
# Introduction to the Tidyverse

## How to be a tidy data scientist

Olivier Gimenez
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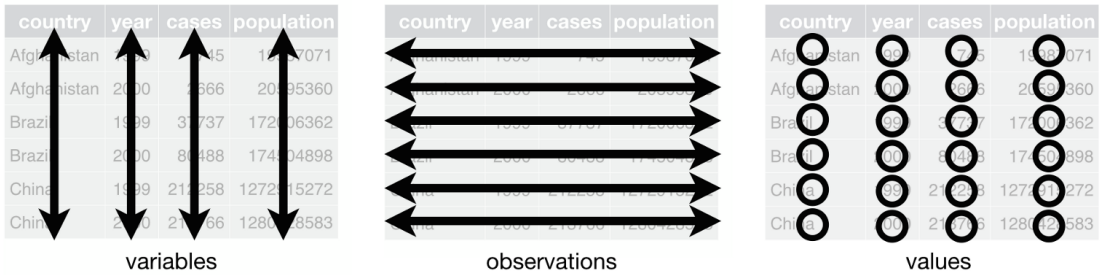
# Tidyverse

- **Ordocosme** in 🇫🇷 with *Tidy* for "bien rangé" and *verse* for "univers"
- A collection of R 📦 developed by H. Wickham and others at Rstudio

# Tidyverse

- "A framework for managing data that aims at making the cleaning and preparing steps [muuuuuuuch] easier" (Julien Barnier).
- Main characteristics of a tidy dataset:
  - each variable is a column
  - each observation is a raw
  - each value is in a different cell



# Tidyverse is a collection of R 

- `ggplot2` - visualising stuff
- `dplyr`, `tidyr` - data manipulation
- `purrr` - advanced programming
- `readr` - import data
- `tibble` - improved data.frame format
- `forcats` - working w/ factors
- `stringr` - working w/ chain of characters

# **Tidyverse** is a collection of R 

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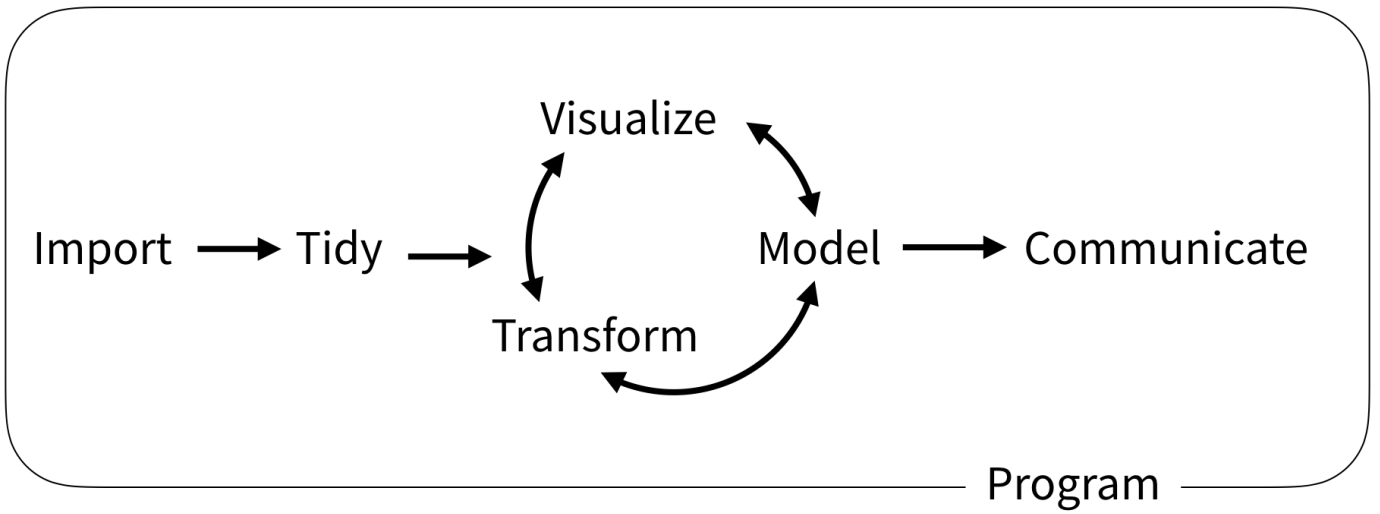
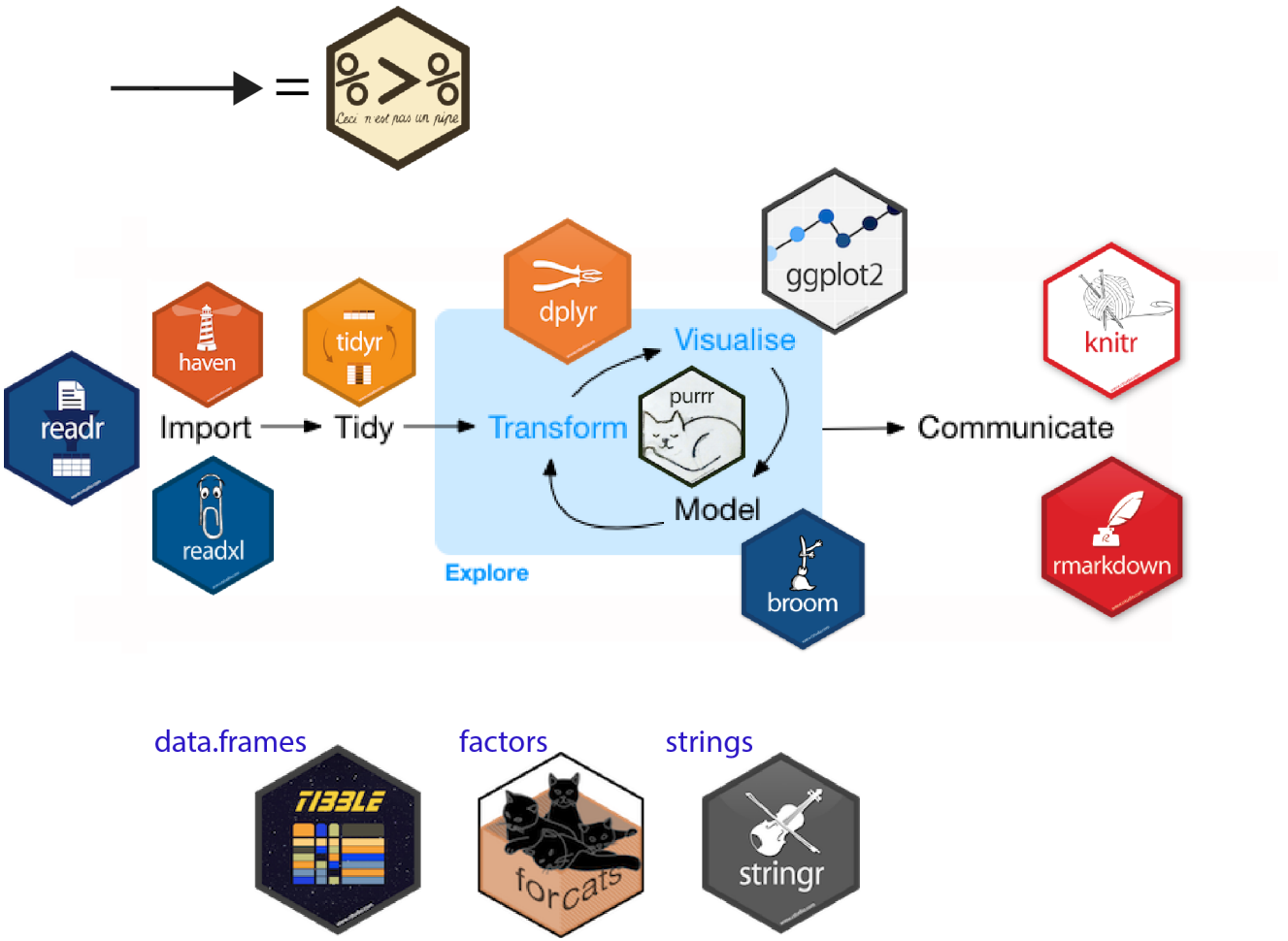
# Workflow in data science



# Workflow in data science, with **Tidyverse**

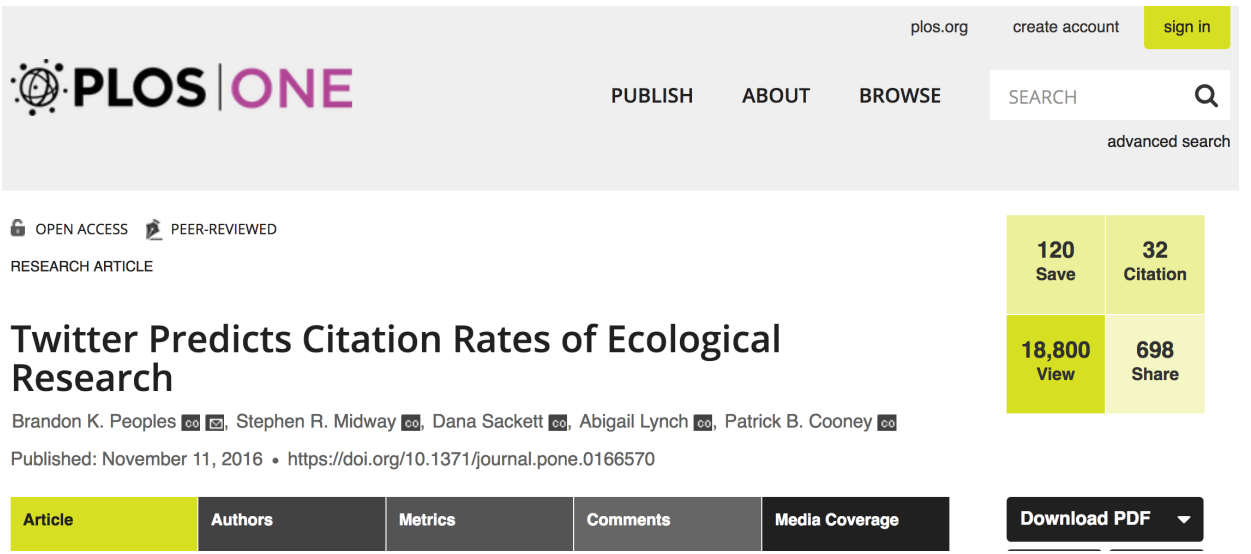


# Load tidyverse 📦


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

# Case study:

# Using Twitter to predict citation rates of ecological research



# Import

# Import data

**readr::read_csv** function:

- ~~keeps input types as is (no conversion to factor)~~ (since `R` 4.0.0)
- creates `tibbles` instead of `data.frame`
  - no names to rows
  - allows column names with special characters (see next slide)
  - more clever on screen display than w/ data.frames (see next slide)
  - no partial matching on column names
  - warning if attempt to access unexisting column
- is daaaaaamn fast 🏎

# Import data

```
citations_raw <- readr::read_csv('https://raw.githubusercontent.com/oliviergimen
citations_raw
```

```
## # A tibble: 1,599 x 12
##    `Journal identi… `5-year journal… `Year published` Volume Issue Authors
##    <chr>                       <dbl>            <dbl>  <dbl> <chr> <chr>
##  1 Ecology Letters              16.7             2014     17 12    Morin …
##  2 Ecology Letters              16.7             2014     17 12    Jucker…
##  3 Ecology Letters              16.7             2014     17 12    Calcag…
##  4 Ecology Letters              16.7             2014     17 11    Segre …
##  5 Ecology Letters              16.7             2014     17 11    Kaufma…
##  6 Ecology Letters              16.7             2014     17 10    Nasto …
##  7 Ecology Letters              16.7             2014     17 10    Tschir…
##  8 Ecology Letters              16.7             2014     17 9     Barnec…
##  9 Ecology Letters              16.7             2014     17 9     Pinto-…
## 10 Ecology Letters              16.7             2014     17 9     Clough…
## # … with 1,589 more rows, and 6 more variables: `Collection date` <chr>,
## #   `Publication date` <chr>, `Number of tweets` <dbl>, `Number of
## #   users` <dbl>, `Twitter reach` <dbl>, `Number of Web of Science
## #   citations` <dbl>
```

# Tidy, transform

# Rename columns

```
citations_temp <- dplyr::rename(citations_raw,
       journal      = 'Journal identity',
       impactfactor = '5-year journal impact factor',
       pubyear      = 'Year published',
       colldate     = 'Collection date',
       pubdate      = 'Publication date',
       nbtweets     = 'Number of tweets',
       woscitations = 'Number of Web of Science citations')
citations_temp
```

```
## # A tibble: 1,599 x 12
##    journal impactfactor pubyear Volume Issue Authors colldate pubdate nbtweets
##    <chr>          <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>      <dbl>
##  1 Ecolog…         16.7    2014     17 12    Morin … 2/1/2016 9/16/2…       18
##  2 Ecolog…         16.7    2014     17 12    Jucker… 2/1/2016 10/13/…       15
##  3 Ecolog…         16.7    2014     17 12    Calcag… 2/1/2016 10/21/…        5
##  4 Ecolog…         16.7    2014     17 11    Segre … 2/1/2016 8/28/2…        9
##  5 Ecolog…         16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…        3
##  6 Ecolog…         16.7    2014     17 10    Nasto … 2/2/2016 7/28/2…       27
##  7 Ecolog…         16.7    2014     17 10    Tschir… 2/2/2016 8/6/20…        6
##  8 Ecolog…         16.7    2014     17 9     Barnec… 2/2/2016 6/17/2…       19
##  9 Ecolog…         16.7    2014     17 9     Pinto-… 2/2/2016 6/12/2…       26
## 10 Ecolog…         16.7    2014     17 9     Clough… 2/2/2016 7/17/2…       44
## # … with 1,589 more rows, and 3 more variables: `Number of users` <dbl>,
## #   `Twitter reach` <dbl>, woscitations <dbl>
```

# Create (or modify) columns

```
citations <- dplyr::mutate(citations_temp, journal = as.factor(journal))
citations
```

```
## # A tibble: 1,599 x 12
##    journal impactfactor pubyear Volume Issue Authors colldate pubdate nbtweets
##    <fct>          <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>      <dbl>
##  1 Ecolog…         16.7    2014     17 12    Morin … 2/1/2016 9/16/2…       18
##  2 Ecolog…         16.7    2014     17 12    Jucker… 2/1/2016 10/13/…       15
##  3 Ecolog…         16.7    2014     17 12    Calcag… 2/1/2016 10/21/…        5
##  4 Ecolog…         16.7    2014     17 11    Segre … 2/1/2016 8/28/2…        9
##  5 Ecolog…         16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…        3
##  6 Ecolog…         16.7    2014     17 10    Nasto … 2/2/2016 7/28/2…       27
##  7 Ecolog…         16.7    2014     17 10    Tschir… 2/2/2016 8/6/20…        6
##  8 Ecolog…         16.7    2014     17 9     Barnec… 2/2/2016 6/17/2…       19
##  9 Ecolog…         16.7    2014     17 9     Pinto-… 2/2/2016 6/12/2…       26
## 10 Ecolog…         16.7    2014     17 9     Clough… 2/2/2016 7/17/2…       44
## # … with 1,589 more rows, and 3 more variables: `Number of users` <dbl>,
## #   `Twitter reach` <dbl>, woscitations <dbl>
```

