University Transportation Research Center - Region 2

Final Report

Suburban Poverty, Public Transit, Economic Opportunities and Social Mobility

Performing Organization: New York University

December 2015

Sponsor:
University Transportation Research Center - Region 2

University Transportation Research Center - Region 2

The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

Research

The research program objectives are (1) to develop a theme based transportation research program that is responsive to the needs of regional transportation organizations and stakeholders, and (2) to conduct that program in cooperation with the partners. The program includes both studies that are identified with research partners of projects targeted to the theme, and targeted, short-term projects. The program develops competitive proposals, which are evaluated to insure the mostresponsive UTRC team conducts the work. The research program is responsive to the UTRC theme: "Planning and Managing Regional Transportation Systems in a Changing World." The complex transportation system of transit and infrastructure, and the rapidly changing environment impacts the nation's largest city and metropolitan area. The New York/New Jersey Metropolitan has over 19 million people, 600,000 businesses and 9 million workers. The Region's intermodal and multimodal systems must serve all customers and stakeholders within the region and globally.Under the current grant, the new research projects and the ongoing research projects concentrate the program efforts on the categories of Transportation Systems Performance and Information Infrastructure to provide needed services to the New Jersey Department of Transportation, New York City Department of Transportation, New York Metropolitan Transportation Council , New York State Department of Transportation, and the New York State Energy and Research Development Authorityand others, all while enhancing the center's theme.

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Project No(s):
UTRC/RF Grant No: 49997-25-25

Project Date: December 2015

Project Title: Suburban Poverty, Public Transit, Economic Opportunities, and Social Mobility

Project's Website:
http://www.utrc2.org/research/projects/public-transit-economic-opportunities

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<table>
<tr><td>1. Report No.</td><td>2. Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="2" rowspan="2">4. Title and Subtitle

Suburban Poverty, Public Transit, Economic Opportunities, and Social Mobility</td><td colspan="2">5. Report Date

December 30, 2015</td></tr>
<tr><td colspan="2">6. Performing Organization Code</td></tr>
<tr><td colspan="2">7. Author(s)

Rae Zimmerman, Carlos E. Restrepo, Hannah B. Kates and Robert Joseph</td><td colspan="2">8. Performing Organization Report No.</td></tr>
<tr><td colspan="2" rowspan="2">9. Performing Organization Name and Address

Robert F. Wagner Graduate School of Public Service (Institute for Civil Infrastructure Systems)
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295 Lafayette Street – 2nd floor
New York, NY 10012</td><td colspan="2">10. Work Unit No.</td></tr>
<tr><td colspan="2">11. Contract or Grant No.

49997-25-25</td></tr>
<tr><td colspan="2" rowspan="2">12. Sponsoring Agency Name and Address

U.S. Department of Transportation Region 2 University Transportation Research Center
City College of the City University of New York
Convent Avenue and 138th Street, Marshak Hall – Suite J-910
New York, NY 10031</td><td colspan="2">13. Type of Report and Period Covered
Research; 3/1/14-12/31/15</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code</td></tr>
<tr><td colspan="4">15. Supplementary Notes</td></tr>
<tr><td colspan="4">16. Abstract
Recent demographic trends suggest an increasing suburbanization of poor populations. Given that poor households are often unable to afford increasing housing prices in many urban areas they are increasingly moving to the suburbs. At the same time, suburbs often do not support the public transit needs of poor populations and access to jobs often with increasing commute time. Insufficient transit can also exacerbate recovery times after extreme weather events for vulnerable populations. Three areas within New York State with transit facilities and areas of poverty were evaluated with respect to the proximity of transit (distance to bus stops), use of transit, and commuting time. Some of the results indicated that certain poor populations in low density areas use transit less and have longer commutes. Historic and projected weather extremes and climate changes could also pose substantial threats to transportation and its users, particularly the poor.</td></tr>
<tr><td>17. Key Words

Transportation, connectivity, vulnerable populations, extreme events</td><td colspan="3">18. Distribution Statement

No restrictions</td></tr>
<tr><td>19. Security Classif. (of this report)

Unclassified</td><td>20. Security Classif. (of this page)

Unclassified</td><td>21. No. of Pages
36</td><td>22. Price n.a.</td></tr>
</table>

Form DOT F 1700.7 (8-72)

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EXECUTIVE SUMMARY

Title: Suburban Poverty, Public Transit, Economic Opportunities and Social Mobility
Researchers: Professor Rae Zimmerman (PI), Carlos E. Restrepo, PhD, Senior Research Scientist, Hannah B. Kates, Graduate Researcher, and Robert Joseph, Graduate Researcher

Introduction. Recent demographic trends suggest an increasing suburbanization of poor populations. Given that poor households are often unable to afford increasing housing prices in many urban areas they are increasingly moving to the suburbs. At the same time, suburbs often do not support the public transit needs of poor populations and access to jobs often with increasing commute time. Insufficient transit can also exacerbate recovery times after extreme weather events for vulnerable populations.

Objectives. The research has two main goals. The first goal is to identify a number of metropolitan areas in UTRC Region II where demographic trends of increasing suburbanization of the poor are taking place and to use a few of them to assess whether current transportation supply is likely to meet the needs of these communities for transit service demand. The second goal addresses risks that vulnerable communities potentially face during extreme weather events based primarily on historical events in the selected areas, the damage to transportation systems that resulted where such data are available, and the lack of access to transportation for evacuation or for emergency preparedness during such events and the ability to regain access to jobs following the events. The research supports the protection of public transit to improve access to the service and meet other public policy goals such as reducing the vulnerability of transit systems to extreme weather events and climate change. This work contributes to two UTRC Research Focus Areas: # 7: livable and sustainable communities and # 8: planning for and response to extreme events.

Scope. Selected metropolitan areas within the NYS Department of Transportation University Transportation Research Center (UTRC) Region 2 were examined, and ultimately three were selected for in depth analysis – the Albany, Buffalo and New York Core-Based Statistical Areas (CBSAs).

Methodology. The research combines case-based and statistical analysis and GIS approaches. First, Census data is obtained to identify suburban areas within UTRC Region 2 metropolitan areas where suburban poverty is increasing, building on existing databases. GIS is used to combine demographic data, transportation data (location of public transit access points) and proximity to jobs data in terms of commuting time.

Results. The research derives relationships among suburban poverty, use of public transit, transit access focusing on distance to bus transit, and access to jobs in terms of commuting time. The findings and methodology are widely applicable. In addition to research benefits, the research has provided education benefits in the form of graduate student training and course curriculum enhancement.

SUBURBAN POVERTY, PUBLIC TRANSIT, ECONOMIC OPPORTUNITIES, AND SOCIAL MOBILITY

I. Introduction

The relationship among being in poverty, access to jobs, public transportation and the growing suburbanization of those in poverty combines a number of different avenues of inquiry.

That poor populations have been increasing in number in areas more distant from central cities was explored by Kneebone and others at the Brookings Institution (Kneebone and Berube 2013; Kneebone and Garr 2010; Tomer et al. 2011; Metropolitan Policy Program, Brookings Institution, undated web site). Zimmerman (2012, p. 15) summarized their early work which indicated that fifty percent of the poor populations in a number of cities were located in suburbs. Using the Kneebone data (Kneebone 2014), 33 cities showed increases in the poor populations in suburbs from 2000 to 2010 and 9 of those cities had increases exceeding 20 percent (Zimmerman 2012, p. 15).

A second area of inquiry is that suburban areas and low density areas generally have little public transit. For example, Zimmerman (2012, p. 16) found that for those cities in which poor populations had increased in suburban areas based on some of the Brookings data, the percent share that rail ridership was of trips was very low.

A third area of inquiry indicates relatively greater use of public transit by the poor, even though transit is less available to them (Sanchez, Stolz and Ma 2004; Wachs 2010). Nationwide, the U.S. Department of Transportation (DOT) Bureau of Transportation Statistics (BTS) noted that the use of public transportation for 2012 was 5% for all workers compared with 8.3% of those below the poverty level (U.S. DOT, BTS 2014, p. 59). Moreover, when transit is less available or unavailable the poor rely more on automobile travel (Kaufman et al. 2014; U.S. DOT, BTS 2014). The use of cars by those in poverty was 63.6% for workers below the poverty level compared to 73.6% for all workers (U.S. DOT, BTS 2014, p. 59).

A fourth dimension is job access via public transportation (including the length of the commute) and poverty. Kneebone and Holmes (2015) have identified the decline of job access with suburbanization, which is being felt by low income and minorities who are moving to suburbs. The importance of the relationship between poverty and the length of the commute to work has been emphasized by the City of New York in its plan, *One New York* (New York City 2015), and emphasized the need to use public transit to access jobs (New York City 2015, p. 25, 47). The plan further identified the association between poverty and the lack of job access via transit (New York City 2015, p. 48): "More than half of the city's neighborhoods with lower-than-average household income—representing 2.3 million residents—have a lower-than-average number of jobs accessible by transit."

Finally, weather extremes and climate change can dramatically reduce transportation resources (Litman 2006) and do so disproportionately for disadvantaged populations (Renne, Sanchez and Litman 2008; Rosenzweig et al. 2011; Bullard 2007). The New York State communities that have been covered in this work exemplify these conditions given the extent and severity of many of these extremes, their impact on transportation, and the reliance of populations, especially in poorer sectors, on transportation services.

In the first section of this report, the existence of poverty, the suburbanization of poverty, access to jobs in terms of commuting time, and use of public transportation are identified for selected New York State urban areas and then evaluated for three Core-Based Statistical Areas (CBSAs) defined by the federal government (Executive Office of the President 2000: 82238). The second section addresses some of the challenges that extreme weather conditions present for transportation services in general and for the poor.

II. Connections Among Poverty, Public Transportation and Commuting Selected New York State Urban Areas

Introduction to Study Area and Characteristics

New York State Selected Urban Area Poverty and Transit Characteristics

Six metropolitan areas in New York State, listed in Table 1, show distinct characteristics with respect to poverty and the use of transit.

Data in Table 1 show that the number of poor people increased in all six metropolitan areas from 1970-2011. Although the city or urban portions of the metropolitan areas had poverty rates that were higher than those in suburbs in 2011, a critical observation is that the percentage change in the number of poor people was consistently higher for suburbs than cities, supporting the fact that there is an increasing suburbanization of poor populations. In fact, the percent change in the number of poor people in suburbs is about 1.4 to over 10 times greater than the percent change in the cities from 2000 to 2011. If these demographic changes continue they will likely have very important implications for public transit service provision, which can be more difficult and expensive to provide in low-density suburbs than in cities.

