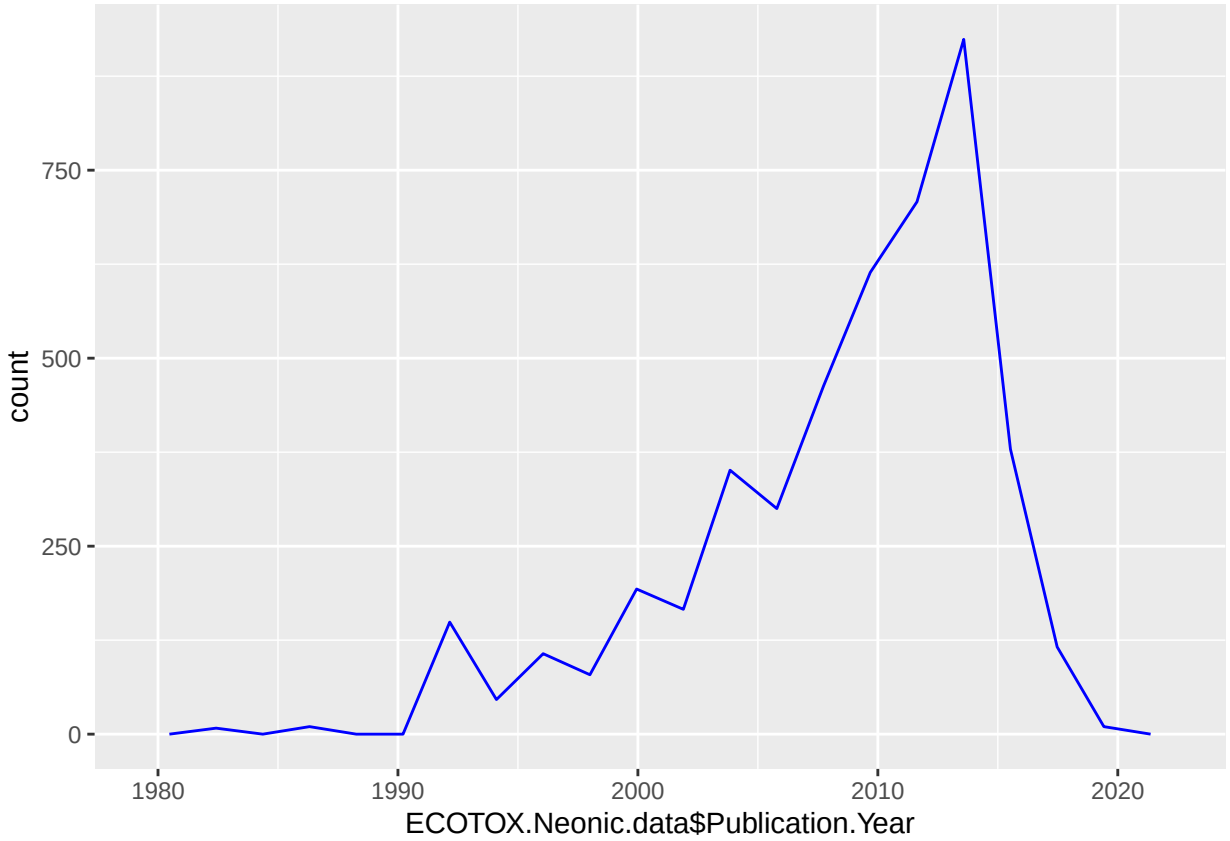
Answer: There are "NR" values located in the 'Conc 1 (Author)' column, and since R makes the column class that of the least common value, it made the entire column categorical instead of numeric.

