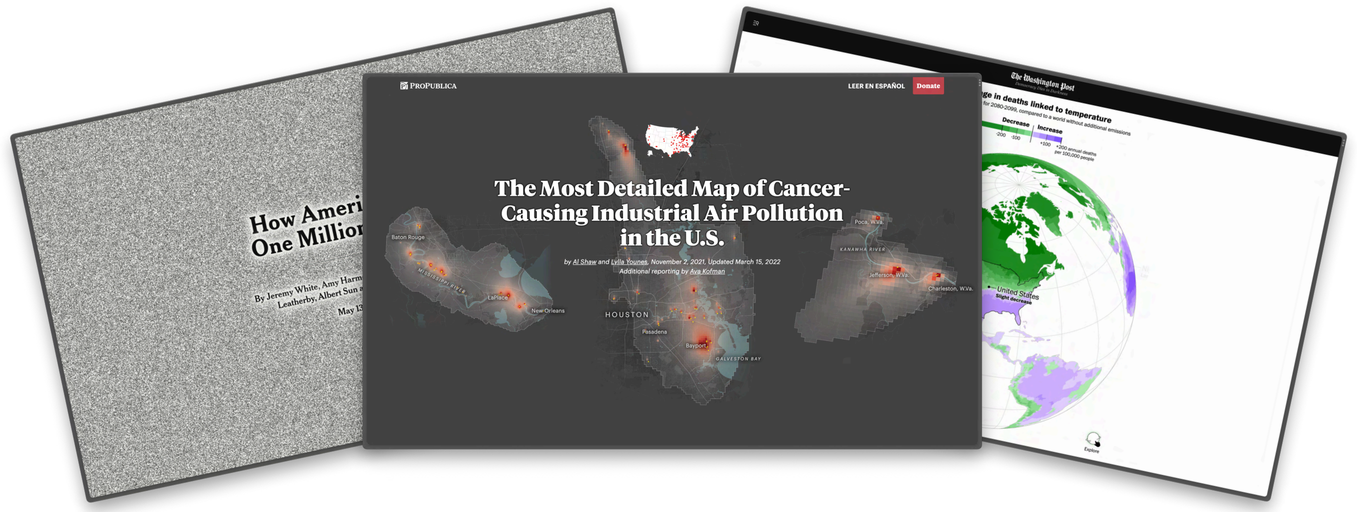
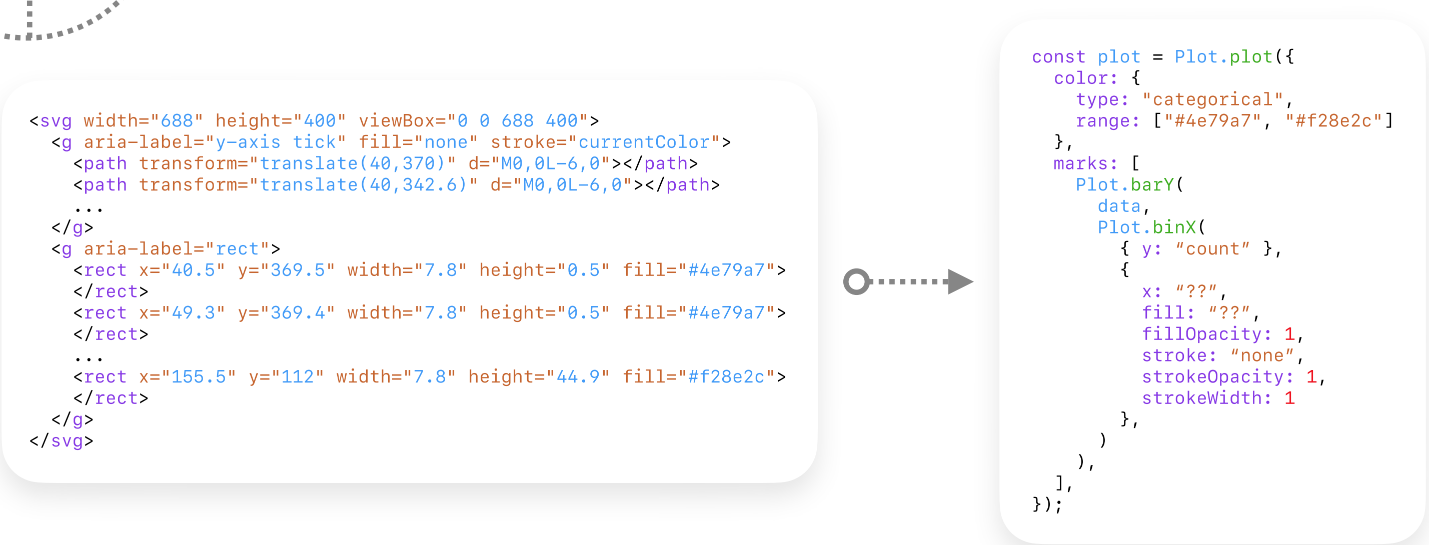
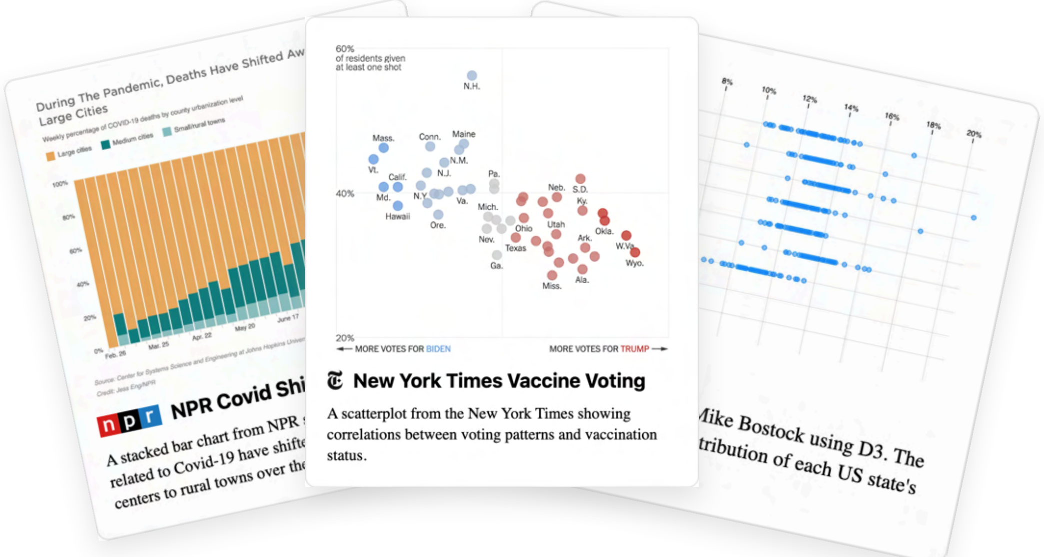

How Ameri
One Million
By Jeremy White, Amy Harm
Leatherby, Albert Sun a
May 13
ProPublica
LEER EN ESPAÑOL
Donate
The Most Detailed Map of Cancer-Causing Industrial Air Pollution in the U.S.
by Al Shaw and Lylla Younes, November 2, 2021, Updated March 15, 2022
Additional reporting by Ava Kofman
Baton Rouge
Mississippi River
LaPlace
New Orleans
Houston
Pasadena
Bayport
Galveston Bay
Poca, W.Va.
Kanawha River
Jefferson, W.Va.
Charleston, W.Va.
The Washington Post
ge in deaths linked to temperature
for 2080-2099, compared to a world without additional emissions
Decrease
Increase
-200
-100
+100
+200 annual deaths per 100,000 people
United States
Slight decrease
Explore

Supporting Data Journalism through Compilers for Visual Inputs



```
<svg width="688" height="400" viewBox="0 0 688 400">
  <g aria-label="y-axis tick" fill="none" stroke="currentColor">
    <path transform="translate(40,370)" d="M0,0L-6,0"></path>
    <path transform="translate(40,342.6)" d="M0,0L-6,0"></path>
    ...
  </g>
  <g aria-label="rect">
    <rect x="40.5" y="369.5" width="7.8" height="0.5" fill="#4e79a7">
    </rect>
    <rect x="49.3" y="369.4" width="7.8" height="0.5" fill="#4e79a7">
    </rect>
    ...
    <rect x="155.5" y="112" width="7.8" height="44.9" fill="#f28e2c">
    </rect>
  </g>
</svg>
```

```
const plot = Plot.plot({
  color: {
    type: "categorical",
    range: ["#4e79a7", "#f28e2c"]
  },
  marks: [
    Plot.barY(
      data,
      Plot.binX(
        { y: "count" },
        {
          x: "??",
          fill: "??",
          fillOpacity: 1,
          stroke: "none",
          strokeOpacity: 1,
          strokeWidth: 1
        },
      )
    ),
  ],
});
```



NPR Covid Shi

A stacked bar chart from NPR s related to Covid-19 have shifte centers to rural towns over the

New York Times Vaccine Voting

A scatterplot from the New York Times showing correlations between voting patterns and vaccination status.

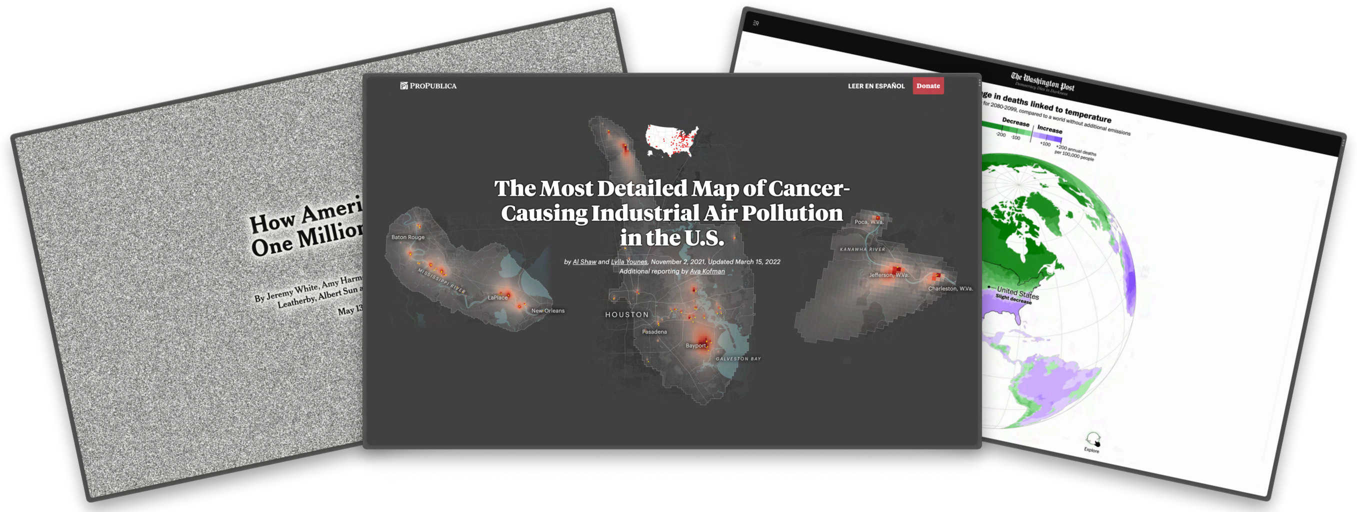
Mike Bostock using D3. The tribution of each US state's

Parker Ziegler // @parker_ziegler

Ph.D. Student, UC Berkeley

Strange Loop

St. Louis, MO • September 21, 2023


How Ameri
One Million
The Most Detailed Map of Cancer-Causing Industrial Air Pollution in the U.S.

Data Journalism

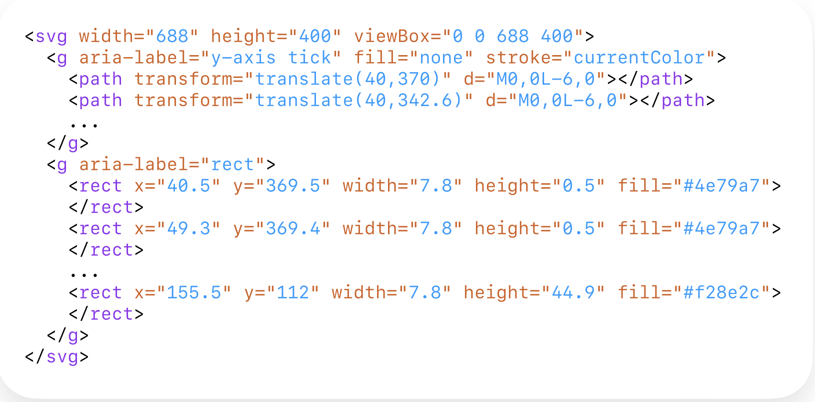
What does **journalism** have to do with **compilation**?

Aren’t compilers for transforming **programs**, not **charts**?

What does this **even mean**?

Compilers

Visual Inputs



```
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    <path transform="translate(40,342.6)" d="M0,0L-6,0"></path>
    ...
  </g>
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    </rect>
    <rect x="49.3" y="369.4" width="7.8" height="0.5" fill="#4e79a7">
    </rect>
    ...
    <rect x="155.5" y="112" width="7.8" height="44.9" fill="#f28e2c">
    </rect>
  </g>
</svg>
```

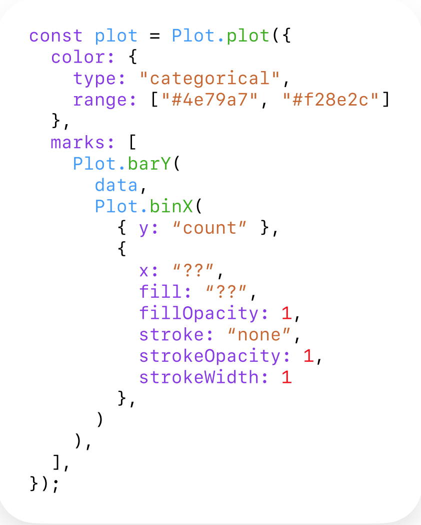

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  color: {
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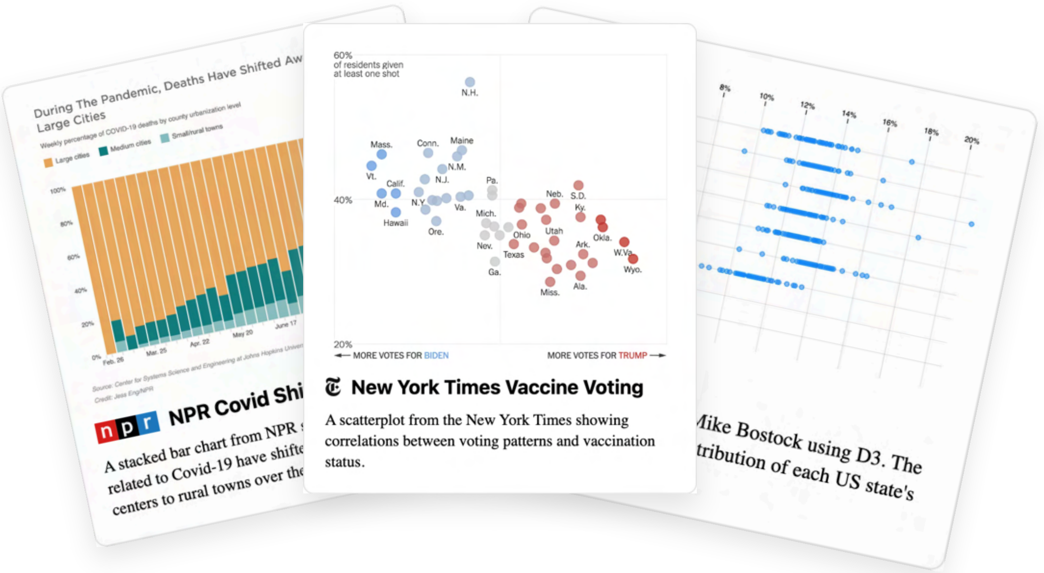
    range: ["#4e79a7", "#f28e2c"]
  },
  marks: [
    Plot.barY(
      data,
      Plot.binX(
        { y: "count" },
        {
          x: "??",
          fill: "??",
          fillOpacity: 1,
          stroke: "none",
          strokeOpacity: 1,
          strokeWidth: 1
        },
      )
    ),
  ],
});
```



NPR Covid Shi

A stacked bar chart from NPR s
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New York Times Vaccine Voting

A scatterplot from the New York Times showing correlations between voting patterns and vaccination status.

Mike Bostock using D3. The
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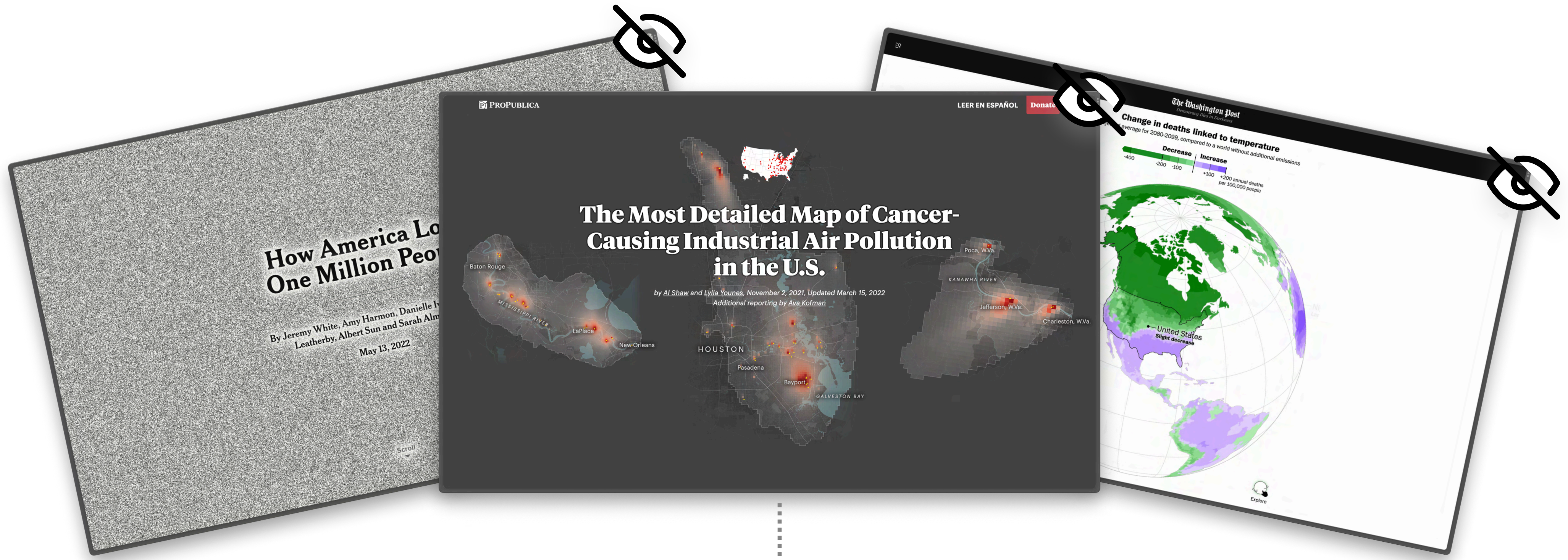
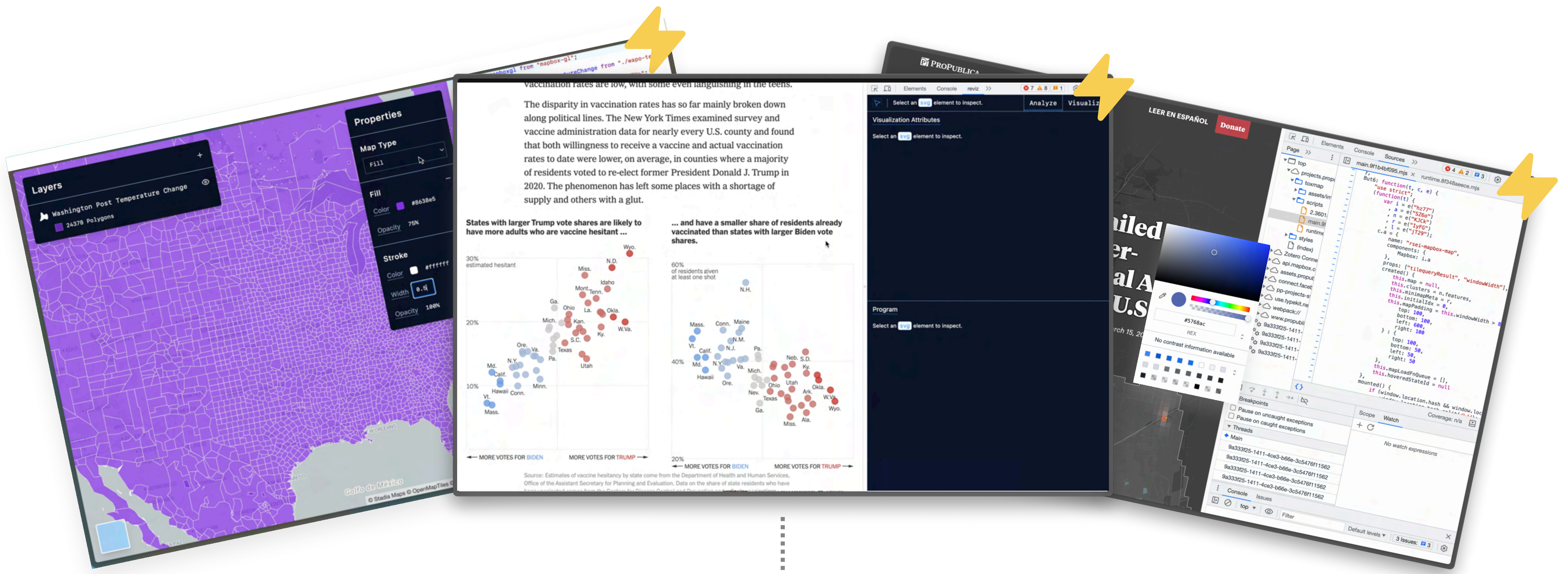
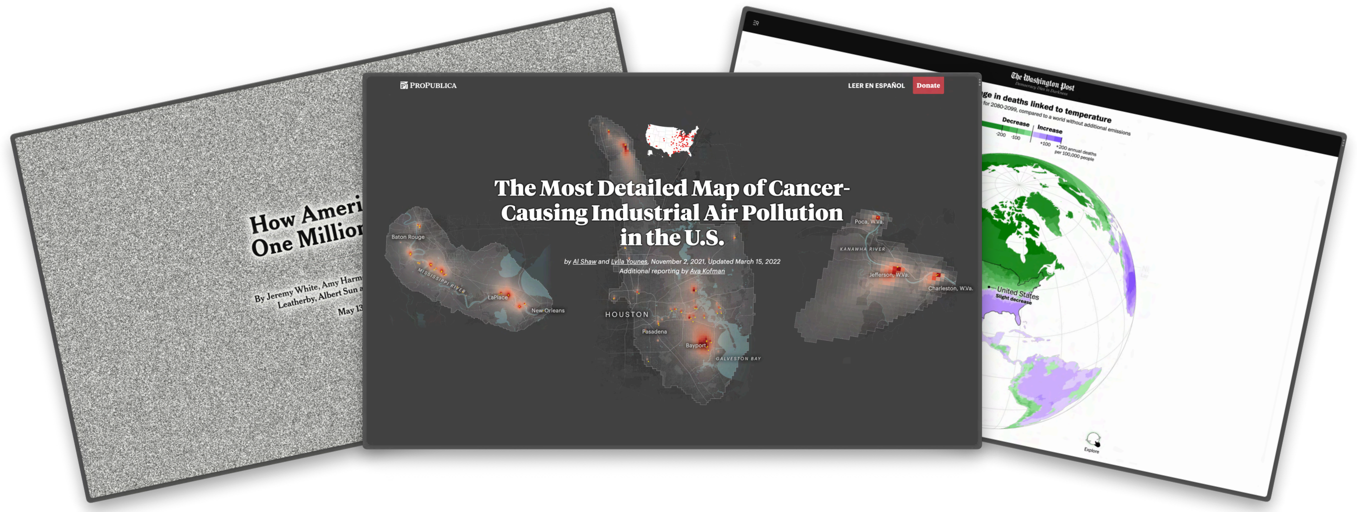
Fixed Entities


How America Lo
One Million Peo
PROPUBLICA
LEER EN ESPAÑOL
Donate
The Most Detailed Map of Cancer-Causing Industrial Air Pollution in the U.S.
HOUSTON
The Washington Post
Change in deaths linked to temperature
Decrease
Increase

Live Objects


Layers
Washington Post Temperature Change
Properties
Map Type
Fill
Stroke
States with larger Trump vote shares are likely to have more adults who are vaccine hesitant ...
... and have a smaller share of residents already vaccinated than states with larger Biden vote shares.
MORE VOTES FOR BIDEN
MORE VOTES FOR TRUMP
Visualization Attributes
Program
PROPUBLICA
LEER EN ESPAÑOL
Donate

Compilers



How Ameri
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May 13

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by Al Shaw and Lylla Younes, November 2, 2021, Updated March 15, 2022
Additional reporting by Ava Kofman

The Washington Post

ge in deaths linked to temperature
for 2080-2099, compared to a world without additional emissions

Data Journalism

Waco
Lufkin
Alexandria
LOUISIANA
Hattiesburg
College Station
Rock
The Woodlands
Beaumont
Lake Charles
Lafayette
Baton Rouge
Gulfport
Houston
New Orleans
Galveston
Victoria
+
−
© Mapbox © OpenStreetMap Improve this map

PROPUBLICA

The Most Detailed Map of Cancer-Causing Industrial Air Pollution in the U.S.

Al Shaw and Lylla Younes

Click inside a hot spot to see how risks combine there.

The coronavirus arrived in the United States by early 2020, setting off wave after wave of infection and death in the months that followed.

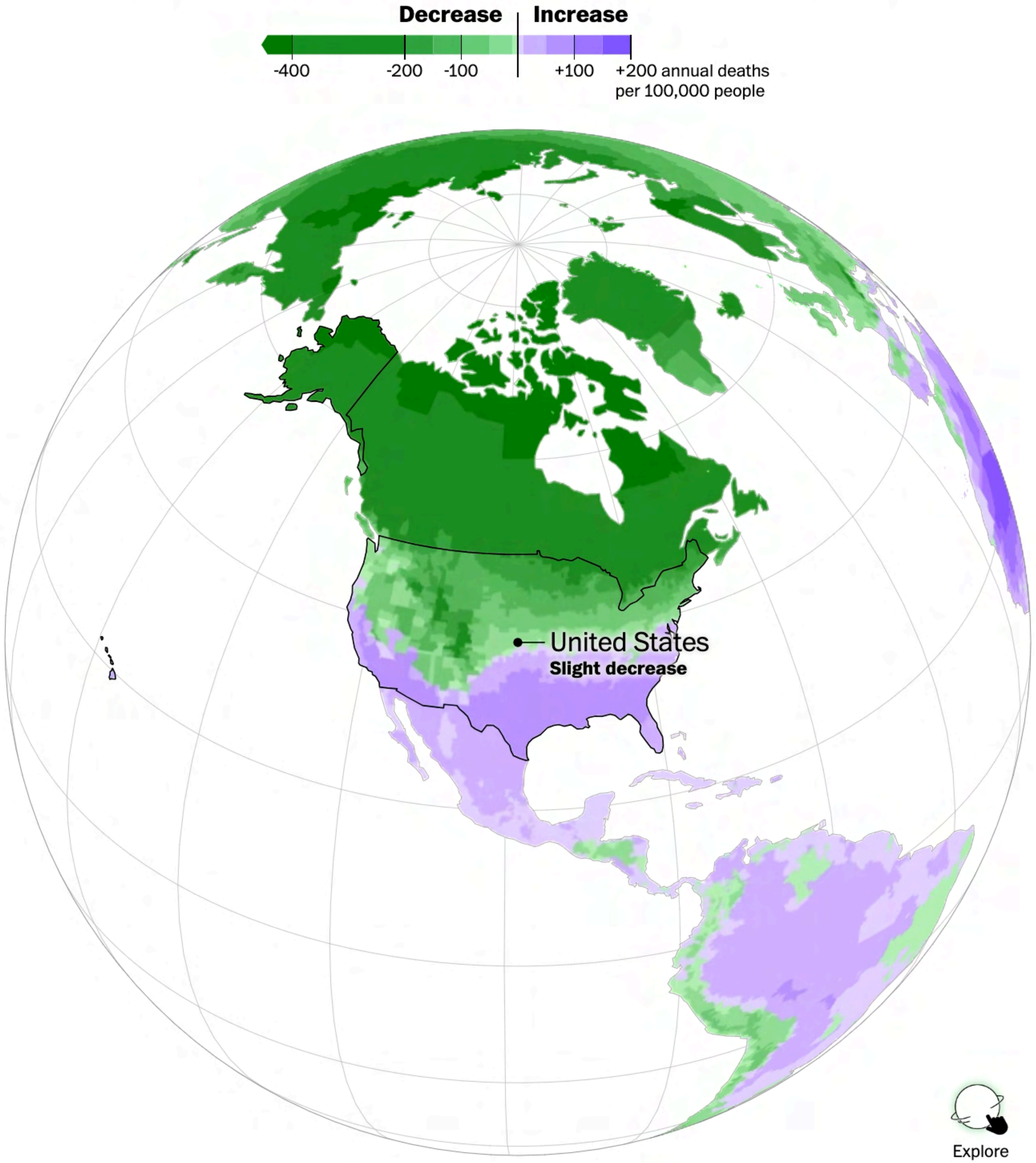
The New York Times

How America Reached One Million Covid Deaths

Jeremy White, Amy Harmon, Danielle Ivory, Lauren Leatherby, Albert Sun, Sarah Almukhtar

Change in deaths linked to temperature

Projected average for 2080-2099, compared to a world without additional emissions

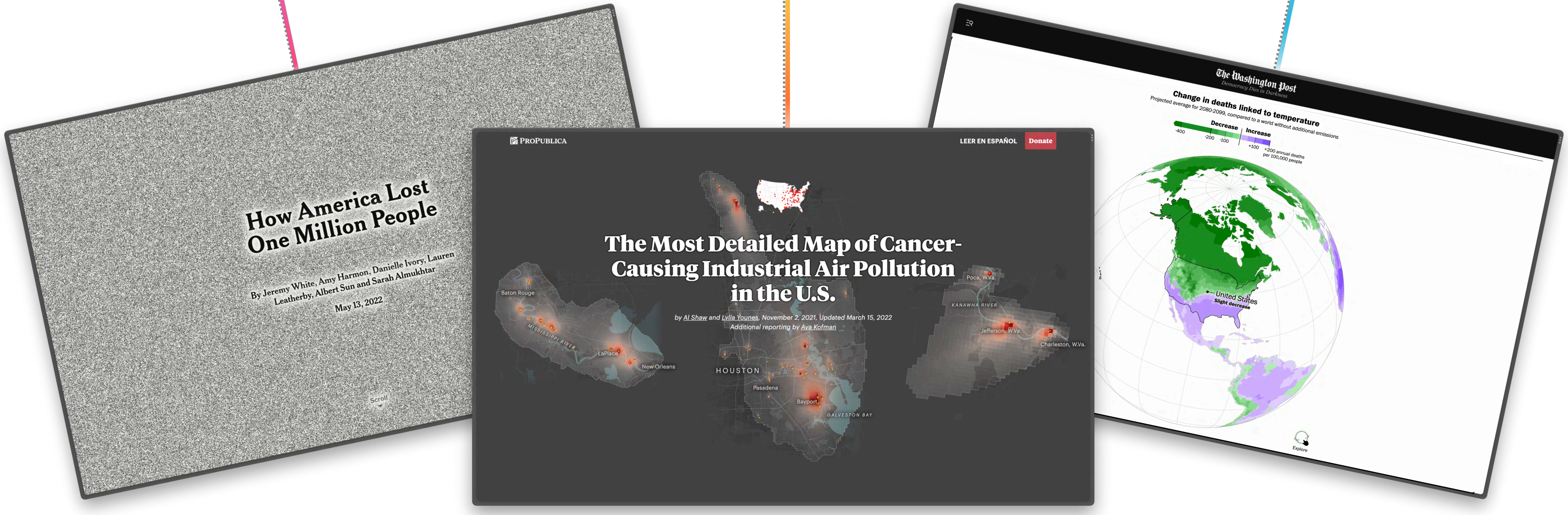


The Washington Post

Will global warming make temperature less deadly?

Harry Stevens

Data Journalism



How America Lost One Million People

By Jeremy White, Amy Harmon, Danielle Ivory, Lauren Leatherby, Albert Sun and Sarah Almukhtar

May 13, 2022

The Most Detailed Map of Cancer-Causing Industrial Air Pollution in the U.S.

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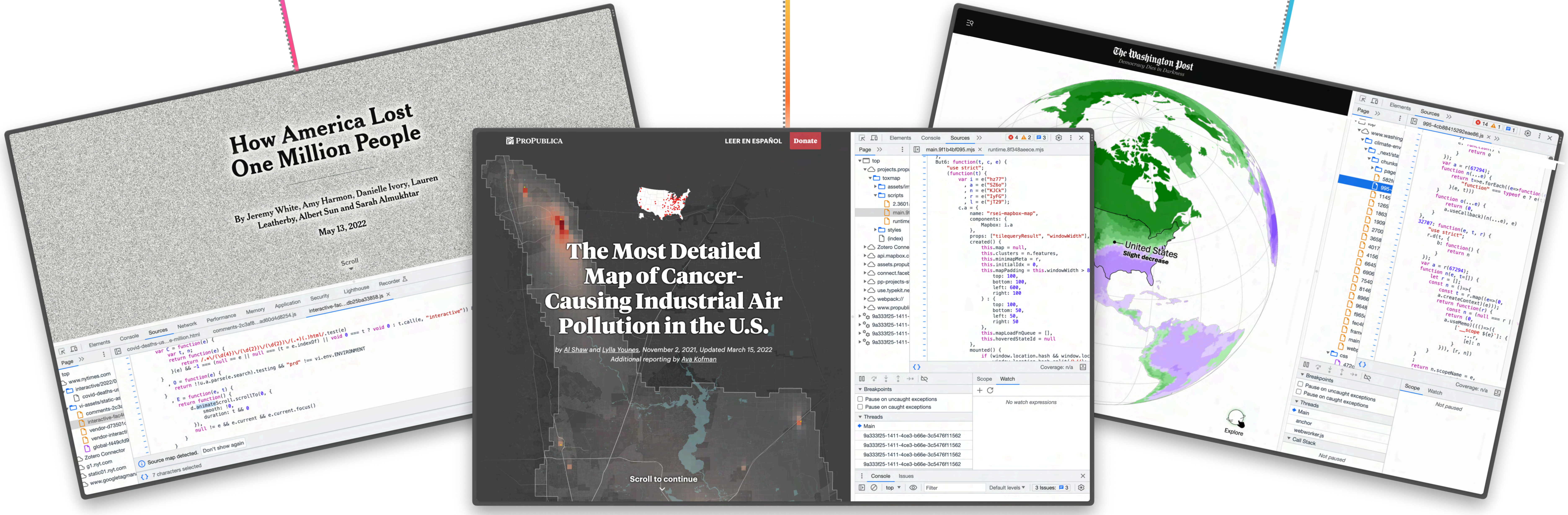
The Washington Post
Democracy Dies in Darkness

Change in deaths linked to temperature

Projected average for 2080-2099, compared to a world without additional emissions

“Telling **stories** with **data**”

Data Journalism



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May 13, 2022

Scroll

PROPUBLICA

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Scroll to continue

The Washington Post
Democracy Dies in Darkness

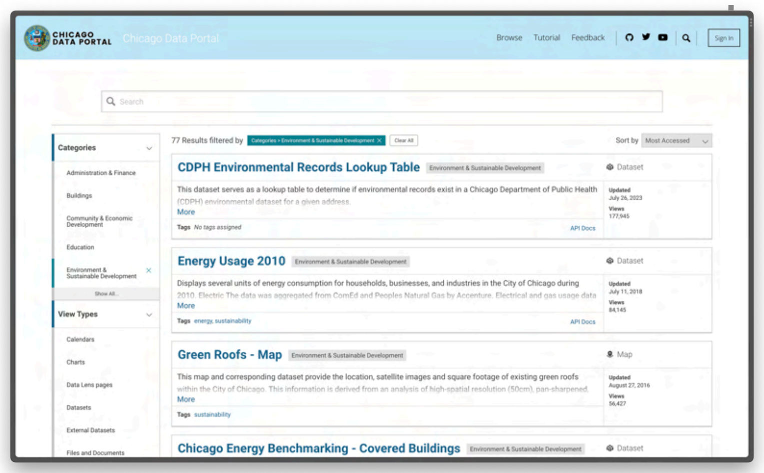
United States
Slight decrease

Explore

(Lots and lots of)

Programming

Data Journalism



CHICAGO DATA PORTAL Chicago Data Portal — Browse Tutorial Feedback Sign In

Search

Categories: Administration & Finance; Buildings; Community & Economic Development; Education; Environment & Sustainable Development; Show All...

View Types: Calendars; Charts; Data Lens pages; Datasets; External Datasets; Files and Documents

77 Results filtered by Categories > Environment & Sustainable Development — Clear All — Sort by Most Accessed

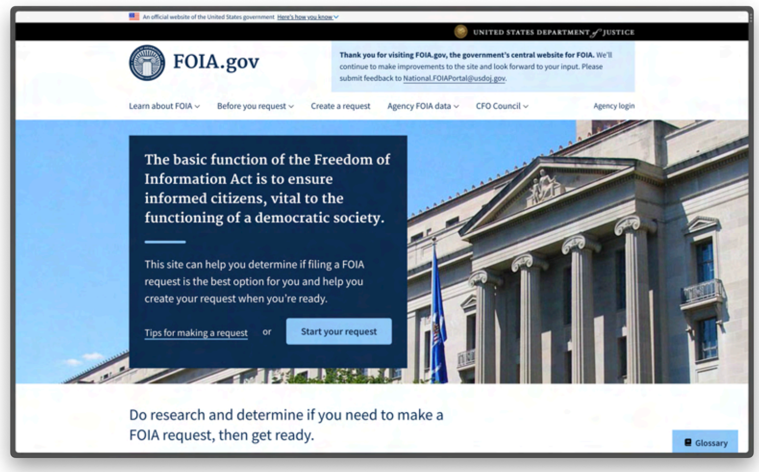
CDPH Environmental Records Lookup Table — Environment & Sustainable Development — Dataset
This dataset serves as a lookup table to determine if environmental records exist in a Chicago Department of Public Health (CDPH) environmental dataset for a given address. More
Tags No tags assigned — API Docs — Updated July 26, 2023 — Views 177,945

Energy Usage 2010 — Environment & Sustainable Development — Dataset
Displays several units of energy consumption for households, businesses, and industries in the City of Chicago during 2010. Electric The data was aggregated from ComEd and Peoples Natural Gas by Accenture. Electrical and gas usage data More
Tags energy, sustainability — API Docs — Updated July 11, 2018 — Views 84,145

Green Roofs - Map — Environment & Sustainable Development — Map
This map and corresponding dataset provide the location, satellite images and square footage of existing green roofs within the City of Chicago. This information is derived from an analysis of high-spatial resolution (50cm), pan-sharpened, More
Tags sustainability — Updated August 27, 2016 — Views 56,427

Chicago Energy Benchmarking - Covered Buildings — Environment & Sustainable Development — Dataset

Municipal Agencies



An official website of the United States government Here's how you know

UNITED STATES DEPARTMENT of JUSTICE

FOIA.gov

Thank you for visiting FOIA.gov, the government's central website for FOIA. We'll continue to make improvements to the site and look forward to your input. Please submit feedback to National.FOIAPortal@usdoj.gov.

Learn about FOIA — Before you request — Create a request — Agency FOIA data — CFO Council — Agency login

The basic function of the Freedom of Information Act is to ensure informed citizens, vital to the functioning of a democratic society.

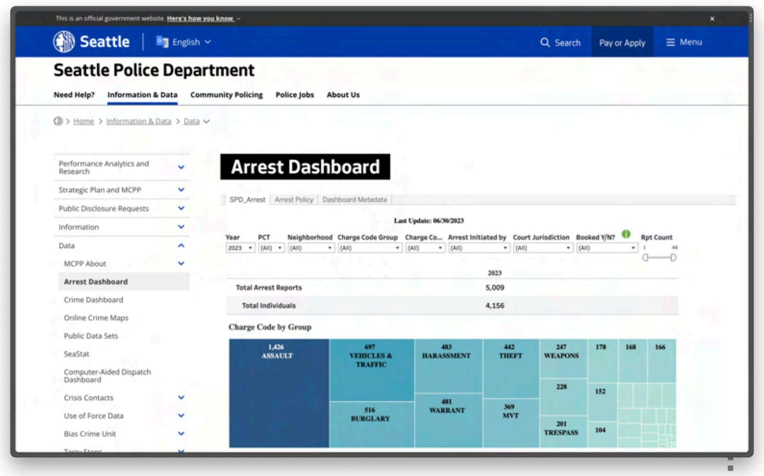
This site can help you determine if filing a FOIA request is the best option for you and help you create your request when you're ready.

Tips for making a request or Start your request

Do research and determine if you need to make a FOIA request, then get ready.

Glossary

FOIA Requests



This is an official government website. Here's how you know

Seattle — English — Search — Pay or Apply — Menu

Seattle Police Department

Need Help? — Information & Data — Community Policing — Police Jobs — About Us

Home > Information & Data > Data

Performance Analytics and Research; Strategic Plan and MCPP; Public Disclosure Requests; Information; Data; MCPP About; Arrest Dashboard; Crime Dashboard; Online Crime Maps; Public Data Sets; SeaStat; Computer-Aided Dispatch Dashboard; Crisis Contacts; Use of Force Data; Bias Crime Unit

Arrest Dashboard

SPD_Arrest — Arrest Policy — Dashboard Metadata

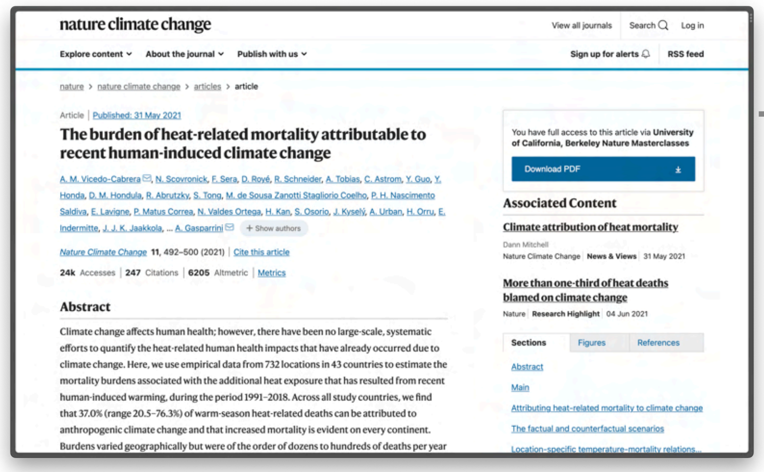
Last Update: 06/30/2023

Year 2023 — PCT (All) — Neighborhood (All) — Charge Code Group (All) — Charge Co... (All) — Arrest Initiated by (All) — Court Jurisdiction (All) — Booked Y/N? (All) — Rpt Count 1 44

	2023
Total Arrest Reports	5,009
Total Individuals	4,156

Charge Code by Group

Police Departments



nature climate change — View all journals — Search — Log in

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Article | Published: 31 May 2021

The burden of heat-related mortality attributable to recent human-induced climate change

A. M. Vicedo-Cabrera, N. Scovronick, F. Sera, D. Royé, R. Schneider, A. Tobias, C. Astrom, Y. Guo, Y. Honda, D. M. Hondula, R. Abrutzky, S. Tong, M. de Sousa Zanotti Stagliorio Coelho, P. H. Nascimento Saldiva, E. Lavigne, P. Matus Correa, N. Valdes Ortega, H. Kan, S. Osorio, J. Kyselý, A. Urban, H. Orru, E. Indermitte, J. J. K. Jaakkola, ... A. Gasparrini + Show authors

Nature Climate Change 11, 492–500 (2021) | Cite this article

24k Accesses | 247 Citations | 6205 Altmetric | Metrics

Abstract

Climate change affects human health; however, there have been no large-scale, systematic efforts to quantify the heat-related human health impacts that have already occurred due to climate change. Here, we use empirical data from 732 locations in 43 countries to estimate the mortality burdens associated with the additional heat exposure that has resulted from recent human-induced warming, during the period 1991–2018. Across all study countries, we find that 37.0% (range 20.5–76.3%) of warm-season heat-related deaths can be attributed to anthropogenic climate change and that increased mortality is evident on every continent. Burdens varied geographically but were of the order of dozens to hundreds of deaths per year

You have full access to this article via University of California, Berkeley Nature Masterclasses

Download PDF

Associated Content

Climate attribution of heat mortality — Dann Mitchell — Nature Climate Change | News & Views | 31 May 2021

More than one-third of heat deaths blamed on climate change — Nature | Research Highlight | 04 Jun 2021

Sections — Figures — References

Abstract; Main; Attributing heat-related mortality to climate change; The factual and counterfactual scenarios; Location-specific temperature-mortality relations...

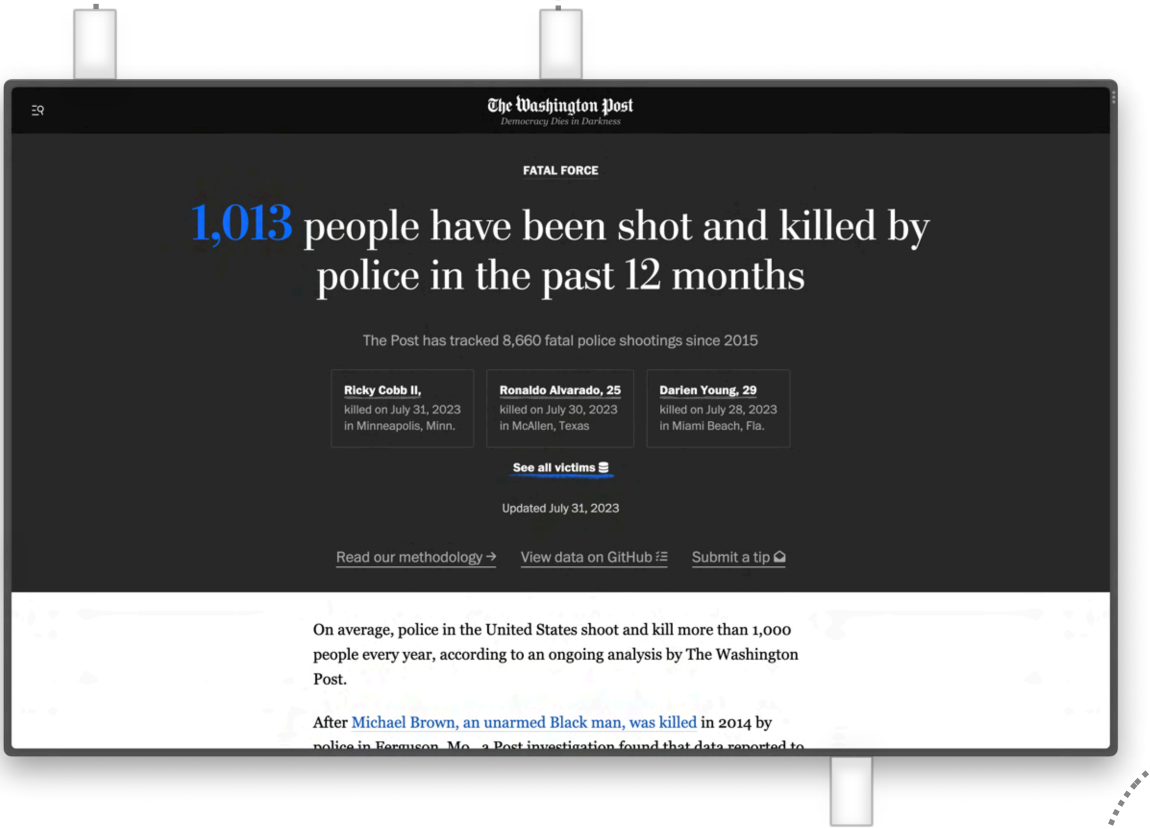
Academic Journals

Normalize

Filter

Transform

Clean



The Washington Post
Democracy Dies in Darkness

FATAL FORCE

1,013 people have been shot and killed by police in the past 12 months

The Post has tracked 8,660 fatal police shootings since 2015

Ricky Cobb II, killed on July 31, 2023 in Minneapolis, Minn.	Ronaldo Alvarado, 25 killed on July 30, 2023 in McAllen, Texas	Darien Young, 29 killed on July 28, 2023 in Miami Beach, Fla.

See all victims

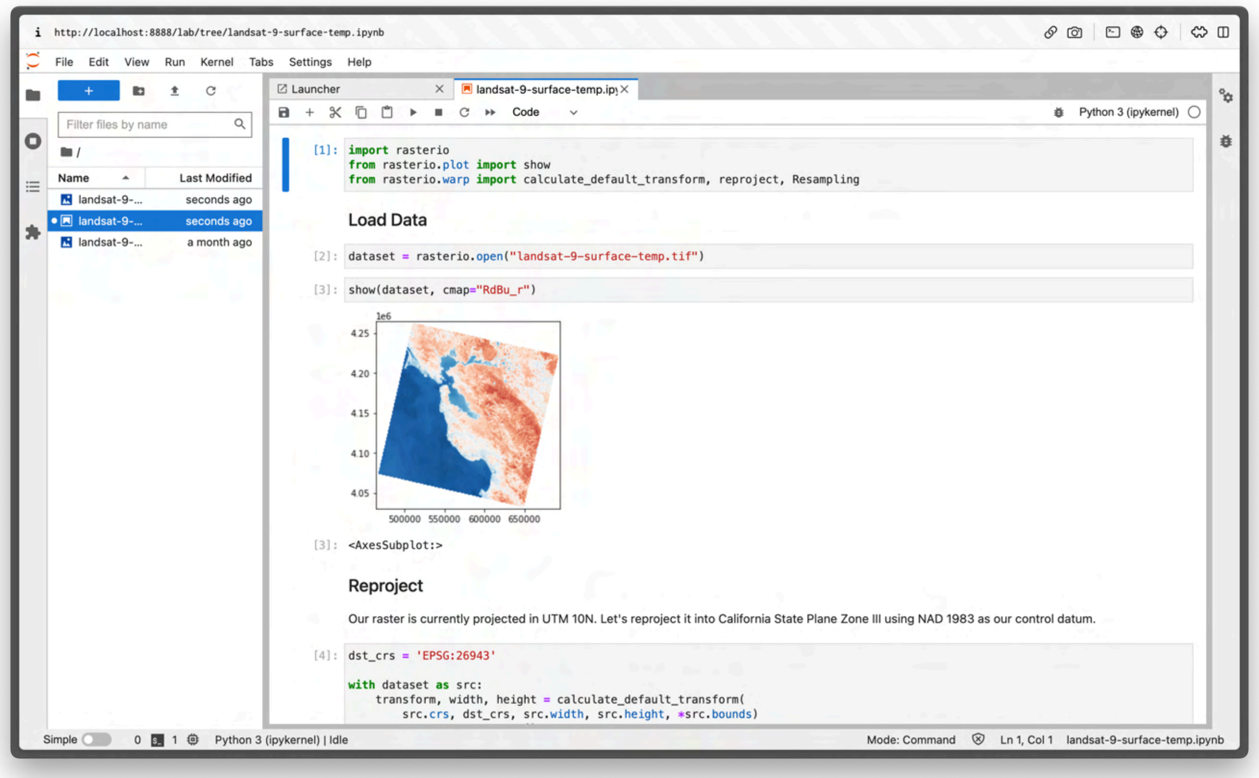
Updated July 31, 2023

Read our methodology → — View data on GitHub — Submit a tip

On average, police in the United States shoot and kill more than 1,000 people every year, according to an ongoing analysis by The Washington Post.

After Michael Brown, an unarmed Black man, was killed in 2014 by police in Ferguson, Mo., a Post investigation found that data reported to

Data Journalism



```
[1]: import rasterio
     from rasterio.plot import show
     from rasterio.warp import calculate_default_transform, reproject, Resampling
```

Load Data

```
[2]: dataset = rasterio.open("landsat-9-surface-temp.tif")

[3]: show(dataset, cmap="RdBu_r")

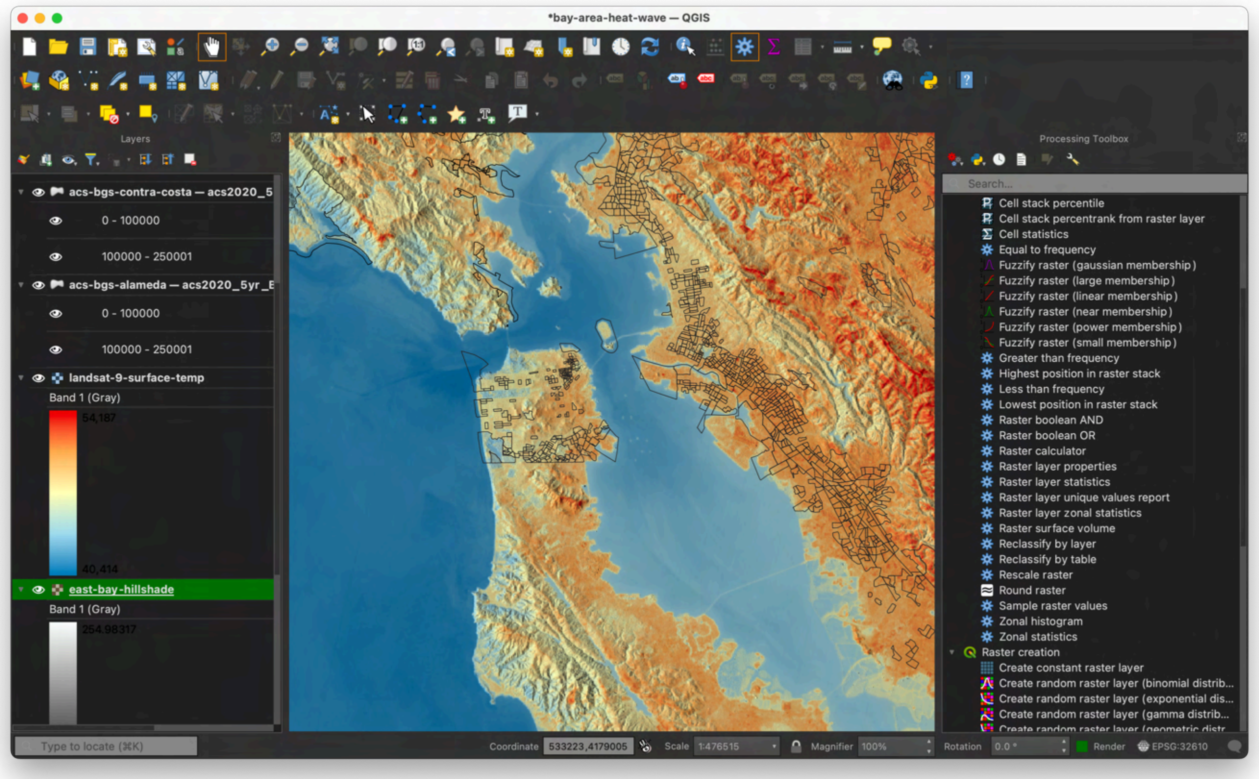
[3]: <AxesSubplot:>
```

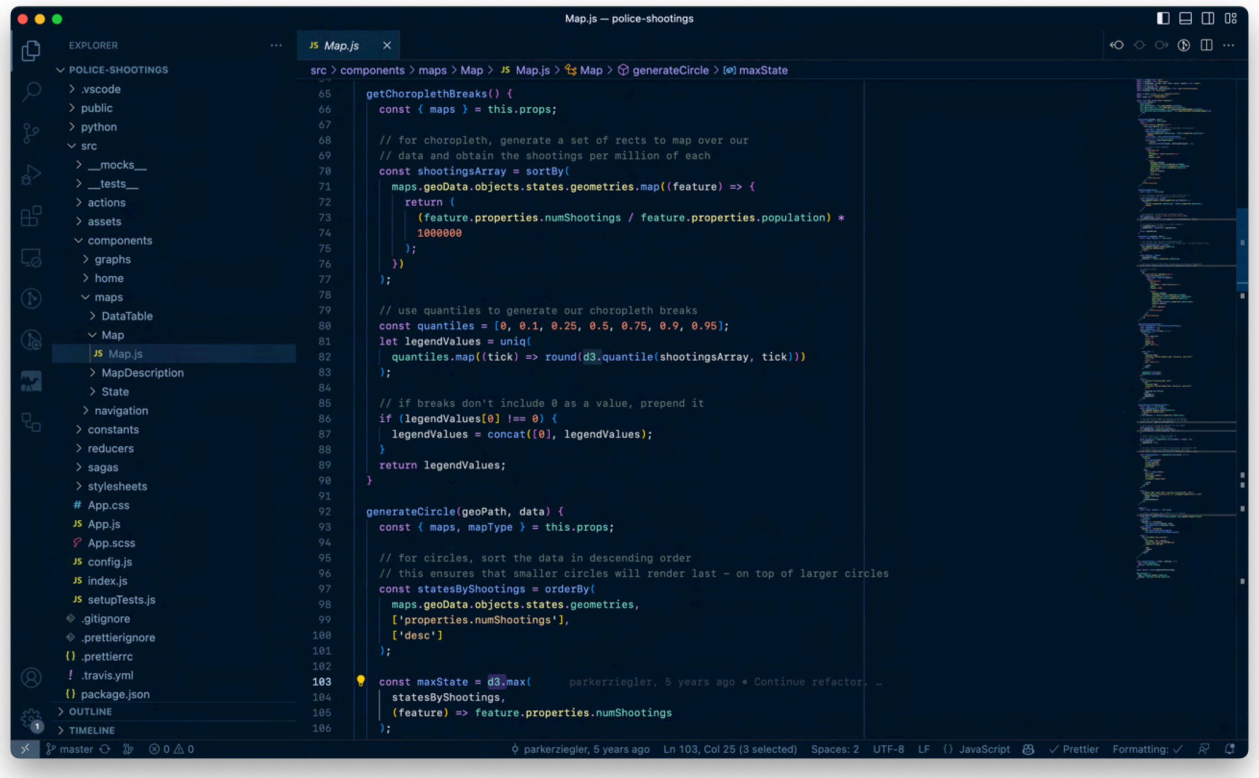
Reproject

Our raster is currently projected in UTM 10N. Let's reproject it into California State Plane Zone III using NAD 1983 as our control datum.

