Interaction

DSC 106: Data Visualization

Jared Wilber

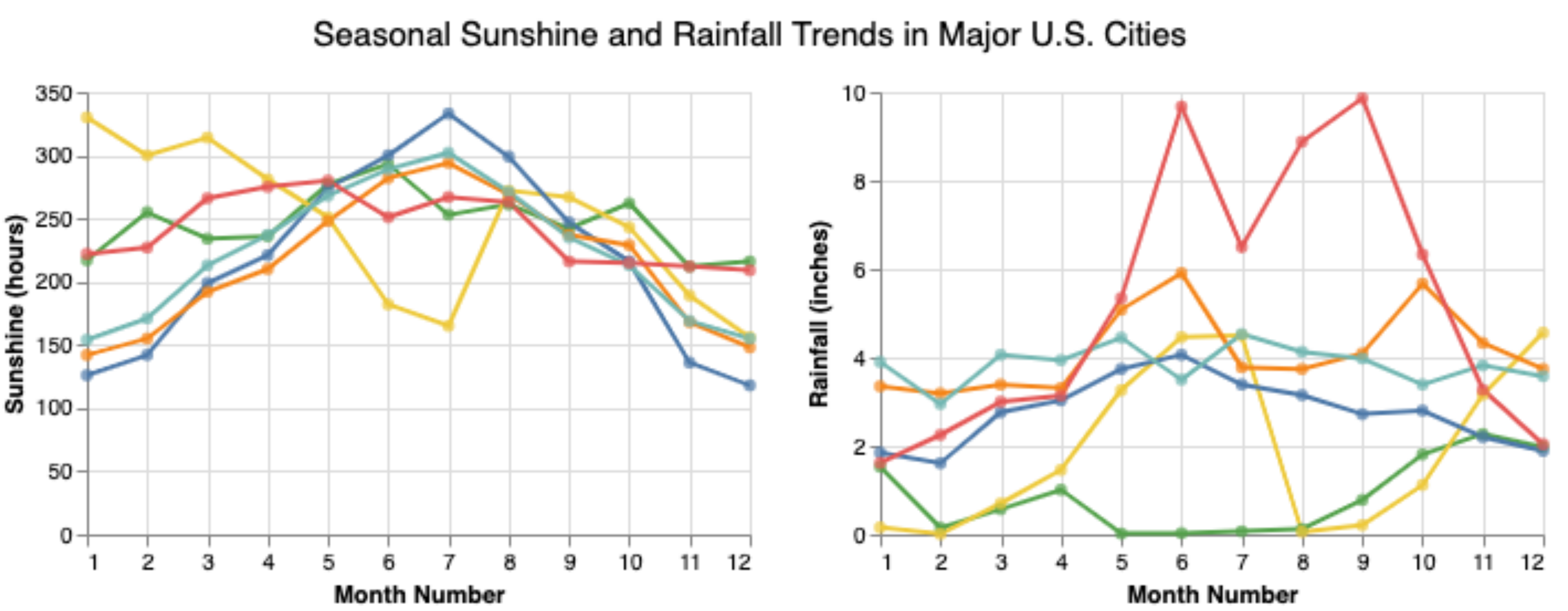
UC San Diego

Announcements

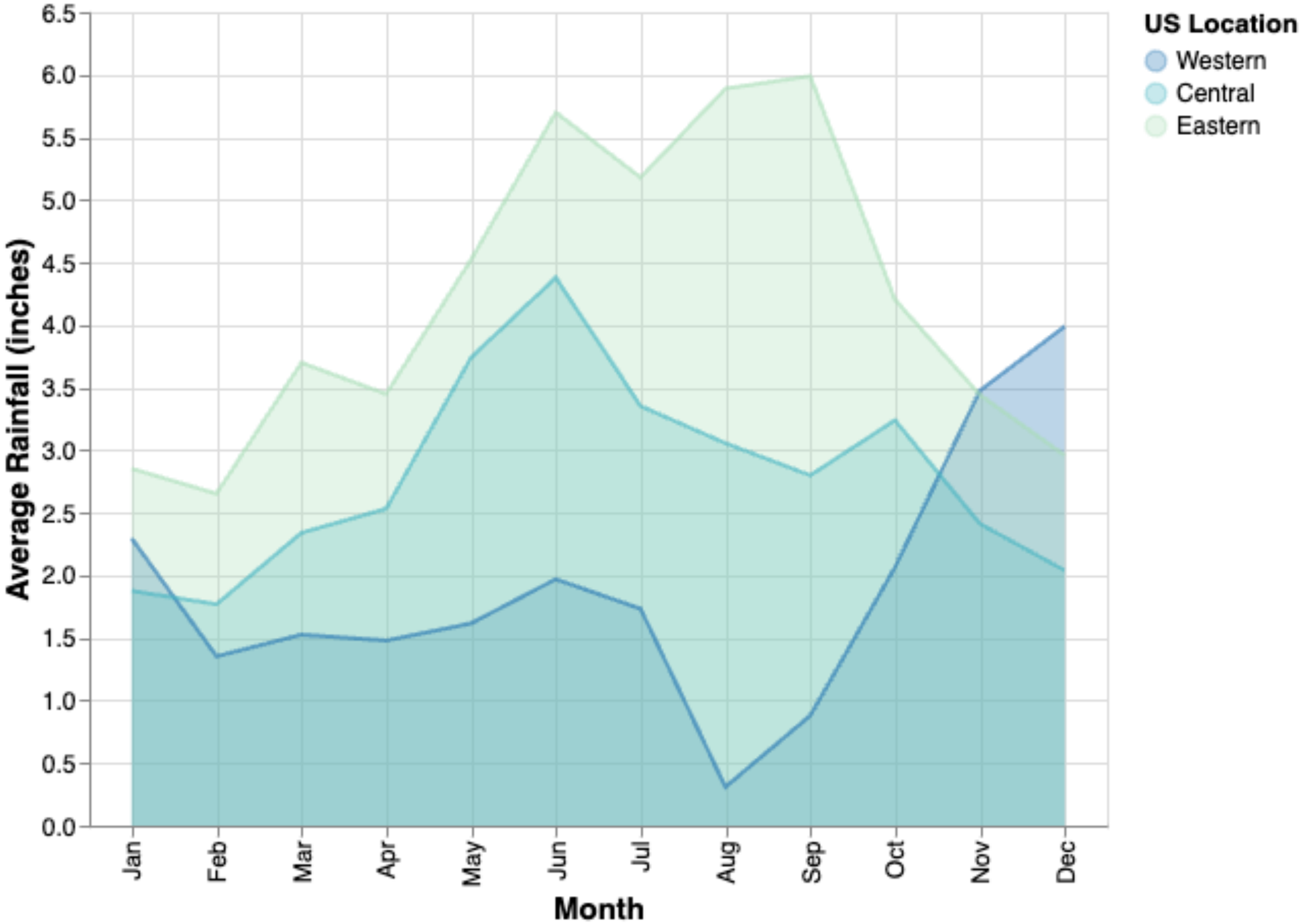
Lab 3 (JavaScript) out, due Friday 4/19.

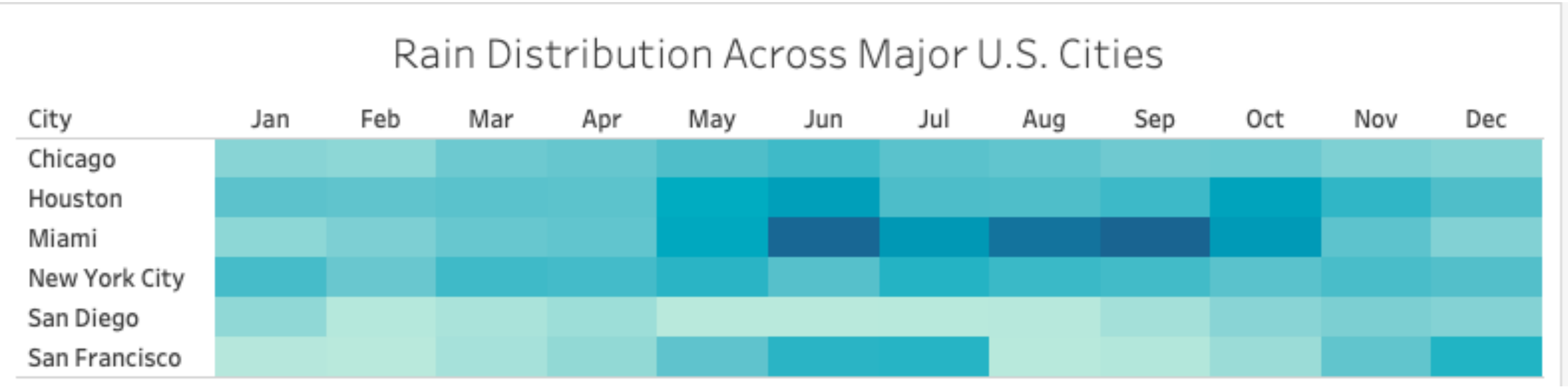
Project 2 out, due next Friday 4/26.

Quality Submissions


Seasonal Sunshine and Rainfall Trends in Major U.S. Cities
Sunshine (hours)
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
Month Number
Rainfall (inches)
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
Month Number
city
Chicago
Houston
Miami
New York City
San Diego
San Francisco

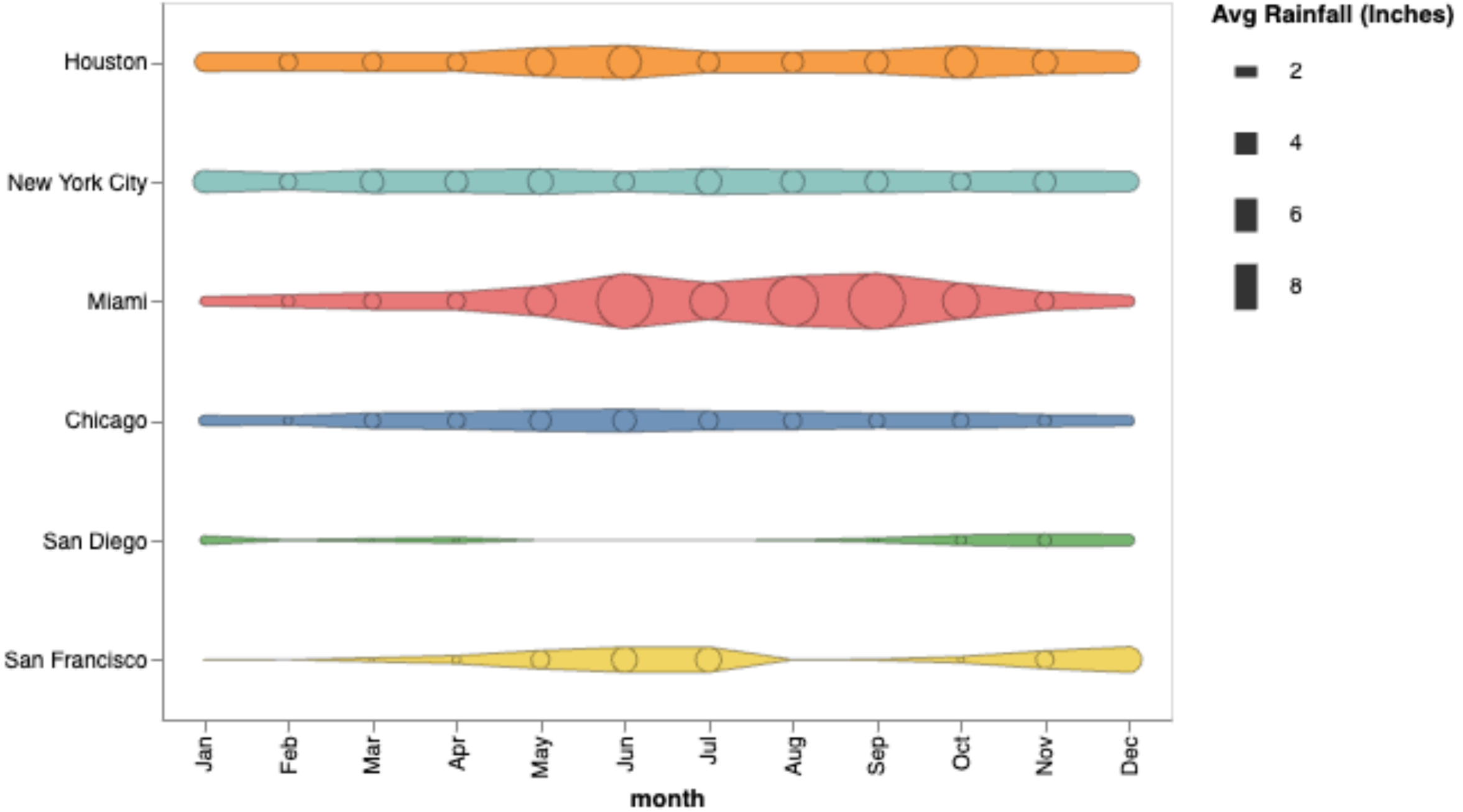
Which US region (Western, Central, or Eastern) has the highest average rainfall throughout the year?

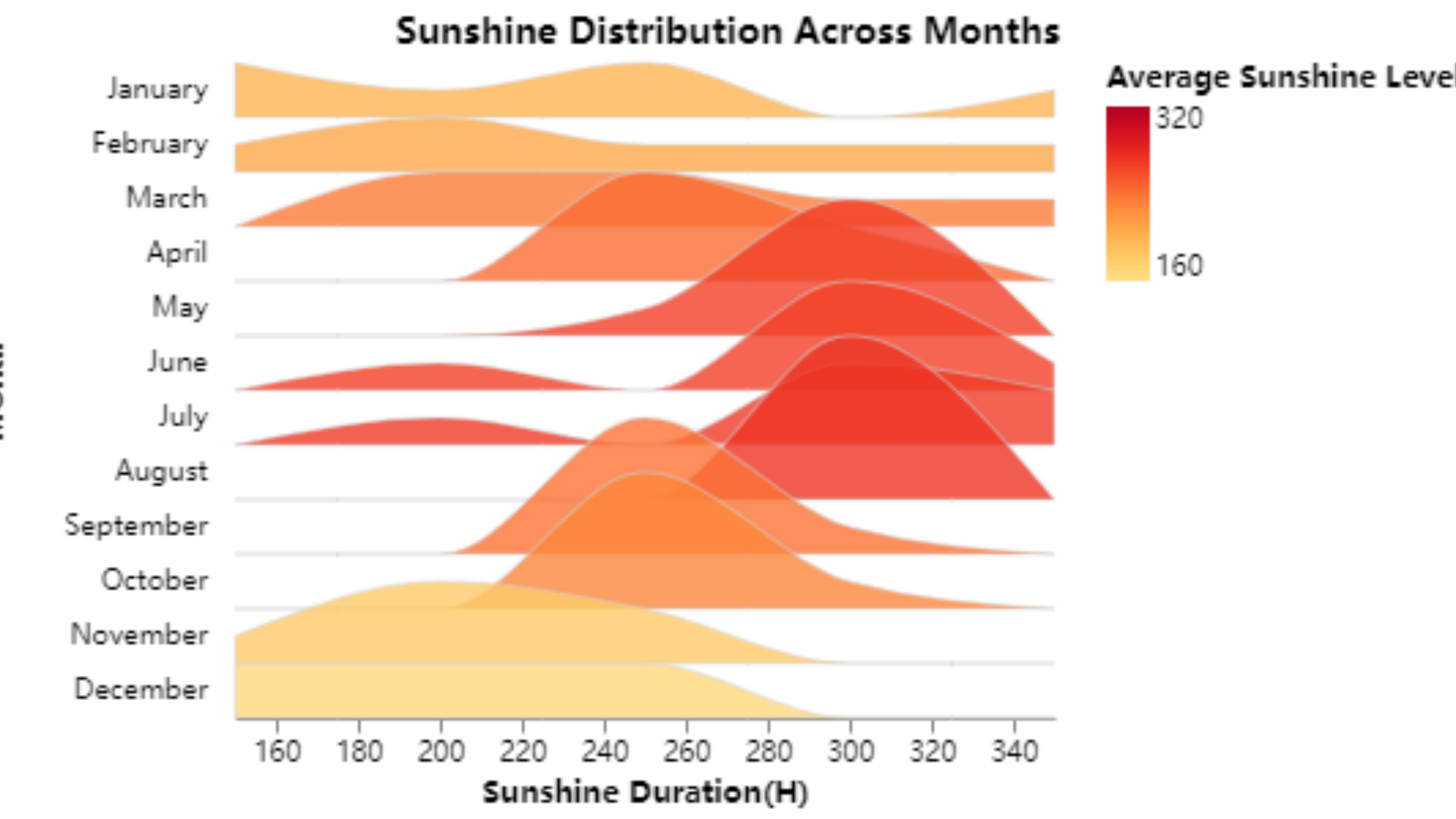



Rain Distribution Across Major U.S. Cities
City
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Chicago
Houston
Miami
New York City
San Diego
San Francisco
Rain (inches)
0.010
9.860

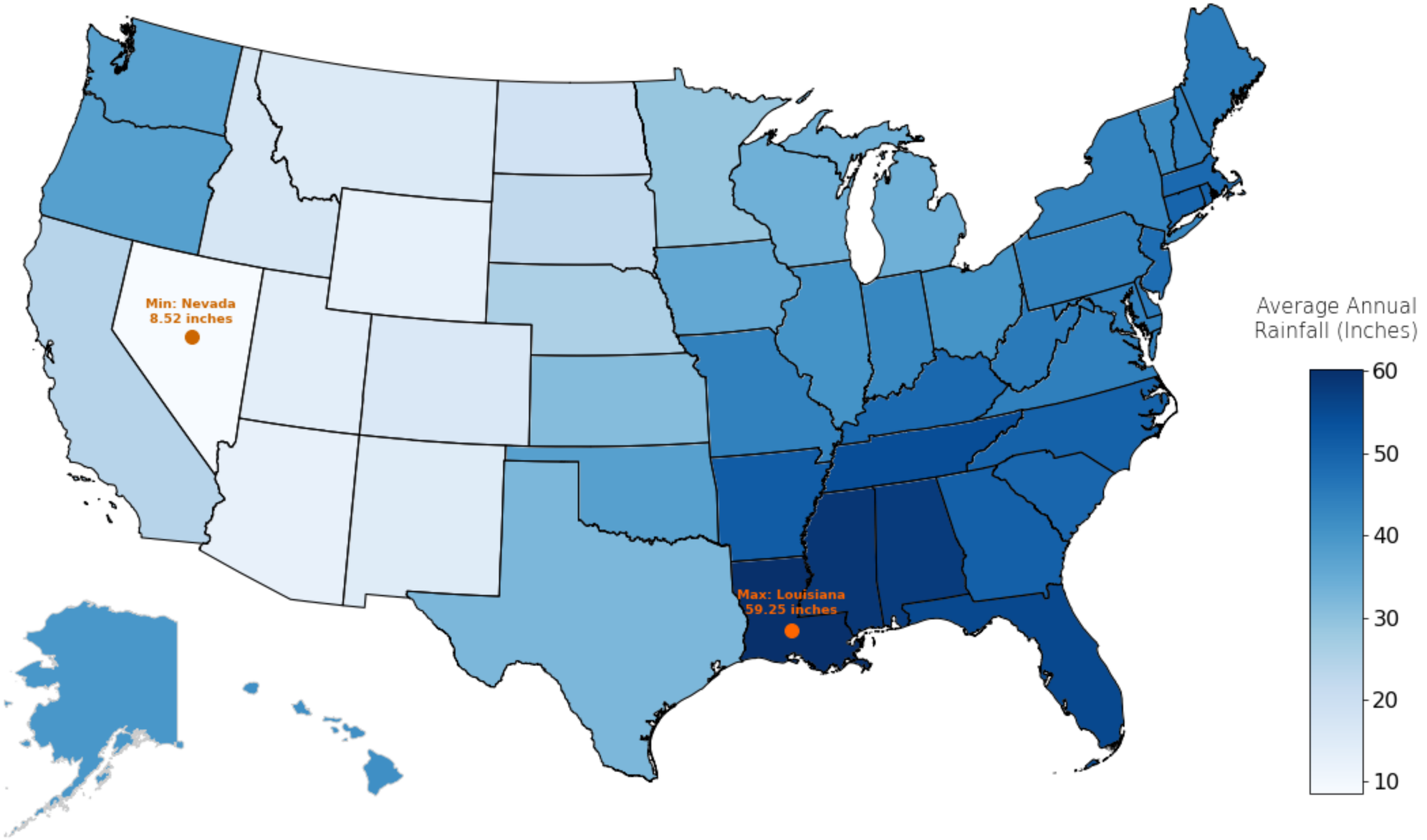
How Rainfall Differs Between Cities Through the Year

The size of the line represents the average inches of rainfall for that month

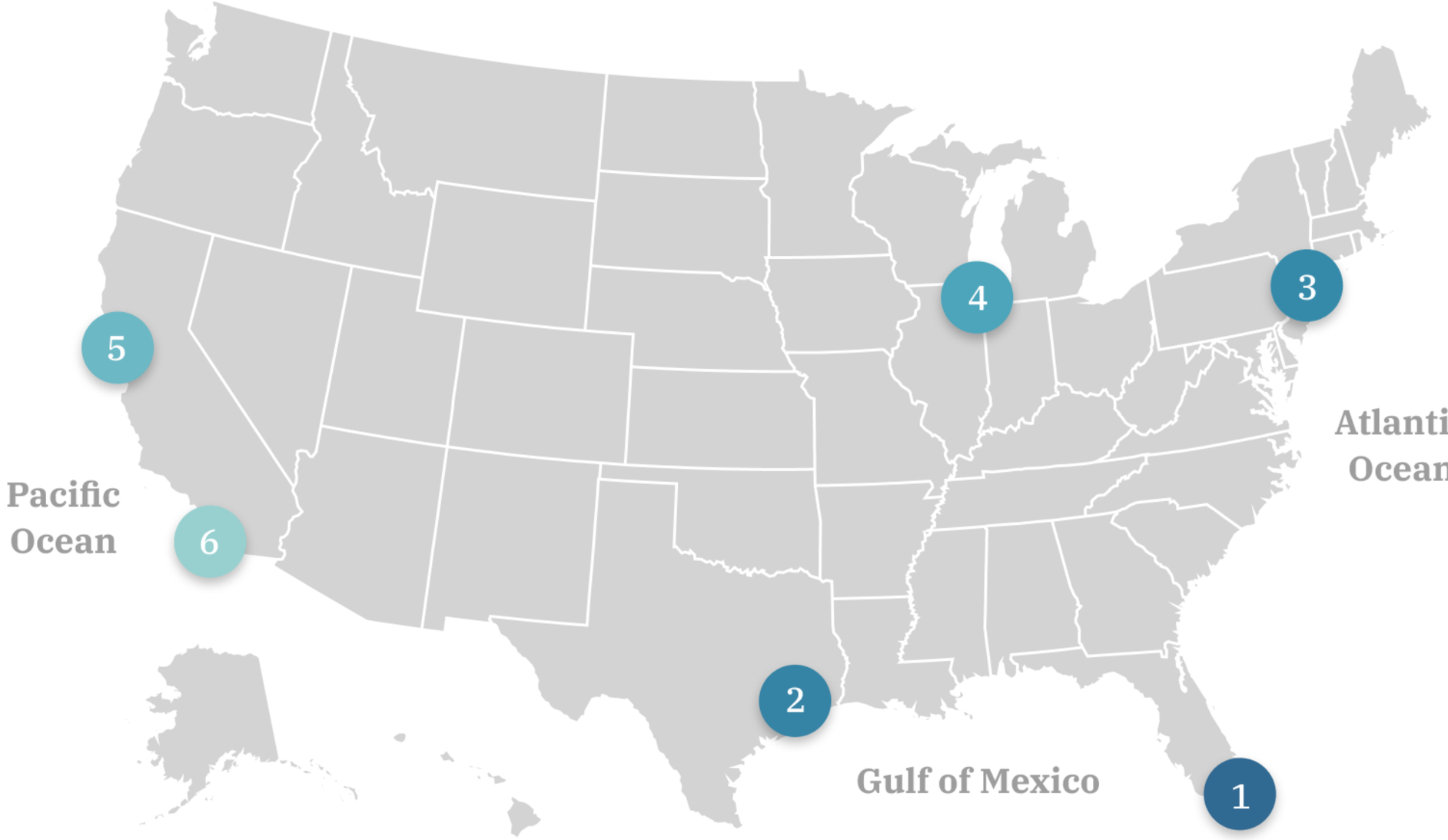



Sunshine Distribution Across Months
Average Sunshine Level
320
160
January
February
March
April
May
June
July
August
September
October
November
December
160
180
200
220
240
260
280
300
320
340
Sunshine Duration(H)

Which U.S. States Receive the Least and Most Rain Yearly, on Average?



How Does Location Impact the Average Annual Rainfall of Major U.S. Cities?



