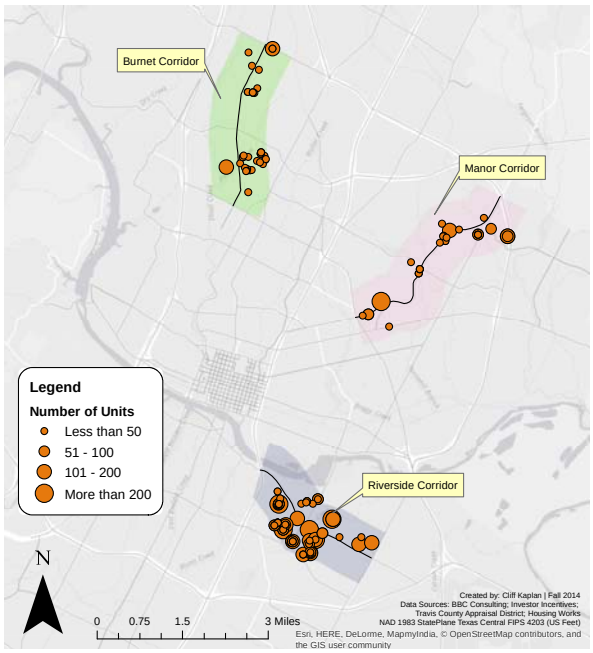
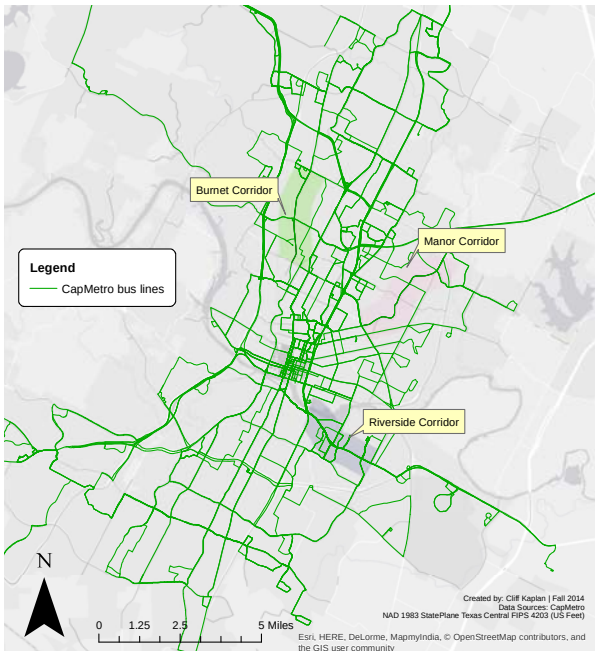
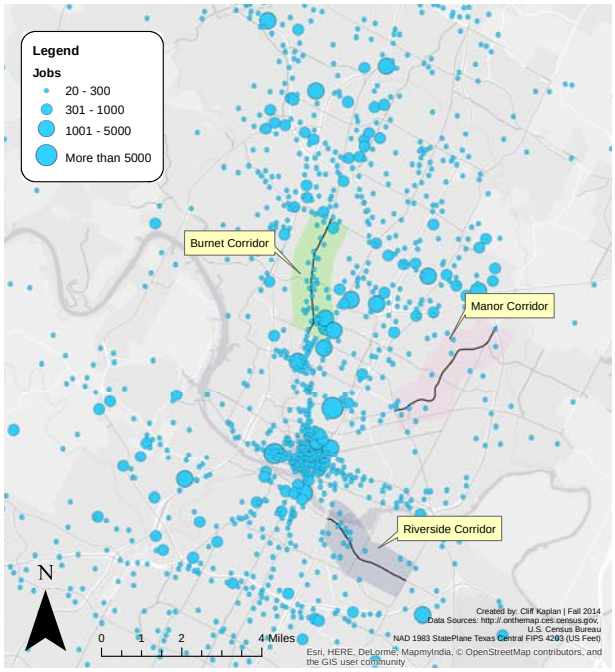
Evaluating access to jobs via transit from disparate neighborhoods

Clifford Kaplan - GIS for Water Resources 2014, Term Project







Summary

For this term project I set out to design and conduct an easily replicable geospatial analytical method to compare urban corridors in terms of the access to low-income jobs via public transit that each corridor has. The method I devised uses nationally available jobs data, publicly available transit data that is generally easy to find in cities with transit systems, and a collection of housing data sets that were more difficult to assemble, but that would be necessary for anyone who is working geospatially on affordable housing issues to have. The analytical method relies on simple GIS skills and is easily modified according to the level of specificity in the data (e.g., number of buildings versus number of units, and whether or not transit headway data is available).

Conducting the analysis for three urban corridors in Austin, TX—Manor Road, Burnet Road, and East Riverside Drive—I found that low-wage jobs (by definition the relevant class of jobs for people living in affordable housing,) are twice as accessible from the Burnet corridor as they are from the Riverside corridor and nearly four times as accessible as they are from the Manor corridor. Affordable housing in the Manor corridor has 76% less accessibility to jobs than does the affordable housing in the Burnet corridor, although the actual number of jobs reachable from the Manor corridor is only 33% less than the number reachable from the Burnet corridor. The differences in accessibility are due not only to the places the buses go, but to where the affordable housing is in relation to the nearest bus lines and how often the buses come.

Context for this project

The Green and Inclusive Corridors project is a U.S. Housing and Urban Development (HUD) funded project led by Dr. Elizabeth Mueller of the Community and Regional Planning department at the University of Texas at Austin. The project's objective is to design and conduct a replicable methodology that planners and advocates can use to evaluate threats to affordable housing from development and to identify opportunities for protecting affordable housing in their cities. As Dr. Mueller's graduate research assistant, I am helping to design a rubric for comparing, across many criteria, "activity corridors" in different parts of the city. One criterion by which we would like to compare the corridors is transit access to jobs for low-income residents of each respective corridor. This term project represents my effort to design a replicable geospatial analytical method for evaluating transit connectivity from affordable housing to jobs in various parts of the city. Although the Green and Inclusive Corridors project compares eight corridors in Austin, for the purposes of developing the methodology and presenting it in this paper, I have narrowed the study areas to three corridors.

Project Objective

The objective of this project is to design and conduct a replicable geospatial analytical method for comparing different neighborhoods in terms of the number of

low-paying jobs that are easily accessible by public transit from each neighborhood.[1]

Data required for the analysis

The analysis I have designed requires the following data, regardless of the city to which the analysis is applied.

- Boundary data for the respective study areas to be compared.
- Location data for the affordable housing stock. If information regarding the number of units in affordable buildings is available, this can be used to improve the precision of the analysis.
- Route data for the public transit system. If headway data is available, this can be used to improve the precision of the analysis.
- Location data for relevant jobs. As this analysis is concerned with *affordable housing* it is assumed that the housing residents work low-paying jobs, so only these are included in the analysis.

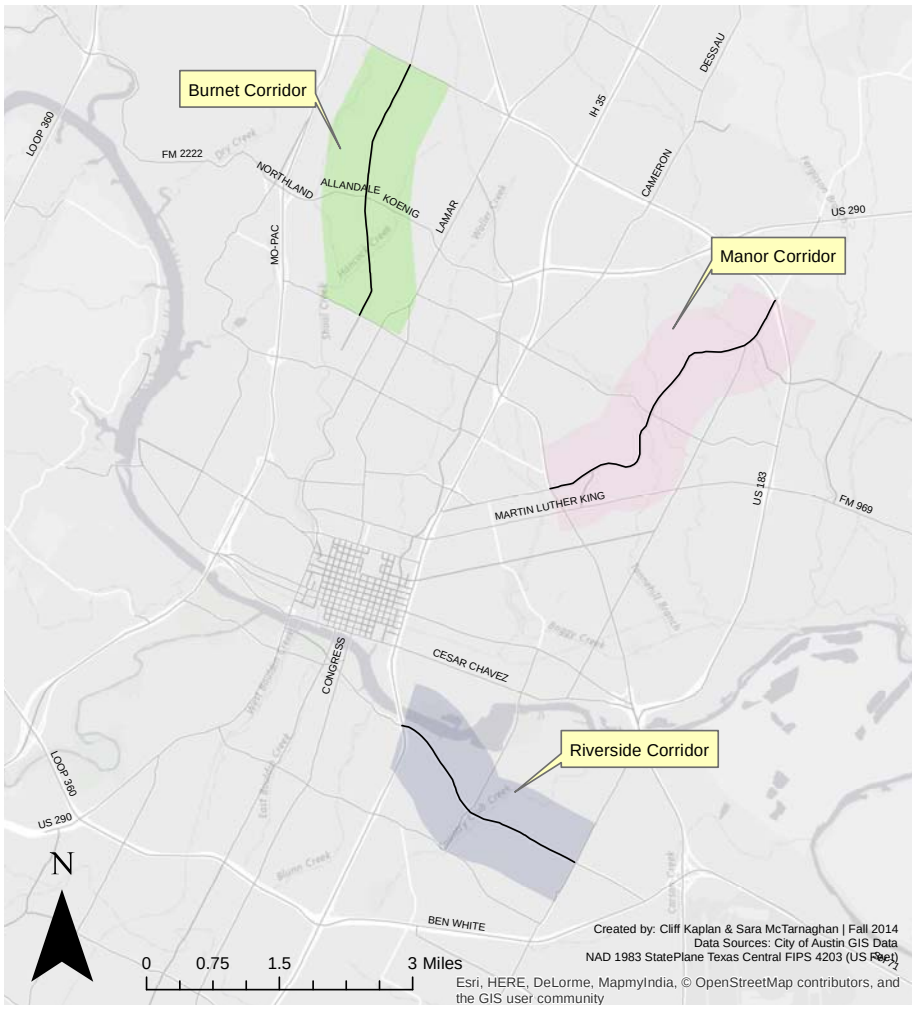
Meeting these data requirements in the Austin context

For this analysis in Austin, I met each of the data requirements in the following ways.

