

# 6: Data Exploration

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## LESSON OBJECTIVES

1. Describe the usefulness of data wrangling and its place in the data pipeline
2. Wrangle datasets with dplyr functions
3. Apply data wrangling skills to a real-world example dataset

## OPENING DISCUSSION

After we've completed basic data exploration on a dataset, what step comes next? How does this help us to ask and answer questions about datasets?

## SET UP YOUR DATA ANALYSIS SESSION

In assignment 3, you explored the North Temperate Lakes Long-Term Ecological Research Station data for physical and chemical data. What did you learn about this dataset in your assignment?

We will continue working with this dataset today.

```
getwd()
```

```
## [1] "/Users/ks501/Documents/GithubRepos/ENV872"
```

```
library(tidyverse)
```

```
## -- Attaching packages -----
```

```
## v ggplot2 3.1.0      v purrr  0.2.5
```

```
## v tibble  1.4.2      v dplyr  0.7.8
```

```
## v tidyr   0.8.2      v stringr 1.3.1
```

```
## v readr   1.3.0      v forcats 0.3.0
```

```
## -- Conflicts -----
```

```
## x dplyr::filter() masks stats::filter()
```

```
## x dplyr::lag()     masks stats::lag()
```

```
NTL.phys.data <- read.csv("../Data/Raw/NTL-LTER_Lake_ChemistryPhysics_Raw.csv")
```

```
head(NTL.phys.data)
```

```
##   lakeid  lakename year4 daynum sampledate depth temperature_C
## 1      L Paul Lake 1984   148   5/27/84  0.00           14.5
## 2      L Paul Lake 1984   148   5/27/84  0.25              NA
## 3      L Paul Lake 1984   148   5/27/84  0.50              NA
## 4      L Paul Lake 1984   148   5/27/84  0.75              NA
## 5      L Paul Lake 1984   148   5/27/84  1.00           14.5
## 6      L Paul Lake 1984   148   5/27/84  1.50              NA
##   dissolvedOxygen irradianceWater irradianceDeck comments
## 1              9.5             1750           1620    <NA>
## 2              NA             1550           1620    <NA>
```

```
## 3      NA      1150      1620      <NA>
## 4      NA      975      1620      <NA>
## 5      8.8      870      1620      <NA>
## 6      NA      610      1620      <NA>
```

```
colnames(NTL.phys.data)
```

```
## [1] "lakeid"      "lakename"     "year4"
## [4] "daynum"      "sampledate"   "depth"
## [7] "temperature_C" "dissolvedOxygen" "irradianceWater"
## [10] "irradianceDeck" "comments"
```

```
summary(NTL.phys.data)
```

```
##      lakeid      lakename      year4      daynum
## R      :11288  Peter Lake  :11288  Min.    :1984  Min.    : 55.0
## L      :10325  Paul Lake   :10325  1st Qu.:1991  1st Qu.:166.0
## T      : 6107  Tuesday Lake : 6107  Median :1997  Median :194.0
## W      : 4188  West Long Lake: 4188  Mean   :1999  Mean   :194.3
## E      : 3905  East Long Lake: 3905  3rd Qu.:2006  3rd Qu.:222.0
## M      : 1234  Crampton Lake : 1234  Max.   :2016  Max.   :307.0
## (Other): 1567  (Other)      : 1567
##      sampledate      depth      temperature_C      dissolvedOxygen
## 5/17/94: 84  Min.    : 0.00  Min.    : 0.30  Min.    : 0.00
## 9/5/90 : 64  1st Qu.: 1.50  1st Qu.: 5.30  1st Qu.: 0.30
## 10/1/07: 61  Median : 4.00  Median : 9.30  Median : 5.60
## 9/10/90: 61  Mean   : 4.39  Mean   :11.81  Mean   : 4.97
## 5/10/87: 60  3rd Qu.: 6.50  3rd Qu.:18.70  3rd Qu.: 8.40
## 5/9/88 : 60  Max.   :20.00  Max.   :34.10  Max.   :802.00
## (Other):38224      NA's    :3858  NA's    :4039
##      irradianceWater      irradianceDeck
## Min.    : -0.337  Min.    : 1.5
## 1st Qu.: 14.000  1st Qu.: 353.0
## Median : 65.000  Median : 747.0
## Mean   : 210.242  Mean   : 720.5
## 3rd Qu.: 265.000  3rd Qu.:1042.0
## Max.   :24108.000  Max.   :8532.0
## NA's   :14287      NA's    :15419
##      comments
## DO Probe bad - Doesn't go to zero: 206
## DO taken with Jones Lab Meter    : 162
## NA's                             :38246
##
##
##
```

```
dim(NTL.phys.data)
```

```
## [1] 38614    11
```