Explore your data graphically (Neonics)

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

```
ggplot(ECOTOX.Neonic.data) + geom_freqpoly(aes(x = ECOTOX.Neonic.data$Publication.Year),
    bins = 20, color = "blue")
```

```
## Warning: Use of `ECOTOX.Neonic.data$Publication.Year` is discouraged.
## i Use `Publication.Year` instead.
```

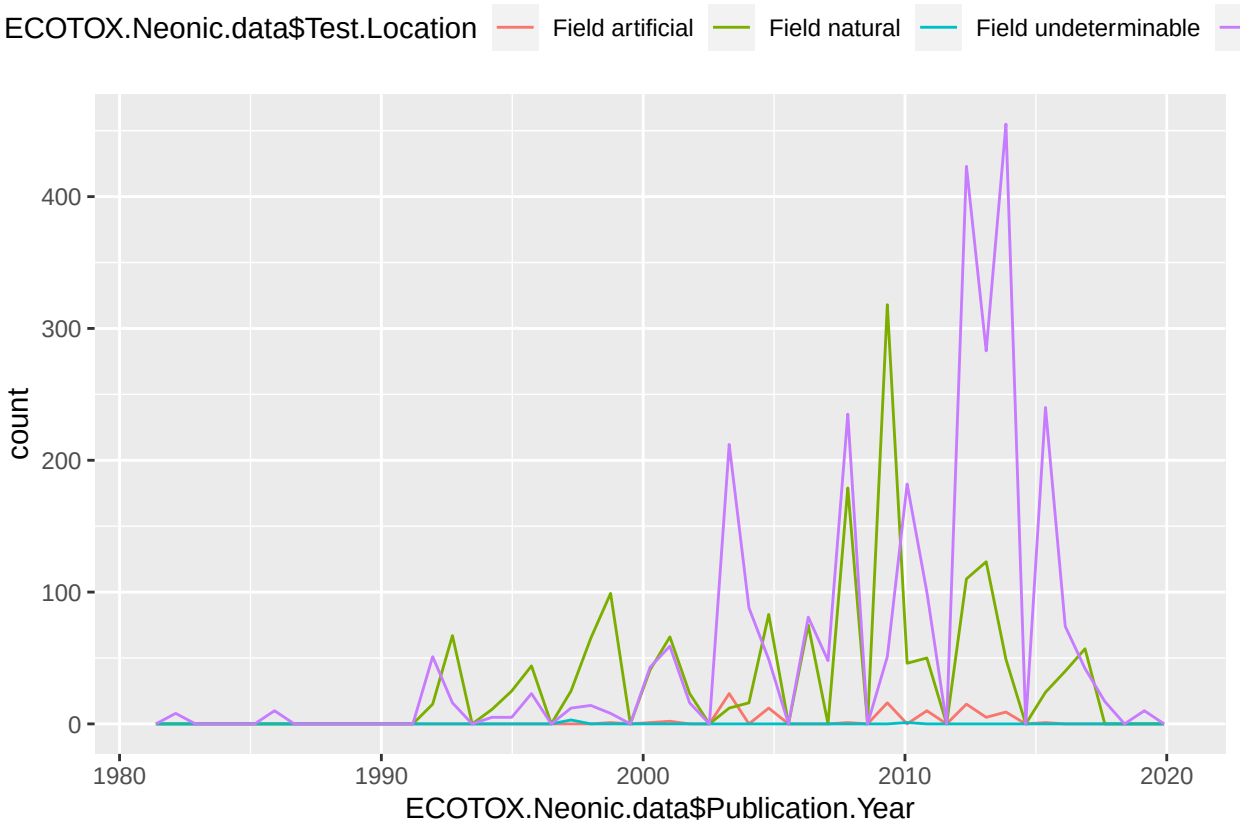


10. Reproduce the same graph but now add a color aesthetic so that different Test.Location are displayed as different colors.

```
ggplot(ECOTOX.Neonic.data) + geom_freqpoly(aes(x = ECOTOX.Neonic.data$Publication.Year,
    color = ECOTOX.Neonic.data$Test.Location), bins = 50) + theme(legend.position = "top")
```

```
## Warning: Use of ‘ECOTOX.Neonic.data$Publication.Year‘ is discouraged.
## i Use ‘Publication.Year‘ instead.
```

```
## Warning: Use of ‘ECOTOX.Neonic.data$Test.Location‘ is discouraged.
## i Use ‘Test.Location‘ instead.
```



