

Using GIS to analyze Spatial and Temporal Trip Patterns and Location of MetroLift Patrons in Harris County, Texas



Subrity Rajbhandari - PhD student, Texas Southern University
Dr. Lalita Sen - Professor, Texas Southern University



Using GIS to analyze Spatial and Temporal Trip Patterns and Location of MetroLift users in Harris County

Why do the analysis?

- Ø Senior/Disabled population is expected to increase in Harris County and surrounding areas- expected increase in MetroLift demand
- Ø Funds are limited- No major increase in Budget since 2009
- Ø Metrolift needs to use its resources wisely
- Ø This analysis can help Metrolift optimize their services by better understanding their customers and their trip behaviors in Harris County
- Ø GIS is an ideal tool to perform the analysis
 - Adds the spatial component along with other analytical capabilities
 - Helps to visualize the problem spatially
 - Provides spatial statistical tool along with modeling

Presentation Content

Ø *Basic facts about MetroLift - Data Source*

Ø *Analysis 1: Spatial Pattern Analysis of the MetroLift Patrons*

- Where do Metro lift users reside? Do block group characteristics reflect the demand of MetroLift?

Ø *Analysis 2: Temporal Pattern analysis of trips based on Activity type of the MetroLift users using the data of October 2013*

- When and how many trips are being made ?
- What types of trips are being made?
- When are these different trips being made?

Ø *Analysis 3: Spatial Analysis of trips based on the activity and frequency*

- Where are the trips going?

Ø *Conclusion and Future Direction*



MetroLift Basic

What is MetroLift? Who is Eligible ?

Ø Complementary paratransit service by the Metropolitan Transit Authority - in compliance with 1990 Americans with Disabilities Act



Ø Healthcare professionals certificate required- METRO makes the final eligibility decision



Ø Provides transportation for persons with disabilities who cannot access fixed route due to limitations preventing them from walking or rolling to a bus stop

Source: Presentation by Art Jackson, Senior Director; METROLift Serving the People of Houston, APTA Conference, Memphis, Tennessee, May 25, 2011

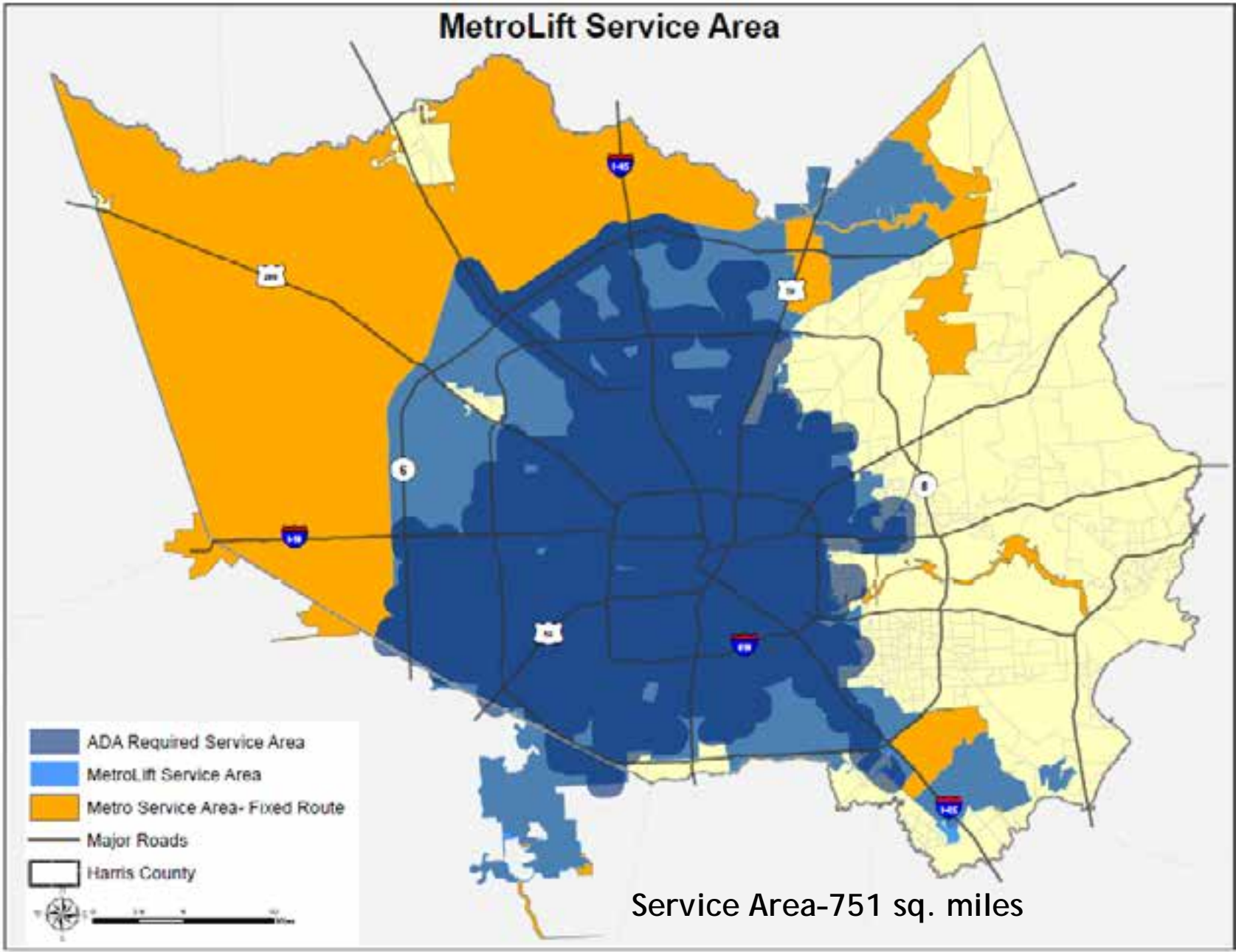
Ø Vehicles Types - 118 First Transit & 200 Yellow Cab: Other Service Modes: Taxicab Backup & MetroLift Subsidy Program (MSP)

Ø Hours of Operation- 7 days a week from 3:45 am to Last Trip Originating at 1:30 am

Ø Fare : Single ticket - \$1.15; 10-ride book - \$9.75; Monthly Pass - \$38.60; Annual Pass - \$347.00

Ø Total Eligible Patrons (as of Dec 2013) = 16,974: Average Trips per weekday = 5000+

MetroLift Basic



Data Sources

Ø *METRO-Lift division*



- Trips - Combined total pickup and/or drop-off trip data for October 2013
- List of customer addresses for December 2013
- Entire MetroLift Service Area

Ø *Houston Galveston Area Council (HGAC)*



- 2010 Parcel Data with Land use classification
- Major Roads, City Boundary, Hospitals, Schools, Grocery Stores, Water features and Boundaries

