Assignment 3: Data Exploration

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Fall 2023

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)

Neonics <- read.csv("/Users/mac/Documents/EDE_Fall2023/Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv",
Litter <- read.csv("/Users/mac/Documents/EDE_Fall2023/Data/Raw/NEON_NIWO_Litter_massdata_2018-08_raw.cs
```

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 extremely common instectidices. Although they are effective at limitting targetted populations of instects, neonictinoids can have effects on insect populations outside of pests that are targetted. It is important to show the effect of neonictinoids on both target populations of insects and on populations like pollinators. One may use this data to judge if neonictinoids are worth it in terms of reducing pests versus reducing desirable insect populations.

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: Debris on forest floors are essential for determining flooding outcomes, fire risk, nutrient cycles, and even carbon sequesteration possibilities. Keeping track of the debris on forest floors and how long it takes for the ecosystem to absorb debris back into the soil can give researchers time frames for seasonal fire risks and flood risks. The presence of these debris also can inform researchers about the quality and nutrient make up of soil.

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. Takes place in 20 40 x 40 meter plots. 2. Trap placement for collection within plots may either be randomized or targeted depending on vegetation cover. 3. Ground traps are sampled only once a year, and elevated traps are sampled more frequently (every month or so for evergreen areas and every 2 weeks for deciduous areas).

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim(Neonics)
```

