Using Suitability and Proximity Analysis to Discover Houston's Accessibility Via Roadways and Public Transportation

By

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ABSTRACT

Houston is one of the fastest growing metropolis' in the country. Driving this growth is the oil and gas industry and also the Texas Medical Center, the world's largest medical center. With such growth comes various problems. One of the leading problems according to its citizens in 2014 was traffic and the lack of access to public transportation.

This project aims to help find solutions to this problem by locating areas that could help improve public transportation access and take a look at Houston's accessibility via roadways. Using datasets from various Houston agencies such as the City of Houston and the Houston-Galveston Area Council, overlay analysis was used to help find prime areas that could be improved. Using ESRI ArcMap, models were completed in order to automate the analysis process. Tools such as raster conversion, Euclidean distance, zonal stats as table, and reclassify were used. In order to analyze Houston accessibility via the roadways, ArcGIS Online was used. Several Proximity analyses were run in order to view various types of dating dealing with the accessibility of Houston using roadways.

The results show areas that do not currently have access to public transportation and areas that would be suitable locations for improvements based on different criteria. For roadway access, the results show average commute times, drive-time accessibility, and freeway access. This will allow for the accessibility of Houston to be shown whether it is by public transportation or by roadway.

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Introduction

Houston is currently the fourth largest metropolitan area in the United States and continues to grow. With that growth comes a number of problems that will need attention in order to try and keep up with the growth Houston and surrounding areas are experiencing. One of the major problems that Houstonian's face is poor traffic conditions and lack of widespread access to public transit. In the Kinder Study, a study conducted by Rice University, twenty-eight percent of people in Harris County, the county that majority of Houston falls in, responded with traffic being the biggest problem Houston currently faces. Sixty-five percent responded that traffic problems have gotten worse in the past three years. The best solution, according to forty-three percent of respondents, was to improve public transportation (Kinder Survey). The traffic problem is evident in the morning when watching the news as normal twenty minute commutes to get into the heart of Houston are taking commuters over an hour. In a recent news article on the ever growing problem of Houston traffic, an analyst stated that:

> trips in the region on average last year took 25 percent longer than they would have in free-flowing conditions, compared with 21 percent longer in 2013.
>
> This means that a hypothetical 30-minute, congestion-free trip, on average, takes about 52 minutes at peak commuting times. For an entire year, it means drivers waste 85 hours - more than 3.5 days - plodding along the highways and streets of Houston. (Begley)

This goes to show the effects that Houston is experiencing while it continues to grow at a rapid rate. With this is mind, it influenced me to take on the challenge to see how Houston could improve its public transportation system and take a look at the accessibility of Houston roadways through a variety of analyses.

Data

Transportation will be subdivided into different categories that includes data on Houston's Metro rail system and Metro Bus system. For the Metro rail, these points represent rail stations and polyline features of currently available routes. For the Metro bus category there ae a number of datasets that includes stops, routes, transit centers, and park and rides. The transit centers are used to allow riders to switch transportation modes and also switch routes, while the park and rides facilities allow users to park personal vehicles in the vicinity of public transportation accessible areas. These datasets came from a combination of websites including the City of Houston GIS website and Houston-Galveston Area Council.

To find suitable areas for new public transportation hubs and routes, population density and median income datasets were used. The population density dataset was used to represent the people of Houston and find highly populated areas in order to obtain a better understanding of areas that would benefit most from improvements. The median income dataset was used in order to find areas of lower income who may not have their own personal transportation and be more likely to rely on public transportation. In order to create these two datasets, data was downloaded from the Census Bureau website. Census tracts of Texas were downloaded and tables for population and income for Harris County from 2013 were downloaded. To prep the data for use, a query was used on the census tracts in order to get the specific tracts needed. Then the tables of population and income were joined separately to the two census tracts files. To create population density, the first step was to create a short integer field entitled "Sq_Acre" since the cell size to be used represents that. The formula to create the field was to use the area land (aland), which was already included in the dataset, times 0.000247105, which is sq. meter to acre found using a quick Google search, then dividing by four to calculate the quarter acre value. The next step was to divide the population field provided in the census tract by the output of the

“Sq_Acre” field in order to get population density. The population density field was created also using short integer as the field type.

The data used for traffic analysis included freeways and census tracts. In order to use the freeways in ArcGIS Online, they first needed to be converted to points. To begin this process, all of the freeways with the same name were merged using a SQL query and then the merge tool found under the editor dropdown menu. Next, the freeways were converted to points but kept under a thousand points in order to publish to ArcGIS Online- given the restrictions of our accounts. For the census tracts, the Polygon to Points tool was used. The output of this tool places a single point in the centroid of every polygon. This was needed because ArcGIS Online only allows points to be used in its proximity analysis tools.

After all of the data was prepped and ready to be used, it was time to run the analyses.

Methods

Public transportation

The first step in this project was to find the areas that had accessibility to current public transportation and find areas that would be suitable locations for future public transportation. The first step in this process was to create models for each individual dataset which included the metro rail stops and routes along with the bus stops, rail routes and stations, transit centers, and park and rides. All of the models for this step were created with the same template. The model environments that were changed were Raster Analysis and Processing Extent. The cell size used was thirty-one, which is equivalent to a quarter of an acre, with the census tracts of the Houston area being used for the processing extent and mask. The models were built from the bottom up with the top section being the final output for that individual model. Figure 1 shows an example of this using the bus stops. The first tool used in the models was the Euclidean Distance tool. That was used in order to convert the vector files into raster format and create rings around the individual dataset using distance of 1320 feet (quarter mile), 2640 (half mile), 3960 (three-quarters of a miles), and 5280 (mile). These distances were chosen because a quarter mile is typically used in public transportation analysis because it is a pretty ideal walking distance. It was topped out at one mile because even though it is longer than the ideal distance, it is a walkable distance for riders if needed (Walker). The next tools used were Zonal Statistics as Table and the Reclassify tool. The Zonal Statistics as Table provides descriptive statistics for the relationship between the distance files and the census tracts, calculated by the census tract zones. The Reclassify tool was used to give a new value to each raster cell value. With the raster being classified in the same manner as the Euclidean Distance tool, new values were given to those classifications and to the values outside of that range. Figure two shows the breakdown of the new classifications. The value of 1 was given to the areas that were between 0 and 1320, 3 to the values between 1320 and 2640, 5 to values between 2640 and 3960, 7 to the values between 3960 and 5280 and a value of 9 was given to the areas further than that and also given to the areas that had no data. The values were assigned as they were to give the areas with high accessibility a low score and no accessibility a high score in order to find the areas that did not have accessibility and could be possible candidates for expansion of the Houston public transportation system. The final tool used in the model was the Extract by Mask tool in order to make sure the final output was restricted to the area of Houston that was used for this project. The final output, Figure 3, shows the areas that are closer to bus stops and areas that are not.

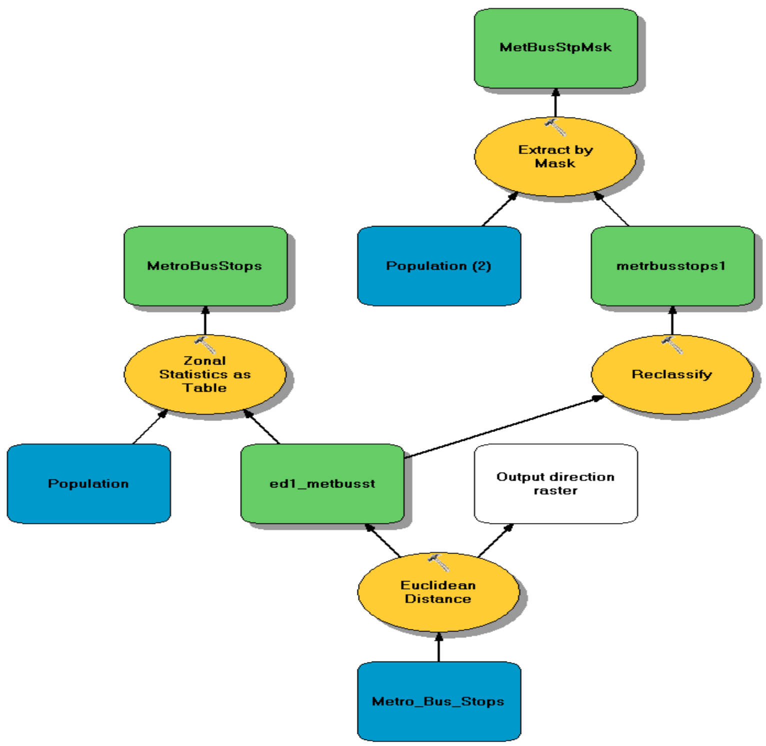

Figure 1: The model process that was used for all of the public transportation datasets used in this project. It includes the Euclidean Distance tool, Zonal Stats as Table, Reclassify, and Extract by Mask

Old values	New values
0 - 1320	1
1320 - 2640	3
2640 - 3960	5
3960 - 5279.928711	7
5279.928711 - 1000000	9
NoData	9

Figure 2: The reclassification process. The higher the old values (feet) the higher the new value was assigned in order to show areas that were further away from current public transportation and would be suitable, according to this criteria, for possible expansion of the public transportation system in the future.

