RUTGERS UNIVERSITY BIKE SHARE

CONNECTING THE RARITAN

HEALTH IMPACT ASSESSMENT

Bloustein School of Planning and Public Policy | Fall 2016 Graduate Studio

ABOUT THE STUDIO

This studio project is an analysis of the health impacts of the potential new bike share program planned for the Rutgers-New Brunswick community. It builds upon our client's – the Rutgers University Department of Institutional Planning and Operation (IPO) – Internal Bicycle Share Proposal. The IPO report highlighted existing bicycle infrastructure, robust public transportation infrastructure, and the high concentration of bicycle commuters in the study area as support for their proposal. This studio expanded on that analysis by examining the physical, mental, social, and economic health of the users and residents of Rutgers campus and the surrounding areas. Our targeted audience for this analysis was people who both currently bike and those who do not, while paying close attention to equity issues and vulnerable populations. We were concerned with issues like ensuring bike share usage for the lower-income residents of New Brunswick's outer wards.

To investigate these concerns, we performed extensive literature reviews to provide a critical context for this project. We issued a survey to the Rutgers-New Brunswick community to assess the current baseline health of campus and community residents.

We met with Bloustein professors, with planning professionals, and with the organizers and staff of bike shares across the country in order to ask questions and gain invaluable advice on how to proceed with our analysis. We used this collected knowledge to build impact projections and develop a list of actionable recommendations targeted at maximizing positive health outcomes while mitigating health concerns.

This studio course is intended to advance the goals of Healthier New Brunswick, a network of partners in the City of New Brunswick that are working together to ensure that all residents have equal access to the services and conditions that allow for good health and well-being. Ensuring equal access to active modes of transportation is one element of Healthier New Brunswick's Blueprint for Action which outlines areas of focus for network partners.

Although the clients for this studio are staff at the Rutgers University Department of Institutional Planning and Operations (IPO), the report contents includes findings and recommendations for Rutgers and the three communities of New Brunswick, Highland Park and Piscataway.

ACKNOWLEDGMENTS

The studio would like to thank our professors for their direction and feedback throughout the process.

Karen W. Lowrie, Ph.D. - Environmental Analysis and Communication Group & Planning Healthy Communities Initiative, Rutgers University
Leigh Ann Von Hagen, PP, AICP - Alan M. Voorhees Transportation Center & Planning Healthy Communities Initiative, Rutgers University

In addition, we would like to thank the professors at Rutgers and professionals in the bike share community who offered their knowledge and provided invaluable insight into bike sharing.

Frank Wong - Institutional Planning and Operations, Rutgers University
Jennifer Stuart, PP, AICP - Institutional Planning and Operations, Rutgers University
Zachary Subar - Institutional Planning and Operations, Rutgers University
Leigh Ann Kimber - Institutional Planning and Operations, Rutgers University
Jack Molenaar, PP, AICP - Department of Transportation Services, Rutgers University

Kelcie Ralph, Ph.D. - Bloustein School of Planning and Public Policy, Rutgers University
Robert B. Noland, Ph.D. - Bloustein School of Planning and Public Policy, Rutgers University

Tiffany R. Robinson - WeHo Pedals Bike Share, City of West Hollywood, CA
Renee Autumn Ray, AICP - Atlanta Regional Commission
Thom Stead - Delaware Valley Regional Planning Commission
Jonathan Monceaux – UVA Ubike,
Dave Fotsch – Boise Reddy Bike, Boise, Idaho
Lauren Severe – Devener BCycle, Denver, Colorado

STUDIO PARTICIPANTS

Nimotalai Azeez - MCRP 2017
Cameron Black - MCRP 2016
Michael Borsellino - MCRP 2017
Dylan Bruchhaus - MCRP 2017
Carrem Gay - MCRP 2017
Jeremy Glover - MCRP 2017
Luis Gonzalez - MCRP 2017
Tian Ruan - MCRP 2017
Holly Sullinger - MCRP 2017
Denis Teoman - MCRP 2017
Yangfan Zhang - MCRP 2017

RUTGERS
Edward J. Bloustein School
of Planning and Public Policy

RUTGERS
Institutional Planning
and Operations

TABLE OF CONTENTS

TABLES AND FIGURES

BIKE SHARE IN THE UNITED STATES

CYCLING AND HEALTH

RUTGERS BIKE SHARE POTENTIAL USER SURVEY

BASELINE CONDITIONS

BIKE SHARE IN THE UNITED STATES

HISTORY OF BIKE SHARING

The concept of bike sharing has existed since the 1960s and the first bike share program was founded in Amsterdam in 1965.[1] It can be said that the development of bike sharing systems has evolved through three generations. In the first generation of bike sharing, like in Amsterdam and La Rochelle, France, bicycles were free for everybody to take; there were no formal rules to rent and return bikes. This form of bike sharing led to chaos and theft because there was no formal way of controlling and tracking customers.

The second generation was marked by the usage of coin deposit systems to rent bicycles. This generation originated in Farsø, Denmark and Grenaa, Denmark in 1991.[2] Even though this allowed customers to become somewhat more trackable, theft still remained a problem due to the anonymity of bike share customers. This generation was also marked by an increased institutionalization of bike shares and the involvement of non-profit organizations. Notably, the non-profit organizations operating bike shares commonly received funding from local communities.

The third and current generation of bike sharing can be marked by the incorporation of information technology into bike share infrastructure; this shift to IT was first witnessed in Portsmouth, England in 1996. Technologies like smart cards and GPS have helped tremendously in reducing bicycle thefts while also providing valuable information on how bike shares are used. These two factors – reduced theft and better information – have led to a rapid adoption of bike share technology arcoss the world.[3]

As stated previously, the origin of bike share was in Europe in the 1960s. It was not until the mid-1990s that bike sharing made its way to the United States; Portland, Oregon is considered the first American city to adopt bike share technology. As of April 2016, there are approximately 70 bike share systems in 104 cities in the United States.[4] This echoes the global trend of bike share growth. In 2006 there were just 24 cities with bike share worldwide, by 2014 there were 855. This is a growth rate of approximately 60 bike shares per year. While the majority of bike share programs are located in Europe, East Asia has made notable strides in adopting bike shares; China now has the largest bike share fleet with over 750,000 total bikes. On the other hand, Africa has lagged behind the rest of the world in adopting bike share technologies.[5] This shows that infrastructure plays an important role in successfully implementing bike share programs.[6]

In the United States, the majority of bike sharing systems are located in major cities mostly on the coasts and the largest bike sharing systems are located on the east coast. This can be viewed in the figure 2. It is interesting to note that more dense cities with larger public transportation networks seem to be friendlier towards bike sharing than car-oriented cities. Therefore, it can be stated that bike sharing in the United States

is not dependent on city size, instead it is dependent on high population density and robust public transportation infrastructures.

It can be concluded, that bike sharing systems are expected to grow further, with the majority of future bike-sharing systems being third generation bikes or even fourth generation bikes with high-tech on-bike computer technology. These fourth generation bikes can be traced more easily and offer more customer-oriented service and more tracking in emergency situations.

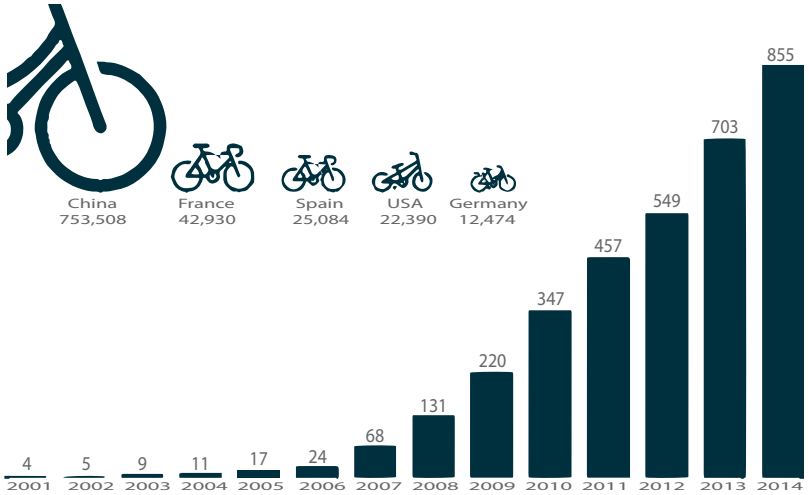


Figure 1: Number of Cities worldwide which have bike sharing systems 2001-2014[7]

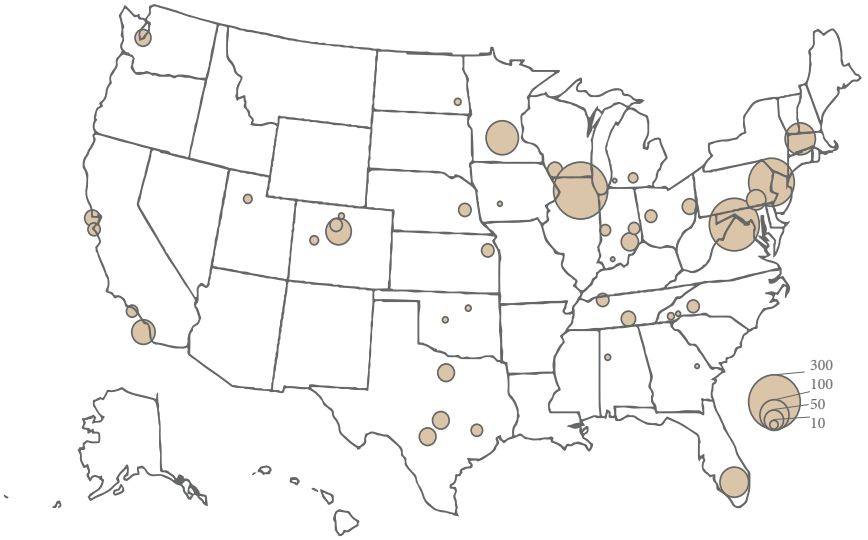


Figure 2: Bike share stations in the United States, April 2016[8]

HOW BIKE SHARES WORK

There are three main types of bike sharing systems: library, kiosk/tech on station, and tech on bike.[9] The mechanism for renting and using a bicycle from each system and three different options for helmet shares will be discussed.

1. Library Model (Bike RU – New Brunswick)

A bike library is a central, staffed location where bicycles can be rented for a specified period of time. This is the original bike share model. Users are responsible for maintaining and locking the bicycle while it is under their care.[10] Rutgers University has a bike library called Bike RU. It allows students, faculty, and staff of the university to rent bicycles by the month or by the semester. To ensure bicycles are returned undamaged, the program can levy fines against a user's Rutgers University account.[11]

2. Kiosk Model (Citi Bike – New York City)

The Kiosk Model relies solely on bicycle docking stations placed around the city. These are special bike racks where the bike share bicycles must be picked up and dropped off.[12] In order to use a bicycle, a pass must be purchased. In the case of New York City's Citi Bike system, a pass can be purchased through the program's mobile app or through the kiosk that accompanies every bike rack. The latter is done via a credit or debit card.[13]

Day Pass
Citi Bike offers day passes and three-day passes; both passes entitle the rider to unlimited 30-minute rides in a 24-hour or 72-hour period, respectively. Upon purchasing a day pass, the rider will be given a 5-digit code through the mobile app or through the kiosk (printed on a receipt).

