

MJPhD

EFFECTIVE COMMUNICATION OF SCIENTIFIC DATA


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CREATIVE DIRECTOR

MJPHD, LLC

27 February 2022





Jump and
a net will
appear

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COMMUNICATION HIERARCHY

Tools
Tactics
Strategy
Audience
Goal

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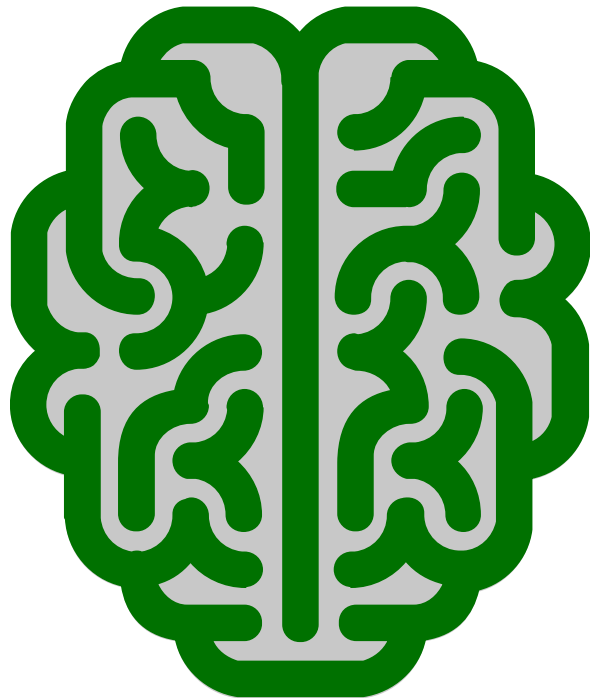


Designing *any communication* a presentation without an audience in mind is like writing a love letter and addressing it 'to whom it may concern'.



Ken Haemer
Presentation Research Manager,
AT&T

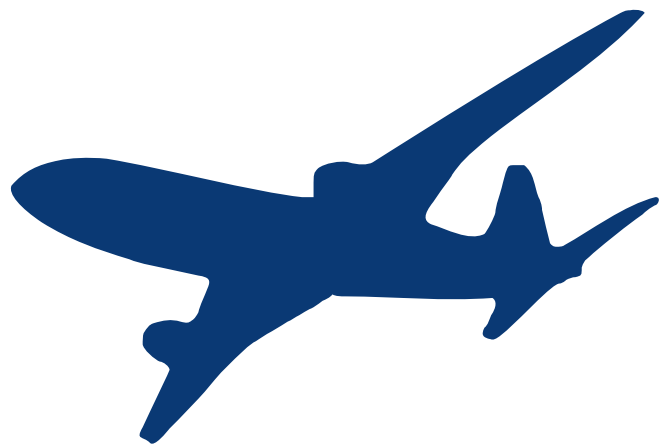
MIND READY



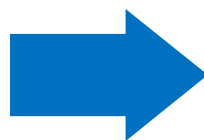
ready

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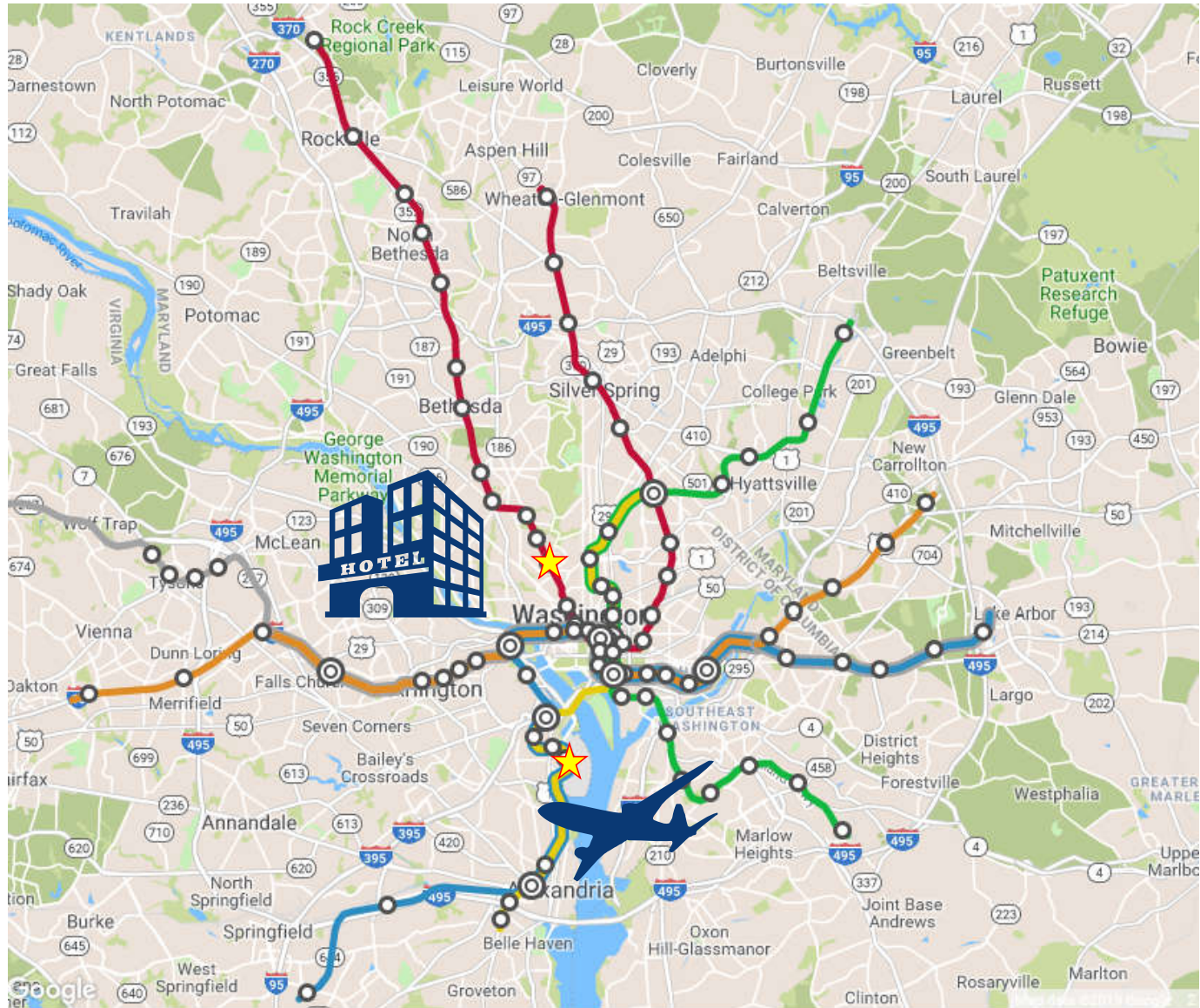
Washington, D.C.



Reagan National Airport



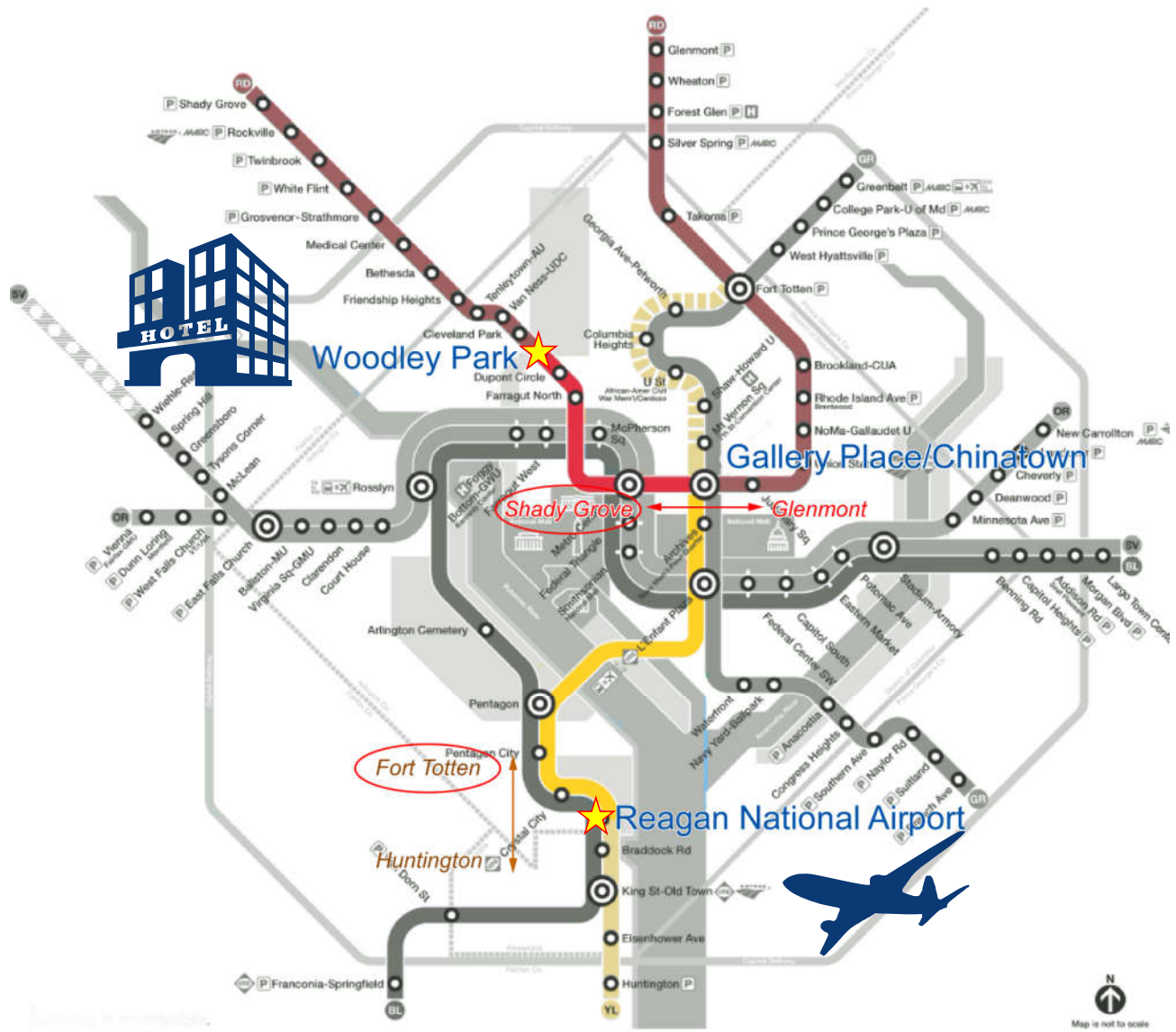
Marriott Woodley Park







Metro is accessible.





Woodley Park

Gallery Place/Chinatown

Shady Grove

Glenmont

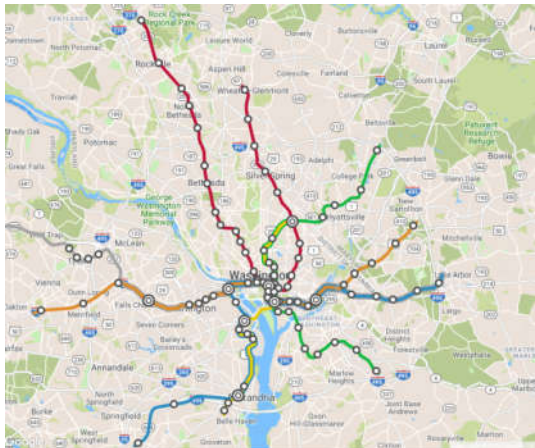
Fort Totten

Reagan National Airport

Huntington

Everything should be
made as simple as
possible, but not simpler.

Albert Einstein



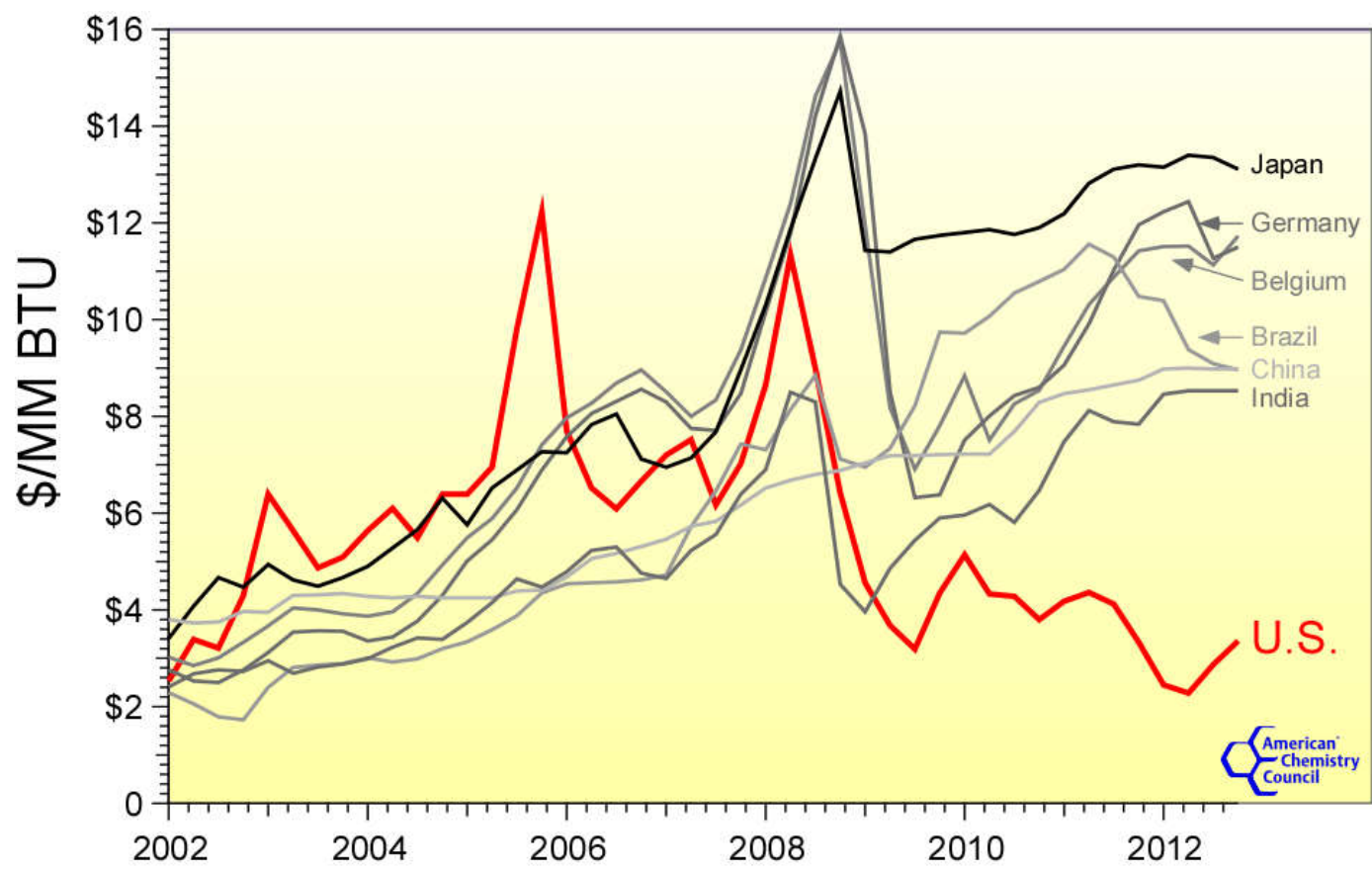
FIVE PRINCIPLES OF DATA PRESENTATION

- Tell the truth
- Get to the point
- Pick the right tool
- Highlight what is important
- Keep it ~~simple~~
appropriate

Everything should be made as simple as possible, but not simpler.

Nancy Duarte in Slideology

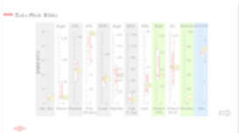
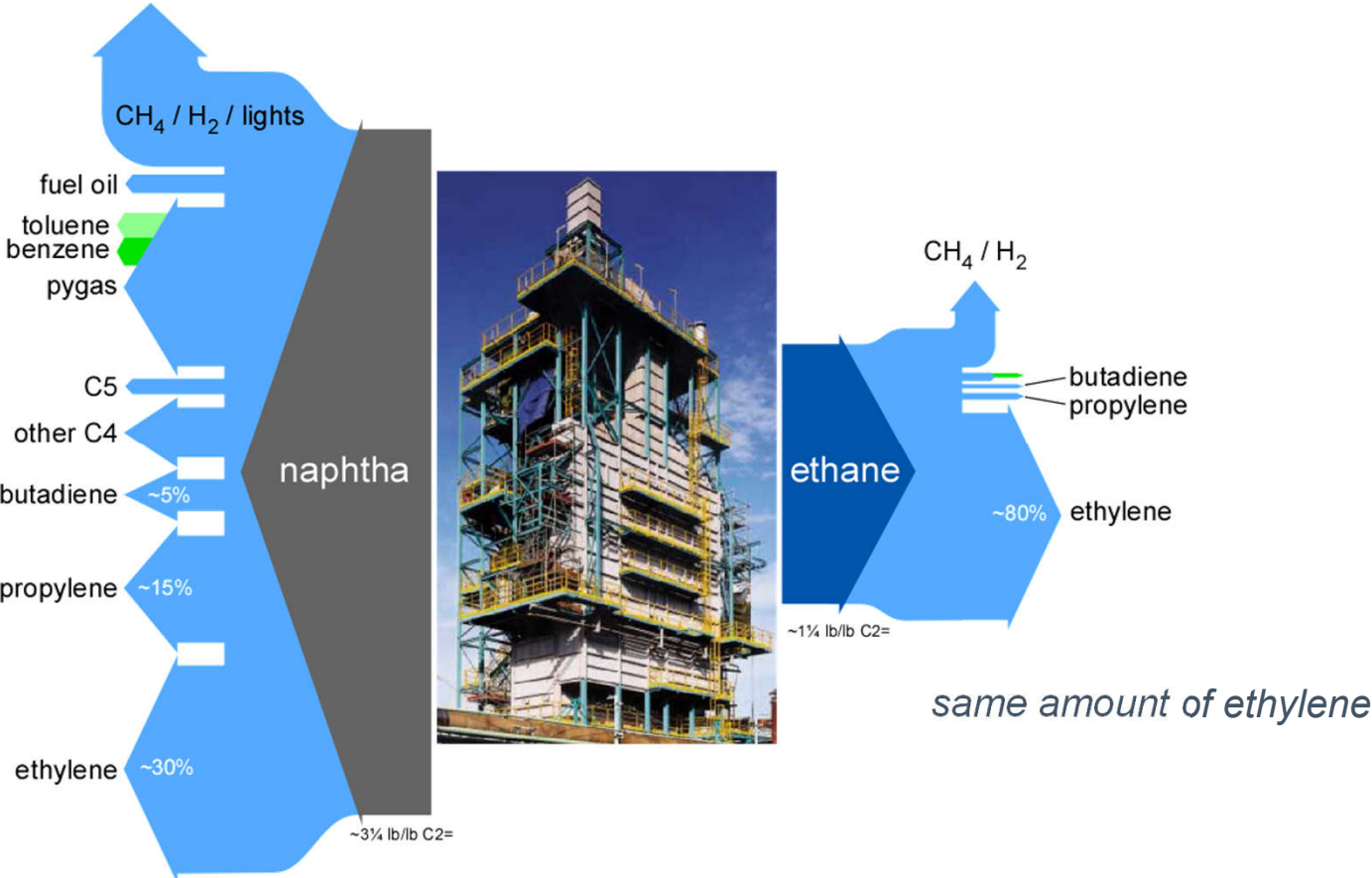
WORLD NATURAL GAS PRICES



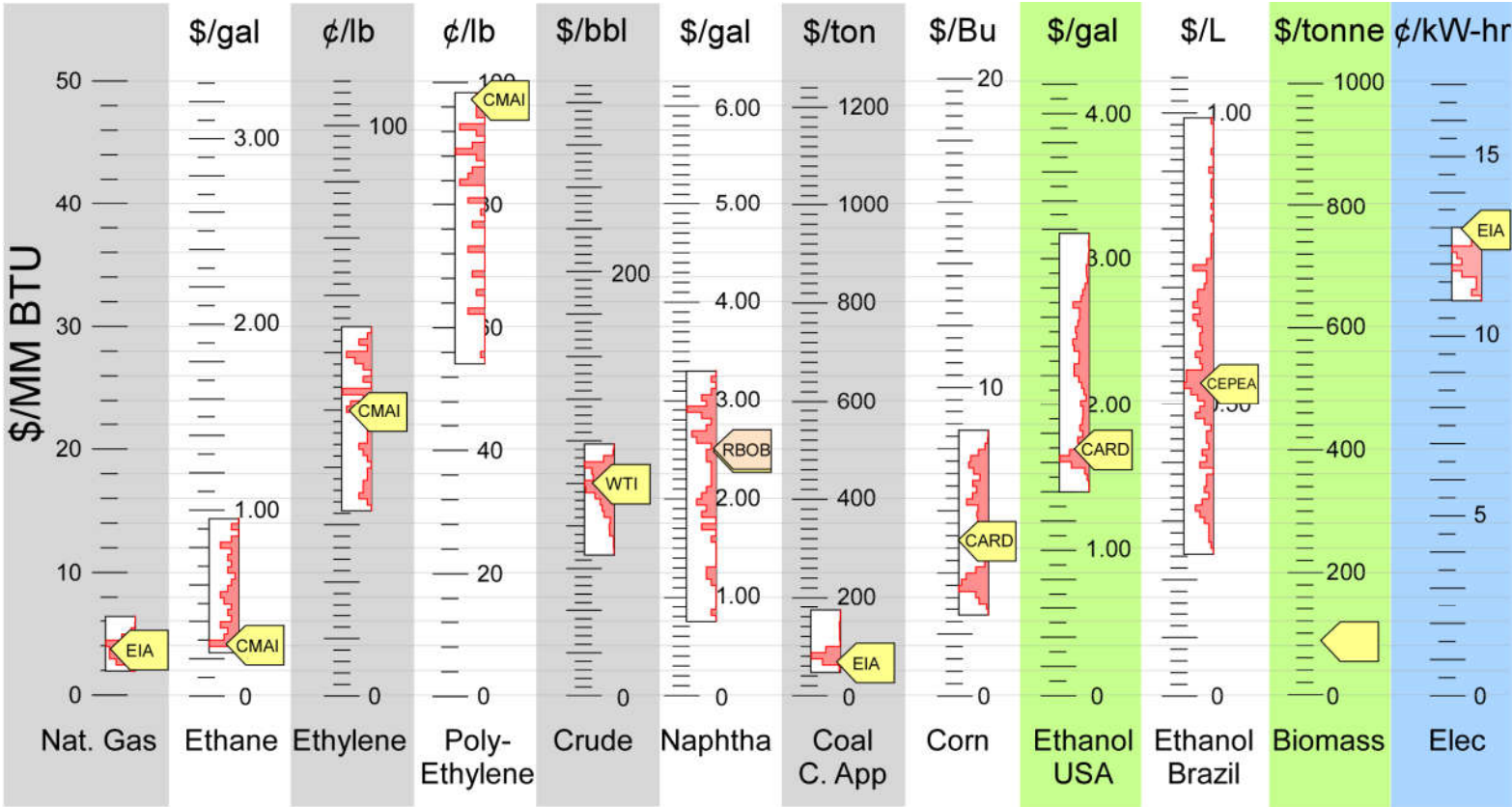
American
Chemistry
Council

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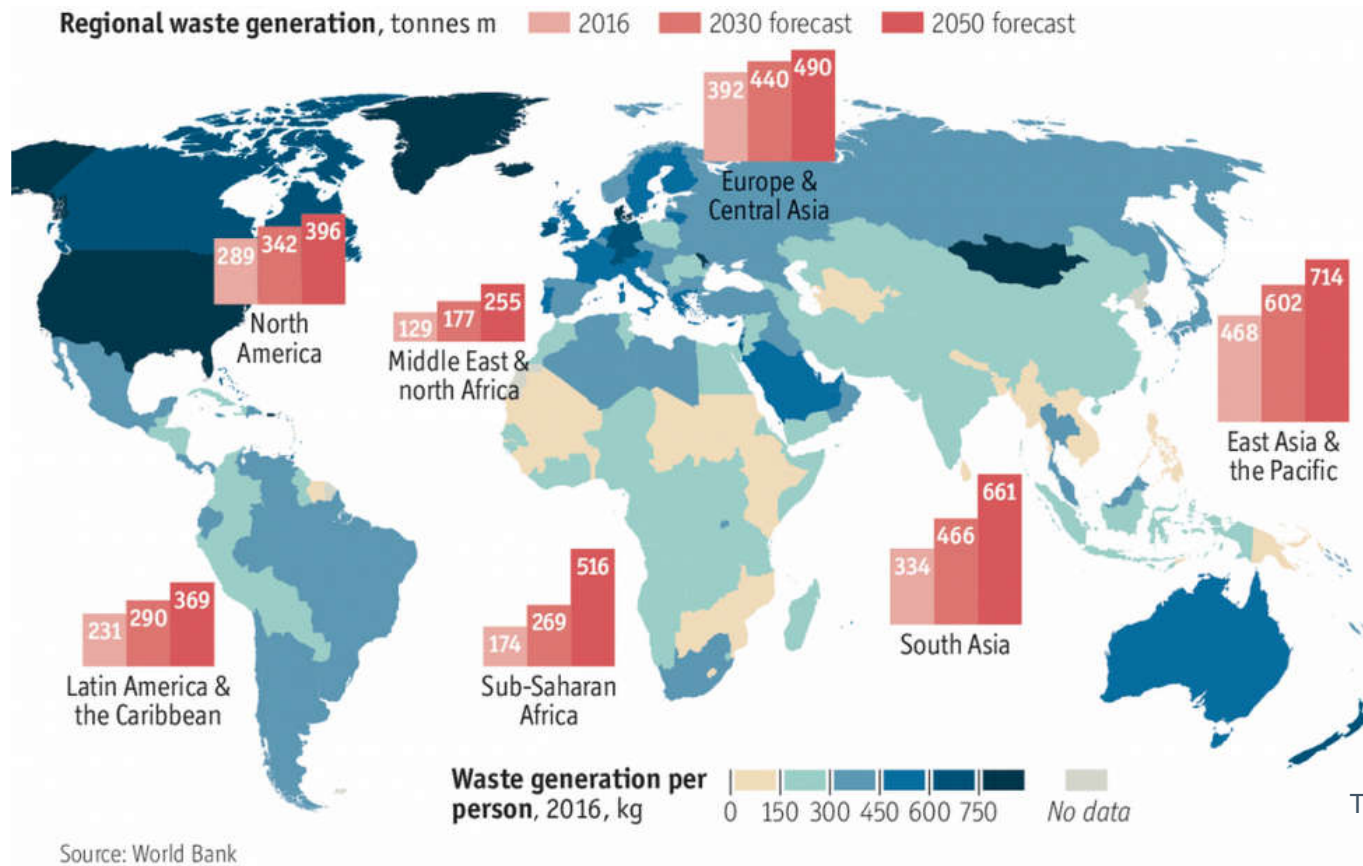
NAPHTHA VS ETHANE CRACKING COMPARISON



DATA RICH SLIDE

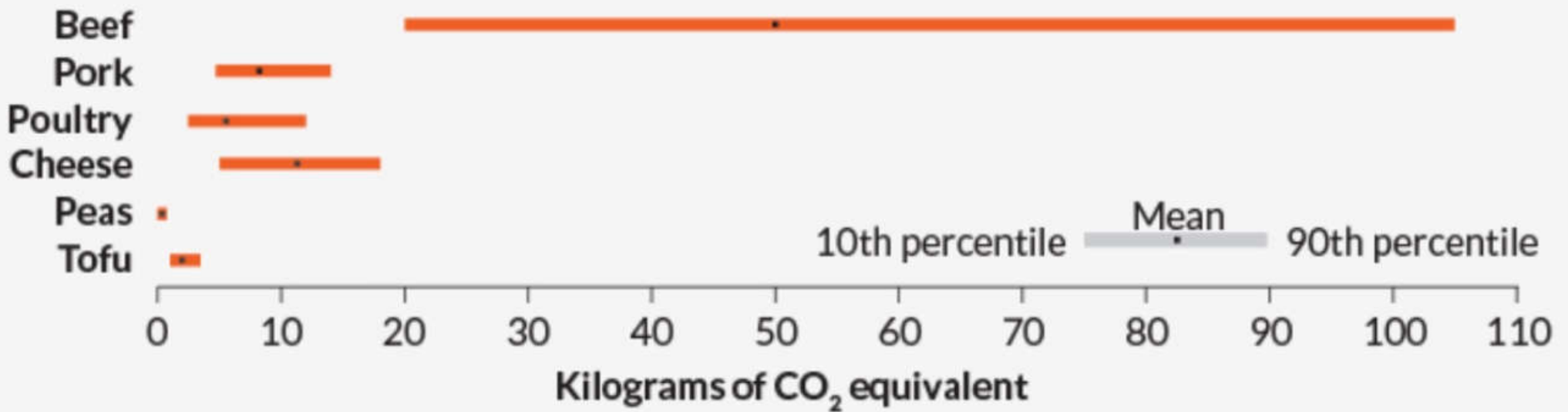


LOTS OF INFORMATION – THROWAWAY WORLD



FARM TO TABLE

Greenhouse gas emissions from protein-rich foods (per 100 grams)



graphic by C. Chang in Milius, Susan; "Can science build a better burger?", *Science News*, September 20, 2018 downloaded from sciencenews.org/article/can-science-build-better-burger on 2 November 2018.