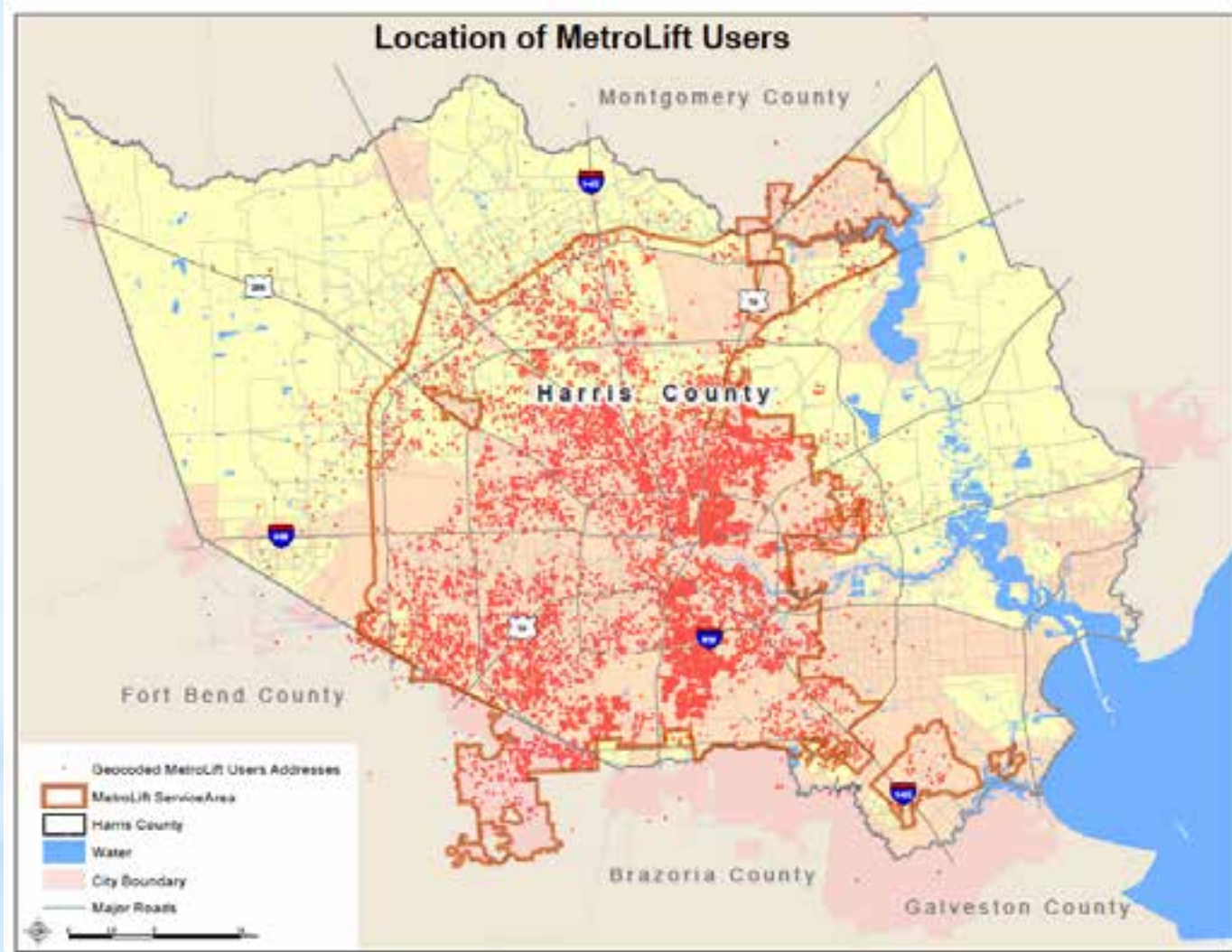
Ø *Census.gov/acs (2008-2012)*



- Several Block Group data - American Community Survey 2008-2012

Analysis 1 : Spatial Pattern Analysis

The Residential Location of MetroLift Patrons



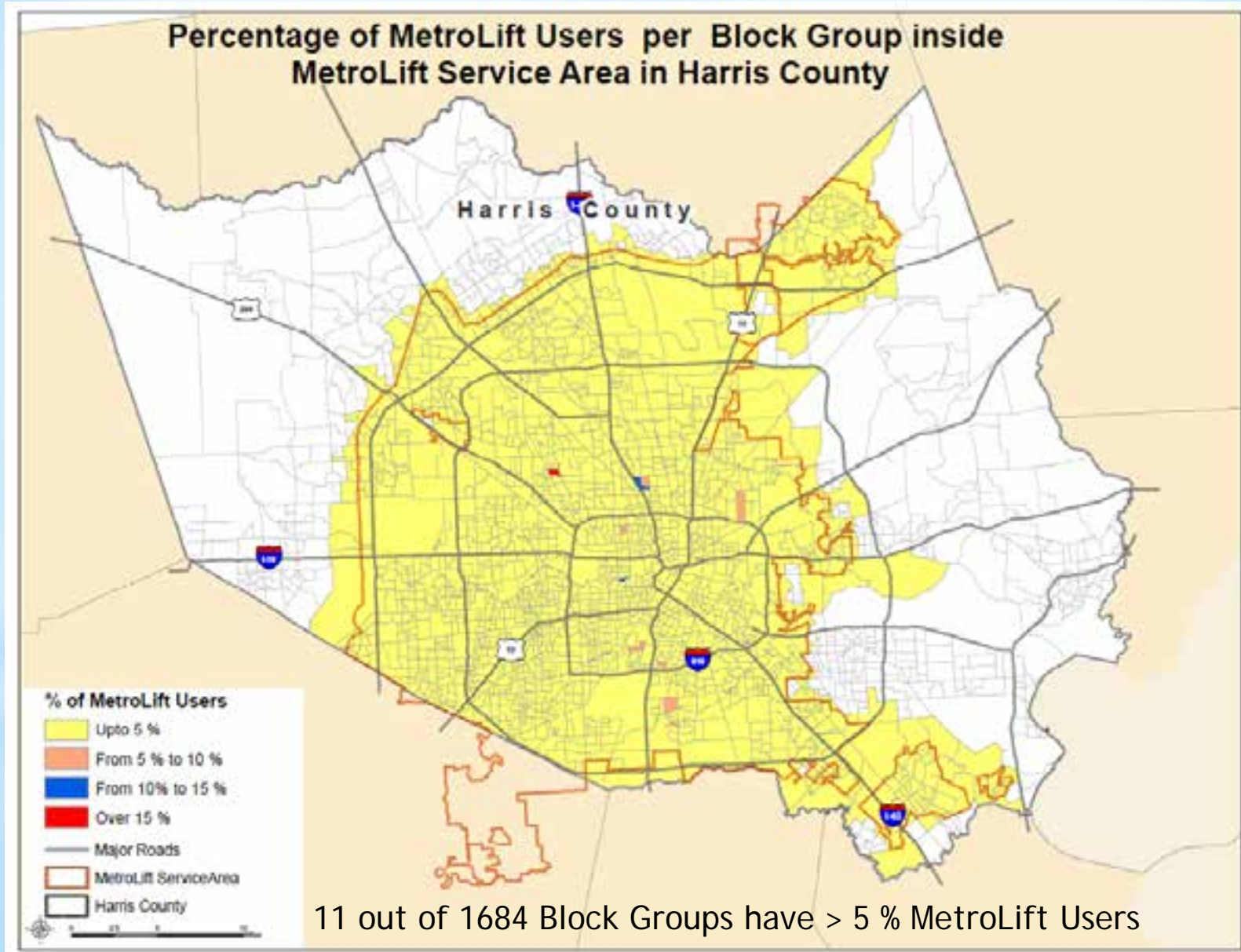
Ø Total MetroLift Users based on Dec 2013- **16,973**

Ø Users inside Harris County- **16,500**

Ø Users inside Harris County and MetroLift Service Area - **15,906**

Analysis 1 :Spatial Pattern Analysis

Percentage of MetroLift Users at the Block Group Level



Analysis 1: Spatial Pattern Analysis

Characteristics of those Block Groups with Highest percentage of Metrolift Users

MetroLift Users (% of BG pop.)	Zip Code	Total Households	Total Population	% Disable over 18 years	% Male over 50 years	% Female over 50 years	% White	% Black	% Household Income below Poverty level	% Household Without Vehicle
20.70	77091	242	343	45.19	9.62	58.31	50.15	37.61	34.30	75.21
14.29	77019	10	168	83.33	29.76	26.79	76.79	14.88	0.00	0.00
13.18	77022	806	1426	40.04	29.10	28.12	79.52	19.07	31.39	61.54

Ø *Block Groups with Highest percentage of Metrolift Users*

- High percentage of Disabled over 18 years
- High percentage of household without vehicles

Ø *Based on the information from Metrolift*

- 79% of users are 50 years and over
- 70% female responded to the customer satisfaction survey

Analysis 1 : Spatial Pattern Analysis

Do block group characteristics reflect the demand for MetroLift?

