

Gulf of Alaska Common names No temperatures

Scatter 1

Pacific cod

2013

Scatter 2

None

Loading...

kg / hectare

19.77 kg/hectare overall CPUE

Dynamic scaling enabled



Hello!

Aleutian Islands Common names No temperatures

Scatter 1

Pacific cod

2000

Scatter 2

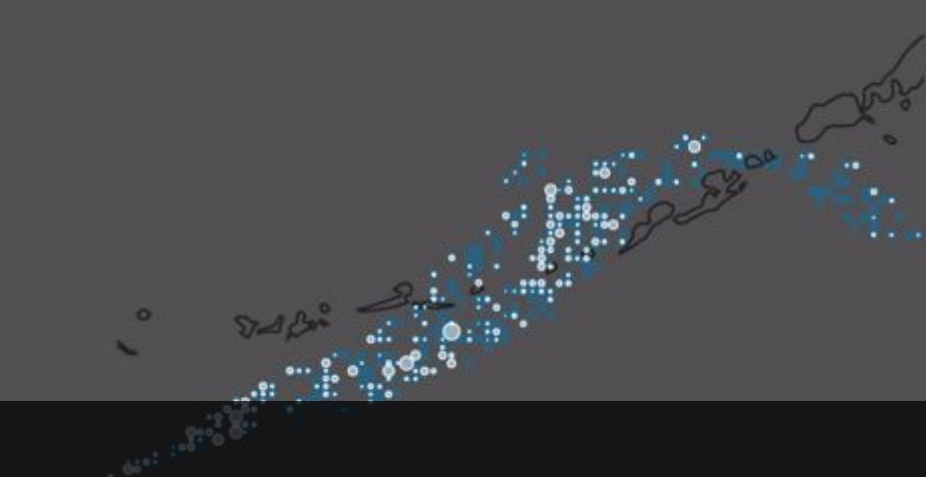
None

Loading...

kg / hectare

22.18 kg/hectare overall CPUE

Dynamic scaling enabled



Please find a seat. We will start at about 2:05 - 2:10

Gulf of Alaska Common names No temperatures

Scatter 1

Scatter 2

Pacific cod

None

2013

Loading...

kg / hectare

19.77 kg/hectare overall CPUE

Dynamic scaling enabled



Aleutian Islands Common names No temperatures

Scatter 1

Scatter 2

Pacific cod

None

2000

Loading...

kg / hectare

22.18 kg/hectare overall CPUE

Dynamic scaling enabled



Data Visualization

A Samuel Pottinger  
Sept 15, 2025  
Stat 159

Collaborative and Reproducible Data Science



**Hello!** I'm a data scientist, software engineer, and information designer.

---

**Sam Pottinger**

A more human-centered AI/ML

<https://gleap.org>

**UC Berkeley** | Data + Environment

EVERY | Data + Synthetic Biology

IDEO | Data + Design

Plenty | Data + Indoor Agriculture

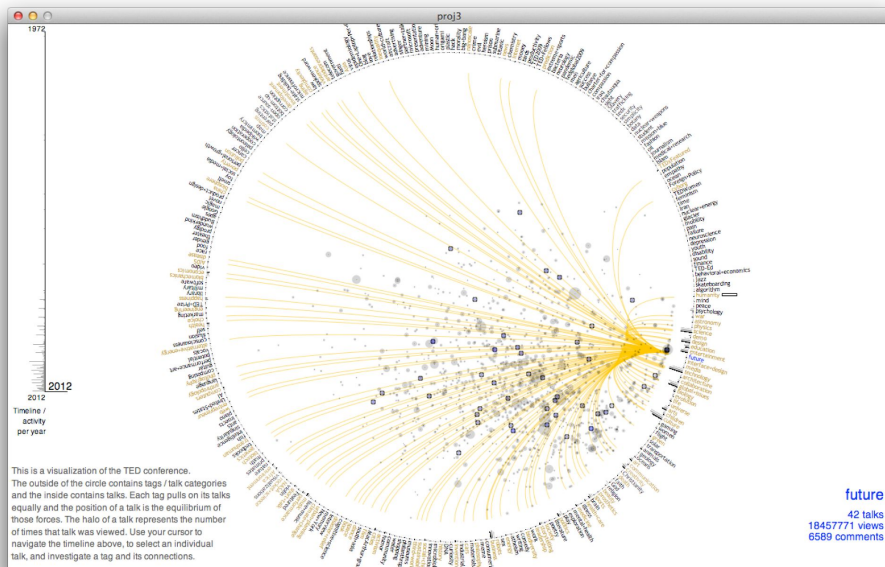
Apple | Data + Engineering

Google | Data + Visualization

LabJack | Data + Hardware

Processing | Data + Love in Java

Sketchingpy | Data + Love in Python



# Today

---

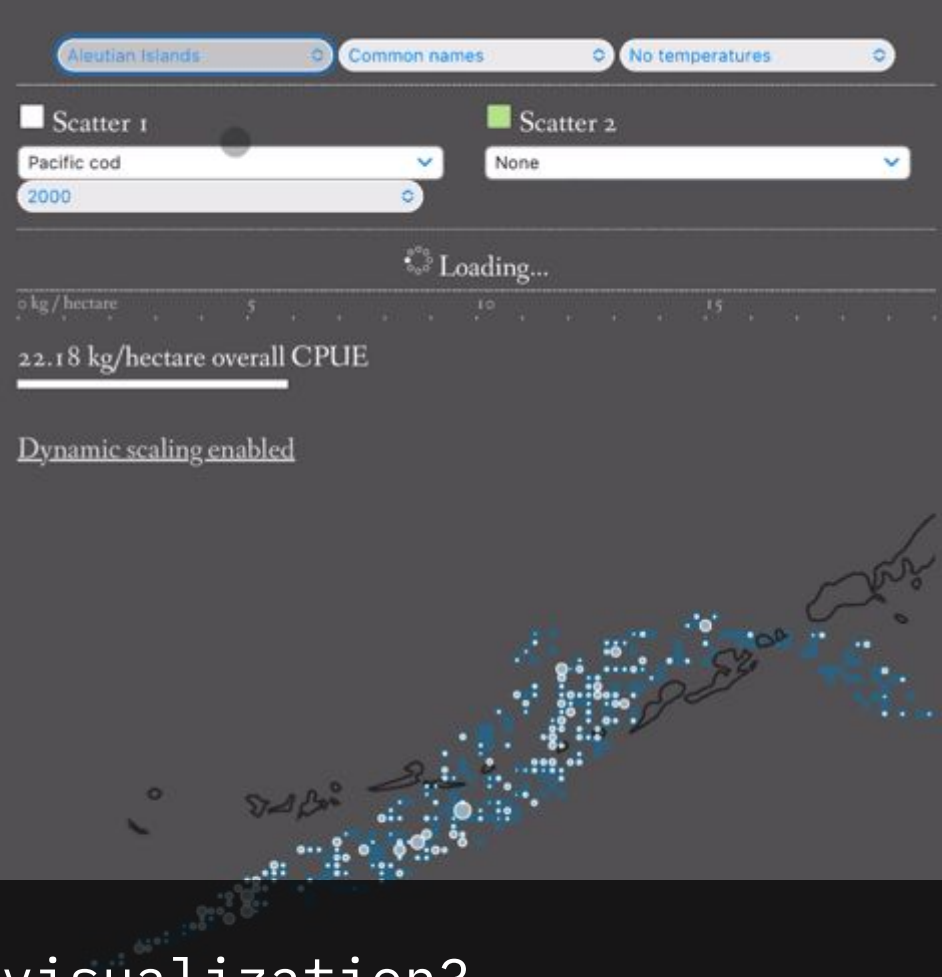
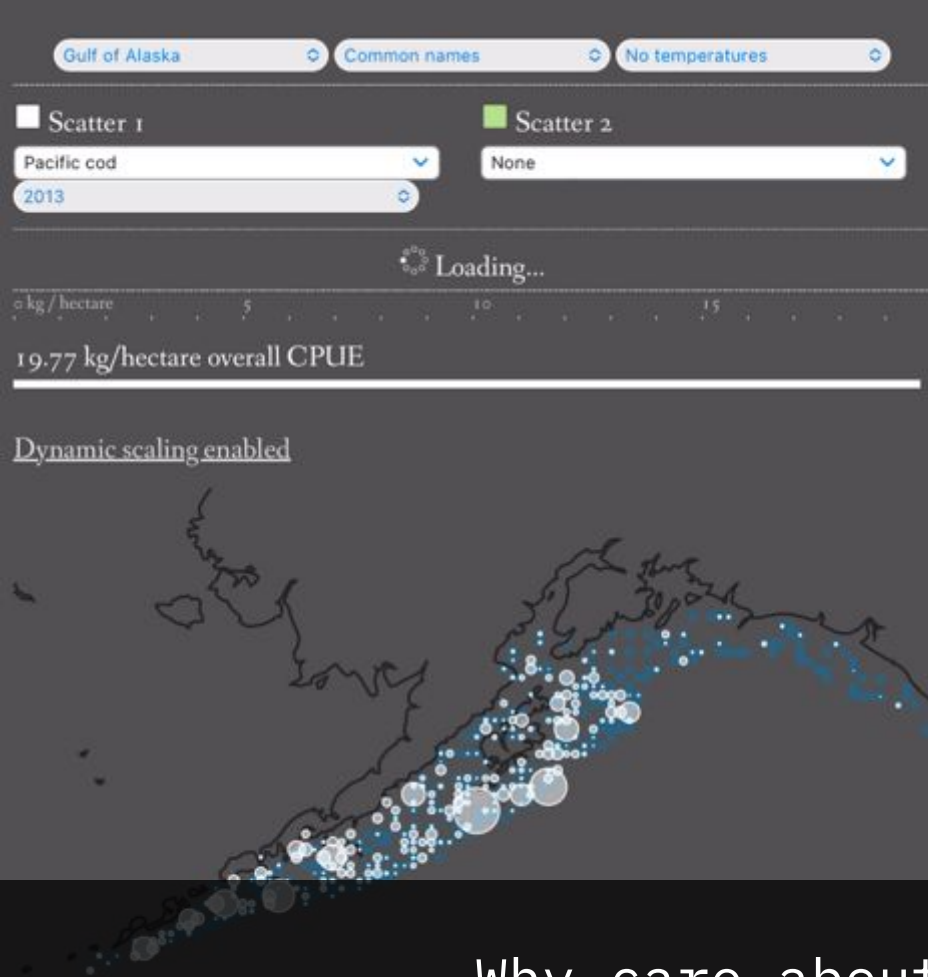
Why care about visualization

How to design data visualizations

How to think about data visualization

How to implement visualizations

How to continue your journey



Why care about visualization?

Year	Number of Wolves	Number of Moose
1980	50	664
1982	14	700
1984	24	811
1986	20	1025
1988	12	1653
1990	15	1216
1992	12	1600
1994	15	1800
1996	22	1200
1998	14	700
2000	29	850
2002	17	1000
2004	29	750
2006	30	385
2008	23	650
2010	19	510
2012	9	750
2014	9	1050
2016	2	1300
2018	2	1500

**Premise:** The human visual system is good at spotting patterns.

What year saw the most moose?

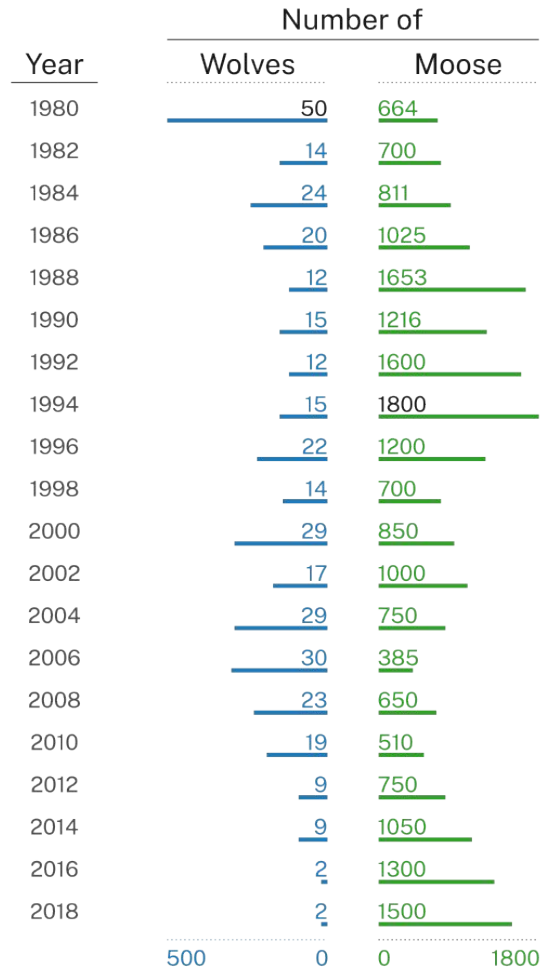
 Raise your hand when you have it.

Year	Number of Wolves	Number of Moose
1980	50	664
1982	14	700
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1986	20	1025
1988	12	1653
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2016	2	1300
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**Premise:** The human visual system is good at spotting patterns.

What year saw the most wolves?

 Raise your hand when you have it.