The data in Table 1 also indicate that most suburban areas in the New York State metropolitan areas included provide relatively high rates of access to transit to the suburban poor defined as the “share of residents in low-income suburbs with transit access.” However, the percentages for jobs access, defined as “the share of jobs accessible via transit within 90 minutes” is relatively low (Tomer et al. 2011). The Tomer et al (2011, p. 17) study of U.S. metropolitan area city/suburban differences in jobs access concluded that “City residents in all regions of the country enjoy greater job access via transit than suburban residents.” Tomer et al. (2011, p. 1) also noted the potential for “large accessibility problems for workers in growing low-income suburban communities, who on average can access only 22 percent of metropolitan jobs in low- and middle-skill industries for which they may be most qualified."

Table 1. Summary Data for Poverty and Transit Access for Selected Metropolitan Areas in New York State

Metropolitan Area	**Number of Poor**		**Poverty Rate (2011)**		**Percent Change in Number of Poor (2000 to 2011)**		**Transportation and Job Access***	
	1970	2011	City	Suburb	City	Suburb	Transit Access	Jobs Access
Albany	64,494	96,317	25.5%	9.8%	19.1%	34.1%	91.3%	38.4%
Buffalo	120,861	162,917	30.9%	10.0%	2.0%	28.1%	95.5%	22.7%
New York	1,780,231	2,686,469	21.2%	8.8%	2.0%	28.1%	94.1%	32.1%
Poughkeepsie	36,007	68,966	25.1%	10.0%	19.4%	27.5%	85.4%	7.5%
Rochester	69,686	157,551	35.5%	10.6%	29.3%	73.5%	50.3%	26.4%
Syracuse	58,442	102,305	36.7%	10.8%	27.5%	37.9%	79.1%	20.7%

Note: *Share of residents in low-income suburbs with transit access and share of jobs accessible via transit within 90 minutes
Source: Metropolitan Policy Program, The Brookings Institution, Confronting Suburban Poverty in America, Profiles of Suburban Poverty (http://confrontingsuburbanpoverty.org/action-toolkit/top-100-us-metros/). Note: The term suburb here is defined as The Brookings Institution defined it.

Table 2 contains a summary of differences in job access for low income populations for the six largest metropolitan areas in New York State and part of New Jersey.

Table 2. Ratio of Suburban to City Percentages for Job Access for Low-Income Populations in Selected Metropolitan Areas

Metropolitan Area	**Suburb / City Ratio (in %)**	**Job Access City Low Income %**	**Job Access Suburb Low Income %**
Albany-Schenectady-Troy, NY	67.4	57.0	38.4
Buffalo-Niagara Falls, NY	42.8	53.1	22.7
New York-Northern New Jersey-Long Island, NY-NJ-PA	64.5	49.8	32.1
Poughkeepsie-Newburgh-Middletown, NY	54.7	13.7	7.5
Rochester, NY	53.6	49.3	26.4
Syracuse, NY	100.8	38.1	38.4

Data source: Compiled and calculated from Appendices 3 and 4 in A. Tomer, E. Kneebone, R. Puentes, and A. Berube (2011) *Missed Opportunity: Transit and Jobs in Metropolitan America*, Washington, DC: The Brookings Institution.

As data in Table 2 indicate, almost without exception, low income populations have greater job access in cities than in suburbs. Tomer et al (2011, p. 5) define job access as the percentage of metropolitan jobs that a person in the labor market can access via public transit. In Table 2 the data are for low income residents living in U.S. Census block groups defined by the authors as suburban or city. The suburban/city ratio for job access expressed as a percent shows that job access for suburban low-income populations ranges from about half to two thirds job access in cities, except for Syracuse where city and suburb job access for low-income populations is similar. In Table 2, the Suburb / City Ratio (in %) in column 2 is calculated by dividing job access for low income residents in suburban block groups (column 4) by job access for low income residents in city block-groups (column 3).

Data compiled from Davis and Baxandall (2013) indicate declining vehicle miles traveled per capita in the six New York State metropolitan areas between 2005-2011. Some of this change may be attributed to decreased economic activity and the 2007-2008 financial recession. The data for transit passenger miles traveled show more variation with significant differences among these urban areas. There are decreases for the Albany and Poughkeepsie-Newburgh urbanized areas but increases in the other areas. The differences could be due to transfers to transit modes. The potential for substituting cars for other means of transportation varies significantly across these urban areas.

Albany, Buffalo and New York CBSAs

To explore the income, transit and commuting patterns in cities located in New York State in more detail, three Core-Based Statistical Areas (CBSAs) [1] were chosen - Albany, Buffalo and the New York areas. This selection was based on the distribution within NYS and the availability of transit data. Each CBSA analyzed in this study was selected based on the availability of open data for transit stop locations for the cities and counties within them. Having access to the locations of the transit stops was essential for the proximity analysis when examining the individual U.S. Census Block Groups. Thus, the final selection for this study consists of the New York-Newark-Jersey City CBSA, Albany-Schenectady-Troy CBSA, and Buffalo-Niagara Falls-Cheektowaga CBSA. Each CBSA encompasses multiple cities and towns, and the New York-Newark-Jersey City CBSA contains cities and towns on both sides of the New York and New Jersey state line. The three cities listed in the name of each CBSA are considered the Principal Cities and are where the majority of the jobs in the CBSA are located, forming the core of the statistical area. For simplicity, each the three CBSAs in this study will be abbreviated as the Albany CBSA, Buffalo CBSA, and New York City CBSA throughout this report.

Selected general characteristics of the population and commuting characteristics in the three cities are shown in Table 3 below.

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[1] Definition of CBSA: U.S. Census Bureau, https://www.census.gov/geo/reference/gtc/gtc_cbsa.html

Table 3. Selected Demographic and Commuting Characteristics of Albany, Buffalo and New York

	Albany CBSA	**Buffalo CBSA**	**New York City CBSA**
Population Density (people/sq. mi)	2,061	4,250	12,956
Percent of Individuals below poverty	7.56	10.59	8.5
Percent Workers >60 minute commute	2.69	1.64	18.05

Source: Compiled from the U.S. Bureau of the Census, American Community Survey (ACS), 2009-2013 5-Year Estimates.

The selected demographic and commuting characteristics of these three cities show considerable differences, though the patterns for Albany and Buffalo are similar. Travel characteristics relative to commuting were identified in terms of selected characteristics of travel in each of the three cities which are tabulated in Table 4 below. One explanation for some of the negative values for vehicle miles of travel over the latter half of the first decade of the twenty first century has often been explained by brief declines due to the effects of the recession.

Table 4. Selected Transportation Trends for Albany, Buffalo and New York

Urbanized Area	**Percent change in vehicle-miles traveled (VMT)/capita from 2006 to 2011**	**Percent change in passenger miles traveled (PMT) on transit/capita from 2005 to 2010**	**Change in proportion of workers who commuted by car from 2000 to 2007-2011**	**Change in proportion of workers who biked to work from 2000 to 2007-2011**	**Change in proportion of workers who worked from home from 2000 to 2007-2011**
Albany	-4.3%	-10.3%	-1.0%	0.1%	0.7%
Buffalo	-7.5%	16.9%	-1.5%	0.2%	0.3%
New York-Newark, NY-NJ-CT	-8.7%	10.3%	-4.8%	0.1%	0.9%

Source: B. Davis and P. Baxandall (2013) *Transportation In Transition: A Look at Changing Travel Patterns in America's Biggest Cities*. U.S. PIRG Education Fund. http://uspirg.org/sites/pirg/files/reports/US_Transp_trans_scrn.pdf

Insights gained from combining income and poverty measures with travel are discussed below. Two measures of income reflect the relationship of income to the use of public transportation: earnings of workers 16 years old or older and percentage of individuals below the poverty level. All of the data is drawn from the U.S. Bureau of the Census American Community Survey (ACS).

Table 5 shows patterns for transportation use according to median income. In Albany and Buffalo, the median income of all workers is much greater than the median for workers using public transportation. In the New York area, the median for workers using public is lower but only slightly, since the median income for workers using carpooling (not shown) is much lower than those using public transportation. However, the focus of this research is on individuals below poverty levels rather than by income.

Table 5. Median Income and Use of Transportation

	Total (All modes)	**Public Transportation**
Albany CBSA	$37,167	$19,474
Buffalo CBSA	$33,569	$17,125
New York City CBSA	$41,731	$39,948

Source: Drawn from U.S. Bureau of the Census, 2009-2013 ACS 5-Year Estimates.

ACS information for each of the three CBSAs for the later 2010-2014 period enables poverty status to be combined with use of public transportation. For workers 16 years and over (for whom poverty status is determined), workers defined as "in poverty" are in the category "Below 100 percent of the poverty level."[2]
For the 2010-2014 5 year ACS estimate:

- In the Albany-Schenectady-Troy, NY Metro Area, 12.9% of workers in poverty used public transportation compared with 3.2% of all workers in the Albany metro area who used public transportation.
- In the Buffalo-Cheektowaga-Niagara Falls, NY Metro Area, 52.4% of workers in poverty used public transportation compared with 3.2% of all Buffalo metro area workers who used public transportation.
- In the New York-Newark-Jersey City, NY-NJ-PA Metro Area, 50.7% of workers in poverty used public transportation compared with 39.3% of all New York metro area workers who used public transportation.

Research Objectives

This research focused on several aspects of the relationships among reliance on and access to public transportation by poorer sectors of the populations in the three New York State CBSAs. The research hypotheses are:

If poorer populations live in less dense areas (i.e., suburban areas) compared to poorer individuals in higher density areas, they:

- are less likely to use public transit,
- have less access to public transit (reflected in distances of bus stops), and
- have longer commutes

Within less dense areas alone, if individuals are poorer, compared to wealthier individuals, they:

[2] Source: U.S. Census Bureau, https://www.census.gov/hhes/www/poverty/methods/definitions.html

- are more likely to use public transit if it is available,
- have less access to public transit (reflected in distances of bus stops), and
- have longer commutes

Methodology

Three urban areas in New York State were selected for the evaluation of the commuting time for poorer populations. The three areas were the New York-Newark-Jersey City CBSA (New York City CBSA), Albany-Schenectady-Troy CBSA (Albany CBSA), and Buffalo-Niagara Falls-Cheektowaga CBSA (Buffalo CBSA). The selection of cities outside of New York City was made on the basis of the availability of bus data. In the New York City CBSA and Buffalo CBSA, rail transit proximity was included but is not analyzed here.