Rainfall

1. Miami — 61.90in

2. Houston — 49.58in

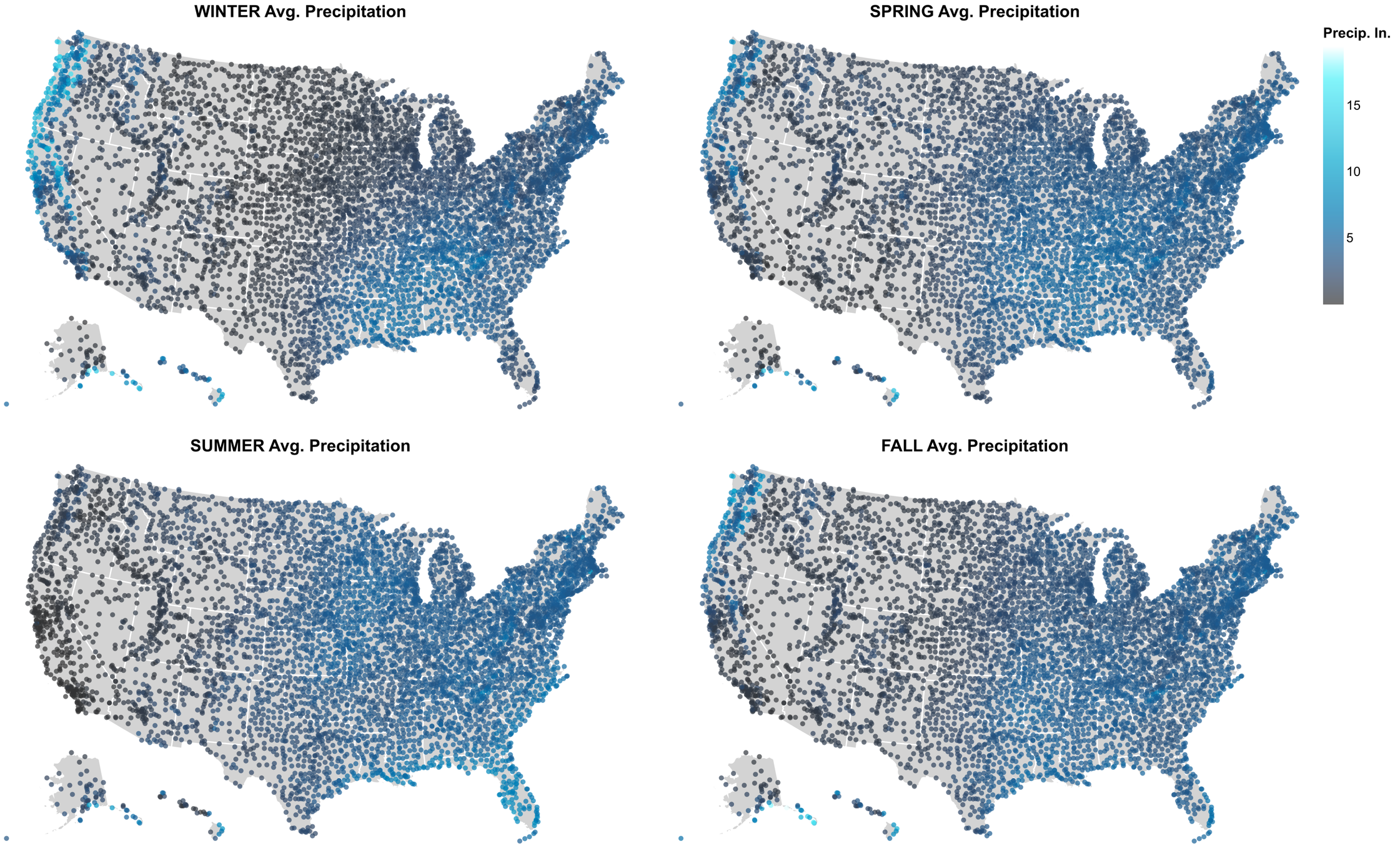
3. New York City — 46.23in

4. Chicago — 33.20in

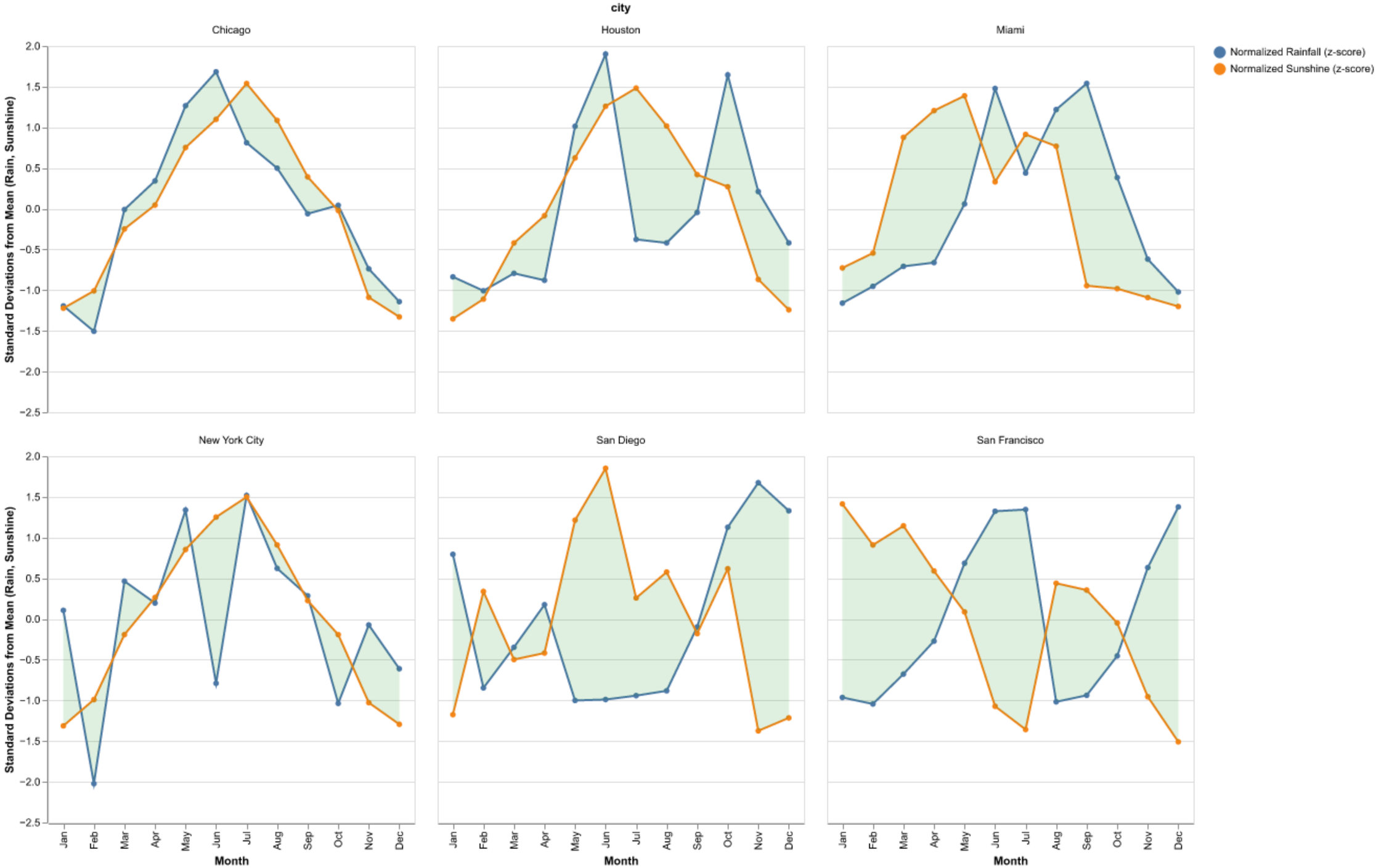
5. San Francisco — 23.66in

6. San Diego — 10.34in

"My Husband Hates Rain. I Love Rain and Hate My Husband. Where's the Best Place to Live in the US?"

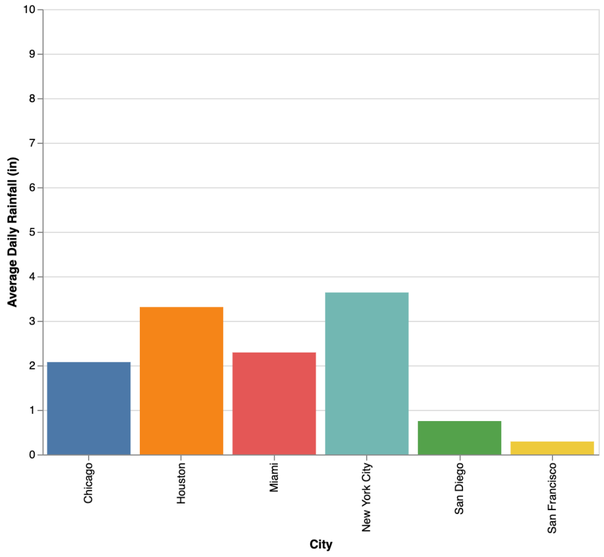


What is the relationship between sunshine and rainfall by month for each city?

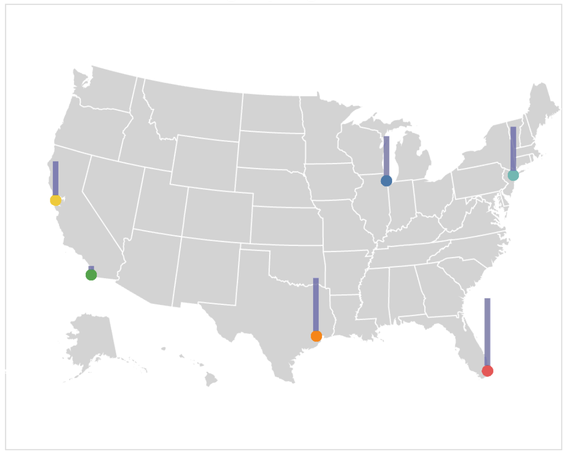


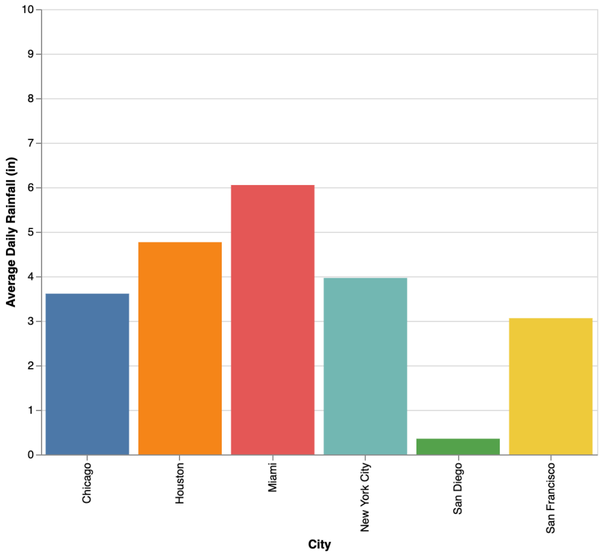
US Rainfall in Major Cities By Season

Average Winter Rainfall

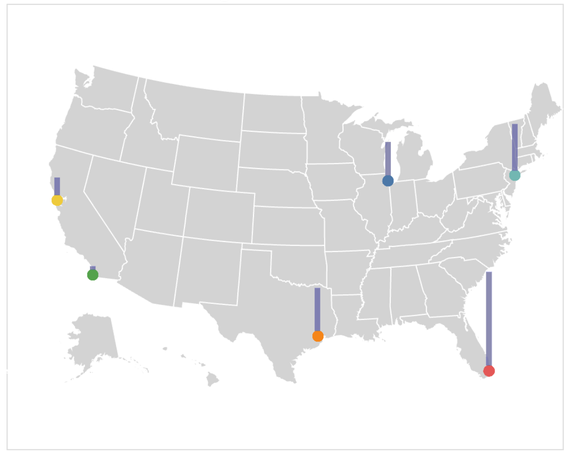


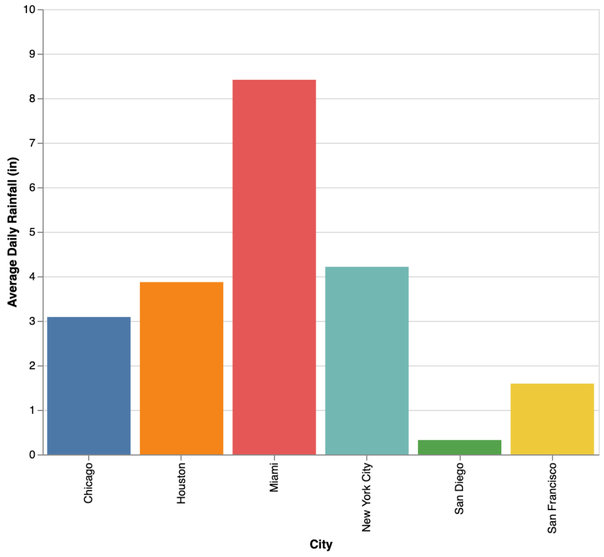
Average Spring Rainfall



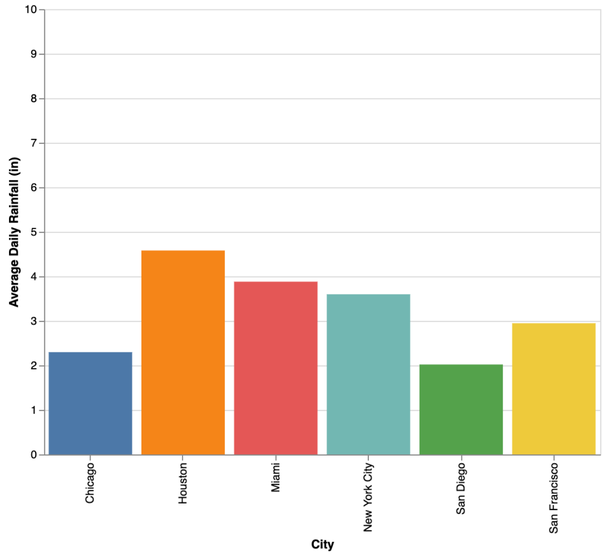


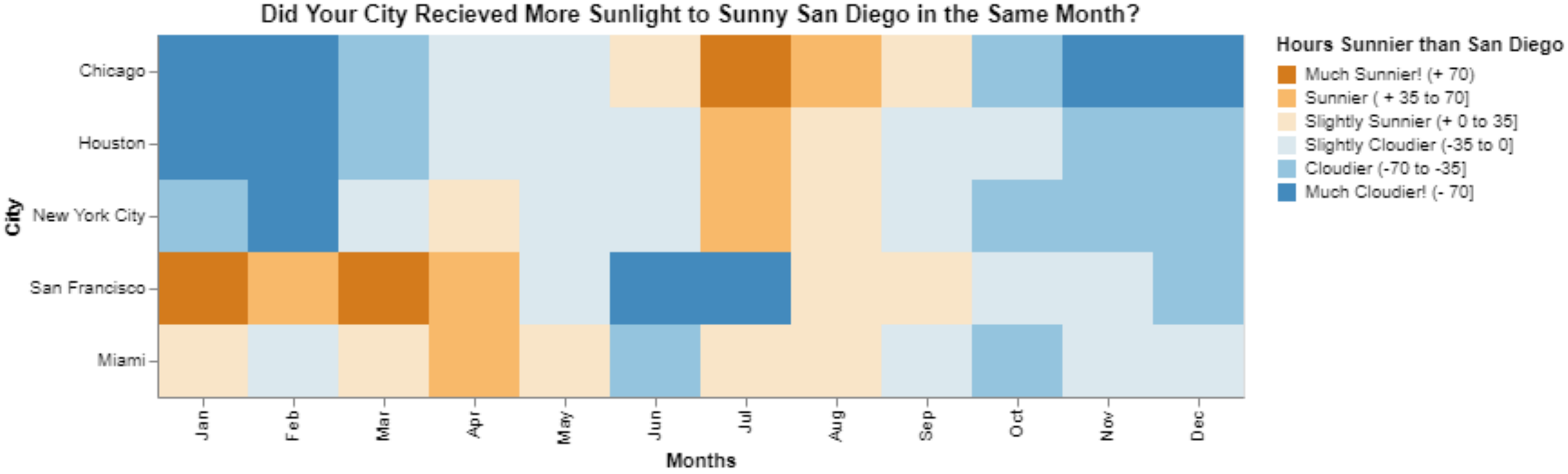
Average Summer Rainfall





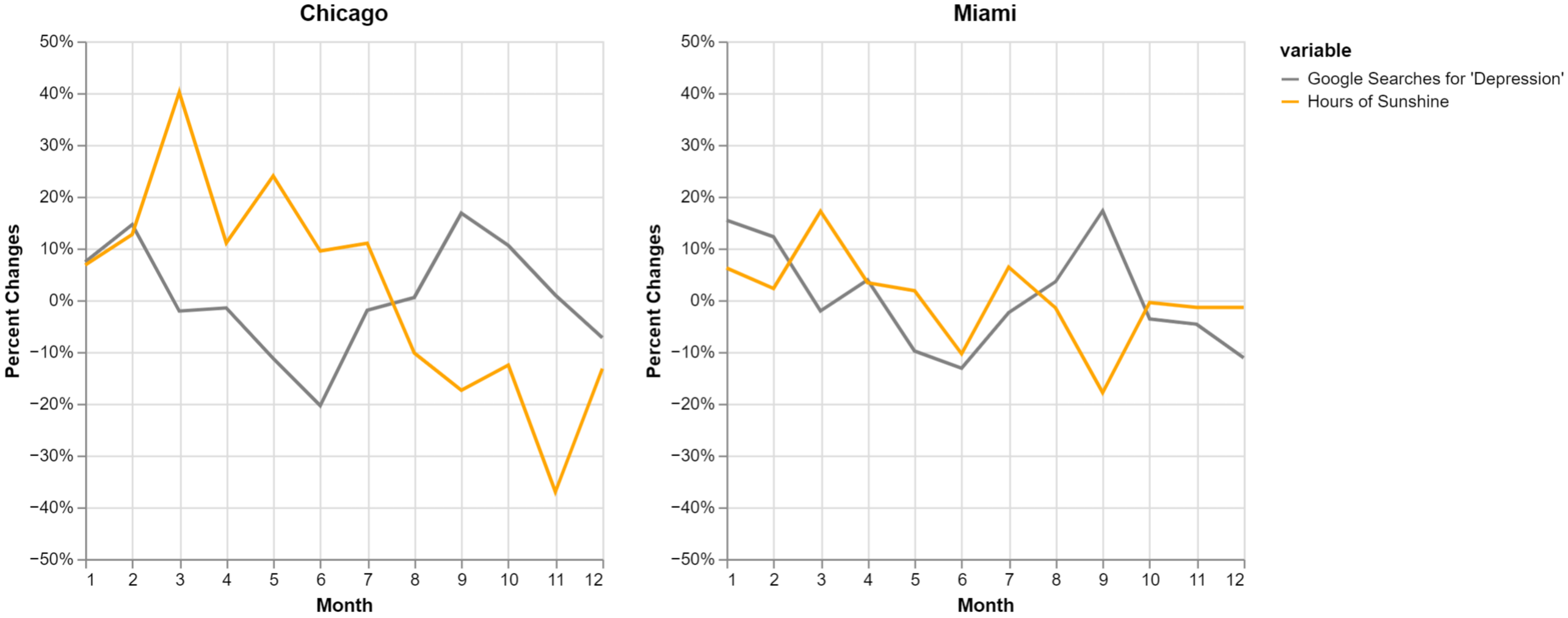
Average Fall Rainfall

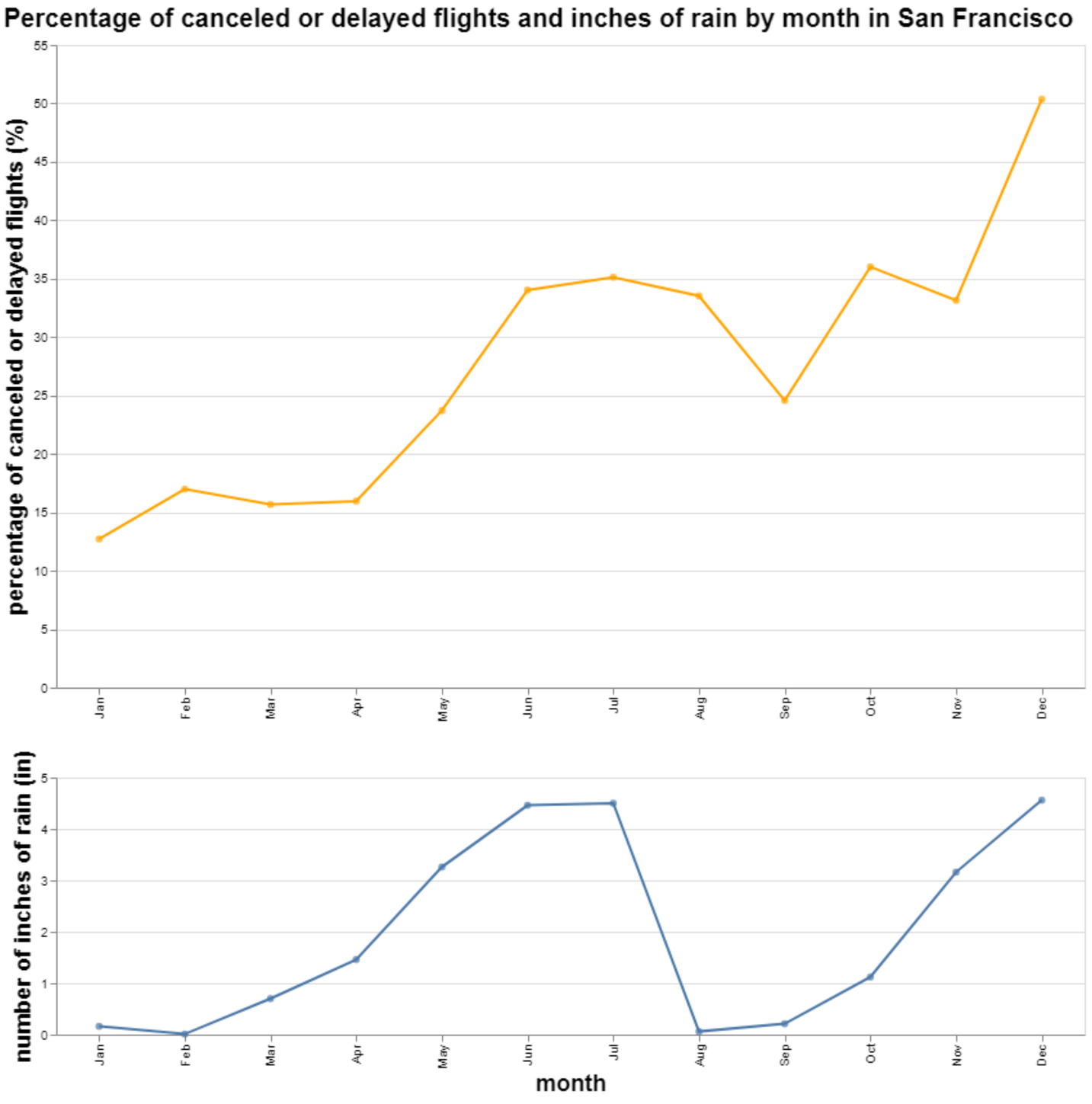


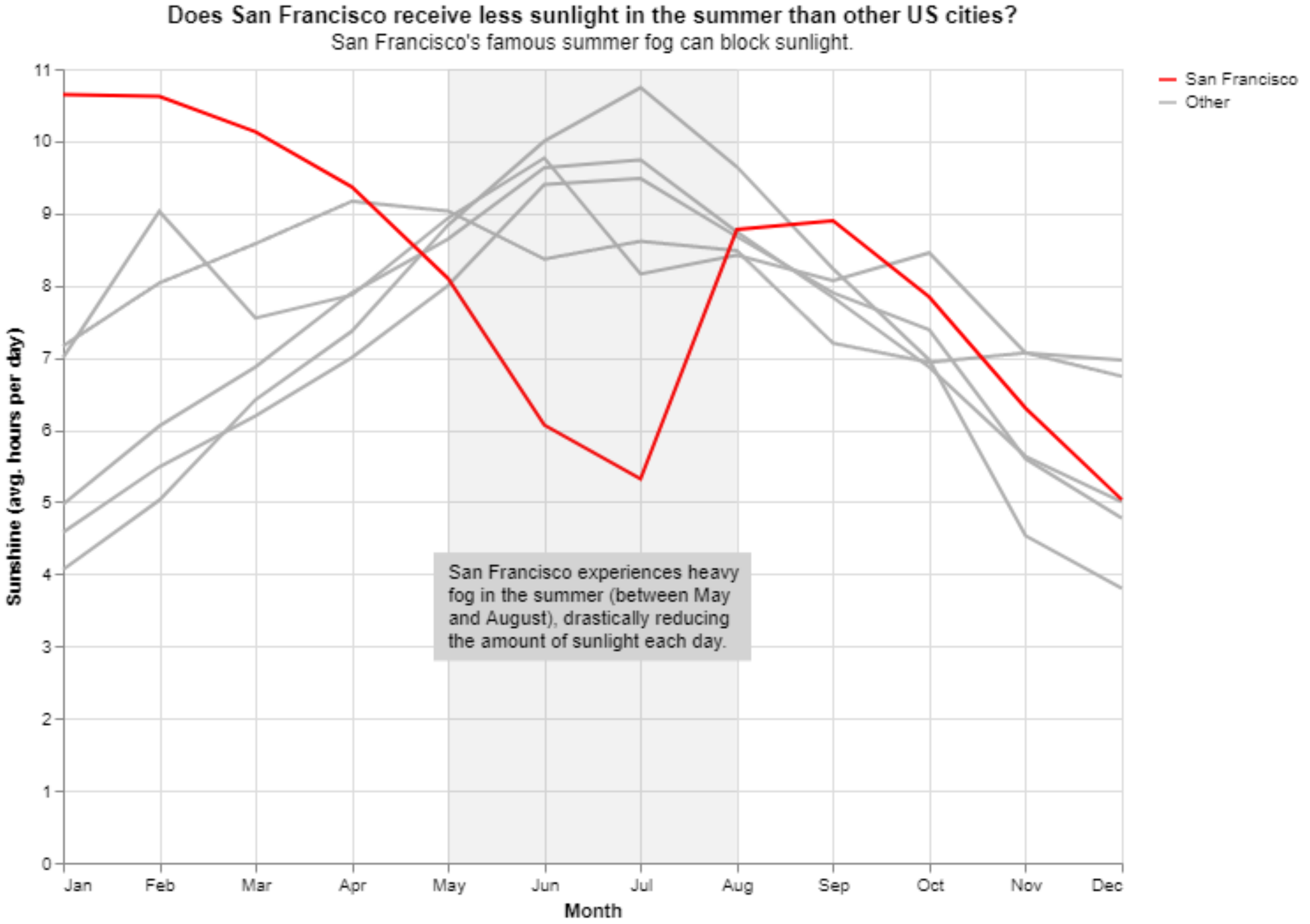

Did Your City Recieved More Sunlight to Sunny San Diego in the Same Month?
City
Chicago
Houston
New York City
San Francisco
Miami
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months
Hours Sunnier than San Diego
Much Sunnier! (+ 70)
Sunnier (+ 35 to 70]
Slightly Sunnier (+ 0 to 35]
Slightly Cloudier (-35 to 0]
Cloudier (-70 to -35]
Much Cloudier! (- 70]