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

```
summary(Neonics)
```

```
##    CAS.Number
##  Min.   : 58842209
##  1st Qu.:138261413
##  Median :138261413
```

```
## Mean   :147651982
## 3rd Qu.:153719234
## Max.   :210880925
##
##                                                                                     Chemical.Name
## (2E)-1-[(6-Chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine                        :2658
## 3-[(2-Chloro-5-thiazolyl)methyl]tetrahydro-5-methyl-N-nitro-4H-1,3,5-oxadiazin-4-imine: 686
## [C(E)]-N-[(2-Chloro-5-thiazolyl)methyl]-N'-methyl-N''-nitroguanidine                     : 452
## (1E)-N-[(6-Chloro-3-pyridinyl)methyl]-N'-cyano-N-methylethanimidamide                    : 420
## N''-Methyl-N-nitro-N'-[(tetrahydro-3-furanyl)methyl]guanidine                            : 218
## [N(Z)]-N-[3-[(6-Chloro-3-pyridinyl)methyl]-2-thiazolidinylidene]cyanamide                : 128
## (Other)                                                                                  :  61
##                                                     Chemical.Grade
## Not reported                                              :3989
## Technical grade, technical product, technical formulation: 422
## Pestanal grade                                            :  93
## Not coded                                                 :  53
## Commercial grade                                          :  27
## Analytical grade                                          :  15
## (Other)                                                   :  24
##                                                   Chemical.Analysis.Method
## Measured                                                     : 230
## Not coded                                                    :  51
## Not reported                                                 :   5
## Unmeasured                                                   :4321
## Unmeasured values (some measured values reported in article):  16
##
##
## Chemical.Purity                  Species.Scientific.Name
## NR     :2502   Apis mellifera               : 667
## 25     : 244   Bombus terrestris            : 183
## 50     : 200   Apis mellifera ssp. carnica  : 152
## 20     : 189   Bombus impatiens             : 140
## 70     : 112   Apis mellifera ssp. ligustica: 113
## 75     :  89   Popillia japonica            :  94
## (Other):1287   (Other)                      :3274
##            Species.Common.Name
## Honey Bee           : 667
## Parasitic Wasp      : 285
## Buff Tailed Bumblebee: 183
## Carniolan Honey Bee  : 152
## Bumble Bee          : 140
## Italian Honeybee    : 113
## (Other)             :3083
##                                                       Species.Group
## Insects/Spiders                                            :3569
## Insects/Spiders; Standard Test Species                     :  27
## Insects/Spiders; Standard Test Species; U.S. Invasive Species: 667
## Insects/Spiders; U.S. Invasive Species                     : 360
##
##
##
##   Organism.Lifestage  Organism.Age            Organism.Age.Units
## Not reported:2271     NR     :3851   Not reported        :3515
```

```
##  Adult       :1222     2      : 111   Day(s)              : 327
##  Larva       : 437     3      : 105   Instar              : 255
##  Multiple    : 285     <24    :  81   Hour(s)             : 241
##  Egg         : 128     4      :  81   Hours post-emergence:  99
##  Pupa        :  69     1      :  59   Year(s)             :  64
##  (Other)     : 211     (Other): 335   (Other)             : 122
##                    Exposure.Type        Media.Type
##  Environmental, unspecified:1599   No substrate:2934
##  Food                      :1124   Not reported: 663
##  Spray                     : 393   Natural soil: 393
##  Topical, general          : 254   Litter      : 264
##  Ground granular           : 249   Filter paper: 230
##  Hand spray                : 210   Not coded   :  51
##  (Other)                   : 794   (Other)     :  88
##              Test.Location  Number.of.Doses       Conc.1.Type..Author.
##  Field artificial    :  96   2      :2441    Active ingredient:3161
##  Field natural       :1663   3      : 499    Formulation      :1420
##  Field undeterminable:   4   5      : 314    Not coded        :  42
##  Lab                 :2860   6      : 230
##                              4      : 221
##                              NR     : 217
##                              (Other): 701
##  Conc.1..Author. Conc.1.Units..Author.             Effect
##  0.37/  : 208    AI kg/ha  : 575       Population      :1803
##  10/    : 127    AI mg/L   : 298       Mortality       :1493
##  NR/    : 108    AI lb/acre: 277       Behavior        : 360
##  NR     :  94    AI g/ha   : 241       Feeding behavior: 255
##  1      :  82    ng/org    : 231       Reproduction    : 197
##  1023   :  80    ppm       : 180       Development     : 136
##  (Other):3924    (Other)   :2821       (Other)         : 379
##              Effect.Measurement    Endpoint                 Response.Site
##  Abundance             :1699     NOEL   :1816   Not reported          :4349
##  Mortality             :1294     LOEL   :1664   Midgut or midgut gland:  63
##  Survival              : 133     LC50   : 327   Not coded             :  51
##  Progeny counts/numbers: 120     LD50   : 274   Whole organism        :  41
##  Food consumption      : 103     NR     : 167   Hypopharyngeal gland  :  27
##  Emergence             :  98     NR-LETH:  86   Head                  :  23
##  (Other)               :1176     (Other): 289   (Other)               :  69
##  Observed.Duration..Days.       Observed.Duration.Units..Days.
##  1      : 713             Day(s)              :4394
##  2      : 383             Emergence           :  70
##  NR     : 355             Growing season      :  48
##  7      : 207             Day(s) post-hatch   :  20
##  3      : 183             Day(s) post-emergence:  17
##  0.0417 : 133             Tiller stage        :  15
##  (Other):2649             (Other)             :  59
##                                                                              Author
##  Peck,D.C.                                                                      : 208
##  Frank,S.D.                                                                     : 100
##  El Hassani,A.K., M. Dacher, V. Gary, M. Lambin, M. Gauthier, and C. Armengaud:  96
##  Williamson,S.M., S.J. Willis, and G.A. Wright                                  :  93
##  Laurino,D., A. Manino, A. Patetta, and M. Porporato                            :  88
##  Scholer,J., and V. Krischik                                                    :  82
##  (Other)                                                                        :3956
```

```
