TEXAS BIOFUEL SUPPLY NETWORK OPTIMIZATION CASE STUDY

BY

CHIBUEZE ENYINNAYA

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ABSTRACT

- This is an Industrial Engineering graduate student case study supporting production of a biofuel company in the state of Texas, USA.
- With a purpose to minimize the investment and transportation costs by finding the optimal number of hubs and plants (biorefineries) that the company needs to install as well as the network between suppliers-hubs and hubs-plants.
- Using Python and its Linear Programming modeler (PuLP) for data analysis and optimization, as well as Tableau for data visualization to provide optimal results and suggest recommendations.

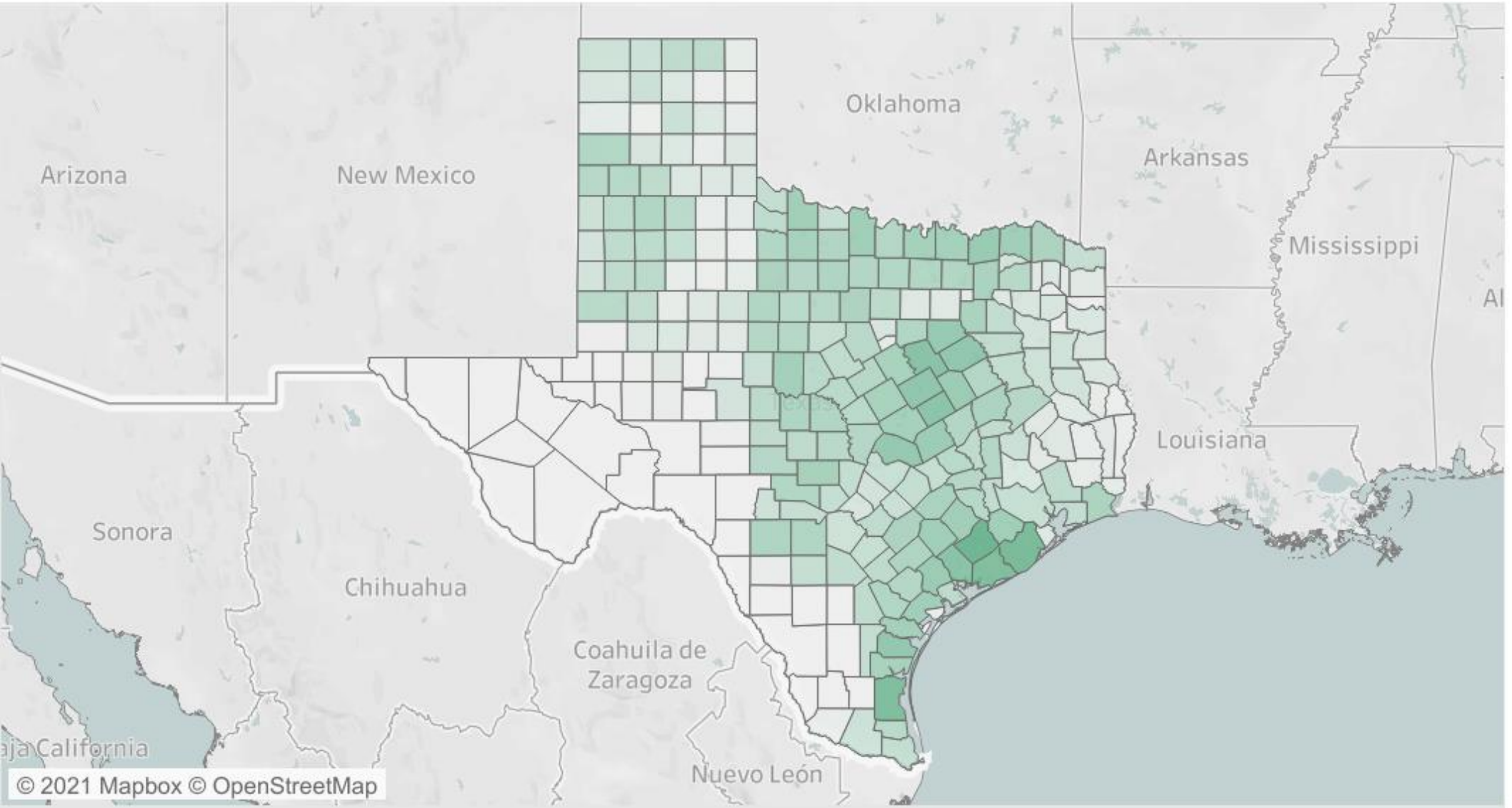
SUPPLY NETWORK

254 County Suppliers

1303 Potential Hubs

167 Potential Biorefineries

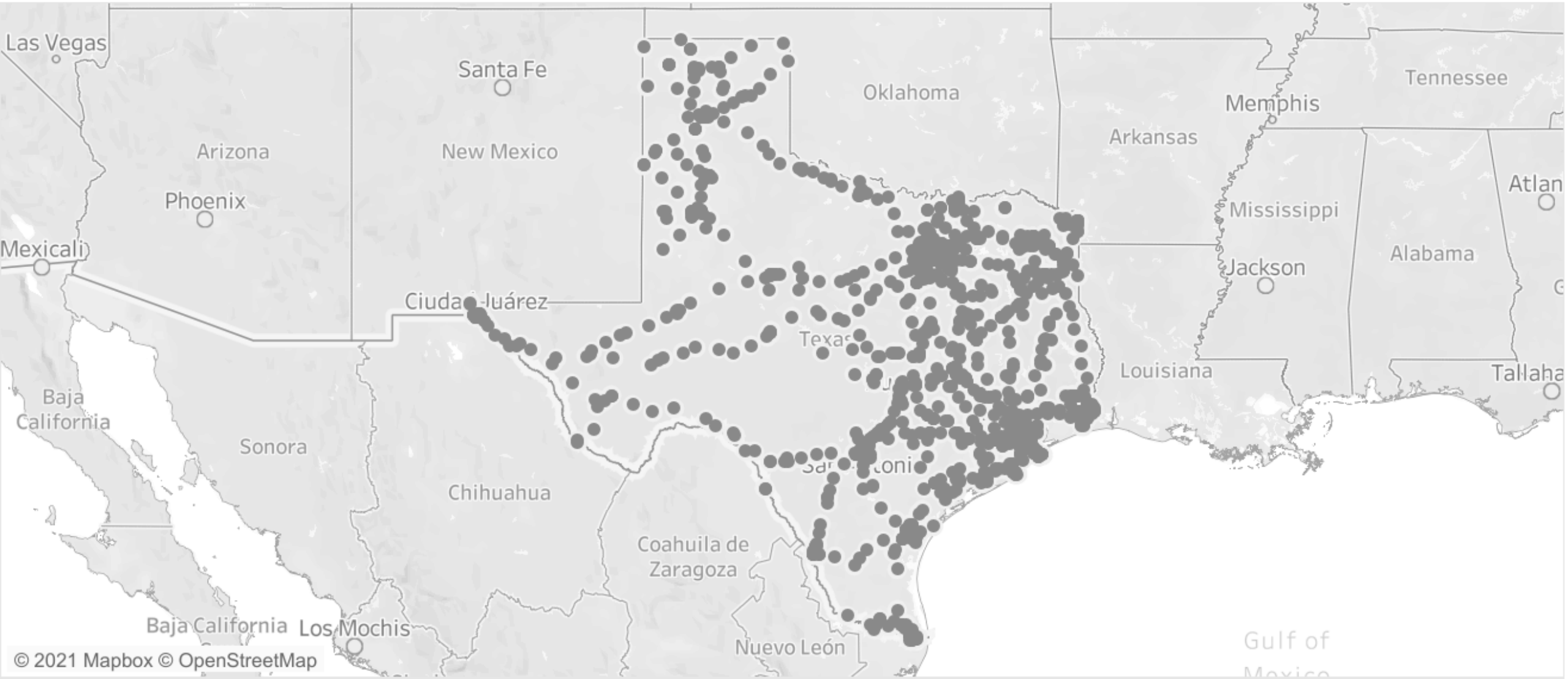
Supply by County



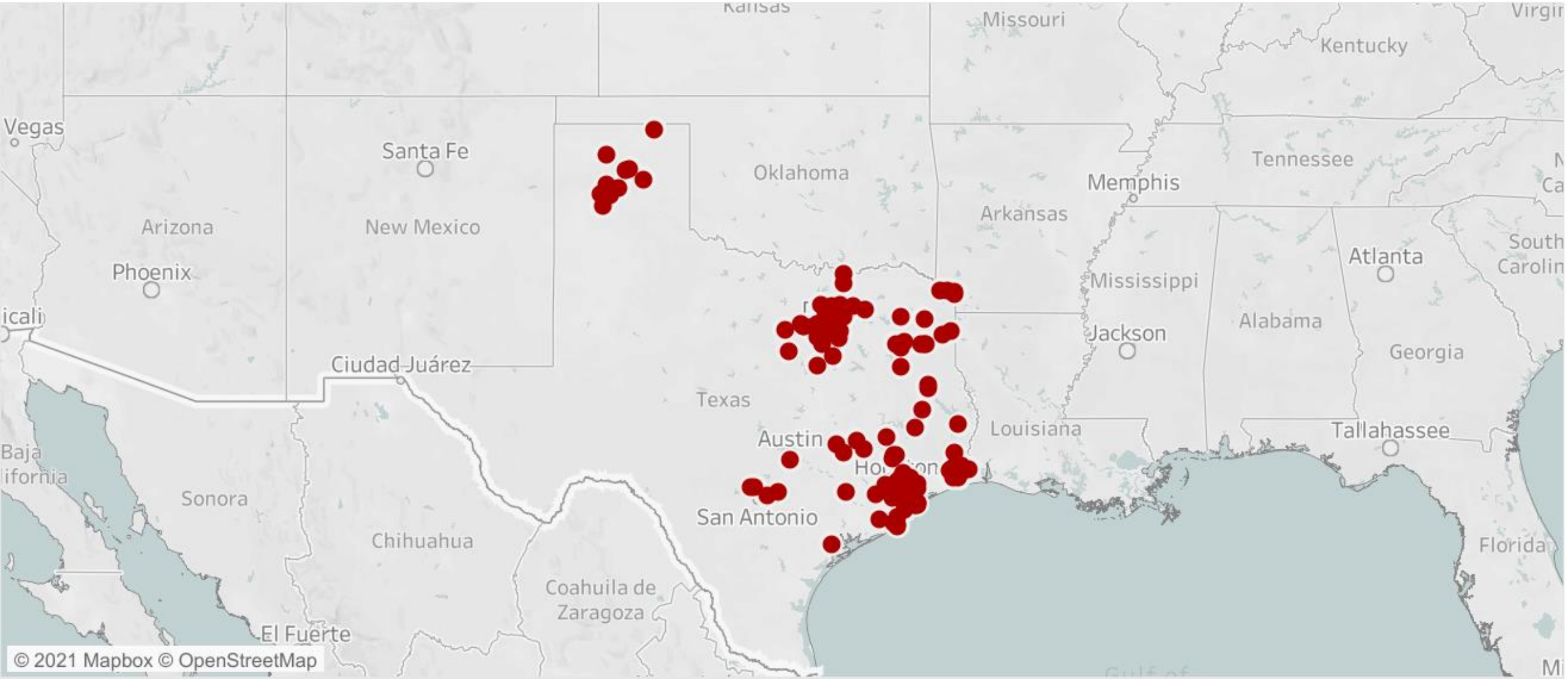
Supply

0 45,431

Potential Hubs



Potential Plants



ASSUMPTIONS

- The centroid of the county is considered as the county supplier
- Road and Rail distances are not accounted for since they correlate with the costs