# Create (or modify) columns

```
levels(citations$journal)
```

```
##  [1] "Animal Conservation"              "Conservation Letters"
##  [3] "Diversity and Distributions"      "Ecological Applications"
##  [5] "Ecology"                          "Ecology Letters"
##  [7] "Evolution"                        "Evolutionary Applications"
##  [9] "Fish and Fisheries"               "Functional Ecology"
## [11] "Global Change Biology"            "Global Ecology and Biogeography"
## [13] "Journal of Animal Ecology"        "Journal of Applied Ecology"
## [15] "Journal of Biogeography"          "Limnology and Oceanography"
## [17] "Mammal Review"                    "Methods in Ecology and Evolution"
## [19] "Molecular Ecology Resources"      "New Phytologist"
```

# Give your code some air

# Cleaner code with "pipe" operator %>%

```
citations_raw %>%
  dplyr::rename(
    journal      = 'Journal identity',
    impactfactor = '5-year journal impact factor',
    pubyear      = 'Year published',
    colldate     = 'Collection date',
    pubdate      = 'Publication date',
    nbtweets     = 'Number of tweets',
    woscitations = 'Number of Web of Science citations') %>%
  dplyr::mutate(journal = as.factor(journal))
```

```
## # A tibble: 1,599 x 12
##    journal impactfactor pubyear Volume Issue Authors colldate pubdate nbtweets
##    <fct>          <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>      <dbl>
##  1 Ecolog…         16.7    2014     17 12    Morin … 2/1/2016 9/16/2…       18
##  2 Ecolog…         16.7    2014     17 12    Jucker… 2/1/2016 10/13/…       15
##  3 Ecolog…         16.7    2014     17 12    Calcag… 2/1/2016 10/21/…        5
##  4 Ecolog…         16.7    2014     17 11    Segre … 2/1/2016 8/28/2…        9
##  5 Ecolog…         16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…        3
##  6 Ecolog…         16.7    2014     17 10    Nasto … 2/2/2016 7/28/2…       27
##  7 Ecolog…         16.7    2014     17 10    Tschir… 2/2/2016 8/6/20…        6
##  8 Ecolog…         16.7    2014     17 9     Barnec… 2/2/2016 6/17/2…       19
##  9 Ecolog…         16.7    2014     17 9     Pinto-… 2/2/2016 6/12/2…       26
## 10 Ecolog…         16.7    2014     17 9     Clough… 2/2/2016 7/17/2…       44
## # … with 1,589 more rows, and 3 more variables: `Number of users` <dbl>,
## #   `Twitter reach` <dbl>, woscitations <dbl>
```

# Name object

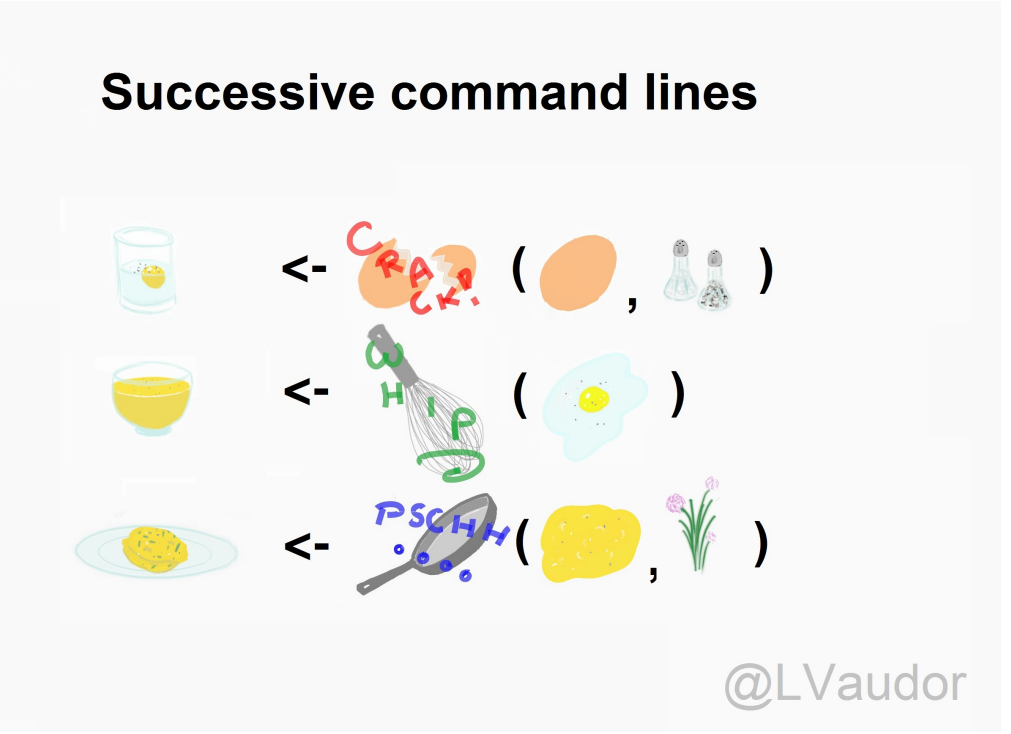
```
citations <- citations_raw %>%
  dplyr::rename(
    journal      = 'Journal identity',
    impactfactor = '5-year journal impact factor',
    pubyear      = 'Year published',
    colldate     = 'Collection date',
    pubdate      = 'Publication date',
    nbtweets     = 'Number of tweets',
    woscitations = 'Number of Web of Science citations') %>%
  dplyr::mutate(journal = as.factor(journal))
```

# Syntax with pipe

- Verb(Subject,Complement) replaced by Subject %>% Verb(Complement)
- No need to name unimportant intermediate variables
- Clear syntax (readability)

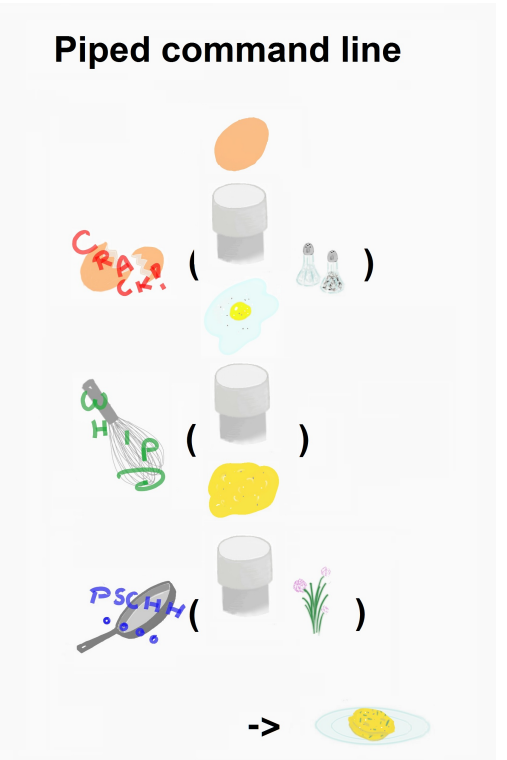
# Base R from Lise Vaudor's blog

```
white_and_yolk       <- crack(egg, add_seasoning)
omelette_batter      <- beat(white_and_yolk)
omelette_with_chives <- cook(omelette_batter,add_chives)
```



# Piping from Lise Vaudor's blog

```
egg %>%
  crack(add_seasoning) %>%
  beat() %>%
  cook(add_chives) -> omelette_with_chives
```



# Tidy, transform

# Select columns

```
citations %>%
  dplyr::select(journal, impactfactor, nbtweets)
```

```
## # A tibble: 1,599 x 3
##    journal         impactfactor nbtweets
##    <fct>                  <dbl>    <dbl>
##  1 Ecology Letters         16.7       18
##  2 Ecology Letters         16.7       15
##  3 Ecology Letters         16.7        5
##  4 Ecology Letters         16.7        9
##  5 Ecology Letters         16.7        3
##  6 Ecology Letters         16.7       27
##  7 Ecology Letters         16.7        6
##  8 Ecology Letters         16.7       19
##  9 Ecology Letters         16.7       26
## 10 Ecology Letters         16.7       44
## # … with 1,589 more rows
```

# Drop columns

```
citations %>%
  dplyr::select(-Volume, -Issue, -Authors)
```

```
## # A tibble: 1,599 x 9
##    journal impactfactor pubyear colldate pubdate nbtweets `Number of user…
##    <fct>          <dbl>   <dbl> <chr>    <chr>      <dbl>             <dbl>
##  1 Ecolog…         16.7    2014 2/1/2016 9/16/2…       18                16
##  2 Ecolog…         16.7    2014 2/1/2016 10/13/…       15                12
##  3 Ecolog…         16.7    2014 2/1/2016 10/21/…        5                 4
##  4 Ecolog…         16.7    2014 2/1/2016 8/28/2…        9                 8
##  5 Ecolog…         16.7    2014 2/1/2016 8/28/2…        3                 3
##  6 Ecolog…         16.7    2014 2/2/2016 7/28/2…       27                23
##  7 Ecolog…         16.7    2014 2/2/2016 8/6/20…        6                 6
##  8 Ecolog…         16.7    2014 2/2/2016 6/17/2…       19                18
##  9 Ecolog…         16.7    2014 2/2/2016 6/12/2…       26                23
## 10 Ecolog…         16.7    2014 2/2/2016 7/17/2…       44                42
## # … with 1,589 more rows, and 2 more variables: `Twitter reach` <dbl>,
## #   woscitations <dbl>
```

# Split a column in several columns

```
citations %>%
  tidyr::separate(pubdate, c('month', 'day', 'year'), sep = '/')
```

```
## # A tibble: 1,599 x 14
##    journal impactfactor pubyear Volume Issue Authors colldate month day   year
##    <fct>          <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr> <chr> <chr>
##  1 Ecolog…         16.7    2014     17 12    Morin … 2/1/2016 9     16    2014
##  2 Ecolog…         16.7    2014     17 12    Jucker… 2/1/2016 10    13    2014
##  3 Ecolog…         16.7    2014     17 12    Calcag… 2/1/2016 10    21    2014
##  4 Ecolog…         16.7    2014     17 11    Segre … 2/1/2016 8     28    2014
##  5 Ecolog…         16.7    2014     17 11    Kaufma… 2/1/2016 8     28    2014
##  6 Ecolog…         16.7    2014     17 10    Nasto … 2/2/2016 7     28    2014
##  7 Ecolog…         16.7    2014     17 10    Tschir… 2/2/2016 8     6     2014
##  8 Ecolog…         16.7    2014     17 9     Barnec… 2/2/2016 6     17    2014
##  9 Ecolog…         16.7    2014     17 9     Pinto-… 2/2/2016 6     12    2014
## 10 Ecolog…         16.7    2014     17 9     Clough… 2/2/2016 7     17    2014
## # … with 1,589 more rows, and 4 more variables: nbtweets <dbl>, `Number of
## #   users` <dbl>, `Twitter reach` <dbl>, woscitations <dbl>
```

# Transform in Date format...

```
citations %>%
  dplyr::mutate(
    pubdate  = lubridate::mdy(pubdate),
    colldate = lubridate::mdy(colldate))
```

```
## # A tibble: 1,599 x 12
##    journal impactfactor pubyear Volume Issue Authors colldate   pubdate
##    <fct>          <dbl>   <dbl>  <dbl> <chr> <chr>   <date>     <date>
##  1 Ecolog…         16.7    2014     17 12    Morin … 2016-02-01 2014-09-16
##  2 Ecolog…         16.7    2014     17 12    Jucker… 2016-02-01 2014-10-13
##  3 Ecolog…         16.7    2014     17 12    Calcag… 2016-02-01 2014-10-21
##  4 Ecolog…         16.7    2014     17 11    Segre … 2016-02-01 2014-08-28
##  5 Ecolog…         16.7    2014     17 11    Kaufma… 2016-02-01 2014-08-28
##  6 Ecolog…         16.7    2014     17 10    Nasto … 2016-02-02 2014-07-28
##  7 Ecolog…         16.7    2014     17 10    Tschir… 2016-02-02 2014-08-06
##  8 Ecolog…         16.7    2014     17 9     Barnec… 2016-02-02 2014-06-17
##  9 Ecolog…         16.7    2014     17 9     Pinto-… 2016-02-02 2014-06-12
## 10 Ecolog…         16.7    2014     17 9     Clough… 2016-02-02 2014-07-17
## # … with 1,589 more rows, and 4 more variables: nbtweets <dbl>, `Number of
## #   users` <dbl>, `Twitter reach` <dbl>, woscitations <dbl>
```

# ...for easy manipulation of dates

```
citations %>%
  dplyr::mutate(
    pubdate  = lubridate::mdy(pubdate),
    colldate = lubridate::mdy(colldate),
    pubyear2 = lubridate::year(pubdate))
```

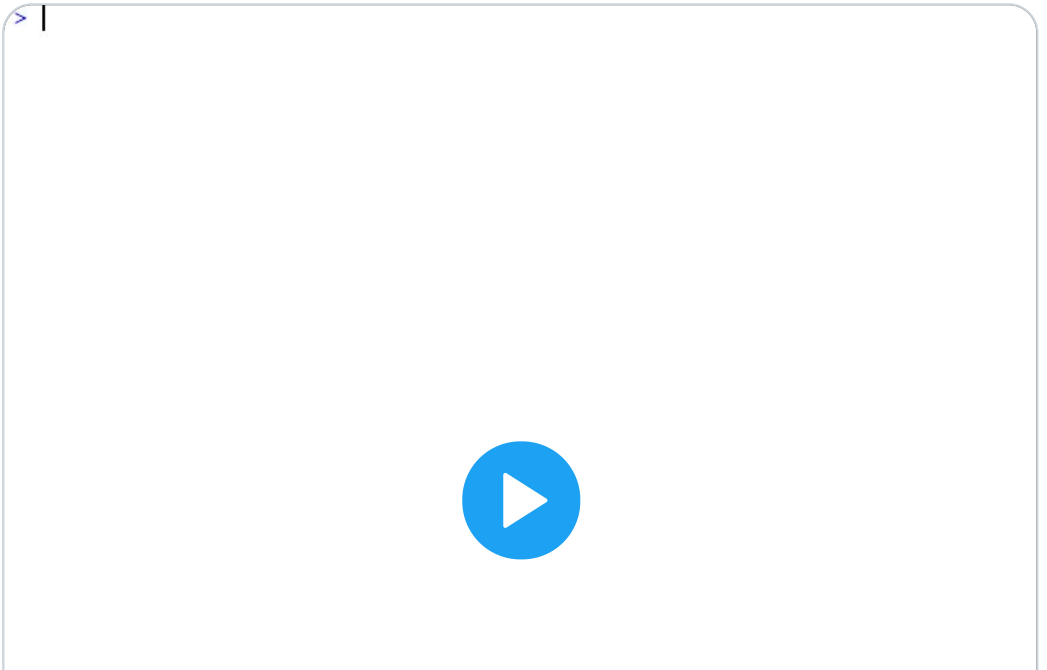
```
## # A tibble: 1,599 x 13
##    journal impactfactor pubyear Volume Issue Authors colldate   pubdate
##    <fct>          <dbl>   <dbl>  <dbl> <chr> <chr>   <date>     <date>
##  1 Ecolog…         16.7    2014     17 12    Morin … 2016-02-01 2014-09-16
##  2 Ecolog…         16.7    2014     17 12    Jucker… 2016-02-01 2014-10-13
##  3 Ecolog…         16.7    2014     17 12    Calcag… 2016-02-01 2014-10-21
##  4 Ecolog…         16.7    2014     17 11    Segre … 2016-02-01 2014-08-28
##  5 Ecolog…         16.7    2014     17 11    Kaufma… 2016-02-01 2014-08-28
##  6 Ecolog…         16.7    2014     17 10    Nasto … 2016-02-02 2014-07-28
##  7 Ecolog…         16.7    2014     17 10    Tschir… 2016-02-02 2014-08-06
##  8 Ecolog…         16.7    2014     17 9     Barnec… 2016-02-02 2014-06-17
##  9 Ecolog…         16.7    2014     17 9     Pinto-… 2016-02-02 2014-06-12
## 10 Ecolog…         16.7    2014     17 9     Clough… 2016-02-02 2014-07-17
## # … with 1,589 more rows, and 5 more variables: nbtweets <dbl>, `Number of
## #   users` <dbl>, `Twitter reach` <dbl>, woscitations <dbl>, pubyear2 <dbl>
```