##  Reference.Number
##  Min.   :   344
##  1st Qu.:108459
##  Median :165559
##  Mean   :142189
##  3rd Qu.:168998
##  Max.   :180410
##
##
##  Long-Term Effects of Imidacloprid on the Abundance of Surface- and Soil-Active Nontarget Fauna in Tu
##  Reduced Risk Insecticides to Control Scale Insects and Protect Natural Enemies in the Production and
##  Effects of Sublethal Doses of Acetamiprid and Thiamethoxam on the Behavior of the Honeybee (Apis mel
##  Exposure to Neonicotinoids Influences the Motor Function of Adult Worker Honeybees
##  Toxicity of Neonicotinoid Insecticides on Different Honey Bee Genotypes
##  Chronic Exposure of Imidacloprid and Clothianidin Reduce Queen Survival, Foraging, and Nectar Storin
##  (Other)
##                                            Source     Publication.Year
##  Agric. For. Entomol.11(4): 405-419          : 200   Min.   :1982
##  Environ. Entomol.41(2): 377-386             : 100   1st Qu.:2005
##  Arch. Environ. Contam. Toxicol.54(4): 653-661:  96   Median :2010
##  Ecotoxicology23:1409-1418                   :  93   Mean   :2008
##  Bull. Insectol.66(1): 119-126               :  88   3rd Qu.:2013
##  PLoS One9(3): 14 p.                         :  82   Max.   :2019
##  (Other)                                     :3964
##  Summary.of.Additional.Parameters
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingred
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingred
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingred
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingred
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingred
##  Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Formulation I
##  (Other)
```

```
head(Neonics)
```

```
##   CAS.Number                             Chemical.Name
## 1   58842209 Tetrahydro-2-(nitromethylene)-2H-1,3-thiazine
## 2   58842209 Tetrahydro-2-(nitromethylene)-2H-1,3-thiazine
## 3   58842209 Tetrahydro-2-(nitromethylene)-2H-1,3-thiazine
## 4   58842209 Tetrahydro-2-(nitromethylene)-2H-1,3-thiazine
## 5   58842209 Tetrahydro-2-(nitromethylene)-2H-1,3-thiazine
## 6   58842209 Tetrahydro-2-(nitromethylene)-2H-1,3-thiazine
##                                              Chemical.Grade
## 1 Technical grade, technical product, technical formulation
## 2 Technical grade, technical product, technical formulation
## 3 Technical grade, technical product, technical formulation
## 4 Technical grade, technical product, technical formulation
## 5 Technical grade, technical product, technical formulation
## 6 Technical grade, technical product, technical formulation
##   Chemical.Analysis.Method Chemical.Purity Species.Scientific.Name
## 1               Unmeasured              99  Araecerus fasciculatus
## 2               Unmeasured              99  Araecerus fasciculatus
## 3               Unmeasured              95         Musca domestica
## 4               Unmeasured              95         Musca domestica
```

```
## 5              Unmeasured             95         Musca domestica
## 6              Unmeasured             95         Musca domestica
##   Species.Common.Name   Species.Group Organism.Lifestage Organism.Age
## 1  Coffee Bean Weevil Insects/Spiders              Adult           NR
## 2  Coffee Bean Weevil Insects/Spiders              Adult           NR
## 3           House Fly Insects/Spiders              Young           NR
## 4           House Fly Insects/Spiders              Young           NR
## 5           House Fly Insects/Spiders              Young           NR
## 6           House Fly Insects/Spiders              Adult            9
##   Organism.Age.Units    Exposure.Type   Media.Type Test.Location
## 1       Not reported Topical, general No substrate           Lab
## 2       Not reported Topical, general No substrate           Lab
## 3            Hour(s)             Food Filter paper           Lab
## 4            Hour(s)             Food Filter paper           Lab
## 5            Hour(s)             Food Filter paper           Lab
## 6             Day(s)             Food Filter paper           Lab
##   Number.of.Doses Conc.1.Type..Author. Conc.1..Author. Conc.1.Units..Author.
## 1              NR    Active ingredient            27.2             ug/g bdwt
## 2              NR    Active ingredient            19.7             ug/g bdwt
## 3              11    Active ingredient              47                  mg/L
## 4              11    Active ingredient              25                  mg/L
## 5              11    Active ingredient              13                  mg/L
## 6              11    Active ingredient             268                  mg/L
##      Effect Effect.Measurement Endpoint Response.Site Observed.Duration..Days.
## 1 Mortality          Mortality     LD50  Not reported                        1
## 2 Mortality          Mortality     LD50  Not reported                        1
## 3 Mortality          Mortality     LC50  Not reported                        1
## 4 Mortality          Mortality     LC50  Not reported                        1
## 5 Mortality          Mortality     LC50  Not reported                        1
## 6 Mortality          Mortality     LC50  Not reported                        1
##   Observed.Duration.Units..Days.
## 1                         Day(s)
## 2                         Day(s)
## 3                         Day(s)
## 4                         Day(s)
## 5                         Day(s)
## 6                         Day(s)
##                                                           Author
## 1                                Childers,C.C., and H.N. Nigg
## 2                                Childers,C.C., and H.N. Nigg
## 3 Johnston,A.M., J. Lohr, J. Moes, K.R. Solomon, and E.R. Zaborski
## 4 Johnston,A.M., J. Lohr, J. Moes, K.R. Solomon, and E.R. Zaborski
## 5 Johnston,A.M., J. Lohr, J. Moes, K.R. Solomon, and E.R. Zaborski
## 6 Johnston,A.M., J. Lohr, J. Moes, K.R. Solomon, and E.R. Zaborski
##   Reference.Number
## 1           107388
## 2           107388
## 3           103312
## 4           103312
## 5           103312
## 6           103312
##
## 1                                                                            Contact Toxicity of Insecti
## 2                                                                            Contact Toxicity of Insecti
```

```
## 3 Toxicity of Synergized and Unsynergized Nitromethylene Heterocycle Insecticide (SD 35651) to Suscep
## 4 Toxicity of Synergized and Unsynergized Nitromethylene Heterocycle Insecticide (SD 35651) to Suscep
## 5 Toxicity of Synergized and Unsynergized Nitromethylene Heterocycle Insecticide (SD 35651) to Suscep
## 6 Toxicity of Synergized and Unsynergized Nitromethylene Heterocycle Insecticide (SD 35651) to Suscep
##                               Source Publication.Year
## 1   J. Econ. Entomol.75(3): 556-559             1982
## 2   J. Econ. Entomol.75(3): 556-559             1982
## 3 J. Econ. Entomol.79(6): 1439-1442             1986
## 4 J. Econ. Entomol.79(6): 1439-1442             1986
## 5 J. Econ. Entomol.79(6): 1439-1442             1986
## 6 J. Econ. Entomol.79(6): 1439-1442             1986
##
## 1 Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingre
## 2 Purity: \xca NR - NR | Organism Age: \xca NR - NR Not reported | Conc 1 (Author): \xca Active ingre
## 3              Purity: \xca NR - NR | Organism Age: \xca 24 - 48 Hour(s) | Conc 1 (Author): \xca Act
## 4              Purity: \xca NR - NR | Organism Age: \xca 24 - 48 Hour(s) | Conc 1 (Author): \xca Act
## 5               Purity: \xca NR - NR | Organism Age: \xca 24 - 48 Hour(s) | Conc 1 (Author): \xca Ac
## 6             Purity: \xca NR - NR | Organism Age: \xca NR - NR Day(s) | Conc 1 (Author): \xca Acti
```

```
#Dimensions: 4623 rows for 30 columns (variables).
```

