TopoJSON

A smaller GeoJSON with some neat tricks

State of the Map US • June 2013

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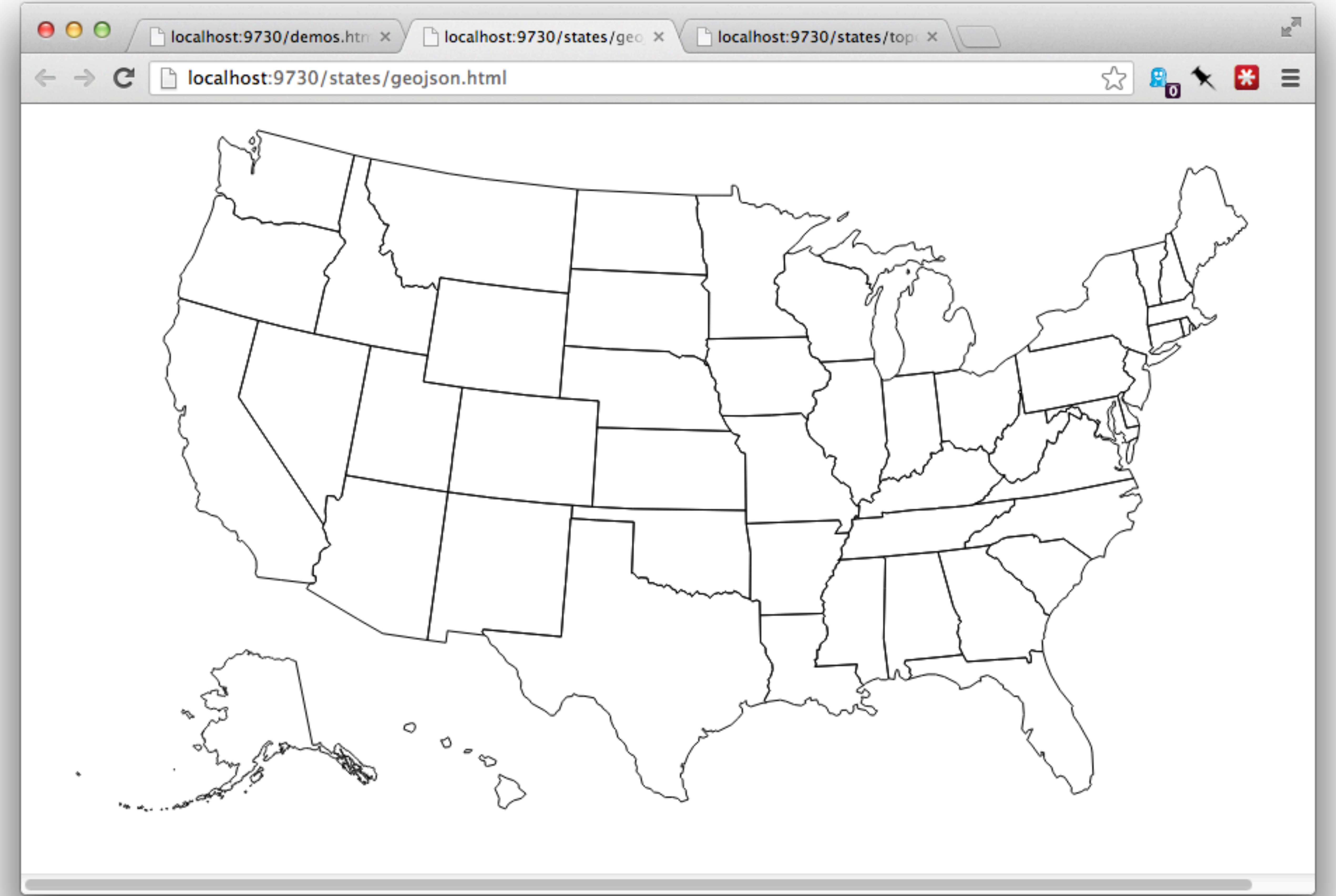
many thanks to Mike Bostock @mbostock

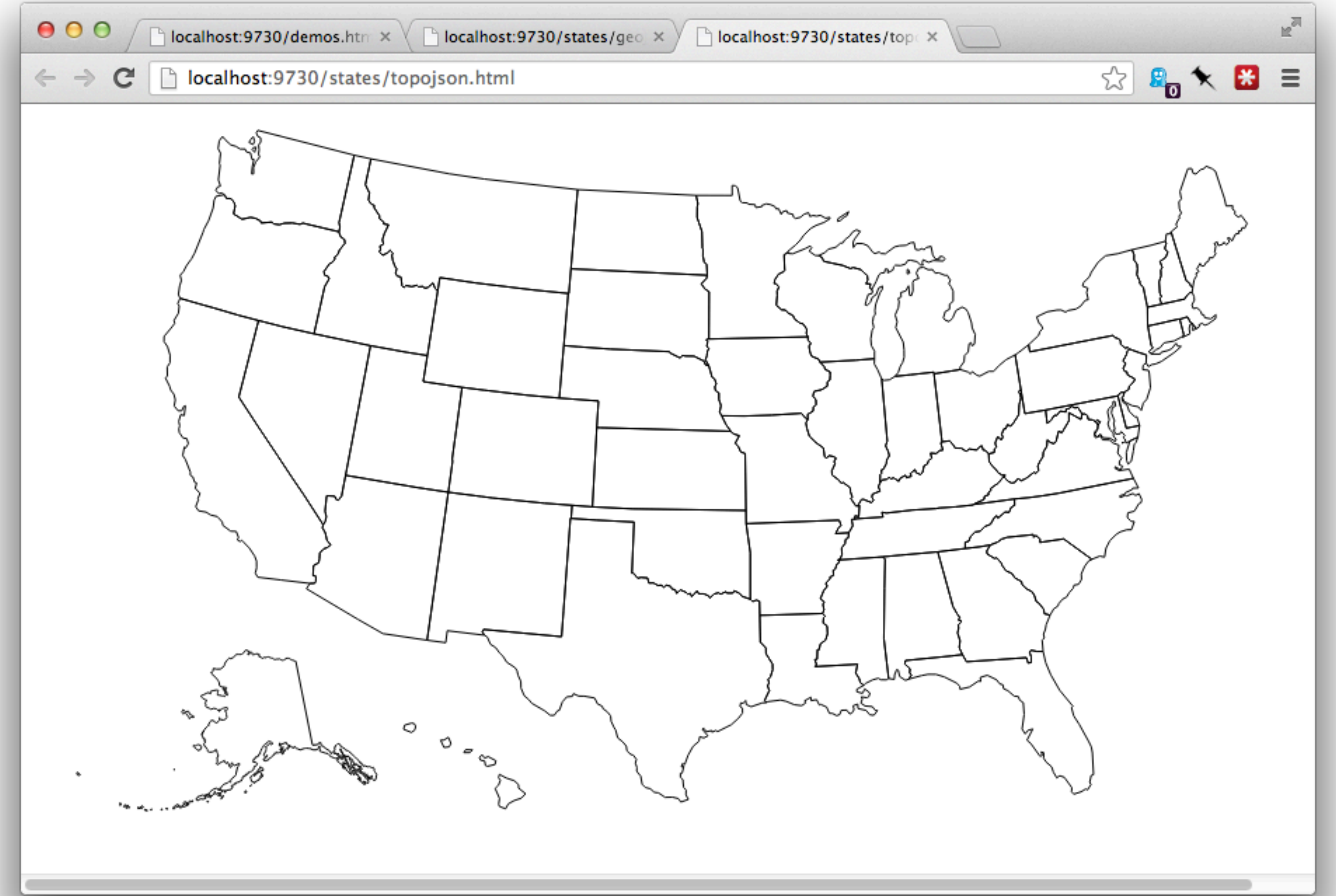
Quick introduction

TopoJSON is...

- Text data format for geographic data
- Extension of GeoJSON
- Encodes topology, not just geometry
  Identification of shared arcs
- Space efficient
- Enables topology-aware visualization
- Particularly good for browser presentation

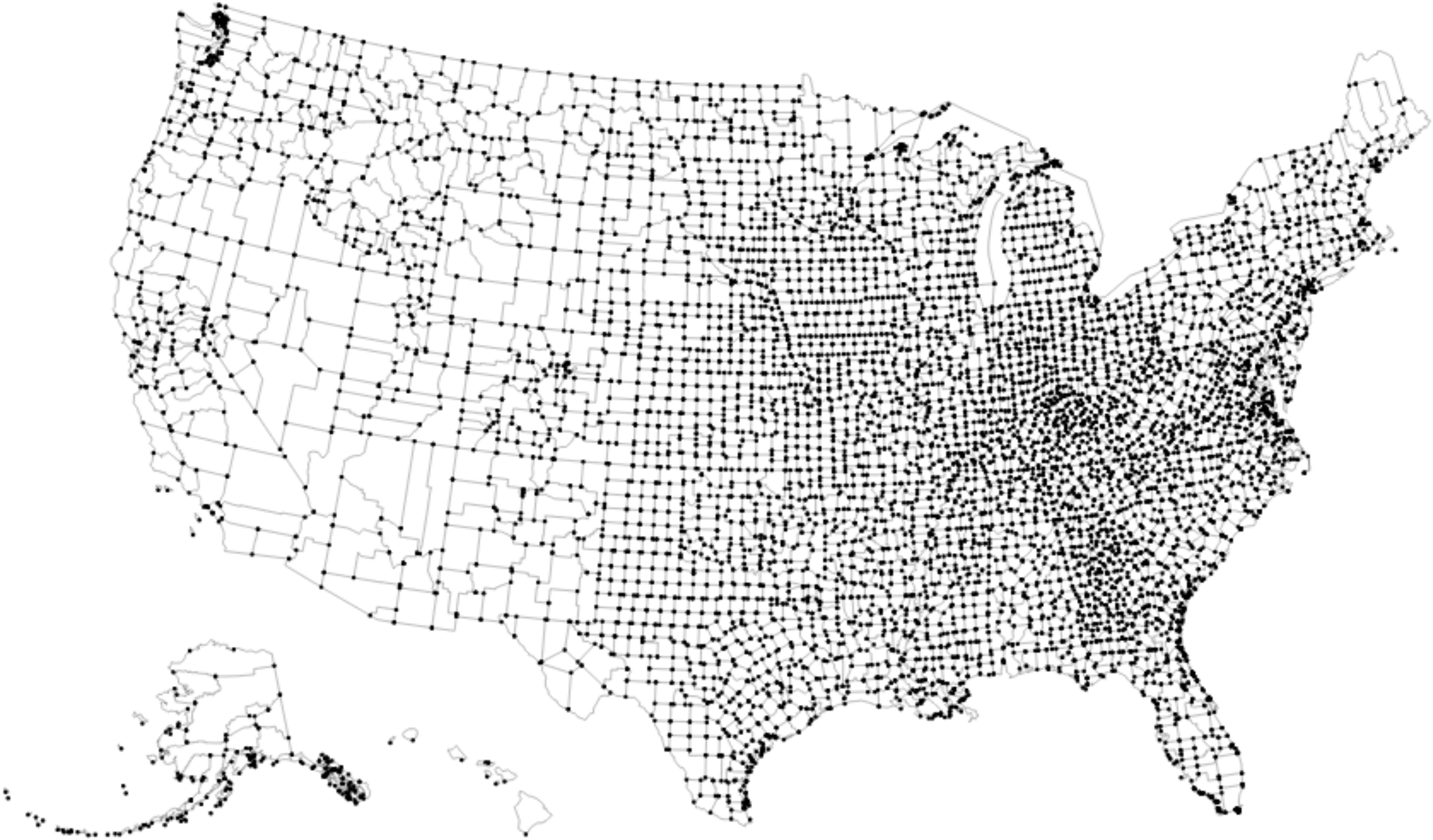
GeoJSON v. TopoJSON


localhost:9730/demos.htm
localhost:9730/states/geo
localhost:9730/states/top
localhost:9730/states/geojson.html
0


localhost:9730/demos.htm
localhost:9730/states/geo
localhost:9730/states/top
localhost:9730/states/topojson.html

