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 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.

```
#imported csv files from file, import dataset, from base text
library(tidyverse)
library(ggplot2)
Neonics <- read.csv(file = "C:/Users/cepaj/OneDrive/Documents/EDE_Fall2023/Data/Raw/ECOTOX_Neonicotinoi
Litter <- read.csv(file = "C:/Users/cepaj/OneDrive/Documents/EDE_Fall2023/Data/Raw/NEON_NIWO_Litter_mas
```

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: Ecotoxicology refers to the way that substances and chemicals interact and affect environmental systems. Since Neonicotinoids have high toxicity specifically to insects and are used in agriculture, it is helpful to know how they affect different insects. For example, bees and ladybugs are helpful pollinators that are also insects, and are often not the target of most insecticides, which typically aim to kill bugs that feed on the crop plants, like whitebugs. This dives into the debate of "kill the 'bad' bugs, keep the 'good' bugs".

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: Nutrient cycling is heavily impacted by the amount of litter and woody debris on the ground, as well as biodiversity of microbes and fungi. Plant productivity can also be measured using woody debris and biomass. Broader implications of studying ground litter and woody debris include assessing a forest's risk for wildfire and creating wildfire management and mitigation plans, such as prescribed burns to decrease fuel for more catastrophic, fast-spreading fires.

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 sampled from litter trap pairs (one elevated trap and one ground trap) that are located every 400 square meters of the research area.Litter and woody debris are sorted into separate functional groups after collection, including leaves, needles, twigs/branches, woody material (cones, bark), seeds, flowers, lichen/mosses, and mixed material. The trap areas may be targeted or randomized. 2. The trap areas may be targeted or randomized depending on the type of vegetation. Sites with greater than 50% aerial cover with woody vegetation are chosen randomly. In areas with less than 50% woody vegetation cover, the sites are distributed randomly. 3.Sampling collection frequency depends on the type of forest: ground traps are sampled once per year, elevated traps in deciduous forest sites are sampled once every 2 weeks, and elevated traps at evergreen sites are sampled once every 1-2 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 "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
```

```
sort(summary(Neonics$Effect), decreasing = TRUE)
```

```
##       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
```

Answer: Effects like population, mortality, behavior, and feeding behavior are all extremely important in regards to direct agricultural significance: If a bug is dead then it isn't killing crops (mortality & population effects), whether the bug continues to eat the crop treated with the insecticide (feeding behavior) can tell you the efficacy of the insecticide.

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

```
summary(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
```

```
sort(summary(Neonics$Species.Common.Name), decreasing = TRUE)
```

```
##                             (Other)                          Honey Bee
##                                 670                                667
##                      Parasitic Wasp               Buff Tailed Bumblebee
##                                 285                                183
##                  Carniolan Honey Bee                        Bumble Bee
##                                 152                                140
##                   Italian Honeybee                    Japanese Beetle
##                                 113                                 94
##                  Asian Lady Beetle                     Euonymus Scale
##                                  76                                 75
##                            Wireworm                  European Dark Bee
##                                  69                                 66
##                  Minute Pirate Bug                Asian Citrus Psyllid
##                                  62                                 60
##                      Parastic Wasp              Colorado Potato Beetle
##                                  58                                 57
##                    Parasitoid Wasp                Erythrina Gall Wasp
##                                  51                                 49
```

