

Hands-On Data Visualization

Interactive Storytelling from Spreadsheets to Code

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Introduction



This open-access **book-in-progress**, by Jack Dougherty and Ilya Ilyankou, is under contract with O'Reilly Media, Inc., and was last updated on: 28 Jul 2020

Tell your story and show it with data, using free and easy-to-learn tools on the web. This introductory book teaches you how to design interactive charts and

customized maps for your website, beginning with easy drag-and-drop tools, such as Google Sheets, Datawrapper, and Tableau Public. You'll also gradually learn how to edit open-source code templates like Chart.js, Highcharts, and Leaflet on GitHub. Follow along with the step-by-step tutorials, real-world examples, and online resources. This book is ideal for students, non-profit organizations, small business owners, local governments, journalists, academics, or anyone who wants to tell their story and show the data. No coding experience is required.

Read for free online at <https://HandsOnDataViz.org> or purchase print/eBook editions, to come from the publisher.

Please send corrections or suggestions for this book-in-progress to handsondataviz@gmail.com, or open an issue or submit a pull request on its GitHub repository. If you submit a GitHub pull request, in your commit message, please add the sentence “I assign the copyright of this contribution to Jack Dougherty and Ilya Ilyankou,” so that we can maintain the option of publishing this book in other forms.

View open-source code for source text and templates at <https://github.com/handsondataviz>.

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	<p>Ilya Ilyankou is a Civic Technologist at Connecticut Data Collaborative. He has completed a double major in Computer Science and Studio Arts in the Class of 2018 at Trinity College. Visit his website or follow him on GitHub.</p>

Acknowledgements

An earlier draft of this book was titled *Data Visualization For All* and designed to accompany a free online edX course by the same name at Trinity College. Two co-instructors for this edX course contributed valuable ideas and co-created videos: Stacy Lam, Trinity Class of 2019, and David Tatem, Instructional Technologist at Trinity College. Veronica X. Armendariz, Trinity Class of 2016, also made valuable contributions to an earlier version of the book while she was a Teaching Assistant for the DataViz internship seminar. Videos for the edX course were produced with Trinity College Information Technology staff and friends: Angie Wolf, Sean Donnelly, Ron Perkins, Samuel Oyebefun, Phil Duffy, and Christopher Brown. Funding for students who worked on the earlier draft was generously provided by the Community Learning Initiative and Information Technology Services at Trinity College in Hartford, Connecticut.

Thanks to many individuals and organizations for generously making time to help us learn many of the skills that we teach in this book: Alvin Chang and Andrew Ba Tran, who tutored and shared their Leaflet map templates while at *The Connecticut Mirror*; Patrick Murray-John, formerly at the Roy Rosenzweig Center for History and New Media, who clued us into being *code-curious*, and

many others at The Humanities and Technology Camp (THATCamp) conference series...

We appreciate everyone who provided feedback to improve this book, especially Amelia Blevins, our developmental editor at O'Reilly, and technical reviewers Carl Allchin,...

What is Data Visualization?

Data visualization is broadly defined as a method of encoding quantitative, relational, or spatial information into images. Classic examples include Charles Menard's figurative map of Napoleon's defeat and retreat during the Russian campaign of 1812, and John Snow's dot map of cholera cases during the London epidemic of 1854.

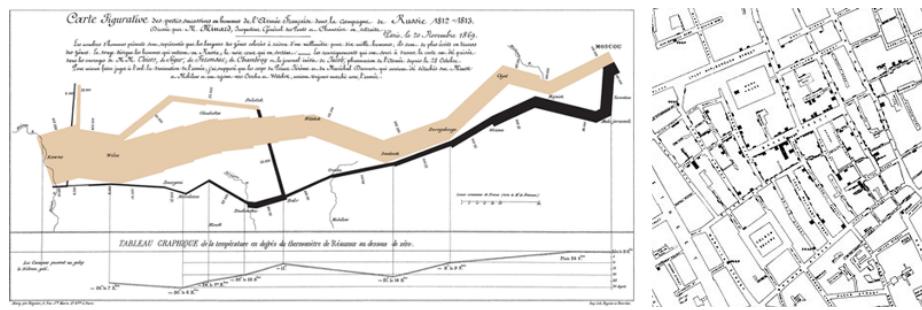


Figure 1: Images: Menard's figurative map (left) and Snow's dot map (right), from Wikimedia

This free online introductory book focuses on selected topics in data visualization:

Charts and maps Despite the growing variety of visualization types, this book features chapters on creating charts and maps, and a wide range of ways to communicate with these classic models.

Reusable tools and templates: Unlike infographics created for one-time use, all of the tools and templates in this book are recyclable, and allow you to upload a new dataset to display your story.

Free and easy-to-learn: We have selected data visualization tools that are free to use (or work on a freemium model, where advanced features or higher usage requires payment), and searched for those that we believe are easy-to-learn, based on our teaching experience with undergraduate students and non-profit community organizations.

Interactive on the open web: Many books assume that you will deliver your data visualizations to in-person audiences on printed paper or presentation

slides. But in this book, we show how to embed interactive charts and maps on your website, to share with the wider public.

Storytelling: Data visualization is more than pretty pictures. In this book, the best visualizations are those that tell your data story – and pull readers’ attention to what really matters – by combining images and text, and offering exploration with explanation.

- Michael Friendly and Daniel J. Denis, “Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization,” 2001, <http://www.datavis.ca/milestones/>
- Isabel Meirelles, *Design for Information: An Introduction to the Histories, Theories, and Best Practices Behind Effective Information Visualizations* (Rockport Publishers, 2013), <http://isabelmeirelles.com/book-design-for-information/>
- Edward Tufte, *The Visual Display of Quantitative Information* (Graphics Press, 1983), and subsequent works at <https://www.edwardtufte.com>

Why this book?

Hands-On Data Visualization, an open-access online textbook, seeks to help you tell your story—and show your data—through the power of the public web.

This open-access book reflects what I’ve learned while teaching data visualization to undergraduate students at Trinity College, and now to a global online class on the Trinity edX platform. Over the past few years, Trinity students and I have built interactive charts and maps in partnership with non-profit organizations in Hartford, Connecticut, to help them share their stories with data on the public web. Also, my students and colleagues have used these tools to create *On The Line: How Schooling, Housing, and Civil Rights Shaped Hartford and its Suburbs*, an open-access book-in-progress that features interactive historical maps of urban-suburban change. Students and colleagues who wrote tutorials, designed learning exercises, or developed code templates for *Hands-On Data Visualization* are listed as authors and contributors.

Although my outstanding colleagues have professional training, do not confuse them with me, the proverbial “Jack of all trades, master of none.” I do not consider myself an expert in data visualization, nor should anyone mistake me for a computer scientist or data scientist. Inspect my higher education transcripts and you’ll see only one computer science class (something called FORTRAN77 back in 1982), and not a single course in statistics, sadly. Instead, my desire to learn data visualization was driven by my need as an historian to tell stories about urban-suburban places and change over time. If you’ve ever watched me teach a class or deliver a presentation on these topics – always talking with my hands in the air – you’ll understand my primal need to create charts and

maps. Stories become more persuasive when supported with data, especially well-crafted images that convey data relationships more clearly than words. Furthermore, these data stories become more powerful when we share them online, where they reach broader audiences who can interact with and evaluate our evidence.

In the early 2000s, when I began to dabble in data visualization, our tools were expensive, not easy to learn, and not designed to share our stories on the public web. (One of my well-worn jokes is point to the bald spot on my head, and claim that it was caused while tearing out my hair in frustration while using ArcGIS.) But everything began to change around 2005 when Google Maps publicly released its application programming interface (API) that allowed people with some coding skills to show data points on an interactive web map. Gradually, between 2008-11, I began learning what was possible by working on map projects with talented programmers and geographers, such as Jean-Pierre Haeberly at Trinity, and Michael Howser at the University of Connecticut Libraries Map and Geographic Information Center (MAGIC, my favorite acronym), thanks to a grant from the National Endowment for the Humanities. Free and low-cost workshops sponsored by The Humanities and Technology Camp (THATCamp) at the Center for History and New Media at George Mason University, and Transparency Camp by the Sunlight Foundation, introduced me to many people (especially Mano Marks and Derek Eder) who demonstrated easier-to-use tools and templates, such as Google Fusion Tables and GitHub. Closer to home, Alvin Chang and other data journalists at the Connecticut Mirror showed me how to tell stories on the web with more flexible open-source tools, such as Leaflet and Highcharts.

All of these data visualization lessons I learned have been so valuable—to me, my students, our community partners, and thousands of readers on the web—that my co-authors and I have agreed to share our knowledge with everyone for free. This open-access book is guided by the principle of democratization of knowledge for the public good, hence the book’s title: *Hands-On Data Visualization*. Not everyone can afford to make this choice, I realize. But the mission of Trinity College is to engage, connect, and transform, with both our local city of Hartford and the world at large. Since Trinity already pays my salary as a tenured professor, the right thing to do with the knowledge my students and I have gained is to pay it forward. That’s why we created *Hands-On Data Visualization*.

If this free book is valuable for your education, then join us by sharing and supporting it for future readers:

- Tell your friends about the book and share the link via social media, text, or email
- Improve the book by adding comments or suggesting new chapters on our GitBook platform

Try out the tutorials, explore the online examples, share what you've learned with others, and dream about better ways to tell your data stories.

Warning: To follow the steps in this book, we recommend either a desktop or laptop computer, running either the Mac or Windows or Linux operating system, with an internet connection and a modern web browser such as Chrome, Firefox, Safari, or Edge. Another good option is a Chromebook laptop, which enables you to complete *most* of the steps in this book, and we'll point out any limitations in specific chapters. While it's possible to use a tablet or smartphone device, we do not recommend it because you cannot follow all of the steps, and you'll also get frustrated with the small screen and perhaps throw your device (or this book) across the room, and possibly hit someone else in the head. Ouch! We are not responsible for injuries caused by flying objects.

Tip: If you're working on a laptop, consider buying or borrowing an external mouse that can plug into your machine. We've met several people who found it much easier to click, hover, and scroll with a mouse rather than a laptop's built-in trackpad.

Tip: If you're new to working with computers—or teaching new users with this book—consider starting with mouse exercises. All of the tools in this book assume that users already know how to click tiny buttons, hover over links, and scroll web pages, but rarely are these skills taught, and everyone needs to learn them at some point in our lives.

How to Read on the Web

TODO: use conditional formatting to make this section appear only in the HTML edition; may need to convert to a free-standing chapter

This open-access book-in-progress is free to read on the web at <http://HandsOnDataViz.org> to fully experience the interactive charts, maps, and video clips. Any modern web browser will display the book, but readers may prefer larger screens (laptops or desktops) over smaller screens (such as smartphones or tablets). In your web browser, try these toolbar features near the top of the page:

- Menu
- Search
- Font to adjust text size and display
- View source code on GitHub
- Shortcuts (arrow keys to navigate; **s** to toggle sidebar; **f** to toggle search)
- Social Media
- Share

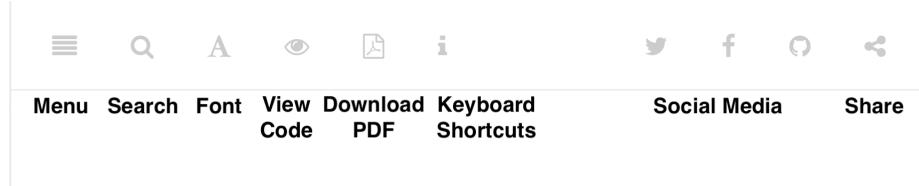


Figure 2: Screenshot: How to read

Open links in new tabs

Keep your place when reading online and moving between pages.

- Two-finger trackpad click
- or Control + click (Mac)
- or Alt + click (Chromebook)
- or right-click (Windows and others)

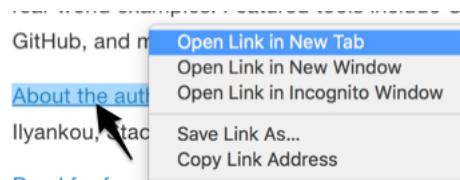


Figure 3: Screenshot: Open link in new tab (on Mac)

Use a second monitor

If you have a small screen, consider connecting a second monitor, or work next to a second computer or tablet. This allows you to view tutorials in one screen and build visualizations in the other screen.

Refresh browser

To view the most up-to-date content in your web browser, do a “hard refresh” to bypass any saved content in your browser cache.

- Ctrl + F5 (most Windows-Linux browsers)
- Command + Shift + R (Chrome or Firefox for Mac)
- Shift + Reload button toolbar (Safari for Mac)



Figure 4: Image: Laptop with second monitor, and with tablet

Chapter 1

Choose Tools to Tell Your Data Story

TODO: Reorganize and rewrite chapter

Do you feel overwhelmed by the enormous range of data visualization tools? There's been so many different tools released in recent years that anyone would have a hard time deciding which ones to use. Even if you limit your choices to the dozen or so tools specifically mentioned in this book, how do you make wise decisions?

- Draw and Write Your Data Story reminds us to start with the most important item in your toolkit: *your story*. Begin by drawing pictures and writing questions or sentences to capture your ideas on paper, and then choose the most appropriate tools to create your vision.
- Ask Questions When Choosing Tools lists several criteria to consider when making software decisions. Many of us look for free or affordable tools in the perfect sweet spot—easy-to-learn, yet powerful—and that's the focus of this book.
- Rate Three Simple Map Tools invites readers to create a basic interactive point map using three different online tools, and to evaluate each one using selected criteria from the chapter above.

TODO: add password manager tutorial to keep track of your accounts for the online tools you'll use in this book. The free and open-source BitWarden.com tool nicely integrates with most browsers and even smartphones.

Enroll in our free online course **TO DO add link**, which introduces these topics in the brief video below, and offers more exercises and opportunities to interact with instructors and other learners.

Watch the YouTube Video

Draw and Write Your Data Story

Before you dive deeply into software, think about the most important item in your toolkit: **your story**. The primary reason we're designing visualizations is to improve how we communicate our data story to other people, so let's begin there.

Push away the computer and pick up some old-school tools:

- colored markers or pencils
- lots of blank paper
- your imagination

First, at the top of the page, write down your data story.

- Is it in the form of a question? If so, figure out how to pose the question.
- Or maybe it's in the form of an answer to that question? If so, spell out your clearest statement.
- If you're lucky, perhaps you already can envision a full story, with a beginning, middle, and end.
- Whatever form it takes in your head, write out the words that come to mind.

Further down the page (or on a separate sheet), draw quick pictures of the visualizations that comes to your mind, even if you don't yet have any data. No artistic skills are required. Just use your imagination. - Do you envision some type of chart? Sketch a picture. - Or do you imagine some type of map? Show what it might look like. - Will your visualization be interactive? Insert arrows, buttons, whatever.

Finally, share your data story with someone else and talk through your preliminary ideas. Does your sketch and sentences help to convey the broader idea that you're trying to communicate? If so, this is one good sign that your data story is worth pursuing, with the visualization tools, templates, and techniques in other chapters of this book.

Ask Questions When Choosing Tools

When each of us decides which digital tools best fit our needs, we often face trade-offs. On one hand, many of us prefer easy-to-learn tools, especially those with a drag-and-drop interface, but they often force us to settle for limited

options. On the other hand, we also favor powerful tools that allow us to control and customize our work, yet most of these require higher-level coding skills. The goal of this book is to find the best of both worlds: that “sweet spot” where tools are both friendly and flexible.

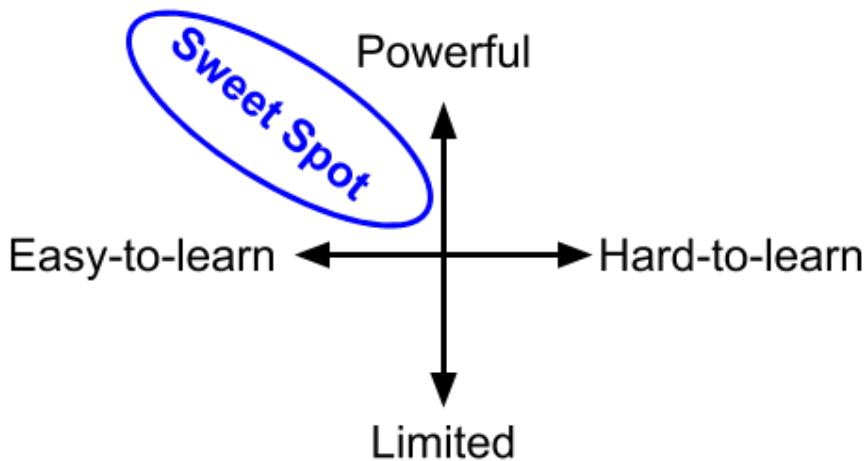


Figure 1.1: Diagram: the ‘sweet spot’ for easy-to-learn and powerful tools

Before testing out new tools, try listing the criteria that guide your decision-making process. What are the most important factors that influence whether or not you add another item to your digital toolkit? Here’s the list that came to our minds:

1. Price: Is the tool free, or is there a “freemium” model to pay for more features or higher usage?
2. Easy-to-learn: Is the tool relatively simple for new users without coding skills?
3. Power: Does the tool support large amounts of data, and various types of visualizations?
4. Customization: Can I modify details about how my work appears?
5. Data Migration: Can I easily move my data in and out, in case I switch to a different tool? Hint for historians: Future-proof your digital history projects! Choose tools that allow you to easily export and migrate data to other platforms. Design projects to keep your data separate from its digital presentation.
6. Hosting: Can I decide exactly where my data and visualizations will be stored online?
7. Support: Is the tool actively maintained by its creators, and do they answer questions?

8. Open Source: Is the tool's software visible, can it be modified, and redistributed?
9. Security: Is the tool and my data protected from malicious hackers and malware?
10. Collaborative: Does the tool allow several people to work together on one shared product?
11. Privacy: Under the terms of service, is my data and work private or public?
12. Error-friendly: When something fails, does the tool point out possible problems and solutions?
13. Cross-platform: Does this tool work across different computer operating systems?
14. Mobile-friendly: Will it correctly display my work on various mobile devices and browsers?

That's a long list! It's even longer than the number of tools we'll mention in this book. But don't let it overwhelm you. The diagram at the top of the page illustrates the two most important criteria for the many free tools that are currently available: easy-to-learn and powerful features.

TODO: expand on privacy to review sample “terms of service” to use free tools such as Google Drive - <https://support.google.com/drive/answer/2450387?hl=en#:~:text=As%20our%20Terms%20of%20Service,store%20in%20your%20Drive%20account.>
 - See alimSpyingStudentsSchool2017 - Many of the free web-based tools in this book require that your publicly share your data. Check each tool and decide whether it is appropriate for your data, which may have some privacy restrictions.

Learn more about choosing tools

Carl V. Lewis, Dataviz.tools: A curated guide to the best tools, resources and technologies for data visualization, <http://dataviz.tools>

Lincoln Mullen, “How to Make Prudent Choices About Your Tools,” ProfHacker blog, Chronicle of Higher Education, August 14, 2013, <http://www.chronicle.com/blogs/profhacker/how-to-make-prudent-choices-about-your-tools>

Lisa Charlotte Rost, “What I Learned Recreating One Chart Using 24 Tools,” Source, December 8, 2016, <https://source.opennews.org/en-US/articles/what-i-learned-recreating-one-chart-using-24-tools/>

Lisa Spiro and colleagues, DiRT: Digital Research Tools Directory (formerly Bamboo), <http://dirtdirectory.org>

Audrey Watters, “‘The Audrey Test’: Or, What Should Every Techie Know About Education?,” Hack Education, March 17, 2012, <http://hackeducation.com/2012/03/17/what-every-techie-should-know-about-education>

Rate Three Simple Map Tools

Let's explore criteria from the previous chapter by comparing three different tools, and reflecting on which factors you feel are most important when making decisions about your toolkit. We'll test three drag-and-drop tools to transform sample address data into a simple interactive point map.

Each tool can **geocode** address data by looking up a location (such as 500 Main Street, Hartford CT) in a large database, deciding on the best match, and converting this data into latitude and longitude coordinates (such as 41.762, -72.674).

For our sample data, we'll use this table of 9 locations in North America, with 3 intentional mistakes to test for geocoding errors.

Group	Description	Address
Government	US Capitol	East Capitol St NE & First St SE, Washington, DC 20004
Government	Parliament Hill	Wellington St, Ottawa, ON K1A 0A4, Canada
Government	Palacio Nacional	Plaza de la Constitución, Centro, 06000 Ciudad de México, CDMX, Mexico
Higher Education	Trinity College	300 Summit Street, Hartford, CT 06106
Higher Education	University of British Columbia	2329 West Mall, Vancouver, BC V6T 1Z4, Canada
Higher Education	Instituto Tecnológico de Monterrey	Av. Eugenio Garza Sada 2501 Sur, 64849 Monterrey, N.L., Mexico
Error Check	Incorrect spelling of Albuquerque	1801 Mountain Rd, Albakerky NM
Error Check	Imaginary street address	1 Stacylam Street, Chicago IL
Error Check	Street address without city	100 Main Street

Figure 1.2: Image: Sample address data screenshot

First, click this link and Save to download the sample file to your computer: sample-address-data in CSV format. CSV means comma-separated-values, a generic spreadsheet format that many tools can easily open. If you need help with downloading, see this short video tutorial.

Next, build a point map with the sample data, by following the tutorials for the three tools below.

Tool	Step-by-step tutorial in this book
Google My Maps	My Maps tutorial
Carto Builder	Carto tutorial

Finally, rate your experience using each tool with these selected criteria:

- Easy-to-learn: Which tool was the simplest for creating a basic point map?
- Price: Which of these free tools provided the most services at no cost?
- Customization: Which tool enabled you to modify the most details about your map?
- Data Migration: Which tool most easily allowed you to import and export your data?

- Error-friendly: Which tool geocoded most accurately or signaled possible errors?

Recommended: Enroll in our free online course **LINK TO DO** to compare your ratings to other students.

Summary

TODO

Chapter 2

Strengthen Your Spreadsheet Skills

Before we begin to design data visualizations, it's important to make sure our spreadsheet skills are up to speed. While teaching this topic, we've heard many people describe how they "never really learned" how to use spreadsheet tools as part of their official schooling or workplace training. But spreadsheet skills are vital to learn, not only as incredible time-savers for tedious tasks, but more importantly, to help us discover the stories buried inside our data.

The interactive charts and maps that we'll construct later this book are built on data tables, which we typically open with spreadsheet tools, such as Google Sheets, LibreOffice, or Microsoft Excel. Spreadsheets typically contain columns and rows of numerical or textual data, as shown in Figure 2.1. The first row often contains headers, meaning labels describing the data in each column. Also, columns are automatically labeled with letters, and rows with numbers, so that every cell or box in the grid can be referenced, such `C2`. When you click on a cell, it may display a formula that automatically runs a calculation with references other cells. Formulas always begin with an equal sign, and may simply add up other cells (such as `=C2+C3+C4`), or may contain a function that performs a specific operation (such as calculating the average of a range of cells: `=average(C2:C7)`). Some spreadsheet files contain multiple sheets (sometimes called workbooks), where each tab across the bottom opens a specific sheet.

In this chapter, we'll start by reviewing basic steps, such as sharing, uploading, and collecting data with online forms. Then we'll move on to ways of organizing and analyzing your data, such as sorting and filtering, calculating with formulas, and summarizing with pivot tables. Finally, we'll examine ways to connect different sheets, such as matching columns with lookup tables, and relational databases. We illustrate all of these methods with beginner-level users in mind, meaning they do not require any prior background.

The screenshot shows a spreadsheet interface with a table of data. The table has columns labeled A through E. Row 1 contains the header labels: Name, Location, Experience, Years of school, and Occupation. Rows 2 through 7 contain data for five individuals: Jack, Anthony, Emily, Hayat, Ignacio, and Carly. The formula bar at the top shows '=average(C2:C7)'. The cell C8 contains the value '2.17', which is highlighted with a blue border and labeled 'Active cell (see formula at top)' in red text. The bottom navigation bar includes buttons for '+', '≡', 'data', 'notes', and 'Tabs for multiple sheets'.

	A	B	C	D	E
1	Name	Location	Experience	Years of school	Occupation
2	Jack	Hartford, Connecticut	4	20	educator
3	Anthony	Juba, South Sudan	1	16	non-profit org
4	Emily	Boston, MA	2	16	non-profit org
5	Hayat	Pakistan	1	16	information technology
6	Ignacio	Buenos Aires, Argentina	3	16	for-profit business
7	Carly	Montreal	2	20	student
8			2.17	Active cell (see formula at top)	
9					

+ ≡ data ▾ notes ▾ Tabs for multiple sheets

Figure 2.1: Screenshot of a typical spreadsheet, with headers, tabs, and the active cell displaying a formula.

If you want to learn ways to make your computer do more of the tedious data preparation work for you, this chapter is definitely for you. Or if you already feel very familiar with spreadsheets, you should at least skim this chapter, and perhaps you'll learn a trick or two that will help you to create charts and maps more efficiently later in the book.

Select your Spreadsheet Tools

Which spreadsheet tools should you use? As we describe in more detail in Chapter 1: Choose Tools to Tell Your Data Story, the answer depends on how you respond to different questions about your work. First, is your data public or private? If private, consider using a downloadable spreadsheet tool that runs on your computer, to reduce the risk of an accidental data breach that might happen when using an online spreadsheet tool that automatically stores your data in the cloud. Second, will you be working solo or with other people? For collaborative projects, consider using an online spreadsheet tool that's designed to allow other team members to simultaneously view or edit data. Third, do you need to import or export data in any specific format (which we'll describe in the next section), such as Comma Separated Values (CSV)? If yes, then choose a spreadsheet tool that supports that format. Finally, do you prefer a free tool, or are you willing to pay for it, or donate funds to support open-source development?

Here's how three common spreadsheet tools compare on these questions:

- Google Sheets is a free online spreadsheet tool that works in any modern web browser, and automatically stores your data in the cloud. While data you upload is private by default, you can choose to share it with specific

individuals or anyone on the internet, and allow them to view or edit for real-time collaboration, similar to Google Documents. Google Sheets also imports and exports data in CSV, ODS, Excel, and other formats. You can sign up for a free personal Google Drive account with the same username as your Google Mail account, or create a separate account under a new username to reduce Google's invasion into your private life. Another option is to pay for a Google Suite business account subscription, which offers nearly identical tools, but with sharing settings designed for larger organizations or educational institutions.

- LibreOffice is a free downloadable suite of tools, including its Calc spreadsheet, available for Mac, Windows, and Linux computers, and is an increasingly popular alternative to Microsoft Office. When you download LibreOffice, its sponsor organization, The Document Foundation, requests a donation to continue its open-source software development. The Calc spreadsheet tool imports and exports data in its native ODS format, as well as CSV, Excel, and others. While an online collaborative platform is under development, it is not yet available for broad usage.
- Microsoft Excel is the spreadsheet tool in the Microsoft Office suite, which is available in different versions, though commonly confused as the company has changed its product names over time. A paid subscription to Microsoft 365 provides you with two versions: the full-featured downloadable version of Excel (which is what most people mean when they simply say "Excel") for Windows or Mac computers and other devices, and access to a simpler online Excel through your browser, including file sharing with collaborators through Microsoft's online hosting service. If you do not wish to pay for a subscription, anyone can sign up for a free version of online Excel at Microsoft's Office on the Web, but this does *not* include the full-featured downloadable version. The online Excel tool has limitations. For example, neither the paid nor the free version of online Excel allows you to save files in the single-sheet generic Comma Separated Values (.csv) format, an important feature required by some data visualization tools in later chapters of this book. You can only export to CSV format using the downloadable Excel tool, which is now available only with a paid Microsoft 365 subscription.

Deciding which spreadsheet tools to use is not a simple choice. Sometimes our decisions change from project to project, depending on costs, data formats, privacy concerns, and the personal preferences of any collaborators. Occasionally we've also had co-workers or clients specifically request that we send them non-sensitive spreadsheet data attached to an email, rather than sharing it through a spreadsheet tool platform that was designed for collaboration. So it's best to be familiar with all three commonly-used spreadsheet tools above, and to understand their respective strengths and weaknesses.

In this book, we primarily use Google Sheets for most of our examples. All of the data we distribute through this book is public. Also, we wanted a spreadsheet

tool designed for collaboration, so that we can share links to data files with readers like you, so that you can view our original version, and either make a copy to edit in your own Google Drive, or download in a different format to use in LibreOffice or Excel. Most of the spreadsheet methods we teach look the same across all spreadsheet tools, and we point out exceptions when relevant.

Sidebar: Common data formats

Spreadsheet tools organize data in different formats. When you download spreadsheet data to your computer, you typically see its filename, followed by a period and a 3- or 4-character abbreviated extension, which represents the data format, as shown in Figure 2.2. The most common data formats we use in this book are:

- `.csv` means Comma Separated Values, a generic format for a single sheet of simple data, which saves no formulas nor styling.
- `.ods` means OpenDocument Spreadsheet, a standardized open format that saves multi-tabbed sheets, formulas, styling, etc.
- `.xlsx` or the older `.xls` means Excel, a Microsoft format that supports multi-tabbed sheets, formulas, styling, etc.
- `.gsheet` means Google Sheets, which also supports multi-tabbed sheets, formulas, styling, etc., but you don't normally see these on your computer because they are primarily designed to exist online.

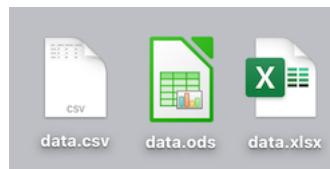


Figure 2.2: Three data formats commonly seen on your computer—`csv`, `ods`, and `xlsx`—when displayed properly in the Mac Finder.

Warning: Several tools in this book may not work properly on a Mac computer that does not display the filename extensions, meaning the abbreviated file format after the period, such as `data.csv` or `map.geojson`. The Mac operating system hides these by default, so you need to turn them on by going to `Finder > Preferences > Advanced`, and check the box to *Show all filename extensions*, as shown in Figure 2.3.

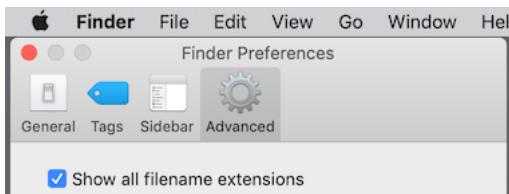


Figure 2.3: On a Mac, go to Finder > Preferences > Advanced and check the box to *Show all filename extensions*.

Download to CSV or ODS Format

In Chapter 1: Choose Tools to Tell Your Data Story, we learned the advantages of selecting software tools that support data migration, so that you can export your work to other platforms. Since digital technology is always changing, it's a good rule of thumb to never upload important data into a tool if you can't easily get it back out. Ideally, spreadsheet tools should allow you to export your work in generic or open-data file formats, such as Comma Separated Values (CSV) and OpenDocument Spreadsheet (ODS), to maximize your options to migrate to other platforms.

Warning: If you're working in any spreadsheet with multiple tabs and formulas, a CSV export will save only the *active sheet* (meaning the one you're currently viewing), and only the *data* in that sheet (meaning that if you inserted formulas to run calculations, only the results would appear, not the formulas). Later in this book you may need to create a CSV file to import into a data visualization tool, so if the source was a multi-tabbed spreadsheet with formulas, keep track of the original.

One reason we feature Google Sheets in this book is because it exports data in several common formats. To try it, open this Google Sheets sample data file in a new tab, and go to *File > Download As* to export in CSV format (for only the data in the active sheet) or ODS format (which keeps data and most formulas in multi-tab spreadsheets), or other formats such as Excel, as shown in Figure 2.4. Similarly, in the downloadable LibreOffice and its Calc spreadsheet tool, select *File > Save As* to save data in its native ODS format, or to export to CSV, Excel, or other formats.

But exporting data can be trickier in Microsoft Excel. Using the online Excel tool in your browser (either the free or paid version), you *cannot* save files in the generic single-sheet CSV format, a step required by some data visualization tools in later chapters of this book. Only the downloadable Excel tool (which now requires a paid subscription) will export in CSV format, a step required by some data visualization tools in later chapters of this book. And when using the downloadable Excel tool to save in CSV format, the steps sometimes confuse people. First, if you see multiple CSV options, choose *CSV UTF-8*, which

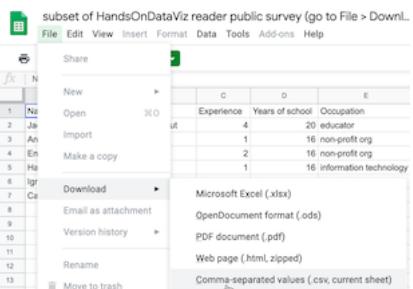


Figure 2.4: In Google Sheets, go to *File > Download As* to export data in several common formats.

should work best across different computer platforms. Second, if your Excel workbook contains multiple sheets or formulas, you may see a warning that it cannot be saved in CSV format, which only saves data (not formulas) contained in the active sheet (not all sheets). If you understand this, click *OK* to continue. Third, on the next screen, Excel may warn you about “Possible data loss” when saving an Excel file in CSV format, for reasons described above. Overall, when working with the downloadable Excel tool, first save the full-version of your Excel file in XLSX format before exporting a single sheet in CSV format.

Once you’ve learned how to export your spreadsheet data into an open format, you’re ready to migrate it into other data visualization tools or platforms that we’ll introduce in later chapters of this book. Data portability is key for ensuring that your charts and maps will last well into the future.

Make a Copy of a Google Sheet

In this book we provide several data files using Google Sheets. Our links point to the online files, and we set the sharing settings to allow anyone to view—but not edit—the original version. This allows everyone to have access to the data, but no one can accidentally modify the contents. In order for you to complete several exercises in this chapter, you need to learn how to make your own copy of our Google Sheets—which you can edit—without changing our originals.

Let’s begin by making a copy of a real dataset that may interest you, because it includes people like you. So far about 3,000 readers of this book have responded to a quick public survey about their general location, prior level of experience and education, and goals for learning data visualization. If you haven’t already done so, fill out the quick survey form to contribute your own response, and also to give you a better sense of how the questions were posed. Later in this chapter you’ll learn how to create your own online form with a link to spreadsheet results.

1. Open this Google Sheet of Hands-On Data Visualization reader public

survey responses in a new tab in your browser. We set it to “View only” so that anyone on the internet can see the contents, but not edit the original file.

2. Sign in to your Google account by clicking the blue button in the upper-right corner.
3. Go to *File > Make a Copy* to create a duplicate of this Google Sheet in your Google Drive, as shown in Figure 2.5. You can rename the file to remove “Copy of...”.

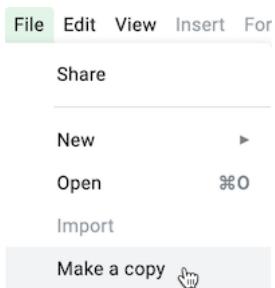


Figure 2.5: Go to *File > Make a Copy* to create your own version of this Google Sheet.

4. To keep your Google Drive files organized, save them in folders with relevant names to make them easier to find. For example, you can click the *My Drive* button and the *New folder* button to create a folder for your data, before clicking *OK*, as shown in Figure 2.6.

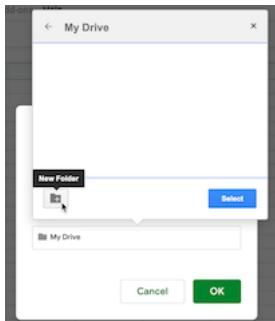


Figure 2.6: Click the *My Drive* and *New folder* buttons to save your work in a folder.

Your copy of the Google Sheet will be private to you only, by default. In the next section we’ll learn about different options for sharing your Google Sheet data with others.

Share Your Google Sheets

If you're working on a collaborative project with other people, Google Sheets offers several ways to share your data online, even with people who do not own a Google account. When you create a new Sheet, its default setting is private, meaning only you can view or edit its contents. In this section, you'll learn how to expand those options using the *Share* button.

1. Log into your Google Drive account, click the *New* button, select *Google Sheets*, and create a blank spreadsheet. You will need to name your file to proceed with next steps.
2. Click the *Share* button in the upper-right corner, and your options will appear on the *Share with people and groups* screen, as shown in Figure 2.7.
3. In the top half of the screen, you can share access with specific individuals by typing their Google usernames into the *Add people and groups* field. For each person or group you add, on the next screen select the drop-down menu to choose if they can *View*, *Comment* on, or *Edit* the file. Decide if you wish to notify them with a link to the file and optional message.
4. In the lower half of the screen, you can share access more widely by clicking on *Change to anyone with the link*. On the next screen, the default option is to allow anyone who has the link to *View* the file, but you can change this to allow anyone to *Comment* on or *Edit* it. Also, you can click *Copy link* to paste the web address to your data in an email or public website.

Tip: If you don't want to send people a really long and ugly Google Sheet web address such as:

https://docs.google.com/spreadsheets/d/1egX_akJccnCSzdk1aaDdtrEGe5HcaTr1OW-Yf6mJ3Uo

then use a free link-shortening service. For example, by using our free Bitly.com account and its handy Chrome browser extension or Firefox browser extension, we can paste in a long URL and customize the back-end to something shorter, such as bit.ly/reader-survey, as shown in Figure 2.8. If someone else has already claimed your preferred custom name, you'll need to think up a different one. Beware that `bit.ly` links are case-sensitive, so we prefer to customize the back-end in all lower-case to match the front-end.

Now that you have different options for sharing a Google Sheet, let's learn how to upload and convert data from different formats.

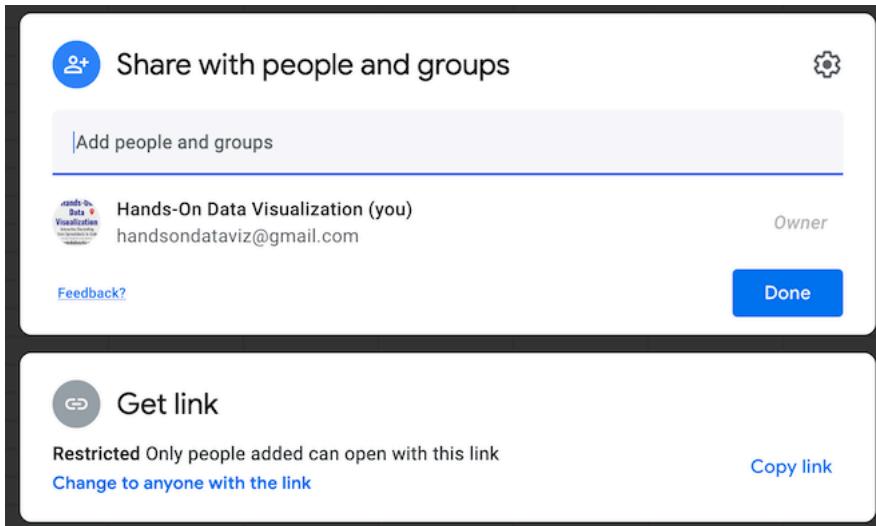


Figure 2.7: Click the *Share* button to grant access to individuals (top half) or anyone with the link (bottom half).

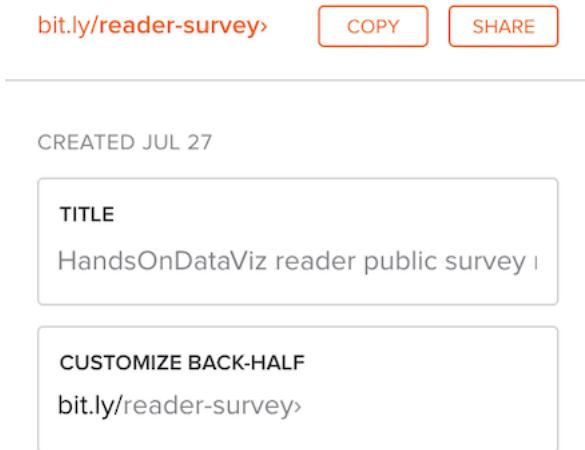


Figure 2.8: Use a free link-shortening service, such as Bitly.com, and customize its back-end.

Upload and Convert to Google Sheets

We feature Google Sheets in this book partly because it supports data migration, meaning the ability to import and export files in many common formats. But imports work best when you check the *Convert uploads* box, which is hidden inside the Google Drive Settings gear symbol as shown in Figure 2.9. Checking this box automatically transforms Microsoft Excel sheets into Google Sheets format (and also Microsoft Word and PowerPoint files into Google Documents and Slides formats), which allows easier editing. If you don't check this box, then Google will keep your files in their original format, which makes them harder to edit. Google turns off this conversion setting by default on new accounts, but we'll teach you how to turn it on, and the benefits of doing so.

1. Find a sample Excel file you can use on your computer. If you don't have one, open and save to download to your computer this Excel file of a subset of the Hands-On Data Visualization reader public survey responses
2. Log into your Google Drive account, and click the *Gear symbol* in the upper-right corner, as shown in Figure 2.9, to open the Settings screen. Note that this global *Gear symbol > Settings* appears at Google Drive level, *not* inside each Google Sheet.

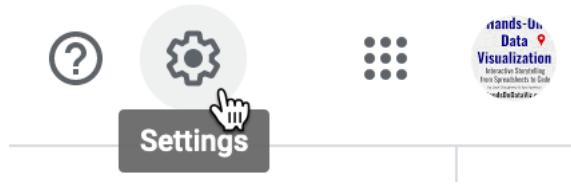


Figure 2.9: Click your Google Drive *Gear Symbol > Settings* in the upper-right corner.

3. On the Settings screen, check the box to *Convert uploaded files to Google Docs editor format*, as shown in Figure 2.10, and click *Done*. This turns on the conversion setting globally, meaning it will convert all possible files that you upload in the future—including Microsoft Excel, Word, PowerPoint, and more—unless you turn it off.
4. Upload a sample Excel file from your computer to your Google Drive. Either drag-and-drop it to the desired folder, as shown in Figure 2.11, or use the *New* button and select *File upload*.

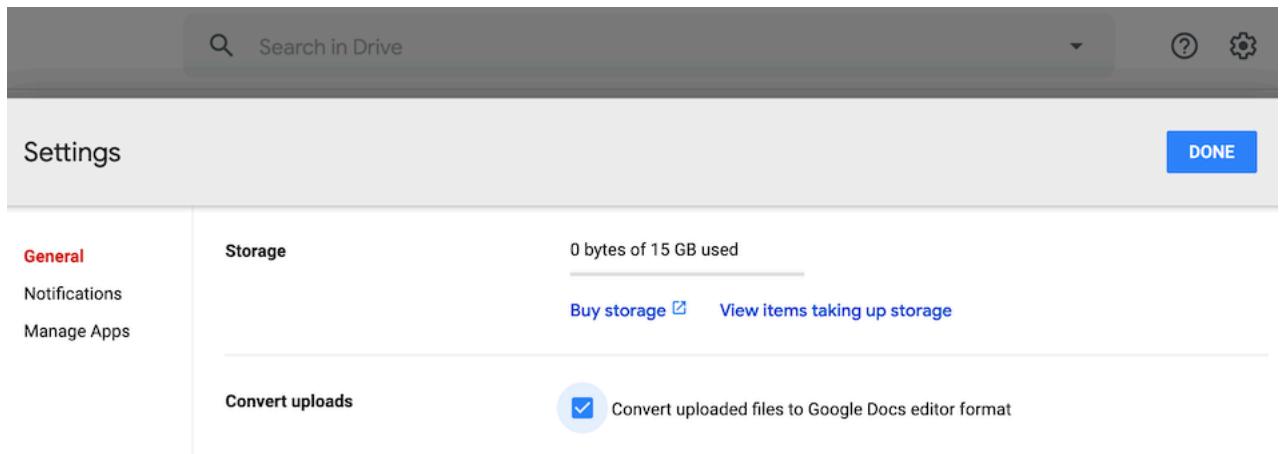


Figure 2.10: Inside your Google Drive Settings, check the box to automatically convert all uploads.

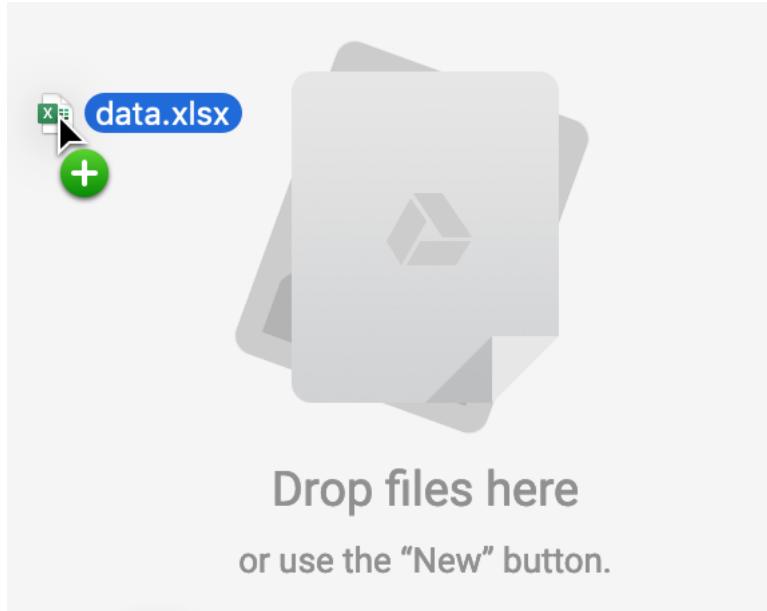


Figure 2.11: Drag-and-drop your sample Excel file into your Google Drive to upload it.

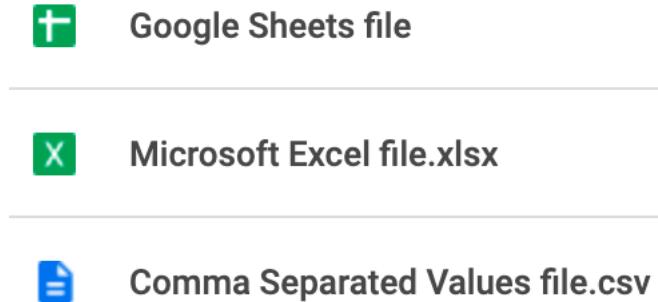


Figure 2.12: If you forget to convert uploads, Google Drive will keep files in their original format with these icons.

If you forget to check the *Convert uploads* box, Google Drive will keep uploaded files in their original format, and display their icons and file name extensions such as `.xlsx` or `.csv`, as shown in Figure 2.12.

Tip: Google Drive now allows you to edit Microsoft Office file formats, but not all features are guaranteed to work across platforms. Also, Google Drive now allows you to convert a specific uploaded Excel file into its Google format by using the *File > Save as Google Sheets* menu. Finally, to convert individual files to your Google Drive, while keeping the global conversion setting off, from inside any Google Sheet you can select *File > Import > Upload*. But we recommend that most people turn on the global conversion setting as described above, except in cases where you intentionally use Google Drive to edit an Excel-formatted file, and understand that some features may not work.

Now that you know how to upload and convert an existing dataset, in the next section you will learn how to collect data using an online form, and access it as a spreadsheet.

Collect Data with Google Forms

As you saw in prior sections, we invite readers of this book to fill out a quick online form so that we can learn more about people like you, and to continue to make revisions to match your expectations. So far about 3,000 readers have responded, and you can view this public spreadsheet of survey responses about their generation location, prior level of experience and education, and goals for learning data visualization. In this section, you'll learn how to create an online form and link the results to a live Google Sheet.

Inside your Google Drive account, one tool that's often overlooked is Google

Forms, which is partially hidden under *New > More > Google Forms*, as shown in Figure 2.13.

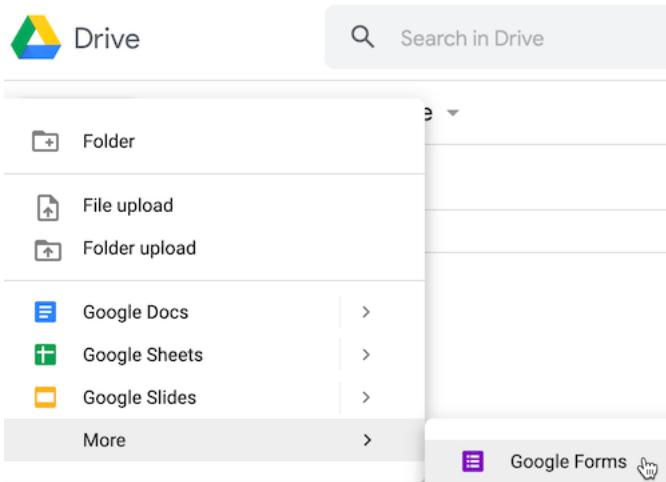


Figure 2.13: The Google Forms tool is partially hidden in the Google Drive *New > More* menu.

The Google Forms *Questions* tab allows you to design questions with different types of responses: short- and paragraph-length answers, multiple choice, checkboxes, file uploads, etc., as shown in Figure 2.14.

Give each question a very short title, since these will appear as column headers in the linked spreadsheet you'll create further below. If a question needs more explanation or examples, click the three-dot kebob menu in the bottom-right corner to *Show > Description*, which opens a text box where you can type in more details, as shown in Figure 2.15. Also, you can *Show > Response validation*, which requires users to follow a particular format, such as an email address or phone number.

To preview how your online will appear to recipients, click the *Eyeball symbol* near the top of the page, as shown in Figure 2.16. When your form is complete, click the *Send* button to distribute it via email, a link, or to embed the live form as an iframe on a web page. Learn more about the latter option in Chapter 7: Embed On Your Web.

The Google Forms *Responses* tab will show individual results you receive, and also includes a powerful button to open the data in a linked Google Sheet, as shown in Figure 2.17.

Now that you've learned how to collect data with an online form and linked spreadsheet, the next two sections will teach you how to sort, filter, and pivot tables to begin analyzing their contents and the stories they reveal.

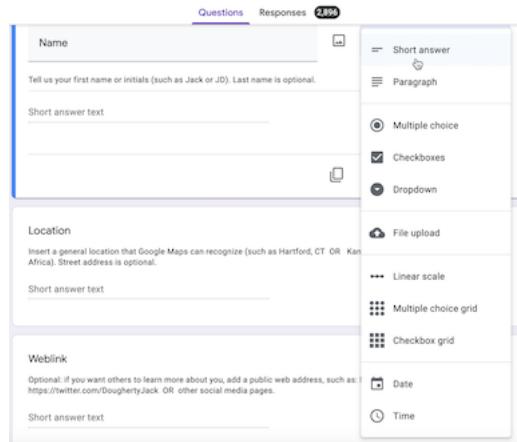


Figure 2.14: The Google Forms *Questions* tab allows you to designate different types of responses.

Name

Tell us your first name or initials (such as Jack or JD). Last name is optional.

Short answer text

Location

Insert a general location that Google Maps can recognize (such as Hartford, CT OR Kansas, USA OR Cape Town, South Africa). Street address is optional.

Required

Show > Description

Description

Response validation

Figure 2.15: Click the three-dot kebab menu to *Show > Description* to add details for any question.

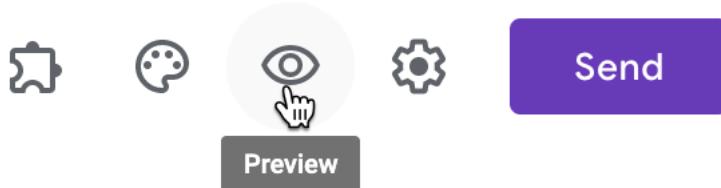


Figure 2.16: Click the *Eyeball symbol* to preview your form.

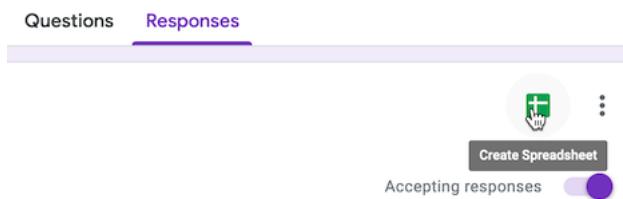


Figure 2.17: The Google Forms *Responses* tab includes a button to open results in a linked Google Sheet.

Sort and Filter Data

Spreadsheet tools help you delve into your data and lift its stories to the surface. A basic step in organizing your data is to *sort* a table by a particular column, to quickly view its minimum and maximum values, and the range that lies in between. A related method is to *filter* an entire table to display only rows that contain certain values, to help them stand out for further study among all of the other entries. Both of these methods become more powerful when your spreadsheets contain hundreds or thousands of rows of data.

To learn how to sort and filter, let's explore a large dataset of around 3,000 readers of this book who responded to a quick public survey about their general location, prior level of experience and education, and goals for learning data visualization. If you haven't already done so, fill out the quick survey form to contribute your own response, and also to give you a better sense of how the questions were posed.

1. Open this Google Sheet of Hands-On Data Visualization reader public survey responses in a new tab in your browser.
2. Login to your Google Sheets account, and go to *File > Make a Copy* to create your own version that you can edit.
3. Before sorting, click the upper-left corner of the sheet to select all cells, as

shown in Figure 2.18. The entire sheet should become light blue to show you've selected all cells.

	A	B	C
1	Timestamp	Name	Location
2	1/14/2017 11:49:02	Jack	Hartford, CT
3	2/4/2017 9:02:39	Ania	Needham, MA
4	2/8/2017 14:35:56	Devan Suggs	Hartford, CT
5	2/8/2017 17:42:02	Alex	Chicago, IL
6	2/8/2017 21:49:00	Nhat Pham	Hanoi, Viet Nam

Figure 2.18: Click the upper-left corner to select all cells before sorting.

Warning: If you forget to select all cells, you might accidentally sort one column independently of the others, which will scramble your dataset and make it meaningless. Always select all cells before sorting!

4. Go to *Data > Sort Range* to review all of your sort options. In the next screen, check the *Data has header row* box to view the column headers in your data. Let's sort the *Experience with data visualization* column in ascending order (from A-Z), as shown in Figure 2.19, to display the minimum at the top, the maximum at the bottom, and the range in between.

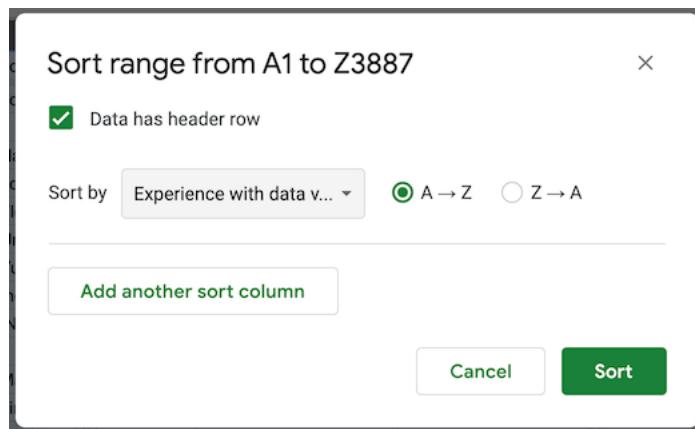


Figure 2.19: Go to *Data > Sort Range*, check the header row box, and sort by *Experience with dataviz* in ascending order.

Scroll through your sorted data and you'll see that over 1,000 readers rated themselves as beginners (level 1) with data visualization.

Tip: When working with large spreadsheets, you can “freeze” the first row so that column headers will still appear as you scroll downward. In Google Sheets, go to *View > Freeze* and select 1 row, as shown in Figure 2.20. You can also freeze one or more columns to continuously display when scrolling sideways. LibreOffice has a same option to *View > Freeze Rows and Columns*, but Excel has a different option called *Window > Split*.

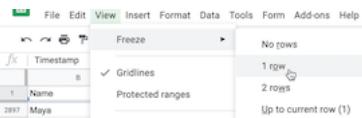


Figure 2.20: In Google Sheets, go to *View > Freeze* to select the number of rows to continuously display when scrolling downward.

- Now let's try filtering your sheet. Go to *Data > Create a Filter*, which inserts downward arrows in each column header. Click on the downward arrow in the *Occupation* column, and see options to display or hide rows of data. For example, click the “Clear” button to undo all options, then click only *educator* to display only rows with that response, as shown in Figure 2.21. Click “OK”.

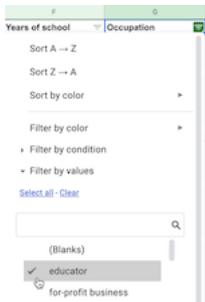


Figure 2.21: Go to *Data > Create a Filter*, click the downward arrow in the *Occupation* column, select only *educator*.

Now your view of reader responses is sorted by experience, and filtered to show only educators. Scroll through their one-sentence goals for learning about data visualization. How do they compare to your own goals? In the next section, we'll learn how to start analyzing your data with simple formulas and functions.

Calculate with Formulas

Spreadsheet tools can save you lots of time when you insert simple formulas and functions to automatically perform calculations across entire rows and columns of data. Formulas always begin with an equal sign, and may simply add up other cells (such as `=C2+C3+C4`), or may contain a function that performs a specific operation (such as calculating the sum of a range of cells: `=SUM(C2:C100)`). In this section you'll learn how to write two formulas with functions: one to calculate an average numeric value, and another to count the frequency of a specific text response.

Let's explore a large dataset of around 3,000 readers of this book who responded to a quick public survey about their general location, prior level of experience and education, and goals for learning data visualization. If you haven't already done so, fill out the quick survey form to contribute your own response, and also to give you a better sense of how the questions were posed.

1. Open this Google Sheet of Hands-On Data Visualization reader public survey responses in a new tab in your browser.
2. Log into your Google Drive account, and go to *File > Make a Copy* to edit your own version.
3. Add a blank row immediately below the header to make space for our calculations. Right-click on row number 1 and select *Insert 1 below* to add a new row, as shown in Figure 2.22.

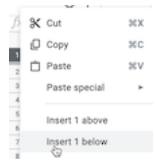


Figure 2.22: Right-click on row number 1 and select *Insert 1 below*.

4. Let's calculate the average level of reader experience with data visualization. Click on cell E2 in the new blank row you just created, and type an equal symbol (=) to start a formula. Google Sheets will automatically suggest possible formulas based on the context, and you can select one that displays the average for current values in the column, such as `=AVERAGE(E3:E2894)`, then press *Return* or *Enter* on your keyboard, as shown in Figure 2.23.

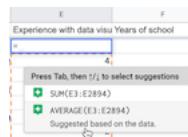


Figure 2.23: Type `=` to start a formula and select the suggestion for average, or type it directly in with the correct range.

Since our live spreadsheet has a growing number of survey responses, you will have a larger number in the last cell reference to include all of the entries in your version. Currently, the average level of reader experience with data visualization is around 2 on a scale from 1 (beginner) to 5 (professional), but this may change

as more readers fill out the survey. Note that if any readers leave this question blank, spreadsheet tools ignore empty cells when performing calculations.

Tip: In Google Sheets, another way to write the formula above is `=AVERAGE(E3:E)`, which averages *all* values in column E, beginning with cell E3, without specifying the last cell reference. Using this syntax will keep your calculations up-to-date if more rows are added, but it does *not* work with LibreOffice or Excel.

5. Part of the magic of spreadsheets is that you can use the built-in hold-and-drag feature to copy and paste a formula across other columns or rows, and it will automatically update its cell references. Click in cell E2, and then press and hold down on the blue dot in the bottom-right corner of that cell, which transforms your cursor into a crosshair symbol. Drag your cursor to cell F2 and let go, and show in Figure 2.24. The formula will be automatically pasted and updated for the new column to `=AVERAGE(F3:F2894)` or `AVERAGE(F3:F)`, depending on which way you entered it above. Once again, since this is a live spreadsheet with a growing number of responses, your sheet will have a larger number in the last cell reference.

E	F	Occ
Experience with data	Years of school	Occ
2.090909091	4	20 edu
Experience with data	Years of school	Occ
2.090909091	4	20 edu
Experience with data	Years of school	Occ
2.090909091	17.80737062	20

Figure 2.24: Click on the blue bottom-right dot in cell E2, then hold-and-drag your crosshair cursor in cell F2, and let go to automatically paste and update the formula.

6. Since the *Occupation* column contains a defined set of text responses, let's use a different function to count them using an *if statement*, such as the number of responses if a reader listed “educator”. Click in cell G2 and type the equal symbol (=) to start a new formula. Google Sheets will automatically suggest possible formulas based on the context, and you can select one that displays the count if the response is *educator* for current values in the entire column. You can directly type in the formula `=COUNTIF(G3:G2894, "=educator")`, where your last cell reference will be a larger number to reflect all of the rows in your version, or type in the Google Sheets syntax `=COUNTIF(G3:G, "=educator")` that runs the calculation on the entire column without naming a specific endpoint, as shown in Figure 2.25.

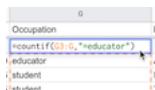


Figure 2.25: Select or enter a formula that counts responses if the entry is *educator*.

Spreadsheet tools contain many more functions to perform numerical calculations and also to modify text. Read more about functions in this support pages for Google Sheets, LibreOffice, or Microsoft Excel support page. See additional spreadsheet skills in later chapters of the book. Chapter 4: Clean Up Messy Data demonstrates how to find and replace, split data into columns, and combine columns of data (such as when you need the street address, city, and postal code all in one line). Chapter 11: Transform Your Map Data also features more advanced spreadsheet skills and tools, such as how to geocode addresses, pivot address points into polygons, and how to normalize data to create more meaningful polygon maps.

Now that you've learned how to count one type of survey response, the next section will teach you how to regroup data with pivot tables that summarize all responses by different categories.

Summarize Data with Pivot Tables

Pivot tables are another powerful feature built into spreadsheet tools to help you reorganize your data and summarize it in a new way, hence the name “pivot.” Yet pivot tables are often overlooked by people who were never taught about them, or have not yet discovered how to use them. In this section, we’ll start with a large dataset of around 3,000 readers of this book who responded to a quick public survey. Each row represents an individual reader, including their occupation and prior level of experience with data visualization. You’ll learn how to “pivot” this individual-level data into a new table that displays the total number of reader responses by two categories: occupation and experience level.

1. Open this Google Sheet of Hands-On Data Visualization reader public survey responses in a new tab in your browser. Log into your Google Drive account, and go to *File > Make a Copy* to edit your own version.
2. Or, if you have already created your own copy for the prior section on Formulas and Functions, delete row 2 that contains our calculations, because we don’t want those getting mixed into our pivot table.
3. Go to *Data > Pivot Table*, and on the next screen, select *Create* in a new sheet, as shown in Figure 2.26. The new sheet will include a Pivot Table tab at the bottom.

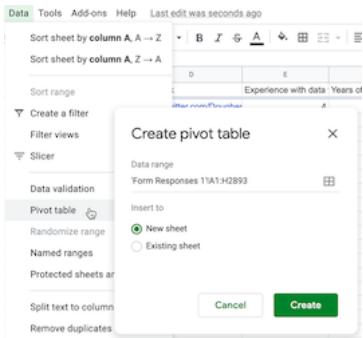


Figure 2.26: Go to *Data > Pivot Table*, and create in a new sheet.

4. In the *Pivot table editor* screen, you can regroup data from the first sheet by adding rows, columns, and values. First, click the Rows *Add* button and select *Occupation*, which displays the unique entries in that column, as shown in Figure 2.27.

Figure 2.27: In the *Pivot table editor*, click the Rows *Add* button and select *Occupation*.

5. Next, to count the number of responses for each entry, click the Values *Add* button and select *Occupation* again. Google Sheets will automatically summarize the values by *COUNTA*, meaning it displays the frequency of each textual response, as shown in Figure 2.28.

Currently, the top three occupations listed by readers are information technology, for-profit business, and student. Since this is a live spreadsheet, these rankings may change as more readers respond to the survey.

6. Furthermore, you can create a more advanced pivot cross-tabulation of occupation and experience among reader responses. Click on the *Columns* button to add *Experience with data visualization*, as shown in Figure 2.29.

The screenshot shows the 'Pivot table editor' interface. In the 'Values' section, the 'Add' button is highlighted. A dropdown menu for 'Occupation' is open, showing options like 'Order', 'Sort by', and 'Show totals'. The 'Show totals' checkbox is checked.

Figure 2.28: In the *Pivot table editor*, click the Values *Add* button and select *Occupation*.

The screenshot shows the 'Pivot table editor' interface. In the 'Columns' section, the 'Add' button is highlighted. A dropdown menu for 'Experience with data visualization' is open, showing options like 'Order', 'Sort by', and 'Show totals'. The 'Show totals' checkbox is checked.

Figure 2.29: In the *Pivot table editor*, click the Columns *Add* button and select *Experience with data visualization*.

To go one step further, *Filter* the data to limit the pivot table results by another category. For example, you can click the Filters *Add* button and select *Years of school* to display only readers who listed 20 or more years.

Deciding how to add *Values* in the *Pivot table editor* can be challenging, because there are multiple options to summarize the data, as shown in Figure 2.30. Google Sheets will offer its automated guess based on the context, but you may need to manually select the best option to represent your data as desired. Three of the most common options to summarize values are:

- SUM: the total value of numeric responses (What is the total years of schooling for readers?)
- COUNT: frequency of numeric responses (How many readers listed 20 years of schooling?)

- COUNTA: frequency of text responses (How many readers listed occupation as “educator”)

Although Google Sheets pivot tables show raw numbers by default, you also can choose to display them as percentages of the row, of the column, or of the grand total.

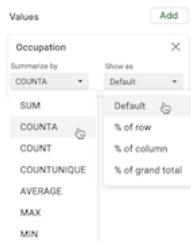


Figure 2.30: In the *Pivot table editor*, see multiple options to summarize *Values*.

While designing pivot tables may look differently across other spreadsheet tools, the concept is the same. Learn more about how pivot tables work in the support pages for Google Sheets or LibreOffice or Microsoft Excel. Remember that you can download the Google Sheets data and export to ODS or Excel format to experiment with pivot tables in other tools.

Now that you’ve learned how to regroup and summarize data with pivot tables, in the next section you’ll learn a related method to connect matching data columns across different spreadsheets using VLOOKUP.

Match Columns with VLOOKUP

Spreadsheet tools also allow you to “look up” data in one sheet and automatically find and paste matching data from another sheet. This section introduces the VLOOKUP function, where the “V” stands for “vertical,” meaning matches across columns, which is the most common way to look up data. You’ll learn how to write a function in one sheet that looks for matching cells in select columns in a second sheet, and pastes the relevant data into a new column in the first sheet. If you’ve ever faced the tedious task of manually looking up and matching data between two different spreadsheets, this automated method will save you lots of time.

Here’s a scenario that illustrates why and how to use the VLOOKUP function. Figure 2.31 shows two different sheets with sample data about food banks that help feed hungry people in different parts of the US, drawn from Feeding America: Find Your Local Food Bank. The first sheet lists individual people at each food bank, the second sheet lists the address for each food bank, and the two share a common column named *organization*. Your goal is to produce one sheet

that serves as a mailing list, where each row contains one individual's name, organization, and full mailing address. Since we're using a small data sample to simplify this tutorial, it may be tempting to manually copy and paste in the data. But imagine an actual case that includes over 200 US food banks and many more individuals, where using an automated method to match and paste data is essential.

	A	B		A	B	C	D	E
1	name	organization	1	organization	street	city	state	zip
2	Denise B.	Central Texas Food Bank	2	Arkansas Food Bank	4301 W 65th St	Little Rock	AR	77209
3	Derrick C.	Central Texas Food Bank	3	Central Texas Food Bank	6500 Metropolis Dr	Austin	TX	78744
4	Eric S.	Arkansas Food Bank	4	Utah Food Bank	3150 South 900 West	Salt Lake City	UT	84119
5	Ginette B.	Utah Food Bank	5					
6	Greg F.	Arkansas Food Bank	6					
7	Kent L.	Utah Food Bank	7					
8	Mark J.	Central Texas Food Bank	8					
9	Rhonda S.	Arkansas Food Bank	9					
10	Sarah R.	Arkansas Food Bank	10					
11	Scott W.	Utah Food Bank	11					
12			12					

Below the table are tabs for 'names' and 'addresses' with dropdown menus for sorting and filtering.

Figure 2.31: Your goal is to create one mailing list that matches individual names and organizations on the left sheet with their addresses on the right sheet.

1. Open this Google Sheet of Food Bank sample names and addresses in a new browser tab. Log into your Google Drive, and go to *File > Make a Copy* to create your own version that you can edit.

We simplified this two-sheet problem by placing both tables in the same Google Sheet. Click on the first tab, called *names*, and the second tab, called *addresses*. In the future, if you need to move two separate Google Sheets into the same file, go to the tab of one sheet, right-click the tab to *Copy to > Existing spreadsheet*, and select the name of the other sheet.