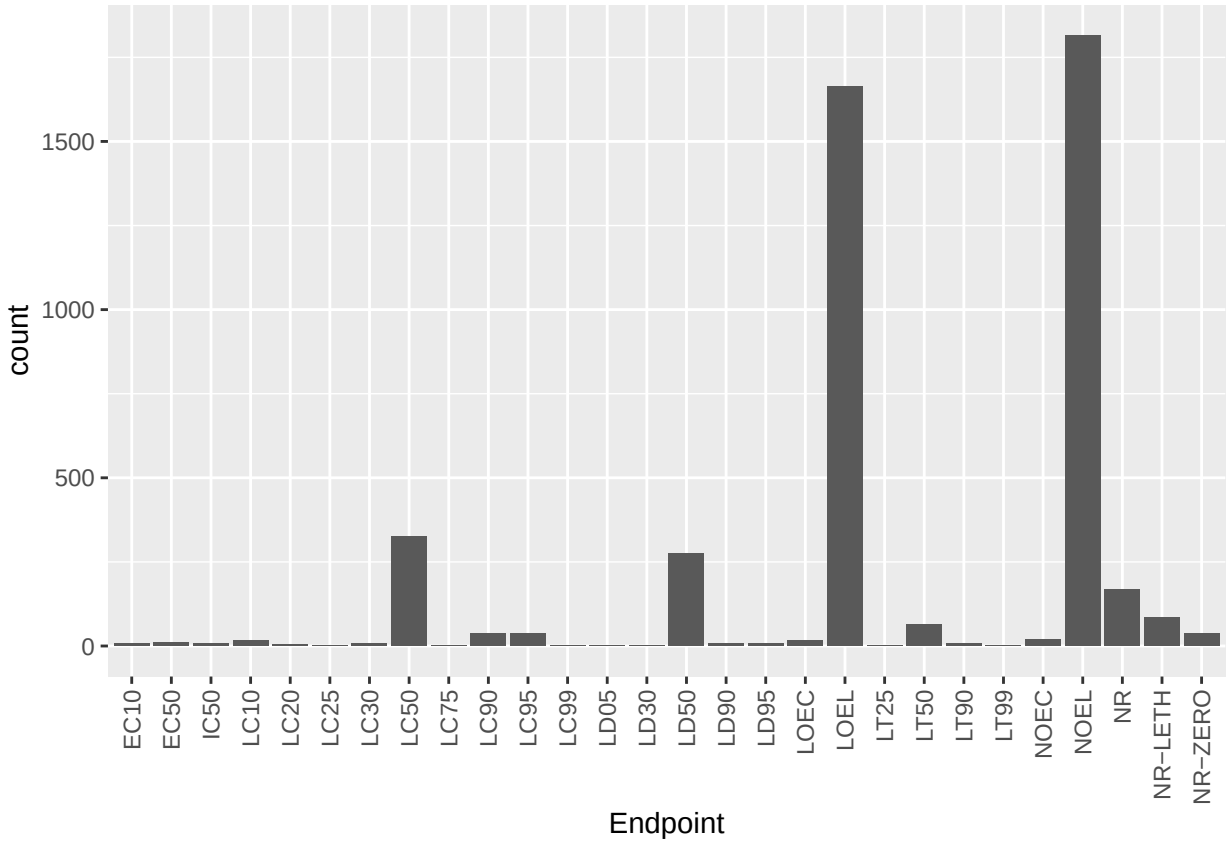
Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer: The most common test functions at first are "lab" test locations which switches overtime with "field natural" location. In more recent years, "lab" test locations have become more prolific over any other test location.

