Assignment 3: Data Exploration

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OVERVIEW

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

Directions

1. Change "Student Name" on line 3 (above) with your name.
2. Work through the steps, **creating code and output** that fulfill each instruction.
3. Be sure to **answer the questions** in this assignment document.
4. When you have completed the assignment, **Knit** the text and code into a single PDF file.
5. After Knitting, submit the completed exercise (PDF file) to the dropbox in Sakai. Add your last name into the file name (e.g., "Salk_A03_DataExploration.Rmd") prior to submission.

The completed exercise is due on <>.

Set up your R session

1. Check your working directory, load necessary packages (tidyverse), and upload two datasets: the ECOTOX neonicotinoid dataset (ECOTOX_Neonicotinoids_Insects_raw.csv) and the Niwot Ridge NEON dataset for litter and woody debris (NEON_NIWO_Litter_massdata_2018-08_raw.csv). Name these datasets "Neonics" and "Litter", respectively.

```
getwd()
```

```
## [1] "C:/Users/Zoe/OneDrive/DukeMEM_Yr1/Spring/Environmental_Data_Analytics_2021/Assignments"
```

```
library(tidyverse)

Neonics <- read.csv("../Data/Raw/ECOTOX_Neonicotinoids_Insects_raw.csv", stringsAsFactors = TRUE)
Litter <- read.csv("../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 ecotoxicologoy of neonicotinoids on insects? Feel free to do a brief internet search if you feel you need more background information.

Answer: Even though they are seen as pests, insects are an important part of an ecosystem. Although insecticides may target specific species that truly are pests, they may also inadvertently kill other insects that play important roles in crop fertilization or ecosystem health. We might be interested in studying this to ensure that crop reproduction is not inadvertently harmed by insecticide use.

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 is an important part of any forest ecosystem, providing habitat and food for some organisms, releasing nutrients into the soil as it decomposes, and helping with temperature regulation and moisture retention in the soil. We might be interested in studying this in order to assess the health of a 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: *One pair of traps (elevated and ground) was placed per 400 m2. Plots were located at a strategic distance from buildings or roads.* The amount of vegetation determined the spatial placement of the plots: if there was lots of vegetation cover, plots were placed randomly. If the vegetation cover was spottier, the plots were placed strategically in areas with cover. *All ground traps were sampled only once per year but elevated traps were sampled more frequently (once every two weeks) at plots with deciduous vegetation versus evergreen vegetation (once every couple months).

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim(Neonics) #4623 rows, 30 columns
```

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

6. Using the `summary` function on the "Effects" 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: The most common effects are population and mortality. Mortality would be of interest in determining whether the insecticide is effective or not, while population would be of interest to see how the distribution of plant or insect population changes with insecticide application, also as a measure of effectiveness.

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.

```
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 common species studied are the Honey Bee (667 observations), Parasitic Wasp (285), Buff Tailed Bumblebee (183), Carniolan Honey Bee (152), Bumble Bee (140), and Italian Honeybee (113). The bee species are critical to study because they are essential crop pollinators, so any negative impact on their populations from insecticides would trickle down to crop success. The parasitic wasp is an important species to study because it naturally controls the populations of other insects by laying eggs in them and killing them once the larvae hatch.

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

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

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

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

```
##    [1] 27.2      19.7      47        25        13        268       170      
##    [8] 28        48        40        83        900       15.3      20.4     
##   [15] 5         NR        ~10       65.56     635.4     239.1     NR/      
##   [22] 80.66     1075.7    75.27     636.5     183.4     1267.9    144.0/   
##   [29] 0.295     0.267     20.636    76.035    148.3     12/       12.8     
##   [36] 43.59     37.83     17.32     14.6      122.4     22.59     36/      
##   [43] 7.6       144       144/      0.013     200       0.01      0.002    
##   [50] 0.001     96        5.1/      12        18        1.2       120      
##   [57] 0.012/    240/      0.012     6.0/      0.491     3.743     6.95     
##   [64] 20.6      13.3      22.4      695.5     228.8     34.3      721.6    
##   [71] 4.92      60.1      18.5      462.9     32.8      133       0.025/   
##   [78] 110.3     1000/     96/       0.007     176.5     1507      17.24    
##   [85] 75.26     1034.8    56.73     461.2     376.3     2240.5    48.96    
##   [92] 5.3/      222.65    480       2.3       60.7      20        1.82     
##   [99] 40.0/     3/        75/       0.048/    0.25/     75        0.39/    
##  [106] 0.026/    0.05/     0.005     2.8       50/       10.0/     20/      
##  [113] 0.43      0.73      8.1       14.53     7.07      64.6      1.69     
##  [120] 537       0.6       0.1/      0.5/      1         6         1.0/     
##  [127] 1/        1.38      6.25      0.0600/   100/      80000     0.125/   
##  [134] 8000      8/        84        112       1.81/     22.2      >100.0   
##  [141] 100       10.37     1.81      4.24      9.94      2.5/      56       
##  [148] 263.44    0.18/     0.56      2.27/     1.051     0.49/     23.93    
##  [155] 0.00084/  12.02     70/       108.27    0.3/      5/        84/      
##  [162] 0.134     <5.00     <4.00     5.8       16.69     0.154     0.080/   
##  [169] 71.3      0.09      <10/      0.084/    0.72/     0.02/     80/      
##  [176] 0.155     0.154/    115/      134.80/   35.183    5.2       4        
##  [183] 87.1      0.013/    22        4.1       23.8      4.34      2.31     
##  [190] 0.091     93.21     0.017     0.53      675.4     0.05      0.32     
##  [197] 24.46     25.39     203.6     19.24     0.609     167.9     43.02    
##  [204] 1.37      383       85.8      85.8/     0.0429/   0.010725  42.9     
##  [211] 42.9/     52.6/     0.0037/   225       12.50/    218.89    1.7      
```