[1] For the purposes of this analysis, we took "accessibility" to mean accessible without having to transfer buses. In Ausitn, transferring between bus lines tends to require long waiting times which makes it far from ideal for commuters. Although people without other options do commute this way, this analysis is designed to produce a measure of quality so we are only including the one-bus commutes.

Boundary data for the respective study areas to be compared. As previously noted, the larger project of which this geospatial analysis is a part is a corridor project that looks at eight corridors in Austin. Dr. Mueller, my colleague Sara McTarnaghan, and I decided to draw our study boundaries as half-mile buffers to each side of the corridor. Sara McTarnaghan created the shape files we are using in this project according to this specification. In this paper, I focus on three of these corridors: Burnet Road, Manor Road, and East Riverside Drive. Map 1 shows the extent and locations of these three study corridors.

Map 1: The three study areas



Location data for the affordable housing stock. The data we use to track the affordable housing stock in Austin comes from three separate sources, each for a different type of housing stock. From BBC Consulting, we obtained address data on government-subsidized multi-family affordable housing, which we geocoded to create a point feature-class. This data included information about the quantity of units at each building. From Investor Incentives, a real estate data firm, we obtained address information for Class C multi-family buildings with more than 50 units.[2] This data included information about the quantity of units at different rental values and sizes, from which we were able to select for inclusion in the analysis only those buildings that meet current affordability standards set by the Housing Authority of the City of Austin.[3] For data on non-subsidized buildings of less than 50 units, we had to combine information from two sources to create an estimate. From the Travis County Appraisal District (TCAD), we acquired data that included the address and number of units for all Class C buildings in the city, from which we used only those with fewer than 50 units. This TCAD data did not include rental values and thus did not indicate which buildings were uniformly affordable, which were uniformly unaffordable to low-income residents, and which had both affordable and unaffordable units and in what proportions. A survey (N=50) of Class C buildings of less than 50 units, conducted last summer by Housing Works, found that

[2] Class C buildings "are typically more than 20 years old and located in less than desirable locations. The property is generally in need of renovation, including updating the building infrastructure to bring it up to date. As a result, Class C buildings tend to have the lowest rental rates in a market with other Class A or Class B properties" (From Realty Mogul: https://www.realtymogul.com/blog/what-does-it-mean-when-a-property-is-class-a-class-b-or-class-c).

[3] As of April 1st, 2014, these affordability standards are: Efficiency - $696; 1 bedroom - $853; 2 bedroom - $1074; 3 bedroom - $1454.

approximately 25% of units surveyed met affordability standards. Therefore, we used the address data obtained from TCAD and multiplied the number-of-units data therein by 0.25 to estimate the number and locations of affordable units in multi-family buildings of less than 50 units. All of the above data came in the form of spreadsheets. We geocoded it ourselves to create point feature-classes. For the purpose of my analysis, it was not necessary to maintain the distinction between these three types of affordable housing stock, so I merged the three feature-classes into one single shape file containing a point for every building in Austin with affordable units. Map 2 shows the locations and sizes (number of units) of the affordable housing stock within the study areas.

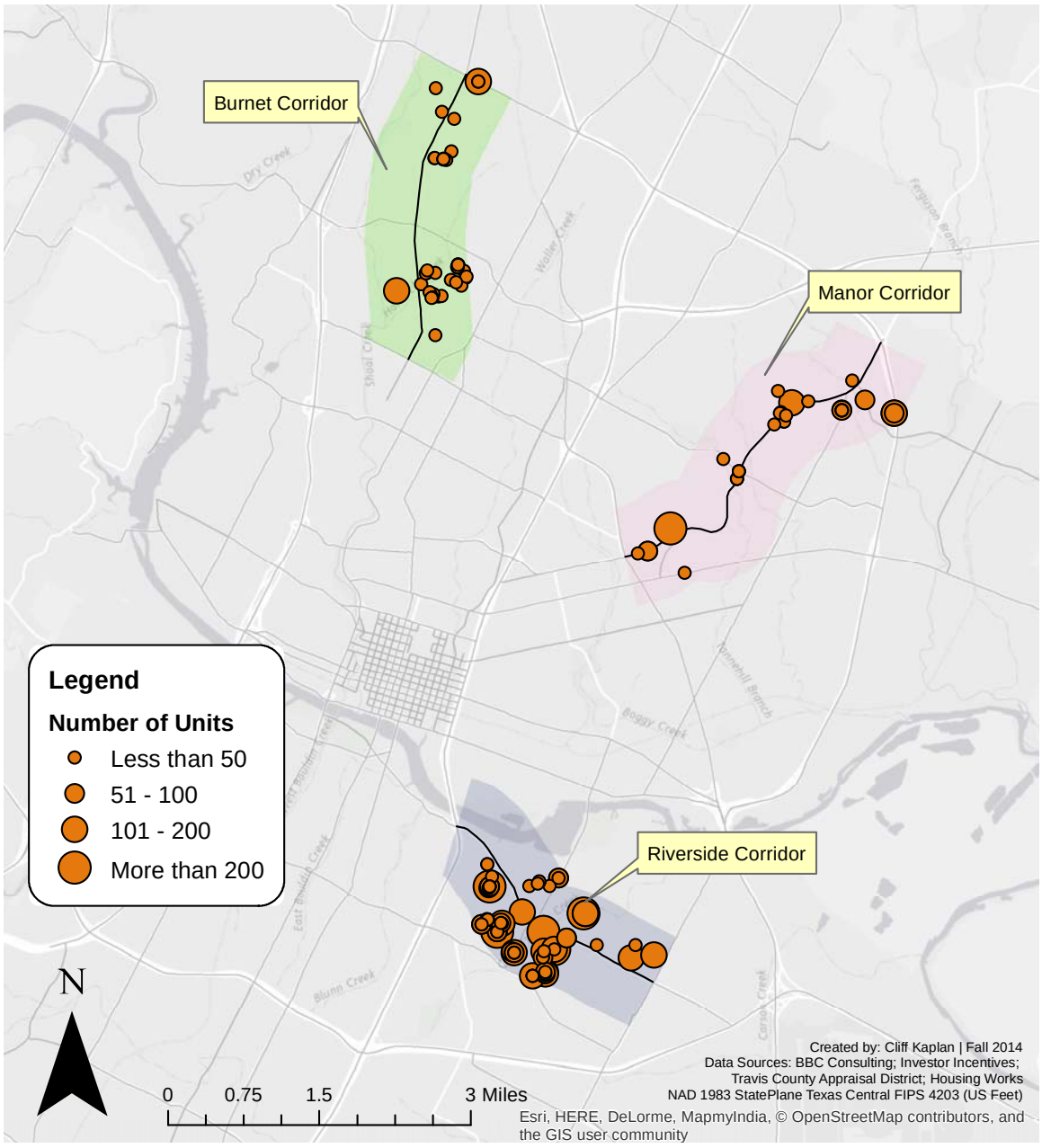
Route data for the public transit system. Although Austin has a rail line used by some commuters, this analysis focuses exclusively on the much more extensive bus system. From CapMetro, we acquired a line feature class containing a line feature for each public bus line. Map 3 shows the full extent of the bus system in Austin, as it relates to the locations of the study areas.

Location data for relevant jobs. From the U.S. Census Bureau website, http://onthemap.ces.census.gov/, I exported a point shape file that has a point for every census block in Austin, with a field that contains the number of jobs within the $15,000 to $40,000 annual pay range. (The data is from 2011). Map 4 shows the spatial distribution of jobs within the $15,000 to $40,000 annual pay range, as they relate to the locations of the study areas.