```
[4]: dst_crs = 'EPSG:26943'

     with dataset as src:
         transform, width, height = calculate_default_transform(
             src.crs, dst_crs, src.width, src.height, *src.bounds)
```


*bay-area-heat-wave — QGIS
Layers
acs-bgs-contra-costa — acs2020_5
0 - 100000
100000 - 250001
acs-bgs-alameda — acs2020_5yr_
0 - 100000
100000 - 250001
landsat-9-surface-temp
Band 1 (Gray)
east-bay-hillshade
Band 1 (Gray)
Processing Toolbox
Search...
Cell stack percentile
Cell stack percentrank from raster layer
Cell statistics
Equal to frequency
Fuzzify raster (gaussian membership)
Fuzzify raster (large membership)
Fuzzify raster (linear membership)
Fuzzify raster (near membership)
Fuzzify raster (power membership)
Fuzzify raster (small membership)
Greater than frequency
Highest position in raster stack
Less than frequency
Lowest position in raster stack
Raster boolean AND
Raster boolean OR
Raster calculator
Raster layer properties
Raster layer statistics
Raster layer unique values report
Raster layer zonal statistics
Raster surface volume
Reclassify by layer
Reclassify by table
Rescale raster
Round raster
Sample raster values
Zonal histogram
Zonal statistics
Raster creation
Create constant raster layer
Create random raster layer (binomial distrib...
Create random raster layer (exponential dis...
Create random raster layer (gamma distrib...
Rotation
0.0 °
Render
EPSG:32610


Map.js — police-shootings
EXPLORER
POLICE-SHOOTINGS
Map.js
src > components > maps > Map > Map.js > Map > generateCircle > maxState
parkerziegler, 5 years ago
Ln 103, Col 25 (3 selected)
Spaces: 2
UTF-8
LF
JavaScript

```
getChoroplethBreaks() {
  const { maps } = this.props;

  // for choropleth, generate a set of rects to map over our
  // data and obtain the shootings per million of each
  const shootingsArray = sortBy(
    maps.geoData.objects.states.geometries.map((feature) => {
      return (
        (feature.properties.numShootings / feature.properties.population) *
        1000000
      );
    })
  );

  // use quantiles to generate our choropleth breaks
  const quantiles = [0, 0.1, 0.25, 0.5, 0.75, 0.9, 0.95];
  let legendValues = uniq(
    quantiles.map((tick) => round(d3.quantile(shootingsArray, tick)))
  );

  // if breaks don't include 0 as a value, prepend it
  if (legendValues[0] !== 0) {
    legendValues = concat([0], legendValues);
  }
  return legendValues;
}

generateCircle(geoPath, data) {
  const { maps, mapType } = this.props;

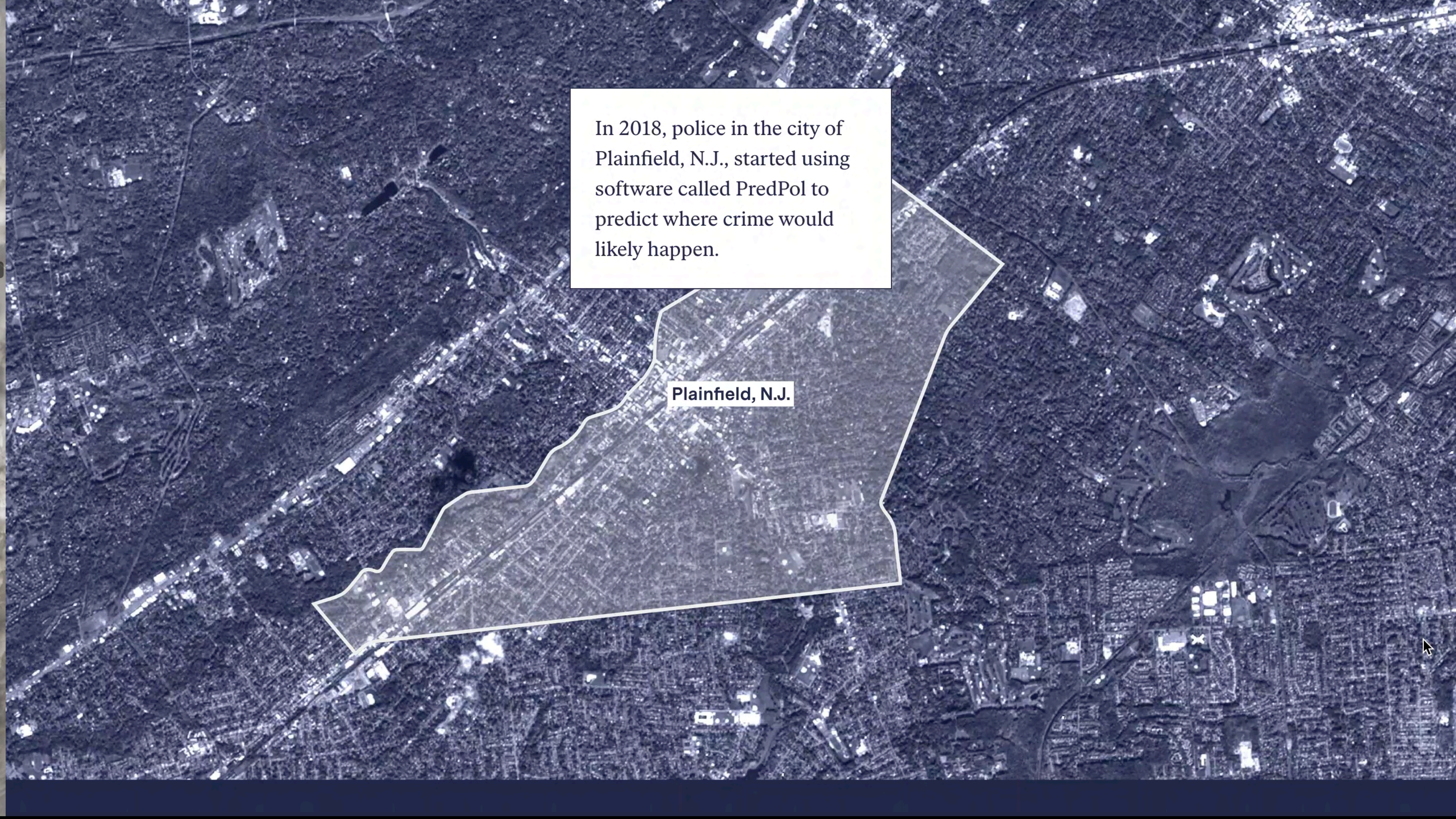
  // for circles, sort the data in descending order
  // this ensures that smaller circles will render last - on top of larger circles
  const statesByShootings = orderBy(
    maps.geoData.objects.states.geometries,
    ['properties.numShootings'],
    ['desc']
  );

  const maxState = d3.max(      parkerziegler, 5 years ago • Continue refactor. …
    statesByShootings,
    (feature) => feature.properties.numShootings
  );
```

Computational Notebooks

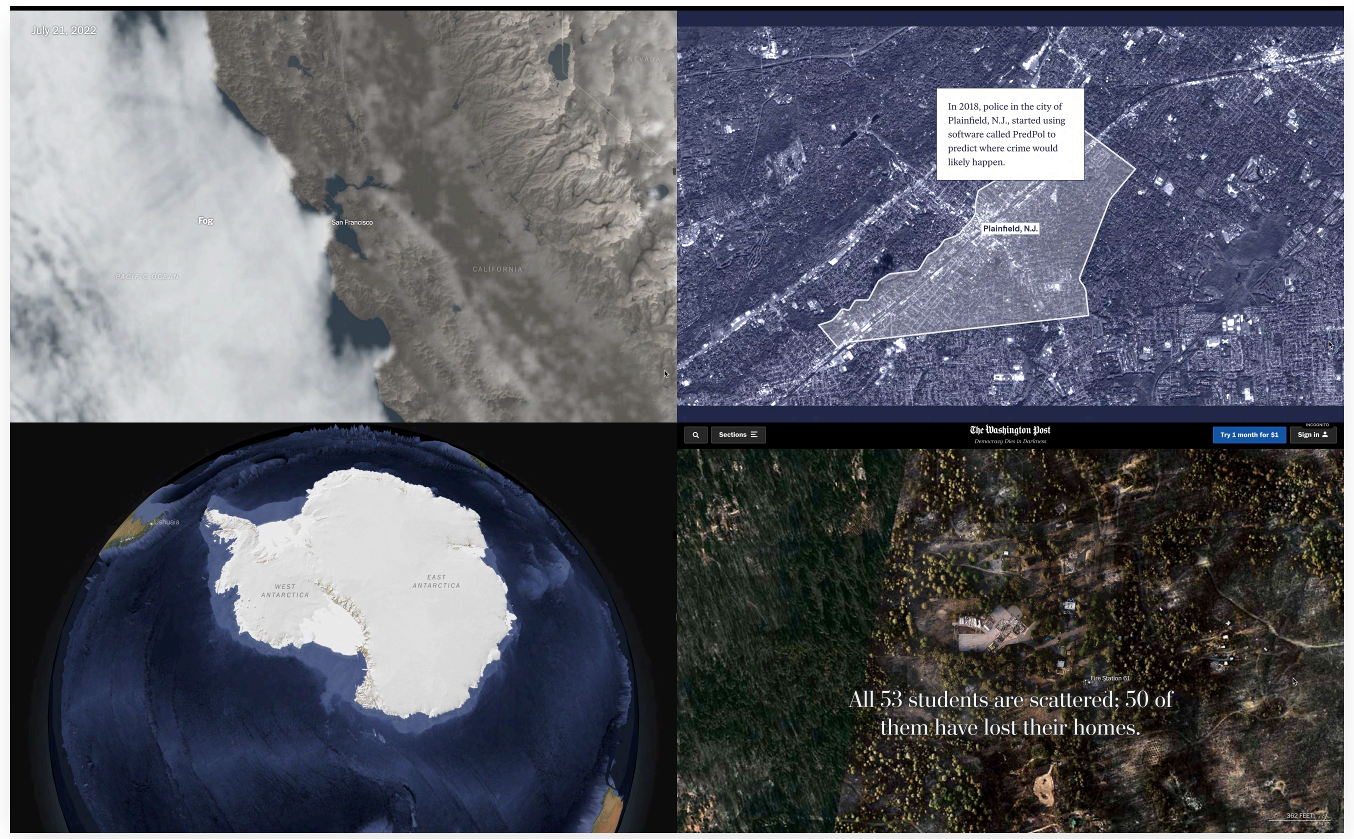
GIS Software

Web Frontends


In 2018, police in the city of Plainfield, N.J., started using software called PredPol to predict where crime would likely happen.

All 53 students are scattered; 50 of them have lost their homes.

Data Journalism



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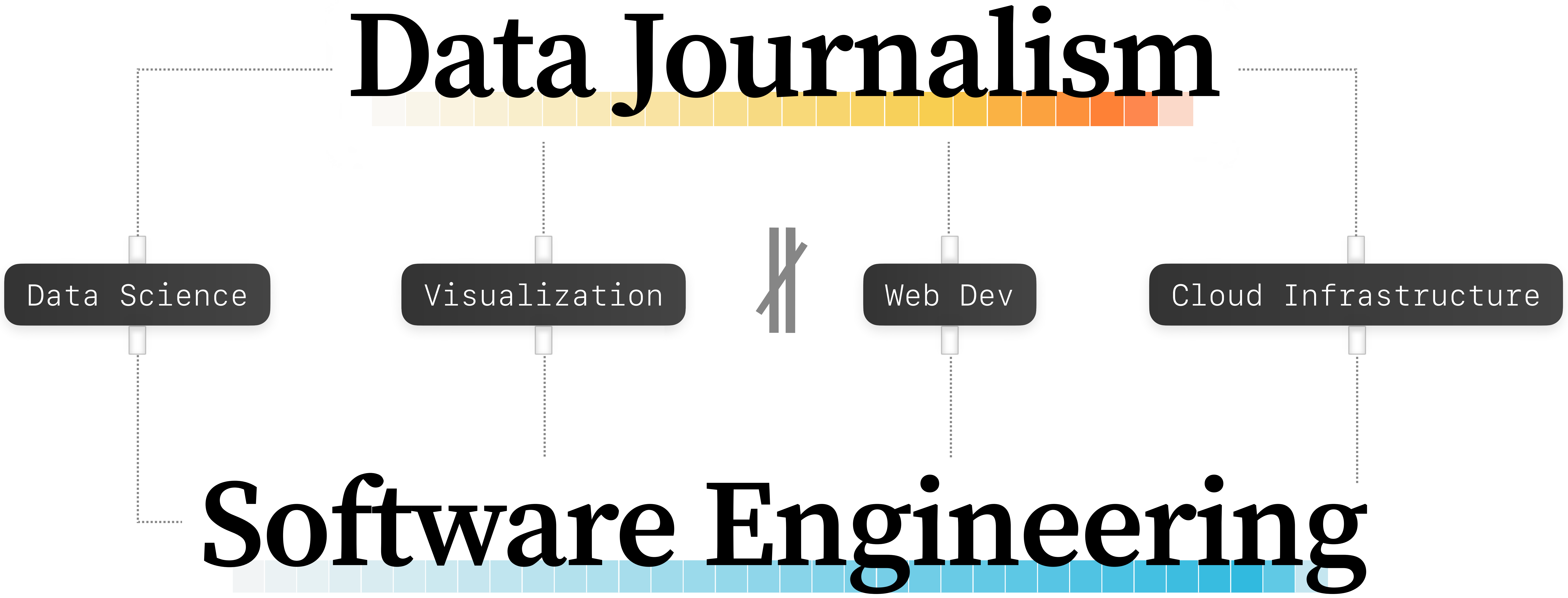
All 53 students are scattered; 50 of them have lost their homes.

Programming



Data Journalism

Data Science

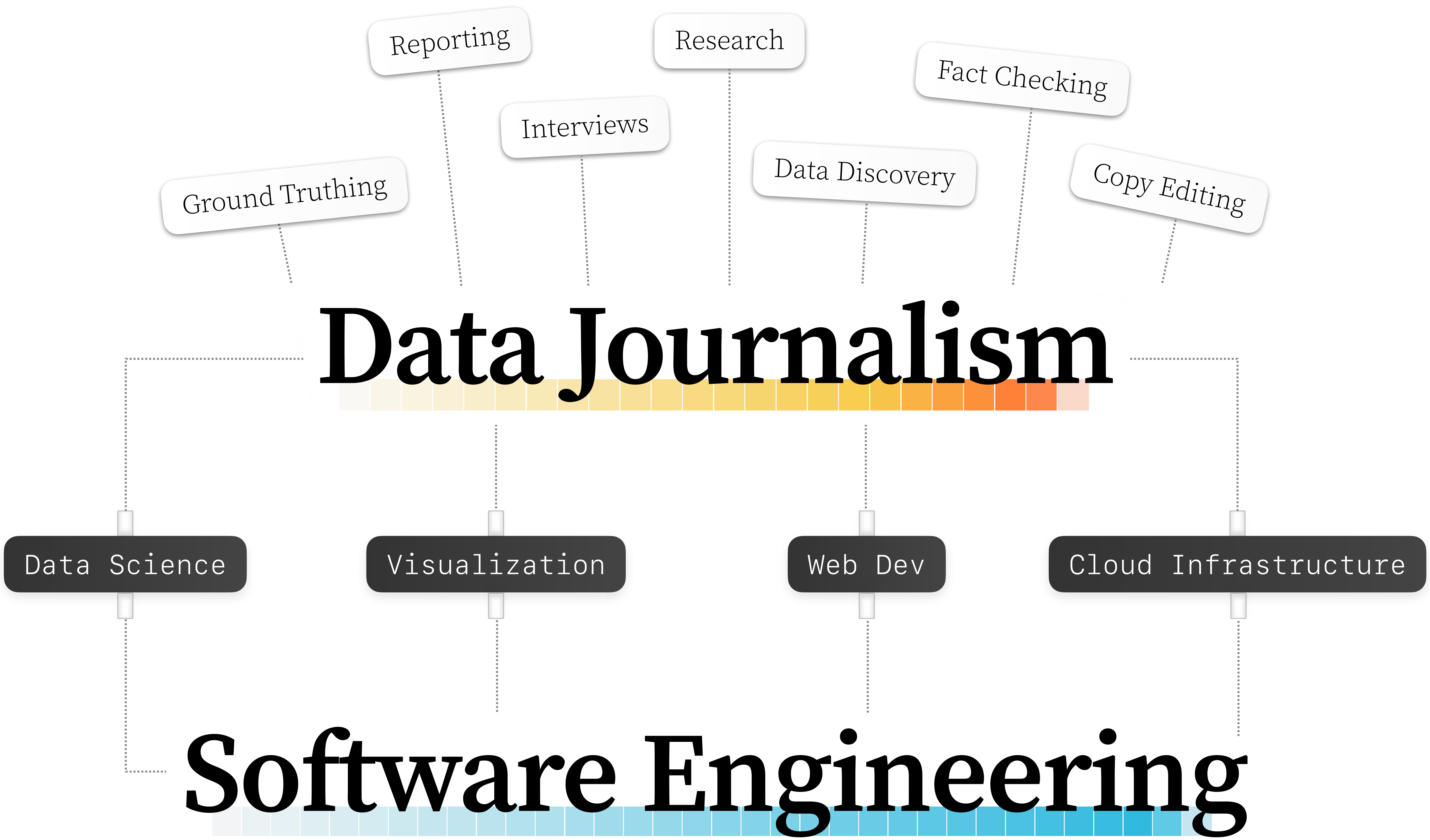
Visualization

∦

Web Dev

Cloud Infrastructure

Software Engineering



Reporting

Research

Fact Checking

Interviews

Data Discovery

Copy Editing

Ground Truthing

Data Journalism

Data Science

Visualization

Web Dev

Cloud Infrastructure

Software Engineering

T wp

Los Angeles Times

PROPUBLICA

FiveThirtyEight

Graphics

Desk

Grist

THE CITY

The Markup

T

wp

Los Angeles Times

PROPUBLICA

FiveThirtyEight

KQED

CALMATTERS

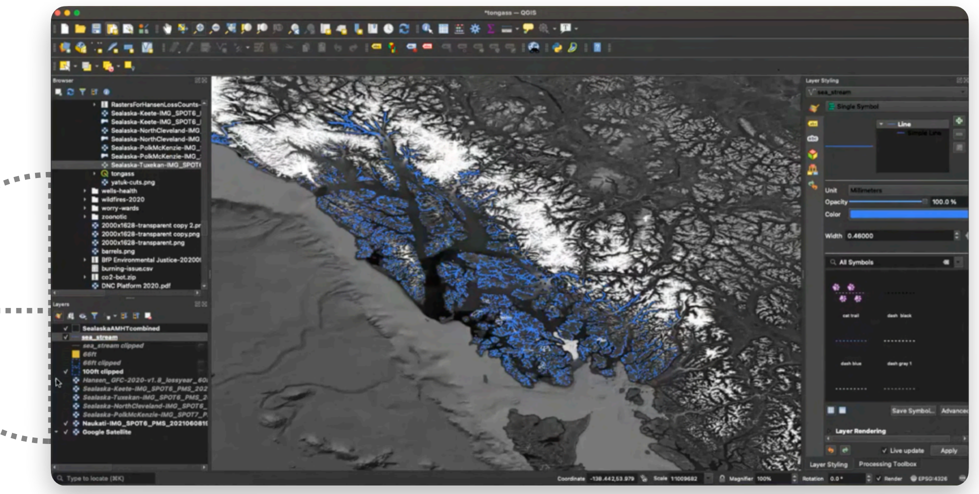
EYE ON OHIO
Ohio Center for Journalism

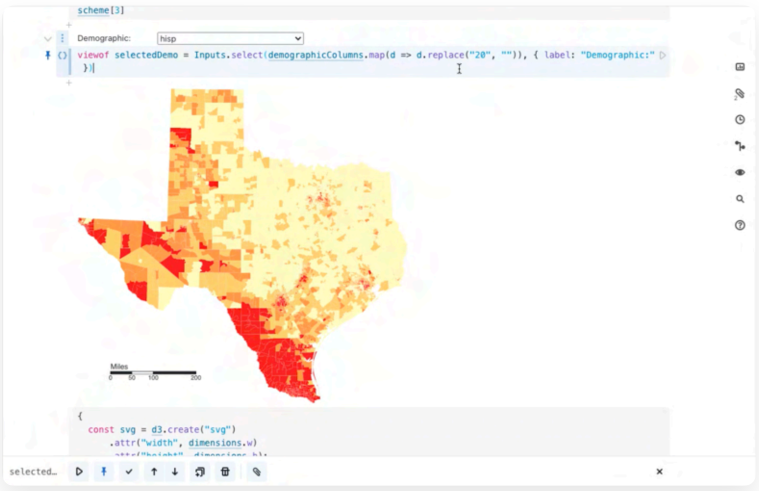
~~Graphics~~ ~~Desk~~

(1 or 2 data journalists)

How can we design and build **programming tools** to support the working practices of **data journalists**?

How can we design and build **programming tools** to support the **working practices** of **data journalists**?



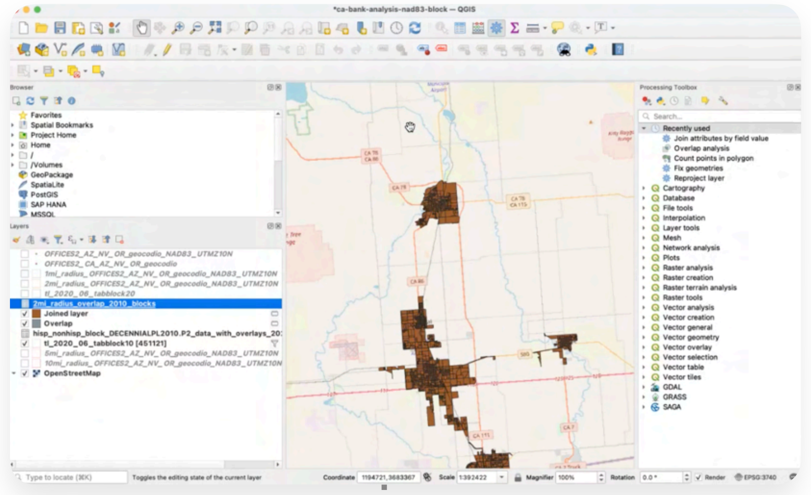


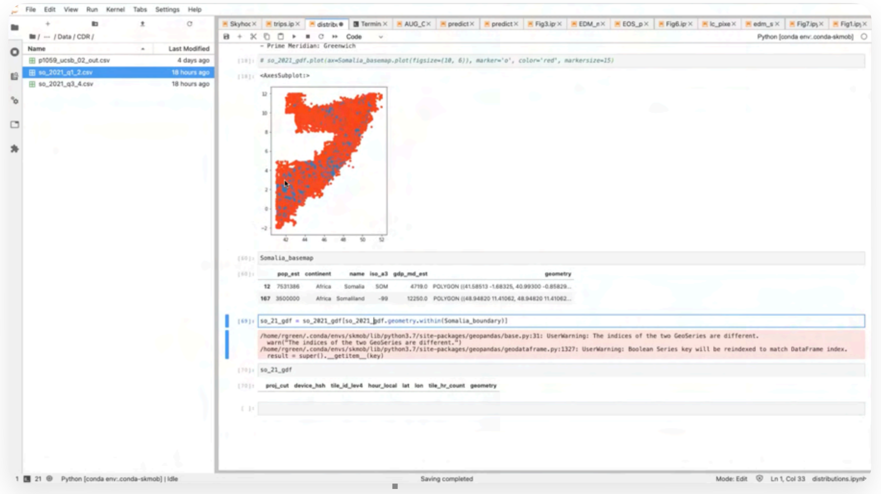
```
scheme[3]
```

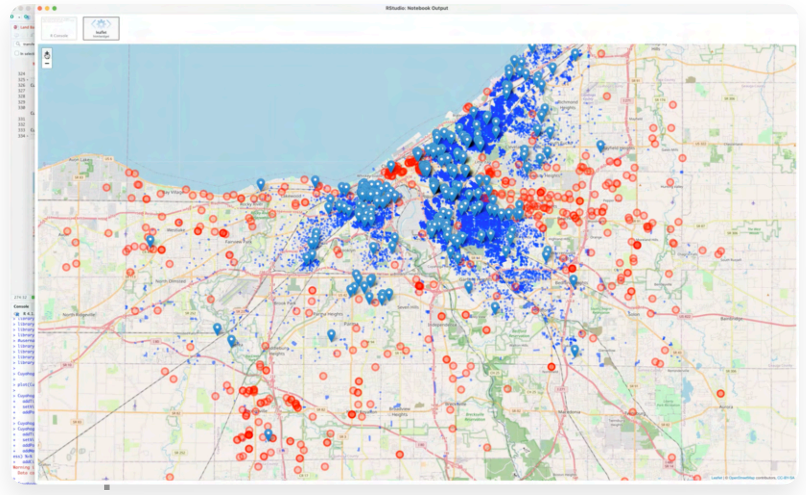
Demographic: hisp

```
viewof selectedDemo = Inputs.select(demographicColumns.map(d => d.replace("20", "")), { label: "Demographic:"
 })
```

```
{
  const svg = d3.create("svg")
      .attr("width", dimensions.w)
```







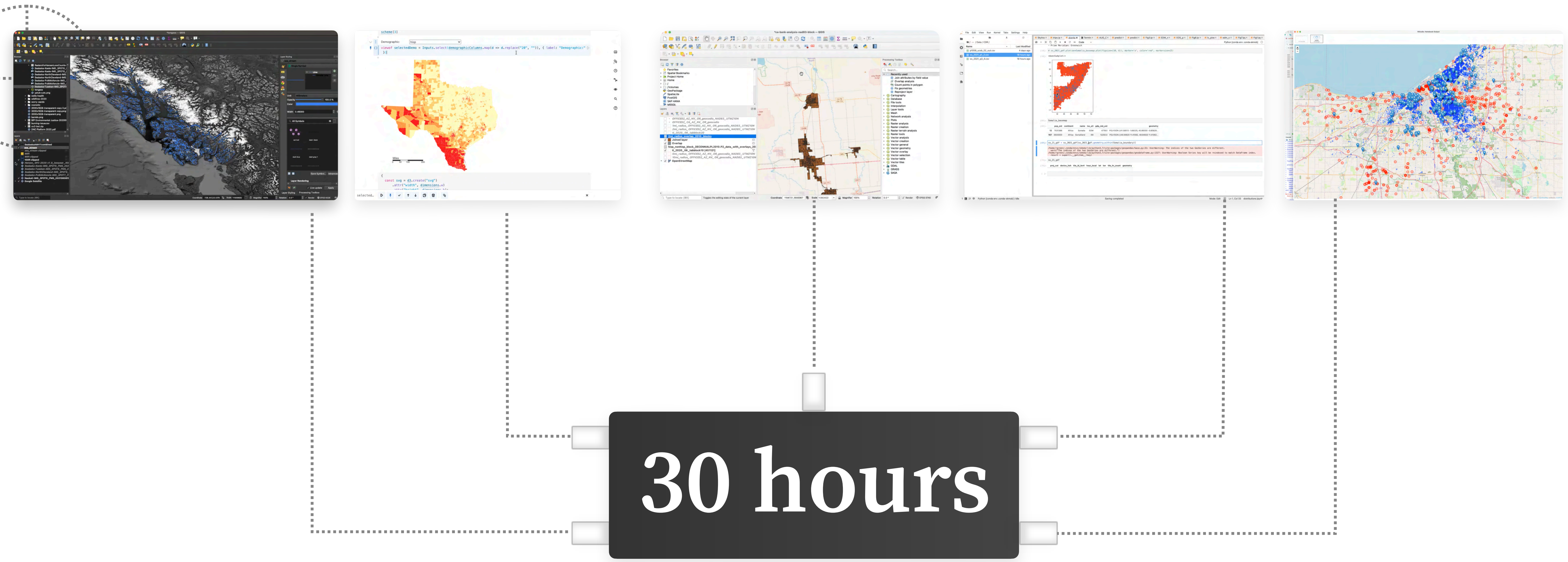
30 hours

of video observation with

Data Journalists

Social Scientists

Earth and Climate Scientists



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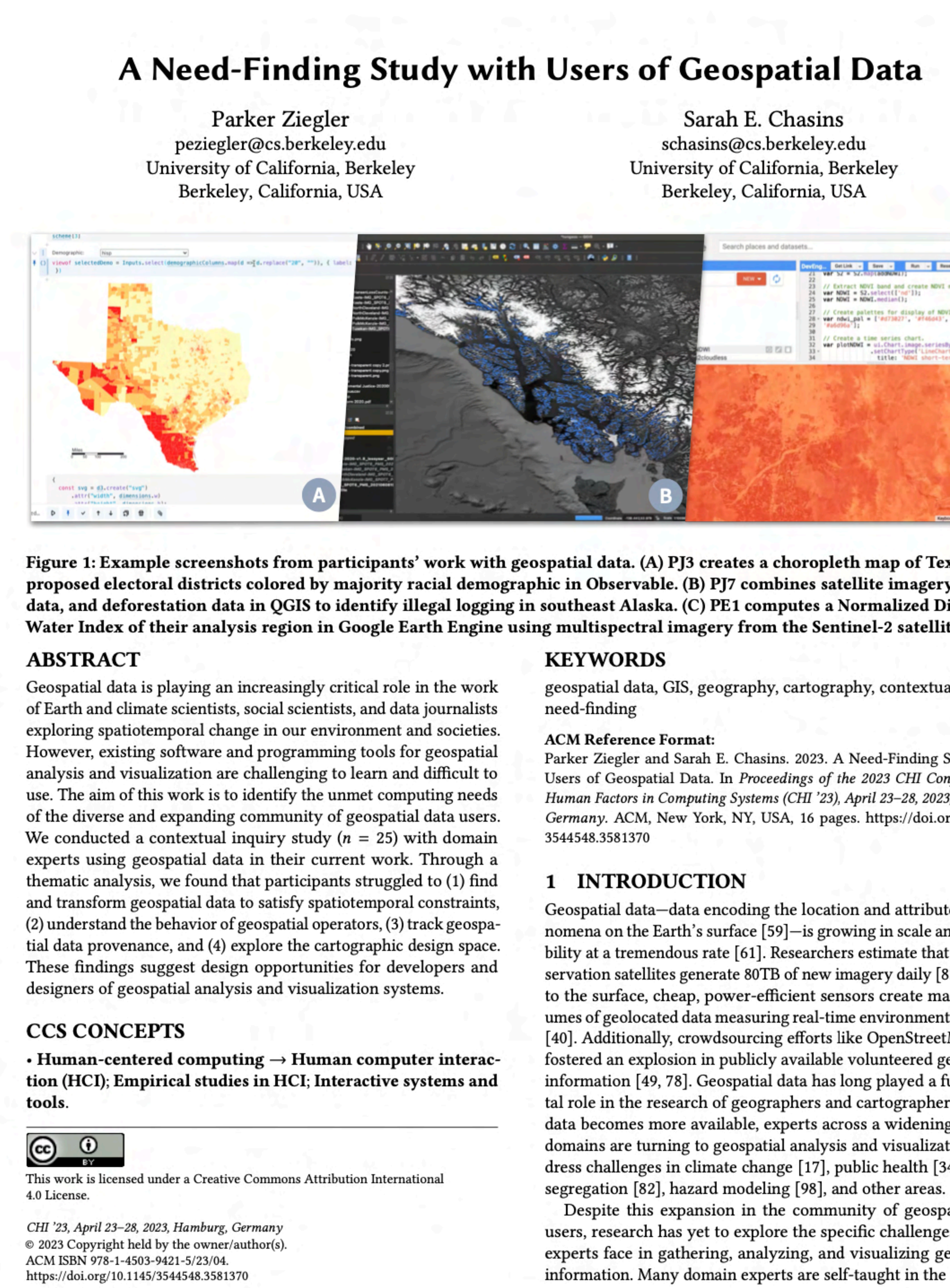

A Need-Finding Study with Users of Geospatial Data

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Berkeley, California, USA

Sarah E. Chasins
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Berkeley, California, USA

**Figure 1: Example screenshots from participants' work with geospatial data. (A) PJ3 creates a choropleth map of Tex
proposed electoral districts colored by majority racial demographic in Observable. (B) PJ7 combines satellite imagery
data, and deforestation data in QGIS to identify illegal logging in southeast Alaska. (C) PE1 computes a Normalized Di
Water Index of their analysis region in Google Earth Engine using multispectral imagery from the Sentinel-2 satellit**

ABSTRACT

Geospatial data is playing an increasingly critical role in the work of Earth and climate scientists, social scientists, and data journalists exploring spatiotemporal change in our environment and societies. However, existing software and programming tools for geospatial analysis and visualization are challenging to learn and difficult to use. The aim of this work is to identify the unmet computing needs of the diverse and expanding community of geospatial data users. We conducted a contextual inquiry study ($n = 25$) with domain experts using geospatial data in their current work. Through a thematic analysis, we found that participants struggled to (1) find and transform geospatial data to satisfy spatiotemporal constraints, (2) understand the behavior of geospatial operators, (3) track geospatial data provenance, and (4) explore the cartographic design space. These findings suggest design opportunities for developers and designers of geospatial analysis and visualization systems.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI); Empirical studies in HCI; Interactive systems and tools.**

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KEYWORDS

geospatial data, GIS, geography, cartography, contextua
need-finding

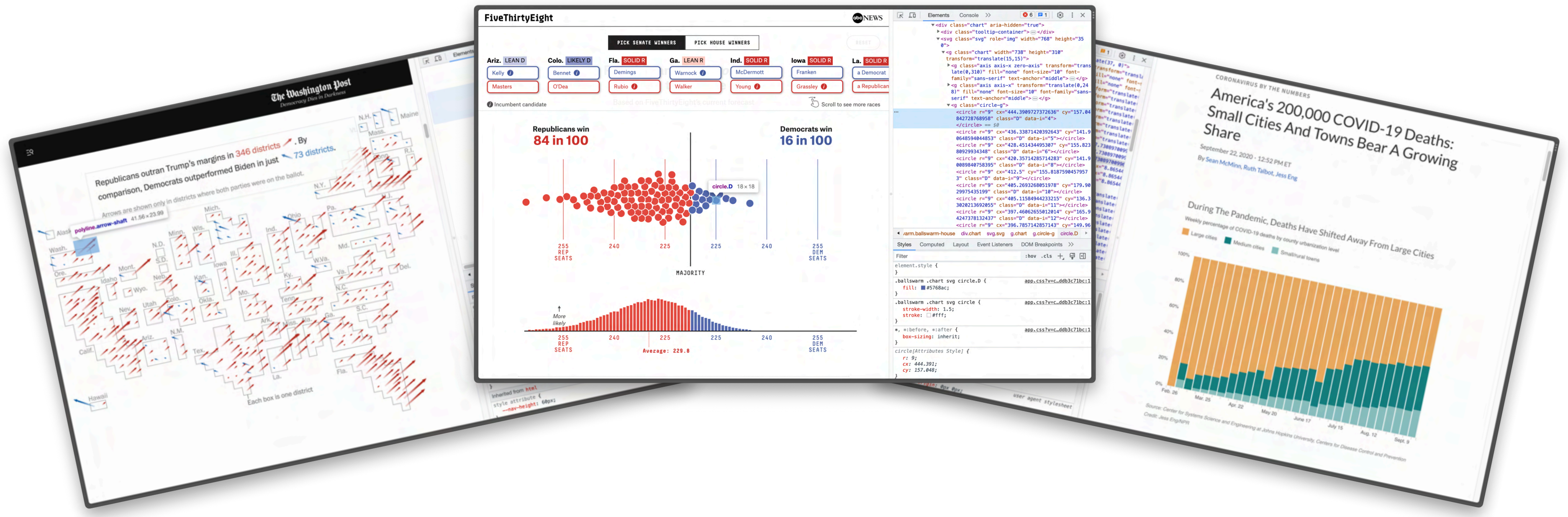
ACM Reference Format:
Parker Ziegler and Sarah E. Chasins. 2023. A Need-Finding S
Users of Geospatial Data. In *Proceedings of the 2023 CHI Con
Human Factors in Computing Systems (CHI '23), April 23–28, 2023
Germany.* ACM, New York, NY, USA, 16 pages. https://doi.or
3544548.3581370

1 INTRODUCTION

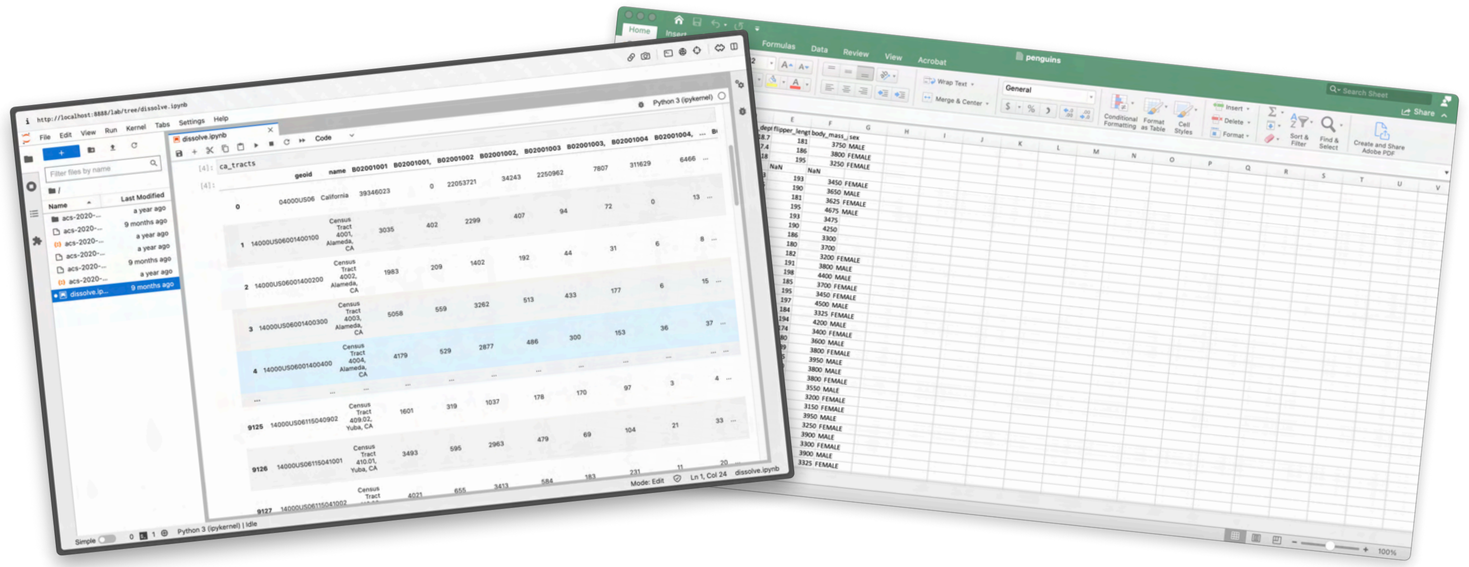
Geospatial data—data encoding the location and attribut
nomena on the Earth's surface [59]—is growing in scale an
bility at a tremendous rate [61]. Researchers estimate that
servation satellites generate 80TB of new imagery daily [8
to the surface, cheap, power-efficient sensors create ma
umes of geolocated data measuring real-time environment
[40]. Additionally, crowdsourcing efforts like OpenStreet
fostered an explosion in publicly available volunteered ge
information [49, 78]. Geospatial data has long played a fu
tal role in the research of geographers and cartographer
data becomes more available, experts across a widening
domains are turning to geospatial analysis and visualizat
dress challenges in climate change [17], public health [3
segregation [82], hazard modeling [98], and other areas.

Despite this expansion in the community of geospa
users, research has yet to explore the specific challenge
experts face in gathering, analyzing, and visualizing ge
information. Many domain experts are self-taught in the

Lift **visual styles** and **graphical forms** from **examples**


The Washington Post
FiveThirtyEight
Republicans win
84 in 100
Democrats win
16 in 100
America's 200,000 COVID-19 Deaths: Small Cities And Towns Bear A Growing Share
During The Pandemic, Deaths Have Shifted Away From Large Cities

Apply to new datasets

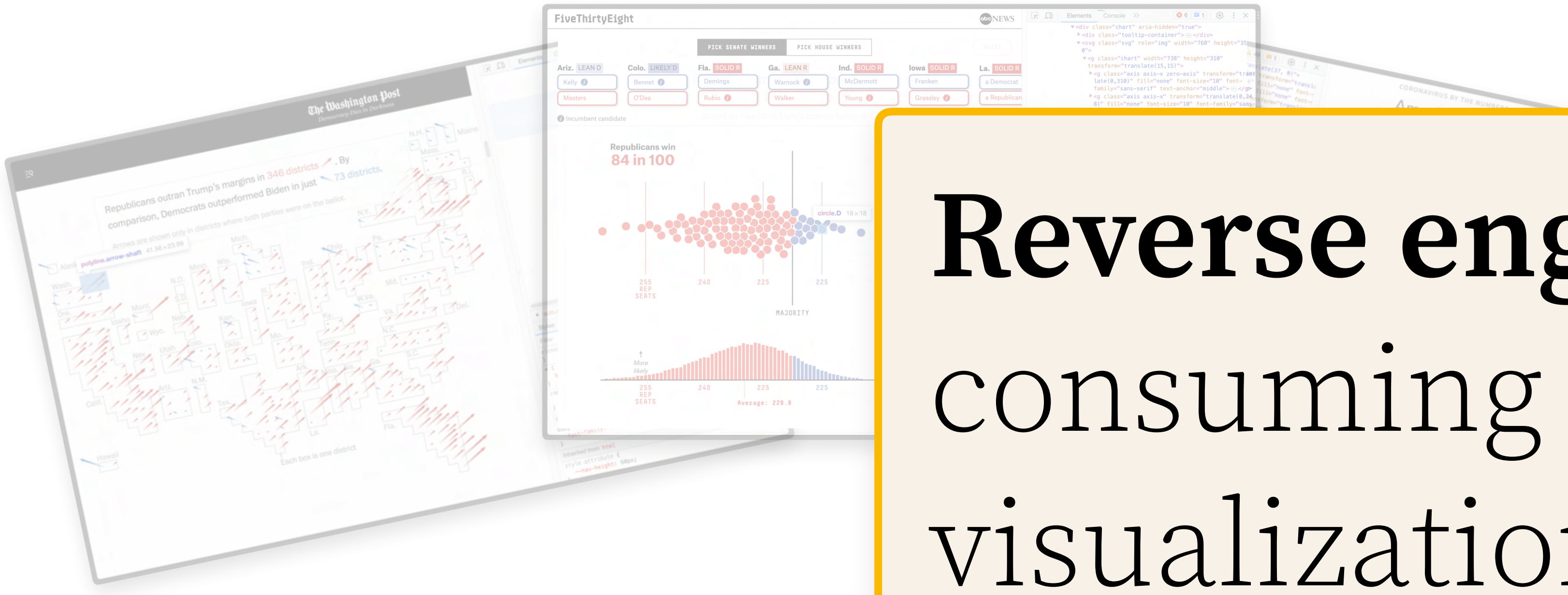


Data Journalists

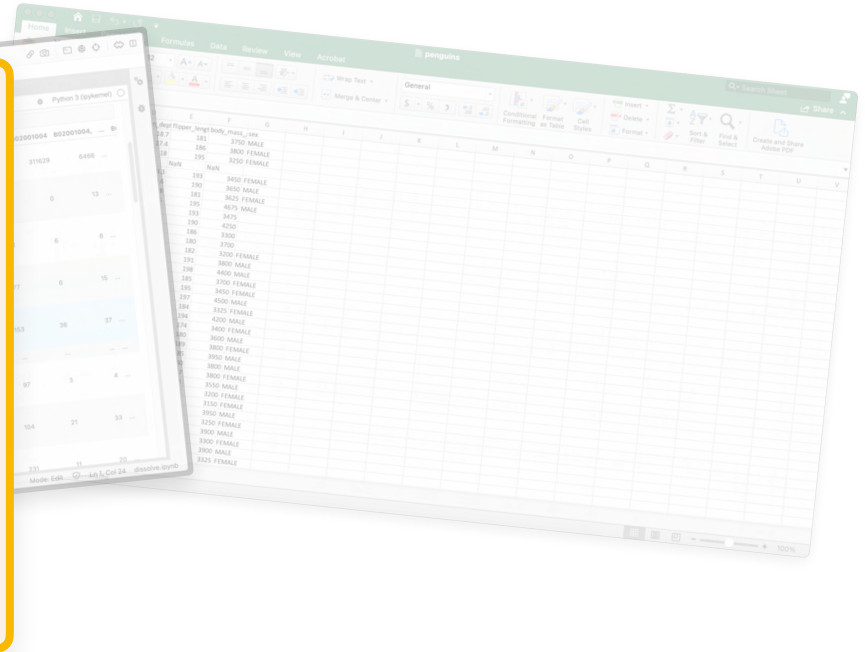
Social Scientists

Earth and Climate Scientists

Lift **visual styles** and **graphical forms** from **examples**



Apply to new datasets



Reverse engineering was as time-consuming as developing the visualization **from scratch**.

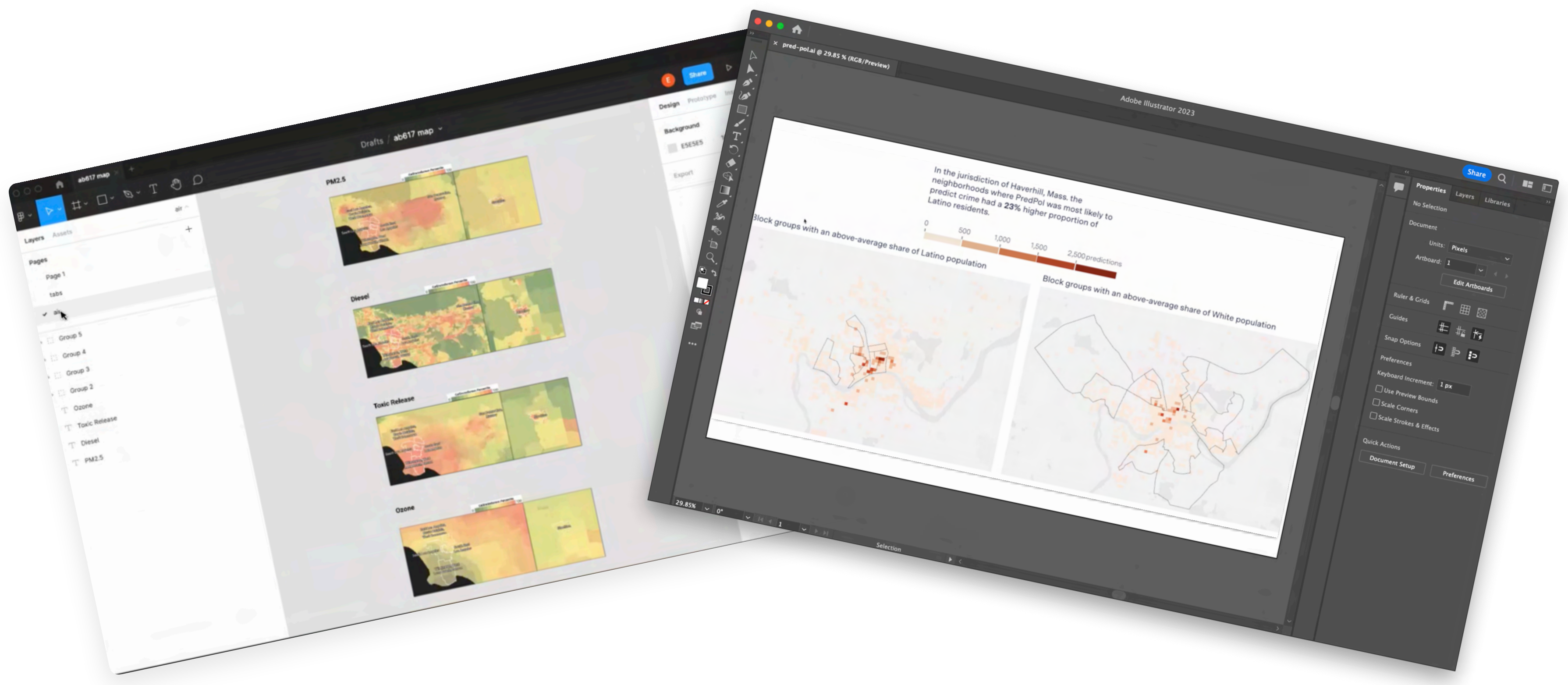
Data Journalists

Social Scientists

Earth and Climate Scientists

Sketch visualizations in **design software**

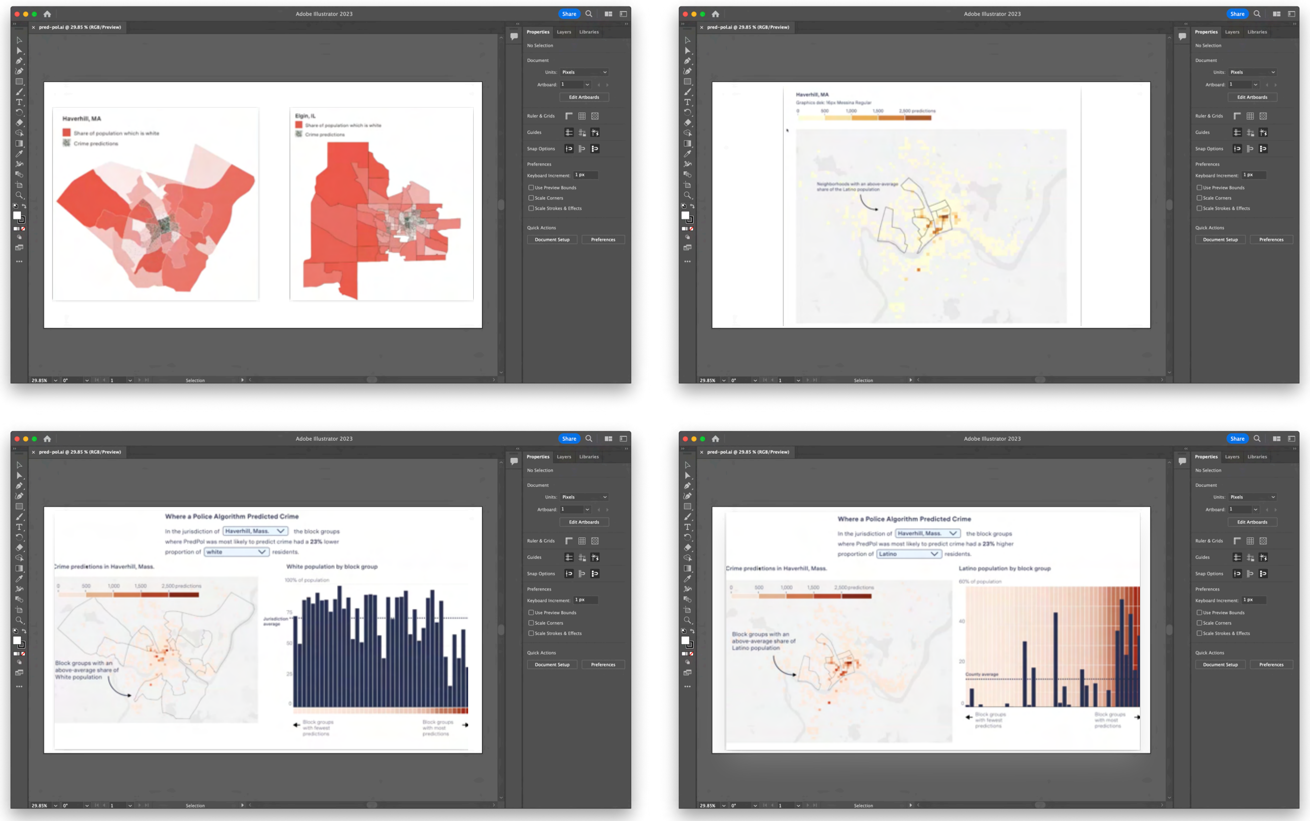
Explore a wide design space **without code**



In the jurisdiction of Haverhill, Mass. the neighborhoods where PredPol was most likely to predict crime had a **23%** higher proportion of Latino residents.

Block groups with an above-average share of Latino population

Block groups with an above-average share of White population



Data Journalists

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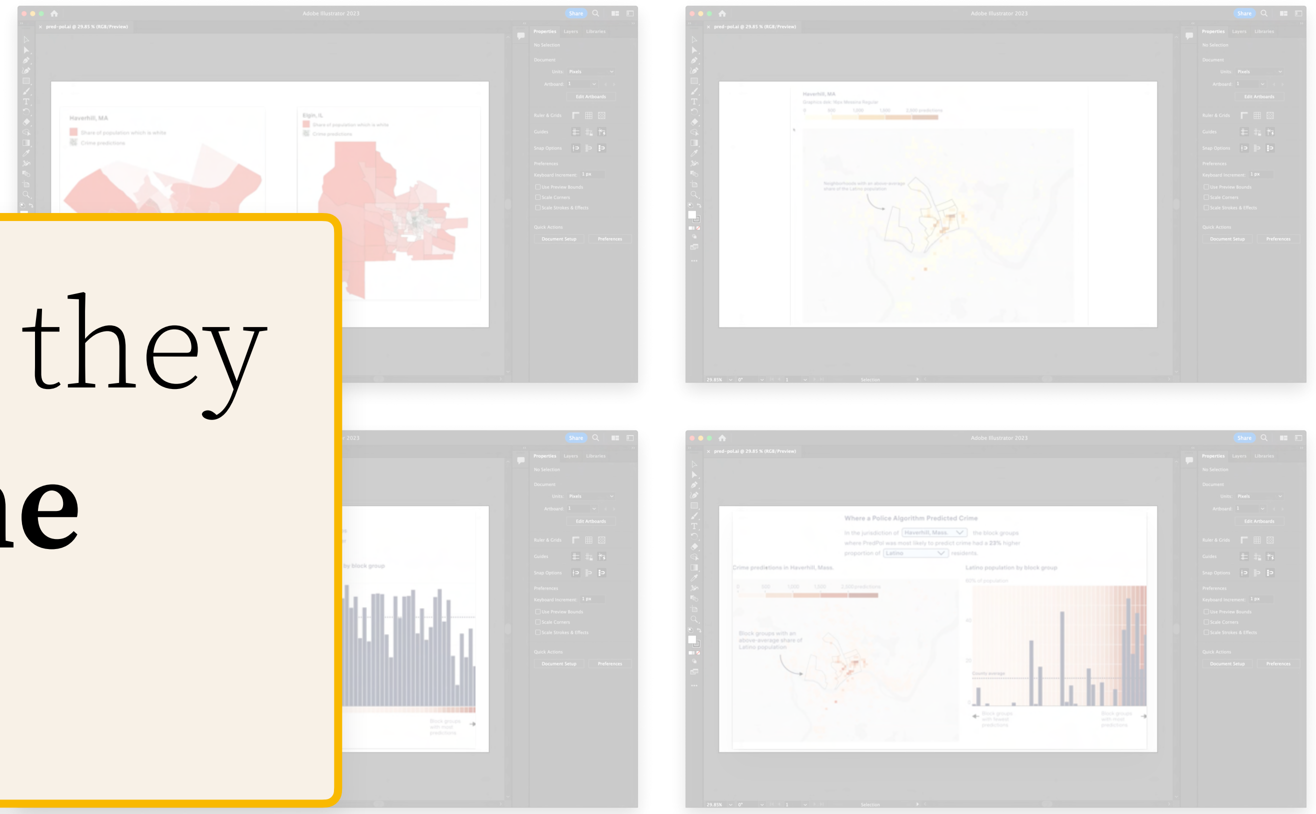
Explore a wide design space **without code**



After selecting a design, they still had to **reproduce the visualization in code**.

Data Journalists

Social Scientists

Earth and Climate Scientists

Visual Inputs → Programs

JS

