Data Wrangling with Dplyr

Symposium: Using RStudio for Visualization and Analysis of Weed Science Experiments

Maxwel Coura Oliveira, PhD

Department of Agronomy
University of Wisconsin-Madison

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Outline

- 7 dplyr verbs for data manipulation
  - **select**, **filter**, **group_by**, **summarize**, **mutate**, **count**, **arrange**
- Combining verbs using pipes **%>%**
- 2 tidyr verbs to reshape your data (**spread**, **gather**)

Prerequisites

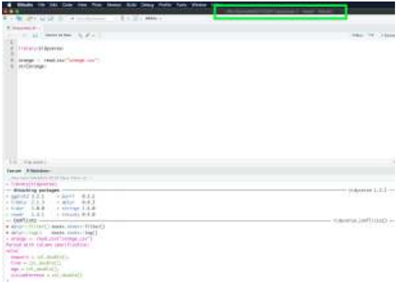
- Install R and R studio
- See the R basics lesson if you're unfamiliar with R or R studio

Create a new R script

- **File > New File > R script**

- Save it in your project directory

- Look on the top left of the R Studio window to find project directory



```
library(tidyverse)

orange <- read.csv("orange.csv")
str(orange)
```

```
> library(tidyverse)
── Attaching packages ─────────────────────────── tidyverse 1.2.1 ──
✔ ggplot2 3.2.1     ✔ purrr   0.3.2
✔ tibble  2.1.3     ✔ dplyr   0.8.3
✔ tidyr   1.0.0     ✔ stringr 1.4.0
✔ readr   1.3.1     ✔ forcats 0.4.0
── Conflicts ──────────────────────────── tidyverse_conflicts() ──
✖ dplyr::filter() masks stats::filter()
✖ dplyr::lag()    masks stats::lag()
> orange <- read_csv("orange.csv")
Parsed with column specification:
cols(
  [illegible] = col_double(),
  Tree = col_double(),
  age = col_double(),
  circumference = col_double()
)
```

What is the tidyverse?

- Packages for data manipulation
- Built for data tables
- Makes data manipulation easier than in base R
- Combine verbs using pipes

Installing packages

```
install.packages()
```

- Input: package name
- Downloads packages from CRAN (Comprehensive R Archive Network)
- Install once per machine

```
install.packages("tidyverse")
```

Loading packages

```
library(packagename)
```

- Input: package name
- Gives R access to functions in the package
- Load packages every time you restart R

```
library(tidyverse)
```

Data set: barley yields in Minnesota

- Stored in R as barley dataset at lattice package

```
library(lattice)
```

- *Rows*: observations of individual columns
- *Columns*: Variables that describe the experiment
  - yield, variety, year, site

barley data

```
barley
```

```
##          yield          variety year            site
## 1   27.00000        Manchuria 1931 University Farm
## 2   48.86667        Manchuria 1931          Waseca
## 3   27.43334        Manchuria 1931          Morris
## 4   39.93333        Manchuria 1931       Crookston
## 5   32.96667        Manchuria 1931    Grand Rapids
## 6   28.96667        Manchuria 1931          Duluth
## 7   43.06666          Glabron 1931 University Farm
## 8   55.20000          Glabron 1931          Waseca
## 9   28.76667          Glabron 1931          Morris
## 10  38.13333          Glabron 1931       Crookston
## 11  29.13333          Glabron 1931    Grand Rapids
## 12  29.66667          Glabron 1931          Duluth
## 13  35.13333         Svansota 1931 University Farm
## 14  47.33333         Svansota 1931          Waseca
## 15  25.76667         Svansota 1931          Morris
## 16  40.46667         Svansota 1931       Crookston
## 17  29.66667         Svansota 1931    Grand Rapids
## 18  25.70000         Svansota 1931          Duluth
```

Import data in tidyverse

- *read_csv()* – loads contents of a CSV file

- *Input*: a file path

- *Output* a “tibble”

Why not read.csv()?