Further, when a pass is purchased, a security deposit ($101) will be placed on the rider's credit card. This will be used to cover overage charges and to insure against lost or stolen bicycles. A lost or stolen bike will cost the user over $1,200.[14]

Annual Pass
Citi Bike also offers annual passes; this pass entitles the rider to unlimited 45-minute rides. The functionality of the bicycle remains the same as with the day passes. Riders may generate a 5-digit code via the mobile app or by swiping their account credit card at any kiosk. Annual members have the additional option of using a membership key to rent bicycles. The membership key is essentially a USB stick; it can be inserted into the dock of any bike, immediately unlocking the bike. That being said, regular users prefer the mobile app to the kiosk and membership key.[15]

Renting a Bicycle
To unlock a bicycle, enter the 5-digit code on any docked bicycle (or insert the membership key). A bicycle can be kept out indefinitely, though there are overage fees for keeping bicycles out longer than 30 minutes or 45 minutes (day pass or annual pass, respectively). Once the bicycle is returned, a rider may rent another bicycle as long as their pass is still valid.[16]

Summary
This model is effective in places like New York City where there is a high density of riders and many stations. They are incredibly

efficient for one way trips and the concrete kiosk locations make bike renting, returning, and maintenance very easy. However, bike racks can easily be emptied or filled up, requiring riders to find other nearby racks to either rent or return a bicycle. The lack of a cash option for renting bicycles leaves users outside of the formal banking sector at a disadvantage, but the need for a variable payment system makes a cash option difficult. The need for a large number of stations also means that this system has a high startup cost.[17]

3. Tech on Bike Model/Smart Bike (Hudson Bike Share – Hoboken)

The Tech on Bike Model relies on GPS-enabled bikes with self-contained locking mechanisms, as opposed to bike docks. In order to use a bicycle, a pass must be purchased.[18] For example, Hoboken's Hudson Bike Share offers many methods to purchase a pass. A user may purchase a pass through the programs mobile app, through their website, through one of several kiosks, or by calling customer service. Users may purchase single rides, monthly memberships, or annual memberships; these entitle the rider to a single 30-minute trip for the pay as you go option, or unlimited 45-minute trips for either recurring membership.[19]

Renting a Bicycle
Since the bicycles locking mechanism is self-contained, the ways to unlock a bicycle revolve arond direct contact with the bicycle. The rider may use the mobile app to generate a pin number which can keyed into the bicycle's onboard computer; this is the recommended option. A rider may also use one of the kiosks (though they are few and far between), they may hold their customer card up to the bicycle's computer, they may enter their phone number on the bicycle's computer, or they may call customer service to unlock a bicycle.[20]

If a rider wishes to temporarily stop using the bicycle during a ride, they may do so. They must click the 'Park' option on the bicycle's computer and engage the front lock; a bicycle in 'Park' will count against a rider's time limit. To continue the trip, the rider must reenter the pin number on the bicycle's computer.[21]

Parking a Bicycle
Because the Tech on Bike Model has very few kiosks, the options for returning a bicycle are much for flexible than with the kiosk model. Bicycles may be returned to one of the kiosks; this is the most desirable option. However, if a kiosk is full, a rider may place the bicycle next to the kiosk, click the 'Returned' option on the bicycle's computer, and engage the front lock. There are also no-fee regional zones, GPS-designated areas where a rider may engage the bicycle's on-board locking mechanism to return a bike. Lastly, if neither of these is a viable option for the rider, bicycles can be left anywhere, a rider just needs to follow the same protocol to engage the bicycle's self-contained lock. This option will levee a small fee against the rider's credit card ($10 or $25 based on bike location).[22]

This system is perfect for areas with a modest density of riders because it allows the systems to operate with much fewer stations, greatly lowering startup and operating costs. The "No Fee Regional Zones" are entirely GPS-designated which means they can be easily moved. This is flexibility is unrivaled, especially when planning for large scale events that would redistribute bicycle concentrations. However, allowing all bicycles to temporarily be relocated to one area could also be considered a flaw; taking advantage of this flexibility should be done carefully. The biggest complaint about these models is that it is sometimes difficult to tell which bicycles are part of the program, and which bicycles are available (versus being in "Park"). As with the Kiosk Model, the lack of a cash option for renting bicycles leaves users outside of the formal banking sector at a disadvantage, but the need for a variable payment system makes a cash option difficult.[23]

HELMET SHARES

Helmets are a controversial issue when it comes to bike shares. This section will not explore into the arguments for or against helmets, rather it will present three options for Helmet Shares that have been proposed.

1. Helmet Vending Machines (HelmetHub - Boston)

HelmetHub is network of helmet vending machines placed adjacent to some of the kiosks for Boston's Hubway Bike Share. Helmets may be rented from the vending machine ($2) for a 24-hour period. To return a helmet, users need to return the helmet to a designated drop box. From here, the helmets will be picked up by HelmetHub staff, sanitized, and placed back into a vending machine for further use. HelmetHub vending machines cost over $10,000 to install.[24]

2. Helmet Bins (Pronto Cycle Share - Seattle)

Seattle's Pronto Cycle Share uses an honor system to distribute helmets to its riders. Next to each kiosk are two bins, one containing sanitized helmets and the other containing used helmets. A rider can pick up a helmet from an unlocked bin and return it to the adjacent used helmet bin at any time. Currently, the helmet loss rate is under four percent.

Seattle does plan to go to a pay per helmet system in the future. However, instead of using vending machines, they intend to keep using bins. The Pronto Cycle Share estimates that locking bins with an onboard computer will cost only $2,500 to install.[25]

3. Helmet on Bike (Mobi - Vancouver)

Vancouver's Mobi system provides a free helmet rental with each bicycle. The unisize helmets are attached to each bike share bicycle via a cable lock. To adress sanitation concerns, Mobi

provides disposable helmet liners at each kiosk for free. Further, Mobi staff spray the helmets with disinfectant every day and they periodically remove helmets from the rotation for deep cleaning.[26][27]

PRICING

Table 1 gives an overview of the pricing structure of six selected bike sharing systems based on independent research. There is remarkable consistency in the cost of day passes and single rides across all six systems, and every system offers some form of subsidy for lower-income users. It is interesting to note how the systems' membership pricing structures diverge. For example, Philadelphia's Indego bike has IndegoFlex. This annual pass costs $10 and allows users to "Pay As You Go" at a rate of $4 per hour. Only Denver B-cycle offers a similar annual flexible pass, which is aimed at permanent residents who do not ride frequently. Most other bike sharing systems offer flat-rate annual memberships that allow unlimited bicycle use; this is reflected in the table.

It can be seen that the pricing schemes vary throughout the systems. It is important to note that many systems do not offer cash payment options. Further analysis can look at the effects of cash payment options on bike share ridership, specifically its ability to effectively include lower-income residents.

The different pricing schemes can also hint to which socioeconomic groups the different bike shares target. For example, Hudson Bike Share and LA Metro Bike do not offer single day or three-day passes. Instead, they offer only single rides and memberships. This implies that these bike shares target frequent users at the expense of tourists and lower-income residents who cannot afford memberships.

It can be seen that the pricing schemes vary throughout the systems. It is important to note that many systems do not offer cash payment options. Further analysis in the future can look at the effects of cash payment options on bike share ridership, specifically its ability to effectively include lower-income residents.

Table 2 displays the pricing structure of three selected university-affiliated bike sharing systems. It is interesting to note that Reddy Bike in Buffalo does not offer Pay As You Go fares, while semester fares are only offered by UBike at the University of Virginia.

	Indego Philadelphia, Pennsylvania	Hubway Boston, Massachusettes	DENVER B cycle Denver, Colorado	capital bikeshare Washington, District of Columbia	citi bike New York City, New York	HUDSON BIKE SHARE Hoboken, New Jersey	Metro Los Angeles, California
Single Ride	$4 / 30 minutes	N / A	$2 / 30 minutes	$2 / 30 minutes	N / A	$2 / 30 minutes	$3.50 / 30 minutes
Day Pass	N / A	$6	$9	$8	$12	N / A	N / A
Three Day Pass	N / A	$12	N / A	$17	$24	N / A	N / A
Per Month	$15	$20	$15	$28	$14.95	$12.95	$20
Annual	$10 with additional $4 / hour	$85	$135 or $15 with $3 / 30 minutes	$85 or $96 with $8 / month	$155	$95	$40 / 30 minutes (additional $1.75 per ride)
Subsidized Membership Per Month	$5	N / A	N / A	1 year free (Montgomery County only)	$14.95	N / A	N / A
Subsidized Membership Annual	N / A	$5 + helmet fee	$10	N / A	N / A	1 year free for housing authority residents	annaul fee waived for individuals enrolled in LA's Metro Rider Relief program
Cash Payment Option	yes	no	no	yes (Arlington County only)	no	no	no
Subsidized Overage	$2 / hour	N / A	$5 / 30 minutes after the first hour	N / A	N / A	N / A	N / A
Standard Overage	$4 / hour	variable	$5 / 30 minutes	$1.50 - $2 / 30 minutes	$2.50 - $9 / additional 30 minute variables	$3 / 30 minutes	$1.75 / 30 minutes

Table 1: Pricing Schemes of Selected Bike Sharing Systems [28] [29] [30] [31] [32] [33] [34]

	UBIKE University of Virginia Charlottesville, Virginia	BOISE green BIKE Boise State University Boise, Idaho	REDDY bikeshare University of Buffalo Buffalo, New York
Pay As You Go	$3 / hour	$4 / hour	N / A
Per Month	15	$15	$8.50 signup fee $0.06 / minute
Per Semester	$30	N / A	N / A
Annual	$80	$15	$55 signup fee $0.01 / minute
Overage	$1 / hour	$4 / hour	N / A
Other	$60 student annual	$46 student annaul $100 premium	N / A

Table 2: Comparing the Pricing Structure of Three University Bike Sharing Systems [35] [36] [37]

Another interesting approach is to look at the pricing of bike sharing systems in relation to resident income. The following tables compare the annual membership fee as a percentage of per capita mean income in 2016 in the respective cities for three university-affiliated bike sharing systems and four city-based bike sharing systems. Overall, it can be seen that the percentage of the annual membership in regards to the mean income is much lower for the university-affiliated bike sharing systems compared to the city-based bike sharing systems. Extrapolating per capita income of $24,849 for Rutgers Bike Share the study area combined with the university-affiliated system pricing trend - 0.11% of per capita income (Table 3) - would suggest an annual membership fee of $27.33 for this bike share. It would be interesting to see, with what considerations these pricing schemes were developed. The prices for the city-based bike sharing systems seems to be high in comparison to the university-affiliated bike sharing systems (Table 4); this may be because those cities also have a large population of higher-income residents. However, the high cost is potentially excluding those lower-income residents. It is important to look at the pricing schemes not only from an absolute perspective, but also from a relative perspective.

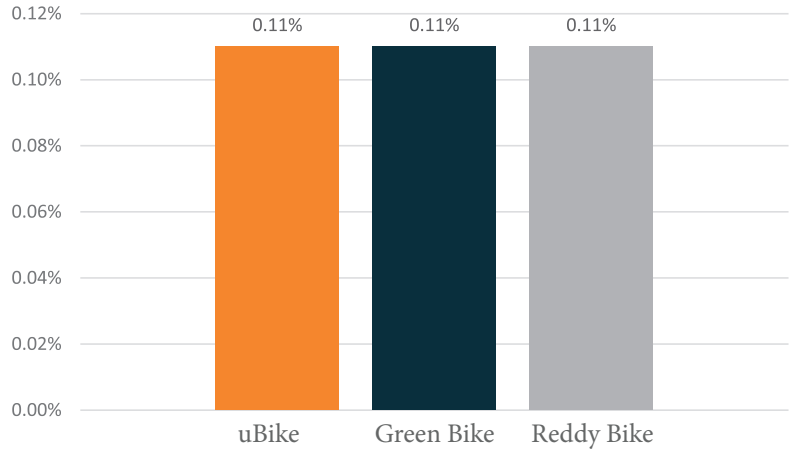


Table 3: Annual Membership of University Affiliated Bike Sharing Systems as a Percentage of Annual per Capita Mean Income (2016) [39] [40] [41] [42]

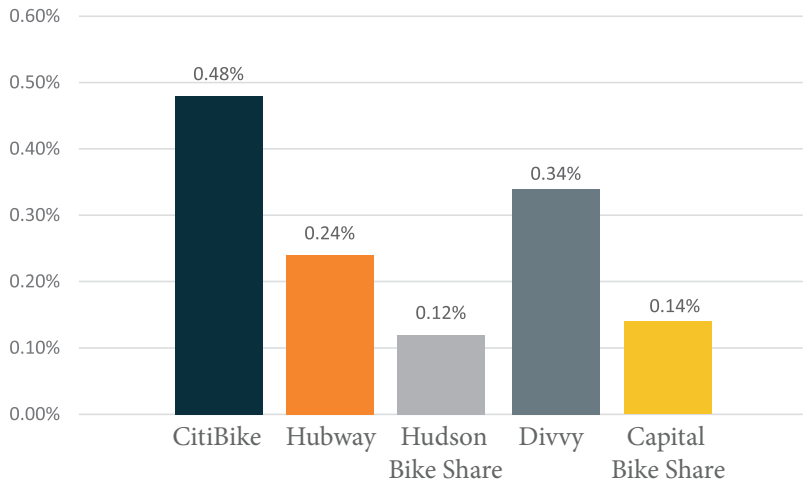


Table 4: Annual Membership of Bike Sharing Systems in Major American Cities as a Percentage of Annual per Capita Mean Income (2016) [43 44 45 46 47 48 49]

