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How to Package YouR Functions: From Standalone to R Packages

Damiano Oldoni

Research Institute for Nature and Forest (INBO)



Funded by
the European Union

RESEARCH INSTITUTE
NATURE AND FOREST

4th B-Cubed Workshop/2024-11-07

Workshop material

The image features a large number of bees, both on the ground and in flight, against a green-tinted background. The bees are concentrated in a large cluster in the lower center, with many others scattered throughout the scene, some appearing to fly towards the viewer. The overall aesthetic is natural and focused on the subject of bees.

Workshop material

Code and slides



Code and slides

 All material is on GitHub:

github.com/b-cubed-eu/b-cubed-workshops/tree/main/workshops/04

 In particular: [slides](#) (pdf)



Introduction





A close-up photograph of a large cluster of bees on a light-colored surface, with many more bees flying in the air around them. The image has a green tint.

Introduction

Why packaging functions in R?



Why packaging your functions?

-  Code organization
-  Documentation
-  Easy to share
-  Quality control (testing)






Introduction

What is an R Package?




The cooking metaphor

-  R is our kitchen
-  R console is our food processor
-  Functions are recipes. They tell you how to:
 - Take inputs (ingredients)
 - Process them
 - Return an output (food)





The cooking metaphor

-  Define the function `make_bread()`
-  Define the recipe to make bread in the food processor settings

```
make_bread <- function(grains, yeast, water, salt) {  
  # Code to generate `bread`.  
  # The code here can be easy (easy bread recipes do exist)  
  # or quite complex (complex bread recipes do exist too)  
  bread <- grains + yeast + water + salt  
  return(bread)  
}
```



The cooking metaphor

-  Add ingredients to the food processor, select your own recipe, press “Play
-  Pass inputs to the function, call it, press Enter





```
# Prepare ingredients
g <- 20 # Prepare amount of grains)
y <- 1 # Prepare amount of yeast)
w <- 2 # Prepare amount of water)
s <- 3 # Prepare amount of salt)

# Add ingredients in food processor = Pass values to arguments of the function
bread <- make_bread(grains = g, yeast = y, water = w, salt = s)

# Press `Enter`
bread
```



The cooking metaphor

-  R is our kitchen
-  R console is our food processor
-  Functions are recipes. They tell you how to:
 - Take inputs (ingredients)
 - Process them
 - Return an output (food)
-  R package is well-organised bundle of recipes, a cookbook. It:
 - Bundles functions (recipes)
 - Comes with metadata (book details, title, authors, licence, ...)






The cooking metaphor

 From our notes about culinary art of grandma to a cookbook



What is an R package?

-  Fundamental unit of code in R
-  Standardized way for organizing, documenting, testing, distributing functions
-  Enhance reproducibility and reusability









Introduction

Overview of necessary software tools



Software

-  Programming language: [R](#)
-  IDE: [RStudio](#)
-  Software development package: [devtools](#) and [usethis](#)
-  Testing: [testthat](#)
-  Documentation: [Roxygen2](#) and [pkgdown](#)
-  Version control: [git](#), [GitHub](#)



R Package Essentials

The image features a background of a beehive with numerous bees in flight. The scene is overlaid with a semi-transparent green gradient, which is darker at the top and lighter at the bottom. The text 'R Package Essentials' is centered in the upper half of the image in a white, bold, sans-serif font.





R Package Essentials

Structure of an R package



Structure of an R package





Essential components

-  **DESCRIPTION** : file (metadata)
-  **R/** : directory (source code)
-  **man/** : directory (documentation)
-  **NAMESPACE**: file (export/import declarations)



Structure of an R package

Optional components

-  **tests/**: directory (code for testing)
-  **vignettes/**: directory (long-form documentation)
-  **data/**: directory (datasets)
-  **inst/**: directory (additional resources)













R Package Essentials

Key components



R Package essentials

DESCRIPTION file

-  **Package:** package name
-  **Title:** Very Short Description in Title Case
-  **Version:** Use x.y.z or x.y.z.9000. See [Lifecycle](#) from R Packages (2e)
-  **Authors@R:** maintainer (author and creator) and any other author/contributor
-  **Description:** Long description. One or more paragraphs.
-  **License:** MIT + file LICENSE
-  **Encoding:** UTF-8
-  **Roxygen:** instructions for Roxygen about documentation
-  **RoxygenNote:** Roxygen version, e.g. 7.3.2
-  **Imports:** dependencies (packages it depends on)








Create Your First Package

Create Your First Package

Naming your package



Naming your package

-  Check [“Naming your package”](#) from the B-Cubed software dev guide
-  Is your package name available, informative and not offensive?
`pak::pkg_name_check("mycoolpkgname")`
-  Most generic tool: `available::available("mycoolpkgname")`