- read_csv() is faster
- Create tibbles
- More reproducible

Data frame	Tibble
Strings to factors	Keeps character
Has row names	No row names
Changes column names	Keeps column nas as they are

dplyr verbs

- First argument is always a table
  - Tibble or data frame
- Output is a new table
- Doesn't change input data
  - Must save the output using <-

new_df <- verb(old_df, . . .)

OR

old_df <- verb(old_df, . . .)

select()

- Selects columns from a data frame
- Input: data and columns to be kept
- Output: data with only the specified columns

```
select(barley, site)
```

```
##                 site
## 1   University Farm
## 2            Waseca
## 3            Morris
## 4         Crookston
## 5      Grand Rapids
## 6            Duluth
## 7   University Farm
## 8            Waseca
## 9            Morris
## 10        Crookston
## 11     Grand Rapids
## 12           Duluth
## 13  University Farm
## 14           Waseca
## 15           Morris
## 16        Crookston
## 17     Grand Rapids
## 18           Duluth
## 19  University Farm
## 20           Waseca
## 21           Morris
## 22        Crookston
## 23     Grand Rapids
## 24           Duluth
## 25  University Farm
```

filter()

- Choose rows based on values of a variable
- **Input**: data and a logical expression (returns true/false)
    - <, >, >=, <=, ==, !=
- **Output**: data with rows that match the expression

```
filter(barley, site == "Waseca")
```

```
##       yield          variety year   site
## 1  48.86667        Manchuria 1931 Waseca
## 2  55.20000          Glabron 1931 Waseca
## 3  47.33333         Svansota 1931 Waseca
## 4  50.23333           Velvet 1931 Waseca
## 5  63.83330            Trebi 1931 Waseca
## 6  58.10000          No. 457 1931 Waseca
## 7  65.76670          No. 462 1931 Waseca
## 8  48.56666         Peatland 1931 Waseca
## 9  46.76667          No. 475 1931 Waseca
## 10 58.80000 Wisconsin No. 38 1931 Waseca
## 11 33.46667        Manchuria 1932 Waseca
## 12 37.73333          Glabron 1932 Waseca
## 13 38.50000         Svansota 1932 Waseca
## 14 37.40000           Velvet 1932 Waseca
## 15 49.23330            Trebi 1932 Waseca
## 16 42.20000          No. 457 1932 Waseca
## 17 44.70000          No. 462 1932 Waseca
## 18 36.03333         Peatland 1932 Waseca
## 19 41.26667          No. 475 1932 Waseca
## 20 58.16667 Wisconsin No. 38 1932 Waseca
```

Pipe operator %>%

- Combine multiple verbs
- **Syntax**: %>% at the end of the line
- Output of the first line becomes input of next line, etc.
- Say it out loud as “then”

```
barley %>%
  filter(yield > 50) %>%
     select(site, yield)
```

```
##     site    yield
## 1 Waseca 55.20000
## 2 Waseca 50.23333
## 3 Waseca 63.83330
## 4 Waseca 58.10000
## 5 Waseca 65.76670
## 6 Waseca 58.80000
## 7 Waseca 58.16667
```

Exercise #1: practice pipes

- Using pipes, subset the barley data to include

- **yield** of individuals higher than 40 and lower than 25

mutate()

- Creates a new column
- Input: data and the definition of a new column
- col_name =
- Output: data with a new column

```
barley %>%
  mutate(yield_kgha = round(yield * 67.25, 0))
```

```
##        yield          variety year            site yield_kgha
## 1   27.00000        Manchuria 1931 University Farm       1816
## 2   48.86667        Manchuria 1931          Waseca       3286
## 3   27.43334        Manchuria 1931          Morris       1845
## 4   39.93333        Manchuria 1931       Crookston       2686
## 5   32.96667        Manchuria 1931    Grand Rapids       2217
## 6   28.96667        Manchuria 1931          Duluth       1948
## 7   43.06666          Glabron 1931 University Farm       2896
## 8   55.20000          Glabron 1931          Waseca       3712
## 9   28.76667          Glabron 1931          Morris       1935
## 10  38.13333          Glabron 1931       Crookston       2564
## 11  29.13333          Glabron 1931    Grand Rapids       1959
## 12  29.66667          Glabron 1931          Duluth       1995
## 13  35.13333         Svansota 1931 University Farm       2363
```