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$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: Some of the most common effects are population, mortality, and behavior. These are of interest because they are critical to maintaining an ecosystem. Rapid increases in mortality, decreases in population, or change in behavior for key organisms in an ecosystem can cause a collapse.

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…]

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

```
##                         Ant Family                        Apple Maggot
##                                  9                                   9
```

```
##           Glasshouse Potato Wasp                               Lacewing
##                               10                                     10
##          Southern House Mosquito                Two Spotted Lady Beetle
##                               10                                     10
##         Spotless Ladybird Beetle                    Braconid Parasitoid
##                               11                                     12
##                     Common Thrip       Eastern Subterranean Termite
##                               12                                     12
##                           Jassid                             Mite Order
##                               12                                     12
##                        Pea Aphid                       Pond Wolf Spider
##                               12                                     12
##            Armoured Scale Family                        Diamondback Moth
##                               13                                     13
##                    Eulophid Wasp                      Monarch Butterfly
##                               13                                     13
##                    Predatory Bug                  Yellow Fever Mosquito
##                               13                                     13
##                     Corn Earworm                      Green Peach Aphid
##                               14                                     14
##                        House Fly                              Ox Beetle
##                               14                                     14
##               Red Scale Parasite                     Spined Soldier Bug
##                               14                                     14
##            Western Flower Thrips Hemlock Woolly Adelgid Lady Beetle
##                               15                                     16
##            Hemlock Wooly Adelgid                                   Mite
##                               16                                     16
##                      Onion Thrip                  Araneoid Spider Order
##                               16                                     17
##                        Bee Order                        Egg Parasitoid
##                               17                                     17
##                     Insect Class             Moth And Butterfly Order
##                               17                                     17
##      Oystershell Scale Parasitoid              Black-spotted Lady Beetle
##                               17                                     18
##                     Calico Scale                    Fairyfly Parasitoid
##                               18                                     18
##                      Lady Beetle                 Minute Parasitic Wasps
##                               18                                     18
##                        Mirid Bug                       Mulberry Pyralid
##                               18                                     18
##                         Silkworm                         Vedalia Beetle
##                               18                                     18
##                     Codling Moth            Flatheaded Appletree Borer
##                               19                                     20
##             Horned Oak Gall Wasp                     Leaf Beetle Family
##                               20                                     20
##                Potato Leafhopper            Tooth-necked Fungus Beetle
##                               20                                     20
##                    Argentine Ant                                 Beetle
##                               21                                     21
##                        Mason Bee                               Mosquito
##                               22                                     22
```

```
##                  Citrus Leafminer                   Ladybird Beetle
##                                23                                23
##                 Spider/Mite Class                Tobacco Flea Beetle
##                                24                                24
##                      Chalcid Wasp           Convergent Lady Beetle
##                                25                                25
##                     Stingless Bee              Ground Beetle Family
##                                25                                27
##                Rove Beetle Family                     Tobacco Aphid
##                                27                                27
##                     Scarab Beetle                     Spring Tiphia
##                                29                                29
##                       Thrip Order           Ladybird Beetle Family
##                                29                                30
##                       Parasitoid                    Braconid Wasp
##                                30                                33
##                      Cotton Aphid                    Predatory Mite
##                                33                                33
##              Sweetpotato Whitefly                      Aphid Family
##                                37                                38
##                    Cabbage Looper             Buff-tailed Bumblebee
##                                38                                39
##                    True Bug Order          Sevenspotted Lady Beetle
##                                45                                46
##                      Beetle Order      Snout Beetle Family, Weevil
##                                47                                47
##               Erythrina Gall Wasp                   Parasitoid Wasp
##                                49                                51
##           Colorado Potato Beetle                    Parastic Wasp
##                                57                                58
##              Asian Citrus Psyllid                 Minute Pirate Bug
##                                60                                62
##                 European Dark Bee                          Wireworm
##                                66                                69
##                    Euonymus Scale                 Asian Lady Beetle
##                                75                                76
##                   Japanese Beetle                  Italian Honeybee
##                                94                               113
##                        Bumble Bee               Carniolan Honey Bee
##                               140                               152
##              Buff Tailed Bumblebee                    Parasitic Wasp
##                               183                               285
##                         Honey Bee                           (Other)
##                               667                               670
```