Let’s compare

- Nearly visually identical
- GeoJSON: 67,859 bytes
- TopoJSON: 29,456 bytes
- 43% the size
- After gzip: 20k v. 9k, 46%



Luminary mentions

- Mike Bostock @mbostock
- Jason Davies @jasondavies
- Shan Carter @shancarter

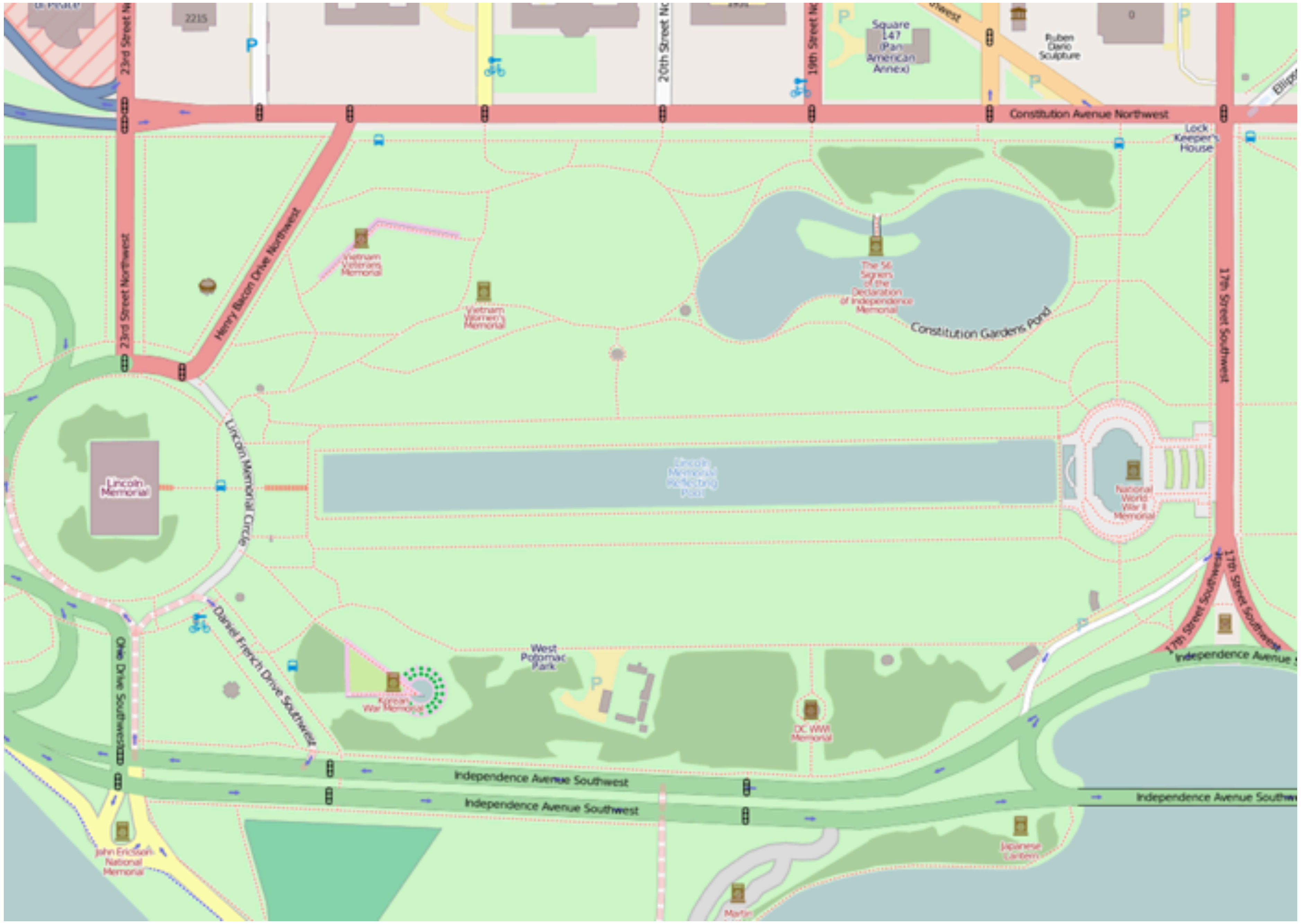
TopoJSON definition

GeoJSON schema

- FeatureCollection
  - Feature
    - *properties*
    - GeometryCollection
      - Point, MultiPoint
      - LineString, MultiLineString
      - Polygon, MultiPolygon

Shapes: sequence of points

Reflecting Pool


2215
23rd Street Northwest
20th Street Northwest
19th Street Northwest
Square 147 (Pan American Annex)
Ruben Dario Sculpture
Constitution Avenue Northwest
Lock Keeper's House
Henry Bacon Drive Northwest
Vietnam Veterans Memorial
Vietnam Women's Memorial
The 56 Signers of the Declaration of Independence Memorial
Constitution Gardens Pond
17th Street Southwest
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Lincoln Memorial Circle
Lincoln Memorial Reflecting Pool
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Daniel French Drive Southwest
Ohio Drive Southwest
West Potomac Park
Korean War Memorial
DC WWI Memorial
Independence Avenue Southwest
Independence Avenue Southwest
Independence Avenue Southwest
John Ericsson National Memorial
Japanese Lantern
Martin

GeoJSON example

```
{ "type":"FeatureCollection",
  "features": [{
    "type": "Feature",
    "geometry": {
        "type":"Polygon",
        "coordinates":[[
          [-77.0482, 38.8891],
          [-77.0482, 38.8895],
          ...]]}
    "properties": {
      "kind":"water",
      "name":"Reflecting Pool",
      "area":49918.195312
}}]}
```

“GeoJSON is spectacularly wrong, yet somehow right enough“

– Sean Gillies

GeoJSON in context

- Simple text format
- Easy export from GIS systems
- Excellent web support
  - Leaflet, D3, OpenLayers, Polymaps, ...
  - Vector tiles (OpenStreetMap, etc)
- Not very space efficient

```
[ -59.57209469261529, -80.040178725096297 ]
```

“GeoJSON is spectacularly wrong, yet somehow right enough” – Sean Gillies

- Simple text format
  - Shapes: sequence of points
- Easy export from GIS systems
- Excellent web support
- Not very space efficient

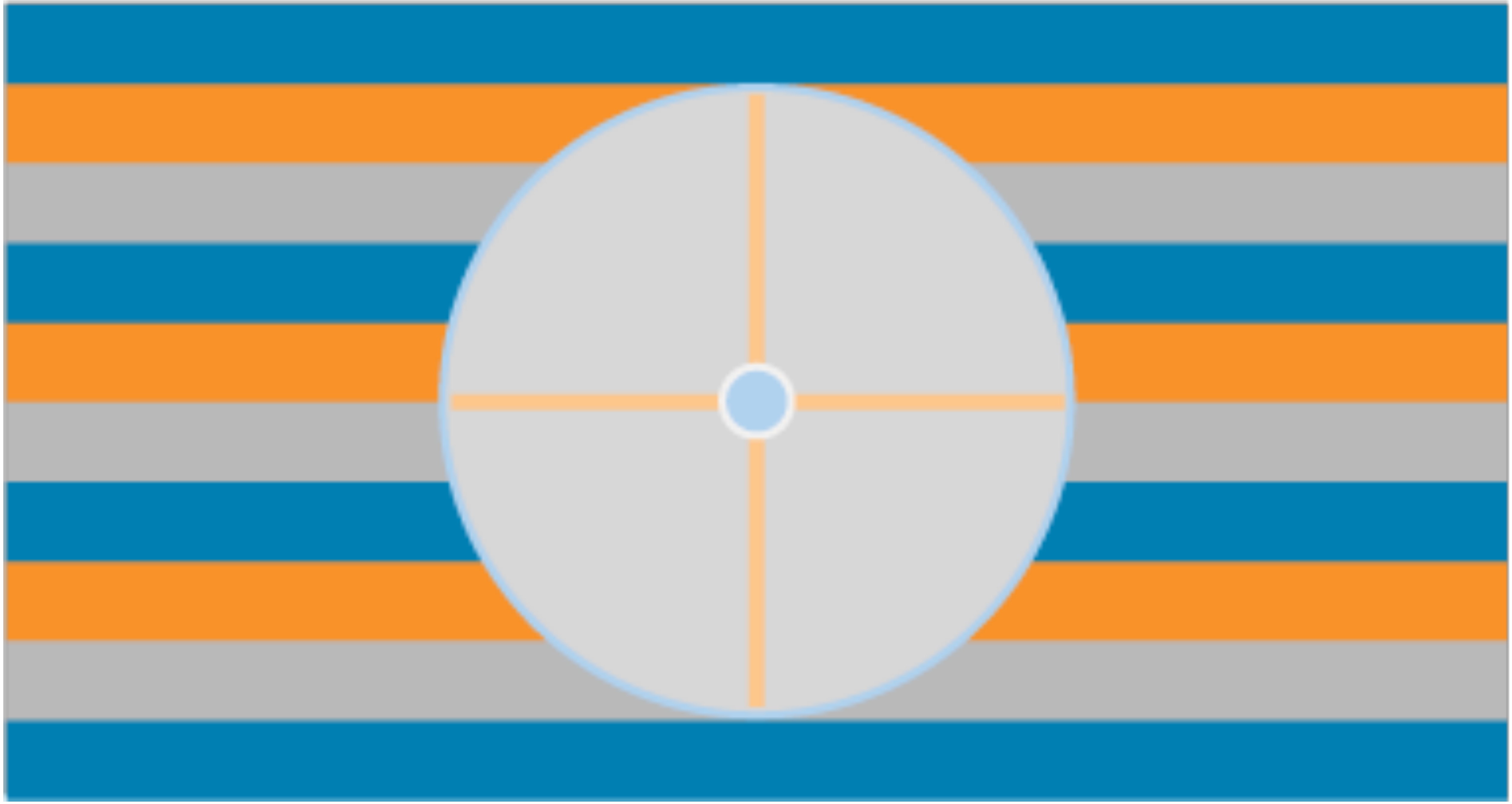
```
[ -59.57209469261529, -80.040178725096297 ]
```

TopoJSON schema

Type: “topology”
Objects
Type: LineString, Polygon, ...
Arcs: included by reference
properties
Arcs: LineStrings
Transform: Scale, Translate