- 2nd Law of Thermodynamics is ignored since there is no energy loss from Biomass conversion to liters
- Cleaned data errors and redundancies are considered as supply, production, and policy issues

PARAMATERS

HUB PARAMETERS	
Investment cost	$ 3,476,219
Preprocessing capacity	300,000 Mg
PLANT PARAMETERS	
Investment cost	$ 130,956,797
Annual conversion capacity	152,063,705 liters
Conversion yield	232 liters/Mg
DEMAND	
Network demand	1,476,310,602 liters

Note: All the parameters are considered for a period of time of one year.

CALCULATIONS

From the datasets and parameters:

Total Supply = 3,053,377.71 Mg

Demand in Mg = Network demand in liters / Conversion yield

= 1,476,310,602 liters / 232 liters/Mg

= 6,363,407.77 Mg

Train loading/unloading cost= $3,066,792

Since the demand supersedes the total supply, a third-party supplier is to be introduced:

3rd party Supply = Demand – Total Supply = 3,310,030.06 Mg

CALCULATIONS

- The estimated 3rd party road cost supply per unit is calculated by averaging the road cost supply to the optimal hubs: $ 29.96/Mg

- Number of plants to meet demand

  = Demand / Annual Conversion Capacity = 9.7085 ≈ 10 plants

- Total Plant Investment Cost = 10 x $ 130,956,797 = $ 1,309,567,970
- Number of hubs to meet plant requirement

  = Demand / Hub Capacity = 21.21 ≈ 22 hubs

- Total Hub Investment Cost = 22 x $ 3,476,219 = $ 76,476,818

RESULTS

List of Optimal Hubs And
Total Supply Received

	hub_status	road_supply
hubs		
512	1.0	300000.000
17246	1.0	300000.000
17318	1.0	300000.000
17387	1.0	300000.000
17399	1.0	300000.000
17482	1.0	300000.000
17517	1.0	300000.000
17623	1.0	300000.000
17695	1.0	63407.767
17850	1.0	300000.000
17886	1.0	300000.000
17909	1.0	300000.000
17969	1.0	300000.000
18006	1.0	300000.000
18012	1.0	300000.000
18097	1.0	300000.000
18103	1.0	300000.000
18119	1.0	300000.000
18255	1.0	300000.000
18264	1.0	300000.000
18307	1.0	300000.000
18483	1.0	300000.000

List of Optimal Plants And
Total Supply Received

	plt_status	rail_supply
plants		
543	1.0	655447.00
9088	1.0	655447.00
9091	1.0	655447.00
9104	1.0	655447.00
9142	1.0	655447.00
9167	1.0	464384.73
9188	1.0	655447.00
9203	1.0	655447.00
10060	1.0	655447.00
10061	1.0	655447.00