EDWARD TUFTE'S FIVE PRINCIPLES OF DATA PRESENTATION

1. Above all else show the data

*Pick the right tool
Tell the truth*

2. Maximize the data-ink ratio

Get to the point

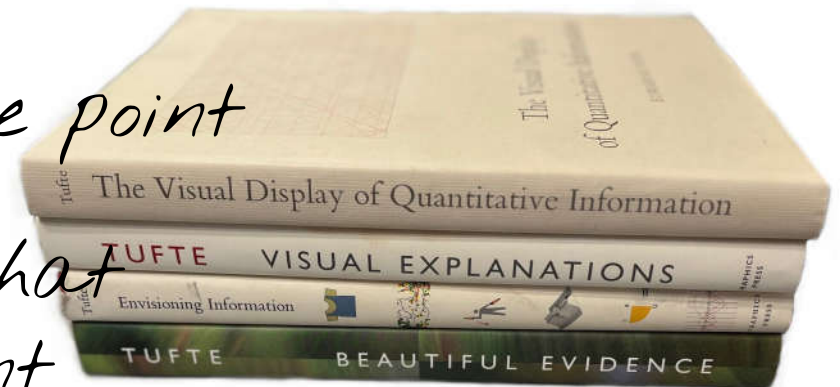
3. Erase non-data ink

*Highlight what
is important*

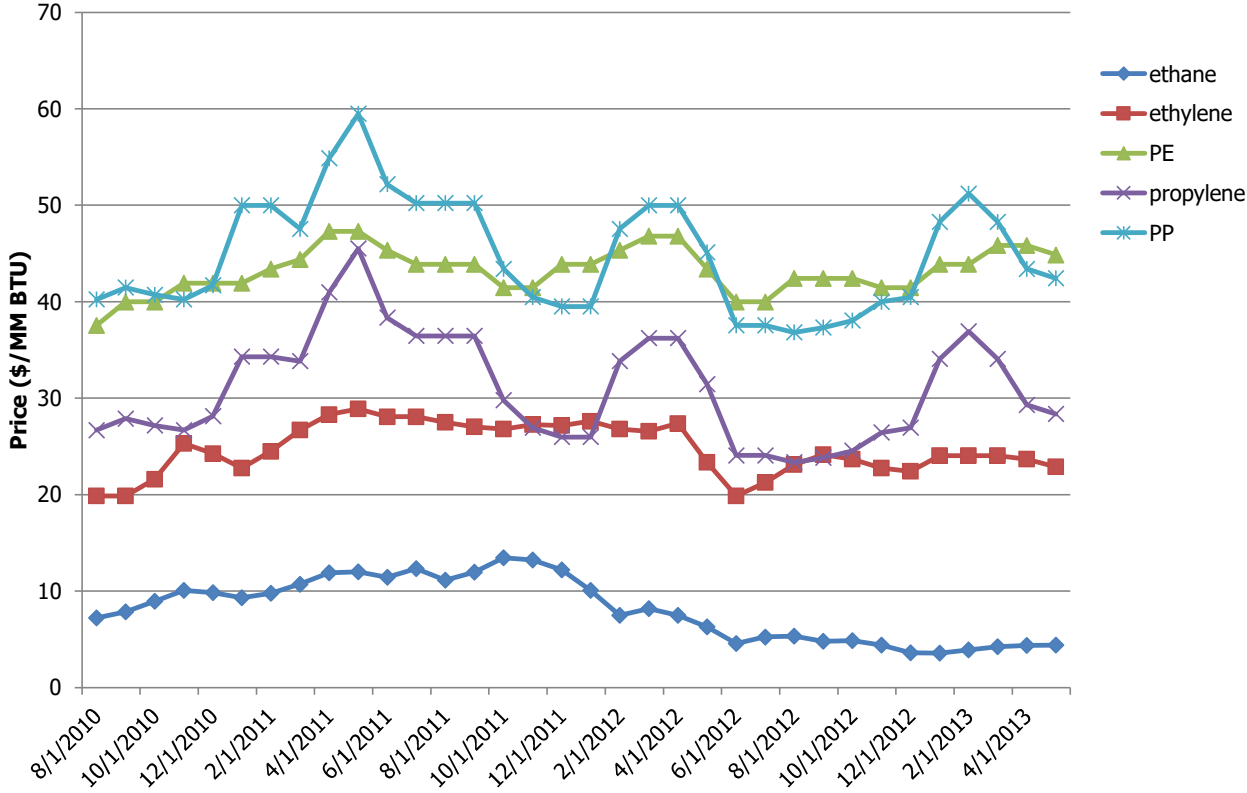
4. Erase redundant data

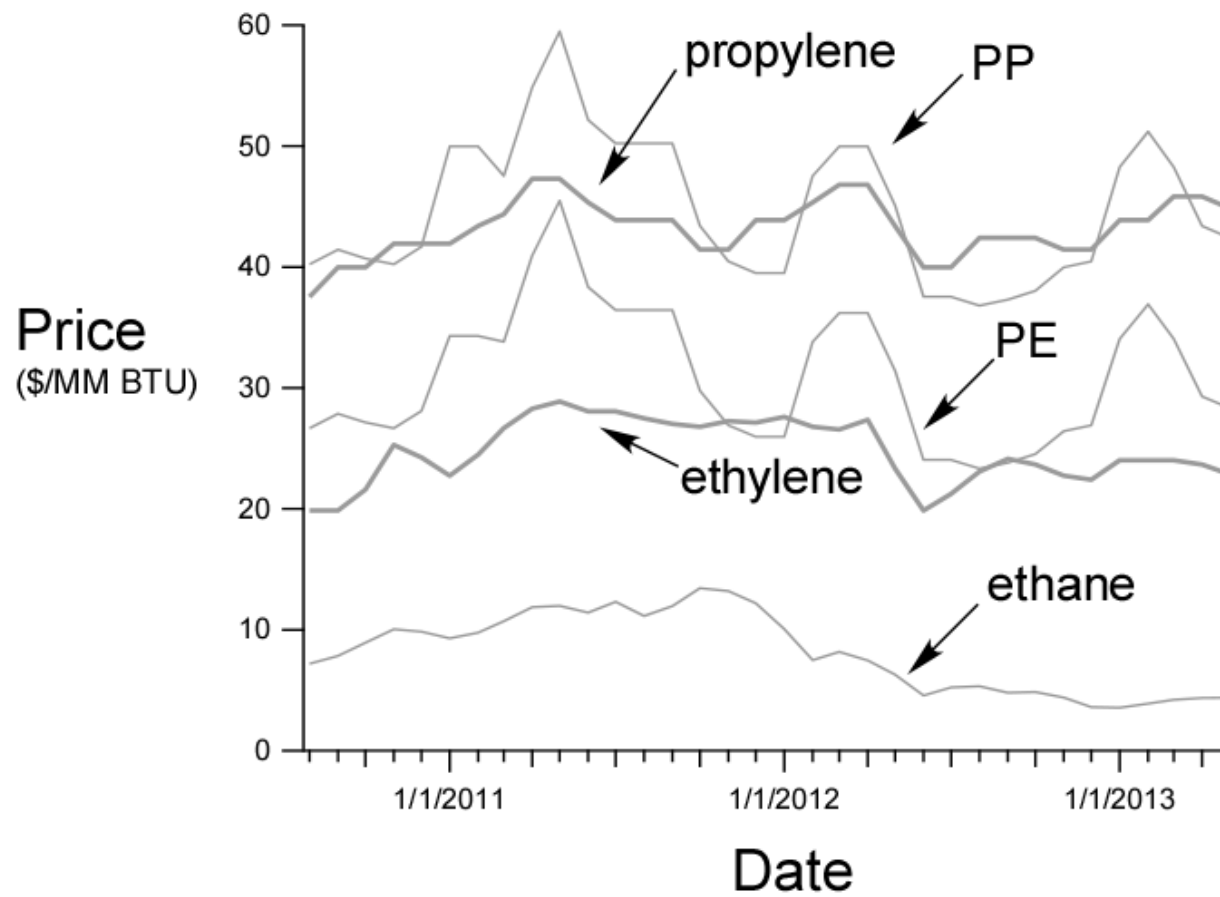
5. Revise and Edit.

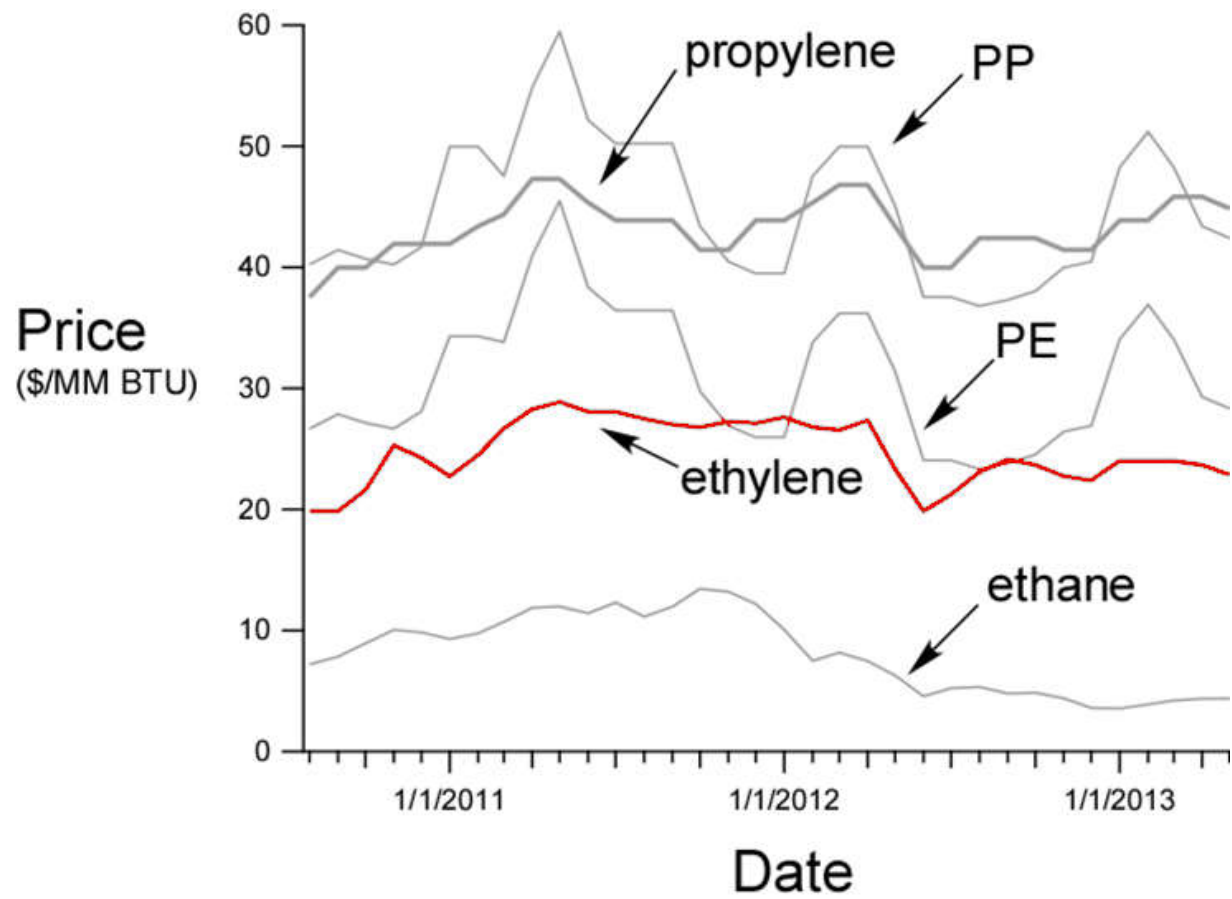
Keep it appropriate



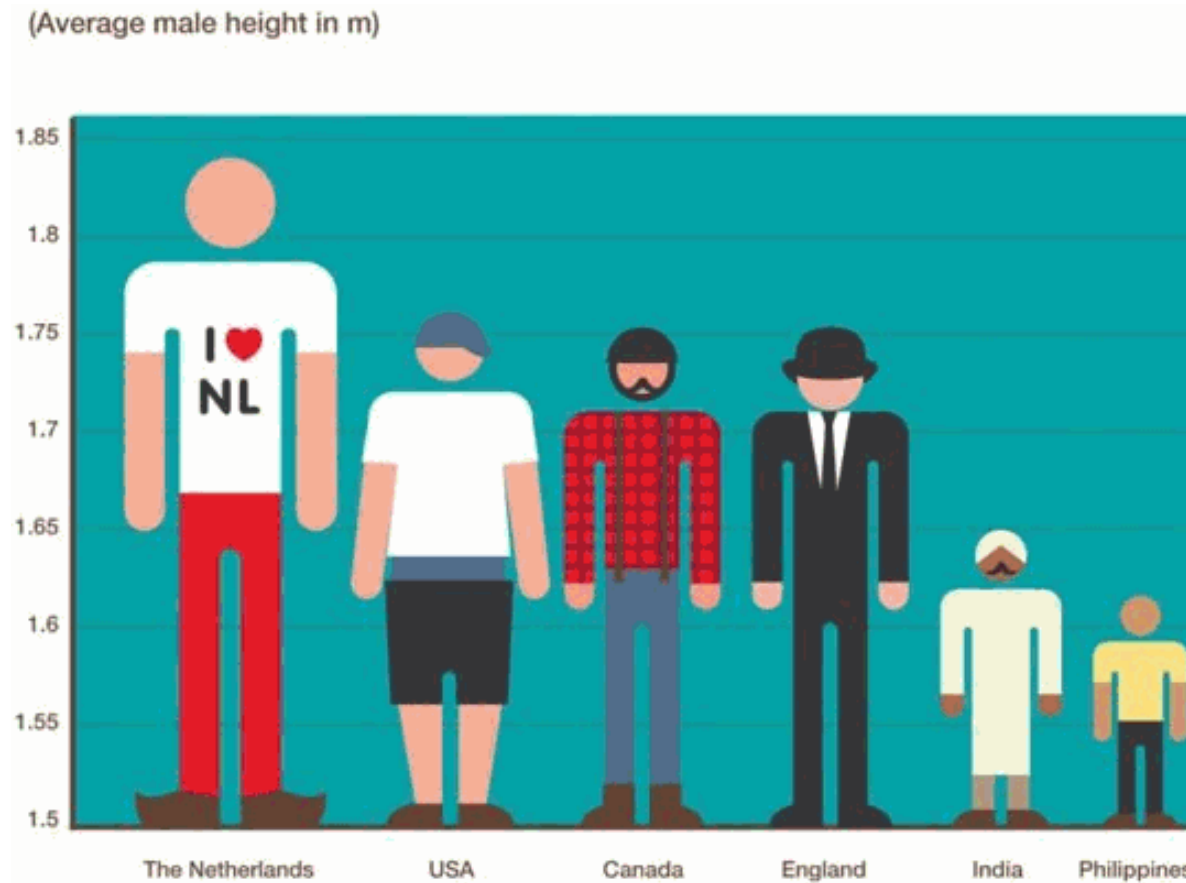
STANDARD EXCEL PLOT





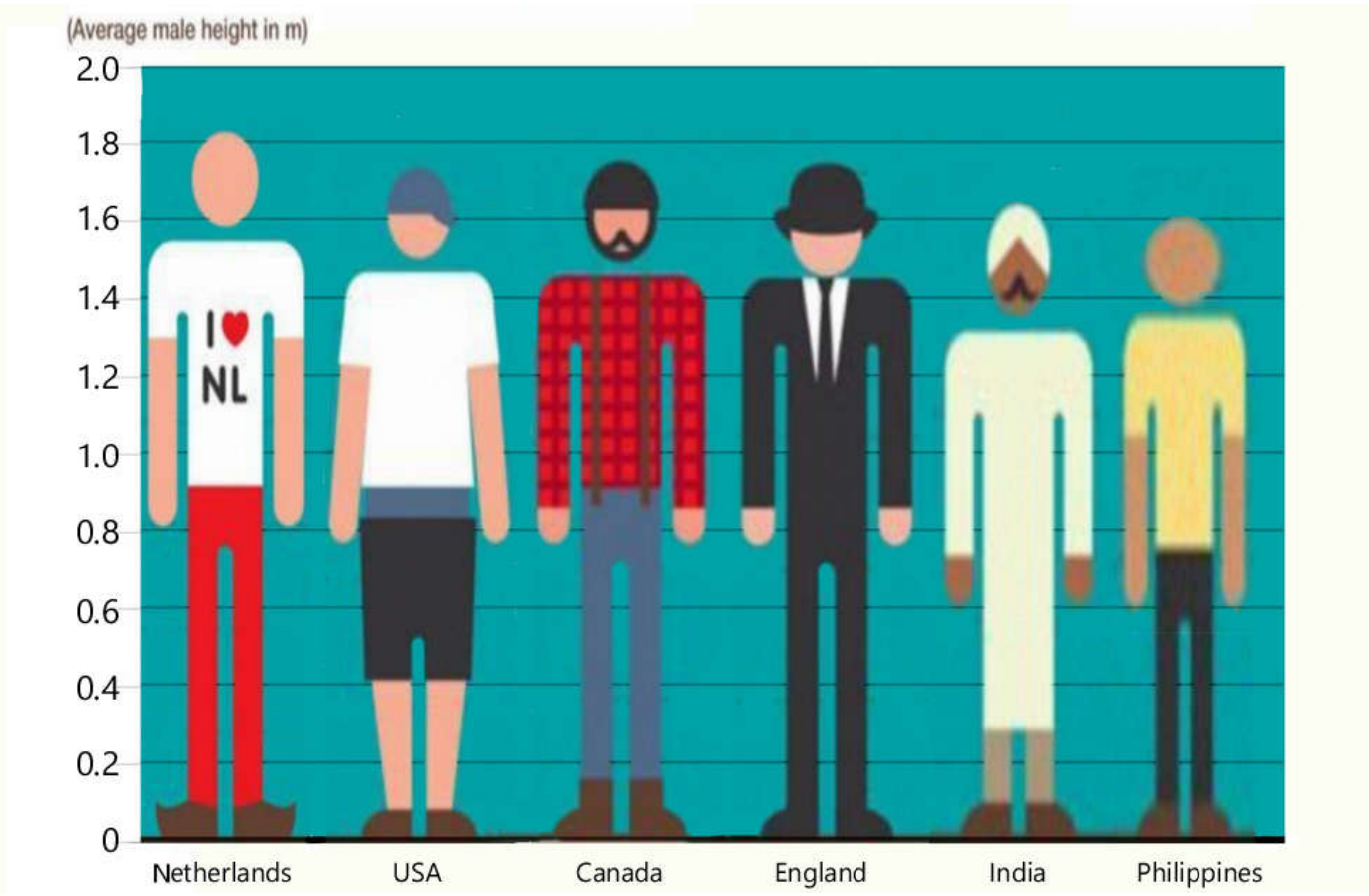


BAD GRAPHS – LOOKING DOWN ON THE REST OF THE WORLD

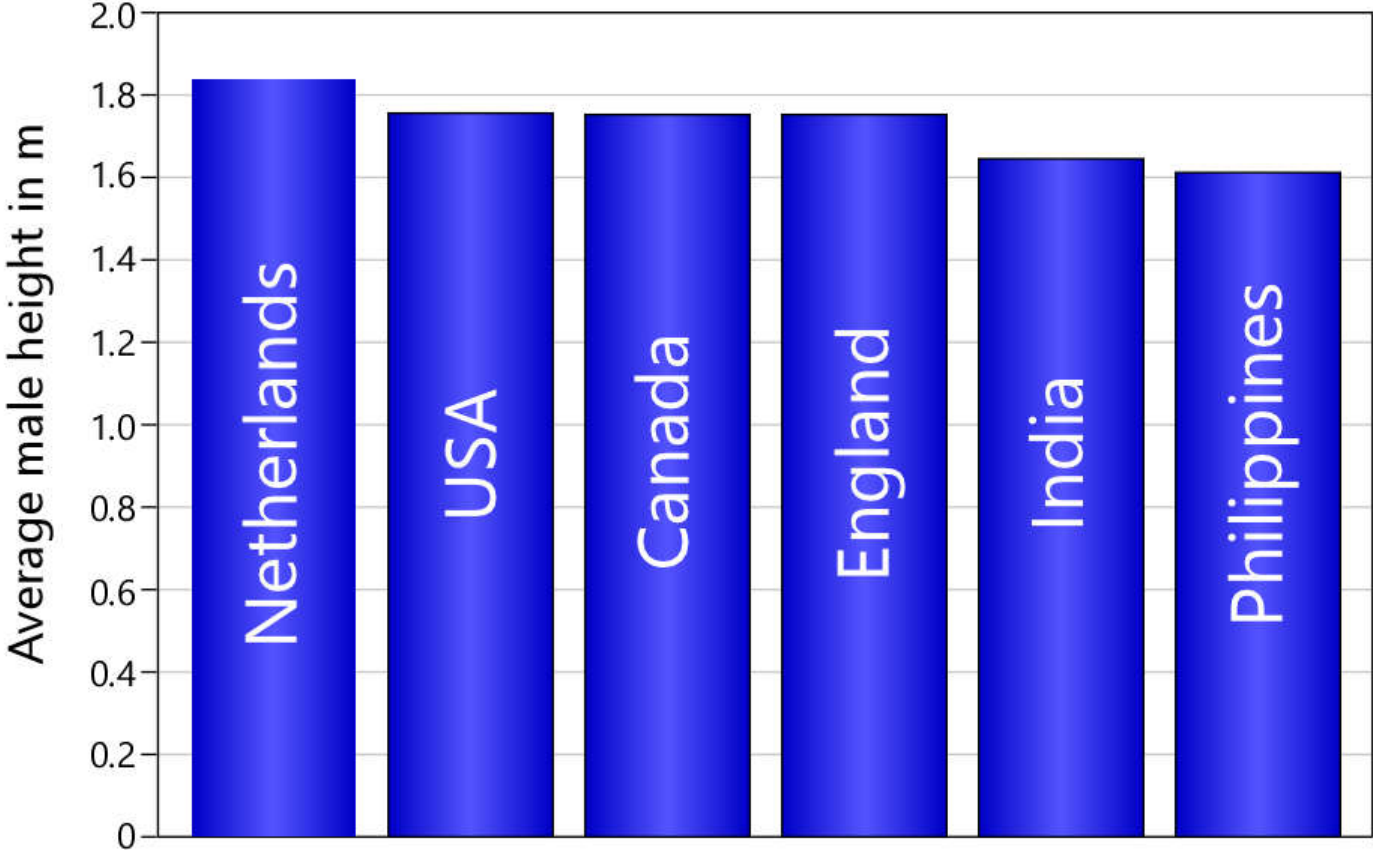


ticktockmaths.co.uk/bad-graphs/

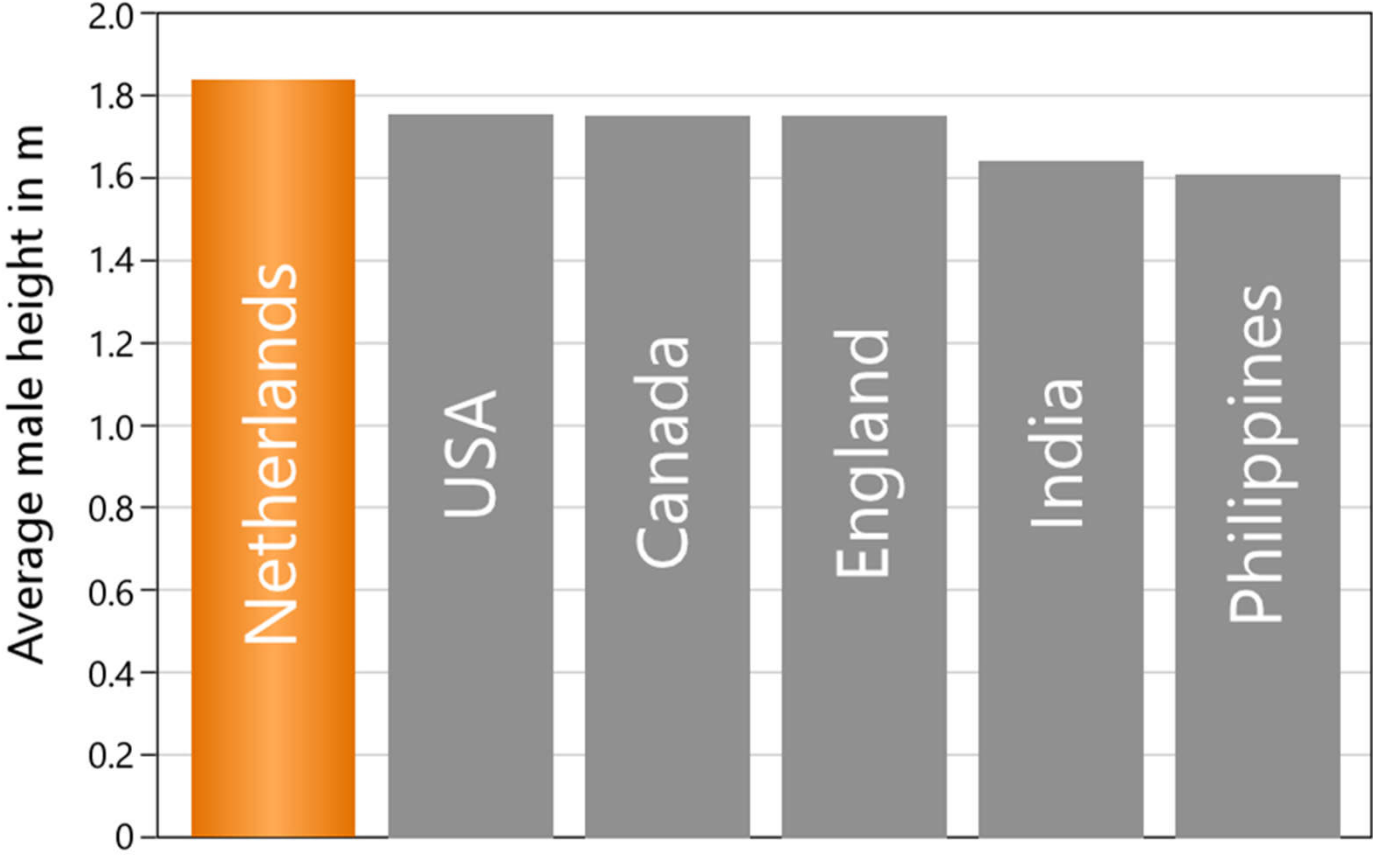
BETTER – BUT NOT GOOD ENOUGH



BETTER GRAPH

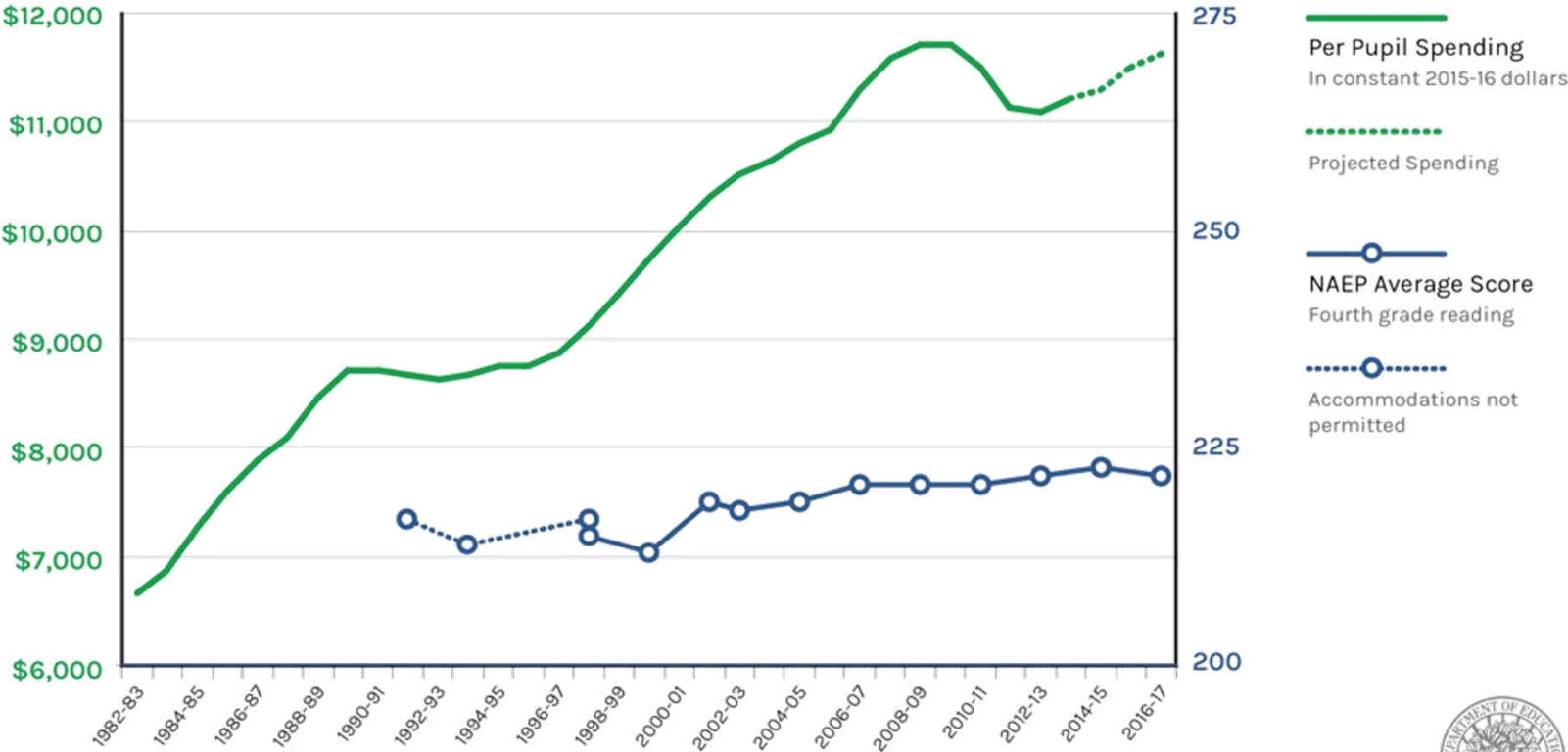


MAKING THE POINT



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GAMES WITH 2 AXES



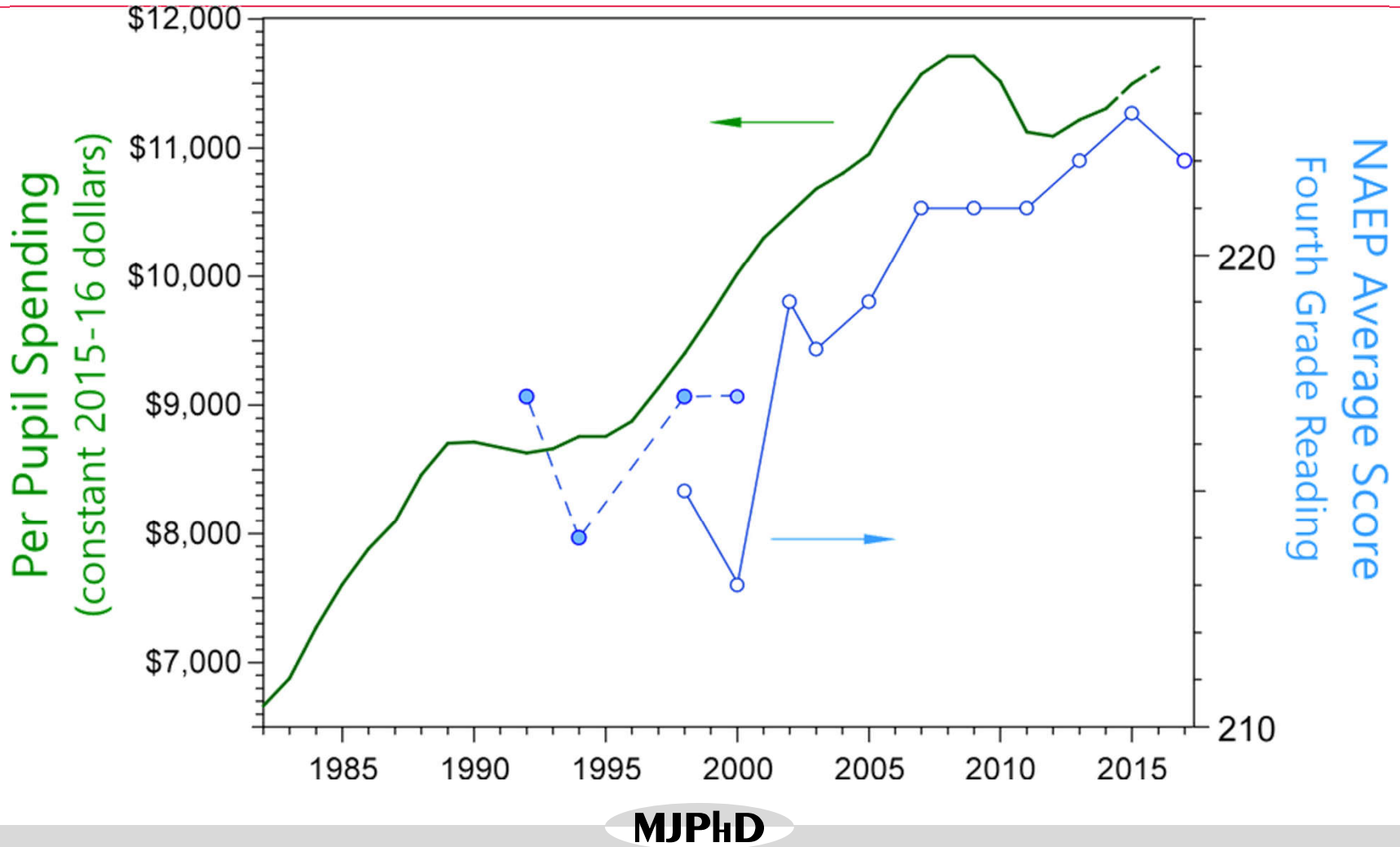
Source: U.S. Department of Education, National Center for Education Statistics, Revenues and Expenditures for Public Elementary and Secondary Education, 1970-71 through 1986-87; Common Core of Data (CCD), "National Public Education Financial Survey," 1987-88 through 2013-14; National Elementary and Secondary Enrollment Projection Model, 1972 through 2026; Public Elementary and Secondary Education Current Expenditure Projection Model, 1973-74 through 2026-27; and National Assessment of Educational Progress, Reading Report Card, 2017