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(ECOTOX.Neonic.data) + geom_bar(aes(x = Endpoint)) + theme(axis.text.x = element_text(angle = 90,
    vjust = 0.5, hjust = 1))
```



Answer: The two most common endpoints are "NOEL" which means no-observable-effect-level (the highest dosage that produced effects NOT significantly different from control responses) and "LOEL" which means lowest-observable-effect-level (the lowest dosage that produced effects that were significantly different from control responses).

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

```
## [1] "character"
```

```
unique(NEON.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(NEON.Litter.data$plotID)
```

```
##  [1] "NIWO_061" "NIWO_064" "NIWO_067" "NIWO_040" "NIWO_041" "NIWO_063"
##  [7] "NIWO_047" "NIWO_051" "NIWO_058" "NIWO_046" "NIWO_062" "NIWO_057"
```

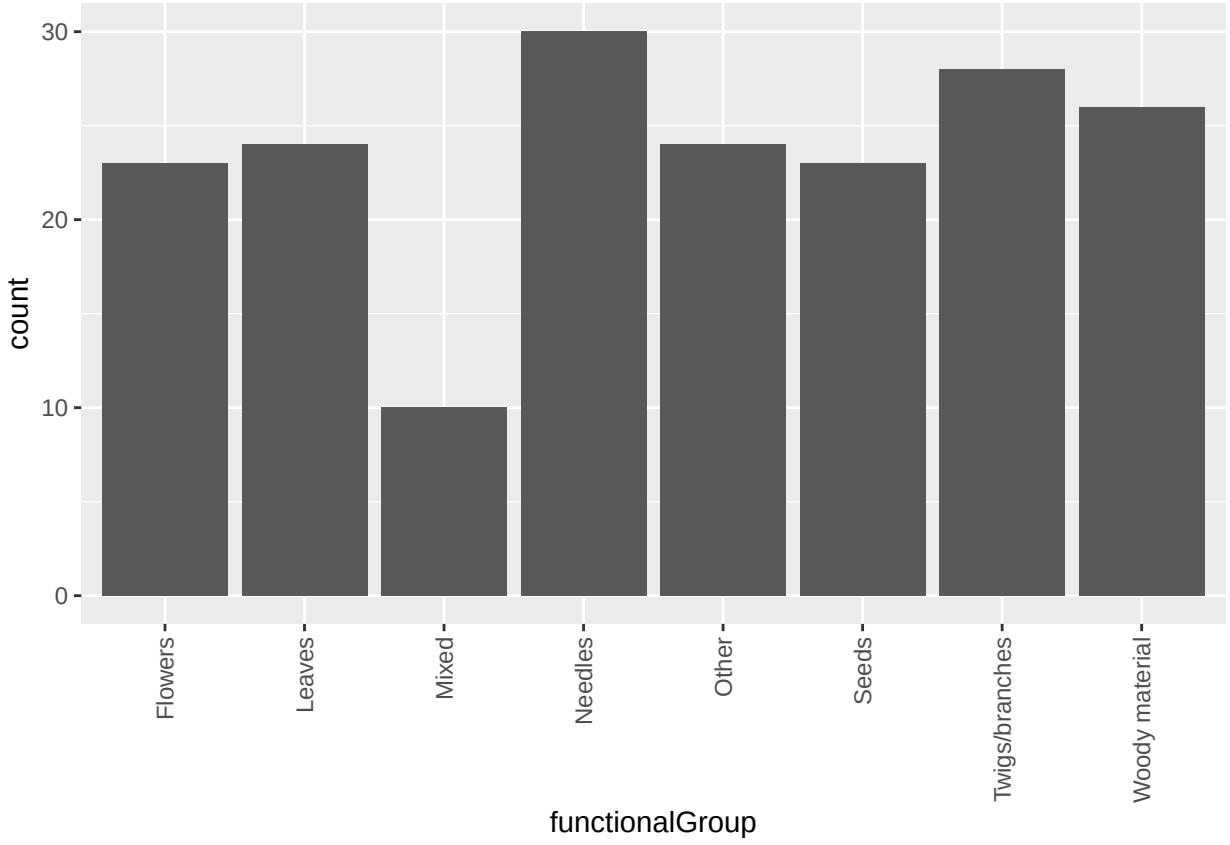
```
summary(NEON.Litter.data$plotID)
```

