Documenting and Data Analysis in R

R Basics

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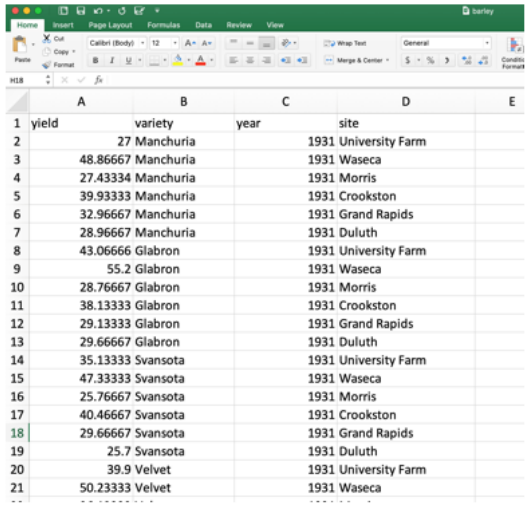
Outline

- How to install R and Rstudio
- Intro to R, RStudio and Markdown
- Data types
- Importing datasets

+ - * / ^ <- [ ] $ > <
== ! %in% & |



	A	B	C	D	E
1	yield	variety	year	site	
2	27	Manchuria	1931	University Farm	
3	48.86667	Manchuria	1931	Waseca	
4	27.43334	Manchuria	1931	Morris	
5	39.93333	Manchuria	1931	Crookston	
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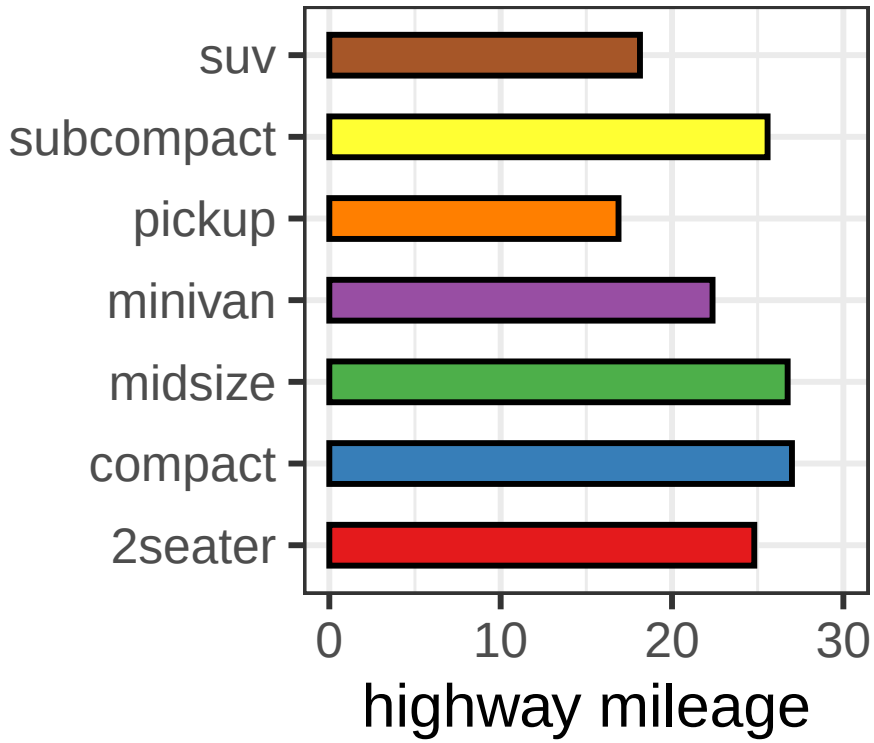
21	50.23333	Velvet	1931	Waseca	

Whats is R? RStudio?

- R – a programming language + software that interprets it
- RStudio – popular software to write R scripts and interact with the R software