Answer: The most commonly studied species include Honey Bees, Parasitic Wasps, Buf Tailed Bumblebees, Asian Lady Beetles, Euonymus Scale, and Wireworms. The insects have things in common. The bees are common pollinator and are critical for ecosystem health. Parasitic wasps and and Asian Lady Beetles are known for consuming pests as they are predators Scale and Wire worm are common pests that can damage crops. The interaction between the populations of predators, pollinators, and pests is an important aspect for studies.

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

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

```
#Class: factor
```

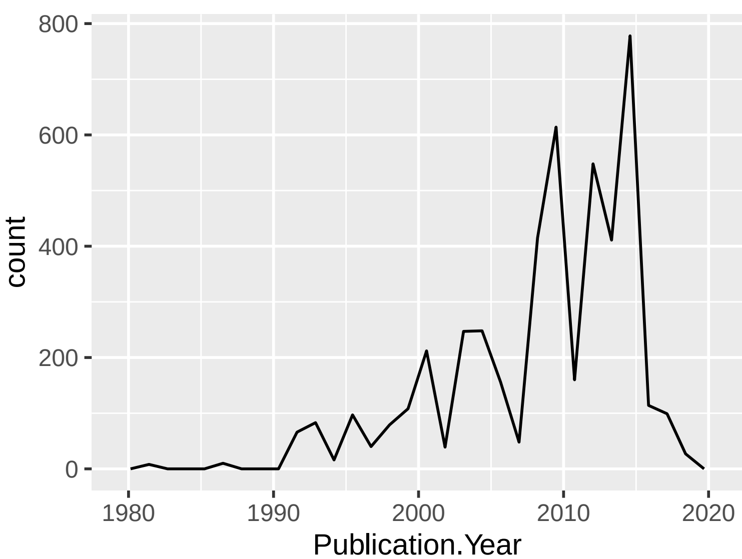
Answer: The column represents a factor class of data. This class categorizes data rather than representing only the discrete numeric value.

Explore your data graphically (Neonics)

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

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

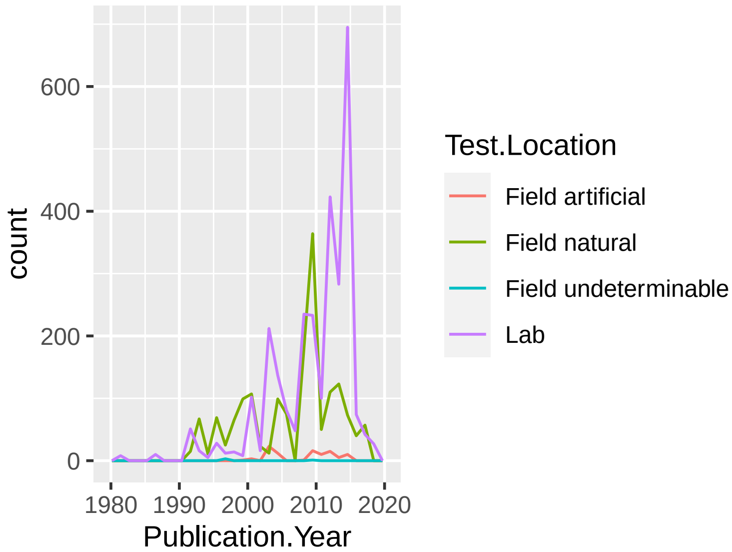
```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



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

