

# Not just for programmers: A friendly guide on the versatility/benefits of GitHub for accelerating collaborative research in Ecology and Evolution

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**Abstract**

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**Importance**

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# Introduction

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## High-level/general background about GitHub

*Contributors to this section: RCO, .*

With over 73 million registered users, GitHub and its underlying version control system Git, are the *de facto* platform for collaboration on computer code [1]. GitHub has become an indispensable tool for software developers because, through version control, users can track changes to multiple files and folders over time [2]. Thus, users have an “audit trail” on the files they choose to store on their GitHub repositories which simultaneously less *ad hoc* than passing files back and forth yet able to scale up as projects take on more files or collaborators [3].

Researchers in ecology and evolutionary biology (EEB) are starting to collaborate on software as part of their research, and some are interacting with GitHub for the first time [4]. For first-time users, the GitHub learning curve can seem overwhelming because the creation of the platform and its features were initially centred in collaboration for software development [CITE]. However, by leveraging existing tools on GitHub and the wide range of collaborations they can enable, researchers in EEB can make the most out of their research and collaborative projects.

## What’s already been written about GitHub

*Contributors to this section: RCO, PHPB.*

[Git](#) is the version control system that enables all the collaborative tools available on GitHub. In Git, changes performed to files are registered as uniquely identified “commits”, which are a snapshot of the line-by-line changes that have been voluntarily performed at that moment. Because the details of interacting with Git can get very technical very quick, we focus instead on the web platform GitHub. However, we suggest those interested in Git explore the many papers [5] [6] and books [7] that can provide an introduction to git. Despite the prevalence of technical papers and books that focus on Git or GitHub for the software development community, there are much fewer resources for EEB researchers who want to begin collaborating through GitHub. We acknowledge that GitHub is not the only way for productive collaboration on cloud-based research documents and code, so we encourage researchers in EEB to take the elements of a GitHub that fit into their workflow. Because GitHub as web platform is so well documented and has a robust user community, scientists can take advantage of many collaborative aspects without knowing even a line of Git code.

## What’s already been done with GitHub in EcoEvo

*Contributors to this section:*

Very friendly description of what GitHub is and the main uses and advantages of using it in the natural sciences back in 2016 (Perkel 2016). What’s missing about GitHub in EcoEvo and our objective: Introducing the GitHub ecosystem that’s composed of many different elements!

## What’s missing about GitHub in EcoEvo and our objective

*Contributors to this section:*

Simple habits (of which github is one component) can do a lot to make research more reproducible and collaborative (Alston and Rick 2021). In EcoEvo Github use is predicated on an understanding in R. This close connection has some benefits, but other programming languages are frequently used by researchers (e.g. Python, Julia). Lots of ways to use GitHub that are independent from R. We have in this hackathon a definite focus on R tools for interacting with GitHub, but sometimes the issues we present at 'Github' issues might be more about the ways that we interact with Github (i.e. through R vs. bash shell)

I am just testing what happens if I add a sentence. (Saeed) :) It is also important to consider what are the aims of researchers and how they want contribute in...

## GitHub in EcoEvo examples (Part 1)

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### Storing and archiving version-controlled data

*contributors to this section:* Another potential use case/user perspective: Some people are just using GitHub to backup their data, use their code on different machines. Just push and pull (Box 1) from their own repo. GitHub integrates with Zenodo, a popular, free data archiving service funded by CERN. After linking your GitHub account to Zenodo and turning on archiving, any time a release (Box 1) is made, a snapshot of the entire repository is archived in Zenodo with a versioned, citable DOI

### Virtual lab notebook

*contributors to this section:* commits as a way to record daily progress issues as a way to keep track of short-term objectives/goals, and progress towards them

### Responding to reviewer comments

*contributors to this section:* using github issues (Box 1) to organize and respond to reviewer comments on a manuscript. See example [here](#)

### Classroom teaching / educational materials

*contributors to this section:* Matthew D. Beckman, Mine Çetinkaya-Rundel, Nicholas J. Horton, Colin W. Rundel, Adam J. Sullivan & Maria Tackett (2021) Implementing Version Control With Git and GitHub as a Learning Objective in Statistics and Data Science Courses, Journal of Statistics and Data Science Education, 29:sup1, S132-S144, DOI: 10.1080/10691898.2020.1848485