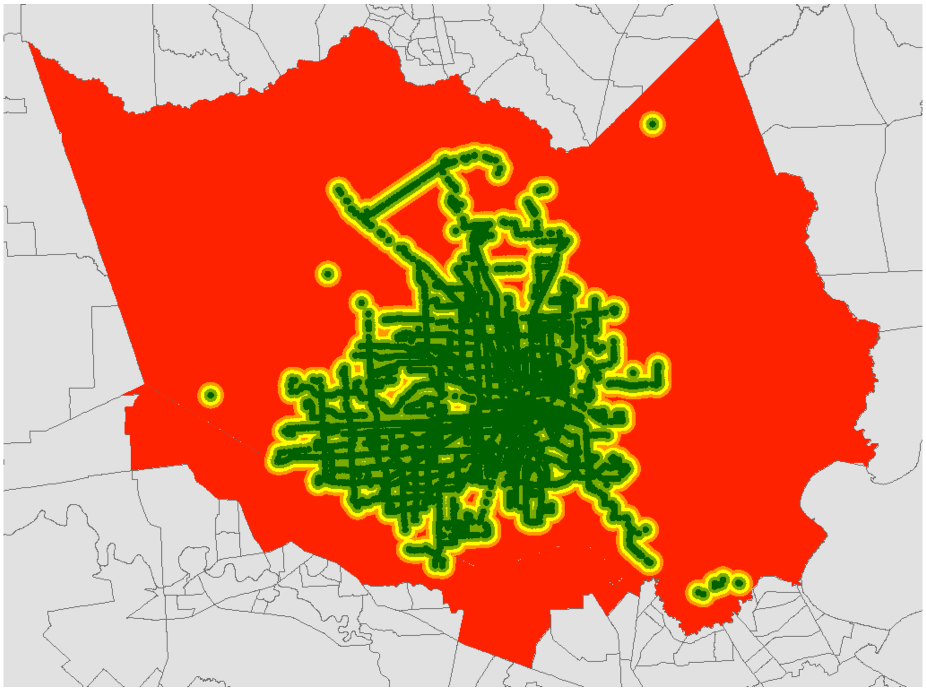

Figure 3: The final output of the bus stops model. The red areas are the areas that do not have access to public transportation within one mile. The green areas are where there are bus stops currently.

The same process was taken for the rest of the datasets in order to prep them to be combined together to find areas that would be suitable for public transportation expansion. The next step in the process was to combine the six datasets, bus stops and routes, transit centers, park and rides, and metro rail stations and routes, in order to get one raster output featuring all of the final outputs from each of those models. After completing the models for all of the datasets and running them, it was time to combine them. In order to combine all of the final outputs, the weighted sum tool was used. They were given different weights based on how important they were to Houston. So with bus stops being the most wide spread type of public transportation, it was given a value of 0.3. The metro rail stations were the second most important so it was given a value of 0.2. The metro bus transit centers and park and rides were given a value of 0.15. The reasoning behind this was that for the transit centers, they were not a necessity and riders could switch bus routes or types of transportation outside of a transit center if necessary, it may just require more walking. For the park and rides, this weight was given because if a rider has a vehicle to park then public transportation is probably not as much of a necessity as it is a convenience for them. Finally, the bus and rail routes were each given a weight of 0.1 apiece. The routes were not as important as they were used to judge which areas are closer to the routes and if new stops or stations were added to the routes they would be in the vicinity without new routes having to be created in order reach those riders. Figures 4, 5, and 6 shows the model of the weighted sum and the weights.

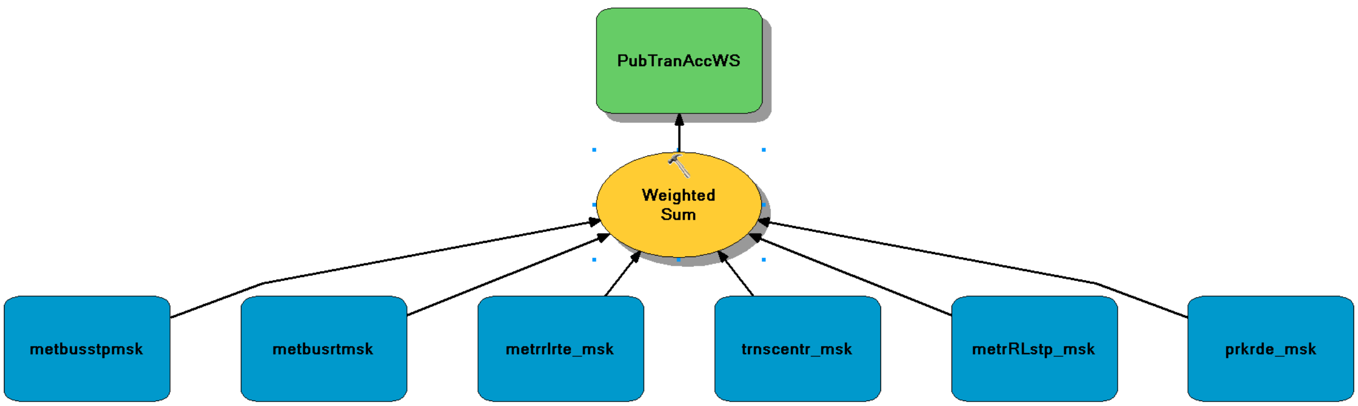

Figure 4: The weighted sum model, combining the six dataset together to make one final output for the public transportation datasets.

Raster	Field	Weight
metbusstpmsk	VALUE	0.3
metrRLstp_msk	VALUE	0.2
prkrde_msk	VALUE	0.15
trnscentr_msk	VALUE	0.15
metbusrtmsk	VALUE	0.1
metrrlrte_msk	VALUE	0.1

Figure 5: The weights that were used.

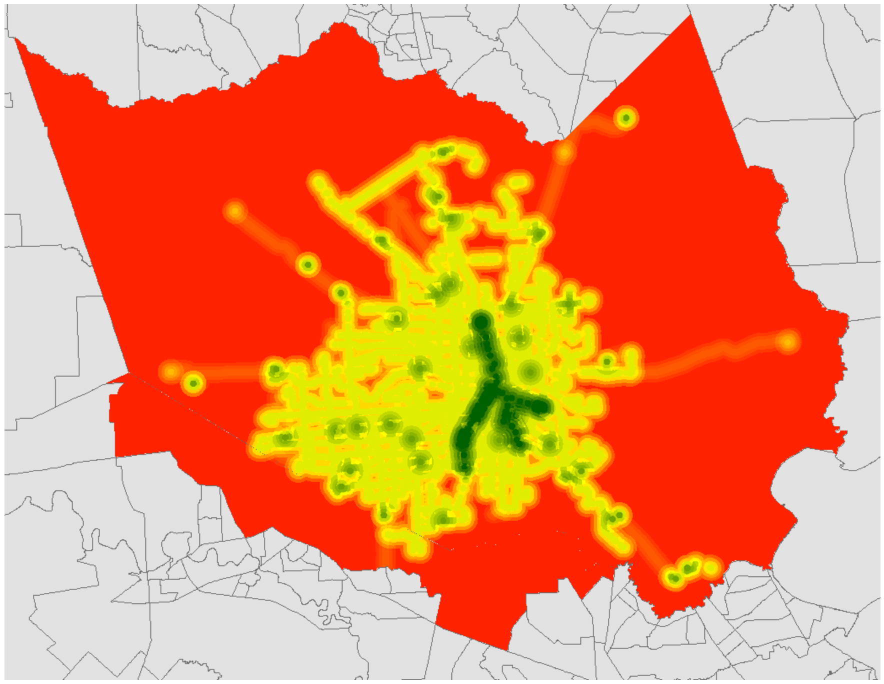

Figure 6: The final weighted sum output of all the current public transportation in Houston. The rea areas are not located near public transportation.

The next step in the process creates the rasters for population density and median income. For these two datasets they were both given separate models with the exact steps. They were first converted to rasters using the Feature to Raster tool. Next they were reclassified with standard deviation classifications and given values of one through nine with the lower populated areas being given values of one and the higher populated areas being given values of nine. For the median income dataset, the lower income areas were given values of nine while the highest income category was given a value of one. This is to help find areas that have low income who may need to rely on public transportation in their daily lives. The final step was using the Extract by Mask tool in order to have all the datasets with the same shape. Figures 7 and 8 show a model of the process and what the final output of population density looks like.