```
ggplot(Neonics, aes(x = Publication.Year, color = Test.Location)) +
  geom_freqpoly()
```

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



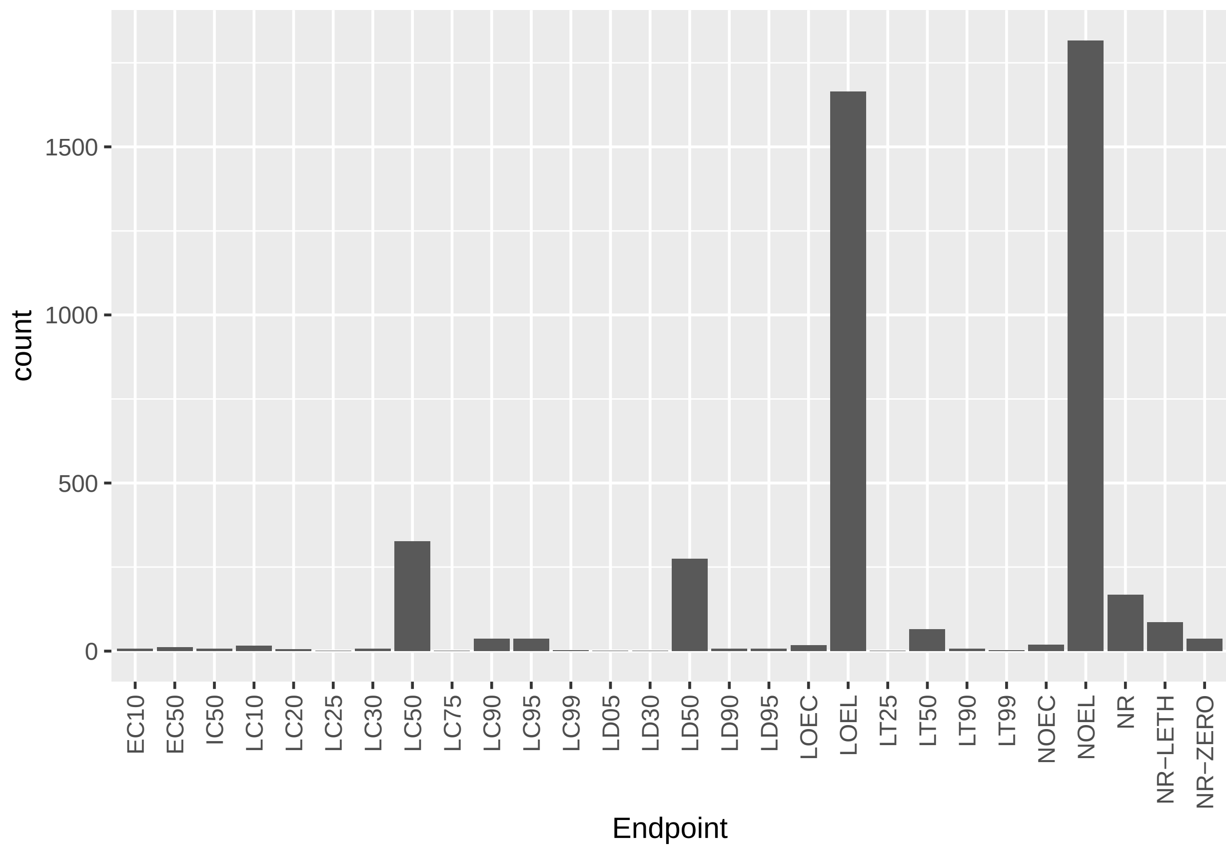
Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer: Lab locations are the most frequent locations for studies after 2010. The second most common test location is "field natural". "Field Natural" was the most frequent test location from 1990-2000, and briefly in 2007-2010.

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



Answer: Endpoints are outcomes that can help measure the effects of ecotoxins. NOEL and LOEL are the most common endpoints. NOEL stands for no observable effect level, and LOEL stands for lowest observable effect levels. NOEL findings are not significantly different from controls, while LOEL findings are slightly but significantly different.

Explore your data (Litter)

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

```
class(Litter$collectDate)
```

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

```
Litter$collectDate <- ymd(Litter$collectDate)

class(Litter$collectDate)
```

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

```
unique(Litter$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`?