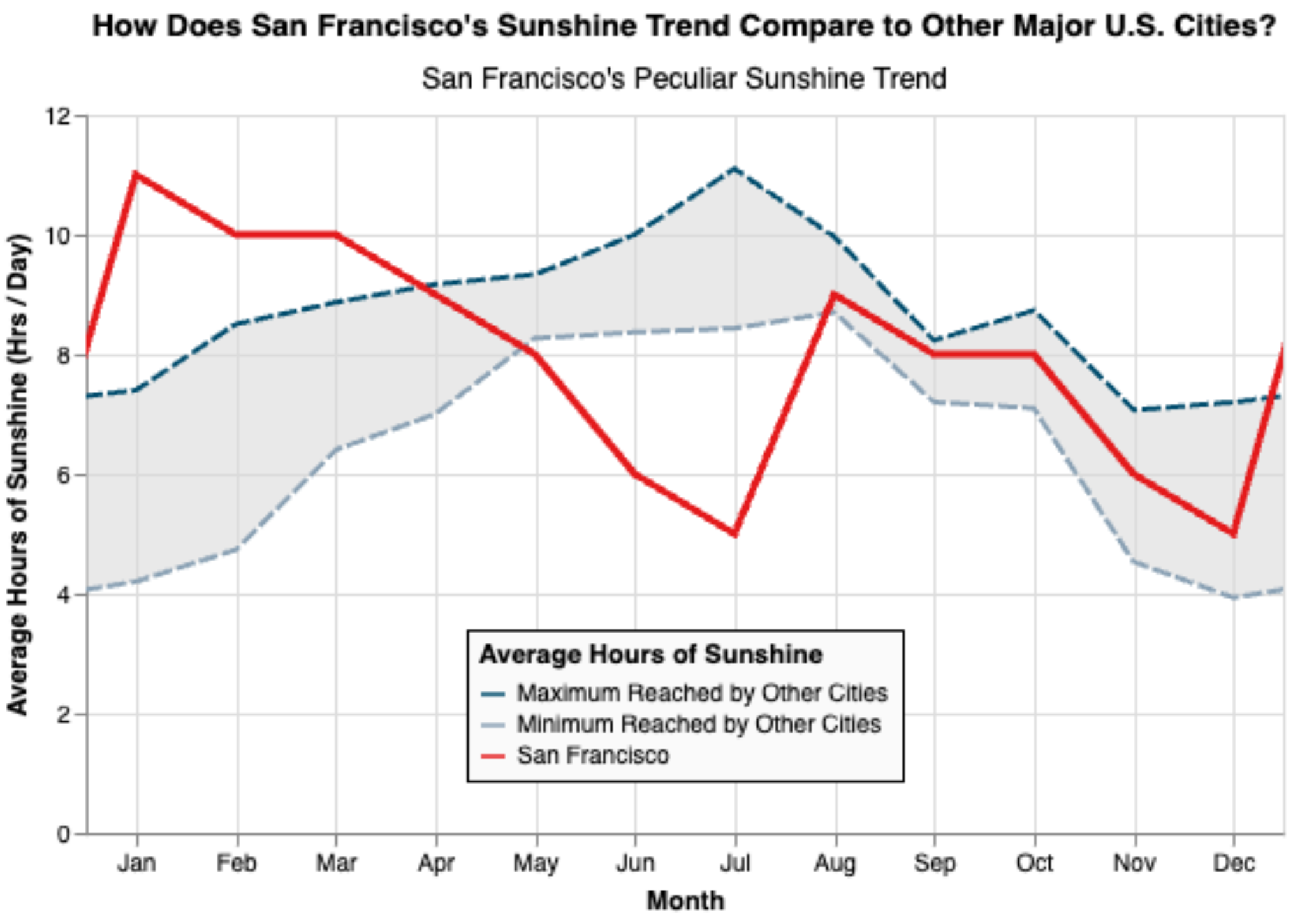
A Tale of Two Cities: How Dramatic are the Effects of Seasonal Depression?

Compared to a city like Miami, where sunshine hardly changes year round, Google searches for depression flucates much more in Chicago.



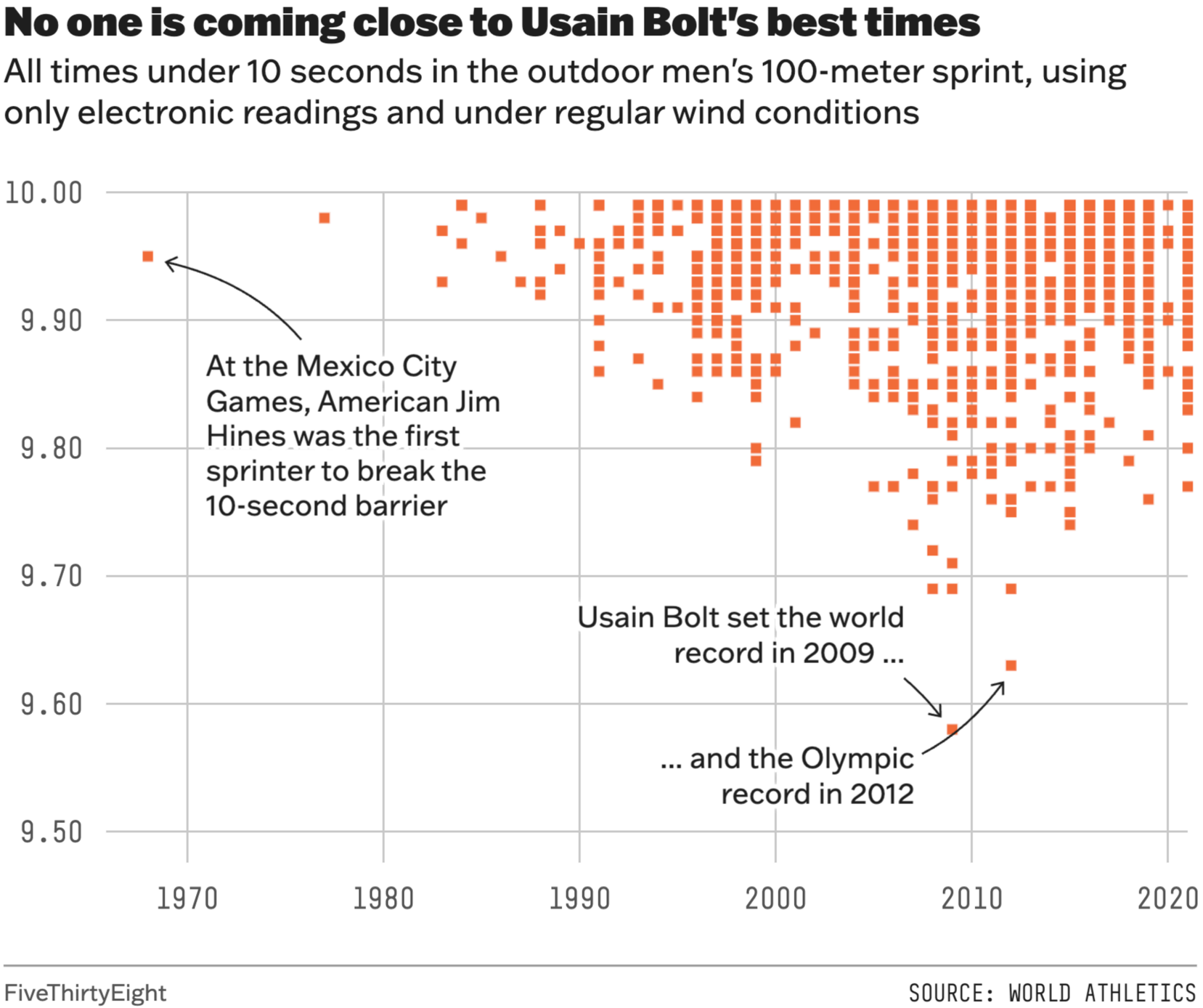

Percentage of canceled or delayed flights and inches of rain by month in San Francisco
percentage of canceled or delayed flights (%)
0
5
10
15
20
25
30
35
40
45
50
55
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
number of inches of rain (in)
0
1
2
3
4
5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month


Does San Francisco receive less sunlight in the summer than other US cities?
San Francisco's famous summer fog can block sunlight.
San Francisco
Other
Sunshine (avg. hours per day)
0
1
2
3
4
5
6
7
8
9
10
11
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
San Francisco experiences heavy fog in the summer (between May and August), drastically reducing the amount of sunlight each day.
Data from usclimatedata.com, obtained through dsc106.com


How Does San Francisco's Sunshine Trend Compare to Other Major U.S. Cities?
San Francisco's Peculiar Sunshine Trend
Average Hours of Sunshine (Hrs / Day)
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Average Hours of Sunshine
Maximum Reached by Other Cities
Minimum Reached by Other Cities
San Francisco

Interactivity

Exemplar: Usain Bolt

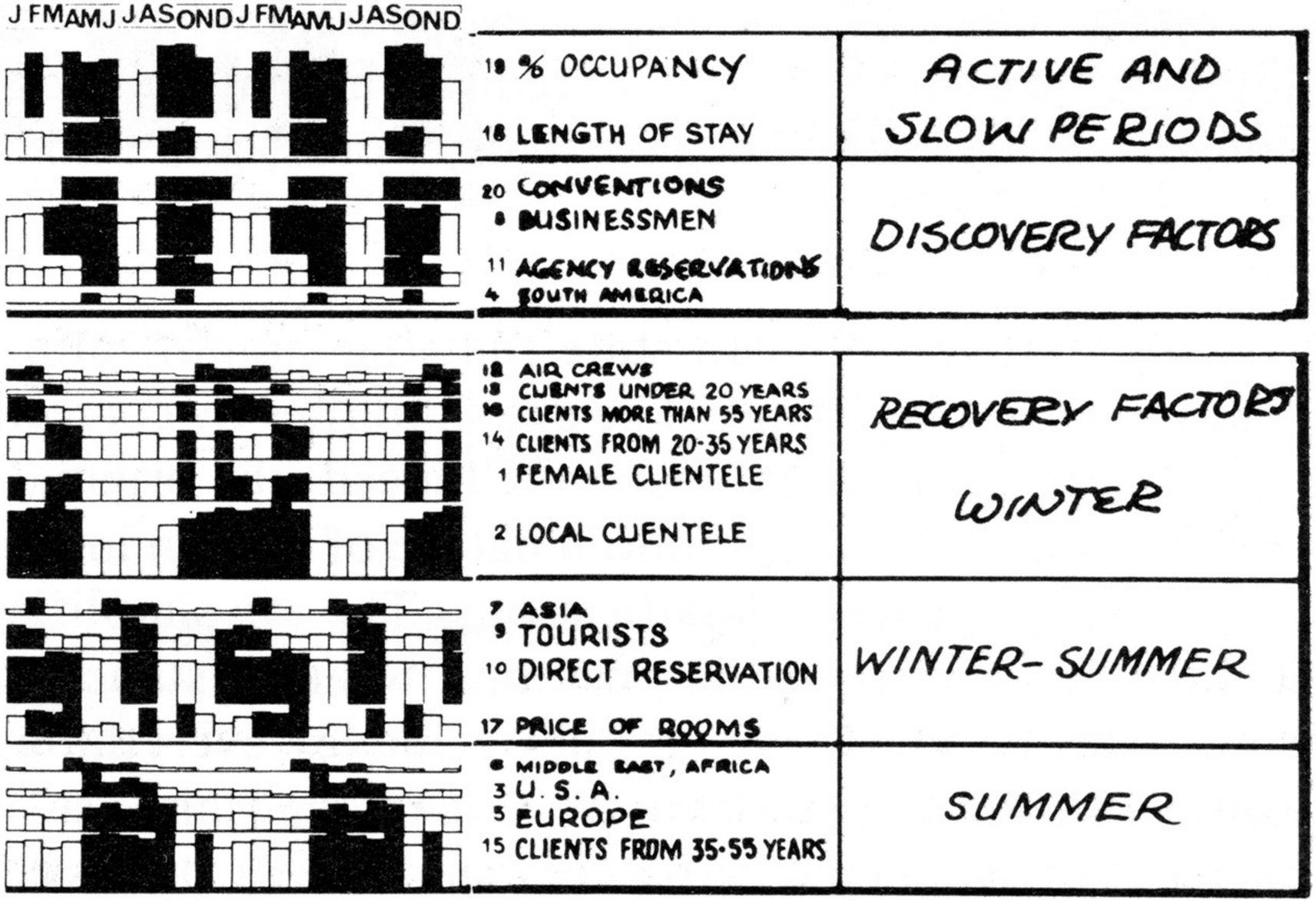


https://fivethirtyeight.com/features/the-fastest-men-in-the-world-are-still-chasing-usain-bolt/

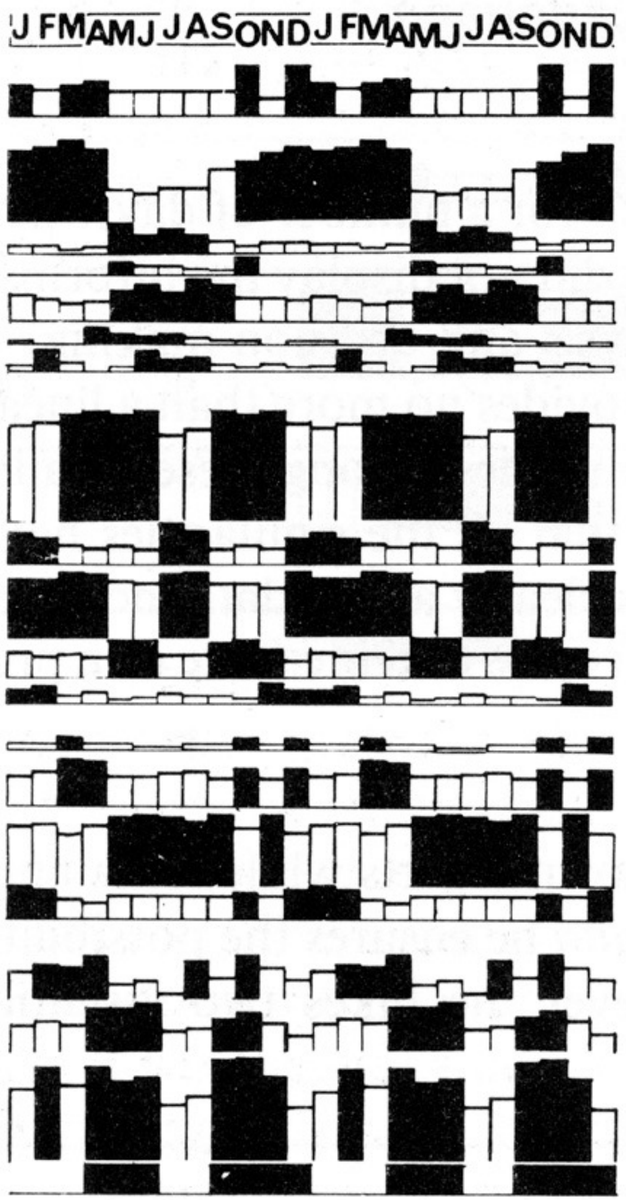
Example: Bertin's Hotel Data

J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —〃— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —〃— U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —〃— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —〃— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —〃— M.EAST, AFRICA
3	10	6	0	3	13	8	9	5	2	5	2	7	% —〃— ASIA
78	80	85	86	85	87	70	76	87	85	87	80	8	% BUSINESSMEN
22	20	15	14	15	13	30	24	13	15	13	20	9	% TOURISTS
70	70	75	74	69	68	74	75	68	68	64	75	10	% DIRECT RESERVATIONS
20	18	19	17	27	27	19	19	26	27	21	15	11	% AGENCY ——〃——
10	12	6	9	4	5	7	6	6	5	15	10	12	% AIR CREWS
2	2	4	2	2	1	1	2	2	4	2	5	13	% CLIENTS UNDER 20 YEARS
25	27	37	35	25	25	27	28	24	30	24	30	14	% —〃— 20-35 —〃—
48	49	42	48	54	55	53	51	55	46	55	43	15	% —〃— 35-55 —〃—
25	22	17	15	19	19	19	19	19	20	19	22	16	% —〃— MORE THAN 55 —〃—
163	167	166	174	152	155	145	170	157	174	165	156	17	PRICE OF ROOMS
1.65	1.71	1.65	1.91	1.90	2.	1.54	1.60	1.73	1.82	1.66	1.44	18	LENGTH OF STAY
67	82	70	83	74	77	56	62	90	92	78	55	19	% OCCUPANCY
			X	X	X			X	X	X	X	20	CONVENTIONS

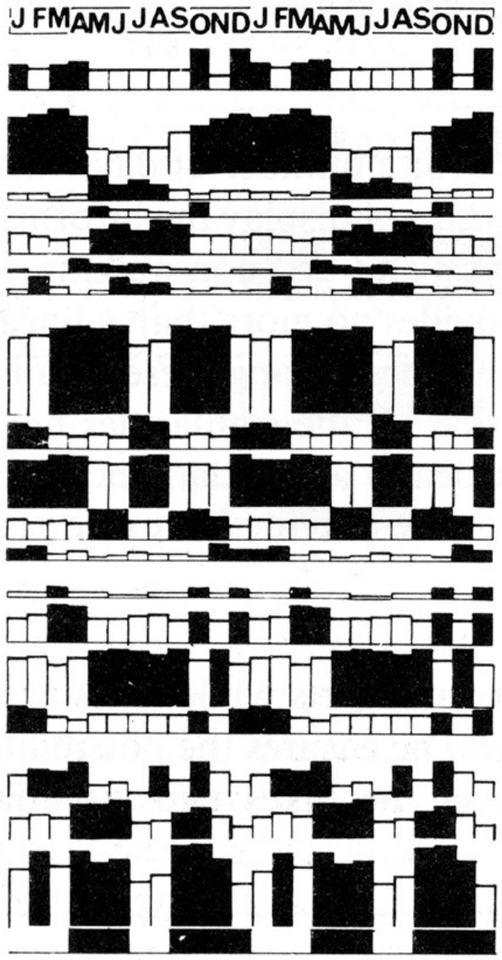
[Graphics and Graphic Information Processing, Bertin 81]


J FMAMJ JASONDJ FMAMJ JASOND
18 % OCCUPANCY
18 LENGTH OF STAY
ACTIVE AND SLOW PERIODS
20 CONVENTIONS
8 BUSINESSMEN
11 AGENCY RESERVATIONS
4 SOUTH AMERICA
DISCOVERY FACTORS
12 AIR CREWS
13 CLIENTS UNDER 20 YEARS
16 CLIENTS MORE THAN 55 YEARS
14 CLIENTS FROM 20-35 YEARS
1 FEMALE CLIENTELE
2 LOCAL CLIENTELE
RECOVERY FACTORS WINTER
7 ASIA
9 TOURISTS
10 DIRECT RESERVATION
17 PRICE OF ROOMS
WINTER-SUMMER
6 MIDDLE EAST, AFRICA
3 U.S.A.
5 EUROPE
15 CLIENTS FROM 35-55 YEARS
SUMMER

J	F	M	A	M	J	J	A	S	O	N	D		
26	21	26	28	20	20	20	20	20	40	15	40	1	% CLIENTELE FEMALE
69	70	77	71	37	36	39	39	55	60	68	72	2	% —〃— LOCAL
7	6	3	6	23	14	19	14	9	6	8	8	3	% —〃— U.S.A.
0	0	0	0	8	6	6	4	2	12	0	0	4	% —〃— SOUTH AMERICA
20	15	14	15	23	27	22	30	27	19	19	17	5	% —〃— EUROPE
1	0	0	8	6	4	6	4	2	1	0	1	6	% —〃— M.EAST, AFRICA
3	10	6	0	3	13	8	9	5	2	5	2	7	% —〃— ASIA
78	80	85	86	85	87	70	76	87	85	87	80	8	% BUSINESSMEN
22	20	15	14	15	13	30	24	13	15	13	20	9	% TOURISTS
70	70	75	74	69	68	74	75	68	68	64	75	10	% DIRECT RESERVATIONS
20	18	19	17	27	27	19	19	26	27	21	15	11	% AGENCY ———〃———
10	12	6	9	4	5	7	6	6	5	15	10	12	% AIR CREWS
2	2	4	2	2	1	1	2	2	4	2	5	13	% CLIENTS UNDER 20 YEARS
25	27	37	35	25	25	27	28	24	30	24	30	14	% —〃— 20-35 —〃—
48	49	42	48	54	55	53	51	55	46	55	43	15	% —〃— 35-55 —〃—
25	22	17	15	19	19	19	19	19	20	19	22	16	% —〃— MORE THAN 55 —〃—
163	167	166	174	152	155	145	170	157	174	165	156	17	PRICE OF ROOMS
1.65	1.71	1.65	1.91	1.90	2.	1.54	1.60	1.73	1.82	1.66	1.44	18	LENGTH OF STAY
67	82	70	83	74	77	56	62	90	92	78	55	19	% OCCUPANCY
			X	X	X			X	X	X	X	20	CONVENTIONS



1	% CLIENTELE FEMALE
2	% —〃— LOCAL
3	% —〃— U.S.A.
4	% —〃— SOUTH AMERICA
5	% —〃— EUROPE
6	% —〃— M.EAST, AFRICA
7	% —〃— ASIA
8	% BUSINESSMEN
9	% TOURISTS
10	% DIRECT RESERVATIONS
11	% AGENCY ———〃———
12	% AIR CREWS
13	% CLIENTS UNDER 20 YEARS
14	% —〃— 20-35 —〃—
15	% —〃— 35-55 —〃—
16	% —〃— MORE THAN 55 —〃—
17	PRICE OF ROOMS
18	LENGTH OF STAY
19	% OCCUPANCY
20	CONVENTIONS