Methods used for Analysis

- Ø Geocoded the Residential addresses - Only selected the Residences inside Metrolift Service Area in Harris County
- Ø Used *Spatial Join* to combine the Geocoded results with Block Group data of Harris county to obtain the Number of Residences by Block Group
- Ø Based on the data availability at Block Group level for ACS 2008-2012 -Joined several Block Group Data to use as Explanatory variables
- Ø Used Exploratory Regression and Ordinary Least Square (OLS) Regression data to explore the relationship between percentage of metroflit users and block group characteristics

Analysis 1: Spatial Pattern Analysis

Exploratory Regression: What are different Block Group characteristics related to MetroLift Demand?

Dependent Variable				
Percent of MetroLift Residences (Number of MetroLift Users per Block Group/Total Population of Block Group (BG))				
Explanatory Variables				
Disability	Income	Age	Race	Vehicle Availability
+ Percent of Disable Population 18 years and over	+ Percent of Householder between 45 to 64 years that has income below poverty level in past 12 months	Percent of Total male over 65 years	Percent of White Alone	+ Percent of Household without vehicle
Percent of Disable Population 65 years and over	+ Percent of Householder 65 and over that has income below poverty level in past 12 months	Percent of Total male over 50 years	+ Percent of African American alone	Percent of Household with one or more vehicle
Percent of Male Disabled and unemployed population between 16 to 64 years		Percent of Total Female over 65 years	Percent of Asian alone	
Percent of Female Disabled and unemployed population between 16 to 64 years		Percent of Total female over 50 years	American Indian & Alaskan Native Alone	
Percent of Female Disabled and employed population between 16 to 64 years			Native Hawaiian & Pacific Islander Alone	
			Some Other Race Alone	

Highlighted Variables are significant- P -Value < 0.05

Analysis 1: Spatial Pattern Analysis

Ordinary Least Square Regression (OLS) for the significant variables

1. OLS Equation

% Metrolift Users = % Disable18yrs & over + % Black+ % Householder 65 years over & below poverty Level + % Household without vehicle

OLS Diagnostics			
Input Features:	RegressionDataResidence	Dependent Variable:	PCTRESIDENCE
Number of Observations:	1463	Akaike's Information Criterion (AICc) [d]:	-9965.891982
Multiple R-Squared [d]:	0.505912	Adjusted R-Squared [d]:	0.503535
Joint F-Statistic [e]:	212.831502	Prob(>F), (7,1455) degrees of freedom:	0.000000*
Joint Wald Statistic [e]:	741.449697	Prob(>chi-squared), (7) degrees of freedom:	0.000000*
Koenker (BP) Statistic [f]:	189.267168	Prob(>chi-squared), (7) degrees of freedom:	0.000000*
Jarque-Bera Statistic [g]:	763196.150869	Prob(>chi-squared), (2) degrees of freedom:	0.000000*
Notes on Interpretation			
* An asterisk next to a number indicates a statistically significant p-value ($p < 0.05$).			

2. Key Results

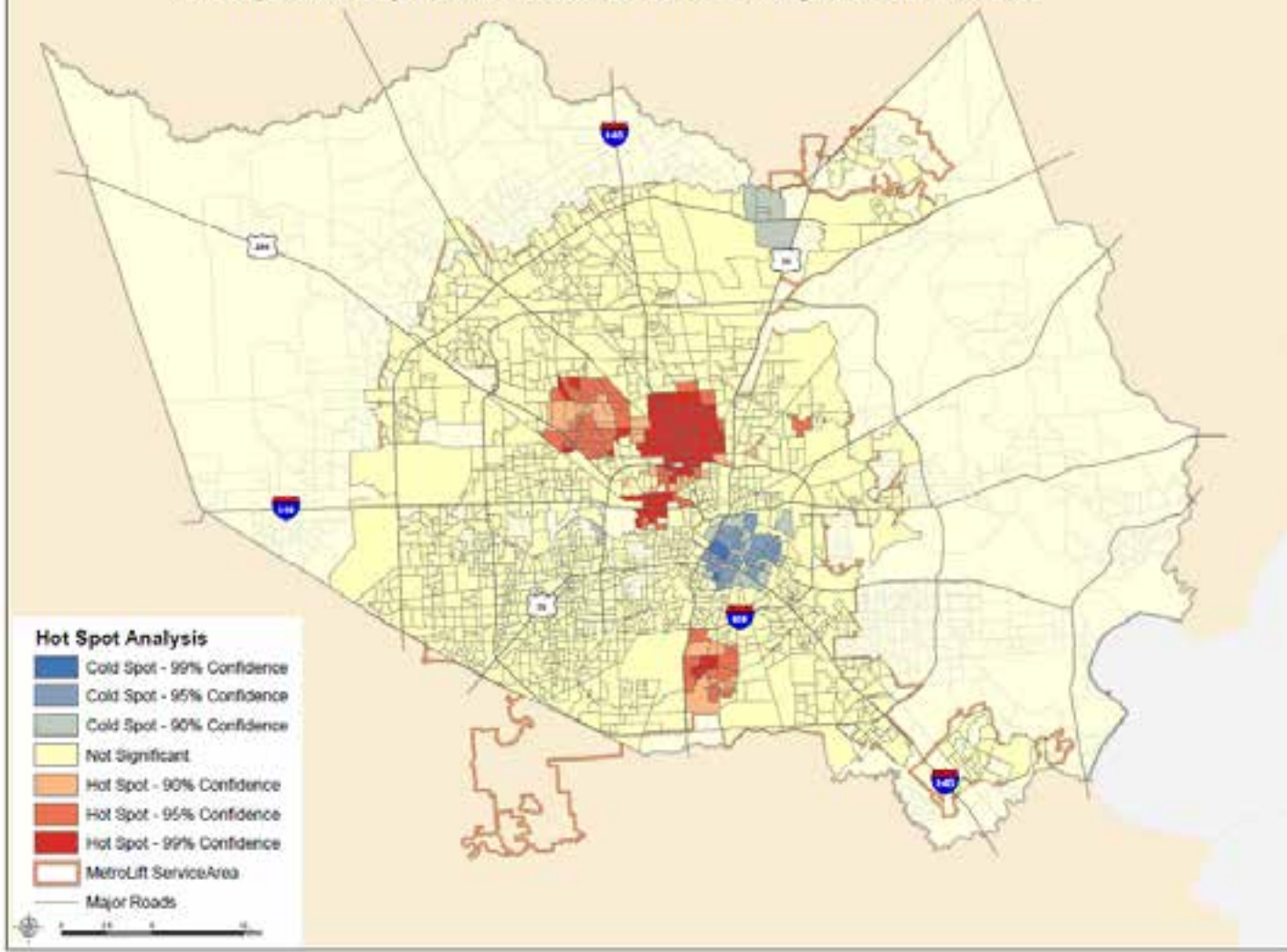
Ø Adjusted R-Square around 50%

Ø Significant Koenker statistic -Significant Jarque-Bera statistic - relationship is non-stationary- result can be improved by using some spatial regression - residue is not normally distributed - hence not valid

Analysis 1: Spatial Pattern Analysis

Analysis of OLS Results

HotSpot Analysis of Residue of the Regression Model



3. Analysis of Results

∅ *Spatial Autocorrelation of Residue*- statistically significant

∅ *Hot Spot Analysis on Regression Residue (BGL):*

- Red area - over performance
- Blue area- under performance

Regression Model:

$\% \text{ Metrolift Users} = \% \text{ Disable 18yrs \& over} + \% \text{ Black} + \% \text{ Householder 65 years over \& below poverty Level} + \% \text{ Household without vehicle}$