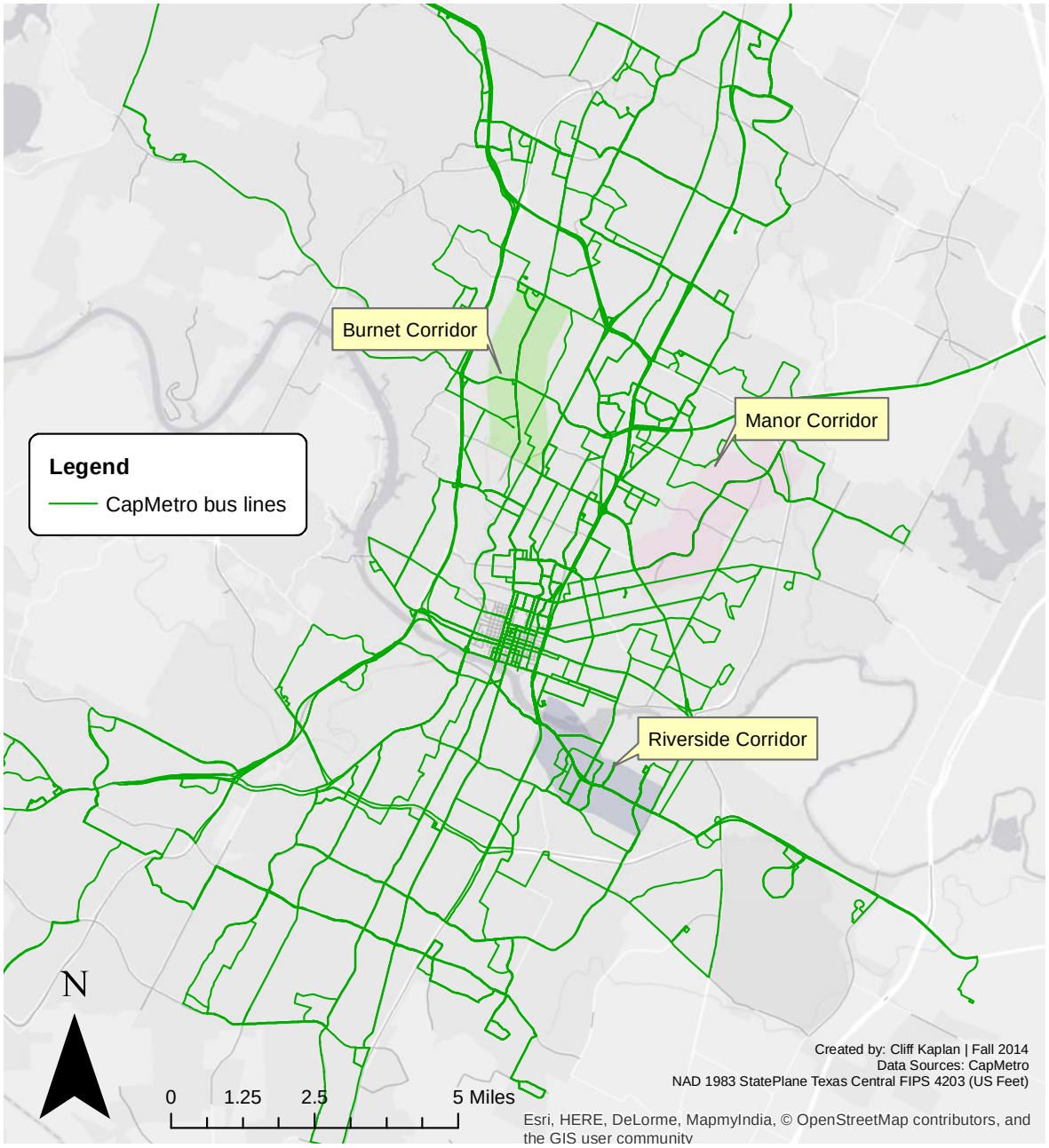
Of the data required for this analysis, the housing stock data was the most complicated to acquire and this will likely be the case anywhere this analysis is

conducted. Transit route data tends to be easy to acquire in cities that have transit systems. The jobs data I used is available for the entire United States.

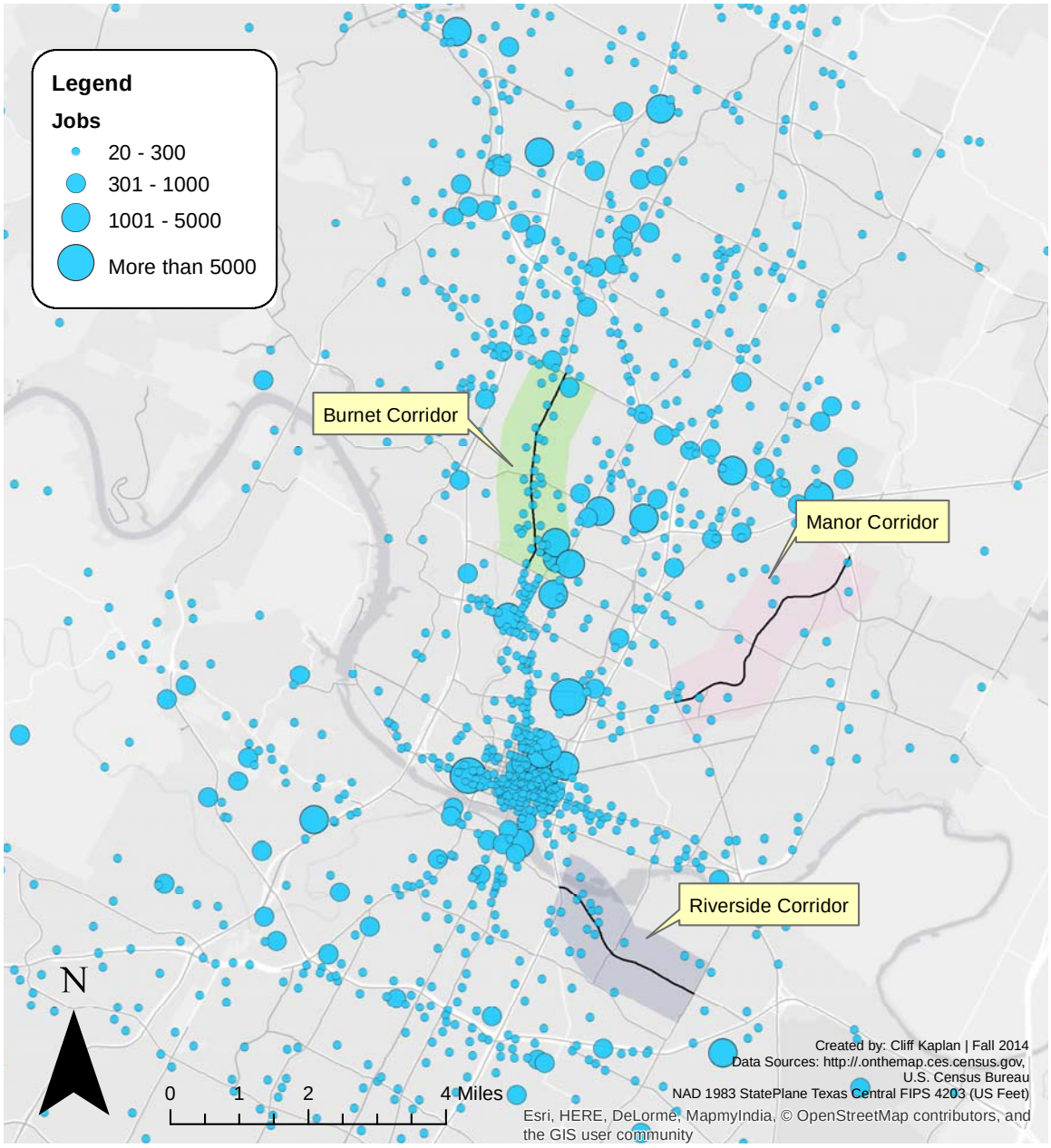
Map 2: The locations and sizes of the affordable housing stock within the study areas



Map 3: The CapMetro bus system in Austin, TX



Map 4: Jobs within the $15,000 to $40,000 annual pay range



Outlining the objectives of the analysis

To accurately describe and compare different corridors in terms of the number of low-paying jobs that are easily accessible by public transit from affordable housing within each corridor, the analysis must consider:

- The bus lines serving each corridor,
- the number of jobs to which those bus lines provide access,
- the frequency with which the buses pass through the corridor, and
- the portion of affordable units with access to each bus line.

Conducting the analysis

The analysis that I have designed is conducted on one corridor at a time, allowing the analyst to compare the results among the corridors at the end.

For clarity, I will describe the step-by-step process of analysis for the Manor corridor. In the Results section, I will provide the results of analysis for all three corridors, along with illustrative maps.

Step 1*: *Identify the bus lines that serve the study area and create a feature class of only those lines.