<http://www.shankerinstitute.org/blog/we-cant-graph-our-way-out-research-education-spending>



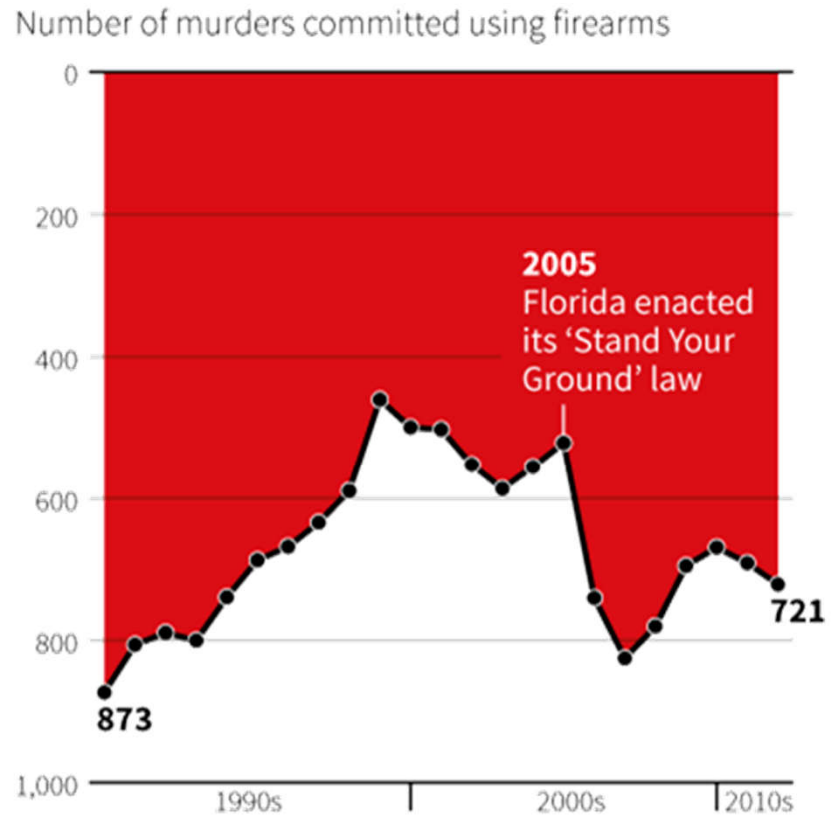
MORE HONEST AXES



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AXIS GAMES - GUN DEATHS IN FLORIDA



Source: Florida Department of Law Enforcement

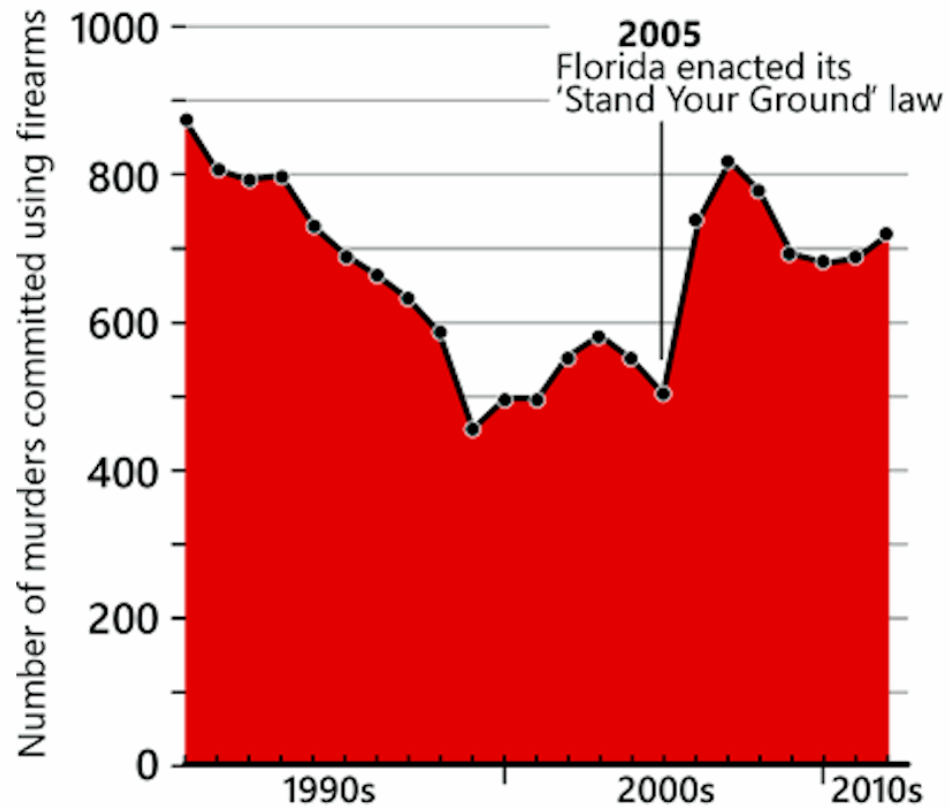
C. Chan 16/02/2014

REUTERS

methodsavvy.com/good-data-bad-graphs/

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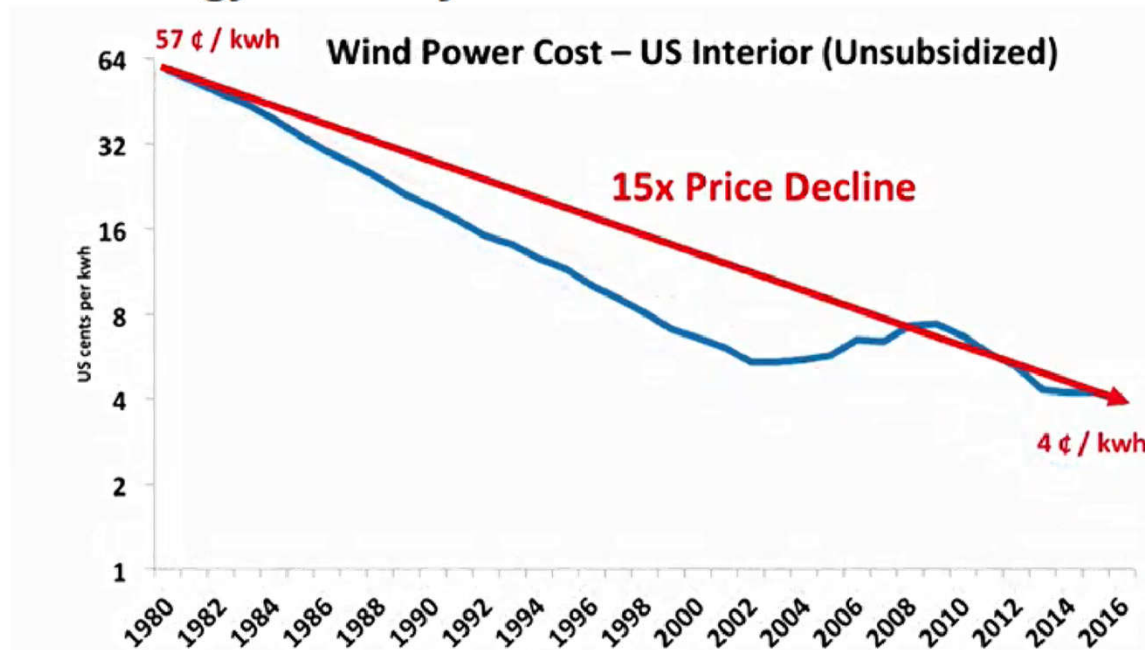
GUN DEATHS IN FLORIDA



Source: Florida Dept of Law Enforcement

AXIS GAMES – HIDDEN LOG AXIS

The Clean Energy Revolution – and the Disruption of the Energy Industry

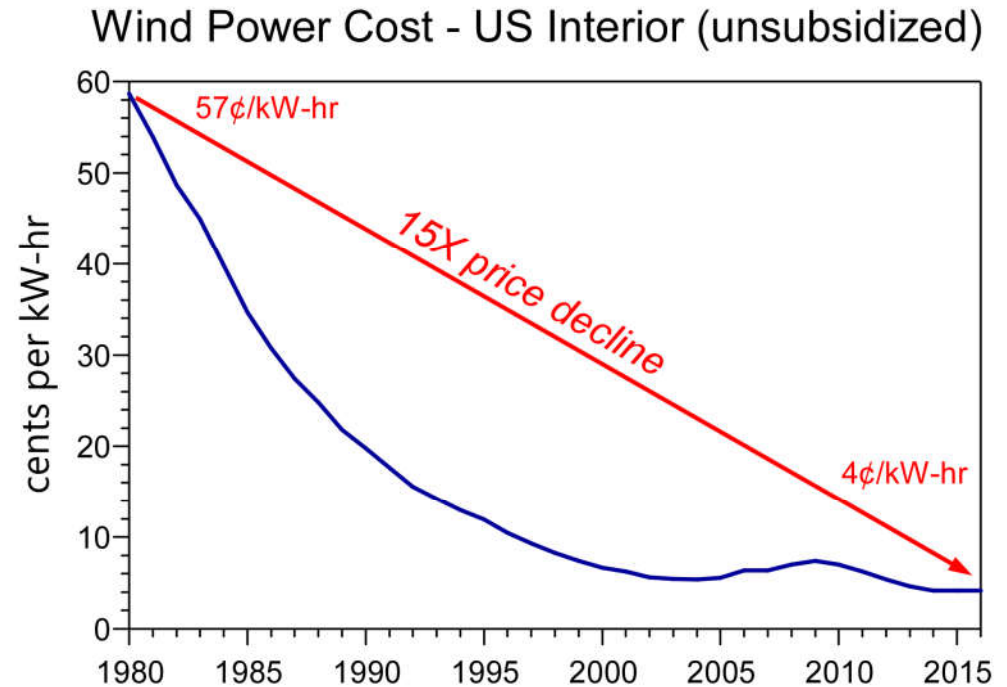
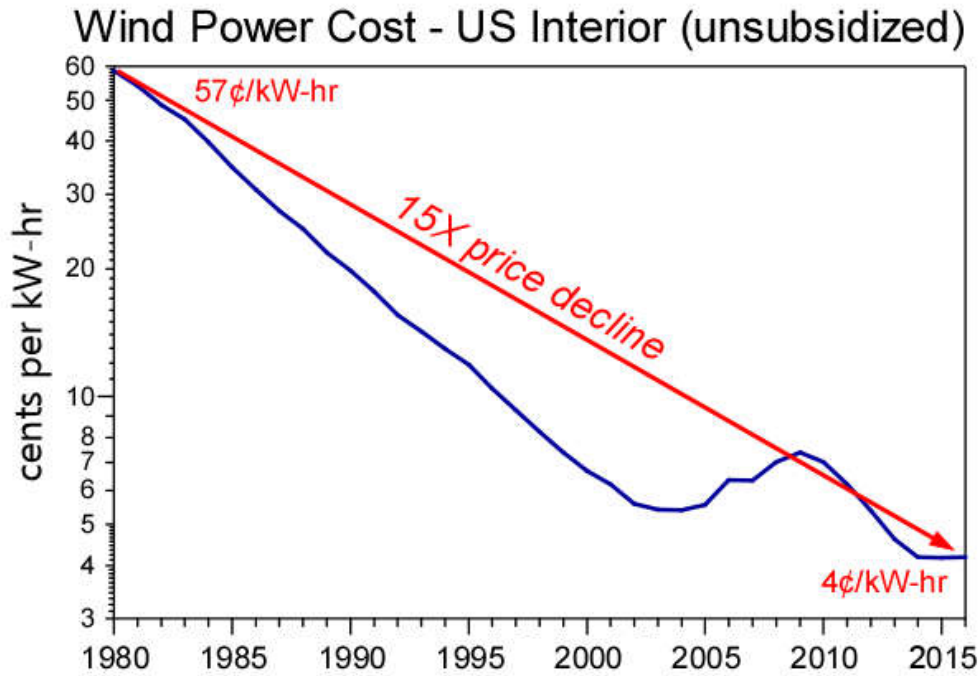


rameznaam.com/ video "The Clean Energy Revolution – and the Disruption of the Energy Industry",

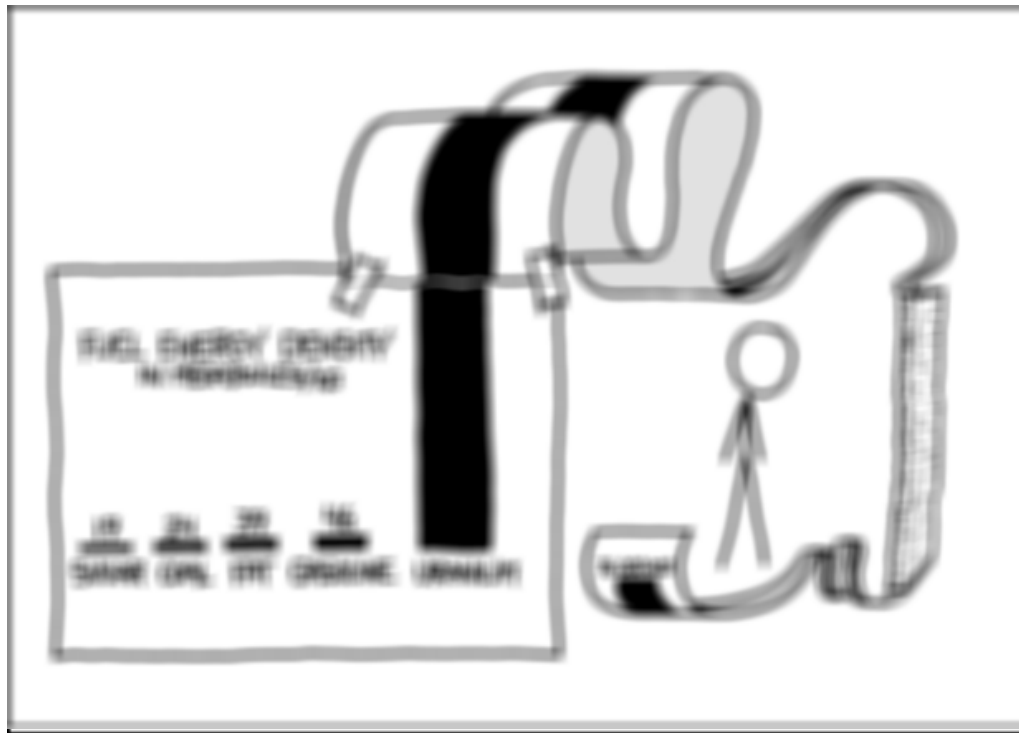
youtu.be/fwSkQa1tNmE

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CLEAN ENERGY



PROBLEMS WITH LOG AXES



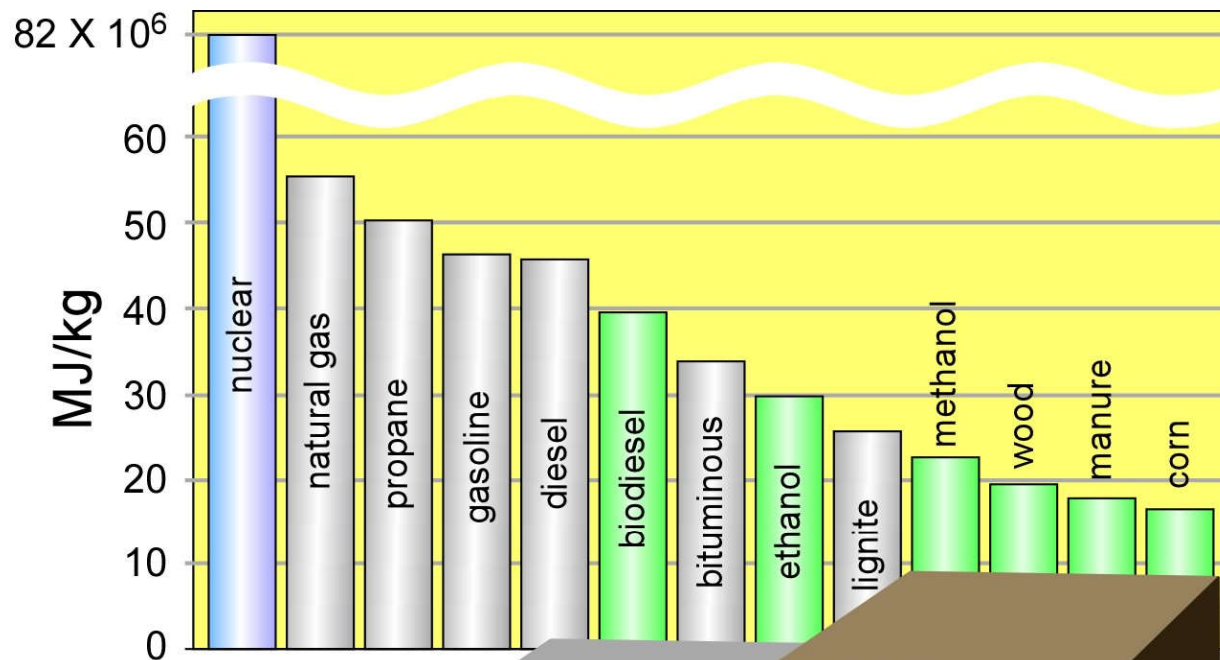
SCIENCE TIP: LOG SCALES ARE FOR QUITTERS WHO CAN'T FIND ENOUGH PAPER TO MAKE THEIR POINT *PROPERLY*.

Human perception is linear.

Log axes are great for detailed understanding, not for instantaneous recognition.

Permanent link to this comic: <https://xkcd.com/1162/>

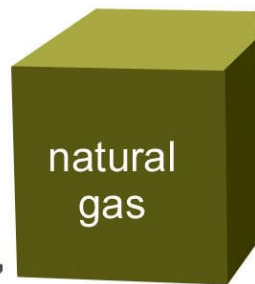
Image URL (for hotlinking/embedding): https://imgs.xkcd.com/comics/log_scale.png



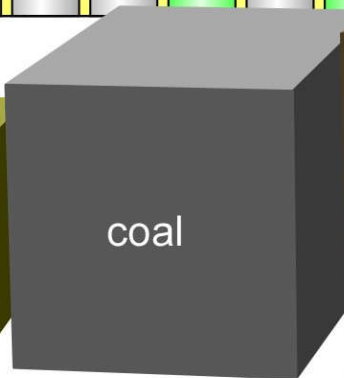
kg/day
for
1000 MW

²³⁵U

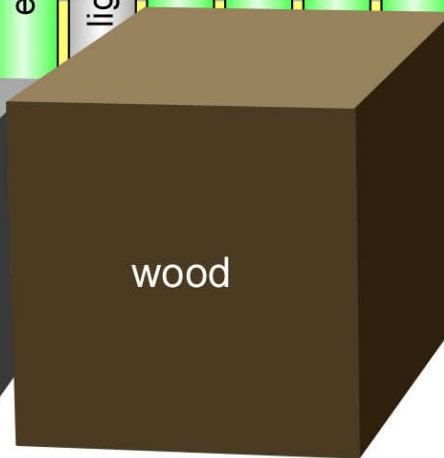
3.3



2.6 million



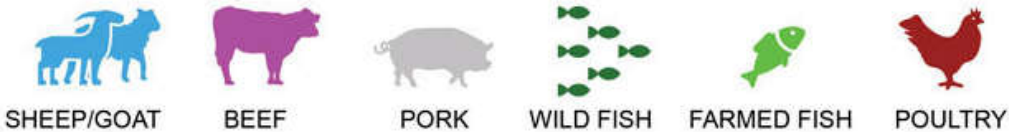
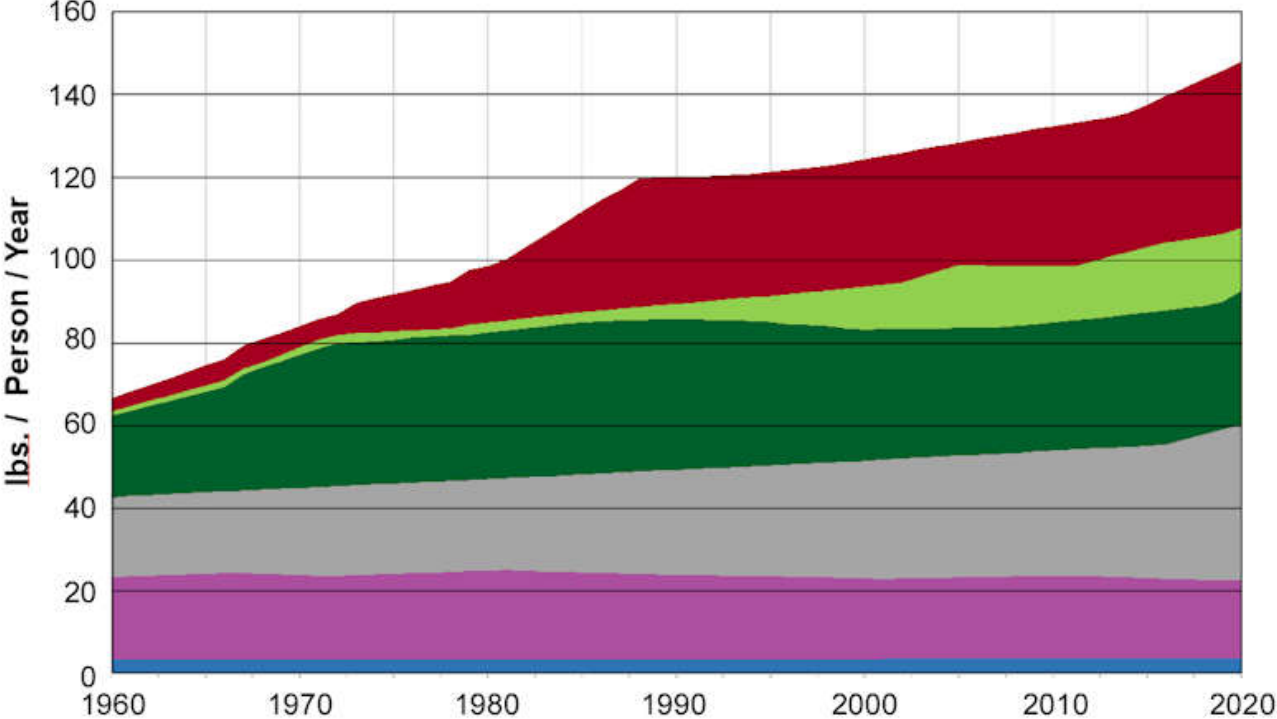
6.9 million



