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.

```
getwd()
```

```
## [1] "/home/guest/RStudio Project Folder/EDA_Spring2024"
```

```
library(tidyverse)
library(lubridate)
Neonics <- read.csv("Data/Raw/Neonics.csv", stringsAsFactors = TRUE)
Litter <- read.csv("Data/Raw/Litter.csv", stringsAsFactors = TRUE)
```

Learn about your system

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

   Answer: Neonicotinoids are are a class of neuro-active insecticides chemically similar to nicotine developed by scientists at Shell and Bayer in the 1980s. Because they affect the central nervous system of insects, neonicotinoids kill or deleteriously affect a wide variety of both target and non-target insects. Their use has been linked to adverse ecological effects, including risks to many non-target organisms, and specifically on bees and pollinators. In 2022 the EPA concluded that neonicotinoids are likely to adversely affect the majority of federally listed endangered or threatened species and of critical habitats.They also widely contaminate wetlands, streams, and rivers, and due to their widespread use, pollinating insects are chronically exposed to them. Thus it is important to understand their ecotoxicology in order to understand if and how they adversely impact insects that could have cascading effects on our ecosystems and food systems. Source: Wikipedia (https://en.wikipedia.org/wiki/Neonicotinoid)

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 is material that dropped from the forest canopy and has a butt end diameter $<$ 2cm and a length $<$ 50 cm, while fine woody debris is dead, woody, plant material, including logs, branches, standing dead trees, and root wads that dropped from the forest canopy and have a butt end diameter $<$ 2cm and a length $>$50. We are interested in studying them because woody debris is an important part of forest and stream ecosystems as it has a role in carbon budgets and nutrient cycling, is a source of energy for aquatic ecosystems, provides habitat for terrestrial and aquatic organisms, and contributes to structure and roughness, thereby influencing water flows and sediment transport (Harmon and others 1986). Source: (https://data.neonscience.org/data-products/DP1.10033.001 https://data.neonscience.org/data-products/DP1.10033.001)

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 fine woody debris are collected from elevated and ground traps, respectively. 2.All masses reported following processing are reported at the spatial reso- lution of a single trap and the temporal resolution of a single collection event. 3. Litter and fine woody debris sampling is executed at terrestrial NEON sites that contain woody vegetation $>$ 2m tall.

Obtain basic summaries of your data (Neonics)

5. What are the dimensions of the dataset?

```
dim(Neonics)
```

```
## [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
```

Answer: The effects column gives information on how the Neonics chemicals impact the samples (mortality/ growth/ behavior/ reproduction/ etc). This is important to study to assess if the chemicals have a detrimental effect on the samples and of what kind. The most important effects are mortality and population in terms of data results as well as negative impact of the chemicals on insects.

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...]

```
head(sort(summary(Neonics$Species.Common.Name), decreasing=TRUE), 6)
```

```
##               (Other)             Honey Bee        Parasitic Wasp
##                   670                   667                   285
## Buff Tailed Bumblebee   Carniolan Honey Bee            Bumble Bee
##                   183                   152                   140
```

Answer:The most common species studied with their frequency in this dataset are: Other (670), (1)Honey Bee (667), Parasitic Wasp(285), Buff Tailed Bumblebee (183), Carniolan Honey Bee (152), Bumble Bee (140). What they have in common is that they are all different species of bees. They are important because they are the most important pollinating insects.