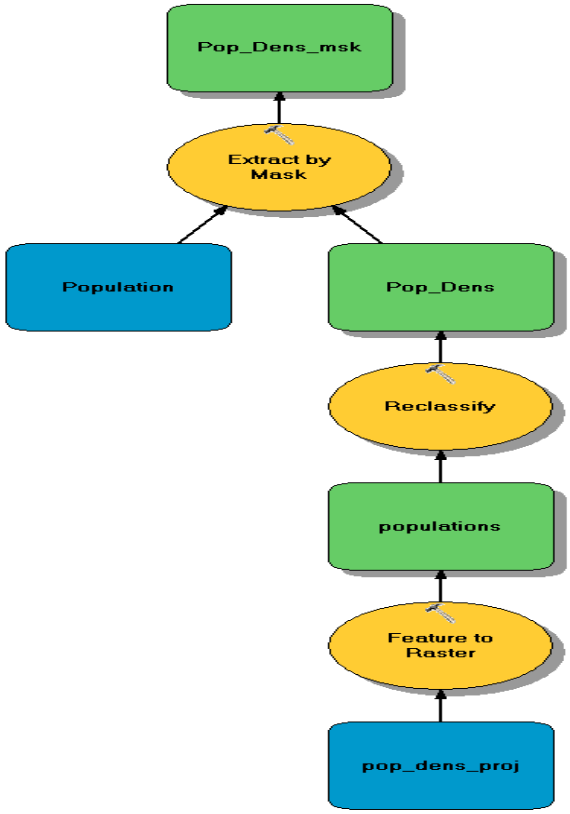

Figure 7: The modeling process that
was used for both population density and income.

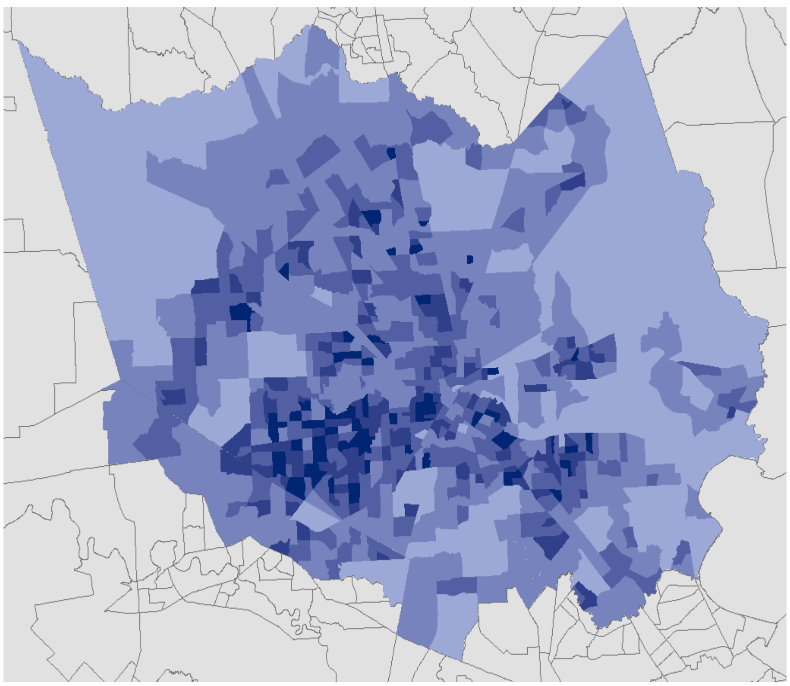

Figure 8: The final of population density.
The darker areas are where the higher population density areas are.

Next, the two outputs of population density and income were combined once again using the Weighted Sum tool. They were both given an equal weight of 0.5 because median income and population density were both equally important in this process. Figure 9 shows the output of the public transportation segment.

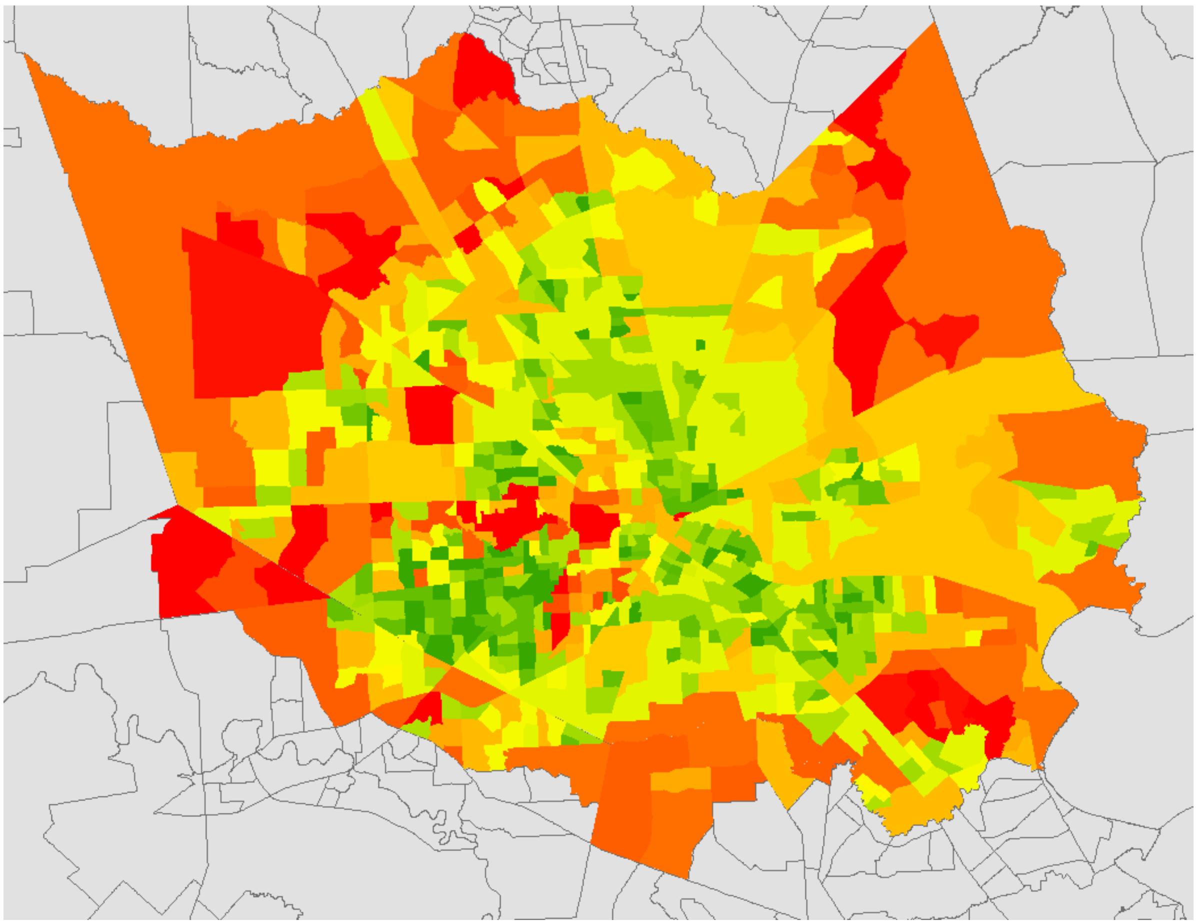

Figure 9: The output from the weighted sum of population density and median income. The green areas are suitable areas where there is high population and a lower median income.

The last step of the public transportation process was to combine the weighted sum outputs from the public transportation datasets and the population and income dataset. This combination also used an equal weighted sum of 0.5 for each. The current public transportation access was just as important of finding the areas with the ideal criteria who would make use of the public transportation if afforded the opportunity. Figure 10 shows the final output for the public transportation section of this project. The map shows the difference between the areas that do not currently have access and do have access to public transportation and the areas that meet the criteria for high population density and low median income.