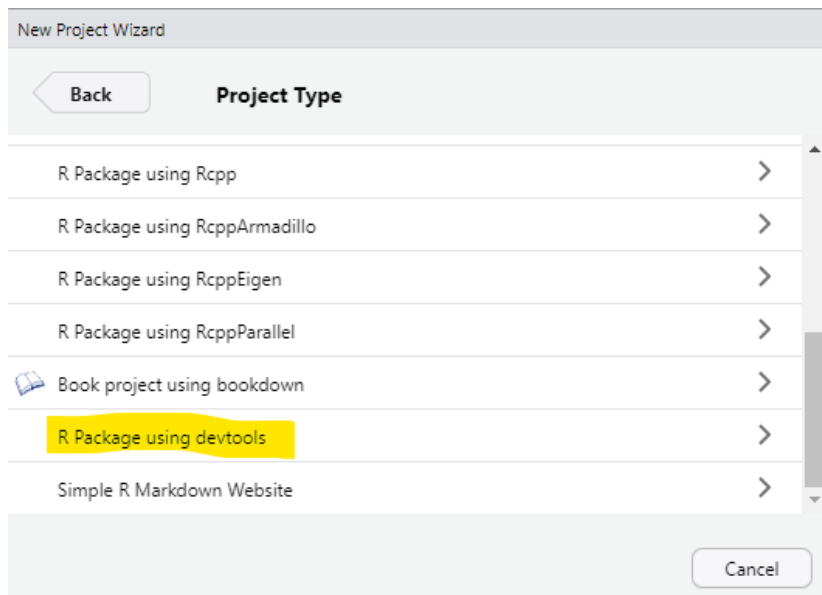


Create Your First Package

Setting up a new package project in RStudio



Setting up a new package project in RStudio



Setting up a new package project in Rstudio

 Setup everything we need in a single line, isn't [usetthis](#) amazing?

```
usetthis::create_package("path/to/packageName")
```

 Example:

```
usetthis::create_package("./workshops/04/bRead")
```

 Redirected to new Rstudio session linked to bRead.Rproj



Create Your First Package

Update the DESCRIPTION file






Update the DESCRIPTION file

```
Package: bRead
Title: What the Package Does (One Line, Title Case)
Version: 0.0.0.9000
Authors@R:
  person("First", "Last", , "first.last@example.com", role = c("aut", "cre"),
    comment = c(ORCID = "YOUR-ORCID-ID"))
Description: what the package does (one paragraph).
License: `use_mit_license()`, `use_gpl3_license()` or friends to pick a
  license
Encoding: UTF-8
Roxygen: list(markdown = TRUE)
RoxygenNote: 7.3.2
```



Setting up a new package project in Rstudio

-  Update **License**: set MIT licence `usethis::use_mit_license()`
-  [choosealicense](#): overview software dedicated licences
-  Update **Title**, **Authors@R** and **Description** manually



Update the DESCRIPTION file

Package: bRead

Title: Make Tasty Doughs with R

Version: 0.0.0.9000

Authors@R:

```
c(  
  person("Damiano", "oldoni", , "damiano.oldoni@inbo.be", role = c("aut", "cre"),  
        comment = c(ORCID = "0000-0003-3445-7562")),  
  person("Emma", "Cartuyvels", , "emma.cartuyvels@inbo.be", role = "ctb",  
        comment = c(ORCID = "0000-0001-7856-6360")))
```

Description: A elegant way to create doughs using R.

Typically doughs you can create are bread and focaccia. But who knows, maybe in the future we will add more doughs.

License: MIT + file LICENSE

Encoding: UTF-8

Roxygen: list(markdown = TRUE)

RoxygenNote: 7.3.2










Create Your First Package

Moving functions into the package structure



Moving functions into the package structure

-  We have a package, nice! But empty
-  Add two functions: `make_bread()` and `make_focaccia()`
-  Take code from [20241107_basic_functions.R](#)
-  MUST: R files in **R/** folder
-  Best practice: one file = one function
-  Best practice: file name = function name
-  Two files: **make_bread.R** and **make_focaccia.R**



Create Your First Package

Writing documentation with roxygen2



Writing documentation with roxygen2

- 📦 Function documentation = **.Rd** files in the **man/** folder
- 📦 Very, very old school: write .Rd files yourself. Please, don't 🙏
- 📦 Nowadays, documentation is written in the form of [Roxygen2](#) documentation
- 📦 Put the mouse in the function you want to document
- 📦 In Rstudio, click on **Code** → **Insert Roxygen skeleton** (Alt + Ctrl + Shift + R)










Writing documentation with roxygen2

```
#' Title
#'
#' @param grains
#' @param yeast
#' @param water
#' @param salt
#'
#' @return
#' @export
#'
#' @examples
make_bread <- function(grains, yeast, water, salt) {
  # Code to generate `bread`.
  # The code here can be easy (easy bread recipes do exist)
  # or quite complex (complex bread recipes do exist too)
  bread <- grains + yeast + water + salt
  return(bread)
}
```



Writing documentation with roxygen2

-  MUST: set title (active form)
-  SHOULD: add description (**@description** or add text under title, separated by one empty line)
-  MUST: document arguments (**@param**)
-  MUST: document output (**@return**)
-  SHOULD: add at least an example (**@example**)
-  Allow users of the package to use the function (**@export**)
-  Documented functions: [20241107_documented_functions.R](#)



Writing documentation with roxygen2

```
#' Make bread
#'  
#' @param grains Amount of grains (numeric).  
#' @param yeast Amount of yeast (numeric).  
#' @param water Amount of water (numeric).  
#' @param salt Amount of salt (numeric).  
#'  
#' @return Amount of bread.  
#' @export  
#'  
#' @examples  
#' make_bread(  
#'   grains = 1,  
#'   yeast = 2,  
#'   water = 3,  
#'   salt = 4  
#' )  
make_bread <- function(grains, yeast, water, salt) {
```