```
## [218] 13.8      35        245.5     87.5      242       1.5/      0.375
## [225] 0.1       0.15      7.32      0.558     >6300     6830      8352
## [232] 6.135     0.00077   1.5       0.15/     0.0400/   0.06825/  138.21
## [239] 53        32/       28/       0.83      10        2         25.0/
## [246] 0.03      0.06/     17.5      125/      0.021     46.7      6.55
## [253] 0.053     1000      2.217     0.297     5.7       1.847     0.047/
## [260] 0.5       0.75/     0.75      0.56/     0.00053   156       0.16
## [267] 0.88      0.125     90        360/      2.4       1.3       8
## [274] 0.4/      326.69    620.21    1104      217       0.29/     4.375/
## [281] 0.031     0.047     14        0.4       0.035     0.053/    0.291
## [288] 0.233     0.113     0.246     500       250       125       0.0022/
## [295] 0.227     138.84    0.0439    >0.5      0.0039    >0.1      0.078
## [302] >81       74.9      ~41       37        50        104       57
## [309] 42        30.6      >20       61        0.0179    80.9      0.0671
## [316] 0.536     4.17      1400      1.53      0.112     0.74/     0.08/
## [323] 48/       0.24      400/      0.12      1.25/     1200/     1.16
## [330] 1.62      2.5       2/        1.25      0.7       0.50/     200/
## [337] 0.24/     10/       500/      3.49      0.16/     0.3       24
## [344] 45.9      70        3.7       11.7      2.2/      0.118     7/
## [351] <0.025    <0.5      0.0015    40/       0.0626    300       3
## [358] 0.00355/  30        15.1      6.6       6.5       191.044   99.063
## [365] 74.631    173.088   103.705   46.763    187.208   109.579   97.425
## [372] 99.82     34.37     29.79     170.52    85.47     65.14     83.97
## [379] 28.81     24.96     120.65    59.36     34.96     21.209    0.21
## [386] 2.16      0.21/     <1.5      24.33     6.7       4.8       5.4
## [393] 242.45    193.59    1.28/     6/        0.2/      0.37/     0.007/
## [400] 0.336     60/       5.6       9.6       30/       145.3     212
## [407] 286/      0.02      180       0.692     5.49      0.003     0.13/
## [414] 0.28/     0.00322   127       0.0192/   16        71        16/
## [421] 71/       0.4483    14/       59        0.04      0.2       1.28
## [428] 6.7/      0.064     15/       4/        0.01/     <2.5/     0.51
## [435] 13.9      23.6      16.2      32.4      4.4       >98.43    43.7
## [442] >98       1.44      98.43/    98.43     39.37     0.13      0.96
## [449] 0.48      0.17      0.18      0.29      0.23      150.5     1.00/
## [456] 0.005/    350/      26.63     35.813    0.1332    683.2     27.16
## [463] 6.57      5.53      5.35      5.71      5.79      4.76      4.45
## [470] 4.27      5.06      4.82      5.16      4.07      6.83      13.66
## [477] 120/      >=13.66   3.42      447.82    60        0.000048  2.86
## [484] 49.42     0.112/    136/      0.009     1.59      12.17     0.40/
## [491] 0.0005/   0.0005    21.4      16.4      0.36      150       0.081
## [498] 105       2558      132       3390      2051      7839      5.11
## [505] 1023      450       11.3      7.8       0.96/     0.33/     0.98
## [512] 3.3       23.37     208.9     13407     90/       62.5/     0.14/
## [519] 23.37/    3.6       0.063     0.102     0.105     0.14      0.071
## [526] 0.085     0.07      1.93      4.75      95.8      0.580/    0.699/
## [533] 0.06      21.5      5.18      ~40/      ~30/      801       2.63
## [540] 65.68     0.64      0.28      10.62     3.56      1.21      0.25
## [547] <8.79     190.2     364.07    30.3      >1000.00  1.4       0.45
## [554] 0.0375    1.8       800       0.0206/   39.32     46/       45.4/
## [561] 0.41      1.11      0.47      0.58      3.75      2.9       8.6
## [568] 0.44      4.6       0.022     0.9       0.061/    3.75/     1.3/
## [575] 0.0001    2.84      0.00071   4.66      0.018     0.00017   5.38
## [582] 23.54     5.38/     0.0056    0.014     0.028     0.037     0.051
## [589] 0.056     0.08      0.37      1.12      1.75      3.5       7
```