RESULTS

Supply from Counties to Optimal Hubs

County Code	Hub ID	Supply (Mg)	Road Cost ($/Mg)	Supply Cost ($)
48037	512	12,619.55	12.94	$ 163,253.93
48067	512	4,147.38	17.65	$ 73,189.91
48237	512	19,014.92	71.50	$ 1,359,499.13
48085	17246	19,739.69	16.09	$ 317,536.11
48113	17246	4,701.77	7.63	$ 35,895.74
48139	17246	28,926.45	14.89	$ 430,583.23
48147	17246	28,447.25	26.12	$ 743,140.79
48231	17246	21,721.83	20.02	$ 434,857.25
48257	17246	22,038.75	15.92	$ 350,781.00
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48287	18307	12,660.40	16.51	$ 208,964.72
48477	18307	17,817.90	19.20	$ 342,015.03
48319	18307	15,508.80	49.37	$ 765,677.23
48325	18307	13,192.60	43.38	$ 572,348.74
48385	18307	10,254.99	61.65	$ 632,204.77
48463	18307	20,170.88	57.16	$ 1,153,031.26
48507	18307	1,756.65	57.18	$ 100,440.75
48039	18483	40,515.13	6.38	$ 258,333.12
48057	18483	15,211.35	33.46	$ 508,915.29
Total Hub Supply Cost				$ 81,325,476.68

Supply from 3rd Party Suppliers(s) to Optimal Hubs

Supplier	Hub ID	Supply (Mg)	Road Cost ($/Mg)	Supply Cost ($)
3rd_party	512	264,218.14	29.96	$ 7,915,889.95
3rd_party	17246	69,185.83	29.96	$ 2,072,785.14
3rd_party	17318	8,469.32	29.96	$ 253,738.10
3rd_party	17387	111,524.33	29.96	$ 3,341,232.70
3rd_party	17399	190,164.05	29.96	$ 5,697,253.42
3rd_party	17482	179,605.28	29.96	$ 5,380,916.12
3rd_party	17517	5,187.26	29.96	$ 155,408.60
3rd_party	17850	260,856.01	29.96	$ 7,815,161.51
3rd_party	17909	78,777.72	29.96	$ 2,360,154.87
3rd_party	17969	33,364.07	29.96	$ 999,576.62
3rd_party	18006	264,356.11	29.96	$ 7,920,023.34
3rd_party	18012	193,194.99	29.96	$ 5,788,059.43
3rd_party	18097	272,131.57	29.96	$ 8,152,973.71
3rd_party	18103	278,668.92	29.96	$ 8,348,830.54
3rd_party	18119	257,087.46	29.96	$ 7,702,257.07
3rd_party	18255	240,503.61	29.96	$ 7,205,410.24
3rd_party	18264	276,729.54	29.96	$ 8,290,727.49
3rd_party	18307	81,732.32	29.96	$ 2,448,673.86
3rd_party	18483	244,273.53	29.96	$ 7,318,355.69
Total 3rd Party Estimated Supply Cost				$ 99,167,428.42