Create Your First Package

README



README

-  The **README** is the welcome sign for users
-  Use `usethis::use_readme_md()` to create a **README.md** file
-  Check "[The README file](#)" from the B-Cubed software dev guide
-  Use [20241107_readme_content.md](#)





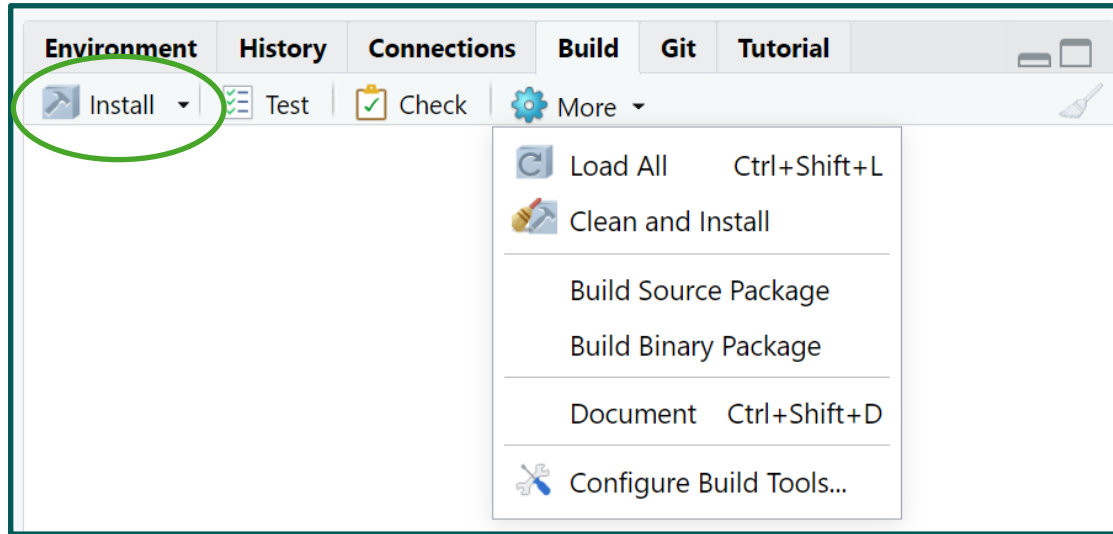
Create Your First Package

Using devtools functions



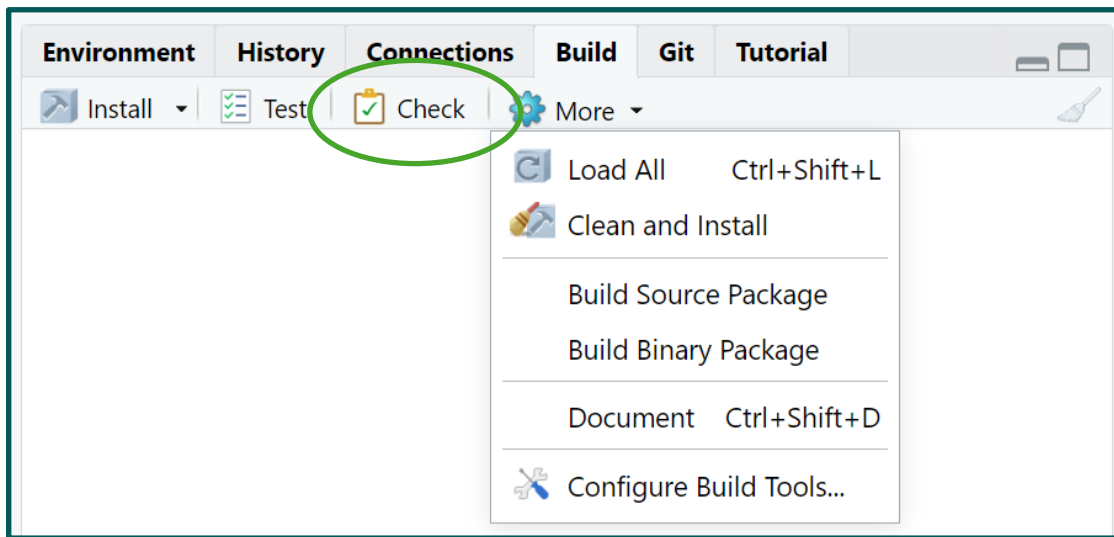
Using devtools functions

-  **Install** icon: install + restart R session + load package (**library(bRead)**)
-  Equivalent of `devtools::install()`





