TEXAS BIOFUEL SUPPLY NETWORK OPTIMIZATION

BY

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ABSTRACT

- This is an Industrial Engineering graduate student case study and project 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.

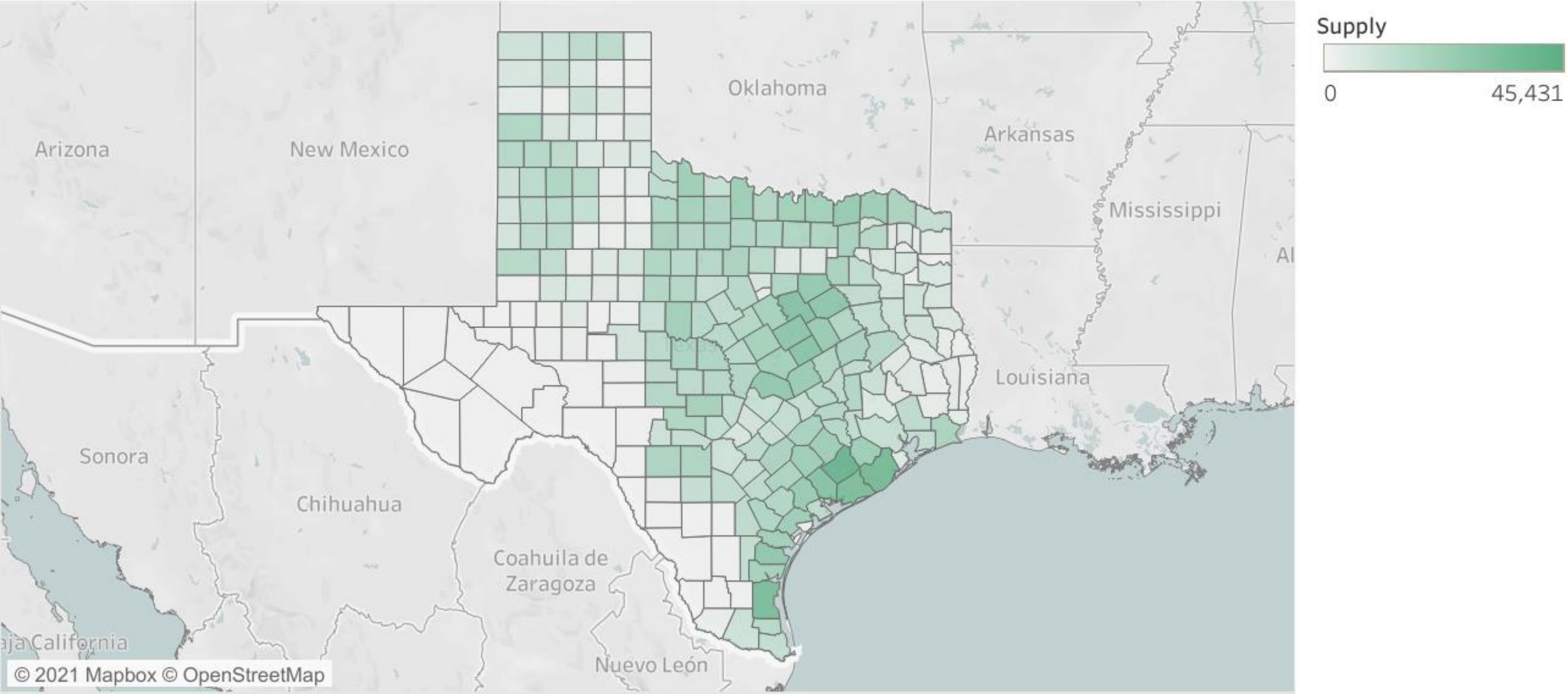
SUPPLY NETWORK

254
County
Suppliers

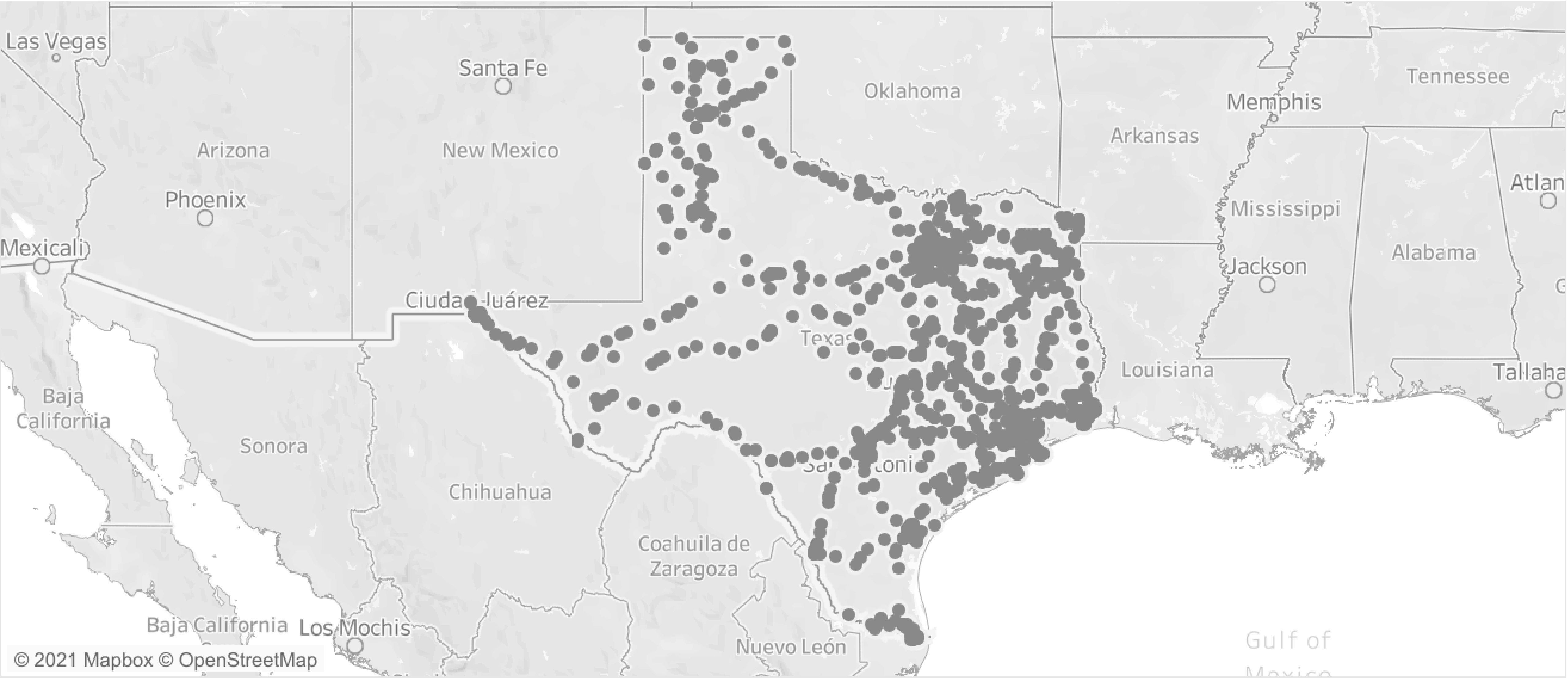
1303
Potential
Hubs

167
Potential
Biorefineries

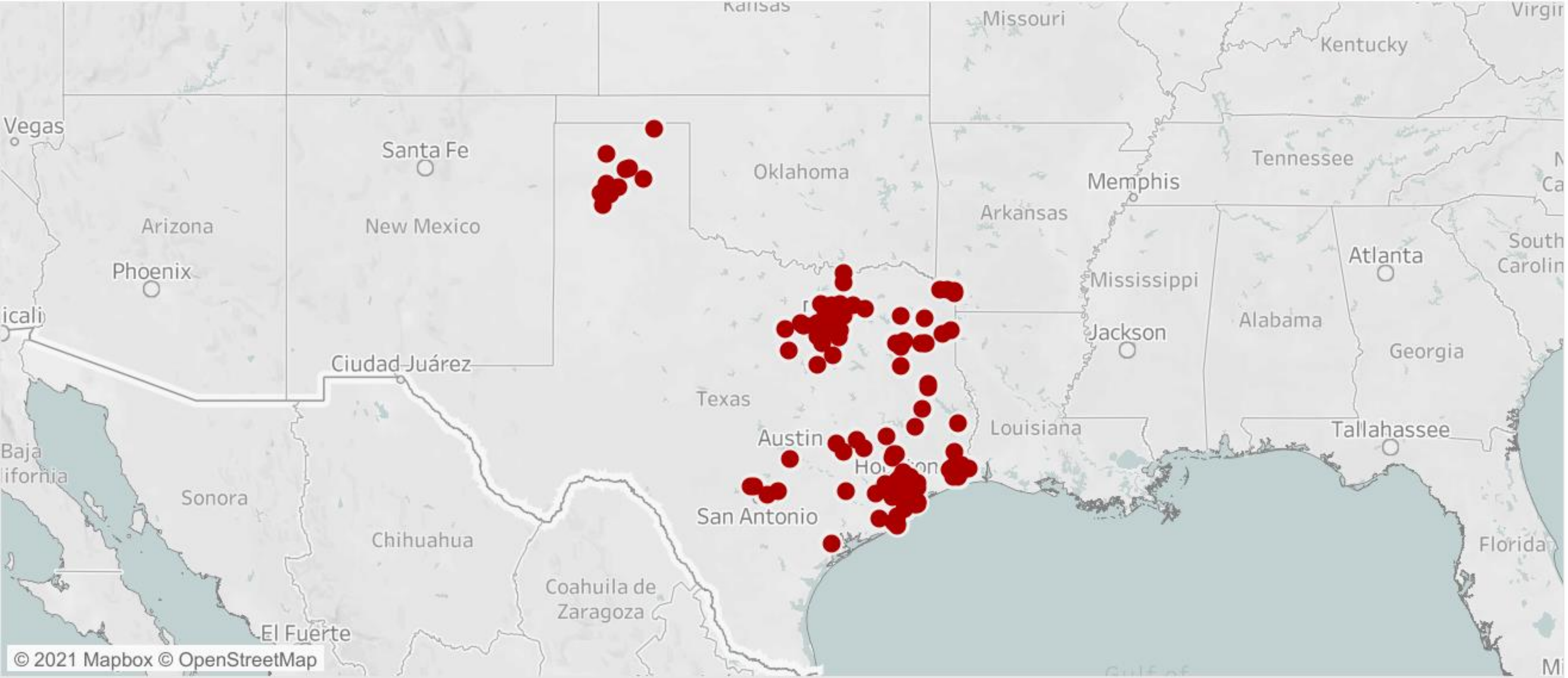
Supply by County



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

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 Average Road Cost is used as the estimated 3rd party cost per unit