1	% CLIENTELE FEMALE
2	% —//— LOCAL
3	% —//— U.S.A.
4	% —//— SOUTH AMERICA
5	% —//— EUROPE
6	% —//— M.EAST, AFRICA
7	% —//— ASIA
8	% BUSINESSMEN
9	% TOURISTS
10	% DIRECT RESERVATIONS
11	% AGENCY ———//———
12	% AIR CREWS
13	% CLIENTS UNDER 20 YEARS
14	% —//— 20-35 —//—
15	% —//— 35-55 —//—
16	% —//— MORE THAN 55 —//—
17	PRICE OF ROOMS
18	LENGTH OF STAY
19	% OCCUPANCY
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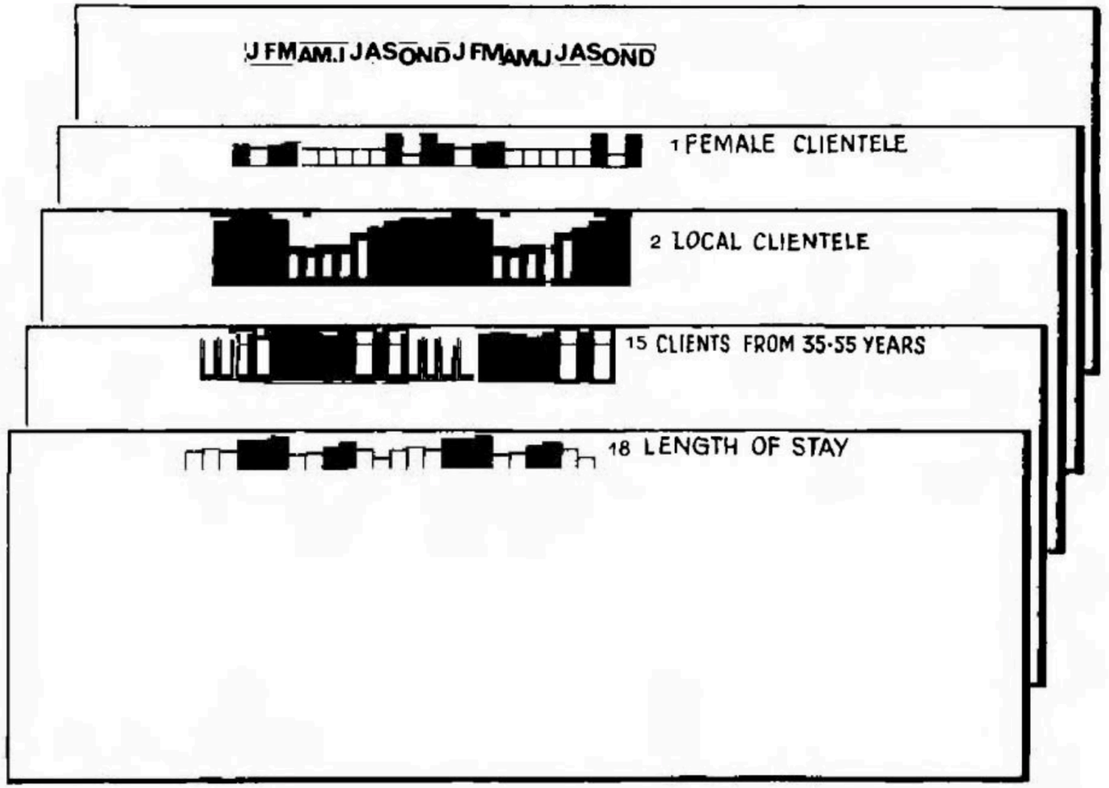
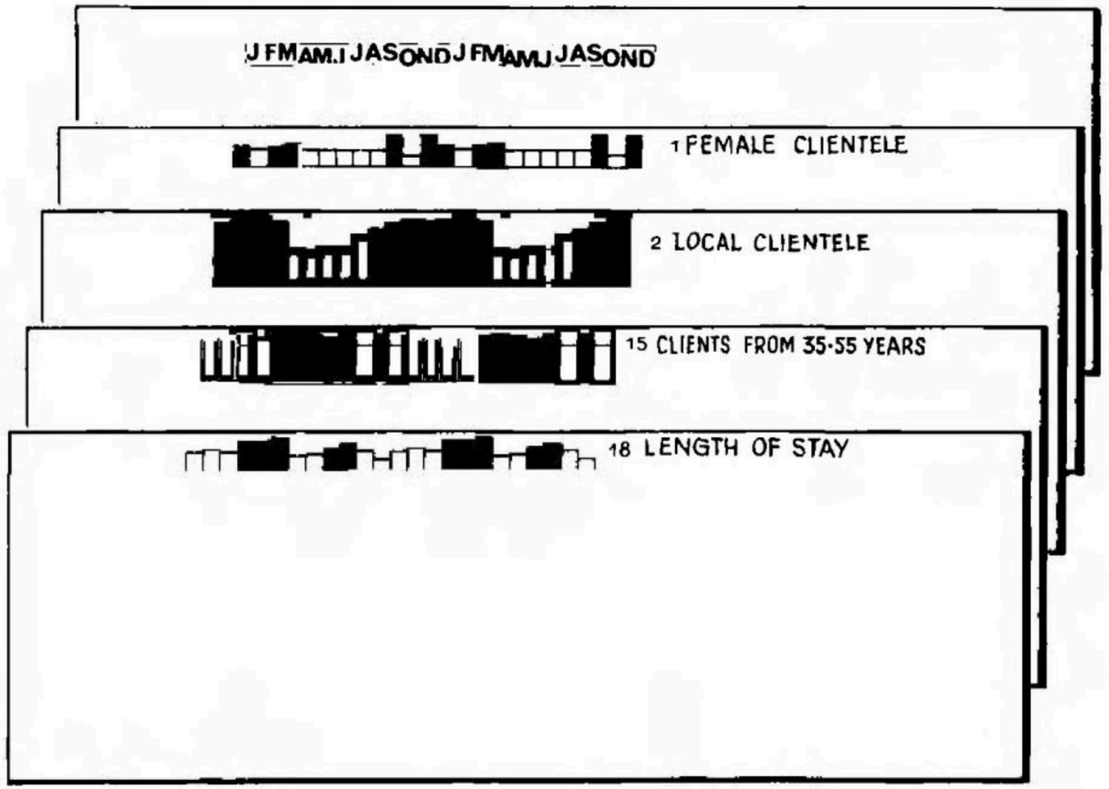
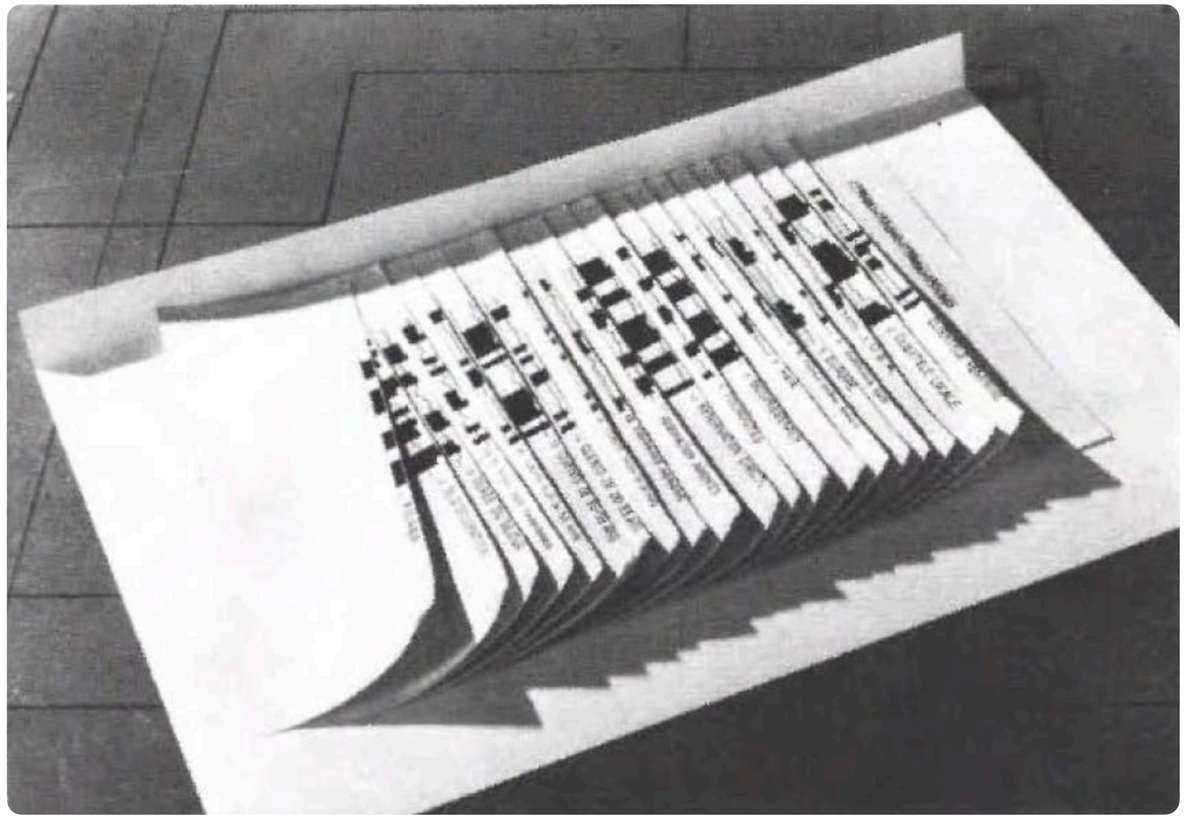
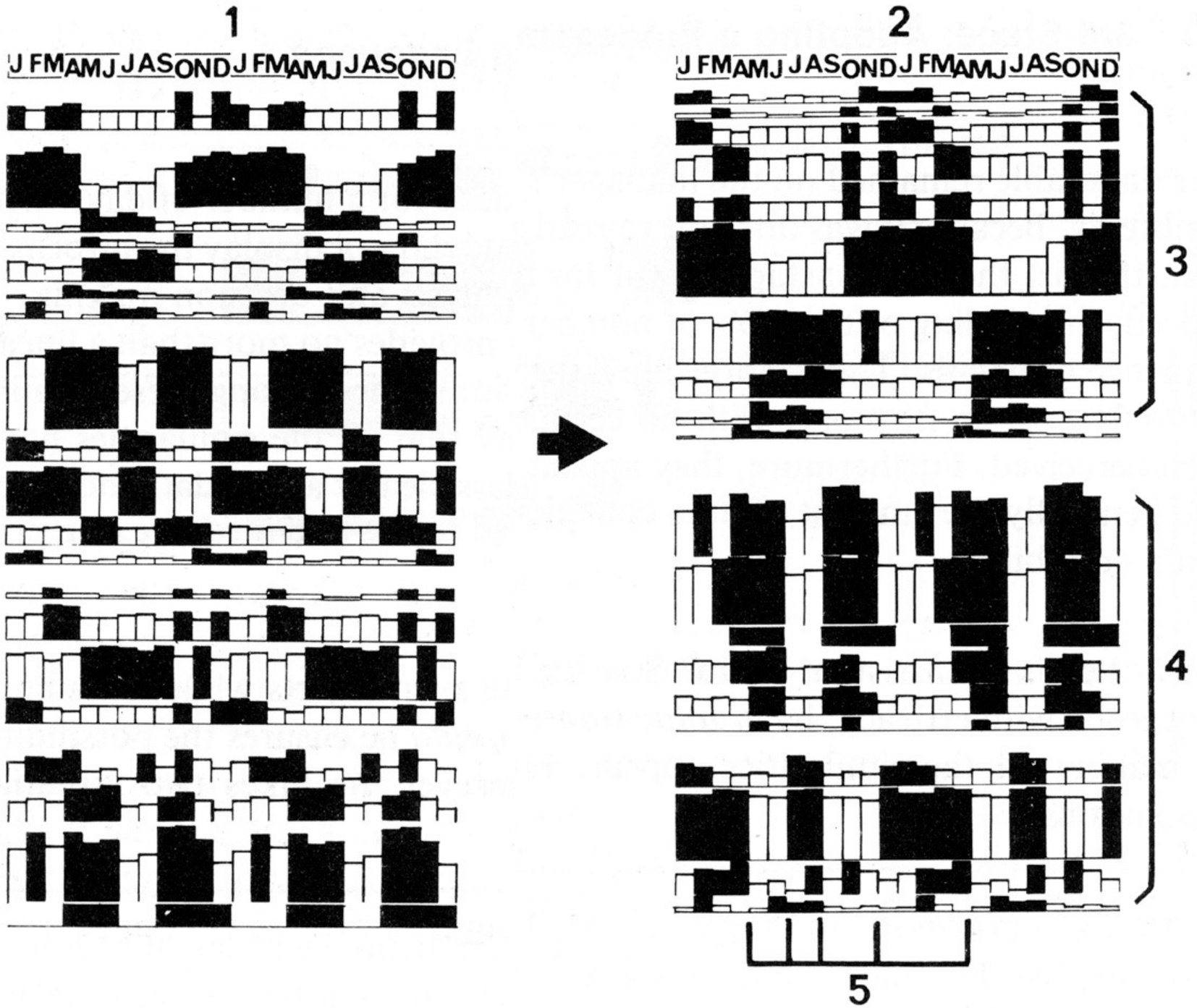
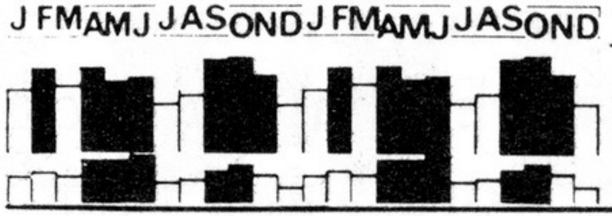



J FMAMJJASONDJ FMAMJJASOND
1 FEMALE CLIENTELE
2 LOCAL CLIENTELE
15 CLIENTS FROM 35-55 YEARS
18 LENGTH OF STAY



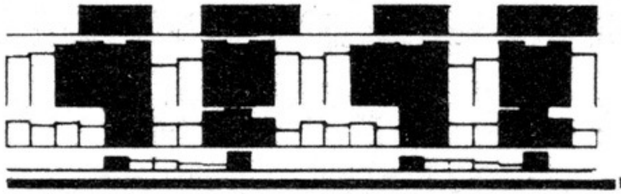

1
J FMAMJ JASOND J FMAMJ JASOND
2
J FMAMJ JASOND J FMAMJ JASOND
3
4
5



19 % OCCUPANCY

18 LENGTH OF STAY

ACTIVE AND SLOW PERIODS



20 CONVENTIONS
8 BUSINESSMEN
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DISCOVERY FACTORS

18 AIR CREWS
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16 CLIENTS MORE THAN 55 YEARS
14 CLIENTS FROM 20-35 YEARS
1 FEMALE CLIENTELE
2 LOCAL CLIENTELE

RECOVERY FACTORS

WINTER

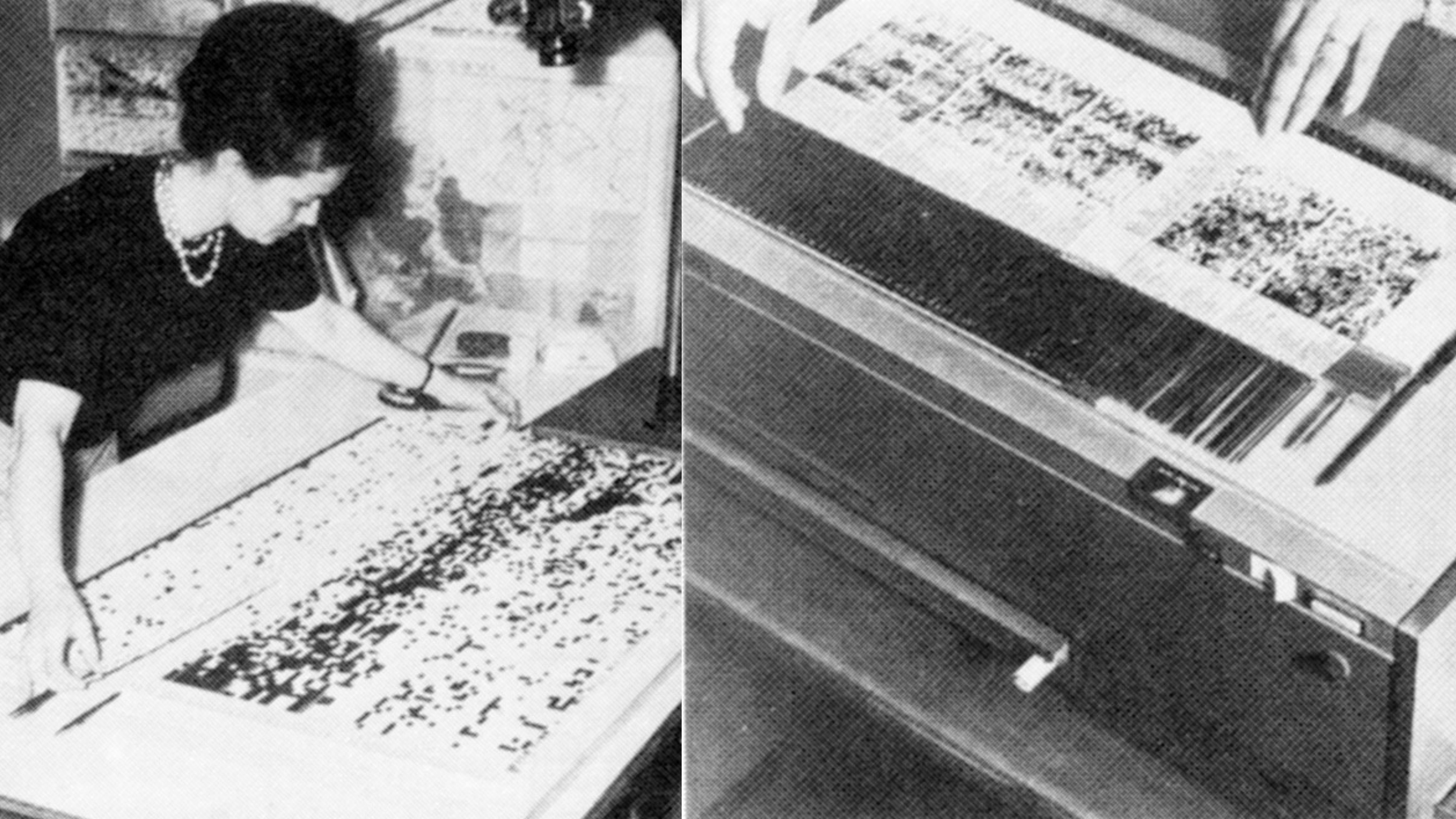
7 ASIA
9 TOURISTS
10 DIRECT RESERVATION
17 PRICE OF ROOMS

WINTER-SUMMER

6 MIDDLE EAST, AFRICA
3 U.S.A.
5 EUROPE
15 CLIENTS FROM 35-55 YEARS

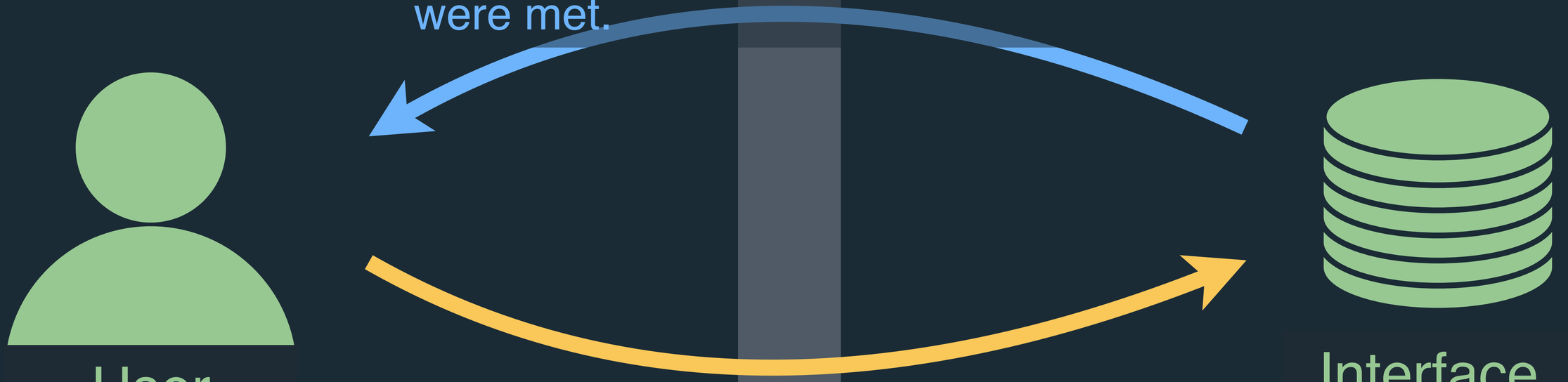
SUMMER

19 % OCCUPANCY 18 LENGTH OF STAY	ACTIVE AND SLOW PERIODS
20 CONVENTIONS 8 BUSINESSMEN 11 AGENCY RESERVATIONS 4 SOUTH AMERICA	DISCOVERY FACTORS
12 AIR CREWS 13 CLIENTS UNDER 20 YEARS 16 CLIENTS MORE THAN 55 YEARS 14 CLIENTS FROM 20-35 YEARS 1 FEMALE CLIENTELE 2 LOCAL CLIENTELE	RECOVERY FACTORS WINTER
7 ASIA 9 TOURISTS 10 DIRECT RESERVATION 17 PRICE OF ROOMS	WINTER-SUMMER
6 MIDDLE EAST, AFRICA 3 U.S.A. 5 EUROPE 15 CLIENTS FROM 35-55 YEARS	SUMMER



Gulf of Evaluation

The level of difficulty in interpreting the system and assessing if goals were met.



Gulf of Execution

The gap between the user's goals and their ability to achieve them using the system.

Hutchins, Edwin L., James D. Hollan, and Donald A. Norman. "Direct manipulation interfaces."1985.

Gulf of Evaluation

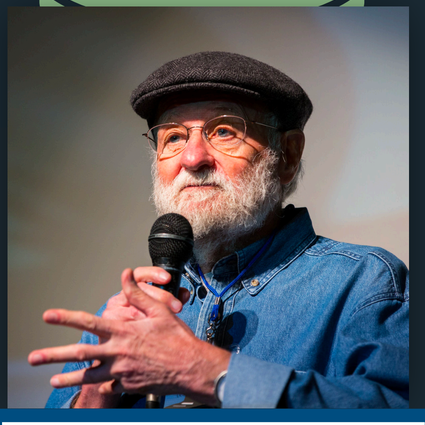
The level of difficulty in interpreting the system and assessing if goals were met.

Edwin Hutchins

Gu tion

The gap be r's goals and their abi e them using the sy tem.

Jim Hollan



Don Norman

Hutchins, Edwin L., James D. Hollan, and Donald A. Norman. "Direct manipulation interfaces."1985.

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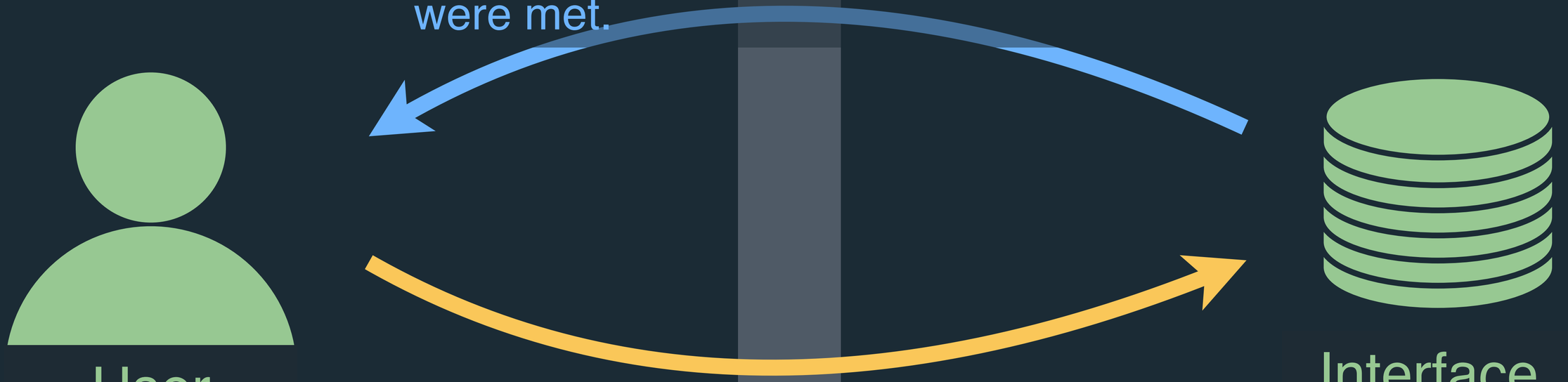

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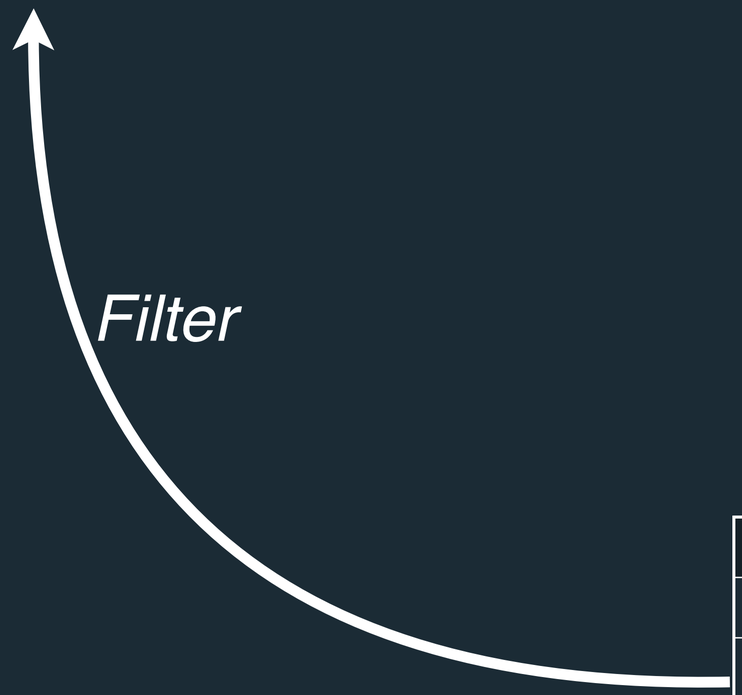
day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

```
pd.read_csv('stocks.csv')
```

day	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45

```
df[df['price'] > 900]
```



day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

```
pd.read_csv('stocks.csv')
```

day	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45

```
df[df['price'] > 900]
```

day	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45
10/3	MSFT	74.26
10/4	MSFT	74.69

```
df.sort_values('price',
    ascending=False)
```

Filter

Sort

day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

```
pd.read_csv('stocks.csv')
```

day	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45

```
df[df['price'] > 900]
```

Filter

day	symbol	price
10/3	AMZN	957.10
10/4	AMZN	965.45
10/3	MSFT	74.26
10/4	MSFT	74.69

```
df.sort_values('price',
ascending=False)
```

Sort

symbol	avg(price)
AMZN	961.275
MSFT	74.475

```
df.groupby('symbol')
.mean()
```

"Small Multiples" + Aggregation

day	stock	price
10/3	AMZN	957.10
10/3	MSFT	74.26
10/4	AMZN	965.45
10/4	MSFT	74.69

```
pd.read_csv('stocks.csv')
```

Gulf of Evaluation

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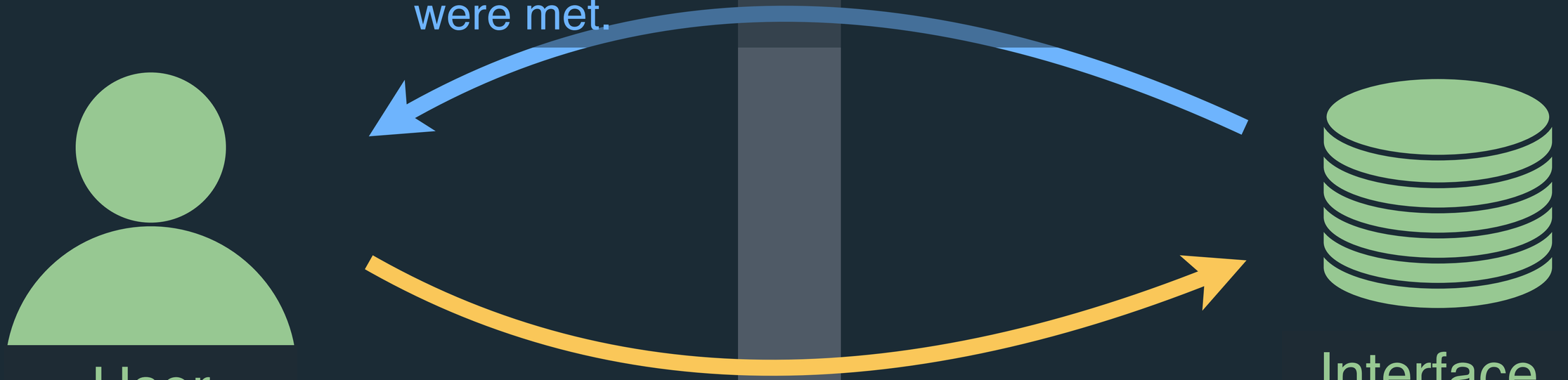

Gulf of Execution

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[Hutchins, Hollan, and Norman, 1985]

✘ Results returned as a table.