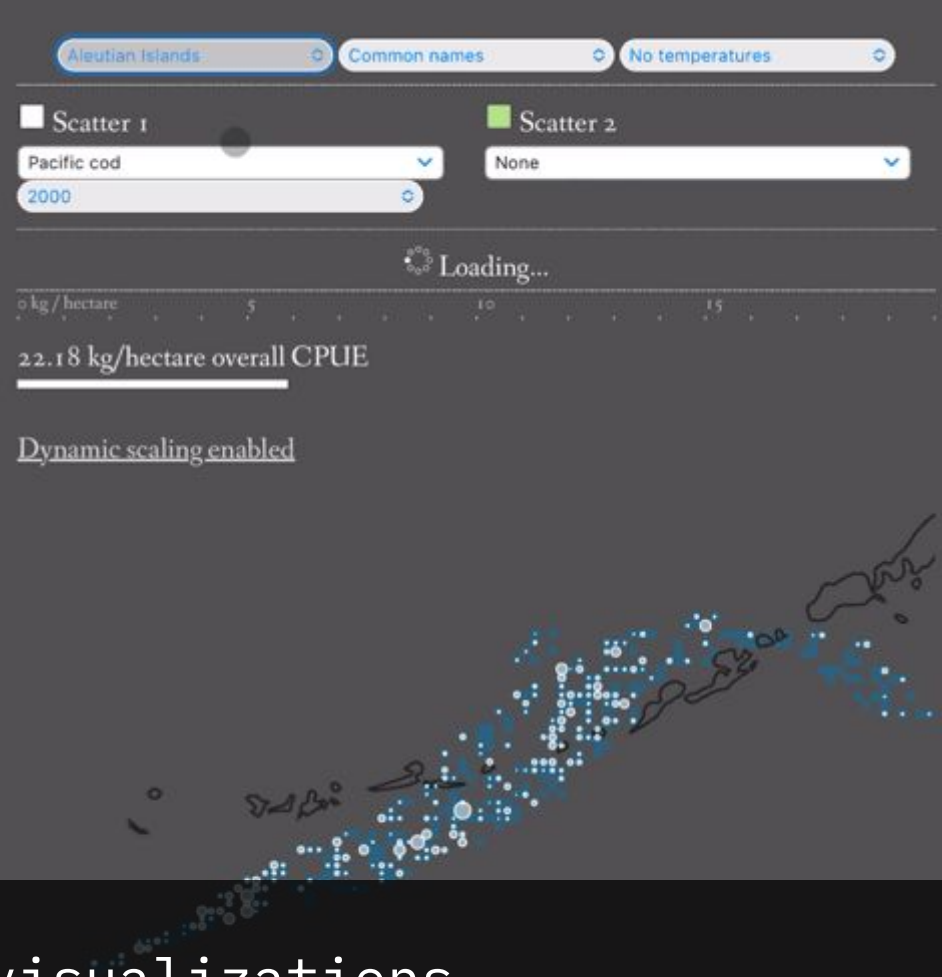
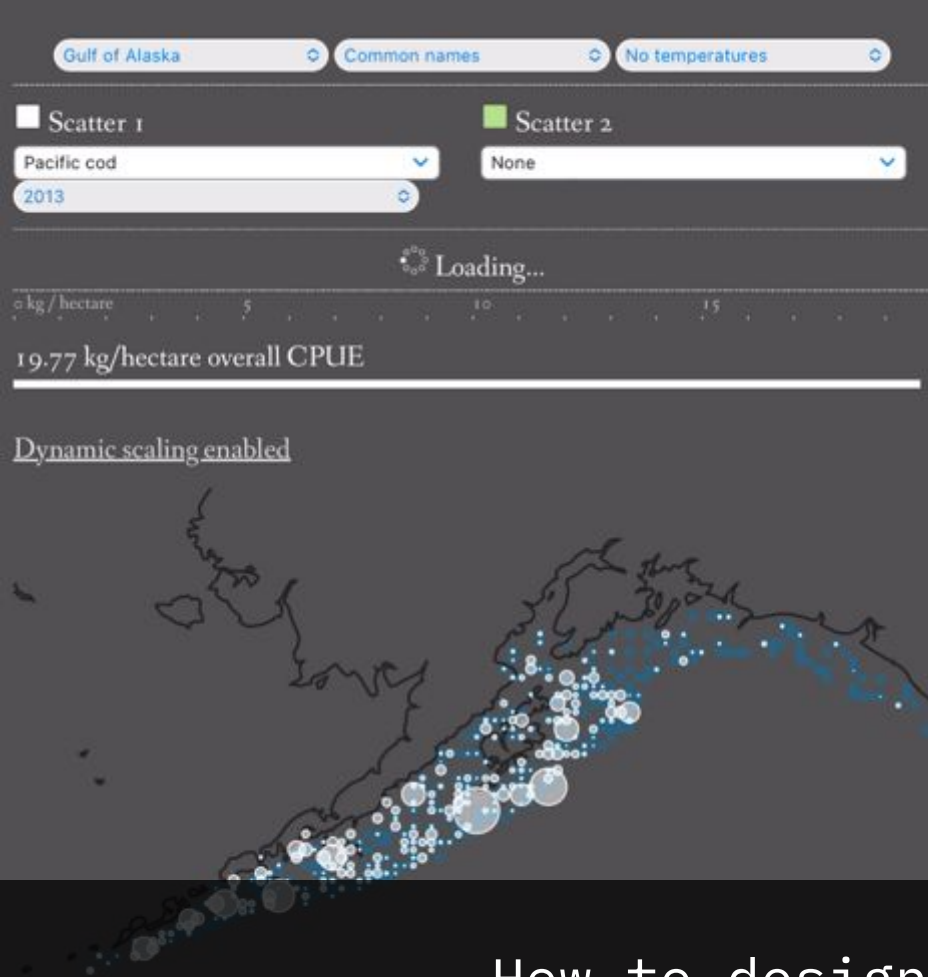


**Premise:** The human visual system is good at spotting patterns.

What is the relationship between wolves and moose in Isle Royale?

 Raise your hand when you have it.





How to design visualizations

# Cleveland and McGill

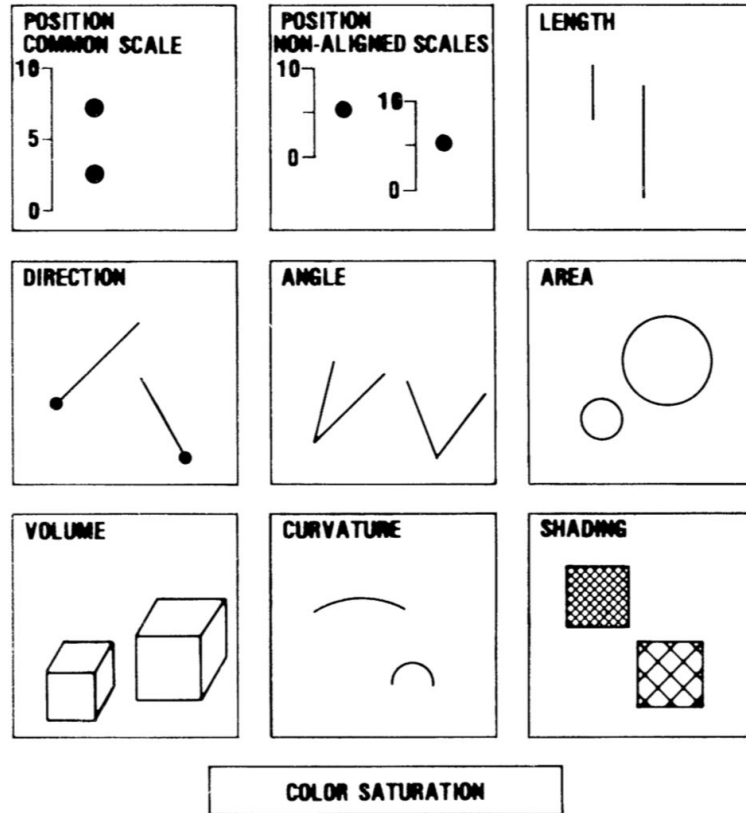


Figure 1. Elementary perceptual tasks.

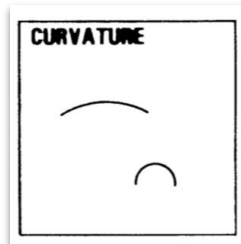
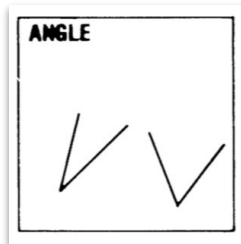
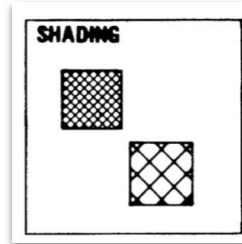
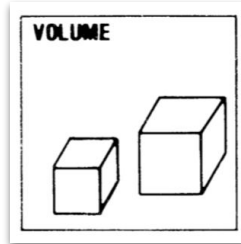
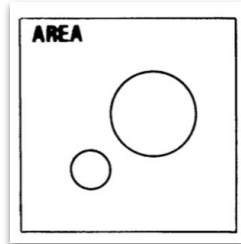
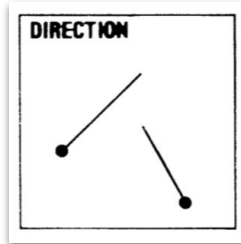
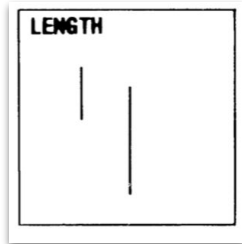
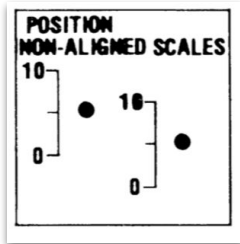
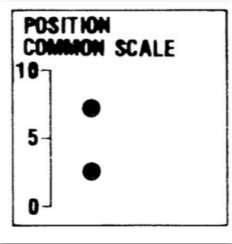
Evolution gives us preattentive features.

However, what is the right design of using those features?

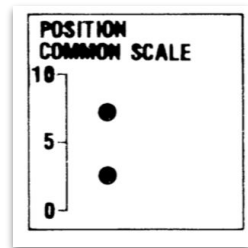
Presenting on Cleveland and McGill in addition to some work that came after as cited.

# Fairly robust hierarchy

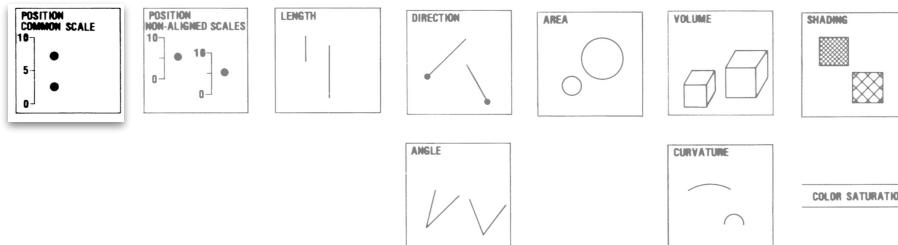
Higher Accuracy ————— Lower or Inconsistent



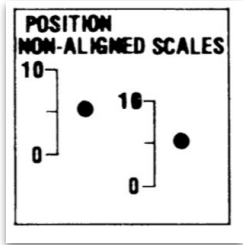
# Fairly robust hierarchy



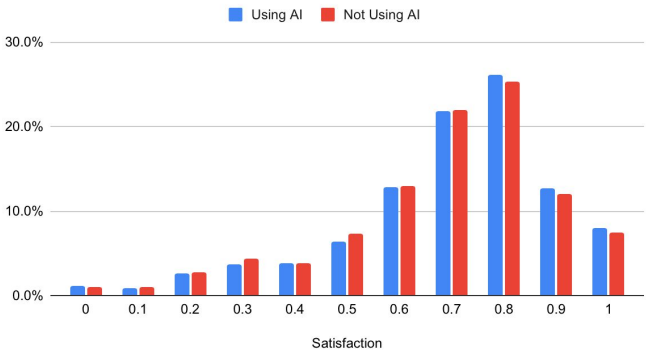
The highest accuracy encoding device is potentially not surprising as it underpins common patterns like scatter plots.



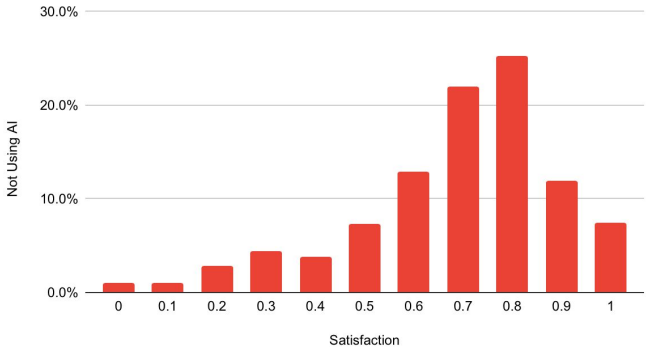
# Fairly robust hierarchy



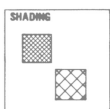
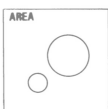
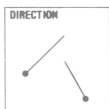
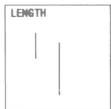
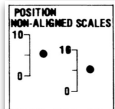
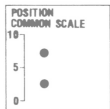
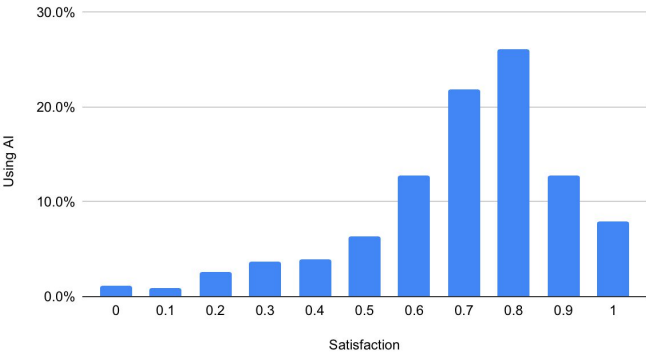
Satisfaction Using AI and Not Using AI



Satisfaction Not Using AI

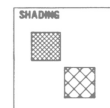
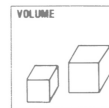
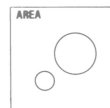
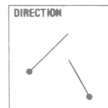
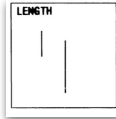
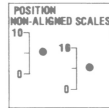
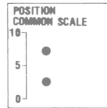
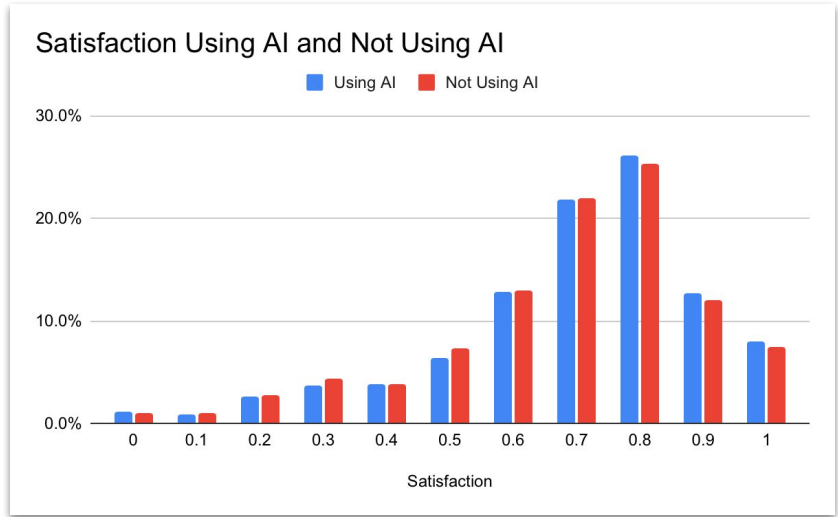
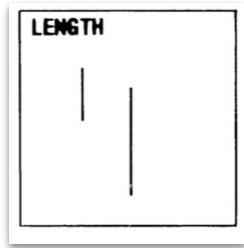


Satisfaction Using AI



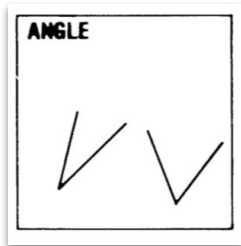
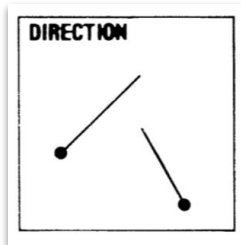
COLOR SATURATION

# Fairly robust hierarchy



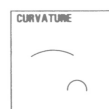
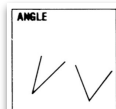
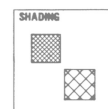
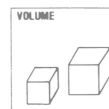
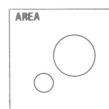
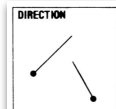
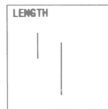
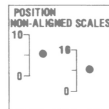
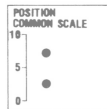
COLOR SATURATION

# Fairly robust hierarchy

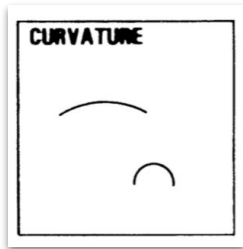
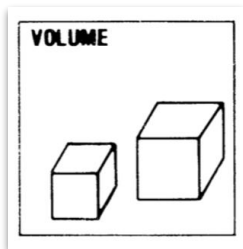
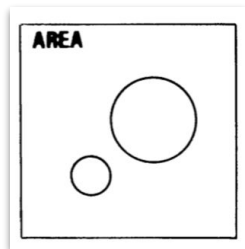


I am placing length higher than direction (slope) and angle because of consistency. There's evidence that we do better with angle closer to cardinal directions.

This is why pie charts may perform relatively poorly. Length typically has an easy fix: align against a common axis.



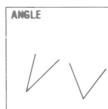
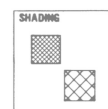
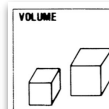
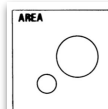
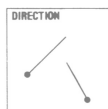
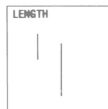
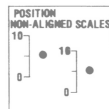
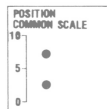
# Fairly robust hierarchy



Volume generally goes poorly. This may be partially due to 3D representation within 2D media.

In general, area is good for less important “contextualizing” metrics.

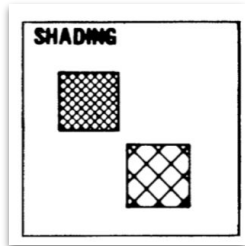
Area has an issue: area vs radius.