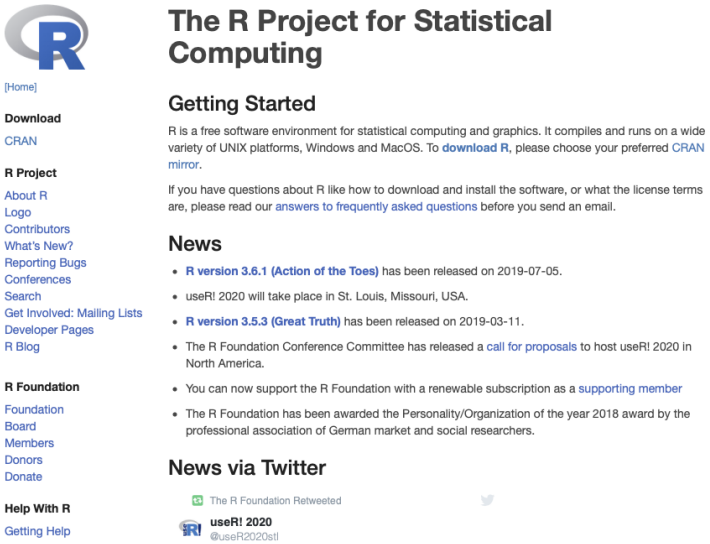
Why learn R?

- Free, open source, cross platform
  - 10,000+ "packages"
  - Works on many data types
- Statistical data analysis
- Produced high-quality graphics
- Reproducibility and repeatability
- Write documents and manuscripts

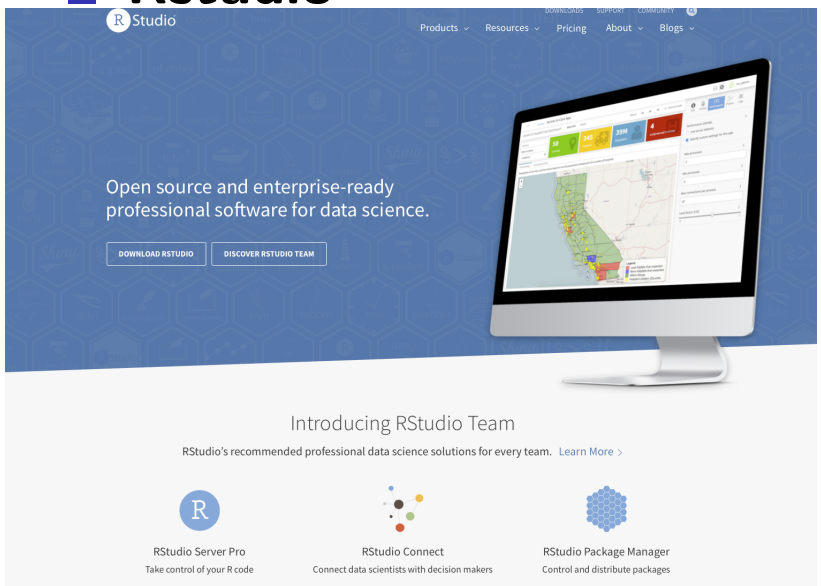


How to download R? RStudio?

