Assignment 3: Data Exploration

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OVERVIEW

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

Directions

1. Rename this file `<FirstLast>_A03_DataExploration.Rmd` (replacing `<FirstLast>` with your first and last name).
2. Change "Student Name" on line 3 (above) with your name.
3. Work through the steps, **creating code and output** that fulfill each instruction.
4. Assign a useful **name to each code chunk** and include ample **comments** with your code.
5. Be sure to **answer the questions** in this assignment document.
6. When you have completed the assignment, **Knit** the text and code into a single PDF file.
7. After Knitting, submit the completed exercise (PDF file) to the dropbox in Canvas.

TIP: If your code extends past the page when knit, tidy your code by manually inserting line breaks.

TIP: If your code fails to knit, check that no `install.packages()` or `View()` commands exist in your code.

Set up your R session

1. Load necessary packages (tidyverse, lubridate, here), check your current working directory and upload two datasets: the ECOTOX neonicotinoid dataset (ECOTOX_Neonicotinoids_Insects_raw.csv) and the Niwot Ridge NEON dataset for litter and woody debris (NEON_NIWO_Litter_massdata_2018-08_raw.csv). Name these datasets "Neonics" and "Litter", respectively. Be sure to include the subcommand to read strings in as factors.

```
#Load the dplyr, tidyverse, ggplot2, and here package
library(dplyr)
library(ggplot2)
library(here)
library(tidyverse)

#Upload the Neonics dataset
neonics <- read.csv(
  file = here("./Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv"),
  stringsAsFactors = TRUE)
```

```r
#Upload the Litter dataset
litter <- read.csv(
  file = here("./Data/Raw/NEON_NIWO_Litter_massdata_2018-08_raw.csv"),
  stringsAsFactors = TRUE)
```

Learn about your system

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

   Answer: Neonicotinoids were originally introduced as a less harmful insecticide. However, research now shows that they are harmful to insects. For example, they are very harmful to bees. The chemicals are absorbed by plants and are thus present in pollen and nectar. Additionally, they have long-lasting lifespans in plants. Overall, we are interested in the ecotoxicology of neonicotinoids on insects because they will affect insect populations, which will then have a cascading effect on ecosystems, as many of these insects are beneficial.

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 has many important ecological functions. First, litter and woody debris breaks down organic matter and returns nutrients back into the soil. Second, they provide habitat for organisms (including insects), helping to sustain biodiversity. Third, litter and woody debris helps retain moisture in the soil which is necessary for plant growth. They can also stabilize soils, helping to prevent erosion. Litter and woody debris are crucial for preserving biodiversity in ecosystems.

4. How is litter and woody debris sampled as part of the NEON network? Read the NEON_Litterfall_UserGuide.pdf document to learn more. List three pieces of salient information about the sampling methods here:

   Answer: 1. Litter and woody debris are collected from ground traps and elevated traps. These samples are then weighed. 2. Traps are placed in both targeted and randomized ways, depending on vegetation. Traps are only placed in tower plots. 3. Ground traps are sampled once per year, while elevated traps are sampled at varying frequencies depending on amount of vegetation.

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```r
#Use the `dim` function to find the number of rows and columns in the dataset
dim(neonics)
```

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

```
#The dataset has 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? [Tip: The `sort()` command is useful for listing the values in order of magnitude...]

```
#Use the `summary` function to look at an overview of the types of effects
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
```

```
#Create a table summarizing these effects
neonics_summary <- table(neonics$Effect)

#Now, sort the table using the `sort` function. Decreasing = TRUE indicates that
#the sort should be decreasing (so it starts with the most common effect).
sorted_neonics_summary <- sort(neonics_summary, decreasing = TRUE)
sorted_neonics_summary
```

```
##
##       Population        Mortality         Behavior Feeding behavior
##             1803             1493              360              255
##     Reproduction      Development        Avoidance         Genetics
##              197              136              102               82
##        Enzyme(s)           Growth       Morphology    Immunological
##               62               38               22               16
##     Accumulation     Intoxication     Biochemistry          Cell(s)
##               12               12               11                9
##       Physiology        Histology       Hormone(s)
##                7                5                1
```

```
#Population is the most common effect. Mortality is the second most common.
```

Answer: Population is the most common effect. Mortality is the second most common. These effects are specifically of interest because they reflect the impact that neonicotinoids have on insect population sizes. This data can be useful for predicting ecosystem dynamics.