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.)
```

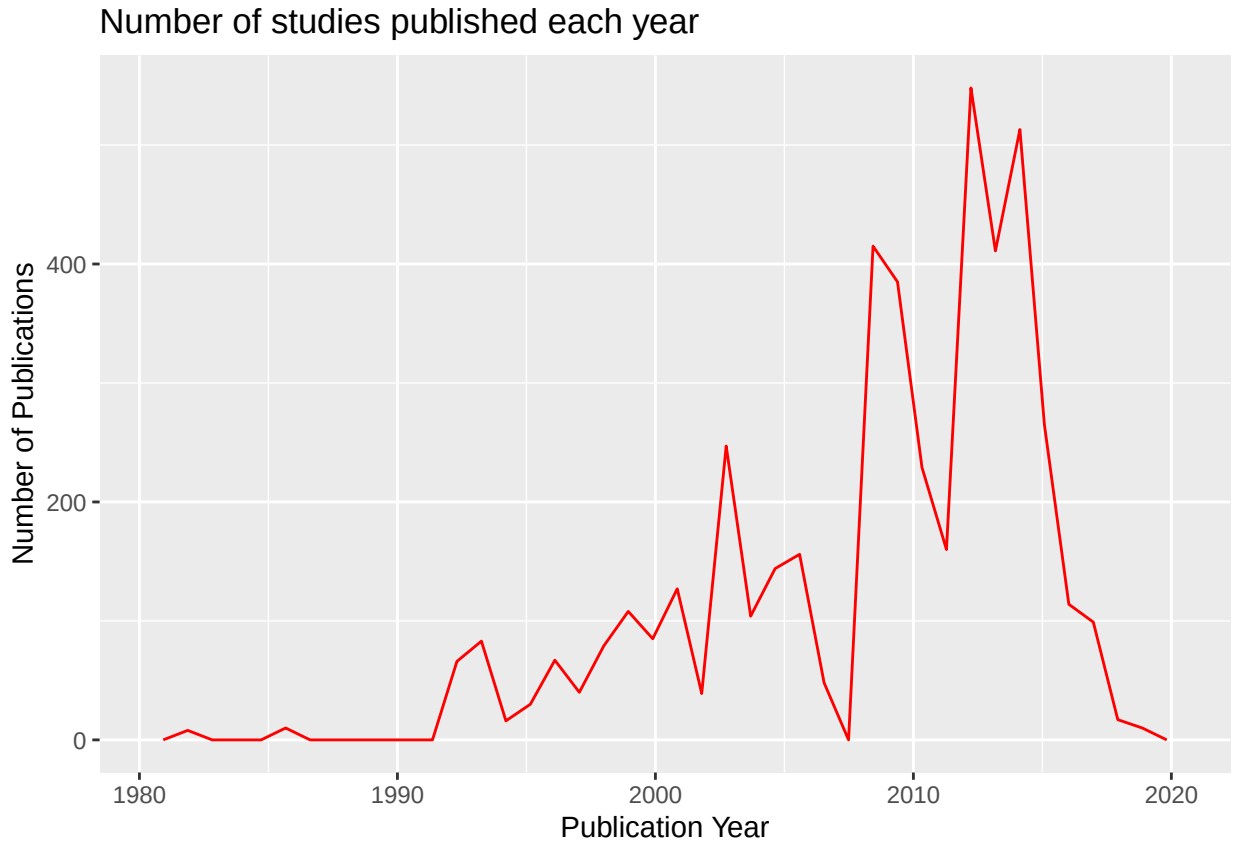
```
## [1] "factor"
```

Answer: The class of this column is factor because data imported from CSV files is not always recognized as numeric data, especially if the data is not cleaned. In this case, the numeric data is accompanied with characters like /, ~ and >, rendering it a character vector instead of numeric.

Explore your data graphically (Neonics)

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

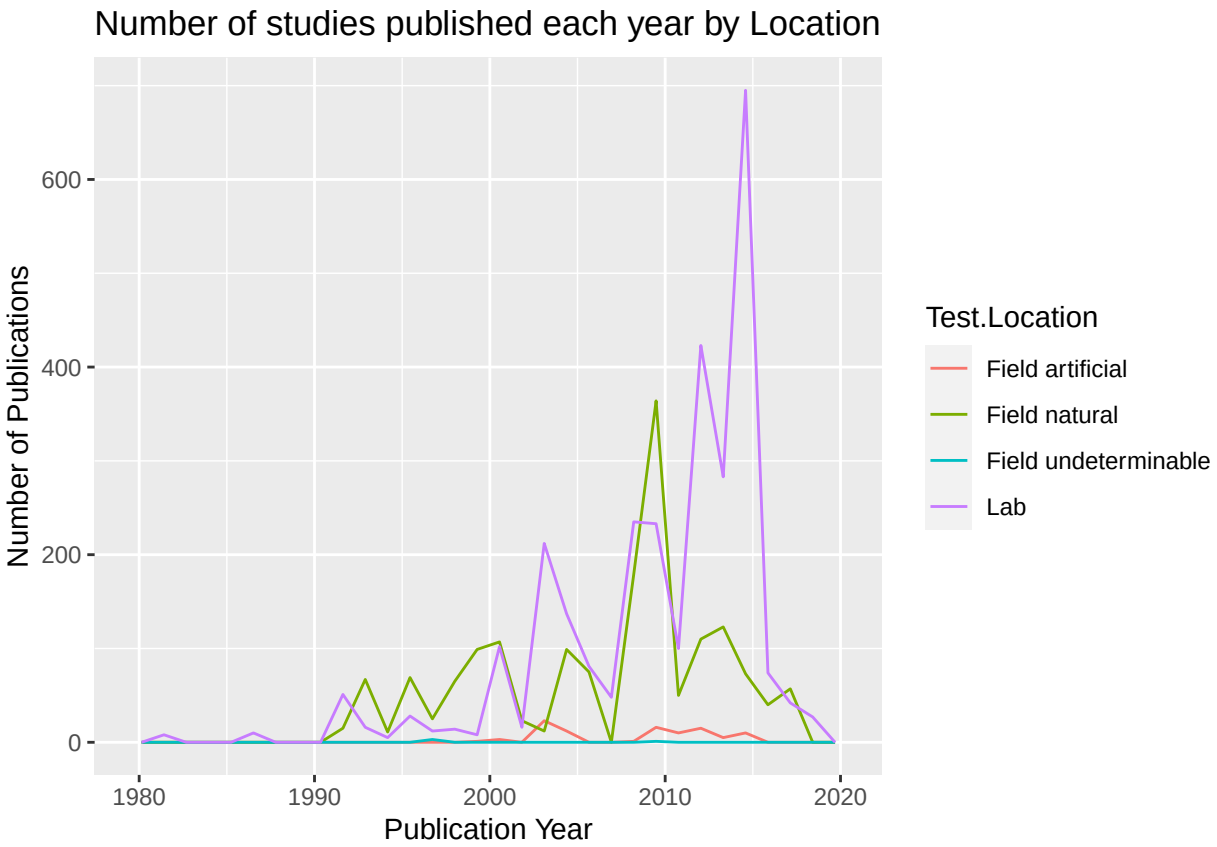
```
library(ggplot2)

ggplot(Neonics)+
   geom_freqpoly(aes(x=Publication.Year), col = "red", bins = 40)+
  ggtitle("Number of studies published each year")+
  labs (x = "Publication Year", y = "Number of Publications")
```



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))+
  ggtitle("Number of studies published each year by Location")+
  labs (x = "Publication Year", y = "Number of Publications")
```