According to statistics released by Chicago's Divvy Bike, 47% of total trips are made by customers with day passes. These customers have longer trip durations, on average, than annual members. They also make longer distance trips than annual members; compared to annual members, day pass holders make 25% more trips longer than two miles. Interestingly, only 29.2% of all Divvy Bike trips are longer than two miles, and only 5.8% of all trips exceed 4 miles.[50] Of the remaining bike shares with accessible data, Los Angeles Metro had the longest average trip duration and Chicago Divvy´s had the shortest average trip duration.[51 52 53 54]

	DIVVY Chicago	capital bikeshare Washington D.C.	citi bike New York City	Indego Philadelphia	Metro Los Angeles
Average Ride Duration: Non-members	30 minutes	11.7 minutes	37 minutes	20 minutes	43 minutes
Average Ride Duration: Members	12 minutes	10.4 minutes	14 minutes	13 minutes	19 minutes
Average Ride Duration: Members & Non-members	21 minutes	21 minutes	25.5 minutes	16.5 minutes	31 minutes
Average Trip Distance: Members & Non-members	1.8 miles	-	1.87 miles	-	2.57 miles

Table 5: Comparison of Ride Duration of Bike Share Systems from Major American Cities [55 56 57 58 59]

Table 6 compares two university-affiliated bike sharing systems regarding their ride duration and average trip length. It is interesting to note that in the Boise GreenBike system the ride duration differs much more compared to the UBike system in Virginia. The systems also differ regarding their average trip length in miles. In the UBike system in Virginia the average trip

distance for day pass holders is smaller than for members, while in the Boise GreenBike system the average trip distance for day pass holders is almost twice as much as for members.

	UBIKE University of Virginia Charlottesville, Virginia	BOISE green BIKE Boise State University Boise, Idaho
Average Trip Distance: Day Pass Holders	1.6 miles	3.4 miles
Average Trip Distance: Members	1.8 miles	1.72 miles
Average Trip Distance: Members & Non-Members	1.7 miles	2.56 miles

Table 6: Comparison of Trip Length for University - Affiliated Bike Share Systems

	UBIKE University of Virginia Charlottesville, Virginia	BOISE green BIKE Boise State University Boise, Idaho
Average Ride Duration: Day Pass Holders	30 minutes	83 minutes
Average Ride Duration: Members	12 minutes	20 - 23 minutes
Average Ride Duration: Members & Non-Members	21 minutes	48 minutes

Table 7: Comparison of Ride Duration for University - Affiliated Bike Share Systems

PRECEDENT RESEARCH

Bike sharing is becoming increasingly popular in the United States. Given the number of existing bike share systems, the first goal of the precedent research was to find systems that are similar to the proposed Rutgers Bike Share. This report focuses on four university-affiliated systems which share similar characteristics to the proposed system. While no university-affiliated system has to operate across five campuses and three cities, each of the

chosen model systems accurately reflects key aspects of the proposed Rutgers Bike Share.

Criteria

New Brunswick, New Jersey and its environs is home to over 50,000 undergraduate and graduate students, resulting in a city identity that is tied to the university. As a result, model systems must exist in similar cities with a strong collegiate culture. However, the bike share systems must not be focused solely on university campuses. Instead, they must be integrated into the surrounding communities and greater region. In addition, New Brunswick's location along the Northeast Corridor Rail Line, and thus its connection to Philadelphia and New York, allows unique opportunities in terms of commuting and mobility. Given the need for robust public transportation infrastructure, model cities must have similar connections to metropolitan networks. Furthermore, New Brunswick has a diverse population, including a large percentage of vulnerable populations. Model systems must serve diverse communities and actively address equitable bike share issues. Finally, systems that operate within similar climate and those that rely on hub infrastructure, as opposed to kiosk infrastructure, are preferred.

Systems Meeting Criteria

1. uBike from University of Virginia and Charlottesville, VA
2. mBike from University of Maryland and College Park, Maryland
3. Boise Green Bike from Boise State University and Boise, Idaho
4. Reddy Bike from University of Buffalo and Buffalo, New York

University of Virginia
Charlottesville, Virginia

Implemented: 2015
Service Area: University of Virginia - Grounds & Northern Grounds, with plans of expansion into Charlottesville
System: 11 Hubs
Fleet: 120 bikes
Objective: reduce emissions and foster an overall biking community

Connection to RU?
- large college town with an overall population of ~30,000 while with a student population of ~25,000
- bike share system connects two distinctive UVA campuses
- planned strategy to expand into Charlottesville through a phased approach

What to learn from?
- how to phase a project from a campus setting into the existing community

mbike — University of Maryland, College Park, Maryland

Implemented: 2016
Service Area: University of Maryland and College Park, Maryland
System: 14 kiosks
Fleet: 120 bikes
Objective: fill in gaps in transporation system, increase last mile transit, decrease cars and roadways

Connection to RU?
- large college town with an overall population of ~38,000 while with a student population of ~30,000
- mBike serves as a last mile connector from major regional transit systems to the campus and downtown College Park, MD

BOISE green BIKE — Boise State University, Boise, Idaho

Implemented: 2015
Service Area: Boise State University and downtown Boise, Idaho
System: 14 Hubs
Fleet: 120 bikes
Objective: reduce environmental impacts

Connection to RU?
- climate has a harsh winter that impacts biking

What to learn from?
- Boise has an existing strong bike culture - both the campus and the city are gold status
- robust biking infrastructure already exists, including greenbelts along the Boise River

REDDY bikeshare — University of Buffalo, Buffalo, New York

Implemented: 2016; pilot program originally in 2013
Service Area: University of Buffalo and Buffalo, New York
System: 30+ hubs
Fleet: 200 bikes
Objective: improve existing bike culture and reduce environmental impacts

Connection to RU?
- similar demographics to New Brunswick - large lower-income and ethnically diverse people
- climate has a harsh winter that impacts biking

What to learn from?
- Buffalo has parterned with local non-profits to dramatically increase participation in vulnearble popluation in its car share program, and is expanding into the bike share program

These four systems provide insight into implementation strategies and overall strategic management of the system. More importantly, they provide insight into health considerations and how to increase biking and bike share equity in the community.

Best Practices

Each of these four systems have different approaches to improving health, though they share a dominant focus on infrastructure improvements. This is because research an ancedotal acconts

suggest that as bike share participation increases, so does participation in private cycling.[64] The mechanism behind this may be that as more bicycles are on the road, more people feel safe cycling. Simultaneously, as the number of active riders increases, vehicular traffic becomes more cognizant of riders; this again makes more people feel safe cycling. This compounding effect leads to better overall health outcomes for the community as a whole. However, to get the maximum ridership and to reap the corresponding health benefits, infrastructure improvements are needed to encourage low-propensity riders to participate and feel safe doing so. As a result, in the four aforementioned systems, cities and universities have worked together to improve bike lanes and add accessible bike repair stations. For example, Buffalo, New York has added over 500 miles of new bikes lanes and Boise, Idaho has added new greenways for bicycling. These partnerships have also yielded showers, bike storage, and rider education courses.

Health Data Collection

Monitoring is crucial for providing direct evidence that biking does improve health. Reddy Bike uses technology to measure carbon dioxide and calories burned during a trip. The pilot program of over 800 users saw 7,100 pounds of CO2 not emitted and over 324,000 calories burned. After fully launching, the program's users burned 199,000 calories in the first month of operation.[65] In addition to Buffalo's bike sharing system, the bike share company, Social Bicycles, who operates over 25 bike shares systems in the Unite States, provided montioring data to both the consumer and the bike share operator. The consumer, when using app based technology receives estiamates of calories burned, CO2 not emitted, and trip length/duration data. Morevoer, the operator receives all of this data, and ultimately the discretion

As noted, Reddy Bike actively monitors overall calories burned, and uBike is the process of working with Aenta to use data from the bike share program in its wellness program.

CURRENT EFFORTS TO INCREASE CYCLING IN THE RUTGERS AREA

BikeRU Initiative

As a part of the BikeRU Initiative, the Rutgers University Department of Transportation Services (RUDOTS) started a bicycle rental library. Additionally, the University has installed Bicycle Lockers and Bicycle Repair Stations on each of its five New Brunswick campuses.

Ciclovia

In an effort to promote healthy active lifestyles to the greater New Brunswick community, New Brunswick Tomorrow introduced

Ciclovia to the area in 2013. During Ciclovia, the city's streets are barred from car-use for five hours, allowing citizens the chance to run, walk, skate, bicycle, and enjoy active events along the route, all while exploring the open and safe streets.[67]

MODE SHIFT

The ideal goal of implementing a bike share is to shift people from sedentary modes of transportation, such as automobiles, to a more active form of transportation in cycling. This would result in overall net positive health benefits as people shifted from car usage to cycling. However, the direct relationship between bike shares and mode shift is limited in terms of the number of studies and existing literature readily available. A few studies have undertaken efforts to quantify the shift and have found varied results. Overall, the research emphasizes the substantial benefits that occur from reducing the number of people using sedentary modes of transportation. The following will summarize those studies and their findings.

A study of the Montreal bike share program conducted through 2009 and 2010 examined mode shift from automobile use to other forms of transit. The research found that, overall, there was a mode shift from automobiles to other forms of transit at a rate of between 0.34% and 0.43%. However, the largest limitation of the study was understanding where the shift went to; it is unknown whether cycling accounted for the majority of the shift. Therefore, the conclusion reached is that bike share increases the use of non-sedentary modes of transportation, while not necessarily causing a one-to-one shift from car to bicycle.[68] Further backing up this conclusion is a study examining the shift from sedentary modes of transportation in Melbourne, Australia, Brisbane, Australia, Washington D.C., London, and Minneapolis–St. Paul, Minnesota after the implementation of bike sharing systems. On average, 60% of bike share trips replaced sedentary modes of transportation, and the number of additional active minutes of transportation varied between 1.4 million minutes in Minneapolis–St. Paul to 74 million minutes in London.[69]

However, the question remains: what makes a city more likely to experience a modal shift away from automobile use due to bike share? A 2015 article looked at systems across the globe and concluded that areas with congested transit networks could see greatest modal shifts to bike sharing. This is because of bike sharing's potential to serve as first and last mile connector. To give an example, 36% of bike share users in Montreal drive less because of bike share. This is similar to other cities, as well: 25% of bike share users in Toronto, 41% of bike share users in Washington, D.C., and 52% of bike share users in Minneapolis–St. Paul stated that they drive less because of bike share.[70]

CYCLING AND HEALTH

One of the principle goals of this study is to understand the pathways through which bike share programs impact public health outcomes. A review of the literature reveals two broad categories: physiological and economic. This section takes a closer look at how physical activity from cycling directly impacts health, both positively and negatively. It also considers how creating a bike share program impacts the local economy, and the repercussions this can have on health. Lastly, these health benefits are not evenly distributed throughout all parts of the socioeconomic order, so the challenges of equity and access are explored.

HEALTH IMPACT PATHWAY

To represent the potential relationship between the implementation of the Rutgers University Bike Share program and health outcomes, a causal model (pathway diagram) was created. Pathway diagrams serve as visual aids for organizing and guiding research, while communicating it all in a clear and succinct manner. Generally, pathway diagrams depict how changes in environmental or social conditions (health determinants) can lead to proximate effects, as well as intermediate outcomes, which may ultimately manifest as health effects, be they improvements or declines. Taking into account that cycling serves as a form of active transportation, health outcomes were determined by the program's attributes in both increasing access to bicycles in the area, while also proving an outlet for physical activity. Figure 3 depicts the immediate and secondary effects, as well as health outcomes, associated with the implementation of the Rutgers Bike Share Program.