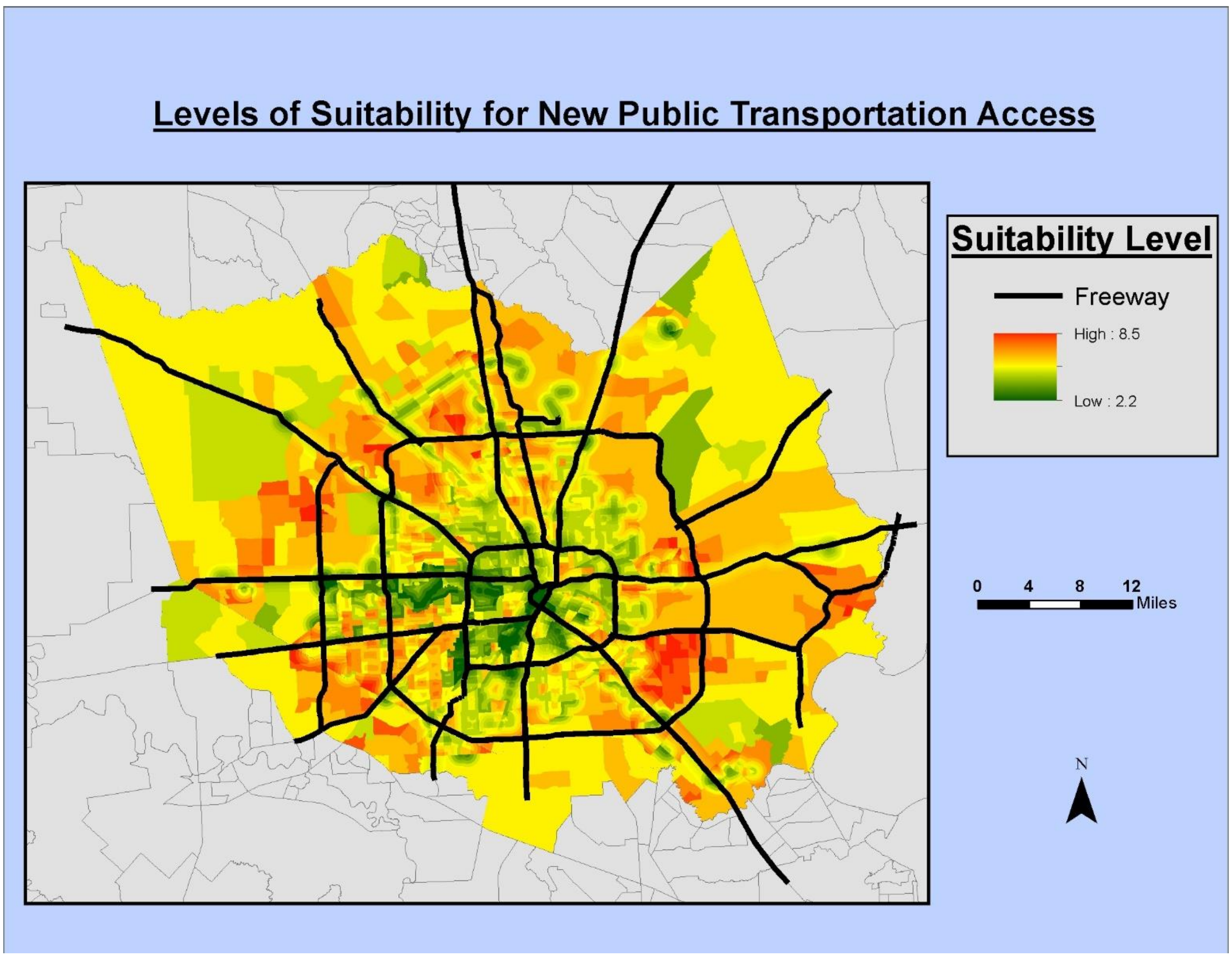

Figure 10: The areas that would be suitable for possible future public transportation expansion. The red areas are areas that have lower income and a higher population density and do not currently have access to public

Roadway Accessibility

The process of examining the accessibility to Houston using roadways took a different route from the way the public transportation was done. All of the analyses for this part used an ArcGIS Online account provided by the University of Arizona for the GIST program. The first type of analyses completed for roadway access was to calculate commute times from census tract points to a points near the center of downtown Houston. The Open Street Map basemap was used to provide the roadways data. The basemap substituted for a Network Dataset. They are pretty similar except this is not customizable and includes roads for majority of the country with traffic simulation available. The drive time analysis was used to show the number of minutes it would take for commuters to get from their census tract to downtown Houston in minutes depending on traffic conditions provided by ArcGIS Online. The first time used was 7:30 am which was considered to be prime rush hour time. This time was chosen based off of charts on the Houston Transtar website where traffic and speed charts are available. After reviewing the charts, the time 7:30 am appeared to be where speeds were generally the slowest during the morning commute. The website allows you to choose a variety of options in order to view specific road areas and their speeds for present day and also has historical data. After uploading the census tract points and downtown points it was time to run the analysis. Using the census tracts as the origins and the downtown point as the destination with 7:30 am traffic being used it was time to begin the analysis. The first analysis was run once for each day during the work week and on Saturday. Figure 11 shows the settings used and what the output for a Monday morning commute looks like in ArcGIS Online and in ArcMap while figure 12 shows the output of the commute times.

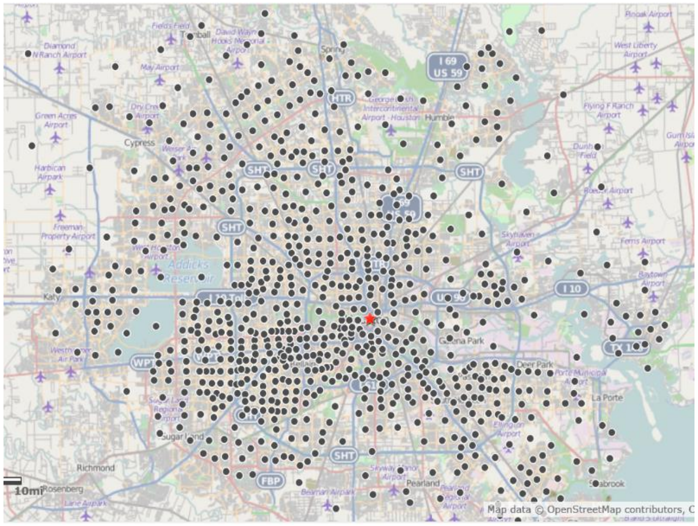

Figure 11A: The census tract downtown point represented by the red star.

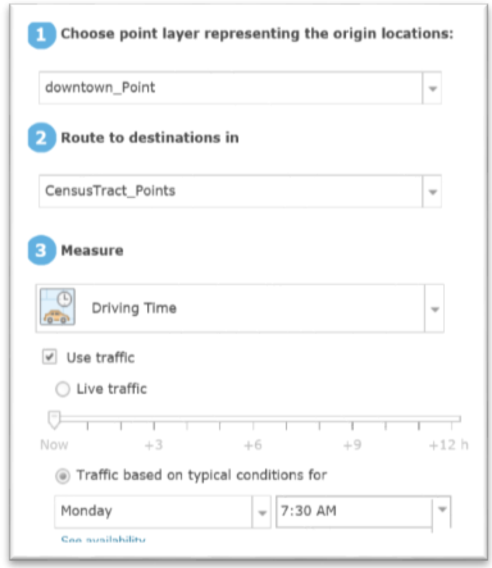

Figure 11B: The settings. Used in the origin to point and destination tool, with traffic being changed for each day.

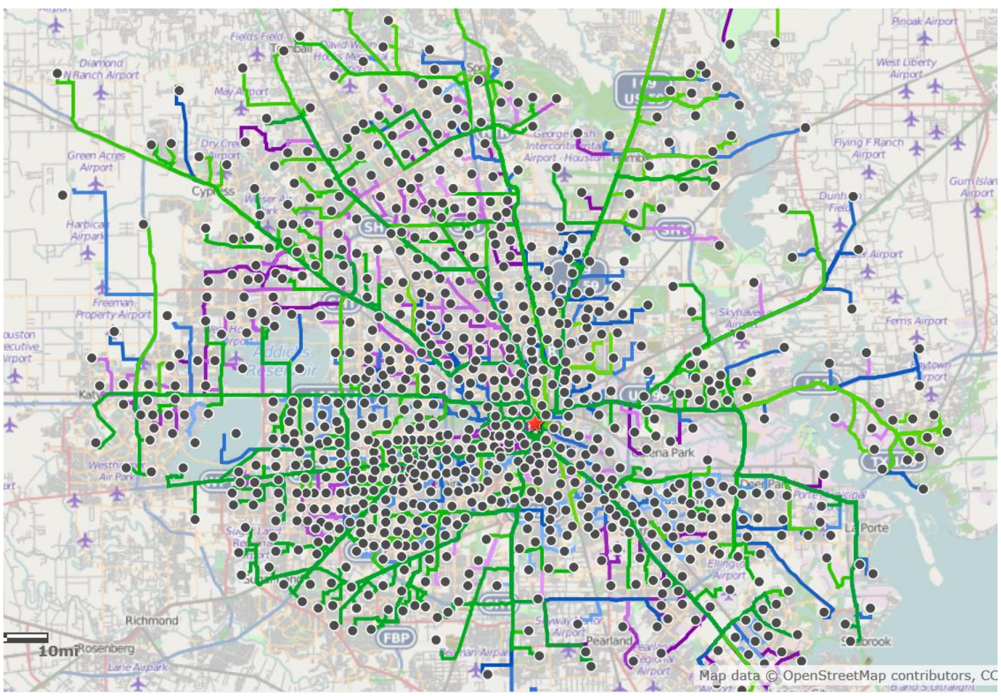

Figure 11C: The output of the analysis for Monday commutes.
The data is randomly symbolized in this picture and correctly symbolized after being exported to ArcMap.