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



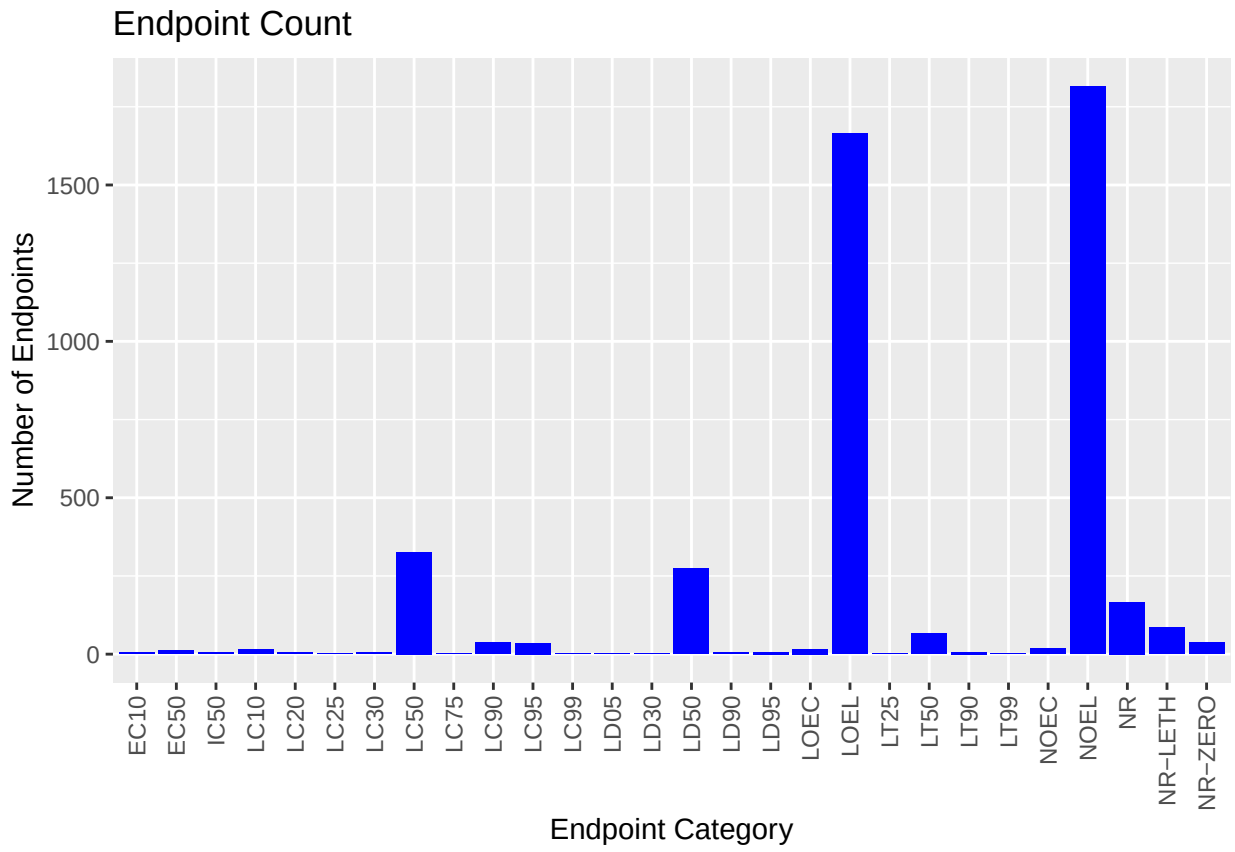
Interpret this graph. What are the most common test locations, and do they differ over time?

Answer: The most common test location between 1990-2000 and 2005-2010 was "field natural" while between 2000-2005 and 2010-2015 was the lab.

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), fill = "blue")+
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1))+
  ggtitle("Endpoint Count")+
  labs (x = "Endpoint Category", y = "Number of Endpoints")
```




```
#Using code to double check the two most common endpoints
sort(table(Neonics$Endpoint), decreasing = TRUE)
```

```
##
##    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: "NOEL" and "LOEL" are the two most common endpoints. The "highest tested concentration having no statistically significant adverse effect" is coded as NOEL and the "lowest tested concentration having a statistically significant adverse effect" is coded as a LOEL. Source: https://cfpub.epa.gov/ecotox/pdf/ecotoxsop.pdf

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.

```
head(Litter$collectDate)
```

```
## [1] 2018-08-02 2018-08-02 2018-08-02 2018-08-02 2018-08-02 2018-08-02
## Levels: 2018-08-02 2018-08-30
```

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

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

```
#The column collectDate is a factor.
Litter$collectDate <- ymd(Litter$collectDate)
class(Litter$collectDate)
```

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

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

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

```
#The litter was collected on 2nd August 2018 and 30th August 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`?