```
const x = d3.scaleLinear()
  .domain(d3.extent(cars, d => d["weight (lb)”]))
  .range([marginLeft, width - marginRight]);

const svg = d3.create(“svg")
  .attr("width", width)
  .attr("height", height)
  .attr("viewBox", [0, 0, width, height])
  .attr("style", "max-width: 100%; height: auto;");

svg.append(“g")
  .attr("transform", `translate(0,${height - marginBottom})`)
  .call(d3.axisBottom(x).tickSizeOuter(0));

svg.append(“g")
  .selectAll()
  .data(dodge(cars, {radius: radius * 2 + padding}))
  .join(“circle")
    .attr("cx", d => d.x)
    .attr("cy", d => height - marginBottom - radius - padding - d.y)
    .attr("r", radius)
  .append("title")
    .text(d => d.data.name);
```

Visual Inputs → Programs

```
const x = d3.scaleLinear()
  .domain(d3.extent(cars, d => d["weight (lb)”]))
  .range([marginLeft, width - marginRight]);

const svg = d3.create(“svg")
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    .attr("r", radius)
  .append("title")
    .text(d => d.data.name);
```

Could this be a **compilers** problem?

Maybe?

Could this be a **compilers** problem?

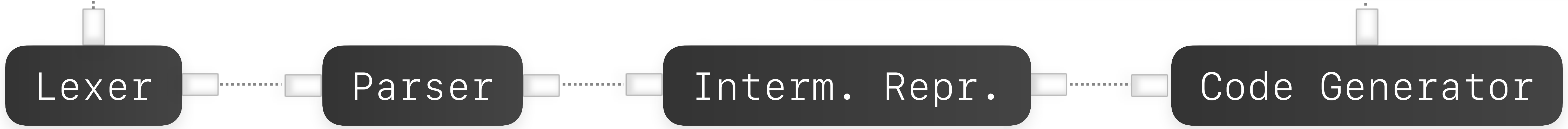
PL RESEARCHERS
LITERALLY ANYTHING
IS THIS A COMPILERS PROBLEM?

How do we compile from a **visual form** to a **textual symbolic representation**?

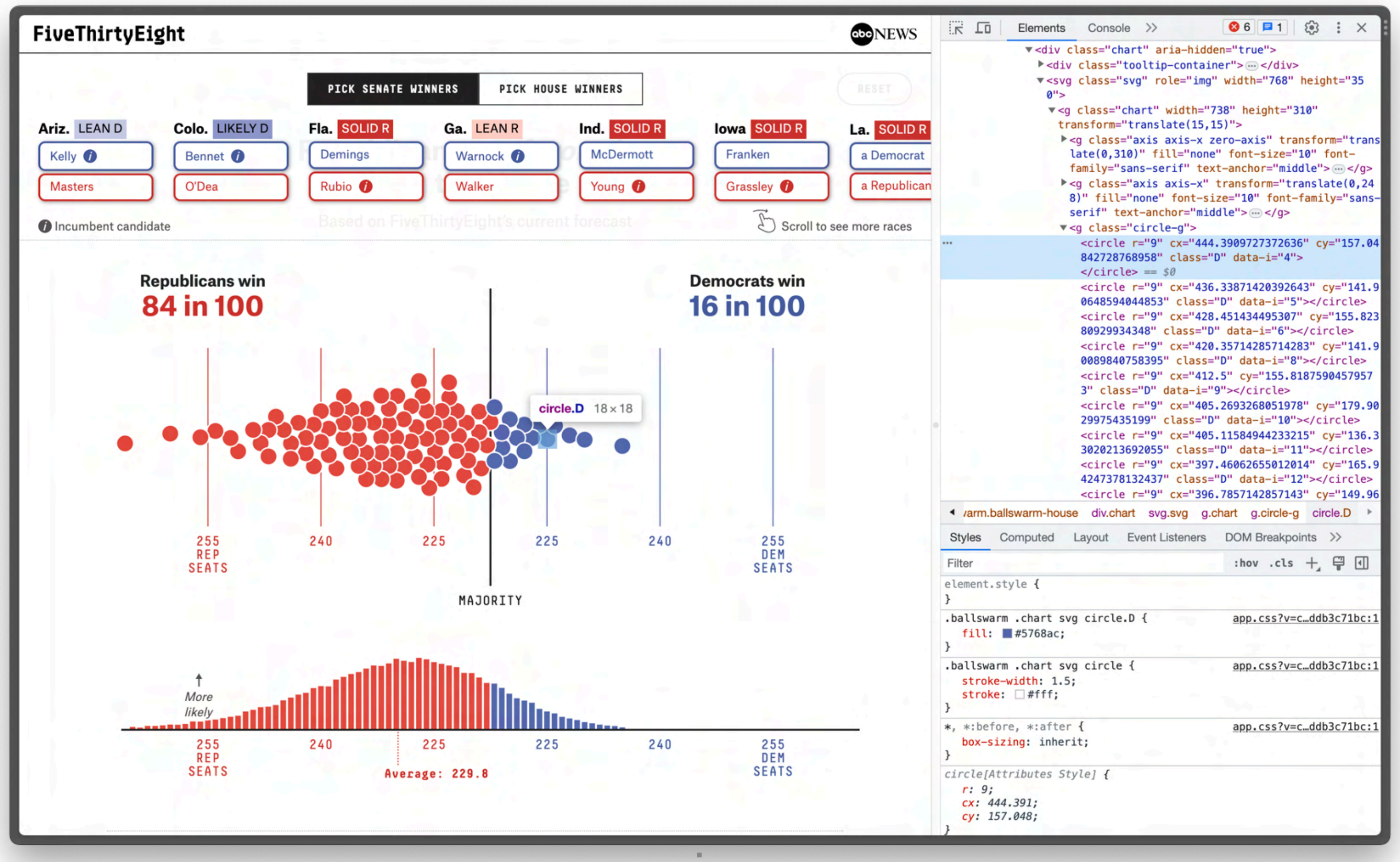
```
use wasm_bindgen::prelude::*

#[wasm_bindgen]
pub fn add(a: u32, b: u32) -> {
    a + b
}
```

```
(module
  (type (;0;) (func (param i32 i32) (result i32)))
  (func (;0;) (type 0) (param i32 i32) (result i32)
    get_local 1
    get_local 0
    i32.add)
  (table (;0;) 1 1 anyfunc)
  (memory (;0;) 17)
  (global (;0;) i32 (i32.const 1049118))
  (global (;1;) i32 (i32.const 1049118))
  (export "memory" (memory 0))
  (export "__indirect_function_table" (table 0))
  (export "__heap_base" (global 0))
  (export "__data_end" (global 1))
  (export "add" (func 0))
  (data (i32.const 1049096) "invalid malloc request"))
```



How do we compile from a **visual form** to a **textual symbolic representation**?



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(module
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  (func (;0;) (type 0) (param i32 i32) (result i32)
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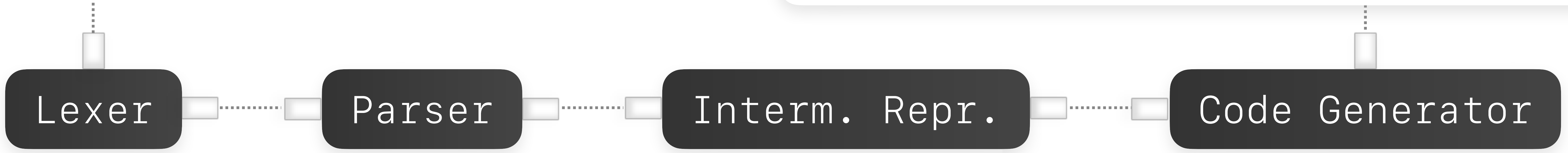
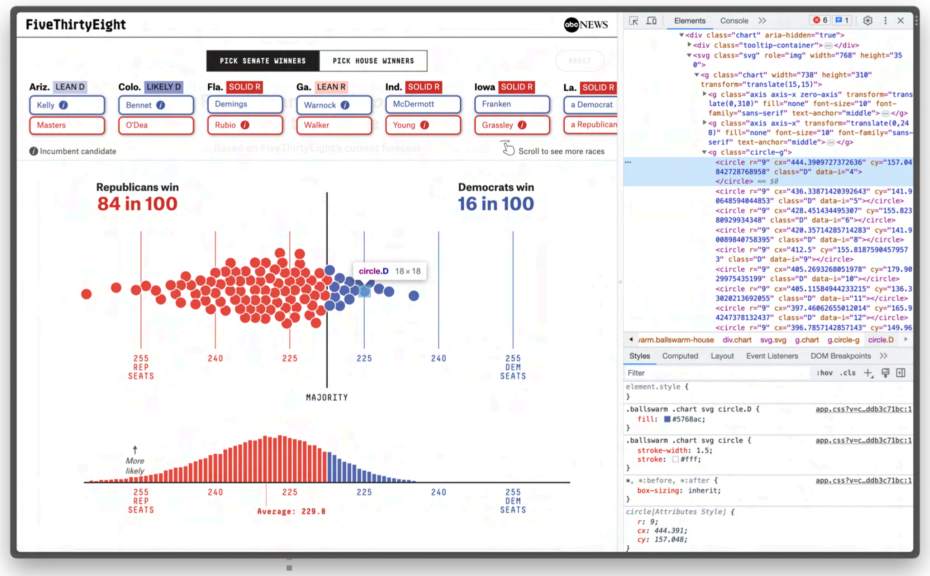


How do we compile from a **visual form** to a **textual symbolic representation**?



Lexer

Parser

Recover (or infer) **semantic information** from the visual form that we can represent **symbolically**.

WA

```
(module
  (type (;0;) (func (param i32 i32) (result i32)))
  (func (;0;) (type 0) (param i32 i32) (result i32)
    get_local 1
    get_local 0
    i32.add)
  (table (;0;) 1 1 anyfunc)
  (memory (;0;) 17)
  global (;0;) i32 (i32.const 1049118))
  global (;1;) i32 (i32.const 1049118))
  export "memory" (memory 0))
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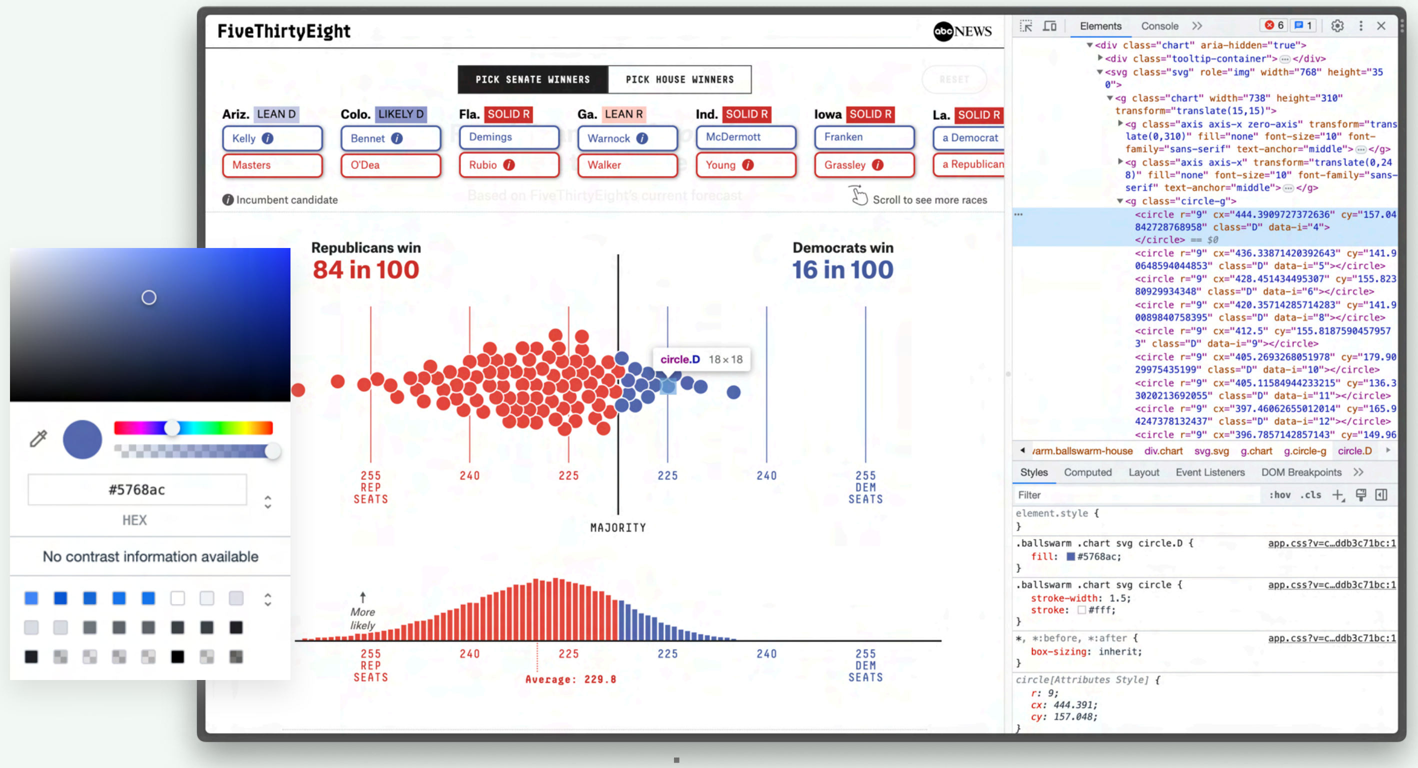
  export "__heap_base" (global 0))
  export "__data_end" (global 1))
  export "add" (func 0))
  data (i32.const 1049096) "invalid malloc request"))
```

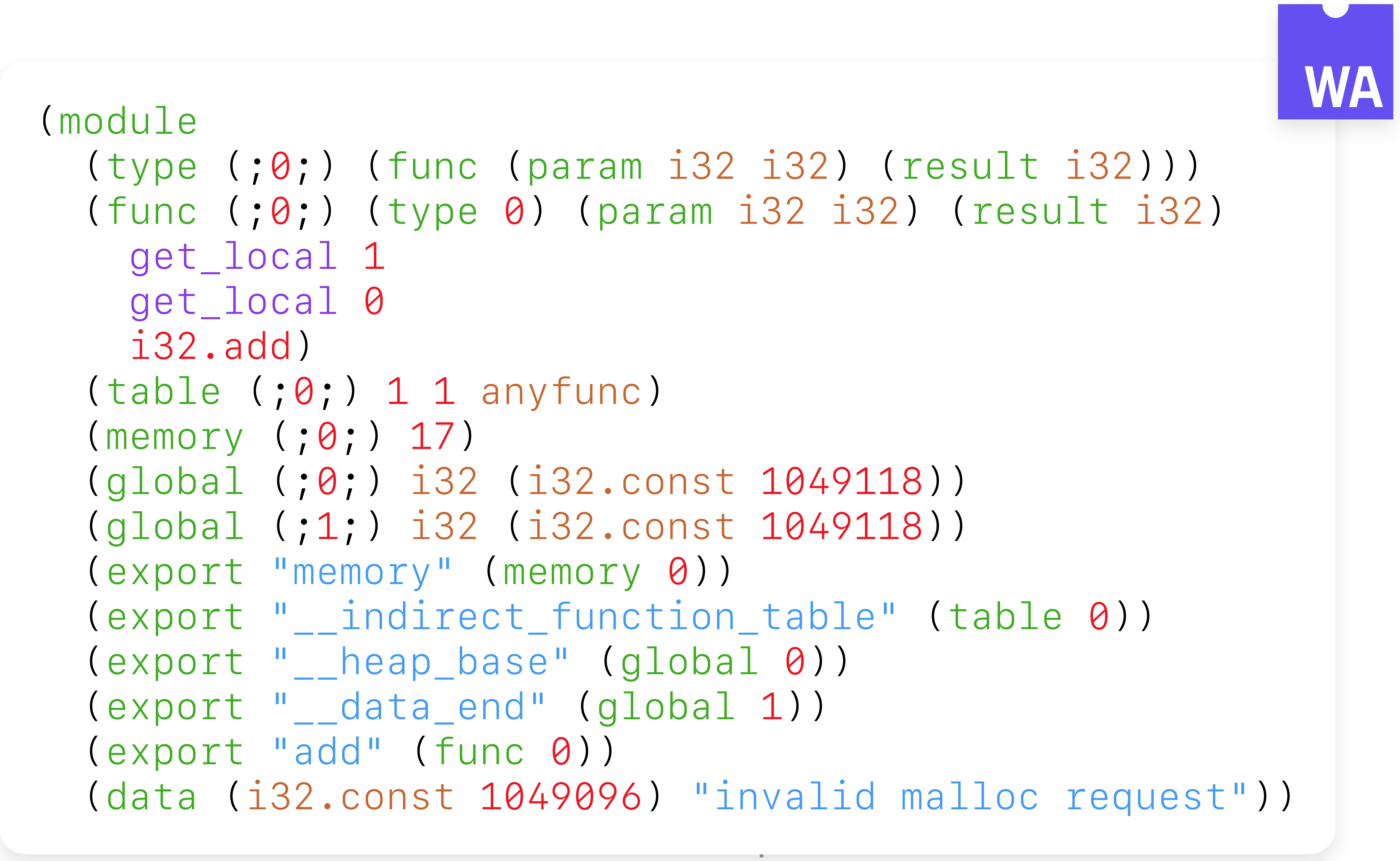
Interm. Repr.

Code Generator

How do we compile from a **visual form** to a **textual symbolic representation**?

Map **interactions** with the visual form to **program edits**.





```
(module
  (type (;0;) (func (param i32 i32) (result i32)))
  (func (;0;) (type 0) (param i32 i32) (result i32)
    get_local 1
    get_local 0
    i32.add)
  (table (;0;) 1 1 anyfunc)
  (memory (;0;) 17)
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  (export "memory" (memory 0))
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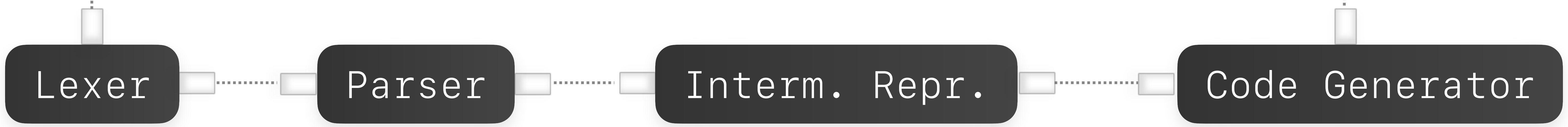
  (export "__heap_base" (global 0))
  (export "__data_end" (global 1))
  (export "add" (func 0))
  (data (i32.const 1049096) "invalid malloc request"))
```



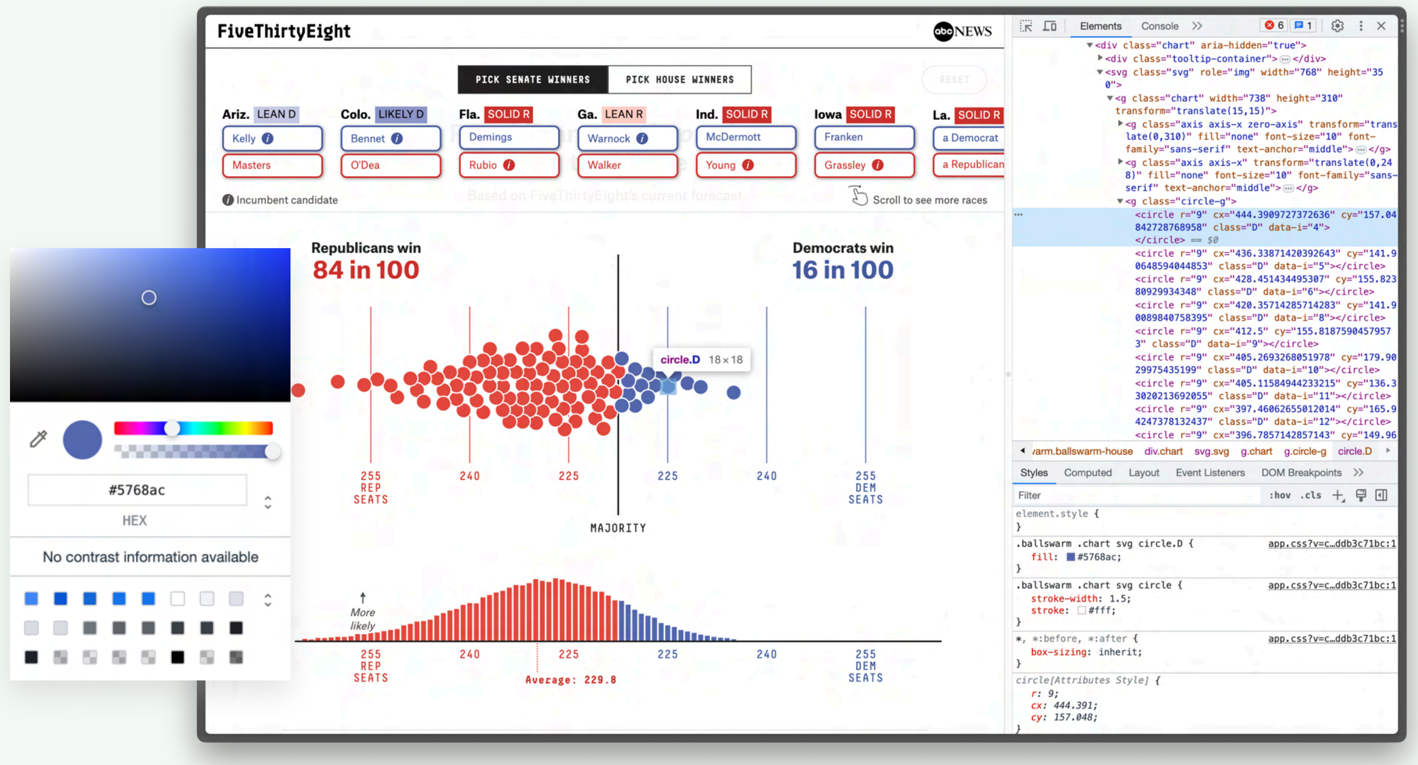
Lexer

Parser

Recover (or infer) **semantic information** from the visual form that we can represent **symbolically**.

reviz

Map **interactions** with the visual form to **program edits**.



```
▼<div class="chart" aria-hidden="true">
  ▶<div class="tooltip-container">⋯</div>
  ▼<svg class="svg" role="img" width="768" height="350">
    ▼<g class="chart" width="738" height="310" transform="translate(15,15)">
      ▶<g class="axis axis-x zero-axis" transform="translate(0,310)" fill="none" font-size="10" font-family="sans-serif" text-anchor="middle">⋯</g>
      ▶<g class="axis axis-x" transform="translate(0,248)" fill="none" font-size="10" font-family="sans-serif" text-anchor="middle">⋯</g>
      ▼<g class="circle-g">
          <circle r="9" cx="444.3909727372636" cy="157.04842728768958" class="D" data-i="4">
          </circle> == $0
          <circle r="9" cx="436.33871420392643" cy="141.90648594044853" class="D" data-i="5"></circle>
          <circle r="9" cx="428.451434495307" cy="155.82380929934348" class="D" data-i="6"></circle>
          <circle r="9" cx="420.35714285714283" cy="141.90089840758395" class="D" data-i="8"></circle>
          <circle r="9" cx="412.5" cy="155.81875904579573" class="D" data-i="9"></circle>
          <circle r="9" cx="405.2693268051978" cy="179.9029975435199" class="D" data-i="10"></circle>
          <circle r="9" cx="405.11584944233215" cy="136.33020213692055" class="D" data-i="11"></circle>
          <circle r="9" cx="397.46062655012014" cy="165.94247378132437" class="D" data-i="12"></circle>
          <circle r="9" cx="396.7857142857143" cy="149.96
```

```
element.style {
}
.ballswarm .chart svg circle.D {          app.css?v=c…ddb3c71bc:1
  fill: #5768ac;
}
.ballswarm .chart svg circle {            app.css?v=c…ddb3c71bc:1
  stroke-width: 1.5;
  stroke: #fff;
}
*, *:before, *:after {                    app.css?v=c…ddb3c71bc:1
  box-sizing: inherit;
}
circle[Attributes Style] {
  r: 9;
  cx: 444.391;
  cy: 157.048;
}
```

cartokit

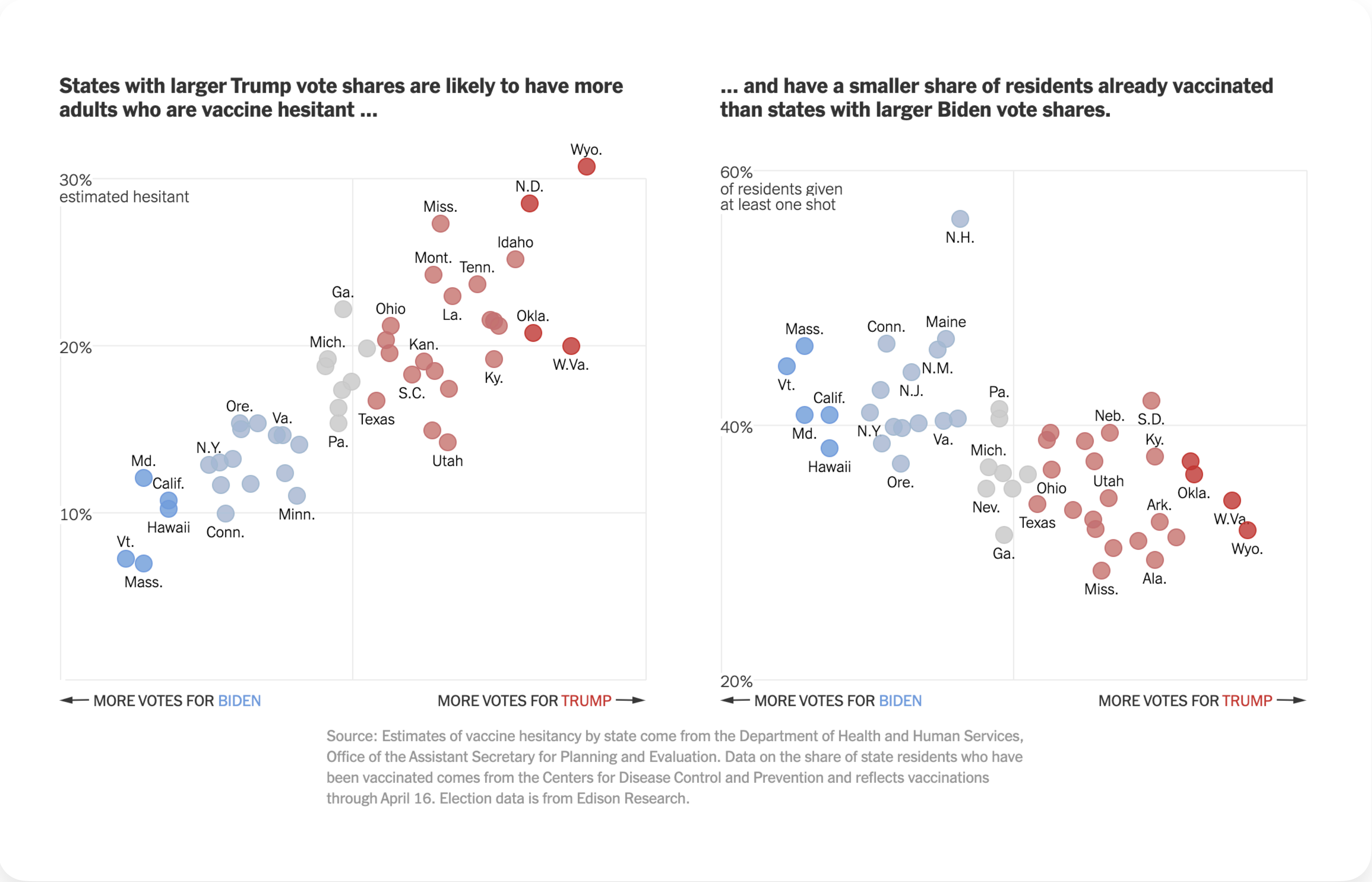
reviz

A compiler from **SVG subtrees** to **data visualizations**

reviz

A compiler from **SVG subtrees** to ~~**data visualizations**~~
partial programs

Demo



States with larger Trump vote shares are likely to have more adults who are vaccine hesitant ...

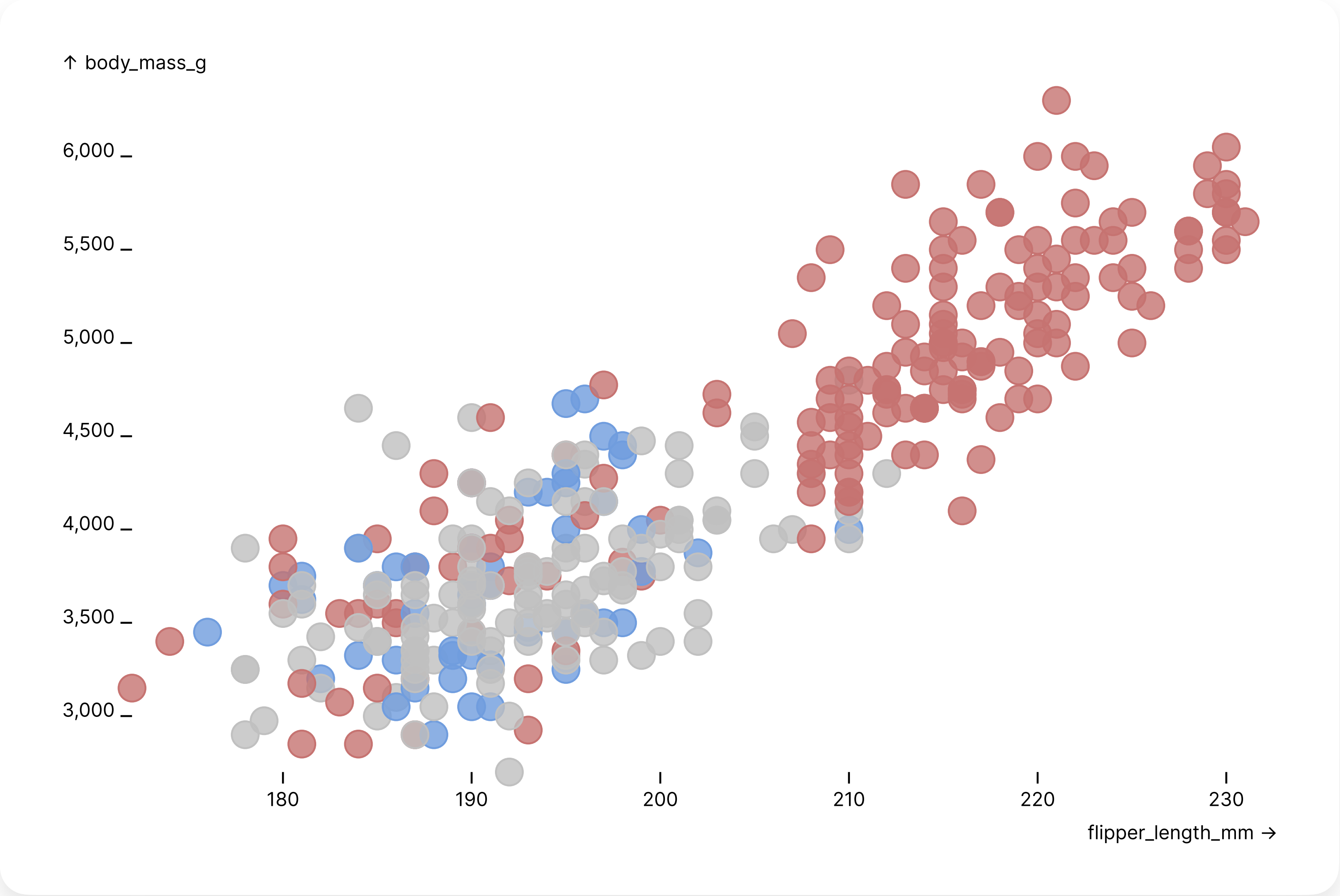
... and have a smaller share of residents already vaccinated than states with larger Biden vote shares.

Source: Estimates of vaccine hesitancy by state come from the Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation. Data on the share of state residents who have been vaccinated comes from the Centers for Disease Control and Prevention and reflects vaccinations through April 16. Election data is from Edison Research.

The New York Times

Least Vaccinated U.S. Counties Have Something in Common: Trump Voters

Danielle Ivory, Lauren Leatherby and Robert Gebeloff



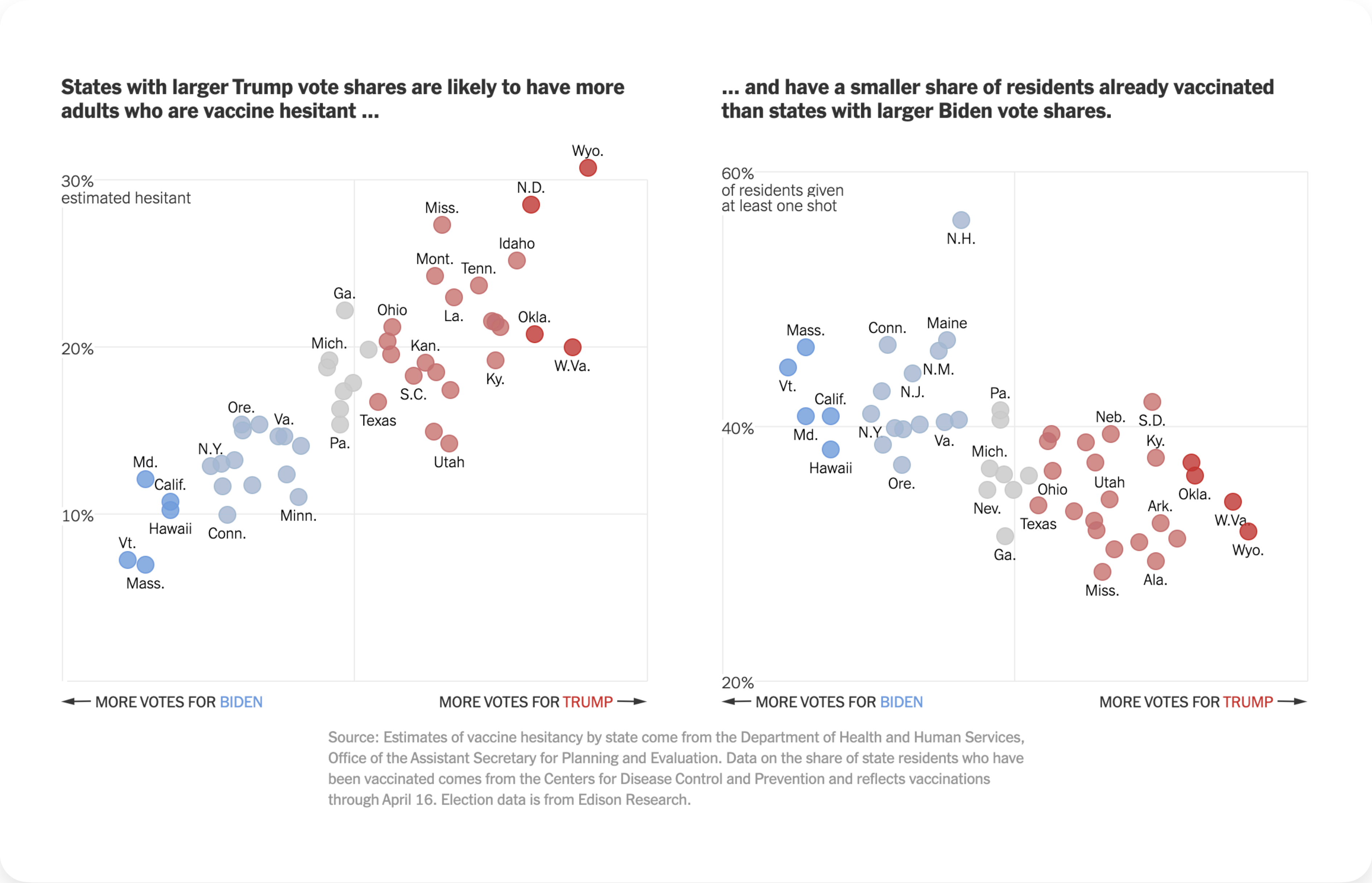
+ reviz

Comparing Flipper Length and Body Mass of the Palmer Penguins

Can we automatically retarget **existing visualizations** at **new datasets**?

reviz

A user **identifies a visualization** they want to use as a visual input.



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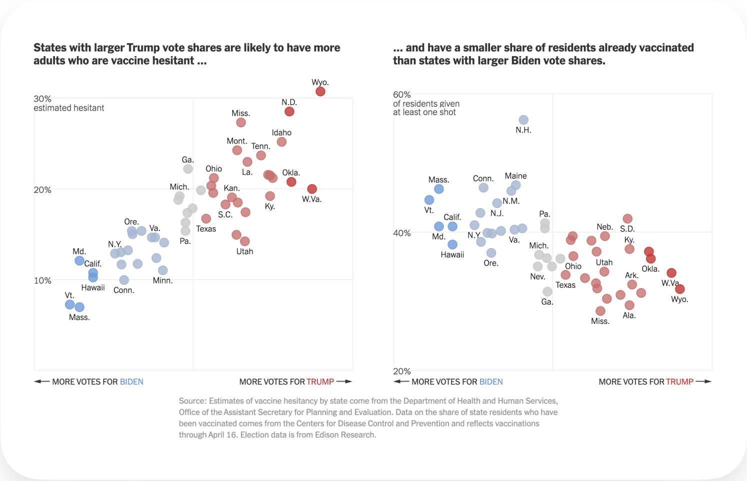
1.



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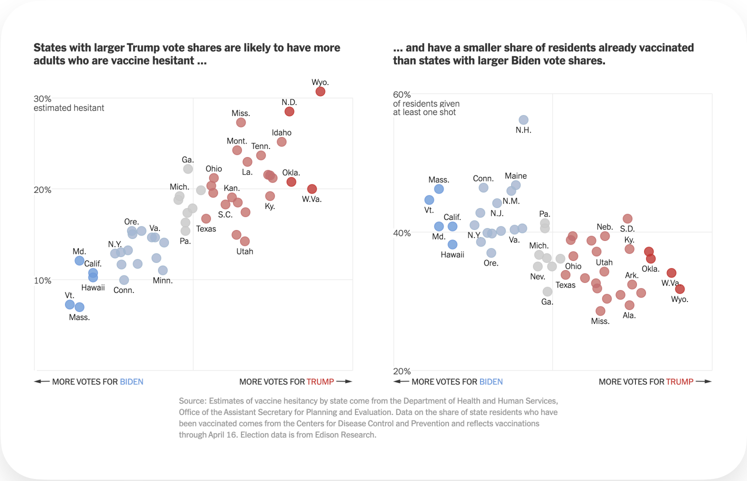
They pass its `svg` subtree to

reviz

1.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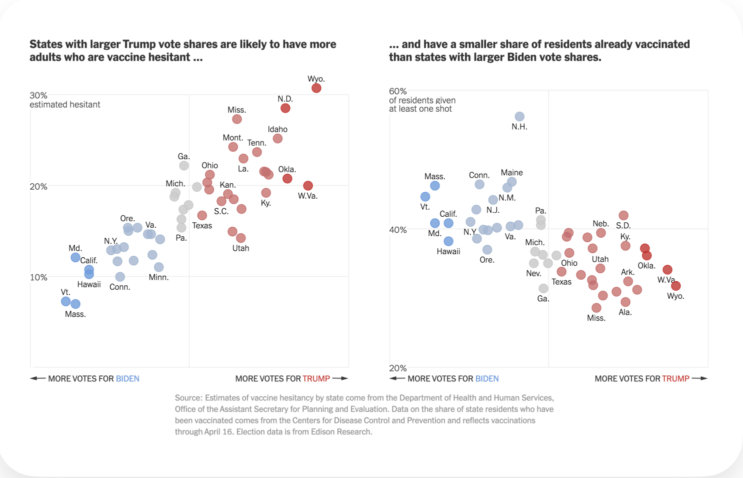
2.

`reviz` compiles a **partial JavaScript program** using Observable's Plot library.

```
const plot = Plot.plot({
  color: {
    type: "categorical",
    range: ["#C67371", "#ccc", "#709DDE", #A7B9D3", "#C23734"]
  },
  marks: [
    Plot.dot(data, {
      x: "??",
      y: "??",
      fill: "??",
      fillOpacity: 1,
      stroke: "??",
      strokeOpacity: 1,
      strokeWidth: 1
    }),
  ],
});
```

1.



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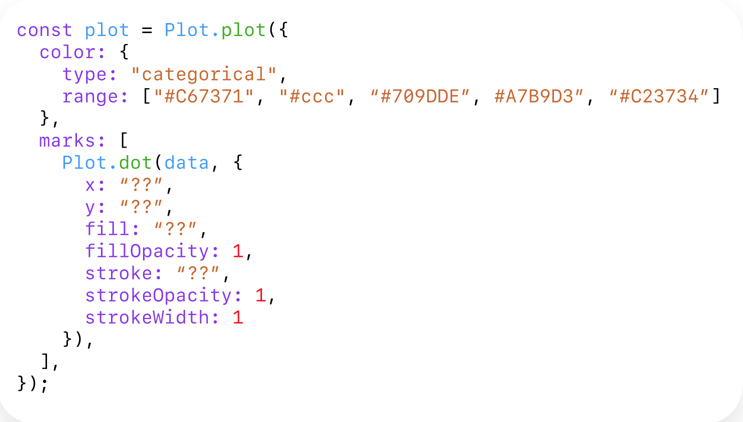
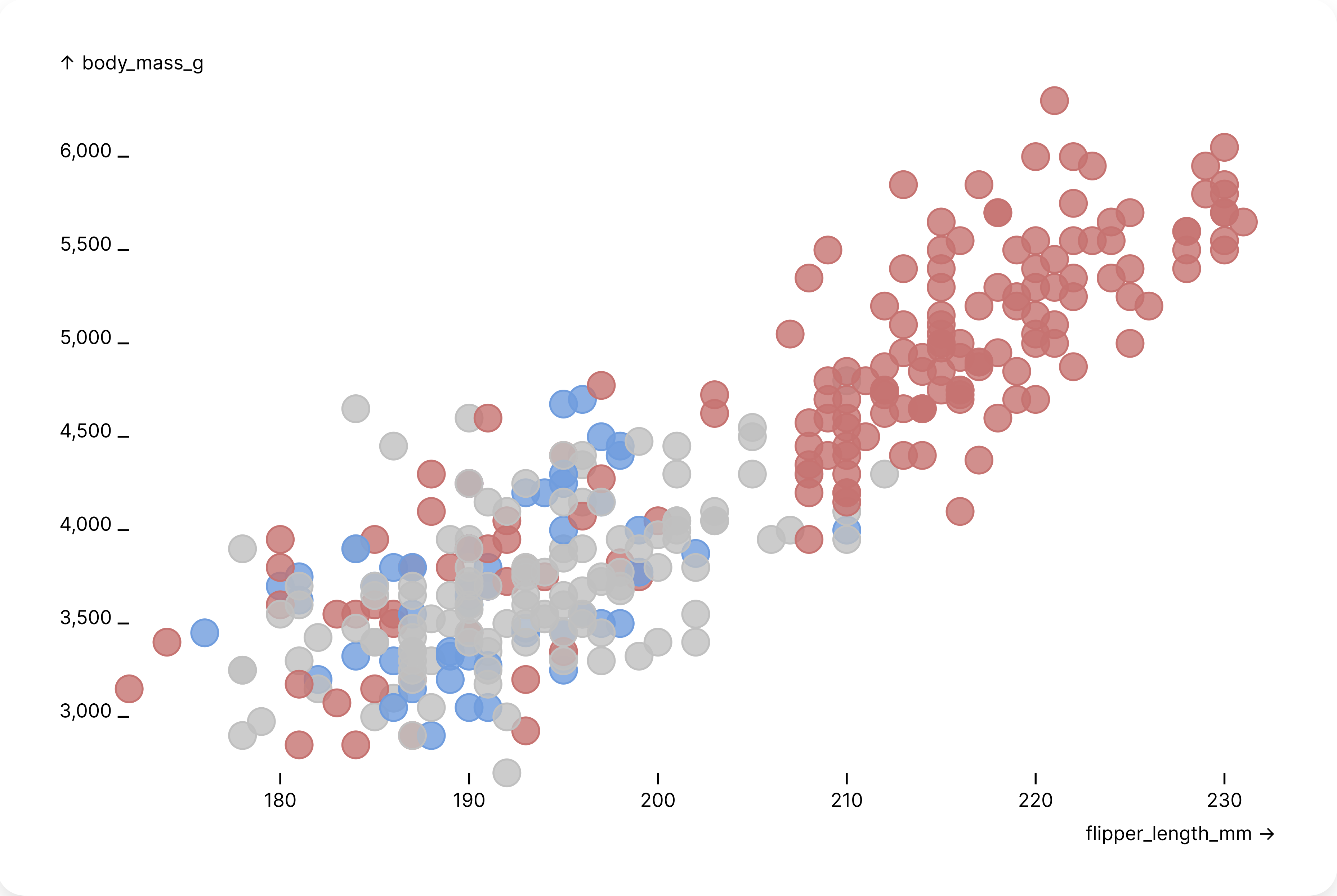
2. reviz

3.



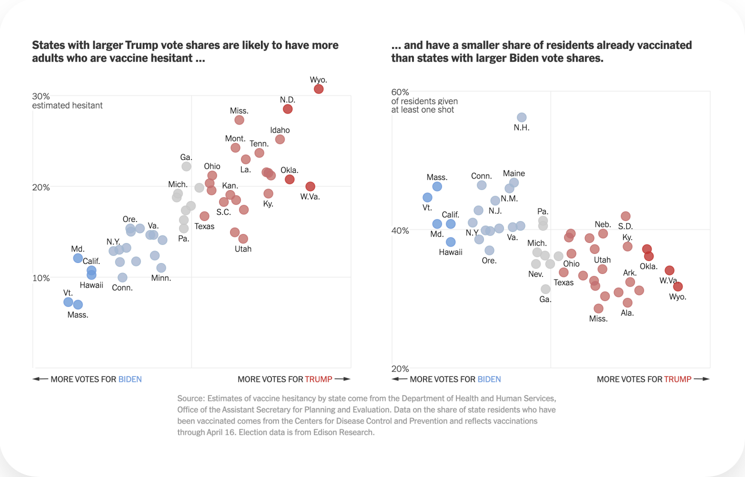
```
const plot = Plot.plot({
  color: {
    type: "categorical",
    range: ["#C67371", "#ccc", "#709DDE", #A7B9D3", "#C23734"]
  },
  marks: [
    Plot.dot(data, {
      x: "??",
      y: "??",
      fill: "??",
      fillOpacity: 1,
      stroke: "??",
      strokeOpacity: 1,
      strokeWidth: 1
    }),
  ],
});
```

A user **fills in the holes** ("??") in the partial program to produce a new visualization.



reviz

1.



States with larger Trump vote shares are likely to have more adults who are vaccine hesitant ...

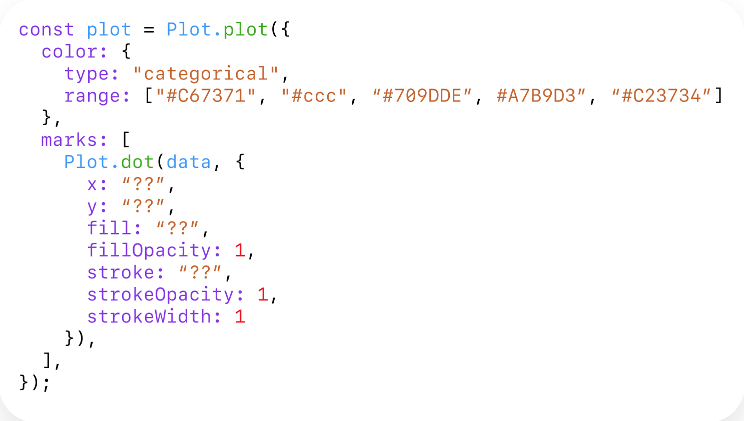
... and have a smaller share of residents already vaccinated than states with larger Biden vote shares.

Source: Estimates of vaccine hesitancy by state come from the Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation. Data on the share of state residents who have been vaccinated comes from the Centers for Disease Control and Prevention and reflects vaccinations through April 16. Election data is from Edison Research.

2.

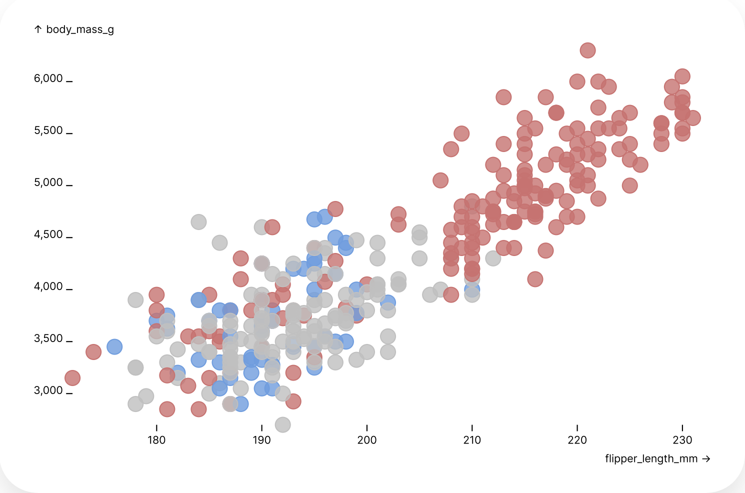
reviz

3.

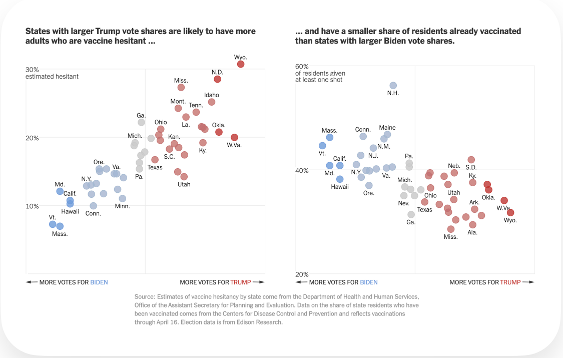


```
const plot = Plot.plot({
  color: {
    type: "categorical",
    range: ["#C67371", "#ccc", “#709DDE”, #A7B9D3”, “#C23734”]
  },
  marks: [
    Plot.dot(data, {
      x: “??”,
      y: “??”,
      fill: “??”,
      fillOpacity: 1,
      stroke: “??”,
      strokeOpacity: 1,
      strokeWidth: 1
    }),
  ],
});
```

4.



1.



States with larger Trump vote shares are likely to have more adults who are vaccine hesitant ...

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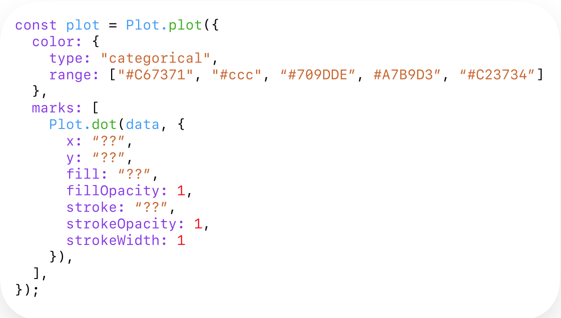
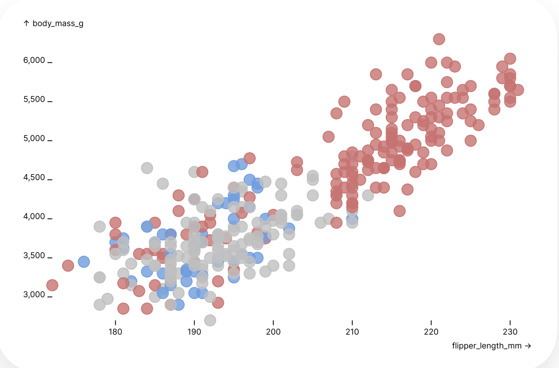
2. reviz

3.



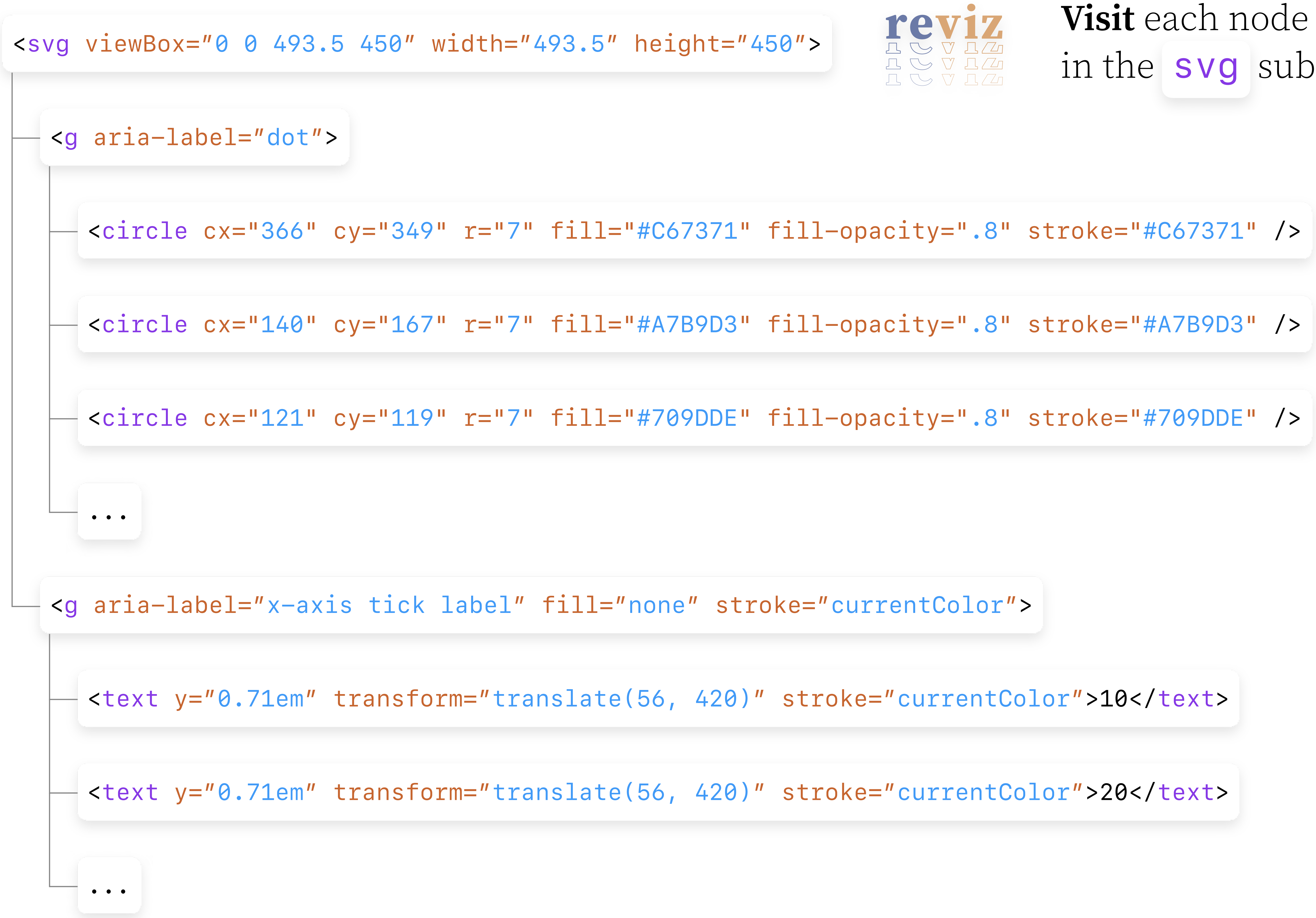
```
const plot = Plot.plot({
  color: {
    type: "categorical",
    range: ["#C67371", "#ccc", "#709DDE", #A7B9D3", "#C23734"]
  },
  marks: [
    Plot.dot(data, {
      x: "??",
      y: "??",
      fill: "??",
      fillOpacity: 1,
      stroke: "??",
      strokeOpacity: 1,
      strokeWidth: 1
    }),
  ],
});
```

4.



What **actually happens** in this step?

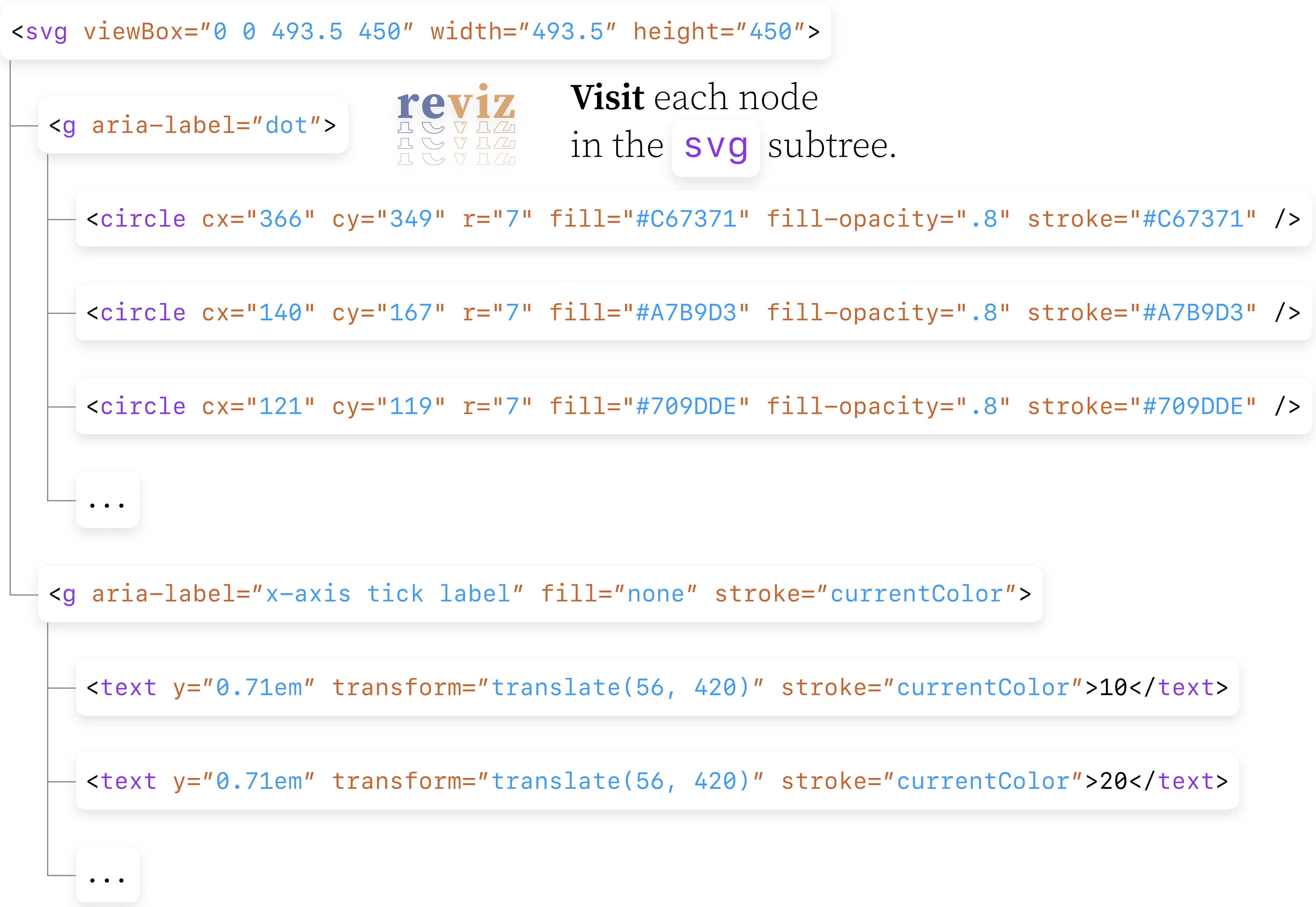
It all starts with a **walk**.