12 million

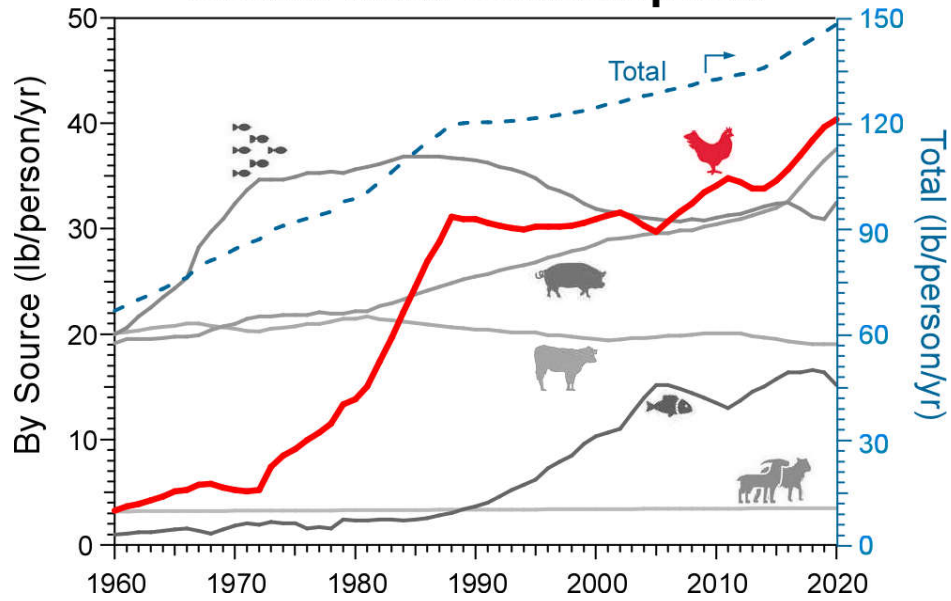


MEAT CONSUMPTION

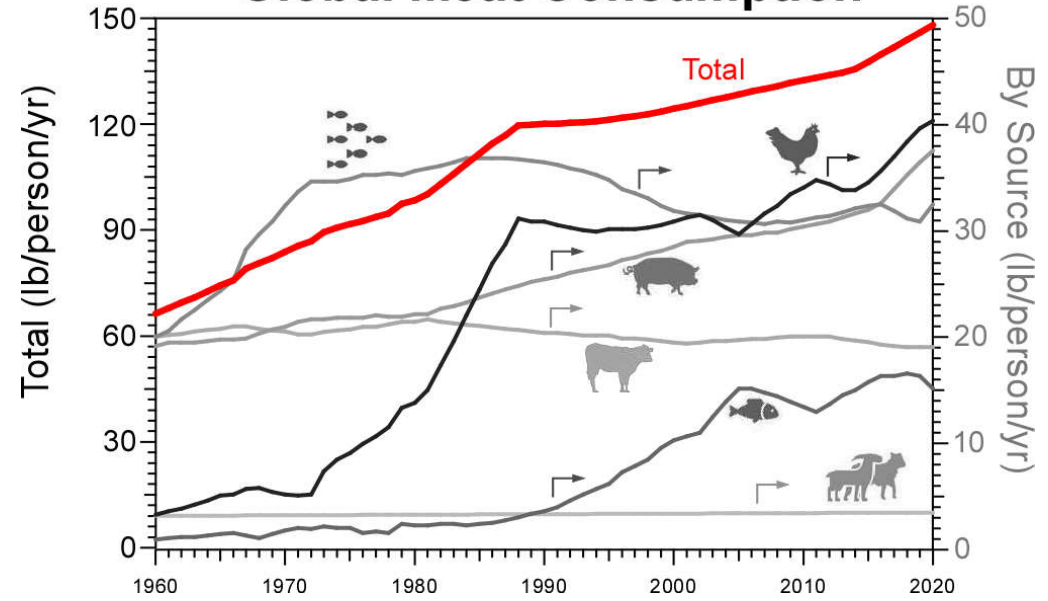


www.ethanolproducer.com/articles/16179/opportunities-in-high-protein-feed

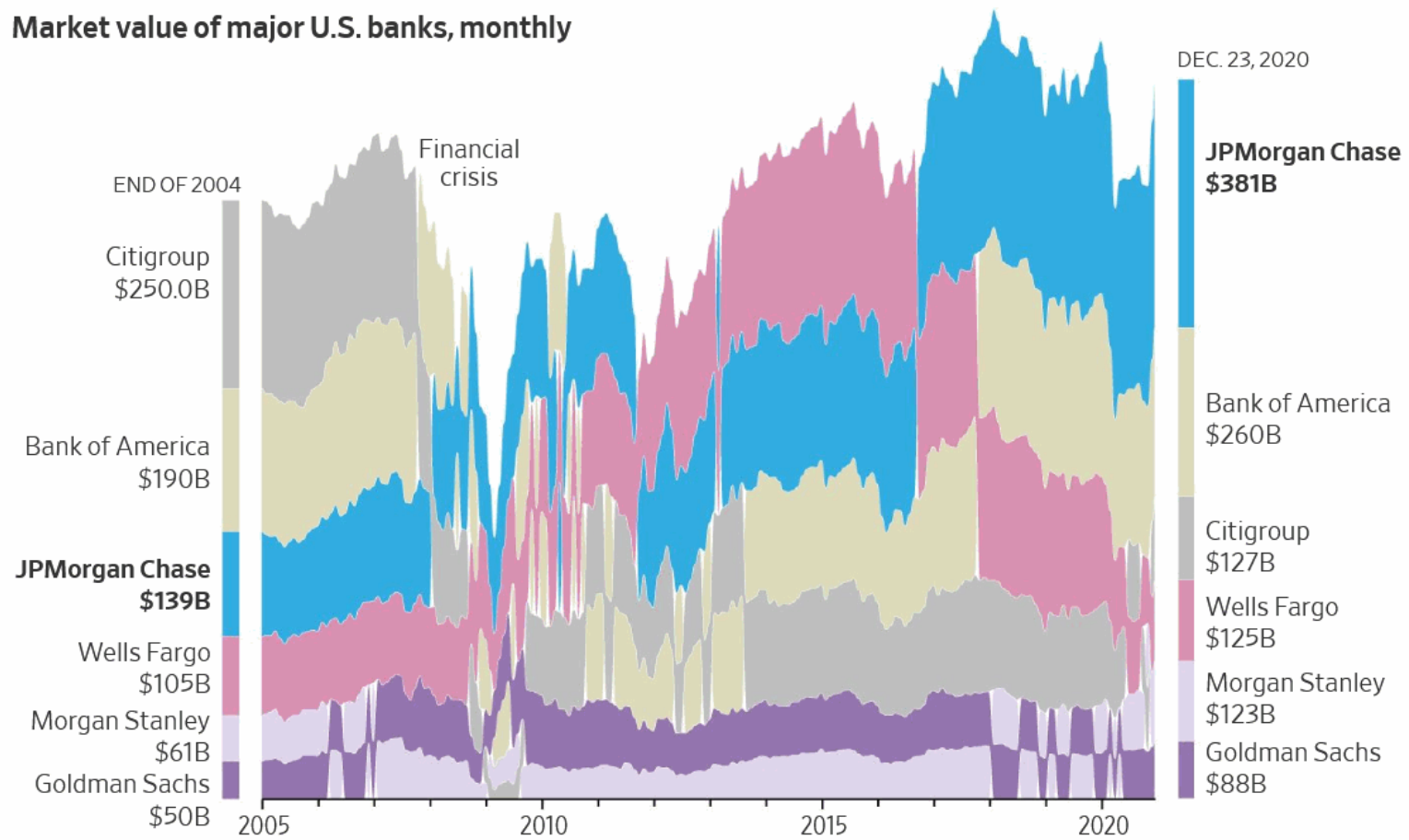
Global Meat Consumption



Global Meat Consumption



Market value of major U.S. banks, monthly



Source: FactSet

source: WSJ, 26 Dec 2020



HOMWORK

2 Periodic

1 Births

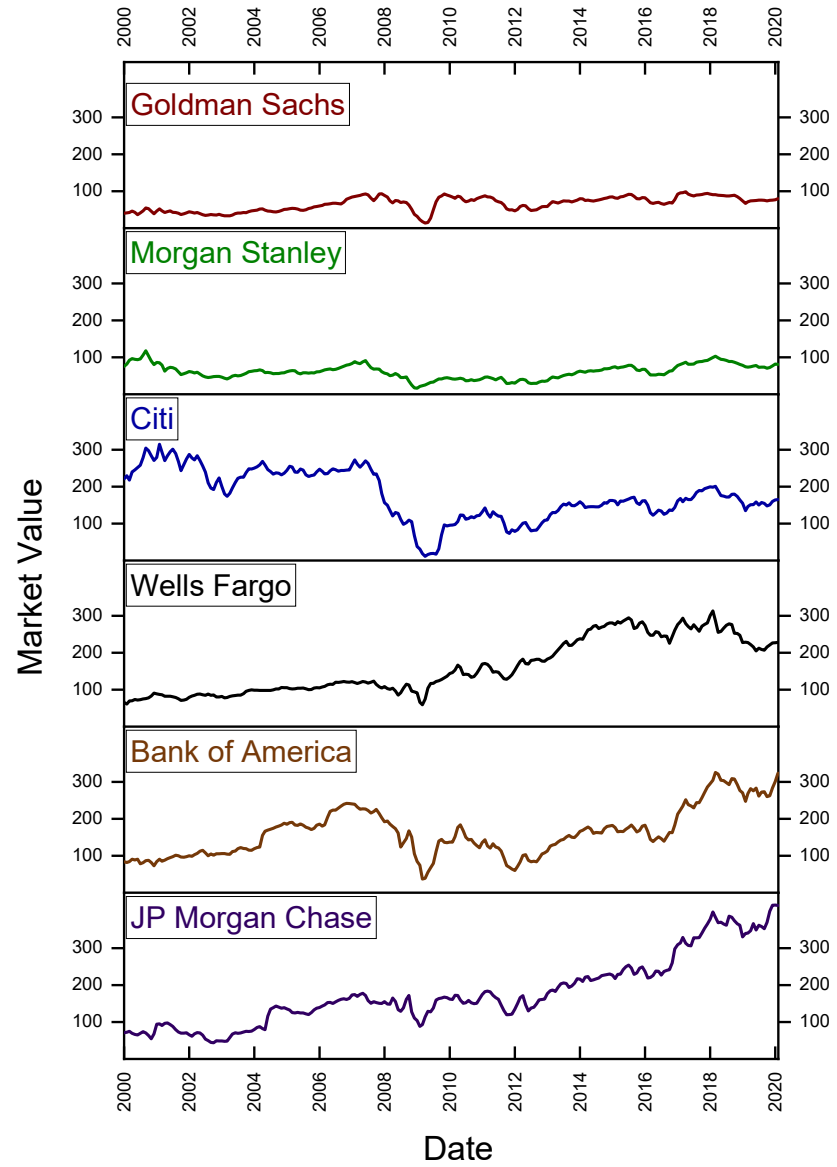
12 Tech Layoffs

8 Banks

4 COVID Deaths

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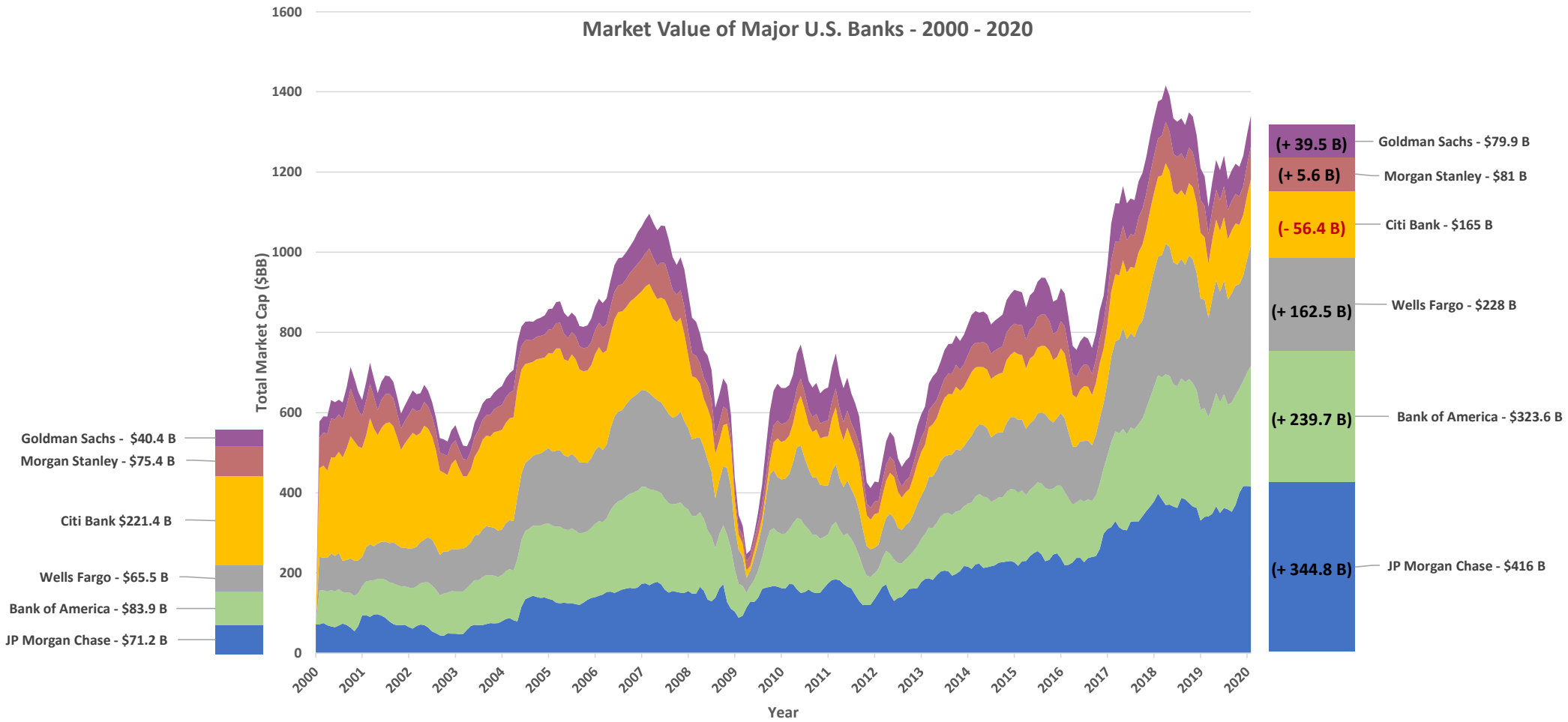
Amy Wahlmeier

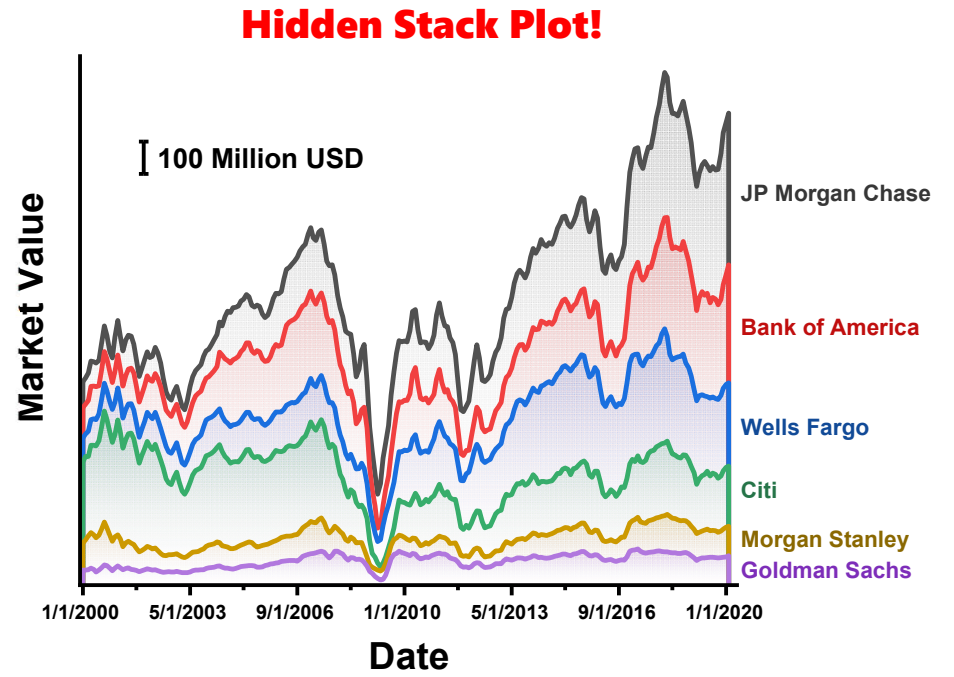
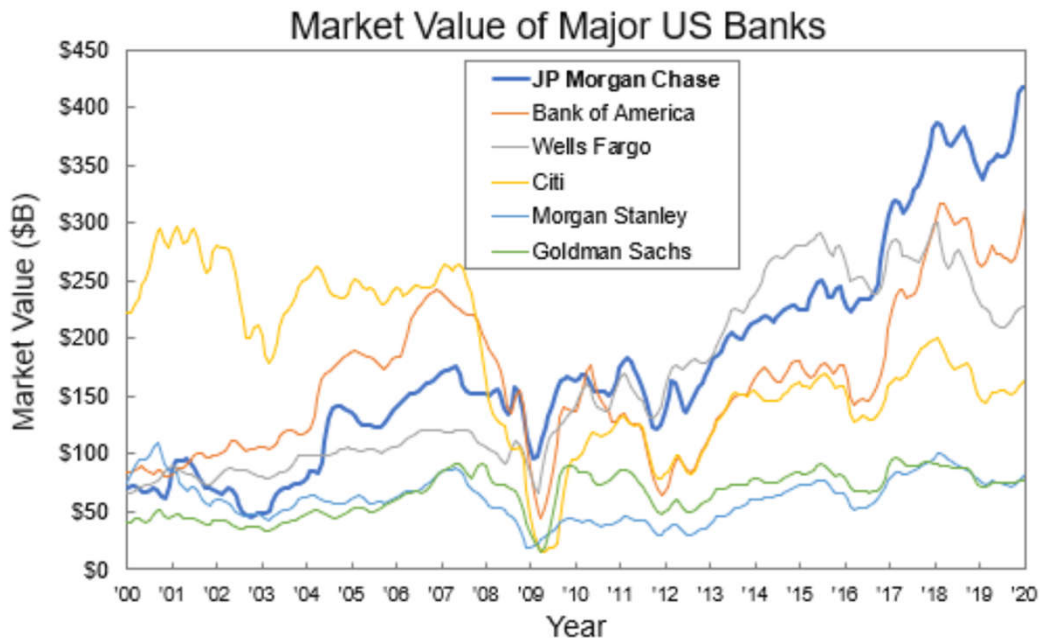


Zachary Firestein

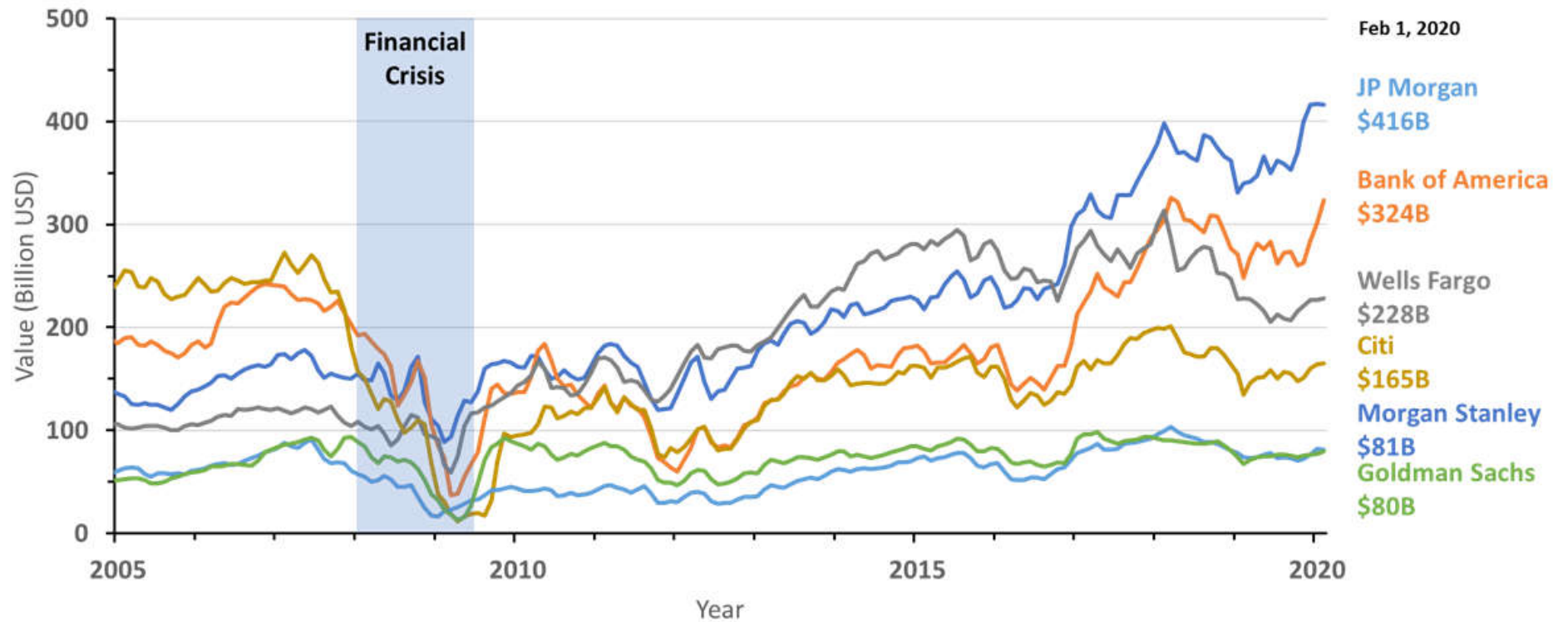


Market Value of Major U.S. Banks - 2000 - 2020

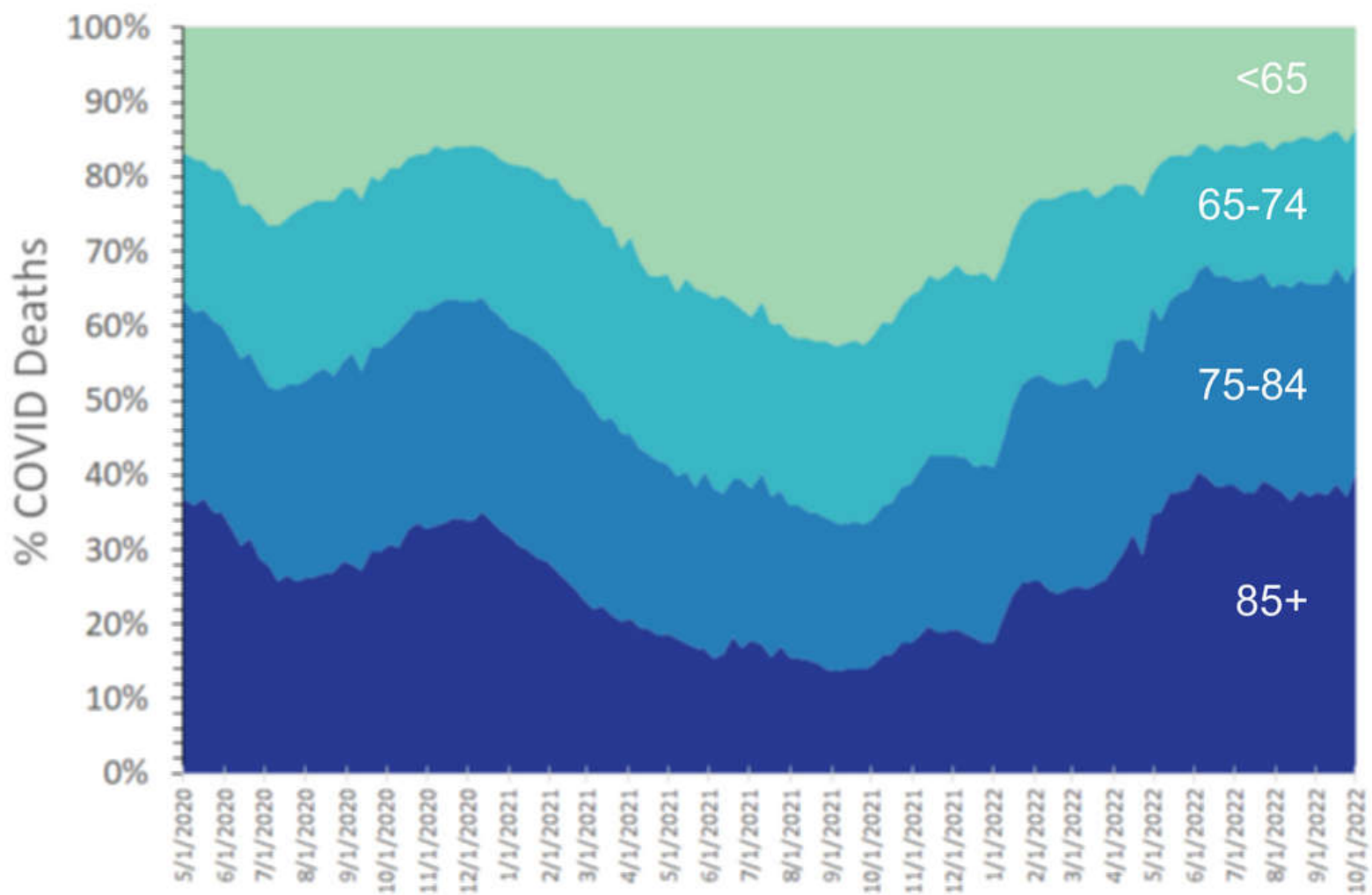




Market Value of Major U.S. Banks, Monthly

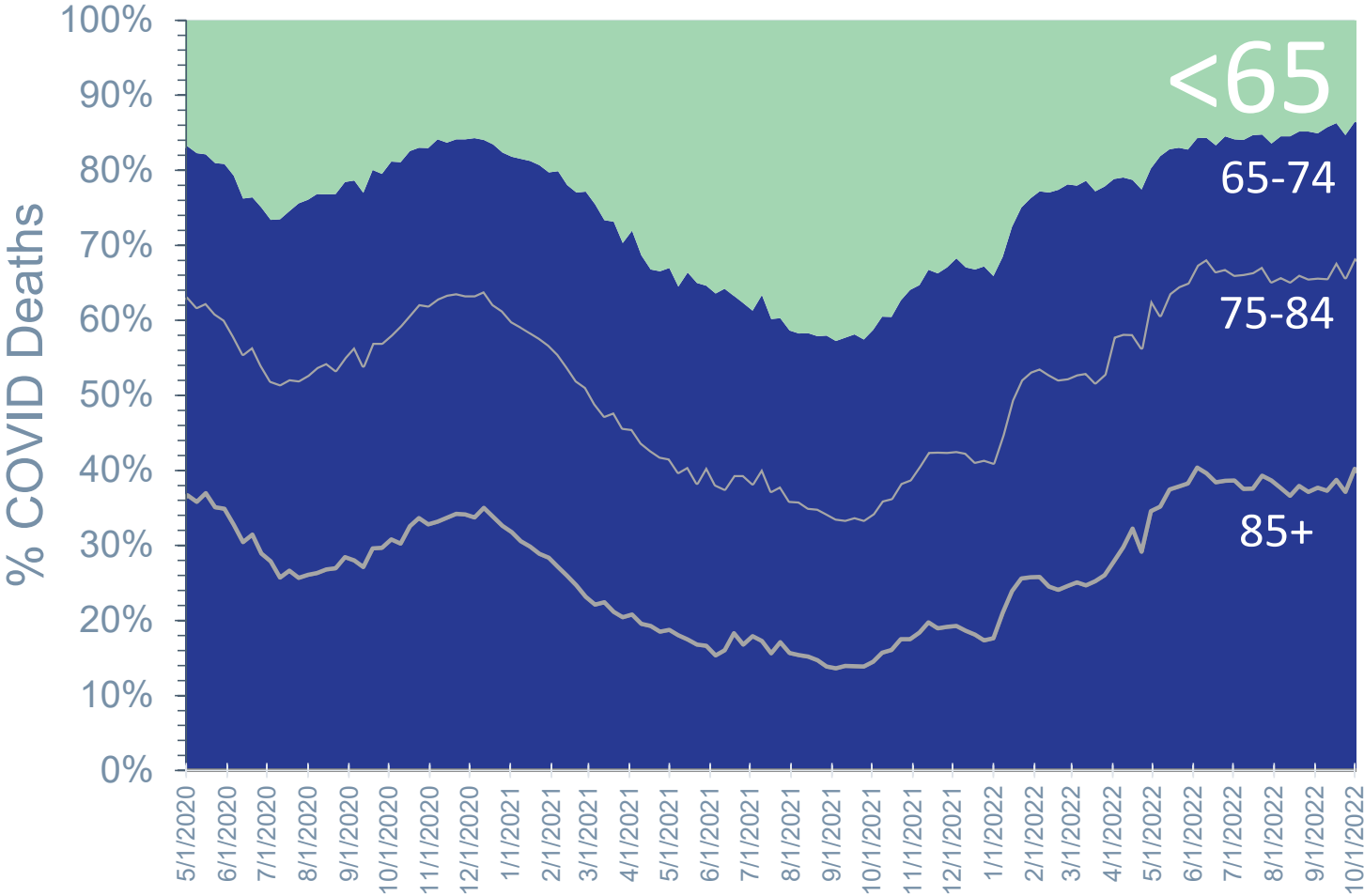


While the total number of COVID deaths has fallen, the burden of mortality is shifting even more to people older than age 64.

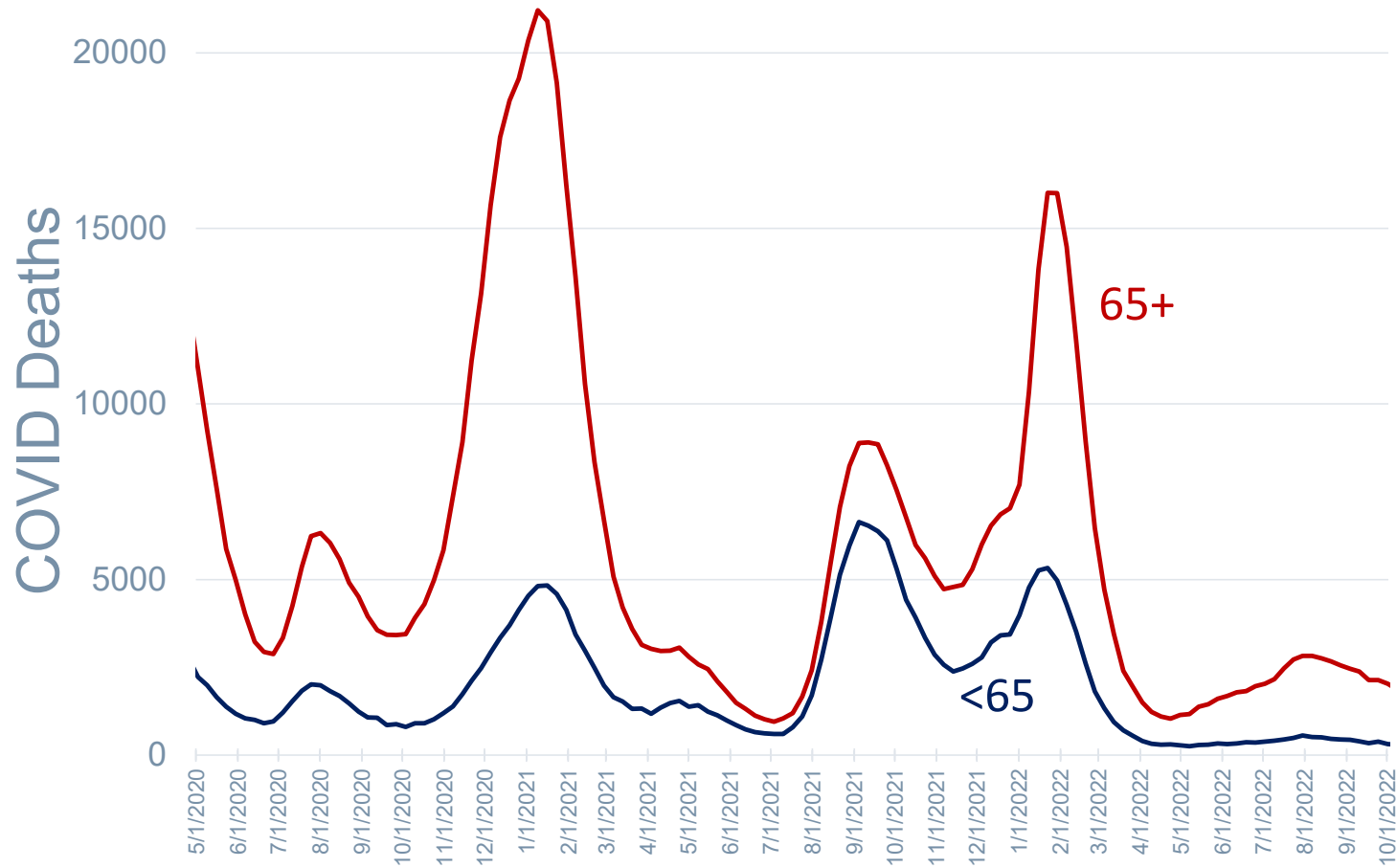


<https://www.scientificamerican.com/article/who-is-dying-from-covid-now-and-why/>

While the total number of COVID deaths has fallen, the burden of mortality is shifting even more to people older than age 64.



While the total number of COVID deaths has fallen, the burden of mortality is shifting even more to people older than age 64.





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CHART JUNK

Median student debt of households headed by people 55-64 and owing student loans (all figures in 2016 dollars).

