

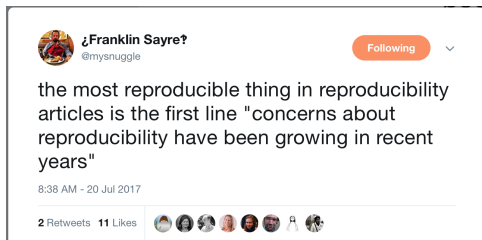
Developing a Workflow to Maximize Reproducibility and Research Impact: Managing Data, Computer Code, and Projects for Success

Althea A. ArchMiller & John R. Fieberg

7/12/2017

Developing a Workflow to Maximize Reproducibility and Research Impact: Managing Data, Computer Code, and Projects for Success

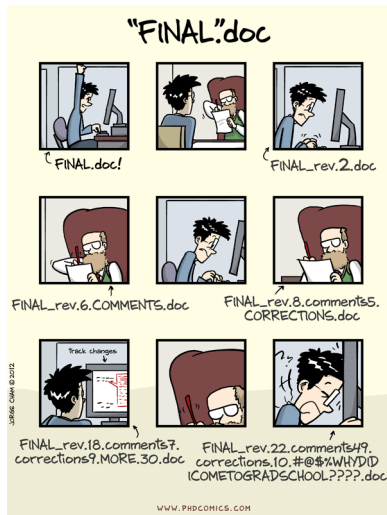
Althea A. ArchMiller & John R. Fieberg



Why worry about reproducibility?

Working towards future reproducibility makes my code easier for my collaborators (and me) to read, run, and debug today, and that's why I think reproducibility is a **win-win for all researchers.**"

-Althea



Why worry about reproducibility?



Vince Buffalo

@vsbuffalo



 Follow

Managing your projects in a reproducible fashion doesn't just make your science reproducible, it makes your life easier.

- ▶ make your life easier! Now, and in the future
- ▶ collaborations
- ▶ broader research impact
- ▶ increased citations
- ▶ transparency
- ▶ grant and journal requirements

“[Reproducibility] provides security, saves time, and forces me to be more thoughtful about my workflow.” - Ethan Young

Is my research reproducible?

What formats are your research documents stored in?

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- ▶ .csv
- ▶ .txt
- ▶ .pdf
- ▶ .html
- ▶ .R/.Rdata
 - ▶ YES - these are considered "reproducible"

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What formats are your research documents stored in?

- ▶ .csv
- ▶ .txt
- ▶ .pdf
- ▶ .html
- ▶ .R/.Rdata
 - ▶ YES - these are considered "reproducible"
- ▶ .doc/.docx
- ▶ .sas
- ▶ .xls/.xlsx
- ▶ any other proprietary file format
 - ▶ NO - these are not "reproducible"

Is my research reproducible?

- ▶ Is your code linear?
 - ▶ Clear environment often and at beginning of script
 - ▶ Each program should focus on one main task or analysis
 - ▶ Don't rely on manual commenting/uncommenting

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```
# Here, I want to know what variables are significant?  
# I will try each variable in turn  
lm.out <- lm(weight ~ height, data = trial.data)  
remove(lm.out) # clear previous lm.out for each  
               # new lm() definition above  
  
# Is the relationship significant?  
# (If not, clear and try a new variable)  
summary(lm.out)
```

Is my research reproducible?

- ▶ Are your files easily shared with others?
 - ▶ Organized directory structure
 - ▶ Files relatively linked
 - ▶ Well-documented & commented
 - ▶ Consistency in coding practices

“The point of having style guidelines is to have a common vocabulary of coding so people can concentrate on *what* you are saying, rather than on *how* you are saying it.” - Google’s R Style Guide

Is my research reproducible?

Do you treat your data as read-only?

- ▶ Don't use Excel, etc., to manipulate raw data
- ▶ Use an R script for data processing
 - ▶ Process data in one script, then save for loading into subsequent scripts
- ▶ When archiving, provide raw data and processing code not just final tables

Workshop Outline

The goal for this workshop is to help you develop the tools to develop a workflow to maximize reproducibility, collaborations, and research impact.

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1. RStudio Projects for organizing data, code, and output
2. R-Markdown and R-Oxygen with knitr for documenting your code and creating reproducible reports
3. GitHub for version-control, collaborating and archiving

1. RStudio Projects for organizing data, code,
and output

1: Introduction to RStudio

The image shows the RStudio desktop application. The interface is divided into several panes. The top-left pane is the Code Editor, showing R code for loading data and calculating abundance. The top-right pane is the Environment and History pane, showing the current workspace with objects like 'posteriors'. The bottom-left pane is the R Console, showing the execution of the code. The bottom-right pane is the Files and Plots pane, showing the file explorer and a list of files in the project directory.

1. Code Editor