7. Using the `summary` function, determine the six most commonly studied species in the dataset (common name). What do these species have in common, and why might they be of interest over other insects? Feel free to do a brief internet search for more information if needed.[TIP: Explore the help on the `summary()` function, in particular the `maxsum` argument...]

```r
#Use the summary function to look at an overview of the common species names.
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
#Create a table summarizing these species.
neonics_species <- table(neonics$Species.Common.Name)
```

```
#Now, sort the table using the sort function. Decreasing = TRUE indicates that
#the sort should be decreasing (so it starts with the most common species).
sorted_neonics_species <- sort(neonics_species, decreasing = TRUE)
sorted_neonics_species
```

```
##
##                          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 Apple Leafhopper Nymph
##                             2                             2
##       White-backed Planthopper           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
```

```
#The six most commonly studied species are the honey bee, parasitic wasp, buff
#tailed bumblebee, carniolan honey bee, bumble bee, and Italian honeybee.

#This is another way to do it using maxsum. Here, I'm indicating I want seven
#levels to show (because the 7th will be (other)).
summary(neonics$Species.Common.Name, maxsum = 7)
```

```
##             Honey Bee        Parasitic Wasp Buff Tailed Bumblebee
##                   667                     285                     183
##   Carniolan Honey Bee             Bumble Bee       Italian Honeybee
##                   152                     140                     113
##               (Other)
```

```
##                    3083
```

Answer: The six most commonly studied species are the honey bee, parasitic wasp, buff tailed bumblebee, carniolan honey bee, bumble bee, and Italian honeybee. Most of these species are pollinators; they are therefore of more interest because pollination is crucial for plant reproduction. Although parasitic wasps are not pollinators, they too are can indirectly contribute to plant reproduction.

8. Concentrations are always a numeric value. What is the class of `Conc.1..Author.` column in the dataset, and why is it not numeric? [Tip: Viewing the dataframe may be helpful...]

```
#Use the `view` function to view the dataframe.
view(neonics)

#Use the `class` function to view the class of the `Conc.1..Author` column.
class(neonics$Conc.1..Author.)
```

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

```
#The class is factor.

#Examine the specific categories.
summary(neonics$Conc.1..Author.)
```

```
##    0.37/      10/      NR/       NR        1     1023    0.40/       2/
##      208      127      108       94       82       80       69       63
##       10   0.053/      100      50/     0.5/     0.03    0.05/     0.45
##       62       59       56       51       45       44       43       43
##     0.1/    0.45/     1.0/    2.27/       50    0.125     500/      0.5
##       42       40       40       40       36       33       33       32
##   0.048/    0.15/       1/       48    25.0/      12/    0.027      2.4
##       30       30       30       30       28       27       26       26
##     0.2/    0.56/     100/        3    0.01/    1000/       3/    0.336
##       25       24       23       23       22       22       22       21
##     1.5/     0.05      1.5    2.60/    20.0/        6    6.80/    62.5/
##       21       20       20       20       20       20       20       20
##    0.005     0.4/    0.18/     0.3/     1000       40 0.00355/      0.1
##       18       18       17       17       17       17       16       16
##      0.4     150/      300      80/    0.053     0.24     0.28     125/
##       16       16       16       16       15       15       15       15
##        9   0.0001  0.0004/   0.084/     0.15      0.6    12.5/   144.0/
##       15       14       14       14       14       14       14       14
##     350/    40.0/      48/       56      84/    0.17/      125       14
##       14       14       14       14       14       13       13       13
##       16       17   0.047/    0.25/    0.28/    1.28/    1.81/      112
##       13       13       12       12       12       12       12       12
##      150     2.5/       25      60/      75/    0.02/   0.025/     0.29
##       12       12       12       12       12       11       11       11
##    37.5/       4/        5  (Other)
##       11       11       11     1817
```