Exercise 2: data frame challenge

- Create a new data frame from the barley data that meets the following criteria:
  1. contains only the site and yield column and a new column called **yield_lb**
  2. **yield_lb** contains values that are yield in lb / 1000 sq. ft

- **Hint**: 1 bu/acre = 1.38 lb/1000 sq. ft

Creating a summary table

- summarize()
- Input: data and a summary statistic
  - Eg: mean()
  - na.rm = TRUE
- Output: a table with the calculated summary statistic

```r
barley %>%
  summarize(mean_yield = mean(yield,
                              na.rm=TRUE))
```

```
##   mean_yield
## 1   34.42056
```

Creating a grouped summary table

- **group_by()**
- Input: data and a variable
- Output: a table with the calculated summary statistic for each unique value in the variable

```
barley %>%
  group_by(site) %>%
  summarize(mean_yield = mean(yield,
                             na.rm=TRUE))
```

```
## # A tibble: 6 x 2
##   site            mean_yield
##   <fct>                <dbl>
## 1 Grand Rapids          24.9
## 2 Duluth                28.0
## 3 University Farm       32.7
## 4 Morris                35.4
## 5 Crookston             37.4
## 6 Waseca                48.1
```

Removing missing values

- **is.na()**
  - missing = TRUE
  - not missing = FALSE

- Input: a column

- Output: logical vector

- Use it as input to filter()

```
barley %>%
  filter(!is.na(yield)) %>%
  group_by(variety) %>%
  summarize(mean_yield = mean(round(yield),
                              na.rm=TRUE))
```

```
## # A tibble: 10 x 2
##    variety           mean_yield
##    <fct>                  <dbl>
##  1 Svansota                30.3
##  2 No. 462                 35.5
##  3 Manchuria               31.4
##  4 No. 475                 31.8
##  5 Velvet                  32.9
##  6 Peatland                34.2
##  7 Glabron                 33.3
##  8 No. 457                 35.8
##  9 Wisconsin No. 38        39.3
## 10 Trebi                   39.6
```

count()

- Count the number of observations
- Input:
  - categorical variable
- **sort** = TRUE: sorts the results
- Output: a table with a row for each categorical variable and a column called n with counts

```
barley %>%
  count(site)
```

```
## # A tibble: 6 x 2
##   site                 n
##   <fct>            <int>
## 1 Grand Rapids        20
## 2 Duluth              20
## 3 University Farm     20
## 4 Morris              20
## 5 Crookston           20
## 6 Waseca              20
```

Same as

```
barley %>%
  group_by(site) %>%
  summarize(count=n())
```

```
## # A tibble: 6 x 2
##   site             count
##   <fct>            <int>
## 1 Grand Rapids        20
## 2 Duluth              20
## 3 University Farm     20
## 4 Morris              20
## 5 Crookston           20
## 6 Waseca              20
```

arrange()

- Order results in ascending order
- Input:
  - A variable
  - Use desc() to put them in descending order
- Output: A table ordered by the values of the input column

```
barley %>%
  group_by(variety) %>%
  arrange(desc(yield))
```

```
## # A tibble: 120 x 4
## # Groups:   variety [10]
##    yield variety           year  site
##    <dbl> <fct>             <fct> <fct>
##  1  65.8 No. 462           1931  Waseca
##  2  63.8 Trebi             1931  Waseca
##  3  58.8 Wisconsin No. 38 1931  Waseca
##  4  58.2 Wisconsin No. 38 1932  Waseca
##  5  58.1 No. 457           1931  Waseca
##  6  55.2 Glabron           1931  Waseca
##  7  50.2 Velvet            1931  Waseca
##  8  49.9 Wisconsin No. 38 1931  Crookston
##  9  49.2 Trebi             1932  Waseca
## 10  48.9 Manchuria         1931  Waseca
## # ... with 110 more rows
```

Exercise 3

1 - Use **group_by()** and summarize() to find the mean(), min(), and max() yield for each site.