Use *Select by location* to select from the bus lines layer those lines that intersect the study area. Then, use *Export data* to create a feature class that is only those lines that serve the study area. Use the Attribute Table for this new layer to examine the lines and their relevance to this analysis. In the case of Austin, the bus data does not include information about hours of operation or the bus headways (which correspond to the number of buses on the line at a given time.) For this information, I used bus schedules from the CapMetro website and I manually added

this information to a field I created in the Attribute Table, called Bus_at_RH (Buses at rush hour). I chose to eliminate certain buses that appeared to not be useful for getting to and from work for most people. (For instance, I eliminated UT Shuttle Buses which run to and from the University of Texas campus and are operated by CapMetro for the exclusive use of the university community.)

After deleting the bus lines that are not relevant to this study, there remain six lines that serve the Manor corridor, shown in Map 5.

Figure 1: The Attribute Table containing the six bus lines that serve the Manor Corridor that I included in this study, with the added field for the number of buses that pass during rush hour.

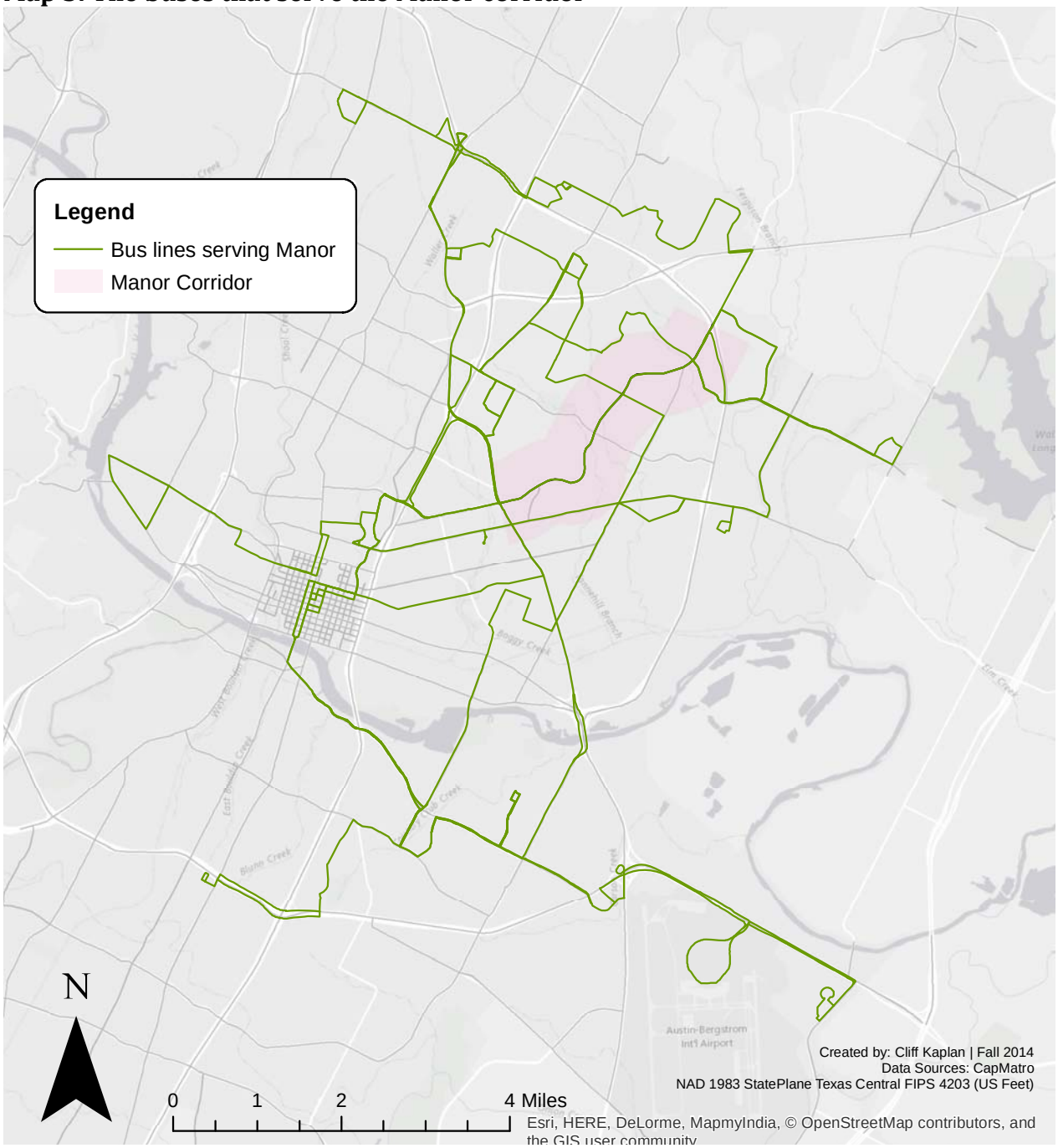
FID	Shape *	LINE_ID	LINE_NAME	Bus_at_RH
0	Polyline	300	300 - GOVALLE	8
1	Polyline	18	18 - MARTIN LUTHER KING	4
2	Polyline	350	350 - AIRPORT BLVD	4
3	Polyline	323	323 - ANDERSON / JOHNNY MORRIS	3
4	Polyline	20	20 - MANOR RD/LBJ HIGH	5
5	Polyline	37	37 - COLONY PARK/WINDSOR PARK	6

Step 2: Count the total number of jobs (in the relevant pay bracket) that are accessible on these bus lines.

Use *Select by location* to select from the jobs layer those jobs (point features) that are within 0.5 miles of the newly created bus line layer.[4] Use the Statistics dialogue box, accessible through the jobs layer Attribute Table to sum the quantity of highlighted jobs. Make a note of this number; it will be used later in the analysis. Map 6 shows the jobs that are accessible by bus from the Manor corridor. It is not

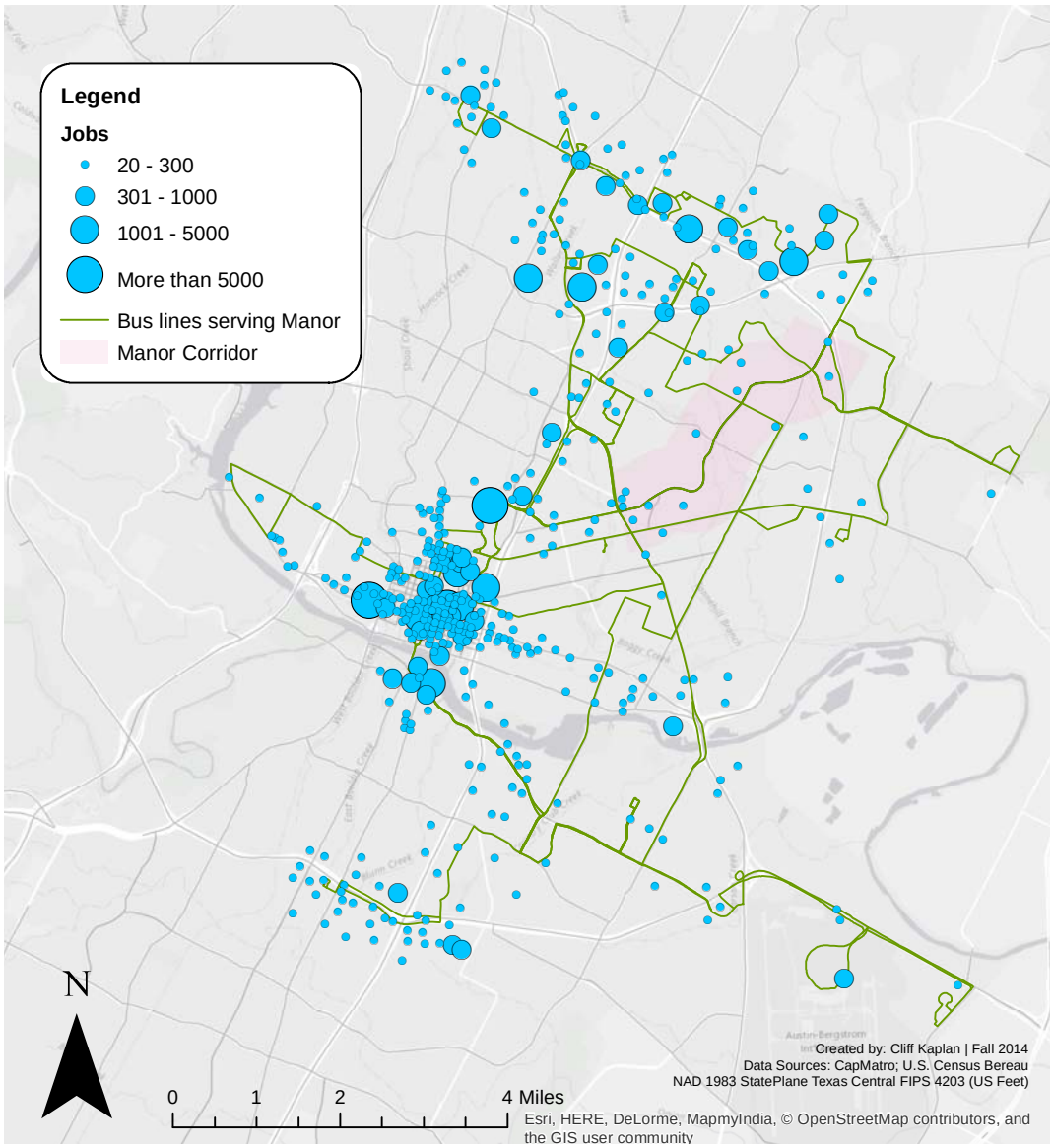
[4] 0.5 miles is a conventional estimate for the distance that people will generally be willing to walk to or from public transport on a daily basis.