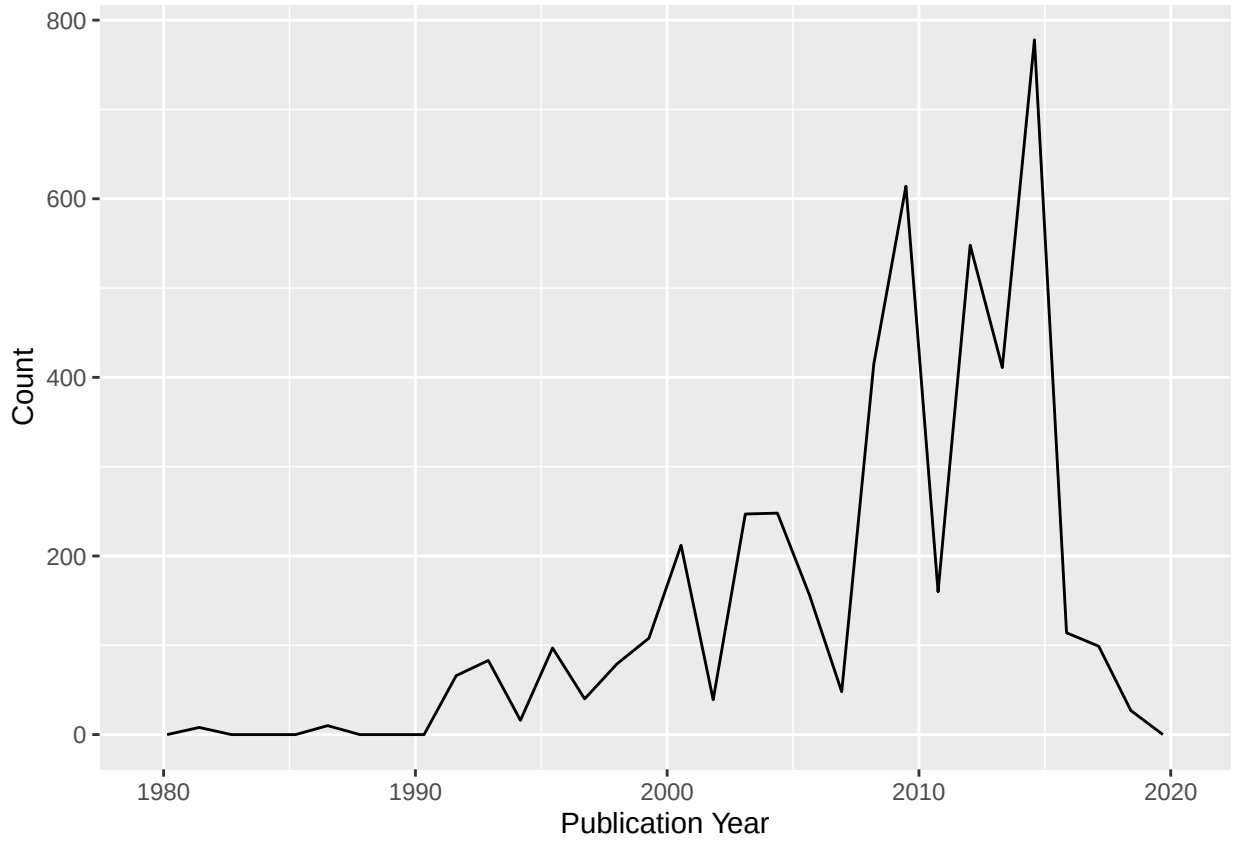
Answer: The class is factor. It is not numeric. Factors are categorical; because some of the data entries include "/" after the number, R reads this data as a factor rather than a number.

Explore your data graphically (Neonics)

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

```
ggplot(neonics, aes(Publication.Year)) + #Specify which data frame and which
  #column to use along the x-axis
        geom_freqpoly() + #Specify the type of plot to be used
  labs(x = "Publication Year", y = "Count") #Change axis lables
```