2 - **Bonus**: What is the yield gap between varieties in each site and location?

Reshaping data with tidyr

- The shape of your data affects what you can do with it

- **Example**: compare the mean yield of each variety adding a new column (High or Low)

Exercise

- Create a table with columns for variety and **mean** yield. Add a logical parameter for mean yield, > 35 (High) or < 35 (Low)
- Save to a new object called **barley_nd**

```
barley_nd <- barley %>%
  select(variety, yield) %>%
  group_by(variety) %>%
  summarise(mean_yield = mean(round(yield))) %>%
  mutate(size = ifelse(mean_yield > 35,
                       "High", "Low"))

barley_nd
```

```
## # A tibble: 10 x 3
##    variety          mean_yield size
##    <fct>                 <dbl> <chr>
##  1 Svansota               30.3 Low
##  2 No. 462                35.5 High
##  3 Manchuria              31.4 Low
##  4 No. 475                31.8 Low
##  5 Velvet                 32.9 Low
##  6 Peatland               34.2 Low
##  7 Glabron                33.3 Low
##  8 No. 457                35.8 High
##  9 Wisconsin No. 38       39.3 High
## 10 Trebi                  39.6 High
```

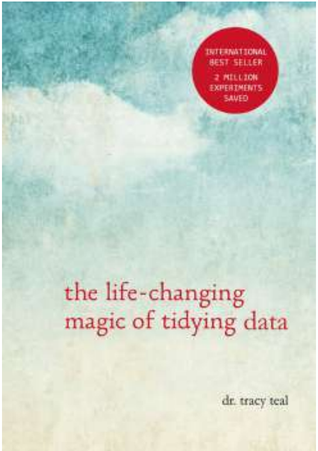
Tidy Data

1) Each variable has its own column

2) Each observation has its own row

3) Each value has its own cell

4) Each type of observational unit forms a table


INTERNATIONAL BEST SELLER
2 MILLION EXPERIMENTS SAVED
the life-changing magic of tidying data
dr. tracy teal

Reshaping data with tidyr

- Spreading: makes a wider table
  - Unique values in a specified column (key) become variable names

- Gathering: makes a longer table
  - Variable names become values in a new column (key)

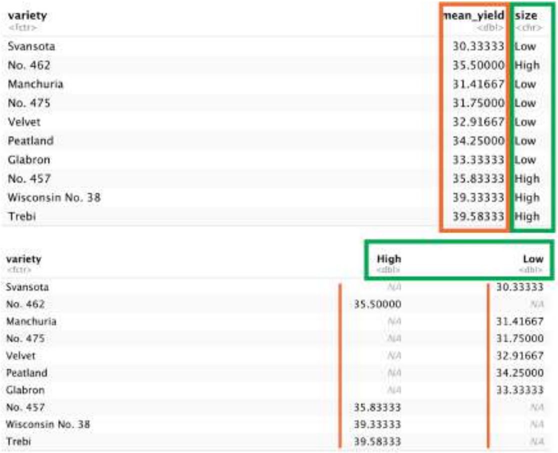
spread()

- use it when an observation is scattered across multiple rows
- Input:
  - data (a tibble)
  - key column (values become new column names)
  - value column (to fill new column variables)
- Output: a table with columns for each value of sex

```
barley_spread <- barley_nd %>%
  spread(key = size,
         value = mean_yield)

barley_spread
```

```
## # A tibble: 10 x 3
##    variety           High   Low
##    <fct>            <dbl> <dbl>
##  1 Svansota          NA    30.3
##  2 No. 462           35.5  NA
##  3 Manchuria         NA    31.4
##  4 No. 475           NA    31.8
##  5 Velvet            NA    32.9
##  6 Peatland          NA    34.2
##  7 Glabron           NA    33.3
##  8 No. 457           35.8  NA
##  9 Wisconsin No. 38  39.3  NA
## 10 Trebi             39.6  NA
```

