Visualize your data with simplicity, accuracy and beauty

Kate Bredbenner (John Wiley & Sons, USA)

Creating a compelling visual representation of your data can be challenging, but it is worth it. Infographics and graphical abstracts are common forms of data visualizations within the world of science, but no matter what you call them, these visuals are short stories meant to be shared widely. When done well, a visualization of your data can attract new readers and quickly tell them the main point of your research. Your visual can get more people to read your paper and engage with you about your research. In this article, we'll talk through the steps of making a simple, accurate and beautiful visual that is sure to catch the eyes of readers everywhere.

Deciding to make a data visualization

There is nothing quite like getting a positive result from an experiment. Maybe it is the first time you ran it or, let's be honest, it's probably the 500th time, but still, there you are with this new shiny result. The first feelings are often surprise, followed by vindication and then finally scepticism. Is this result an artefact? Have I done the proper controls? In short, is this real? Once you've quelled those concerns, run the controls, done another literature search (or five) and your scientist's scepticism is soothed, you're now alone with your answer to one of life's little mysteries.

Even though you've answered your scientific question, you need to share those results with the scientific community to move our collective knowledge forward. You'll want to write up and publish a full-fledged journal article complete with all the details, but you might want to share your results as a short data visualization as well. A data visualization, like an infographic or a graphical abstract, can do wonders for your paper. Whether you share it at a field-specific conference or tweet it out to a bunch of strangers, a visual can draw people in and have them understand and appreciate your scientific contribution to the world.

Preparing a compelling and effective visual can be daunting, but there are three elements to any successful visualization of data: simplicity, accuracy and beauty. A visual that is simple and accurate, but not beautiful, won't draw others to your results and make them want to stay a while. A visual that is simple and beautiful without being accurate is an insult to the hard work you put in and misleading to your readers. Finally, a visual that is accurate and beautiful, but not simple, can confuse your readers as they struggle to understand the story you're telling. With a visual that is simple, accurate and beautiful, you can draw readers to your research, tell them a compelling story backed up by data and have them share that story with their friends and colleagues. Since there is so much to gain with a good visual, let's focus on hitting the sweet spot of simplicity, accuracy and beauty.
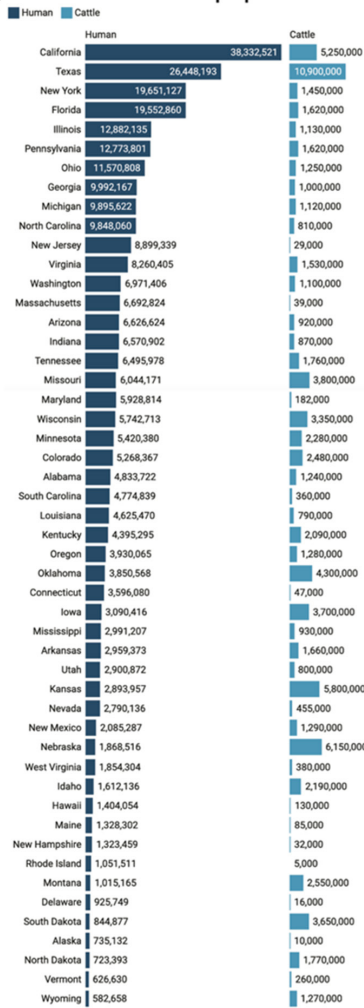
Mastering the art of simplicity