General Considerations and Assumptions for Data Design

Population density and suburbanization

Population density was used to reflect suburban location. Population density below the median density for the CBSA was used to reflect a suburban area. The purpose of the research was to capture areas of lower density and whether or not they are referred to as suburban is not really relevant. A review of the literature and census documents indicated that the concept of suburban, though used often does not appear to be a geographic entity used in census databases.

The Census datasets covered three types of geographic areas: "urbanized areas," "urbanized clusters," and "rural" areas, however, these do not necessarily correspond to suburban areas. The U.S. Census Bureau provides clear definitions of rural versus urban designations, however, there is no technical definition of what constitutes a suburban area. Urban areas have a minimum population density of 1,000 people per square mile.[3] Additionally, urban areas are further categorized into two different urban classifications based on the total population size. Urbanized Areas have a minimum population of 50,000 people and Urban Clusters have a population between 2,500 and 49,999 people.[4] Based on the population density minimum, the subjective mental image of what many consider a suburban area actually falls within the U.S. Census Bureau's designation as urban.

In its 2013 book, *Confronting Suburban Poverty in America* (Kneebone and Berube 2013), The Brookings Institution developed its own methodology for defining suburban areas:

> "For each metropolitan area, we identify primary cities and suburbs. Primary cities (also referred to as cities) are those that appear first in the official metropolitan statistical area name and any other cities in the official name that have populations of at least 100,000. Suburbs make up the remainder of

[3] Source: U.S. Census Bureau, http://www.census.gov/history/www/programs/geography/urban_and_rural_areas.html

[4] Source: U.S. Census Bureau, https://www.census.gov/geo/reference/ua/urban-rural-2010.html

> the metropolitan areas outside of primary cities. In each profile, the metropolitan area name has been adjusted to reflect only the names of places treated as primary cities in the analysis."[5]

The approach used by Brookings was not selected for this research, because the delineation of municipal boundaries can often be arbitrary. Municipal boundaries do not necessarily reflect the development patterns of urban areas which can cross those boundaries or stay well within them and include undeveloped area. Instead, this research used the CBSA's median population density as a way of distinguishing block groups as being high or low density urban areas.

Poverty

"Poor populations" as used in this report refer to individuals below the poverty level as defined by the U.S. Census, which gives a conservative approach to poverty. Individuals rather than households in poverty were used since the two are highly correlated in all three cities (a correlation coefficient greater than 0.9). Alternative definitions of poor populations have used low-income (Tomer et al. 2011, p. 5; Bishaw 2013; Kneebone and Berube 2013, p. 15).

Commuting time to work as a reflection of job access

Commuting time is a surrogate for and is assumed to reflect access to jobs via public transit. Two commuting time periods by any mode were used: 60 – 89 minutes and 90 or more minutes. Given the very small population in the latter category, long commutes were defined as those exceeding 60 minutes.

<u>Data Description</u>

Two separate data sets were included and combined. One was Census data from the American Community Survey (ACS) 5-year Estimates[6] for demographics covering two time periods 2007-2011 and 2009-2013 including population density, individuals below the poverty level, commuting time, and use of public transit. Data were defined at the Census block group level.

Below is a summary of the variables were used in the analysis, and a detailed description for each variable from the U.S. Census is contained in Appendix 1:

For the ACS data, the following variables were used. Percentages were computed using the usable or reporting population.

- Population density (population divided by land area)
- Percent of Individuals in poverty (below the poverty level defined by the U.S. Census)
- Percent of workers who commute via public transportation
- Percent of workers with a 60-89 minute commute
- Percent of workers with a 90+ minute commute

Public transit agency data was used for the following variables:

[5] Source: Brookings Institution, http://confrontingsuburbanpoverty.org/wp-content/uploads/2013/04/Methodology.xlsx on the "Notes on City vs. Suburb" tab

[6] Data source: U.S. Census Bureau TIGER files, https://www.census.gov/geo/maps-data/data/tiger-data.html

- Distance to the nearest active bus stop (meters) calculated from the centroid of the block group
- Distance to the nearest rail station (meters) calculated from the centroid of the block group (New York City and Buffalo CBSAs)

Other factors such as employment density were identified as well.

It is important to note that although few block groups had no populations, a large number of blocks had no populations below the poverty line and in some case had no reported usage of transit. The analysis focused on those areas where these characteristics had non-zero values.

Findings

General Relationships for Poverty and Transit Use

The data for population density, the location of public transit stops (bus and rail transit), and populations in poverty were mapped. Data for demographic characteristics were mapped at the block group level, and the location of public transit stops used coordinates from publicly available data sets.

These maps are contained in Appendix 2 for the three metropolitan areas. The maps provide some distinct initial insights. For all three cities, as one might expect, population density increases toward the urban core. For the Albany CBSA and Buffalo CBSA, the percentage of individuals in poverty is higher in the outlying areas with some small concentrations of higher poverty areas toward the core. In contrast, in the New York City CBSA, somewhat of a patchwork pattern is shown with areas of high poverty interspersed with areas of lower poverty.

For commuting time, all three cities as one might expect show a greater concentration of the population in general (not necessarily poor populations) with longer commutes (60 minutes or more) in areas further away from the core given that public transportation is concentrated in and around the core areas.

One important factor in the relationship between poverty and transit use is the location of jobs. Factors that reflect job density were explored spatially to a limited extent in order to describe broadly how prevalent higher paying jobs were in the urban portions of the cities.

A summary of the distribution of jobs by earning level within the urban portion of each of the three areas is presented in Table 6. What is apparent is the greater share of jobs with higher earnings in the urban core of each area.

Table 6. Distribution of Primary Jobs by Earnings for Albany, Buffalo and New York CBSAs, 2013

	Percentage Share of Primary Jobs by City 2013						
	Albany	Buffalo	New York City (Boroughs)				
			Bronx	Kings	New York	Queens	Richmond
Monthly Earnings							
$1250 or less	12.4	19.1	22.0	20.1	13.0	22.3	27.3
$1,251 to $3,333	26.2	33.9	31.0	32.5	22.4	38.2	34.4
>$3,333	61.4	47.0	47.0	47.4	64.6	39.5	38.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Compiled from U.S. Bureau of the Census, Center for Economic Studies (2013) Census On the Map.

New York City provides an example of the spatial variations in employment density. Employment density in New York City by borough is a function of the number of jobs and also reflects wealth. New York County (Manhattan) with 2,141,590 jobs has an employment density of 93,113 jobs per square mile and Richmond (Staten Island) with the least number of jobs, 80,393, has the lowest employment density of 1,386 jobs per square mile.

Statistical Analyses: Correlations and Regressions

In order to identify general relationships among poverty, transit use and commuting, correlation analysis and selected regression analyses were used.

Correlation analyses

Correlation analyses were used using Pearson correlation coefficients for the key variables listed above.

As indicated earlier, the correlation between the percentage of Individuals below the poverty line and the percentage of households below the poverty line was highly correlated (above 0.9 in all three cities), supporting the use of just one of those variables to avoid multicollinearity. The percentage of individuals below poverty was chosen since this variable may better reflect the working/commuting population.

Population density and poverty. Correlation results showed that density was correlated with the percentage of both individuals and households below the poverty level. For density and individuals below the poverty level, in the Albany CBSA the correlation coefficient was 0.546, in Buffalo CBSA 0.401, and in New York City CBSA 0.376, all significant at the 0.01 level (2-tailed).

Population density and transit use. Density was also correlated with the use of transit. In the Albany CBSA the correlation coefficient was 0.502, in Buffalo CBSA 0.327, and in New York City CBSA 0.647, all significant at the 0.01 level (2-tailed).

Poverty and transit use. Poverty and use of transit was also correlated, supporting the general literature described above. For Albany CBSA the correlation coefficient was 0.546, in Buffalo CBSA 0.554, and in New York City CBSA 0.426, all significant at the 0.01 level (2-tailed).

Poverty and commute time to work. Poverty and commute time (60 minutes or more) had extremely low but positive correlations all significant at the 0.01 level (2-tailed). For Albany CBSA it was 0.189 in Buffalo CBSA 0.189, and in New York City CBSA 0.093

Regression analyses

A number of regression models were developed that produced similar results. One of the models is structured in the following way that tests the hypothesis of whether or not poorer people, taking transit, in less dense areas, and longer distances between bus stops have a longer commute:

- **Dependent variable:** % of workers with a commute between 60 and 89 minutes
- **Independent variables:** % of Individuals Below the Poverty Level (PerPovInd), Percentage of the Population Using Public Transit (PerTransit), Population Density in Square Miles (PopDensity), and the distance between a bus stop and the centroid of the block group in which it stops (NBusA_Dist)

The results of one of the models of the regression analyses are shown in Table 7 for the independent variables as they relate to one of the dependent variables, % of workers with a commute between 60 and 89 minutes.

Table 7. Results of Regression Analysis

	Albany CBSA	**Buffalo CBSA**	**New York City CBSA**
R Square	0.244	0.186	0.188
Independent Variable	Beta Coefficient	Beta Coefficient	Beta coefficient
PopDensity	-4.817E-5	-5.101E-5**	-5.688E-5*
PerPovInd	0.038*	-0.005	-0.019*
PerTransit	0.135*	0.176*	0.233*
NBusA_Dist	0.000*	0.000*	-0.000*

Notes:
*Indicates significance at the 0.01 level
**Indicates significance between the 0.01 and 0.10 levels
Beta coefficients are unstandardized.
Urbanized area was added in as a fourth independent variable

The low R Square values in these models suggest that the linear regression model is unable to explain most of the variation in the data. This suggests there are other variables not included in the model that could explain these differences and suggest future research could include using different statistical models to explore these associations. Such models could include Poisson regression and other non-linear models. Given this condition, another approach was taken in analyzing the data that identified density groupings and population groupings within them as a basis for analyzing transportation characteristics.

Descriptive Statistics: Transit and commuting characteristics of poor populations

Using population density as a surrogate for suburban areas, the block groups of each of the three CBSAs were divided into low and high density areas, and the median population density in each CBSA was used as the dividing point.

The frequency distributions for poverty in each of the three cities were used to identify a cutoff point to divide the poor populations in both low and high density populations into two groups. The threshold of 30% was used as a cutoff point, that is, both the low and high density areas were divided into separate groups – those that had more than 30% of the block group population below the poverty level and those that had less. Then transit and commuting time patterns were identified for these density/poverty subgroups. The data for population density, poverty, use of transit, and commuting time is drawn from the 2009-2013 ACS data.