```
46 load("data/output_data/posteriors_sptFChIsh_1stHalf.Rdata")
47 load("data/output_data/posteriors_sptFChIsh_2ndHalf.Rdata")
48 posteriors.sptFChI.sh <- NULL
49 for(ii in 1:75){
50   if(ii <= 40){
51     temp <- 
52   }else{
53     temp <- 
54   }
55   posteriors
56 }
57
58 #' Spatial data for getting mixed forest for unsampled plots
59 load("data/spatial_data/plotdata.R")
60
```

2. Workspace & Git

Environment History Git

Global Environment

Data

- operdat... 29120 obs. of 12 va...
- plotdat... 482 obs. of 10 vari...
- poster... 75000 obs. of 128 ..

poster... Large list (35 elemen...
year num [1:12] 2005 2006 ...

3. R Console

```
> #' Posteriors from the models
> load("data/output_data/posteriors_sptFChIsh_1stHalf.Rdata")
> load("data/output_data/posteriors_sptFChIsh_2ndHalf.Rdata")
> posteriors.sptFChI.sh <- NULL
> for(ii in 1:75){
+   if(ii <= 40){
+     temp <- posteriors
+   }else{
+     temp <- posteriors
+   }
+   posteriors.sptFChI.sh <- rbind(posteriors.sptFChI.sh, temp)
+ }
> View(sightdata)
>
```

4. Files & Plots

Files Plots Packages Help Viewer

New Folder Delete Rename More

sightability_with_spatial_augmentation

Name	Size
nitinnr	39 B
...	2.5 K
...	0 B
...	142 B
sightability_with_spatial_augme...	205 B
support docs	

1: Introduction to RStudio

The screenshot displays the RStudio environment with the following components:

- Source Editor:** Contains R code for loading data and processing posteriors. The code is as follows:

```
46 load("data/output_data/posteriors_sptFChIsh_1stHalf.Rdata")
47 load("data/output_data/posteriors_sptFChIsh_2ndHalf.Rdata")
48 posteriors.sptFChI.sh <- NULL
49 for(ii in 1:75){
50   if(ii <= 40){
51     temp <- posteriors.sptFChI.sh.1of2[[ii]]
52   }else{
53     temp <- posteriors.sptFChI.sh.2of2[[ii-40]]
54   }
55   posteriors.sptFChI.sh <- rbind(posteriors.sptFChI.sh, temp)
56 }
57
58 #' Spatial data for getting mixed forest for unsampled plots
59 load("data/spatial_data/plotdata.R")
60
```
- Console:** Shows the execution of the code from the source editor:

```
> #' Posteriors from the models
> load("data/output_data/posteriors_sptFChIsh_1stHalf.Rdata")
> load("data/output_data/posteriors_sptFChIsh_2ndHalf.Rdata")
> posteriors.sptFChI.sh <- NULL
> for(ii in 1:75){
+   if(ii <= 40){
+     temp <- posteriors.sptFChI.sh.1of2[[ii]]
+   }else{
+     temp <- posteriors.sptFChI.sh.2of2[[ii-40]]
+   }
+   posteriors.sptFChI.sh <- rbind(posteriors.sptFChI.sh, temp)
+ }
> View(sightdata)
>
```
- Environment:** Displays the current data environment:
 - Data:**
 - operdat... 29120 obs. of 12 va...
 - plotdat... 482 obs. of 10 vari...
 - posteri... 75000 obs. of 128 v...
 - sightda... 124 obs. of 26 vari...
 - temp 1000 obs. of 128 va...
 - Values:**
 - ii 75L
 - landsat... num [1:12] 2005 2005 ...
 - posteri... Large list (40 elemen...
 - posteri... Large list (35 elemen...
 - year num [1:12] 2005 2006 ...
- Files:** Shows the project file structure:
 - ..
 - .gitignore (39 B)
 - .RData (2.5 K)
 - .Rhistory (0 B)
 - data
 - documents
 - output
 - programs
 - README.md (142 B)
 - sightability_with_spatial_augme... (205 B)
 - suooop docs

1: Introduction to RStudio

~/Documents/postdoc/R_projects/sightability_with_spatial_augmentation - master - RStudio

Go to file/function Addins

sightability_with_spatial_augmentation

Environment History Git

Diff Commit Staged Status Path

programs/two-step/e_calculate_abundance_sptFChI

year	juldate	plot	offplot	waypoint	observed	pilot	leftseat	rightseat	snowdepth	wind	wdir	tempf	bar	btrend	
1	2005	5	58	2	620	1	2	2	3	3	0	0	-10	3049	3
2	2005	5	23	2	80	1	1	1	1	3	0	0	10	3035	3
3	2005	11	105	2	147	0	1	1	4	3	0	0	14	2996	2
4	2005	5	60	2	634	0	2	2	3	3	0	0	-5	3033	2
5	2005	11	100	2	148	0	1	1	4	3	0	0	18	3001	2
6	2005	27	100	2	200	0	1	1	3	3	5	200	21	3037	3
7	2005	11	128	2	138	1	1	1	3	3	0	0	-14	3001	2
8	2005	5	72	2	624	1	2	2	3	3	0	0	-10	3035	2
9	2005	11	72	2	153	1	1	1	4	3	0	0	14	2994	2
10	2005	20	75	2	158	1	1	1	3	3	4	30	9	3010	3
11	2005	5	60	2	636	0	2	2	3	3	0	0	-5	3033	2

Showing 1 to 11 of 124 entries

Console ~/Documents/postdoc/R_projects/sightability_with_spatial_augmentation/

```
> #' ## Plots
> #'
> #' Abundance
> #' popnEsts
> ggplot(data = popn.data[popn.data$Method!="b: FE model"&
+   popn.data$Method!="d:spt FChI (mixed)"&
+   popn.data$Method!="e:Spt RChI (mixed)"&
+   popn.data$Method!="e:spt RChI (shrub)"&
+   popn.data$Method!="f:spt RC (shrub)",],
+   aes(x = Year, y = tauhat, colour=Method, shape=Method))+
+   geom_pointrange(aes(ymin=tau.LL90, ymax=tau.UL90), position=position_dodge(0.3))+
+   ylab("Abundance and 90% CI")
+   scale_x_continuous(breaks=seq(2004, 2016, 1))+
+   theme_minimal()
> |
```

Files Plots Packages Help Viewer

Zoom Export

Abundance and 90% CI

Method

- a: mHT
- c: TS model

Year

1. RStudio Projects

Think about a typical research project, maybe a dissertation chapter or an experiment that you've managed from data collection through publication. What are typical **folders** that you've used?

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Think about a typical research project, maybe a dissertation chapter or an experiment that you've managed from data collection through publication. What are typical **folders** that you've used?

- ▶ Raw data
- ▶ Processed data
- ▶ Analysis scripts
- ▶ Paper/Manuscript-related documents
- ▶ Sharing documents (“transmittals”)
- ▶ Metadata
- ▶ Maps or other deliverables

RStudio Projects provide an opportunity for you to organize and manage all of these types of folders in **one place** in a way that **relatively links** everything together and **eases sharing**.

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Up next, Activity 1!

Activity 1: Data management and updating

Here, we will read in and process three weeks of experimental data and do some preliminary analysis. Then, we will get a final (4th) week of data, which we will merge with the original data.

The goals are to:

1. Be introduced to RStudio
2. Create a framework for keeping data organized and up-to-date
3. Automatically update our analyses based on the master dataset

Context: Abundance data from ~75 invertebrate species sampled on various beaches along the Dutch coast.

Zuur, A.F., E.N. Ieno, and G.M. Smith (2007) Analysing Ecological Data. Springer, New York.

Activity 1: Data management and updating

Before we begin today, we need sync your individual versions of the workshop documents with Althea's master branch:

Activity 1: Data management and updating

Before we begin today, we need sync your individual versions of the workshop documents with Althea's master branch:

1. Open RStudio and your reproducibility_workshop.rproj. (File > Open Project...)
2. Open shell (Tools > Shell...)
3. Type in exactly, then press enter:

```
$ git fetch upstream
```

4. Type in exactly, then press enter:

```
$ git checkout master
```

5. Type in exactly, then press enter:

```
$ git merge upstream/master
```


Activity 1: Data management and updating

1. In the File window of RStudio, copy the **student_folders/student_template** folder. Rename the folder after yourself (or an alias).
2. Open a new R Script file and save it to that new folder as **student_folders/yourname/activity1a_data_processing.R**

Activity 1: Data management and updating

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Activity Overview:

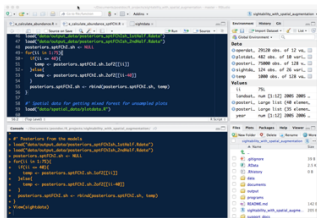
1. We will read in first three weeks of data and combine them, process the data a little bit, and save the merged/processed data for analysis.
2. We will save another new R Script file as **“activity1b_data_analysis.R”** and code/run some preliminary regression analysis.
3. We will pretend to have just gotten the final week's data in and update everything in a “reproducible” way.

2. R-Markdown and R-Oxygen with knitr for documenting your code and creating reproducible reports

Overview of knitr

R Code

written with
R-Markdown or
R-Oxygen



The screenshot shows the RStudio interface. The top-left pane contains R code for a hierarchical model using the `posterior` package. The code defines a function `posterior_aptfde_sh` and runs it. The bottom-left pane shows the R console output, including the function definition and the results of the model fit. The right-hand pane displays the output of the `print` function, showing a list of parameters and their estimated values.

```
# R: Posterior from the model
load("data/output_data/posterior_aptfde_sh_100000.RData")
load("data/output_data/posterior_aptfde_sh_100000.RData")
posterior_aptfde_sh = NULL
fit11 = fit11
fit11 = fit11
temp = posterior_aptfde_sh$fit11[1:10]
temp = posterior_aptfde_sh$fit11[1:10]
posterior_aptfde_sh = rbind(posterior_aptfde_sh, temp)
# Spatial data for getting wind forest for unvisited plots
load("data/output_data/indices.R")
```

```
## [1] 761
## [2] 100000
## [3] 100000
## [4] 100000
## [5] 100000
## [6] 100000
## [7] 100000
## [8] 100000
## [9] 100000
## [10] 100000
```



Report

.html
.doc
.pdf



Why **knitr** for manuscripts?



Julia Silge
@juliasilge



 Follow

I am having to re-do some pretty onerous data cleaning work, and I am SO THANKFUL that it is all in knitr, fully reproducible, etc. #rstats

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 Follow

I am having to re-do some pretty onerous data cleaning work, and I am SO THANKFUL that it is all in knitr, fully reproducible, etc. [#rstats](#)

“I can do reproducible work in R (making me happy) and format the output report in Word (making my collaborators happy)” - Richard Layton http://rmarkdown.rstudio.com/articles_docx.html

Why **knitr** for manuscripts?

Native R Scripts (.R extensions) (or any analysis code) are generally not designed for reading, but the **knitr** library has been designed for converting R scripts into readable reports, such as Word, PDF, and/or html documents.

Not only do these types of reports help with collaborating, they provide a great framework for archiving your analyses and results.

Example:

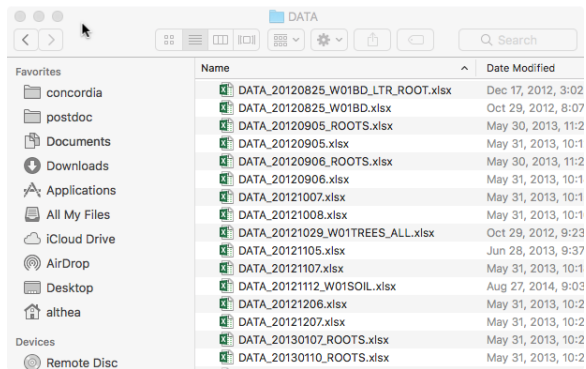
<https://conservancy.umn.edu/handle/11299/181607>

Documenting Code: General tips

- ▶ Consistent and meaningful naming conventions
 - ▶ `a = b*c`
 - ▶ `weekly.pay = hours.worked*pay.rate` (not cross-compatible)
 - ▶ `weekly_pay = hours_worked*pay_rate`
 - ▶ `weeklyPay = hoursWorked*payRate`

Documenting Code: General tips

- ▶ Consistent and meaningful naming conventions
 - ▶ $a = b * c$
 - ▶ `weekly.pay = hours.worked*pay.rate` (not cross-compatible)
 - ▶ `weekly_pay = hours_worked*pay_rate`
 - ▶ `weeklyPay = hoursWorked*payRate`
- ▶ Use YYYYMMDD or equivalent for dates



Documenting Code: R-Markdown

R-Markdown combines `markdown` language, which is “an easy-to-write plain text format” and embedded `R code chunks` that are “run so their output can be included in the final document” [1]

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This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see <http://rmarkdown.rstudio.com>.

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
summary(cars)
```