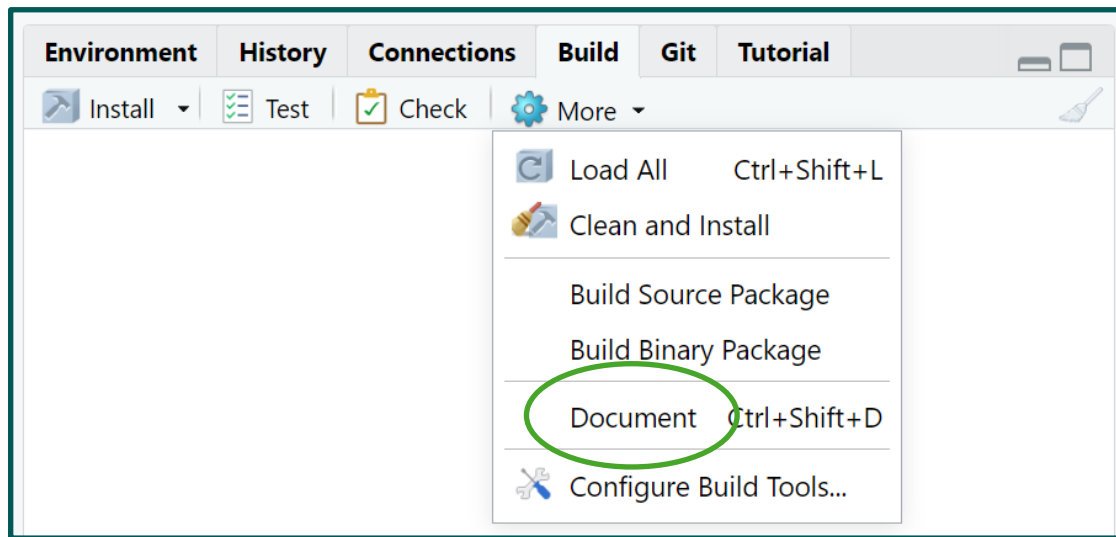
Using devtools functions

-  **Check** icon: check package (are metadata correct? Can be installed? Tests ok?)
-  Equivalent of `devtools::check()`



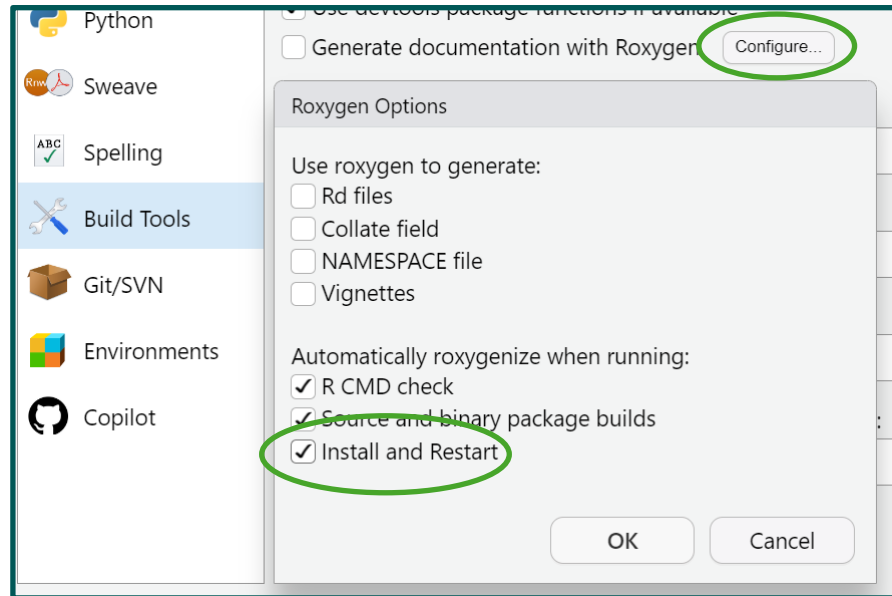
Using devtools functions

-  **Document** (Ctrl + Shift + D): create documentation = **.Rd** files in **man/** folder
-  Equivalent of `devtools::document()`



Using devtools functions

- More → Configure Build Tools... → Configure (next “Generate documentation with Roxygen”)
- Check **Install and Restart** option under “Automatically roxygenize when running:”





Create Your First Package

Dependencies





Dependencies

-  Often our packages depend on other packages
-  Somewhere in our functions we use functions of other packages



Dependencies

-  Example: [20241107_functions_with_assertions.R](#)
-  Add some assertions in `make_bread()` and `make_focaccia()`

```
make_bread <- function(grains, yeast, water, salt) {  
  # Check that inputs are numeric scalars  
  assertthat::assert_that(assertthat::is.number(grains))  
  assertthat::assert_that(assertthat::is.number(yeast))  
  assertthat::assert_that(assertthat::is.number(water))  
  assertthat::assert_that(assertthat::is.number(salt))  
  # Make bread  
  bread <- grains + yeast + water + salt  
  return(bread)  
}
```



Dependencies

Add Imports: field in DESCRIPTION

```
Package: bRead
Title: Make Tasty Doughs With R
Version: 0.0.0.9000
Authors@R:
  c(
    person("Damiano", "oldoni", , "damiano.oldoni@inbo.be", role = c("aut", "cre"),
          comment = c(ORCID = "0000-0003-3445-7562")),
    person("Emma", "Cartuyvels", , "emma.cartuyvels@inbo.be", role = "ctb",
          comment = c(ORCID = "0000-0001-7856-6360")))
Description: A elegant way to create doughs using R.
  Typically doughs you can create are bread and focaccia. But who knows,
  maybe in the future we will add more doughs.
License: MIT + file LICENSE
Encoding: UTF-8
Roxygen: list(markdown = TRUE)
RoxygenNote: 7.3.2
Imports:
  assertthat
```










Create Your First Package

Addressing common errors and warnings



Addressing common errors and warnings

What happens if:

-  Syntax **DESCRIPTION** not correct
-  Forgotten to add **dependency** in **DESCRIPTION**
-  Function without documentation
-  **README** missing
-  Forgotten to document an argument in **@param**
-  **@export** not present
-  Function deprecated



Testing

The image features a green background with a semi-transparent white mesh overlay. Numerous bees are depicted in various states of activity: some are in flight, others are landing on or clustered on a light-colored, textured surface that resembles a piece of fabric or paper. The bees are rendered in a realistic style with yellow and black stripes. The overall scene suggests a controlled environment for studying bee behavior.