Low vs. High Density Areas

First, the location of the resident population in general and the distribution of that population by density area relative to transit is presented in order to provide a context for evaluating these characteristics for poor populations. Table 8 presents this data for proximity to where buses stop for the three CBSAs. This data indicates that significant proportions of the total population are located within less than 500 meters of where buses stop. This proportion is much larger in high density areas than in low density areas. Rail data is available also (not shown), however, for Buffalo, the percentage of the population living less than or equal to 500 meters of a rail stop is 1% or fewer. Albany rail data was not available. For New York City 24% of the population in high density areas and 2% of the people in low density areas lived less than or equal to 500 meters of a rail stop.

Table 8. Percent of CBSA Population Close to Bus Public Transit for Total Population and Populations in High and Low Density Areas

	Albany	Buffalo	NYC
	Percentage of the Population Residing Within 500 m of a bus stop		
Total CBSA Population	38%	51%	67%
High Density Area	33	36	47
Low Density Area	5	15	20
	Percentage of the Population Residing Within 500 m of a rail stop		
Total CBSA Population	NA	1%	26%
High Density Area	NA	1	24
Low Density Area	NA	0	2

Table 9 provides the results for populations where block groups exceed 30% in individuals below poverty, divided into high and low density areas as surrogates for urbanized and suburban areas respectively.

Table 9. Comparison of Low and High Density Areas with Highest Poverty (using 30% threshold)

Block Groups >30% Below Poverty	**Median Bus Distance (in meters)**	**Median % Commuting time 60 minutes or more**	**Median % Using Public Transit**
ALBANY CBSA			
High Density Area	163.3	7.1	12.9
Low Density Area	836	15	12.3
BUFFALO CBSA			
High Density Area	175.3	7.4	15
Low Density Area	376.8	5.7	13
NEW YORK CBSA			
High Density Area	117.6	24.5	60
Low Density Area	295.1	12.9	17.1

Proximity of bus stops. In all three cities, the proximity of bus stops, defined as the distance of bus stops from the centroid of the block group in which the stop was located, is much larger in lower density poor areas than higher density poor areas ranging from between about two and three times as large. This may in part be because block groups in low density areas are much larger in size, however, it does potentially reflect a greater bus access problem in poorer low density areas.

Commute time (60 minutes or more).

- In Albany the percentage of poor populations that has a commute time of 60 minutes or more is larger (about double) in low density areas than in high density areas.
- In Buffalo the percentage commute time for poor populations is about the same in both low and high density areas.
- In New York City the percentage commute time for poor populations is slightly greater in higher density areas than in lower density areas. This may in part be due to the fact that very high density areas are far away from job centers. In other cities, high density populations are usually closer to the core of the city.

Transit Use.

- In both Albany and Buffalo, the percentage of the poor population using transit is slightly higher (really about the same) for poor populations in high density areas and low density areas.

- In New York City, however, the percentage of the poor population using transit is much higher for poor populations in the higher density areas (almost double) probably reflecting the greater prevalence of transit in higher density areas in NYC.

Populations Below the Poverty Level in Low Density Areas Only

It is instructive to compare travel for low and high poverty populations within the lower density areas only to capture the suburban phenomenon. Table 10 provides the results for populations in low density areas only for block groups below and above the threshold of 30% of individuals below poverty.

Table 10. Commuting Characteristics of Populations in Block Groups with Low Population Density, Broken Down by Percent of Population Living in Poverty

Low population density block groups only and percent in poverty	**Median Distance to Nearest Bus Stop (in meters)**	**Median % of Population with Commuting time 60 minutes or more**	**Median % of Population Using Public Transit**
ALBANY CBSA			
>30%	836	15	12.3
<30%	2,475	4	1.8
BUFFALO CBSA			
>30%	376.8	5.7	13
<30%	826.2	3.7	2
NEW YORK CBSA			
>30%	295.1	12.9	17.1
<30%	573.4	17	9.5

Note: 30% listed in the first column refers to the percent of the population in poverty (below the federal poverty line) in low density blocks. The percentages in columns 3 and 4 refer to the percentages of individuals in each block group population that fall below or above the 30% of population in poverty.

Proximity of bus stops. For all three areas the median bus distance is smaller for poorer populations than for populations in blocks with relatively wealthier populations.

Commute time (60 minutes or more). In Albany and Buffalo, the commute times for poorer populations is greater than for populations in blocks with relatively wealthier populations, but in NYC the opposite is true again because of the configuration of transit in NYC.

Transit use. The use of transit in all three cities is much greater for poorer populations than for populations in blocks with relatively wealthier populations.

Conclusions and Discussion for the Poverty, Public Transportation, and Commuting Nexus

A review of a half dozen large New York State metropolitan areas revealed that suburbs had a generally consistently higher percentage change in the number of poor people than cities, leading to the conclusion that poor populations are suburbanizing. This supports the findings of other national studies (Kneebone and Berube 2013). Three areas of those areas were chosen for study on the basis of their demographic and travel characteristics as well as the availability of transit data. Poor populations and their use of transit, access to transit in terms of proximity to bus stops, and potential job access in terms of commuting distances in low density and high density areas were evaluated. All three areas showed the effects of suburbanization (lower density) in reducing transit access measured in terms of increasing distance from bus stops. Commuting time showed a mixed picture. The Albany CBSA showed higher commuting time for poor populations living in low density areas than those living in high density areas, but the Buffalo CBSA showed about the same commuting time. The New York CBSA showed the opposite pattern – longer commutes by the poor in the higher density areas compared with the poor in lower density areas – probably given the unique configuration of the city with pockets of high population density in areas that are very far from jobs. Although there are some mixed patterns in each of the three cities, there are strong indications that poorer areas have fewer transit benefits than wealthier areas, which in part may be attributed to the suburbanization of the poor populations. Other analyses were performed as well.

III. Weather and Climate Extremes and Public Transportation

A second and critical element of poverty, public transportation and commuting is the impact of weather and climate extremes. These events often occur episodically with often uncertain, lingering or long-term consequences, felt disproportionately by poorer sectors of the population.

This portion of the report identifies some of the patterns and trends in these events in the three New York State metropolitan areas, the consequences for transportation to the extent that this was available, and the potential impact on poor populations. It is noted that the numerous post-event damage assessments often do not focus on transportation damages, and that information as well as the extent to which transportation damages particularly affected the poor is often anecdotal.

Patterns and Trends in Extreme Weather and Climate Events in Albany, Buffalo, and the New York City Area

Extreme weather events, conditions associated with climate change, and other natural phenomena pose particular threats to transportation infrastructure. New York State and the three metropolitan areas that are the subject of this report have experienced many of these events over the past many decades. Transportation systems at all levels have often been severely damaged and the service interruptions that result have not only impeded normal activities of the users but emergency services such as evacuation as well. The experiences from many of these have led to proactive changes in the design and delivery of transportation services.

Within the first decade of the 21st century, a number of critical hurricanes and numerous flash flooding events severely damaged road and rail systems, not only affecting the conveyances but vehicles and support facilities such as maintenance and storage sites as well. One of the worst was the flash floods of August 8, 2007 that disrupted the New York City subway system for about twelve hours (Metropolitan Transportation Authority (MTA) 2007) that followed others within that same decade. In the second decade of the 21st century, Hurricane Irene and Hurricane Sandy were the two most notable events for New York City and surrounding areas. In both hurricanes, New York City subways were shutdown proactively, which at least in the case of Sandy did not prevent substantial damage from occurring though recovery was relatively quick given the catastrophic nature of the storm, especially with respect to service levels of a year earlier (Zimmerman 2014). Hurricane Irene damaged many rail facilities throughout New York State. Service from Port Jervis, for example was disrupted for months (U.S. DOC, NOAA 2012).

The NYS Hazard Mitigation Plan (NYS 2014) provides county level data for the number of hazard events by type and the dollar amount of destruction for each as well as for the number of presidential declared disasters. Although the counties do not correspond to the areas used in this research, they are a close approximation. Obtaining damage descriptions and costs specific to transportation is not easily obtained, some case-specific data does exist for example for Hurricane Sandy (Hurricane Sandy Rebuilding Task Force August 2013; numerous after action reports in connection with Hurricane Sandy). A statewide study of climate change impacts described and evaluates the threats of climate change statewide with some specific information for cities as well (Rosenzweig et al. 2011). There are also some city specific hazard mitigation and resilience plans, such as the ones for New York City (NYC 2013a,b; 2014a,b; 2015).

In addition to the data from the NYS Hazard Mitigation Plan, data for counties were compiled to reflect number of events alone for Albany, Buffalo and the New York area from NOAA data (U.S. Department of Commerce, NOAA undated web site). This data are summarized in Table 11.

Table 11. Weather-related Events, Selected Counties in New York State

County	PDD 1954-Aug. 2013 [7]	PDDs Floods Only 1954-Aug. 2013 [8]	No. of Hazard Events (total) 1960-2012 [9]	Damage Estimate (total) 1960-2012 [10]
Albany	9	3	516	$116,153,322
Erie	11	6	823	$121,498,228
Bronx	8	2	225	$35,406,271
Kings	10	3	235	$38,571,913
New York		2	251	$26,595,276
Queens	12	4	284	$53,751,855
Richmond	11	3	193	$12,772,028

PDDs: Presidential Disaster Declarations
Sources: Compiled from NYS (2014) and U.S. DOC, NOAA (undated web site).

Both the U.S. DOT Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) provide emergency relief funds for road/bridge and rail repairs respectively. The FTA awarded NYS about 1.9 billion for Hurricane Sandy and most of it went to New York City Transit for flood mitigation. [11]

Selected Cases

It is generally difficult to separate out transportation costs from other damage estimates in storms given that the allocation of funds occur in a number of different ways and often over long periods of time. A few notable events, however, serve to illustrate the magnitude of damage to transportation infrastructure and its users in New York State.