```
## [596] 0.34      31.42     0.011     0.0000073 0.9535    0.0011    0.033
## [603] 0.0035/   0.57      2.6       0.00005   0.0298    2.78      0.027
## [610] 0.024     0.004     1.1       2.1       365.6     85.3      0.008
## [617] 3.82      57.7      0.00007   276       0.6/      440       40.44
## [624] 12.5      0.0002    >0.01     0.026     13.3/     >0.220    40.7
## [631] 28.4      0.79      20.3      4.15      0.46      86.9      137/
## [638] 0.30/     1.35      0.0004/   12.429    150/      1500      31.3
## [645] 0.625     0.71      451       1.75/     8.0/      3.5/      17.92
## [652] 0.025     0.116/    0.594     3.392     4.552     3.392/    288
## [659] 0.8/      136       0.202     0.161     0.015     2.6/      0.225
## [666] 0.45/     5.25      0.49      3.2       0.0027    754.2     0.016
## [673] 1.04      9.5858    5737      0.088     50.28     95.48     1056.7
## [680] 311.9     2.008     2675      1.51      2.94      503.6     0.61
## [687] 15.09     4399      1.51/     13.45     15        995       0.138
## [694] 0.493     63.54     54.67     0.84      6.36      37.5/     0.72
## [701] 8.38      4.37      31.37     0.43/     0.93      1.58      4.93
## [708] 5.77      21.6      0.93/     232.37    750       56.35     0.35
## [715] 0.17/     0.52      17.6      112.5     0.946     0.302     241.3
## [722] 99.75     7.7       4.28      0.126/    0.123     3.313     2.462
## [729] 14.34     0.000047  0.000074  0.0000814 0.000101  3.21      4.51
## [736] >5.0      <0.088    0.0299    51.16     4.679     4.411     4.316
## [743] 0.124     0.0112    0.0373    0.0641    2.46      1.07      0.141
## [750] 3.8/      1.34/     3.62      10.3      7.5       0.0428    0.428
## [757] 0.1500/   51.32     <0.0004   0.481     3.8       1.43/     9
## [764] 9.07      8.86      5.73      5.56      5.46      5.64      5.36
## [771] 4.44      3.11      2.68      2.761     2.644     2.556     3.336
## [778] 3.018     2.936     4.546     4.383     3.151     4.32      3.9
## [785] 3.59      2.26      2.15      5.01      5.08      4.52      4.13
## [792] 3.68      2.48      2.44      1.99      1.65      1.64      3.53
## [799] 2.75      5.27      5.3       6.03      4.61      3.4       3.36
## [806] 3.38      3.31      3.09      12.5/     33.6      7.379     14.785
## [813] 5.101     7.379/    1.48/     8.03      3.18      2.38      25/
## [820] 0.0812/   0.003/    296.62    