Testing

Why writing tests?



Why writing tests?

Tests are important to check if your functions work as expected. Why testing?

-  **Fewer bugs:** you can catch bugs before they become a bug 🐛
-  **Better code structure:** you need to think about how to test your code, which often leads to better code structure
-  **Call to action:** you can write tests for your functions before you write the functions themselves. This is called [test-driven development](#) (TDD)
-  **Robust code:** if you change something in your code, you can run the tests to see if everything still works as expected.

Source: chapter "[Why is formal testing worth the trouble?](#)", from [R Packages \(2e\)](#), Hadley Wickham and Jennifer Bryan.



Testing

Testing tools




Testing tools

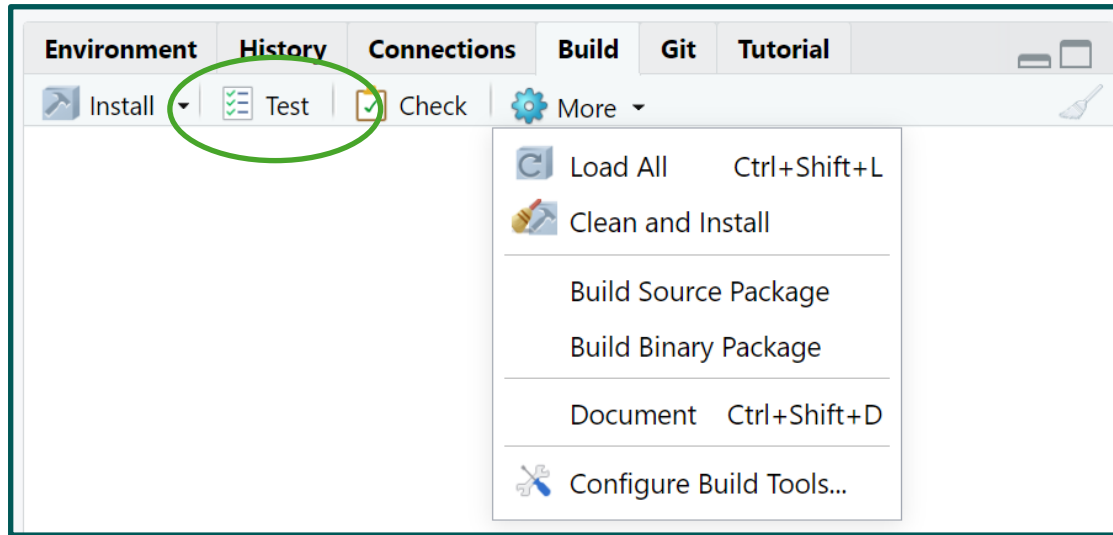
- Use [testthat](#) R package
- Run `usethis::use_testthat()`: set up the test infrastructure for our package
- Check "[Using testthat in practise](#)" from the B-Cubed software dev guide
- Add R file with tests using `usethis::use_test()`
- Tests for **R/xyz.R** live in **tests/testthat/test-xyz.R**
- Example tests: [20241107_tests_for_our_functions.R](#)
- Run tests with `devtools::test()`



Testing tools

 **Test** (Ctrl + Shift + T): run tests for package

 Equivalent of `devtools::test()`



Version control








The image features a background of a beehive with numerous bees. The scene is overlaid with a semi-transparent green filter. The bees are shown in various positions, some clustered on the hive and others in flight. The text 'Version control' is prominently displayed in the upper left quadrant in a white, bold, sans-serif font.

Version control

Create new GitHub repository



Create new GitHub repository

-  Check [“Create a repository”](#) from the B-Cubed software dev guide
-  The **repository name** SHOULD be **lowercase**, dash-separated and short.
-  The **description** SHOULD be a **one-sentence title** (no period at the end)
-  The **visibility** MUST be set to **public**.
-  Check “Add a README file”.
-  You MUST select **.gitignore** template for **R**
-  You MUST select a **licence** and you MUST set it to **MIT License**.





Create new GitHub repository

Owner * damianooldoni / Repository name *
 bread is available.

Great repository names are short and memorable. Need inspiration? How about [cuddly-waddle](#) ?

Description (optional)

 **Public**
Anyone on the internet can see this repository. You choose who can commit.

 **Private**
You choose who can see and commit to this repository.

Initialize this repository with:

Add a README file
This is where you can write a long description for your project. [Learn more about READMEs.](#)

Add .gitignore


Choose which files not to track from a list of templates. [Learn more about ignoring files.](#)

Choose a license


A license tells others what they can and can't do with your code. [Learn more about licenses.](#)







Create new GitHub repository

 **bread** PublicPin Unwatch 1 Fork 0 Star 0

main 1 Branch Tags Add file Code

 **damianooldoni** Initial commit 08ea6c4 · now 1 Commit

| | | |
|---|----------------|-----|
|  .gitignore | Initial commit | now |
|  LICENSE | Initial commit | now |
|  README.md | Initial commit | now |

README MIT license 

bread

R package to learn how to work with packages during B-Cubed workshop of Nov 7, 2024

About

R package to learn how to work with packages during B-Cubed workshop of Nov 7, 2024