COLOR SATURATION



# Fairly robust hierarchy



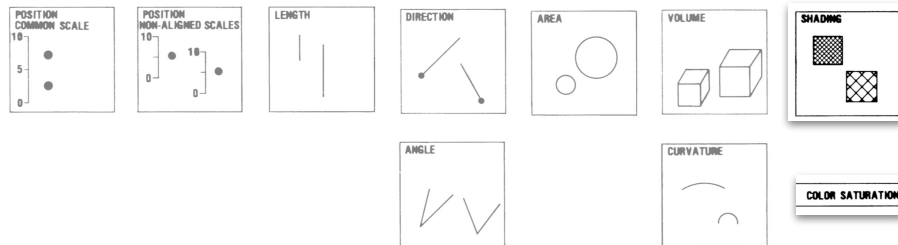
Color is fairly unreliable. It is often better for branding or complementing a message through emotion and aesthetic than it is for conveying quantitative information.

It may still serve a purpose for a limited number of qualitative groups.



Lightness generally better than hue.

Accessibility issues: readability and color-blindness.



# Group Activity



**Which graphic is more likely to be read accurately?**

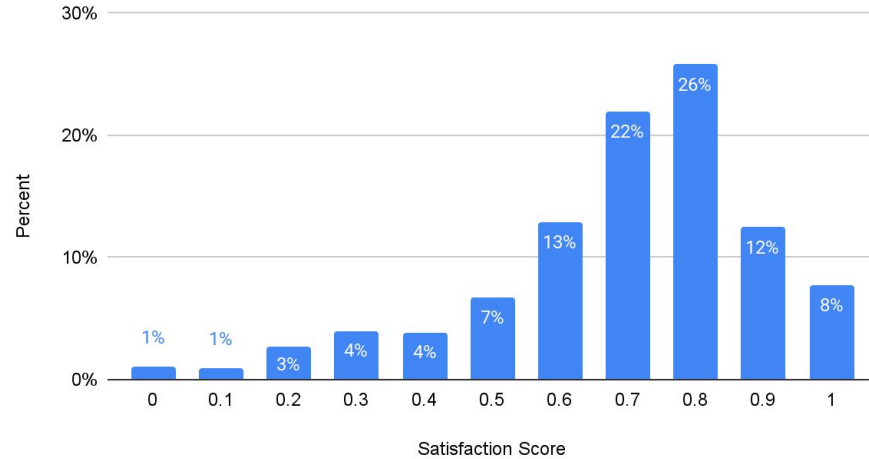
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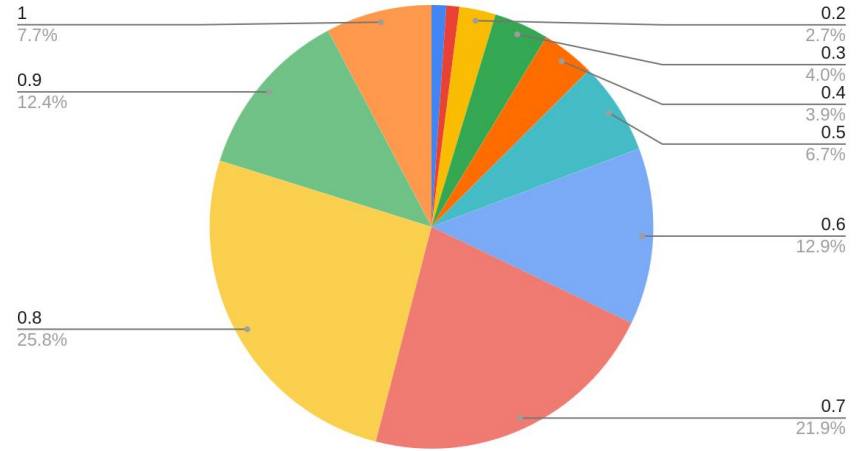
[https://  
interactivedatascience  
.courses  
/stat159.pdf](https://interactivedatascience.courses/stat159.pdf)

# Which one is more likely to be successful?

Satisfaction Score Frequency

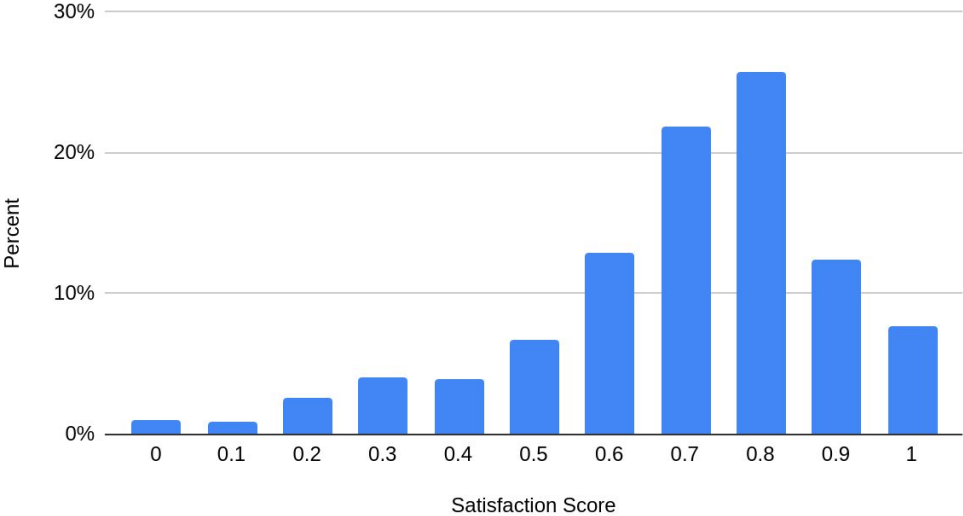


Satisfaction Score Frequency



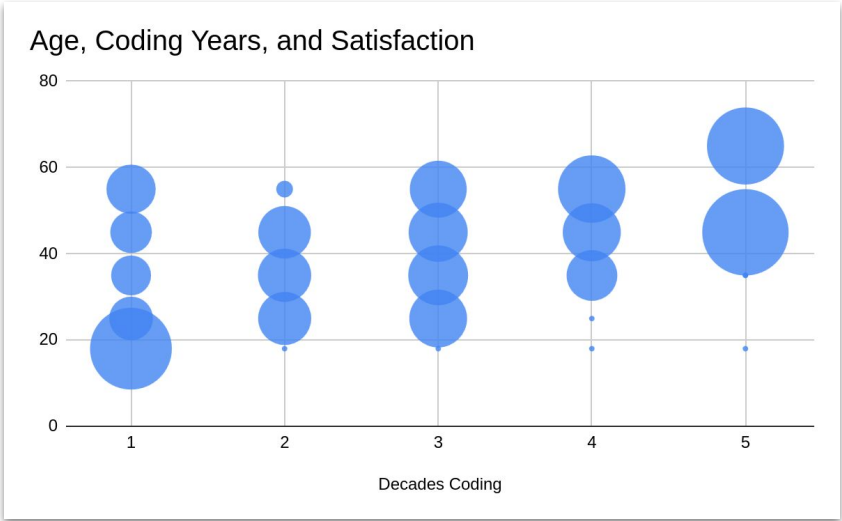
# Which one is more likely to be successful?

Satisfaction Score Frequency



Satisfaction Score	Percent
0	
0.1	
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1	

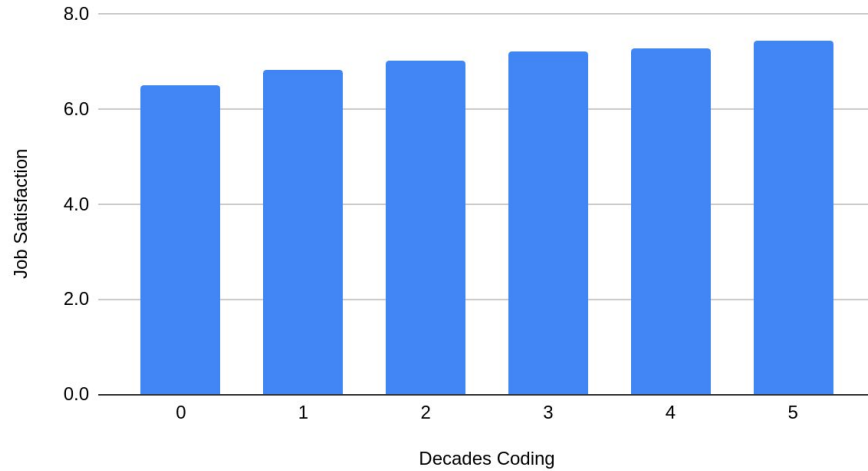
# Which one is more likely to be successful?



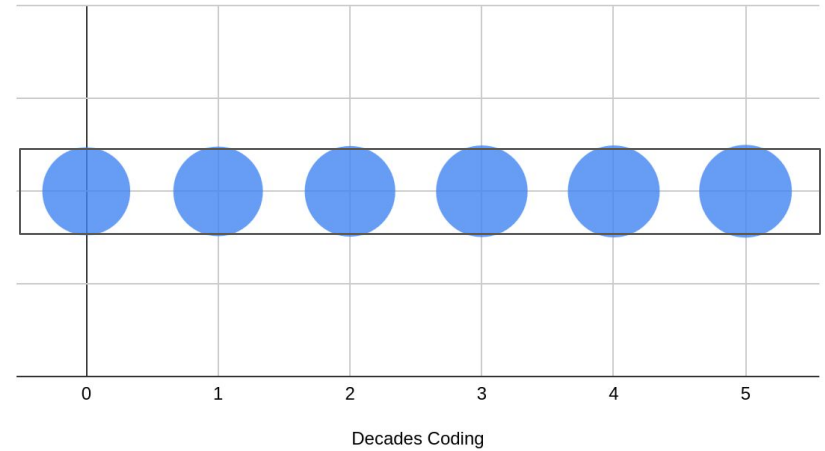
		Decades Coding				
		1	2	3	4	5
Age Group	65					1
	55	1	1	1	1	
	45	1	1	1	1	1
	35	1	1	1	1	
	25	1	1	1		
	18	1				

# Which one is more likely to be successful?

Job Satisfaction vs. Decades Coding



Job Satisfaction vs. Decades Coding

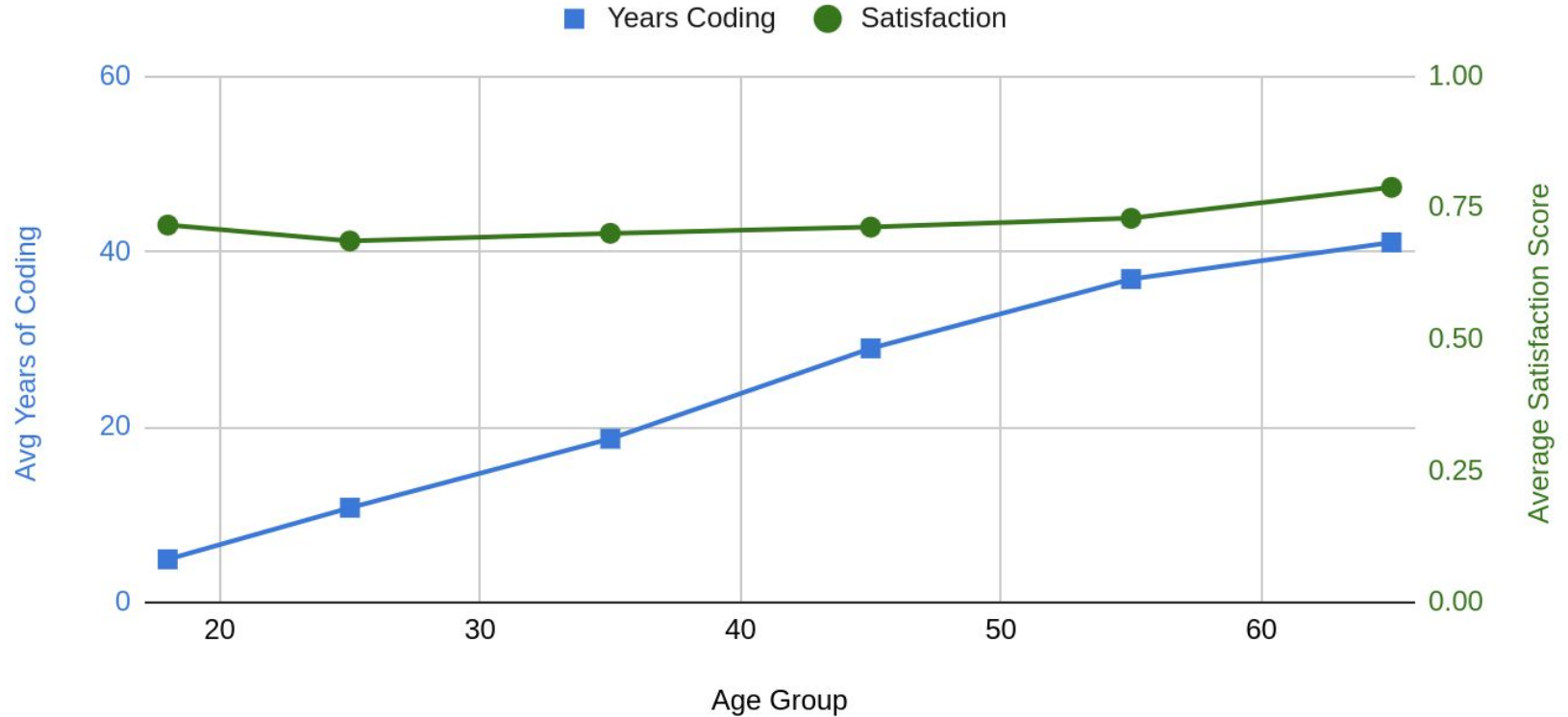


# Working in limitations

**Shared axes, dual axes, and direct labeling.**

# Dual Axes

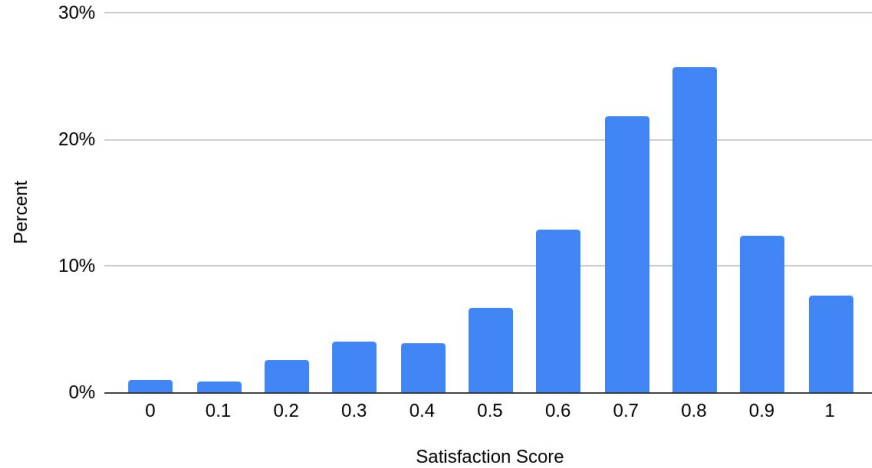
## Age vs Years of Coding and Satisfaction