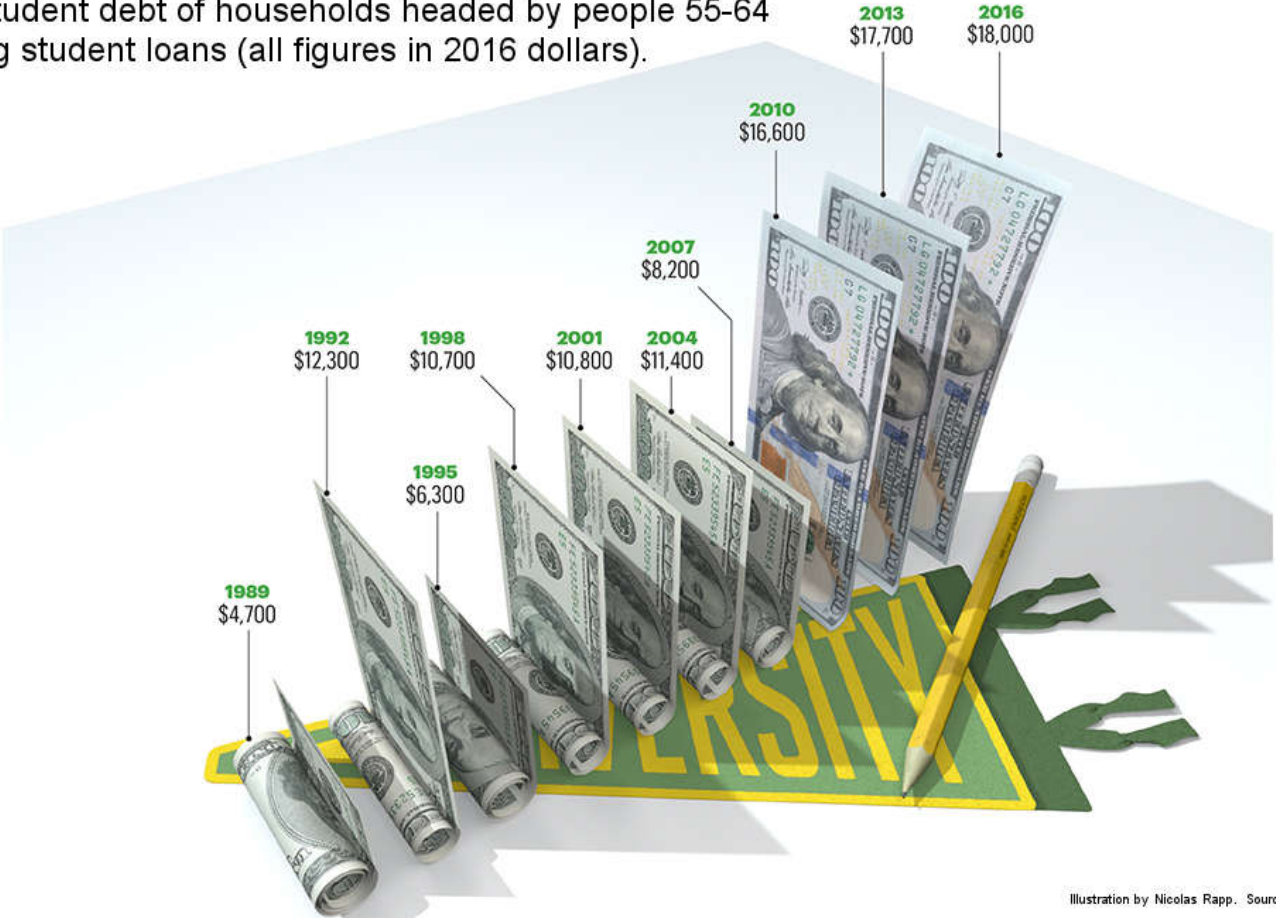
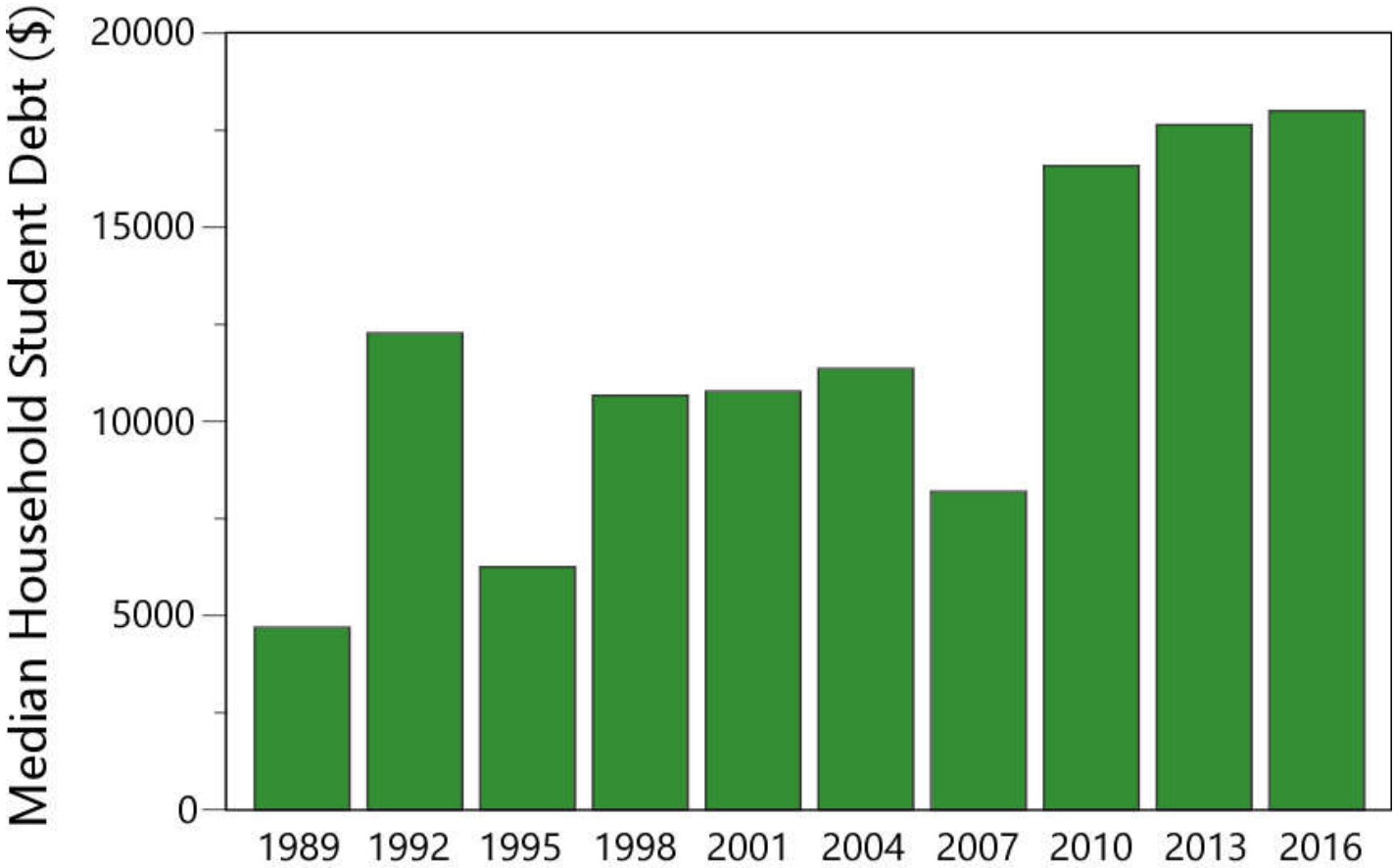


Illustration by Nicolas Rapp. Source: Federal Reserve Board

REMOVE THE JUNK



REMOVE THE JUNK



HOW MANY TIMES BIGGER?



aligned with axis is easiest to accurately quantify.



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4x

5x

6x

7x



HOW MANY TIMES BIGGER?



4x

5x

6x

7x



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HOW MANY TIMES BIGGER?



3x

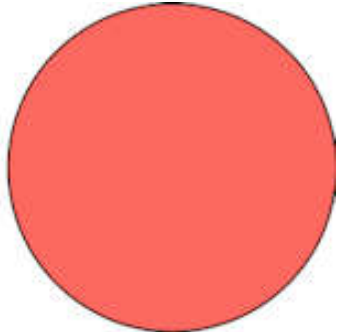
4x

5x

6x



HOW MANY TIMES BIGGER?



3x

4x

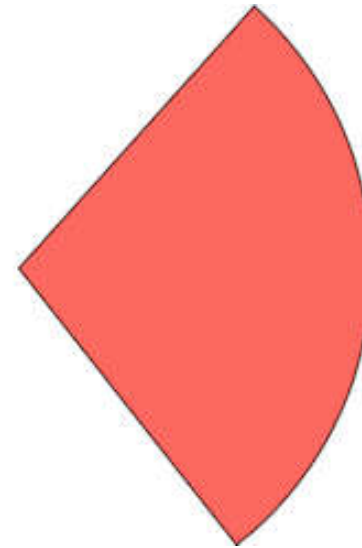
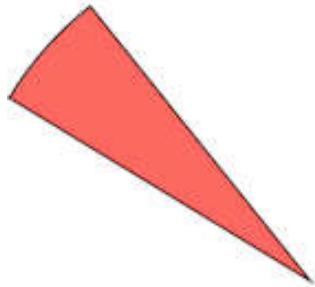
5x

6x

area is hard to judge



HOW MANY TIMES BIGGER?



5x

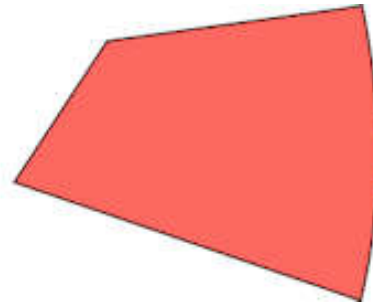
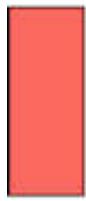
6x

7x

8x



HOW MANY TIMES BIGGER?



4x

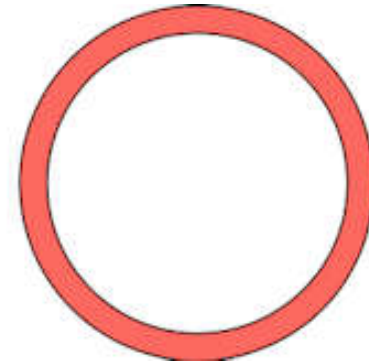
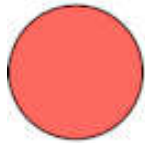
5x

6x

7x



HOW MANY TIMES BIGGER?



1x

1.5x

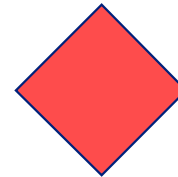
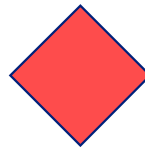
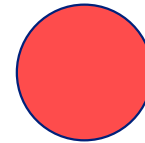
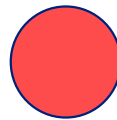
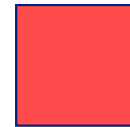
2x

3x



PERCEPTION

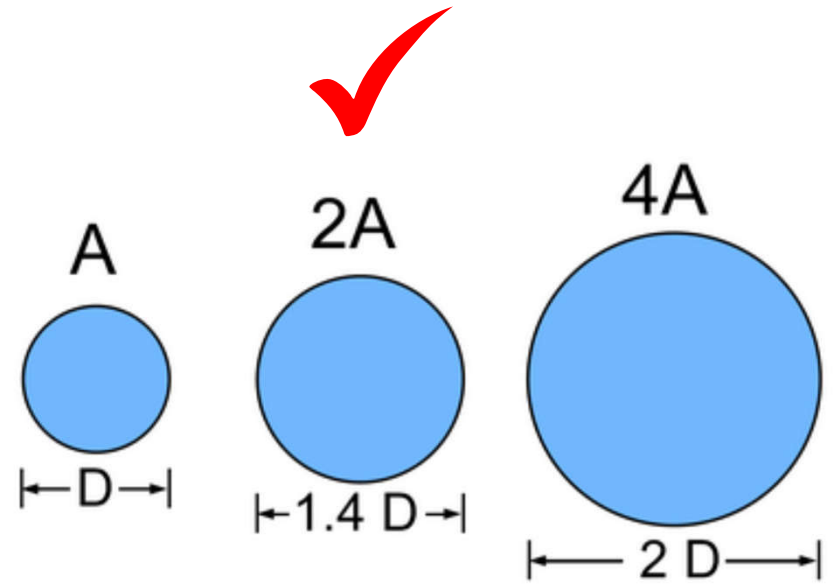
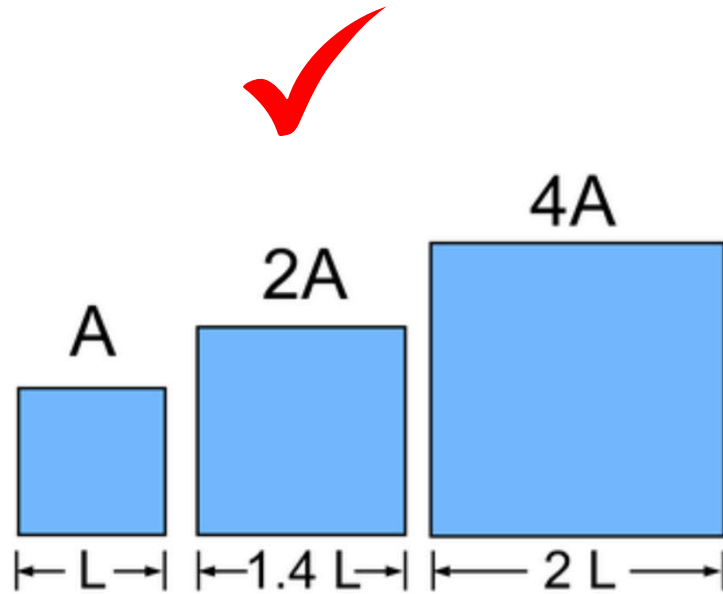
in each pair, the size differs by 1.5X



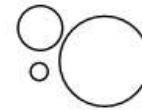
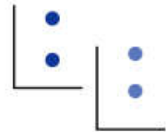
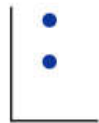
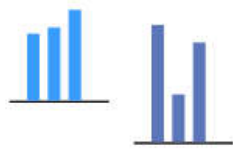
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AREA CONFUSION



HUMAN PERCEPTION



position
(aligned)

position
(unaligned)

length

angle

area

color intensity

color hue

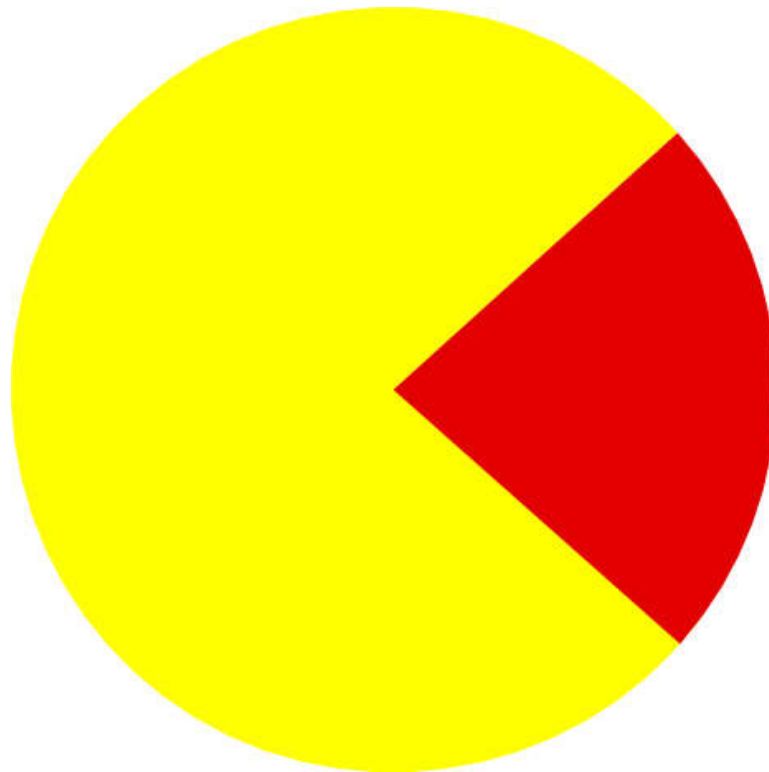
more
accurate

human perception

less
accurate

Cleveland, W.S. and McGill, R., 1984. Graphical perception: Theory, experimentation, and application to the development of graphical methods. *Journal of the American statistical association*, 79(387), pp.531-554.

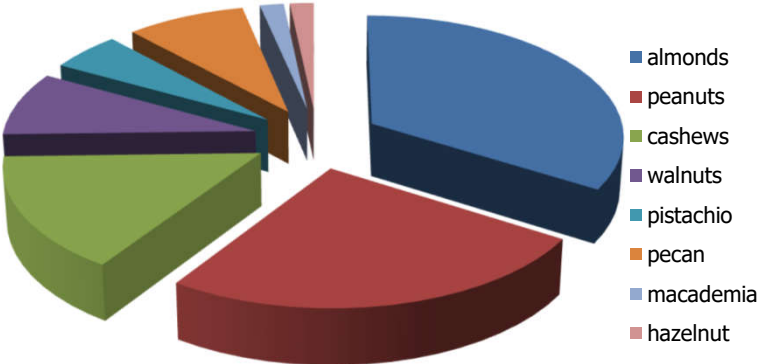
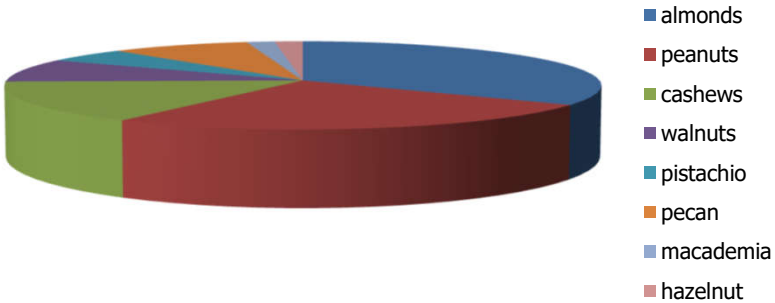
PIE CHARTS



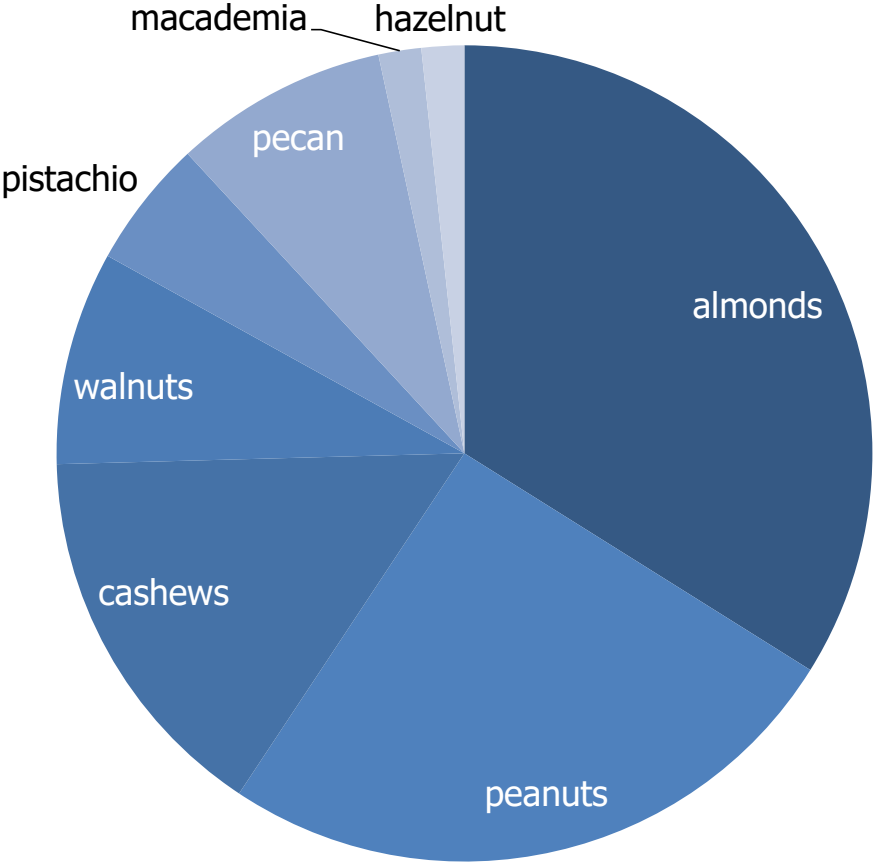
 doesn't look like Pacman

 looks like Pacman

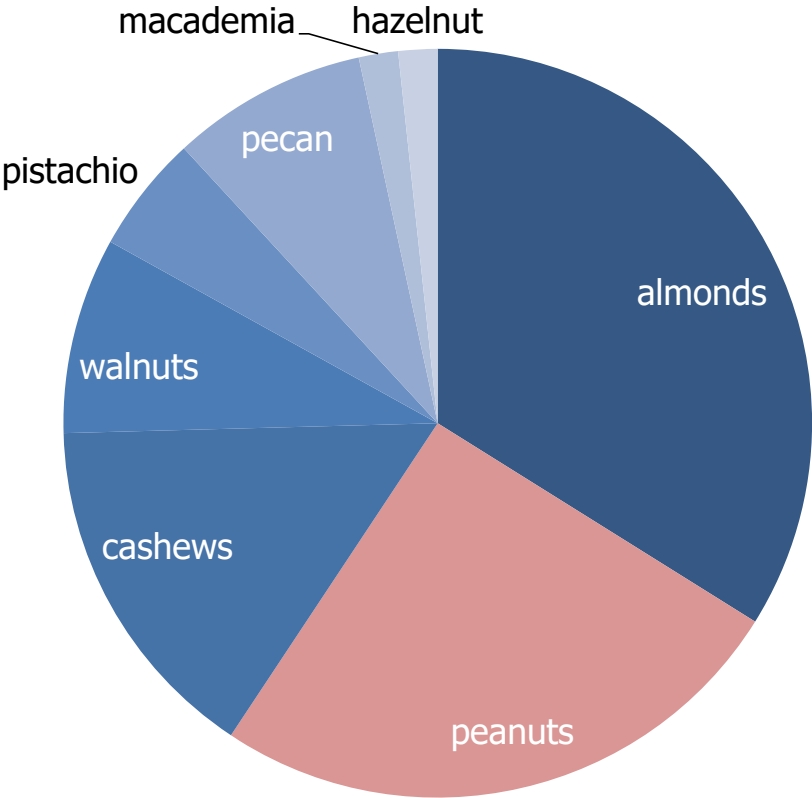
U.S. NUT PRODUCTION



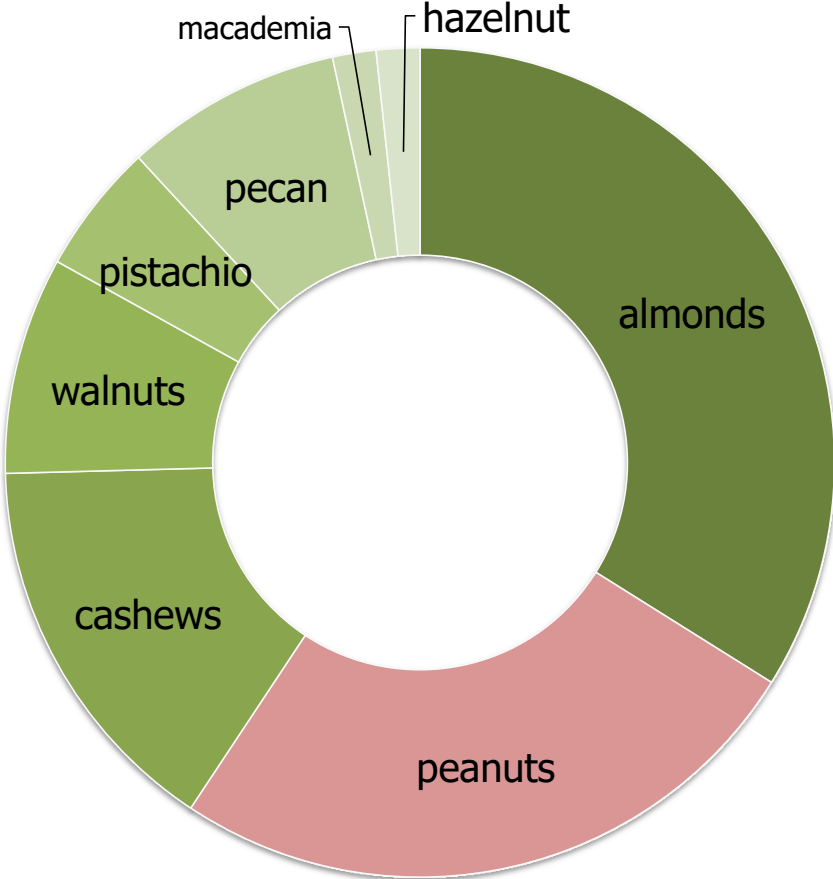
U.S. NUT PRODUCTION



U.S. NUT PRODUCTION

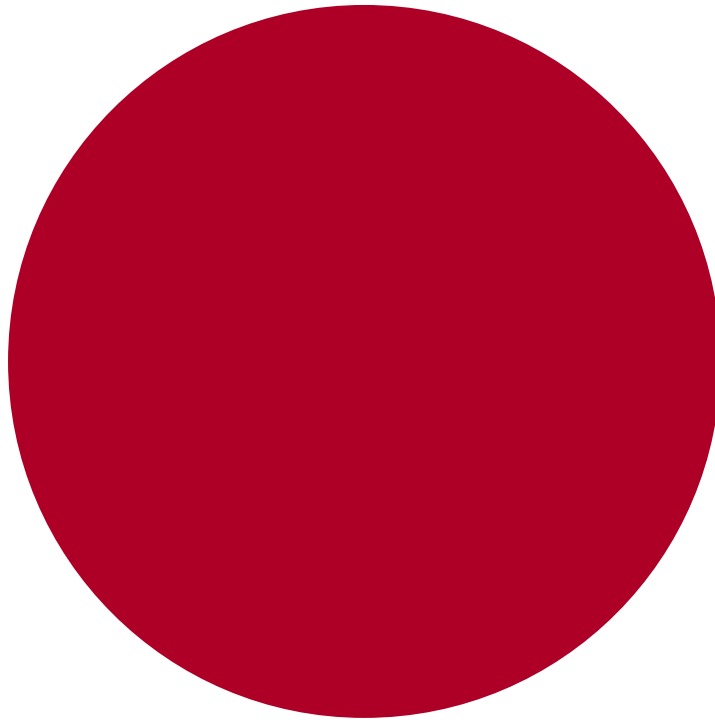


U.S. NUT PRODUCTION



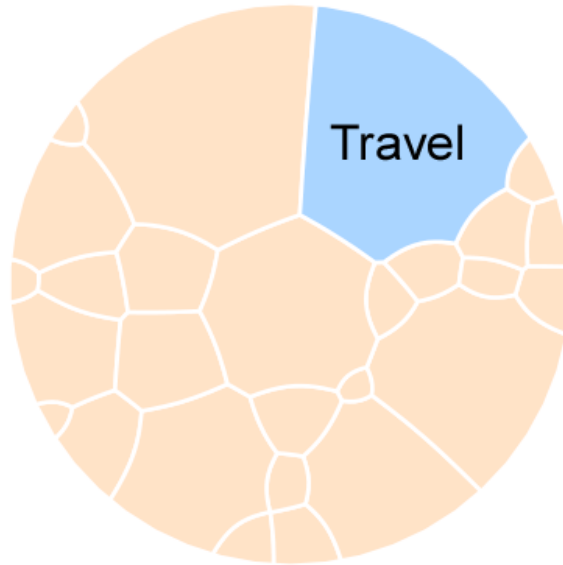
PIE CHARTS

When should you use a pie chart?