## DATA WRANGLING

Data wrangling takes data exploration one step further: it allows you to process data in ways that are useful for you. An important part of data wrangling is creating tidy datasets, with the following rules:

1. Each variable has its own column
2. Each observation has its own row
3. Each value has its own cell

What is the best way to wrangle data? There are multiple ways to arrive at a specific outcome in R, and we will illustrate some of those approaches. Your goal should be to write the simplest and most elegant code that will get you to your desired outcome. However, there is sometimes a trade-off of the opportunity cost to learn a new formulation of code and the time it takes to write complex code that you already know. Remember that the best code is one that is easy to understand for yourself and your collaborators. Remember to comment your code, use informative names for variables and functions, and use reproducible methods to arrive at your output.

## WRANGLING IN R: DPLYR

`dplyr` is a package in R that includes functions for data manipulation (i.e., data wrangling or data munging). `dplyr` is included in the tidyverse package, so you should already have it installed on your machine. The functions act as verbs for data wrangling processes. For more information, run this line of code:

```
vignette("dplyr")
```

```
## starting httpd help server ... done
```

### Filter

Filtering allows us to choose certain rows (observations) in our dataset.

A few relevant commands: `==` `!=` `<` `<=` `>` `>=` `&` `|`

```
class(NTL.phys.data$lakeid)
```

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

```
class(NTL.phys.data$depth)
```

```
## [1] "numeric"
```

```
# matrix filtering
```

```
NTL.phys.data.surface1 <- NTL.phys.data[NTL.phys.data$depth == 0,]
```

```
# dplyr filtering
```

```
NTL.phys.data.surface2 <- filter(NTL.phys.data, depth == 0)
```

```
NTL.phys.data.surface3 <- filter(NTL.phys.data, depth < 0.25)
```

```
# Did the methods arrive at the same result?
```

```
head(NTL.phys.data.surface1)
```

```
##   lakeid   lakename year4 daynum sampledate depth temperature_C
## 1      L    Paul Lake  1984   148   5/27/84     0          14.5
## 18     R    Peter Lake  1984   149   5/28/84     0          14.8
## 40     T Tuesday Lake  1984   150   5/29/84     0          15.0
## 56     L    Paul Lake  1984   155   6/3/84      0          18.8
## 72     R    Peter Lake  1984   156   6/4/84      0          18.8
## 90     T Tuesday Lake  1984   157   6/5/84      0          21.0
## dissolvedOxygen irradianceWater irradianceDeck comments
## 1              9.5             1750             1620    <NA>
## 18             9.2             1630             1540    <NA>
```

```
## 40          9.5          1850          1960      <NA>
## 56          8.0          1100          1050      <NA>
## 72          9.0           275           275      <NA>
## 90          8.4          1200          1200      <NA>
```

```
dim(NTL.phys.data.surface1)
```

```
## [1] 1902  11
```

```
head(NTL.phys.data.surface2)
```

```
##   lakeid    lakename year4 daynum sampledte depth temperature_C
## 1      L    Paul Lake  1984   148   5/27/84     0           14.5
## 2      R    Peter Lake  1984   149   5/28/84     0           14.8
## 3      T Tuesday Lake  1984   150   5/29/84     0           15.0
## 4      L    Paul Lake  1984   155   6/3/84     0           18.8
## 5      R    Peter Lake  1984   156   6/4/84     0           18.8
## 6      T Tuesday Lake  1984   157   6/5/84     0           21.0
##   dissolvedOxygen irradianceWater irradianceDeck comments
## 1              9.5             1750             1620      <NA>
## 2              9.2             1630             1540      <NA>
## 3              9.5             1850             1960      <NA>
## 4              8.0             1100             1050      <NA>
## 5              9.0              275              275      <NA>
## 6              8.4             1200             1200      <NA>
```

```
dim(NTL.phys.data.surface2)
```

```
## [1] 1902  11
```

```
head(NTL.phys.data.surface3)
```

```
##   lakeid    lakename year4 daynum sampledte depth temperature_C
## 1      L    Paul Lake  1984   148   5/27/84     0           14.5
## 2      R    Peter Lake  1984   149   5/28/84     0           14.8
## 3      T Tuesday Lake  1984   150   5/29/84     0           15.0
## 4      L    Paul Lake  1984   155   6/3/84     0           18.8
## 5      R    Peter Lake  1984   156   6/4/84     0           18.8
## 6      T Tuesday Lake  1984   157   6/5/84     0           21.0
##   dissolvedOxygen irradianceWater irradianceDeck comments
## 1              9.5             1750             1620      <NA>
## 2              9.2             1630             1540      <NA>
## 3              9.5             1850             1960      <NA>
## 4              8.0             1100             1050      <NA>
## 5              9.0              275              275      <NA>
## 6              8.4             1200             1200      <NA>
```

```
dim(NTL.phys.data.surface3)
```

```
## [1] 1902  11
```

```
# Choose multiple conditions to filter
summary(NTL.phys.data$lakename)
```

```
## Central Long Lake    Crampton Lake    East Long Lake    Hummingbird Lake
##              539              1234              3905              430
##      Paul Lake      Peter Lake      Tuesday Lake      Ward Lake
##      10325          11288          6107          598
```

```
##      West Long Lake
##              4188

NTL.phys.data.PeterPaul1 <- filter(NTL.phys.data, lakename == "Paul Lake" | lakename == "Peter Lake")
NTL.phys.data.PeterPaul2 <- filter(NTL.phys.data, lakename != "Central Long Lake" &
                                   lakename != "Crampton Lake" & lakename != "East Long Lake" &
                                   lakename != "Hummingbird Lake" & lakename != "Tuesday Lake" &
                                   lakename != "Ward Lake" & lakename != "West Long Lake")
NTL.phys.data.PeterPaul3 <- filter(NTL.phys.data, lakename %in% c("Paul Lake", "Peter Lake"))

# Choose a range of conditions of a numeric or integer variable
summary(NTL.phys.data$daynum)

##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##      55.0   166.0   194.0   194.3   222.0   307.0

NTL.phys.data.JunethruOctober1 <- filter(NTL.phys.data, daynum > 151 & daynum < 305)
NTL.phys.data.JunethruOctober2 <- filter(NTL.phys.data, daynum > 151, daynum < 305)
NTL.phys.data.JunethruOctober3 <- filter(NTL.phys.data, daynum >= 152 & daynum <= 304)
NTL.phys.data.JunethruOctober4 <- filter(NTL.phys.data, daynum %in% c(152:304))

# Exercise:
# filter NTL.phys.data for the year 1999
# what code do you need to use, based on the class of the variable?
class(NTL.phys.data$year4)

## [1] "integer"

# Exercise:
# filter NTL.phys.data for Tuesday Lake from 1990 through 1999.
```