```
unique(Litter$uid)
```

```
##  [1] 7f065fec-bcb2-4af9-b742-8e520fab7f6e 88df210b-1445-4c3f-b19e-5dabd9305c6e
##  [3] 7f3c549c-1dfa-43bf-a485-c7c2bcb31fd6 97806ab5-42d2-49c0-8463-db48cd5eab12
##  [5] 9d7c89f5-85f8-47b6-b415-1ae208580e6f 6ca7a3e8-4d9e-4062-91a0-845f23b5b925
##  [7] a0f02718-2a8e-4f02-beaa-edac27ab1b74 500eb7f8-1881-4a10-bd41-cce84f3b3c47
##  [9] aa0ce5fb-6c8f-42cb-a325-f8c6ab214cff a588a308-b670-4f07-8040-6980d6cfdb72
## [11] 9df0737f-67f3-4d29-a1ec-8eab4ebc2726 53ec9ef3-bd18-4712-9517-4132649cafe7
## [13] 57f5c94c-1655-4ea8-a492-64a660c26803 65134dbe-0a9d-446c-a600-4740f396c201
## [15] be43eacf-16e0-4f2b-b928-2bbf0de2f3c1 836b268d-5e2f-4781-8457-b7b622d13ccd
## [17] 0fc3a175-47a1-4bd3-9158-96d0ec3815f9 c9bb4c46-d98f-45de-9f17-8a2c608dfe79
## [19] 4e6bbdd4-3151-4a05-8b77-f5757b11531b ebf1432e-c43e-48c1-ad32-ae4ce423808b
## [21] 9feeb756-46f9-4bf0-8e94-f2e856728889 edbee742-9d18-4c23-a097-d695a23a4e30
## [23] 1537c343-14f2-4a75-b91d-c827dd529b55 e101681f-57df-44ca-8d24-b14496813e8c
## [25] 07780a1e-8af9-4b8a-bb9b-be8add15a1e0 4bca72cc-6f04-480b-95c9-4f55345f32bd
## [27] b0be64dc-fb65-41e6-b9fa-30201c94606b 6856b517-6d05-403c-893a-3dd8a7b30bff
## [29] ba9800b5-b01d-4ad3-87fb-1e512c8dc17d f1a1cf1e-1f74-4500-81e3-d179dabed35c
## [31] acf36093-4706-4dcb-be8c-d4d3a845548f 1475c9b3-a732-4617-bffa-406b072d382e
## [33] 0f34060c-fc8a-4c8c-bd71-5836e9bbfb05 c1b97ed7-ff4e-4982-9e61-a41d0ab8cbbd
## [35] f7577092-93be-4a42-9157-f2ee2b12318f 99709f0e-3989-412e-a80d-6987d2ac54e9
## [37] 4920d35f-624a-45cc-9c75-dac8f9f1d9f8 a1afcbb7-add9-4dd5-8feb-1b0a5e295fed
## [39] 9cf0463e-c60b-4619-8658-2ed071ae3dcd 73a932ba-e4c5-4ca7-9f19-8d34ef1dea5a
## [41] a94addfa-17fc-47cb-8d69-4af3903c8bec 51b709df-af0d-441c-8835-b4bf2251ac17
## [43] cb0eb445-e514-468e-bcad-b6b4ae52ccba f7188915-7307-4a91-b71c-7e3ff38f7d0b
## [45] c5b62b0f-e753-40e0-8cf3-e78d8a2c6c8a 85a503a8-6817-4513-8a64-d780842d6947
## [47] 1b049f51-fbda-4b62-83fb-652da4308f5a 3f0a9383-16f4-4197-808c-55ac449b952d
## [49] 25fff36f-f181-4f62-8529-b419227909d2 ce1f0639-26a8-4a90-9df5-39549bfa412b
## [51] 028eea3d-5c20-4afc-bb7e-a05bab305152 89f98b92-bbc5-4a43-a852-46db48f6b16f
## [53] fc47bdf8-99aa-4289-9158-6ebe5b4ccb06 88ae9d88-44fd-4ef3-ba99-bd5c0590b507
## [55] 7dd99eca-b6ef-42f7-8ce1-672c1d4626a5 0cbcd7ab-3995-49c8-8a36-6361dee82bc6
## [57] 2a87c5aa-60ab-4ba1-afe5-24e0b52aa7d8 491fba9a-a682-4f7c-ac22-5b01b759f734
```