2. In your editable copy of the Google Sheet, the *names* tab will be our destination for the mailing list we will create. Go to the *addresses* sheet, copy the column headers for *street - city - state - zip*, and paste them into cells C1 through F1 on the *names* sheet, as shown in Figure 2.32. This creates new column headers where our lookup results will be automatically pasted.
3. In the *names* sheet, click in cell C2 and type `=VLOOKUP`, and Google Sheets will suggest that you complete the full formula in this format:

	A	B	C	D	E	F
1	name	organization	street	city	state	zip
2	Denise B.	Central Texas Food Bank				
3	Derrick C.	Central Texas Food Bank				
4	Eric S.	Arkansas Food Bank				
5	Ginette B.	Utah Food Bank				

+ names addresses source

Figure 2.32: Paste the last four column headers from the *addresses* sheet into the *names* sheet.

```
VLOOKUP(search_key, range, index, [is_sorted])
```

Here's what each part means:

- search_key = The cell in 1st sheet you wish to match.
 - range = At least two columns in the 2nd sheet to search for your match and desired result.
 - index = The column in the 2nd sheet range that contains your desired result, where 1 = first column, 2 = second column, etc.
 - [is_sorted] = Enter `false` to find exact matches only, which makes sense in this case. Otherwise, enter `true` if the first column of the 2nd sheet range is sorted and you will accept the closest match, even if not an exact one.
4. You can either type in the formula with comma separators =VLOOKUP(B2,'addresses'!A:E,2,false), or click on the relevant cells, columns, and sheets for the tool to automatically enter it for you, as shown in Figure 2.33. What's new here is that this formula in the *names* sheet refers to a range of columns A to E in the *addresses* sheet. Press *Return* or *Enter* on your keyboard.

	A	B	C	D	E	F
1	name	organization	street	city	state	zip
2	Denise B.	Central Texas Food Bank	VLOOKUP(B2,'addresses'!A:E,2,false)			
3	Derrick C.	Central Texas Food Bank				
4	Eric S.	Arkansas Food Bank				
5	Ginette B.	Utah Food Bank				

+ names addresses source

	A	B	C	D	E
1	organization	street	city	state	zip
2	Arkansas Food Bank	4301 W 65th St	Little Rock	AR	72209
3	Central Texas Food Bank	6500 Metropolis Dr	Austin	TX	78744
4	Utah Food Bank	3150 South 900 West	Salt Lake City	UT	84119
5					

+ names addresses source

Figure 2.33: The VLOOKUP formula in cell C2 of the *names* sheet (top) searches for matches across columns A to E in the *addresses* sheet (bottom).

Let's break down each part of the formula you entered in cell C2 of the *names* sheet:

- B2 = The search_key: the cell in the *organization* column you wish to match in the *names* sheet

- '`addresses`'!A:E = The range where you are searching for your match and results across columns A to E in the *addresses* sheet.
 - 2 = The index, meaning your desired result appears in the 2nd column (*street*) of the range above.
 - `false` = Find exact matches only.
5. After you enter the full VLOOKUP formula, it will display the exact match for the first organization, the Central Texas Food Bank, whose address is 6500 Metropolis Dr. Click and hold down on the blue dot in the bottom-right corner of cell C2, and drag your crosshair cursor across columns D to F and let go, which will automatically paste and update the formula for the city, state, and zip columns, as shown in Figure 2.34.

	A	B	C	D	E	F
1	name	organization	street	city	state	zip
2	Denise B.	Central Texas Food Bank	6500 Metropolis Dr	Austin	TX	78744
3	Derrick C.	Central Texas Food Bank				

Figure 2.34: Click on cell C2, then hold-and-drag the bottom-right blue dot across columns D to F, which automatically pastes and updates the formula.

6. Finally, use the same hold-and-drag method to paste and update the formula downward to fill in all rows, as shown in Figure 2.35.

	A	B	C	D	E	F
1	name	organization	street	city	state	zip
2	Denise B.	Central Texas Food Bank	6500 Metropolis Dr	Austin	TX	78744
3	Derrick C.	Central Texas Food Bank	6500 Metropolis Dr	Austin	TX	78744
4	Eric S.	Arkansas Food Bank	4301 W 65th St	Little Rock	AR	77209
5	Ginette B.	Utah Food Bank	3150 South 900 West	Salt Lake City	UT	84119
6	Greg F.	Arkansas Food Bank	4301 W 65th St	Little Rock	AR	77209
7	Kent L.	Utah Food Bank	3150 South 900 West	Salt Lake City	UT	84119
8	Mark J.	Central Texas Food Bank	6500 Metropolis Dr	Austin	TX	78744
9	Rhonda S.	Arkansas Food Bank	4301 W 65th St	Little Rock	AR	77209
10	Sarah R.	Arkansas Food Bank	4301 W 65th St	Little Rock	AR	77209
11	Scott W.	Utah Food Bank	3150 South 900 West	Salt Lake City	UT	84119
12						

Figure 2.35: Click on cell F2, then hold-and-drag the bottom-right blue dot down to row 11, which automatically pastes and updates the formula.

Warning: If you save this spreadsheet in CSV format, your calculated results will appear in the CSV sheet, but any formulas you created to produce those results will disappear. Always keep track of your original spreadsheet to remind yourself how you constructed formulas.

You've successfully created a mailing list—including each person's name, organization, and full mailing address—using the VLOOKUP function to match and paste data from two sheets. Now that you understand how to use formulas to connect different spreadsheets, the next section will teach you how to manage multiple relationships between spreadsheets with the help of a relational database.

Connect Sheets with a Relational Database

In the previous section, you learned how the VLOOKUP function can search for matching data in columns across spreadsheets and automatically paste results. Building on that concept, let's distinguish between a spreadsheet and a relational database, and under what circumstances it might be wiser to use the latter.

A spreadsheet is sometimes called a “flat-file database” because all of the records are stored in rows and columns in a single table. For example, if you kept a single spreadsheet of US food bank staff, every row would list an individual person, organization, and addresses, just like the mailing list we created in Figure 2.35 in the prior section on VLOOKUP.

But keeping all of your data in a single spreadsheet can raise problems. For example, it contains lots of duplicated entries. For people who all work at the same food bank, each row contains a duplicate of that organization’s address. If an organization moves to a new location, you need to update all of the rows that contain those addresses. Or if two organizations merge together under a new name, you need to update all of the rows for individuals affected by that change. While keeping all of your information organized in a single spreadsheet initially sounds like a good idea, when your dataset grows in size and internal relationships (such as tracking people who are connected to organizations, etc.), continually updating every row becomes a lot of extra work.

Instead of a single spreadsheet, consider using a relational database, which organizes information into separate sheets (also known as tables), but continually maintains the relevant connections between them. Look back at the two-sheet problem we presented in Figure 2.31 at the beginning of the VLOOKUP section. The first sheet lists individual people at each food bank, the second sheet lists the address for each food bank, and the two sheets share a column named *organization* that shows how they are related. Relational databases can save you time. For example, if you update an organization’s address in one sheet, the linked sheet will automatically reflect this change in every row for staff who work at that organization.

Although Google Sheets is a great spreadsheet, it’s not a relational database. Instead, consider a better tool such as Airtable, which allows you to create relational databases in your web browser with up to 1,200 free records (or more with the paid version), using existing templates or your own designs. Airtable enables data migration by importing or exporting all records in CSV format, and it also supports real-time editor collaboration with co-workers.

To demonstrate, we imported both of the Google Sheets above into this live Airtable database called Food Banks sample, which anyone with the link can view, but not edit. At the top are tabs to view each sheet, named *people* and *food banks*. To transform this into a relational database, we used Airtable settings to

link the *organization* column in the *people* sheet to the *food banks* sheet, where the addresses are stored, as shown in Figure 2.36.

The screenshot shows the Airtable interface with two sheets: 'people' and 'food banks'. The 'people' sheet is active, displaying a list of names. A modal window is open over the list, specifically for the row at index 1, which contains the name 'Denise B.'. The modal is titled 'Link to food banks' and contains a dropdown menu with three options: 'Arkansas Food Bank', 'Arkansas Food Bank', and 'Utah Food Bank'. The first option is selected. Below the dropdown, there are two checkboxes: 'Allow linking to multiple records' (which is checked) and 'Limit record selection to a view'. At the bottom right of the modal are 'Cancel' and 'Save' buttons. The background shows the rest of the 'people' sheet with other names listed from index 2 to 10.

Figure 2.36: In this Airtable sample, we linked the *organization* column in the *people* sheet to the *food banks* sheet.

In Airtable, click on a linked row to expand it and view related data. For example, if you click and expand on the first row in the *people* sheet, their organization's full address appears from the *food banks* sheet, as shown in Figure 2.37. In our editable version, if we update the address for one organization in the *food banks* sheet, it's automatically changed for all employees linked to that organization in the *people* sheet. In addition, Airtable allows you to sort, filter, and create different views of your data that you can share with others, a topic we'll cover in Chapter 7: Embed on your Web. See more about its features in the Airtable Support page.

It's important to understand the conceptual differences between a "flat-file" spreadsheet and a relational database to help you determine when to use one tool versus another. As you've learned in the sections above, spreadsheets are your best choice to begin organizing and analyzing your data, using methods such as sorting, filtering, pivoting, and lookup, to help reveal the underlying stories that you may wish to visualize. But relational databases are your best choice when maintaining large amounts of data with internal links, like one-to-many relationships, such as an organization with several employees.

The screenshot shows the Airtable interface with two sheets. The left sheet, titled 'people', has a grid view with columns for 'name' and 'organization'. The right sheet, titled 'Food Banks sample', displays detailed information for the row where 'Denise B.' is selected in the grid. The expanded view includes fields for 'NAME' (Denise B.) and 'ORGANIZATION' (Central Texas Food Bank), which is further expanded to show address details: STREET (6500 Metropolis Dr), CITY (Austin), and STATE (TX).

	name	organization
1	Denise B.	Central Texas Food Bank
2	Derrick C.	Central Texas Food Bank
3	Eric S.	Arkansas Food Bank
4	Ginette B.	Utah Food Bank
5	Greg F.	Arkansas Food Bank
6	Kent L.	Utah Food Bank
7	Mark J.	Central Texas Food Bank

Denise B.

NAME
Denise B.

ORGANIZATION

Central Texas Food Bank

STREET	CITY	STATE
6500 Metropolis Dr	Austin	TX

Figure 2.37: In this Airtable demo, click on a row in one sheet to expand and view its linked data in another sheet.

Summary

If you’re one of the many people who “never really learned” about spreadsheets in school or on the job, or if you’ve taught yourself bits and pieces along the way, we hope that this chapter has successfully strengthened your skills. All of the subsequent chapters in this book, especially those on designing interactive charts in chapter 5 and interactive maps in chapter 6, require a basic level of familiarity with spreadsheets. In addition to serving as incredible time-savers when it comes to tedious data tasks, the spreadsheet tools and methods featured above are designed to help you share, sort, calculate, pivot, and lookup matching data, with the broader goal of visualizing your data stories.

The next chapter describes strategies for finding data, particularly on open data sites operated by governmental and non-profit organizations, where you’ll also need spreadsheet skills to download and organize public information.

Chapter 3

Find and Know Your Data

In the early stages of a visualization project, you will likely ask two important and related questions: *Where can I find data?* and when I do, *How do I know what it really means?* If you skip over these questions and leap too quickly into constructing charts and maps, you run the risk of creating meaningless, or perhaps worse, misleading visualizations. This chapter breaks down both of these broad questions in greater detail, and provides concrete strategies to recognize bad data, source your data, navigate public versus private data, and search a growing number of open data repositories.

When searching for data, your newest best friend may be a librarian. Sometimes a data-smart librarian happens to know exactly where to locate a dataset that you've been seeking for day. But their more valuable skill is guiding us on *how to search* by reflecting on the types of questions librarians commonly ask:

1. What types of organizations may have collected or published the data you seek? If a governmental organization may have been involved, then at what level (national, state/provincial, regional, or municipal), and which branch or agency? Or might data have been compiled by a non-governmental organization, such as academic institutions, journalists, for-profit corporations, or non-profit groups? Figuring out which organizations might have collected the data can help point you to the digital or print materials they typically publish, and most appropriate tools to focus your search in that particular area.
2. Have any prior publications drawn on similar datasets, and if so, how can we trace their sources? Some of our best data visualization ideas began while reading textual evidence or noticing a table in a print publication or outdated web page, which convinced us that the data existed *somewhere*. With these valuable leads, librarians can help you track down source notes on where the data originated, or sometimes find more up-to-date versions of the data.

3. What level(s) of data are available? Is information disaggregated by individual cases or aggregated into larger groups? Librarians can help us to decipher how and why different organizations publish data in different formats. For example, US Census seeks to collect data every ten years about each person residing in the nation, but under the law, this individual-level data is confidential and not released to the public for 72 years. You can look up individual census data for 1940 and earlier decades at the US National Archives and other websites. But the US Census publishes current data for larger areas, such as neighborhood-level block groups, census tracts, cities, and states, by aggregating individual records into data tables, and suppressing small-numbered cells to protect people's privacy. Librarians can help us understand organization's guidelines on when and how they make data available at different levels.

If your search has produced some results, the next step is to get to know your data. Closely examine your files and ask questions about their origin, meaning, and limitations:

4. Who collected and published this data, and for what purpose? Since individuals and organizations require time and resources to do this work, seek to clarify their motivations and assumptions, both explicit and implicit ones. Who was the intended audience of the work? Whose perspectives does the data privilege? Whose stories remain untold? As practitioners of data visualization, we strongly favor evidence-based reasoning over its less-informed alternatives. But we also caution against embracing so-called data objectivity. Numbers are *not* neutral, and we always need to consider the broader contexts in which people created them.
5. What do the data labels *really* mean? Most spreadsheets contain abbreviated column headers, particularly due to software character limits, but some questions of data interpretation run much deeper. For example, socially-constructed labels such as "race" or "gender" may not clarify how the creators defined their terms, or what role respondents played in the collection process. Even seemingly objective labels such as "income" or "population" or "elevation" may not adequately describe exactly what was counted, how it was measured, and the margins of error. Better-quality datasets include detailed definitions of the collection process to help you to understand the decisions made by its creators. If not, then your next best option may be to go out into the field, if feasible, and directly observe how the data is measured and collected.

To be clear, you may never *truly know* your data if it was collected by someone else, particularly a different person in a distant place or time. But don't let that philosophical obstacles stop you from asking good questions about the origins and limitations of your data. Only by clarifying what we know—and what we don't know—can we create meaningful data visualizations that bring their inner-stories to life.

Recognize Bad Data

A vital skill needed by all data visualization creators is the ability to recognize bad data. If you fail to catch a problem in your data at an early stage, someone else may discover it later, which could diminish the credibility of all of your work. Fortunately, members of the data visualization community have shared multiple examples of issues we've encountered in our work, and newer members will benefit from our embarrassing mistakes. One popular crowd-sourced compilation by data journalists was The Quartz Guide to Bad Data, last updated in 2018, which includes several of these helpful warning signs:

Watch out for spreadsheets with “bad data”:

- Missing values: If you see blank or “null” entries, does that mean data was not collected? Or maybe a respondent did not answer? If you’re unsure, find out from the data creator. Also beware when humans enter a 0 or -1 to represent a missing value, without thinking about the consequences of running calculations.
- Missing leading zeros: The US Census Bureau lists every place using a FIPS code, and some spreadsheet users may accidentally convert text to numbers and strip out the leading zeroes. For example, the FIPS code for Los Angeles County is 037, but someone might accidentally strip out the leading zero and convert it to 37, which represents North Carolina.
- 65536 rows or 255 columns: These are the maximum number of rows supported by older-style Excel spreadsheets, or columns supported by Apple Numbers spreadsheet, respectively. If your spreadsheet stops exactly at either of these limits, you probably have only partial data.
- Inconsistent date formats: For example, November 3rd, 2020 is commonly entered in spreadsheets by Americans as 11/3/2020 (month-date-year), while many others around the globe type 3/11/2020 (date-month-year). Check your source.
- Dates such as January 1st 1900, 1904, or 1970: These are default timestamps in Excel spreadsheets and Unix operating systems, which may indicate the actual date was blank or overwritten.
- Dates similar to 43891: When you type March 1 during the year 2020 into Microsoft Excel, it automatically displays as 1-Mar, but is saved using Excel’s internal date system as 43891. If someone converts this column from date to text format, you’ll see Excel’s 5-digit number, not the dates you’re expecting. According to a 2016 report in the Washington Post, a team of geneticists detected a surprisingly high number of related Excel errors in papers published in leading scientific journals.

Source Your Data

Another way to reduce “bad data” issues is to clarify the source every time you download or create a new spreadsheet file. Add details about where the data came from, so that someone other than you, several years in the future, has sufficient information to understand its origin and limitations.

The first step is to label every data file that you download or create. All of us have experienced bad file names like these:

- data.csv
- file.xls
- download.xlsx

Write a short but meaningful file name. While there’s no perfect system, a good strategy is to abbreviate the source (such as `census` or `worldbank` or `eurostat`), with topic keywords, and a date or range. If you or co-workers will be working on different versions of a downloaded file, include the current date in YYYY-MM-DD (year-month-date) format. If you plan to upload files to the web, type names in all lower-case and replace blank spaces with dashes (-) or underscores (_). Better file names look like this:

- town-demographics-2019-12-02.csv
- census2010_population_by_county.xls
- eurostat-1999-2019-CO2-emissions.xlsx

The second step is to save more detailed source notes about the data on a separate tab inside the spreadsheet (which works for multi-tab spreadsheet tools such as Google Sheets, LibreOffice, and Excel). Add a new tab named *notes* that describes the origins of the data, a longer description for any abbreviated labels, and when it was last updated, as shown in Figure 3.1. Add your own name and give credit to collaborators who worked with you. For CSV files, which do not support multi-tabs sheets, create a text file using a parallel file name.

A third step is to make a backup of the original data before cleaning or editing it. For a simple one-sheet file in a multi-tab spreadsheet tool, right-click on the tab containing the data to make a duplicate copy in another tab, also shown in the preceding figure. Clearly label the new tab as a backup and leave it alone! For CSV files or more complex spreadsheets, create a separate backup file.

Make a habit of using these three sourcing strategies—filenames, notes, and backups—to reduce your chances of making “bad data” errors and to increase the credibility of your data visualizations. In the next section, we’ll address a related set of questions you should ask yourself regarding public versus private data.

The screenshot shows a Google Sheets interface. At the top, there's a toolbar with a 'fx' button, a formula bar, and a tab bar with tabs labeled A, B, C, D, E, F, and a new tab icon. Below the toolbar is a header row with columns A through F. Rows 1 through 6 contain the following text:

- Row 1: DOHMH (Department of Health and Mental Hygiene) New York City Restaurant Inspection Results
- Row 2: data only for January 2020
- Row 3: Each row is a restaurant citation
- Row 4: Source:
- Row 5: <https://nycopendata.socrata.com/Health/DOHMH-New-York-City-Restaurant-Inspection-Results/43nn-pn8j>
- Row 6: Downloaded by Jack Dougherty, July 2020

At the bottom of the sheet, there are buttons for '+', 'notes', 'data', and 'backup'.

Figure 3.1: Create separate spreadsheet tabs for data, notes, and backup.

Public versus Private Data

In addition to asking questions about the origins and limitations of your data, it's also important for you to be aware of important distinctions between public versus private data, and their implications for designing your visualizations. This section offers some general observations about data privacy based on our context in the United States. Since we are not lawyers (thank goodness!), please consult with legal experts for advice about your specific case.

Here's what's most important—and confusing—about access to data in the US. Individual-level data is often considered private, except in certain areas where our governmental process has determined that broader interests are served by making it public. First, here are two examples where individual-level data generally remains private:

- Patient-level health data is generally protected under the Privacy Rule of the Health Insurance Portability and Accountability Act, commonly known as HIPAA. But public health officials regularly aggregate individual patient records into larger anonymized public datasets to track progress about various illnesses.
- Student-level education data is generally protected under the Family Educational Rights and Privacy Act, commonly known as FERPA. But education officials regularly aggregate individual student records into larger anonymized public datasets to track the progress of schools, districts, and states.

But here are other examples where our government has determined that a broader interest is served by making individual-level data available to the public:

- Individual contributions to political candidates are public. You can search donors by name and address in this US Federal Election Commission public database, as well as other state-level sites.

- Individual salaries for officers of tax-exempt organizations are public. You can search by name across a digitized database of Internal Revenue Service (IRS) 990 forms that tax-exempt organizations are required to submit on several platforms, such as ProPublica's Nonprofit Explorer.
- Individual property ownership records are public, and increasingly online in many locations. For example, one company provides a US public records directory with links to local government property records, where available. Follow the links to search the value of the home owned by the first author in West Hartford, Connecticut, how much he and his spouse paid for it, the number of bathrooms, and so forth.
- Individual police officer reports regarding “use of force” are public by New Jersey state law. But no one could easily search these local police department records until a team of journalists from NJ Advance Media created a public database, The Force Report, where anyone can look up individual officers and investigate patterns of violence.

Also, the US federal government is subject to the Freedom of Information Act, which enables people to submit a “FOIA” request to obtain certain types of public records to improve government transparency. Individual states and their municipalities are subject to their own Freedom of Information laws, which are summarized in the Open Government Guide by the Reporters Committee for Freedom of the Press, and also by the National Freedom of Information Coalition. While some government agencies delay or reject FOIA requests, which can result in expensive litigation, others have begun to pro-actively share more public information on open data repositories.

Open Data Repositories

Over the past decade, an increasing number of governmental and non-governmental organizations have begun to publicly share data through open data repositories. While some of these datasets were previously available as individual files on isolated websites, these growing networks have made open data easier to find, enabled more frequent updates, and sometimes have allowed live interaction. Open data repositories often include these features:

- **View and Export:** At minimum, open data repositories allow users to view and export data in common spreadsheet formats, such as CSV, ODS, and XLSX. Some repositories also provide geographical boundary files for creating maps.
- **Built-in Visualization Tools:** Several repositories offer built-in tools for users to create interactive charts or maps on the platform site. Some also provide code snippets for users to embed these built-in visualizations into their own websites, which you'll learn more about in Chapter 7: Embed on Your Web.

- Application Programming Interface (APIs): Some repositories provide endpoints with code instructions that allow users to pull data directly from the platform into an external site or online visualization. When repositories continuously update data and publish an API endpoint, it can be an ideal way to display “nearly live” data in your visualization, which you’ll learn more about in Chapter 10: Leaflet Map Templates.

Due to the recent growth of open data repositories, especially in governmental policy and scientific research, there is no single website that lists all of them. Instead, we briefly mention just a few of the sites we turn to when hunting for types of data that may interest our readers, while acknowledging that we could have added many others:

TODO: Decide which links to include, remove, or others to add below....

United States open data:

- Data.gov, the official repository for US federal government agencies.
- Data.census.gov, the main platform to access US Census Bureau data. The Decennial Census is a full count of the population every ten years, while the American Community Survey (ACS) is an annual sample count that produces one-year, three-year, or five-year estimates for different census geographies, with margins of error.
- Open Data Network directory of primarily US state and municipal open data platforms by Socrata

International open data:

- Eurostat, the statistical office of the European Union
- Global Open Data Index by the Open Knowledge Foundation
- Google Public Data
- openAfrica by Code for Africa
- Open Data Inception a map-oriented global directory
- World Bank Open Data

In addition, students, staff, and faculty at better-resourced institutions of higher education also may have access to a paid library subscription to “closed” data repositories:

- Social Explorer includes decades of demographic, economic, health, education, religion, and crime data for local and national geographies, primarily for the US, Canada, and Europe. Previously, some access was public, but now requires paid subscription or 14-day free trial.
- IPUMS NHGIS?
- more?

Summary

This chapter reviewed two broad questions that everyone should ask during the early stages of their visualization project: *Where can I find data?* and *How do I know what it really means?* We broke down both questions into more specific parts to develop your knowledge and skills in recognizing bad data, sourcing the origins of your data, distinguishing between public versus private data, and navigating the growing number of open data repositories. As you leap into the next few chapters on cleaning data and creating interactive charts and maps, remember these lessons as you strive to create meaningful visualizations.

Chapter 4

Clean Up Messy Data

More often than not, datasets will be messy and hard to visualize right away. They will have missing values, various spelling of the same categories, dates in different formats, text in numeric-only columns, multiple things in the same columns, and other unexpected things (see Figure 4.1 for inspiration). Don't be surprised if you find yourself spending longer cleaning up data than actually analyzing and visualizing it—it is often the case for data analysts.

Year	City	Amount
1990	New York City	\$1,123,456.00
1995-96		2.2 mil
2000s	NYC	No data
2020	New_York	5000000+

Figure 4.1: More often than not, raw data looks like this.

It is important to learn several tools in order to know which one to use to clean your data efficiently. We will start by looking at fairly basic data cleanup using Google Sheets. Keep in mind that the same principles (and in most cases even the same formulas) can be used in Microsoft Excel, LibreOffice Calc, Mac's Numbers, or other spreadsheet packages.

We will then show you how to extract table data from PDF documents using a free tool called Tabula. Tabula is used by data journalists and researchers worldwide to analyze government spendings, procurement records and all sorts of other datasets that get trapped in PDFs.

At the end, we will introduce OpenRefine, an extremely powerful and versatile tool to clean up the messiest spreadsheets, such as those containing dozens of misspelled versions of universities or town names.

Clean Data with Spreadsheets

Let's take a look at some techniques to clean up data directly in your favorite spreadsheet tool. We will use Google Sheets as an example, but the same principles will apply to most other software packages, such as Excel, Calc, or Numbers.

Find and Replace with a blank

A common problem with census data is that geographic names contain unnecessary words. For example, your data can look something like that:

```
Hartford town  
New Haven town  
Stamford town
```

But you want a clean list of towns, either to display in a chart, or to merge with a different dataset:

```
Hartford  
New Haven  
Stamford
```

Here's one quick solution: In any spreadsheet tool, use the Find and Replace command to remove unwanted characters. You can download our sample file, which contains 169 Connecticut towns and their population, for the exercise.

1. Select the column you want to modify by clicking on the column header. If you don't, you will be searching and replacing in the entire spreadsheet.
2. From *Edit* menu, choose *Find and replace* item. You will see the window like is shown in Figure 4.2.
3. In the *Find* field, type `town`, without quotation marks and leaving a space before the word. If you don't leave the space, you will accidentally remove `town` from `Newtown`, and you will end up with trailing spaces which can cause troubles in the future.
4. Leave the *Replace with* field blank.
5. *Search* field should be set to the range you selected in step 1, or *All sheets* if you didn't select anything.
6. You have the option to *match case*. If checked, `town` and `Town` and `t0wn` will be treated differently. For our purpose, you can leave *match case* unchecked.
7. Press the *Replace all* button. Since this sample file contains 169 towns, the window will state that 169 instances of "town" have been replaced.

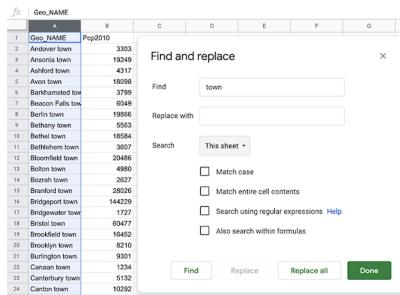


Figure 4.2: Find and Replace window in Google Sheets.

Split data into two or more columns

Sometimes multiple pieces of data appear in a single cell, such as names (John Doe), coordinate pairs (40.12,-72.12), or addresses (300 Summit St, Hartford, CT, 06106). For your analysis, you might want to split them into separate entities, so that your *FullName* column (with John Doe in it) becomes *FirstName* (John) and *LastName* (Doe) columns, coordinates become *Latitude* and *Longitude* columns, and your *FullAddress* column becomes 4 columns, *Street*, *City*, *State*, and *Zip* (postcode).

Example 1 Let's begin with a simple example of coordinate pairs. You can use our sample file, which is a collection of latitude-longitude pairs separated by a comma, with each pair on a new line.

1. Select the data you wish to split, either the full column or just several rows. Note that you can only split data from one column at a time.
2. Make sure there is no data in the column to the right of the one you're splitting, because all data there will be written over.
3. Go to *Data* and select *Split text to columns*, as in Figure 4.3.
4. Google Sheets will try to guess your separator automatically. You will see that your coordinates are now split with the comma, and the Separator is set to *Detect automatically* in the dropdown. You can manually change it to a comma (,), a semicolon (;), a period (.), a space character, or any other custom character (or even a sequence of characters — more about that in Example 2 of this section).
5. You can rename columns into *Longitude* (first number) and *Latitude* (second number).

Example 2 Now, let's look at a slightly more complicated example. Imagine your dataset is structured as follows:

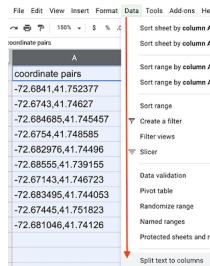


Figure 4.3: Select Data > Split text to columns to automatically separate data.

Location	
300 Summit St, Hartford CT--06106	
1012 Broad St, Hartford CT--06106	
37 Alden St, Hartford CT--06114	

Each cell contains a full address, but you want to split it into four cells: street address (300 Summit St), city (Hartford), state (CT), and zipcode (06106). Notice that the separator between the street and the rest of the address is a comma, a separator between the city and state is a space, and there are two dash lines between state and zipcode.

1. Start splitting left to right. So your first separator will be a comma. Select your column (or one or more cells within that column), and go to *Data > Split text to columns*.
2. Google Sheets should automatically split your cell into two parts, **300 Summit St** and **Hartford CT--06106**, using comma as a separator. (If it didn't, just select *Comma* from the dropdown menu that appeared).
3. Now, select only the second column and perform *Split text to columns*. You will see that the city is now separate from the state and zipcode, and Google Sheets chose space as a separator (if it didn't, choose *Space* from the dropdown menu).
4. Next, select only the third column and perform *Split text to columns* again. Google Sheets won't recognize -- as a separator, so you will have to manually select *Custom*, type -- in the text field, and hit Enter. You should now have four columns.

Tip: Google Sheets will treat zipcodes as numbers and will delete leading zeros (so 06106 will become 6106). To fix that, select the column, and go to *Format > Number > Plain text*. Now you can manually re-add zeros. If your dataset is large, consider concatenating 0s using the formula introduced in Combine separate columns into one.

Combine separate columns into one

Now, let's see how to perform the reverse action. Imagine you receive address data in separate columns, formatted like this:

Street	City	State	Zip	
300 Summit St	Hartford	CT	06106	

The data comes is four columns: street address, city, state, and zipcode. Let's say your mapping tool requires you to combine all of this terms into one location column, like that:

Location	
300 Summit St, Hartford, CT 06106	

You can write a simple formula to combine (or concatenate) terms using ampersands (`&`) as cells values connectors, and quoted spaces (" "), or spaces with commas (", "), or a dash with spaces on both sides (" - "), or anything else as term separators.

For example, imagine that a spreadsheet contains an address that is separated into four columns—*Address*, *City*, *State*, and *Zip*—as shown in columns A-D in Figure 4.4. In column E, you can add new header named *Location* and insert a formula in this format, to combine the items using ampersands (`&`) and separating them with quoted spaces (" "), like this: `=A2&" "&B2&" "&C2&" "&D2`

	A	B	C	D	E	F
1	Street	City	State	Zip	E2 Location	
2	300 Summit St	Hartford	CT	06106	?=A2&" "&B2&" "&C2&" "&D2	
3						
4						

Figure 4.4: Use ampersands to combine items and separate them with spaces.

You are now able to split data to columns using custom separators, and concatenate values from different cells into one. But what if your table is trapped inside a PDF? In the next section, we will introduce Tabula and show you how to convert tables from PDF documents into tables that you can analyze in Google Sheets, Microsoft Excel, or similar packages.

Extract Tables from PDFs with Tabula

It sometimes happens that the dataset you are interested in is only available as a PDF document. Don't despair, you can *likely* use Tabula to extract tables and save them as CSV files.

Tabula is a free tool that runs on Java, and is available for Mac, Windows, and Linux computers. It runs on your local machine and does not send your data to the cloud, so you can also use it for sensitive documents.

Note: Keep in mind that PDFs generally come in two flavors, image-based and text-based. You know your PDF is text-based if you can use cursor to select and copy-paste text. These are great for Tabula. Image-based PDFs are those that were created from scanning documents. Before they can be processed with Tabula, you will need to use an optical character recognition (OCR) software, such as Adobe Acrobat, to create a text-based PDF.

Set Up Tabula

Download the newest version of Tabula. You can use download buttons on the left-hand side, or scroll down to the *Download & Install Tabula* section to download a copy for your platform.

Unlike most other programs, Tabula does not require installation. Just unzip the downloaded archive, and double-click the icon. If prompted with a security message (such as “Tabula is an app downloaded from the internet. Are you sure you want to open it?”), follow the instruction to proceed (on a Mac, click *Open*; you might have to go to System Preferences > Security & Privacy, and resolve the issue there).

Your default system browser should open, like shown in Figure 4.5. The URL will be something like `http://127.0.0.1:8080/`, meaning Tabula is running on your local machine. 127.0.0.1, also known as `localhost`, is the hostname for your machine. 8080 is called port (it's okay if you see a different port—most likely because 8080 was taken by some other program running on your computer). If for any reason you decide to use a different browser, just copy-paste the URL.

Load a PDF and Autodetect Tables

Since the beginning of the Covid-19 pandemic, the Department of Public Health in Connecticut has been issuing daily PDFs with case and death count by town. For the demonstration, we will use one of those PDFs from May 31, 2020.

1. Select the PDF you want to extract data from by clicking the blue *Browse...* button.

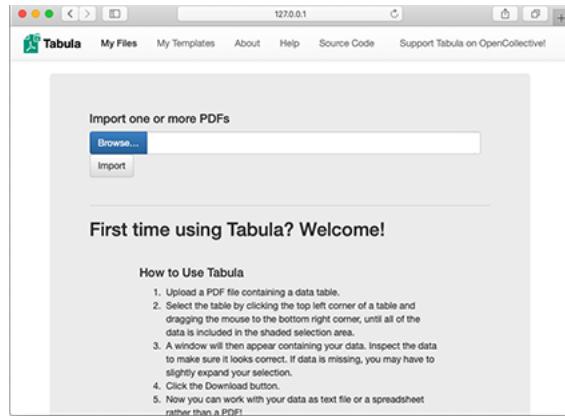


Figure 4.5: Tabula welcome page.

2. Click *Import*. Tabula will begin analyzing the file.
3. As soon as Tabula finishes loading the PDF, you will see a PDF viewer with individual pages. The interface is fairly clean, with only four buttons in the header.
4. The easiest first step is to let Tabula autodetect tables. Click the relevant button in the header. You will see that each table is highlighted in red, like shown in Figure 4.6.

APPENDIX A. Towns with Confirmed and Probable Cases of COVID-19
Table does not include 23M cases pending address validation

Case Number	Town	County
1	Ashley	24
2	Bethel	24
3	Bethel	24
4	Bethel	24
5	Bethel	24
6	Bethel	24
7	Bethel	24
8	Bethel	24
9	Bethel	24
10	Bethel	24
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12	Bethel	24
13	Bethel	24
14	Bethel	24
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410	Bethel	

Manually Adjust Selections and Export

1. Click *Preview & Export Extracted Data* green button to see how Tabula thinks the data should be exported.
2. If the preview tables don't contain the data you want, try switching between *Stream* and *Lattice* extraction methods in the left-hand-side bar.
3. If the tables still don't look right, or you wish to remove some tables that Tabula auto-detected, hit *Revise selection* button. That will bring you back to the PDF viewer.
4. Now you can *Clear All Selections* and manually select tables of interest. Use drag-and-drop movements to select tables of interest (or parts of tables).
5. If you want to "copy" selection to some or all pages, you can use *Repeat this Selection* dropdown, which appears in the lower-right corner of your selections, to propagate changes. This is extremely useful if your PDF consists of many similarly-formatted pages.
6. Once you are happy with the result, you can export it. If you have only one table, we recommend using CSV as export format. If you have more than one table, consider switching export format to *zip of CSVs*. This way each table will be saved as an individual file, rather than all tables inside one CSV file.

Once you exported your data, you can find it in a Downloads folder on your computer (or wherever you chose to save it). It is ready to be opened in Google Sheets or Microsoft Excel, analyzed, and visualized! In the following section, we are going to look how to clean up messy datasets with OpenRefine.

Clean Data with OpenRefine

Consider a dataset that looks like the one in Figure 4.7. Can you spot any problems with it?

Notice how the funding amounts (last column) are not standardized. Some amounts have commas as thousands separators, some have spaces, and some start with a dollar character. Notice also how the Country column includes various spellings of North and South Korea. Datasets like this can be an absolute nightmare to analyze. Luckily, OpenRefine provides powerful tools to clean up and standardize such data.

Note: This data excerpt is from US Overseas Loans and Grants (Greenbook) dataset, which shows US economic and military assistance to various countries. We chose to only include assistance to South Korea and North Korea for the years between 2000 and 2018. We added deliberate misspellings and formatting issues for demonstration purposes (although we did not alter values).

	A	B	C	D
1	Year	Country	FundingAgency	FundingAmount
2	2000	Korea, N	Dept of Agriculture	\$32 242 376
3	2000	Korea-North	Dept of Agriculture	\$86,151,301
4	2000	Korea North	department of State	166855
5	2000	SouthKorea	U.S. Agency for International Development	282,805a
6	2000	south Korea	Trade and Development Agency	735718
7	2001	North Korea	US Agency for International Development	345,399
8	2001	N Korea	Department of Argic	117715223
9	2001	So Korea	Department of agriculture	2260293
10	2001	Korea, North	State Department	183,752
11	2001	Korea, South	Trade and Development Agency	329,953
12	2002	Korea, N	Department of Agriculture	37,322,244.00
13	2002	Korea, South	U.S. Agency for International Development	67,990.00
14	2002	Korea, South	Trade and Development Agency	\$294,340
15	2003	Korea, North	U.S. Agency for International Development	\$333 823
16	2003	Korea, North	Department - Agriculture	\$26,766,828
17	2003	Korea, North	Department - Agriculture	\$19,337,695
18	2003	Korea, No	Department of State	220,323
19	2003	Korea, South	U.S. Agency for International Development	66,765
20	2003	Korea, South	Trade and Development Agency	19,899

Figure 4.7: First 20 rows of the sample dataset. Can you spot any problems with it?

Download this sample dataset or use your own file with messy data. Inspect the file in any spreadsheet software. You can see that the dataset has four columns: year (between 2000 and 2018, inclusive), country (North or South Korea), a US funding agency, and funding amount (in 2018 US dollars). Let's now use OpenRefine to clean it up.

Set up OpenRefine

You can download a copy of OpenRefine for Linux, Mac, or Windows from the official download page. Just like Tabula, it runs in your browser and no data leaves your local machine, which is great for confidentiality.

If you work on a **Mac**, the downloaded file will be a .dmg file. You will likely encounter a security message that will prevent OpenRefine from launching. Go to System Preferences -> Security and Privacy, and hit *Open Anyway* button in the lower half of the window. If prompted with another window, click *Open*.

If you use **Windows**, unzip the downloaded file. Double-click the .exe file, and OpenRefine should open in your default browser.

Once launched, you should see OpenRefine in your browser with 127.0.0.1:3333 address (localhost, port 3333), like shown in Figure 4.8.

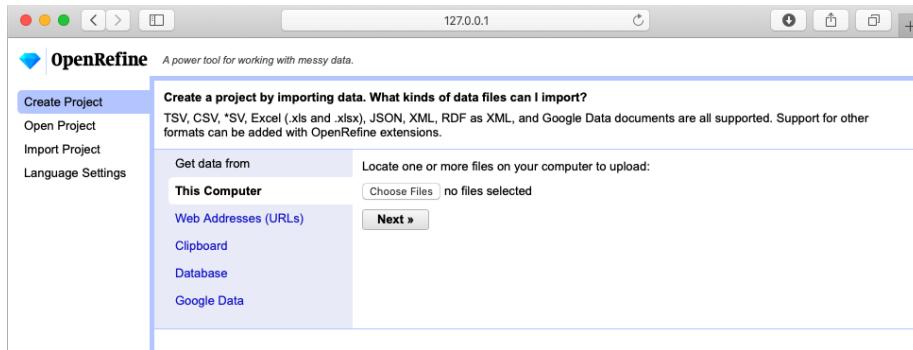


Figure 4.8: OpenRefine starting page.

Load Data and Start a New Project

To begin cleaning up your messy dataset, you should load it into a new project. OpenRefine lets you upload a dataset from your local machine, or a remote URL on the web (including a Google Spreadsheet), or copy/paste data into a text field. OpenRefine is able to extract data directly from SQL databases, but this is beyond the scope of this book. We assume that you downloaded the sample dataset we provided (or you are using your own file), so let's load it from your computer.

1. Under *Get data from: This computer*, click *Browse...* and select the file. Click Next.
2. Before you can start cleaning up data, OpenRefine allows you to make sure data is **parsed** properly. In our case, parsing means the way the data is split into columns. Make sure OpenRefine assigned values to the right columns, or change setting in *Parse data as* block at the bottom of the page until it starts looking meaningful, like shown in Figure 4.9.
3. Hit *Create Project* in the upper-right corner.

Now when you've successfully read the data into a new project, let's start the fun part: converting text into numbers, removing unnecessary characters, and fixing the spellings for North and South Koreas.

Convert Dollar Amounts from Text to Numbers

Once your project is created, you will see the first 10 rows of the dataset. You can change it to 5, 10, 25, or 50 by clicking the appropriate number in the header

Each column header has its own menu (callable by clicking the arrow-down button). Left-aligned numbers in a column are likely represented as text (as

Figure 4.9: OpenRefine parsing options.

is the case with *FundingAmount* column in our example), and they need to be transformed into numeric format.

1. To transform text into numbers, open the column menu, and go to *Edit cells > Common transforms > To number*.
2. You will see that some numbers became green and right-aligned (success!), but most did not change. That is because dollar sign (\$) and commas (,) confuse OpenRefine and prevent values to be converted into numbers.
3. Let's remove \$ and , from the *FundingAmount* column. In the column menu, choose *Edit cells > Transform*. In the Expression window, type `value.replace(',', '')` and notice how commas disappear in the preview window. When you confirm your formula works, click *OK*.
4. Now, repeat the previous step, but instead of a comma, remove the \$ character. (Your expression will become `value.replace('$', '')`).
5. Perform Step 1 again. You will see that all but three cells turned green. That is because we have spaces and an a character at the end of one number. Fix those manually by hovering over cells, and clicking the *edit* button (in the new popup window, make sure to change *Data type* to *number*, and hit *Apply*, like in Figure 4.10).

At this point, all funding amounts should be clean numbers, right-aligned and colored in green. We're ready to move on to the *Country* column and fix different spellings of Koreas.

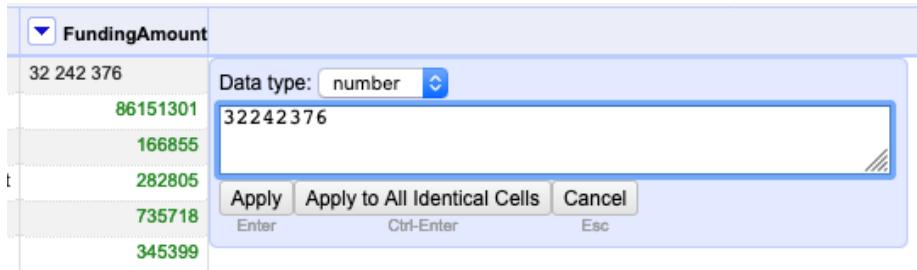


Figure 4.10: Manually remove spaces and extra characters, and change data type to number.

Cluster Similar Spellings

When you combine different data sources, or process survey data where respondents wrote down their answers as opposed to selecting them from a dropdown menu, you might end up with multiple spellings of the same word (town name, education level – you name it!). One of the most powerful features of OpenRefine is the ability to cluster similar responses.

If you use our original sample file, take a look at the *Country* column and all variations of North and South Korea spellings. From *Country* column’s dropdown menu, go to *Facet > Text facet*. This will open up a window in the left-hand side with all spellings (and counts) of column values. 26 choices for a column that should have just two distinct values, North Korea and South Korea!

1. To begin standardizing spellings, click on the arrow-down button of *Country* column header, and choose *Edit cells > Cluster and edit*. You will see a window like the one shown in Figure 4.11.
2. You will have a choice of two clustering methods, *key collision* or *nearest neighbor*. Both methods can be powered by different functions, but let’s leave the default *key collision* with *fingerprint* function.
3. OpenRefine will calculate a list of clusters. *Values in Cluster* column contains grouped spellings that OpenRefine considers the same. If you agree with a grouping, check the *Merge?* box, and assign the “true” value to the *New Cell Value* input box. In our example, this would be either **North Korea** or **South Korea**.
4. You can go through all groupings, or stop after one or two and click **Merge Selected & Re-Cluster** button. The clusters you chose to merge will be merged, and grouping will be re-calculated (don’t worry, the window won’t go anywhere). Keep regrouping until you are happy with the result.

Spend some time playing with *Keying function* parameters, and notice how they produce clusters of different sizes and accuracy.

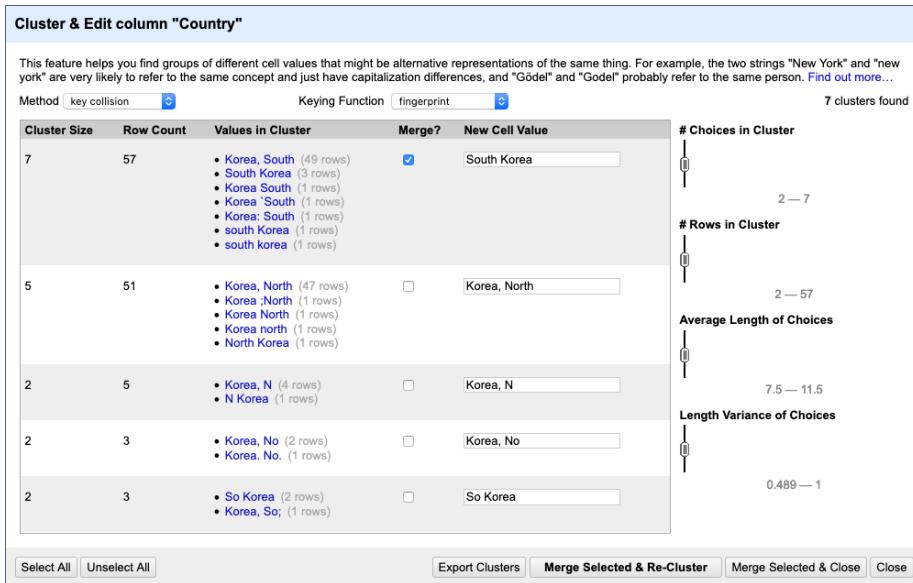


Figure 4.11: Cluster similar text values.

Export

Once you are done cleaning up and clustering data, save the clean dataset by clicking *Export* button in the upper-right corner of OpenRefine window. You can choose your format (we recommend CSV, or comma-separated value). Now you have a clean dataset that is ready to be processed and visualized.

Summary

In this chapter, we looked at cleaning up tables in Google Sheets, liberating tabular data trapped in PDFs using Tabula, and using OpenRefine to clean up very messy datasets. You will often find yourself using several of these tools on the same dataset before it becomes good enough for your analysis. We encourage you to learn more formulas in Google Sheets, and explore extra functionality of OpenRefine in your spare time.

You now know how to clean up your data, so let's proceed to visualizing it. In the following chapter, we will introduce you to a range of free data visualization tools that you can use to build interactive charts and embed them in your website.

Chapter 5

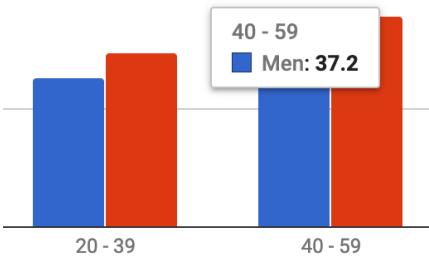
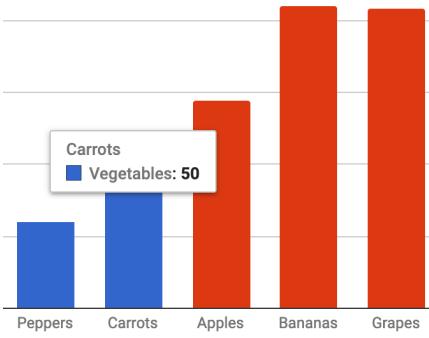
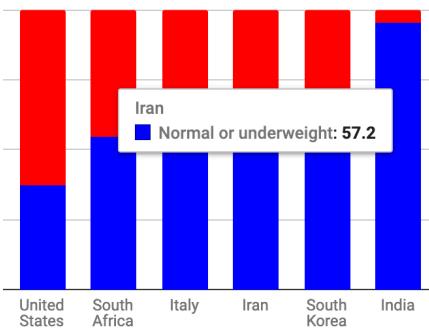
Chart Your Data

Charts pull readers deeper into your story. Even if your data contains geographical information, sometimes a chart tells your story better than a map. But designing meaningful, interactive charts requires careful thought about how to communicate your data story with your audience.

In this chapter, we will look at main principles of chart design, and learn to identify good charts from bad ones. You will learn important rules that apply to all charts, and also some aesthetic guidelines to follow when customizing your own designs. In addition to static chart images, this book focuses on interactive charts that display more data when you float your cursor over them in your web browser. Later you'll learn how to embed interactive charts on your web in chapter 7.

To begin, this grid of basic chart types will help you decide which type you wish to create. Your decision will be based on the format of your data, and the story you wish to tell, such as the type of data comparison you wish to draw to your reader's attention. Once you choose your chart type, follow our tool recommendations to create it. This chapter features easy-to-learn drag-and-drop tools, such as the Google Sheets chart tool, and for more advanced charts, Tableau Public, the free version of the powerful software used by many data analysts and visualization practitioners. The grid also refers to more powerful chart tools, such as Chart.js and Highcharts templates in chapter 9, which give you ever more control over how your design and display your data, but also require learning how to edit and host code templates with GitHub in chapter 8.

Table 5.1: Chart types covered in this book

Basic chart types	Best use and tutorial chapters														
Grouped column or bar	<p>Best to compare categories side-by-side. Vertical columns, or horizontal bars for long labels. Easy tool: Google Sheets bar and column tutorialPower tool: Chart.js and Highcharts templates</p>  <p>A grouped bar chart comparing men's health status across two age groups: 20-39 and 40-59. The y-axis represents a scale from 0 to 100. The legend indicates blue for 'Men'. The chart shows that the 40-59 age group has a higher value (approximately 37.2) compared to the 20-39 group (approximately 34.5). A callout box highlights the 40-59 group with the text '40 - 59' and 'Men: 37.2'.</p> <table border="1"> <thead> <tr> <th>Age Group</th> <th>Men</th> </tr> </thead> <tbody> <tr> <td>20 - 39</td> <td>34.5</td> </tr> <tr> <td>40 - 59</td> <td>37.2</td> </tr> </tbody> </table>	Age Group	Men	20 - 39	34.5	40 - 59	37.2								
Age Group	Men														
20 - 39	34.5														
40 - 59	37.2														
Separated column or bar	<p>Best to compare categories in separate clusters. Vertical columns, or horizontal bars for long labels. Easy tool: Google Sheets bar and column tutorialPower tool: Chart.js and Highcharts templates</p>  <p>A separated bar chart comparing vegetable consumption across five fruit types: Peppers, Carrots, Apples, Bananas, and Grapes. The y-axis represents a scale from 0 to 100. The legend indicates blue for 'Vegetables'. The chart shows that Apples have the highest consumption (approximately 50), followed by Bananas (approximately 48) and Grapes (approximately 45). A callout box highlights the Carrots cluster with the text 'Carrots' and 'Vegetables: 50'.</p> <table border="1"> <thead> <tr> <th>Fruit Type</th> <th>Vegetables</th> </tr> </thead> <tbody> <tr> <td>Peppers</td> <td>~20</td> </tr> <tr> <td>Carrots</td> <td>50</td> </tr> <tr> <td>Apples</td> <td>~48</td> </tr> <tr> <td>Bananas</td> <td>~48</td> </tr> <tr> <td>Grapes</td> <td>~45</td> </tr> </tbody> </table>	Fruit Type	Vegetables	Peppers	~20	Carrots	50	Apples	~48	Bananas	~48	Grapes	~45		
Fruit Type	Vegetables														
Peppers	~20														
Carrots	50														
Apples	~48														
Bananas	~48														
Grapes	~45														
Stacked column or bar	<p>Best to compare sub-categories, or parts of a whole. Vertical columns, or horizontal bars for long labels. Easy tool: Google Sheets bar and column tutorialPower tool: Chart.js and Highcharts templates</p>  <p>A stacked bar chart comparing the normal or underweight population across six countries: United States, South Africa, Italy, Iran, South Korea, and India. The y-axis represents a scale from 0 to 100. The legend indicates blue for 'Normal or underweight'. The chart shows that India has the highest percentage of normal or underweight individuals (approximately 57.2), followed by the United States (approximately 55.5). A callout box highlights the India cluster with the text 'Iran' and 'Normal or underweight: 57.2'.</p> <table border="1"> <thead> <tr> <th>Country</th> <th>Normal or underweight</th> </tr> </thead> <tbody> <tr> <td>United States</td> <td>~55.5</td> </tr> <tr> <td>South Africa</td> <td>~55.5</td> </tr> <tr> <td>Italy</td> <td>~55.5</td> </tr> <tr> <td>Iran</td> <td>~55.5</td> </tr> <tr> <td>South Korea</td> <td>~55.5</td> </tr> <tr> <td>India</td> <td>57.2</td> </tr> </tbody> </table>	Country	Normal or underweight	United States	~55.5	South Africa	~55.5	Italy	~55.5	Iran	~55.5	South Korea	~55.5	India	57.2
Country	Normal or underweight														
United States	~55.5														
South Africa	~55.5														
Italy	~55.5														
Iran	~55.5														
South Korea	~55.5														
India	57.2														

Basic chart types	Best use and tutorial chapters
Histogram	Best to show distribution of raw data, with number of values in each bucket. Easy tool: Google Sheets bar and column tutorial Power tool: Chart.js and Highcharts templates
Pie chart	Best to show parts of a whole, but hard to estimate size of slices. Easy tool: Google Sheets pie chart tutorial Power tool: Chart.js and Highcharts templates
Line chart	Best to show continuous data, such as change over time. Easy tool: Google Sheets line chart tutorial Power tool: Chart.js and Highcharts templates
Filtered line chart	Best to show multiple lines of continuous data, with on-off toggle buttons. Easy tool: Tableau Public filtered line chart tutorial

Basic chart types	Best use and tutorial chapters
Stacked area chart	Best to show parts of a whole, with change over time. Easy tool: Google Sheets stacked area tutorialPower tool: Chart.js and Highcharts templates
XY Scatter chart	Best to show the relationship between two sets of data. Easy tool: Google Sheets scatter chart tutorial or Tableau Public scatter chart tutorialPower tool: Chart.js and Highcharts templates
Bubble chart	Best to show the relationship between three or four sets of data, using bubble size and color. Easy tool: Google Sheets bubble chart tutorialPower tool: Chart.js and Highcharts templates

Chart Design Principles

Although not a science, data visualization comes with a set of rules, principles, and best practices that create a basis for clear and eloquent charts. Some of those rules are less rigid than others, but prior to “breaking” them, it is important to establish why they are important.

Before you begin, ask yourself: Do I really need a chart to tell this data story? Or would a table or text alone do a better job? Making a good chart takes time and effort, so make sure it enhances your story.

Deconstructing a Chart

Let's take a look at Figure 5.1. It shows basic chart components that are shared among most chart types.

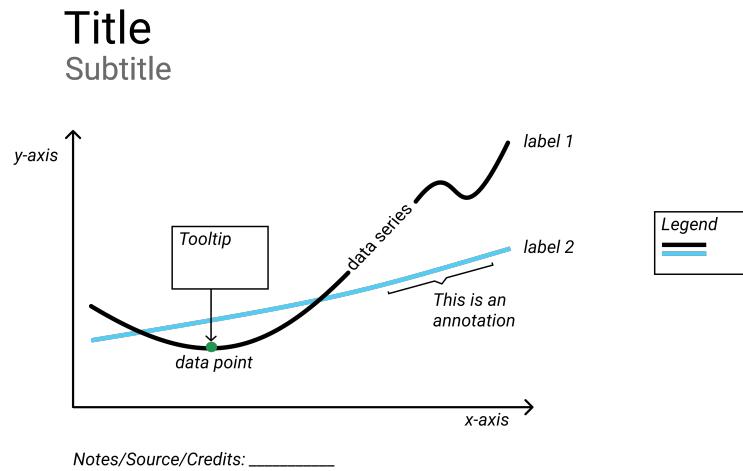


Figure 5.1: Common chart components.

A *title* is perhaps the most important element of any chart. A good title is short, clear, and tells a story on its own. For example, “Black and Asian Population More Likely to Die of Covid-19”, or “Millions of Tons of Plastic Enter the Ocean Every Year” are both clear titles.

Sometimes a more “dry” and “technical” title is preferred. Our two titles can then be changed to “Covid-19 Deaths by Race in New York City, March 2020” and “Tons of Plastic Entering the Ocean, 1950–2020”, respectively.

Often these two styles are combined into a title (“story”) and a subtitle (“technical”), like that:

**Black and Asian Population More Likely to Die of Covid-19
Covid-19 Deaths by Race in New York City, March 2020**

Make sure your subtitle is less prominent than the title. You can achieve this by decreasing font size, or changing font color (or both).

Horizontal (x) and vertical (y) *axes* define the scale and units of measure.

A *data series* is a collection of observations, which is usually a row or a column of numbers, or *data points*, in your dataset.

Labels and *annotations* are often used across the chart to give more context. For example, a line chart showing US unemployment levels between 1900 and

2020 can have a “Great Depression” annotation around 1930s, and “Covid-19 Impact” annotation for 2020, both representing spikes in unemployment. You might also choose to label items directly instead of relying on axes, which is common with bar charts. In that case, a relevant axis can be hidden and the chart will look less cluttered.

A *legend* shows symbology, such as colors and shapes used in the chart, and their meaning (usually values that they represent).

You should add any *Notes*, *Data Sources*, and *Credits* underneath the chart to give more context about where the data came from, how it was processed and analyzed, and who created the visualization. Remember that being open about these things helps build credibility and accountability.

In interactive charts, a *tooltip* is often used to provide more data or context once a user clicks or hovers over a data point or a data series. Tooltips are great for complex visualizations with multiple layers of data, because they declutter the chart. But because tooltips are harder to interact with on smaller screens, such as phones and tablets, and are invisible when the chart is printed, only rely on them to convey additional, nice-to-have information. Make sure all essential information is visible without any user interaction.

Some Rules are More Important than Others

Although the vast majority of rules in data visualization are open to interpretation, there are some that are hard to bend.

Bar charts must start at zero

Unlike line charts, bar or column charts need to have their value axis start at zero. This is to ensure that a bar twice the length of another bar represents twice its value. The Figure 5.2 shows a good and a bad example.

Starting y-axis at anything other than zero is a common trick used by some media and politicians to exaggerate differences in surveys and election results. Learn more about how to detect bias in data stories in chapter 12.

Pie Charts Represent 100%

Pie charts is one of the most contentious issues in data visualization. Most dataviz practitioners will recommend avoiding them entirely, saying that people are bad at accurately estimating sizes of different slices. We take a less dramatic stance, as long as you adhere to the recommendations we give in the next section.

But the one and only thing in data visualization that every single professional will agree on is that *pie charts represent 100% of the quantity*. If slices sum up

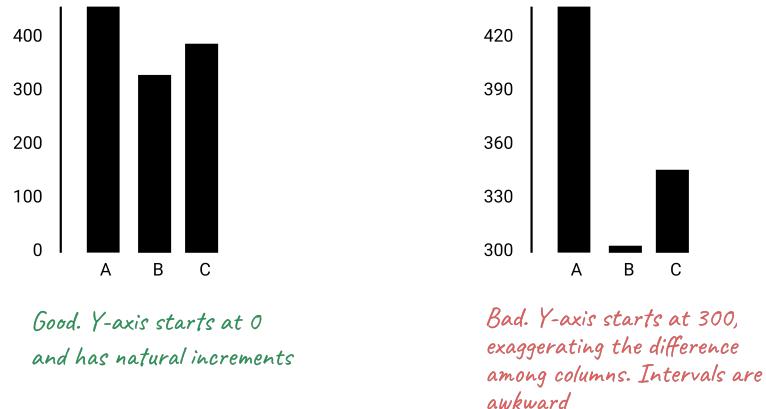


Figure 5.2: Start your bar chart at zero.

to anything other than 100%, it is a crime. If you design a survey titled *Are you a cat or a dog person?* and include *I am both* as the third option, forget about putting the results into a pie chart.

Chart Aesthetics

Remember that you create a chart to help the reader understand the story, not to confuse them. Decide if you want to show absolute numbers, percentages, or percent changes, and do the math for your readers.

Avoid chart junk

Start with a white background and add elements as you see appropriate. You should be able to justify each element you add. To do so, ask yourself: Does this element improve the chart, or can I drop it without decreasing readability? This way you won't end up with so-called "chart junk" as shown in Figure 5.3, which includes 3D perspectives, shadows, and unnecessary elements. They might have looked cool in early versions of Microsoft Office, but let's stay away from them today.

Do not use shadows or thick outlines with bar charts, because the reader might think that decorative elements are part of the chart, and thus misread the values that bars represent.

The only justification for using three dimensions is to plot three-dimensional data, which has x, y, and z values. And don't let anyone tell you otherwise.

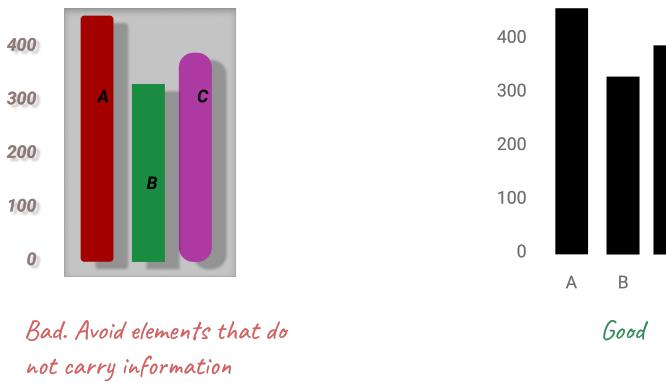


Figure 5.3: Avoid chart junk.

Beware of pie charts

Remember that pie charts only show part-to-whole relationship, so all slices need to add up to 100%. Generally, the fewer slices—the better. Arrange slices from largest to smallest, clockwise, and put the largest slice at 12 o'clock. Figure 5.4 illustrates that.

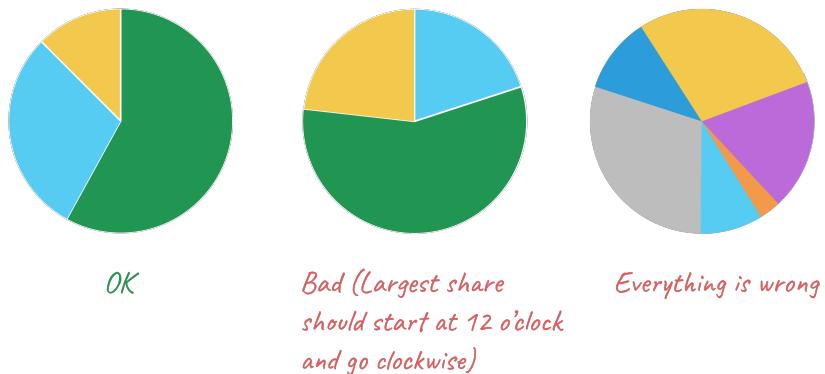


Figure 5.4: Sort slices in pie charts from largest to smallest, and start at 12 o'clock.

If your pie chart has more than five slices, consider showing your data in a bar chart, either stacked or separated, like Figure 5.5 shows.

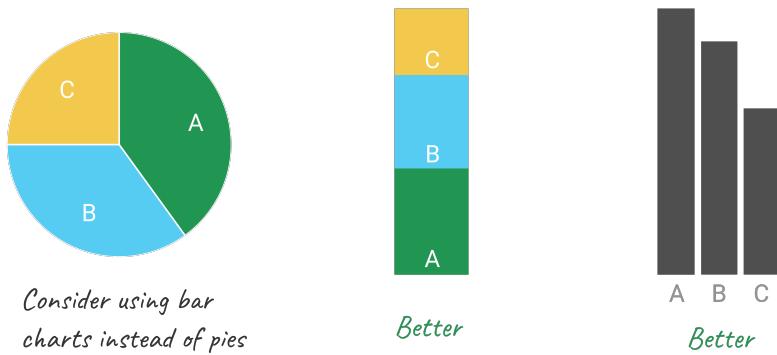


Figure 5.5: Consider using bar charts instead of pies.

Don't make people turn their heads to read labels

When your column chart has long x-axis labels that have to be rotated (often 90 degrees) to fit, consider turning the chart 90 degrees so that it becomes a horizontal bar chart. Take a look at Figure 5.6 to see how much easier it is to read horizontally-oriented labels.

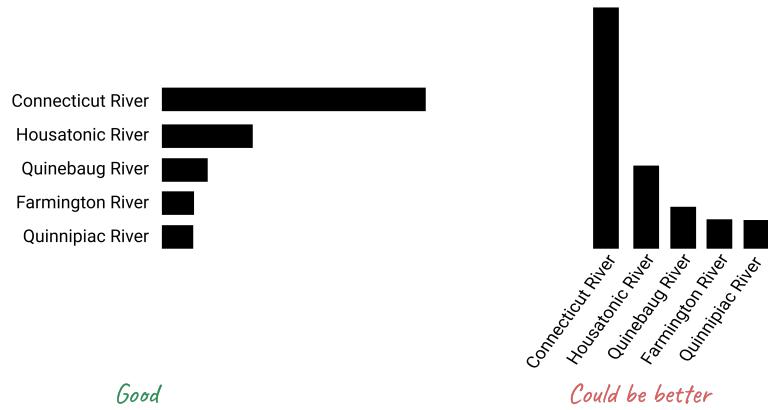


Figure 5.6: For long labels, use horizontal bar charts.

Arrange elements logically

If your bar chart shows different categories, consider ordering them, like is shown in Figure 5.7. You might want to sort them alphabetically, which can be useful

if you want the reader to be able to quickly look up an item, such as their town. Ordering categories by value is another common technique that makes comparisons possible. If your columns represent a value of something at a particular time, they have to be ordered sequentially, of course.



Figure 5.7: For long labels, use horizontal bar charts.

Do not overload your chart

When labelling axes, choose natural increments that space equally, such as [0, 20, 40, 60, 80, 100], or [1, 10, 100, 1000] for a logarithmic scale. Do not overload your scales. Keep your typography simple, use (but do not overuse) **bolding** to highlight major insights. Consider using commas as thousands separators for readability (1,000,000 is much easier to read than 1000000).

Be careful with the colors

The use of color is a complex topic, and there are plenty of books and research devoted to it. But some principles are fairly universal. First, do not use colors just for the sake of it, most charts are fine being monochromatic. Second, remember that colors come with some meaning attached, which can vary among cultures. In the world of business, red is conventionally used to represent loss, and it would be unwise to use this color to show profit. Make sure you avoid random colors.

Whatever colors you end up choosing, they need to be distinguishable (otherwise what is the point?). Do not use colors that are too similar in hue (for example, various shades of green—leave them for choropleth maps). Certain color combinations are hard to interpret for color-blind people, like green/red or yellow/blue, so be very careful with those. Figure 5.8 shows some good and bad examples of color use.

If you follow the advice, you should end up with a de-cluttered chart as shown in Figure 5.9. Notice how your eyes are drawn to the bars and their corresponding values, not bright colors or secondary components like the axes lines.

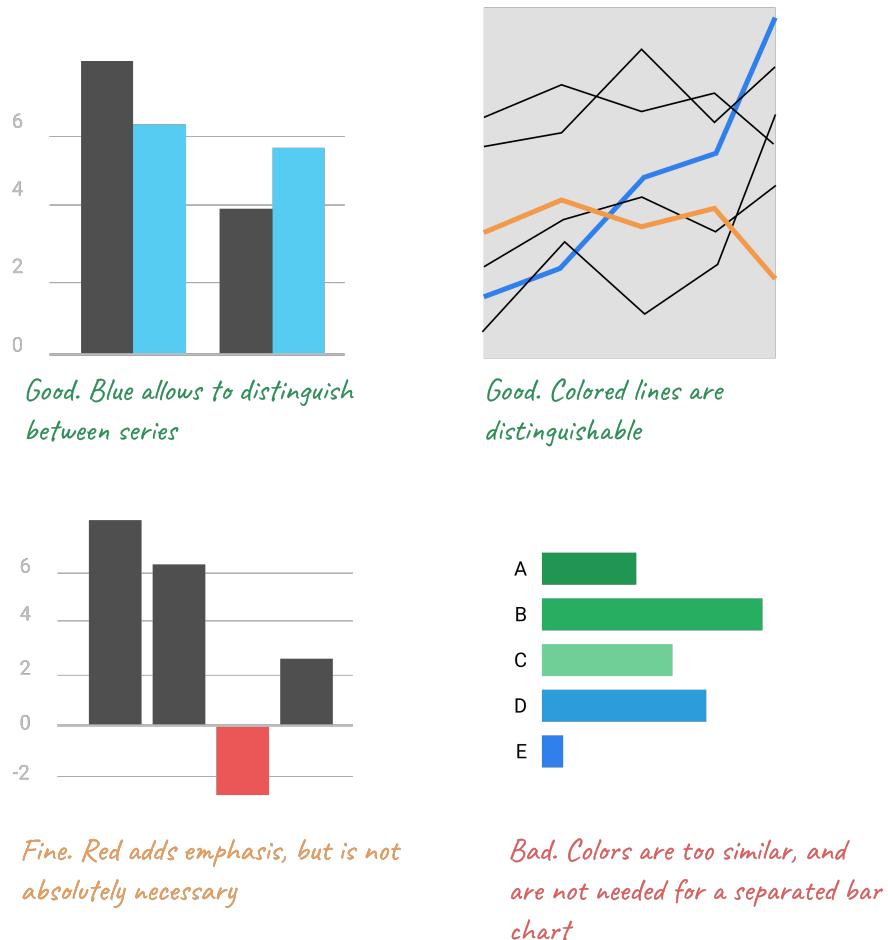


Figure 5.8: Don't use colors just for the sake of it.