##	speed	dist
##	Min. : 4.0	Min. : 2.00
##	1st Qu.:12.0	1st Qu.: 26.00
##	Median :15.0	Median : 36.00
##	Mean :15.4	Mean : 42.98
##	3rd Qu.:19.0	3rd Qu.: 56.00
##	Max. :25.0	Max. :120.00

```
14 This is an R Markdown document. Markdown is a
15 simple formatting syntax for authoring HTML,
16 PDF, and MS Word documents. For more details
17 on using R Markdown see
18 <http://rmarkdown.rstudio.com>.
19
20 When you click the Knit button a document
21 will be generated that includes both content
22 as well as the output of any embedded R code
23 chunks within the document. You can embed an
24 R code chunk like this:
```

```
18 ```{r cars}
19 summary(cars)
20 ```
21
```

Documenting code: R-Markdown

Exercise 2a: Introduction to R-Markdown

- ▶ File > New File > R Markdown...
- ▶ Choose “html” - optionally put in a title and press “OK”
- ▶ This R-Markdown template is ready to “knit” into an html as-is
 - ▶ Click the blue Knit button
 - ▶ Save as “**student_folders/yourname/activity2a_intro_rmarkdown.Rmd**”
 - ▶ View the resultant html
- ▶ Take a few minutes to modify the .Rmd and view how the changes appear in the knit html document.

<https://www.rstudio.com/wp-content/uploads/2015/02/rmarkdown-cheatsheet.pdf>

Documenting code: ezknitr

What folder did the html end up in?

Documenting code: ezknitr

What folder did the html end up in?

Now imagine if you wanted to keep the programs/scripts in a folder separate from reports ([highly recommended!](#)). You can easily direct the output html file into a different folder using **ezknitr** package.

Documenting code: ezknitr

What folder did the html end up in?

Now imagine if you wanted to keep the programs/scripts in a folder separate from reports (**highly recommended!**). You can easily direct the output html file into a different folder using **ezknitr** package.

```
library(ezknitr)
ezknit("student_folders/yournm/activity2a_intro_rmarkdown.Rmd",
      out_dir = "student_folders/yournm/reports",
      fig_dir = "figures",
      keep_md = F)
```

Note: When using ezknit, must manually save the .Rmd file before knitting!

Documenting Code: R-Oxygen

Instead of using the R-Markdown language, you can also use **pure R scripts** plus **Roxygen comments** (`#'`) to create fully reproducible reports.

Documenting Code: R-Oxygen

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Benefit: The entire program can be written and run in the familiar R Script file, then “spun” into an html/Word/pdf document at any point.

- ▶ Learning to code with R-Oxygen is arguably more natural since we already use `#` for commenting

Documenting Code: R-Oxygen

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Benefit: The entire program can be written and run in the familiar R Script file, then “spun” into an html/Word/pdf document at any point.

- ▶ Learning to code with R-Oxygen is arguably more natural since we already use `#` for commenting

Additionally, use `#+` to define and label R chunks like we did with the `“{r ...}”` code in the R-Markdown language.

Documenting Code: R-Oxygen

Activity 2b: Introduction to R-Oxygen

Here, we'll quickly convert “activity1b_data_analysis.R” into an html document.

1. Open “activity1b_data_analysis.R”
2. Save As. . .
“student_folder/yourname/activity2b_intro_roxygen.R”

LaTeX

Another benefit of using knitr/Rmd/Roxygen for creating statistical reports is the nice interface with LaTeX equation syntax.