I recommend starting with simplicity because it is often the hardest of the three to master. You've just spent a significant amount of time getting all the data you need to answer your scientific question. Now, you need to condense all of that work, complete with caveats and details, down to a single concise finding. The simplification process is often the easiest (and most fun) to do with a friend who isn't already familiar with your work. Grab some pizza and your beverage of choice and regale them with the story of your research! Then, after you've talked for a bit, ask them to summarize it back to you.
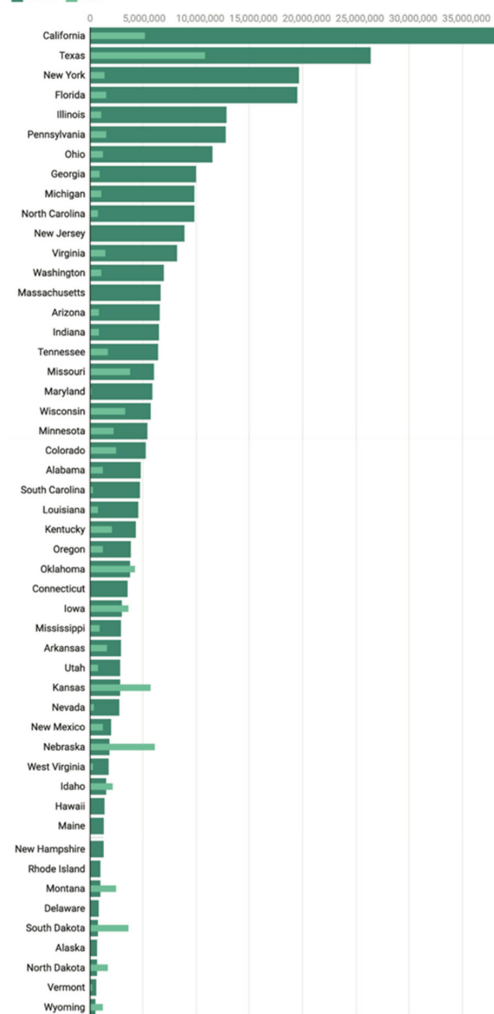
Your friend's summary definitely won't have all the details that you gave, but it probably has the main point of your research. If it's missing the main point, then you need to work on explaining your results more simply and clearly. This is an iterative process and failure is a good thing. It's how you learn what is understandable and what is just confusing. Good scientific process suggests that you should do experiments in triplicate to be sure of your results. Simplifying your story isn't any different. Try to explain your research to three different friends in series. By the third time through, you should be able to summarize the main point of your research in two sentences. One is even better if you can manage it. Remember, practice makes perfect and simplification is the hardest part.

Although I've only outlined one approach for working on simplifying your results, it's an approach that
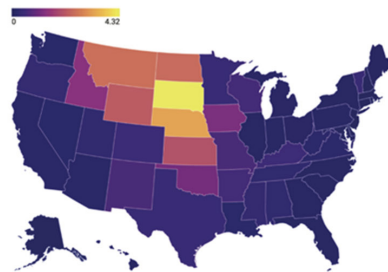
(a) Human and cattle populations

■ Human ■ Cattle

	Human	Cattle
California	38,332,521	5,250,000
Texas	26,448,193	10,900,000
New York	19,651,127	1,450,000
Florida	19,552,860	1,620,000
Illinois	12,882,135	1,130,000
Pennsylvania	12,773,801	1,620,000
Ohio	11,570,808	1,250,000
Georgia	9,992,167	1,000,000
Michigan	9,895,622	1,120,000
North Carolina	9,848,060	810,000
New Jersey	8,899,339	29,000
Virginia	8,260,405	1,530,000
Washington	6,971,406	1,100,000
Massachusetts	6,692,824	39,000
Arizona	6,626,624	920,000
Indiana	6,570,902	870,000
Tennessee	6,495,978	1,760,000
Missouri	6,044,171	3,800,000
Maryland	5,928,814	182,000
Wisconsin	5,742,713	3,350,000
Minnesota	5,420,380	2,280,000
Colorado	5,268,367	2,480,000
Alabama	4,833,722	1,240,000
South Carolina	4,774,839	360,000
Louisiana	4,625,470	790,000
Kentucky	4,395,295	2,090,000
Oregon	3,930,065	1,280,000
Oklahoma	3,850,568	4,300,000
Connecticut	3,596,080	47,000
Iowa	3,090,416	3,700,000
Mississippi	2,991,207	930,000
Arkansas	2,959,373	1,660,000
Utah	2,900,872	800,000
Kansas	2,893,957	5,800,000
Nevada	2,790,136	455,000
New Mexico	2,085,287	1,290,000
Nebraska	1,868,516	6,150,000
West Virginia	1,854,304	380,000
Idaho	1,612,136	2,190,000
Hawaii	1,404,054	130,000
Maine	1,328,302	85,000
New Hampshire	1,323,459	32,000
Rhode Island	1,051,511	5,000
Montana	1,015,165	2,550,000
Delaware	925,749	16,000
South Dakota	844,877	3,650,000
Alaska	735,132	10,000
North Dakota	723,393	1,770,000
Vermont	626,630	260,000
Wyoming	582,658	1,270,000