```
##  [59] ba4d7a74-4570-4317-bea1-69a81b8083bf cbf183ba-6177-4afc-88d6-328f37fd57d4
##  [61] 77a0a09f-c819-4e54-b322-0529fa585d02 e5bbc4fc-92d5-4fab-b151-3e9655678e65
##  [63] 0a6cae78-ea42-4e68-98c6-9d929068a38a 80263145-05ab-4b6c-93d3-b058fd56a044
##  [65] fe503f47-15a6-497f-b7dc-b865099d0faa 76676d6a-bdd4-4764-b56f-1e8abd242d62
##  [67] 3eb148f7-219b-43ba-9d39-7c9ea4c6f569 fbc280eb-cd64-41d6-bb82-616d9b11a8a5
##  [69] 63867744-5cd5-4c61-96f1-e6522ea3ef55 ea74be18-c9ce-4708-8ad6-513be0e66a22
##  [71] 3933adbb-6a03-4a7b-b87f-74af1fd92b50 c6a43776-e89f-463b-b27a-fa7b5de8a334
##  [73] b209072a-dc98-480b-b41c-1da05d97a137 9812f8f1-25bf-4b29-8a51-5762e99b7578
##  [75] d2c18392-2022-4984-86e1-290749d371bc 324775a3-4799-4496-b545-8770724212ed
##  [77] 47c666c6-577b-4de5-90d1-972eb7dd7820 3195d37b-860c-400e-ab26-3cf08f034563
##  [79] aa7ef4c5-da6d-4455-8761-730dd4135191 38e221c3-5011-4d73-aa99-8127154ddd0c
##  [81] f8ef9082-9281-4c65-862c-f2696da58e2a b6582d1e-b9c3-4a0d-bb37-aac749b1642e
##  [83] 3e567fbb-9616-444f-9d13-da894718ecf1 8c02f879-d03e-4903-9ca8-5d4dbcacac57
##  [85] d1dc46e9-052d-4638-bdfd-840a9dc51f44 33aa6853-b3fd-4321-b8f0-9aa144867d6b
##  [87] 78c8dd41-483f-4f1d-9d35-0b775d0901f2 9a6bc315-d122-49a6-9817-8288703b1277
##  [89] 250f0c64-4927-4999-aae6-0d58b1dd7cbf 11d4f1e8-a7d2-4bb6-b25c-ad8296689ba5
##  [91] 1ec020ef-5c48-4b39-b6a7-f94f6a739987 ca636d0d-d049-4e76-be36-4a355a107b6a
##  [93] 84f9566d-5364-4af7-9981-b94a494dc892 89a7b052-f348-4967-b79b-bccfb428d44f
##  [95] 61d57643-995d-482b-ba4a-2fa58d064555 6785dc11-9504-4fd0-9bbe-9bef31f51218
##  [97] 0ae1c621-387e-42a9-bcf3-7ad1c9b97ab4 be20875b-99a3-452e-9102-8a80d59fe527
##  [99] e923388d-bcb1-40ad-b48b-514951f98a94 f67211cc-cfdf-446b-a470-34801aed6539
## [101] 30b7312e-690a-41ed-9aa2-4510769172db 68becebd-7288-4060-86a4-d0d8bfe8967b
## [103] 81c5d213-3ed3-44c6-a250-6365b405aaab a8f15620-bac0-4c39-8d1d-3351d5647165
## [105] 94c59c93-b569-495f-adca-9f711a2a6eb3 94b4a3e9-bb28-48ee-9098-fb99a22f82aa
## [107] b481266c-37f9-462b-b810-51984d506c8d 51a2740a-009c-4262-be1f-b8142eebabfc
## [109] 65bbf249-f8e4-419a-b5fd-0b597900d074 a6f6ad8c-3de1-4723-81f0-0e11b98c5b02
## [111] 06789d7b-b742-41d9-8556-79d23c193dc0 bc63b722-e358-486c-9505-9b0bf85dfef4
## [113] 81014f97-1cda-49f0-adfc-52b93890bba2 14b12019-d75f-47e7-a9b9-933a63701168
## [115] 5fb584f4-e59e-488d-8337-8495e43f3fc0 1868228c-b789-4ed1-a688-d6b19fcdcf31
## [117] 74cde2d3-9540-4012-bc2a-341b5385d59e c13adcbc-da15-4a50-a2ee-fcc81c3722cf
## [119] 1ec4b7ae-7690-48b8-8524-ee1e1ab18992 1ac9e884-e1f8-4138-919b-d295cfa1a215
## [121] 7ccd74d3-fee9-4ff9-8fdb-6aaa11ae857b 36f4f5c4-4a49-43f7-bb4f-4290361e5674
## [123] f52fb766-633a-4141-bd66-fb13dbfdbd0a dd4fb81c-682e-47b5-b698-2186bc1e01be
## [125] e79a0db0-a9da-47bb-9cce-fd50084e1edc 32bd2f37-1274-4c59-95f6-2c7a7c04c814
## [127] 72d1615a-c544-4165-9bdc-dfafa6914a76 aa743782-0a16-4ae8-9891-8c82ee443fc0
## [129] b57cc043-c38c-44ab-9b74-722a5a6bef98 ff27be98-6c8e-440b-8bc6-6b2aae7414d9
## [131] cd691903-631f-40bf-9e89-f895e6e81ca0 480726a3-d83f-4144-a35d-ab986c85512c
## [133] f0e67fb7-03a9-477a-af89-43e1b4f80a8b 1de997a7-2d93-4d99-950d-b374cc71d64d
## [135] 1fb74156-86e2-4b59-a8ab-ff0a1dcd4e45 86301cd8-7886-421c-aaad-56f49a09d9c7
## [137] e61dcc1c-13b6-4b3e-b5b7-ca845eb2a661 d89bb8fd-6cae-4089-9d08-091a608c21a3
## [139] c33d2042-6a5b-4c47-8f7f-e516f1781539 652a84e7-5004-465f-afd5-c42a5690c7c8
## [141] 8b4b0878-e627-44a6-97d7-be404cc3c1f3 86071f09-1d00-44b8-a6d5-506d0fdc0571
## [143] 368a8fb4-4955-4547-833a-3113f8e0a37a 0b274782-8e52-4f6a-bb17-36daa821f929
## [145] 3edbccc1-9e9c-4af9-8ff4-89f05ca76309 abcfac6e-f18e-422b-82e7-26680263d098
## [147] 8301d028-dff9-4927-a898-e305352d4867 4a0a0228-b65f-43fc-893d-8b09408fe851
## [149] 63cb6b0a-d92c-4628-a66a-30fca548598a e11be8c9-5bae-4b59-ae17-73d6361d13c6
## [151] 894b404a-36b3-4ac1-b174-04fca02ae9c8 ca411347-6a76-46a7-a649-1d4c8437ae6e
## [153] 6bafe7ec-7b7a-4fb7-b5e4-8c416631dbf0 8983b717-6a35-4990-98e1-662d19bc50a4
## [155] 647d3e0c-5479-4dc6-80ff-a421e58d4892 58b99e74-2267-4f04-99a5-1d5850502a7b
## [157] 1ace6e31-6078-413a-9ccf-97ab249f2469 f1a11408-0c9d-4071-813e-3f03d71a98d7
## [159] f96bad2d-73b0-4319-82be-d8a180d0ef72 28e788d5-7b1f-4873-b173-79582bdc73b4
## [161] e4a1d2cd-0eb4-4e7c-8dab-925ee15e7c97 c847a531-666b-4271-9675-b3e6a4a9ebb4
## [163] 729390b7-45a6-4b78-a568-ac5b2d01fd6d a424b04b-bdd7-4432-96be-1c4f7618c5a3
## [165] 3803299c-3849-4efe-8b58-1944a97dbbf1 424d28fc-f70d-4e33-b540-89d1dcfe61aa
```