```
##                     Beetle Order        Snout Beetle Family, Weevil
##                               47                                 47
##          Sevenspotted Lady Beetle                  True Bug Order
##                               46                                 45
##             Buff-tailed Bumblebee                     Aphid Family
##                               39                                 38
##                   Cabbage Looper              Sweetpotato Whitefly
##                               38                                 37
##                   Braconid Wasp                   Cotton Aphid
##                               33                                 33
##                   Predatory Mite            Ladybird Beetle Family
##                               33                                 30
##                      Parasitoid                   Scarab Beetle
##                               30                                 29
##                   Spring Tiphia                    Thrip Order
##                               29                                 29
##             Ground Beetle Family               Rove Beetle Family
##                               27                                 27
##                   Tobacco Aphid                   Chalcid Wasp
##                               27                                 25
##           Convergent Lady Beetle                   Stingless Bee
##                               25                                 25
##                Spider/Mite Class               Tobacco Flea Beetle
##                               24                                 24
##                Citrus Leafminer                   Ladybird Beetle
##                               23                                 23
##                       Mason Bee                         Mosquito
##                               22                                 22
##                   Argentine Ant                           Beetle
##                               21                                 21
##        Flatheaded Appletree Borer             Horned Oak Gall Wasp
##                               20                                 20
##               Leaf Beetle Family                Potato Leafhopper
##                               20                                 20
##        Tooth-necked Fungus Beetle                   Codling Moth
##                               20                                 19
##         Black-spotted Lady Beetle                    Calico Scale
##                               18                                 18
##              Fairyfly Parasitoid                     Lady Beetle
##                               18                                 18
##            Minute Parasitic Wasps                      Mirid Bug
##                               18                                 18
##                 Mulberry Pyralid                        Silkworm
##                               18                                 18
##                   Vedalia Beetle            Araneoid Spider Order
##                               18                                 17
##                       Bee Order                  Egg Parasitoid
##                               17                                 17
##                     Insect Class          Moth And Butterfly Order
##                               17                                 17
##      Oystershell Scale Parasitoid Hemlock Woolly Adelgid Lady Beetle
##                               17                                 16
##             Hemlock Wooly Adelgid                               Mite
##                               16                                 16
```

```
##                         Onion Thrip              Western Flower Thrips
##                                  16                                 15
##                        Corn Earworm                  Green Peach Aphid
##                                  14                                 14
##                           House Fly                        Ox Beetle
##                                  14                                 14
##                  Red Scale Parasite                 Spined Soldier Bug
##                                  14                                 14
##              Armoured Scale Family                   Diamondback Moth
##                                  13                                 13
##                       Eulophid Wasp                  Monarch Butterfly
##                                  13                                 13
##                       Predatory Bug              Yellow Fever Mosquito
##                                  13                                 13
##                 Braconid Parasitoid                       Common Thrip
##                                  12                                 12
##       Eastern Subterranean Termite                             Jassid
##                                  12                                 12
##                           Mite Order                        Pea Aphid
##                                  12                                 12
##                   Pond Wolf Spider           Spotless Ladybird Beetle
##                                  12                                 11
##              Glasshouse Potato Wasp                         Lacewing
##                                  10                                 10
##             Southern House Mosquito            Two Spotted Lady Beetle
##                                  10                                 10
##                           Ant Family                      Apple Maggot
##                                   9                                  9
```

Answer: Honey Bee, Parasitic Wasp, Buff Tailed Bumblebee, Carniolan Honey Bee, Bumble Bee, Italian Honeybee. These are all species of interest in that they are likely not the intended target of the insecticide: they are all crucial pollinators, and studying adverse affects to these species in response could tell researchers how much 'collateral damage' to unintended species there is from nicotinoid use.

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"
```

Answer: It is a factor class. This may be because certain entries have non-numeric data in them. Some rows have NR in place of a number, Rstudio will not classify NR as a numeric value.