HEALTH IMPACTS OF PHYSICAL ACTIVITY, ACTIVE TRANSPORTATION, AND BICYCLING

It is well established that physical activity is directly linked to positive outcomes in all areas of human health, such as cardiorespiratory, musculoskeletal, and metabolic health. The US Department of Health and Human Services (HHS) states that daily moderate physical activity can reduce the risk for many of the most common chronic health conditions and causes of death. These reductions may be as high as 30% for all-cause mortality; 20% to 35% for cardiovascular disease, coronary heart disease, and stroke; between 30% and 40% for type 2 diabetes; 30% for colon cancer; and 20% for breast cancer.[69] HHS has also found strong evidence that physical activity positively benefits mental health, protecting against symptoms of depression, anxiety and cognitive decline associated with aging.

The amount of physical activity required to access these benefits varies depending on the individual's physiology and baseline health, and the intensity of the activity. However, both the World Health Organization and HHS recommend 150

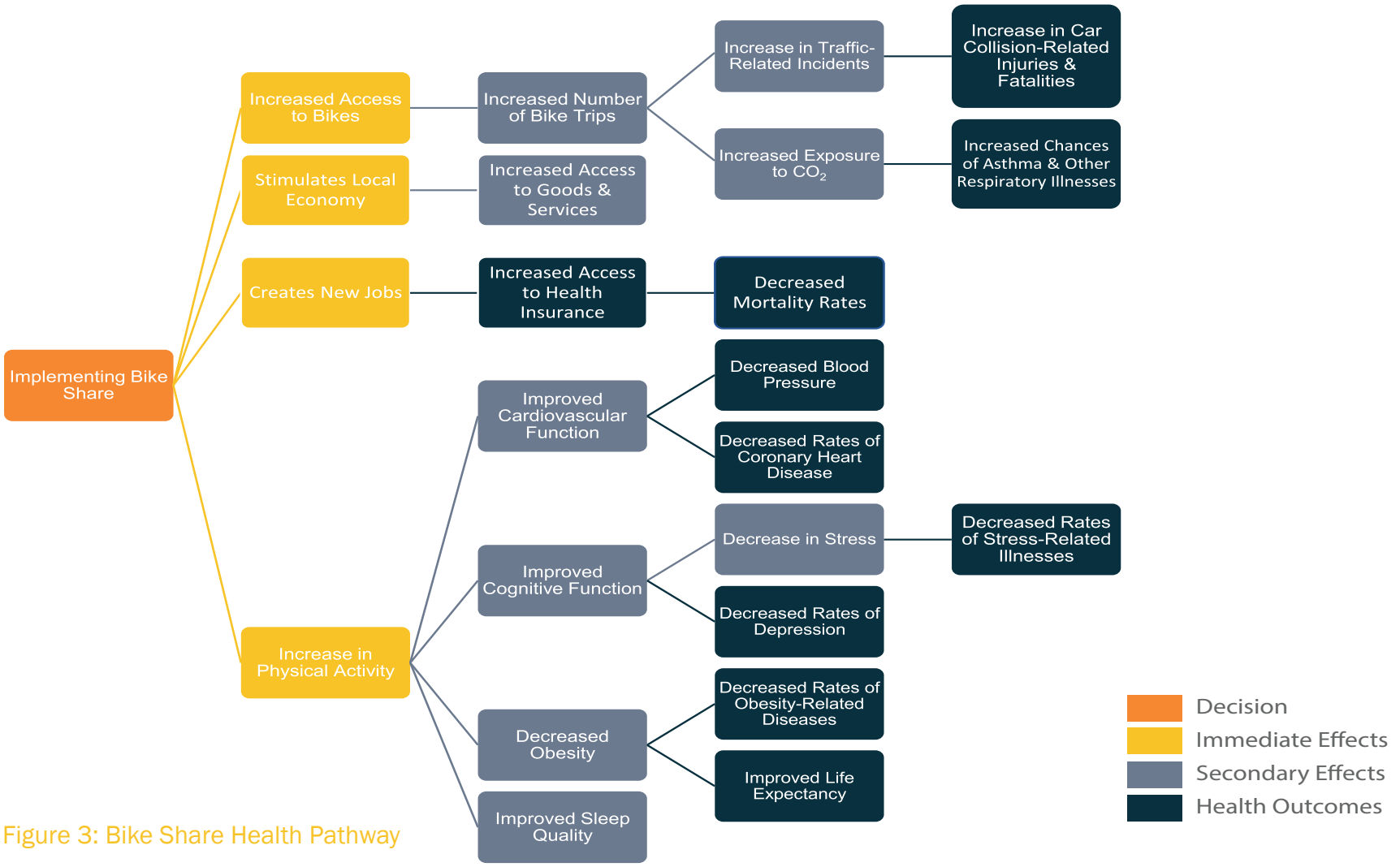


Figure 3: Bike Share Health Pathway

minutes of moderate physical activty a week, or 30 minutes five times a week.[70]

Physical activity can be broken down into several categories: leisure-time physical activity (LTPA), occupational physical activity, and active transportation (AT). The amount of physical activity achieved from the latter two categories has been steadily decreasing for American adults in the last 50 years, without a corresponding increase in LTPA. Therefore, the overall level of physical activity is decreasing. As of 2005, less than 50% of American adults achieved the recommended levels of total physical activity on a weekly basis.[71] This trend has been stable for some time.

Relying on LTPA alone to achieve recommended levels of physical activity is problematic for several reasons. First, not everybody has the time or money to participate in leisure-time physical activity. Rates of LTPA are much lower for vulnerable populations such as the poor, low-educated, and people of color.[72] Second, not everybody enjoys common leisure-time physical activities like jogging and organized sports. Third, most municipalities lack enough recreational facilities to accommodate the entire population's physical activity needs.[73] For these reasons, and the fact that occupational physical activity is likely to continue trending downward, active transportation stands to fill the gap in our physical activity needs. In fact, it is already doing so. According to a study using data from the 2001 California Health Interview Survey, only 41.9% of adults adhere to exercise recommendations when considering LTPA alone. However, that number increases to 52.9% when active transportation is included. This gap is even more pronounced for vulnerable populations. Blacks, Latinos, and Asians were all less likely to adhere to physical activity recommendations based on LTPA than whites, but that gap was closed significantly (though not entirely) when including AT. For people below the poverty line, only 26.8% achieve recommended levels of physical activity based on LTPA, but that number doubles to 47.5% when including AT.[74]

Bike share programs have already shown their potential at helping people achieve physical activity recommendations. A study of Barcelona's bike share system, Bicing, found that the mean duration of workweek trips was 14.1 minutes, and 17.8 minutes on weekends. With just one trip a day, assuming a moderate pace, using bike share as active transportation would fulfill over 70% of weekly recommended physical activity.[75] Measured another way, using a standard of 4 megajoules a week (about 950 food calories), one can achieve weekly physical activity recommendations by cycling 10 mph or more for only 11 minutes twice a day, 5 times a week.[76] By simply using a bicycle for daily trips, and riding at a moderate pace, it is possible to get enough weekly physical activity to see positive health outcomes.

Despite these encouraging figures, active transportation remains relatively rare. According to a study using data from the National Longitudinal Study of Adolescent Health, only 8.1% of young adults use active transportation to get to work.[77]

This number is significantly higher (26.7%) for school commutes. Additionally, those who are using active transportation tend to be white, already fit, and of high socio-economic status. This is true of bike share programs as well. A 2012 study of user survey data from the first four years of Capital Bikeshare in Washington D.C. found that members tended to be a fairly homogenous group, comprised mostly of Caucasian males aged 25-34. Respondents also reported having a high baseline health, painting an overall picture that is not very representative of the wider D.C. area. The survey asked participants rank their primary motivation for joining the program. Interestingly, exercise, fitness, and health concerns were not ranked particularly high. However, health effects were reported nonetheless. The surveys suggest that bike share users increased their physical activity outside of cycling, implying that bike sharing may encourage a more healthy lifestyle overall. Additionally many users reported improvement in key health indicators, such as: reduced stress (31.5%), improved stamina (26.7%), increased energy (21.8%), and weight loss (30%).[78] Encouraging more people to use bicycles as transportation, as with a bike share program, could be a very useful way to improve the health outcomes of vulnerable population at relatively little cost to the users.

A bike share system in the New Brunswick-Piscataway-Highland Park area would target two particular groups of users that could especially benefit from the mental health effects of active transportation: students and lower-income households. Compared to the general population, both groups tend to have higher levels of stress and stress-related illnesses.[79] [80] For students, high stress levels arise when academic demands pair with irregular sleep, new social environments, and substance use. For lower-income households, stress comes from financial pressures, higher exposure to family or neighborhood violence, and a lack of access to resources such as adequate housing, food, or health care. There is evidence that cycling improves the body's ability to combat stress and defend against anxiety, and has even been shown to improve cognitive functions by increasing the number of neurons in the brain.[81]

Nevertheless, there are health concerns and dangers to cycling. In 2001, cyclists in America were 12 times more likely to be killed than drivers for every kilometer traveled.[82] A study of London's bike share program found that in certain cohorts, such as women ages 15-29, higher rates of fatal injuries negated the health benefits of additional physical activity.[83] Air pollution also plays a role. Although cyclists and drivers face similar levels of incidental exposure, increased rates of respiration associated with physical activity mean cyclists face a higher dosage.[84]

Several studies have attempted to find the relative impact of all these factors. A 2010 study modeled the effects of a short-trip mode shift from car to bicycle for 500,000 people in the Netherlands. They found that the mortality effects of increased air pollution inhalation equaled 0.8-40 days of life lost. Effects of increased traffic crashes equaled 5-9 days lost. However, they found the beneficial effects of increased physical activity equaled 3-14 months gained.[85] Similarly, a 2012 study in Barcelona looked at a theoretical mode 40% mode shift for all local trips within the city. They found that such a shift would lead to 1.15 more annual pollution deaths and 0.17 more traffic deaths. Yet the additional physical activity would lead to 67.46 fewer deaths.[86] The Spanish study also looked at societal impacts of such a shift, and found that an additional 10.03 annual deaths could be avoided due to the corresponding reduction in PM2.5.

Although the health benefits of cycling far outweigh the risks, it is still important to investigate risk factors that may contribute to mortality. Health implications due to increased pollution exposure are difficult to study in the near-term, but crash data is readily available. A 2013 study looked at all road crashes involving bicycles in Spain between 1993 and 2009 to identify the risk factors that are associated with crash incidents. For crashes involving a car where fault is assigned to the cyclist, risk is highest for those under 19 and over 69. Alcohol and drug use greatly increases the likelihood of causing a crash. The riskiest traffic maneuvers are turning and joining the flow of traffic. Unsurprisingly, defective brakes were also found to be a contributing risk factor. For crashes involving the cyclist alone, the biggest risk factors were alcohol and drug use, sudden illness, and brake defects. No clear age pattern was present.[87]

From 1975 to 2001, Germany experienced a 50% growth rate in the share of bicycle trips, yet reduced its bicycle fatality rate by 64%. Over the same time period, the Netherlands reduced their cyclist fatality rate by 57%. In contrast, the US reduced its rate by only 27%, however most of this was due to the sharp decline in children bicycling. As sobering as these numbers may be, it suggests room for improvement if best practices are implemented. Strategies to improve safety include: better facilities for cycling; traffic calming of residential areas; people-oriented urban design; learn-to-ride and traffic education, regulation, and enforcement.[88] Implementing these strategies can result in real improvements.

For example, in Vancouver and Toronto, Canada, the probability for a crash was about nine times lower in protected bike lanes compared to major streets with parked cars.[89]

ECONOMIC EFFECTS OF BICYCLING

There's a new adage in the field of public health: 'your zip code matters more than your genetic code'. In other words, socioeconomic factors play a large role in health outcomes.