Analysis 1: Spatial Pattern Analysis of MetroLift Patrons

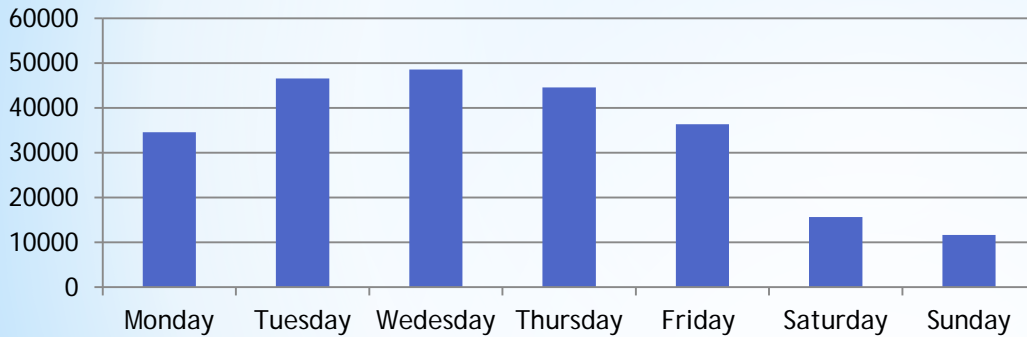
Future steps for Analysis 1

- Ø Explore other spatial models- such as Geographically Weighted Regression (GWR)
- Ø Identify additional significant variables from additional analysis
- Ø **Analysis 2:** Temporal Pattern analysis of trips based on Activity type of the MetroLift users using the data of October 2013
 - When and how many trips are being made ?
 - What types of trips are being made?
 - When are these different Activity Trips being made?
- Ø **Analysis 3:** Spatial Analysis of trips based on the activity and frequency
 - Where are the trips going?

Analysis 2: Temporal Trip Pattern Analysis of the MetroLift Patrons

When and how many trips are being made ?

Number of Trips By Day

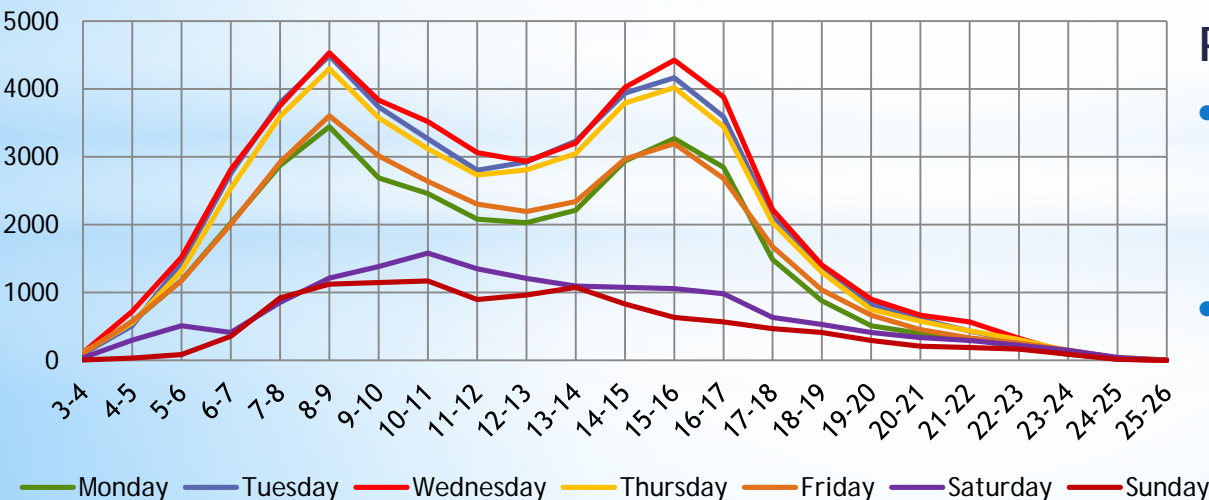


Total Trips= 237, 869

Peak Day for the Trips

- Tuesdays, Wednesdays and Thursdays are peak days for the trips

Number of Trips by Time



Peak Period for Seven days

- Weekdays Peak Period: 8-9 am and 3-4 pm
- Saturday= 10-11 am & Sunday= 10-11am & 1-2 pm

Analysis 2: Temporal Trip Pattern Analysis on Activity Type

What types of trips are being made?

Number of Trips by Activity Type



Methods used for Analysis

- Ø Geocoded the trip addresses - Created 50 feet Buffer
- Ø Spatial Join the Buffer with the Parcel data
- Ø Based on the land use code of the parcel, Activity types were classified
- Ø Used Summary Statistic and Pivot table to obtain a table that have frequency of the trips by Activity type, Time of a day and Day of a week - Graphed the results

Analysis 2: Trip Pattern Analysis by Days of the Week

When are these different Activity Trips being made?

Number of different Activity Trips based on days

Day	Education	Medical	Religious	Shopping	Work	Residential	Leisure
Monday	1034	965	1173	12212	3403	14172	680
Tuesday	1523	1310	1544	16471	4507	19632	942
Wednesday	1472	1278	2014	17041	4572	20599	998
Thursday	1460	1170	1362	15838	4327	18935	861
Friday	1016	921	1031	13239	3533	15433	737
Saturday	340	128	741	6304	1050	6411	369
Sunday	266	59	1430	3575	607	5322	234
Total trips	7111	5831	9295	84680	21999	100504	4821

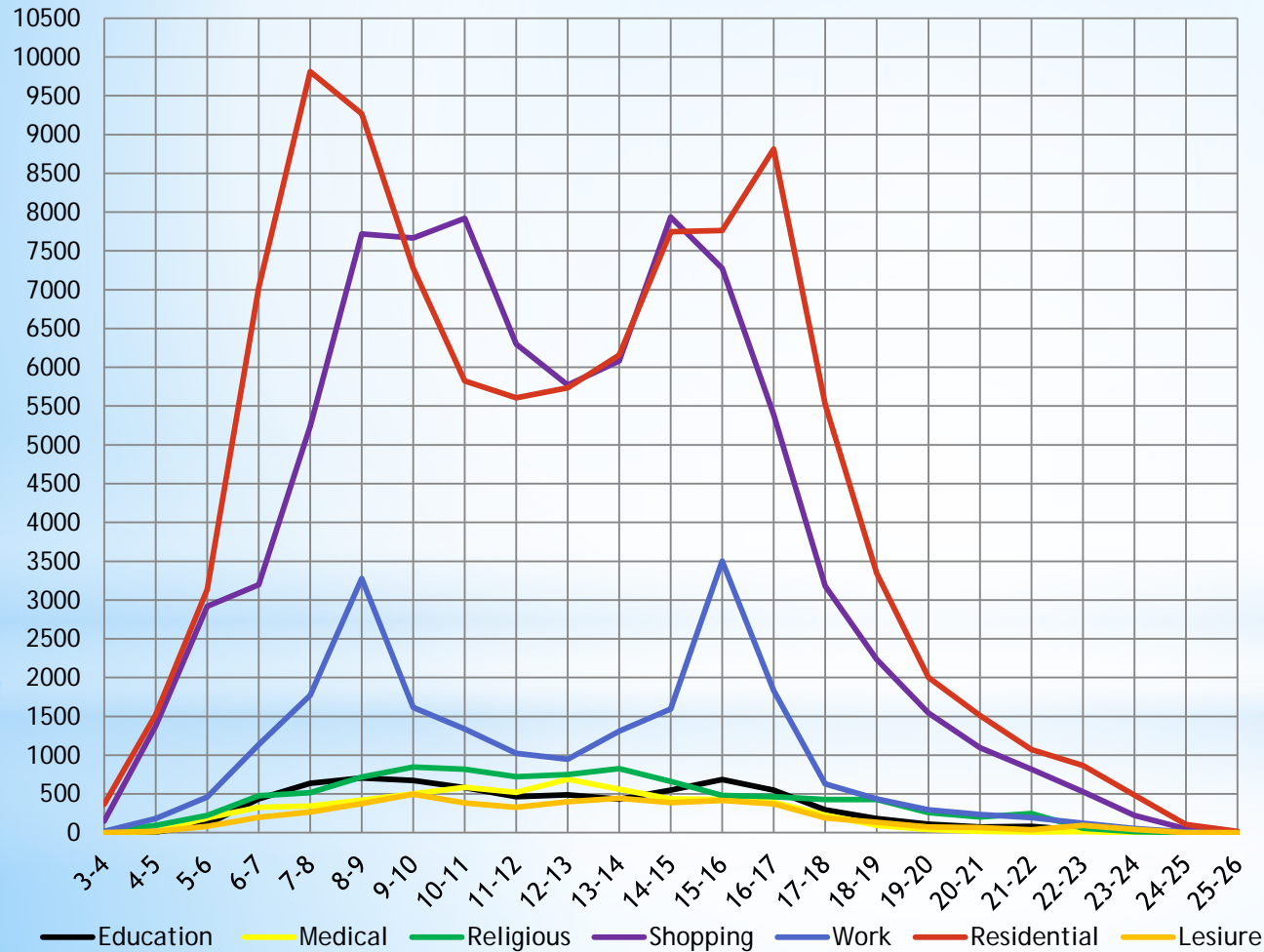
Ø Highest Number of Education and Medical trips - Tuesday

Ø For all other Activity Types- Peak day is Wednesday

Analysis 2: Trip Pattern Analysis by Time

At What times are these different Activity Trips being made?