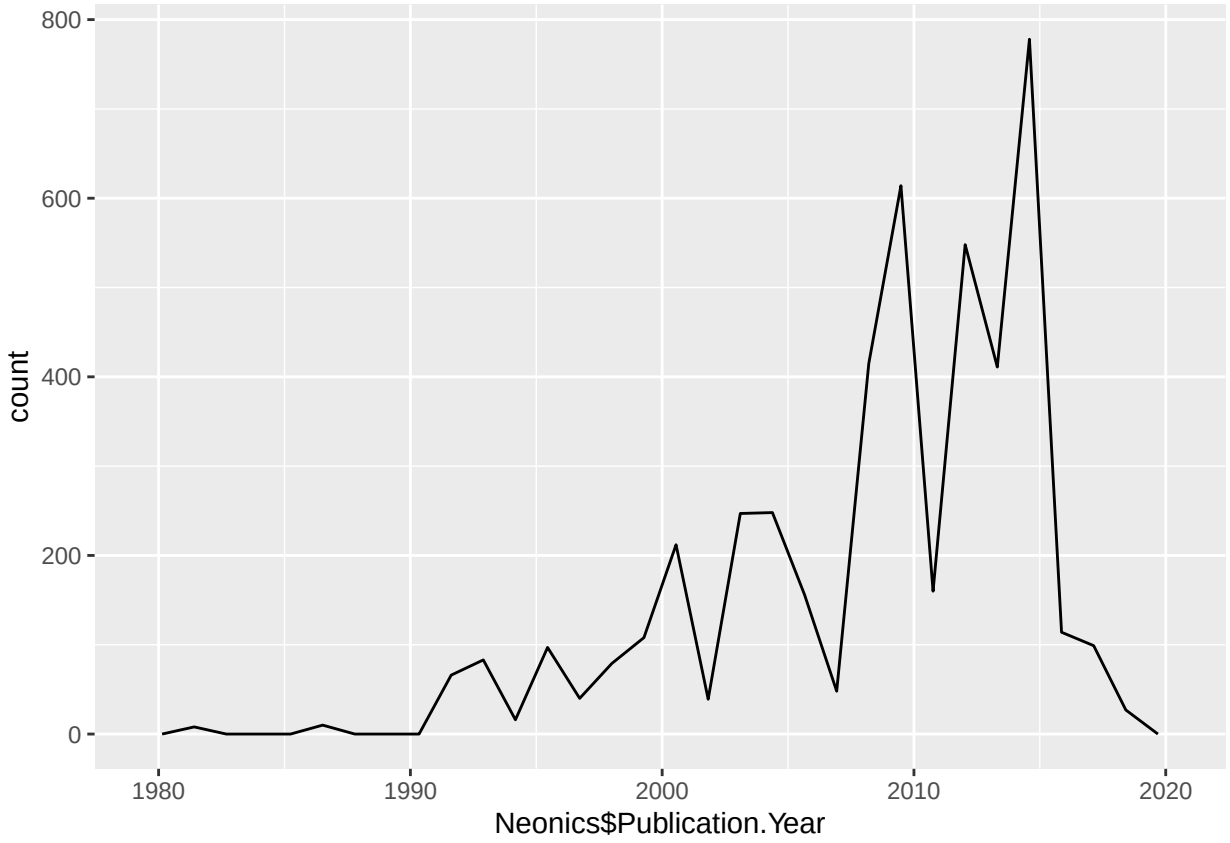
Explore your data graphically (Neonics)

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

```
ggplot(Neonics) +
  geom_freqpoly(aes(x = Neonics$Publication.Year)) #do I need limits here
```

```
## Warning: Use of ‘Neonics$Publication.Year‘ is discouraged.
## i Use ‘Publication.Year‘ instead.
```