```
<svg viewBox="0 0 493.5 450" width="493.5" height="450">
  <g aria-label="dot">
    <circle cx="366" cy="349" r="7" fill="#C67371" fill-opacity=".8" stroke="#C67371" />
    <circle cx="140" cy="167" r="7" fill="#A7B9D3" fill-opacity=".8" stroke="#A7B9D3" />
    <circle cx="121" cy="119" r="7" fill="#709DDE" fill-opacity=".8" stroke="#709DDE" />
    ...
  <g aria-label="x-axis tick label" fill="none" stroke="currentColor">
    <text y="0.71em" transform="translate(56, 420)" stroke="currentColor">10</text>
    <text y="0.71em" transform="translate(56, 420)" stroke="currentColor">20</text>
    ...
```

Visit each node
in the `svg` subtree.

It all starts with a **walk**.



```
<svg viewBox="0 0 493.5 450" width="493.5" height="450">
  <g aria-label="dot">
    <circle cx="366" cy="349" r="7" fill="#C67371" fill-opacity=".8" stroke="#C67371" />
    <circle cx="140" cy="167" r="7" fill="#A7B9D3" fill-opacity=".8" stroke="#A7B9D3" />
    <circle cx="121" cy="119" r="7" fill="#709DDE" fill-opacity=".8" stroke="#709DDE" />
    ...
  <g aria-label="x-axis tick label" fill="none" stroke="currentColor">
    <text y="0.71em" transform="translate(56, 420)" stroke="currentColor">10</text>
    <text y="0.71em" transform="translate(56, 420)" stroke="currentColor">20</text>
    ...
```

reviz

Visit each node in the `svg` subtree.

It all starts with a **walk**.

```
<svg viewBox="0 0 493.5 450" width="493.5" height="450">
    <g aria-label="dot">
        <circle cx="366" cy="349" r="7" fill="#C67371" fill-opacity=".8" stroke="#C67371" />
        <circle cx="140" cy="167" r="7" fill="#A7B9D3" fill-opacity=".8" stroke="#A7B9D3" />
        <circle cx="121" cy="119" r="7" fill="#709DDE" fill-opacity=".8" stroke="#709DDE" />
        ...
    <g aria-label="x-axis tick label" fill="none" stroke="currentColor">
        <text y="0.71em" transform="translate(56, 420)" stroke="currentColor">10</text>
        <text y="0.71em" transform="translate(56, 420)" stroke="currentColor">20</text>
        ...
```

Visit each node
in the `svg` subtree.

Read geometric and presentational attributes off of each DOM node and its computed styles.

```
<circle cx="366" cy="349" r="7" fill="#C67371" fill-opacity=".8" stroke="#C67371" />
```

cx → 366

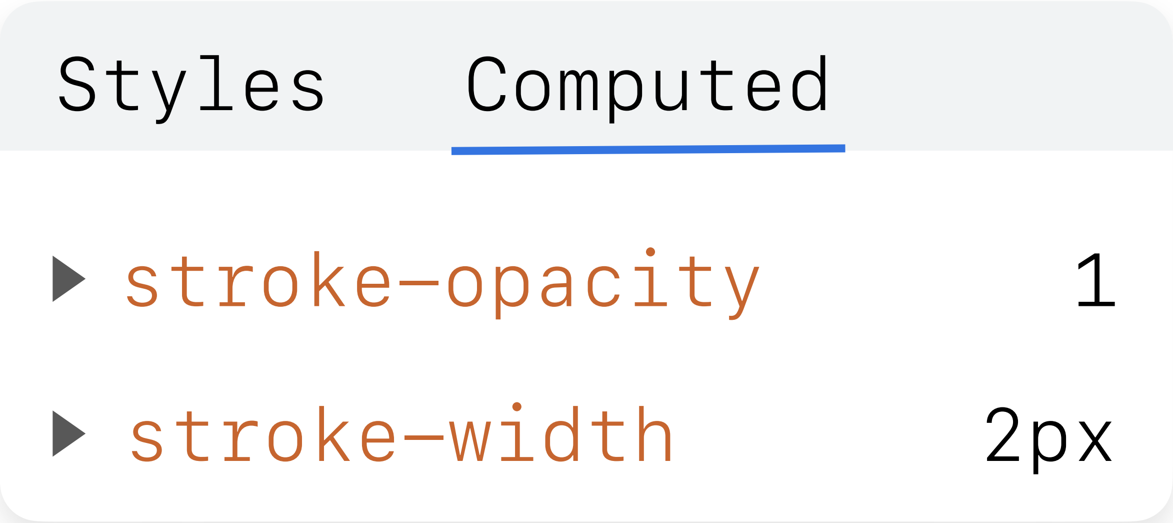
cy → 349

r → 7

fill → “#C67371”

fill-opacity → 0.8

stroke → “#C67371”



▸ stroke-opacity	1
▸ stroke-width	2px

stroke-opacity → 1

stroke-width → 2px

Store collected attributes in **attribute sets**.

```
cx: { cx → 366 , cx → 398 , cx → 422 , cx → 543 ,… }
cy: { cy → 349 , cy → 218 , cy → 265 , cy → 121 ,… }
r: { r → 7 }
fill: { fill → "#C67371" , fill → "#A7B9D3" , fill → "#709DDE" ,… }
fill-opacity: { fill-opacity → 0.8 }
stroke: { stroke → "#C67371" , stroke → "#A7B9D3" , stroke → "#709DDE" ,… }
stroke-opacity: { stroke-opacity → 1 }
stroke-width: { stroke-width → 2px }
```

Apply a set of **predicate functions** associated with a **visualization type**.

```
cx: { cx → 366 ,… }
cy: { cy → 349 ,… }
r: { r → 7 }
fill: { fill → “#C67371” ,… }
fill-opacity: { fill-opacity → 0.8 }
stroke: { stroke → “#C67371” ,… }
stroke-opacity: { stroke-opacity → 1 }
stroke-width: { stroke-width → 2px }
```

Bar Chart

```
hasMarkType(“rect”)
hasConsistentGeomAttr(“width”)
hasXScaleType(“discrete”)
```

Compute the **ratio of predicates** returning `true` for each **visualization type.**

Bar Chart (0/3 predicates)

```
hasMarkType("rect")
hasConsistentGeomAttr("width")
hasXScaleType("width")
```

Strip Plot (2/3 predicates)

```
hasMarkType("circle")
hasConsistentGeomAttr("r")
hasSiblingsWithConsistentCyAttr
```

Scatterplot (2/2 predicates)

```
hasMarkType("circle")
hasConsistentGeomAttr("r")
```

Bubble Chart (1/2 predicates)

```
hasMarkType("circle")
hasDivergentGeomAttr("r")
```

Merge the inferred **visualization type** with the **attribute sets** to produce the **intermediate representation (IR)**.

Scatterplot (2/2 predicates)

```
r: { r → 7 }

fill: { fill → “#C67371” ,… }

fill–opacity: { fill–opacity → 0.8 }

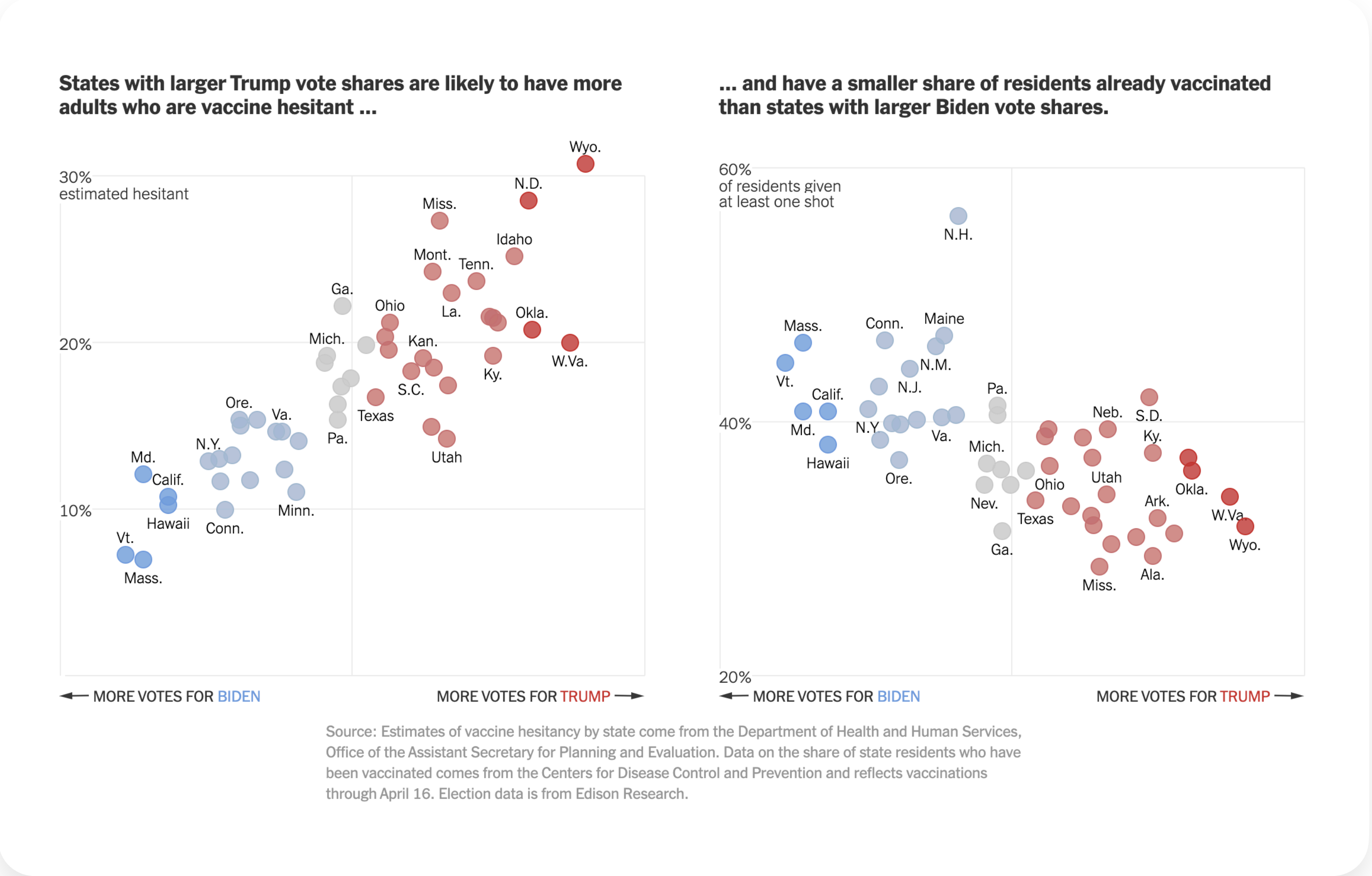
stroke: { stroke → “#C67371” ,… }

stroke–opacity: { stroke–opacity → 1 }

stroke–width: { stroke–width → 2px }
```

```
{
  type: “Scatterplot”,
  r: [7],
  fill: ["#C67371", "#ccc", “#709DDE”],
  fill–opacity: [0.8],
  stroke: ["#C67371", "#ccc", “#709DDE”],
  stroke–opacity: [1],
  stroke–width: [“2px”]
}
```

The *frontend* of the reviz compiler



States with larger Trump vote shares are likely to have more adults who are vaccine hesitant ...

... and have a smaller share of residents already vaccinated than states with larger Biden vote shares.

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```
{
  type: “Scatterplot”,
  r: [7],
  fill: ["#C67371", "#ccc", “#709DDE”],
  fill-opacity: [0.8],
  stroke: ["#C67371", "#ccc", “#709DDE”],
  stroke-opacity: [1],
  stroke-width: [“2px”]
}
```

Input Visualization

Intermediate Representation

The *backend* of the reviz compiler

```
{
  type: “Scatterplot”,
  r: [7],
  fill: ["#C67371", "#ccc", “#709DDE”],
  fill-opacity: [0.8],
  stroke: ["#C67371", "#ccc", “#709DDE”],
  stroke-opacity: [1],
  stroke-width: [“2px”]
}
```

Intermediate Representation

```
const plot = Plot.plot({
  color: {
    type: "categorical",
    range: ["#C67371", "#ccc", “#709DDE”]
  },
  marks: [
    Plot.dot(data, {
      x: “??”,
      y: “??”,
      fill: “??”,
      fillOpacity: 1,
      stroke: “??”,
      strokeOpacity: 1,
      strokeWidth: 1
    }),
  ],
});
```

Partial Program

Start with the IR and an empty program, signified by an **evaluation hole**.

```
{
  type: “Scatterplot”,
  r: [7],
  fill: ["#C67371", "#ccc", “#709DDE”],
  fill-opacity: [0.8],
  stroke: ["#C67371", "#ccc", “#709DDE”],
  stroke-opacity: [1],
  stroke-width: [“2px”]
}
```

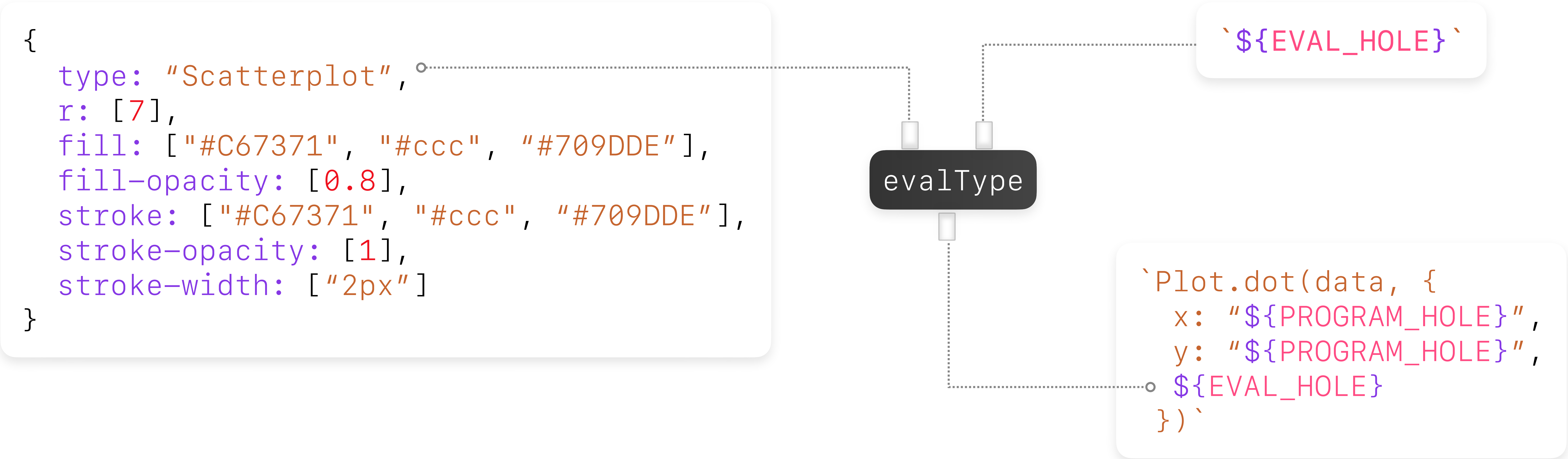
Intermediate Representation

Insertion point for generated code

```
`${EVAL_HOLE}`
```

Partial Program

Apply a set of **rewrite rules** to transform **key-value pairs** in the IR into **program fragments**.



```
{
  type: “Scatterplot”,
  r: [7],
  fill: ["#C67371", "#ccc", “#709DDE”],
  fill-opacity: [0.8],
  stroke: ["#C67371", "#ccc", “#709DDE”],
  stroke-opacity: [1],
  stroke-width: [“2px”]
}
```

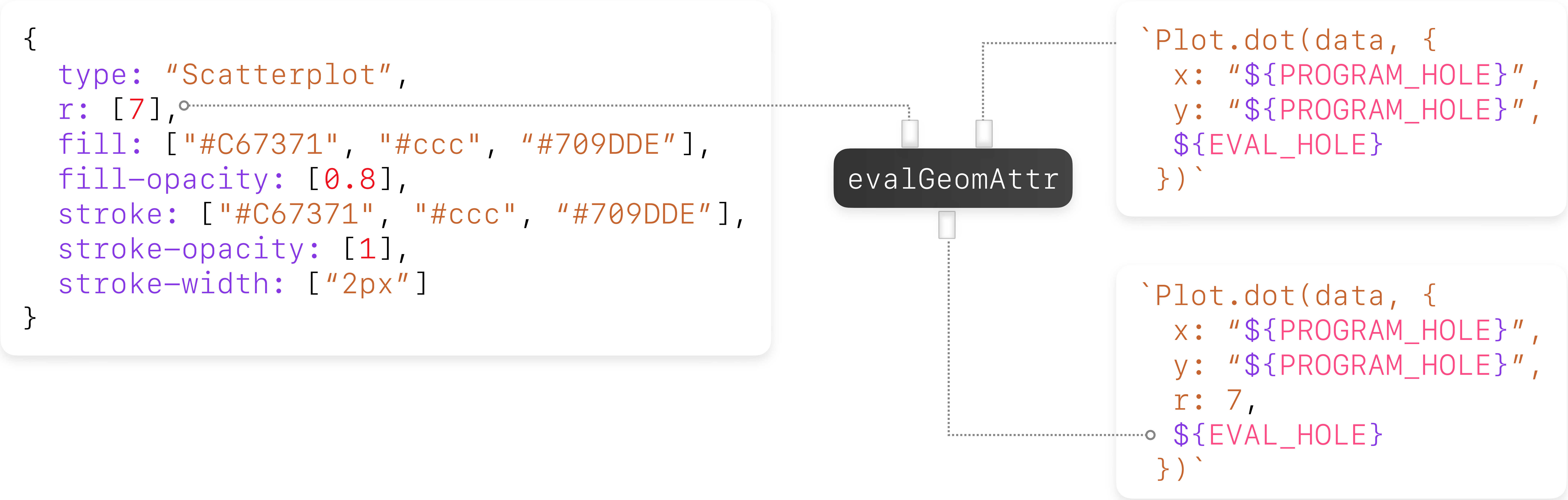
```
`${EVAL_HOLE}`
```

```
`Plot.dot(data, {
  x: “${PROGRAM_HOLE}”,
  y: “${PROGRAM_HOLE}”,
  ${EVAL_HOLE}
})`
```

Intermediate Representation

Partial Program

Apply a set of **rewrite rules** to transform **key-value pairs** in the IR into **program fragments**.



```
{
  type: “Scatterplot”,
  r: [7],
  fill: ["#C67371", "#ccc", “#709DDE”],
  fill-opacity: [0.8],
  stroke: ["#C67371", "#ccc", “#709DDE”],
  stroke-opacity: [1],
  stroke-width: [“2px”]
}
```

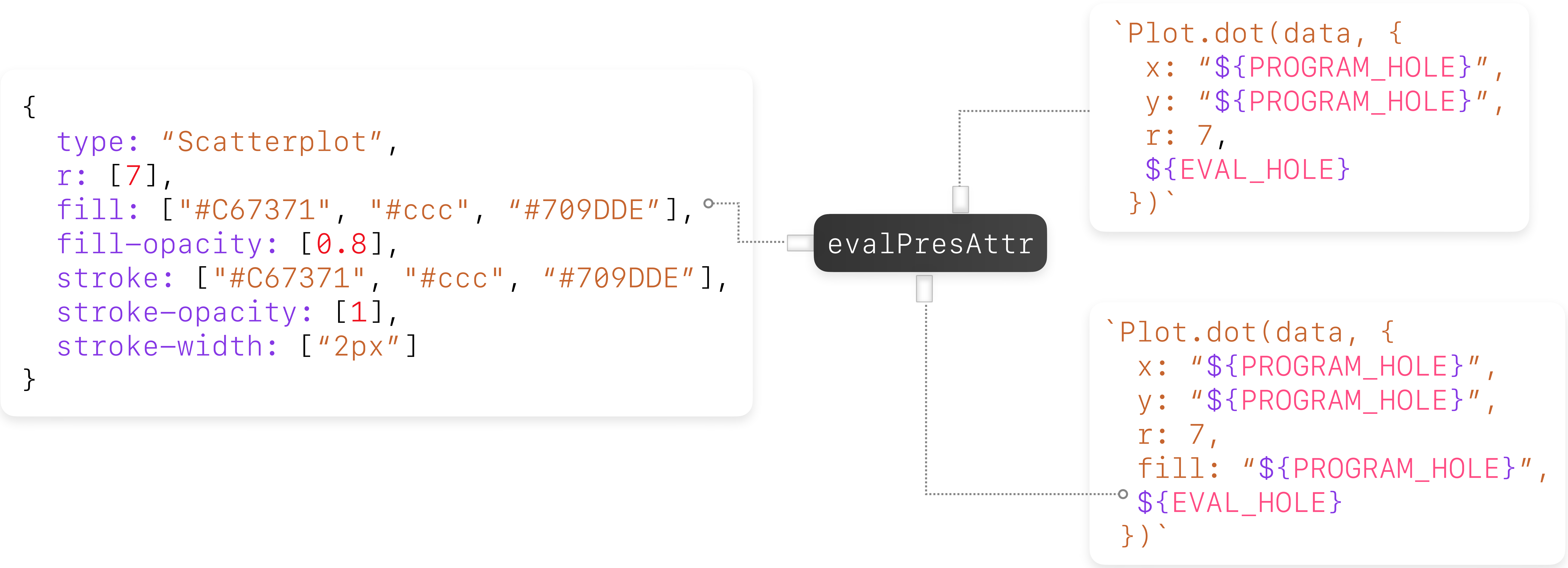
```
`Plot.dot(data, {
  x: “${PROGRAM_HOLE}”,
  y: “${PROGRAM_HOLE}”,
  ${EVAL_HOLE}
})`
```

```
`Plot.dot(data, {
  x: “${PROGRAM_HOLE}”,
  y: “${PROGRAM_HOLE}”,
  r: 7,
  ${EVAL_HOLE}
})`
```

Intermediate Representation

Partial Program

Continue applying rewrites until we’ve read all key-value pairs in the IR.



```
{
  type: “Scatterplot”,
  r: [7],
  fill: ["#C67371", "#ccc", “#709DDE”],
  fill-opacity: [0.8],
  stroke: ["#C67371", "#ccc", “#709DDE”],
  stroke-opacity: [1],
  stroke-width: [“2px”]
}
```

```
`Plot.dot(data, {
  x: “${PROGRAM_HOLE}”,
  y: “${PROGRAM_HOLE}”,
  r: 7,
  ${EVAL_HOLE}
 })`
```

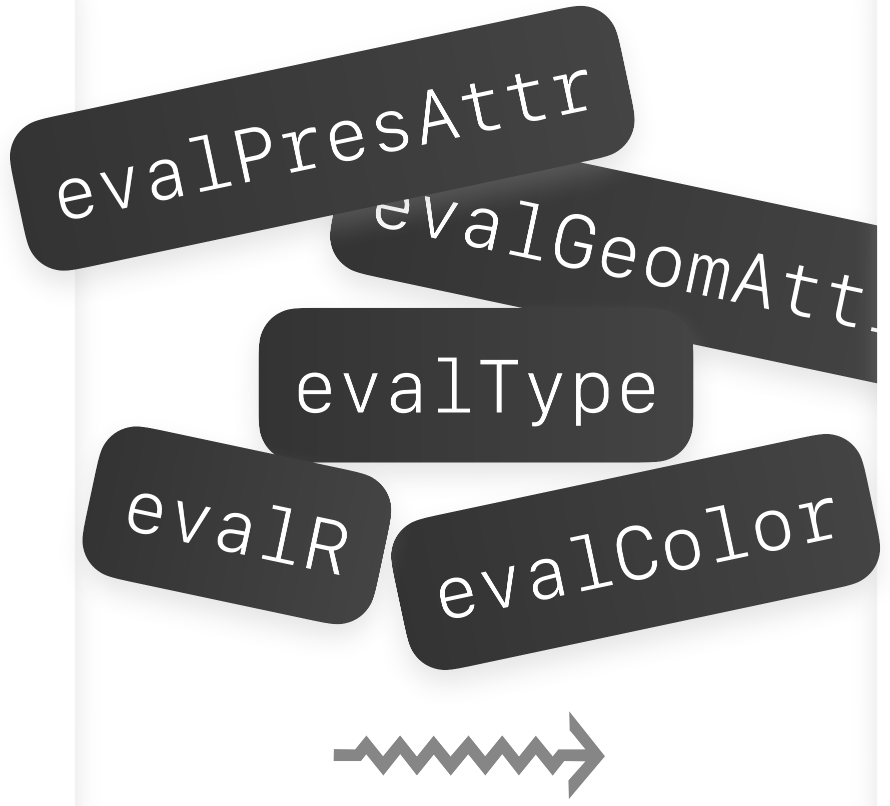
```
`Plot.dot(data, {
  x: “${PROGRAM_HOLE}”,
  y: “${PROGRAM_HOLE}”,
  r: 7,
  fill: “${PROGRAM_HOLE}”,
  ${EVAL_HOLE}
 })`
```

Intermediate Representation

Partial Program

Continue applying rewrites until we’ve read all key-value pairs in the IR.

```
{
  type: “Scatterplot”,
  r: [7],
  fill: ["#C67371", "#ccc", “#709DDE”],
  fill-opacity: [0.8],
  stroke: ["#C67371", "#ccc", “#709DDE”],
  stroke-opacity: [1],
  stroke-width: [“2px”]
}
```



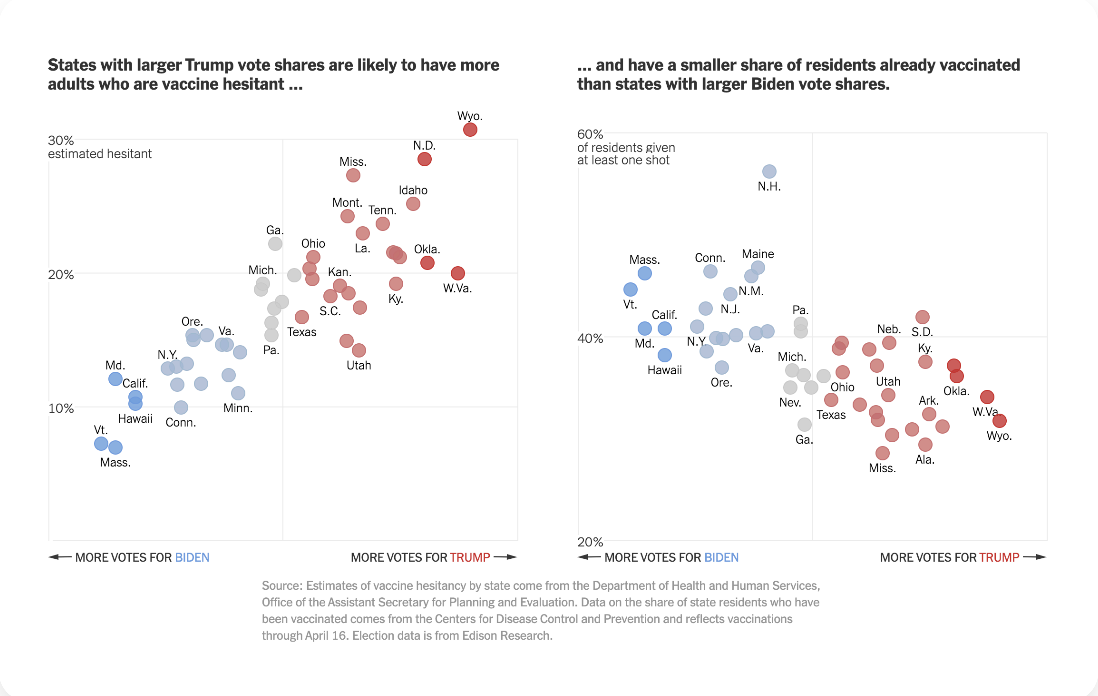
```
`Plot.dot(data, {
  x: “${PROGRAM_HOLE}”,
  y: “${PROGRAM_HOLE}”,
  r: 7,
  fill: “${PROGRAM_HOLE}”,
  fillOpacity: 0.8,
  stroke: “${PROGRAM_HOLE}”,
  strokeOpacity: 1,
  strokeWidth: “2px”
})`
```

Intermediate Representation

Partial Program

reviz

Input Visualization



States with larger Trump vote shares are likely to have more adults who are vaccine hesitant ...

... and have a smaller share of residents already vaccinated than states with larger Biden vote shares.

Source: Estimates of vaccine hesitancy by state come from the Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation. Data on the share of state residents who have been vaccinated comes from the Centers for Disease Control and Prevention and reflects vaccinations through April 16. Election data is from Edison Research.

Attribute Sets

r → 7

cx → 366

fill → "#C67371"

fill-opacity → 0.8

Intermediate Representation

```
{
  type: "Scatterplot",
  r: [7],
  fill: ["#C67371", "#ccc", "#709DDE"],
  fill-opacity: [0.8],
  stroke: ["#C67371", "#ccc", "#709DDE"],
  stroke-opacity: [1],
  stroke-width: ["2px"]
}
```

Rewrite Rules and Codegen

evalPresAttr

evalGeomAttr

evalType

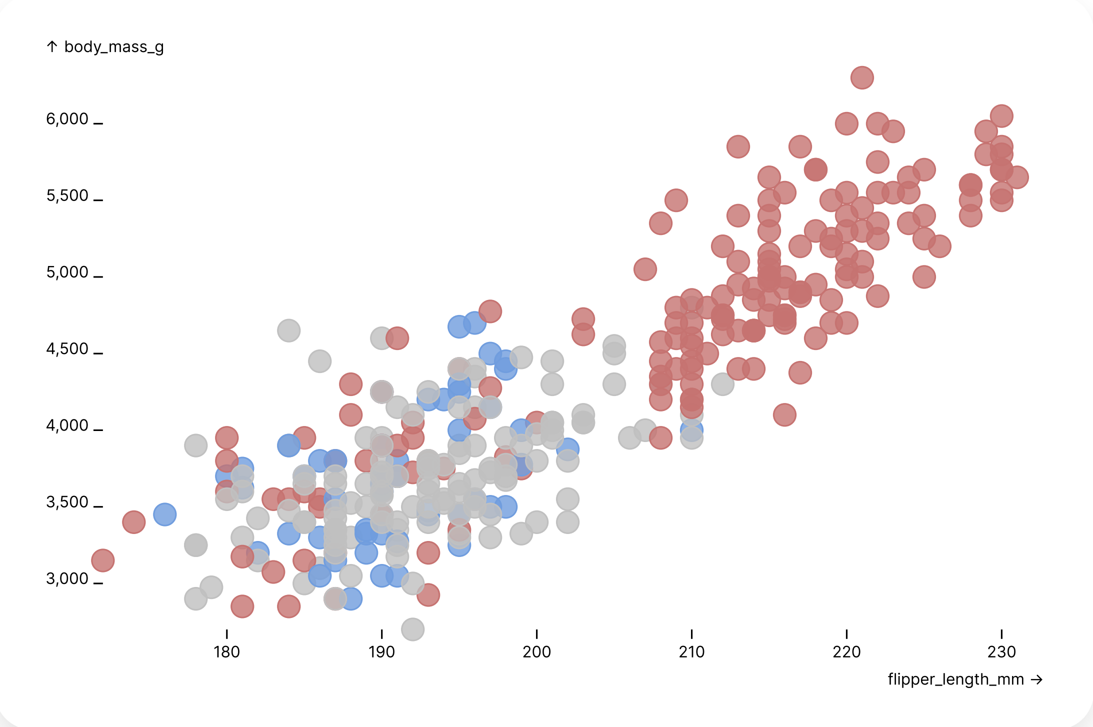
evalR

evalColor

Partial Program

```
const plot = Plot.plot({
  color: {
    type: "categorical",
    range: ["#C67371", "#ccc", "#709DDE"]
  },
  marks: [
    Plot.dot(data, {
      x: "??",
      y: "??",
      fill: "??",
      fillOpacity: 1,
      stroke: "??",
      strokeOpacity: 1,
      strokeWidth: 1
    }),
  ],
});
```

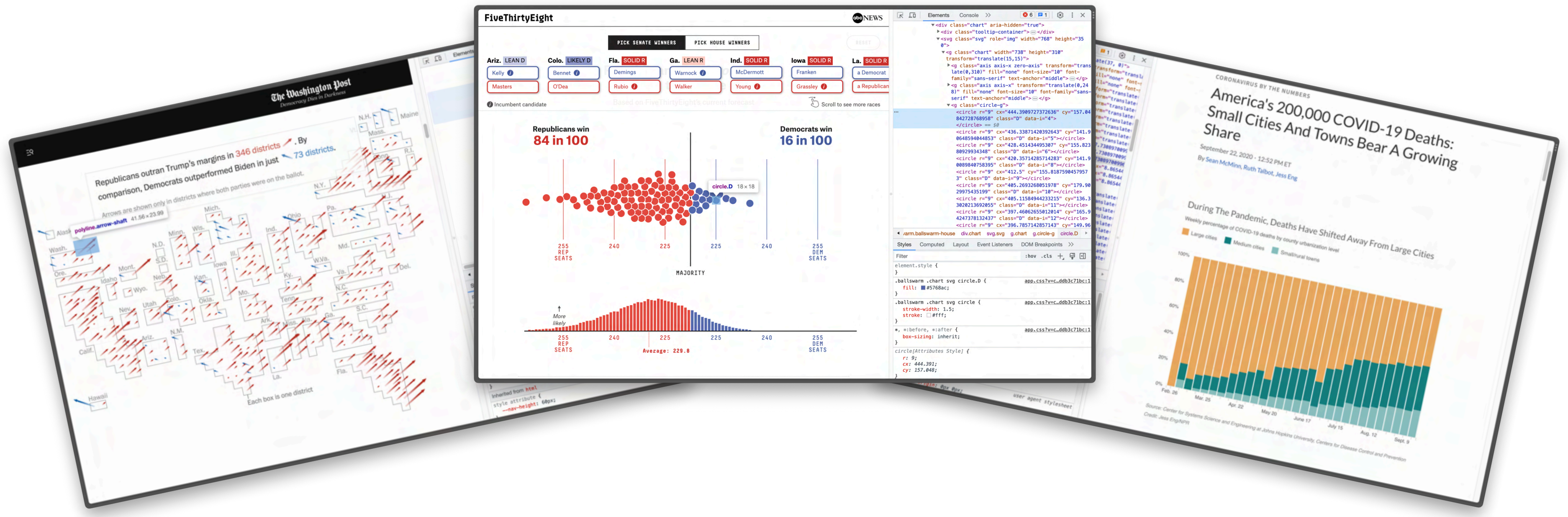
Output Visualization



Working Practice

Lift **visual styles** and **graphical forms** from **examples**

Apply to new datasets



The Washington Post

Republicans outran Trump's margins in 346 districts. By comparison, Democrats outperformed Biden in just 73 districts.

Each box is one district

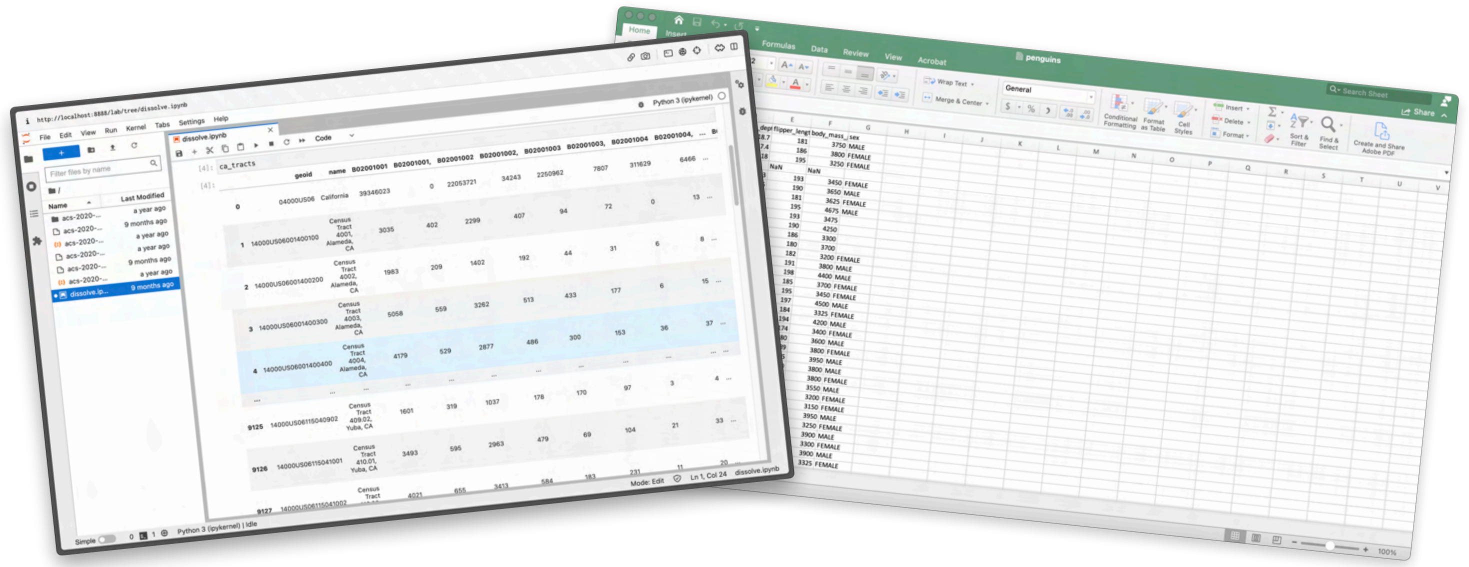
FiveThirtyEight

Republicans win 84 in 100

Democrats win 16 in 100

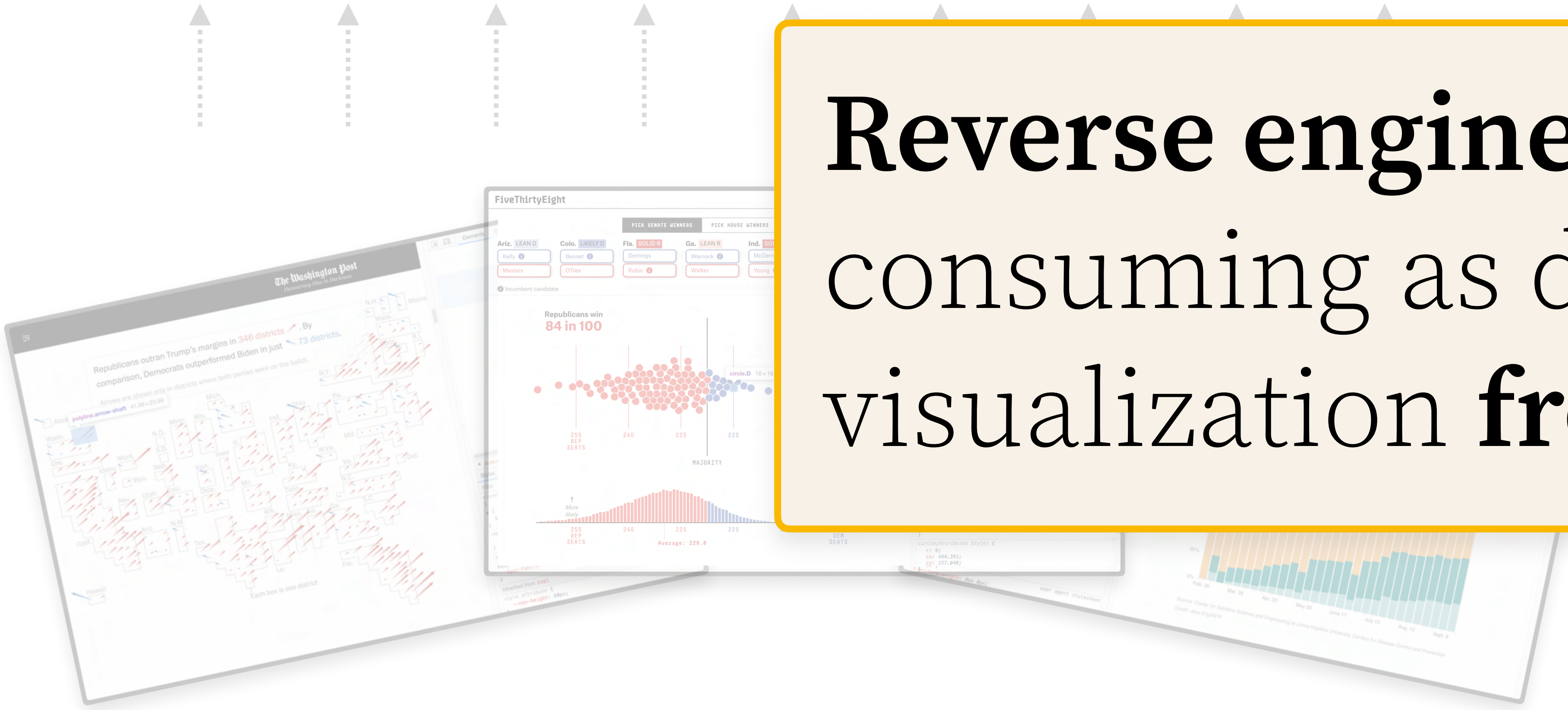
America's 200,000 COVID-19 Deaths: Small Cities And Towns Bear A Growing Share

During The Pandemic, Deaths Have Shifted Away From Large Cities

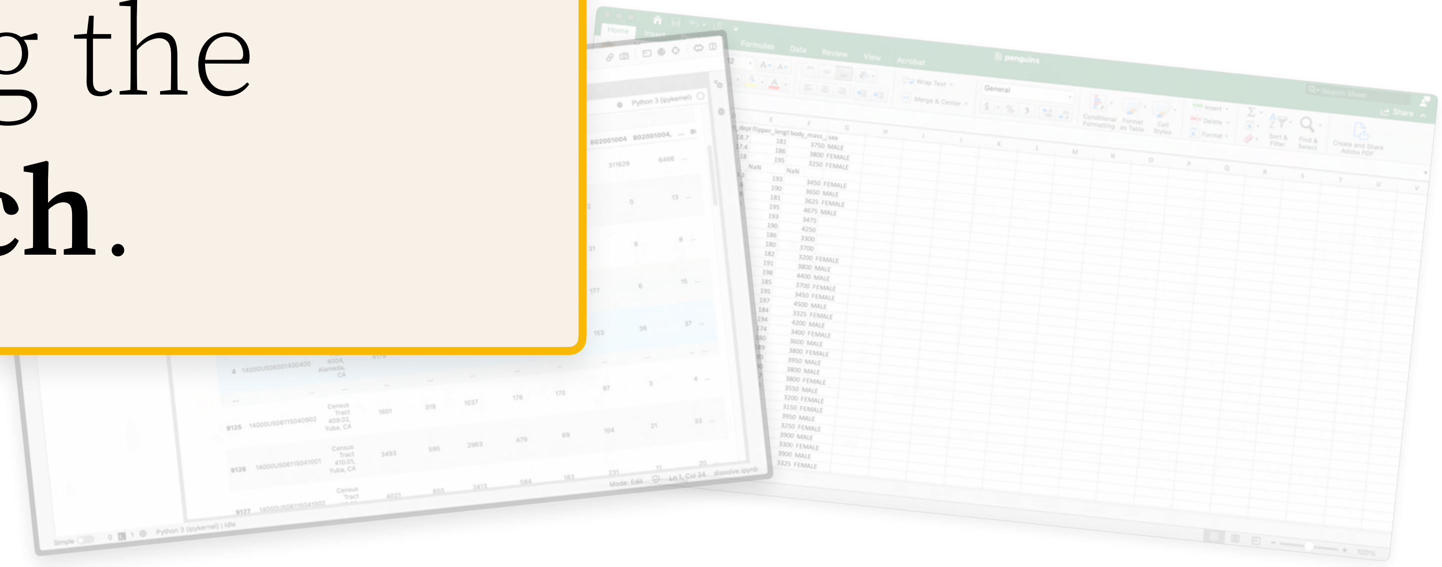


Working Practice

Lift **visual styles** and **graphical forms** from **examples**



Apply to new datasets



Reverse engineering was as time-consuming as developing the visualization **from scratch**.

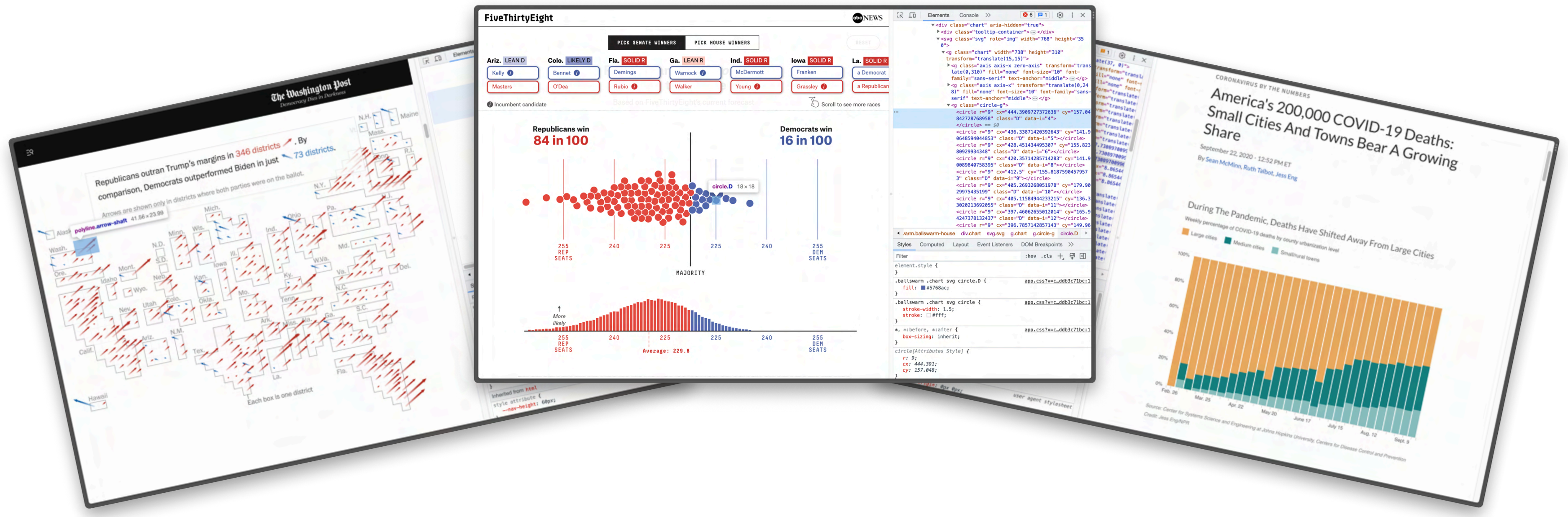
reviz

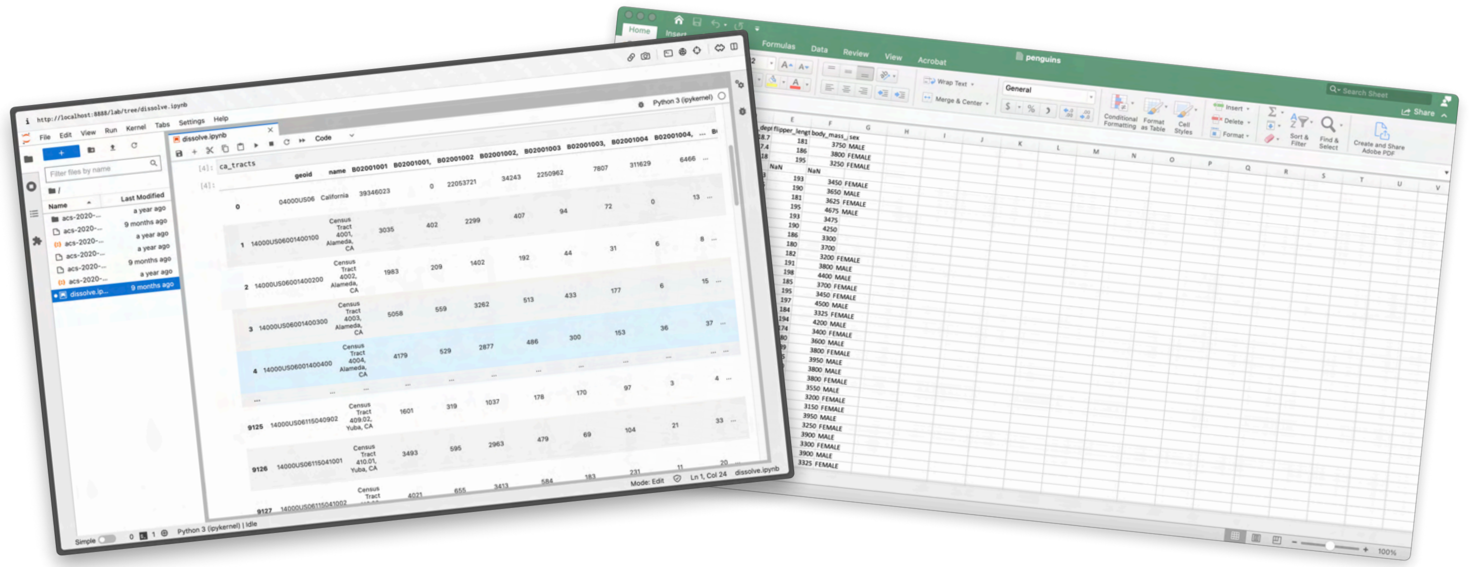
Working Practice

Lift **visual styles** and **graphical forms** from **examples**

Hours

Apply to new datasets


The Washington Post
FiveThirtyEight
Republicans win 84 in 100
Democrats win 16 in 100
America's 200,000 COVID-19 Deaths: Small Cities And Towns Bear A Growing Share

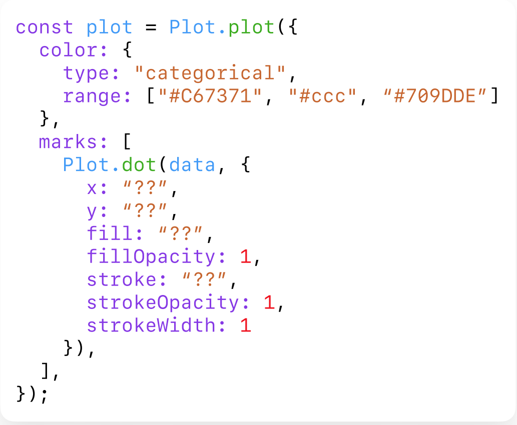


reviz

Automatically compile **partial programs** from **examples**

Feed in any dataset

Milliseconds



```
const plot = Plot.plot({
  color: {
    type: "categorical",
    range: ["#C67371", "#ccc", "#709DDE"]
  },
  marks: [
    Plot.dot(data, {
      x: "??",
      y: "??",
      fill: "??",
      fillOpacity: 1,
      stroke: "??",
      strokeOpacity: 1,
      strokeWidth: 1
    }),
  ],
});
```

> “Don’t commit to a specific visual form before seeing your data in it. A given visual form — say the pie chart or treemap — isn’t “good” or “bad” in an absolute sense, but it may or may not be appropriate to your data and the specific question you want answered. **The only way to know whether a form is effective is if it communicates: you must put your data in it and see.**”

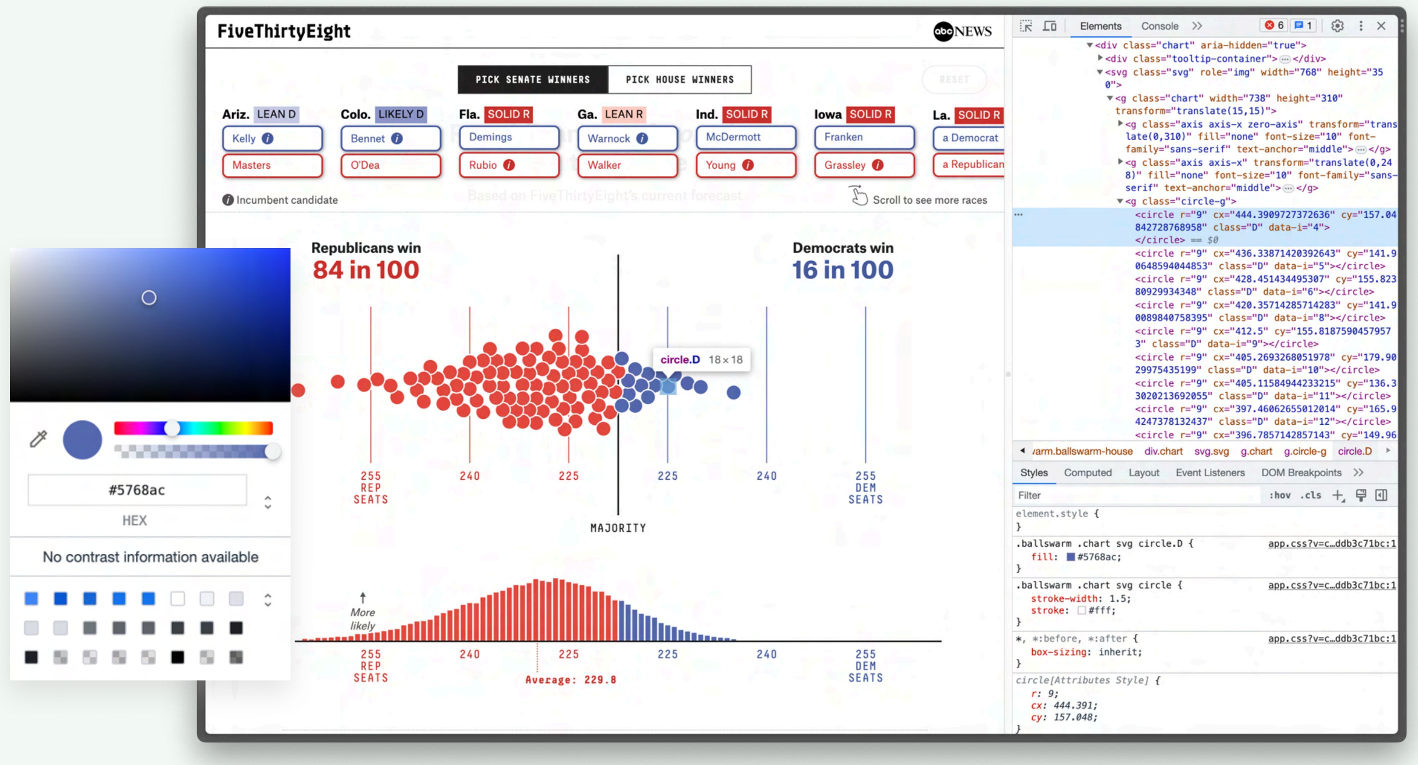
Mike Bostock • *“10 Years of Open-Source Visualization”*

Lexer

Parser

Recover (or infer) **semantic information** from the visual form that we can represent **symbolically**.