Number of Trips based on Activity by time of a day



Peak Time varies by trip type

- ∅ Education Trips : 8-9 am
- ∅ Medical Trips : 12pm -1pm
- ∅ Religious Trips: 9-10am
- ∅ Shopping Trips: 2 pm- 3 pm
- No distinct Peak
- ∅ Work Trips : 3 - 4pm
distinct peak
- ∅ Residential Trips: 7-8 am
and 4-5 pm- distinct peak
- ∅ Leisure Trips: 8-9 am and
1-2 pm- less distinct peak

Analysis 3: Spatial Analysis of Trips by Activity and Frequency

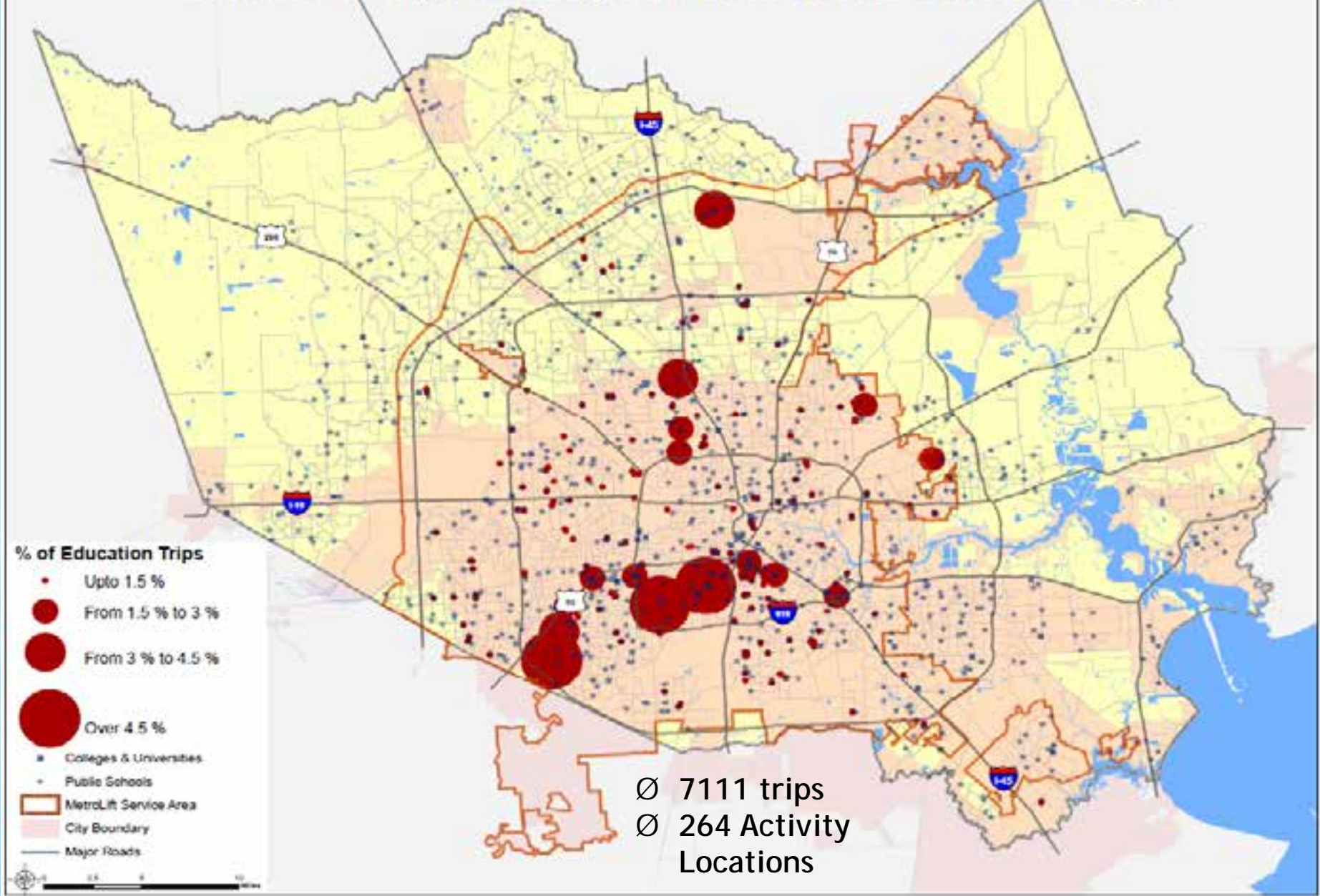
Next question is: *Where are the trips going?*

Methods used for Analysis

- Ø Geocoded trips - Buffer - Spatial Join with Parcel data
- Ø Based on the land use code of the parcel, Activity types were classified
- Ø Used Summary Statistics and Frequency Tools to create feature class that has the attributes which include location of the trips, and the frequency of each activity
- Ø Used Field Calculator to calculate Concentration (%) of trips - (Frequency of trips in the location/ total number of trips in that category)
- Ø Using Symbology- mapped the location of different activities