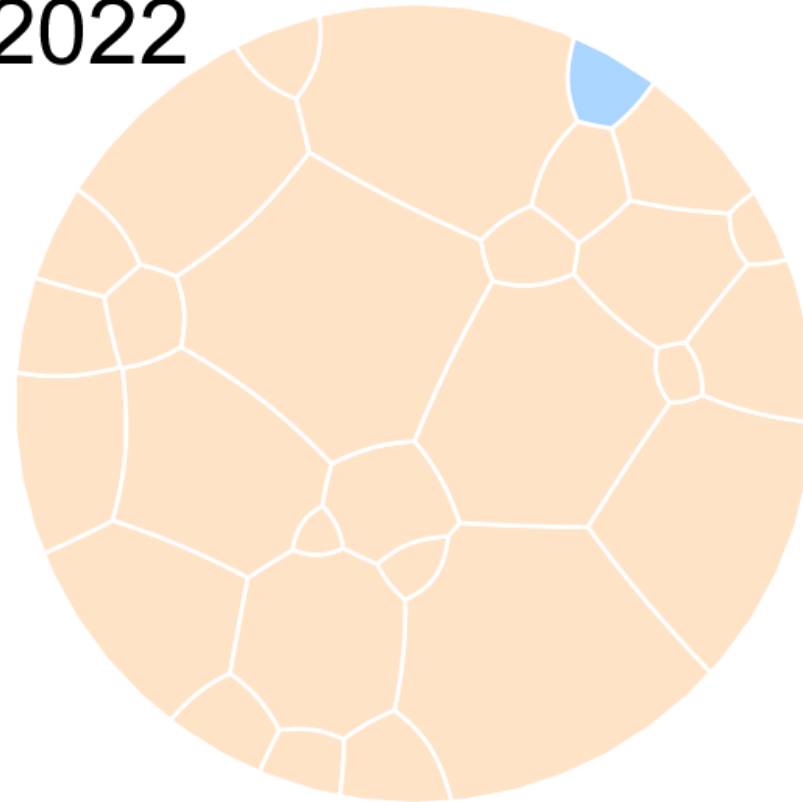


 **Never**

2020



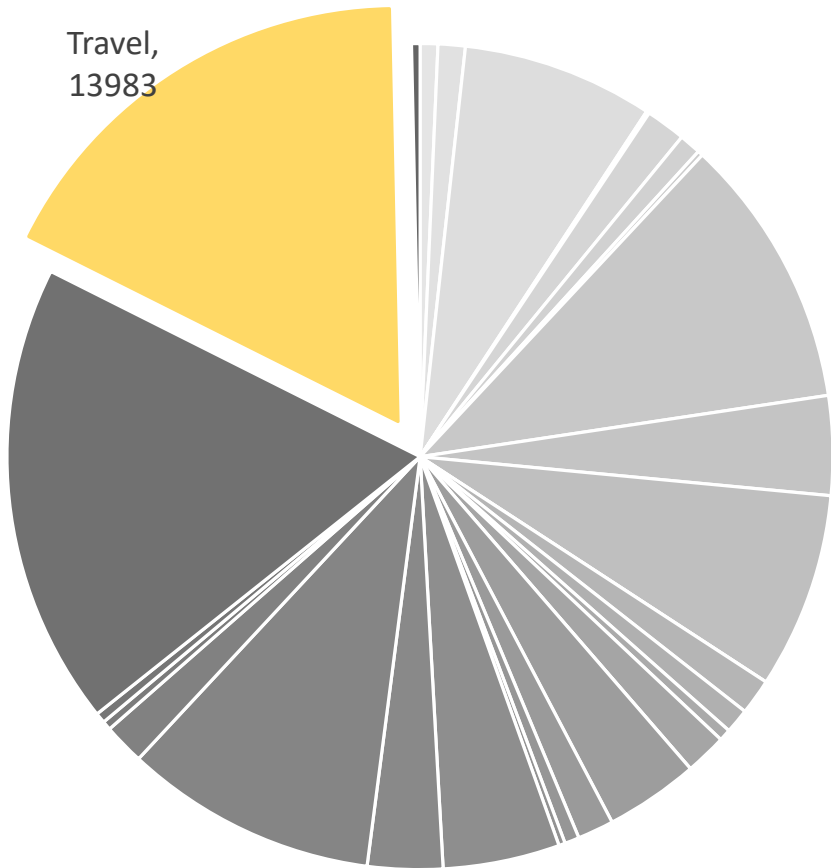
2022



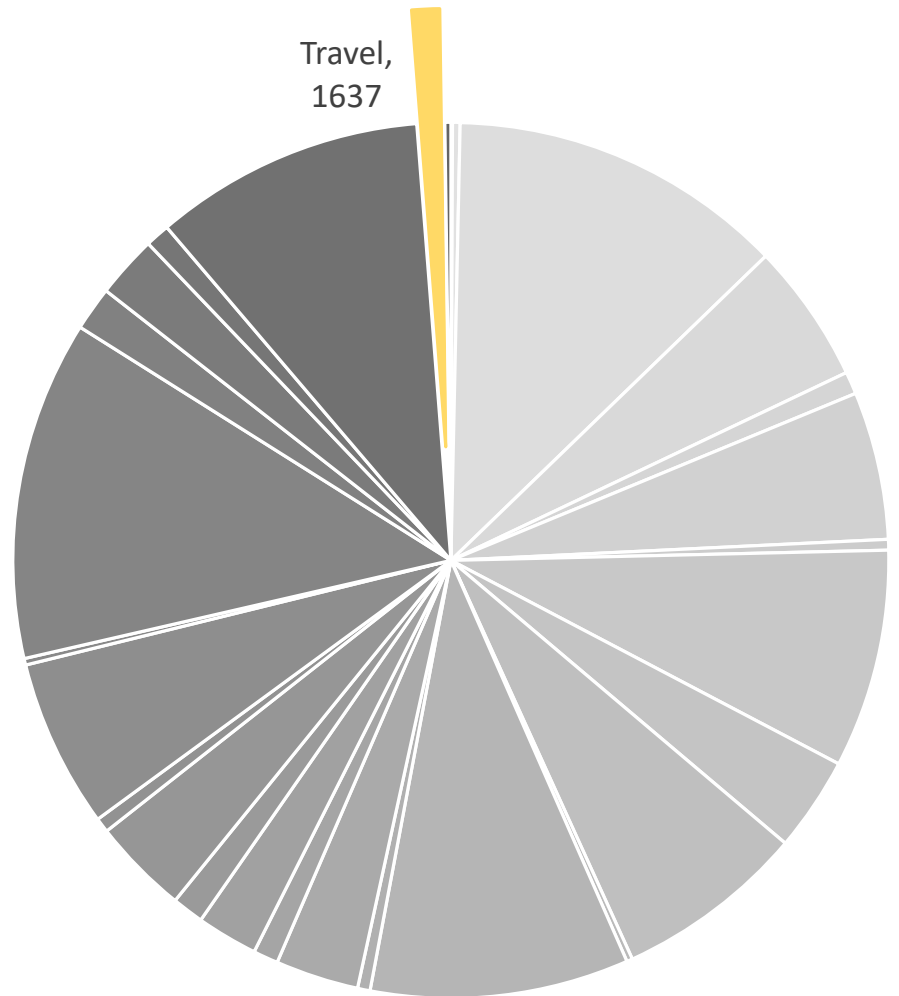
Travel-related tech companies were hit hard by layoffs in 2020 because of lockdowns and pandemic travel restrictions. In 2022, travel was among the areas that had the least job losses.

<https://www.wsj.com/articles/tech-layoffs-are-happening-faster-than-at-any-time-during-the-pandemic-11672705089>

Technology Company Layoffs for 2020 and 2022



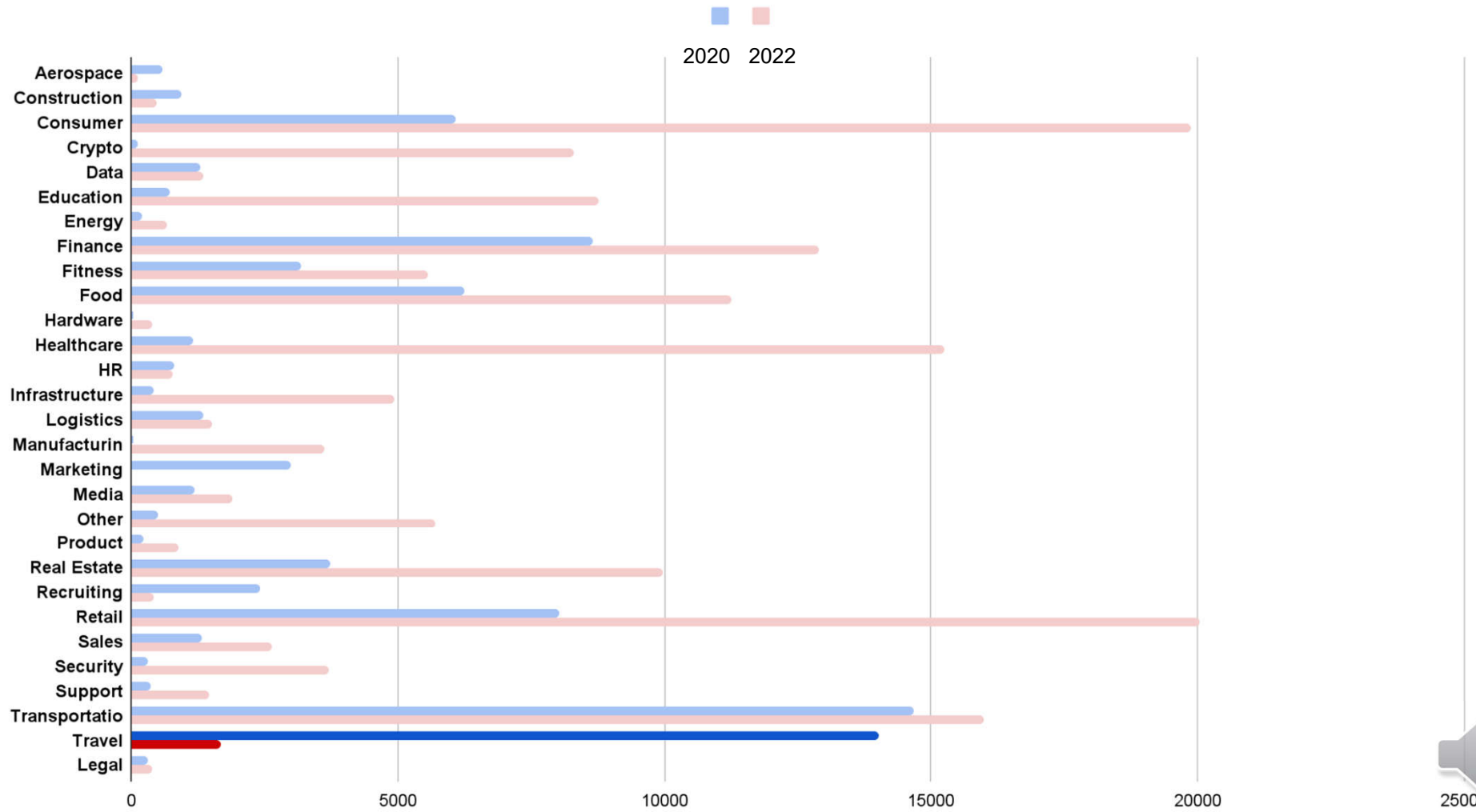
2020



2022

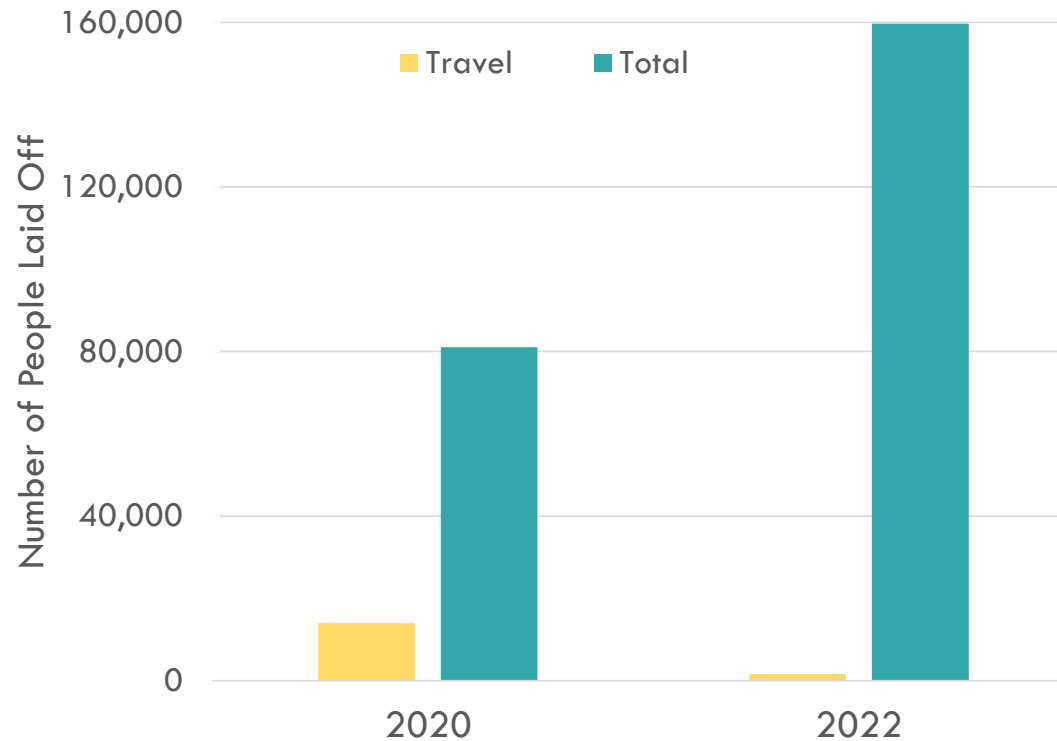
Tech company layoffs

Lakshmy Priya Ajayakumar



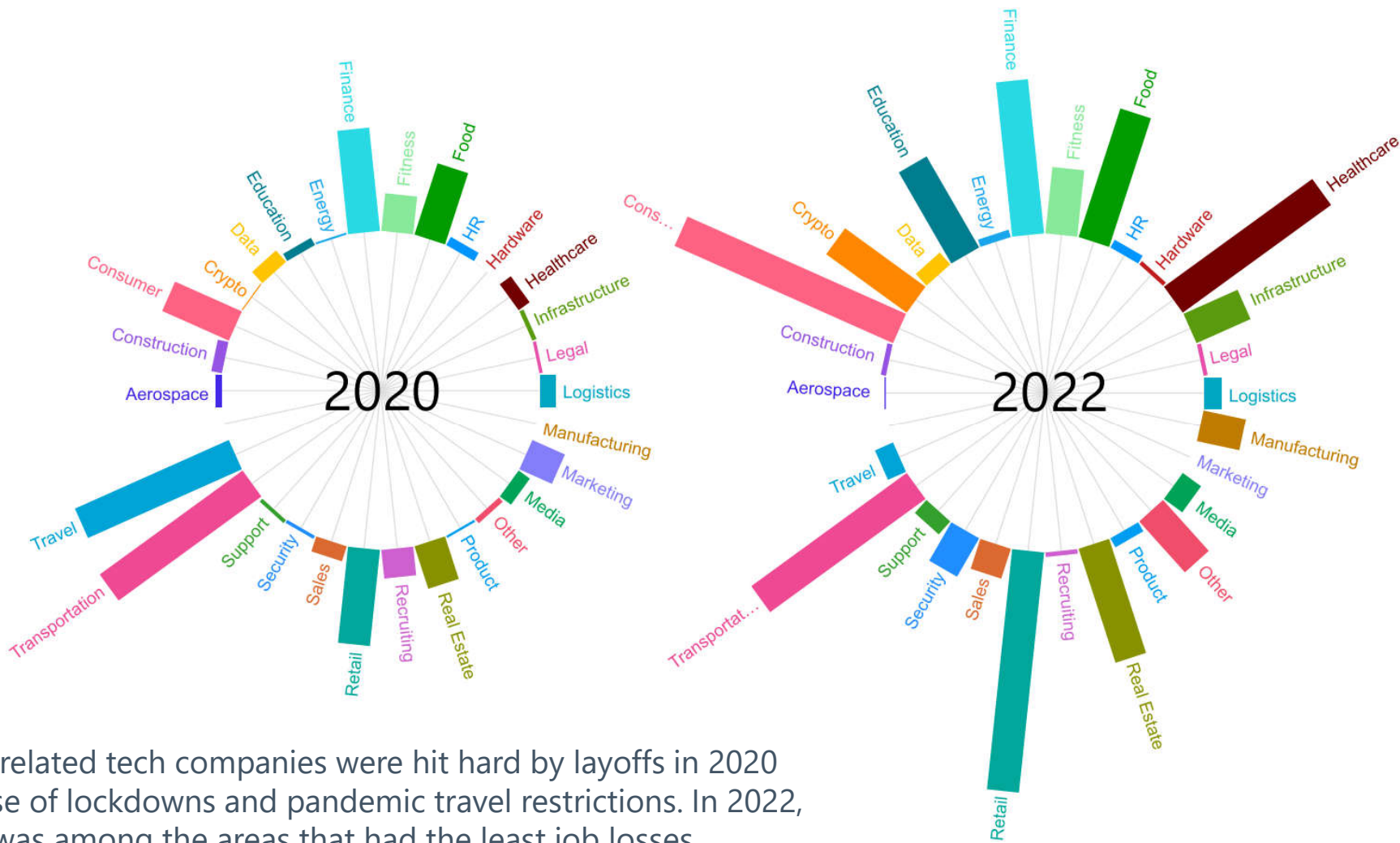
Alexis Lower

Technology Company Layoffs for 2020 and 2022

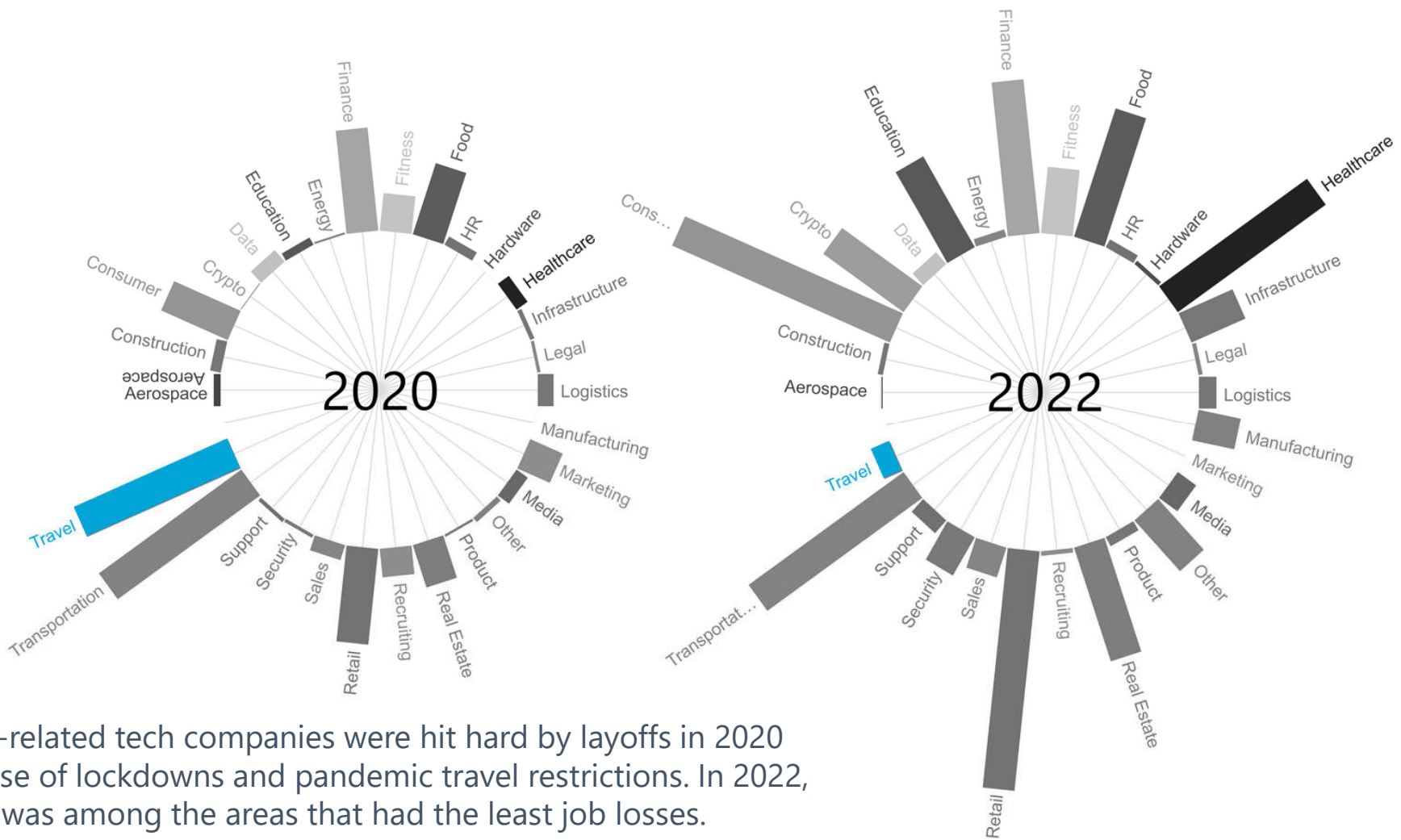


Travel-related tech companies were hit hard by layoffs in 2020 because of lockdowns and pandemic travel restrictions. In 2022, travel was among the areas that had the least job losses.





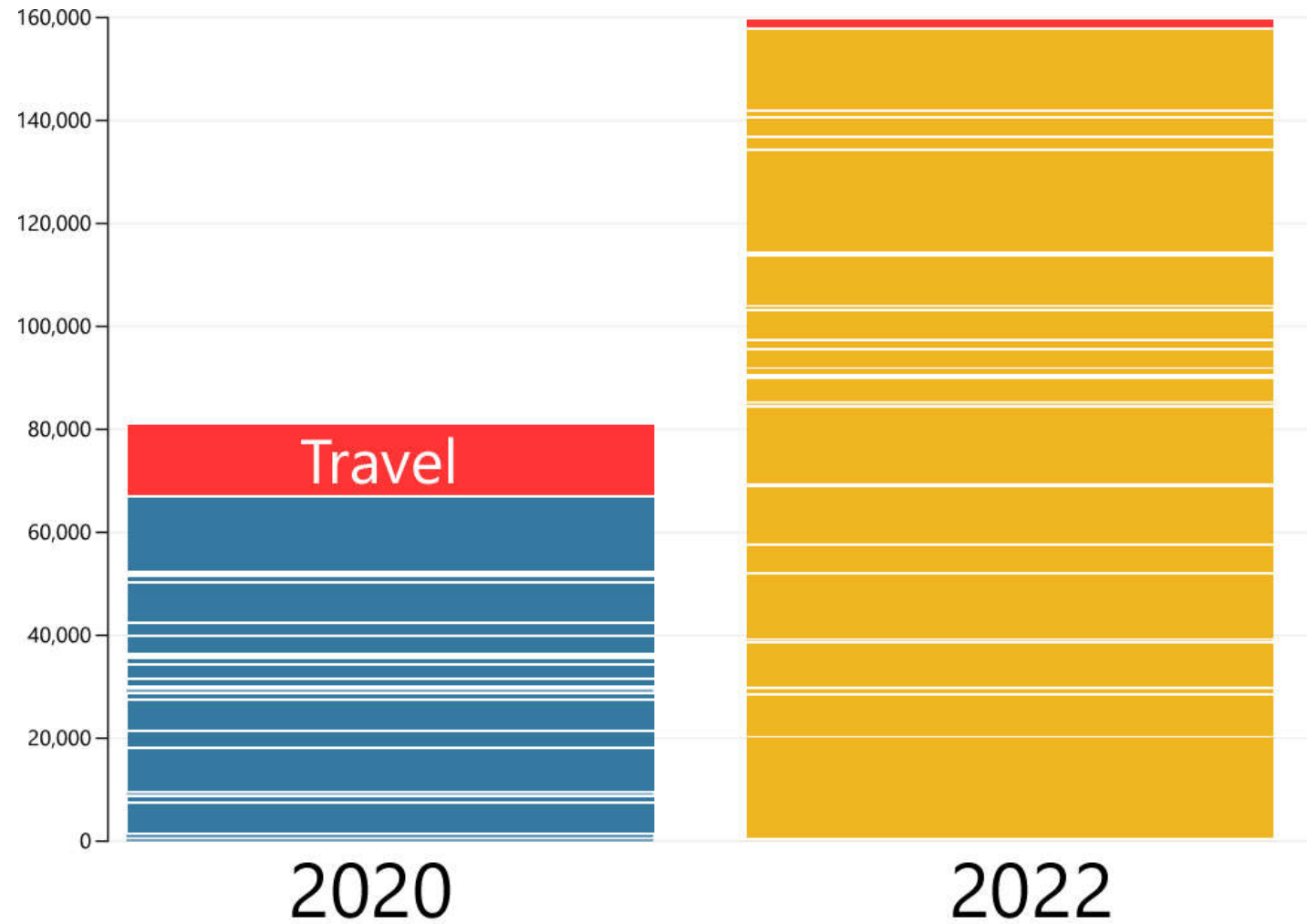
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<https://layoffs.fyi/>

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SANFORD AND SELNICK

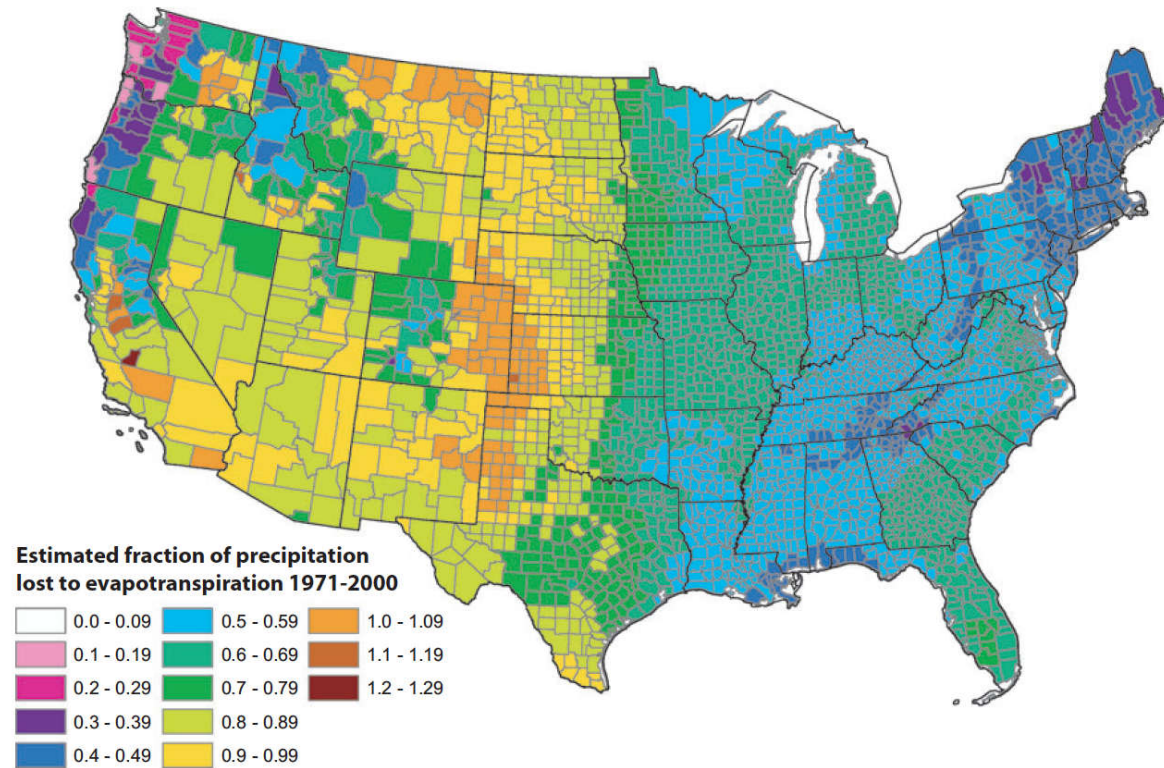


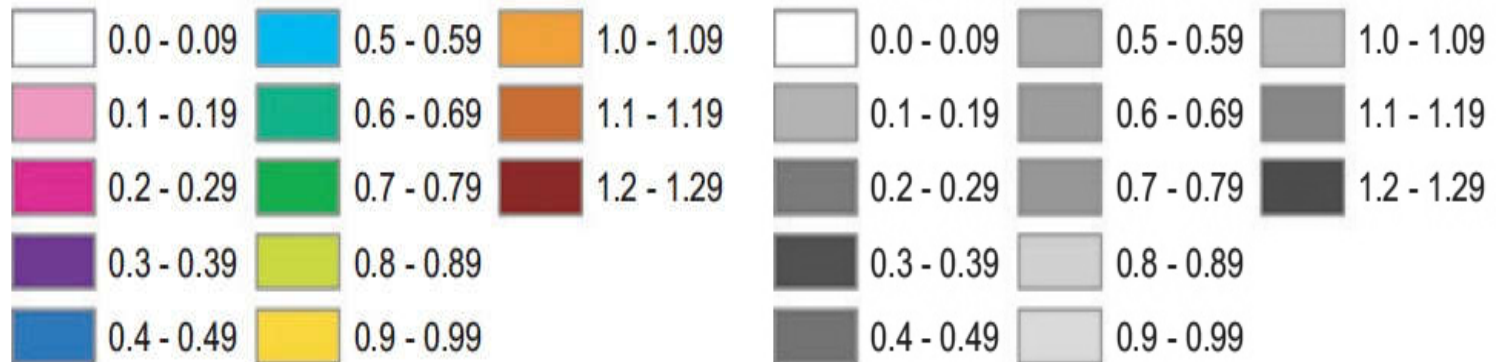
FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/P were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.

Sanford, W.E. and Selnick, D.L., 2013. Estimation of Evapotranspiration Across the Conterminous United States Using a Regression With Climate and Land-Cover Data. *JAWRA Journal of the American Water Resources Association*, 49(1), pp.217-230.

<https://eagereyes.org/basics/rainbow-color-map>

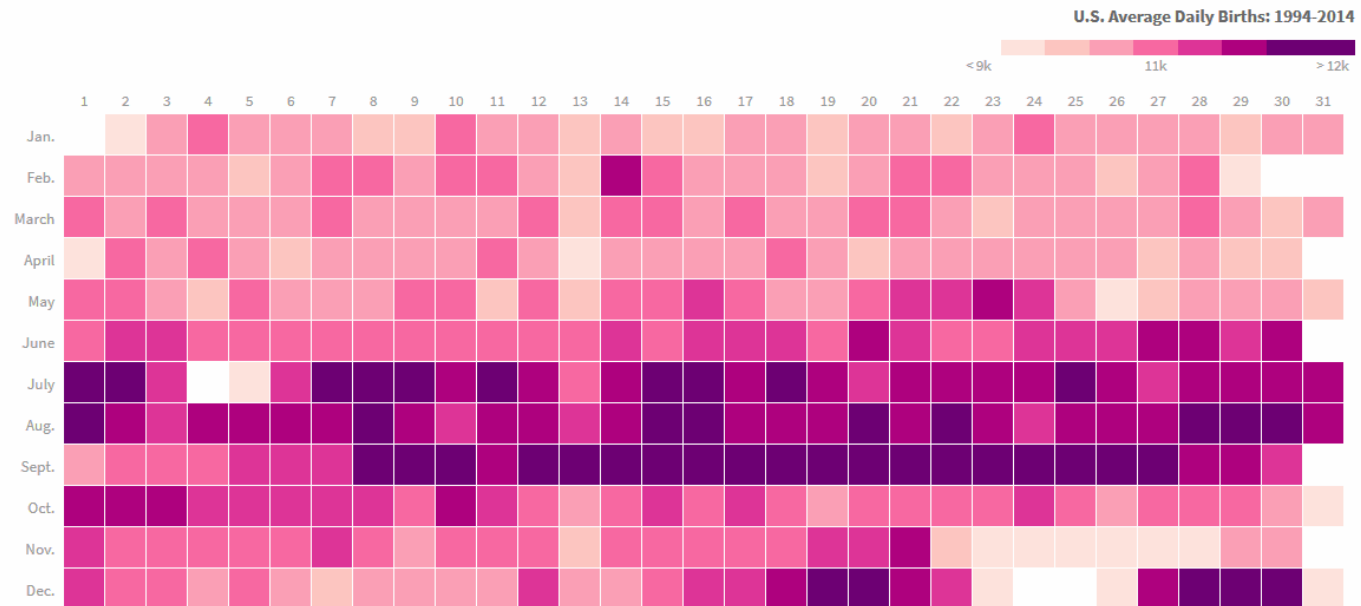
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ABRUPT CHANGE IN LUMINANCE



HOW POPULAR IS YOUR BIRTHDAY?