- R



- Rstudio



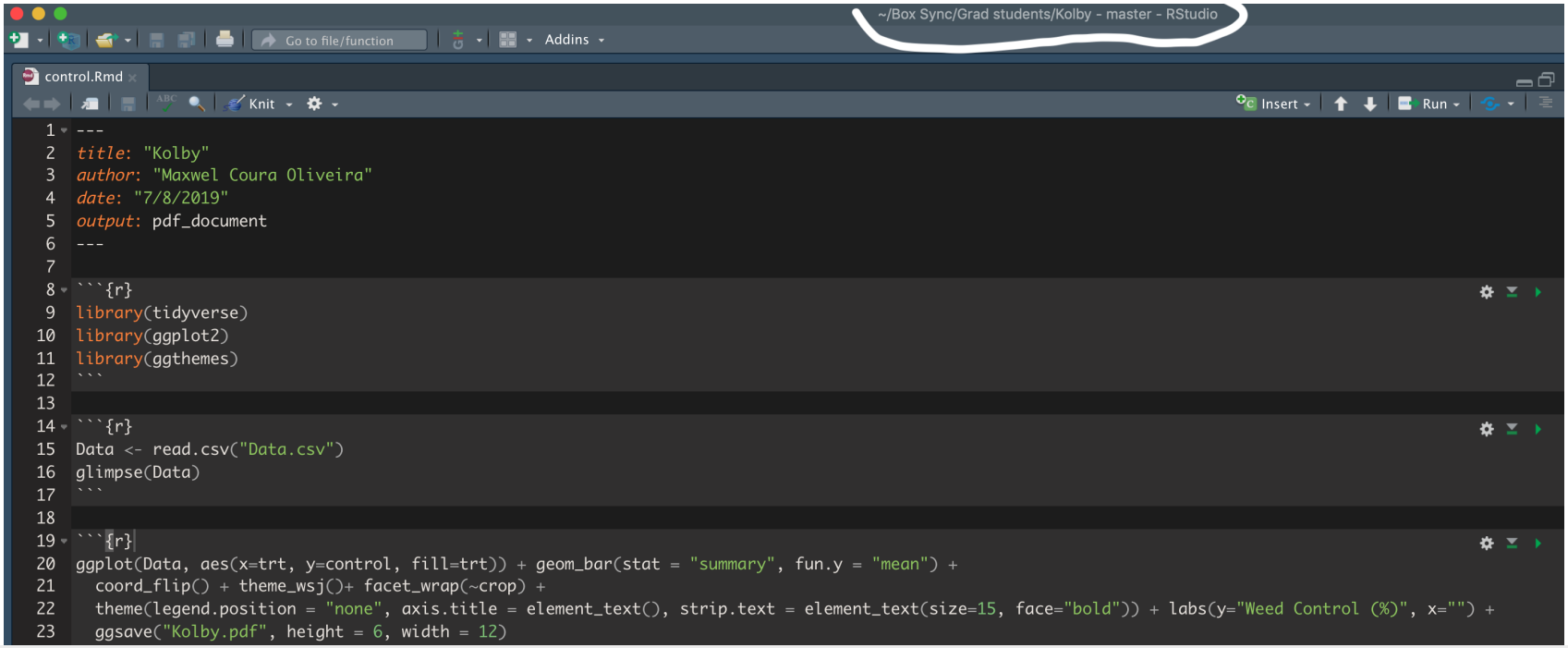
- Video tutorial

Setup a working directory

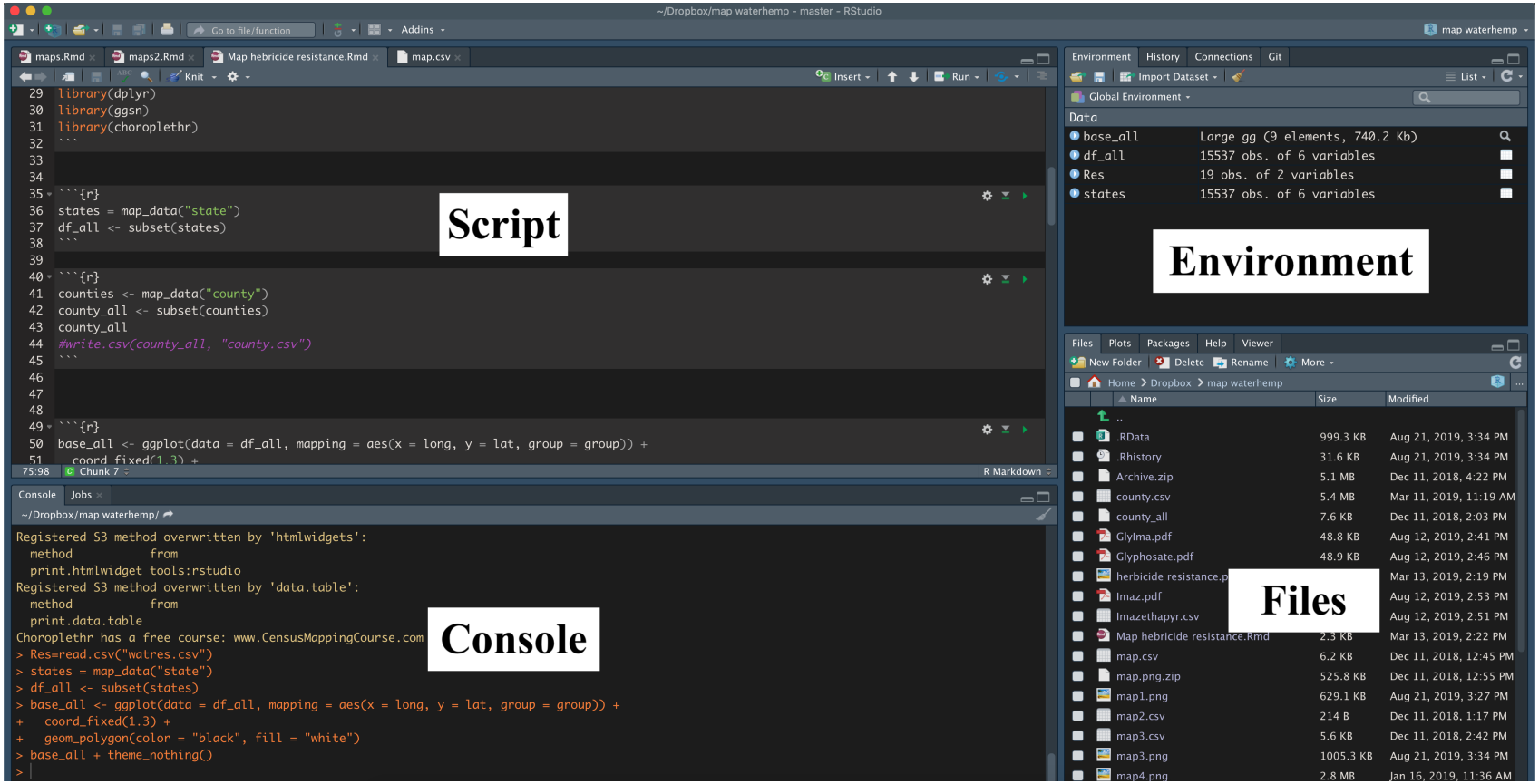
- Open RStudio
- *File* > *New project* > *New directory* > Empty project
- Enter a name for this new folder: r-basics
- Choose a convenient location:
- ~/ is the Documents folder on the computer
- Click "*Create project*"