✘ No hint on how to reformulate query.

✘ Slow question-answer loop.

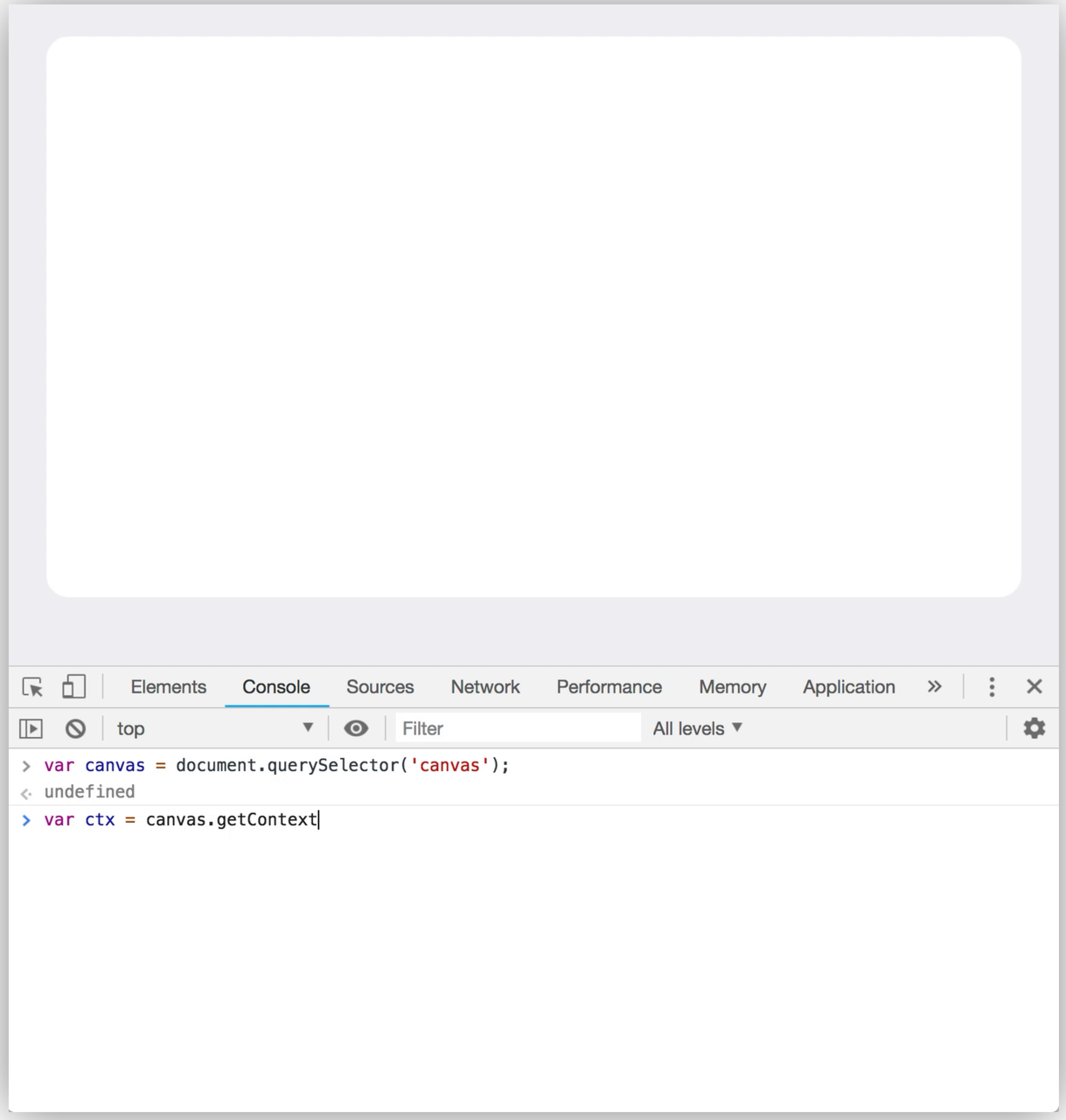
Gulf of Evaluation

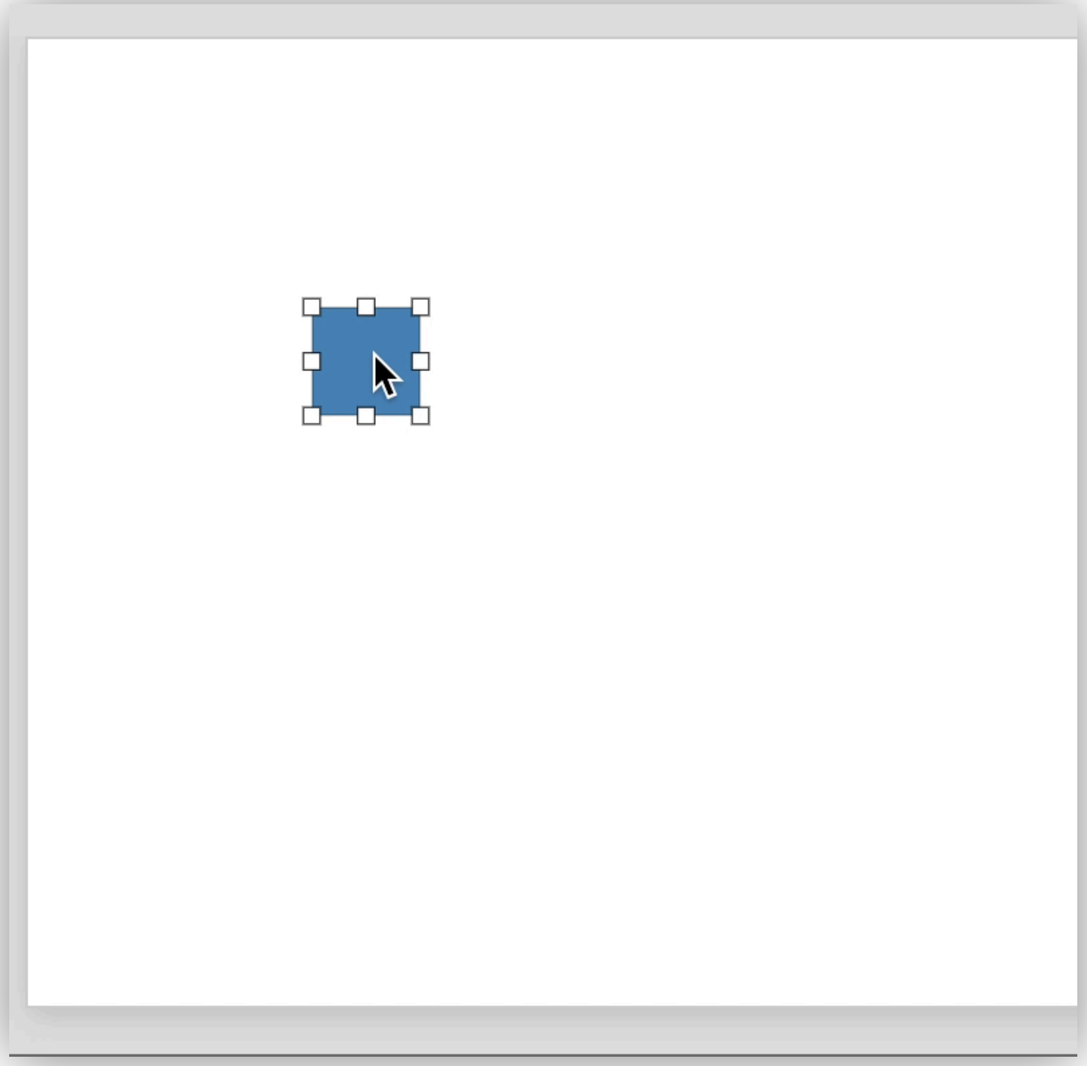
Gulf of Execution

✘ A rigid syntax designed by/for programmers.

✘ Difficult to do "fuzzy" matching.

[Hutchins, Hollan, and Norman, 1985]


Elements
Console
Sources
Network
Performance
Memory
Application
top
Filter
All levels
> var canvas = document.querySelector('canvas');
undefined
> var ctx = canvas.getContext



✓ Visual representation of objects + actions.

✓ Immediate + continuous display of results.

Gulf of Evaluation

Gulf of Execution

✓ Physical actions or labeled buttons instead of complex syntax.

✓ Rapid, incremental, and reversible actions.

Hutchins, Edwin L., James D. Hollan, and Donald A. Norman. "Direct manipulation interfaces."1985.

Interaction in Visualization

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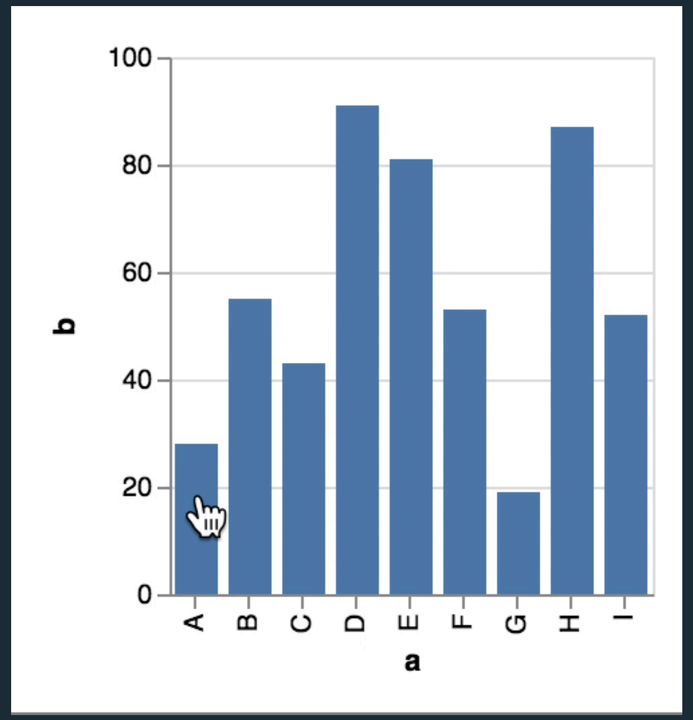
Point Selection

Select discrete data values.

Point Selection

Select discrete data values.

How many points are selected? 1, 2, 3, ...

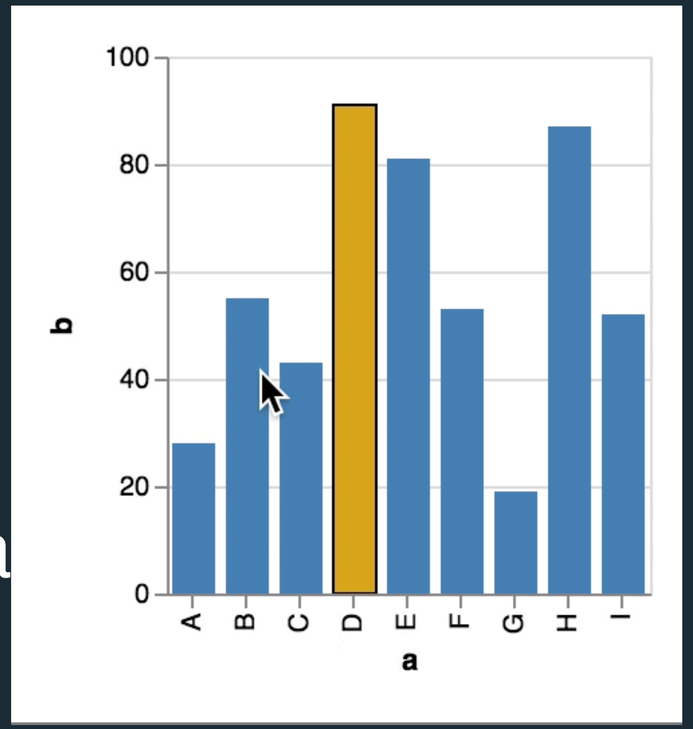


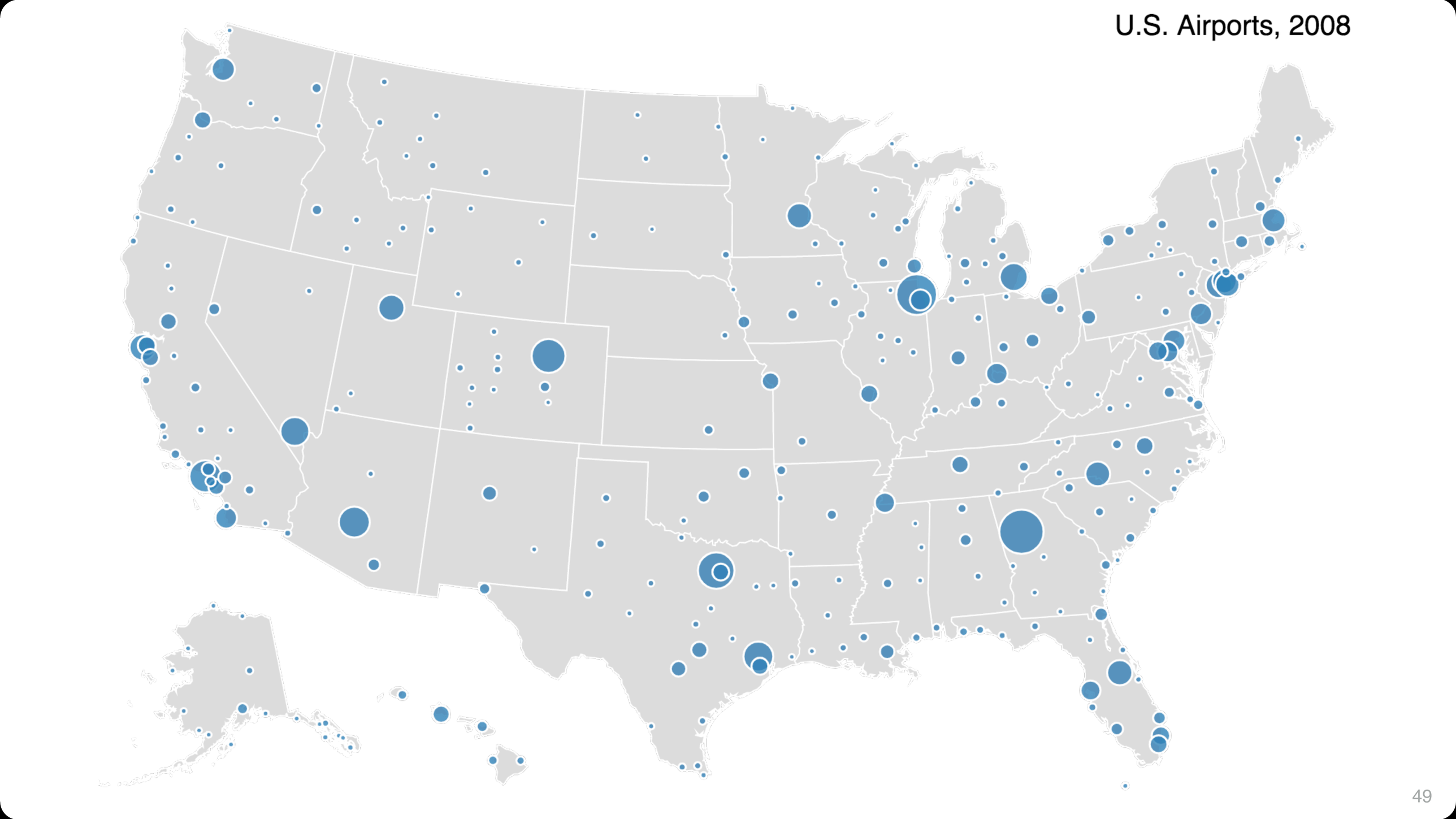
Point Selection

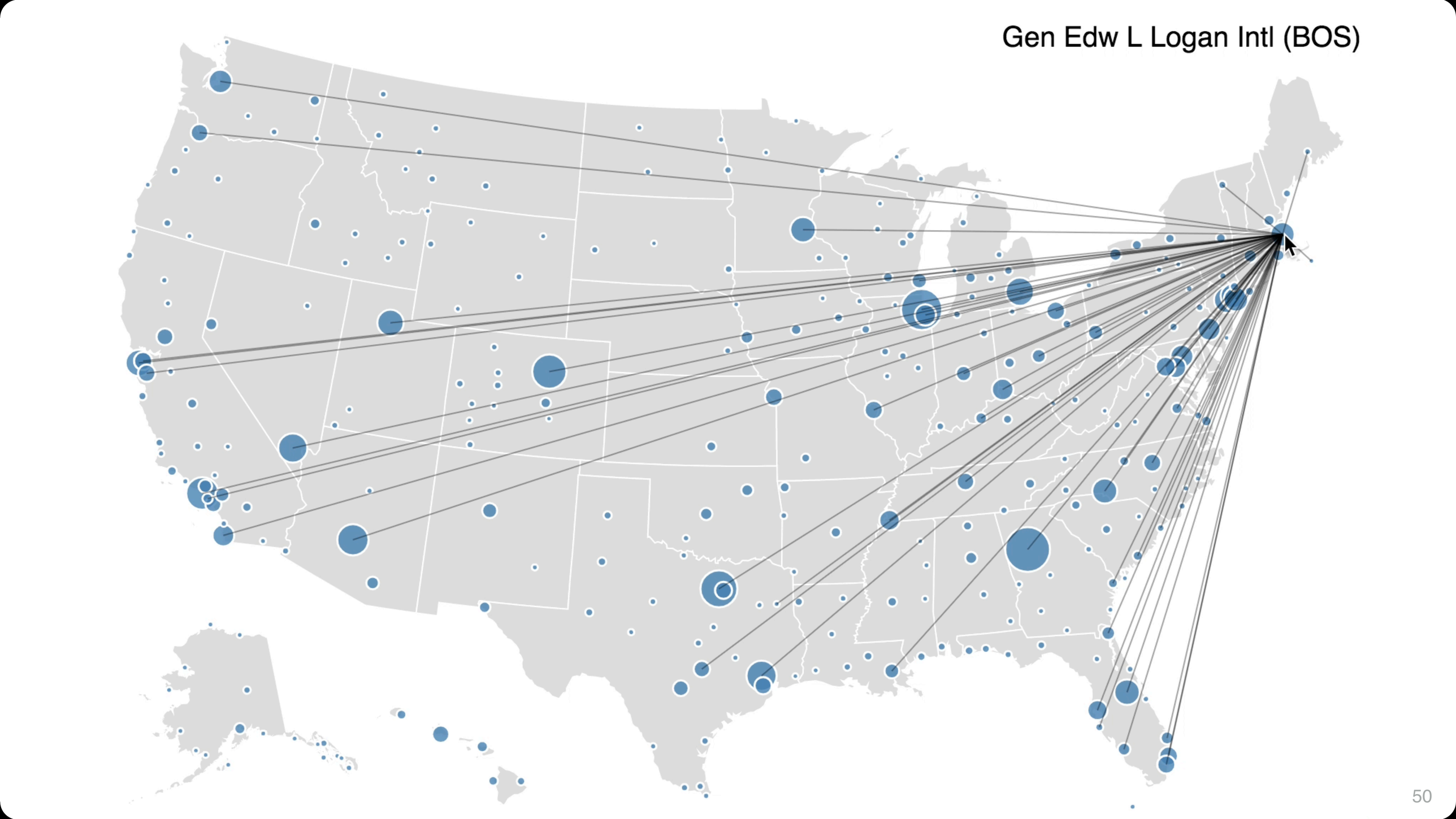
Select discrete data values.

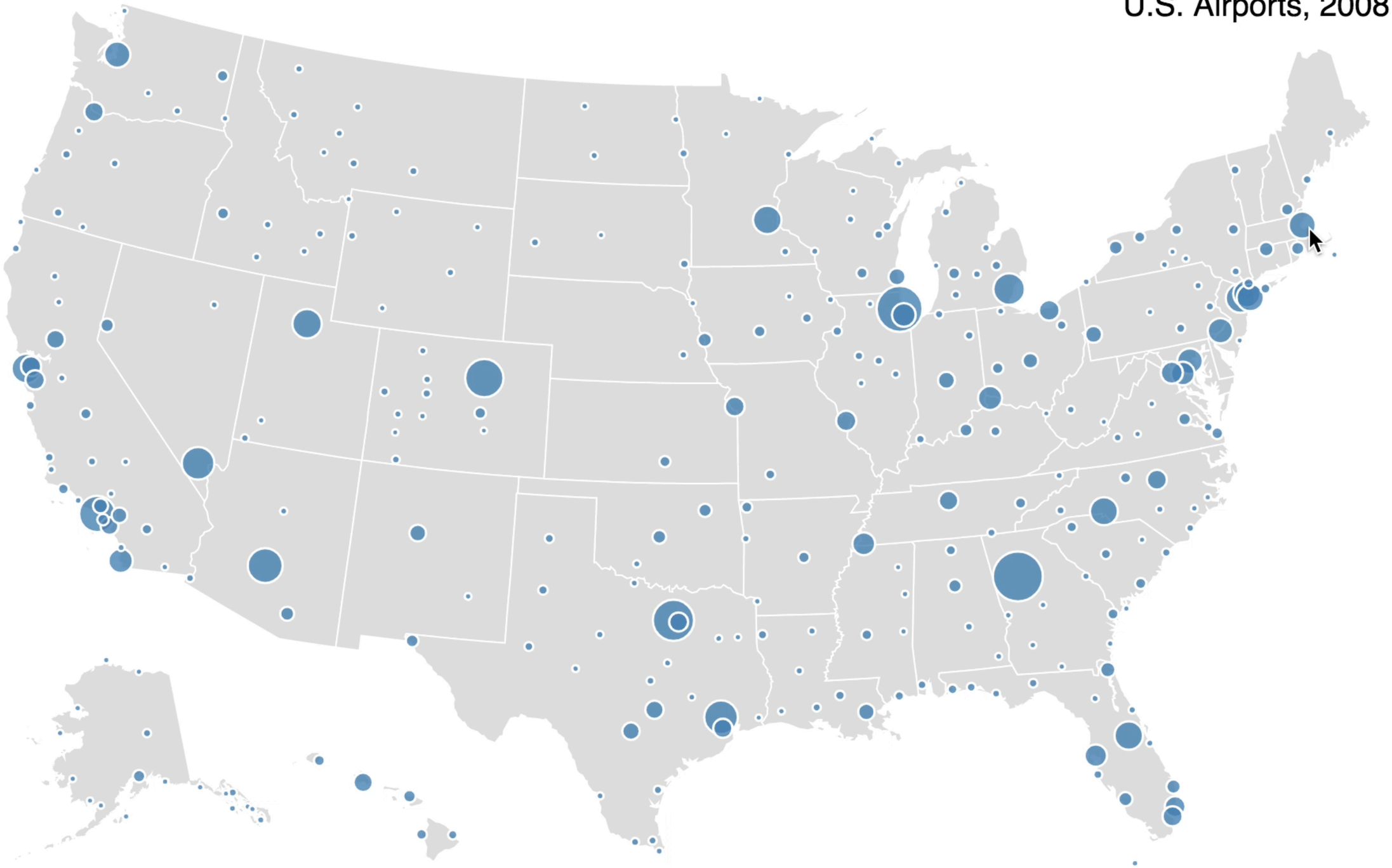
How many points are selected? 1, 2, 3, ...