Map 5: The buses that serve the Manor corridor



necessary to create a shape file containing only these jobs; the analysis can be done leaving the original jobs shape file intact. I have exported the highlighted jobs to create a "Jobs from Manor" point feature class for the purposes of Map 6, which shows the jobs accessible by transit from the Manor corridor, along with the transit lines.

Map 6: The low-paying jobs accessible by transit from the Manor corridor



From the Manor corridor, there are 97,151 low-paying jobs accessible by bus.

Steps 3, 4, 5, are repeated sequentially for each bus line that serves the study area:

Step 3: Count the number of jobs accessible by bus line X.

Use *Select by Location* to select the jobs within 0.5 miles of bus line X. Use the Statistics dialogue box in the Attribute Table to sum the quantity of highlighted jobs, and make a note of this number. In the Attribute Table for the buses serving the study area, create a field called Jobs and populate it with the number of jobs within the reach of each bus line. Map 7 (as an example) shows bus line #18 along with the 49,808 jobs within 0.5 miles of the bus line. Map 8 (as another example) shows bus line #350 along with the 12,412 jobs within 0.5 miles of that bus line.

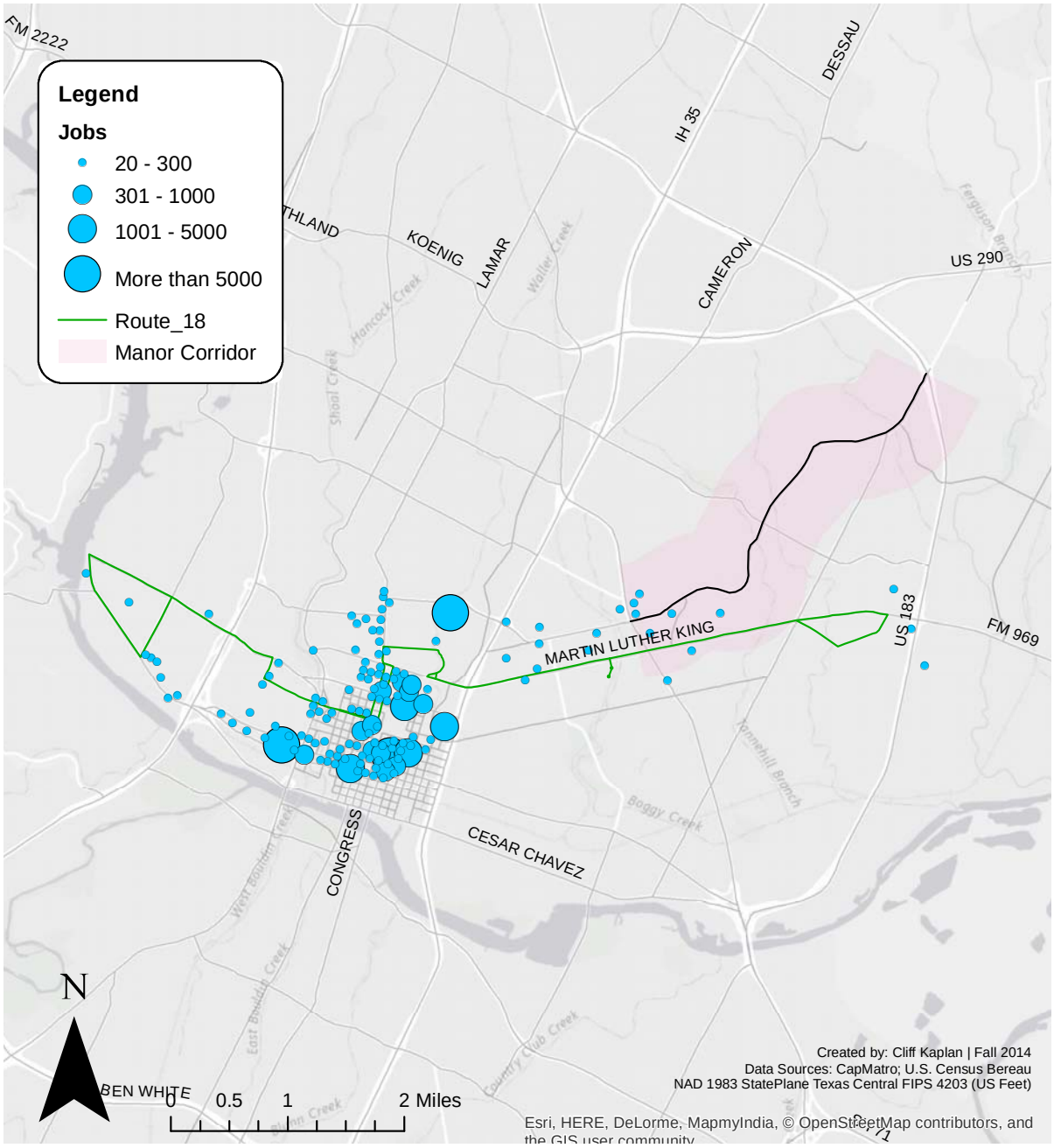
Figure 2: The same attribute table, now with the added "Jobs" field.

FID	Shape *	LINE_ID	LINE_NAME	Bus_at_RH	Jobs
0	Polyline	300	300 - GOVALLE	8	19828
1	Polyline	18	18 - MARTIN LUTHER KING	4	49808
2	Polyline	350	350 - AIRPORT BLVD	4	12412
3	Polyline	323	323 - ANDERSON / JOHNNY MORRIS	3	13902
4	Polyline	20	20 - MANOR RD/LBJ HIGH	5	55590
5	Polyline	37	37 - COLONY PARK/WINDSOR PARK	6	51485

Step 4: Multiply the number of buses at rush hour by the number of jobs on the bus line to create a composite "Usefulness" score.

The number of jobs on the bus line and the frequency of buses are both factors in the "usefulness" of that bus line for commuting. Add a field in the Attribute Table and use the *Field Calculator* to populate the field, multiplying the number of buses at rush hour by the number of jobs reached by the bus line.