Map **interactions** with the visual form to **program edits**.



```
▼<div class="chart" aria-hidden="true">
  ▶<div class="tooltip-container">⋯</div>
  ▼<svg class="svg" role="img" width="768" height="350">
    ▼<g class="chart" width="738" height="310" transform="translate(15,15)">
      ▶<g class="axis axis-x zero-axis" transform="translate(0,310)" fill="none" font-size="10" font-family="sans-serif" text-anchor="middle">⋯</g>
      ▶<g class="axis axis-x" transform="translate(0,248)" fill="none" font-size="10" font-family="sans-serif" text-anchor="middle">⋯</g>
      ▼<g class="circle-g">
          <circle r="9" cx="444.3909727372636" cy="157.04842728768958" class="D" data-i="4">
          </circle> == $0
          <circle r="9" cx="436.33871420392643" cy="141.90648594044853" class="D" data-i="5"></circle>
          <circle r="9" cx="428.451434495307" cy="155.82380929934348" class="D" data-i="6"></circle>
          <circle r="9" cx="420.35714285714283" cy="141.90089840758395" class="D" data-i="8"></circle>
          <circle r="9" cx="412.5" cy="155.81875904579573" class="D" data-i="9"></circle>
          <circle r="9" cx="405.2693268051978" cy="179.9029975435199" class="D" data-i="10"></circle>
          <circle r="9" cx="405.11584944233215" cy="136.33020213692055" class="D" data-i="11"></circle>
          <circle r="9" cx="397.46062655012014" cy="165.94247378132437" class="D" data-i="12"></circle>
          <circle r="9" cx="396.7857142857143" cy="149.96
```

```
◀ /arm.ballswarm-house  div.chart  svg.svg  g.chart  g.circle-g  circle.D ▶
```

```
element.style {
}
.ballswarm .chart svg circle.D {          app.css?v=c…ddb3c71bc:1
  fill: #5768ac;
}
.ballswarm .chart svg circle {            app.css?v=c…ddb3c71bc:1
  stroke-width: 1.5;
  stroke: #fff;
}
*, *:before, *:after {                    app.css?v=c…ddb3c71bc:1
  box-sizing: inherit;
}
circle[Attributes Style] {
  r: 9;
  cx: 444.391;
  cy: 157.048;
}
```

reviz

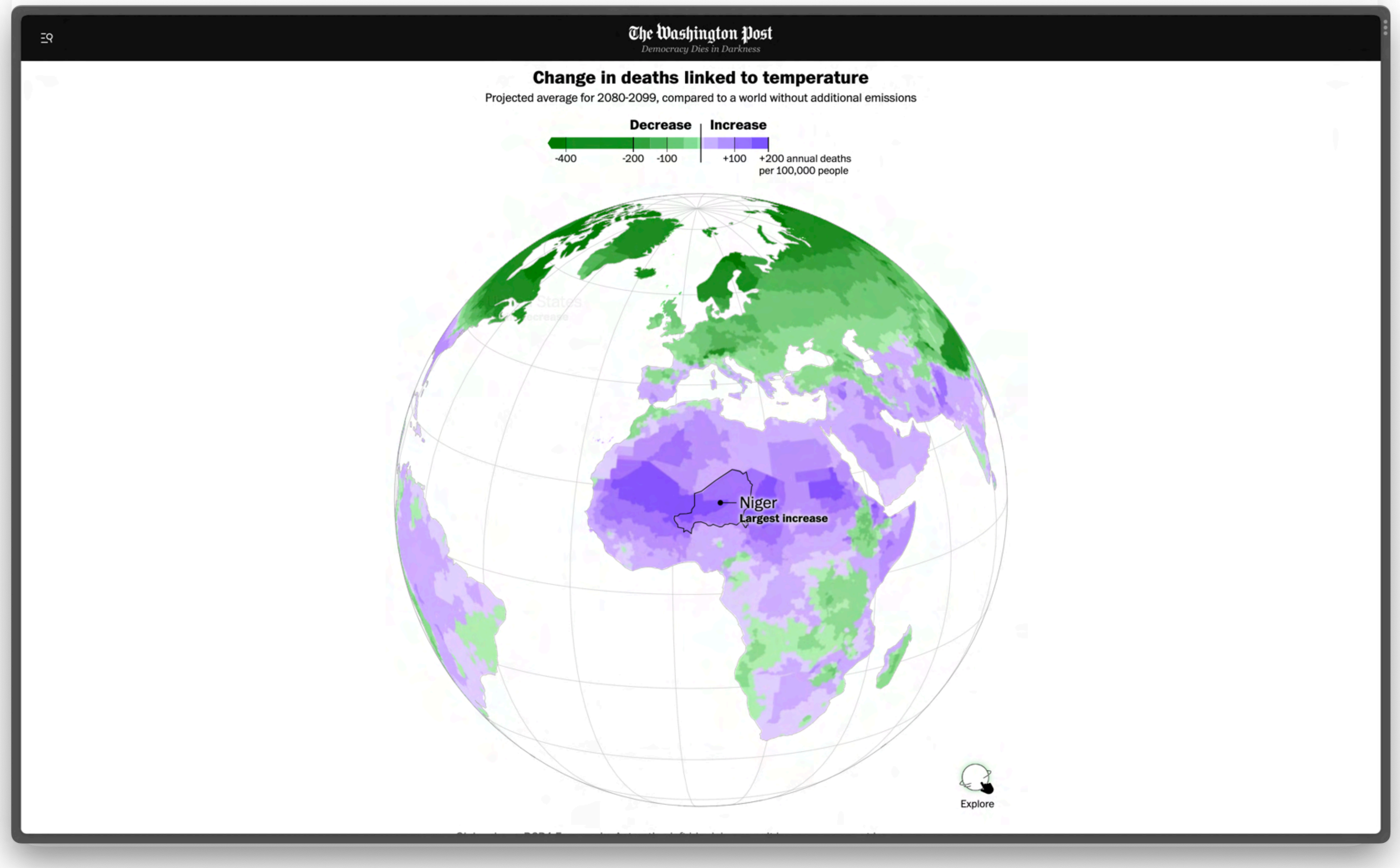
cartokit

cartokit

A **direct manipulation** programming environment for **interactive cartography**

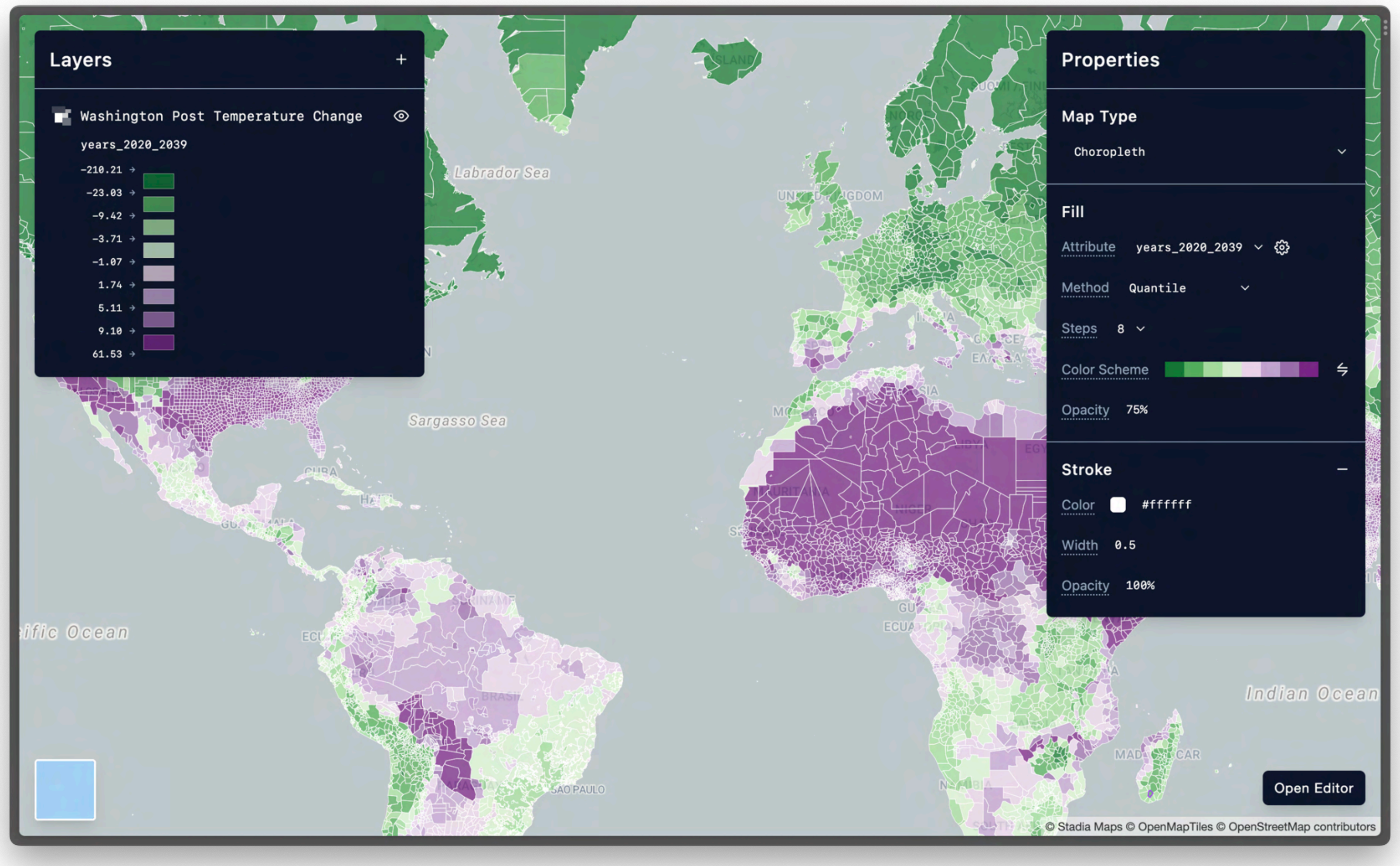
cartokit

Demo


The Washington Post
Democracy Dies in Darkness

Change in deaths linked to temperature

Projected average for 2080-2099, compared to a world without additional emissions


Layers +

Washington Post Temperature Change

years_2020_2039

-210.21 →
-23.03 →
-9.42 →
-3.71 →
-1.07 →
1.74 →
5.11 →
9.10 →
61.53 →

Properties

Map Type
Choropleth

Fill
Attribute years_2020_2039
Method Quantile
Steps 8
Color Scheme
Opacity 75%

Stroke
Color #ffffff
Width 0.5
Opacity 100%

The Washington Post

Will global warming make temperature less deadly?

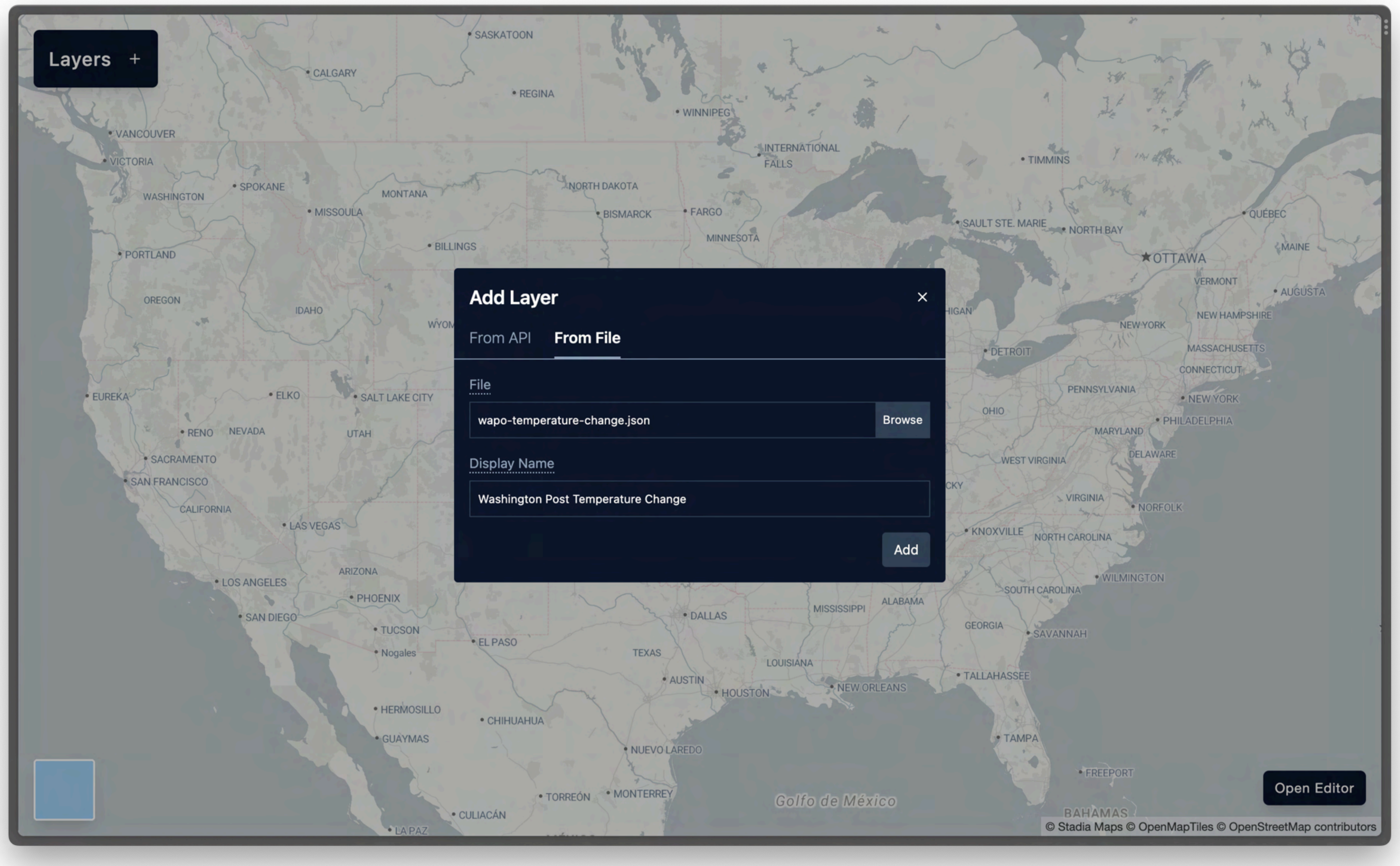
Harry Stevens

cartokit

A reproduction of the map in `cartokit`.

Can we author programs through **direct manipulation** of their outputs?

A user uploads their geospatial data to **cartokit**.



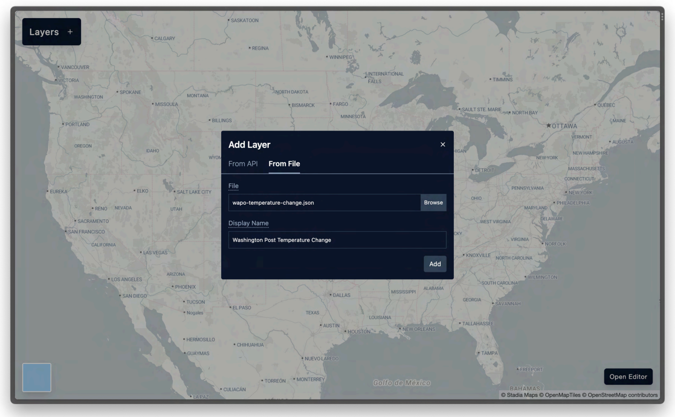
Add Layer

From API | From File

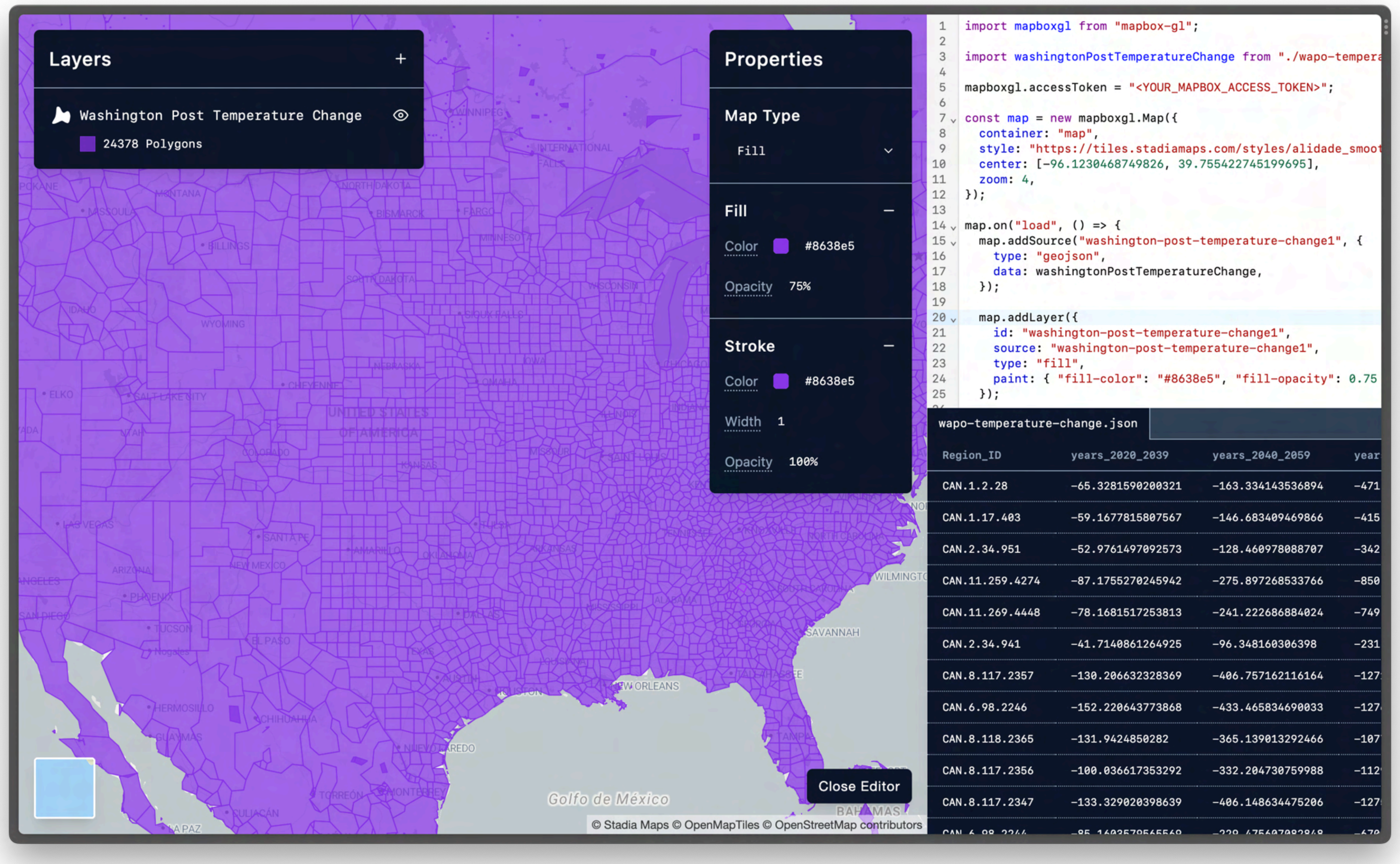
File: wapo-temperature-change.json

Display Name: Washington Post Temperature Change

cartokit

1. 

cartokit renders and displays the data while simultaneously **generating a program**.



Layers +

Washington Post Temperature Change

24378 Polygons

Properties

Map Type

Fill

Fill

Color #8638e5

Opacity 75%

Stroke

Color #8638e5

Width 1

Opacity 100%

```
import mapboxgl from "mapbox-gl";

import washingtonPostTemperatureChange from "./wapo-tempera

mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

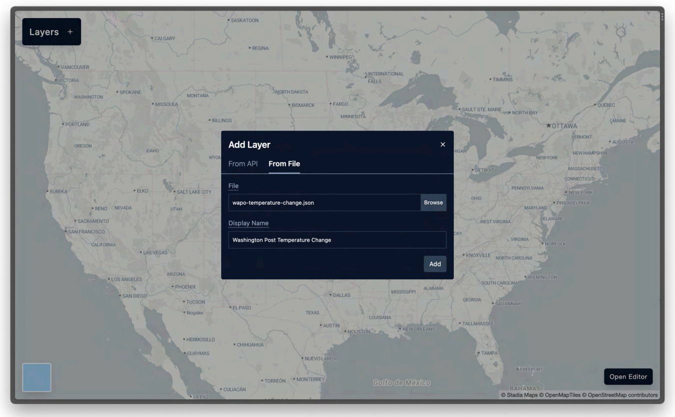
  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });
```

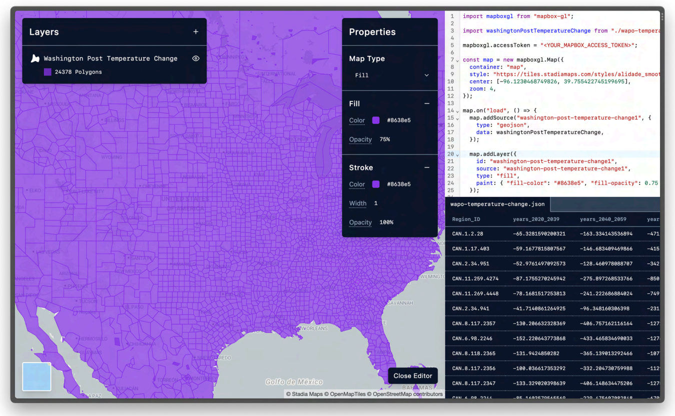
wapo-temperature-change.json

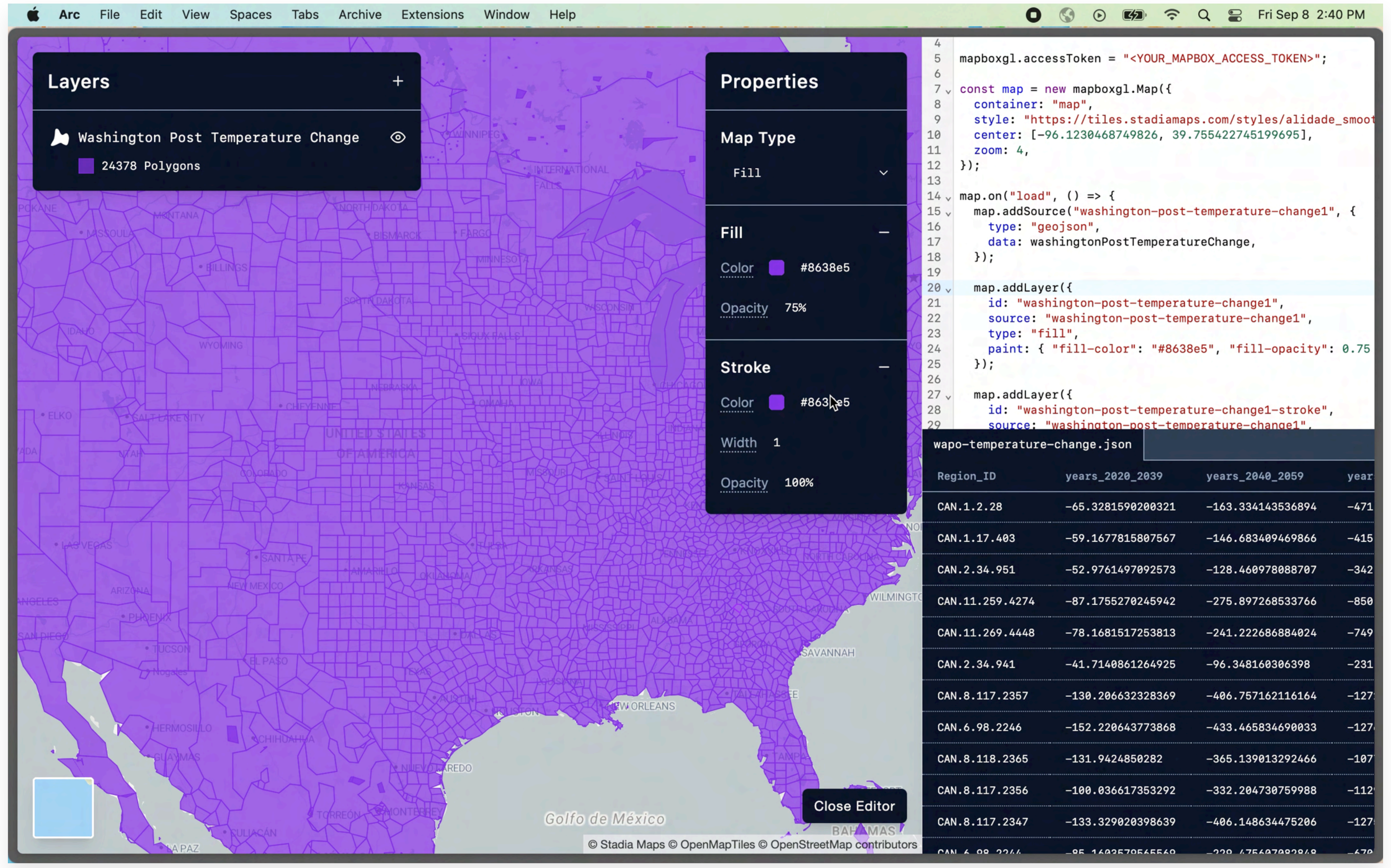
Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127
CAN.6.98.2244	-85.1603579565569	-229.475607082848	-670

cartokit

A user styles the map via **direct manipulation** while cartokit recompiles a matching program.

1. 

2. 



Washington Post Temperature Change

24378 Polygons

Properties

Map Type: Fill

Fill

Color #8638e5

Opacity 75%

Stroke

Color #8638e5

Width 1

Opacity 100%

```
mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

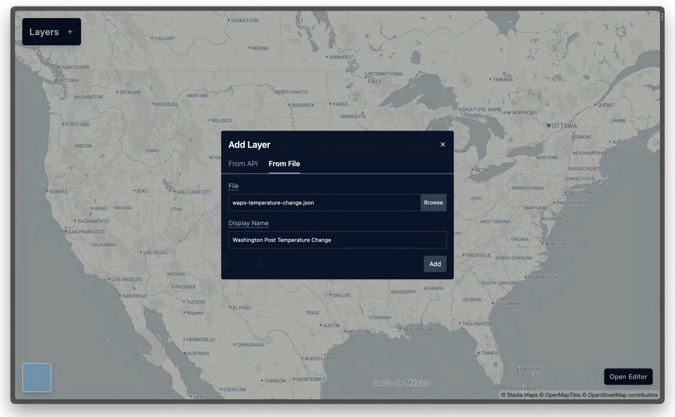
  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });

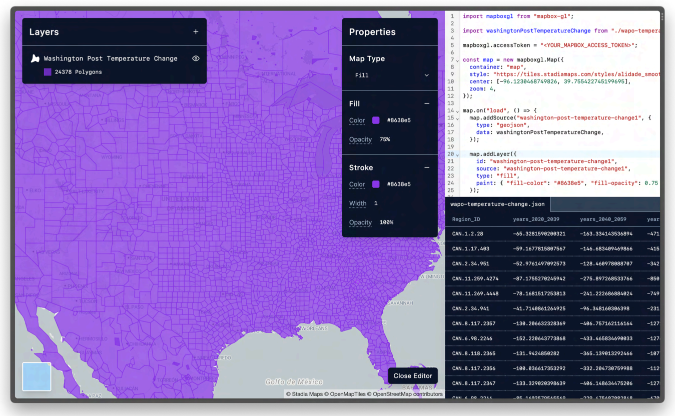
  map.addLayer({
    id: "washington-post-temperature-change1-stroke",
    source: "washington-post-temperature-change1",
```

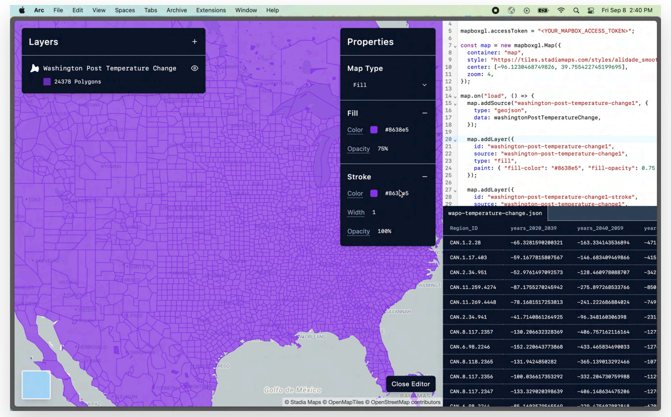
wapo-temperature-change.json

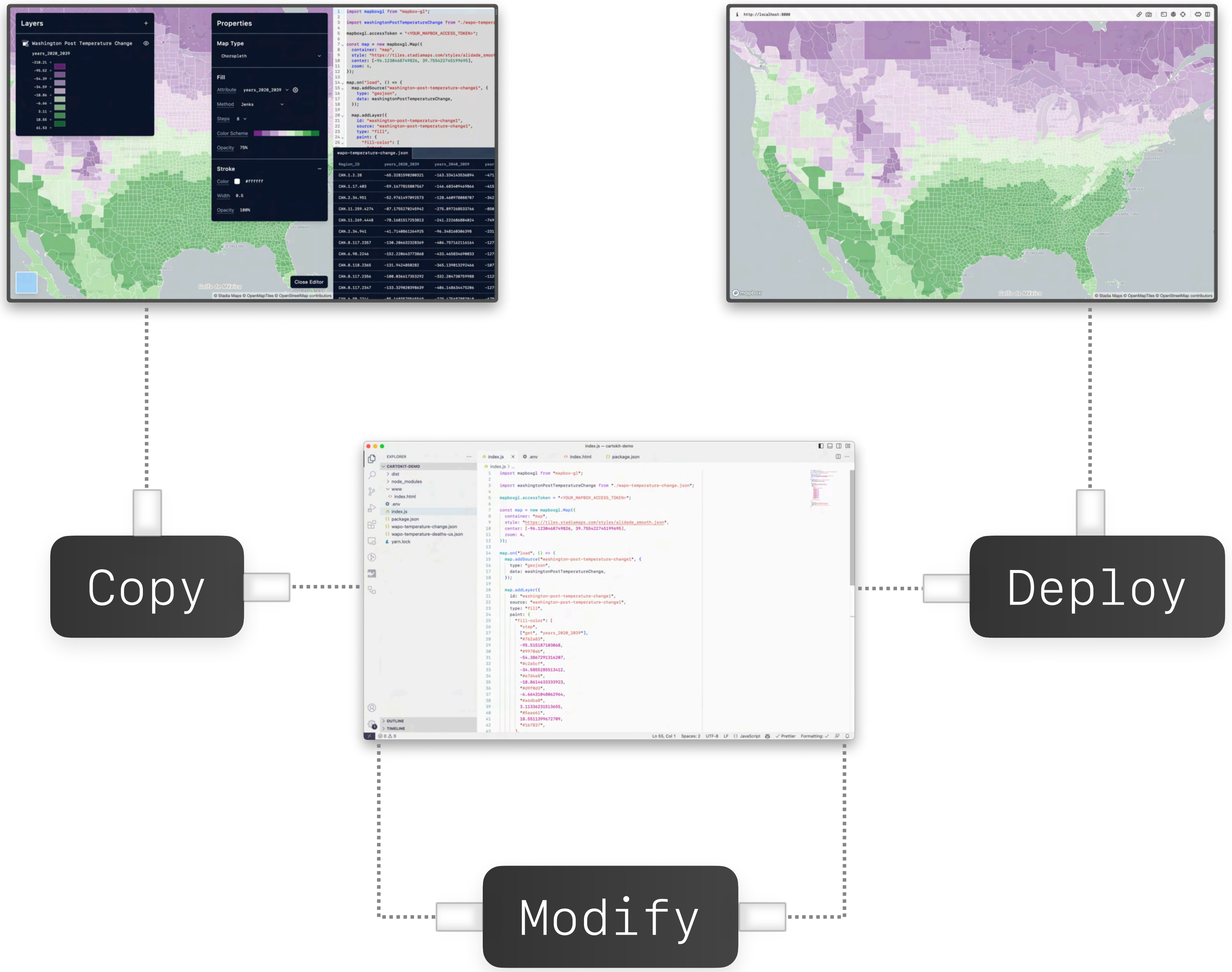
Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127
CAN.6.98.2244	-85.1603579565569	-229.475607082848	-670

A user can **copy**, **modify**, and **deploy** the compiled program as desired.

1. 

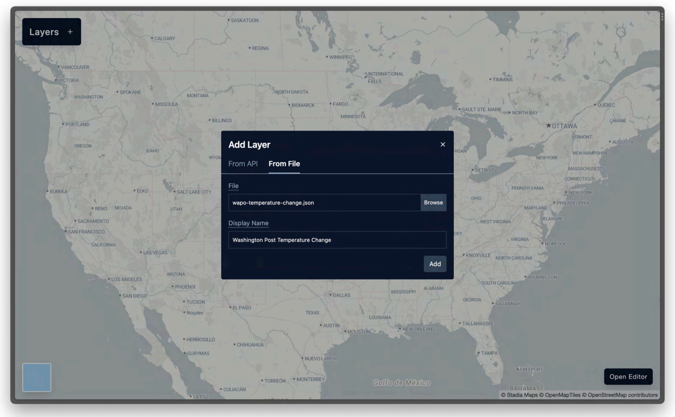
2. 

3. 



cartokit

1.



Add Layer ×

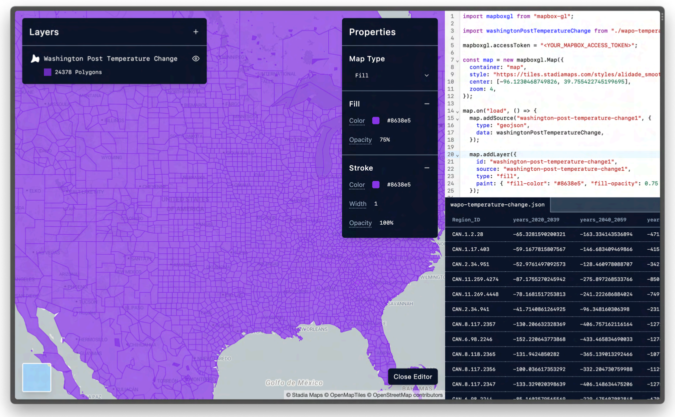
From API | From File

File: wapo-temperature-change.json [Browse]

Display Name: Washington Post Temperature Change

[Add]

2.



Layers +

Washington Post Temperature Change

24378 Polygons

Properties

Map Type: Fill

Fill
- Color: #8638e5
- Opacity: 75%

Stroke
- Color: #8638e5
- Width: 1
- Opacity: 100%

```
import mapboxgl from "mapbox-gl";

import washingtonPostTemperatureChange from "./wapo-tempera

mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

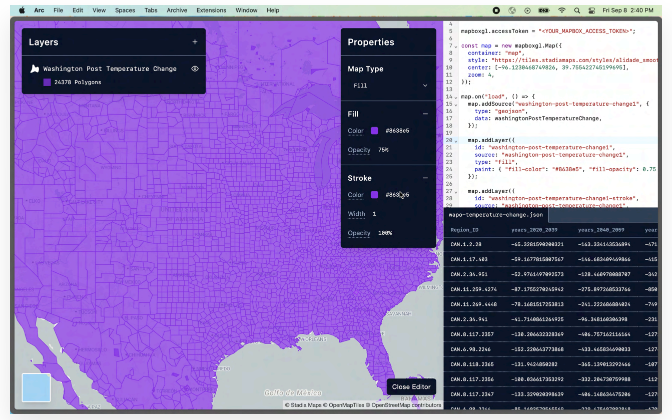
map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });
```

wapo-temperature-change.json

Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127

3.



Properties

Map Type: Fill

Fill
- Color: #8638e5
- Opacity: 75%

Stroke
- Color: #8638e5
- Width: 1
- Opacity: 100%

```
mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

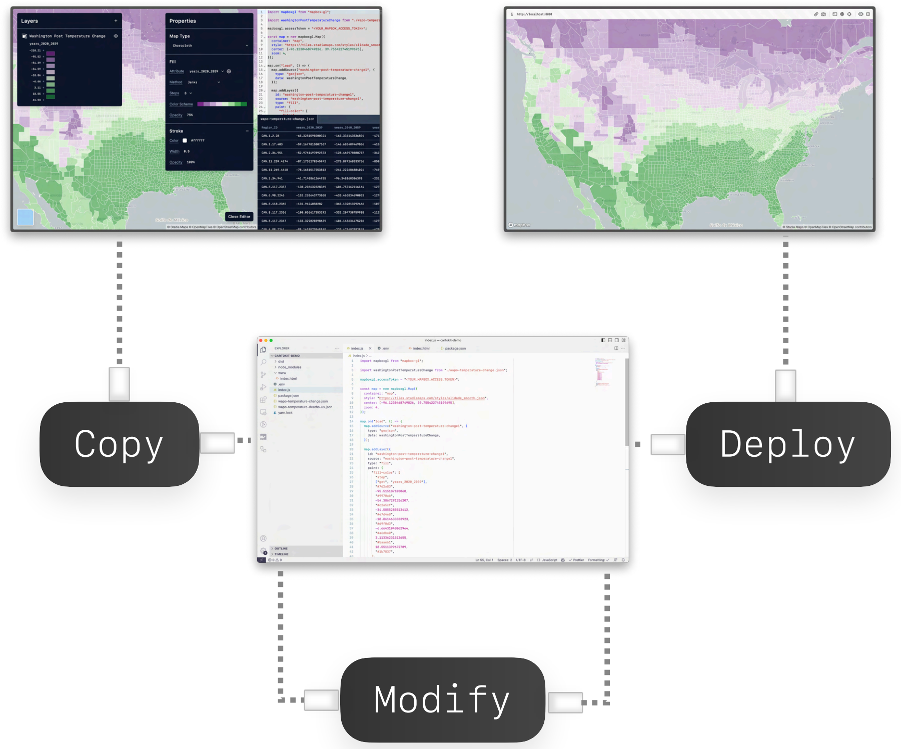
  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });

  map.addLayer({
    id: "washington-post-temperature-change1-stroke",
    source: "washington-post-temperature-change1",
```

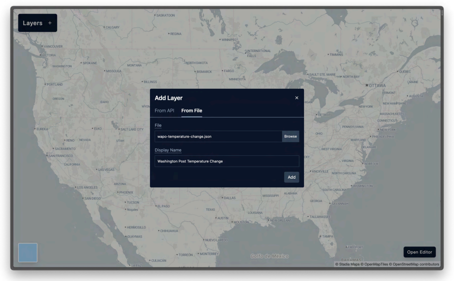
wapo-temperature-change.json

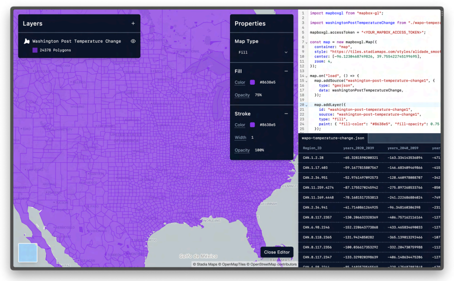
Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127

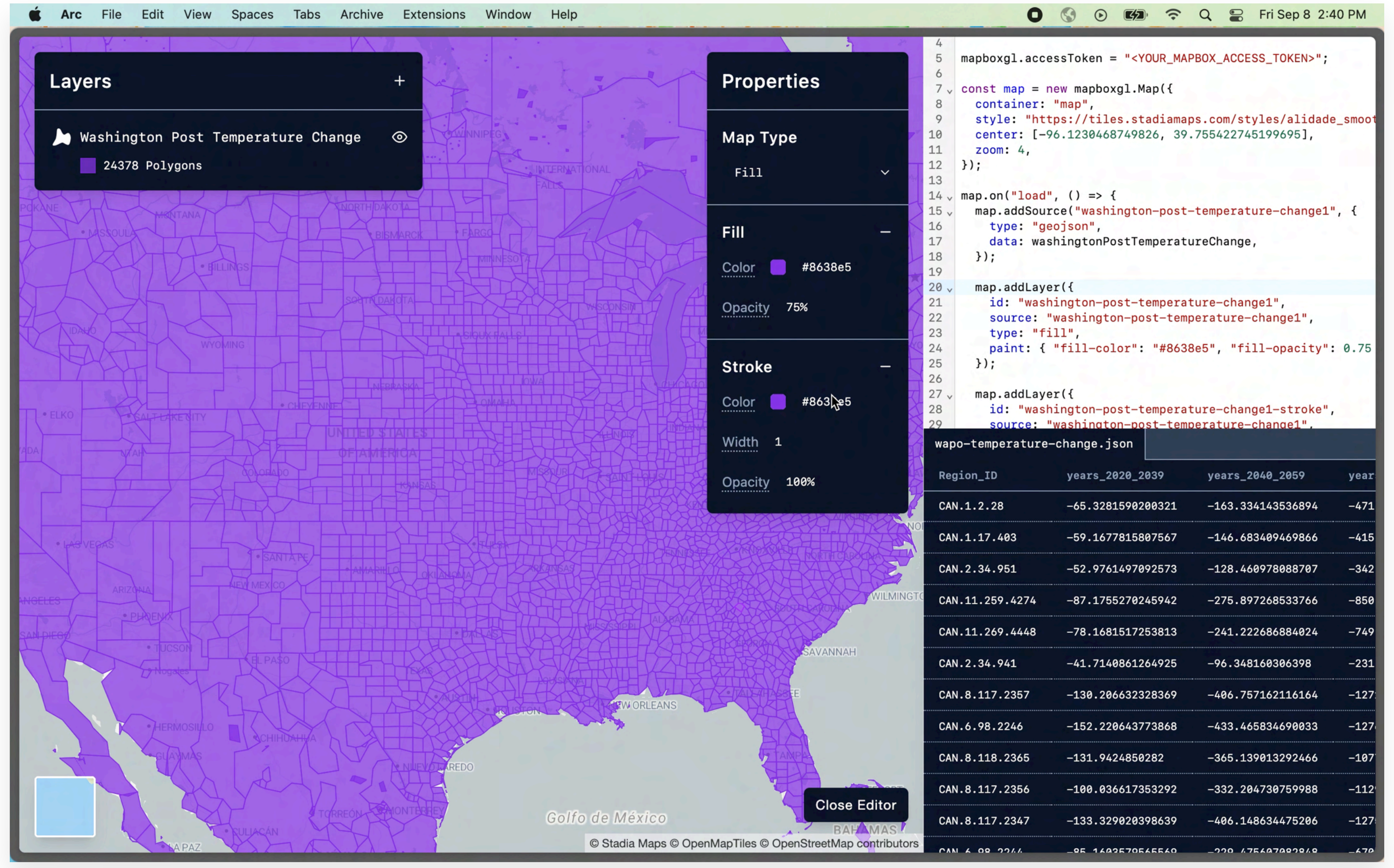
4.



cartokit

1. 

2. 

3. 

Arc File Edit View Spaces Tabs Archive Extensions Window Help
Fri Sep 8 2:40 PM
Layers +
Close Editor

Washington Post Temperature Change

24378 Polygons

Properties

Map Type: Fill

Fill

Color #8638e5

Opacity 75%

Stroke

Color #8638e5

Width 1

Opacity 100%

```
mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

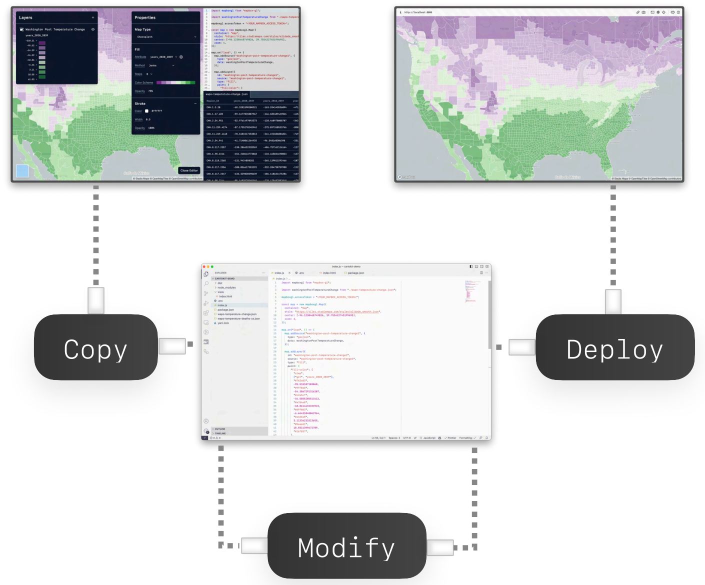
  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75

  });

  map.addLayer({
    id: "washington-post-temperature-change1-stroke",
    source: "washington-post-temperature-change1",
```

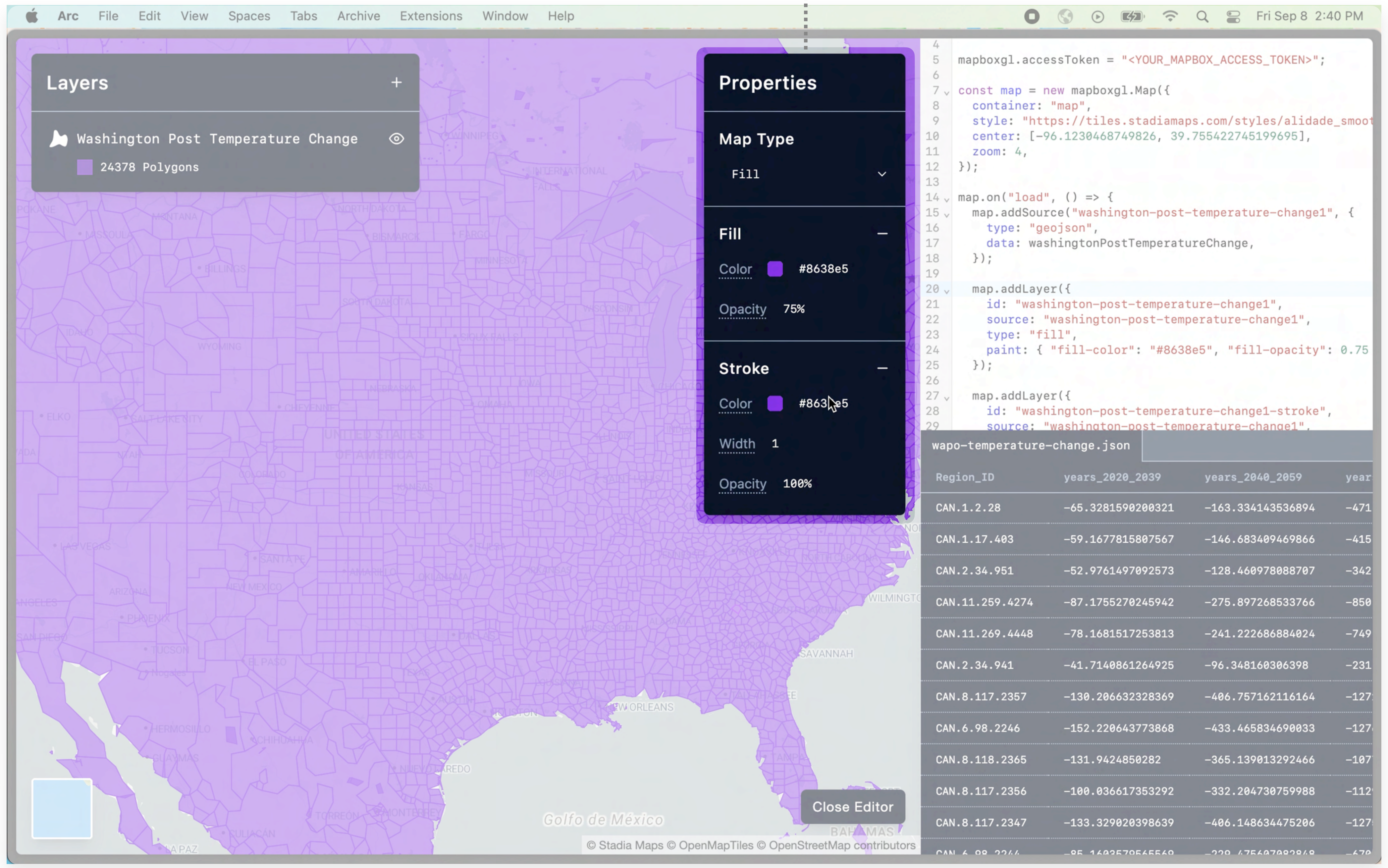
wapo-temperature-change.json

Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127
CAN.6.98.2244	-85.1603579565569	-229.475607082848	-670

4. 

How do we get from **interactions** to **program edits**?

Map **property controls** in the UI to an **intermediate representation**.