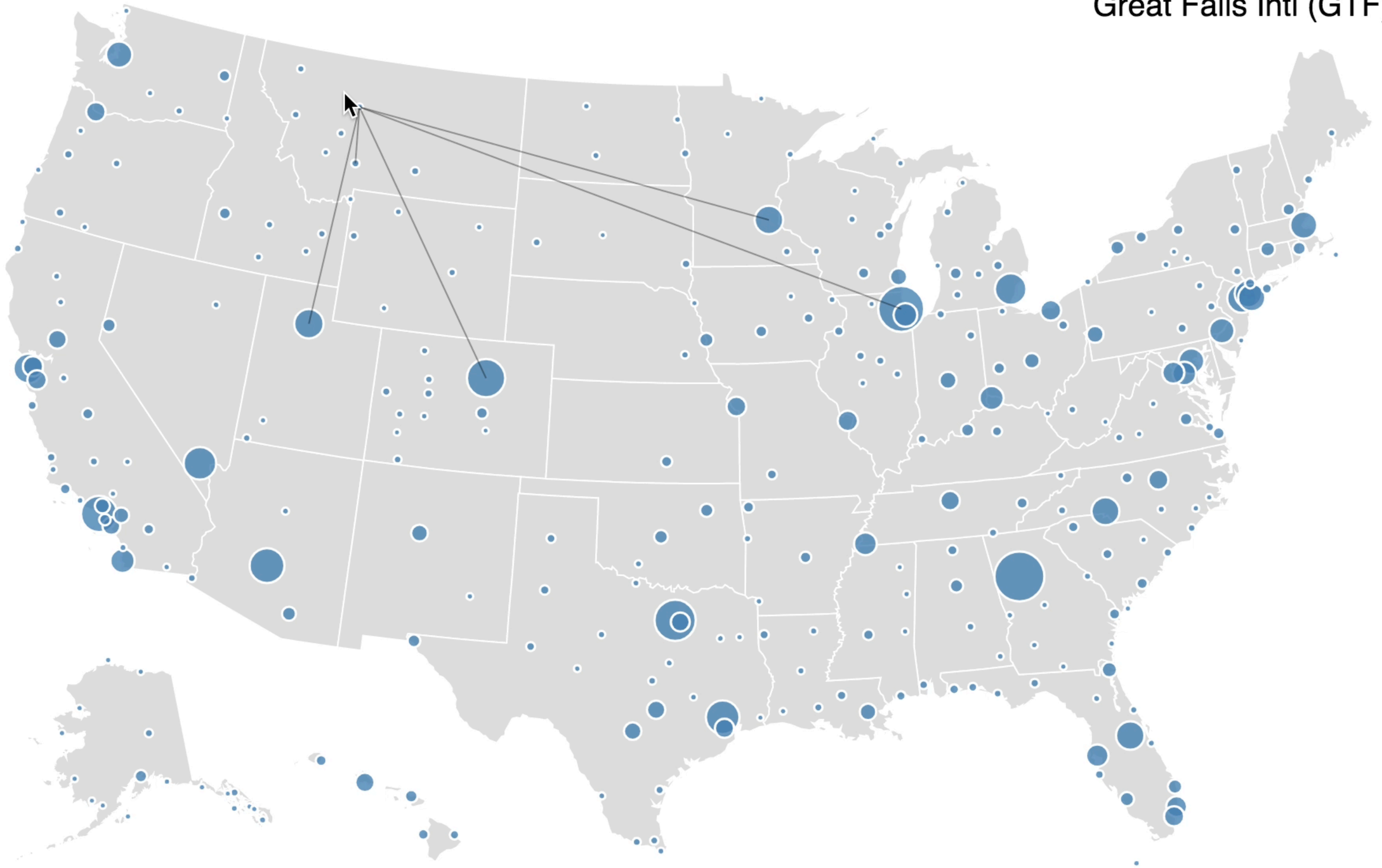
How are points selected? Mouse hover, click, ta




U.S. Airports, 2008


Gen Edw L Logan Intl (BOS)

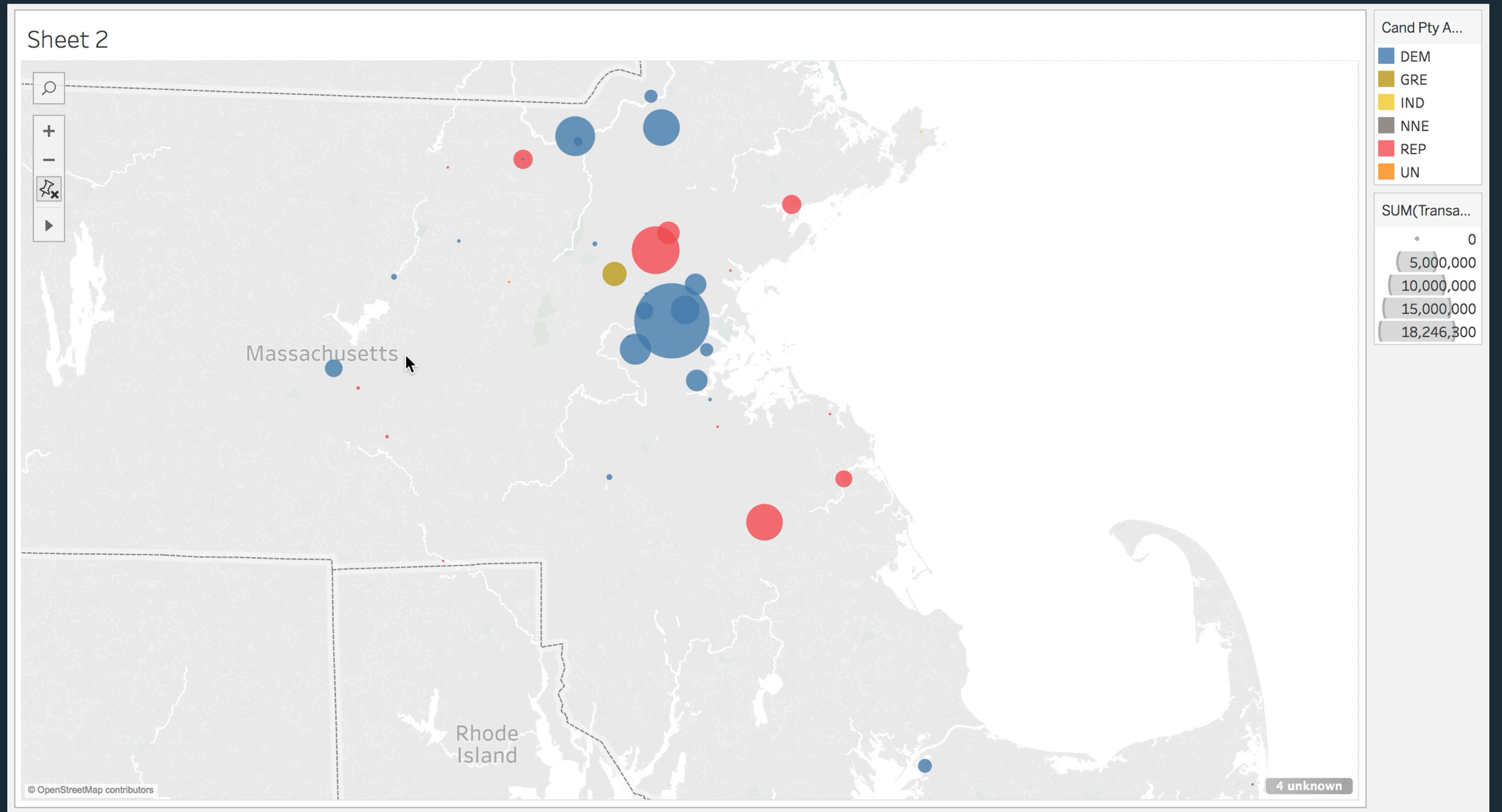

U.S. Airports, 2008


Great Falls Intl (GTF)

Region Selection

Extensional Selections: enumerate all points

Intentional Selections: describes common properties



Generalized Selection via Interactive Query Relaxation

Jeffrey Heer | Maneesh Agrawala | Wesley Willett
University of California, Berkeley

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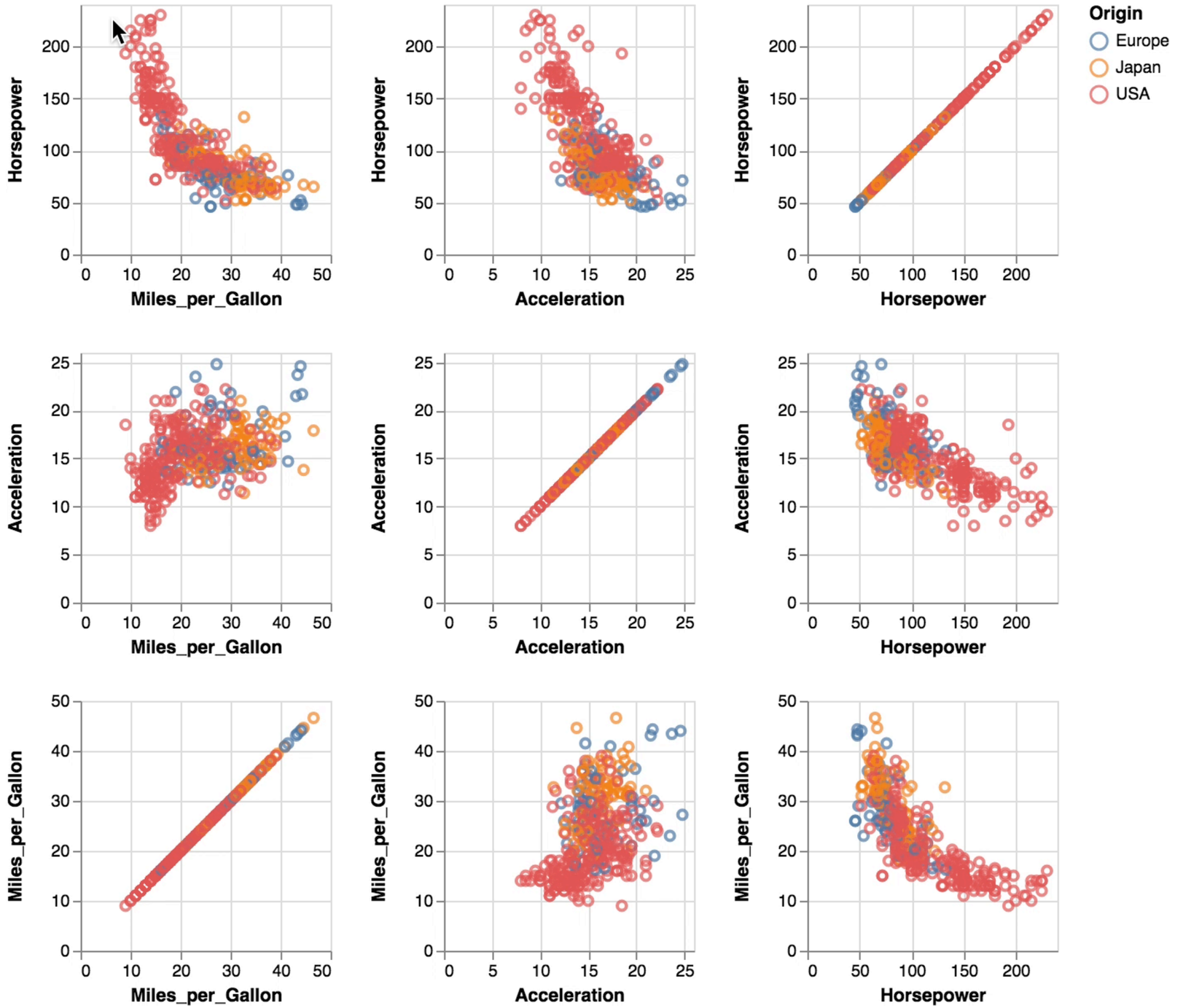
Connect

Brushing & linking: selection is called a "brush", and the selected data is shown ("linked") in other views.

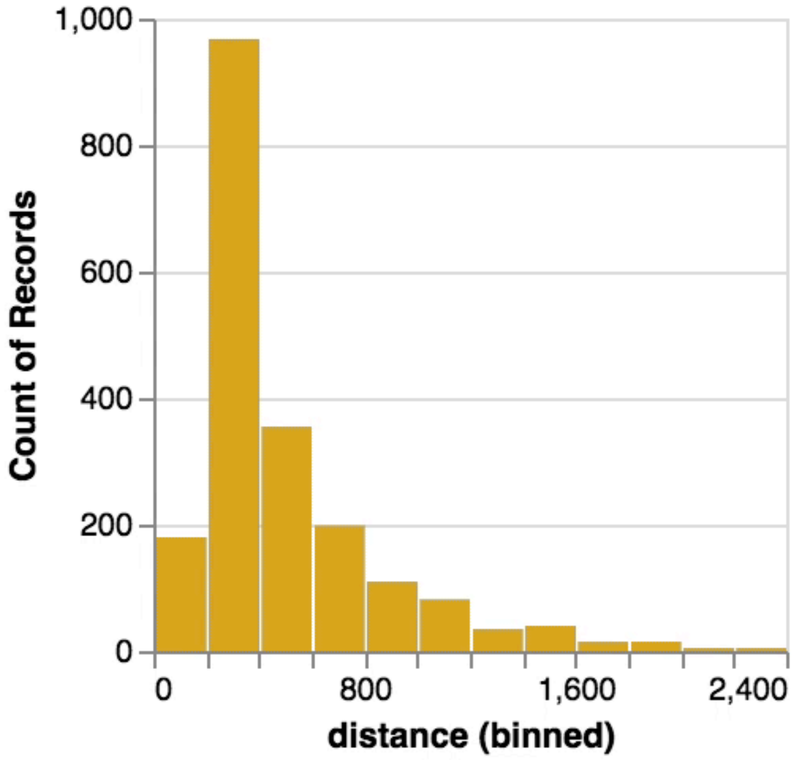
Link by *tuple* (i.e., explicitly identify and match the same data values across every view).

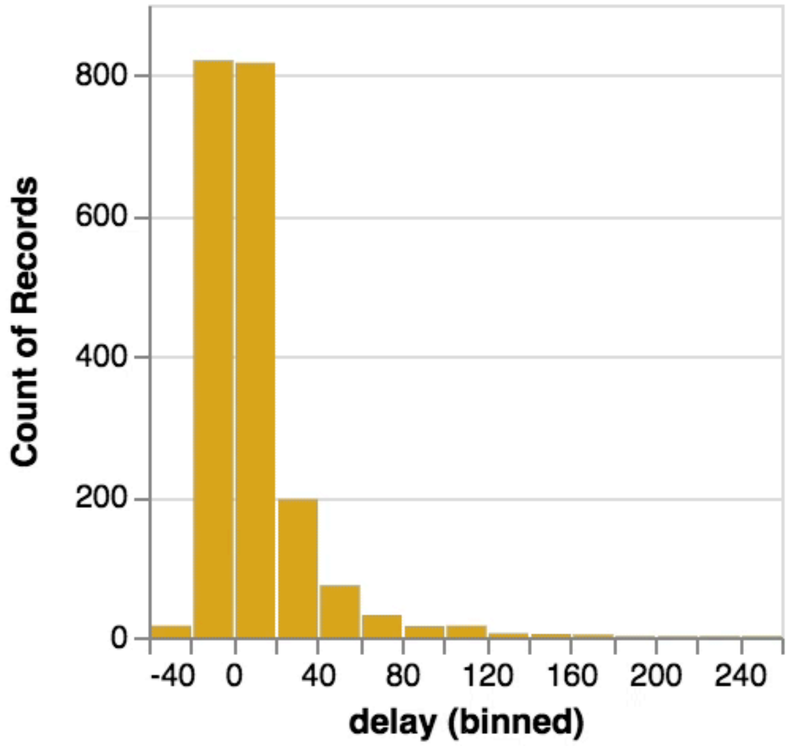


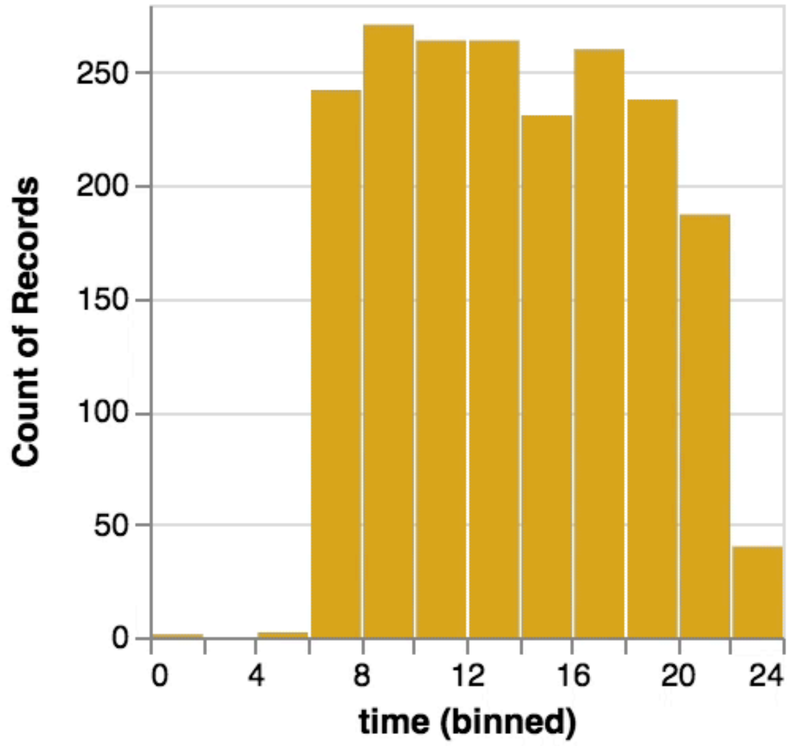
Connect

Link by *query* (i.e., matching range or values of fields).

Type of linking operation is not dependent on selection type (i.e., point and region selections can both be used to link by either tuple or query).







Connect

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POLITICS | EDUCATION | TEXAS

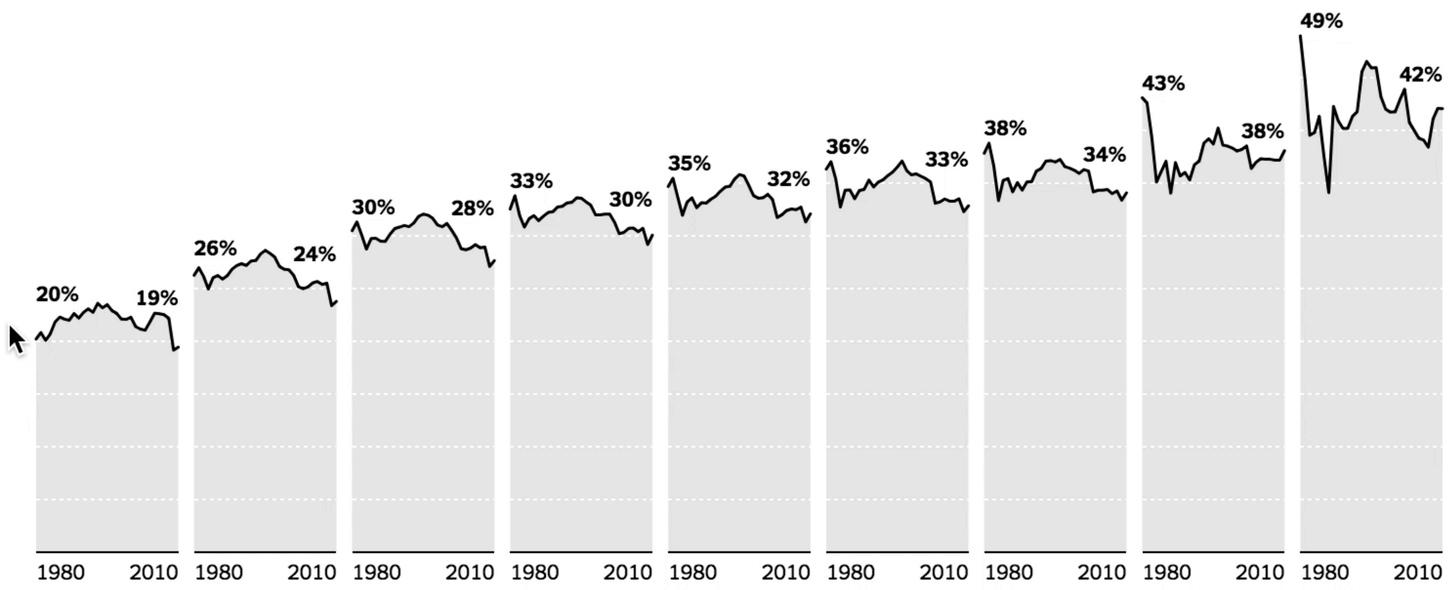
How the Tax Burden Has Changed

Most Americans paid less in taxes in 2010 than people with the same inflation-adjusted incomes paid in 1980, because of cuts in federal income taxes. At lower income levels, however, much of the savings was offset by increases in federal payroll taxes, state sales taxes and local property taxes. About half of households making less than $25,000 saved nothing at all. About the Data » | Related Article »

$0-25k | $25-50k | $50-75k | $75-100k | $100-125k | $125-150k | $150-200k | $200-350k | $350k+

Tax rates have fallen for most Americans, especially high earners.

Share of yearly income paid in federal, state and local taxes, by income bracket.



Mike Bostock, Matthew Ericson and Robert Gebeloff. *The New York Times*, November 2011.