80        0.745     45.37     0.26/
## [827] 20.0/     0.26      0.42      0.075     0.63/     0.397     0.137
## [834] 0.114/    1.01      0.04/     5.1       2.17      249.23/   >2500.00
## [841] 382.31    150.46    81.09     37.01     124.03    48.2      251.3
## [848] 788.5     251.3/    43.4      1.6/      3.23      1.67      0.38
## [855] 32        0.2175    94        0.494     0.00027/  0.87      0.145
## [862] 0.52/     41.94     1.092     2.403     2.947     2.403/    0.150/
## [869] 0.0014    0.1039    1.72      250/      3.41      1.86      13.35
## [876] 21.19     0.09/     7.14      12.57     24.54     41.6      168/
## [883] 0.000069/ 0.000006  0.91      1.45      0.023     0.032     0.0076
## [890] 0.061     0.0006    1.29      2.0/      7.5/      2.89      0.0032
## [897] 0.0013    0.0063    0.0125    1.20/     13.75     31.16     9.49
## [904] 28.2      65.37     21.06     6.80/     2.60/     12.0/     600
## [911] 0.567/    0.470/    13.9/     10.5/     2.24/     52.2      0.95
## [918] 0.07/     136.25/   26.025/   52.05/    272.5/    545/      104/
## [925] 26/       104.1/    105/      0.0002/   0.077     4.485     2.967
## [932] 2.667     0.00368   0.0218    2.844     2.689     2.608     0.00739
## [939] 26.9      9.5       1.08      2.18/     8.51      2.99      0.0095
## [946] 0.0009    1.09/     4.671     4.514     3.885     3.789     3.747
## [953] 4.627     4.507     4.369     1.24      2.82      2.79      5.37
## [960] 5.07      4.83      2.85      2.61      2.2       2.19      4.53
## [967] 3.12      2.96      4.71      4.64      4.29      21.418    21/
```

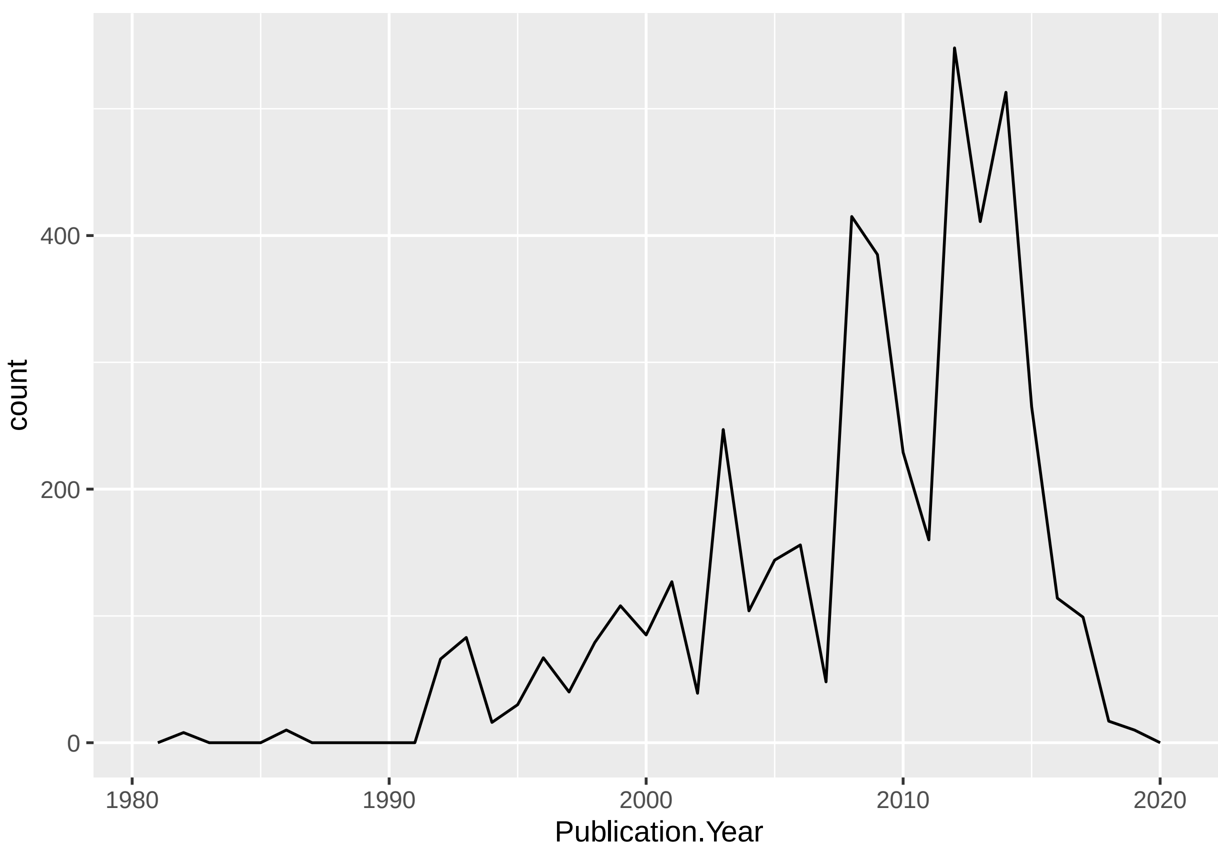
```
##  [974] 6.76      6.27      6.13      4.08      3.28      3.03      3.0/
##  [981] 0.00039   17        39        76        76/       5.28      0.647
##  [988] 0.46/     0.056/    0.225/    0.31      4.0/      7.72      9.89
##  [995] 15.63     30.7      5.0/      4.39/     40.019    1.12/     0.00008
## [1002] 0.0231    0.76/     224.05/   0.0113    3.4859
## 1006 Levels: ~10 ~30/ ~40/ ~41 <0.0004 <0.025 <0.088 <0.5 <1.5 <10/ ... NR/
```

> Answer: It's not numeric because some of the data include additional non-numeric characters like "/", "<", and letter abbreviations.

Explore your data graphically (Neonics)

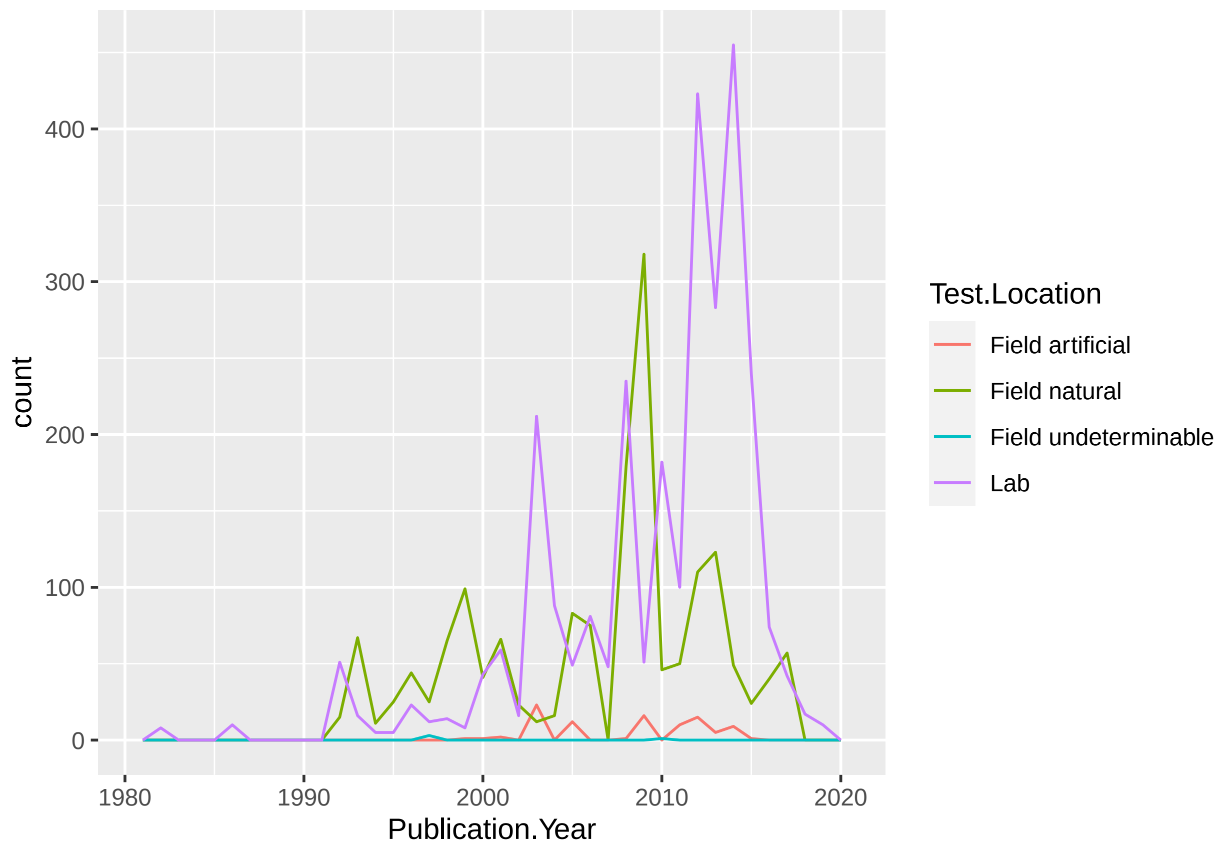
9. Using `geom_freqpoly`, generate a plot of the number of studies conducted by publication year.