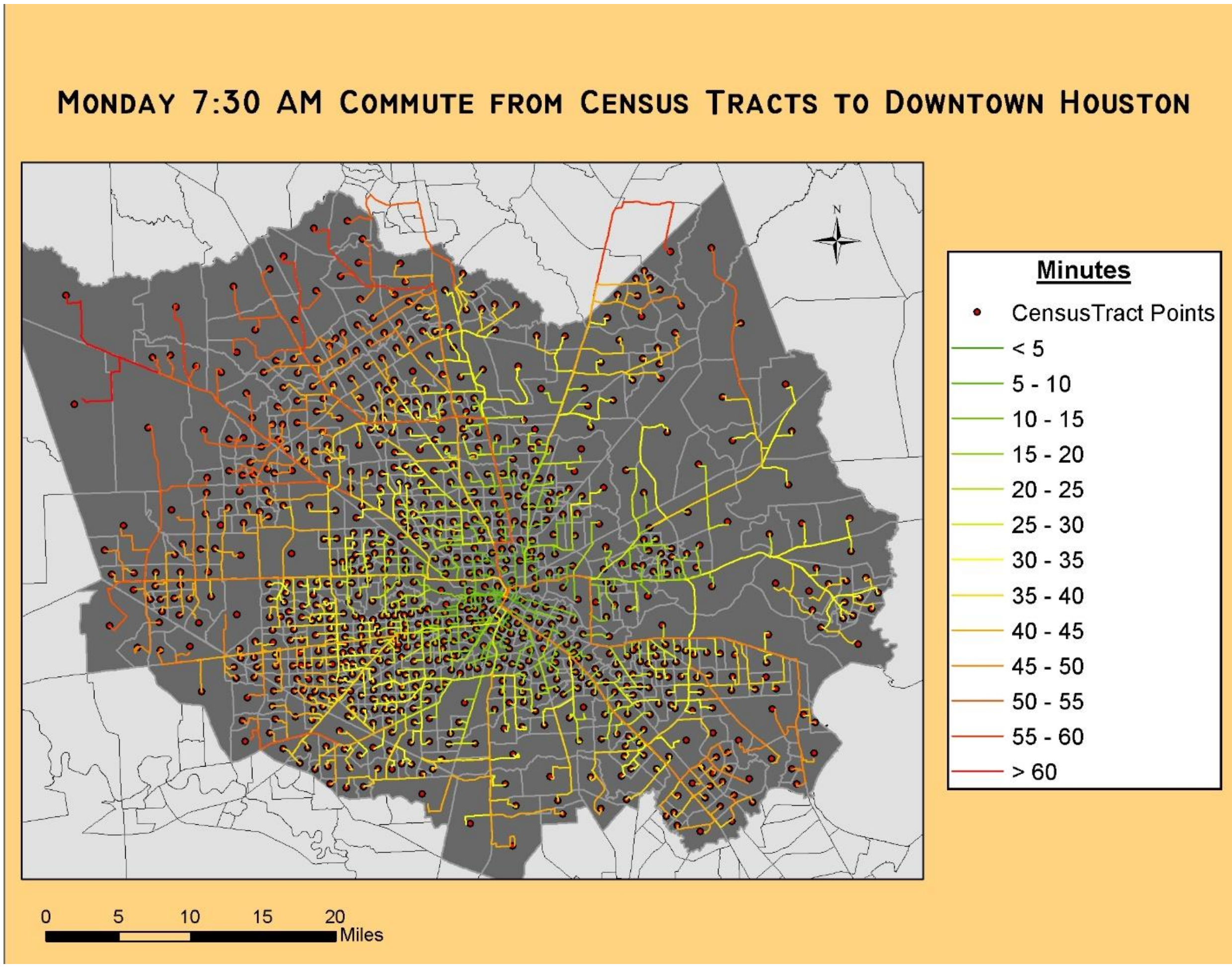

Figure 12: The final output after being exported into ArcMap and being symbolized.

The same process was then completed for the rest of the days of the work week and also Saturday. Saturday was included in order to show weekday times vs the same commute completed during weekend traffic. After all of the analyses were run and exported to ArcMap it was time to compile the weekday times together and get a weekly average of 7:30 am commutes. In order to make the data easier to read all of the routes were joined to their census tracts using the census tract name and origin destination. This allows for each census tract to display their commute time without having the lines displayed. This was also needed in order to be able to combine the datasets to get the weekly average. Figure 13 shows what the census tracts look like after being joined and symbolized.

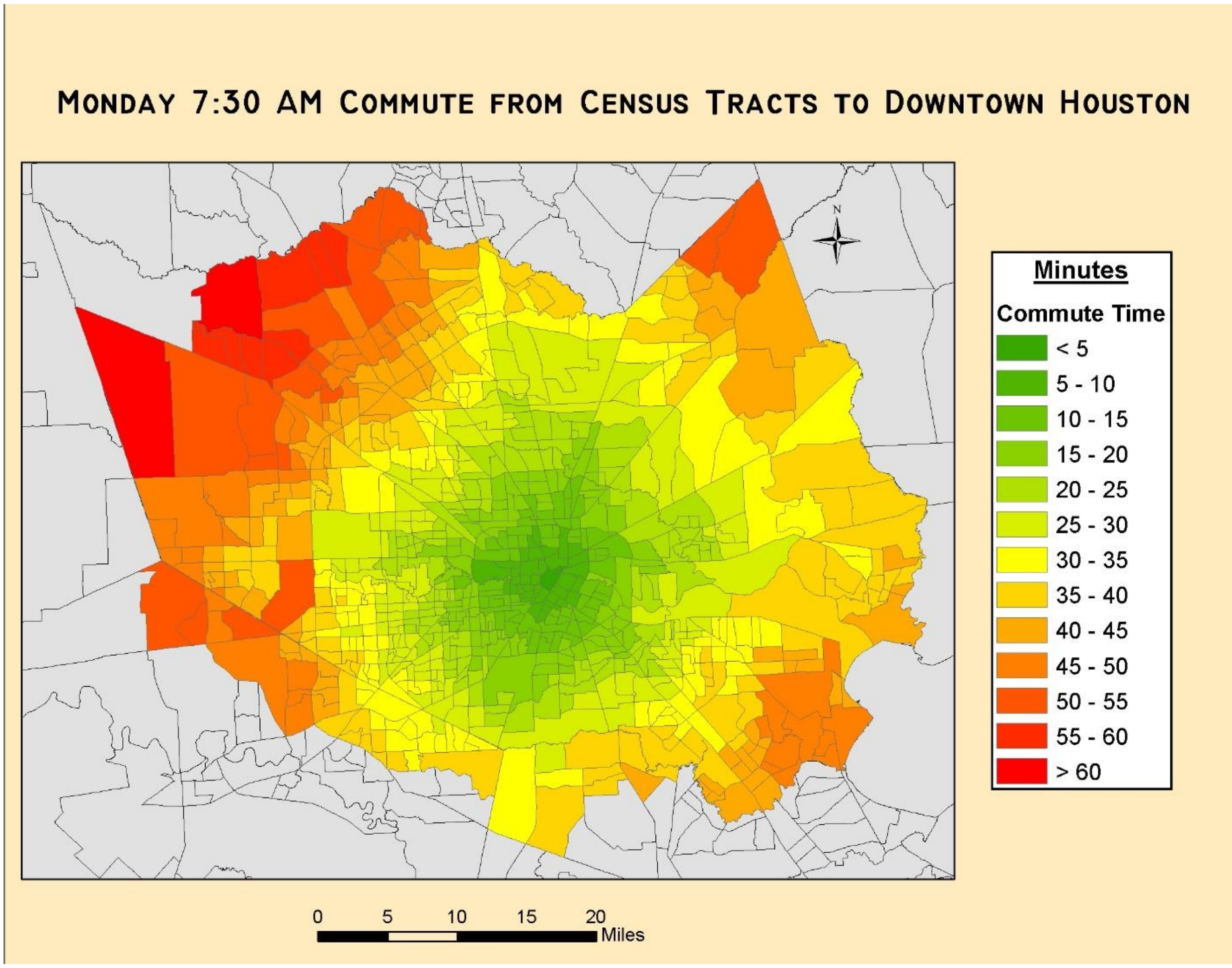

Figure 13: The product of the commute routes being joined to their respective census tract. It makes for a much clearer map to read and understand.

The steps of combing the datasets was to convert all of the outputs from ArcGIS online to rasters and use the weighted sum tool to get one final output that shows the average commute to downtown Houston. Figure 14 shows the final output after combining all of the Monday commutes together.