Arc File Edit View Spaces Tabs Archive Extensions Window Help
Fri Sep 8 2:40 PM
Layers
+
Close Editor
Golfo de México
© Stadia Maps © OpenMapTiles © OpenStreetMap contributors

Washington Post Temperature Change

24378 Polygons

Properties

Map Type: Fill

Fill
- Color: #8638e5
- Opacity: 75%

Stroke
- Color: #863 e5
- Width: 1
- Opacity: 100%

```
mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });

  map.addLayer({
    id: "washington-post-temperature-change1-stroke",
    source: "washington-post-temperature-change1",
```

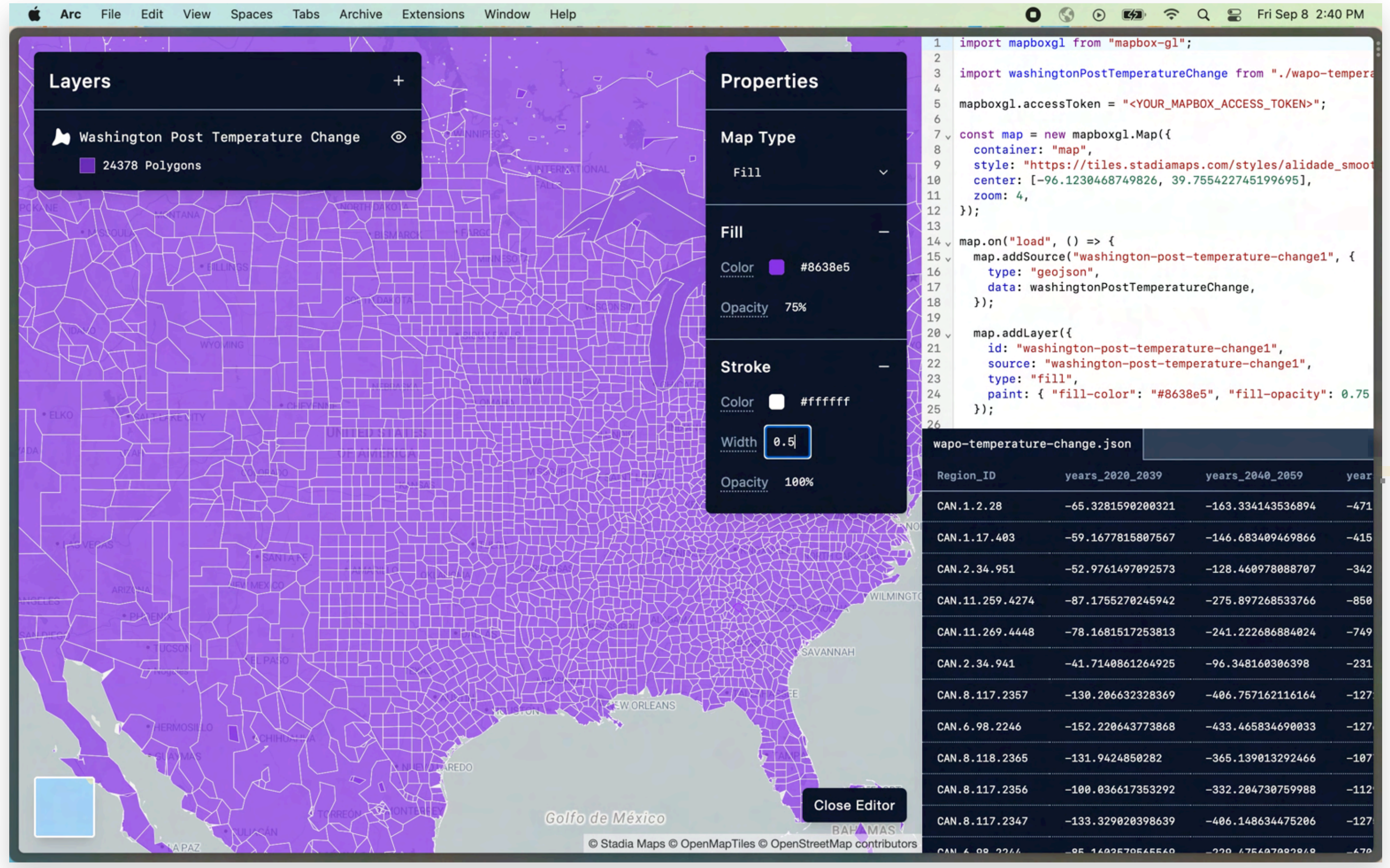
wapo-temperature-change.json

Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127

```
const ir = {
  center: [-106.1086, 37.7531],
  zoom: 4,
  basemap: {
    url: "https://tiles.stadiamaps.com/styl…",
    provider: "Stadia Maps",
  },
  layers: [
    {
      type: "Fill",
      style: {
        fill: {
          color: "#8638e5",
          opacity: 0.75,
        },
        stroke: {
          color: "#ffffff",
          width: 1,
          opacity: 0.5,
        },
      },
    },
  ],
};
```

When a user alters a property in the UI, **dispatch an update** to the IR.

Fill Layer



Layers +

Washington Post Temperature Change

24378 Polygons

Properties

Map Type: Fill

Fill

Color: #8638e5

Opacity: 75%

Stroke

Color: #ffffff

Width: 0.5

Opacity: 100%

```
import mapboxgl from "mapbox-gl";

import washingtonPostTemperatureChange from "./wapo-tempera

mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

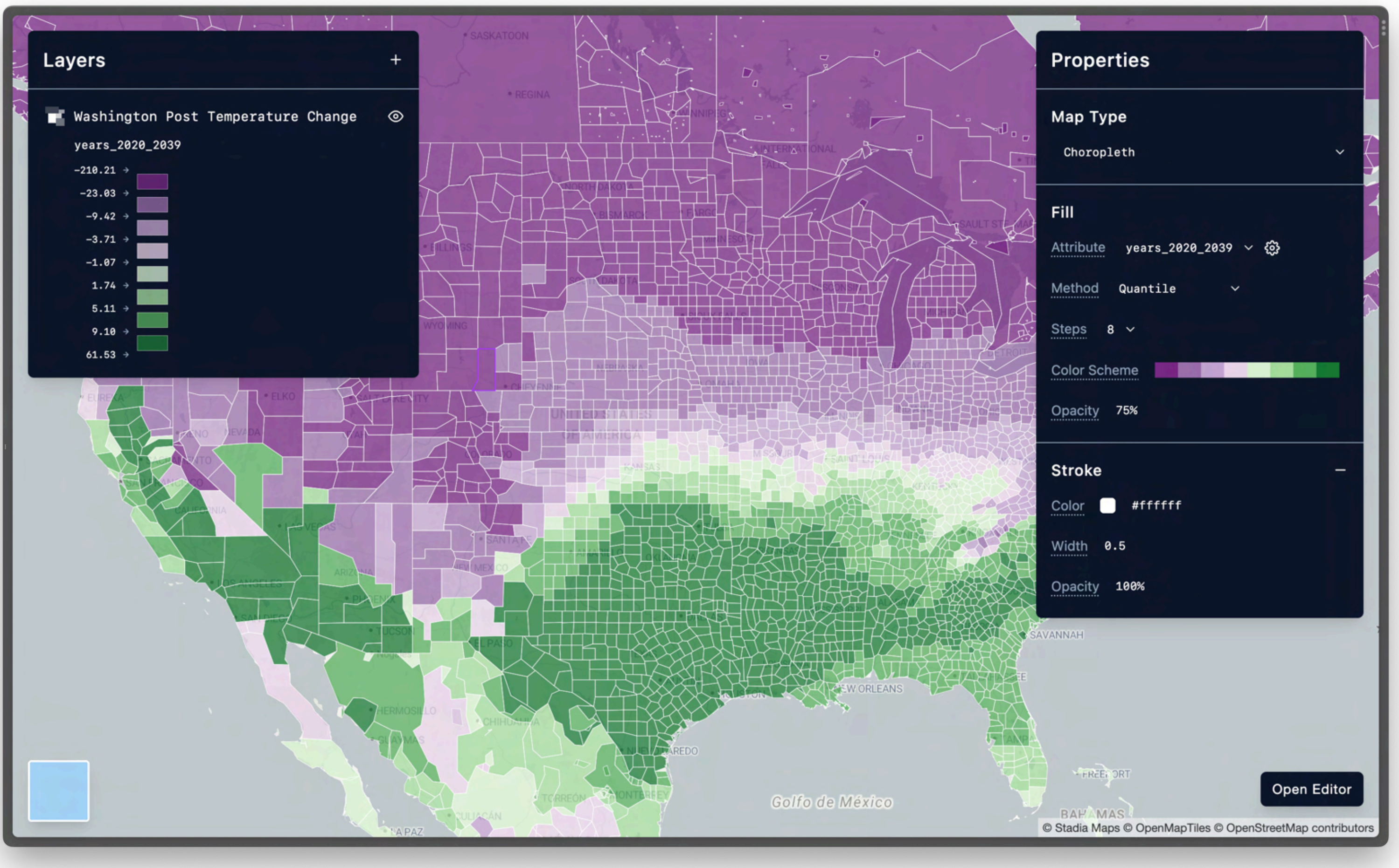
  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });
```

wapo-temperature-change.json

Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127
CAN.6.98.2244	-85.1603579545569	-229.475607082848	-470

dispatchLayerUpdate

Choropleth Layer



Layers +

Washington Post Temperature Change

years_2020_2039

-210.21 →
-23.03 →
-9.42 →
-3.71 →
-1.07 →
1.74 →
5.11 →
9.10 →
61.53 →

Properties

Map Type: Choropleth

Fill

Attribute: years_2020_2039

Method: Quantile

Steps: 8

Color Scheme

Opacity: 75%

Stroke

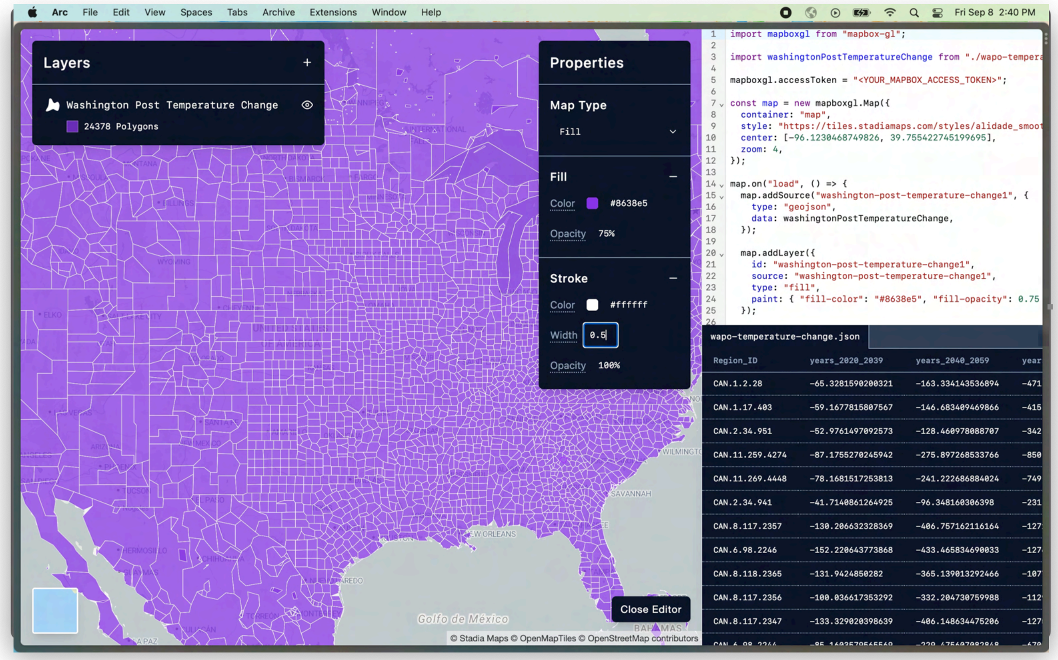
Color: #ffffff

Width: 0.5

Opacity: 100%

When a user alters a property in the UI, **dispatch an update** to the IR.

Fill Layer



Arc File Edit View Spaces Tabs Archive Extensions Window Help
Fri Sep 8 2:40 PM
Layers
+
Close Editor
Golfo de México
© Stadia Maps © OpenMapTiles © OpenStreetMap contributors

Washington Post Temperature Change
24378 Polygons

Properties

Map Type: Fill

Fill
Color #8638e5
Opacity 75%

Stroke
Color #ffffff
Width 0.5
Opacity 100%

```
import mapboxgl from "mapbox-gl";

import washingtonPostTemperatureChange from "./wapo-tempera

mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.7554227451996 95],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

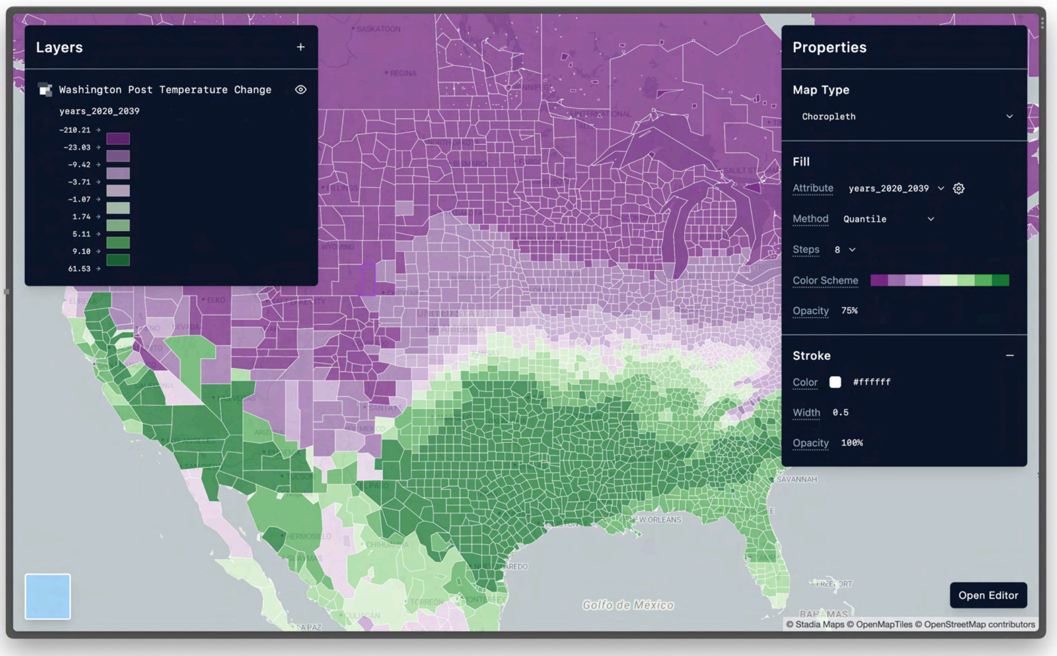
  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });
```

wapo-temperature-change.json

Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127

dispatchLayerUpdate

Choropleth Layer



Washington Post Temperature Change
years_2020_2039
-210.21 →
-23.03 →
-9.42 →
-3.71 →
-1.07 →
1.74 →
5.11 →
9.10 →
61.53 →

Properties

Map Type: Choropleth

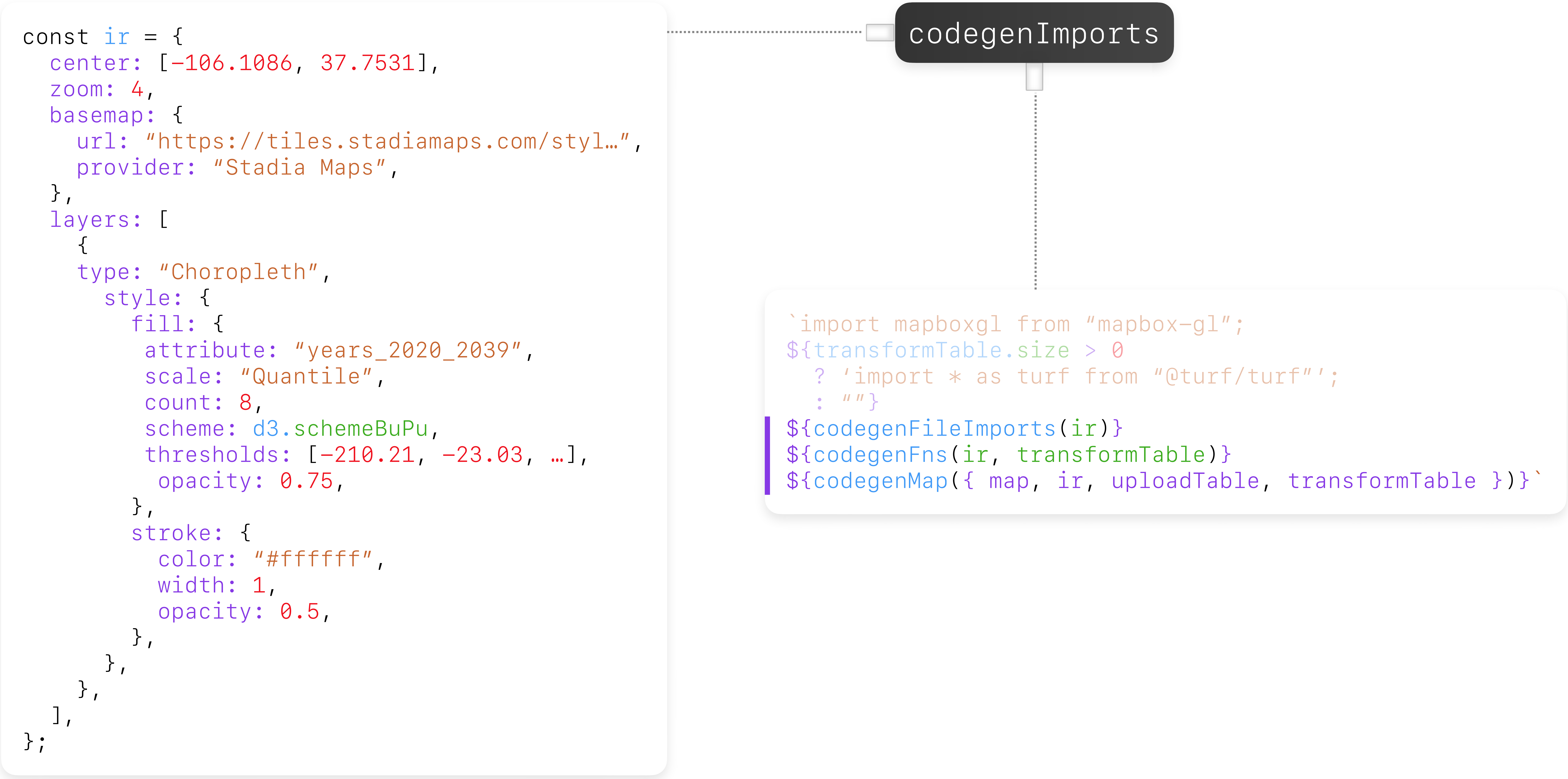
Fill
Attribute years_2020_2039
Method Quantile
Steps 8
Color Scheme
Opacity 75%

Stroke
Color #ffffff
Width 0.5
Opacity 100%

```
const ir = {
  center: [-106.1086, 37.7531],
  zoom: 4,
  basemap: {
    url: "https://tiles.stadiamaps.com/styl…",
    provider: "Stadia Maps",
  },
  layers: [
    {
–     type: "Fill",
      style: {
        fill: {
–         color: "#8638e5",
          opacity: 0.75,
        },
        stroke: {
          color: "#ffffff",
          width: 1,
          opacity: 0.5,
        },
      },
    },
  ],
};
```

```
const ir = {
  center: [-106.1086, 37.7531],
  zoom: 4,
  basemap: {
    url: "https://tiles.stadiamaps.com/styl…",
    provider: "Stadia Maps",
  },
  layers: [
    {
+     type: "Choropleth",
      style: {
        fill: {
+         attribute: "years_2020_2039",
+         scale: "Quantile",
+         count: 8,
+         scheme: d3.schemeBuPu,
+         thresholds: [-210.21, -23.03, …],
          opacity: 0.75,
        },
        stroke: {
          color: "#ffffff",
          width: 1,
          opacity: 0.5,
        },
      },
    },
  ],
};
```

Begin **code generation**, starting with dependencies.

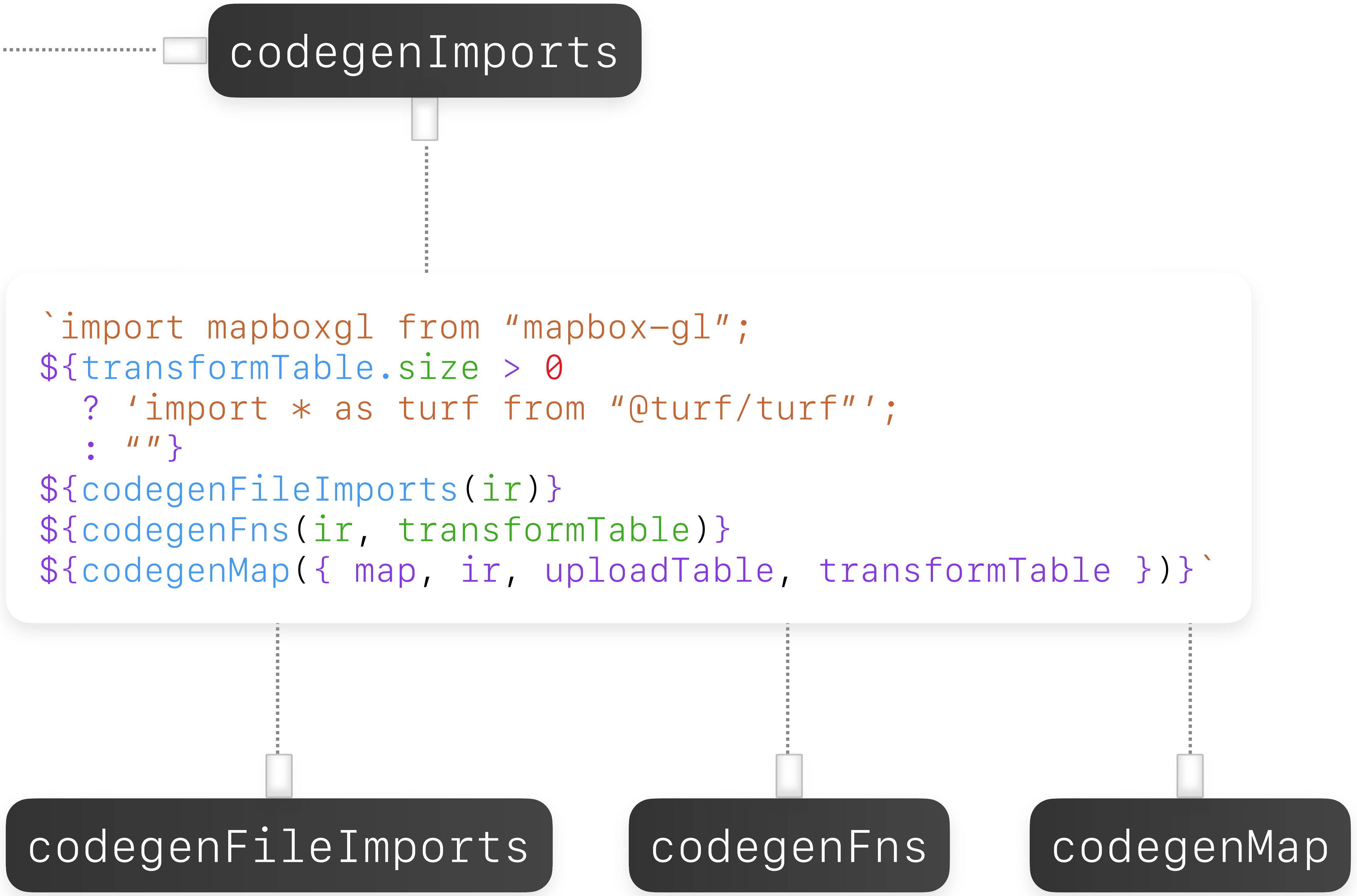


```
const ir = {
  center: [-106.1086, 37.7531],
  zoom: 4,
  basemap: {
    url: “https://tiles.stadiamaps.com/styl…”,
    provider: “Stadia Maps”,
  },
  layers: [
    {
    type: “Choropleth”,
      style: {
        fill: {
         attribute: “years_2020_2039”,
         scale: “Quantile”,
         count: 8,
         scheme: d3.schemeBuPu,
         thresholds: [-210.21, -23.03, …],
          opacity: 0.75,
        },
        stroke: {
          color: “#ffffff”,
          width: 1,
          opacity: 0.5,
        },
      },
    },
  ],
};
```

```
`import mapboxgl from “mapbox-gl”;
${transformTable.size > 0
  ? ‘import * as turf from “@turf/turf”’;
  : “”}
${codegenFileImports(ir)}
${codegenFns(ir, transformTable)}
${codegenMap({ map, ir, uploadTable, transformTable })}`
```

Pass execution to **codegen functions** to produce **program fragments** for distinct parts of the IR.

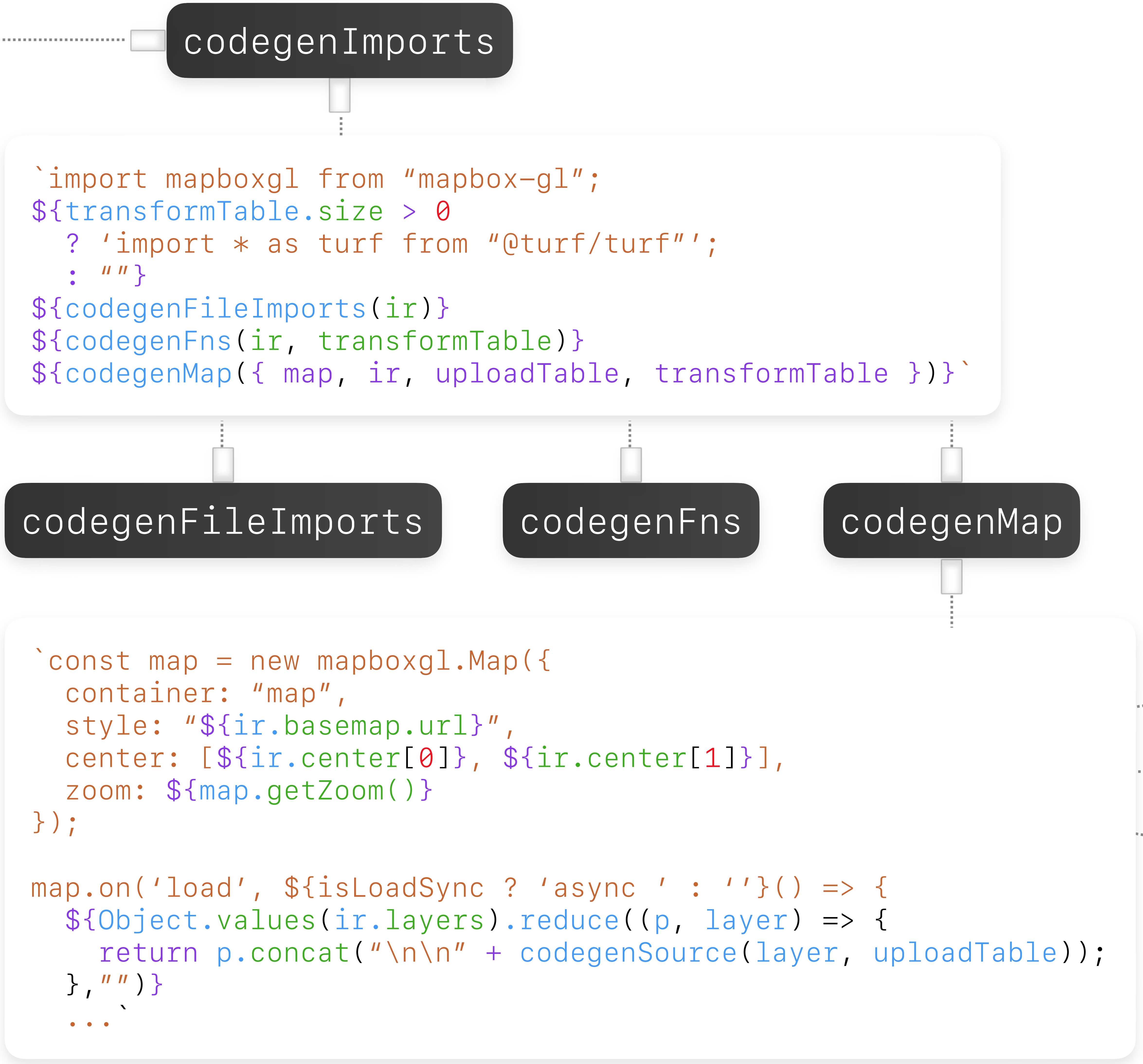
```
const ir = {
  center: [-106.1086, 37.7531],
  zoom: 4,
  basemap: {
    url: “https://tiles.stadiamaps.com/styl…”,
    provider: “Stadia Maps”,
  },
  layers: [
    {
    type: “Choropleth”,
      style: {
        fill: {
         attribute: “years_2020_2039”,
         scale: “Quantile”,
         count: 8,
         scheme: d3.schemeBuPu,
         thresholds: [-210.21, -23.03, …],
          opacity: 0.75,
        },
        stroke: {
          color: “#ffffff”,
          width: 1,
          opacity: 0.5,
        },
      },
    },
  ],
};
```



```
`import mapboxgl from “mapbox-gl”;
${transformTable.size > 0
  ? ‘import * as turf from “@turf/turf”’;
  : “”}
${codegenFileImports(ir)}
${codegenFns(ir, transformTable)}
${codegenMap({ map, ir, uploadTable, transformTable })}`
```

Pass execution to **codegen functions** to produce **program fragments** for distinct parts of the IR.

```
const ir = {
  center: [-106.1086, 37.7531],
  zoom: 4,
  basemap: {
    url: “https://tiles.stadiamaps.com/styl…”,
    provider: “Stadia Maps”,
  },
  layers: [
    {
    type: “Choropleth”,
      style: {
        fill: {
         attribute: “years_2020_2039”,
         scale: “Quantile”,
         count: 8,
         scheme: d3.schemeBuPu,
         thresholds: [-210.21, -23.03, …],
          opacity: 0.75,
        },
        stroke: {
          color: “#ffffff”,
          width: 1,
          opacity: 0.5,
        },
      },
    },
  ],
};
```



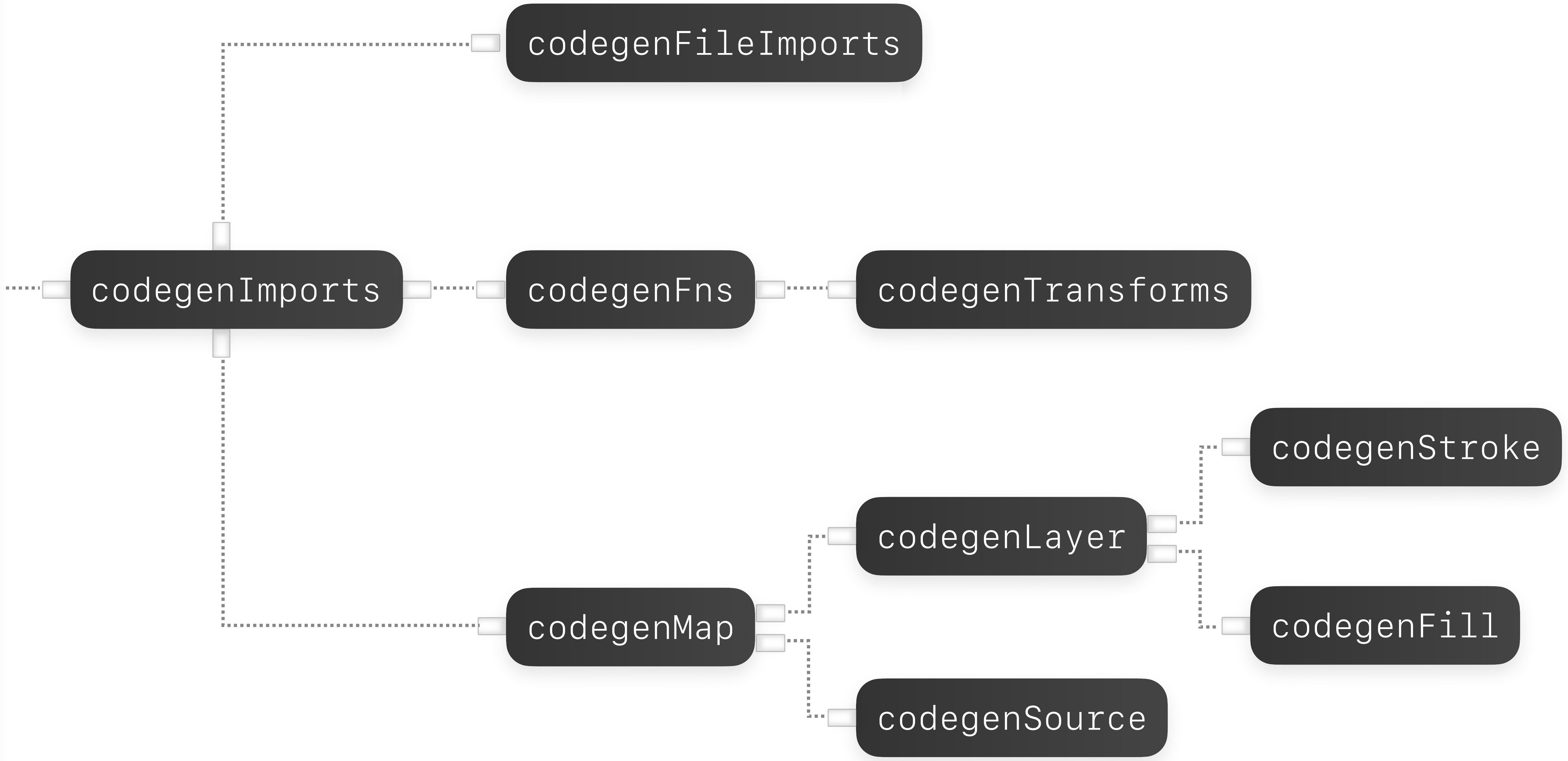
```
`import mapboxgl from “mapbox-gl”;
${transformTable.size > 0
  ? ‘import * as turf from “@turf/turf”’;
  : “”}
${codegenFileImports(ir)}
${codegenFns(ir, transformTable)}
${codegenMap({ map, ir, uploadTable, transformTable })}`
```

```
`const map = new mapboxgl.Map({
  container: “map”,
  style: “${ir.basemap.url}”,
  center: [${ir.center[0]}, ${ir.center[1]}],
  zoom: ${map.getZoom()}
});

map.on(‘load’, ${isLoadSync ? ‘async ’ : ‘’}() => {
  ${Object.values(ir.layers).reduce((p, layer) => {
    return p.concat(“\n\n” + codegenSource(layer, uploadTable));
  },“”)}
  ...`
```

Pass execution to **codegen functions** to produce **program fragments** for distinct parts of the IR.

```
const ir = {
  center: [−106.1086, 37.7531],
  zoom: 4,
  basemap: {
    url: “https://tiles.stadiamaps.com/styl…”,
    provider: “Stadia Maps”,
  },
  layers: [
    {
    type: “Choropleth”,
      style: {
        fill: {
         attribute: “years_2020_2039”,
         scale: “Quantile”,
         count: 8,
         scheme: d3.schemeBuPu,
         thresholds: [−210.21, −23.03, …],
          opacity: 0.75,
        },
        stroke: {
          color: “#ffffff”,
          width: 1,
          opacity: 0.5,
        },
      },
    },
  ],
};
```



codegenFileImports

codegenImports

codegenFns

codegenTransforms

codegenStroke

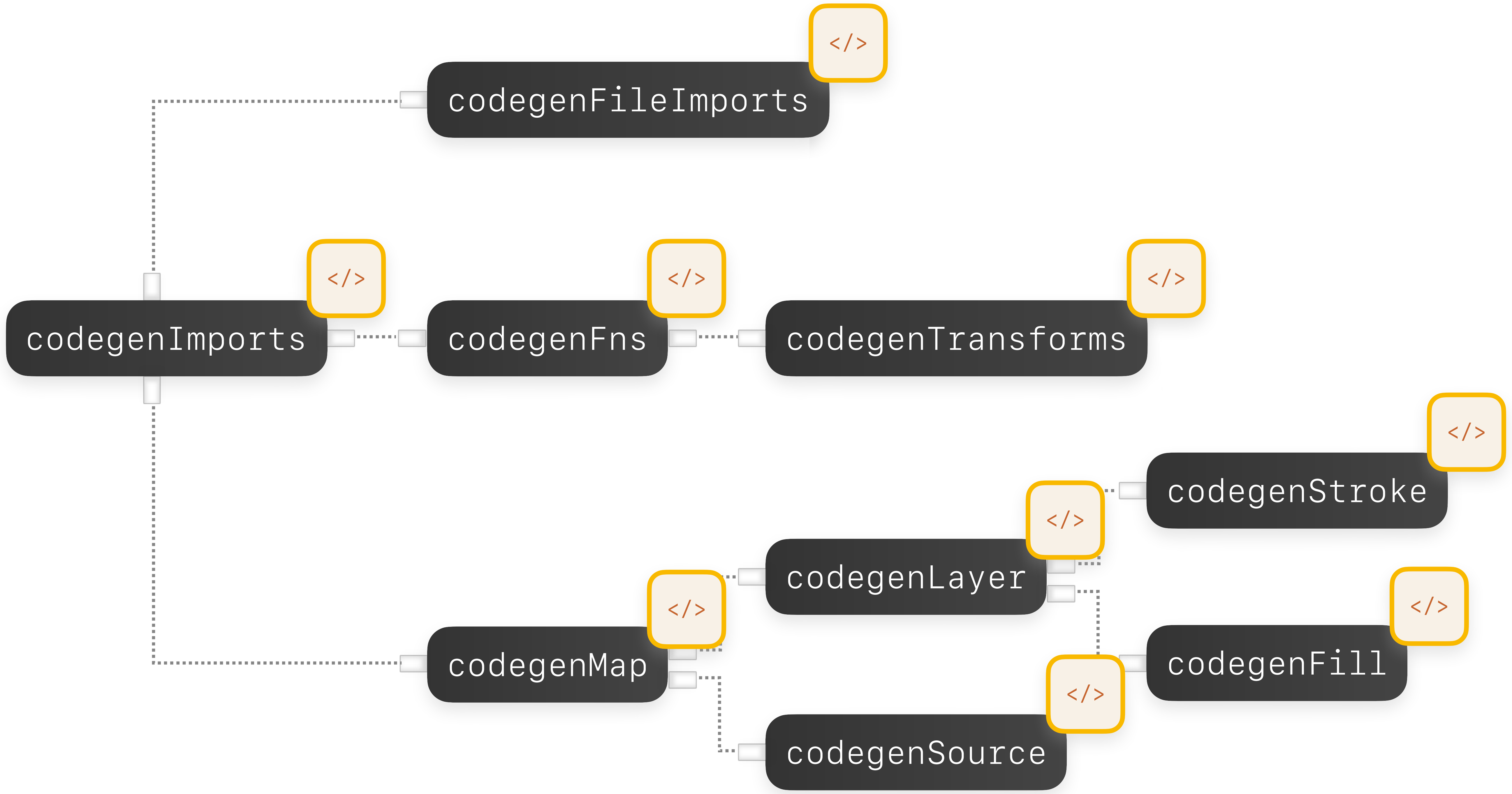
codegenLayer

codegenMap

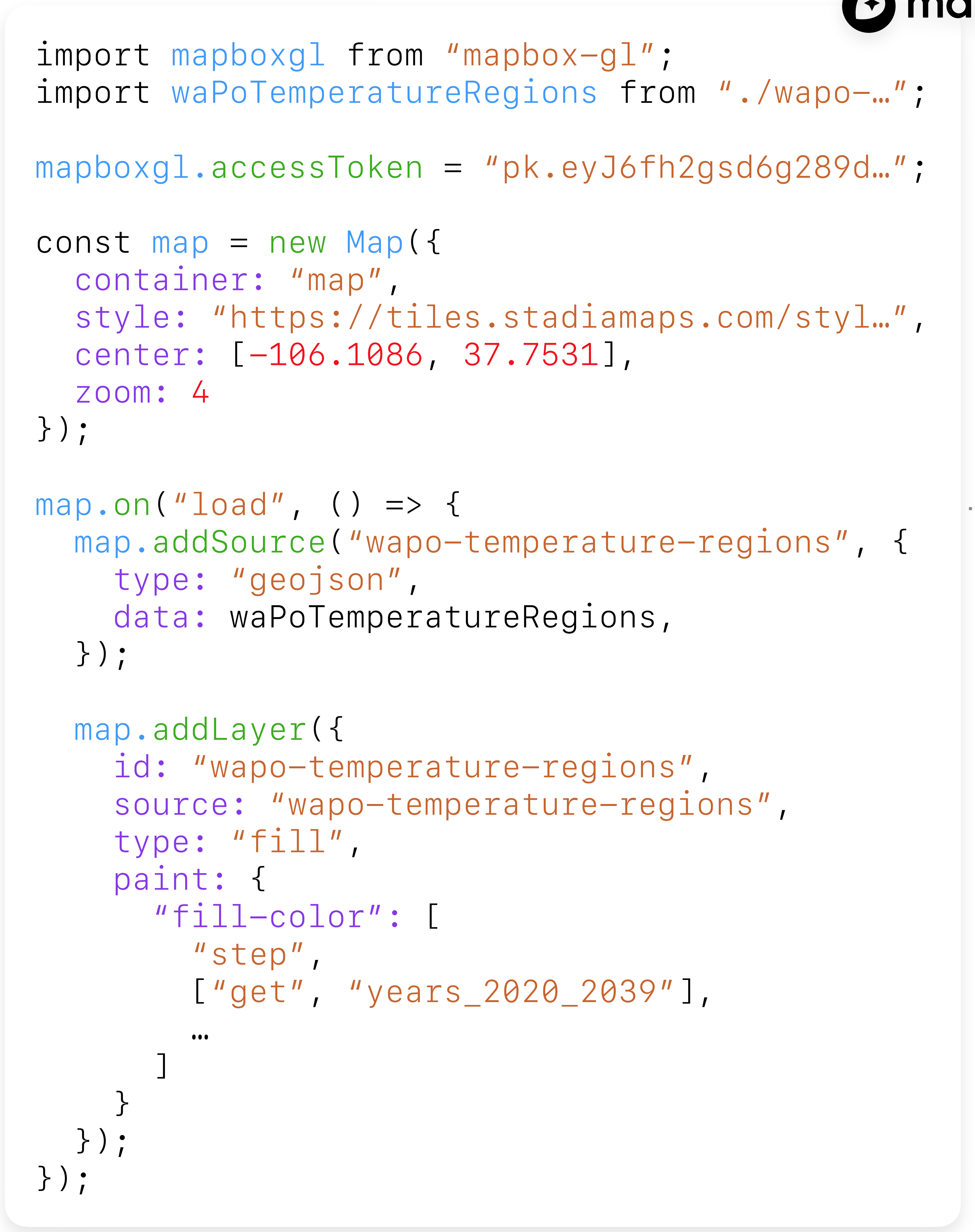
codegenFill

codegenSource

Each codegen function produces its own **program fragment**, with callers deciding **insertion points**.



The **program fragments** are assembled into an output JavaScript program.



mapbox

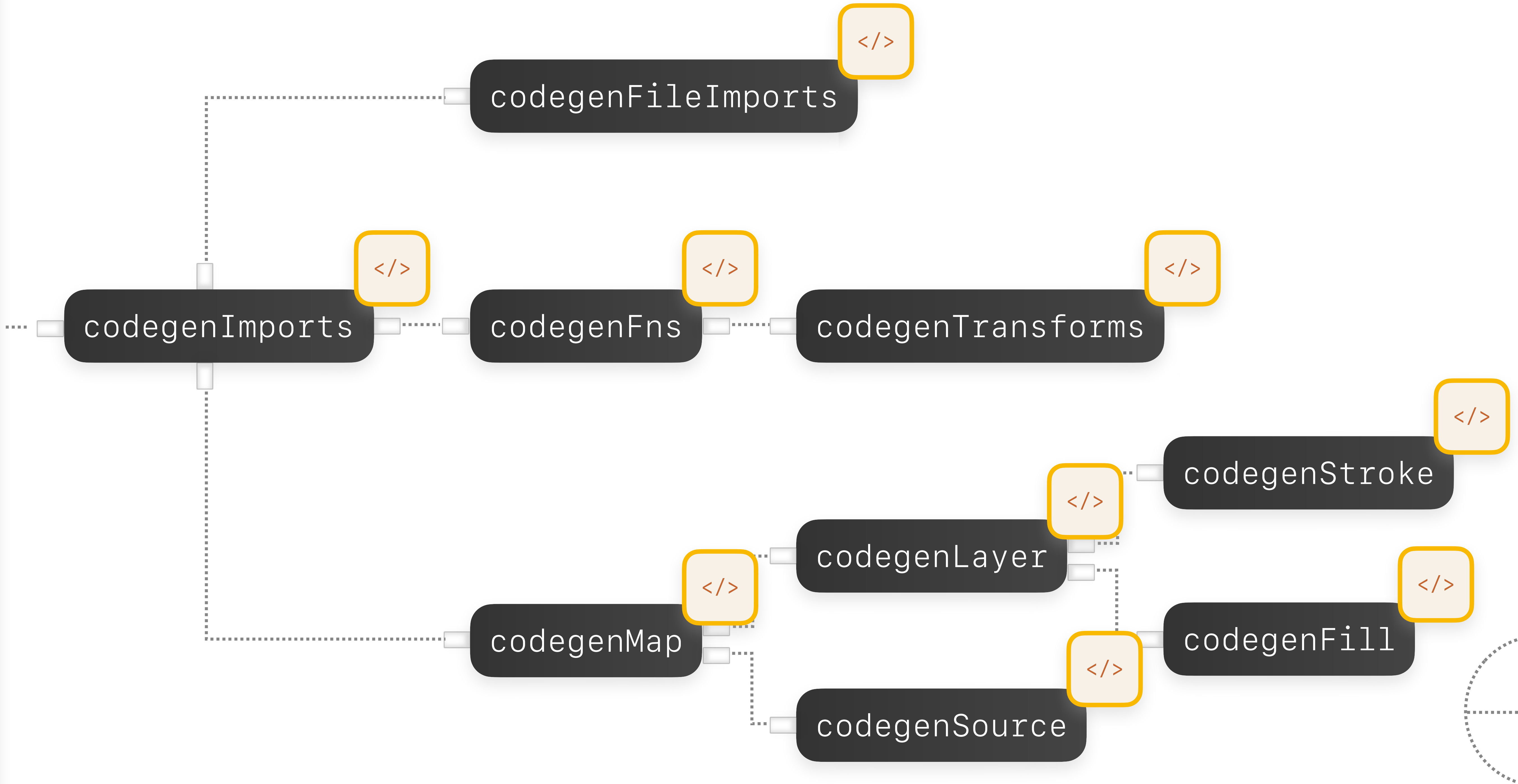
```
import mapboxgl from “mapbox-gl”;
import waPoTemperatureRegions from “./wapo-…”;

mapboxgl.accessToken = “pk.eyJ6fh2gsd6g289d…”;

const map = new Map({
  container: “map”,
  style: “https://tiles.stadiamaps.com/styl…”,
  center: [-106.1086, 37.7531],
  zoom: 4
});

map.on(“load”, () => {
  map.addSource(“wapo-temperature-regions”, {
    type: “geojson”,
    data: waPoTemperatureRegions,
  });

  map.addLayer({
    id: “wapo-temperature-regions”,
    source: “wapo-temperature-regions”,
    type: “fill”,
    paint: {
      “fill-color”: [
        “step”,
        [“get”, “years_2020_2039”],
        …
      ]
    }
  });
});
```



The **program fragments** are assembled into an output JavaScript program.

mapbox

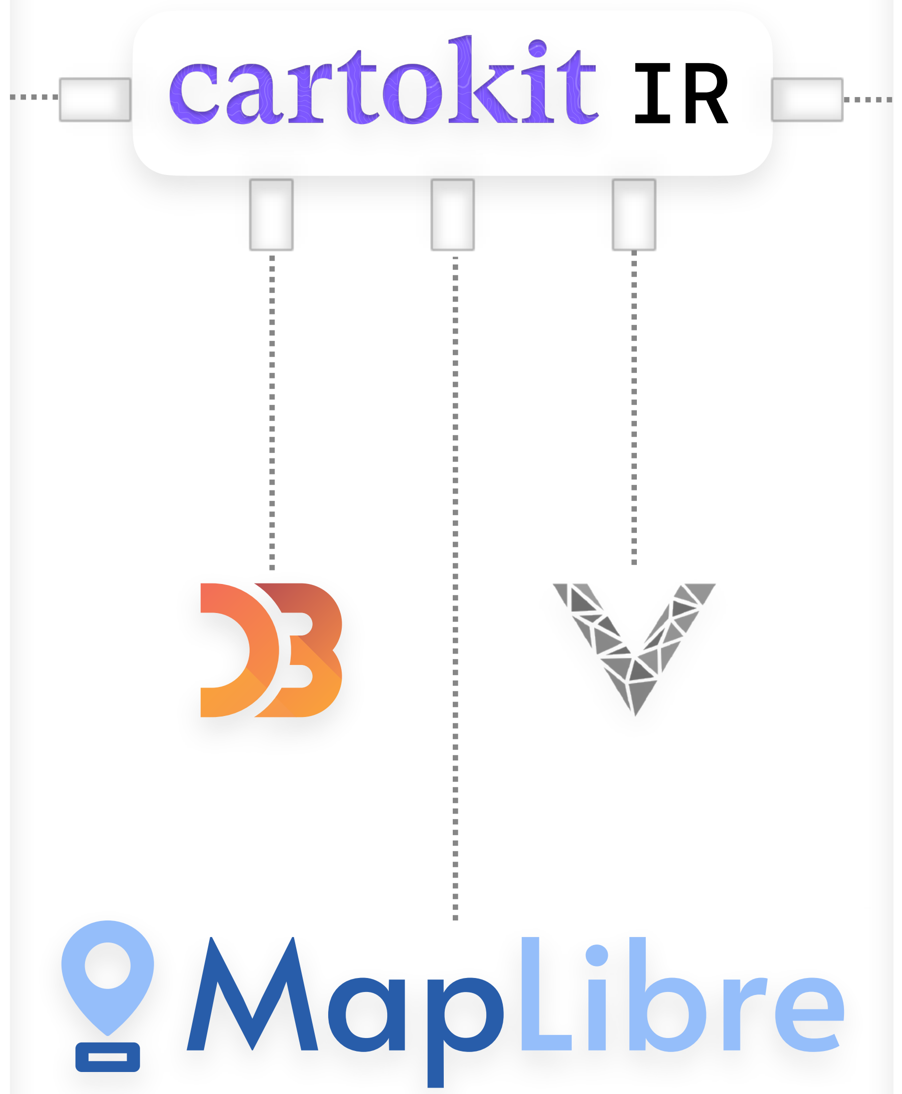
```
import mapboxgl from “mapbox-gl”;
import waPoTemperatureRegions from “./wapo-…”;

mapboxgl.accessToken = “pk.eyJ6fh2gsd6g289d…”;

const map = new Map({
  container: “map”,
  style: “https://tiles.stadiamaps.com/styl…”,
  center: [-106.1086, 37.7531],
  zoom: 4
});

map.on(“load”, () => {
  map.addSource(“wapo-temperature-regions”, {
    type: “geojson”,
    data: waPoTemperatureRegions,
  });

  map.addLayer({
    id: “wapo-temperature-regions”,
    source: “wapo-temperature-regions”,
    type: “fill”,
    paint: {
      “fill-color”: [
        “step”,
        [“get”, “years_2020_2039”],
        …
      ]
    }
  });
});
```



Leaflet

```
import L from “leaflet”;
import waPoTemperatureRegions from “./wapo-…”;

const map = L.map(“map”)
  .setView([-106.1086, 37.7531], 4);

L.tileLayer(
  “https://tiles.stadiamaps.com/tiles/alida…”,
  {
    maxZoom: 20,
    attribution:
      ‘&copy; <a href=“https://stadiamaps.…”’,
  }
).addTo(map);

L.geoJSON(waPoTemperatureRegions, {
  style: (feature) => {
    const attr =
      feature.properties[“years_2020_2039”];

    if (attr < -23.03) {
      return {
        fillColor: “#762a83”,
        fillOpacity: 0.75,
        color: “#FFFFFF”,
        weight: 0.5,
      };
    } else if (attr < 9.42) {
    ...
  },
}).addTo(map);
```

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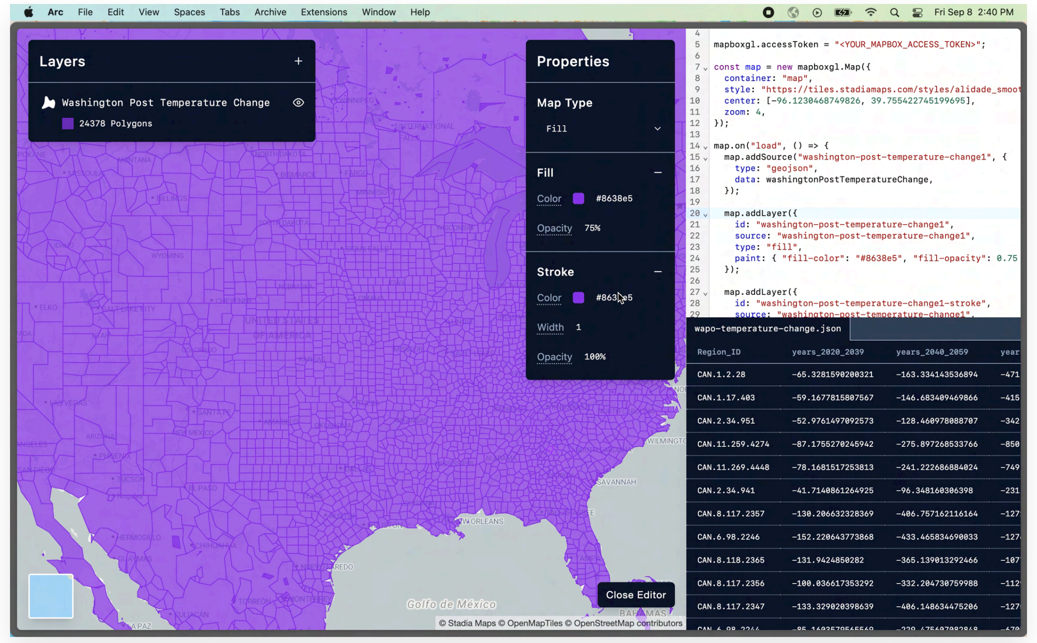
Direct Manipulation


Arc File Edit View Spaces Tabs Archive Extensions Window Help
Fri Sep 8 2:40 PM
Layers
+
Washington Post Temperature Change
24378 Polygons
Properties
Map Type
Fill
Fill
Color
#8638e5
Opacity
75%
Stroke
Color
#8638e5
Width
1
Opacity
100%
Close Editor
Golfo de México
© Stadia Maps © OpenMapTiles © OpenStreetMap contributors

```
mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.7554227451996951],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

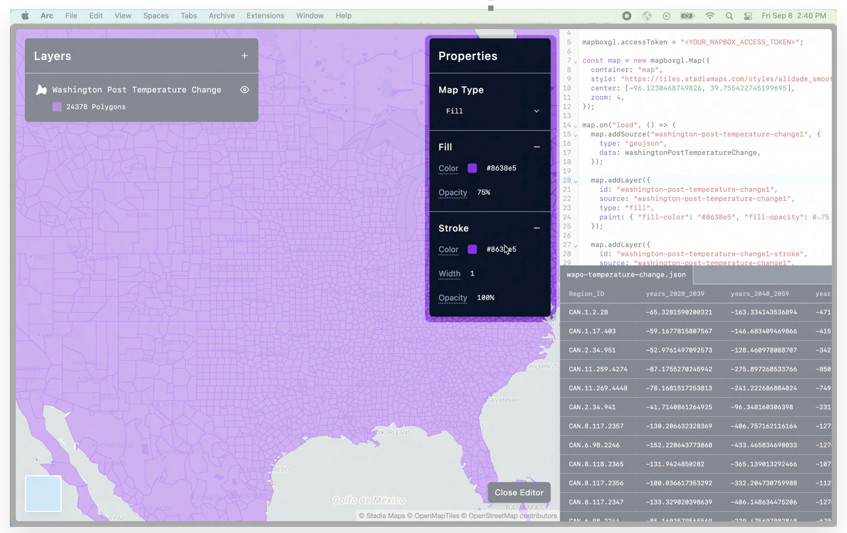
  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });

  map.addLayer({
    id: "washington-post-temperature-change1-stroke",
    source: "washington-post-temperature-change1",
```

wapo-temperature-change.json

Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127

UI controls → Intermediate Representation



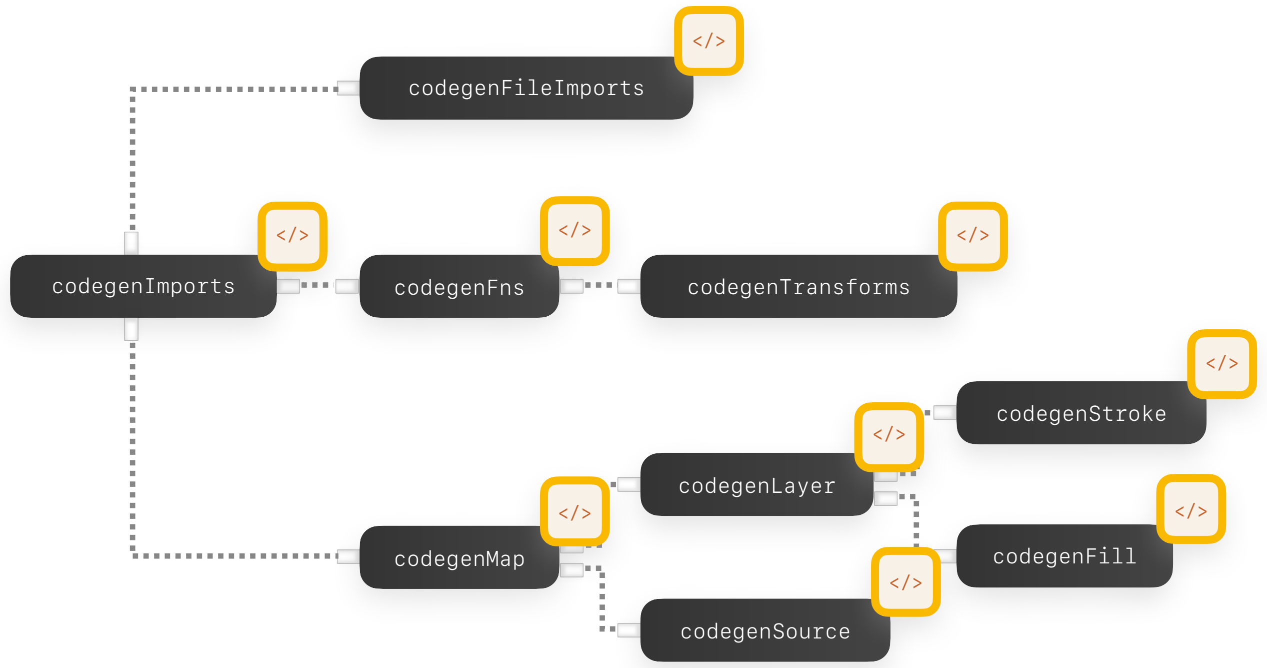
```
const ir = {
  center: [-106.1086, 37.7531],
  zoom: 4,
  basemap: {
    url: "https://tiles.stadiamaps.com/styl…",
    provider: "Stadia Maps",
  },
  layers: [
    {
      type: "Fill",
      style: {
        fill: {
          color: "#8638e5",
          opacity: 0.75,
        },
        stroke: {
          color: "#ffffff",
          width: 1,
          opacity: 0.5,
        },
      },
    },
  ],
};
```