```
ggplot(Neonics) +
  geom_freqpoly(aes(x=Publication.Year), binwidth=1)
```



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

```
ggplot(Neonics) +
  geom_freqpoly(aes(x=Publication.Year, color = Test.Location), binwidth = 1)
```

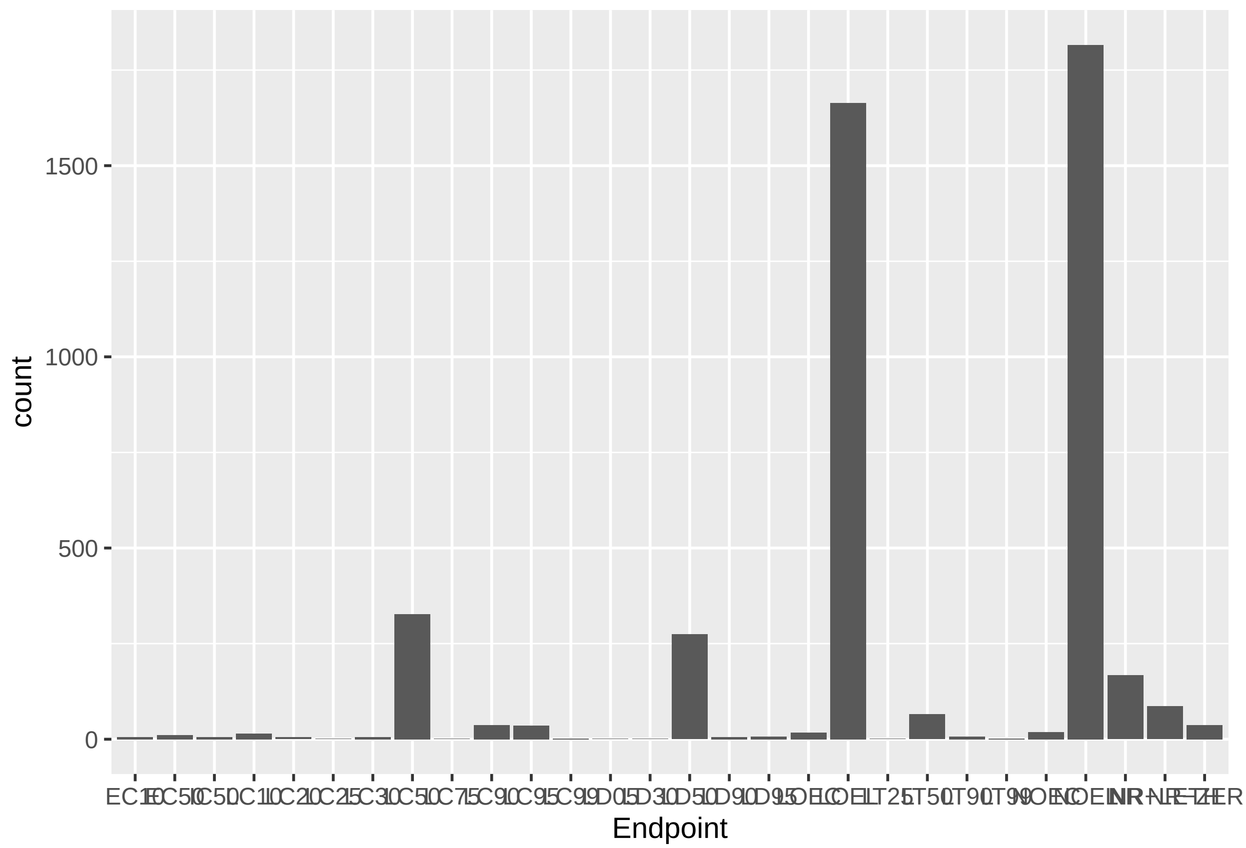


Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer: The most common test locations are natural field and lab locations. These are the most common across the duration of the study, although natural field locations were more common than lab locations in the 1990s but became much less common after 2008.

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