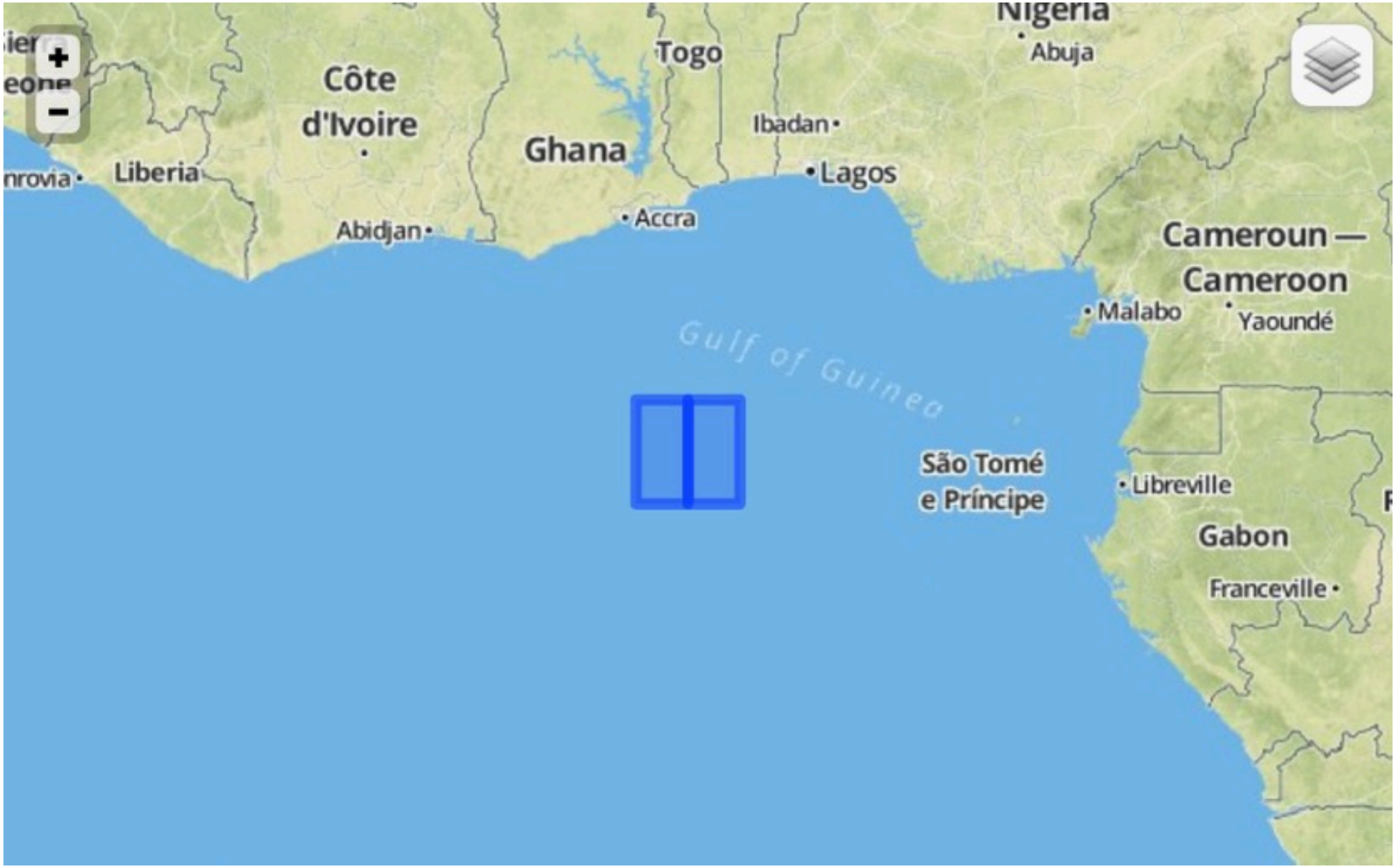
Shapes: sequence of arcs
Arcs: sequence of points

Null Island



Like no place on earth

Two rectangles



Two rects: GeoJSON

```
{ "type": "FeatureCollection",
  "features": [
    { "type": "Feature",
      "geometry": {
        "type": "Polygon",
        "coordinates": [[
          [0,0], [0,2], [1,2], [1,0], [0,0]
        ]] },
      "properties": { "name": "left" } },
    { "type": "Feature",
      "geometry": {
        "type": "Polygon",
        "coordinates": [[
          [1,0], [1,2], [2,2], [2,0], [1,0]
        ]] },
      "properties": { "name": "right" } }]}
```

Two rects: TopoJSON

```
{ "type": "Topology",
  "transform": { "scale": [1,1], "translate": [0,0] },
  "objects": {
    "two-squares": {
      "type": "GeometryCollection",
      "geometries": [
        { "type": "Polygon",
          "arcs": [[0,1]],
          "properties": {"name": "left"}},
        { "type": "Polygon",
          "arcs": [[2,-1]],
          "properties": {"name": "right"}}
  ]}},
  "arcs":[
    [[1,2],[0,-2]],
    [[1,0],[-1,0],[0,2],[1,0]],
    [[1,2],[1,0],[0,-2],[-1,0]]
]}
```

Arcs

- Geometry defined by referencing arcs

```
"arcs": [[0,1]]   "arcs": [[2,-1]]
```

- Encoding of shared arcs
- Integer delta encoding of arc shape

```
[[1,0],[-1,0],[0,2],[1,0]]
```

- Scale and translate

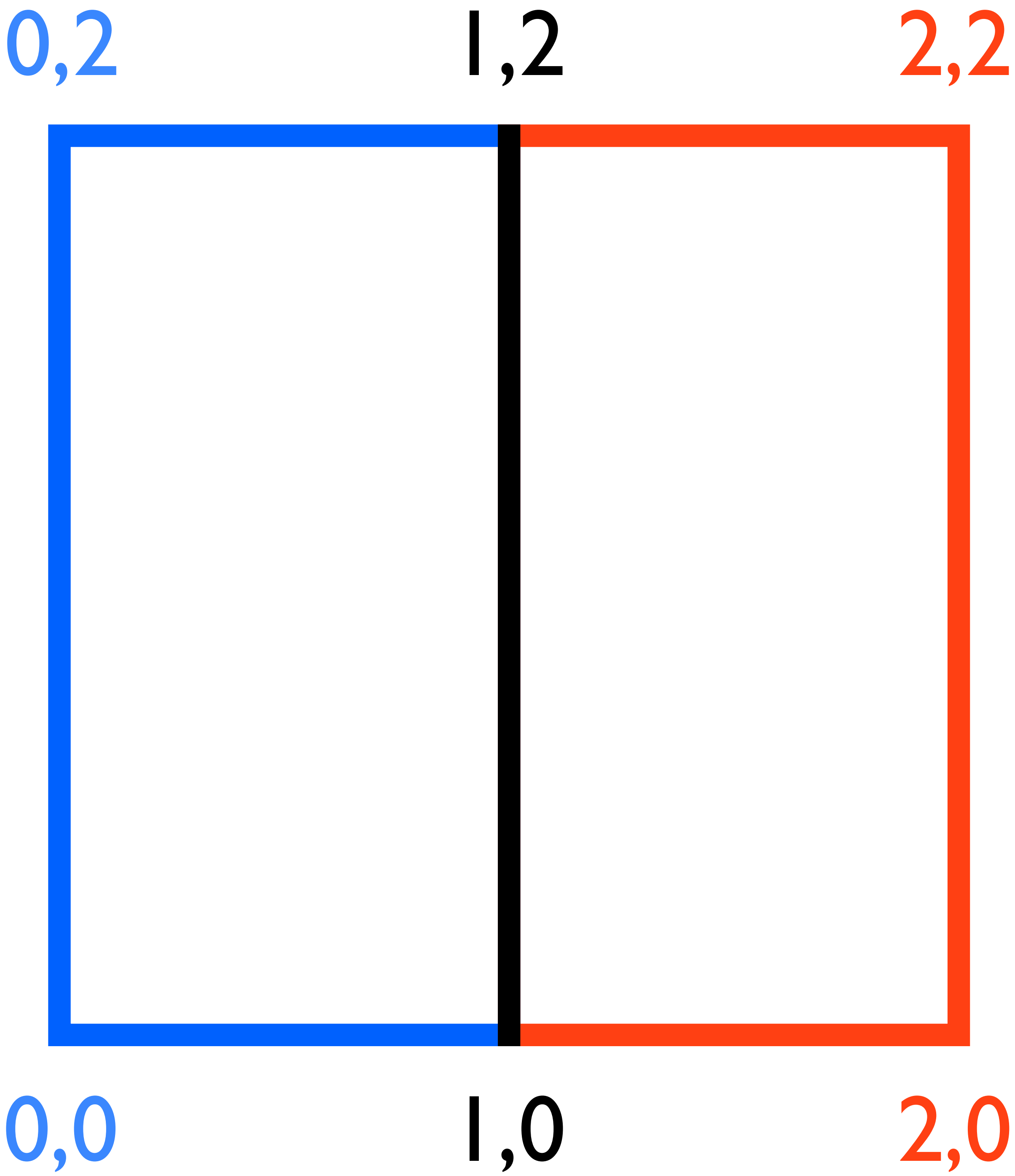
Left

```
"arcs": [[0,1]]
```

Right

```
"arcs": [[2,-1]]
```

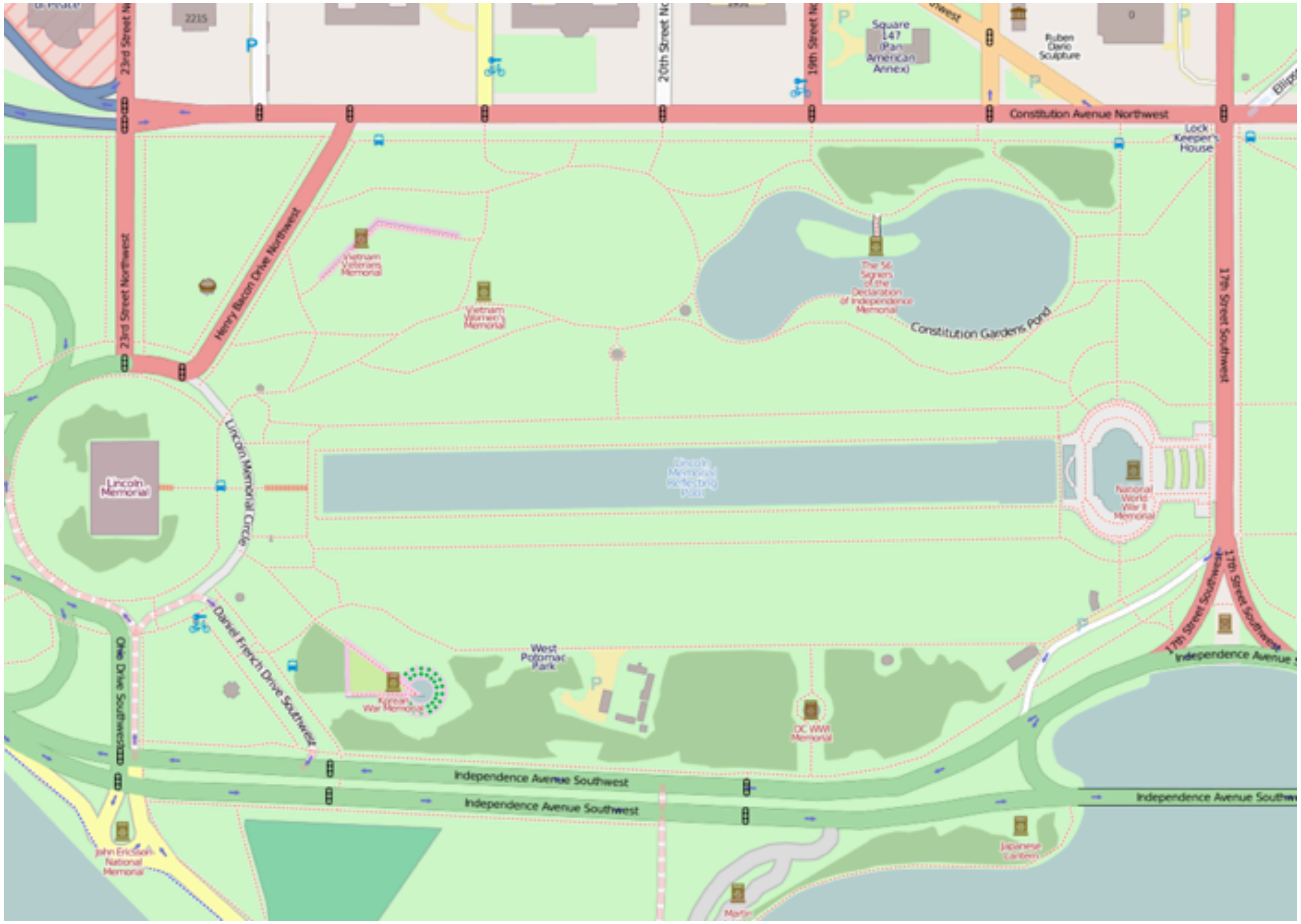
```
"arcs":[
    [[1,2],[0,-2]],
    [[1,0],[-1,0],[0,2],[1,0]],
    [[1,2],[1,0],[0,-2],[-1,0]]
```