```
## [167] a06569ed-afbc-4cb5-9a62-c3d03ed10f0c 50ebc822-1a19-4741-81ca-93ce060c8381
## [169] efeba585-efea-4fda-9b26-5c47c2725f8d 55afd7c2-ebf7-4581-a4c2-76af701a13da
## [171] e5e3eb9e-5813-448d-8b62-160d50634251 62b2bb98-cf97-4444-ba3e-b608c799e378
## [173] 1c833228-0664-4237-abed-ecfbe4fc14f8 dfd5b756-bfed-457f-af58-fbcc88d67690
## [175] adee8e06-a895-4eb8-9dfd-baaf7198efbc b4b0d964-8f8a-499c-b741-bf370d598fcc
## [177] a839c806-7344-4727-b36f-24a109589729 e48b40e8-f16c-4dd6-bea9-7c64efe27202
## [179] f6aaf2c1-9555-41ca-9101-5eaea74d6639 7cda3549-f9e6-4f46-8f5c-f16406a52b50
## [181] 68e8292f-b86a-4efb-88d1-7820c853fe15 89f1d431-0743-4504-9e5e-be3b39c44875
## [183] ebeec5a0-815d-4f3d-a94f-759cca792b11 d91a07ab-0da7-4182-9e61-a04d01612f83
## [185] cc4285fd-d7cf-40b1-9f67-27aa04b502c3 93f8312d-c181-4613-80af-4d081b29bf0d
## [187] 5b7c6e0e-40c8-4bc6-b509-a760cbe1a5e4 6de90fcf-901c-44c1-88b9-424c92df8c06
## 188 Levels: 028eea3d-5c20-4afc-bb7e-a05bab305152 ...
```

```
summary(Litter)
```

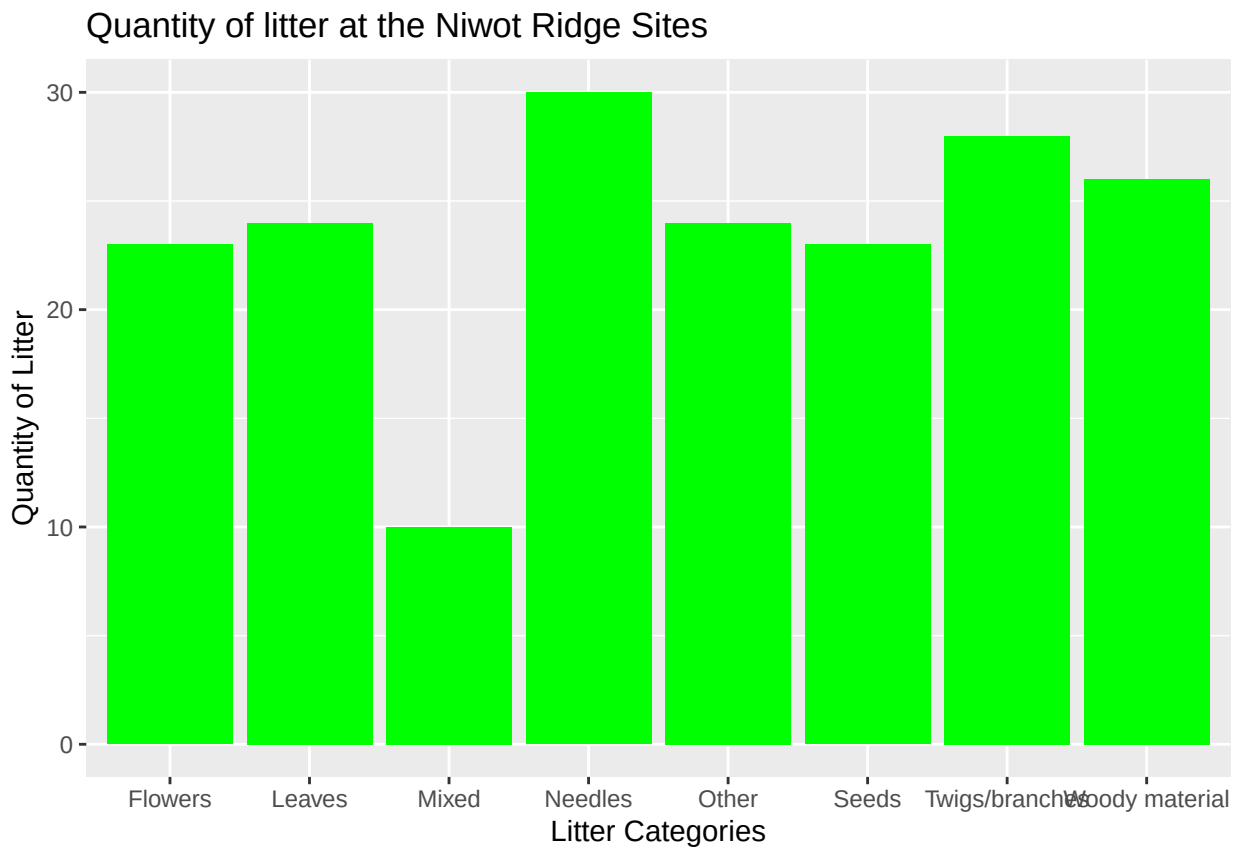
```
##                                     uid                     namedLocation
##  028eea3d-5c20-4afc-bb7e-a05bab305152:  1   NIWO_040.basePlot.ltr:20
##  06789d7b-b742-41d9-8556-79d23c193dc0:  1   NIWO_041.basePlot.ltr:19
##  07780a1e-8af9-4b8a-bb9b-be8add15a1e0:  1   NIWO_046.basePlot.ltr:18
##  0a6cae78-ea42-4e68-98c6-9d929068a38a:  1   NIWO_061.basePlot.ltr:17
##  0ae1c621-387e-42a9-bcf3-7ad1c9b97ab4:  1   NIWO_067.basePlot.ltr:17
##  0b274782-8e52-4f6a-bb17-36daa821f929:  1   NIWO_058.basePlot.ltr:16
##  (Other)                               :182   (Other)              :81
##  domainID   siteID         plotID            trapID        weighDate
##  D13:188   NIWO:188   NIWO_040:20   NIWO_040_205:20   2018-08-06:91
##                       NIWO_041:19   NIWO_041_059:19   2018-09-05:97
##                       NIWO_046:18   NIWO_046_155:18
##                       NIWO_061:17   NIWO_061_169:17
##                       NIWO_067:17   NIWO_067_017:17
##                       NIWO_058:16   NIWO_058_101:16
##                       (Other) :81   (Other)     :81
##        setDate    collectDate                  ovenStartDate
##  2018-07-05:91   Min.   :2018-08-02   2018-08-02T21:00Z:91
##  2018-08-02:97   1st Qu.:2018-08-02   2018-08-30T22:30Z:97
##                  Median :2018-08-30
##                  Mean   :2018-08-16
##                  3rd Qu.:2018-08-30
##                  Max.   :2018-08-30
##
##             ovenEndDate                       fieldSampleID
##  2018-08-06T18:02Z:91   NEON.LTR.NIWO041059.20180830: 11
##  2018-09-05T19:30Z:97   NEON.LTR.NIWO040205.20180802: 10
##                         NEON.LTR.NIWO040205.20180830: 10
##                         NEON.LTR.NIWO046155.20180802: 10
##                         NEON.LTR.NIWO058101.20180802:  9
##                         NEON.LTR.NIWO061169.20180802:  9
##                         (Other)                     :129
##                            massSampleID      samplingProtocolVersion
##  NEON.LTR.NIWO040205.20180802.MXT:  2   NEON.DOC.001710vE:188
##  NEON.LTR.NIWO040205.20180802.NDL:  2
##  NEON.LTR.NIWO040205.20180830.MXT:  2
##  NEON.LTR.NIWO040205.20180830.NDL:  2
##  NEON.LTR.NIWO041059.20180830.MXT:  2
##  NEON.LTR.NIWO041059.20180830.NDL:  2
```