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

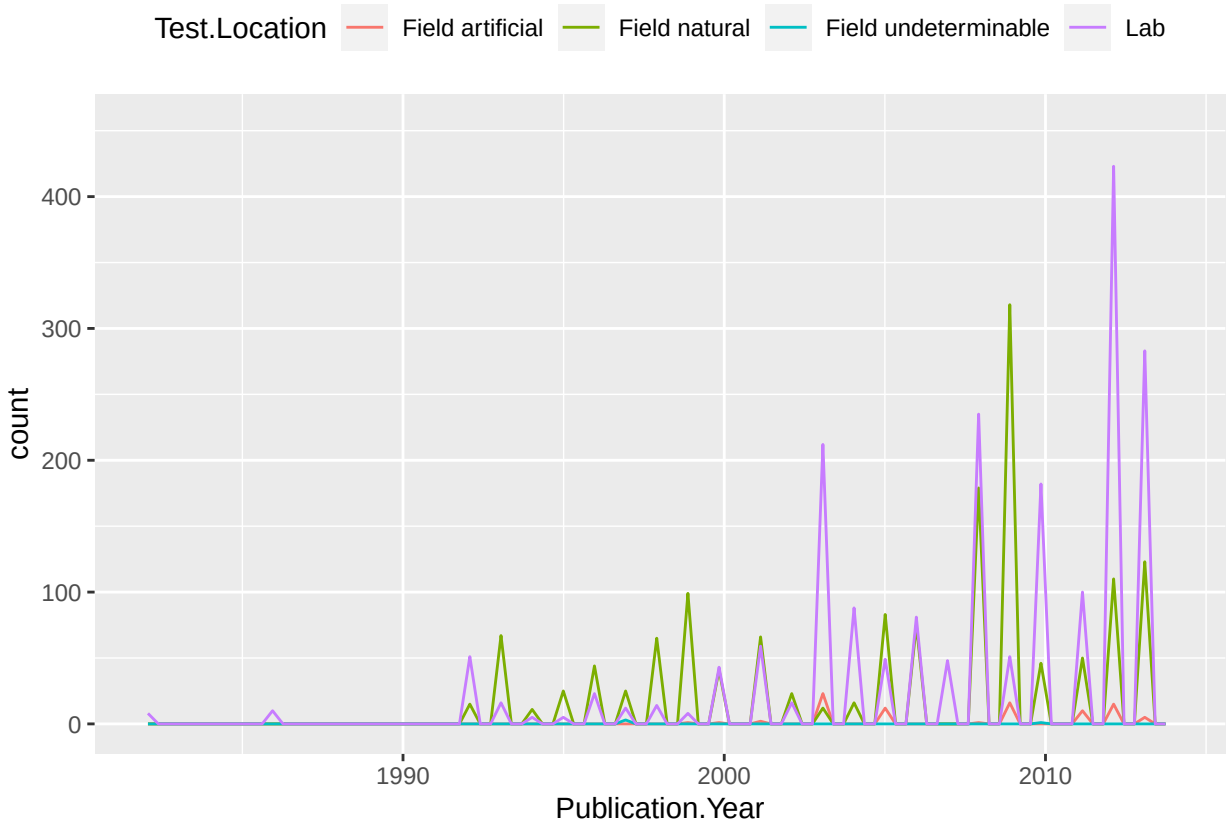


10. Reproduce the same graph but now add a color aesthetic so that different Test.Location are displayed as different colors.

```
ggplot(Neonics) +
  geom_freqpoly(aes(x = Publication.Year, color=Test.Location), bins=100) +
  scale_x_continuous(limits = c(1982,2014))+
  theme(legend.position = "top")
```

```
## Warning: Removed 505 rows containing non-finite values (‘stat_bin()‘).
```

```
## Warning: Removed 12 rows containing missing values (‘geom_path()‘).
```