Activity 3. LaTeX Equations

1. Create a new .Rmd html document
2. Save it as “student_folders/yourname/activity3_latex.Rmd”
3. Create the following in the output html
 - ▶ $\alpha + \beta = 2\theta$
 - ▶ $\pi^2 = 9.86$
 - ▶ $\sum_{i=1}^n \sqrt{i} = 42$ (advanced)
4. When you “knit” remember to use ezknitr:

```
library(ezknitr)
ezknit("student_folders/yourname/activity3_latex.Rmd",
      out_dir = "student_folders/yourname/reports",
      fig_dir = "figures",
      keep_md = F)
```

<https://tobi.oetiker.ch/lshort/lshort.pdf> (hint: tables on p75)

Project Workflow w/ RStudio & knitr

Example project directory

- ▶ data/
 - ▶ raw_data/
 - ▶ processed_data/
 - ▶ output_data/
- ▶ manuscript/
 - ▶ ms_figures/
 - ▶ transmissions/
 - ▶ submission/
- ▶ output/
 - ▶ figures/
- ▶ programs/
- ▶ project_file.Rproj

Project Workflow w/ RStudio & knitr

- ▶ **data/**
 - ▶ **raw_data/**
 - ▶ survey_data20161227.csv
 - ▶ survey_data20161230.csv
 - ▶ survey_data20170103.csv
 - ▶ **processed_data/**
 - ▶ survey_data_all.Rdata
 - ▶ **output_data/**
 - ▶ model_out.Rdata

Project Workflow w/ RStudio & knitr

- ▶ **programs/**

- ▶ a_data_processing.R
- ▶ b_data_analysis.R
- ▶ c_plots.R

Project Workflow w/ RStudio & knitr

- ▶ **output/**
 - ▶ a_data_processing.html
 - ▶ b_data_analysis.html
 - ▶ c_plots.html
 - ▶ **figures/**
 - ▶ eda1.jpg
 - ▶ scatter1.jpg

Project Workflow w/ RStudio & knitr

- ▶ **manuscript/**
 - ▶ ms.Rmd
 - ▶ ms.pdf
 - ▶ ms.docx
 - ▶ **ms_figures/**
 - ▶ fig1.jpg
 - ▶ fig2.jpg

Project Workflow w/ RStudio & knitr

- ▶ **manuscript/**

- ▶ ms.Rmd
- ▶ ms.pdf
- ▶ ms.docx
- ▶ **ms_figures/**
 - ▶ fig1.jpg
 - ▶ fig2.jpg

- ▶ **transmittals/**

- ▶ **from_john/**
- ▶ ms20170523.docx
- ▶ ms20170625.docx
- ▶ **from_bob/**
- ▶ ms20170626.docx

Project Workflow w/ RStudio & knitr

- ▶ **manuscript/**

- ▶ ms.Rmd
- ▶ ms.pdf
- ▶ ms.docx
- ▶ **ms_figures/**
 - ▶ fig1.jpg
 - ▶ fig2.jpg

- ▶ **transmittals/**

- ▶ **from_john/**
- ▶ ms20170523.docx
- ▶ ms20170625.docx
- ▶ **from_bob/**
- ▶ ms20170626.docx

- ▶ **submission/**

- ▶ ms.pdf
- ▶ fig1.pdf
- ▶ fig2.pdf
- ▶ coverletter.docx

Project Workflow w/ RStudio & knitr

Example of an RStudio project that Althea & John used from conceptualization through publication.

Project Workflow w/ RStudio & knitr

Example of an RStudio project that Althea & John used from conceptualization through publication.

Activity 3: Creating a reproducible report using R-Markdown

Tasks:

1. Knit the rmd as is into a .doc file
2. Add a third week of data and update report
3. Change the formatting using the word-styles-reference-01.docx

3. GitHub for version-control, collaborating and archiving

Introduction to GitHub

GitHub provides a place for you to back-up and version-control your R projects.

- ▶ Interfaces directly with RStudio
- ▶ Free (public repositories or with university email) or cheap (private repositories)
- ▶ Facilitates collaboration with other co-authors (or the public)
- ▶ Can go back to previous code versions (version-control aspect)

Once you're up and running, it's (usually) simple to use!