Create a new R script

- File > New File > R script (.R or .Rmd)
- Save it in your project directory
- Look on the top left of the R Studio window to see where it's saved

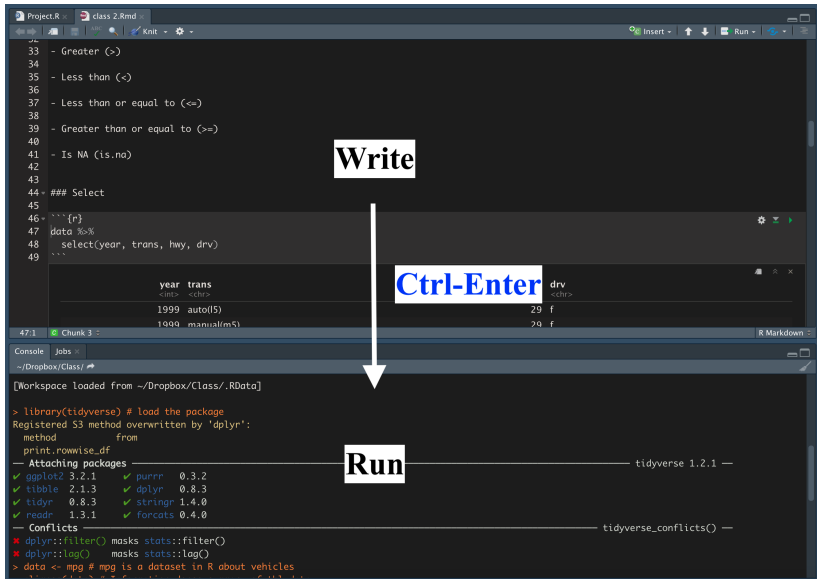


RStudio interface



Script vs Console

- Both accept commands
- Console: runs the commands
- Script: commands you want to save for later;
  - Must be run in console
  - Ctrl+enter to run



Let's start coding!

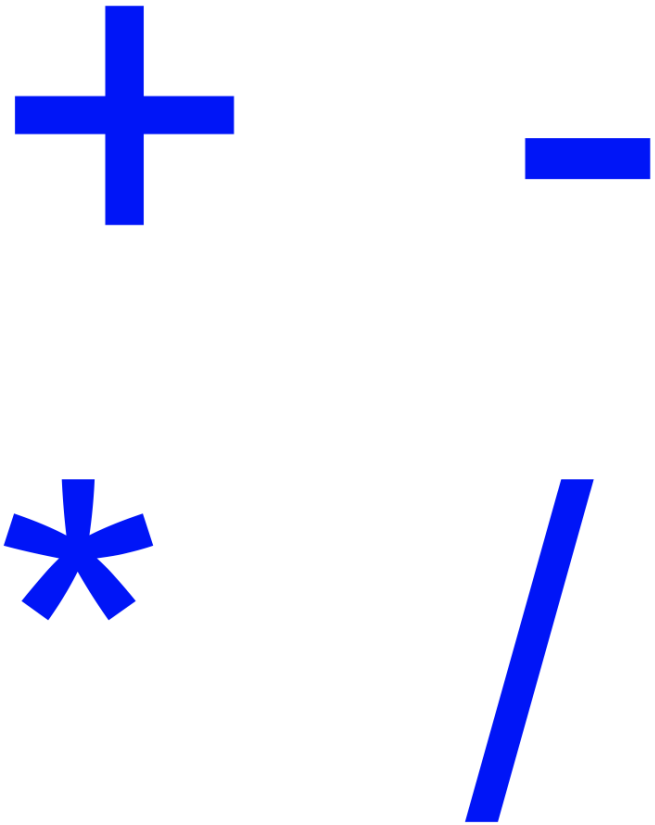
- Operators: Arithmetic, assignment, extraction, logical
- Functions: names, arguments, output
- Data types: classes, vectors, data frames