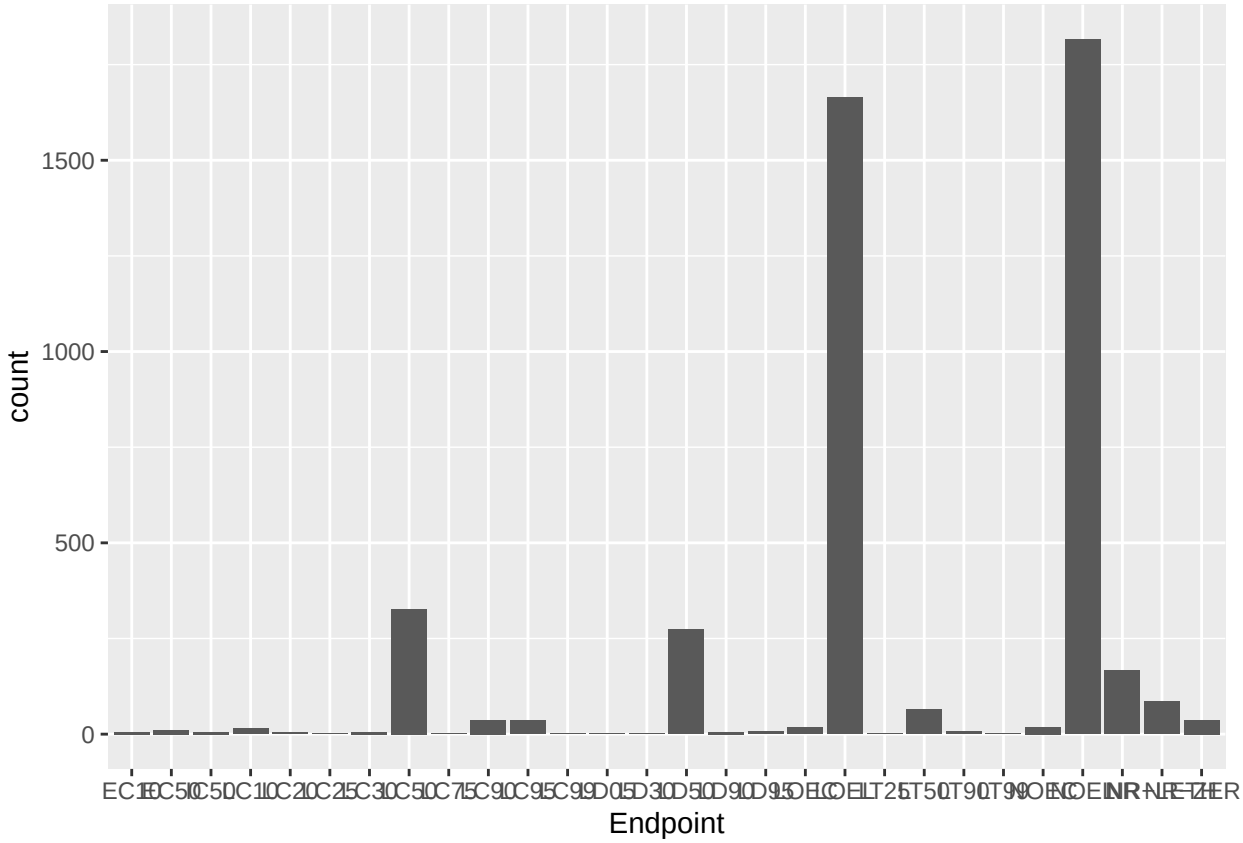
Interpret this graph. What are the most common test locations, and do they differ over time?

> Answer: Test location does vary over time. Between 1990 and 2000, natural fields were a more common test location than labs, however, after 2000, the lab test locations started increasing and was higher than natural field test locations, especially in the years following 2010. This can be displayed better after increasing the bins from 50 to 100. Artificial fields tended to be lower than both natural fields and lab test locations.

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(x= Endpoint))+
        geom_bar()
```




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

```
## List of 1
##  $ axis.text.x:List of 11
##   ..$ family       : NULL
##   ..$ face         : NULL
##   ..$ colour       : NULL
##   ..$ size         : NULL
##   ..$ hjust        : num 1
##   ..$ vjust        : num 0.5
##   ..$ angle        : num 90
##   ..$ lineheight   : NULL
##   ..$ margin       : NULL
##   ..$ debug        : NULL
##   ..$ inherit.blank: logi FALSE
##   ..- attr(*, "class")= chr [1:2] "element_text" "element"
##  - attr(*, "class")= chr [1:2] "theme" "gg"
##  - attr(*, "complete")= logi FALSE
##  - attr(*, "validate")= logi TRUE
```

```
sort(summary(Neonics$Endpoint), decreasing = TRUE) #Double checking that graph matches the data shown.
```

```
##    NOEL    LOEL    LC50    LD50      NR NR-LETH    LT50    LC90 NR-ZERO    LC95
##    1816    1664     327     274     167      86      65      37      37      36
```