Map 7: Jobs accessible from the bus line #18



Map 8: Jobs accessible from the bus line #350

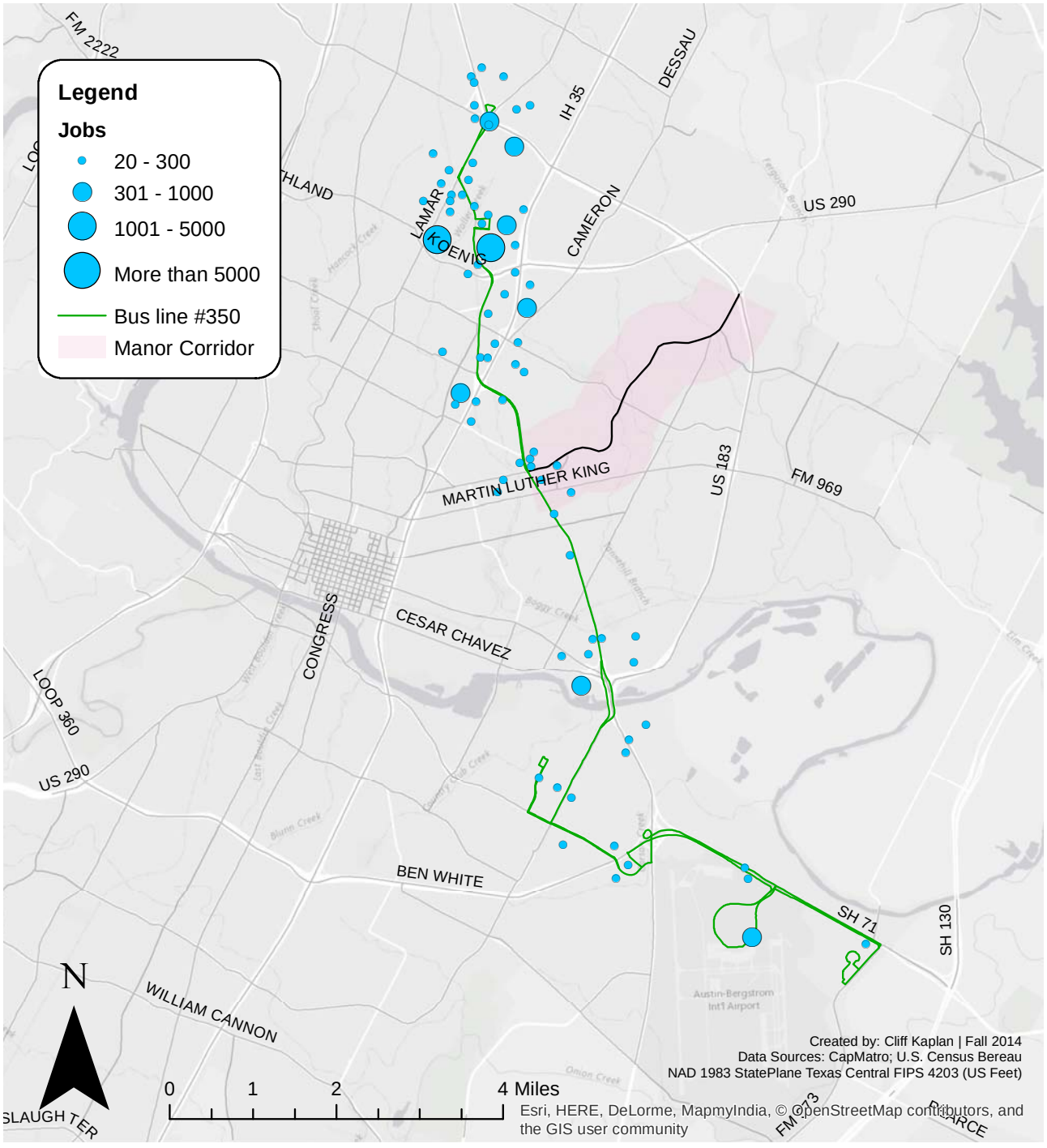


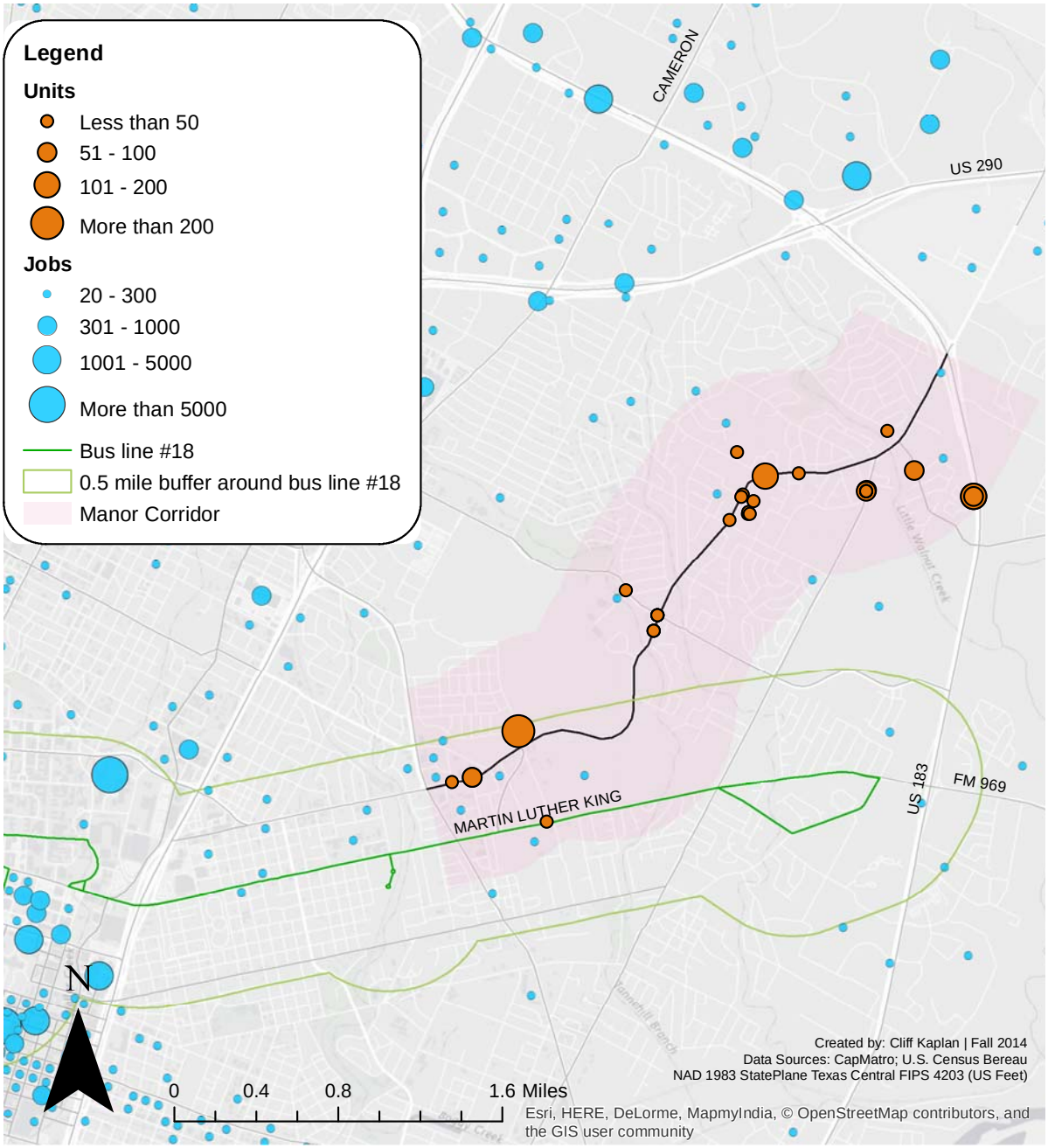
Figure 3: The same attribute table, now with the added "B_x_J" (Bus x Jobs) field, which is an expression of "Usefulness" for commuters.

FID	Shape *	LINE_ID	LINE_NAME	Bus_at_RH	Jobs	B_x_J
0	Polyline	300	300 - GOVALLE	8	19828	158624
1	Polyline	18	18 - MARTIN LUTHER KING	4	49808	199232
2	Polyline	350	350 - AIRPORT BLVD	4	12412	49648
3	Polyline	323	323 - ANDERSON / JOHNNY MORRIS	3	13902	41706
4	Polyline	20	20 - MANOR RD/LBJ HIGH	5	55590	277950
5	Polyline	37	37 - COLONY PARK/WINDSOR PARK	6	51485	308910

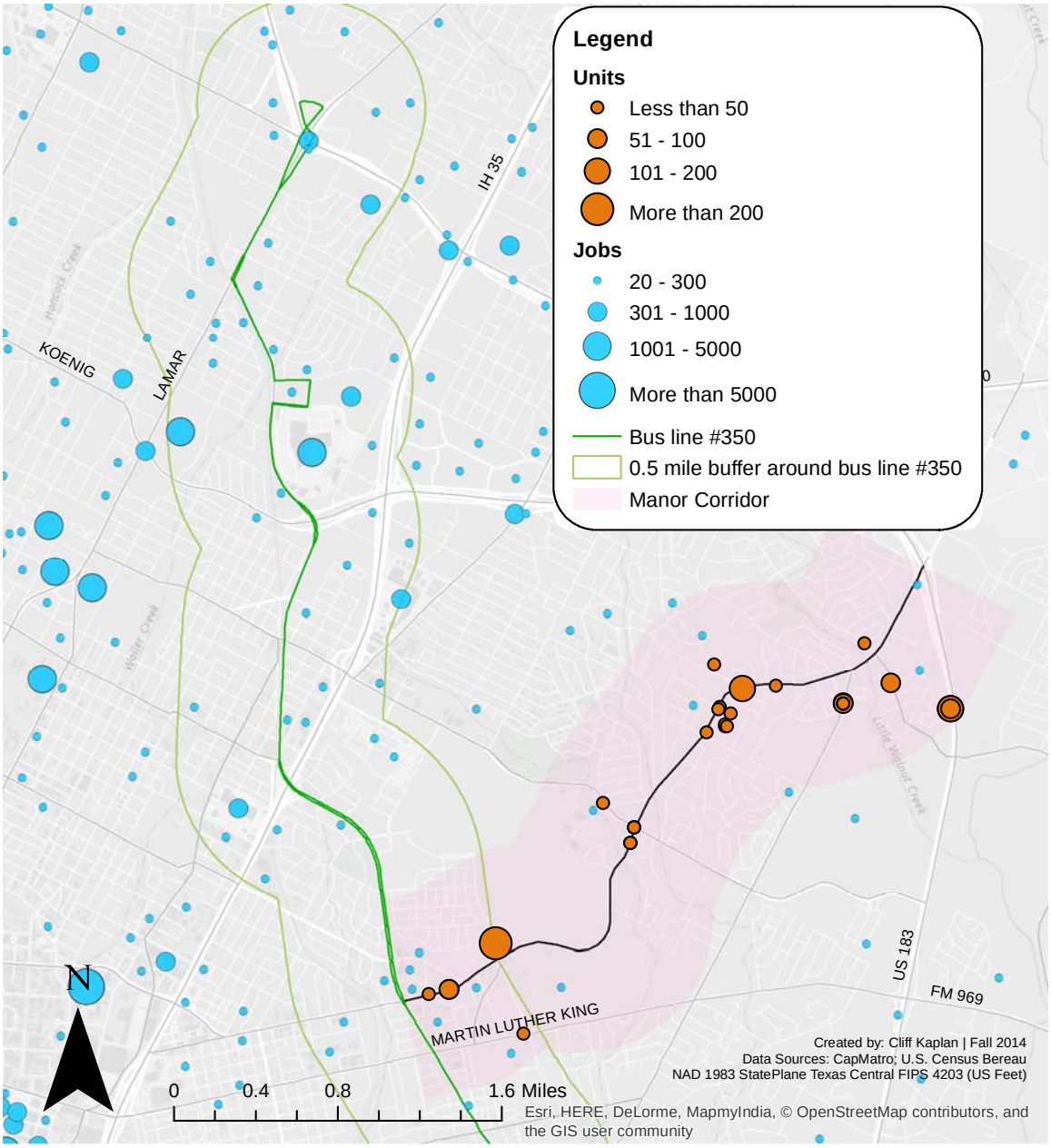
Step 5: Weight each bus line's Usefulness score according to the portion of the study area's affordable housing stock that the bus line serves.