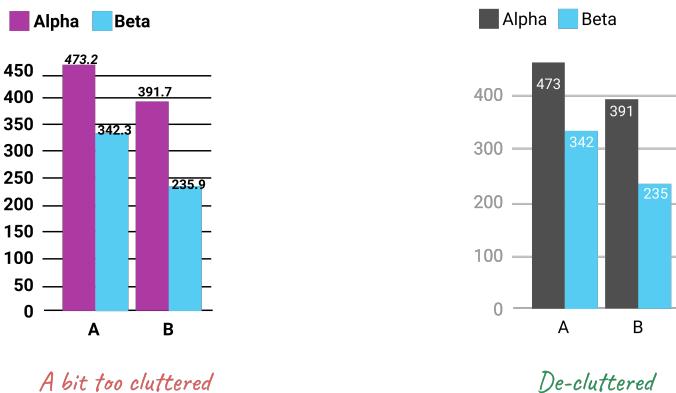


Figure 5.9: Make sure important things catch the eye first.

Google Sheets Charts

Google Sheets is a well-known spreadsheet program that allows you to create basic charts using its intuitive drag-and-drop interface. Most people who create charts with Google Sheets export them as static *png* images. But in fact these interactive charts can be easily embedded on your website, as you'll learn in chapter 7.

In this section, we will look at creating column and bar charts that are separated, grouped, and stacked. We will also look at making pie, line, area, and scatter charts, and learn to visualize three-dimensional data using bubble charts.

As most easy-to-use tools, Google Sheets has its shortcomings. You won't be able to control tooltips of scatterplot tooltips, or cite or link to source data inside charts. You won't be able to annotate or highlight items. But you *will* be able to *quickly* make good-looking interactive charts *quickly*.

Tip: Visit Types of charts & graphs in Google Sheets for an overview of the various chart types supported by this tool.

Column and Bar Charts with Google Sheets

Column and bar charts are some of the most common types of charts in data visualization (column charts are just vertical bar charts). They are used to compare values across categories.

In this tutorial, we will use three small datasets to build interactive separated, grouped, and stacked bar charts in Google Sheets:

- Obesity in the US (by US CDC and StateOfObesity.org project)
- High-Calorie Fast-Food Items
- Global Database on Body Mass Index by World Health Organization

Before you begin, you will need to create a free Google Drive account. If you already use Google Mail (Gmail), you can use the same username for your Google Drive account.

Grouped Column and Bar Charts

Figure 5.10 shows differences in obesity between men and women, grouped together in three age brackets to allow for easier gender comparisons across the same ages. In the interactive web version, hover over columns and see tooltips with data.

US Adult Obesity Rate by age and gender, 2013-14

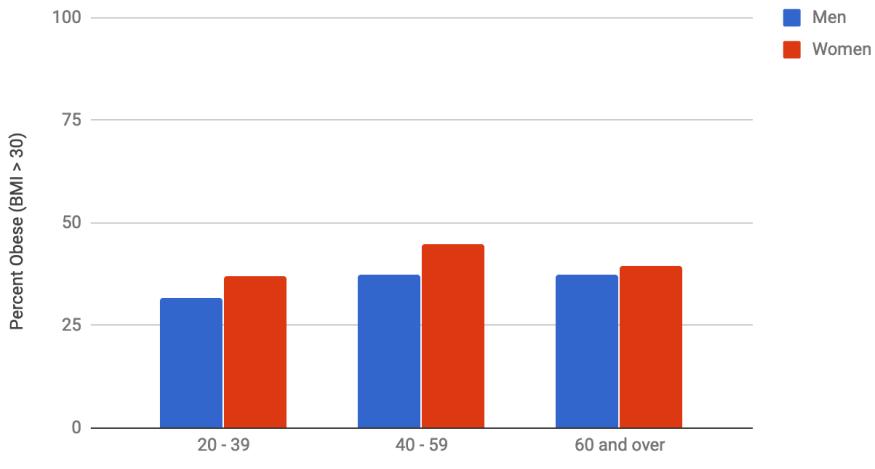


Figure 5.10: Grouped column chart with data from StateOfObesity.org. Explore the full-screen interactive version.

The following steps will help you recreate an interactive grouped column (or horizontal bar) chart.

1. Right-click to open link in new tab: Google Sheet Column chart with grouped data template
2. Sign in to continue to Google Sheets (which is part of Google Drive). If you don't already have a Google account, you can create one.

3. Select File > Make a Copy to save your own version to your Google Drive, as shown in Figure 5.11.

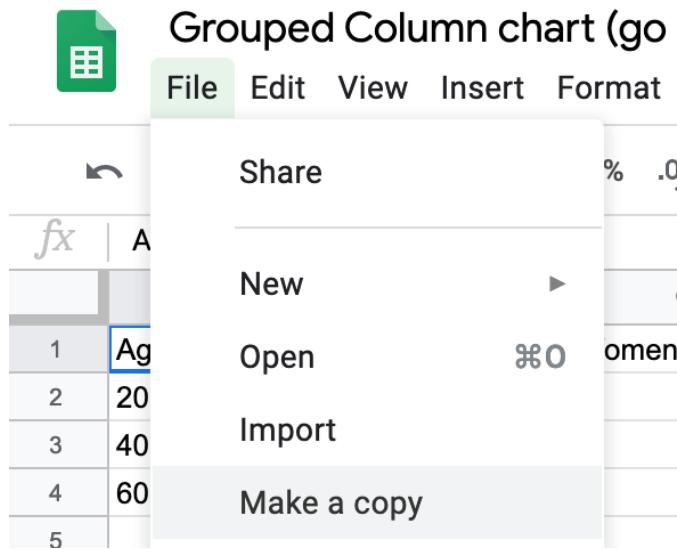


Figure 5.11: Make your own copy of the Google Sheet template.

4. To remove the current chart from your copy of the spreadsheet, float your cursor to the top-right corner of the chart to make the 3-dot menu appear, and select Delete, as shown in Figure 5.12.

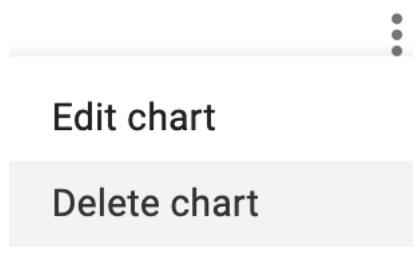


Figure 5.12: Float cursor in top-right corner of the chart to make the 3-dot (kebab) menu appear, and select Delete.

5. Format your data to make each column a data series, as shown in Figure 5.13, which means it will display as a separate color in the chart.

	A	B	C
1	Age Range	Men	Women
2	20 - 39	31.6	37
3	40 - 59	37.2	44.6
4	60 and over	37.5	39.4

Figure 5.13: Format data in columns to make colored grouped columns in your chart.

6. Use your cursor to select only the data you wish to chart, then go to the Insert menu and select Chart, as shown in Figure 5.14.
7. In the Chart Editor, change the default selection to Column chart, with Stacking none, to display Grouped Columns, as shown in Figure 5.15. Or select *Horizontal bar chart* if you have longer labels.
8. To customize title, labels, and more, in the Chart Editor select Customize, as shown in Figure 5.16.
9. To make your data public, go to the upper-right corner of your sheet to click the Share button, and in the next screen, click the words “Change to anyone with the link,” as shown in Figure 5.17. This means your sheet is no longer Restricted to only you, but can be viewed by anyone with the link. See additional options.
10. To embed an interactive version of your chart in another web page, click the 3-dot menu in the upper-right corner of your chart, and select Publish Chart, as shown in Figure 5.18. In the next screen, select Embed and press the Publish button. See Chapter 7 Embed on the Web to learn what to do with the iframe code.

Note: Currently, there is no easy way to cite or link to your source data inside a Google Sheets chart. Instead, cite and link to your source data in the text of the web page. Remember that citing your sources adds credibility to your work.

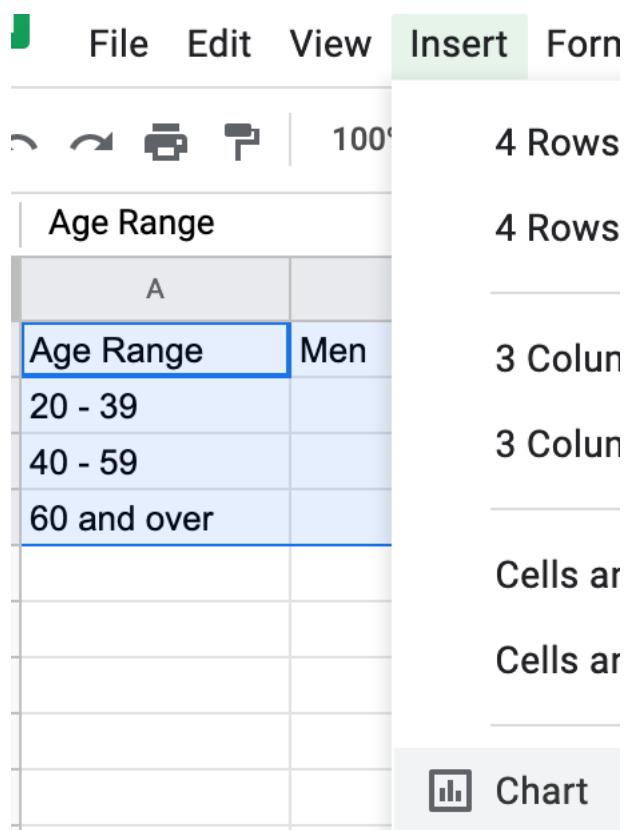


Figure 5.14: Select your data and then Insert > Chart.

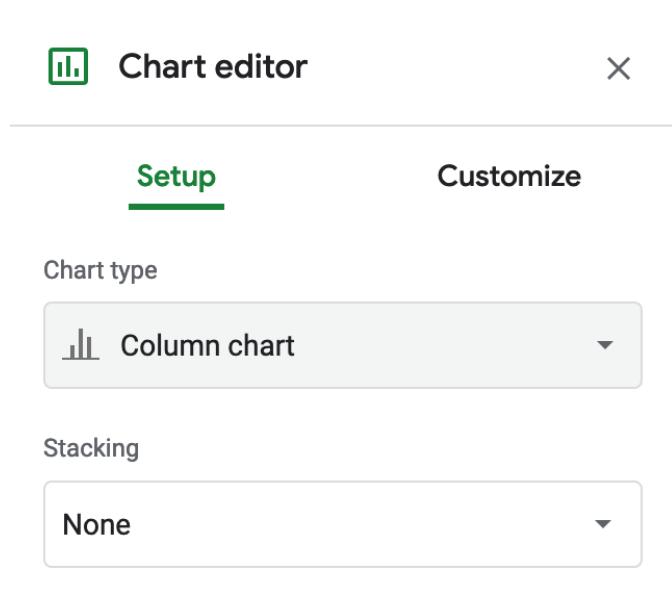


Figure 5.15: Change the default to Column chart, with Stacking none.

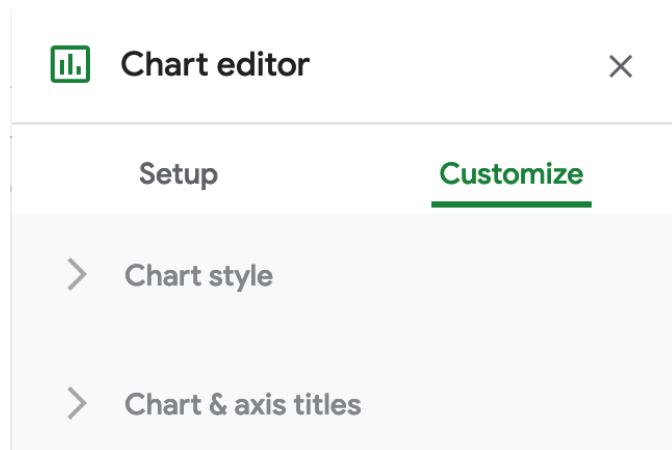


Figure 5.16: Select Customize to edit title, labels, and more.

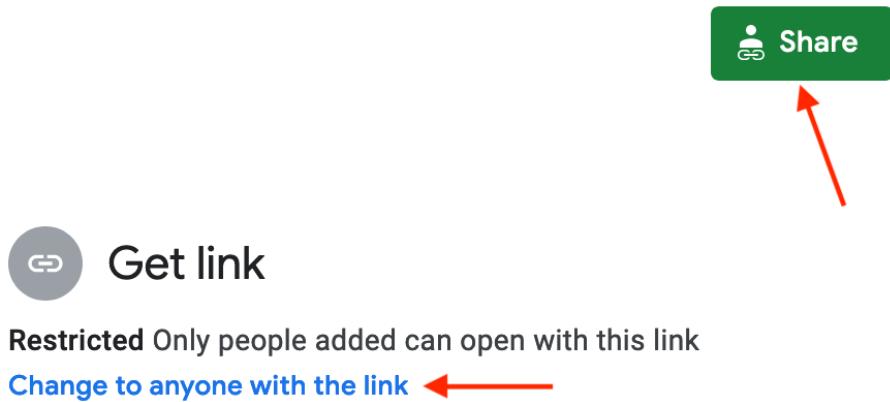


Figure 5.17: Click the Share button and then click “Change to anyone with the link.” to make your data public.

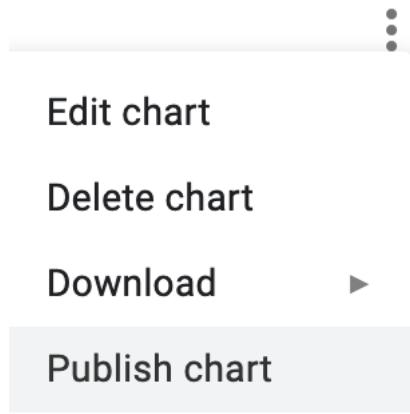


Figure 5.18: Select Publish Chart to embed an interactive chart on another web page, as described in Chapter 7.

Separated Column and Bar Charts

When you visualize independent categories of data, and you don't want them to appear grouped together, then create a chart with separated columns (or horizontal bars, if you have long data labels). For example, Figure 5.19 is a separated bar chart of calorie counts of fast food items for two restaurant chains, Starbucks and McDonald's. Unlike the grouped column chart in Figure 5.10, here the bars are separated from each other, because we do not need to make comparisons between sub-groups.

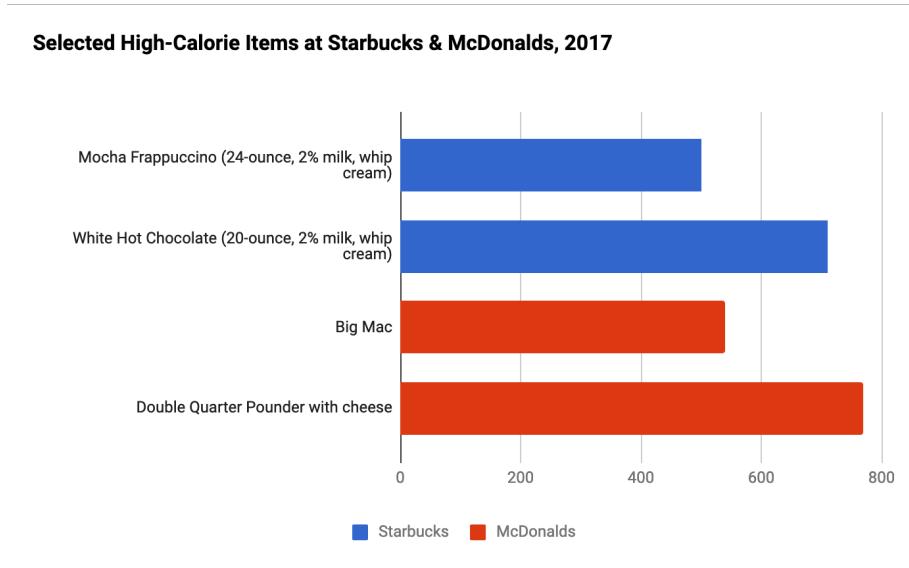


Figure 5.19: Separated bar chart with data from Starbucks and McDonalds. Explore the full-screen interactive version.

The only difference between making a grouped versus a separated chart is how you structure your data. To make Google Sheets separate columns or bars, you need to leave some cells blank, as shown in Figure 5.20. The rest of the steps remain the same as above.

To create your own separated column or bar chart using the fast-food example, right-click to open this link in a new tab: [Google Sheet Separated Bar Chart template](#).

Stacked Column and Bar Charts

Stacked column and bar charts can be used to compare subcategories. They can also be used to represent parts of a whole instead of pie charts. For example, the stacked column chart in Figure 5.21 compares the percentage of overweight

	A	B	C
1	Fast Food items	Starbucks	McDonalds
2	Mocha Frappuccino (24-ounce, 2% milk, whip cream)	500	
3	White Hot Chocolate (20-ounce, 2% milk, whip cream)	710	
4	Big Mac		540
5	Double Quarter Pounder with cheese		770

Figure 5.20: Create a separated column or bar chart by leaving some cells blank.

residents across nations, where colors allow for easy comparisons of weight-group subcategories across nations.

Percent of Population by Weight Level for most recent year

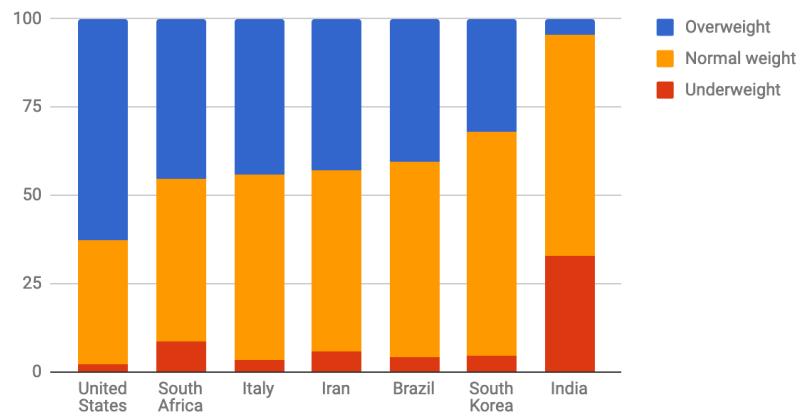


Figure 5.21: Stacked column chart with data from WHO and CDC. Explore the full-screen interactive version.

To create a stacked column or bar chart, structure your data so that each column will become a new series with its own color, as shown in Figure 5.22. Then in the Chart Editor window, choose Chart Type > Stacked column chart (or Stacked bar chart). The rest of the steps are similar to the ones above.

To create your own stacked column or bar chart using the international weight level example, right-click to open this link in a new tab: Google Sheets Stacked Column Chart template.

	A	B	C	D
1	Nation	Underweight	Normal weight	Overweight
2	United States	2	35.2	62.8
3	South Africa	8.6	46.2	45.1
4	Italy	3.4	52.6	44
5	Iran	5.7	51.5	42.8
6	Brazil	4	55.4	40.6
7	South Korea	4.7	63.2	32.1
8	India	32.9	62.5	4.5

Figure 5.22: Create a stacked column or bar chart by structuring your data as shown.

Histograms

Histogram is a type of bar chart that represents distribution of items, whether numerical or categorical. To build a histogram, you need to assign each data point to one of the non-overlapping *buckets* (or *bins*).

Let's say you want to know what time of day you are more likely to get an email. One approach would be to download metadata about all emails you received in 2020, and assign them to a bucket between 0 and 23 according to the email hour. Hours will become your bins, and email counts will be your frequency data. Then your final dataset would look something like this:

Hour	Emails
0	12
1	11
2	7
...	
21	24
22	34
23	22

You can now make a histogram. The good news is, Google Sheets considers histograms to be regular column charts, so you should be able to use a previous tutorial to make one.

Select two columns with the data you want to visualize, and go to Insert > Chart. In the Chart editor window, in the Setup tab, select Chart type >

Column chart. See the result in Figure 5.23

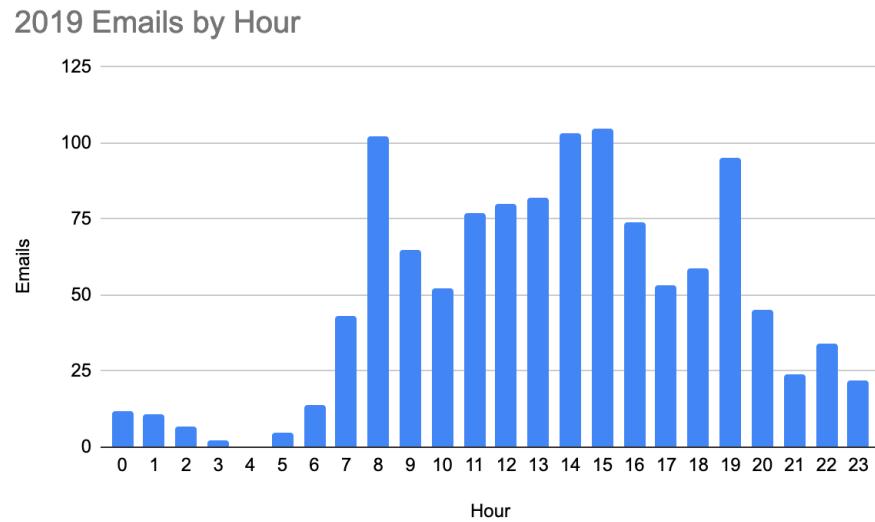


Figure 5.23: Histogram chart with fictitious source data. Explore the full-screen interactive version.

To create your own histogram chart using our fictional email dataset, right-click to open this link in a new tab: [Histogram Chart template](#).

Bins in a histogram should span (in other words, “cover”) the entire range of values of your dataset. This way you don’t leave out any data. We recommend you use bins of the same size (like 24 1-hour bins, or four 6-hour bins) to ensure readers can compare across bars. For example, if you want to create a less detailed histogram, you can combine hours into larger bins, such as *Morning*, *Afternoon*, *Evening*, and *Night* to cover the hours of 6–11, 12–17, 18–23, and 0–5, respectively. Then your dataset will look like:

TimeOfDay	Emails
Morning	353
Afternoon	497
Evening	279
Night	37

Pie, Line, and Area Charts with Google Sheets

Pie Chart

As we mentioned in the Chart Aesthetics section, you need to be careful when using pie charts. First, remember to not have too many slices (ideally you should limit slices to 5). They should be arranged from largest to smallest and start at 12 o'clock. To separate slices, you can use different slice colors, or lines.

Make sure your data adds up to 100%. For example, if you want to show a pie chart with the number of fruit your store had sold in a day—21 apples, 5 oranges, and 32 bananas—the sum of all fruit, 58, is your 100%. Then a reader can figure out that of all fruits sold, approximately 55% were bananas. This example is illustrated in Figure 5.24. If you decided to include *some*, but *not all* other items that your store has sold (for example, you include pizzas but exclude ice cream), your pie chart would not make sense.

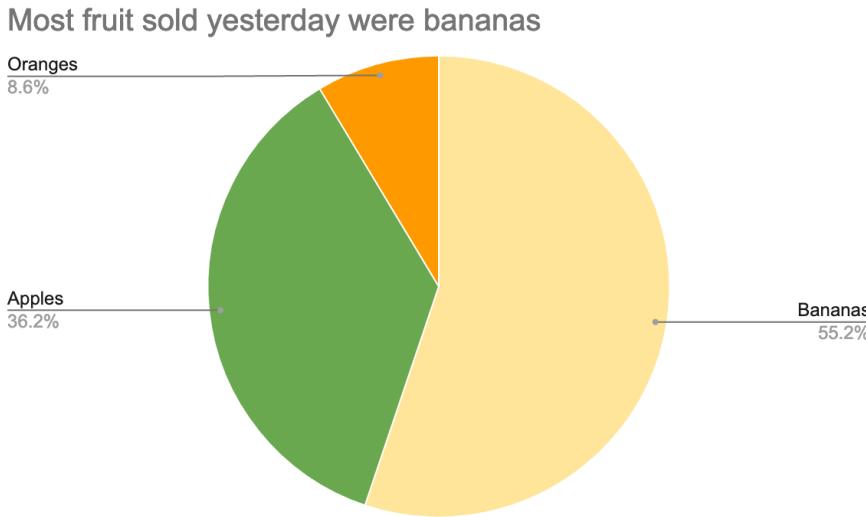


Figure 5.24: Pie chart with fictitious source data. Explore the full-screen interactive version.

To make a pie chart with Google Sheets, arrange your data in two columns, *Label* and *Value*. Values can be expressed as either percentages or counts. For example,

Apple 21		
Orange 5		
Banana 32		

Select all cells and go to *Insert > Chart*. Google Sheets is good at guessing chart types, so it is possible the chart you will see right away will be a pie. If not, in Chart editor in tab Setup, select *Pie chart* from the Chart type dropdown list.

Notice that slices are ordered the same way they appear in the spreadsheet. We highly recommend you sort values from largest to smallest: right-click the header of your values column, and click **Sort sheet Z-A**. You will see that the chart updates automatically.

Right-click on the chart, and choose *Chart & axis titles > Chart title* to add a meaningful title. In *Customize* tab of the Chart editor, you can also change colors and add borders to slices.

Line Chart

The most common use of line charts is to represent values at different points in time, in other words to show change over time. The line chart in Figure 5.25 shows per-capita meat availability in the US for the past 110 years. You can see that the level of chicken (shown in orange) rises steadily and surpasses beef (red) and pork (blue).

Beef, Pork and Chicken Availability per Capita in US, 1910-2017

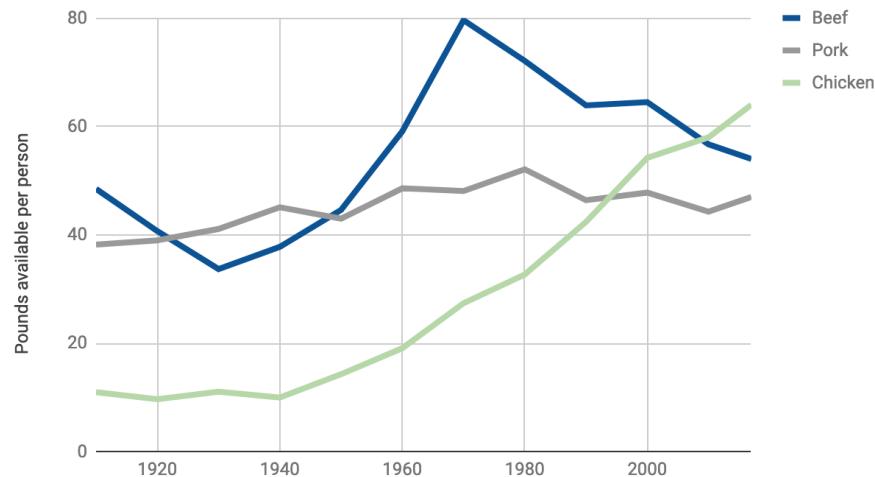


Figure 5.25: Line chart showing meat availability per capita in the US, according to the US Department of Agriculture. Explore the full-screen interactive version.

The simplest way to organize your data is to use the first column as x-axis labels, and each additional column as a new series (which will become its own line). For example, the meat data from the line chart is structured as shown in Figure 5.26.

	A	B	C	D
1	Year	Beef	Pork	Chicken
2	1910	48.5	38.2	11
3	1920	40.7	39	9.7
4	1930	33.7	41.1	11.1
5	1940	37.8	45.1	10
6	1950	44.6	43	14.3
7	1960	59.1	48.6	19.1
8	1970	79.6	48.1	27.4
9	1980	72.1	52.1	32.7
10	1990	63.9	46.4	42.4
11	2000	64.5	47.8	54.2
12	2010	56.7	44.3	58
13	2017	54	47	64

Figure 5.26: Data for the line chart shown in Figure 5.25.

The data is available in the Google Sheet Line chart template. If you wish to use it, just make a copy to your own Google Drive from the File menu.

Select the data, and choose *Insert > Chart*. It is possible Google Sheets will create a line chart right away. If not, in Chart editor in tab Setup, select *Line chart* from the Chart type dropdown list.

Stacked Area Chart

The line chart in the previous example made it possible to see how individual meat availability changed over time. It was hard, however, to estimate if the overall meat availability went up or down. (That is, of course, if we assume that beef, pork, and chicken are the only meats we eat).

We can see how availability of individual meat types, *and* the total meat availability over time using a stacked area chart, like shown in Figure 5.27. Here, we can still see that chicken has been on the rise since the 1970s. We can also see that the total availability was on the rise between 1910 and 1970 with a small dip around 1930s, and it didn't change much between 1970 and 2017.

Beef, Pork and Chicken Availability per Capita in US, 1910-2017

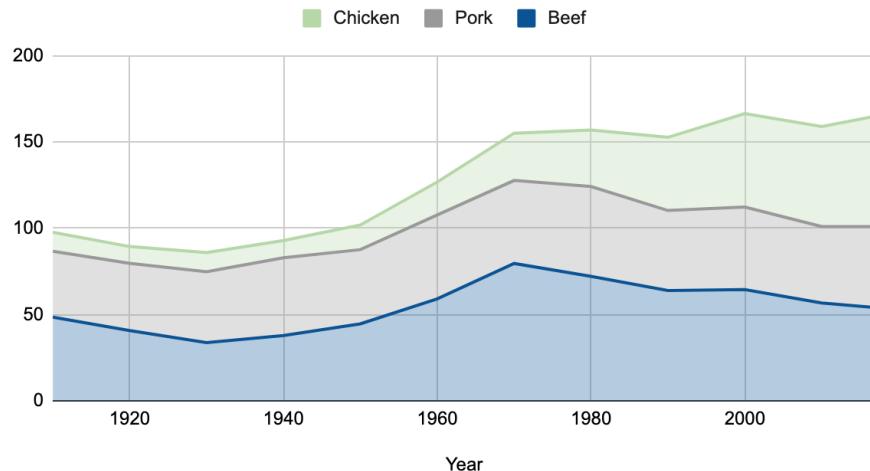


Figure 5.27: In addition to individual meat availability, stacked area charts show the overall availability. See data by US Department of Agriculture. Explore the full-screen interactive version.

The data for the stacked area chart is available from the Google Sheet Stacked area chart template, which you copy to your own Drive.

Set up the data exactly as you would with a line chart (first column is labels for the x-axis, second and following columns are series, or lines). Select it, and

choose *Insert > Chart*. In the Chart editor, in tab Setup, select *Stacked area chart* from the Chart type dropdown list.

XY Scatter and Bubble Charts with Google Sheets

Consider using XY scatter charts, also known as scatterplots, to display data coordinates to show the relationship between two variables. The first example below compares the relationships between life expectancy (shown on the X axis) and fertility (shown on the Y axis), which each nation is represented as a dot (an X-Y coordinate). Bubble charts are basically scatter charts on steroids, meaning that they can display the relationship of up to five variables. Further below you'll build a bubble chart based on the same XY life expectancy-fertility dataset, with added variables for population (displayed as circle size) and region of the world (displayed as circle color).

Fancier bubble charts animate the circles to represent one more variable: change over time. Such animated bubble charts were popularized by Hans Rosling, a renowned Swedish professor of global health. You can watch one of his famous TED talks to see animated bar charts in action.

XY Scatter chart

The scatter chart in Figure 5.28 uses World Bank data to reveal a downward slope: nations with lower fertility (births per woman) tend to have higher life expectancy. You can also phrase it the other way, nations with higher life expectancy at birth have lower fertility. Remember that correlation does not mean causation, so you cannot use this chart to argue that fewer births result in longer lives, or that longer-living females give birth to fewer children.

The data used in Figure 5.28 is available from our Google Sheets Scatter chart template. You can copy it to your own Google Drive so that you're able to edit it (go to *File > Make a copy*).

Figure 5.29 shows the first few rows of the dataset. Notice that the data is structured in three columns. The first column, *Life Expectancy*, is plotted on the x-axis (horizontal). The second column, *Fertility*, is plotted on the y-axis (vertical). The third column contains *Country* labels.

To build a scatter chart, select the **two** columns that contain your numeric data, and go to *Insert > Chart*. Google Sheets will likely to guess the chart type and you will see a scatterplot, but if not, you can always manually pick Scatter chart from the *Chart type* dropdown. Make sure your x-axis is set to Life Expectancy, and your Series shows Fertility. Note that both Life Expectancy and Fertility have 123 icon, meaning they are numeric.

Fertility and Life Expectancy in Selected Nations, 2018

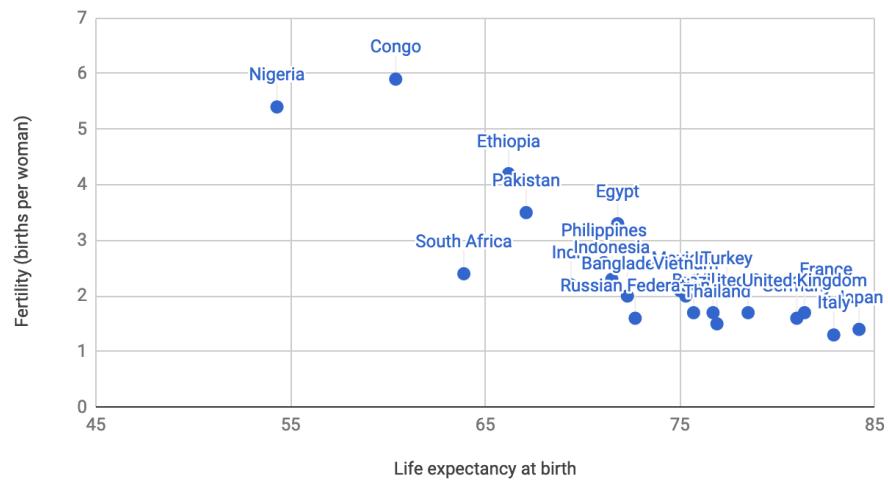


Figure 5.28: This scatter chart shows that nations with lower fertility tend to have higher life expectancy. See data by World Bank. Explore the full-screen interactive version.

	A	B	C
1	Life Expectancy	Fertility	Country
2	76.7	1.7	China
3	69.4	2.2	India
4	78.5	1.7	United States
5	71.5	2.3	Indonesia
6	75.7	1.7	Brazil
7	67.1	3.5	Pakistan
8	54.3	5.4	Nigeria
9	72.3	2	Bangladesh
10	72.7	1.6	Russian Federation

Figure 5.29: Data for a scatterplot is usually represented in 3 columns: x-values, y-values, and labels.

You will see a lot of scatter charts out there that do not label data points, and that's okay. Some scatter plots are designed to show whether or not there is a correlation, and knowing which points are which is not important. But sometimes labels are important for your storytelling.

In Chart editor, click on the 3-dot menu for your Series dataset (Fertility), and then *Add labels* (see Figure 5.30). The labels added by default will be the x-values of points. To make Google Sheets read labels from the third column (*Country*), click the name of your label dataset (Life Expectancy), then *Select a data range* button in the upper-right corner of the dropdown, and choose cells in the relevant columns. Make sure to include the header (first row) if all other data ranges include it.

Series

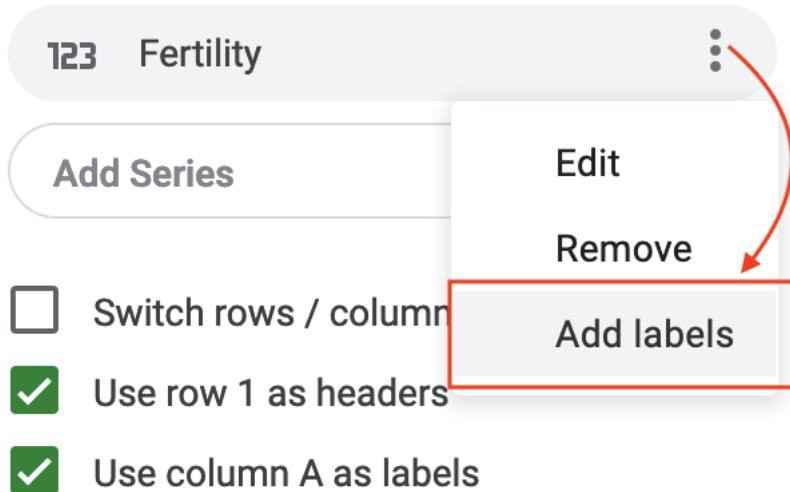


Figure 5.30: In the chart's Setup window, choose *Add labels* to the Series.

Tip: You may notice that some data points are too close to edges, and their labels are cut off. To fix this, go to Customize tab of the Chart editor. There, you can set minimum and maximum values for both horizontal and vertical axes. Unlike in bar charts, axes in scatter plots do not have to start at zero. You can set your minimum and maximum values to be a few units below and above the extreme points of your data range.

Note: Another name for the 3-dot menu symbol is the “kebab menu” because it resembles Middle Eastern food cooked on a skewer, in contrast to the three-line “hamburger menu” on many mobile devices, as shown in Figure 5.31.



Hamburger menu



Kebab menu

Figure 5.31: You should be able to distinguish kebab from hamburger menu icons.

Bubble chart with 3 columns

In this tutorial, we will show you a little trick that you can use if you want a scatter chart with both data values displayed in a tooltip. We will use the same World Bank dataset as we did for the scatter plot.

The bubble chart (more about the *proper* use of bubble charts in the next section) in Figure 5.32 shows the same data as our scatterplot on life expectancy vs fertility.

In the interactive version of the chart, hover your cursor over each bubble (dot) to reveal a tooltip with the country name and the two data points.

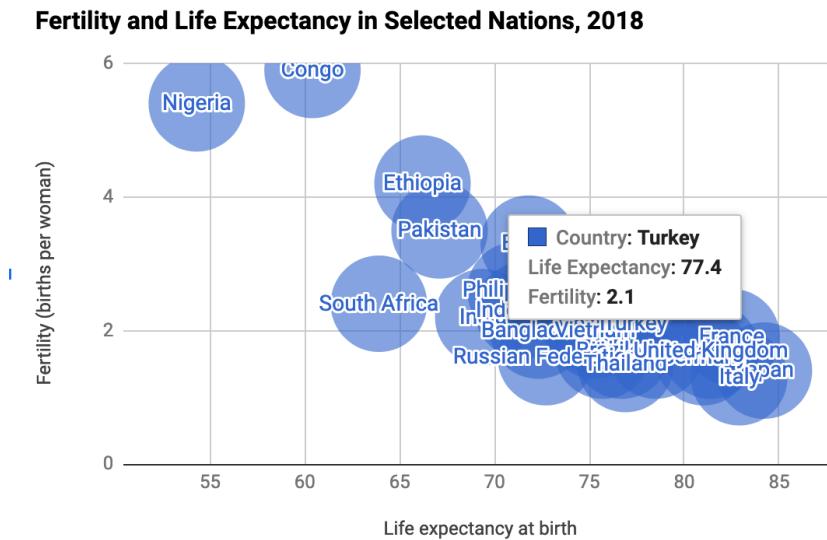


Figure 5.32: This bubble chart is essentially a scatter chart, because no other dimensions (colors, sizes) are used. See data by World Bank. Explore the full-screen interactive version.

The data for this example is available in Google Sheets Bubble chart with 3

columns template.

Notice that we moved the labels column (*Country*) to be the first one in the dataset, but the order shouldn't matter in this case. So our first column is the label for each bubble, the second column is the data to be plotted on horizontal x-axis, and the third column (fertility) will be placed on the y-axis.

Select all three columns, and go to *Insert > Chart*. Google Sheets will likely create a stacked column chart by default, so choose *Bubble* from the Chart type dropdown window.

If you want to remove labels from the bubbles, remove the **ID** series (click on the kebab menu > Remove).

Unfortunately, there is no easy way to reduce all bubbles to a uniformly smaller size. In the following section, we will introduce you to the proper way of using bubble charts.

Bubble chart with 5 columns

Bubble charts are a good alternative to scatter charts if you need to include one or two extra series in addition to your x- and y-coordinates. One of those can be expressed through bubble size (bigger bubbles represent larger values). Another one can make use of color (best for categorical data).

The bubble chart in Figure 5.33 shows fertility and life expectancy for a subset of the nations, with population (shown by bubble size) and region (shown by bubble color). Float your cursor over bubbles to view data details in the interactive version of the chart.

The five-column dataset is available in this Google Sheets Bubble chart with 5 columns template. The columns are arranged in the following order: country label, x-axis value, y-axis value, color, and bubble size.

Select all data and go to *Insert > Chart*, and choose Bubble as the Chart type. Make sure your **ID**, **X-axis**, **Y-axis**, **Series**, and **Size** fields contains the series you want to display, and make sure to have *Use row 1 as headers* option checked.

To change labels color, go to Customize tab of the Chart editor, and set Text color under the Bubble menu. Make it gray or black, so that it won't interfere with the bubble colors themselves.

Tip: If some of your bubbles are too close to the borders, set Min and Max values for the axis manually under Horizontal axis and Vertical axis menus.

Create Charts with Tableau Public

Tableau is powerful data visualization software used by many professionals and organizations to analyze and present data. Tableau can combine multiple

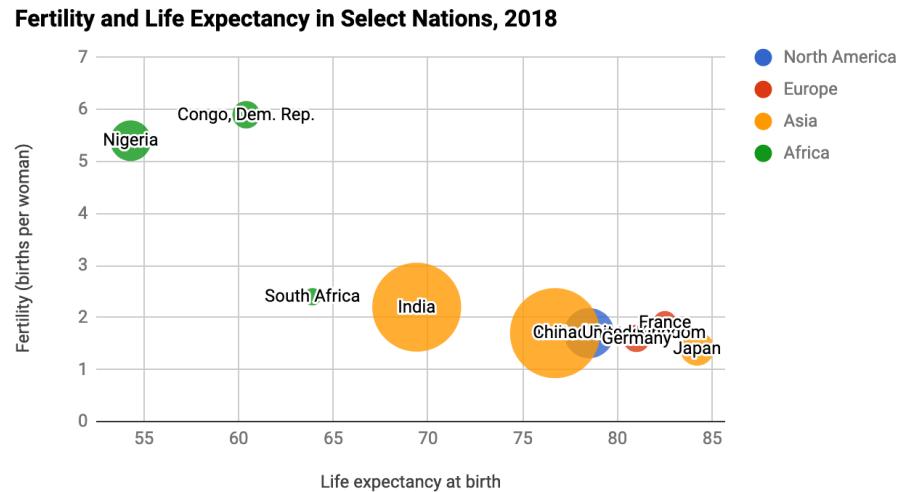


Figure 5.33: This bubble chart shows fertility and life expectancy for several countries, including their population (shown by bubble size) and region (shown by bubble color). See data by World Bank. Explore the full-screen interactive version.

	A	B	C	D	E
1	Country	Life expectancy	Fertility	Region	Population
2	United States	78.5	1.70	North America	326687501
3	United Kingdom	81.4	1.70	Europe	66460344
4	China	76.7	1.70	Asia	1392730000
5	India	69.4	2.20	Asia	1352617328
6	Japan	84.2	1.40	Asia	126529100
7	Germany	81.0	1.60	Europe	82905782
8	France	82.5	1.90	Europe	66977107
9	Congo, Dem. Rep.	60.4	5.90	Africa	84068091
10	Nigeria	54.3	5.40	Africa	195874740
11	South Africa	63.9	2.40	Africa	57779622

Figure 5.34: Bubble chart data. Bubble size represents population, color – region.

datasets to show in a single chart (or a map), and allows to create dashboards with multiple visualizations. Individual visualizations and dashboards can be published and embedded on your website through an iframe.

This book focuses on the free Tableau Public tool, available to download for Mac or Windows. This free version of Tableau Public is very similar to the pricier versions that the company sells, but one constraint is that the data visualizations you create will be public, as the name suggests, so do not use it for any sensitive or confidential data that should not be shared with others.

You might be overwhelmed by the amount of options and features Tableau provides through its interface. We will show you the very basics enough to get started, and if you want to dive further, there are many great books on Tableau available.

In this book, we will show you how to add datasets to Tableau Public, and how to create a scatterplot and a filtered line chart.

Create XY Scatter Chart with Tableau Public

Just to remind you, scatter charts plot two variables against each other, on x- and y-axis, revealing possible correlations. With Tableau Public, you can create an interactive scatter chart, letting users hover over points to view specific details.

Figure 5.35 illustrates a strong relationship between Connecticut school district income and test scores.

Install Tableau and Get Data

You can download Tableau Public for Windows or Mac from Tableau's official website. You will need to provide your email address.

If you wish to use the dataset from the scatter plot in Figure 5.35, you can download the sample Excel file. This data file consists of three columns: district, median household income, and grade levels (above/below national average for 6th grade Math and English test scores). The Notes tab explains how this data is based on the work of Sean Reardon et al. at the Stanford Education Data Archive, Motoko Rich et al. at The New York Times, Andrew Ba Tran at TrendCT, and the American Community Survey 2009-13 via Social Explorer.

Connect Data and Create a Scatterplot

Tableau Public's welcome page includes three sections: Connect, Open, and Discover.

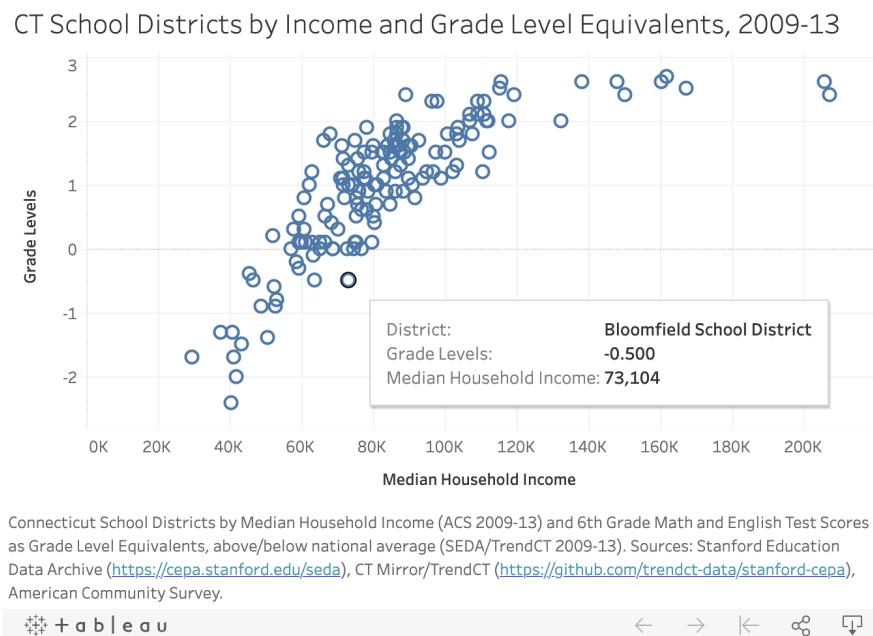


Figure 5.35: This scatterplot is made in Tableau Public and shows the relationship between household income and test scores in Connecticut school districts.

1. Under Connect, choose Microsoft Excel if you decided to use the sample dataset or your own Excel file. To load a CSV file, choose *Text file*. If your data is in Google Sheets, click *More...* and choose Google Sheets. Once you successfully connect to your data source, you will see it under Connections in the Data Source tab. Under Sheets, you will see two tables, **data** and **notes**.
2. Drag **data** sheet into *Drag tables here* area, like is shown in Figure 5.36. You will see the preview of the table under the drag-and-drop area. You have successfully connected one data source to Tableau Public, and you are ready to build your first chart.

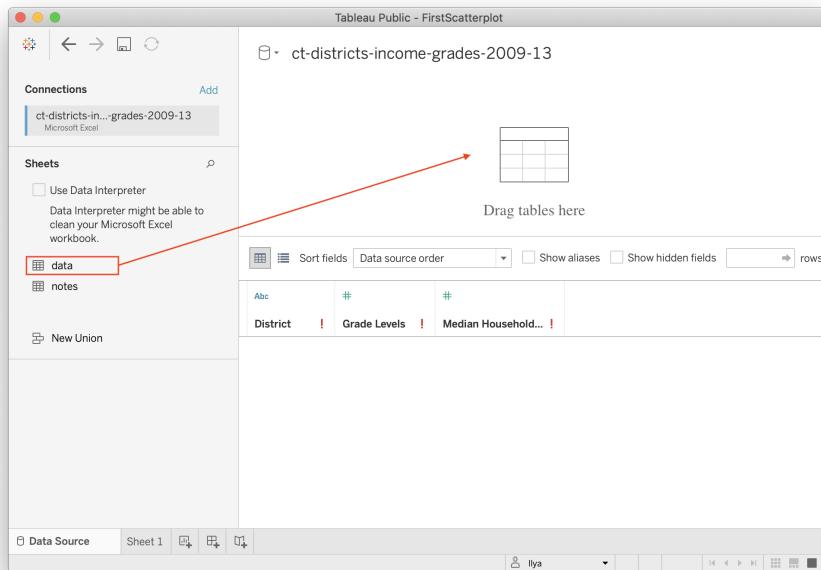


Figure 5.36: Drag **data** sheet into *Drag tables here* area.

3. Go to *Sheet 1* tab (in the lower-left corner of the window) to view your worksheet. Although it may feel overwhelming at first, the key is learning where to drag items from the Data pane (left) into the main worksheet. **Dimensions** are any information that is qualitative or categorical, and are shown in blue with *Abc* tables. **Measures** are quantitative information about the dimensions, shown in green with *#* icons.
4. Drag the *Grade Levels* measure into the **Rows** field above the charting area, which for now is just empty space. You can consult Figure 5.37 for

this and two following steps. Tableau will apply a summation function to it, and you will see the `SUM(Grade Levels)` appearing in the Rows row, and a blue bar in the charting area. It makes little sense so far, so let's plot another measure (variable).

5. Drag *Median Household Income* to the **Columns** field (just above the Rows field). Tableau will once again apply the summation function, so you will see `SUM(Median Household Income)` in the Columns. The bar chart will transform into a scatter chart with just one data point in the upper-right corner. That is because the data for both is aggregated (remember the `SUM` function).
6. We want to tell Tableau to disaggregate the household and grade levels variables. To do so, drag *District* dimension into the lower portion of the Marks area. You will now see a real scatter chart in the charting area. If you hover over points, you will see all three values associated with it.

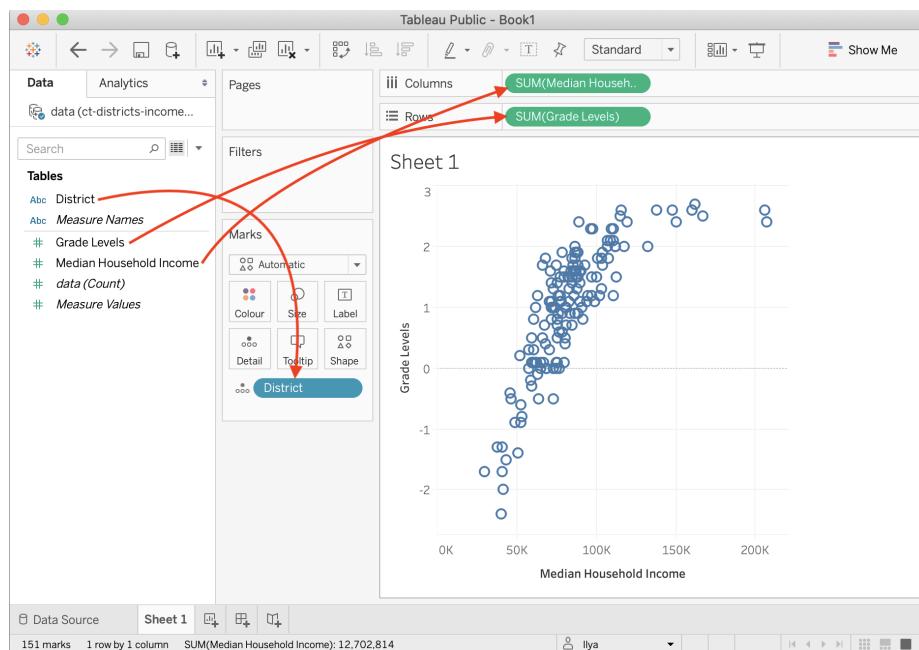


Figure 5.37: Drag measures and dimensions to the right places in Tableau.

Add Title and Caption, and Publish

Give your scatter chart a meaningful title by double-clicking on default *Sheet 1* title above the charting area.

You will normally need to provide additional information about the chart, such as source of the data, who built the visualization and when, and other important things. You can do so inside a *Caption*, a text block that accompanies your Tableau visualization. In the menu, go to *Worksheet > Show Caption*. Double-click the *Caption* block that appeared, and edit the text.

As a result, your final worksheet will look like shown in Figure 5.38.

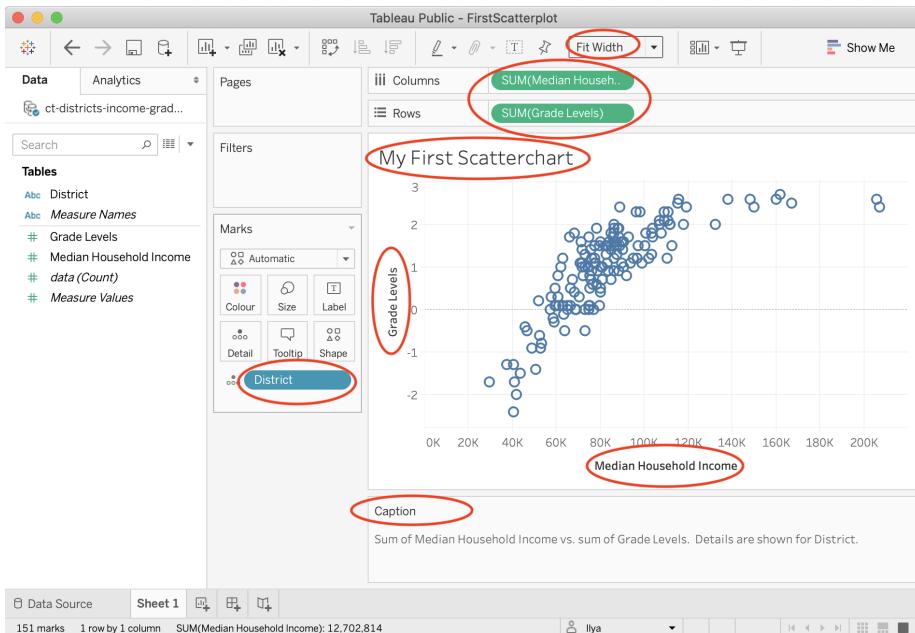


Figure 5.38: This scatter chart is ready to be published.

Tip: In the dropdown above Columns section, change *Standard* to *Fit Width* to ensure your chart occupies 100% of available horizontal space.

To publish the chart to the web,

1. Go to *File > Save to Tableau Public As....* A window to sign in to your account will pop up. If you don't have an account, click *Create one now for free* at the bottom.
2. Once signed in, a window to set the workbook title will appear. Change the default *Book1* title to something meaningful, as this name will appear in the URL for your published work. Click *Save*.
3. Once the dashboard is saved, Tableau Public will open up a window in your default browser with the visualization. In the green ribbon above the chart, click *Edit Details* to edit the title or description. Under *Toolbar*

Settings, see checkbox to *Allow others to download or explore and copy this workbook and its data* (Figure 5.39), and enable/disable it as you think is appropriate. As advocates for open and accessible data, we recommend leaving the box checked.



Figure 5.39: This scatter chart is ready to be published.

See the Embed Tableau Public on Your Website section of this book to insert the interactive version of your chart on a web page that you control.

Tip: Your entire portfolio of Tableau Public visualizations is online at <https://public.tableau.com/profile/USERNAME>, where USERNAME is your unique username.

To learn more, see Tableau Public resources page.

Create Filtered Line Chart with Tableau Public

One of the advantages of interactive visualizations over static (including printed) is the ability to store a lot more data, and show it only when required. In other words, an interactive visualization can be made into a data-exploration tool that won't overwhelm the viewer at first sight, but will allow the viewer to "dig" and find specific data points and patterns.

In this tutorial, we will build an interactive filtered line chart with Tableau Public like is shown in Figure 5.40. The filter will be a collection of checkboxes that allow to add/remove lines from the chart. Viewers can hover over each line to identify the school name and data attached to it.

We will use % Population with Internet Access by the World Bank. You can download the dataset [here](#).

We assume that you have Tableau installed. If not, see the previous tutorial, Create XY Scatter Chart with Tableau Public.

Connect Text File and Build a Line Chart

Open Tableau Public, and under Connect menu, choose *Text file*. Tableau may or may not have imported the table automatically. If you see the preview of the

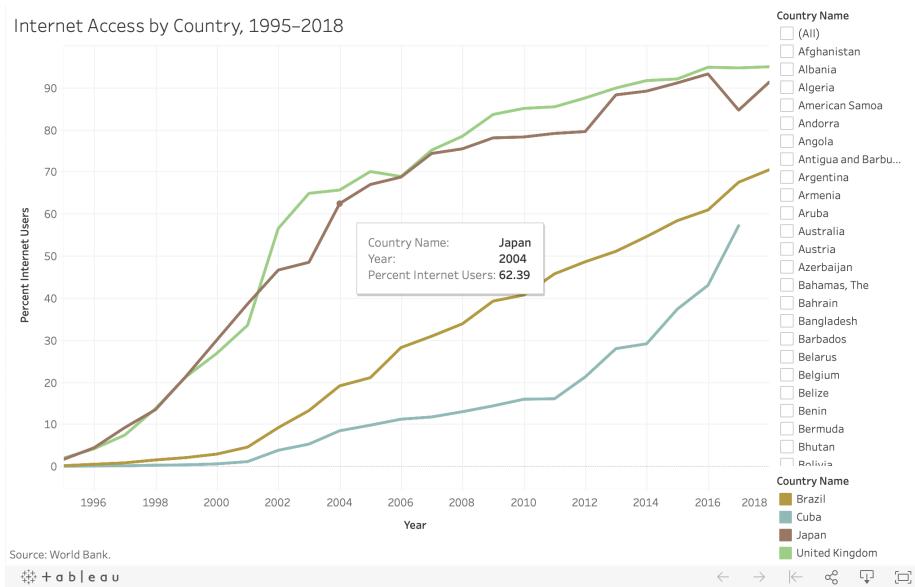


Figure 5.40: Internet Access by Country, 1995–2018.

table with three columns: *Country Name*, *Year*, and *Percent Internet Users*, you can proceed to Sheet 1.

If not, drag and drop the file (under Files section in the left) to the *Drag tables here* area. Once you see the preview, go to Sheet 1.

Your variables will be listed under Tables in the left-hand side. The original variables are displayed in normal font, the *generated* variables will be shown in *italics* (such as *Latitude* and *Longitude* that Tableau guessed from the country names).

To build a line chart,

1. Drag Year variable to **Columns**.
2. Drag Percent Internet Users variable to **Rows**. The variable will change to **SUM(Percent Internet Users)**. You should see a single line chart that sums up percentages for each year. That is completely incorrect, so let's fix it.
3. In order to "break" aggregation, drag and drop Country Name to the Color box of the Marks card. Tableau will warn you that the recommended number of colors should not exceed 20. Since we will be adding filtering, we don't care about it much. So go ahead and press *Add all members* button.
4. Now you should see an absolute spaghetti plate of lines and colors. To add filtering, drag *Country Name* to the Filters card. In the Filter window,

make sure all countries are checked, and click *OK*.

5. Right-click on *Country Name* pill in Filters card, and check Show Filter (see Figure @ref(fig:tableau-filtered-show-filter.png))
6. You will see a list of options with all checkboxes on have appeared to the right of the visualization. Click *(All)* to add/remove all options, and add a few of your favorite countries to see how the interactive filtering works.

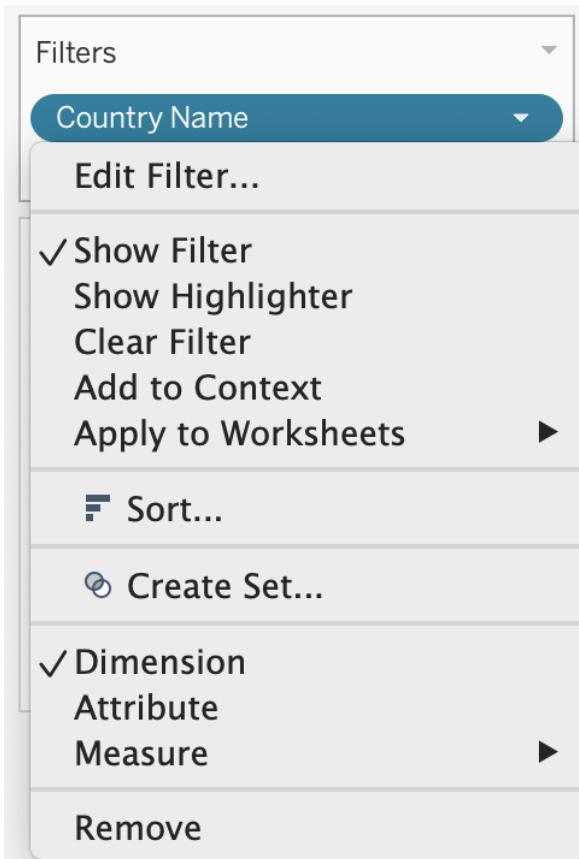


Figure 5.41: Once you dragged Country Name to the Filters card, make sure the Filter is displayed.

Add Title and Caption, and Publish

Replace *Sheet 1* title (above the chart) with “Internet Access by Country, 1995–2018” by double-clicking on it. In the menu, go to *Worksheet > Show Caption* to add a Caption block under the chart. Use this space to add source of your data (World Bank), and perhaps credit yourself as the author of this visualization.

Change *Standard* to *Fit Width* in the dropdown above the Columns field.

You may notice that the x-axis (Year) starts with 1994 and ends with 2020, although our data is for 1995–2018. Double-click on the x-axis, and change **Range** from *Automatic* to *Fixed*, with the Fixed start of 1995, and the Fixed end of 2018. Close the window and see that the empty space on the edges has disappeared.

Once your filtered line chart looks like the one shown in Figure 5.42, you are ready to publish.

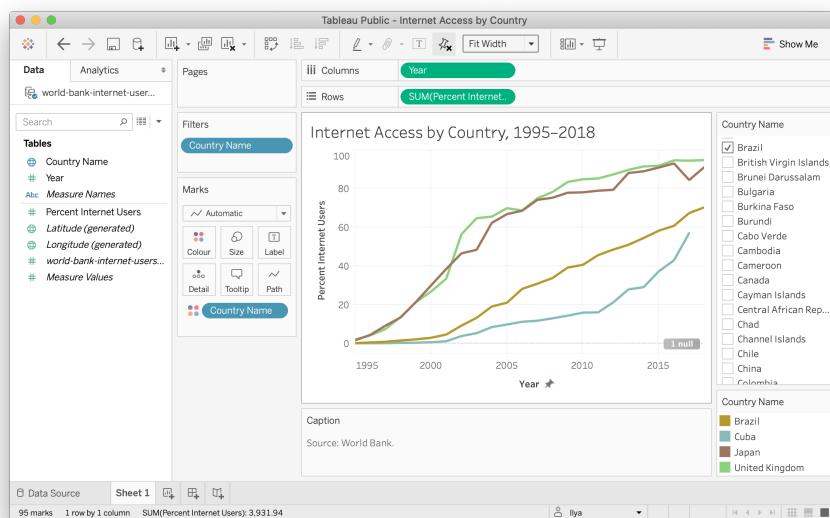


Figure 5.42: This workbook is ready to be published.

To publish the filtered line chart to the web, go to *File > Save to Tableau Public As...*. You may be prompted with the window to log in to your account (or create one if you don't have it yet). The next steps are fairly self-explanatory, and you can consult the previous tutorial for more information on publishing.

See the [Embed Tableau Public on Your Website](#) section of this book to insert the interactive version of your chart on a web page that you control.

To learn more, see [Tableau Public resources](#) page.

Summary

Congratulations on creating interactive charts that pull readers deeper into your story, and encourage them to explore the underlying data! As you continue to

create more, always match the chart type to your data format and the story you wish to emphasize. Also, design your charts based on the principles and aesthetic guidelines in this chapter. While anyone can click a few buttons to quickly create a chart nowadays, your audiences will greatly appreciate well-designed charts that thoughtfully call their attention to meaningful patterns in the data.

The next chapter on Map Your Data follows a similar format to introduce different map types, design principles, and hands-on tutorials to create interactive visualizations with spatial data. Later you'll learn how to embed interactive charts on your web in chapter 7.

To learn about more powerful charting tools, see Chart.js and Highcharts templates in chapter 9, which give you ever more control over how your design and display your data, but also require learning how to edit and host code templates with GitHub in chapter 8.

Chapter 6

Map Your Data

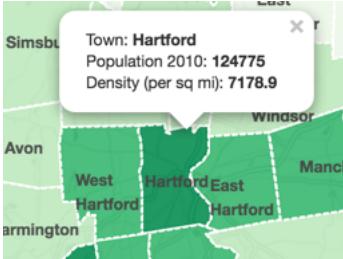
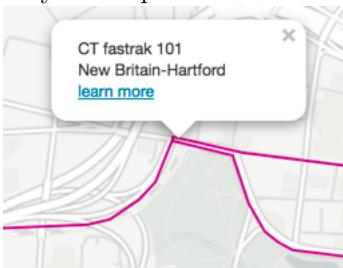
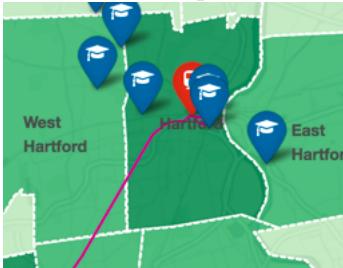
TODO: Rewrite chapter

Maps entice readers to explore your data story and develop a stronger sense of place. But good maps require careful thought about how to clearly communicate spatial concepts with your audience. This book features free tools to create interactive maps that you can embed in your website. In this chapter, you will learn how to:

- Practice key principles of map design.
- Choose a map type that matches your data story and format, with tutorial links in the table below. Beginners may start with easy-to-learn tools such as Google My Maps, then move up to more powerful tools, such as Leaflet, which require you to Edit and Host Code with GitHub or other web servers.

See also related chapters in this book:

- Draw and write your data story to capture your ideas on paper
- Strengthen spreadsheet skills, Find and know your data, and Clean your data
- Transform your map data
- Embed your interactive chart on your website
- Detect bias in data stories, including How to lie with maps
- Tell your data story, including its most meaningful insights and limitations

Basic map types	Best use and tutorial chapters
Point map	Best to show specific locations, such as addresses with geocoded coordinates, with colors for different categories. Easy tool: Google My Maps tutorial Power tool: Leaflet Maps with Google Sheets and other Leaflet templates
	
Polygon map	Best to show regions (such as nations or neighborhoods), with colors or shading to represent data values. Also known as choropleth map. Easy tool: n/a Power tools: Tableau Public or Leaflet Maps with Google Sheets and other Leaflet templates
	
Polyline map	Best to show routes (such as trails or transit), with colors for different categories. Easy tool: n/a Power tool: Leaflet Maps with Google Sheets and other Leaflet templates
	
Combination map	Best to show any combination of points, polygons, or polylines. Easy tool: n/a Power tool: Leaflet Maps with Google Sheets and other Leaflet templates
	

Basic map types	Best use and tutorial chapters
Storymap  <p>This screenshot shows a Storymap interface. On the left, there is a thumbnail of a historical building labeled "FIRST HIGH SCHOOL MELBOURNE, 1847". To its right is a map of a city area with several location markers. Below the map is a detailed street-level view of a specific location. At the bottom of the screen, there is a navigation bar with zoom controls (+, -, ×).</p>	Best for guided point-by-point journey through a historical narrative, with optional photos, audio, or video on an interactive map. Easy tool: Knight Lab's StoryMap, ESRI Story Maps Power tool: Leaflet Storymaps with Google Sheets

TODO:

- heat map
- tab-view map for historical change
- synchronized side-by-side map

Map Design Principles

Ask Before You Map: Before you leap into a mapping project, consider these questions:

Does your data contain geographic information? Common examples:

- Specific locations or addresses (examples: *Trinity College*, or *300 Summit St, Hartford, CT*)
- Latitude and longitude coordinates (example: *41.756, -72.675*)
- Regions that are legally recognized (such as nations, states, counties, census tracts) or that correspond to a boundary map in your possession (such as designated neighborhoods or health districts)

While there are many more types of geographic information, these examples above are the most common. If your data lacks geographic information, or if you do not possess the corresponding boundary information, it may not be possible to map it.