```
##    NOEC    LOEC    LC10    EC50    LD95    LT90    EC10    IC50    LC30    LD90
##      19      17      15      11       7       7       6       6       6       6
##    LC20    LC99    LT99    LC25    LC75    LD05    LD30    LT25
##       5       2       2       1       1       1       1       1
```

Answer:The two most common endpoints are NOEL and LOEL. According to the EPAs' ECOTOX Code Appendix, NOEL stands for No Observable Effect Level and is defined as "the highest dose (concentration) producing effects not significantly different from responses of controls according to author's reported statistical test." LOEL is used for terrestrial responses, stands for Lowest Observable Effect Level, and is defined as "the lowest dose producing effects statistically different from responses of controls."

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) #factor originally, not date
```

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

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

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

```
unique(Litter$collectDate) #August 2nd 2018, and August 30th 2018
```

```
## [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$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
```

```
length(unique(Litter$namedLocation))
```

```
## [1] 12
```

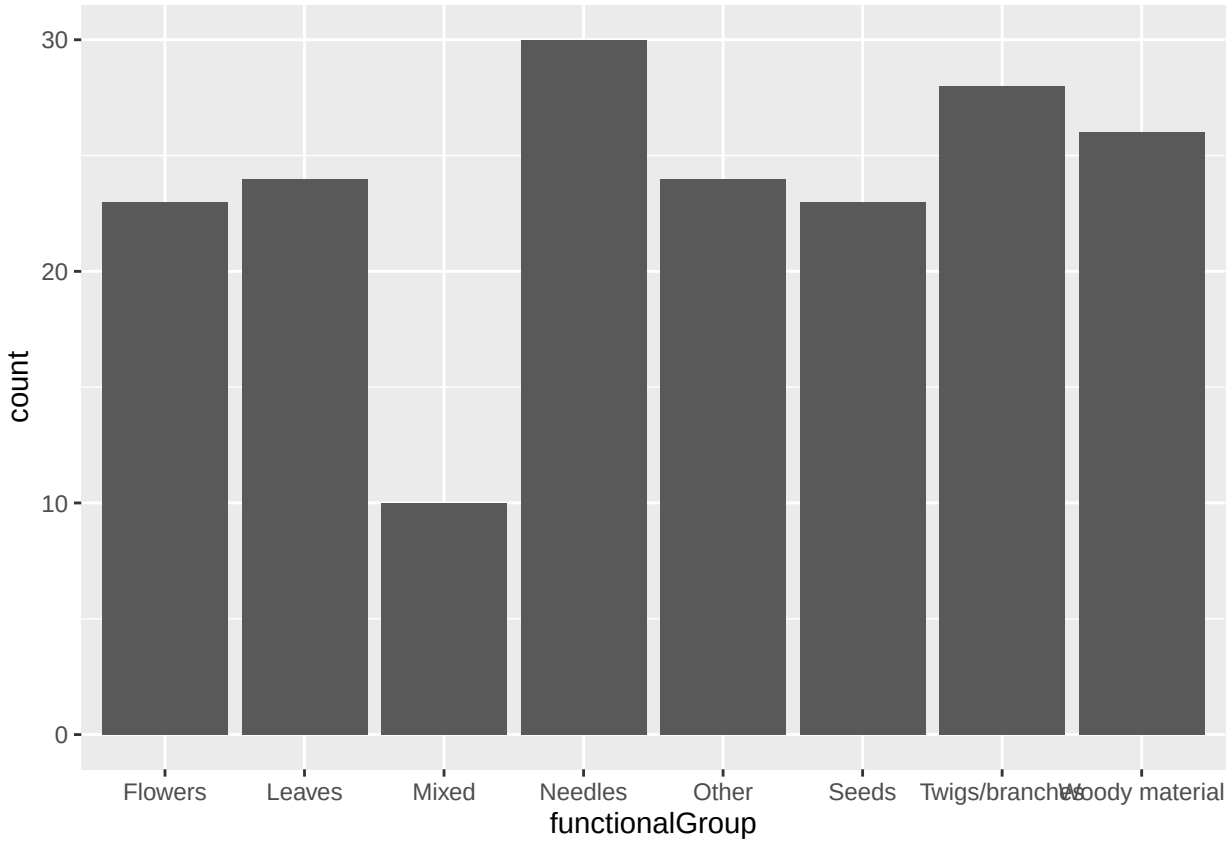
```
summary(Litter$namedLocation)
```

```
## 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
```

Answer: 12 plots were sampled. The information given in Summary provides statistical values, so in this case, the number of times litter was sampled at each given location. The unique function is not counting the number of times each plot was sampled, but counting each sample site only once so that the output accounts for every individual (unique) site.