```
ggplot(Neonics) +
  geom_bar(aes(x=Endpoint))
```




```
sort(table(Neonics$Endpoint))
```

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

Answer: The most common endpoints are LOEL (1664 observations), which describes the lowest insecticide dose that produced results different from the control, and NOEL (1816 observations), which describes the highest insecticide dose administered before results different from the control were observed.

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) #character, not date
```

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

```r
Litter$collectDate <- as.Date(Litter$collectDate, "%Y-%m-%d") #change to date format
class(Litter$collectDate) #now class is date
```

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

```r
unique(Litter$collectDate)
```

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

> Answer: Litter was sampled on August 2, 2018 and August 30, 2018.

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

```r
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
```

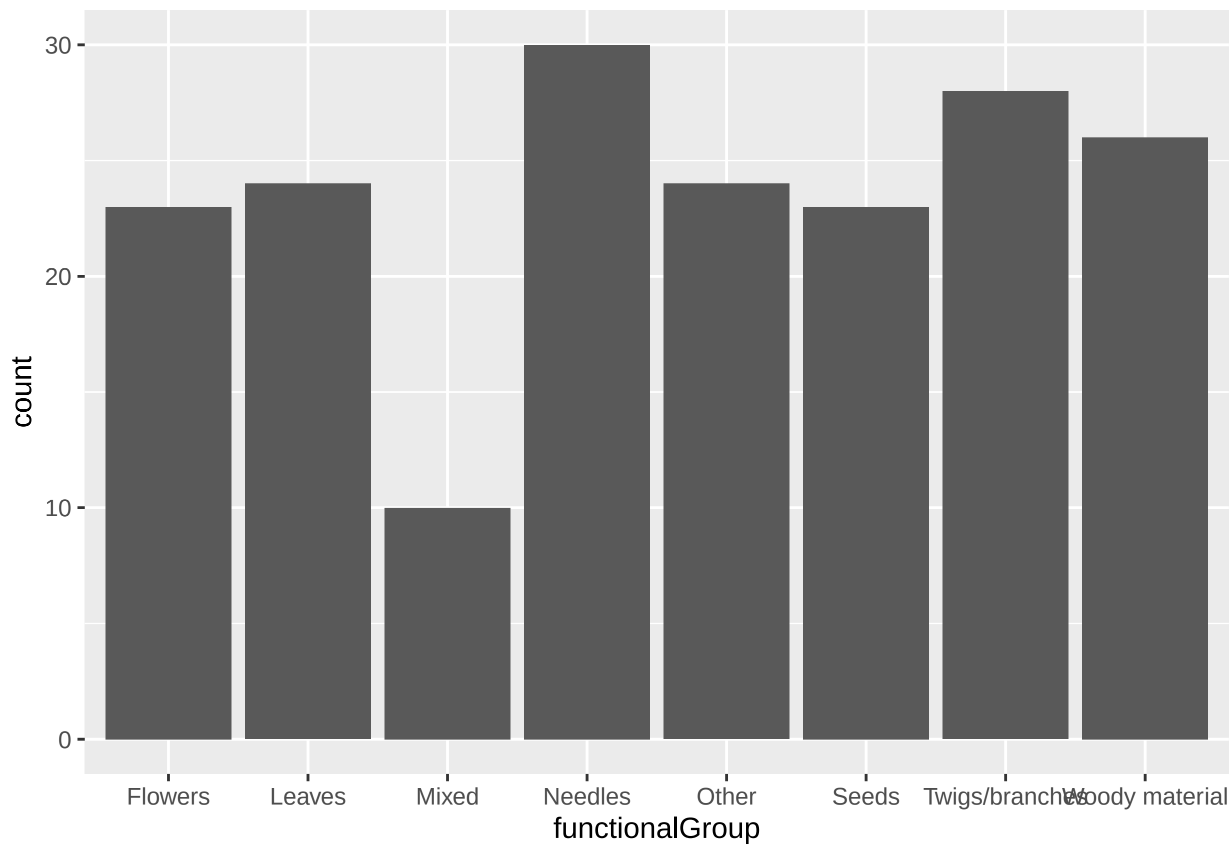
```r
summary(Litter$plotID)
```

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

> Answer: 12 plots were sampled at Niwot Ridge. unique() returns each unique value within the column, whereas summary() returns only the length and class of the column.

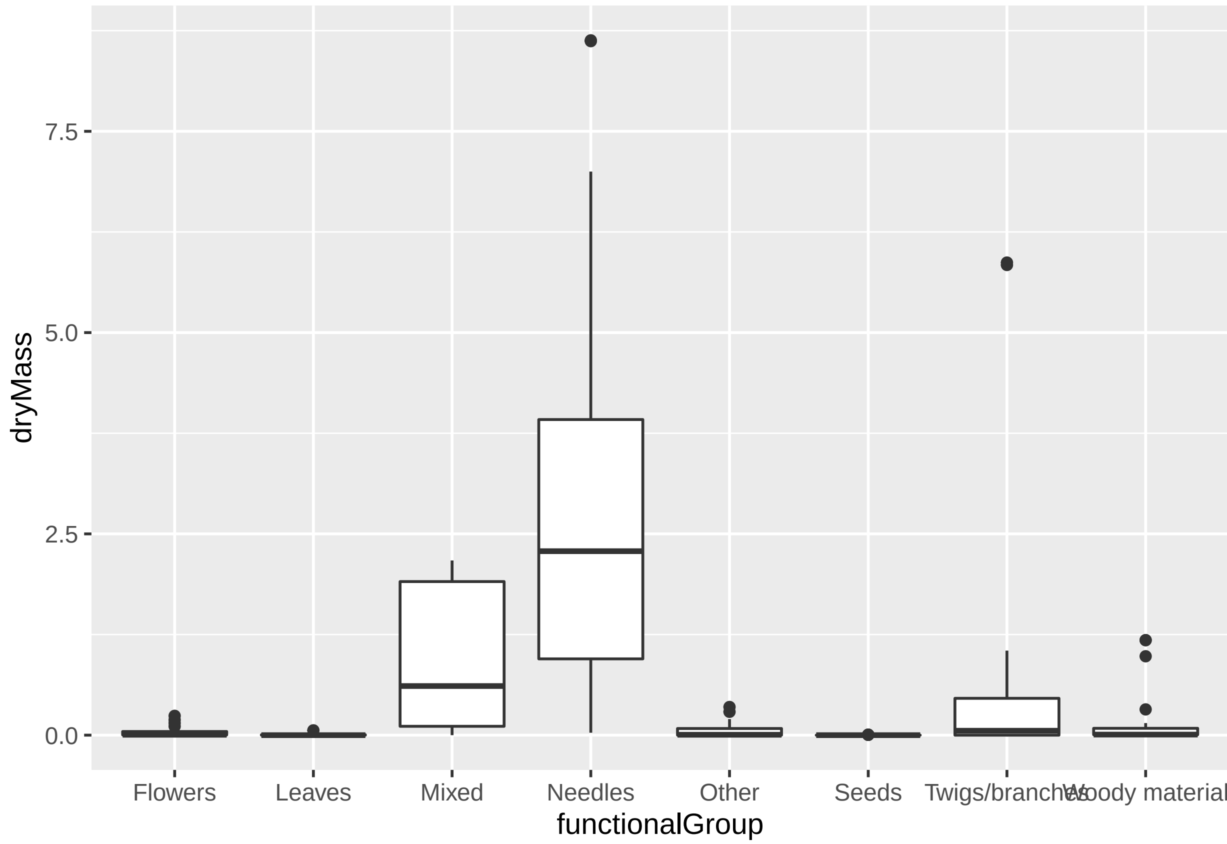
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