  = $ 30,488,893.10 / 330,962 = $92.122 ≈ $92

- 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

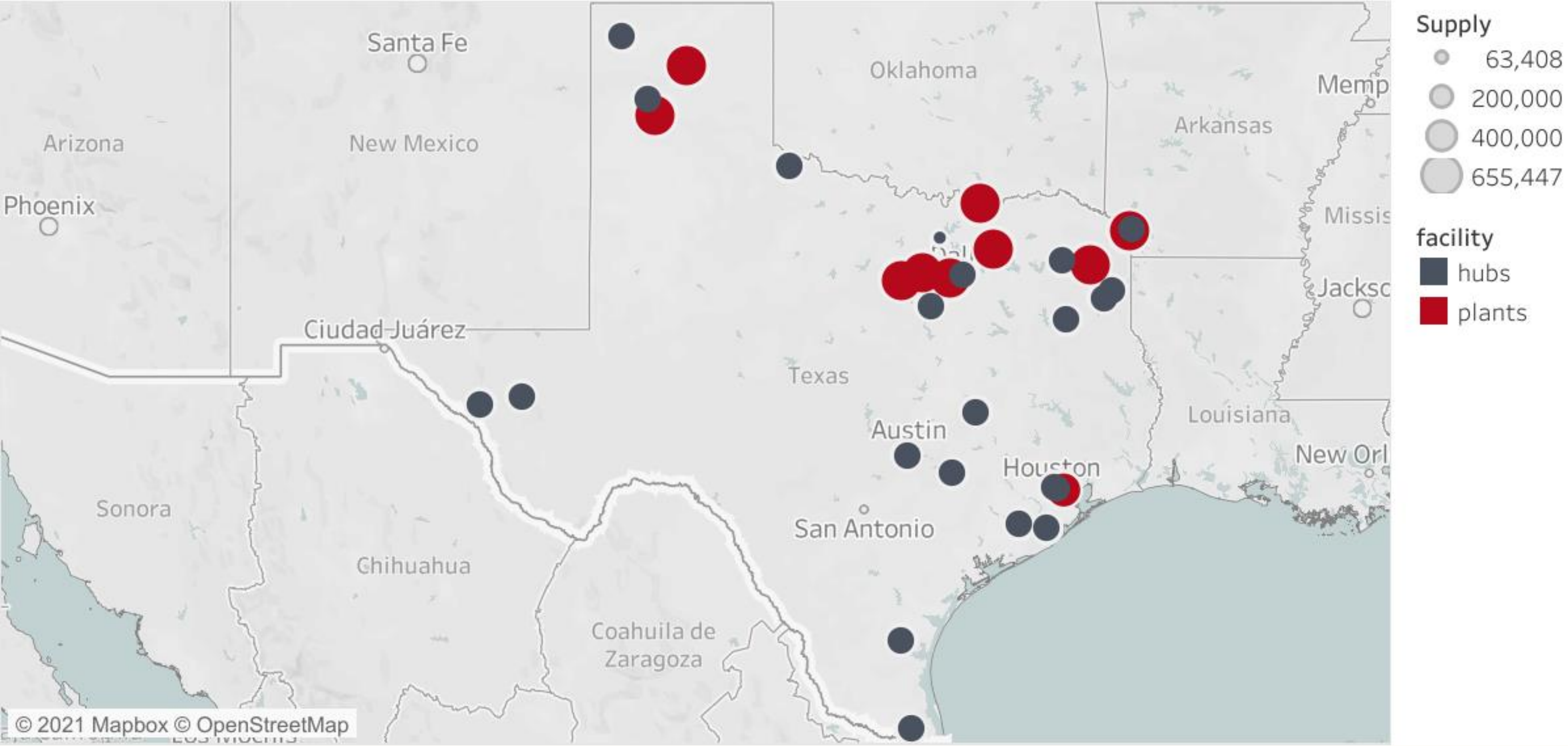
- Total Hub Investment Cost = 22 x $ 3,476,219 = $ 76,476,818