```
##    Length     Class      Mode
##       188 character character
```

Answer: When running the unique() function, it tells me how many specific locations the plots were sampled at (e.g., NIWO_061 vs NIWO_064), whereas when I use summar(), it tells me how many samples were taken (e.g., length is 188).

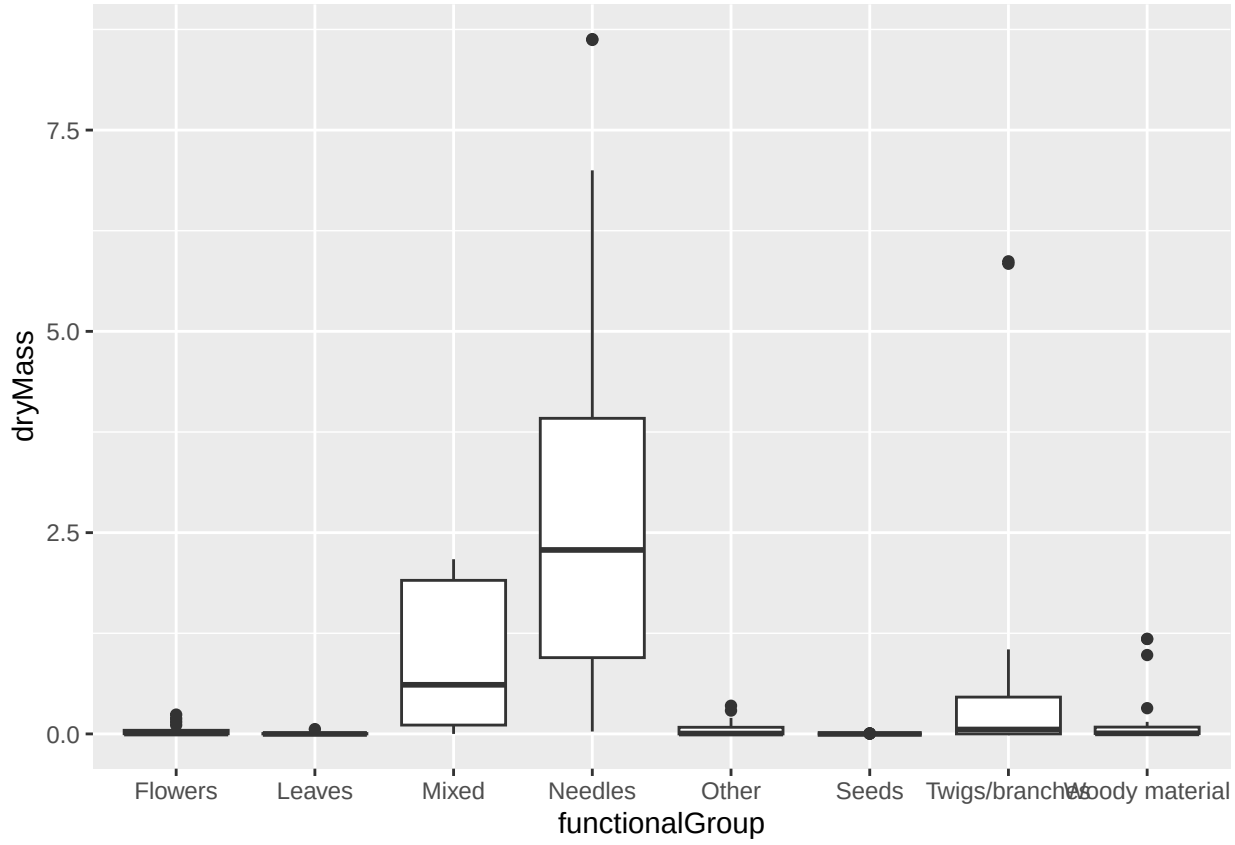
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
ggplot(NEON.Litter.data) + geom_bar(aes(x = functionalGroup)) + theme(axis.text.x = element_text(angle =
    vjust = 0.5, hjust = 1))
```