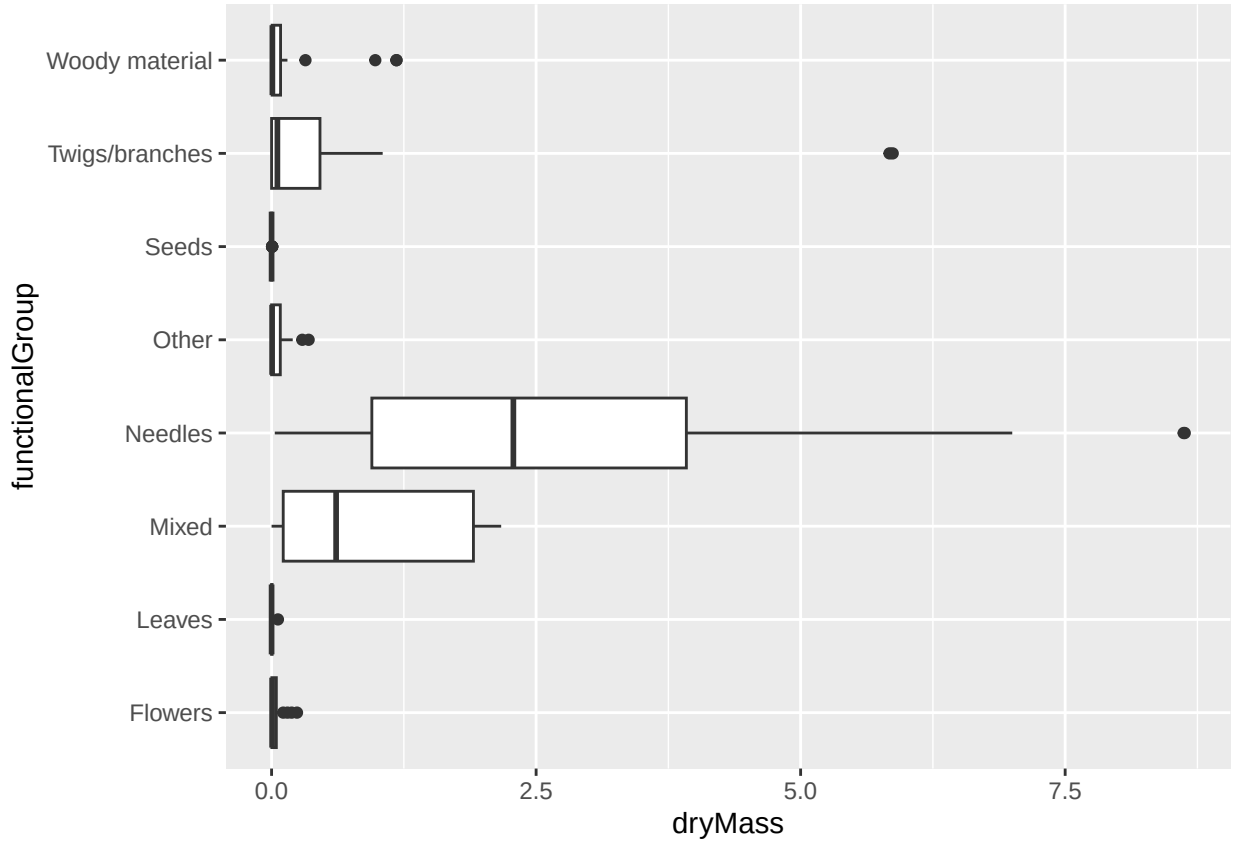
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