(b) Human and cattle populations

■ Human ■ Cattle

(c) Ratio of cattle to human population

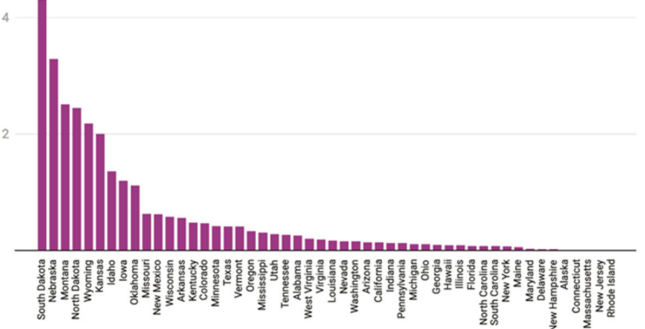## (d) Ratio of cattle to human population

Figure 1. Graphing the same data many ways. This figure shows the human and cattle populations for each state in the United States. A and B both show the overall population numbers for humans and cattle per state. C and D both plot the ratio of cattle to humans per state. D shows that data as a bar graph, but C shows it as a map. Showing these graphs to a colleague will be sure to spark a conversation about the best way to display your data 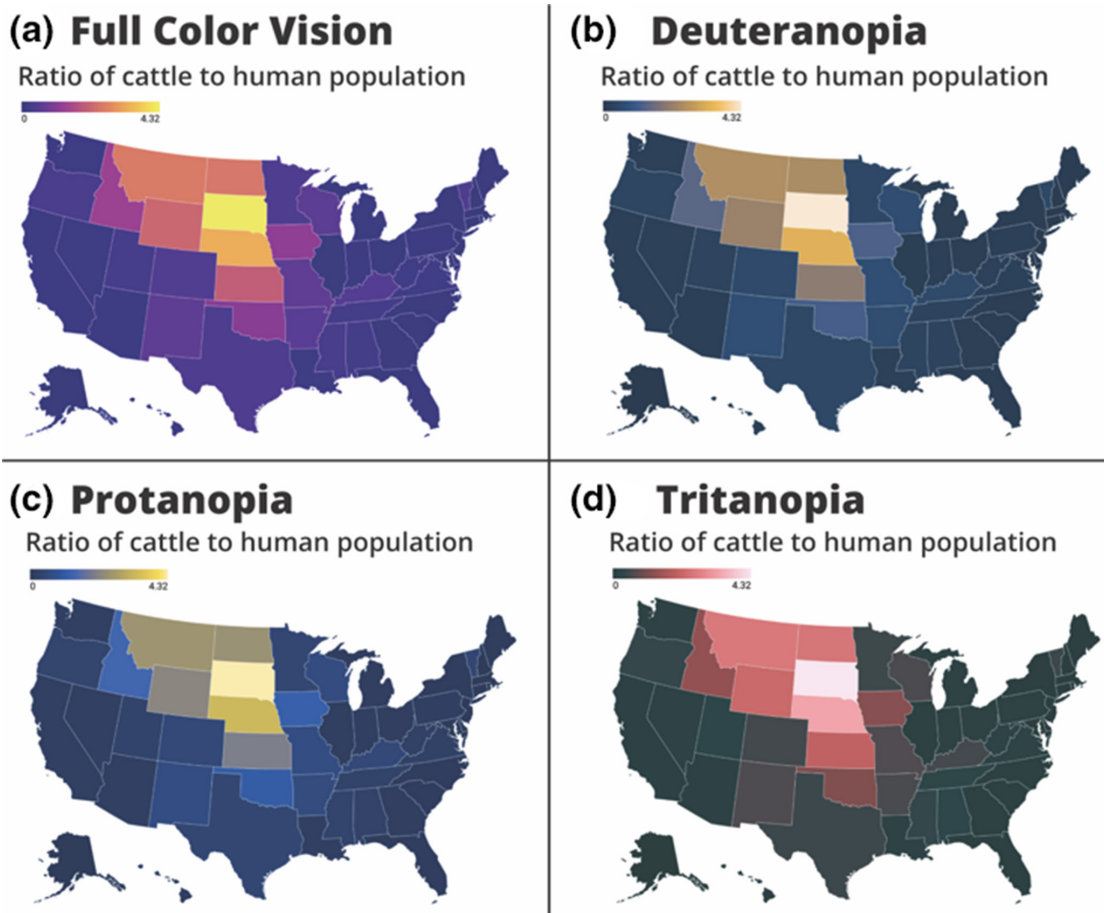to tell your story. Human and cattle data from: https://beef2live.com/story-cattle-inventory-vs-human-population-state-0-114255