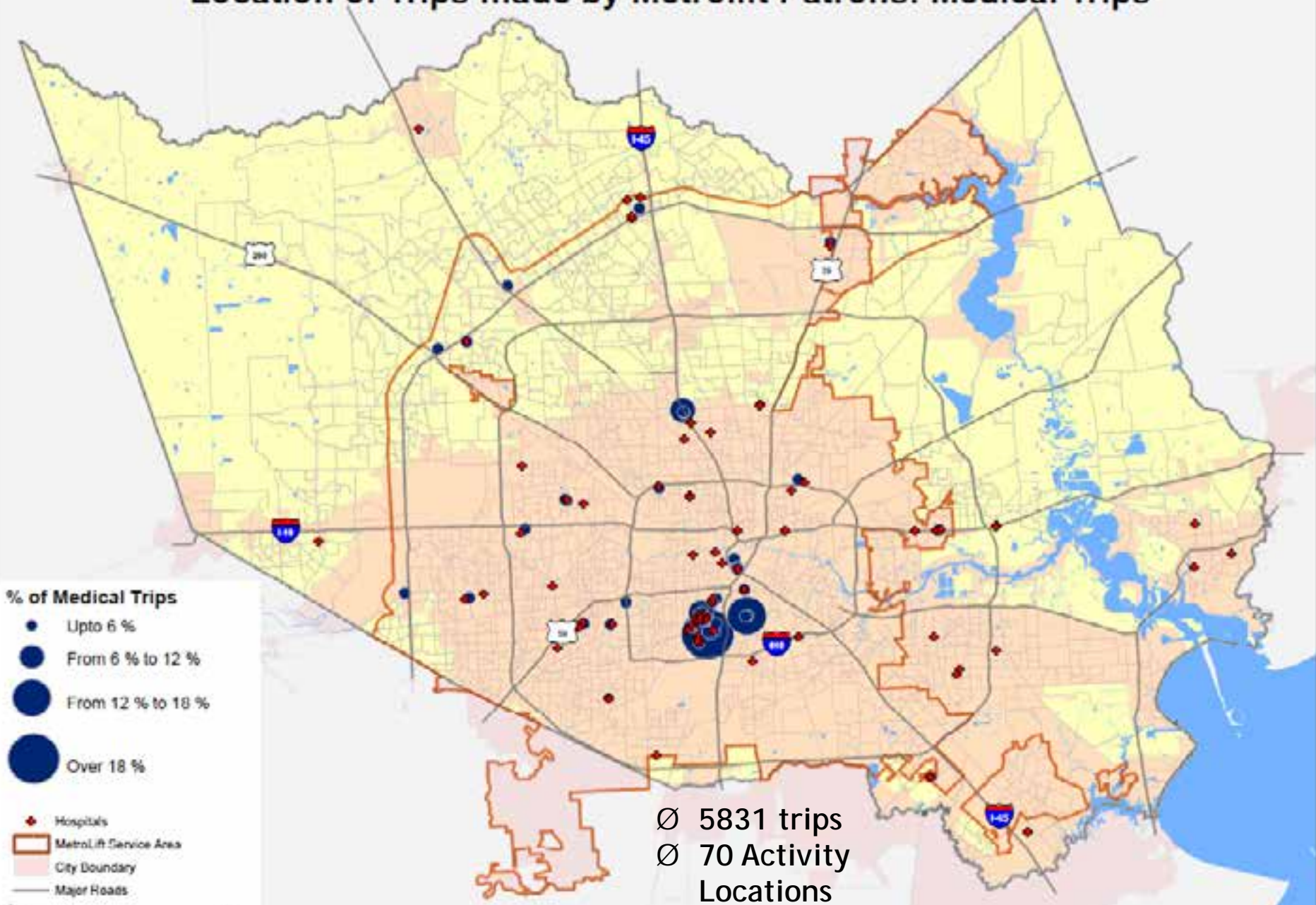
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Education Trips



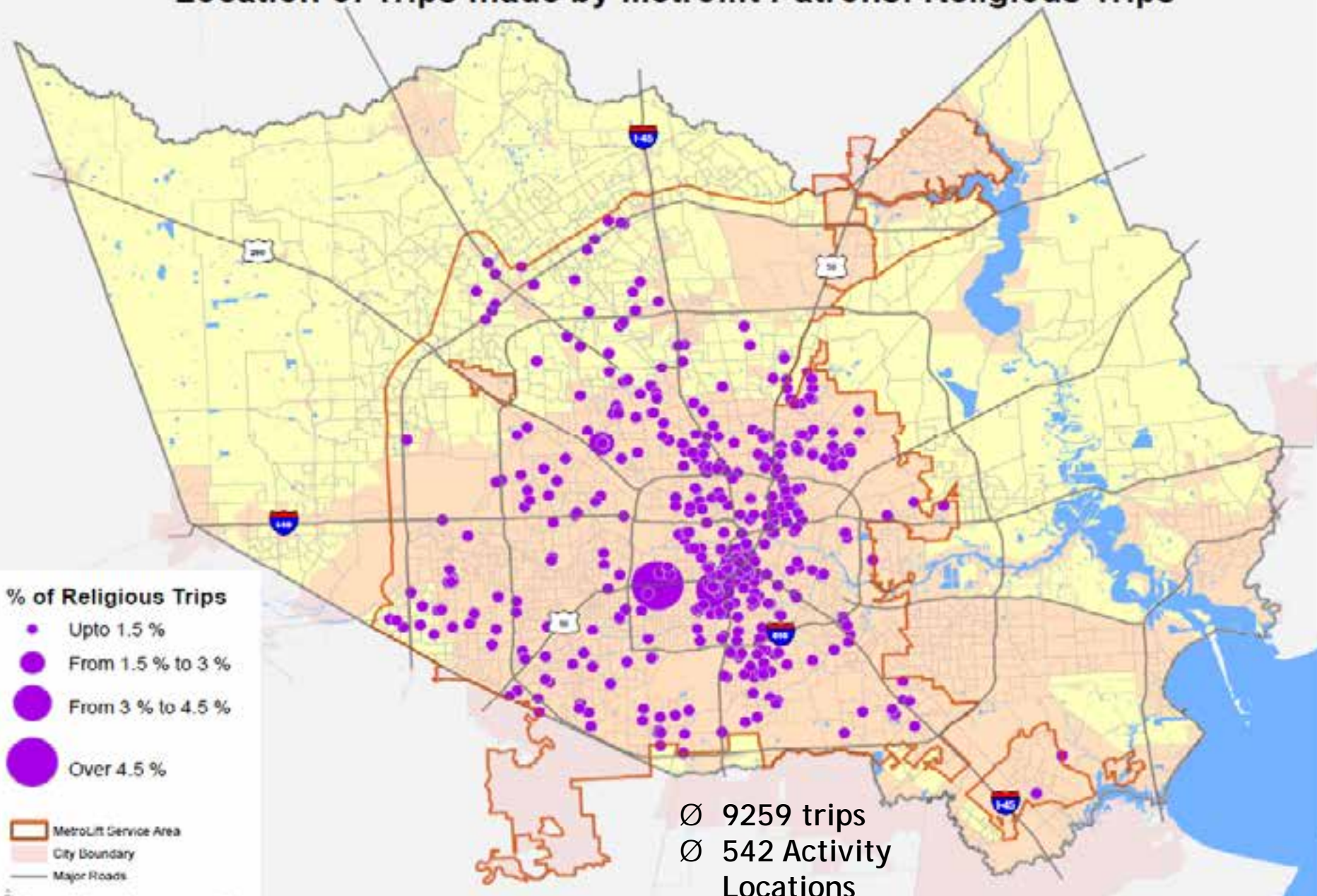
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Medical Trips