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[7] New York State (2014) New York State Hazard Mitigation Plan, page 3.0:22
[8] New York State (2014) New York State Hazard Mitigation Plan, page 3.9:28
[9] New York State (2014) New York State Hazard Mitigation Plan, pages 3.0:23-25
[10] New York State (2014) New York State Hazard Mitigation Plan, pages 3.0:47-49
[11] Source: U.S. DOT FTA (September 22, 2014) http://www.fta.dot.gov/15138_16147.html

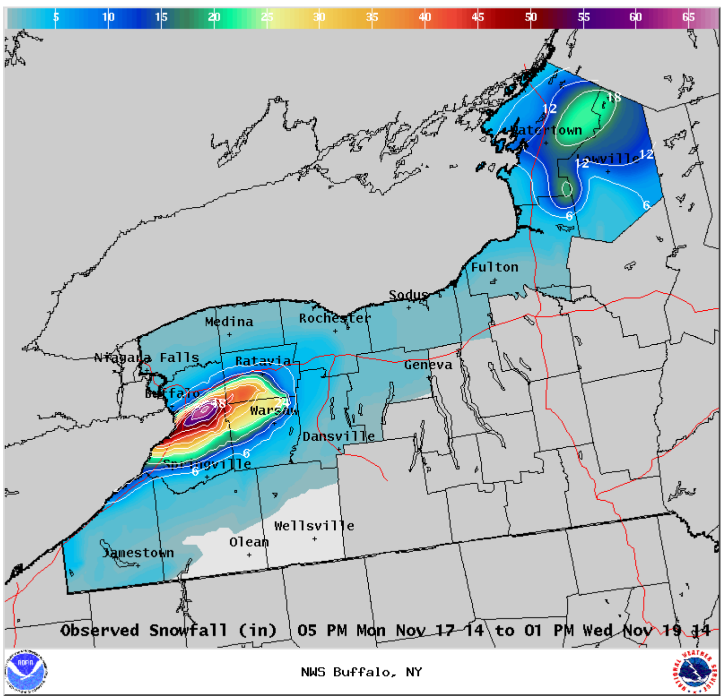
New York area

Hurricane Irene in 2011 resulted in 40 deaths and the damages were estimated at $6.5 billion in damages. The transportation sector experienced the closure pre-emptively of the three NYC airports, the NYC mass transit system as well as transit systems in the region including Amtrak, and some long distance bus services (U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA) 2012, p. x, 12, 13; U.S. DOC, NOAA 2011).

Damage from Hurricane Sandy in New York City was estimated at almost ten times the cost of Hurricane Irene at $67 billion in all areas and sectors [12]. Blake et al (2013, p. 18) cite a damage estimate of $5 billion to the MTA from water inundation due to storm surge and flooding that affected eight subway tunnels, and an additional $2.5 billion to other infrastructure.

Buffalo area

Buffalo often experiences lake effect snow. From November 17-19th 2014 the winter storm "Knife" resulted in over five feet of snow east of Buffalo. It resulted in the closure of the Thruway from Pennsylvania's border to Rochester as well as routes 190, 290 and 400 (U.S. DOC, NOAA, NWS), and the NWS noted that "Travel was forecast to become nearly impossible." Costs were initially estimated at $7.5 million, expected to increase (McNeil December 5, 2014).



Note: Snow intensities in the Buffalo area during the November 17-19, 2014 record snowstorm. Colors are inches of snowfall ranging from 5" to 65".
Source: U.S. DOC, NOAA, NWS Lake Effect Summary: November 17-19, 2014
http://www.weather.gov/buf/lake1415_stormb.html

[12] Source: NOAA, http://www.ncdc.noaa.gov/billions/events

The October 2006 storm in the Buffalo area was estimated at costs countywide of $100 million and possibly reaching $250 million in total, but transportation costs were not separated out (Erie County Comptroller September 2010).

Albany area

Albany has experienced numerous flash floods that have had considerable impacts on its transportation networks for both road and rail systems. A search of the U.S. Department of Commerce, NOAA, Storm Events Database for Albany County, New York, from 2000 through mid-2015 identified 57 flash flood events.

Severe episodes occurred most recently for example on July 10, 2013 and August 6, 2014. Flooding and high winds from Hurricane Irene led to numerous road and bridge closings in the Albany area as reported in the U.S. Department of Commerce, NOAA, Storm Events Database for Albany County, New York, which reported that "In Albany County, numerous roads were also closed, including the New York State Thruway from exit 24 in Albany to exit 8 in White Plains due to flooding and downed trees. Major flooding occurred on the Hudson River at Albany, with moderate flooding occurring on the Mohawk River at Schenectady and Cohoes."[13]

Summary of Findings for Weather, Climate and Transportation

Numerous studies throughout the U.S. and specific to New York State indicate the considerable threat of weather and climate changes to transportation systems (New York State 2015). Both historic and projected changes in climate in New York State from the NYS ClimAID report (Rosenzweig et al 2011) and within New York City by the New York Panel on Climate Change (2015) indicate at least persistent if not growing vulnerabilities for weather and climate change. The impacts of these events have been underscored throughout the U.S. for transportation (Transportation Research Board 2008a). The critical role of transportation in such events for evacuation (Transportation Research Board 2008b) has been underscored as well as the need for multi-modal configurations for transit to allow for flexibility in transit services during and following these events (Zimmerman et al 2015). Information on federal and state emergency funds targeted to transportation following disruptions provides some indication of transportation damage following weather emergencies however these should be combined with demographic information and transportation usage. Future research is recommended to develop specific transportation vulnerability and damage inventories, particularly damages experienced by vulnerable populations.

[13] U.S. DOC, NOAA (undated web site) https://www.ncdc.noaa.gov/stormevents/

ACKNOWLEDGEMENTS

We gratefully acknowledge The U.S. Department of Transportation Region 2 Urban Transportation Research Center that funded the research as a Faculty-Initiated Research project in two of the UTRC Research Focus Areas. The authors also thank the Metropolitan Transportation Authority and the New York Metropolitan Transportation Council for providing access to publicly available transit data without which this research would not have been possible.

REFERENCES

Bishaw, A. (2013) Poverty: 2000 to 2012. American Community Survey Briefs. U.S. Bureau of the Census.

Blake, E.S., Kimberlain, T.B., Berg, R.J., Cangialosi, J.P., and Beven, J.L. II (2013) Tropical Cyclone Report, Hurricane Sandy (AL182012) 22029 October 2012. Published 12 February 2013, http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.

Bullard, R. D. (2007) Growing Smarter, Cambridge, MA: MIT Press.

Davis, B. and Baxandall, P. (2013) *Transportation In Transition: A Look at Changing Travel Patterns in America's Biggest Cities*. U.S. PIRG Education Fund, http://uspirg.org/sites/pirg/files/reports/US_Transp_trans_scrn.pdf.

Erie County Comptroller (September 2010) Review of the Erie County Storm Fund Analysis of the County's Expenses and Reimbursements Associated with the October 12-13, 2006 Storm, http://www.erie.gov/comptroller/pdfs/October_2006_Storm_Report_FINAL.pdf.

Executive Office of the President, Office of Management and Budget, Office of Information and Regulatory Affairs (December 27, 2000) Standards for Defining Metropolitan and Micropolitan Statistical Areas Federal Register / Vol. 65, No. 249 / Wednesday, December 27, 2000 / Notices pp. 82228-82238, https://www.whitehouse.gov/sites/default/files/omb/fedreg/metroareas122700.pdf.

Hurricane Sandy Rebuilding Task Force (August 2013) Hurricane Sandy Rebuilding Strategy. http://www.dot.gov/fastlane/task-force-releases-hurricane-sandy-rebuilding-strategy http://portal.hud.gov/hudportal/HUD?src=/press/press_releases_media_advisories/2013/HUD No.13-125.

Kaufman, S. M., Moss, M. L., Tyndall, J. and Hernandez, J. (December 2014) Mobility, Economic Opportunity and New York City Neighborhoods, New York, NY: NYU Rudin Center. http://wagner.nyu.edu/rudincenter/wp-content/uploads/2014/12/NYURudinJobAccessReport.pdf.

Kneebone, E. (2011) Brookings Institution analysis of decennial census and American Community Survey data, 2010 Suburban Poverty 9-26-11; suburban tip. Data provided courtesy of E. Kneebone.

Kneebone, E. (July 31, 2014) The Growth and Spread of Concentrated Poverty, 2000 to 2008-2012, Washington, DC: Brookings Institution, http://www.brookings.edu/research/interactives/2014/concentrated-poverty#/M10420.

Kneebone, E. and Berube, A. (2013) Confronting Suburban Poverty in America. Brookings Institution Press. http://confrontingsuburbanpoverty.org/.

Kneebone, E. and Garr, E. (January 2010) The Suburbanization of Poverty: Trends in Metropolitan America, 2000 to 2008, Washington, DC, USA: The Brookings Institution.

Kneebone, E. and Holmes, N. (2015) The growing distance between people and jobs in metropolitan America, Washington, DC: The Brookings Institution, http://www.brookings.edu/~/media/research/files/reports/2015/03/24-job-proximity/srvy_jobsproximity.pdf.

Litman, T. (2006) Lessons from Katrina and Rita: What Major Disasters Can Teach Transportation Planners, Victoria, BC, Canada: Victoria Transport Policy Institute.

McNeil, H. (December 4, 2014) Erie County's expenses for November lake-effect storms hit $7.5 million, The Buffalo News, http://www.buffalonews.com/feed/erie-countys-expenses-for-november-lake-effect-storms-hit-75-million-20141204

Metropolitan Policy Program, The Brookings Institution, Confronting Suburban Poverty in America, Profiles of Suburban Poverty, http://confrontingsuburbanpoverty.org/action-toolkit/top-100-us-metros/.

Metropolitan Transportation Authority (September 2007) August 8, 2007 storm report. New York, NY: Metropolitan Transportation Authority, 1-115, http://web.mta.info/mta/pdf/storm_report_2007.pdf.

New York City (2013a) PlaNYC A Stronger, More Resilient New York. New York, NY: City of New York, Chapter on transportation, http://www.nyc.gov/html/sirr/html/report/report.shtml.

New York City (2014a) Hazard Mitigation Plan Update 2014, Draft for Public Review, http://www.nyc.gov/html/oem/html/planning_response/planning_hazard_mitigation_2014.shtml.

New York City (2014b) New York City Hazard Mitigation Strategy 2014, New York, NY: NYC, http://www.nyc.gov/html/oem/downloads/pdf/hazard_mitigation/plan_update_2014/final_nyc_hmp.pdf.

New York City (2015) NYC Hazard Mitigation Plan Update 2015. Annex: 2015 Hazard Mitigation Plan Update, http://www.nyc.gov/html/oem/downloads/pdf/hazard_mitigation/hmp_annual_update_2015.pdf.

New York City Office of the Mayor (2015) One New York: The Plan for a Strong and Just City. New York, NY: NYC Office of the Mayor, http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf.