- Check out `?lubridate::lubridate` for more functions

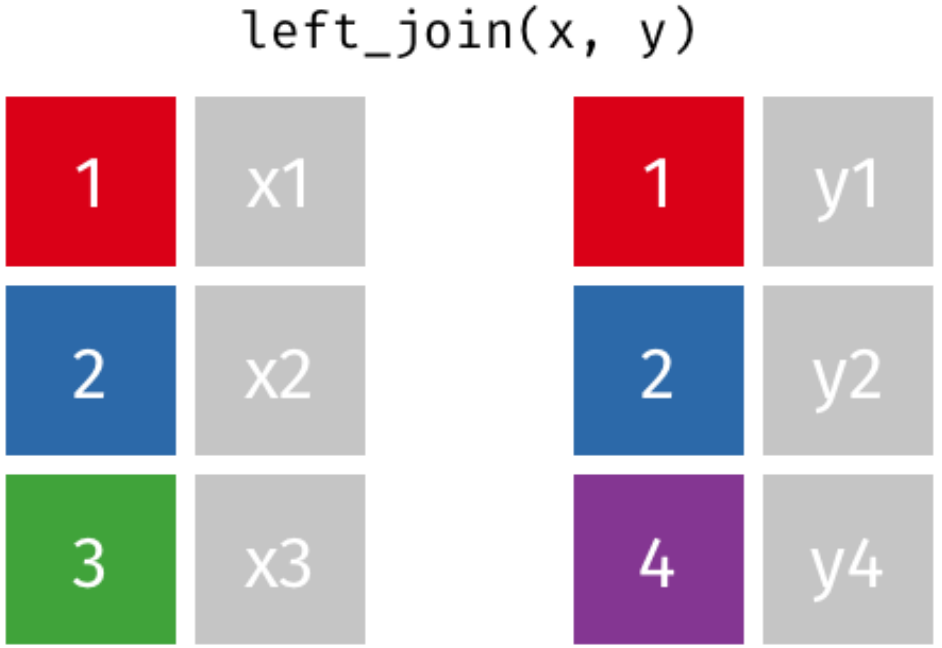
# How to join tables together?

**Nic Crane**
@nic_crane

More #dplyr 🔧 gifs! It took me a hella long time to wrap my head around the different types of joins when I first started learning them, so here's a few examples with some excellent mini datasets from #dplyr designed specifically for this purpose! #rstats #tidyverse



https://www.garrickadenbuie.com/project/tidyexplain/



# Easy character manipulation

# Select rows corresponding to papers with more than 3 authors

```
citations %>%
  dplyr::filter(stringr::str_detect(Authors, 'et al'))
```

```
## # A tibble: 1,280 x 12
##    journal impactfactor pubyear Volume Issue Authors colldate pubdate nbtweets
##    <fct>          <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>      <dbl>
##  1 Ecolog…         16.7    2014     17 12    Morin … 2/1/2016 9/16/2…       18
##  2 Ecolog…         16.7    2014     17 12    Jucker… 2/1/2016 10/13/…       15
##  3 Ecolog…         16.7    2014     17 12    Calcag… 2/1/2016 10/21/…        5
##  4 Ecolog…         16.7    2014     17 11    Segre … 2/1/2016 8/28/2…        9
##  5 Ecolog…         16.7    2014     17 11    Kaufma… 2/1/2016 8/28/2…        3
##  6 Ecolog…         16.7    2014     17 10    Nasto … 2/2/2016 7/28/2…       27
##  7 Ecolog…         16.7    2014     17 10    Tschir… 2/2/2016 8/6/20…        6
##  8 Ecolog…         16.7    2014     17 9     Barnec… 2/2/2016 6/17/2…       19
##  9 Ecolog…         16.7    2014     17 9     Pinto-… 2/2/2016 6/12/2…       26
## 10 Ecolog…         16.7    2014     17 9     Clough… 2/2/2016 7/17/2…       44
## # … with 1,270 more rows, and 3 more variables: `Number of users` <dbl>,
## #   `Twitter reach` <dbl>, woscitations <dbl>
```

# Get column with rows corresponding to papers with more than 3 authors

```
citations %>%
  dplyr::filter(stringr::str_detect(Authors, 'et al')) %>%
  dplyr::select(Authors)
```

```
## # A tibble: 1,280 x 1
##    Authors
##    <chr>
##  1 Morin et al
##  2 Jucker et al
##  3 Calcagno et al
##  4 Segre et al
##  5 Kaufman et al
##  6 Nasto et al
##  7 Tschirren et al
##  8 Barnechi et al
##  9 Pinto-Sanchez et al
## 10 Clough et al
## # … with 1,270 more rows
```

# Select rows corresponding to papers with less than 3 authors

```
citations %>%
  dplyr::filter(!stringr::str_detect(Authors, 'et al'))
```

```
## # A tibble: 319 x 12
##    journal impactfactor pubyear Volume Issue Authors colldate pubdate nbtweets
##    <fct>          <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>      <dbl>
##  1 Ecolog…         16.7    2014     17 6     Neutle… 2/15/20… 3/17/2…        8
##  2 Ecolog…         16.7    2014     17 5     Kellne… 2/15/20… 2/20/2…       18
##  3 Ecolog…         16.7    2014     17 4     Griffi… 2/15/20… 1/16/2…        4
##  4 Ecolog…         16.7    2014     17 3     Gremer… 2/15/20… 1/17/2…        4
##  5 Ecolog…         16.7    2014     17 2     Cavier… 2/15/20… 10/17/…       16
##  6 Ecolog…         16.7    2014     17 2     Haegma… 2/15/20… 12/5/2…        9
##  7 Ecolog…         16.7    2013     16 12    Kearney 2/15/20… 10/1/2…       13
##  8 Ecolog…         16.7    2013     16 9     Locey … 2/15/20… 7/15/2…       28
##  9 Ecolog…         16.7    2013     16 8     Quinte… 2/15/20… 6/26/2…      120
## 10 Ecolog…         16.7    2013     16 3     Lesser… 2/15/20… 12/22/…        9
## # … with 309 more rows, and 3 more variables: `Number of users` <dbl>, `Twitter
## #   reach` <dbl>, woscitations <dbl>
```

# Get column with rows corresponding to papers with less than 3 authors

```
citations %>%
  dplyr::filter(!stringr::str_detect(Authors, 'et al')) %>%
  dplyr::select(Authors)
```

```
## # A tibble: 319 x 1
##    Authors
##    <chr>
##  1 Neutle and Thorne
##  2 Kellner and Asner
##  3 Griffin and Willi
##  4 Gremer and Venable
##  5 Cavieres
##  6 Haegman and Loreau
##  7 Kearney
##  8 Locey and White
##  9 Quintero and Weins
## 10 Lesser and Jackson
## # … with 309 more rows
```

# Get column with rows corresponding to papers with less than 3 authors

```
citations %>%
  dplyr::filter(!stringr::str_detect(Authors, 'et al')) %>%
  dplyr::pull(Authors) %>%
  head(10)
```

```
##  [1] "Neutle and Thorne"  "Kellner and Asner"  "Griffin and Willi"
##  [4] "Gremer and Venable" "Cavieres"           "Haegman and Loreau"
##  [7] "Kearney"            "Locey and White"    "Quintero and Weins"
## [10] "Lesser and Jackson"
```

# Select rows corresponding to papers with less than 3 authors in journal with IF < 5

```
citations %>%
  dplyr::filter(!stringr::str_detect(Authors, 'et al'), impactfactor < 5)
```

```
## # A tibble: 77 x 12
##    journal impactfactor pubyear Volume Issue Authors colldate pubdate nbtweets
##    <fct>          <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>      <dbl>
##  1 Molecu…          4.9    2014     14 6     Gautier 2/27/20… 5/14/2…        2
##  2 Molecu…          4.9    2014     14 5     Gambel… 2/27/20… 3/7/20…        7
##  3 Molecu…          4.9    2014     14 4     Kekkon… 2/27/20… 3/10/2…        4
##  4 Molecu…          4.9    2014     14 3     Bhatta… 2/27/20… 12/8/2…        0
##  5 Molecu…          4.9    2014     14 1     Christ… 2/28/20… 10/25/…        0
##  6 Molecu…          4.9    2013     13 4     Villar… 2/28/20… 5/2/20…        0
##  7 Molecu…          4.9    2013     13 4     Wang    2/28/20… 4/25/2…        0
##  8 Molecu…          4.9    2012     12 1     Joly    2/28/20… 9/7/20…        3
##  9 Animal…          3.21   2014     17 6     Plavsic 2/9/2016 4/17/2…        9
## 10 Animal…          3.21   2014     17 Supp… Knox a… 2/11/20… 11/13/…        1
## # … with 67 more rows, and 3 more variables: `Number of users` <dbl>, `Twitter
## #   reach` <dbl>, woscitations <dbl>
```

# Convert words to lowercase

```
citations %>%
  dplyr::mutate(authors_lowercase = stringr::str_to_lower(Authors)) %>%
  dplyr::select(authors_lowercase)
```

```
## # A tibble: 1,599 x 1
##    authors_lowercase
##    <chr>
##  1 morin et al
##  2 jucker et al
##  3 calcagno et al
##  4 segre et al
##  5 kaufman et al
##  6 nasto et al
##  7 tschirren et al
##  8 barnechi et al
##  9 pinto-sanchez et al
## 10 clough et al
## # … with 1,589 more rows
```

# Remove all spaces in journal names

```
citations %>%
  dplyr::mutate(journal = stringr::str_remove_all(journal, " ")) %>%
  dplyr::select(journal) %>%
  unique() %>%
  head(5)
```

```
## # A tibble: 5 x 1
##   journal
##   <chr>
## 1 EcologyLetters
## 2 GlobalChangeBiology
## 3 GlobalEcologyandBiogeography
## 4 MolecularEcologyResources
## 5 DiversityandDistributions
```

# Explore  stringr and regular expressions

- Check out the vignette on stringr for more examples on character manipulation and pattern matching functions.
- Check out the vignette on regular expressions which are a concise and flexible tool for describing patterns in strings.

# Basic exploratory data analysis

# Count

```
citations %>% dplyr::count(journal, sort = TRUE)
```

```
## # A tibble: 20 x 2
##    journal                                n
##    <fct>                              <int>
##  1 New Phytologist                      144
##  2 Ecology                              108
##  3 Evolution                            108
##  4 Global Change Biology                108
##  5 Global Ecology and Biogeography      108
##  6 Journal of Biogeography              108
##  7 Ecology Letters                      106
##  8 Diversity and Distributions          105
##  9 Animal Conservation                  102
## 10 Methods in Ecology and Evolution      90
## 11 Evolutionary Applications             74
## 12 Functional Ecology                    54
## 13 Journal of Animal Ecology             54
## 14 Journal of Applied Ecology            54
## 15 Limnology and Oceanography            54
## 16 Molecular Ecology Resources           54
## 17 Conservation Letters                  53
## 18 Ecological Applications               48
## 19 Fish and Fisheries                    36
## 20 Mammal Review                         31
```

# Count

```
citations %>%
  dplyr::count(journal, pubyear) %>%
  head()
```

```
## # A tibble: 6 x 3
##   journal               pubyear     n
##   <fct>                   <dbl> <int>
## 1 Animal Conservation      2012    18
## 2 Animal Conservation      2013    18
## 3 Animal Conservation      2014    66
## 4 Conservation Letters     2012    17
## 5 Conservation Letters     2013    18
## 6 Conservation Letters     2014    18
```

# Count sum of tweets per journal

```
citations %>%
  dplyr::count(journal, wt = nbtweets, sort = TRUE)
```

```
## # A tibble: 20 x 2
##    journal                                n
##    <fct>                              <dbl>
##  1 Ecology Letters                     1538
##  2 Animal Conservation                 1268
##  3 Journal of Applied Ecology          1012
##  4 Methods in Ecology and Evolution     699
##  5 Global Change Biology                613
##  6 Conservation Letters                 542
##  7 New Phytologist                      509
##  8 Global Ecology and Biogeography      379
##  9 Ecology                              335
## 10 Evolution                            335
## 11 Journal of Animal Ecology            323
## 12 Fish and Fisheries                   261
## 13 Evolutionary Applications            238
## 14 Journal of Biogeography              209
## 15 Diversity and Distributions          200
## 16 Mammal Review                        166
## 17 Functional Ecology                   155
## 18 Molecular Ecology Resources          139
## 19 Ecological Applications              125
## 20 Limnology and Oceanography             0
```

# Group by variable to calculate stats

```
citations %>%
  dplyr::group_by(journal) %>%
  dplyr::summarise(avg_tweets = mean(nbtweets)) %>%
  head(10)
```