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

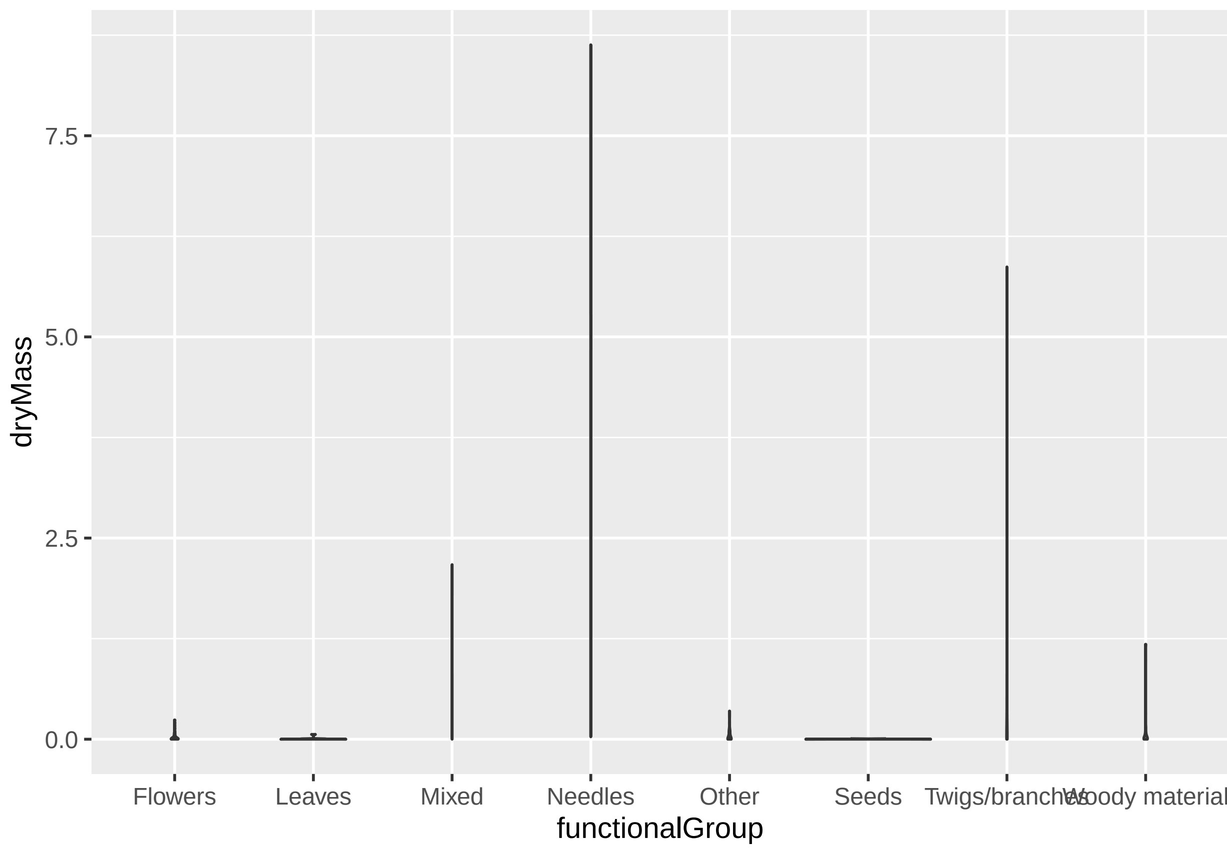


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

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




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



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

> Answer: The boxplot is more effective because dry mass is either very spread out within the functional group (ex. mixed, needles) or very bunched up (ex. seeds, leaves). There isn't much in between in this dataset, and the violin plot isn't able to visualize that very well.

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

> Answer: It seems that needles and twigs/branches tend to have the highest biomass overall.