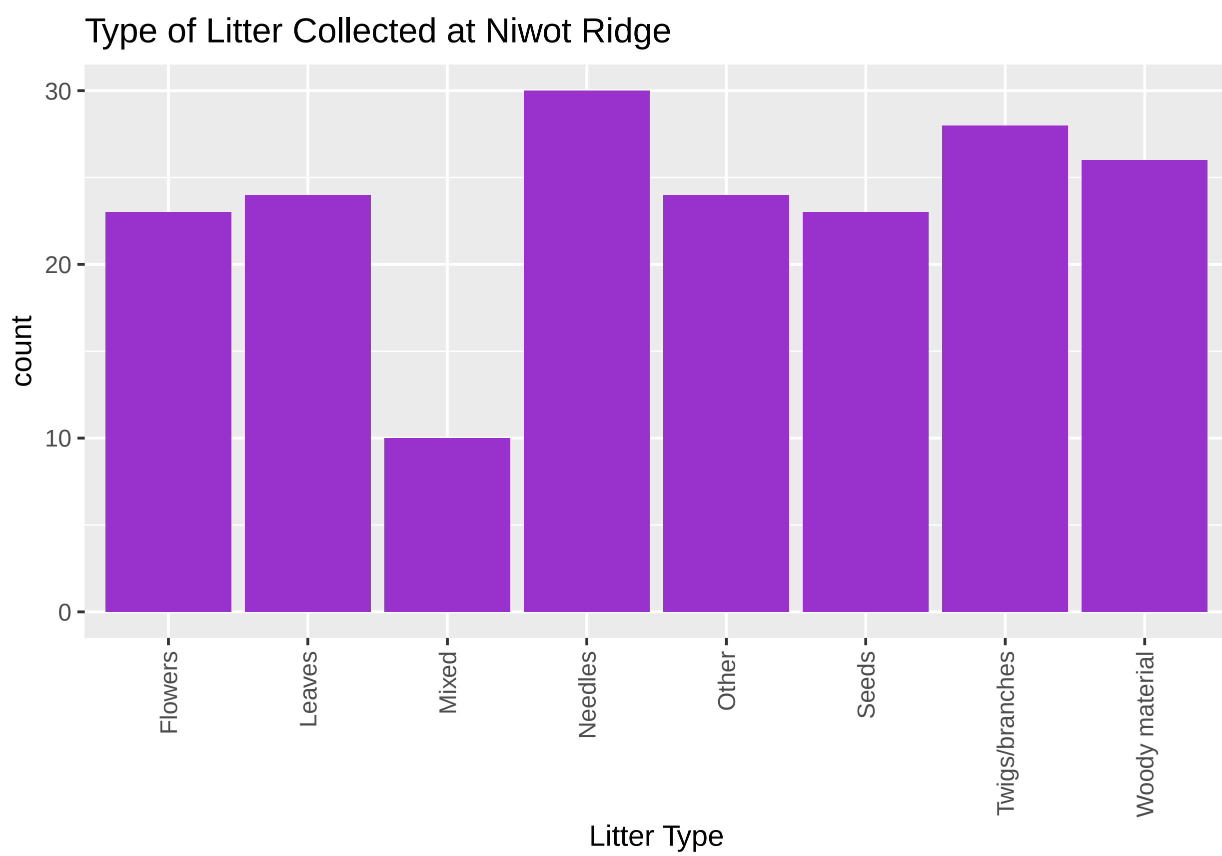
```
unique(Litter$plotID)
```

```
##  [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
```

Answer: Unique displayes the data for each of the distinct values in the plotID column.

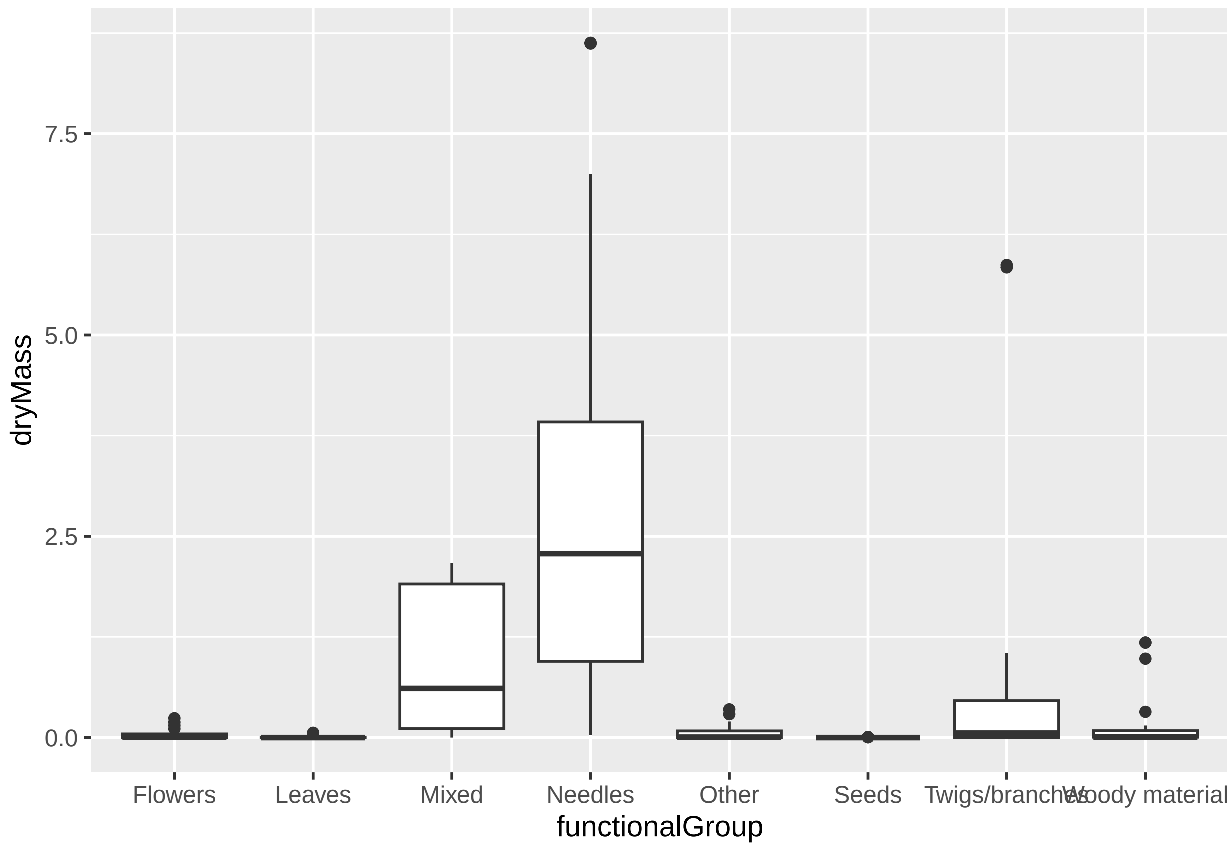
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
ggplot(Litter, aes(x=functionalGroup)) +
  geom_bar(fill = "darkorchid") +
  labs(title="Type of Litter Collected at Niwot Ridge", x="Litter Type") +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```