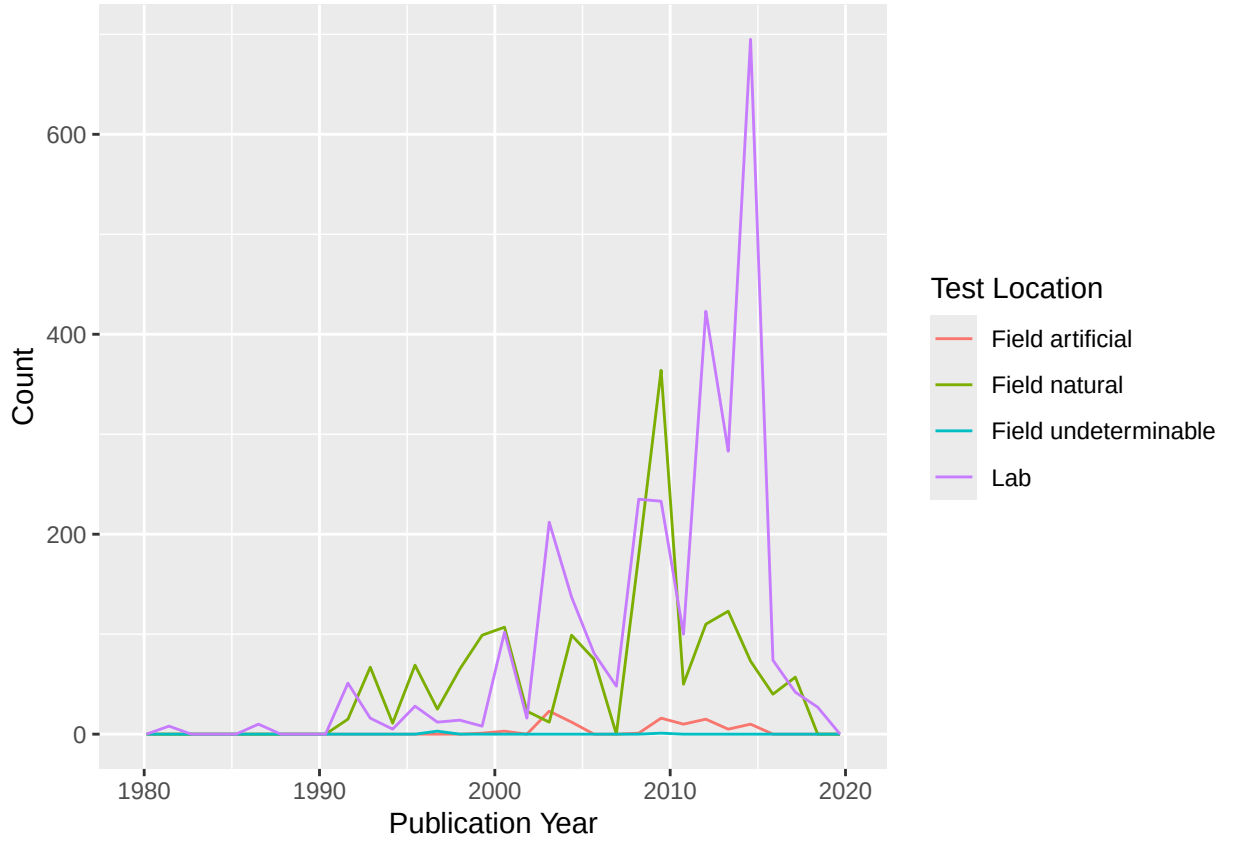
```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



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