Reflecting Pool

```
{ "type": "Topology",
  "transform": {
    "scale": [0.00007125, 0.00000554],
    "translate": [-77.048238, 38.889085]
  },
  "objects": {
    "pool": {
        "type":"GeometryCollection",
        "geometries": [{
            "type":"Polygon",
            "arcs":[[0]],
            "properties":{"name":"Reflecting Pool"}}]}},
  "arcs":[[
    [0,0],[0,79],[92,16],[0,4],[7,1],[0,-4],[1,0],
    [0,-79],[0,-4],[-8,-1],[0,4],[-92,-16]]]}
```

Reflecting Pool


23rd Street Northwest
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Daniel French Drive Southwest
Ohio Drive Southwest
West Potomac Park
Korean War Memorial
DC WWI Memorial
Independence Avenue Southwest
John Ericsson National Memorial
Japanese Lantern

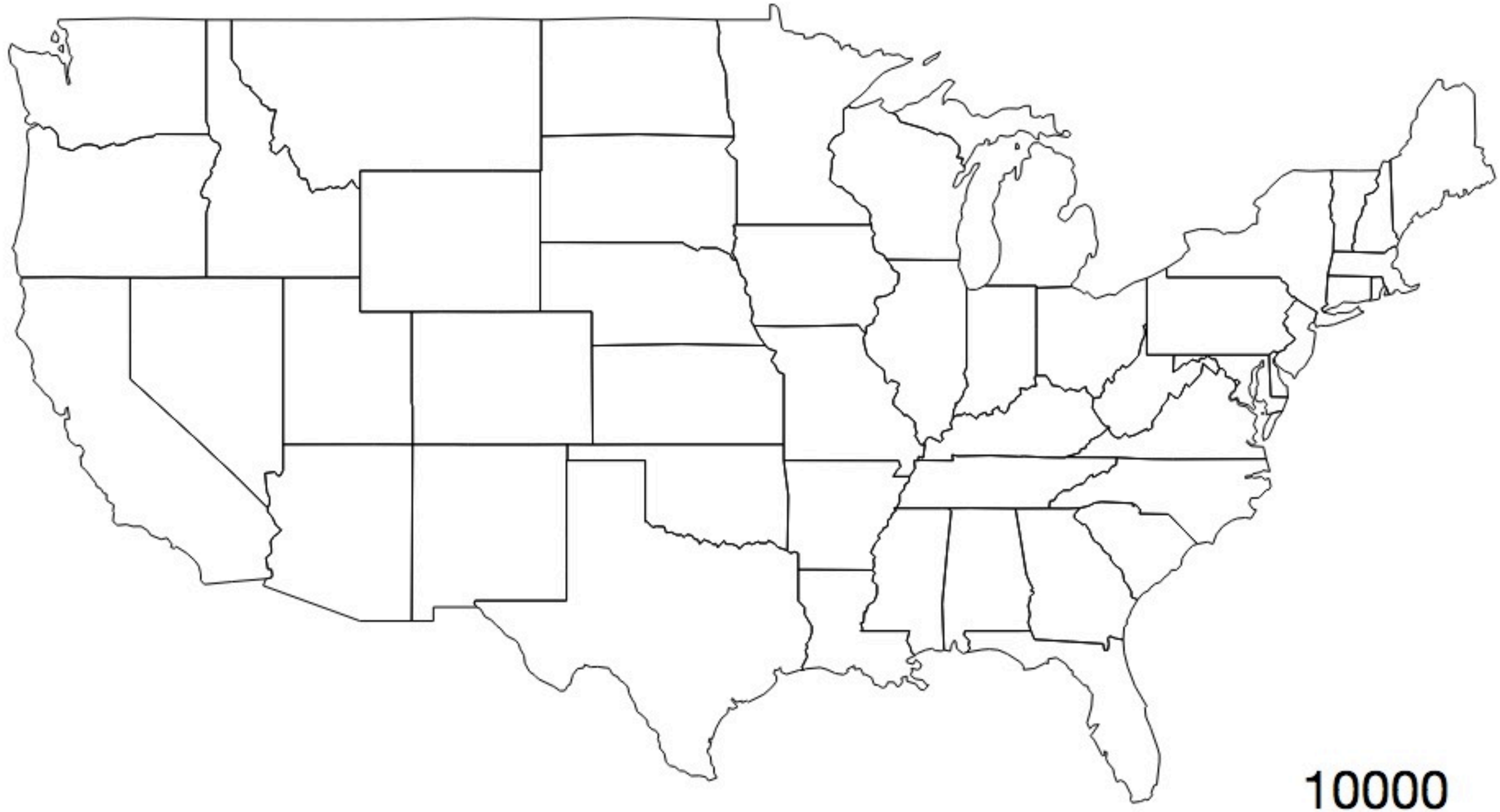
TopoJSON algorithm

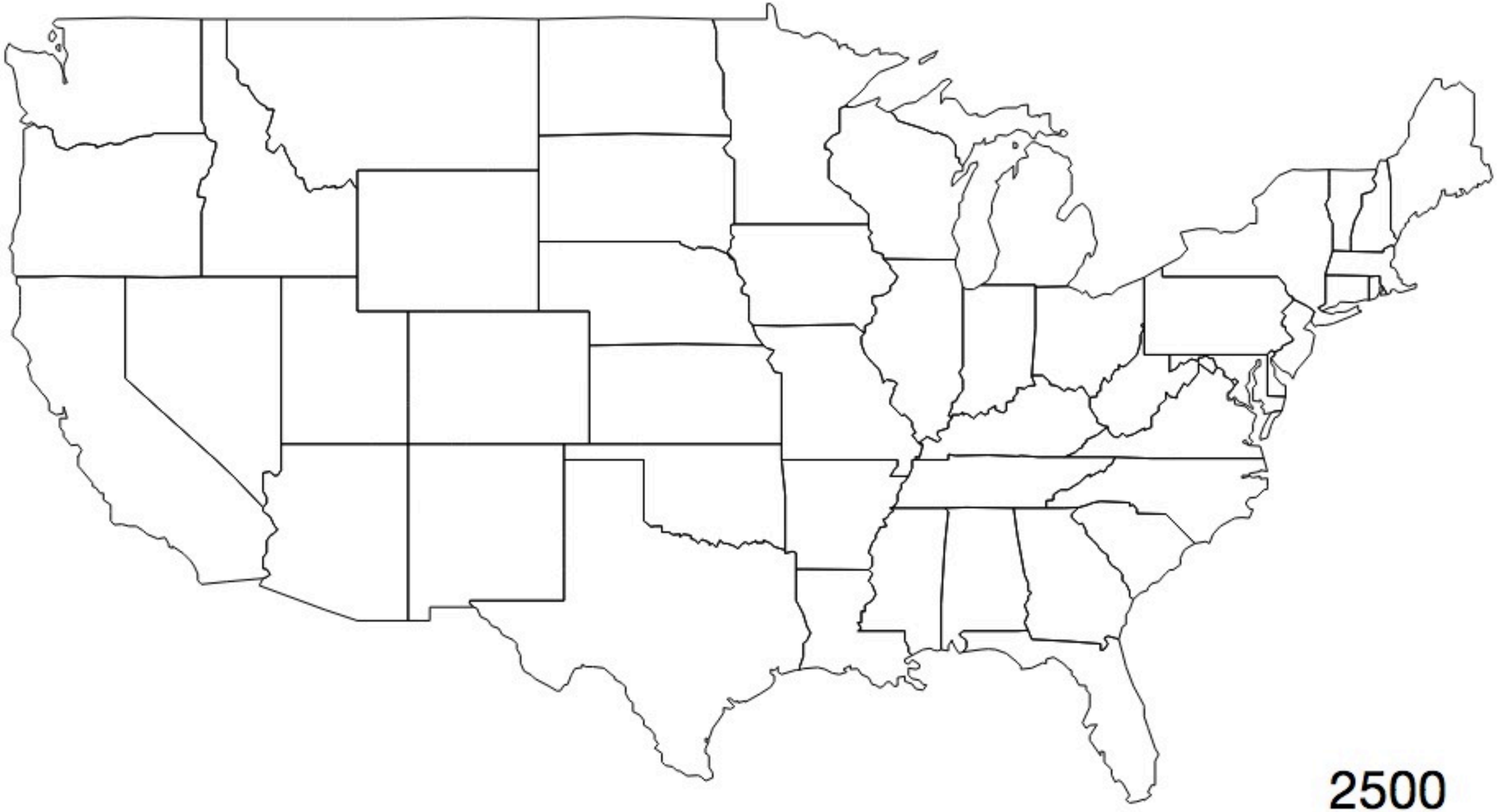
- Quantize points to a grid
- Draw every line on the grid
- Pick out common arcs
- Simplify arcs
- Encode all arcs
- Encode all geometries referencing arcs
- 200MB inputs require subtlety

Downsampling

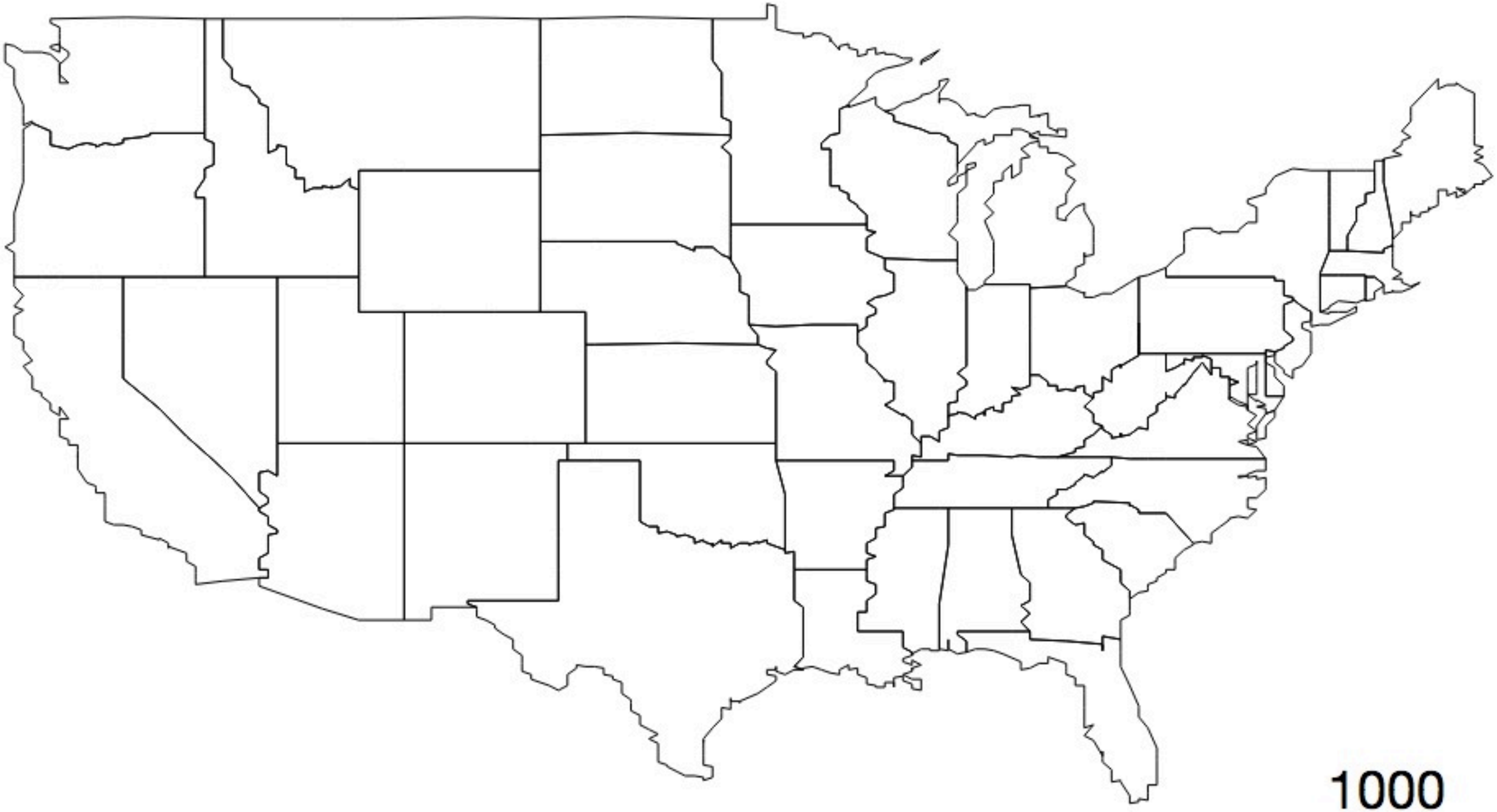
- Quantization: lower precision points
  - Default: 10,000 x 10,000
  - Similar to rounding GeoJSON
- Simplification: fewer points
  - Default: none
  - Preserves topology