Does location really matter to your data story?

Sometimes a well-designed chart, rather than a map, may be the best way to visualize your data story. Consider these alternatives:

- to show change over time across different locations, consider a line chart

- to show the relationship between two or more datasets across different locations, consider an XY scatter chart or bubble chart

If a map is the best way to tell your data story, then choose an appropriate type. See table of basic map types in this book.

Map Design Principles

1. Understand basic map vocabulary: title, legend, baselayer, marker, popup, tooltip, zoom level, polygon, polyline, source.
2. Add source credits and bylines—with links to view data tables and details—to build credibility and accountability.
3. Choose colors wisely.
 - Use color to logically organize your data. Avoid random colors (Wong pp. 40, 44).
 - Avoid bad combinations from opposite sides of color wheel, such as red/green or yellow/blue (Wong pp. 40, 44).
 - Use contrast (such as color vs gray) to call attention to your data story (Knaflic pp. 87-88)
4. Choose basemaps wisely. Basemaps themselves may contain a lot of information, such as terrain, roads, parks, town names, buildings, etc. They may also use colors that can be distracting to the viewer. Think about the minimum number of elements required in the basemap to tell your story.

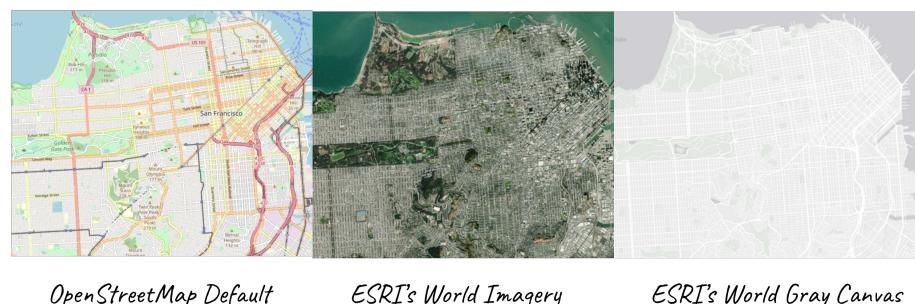


Figure 6.1: The view of San Francisco with different basemaps

Design polygon maps with ColorBrewer

One of the most useful tools for creating meaningful polygon (or choropleth) maps is ColorBrewer <http://colorbrewer2.org> created by Cynthia Brewer, Mark Harrower and the Pennsylvania State University.

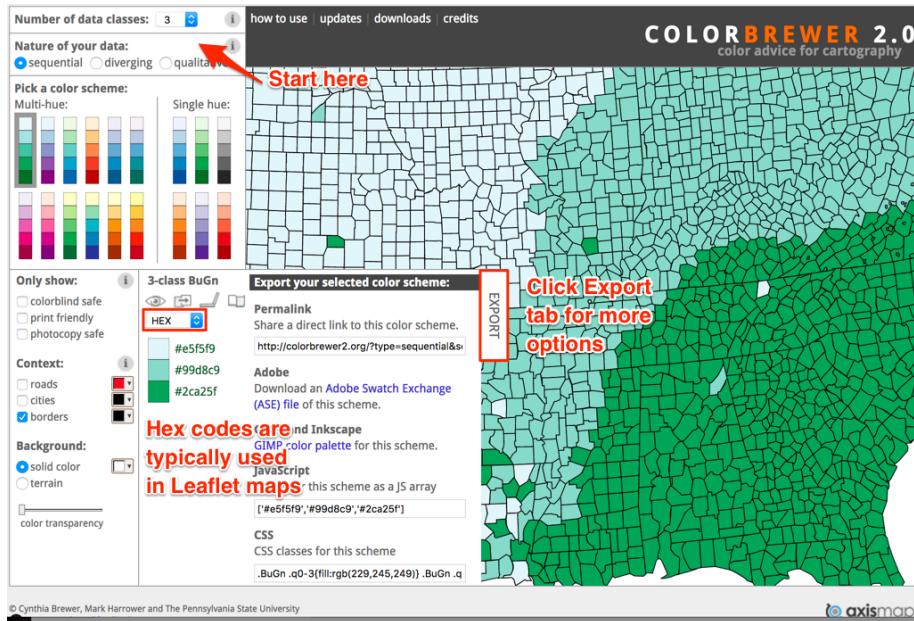


Figure 6.2: Screenshot: ColorBrewer web interface

- 1) Think about the **number of data classes** (or “dividers” or “buckets”). More does not necessarily mean better. Try different numbers and color schemes, and decide if you (and your audience) can easily distinguish between them.
 - A smaller number sorts your data into fewer buckets, and shows a more **coarse map**, but differences in colored ranges become **more visible**.
 - A larger number sorts your data into more buckets, and shows a more **granular map**, but differences in colored ranges become **less visible**.
- 2) Think about the **nature of data** you are going to display.
 - Sequential: best to show steps from lower values (light color) to higher values (dark color)

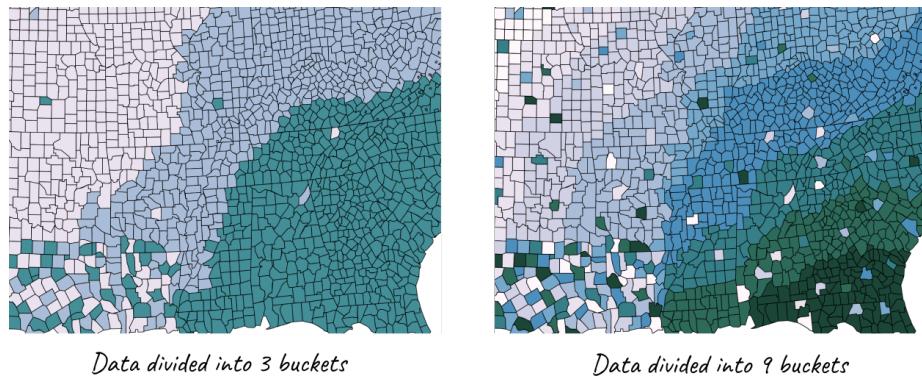


Figure 6.3: Screenshots: ColorBrewer web interface

- Example: a scale that increases from 1 to 100
- Diverging: best to show extremes (dark colors) around a neutral middle (light color)
 - Example: a scale that highlights extremes from -100 to 0 to 100
- Qualitative: best to show different categories, represented by their own color
 - Example: a map legend of the dominant crop in each area: apples, oranges, bananas

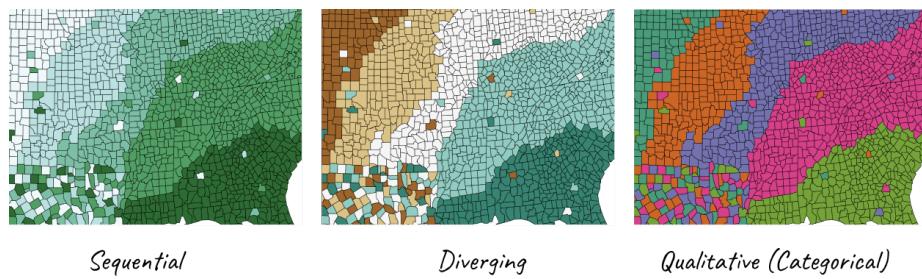


Figure 6.4: Screenshots: ColorBrewer web interface

- 3) Pick a **color scheme**, with options for colorblind-safe and print-friendly.
 - Think about the ideal format for your audiences. Are readers more likely to view your visualization on a computer screen, or in print, or both?
- 4) Click the Export tab to view all options. Some Leaflet map templates in this book use specific color names (such as “red” or “darkgreen”) and

some use hexadecimal codes, abbreviated as “hex codes” (such as #ff0000 or #336600). To learn more, use a Color Picker tool, such as https://www.w3schools.com/colors/colors_picker.asp

Beware that polygon map design choices about data classes and colors reflect the biases of the author and the software. Read the Detect Bias in Data Stories chapter in this book, especially How to Lie with Maps

Learn more: - Axis Maps, “The Basics of Data Classification,” 2010, <http://axismaps.github.io/thematic-cartography/articles/classification.html> - Lisa Charlotte Rost, “Your Friendly Guide to Colors in Data Visualisation,” Lisa Charlotte Rost, April 22, 2016, <https://lisacharlotterost.github.io/2016/04/22/Colors-for-DataVis/>. - Josh Stevens, “Bivariate Choropleth Maps: A How-To Guide,” February 18, 2015, <http://www.joshuastevens.net/cartography/make-a-bivariate-choropleth-map/>.

Point Map with Google My Maps

TODO: add text, check current documentation and features at <https://www.google.com/maps/about/mymaps/>

Try it: Explore the interactive point map below, or view the full-screen version, created with Google My Maps <https://www.google.com/maps/d/>.

Tool review: - Pros - Easy-to learn free mapping tool to import and style point, polyline, and polygon layers and basemap layers - Share and collaborate through the Google Drive platform - Geocoding error warning - Cons - Limited options to customize map markers - Cannot easily create colored polygon maps from data values - Cannot extract geocoded data to migrate to another tool

Video:

Let's build a simple point map with sample data, using Google My Maps <https://www.google.com/maps/d/>. Requires signing up for a free Google Drive account.

- 1) Click this link and Save to download to your computer: sample-address-data in CSV format. CSV means comma-separated values, a generic spreadsheet format that most tools can easily open. For help with downloading, see this short video tutorial.
- 2) Open and sign in to Google My Maps <https://www.google.com/maps/d/>
- 3) Click the red + symbol to create a new map, which will be saved automatically to your Google Drive folder.

 Google My Maps[+ CREATE A NEW MAP](#)

Figure 6.5: Image: Create a new map

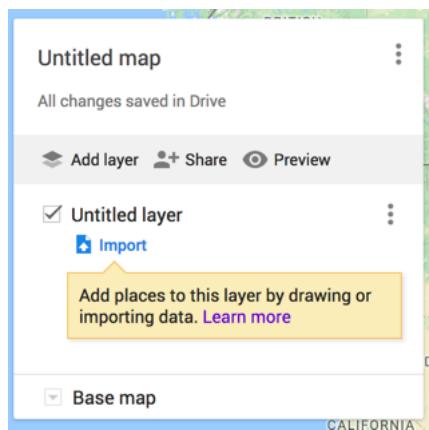


Figure 6.6: Image: Import a data layer

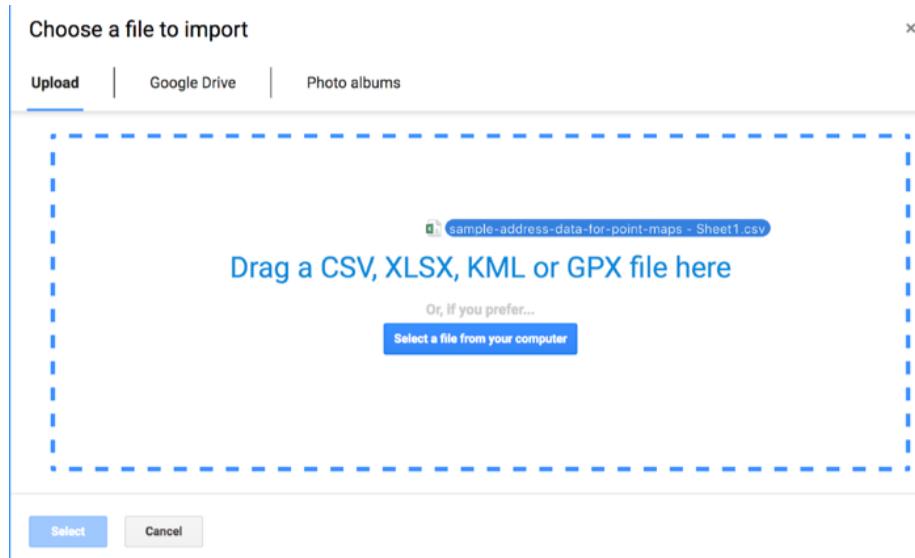


Figure 6.7: Image: Drag-and-drop data into My Maps

- 4) In the map layers area, click the blue Import link. Drag-and-drop the CSV address data file into the web interface to import it.
- 5) Choose columns to position your placements. Select “Address” for this sample data, then Continue.

Choose columns to position your placemarks

Select the columns from your file that tell us where to put placemarks on the map, such as addresses or latitude-longitude pairs. All columns will be imported.

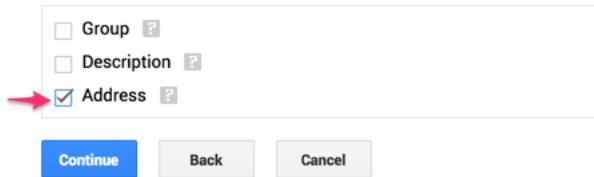


Figure 6.8: Image: Choose columns to position placemarks

- 6) Choose a column to title your markers. Select “Description” for this sample data, then Finish.

Choose a column to title your markers

Pick a column to use as the title for the placemarks, such as the name of the location or person.

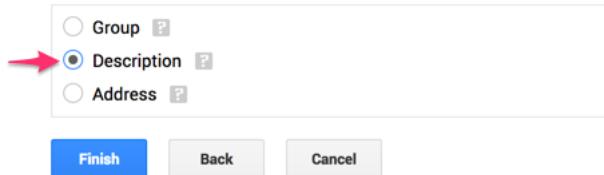


Figure 6.9: Image: Choose column to title markers

- 7) After My Maps uploads and geocodes your sample data, click Open Data Table to inspect the results.

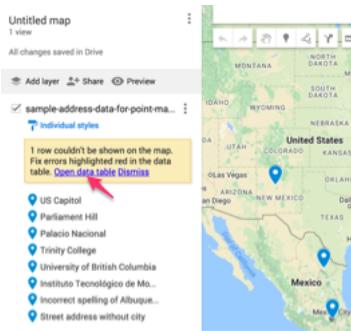


Figure 6.10: Image: Open Data Table to inspect geocoding errors

- 8) To style the map markers, click Individual Styles. In this sample data, you can select Group Places By > Style By > Group. This will color markers according to the three categories.



- 9) To publish your map on the web, click Share, add a map title, change from Private to Public on the Web, so that anyone can view your map. Click Save and Done.

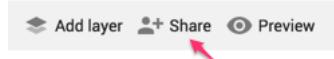


Figure 6.11: Image: Share link

- 10) To embed the map on your own website, click the three vertical dots next to the map title for more options, and select Embed On My Site. The tool will generate an iframe code for you to copy. For next steps, go to the Embed on Your Web chapters in this book.

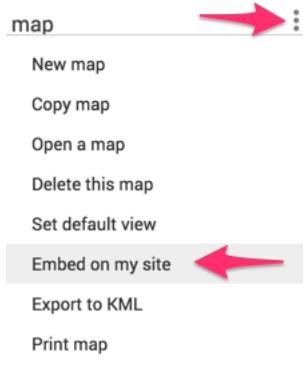


Figure 6.12: Image: Embed map on your site

Learn more: - Google My Maps Help Page <https://support.google.com/mymaps/answer/3024396>

Point Map with Carto Builder

TODO:

- Test this tool and decide if it still warrants inclusion in this book
- See note about old versus newer Cartobuilder – still relevant?
- if this tool stays in the book, check the iframe below to see if update is needed

Try it: Explore the interactive point map below, or view the full-screen version ,created with Carto Builder <https://carto.com>.

Tool review: - Pros: - Free and powerful drag-and-drop map tool in the browser - Customize point markers and polygon colors by data values - Additional features include geographic analysis tools - Cons: - Several steps required to create simple point or polygon map - New users may get lost when moving through multiple screens - Free account allows only 400 geocodes per month

Video:

Before you begin: This tutorial uses the newer Carto Builder, rather than older Carto Editor tool. Learn more at <https://carto.com/learn/guides/intro/migrating-from-carto-editor-to-carto-builder>. If you have an old Carto account that has not automatically updated to the new Builder tool, you may need to create a brand-new account to use this tutorial.

Let's build a simple point map with sample data, using Carto Builder <https://carto.com>. Requires signing up for a free account.

- 1) Click this link and Save to download to your computer: sample-address-data in CSV format. CSV means comma-separated-values, a generic spreadsheet format that many tools can easily open.
- 2) Open Carto in your browser <https://carto.com>.
- 3) The Carto Dashboard displays two views: Maps and Datasets. Always begin with Datasets, then move to Maps. (Hint: If your dashboard looks very different than mine, then you might still be using the older Carto Editor, rather than the newer Carto Builder.)

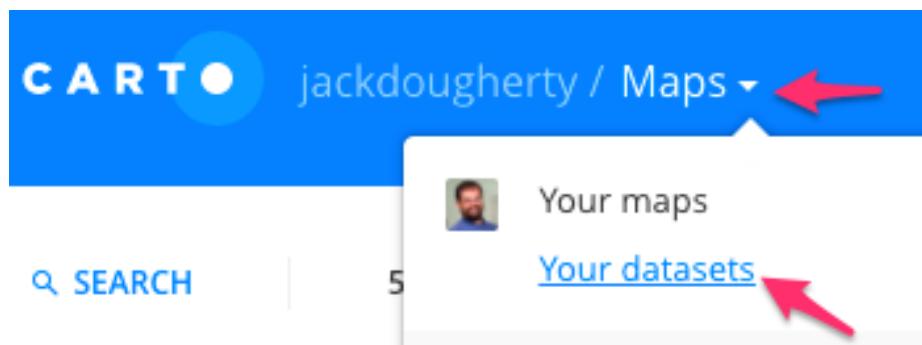


Figure 6.13: Image: Carto Builder dashboard: Begin with Datasets

- 4) First, connect your dataset, and soon we'll turn it into a map. Click blue button to add New Dataset.
- 5) Drag-and-drop the CSV sample address data to upload it, and select Connect Dataset. (Be patient. Sometimes this takes more than 30 seconds.)
- 6) Inspect your connected dataset.
- 7) Click the blue Create Map button.
- 8) Click the Edit Your Map button.
- 9) In your map data layer, click Add Analysis.
- 10) In the next screen of Analysis options, select Georeference, then click the Add Analysis button.
- 11) Back in your map data layer, under Georeference options, select Type > Street Addresses (scroll down to the bottom) for this sample data.
- 12) Under Parameters, for Column Street Address (abbreviated as Col. Street Ad.), select the “address” field for this sample data. Press the Apply button.

- 13) After Carto has attempted to geocode your address data, click Style This Analysis. Or, go to the map data layer and click the Style tab.
- 14) In Style options, for Aggregation select none (the default).
- 15) Under Style options:
 - select Fill Number to change circle sizes
 - enter a larger size, such as 13, to make our sample points more visible
 - select Fill Color to change circle color
 - switch from Solid (all points are same color) to By Value, and scroll down to Group (at the bottom) to automatically color by categories for this sample data. (Hint: If you don't see Group in the menu, click somewhere else and try it again.)
- 16) In the Pop-up tab, select a Window Style, then select boxes in Show Items to display.
- 17) In the Legend tab, click Select a Style to display information, and your color-coded groups from above should automatically appear on your map. (Hint: A legend may automatically appear after styling your markers by color.)
- 18) Before publishing your map: If you wish to rename it, do it now by selecting the three vertical dots next to the file name, and select Rename.
- 19) To publish your map on the web: Next to your map file name, click the blue "back" arrow (NOT your browser back button) to return to the data layer. Click the green Public button, and on the next screen, click the blue Publish button.
- 20) On the next screen, Get The Link generates a weblink to your map, and Embed It generates an iframe code to insert the live map in your website. For next steps, go to the Embed on Your Web chapters in this book.
- 21) If you make edits to your map, you must click the blue Update button to republish your map to the web.

Learn more: - Getting Started with Carto Builder <https://carto.com/learn/guides/intro/getting-started-with-carto-builder>

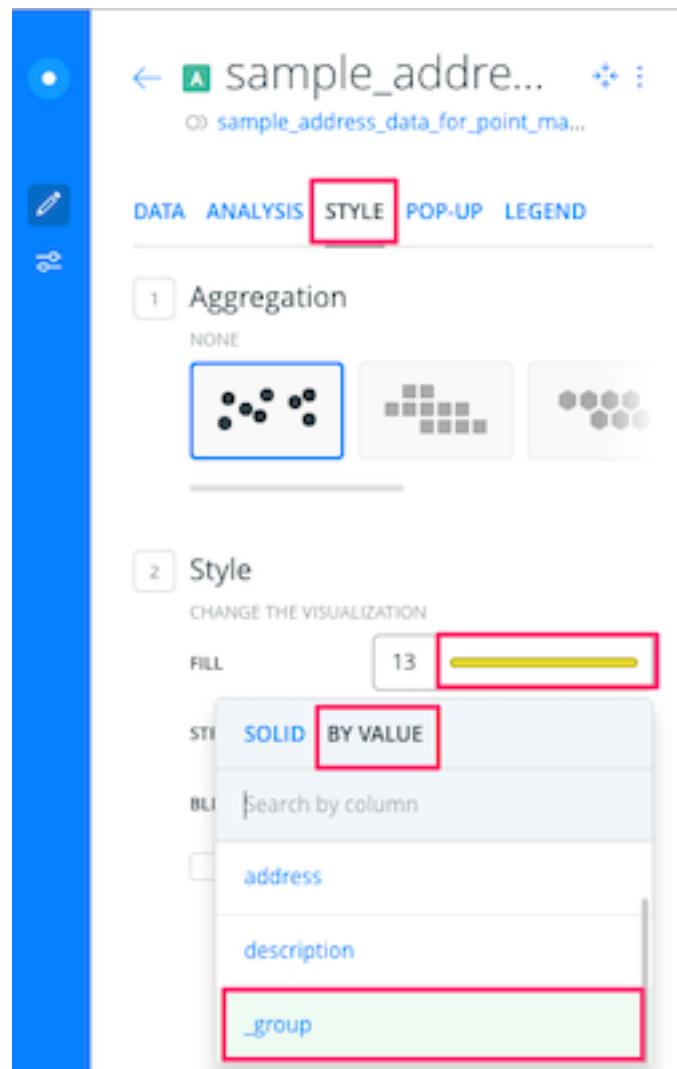


Figure 6.14: Image: Style points by value

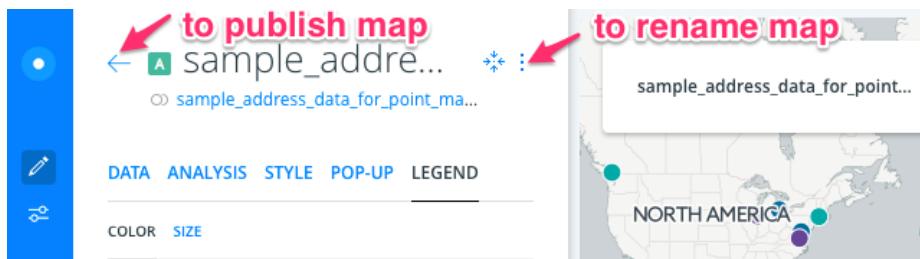


Figure 6.15: Image: Click to rename or publish your map

Filtered Point Map with Socrata Open Data

TODO: decide whether to keep or not; originally co-authored with Veronica.

Open data repositories recently launched by the State of Connecticut and the City of Hartford both use the Socrata platform, which offer user-friendly ways to view, filter, and export data. Also, the Socrata platform includes built-in support to create interactive charts and maps, and to embed them on your own websites. This tutorial demonstrates these features by creating an interactive point map of selected schools from the Connecticut Education Directory in the state data portal. The final product looks like this:

CT Schools Map 2015

Powered by Socrata

One advantage of creating data visualizations directly on an open data platform is that the chart or map is linked to the data repository. For example, if the Socrata platform administrator updates the data table, then a Socrata dataviz based on that data will be automatically updated, too. This may be especially useful for “live” data that is continuously updated by agency administrators, such as fire, crime, and property data repositories.

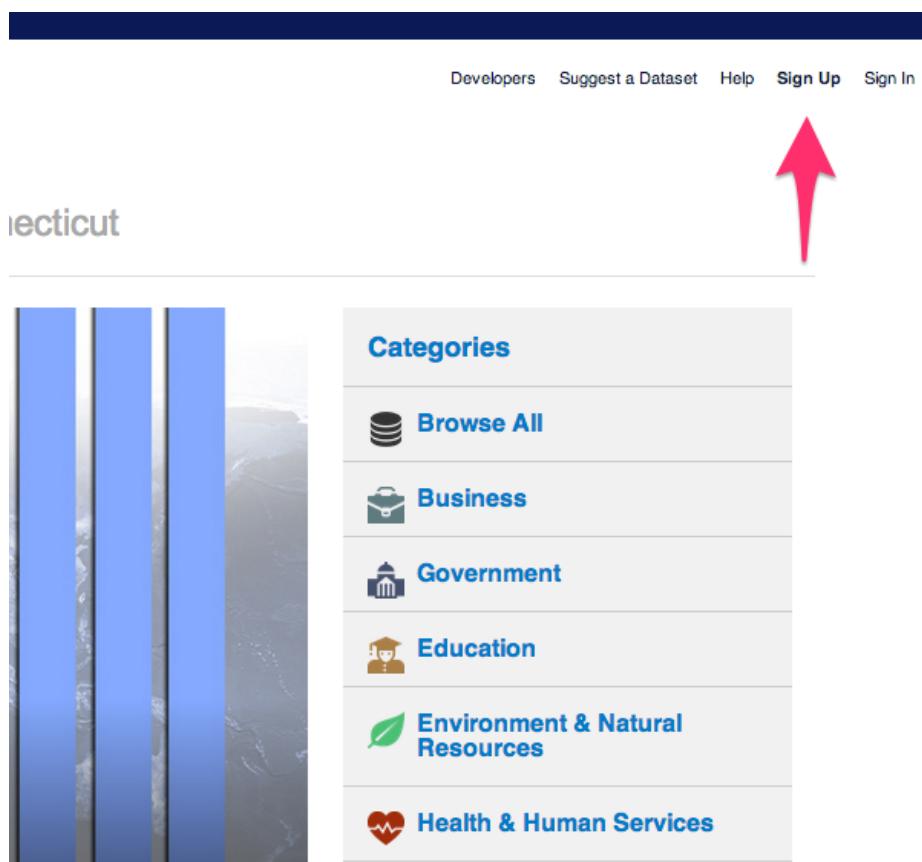
But there are limitations to creating your chart or map on an open data repository platform. First, if the agency stops using the platform, or changes the structure of the underlying data, your online chart or map may stop functioning. Second, you are usually limited to using data tables and geographic boundaries that already exist on that platform, since importing your own may not be an option.

If these limitations concern you, a simple alternative is to export data from the open repository (which means that any “live” data would become “static” data), and import it into your preferred dataviz tool, such as those described in other chapters of this book. A second, more advanced alternative, is to learn how to pull live data from the repository directly into your dataviz, using an Application Programming Interface (API), which requires coding skills that

are beyond the scope of this tutorial. To learn more about the Socrata API: <https://dev.socrata.com/>.

Steps to create a filtered point map

Sign up for a free account ID on any Socrata platform, such as <https://data.ct.gov/signup>. One account will work on all Socrata sites.



Select your desired dataset in Socrata. In this tutorial, we will use CT Open Data > Education > CT Education Directory. The data table must include a location column that includes geocoordinates. If there is address data but no geocoordinates, then post a suggestion to the Socrata site administrator to add a geocoded column.

Results matching category of Education

Name
1. Special Education Prevalence 2008-2013 Education This dataset contains K-12 special education prevalence data.
2. SAT School Participation and Performance 2012-13 Education This dataset contains data by school on student SAT scores.
3. SAT District Participation and Performance 2012-13 Education This dataset contains data by district on student SAT scores.
4. School Cohort Graduation Rates 2013 Education This dataset contains the 2013 four-year cohort graduation rates.
5. District Cohort Graduation Rates 2013 Education This dataset contains the 2013 four-year cohort graduation rates.
6. District Enrollment 2013-14 Education education, This dataset contains district-level enrollment counts.
7. School Enrollment 2013-14 Education education, This dataset contains school-level enrollment counts.
8. District Enrollment 2012-13 Education education, This dataset contains district-level enrollment counts.
9. School Enrollment 2012-13 Education education, This dataset contains school-level enrollment counts.
Education Directory Education education, school, education This dataset contains the official listing of all public education entities.

Filter the data to display only the desired rows. The CT Education Directory lists both district offices and school addresses, but for this map we only wish to display the latter. On the top-right corner of the table, click the Filter tab.

The screenshot shows a dataset interface with a list of locations on the left and a filter sidebar on the right.

Left Panel (Dataset View):

- Header: Location 1
- Items:
 - 68 Bullard Dr. Wallingford, CT 06492
 - 401 Flatbush Ave. Wallingford, CT 06492
 - 143 Three Mile Course Wallingford, CT 06492
 - 945 Mountain Rd. Wallingford, CT 06492
 - 75 East Main St. Cheshire, CT 06410
 - 15 Vernon St. Wallingford, CT 06492
 - 525 Brook Street Wallingford, CT 06492
 - 655 Stillman St. Wallingford, CT 06492
 - 395 Lyme St. Wallingford, CT 06492
 - 896 Main St. Wallingford, CT 06492
 - 212 King Philip Dr. Wallingford, CT 06492
 - 144 Bailey Rd. Wallingford, CT 06492
 - 1490 Woodtick Rd. Wallingford, CT 06492
 - 50 Francis St. Wallingford, CT 06492
 - 30 Coer Rd. Wallingford, CT 06492
 - 33 Turkey Hills Rd. Farmington, CT 06428
 - 26 Benham Hill Rd. Wallingford, CT 06492
 - 26 Locust Ave.

Right Panel (Filter Sidebar):

- Header: Filter
- Options: Conditional Formatting, Sort & Roll-Up, Filter
- Description: Filter this dataset based on contents.
- Text: No conditions defined yet.
- Button: + Add a New Filter Condition
- Text: Never created a filter before? Watch a short tutorial video here.

Add a New Filter Condition, which displays only the rows you select. In this tutorial, select “Organization Type” and “is”, then type the exact name from the table, such as “Public Schools.” Be sure to type it correctly or the filter may not work. If you wish to select multiple types, add a new filter condition for each. In this tutorial, we also will filter for other types: Public Charter Schools, CT Technical High Schools, Regional Schools, State Agency Facilities, Endowed and Incorporated Academies Schools, and Regional Education Service Center Schools.

The screenshot shows a dataset interface with a list of locations on the left and a filter panel on the right.

Left Panel (List of Locations):

- 68 Bullard Dr., Guilford, CT 06437
- 143 Three Mile Course, Guilford, CT 06437
- 945 Mountain Rd., Guilford, CT 06437
- 75 East Main St., Glastonbury, CT 06033
- 655 Stillman St., Glastonbury, CT 06033
- 395 Lyme Ln., Hartford, CT 06016
- 212 King St., Hartford, CT 06016
- 144 Ballou St., Hartford, CT 06003
- 1490 Wethersfield Ave., Wallingford, CT 06492
- 50 Franklin St., Wallingford, CT 06492
- 30 Coe St., Wallingford, CT 06492
- 33 Turkey Hill Rd., East Granby, CT 06026
- 26 Benham Hill Rd., West Union, CT 06516
- 26 Locust Ave., Rockville, CT 06061
- 1750 Main St., Hartford, CT 06016
- 407 James St., New Haven, CT 06510
- 190 Luke Hill Rd., Rockville, CT 06061
- 100 Ohman Ave.

Right Panel (Filter):

Conditional Formatting

Sort & Roll-Up

Filter

Filter this dataset based on contents.

Organization Type is:

- Public Schools
- Public Charter Schools
- Regional Schools
- []
- []

[+ Add a New Filter Condition](#)

Never created a filter before? Watch a short tutorial video [here](#).

Handwritten Notes:

Type the Org. Types of the schools you want to appear exactly the way they appear in the chart.

A red arrow points from the handwritten note to the "Add a New Filter Condition" button.

Select the Visualize tab and choose Map, which will display several options. First, under Config for Education Direction, select Point Map as the Plot Style, and choose the Location column to identify the geocoordinates.

The screenshot shows a dataset visualization interface. At the top, there are several buttons: Manage, More Views, Filter, Visualize (which is highlighted in green), Export, Discuss, Embed, and About. Below these is a search bar labeled "Find in this Dataset".

The main area displays a list of locations under the heading "Location 1". The locations listed are:

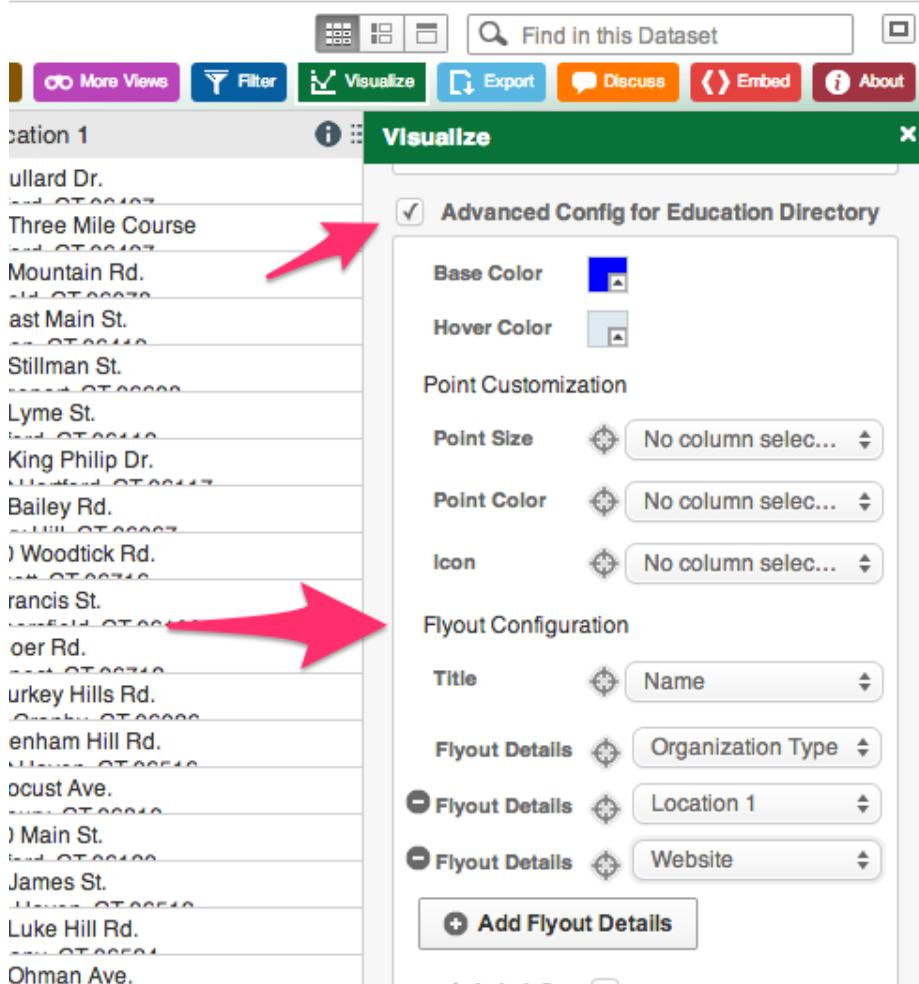
- 68 Bullard Dr. - Glastonbury, CT 06033
- 143 Three Mile Course - Glastonbury, CT 06033
- 945 Mountain Rd. - Glastonbury, CT 06033
- 75 East Main St. - Glastonbury, CT 06033
- 655 Stillman St. - Glastonbury, CT 06033
- 395 Lyme St. - Glastonbury, CT 06033
- 212 King Philip Dr. - Glastonbury, CT 06033
- 144 Bailey Rd. - Glastonbury, CT 06033
- 1490 Woodtick Rd. - Glastonbury, CT 06033
- 50 Francis St. - Glastonbury, CT 06033
- 30 Coer Rd. - Glastonbury, CT 06033
- 33 Turkey Hills Rd. - East Granby, CT 06026
- 26 Benham Hill Rd. - East Granby, CT 06026
- 26 Locust Ave. - East Granby, CT 06026
- 1750 Main St. - East Granby, CT 06026
- 407 James St. - East Granby, CT 06026
- 190 Luke Hill Rd. - East Granby, CT 06026
- 100 Ohman Ave.

To the right of the location list is a configuration panel titled "Visualize". The "Map" tab is selected. The panel contains the following information:

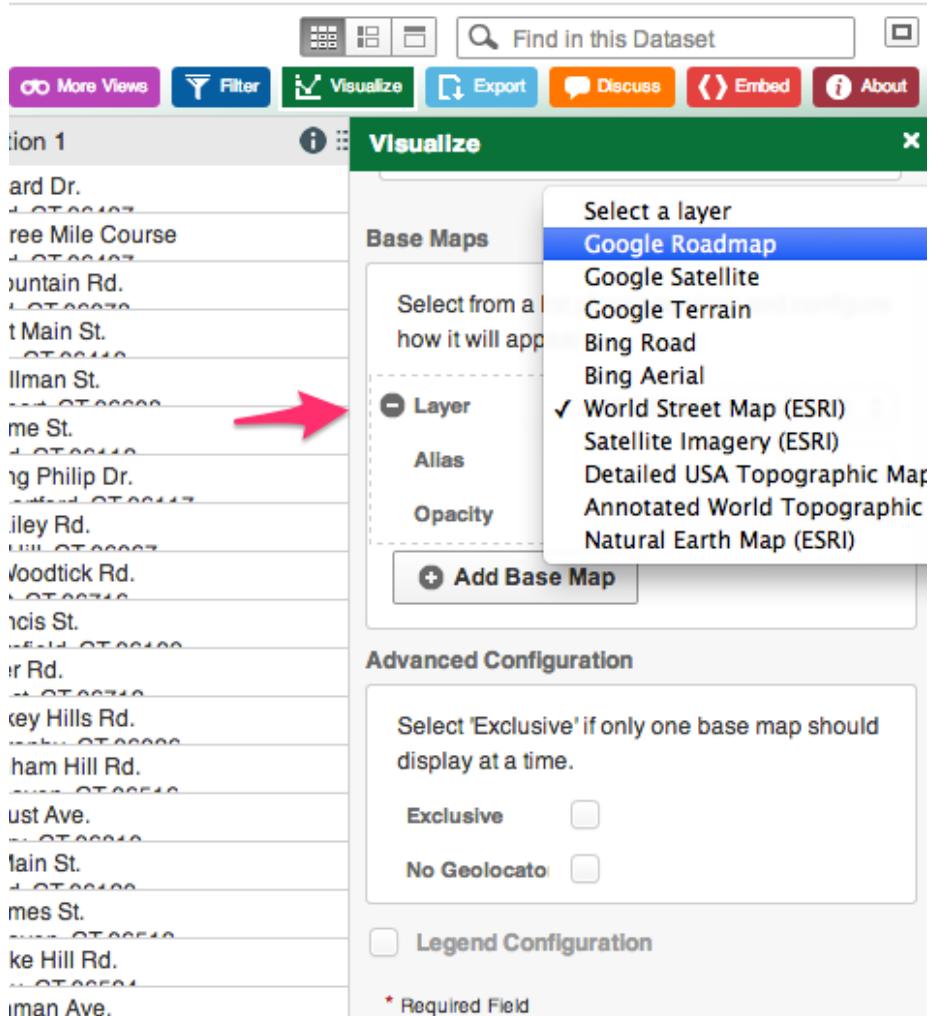
- Dataset Summary:** Shows "Dataset" and "Education Directory" with an "Add Data" button.
- Config for Education Directory:** Includes fields for "Alias" (Describe the dataset), "Plot Style" (Point Map), and "Location" (Location 1).
- Base Maps:** A checkbox for "Advanced Config for Education Directory" is present.

Red arrows point from the text in the first two paragraphs of the instructions to the "Location" field in the "Config for Education Directory" section of the panel.

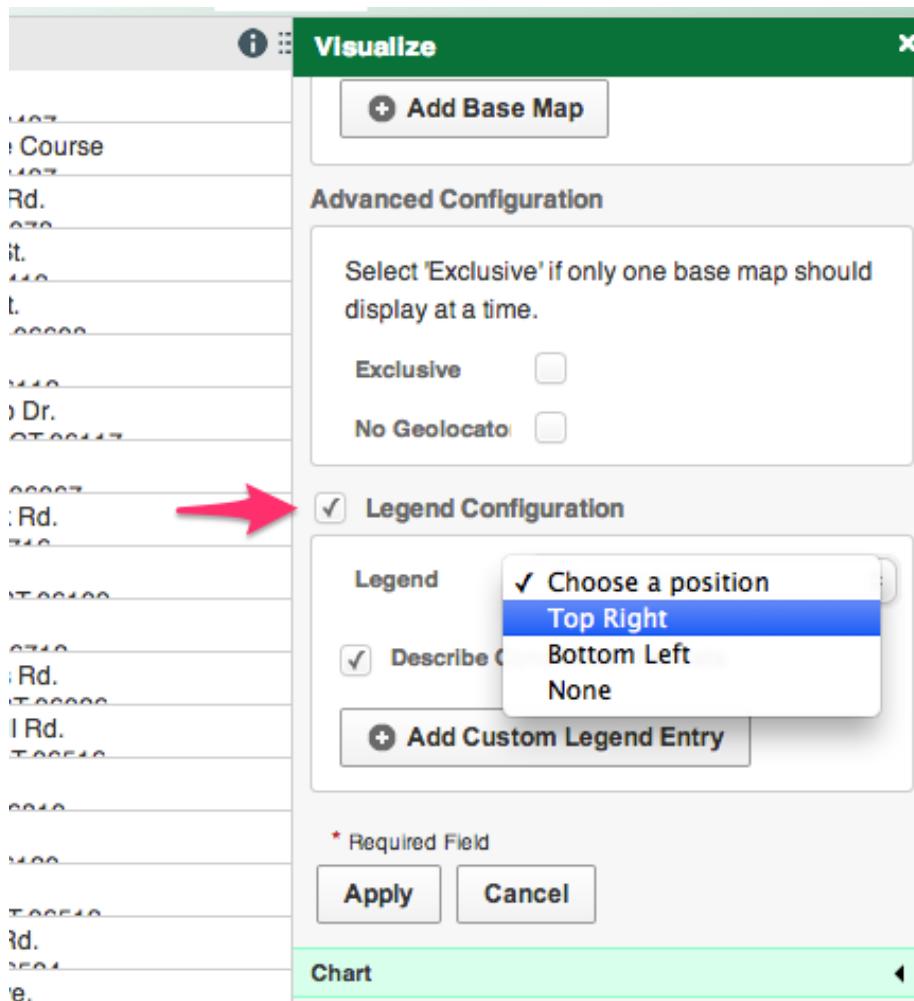
Further below in the Visualize > Map options, select the checkbox for Advanced Config for the Education Directory to edit the Flyout Details (similar to a pop-up information window) that displays details when users click on a map point. Select data items you wish to display, such as Title: Name, and additional Flyout Details: Organization Type, Location I, and Website. Further down, select the “w/o labels” checkbox to avoid displaying the column headers in your flyout details.



In Visualize > Map > Base Maps, select your desired background map, such as Google Roadmap.



Add a legend to display once you build the map. In the Advanced Configuration area, select the Legend Configuration checkbox and mark its position. After selecting all of these map options, click Apply. Socrata will generate your map with default point colors. Double-check to make sure your data appear, and that your Visualize settings are correct, before moving to the next step.



Assign point colors and legend labels by returning to the Filter tab, and select Conditional Formatting. Understand the difference between these two features. Previously, we used Filter to display only selected types of data (in this case, school buildings, rather than district administrative offices). Now, we will use Conditional Formatting to assign color codes and labels to our filtered data.

Conditional Formatting allows you to change the background color of rows based on custom criteria. Each row will be assigned the color of the first matching condition.

Base Layers

- Education Directory
- Roadmap
- Vineyard

Map data ©2014 Google

Location 1

Address	City	State
201 West Main St.	Marlboro	MA
42 Jarvis St.	Charlton	MA
500 Vine St.	Uxbridge	MA
391 Shaker Rd.	Foxfield	MA

Filter

Conditional Formatting

Conditional Formatting allows you to change the background color of rows based on custom criteria. Each row will be assigned the color of the first matching condition.

Conditions

Description:

Use
 this color
 or this icon
 (change)

When All Conditions

Condition:

Add Condition

Add New Rule

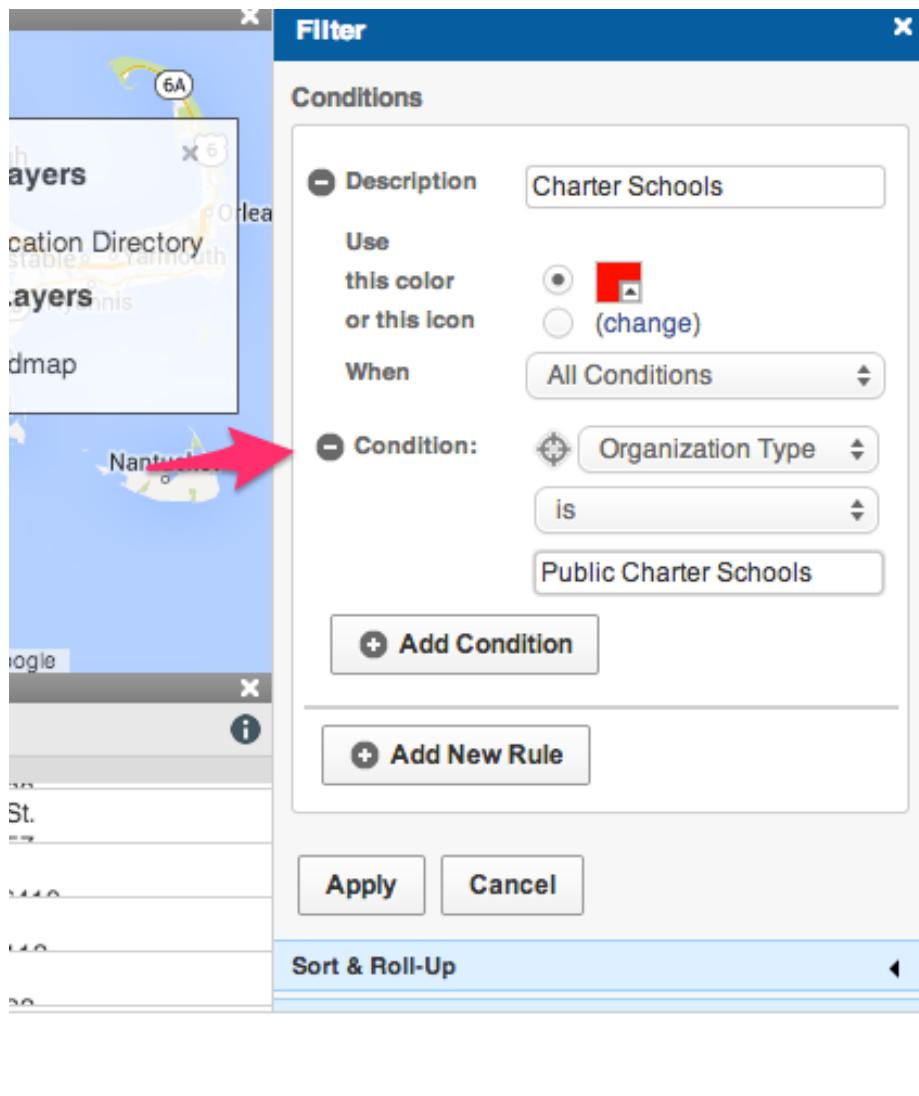
[Contact Us](#)

[Socrata](#)

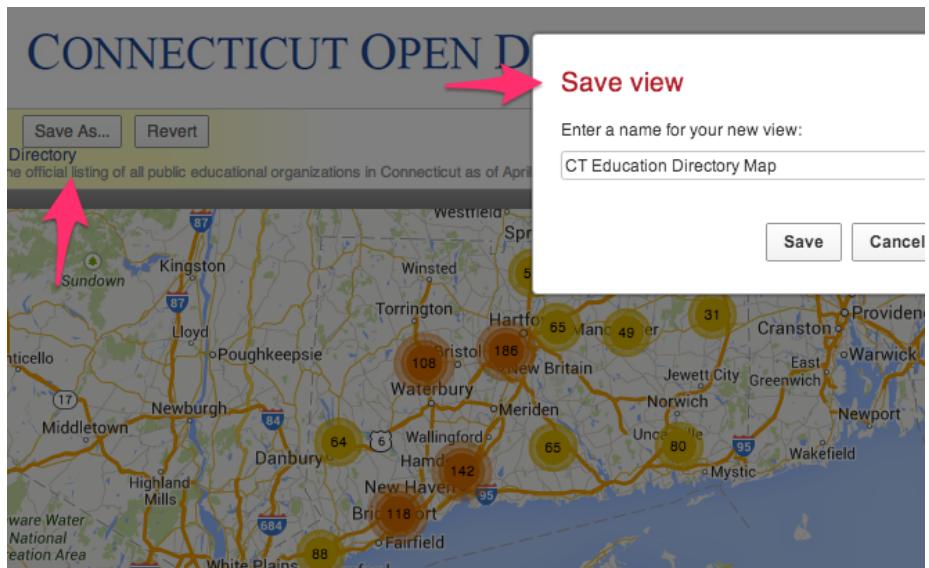
In the Conditional Formatting section, type a name into the Description that you wish to display in the legend. You may type a shorter name than the longer name that appears in the data table, such as “Charter Schools” instead of the longer “Public Charter Schools.” Also, select a color for each Description.

The screenshot shows a map interface with various tools at the top: Manage, More Views, Filter, Visualize, Export, Discuss, Embed, and About. A search bar says 'Find in this Dataset'. Below the map is a 'Data Layers' panel with 'Education Directory' checked. To the right is a 'Filter' panel titled 'Conditional Formatting'. It contains a descriptive text about conditional formatting and a 'Conditions' section. The first condition is for 'Charter Schools' using a red square icon. The second condition is for 'No column selected' with a 'Select a comparison' dropdown. Buttons for 'Add Condition' and 'Add New Rule' are at the bottom.

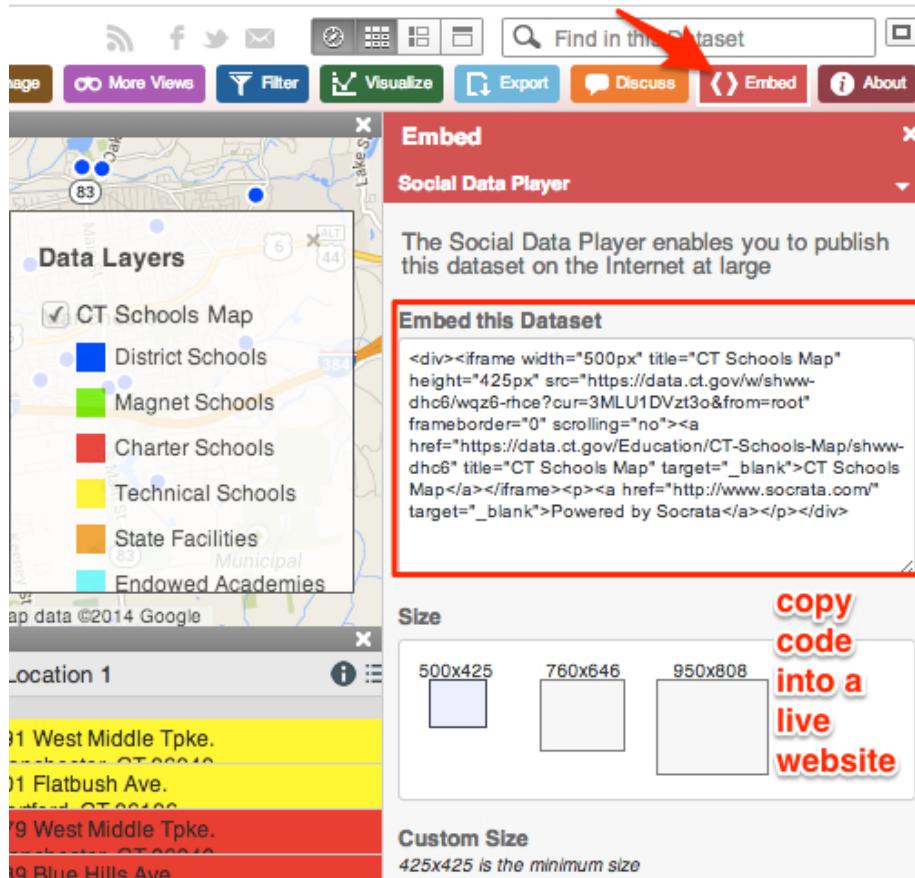
Continue to add Conditional Formatting by defining the data columns. In this example, select “All Conditions Apply,” choose “Organization Type” and “Is”, then type the category exactly as it appears in the data table (such as Public Charter Schools). For this map of schools in the CT Education Directory data table, we added several more types (Regional Schools, CT Technical High Schools, etc.) and also added a second rule to identify Magnet Schools (where Organization Type is Public Schools, and Interdistrict Schools is 1).



After setting all of your Conditional Formatting, press Apply at the bottom of the tab. Double-check that your visualization appears exactly as you wish, then Save As under an appropriate name. Note that your visualization will become **publicly visible** to other users on the Socrata open data platform, though you have the option to remove it via your individual profile view.



Visualizations created in the Socrata platform produce HTML iframe codes, which allows you to embed the dataviz in your own website. Select the Embed tab to view and copy the code. Then go to the Embed on the Web chapters in this book.



Polygon Maps and Storyboards with Social Explorer

TODO: decide whether to keep or not, since free license terms changed

The Social Explorer free edition <http://socialexplorer.com> offers one solution to creating colored polygon maps with US Census demographic data. Explore the embedded sample map below.

Advantages

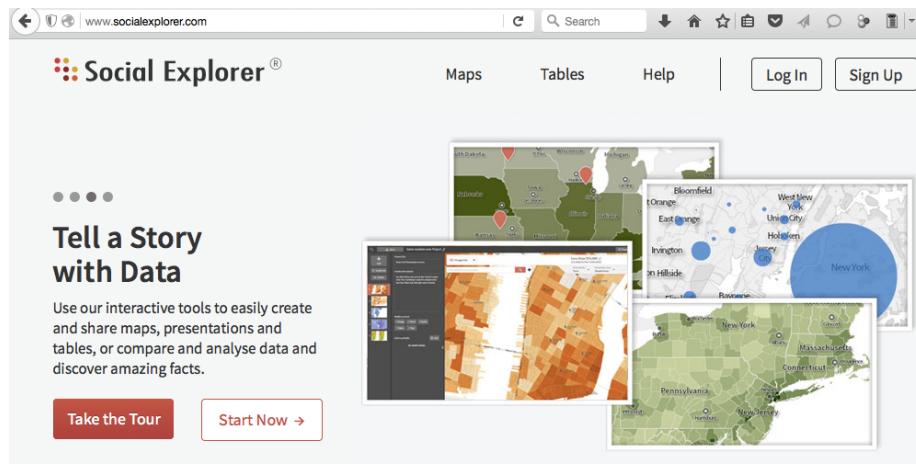
- Quick and easy-to-learn
- Free edition includes basic census data
- Export your static maps into presentation slides
- Share link or embed iframe to your interactive map

Limitations

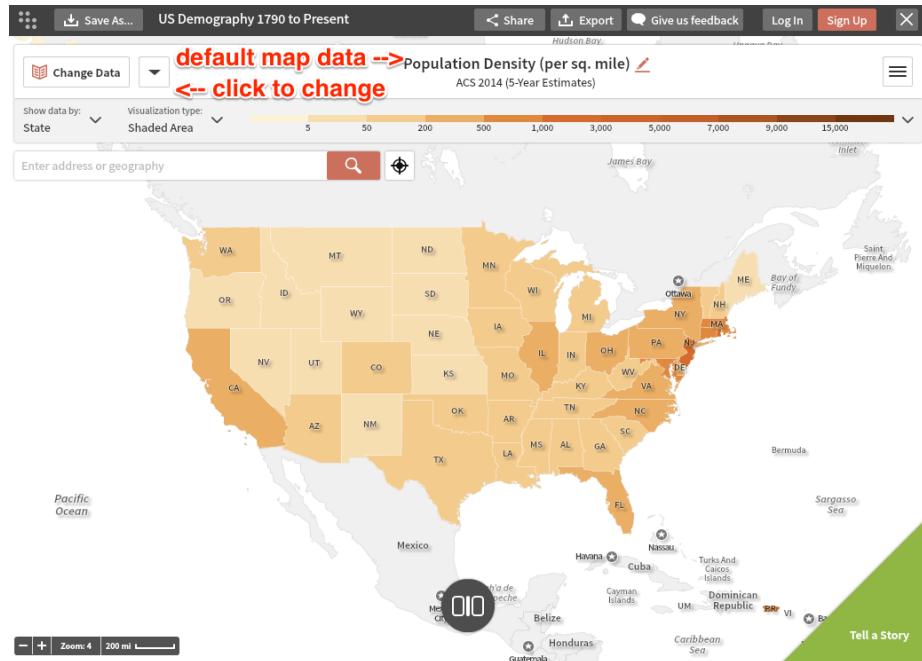
- Maps are limited to the demographic data inside the tool.
- Polygon map boundaries are limited to state, county, census tract. The tool does not display municipal data for cities, towns, etc.
- Full census and historical data requires professional subscription.
- Pro subscription available through several academic libraries, but few public libraries.

Quick overview of features

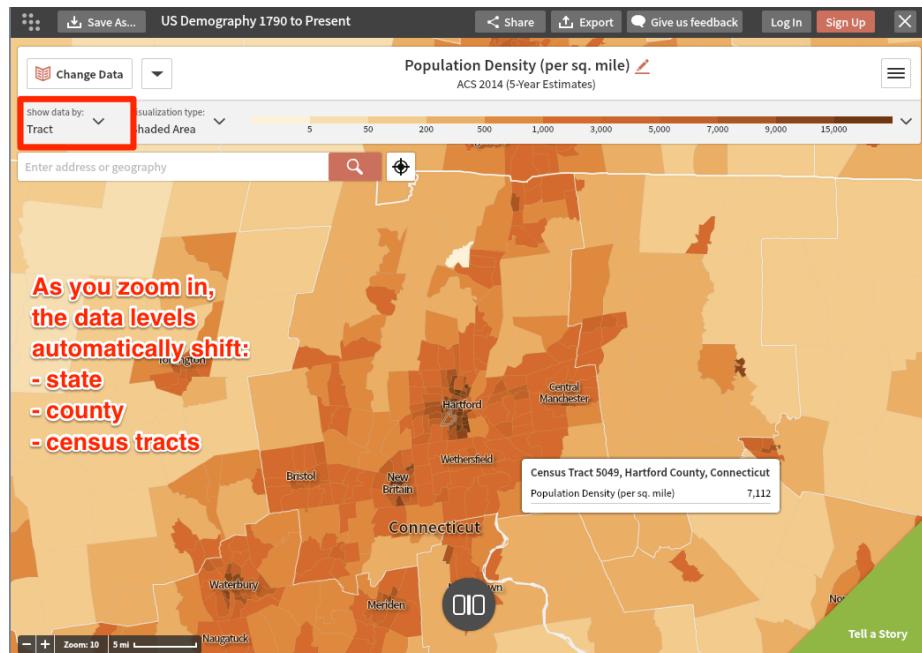
Start at the Social Explorer website <http://socialexplorer.com> and click on Maps. This tutorial demonstrates features available on the free edition.



The default map view shows US population density, based on the American Community Survey (ACS) 5-year estimates. Click the Change Data button to explore other options.

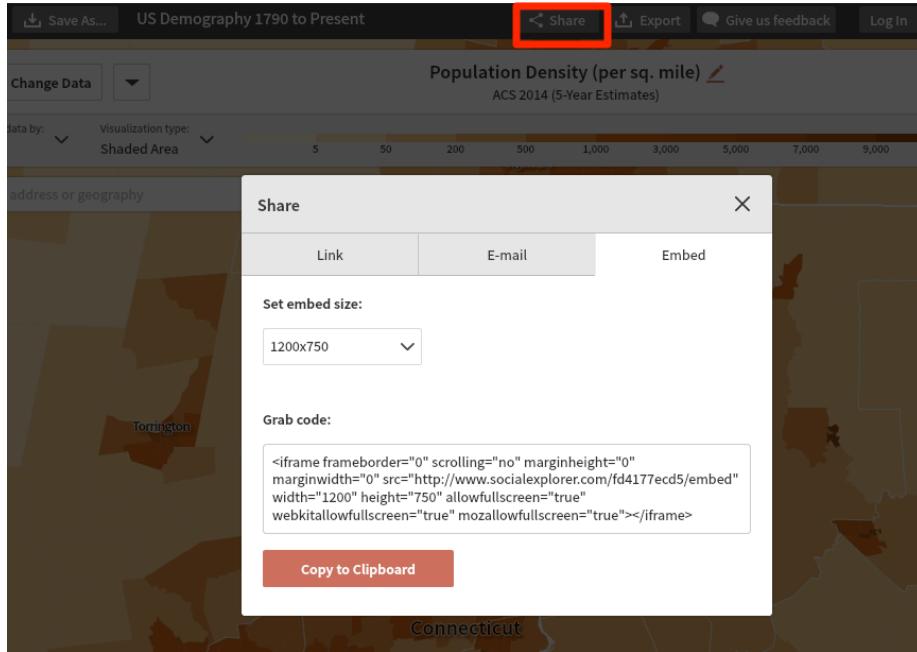


Geographic boundaries automatically change with the zoom level. As you zoom in, the data levels automatically shift from state, to county, to census tract.

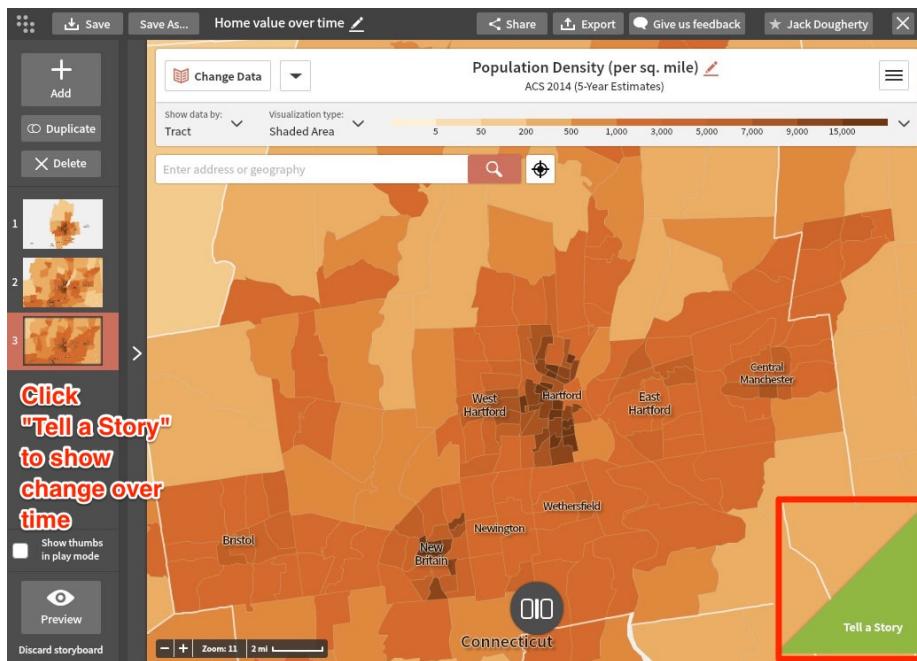


Click the Share button to copy the link to your map, or the iframe code to

embed it inside your own website.



Create a free account to save your online map views. Click the Tell a Story button, add a series of interactive map views, and show change over time.



TODO: Is this still true? All of the steps above can be done with the free version, but data is limited. Check if an academic library near you has a professional subscription.

Polygon Map with Tableau Public

Tableau Public is freely-available software that contains powerful tools to quickly create interactive polygon maps for common boundaries (such as US States, or World Nations.) If you need to create customized maps for less-common boundaries, see our chapter on Leaflet Maps with Google Sheets in this volume.

Important: Tableau Public is designed to publicly display your data, which makes this free tool very appropriate for educators, journalists, non-profit organizations, or other users who wish to openly share their map. If you desire a private tool to restrict your data, Tableau offers other tools that require payment.

See also the Tableau Public support page <https://www.tableau.com/support/public> for additional resources, including video tutorials.

- 1) Download and install the free Tableau Public tool, available for Mac or Windows, at <https://public.tableau.com/en-us/s/download>. Do not confuse with other Tableau products that require payment. Installation may require up to 5-10 minutes.
- 2) Click this link and Save to download to your computer: us-sample-data in CSV format. CSV means comma-separated values, a generic spreadsheet format that most tools can easily open. For help with downloading, see this short video tutorial.
- 3) Open the us-sample-data.csv file with any spreadsheet tool to view its contents.
- 4) Launch Tableau Public. In the Connect column of the first screen, click “Text file” to connect to the CSV file you downloaded above. (If you had an Excel file in .xlsx format, you would click that instead.) Navigate to select the us-sample.data.csv file on your computer.
- 5) At first, Tableau Public does **NOT** recognize the names of US areas, which initially appear simply as “text” values (with the “Abc” symbol). Click and hold down the mouse directly on the “Abc” symbol, and use the drop-down menu to convert to Geographic role > State/Province. A tiny globe symbol will appear to show that Tableau Public now recognizes this column as geographic data, which is essential in order to make a map.

us-sample-data.csv

New Union

Sort fields Data source order

Abc us-sample-data.csv Abbreviation	Abc us-sample-data.csv Area	Abc us-sample-data.csv Type	# us-sample-data.csv PopEst2018
AL	Alabama	Later state	4,887,871
AK	Alaska	Later state	737,438
AZ	Arizona	Later state	7,171,646
AR	Arkansas	Later state	3,013,825
CA	California	Later state	39,557,045
CO	Colorado	Later state	5,695,564
CT	Connecticut	Original state	3,572,665
DE	Delaware	Original state	967,171
DC	District of Columbia	District	702,455
FL	Florida	Later state	21,299,325
GA	Georgia	Original state	10,519,475

Go to Worksheet

Data Source Sheet 1

Figure 6.16: Column displayed as text data

us-sample-data.csv

New Union

Sort fields Data source order

Abc us-sample-data.csv Abbreviation	Abc us-sample-data.csv Number (decimal)	Abc us-sample-data.csv Number (whole)	Abc us-sample-data.csv Date & Time	# us-sample-data.csv PopEst2018
AL				4,887,871
AK				737,438
AZ				7,171,646
AR				3,013,825
CA				
CO	Colorado	Later st		
CT	Connecticut	Origina		
DE	Delaware	Origina		
DC	District of Columbia	District		
FL	Florida	Later st		
GA	Georgia	Origina		

Geographic Role

- ✓ None
- Airport
- Area Code (U.S.)
- CBSA/MSA (U.S.)
- City
- Congressional District (U.S.)
- Country/Region
- County
- NUTS Europe
- State/Province
- ZIP Code/Postcode

Go to Worksheet

Data Source Sheet 1

Figure 6.17: Column converted to geographic data

- 6) Go to the Worksheet view, by clicking on “Sheet 1” in the bottom-left corner. The goal is to build a polygon map, based on the dimensions and variables provided by Tableau Public.

Step A - Drag the “Area” dimension to the middle of the worksheet to create the geographic areas

Step B - In the “Marks” panel, change the drop-down menu from “Automatic” to “Map”

Step C - Drag the “Type” dimension into the “Color” box of the Marks panel to show polygon colors according to type

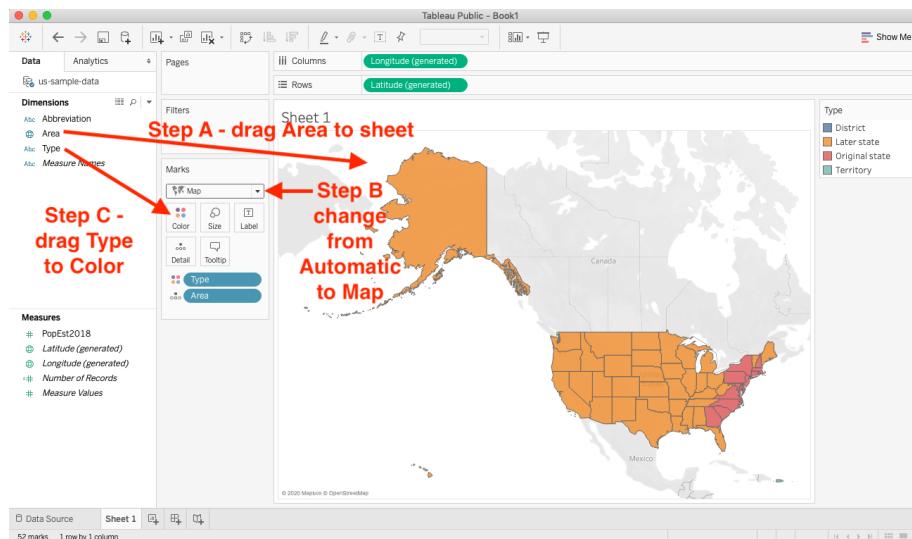


Figure 6.18: Steps A-B-C above

Optional: Add more items, such as “Abbreviation” dimension to “Label” box to display state abbreviations, or “Area” dimension to “tooltips” to display on mouseover.