```
ggplot(neonics, aes(Publication.Year, color = Test.Location)) + #Specify which
  #data frame and which column to use along the x-axis and that color should
  #vary based on test location
        geom_freqpoly() + #Specify the type of plot to be used
  labs(x = "Publication Year", y = "Count", color = "Test Location") #Change the
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
#axis labels and legend title
```

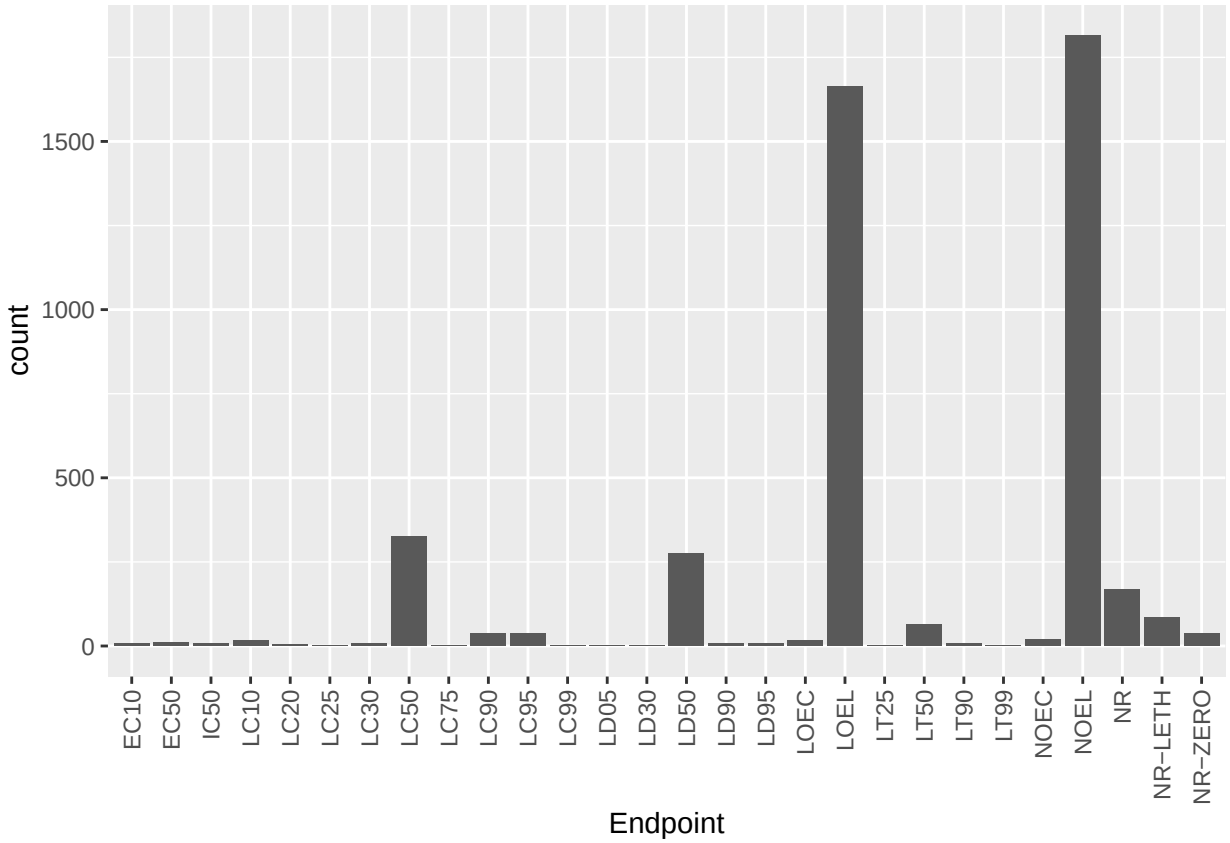
Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer: The most common test locations are the lab and natural field. Natural field peaked right before 2010 and then dropped; lab peaked in about 2015 and then dropped drastically. Both natural field and lab were far less common before the 2000s.

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

[**TIP**: Add `theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))` to the end of your plot command to rotate and align the X-axis labels...]

```
ggplot(neonics, aes(Endpoint)) + #Specify which
  #data frame and which column to use along the x-axis.
  geom_bar() + #Specify we want to use a bar graph.
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) #This
```




```
#rotates and aligns and the x-axis labels so we can see them clearly.
```

Answer: The two most common endpoints are LOEL and NOEL. LOEL is defined as the Lowest-observable-effect-level: lowest dose (concentration) producing effects that were significantly different (as reported by authors) from responses of controls (LOEAL/LOEC). NOEL is defined as no-observable-effect-level: highest dose (concentration) producing effects not significantly different from responses of controls according to author's reported statistical test (NOEAL/NOEC).

Explore your data (Litter)

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

```
#Use the `class` function to determine the class of collectDate.
class(litter$collectDate)
```

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

```
#The class is factor,

#Change the class of collectDate to date using the `as.Date` function.
litter$collectDate <- as.Date(litter$collectDate)

#Confirm the new class of the variable.
class(litter$collectDate)
```

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

```
#The class is now date.

#Use the `unique` function to determine which dates litter were sampled in
#August 2018.
unique(litter$collectDate)
```

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

```
#Sampling occurred on August 2nd and August 30th.
```

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

```
#Use `unique` to determine how many different plots were sampled at Niwot Ridge.
unique(litter$namedLocation)
```

```
##  [1] NIWO_061.basePlot.ltr NIWO_064.basePlot.ltr NIWO_067.basePlot.ltr
##  [4] NIWO_040.basePlot.ltr NIWO_041.basePlot.ltr NIWO_063.basePlot.ltr
##  [7] NIWO_047.basePlot.ltr NIWO_051.basePlot.ltr NIWO_058.basePlot.ltr
## [10] NIWO_046.basePlot.ltr NIWO_062.basePlot.ltr NIWO_057.basePlot.ltr
## 12 Levels: NIWO_040.basePlot.ltr ... NIWO_067.basePlot.ltr
```

```
#There are 12 levels, so 12 different plots were sampled.