Let's start coding!

textbf	What it does	Symbol
Arithmetic	Math on numbers	+ - * / ^
Assignment	Creates objects (left) with	<-
Extraction	Take out or replace part of an object	[ ] $
Logical	Compares values, returns TRUE/FALSE	>< == ! %in% & |

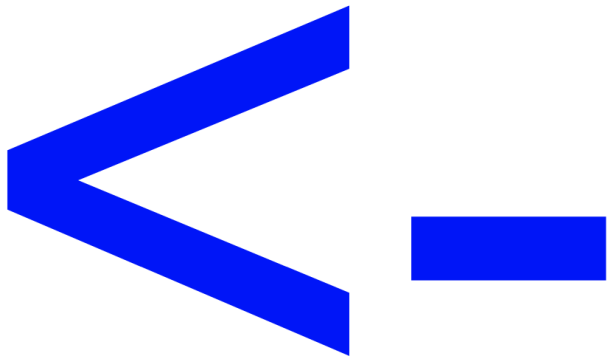
Let's start coding!

- Does math
  - Add: 2+2
  - Subtract: 3-1
  - Multiply: 4*4
  - Divide: 5/2
- Sends results to the console
  - CTRL+Enter



Assignment operator

- Saves values into objects
  - object <- value
  - weightkg <- 55
- Overwrites previous values
- Combine with arithmetic operators:
  - weightlb <- 2.2*weightkg



Exercise: Operators

What are the values of each variable after each statement?

```
mass <- 47.5                                  # mass?
age <- 122                                    # age?
mass <- mass * 2.0                            # mass?
age <- age - 20                               # age?
\textcolor{purple}{mass_index}                # \text-
<- mass/age                                   color{purple}{mass_index}?
```

Functions and arguments

- A sequence of instructions that perform a task
  - Have names
  - Accepts arguments (input)
  - Return a value (output)

Input	Output
sqrt(9)	3
round(3.14159)	3
round(x=3.14159), digits=2	3

Getting help

- Documentation

```
?round # Opens a page for round
```

```
args(round) # display arguments
```

```
## function (x, digits = 0)
## NULL
```

- **Google "R +"function name"**
- Other websites
  - Stack overfolow (Q&A)
  - R bloggers (tutorials)

Data types

- R guesses what type of data is sotred in an object
- Basic types:

  Numeric?

  Character

  Logical
- Can be easy to tell

Examples:

- x <- 32 (Numeric)
- x <- "car" (Character)
- x <- TRUE (Logical)

Data structures

Data structure	Description	Function
vector	Multiple values of the same type	c(), vector
factor	Multiple integers with text labels	factor
data frame	Multiple vectors of the same length grouped to make columns	read.csv(), data frame

Vector

- Most common data type
- Series of one data type
- Concatenate function: c()

  Input: values separately by commas

  Output: a vector object

```
# Exemple: a list of yields
yield_ha <- c(3000, 2890, 3100, 2990)
# Exemple: a list of cars
cars <- c("audi", "toyota", "ford")
```

Inspecting vectors

- Vectors have characteristics:
  - **Length**: number of values
  - **Class**: type of values

```
length(yield_ha)  # Try with length(cars)
```

```
## [1] 4
```

```
class(cars)       # Try with class(yield_ha)
```

```
## [1] "character"
```

```
str(yield_ha)    # Try with str(cars)
```

```
##  num [1:4] 3000 2890 3100 2990
```

Adding values to a vector

- Use an existing vector as an argument to c()
- Put it in the order you want them to appear in the output vector

```
# Add to the end of the vector
yield_ha <- c(yield_ha, 3315)
```

```
# Add to the beginning of the vector
yield_ha <- c(3050, yield_ha)
```