Supply from Optimal Hubs to Optimal Plants

Hub ID	Plant ID	Supply (Mg)	Rail Cost ($/Mg)	Supply Cost ($)
512	9188	300,000.00	2.41	$ 721,946.24
17246	543	60,000.00	5.69	$ 341,551.75
17246	9088	60,000.00	4.27	$ 256,391.81
17246	9091	60,000.00	4.31	$ 258,649.16
17246	9104	120,000.00	2.89	$ 346,583.28
17318	9104	244,553.00	4.11	$ 1,004,315.96
17318	9203	55,447.00	4.78	$ 265,293.86
17387	9167	164,384.73	6.05	$ 994,542.73
17387	10060	135,615.23	32.07	$ 4,349,414.23
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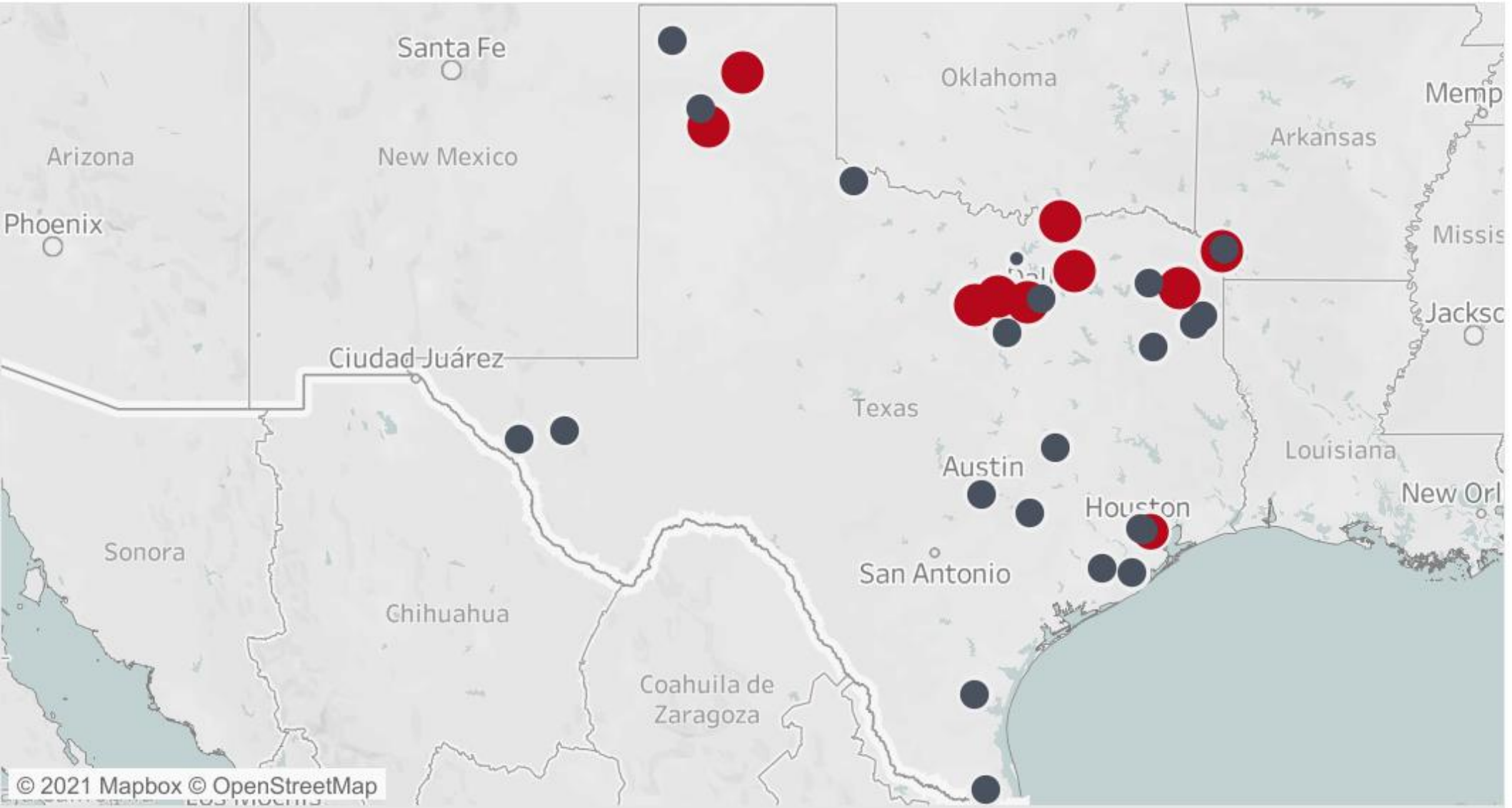
18119	9088	150,000.00	26.00	$ 3,900,544.30
18255	10060	150,000.00	8.03	$ 1,204,984.87
18255	10061	150,000.00	6.55	$ 982,783.50
18264	9203	300,000.00	24.69	$ 7,407,940.68
18307	9091	232,039.23	12.52	$ 2,905,846.10
18307	9188	67,960.77	16.33	$ 1,109,621.78
18483	543	103,172.77	17.91	$ 1,847,439.91
18483	9088	103,000.00	16.26	$ 1,674,638.44
18483	9188	93,827.23	17.83	$ 1,672,905.64
Total Plant Supply Cost				$ 75,902,547.06

RESULTS

COST SUMMARY		
Counties Supply		3,053,377.71
Total County-Hub Supply Cost	$	**81,325,476.68**
3rd Party Supply		3,310,030.06
3rd Party Supply Unit Cost	$	**29.96**
3rd Party Supply Cost	$	**99,167,428.42**
Total Hub Supply Cost	$	**180,492,905.10**
Total Loading/Unloading Cost	$	**150,272,808.00**
Total Plant Supply Cost	$	**75,902,547.06**
Optimal Plant Count		10
Unit Plant Investment Cost	$	**130,956,797.00**
Total Plant Investment Cost	$	**1,309,567,970.00**
Optimal Hub Count		22
Unit Hub Investment Cost	$	**3,476,219.00**
Total Hub Investment Cost	$	**76,476,818.00**
TOTAL COST	$	**1,792,713,048.16**