Quantization

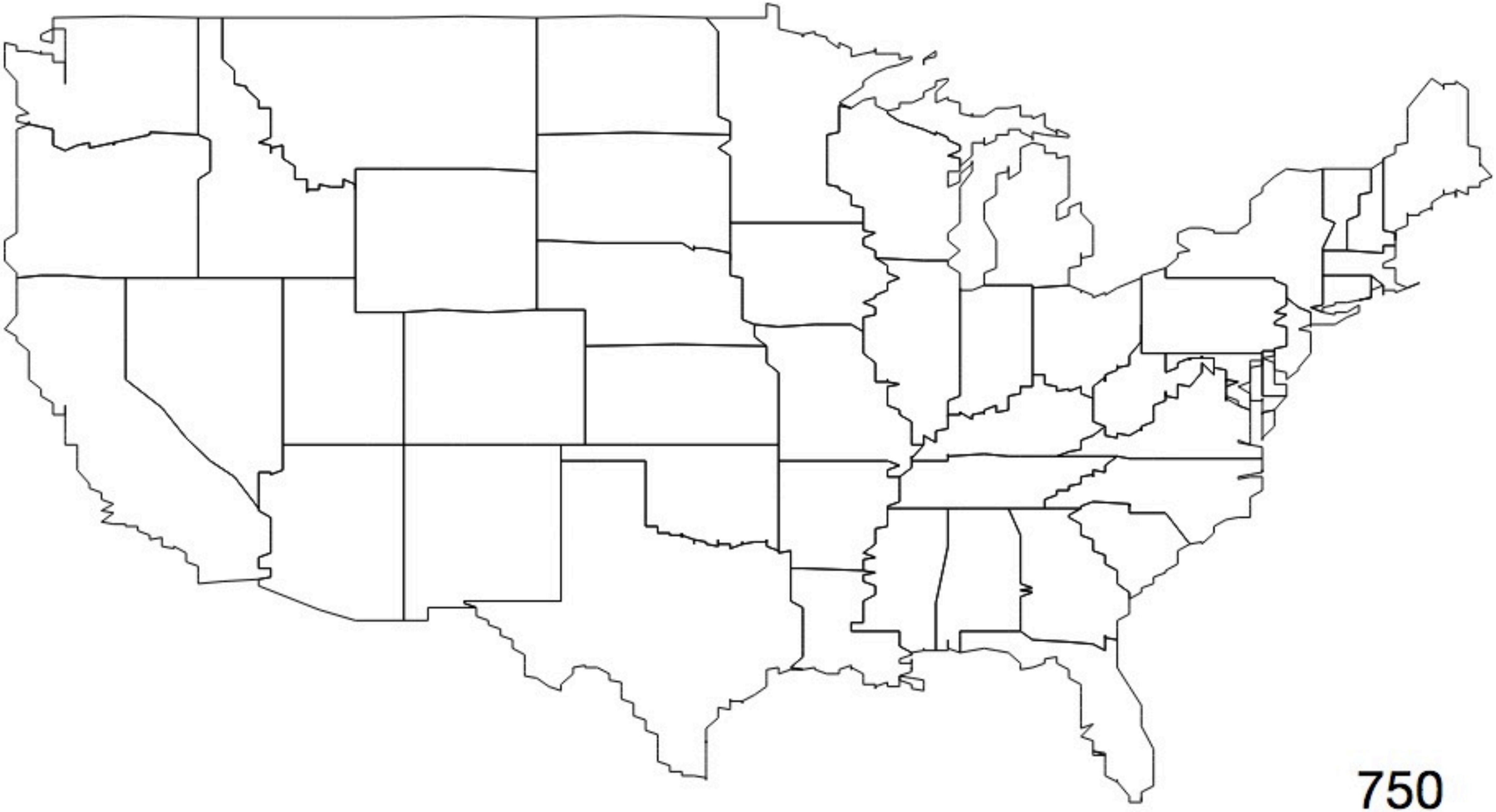

10000



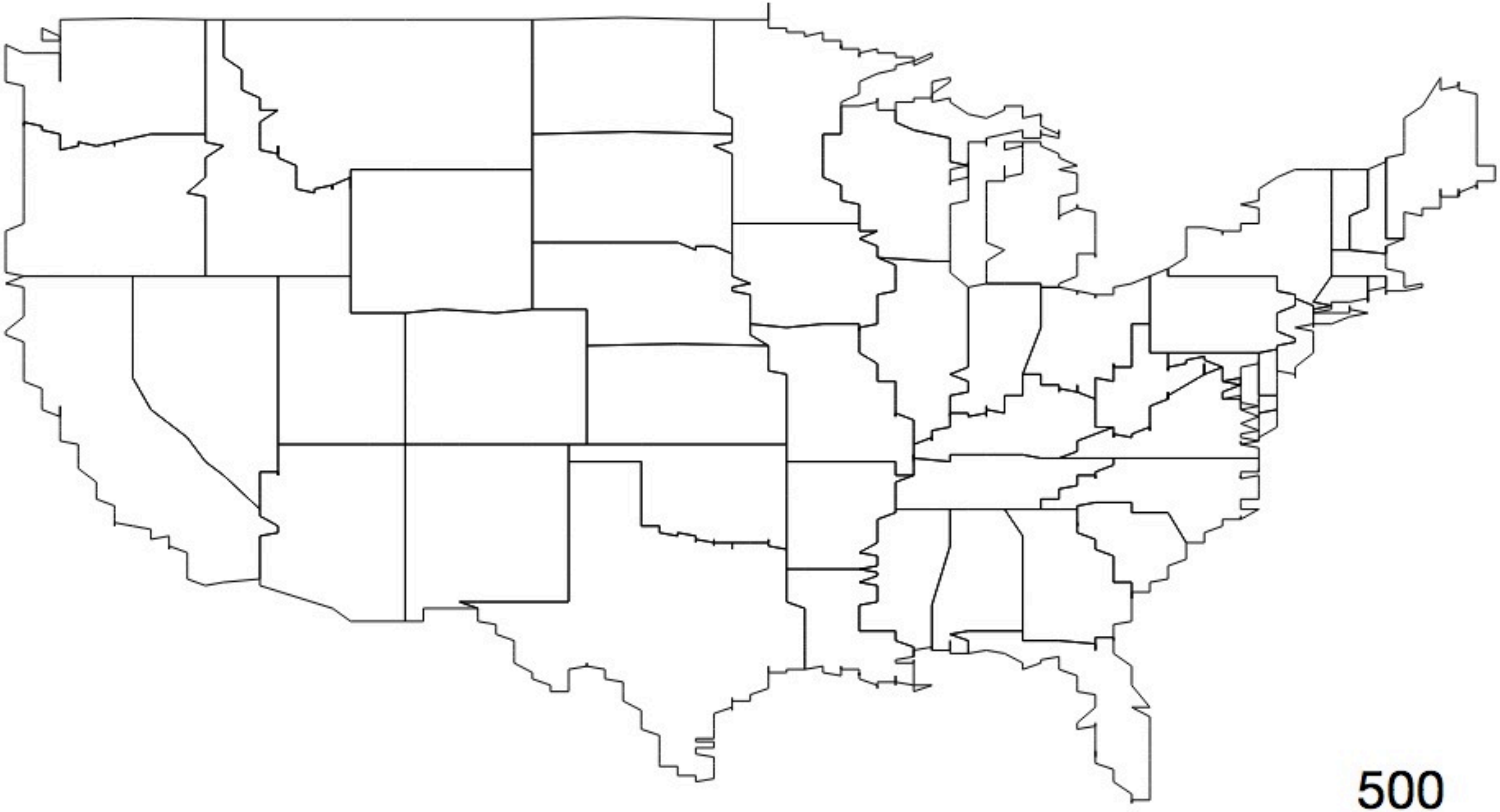
2500



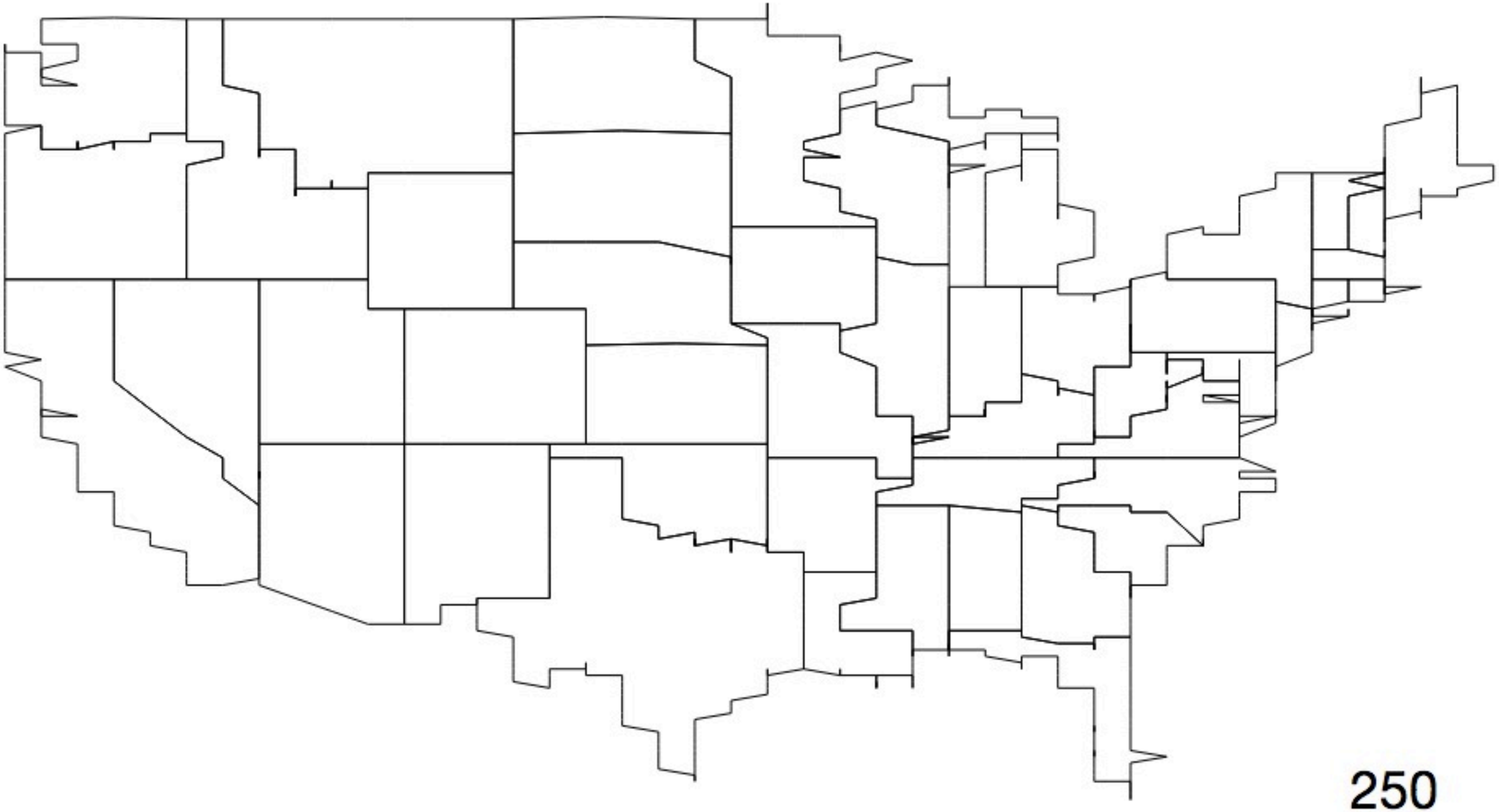
1000



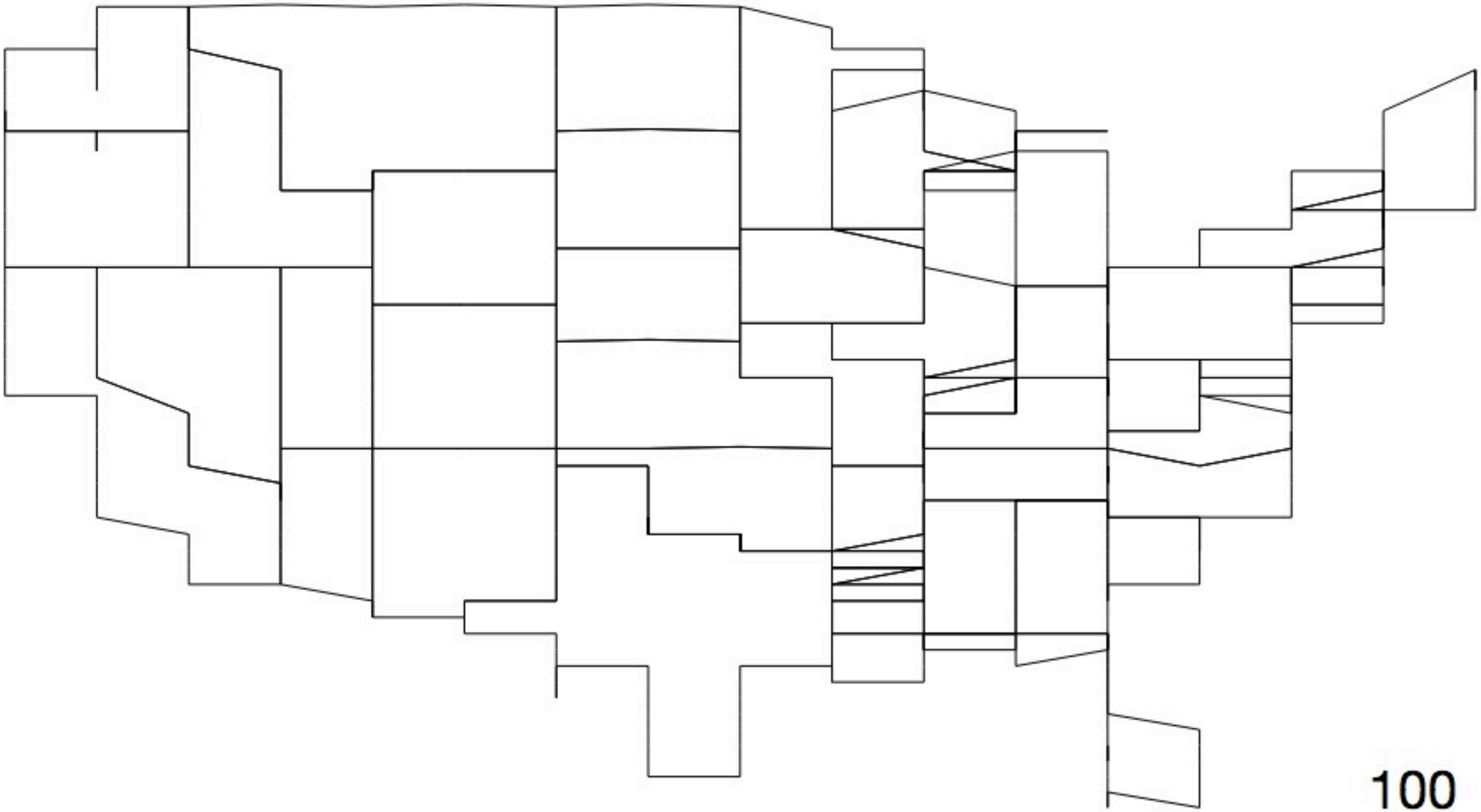
750



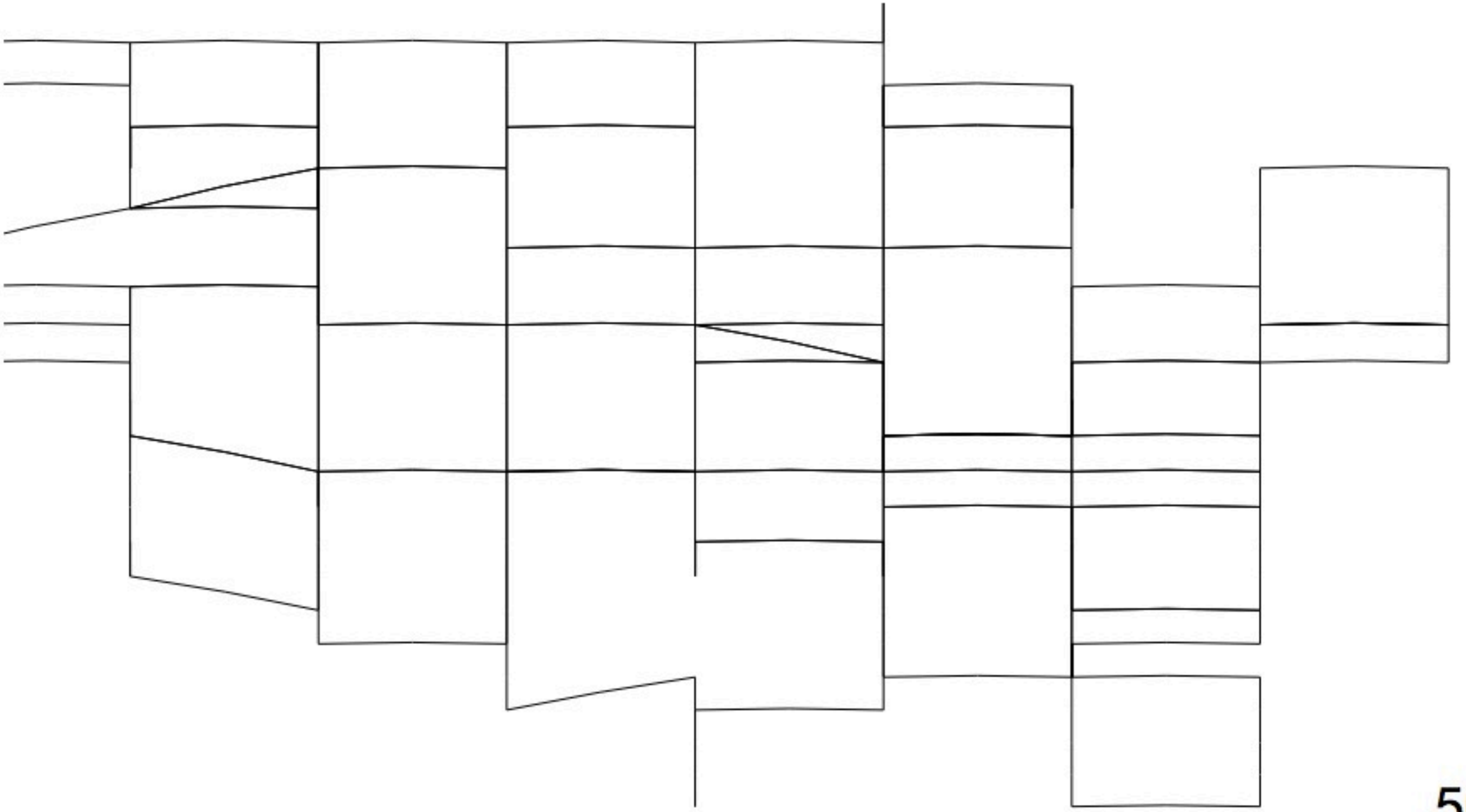
500

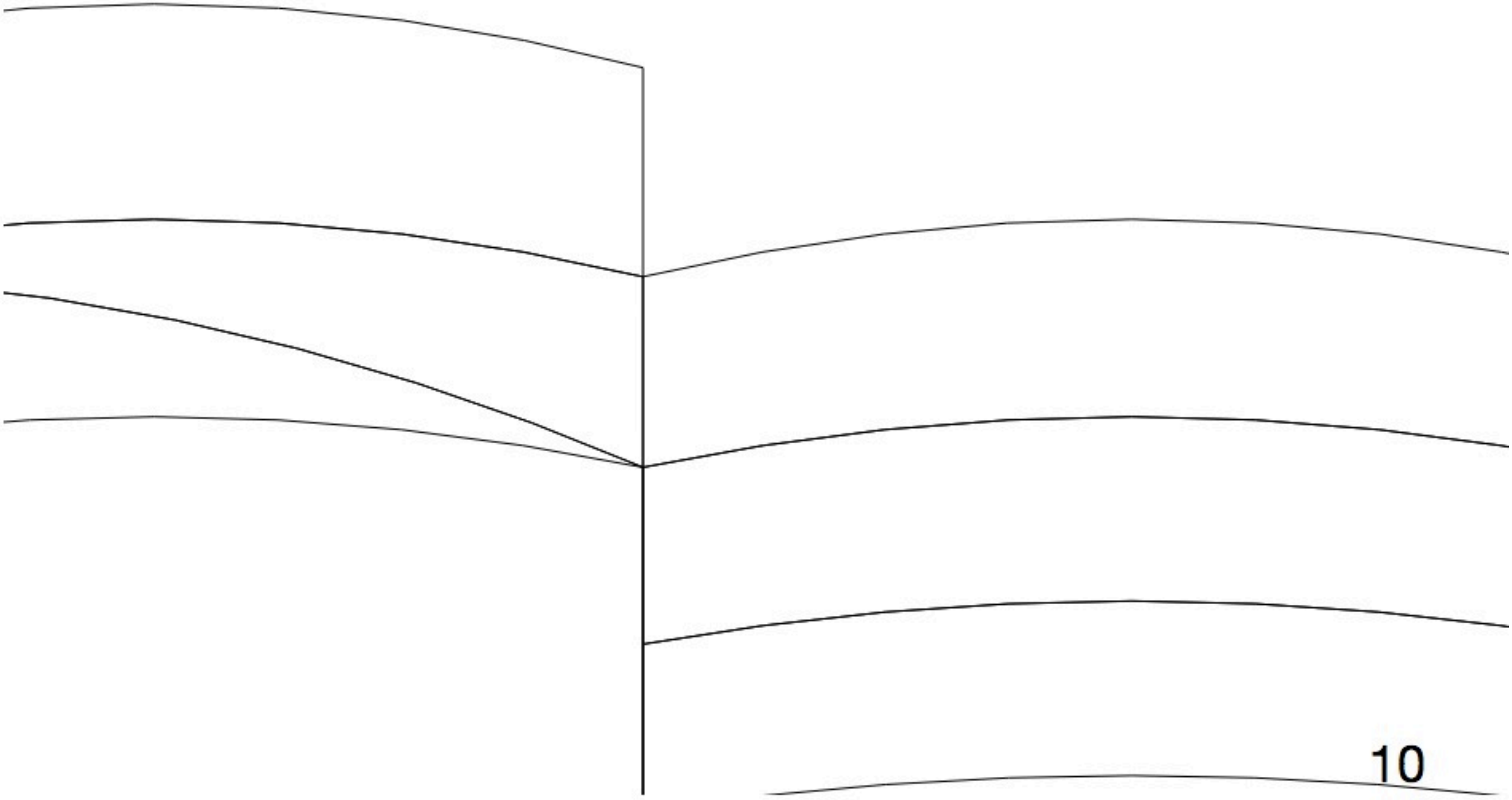


250



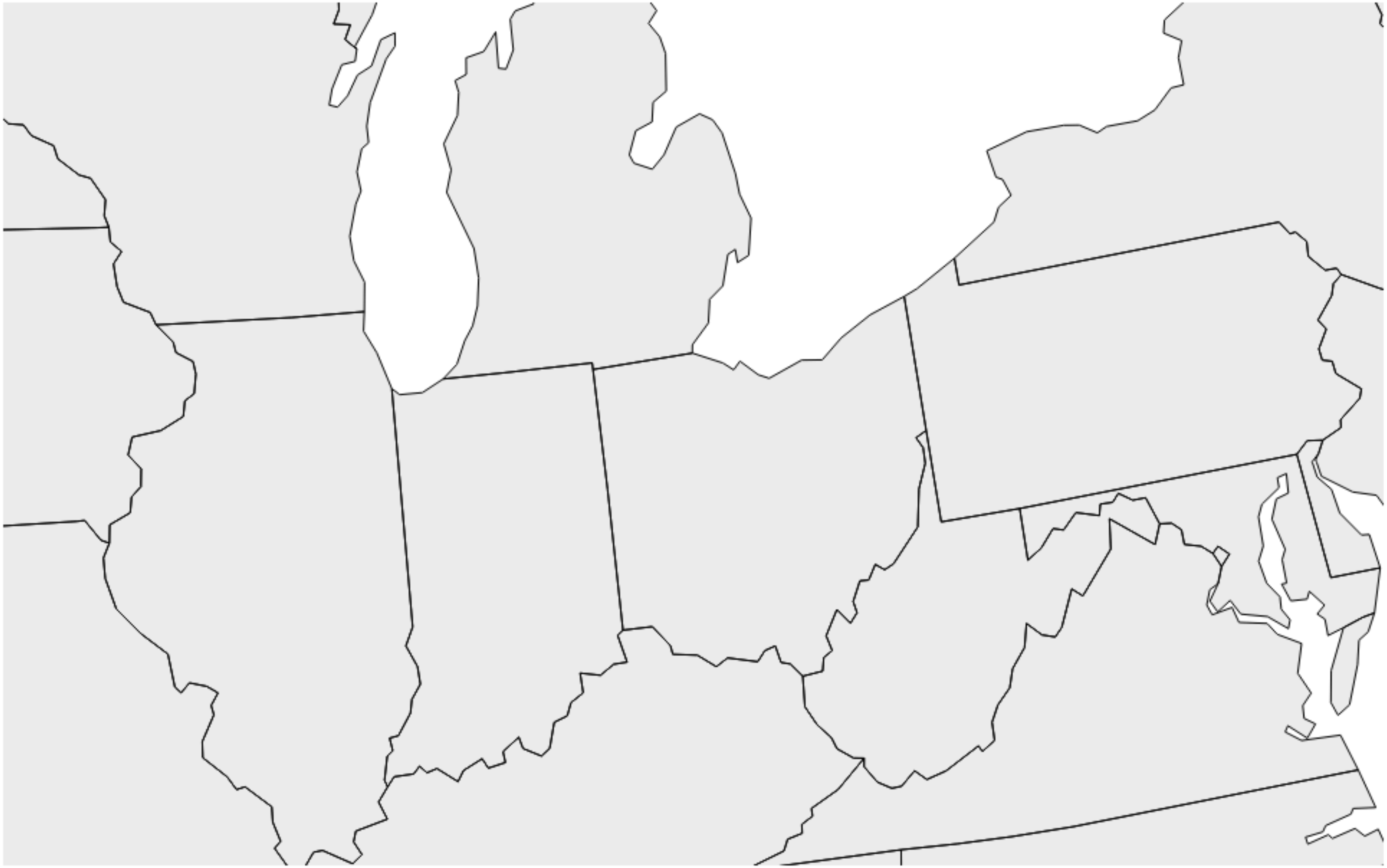
100



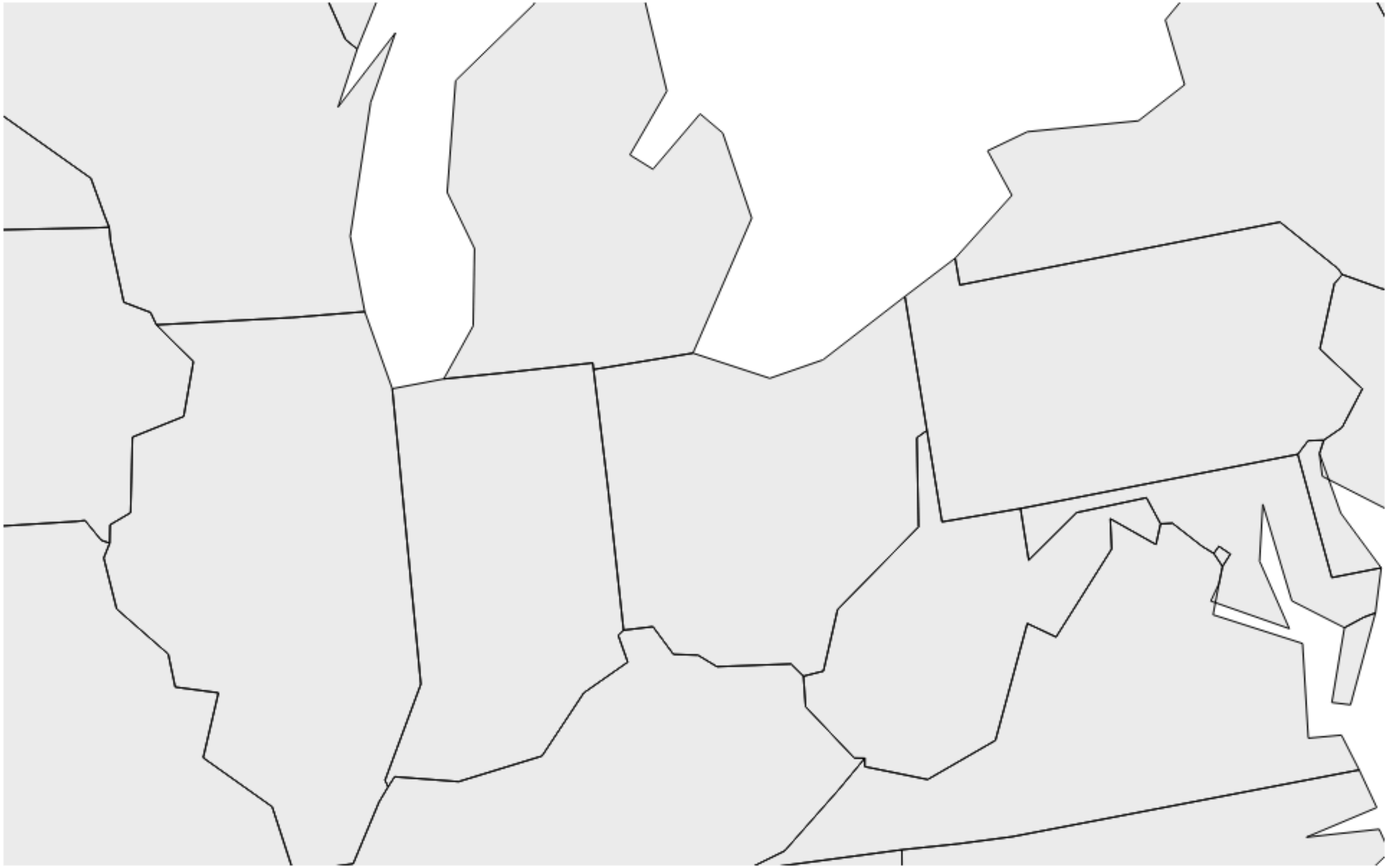

10

Simplification

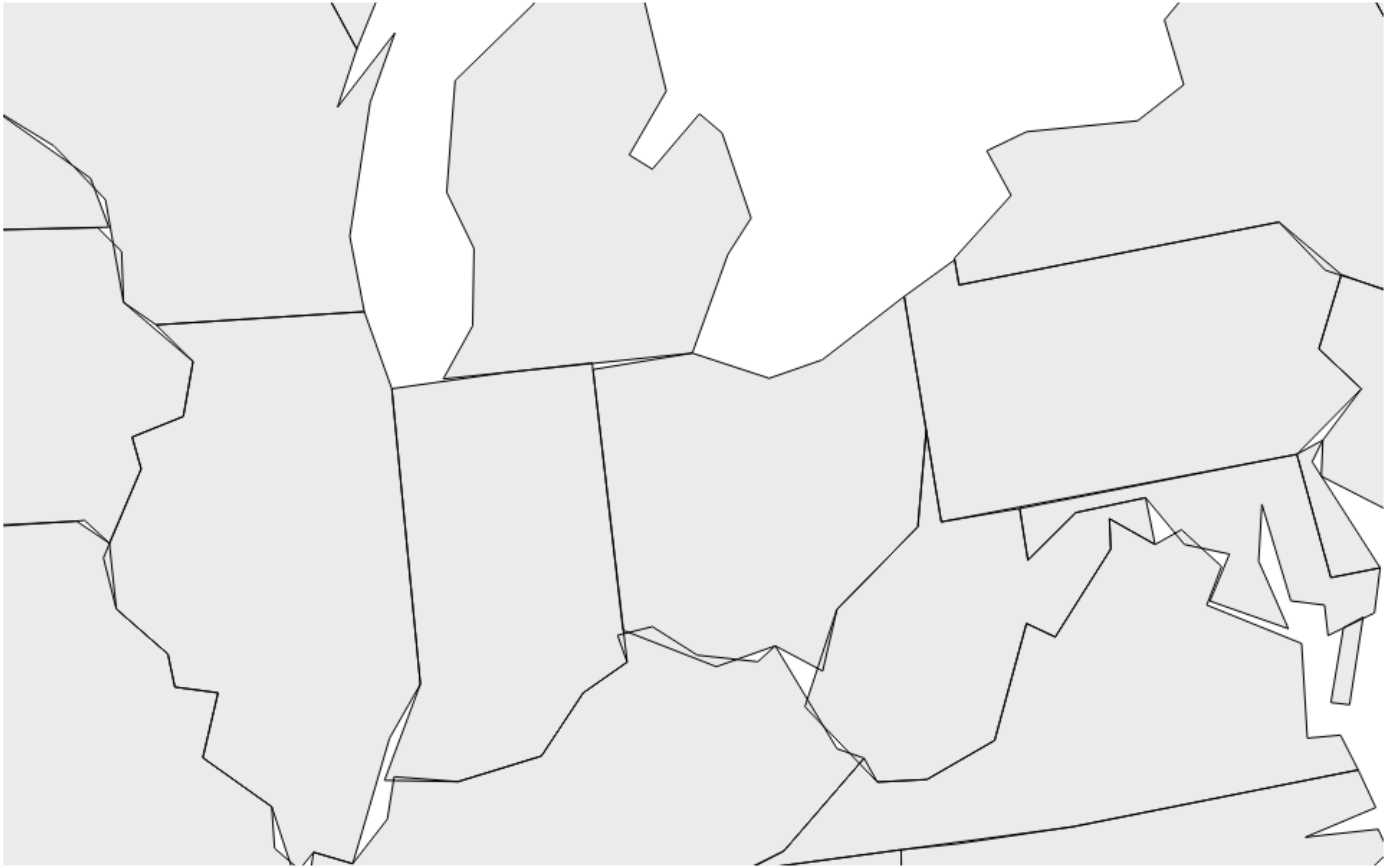
☑ *Preserve topology*



☑ *Preserve topology*



☐ *Preserve topology*



TopoJSON in practice

Applications

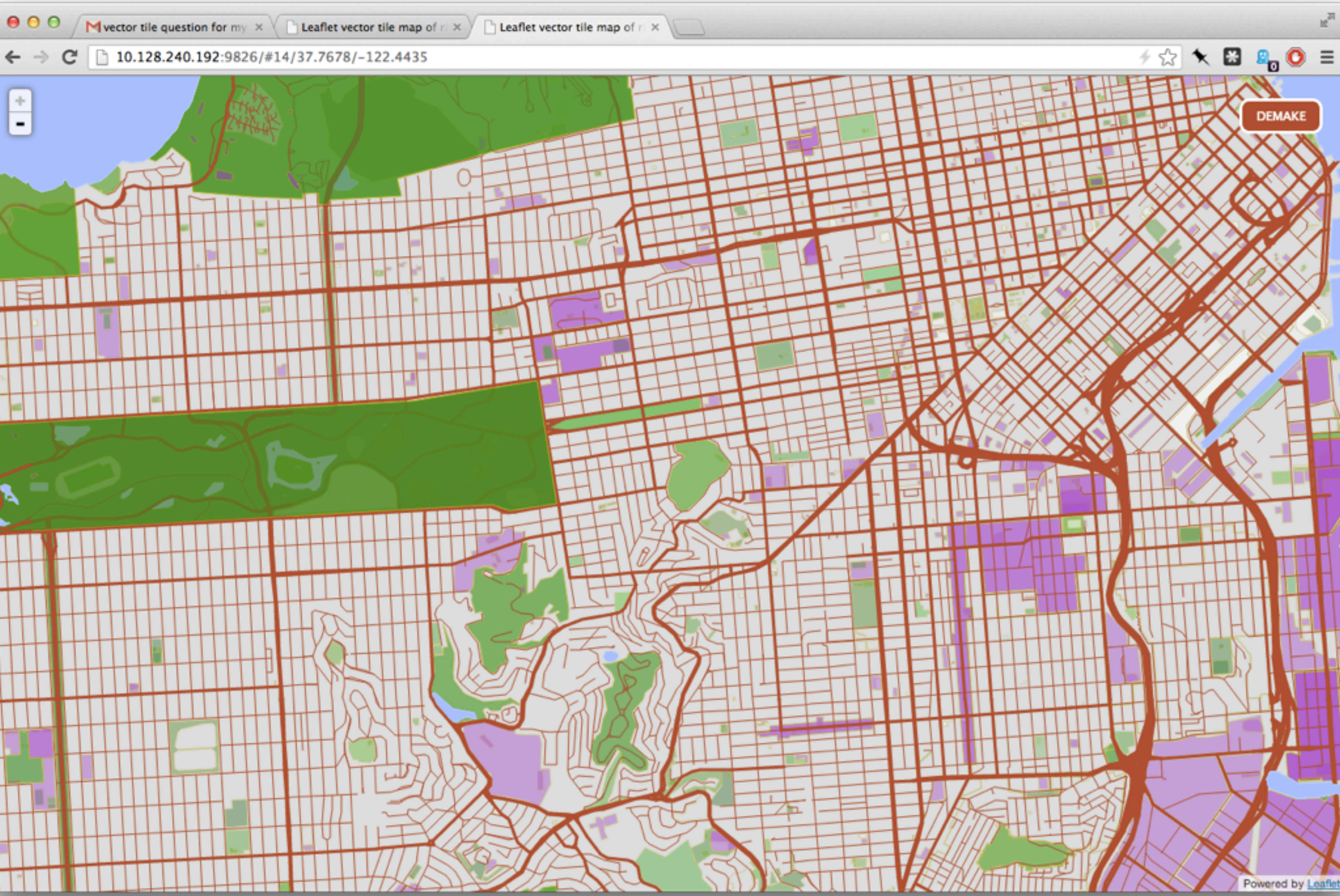
- Browser delivery
- Smaller files, less bandwidth
- Topology-aware visualizations
- Presentation, not archival

Smaller sizes

	Source	GeoJSON	TopoJSON	Pct	gzip
SF (lines)	79M	84M	69M	83%	56%
SF (polys)	68M	64M	49M	75%	42%
Chongqing	22M	21M	13M	61%	27%
CA Rivers	174M	258M	81M	31%	12%
Zipcodes (no props)	839M	17M	6M	39%	54%

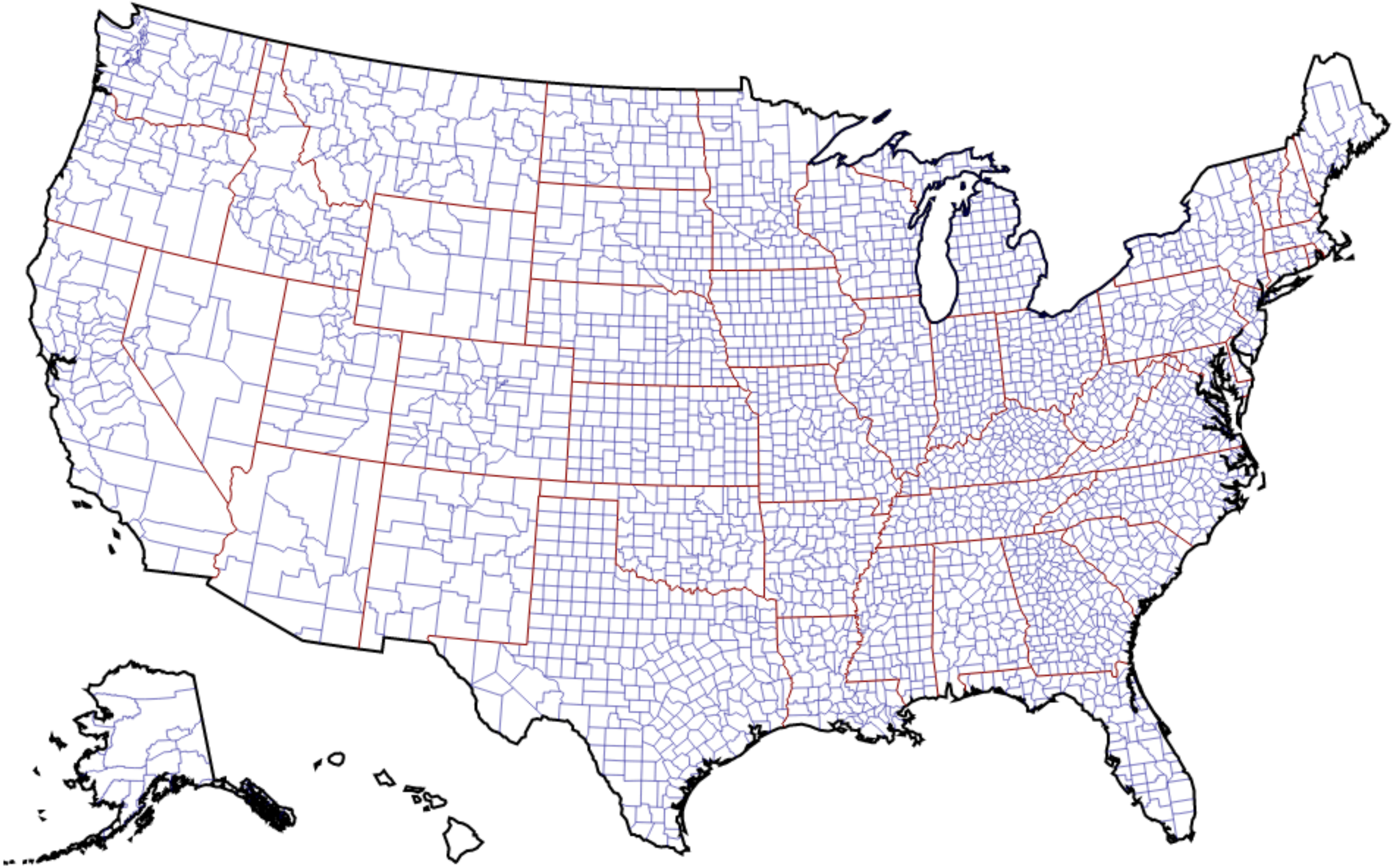
OSM Vector tile map

- 30 tiles, 4 layers
  - OSM land usage, roads, water; NHD rivers
- GeoJSON: 9904k, 1311k gzip