Class coercion

- What happens if you mix types?
- R converts to a type that works for all elements
- Use *class()* to see what R picked

Type	As character	As numeric	As logical
logical	"TRUE"	1	TRUE
numeric	"35"	35	NA
character	"Paulista"	NA	NA

Exercises

```
num_char <- c(1, 2, 3, "a")
num_logical <- c(1, 2, 3, TRUE)
char_logical <- c("a", "b", "c", TRUE)
tricky <- c(1, 2, 3, "4")
```

Hint: use *class()*

Factors

- Represent categorical data
  - Stored as integers with text labels
  - Data frames convert character columns to factors
- *factor()* - create a factor
- Create a character vector

```
sex <- c("male", "female", "female", "male")
```

- Change vector to a factor

```
sex <- factor(sex)
```

Levels

- Unique text labels of a factor object
- *levels()* - displays labels
- *nlevels()* - displays number of levels

Function	**Output**
levels(sex)	“female”, “male”
nlevels(sex)	2
factor(sex, levels = c("male", female")) levels(sex)	“male”, “female”

Exercises

```
ranks <- c("2", "5", "7", "3", "3")
f_ranks <- factor(ranks)
n_ranks <- as.numeric(f_ranks)
```

- What result do you expect to get?
- What do you get when you run the code?

Subsetting vectors

- Subset by position
- Syntax: square brackets [ ]
- Combine with c()

```
animals<-c("cat", "dog", "pig")
```

```
animals[] #Display second value
```

```
## [1] "cat" "dog" "pig"
```

```
animals[c(3,2)] #Display multiple values
```

```
## [1] "pig" "dog"
```

```
animals[c(1,2,3,2,1)] #Display repeated values
```

```
## [1] "cat" "dog" "pig" "dog" "cat"
```

Logical expressions

- Make comparisons
- Evaluates each element in a vector against a value
- Output: TRUE or FALSE
  - For each vector value

Logical expressions

Logical operator	Meaning
>	Greater than
<	Less than
==	Equal to
!=	Not equal to
&	and
|	or
!	not
%in%	Contained in

Example: logical expressions

- Create a weight variable:

```
biomass_g <- c(22, 33, 37, 51, 59)
```

- Evaluate each weight:

```
biomass_h <- biomass_g > 50
biomass_h
```

```
## [1] FALSE FALSE FALSE  TRUE  TRUE
```

Conditional subsetting

- Keep TRUE, drop FALSE
- Input: a logical expression
- **Output**: vector with elements that match the logical expression
- Subset using TRUE/FALSE vector

```
biomass_g[biomass_h]
```

```
## [1] 51 59
```

- Same as

```
biomass_g[biomass_g>50]
```

```
## [1] 51 59
```

Combining logical expressions

- Combine multiple conditionals
- | = or (either)
- & = and (both)
- Biomass under 30 or over 50:

```
biomass_g[biomass_g<30 | biomass_g>50]
```

```
## [1] 22 51 59
```

- Biomass over 30 and under 50:

```
biomass_g[biomass_g>30 & biomass_g<50]
```

```
## [1] 33 37
```

Conditional subsetting: characters (==)

- == operator
- Compares each value in a vector with a character string
- Combine with | for multiple

Make a character vector

```
crops <- c("corn", "soybean", "wheat", "alfalfa")
```

Crops that are corn

```
crops[crops=="corn"]
```

```
## [1] "corn"
```

Crops that are corn or cats

```
crops[crops=="corn" | crops=="wheat"]
```

```
## [1] "corn"  "wheat"
```

Conditional subsetting: characters (%in%)

- \textcolor{blue}{%in%} operator
- Selects elements of the first vector that are in the second vector
- **Input**: vectors
- **Output**: a TRUE/FALSE list

Which values in animals are in the right hand vector?

```
crops %in% c("corn", "soybean", "hemp", "wheat", "beans")
```

```
## [1]  TRUE  TRUE  TRUE FALSE
```

Use TRUE/FALSE vector to subset

```
crops[crops %in% c("corn", "soybean", "hemp", "wheat", "beans")]
```

```
## [1] "corn"    "soybean" "wheat"
```

Missing data

- NA - harder to overlook missing data
- Argument: na.rm = TRUE

```
na.rm = TRUE #Ignores missing data
```

```
heights <- c(2, 4, 4, NA, 6, 7) #create a dataset
```