Data Visualization

Figure 2. Graph with multiple colour-blindness filters. These graphs plot the ratio of cattle to human population per state in the United States. A shows the full colour version that the majority of readers will see. B–D show variations of the same graph representing different forms of colour blindness. Choosing an attractive colour palette that is also colour-blind friendly will ensure that your visual is beautiful and accurate no matter who looks at it.

will not only get you results, but also get you pizza and friendship. If you don't like pizza or you're too shy to do this activity with friends, you can do this exercise alone. If you summarize alone, I still recommend running your final product past someone else to make sure it is understandable before moving to the next stage.

Accurately backing up your simple story

Once you have your simple story down, it's time to work on backing that story up with data. Write down the one or two sentences of your simple story and then write down exactly which experiments and which data back up that story. It can be tempting to fall into the trap of thinking that every experiment and data point you have is important, but, as harsh as it sounds, some experiments and data points are more important than others. You're looking for the smoking gun experiment that proves your conclusion is correct. Your smoking

gun experiment may not scientifically stand on its own without the proper control experiments. For data visualization purposes, that's okay. If you make a good visual, your readers may ask themselves if you did this or that control. Once they're curious, they can go over to your paper to read the full text and be impressed!

Even though you're leaving off some supporting experiments, you should still put effort into making your visual as accurate as possible. You may want to show the data in the same way that you did for your paper, but you don't have to. Now is the time to play with your data and figure out exactly what kind of plot is right for you and your story. You can use anything from a simple bar graph to a complex timeline, but no matter what you choose, beware vague axes, unclear legends and graphs that are trying to do too much at one time. You spent too much time simplifying your story to follow it up with a graph that no one can read.