- TopoJSON: 6562k, 815k gzip
- 66% the size (62% after gzip)
- No properties: 6011k vs 2725k, 45% the size


vector tile question for my
Leaflet vector tile map of r
Leaflet vector tile map of r
10.128.240.192:9826/#14/37.7678/-122.4435
+
-
DEMAKE
Powered by Leaflet

MapBox PBF vectiles

- z=14, 28 tiles in San Francisco
  - gzip GeoJSON: 851k
  - gzip TopoJSON: 364k
  - gzip PBF: 1040k
- *But*: PBF has many more layers in it!
  - z=12 misc: 815k Topo vs. 706k PBF
  - z=14 roads: 90k Topo vs. 71k PBF
- Thanks Dane Springmeyer!



Internal boundaries

- Polygons: land, states, counties
- Renderer extracts internal boundaries
- 2374k of GeoJSON data
- 642k of TopoJSON data
- 27% the size

Testing boundaries

```
topojson.mesh(
  topology,
  topology.objects.counties,
  function(a, b) {
    return a !== b &&
     a.state === b.state;
  })
```

Polygon adjacency

- Dorling cartogram
  - Replace geometry with scaled circle
- Force directed layout
- Preserve country adjacency

Demo

TopoJSON tools

TopoJSON project

https://github.com/mbostock/topojson

- Command line tools (NodeJS)