RESULTS

	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

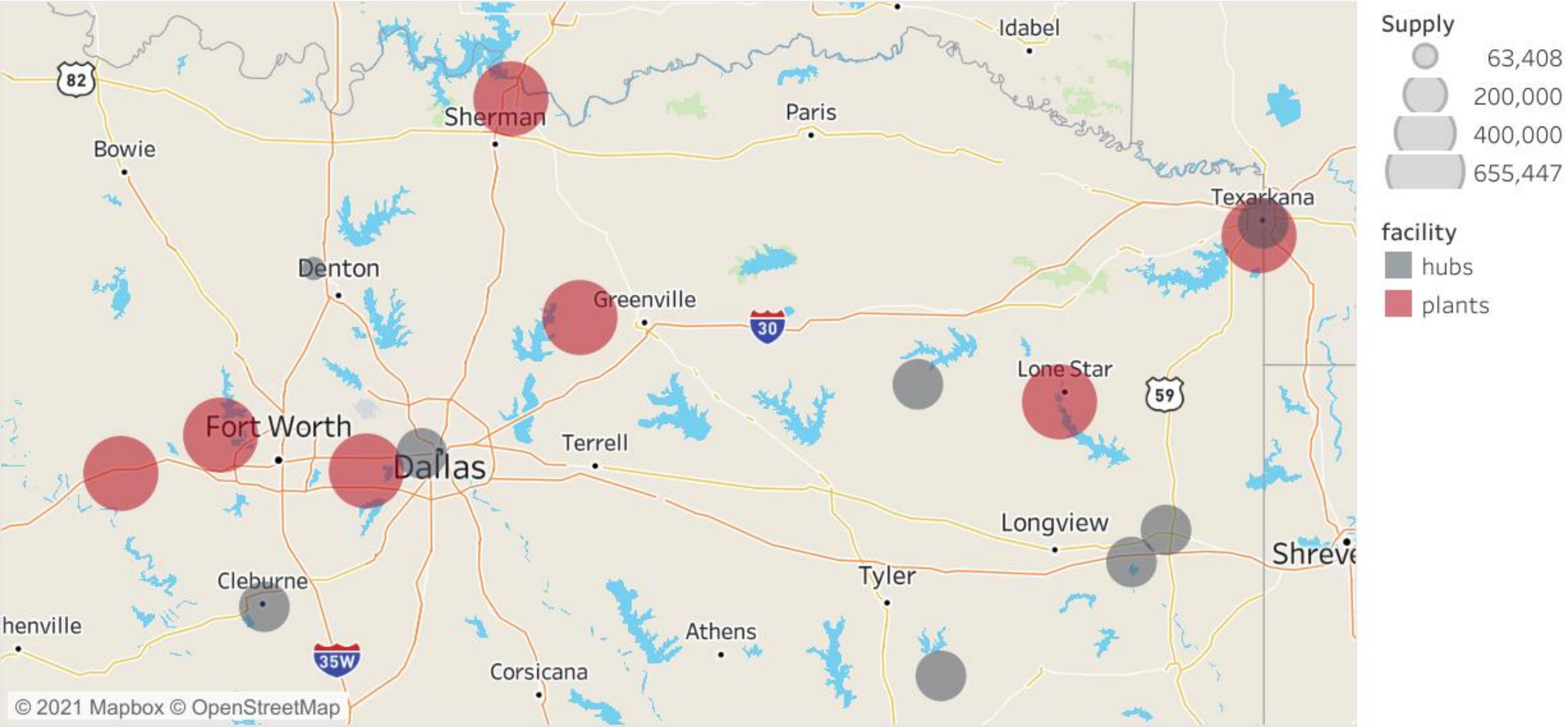
	plt_status	rail_supply
plants		
543	1.0	655447.00
9088	1.0	655447.00
9091	1.0	655447.00
9104	1.0	655447.00
9142	1.0	655447.00
9167	1.0	464384.73
9188	1.0	655447.00
9203	1.0	655447.00
10060	1.0	655447.00
10061	1.0	655447.00