Two decades of American birthdays, averaged by month and day.



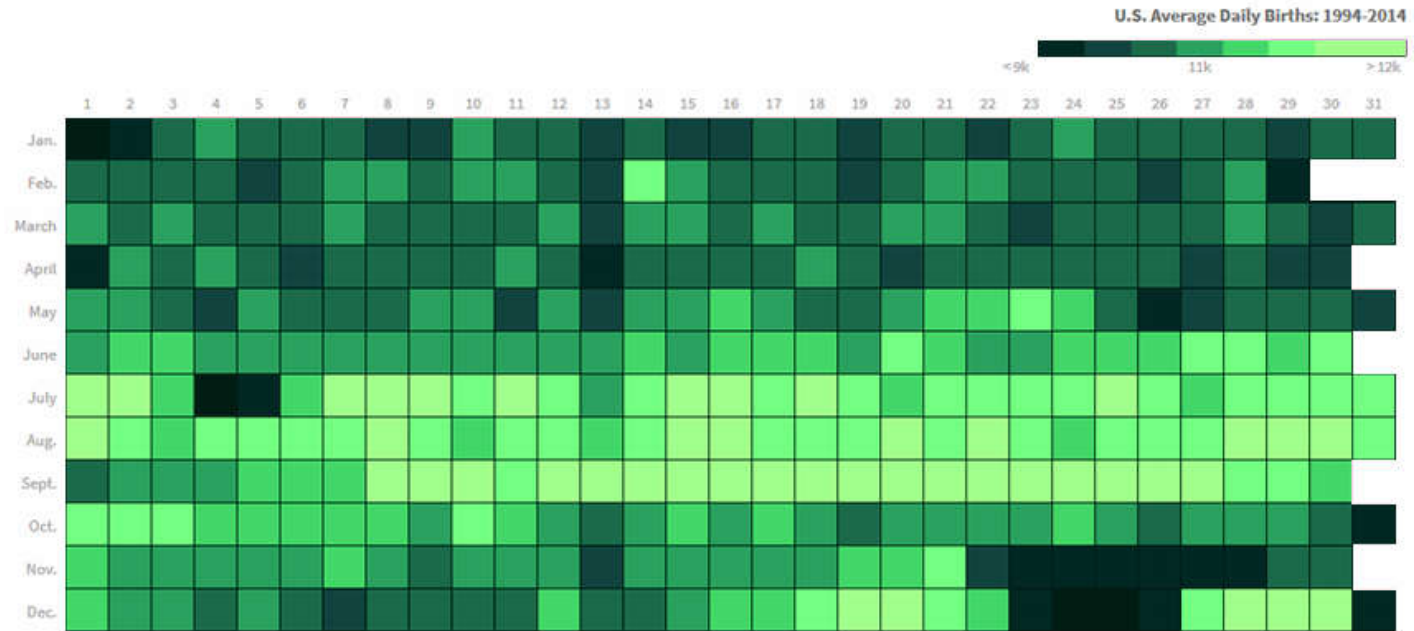
Notes: The conception date, purely for illustration, is 266 days prior to birth. It represents a hypothetical "moment of conception" based on the normal gestation period for humans, 280 days, minus the average time for ovulation, two weeks.

Data: U.S. National Center for Health Statistics (1994-2003); U.S. Social Security Administration (2004-2014) — via [FiveThirtyEight](#)

Credit: [Matt Stiles/The Daily Viz](#)

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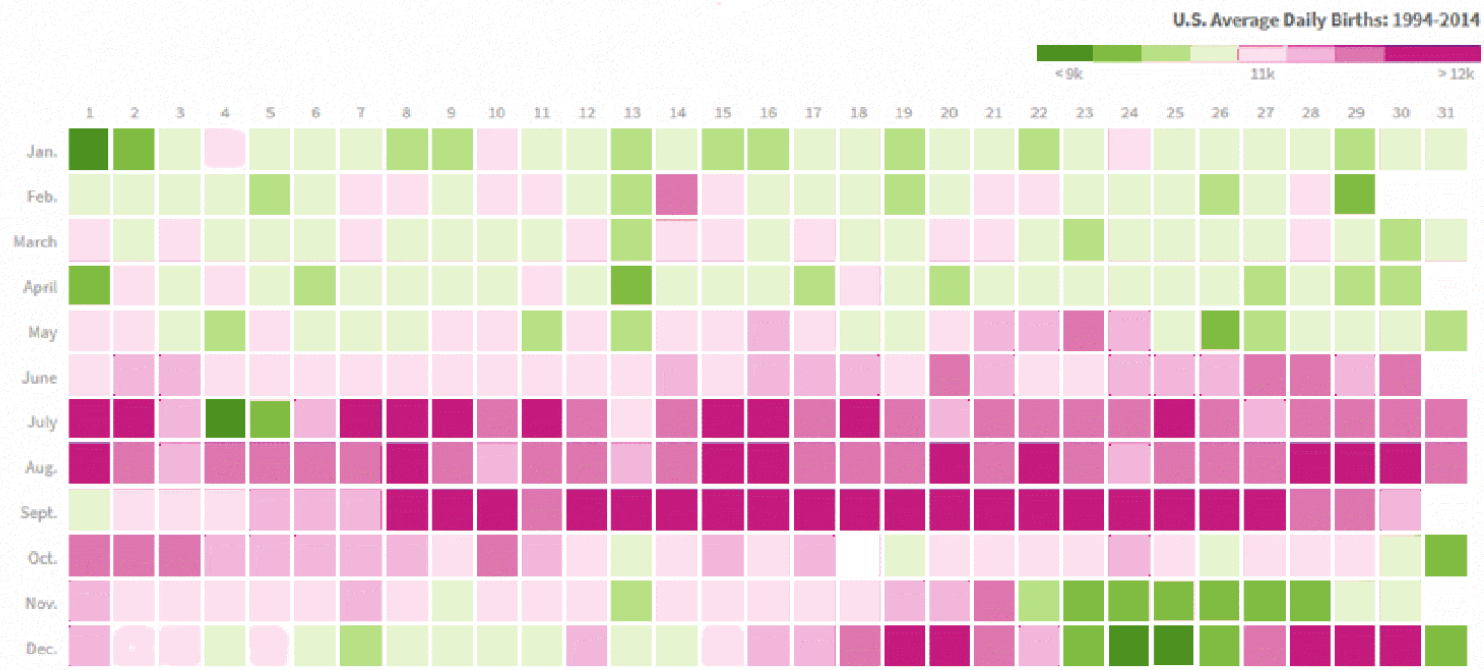
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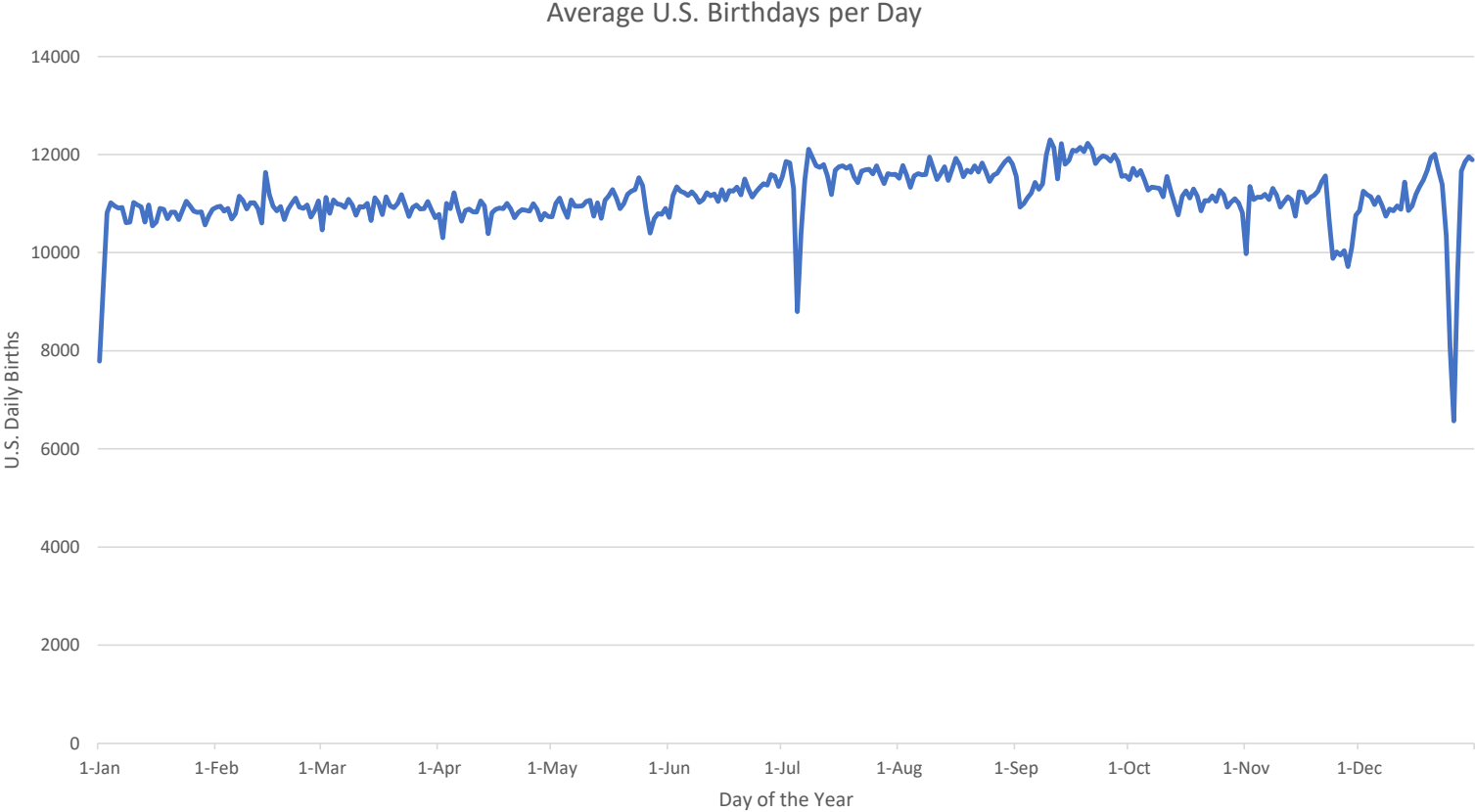


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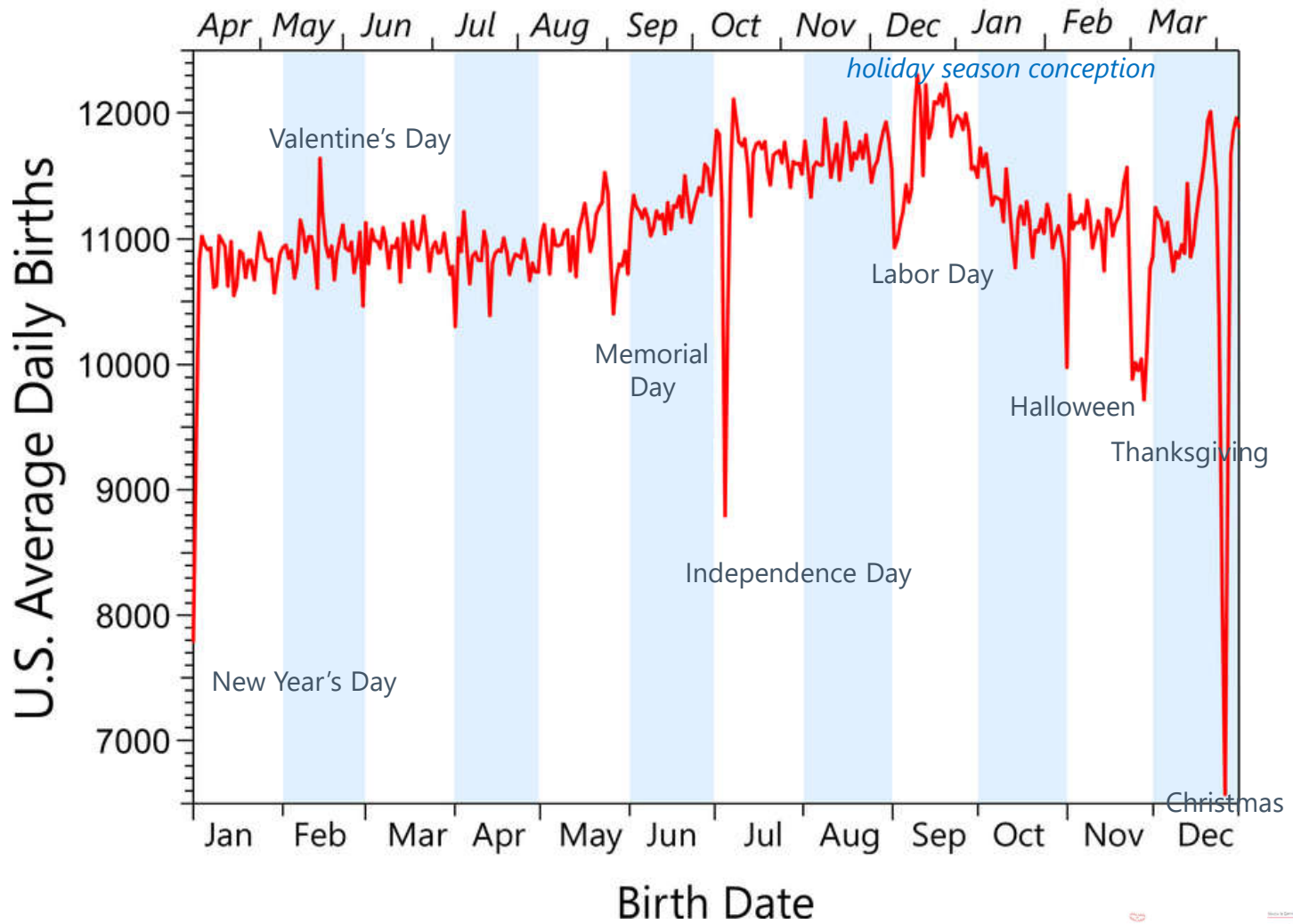
Data: U.S. National Center for Health Statistics (1994-2003); U.S. Social Security Administration (2004-2014) — via [FiveThirtyEight](#)

Credit: [Matt Stiles/The Daily Viz](#)

Nolan Green

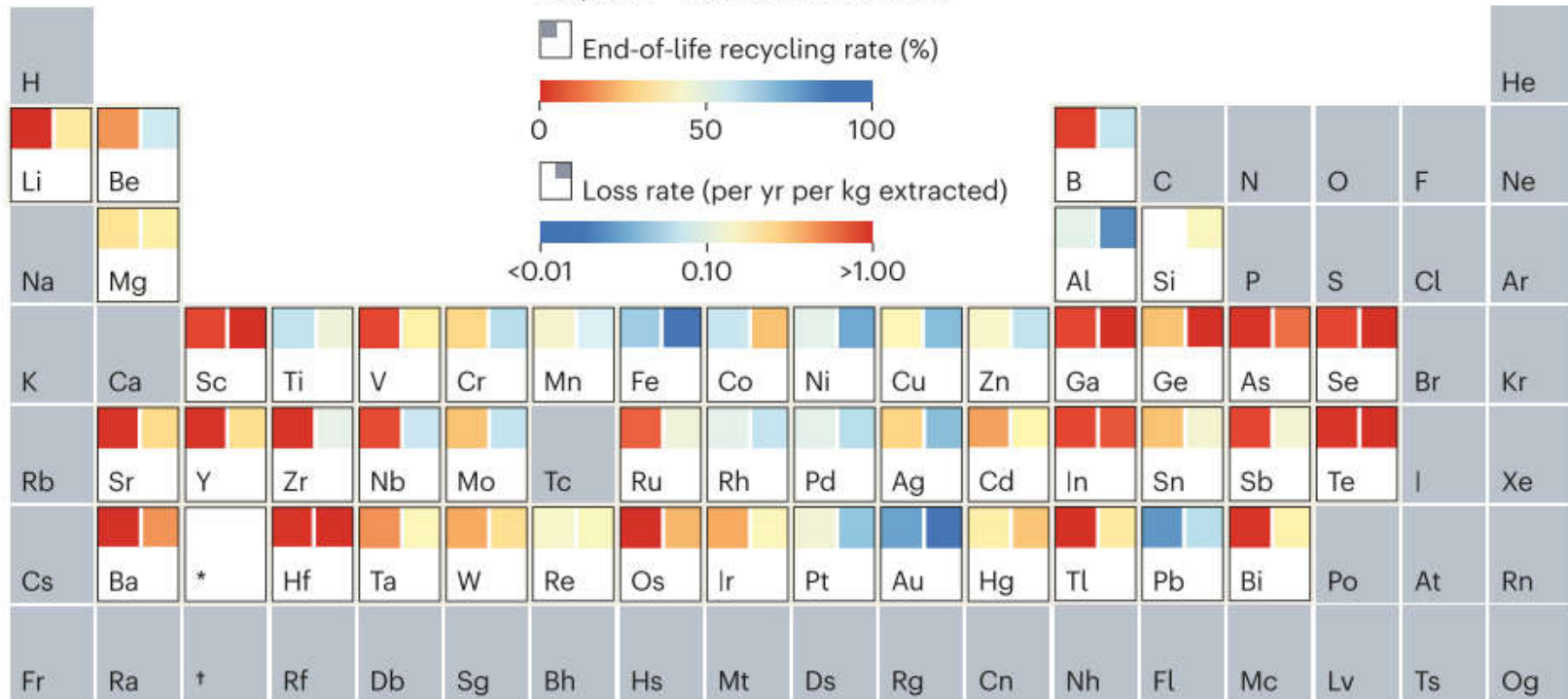


Approximate Conception Date

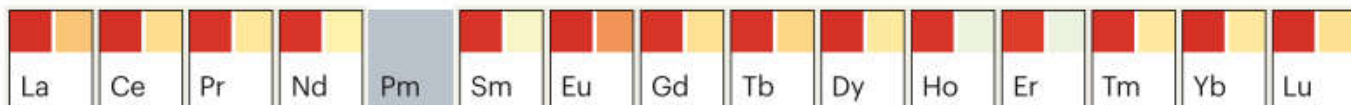


SCRAP METAL

In general, metals with a higher end-of-life recycling rate — the percentage of scrap that is functionally recycled — have lower loss rates.



*Lanthanide series

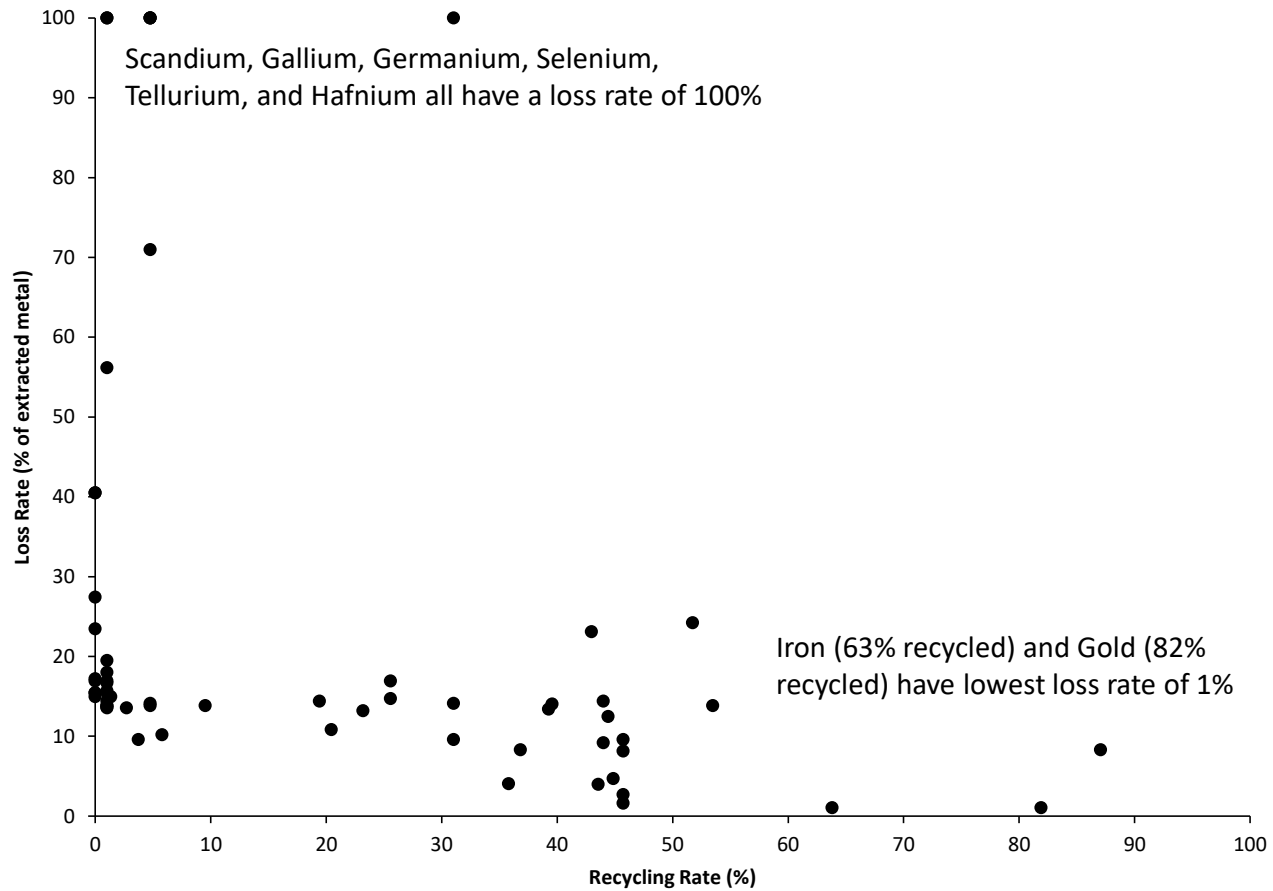


†Actinide series



Thomas Tzuppek

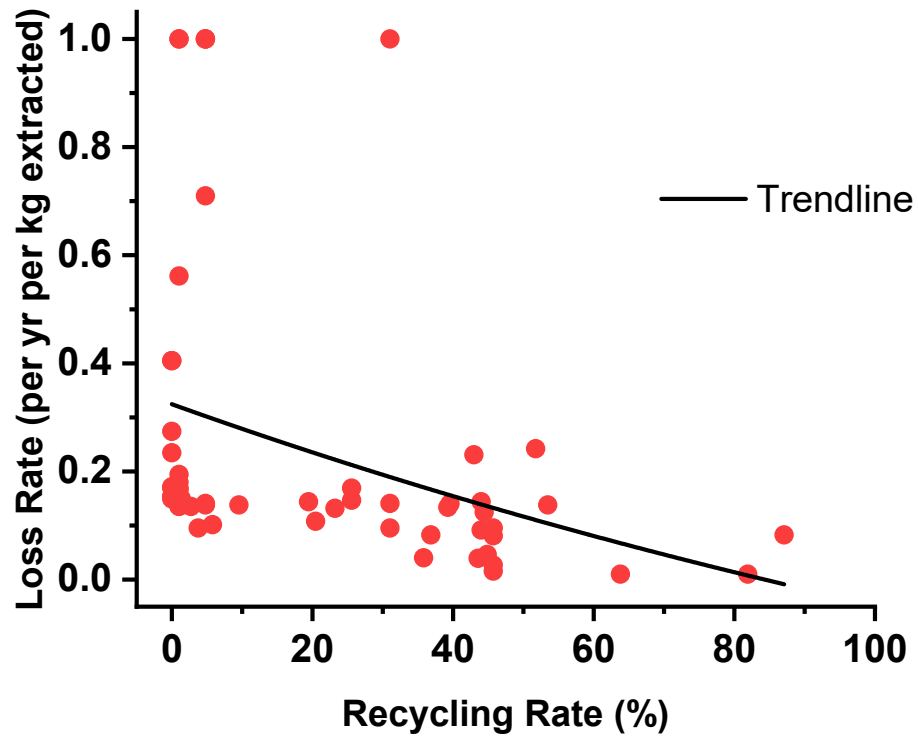
Relationship Between Loss and Recycling Rate of Transition Metals



Data from Charpentier Poncelet A, Helbig C, Loubet P, Beylot A, Muller S, Villeneuve J, Laratte B, Thorenz A, Tuma A, Sonnemann G. "Losses and lifetimes of metals in the economy." *Nature Sustainability*. 19 May 2022 :1-10.



Scrap Metal -- Annual Recycling Rate vs. Loss Rate



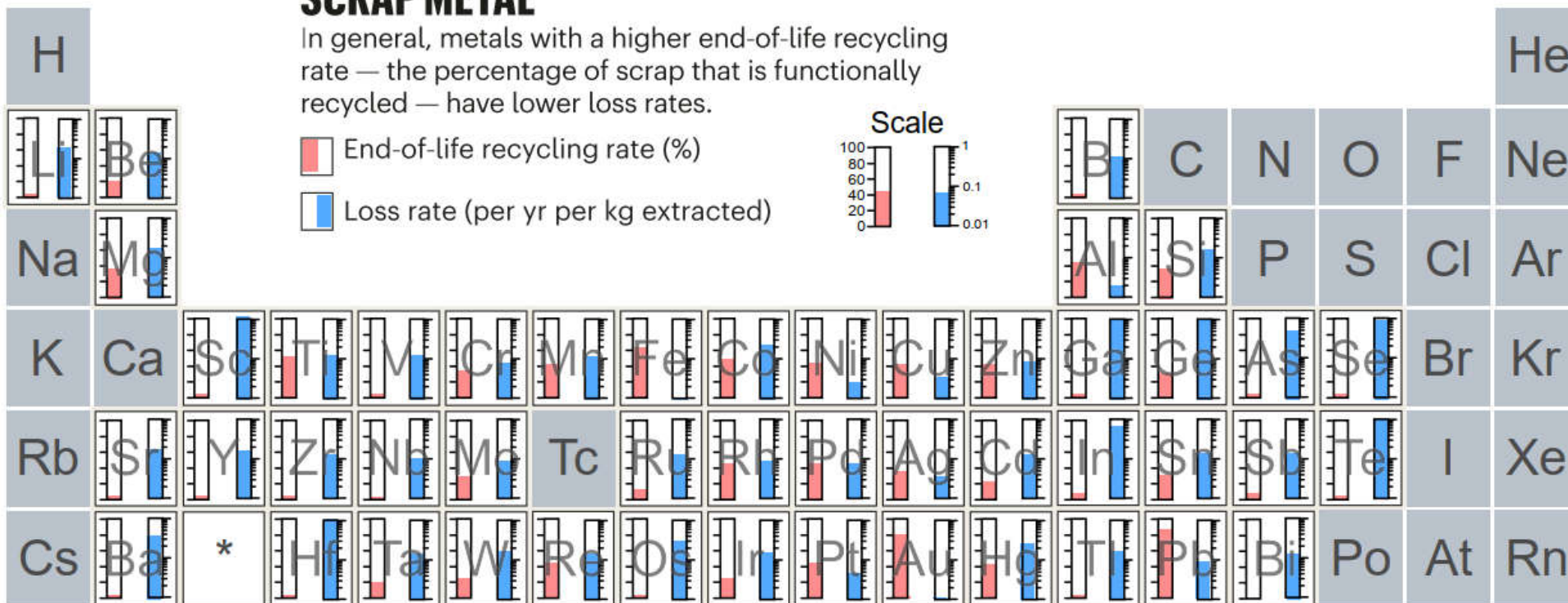
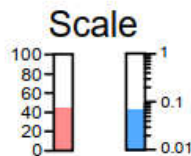
Graph redone by Justin Malme
Data from Poncelet, et al. *Nat. Sustain* 2022, 5, 717-726.



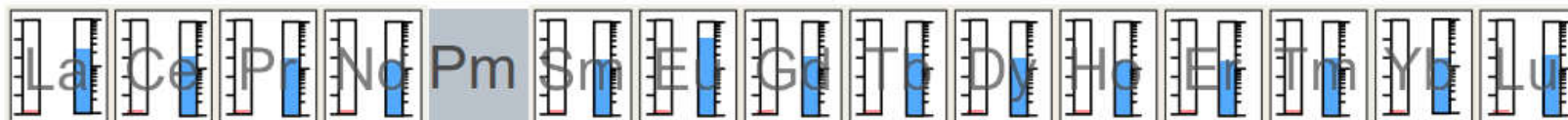
SCRAP METAL

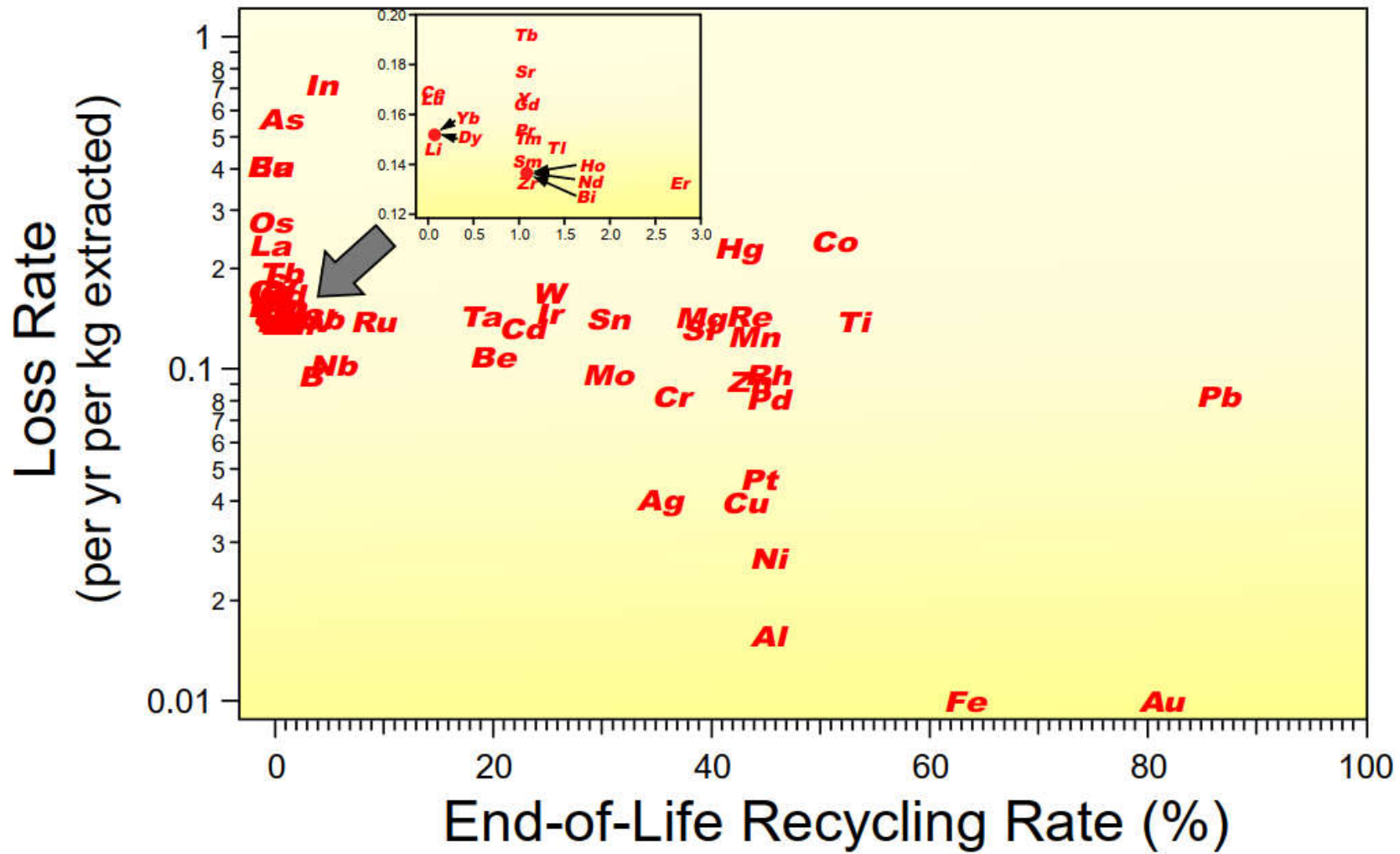
In general, metals with a higher end-of-life recycling rate — the percentage of scrap that is functionally recycled — have lower loss rates.