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

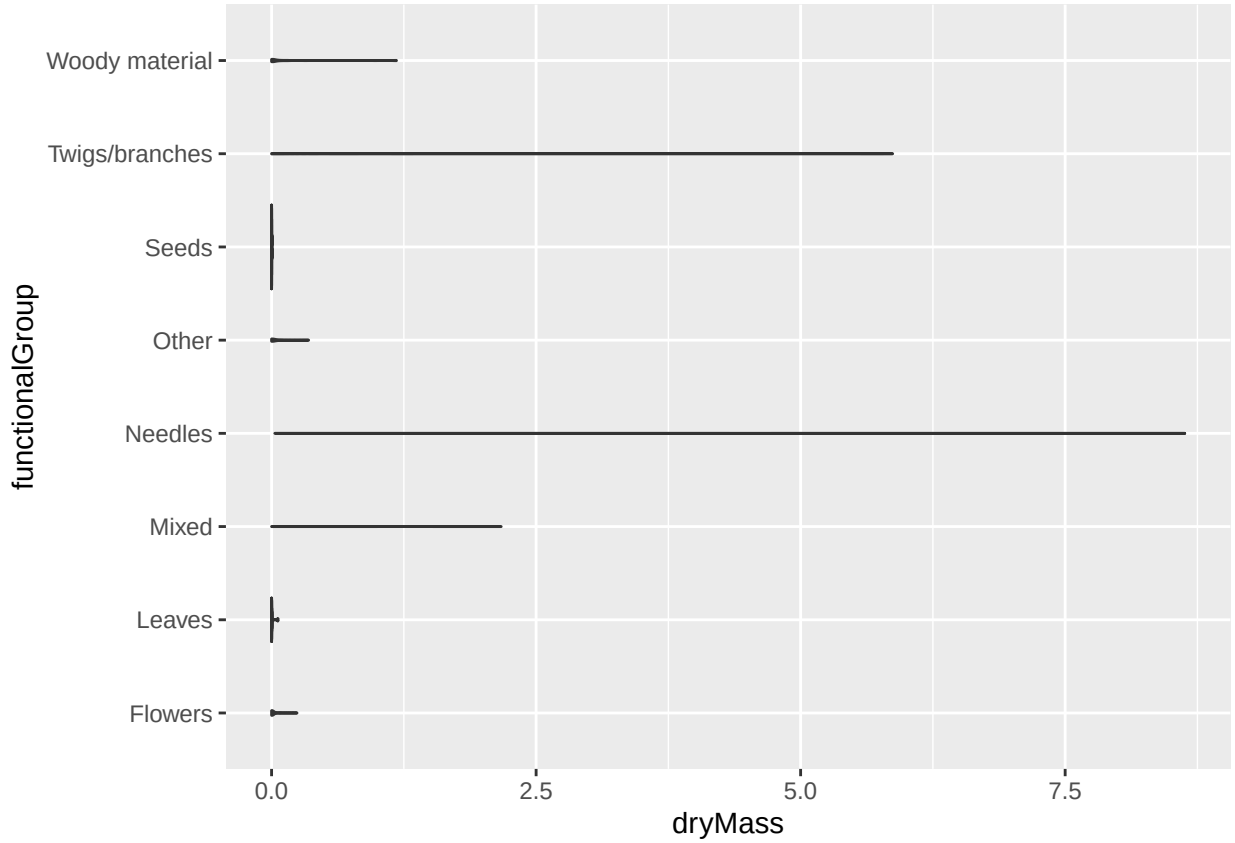


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

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




```
ggplot(Litter)+
  geom_violin(aes(x=dryMass, y=functionalGroup),
              draw_quantiles = c(0.25, 0.5, 0.75))
```



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

> Answer: There are outliers in the data (especially for twigs/branches, and needles) that can be seen clearly on the boxplot. The violin plot doesn't show this outlier, and displays the drymass as a higher value than it is in reality (it draws the line all the way to the outlier, and doesnt visual the outlier.) OR Because the functional groups were evenly distributed, the violin plot is not as applicable than the box plot.

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

> Answer: Needles and mixed litter tend to have the highest biomass at these sites, followed by twigs/branches with a fairlt lower biomass.