Optimal Hubs and Plants



South East Map

East Map


Supply
63,408
200,000
400,000
655,447
facility
hubs
plants
Idabel
82
Sherman
Paris
Bowie
Texarkana
Denton
Greenville
30
Lone Star
59
Fort Worth
Dallas
Terrell
Longview
Shreve
Tyler
Cleburne
henville
Athens
35W
Corsicana
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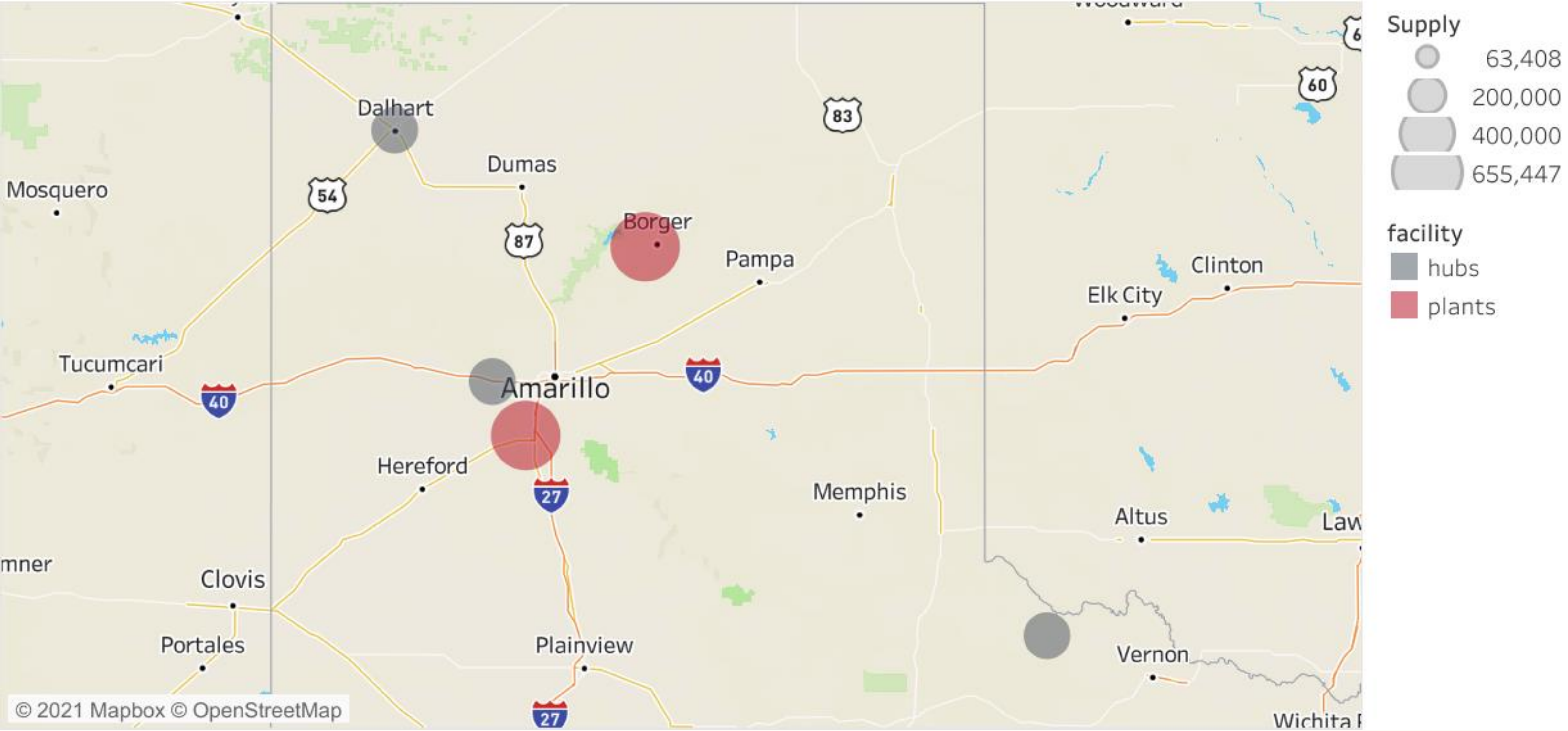
North Map



Dalhart
Dumas
Mosquero
Borger
Pampa
Tucumcari
Amarillo
Hereford
Memphis
Clovis
Portales
Plainview
Clinton
Elk City
Altus
Vernon
54
87
83
60
40
27
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Supply
63,408
200,000
400,000
655,447
facility
hubs
plants