- Mean of a missing value?

```
mean(heights)
```

```
## [1] NA
```

- Remove the missing data

```
mean(heights, na.rm = TRUE)
```

```
## [1] 4.6
```

Remove missing data

- is.na() - Returns TRUE if the value is NA
- complete.cases() - returns FALSE if missing
- na.omit() - returns object with missing values removed

Remove NAs 3 ways:

```
heights[!is.na(heights)]
```

```
## [1] 2 4 4 6 7
```

```
heights[complete.cases(heights)]
```

```
## [1] 2 4 4 6 7
```

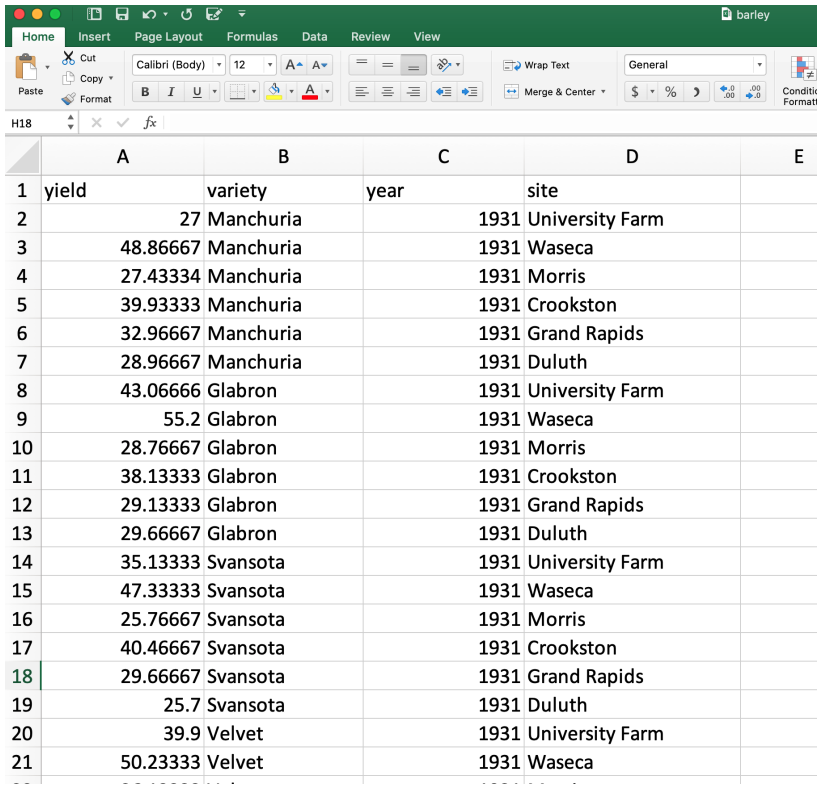
```
na.omit(heights)
```

```
## [1] 2 4 4 6 7
## attr(,"na.action")
## [1] 4
## attr(,"class")
## [1] "omit"
```

Starting with data!

- How to load data tables into R
- Data set: barley yield in Minnesota, USA

- Stored in a **.csv** file
- **Rows**: observations of individual treatments
- **Columns**: Variables that describe the study
- factor() - create a factor



	A	B	C	D	E
1	yield	variety	year	site	
2	27	Manchuria	1931	University Farm	
3	48.86667	Manchuria	1931	Waseca	
4	27.43334	Manchuria	1931	Morris	
5	39.93333	Manchuria	1931	Crookston	
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20	39.9	Velvet	1931	University Farm	
21	50.23333	Velvet	1931	Waseca	

Download the data file

- Download data here - Link
- Right click (barley.csv) > Download Linked File
- Save it to your project folder

Tables to data frames

- **R** can read data tables
- Read tables using *read.csv()* or *read.csv2*
- **Input**: a file name
- **Output**: table stored in a data frame

```
barley <- read.csv("barley.csv")
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
```