New York City Panel on Climate Change (NPCC) (January 2015) Building the Knowledge Base for Climate Resiliency: New York City Panel on Climate Change 2015 Report Annals of the New York Academy of Sciences The New York Academy of Sciences Vol. 1336.

New York State (2014) 2014 New York State Hazard Mitigation Plan, Albany, NY: NYS, http://www.dhses.ny.gov/oem/mitigation/documents/2014-shmp/2014-SHMP-full.pdf.

New York State (August 2012) Hurricane Irene and Tropical Storm Lee: One Year Later August 2012, http://www.governor.ny.gov/sites/governor.ny.gov/files/archive/assets/documents/Irene-Lee-One-Year-Report.pdf.

Renne, J.L., Sanchez, T.W., and Litman, T. (October 2008) National Study on Carless and Special Needs Evacuation Planning: A Literature Review, New Orleans, LA: UNO Transportation Center, http://www.planning.uno.edu/docs/CarlessEvacuationPlanning.pdf.

Rosenzweig, C., Solecki, W., DeGaetano, A., O'Grady, M., Hassol, S., and Grabhorn, P. (Eds.) (2011) Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation. Technical Report. New York State Energy Research and Development Authority (NYSERDA), Albany, New York, www.nyserda.ny.gov.

Sanchez, T., Stolz, R. and Ma, J. (2004) Inequitable Effects of Transportation Policies on Minorities. Transportation Research Record 1885:104–110.

Tomer, A., Kneebone, E., Puentes, R. and Berube, A. (May 2011) Missed Opportunity: Transit and Jobs in Metropolitan America, Washington, DC: The Brookings Institution. Available at: http://www.brookings.edu/research/reports/2011/05/12-jobs-and-transit, http://www.brookings.edu/~/media/research/files/reports/2011/5/12%20jobs%20and%20transit/0512_jobs_transit.pdf.

Transportation Research Board (TRB) (2008a) Potential Impacts of Climate Change on U.S. Transportation. Special Report 290. Washington, DC: The National Academies, National Research Council.

Transportation Research Board (TRB) (2008b) The Role of Transit in Emergency Evacuation. Special Report 294. Washington, DC: The National Academies, National Research Council. University of South Carolina, Hazards and Vulnerability Research Institute. Social Vulnerability Index, http://webra.cas.sc.edu/hvri/products/sovi.aspx.

U.S. Bureau of the Census, https://www.census.gov/hhes/www/poverty/methods/definitions.html.

U.S. Bureau of the Census, 2005-2009 American Community Survey 5-Year Estimates. Washington, DC: U.S. Bureau of the Census.

U.S. Bureau of the Census, Center for Economic Studies (2013) Census On the Map.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) (undated web site), https://www.ncdc.noaa.gov/stormevents/.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) (8/31/11) Irene by the Numbers http://www.noaa.gov/images/Hurricane%20Irene%20by%20the%20Numbers%20-%20Factoids_V4_083111.pdf.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) (September 2012) Service Assessment Hurricane Irene, August 21–30, 2011.

U.S. Department of Commerce, NOAA, NWS Lake Effect Summary: November 17-19, 2014 http://www.weather.gov/buf/lake1415_stormb.html.

U.S. Department of Transportation, Bureau of Transportation Statistics (2014) Transportation Statistics Annual Report 2013, Washington, DC: U.S. DOT, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/TSAR_2013.pdf.

U.S. Department of Transportation, FTA September 22, 2014 Resilience Projects in Response to Hurricane Sandy, http://www.fta.dot.gov/15138_16147.html.

Wachs, M. (2010) Transportation policy, poverty, and sustainability: history and future, Transportation Research Record: Journal of the Transportation Research Board, 2163, 5–12.

Zimmerman, R. (2012) Transport, the Environment and Security. Making the Connection, Cheltenham, UK and Northampton, MA: Edward Elgar Publishing, Ltd.

Zimmerman, R. (2014, August) Planning restoration of vital infrastructure services following hurricane sandy: Lessons learned for energy and transportation. J. Extreme Events, 1(2), http://www.worldscientific.com/doi/pdf/10.1142/S2345737614500043.

Zimmerman, R., Restrepo, C.E., Sellers, J., Amirapu, A., and Pearson, T.R. (June 2014) Promoting Transportation Flexibility in Extreme Events through Multi-Modal Connectivity, U.S. Department of Transportation Region II Urban Transportation Research Center, New York, NY: NYU-Wagner. Final report, http://www.utrc2.org/sites/default/files/pubs/Final-NYU-Extreme-Events-Research-Report.pdf.

Zimmerman, R., Restrepo, C.E., Sellers, J., Amirapu, A., and Pearson, T.R. and Kates, H. B. (2015) MultiModal Transit Connectivity for Flexibility in Extreme Events, Transportation Research Record: Journal of the Transportation Research Board, No. 2532, pp. 64-73. DOI: 10.3141/2532-08.

APPENDICES

APPENDIX 1. Data Description

APPENDIX 2. Maps for Population Density, Transit Location, and Poverty

APPENDIX I. DATA DESCRIPTION

The following data variables were the focus on this research:

Urban or Rural:
This was assigned according to whether the block group centroid was within the 2014 "Urban Areas" boundary provided by the U.S. Census Bureau. Some additional waterfront block groups were given this designation manually if their centroid was in the water and outside the Urban boundary. The block groups that were designated as Urban were further classified on whether they are part of an Urbanized Area or and Urban Cluster explained above in the text on suburbanization.
Data source: https://www.census.gov/geo/maps-data/data/cbf/cbf_ua.html

Population Density:
This was calculated using the ACS's Total Population estimate from the Sex by Age estimates (B01001e1) and Land Area (ALAND10) provided in square meters. Block groups that had a Land Area of zero were excluded from the analysis.
Metadata for ACS fields:
http://www2.census.gov/geo/docs/maps-data/data/tiger/prejoined/ACSMetadata2011.txt

Percent of Individuals in Poverty:
This was calculated using the total population for whom poverty status is determined (B17021e1) and the number of individuals for whom income in the past 12 months was below poverty level (B17021e2). Block groups that had a zero value for the total population for whom poverty status is determined (B17021e1) were excluded from the analysis.
Metadata for ACS fields:
http://www2.census.gov/geo/docs/maps-data/data/tiger/prejoined/ACSMetadata2011.txt

Percent of Workers with Commute Time of 60-89 Minutes:
This was calculated using the total population of workers 16 years and over who did not work at home (B08303e1) and the number of those workers with commutes of 60-89 minutes (B08303e12). Block groups that had a zero value for total population of workers 16 years and over who did not work at home (B08303e1) were excluded from the analysis.
Metadata for ACS fields:
http://www2.census.gov/geo/docs/maps-data/data/tiger/prejoined/ACSMetadata2011.txt

Percent of Workers with Commute Time of 90 or More Minutes:
This was calculated using the total population of workers 16 years and over who did not work at home (B08303e1) and the number of those workers with commutes of 90 or more minutes (B08303e13). Block groups that had a zero value for total population of workers 16 years and over who did not work at home (B08303e1) were excluded from the analysis.
Metadata for ACS fields:
http://www2.census.gov/geo/docs/maps-data/data/tiger/prejoined/ACSMetadata2011.txt

Percent of Workers with Commute Time of 60 or More Minutes:
This was calculated by combining the Percent of Workers with Commute Time of 60-89 Minutes and Percent of Workers with Commute Time of 90 or More Minutes.

Percent of Workers that Commute by Public Transit:
This was calculated using the total population of workers 16 years and over who did not work at home (B08303e1) and the number of those workers that used public transit as their means of transportation to work (B08301e10). Block groups that had a zero value for total population of workers 16 years and over who did not work at home (B08303e1) were excluded from the analysis.
Metadata for ACS fields:
http://www2.census.gov/geo/docs/maps-data/data/tiger/prejoined/ACSMetadata2011.txt

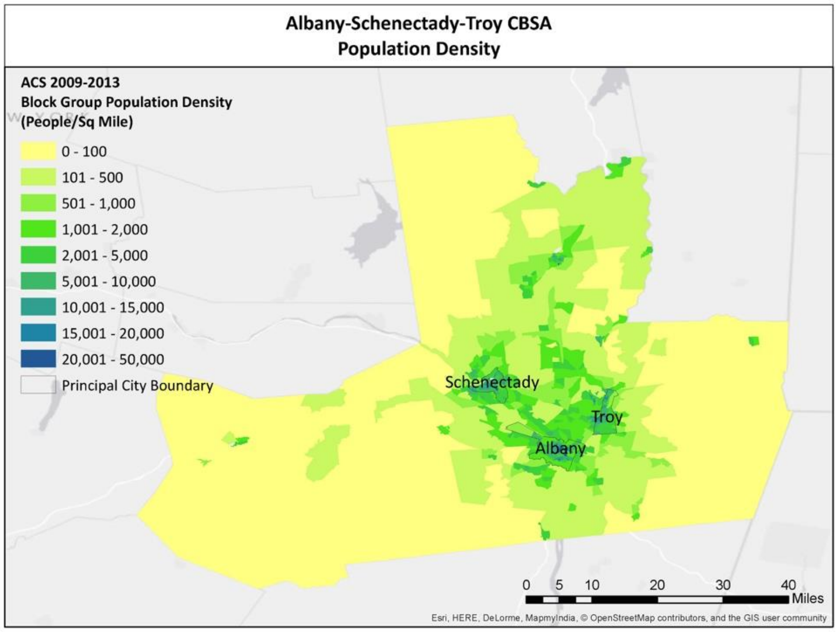
Distance to Nearest Public Transit Rail Station:
This distance to the nearest public transportation rail station (meters) was calculated from the centroid of the block group.