- Browser API (Javascript)
- TopoJSON Wiki

Encoding

```
$ topojson
   --id-property osm_id
   -p name
   -s 0.00001
   -q 10000
   -o sf.json
   san-francisco.osm-line.shp

quantization: bounds -122.7368806 37.4490002
  -122.0110009 37.9549999 (spherical)
quantization: maximum error 4.26m (0.0000383°)
simplification: retained 334873 / 733786 points (46%)
prune: retained 167509 / 167509 arcs (100%)
```

Input files

- GeoJSON, Shapefiles, CSV, TopoJSON
- Inputs need to be topologically valid
- Giant files (> 100MB)
  - Shapefiles stream better than GeoJSON
  - `node --max_old_space_size=8192`
  - Rivers (132MB .shp): 45 seconds
  - Zip codes (836MB .shp): 150 seconds?

Properties

- Stripped by default
- -p flag; list which to include
- ISO-8859-1 by default
- Can join to CSV files

Quantization

- 10,000 x 10,000 by default
- Similar to rounding GeoJSON coords
  But more specific: 10,000 for bbox
- Think about pixels on screen

```
quantization: bounds
  -124.40958558399814 32.50005761622009
  -114.58848453257576 43.33627233273347 (spherical)
quantization: maximum error 75.5m (0.000679°)
```

Simplification

- `--spherical`
  - Simplify in geographic space
  - `-s <steradians>` (area)
  - `--simplify-proportion` (fraction)
- `--cartesian`
  - Simplify in projected pixel space
  - `--width --height`

Demo

Serving via HTTP

- Treat it like GeoJSON
- MIME type: `application/json`
- compress, serve cache headers
- `Access-Control-Allow-Origin: *`
- Beware `.topojson` file extension

Javascript client API

- `topojson.feature(topology, object)`
  - converts object to GeoJSON
- `topojson.mesh(topology, object, filter)`
  - returns merged arcs as LineString
  - filter(a, b); either side of each arc
- `topojson.neighbors(objects)`
  - list of adjacent objects

Other tools

- Sean Gillies' Python decoder
- Shan Carter's Distillery
- Josh Livni's ShpEscape
- Mike Bostock's US-Atlas
- Wanted: Python encoder (TileStache)
- Wanted: GDAL/OGR support

Use TopoJSON!

- Efficient wire format
- Easy to use simplification, quantization
- Visualize topologies, not just geometries
- Open source, simple, lots of examples

https://github.com/mbostock/topojson