- Readme
- Activity
- 0 stars
- 1 watching
- 0 forks

Releases



No releases published

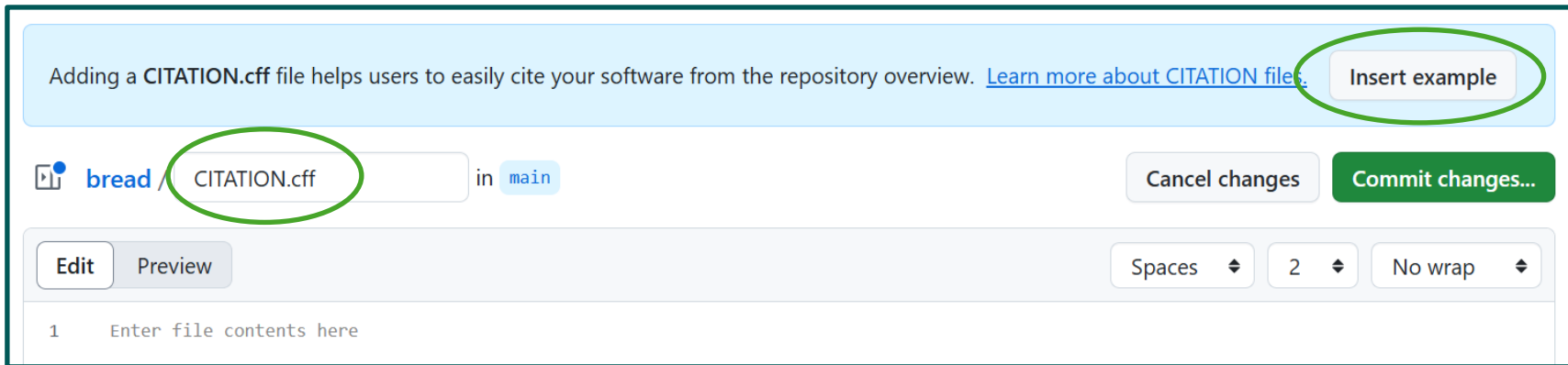
[Create a new release](#)

Packages



Add a CITATION.cff file

-  Allow users to know how to cite your package
-  See steps in [“Add a CITATION.cff file”](#) from the B-Cubed software dev guide

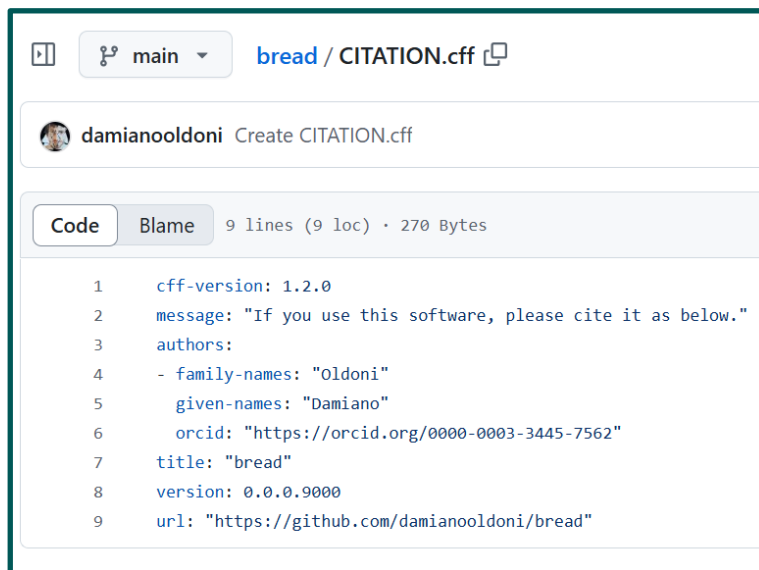


The screenshot shows a code editor interface. At the top, a light blue banner contains the text: "Adding a CITATION.cff file helps users to easily cite your software from the repository overview. [Learn more about CITATION files.](#)" and a green "Insert example" button. Below the banner, the file path is shown as "bread / CITATION.cff" in a light blue box, with "in main" to its right. To the right of the file path are two buttons: "Cancel changes" and "Commit changes...". Below the file path, there are two buttons: "Edit" and "Preview". To the right of these buttons are three dropdown menus: "Spaces" (set to 2), "2", and "No wrap". At the bottom, the code editor shows a single line of text: "1 Enter file contents here".



Add a CITATION.cff file

- 1 Include the name and [ORCID](#) of the maintainers
- 2 Remove the lines **doi** and **date-release** and commit
- 3 Update it with `cffr::cff_write()`