Question: Why don't we filter using row numbers? > ANSWER:

## Arrange

Arranging allows us to change the order of rows in our dataset. By default, the arrange function will arrange rows in ascending order.

```
NTL.phys.data.depth.ascending <- arrange(NTL.phys.data, depth)
NTL.phys.data.depth.descending <- arrange(NTL.phys.data, desc(depth))

# Exercise:
# Arrange NTL.phys.data by temperature, in descending order.
# Which dates, lakes, and depths have the highest temperatures?
```

## Select

Selecting allows us to choose certain columns (variables) in our dataset.

```
NTL.phys.data.temps <- select(NTL.phys.data, lakename, sampledate:temperature_C)
```

## Mutate

Mutating allows us to add new columns that are functions of existing columns. Operations include addition, subtraction, multiplication, division, log, and other functions.

```
NTL.phys.data.temps <- mutate(NTL.phys.data.temps, temperature_F = (temperature_C*9/5) + 32)
```

## Pipes

Sometimes we will want to perform multiple commands on a single dataset on our way to creating a processed dataset. We could do this in a series of subsequent commands or create a function. However, there is another method to do this that looks cleaner and is easier to read. This method is called a pipe. We designate a pipe with `%>%`. A good way to think about the function of a pipe is with the word “then.”

Let’s say we want to take our raw dataset (NTL.phys.data), *then* filter the data for Peter and Paul lakes, *then* select temperature and observation information, and *then* add a column for temperature in Fahrenheit:

```
NTL.phys.data.processed <-  
  NTL.phys.data %>%  
  filter(lakename == "Paul Lake" | lakename == "Peter Lake") %>%  
  select(lakename, sampledate:temperature_C) %>%  
  mutate(temperature_F = (temperature_C*9/5) + 32)
```

Notice that we did not place the dataset name inside the wrangling function but rather at the beginning.

## Saving processed datasets

```
write.csv(NTL.phys.data.PeterPaul1, row.names = FALSE, file = "./Data/Processed/NTL-LTER_Lake_Chemistry")
```

## CLOSING DISCUSSION

How did data wrangling help us to generate a processed dataset? How does this impact our ability to analyze and answer questions about our data?