West Map

as Cruces
El Paso
Guadalupe
Villa Ahumada
Van Horn
Kermit
Odessa
Midland
Pecos
Rankin
Fort Stockton
Alpine
Marathon
Sanderson
45
20
10
90
90
90
Supply
63,408
200,000
400,000
655,447
facility
hubs
plants
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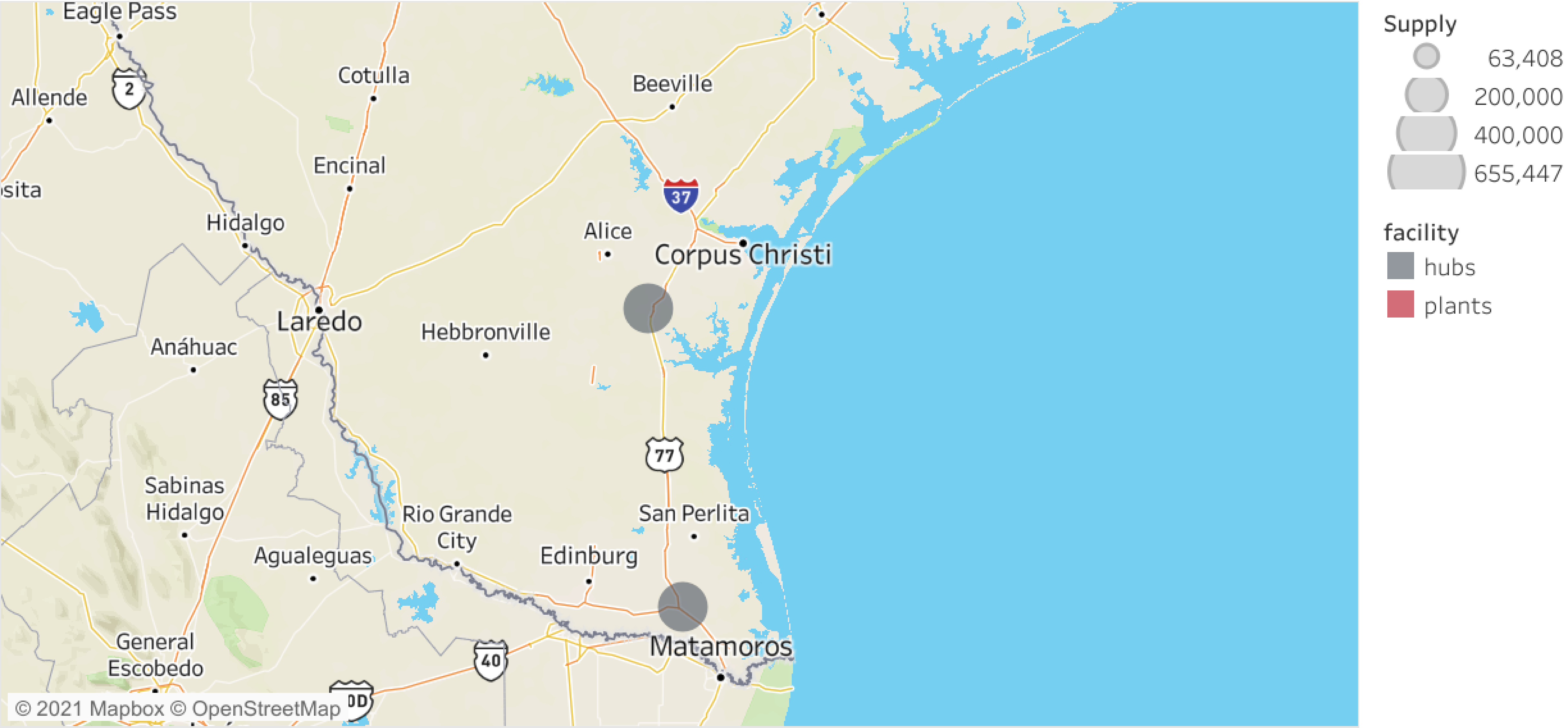
South Map


Eagle Pass
Cotulla
Beeville
Allende
Encinal
sita
Hidalgo
Alice
Corpus Christi
Laredo
Hebbronville
Anáhuac
Sabinas
Hidalgo
Rio Grande
City
San Perlita
Agualeguas
Edinburg
General
Escobedo
Matamoros
2
37
85
77
40
© 2021 Mapbox © OpenStreetMap
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 $1,725,868,653,500

- 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.

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