Our interest is in comparing *corridors* by the accessibility to jobs provided to them by public transit. Therefore, the "Usefulness" scores of bus lines that do not serve the entire corridor (which is most bus lines) must be weighted accordingly. As shown in Map 9, for instance, bus line #18 (shown with a 0.5 mile buffer around it) only serves a portion of the affordable housing stock in the Manor corridor. To calculate this portion, use *Select by Location* to select the housing that intersects the study area. Use the Statistics dialogue box in the Attribute Table to sum the number of affordable units in the study area. This will be the denominator in the proportion. For the Manor corridor, this number is 1373.5. (Recall that the housing data includes an estimate that 25% of all units in small Class C buildings are affordable. This explains the possibility of fractions of units in the data.) Now use *Select by Location* to select the housing within 0.5 miles of the bus line. Use the Statistics dialogue box to sum the quantity of selected housing units. This number is the numerator. In the case of bus line #18 passing through the Manor corridor, this number is 373.5. Divide the numerator by the denominator and enter the result into

Map 9: The #18 bus line serves only a portion of the Manor Corridor



Map 10: The #350 bus line serves only a portion of the Manor Corridor



a new field in the attribute table; this is the proportion be which we will weigh the "Usefulness" scores. Bus line #18 is useful to 373.5 / 1373.5 = 0.27, or approximately 27% of the affordable housing in the corridor. Map 10 shows the portion of the Manor corridor that is served by bus line #350.

Figure 4: The same attribute table, now with the added Pn_of_Uts field ("Portion of Units Served"), which will serve as the weights for the "Usefulness" of each bus line.

FID	Shape *	LINE_ID	LINE_NAME	Bus_at_RH	Jobs	B_x_J	Pn_of_Uts
0	Polyline	300	300 - GOVALLE	8	19828	158624	0.34
1	Polyline	18	18 - MARTIN LUTHER KING	4	49808	199232	0.27
2	Polyline	350	350 - AIRPORT BLVD	4	12412	49648	0.13
3	Polyline	323	323 - ANDERSON / JOHNNY MORRIS	3	13902	41706	0.46
4	Polyline	20	20 - MANOR RD/LBJ HIGH	5	55590	277950	1
5	Polyline	37	37 - COLONY PARK/WINDSOR PARK	6	51485	308910	0.57

Repeat Steps 3, 4, and 5 until the Buses at Rush Hour, Jobs, B_x_J (Usefulness), and Pn_of_Unts (the weights) fields have been populated for all of the bus lines.

Step 6: Weigh and sum the "Usefulness" scores

Add a new field to the Attribute Table and use the *Field Calculator* to multiply the "Usefulness" score by the associated weight (representing the portion of units in the corridor that is able to take advantage of the usefulness of that particular bus line).

Figure 5: The same attribute table, now with the added "Weighted Usefulness" field.

FID	Shape *	LINE_ID	LINE_NAME	Bus_at_RH	Jobs	B_x_J	Pn_of_Uts	Wtd_Usflns
0	Polyline	300	300 - GOVALLE	8	19828	158624	0.34	53615.7
1	Polyline	18	18 - MARTIN LUTHER KING	4	49808	199232	0.27	54177.8
2	Polyline	350	350 - AIRPORT BLVD	4	12412	49648	0.13	6235.37
3	Polyline	323	323 - ANDERSON / JOHNNY MORRIS	3	13902	41706	0.46	19312
4	Polyline	20	20 - MANOR RD/LBJ HIGH	5	55590	277950	1	277950
5	Polyline	37	37 - COLONY PARK/WINDSOR PARK	6	51485	308910	0.57	176046

Sum these weighted scores. In the case of the Manor corridor, the sum is 587,336.93.

Step 7: Multiply the study area's Usefulness score sum by the portion of all transit-accessible jobs that are transit-accessible from the study area.

When we added together the weighted Usefulness score for each bus line, we necessarily double counted any jobs that are served by more than one bus line (or triple counted them, etc.). We can imagine a corridor that has transit access to a low number of jobs, but for which there are many buses that come frequently to take commuters to those jobs. If there are many more workers living in the corridor than there are jobs that are accessible from the corridor, it is not as good as having enough jobs for all the workers. We account for this by multiplying the summed Usefulness score for the study area (587,336.93 in the case of Manor) by the portion of all transit-accessible jobs that are transit-accessible from the study area. As we calculated earlier, there are 97,151 jobs that are transit-accessible from the Manor corridor. There are 198,082 jobs accessible by transit city wide, which is calculated by using *Select by Location* to select all of the jobs within 0.5 miles of the entire bus system and using Statistics in the Attribute Table to sum the number of jobs in the relevant pay range. Therefore, the final score for the Manor corridor is 587,336.93 x [97,151 / 198,082] = **288,064.39.**

This score is a composite of the number of accessible jobs from each bus line multiplied by the number of buses running on the line, weighted for the extent to which the line serves the affordable units in the corridor, and the total number of jobs accessible by transit from the corridor. Therefore, the final score is best understood as an index useful for comparing corridors to one another, but without an easily graspable meaning in its own right.

Results

I conducted the analysis described above on the Manor, Burnet, and Riverside corridors. The following tables show the resulting numbers.

Figure 6: Calculation of results for the Manor corridor

Line	Buses during rushhour	X	Jobs	X	Number of units served	÷	Number of units in corridor	=	Job Access
300	8		19828		464.25		1373.50	0.34	53615.72
18	4		49808		373.5		1373.50	0.27	54177.76
350	4		12412		172.5		1373.50	0.13	6235.37
323	3		13902		636		1373.50	0.46	19311.99
20	5		55590		1373.5		1373.50	1.00	277950.00
37	6		51485		782.75		1373.50	0.57	176046.09
					Sum of weighted Usefulness Scores			**=**	**587,336.93**

587,336.93 X (97,151 jobs on the Manor bus lines / 198,082 jobs on complete bus system) = **FINAL CORRIDOR SCORE** 288,064.39

Figure 7: Calculation of results for the Burnet corridor

Line	Buses during rushhour	X	Jobs	X	Number of units served	÷	Number of units in corridor	=	Job Access
3	4		79829		417.25		417.25	1.00	319,316.00
5	5		73552		405.75		417.25	0.97	357,624.01
19	3.5		50520		295.5		417.25	0.71	125,225.43
325	5.5		13331		172.25		417.25	0.41	30,268.32
323	3.5		13904		172.25		417.25	0.41	20,089.57
1	5		71236		62.75		417.25	0.15	53,565.72
320	3.5		18960		62.5		417.25	0.15	9,940.08
803	9		79829		417.25		417.25	1.00	718,461.00
					Sum of weighted Usefulness Scores			**=**	**1,634,490.13**

1,634,490.13 X (144,894 jobs on the Burnet bus lines / 198,082 jobs on complete bus system) = **FINAL CORRIDOR SCORE** 1,195,604.92