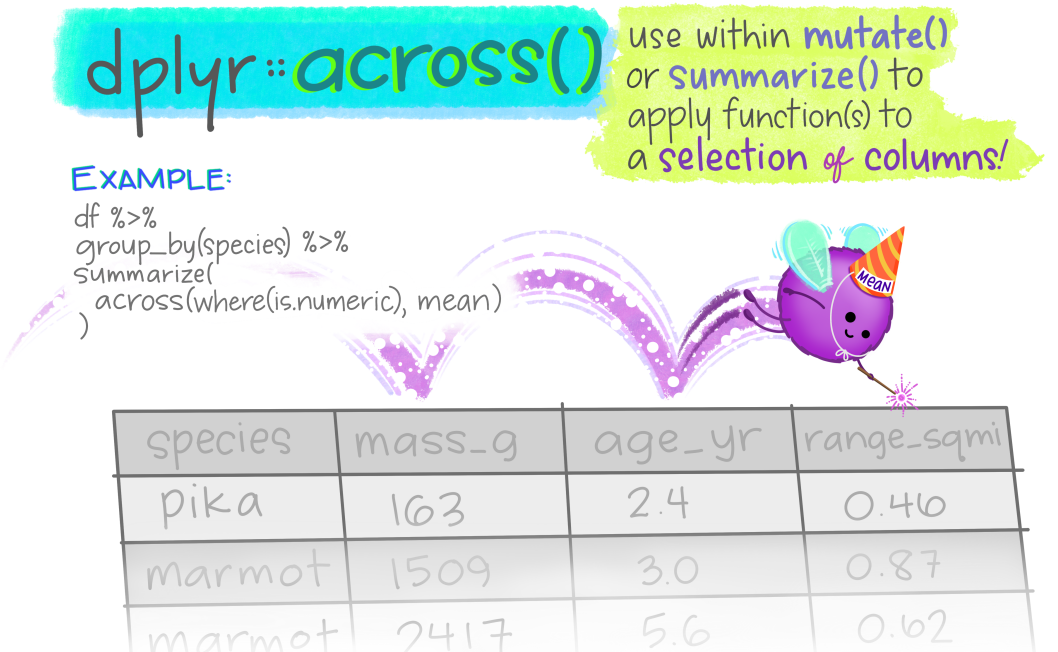
```
## # A tibble: 10 x 2
##    journal                      avg_tweets
##    <fct>                             <dbl>
##  1 Animal Conservation               12.4
##  2 Conservation Letters              10.2
##  3 Diversity and Distributions        1.90
##  4 Ecological Applications            2.60
##  5 Ecology                            3.10
##  6 Ecology Letters                   14.5
##  7 Evolution                          3.10
##  8 Evolutionary Applications          3.22
##  9 Fish and Fisheries                 7.25
## 10 Functional Ecology                 2.87
```

# Order stuff

```
citations %>%
  dplyr::group_by(journal) %>%
  dplyr::summarise(avg_tweets = mean(nbtweets)) %>%
  dplyr::arrange(dplyr::desc(avg_tweets)) %>% # decreasing order (wo desc for in
  head(10)
```

```
## # A tibble: 10 x 2
##    journal                           avg_tweets
##    <fct>                                  <dbl>
##  1 Journal of Applied Ecology              18.7
##  2 Ecology Letters                         14.5
##  3 Animal Conservation                     12.4
##  4 Conservation Letters                    10.2
##  5 Methods in Ecology and Evolution         7.77
##  6 Fish and Fisheries                       7.25
##  7 Journal of Animal Ecology                5.98
##  8 Global Change Biology                    5.68
##  9 Mammal Review                            5.35
## 10 New Phytologist                          3.53
```

# What if we want to work on several columns?

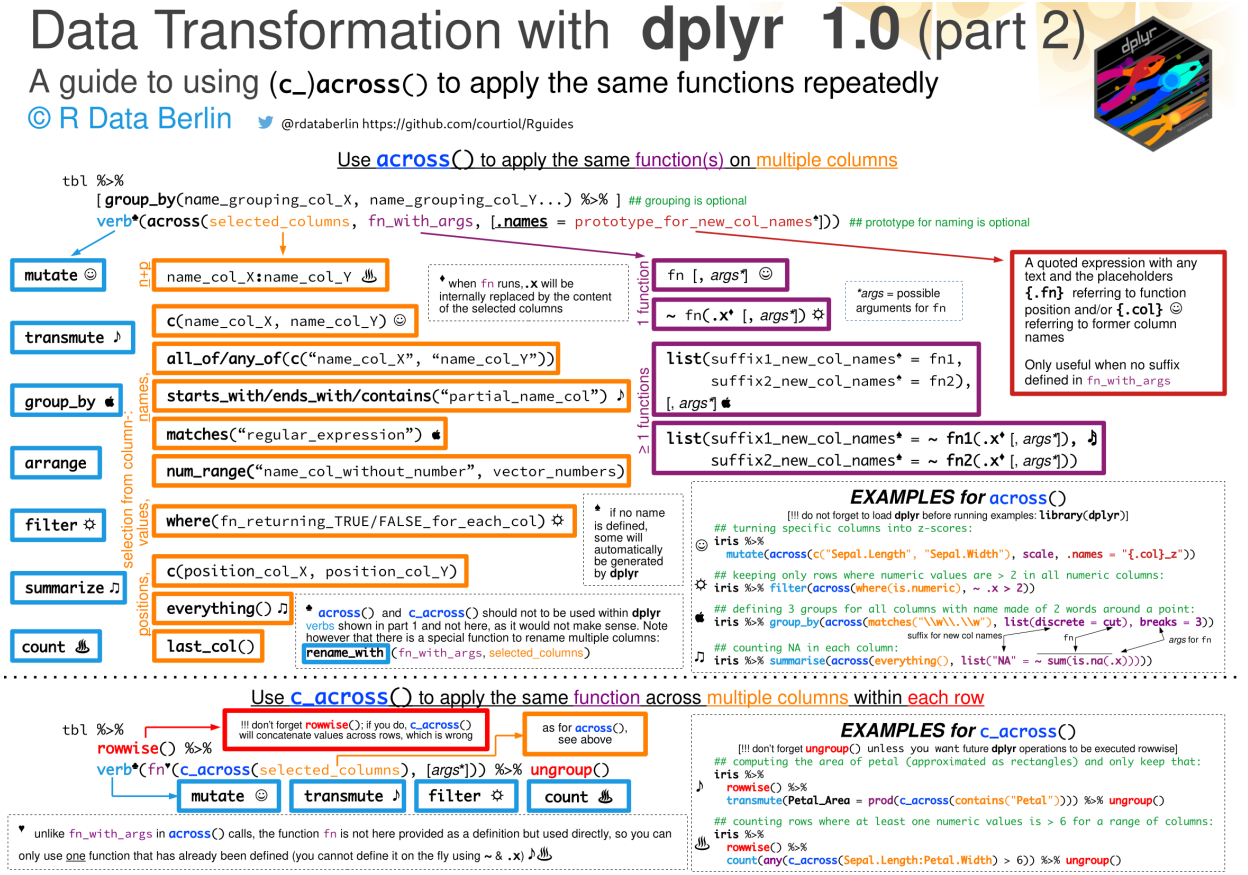


# Compute mean across all numeric columns for each journal

```
citations %>%
  dplyr::group_by(journal) %>%
  dplyr::summarize(dplyr::across(where(is.numeric), mean)) %>%
  head()
```

```
## # A tibble: 6 x 8
##   journal impactfactor pubyear Volume nbtweets `Number of user… `Twitter reach`
##   <fct>          <dbl>   <dbl>  <dbl>    <dbl>             <dbl>           <dbl>
## 1 Animal…         3.21   2013.  16.5     12.4               9.71           28345.
## 2 Conser…         6.4    2013.   6.02    10.2               8.85           23234.
## 3 Divers…         5.4    2013   19        1.90              1.77            2350.
## 4 Ecolog…         5.06   2013   23        2.60              2.5             5727.
## 5 Ecology         6.16   2013   94        3.10              2.87            6176.
## 6 Ecolog…        16.7    2013.  16.0     14.5              14.0            44748.
## # … with 1 more variable: woscitations <dbl>
```

# https://github.com/courtiol/Rguides



# Tidying tibbles

`wide`

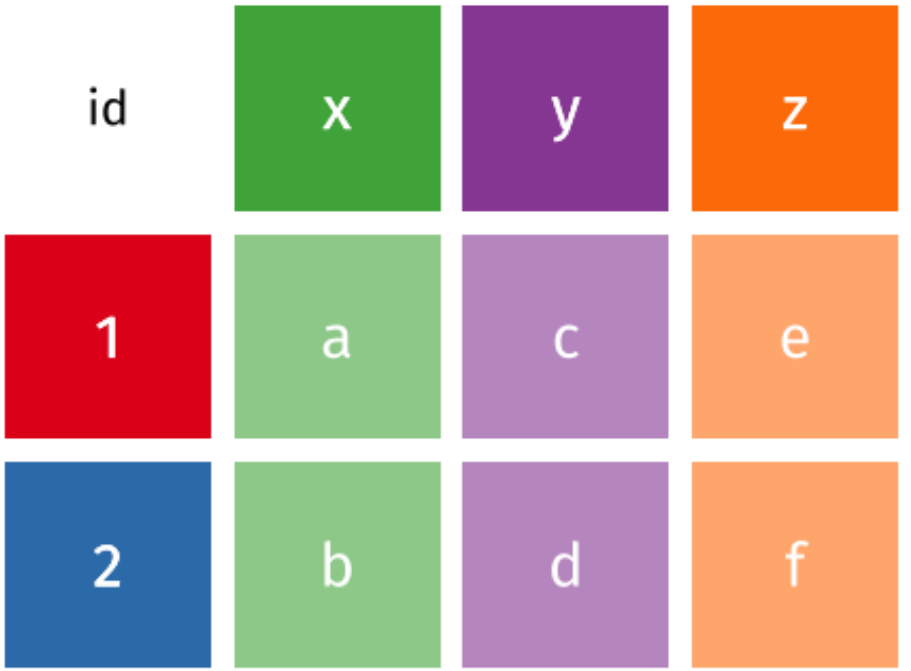
| id | x | y | z |
|---|---|---|---|
| 1 | a | c | e |
| 2 | b | d | f |

`long`

| id | key | val |
|---|---|---|
| 1 | x | a |
| 2 | x | b |
| 1 | y | c |
| 2 | y | d |
| 1 | z | e |
| 2 | z | f |

# Going from long to wide format and vice-versa

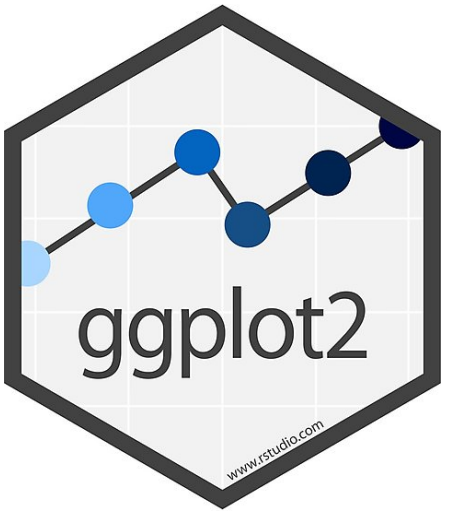
wide



# Visualize

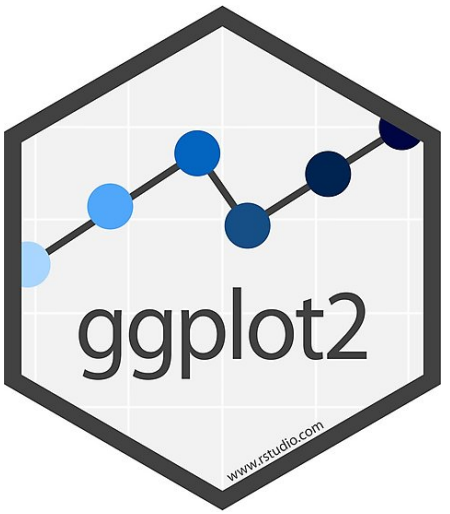
# Visualization with ggplot2

- The package ggplot2 implements a **g**rammar of **g**raphics
- Operates on data.frames or tibbles, not vectors like base R
- Explicitly differentiates between the data and its representation



# The ggplot2 grammar

| Grammar element | What it is |
|---|---|
| **Data** | The data frame being plotted |
| **Geometrics** | The geometric shape that will represent the data (e.g., point, boxplot, histogram) |
| **Aesthetics** | The aesthetics of the geometric object (e.g., color, size, shape) |



# Scatterplots

```
citations %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_point()
```

- Pass in the data frame as your first argument

# Scatterplots

```
citations %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_point()
```

- Pass in the data frame as your first argument
- Aesthetics maps the data onto plot characteristics, here x and y axes

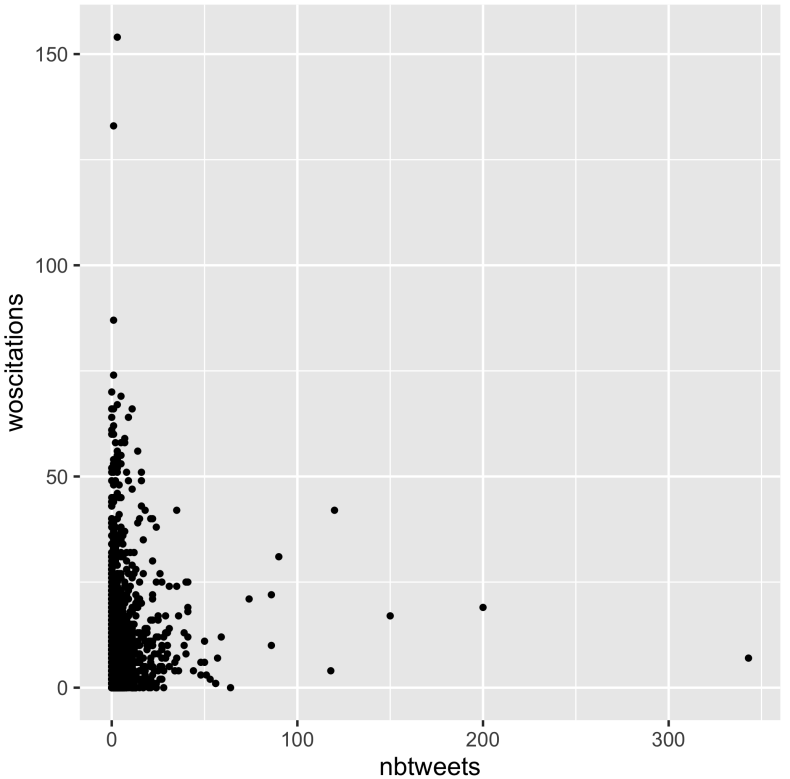
# Scatterplots

```
citations %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_point()
```

- Pass in the data frame as your first argument
- Aesthetics maps the data onto plot characteristics, here x and y axes
- Display the data geometrically as points