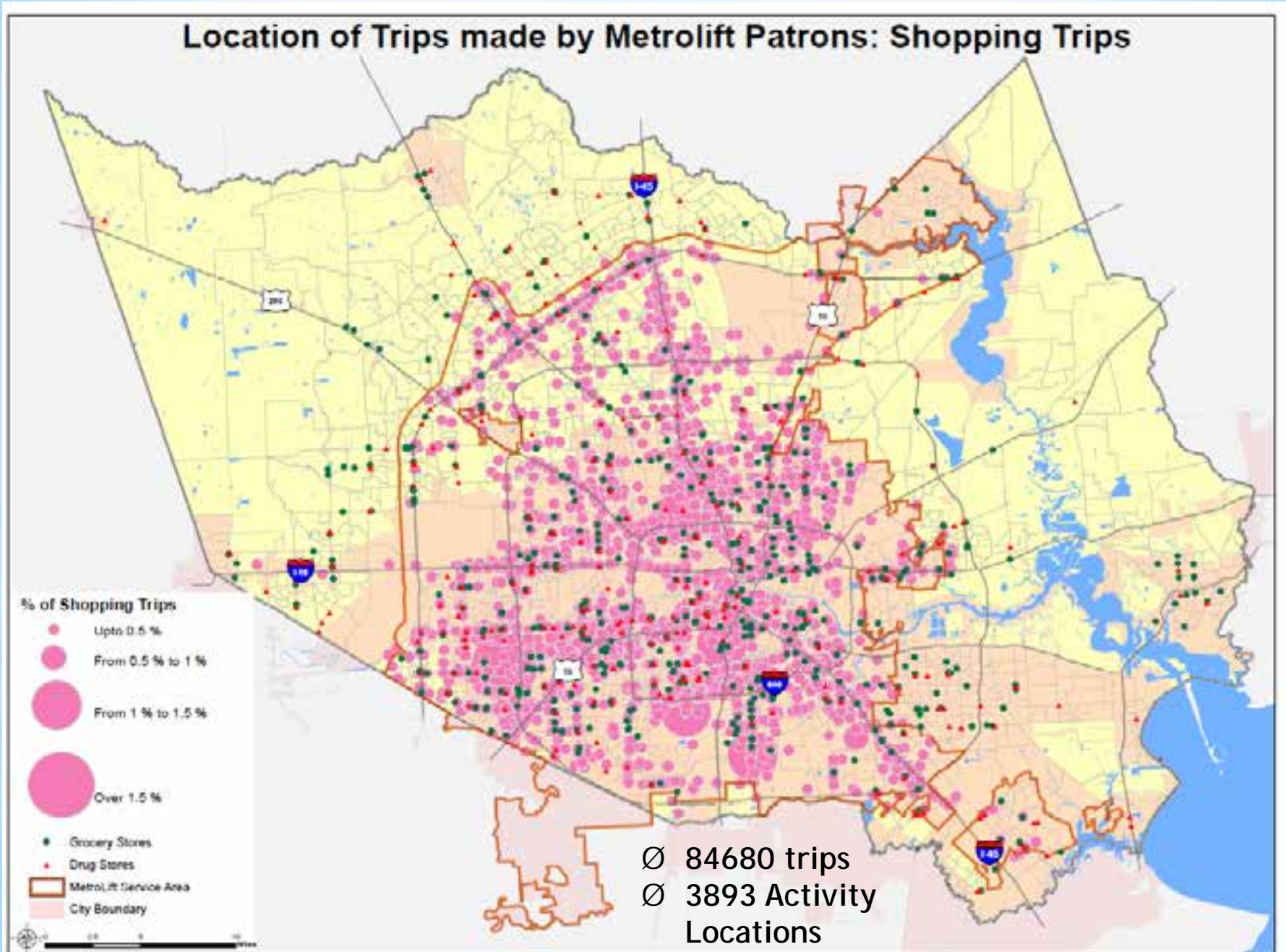


Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Religious Trips

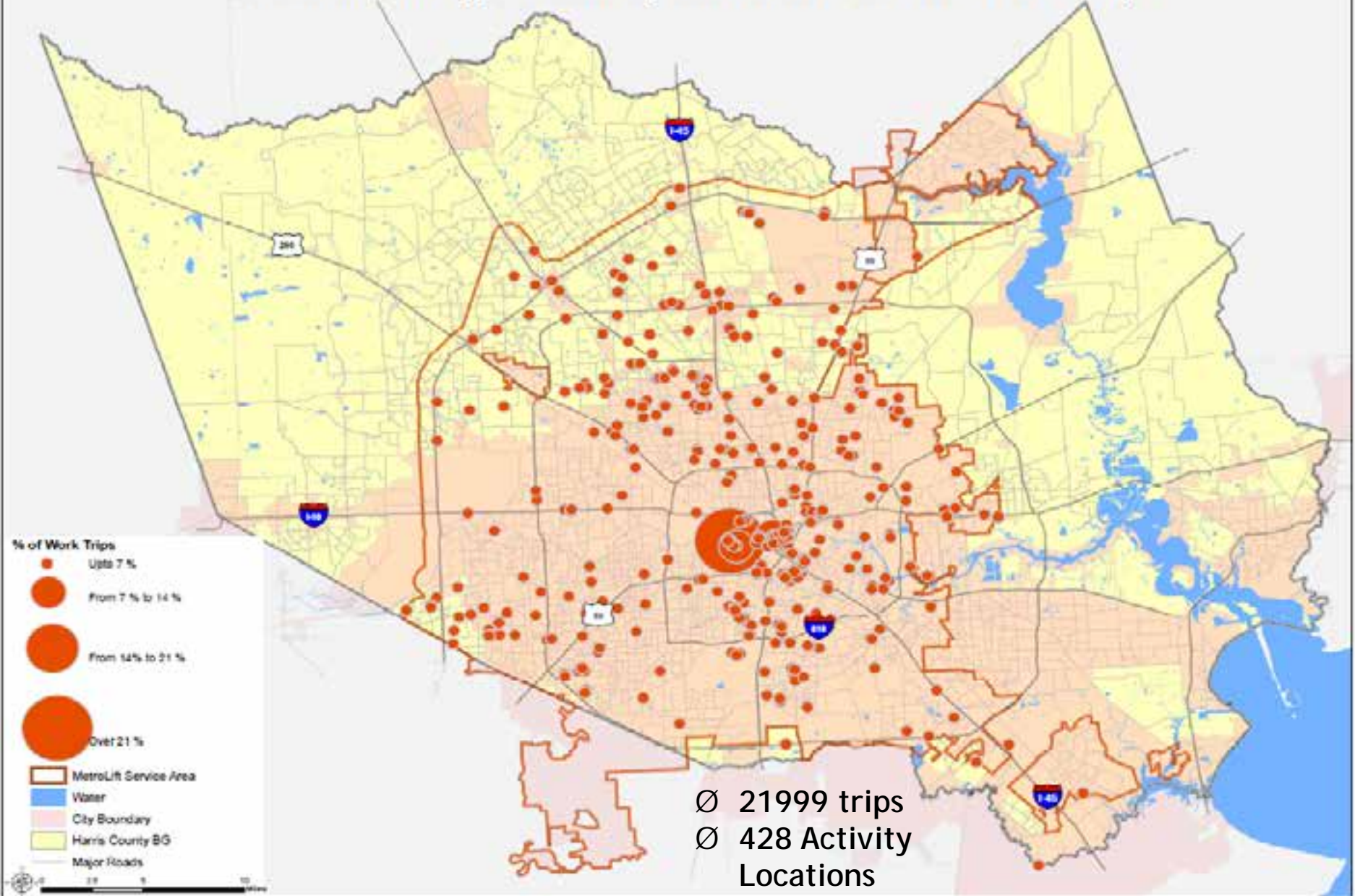


Analysis 3: Spatial Analysis of Trips by Activity and Frequency



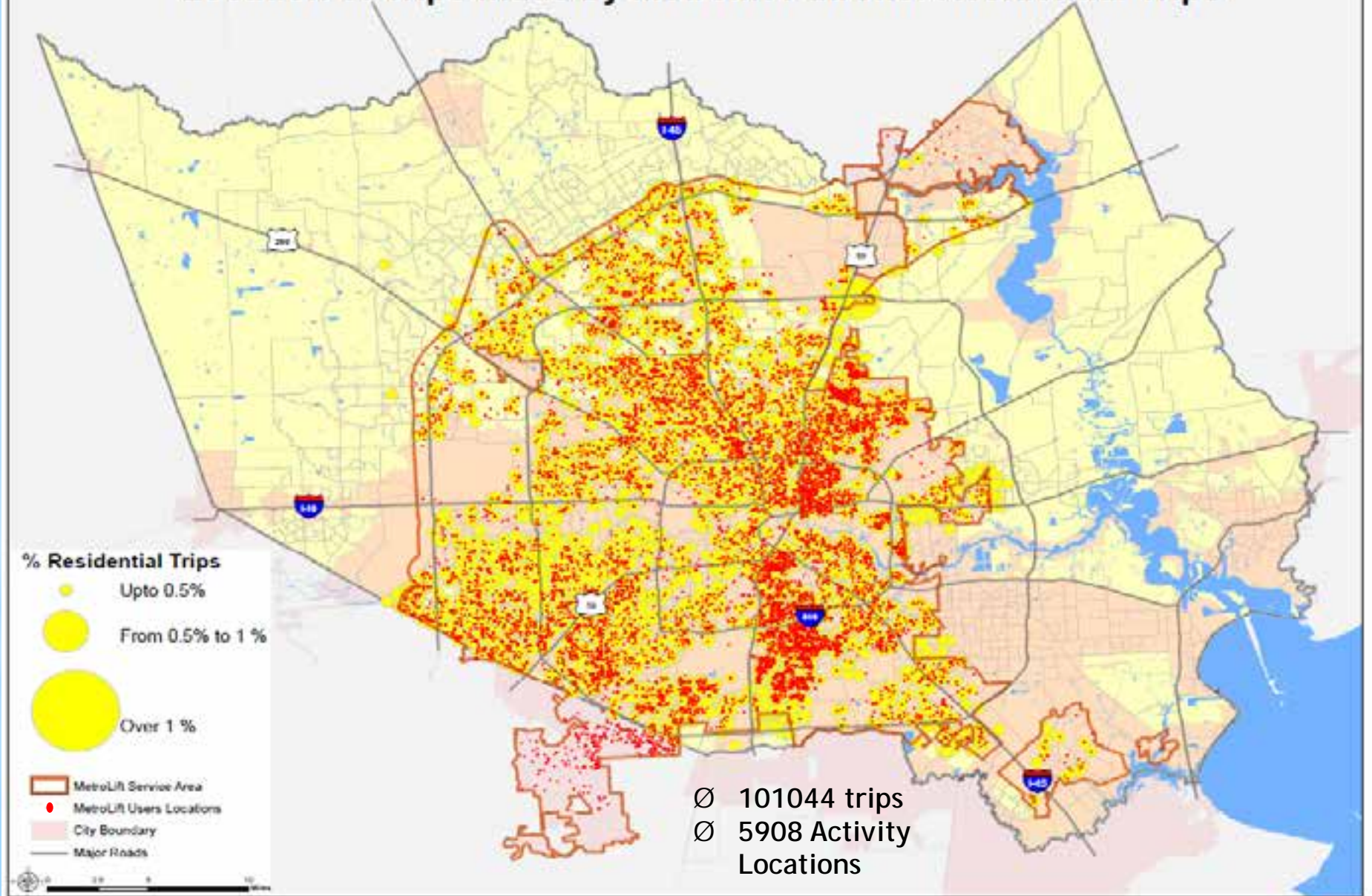
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Work Trips