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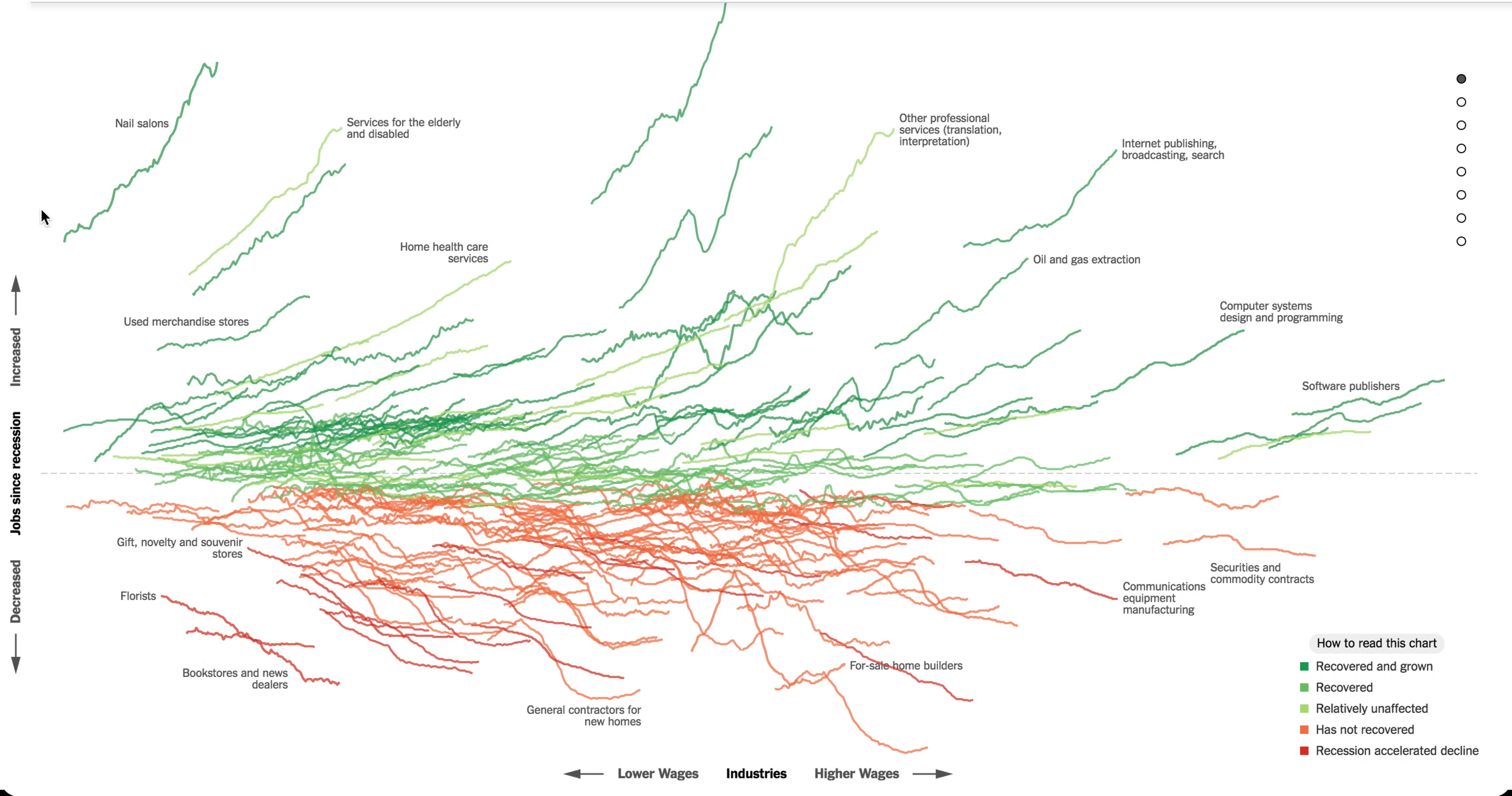
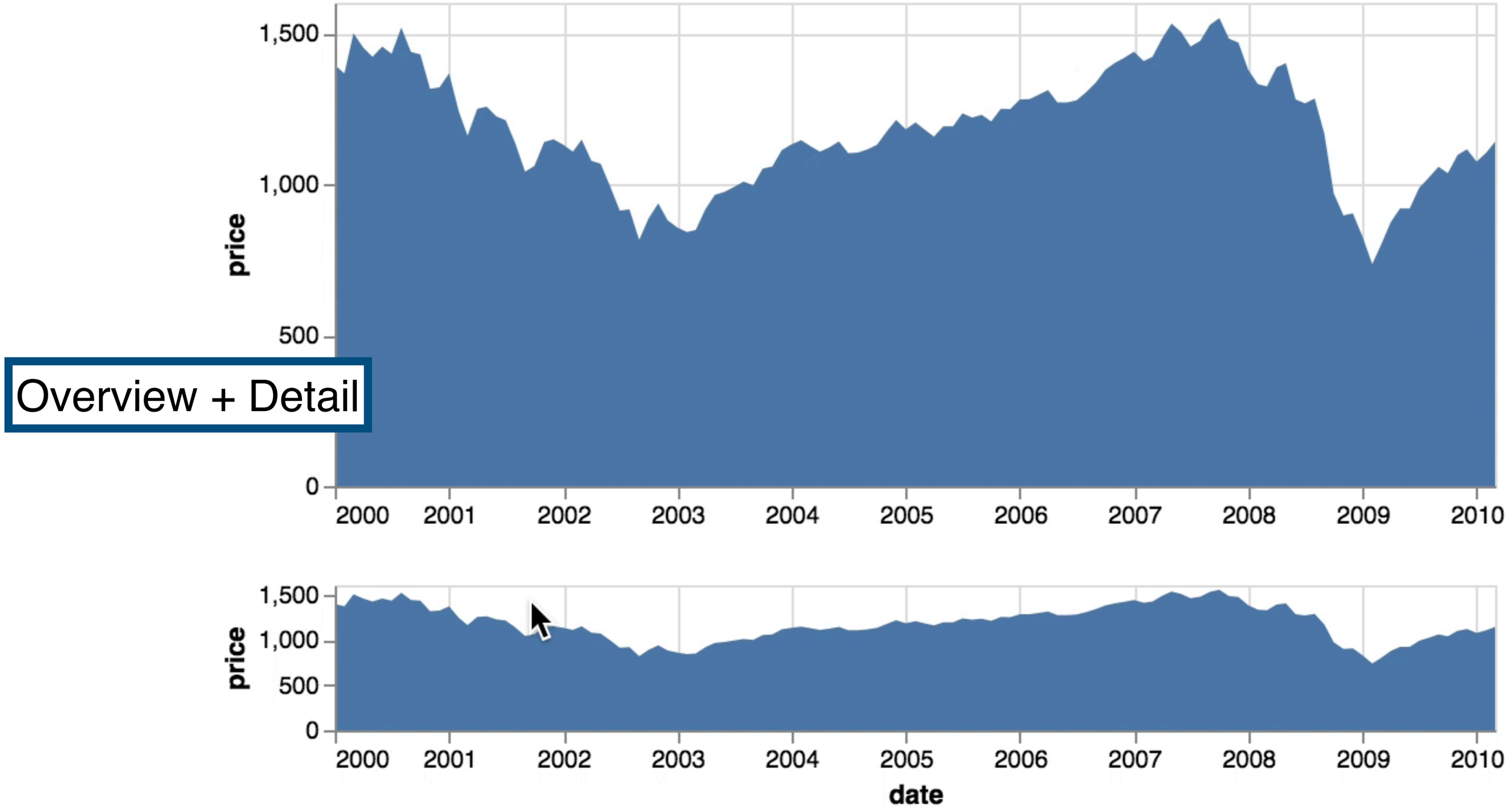

Nail salons
Services for the elderly and disabled
Other professional services (translation, interpretation)
Internet publishing, broadcasting, search
Home health care services
Oil and gas extraction
Used merchandise stores
Computer systems design and programming
Software publishers
Gift, novelty and souvenir stores
Securities and commodity contracts
Florists
Communications equipment manufacturing
Bookstores and news dealers
For-sale home builders
General contractors for new homes
Increased
Jobs since recession
Decreased
Lower Wages
Industries
Higher Wages
How to read this chart
Recovered and grown
Recovered
Relatively unaffected
Has not recovered
Recession accelerated decline


Overview + Detail
price
1,500
1,000
500
0
2000
2001
2002
2003
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2005
2006
2007
2008
2009
2010
price
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2008
2009
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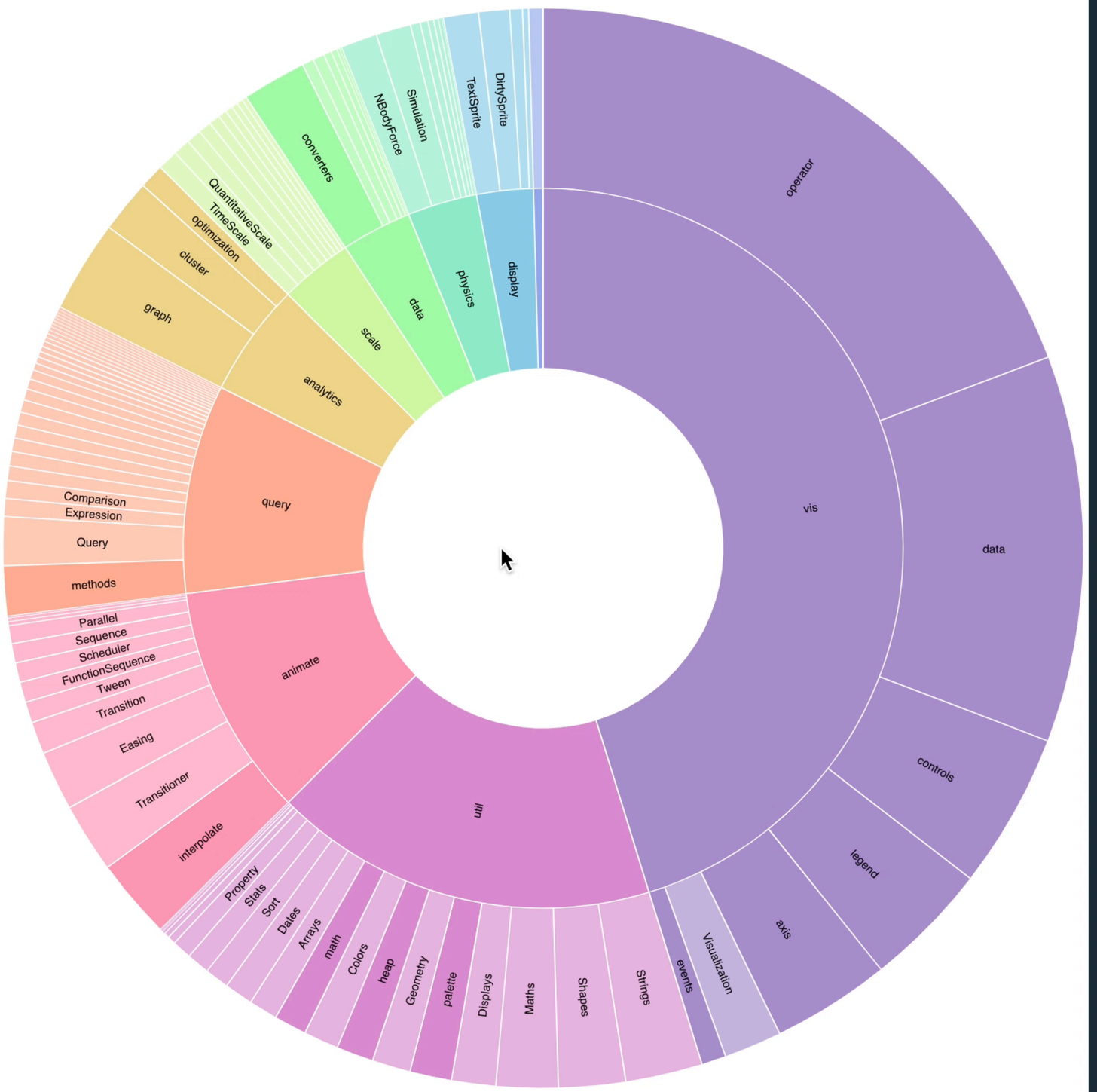
date



Mike Bostock, April 2018.

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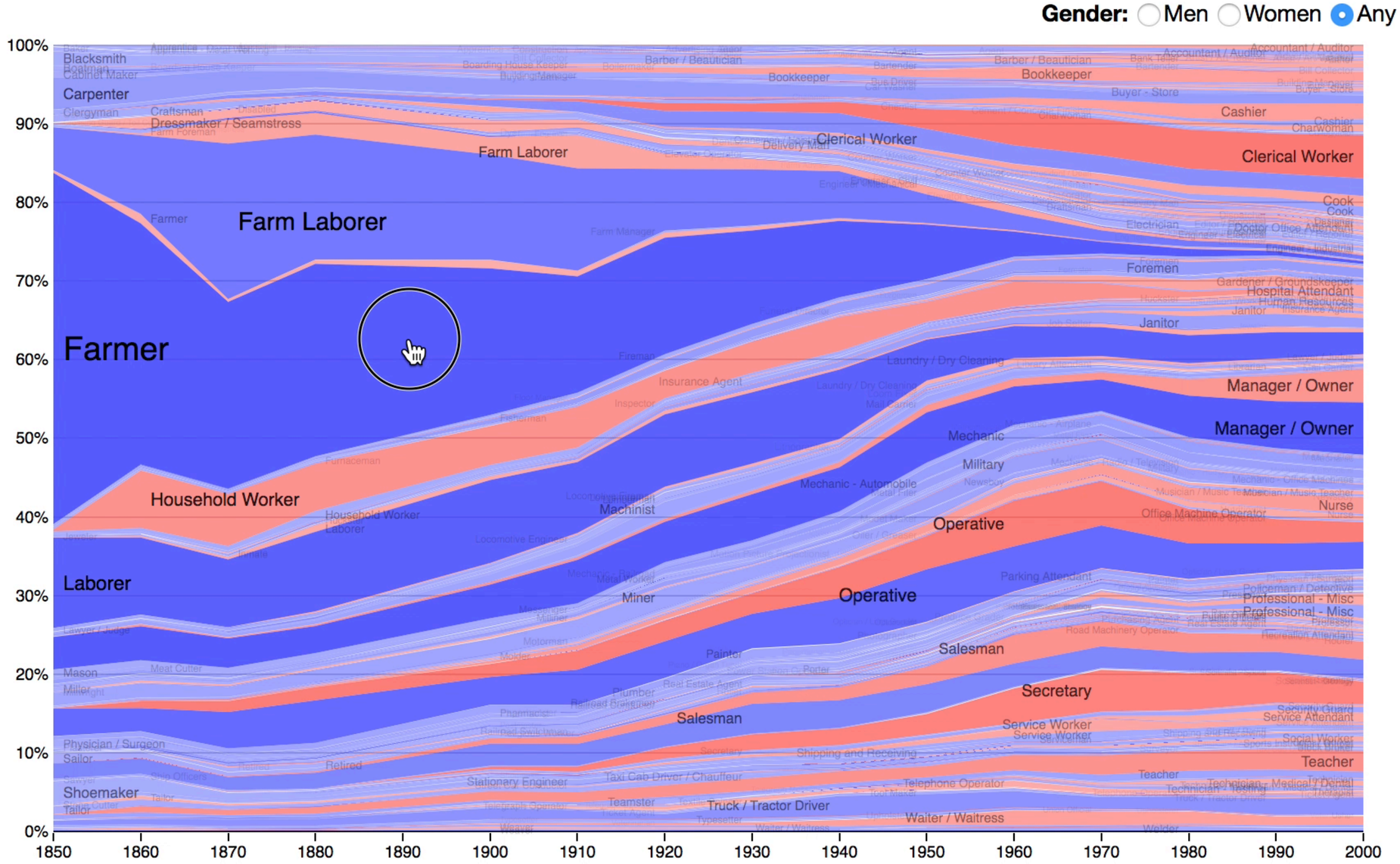
Job Voyager


Gender: Men Women Any
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1850
1860
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1920
1930
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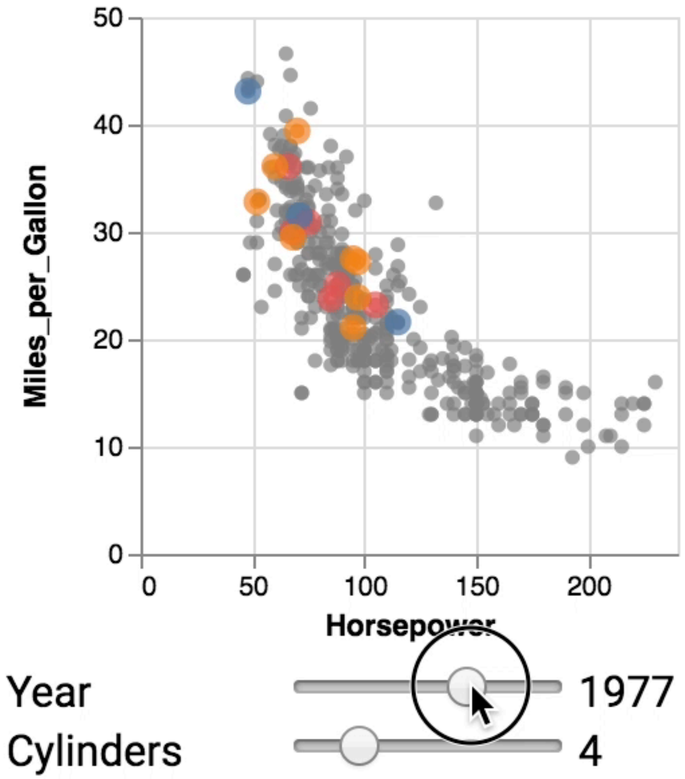
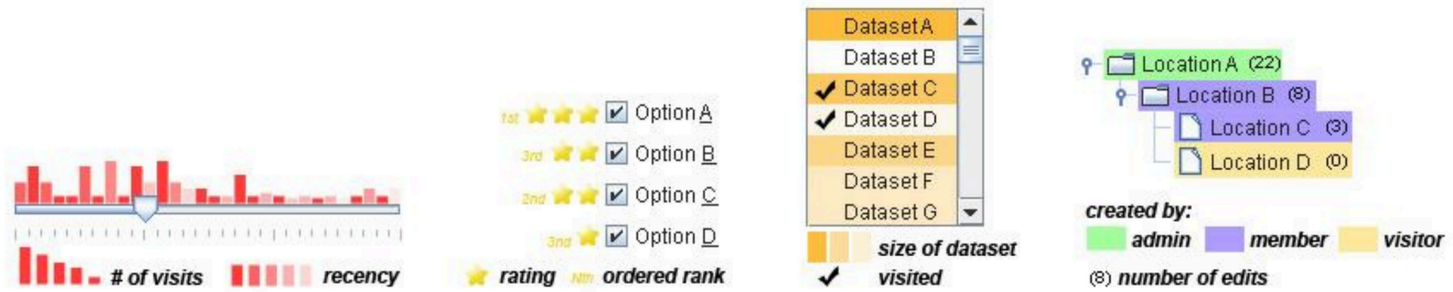
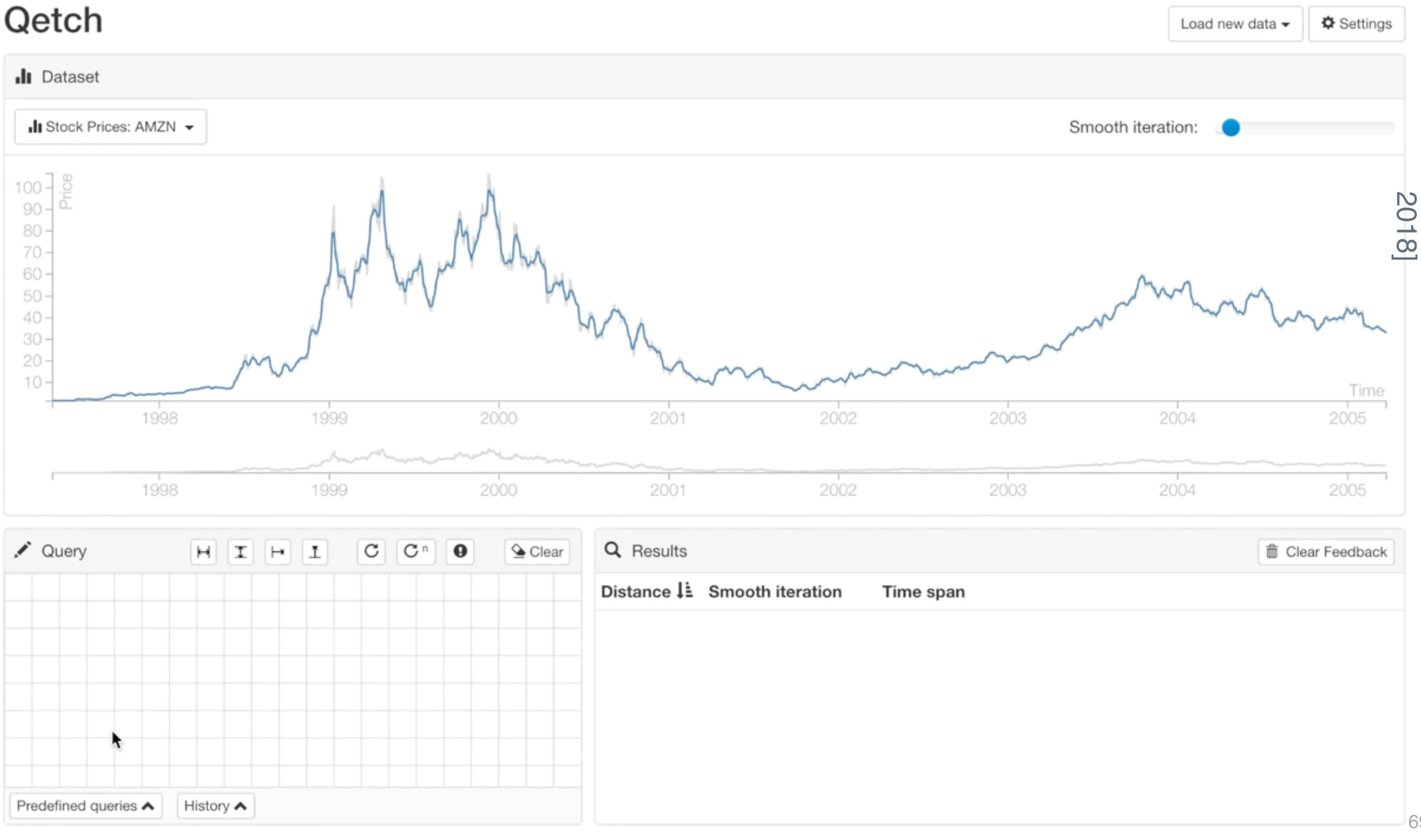
1970
1980
1990
2000
Farmer
Farm Laborer
Household Worker
Laborer
Shoemaker
Tailor
Physician / Surgeon
Sailor
Mason
Miller
Carpenter
Blacksmith
Cabinet Maker
Clergyman
Craftsman
Dressmaker / Seamstress
Clerical Worker
Cashier
Bookkeeper
Barber / Beautician
Accountant / Auditor
Buyer - Store
Cook
Janitor
Foremen
Manager / Owner
Hospital Attendant
Nurse
Teacher
Secretary
Salesman
Operative
Mechanic
Machinist
Miner
Military
Laundry / Dry Cleaning
Insurance Agent
Truck / Tractor Driver
Waiter / Waitress
Telephone Operator
Taxi Cab Driver / Chauffeur
Stationary Engineer
Retired
Service Worker
Professional - Misc
Parking Attendant
Office Machine Operator
Mechanic - Automobile
Shipping and Receiving
Teamster
Plumber
Painter
Meat Cutter
Lawyer / Judge
Household Worker
Laborer
Farm Laborer
Farmer
Fireman
Inspector
Fisherman
Furnaceman
Locomotive Engineer
Mail Carrier
Newsboy
Metal Worker
Molder
Motorman
Messenger
Real Estate Agent
Railroad Switchman
Pharmacist
Typesetter
Weaver
Delivery Man
Boarding House Keeper
Boilermaker
Bus Driver
Car Washer
Bartender
Bank Teller
Bill Collector
Charwoman
Draftsman
Electrician
Engineer - Industrial
Gardener / Groundskeeper
Human Resources
Insurance Agent
Musician / Music Teacher
Policeman / Detective
Public Official
Real Estate Agent
Road Machinery Operator
Recreation Attendant
Security Guard
Service Attendant
Social Worker
Technician - Medical / Dental
Technician - Testing
Welder
search:

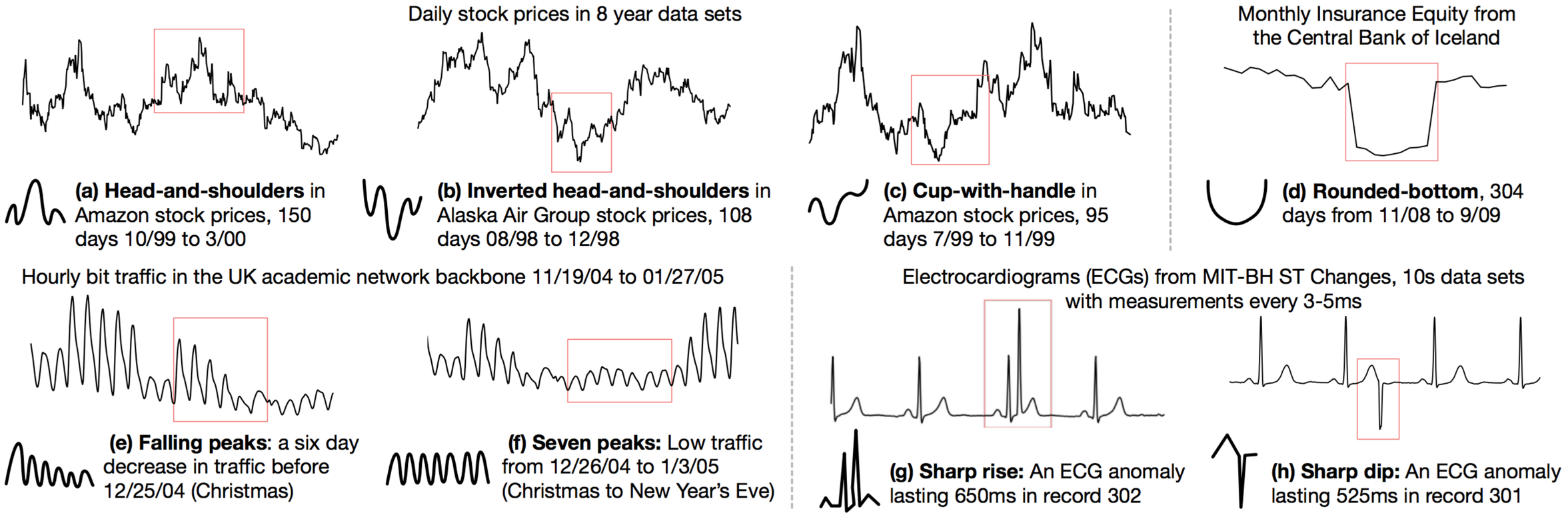




Willet, Heer, and Agrawala. Scented Widgets. *InfoVis*, 2007.