Figure 8: Calculation of results for the Riverside corridor

Line	Buses during rushhour	X	Jobs	X	Number of units served	÷	Number of units in corridor	=	Job Access
331	8.5		7357		3630.5		5382	0.67	42,183.48
300	6		19828		4351		5382	0.81	96,177.96
350	9		12412		352		5382	0.07	7,306.06
100	4		52814		5382		5382	1.00	211,256.00
4	5		42722		352		5382	0.07	13,970.78
311	4		4203		352		5382	0.07	1,099.56
7	8		71214		2868		5382	0.53	303,592.35
20	5		55590		5382		5382	1.00	277,950.00
320	4		18960		5030		5382	0.93	70,879.82
							Sum of weighted Usefulness Scores	=	1,024,416.00

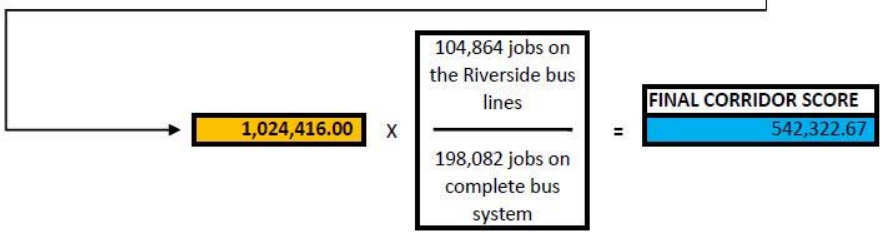


Figure 9: A summary of the final scores

Corridor	Final Score	Actual number of accessible jobs
Manor	**288,064.39**	**97,151**
Burnet	**1,195,604.92**	**198,082**
Riverside	**542,322.67**	**104,864**

Analysis

According to this geospatial analytical method, affordable housing in the Burnet corridor has slightly more than two times as much accessibility via transit to low-paying jobs in Austin as does affordable housing in the Riverside corridor, and slightly more than four times as much as that in the Manor corridor. That result is made more interesting by the observation that those relationships are not mirrored

by the actual number of jobs accessible by transit from each corridor. For instance, the Manor corridor's final accessibility score is only 47% less than that of the Riverside corridor. However, the actual number of jobs accessible by transit from Manor is only 7% less than the number of jobs accessible by transit from Riverside.

The disparity between the final accessibility scores for these two corridors is largely explained by the fact that the Riverside corridor has much higher volumes of bus traffic. 30 buses typically pass through the Manor corridor during rush hour, while 54 typically pass through the Riverside corridor, according to CapMetro bus schedules. This disparity is exacerbated by the fact that, on average, buses passing through the Manor corridor only run within an easy walk (0.5 miles) of 46% of the affordable units in the corridor, while that figure is 57% in the Riverside corridor.

But what accounts for the Burnet corridor's score being twice that of the Riverside corridor? Typically, 39 buses pass through the Burnet corridor during rush hour, 20% fewer than pass through the Riverside corridor. Nor is coverage remarkably better in the Burnet corridor than it is in the Riverside corridor; the average bus passing through the Burnet corridor is accessible to 60% of the affordable units therein, compared to 57% in the Riverside corridor.

The difference in accessibility between the Burnet corridor and the Riverside corridor appears to be explained by where the buses go. The average number of jobs accessible from a bus that passes through the Burnet corridor is 50,145 whereas the average number of jobs accessible from a bus that passes through the Riverside corridor is 31,678, 37% fewer. The "Usefulness" scores for the average bus lines that

pass through the Burnet and Riverside corridors respectively are 265,860 and 184,266; Riverside's score is 31% lower than Burnet's.

According to these observations, it appears that Manor's low accessibility score is caused by infrequent buses and a selection of buses that travels to a relatively low number of jobs (97,151), while Burnet's high accessibility score is caused by the fact that each bus serving the Burnet corridor tends to travel to many more jobs than do the buses serving the other corridors, and together the Burnet buses reach many more jobs (144,894) than do the buses serving the other corridors. Maps 11a, 11b, and 11c show the affordable housing stock in each study corridor, as it relates to bus lines of varying "Usefulness."

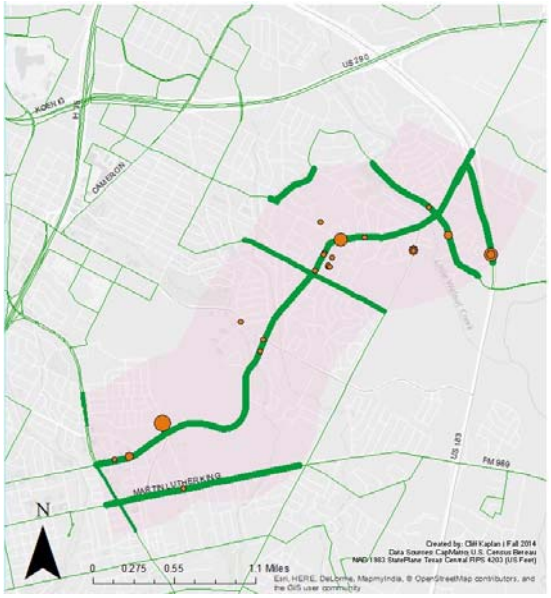
Future work and conclusion

Continued development of this analytical method is warranted. Conceptually, many of the measures used to compare the corridors to one another ("Usefulness," for example) are not as clear as they might be, in part due to their composite natures. It will be worthwhile to find ways of combining the data that captures the variation but is more intuitive to interpret. Technically, this method is time consuming; its iterative nature (repeating several steps for each bus line in each corridor) ought to make it automatable using Model Builder. I will likely pursue both conceptual and technical streamlines, as I continue to use this method for the Green and Inclusive Corridors project. Thus far, the analysis shows that there are several factors that can cause a corridor's housing stock to have more or less transit access to job opportunities, and that these factors affect different corridors in different ways. Planners seeking to preserve affordable housing with high

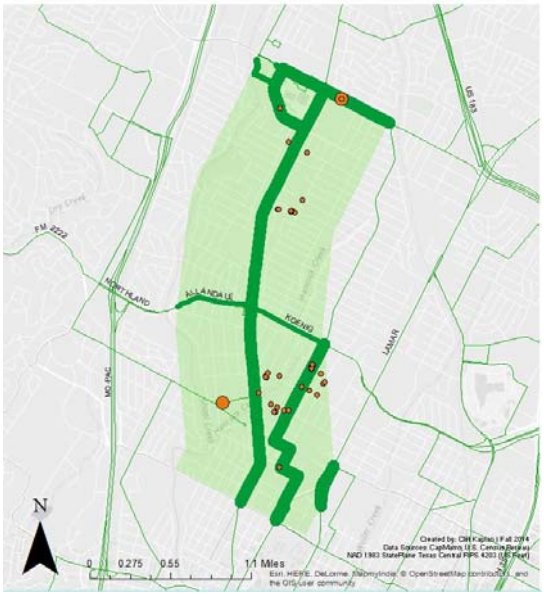
accessibility to work, or those seeking to improve accessibility where it is low, can use this analytical method to diagnose problems and strategize for solutions.

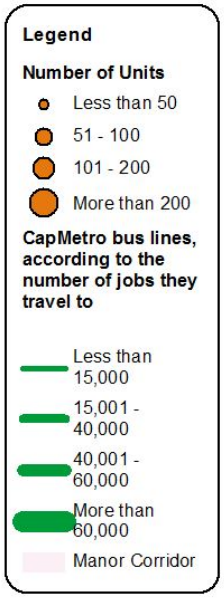
Maps 11a, 11b, and 11c: The affordable housing stock in each study corridor, as it relates to bus lines of varying "Usefulness." The thickness of the bus line indicates the number of jobs that are accessible from that line.

Map 11a: Manor

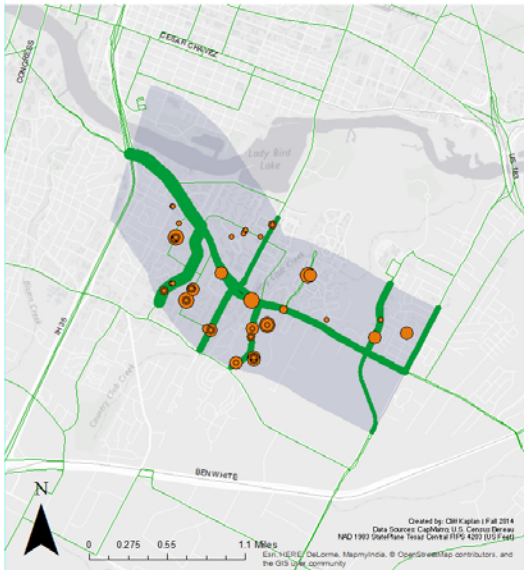


Map 11b: Burnet





Map 11c: Riverside



List of Maps

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