```
##  (Other)                          :176
##        functionalGroup    dryMass       qaDryMass remarks
##  Needles        :30     Min.   :0.0000   N:168     Mode:logical
##  Twigs/branches:28     1st Qu.:0.0000   Y: 20     NA's:188
##  Woody material:26     Median :0.0050
##  Leaves         :24     Mean   :0.6115
##  Other          :24     3rd Qu.:0.3200
##  Flowers        :23     Max.   :8.6300
##  (Other)        :33
##                         measuredBy
##  kstyers@battelleecology.org:91
##  szrillo@battelleecology.org:97
##
##
##
##
##
```

Answer:188 plots were sampled at Niwot Ridge 'Unique' gives the list of unique data in the column, whereas 'Summary' gives the number of datapoints in the column along with their class and mode.

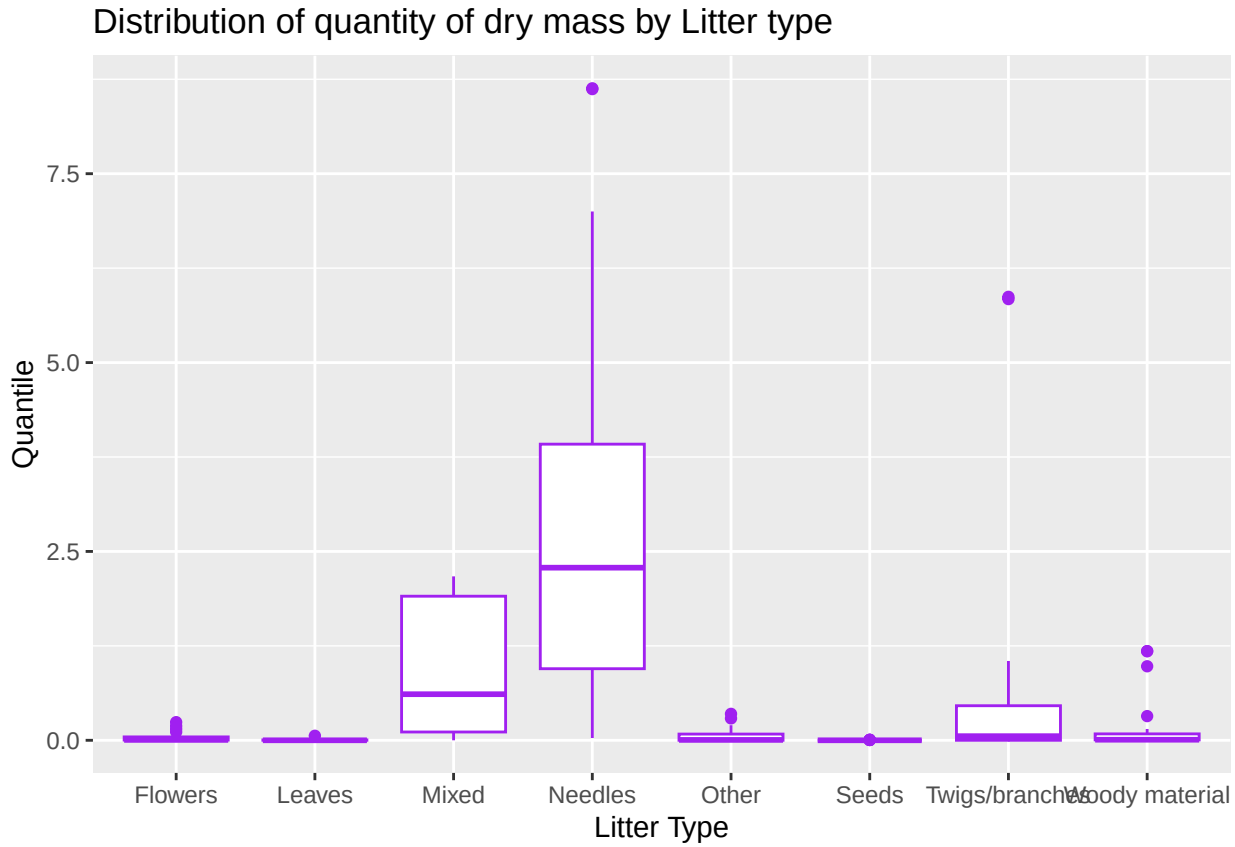
14. Create a bar graph of functionalGroup counts. This shows you what type of litter is collected at the Niwot Ridge sites. Notice that litter types are fairly equally distributed across the Niwot Ridge sites.