#Use `summary` to determine how many different plots were sampled at Niwot Ridge.
summary(litter$namedLocation)
```

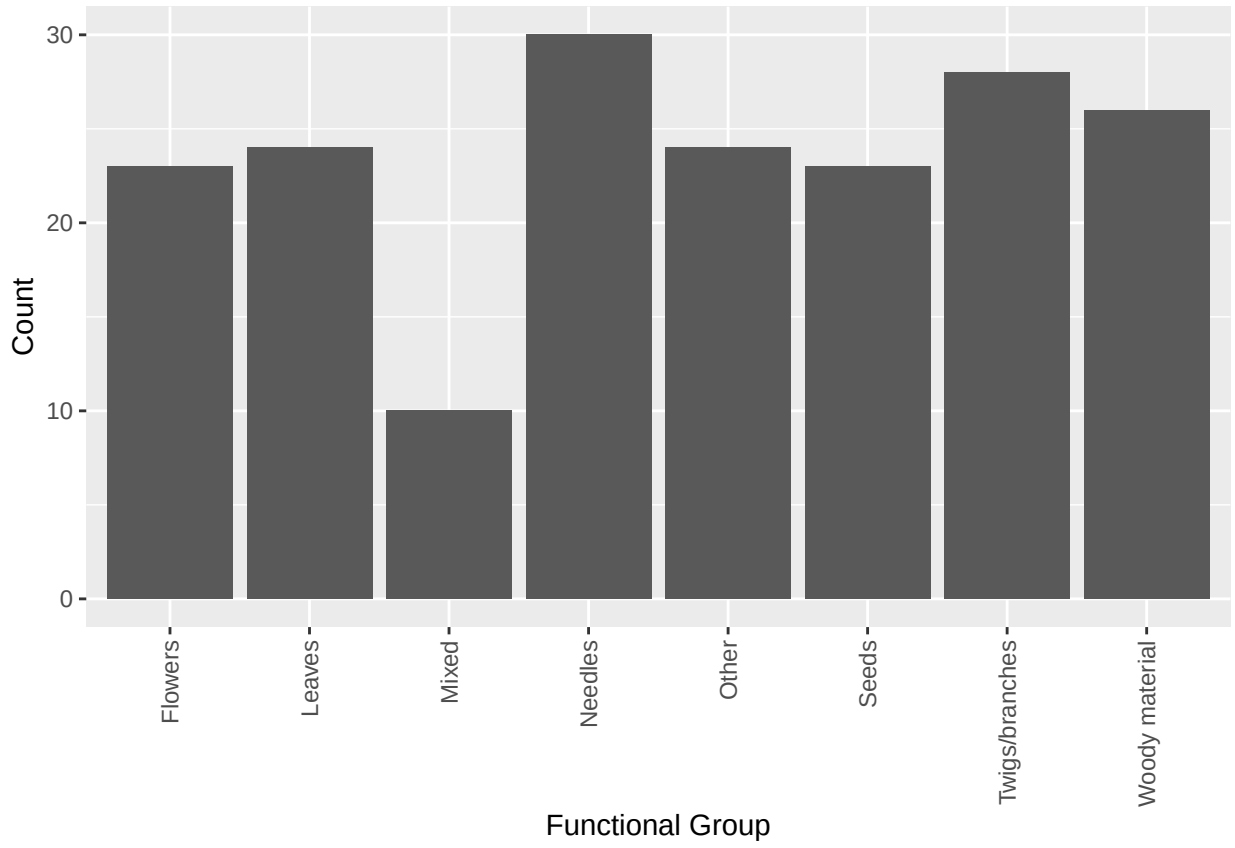
```
## NIWO_040.basePlot.ltr NIWO_041.basePlot.ltr NIWO_046.basePlot.ltr
##                    20                    19                    18
## NIWO_047.basePlot.ltr NIWO_051.basePlot.ltr NIWO_057.basePlot.ltr
##                    15                    14                     8
## NIWO_058.basePlot.ltr NIWO_061.basePlot.ltr NIWO_062.basePlot.ltr
##                    16                    17                    14
## NIWO_063.basePlot.ltr NIWO_064.basePlot.ltr NIWO_067.basePlot.ltr
##                    14                    16                    17
```