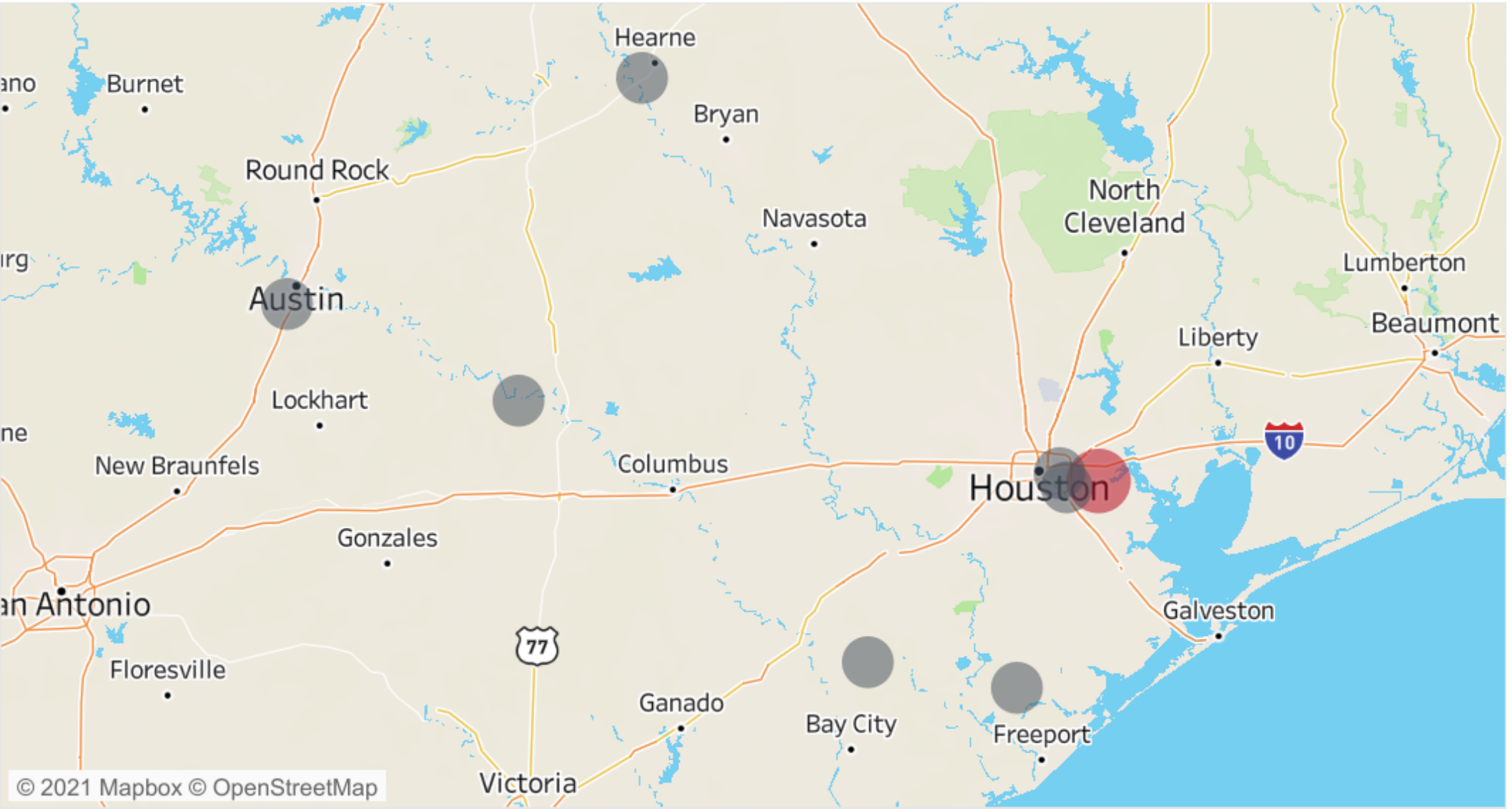
Optimal Hubs and Plants



Supply
63,408
200,000
400,000
655,447

facility
hubs
plants

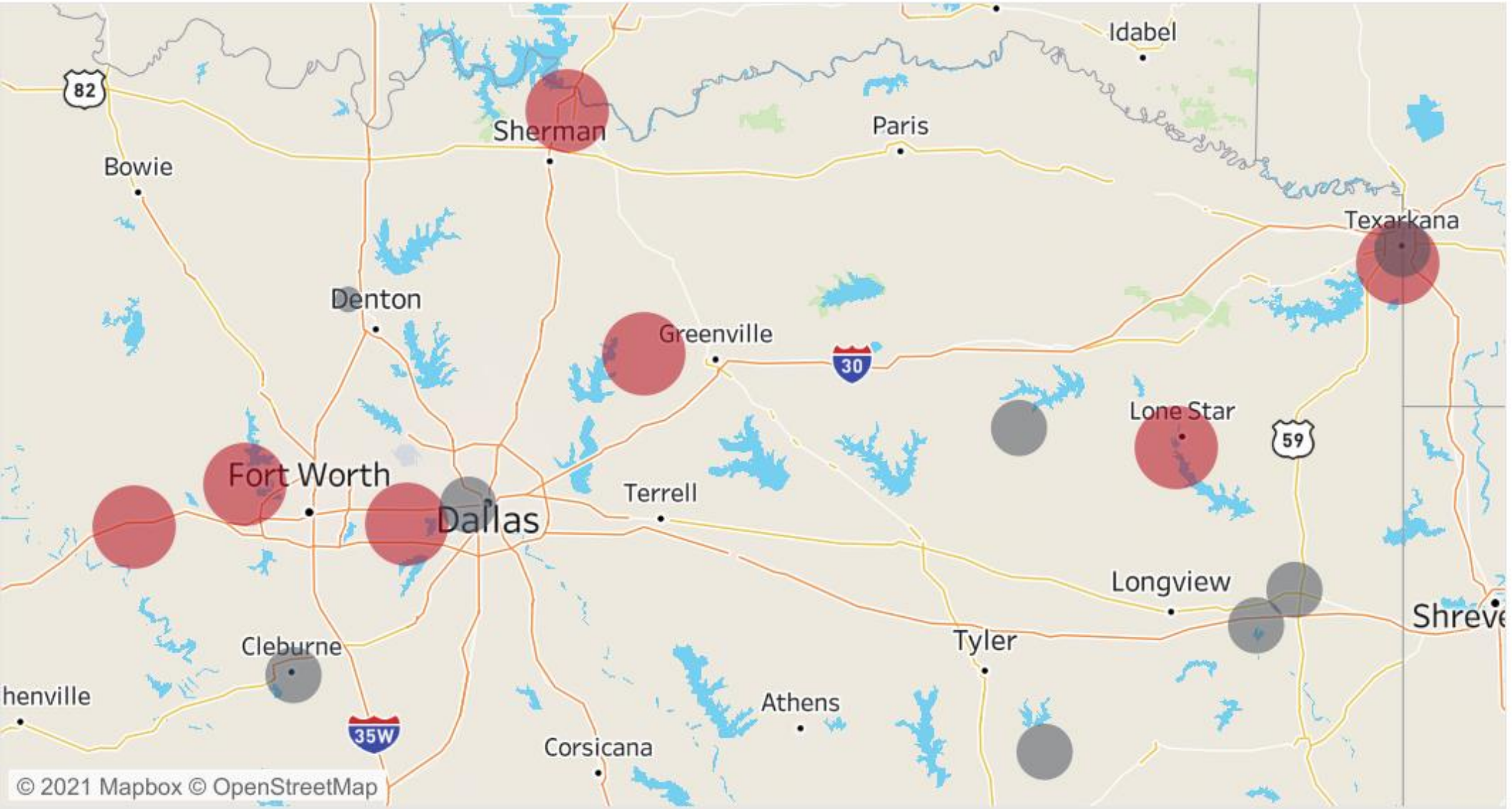
South East Map



Supply
63,408
200,000
400,000
655,447

facility
hubs
plants

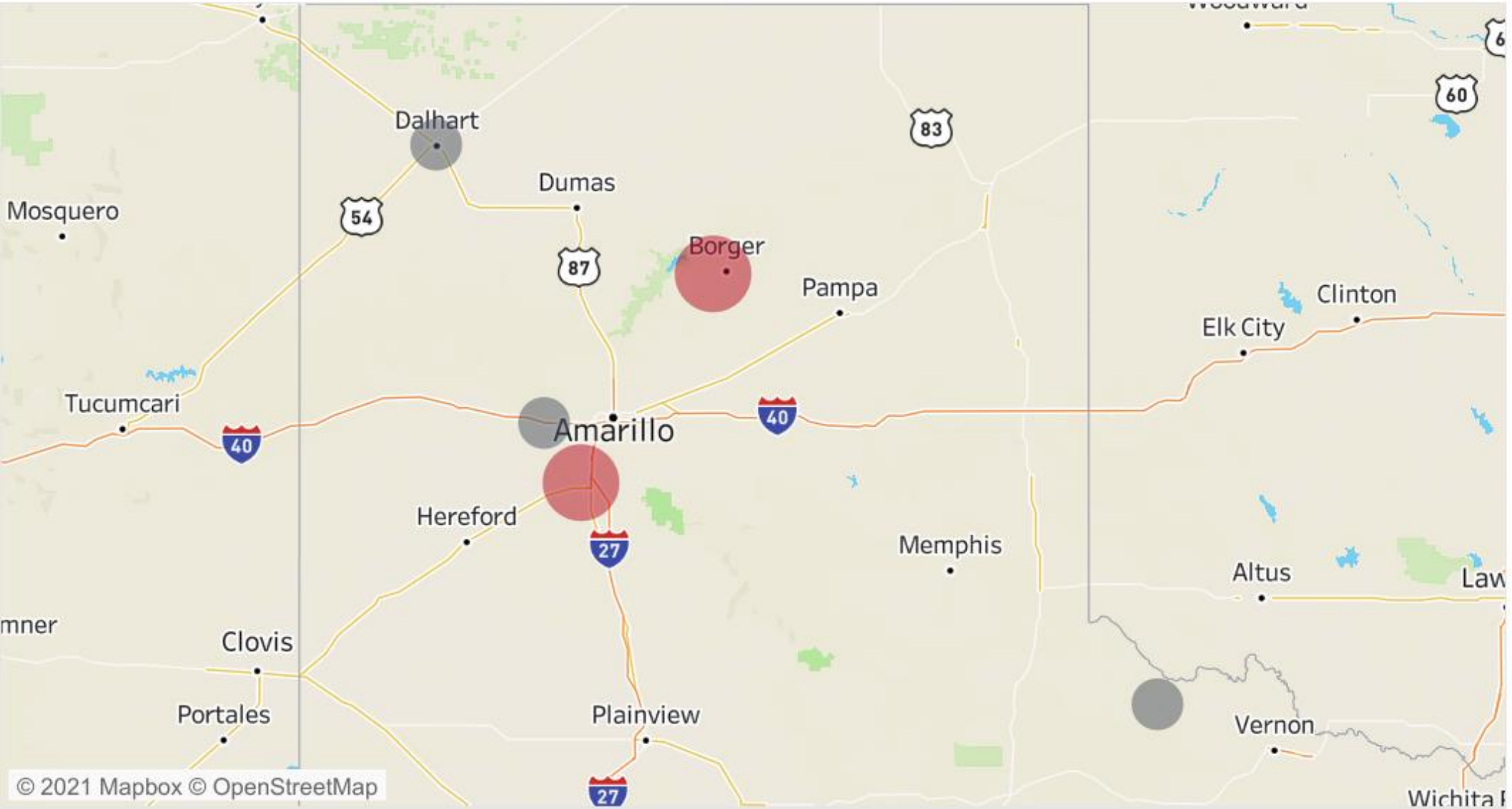
East Map



Supply
63,408
200,000
400,000
655,447

facility
hubs
plants