Introduction to GitHub



Jonathan Tonkin

@jdtonkin



 Follow

Finally made the jump to using **#git** to version control my **#rstats** code in **#rstudio**. No more dozens of versions and cluttered folders!

Introduction to GitHub



Jonathan Tonkin

@jdtonkin



 Follow

Finally made the jump to using **#git** to version control my **#rstats** code in **#rstudio**. No more dozens of versions and cluttered folders!



Callum Macgregor

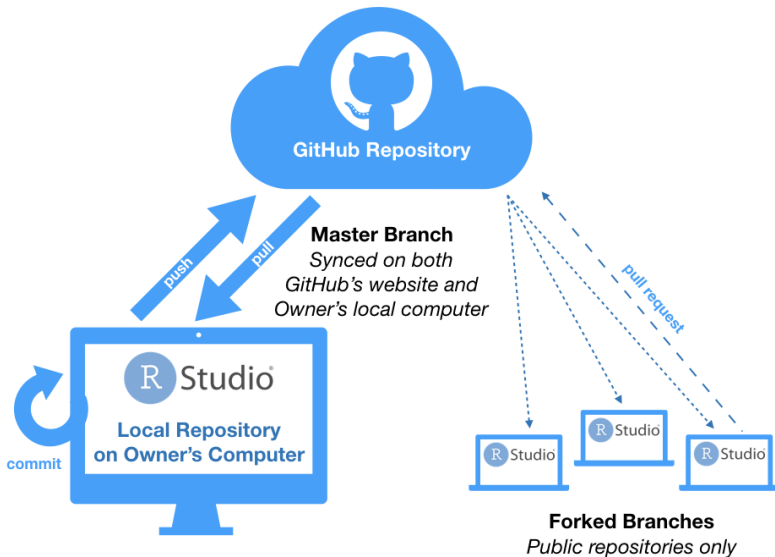
@Macgregor_Cal



 Follow

Managed to delete important R script when tidying up for Github commit. Managed to rescue it, thanks to previous Github commit!
#rstats

GitHub Overview



Activity 4: GitHub in RStudio

First, we will use the built-in interface for GitHub within RStudio.

Secondly, we will use the most common git commands in shell.

Activity 4: GitHub in RStudio

First, we will use the built-in interface for GitHub within RStudio.

Secondly, we will use the most common git commands in shell.

```
git pull origin master # To pull
git add data # add files to a commit
git commit -m "commit message here" #commit
git push origin master # To push commit(s)
```

Additional GitHub Tips

- ▶ Don't use github with large files (push limit of 100MB, warning >50MB)
 - ▶ If necessary, use git-large-file add on (advanced!)
- ▶ Create new projects in GitHub first, then sync them with RStudio (File > New Project > Version Control > Git)

Thanks!

We can use your feedback for the workshop at TWS. Please take a moment or two to fill out our survey.

https://docs.google.com/forms/d/e/1FAIpQLSdmvePcbb3wztx2JpJUhgTqpjvbr0z3etpnjGrRSRfTBnLpcQ/viewform?usp=sf_link

	COMMENT	DATE
○	CREATED MAIN LOOP & TIMING CONTROL	14 HOURS AGO
○	ENABLED CONFIG FILE PARSING	9 HOURS AGO
○	MISC BUGFIXES	5 HOURS AGO
○	CODE ADDITIONS/EDITS	4 HOURS AGO
○	MORE CODE	4 HOURS AGO
○	HERE HAVE CODE	4 HOURS AGO
○	AAAAAAA	3 HOURS AGO
○	ADKFJSLKDFJSDKLFJ	3 HOURS AGO
○	MY HANDS ARE TYPING WORDS	2 HOURS AGO
○	HAAAAAAAAAANDS	2 HOURS AGO

AS A PROJECT DRAGS ON, MY GIT COMMIT MESSAGES GET LESS AND LESS INFORMATIVE.

Additional resources

- ▶ <https://swcarpentry.github.io/r-novice-gapminder/02-project-intro/>
- ▶ knitr documentation and help <https://yihui.name/knitr/>
- ▶ Markdown basics <https://daringfireball.net/projects/markdown/basics>
- ▶ R-Oxygen formatting/tips
<https://rpubs.com/alobo/spintutorial>
- ▶ Online Reproducible Research Course
<http://eriqande.github.io/rep-res-web/>