Storing data in data frame

1 - Rows = observations

2 - Columns = variables

3 - All values in a column must be the same data type

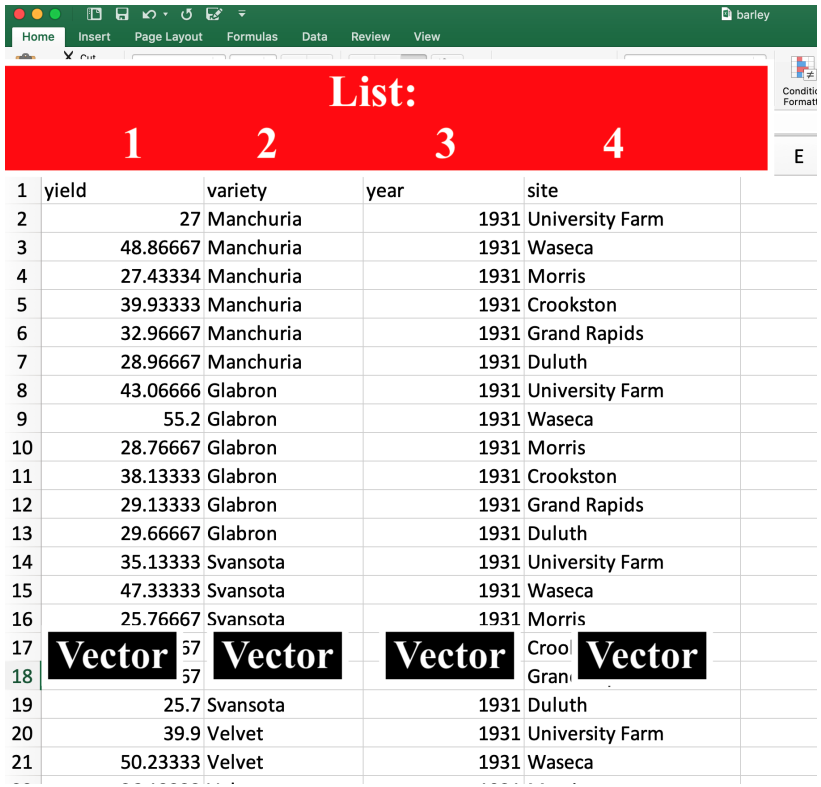
4 - Must have same # rows in each column

Structure of a data frame

- A list of vectors
- Each column
- Is a vector
- Has a name
- Has a data type
- Is a subject to coercion
- List: any data type - every column can have a different data type

Structure of a data frame

- Stored in a **.csv** file
- **Rows**: observations of individual treatments
- **Columns**: Variables that describe the study
- factor() - create a factor



	yield	variety	year	site
2	27	Manchuria	1931	University Farm
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17	57			
18	57			
19	25.7	Svansota	1931	Duluth
20	39.9	Velvet	1931	University Farm
21	50.23333	Velvet	1931	Waseca

Inspecting data frames

Function	Output
class	Class of the object
fstr	structure: # rows, cols, data types
head	look at first 6 rows (all columns)
nrow/ncol	number of rows/columns
names	column names
summary	summary stats for each column

Subsetting data frames

- Use the extraction operator [ ]
- Row column format: data[row, column]
- Select entire row/col: data[, column]
- Ranges: data[a:b, column]

Subsetting data frames

- First row, second col:

```
barley[1,2]
```

```
## [1] Manchuria
## 10 Levels: Glabron Manchuria No. 457 No. 462 No. 475 Peatland ... Wisconsin No. 38
```

  - First row, all cols:

```
barley[1,]
```

```
##   yield   variety year            site
## 1    27 Manchuria 1931 University Farm
```

  - Rows 1-3, 3 column:

```
barley[1:3, 3]
```

```
## [1] 1931 1931 1931
```

Subsetting data frames

- First column, all rows:

```
barley[,3]
```

```
##   [1] 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931
##  [15] 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931
##  [29] 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931
##  [43] 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 1931
##  [57] 1931 1931 1931 1931 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932
##  [71] 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932
##  [85] 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932
##  [99] 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932 1932
## [113] 1932 1932 1932 1932 1932 1932 1932 1932
```

Subsetting data frames

barley[“variety”]	Result is a data.frame
barley[, “variety”]	Result is a vector
barley[[“variety”]]	Result is a vector
barley$variety	Result is a vector

Exercise: subsetting

1) Create a data frame (\textcolor{blue}{barley_70}) containing only the observations from rows 1 to 70 of the surveys dataset.
2) Use *nrow()* to subset the last row in \textcolor{blue}{barley_70}.
3) Use *nrow()* to extract the row that is in the middle \textcolor{blue}{barley_70}. Store in a variable called \textcolor{purple}{barley_mid}.

Saving Data as .csv

- write.csv()
- Input: data frame, destination file
- Output: a file to the specified location
- write.csv(x = barley_70, file = "barley_70.csv")

Need help

- **Email**: max.oliveira@wisc.edu
- Base R Cheat sheet: Link