- 7) To display your map online, click “Dashboard” tab in the bottom-left corner.
- 8) Drag “Sheet 1” (the default name of your map) into your dashboard. Also, drag the map legend from the corner into the lower body of the map (or choose other legend options).
- 9) To publish your map online, go to File > Save to Tableau Public As... This will require you to create a free Tableau Public Account.
- 10) Modify your final online product as desired, and see options to embed elsewhere on the web.

Chapter 7

Embed On Your Web

TODO: Reorganize and rewrite chapter

After you create a chart or map, how do display it inside your website as an *interactive* visualization? Our goal is not a static picture, but a live chart or map that users can explore. This is an important question for beginners, since data visualizations are not valuable unless you can control where and how your work appears. This chapter walks you through the key steps.

First, you need to own a website that supports iframe codes (which we'll explain below). If you do not have a website that supports this, then follow this quick tutorial to Create a simple web page with GitHub Pages. Even if you already have a website, still do this tutorial, because it introduces a tool used many times in this book.

Second, you need to copy or create an iframe code from your chart or map. An iframe is one line of HTML code with instructions on how to display a web page from a specific address (called a URL). A simple iframe looks like this:

```
<iframe src="https://handsondataviz.org/embed/index.html"></iframe>
```

No coding skills are necessary. See these easy-to-follow examples:

-Copy iframe from a Google Sheets chart -Convert a link into an iframe

Finally, you need to paste (or embed) the iframe code inside your website. Like a picture frame, an iframe allows you to display one web page (your data visualization) inside another web page (your personal website). But unlike a picture frame, where the image is static, an iframe makes content interactive, so visitors can explore the chart or map on your site, even though it may actually be hosted on an entirely different website. Go to this third tutorial, which combines the two steps above, called Embed Iframe in GitHub Pages.

See more tutorials in this chapter to copy iframes from other visualization tools (such as Tableau Public and embed them in other common websites (such as WordPress, etc.) ** TO DO: add more tutorials and links **

Enroll in our free online course **link to do**, which introduces these topics in the brief video below, and offers more exercises and opportunities to interact with instructors and other learners.

Create a Simple Web Page with GitHub Pages

Question: After you create an interactive chart or map, how do you embed the live version in a website that you control?

The full answer requires three steps:

- 1) Create a web page that supports iframe codes
- 2) Copy or create an iframe code from your visualization
- 3) Embed (or paste) the iframe code into your web page

This tutorial focuses on the **first step**. If you don't already have your own website, or if you are not sure whether your site supports iframe codes, then follow the steps below. We will create a simple web page with a free and friendly tool called GitHub <http://github.com>, and host it on the public web with the built-in GitHub Pages feature. For **steps 2 and 3**, see the Copy iframe from Google Sheets tutorial and the Embed iframe in GitHub Pages tutorial in this chapter.

Tool review: GitHub <http://github.com> is a versatile tool that can be used to create simple web pages.

- Pros:
 - Free and easy-to-learn tool to edit and host simple pages on the public web.
 - All steps below can be completed in your web browser.
- Cons:
 - All work on GitHub is public by default. Private repositories (folders) require payment.
 - New users sometimes confuse the links for code repositories versus published web pages.

Video:

- 1) Sign up for free GitHub account, then sign in, at <http://github.com>.
- 2) Create a new repository (also called a “project” or similar to a “folder”).
- 3) Name your repository (or “repo”), and select Initialize with a README file. Optional steps: add a description and select a license.
- 4) Scroll down and click the green button to Create your repo, which will appear in a new browser tab, with this URL format:

`https://github.com/YOUR-USERNAME/YOUR-REPO-NAME`

- 5) In your GitHub repo, click on Settings, scroll down to GitHub Pages, select Master branch as your source, then Save. This publishes the code from your repo to the public web.

Hint: Do NOT select Theme Chooser for this exercise. It will create additional files that will interfere with displaying an iframe in your README.md file.

- 6) When the Settings page refreshes, scroll back down to GitHub Pages to see the new link to your published website, which will appear in this format:

`https://YOUR-USERNAME.github.io/YOUR-REPO-NAME`

- 7) Right-click and Copy the link to your published web site.
- 8) At the top of the page, click on the repo name to return to the main level.
- 9) Click the README.md file to open it in your browser, and click the pencil symbol to edit it.
- 10) Inside your README.md file, paste the link to your published web site, and type any text you wish to appear. The .md extension refers to Markdown, an easy-to-read computer language that GitHub Pages can process.
- 11) Scroll down and click the green Commit button to save your edits.
- 12) When your GitHub repo page refreshes, click on the new link to go to your published web site. **BE PATIENT!** Your new site may not appear instantly. Refresh the browser every 10 seconds. You may need to wait up to 1 minute for a new site to appear the first time, but later changes will be much faster.

Remember that GitHub Pages is designed to create simple web pages and sites. See other web publishing tools mentioned in this chapter to create more sophisticated web sites.

Copy an iframe code from a Google Sheets interactive chart

Question: After you create an interactive chart or map, how do you embed the live version in a website that you control?

The full answer requires three steps:

1. Create a web page that supports iframe codes
2. Copy the iframe code from your visualization
3. Embed (or paste) the iframe code into your web page

This tutorial focuses on the **second step**, and shows how to publish a Google Sheets interactive chart, and copy its iframe code. Details may differ for other visualization tools, but the general iframe concept will be similar to most cases. For **steps 1 and 3**, see the Create a Simple Web Page with GitHub Pages tutorial and the Embed iframe in GitHub Pages tutorial in this chapter.

Tutorial

- 1) Create a Google Sheets chart, which requires a free Google Drive account.
Learn more in the Google Sheets Charts tutorial in this book.
- 2) Click the drop-down menu in the upper-right corner of the interactive chart and select Publish chart. Click OK on next screen.
- 3) Select the Embed tab, select the Interactive version, and click the blue Publish button. If you make changes to the chart, they will continue to be published to the web automatically, unless you click the Stop button or checkbox at the bottom.
- 4) Copy the iframe embed code.

No coding skills are necessary, but it helps to be code-curious. This iframe is a line of HTML code that contains these instructions:

- iframe tags to mark the beginning and end
- width and height: to display your chart in a second site, in pixels
- seamless frameborder: “0” means no border will appear around the chart in the second site
- scrolling: “no” means the chart will not include its own web scrolling feature

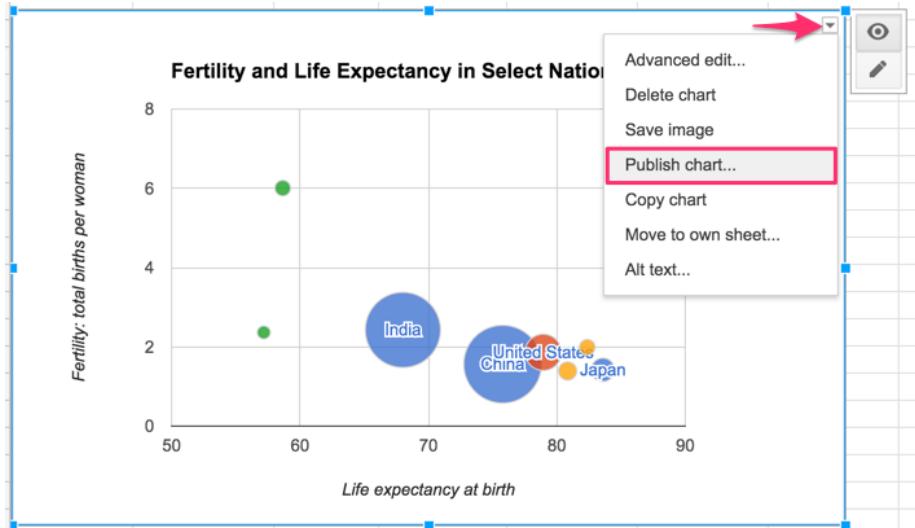


Figure 7.1: Screenshot: Drop-down menu to publish a Google Sheets chart

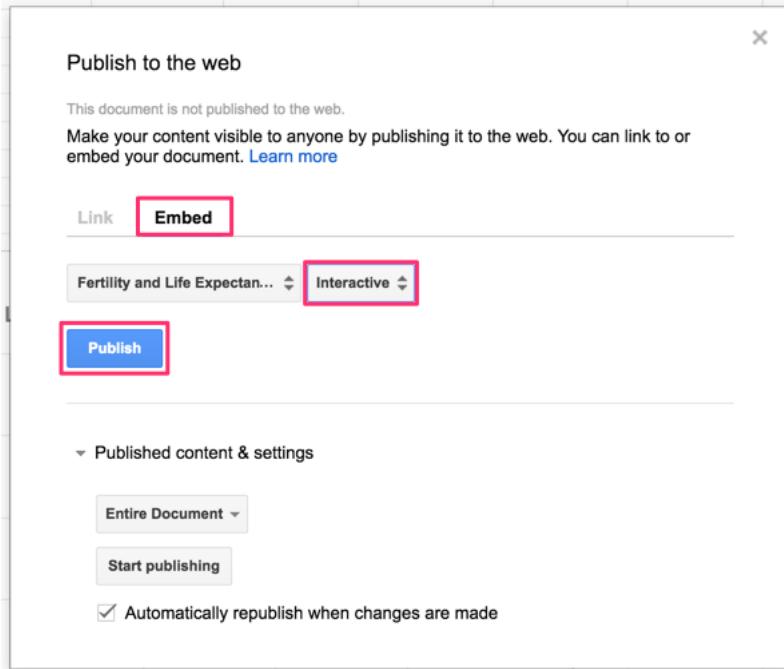


Figure 7.2: Screenshot: Publish to the web for a Google Sheets chart

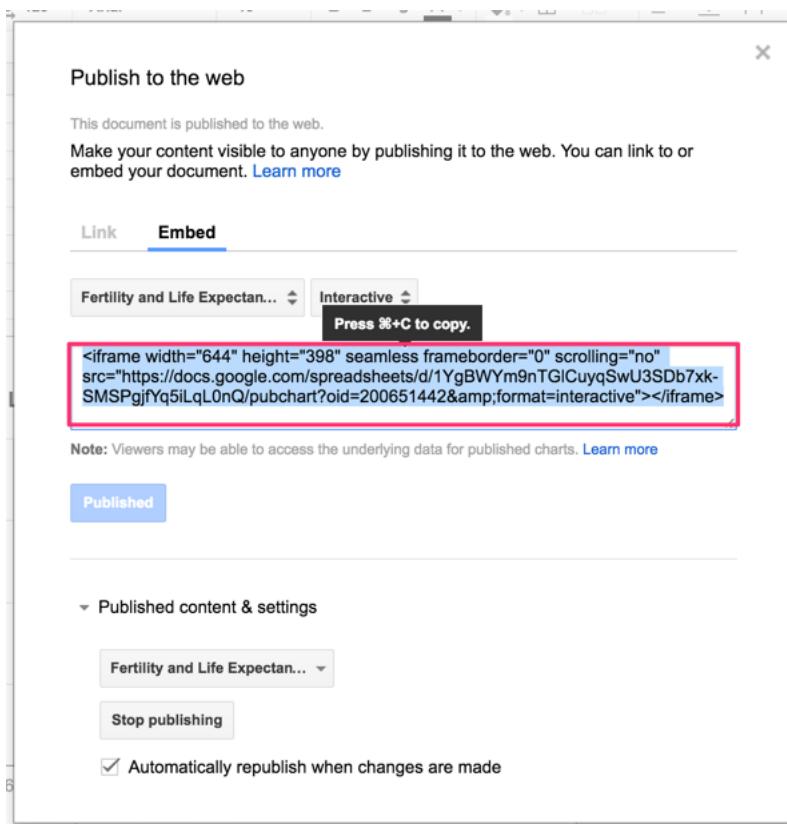


Figure 7.3: Screenshot: Copy the iframe code from a Google Sheets chart

- src: the web address (or URL) of the visualization to be displayed in the second site

See the next tutorial in this chapter, Embed iframe in GitHub Pages, to learn how to paste the iframe into a simple web page. Or see related tutorials in this chapter to embed an iframe in other common web sites.

Convert a Weblink into an Iframe

After you publish your data visualization to the web, how do you convert its weblink (or URL) into an iframe, to embed in your personal website?

The answer depends: did you publish your visualization as a code template on GitHub Pages? Or did you publish it using a drop-and-drag tool such as Google Sheets or Tableau Public?

Published with a code template on GitHub Pages

If you published your visualization from a code template (such as Leaflet or Chart.js) with GitHub Pages, follow these easy steps:

- 1) Copy the URL of your published visualization on GitHub, which will be in this format:

```
https://USERNAME.github.io/REPOSITORY
```

- 2) Add `iframe` tags to the beginning and end, insert `src=` and enclose the URL inside quotation marks, like this:

```
<iframe src="https://USERNAME.github.io/REPOSITORY"></iframe>
```

- 3) Optional: Insert preferred width and height (in pixels by default, or percentages), like this:

```
<iframe src="https://USERNAME.github.io/REPOSITORY" width="90%" height="400"></iframe>
```

- 4) Go to the appropriate tutorial to embed your iframe in your personal website:
 - Embed an iframe in GitHub Pages
 - Embed an iframe in WordPress.org

Published with Google Sheets or Tableau Public

Or, if you published your visualization using a drop-and-drag tool, see these tutorials:

- Copy an iframe code from a Google Sheets interactive chart
- Embed Tableau Public on your Website

Embed an Iframe in GitHub Pages

Question: After you create an interactive chart or map, how do you embed the live version in a website that you control?

Here's the full three-step answer that combines lessons from the Embed on the Web chapter introduction and the two previous tutorials:

- 1) First, create a web page that supports iframe embed codes. If you don't know what that means or don't yet have a personal website, go back to the previous tutorial, Create a Simple Web Page with GitHub Pages, or see the video and step-by-step instructions below.
- 2) Second, copy or create an iframe code from your data visualization. Go back to the previous tutorial, Copy an iframe code from a Google Sheets interactive chart, or see the video and step-by-step instructions below.
- 3) Third, embed (or paste) the iframe code into your website. The video and instructions below show how to paste an iframe from a Google Sheets interactive chart into a simple web page with GitHub Pages.

Try it:

The goal is to embed the iframe code from a Google Sheets interactive chart, which resides on a Google web server, into your GitHub Pages web site. The result will be similar to the one below:

Video tutorial and step-by-step instructions

- 1) Sign up for free GitHub account, then sign in, at <https://github.com>.
- 2) Create a **new repository** (think of it as a folder that contains your project).
- 3) Name your repository (or “repo”), and select *Initialize this repository with a README*. Optional steps: add a description and select a license.

- 4) Scroll down and click the green button to Create your repo, which will appear in a new browser tab, with this URL format:

`https://github.com/YOUR-USERNAME/YOUR-REPO-NAME`

- 5) In your GitHub repo, click on Settings tab, scroll down to *GitHub Pages*, select **master branch** as your Source, then Save. This publishes the code from your repo to the public web.
- 6) When the Settings page refreshes, scroll back down to GitHub Pages to see the new link to your published website, which will appear in this format:

`https://YOUR-USERNAME.github.io/YOUR-REPO-NAME`

- 7) Right-click and Copy this link to your published web site.
- 8) At the top of the page, click on the repo name to return to the main level.
- 9) Click the README.md file to open it in your browser, and click the pencil symbol in the upper right corner to edit it.
- 10) Inside your README.md file, paste the link to your published web site, and type any text you wish to appear. The .md extension refers to Markdown, an easy-to-read markup language that GitHub Pages can process and display as HTML.
- 11) Go to a data visualization you have created, such as a Google Sheets chart, select Publish > Embed, and copy the iframe code. This line of HTML code displays the interactive visualization website inside your personal website.
- 12) Scroll down and click Commit to save your edits.
- 13) When your GitHub repo page refreshes, click on the new link to go to your published web site. **BE PATIENT!** Your new site may not appear instantly. Refresh the browser every 10 seconds. You may need to wait for a few minutes for a new site to appear the first time, but later changes will be much faster.

Important:

- A published README.md file will display an HTML iframe code, unless you add other HTML files (such as index.html) to your repository.

Remember that GitHub Pages is designed to create simple web pages and sites. See other web publishing tools mentioned in this chapter to create more sophisticated web sites.

Embed an Iframe on WordPress.org

TODO:

- rewrite this tutorial to merge the two versions (top and bottom)
- then update all links and check all `code` tags

To embed one web page (the data visualization) inside a second web page (the organization's website), we use a simple HTML code known as **iframe**. (Read more about the iframetag at W3Schools.)

The **general iframe concept** works across many data visualization tools and many websites: - Copy the embed code or URL from your dataviz website - Paste (and modify) the code as an iframe in your destination website

To embed your dataviz in a self-hosted Wordpress.org site, the [iframe plugin] (<http://wordpress.org/plugins/iframe/>) must be installed and activated. This plugin allows authors to embed iframe codes inside posts/pages, in a modified "shortcode" format surrounded by square brackets. Without the plugin, self-hosted WordPress.org sites will usually "strip out" iframe codes for all users except the site administrator. **I have already installed and activated** the iframe plugin on my site, and the Dashboard view looks like this:



Note that most WordPress.com sites do NOT support an iframe embed code.

But details vary, so read and experiment with the examples that follow.

- 5) To embed the iframe in a WordPress.org site, the iframe plugin must be installed, as explained in the Embed with iframe on WordPress.org chapter. **TO DO** fix self-reference

- 6) Log into your Wordpress.org site and create a new post. In the editor window, switch from the Visual to the Text tab, which allows users to modify the code behind your post. Paste the iframe code from your interactive dataviz.

The screenshot shows the WordPress editor's Text tab selected. The toolbar above includes buttons for Add Media, Visual, bold (b), italic (i), link, b-quote, del, ins, img, ul, ol, li, code, and more. A red box highlights the 'Text' tab. Below the toolbar, there is a 'close tags' button. The main area contains the following HTML code:

```
<iframe width="600" height="371" seamless frameborder="0" scrolling="no" src="https://docs.google.com/spreadsheets/d/1fwnl5hvkkwz-YDZrogGnx274BqmozG1ieXyjJ2TKmE/pubchart?oid=462316012&format=interactive"></iframe>
```

- 7) Initially, the code you pasted includes HTML iframe tags at the front <iframe... and the end ...></iframe>, which looks like this:

```
<iframe width="600" height="371" seamless frameborder="0" scrolling="no" src="https://docs.google...
```

- 8) Modify the front end of the iframe code by replacing the less-than symbol (<) with a square opening bracket ([). Modify the back end by erasing the greater-than symbol (>) and the end tag (). Replace the back end with a square closing bracket (]).

The screenshot shows the WordPress editor's Text tab selected. The toolbar and code area are identical to the previous screenshot. Red annotations are present: an arrow points to the word 'close tags' with the text 'replace with square bracket'; another arrow points to the closing bracket ')' with the text 'replace the end tag with square bracket'.

Your modified code should look like this:

```
[iframe width="600" height="371" seamless frameborder="0" scrolling="no" src="https://docs.google...
```

- 9) Click Preview or Publish/View Post to see how it appears on the web.
 10) If desired, continue to modify the iframe code to improve the display of your dataviz on your website. For example, the initial code was 600 pixels wide (width="600"). To display the dataviz across the full width of your website, change this part of the code to 100% (width="100%").

The goal is to embed an interactive chart inside your website, so that users can explore the data. This tutorial displays a *very basic chart* to simplify the process, and the end result will appear like the one below. Try it.

Embed Tableau Public on your Website

Question: After learning how to create an interactive data visualization with Tableau Public in this book, how do I embed it on my website?

Answer: Tableau Public supports two embedding methods, and your choice depends on your type of website.

- A) Embed code: if you can paste directly into an HTML web page
- B) Convert Link to iframe: to paste into WordPress.org, Wix, SquareSpace, Weebly, and many other web platforms

Try it:

Both methods produce an embedded visualization like the one below. Float your cursor over points to view data details.

A) Embed code method for HTML web pages

- 1) Use this method if you can paste HTML and JavaScript code directly into a website with HTML pages.
- 2) Go to the public web page of any Tableau Public visualization, such as this sample: <https://public.tableau.com/profile/jackdougherty#!vizhome/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Sheet1>
- 3) Before you begin the embed process, click the upper-right Edit Details button to make any final modifications to the title or toolbar settings.
- 4) Click the bottom-right Share button, click inside the **Embed Code** field, and copy its contents. A typical embed code is a long string of HTML and JavaScript instructions to display the visualization.
- 5) Open an HTML page on your website and paste the embed code in the body section. Below is an example of a sample Tableau Public embed code pasted between the body tags of a simple HTML page.

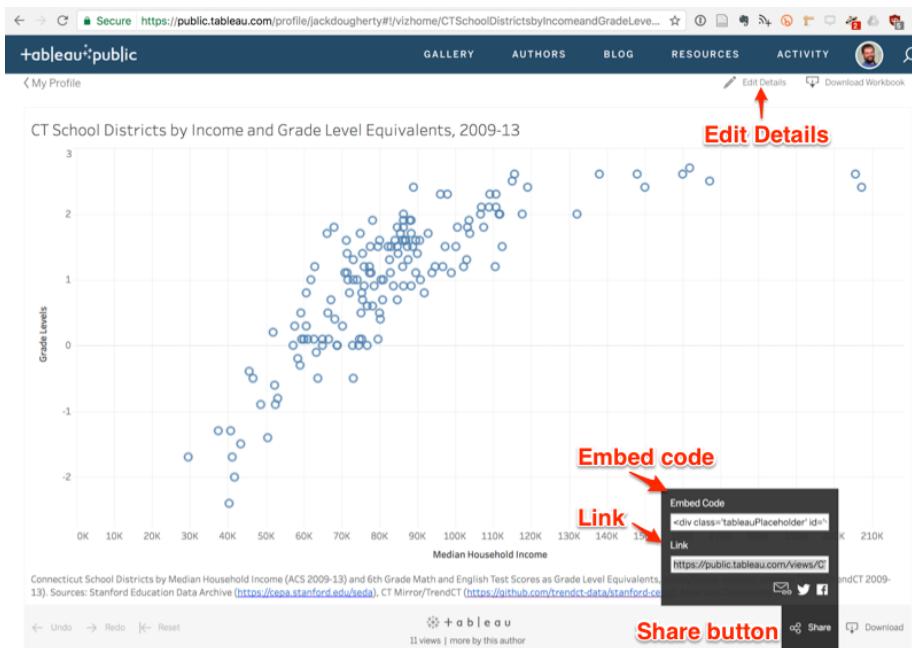


Figure 7.4: Screenshot: Edit and Share buttons in Tableau Public web page

```
<!DOCTYPE html>
<html>
<head>
  <title>sample web page</title>
  <meta name="viewport" content="width=device-width, initial-scale=1.0">
  <meta charset="utf-8">
</head>
<body>
  <div class='tableauPlaceholder' id='viz1489158014225' style='position: relative'><noscript><a href='http://www.tableau.com/about/contact'>View in Browser</a></noscript><img alt='Tableau visualization placeholder' data-bbox='107 168 908 360' /></div>
</body>
</html>
```

B) Convert Link to iframe method

- 1) Use this method if you need to paste an iframe into common web authoring platforms (such as WordPress.org, Squarespace, Wix, Weebly, etc.), since these platforms typically do not support HTML and JavaScript code pasted directly into content.
 - 2) Go to the public web page of any Tableau Public visualization, such as this sample: <https://public.tableau.com/profile/jackdougherty#/>

vizhome/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Sheet1

- 3) Before you begin the embed process, click the upper-right Edit Details button to make any final modifications to the title or toolbar settings.
- 4) Click the bottom-right Share button, click inside the **Link** field (NOT the Embed Code field), and copy its contents.



Figure 7.5: Screenshot: Edit and Share buttons in Tableau Public web page

- 5) A typical link will look similar to this example (scroll to right to see all):

<https://public.tableau.com/views/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Sheet1>

- 6) We need to edit the link to convert it into an iframe format. First, delete any code that appears after the question mark, to make it look like this (scroll to right to see all):

<https://public.tableau.com/views/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Sheet1>

- 7) Add this snippet of code to the end, to replace what you deleted above:

```
:showVizHome=no&:embed=true
```

- 8) Now your edited link should look similar to this (scroll to right to see all):

```
https://public.tableau.com/views/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Sheet1?":showVizHo
```

- 9) Enclose the link inside an iframe source tag `src=` with quotes, to make it look similar to this (scroll to right to see all):

```
src="https://public.tableau.com/views/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Sheet1?":show
```

- 10) Add iframe tags for `width` and `height` in percentages or pixels (default), to make it look similar to this (scroll to right to see all):

```
src="https://public.tableau.com/views/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Sheet1?":show
```

Hint: Insert 90% width, rather than 100, to help readers easily scroll down your web page

- 11) Add iframe tags at the beginning and end, to make it look similar to this (scroll to right to see all):

```
<iframe src="https://public.tableau.com/views/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Shee
```

Exceptions to the last step above. As described in the Embed iframe on WordPress chapter in this book, in a self-hosted WordPress.org site, with the iframe plugin, insert iframe brackets rather than HTML tags to make a shortcode like this (scroll to right to see all):

```
[iframe src="https://public.tableau.com/views/CTSchoolDistrictsbyIncomeandGradeLevels2009-13/Shee
```

Learn more: Embedding Tableau Public Views in iframe, Tableau Support page <http://kb.tableau.com/articles/howto/embedding-tableau-public-views-in-iframes>

Chapter 8

Edit and Host Code with GitHub

In the first half of this book, you created interactive charts and maps on free drag-and-drop tool platforms created by companies such as Google and Tableau. These platforms are great for beginners, but their pre-set tools limit your options for designing and customizing your visualizations, and they also require you to depend upon their web servers and terms of service to host your data and work products. If these companies change their tools or terms, you have little choice in the matter, other than deleting your account and switching services, which means that your online charts and maps would appear to audiences as dead links.

In the second half of this book, get ready to make a big leap—and we'll help you through every step—by learning how to copy, edit, and host code templates. These templates are pre-written software instructions that allow you to upload your data, customize its appearance, and display your interactive charts and maps on a web site that you control. No prior coding experience is required, but it helps if you're *code-curious* and willing to experiment with your computer.

Code templates are similar to cookbook recipes. Imagine you're in your kitchen, looking at our favorite recipe we've publicly shared to make brownies (yum!), which begins with these three steps: `Melt butter`, `Add sugar`, `Mix in cocoa`. Recipes are templates, meaning that you can follow them precisely, or modify them to suit your tastes. Imagine that you copy our recipe (or “fork” it, as coders say) and insert a new step: `Add walnuts`. If you also publicly share your recipe, now there will be two versions of instructions, to suit both those who strongly prefer or dislike nuts in their brownies. (We do not take sides in this deeply polarizing dispute.)

Currently, the most popular cookbook among coders is GitHub, with more than 40 million users and over 100 million recipes (or “code repositories” or “repos”).

You can sign up for a free account and choose to make your repos private (like Grandma’s secret recipes) or public (like the ones we share below). Since GitHub was designed to be public, think twice before uploading any confidential or sensitive information that should not be shared with others. GitHub encourages sharing *open-source code*, meaning the creator grants permission for others to freely distribute and modify it, based on the conditions of the type of license they have selected.

When you create a brand-new repo, GitHub invites you to Choose a License. Two of the most popular open-source software licenses are the MIT License, which is very permissive, and the GNU General Public License version 3, which mandates that any modifications be shared under the same license. The latter version is often described as a *copyleft* license that requires any derivatives of the original code to remain publicly accessible, in contrast to traditional *copyright* that favors private ownership. When you fork a copy of someone’s open-source code on GitHub, look at the type of license they’ve chosen (if any), keep it in your version, and respect its terms.

To be clear, the GitHub platform is also owned by a large company (Microsoft purchased it in 2018), and when using it to share or host code, you’re also dependent on its tools and terms. But the magic of code templates is that you can migrate and host your work anywhere on the web. You could move to a competing repository-hosting service such as GitLab, or purchase your own domain name and server space through one of many web hosting services. Or you can choose a hybrid option, such as hosting your code on GitHub and choosing its custom domain option, to display it under a domain name that you’ve purchased, just like the web version of this book is hosted on GitHub under our domain name, <https://HandsOnDataViz.org>. If we choose to move the code away from GitHub, we have the option to repoint our domain to a different web host.

In the next section of this chapter, we will introduce basic steps to copy, edit, and host a simple Leaflet map code template on GitHub. Later you’ll learn how to create a new GitHub repo and upload code files.

This chapter introduces GitHub using its web browser interface, which works best for beginners. Later you’ll learn about intermediate-level tools, such as GitHub Desktop and Atom Editor, to work more efficiently with code repos on your personal computer.

If problems arise, turn to the Fix Common Mistakes section in the appendix. All of us make mistakes and accidentally “break our code” from time to time, and it’s a great way to learn how things work—and what to do when it doesn’t work!

Copy, Edit, and Host a Simple Leaflet Map Template

Now that you understand how GitHub code repositories are like a public cookbook of recipes, which anyone can copy and modify, let's get into the kitchen and start baking! In this section, we'll introduce you to a very simple code template that creates an interactive map using Leaflet, an open-source code library that's very popular with coders, journalists, businesses, and government agencies. Many people chose Leaflet because the code is freely available to everyone, relatively easy to use, and has an active community of supporters who regularly update it. But unlike drag-and-drop tools that we covered in previous chapters, such as Google My Maps or Tableau Public, Leaflet requires you to write (or copy and paste) several lines of code, which need to be hosted on a web server so that other people can view your map in their web browser. Fortunately, we can do all of these steps in our web browser on GitHub. This means you can do this on any type of computer: Mac, Windows, Chromebook, etc.

Here's an overview of the key steps you'll learn about GitHub in this section:

- Make a copy of our simple Leaflet map code template
- Edit the map title, start position, background layer, and marker
- Host a live online version of your modified map code on the public web

Your goal is to create your own version of this simple interactive map, with your edits, as shown in Figure 8.1.



Figure 8.1: Create your own version of this simple interactive Leaflet map.

1. Create your own free account on GitHub. It may ask you to do a simple quiz to prove you're a human! If you don't see a confirmation message in your email, check your spam folder.

Tip: Choose a GitHub username that's relatively short, and one that you'll be happy seeing in the web address of charts and maps you'll publish online. In other words, `DrunkBrownieChef6789` may not be the wisest choice for a username, if `BrownieChef` is also available.

2. After you log into your GitHub account in your browser, go to our simple Leaflet map template at <https://github.com/HandsOnDataViz/leaflet-map-simple>
3. Click the green *Use this template* button to make your own copy of our repo, as shown in Figure 8.2.

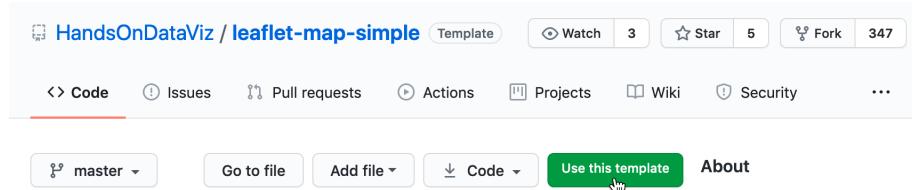


Figure 8.2: Click *Use this template* to make your own copy.

4. On the next screen, your account will appear as the owner. Name your copy of the repo **leaflet-map-simple**, the same as ours, as shown in Figure 8.3. Click the green *Create repository from template* button.

Create a new repository from leaflet-map-simple

The new repository will start with the same files and folders as [HandsOnDataViz/leaflet-map-simple](#).

Owner * **Repository name ***

HandsOnDemo / leaflet-map-simple ✓

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

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.

Include all branches
Copy all branches from HandsOnDataViz/leaflet-map-simple and not just master.

Create repository from template

Figure 8.3: Name your copied repo **leaflet-map-simple**.

Note: We set up our repo using GitHub's template feature to make it easier for users to create their own copies. If you're trying to copy someone else's GitHub

repo and don't see a *Template* button, then click the *Fork* button, which makes a copy a different way. Here's the difference: *Template* allows you to make *multiple* copies of the same repo by giving them different names, while *Fork* allows you to create *only one copy* of a repo because it uses the same name as the original, and GitHub prevents you from creating two repos with the same name. If you need to create a second fork of a GitHub repo, go to the Create a New Repo and Upload Files on GitHub section of this chapter.

The upper-left corner of the next screen will say `USERNAME/leaflet-map-simple` generated from `HandsOnDataViz/leaflet-map-simple`, where `USERNAME` refers to your GitHub account username. This confirms that you copied our template into your GitHub account, and it contains only three files:

- `LICENSE` shows that we've selected the MIT License, which allows anyone to copy and modify the code as they wish.
- `README.md` provides a simple description and link to the live demo, which we'll come back to later.
- `index.html` is the key file in this particular, because it contains the map code.

5. Click on the `index.html` file to view the code, as shown in Figure 8.4.

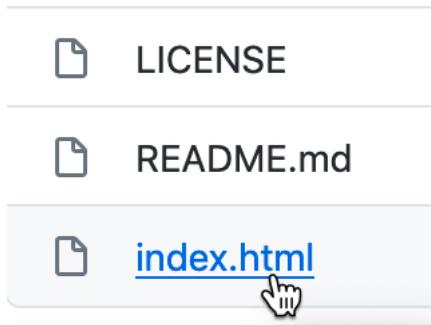


Figure 8.4: Click the Index file to view the code.

If this is the first time you're looking at computer code, it may feel overwhelming, but relax! We've inserted several "code comments" to explain what's happening. The first block you see is written in HyperText Markup Language (HTML) that tells web browsers the formatting to read the rest of the page of code. The second block instructs the browser to load the Leaflet code library, the open-source software that constructs the interactive map. The third block describes where the map and title should be positioned on the screen, written in a language called Cascading Style Sheet (CSS). The good news is that you don't need to touch any of those blocks of code, so leave them as-is. But you do want to modify a few lines further below.

6. To edit the code, click on the pencil symbol in the upper-right corner, as shown in Figure 8.5.

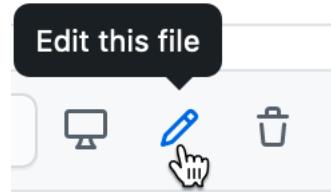


Figure 8.5: Click the pencil button to edit the code.

Let's start by making one simple change to prove to everyone that you're now editing *your* map, by modifying the map title, which appears in the HTML division tag block around lines 21-23.

7. In this line `<div id="map-title">EDIT your map title</div>`, type your new map title in place of the words `EDIT your map title`. Be careful not to erase the HTML tags that appear on both ends inside the `< >` symbols.
8. To save your edit, scroll to the bottom of the page and click the green *Commit Changes* button, as shown in Figure 8.6.

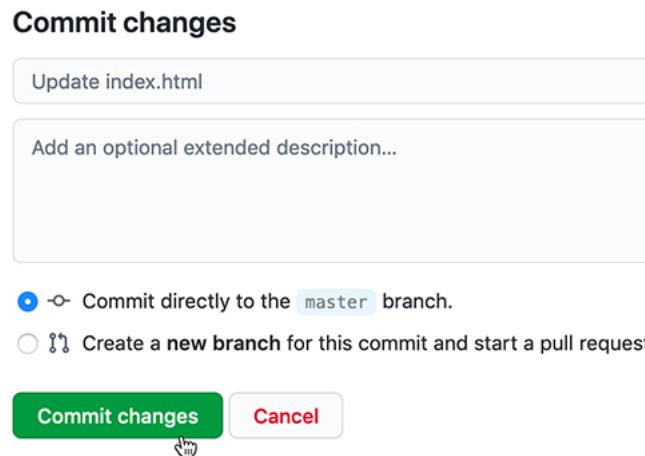


Figure 8.6: Click the green *Commit Changes* button to save your edits.

In the language of coders, we “commit” our changes in the same way that most people “save” a document, and later you’ll see how GitHub tracks each code

commit so that you can roll them back if needed. By default, GitHub inserts a short description of your commit as “Update index.html”, and you have the option to customize that description when you start making lots of commits to keep track of your work. Also, GitHub commits your changes directly to the default branch of your code, which we’ll explain later.

Now let’s publish your edited map to the public web to see how it looks in a web browser. GitHub not only stores open-source code, but its built-in GitHub Pages feature allows you to host a live online version of your HTML-based code, which anyone with the web address can view in their browser. While GitHub Pages is free to use, there are some restrictions on size and content and it is not intended for running an online business or commercial transactions. But one advantage of code templates is that you can host them on any web server you control. Since we’re already using GitHub to store and edit our code template, it’s easy to turn on GitHub Pages to host it online.

9. To access GitHub Pages, scroll to the top of your repo page and click the *Settings* button as shown in Figure 8.7.

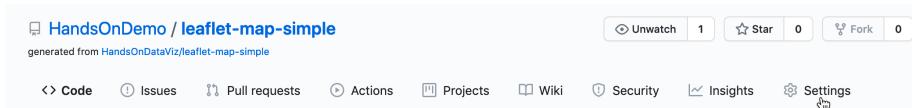


Figure 8.7: Click the *Settings* button to access GitHub Pages and publish your work on the web.

10. In the Settings screen, scroll way down to the GitHub Pages area, and use the drop-down menu to change *Source* from *None* to *Master Branch*, as shown in Figure 8.8. There is no *commit* or *save* button here, and the change will happen automatically. This step tells GitHub to publish a live version of your map on the public web, where anyone can access it in their browser, if they have the web address.

Note: GitHub recently announced it plans to change the default branch from *Master* to *Main* to eliminate its master-slave metaphor. **TODO:** Update repos, text, and screenshots when this happens.

11. Scroll back down to *Settings > GitHub Pages* to see the web address where your live map has been published online, and right-click it to open in a new browser tab, as shown in Figure 8.9.

Now you should have at least two tabs open in your browser. The first tab contains your GitHub repo, where you edit your code, with a web address in this format, and replace **USERNAME** and **REPOSITORY** with your own:

GitHub Pages

GitHub Pages is designed to host your personal, organization, or project pages from a GitHub repository.

Source
GitHub Pages is currently disabled. Select a source below to enable GitHub Pages for this repository. [Learn more.](#)

None ▾

Select source ×

- master branch
- master branch /docs folder
- None

If theme using the master branch. [Learn more.](#)

Use the master branch for GitHub Pages.

Use only the /docs folder for GitHub Pages.

Disable GitHub Pages.

Figure 8.8: In *Settings > GitHub Pages*, switch the source from *None* to *Master*.

GitHub Pages

GitHub Pages is designed to host your personal, organization, or project pages from a GitHub repository.

Your site is ready to be published at <https://handsondemo.github.io>

[Open Link in New Tab](#) [Open Link in New Window](#)

Figure 8.9: In *Settings > GitHub Pages*, right-click your published map link to open in a new tab.

`https://github.com/USERNAME/REPOSITORY`

The second tab contains your GitHub Pages live website, where your edited code appears online. GitHub Pages automatically generates a public web address in this format:

`https://USERNAME.github.io/REPOSITORY`

Remember how we told you not to create your account with a username like `DrunkBrownieChef6789?` GitHub automatically places your username automatically in the public web address.

Keep both tabs open so you can easily go back and forth between editing your code and viewing the live results online.

Note: The live version of your code points to the `index.html` page by default, so it's not necessary to include it in the web address. Also, web addresses are *not* case sensitive, meaning you can save time by typing all of it in lower-case.

Tip: If your live map does *not* appear right away, wait up to 30 seconds for GitHub Pages to finish processing your edits. Then do a “hard refresh” to bypass any saved content in your browser cache and re-download the entire web page from the server, using one of these key combinations:

- Ctrl + F5 (most browsers for Windows or Linux)
- Command + Shift + R (Chrome or Firefox for Mac)
- Shift + Reload button toolbar (Safari for Mac)
- Ctrl + Shift + Backspace (on Chromebook)

Now let's edit your the GitHub repo so that the link points to *your* live map, instead of *our* live map.

12. Copy the web address of your live map from your second browser tab.
13. Go back to your first browser tab with your GitHub repo, and click on the repo title to return to its home page, as shown in Figure 8.10.



Figure 8.10: On your first browser tab, click the repo title.

14. On your repo page, click to open the `README.md` file, and click the pencil again to edit it, as shown in Figure 8.11. Paste your live web link under the label (*replace with link to your site*) and scroll down to commit the change.

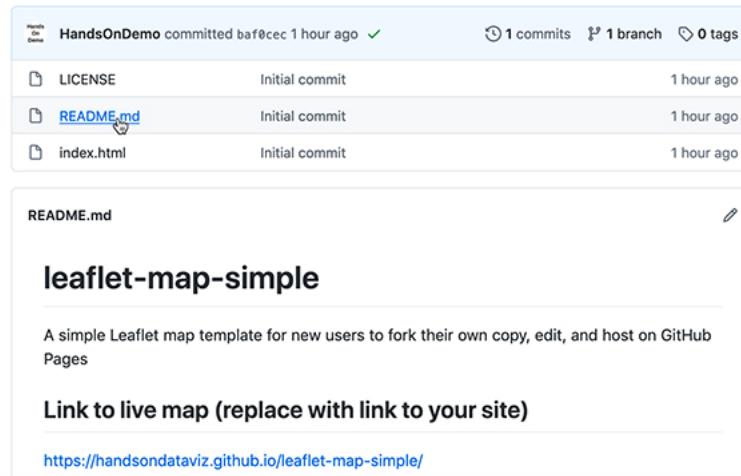


Figure 8.11: Open and edit the `README` file to paste the link to your live map.

Now that you've successfully made simple edits and published your live map, let's make more edits to jazz it up and help you learn more about how Leaflet code works.

15. On your repo home page, click to open the `index.html` file, and click the pencil symbol to edit more code.

Wherever you see the `EDIT` code comment, this points out a line that you can easily modify. For example, look for the code block shown below that sets up the initial center point of the map and its zoom level. Insert a new latitude and longitude coordinate to set a new center point. To find coordinates, right-click on any point in Google Maps and select *What's here?*, as described in the Geocode Locations into Coordinates section of Chapter 11.

```
var map = L.map('map', {
  center: [41.77, -72.69], // EDIT latitude, longitude to re-center map
  zoom: 12, // EDIT from 1 to 18 -- decrease to zoom out, increase to zoom in
  scrollWheelZoom: false
});
```

The next code block displays the basemap tile layer that serve as the map background. Our template uses a light map with all labels, publicly provided

by CARTO, with credit to OpenStreetMap. One simple edit is to change `light_all` to `dark_all`, which will substitute a different CARTO basemap with inverted coloring. Or see many other Leaflet basemap code options that you can paste in at <https://leaflet-extras.github.io/leaflet-providers/preview/>. Make sure to attribute the source, and also keep `) .addTo(map);` at the end of this code block, which displays the basemap.

```
L.tileLayer('https://.basemaps.cartocdn.com/light_all/{z}/{x}/{y}.png', {
    attribution: '&copy; <a href="http://www.openstreetmap.org/copyright">OpenStreetMap</a>,
    &copy; <a href="https://carto.com/attribution">CARTO</a>'
}).addTo(map);
```

The last code block displays a single point marker on the map, colored blue by default in Leaflet, with a pop-up message when users click it. You can edit the marker coordinates, insert the pop-up text, or copy and paste the code block to create a second marker.

```
L.marker([41.77, -72.69]).addTo(map) // EDIT latitude, longitude to re-position marker
.bindPopup("Insert pop-up text here"); // EDIT pop-up text message
```

15. After making edits, remember to scroll down and press the *Commit* button to save changes. Then go to your browser tab with the live map, and do a hard-refresh to view changes. If your map edits do not appear right away, remember that GitHub Pages sometimes requires up to 30 seconds to process code edits. If you have problems, see the Fix Common Mistakes section in the appendix.

Congratulations! If this is the first time that you've edited computer code and hosted it online, you can now call yourself a "coder". The process is similar to following and modifying a cookbook recipe, just like you also can call yourself a "chef" after baking your first batch of brownies! Although no one is likely to hire you as a full-time paid coder (or chef) at this early stage, you now understand several of the basic skills needed to copy, edit, and host code online, and you're ready to dive into the more advanced versions, such as Chart.js and Highcharts templates in chapter 9 and Leaflet map templates in chapter 10.

The next section describes how to enhance your GitHub skills by creating new repos and uploading your files. These are essential steps to create a second copy of a code template or to work with more advanced templates in the next two chapters.

Create a New Repo and Upload Files on GitHub

Now that you've made a copy of our GitHub template, the next step is to learn how to create a brand-new repo and upload files. These skills will be

helpful for several scenarios. First, if you have to fork a repo, which GitHub allows you to do only one time, this method will allow you to create additional copies. Second, you'll need to upload some of your own files when creating data visualizations using Chart.js and Highcharts templates in Chapter 9 and Leaflet map templates in Chapter 10. Once again, we'll demonstrate how to do all of these steps in GitHub's beginner-level browser interface, but see the next section on GitHub Desktop for an intermediate-level interface that's more efficient for working with code templates.

In the previous section, you created a copy of our GitHub repo with the *Use this template* button, and we intentionally set up our repos with this newer feature because it allows the user to make *multiple* copies and assign each one a different name. Many other GitHub repos do not include a *Template* button, so to copy those you'll need to click the *Fork* button, which automatically generates a copy with the same repo name as the original. But what if you wish to fork someone's repo a second time? GitHub prevents you from creating a second fork to avoid violating one of its important rules: every repo in your account must have a unique name, to avoid overwriting and erasing your work.

So how do you make a second fork of a GitHub repo, if there's no *Use this template* button? Follow our recommended workaround that's summarized in these three steps:

- Download the existing GitHub repo to your local computer
 - Create a brand-new GitHub repo with a new name
 - Upload the existing code repo files to your brand-new repo
1. Click on the *Code > Download Zip* drop-down menu button on any repo, as shown in Figure 8.12. Your browser will download a zipped compressed folder with the contents of the repo to your local computer, and it may ask you where you wish to save it. Decide on a location and click OK.
 2. Navigate to the location on your computer where you saved the folder. Its file name should end with `.zip`, which means you need to double-click to “unzip” or de-compress the folder. After you unzip it, a new folder will appear named in this format, `REPOSITORY-BRANCH`, which refers to the repository name (such as `leaflet-map-simple`) and the branch name (such as `master` or `main`), and it will contain the repo files.
 3. Go back to your GitHub account in your web browser, click on the plus (+) symbol in the upper-right corner of your account, and select *New repository*, as shown in Figure 8.13.
 4. On the next screen, GitHub will ask you to enter a new repo name. Choose a short one, preferably all lower-case, and separate words with hyphens if

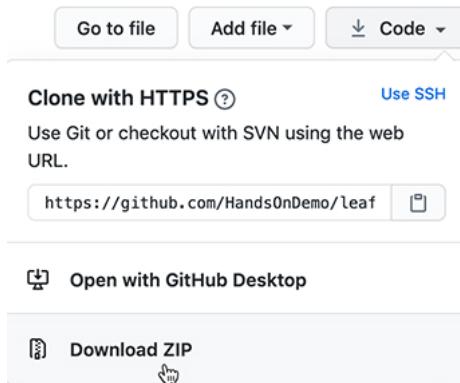


Figure 8.12: Click *Code > Download Zip* to create a compressed folder of a repo on your computer.

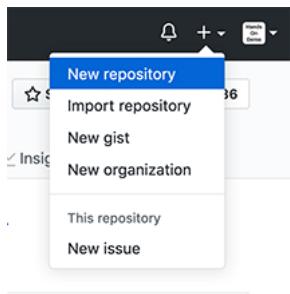


Figure 8.13: Click the plus (+) symbol in upper-right corner to create a new repo.

needed. Let's name it `practice` because we'll delete it at the end of this tutorial.

Check the box to *Initialize this repository with a README* to simplify the next steps.

Also, select *Add a license* that matches the code you plan to upload, which in this case is “MIT License.” Other fields are optional. Click the green *Create Repository* button at the bottom when done, as shown in Figure 8.14.

Create a new repository
A repository contains all project files, including the revision history. / elsewhere? [Import a repository](#).

Repository template
Start your repository with a template repository's contents.
[No template](#)

Owner * **Repository name ***
HandsOnDemo / practice

Great repository names are short and memorable. Need inspiration?

Description (optional)

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

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

Skip this step if you're importing an existing repository.
 Initialize this repository with a README
This will let you immediately clone the repository to your computer.

Add .gitignore: None Add a license: MIT License

Create repository

Figure 8.14: Name your new repo “practice”, check the box to *Initialize this repo with a README*, and *Add a license* (select “MIT”) to match any code you plan to upload.

Your new repo will have a web address similar to <https://github.com/USERNAME/practice>.

5. On your new repo home page, click the *Add File > Upload Files* drop-down menu button, near the middle of the screen, as shown in Figure 8.15.
6. Drag-and-drop the `index.html` file that you previously downloaded to your local computer into the upload screen of your GitHub repo in your browser, as shown in Figure 8.16. Do not upload `LICENSE` or `README.md` because your new repo already contains those two files. Scroll down to click the green *Commit Changes* button.

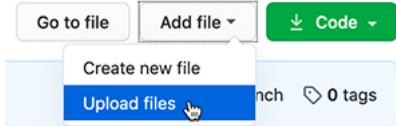


Figure 8.15: Click the *Upload Files* button.

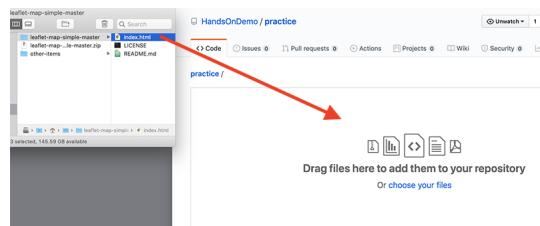


Figure 8.16: Drag-and-drop the `index.html` file to the upload screen.

When the upload is complete, your repo should contain three files, now including a copy of the `index.html` code that you previously downloaded from the `leaflet-map-simple` template. This achieved our goal of working around GitHub's one-fork rule, by creating a new repo and manually uploading a second copy of the code.

Optionally, you could use GitHub Pages to publish a live version of the code online, and paste the links to the live version at the top of your repo and your `README.md` file, as described in the Copy, Edit, and Host a Simple Leaflet Map Template section of this chapter.

7. Since this was only a `practice` repo, let's delete it from GitHub. In the repo screen of your browser, click the top-right *Settings* button, scroll all the way down to the *Danger Zone*, and click *Delete this repository*, as shown in Figure 8.17. GitHub will ask you to type in your username and repo name to ensure that you really want to delete the repo, to prove you are not a drunken brownie chef.

So far, you've learned how to copy, edit, and host code using the GitHub web interface, which is a great introduction for beginners. Now you're ready to move up to tools that will allow you to work more efficiently with GitHub, such as GitHub Desktop and Atom Editor, to quickly move entire repos to your local computer, edit the code, and move them back online.

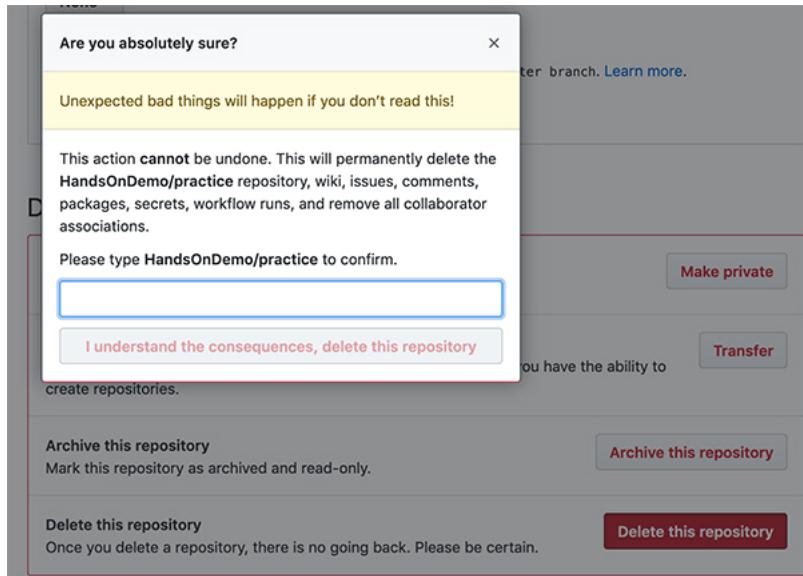


Figure 8.17: After clicking the Delete Repository button, GitHub will ask you to type your username and repo name to confirm.

GitHub Desktop and Atom Editor to Code Efficiently

Editing your code through the GitHub web interface is a good way to start, but it can be very slow, especially if you need to modify or upload multiple files in your repo. To speed up your work, we recommend that you download two free tools—GitHub Desktop and Atom Text Editor—which run on Mac or Windows computers. When you connect your GitHub web account to GitHub Desktop, it allows you to “pull” the most recent version of the code to your local computer’s hard drive, make and test your edits, and “push” your commits back to your GitHub web account. Atom Text Editor, which is also created by the makers of GitHub, allows you to view and edit code repos on your local computer more easily than the GitHub web interface. While there are many text editors for coders, Atom is designed to work well with GitHub Desktop.

Tip: Currently, neither GitHub Desktop nor Atom Editor are supported for Chromebooks, but Google’s Web Store offers several text editors, such as Text and Caret, which offer some of the functionality described below.)

Let’s use GitHub Desktop to pull a copy of your `leaflet-map-simple` template to your local computer, make some edits in Atom Editor, and push your commits back up to GitHub.

1. Go to the GitHub web repo you wish to copy to your local computer. In your browser, navigate to <https://github.com/USERNAME/leaflet-map-simple>, using your GitHub username, to access the repo you created in the Copy, Edit, and Host a Simple Leaflet Map Template section of this chapter. Click the *Add file > Open with GitHub Desktop* drop-down menu button near the middle of your screen, as shown in Figure 8.18. The next screen will show a link to the GitHub Desktop web page, and you should download and install the application.

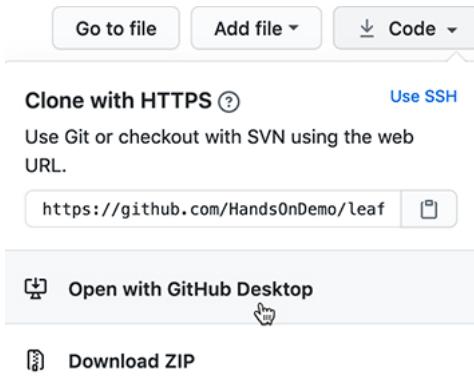


Figure 8.18: In your GitHub repo on the web, click *Add file > Open with GitHub Desktop* to download and install GitHub Desktop.

2. When you open GitHub Desktop for the first time, you'll need to connect it to the GitHub web account you previously created in this chapter. On the welcome screen, click the blue *Sign in to GitHub.com* button, as shown in Figure 8.19, and login with your GitHub username and password. On the next screen, GitHub will ask you to click the green *Authorize desktop* button to confirm that you wish to connect to your account.
3. In the next setup screen, GitHub Desktop asks you to configure Git, the underlying software that runs GitHub. Confirm that it displays your username and click *Continue*, as shown in Figure 8.20.
4. On the “Let’s Get Started” with GitHub Desktop screen, click on *Your Repositories* on the right side to select your `leaflet-map-sample`, and further below click the blue button to *Clone* it to your local computer, as shown in Figure 8.21.

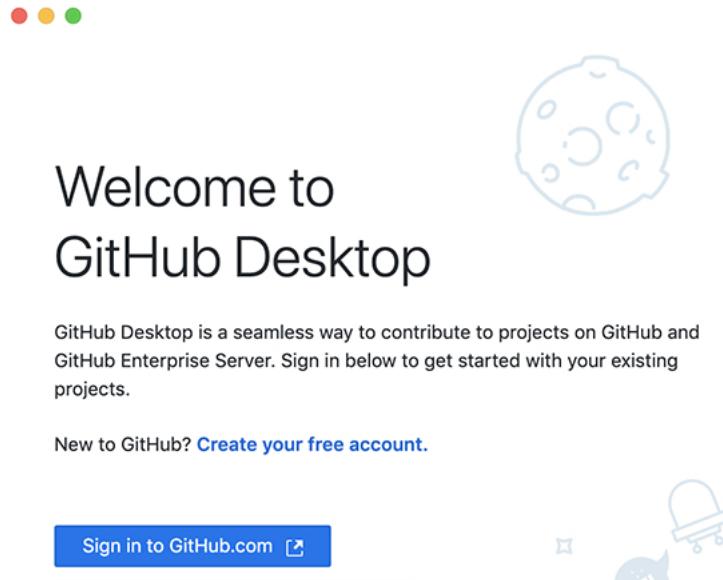


Figure 8.19: Click the blue *Sign in to GitHub.com* button to link GitHub Desktop to your GitHub account.

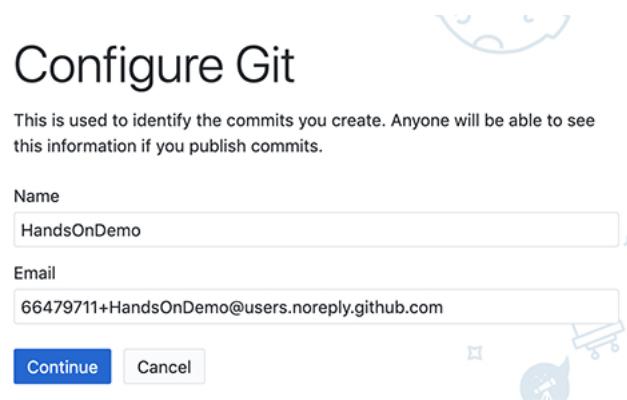


Figure 8.20: Click the *Continue* button to authorize GitHub Desktop to send commits to your GitHub account.

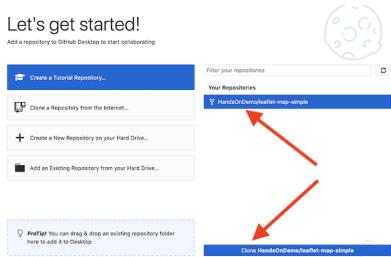


Figure 8.21: Select your “leaflet-map-simple” repo and click the *Clone* button to copy it to your local computer.

- When you clone a repo, GitHub Desktop asks you to select the Local Path, meaning the location where you wish to store a copy of your GitHub repo on your local computer, as shown in Figure 8.22. Before you click the *Clone* button, remember the path to this location, since you’ll need to find it later.

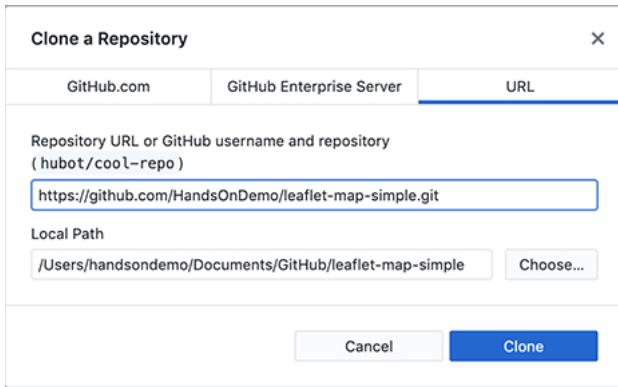


Figure 8.22: Select the Local Path where your repo will be stored on your computer, then click *Clone*.

- On the next screen, GitHub Desktop may ask, “How are you planning to use this fork?” Select the default entry “To contribute to the parent project,” which means you plan to send your edits back to your GitHub web account, and click *Continue*, as shown in Figure 8.23.
- Now you have copies of your GitHub repo in two places—in your GitHub web account and on your local computer—as shown in Figure 8.24. Your screen may look different, depending on whether you use Windows or Mac, and the Local Path you selected to store your files.

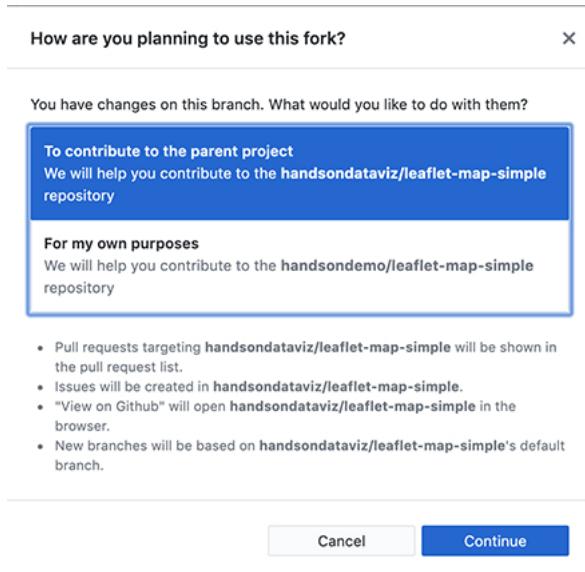


Figure 8.23: If asked how you plan to use this fork, select the default “To contribute to the parent project” and click *Continue*.

8. Before we can edit the code in your local computer, download and install the Atom Editor application. Then go to your GitHub Desktop screen, confirm that the Current Repository is `leaflet-map-simple`, and click the *Open in Atom* button as shown in Figure 8.25.
9. Since Atom Editor is integrated with GitHub Desktop, it opens up your entire repo as a “project,” where you can click files in the left window to open as new tabs to view and edit code, as shown in Figure 8.26. Open your `index.html` file and edit the title of your map, around line 22, then save your work.
10. After saving your code edit, it’s a good habit to clean up your Atom Editor workspace. Right-click on the current Project and select *Remove Project Folder* in the menu, as shown in Figure 8.27. Next time you open up Atom Editor, you can right-click to *Add Project Folder*, and choose any GitHub repo that you have copied to your local computer.
11. Now that you’ve edited the code for your map on your local computer, let’s test how it looks before uploading it to GitHub. Go to the location where you saved the repo on your local computer, and right-click the `index.html`

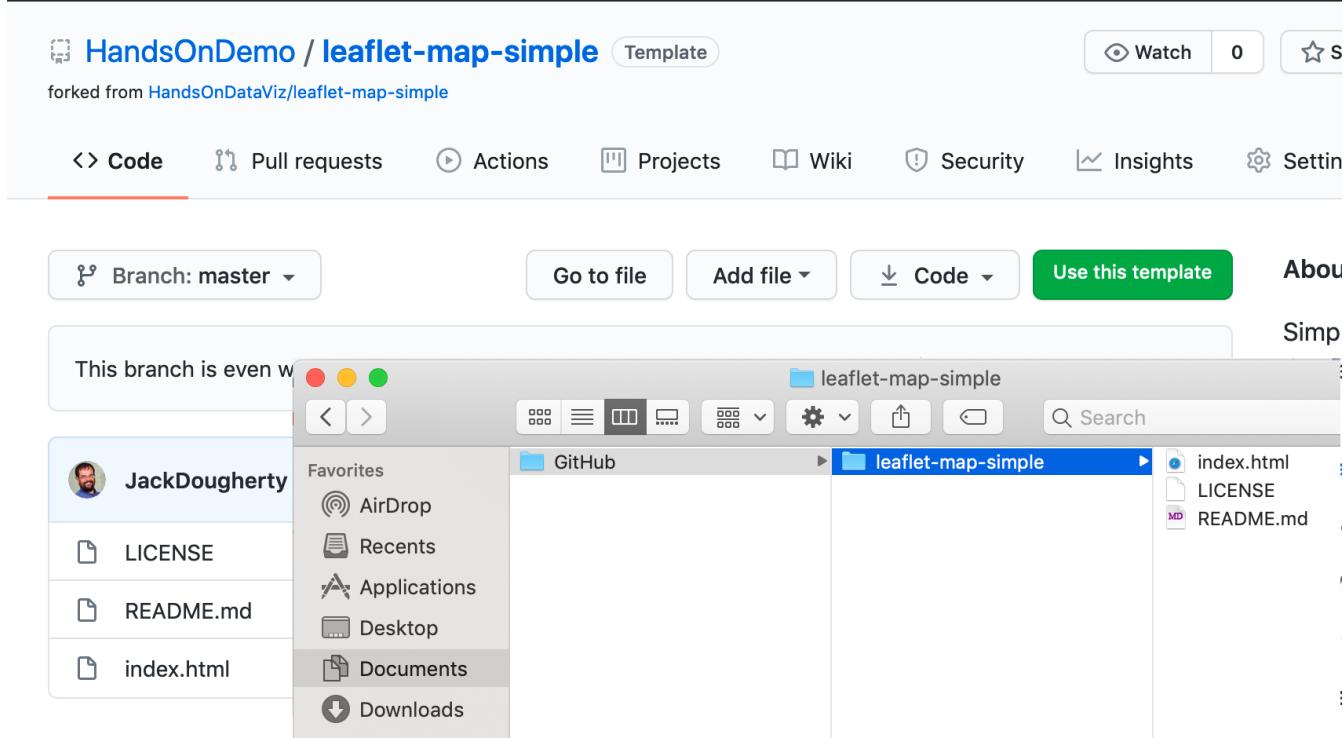


Figure 8.24: Now you have two copies of your repo: in your GitHub online account (on the left) and on your local computer (on the right, as shown in the Mac Finder). Windows screens will look different.

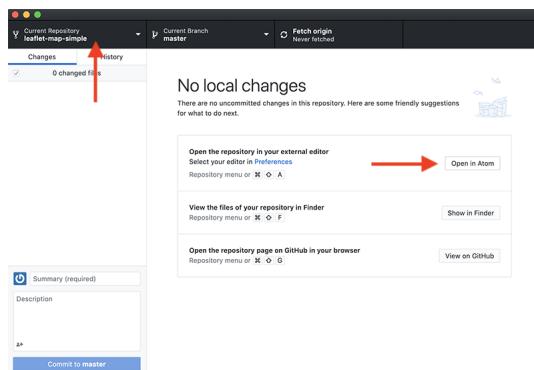


Figure 8.25: In GitHub Desktop, confirm the Current Repo and click the *Open in Atom* button to edit the code.

```

1 <!DOCTYPE html>
2 <html>
3   <head>
4     <title>leaflet-map-simple</title>
5     <meta name="viewport" content="width=device-width, initial-scale=1.0">
6     <meta charset="utf-8">
7
8     <!-- Load Leaflet code library: see https://leafletjs.com/download.html -->
9     <link rel="stylesheet" href="https://unpkg.com/leaflet@1.6.0/dist/leaflet.css">
10    <script src="https://unpkg.com/leaflet@1.6.0/dist/leaflet.js"></script>
11
12     <!-- Position the map and title with Cascading Style Sheet (.css) -->
13     <style>
14       body { margin:0; padding:0; }
15       #map { position: absolute; top:0; bottom:0; right:0; left:0; }
16       #map-title { position: relative; margin-top: 10px; margin-left: 50px; float: left; }
17     </style>
18
19   </head>
20
21   <!-- Display the map and title with HTML division tags -->
22   <div id="map-title">NEW map title</div>
23   <div id="map"></div>

```

Figure 8.26: Atom Editor opens your repo as a “project,” where you can click files to view code. Edit your map title.

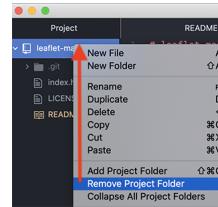


Figure 8.27: To clean up your Atom Editor workspace, right-click to *Remove Project Folder*.

file, select Open With, and choose your preferred web browser, as shown in Figure 8.28.

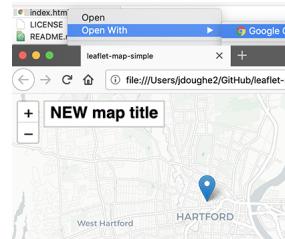


Figure 8.28: Right-click the index.html file on your local computer and open with a browser to check your edits.

Note: Since your browser is displaying only the *local computer* version of your code, the web address will begin with `file:///...` rather than `https://...`, as appears in your GitHub Pages online map. Also, if your code depends on online elements, those features may not function when viewing it locally. But for this simple Leaflet map template, your updated map title should appear, allowing you to check its appearance before pushing your edits to the web.

Now let's transfer your edits from your local computer to your GitHub web account, which you previously connected when you set up GitHub Desktop.