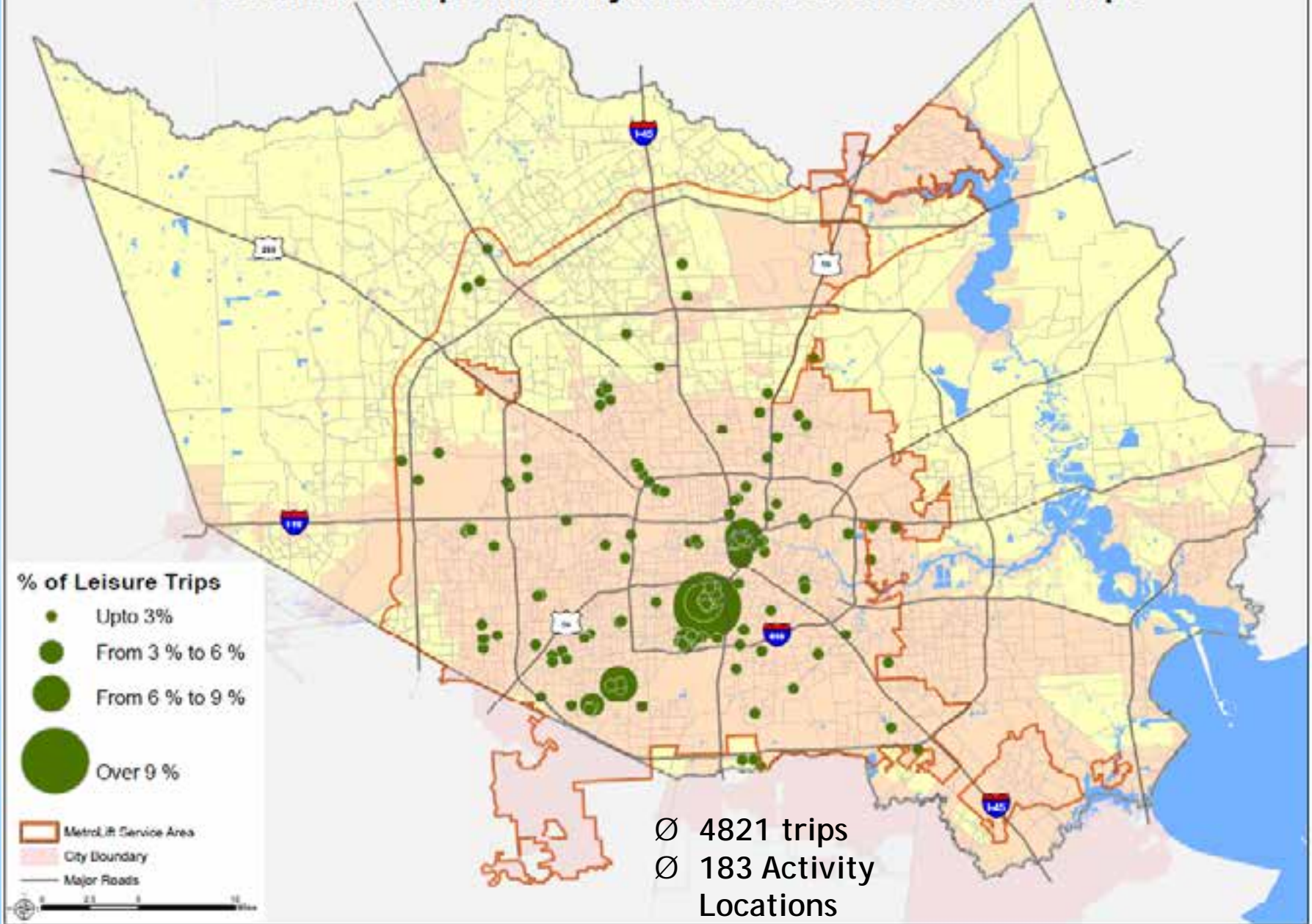
Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Residential Trips



Analysis 3: Spatial Analysis of Trips by Activity and Frequency

Location of Trips made by Metrolift Patrons: Leisure Trips



Conclusions

Ø **Analysis 1** helps to understand the characteristic of MetroLift Users and demand for Metrolift services based on Block Group Characteristics

- Key variables : Number of Disabled Persons, Household Income, Race, and Vehicle Availability of Households

Can be helpful in making decisions regarding expanding or contracting Service Area

Ø **Analysis 2** helps to understand users' trip behavior

- Tuesdays and Wednesdays are the peak days for all types of trips
- Peak periods for all trips : 8-9 am and 3-4pm; Peak times and number of trips vary by the activity type and the day of the week
- Maximum trips are residential followed by Shopping and Work related trips

Can be helpful in managing infrastructure decisions- number of drivers and vehicles based on peak days and periods

Ø **Analysis 3** helps to visualize the location and concentration of trips

- Distribution of Shopping trips are near Grocery and Drug stores
- Residential Trips are related to the location of residences of Metrolift Users

Can be helpful in innovative solutions like teaming with Big Box Grocery stores for home delivery of groceries, combining and chaining trips

Limitations and Future Directions



Limitations

- Ø Data did not have directional components - no way of knowing the origin and destination of trips
- Ø Geocoding addresses place the points on the streets not inside the parcel- makes it difficult to identify the related parcel
- Ø Trip data was available for only October 2013 while land use data used was for 2010

Future steps

- Ø Get hold of additional and current data for Trips, Residences of Metrolift Users, relevant parcels and block group data
- Ø Rerun analysis for at least 3 months
- Ø Further analyze the findings - i.e. Why Wednesdays are Peak days ?
- Ø Continue working on Model to establish relationship between Metrolift Demand and additional block group Characteristic - Explore variables such as the type of disability, sidewalk conditions, distance to grocery stores etc.
- Ø Complete paper for publication

THANK YOU



Subrity Rajbhandari, M.E, MUP
Urban Planning and Environmental Policy
Texas Southern University, Houston, TX
Email: rajbhandaris@tsu.edu

Dr. Lalita Sen
Professor
Urban Planning and Environmental Policy
Texas Southern University, Houston, TX
Email: sen_lx@tsu.edu