## GitHub in EcoEvo examples (Part 2)

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### Project management

*Contributors to this section:* Kaitlyn Gaynor, Rob Crystal-Ornelas

GitHub can be a powerful tool for team-based project management, allowing collaborators to share feedback, brainstorm ideas, and troubleshoot problems. The "Issues" feature of GitHub allows for discrete tasks and sub-tasks to be identified, assigned to team members, and categorized with custom labels, and the new "Discussion" feature serves as a message board for conversation. Scripts, commit messages, and pull requests can be linked directly to issues and discussions, providing a clear record of project workflow. The use of GitHub for all project-related conversation and planning, rather than

e-mail or messaging tools, makes it easier to keep track of progress throughout the lifespan of a project and less likely for issues to slip through the cracks. It is not essential for all team members to have proficiency in git or programming, as users can interact with Issues and Discussions via web browser or e-mail. By default, GitHub repositories are publicly visible, and so anyone with a GitHub account can not only view content, but also engage with repository administrators through Issues and Discussions.

Can talk about ESS-DIVE's project management using ZenHub/Jira to manage customer support requests, feature updates to our data sharing platform.

## Building website

*Contributors to this section: Emma Hudgins*

Seems like the technical aspect of this is discussed in Dawson, Chris (2016). Building Tools with GitHub: Customize Your Workflow. O'Reilly Media GitHub pages allows any .html document to be rendered as a website with a URL. This could be, for example, a report written in markdown or R Markdown rendered into a .html file.

[Jekyll](#) and [Hugo](#) are both “static website generators”, which you can use as template libraries for websites that can be hosted freely via GitHub pages. Both of these tools require some additional learning because they are deployed locally via the terminal, but they are a great resource for creating free, eye-catching websites. If you wish to use your own domain name, you can purchase a domain for your GitHub pages site. It is also possible to fork the website of someone else who has publicly hosted their website on GitHub in order to use it as a template.

## Making code citable

*Contributors to this section: Rob Crystal-Ornelas, Emma Hudgins*

GitHub makes it easy to store and share a variety of data files in the cloud. But for a variety of reasons (e.g., privately owned company, ability to make repositories private, accounts can be deleted at will) GitHub is not considered a long-term data or code repository like [zenodo](#) and [figshare](#) [8] [6.]. Also, unlike the long-term repositories, GitHub does not issue Digital Object Identifiers (DOIs) for content uploaded to their servers. DOIs are persistent and unique alpha-numeric IDs assigned to research products like papers, code, and data. DOIs allows tracking and citing research products. For this reason, scientists who share code and data through GitHub are strongly encouraged to also submit GitHub repository content to a long-term data archive [9]. Fortunately, both long-term repositories mentioned above (zenodo and figshare) have integrations with GitHub which facilitates archiving a snapshot of all repository content with the click of a button.

GitHub Linking with Zenodo, etc. to achieve a DOI helps work become findable, gives proper attribution, and that can ensure long-term stability (Hampton et al. 2015) Another key step researchers should consider taking when they receive a DOI for the content they archive on GitHub is choose a usage license [[10]. This helps

The standard GitHub licensing options are best suited for software. If your code is intended only for your specific analysis, consider a Creative Commons License. The [Choose a License](#) website can offer further guidance. If you wish to allow anyone to re-use your code, consider a CC0 1.0 public domain dedication. If you wish to receive attribution for any reuse of your code, consider a CC BY 4.0 license, which requires attribution upon reuse.

Many researchers believe that their code is not useful because their analysis is context-specific and not designed for re-use like software. However, even if code is rough, it shows the exact steps taken to conduct an analysis, and therefore provides the most detailed look into how to reproduce a given analysis [11].

## Collaborative (code) editing

*Contributors to this section: Kaitlyn Gaynor, Rob Crystal-Ornelas*

From its inception, one of the primary uses of GitHub has been for collaborative coding. We acknowledge that the average software developer and EcoEvo researcher using GitHub

Is it worth walking through how collaborative code editing works through GitHub, or just pointing to all the available resources for this? (e.g. <https://docs.github.com/en/pull-requests/collaborating-with-pull-requests/incorporating-changes-from-a-pull-request/merging-a-pull-request>). Rob: I think pointing to available resources and citing them here is great [10].

GitHub can facilitate interactions between research advisors and advisees, providing a platform for students or other trainees to share in-progress code, and flag specific challenges or questions for their supervisors or mentors. Periodic code review can also help advisors to identify errors early in the process, and inform further training and mentorship to fill gaps in skills.

## Writing manuscript

*contributors to this section:*

Caveat that GitHub has been called out for not being so user-friendly for manuscript development (Ram 2013). But getting better? Tools that link with GitHub have been developed with synchronous writing in mind. HackMD provides a collaborative writing platform based on Markdown that integrates with GitHub.