```
#This returned the sample counts at each plot.
```

Answer: `unique` returns the number of levels of our data (12). `summary` returns the number of counts of each level. We can still find the number of levels using summary by manually counting the number of categories in the output.

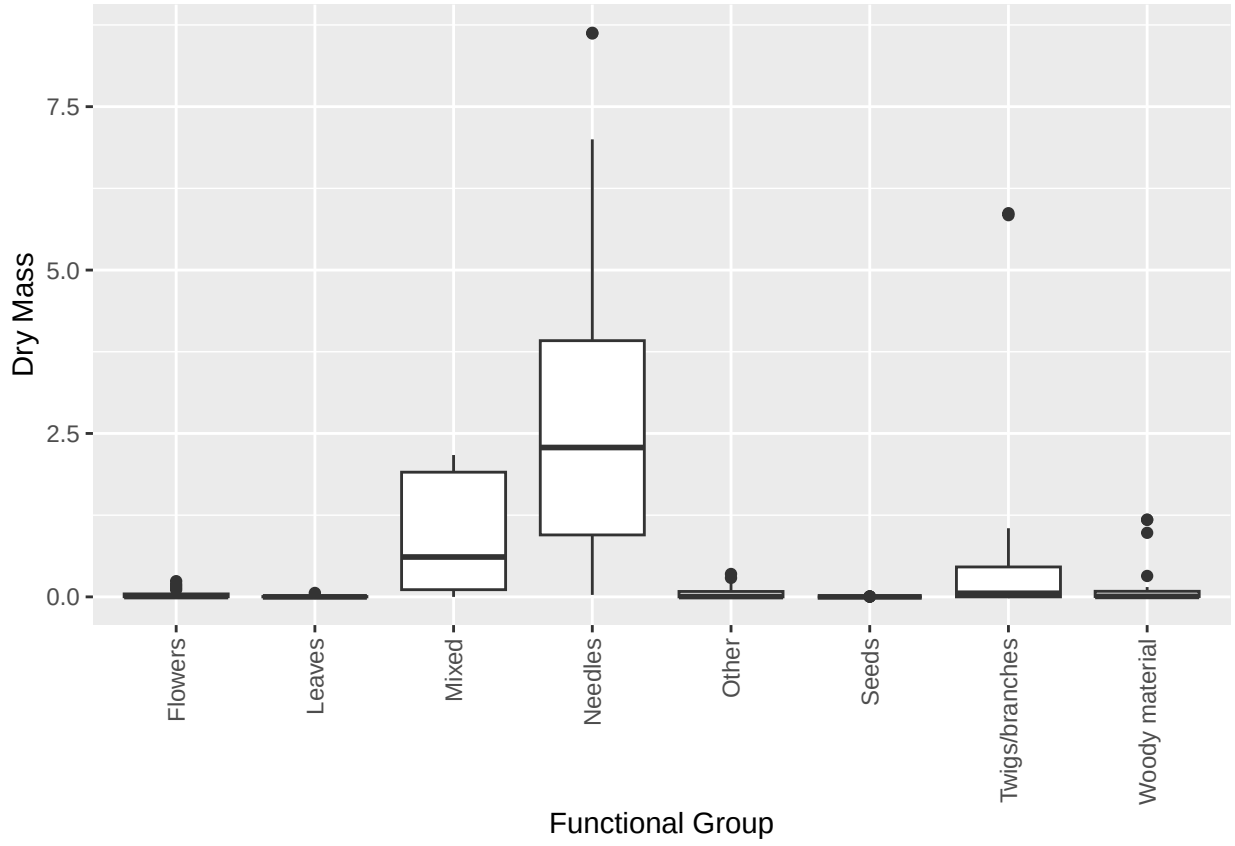
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
ggplot(litter, aes(functionalGroup)) + #Specify which
  #data frame and which column to use along the x-axis.
  geom_bar() + #Specify we want to use a bar graph.
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) + #This
#rotates and aligns and the x-axis labels so we can see them clearly.
  labs(x = "Functional Group", y = "Count") #Change axis labels.
```