[Mannino and Abouzied. Qetch. *CHI*, 2018]



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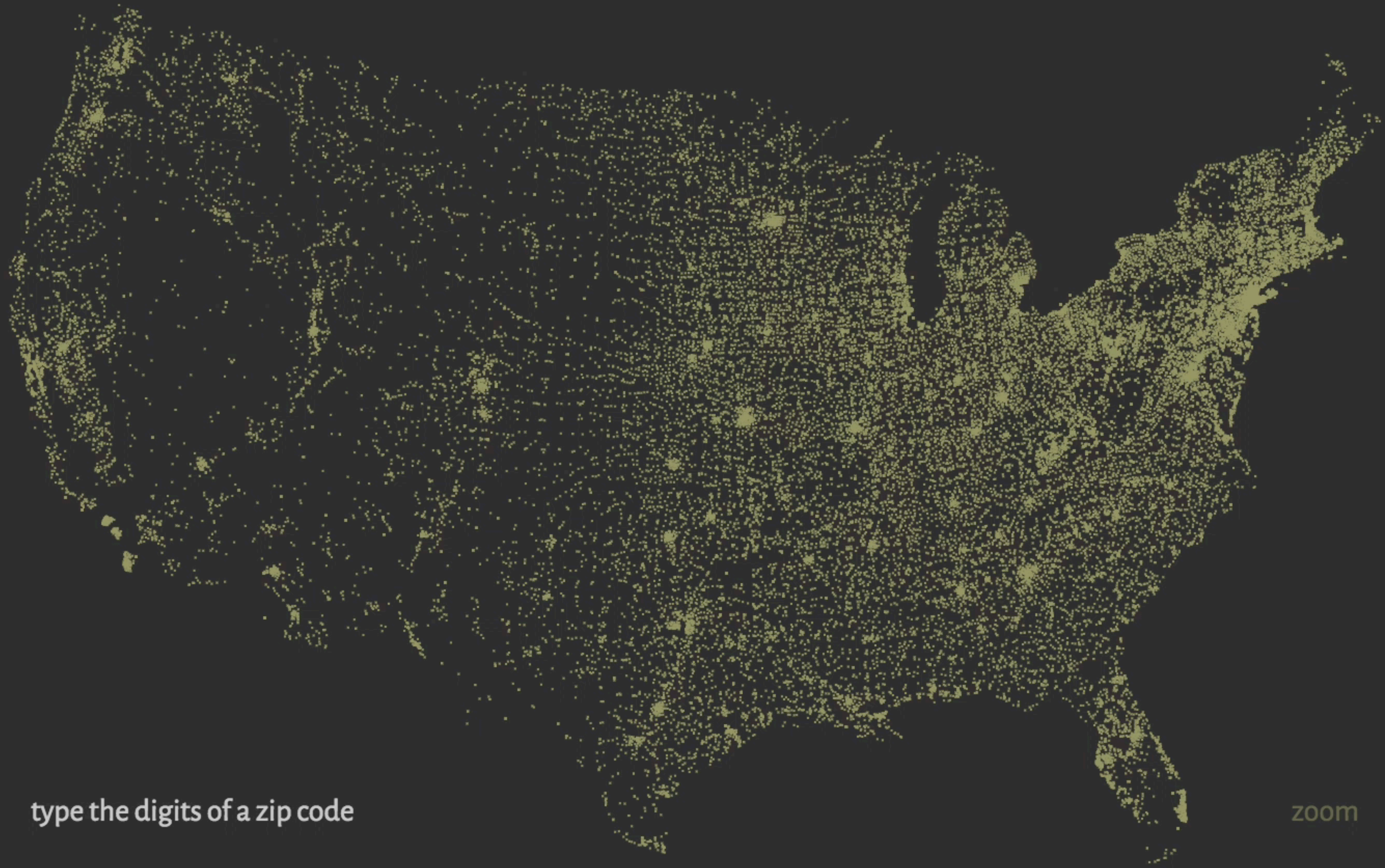

ZioDecode. Ben Fry, 1999–2014.

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Yi, Ji Soo, et al. "Toward a deeper understanding of the role of interaction in information visualization." 2007.

Interaction in Visualization

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Abstract/Elaborate	show me related items.
Filter	show me more or less detail.
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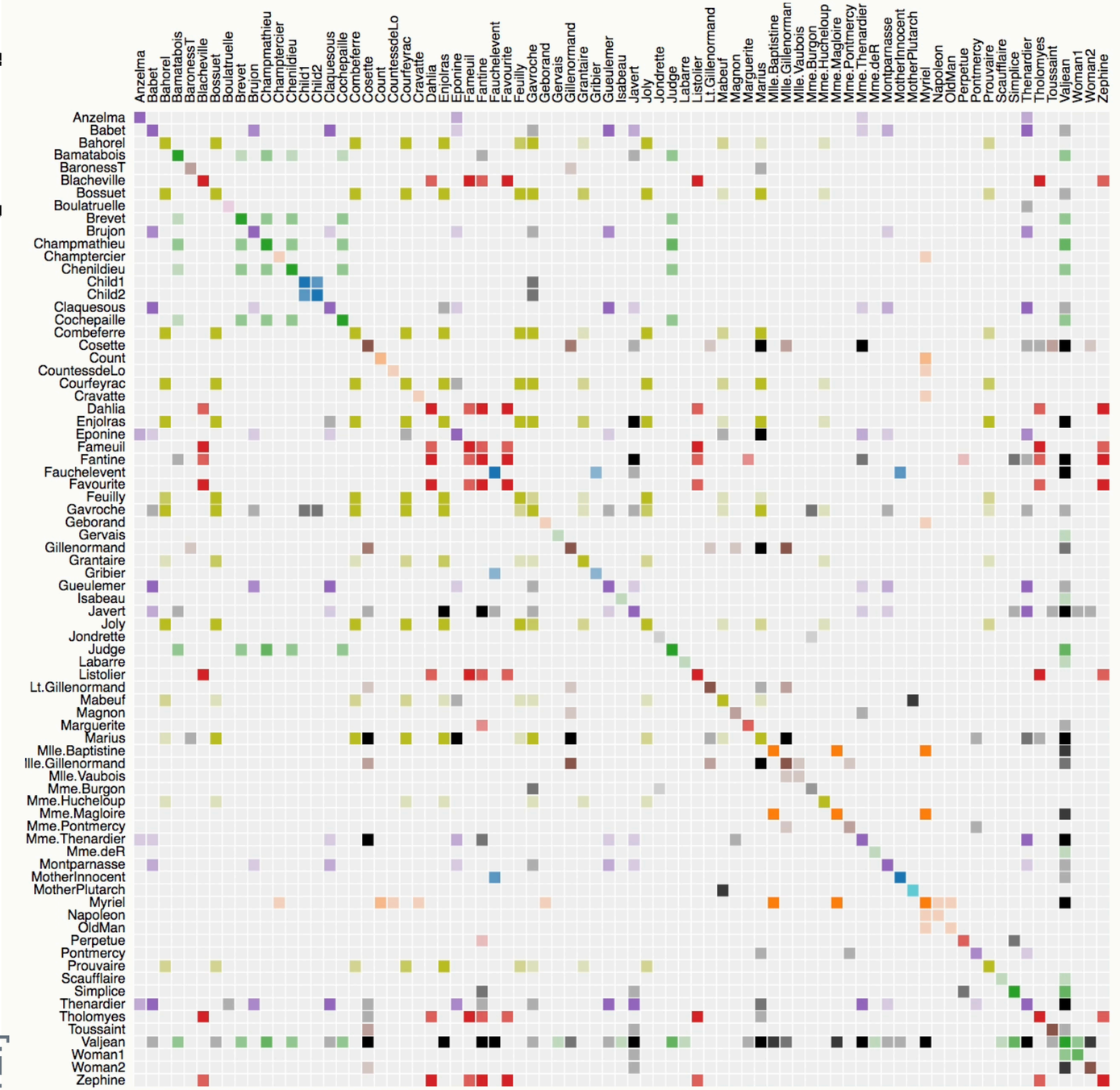
Reconfigure



Source: The Stanford GraphBase.

Order: by Name

This matrix diagram visualizes character co-occurrences in Victor Hugo's *Les Misérables*.

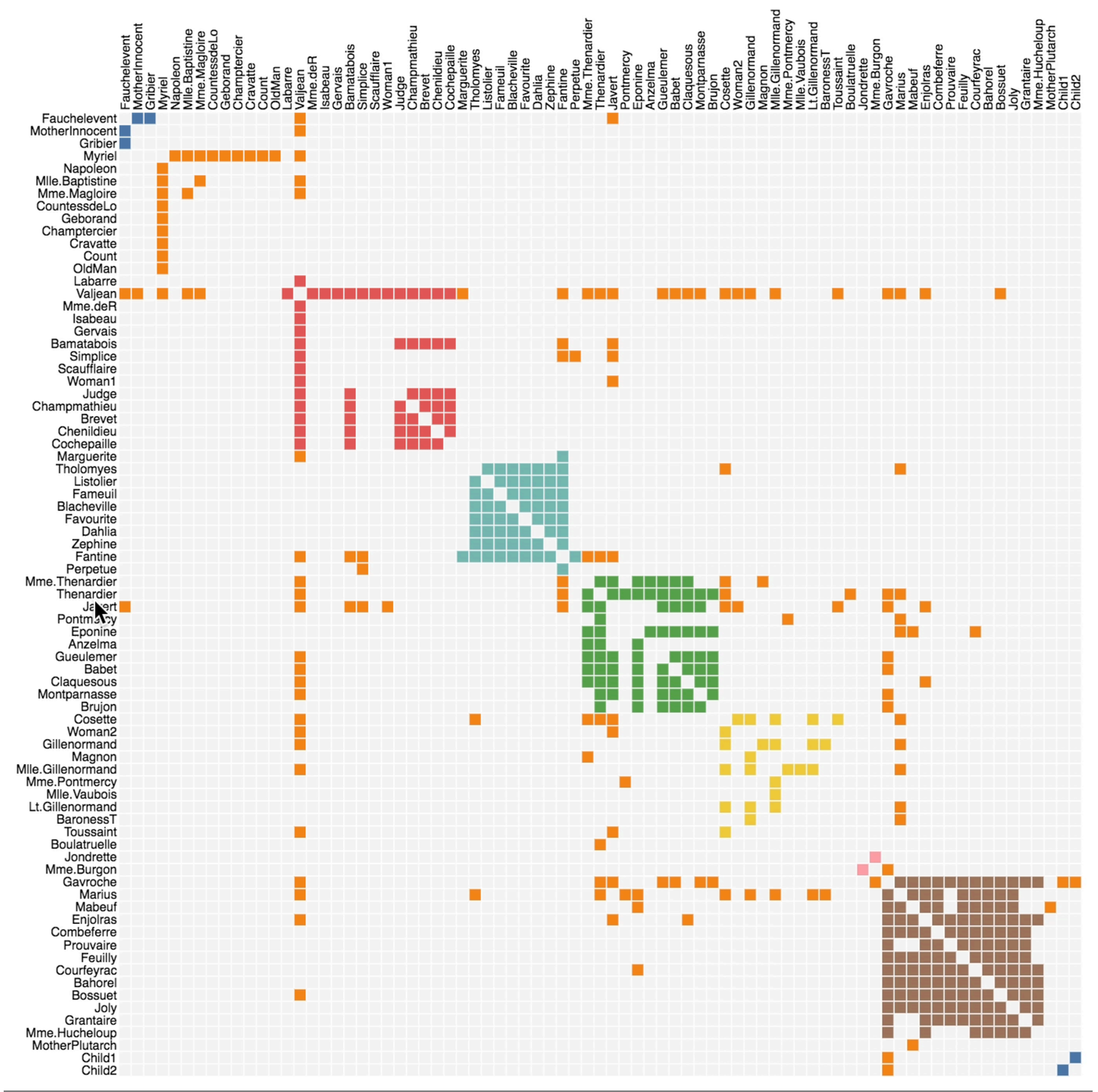
Each colored cell represents two characters that appeared in the same chapter; darker cells indicate characters that co-occurred more frequently.

Use the drop-down menu to reorder the matrix and explore the data.

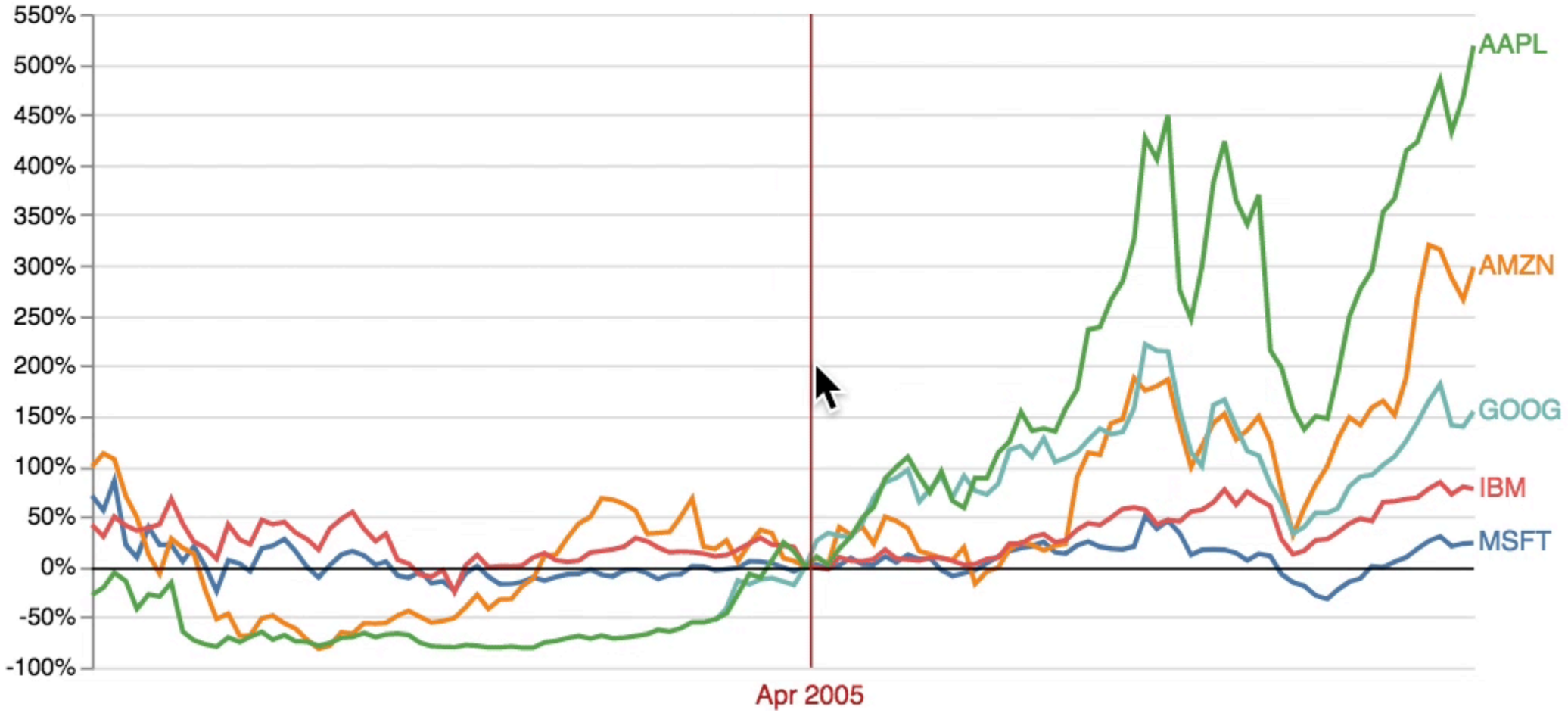
Built with d3.js.

[Mike Bostock. April 2012.]

Reconfigure



Reconfigure



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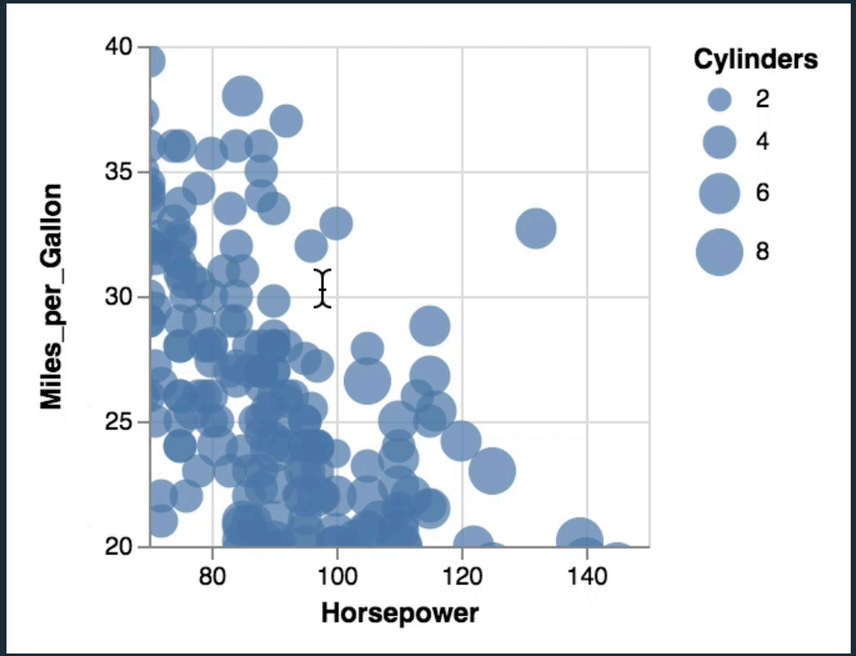
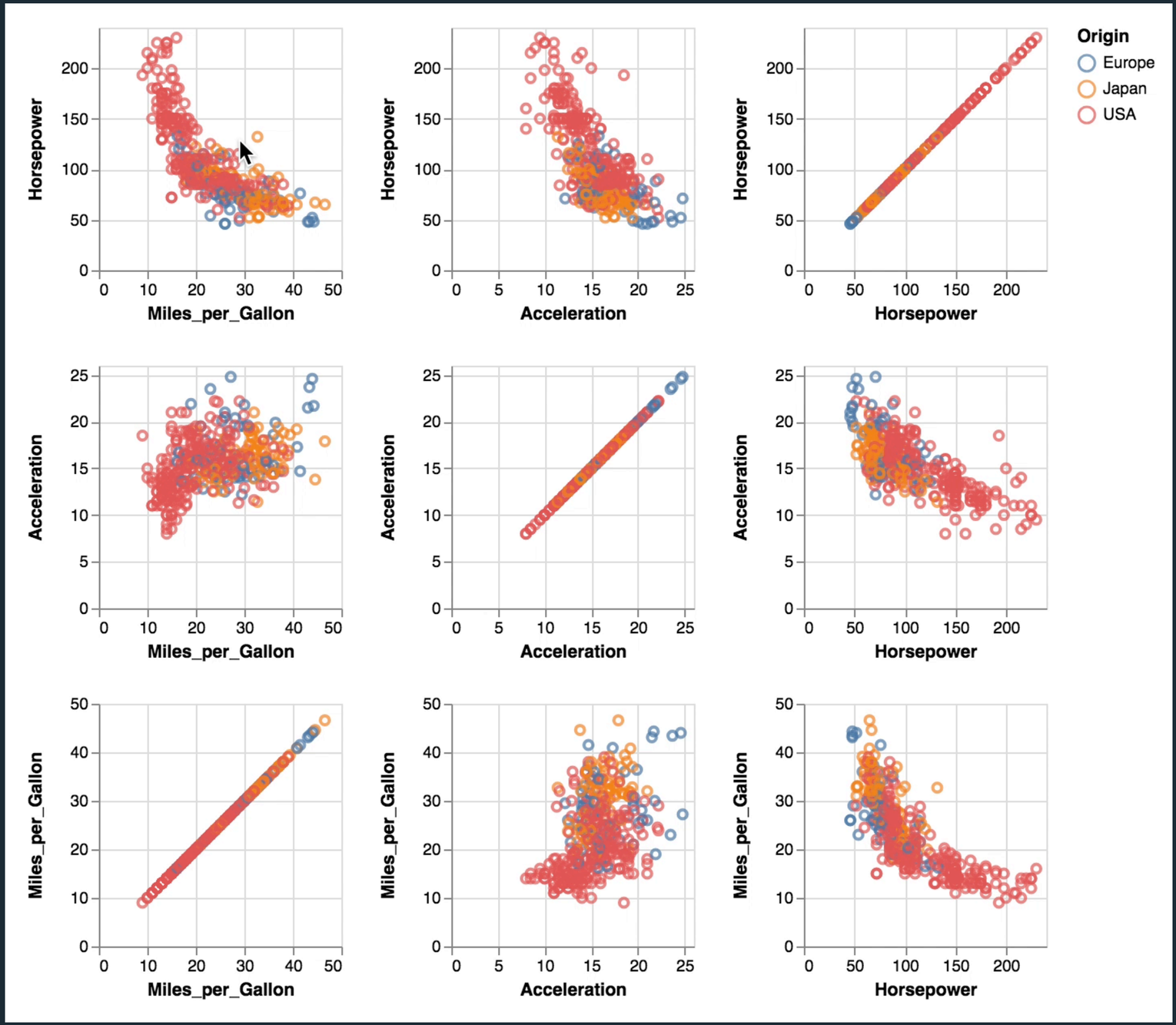
Explore


Miles_per_Gallon
Horsepower
Cylinders
2
4
6
8


Origin
Europe
Japan
USA
Horsepower
Miles_per_Gallon
Acceleration

Explore

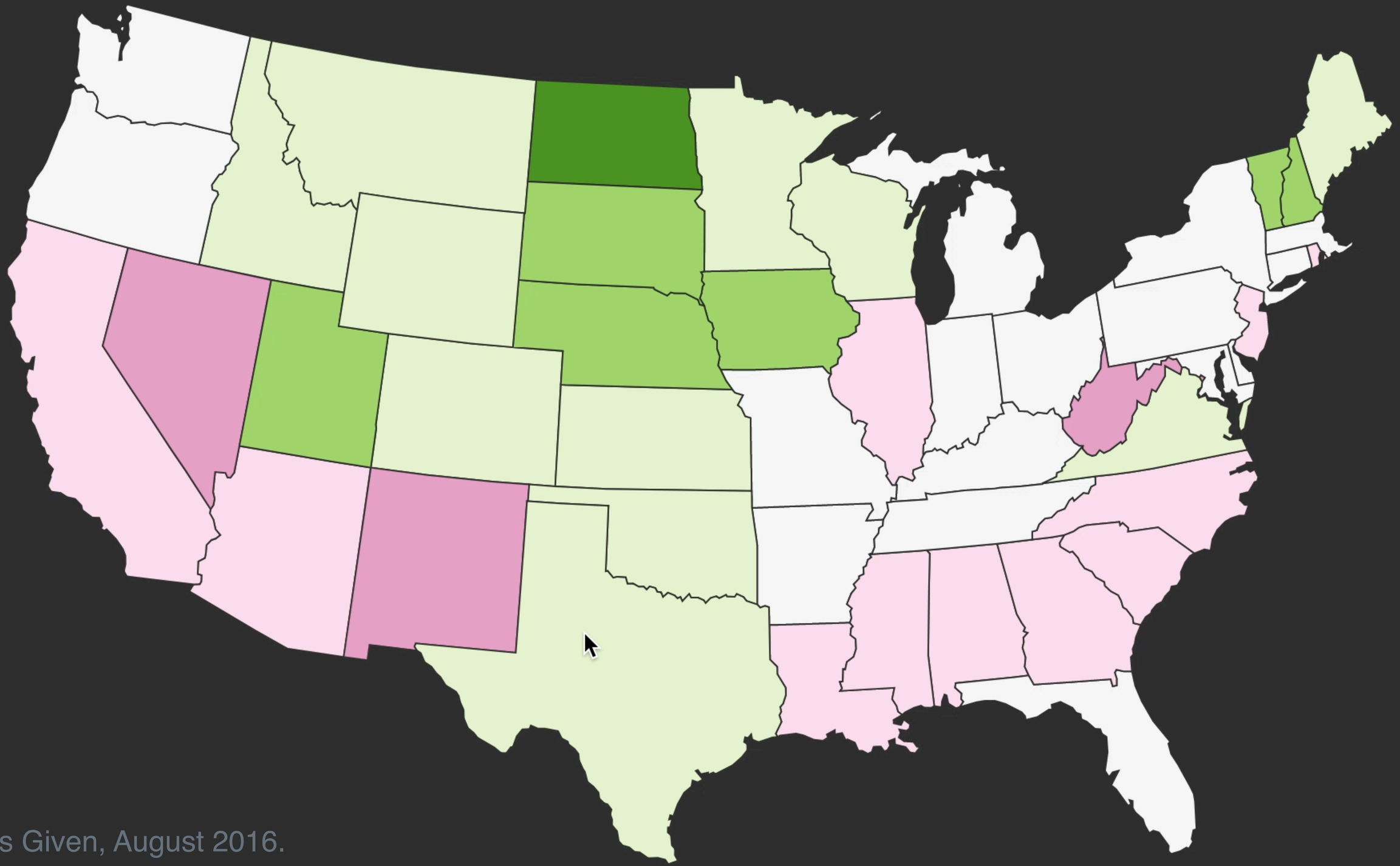
Geometric zoom: transforms the *physical view* (i.e., objects get larger as they get "closer").

[Mike Bostock. August 2017.]

Explore

Semantic zoom: transforms the *data space* (i.e., objects stay the same size, but get further apart).

[Mike Bostock. August 2017.]



Chris Given, August 2016.

Interaction in Visualization

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Interaction in Visualization

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Filter show me more or less detail.

Re ement.

No time, but see interactive systems like Tableau / Voyager

Encode show me a different visual representation.

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Interaction in Visualization

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Filter	show me more or less detail.
Reconfigure	show me a different arrangement.
Explore	show me some
Encode	show me a diff

Use interaction to help audience see something new, not just for visual eye candy!

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