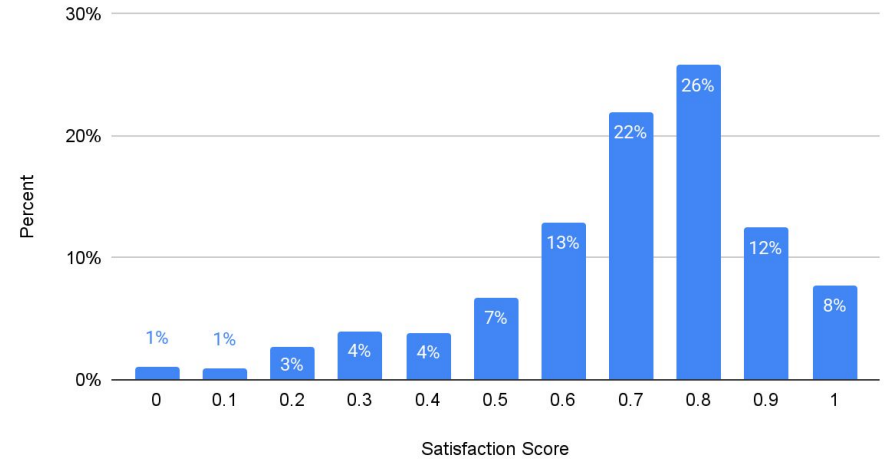


# Direct Labeling

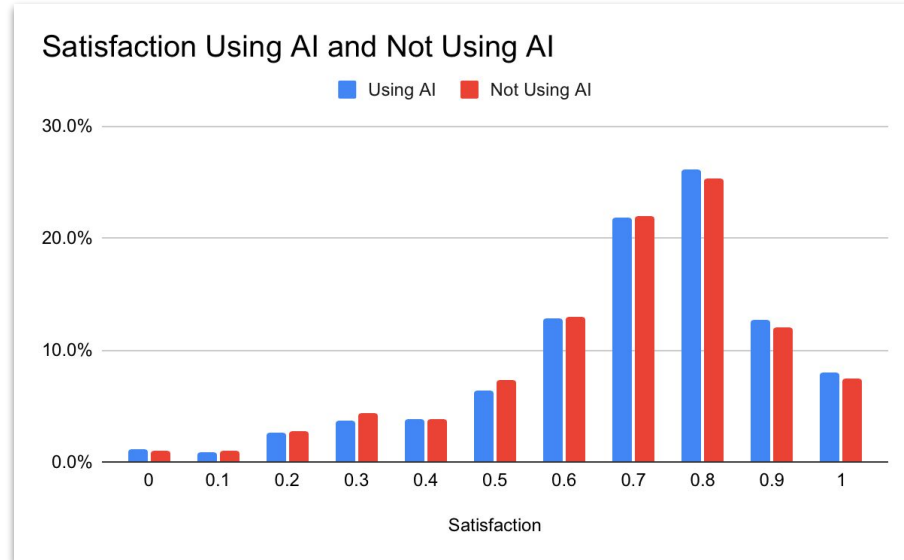
Satisfaction Score Frequency



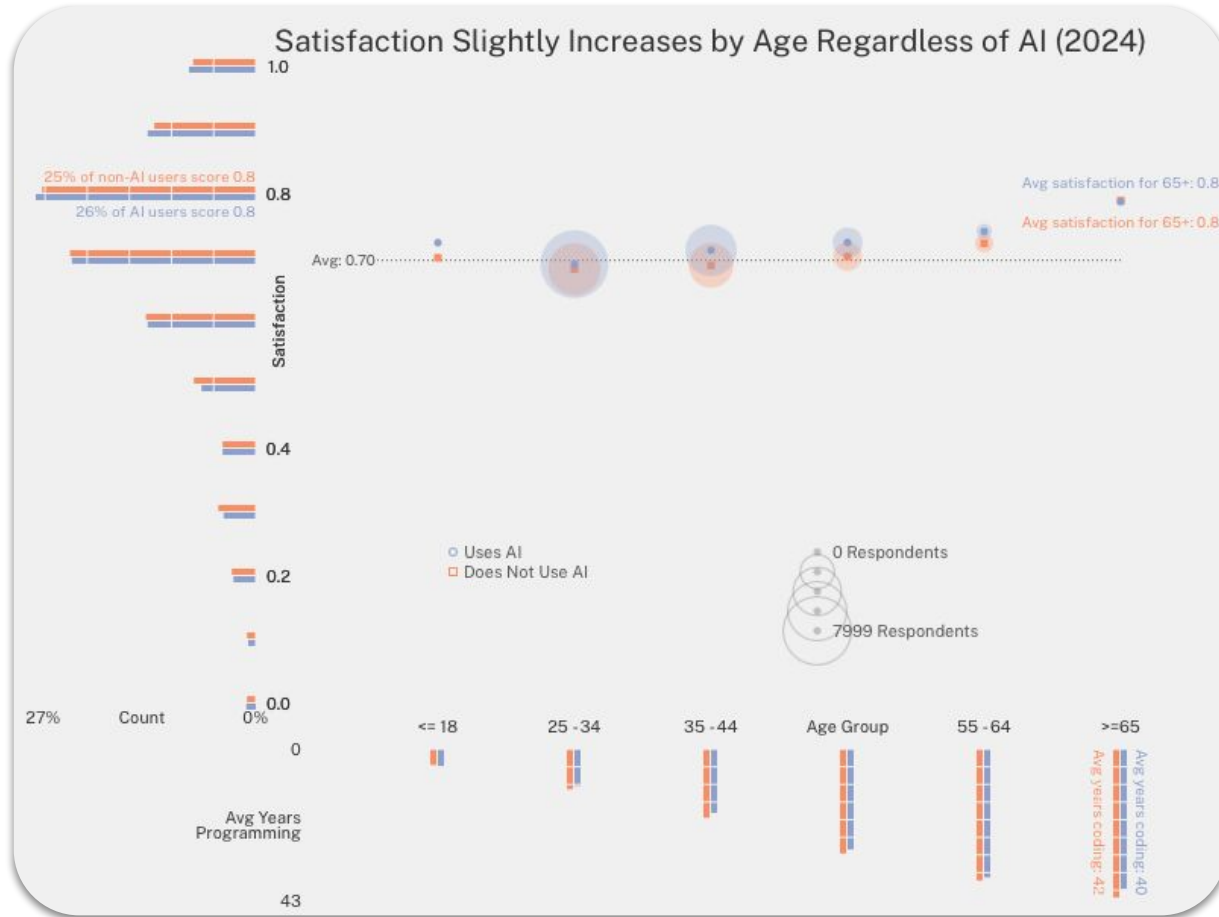
Satisfaction Score Frequency



# Keeping channels clear



# Tie it together



Gulf of Alaska Common names No temperatures

Scatter 1

Pacific cod

2013

Scatter 2

None

Loading...

kg / hectare

19.77 kg/hectare overall CPUE

Dynamic scaling enabled



Aleutian Islands Common names No temperatures

Scatter 1

Pacific cod

2000

Scatter 2

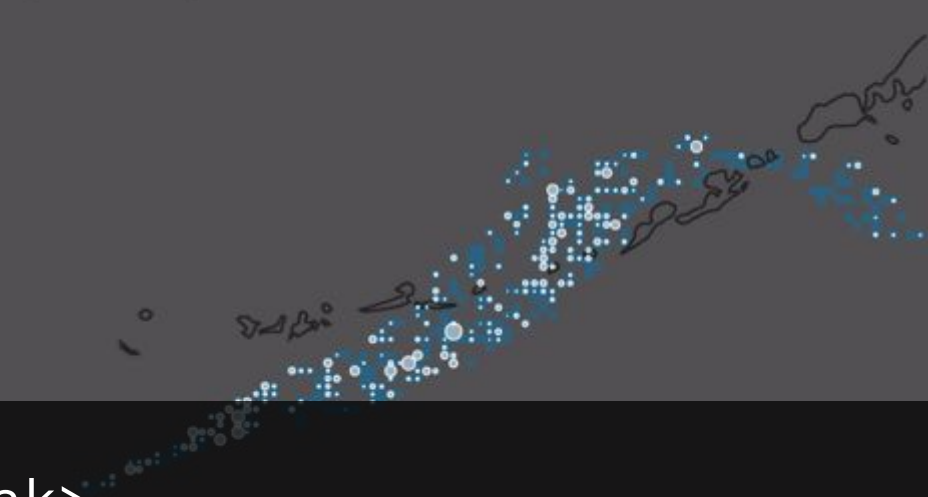
None

Loading...

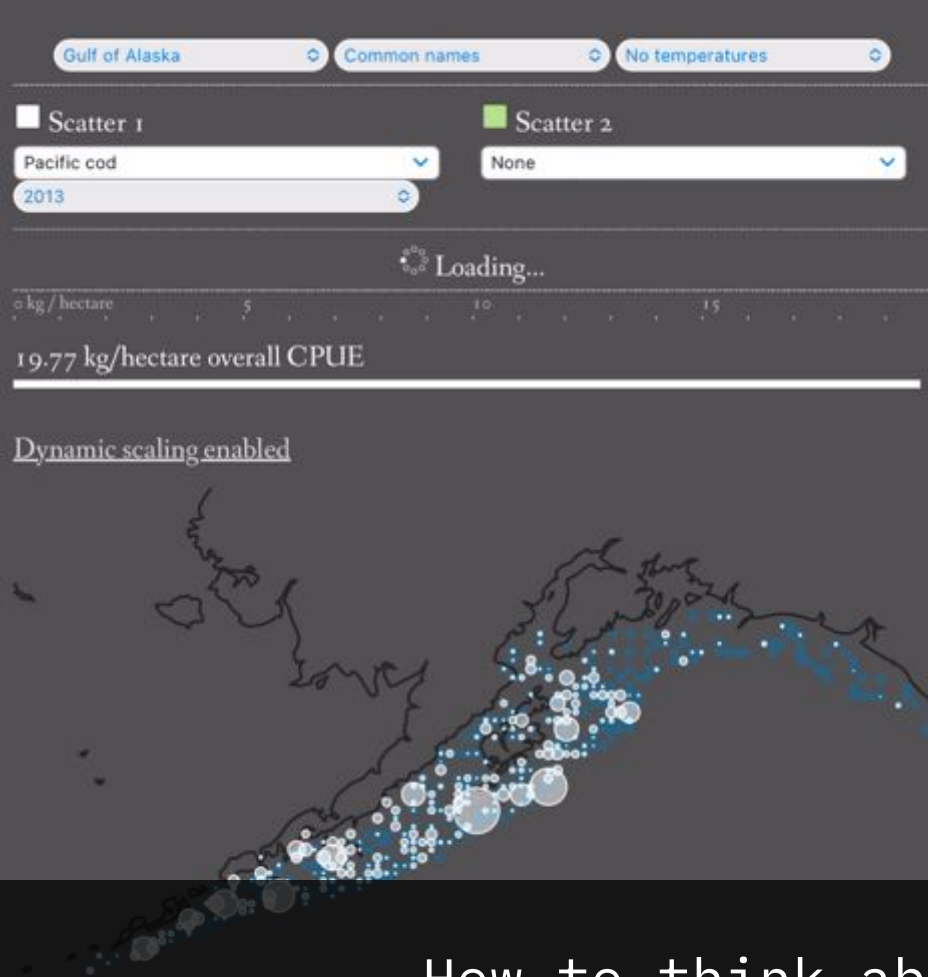
kg / hectare

22.18 kg/hectare overall CPUE

Dynamic scaling enabled

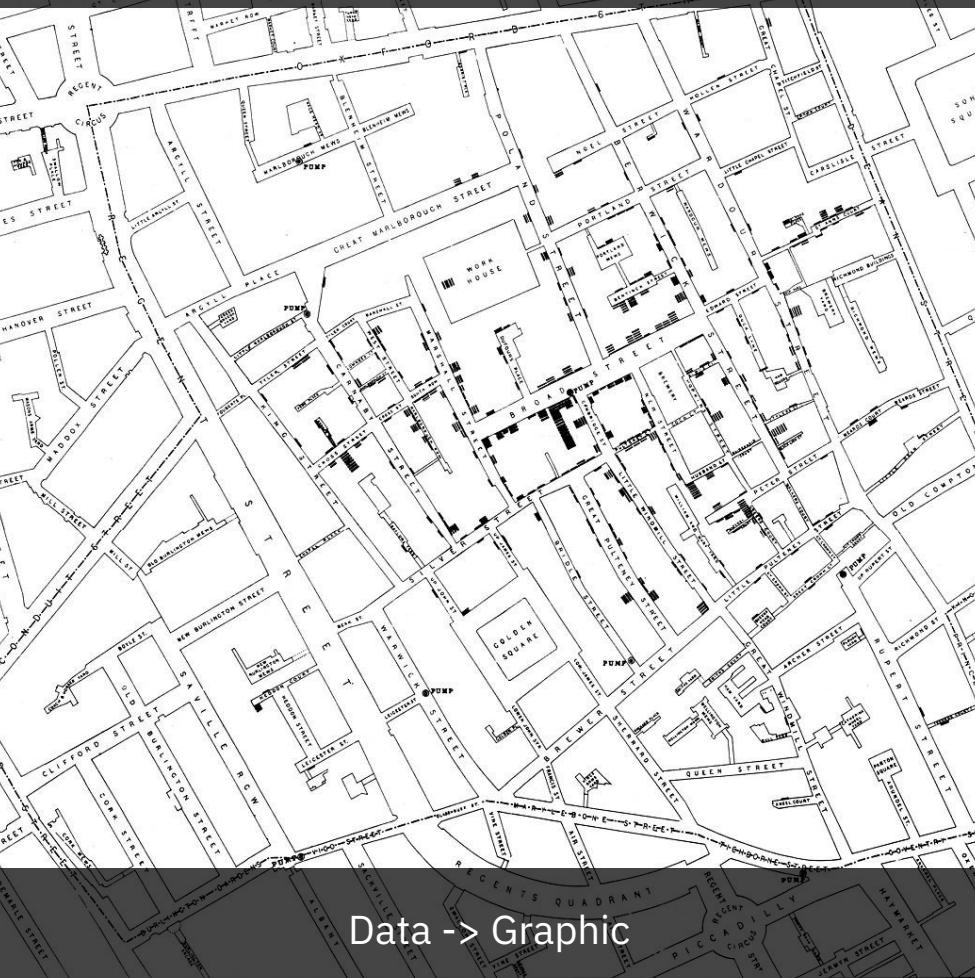


<Break>



How to think about visualization

How can data become visible?



## 4 Perspectives

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| As representation

As task

As message

As dialogue

---

Why and how different groups do data visualization. How you can think about it in your work.

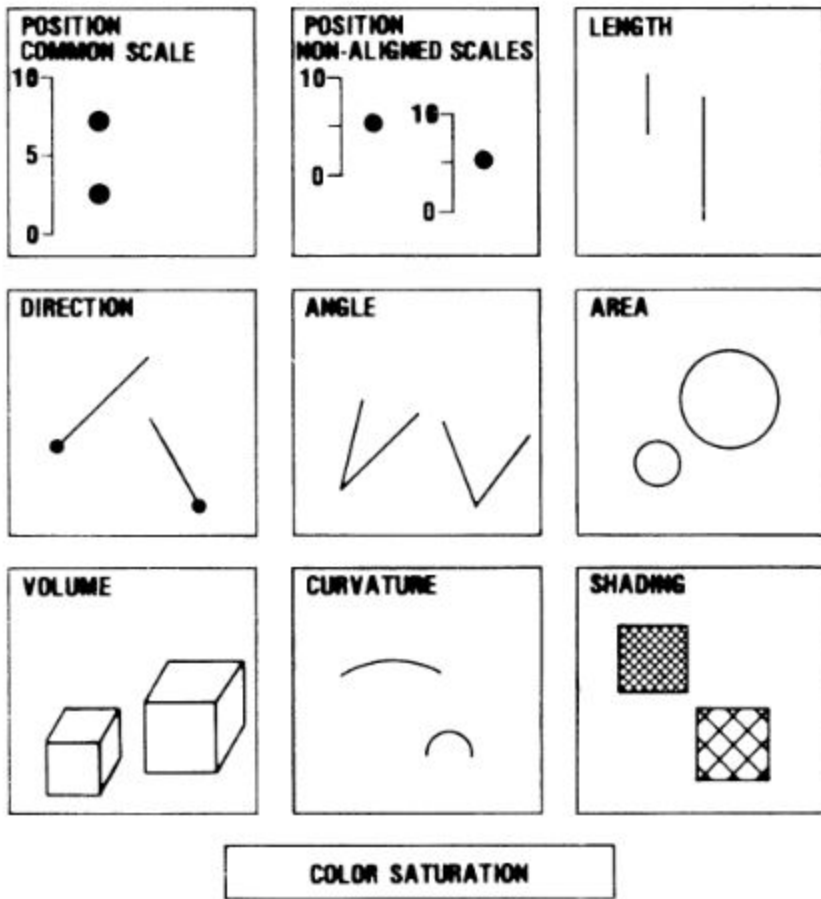


Figure 1. Elementary perceptual tasks.