Therefore, when considering the health impact of bike sharing programs, it's important to consider the economic impact as well. There have been several studies on the economic impacts of bike shares, and the results are unanimously positive. Most research suggests that bike share users spend more than those who drive. This is achieved in two different ways. First, bike share users simply spent more per month; second, bike share users spent less per trip but took more trips, thus accounting for more spending.[90] [91] A Minnesota study reported the value of this spending to be $1.20 per user per week,[92] while a study by the European Cycling Federation found that tourists using bike share spend approximately $31 per day compared to $9 by tourists who drive.[93] This spending benefit is expected to take place around hub locations and upgraded bike infrastructure: 83% of Washington D.C.'s Capital Bikeshare users stated they were "more likely to patronize a business" located near a bike station,[94] while businesses along Victoria Street in San Francisco's Mission District experienced a 60% increase in sales after the creation of a new bike lane.[95] Another mechanism that may drive increased spending habits is the installation of bike corrals. Since a bike corral can hold ten bicycles in the same space it takes for one car to park, the installation of a bike corral could increase parking capacity by up to 900%.[96]

Businesses are starting to hear about these benefits and they are thrilled; many have begun investing in constructing a bicycle-friendly image to attract customers. Further, 86% of surveyed businesses in Washington, D.C. indicated "a positive attitude about the presence of stations within their neighborhood", 70% indicated that the bike share had a positive effect onneighborhood, and 59% asked for more stations to be added in their neighborhood.[97] Most importantly, 26% of surveyed businesses were willing to offer discount to bike share members.[98] Despite these positive effects, 60% of businesses were unsure of the bike shares effects on customer traffic.[99]

Bike shares also serve as job creators. Table 8 shows the job creation figures for several bike shares around the United States and Europe. On average, one full-time job is created for every 74.9 United States bike share bicycles. Further, people who use the bike share to commute to work save an estimated $819 per year. For Washington, D.C., this benefit is worth $15 million per year.[100] Given these estimates, the current 39,012 personal vehicle commuters in study area, and an expected mode shift between 0.34% and 0.43%,[101] this bike share is expected to save area commuters between $110,000 and $140,000 each year.

Finally, a 2012 study estimated national congestion costs associated with time loss and wasted fuel to be $120 billion (2011 dollars) annually, while annual CO2 emissions attributed to this congestion were estimated to be 56 billion pounds. This study also concluded that the presence of bike share docks was equated with a 2% to 3% reduction in traffic congestion. Realized on a national scale, bike share implementation would save $2.4 to $3.6 billion in wasted time and fuel costs and would reduce CO2 emissions by 1.12 to 1.68 billion pounds per year.[103]

	Full Time	Part Time	Bikes	Bikes per Full Time Employee
capital bikeshare Washington, DC	17	31	1,505	88.5
DECOBIKE Miami	25	3	1,000	40
DENVER B cycle Denver	7	6	500	71.1
Hubway Boston	9	17	1,065	118.3
NICE RIDE MINNESOTA Minneapolis	14	6	1,325	94.6
bicing Barcelona, Spain	162	N/A	6,000	37
vélo'v Lyon, France	32	N/A	4,000	125

Table 8: Bikeshare Job Creation Statistics[104]

EQUITY AND ACCESS

Around the country bike shares are grappling with the question of equity. The predominant user group tends to be Caucasian, male and upper-middle class. However, working-class individuals disproportionately rely on cycling as a principal form of transportation to places of employment. Kinder Institute for Urban Research found that 49% of those who earn less than $25,000 a year cycle to work.[106] Programs around the country have been researching ways to integrate underrepresented groups into bike share, namely lower-income individuals, the unbanked (individuals not attached to the formal banking sector), Blacks, Latinos, and women. An initial step may be to build more and safer bike lanes. Research shows these groups tend to be more risk averse and make up more cycling related crashes.[107] The League of American Bicyclists found that Black and Latino cyclists had fatality rates 30% and 23% higher than for Caucasians. Transportation London found that women made up 39% of cycling fatalities, while making up only of a quarter of cyclists.[108]

A second step relates to the transfer of information. Studies have shown one of the biggest barriers to lower-income individuals accessing bike share is incomplete or misinformation.[109] Ways to tackle the issue include greater distribution of material, multilingual information, as well as simple instrutions on methods of signing-up offered on neighborhood kiosks. A Temple University study found that 65% of people learned about

Philadelphia's bike share, Indigo, by seeing the kiosk stations.[110] Knowing lower-income individuals often have less access to technology, not having simple instructions on signing up, as well as subsidized rates on kiosks could potentially be a huge miss in terms of equity.

A third step is giving marginalized groups a means to participate. Bike shares have integrated lower-income individuals by offering cash payment options, subsidized monthly or annual rates, reduced overage charges, as well integrating bike share with local transit cards – standardizing pricing.[111] Integrating bike share with more dominant forms of public transit in lower-income communities has the potential to elevate another barrier to use – the feeling that bike shares are not for them. A recurring theme in survey research on Northeast bike shares has found perceptions on who bike shares are for among lower-income respondents.[112] [113]

A fourth step involves inclusive marketing strategies. Using images that represent cultural, economic, body size, age, education and language differences reinforce use outside the upper-middle class milieu bike share currently occupies. Survey and focus group research completed in the Northeast found lower-income respondents identified with images of families cycling, and one respondent stated, if she saw an image of a little black girl cycling, she would try it. Catch phrases such as, "no more waiting for the bus", "to take care of business", "save on gas", and "no more tickets" were also identified to reach lower-income users.[114]

Lastly, incorporating Ambassador programs -- building confidence and excitement in cycling in working-class neighborhoods. Ambassadors are individuals who live within and are connected to specific marginalized communities; who encourage members of their community to sign up, teach safety and maintenance classes and foster group rides.[115] Ambassador programs can be initiated by partnering across communities with local non-profits.

Partnerships

National, local, public, and private partnerships are necessary for the overall success of bike share, however, are essential whenconsidering aspects of equity. Better Bike Share Partnership, a national organization, has been pivotal in innovation and information sharing, as well funding equitable practices in burgeoning bike shares. With financial contributions from Better Bike Share, Hubway in Boston launched its program, Prescribe-a-Bike, which allows Boston Medical doctors to write prescriptions for Hubway. The prescription includes a $5 annual membership.[116]

Institutions serve as intermediaries across populations. Local non-profits have a similar function at the micro level. Cross community involvement takes the form of sponsoring and participating in local cultural events. Multicultural Communities for Mobility in LA, for instance, partnered with Metro Bike to

bridge intercultural gaps initiating bilingual safety and legal workshops and sponsoring community events, such as their Day of the Dead Ride.[117] Programs around the country have taken similar approaches specific to their demographics.

The question remains though, why despite efforts toward inclusivity are there such disparities in bike share users? Equity advocates urge us to see incremental changes are occurring. Gains, for projects initiated years back, are beginning to be realized.[118] Anthropologist Adonia Lugo explores this further explaining that for bicycle advocates cycling represents a freedom from the culture of car driven life, however, for other more disenfranchised groups the bike may not be an emancipating tool.[119] As stated previously, those most economically marginalized rely oncycling as a dominant form of transportation, and on the other end of the spectrum upper-income individuals may incorporate cycling for its health benefits or environmental reasons.[120] The car may serve as status symbol or a necessary convenience in a full life. The economic underpinnings of this are beyond the scope of this report; though expelling myths and forging partnerships with organizations like Puerto Rican Action Board in New Brunswick, who help newly arriving and settled immigrants in the community gain access to social services, as well as promote bicycle culture, are vital in shifting the paradigm of who cycles.

The following table displays demographics and correlated aspects of equity by location. Philadelphia, PA's bike share, Indego, and Los Angeles, CA's bike share, Metro Bike, were included in this table to have a closer look at how cities with similar demographics and population densities are engaging with vulnerable populations.

	Indego Philadelphia, Pennsylvania	Metro Los Angeles, California	New Brunswick, New Jersey (city only)
Ethno-racial Composition	Latino 12% Black 43% White 41%	Latino 49% Black 10% White 50%	Latino 50% Black 16% White 45%
Median Household Income	$37,460	$49,682	$38,399
Population Below Poverty-line	26.7%	22.4%	34.9%
Equity and Access	• Cash payment option • Subsizied membership • Reduced overage charg • Amabassador program • 30 stations in lower income neighborhoods	• Bike share cards linked to public transit • Flex Pass annnual fee waived for lower - income users enrolled in LA's Metro Rider Relief Program	-

Table 9: Equity and Access[121]

RUTGERS BIKE SHARE POTENTIAL USER SURVEY

Methodology

This studio issued a survey to the Rutgers-New Brunswick population of students, faculty, and staff in order to inform the recommendations that this studio will present to Rutgers University's Department of Institutional Planning and Operations. The objective of the survey was to understand the perspectives of the University community regarding current bike infrastructure in New Brunswick, as well as the perceived efficacy of a bike share in the area. A secondary objective of the survey was to inform the studio of any impediments to bicycle usage in and around the Rutgers-New Brunswick campuses. While this bike share will impact residents outside of the Rutgers community, it was not feasible to survey residents in Highland Park, New Brunswick, and Piscataway due to the uncertain timing of the bike share roll out and the constraints of the University's semester schedule on this studio. Future program development should include public involvement from the affected municipalities. To continue, this section will provide information on how the survey was created and distributed to the University-affiliated community.

The first draft of the survey was devised by the studio professors, Leigh Ann Von Hagen and Karen Lowrie, with input from the transportation planners at the University. This draft was approved Rutgers University's Institutional Review Board. The survey went through several more iterations before being presented to an eight-member pilot session consisting of Bloustein School students, faculty, and staff. After collecting insightful feedback from this session, the survey was finalized. The final iteration had 23 questions (see Appendix E) which prompted respondents about their familiarity with bike shares, their motivation to bicycle, and their personal barriers to bicycling.

The survey was made available online for thirty days in October and November, 2016 through Qualtrics, a research software company specializing in online data collection. To reach the campus in a broad and direct manner, paper flyers were distributed around heavily-trafficked campus areas like student centers and campus buses. Two tabling sessions were also completed outside of student centers. Finally, the link to the survey was distributed electronically through newsletters, email, and social media.

Findings

In total, 122 respondents started the survey and 111 completed it. Of the completed responses, 58 females and 53 males contributed responses and identified themselves as students, faculty, and staff. While the response rate was lower than expected, the results can serve as a baseline for additional research before implementation. Overall, the proposed bike share system was well-received by the Rutgers-New Brunswick community. More than 60% of respondents stated that they would be likely to use a bike share on campus. However, the survey also revealed that respondents view the current bike infrastructure negatively. For

instance, 57% of respondents indicated that they would prefer more bike lanes and paths, and cited the current infrastructure as an impediment to cycling around campus. As a result, the studio team believes that the current bike infrastructure poses the largest challenge to the successful implementation of the bike share.

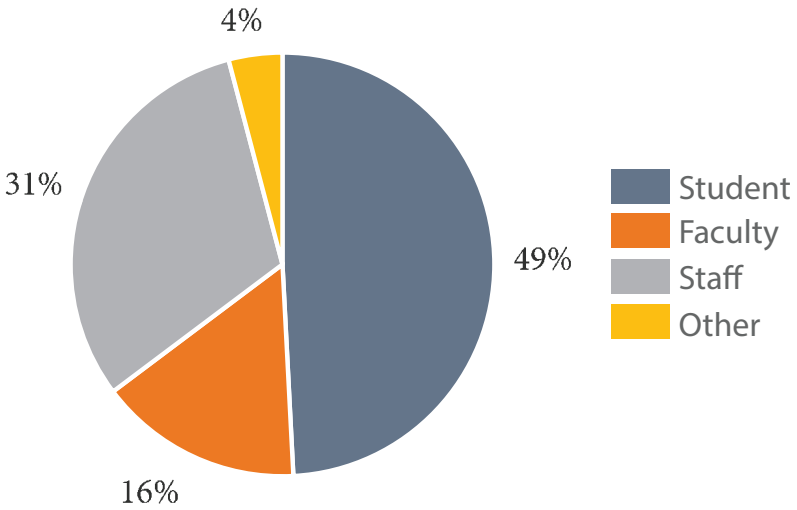


Figure 4: Survey Respondents by Group

Respondents suggested a variety of factors that they perceived as important for the success of this bike share. Notably, 80% of respondents mentioned convenient bicycle pick-up and drop-off around the campus, 68% cited affordability, and 58% cited improved bicycle friendliness in and around the campus. Proposed infrastructure recommendations to improve bicycle friendliness can be found in the Findings and Recommendations section.