Update IR

```
  const ir = {
    center: [-106.1086, 37.7531],
    zoom: 4,
    basemap: {
      url: "https://tiles.stadiamaps.com/styl…",
      provider: "Stadia Maps",
    },
    layers: [
      {
-       type: "Fill",
        style: {
          fill: {
-           color: "#8638e5",
            opacity: 0.75,
          },
          stroke: {
            color: "#ffffff",
            width: 1,
            opacity: 0.5,
          },
        },
      },
    ],
  };
```

```
  const ir = {
    center: [-106.1086, 37.7531],
    zoom: 4,
    basemap: {
      url: "https://tiles.stadiamaps.com/styl…",
      provider: "Stadia Maps",
    },
    layers: [
      {
+       type: "Choropleth",
        style: {
          fill: {
+           attribute: "years_2020_2039",
+           scale: "Quantile",
+           count: 8,
+           scheme: d3.schemeBuPu,
+           thresholds: [-210.21, -23.03, …],
            opacity: 0.75,
          },
          stroke: {
            color: "#ffffff",
            width: 1,
            opacity: 0.5,
          },
        },
      },
    ],
  };
```

Code Generation



JavaScript Program

```
import mapboxgl from "mapbox-gl";
import waPoTemperatureRegions from "./wapo-…";

mapboxgl.accessToken = "pk.eyJ6fh2gsd6g289d…";

const map = new Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styl…",
  center: [-106.1086, 37.7531],
  zoom: 4
});

map.on("load", () => {
  map.addSource("wapo-temperature-regions", {
    type: "geojson",
    data: waPoTemperatureRegions,
  });

  map.addLayer({
    id: "wapo-temperature-regions",
    source: "wapo-temperature-regions",
    type: "fill",
    paint: {
      "fill-color": [
        "step",
        ["get", "years_2020_2039"],
        …
      ]
    }
  });
});
```

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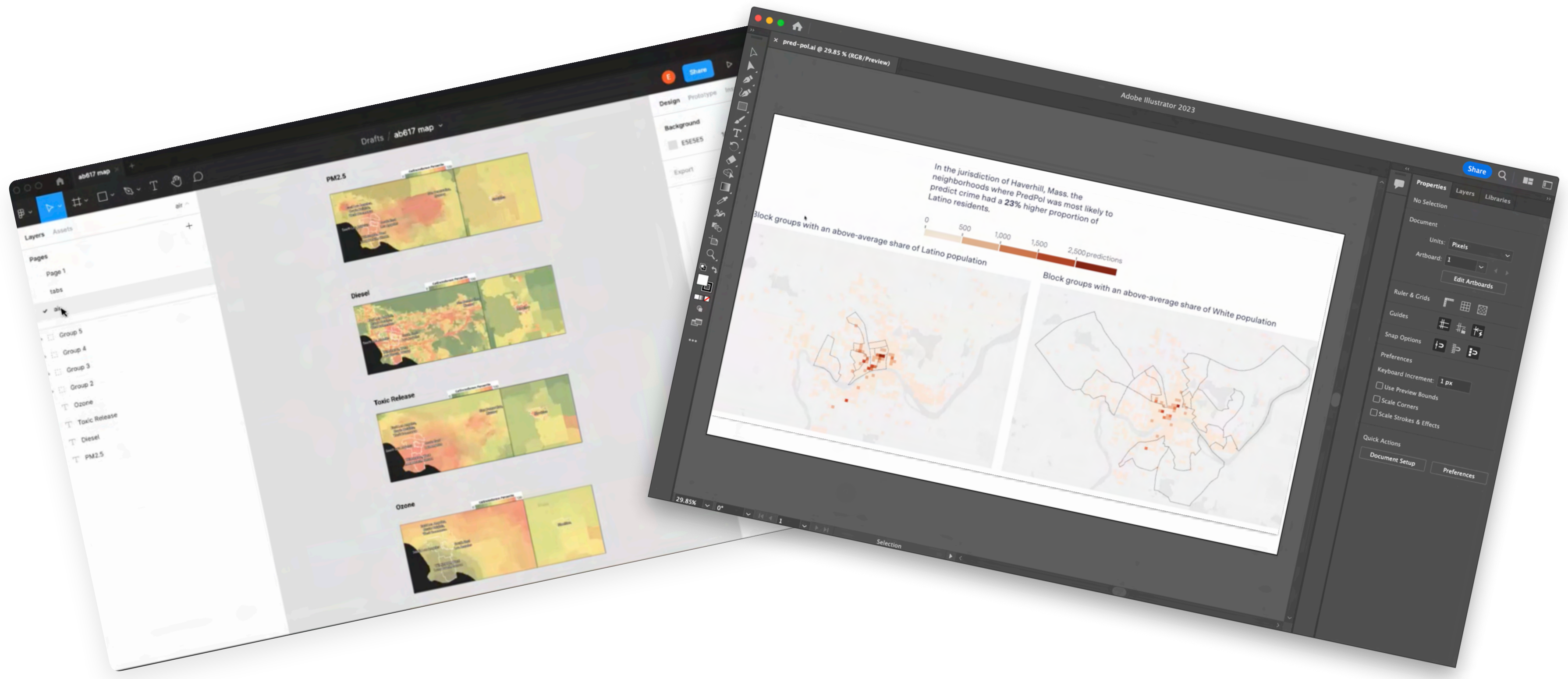
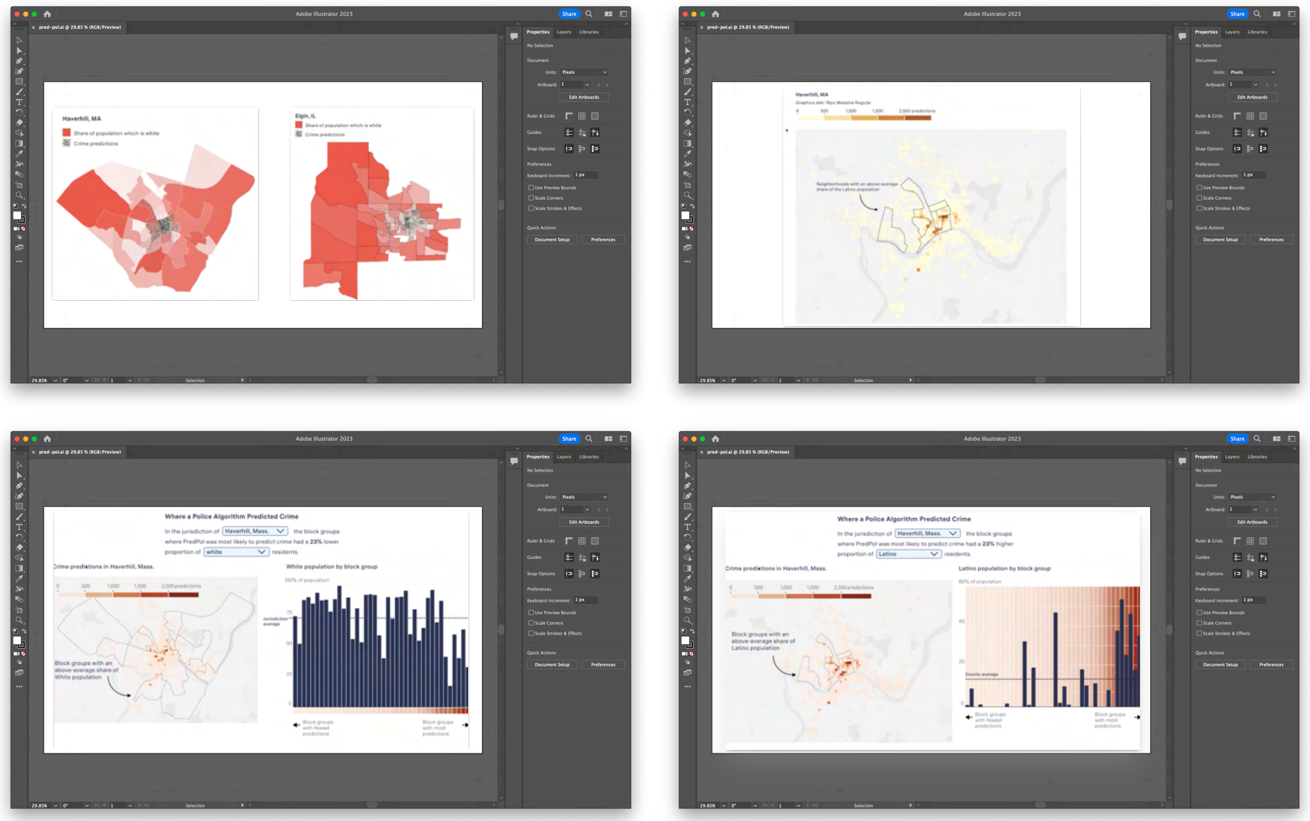
Working Practice

Sketch visualizations in **design software**


In the jurisdiction of Haverhill, Mass. the neighborhoods where PredPol was most likely to predict crime had a **23%** higher proportion of Latino residents.

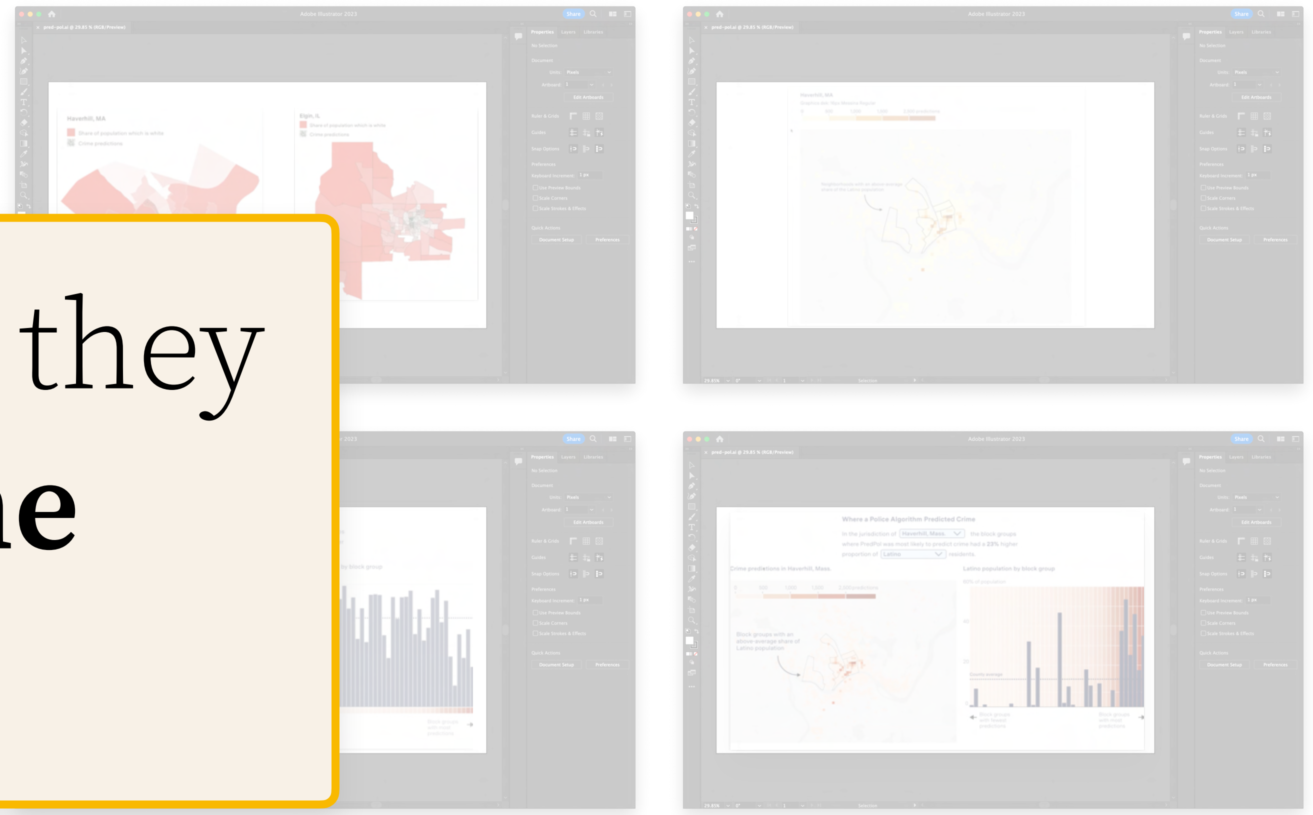
Explore a wide design space **without code**



Working Practice

Sketch visualizations in **design software**

Explore a wide design space **without code**



After selecting a design, they still had to **reproduce the visualization in code**.

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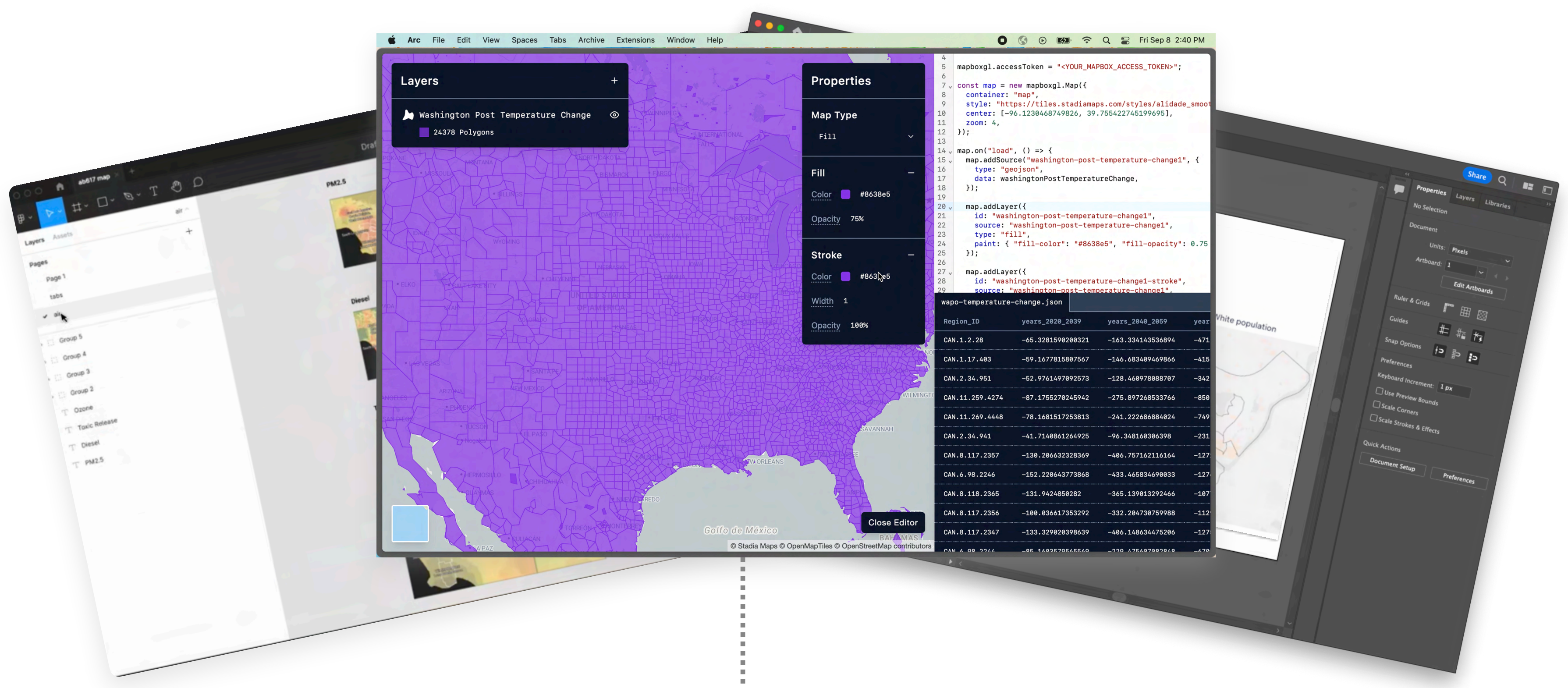
Working Practice

Sketch visualizations in **design software**

Explore a wide design space **without code**



```
mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";

const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

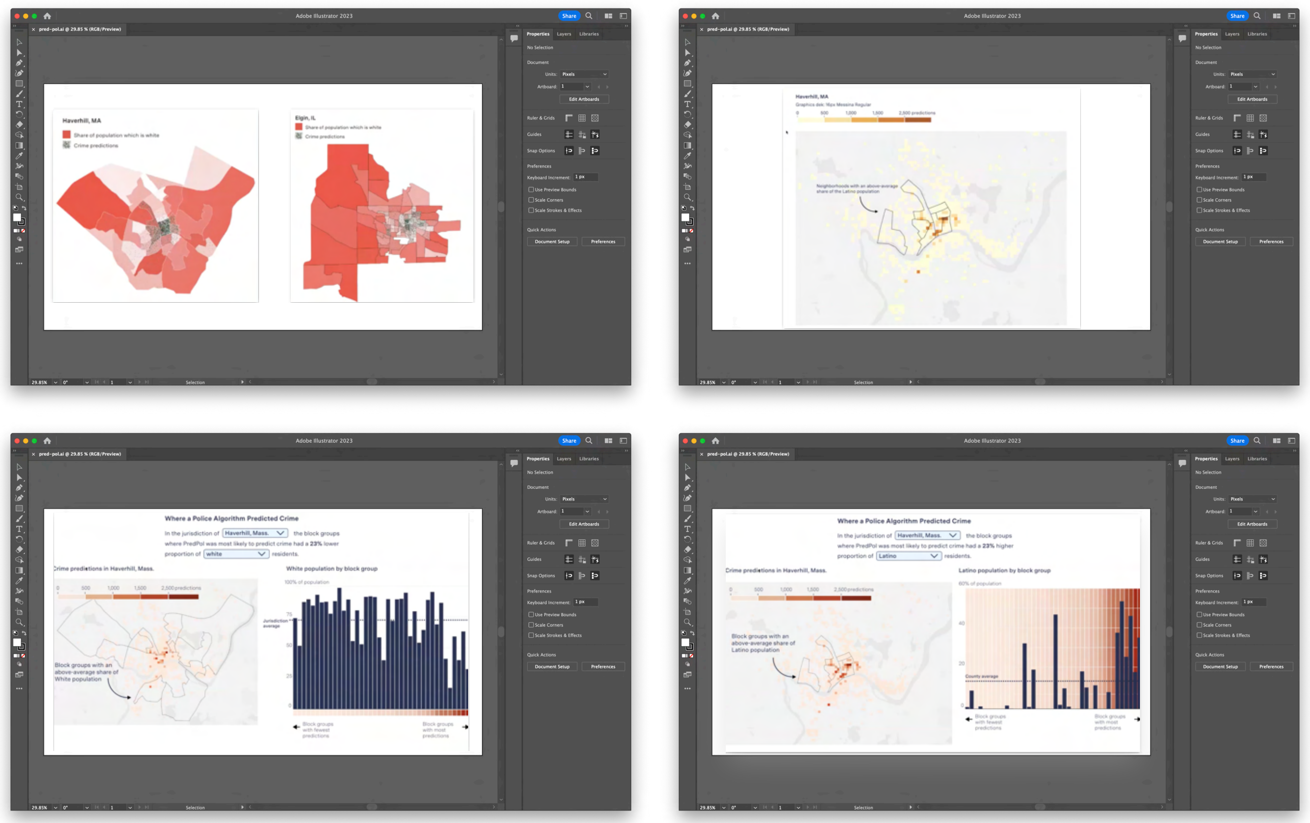
map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });

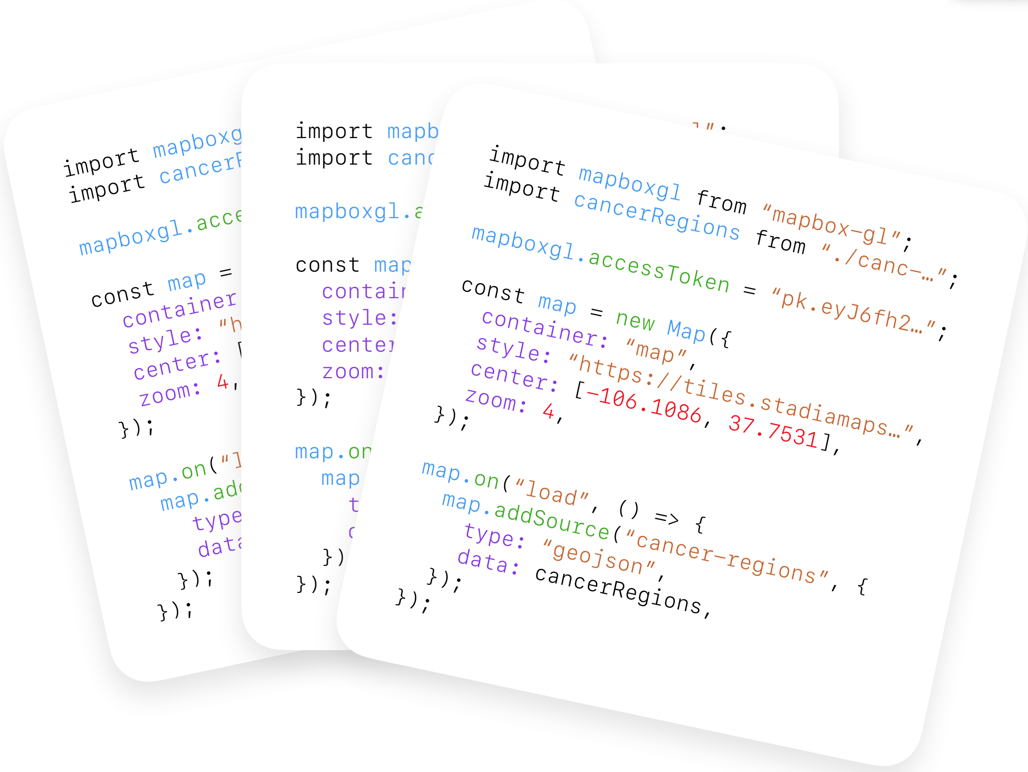
  map.addLayer({
    id: "washington-post-temperature-change1-stroke",
    source: "washington-post-temperature-change1",
```

wapo-temperature-change.json

Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-850
CAN.11.269.4448	-78.1681517253813	-241.222686884024	-749
CAN.2.34.941	-41.7140861264925	-96.348160306398	-231
CAN.8.117.2357	-130.206632328369	-406.757162116164	-127
CAN.6.98.2246	-152.220643773868	-433.465834690033	-127
CAN.8.118.2365	-131.9424850282	-365.139013292466	-107
CAN.8.117.2356	-100.036617353292	-332.204730759988	-112
CAN.8.117.2347	-133.329020398639	-406.148634475206	-127



Milliseconds



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import mapboxgl from “mapbox-gl”;
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  container: “map”,
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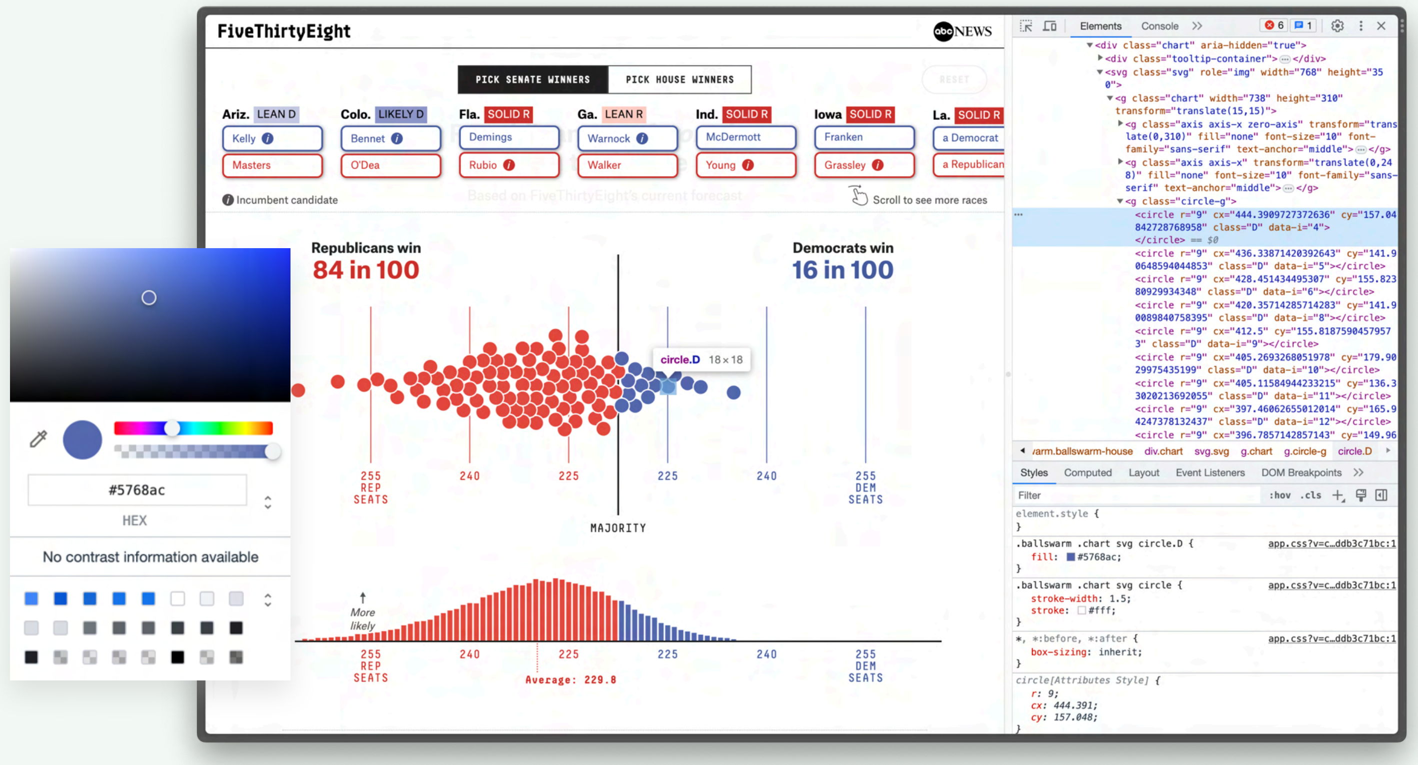
Lexer

Parser

Recover (or infer) **semantic information** from the visual form that we can represent **symbolically**.

reviz

Map **interactions** with the visual form to **program edits**.



```
▼<div class="chart" aria-hidden="true">
  ▶<div class="tooltip-container">⋯</div>
  ▼<svg class="svg" role="img" width="768" height="350">
    ▼<g class="chart" width="738" height="310" transform="translate(15,15)">
      ▶<g class="axis axis-x zero-axis" transform="translate(0,310)" fill="none" font-size="10" font-family="sans-serif" text-anchor="middle">⋯</g>
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      ▼<g class="circle-g">
          <circle r="9" cx="444.3909727372636" cy="157.04842728768958" class="D" data-i="4">
          </circle> == $0
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          <circle r="9" cx="396.7857142857143" cy="149.96
```

```
warm.ballswarm-house  div.chart  svg.svg  g.chart  g.circle-g  circle.D

element.style {
}
.ballswarm .chart svg circle.D {                app.css?v=c…ddb3c71bc:1
  fill: ■#5768ac;
}
.ballswarm .chart svg circle {                  app.css?v=c…ddb3c71bc:1
  stroke-width: 1.5;
  stroke: □#fff;
}
*, *:before, *:after {                          app.css?v=c…ddb3c71bc:1
  box-sizing: inherit;
}
circle[Attributes Style] {
  r: 9;
  cx: 444.391;
  cy: 157.048;
}
```

cartokit

Compilers for Visual Inputs

Lexer

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reviz

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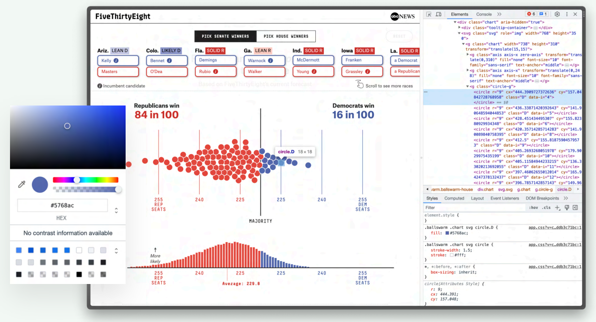
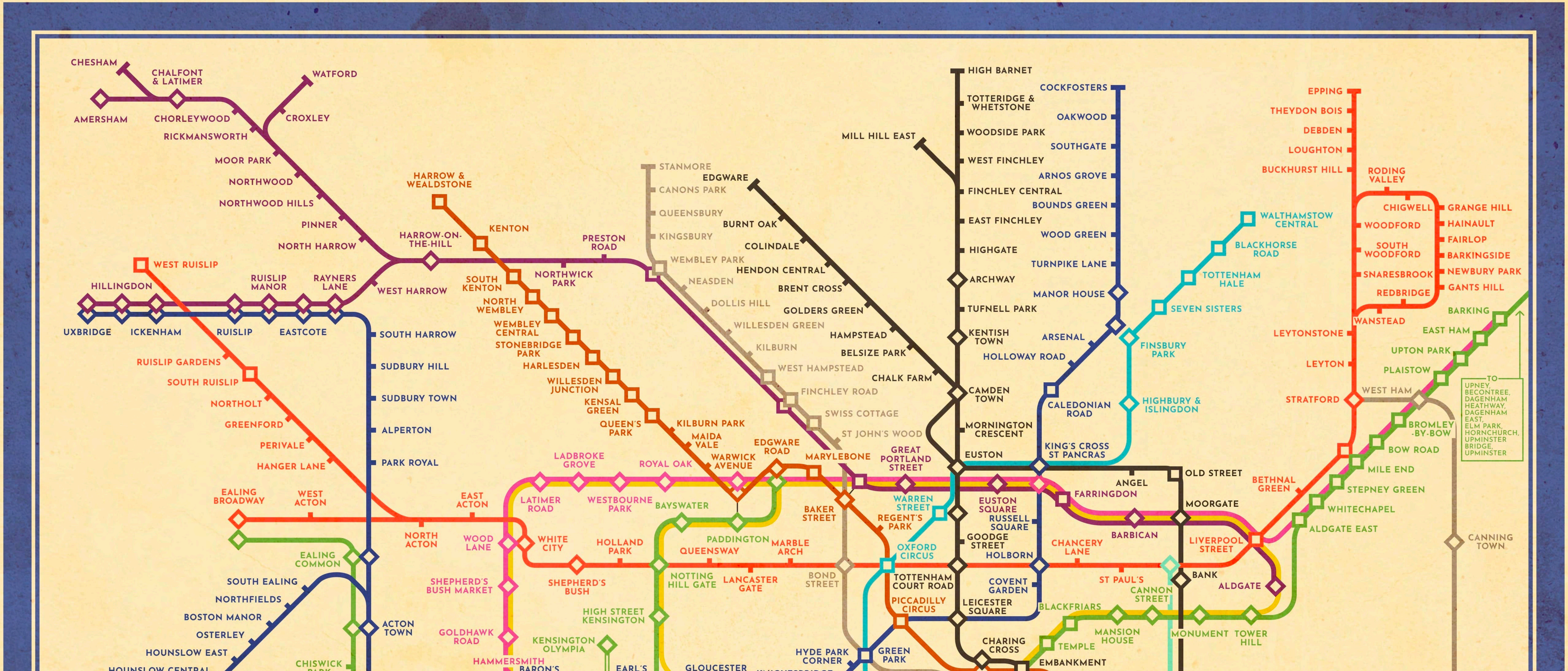


cartokit

Cartography Studio

Linework

“London Underground Tube Map” • *Harry Beck*



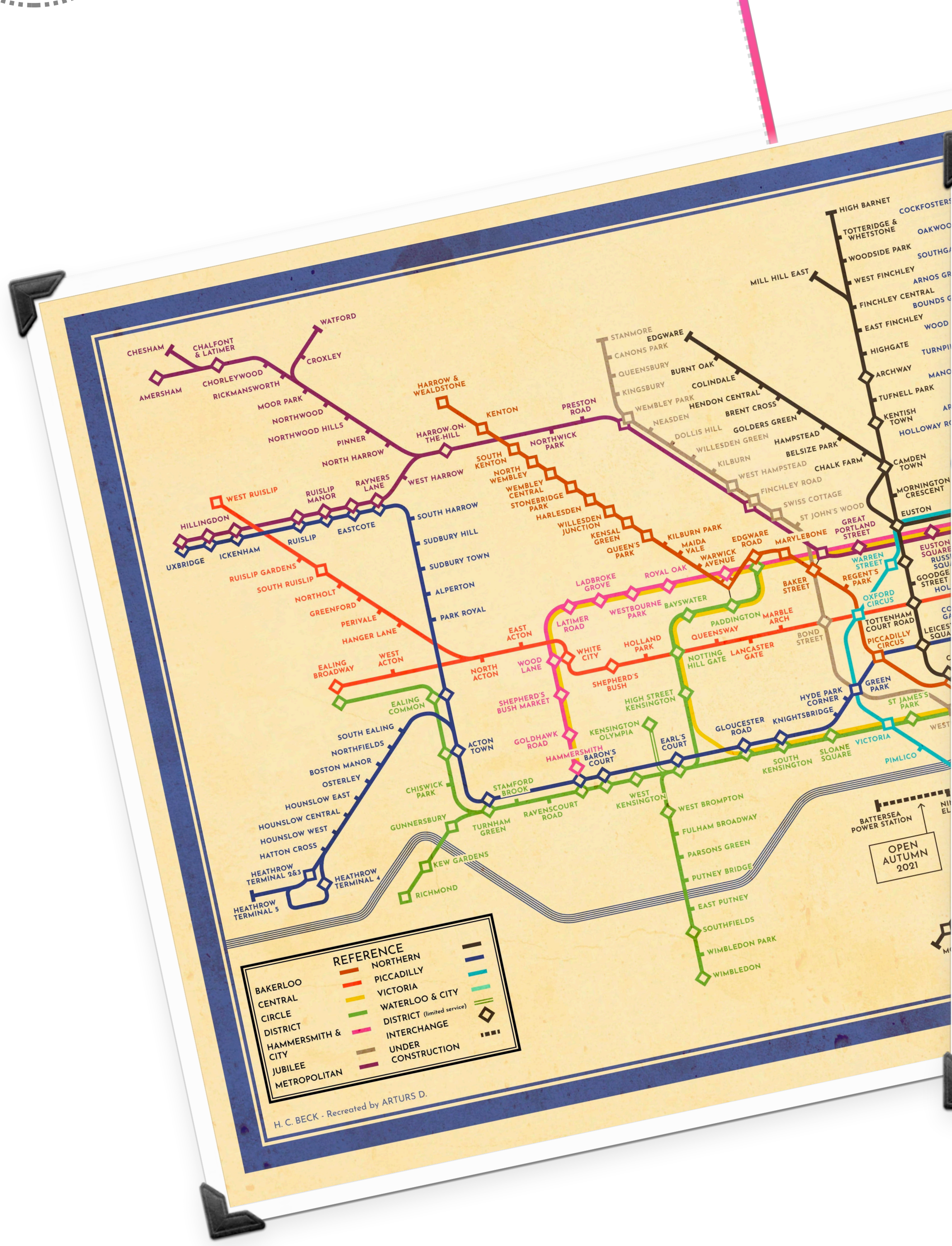
Shaded Relief

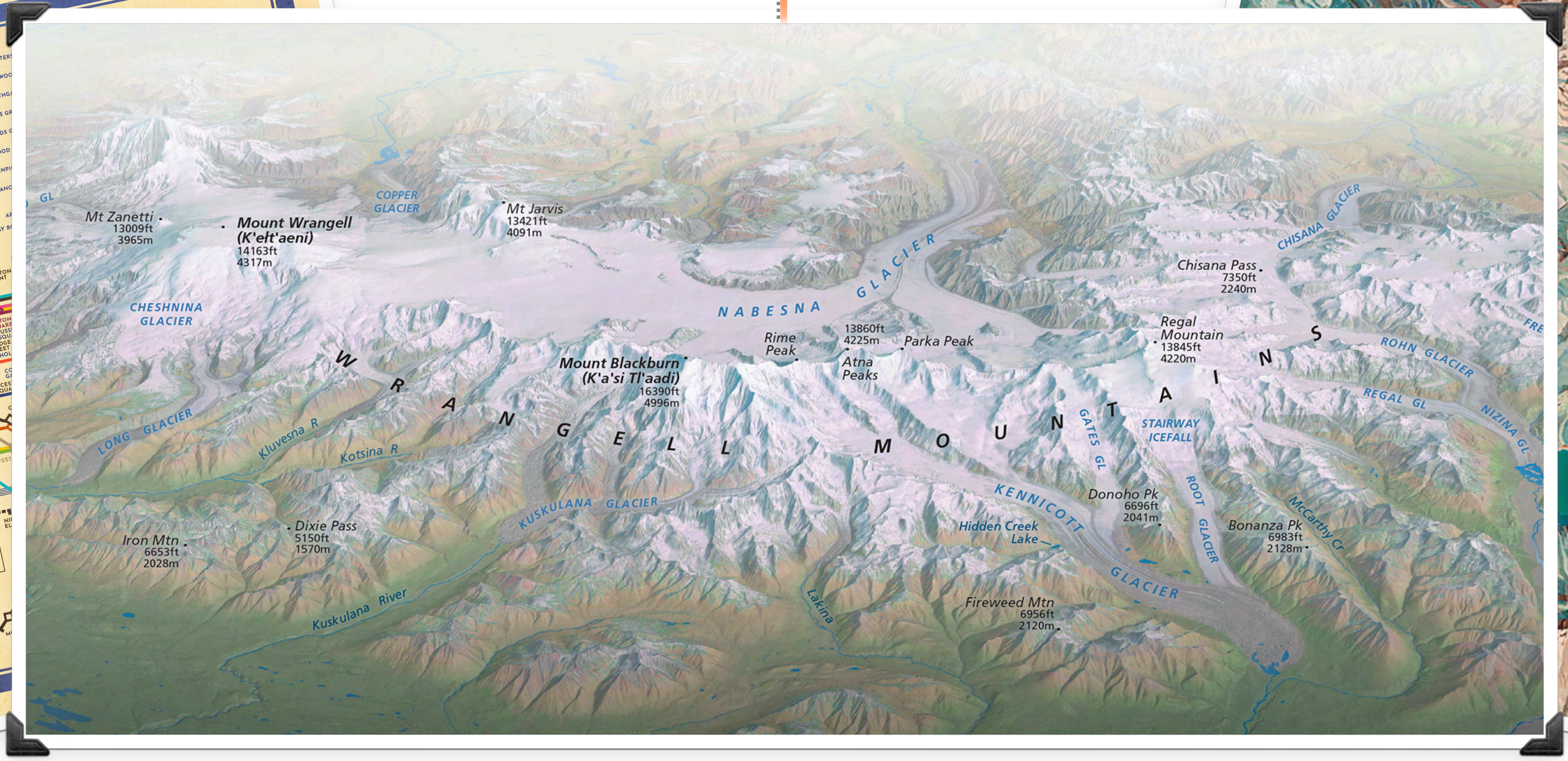
"Walensee und Seeztal" · *Eduard Imhof*

Perspective

“Wrangell Mountains Shaded Relief Map” • *Tom Patterson*

GL
Mt Zanetti 13009ft 3965m
Mount Wrangell (K'ełt'aeni) 14163ft 4317m
COPPER GLACIER
Mt Jarvis 13421ft 4091m
CHESHNINA GLACIER
NABESNA GLACIER
CHISANA GLACIER
Chisana Pass 7350ft 2240m
Rime Peak
13860ft 4225m
Atna Peaks
Parka Peak
Regal Mountain 13845ft 4220m
FRE
ROHN GLACIER
Mount Blackburn (K'a'si Tl'aadi) 16390ft 4996m
WRANGELL MOUNTAINS
LONG GLACIER
Kluvesna R
Kotsina R
GATES GL
STAIRWAY ICEFALL
REGAL GL
NIZINA GL
KUSKULANA GLACIER
KENNICOTT GLACIER
Dixie Pass 5150ft 1570m
Iron Mtn 6653ft 2028m
Donoho Pk 6696ft 2041m
ROOT GLACIER
Bonanza Pk 6983ft 2128m
McCarthy Cr
Hidden Creek Lake
Lakina
Fireweed Mtn 6956ft 2120m
Kuskulana River


REFERENCE
BAKERLOO
CENTRAL
CIRCLE
DISTRICT
HAMMERSMITH & CITY
JUBILEE
METROPOLITAN
NORTHERN
PICCADILLY
VICTORIA
WATERLOO & CITY
DISTRICT
INTERCHANGE
UNDER CONSTRUCTION
OPEN AUTUMN 2021
H. C. BECK - Recreated by ARTURS D.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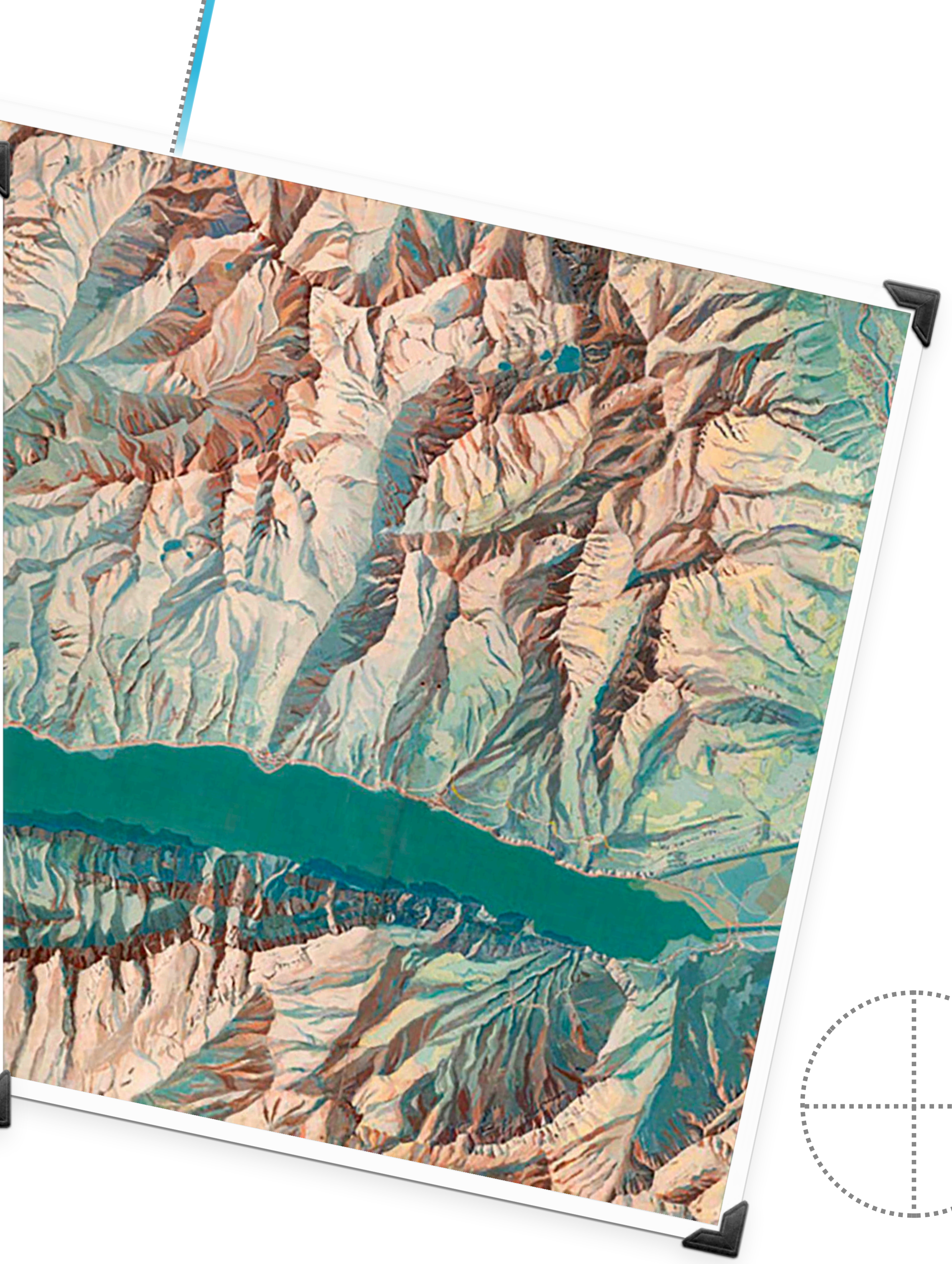
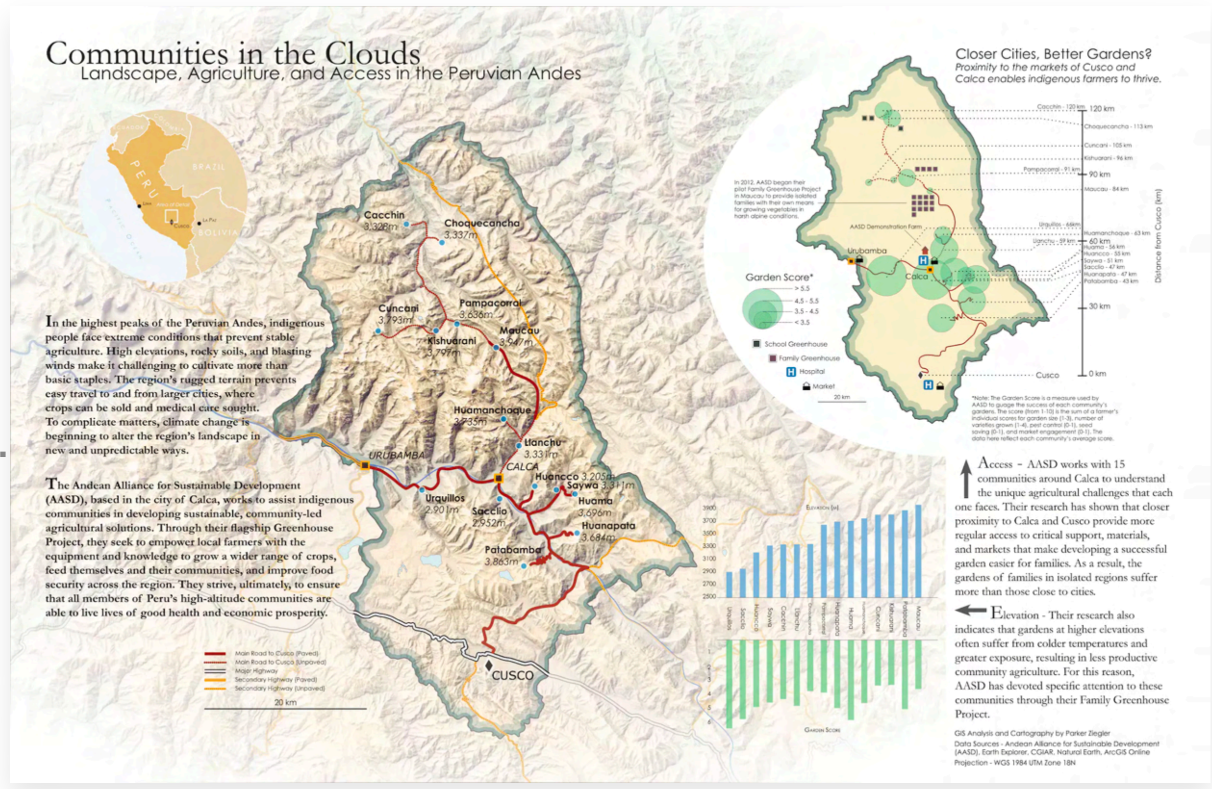
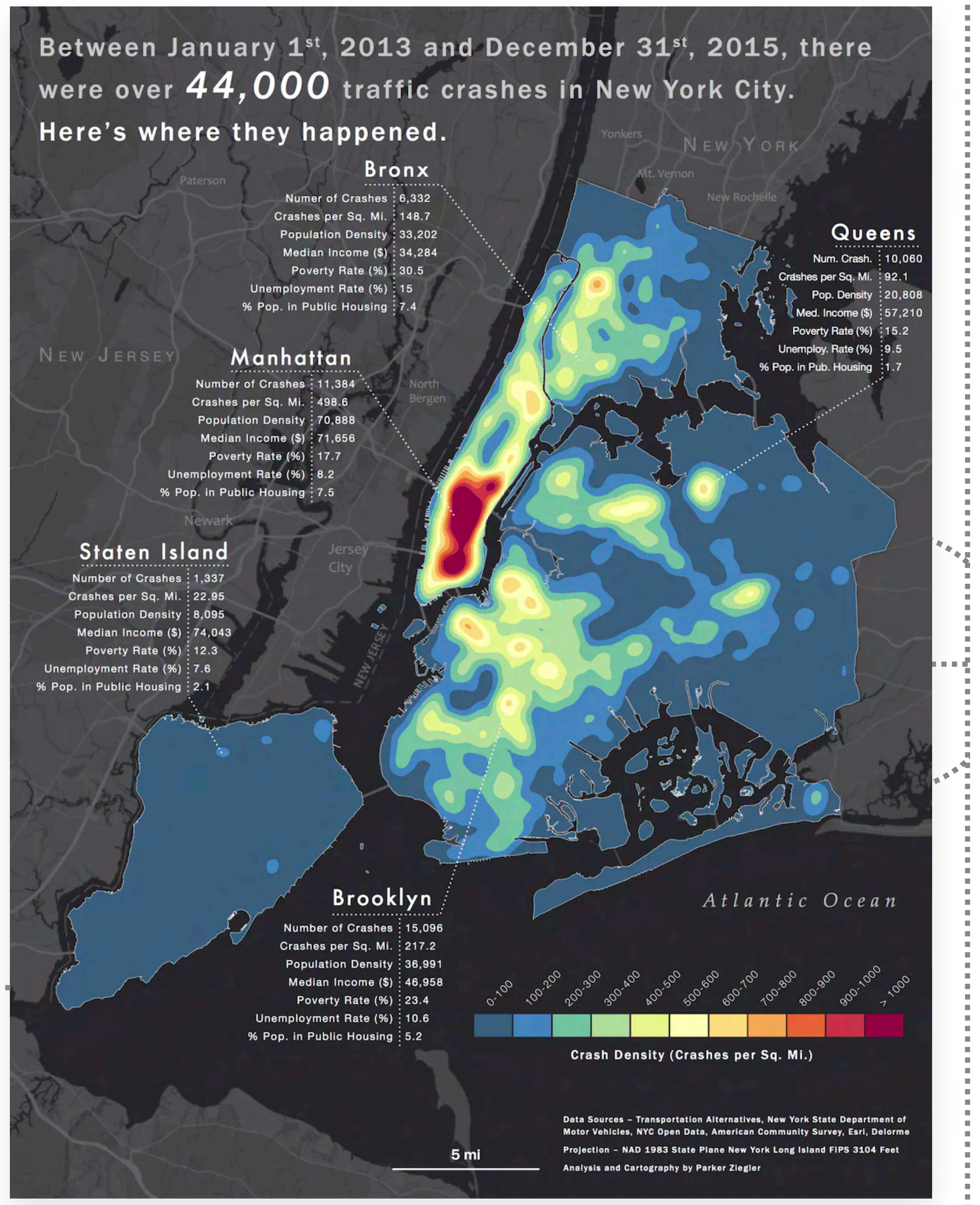



Communities in the Clouds
Landscape, Agriculture, and Access in the Peruvian Andes
Closer Cities, Better Gardens?
CUSCO

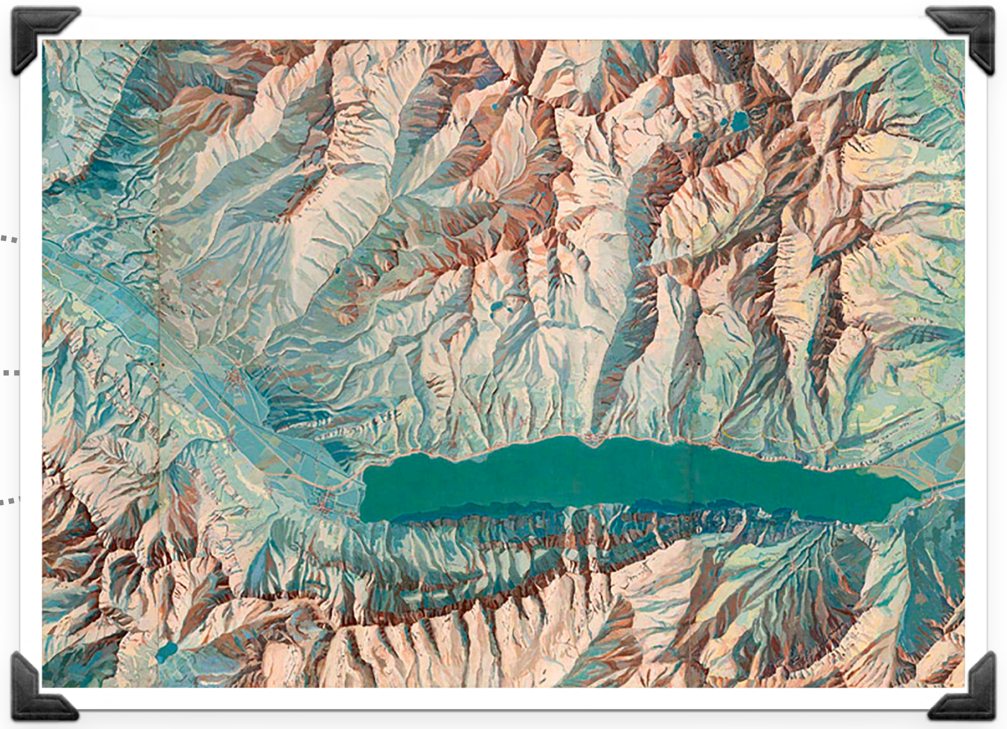
Color Palettes

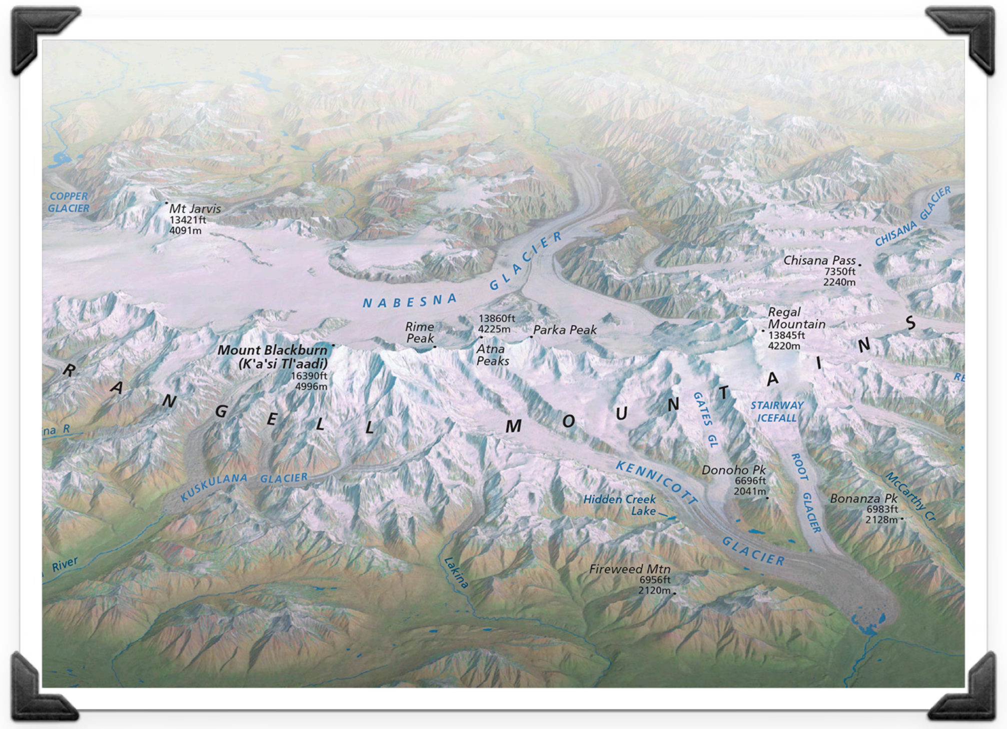

Between January 1st, 2013 and December 31st, 2015, there were over 44,000 traffic crashes in New York City.
Here's where they happened.
Bronx
Queens
Manhattan
Staten Island
Brooklyn
New Jersey
New York
Atlantic Ocean
Crash Density (Crashes per Sq. Mi.)
5 mi