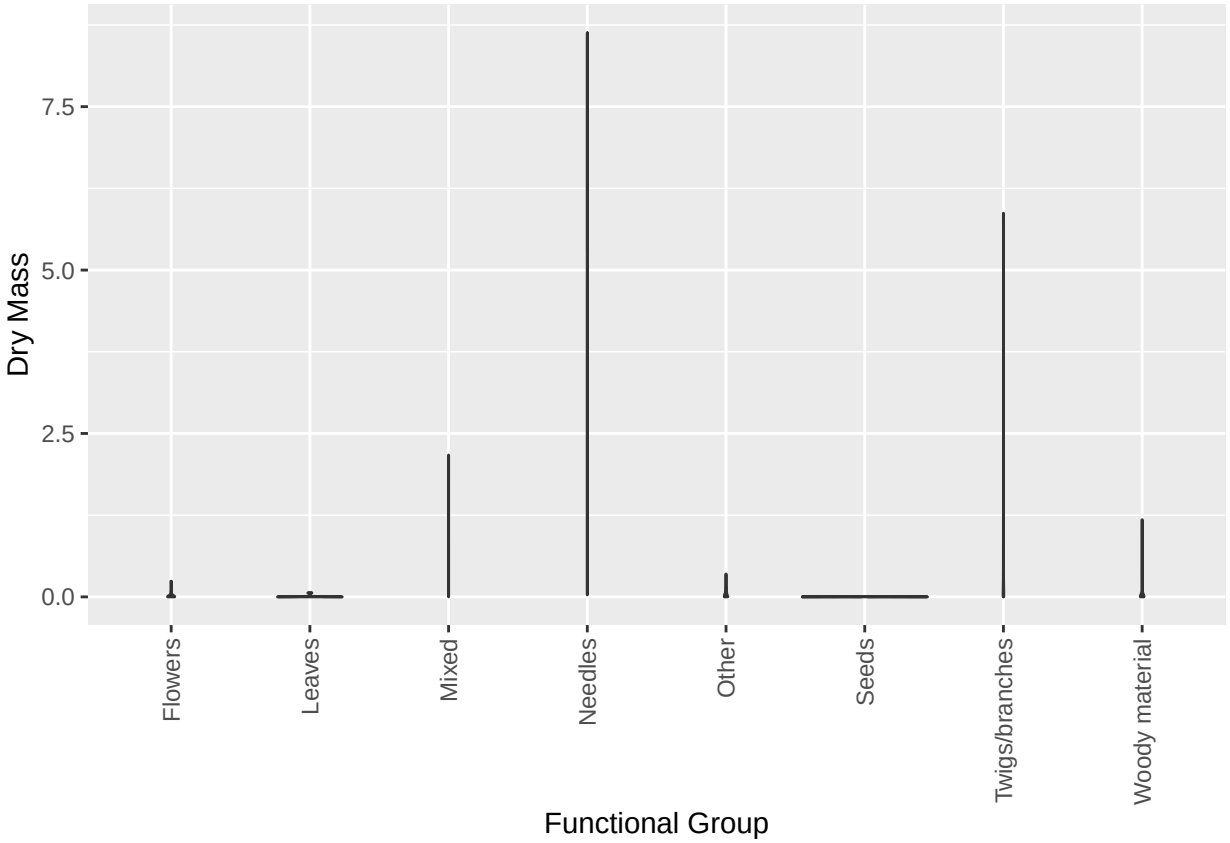


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```
#Start with boxplot:
ggplot(litter) + #Specify which data frame to use.
  geom_boxplot(aes(x = functionalGroup, y = dryMass)) + #Specify we want to use
  #a boxplot with functional group on the x-axis and dry mass on the y-axis
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) + #This
#rotates and aligns and the x-axis labels so we can see them clearly.
  labs(x = "Functional Group", y = "Dry Mass") #Change axis labels.
```




```
#Now a violin plot:
ggplot(litter) + #Specify which data frame to use.
  geom_violin(aes(x = functionalGroup, y = dryMass)) + #Specify we want to use
  #a violin plot with functional group on the x-axis and dry mass on the y-axis
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)) + #This
#rotates and aligns and the x-axis labels so we can see them clearly.
  labs(x = "Functional Group", y = "Dry Mass") #Change axis labels.
```



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

> Answer: The violin plot displays density distributions. However, the width #only changes with a continuous variable along the x-axis. Since functional group is categorical, the "violin" does not have a width.

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

> Answer: Needlles tend to have the highest biomass at these sites.