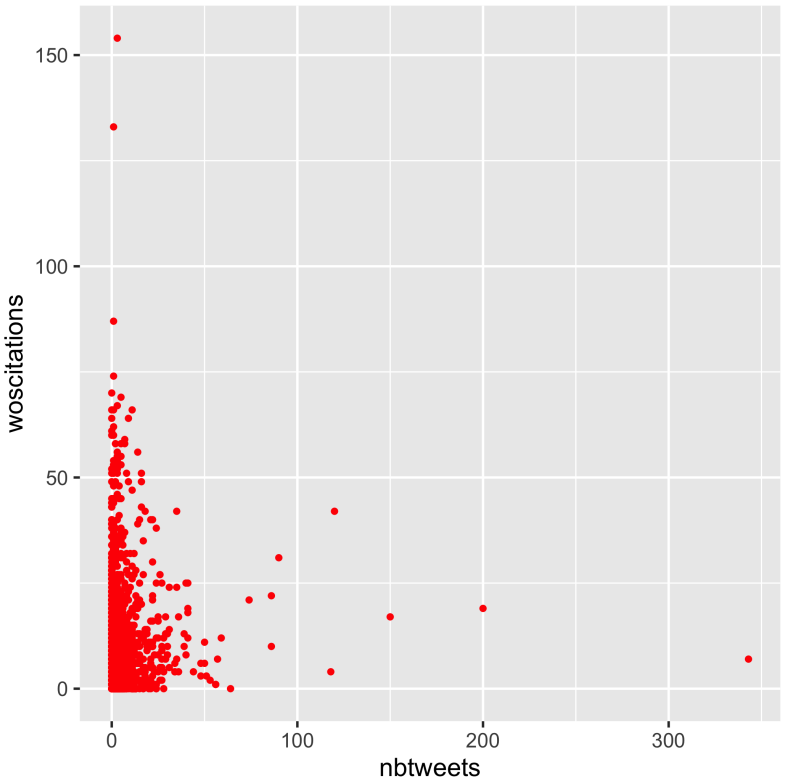
# Scatterplots

```
citations %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_point()
```



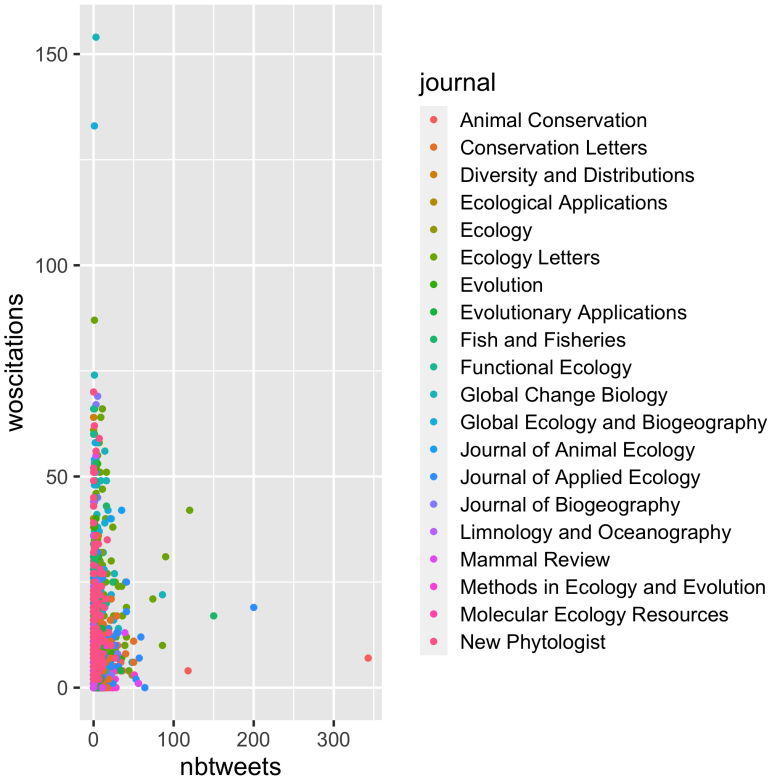
# Scatterplots, with colors

```
citations %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_point(color = "red")
```



# Scatterplots, with species-specific colors

```
citations %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations, color = journal) +
  geom_point()
```



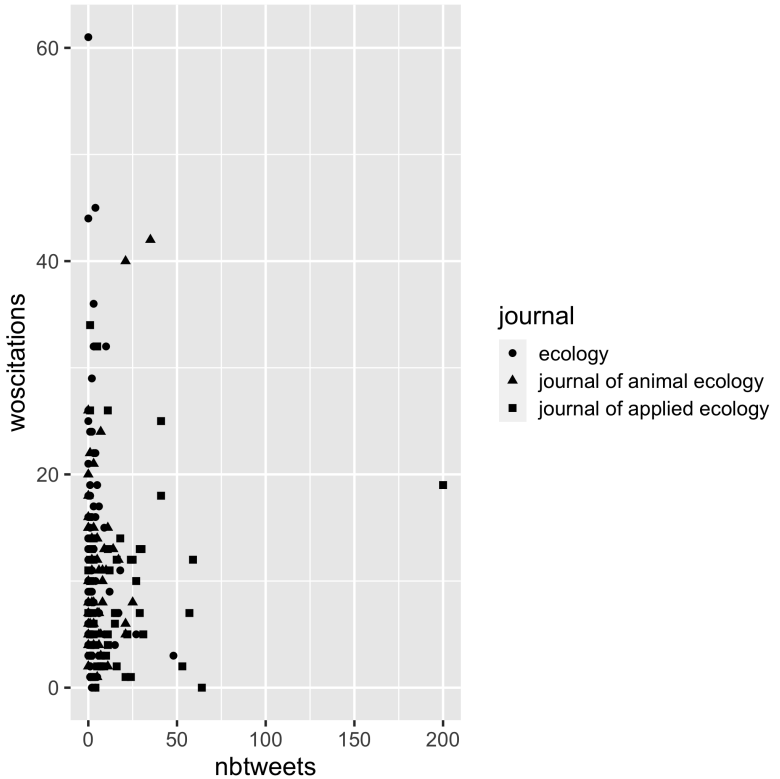
# Pick a few journals

```
citations_ecology <- citations %>%
  mutate(journal = str_to_lower(journal)) %>% # all journals names lowercase
  filter(journal %in%
           c('journal of animal ecology','journal of applied ecology','ecology')
citations_ecology
```

```
## # A tibble: 216 x 12
##    journal impactfactor pubyear Volume Issue Authors colldate pubdate nbtweets
##    <chr>          <dbl>   <dbl>  <dbl> <chr> <chr>   <chr>    <chr>      <dbl>
##  1 ecology         6.16    2014     95 12    Maglia… 3/19/20… 12/1/2…        1
##  2 ecology         6.16    2014     95 12    Soinen  3/19/20… 12/1/2…        6
##  3 ecology         6.16    2014     95 12    Graham… 3/19/20… 12/1/2…        1
##  4 ecology         6.16    2014     95 11    White … 3/19/20… 11/1/2…        9
##  5 ecology         6.16    2014     95 11    Einars… 3/19/20… 11/1/2…       15
##  6 ecology         6.16    2014     95 11    Haav a… 3/19/20… 11/1/2…        2
##  7 ecology         6.16    2014     95 10    Dodds … 3/19/20… 10/1/2…        1
##  8 ecology         6.16    2014     95 10    Brown … 3/19/20… 10/1/2…        1
##  9 ecology         6.16    2014     95 10    Wright… 3/19/20… 10/1/2…        0
## 10 ecology         6.16    2014     95 9     Ramahl… 3/19/20… 9/1/20…       27
## # … with 206 more rows, and 3 more variables: `Number of users` <dbl>, `Twitter
## #   reach` <dbl>, woscitations <dbl>
```

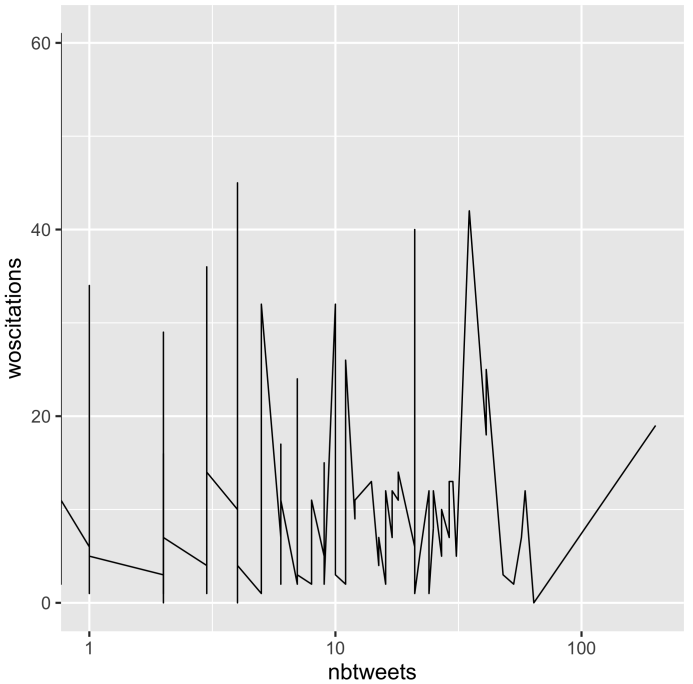
# Scatterplots, with species-specific shapes

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations, shape = journal) +
  geom_point(size=2)
```



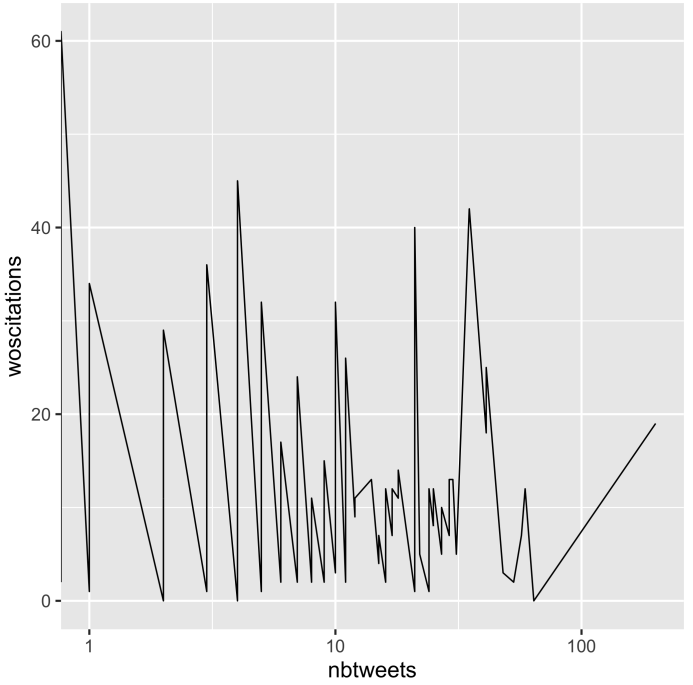
# Scatterplots, lines instead of points

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_line() +
  scale_x_log10()
```



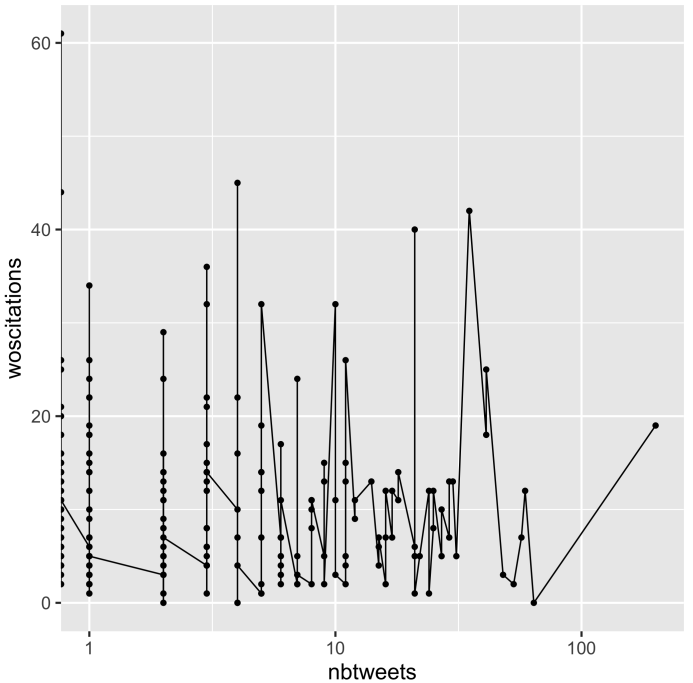
# Scatterplots, lines with sorting beforehand

```
citations_ecology %>%
  arrange(woscitations) %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_line() +
  scale_x_log10()
```



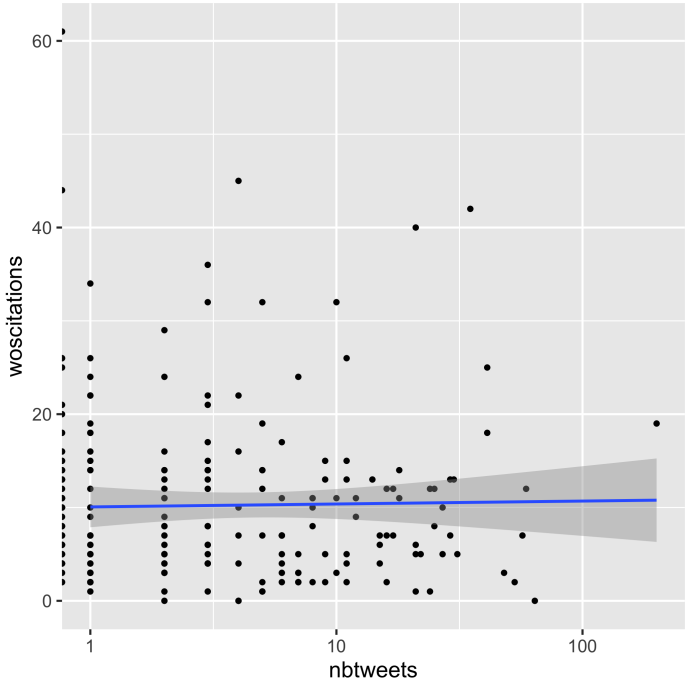
# Scatterplots, add points

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_line() +
  geom_point() +
  scale_x_log10()
```



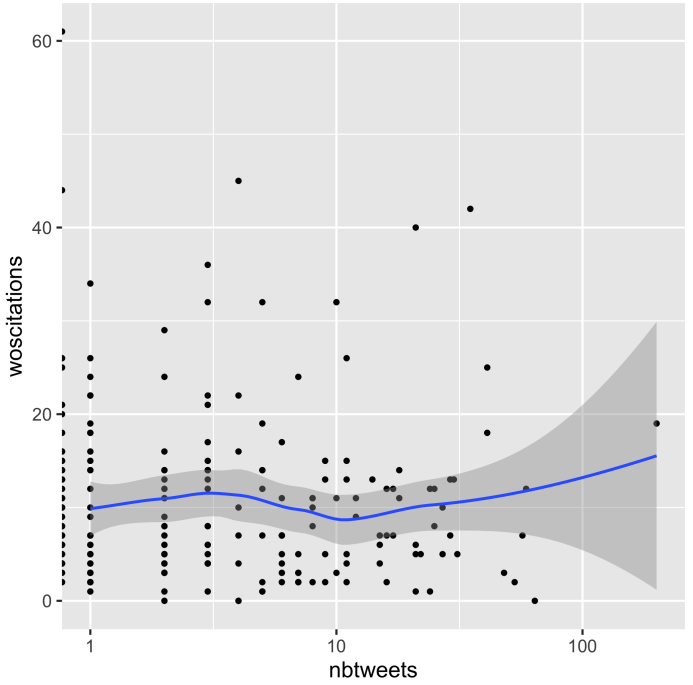
# Scatterplots, add linear trend

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_point() +
  geom_smooth(method = "lm") +
  scale_x_log10()
```