- End-of-life recycling rate (%)
- Loss rate (per yr per kg extracted)



*Lanthanide series



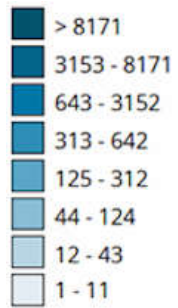


In general, metals with a higher end-of-life recycling rate have lower loss rates.



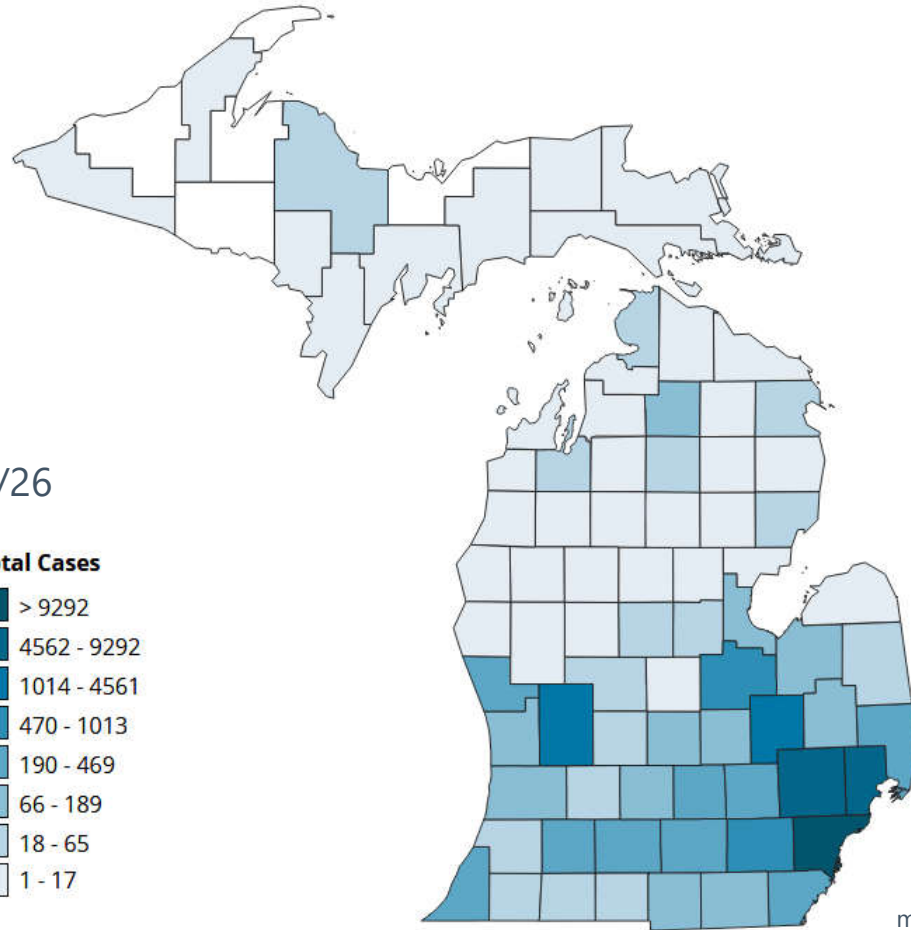
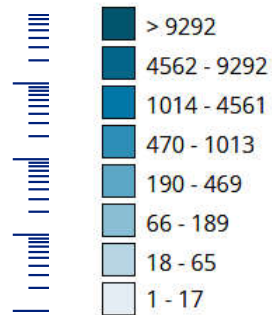
MICHIGAN CORONAVIRUS CASES

4/23



4/26

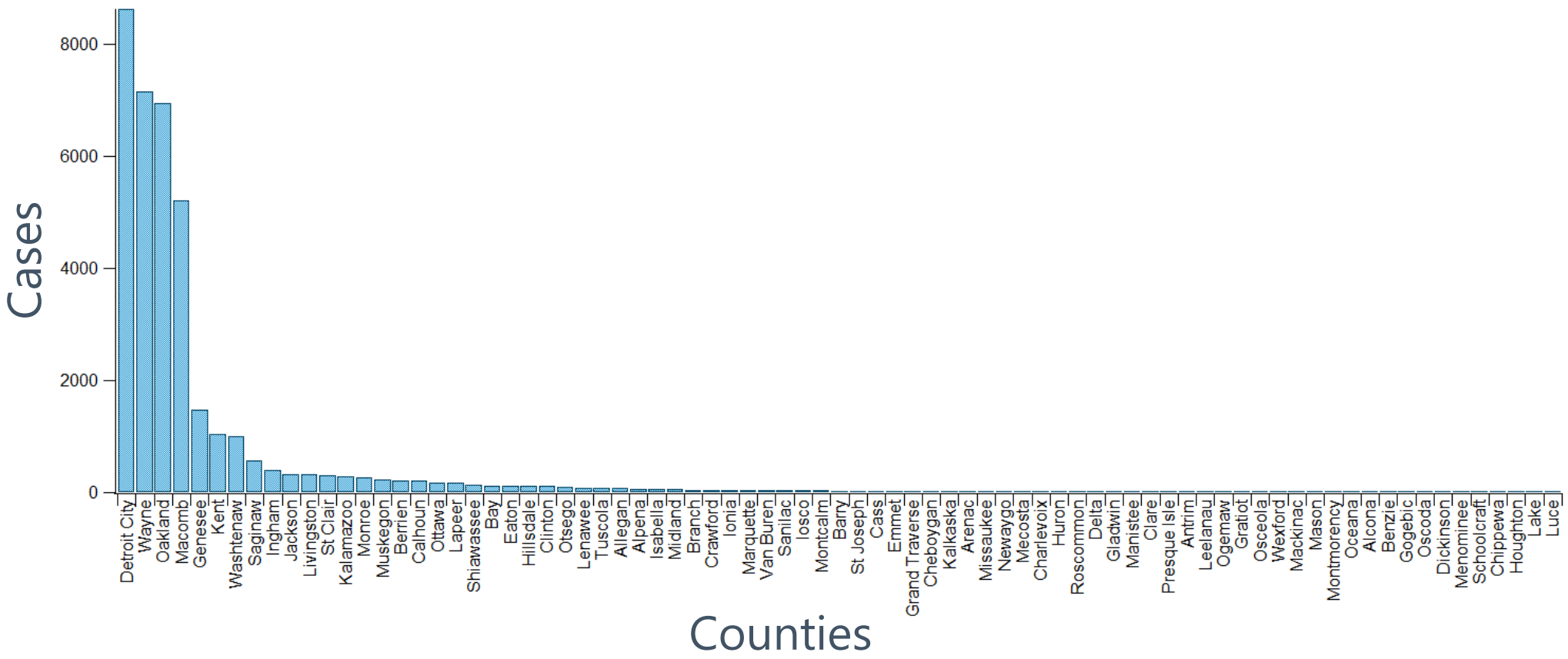
Total Cases



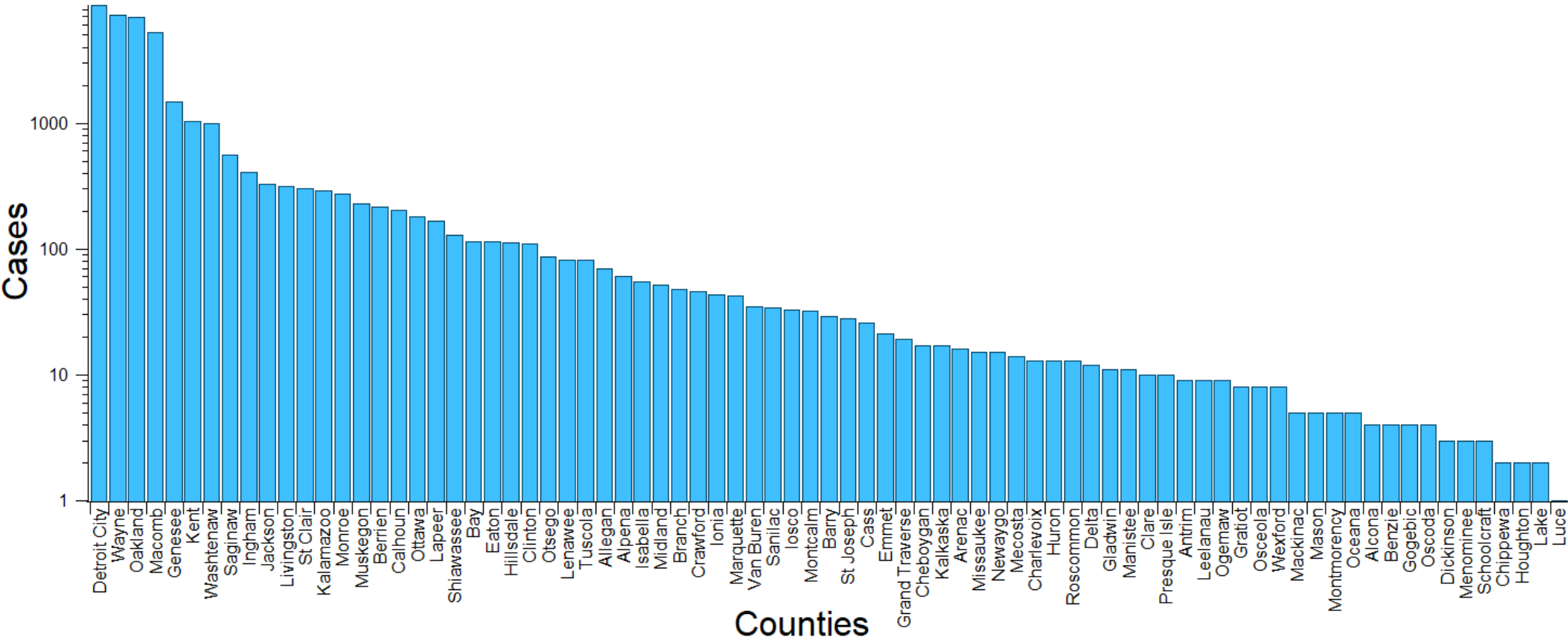
michigan.gov/coronavirus/

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MICHIGAN CORONAVIRUS CASES



MICHIGAN CORONAVIRUS CASES

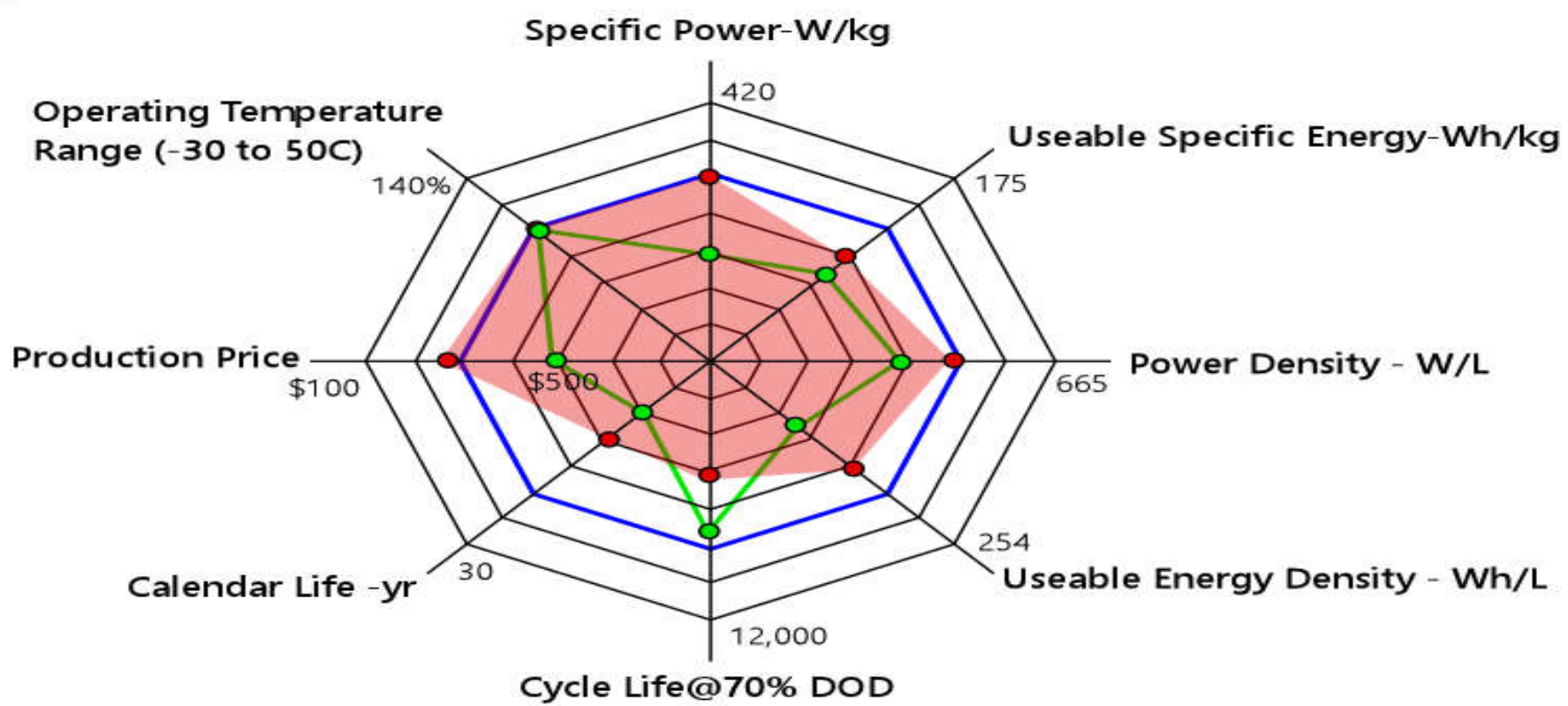


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Battery A **Battery B**



graphs used to gain understanding
are unlikely to be good for explaining



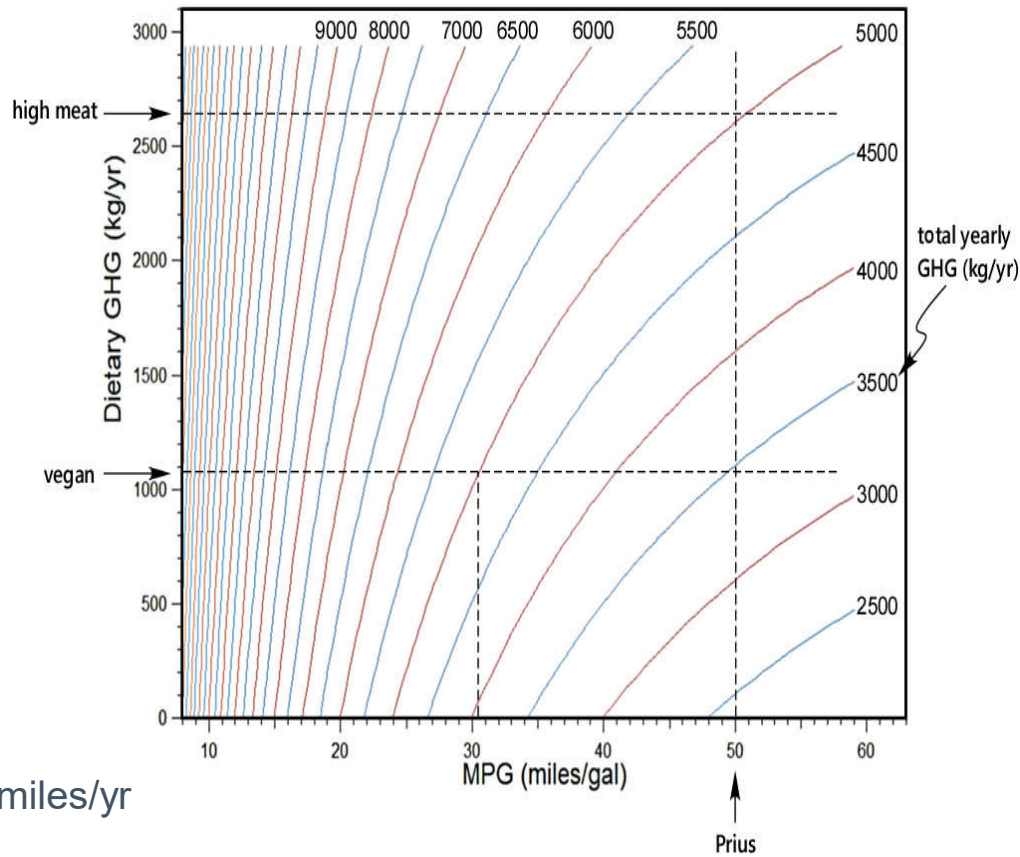
WHICH IS BETTER FOR THE ENVIRONMENT?

A MEAT-EATER IN A PRIUS



A VEGAN IN A HUMMER

VEGAN/MEAT-EATER DRIVING COMPARISON



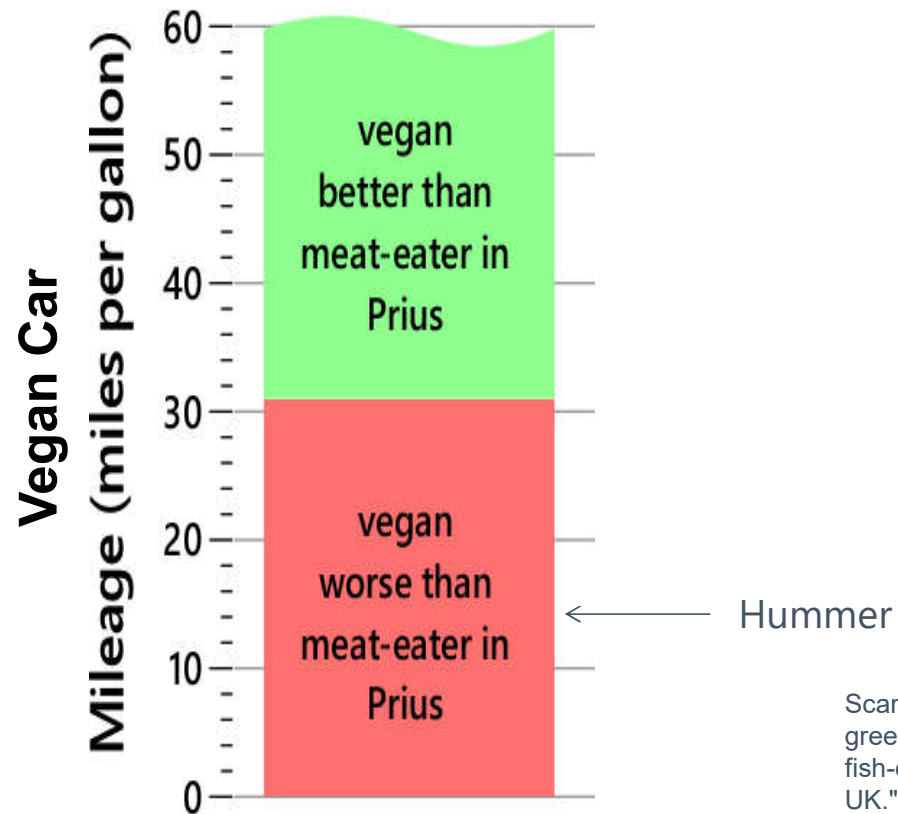
nomograph

assumes 13,476 miles/yr

Scarborough, Peter, et al. "Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK." *Climatic Change* 125.2 (2014): 179-192.

VEGAN/MEAT-EATER DRIVING COMPARISON

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graphs used to gain understanding are unlikely to be good for presentation



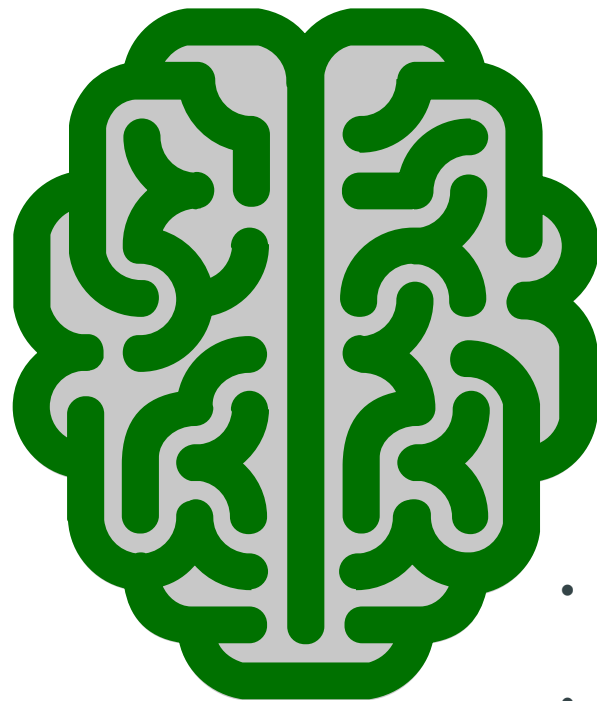
PREPARE PLOTS FOR YOUR AUDIENCE

- Know your audience and craft the presentation for them
- focus on your key message(s)



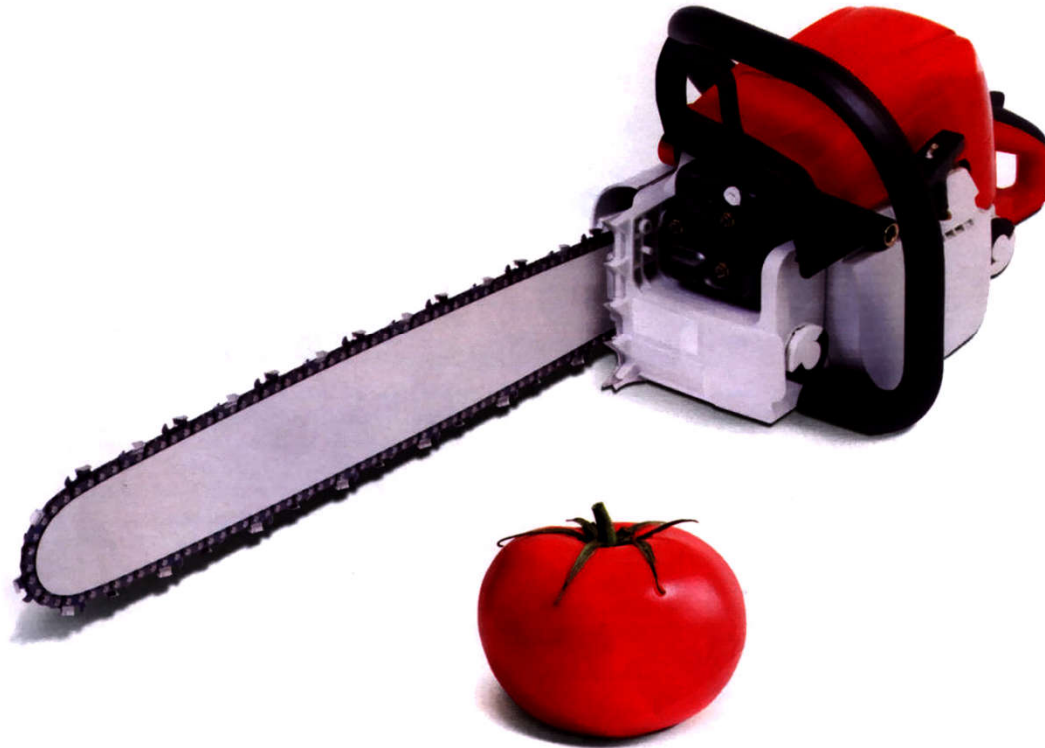
COMMUNICATION HIERARCHY

Tools
Tactics
Strategy
Audience
Goal



ready

- memorable is better than forgettable (pics memorable)
- make graphics *mind ready*
- info density right for material and audience



- *don't let tools get in the way*

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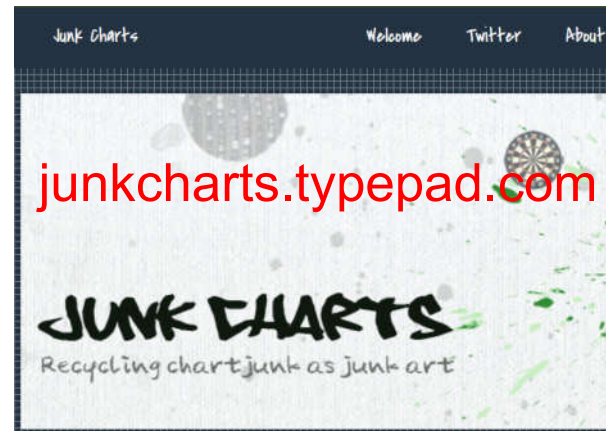
FAVORITE REFERENCES – DISPLAY OF INFORMATION



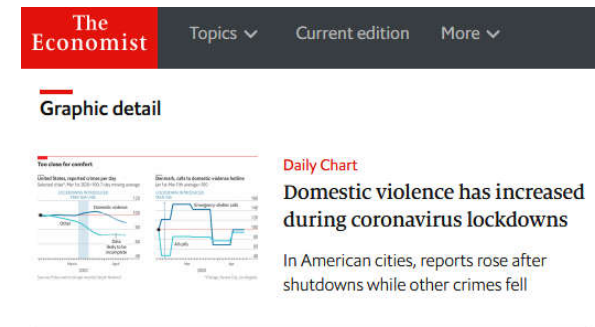
FAVORITE DATA VISUALIZATION WEBSITES - SAMPLES



howmuch.net



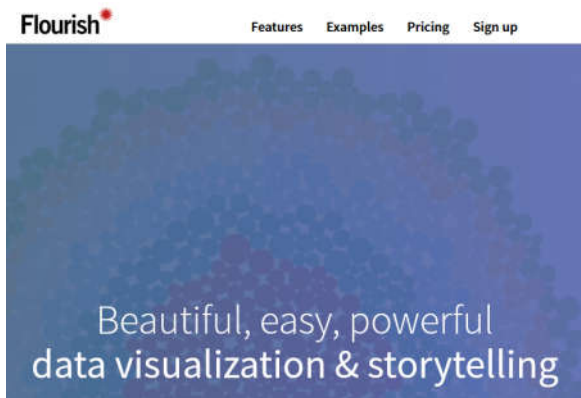
visualcapitalist.com



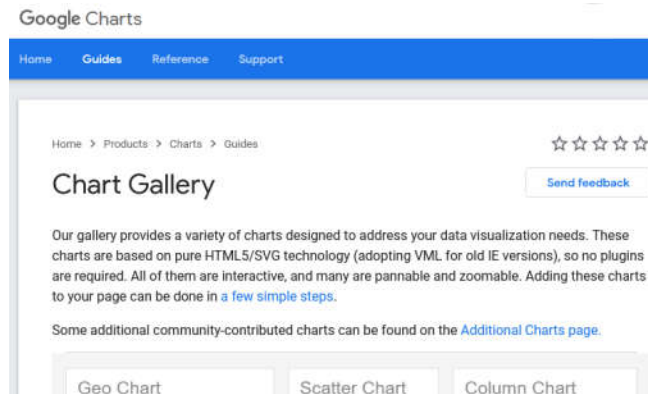
economist.com/graphic-detail/

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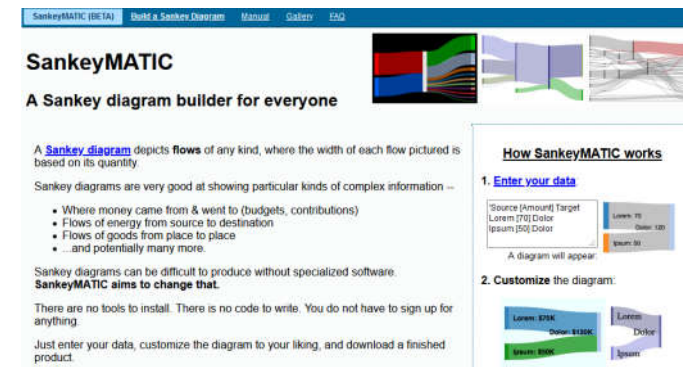
FAVORITE DATA VISUALIZATION WEBSITES - TOOLS



flourish.studio



developers.google.com/chart/interactive/docs/gallery



sankeymatic.com



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