North Map



Supply
63,408
200,000
400,000
655,447

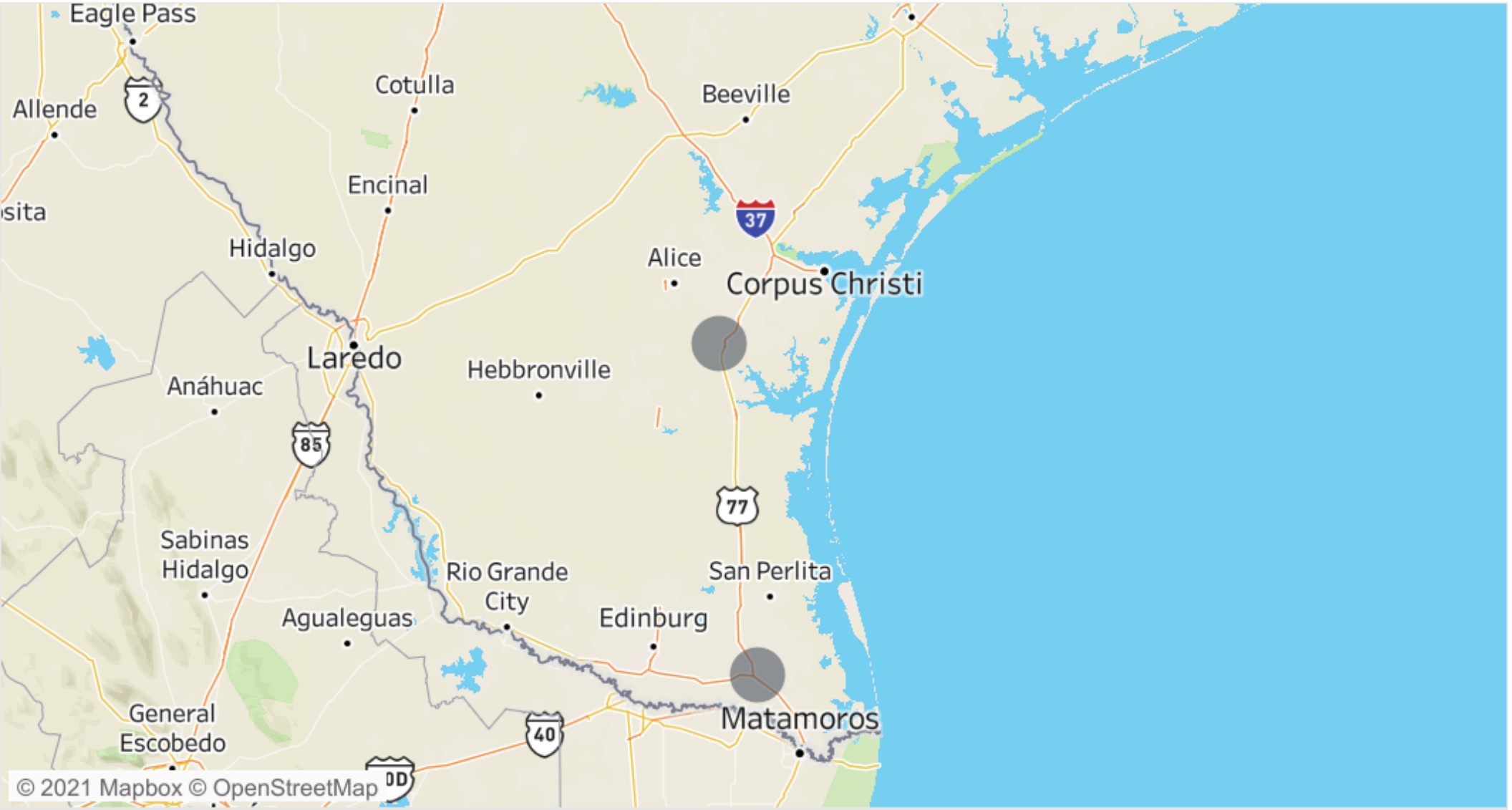
facility
hubs
plants

West Map

Supply
63,408
200,000
400,000
655,447

facility
hubs
plants

South Map



Supply

63,408
200,000
400,000
655,447

facility

hubs
plants

CONCLUSION & RECOMMENDATIONS

- The optimal number of **22 hubs** and **10 plants** were obtained for an overall network (investment and transportation) cost of **$ 1,792,713,048.16**

- With **0.025%** and **0.215%** error rate from the TX_roads and TX_railroad datasets these results were retrieved, but with more accurate data better results would have been reached.

THANK YOU!

For more information: https://github.com/pchibu/Texas-Biofuel-Supply-Network-Optimization