Typography

Visual Hierarchy

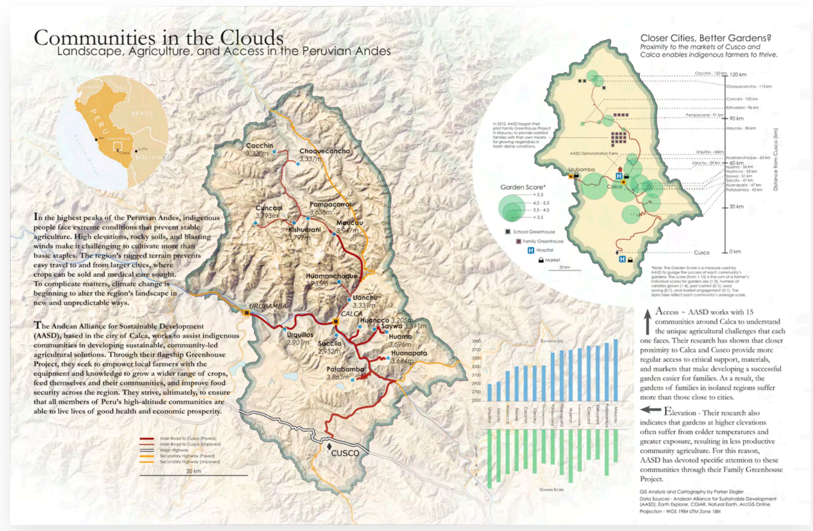
Examples



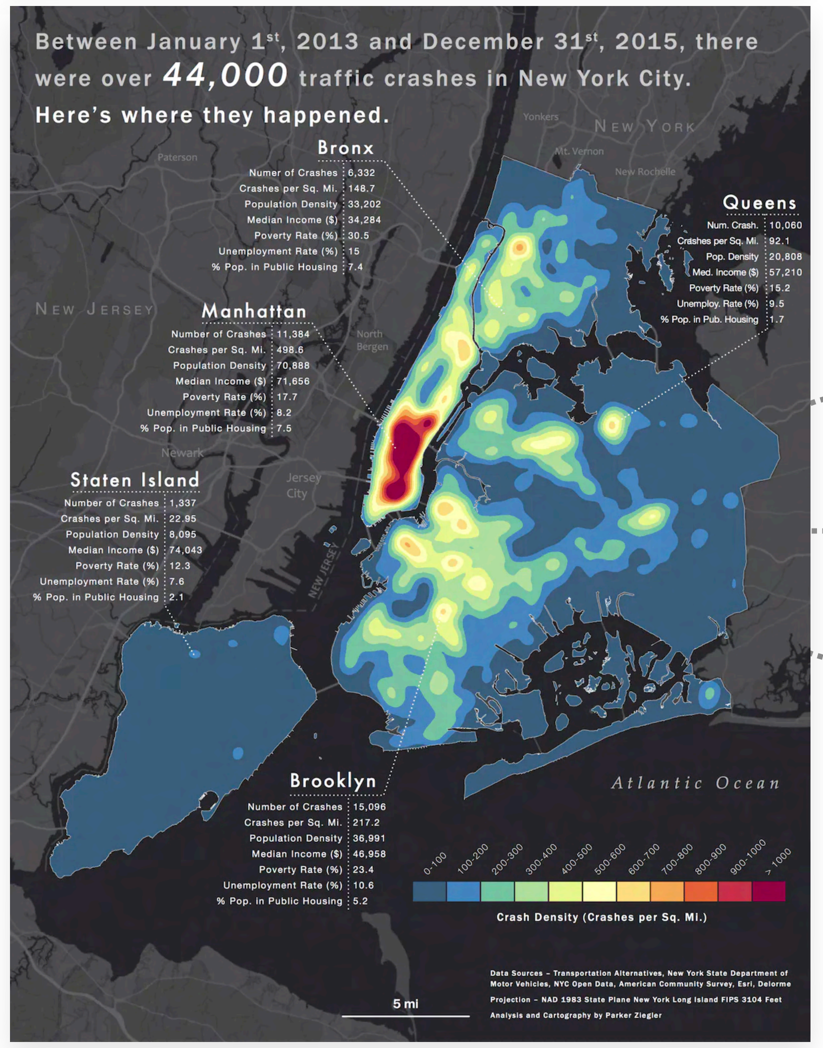


Many, Many (Many) Hours of Painstaking Work

Outputs


Communities in the Clouds
Landscape, Agriculture, and Access in the Peruvian Andes

Unseen, Unheard, and Forgotten
Child Migration from Central America to the United States
Refugees at a Closed Border
UNITED STATES OF AMERICA
MEXICO
PACIFIC OCEAN
EL PASO
TUCSON
YUMA
BIG BEND
LAREDO
DEL RIO
RIO GRANDE VALLEY
8,262
49,959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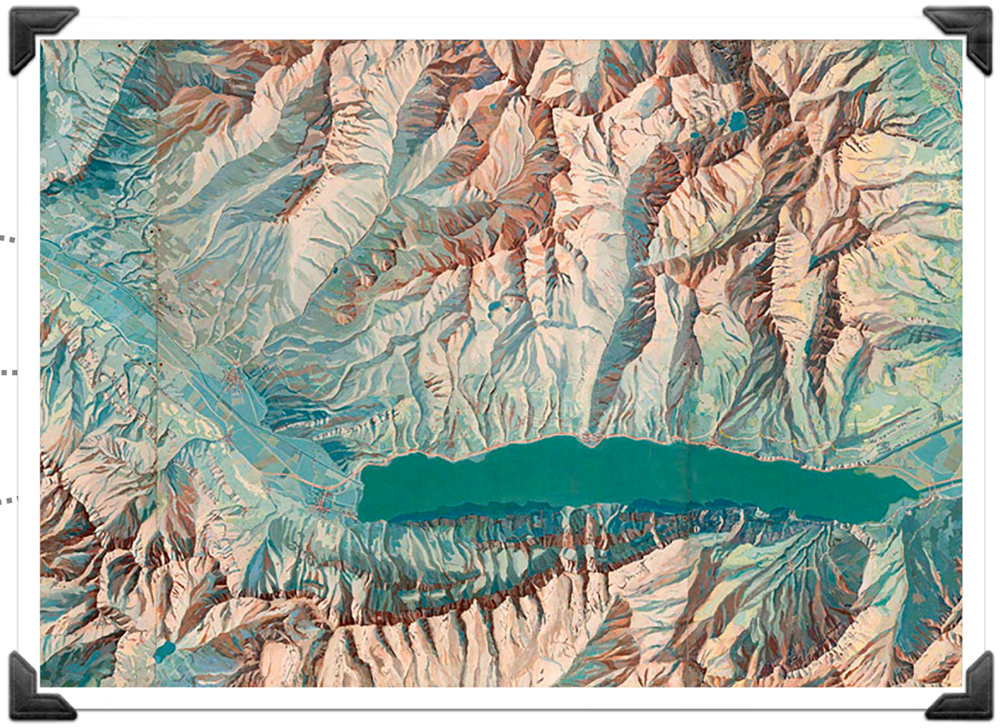

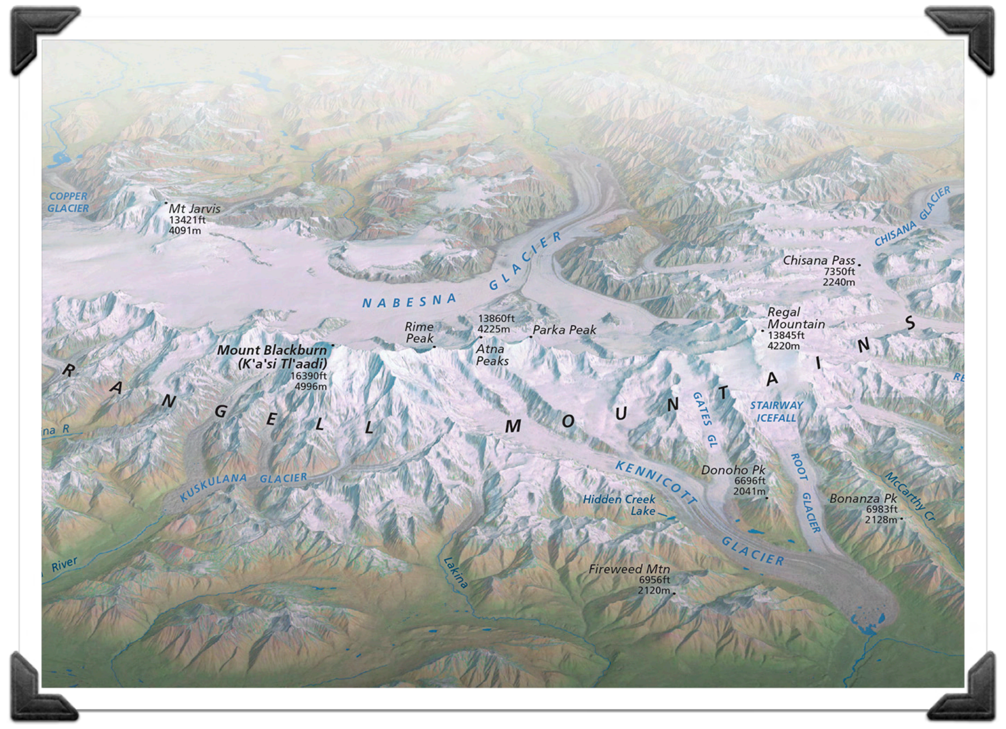

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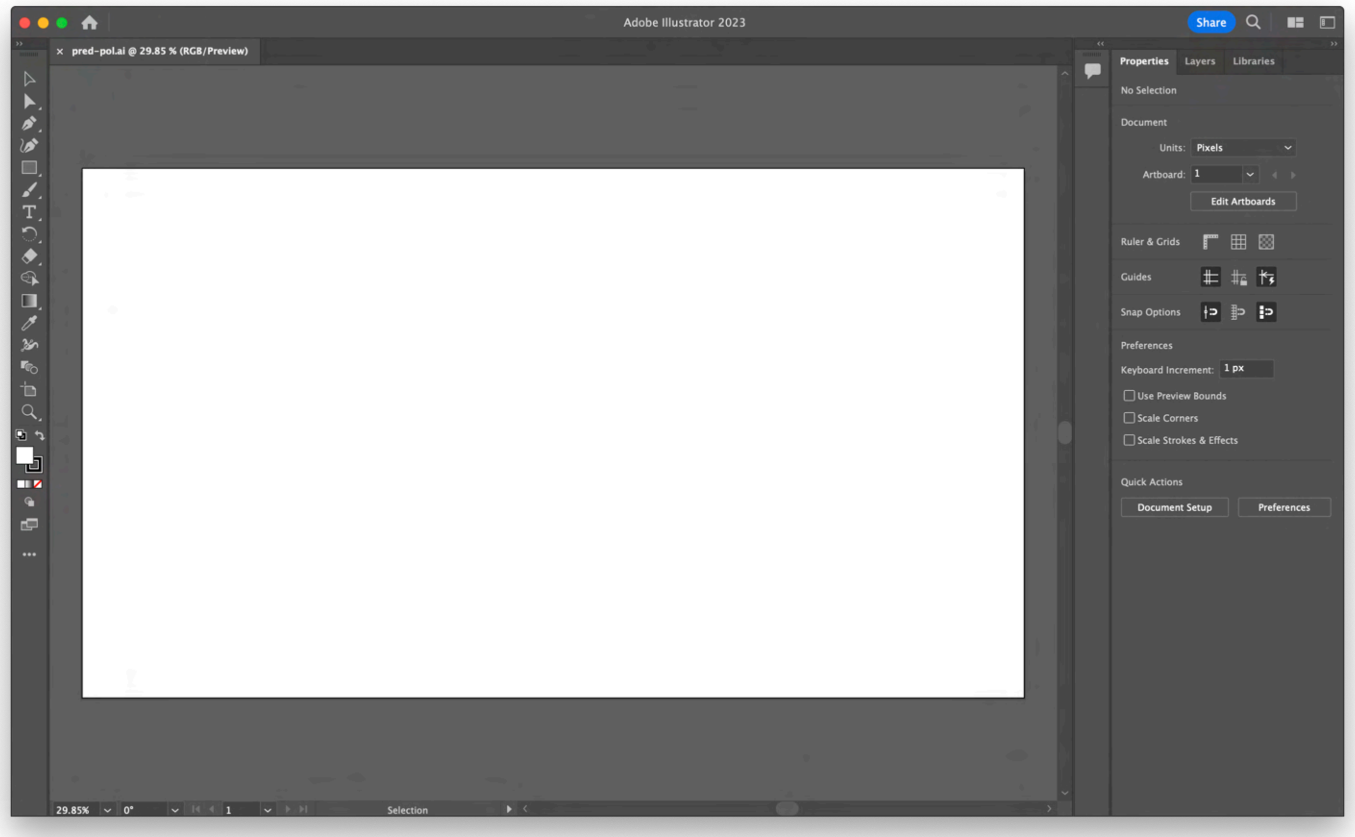
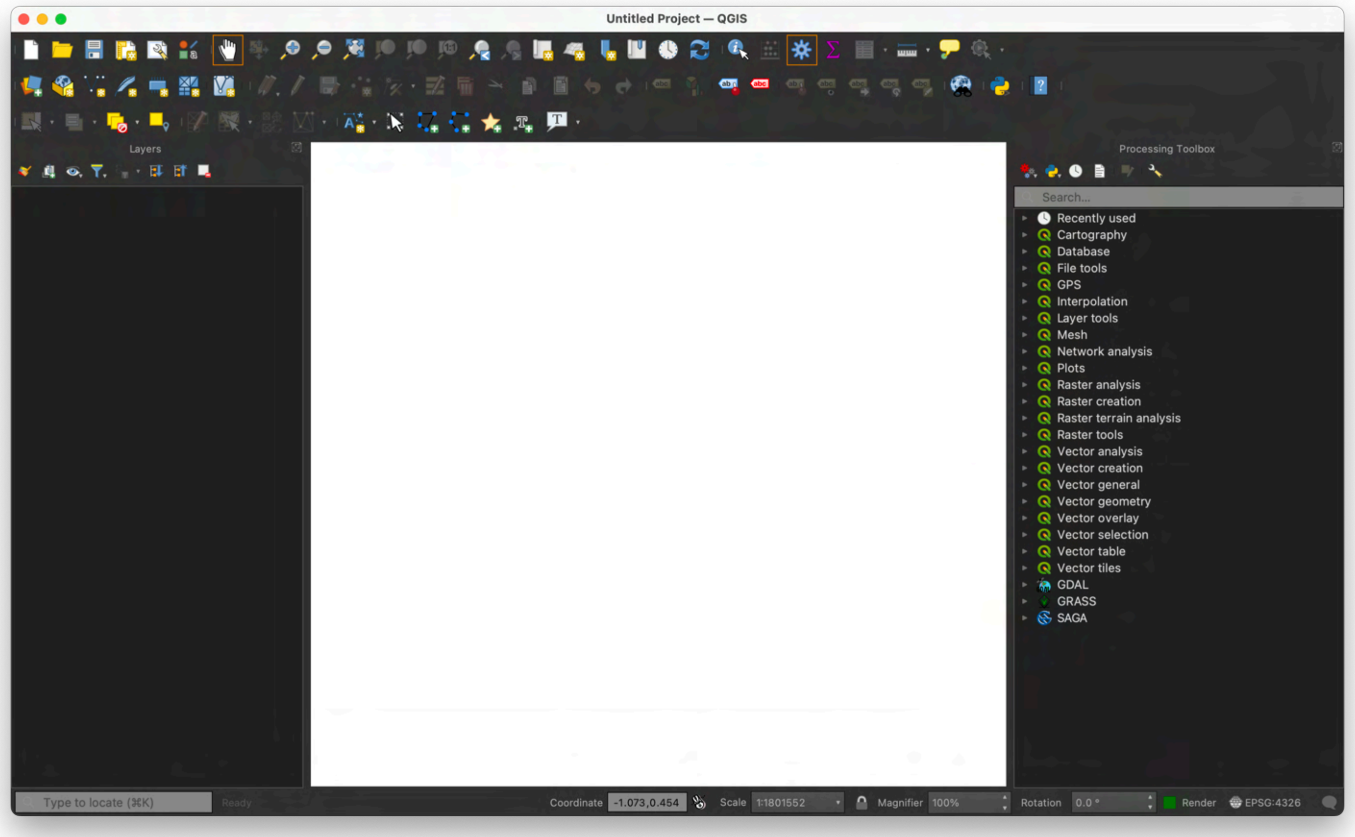
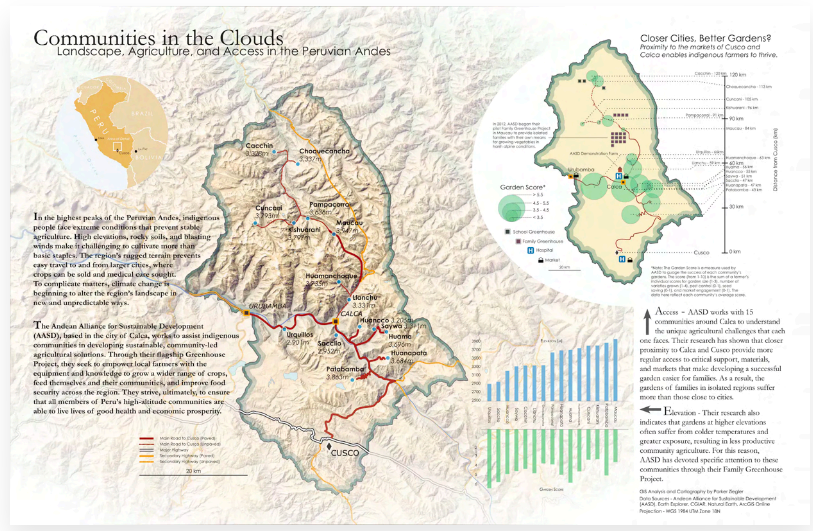




Outputs



Communities in the Clouds
Landscape, Agriculture, and Access in the Peruvian Andes
Closer Cities, Better Gardens?

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Refugees at a Closed Border
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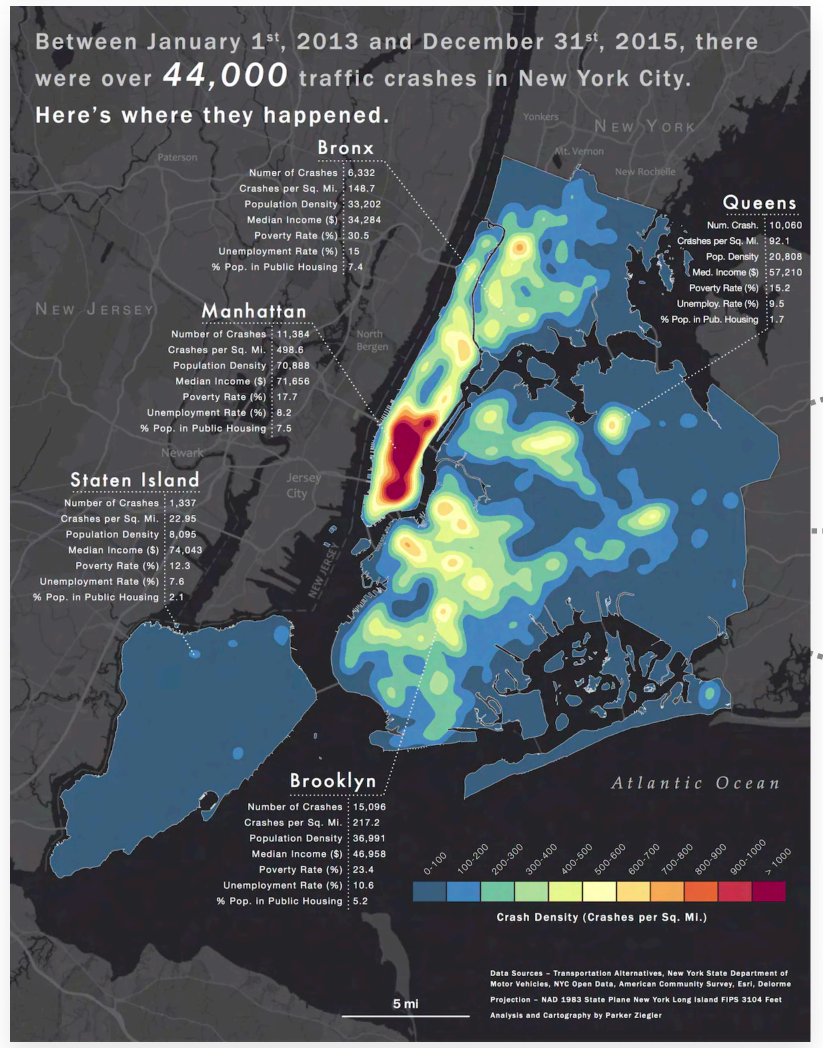

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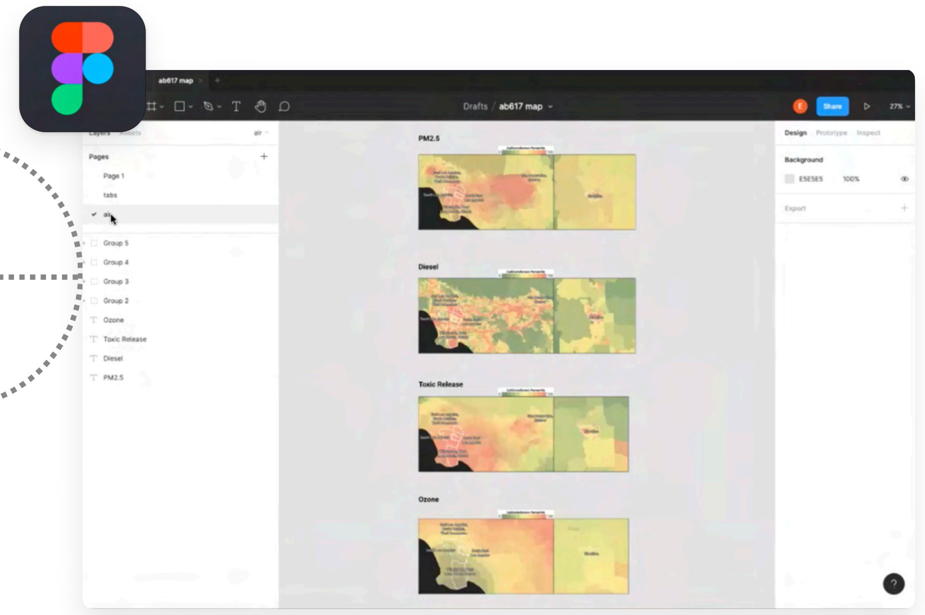
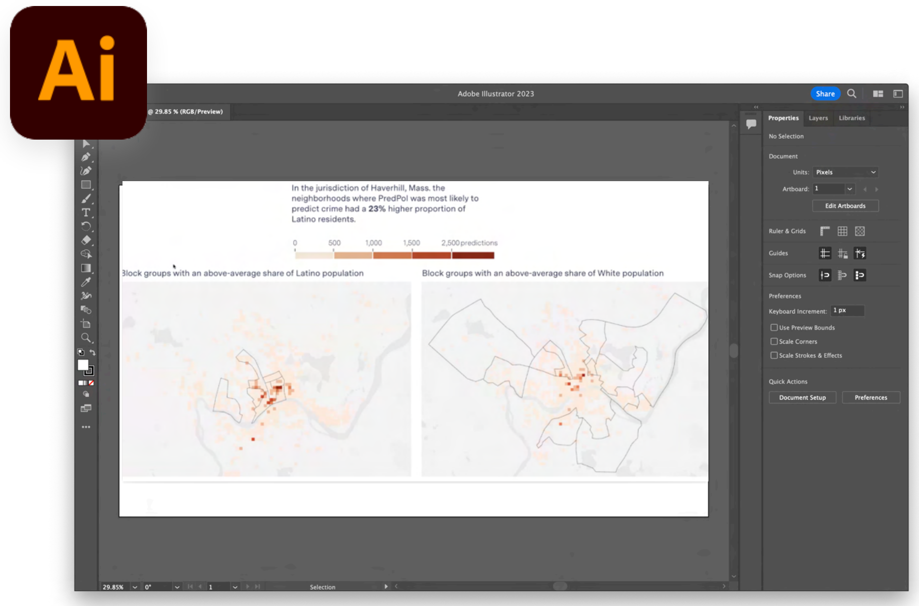
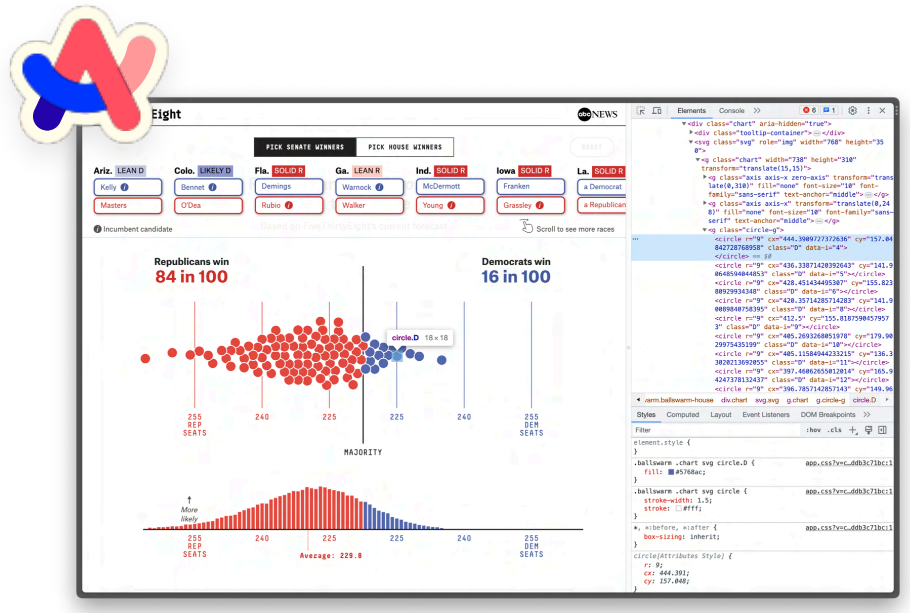
Visual Inputs







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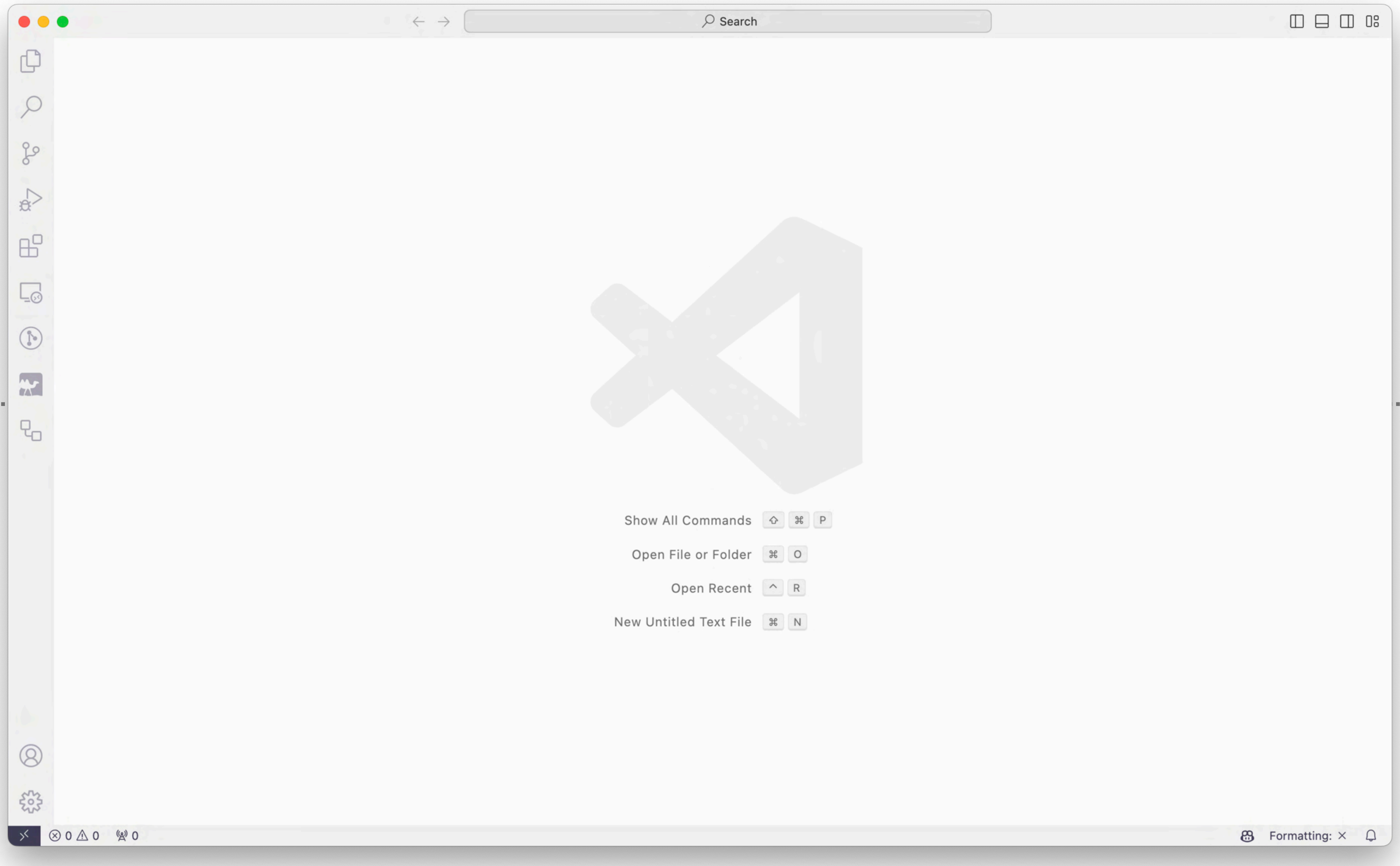

Programs

```
import * as d3 from "d3";

const context =
  canvas.getContext("2d");

regionsGeo.features
  .forEach((feature) => {
    context.beginPath();
    path(feature);

    const c =
      color(
        props.years_2080_2099
      );
  });
```

```
import mapboxgl from "mapbox-gl";
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mapboxgl.accessToken = "pk.eyJ6fh2…";

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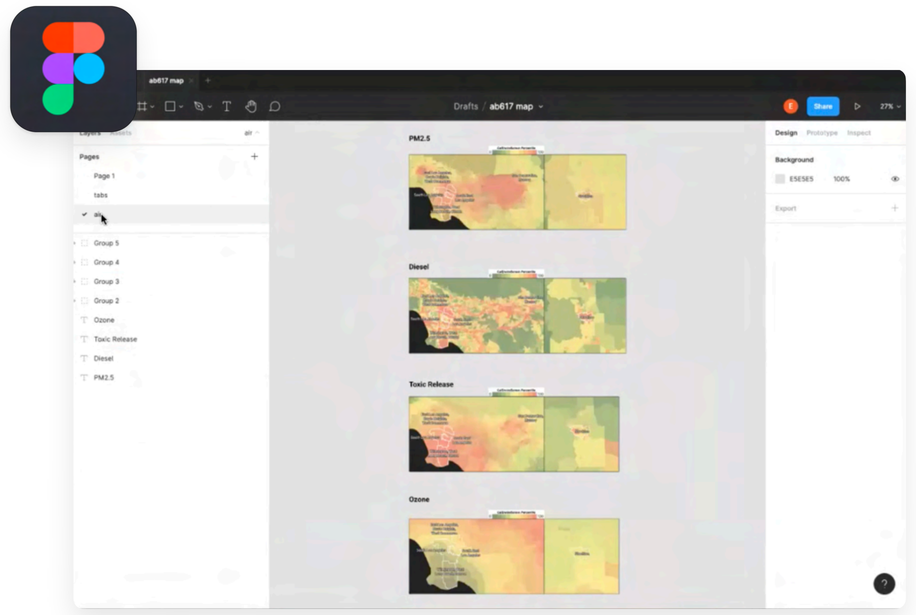
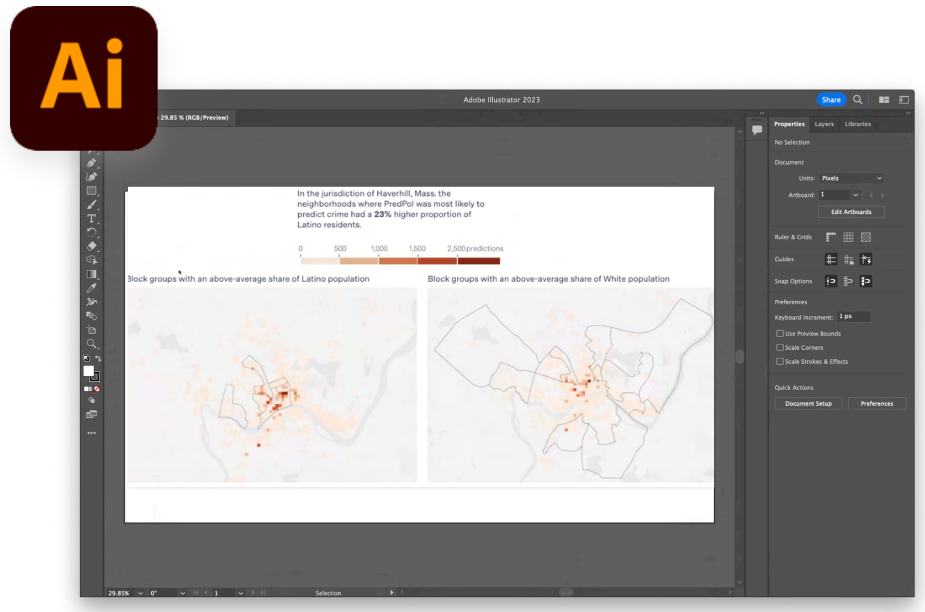
map.on("load", () => {
  map.addSource("cancer-regions", {
    type: "geojson",
    data: cancerRegions,
  });
});
```

```
import * as Plot from "@obs…";

const plot = Plot.plot({
  y: { grid: true },
  marks: [
    Plot.line(covidDeaths,
      Plot.binX(
        { y: "sum" },
        { x: "date" },
      )
    ),
    Plot.ruleY([0])
  ]
});
```

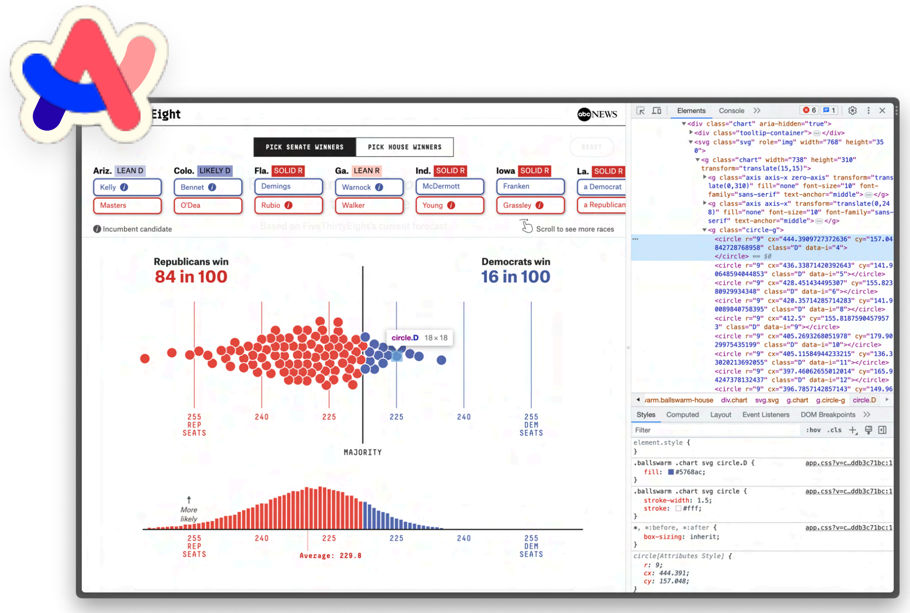
Visual Inputs





In the jurisdiction of Haverhill, Mass. the neighborhoods where PredPol was most likely to predict crime had a **23%** higher proportion of Latino residents.

0
500
1,000
1,500
2,500 predictions
Block groups with an above-average share of Latino population
Block groups with an above-average share of White population



```
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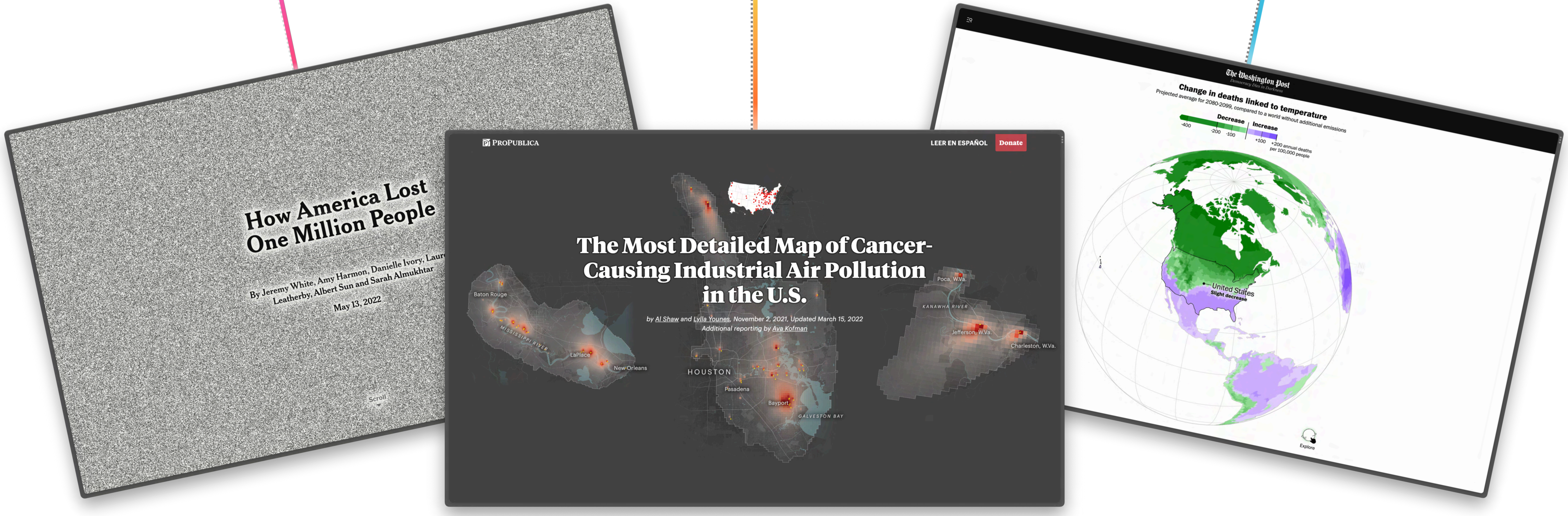
Fixed Entities



How America Lost One Million People

By Jeremy White, Amy Harmon, Danielle Ivory, Laur Leatherby, Albert Sun and Sarah Almukhtar

May 13, 2022

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by Al Shaw and Lylla Younes, November 2, 2021, Updated March 15, 2022
Additional reporting by Ava Kofman

Change in deaths linked to temperature

Projected average for 2080-2099, compared to a world without additional emissions

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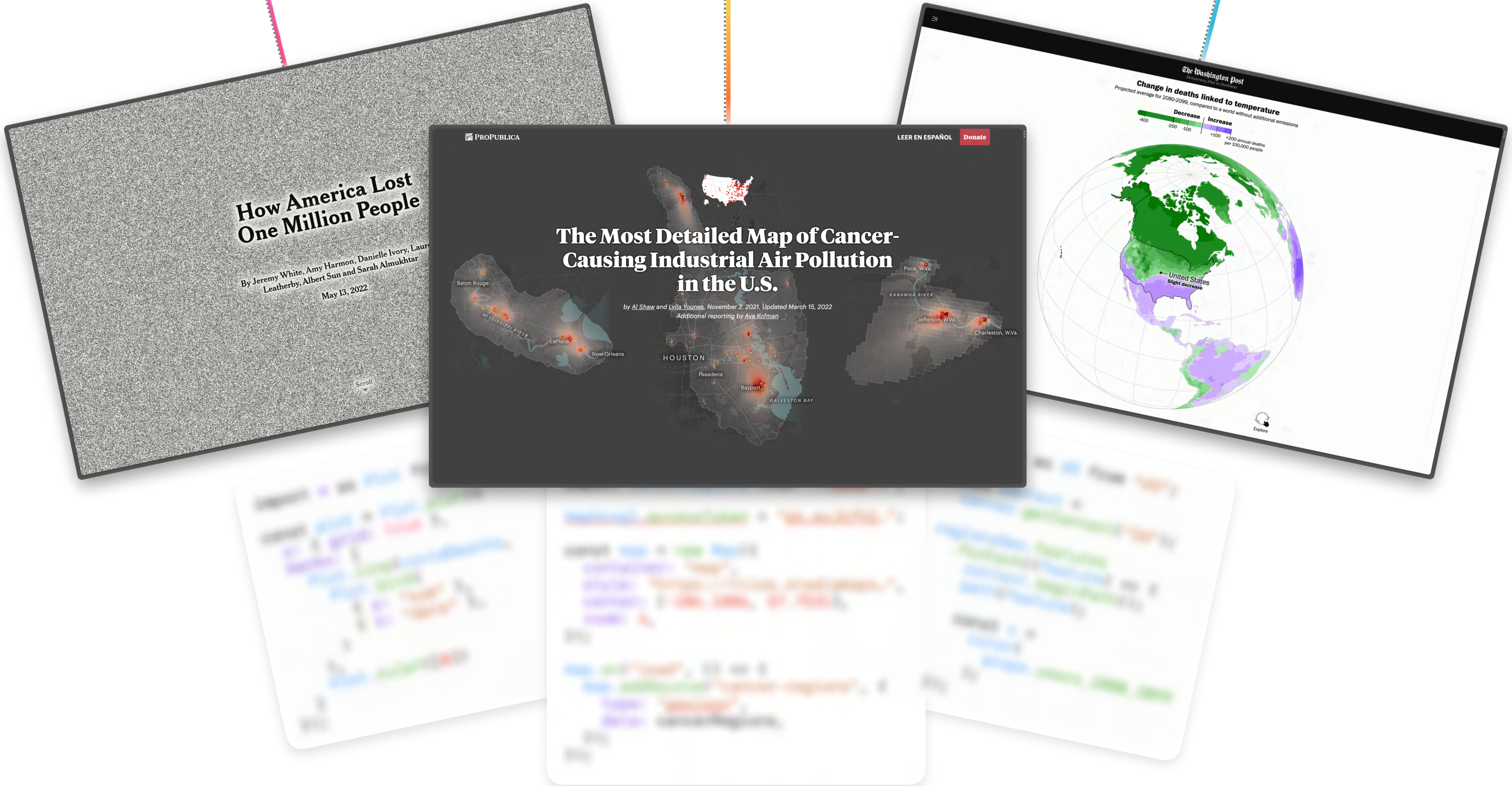

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The Washington Post
Democracy Dies in Darkness

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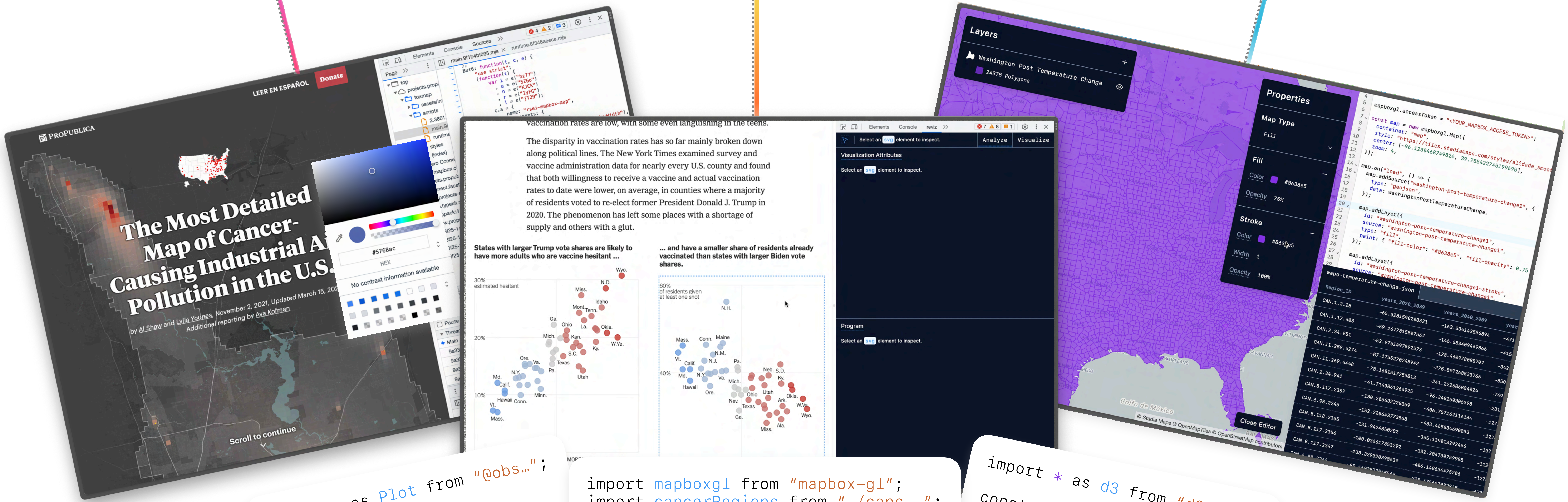
Live Objects



PROPUBLICA

LEER EN ESPAÑOL

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Scroll to continue

```
But6: function(t, c, e) {
    "use strict";
    (function(t) {
        var i = e("hz77")
          , a = e("SZ6o")
          , n = e("KJCk")
          , r = e("IyFG")
          , l = e("jT29");
        c.a = {
            name: "rsei-mapbox-map",
```

vaccination rates are low, with some even languishing in the teens.

The disparity in vaccination rates has so far mainly broken down along political lines. The New York Times examined survey and vaccine administration data for nearly every U.S. county and found that both willingness to receive a vaccine and actual vaccination rates to date were lower, on average, in counties where a majority of residents voted to re-elect former President Donald J. Trump in 2020. The phenomenon has left some places with a shortage of supply and others with a glut.

States with larger Trump vote shares are likely to have more adults who are vaccine hesitant ...

... and have a smaller share of residents already vaccinated than states with larger Biden vote shares.

```
mapboxgl.accessToken = "<YOUR_MAPBOX_ACCESS_TOKEN>";
const map = new mapboxgl.Map({
  container: "map",
  style: "https://tiles.stadiamaps.com/styles/alidade_smoot
  center: [-96.1230468749826, 39.755422745199695],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("washington-post-temperature-change1", {
    type: "geojson",
    data: washingtonPostTemperatureChange,
  });

  map.addLayer({
    id: "washington-post-temperature-change1",
    source: "washington-post-temperature-change1",
    type: "fill",
    paint: { "fill-color": "#8638e5", "fill-opacity": 0.75
  });

  map.addLayer({
    id: "washington-post-temperature-change1-stroke",
    source: "washington-post-temperature-change1",
```

wapo-temperature-change.json

Region_ID	years_2020_2039	years_2040_2059	year
CAN.1.2.28	-65.3281590200321	-163.334143536894	-471
CAN.1.17.403	-59.1677815807567	-146.683409469866	-415
CAN.2.34.951	-52.9761497092573	-128.460978088707	-342
CAN.11.259.4274	-87.1755270245942	-275.897268533766	-858
CAN.11.269.4448	-78.1681517253813	-241.222686084024	-749

```
import * as Plot from "@obs…";

const plot = Plot.plot({
  y: { grid: true },
  marks: [
    Plot.line(covidDeaths,
      Plot.binX(
        { y: "sum" },
        { x: "date" },
      )
    ),
    Plot.ruleY([0])
  ]
});
```

```
import mapboxgl from "mapbox-gl";
import cancerRegions from "./canc-…";

mapboxgl.accessToken = "pk.eyJ6fh2…";

const map = new Map({
  container: "map",
  style: "https://tiles.stadiamaps…",
  center: [-106.1086, 37.7531],
  zoom: 4,
});

map.on("load", () => {
  map.addSource("cancer-regions", {
    type: "geojson",
    data: cancerRegions,
  });
});
```

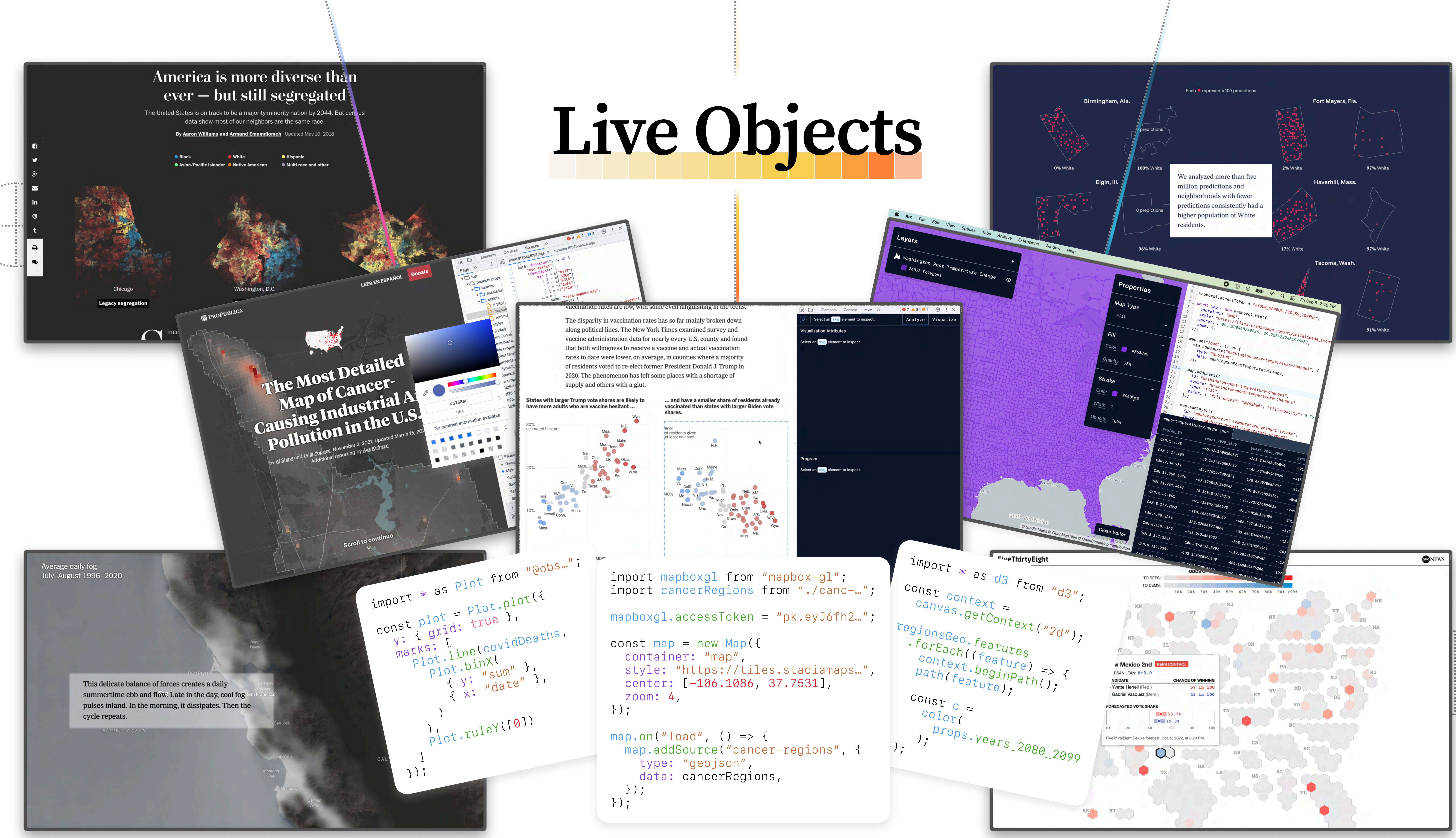
```
import * as d3 from "d3";

const context =
  canvas.getContext("2d");

regionsGeo.features
  .forEach((feature) => {
    context.beginPath();
    path(feature);

    const c =
      color(
        props.years_2080_2099
      );
});
```

Live Objects



America is more diverse than ever — but still segregated

The United States is on track to be a majority-minority nation by 2044. But census data show most of our neighbors are the same race.

By Aaron Williams and Armand Emamdjomeh Updated May 10, 2018

The Most Detailed Map of Cancer-Causing Industrial Air Pollution in the U.S.

by Al Shaw and Lylla Younes, November 2, 2021, Updated March 15, 2022
Additional reporting by Ava Kofman

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States with larger Trump vote shares are likely to have more adults who are vaccine hesitant …

… and have a smaller share of residents already vaccinated than states with larger Biden vote shares.

We analyzed more than five million predictions and neighborhoods with fewer predictions consistently had a higher population of White residents.

Average daily fog
July–August 1996–2020

This delicate balance of forces creates a daily summertime ebb and flow. Late in the day, cool fog pulses inland. In the morning, it dissipates. Then the cycle repeats.

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Supporting Data Journalism through Compilers for Visual Inputs

reviz

cartokit

github.com/parkerziegler/reviz

observablehq.com/@parkerziegler/hello-reviz

github.com/parkerziegler/cartokit

CK alpha.cartokit.dev

Get in touch!

peziegler@cs.berkeley.edu

parkie-doo.sh

Parker Ziegler // @parker_ziegler
Ph.D. Student, UC Berkeley

Strange Loop
St. Louis, MO • September 21, 2023