**Example:** This first way of thinking about data visualization focuses on encoding.

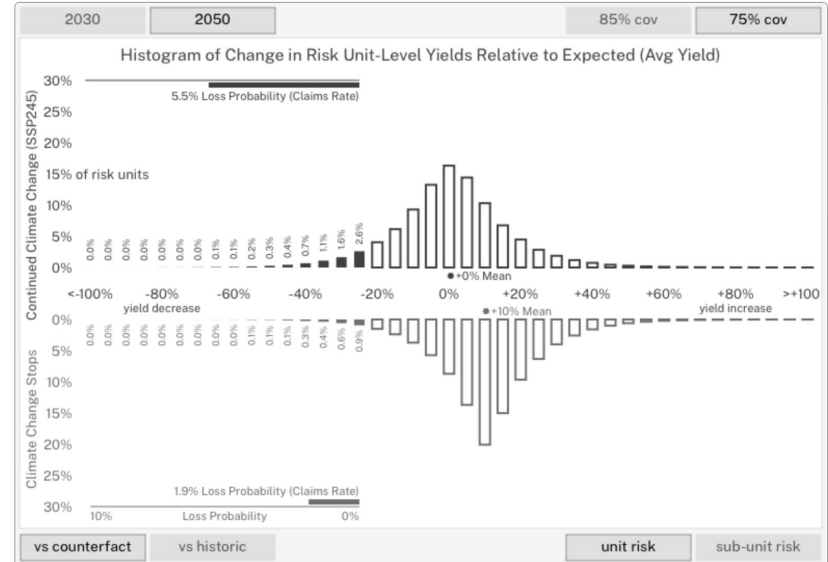
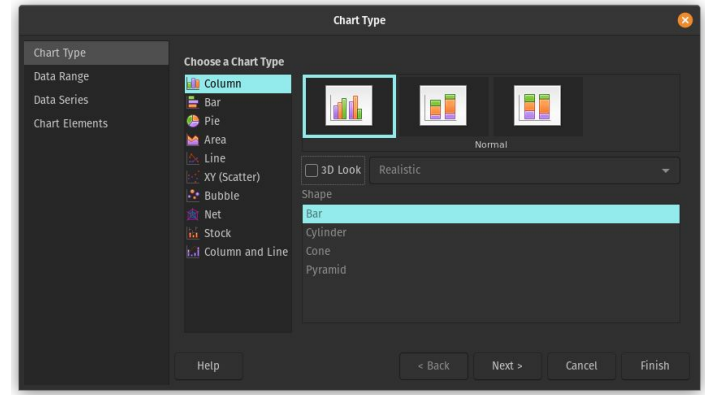
How do we “map” attributes of data to visual attributes?

What visual encodings are better than others?

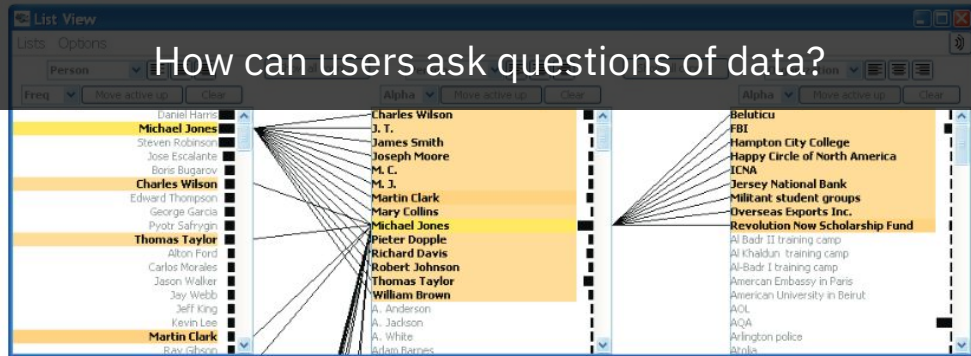
How do we make visualizations accessible?

**Offers:** Flexibility beyond the chart wizard but principles to guide us.

Gives us the basic building blocks for how humans process visual information but lets us use that understanding in many different ways.







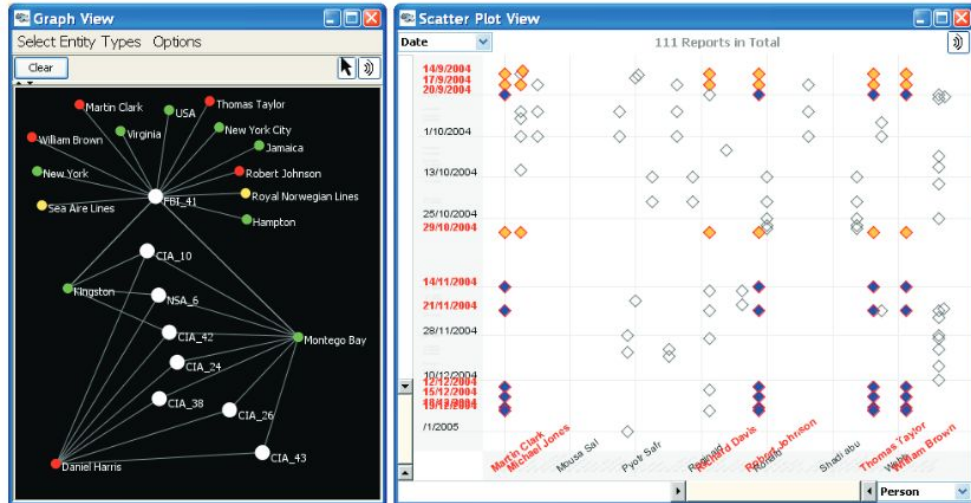
## 4 Perspectives

As representation

| As task

As message

As dialogue



**Text View**

FBI\_11 FBI\_35 FBI\_41

Source: Miami field office  
Date: 15/12/2004

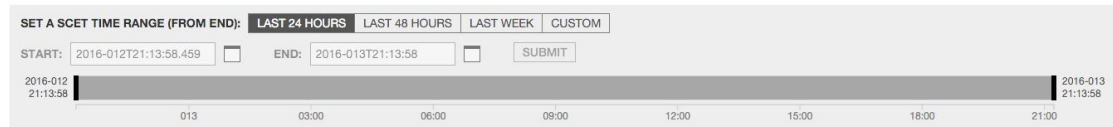
In light of the information in FBI report for [redacted] 2004, and [redacted] made of [redacted] lines to see if there were other occurrences of such double bookings. For [redacted] New York City and the Sea Air Lines in Hampton, VA Royal Norwegian Lines reported that two men named Thomas Taylor and Robert Johnson had, on 20 September, 2004, booked first-class accommodations on the "Viking Holiday" that left NYC on 14 November, 2004 and returned to NYC from Montego Bay on 21 November,

Data > Graphic -> User

Why and how different groups do data visualization. How you can think about it in your work.

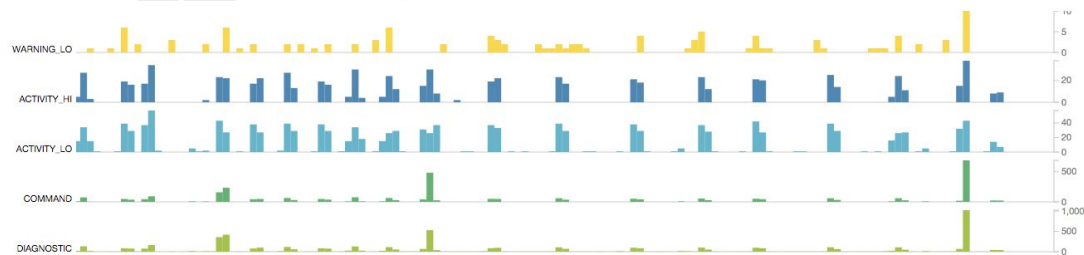
**Premise:** Visualizations  
are part of a broader user  
journey.

A structured way to think about the user  
in the context of data visualization.



▼ EVR COUNTS Click on a bar or brush the graph to select a time range for EVRs, displayed in the table below.

FILTER EVR LEVELS:   **LEGEND:** Each bar represents 10 minutes of EVR data.



▼ EVR TABLE Click on a row to save an EVR to your EVR collection below.

FILTER EVRS:

Level	Name	Task	Message	SCET ▼
ACTIVITY_LO	DWN_EVR_MANAGE_PACKET_BUFFER_GATE	dwn	Pktbuf (PB_RECORDER_DP) enabled status updated to CLOSED.	2016-013T19:57:15.034
DIAGNOSTIC	CMD_EVR_SEQ_CMD_DISPATCH	seqeng	Dispatching sequenced command: engine number=2, seconds=505987127, subseconds=917504.	2016-013T19:57:15.034
DIAGNOSTIC	CMD_EVR_SEQ_CMD_DISPATCHED	seqeng	Successfully dispatched sequenced command: seconds=505987127, subseconds=917504.	2016-013T19:57:15.034
COMMAND	SEQ_EVR_CMD_COMPLETED_SUCCESS	seqeng	Successfully completed sequenced command DMD DOWN dispatched from sequence engine number 2, command number 4142016-013T19:57:15.034	2016-013T19:57:15.034
COMMAND	SEQ_EVR_CMD_DISPATCH	seqeng	Dispatching sequenced command DMD DOWN from sequence engine number 2, from sequence file BKG_COMM_2016_013.se2016-013T19:57:15.033	2016-013T19:57:15.033
COMMAND	SEQ_EVR_CMD_COMPLETED_SUCCESS	seqeng	Successfully completed sequenced command CORRECT TIME PACKET dispatched from sequence engine number 2, command number 4142016-013T19:56:55.956	2016-013T19:56:55.956
ACTIVITY_HI	DWN_EVR_GENERATING_TC_PACKET	dwn	The time correlation packet was created: vcid=0, vctc=1155444, packet_time=1e28c024:e8500000, frame_time=1e28c022:f1f2c2016-013T19:56:55.956	2016-013T19:56:55.956
DIAGNOSTIC	DWN_EVR_TC_TIME_ARRIVED	dwn	The time correlation (TC) time arrived: expected=TRUE, time=1e28c022:f1f2c000.	2016-013T19:56:53.993
DIAGNOSTIC	DWN_EVR_TC_SENDING_FRAME	dwn	The time correlation (TC) reference frame was sent: vcid=0, vctc=1155444.	2016-013T19:56:51.962
DIAGNOSTIC	CMD_EVR_SEQ_CMD_DISPATCHED	seqeng	Successfully dispatched sequenced command 0xC9D3: seconds=505987103, subseconds=917504.	2016-013T19:56:51.034
DIAGNOSTIC	CMD_EVR_SEQ_CMD_DISPATCH	seqeng	Dispatching sequenced command 0xC9D3: engine number=2, seconds=505987103, subseconds=917504.	2016-013T19:56:51.034
COMMAND	SEQ_EVR_CMD_DISPATCH	seqeng	Dispatching sequenced command CORRECT TIME PACKET from sequence engine number 2, from sequence file BKG_COMM_2016-013T19:56:51.033	2016-013T19:56:51.033
COMMAND	SEQ_EVR_CMD_COMPLETED_SUCCESS	seqeng	Successfully completed sequenced command XBAND POWER dispatched from sequence engine number 2, command number 2016-013T19:56:23.685	2016-013T19:56:23.685

## Example: Rachel Binx at NASA.

Looking at “event records” sent from spacecraft to NASA.

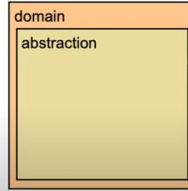
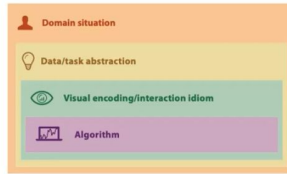
Interviewed a bunch of users to figure out how they worked with these data previously (log files).

Binx talks about how people had never seen their data before visually and the periodicity of events was revelatory for example.

Boils down into “tasks” the user executes and build user experiences to support those tasks.

## From domain to abstraction

- domain characterization:  
details of application domain
  - group of users, target domain, their questions & data
    - varies wildly by domain
    - must be specific enough to get traction
  - domain questions/problems
    - break down into simpler abstract tasks
- abstraction: data & task
  - map *what* and *why* into generalized terms
    - identify tasks that users wish to perform, or already do
    - find data types that will support those tasks
      - possibly transform /derive if need be



## Task Abstraction (Ch 3), Visualization Analysis & Design, 2021



Tamara Munzner  
31.3K subscribers

Subscribe



119



Share

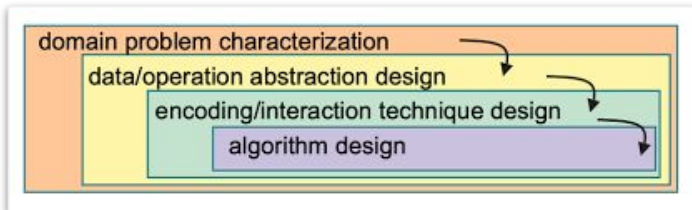


14K views 2 years ago

Task Abstraction Lecture, 2021.

Task Abstraction (Ch 3), Visualization Analysis & Design by Tamara Munzner, CRC/Routledge 2014.

More info including editable slides and free CC-BY diagram figures on book page: <https://www.cs.ubc.ca> ...more



**Offers:** Structured evidence-based understanding of the user to support them in their tasks.

Orients around domains, tasks, questions, and data.

Fits within a broader modern user experience design dialogue.



[illegible]

## As task

## As dialogue

Why and how different groups do data visualization. How you can think about it in your work.

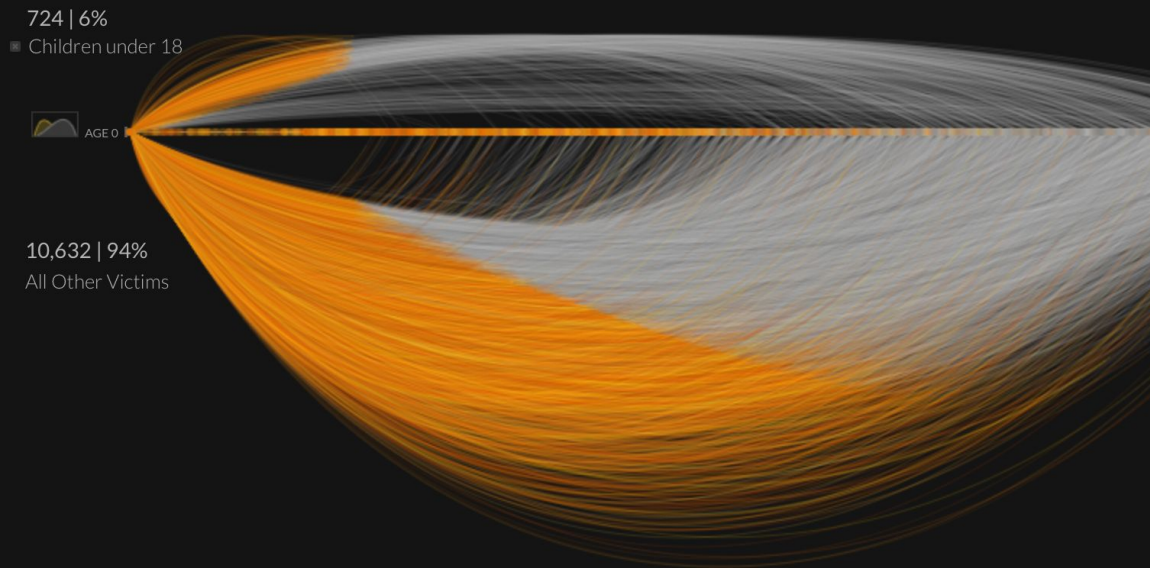
Data -> Graphic -> Audience



U.S. GUN KILLINGS IN 2018

# 11,356

PEOPLE KILLED



**Premise:** Forms given to data enable authors to convey a message to a reader.

How does the reader feel when going through a visualization?