11. Go to GitHub Desktop, confirm that your Current Repo is `leaflet-map-simple`, and you will see your code edits summarized on the screen. In this two-step process, first click the blue *Commit to Master* button at the bottom of the page to save your edits to your local copy of your repo. (If you edit multiple files, GitHub Desktop will ask you write a summary of your edit, to help you keep track of your work.) Second, click the blue *Push origin* button to transfer those edits to the parent copy of your repo on your GitHub web account. Both steps are shown in Figure 8.29.

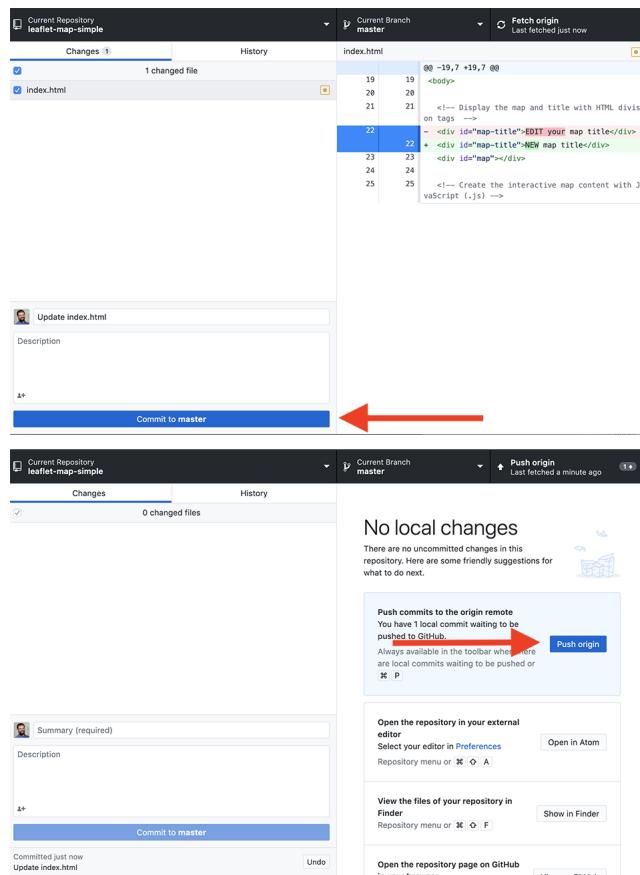


Figure 8.29: In this two-step process, click *Commit to Master*, then click *Push origin* to save and copy your edits from your local computer to your GitHub web account, as shown in this animated GIF.

Congratulations! You've successfully navigated a round-trip journey of

code, from your GitHub account to your local computer, and back again to GitHub. Since you previously used the GitHub Pages settings to create an online version of your code, go see if your edited map title now appears on the public web. The web address you set up earlier follows this format `https://USERNAME.github.io/REPOSITORY`, substituting your GitHub username and repo name.

While you could have made the tiny code edit above in the GitHub web interface, hopefully you've begun to see many advantages of using GitHub Desktop and Atom Editor to edit code and push commits from your local computer. First, you can make more complex code modifications with Atom Editor, which includes search, find-and-replace, and other features to work more efficiently. Second, when you copy the repo to your local computer, you can quickly drag-and-drop multiple files and subfolders for complex visualizations, such as data, geography, and images. Third, depending on the type of code, you may be able to test how it works locally with your browser, before uploading your commits to the public web.

Tip: Atom Editor has many built-in features that recognize and help you edit code, plus the option to install more packages in the Preferences menu. One helpful built-in tool is *Edit > Toggle Comments*, which automatically detects the coding language and converts the selected text from executable code to non-executed code comments. Another built-in tool is *Edit > Lines > Auto Indent*, which automatically cleans up selected text or an entire page of code for easier reading.

GitHub also offers a powerful platform for collaborative projects, such as *Hands-On Data Visualization*. As co-authors, we composed the text of these book chapters and all of the sample code templates on GitHub. Jack started each day by “pulling” the most recent version of the book from our shared GitHub account to his local computer using GitHub Desktop, where he worked on sections and “pushed” his commits (aka edits) back to GitHub. At the same time, Ilya “pulled” the latest version and “pushed” his commits back to GitHub as well. Both of us see the commits that each other made, line-by-line in green and red (showing additions and deletions), by selecting the GitHub repo *Code* tab and clicking on one of our commits, as shown in Figure 8.30.

Although GitHub does not operate like Google Documents, which displays live edits, the platform has several advantages when working collaboratively with code. First, since GitHub tracks every commit we make, it allows us to go back and restore a very specific past version of the code if needed. Second, when GitHub repos are public, anyone can view your code and submit an “issue” to notify the owner about an idea or problem, or send a “pull request” of suggested code edits, which the owner can accept or reject. Third, GitHub allows collaborators to create different “branches” of a repo in order to make edits, and then “merge” the branches back together if desired. Occasionally, if two or more coders attempt to push incompatible commits to the same repo, GitHub will warn about a “Merge Conflict,” and ask you to resolve these conflicts in

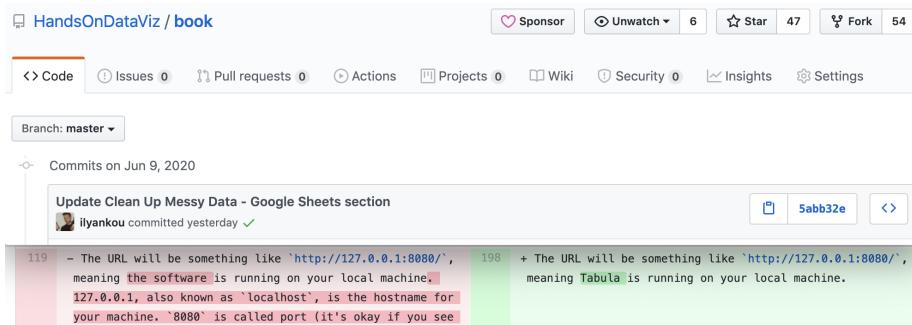


Figure 8.30: Drag-and-drop the file to the upload screen.

order to preserve everyone's work.

Many coders prefer to work on GitHub using its Command Line Interface (CLI), which means memorizing and typing specific commands directly into the Terminal application on Mac or Windows, but this is beyond the scope of this introductory book.

Summary

If this is the first time you've forked, edited, and hosted live code on the public web, welcome to the coding family! We hope you agree that GitHub is a powerful platform for engaging in this work and sharing with others. While beginners will appreciate the web interface, you'll find that the GitHub Desktop and Atom Editor tools make it much easier to work with Chart.js code templates in Chapter 9 and the Leaflet map code templates in Chapter 10. Let's build on your brand-new coding skills to create more customized charts and maps in the next two chapters.

Chapter 9

Chart.js and Highcharts Templates

TODO: Rewrite chapter to include Highcharts

While beginners appreciate the drag-and-drop chart tools and tutorials described earlier in this book, such as Google Sheets and Tableau Public, more advanced users may wish to customize their visualizations, add more complex data, and control exactly how and where their work appears on the web. A more powerful and relatively easy-to-learn solution is to use code templates built with Chart.js <https://www.chartjs.org/>, an open-source library, which you can modify and host on GitHub, as described in this book.

Working with Chart.js

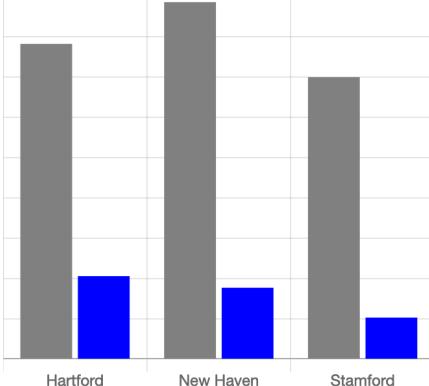
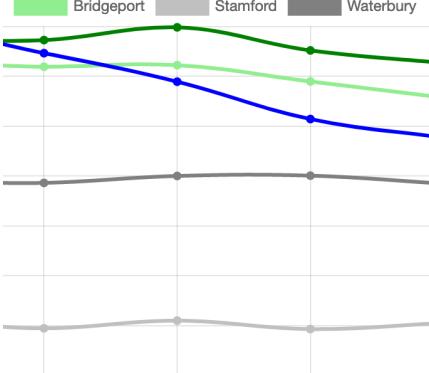
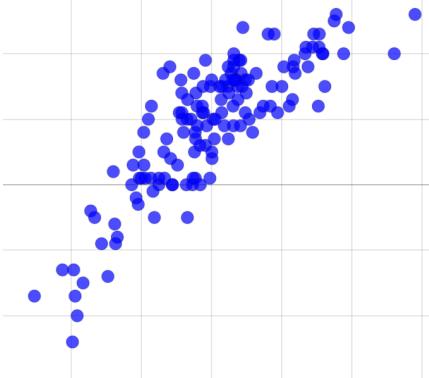
Pros

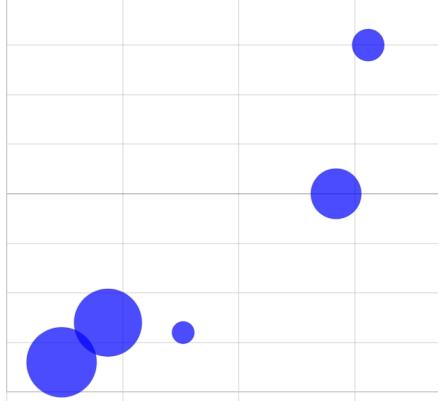
- Open-source code that is distributed under MIT license and is free for all and
- Easier for beginners to understand than more complex visualization code libraries such as D3.js

9.0.0.0.1 Cons

- Must host your own code repositories to publish to the web (with a free service such as GitHub Pages)

9.0.0.1 List of Chart.js templates

Templates	Best use and tutorial chapters			
Chart.js Bar Chart  A bar chart titled "Chart.js Bar Chart". It has three bars representing different locations: Hartford (dark grey), New Haven (blue), and Stamford (dark grey). The y-axis has grid lines, and the x-axis labels are Hartford, New Haven, and Stamford. <table border="1"> <tr> <td>Hartford</td> <td>New Haven</td> <td>Stamford</td> </tr> </table>	Hartford	New Haven	Stamford	Bar charts (vertical bar charts are often called column charts) can be used to compare categorical data. Template with tutorial: Bar Chart.js with CSV Data
Hartford	New Haven	Stamford		
Chart.js Line Chart  A line chart titled "Chart.js Line Chart". It features three data series: Bridgeport (green line with circles), Stamford (light grey line with circles), and Waterbury (dark grey line with circles). The chart shows a general downward trend over time for all three cities. <table border="1"> <tr> <td>Bridgeport</td> <td>Stamford</td> <td>Waterbury</td> </tr> </table>	Bridgeport	Stamford	Waterbury	Line charts are normally used to show trends (temporal data). Template with tutorial: Line Chart with CSV Data
Bridgeport	Stamford	Waterbury		
Chart.js Scatter Chart  A scatter chart titled "Chart.js Scatter Chart". It displays numerous blue circular data points scattered across the plot area, forming a dense cluster in the center. <table border="1"> <tr> <td></td> <td></td> <td></td> </tr> </table>				Scatter charts (also scatterplots) are used to display data of 2 or more dimensions. Template with tutorial: Scatter Chart with CSV Data

Templates	Best use and tutorial chapters
Chart.js Bubble Chart 	Bubble charts are used to display data of 3 or more dimensions. Template with tutorial: Bubble Chart with CSV Data

Inside the templates

The templates featured above vary from simple to complex, but all of them rely on four basic pillars:

- HTML: language to structure content on the web (example: index.html)
- CSS, or Cascading Style Sheet: to shape how content appears on the web (example: style.css)
- JavaScript: code to create the chart and interactivity (example: script.js)
- CSV: data that powers the visualization that is expressed in comma-separated format (example: data.csv)

Also, these templates refer to other code elements:

- library: link to online instructions to complete routine tasks (example: Chart.js)
- data: content to appear in chart, typically in CSV format (example: data.csv) or pulled from Google Sheets

Learn more: - Chart.js Samples, <https://www.chartjs.org/samples/latest/>

Bar Chart.js with CSV Data

Bar charts (vertical bar charts are often called *column charts*) can be used to compare categorical data. The y-axis (or x-axis for horizontal bar chart) should always start at 0.

Demo: <https://handsondataviz.github.io/chartjs-templates/bar-chart/index.html>

Source and instructions: <https://github.com/handsondataviz/chartjs-templates/tree/master/bar-chart>

Line Chart.js with CSV Data

Line charts are often used to show temporal data (trends). The x-axis often represents time intervals. Unlike column or bar charts, y-axes of line charts do not necessarily start at 0.

Demo: <https://handsondataviz.github.io/chartjs-templates/line-chart/index.html>

Source and instructions: <https://github.com/handsondataviz/chartjs-templates/tree/master/line-chart>

Scatter Chart.js with CSV Data

Scatter charts (also *scatterplots*) are used to display data of 2 or more dimensions. The scatter chart below shows the relationship between household income and test performance for school districts in Connecticut. Using x- and y-axes to show two dimensions, it is easy to see that test performance improves as household income goes up.

Demo: <https://handsondataviz.github.io/chartjs-templates/scatter-chart/index.html>

Source and instructions: <https://github.com/handsondataviz/chartjs-templates/tree/master/scatter-chart>

Going beyond two dimensions

To show more than two dimensions in scatter charts, one can:

- **color** each data point differently to show third dimension, eg use shades of red and green to show 5-year trend in test performance;
- **resize** each data point to display fourth dimension, eg number of students in each school district;
- use different **icons or glyphs** to display fifth dimension, eg circles for male students and squares for female students.

Remember not to overwhelm the viewer and communicate only the data that are necessary to prove or illustrate your idea.

Bubble Chart.js with CSV Data

Bubble charts are similar to scatter plots. The size of each dot (marker) is used to represent an additional dimension.

In the demo below, the bubble chart shows the relationship between median household income (x-axis) and test performance (y-axis) in 6 school districts in Connecticut. The size of data point (marker) corresponds to the number of students enrolled in the school district: bigger circles represent larger school districts.

Demo: <https://handsondataviz.github.io/chartjs-templates/bubble-chart/index.html>

Source and instructions: <https://github.com/handsondataviz/chartjs-templates/tree/master/bubble-chart>

Tip: Use semi-transparent circles

Data points may obstruct each other. To avoid this, play with color transparency. For example, `rgba(160, 0, 0, 0.5)` is a semi-transparent red in RGBA color model. The `a` stands for `alpha`, and is a number between 0 and 1, where 1 is solid, and 0 is completely transparent. Using transparency, you will be able to see data points that are hidden behind bigger neighbors.

Going beyond three dimensions

To show more than three dimensions in bubble charts, one can:

- **color** each data point differently to show fourth dimension, eg use shades of red and green to show 5-year trend in test performance;
- use different **icons or glyphs** to display fifth dimension, eg circles for male students and squares for female students.

Remember not to overwhelm the viewer and communicate only the data that are necessary to prove or illustrate your idea.

Chapter 10

Leaflet Map Templates

TODO: Rewrite chapter

While beginners appreciate the drag-and-drop map tools and tutorials described earlier in this book, Google My Maps and Carto, more advanced users may wish to customize their visualizations, add more complex data and interactivity, and control exactly how and where their work appears on the web. A more powerful and relatively easy-to-learn solution is to use code templates built with Leaflet <https://leafletjs.com>, an open-source library, which you can modify and host on GitHub, as described in this book.

Working with Leaflet

Pros:

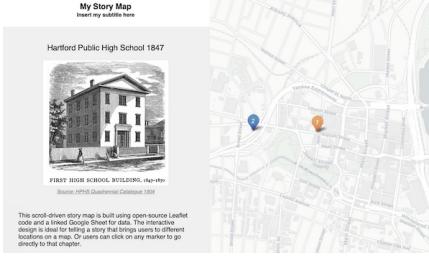
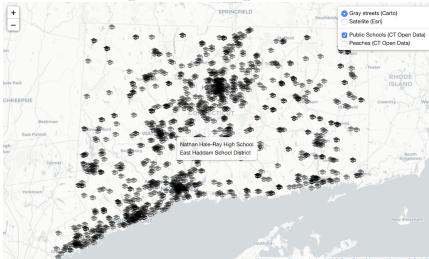
- Open-source code, which anyone can freely use online, download, modify, or expand with plugins
- Easier for beginners to understand than some other map code libraries
- Compact code library (less than 40 KB) that runs on JavaScript in all modern web browsers

Cons:

- Must host your own code repositories to publish to the web (with a free service such as GitHub Pages)
- Must rely on open-source community of developers to maintain the core code or specific plugins

Leaflet Map Templates

TODO: add and clean up Leaflet Map CSV <https://github.com/HandsOnDataViz/leaflet-map-csv> to serve as a fuller tutorial for Leaflet Maps, and explain how this will teach more principles of modifying Leaflet code. . . . then geocode and upload more data points:

Template	Best use and tutorial chapter
Leaflet Maps with Google Sheets 	Best to show points, polygons, polylines, or point table data. Upload your GeoJSON data and modify settings in linked Google Sheet (or CSV) and GitHub repo. Template with tutorial: Leaflet Maps with Google Sheets
Leaflet Storymaps with Google Sheets 	Create a scrolling narrative with points, text, images, and links. Template with tutorial: Leaflet Storymaps with Google Sheets
Leaflet Maps with Open Data API 	Create a Leaflet map powered by an open data repository application programming interface (API), such as a Socrata data repository endpoint. Template with tutorial: Leaflet Maps with Open Data API

Inside Leaflet code templates

The templates featured below vary from simple to complex, but all of them include three basic types of code:

- HTML: to structure content on the web (example: index.html)

- CSS, or Cascading Style Sheet: to shape how content appears on the web (example: style.css)
- JavaScript: to create the map and interactivity (example: script.js)

Also, these templates refer to other types of code:

- library: link to online instructions to complete routine tasks (examples: Leaflet, jQuery)
- basemap tiles: link to online background map (example: Carto Positron, a light-gray street map)
- data: content to appear on map, typically in CSV or GeoJSON format (examples: data.csv, data.geojson)

Fork and Edit Leaflet Map with CSV Data

TODO: REWRITE this to serve as a more advanced version (with repo leaflet-map-csv) than the prior chapter (with leaflet-map-simple)

This tutorial introduces more sophisticated Leaflet map code templates (<http://leafletjs.com>) that you can modify and host online with GitHub in your browser (<http://github.com>). You will learn how to:

- A) Fork (copy) Leaflet template to your GitHub account
- B) Publish your live map to public web with GitHub Pages
- C) Modify your map title and add layer controls
- D) Geocode addresses in a Google Sheet and upload points from data.csv

Code templates help us to move beyond the limits of drag-and-drop web mapping services (such as Google MyMaps) and to create more customized visualizations on a web server that you control. Before you begin, learn the broad concepts in the chapter introduction Edit and Host Code with GitHub. If you have problems with this tutorial, go to the Fix Common Mistakes section of the appendix.

TODO: add demo, remove unnecessary basic steps from below (covered in prior chapter)

Video:

A) Fork (copy) Leaflet template to your GitHub account

Before you begin, sign up for a free GitHub account: <http://github.com>

- 1) Right-click to open this GitHub code template in a new tab: <https://github.com/handsondataviz/leaflet-map-simple>
- 2) In the upper-right corner of the code template, sign in to your free GitHub account
- 3) In the upper-right corner, click Fork to copy the template (also called a code repository, or repo) into your GitHub account. The web address (URL) of the new copy in your account will follow this format:

`https://github.com/USERNAME/REPOSITORY`

Reminder: You can only fork a GitHub repo **one time**. If needed, see how to make a second copy in the Create a New Repo in GitHub chapter in this book.

B) Publish your live map to public web with GitHub Pages

- 4) In your new copy of the code repo, click on Settings, scroll down to the GitHub Pages area, select Master, and Save. This publishes your code template to a live map on a public website that you control.
- 5) Scroll down to GitHub Pages section again, to select and copy the link to your published web site, which will follow this format:

`https://USERNAME.github.io/REPOSITORY`

- 6) Scroll up to the top, and click on your repo name to go back to its main page.
- 7) At the top level of your repo main page, click on README.md, and click the pencil icon to edit this file, written in easy-to-read Markdown code.
- 8) Delete the link to the current live site, and paste in the link to your site. Scroll down and Commit to save your edits.
- 9) On your repo main page, right-click on the link to your published site to open in a new tab. **Be patient** during busy periods, because your website may take up to 1 minute to appear the first time.

C) Modify your map title and add layer controls

- 10) Go back to your browser tab for your code repo. Click on the index.html file (which contains the map code), and click the pencil icon to edit it.
- 11) Explore the map code, which contains HTML, CSS, and JavaScript. Look for sections that begin with “EDIT” for items that you can easily change. Scroll down to Commit your changes.
- 12) Go to your live website browser tab and refresh the page to view your edits. **Be patient** during busy periods, when some edits may take up to 1 minute to appear.
- 13) To change your map title in the index.html file, click the pencil symbol (to edit) and go to lines 23-25. Replace “EDIT your map title” with your new title:

```
<!-- Display the map and title with HTML division tags -->
<div id="map-title">EDIT your map title</div>
<div id="map"></div>
```

- 14) To change your initial map zoom level, edit the index.html file and go to line 33. The zoom range for this map is from 1 (max zoom out) to 18 (max zoom in).

```
// Set up initial map center and zoom level
var map = L.map('map', {
  center: [41.77, -72.69], // EDIT latitude, longitude to re-center map
  zoom: 12, // EDIT from 1 to 18 -- decrease to zoom out, increase to zoom in
  scrollWheelZoom: false
});
```

- 15) To change the default basemap, edit lines 46 and 52 to delete “.addTo(map)” from the Carto light layer, then add it to the Stamen colored terrain layer. DO NOT erase the semicolons!

Your original code looks like this (scroll to right to see all):

```
/* Carto light-gray basemap tiles with labels */
var light = L.tileLayer('https://cartodb-basemaps-{s}.global.ssl.fastly.net/light_all/{z}/{x}/{y}.png',
  attribution: '&copy; <a href="http://www.openstreetmap.org/copyright">OpenStreetMap</a>, &copy; Carto'
).addTo(map); // EDIT - insert or remove ".addTo(map)" before last semicolon to display by default
// controlLayers.addBaseLayer(light, 'Carto Light basemap');
/* Stamen colored terrain basemap tiles with labels */
var terrain = L.tileLayer('https://stamen-tiles.a.ssl.fastly.net/terrain/{z}/{x}/{y}.png', {
```

```

attribution: 'Map tiles by <a href="http://stamen.com">Stamen Design</a>, under <a href="http://creativecommons.org/licenses/by/2.0/>CC-BY' );
}); // EDIT - insert or remove ".addTo(map)" before last semicolon to display by default
// controlLayers.addBaseLayer(terrain, 'Stamen Terrain basemap');

```

After you edit the code, it should look like this (scroll to right to see all):

```

/* Carto light-gray basemap tiles with labels */
var light = L.tileLayer('https://cartodb-basemaps-{s}.global.ssl.fastly.net/light_all/{z}/{x}/{y}.png',
    attribution: '&copy; <a href="http://www.openstreetmap.org/copyright">OpenStreetMap</a>',
}); // EDIT - insert or remove ".addTo(map)" before last semicolon to display by default
// controlLayers.addBaseLayer(light, 'Carto Light basemap');
/* Stamen colored terrain basemap tiles with labels */
var terrain = L.tileLayer('https://stamen-tiles.a.ssl.fastly.net/terrain/{z}/{x}/{y}.png',
    attribution: 'Map tiles by <a href="http://stamen.com">Stamen Design</a>, under <a href="http://creativecommons.org/licenses/by/2.0/>CC-BY' );
).addTo(map); // EDIT - insert or remove ".addTo(map)" before last semicolon to display by default
// controlLayers.addBaseLayer(terrain, 'Stamen Terrain basemap');

```

- 16) To add a control panel that turns on/off map layers, delete the code comment symbols (//) that appear in front of lines 38-41, 47, and 53 to activate these sections. When you remove code comments in GitHub, the color changes from gray text (inactive code) to colored text (active code). After you remove the code comments, your file should look like this (scroll to right to see all):

```

/* Control panel to display map layers */
var controlLayers = L.control.layers( null, null, {
    position: "topright",
    collapsed: false
}).addTo(map);

/* Carto light-gray basemap tiles with labels */
var light = L.tileLayer('https://cartodb-basemaps-{s}.global.ssl.fastly.net/light_all/{z}/{x}/{y}.png',
    attribution: '&copy; <a href="http://www.openstreetmap.org/copyright">OpenStreetMap</a>',
}); // EDIT - insert or remove ".addTo(map)" before last semicolon to display by default
controlLayers.addBaseLayer(light, 'Carto Light basemap');
/* Stamen colored terrain basemap tiles with labels */
var terrain = L.tileLayer('https://stamen-tiles.a.ssl.fastly.net/terrain/{z}/{x}/{y}.png',
    attribution: 'Map tiles by <a href="http://stamen.com">Stamen Design</a>, under <a href="http://creativecommons.org/licenses/by/2.0/>CC-BY' );
).addTo(map); // EDIT - insert or remove ".addTo(map)" before last semicolon to display by default
controlLayers.addBaseLayer(terrain, 'Stamen Terrain basemap');

```

- 17) To change one point on the map, you could edit the latitude and longitude coordinates of the single marker in lines 55-57. To find coordinates for any location and to learn more, go to <http://www.latlong.net>

```
/* Display a blue point marker with pop-up text */
L.marker([41.77, -72.69]).addTo(map) // EDIT latitude, longitude to re-position marker
.bindPopup("Insert pop-up text here"); // EDIT pop-up text message
```

But a better way to display several points is to remove the code comment symbols (//) in front of lines 60-69 to activate this section of code, which pulls map points from the data.csv file in your GitHub repository. After your edits, this section should look like this (scroll right to see all):

```
/* Upload Latitude/Longitude markers from data.csv file, show Title in pop-up, and override initial zoom */
var customLayer = L.geoJson(null, {
  onEachFeature: function(feature, layer) {
    layer.bindPopup(feature.properties.Title);
  }
});
var runLayer = omnivore.csv('data.csv', null, customLayer)
.on('ready', function() {
  map.fitBounds(runLayer.getBounds());
}).addTo(map);
controlLayers.addOverlay(customLayer, 'Markers from data.csv');
```

D) Geocode addresses in Google Sheet and upload points from data.csv

- 18) A better way to display multiple points on your map is to prepare and upload a new data.csv file to your GitHub repository. First, right-click to open this Google Sheets template in a new tab: Leaflet Maps Simple data points with Geocoder
- 19) Since this sheet is view-only, you cannot edit it. Instead, sign in to your Google account in the upper-right corner.
- 20) Go to File > Make a Copy, which will save a duplicate version to your Google Drive, which you can edit.
- 21) In your copy of the Google Sheet, select any cells and press Delete on your keyboard to erase contents. Type new titles and addresses into columns A and B.
- 22) To geocode your new addresses (which means converting them into latitude and longitude coordinates), select all of the contents across 6 columns, from Address (B) to Source (G).
- 23) Go to the Geocoder menu that appears in this special Google Sheet template, and select any service, such as US Census (for US addresses) or Google Maps. The first time you run the geocoder, the script will ask for permission.

- 24) After you have geocoded your addresses, go to File > Download As > Comma-separated values (.CSV format) to save the file to your computer.
- 25) In your computer, right-click the downloaded file to rename it to: data.csv
- 26) In your GitHub repository, click Upload Files, then drag-and-drop your new data.csv file, and Commit to upload it. Go to your live map browser tab and refresh to view changes. **Be patient* during busy periods, when some edits may take up to 1 minute to appear.**

Leaflet Maps with Google Sheets template

Question: If you have moved beyond simple drag-and-drop point tool, such as Google My Maps tutorials in this book, and want to create point and/or polygon and/or polyline maps, where should you go?

Answer: Copy and customize our open-source template for Leaflet Maps with Google Sheets. Control the map options display data that you upload to your Google Sheet and GitHub repository. No coding skills required, other than pasting one line of code to link your map with your sheet. Requires two free accounts: Google and GitHub.

Video and list of features

- Best to show points, polygons, and/or polylines, with table of points in map view
- Free and open-source code template, built on Leaflet and linked to Google Sheets
- Fork the code and host your live map on the web for free with GitHub Pages
- Geocode location data with US Census or Google, using script inside the Google Sheet
- Easy-to-modify data labels and map options in Google Sheet tabs or uploaded CSV files
- Upload your polygon and polyline GeoJSON files, and custom markers, to your GitHub repo
- Show multiple polygon layers, each with their own color legend and ranges (numerical or text)
- Responsive design resizes your maps to display inside most mobile devices

Try it: Explore the map or right-click to view full-screen map in a new tab

The map pulls the point data and settings from a linked Google Sheet, which you can explore below or right-click to view full-screen Sheet in a new tab

Part 1: Create and customize your map

In the first part of this tutorial, you will learn how to create your own copy of the Leaflet Maps with Google Sheets template, publish your Google Sheet, and paste its web address into your GitHub repo.

- A) Fork (copy) the code template and publish your version with GitHub Pages
- B) File > Make a Copy of Google Sheet template, Share, and File > Publish
- C) Paste your Google Sheet URL in two places in your GitHub repo
- D) Modify your map settings in the Options tab and test your live map

Part 2: Upload and display your map data

In the second part of this tutorial, you will learn how to geocode and customize your own point markers, and either hide or upload your own polygon and/or polyline GeoJSON data.

- E) Geocode locations and customize new markers in the Points tab
- F) Hide the polygon and polyline legends and default GeoJSON data
- G) Upload and display your own polygon GeoJSON data
- H) Upload and display your own polyline GeoJSON data
- I) Upload and display customized marker icons
- J) Optional: Save Google Sheets as CSV and upload to GitHub
- ** TO DO: second half video**

To solve problems, see the Fix Common Mistakes section of the appendix.

A) Fork (copy) the code template and publish your version with GitHub Pages

Before you begin, this tutorial assumes that you:

- have a free Google Drive account, and learned the File > Make a Copy in Google Sheets tutorial in this book
- have a free GitHub account, and understand concepts from the Edit and Host Code with GitHub chapter in this book

- 1) Right-click to open this GitHub code template in a new tab: <https://github.com/handsondataviz/leaflet-maps-with-google-sheets>
- 2) In the upper-right corner of the code template, sign in to your free GitHub account
- 3) In the upper-right corner, click Fork to copy the template (also called a code repository, or repo) into your own account. The web address (URL) of the new copy in your account will follow this format:

```
https://github.com/USERNAME/leaflet-maps-with-google-sheets
```

Reminder: You can only fork a GitHub repo **one time**. If needed, see how to make a second copy in the Create a New Repo in GitHub chapter in this book.

- 4) In your new copy of the code repo, click on Settings, scroll down to the GitHub Pages area, select Master, and Save. This publishes your code to a live map on a public website that you control.
- 5) Scroll down to GitHub Pages section again, and copy the link to your published web site, which will follow this format:

```
https://USERNAME.github.io/leaflet-maps-with-google-sheets
```



Figure 10.1: Screencast: Fork

- 6) Scroll up to the top, and click on your repo name to go back to its main page.
- 7) At the top level of your repo main page, click on README.md, and click the pencil icon to edit this file, written in easy-to-read Markdown code.
- 8) Delete the link to the current live site, and paste in the link to YOUR site. Scroll down and Commit to save your edits.

- 9) On your repo main page, right-click the link to your live map to open in a new tab. **Be patient** during busy periods on GitHub, when your website may take up to 1 minute to appear the first time.

B) File > Make a Copy of Google Sheet template, Share, and File > Publish

- 1) Right-click to open this Google Sheets template in a new tab: https://docs.google.com/spreadsheets/d/1ZxvU8eGyuN9M8GxTU9acKVJv70iC3px_m3EVFsOHN9g
- 2) Sign into your Google account
- 3) File > Make a Copy of the Google Sheet template to your Google Drive
- 4) Click the blue Share button, click Advanced, click to change Private to Anyone with the link > Can View the Sheet. This will make your public data easier to view in your map.



Figure 10.2: Screencast: Share Google Sheet

- 5) File > Publish the Link to your Google Sheet to the public web, so the Leaflet map code can read it.
- 6) At the top of your browser, copy your Google Sheet web address or URL (which usually ends in ...XYZ/edit#gid=0). Do NOT copy the published URL (which usually ends in ...XYZ/pubhtml).

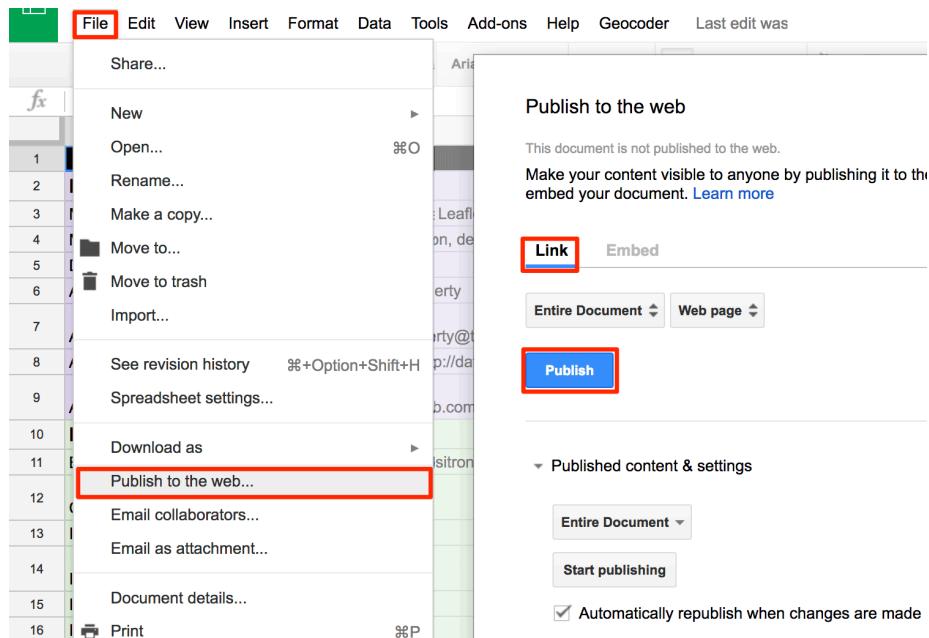


Figure 10.3: Screenshot: File > Publish the link to your Google Sheet

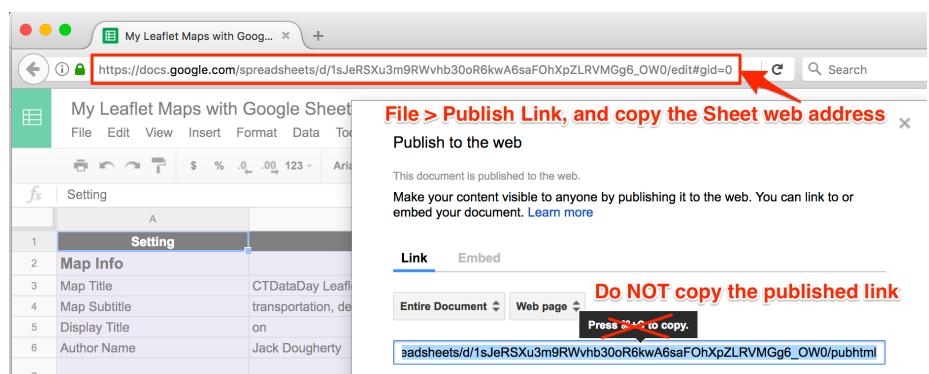


Figure 10.4: Screenshot: Copy the Google Sheet URL, not the Publish URL

C) Paste your Google Sheet URL in two places in your GitHub repo

- 1) First, connect your Google Sheet directly to your Leaflet Map code. In your Github code repo, click to open this file: `google-doc-url.js`
- 2) Click the pencil symbol to edit the file.
- 3) Paste your Google Sheet URL into the code to replace the current URL. Do not delete the single-quotation marks or semicolon.
- 4) Scroll to bottom of page and press Commit to save your changes. Now the Leaflet Map code can locate your published Google Sheet.



Figure 10.5: Screencast: Copy Google Sheet URL and paste into GitHub code

- 5) Next, let's paste your Google Sheet URL in a second place to keep track of it. Go to the `README.md` file in your GitHub repo, click to open and edit, and paste your Google Sheet web address to replace the existing link near the top. Commit to save your changes.

D) Modify your map settings in the Options tab and test your live map

In the top-level of your GitHub repo, test the new links to your map and your Google Sheet to make sure they work and point to your versions.

** TO DO - redo GIF **

In your linked Google Sheet, go to the Options Tab and modify these items:

- 1) Map Title – insert your own title
- 2) Map Subtitle – insert your own version

- 3) Author Name – insert your own name, or first name, or initials (will be public)
- 4) Author Email or Website – insert your own (will be public), or delete the current name to make it blank

Open the link to your live map in a new browser tab and refresh to see your changes.

E) Geocode locations and customize new markers in the Points tab

In your new map, our next goal is to add and modify the appearance of a new set of point markers, based on new addresses that you will enter and geocode.

In the Points tab of your Google Sheet:

- 1) Think of a simple data story that involves at least four geocodeable locations, divided into at least two groups. If you need an example, use this sample table of “Famous Places in New York City”:

Group	Name	Location
Landmark	Empire State Building	350 5th Ave, New York, NY 10118
Landmark	Metropolitan Museum of Art	1000 5th Ave, New York, NY 10028
Transit	Grand Central Terminal	89 E 42nd St, New York, NY 10017
Transit	Penn Station	159 West 33rd Street, New York, NY 10120

- 2) Enter your Group, Name, and Location data into new rows below the current data.
- 3) Go to the Font Awesome Icons site, <http://fontawesome.io/icons>, scroll down to Search Icons, find your desired icon code name, and insert this into the Marker Icon (column B) of your Points sheet. For example, search for and insert the icon code “train” or “building” to display markers with either of these symbols in your map. (To upload your own customized marker, see section H further below.)
- 4) In Marker Color (column C), use the drop-down menu to select a marker color.
- 5) In Icon Color (column D), insert a color word (example: white) or hex code (example: #fff) to color the icon symbol inside your marker. Recommended: use white icon colors with dark marker colors.
- 6) Leave Custom Size (column E) blank.

7) Optional:

- In Image (column G), insert the URL (preferably https://, not http://) of a small-to-medium sized image on the web
 - In Description (column G), insert text and/or a web link enclosed with an HTML a href tag with target set to blank
- 8) Do NOT delete or rename any column headers. However, you have the option to add new column headers to display in your map table.
 - 9) Geocode your new data inside your Google Sheet by dragging your cursor to select 6 columns of data: Location - Latitude - Longitude - Found - Quality - Source
 - 10) In the Geocoder menu that appears in this Google Sheet template, select one of the geocoding services. If one service cannot locate your data, try the other. Always inspect the accuracy of the Found column.

Open the link to your live map in a new browser tab and refresh to see your changes. If your new markers appear correctly, then delete the existing rows that came with this template.

F) Hide the polygon and polyline legends and default GeoJSON data

To show a simple point map, learn how to turn off and hide the polygon and polyline legend and default data that came with this template. (See how to add your own GeoJSON data in section G below.)

In your linked Google Sheet:

- 1) In the Options tab, Polyline Legend Position (cell B 35) – select Off to hide the legend
- 2) In the Polygons tab, Polygon Legend Position (cell B 4) – select Off to hide the legend
- 3) In the Polygons tab, Polygon GeoJSON URL (cell B 6) – delete contents to remove polygons
- 4) Go to the next tab, named Polygons1, in its drop-down menu, select Delete to remove sheet
- 5) In the Polylines tab, delete the entire row (rows 2 and 3) to remove the existing lines

Go to the browser tab with your new map, and refresh the page to see your changes.

Optional:

- in the Options tab, Display Table (cell B 29), turn off to hide the table in your map
- or modify the list of item in Table Columns (cell B 30) to change the display in your table

G) Upload and display your own polygon GeoJSON data

- 1) Prepare your polygon file in GeoJSON format. View or modify the GeoJSON file properties (such as name, data fields, etc.) with one of these tools:
 - GeoJSON.io, <http://geojson.io> – Drag-and-drop your file, and select the Table tab to view or rename properties. See GeoJSON.io tutorial in this book, OR
 - MapShaper, <http://mapshaper.org> – Drag-and-drop your file. To edit, see MapShaper tutorial in this book
- 2) In your GitHub repo, click to open the Geometry subfolder, then click Upload Files, drag-and-drop your geojson file, and Commit changes

** TO DO ** - turn on settings that you turned off in step F above

- 3) In your linked Google sheet, go to Polygons tab to adjust these settings:
 - change Polygon GeoJSON URL (cell B 6) to match the pathname of the file you uploaded above
 - change Polygon GeoJSON Name (cell B 5) to the title to be displayed for this polygon layer
 - change Polygon Legend Title (cell B 3) for the title in the polygon legend box
- 4) To adjust the polygon legend colors and range, see the Polygon Data and Color Settings sections of the Polygon tab in Google Sheets.
- 5) The code supports multiple polygon layers, which you can add (or delete) by duplicating the Polygons tab. Name them Polygons1, Polygons2, etc.
 - TO DO *
 - Explain: To use both the automatic ColorBrewer Palette and manual colors, insert blanks (goes to automatic palette above), separated by semi-colons.

H) Upload and display your own polyline GeoJSON data

Follow similar steps as described in the Polygon section above, but adjust settings in the Polylines tab of your linked Google Sheet.

I) Upload and display customized marker icons

** TO DO **

J) Optional: Save Google Sheets as CSV and upload to GitHub

If desired, you can save your table data with your code, rather than in a separate Google Sheet. Go to each Sheet tab and File > Save As in CSV format, with these file names:

- options.csv
- points.csv
- polygons.csv (also: polygons1.csv, polygons2.csv, etc.)
- polylines.csv
- notes.csv (or .txt)

Upload these files into the main level of your GitHub code repository, where the template will process them automatically.

Learn more: To solve problems, see the Fix Common Mistakes section of the appendix.

Leaflet Storymaps with Google Sheets and Scrolling Narrative

TODO: Add intro text

Try it: Explore the map or right-click to view full-screen map in a new tab

The map pulls the point data and settings from a linked Google Sheet, which you can explore below or right-click to view full-screen Sheet in a new tab

Features

- Show map points, text, images, and links with scrolling narrative
- Free and open-source code template, built on Leaflet and linked to Google Sheets

- Fork the code and host your live map on the web for free with GitHub Pages
- Geocode location data with US Census or Google, using script inside the Google Sheet
- Easy-to-modify data and map options in Google Sheet tabs or uploaded CSV files
- Responsive design resizes your maps to display inside most mobile devices

Create Your Own

- A) Fork (copy) the code template and publish your version with GitHub Pages
- B) File > Make a Copy of Google Sheet template, Share, and File > Publish
- C) Paste your Google Sheet URL in two places in your GitHub repo
- D) Modify your map settings in the Options tab and test your live map
- E) Geocode locations in the Points tab

To solve problems, see the Fix Common Mistakes section of the appendix.

A) Fork (copy) the code template and publish your version with GitHub Pages

Before you begin, this tutorial assumes that you:

- have a free Google Drive account, and learned the File > Make a Copy in Google Sheets tutorial in this book
 - have a free GitHub account, and understand concepts from the Edit and Host Code with GitHub chapter in this book
- 1) Right-click to open this GitHub code template in a new tab: <https://github.com/handsondataviz/leaflet-storymaps-with-google-sheets>
 - 2) In the upper-right corner of the code template, sign in to your free GitHub account
 - 3) In the upper-right corner, click Fork to copy the template (also called a code repository, or repo) into your own account. The web address (URL) of the new copy in your account will follow this format:

`https://github.com/USERNAME/leaflet-storymaps-with-google-sheets`

Reminder: You can only fork a GitHub repo **one time**. If needed, see how to make a second copy in the Create a New Repo in GitHub chapter in this book.

- 4) In your new copy of the code repo, click on Settings, scroll down to the GitHub Pages area, select Master, and Save. This publishes your code to a live map on a public website that you control.
- 5) Scroll down to GitHub Pages section again, and copy the link to your published web site, which will follow this format:

`https://USERNAME.github.io/leaflet-storymaps-with-google-sheets`

- 6) Scroll up to the top, and click on your repo name to go back to its main page.
- 7) At the top level of your repo main page, click on README.md, and click the pencil icon to edit this file, written in easy-to-read Markdown code.
- 8) Delete the link to the current live site, and paste in the link to YOUR site. Scroll down and Commit to save your edits.
- 9) On your repo main page, right-click the link to your live map to open in a new tab. **Be patient** during busy periods on GitHub, when your website may take up to 1 minute to appear the first time.

B) File > Make a Copy of Google Sheet template, Share, and File > Publish

- 1) Right-click to open this Google Sheets template in a new tab: `https://docs.google.com/spreadsheets/d/1AO6XHL_0JafWZF4KEejkdDNqfuZWUk3SlNIQ6MjlRFM/`
- 2) Sign into your Google account
- 3) File > Make a Copy of the Google Sheet template to your Google Drive
- 4) Click the blue Share button, click Advanced, click to change Private to Anyone with the link > Can View the Sheet. This will make your public data easier to view in your map.
- 5) File > Publish the Link to your Google Sheet to the public web, so the Leaflet map code can read it.
- 6) At the top of your browser, copy your Google Sheet web address or URL (which usually ends in ...XYZ/edit#gid=0). Do NOT copy the published URL (which usually ends in ...XYZ/pubhtml).

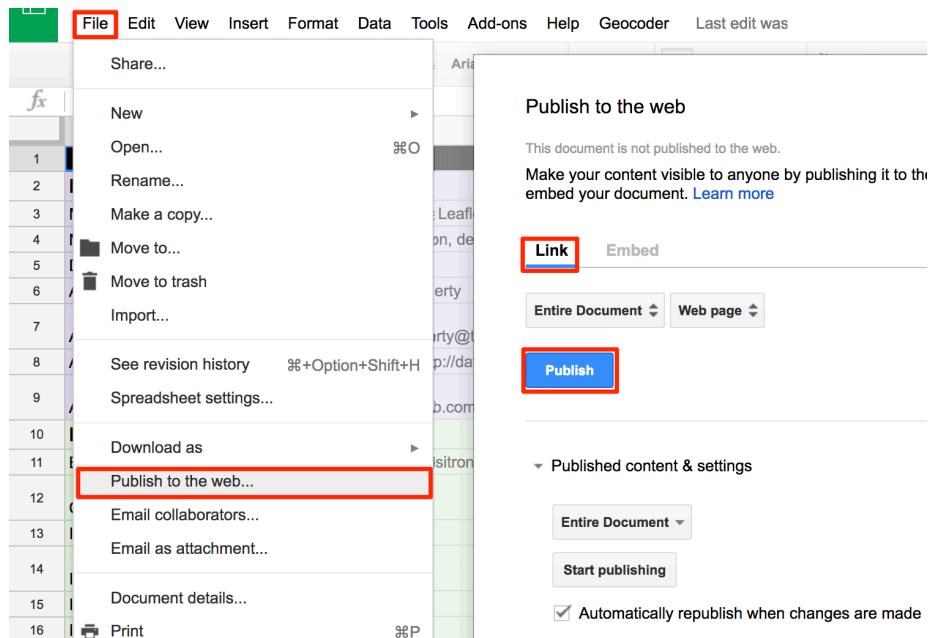


Figure 10.6: Screenshot: File > Publish the link to your Google Sheet

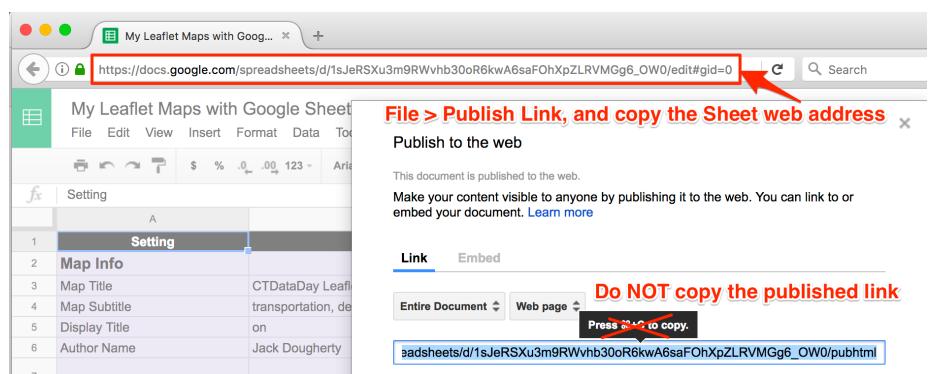


Figure 10.7: Screenshot: Copy the Google Sheet URL, not the Publish URL

C) Paste your Google Sheet URL in two places in your GitHub repo

- 1) First, connect your Google Sheet directly to your Leaflet Map code. In your Github code repo, click to open this file: `google-doc-url.js`
- 2) Click the pencil symbol to edit the file.
- 3) Paste your Google Sheet URL into the code to replace the current URL. Do not delete the single-quotation marks or semicolon.
- 4) Scroll to bottom of page and press Commit to save your changes. Now the Leaflet Map code can locate your published Google Sheet.
- 5) Next, let's paste your Google Sheet URL in a second place to keep track of it. Go to the `README.md` file in your GitHub repo, click to open and edit, and paste your Google Sheet web address to replace the existing link near the top. Commit to save your changes.

D) Modify your map settings in the Options tab and test your live map

In the top-level of your GitHub repo, test the new links to your map and your Google Sheet to make sure they work and point to your versions.

** TO DO - redo GIF **

In your linked Google Sheet, go to the Options Tab and modify these items:

- 1) Map Title – insert your own title
- 2) Map Subtitle – insert your own version
- 3) Author Name – insert your own name, or first name, or initials (will be public)
- 4) Author Email or Website – insert your own (will be public), or delete the current name to make it blank

Open the link to your live map in a new browser tab and refresh to see your changes.

E) Geocode locations and customize new markers in the Points tab

In your new map, our next goal is to add and modify the appearance of a new set of point markers, based on new addresses that you will enter and geocode.

In the Points tab of your Google Sheet:

- 1) Do NOT delete or rename any column headers. However, you have the option to add new column headers to display in your map table.
- 2) Geocode your new data inside your Google Sheet by dragging your cursor to select 6 columns of data: Location - Latitude - Longitude - Found - Quality - Source
- 3) In the Geocoder menu that appears in this Google Sheet template, select one of the geocoding services. If one service cannot locate your data, try the other. Always inspect the accuracy of the Found column.

Open the link to your live map in a new browser tab and refresh to see your changes. If your new markers appear correctly, then delete the existing rows that came with this template.

TODO

Add documentation for new features added in 2020

Add links to your text in the Google Sheet

Add line breaks to your text in the Google Sheet

TODO to code: Add Scroll Down text and symbol after the subtitle

Markers

I added a new column to the Chapter tab called “Marker”. It has a drop-down with currently three options: Numerated (defaults to that, even if empty value), Plain (with no number), and No marker. The latter is what you want. It can be potentially extended to colours, types of markers, etc. <https://github.com/handsondataviz/leaflet-storymaps-with-google-sheets/blob/master/scripts/storymap.js#L121-L131>

Overlay GeoJSONs

I added two columns, GeoJSON Overlay with the URL to the GeoJSON, and GeoJSON Feature Properties, which is CSS that defines style of features. List the styles separated by semicolon, and no quotation marks required. Eg `fillColor: orange; weight:2, opacity: 0.5, color: red, fillOpacity: 0.1` In the code, you will see two vertical lines: they mean “or”. If the value of the left-most expression is not undefined, it uses it. If not, it keeps moving to the right until there is a value that is not an empty string. For example, <https://github.com/handsondataviz/leaflet-storymaps-with-google-sheets/blob/master/scripts/storymap.js#L310> `color: feature.properties.COLOR || props.color || 'silver'`,

Will first attempt to extract the color from the COLOR property of each geoJson feature (useful for choropleth). If not found, it tries the

GeoJSON Feature Properties “color”. If that is not set, it uses silver. <https://github.com/handsondataviz/leaflet-storymaps-with-google-sheets/blob/master/scripts/storymap.js#L288-L316>

Data in local CSV files

If googleDocURL variable does not exist (eg you delete the file) or is an empty string, it reads two spreadsheets: Options.csv and Chapters.csv from the /csv folder. Otherwise, it reads from the google sheet. <https://github.com/handsondataviz/leaflet-storymaps-with-google-sheets/blob/master/scripts/storymap.js#L13-L35> When data is read from a .CSV, it links that in the attribution (<https://github.com/handsondataviz/leaflet-storymaps-with-google-sheets/blob/master/scripts/storymap.js#L393-L396>)

Modify your Style Sheet

To adjust title size: In GitHub, go to css/styles.css file, scroll all the way to the bottom, and adjust font-size values (or just use the links below). See your title around line 170, and change font-size up or down....

To add a horizontal line, you need to be a bit creative (see screenshot attached)! Break down text in your Description with the following code for the horizontal line:

```
<span style="display:block; width:100%; height:1px; background-color:silver; margin: 20px 0;"></span>
```

When you copy-paste this snippet, the straight quotation marks do not turn into curly marks, otherwise it won't work.

Learn more: To solve problems, see Fix Common Mistakes section of the appendix.

Leaflet Maps with Open Data API

TODO: - Note this new title and URL, which is more general than the older title and “leaflet-maps-with-socrata” URL - Update the example to pull map data from a continuously updated map, since the current example has not been updated since 2018 - Decide if there's anything useful to borrow from the other example repo, such as a non-Socrata endpoint?: <https://github.com/HandsOnDataViz/leaflet-data-apis> - write intro to connect more directly to the Open Data section in ch 3, and describe open data APIs in general, with Socrata API serving as a convenient example.

Source: Current Class 1 - Class 4 Food Establishments, City of Hartford

Why pair Leaflet maps with Socrata data?

Leaflet, a friendly and flexible open-source code library for creating interactive web maps, plays nicely with Socrata, an open data platform used by several government agencies and organizations. Benefits of pairing Leaflet and Socrata:

- Although the Socrata data platform includes built-in visualization tools for anyone to create charts and maps, Leaflet gives you more control over your map design. Furthermore, Leaflet allows you to create maps that bring together data from both Socrata and non-Socrata sources.
- Socrata datasets include an API (application program interface) endpoint, in the form of a web address. This endpoint enables other computers to easily access the most recent data online, instead of a static version that was manually downloaded.
- Newer Socrata datasets that include locations (such as latitude and longitude coordinates) also provide endpoints in GeoJSON format. Since Leaflet maps easily process GeoJSON data, only a few lines of code are required.
- However, Socrata GeoJSON endpoints do not currently support “real-time” data, such as up-to-the-minute locations of public transportation, etc. In these cases, you may need to access data through a provider other than Socrata, most likely in a different format, which may require more coding skills.

About Socrata API endpoints

Go to any Socrata open data platform, find a dataset, and click the API tab. As an example, you can use City of Hartford’s Police Incidents dataset.

Copy the API endpoint. The default version is JSON.

If you’re new to APIs, test the endpoint by pasting it into your browser address line. Ideally you would see a formatted JSON view (use Chrome or Firefox for better results).

If your browser does not support JSON view, you will see the raw JSON stream only, like the one shown below.

Test if this Socrata endpoint supports GeoJSON format by changing the extension in the API dropdown menu from `JSON` to `GeoJSON`. GeoJSON format works best with Leaflet because the coding is simpler.

If your endpoint supports GeoJSON format, your browser will display a data stream similar to the one below.

If your Socrata endpoint only supports JSON format, but includes data columns with latitude and longitude, see other Leaflet examples further below.

HartfordData

Catalog Developers Help | f t yu Sign In

Police Incidents 01012005 to Current

Public Safety

This dataset reflects reported incidents of crime (with the exception of sex offenses) from the City of Hartford from 2005 to the present, minus the most recent ten days. The data is updated daily from the CrimeView database on a daily basis. Should you have questions about this dataset, please contact the Hartford Police Department at 860.757.4020 or policechief@Hartford.gov. [More](#)

View Data Visualize Export API ...

Access this Dataset via SODA API

The Socrata Open Data API (SODA) provides programmatic access to this dataset including the ability to filter, query, and aggregate data.

API Docs Developer Portal

API Endpoint

<https://data.hartford.gov/resource/889t-nwfu.j> JSON Copy

Figure 10.8: Police Incidents dataset on Hartford Open Data portal

```

JSON Raw Data Headers
Save Copy Collapse All Filter JSON
8: ...
9: ...
10: ...
11: 
  case_number: "5000007"
  date: "2005-01-01T00:00:00.000"
  time_24hr: "0030"
  address: "CHURCH ST & TRUMBULL ST"
  ucr_1_category: "32* - PROPERTY DAMAGE ACCIDENT"
  ucr_1_description: "PROP DAM ACC"
  ucr_1_code: "3224"
  ucr_2_category: "23* - DRIVING LAWS"
  ucr_2_description: "FOLL TOO CLOSE"
  ucr_2_code: "2334"
  neighborhood: "DOWNTOWN"
  geom: ...
  :@computed_region_ugzy_yqsh: "19"
  :@computed_region_35zh_8f12: "10"
  :@computed_region_2vdc_22if: "15050"
  :@computed_region_haf6_6xye: "1041"
12: ...
13: ...
14: ...
15: ...
16: ...

```

Figure 10.9: Formatted JSON example in Firefox

JSON Raw Data Headers

Save Copy Pretty Print

```
[{"case_number": "0010396", "date": "2005-01-01T00:00:00.000", "time_24hr": "0000", "address": "56 VINNE ST", "ucr_1_category": "55a - REPORT-RELATED", "ucr_1_description": "CASE DRAWN IN ERROR", "ucr_1_code": "5520", "ucr_2_code": "0", "neighborhood": "UPPER ALBANY", "geom": {"lat": 41.7809708152311, "lon": -72.6881141026666}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}, {"case_number": "5001381", "date": "2005-01-01T00:00:00.000", "time_24hr": "0000", "address": "161 ENFIELD ST", "ucr_1_category": "29* - FOUND PERSON/PROPERTY", "ucr_1_description": "M-V-S-0-T-R-L", "ucr_1_code": "2905", "ucr_2_code": "0", "neighborhood": "NORTHEAST", "geom": {"lat": 41.7861451004455, "lon": -72.6840031336575}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}, {"case_number": "5000024", "date": "2005-01-01T00:00:00.000", "time_24hr": "0000", "address": "115 ASYLUM ST", "ucr_1_category": "55a - REPORT-RELATED", "ucr_1_description": "CASE INFO - UNABLE TO", "ucr_1_code": "5510", "ucr_2_code": "0", "neighborhood": "DOWNTOWN", "geom": {"lat": 41.7669464534884, "lon": -72.6753377122733}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}, {"case_number": "5000084", "date": "2005-01-01T00:00:00.000", "time_24hr": "0000", "address": "127 RIVERING ST", "ucr_1_category": "34* - OTHER ACCIDENT", "ucr_1_description": "CAR/INJURY", "ucr_1_code": "1040", "ucr_2_code": "0", "neighborhood": "UPPER ALBANY", "geom": {"lat": 41.76529965414, "lon": -72.6781666787566}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}, {"case_number": "5029127", "date": "2005-01-01T00:00:00.000", "time_24hr": "0000", "address": "14 GILMAN ST", "ucr_1_category": "19* - CRIMES AGAINST THE PUBLIC", "ucr_1_description": "SIMPLE TRESPASS", "ucr_1_code": "1909", "ucr_2_code": "2418", "neighborhood": "SOUTHENDE", "geom": {"lat": 41.7376529965414, "lon": -72.6781666787566}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}, {"case_number": "5000022", "date": "2005-01-01T00:00:00.000", "time_24hr": "0005", "address": "129 ANNAMAN ST", "ucr_1_category": "19* - CRIMES AGAINST THE PUBLIC", "ucr_1_description": "BREACH-PEACE", "ucr_1_code": "1901", "ucr_2_code": "1904", "neighborhood": "BARRY SQUARE", "geom": {"lat": 41.7492666840371, "lon": -72.6754861409539}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}, {"case_number": "5000040", "date": "2005-01-01T00:00:00.000", "time_24hr": "0005", "address": "FOOD GUARD PL & HADLEY PL", "ucr_1_category": "06* - LARCENY", "ucr_1_description": "LARC-FRUIT", "ucr_1_code": "634", "ucr_2_code": "35* - MIS. CRIMES AGAINST PROPERTY", "ucr_2_description": "CR MISCIEF", "neighborhood": "DOWNTOWN", "geom": {"lat": 41.77066928111, "lon": -72.686617911612}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}, {"case_number": "5000006", "date": "2005-01-01T00:00:00.000", "time_24hr": "0010", "address": "949 ALBANY AV", "ucr_1_category": "5211 - SHOTS FIRED UNCONFIRMED", "ucr_1_description": "SHOTS FIRED - UNCONFIRMED", "ucr_1_code": "5211", "ucr_2_code": "0", "neighborhood": "UPPER ALBANY", "geom": {"lat": 41.7803362987827, "lon": -72.6924468975589}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}, {"case_number": "5000001", "date": "2005-01-01T00:00:00.000", "time_24hr": "0010", "address": "144A RUE", "ucr_1_category": "16*", "ucr_1_description": "29* - FOUND PERSON/PROPERTY", "ucr_1_code": "2905", "ucr_2_code": "0", "neighborhood": "NORTHEAST", "geom": {"lat": 41.7861451004455, "lon": -72.6840031336575}, "human_address": {"address": "", "city": "", "state": "", "zip": ""}]
```

Figure 10.10: Unformatted JSON example in Firefox

JSON Raw Data Headers

Save Copy Collapse All

Filter JSON

```
type: "FeatureCollection"
features:
  0:
    type: "Feature"
    geometry:
      type: "Point"
      coordinates:
        0: -72.6840031336575
        1: 41.7861451004455
    properties:
      ucr_2_category: null
      :@computed_region_haf6_6xye: "1041"
      :@computed_region_2vdc_22if: "18493"
      neighborhood: "NORTHEAST"
      ucr_2_code: "0"
      ucr_1_code: "2905"
      ucr_1_description: "M-V-S-0-T-R-L"
      :@computed_region_ugzy_ysqh: "16"
      ucr_1_category: "29* - FOUND PERSON/PROPERTY"
      geom_zip: ...
      :@computed_region_35zh_8fi2: "16"
      geom_address: ...
      date: "2005-01-01T00:00:00.000"
```

Figure 10.11: Formatted GeoJSON example in Firefox

Register for Socrata App Token

- Socrata requires developers to register for a free app token at <https://opendata.socrata.com/signup>

Demonstration Maps

GeoJSON endpoint with circle markers and tooltips

- map <https://handsondataviz.github.io/leaflet-socrata/index.html>
- code <https://github.com/handsondataviz/leaflet-socrata/index.html>
- data <https://data.hartford.gov/Public-Health/Current-Class-1-Class-4-Food-Establishments/xkvv-76v8>
- note: location data appears as latitude and longitude coordinates in the `geom` column
- steps to create your own (MORE TODO HERE)
 - select API button, copy endpoint, and change suffix from `.json` to `.geojson`
 - copy this Leaflet map template, which includes this key section of code:
 - paste and explain the code

GeoJSON endpoint with simple data filter, default marker styling and pop-up info

- map <https://handsondataviz.github.io/leaflet-socrata/index-geojson-filter>
- code <https://github.com/handsondataviz/leaflet-socrata/>
- data <https://data.ct.gov/Environment-and-Natural-Resources/Agricultural-Commodities-Grown-By-Farmer/y6p2-px98>

Multiple Socrata datasets with Leaflet control layers legend

- map <https://handsondataviz.github.io/leaflet-socrata/index-control-layers.html>
- code <https://github.com/handsondataviz/leaflet-socrata/index-control-layers.html>

Older JSON-only endpoint, with separate columns for latitude, longitude

- map <https://handsondataviz.github.io/leaflet-socrata/index-json.html>
- code <https://github.com/handsondataviz/leaflet-socrata/index-json.html>
- data <https://opendata.demo.socrata.com/Government/Kentucky-Farmers-Market-Map/3bfj-rqn7>

Learn more: - <https://dev.socrata.com/> - <https://github.com/chriswhong/simpleSodaLeaflet>

Thanks to

- Chris Metcalf <https://github.com/chrismetcalf>
- Tyler Klyeklamp <https://data.ct.gov/>

Pull Open Data into Leaflet Map with APIs

TODO: Decide whether to keep or not. Up to this point in the book, we've built charts and maps using static data that you have downloaded from other sites. But some open data repositories have APIs, or application program interfaces, which means the software that allows computers to communicate with one another. Below is a Leaflet Map template that uses APIs to pull in the most current data from three different open repository platforms: Socrata, Esri ArcGIS Online, and USGS.

Try it: Explore the map below or view full-screen version in a new tab

How it works

- 1) Go to the GitHub repo for the map above: <https://github.com/handsondataviz/leaflet-data-apis>
- 2) Explore the code to see how different APIs work. For example, see the first map overlay, which pulls Connecticut School Directory data from the CT Open Data repository on a Socrata open data platform: <https://data.ct.gov/resource/v4tt-nt9n>
- 3) Inside the open data repo, look for an API button and copy the endpoint.
- 4) Paste the endpoint link into your browser, change the suffix from `.json` to `.geojson` and press return. In order to show the endpoint data as points on a map in this simple Leaflet template, the points must already

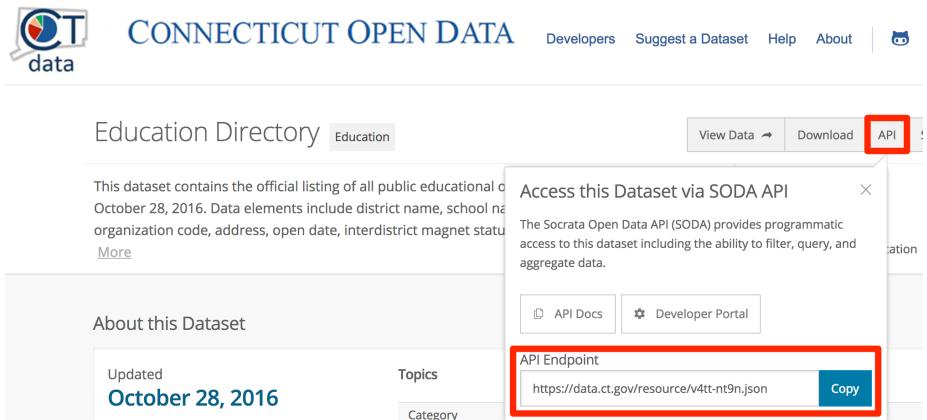


Figure 10.12: Screenshot: Sample API endpoint in Socrata open data repo

be geocoded inside the open data repo, and the platform must support a GeoJSON endpoint. In your browser, one sign of success is a long stream of GeoJSON data like this:



Figure 10.13: Screenshot: API endpoint with .geojson suffix in Chrome browser

- 5) In this section of the Leaflet map template, the code includes a jQuery function `$.getJSON` to call the open data endpoint in GeoJSON format: `https://data.ct.gov/resource/v4tt-nt9n.geojson`. It also requires a Socrata app token, and you can get your own token for free at: `https://dev.socrata.com/register`. Each geocoded school in the Socrata data repository is displayed as a blue circle, with data properties (such as: name) in a clickable pop-up.

```
// load open data from Socrata endpoint in GeoJSON format
// with simple marker styling: blue circles
// register your own Socrata app token at https://dev.socrata.com/register
// Connecticut School Directory, CT Open Data, https://data.ct.gov/resource/v4tt-nt9n
$.getJSON("https://data.ct.gov/resource/v4tt-nt9n.geojson?&$$app_token=QVVY3I72SVPbxBYlTM8fA7eet"
  var geoJsonLayer = L.geoJson(data, {
    pointToLayer: function( feature, latlng) {
```

```

var circle = L.circleMarker(latlng, {
    radius: 6,
    fillColor: "blue",
    color: "blue",
    weight: 2,
    opacity: 1,
    fillOpacity: 0.7
});
circle.bindPopup(feature.properties.name + '<br>' + feature.properties.district_name);
return circle;
}
}).addTo(map); // display by default
controlLayers.addOverlay(geoJsonLayer, 'Public Schools (CT Open Data-Socrata)');
});

```

- 5) Fork a copy of this repo, play with the code, and try to insert GeoJSON endpoints from other open data repositories.

Leaflet Thematic Polygon Map with Clickable Info Window template

TODO: Decide whether to keep or not

Try it:

[View demo in new page](#)

- <https://handsondataviz.github.io/leaflet-map-polygon-click/>

To Do

- Insert internal references to prior steps in this book. See the Edit and Host Code Templates section in this book.
- Requires a free GitHub account to host your own version on the web.