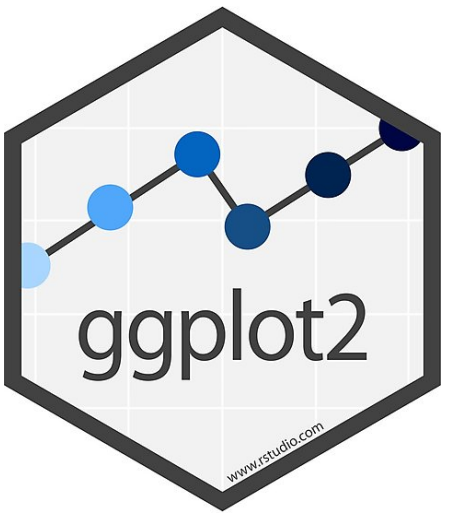
# Scatterplots, add smoother

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, y = woscitations) +
  geom_point() +
  geom_smooth() +
  scale_x_log10()
```



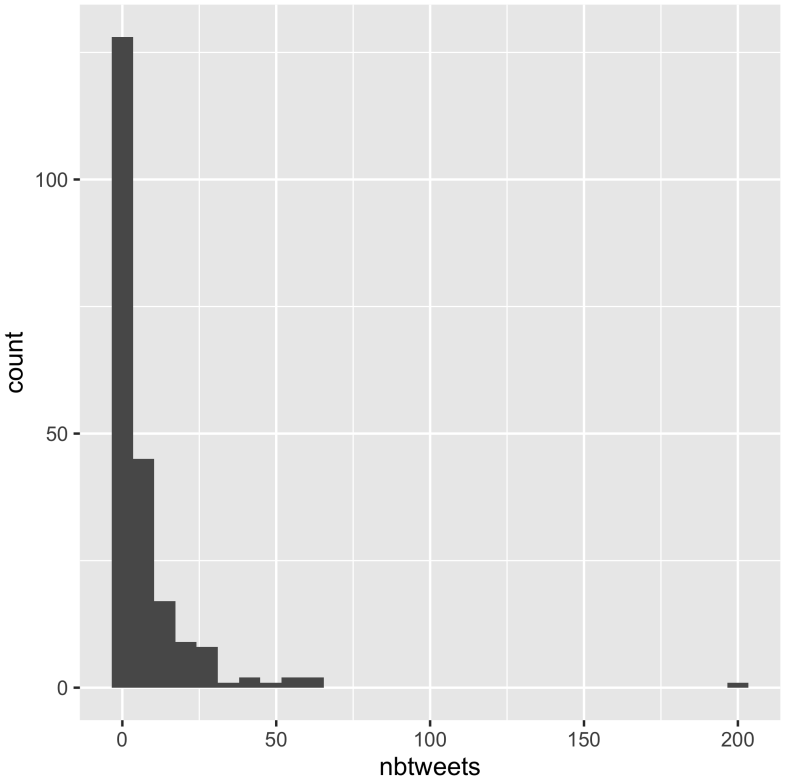
# aes or not aes?

- If we are to establish a link between the values of a variable and a graphical feature, ie a mapping, then we need an aes().
- Otherwise, the graphical feature is modified irrespective of the data, then we do not need an aes().



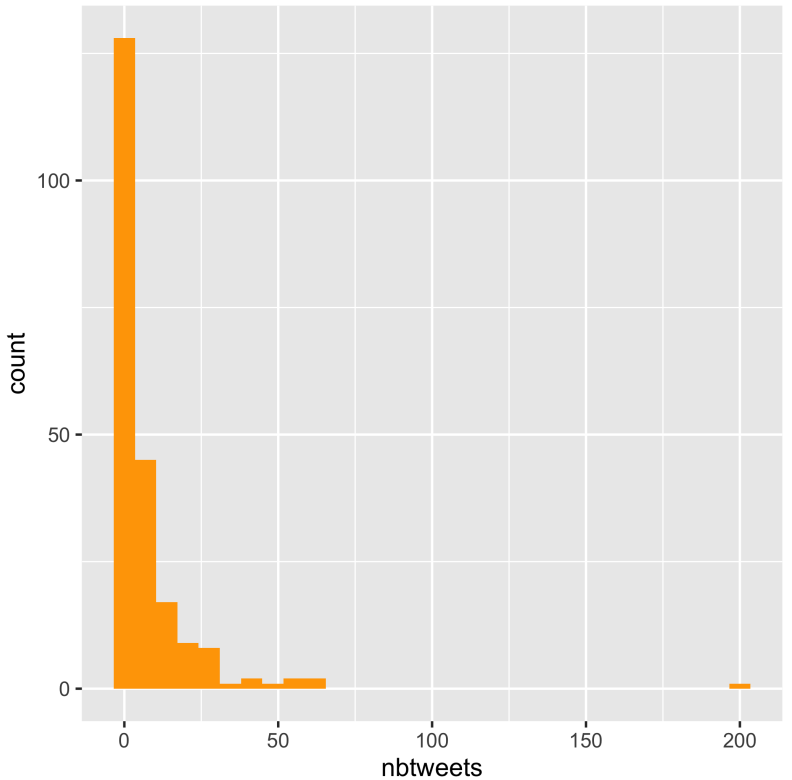
# Histograms

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets) +
  geom_histogram()
```



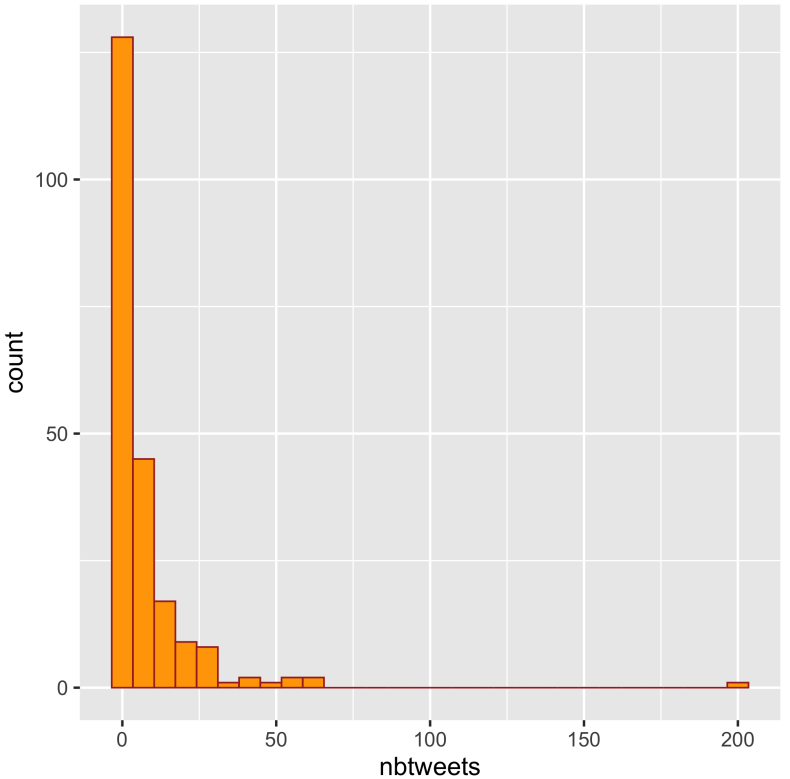
# Histograms, with colors

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets) +
  geom_histogram(fill = "orange")
```



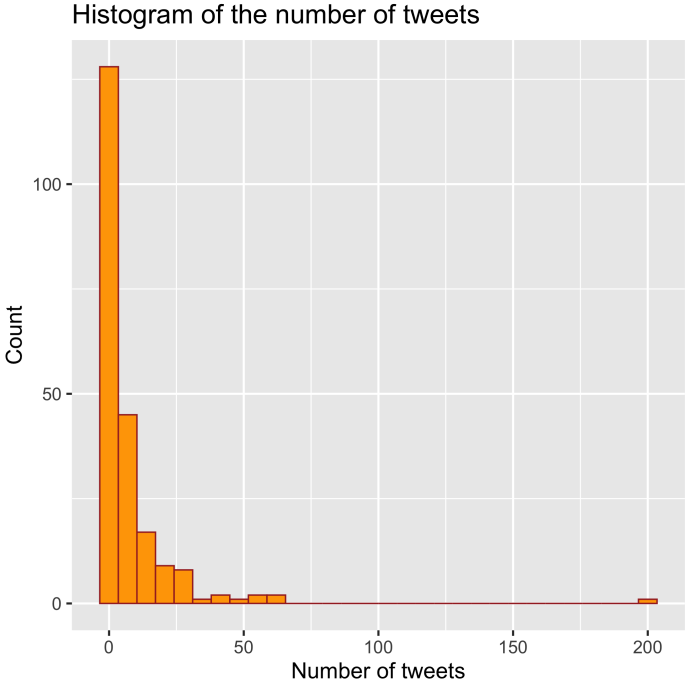
# Histograms, with colors

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets) +
  geom_histogram(fill = "orange", color = "brown")
```



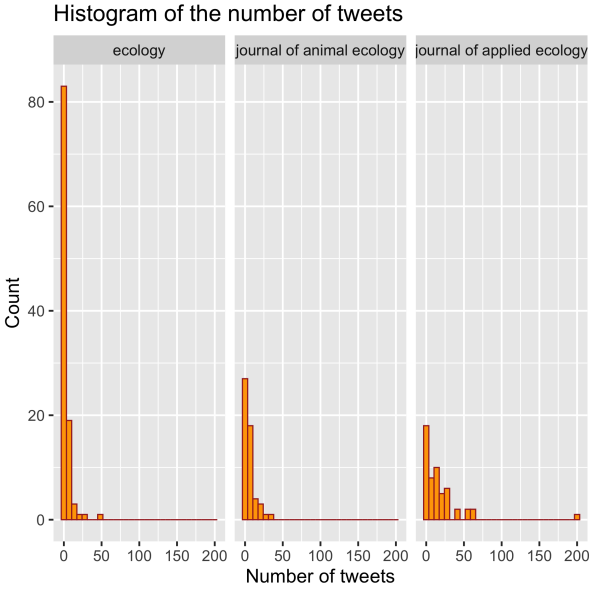
# Histograms, with labels and title

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets) +
  geom_histogram(fill = "orange", color = "brown") +
  labs(x = "Number of tweets",
       y = "Count",
       title = "Histogram of the number of tweets")
```



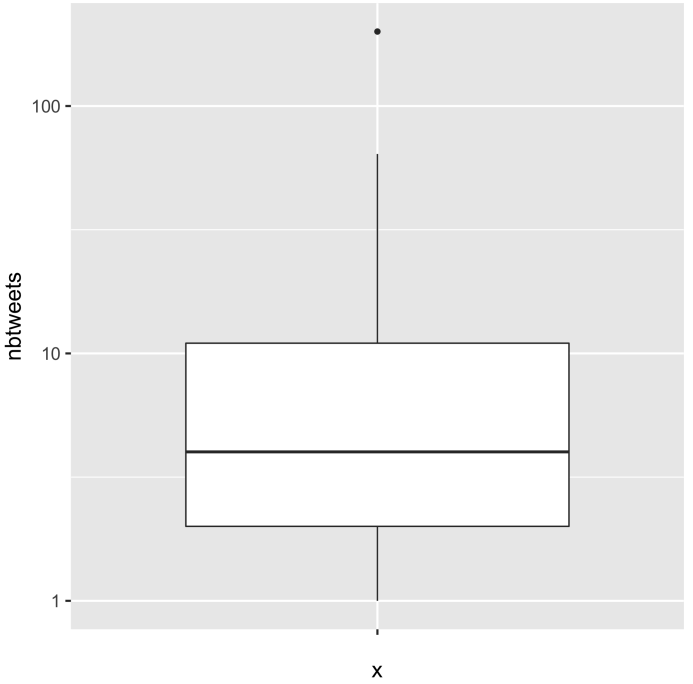
# Histograms, by species

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets) +
  geom_histogram(fill = "orange", color = "brown") +
  labs(x = "Number of tweets",
       y = "Count",
       title = "Histogram of the number of tweets") +
  facet_wrap(vars(journal))
```



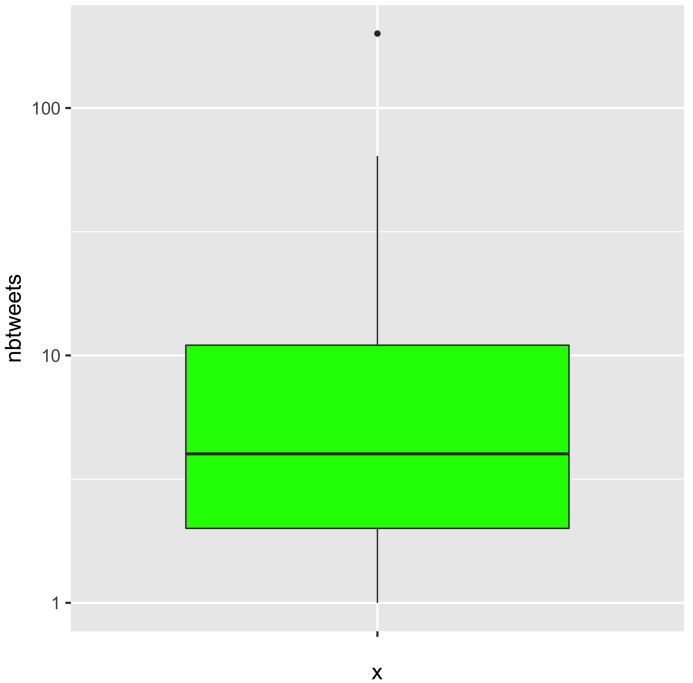
# Boxplots

```
citations_ecology %>%
  ggplot() +
  aes(x = "", y = nbtweets) +
  geom_boxplot() +
  scale_y_log10()
```



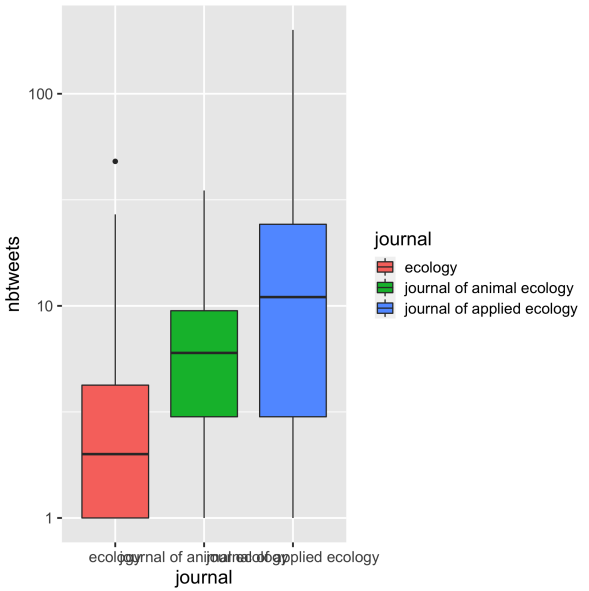
# Boxplots with colors

```
citations_ecology %>%
  ggplot() +
  aes(x = "", y = nbtweets) +
  geom_boxplot(fill = "green") +
  scale_y_log10()
```