Where is efficiency helpful but where does it conflict with the message of the piece?

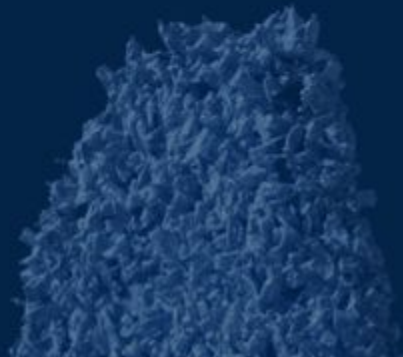
How might we defy reader expectations or have them confront prior held beliefs?

[guns.periscopeic.com](https://guns.periscopeic.com)

# A Treaty To End Plastic Pollution. Forever.

World leaders must take steps to drastically limit the  
impact of plastics on the environment and human  
health

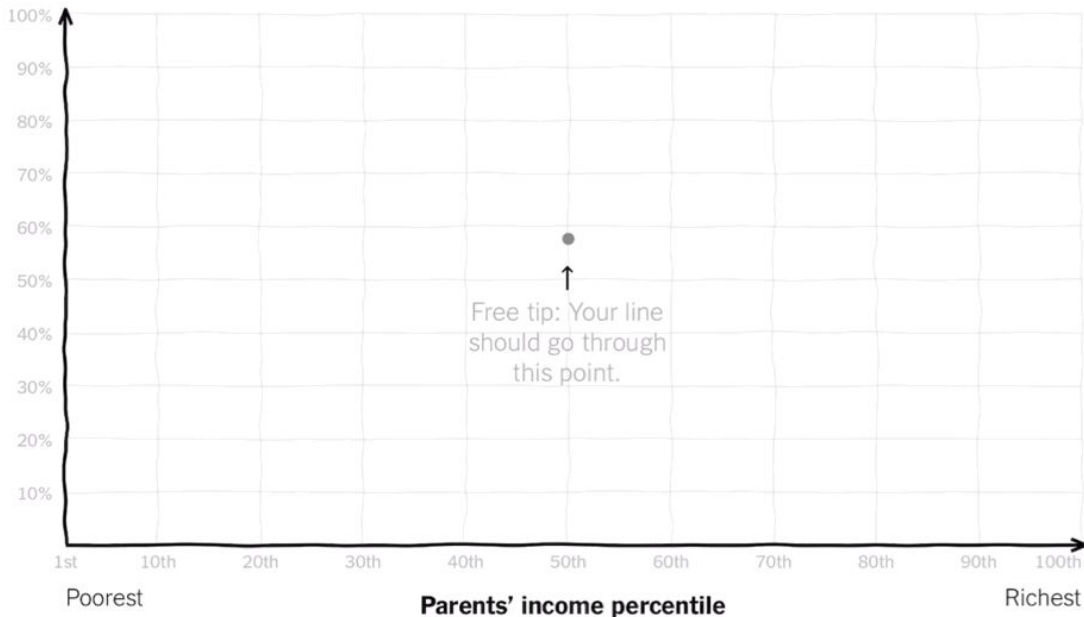
CHOOSE OUR FUTURE





## Draw your line on the chart below

Percent of children who attended college



I'm done

Start over

**Offers:** A way to convey messages with logos and pathos.

How to invoke emotional response.

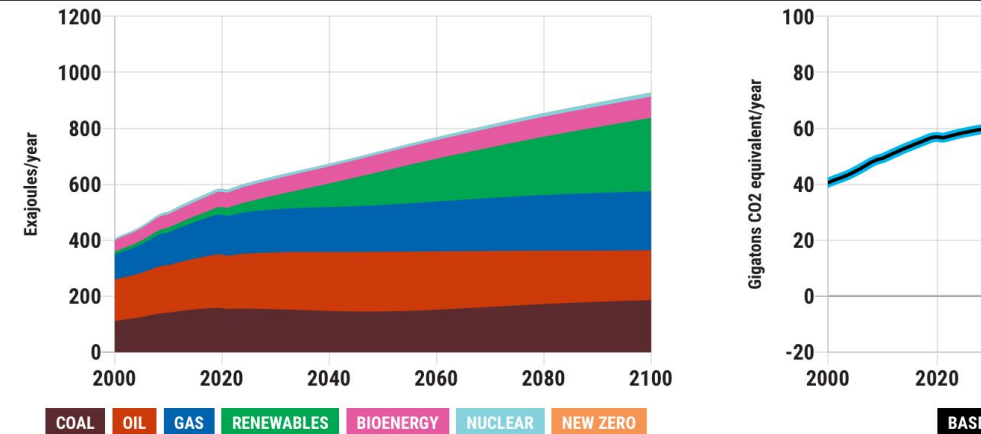
How to challenge reader assumptions.

How to understand the process by which messages and meaning are interpreted.

## How can data help us think?

Global Sources of Primary Energy

Greenhouse Gas Ne



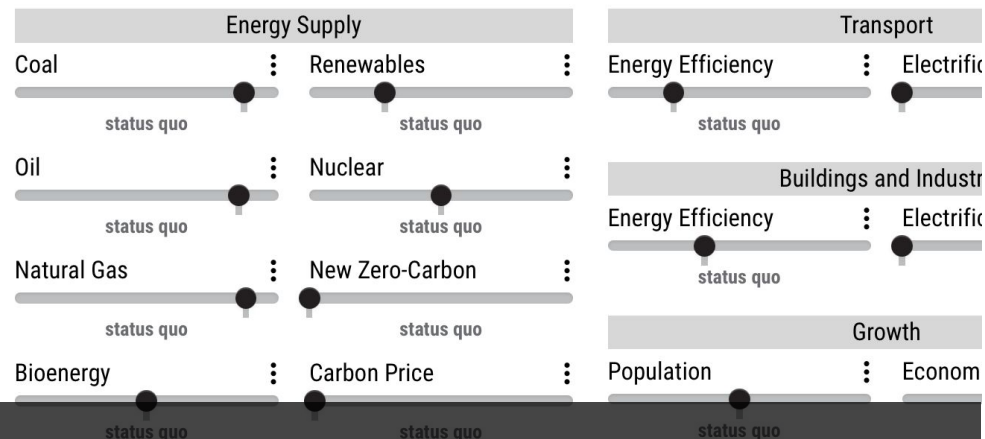
## 4 Perspectives

As representation

As task

As message

| As dialogue



Data &lt;- Tool -&gt; Collaborator

Why and how different groups do data visualization. How you can think about it in your work.

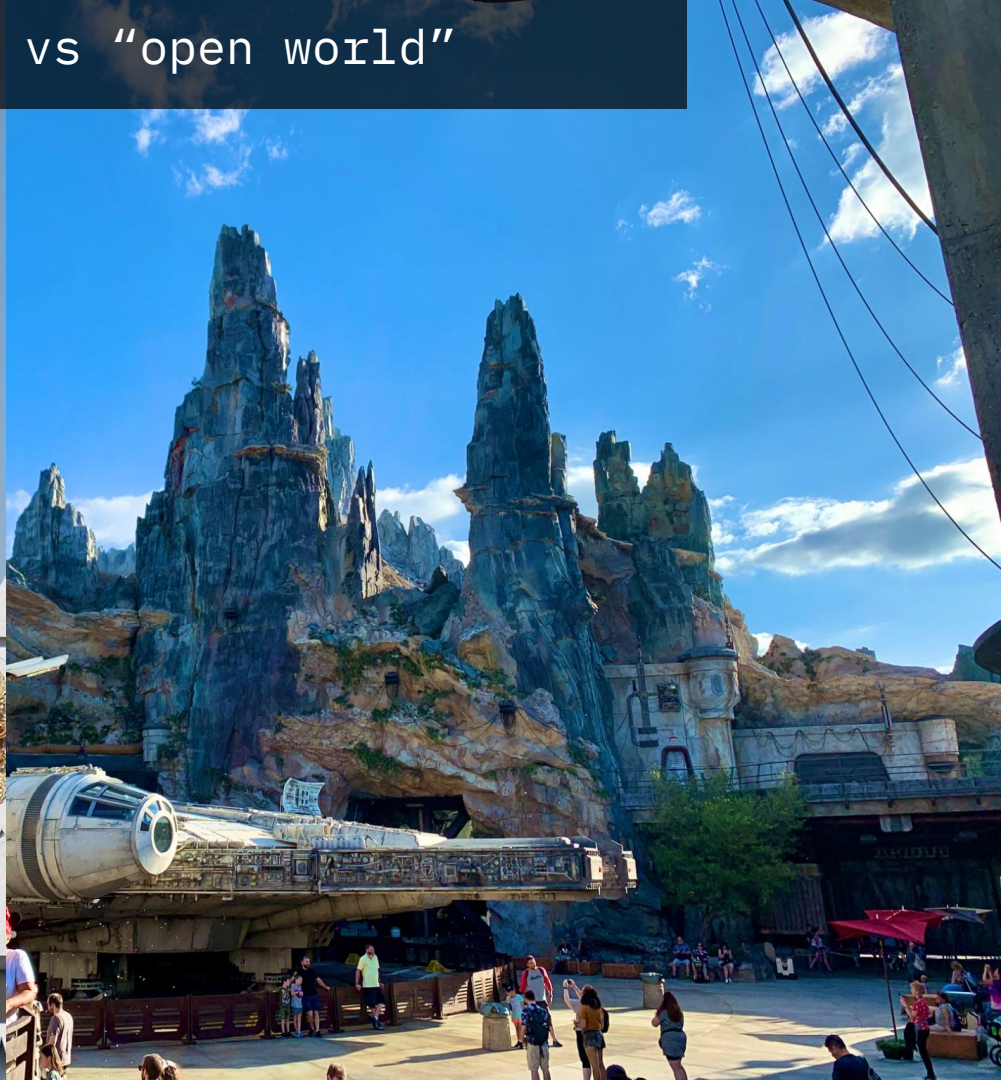
## Premise: Data as humane dynamic media.

The designer creates media for thought, elevating the reader to an author of tools and co-creator of meaning.



```
function drawScene (canvas) {  
  ctx = canvas.getContext("2d");  
  extendCanvasContext(ctx);  
  
  canvasWidth = parseInt(canvas.getAttribute("width"));  
  canvasHeight = parseInt(canvas.getAttribute("height"));  
  
  drawSky();  
  drawMountains();  
  drawTree();  
}  
  
//-----  
//  
// sky  
//  
  
function drawSky () {  
  ctx.save();  
  
  var gradient = ctx.createLinearGradient(0,0,0,canvasHeight);  
  gradient.addColorStop(0, "#b4c0fe");  
  gradient.addColorStop(1, "#d3f8ff");  
  
  ctx.fillStyle = gradient;  
  ctx.fillRect(0,0,canvasWidth,canvasHeight);  
  
  ctx.restore();  
  
  ctx.fillStyle = "#ecf7f8";  
  ctx.fillCircle(300, 99, 67);  
}  
  
//-----  
//
```

"ghost train ride" vs "open world"





Mismanaged Waste ⓘ

71.7

Million Metric Tons



Incinerated Waste ⓘ

129.3

Million Metric Tons



Landfill Waste ⓘ

118.4

Million Metric Tons



Gross GHG ⓘ

2755.7

Million Metric Tons



**Example:**  
Finding a  
solution to  
the plastics  
crisis.

A layered experience  
in which the user can  
simulate different  
policies.

An invitation to build  
outside the original  
designer's intention.



[https://  
global-plastics-tool  
.org](https://global-plastics-tool.org)

## Policies

☐ High > Reduction in Single Use Packaging ⓘ

☐ 90 > % Reduced Additives ⓘ

☐ Ban Polystyrene Packaging ⓘ

☐ Ban Waste Trade ⓘ

☒ Cap to 2020 Virgin Production ⓘ

☐ 40 > % Min Recycle Collection Rate ⓘ

☐ 80 > % Packaging Reuse / Life Extension ⓘ

☐ 40 > % Min Recycled Content ⓘ

☐ High > Packaging Consumption Tax ⓘ

☐ 100 > Billion USD for Plastic Recycling ⓘ

☐ 50 > Billion USD for Waste Infrastructure ⓘ

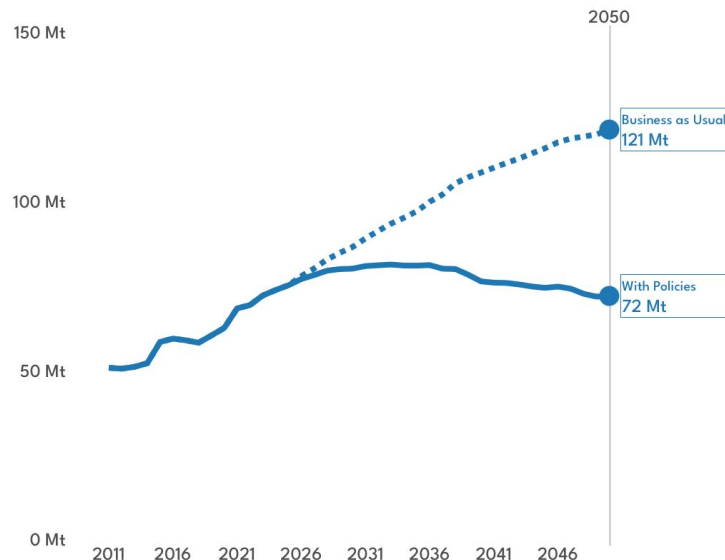
☒ Custom ⓘ







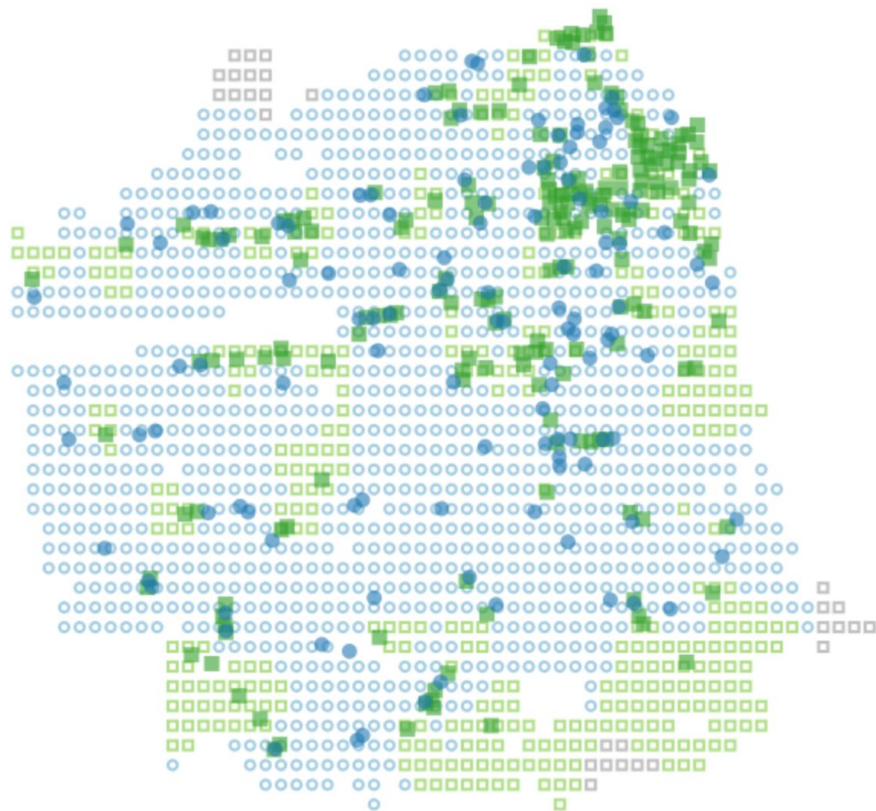

## Global Annual Rate of Mismanaged Waste as Million Metric Tons ⓘ


[Explore detailed projections](#)
[With Policies](#)
[Business as Usual](#)



### Progress:

Keep going! You have spent 0% of your budget (0% on rezoning and construction subsidy, 0% on transit improvement and subsidy). Goal: 80% choose supermarket. You can also [reset your design and try again](#).