" Poorly paved roads and unsafe intersection designs are a huge issue. Not just for cyclists, but for motorists and pedestrians as well. "

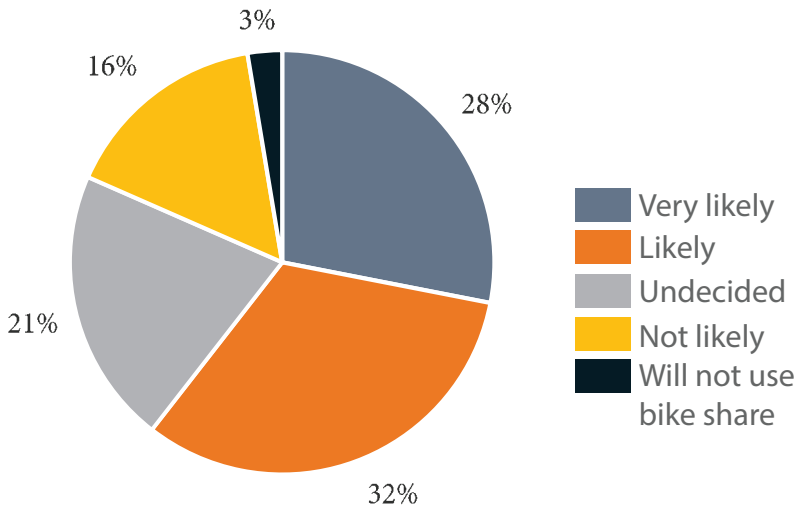


Figure 5: Likelihood to Use Bike Share

" I live in New Brunswick and would like to have a location to drop off/pick up a bike near where I live so I could ride it to school and then leave it there. This would be an ideal scenario so that I do not need to worry about parking, especially on CAC. "

Another insight that the survey yielded was feelings towards bike share pricing. The average hourly rate recommendation from all responses was $2.99 which is comparable with the hourly rate of every bike share system researched by this studio. The average annual membership cost recommendation was $38.03. This figure is above the region per capita income-based recommendation of $27.33 and is similar to LA MetroBike's $40 annual cost and Boise GreenBike's $46 annual student cost. However, it is far below most other annual costs which range from $85 to $135.

Hourly	Annual
$2.99	$38.03
Range ($0-$10)	Range ($0-$100)
n=105	n=110

Table 10: Average Preferred Pay Structure Based on Survey Findings

Half of the survey respondents do not own a bicycle, while the other half have access to a working bicycle. Of those without access to a bicycle, 53% would likely or more than likely utilize a bike-share (n=31). Further, 30% of respondents without access to a bicycle were undecided on whether they would adopt the bike-share or not (n=17). Additional research should be done on trends within the "undecided" community.

A chi-square analysis was performed to determine whether current bike usage has a significant influence likeliness to use a bike share. The analysis produced some significant relationships between non-riders and the perceptions they have of bicycling in and around campus ($p<0.001$). People without bicycle access were interested in the idea of bicycling to combat sedentary lifestyles as 71% of those without access to a bicycle are more inclined to use the bike share for additional fitness benefits, compared to only 34% of those who have access to a bike.

" To be successful, a bike share program must be supported by major improvements in the overall transportation system at Rutgers. "

Further, there is an apparent gender divide, females indicated higher rates of interest in using the bike share for fitness. This also supports the integration of personal fitness tracking or monitoring technology into the bike share hardware or software.

WOULD YOU USE BIKE SHARE FOR FITNESS?						
		Most Often	Sometimes	Almost Never	Never	Total
Do you have access to a working bicycle while living, attending or working at Rutgers?	Yes	10	8	19	17	54
		18.52%	14.81%	35.19%	31.48%	100%
	No	12	26	9	6	53
		22.64%	49.06%	16.98%	11.32%	100%
	Total	22	34	28	23	107
		20.56%	31.78%	26.17%	21.50%	100%

Table 11: Access to Bicycle X Likelihood to Use Bike Share for Fitness

There is also a significant association in the perception of crime and theft between current riders and non-riders (p=0.03). 46% of people without access to a bicycle believe that crime and theft are an issue, whereas just 21% of riders indicate that crime and theft is definitely a problem. This studio believes that this perception by non-riders can be improved by increased rider visibility. Further, effective social marketing can help to reassure riders than bicycling is safer than their initial perceptions.

DO YOU FEAR CRIME OR THEFT					
		Definitely a problem	Somewhat a problem	Not much a problem	Total
Do you have access to a working bicycle while living, attending or working at Rutgers?	Yes	12	19	26	57
		21.05%	33.33%	45.61%	100%
	No	28	15	15	57
		46.43%	26.79%	26.79%	100%
	Total	39	34	41	114
		34%	30%	36%	100%

Table 12: Access to Bicycle X Fear of Crime and Theft

" Traffic enforcement is huge issue. Cars regularly run red lights... the Neilson St bike path is not very useful because it does not connect to Douglass ... the bike crossing over the Route 18 bridge is a disaster waiting to happen. Easy and safe biking routes, such as Suydam St, are not publicized. Sharrows only help so much because perception of biking is still dangerous. Speed bumps and more traffic calming are needed... streets are narrow too and clogged streets at rush hour does not make a great perception of biking safety. "

BASELINE CONDITIONS

To better inform our recommendations, this study undertook a comprehensive examination of baseline conditions in the proposed service area. High-level municipal demographics are complemented by more fine-grained mapping to understand economic and soical patterns.Community health is analyzed to look for areas of need. Existing bike infrastructure is catalogued to frame future investments. Lastly, current planning efforts are scoped to understand where this initiative fits in.

	New Brunswick, New Jersey	Piscataway, New Jersey	Highland Park, New Jersey	Middlesex County, New	New Jersey
Total Population 2014	55,804	57,636	14,224	836,297	8,791,894
% change from 2000	3.5%	4.8%	1.7%	10.3%	4.3%
people per square mile	9,640	3,029	7,820	2,591	1,007
Median Age	23.1	32.6	33.2	37.6	39.3
Race / Ethnicity					
White	22.4%	32.2%	64.8%	46.3%	58.4%
Black	12.6%	18.9%	6.2%	8.9%	12.9%
Asian	8.0%	35.6%	14.2%	22.4%	8.8%
Hispanic	55.6%	10.4%	13.0%	18.9%	18.8%

	New Brunswick, New Jersey	Piscataway, New Jersey	Highland Park, New Jersey	Middlesex County, New	New Jersey
Language (18+)					
Speaks a language other than English at home	27.8%	29.2%	23.7%	31.4%	22.7%
Spanish	20.5%	5.9%	8.6%	10.9%	10.9%
Other	7.3%	23.3%	15.1%	20.5%	11.8%
Speaks English less than 'very well'	11.9%	9.1%	5.7%	10.8%	7.7%
Education					
High school graduation or higher	62.4%	93.0%	94.8%	88.8%	88.4%
Bachelor's degree or higher	20.5%	48.6%	64.1%	41.0%	36.4%
Median Household Income	$38,399	$89,529	$66,414	$80,118	$72,062
Poverty Rate	34.9%	6.0%	13.6%	8.5%	10.7%

Table 13: Service Area Demographics

Middlesex is a diverse county in a diverse state, with communities of all sizes and socioeconomic composition. The Rutgers Bike Share planned service area is no exception. All three municipalities have a higher population density than the state and county as a whole, but New Brunswick is densest by far. Generally speaking, denser places are easier to serve with bike share systems. Middlesex County has experienced enormous population growth since 2000, but very unevenly. The growth rates of New Brunswick and Highland Park are below the statewide rate, meaning that they are not growing proportionately to the rest of the state. All three municipalities trend well below the state and county median age, no doubt due to the influence of the university population, but New Brunswick's median age is remarkably low. For a more detailed look at the age breakdown, see Appendix B.

The racial and ethnic composition of the three proposed service area municipalities is unique and diverse. New Brunswick has over 50% of residents identifying as Hispanic or Latino. Piscataway has a very large South Asian and African American populations. Highland Park is about two-thirds Caucasian, but has substantial Hispanic and Asian populations. The proposed service area is also very linguistically diverse. Over 25% of people in New Brunswick and Piscataway speak a language other than English at home, and around 10% of people over 18 in both municipalities have less-than-proficient English language abilities.

Residents in Piscataway and Highland Park have higher education levels than the county and state. Highland Park has a remarkably high percentage of residents with Bachelor's degrees or higher. New Brunswick's rates of educational attainment, despite the presence of the university, are much lower. This is reflected in the median household incomes and poverty rates of the three municipalities.

New Brunswick has a very high poverty rate and low median income compared to the county and state. Highland Park's levels are surprising given the levels of education there, implying that there must be some pockets of concentrated poverty.

Also of interest to this study are unbanked populations, individuals who are not attached to the formal banking sector, and do not use credit or debit cards for their transactions.[123] In the United States 7.7% of households are unbanked. In New Jersey, 8.2% of the population falls under this category.[124] Causes leading an individual to become unbanked are: language barriers, outstanding issues due to prior banking experience, lack of proper identification, and having limited or unstable income.[125] Local estimates are difficult to find, but are likely higher than the state level.

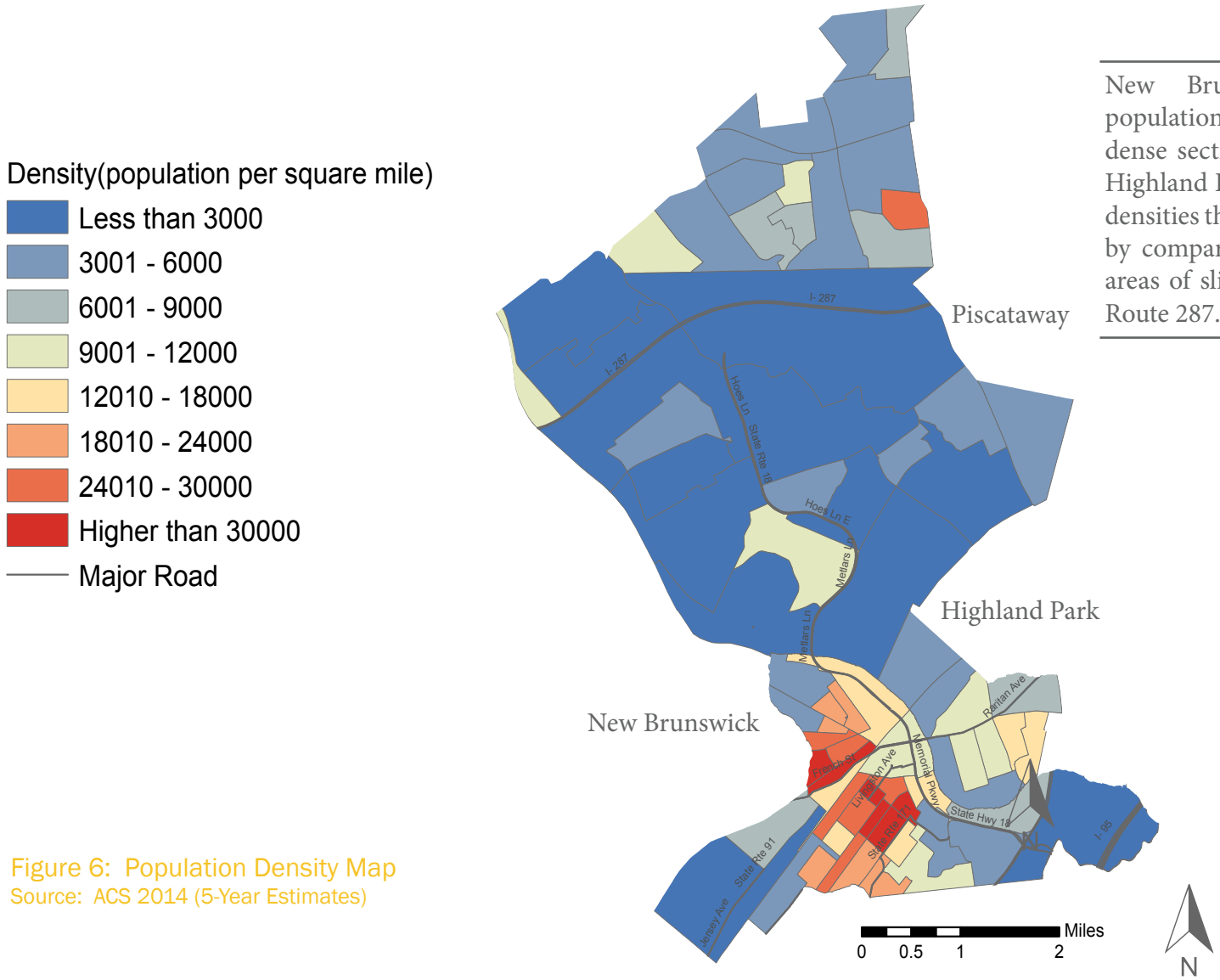


Figure 6: Population Density Map
Source: ACS 2014 (5-Year Estimates)

New Brunswick has the highest population density, with exceptionally dense sections in the center of the city. Highland Park has significant residential densities throughout. Most of Piscataway, by comparison, is sprawled, with some areas of slightly higher density north of Route 287.