Spread



variety <fctr>	mean_yield <dbl>	size <chr>
Svansota	30.33333	Low
No. 462	35.50000	High
Manchuria	31.41667	Low
No. 475	31.75000	Low
Velvet	32.91667	Low
Peatland	34.25000	Low
Glabron	33.33333	Low
No. 457	35.83333	High
Wisconsin No. 38	39.33333	High
Trebi	39.58333	High

variety <fctr>	High <dbl>	Low <dbl>
Svansota	NA	30.33333
No. 462	35.50000	NA
Manchuria	NA	31.41667
No. 475	NA	31.75000
Velvet	NA	32.91667
Peatland	NA	34.25000
Glabron	NA	33.33333
No. 457	35.83333	NA
Wisconsin No. 38	39.33333	NA
Trebi	39.58333	NA

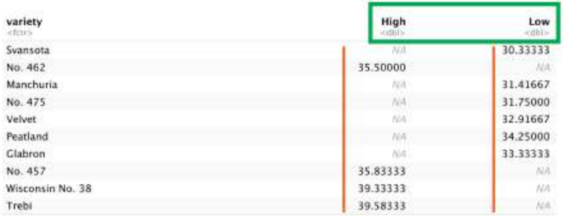
gather()

- Use when column names are not names of variables, but values of a variable
- Input:
  - data (a tibble)
  - key column (created from col names)
  - values column (fill the key variable)
  - A range of columns to gather
- Output: a long tibble

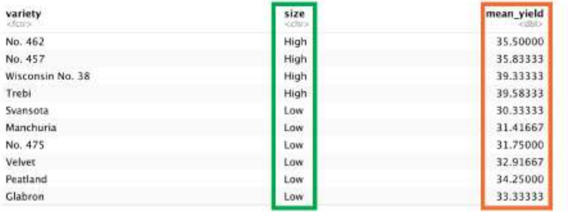
```
barley_gather <- barley_spread %>%
  gather(key = size,
         value = mean_yield, 2:3, na.rm=TRUE)

barley_gather
```

```
## # A tibble: 10 x 3
##    variety          size  mean_yield
##    <fct>            <chr>      <dbl>
##  1 No. 462          High        35.5
##  2 No. 457          High        35.8
##  3 Wisconsin No. 38 High        39.3
##  4 Trebi            High        39.6
##  5 Svansota         Low         30.3
##  6 Manchuria        Low         31.4
##  7 No. 475          Low         31.8
##  8 Velvet           Low         32.9
##  9 Peatland         Low         34.2
## 10 Glabron          Low         33.3
```

Gather



variety <fctr>	High <dbl>	Low <dbl>
Svansota	NA	30.33333
No. 462	35.50000	NA
Manchuria	NA	31.41667
No. 475	NA	31.75000
Velvet	NA	32.91667
Peatland	NA	34.25000
Glabron	NA	33.33333
No. 457	35.83333	NA
Wisconsin No. 38	39.33333	NA
Trebi	39.58333	NA



variety <fctr>	size <chr>	mean_yield <dbl>
No. 462	High	35.50000
No. 457	High	35.83333
Wisconsin No. 38	High	39.33333
Trebi	High	39.58333
Svansota	Low	30.33333
Manchuria	Low	31.41667
No. 475	Low	31.75000
Velvet	Low	32.91667
Peatland	Low	34.25000
Glabron	Low	33.33333

write_csv

- Writes a data table to a file
- Input: a tibble, a file path
- Output: a file at the specified file path

```r
write_csv(barley_gather,
          path = "barley_2.csv")
```

Need help

- E-mail: maxoliveira@wisc.edu
- Data Wrangling Cheat Sheet - Link
- Thanks to Data Camp for sharing slides