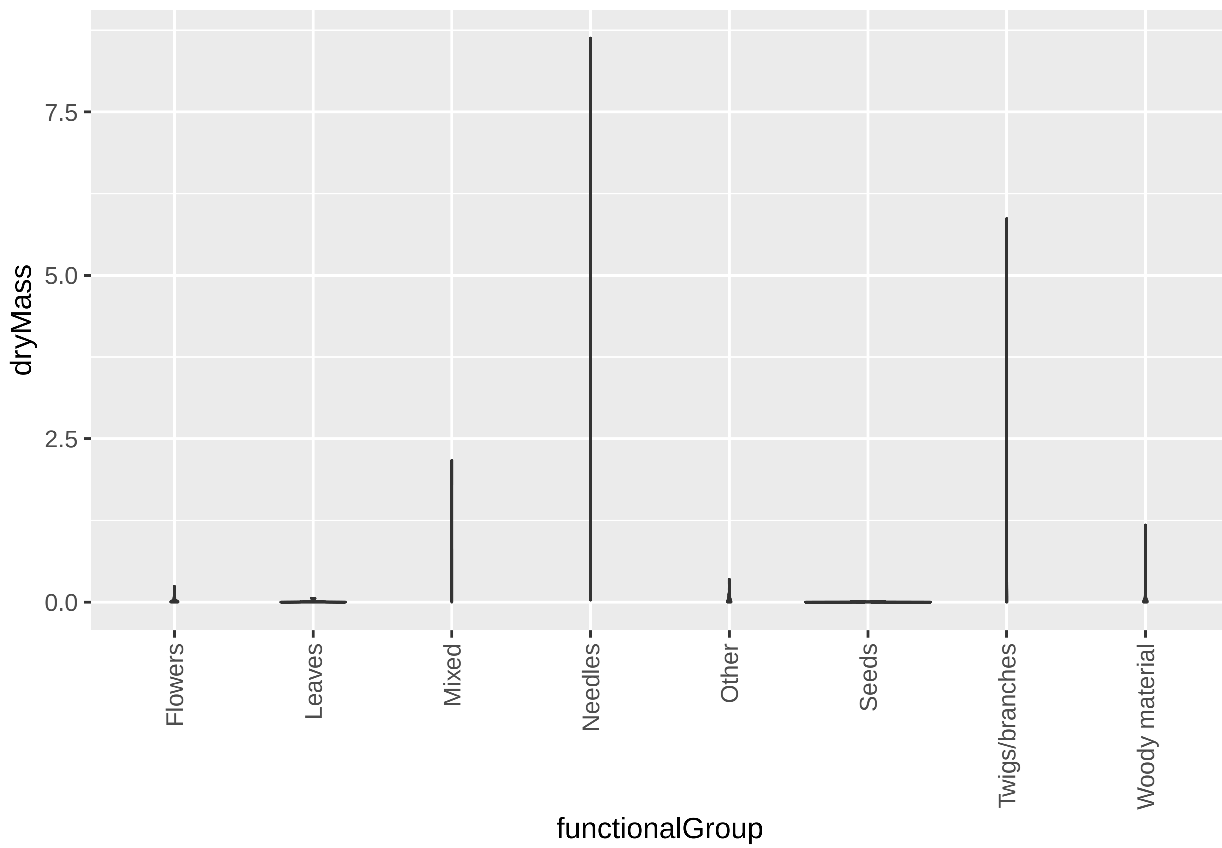


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

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




```r
ggplot(Litter) +
  geom_violin(aes(x = functionalGroup, y = dryMass)) +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))
```



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

> Answer: The boxplot if more effectively showing the variance in the dryMass of litter types. Outliers as well as the median can be seen easily on the boxplot. The violin plot appears to be mostly useless for this calculation. The plot is made up of straight lines in this case that reveal very little about variance in the data.

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

> Answer:Needles have the highest biomass at the sites.