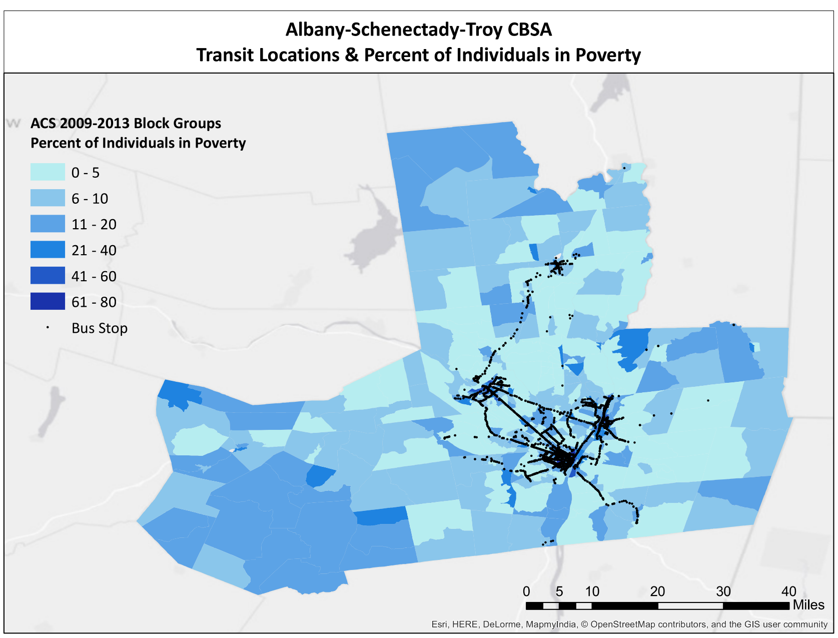
Distance to Nearest Public Transit Bus Stop:
This distance to the nearest active public transportation bus stop (meters) was calculated from the centroid of the block group.

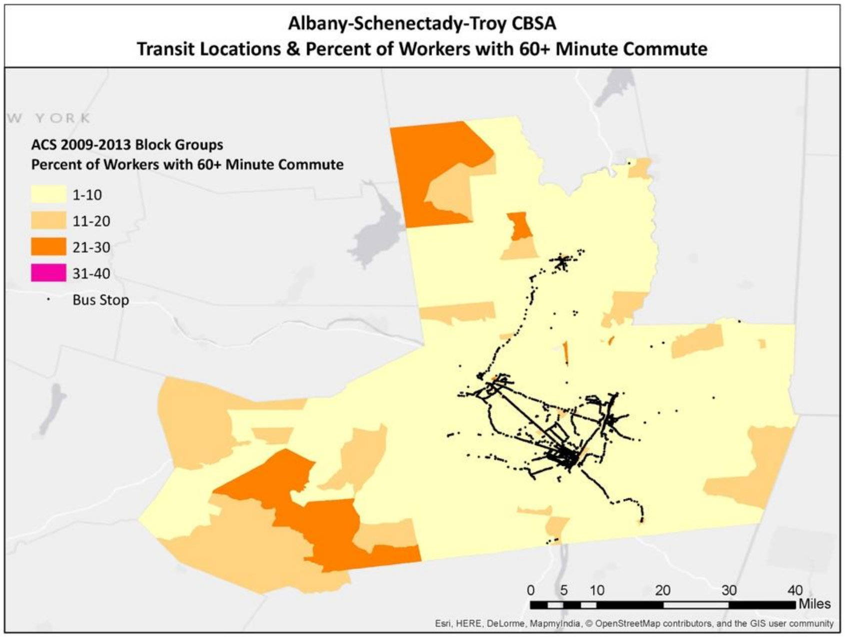
APPENDIX 2. POVERTY, DENSITY, COMMUTE TIME, AND TRANSIT LOCATIONS

ACS 2009-2013 Block Groups

Albany-Schenectady-Troy CBSA Albany-Schenectady-Troy CBSA

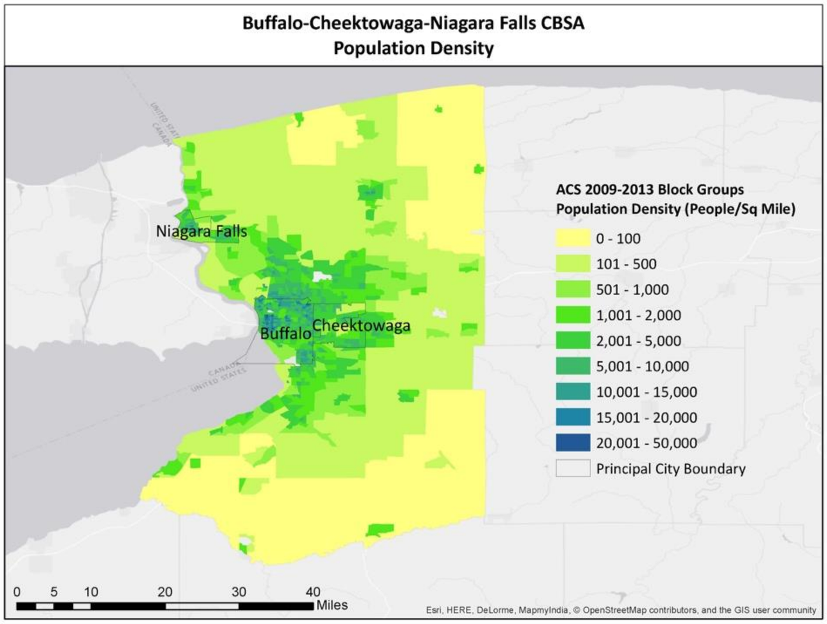


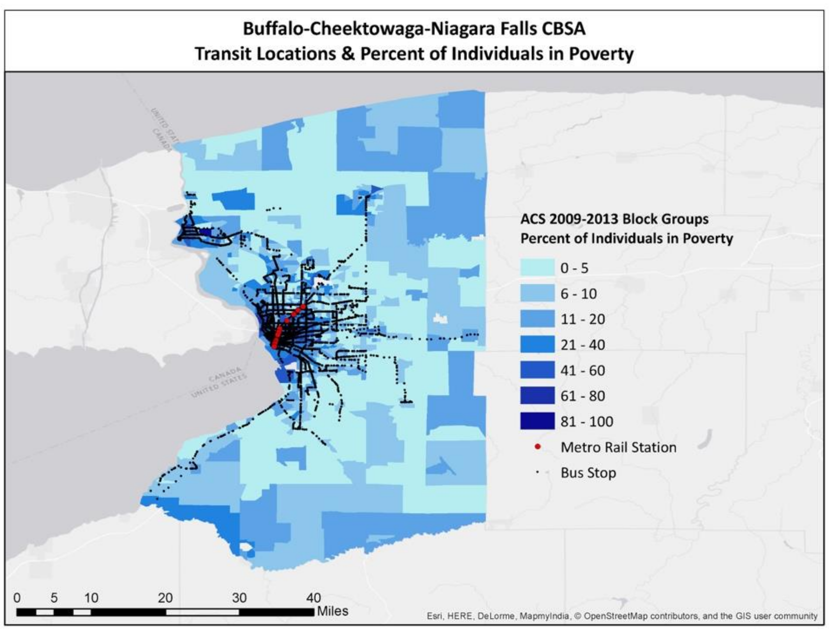


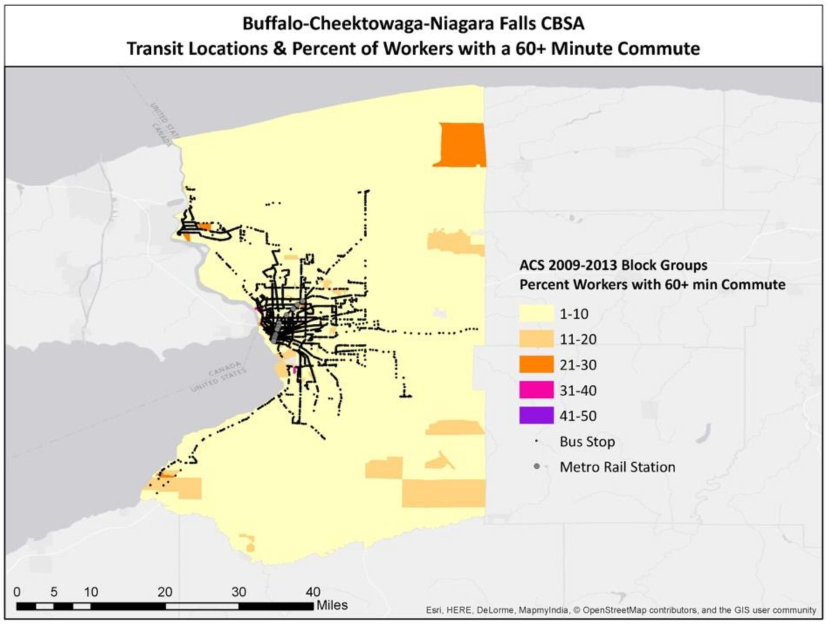

Albany-Schenectady-Troy CBSA
Transit Locations & Percent of Workers with 60+ Minute Commute
W YORK
ACS 2009-2013 Block Groups
Percent of Workers with 60+ Minute Commute
1-10
11-20
21-30
31-40
Bus Stop
0 5 10 20 30 40
Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