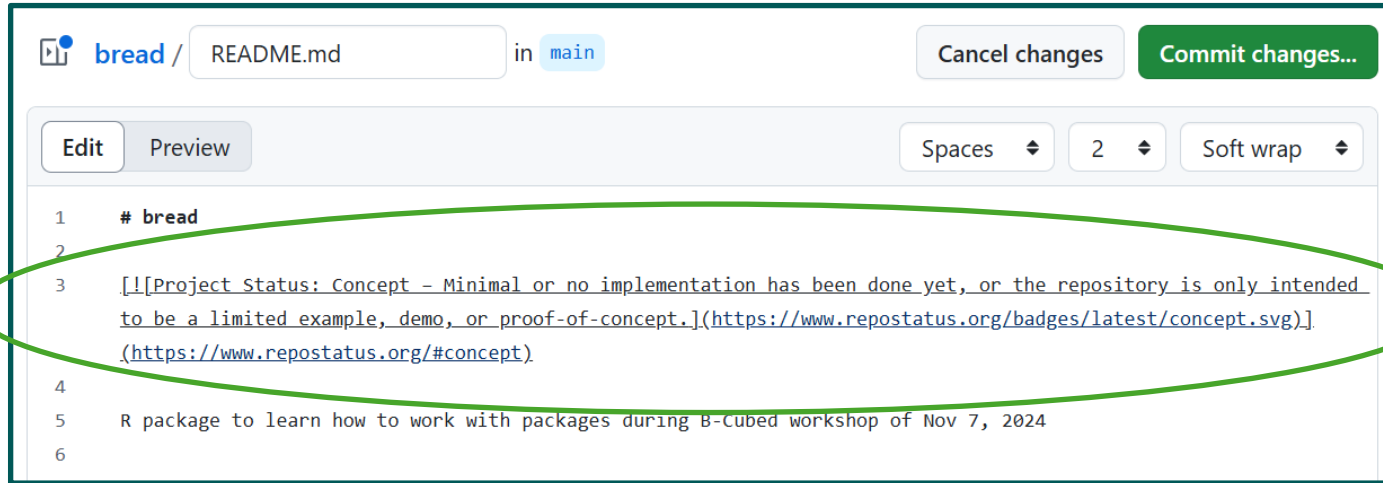
The screenshot shows a GitHub repository view for the file `bread / CITATION.cff` on the `main` branch. The commit was made by `damianooldoni` with the message "Create CITATION.cff". The file content is as follows:

```
1  cff-version: 1.2.0
2  message: "If you use this software, please cite it as below."
3  authors:
4  - family-names: "Oldoni"
5    given-names: "Damiano"
6    orcid: "https://orcid.org/0000-0003-3445-7562"
7  title: "bread"
8  version: 0.0.0.9000
9  url: "https://github.com/damianooldoni/bread"
```



Add a repository status badge

- See [“Badges”](#) from the B-Cubed software dev guide
- Possible statuses: [repostatus.org](https://www.repostatus.org)
- Example: [bread](#) repo is a demo = concept status

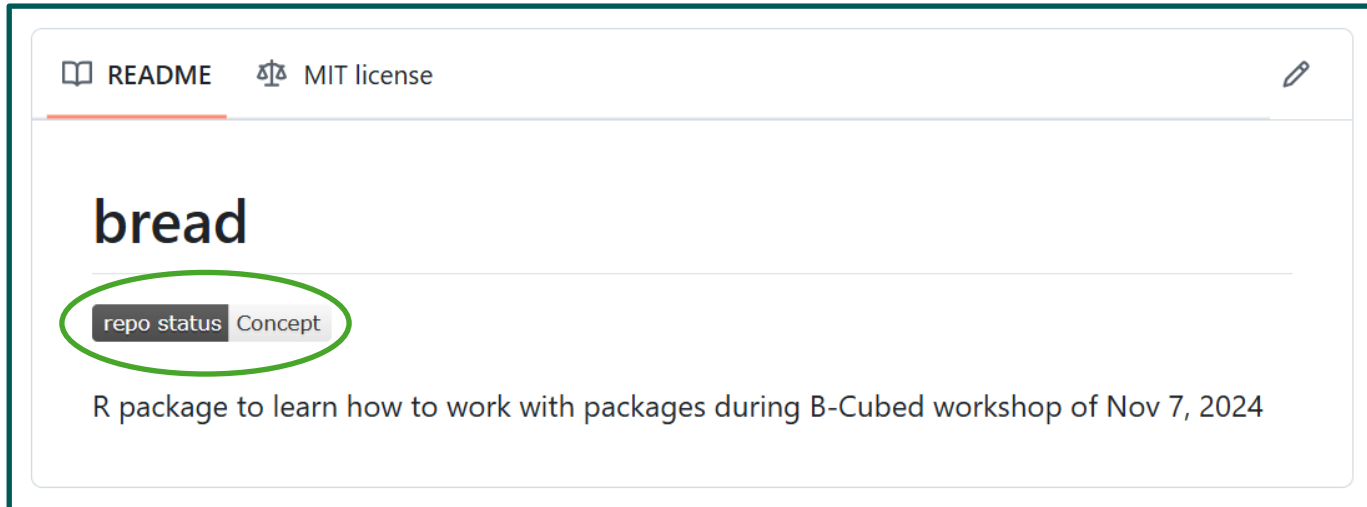


```
bread / README.md in main [Cancel changes] [Commit changes...]  
[Edit] [Preview] [Spaces 2] [Soft wrap]  
1 # bread  
2  
3 [[Project Status: Concept – Minimal or no implementation has been done yet, or the repository is only intended to be a limited example, demo, or proof-of-concept.]](https://www.repostatus.org/badges/latest/concept.svg)]  
4 (https://www.repostatus.org/#concept)  
5 R package to learn how to work with packages during B-Cubed workshop of Nov 7, 2024  
6
```



Add a repository status badge

- See [“Badges”](#) from the B-Cubed software dev guide
- Possible statuses: repostatus.org
- Example: [bread](#) repo is a demo = concept status




Report issues

- See [“Report issues”](#) from the B-Cubed software dev guide
- Issues can be used to report and discuss a bug, idea or task
- Add issue template: `usethis::use_tidy_issue_template()`



















Issue: Bug report or feature request

Describe a bug you've seen or make a case for a new feature. If this doesn't look right, [choose a different type](#).