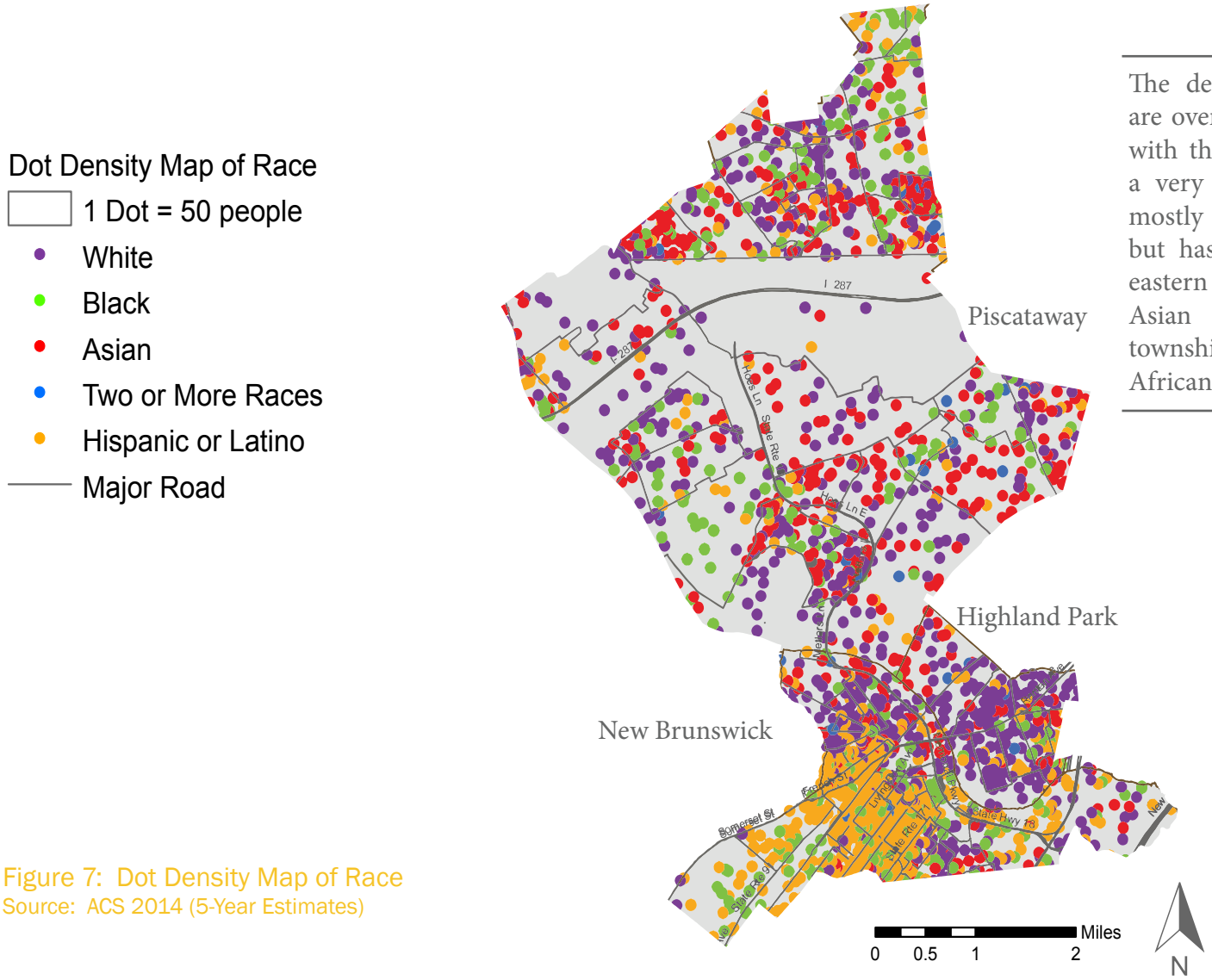
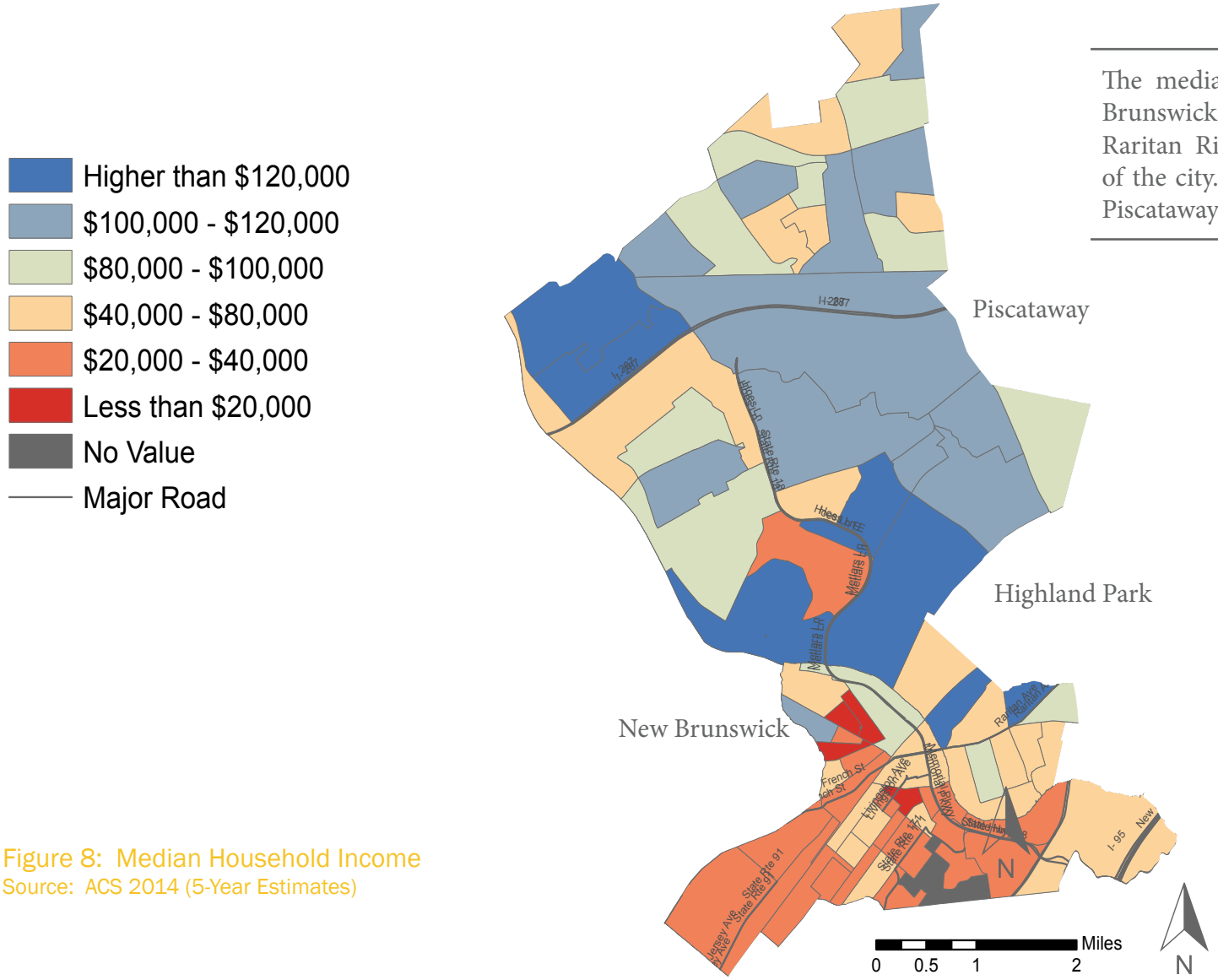


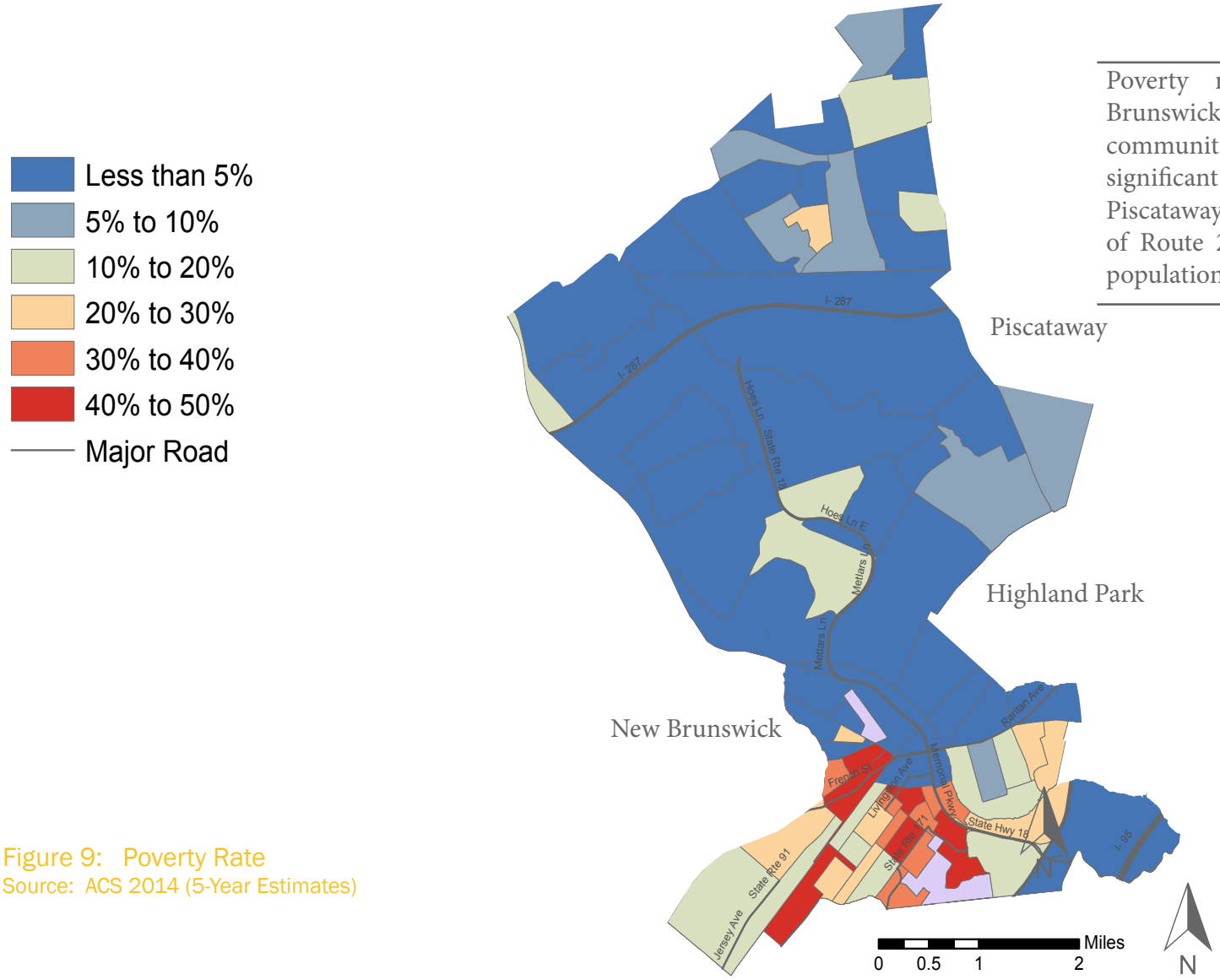
Figure 7: Dot Density Map of Race
Source: ACS 2014 (5-Year Estimates)

The densest parts of New Brunswick are overwhelmingly Hispanic or Latino, with the rest of the municipality being a very diverse mix. Highland Park is mostly Caucasian close to the Raritan, but has an eclectic community on its eastern side. Piscataway has a large Asian community throughout the township, and a higher concentration of African Americans north of Route 287.