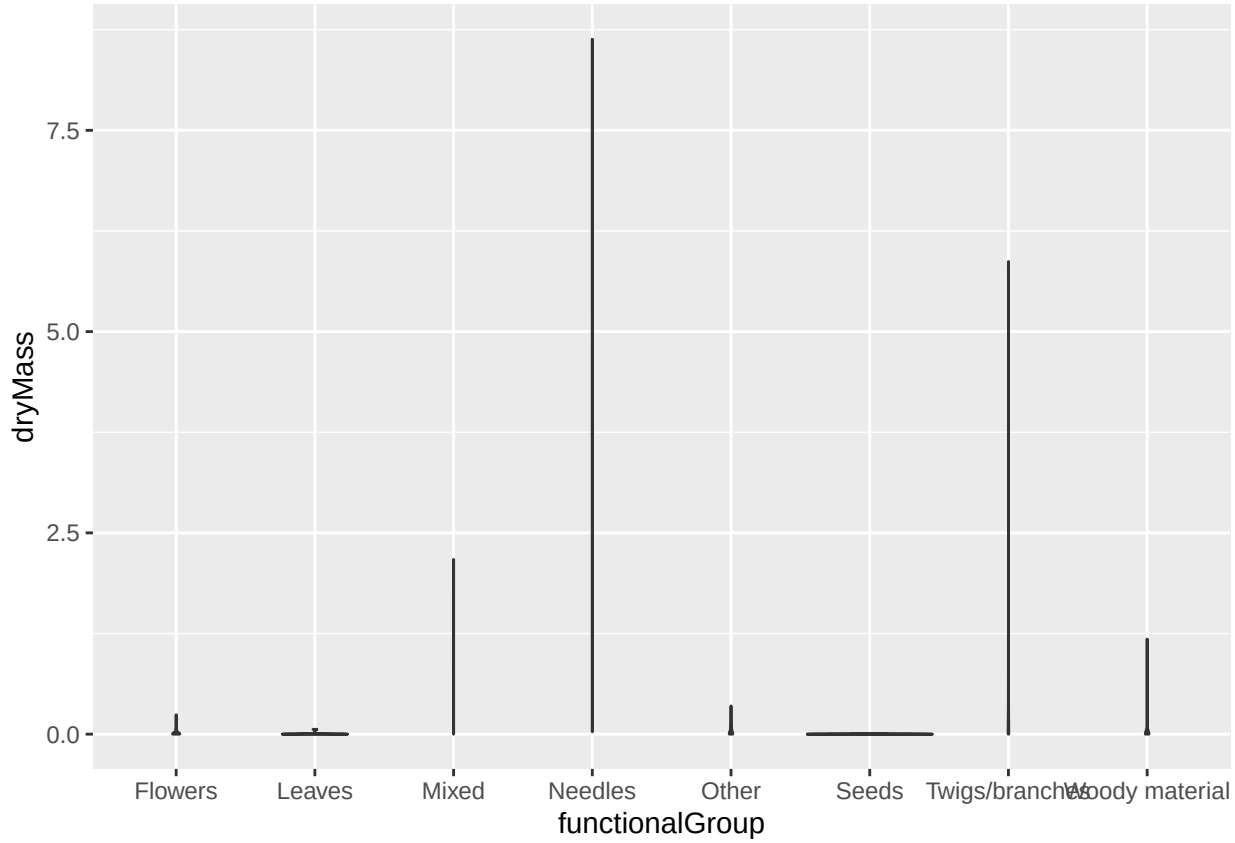


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

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




```
ggplot(NEON.Litter.data) + 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: Visually, the distributions of the data in the boxplot can be seen much better, and this may be because of the large outlier in the "needles" functional group which makes the density of the counts in the violin plot difficult to see.

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

> Answer: Leaflitter that tend to have the highest biomass are the "needles" group since their median is the highest among all the other types of litter.