Create Your Own: Fork a copy of the code template on GitHub

- <https://github.com/handsondataviz/leaflet-map-polygon-click>
- Remember, if you have already forked one copy, go to your GitHub repository Settings to rename it, or create a new GitHub repo and use GitHub Desktop to upload template Files

Obtain a polygon boundary map in GeoJSON format

- Find open data repositories to download maps in geojson and other formats
- If map is in shapefile or KML or other format, convert with <http://geojson.io> or <http://mapshaper.org>
- Import polygon map into <http://mapshaper.org>. In this example, map filename is: ct-towns-simple.geojson
 - See tutorial on Mapshaper.org to delete unwanted data columns or simplify file size
 - Export as CSV to create generic spreadsheet of polygon names. In this example, column header is “town”

Prepare your spreadsheet data and join with the polygon map

- Open CSV with any spreadsheet tool to view data column of polygon names.
- Download or prepare your new spreadsheet data in rows to match polygon names.
- Insert columns of data into the CSV sheet. Use VLOOKUP function if needed.
- Save CSV with new name. In this example: ct-towns.csv
- Import ct-towns.csv as second layer into MapShaper.org.
- Use the drop-down to select the polygon map (ct-towns-simple.geojson) as the active, displayed layer.
- Click the Console and enter command to join the CSV table to the GeoJSON polygon, where the matching data columns are both named “town”


```
-join ct-towns.csv keys=town,town
```
- Export the newly joined map with a new filename in GeoJSON format
- Change the file suffix from .json to .geojson to avoid confusion. The new joined map data file is now named: ct-towns-density.geojson

Upload your map data and edit template in your GitHub repo

- The GitHub repo you created in the first step contains these files:
 - ct-towns-density-2010.csv (the spreadsheet joined into the polygon map)

- ct-towns-density.geojson (the joined map data file)
- index.html (the primary web page)
- script.js (code to operate the map, to be modified below)
- style.css (code that styles the map)
- README.md (edit to insert a link to your own version)
- LICENSE (terms of use for this free and open-source code)
- Upload your own map data geojson file
- Recommended: upload your own CSV spreadsheet file to
- In the script.js file, look for code comments labeled “Edit” to change references to geojson map data and its column headers, and also colors and ranges for the polygons and legend
- In GitHub, go to Branches and delete the existing “gh-pages” branch
- In GitHub, go to drop-down menu for Master branch, and type “gh-pages” to create new branch
- Content in the gh-pages branch will be hosted on the live web
- Edit the README.md link to point to your own gh-pages branch, in this format: <https://USERNAME.github.io/REPO-NAME/>

Leaflet Thematic Polygon Map with Hover Info Window template

TODO: Decide whether to keep or not

Try it:

[View demo in new page](#)

- <https://handsondataviz.github.io/leaflet-map-polygon-hover/>

To Do

- Insert internal references to prior steps in this book. See the Edit and Host Code Templates section in this book.
- Requires a free GitHub account to host your own version on the web.

Create Your Own: Fork a copy of the code template on GitHub

- <https://github.com/handsondataviz/leaflet-map-polygon-hover/>
- Remember, if you have already forked one copy, go to your GitHub repository Settings to rename it, or create a new GitHub repo and use GitHub Desktop to upload template Files

TO DO - describe all steps, which are similar to click version

Leaflet Thematic Polygon Map with Multi-Year Tabs template

TODO: decide whether to keep or not

Try it:

[View demo in new page](#)

- <https://handsondataviz.github.io/leaflet-map-polygon-tabs/>

** To Do **

- Insert internal references to prior steps in this book. See the Edit and Host Code Templates section in this book.
- Requires a free GitHub account to host your own version on the web.
- describe all steps, which are similar to the prior chapter

Create Your Own: Fork a copy of the code template on GitHub

- <https://github.com/handsondataviz/leaflet-map-polygon-tabs/>
- Remember, if you have already forked one copy, go to your GitHub repository Settings to rename it, or create a new GitHub repo and use GitHub Desktop to upload template Files

Chapter 11

Transform Your Map Data

All maps, including interactive web maps, are made up of different layers. These are background basemaps, colored or shaded polygons (also known as *choropleth* layers), lines, and point data that are often represented as markers.

In this chapter, we will look at multiple ways to convert and edit geospatial data to create layers (files) that you can use in your favorite mapping tools.

We will begin by looking at the process of geocoding, or transforming human-friendly address lines into points that can be plotted on the map (see Figure 11.1 for inspiration). We will then talk about polygons and why you should normalize your data before creating choropleth maps. These map transformations happen inside spreadsheets, so you won't directly deal with map data until you are halfway through the chapter.

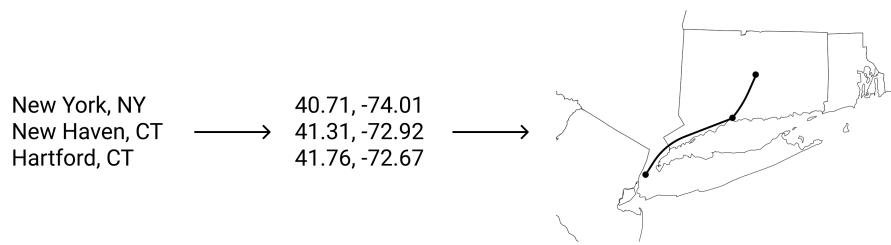


Figure 11.1: To map addresses, you need to geocode them first.

Before you can dive into creating shapes and dealing with boundaries in the map, we will introduce various file formats (most notably GeoJSON) and talk about geospatial data in general. You will learn that map data can be raster and vector, that geospatial data consists of location and attribute components, and how GeoJSON is different from Shapefiles and other geographical data formats.

You will then get a chance to draw your own map layers on top of satellite imagery using GeoJson.io, and learn to simplify, crop, and join spreadsheet and geospatial data in Mapshaper. Both are powerful, web-based open-source geodata tools that for common tasks can substitute for more complex geographic information system tools, such as ArcGIS or QGIS.

By the end of this chapter, you should feel much more confident navigating the overwhelming world of geospatial data.

Geocode Locations into Coordinates with US Census or Google

Before addresses can be mapped, they need to be geocoded. **Geocoding** is a process of transforming a human-readable address, such as *300 Summit St, Hartford, CT* into a latitude-longitude pair, such as *41.747,-72.692*. These numbers are x- and y-coordinates that maps understand.

If you have just a few addresses, it might be faster to geocode them with Google Maps. Search for an address, right-click on that point, and select *What's here?* to reveal a popup window with its latitude and longitude, as shown in Figure 11.2. You can copy and paste the coordinates into your spreadsheet. Similar tools also geocode one place at a time, such as LatLong.net.

But what if you need to geocode dozens, hundreds, or even thousands of addresses? In this section, we will look at two ways to geocode larger lists of addresses. First, you'll learn how to use our custom-built Google Sheets Geocoder, which lets you upload up to 1,000 addresses and choose between Google Geocoder (available pretty much worldwide) and the US Census Geocoder (for US addresses only). Second, you'll learn how to use a stand-alone US Census Geocoder that allows you to upload up to 10,000 addresses (for the US only) and download results.

TODO: I tried to add numerical limitations for each tool to clarify the “two ways”; check details

Geocode addresses with Google Sheets Geocoder

The Google Sheets Geocoder script lives inside a Google Sheet that you can copy to your own Google Drive (you don't need editing access, just go to *File > Make a copy*).

The spreadsheet contains six columns. Populate the first column, *Location*, with your addresses. The remaining five columns will be filled by the geocoding script. Select all six columns, go to *Geocoder* in the menu, and choose which geocoding utility to use, like is shown in Figure 11.3.

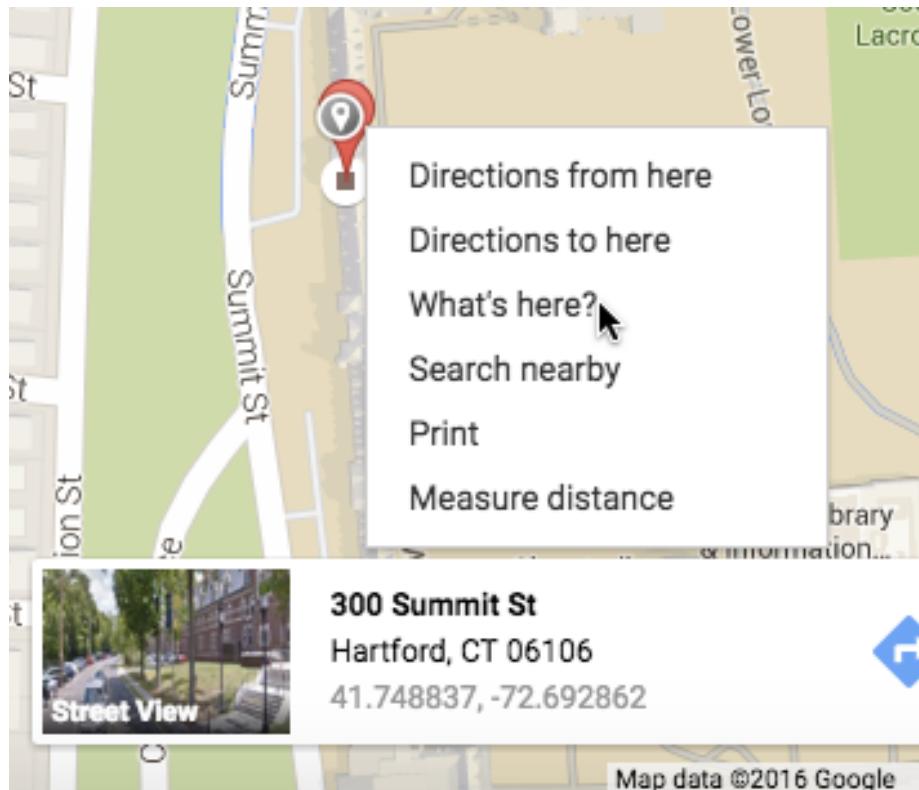


Figure 11.2: To geocode one address, search in Google Maps and right-click *What's here?* to show coordinates.

Geocoder US Census or Google (go to File > Make a Copy)						
	A	B	C	D	E	F
	Location	Latitude	Longitude	Found	Quality	Source
1	300 Summit Street, Hartford, CT 06106					
2	300 Summit Street, Hartford, CT 06106					
3	4 Frederick Rd, West Hartford CT					
4	East Capitol St NE & First St SE, Washington, DC 20004					
5	2329 West Mall, Vancouver, BC V6T 1Z4, Canada					
6	Av. Eugenio Garza Sada 2501 Sur, 64849 Monterrey, N.L., Mexico					
7						

Figure 11.3: Put addresses in the first column, and use Geocoder to fill in the remaining five.

Note: If your address data is split into multiple columns (such as *Street*, *City*, and *State*), revisit Clean Data with Spreadsheets section to remind yourself how to “glue” multiple cells into one.

If you run the script for the first time, Google Sheets may ask for permission or warn that the script is not safe. Disregard this message. The code is open-source and is available on GitHub, so you or your programmer friend can make sure it doesn’t steal your personal data.

TODO: Fix the Google App code to remove warning message

Once the script finishes executing, you will get a pop-up notification that will tell you how many addresses were successfully geocoded, and how many failed. Inspect *Found* and *Quality* columns to ensure the geocoder matched your addresses correctly. Then look at the failed addresses and see if you can spot problems with them. For tips about using Google geocoder, see documentation.

Note: The Geocoder plugin is a small Apps Script program that is connected to your Google sheet. It sends your addresses to either US Census Geocoder, or Google Geocoding API, and gets geocoded results as a response.

Geocode US addresses to census tracts with Google Sheets Geocoder

You can use a modified version of the Google Sheets Geocoder, available in its own spreadsheet, to assign census tracts and GeoIDs to addresses within the United States.

A GeoID is a unique identifier of a place according to the US Census. A sample 15-digit GeoID, 090035245022001, consists of a state (09), followed by county (003), followed by census tract (524502, or more conventional 5245.02), followed by a census block group (2), and finally a census block (001).

Make a copy of the template spreadsheet into your own Google Drive by going to *File > Make a copy*.

You only need to populate the first column, *Location*. The rest seven columns will be populated by the Geocoder. Similar to the previous template, select all eight columns, and go to *Geocoder > US Census 2010 Geographies*, like is shown in Figure 11.4.

If you run this script for the first time, Google Sheets will ask you for permission to run, and will possibly warn you that this script is unsafe. Once again, you shouldn’t worry. The plugin is open-source and you can inspect it to make sure it doesn’t steal or retain your personal data.

	A	B	C	D	E	F	G	H
1	Location	Latitude	Longitude	Found	Quality	Source	GeoID	Tract
2	300 Summit St, Hartford, CT							
3	84 Scarborough St Hartford CT							
4	4 Frederick Rd, West Hartford							
5	4 Fredrick Rd, West Hartford							
6	4 Fredric Rd, West Hartford							
7								

Figure 11.4: Put addresses in the first column, and use Geocoder to fill in the remaining seven.

Insert Google Sheets Geocoder script into your own spreadsheet

If you don't want to make a copy of the Google Sheet templates from the previous examples, you can insert the open-source Geocoder scripts into your own Google sheet.

1. In your personal Google spreadsheet, go to *Tools > Script Editor*. This should open up a new tab.
2. Replace the empty `function myFunction()` with the contents of `geocoder-census-google.gs` from the plugin's repo on GitHub.
3. In Script Editor, click *File > Save*. An *Edit Project Name* window will pop up, where you should give the script a meaningful name, such as "Geocoder".
4. Close the Script Editor, and go back to your spreadsheet. Refresh and wait for a couple of seconds. *Geocoder* should appear in the menu.

Geocode up to 10,000 US addresses with US Census Geocoder

One of the fastest ways to geocode up to 10,000 US addresses at a time is to create a CSV file with 5 columns and upload it to Address Batch form of the US Census Geocoder. In the menu on the left-hand side, you can switch from *Find Locations* to *Find Geographies* if you wish to include census tract and GeoID data in addition to the coordinates.

Your CSV file needs to be formatted the following way, *without the header row*:

```
| 1 | 300 Summit St | Hartford | CT | 06106 |
| 2 | 1012 Broad St | Hartford | CT | 06106 |
```

Here, the first column is unique IDs (make sure it is unique to each address, but they don't have to start at 1 or be in an increasing order). The second column

is street address. The third column is city. Column four is state, and the final fifth column is zip code.

Upload the file using the *Browse...* button of *Select Address File*, use *Public_AR_Current Benchmark*, and hit *Get Results*.

In a few moments (it usually takes longer for larger files), the tool will return a file named *GeocodeResults.csv* with geocoded results. Save it, and inspect it in your favorite spreadsheet tool. The resulting file is an eight-column CSV file with the original ID and address, match type (exact, non-exact, tie, or no match), and latitude/longitude coordinates.

Getting a *tie* matching means there are multiple possible results for your address. To see all possible matches of an address that got a *tie*, use *One Line* or *Address* tools in the left-hand side menu and search for that address.

Tip: If you see some unmatched addresses, use a filtering functionality of your spreadsheet to filter for unmatched addresses, then manually correct them, save as a separate CSV file, and re-upload. You can use the US Census Geocoder as many times as you want, as long as a single file doesn't exceed 10,000 records.

- In reality only the first two columns, *unique ID* and *street address*, are required. City, state, and zip code may be left blank if you don't have that data. But there are usually fewer exact matches for addresses with missing elements.
- If your data lacks ID values, you can create a column of consecutive numbers. See Calculate with Formulas and Functions section of this book to see how.
- Make sure your street addresses don't contain city, state, and zip code data. If they do, use splitting text to columns technique, described in the Clean Data with Spreadsheets section of the book, to get rid of that extra data. But if your street addresses contain apartments, you can leave them in.

US Census Geocoder has a comprehensive overview and documentation that you can refer to if you encounter issues not covered here.

If for some reason you cannot geocode address-level data, but you need to produce some mapping output, you can use pivot tables to get counts of points for specific areas, such as towns or states. In the next section, we will look at hospital addresses in the US and how we can count them by state using pivot tables.

Pivot Address-Level Point Data into Polygon Data

If you deal with geographical data, you may find yourself in a situation where you have a list of addresses which need to be counted (**aggregated**) by area and displayed as a polygon (**choropleth**) map. In this case, a simple pivot table in a spreadsheet software can solve the problem.

Let's take a look at a list of all hospitals that are registered with the Medicare program in the United States. The dataset is stored and displayed by Socrata, a web database popular among government agencies and city administrations. This particular dataset has information on each hospital's name, location (nicely divided into Address, City, State, and ZIP Code columns), a phone number and some other indicators, such as mortality and patient experience.

Now, imagine you are given a task to create a polygon map of total hospitals by US state, so instead of showing individual hospitals as points, you want darker shades of blue to represent states with more hospitals. See Figure 11.5 to see what we are talking about.

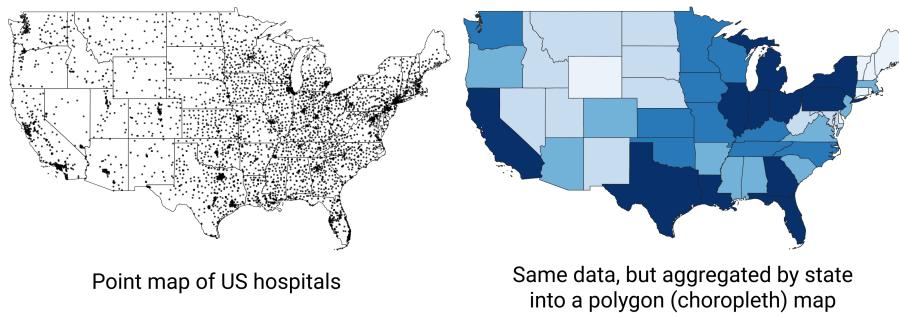


Figure 11.5: You can count addresses by state (or other area) to produce polygon, or choropleth, maps instead of point maps.

First, save the database to your local machine by going to *Export > Download > CSV* of Socrata interface. Figure 11.6 shows where you can find the Export button.

Next, open the file in your favorite spreadsheet tool. If you use Google Sheets, use *File > Import > Upload* to import CSV data. Make sure your address columns are present, and move on to creating a pivot table (in Google Sheets, go to *Data > Pivot table*, make sure the entire data range is selected, and click *Create*). In the pivot table, set **Rows** to *State*, because we want to get counts by state. Next, set pivot table's **Values** to *State*—or really any other column that has no missing values—and choose *Summarize by: COUNTA*. Voila!

A screenshot of a web browser displaying the Data.Medicare.gov website. The page shows a table of hospital general information. At the top right, there is a 'More Views' dropdown menu with several options: Home, Get started, Info, Developers, Sign In, Find in this Dataset, More Views, Filter, Visualize, Export (which is highlighted with a red box), Embed, and About. Below the table, there is a sidebar titled 'Export' containing links for SODA API, OData, Download (also highlighted with a red box), Download Geospatial Data, and various file formats: CSV (also highlighted with a red box), CSV for Excel, CSV for Excel (Europe), JSON, RDF, RSS, TSV for Excel, XML, KML, and KMZ.

Figure 11.6: In Socrata, you can export the entire dataset as a CSV.

A screenshot of a Pivot table editor interface. On the left, there is a table with columns A, B, C, and D. The first row contains the header 'State' and 'COUNTA of State'. The subsequent rows list US states with their corresponding COUNTA values. On the right, there are two sections highlighted with red boxes: 'Rows' and 'Values'. The 'Rows' section contains a 'State' field with 'Order' set to 'Ascending' and 'Sort by' set to 'State', with a checked 'Show totals' option. The 'Values' section contains a 'State' field with 'Summarize by' set to 'COUNTA' and 'Show as' set to 'Default'.

	A	B	C	D
1	State	COUNTA of State		
2	AK	25		
3	AL	97		
4	AR	86		
5	AS	1		
6	AZ	93		
7	CA	380		
8	CO	94		
9	CT	36		
10	DC	9		
11	DE	12		
12	FL	210		
13	GA	147		
14	GU	2		
15	HI	25		
16	IA	118		
17	ID	45		
18	IL	193		
19	IN	146		
20	KS	141		
21	KY	102		
22	LA	152		

Figure 11.7: Use pivot tables in any spreadsheet software to count addresses per area (such as state, county, or zip code).

Your aggregated dataset is ready, so save it as a CSV. If you use Google Sheets, go to *File > Download > Comma-separated values (.csv, current sheet)*. You can now merge this dataset with your polygons manually using editing capabilities of GeoJson.io, or merge it all in one go using powerful Mapshaper.

We will introduce both tools in the next few sections. But before we do that, let's talk about data normalization and why showing counts of hospitals per state doesn't really tell a good story.

Normalize Data to Create Meaningful Polygon Maps

Polygon (choropleth) maps are best when they represent relative, not absolute values. Consider two maps shown in Figure 11.8. They both are about Covid-19 cases in the US states (excluding Alaska and Hawaii) as of June 26, 2020. The map on the left shows total number of recorded cases per state, and the map on the right shows cases adjusted by the state's population. Darker colors represent higher values. Do you notice any differences in spatial patterns?

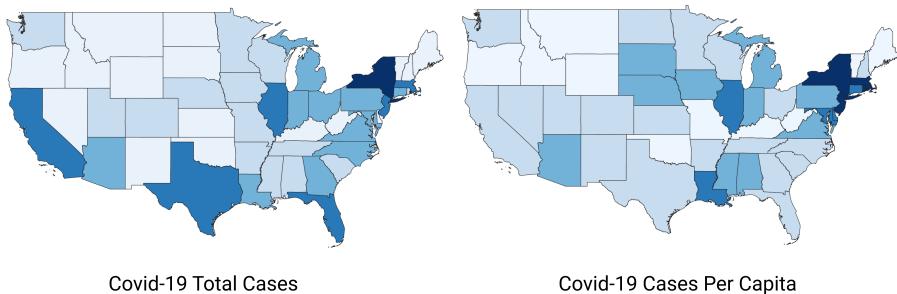


Figure 11.8: Choropleth (polygon) maps work best with normalized values.

Note: Both maps show Covid-19 data collected by the New York Times and published on GitHub. In one map, we normalized (divided) values by population in each state, according to the 2018 US Census American Community Survey, the most recent data available on the day of writing. We didn't add legends and other important cartographic elements so that you can better focus on interpreting spatial patterns. In both cases, we used Jenks natural breaks for classification.

What are the worst-hit states according to the map showing total Covid-19 counts? If you are familiar with the US geography, you can quickly tell that these are New York, New Jersey, Massachusetts, Florida, Illinois, Texas, and

California. But five of these happen to be some of the most populous states in the US, so it makes sense that they will also have higher Covid-19 cases.

Now, how about the map on the right? You can see that New York and its neighbors, including New Jersey and Massachusetts, have by far the highest rates per capita (per person), which we saw in the first map. But you can also see that in fact California, Texas, and Florida were impacted to a lesser extent than the map on the left had suggested. So the map with per-capita values is a much better illustration to the story about New York being the epicenter of the Covid-19 crisis in the United States (at least in the spring of 2020).

Different ways to normalize data

You can normalize data in many ways, and there is not necessarily one acceptable way of doing it.

One of the most common ways of normalization is deriving “per capita”, or “per person” values. If values are small, such as rare disease cases or lottery winners, they can be presented as “per 1,000” or “per 100,000” people. Divide your quantity by population in that area to derive per capita values.

Choropleth (polygon) maps work well with percentages. The good news is, humans like percentages too. It is quite natural for us to understand that a 9% unemployment rate means that of 100 people who were willing to work, nine were unable to find a job. To derive a percentage for unemployment, divide the number of unemployed people by labor force size (adult population who are willing and able to work), and multiply by 100.

Unlike counts, most *measured* variables do not need normalization because they belong to a scale. For example, median age (the age of the “middle” person in a population, when sorted from youngest to oldest) can be directly compared among populations. We know that humans live anywhere between 0 and 120 years or so, and we wouldn’t expect median ages to be vastly different from one country to another (maybe twice, but not tenfold). Median incomes, if measured in the same currency, also belong to the same scale and can be compared directly.

How not to normalize values

Absolute values are very important for context. Saying that “20% of blond men living in town X won the lottery” may sound like a catchy headline, but in reality the town has 450 residents, of those 200 are men, and of those only 5 have light hair color. One of those five (and here comes the 20%) was lucky to win the lottery, so technically the headline didn’t lie.

This is, of course, an extreme and comic example, but exaggerations in this spirit are not uncommon. If you want readers to trust you, make sure you are

open about total counts when reporting normalized values (such as percentages or per capita values).

Absolute values are important for another reason: behind numbers there are often people, and smaller, normalized values may hide the scale of the problem. Saying that “the unemployment rate is only 5%” is valid, but the 5% of, say, Indian labor force (around 522 million) is about 26 million, which is pretty much the total population of Australia.

Exercise your best judgement when you normalize values. Make sure you don’t blow numbers out of proportion by normalizing values in smaller populations. But also don’t hide large counts behind smaller percentages for larger populations.

At this point, you should have enough geocoding and spreadsheet skills to aid you with map making. In the following section, we will talk about geographical data in general and will introduce different geospatial file formats to ensure you are ready to create, use, and share map data.

Convert to GeoJSON format

Geospatial data comes in an overwhelming number of file formats. We will tell you about a few most common ones so that you have a general idea of what tools you can use to work with them. But before we do that, let’s talk about the basics of geospatial (map) data.

About geospatial data

The first thing to know about geospatial data is that it consists of two components, **location** and **attribute**. When you use Google Maps to search for a restaurant, you get a red marker on the screen that points to the latitude and longitude of the physical location of the restaurant in the real world. These latitude and longitude (two numbers) are your location component. The name of the restaurant, its human-friendly address, and guest reviews are the attributes, which bring value to your location data.

Second, geospatial data can be **raster** or **vector**, as illustrated in Figure 11.9. Raster data is a grid of cells (“pixels”) of a certain size (for example, 1 meter by 1 meter). For example, satellite images of the Earth that you see on Google Maps are raster geospatial data. Each pixel contains the color of Earth that satellite cameras were able to capture. People and algorithms can then use raster data (images) to create outlines of buildings, lakes, roads, and other objects. These outlines become vector data. For example, most of OpenStreetMap was built by volunteers tracing outlines of objects from satellite images.

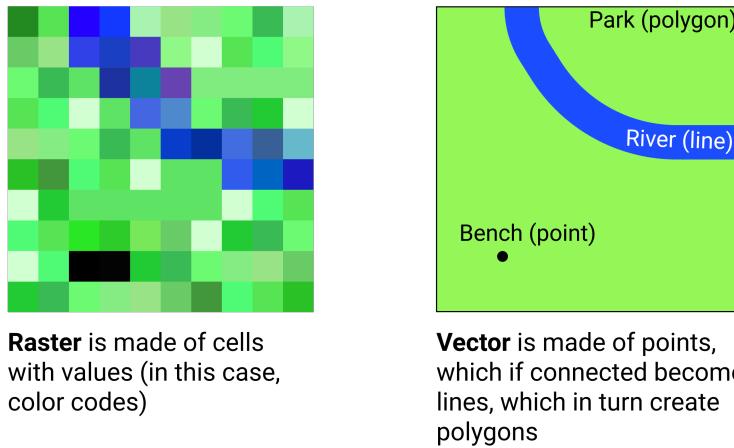


Figure 11.9: Geospatial data can be raster or vector.

In this book, we will focus on vector data, which is based on points, lines, and polygons. Vector data can be much more precise than raster data, because points' coordinates can be expressed with precise decimals. In addition, vector data can contain as much extra *attribute* information about each object as desired, whereas raster data is generally limited to 1 value per cell, whether it is the Earth color, or temperature, or altitude. Moreover, vector map files are usually much smaller in size than raster ones.

Let's take a look at some of the most common vector file formats.

GeoJSON

GeoJSON is a newer, popular open format for map data that comes in `.geojson` or `.json` files. It was first developed in 2008, and then standardized in 2016 by the Internet Engineering Task Force (IETF). The code snippet below represents a single point (feature) with latitude of 41.76 and longitude of -72.67 in GeoJSON format. That point has a *name* attribute (property) whose value is *Hartford*.

```
{
  "type": "Feature",
  "geometry": {
    "type": "Point",
    "coordinates": [-72.67, 41.76]
  },
  "properties": {
```

```

    "name": "Hartford"
}
}
}
```

The simplicity and readability of GeoJSON allows you to edit it even in the most simple text editor. We strongly recommend you use and share your map data in GeoJSON. Web-based maps, such as those built with Leaflet, Mapbox, Google Maps JS API, and Carto, as well as ArcGIS and QGIS all support GeoJSON.

Also, your GitHub repository will automatically display any GeoJSON files in a map view, like is shown in Figure 11.10.

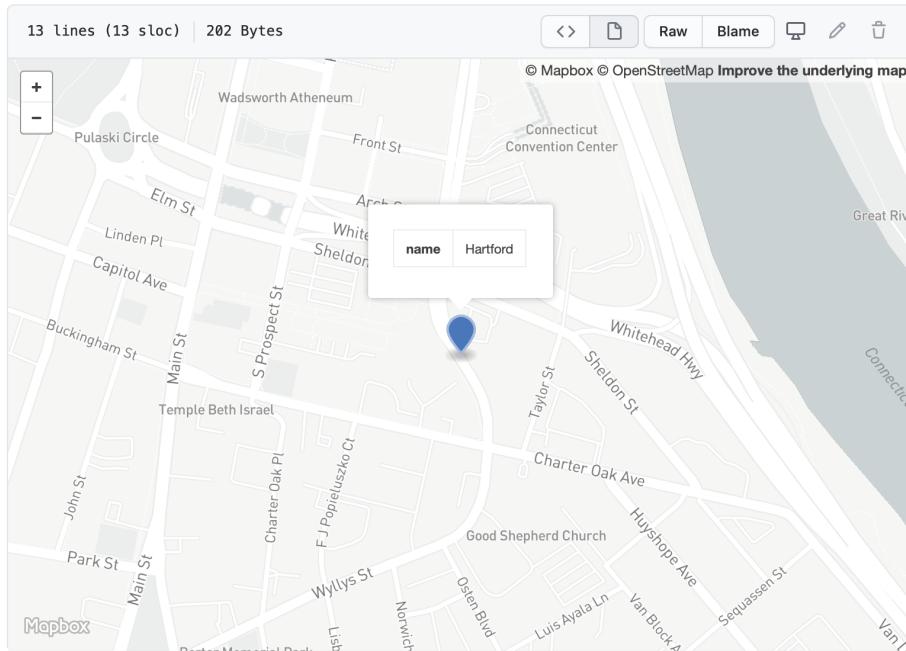


Figure 11.10: GitHub can show previews of GeoJSON files stored in repositories.

In GeoJSON, coordinates are ordered in *longitude-latitude* format, the same as X-Y coordinates in mathematics. This is the opposite of Google Maps and some other web map tools, which order values as *latitude-longitude*. For example, *Hartford, Conn.* is located at (-72.67, 41.76) according to GeoJSON, but at (41.76, -72.67) in Google Maps. Neither notation is right or wrong, just make sure you know which one you are dealing with.

Shapefiles

The shapefile format was created in the 1990s by Esri, the company that develops ArcGIS software. Shapefiles typically appear as a folder of subfiles with suffixes such as `.shp`, `.shx`, and `.dbf`. The folder with shapefiles is often compressed in a `.zip` file.

Although government agencies commonly distribute map data in shapefile format, the standard tools for editing these files—ArcGIS and its free and open-source cousin, QGIS—are not as easy to learn as other tools in this book. For this reason, we recommend converting shapefiles into GeoJSON files if possible. Mapshaper, discussed a bit later in the chapter, can perform such conversion.

GPS Exchange Format (GPX)

If you ever exported your Strava run or a bike ride from a GPS device, chances are you ended up with a `.gpx` file. GPX is an open standard and is based on XML markup language. Like GeoJSON, you can inspect a GPX file in any simple text editor to see its contents. Most likely, you will see a collection timestamps and latitude/longitude coordinates of the recording GPS device at that particular time. You should be able to convert GPX to GeoJSON with GeoJson.io utility discussed later in this chapter.

Keyhole Markup Language (or KML)

The KML format rose in popularity during the late 2000s. Google Earth, a free and user-friendly tool, allowed many people to view and edit geographic data. KML files were often used with maps powered by Google Fusion Tables, but that became history in late 2019. GeoJson.io should be able to convert your KML file into a GeoJSON.

Sometimes `.kml` files are distributed in a compressed `.kmz` format. See Converting from KMZ to KML format section of this book to learn to convert.

MapInfo TAB

Similar to Esri's shapefiles, MapInfo's TAB format comes as a folder with `.tab`, `.dat`, `.ind`, and some other files. It is a proprietary format created and supported by MapInfo, Esri's competitor, and is designed to work well with MapInfo Pro GIS software. Unfortunately, you will most likely need MapInfo Pro, QGIS, or ArcGIS to re-save these as GeoJSON or a Shapefile.

GeoJson.io to Convert, Edit, and Create Map Data

GeoJson.io is a popular open-source web tool to convert, edit, and create GeoJSON files. The tool was originally developed by Tom MacWright in 2013 and quickly became a go-to tool for geospatial practitioners.

In this tutorial, we will show you how to convert existing KML, GPX, Topo-JSON, and even CSV files with lat/lon data into GeoJSON files. We will also look at editing attribute data and adding new features to GeoJSON files, and creating them from scratch by tracing satellite imagery.

Convert KML, GPX, and other formats into GeoJSON

Navigate to GeoJson.io. You will see a map on the left, and a Table/JSON attribute view area on the right. At the start, it represents an empty feature collection (features are your points, lines, and polygons).

Drag and drop your geospatial data file into the map area on the left. Alternatively, you can also import a file from *Open > File* menu. If you don't have a geospatial file, download Hartford parks in KML format. If GeoJson.io was able to recognize and import the file, you will see a green popup message in the upper-left corner saying how many features (in case of Hartford parks, polygons) were imported. Figure 11.11 shows us that 62 features were imported from the sample Hartford parks file. You can see that the polygons appeared on top of the Mapbox world layer.

Note: If GeoJson.io couldn't import your file, you will see a red popup saying it "Could not detect file type". You will need to use a different tool, such as Mapshaper or QGIS, to convert your file to GeoJSON.

You can now save your file to GeoJSON. Go to *Save > GeoJSON* to download a converted GeoJSON file to your computer.

Create GeoJSON from a CSV file

GeoJson.io can transform a spreadsheet with *latitude* (or *lat*) and *longitude* (or *lon*) columns into a GeoJSON file of point features. Each row in the spreadsheet becomes its own point, and all columns other than *lat* and *lon* become *attributes* (or *properties*) of point features. An example of such spreadsheet is shown in Figure 11.12. You can download it for the exercise.

1. Save your spreadsheet as a CSV file, and drag-and-drop it to the map area of GeoJson.io. You should see a green popup in the upper-left corner notifying you how many features were imported.

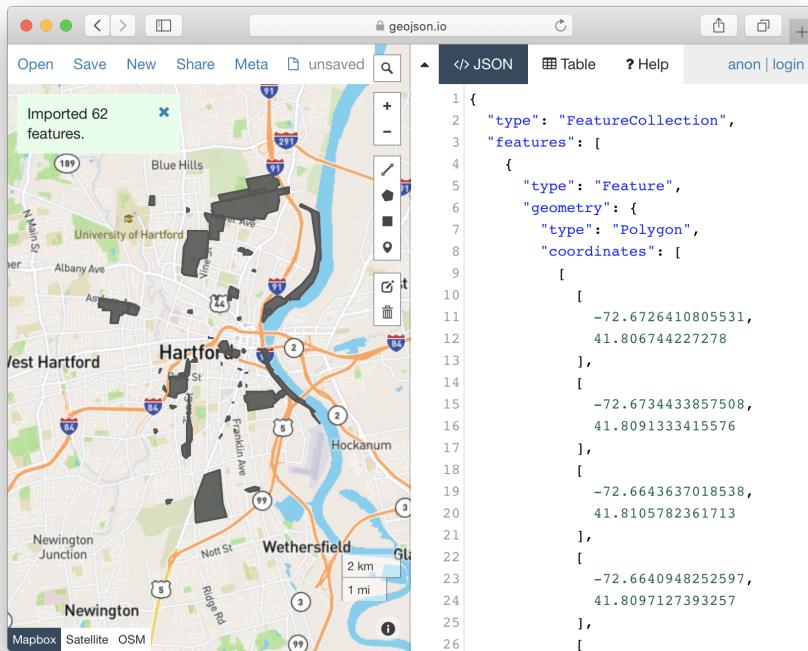


Figure 11.11: GeoJson.io successfully imported Hartford parks KML file.

A	B	C	D	E
town	lat	lon	community_type	wiki_link
Hartford	41.76	-72.67	urban core	https://en.wikipedia.org/wiki/Hartford,_Connecticut
Bloomfield	41.85	-72.73	urban periphery	https://en.wikipedia.org/wiki/Bloomfield,_Connecticut
West Hartford	41.76	-72.75	urban periphery	https://en.wikipedia.org/wiki/West_Hartford,_Connecticut
Wethersfield	41.71	-72.65	urban periphery	https://en.wikipedia.org/wiki/Wethersfield,_Connecticut
Avon	41.79	-72.86	suburban	https://en.wikipedia.org/wiki/Avon,_Connecticut
Glastonbury	41.69	-72.54	suburban	https://en.wikipedia.org/wiki/Glastonbury,_Connecticut

Figure 11.12: A spreadsheet with lat/lon columns can be transformed into a GeoJSON with point features.

Note: If you had some data on the map already, GeoJson.io wouldn't erase anything but instead would add point features to the existing map.

2. Click on a marker to see a popup with point properties. If you used the sample file with towns around Hartford, you will see *town*, *community_type*, and *wiki_link* features in addition to the tool's default *marker-color*, *marker-size*, and *marker-symbol* fields.
3. The popup is interactive, and you can click and edit each property (including property names). You can also add a new property by clicking the *Add row* button. You can delete the marker by clicking *Delete feature* button.
4. Click *Save* to record all marker changes to the GeoJSON. This will close the popup window, and you will see updated markers in the JSON tab to the right of the map.
5. It may be quicker to view all data as a table instead of dealing with individual marker popups. In **Table** tab to the right of the map, you can add, rename, and remove columns from *all* features (markers) at once. Table cells are also modifiable, so you can edit your data there.
6. Once you are happy with your map data, go to *Save > GeoJSON* to download the result to your computer. You can also log into GeoJson.io with your GitHub account and save directly to your repository.

Create a GeoJSON from scratch using drawing tools

GeoJson.io lets you create geospatial files from scratch, using simple drawing tools to put markers (points), lines, and polygons to appropriate locations. These are useful when you have no original file to work with.

1. Open GeoJson.io and in the lower-left corner switch from Mapbox (vector tiles) to Satellite.
2. In the upper-right corner of the map, use the Search tool to find the area you're interested in mapping. For this exercise, we will use tennis courts at Trinity College, Hartford, as shown in Figure 11.13.
3. In the toolbar, you have a choice of four drawing tools: a polyline (which is a series of points connected by lines, but not closed like a polygon), a polygon, a rectangle (which is just an instance of a polygon), and a marker (point). Let's start with the latter.
4. Click on the *Draw a marker* button, and click anywhere on the map to place it. You will see a gray marker that is now part of your map. You can modify its properties, or delete it in the interactive pop-up.
5. Next, choose *Draw a polyline* and click on multiple locations in the map to see connected lines appearing. To finish and create a feature, click again on the final point. Polylines are generally used for roads and paths.

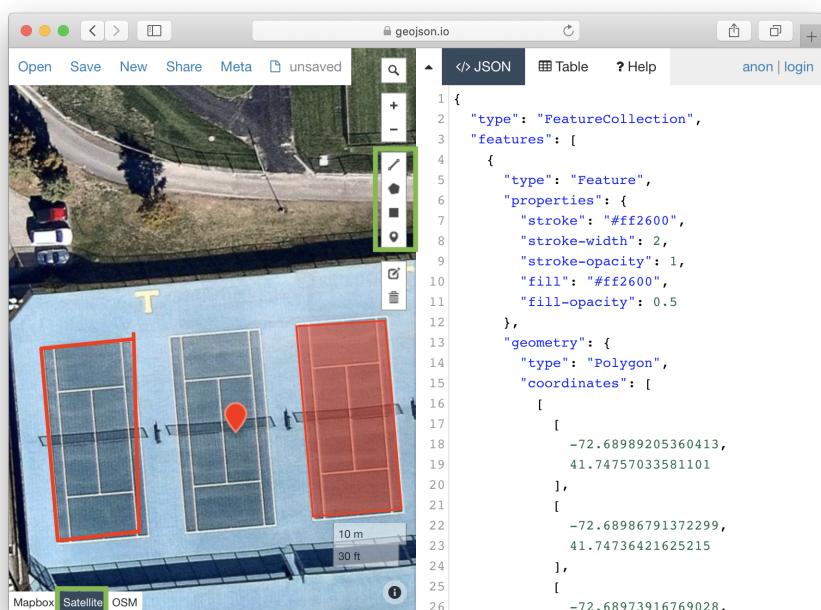


Figure 11.13: Use drawing tools to create points, lines, and polygons in GeoJSON.

6. Drawing a polygon is similar to drawing a polyline, except that you need to complete the feature by making your final point at the same location as your initial point. Polygons are used to define object boundaries, from continents to buildings, cars, and anything that has significant dimensions.
7. Use *Edit layers* tool (the one above *Delete*) to move a marker to a better position, or adjust the shapes of your features.

Once you are done creating features and their physical boundaries, it is time to add meaningful attribution data. Use the interactive popups or the Table view to give objects names and other qualities. When finished, save the GeoJSON to your computer.

Drawing tools can be used to correct your existing GeoJSON files. For example, if you created a GeoJSON from a CSV file, you might decide to move some markers with *Edit layers* tool instead of modifying their latitude and longitude values. Or you might decide that your polygons (eg those representing Hartford parks) are too “simplified”, and make them more precise with the satellite imagery.

In the next section, we will introduce Mapshaper, another free online tool to convert and modify geospatial files.

Mapshaper to Convert, Edit, and Join Data

Like GeoJson.io, Mapshaper is a free, open-source editor that can convert geospatial files, edit attribute data, filter and dissolve features, simplify boundaries to make files smaller, and many more. Unlike GeoJson.io, Mapshaper doesn’t have drawing tools, so you won’t be able to create geospatial files from scratch.

Mapshaper is developed and maintained by Matthew Bloch on GitHub. It is written in JavaScript, so we recommend you use a recent version of Firefox or Chrome.

This free and easy-to-learn Mapshaper web tool has replaced *many* of our map preparation tasks that previously required expensive and hard-to-learn ArcGIS software, or its free but still-challenging-to-learn cousin, QGIS. Even advanced GIS users may discover Mapshaper to be a quick alternative for some common but time-consuming tasks.

Import, convert, and export map boundary files

You can use Mapshaper to convert between geospatial file formats. Unlike GeoJson.io, Mapshaper also supports Esri Shapefiles (which is a folder of individual files with the same name, but different extensions), so you can easily convert a Shapefile into a web-friendly GeoJSON.

1. Navigate to Mapshaper.org. The start page is two large drag-and-drop zones which you can use to import your file. The smaller area at the bottom, *Quick import*, uses default import settings and is a good way to begin.
2. Drag and drop your geospatial file to the *Quick import* area, or use our sample Shapefile of US state boundaries. This is a `.zip` archive which contains a folder with all necessary files.

Note: If you want to import a folder, you need to either select all files inside that folder and drop them all together to the import area, or create a `.zip` archive.

3. Each imported file becomes a layer, and is accessible from the dropdown menu in the top-middle of the browser window. There, you can see how many features each layer has, toggle their visibility, or delete them.
4. To export, go to *Export* in the upper-right corner, and select a desired file format. The choice of export formats is shown in Figure 11.14. As of July 2020, these are Shapefile, GeoJSON, TopoJSON (similar to GeoJSON, but with topographical data), JSON records, CSV, or SVG (Scalable Vector Graphics, for web and print). If you export more than one layer at a time, Mapshaper will archive them first, and you will download an `output.zip` that contains all exported layers.

Tip: Mapshaper doesn't work with KML or KMZ files, but you can use GeoJSON.io to convert these.

Edit data for specific polygons

You can edit attribute data of individual polygons (and also points and lines) in Mapshaper. Figure 11.15 shows you how.

1. Import the file whose polygon attributes you want to edit.
2. Under the cursor tool, select *edit attributes*.
3. Click on the polygon you want to edit. A pop-up will appear in the upper-left corner listing all attributes and values of the polygon.
4. Click on any value (underlined, in blue) and edit it.
5. When you are done, export your geospatial file by clicking *Export* and choosing the desired file format.

Simplify map boundaries to reduce file size

You may not need precise and detailed map boundaries for data visualization projects where zoomed-out geographies are shown. Detailed boundaries are heavy, and may slow down your web maps.

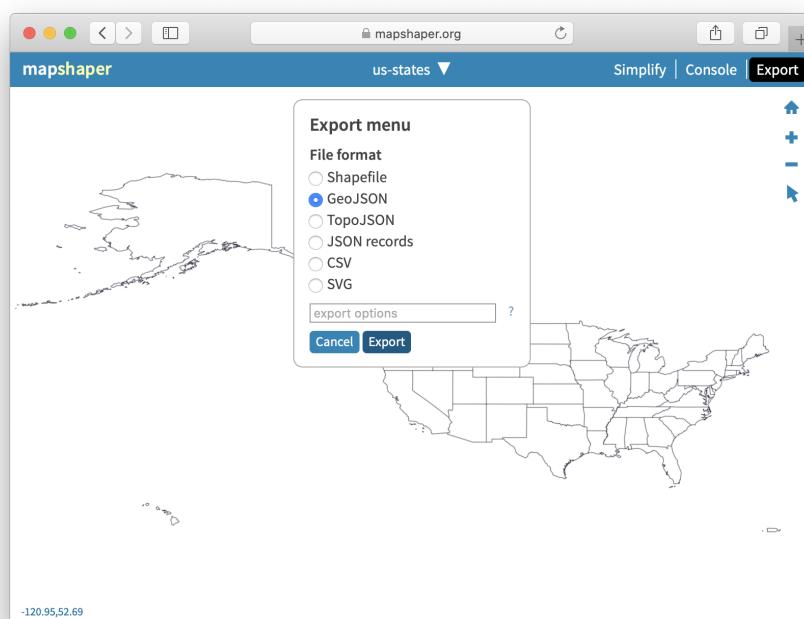


Figure 11.14: You can use Mapshaper to quickly convert between geospatial file formats.

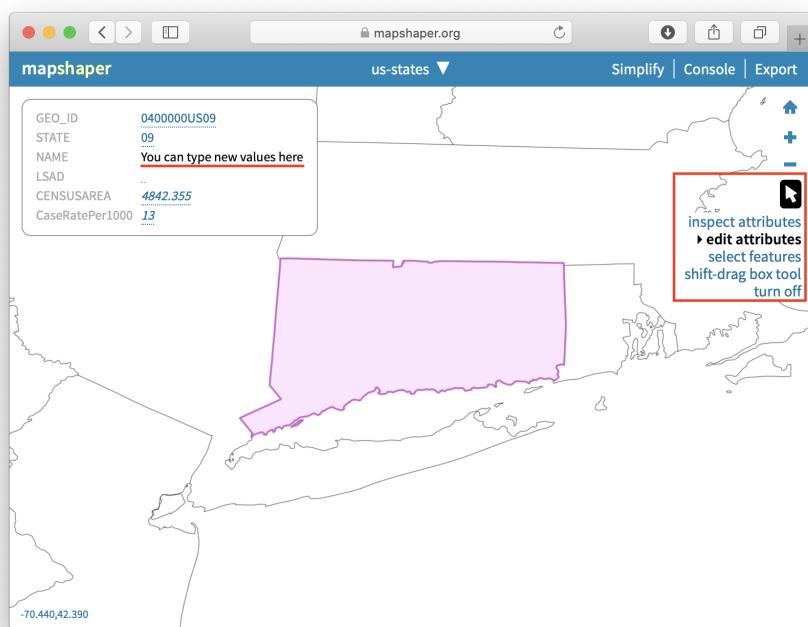


Figure 11.15: Use *edit attributes* tool (under Cursor tool) to edit attributes of polygons, lines, and points.

Consider two maps of the contiguous US states, also known as Lower-48, shown in Figure 11.16. The map on the left is more detailed and is about 230 kilobytes, but the map on the right is only 37 kilobytes, 6 times smaller!

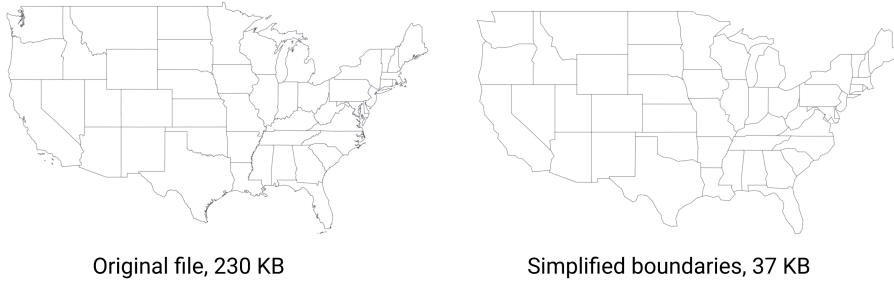


Figure 11.16: Consider simplifying geometries with Mapshaper to make your web maps faster.

1. Import your geo file to Mapshaper. You can use the sample contiguous US states GeoJSON.
2. Click the *Simplify* button in the upper-right corner. The Simplification menu will appear, where you can choose one of three methods. We recommend checking *prevent shape removal*, and leaving the default *Visvalingam / weighted area*. Click *Apply*.
3. You will see a slider with 100% appear on top (Figure 11.17), replacing the layer selection dropdown. Move the slider to the right and see the map simplify its shape as you go. Stop when you think the map looks appropriate (when the shapes are still recognizable).
4. Mapshaper may suggest to repair line intersections in the upper-left corner. Click *Repair*.
5. You can now export your file using the *Export* feature.

Tip: You may find the US shape a bit unusual and vertically “shrunk”. In **Console**, type `-proj EPSG:3857` to change projection to Web Mercator, which is more common.

Dissolve internal polygons to create an outline map

Mapshaper’s most powerful tools are available through **Console**, which allows you to type commands for common map editing tasks. One of such tasks is to create an outline map by removing the internal boundaries. For example, you can dissolve state boundaries of the US map in the previous exercise to get the outline of the country, like is shown in Figure 11.18.

Click the Console button, which opens a window to type in commands. Enter the command below, then press return (Enter).

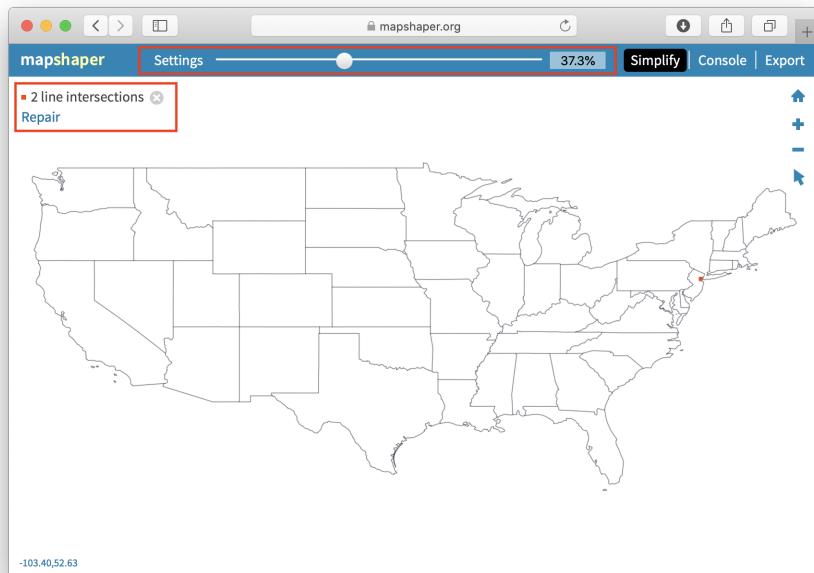


Figure 11.17: Use Simplify & Repair tools in Mapshaper.

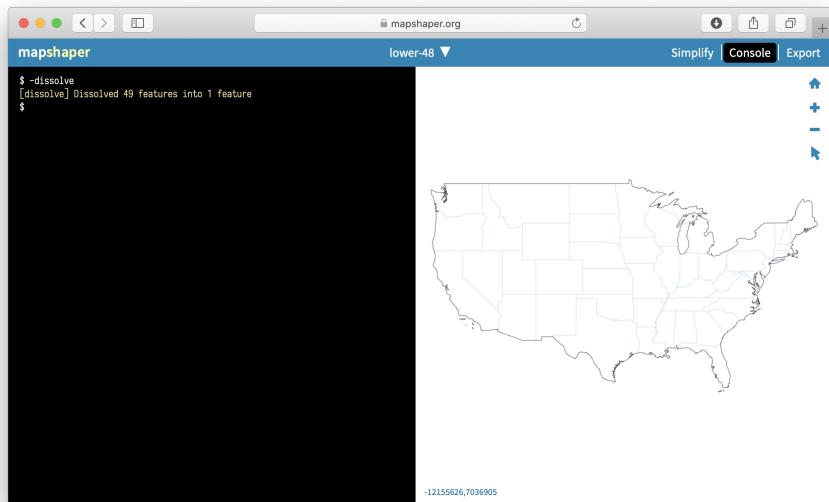


Figure 11.18: Mapshaper lets you dissolve boundaries to create an outline shape.

```
-dissolve
```

You will see that internal boundaries became lighter color, and that's Mapshaper's way of saying they no longer exist. You can now export your outline shape.

Clip a map to match an outline layer

The state of Connecticut consists of 8 counties, which in turn are divided into towns. There are a total of 169 towns in Connecticut. Imagine you are given a boundary file of all 169 towns, and the outline of Hartford county. You need to "cut" the original towns map to only include those towns that fall within Hartford county.

Mapshaper allows you to do just that using one simple `-clip` command.

1. Import two boundary files into Mapshaper. One is the larger one that is being clipped (if you use sample files, *ct-towns*), and one is the desired final shape (*hartfordcounty-outline*). The latter is what ArcGIS calls the "clip feature".
2. Make sure your active layer is set to the map you are clipping (*ct-towns*).
3. In the **Console**, type `-clip` followed by the name of your clip layer, like that:

```
-clip hartfordcounty-outline
```

4. You should see your active layer got clipped. Sometimes you end up with tiny "slivers" of clipped areas that remain alongside the borders. If that is the case, use the `-filter-slivers` command to remove them, like that:

```
-clip hartfordcounty-outline -filter-slivers
```

5. Your Mapshaper state should look like pictured in Figure 11.19. You can now save the file on your computer using the *Export* button.

Remove unwanted data fields

Sometimes map features, such as polygons, lines, and points, contain unwanted *attributes* (or fields, or columns) that you may want to remove. In **Console**, use `-filter-fields` editing command to remove unnecessary fields.

For example, remove all fields except *town*:

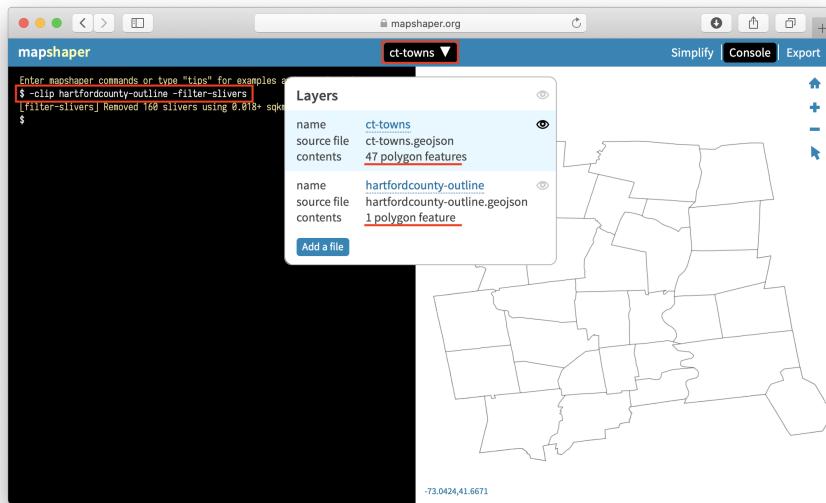


Figure 11.19: When clipping, make sure your active layer is the one being clipped (with many features), not the clipping feature itself.

-filter-fields town

If you want to leave more than one field, separate them by a comma, but without spaces, like that:

-filter-fields town,state

Note: If you leave a space after comma, you will get a *Command expects a single value* error.

Join spreadsheet data with polygon map

Combining spreadsheet data with geographical boundaries is a common task for geospatial practitioners. Imagine you have a file with Connecticut town boundaries, and you want to add population data to each of them in order to build a choropleth map.

Mapshaper provides a powerful **-join** command to join such files. Remember that you need some common keys in both datasets (such as *town name*, or *state*, or *country*) in order to join files. Otherwise Mapshaper has no way of knowing which numbers belong to which polygons.

1. Import both geospatial file and a CSV dataset into Mapshaper using Quick import box.
2. Make sure both files appear in the drop-down list of layers. Your CSV data will be shown as something that resembles a table. Use the *Cursor > inspect attributes* tool to make sure the data is imported correctly. If you use the sample CT files, note that the *ct-towns* layer has *name* attribute with the name of the town, and *ct-towns-popdensity* has town names in the *town* column.
3. Make your geospatial layer (*ct-towns*) is the one active.
4. Open **Console**, and use the **-join** command, like that:

```
-join ct-towns-popdensity keys=name,town
```

where **ct-towns-popdensity** is the CSV layer you are merging with, and **keys** are the attributes that contain values to join by. In case with our sample files, these would be town names which are stored in **name** attribute of the map file, and **town** column of the CSV file.

5. You will see a message in the console notifying you if join was performed successfully, or if Mapshaper encountered any errors.
6. Use the *Cursor > inspect attributes* tool to make sure you see CSV columns as fields of your polygons, like is shown in Figure 11.20.
7. You can now save the file to your computer by clicking the *Export* button.

Tip: To avoid confusion, it may be useful to re-name your CSV column that contains key values to match the key attribute name of your map. In our example, you would rename *town* column to *name* column in the CSV, and your command would end with **keys=name,name**.

Do you remember aggregating address-level point records of hospitals into hospital counts per state? Now is a good time to find that .CSV file and practice your merging skills.

Count points in polygons with Mapshaper

Mapshaper lets you count points in polygons, and record that number in polygon attributes using **-join** command.

1. Import two geospatial files, one containing polygon boundaries (for example, US state boundaries), and another containing points that you want to aggregate (for example, hospitals in the US).
2. Make sure your polygons (not points) layer is active by selecting it from the dropdown menu.

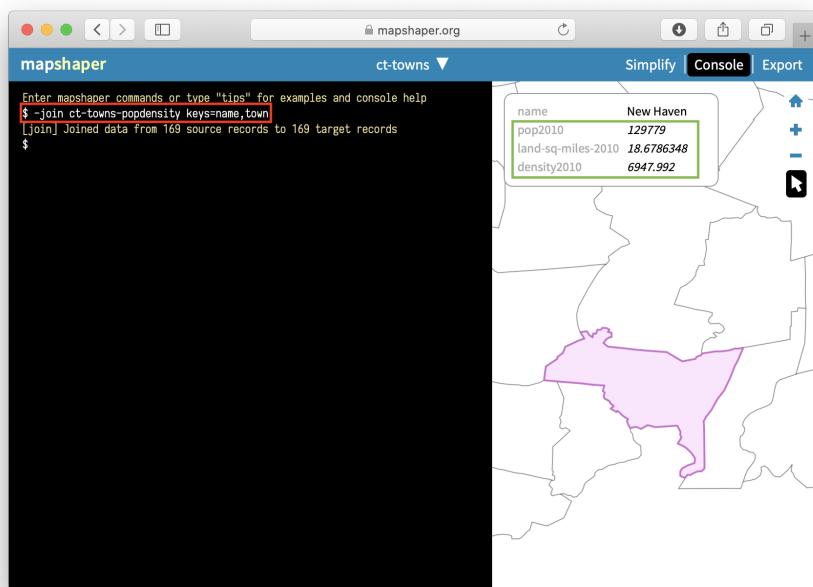


Figure 11.20: Mapshaper lets you join spatial and CSV files using common keys (for example, town names).

3. In **Console**, perform `-join` using a `count()` function, like that:

```
-join hospitals-points calc='hospitals = count()' fields=
```

This command tells Mapshaper to count points inside *hospitals-points* layer and record them as *hospitals* attribute of the polygons. The `fields=` part tells Mapshaper to not copy any fields from the points, because we are performing many-to-one matching (many hospitals per state, in our case).

4. Use the *Cursor > inspect attributes* tool to make sure polygons obtained a new field with the recorded count of points, like is shown in Figure 11.21.
5. Save the new file using *Export* button and choosing the desired output format.

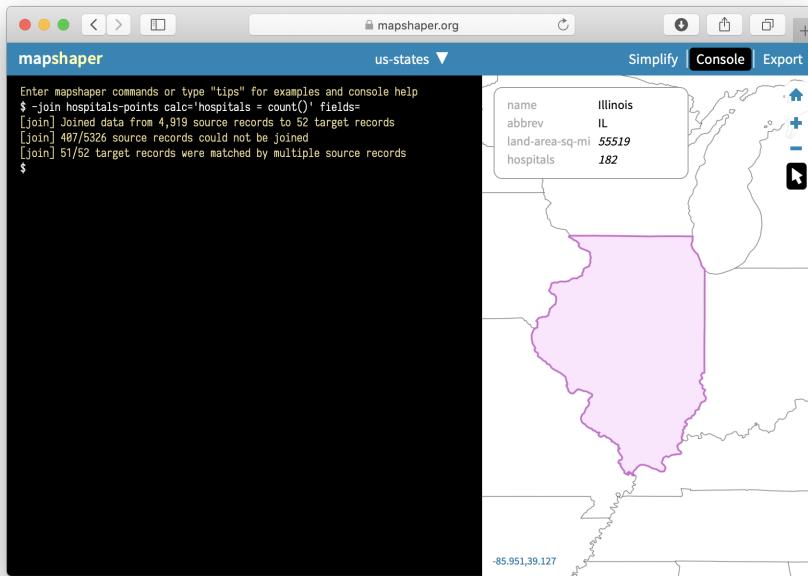


Figure 11.21: Mapshaper's `-join` can count points in polygons.

More about joins

As you saw in counting points in polygons example, you do not need to specify *keys* if you want to perform join based on geographical locations between two geo files. If one of your files is a CSV, you need *keys*.

If you don't have a CSV table that matches the columns in your boundary map data, you can easily create one. Upload the boundary map to Mapshaper, and export in CSV format. Open the downloaded file in any spreadsheet tool. To match data columns in the CSV spreadsheet, use the VLOOKUP function.

In real life, you will rarely have perfect files with one-to-one matches, so you might want to have more information about which features didn't get matched so that you can fix your data. Mapshaper helps you keep track of data that is not properly joined or matched. For example, if the polygon map contains 169 features (one for each town in Connecticut), but the CSV table contains only 168 rows of data, Mapshaper will join all of those with matching keys, and then display this message:

```
[join] Joined data from 168 source records to 168 target records
[join] 1/169 target records received no data
[join] 1/169 source records could not be joined
```

To get more details on which values were not joined, add `unjoined unmatched -info` flags to your join command, like this:

```
-join ct-towns-popdensity keys=name,town unjoined unmatched -info
```

The `unjoined` flag saves a copy of each unjoined record from the source table into another layer named *unjoined*. The `unmatched` flag saves a copy of each unmatched record from the target table to a new layer named *unmatched*. And the `-info` flag outputs some additional information about the joining procedure to the console.

Merge selected polygons with join and dissolve commands

In Mapshaper, you can merge selected polygons into larger “clusters” using `-join` and `-dissolve` commands.

Imagine that you are employed by the CT Department of Public Health, and your task is to divide 169 towns into 20 so-called Health Districts and produce a new geospatial file. By the way, health districts are a real thing in Connecticut.

You should begin by creating a *crosswalk* of towns and their health districts. It can be as simple as a two-column CSV list of a town and its district. Because your boss didn't give you a list of towns in a spreadsheet format, but instead a GeoJSON file with town boundaries, let's extract a list of towns from it.

1. Import `ct-towns.geojson` to Mapshaper using Quick import box.
2. You can use the *Cursor > inspect attributes* tool to see that each polygon has a *name* attribute with the name of the town.

3. Save attribute data as a CSV file using *Export* button. Open the file in any spreadsheet tool. You will see that your data is a one-column file with a `*name` column that lists 169 towns.
4. Create a second column titled *merged* and copy-paste values from the first, *name* column. At this point your spreadsheet contains two columns with the same values.
5. Pick a few towns, for example *West Hartford* and *Bloomfield*, and assign “Bloomfield-West Hartford” to their *merged* column, like is shown in Figure 11.22. You may stop right here and move to the next step, or keep assigning district names to a few other neighboring towns.

	A	B	C
1	name	merged	
2	Bloomfield	Bloomfield-West Hartford	
3	West Hartford	Bloomfield-West Hartford	
4	Bethel	Bethel	
5	Bridgeport	Bridgeport	
6	Brookfield	Brookfield	
7	Danbury	Danbury	
8	Darien	Darien	
9	Easton	Easton	
10	Fairfield	Fairfield	
11	Greenwich	Greenwich	

Figure 11.22: Create a two-column crosswalk of towns and which districts they should be merged to.

6. Save this new file as `ct-towns-merged.csv`, and drag-and-drop it to Mapshaper on top of your `ct-towns` layer. Click *Import*.
7. This new CSV layer will be added as `ct-towns-merged` and will appear as a series of table cells. From the dropdown menu, select `ct-towns` to get back to your map.
8. Now you are ready to merge certain towns into districts according to your uploaded CSV file. Open **Console**, and type:

```
-join ct-towns-merged keys=name,name
```

to join the CSV layer with the boundaries layer that you see on the screen, followed by

```
-dissolve merged
```

to dissolve polygons of towns according to the *merged* column of the CSV file.

In our example, only Bloomfield and West Hartford are dissolved into a combined “Bloomfield-West Hartford” regional health district (with the shared boundary between towns becoming grayed out), and all of the other polygons remain the same. Figure 11.23 shows the final result.

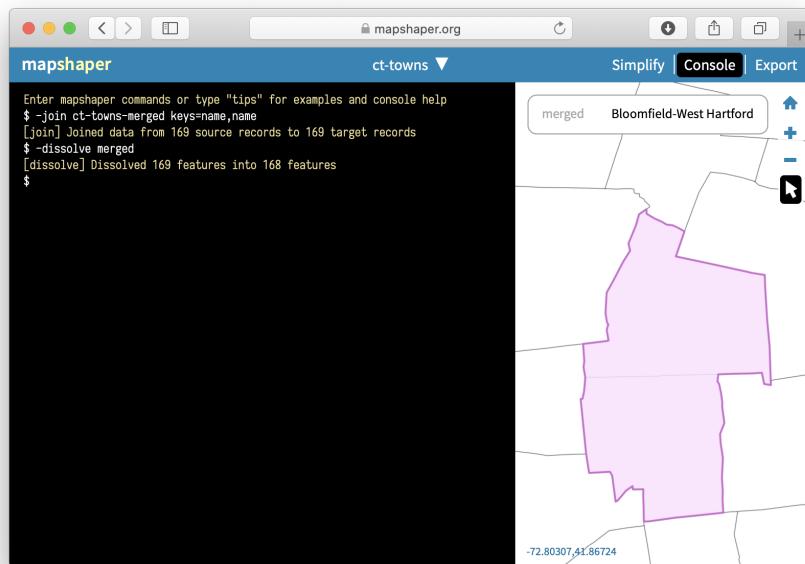


Figure 11.23: Merge polygons based on a predefined crosswalk.

You can inspect attribute data of polygons using *Cursor > inspect attributes* tool, and save the resulting file using the *Export* button.

Learn more advanced MapShaper methods

There are many more commands within Mapshaper that are worth exploring if you are serious about GIS, such as changing projections, filtering features using JavaScript expressions, assigning colors to polygons based on values, and many more. Explore the Wiki of Mapshaper project on GitHub for more commands and examples.

TODO: Add Mapwarper section here

Convert a Compressed KMZ file to KML format

Sometimes KML files are distributed in compressed KMZ format. The easiest way to convert is to use free Google Earth Pro.

1. Download and install Google Earth Pro for desktop.
2. Double-click on any .kmz file to open it in Google Earth Pro. Alternatively, open Google Earth Pro first, and go to *File > Open* and choose your KMZ file.
3. Right-click (or control-click) on the KMZ layer under Places menu, and select *Save Place As...*, like is shown in Figure 11.24.
4. In the dropdown menu of *Save file...* window, choose KML format, like is shown in Figure 11.25.

Alternatively, you can use any zip-utility to extract a KML file from KMZ. KMZ is simply a ‘zipped’ version of a KML file!