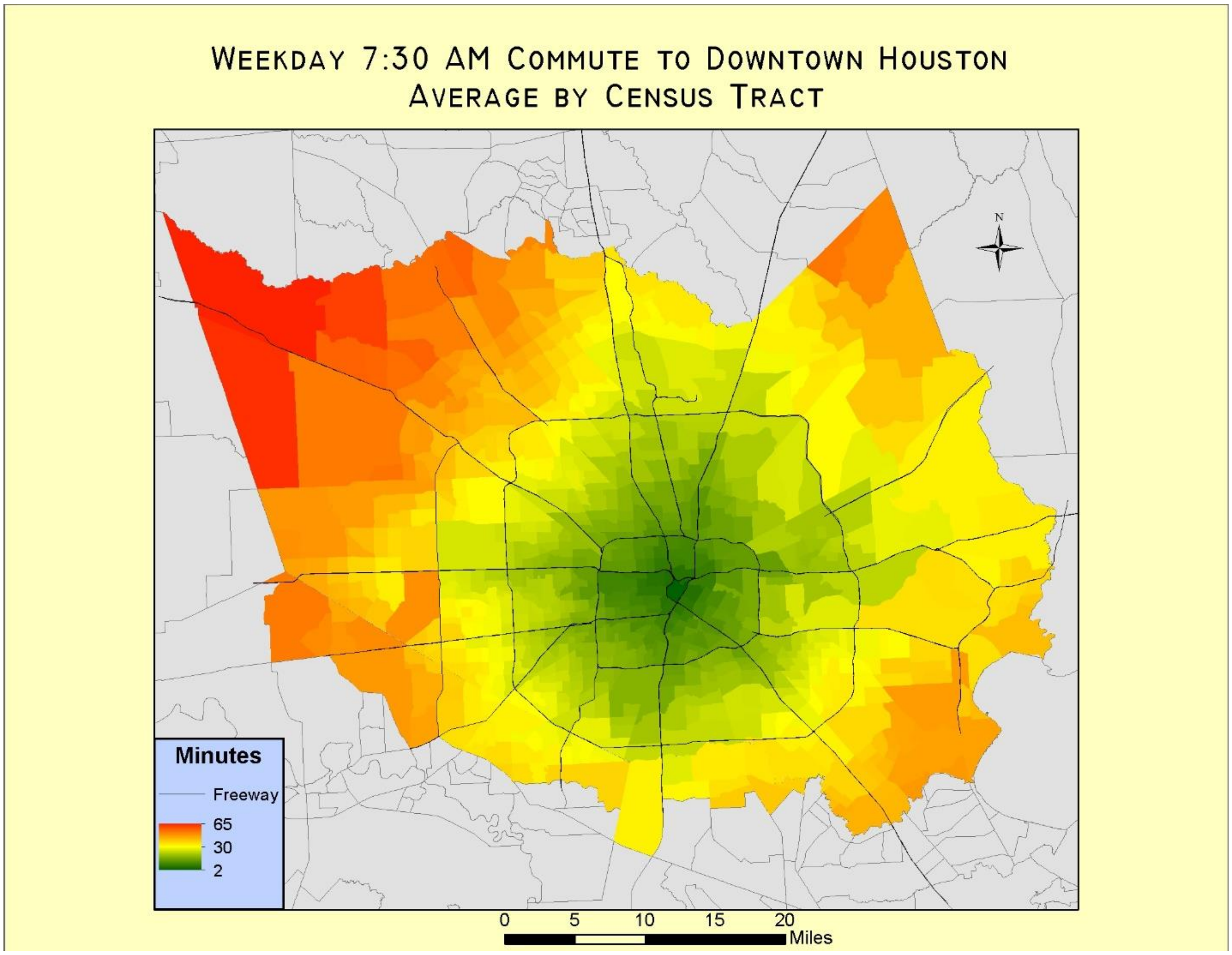

Figure 14: The weekly average computed as a raster after combining all of the weekday commutes.

The next step was to look at the afternoon commute for the work week. The same process was undertaken as far as doing the analyses online except this time the origin point was downtown and the destination was the census tracts and the traffic of 5:30 pm was used this time. Again, to establish this time as an ideal time the charts from Houston Transtar were used and at 5:30 pm is when speeds were at or near the lowest point. After running the analyses again for each day of the week they were exported into ArcMap. Once exported into ArcMap, the routes were joined to the census tracts again. After this step is when a problem arose. Every time when attempting to convert the census tracts to rasters ArcMap would crash. So in order to look at the data, tables were relied upon for data for each individual day, and a final output of the weekly commute in the afternoon average was not created.

The last step of this section for traffic analysis was to get commute times for Saturday to show the difference in travel times when it is not a work day. The same analysis method was performed again using 7:30 am and 5:30 pm in order to see the difference between weekend times and weekday times. They were then brought into ArcMap for comparison to the weekday times.

The next part of the roadway analysis was to the drive time access. This uses a specified time and analyzes how far a commuter could get in every direction in the specified time limit. For this analysis, Monday through Saturday were used. The times of traffic that were used were 7:30 am, 5:30 pm, and 12:00 am the following morning. Once again the times 7:30 am and 5:30 pm were used because those are primarily peak traffic times for commuters. Midnight of the following morning was used to show how accessible Houston is when there is minimal traffic on the road. In order to do this analysis, six random points were created around Houston, all inside Beltway 8 which is the “outer loop” that circles Houston. After uploading the points into ArcGIS Online, the Proximity tool was used to create the drive-time areas. The analysis was run several times for Monday through Saturday. Fifteen minutes was used for the driving time, this was chosen to give an idea of how accessible Houston is but not have the different areas overlapping too much and making the data harder to read on a map. The output shows the areas that would be accessible during those fifteen minutes in every direction. Figure 15 shows an example of the drive-time areas for a Monday.

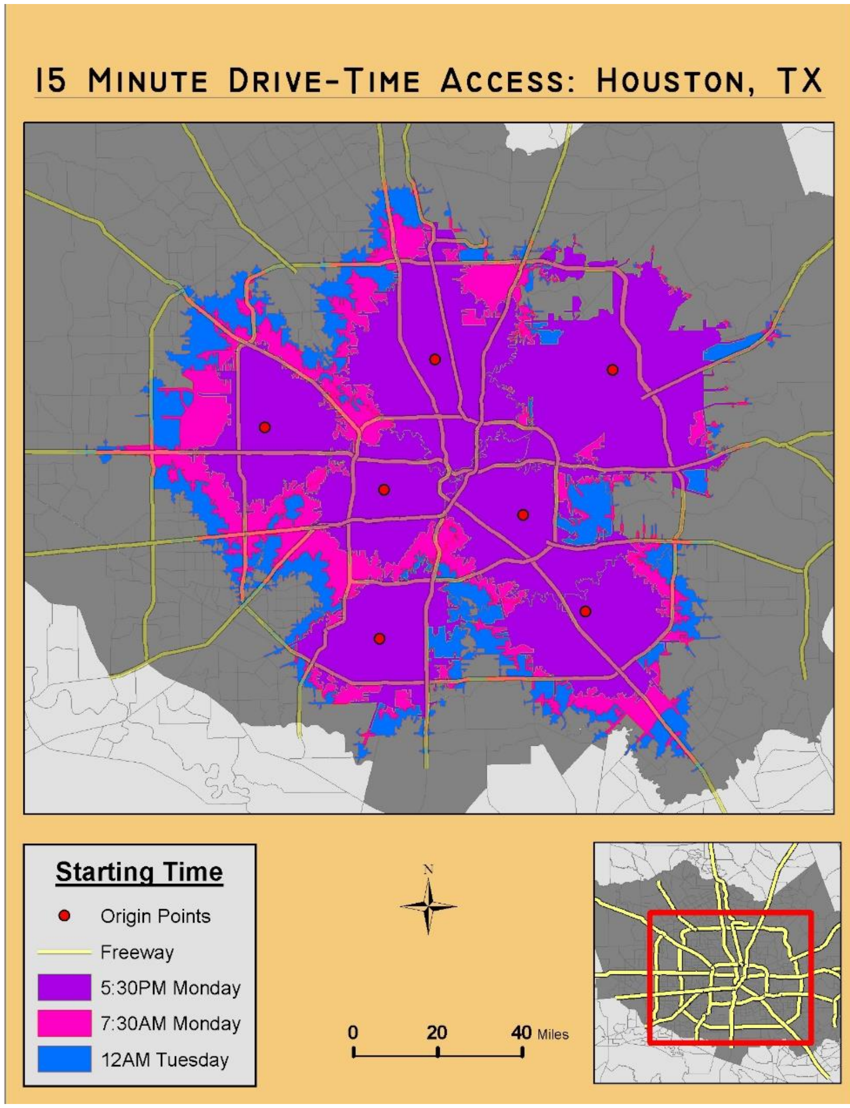

Figure 15: The drive-time accessibility of Houston for Monday/Tuesday

The final part of the roadway accessibility of Houston was to look at freeway access. In order to do this, the freeway points earlier described and census tract points were used in ArcGIS online. The Find Nearest tool was used to find the closest freeway to each census tract. This does not take into consideration the actual destination direction of the commuter nor does it avoid tollways. This was used to simply find the closest freeway that would allow commuters to access when needed. For this analysis no traffic was used. The analysis was only run once and from that it gave the output routes that each census tract would need to take in order to access the closest freeway. From there the routes were joined to the census tracts. They were then able to be symbolized by which freeway the route connected to. This cleared up the map and made it much easier to read. Figure 16 shows what the output was by the routes and what it looks like after the routes were joined to the census tracts and symbolized by which freeway was the closest.