### Summary

74% c

24% c

2% m

0%

### Buildings

Left cl

☒ Su

☐ Fa

☐ Re

☐ Re

### Transit

Invest

travel

## Offers: Co-creation and user agency.

Often leaning on game design concepts.

How to teach with/without tutorializing.

How to create spaces to interrogate assumptions.

How to build media to be repurposed.

How to design experiences where the user is co-author.

**Keep it going:** Check-in before we go to code.



What's something you  
learned today?

Gulf of Alaska Common names No temperatures

Scatter 1

Scatter 2

Pacific cod

None

2013

Loading...

kg / hectare

19.77 kg/hectare overall CPUE

Dynamic scaling enabled



Aleutian Islands Common names No temperatures

Scatter 1

Scatter 2

Pacific cod

None

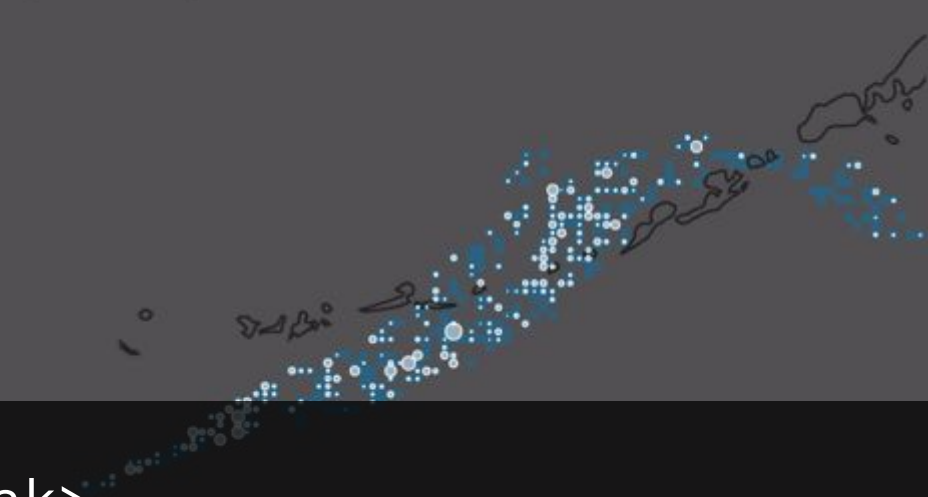
2000

Loading...

kg / hectare

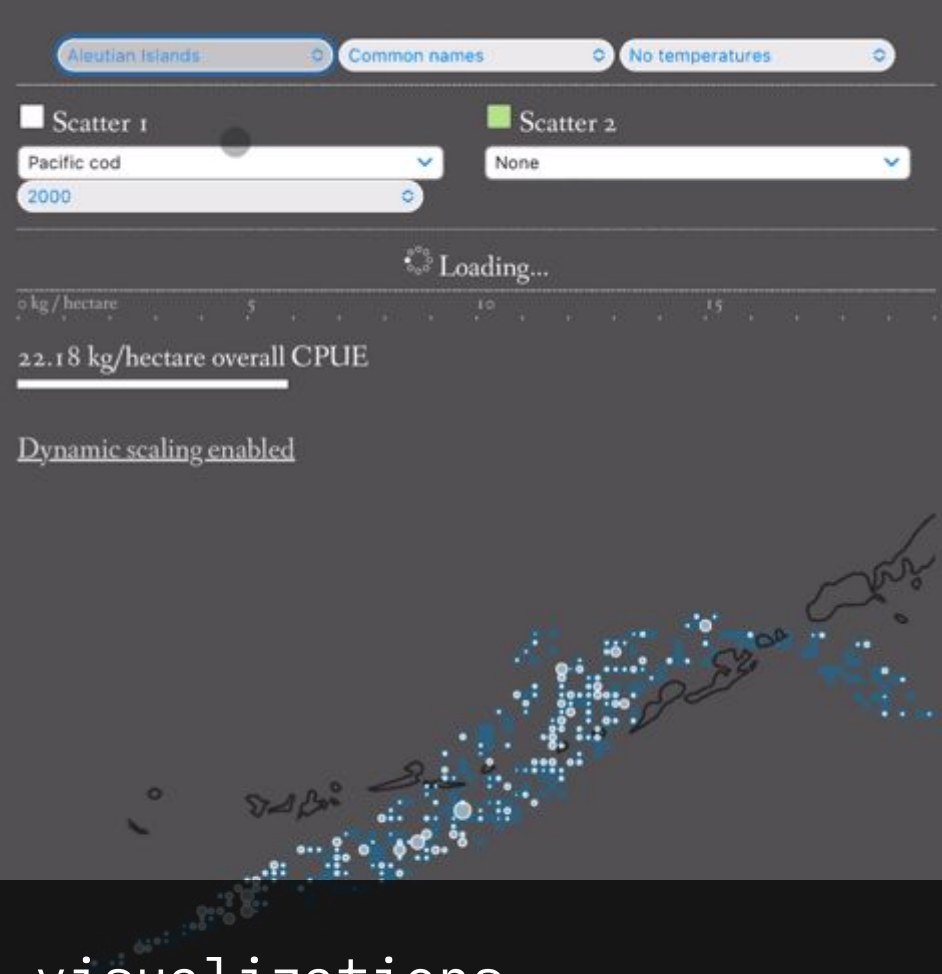
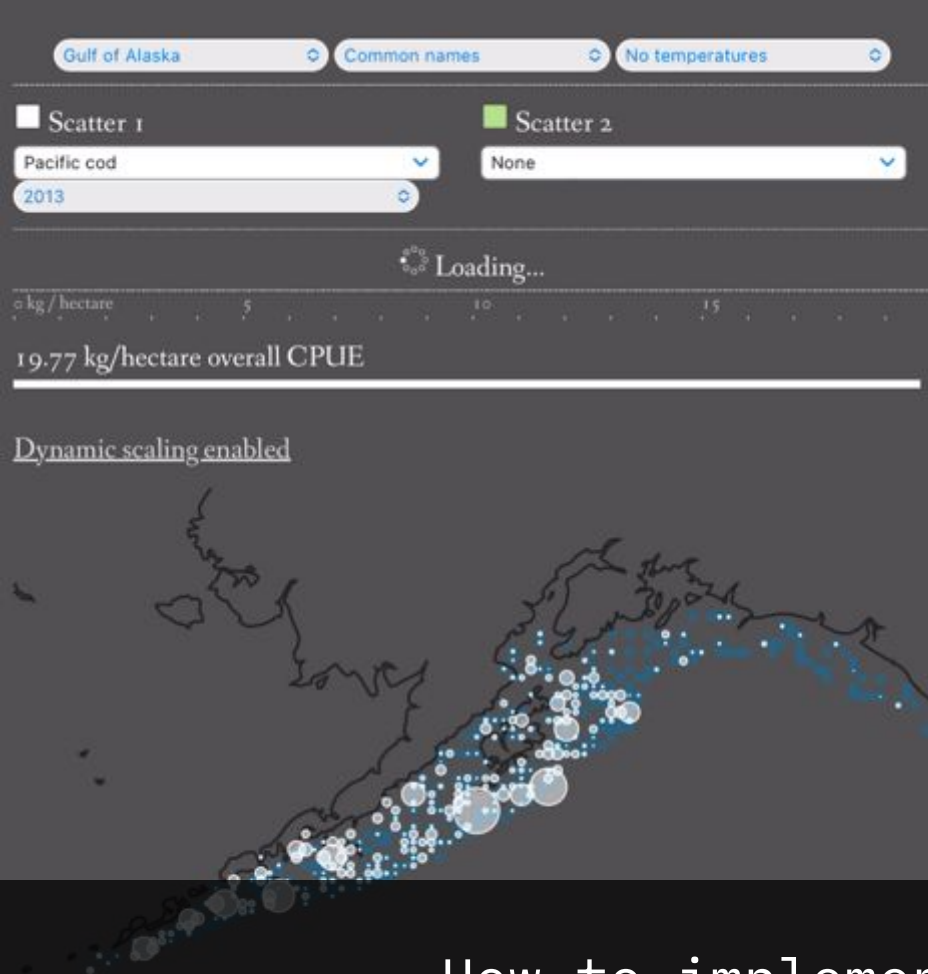
22.18 kg/hectare overall CPUE

Dynamic scaling enabled



<Break>





How to implement visualizations

# Let's start with a pre-built chart

## **Data:**

```
https://  
interactivedatascience.courses  
/labs  
/wolvesMoose.csv
```

## Let's start with a pre-built chart



```
import matplotlib.pyplot  
import pandas  
  
# Load data into pandas DataFrame  
df = pandas.read_csv('wolvesMoose.csv')
```

## Let's start with a pre-built chart



```
# Create figure with subplots  
fig, (ax1, ax2) = matplotlib.pyplot.subplots(2, 1, figsize=(15, 6))
```

## Let's start with a pre-built chart



```
# Plot wolves data
ax1.bar(df['Year'], df['Wolves'], color='#d95f02', alpha=0.8)
ax1.set_title('Wolf Population Over Time', fontsize=14, fontweight='bold')
ax1.set_xlabel('Year', fontsize=12)
ax1.set_ylabel('Number of Wolves', fontsize=12)
ax1.grid(True, alpha=0.3)
```

## Let's start with a pre-built chart



```
# Plot moose data
ax2.bar(df['Year'], df['Moose'], color='#7570b3', alpha=0.8)
ax2.set_title('Moose Population Over Time', fontsize=14, fontweight='bold')
ax2.set_xlabel('Year', fontsize=12)
ax2.set_ylabel('Number of Moose', fontsize=12)
ax2.grid(True, alpha=0.3)
```

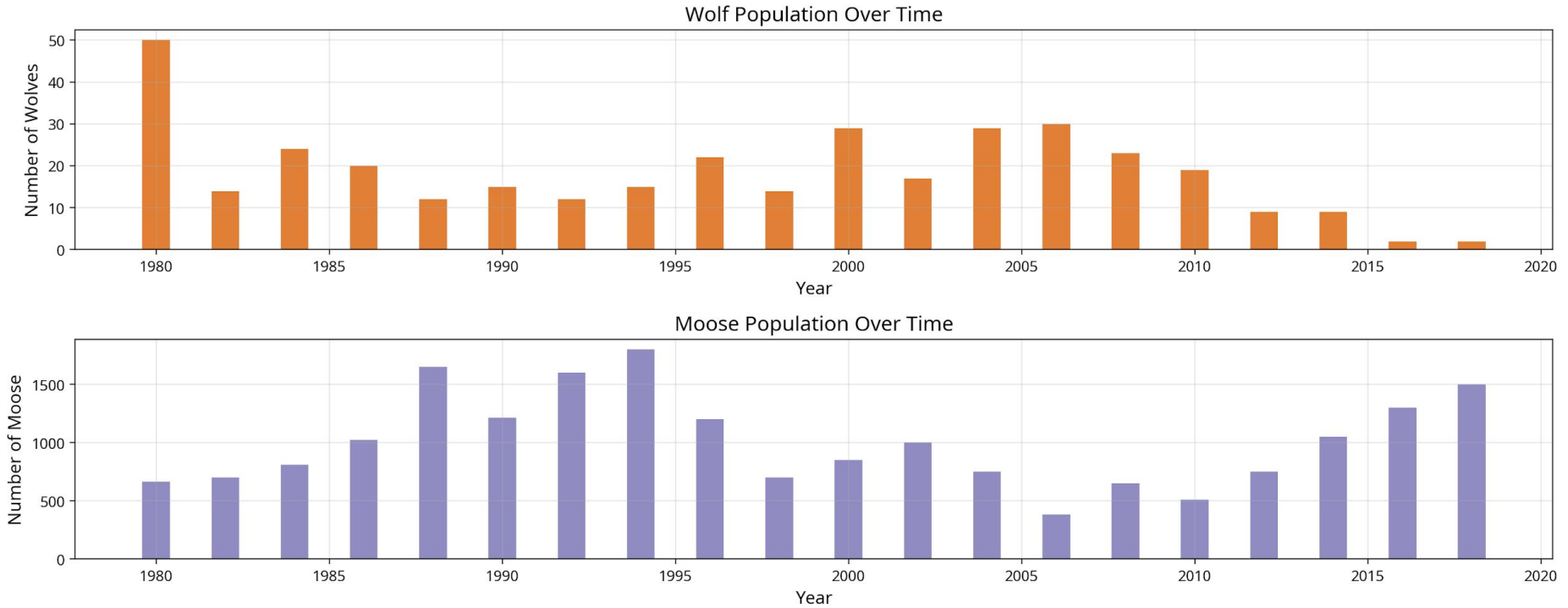
## Let's start with a pre-built chart



```
# Adjust layout to prevent overlap
matplotlib.pyplot.tight_layout()

# Show the plot
matplotlib.pyplot.show()
```

# Let's start with a pre-built chart

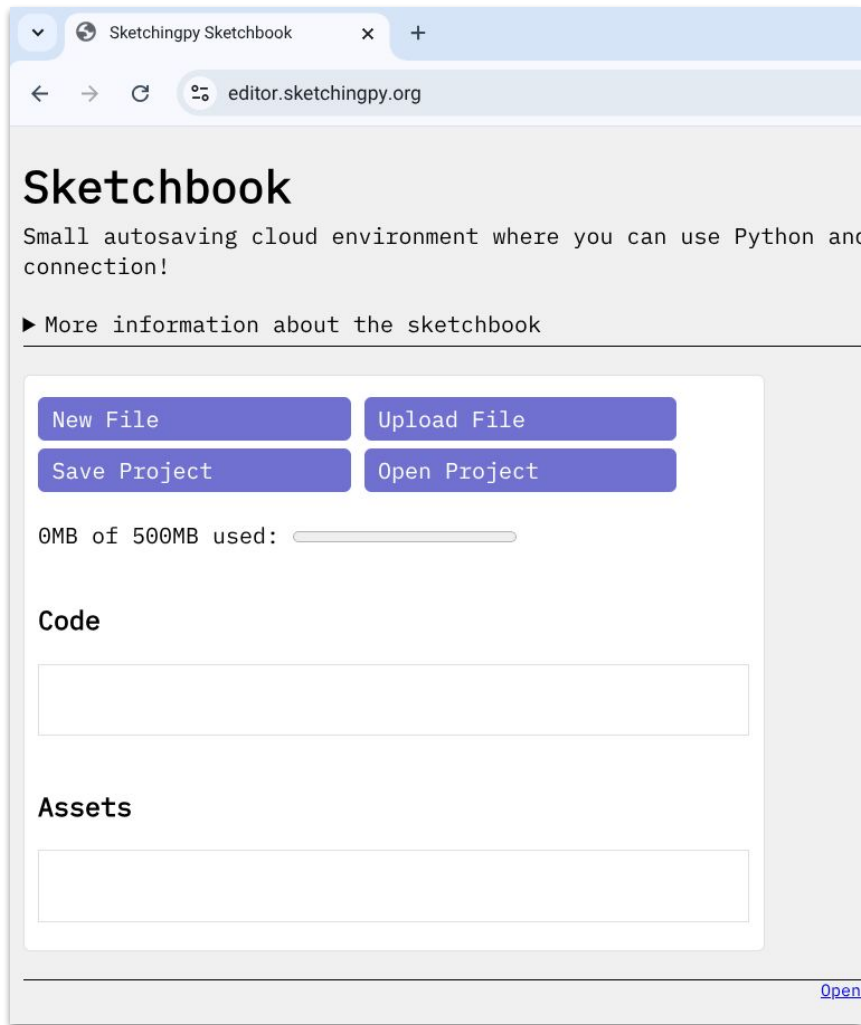




# Where did the colors come from?

<https://colorbrewer2.org/>

<https://webaim.org/resources/contrastchecker/>



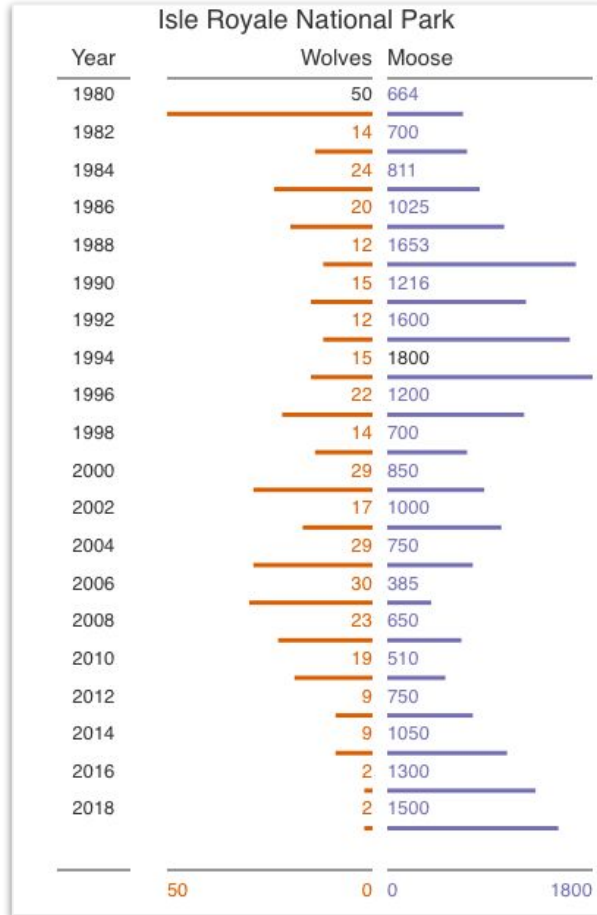
## Tool:

`https://  
editor  
.sketchingpy  
.org`

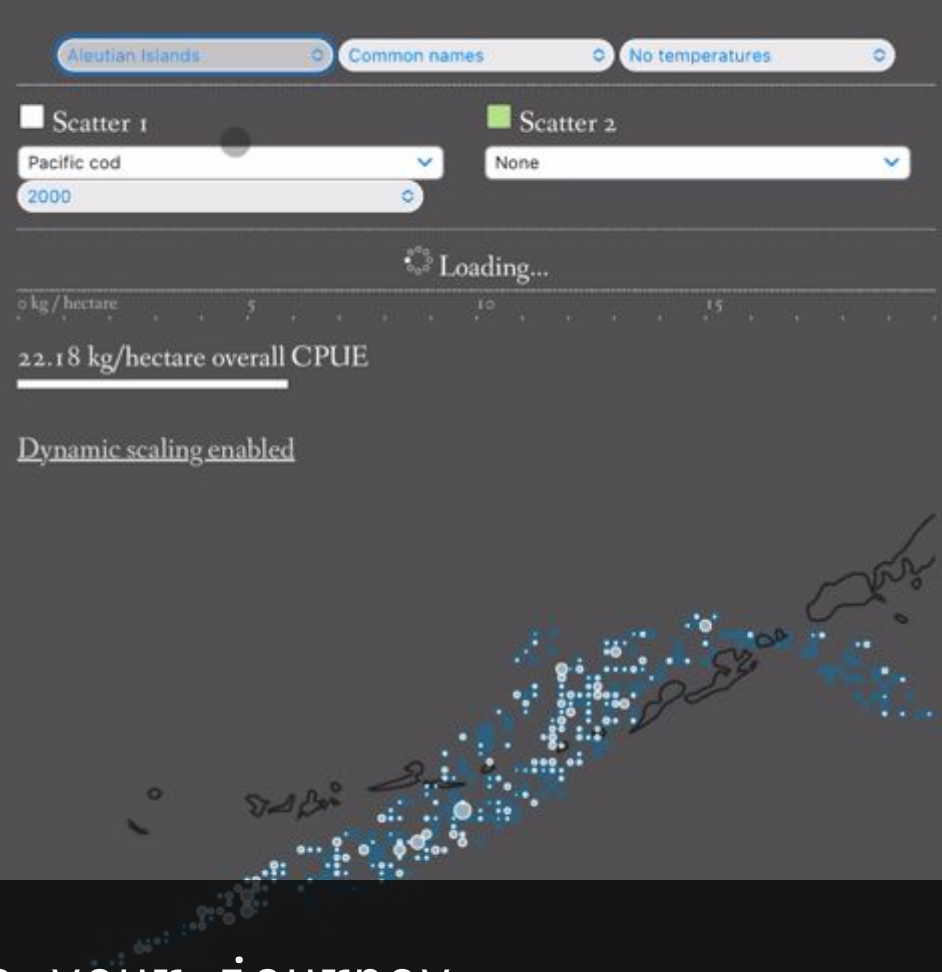
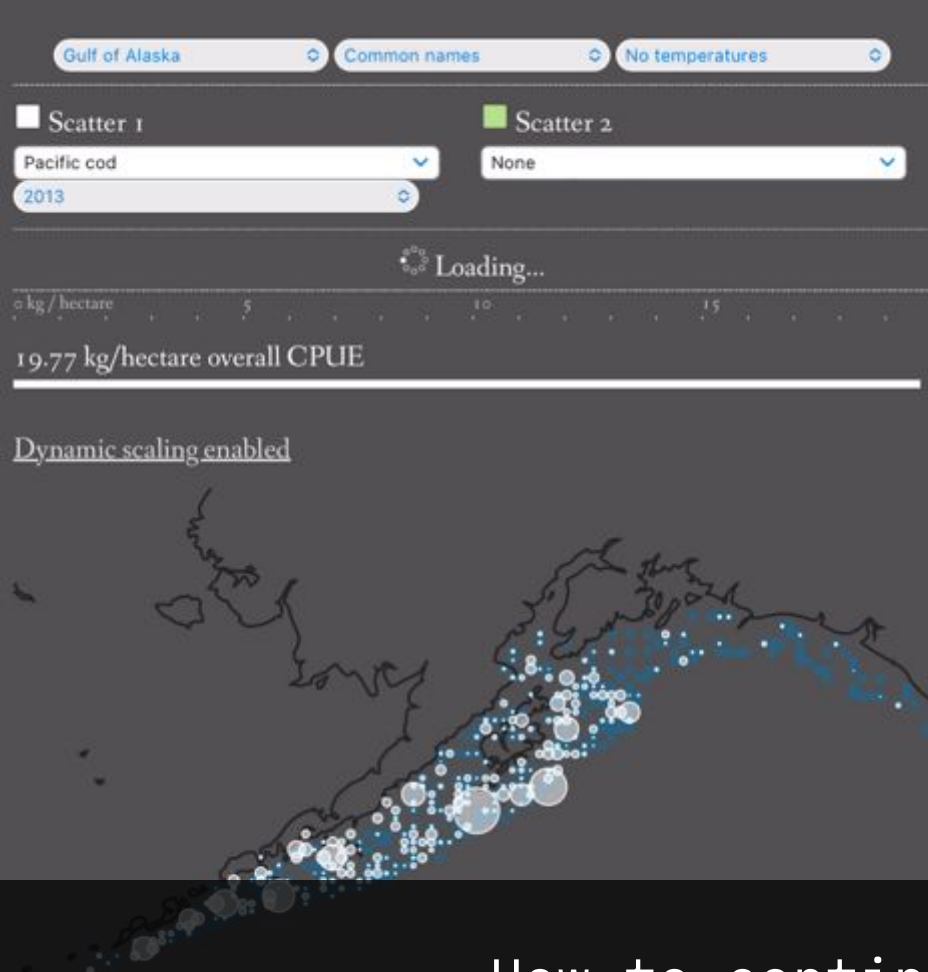
## Data:

`https://  
interactivedatascience.courses  
/labs  
/wolvesMoose.csv`

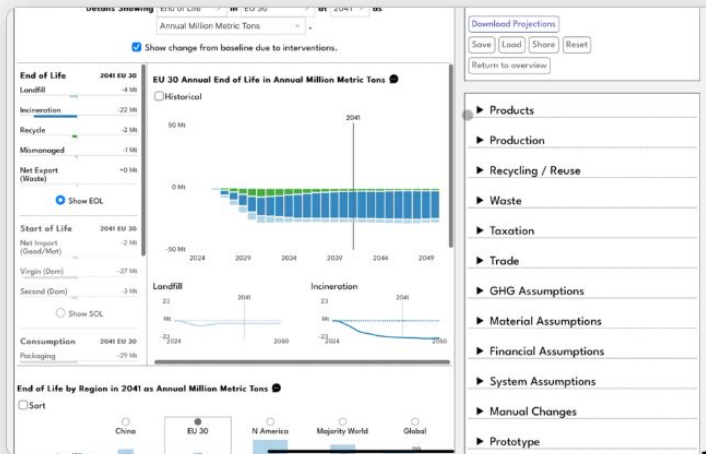
# An alternative



<https://gist.github.com/sampottinger/8721ba6d20f9f5387900e393f5a9b3cd>



How to continue your journey



**Keep going:**  
Resources online.

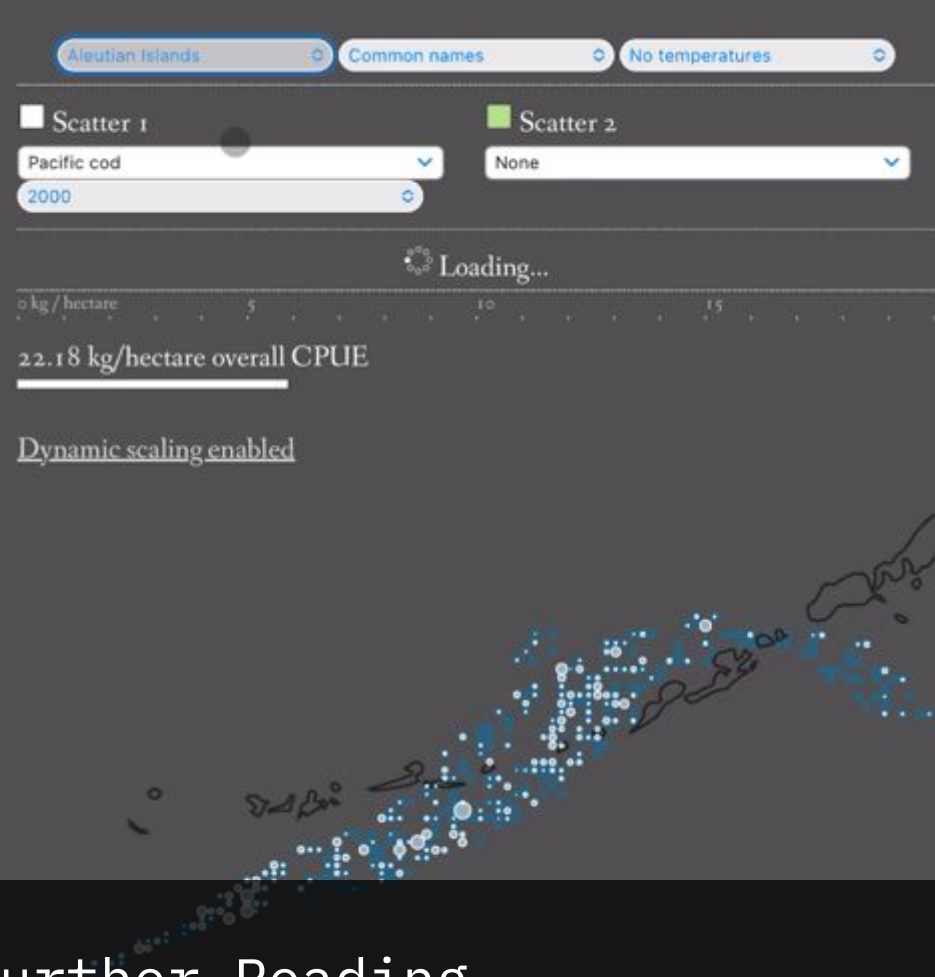
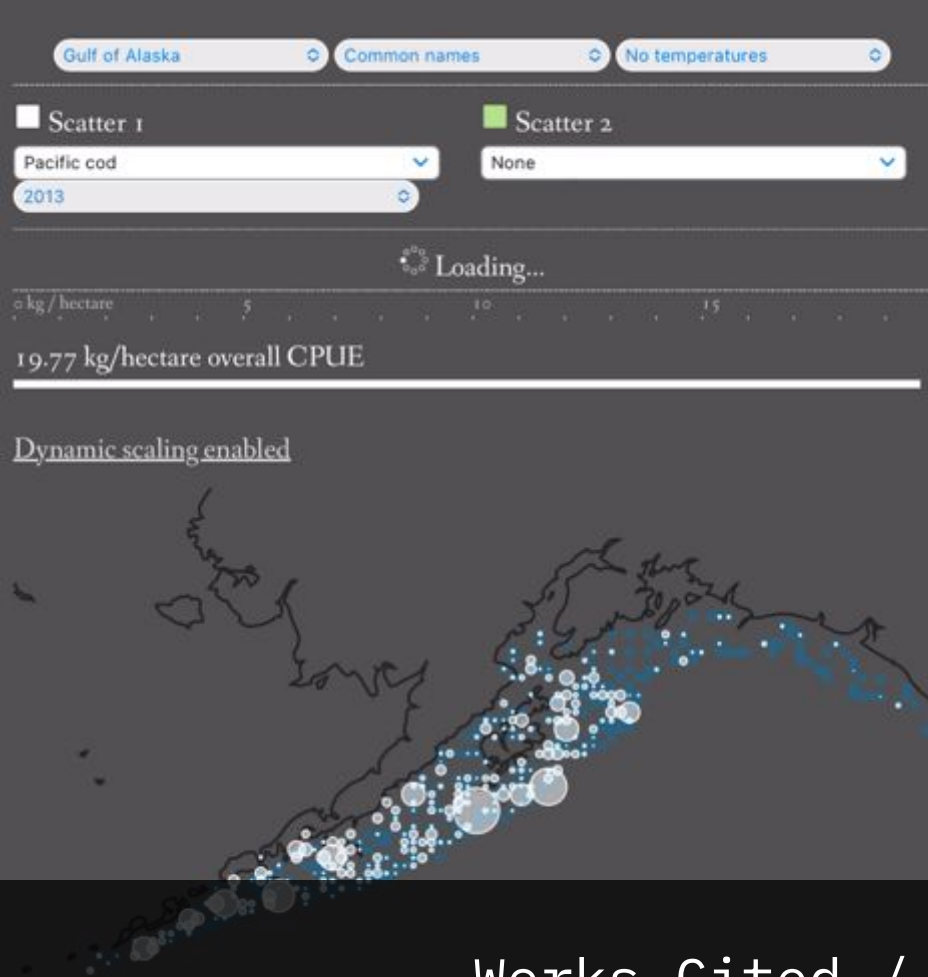
[https://  
interactive  
data  
science  
.courses](https://interactive-data-science.courses)

## Interactive Data Science

👋 Hello! I'm [Sam](#). This website houses my courses, workshops, and lectures on interactive data, participatory science, democratized AI, and user-centered data visualization.

🚀 Get learning! Try [my open source online course](#) (free and self-paced) or, if you are in Berkeley, [participate in-person](#).

[Course](#) / [Why](#) / [Upcoming](#) / [Materials](#) / [Sign Up](#) / [About](#)



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