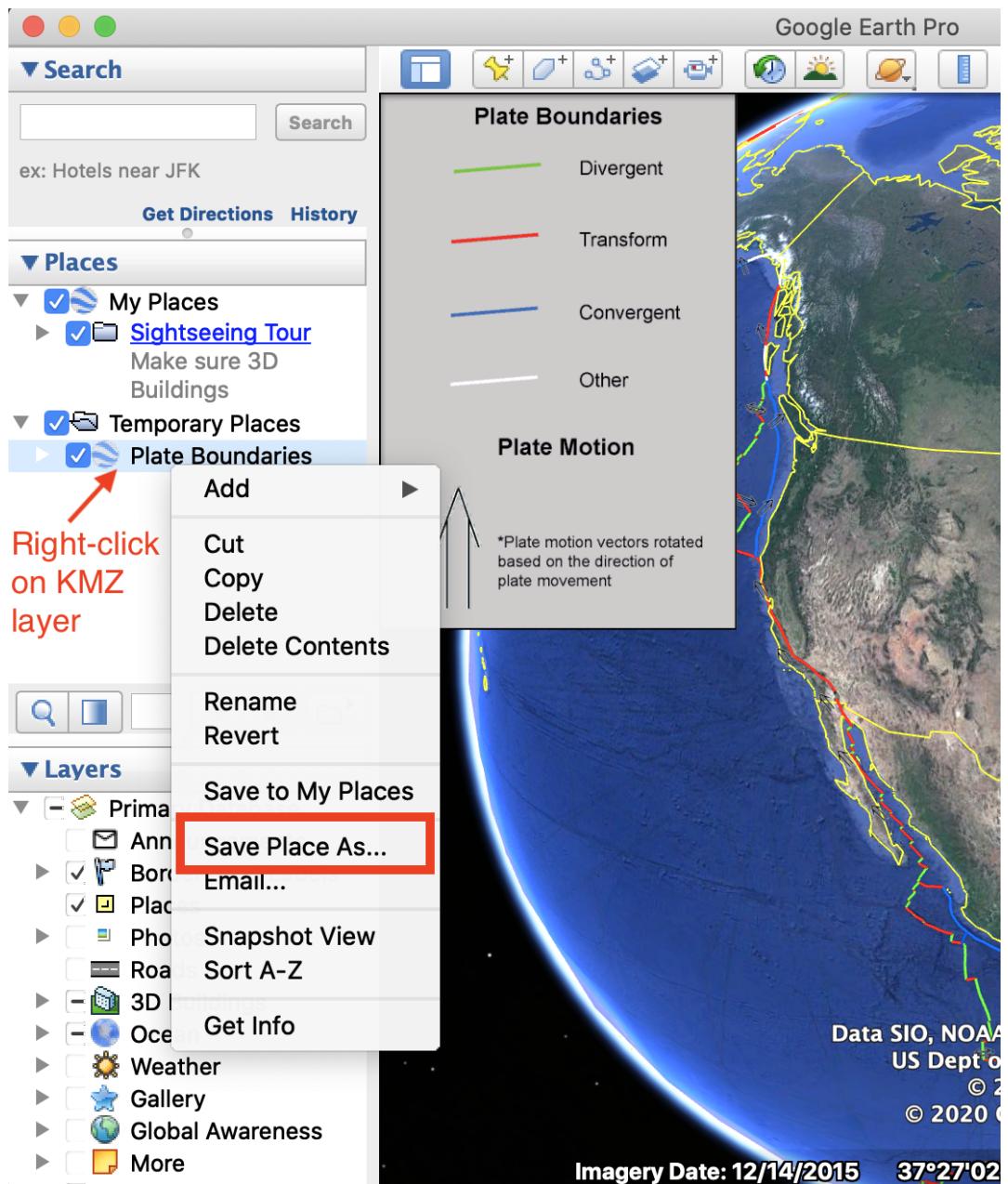


Figure 11.24: In Google Earth Pro, right-click KMZ layer and choose *Save Place As...*.

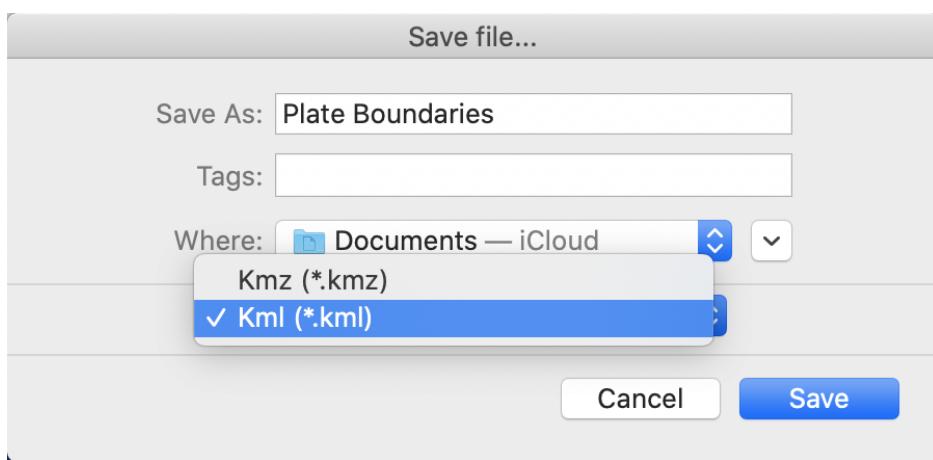


Figure 11.25: Save as KML, not KMZ.

Chapter 12

Detect Bias in Data Stories

TODO: Rewrite chapter

While we like to believe data visualizations simply “tell the truth,” when you dig further into this topic, you realize that there are multiple ways to represent reality. In this chapter, you will learn how visualizations display the biases of the people and the software that create them. Although we cannot stop bias, we can teach people to look for and detect it, and be aware of our own.

Sections in this chapter:

- How to Lie with Charts, inspired by Darrell Huff (1954)
- How to Lie with Maps, inspired by Mark Monmonier (1996)

Enroll in our free online course *TO DO add link*, which introduces these topics in the brief video below, and offers more exercises and opportunities to interact with instructors and other learners.

Learn more: - Darrell Huff, How to Lie with Statistics (W. W. Norton & Company, 1954), <http://books.google.com/books?isbn=0393070875> - Mark S. Monmonier, How to Lie with Maps, 2nd ed. (University of Chicago Press, 1996), <http://books.google.com/books?isbn=0226534219> - Nathan Yau, “How to Spot Visualization Lies,” FlowingData, February 9, 2017, <http://flowingdata.com/2017/02/09/how-to-spot-visualization-lies/>

How to Lie with Charts

One of the best ways to learn how to detect bias in data visualization is to intentionally manipulate a chart, and tell two (or more) opposing stories with the same data. You’ll learn what to watch out for when viewing other people’s

charts, and think more carefully about the ethical issues when you design your own.

This exercise was inspired by a classic book published more than fifty years ago: Darrell Huff, *How to Lie with Statistics* (W. W. Norton & Company, 1954), <http://books.google.com/books?isbn=0393070875>

Right-click this link and Save to download this sample data in CSV format to your computer: <us-gross-domestic-product-per-capita>. This historical data on economic productivity comes from the World Bank, World Development Indicators, <http://data.worldbank.org/data-catalog/world-development-indicators>

Upload the CSV file to your Google Drive (with Settings to Convert to Google format) to create a Google Sheet.

Select the data cells and Insert > Chart > Line chart, similar to the default version shown below:

In your Google Sheet chart, double-click the vertical y-axis to edit the Minimum and Maximum values.

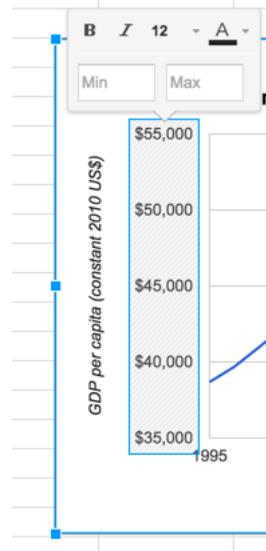


Figure 12.1: Screenshot: Edit the Min and Max values of the Y-axis

Make the line look “flatter” (slower economic growth) by lowering the minimum to \$36,000, and increasing the maximum to \$100,000, as shown below:

Make the line look like a “sharper increase” (faster economic growth) by increasing the minimum to \$38,000, and lowering maximum to \$52,000, as shown below:

** TO DO – add conclusion **

How to Lie with Maps

One of the best ways to learn how to detect bias in data visualization is to intentionally manipulate a map, and tell two (or more) opposing stories with the same data. You'll learn what to watch out for when viewing other people's maps, and think more carefully about the ethical issues when you design your own.

This exercise was inspired by Mark S. Monmonier, *How to Lie with Maps*, 2nd ed. (University of Chicago Press, 1996), <http://books.google.com/books?isbn=0226534219>

First, scroll through this data on Median Household Income for Hartford-area towns, 2011-15, from American Community Survey 5-year estimates. Or right-click to open this Google Sheet in a new tab.

Next, explore two different polygon maps of the same data. Use the drop-down menu to compare “Extreme Differences” versus “Uniform Equality”

Why are these two maps portray the same data so differently? To see the answer, look at the data ranges. . ..

** TO DO **

Create your own version...

TODO: Add section on how interactive maps such as Google Maps change borders and data depending on the internet address of the user

Chapter 13

Tell Your Data Story

TODO: Write this chapter: Tell the story about your data, including its most meaningful insights and limitations Write compelling titles, labels, and sentences to accompany your visualization. Call attention to the most meaningful insights in your chart, and explain any data limitations.

This chapter draws inspiration from Cole Nussbaumer Knaflic, *Storytelling with Data: A Data Visualization Guide for Business Professionals* (Wiley, 2015), <http://www.storytellingwithdata.com/book/>

- Beginning, Middle, and End
- Draw Attention to Meaning
- Integrate Story with Your Data
- Write Clearly about What You Visualize
- Credit Data Sources and Collaborators

Credit sources and collaborators on dataviz products and readme files

Under US law, you cannot copyright data, such as the raw information in the rows and columns of a spreadsheet. But you can copy, but representations of data can be protected by copyright. ... explain... In the spirit of openness, we encourage you to share your data visualizations under a Creative Commons license... explain... in fact, this book is copyrighted, and the source text is publicly available under a Creative Commons TODO: TYPE license...

Appendix A

Fix Common Mistakes

TODO: Rewrite appendix to focus more broadly on “common mistakes” not just “code errors”

Creating your data visualizations through code templates hosted on GitHub has multiple advantages over drag-and-drop tools. Coding gives you more power to customize their appearance and interactive features, and to control where your data and products reside online. But there’s also a trade-off. Code can “break” and leave you staring at a blank screen. Sometimes problems happens through no fault of your own, such as when a “code dependency” to an online background map or code library is unexpectedly interrupted. But more often it seems that problems arise because we make simple mistakes that break our own code. Whatever the cause, one big drawback of working with code is that you’re also responsible for fixing it.

We designed this section as a guide to help new coders diagnose and solve common errors when working with code templates on GitHub. We understand the feeling you experience when a simple typo—such as a misplaced semicolon (;)—makes your data visualization disappear from the screen. Finding the source of the problem can be very frustrating. But breaking your code—and figuring out how to fix it—also can be a great way to learn, because trial-and-error on a computer often provides immediate feedback that supports the learning process and develops our thinking.

TODO: Reorganize contents, perhaps using this outline?

- Problems with Mac computers
- Problems with data tables
- Problems with iframes (since this chapter appears before code templates)
- Problems with GitHub forking and hosting
- Problems with code templates

Problems with Mac computers: cannot see filename extension

Several tools in this book will not work properly if your computer does not display the filename extensions, meaning the abbreviated file format that appears after the period, such as `data.csv` or `map.geojson`. The Mac computer operating system hides these by default, so you need to turn them on by going to `Finder > Preferences > Advanced`, and check the box to *Show all filename extensions*, as shown in Figure A.1.

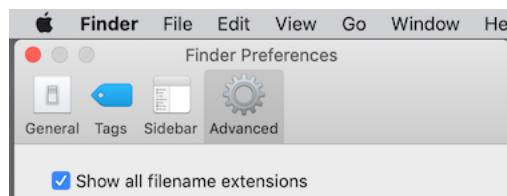


Figure A.1: On a Mac, go to `Finder > Preferences > Advanced` and check the box to *Show all filename extensions*.

Problems with data tables

Avoid typing blank spaces after column headers—or any spreadsheet entries—since some data visualization tools will not match them with headers lacking a blank character.

	A	B	C	D
1	name	all2015	healthcare2015	manufactur
2	Andover	189	36	67
3	Avon	2536	1866	391
4	Berlin	4907	1159	2822
5	Bloomfield			3688
6	Bolton	488	60	269

Problems with iframes

My iframe does not appear in my web page

- Go back to the Embed tutorials in this book to double-check the directions
- Items listed in your iframe (such as the URL, width, or height) should be enclosed inside straight quotation marks (single or double)
 - BROKEN iframe (missing quotation marks for width and height)

```
<iframe src="https://handsondataviz.github.io/leaflet-map-simple" width=90% height=350></ifr
```

– FIXED iframe (with correct quotation marks)

```
<iframe src="https://handsondataviz.github.io/leaflet-map-simple" width="90%" height="350"></ifr
```

- Use only **https** (the extra ‘s’ means ‘secure’), not **http**. Some web browsers will block content if it mixes http and https resources, and some code templates in this book require https.

<iframe src="http://ik
Change to https

Correct

<iframe src="https://

Figure A.2: Screenshot: Replace http with https

- Use only straight quotes, not curly quotes. Avoid pasting text from a word-processor into GitHub, which can accidentally carry over curly quotes. Typing directly into the GitHub editor will create straight quotes.

TODO: Test one way to fix GitHub errors by going into the commits and going back to a previous version of the code. Is this possible in the web version?

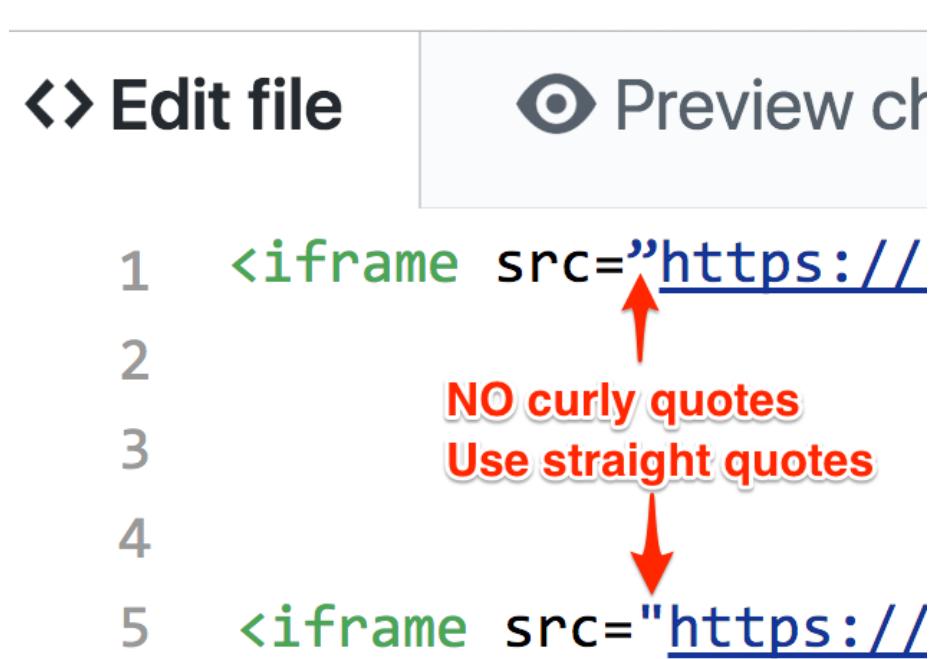


Figure A.3: Screenshot: Curly quotes versus straight quotes

Safely Delete your GitHub Repo and Start Over

If you need to delete your GitHub repo and start over, here's a simple way to safely save your work:

- Go to the top-level of your GitHub repository, similar to <https://github.com/USERNAME/REPOSITORY>
- Click the green “Clone or Download” button, and select Download Zip to receive a compressed folder of your repo contents on your computer.
- In your GitHub repo, click on Settings (upper-right area) and scroll down to Delete This Repository.
- To prevent accidental deletions, GitHub requires you to type in the REPOSITORY name.
- Now you can start over in one of these ways:
 - If you wish to Create a Simple Web Page with GitHub Pages, follow that tutorial again.
 - OR
 - Fork another copy of the original GitHub repository to your account. After you create your copy, if you wish to add selected files that you previously downloaded to your computer, follow directions to Upload Code with GitHub in the second half of this tutorial in this book

Problems with Creating a Simple Web Page with GitHub Pages

If you followed the Create a Simple Web Page with GitHub Pages tutorial, it should have created two web links (or URLs):

- your code repository, in this format: <https://github.com/USERNAME/REPOSITORY>
- your published web page, in this format: <https://USERNAME.github.io/REPOSITORY>

Be sure to insert your GitHub username, and your GitHub repository name, in the general formats above.

These URLs are NOT case-sensitive, which means that <https://github.com/USERNAME> and <https://gitub.com/username> point to the same location.

My simple GitHub web page does not appear

- Make sure that you are pointing to the correct URL for your published web page, in the format shown above.
- Be patient. During busy periods on GitHub, it may take up to 1 minute for new content to appear in your browser.

- **MOVE UP** If your map does *not* appear right away, wait up to 30 seconds for GitHub Pages to finish processing your edits. Then do a “hard refresh” to bypass any saved content in your browser cache and re-download the entire web page from the server, using one of these key combinations:
 - Ctrl + F5 (most browsers for Windows or Linux)
 - Command + Shift + R (Chrome or Firefox for Mac)
 - Shift + Reload button toolbar (Safari for Mac)
 - Ctrl + Shift + Backspace (on Chromebook)
- Test the link to your published web page in a different browser. If you normally use Chrome, try Firefox.
- On rare occasions, the GitHub service or GitHub Pages feature may be down. Check <https://status.github.com>.

My simple GitHub web page does not display my iframe

- If you followed the Create a Simple Web Page with GitHub Pages tutorial and inserted an iframe in the README.md file, it will appear in your published web page, under these conditions:
 - Ideally, your README.md should be the ONLY file in this GitHub repository
 - Any other files in your repo (such as index.html, default.html, or index.md) will block the iframe HTML code in your README.md from being published on the web. If you accidentally selected a GitHub Pages Theme, you need to delete any extra files it created: click each file, select trash can to delete it, and commit changes.

Problems with Leaflet Maps with Google Sheets template

My map does not appear

- 1) Confirm that you have completed all of the key steps in the Leaflet Maps with Google Sheets tutorial in this book, especially these:
 - Sign in to Google and File > Make a Copy of the Google Sheet to your Google Drive.
 - File > Publish your Google Sheet (Jack often forgets this key step!)
 - Copy your Google Sheet web address from top of your browser (usually ends with ...XYZ/edit#gid=0) and paste into your `google-doc-url.js` file in your GitHub repo. Do NOT copy the *Published* web address (which usually ends with ...XYZ/pubhtml)

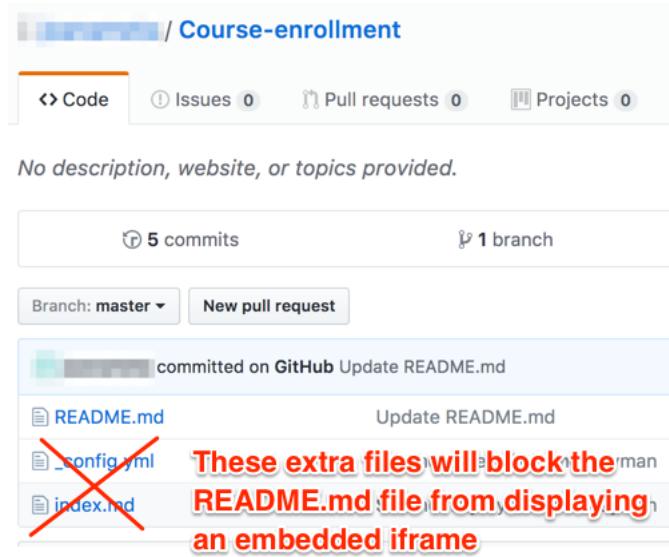


Figure A.4: Screenshot: Extra files in GitHub repo will block iframe in your README

- When you paste your Google Sheet web address into `google-doc-url.js`, be careful not to erase single-quote marks or semicolon
 - Go to your live map link, which should follow this format: <https://USERNAME.github.io/REPOSITORY>, refresh the browser, and wait at least 30 seconds.
- 2) Check your Google Sheet for errors:
 - Do NOT rename column headers (in row 1) of any sheet, because the Leaflet Map code looks for these exact words.
 - Do NOT rename row labels (in column A) of any sheet, due to the same reason above.
 - In your Points tab, DO NOT leave any blank rows
 - 3) Confirm on GitHub Status (<https://status.github.com/>) that all systems are operational.
 - 4) If you cannot find the problem, go to the top of this page to Safely Delete Your GitHub Repo and Start Over. Also, make a new copy of the Google Sheet template, give it a new name, and copy data from your old sheet using File > Paste Special > Values Only.

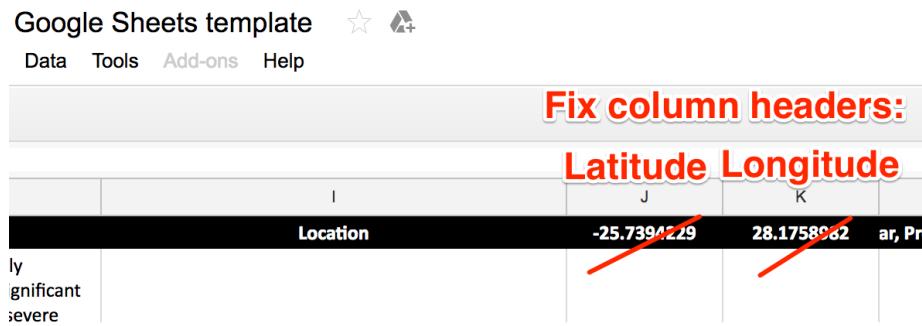


Figure A.5: Screenshot: User accidentally renamed column headers in the Points tab

Problems with Chart.js code templates

Chart displays old data If you upload new data to your Chart.js code template on GitHub Pages, and it does not appear in your browser after refreshing and waiting up to one minute, then GitHub Pages is probably not the cause of the problem. Instead, some browsers continue to show “old” Chart.js in the web cache. The simplest solution is to File > Quit your browser and re-open the link to your Chart.js

TODO: Our Chart.js templates appear blank (just text, no chart) when viewed in the local browser. But Leaflet maps appear mostly or partially complete. Why is this, and how should we inform readers about this? Discuss with Ilya

Solve Problems with Browser Developer Tools

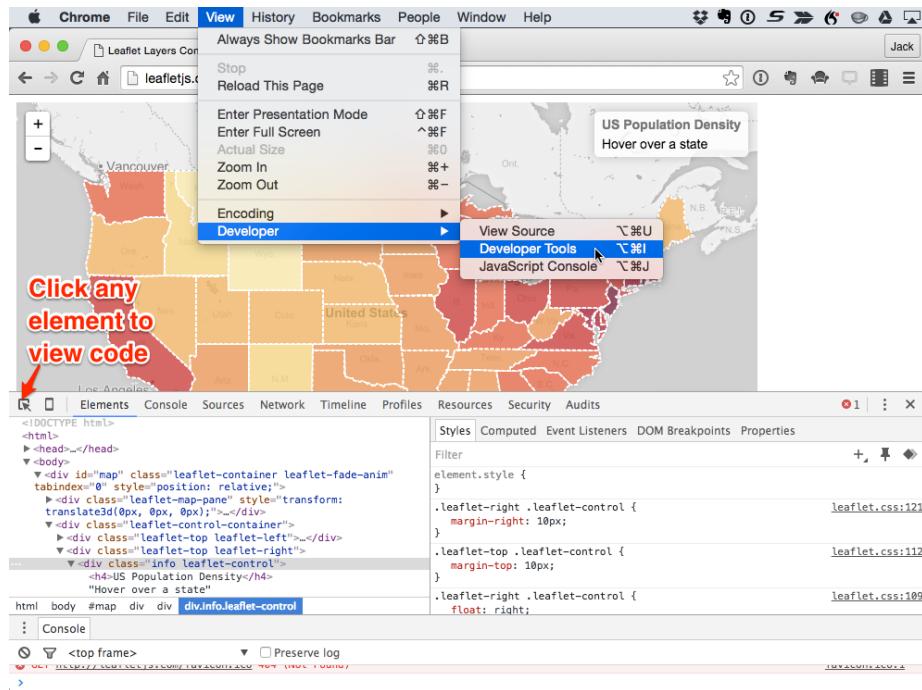
Peek inside any website and view the web code under the hood with the browser developer tools.

In Chrome for Mac, go to View > Developer > Developer Tools

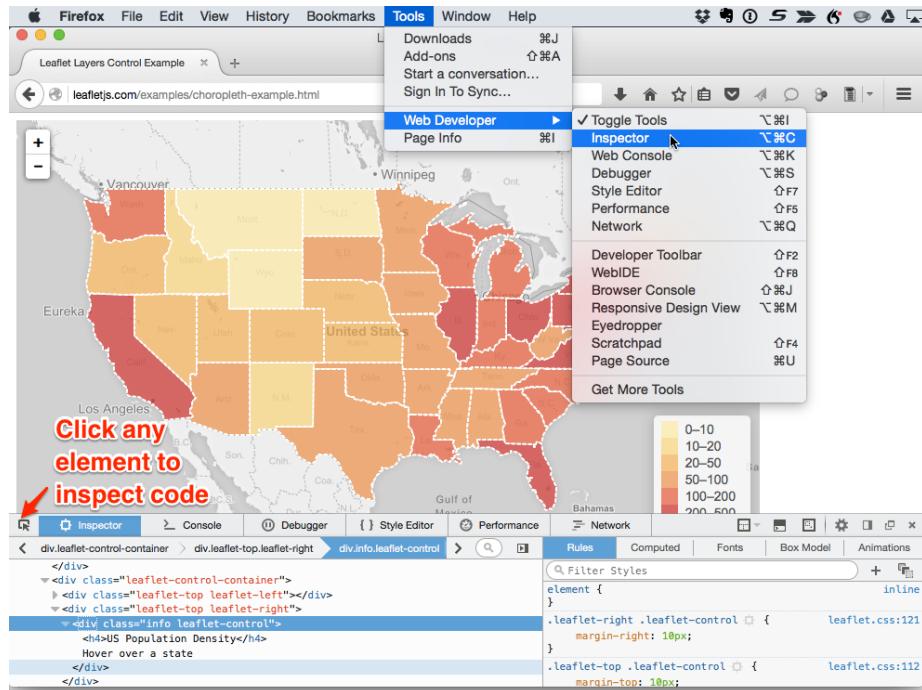
The screenshot shows a Microsoft Excel spreadsheet with the title "Leaflet Maps with Google Sheets" in the top bar. The menu bar includes File, Edit, View, Insert, Format, and a ribbon with icons for print, refresh, and search. The formula bar shows "fx". The main content is a table with 12 rows and 3 columns. The first column contains row numbers from 1 to 12. The second column contains labels for settings, and the third column contains their values. Rows 1 through 9 have light purple backgrounds, while rows 10 through 12 have light green backgrounds. A large red watermark with the text "Do NOT rename or delete these labels" is overlaid across the middle of the table.

	A	
1	Setting	
2	Map Info	Do NOT rename or delete these labels
3	Map Title	Demo
4	Map Subtitle	trans
5	Display Title	on
6	Author Name	Jack
7	Author Email or	jack.
8	Author Code Credit	<a href
9	Author Code Repo	https://
10	Map Settings	
11	Basemap Tiles	Carto
12	Cluster Markers	off

Figure A.6: Screenshot: Do not rename or delete



In Firefox for Mac, go to Tools > Web Developer > Inspector



Appendix B

Find Connecticut Data

TODO: Rewrite and update this appendix

Since this book was created in Hartford, Connecticut, we include state and municipal open data repositories and boundary files.

Connecticut Open Data (<http://data.ct.gov>), the official portal for state government agencies, is hosted on the Socrata platform, which offers built-in data visualization tools and APIs. See also how to create a filtered point map with Socrata in this book.

See also separate repositories for individual state agencies:

- Office of the State Comptroller (<http://www.osc.ct.gov/openCT.html>)
- CT State Department of Education (<http://www.sde.ct.gov/sde/cwp/view.asp?a=2758&q=334520>)
- Office of Policy and Management (http://ct.gov/opm/cwp/view.asp?a=3006&Q=383258&opmNav_GID=1386)
- link to all CT state government agencies (<http://portal.ct.gov/Department-and-Agencies/>)

Connecticut State Data Center (<http://ctsdc.uconn.edu/>), part of the U.S. Census Data Center Network, is the lead agency for US Census data and other socioeconomic data for Connecticut, and is based at the University of Connecticut Libraries. The site also features data visualizations created on the Tableau platform and provides population projections for the state of Connecticut.

MAGIC: The Map and Geographic Information Center (<http://magic.lib.uconn.edu>), based at the University of Connecticut Libraries, specializes in providing geographic, aerial photography, and map images for the state, past and present. The site also features interactive maps.

DataHaven (<http://ctdatahaven.org/>), a non-profit organization, collects and interprets information about Connecticut neighborhoods, such as its Community Wellbeing Survey. Data resources feature neighborhood profiles for densely-populated areas (New Haven and Hartford-West Hartford), and town profiles for other areas across the state.

Connecticut Data Collaborative (<http://ctdata.org>) is a public-private partnership that advocates for open data access to drive planning, policy, budgeting and decision making in Connecticut at the state, regional and local levels. We democratize public data through custom data exploration tools and a dynamic town profile tool, hosted on the open-source CKAN platform. Users can find state and federal data on topics such as public health, education, crime, municipal data, and racial profiling data.

Hartford Data (<http://data.hartford.gov>), the official portal of the City of Hartford municipal government, is hosted on the Socrata platform, which features built-in visualizations and APIs. See also how to create a filtered point map with Socrata in this book. Also, the Hartford Data site links to the City's ArcGIS Online geographic data (<http://gisdata.hartford.gov/>) and the City's financial data (<http://checkbook.hartford.gov/>) and budget (<http://budget.hartford.gov/>).

In addition to the official repositories above, Connecticut news organizations that create data visualizations often include links to download data files.

Connecticut Mirror / Trend CT (<http://ctmirror.org/>) and (<http://trendct.org/>) are publications of the Connecticut News Project, an independent, nonpartisan, nonprofit organization that focuses on state policy issues. Most of their data visualizations are built with open-source code, with publicly accessible data files. See also their GitHub repository (<https://github.com/trendct>).

Hartford Courant Data Desk (<http://www.courant.com/data-desk>) produces digital visualizations for the *Hartford Courant*, the largest daily newspaper in Connecticut, owned by Tribune Publishing. Many of these data visualizations are published on the Tableau platform, which allows readers to download the underlying data.

Census areas in the Hartford region

The U.S. Census Bureau collects and shares population, housing, and economic data on its open repositories.

- The Decennial Census is a full count of the population every ten years, most recently in 2010 and the upcoming one in 2020. Because decennial data are counts and not estimates, they represent “true” values and hence come without margins of errors.

- The American Community Survey (ACS) (<https://www.census.gov/programs-surveys/acs/>) is annual sample count, which produces:
 - 1-year estimates for areas with populations of 65,000+
 - 5-year estimates for all census areas
 - ACS used to release 3-year estimates for geographies with population of 20,000+, but discontinued after the 2011-2013 release.

Because ACS produces estimates and not “true” counts, data comes with margins of errors. Generally, margins of errors are higher for smaller geographies (eg census blocks) and smaller values (eg the number of Asian females aged 60+ who live in Union, CT). Hence, one needs to be critical when using ACS or other survey data.

Data.census.gov

Data.census.gov (<https://data.census.gov>) is the main platform to access US Census data. It provides an easy search across census and survey tables. There is an interface to view tables for various years and geographies, and a download button to save data as CSV or PDF. It replaced American FactFinder (<https://factfinder.census.gov>) in July 2019.

Social Explorer

Social Explorer (<https://www.socialexplorer.com/>) is a popular tool to view and download census and related demographic data, past and present. The platform allows users to create data maps that may be exported as static images or presentation slides. Social Explorer requires subscription, but many academic institutions provide access.

TODO: create tutorial on how to cleanly download census data from Social Explorer and Census.gov to join with geography, especially census tract numbers

Census areas are geographic divisions in this *general format*:

- State
- County
- County subdivisions (equivalent to Connecticut towns and cities)
- Census tracts (designated areas, roughly 2,500 to 8,000 people)
- Block groups (sub-unit of tract, roughly 600 to 3,000 people)
- Census blocks (sub-unit of block group, but not always a city block)

ADD individual data from Census Manuscript available 70+ years later – link to national archives

The interactive map below illustrates hierarchical relations among geographical census entities for the Hartford region, from state to census block level.

Learn more: Explore the standard hierarchy of US Census geographic entities and definitions (<https://www2.census.gov/geo/pdfs/reference/geodiagram.pdf>)

See also in this book: Geocode addresses with the US Census Geocoder

National Center for Education Statistics

National Center for Education Statistics (NCES) (<https://nces.ed.gov/>) is the primary federal agency for collecting and reporting education data.

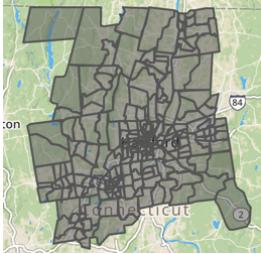
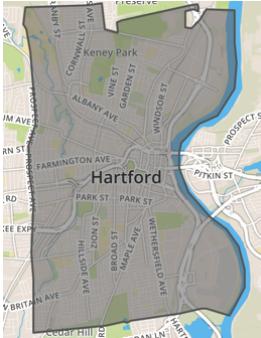
- Elementary/Secondary Information System (ELSi) (<https://nces.ed.gov/ccd/elsi>) - create custom tables and charts from the Common Core of Data (CCD) and Private School Survey.

Boundaries

- Converted from shapefile WGS84 to GeoJSON format
- To download a GeoJSON file, right-click the link and Save to your computer
- If you accidentally open the GeoJSON code in your browser, select File > Save Web Page to download it
- To view or edit, drag files into <http://geojson.io> or <http://mapshaper.org>
- Learn more in the Transform Your Map Data chapter of this book

Geography	Year-Source-Size	Right-click + Save to download GeoJSON
CT outline	2010 Census UConn MAGIC WGS84 1:100,000	ct- outline.geojson
CT counties	2010 Census UConn MAGIC WGS84 1:100,000	ct- counties.geojson

Geography	Year-Source-Size	Right-click + Save to download GeoJSON
CT towns	2010 Census UConn MAGIC WGS84 simplified to 224k	ct- towns.geojson
CT census tracts	2010 Census UConn MAGIC WGS84 1:100,000	ct-tracts- 2010.geojson
Hartford County outline	2010 Census UConn MAGIC WGS84 1:100,000	hartfordcounty- outline.geojson
Hartford County towns	2010 Census UConn MAGIC WGS84 1:100,000	hartfordcounty- towns.geojson

Geography	Year-Source-Size	Right-click + Save to download GeoJSON
Hartford County tracts	2010 Census UConn MAGIC WGS84 1:100,000	hartfordcounty-tracts-2010.geojson
		
Hartford outline	2010 Census UConn MAGIC WGS84 1:100,000	hartford-outline.geojson
		
Hartford census tracts	2010 Census UConn MAGIC WGS84 1:100,000	hartford-tracts-2010.geojson
		

Geography	Year-Source-Size	Right-click + Save to download GeoJSON
Hartford neighborhoods	2015 Hartford Open Data 1:50,000	hartford-neighborhoods.geojson



The map displays the city of Hartford, Connecticut, with its neighborhood boundaries outlined in black. Labeled streets include Park Street, Prospect Street, Pitkin Street, Broad Street, Jay Street, and Farmington Avenue. Other features shown include the Connecticut River, the Greenway, and several parks and preserves such as Bushnell Park, Colt Park, and Kliney Park. The map also shows the location of the State Capitol building.

TODO: - add Capitol Region Council of Governments (CRCOG) <http://www.crcog.org/> - add school districts (and clarify elementary-secondary) - add Capitol Region Education Council (CREC) <http://www.crec.org/> - add school attendance areas from federal site - describe Freedom of Information Act (FOIA) data requests in Connecticut

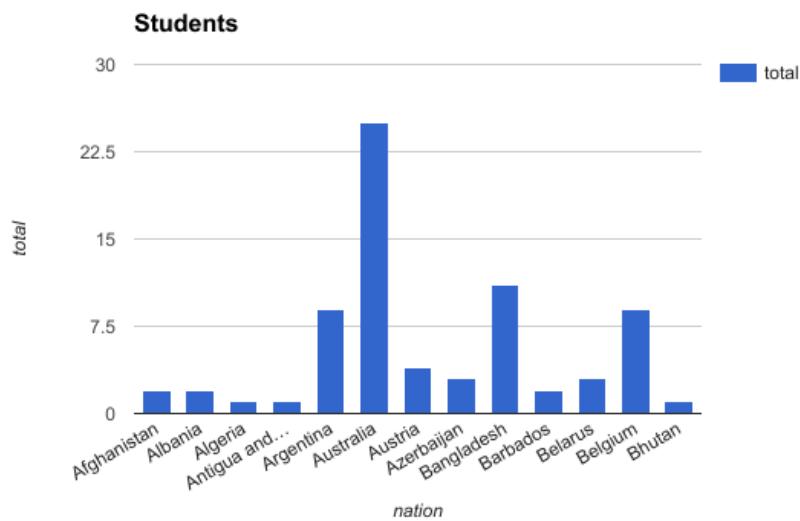
Appendix C

Peer Review Samples

ONLY FOR WEB EDITION: The next pages include partial-credit and full-credit samples for peer review in the Data Visualization for All edX course.

Section 2 Chart 1 Peer Review Sample

Students in the Data Visualization for All course come from several different countries, including Australia, Bangladesh, and Belgium.

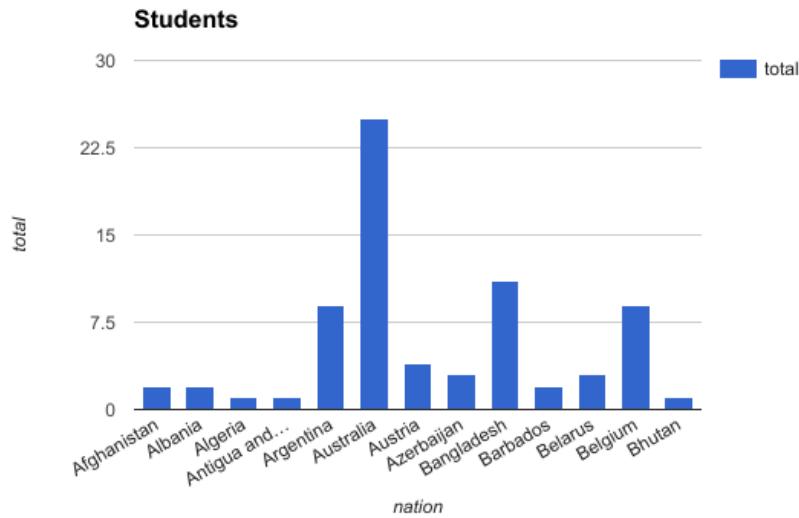


Evaluate

1. Story: Did the author clearly tell a meaningful story about the data, with text and visuals?
2. Chart Type: Did the author choose a chart type that best matches their data story?
3. Embed: Did the author embed an interactive chart into the web page?
4. Good Design: Did the author follow principles of good chart design?

Section 2 Chart 1 Peer Review Sample with Notes

Students in the Data Visualization for All course come from several different countries, including Australia, Bangladesh, and Belgium.



Evaluate

1. Story: Did the author clearly tell a meaningful story about the data, with text and visuals?
 - No, this simple statement that students come from “several different countries” is not a very meaningful story.
2. Chart Type: Did the author choose a chart type that best matches their data story?

- No. Although a vertical column chart is a good start, a horizontal bar chart would be a better match for these long labels.
3. Embed: Did the author embed an interactive chart into the web page?
- No, when you try to float your cursor over the chart, it is a static image, not an interactive visualization.
4. Good Design: Did the author follow principles of good chart design?
- No, the chart ignores several design principles, such as:
 - Failure to sort data into a meaningful order
 - Failure to declutter the chart by removing the unnecessary legend

Section 2 Chart 2 Peer Review Sample

Nations with the highest percentage of female students enrolled in Data Visualization for All are the Ukraine (51 percent) and Turkey (47 percent), based on preliminary data for those with high enrollment levels (25 or more students).

View the preliminary data for 21 Feb 2017 from <http://handsondataviz.org>

Evaluate

1. Story: Did the author clearly tell a meaningful story about the data, with text and visuals?
2. Chart Type: Did the author choose a chart type that best matches their data story?
3. Embed: Did the author embed an interactive chart into the web page?
4. Good Design: Did the author follow principles of good chart design?

Section 2 Chart 2 Peer Review Sample with Notes

Nations with the highest percentage of female students enrolled in Data Visualization for All are the Ukraine (51 percent) and Turkey (47 percent), based on preliminary data for those with high enrollment levels (25 or more students).

View the preliminary data for 21 Feb 2017 from <http://handsondataviz.org>

Evaluate

1. Story: Did the author clearly tell a meaningful story about the data, with text and visuals?
 - Yes, this insight on gender differences in student enrollments across nations is a meaningful story.
2. Chart Type: Did the author choose a chart type that best matches their data story?
 - Yes, this stacked horizontal bar chart is a good match for showing part-to-whole relationships (gender by percentage) between different nations.
3. Embed: Did the author embed an interactive chart into the web page?
 - Yes, when you float your cursor over it, the interactive chart tooltip shows data labels and values.
4. Good Design: Did the author follow principles of good chart design?
 - Yes, the chart demonstrates good design principles, such as:
 - Sorting data into a meaningful order
 - Using color contrast (blue vs grays) to highlight percentages of female students

Section 3 Peer Review Sample 1

My Leaflet map**My Highcharts scatter chart****Evaluate**

1. Leaflet map and title: Did the author embed an interactive Leaflet map with a new title?
2. Leaflet map layers: Did the author add controls that toggle on/off different map layers?
3. Leaflet point markers: Did the author upload a new set of markers, with pop-ups that show titles for each point?
4. Highcharts scatter chart: Did the author embed an interactive Highcharts scatter chart with a new title and axis labels?

5. Highcharts data tooltips: Did the author upload a new set of data, with tooltips that show labels and details for each point?
6. Additional comments for the author. What works well? What could be improved?

Section 3 Peer Review Sample 1 with Notes

My Leaflet map

My Highcharts scatter chart

Evaluate

1. Leaflet map and title: Did the author embed an interactive Leaflet map with a new title?
 - No, the map title is the same as the original template, and is not new.
2. Leaflet map layers: Did the author add controls that toggle on/off different map layers?
 - No, the map does not contain layer controls.
3. Leaflet point markers: Did the author upload a new set of markers, with pop-ups that show titles for each point?
 - No, the map only contains one point, and the author did not upload a new set of points.
4. Highcharts scatter chart: Did the author embed an interactive Highcharts scatter chart with a new title and axis labels?
 - No, the chart title and axis labels are the same as the original template, and are not new.
5. Highcharts data tooltips: Did the author upload a new set of data, with tooltips that show labels and details for each point?
 - No, the author did not upload a new set of data points.
6. Additional comments for the author. What works well? What could be improved?

Section 3 Peer Review Sample 2

My Leaflet map

My Highcharts scatter chart

Evaluate

1. Leaflet map and title: Did the author embed an interactive Leaflet map with a new title?
2. Leaflet map layers: Did the author add controls that toggle on/off different map layers?
3. Leaflet point markers: Did the author upload a new set of markers, with pop-ups that show titles for each point?
4. Highcharts scatter chart: Did the author embed an interactive Highcharts scatter chart with a new title and axis labels?
5. Highcharts data tooltips: Did the author upload a new set of data, with tooltips that show labels and details for each point?
6. Additional comments for the author. What works well? What could be improved?

Section 3 Peer Review Sample 2 with Notes

My Leaflet map

My Highcharts scatter chart

Evaluate

1. Leaflet map and title: Did the author embed an interactive Leaflet map with a new title?
 - Yes, the title in this map has changed from the original template
2. Leaflet map layers: Did the author add controls that toggle on/off different map layers?
 - Yes, this map contains map layer controls.
3. Leaflet point markers: Did the author upload a new set of markers, with pop-ups that show titles for each point?

- Yes, this map contains new points that were added to the original template.
4. Highcharts scatter chart: Did the author embed an interactive Highcharts scatter chart with a new title and axis labels?
- Yes, this chart contains a new title and axis labels.
5. Highcharts data tooltips: Did the author upload a new set of data, with tooltips that show labels and details for each point?
- Yes, this chart contains a new set of data points that were uploaded to the original.
6. Additional comments for the author. What works well? What could be improved?

Appendix D

Publishing with Bookdown

This open-access book is built with free-to-use, open-source tools—primarily Bookdown, GitHub, and Zotero—and this chapter explains how, so that readers may do it themselves and share their knowledge to improve the process. In addition to our notes below, see also Yihui Xie’s more comprehensive Bookdown guide.¹

Our broad goal is an efficient workflow to compose one document in the easy-to-write Markdown format that Bookdown generates into multiple book products: an HTML web edition to read online, a PDF print edition for traditional book publishing, a Microsoft Word edition for editors who request it for copyediting, and option for other formats as desired.

Since Bookdown is an R code package, we composed the book manuscript in R-flavored Markdown, with one file (.Rmd) for each chapter. We use Bookdown to build these files in its GitBook style as a set of static HTML pages, which we upload to our GitHub repository. Readers can view the open-access web edition of the book at our custom domain: <https://HandsOnDataViz>. Also, we use Bookdown to build additional book outputs (PDF, MS Word, Markdown) and upload these to the `docs` folder of our GitHub repository, so that our O’Reilly Media editor may download and comment on the manuscript as we revise. Finally, we also have the option to use Pandoc alone to convert the full-book Markdown file (.md) into an AsciiDoc file (.asciidoc) for easier importing into the O’Reilly Atlas platform. See some caveats and workarounds below.

File Organization and Headers

We organized the GitHub repository for this book as a set of .Rmd files, one for each chapter. As co-authors, we are careful to work on different chapters of the

¹Yihui Xie, *Bookdown: Authoring Books and Technical Documents with R Markdown*, 2018, <https://bookdown.org/yihui/bookdown/>

book, and to regularly push our commits to the repo. Only one of us regularly builds the book with Bookdown to avoid code merge conflicts.

Bookdown assigns a default ID to each header, which can be used for cross-references. The default ID for **# Topic** is `{#topic}`, and the default ID for **## Section Name** is `{#section-name}`, where spaces are replaced by dashes. But we do *not* rely on default IDs because they might change due to editing or contain duplicates across the book.

Instead, we *manually assign a unique ID* to each first- and second-level header in the following way. Note that the `{-}` symbol, used alone or in combination with a space and a unique ID, prevents auto-numbering in the second- thru fourth-level headers:

```
# Top-level chapter title {#unique-name}
## Second-level section title {- #unique-name}
### Third-level subhead {-}
#### Fourth-level subhead {-}
```

Also, we match the unique ID keyword to the file name for top-level chapters this way: `01-keyword.Rmd` to keep our work organized. Unique names should contain only *alphanumeric* characters (a-z, A-Z, 0-9) or dashes (-).

Subheaders must have unique names or IDs to avoid Bookdown errors about duplicated references. To avoid this issue for repeated subheaders (such as “Summary”), at the end of each chapter insert a third-level summary subhead, but insert a unique ID that matches each chapter number, like this: `### Summary {- #summary17}`

A special header in this book is the unnumbered header beginning with `(APPENDIX)`, which indicates that all chapters appearing afterwards are appendices. According to Bookdown, the numbering style will appear correctly in HTML and LaTeX/PDF output, but not in Word or ebooks.

```
# Chapter One
# Chapter Two
# (APPENDIX) Appendix {-}
# Appendix A
# Appendix B
```

In the Bookdown `index.Rmd` for the HTML book output and the PDF output, the `toc_depth: 2` setting displays chapter and section headers down to the second level in the Table of Contents.

The `split_by: section` setting divides the HTML pages at the second-level header, which creates shorter web pages with reduced scrolling for readers. For each web page, the unique ID becomes the file name, and is stored in the `docs` subfolder.

The `number_sections` setting is true for the HTML and PDF editions, and given the `toc_depth: 2`, this means that they will display two-level chapter-section numbering (1.1, 1.2, etc.) in the Table of Contents. Note that `number_sections` must be true to display Figure and Table numbers in `x.x` format, which is desired for this book. See relevant settings in this excerpt from `index.Rmd`:

```
output:
  bookdown::gitbook:
    ...
    toc_depth: 2
    split_by: section
    number_sections: true
    split_bib: true
    ...
  bookdown::pdf_book:
    toc_depth: 2
    number_sections: true
```

Note that chapter and section numbering do *not* appear automatically in the MS Word output unless you supply a `reference.docx` file, as described below:

- <https://bookdown.org/yihui/rmarkdown/word-document.html>
- <https://stackoverflow.com/questions/52924766/numbering-and-referring-sections-in-bookdown>
- <https://stackoverflow.com/questions/50609212/caption-styles-for-word-document2-in-bookdown>

In the `_bookdown.yml` settings, all book outputs are built into the `docs` subfolder of our GitHub repo, as shown in this excerpt:

```
output_dir: "docs"
book_filename: "HandsOnDataViz"
language:
  label:
    fig: "Figure "
  chapter_name: "Chapter "
```

In our GitHub repo, we set GitHub Pages to publish to the web using `master/docs`, which means that visitors can browse the source files at the root

level, and view the HTML web pages hosted in the `docs` subfolder. We use the GitHub Pages custom domain setting so that the HTML edition is available at <https://HandsOnDataViz.org>.

The `docs` subfolder also may contain the following items, which are *not* generated by Bookdown and need to be manually created:

- CNAME file for the custom domain, generated by GitHub Pages.
- `.nojekyll` invisible empty file to ensure speedy processing of HTML files by GitHub Pages.
- `404.html` custom file to redirects any mistaken web addresses under the domain back to the `index.html` page.

One more option is to copy the Google Analytics code for the web book, paste it into an HTML file in the book repo, and include this reference in the `index.Rmd` code:

```
output:
bookdown::gitbook:
...
includes:
in_header: google-analytics.html
```

Style Guide for *Hands-On Data Visualization*

View the underlying source code to understand how this page was composed at:
<https://github.com/HandsOnDataViz/book/blob/master/17-bookdown.Rmd>

This book is composed in R-flavored Markdown (.Rmd), and each paragraph begins on a separate line. O'Reilly style guide prefers *italics* rather than bold. Use single back ticks to display a monospaced `code` word.

O'Reilly guidelines recommend making your writing as conversational as possible. Imagine you're speaking to someone one on one, not giving a formal lecture to a large group. Refer to the reader as "you" and to yourself as "I" for a single-author book, and refer to yourselves as "we" for a co-authored book. Use active voice, not passive voice.

More from O'Reilly about chapter structure: Each chapter should begin with a paragraph or two that summarizes what the chapter is about and why that information is important to the overall topic of your book. Subsequent sections should walk readers through the information you're presenting. Keep readers oriented by including signposts like "As you learned in Chapter 3" and "I'll discuss this topic in more detail later in this chapter."

More from O'Reilly about transitions: End section X by saying something like, "Now that you understand X, you're ready to dig into topic Y," and start

section Y by explaining how it relates to topic X. Daisy-chaining helps readers understand how concepts are connected and why you're covering them in this order. Finally, at the end of each chapter, summarize what you discussed in that chapter, and mention what the following chapter is going to cover.

O'Reilly encourages the use of tips, notes, and warnings, and assigns each of them an animal icon in their books (lemur, crow, and scorpion, respectively). In this book manuscript, simply start each with a paragraph beginning with the keyword, followed by a colon, to simplify find-and-replace at a later date:

- Tip: A couple of sentences that convey a helpful bit of information, a quick way to do things better.
- Note: A couple of sentences of supplemental information. It describes something you want readers to keep in mind as they work, so you use a note to set it apart and make sure they see it.
- Warning: Similar to a note or tip, but specifically focused on a way to help readers avoid making a mistake or getting into trouble.

Also:

- Sidebar: Use this to note where the editor has requested a boxed sidebar. If longer than one paragraph, add “End Sidebar” to close it.

Insert an embedded link to O'Reilly. This appears as a colored clickable link in HTML and Word editions, and a non-colored but clickable link in the PDF edition. According to O'Reilly Atlas documentation, the AsciiDoc version should automatically unfurl for the printed edition.

Also, embed the link directly in the sentence, such as download this sample PDF. Avoid linking words such as “here” or “this web page.” Also, avoid writing “Click on this...” in the main text, such as when downloading a sample file, since readers cannot click on the print edition. However, it is acceptable to write “click on” or “right-click on” in a tutorial on interacting with software.

When instructions refer to software menu items, use italics. Example: Select *File > Make a Copy* to save your own version to your Google Drive.

For lists, always insert a blank line *before* the items, unless they appear directly after hashtag header.

- unordered
 - list
1. ordered
 2. list

Dashes:

- Use a hyphen (1 dash) for hyphenated words, such as two-thirds or dog-friendly hotel.
- Use an en-dash (2 dashes) for ranges, such as the May–September magazine issue.
- Use an em-dash (3 dashes) to insert an additional thought—like this—in a sentence.

Insert `TODO` to note items to finish or review with co-author or editor.

Insert three back ticks to insert a code block. Check character line length limits in O'Reilly style guide:

```
<link rel="stylesheet" href="https://unpkg.com/leaflet@1.6.0/dist/leaflet.css" />
<script src="https://unpkg.com/leaflet@1.6.0/dist/leaflet.js"></script>
```

Conditional Formatting

Conditional formatting offers the option to display text or images in some editions, but not other editions. Options:

1. Insert a HTML code comment `<!-- Comment -->` in the .Rmd file to hide a few lines of text. This appears as commented-out text in the HTML and .md formats, is not displayed in the HTML browser, and does not appear in any way in the PDF, MS Word or AsciiDoc formats.

Demo:

2. R package function `is_[html/latex]_output` allows conditional output for different book products, such as text that should appear in the HTML edition but not the PDF edition, or vice versa.

Demos:

This line appears in the PDF and Word versions, and is commented-out in the HTML and Markdown and AsciiDoc versions.

TODO: Create conditional formatting that displays *only* in the HTML edition, and allows the inclusion of R code-chunks to conditionally display images. See links for more complex conditional formatting:

- <https://stackoverflow.com/questions/56808355/how-to-conditionally-process-sections-in-rmarkdown>

- <https://bookdown.org/yihui/rmarkdown-cookbook/latex-html.html>
- <https://blog.earo.me/2019/10/26/reduce-frictions-rmd/>
- <https://stackoverflow.com/questions/53861244/html-specific-section-in-bookdown>
- <https://stackoverflow.com/questions/41084020/add-a-html-block-above-each-chapter-header>
- <https://stackoverflow.com/questions/45360998/code-folding-in-bookdown>

3. Option to customize the `style.css` code for the HTML book.
4. Option to add headers, footers, preambles to the HTML or LaTeX versions.
5. Build different versions of the HTML and LaTeX (PDF) books using different chapters by listing them in order in the `_bookdown.yml` file:

```
rmd_files:
  html: ["index.Rmd", "abstract.Rmd", "intro.Rmd"]
  latex: ["abstract.Rmd", "intro.Rmd"]
```

Cross-references

In order to cross-reference in Bookdown, assign a unique name or R code-chunk label to each chapter, section, figure, and table. Unique names and labels should contain only *alphanumeric* characters (a-z, A-Z, 0-9) or dashes (-).

To cross-reference any *chapter or section*, and allow readers to jump there, use a HTML link with the unique name, such as `index.html` or `style-guide.html`. Demos:

- See Introduction
- See “Style Guide” in Chapter x.

Contrary to the Bookdown manual, *avoid* using Bookdown unique ID links to cross-reference chapters or sections, because these create extraneous and imprecise URLs, such as this bad example.

To cross-reference figures and tables, and display their auto-number and allow readers to jump there, write a call-out with a Bookdown reference to a code-chunk label, such as `See Figure \eref{fig:sample-map}` or `See Table \eref{tab:left-table}`. Demos:

- See Figure D.1.
- See Table D.2.

Cross-reference interactivity varies by output:

- In HTML, all cross-refs are clickable.
- In PDF, all cross-refs are clickable (except chapter-level HTML links).
- In Word, no cross-refs are clickable (unless this varies with reference.docx).
- TBA with Markdown (.md) and AsciiDoc.

When writing cross-references in the text, the O'Reilly Style Guide prefers live cross references (e.g., "see Figure 2-1"), but if not feasible, use "preceding" or "following" because physical placement of elements may vary across print and digital formats. *Avoid* using "above" or "below."

Images

View the underlying source code to understand how this page was composed at:
<https://github.com/HandsOnDataViz/book/blob/master/17-bookdown.Rmd>

Create high-resolution color screenshots and other static images in .png or .jpg format, with tight cropping on a high-resolution Retina monitor, typically at 144 ppi. Save items into the `images` subfolder by chapter. Make sure that color images include high contrast and/or shading, because they will be converted to grayscale by the publisher for the print book. Write file names in lowercase with dashes (not spaces) and begin with keyword of relevant section to keep related images grouped together. Despite being in separate folders, avoid duplicate image file names across the book. Avoid numbering images since they may not match the final sequence.

If a screenshot requires additional artwork or text for the HTML edition, make a copy of the original and add `-ann` to note that this version is annotated, save into the same folder with the same root file name, and use in the code-chunk image pathnames. The publisher will use the original image and add their own artwork for their editions.

If an image is larger than approximately 300px on either side, one more option is to reduce the image size in the PDF version. Use Photoshop (*not* Preview) to reduce the image size, and save a copy with the same file name with the .pdf extension into the folder.

In some cases (such as images inside Markdown tables, or static screenshots to accompany iframes), it may make sense to save a full-size version, with `-original` in the file name, for the publisher to use when creating the print book.

Overall, sometimes the folder will contain only one version of a simple image, but in other cases it may contain up to 3-4 versions of an image:

```
images/05-chart/design-setup.png
images/05-chart/design-setup-ann.png
```

```
images/05-chart/design-setup-ann.pdf
images/05-chart/design-setup-original.png
```

If creating images to appear as the same size in sequence, add a code-comment with the image width, height, and resolution as a reminder to make others match up, like this:

```
<!-- Images below are 200x200 at 300 resolution -->
```

In this book, use *Markdown formatting only for images that appear inside tables or do not require captions or figure numbering*, and leave the caption field blank, like this example:

Co-Authors	About Us
	About Jack Dougherty
	About Ilya Ilyankou

Although Markdown formatting offers a simple syntax that easily converts into other formats with Bookdown/Pandoc, there is no auto-numbering in the HTML edition, while auto-numbering appears in the PDF edition, and numbered figures are required by the publisher. Furthermore, Markdown formatting does not allow conditional output.

Images using R code-chunks

For these reasons, this book *primarily uses R code-chunk formatting for images*. The syntax is more complex but supports auto-numbering in HTML and PDF, and conditional output for interactive and static images. Note that R code-chunk images do *not* easily convert with Pandoc from Markdown to AsciiDoc, but “Figure x Caption” appears as a placeholder.

Auto-numbering appears in `Figure x.x` format in HTML and PDF, but `Figure x` format in MS Word. Note that Word formatting can be changed with `reference.docx`.

Note that images in PDF output will “float” by design and may appear before or after the desired page, so always add a cross-reference call-out.

Write R code-chunk labels that follow the image file name, and avoid duplicate labels across the book:

```
ref:design-setup
images/05-chart/design-setup.png
```

Do not insert spaces inside the `ref:chunk-label` for the caption, but add a blank line to separate it from the code-chunk. After the code-chunk, add *another* blank line to avoid “undefined reference” Bookdown errors.

For each figure, manually add a cross-reference call-out and insert `fig.pos='h'` to place the image “here” on the page in the PDF output, to *attempt* to avoid PDF floating. Ignore the Bookdown LaTeX warning message “h float specifier changed to ht.” See more at <https://bookdown.org/yihui/bookdown/figures.html> and <https://bookdown.org/yihui/rmarkdown-cookbook/figure-placement.html>

This Bookdown `index.Rmd` file includes two global R code-chunk settings immediately after the first header. One setting displays each code-chunk image without a code echo. The other setting automatically inserts the PDF version of an PNG/JPG image, whenever it exists, in the PDF output, which allows us to manually reduce the image sizes for the PDF book. Read more about these options in this Bookdown chapter: <https://bookdown.org/yihui/bookdown/figures.html>.

```
{r setup, include=FALSE}
knitr::opts_chunk$set(echo = FALSE)
options(knitr.graphics.auto_pdf = TRUE)
```

Demo: R code-chunk for small static image for HTML and PDF editions

Small is defined as each side less than 300px, as shown in Figure D.1.

R code-chunk for larger static image using out.width and PDF img

For larger images, where one side is greater than 300px, set the `out.width` to a pixel number for ideal display in the HTML edition. Also optional to reduce float in PDF: `fig.pos='h'`,. If necessary, copy the image, use Photoshop to create a smaller image size, and save with same file name and a .pdf extension for auto-substitution in the PDF output ...as shown in Figure D.2.



Figure D.1: Caption here. Markdown embedded links are acceptable.

	Location
1	300 Summit St, Hartford, CT
2	84 Scarborough St Hartford CT
3	4 Frederick Rd, West Hartford
4	4 Fredrick Rd, West Hartford
5	4 Fredric Rd, West Hartford
6	4 Fredric Rd, West Hartford
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	

Figure D.2: Using `out.width=200` and smaller PDF image size.

R code-chunks allow more complex conditional formatting, where an interactive map or animated GIF or YouTube video clip appears in the web version, and a static image with an embedded link appears in the PDF and MS Word outputs. To change the height of the default 400px iframe, add the new height to `include_url` as shown in the examples. However, to change the width of the default 675px iframe to less than 100 percent, add a line in a `custom-scripts.html` file.

Demo: R code-chunk for iframe in HTML and static image in PDF

... as shown in Figure D.3.

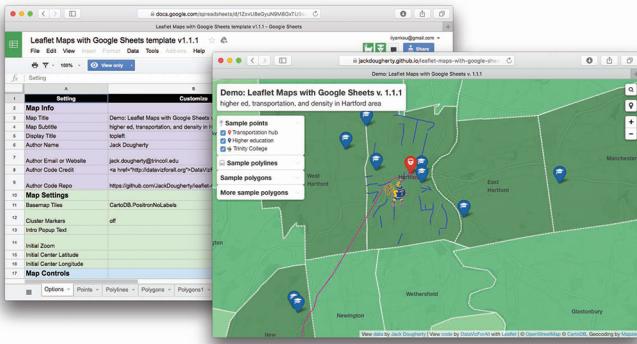


Figure D.3: Caption here, and add embedded link to explore the full-screen interactive map.

Demo: R code-chunk for animated GIF in HTML and static image in PDF

When appropriate, create animated GIF files using Camtasia, and add fade-to-black to mark the end-point in the looped version. Add ... as shown in Figure D.4.

Demo: R code-chunk for Youtube video in HTML and static image in PDF

Be sure to use the *embed* link from the YouTube *share* button.

... as shown in the video D.5.

	A	B
1	1	
2	2	
3	3	
4	4	
5	5	
6	6	
7		

Figure D.4: Caption here, with embedded link to the animated GIF.

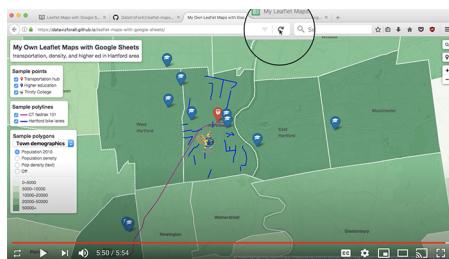


Figure D.5: Caption here, with embedded link to the YouTube video.

Demo: R code-chunk for YouTube video in HTML, with NO static image in PDF

This option may be relevant when you wish to display a video only in the HMTL edition, with no screenshot of it in the PDF edition. Note that this will alter figure-numbering between the HTML and PDF editions.

Tables

View the underlying source code to understand how this page was composed at:
<https://github.com/HandsOnDataViz/book/blob/master/17-bookdown.Rmd>

Create tables in Markdown format, since it produces good output for HTML, PDF, Word, and Markdown. Use a tool such as Tables Generator to import significant table data in CSV format, format the column alignment as desired, and press Generate button to create table in Markdown format. For significant table data, save the CSV version in a GitHub repo for potential later use.

TODO: Check if any un-numbered Markdown tables in the chapter affect table auto-numbering.

Add the Markdown table code shown below to auto-number (Table x) in HTML, PDF, Word.

...as shown in Table D.2.

Table D.2: Left-justify content, remember blank Line

Much Much Longer Header	Short Header	Short Header
Left-justify text content with left-colons	Less	Here
Use more hyphens to grant more space to some columns	Less	Here

Table D.3: Right-justify content, remember blank line

Header1	Header2	Header3
123	456	789
Right-justify	numerical content	with right-colons
Use equal hyphens	to make equal space	for all columns

Workaround for Markdown-to-AsciiDoc: Currently, our attempt to use Pandoc to directly convert a Bookdown-generated Markdown file to AsciiDoc fails because Bookdown creates the .md file with tables in .html format, not Markdown. Our workaround is to paste the individual Markdown-formatted tables directly from the .Rmd into the large .md file prior to converting with Pandoc to AsciiDoc.

Notes and Bibliography

This book displays endnotes for each chapter in the HTML book, and footnotes at the bottom of pages for the PDF and MS Word books, followed by an alphabetized bibliography of all references cited on the last page. The notes and bibliography also appear in the full-book Markdown file.

To create notes, insert citation keys in the text, such as @huffHowLieStatistics1954, which are generated by Zotero bibliographic database with the Better Bib-Tex extension, and export these in the *Better BibLaTeX* format into the `dataviz.bib` in the book repo. The repo also contains `.csl` file to generate the notes and bibliography in a specific Chicago-style format, downloaded from the Zotero Styles Repository. These instructions are referenced in the `index.Rmd` file for both the HTML and PDF formats, as shown in these excerpts:

```
bibliography: dataviz.bib
citation-style: chicago-fullnote-bibliography.csl
...
output:
```

```

bookdown::gitbook:
  ...
  pandoc_args: [ "--csl", "chicago-fullnote-bibliography.csl" ]

bookdown::pdf_book:
  ...
  citation_package: none
  pandoc_args: [ "--csl", "chicago-fullnote-bibliography.csl" ]

```

Here's a text-only note, with no Zotero citation.²

To create a note with citations only, separate Zotero/BibTeX citation keys with semi-colons:³

Since notes also may include text and punctuation in Markdown syntax, always insert a caret symbol prior to the brackets to demarcate a note:⁴

Note that the `chicago-fullnote-bibliography.csl` format automatically shortens the note after its first reference.

Manual Pandoc Conversion to AsciiDoc

The O'Reilly Atlas platform can import AsciiDoc documents. While Bookdown does not directly generate this format, one workaround is to use the Bookdown-generated large Markdown file, and manually convert it with Pandoc to AsciiDoc format.

See also workaround notes in the Tables section and other sections above.

- Download Pandoc
- Build the book with Bookdown, including one large Markdown file (docs folder, suffix .md)
- Manually rename it as HandsOnDataViz-modified.md
- Manually paste in these Markdown tables (to replace HTML tables)
 - table of authors in index.Rmd
 - table of charts in 05-chart.Rmd
- Use command line to navigate to subfolder with `pwd` and `cd`.
- Convert with: `pandoc handsondataviz-modified.md --from markdown --to asciidoc --standalone --output handsondataviz-modified.asciidoc`

²This is a note, with no bibliographic reference.

³Darrell Huff, *How to Lie with Statistics* (W. W. Norton & Company, 1954–2010), <http://books.google.com/books?isbn=0393070875>; Mark S. Monmonier, *How to Lie with Maps*, 2nd ed. (University of Chicago Press, 1996), <http://books.google.com/books?isbn=0226534219>

⁴Compare how “lying” is justified by Huff, *How to Lie with Statistics*, pp. 10-11 and Monmonier, *How to Lie with Maps*, pp. 11-12.

Huff, Darrell. *How to Lie with Statistics*. W. W. Norton & Company, 1954–2010. <http://books.google.com/books?isbn=0393070875>.

Monmonier, Mark S. *How to Lie with Maps*. 2nd ed. University of Chicago Press, 1996. <http://books.google.com/books?isbn=0226534219>.

Xie, Yihui. *Bookdown: Authoring Books and Technical Documents with R Markdown*, 2018. <https://bookdown.org/yihui/bookdown/>.