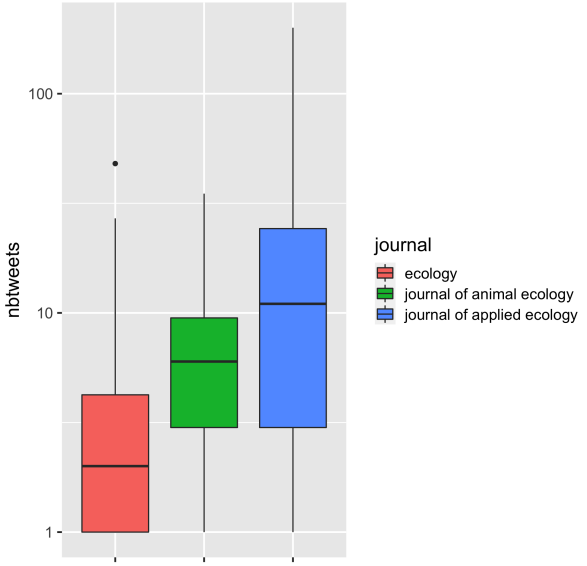
# Boxplots with colors by species

```
citations_ecology %>%
  ggplot() +
  aes(x = journal, y = nbtweets, fill = journal) +
  geom_boxplot() +
  scale_y_log10()
```



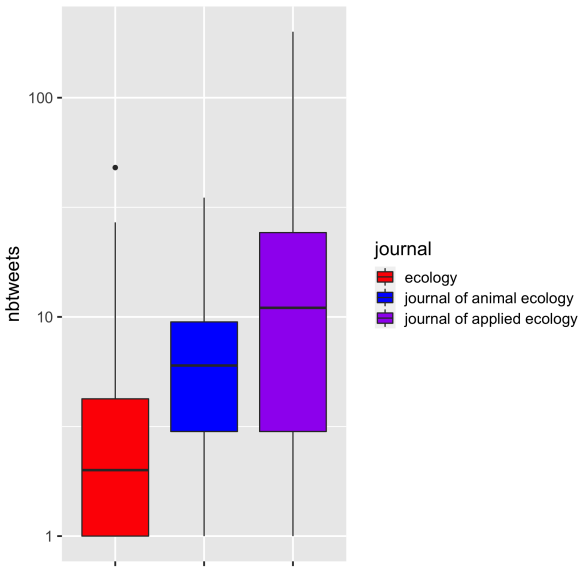
# Get rid of the ticks on x axis

```
citations_ecology %>%
  ggplot() +
  aes(x = journal, y = nbtweets, fill = journal) +
  geom_boxplot() +
  scale_y_log10() +
  theme(axis.text.x = element_blank()) +
  labs(x = "")
```



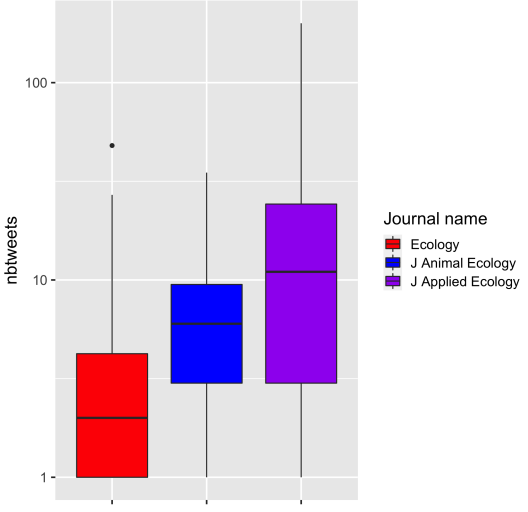
# Boxplots, user-specified colors by species

```
citations_ecology %>%
  ggplot() +
  aes(x = journal, y = nbtweets, fill = journal) +
  geom_boxplot() +
  scale_y_log10() +
  scale_fill_manual(
    values = c("red", "blue", "purple")) +
  theme(axis.text.x = element_blank()) +
  labs(x = "")
```



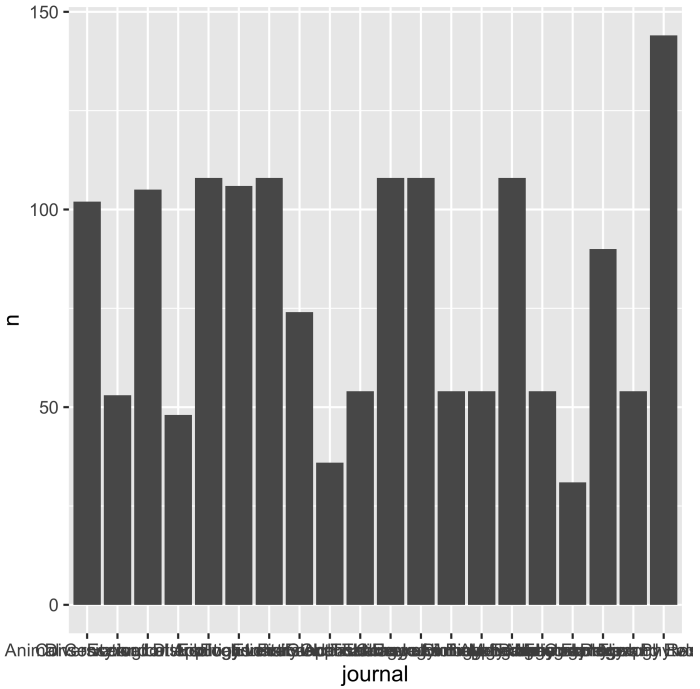
# Boxplots, change legend settings

```
citations_ecology %>%
  ggplot() +
  aes(x = journal, y = nbtweets, fill = journal) +
  geom_boxplot() +
  scale_y_log10() +
  scale_fill_manual(
    values = c("red", "blue", "purple"),
    name = "Journal name",
    labels = c("Ecology", "J Animal Ecology", "J Applied Ecology")) +
  theme(axis.text.x = element_blank()) +
  labs(x = "")
```



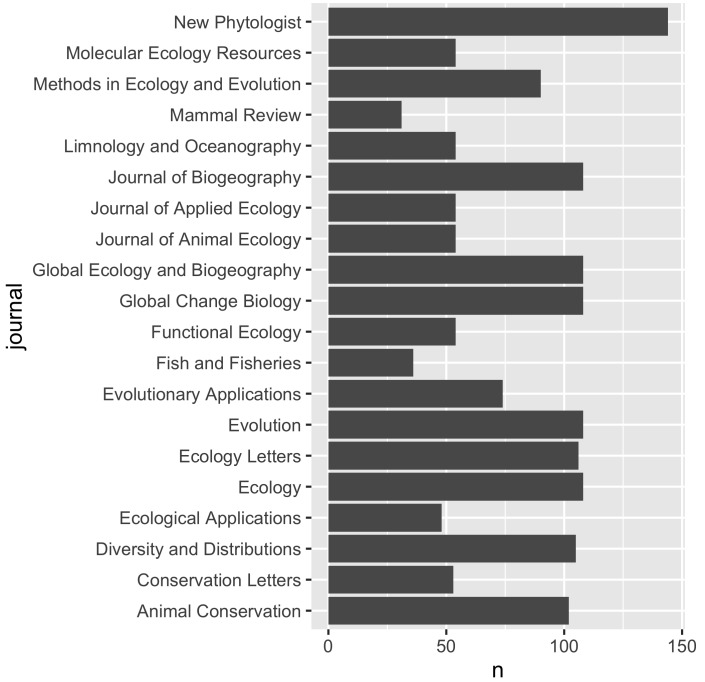
# Ugly bar plots

```
citations %>%
  count(journal) %>%
  ggplot() +
  aes(x = journal, y = n) +
  geom_col()
```



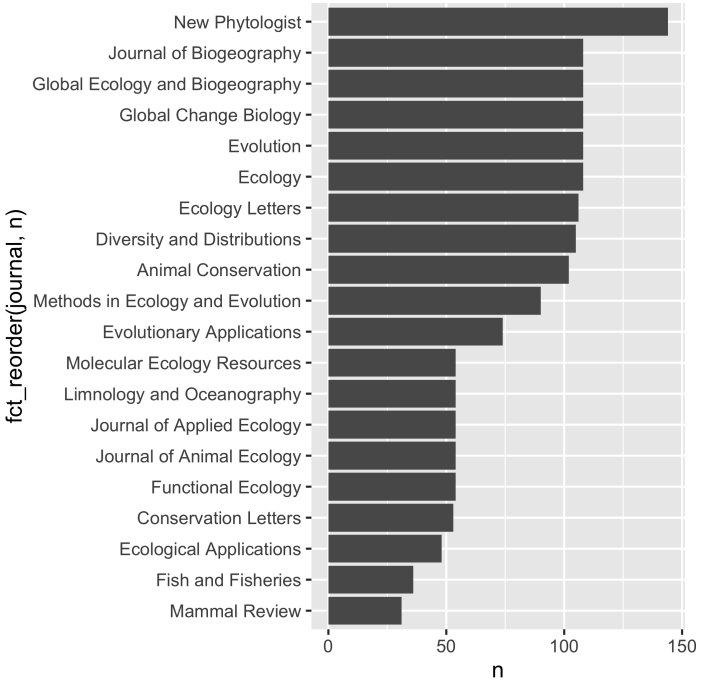
# Idem, with flipping

```
citations %>%
  count(journal) %>%
  ggplot() +
  aes(x = n, y = journal) +
  geom_col()
```



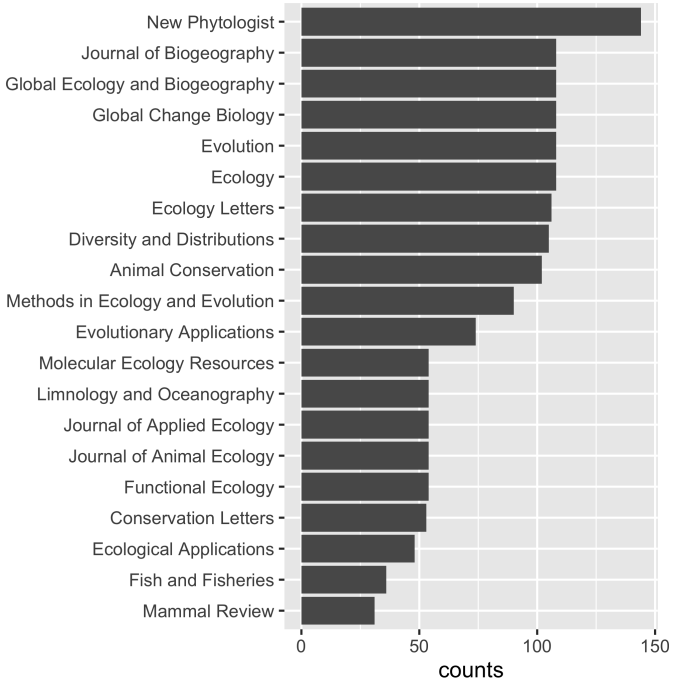
# Idem, with factors reordering and flipping

```
citations %>%
  count(journal) %>%
  ggplot() +
  aes(x = n, y = fct_reorder(journal, n)) +
  geom_col()
```



# Further cleaning

```
citations %>%
  count(journal) %>%
  ggplot() +
  aes(x = n, y = fct_reorder(journal, n)) +
  geom_col() +
  labs(x = "counts", y = "")
```

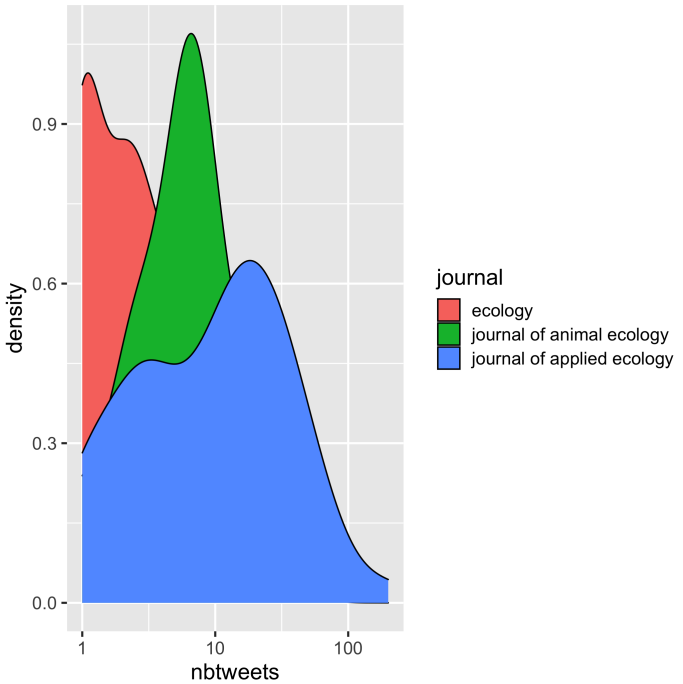


# More about how to (tidy) work with factors

- Be the boss of your factors and
- forcats, forcats, vous avez dit forcats ?.