If you're feeling unsure about the way you're displaying your data, talk to a friend or colleague that
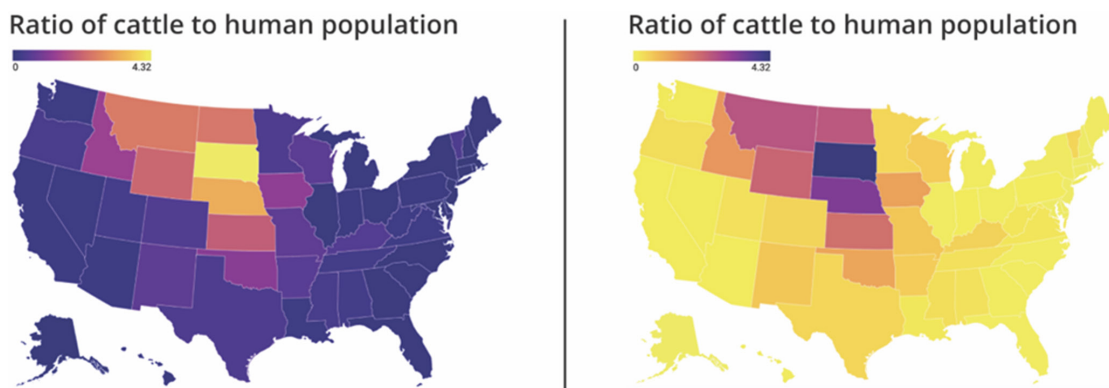
Figure 3. Recognizing an accent colour. These graphs, once again, plot the ratio of cattle to human population per state in the United States. The only difference between the left and right graph is that the colour gradient is inverted. Notice that the bright yellow colour draws your eye immediately to South Dakota in the left graph whereas your eye sweeps across all the yellow states on the right graph. Yellow is the accent colour in this gradient and draws the eye. Be sure to use accent colours sparingly and carefully in your visuals.

is familiar with graphs (pizza and drinks are optional). Consider creating a couple of different graphs of the same data for you two to talk about (Figure 1). Ask your friend or colleague what they think the graph shows and what conclusion they take from it. If their conclusion isn't the same as your simple story, then talk with them about what went wrong and any pitfalls of that kind of graph. Collecting your data is often a solo experience, but telling your story is a social one. Don't forget to use the collective wisdom of your network to help you. It's much better to notice any confusing points at this stage before you push your visual live to the world.

Turning your simple and accurate story into a work of art

Once you've got your story and you've got an accurate graph to tell it, it's time to make your visual beautiful. Beauty has a complicated place within the world of science. We often feel that results should stand on their own because they don't need to be beautiful to be true. However, we are all only human and beautiful things catch our attention, bring us in and make us stay around longer.

There is a popular saying that beauty is in the eye of the beholder, and if you're not a particularly aesthetic person, you may feel at a loss for how to create a pleasing visual. Luckily, there are a few simple rules to follow that can help. The first is to go find a colour-blind friendly colour palette online and use that palette for your visual. Those colour palettes are created by artists or designers with accessibility and beauty in mind ensuring that

everyone who sees your graph will be able to read and enjoy it (Figure 2).

The second rule is to consider the flow of your visual. Like all stories, your visual should have a beginning, middle and end. For a single graph, the beginning is the title, legend and axes because they set the scene for the results that will be graphed. The middle is the graphed data, and the end is the conclusion that a reader draws from seeing that data. You'll want to pay close attention to the beginning, middle and end of your story and make sure the placement of your visuals are telling your story well. You don't want your reader's eyes to bounce all over the visual to get your point. It should flow logically in some fashion whether that is top to bottom or left to right.

In addition to placement, pay attention to the accent colours in your chosen palette and use those sparingly to really draw your reader's eye to exactly where you want them to go (Figure 3). When in doubt, find a friend with great style to take a look and give you some suggestions. With a nice palette and an eye for flow, you'll go far in taking your accurate and simple visual and making it beautiful.

You can do this

As long as you pay attention to the elements of simplicity, accuracy and beauty, you'll be able to create an excellent data visualization. Don't be afraid to try new things and talk to your friends and colleagues to get feedback. Science can be a lonely endeavour at times, but sharing your findings is inherently social. Now, get out there and create your visual because your story is worth telling. ∎

Further Reading

- Rossi, T. (2019). Graphical Abstracts: How to Master the Latest Trend in Publishing. https://www.animateyour.science/post/graphical-abstracts-how-to-master-the-latest-trend-in-publishing
- To help with choosing and exploring graph types: https://datavizcatalogue.com/
- To see if your images are colour-blind friendly: https://www.color-blindness.com/coblis-color-blindness-simulator/
- For inspiration: https://informationisbeautiful.net/
- For choosing a color palette: https://davidmathlogic.com/colorblind/ and https://colorbrewer2.org

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