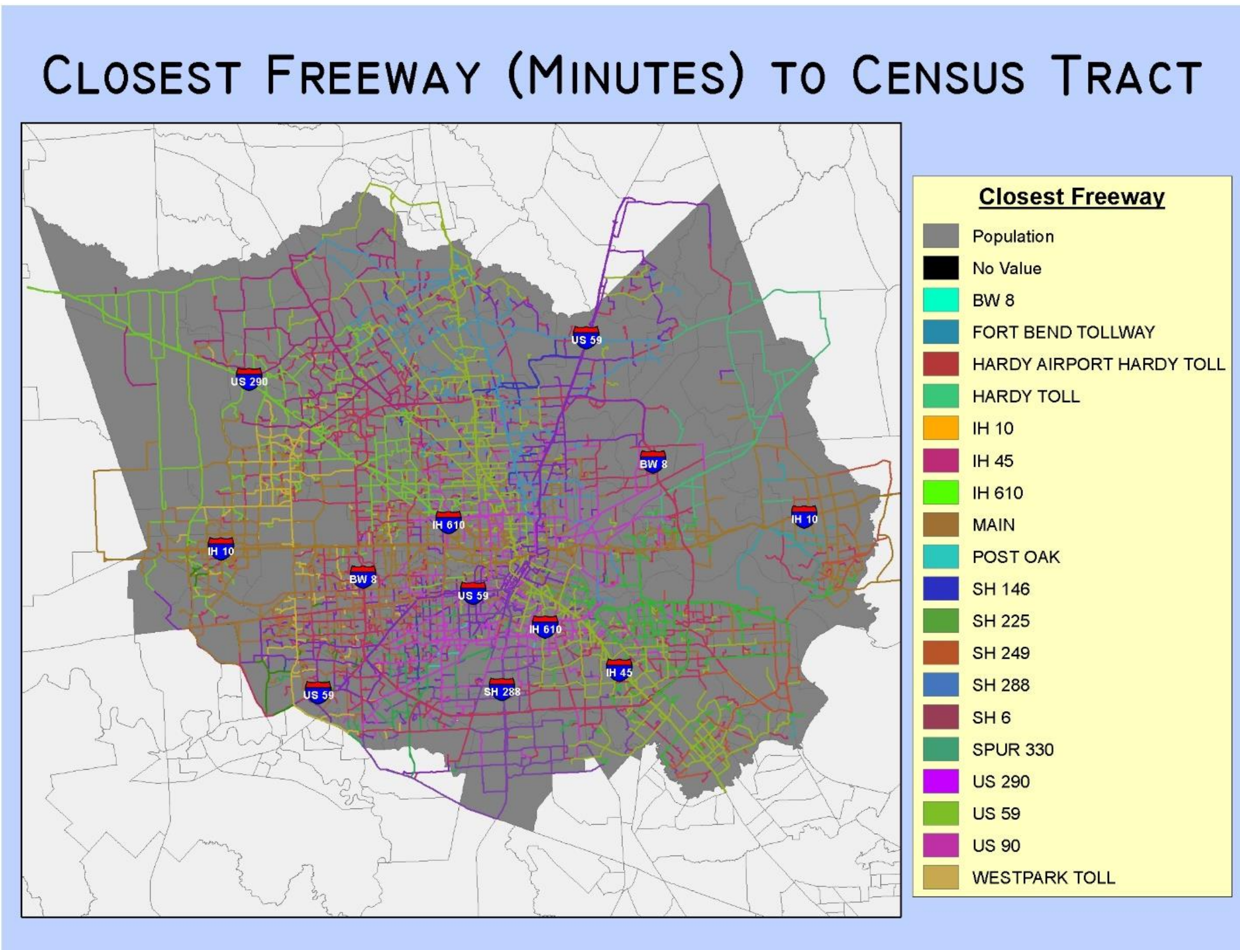

Figure 16A: The closest freeways to each census tract. This does not take into consideration of route destination or if they are tollways.

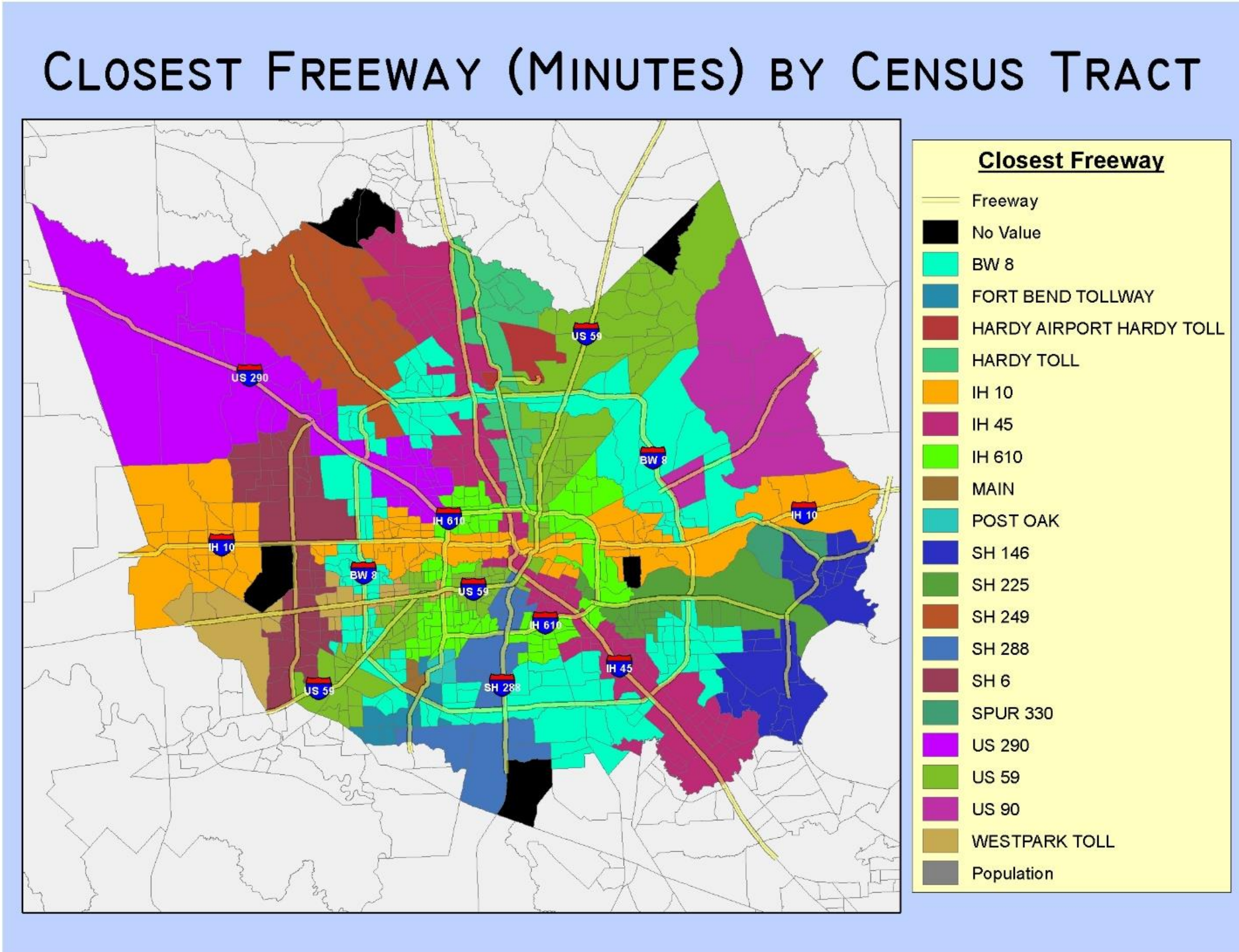

Figure 16B: The closest freeway by census tract.

The roadway accessibility and traffic analysis had several parts to it examined different segments of the full analysis. It allowed to see travel times, drive-time accessibility, and the closest freeway to each census tract. The results in the next section will take a look at all of these analyses and examine what was learned from the outputs of these analyses.

Results

The public transportation output (Figure 7) illustrates the areas that would be most suitable or least suitable for public transportation. The criteria were based on current public transportation access, population density, and median income. Reviewing the final output map, it can be seen that the further away from the downtown area the more suitable areas for public transportation expansion are. The area that is most prevalent in suitability is the southeast side of Houston near Beltway 8 (outer loop). Selecting these areas and looking at the statistics shows that that the population density average for this area is thirty-eight people per quarter acre while the average for all of the census tracts is around thirty people and the max in this area is ninety-nine per quarter acre. This puts the area above average, which is good for the suitability of new public transportation. The average median income for this area is right above $40,000 but the minimum is just below $20,000 a year. The average income for all of the census tracts is almost $60,000. That would mean the suitable area brings home almost $20.000 less than the city average. With this combination of high population density and lower median income, the area would be a prime candidate for public transportation expansion. It would have better chances of getting used with the high population density and low income. Figure 17 shows the area selected that would be most suitable for new public transportation.

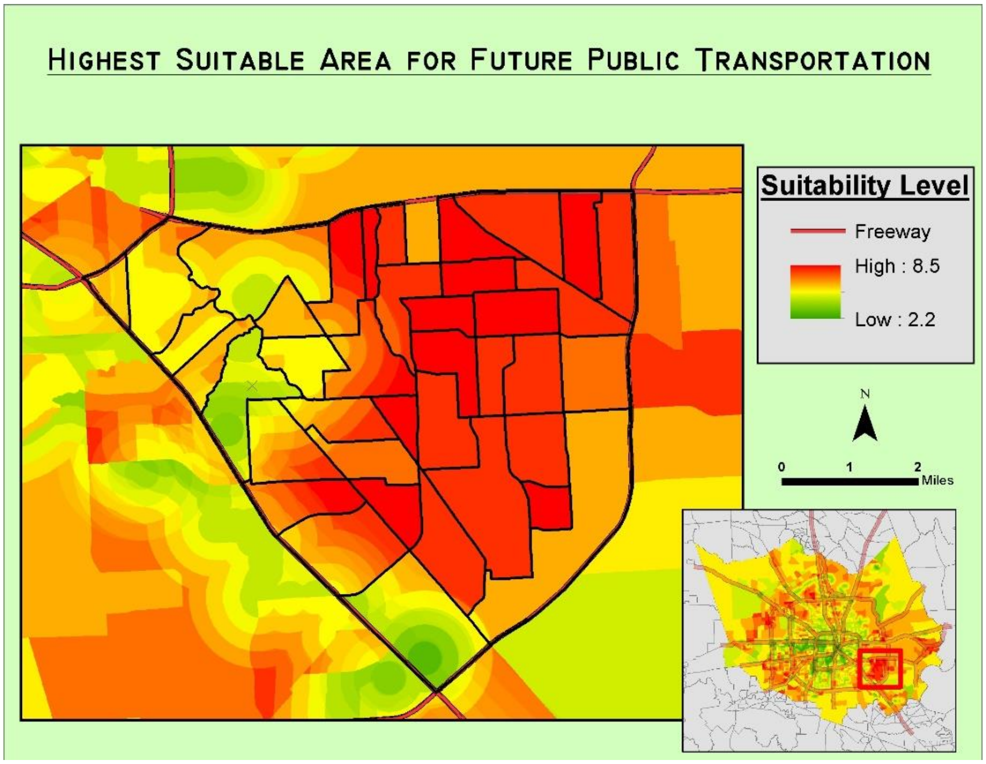

Figure 17: The area that was picked as the most suitable area for future public transportation. This area has a higher population density and a lower median income.