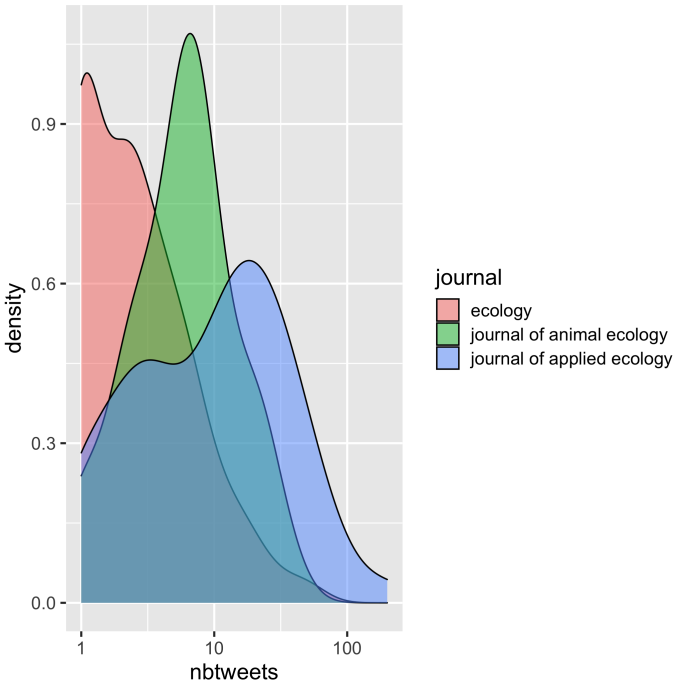
# Density plots

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, fill = journal) +
  geom_density() +
  scale_x_log10()
```



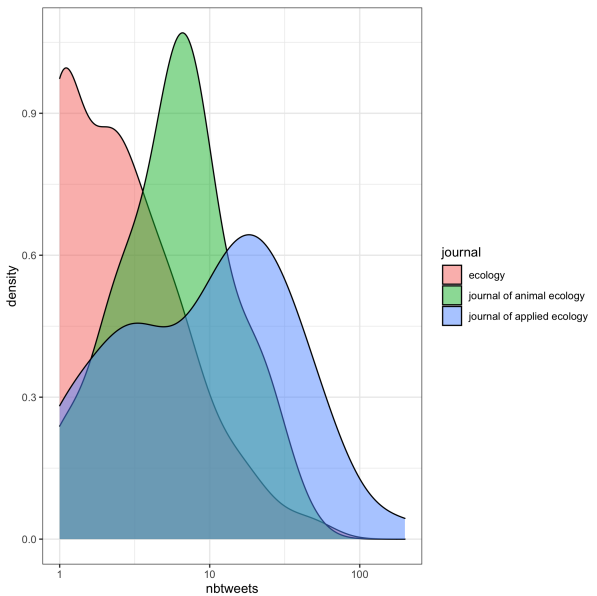
# Density plots, control transparency

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, fill = journal) +
  geom_density(alpha = 0.5) +
  scale_x_log10()
```



# Change default background B & W theme

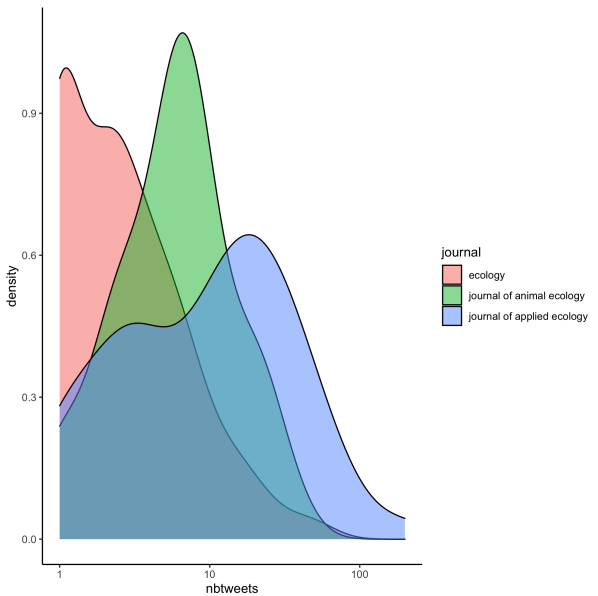
```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, fill = journal) +
  geom_density(alpha = 0.5) +
  scale_x_log10() +
  theme_bw()
```



# Change default background theme

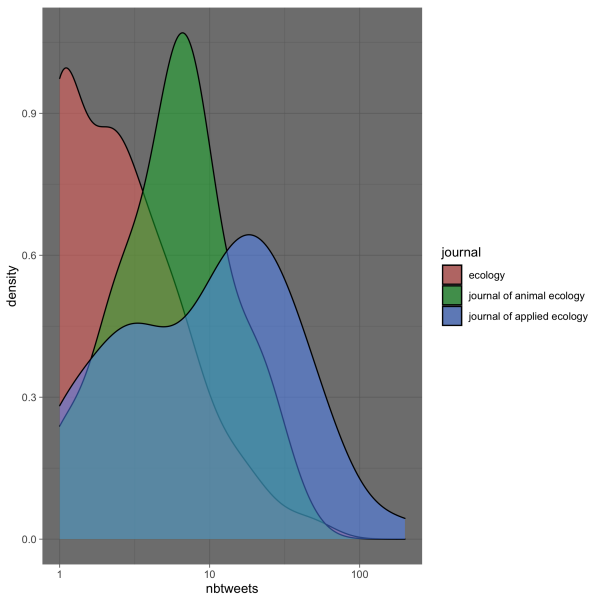
## `classic theme`

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, fill = journal) +
  geom_density(alpha = 0.5) +
  scale_x_log10() +
  theme_classic()
```



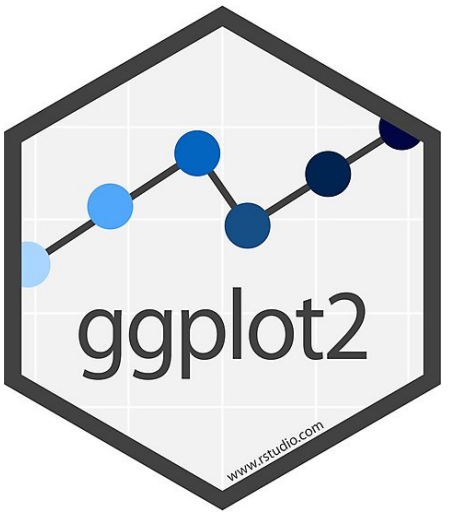
# Change default background theme `dark theme`

```
citations_ecology %>%
  ggplot() +
  aes(x = nbtweets, fill = journal) +
  geom_density(alpha = 0.5) +
  scale_x_log10() +
  theme_dark()
```



# More on data visualisation with ggplot2

- Portfolio of ggplot2 plots
- Cédric Scherer's portfolio of data visualisations
- Top ggplot2 visualizations
- Interactive ggplot2 visualizations




tidyverse
www.rstudio.com

# To dive even deeper in the tidyverse

- Learn the tidyverse: books, workshops and online courses
- My selection of books:
  - R for Data Science et Advanced R
  - Introduction à R et au tidyverse
  - Fundamentals of Data visualization
  - Data Visualization: A practical introduction
- Tidy Tuesdays videos by D. Robinson chief data scientist at DataCamp
- Material of the 2-day workshop Data Science in the tidyverse held at the RStudio 2019 conference
- Material of the stat545 course on Data wrangling, exploration, and analysis with R at the University of British Columbia
- List of best R packages (with their description) on data import, wrangling and visualization

# How to switch from base R to tidyverse?

Couple of notes before we start. The list below is not exhaustive (best to read package documentation for that). For instance, it doesnt cover lubridate (which covers date/time related functions), forcats (which covers everything you would want to do to factors), broom (which tidies up messy R objects), modelr (which has helper functions for creating models) or ggplot. I also use data frame and tibble interchangeably, although they are obviously different.

| Base R command | Tidyverse Command | What it does and why you should use the tidyverse version | Comment |
|---|---|---|---|
| read.csv() | read_csv() | reads in a csv file, but its much faster, shows progress bar for large files, can automatically parse data types | also see read_delim(), read_tsv() and readxl::read_xlsx() |
| sort(), order() | arrange() | sort column(n) within a data frame | see also order_by() |
| mtcars$mpg = … | mutate() | modify a column | see also transmute() which drops existing variables |
| mtcars[,c("mpg", "am")], subset() | select(), rename() | select or rename columns | see also pull() |
| mtcars[mtcars$am == 1,], subset() | filter() | select rows based on a criterion | |
| aggregate() | summarise(), summarize(), do() | reduce grouped values to a single value | see also varaints like summarize_if() |
| ifelse() | if_else(), case_when() | standand vectorized if else, but stricter than base version | see also near() |
| unique() | distinct() | finds unique rows in a data frame, but its much, faster | |
| length(unique()) | n_distinct() | count the number of distinct values in a vector, faster | |
| sample(), sample.int() | sample_n(), sample_frac() | sample n rows or a fraction of rows from a dataframe | |
| all.equal() | all_equal() | checks if two vectors are the same | |
| merge() | inner_join(), left_join() | perform joins, much faster, verbose, and row order is maintain | see also right_join(), full_join(), semi_join(), anti_join() |
| rbind(), cbind() | bind_rows(), bind_cols() | concatenate two dataframes along rows or columns, much faster | |
| x >= left & x <= right | between() | easier to read and faster implementation for larege datasets | see also near() |
| nrow(), sum() | tally(), count(), add_tally(), add_count() | count or sum up rows | |
| c() | combine() | combine into a vector | |
| extends base R | cumall(), cumany(), cummean() | extends base R collection of cumsum(), cumprod() etc | |
| mtcars$mpg[1,] etc | first(), last(), n(), top_n() | works within groups, allows you to order by another column(s) and provide defaults for missing values | |
| split(), aggregate() | group_by() | create a grouped data frame (tibble) to perform operations on groups | see also ungroup() |
| intersect(), union() | intersect(), union() | set operations, but dplyr works on data frames as well | |
| mtcars\(mpg2 = c(NA, mtcars\)mpg[1:nrow(mtcars)-1]) | lead(), lag() | No equivalent command in base R, easier to read | |
| ifelse(…, NA) | na_if() | convert a value to NA | |
| switch() | recode() | change certain values in your vector | see also forcats package when dealing with factors |
| mtcars[3:5,] | slice() | select rows bases on row numbers | |
| seq_along(), quantile() | row_number(), ntile(), min_ran() etc | add rankings in various ways, much richer set of rankings supported than base r | |
| no easy way | complete(), expand() | expands the dataframe so that supplied columns are completely filled out | often used with nesting(), see also full_seq() |
| expand.grid() | crossing() | create a data frame of all possible combinations of supplied vectors | |
| ifelse(is.na(…), …) | drop_na(), replace_na() | drop rows with missing values or convert NAs to supplied values | see also fill(), coalesce() |
| some mix of paste/strsplit | separate(), unite() | separate two columns based on regex or combine two columns into one | |
| reshape2::dcast() | spread() | convert long (tidy) data into wide (untidy) format | |
| reshape2::melt() | gather() | convert wide (untidy) data into long(tidy) format | |
| replicate() | rerun() | run an expression n number of times | |
| unlist(lapply(x, [[, n)) | pluck() | extract elements out of a list | |
| lapply(), sapply() | map(), map2() | apply a function to a set of values, working with lists | see also map_chr(), map_lgl(), map_int(), map_dbl(), map_df() |
| paste0() | glue() | combine two strings together, but much more powerful because it allows for expressions | |

# The RStudio Cheat Sheets

## Data Transformation with dplyr : : CHEAT SHEET

**dplyr** functions work with pipes and expect **tidy data**. In tidy data:

Each **variable** is in its own **column**

&

Each **observation**, or **case**, is in its own **row**


**x %>% f(y)** becomes **f(x, y)**

### Summarise Cases

These apply **summary functions** to columns to create a new table of summary statistics. Summary functions take vectors as input and return one value (see back).

**summary function**

**summarise**(.data, …)
Compute table of summaries.
*summarise(mtcars, avg = mean(mpg))*

**count**(x, ..., wt = NULL, sort = FALSE)
Count number of rows in each group defined by the variables in … Also **tally**().
*count(iris, Species)*

**VARIATIONS**

**summarise_all()** - Apply funs to every column.
**summarise_at()** - Apply funs to specific columns.
**summarise_if()** - Apply funs to all cols of one type.

### Group Cases

Use **group_by()** to create a "grouped" copy of a table. dplyr functions will manipulate each "group" separately and then combine the results.

mtcars %>%
group_by(cyl) %>%
summarise(avg = mean(mpg))

**group_by**(.data, ..., add = FALSE)
Returns copy of table grouped by …
*g_iris <- group_by(iris, Species)*

**ungroup**(x, …)
Returns ungrouped copy of table.
*ungroup(g_iris)*

### Manipulate Cases

**EXTRACT CASES**

Row functions return a subset of rows as a new table.

**filter**(.data, …) Extract rows that meet logical criteria. *filter(iris, Sepal.Length > 7)*

**distinct**(.data, ..., .keep_all = FALSE) Remove rows with duplicate values.
*distinct(iris, Species)*

**sample_frac**(tbl, size = 1, replace = FALSE, weight = NULL, .env = parent.frame()) Randomly select fraction of rows.
*sample_frac(iris, 0.5, replace = TRUE)*

**sample_n**(tbl, size, replace = FALSE, weight = NULL, .env = parent.frame()) Randomly select size rows. *sample_n(iris, 10, replace = TRUE)*

**slice**(.data, …) Select rows by position.
*slice(iris, 10:15)*

**top_n**(x, n, wt) Select and order top n entries (by group if grouped data). *top_n(iris, 5, Sepal.Width)*

**Logical and boolean operators to use with filter()**

| | | | | | |
|---|---|---|---|---|---|
| < | <= | is.na() | %in% | \| | xor() |
| > | >= | !is.na() | ! | & | |

See **?base::logic** and **?Comparison** for help.

**ARRANGE CASES**

**arrange**(.data, …) Order rows by values of a column or columns (low to high), use with **desc()** to order from high to low.
arrange(mtcars, mpg)
arrange(mtcars, desc(mpg))

**ADD CASES**

**add_row**(.data, ..., .before = NULL, .after = NULL) Add one or more rows to a table.
*add_row(faithful, eruptions = 1, waiting = 1)*

### Manipulate Variables

**EXTRACT VARIABLES**

Column functions return a set of columns as a new vector or table.

**pull**(.data, var = -1) Extract column values as a vector. Choose by name or index.
*pull(iris, Sepal.Length)*

**select**(.data, …)
Extract columns as a table. Also **select_if()**.
*select(iris, Sepal.Length, Species)*

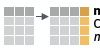
**Use these helpers with select (),**
*e.g. select(iris, starts_with("Sepal"))*

**contains**(match) **num_range**(prefix, range) **:**, e.g. mpg:cyl
**ends_with**(match) **one_of**(…) **-**, e.g, -Species
**matches**(match) **starts_with**(match)

**MAKE NEW VARIABLES**

These apply **vectorized functions** to columns. Vectorized funs take vectors as input and return vectors of the same length as output (see back).

**vectorized function**

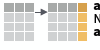


**mutate**(.data, …)
Compute new column(s).
*mutate(mtcars, gpm = 1/mpg)*

**transmute**(.data, …)
Compute new column(s), drop others.
*transmute(mtcars, gpm = 1/mpg)*

**mutate_all**(.tbl, .funs, …) Apply funs to every column. Use with **funs()**. Also **mutate_if()**.
*mutate_all(faithful, funs(log(.), log2(.)))*
*mutate_if(iris, is.numeric, funs(log(.)))*

**mutate_at**(.tbl, .cols, .funs, …) Apply funs to specific columns. Use with **funs()**, **vars()** and the helper functions for select().
*mutate_at(iris, vars(-Species), funs(log(.)))*



**add_column**(.data, ..., .before = NULL, .after = NULL) Add new column(s). Also **add_count()**, **add_tally()**. *add_column(mtcars, new = 1:32)*

**rename**(.data, …) Rename columns.
*rename(iris, Length = Sepal.Length)*

# Thanks!

I created these slides with xaringan and RMarkdown using the rutgers css that I slightly modified.

Credit: I used material from Cécile Sauder, Stephanie J. Spielman and Julien Barnier.


olivier.gimenez@cefe.cnrs.fr
https://oliviergimenez.github.io/
@oaggimenez
@oliviergimenez