We used this platform early on in the process of writing this manuscript to generate an outline.

## GitHub in EcoEvo examples (Part 3)

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### Open science discussion

*Contributors to this section:* <https://github.community/> GitHub new discussion tool

### Project continuity

*Contributors to this section:* 'thus preserving the long-term integrity of the project even as collaborations form and shift.' (Hampton et al. 2015) better to have old versions on GitHub than on somebody's personal hard drive!

### Asynchronous working

*Contributors to this section:*

### GitHub organizations

*Contributors to this section: Katherine Hébert*

Whether experiments are done in a wetlab, data are gathered in a field site, or analyses are run in a shared office, even conceptually distinct projects are often carried out in a common physical space. GitHub Organisations offer a shared virtual space that allows a team to work in different repositories, while remaining tied together under a larger figurehead, such as a laboratory, a department, an organisation, or a large project involving several teams. Organisations are well-suited to ensure larger projects with many steps or moving parts are constrained to one virtual space, where outputs and sub-projects can be easily accessed and located without relying on any one individual. Because the repositories are grouped in one virtual space, members can reference and contribute to each other's work without necessarily being part of the same repository, broadening the accessibility and longevity of code and writing contributions.

Contributors can be assembled into teams within an organisation, which allows administrators to assign roles and tasks to groups of people. Whereas access to repositories is usually assigned to individual contributors, Organizations facilitate the management of access permissions by allowing each team to be granted access to certain repositories, and not to others. This ensures that more sensitive repositories remain as restricted as needed, while repositories with greater general interest can be easily accessible to many members at once.

As an example, GitHub Organizations are particularly well-suited to house documents and projects within a laboratory, such as research compendia, codes of conduct, protocols, training documents, and other such documents that evolve collaboratively over time and are relevant to many colleagues. In this way, students or teams can have full ownership of repositories within an organization, while ensuring that these materials stay accessible to the laboratory after people have moved on (or upgraded their computers). This application extends to research centres, which may include several distinct projects that remain linked under a given institution, such as the [German Centre for Integrative Biodiversity Research \(iDiv\)](#). Of course, the utility of this tool goes beyond laboratories - they are useful to structure the organisation, presentation, and outcomes of working groups such as the hackathon which inspired this paper ( [SORTEE-Github-Hackathon](#) ) by keeping track of all materials as ideas develop and take shape in one virtual space. Organisations are also convenient for hosting a set of related learning materials such as a set of lectures or workshops, such as the Québec Centre for Biodiversity Science R Workshop Series ( [QCBSRworkshops](#) ) or the University of Edinburgh's Coding Club ( [Coding Club](#) ), which may be updated by an ever-evolving group of contributors over time.

## Misc other uses

*Contributors to this section: RCO* There are many more potential uses of GitHub for EEB researchers, and we briefly highlight several of them here. First, community-driven data standards include instructions and templates that can help researchers format their data and metadata more consistently [12]. Often, these documents and templates are hosted on static websites as PDFs. However, GitHub is now seen as a useful site for storing the data standard documents since they can be version controlled, and commented on by the user community e.g., [ESS-DIVE's GitHub Community Space](#) [9].

Second ...

Code review rOpenSci's code review process, and also caught mistakes in code of published papers that could have been caught in peer code review. Also maybe say something about ReproHack.

## Discussion

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### General paragraph on what GitHub can enable in EcoEvo



General paragraph on GitHub on how, given all the potential uses of GitHub, it can enable more collaborative EcoEvo research Despite all the awesomeness of GitHub, there are still plenty of times when you might look to other platforms for collaboration

## **Why aren't more people using GitHub?**

Learning to use Github requires time, but the payoff is *[may be?]* worth it. Time vs. effort examples or analyses to demonstrate the payoff can help drive the point home to convince people to learn these tools

## **Limitations**

Our own limitations since we are mostly writing from the EcoEvo perspective/ additional github limitation Reliance on R since we are generally in EcoEvo Discussion of free vs. paid plans. When projects get highly collaborative may have to add / pay for accounts. At this point, little difference between paid and free.

## **Using GitHub is a good start, but lots of practices to make repo more user friendly**

end off with our 5/10 tips for how to gain knowledge/practice with GitHub here

## **Conclusion**

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## **Acknowledgements**

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This manuscript arose from a hackathon at the Society for Open, Reliable, and Transparent Ecology and Evolution (SORTEE) virtual meeting in 2020.

(add funding as needed!)

## **Code and data availability**

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The source code and data for this manuscript are available at <https://github.com/SORTEE-Github-Hackathon/manuscript>.

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