In the high suitability area there is not much public transportation currently available. There are only 111 bus stops currently and they are primarily in only about five of the census tracts closest to the center of Houston. With the population of Houston growing and spreading out more to the suburbs, public transportation will need to be extended to outlying areas to accommodate for these people. Houston will need to continue to improve its public transportation system not only for those who do not have cars but also to help relieve traffic congestion.

The roadway analysis was done in three parts which included commute times, drive-time access, and freeway access. These three analyses allowed a better look of which days created the most traffic and also how accessible the freeways are to different parts of Houston. The following section discusses the commutes times.

Traffic is not always the most predictable item as it can vary day to day depending on a variety of different factors including wrecks, construction, and weather. These results do not really include these types of anomalies that could take place on any given day. It is still a great insight as to which days are the busiest and what the commute times would look like with minimal traffic.

Commute times for the work week and Saturdays will be the first set of results. After creating a table with all the average commute times for each day between 7:30 am and 5:30 pm, the results showed which days had the shortest and longest commute times for each timeframe. The weekday with the fastest commute time for the morning is Friday with an average of around twenty-six and half minutes. The slowest time is Tuesday with just over a thirty-minute average. For the afternoon the fastest commute time is again Friday with an average of around twenty-nine minutes. The slowest time is Thursday with close to a forty-minute average. In order to see how this relates to a day with minimal traffic Saturday was used. The times for Saturday are around twenty-two minutes for the 7:30 am commute and twenty-three and a half minutes for the afternoon commute. Table 1 shows all of the commute time averages for all of the census tracts broken up by day and time that traffic was used during the analysis.

Day/Time	Drive Time (Minutes)
Mon 730	28.952373
Mon 530	29.901987
Tues 730	30.3139
Tues 530	30.558937
Wed 730	29.822852
Wed 530	30.202242
Thurs 730	29.78938
Thurs 530	30.752861
Fri 730	26.57832
Fri 530	29.345485
Sat 730	22.472394
Sat 530	23.594937

Table 1: The commute average of all the census tracts divided up by the day and time that was used to simulate traffic.

Drive-time analysis was done in order to get a better reading of how accessible Houston actually is during rush hour traffic. After getting the layers exported to ArcMap, it was time to look at how different the accessibility from the random placed points was. The best way to judge this outside of just visually looking at it was to examine the area (miles) that were reachable during the fifteen-minute time period that was given for the analysis. The day that had the least accessibility during the morning commute was Tuesday with just over a ninety square miles access area, followed closely by Wednesday and Thursday with also just over a ninety square mile access area. Friday and Monday both had a higher access area by a couple of miles with an average of just over ninety-two miles which made them the most accessible. For the afternoon commutes, Thursday had the lowest average with just over sixty-five and a half square mile average. The surprise of this analysis was that Friday afternoon had the third lowest access area. This could be due to not only the commuters coming home from work but also because of drivers leaving town for the weekend adding even more cars on the road. Monday had the highest accessibility with over sixty-seven miles being the average. It is clear that the afternoon commutes are much worse than the morning commutes as there is a twenty-five miles difference. The baseline for this analysis was to use Saturday and Midnight times as a reference in order to see the accessibility with a lot less traffic on the road. Saturday morning had a much higher accessibility average as it averaged nearly one hundred and twelve miles. Saturday afternoon's average was also higher with around an eighty-seven mile average. Both Saturday morning and afternoon covered around twenty more miles than its counterparts of during the week. The other baselines to judge accessibility with minimal traffic was using the midnight times for traffic. All of the times at midnight averaged almost one hundred and thirty-eight miles. This means that the midnight times averaged over seventy miles more area than the lowest accessible time of Thursday afternoon. This goes to show how much traffic does play a part in the accessibility of the city. Table 2 shows the different drive-time accesses broken up by day and time.

Day/Time	Driving Area (SqMiles)
Mon 730	92.475474
Mon 530	67.683412
Tues 12	137.753249
Tues 730	90.060811
Tues 530	66.611505
Wed 12	137.747745
Wed 730	90.210407
Wed 530	65.708868
Thurs 12	137.747156
Thurs 730	90.412838
Thurs 530	65.634842
Fri 12	137.749651
Fri 730	92.118388
Fri 530	65.938661
Sat 12	137.748422
Sat 730	111.8342
Sat 530	86.833255
Sun 12	137.747792

Table 2: The drive-time accessibility averages from
randomly placed points around Houston for different days and times of the week.

In the final analysis of Houston's accessibility freeway access for each census tract was studied. After exporting the results from the analysis to ArcMap and joining to the census tracts it was time to look at which freeway was the closest to the census tract. The freeway that was the closest to the most census tracts was Beltway 8, which was the closest freeway to 144 census tracts. Beltway 8 is a tollway that makes a loop around the outer portion of Houston. This road does offer service roads to be taken for free but that means drivers will encounter red lights as it crosses paths with other roads. The next two freeways with the highest census tracts count, 116 apiece, was Interstate Highway 45 and US 59. Interstate 45 towards downtown Houston from the southeast, which carries a lot of traffic from the major suburbs south of Houston. US 59 travels from the Southwest to the Northeast going near downtown Houston, which also gets a lot of commuters from the suburbs. Interstate 610 is the next highest, this freeway is considered the inner loop and is the primary road to get to different areas around the heart of Houston. Other major freeways that are integral for bringing commuters from the suburbs to the heart of Houston are Interstate 10, Sam Houston 288, and US 290. The roads mentioned are some of the busiest roads that see large amounts of traffic daily. This analysis does not actually show how much the freeways are used on a daily basis or their importance but it does show the closeness of freeways which is an integral part of getting around Houston. Table 3 shows the chart of the freeways and the number of census tracts they are closest to.

Closest Freeway (Miles)	Count
Beltway 8	144
Interstate Highway 45	116
US 59	116
Interstate Highway 610	89
Interstate Highway 10	87
Sam Houston 6	50
US 290	47
Sam Houston 249	32
Westpark Tollway	28
Hardy Toll	27
Sam Houston 146	24
Sam Houston 225	22
Sam Houston 288	21
Fort Bend Tollway	10
US 90	7
Main	4
Post Oak	4
Spur 330	3

Table 3: The freeways broken down by the number of census tracts that they are closest to.

The roadway analysis showed the affects traffic have on daily commuters and the amount of distance and time loss caused by the traffic. Houston will need to find ways to improve traffic conditions if it wants to continue to grow as fast as it is. In order to improve the roadways requires construction which does increase traffic temporarily but will benefit the city in the future. This report could help planners in seeing the affects that traffic on the city and aid them in going forward in trying to improve the roadways.

Discussion

There were several problems that arose throughout the project that were great learning experiences going forward. The first dealt with trying to get the correct data in order to build a network dataset for the roadway analysis. All of the roadway and freeway datasets that were available through the City of Houston GIS website and the Houston Galveston Area Council did not include an elevation field. This field is essential to building the network dataset because it allows for the system to differentiate hierarchy between roads that cross over each other but do not actually intersect, such as overpasses and underpasses and freeways that are raised above other roads. So this problem forced me to find a different way of doing the project which led me to doing the roadway analysis through ArcGIS Online. Another problem that I faced was with my final output rasters. They were not coming out with the right values. The problem causing this was my reclassification did not include the maximum values of the raster dataset, which throws off the reclassification system. To fix this problem I had to be sure to include the highest value in the dataset in one of the classifications. Another problem faced was when trying to create the final raster output for public transportation, ArcMap crashed every time I tried to run the weighted sum tool between the public transportation and the income and population dataset. The simple fix was that I had a space in the parent folder that was housing my data. There were several other instances where ArcMap would crash when trying to run analysis. It could be because the project was being completed on a laptop without enough processing power or just simply user error. All of these problems allowed me to gain experience and to learn from my mistakes which will benefit me going forward in my GIS career.

CONCLUSION

The results show a variety of different sets of data in order to look at the accessibility of Houston. Public transportation accessibility was examined to identify potential areas for future expansion. The results from the different types of roadway analysis is evaluated to determine the accessibility of Houston through the different types of analysis performed. These results, including the preceding data, could be used by local agencies to help plan for future expansion of the Houston public transportation system and to look at the traffic problems of Houston. From the results they could pinpoint areas in need of public transportation and would have the characteristics suitable for expansion. They will also be able to look at the different commutes and drive-time accessibility in order to get a better picture of accessibility in Houston when dealing with traffic. It could also be used by the public to get an insight to public transportation and their daily commutes.

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