POVERTY, DENSITY, COMMUTE TIME, AND TRANSIT LOCATIONS
ACS 2009-2013 Block Groups

Buffalo-Cheektowaga-Niagara Falls CBSA

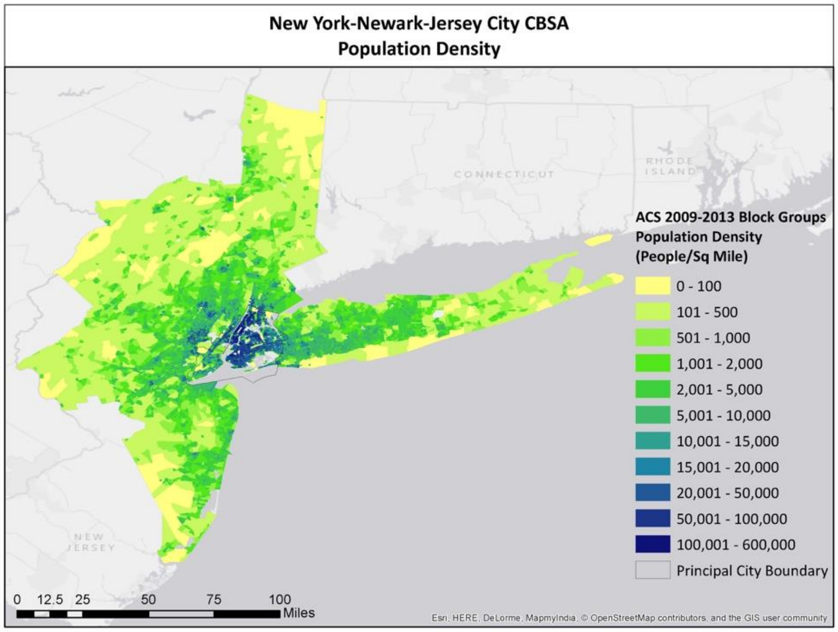


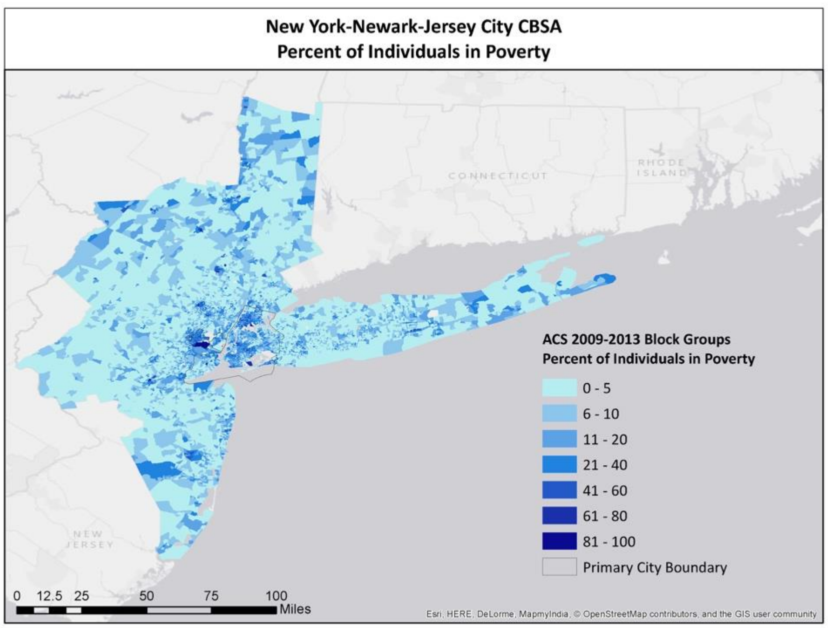


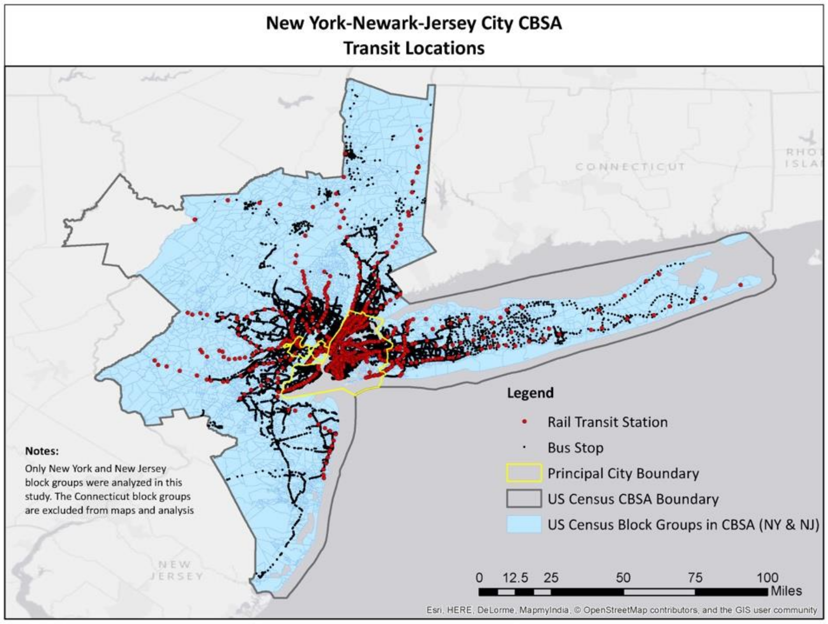

Buffalo-Cheektowaga-Niagara Falls CBSA
Transit Locations & Percent of Workers with a 60+ Minute Commute
ACS 2009-2013 Block Groups
Percent Workers with 60+ min Commute
1-10
11-20
21-30
31-40
41-50
Bus Stop
Metro Rail Station
0 5 10 20 30 40
Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

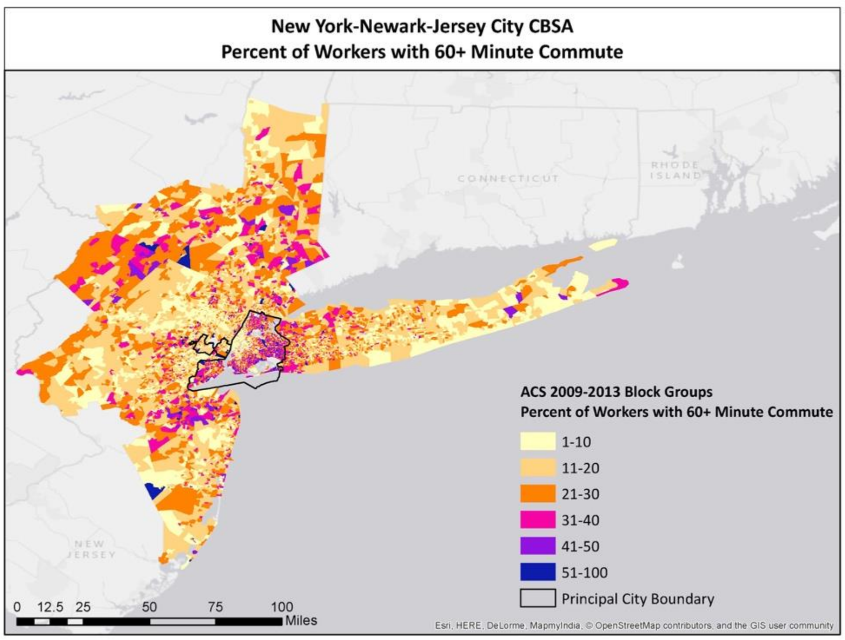
POVERTY, DENSITY, COMMUTE TIME, AND TRANSIT LOCATIONS
ACS 2009-2013 Block Groups

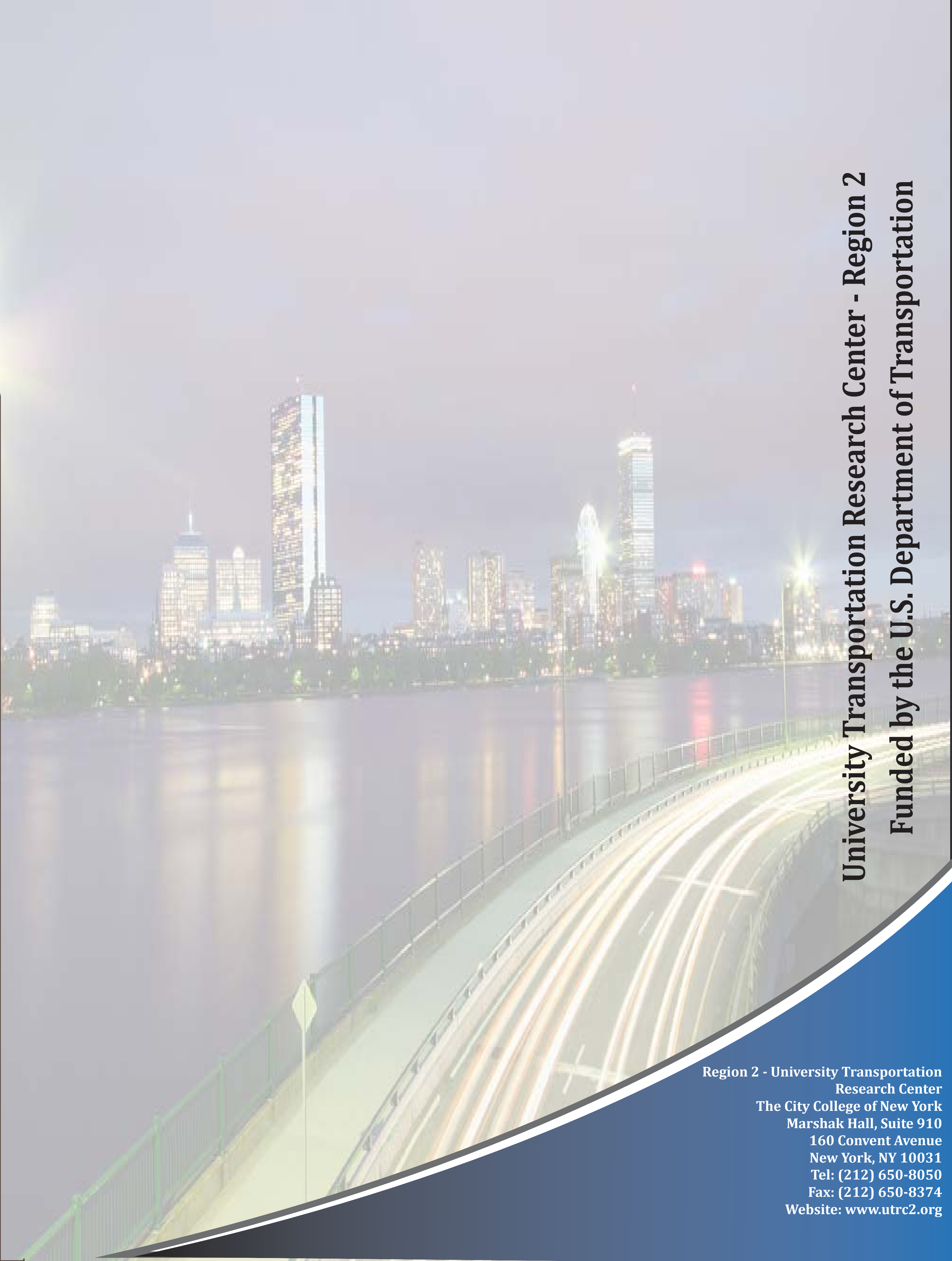
New York-Newark-Jersey City CBSA






New York-Newark-Jersey City CBSA
Transit Locations
CONNECTICUT
RHODE ISLAND
Legend
Rail Transit Station
Bus Stop
Principal City Boundary
US Census CBSA Boundary
US Census Block Groups in CBSA (NY & NJ)
Notes:
Only New York and New Jersey block groups were analyzed in this study. The Connecticut block groups are excluded from maps and analysis
NEW JERSEY
0 12.5 25 50 75 100 Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community


New York-Newark-Jersey City CBSA
Percent of Workers with 60+ Minute Commute
CONNECTICUT
RHODE ISLAND
NEW JERSEY
ACS 2009-2013 Block Groups
Percent of Workers with 60+ Minute Commute
1-10
11-20
21-30
31-40
41-50
51-100
Principal City Boundary
0 12.5 25 50 75 100 Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



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Funded by the U.S. Department of Transportation

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