 **Add a title**

Title

Add a description

Write Preview H B I                  

Please briefly describe your problem and what output you expect. If you have a question, please don't use this form. Instead, ask on [<https://stackoverflow.com/>](https://stackoverflow.com/) or [<https://community.rstudio.com/>](https://community.rstudio.com/).

Please include a minimal reproducible example (AKA a reprex). If you've never heard of a [reprex](<http://reprex.tidyverse.org/>) before, start by reading <https://www.tidyverse.org/help/#reprex>.

For more advice on how to write a great issue, see <https://code-review.tidyverse.org/issues/>.

Brief description of the problem

```
...  
r  
# insert reprex here  
...
```

Markdown is supported Paste, drop, or click to add files

[Submit new issue](#)













Resources, Best Practices, Q&A

Resources, Best Practices, Q&A

Useful links



Useful links

-  The [B-Cubed software development guide](#)
-  The main resource for package development: the [R packages book, 2nd edition](#)
-  The [rOpenSci Packages: Development, Maintenance, and Peer Review](#) guide
-  The [tidyverse style guide](#): B-Cubed's official style guide
-  Packages: [Roxygen2](#) and [pkgdown](#) (documentation), [devtools](#) and [usethis](#) (software development), [testthat](#) (tests)
-  The [checklist](#) package: the "usethis" on steroids 💪
-  [Naming Things](#): Blogpost about naming R packages
-  [choosealicense](#): overview software dedicated licences



Dedicated support channels – updates

 [rOpenSci Slack](#)

 For B-Cubed people: Slack Channel **#wp3-software-helpdesk**

 Subscribe to the monthly [rOpenSci Newsletter](#)

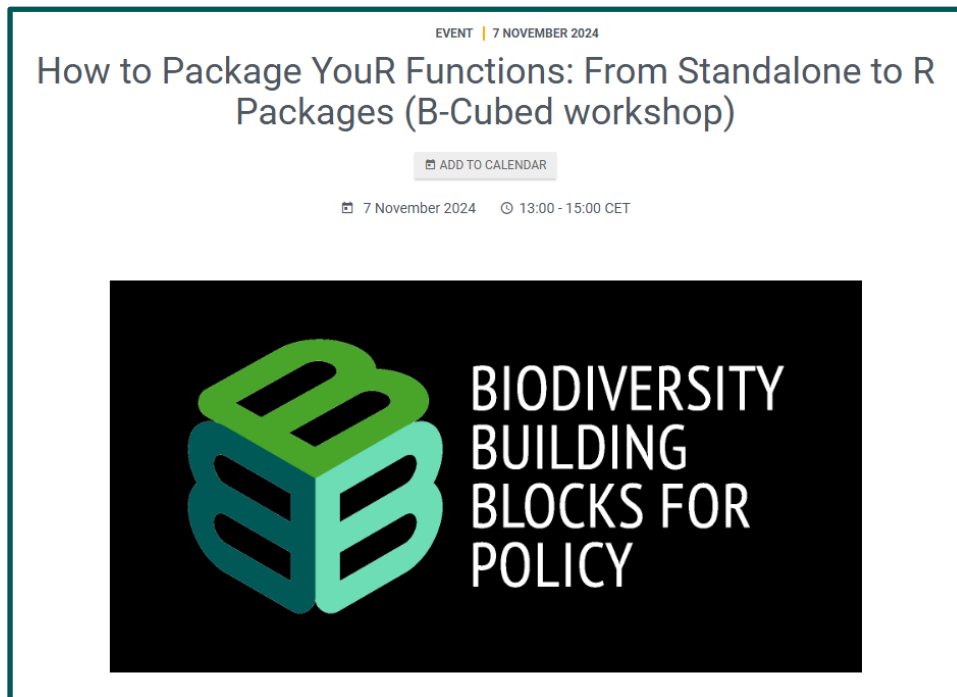


GBIF Workshop



GBIF Workshop

 This workshop is a **GBIF Event** and has been recorded




EVENT | 7 NOVEMBER 2024

How to Package YouR Functions: From Standalone to R Packages (B-Cubed workshop)

[ADD TO CALENDAR](#)

📅 7 November 2024 ⌚ 13:00 - 15:00 CET



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POLICY**



Thank you!

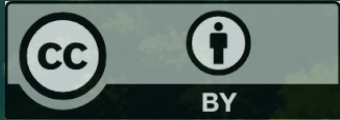
Damiano Oldoni

damiano.oldoni@inbo.be

 [0000-0003-3445-7562](https://orcid.org/0000-0003-3445-7562)

 [@damianooldoni@fosstodon.org](https://fosstodon.org/@damianooldoni)

Open science lab for biodiversity ([oscibio](#))
Research Institute Nature and Forest ([INBO](#))



b-cubed.eu



[@BCubedProject](https://twitter.com/BCubedProject)



[B-Cubed Project](https://www.linkedin.com/company/b-cubed-project/)

Photo by Viridiflavus - Own work, CC BY-SA 3.0,
<https://commons.wikimedia.org/w/index.php?curid=4956453>



Biodiversity Building Blocks for policy

This project receives funding from the European Union's Horizon Europe Research and Innovation Programme (ID No 101059592). Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the EU nor the EC can be held responsible for them.



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