```
ggplot(Litter)+
  geom_bar(aes(x=functionalGroup), fill = "green") +
  ggtitle("Quantity of litter at the Niwot Ridge Sites")+
  labs (x = "Litter Categories", y = "Quantity of Litter")
```

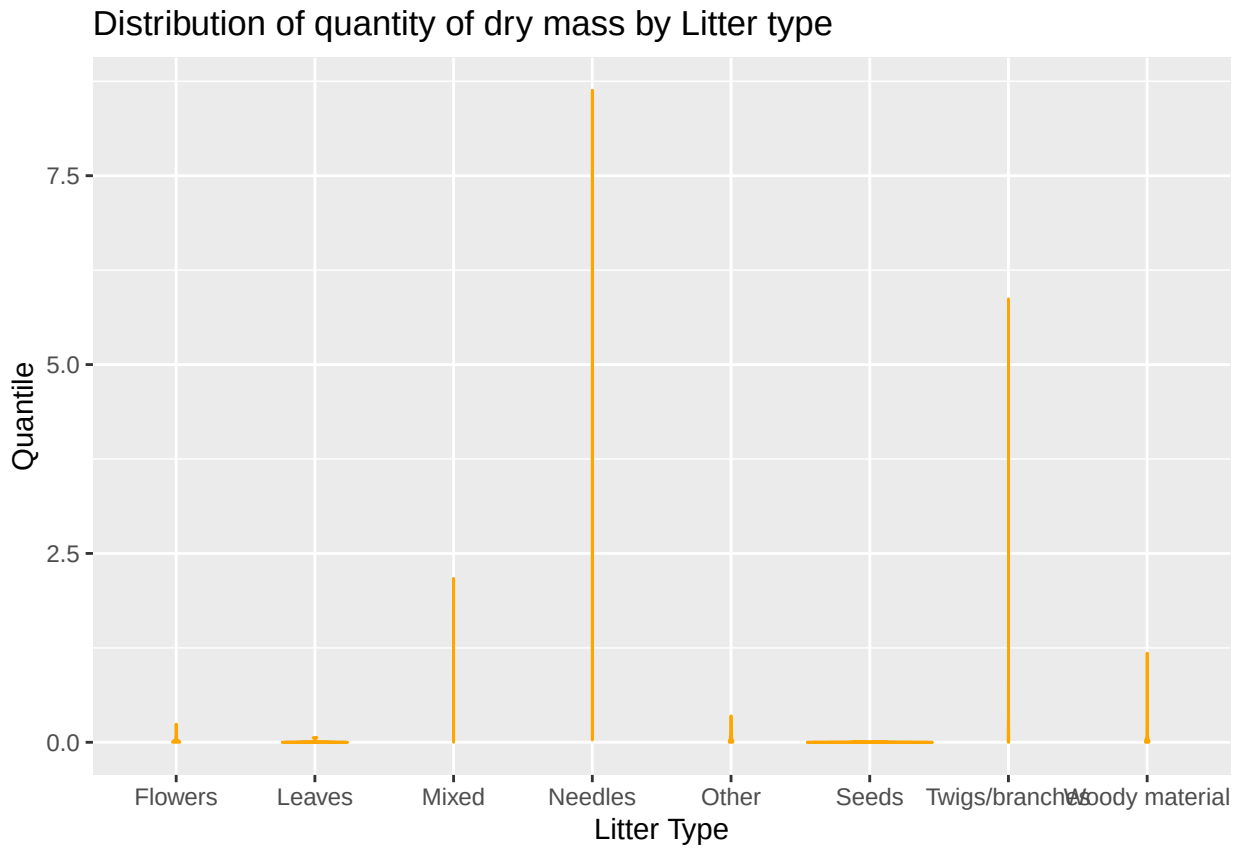


15. Using `geom_boxplot` and `geom_violin`, create a boxplot and a violin plot of dryMass by functionalGroup.

```
ggplot(Litter)+
  geom_boxplot(aes(x=functionalGroup, y=dryMass), col = "purple")+
  ggtitle("Distribution of quantity of dry mass by Litter type")+
  labs (x = "Litter Type", y = "Quantile")
```




```
ggplot(Litter)+
  geom_violin(aes(x=functionalGroup, y=dryMass),
  draw_quantiles = c(0.25, 0.5, 0.75 ), col = "orange")+
  ggtitle("Distribution of quantity of dry mass by Litter type")+
  labs (x = "Litter Type", y = "Quantile")
```



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

> Answer: The boxplot shows the distribution of the data a lot more clearly along with the outliers whereas the violin plot shows the probability distribution of the data. In this case, given the outliers and low frquency of the data, the violin plot does not show much making it a less effective visualisation.

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

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