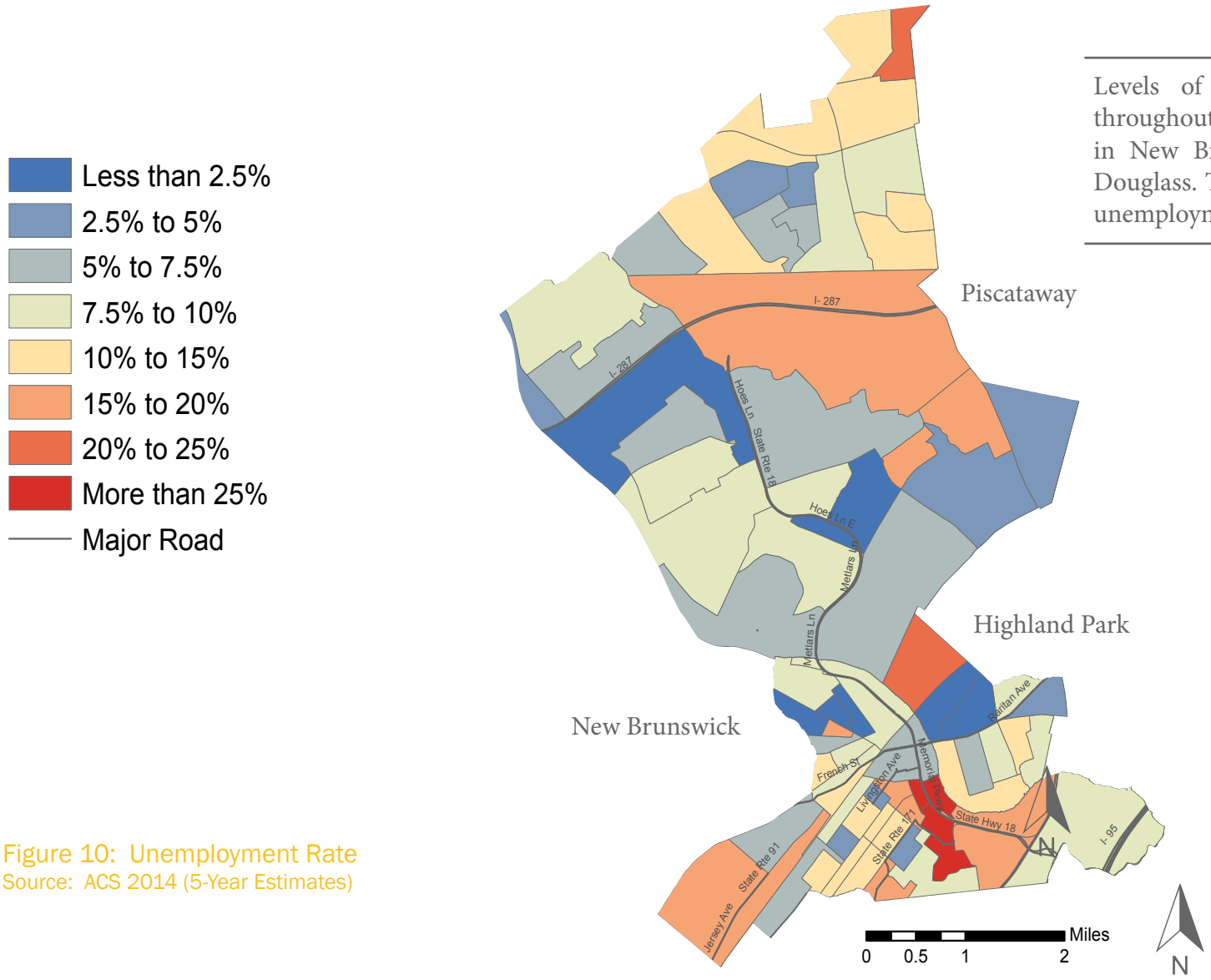
The median income is lowest in New Brunswick, especially the areas along the Raritan River and in the western part of the city. The more sprawled areas of Piscataway are the most affluent.

Figure 8: Median Household Income
Source: ACS 2014 (5-Year Estimates)



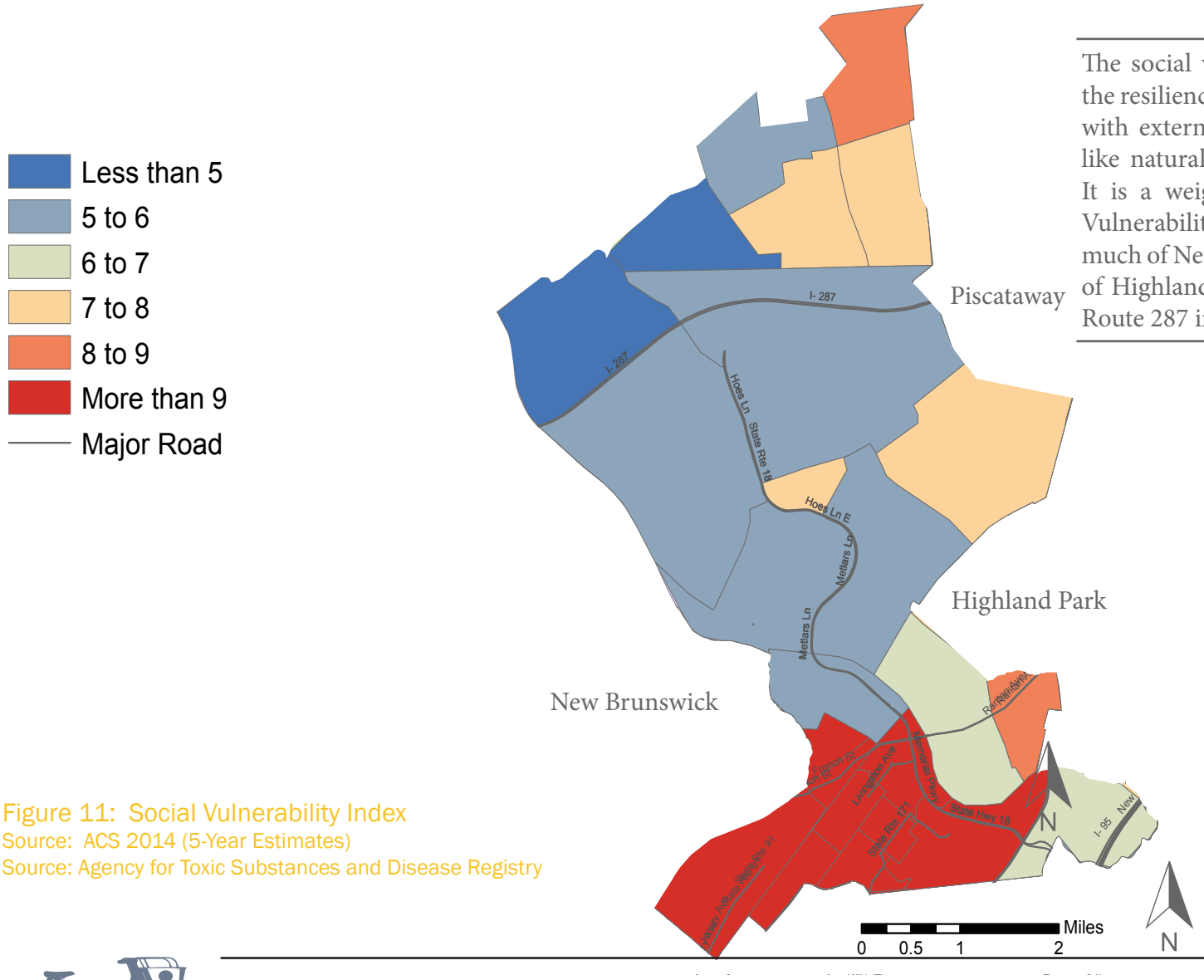
Poverty rates are higher in New Brunswick, especially in the Hispanic communities. Highland Park also has significant levels of poverty. Most of Piscataway, except for some areas north of Route 287, has less than 5% of the population in poverty.

Figure 9: Poverty Rate
Source: ACS 2014 (5-Year Estimates)



Levels of unemployment are mixed throughout the service area; it is highest in New Brunswick adjacent to Cook/ Douglass. There are also pockets of high unemployment throughout Piscataway.

Figure 10: Unemployment Rate
Source: ACS 2014 (5-Year Estimates)



The social vulnerability index measures the resilience of communities when faced with external stresses on human health like natural or human-caused disasters. It is a weighted index of census data. Vulnerability is very high throughout much of New Brunswick, the eastern part of Highland Park, and in areas north of Route 287 in Piscataway.

Figure 11: Social Vulnerability Index
Source: ACS 2014 (5-Year Estimates)
Source: Agency for Toxic Substances and Disease Registry

COMMUNITY HEALTH

Studies show that economically vulnerable populations are likely to suffer from poor health. In New Brunswick, those making less than $20,000 a year were three times more likely to self report having "poor" health.[126] While local health data can be difficult to obtain, the Rutgers Robert Wood Johnson Medical School released a report in 2014 that contained a great deal of useful information. In "Measurement to Promote a Healthier New Brunswick," the researchers looked at a variety of health factors, including asthma, substance abuse, lead exposure, reproductive health, and more.[127] For this report, we chose the factors most pertinent to the health benefits of cycling: nutrition and physical activity, diabetes, and mental health.

Nutrition and Physical Activity

Most of the data collected for New Brunswick on this health indicator comes from the New Jersey Childhood Obesity Study.[128] However, this study is operating under the assumption that Rutgers bike share use will be restricted to adults. The only local data collected for adults is self-reported body weight and physical activity. The data found that only 10% of adults in New Brunswick exercise every day. Additionally, about 60% of of residents have been instructed by a physician to increase their amount of exercise. Finally, 21% of residents report having someone in their household who is overweight or deals with other weight-related health issues.[129]

There has been recent movements in the city to address these health concerns.[130] The New Brunswick Blueprint for Action developed under the Robert Wood Johnson Foundation's Culture of Health initiative, provides a comprehensive and long-term plan for ensuring equitable access for all New Brunswick residents to the services, programs and conditions that ensure good health and well-being. The Blueprint for Action identifies specific community-based priorities (e.g. access to nutritious food and active transportation, development of a parks strategic plan, healthy housing efforts, school-based efforts, and partnerships with health provider in the City) that a partnership of many individuals and organizations that cut across diverse disciplines within the city of New Brunswick agree to advance.[131] Additionally, the Robert Wood Johnson Fitness and Wellness Center, which opened in 2012, offers reduced membership rates to New Brunswick residents. This allows residents to take advantage of the facilities available to exercise and also receive free educational programming on wellness topics.[132]

Diabetes

Research shows being overweight increases the risk of developing type 2 diabetes, and multiple surveys suggest that diabetes rates in New Brunswick are substantially higher than county and statewide figures. When asked if any household members suffered from diabetes, response rates ranged from 24-36%.[133]

Mental Health

There are inherent links between social vulnerability and mental health. Vulnerable populations have less access to resources to promote positive mental health, and lack financial safety nets. In 2014, 8% of residents in Middlesex County reported seeking mental health resources. However, over 25% of New Brunswick residents report that someone in their household suffers from a mental health condition, such as depression or anxiety.[134] This disparity may be attributed to the high rate of poverty. Additionally, New Brunswick has one of the highest homeless populations in Middlesex County. National reporting shows that 39% of the homeless population suffers from a mental health condition. In New Jersey, 8,000 chronically homeless people report suffering from a mental health condition.[135]

County Context

To account for gaps in baseline health information for Highland Park and Piscataway, this study looked at health information for Middlesex County as a whole. In relation to physical activity, 96% of county residents have access to exercise facilities, defined as living ½-1 mile from a park or recreational facility. Another strength for the county was the "years of potential life loss" metric, which means people are living longer. One area for improvement is the length of commute. 44% of residents are in the car for longer than 30 minutes each way.[136] In addition, Middlesex County has an obesity rate of 24%, and it has not improved for a considerable time.[137]

EXISTING BICYCLE INFRASTRUCTURE

There are 27.6 miles of bike routes across New Brunswick, Highland Park and Piscataway.[138] Four different types of bike routes exist in the area: bike lanes, sharrows, shared pedestrian and bike paths, and bicycle-friendly roadways (see Figure 13). Figure 12 shows a current sharrow in New Brunswick.

Figure 12: Sharrow Lane in New Brunswick, New Jersey [139]

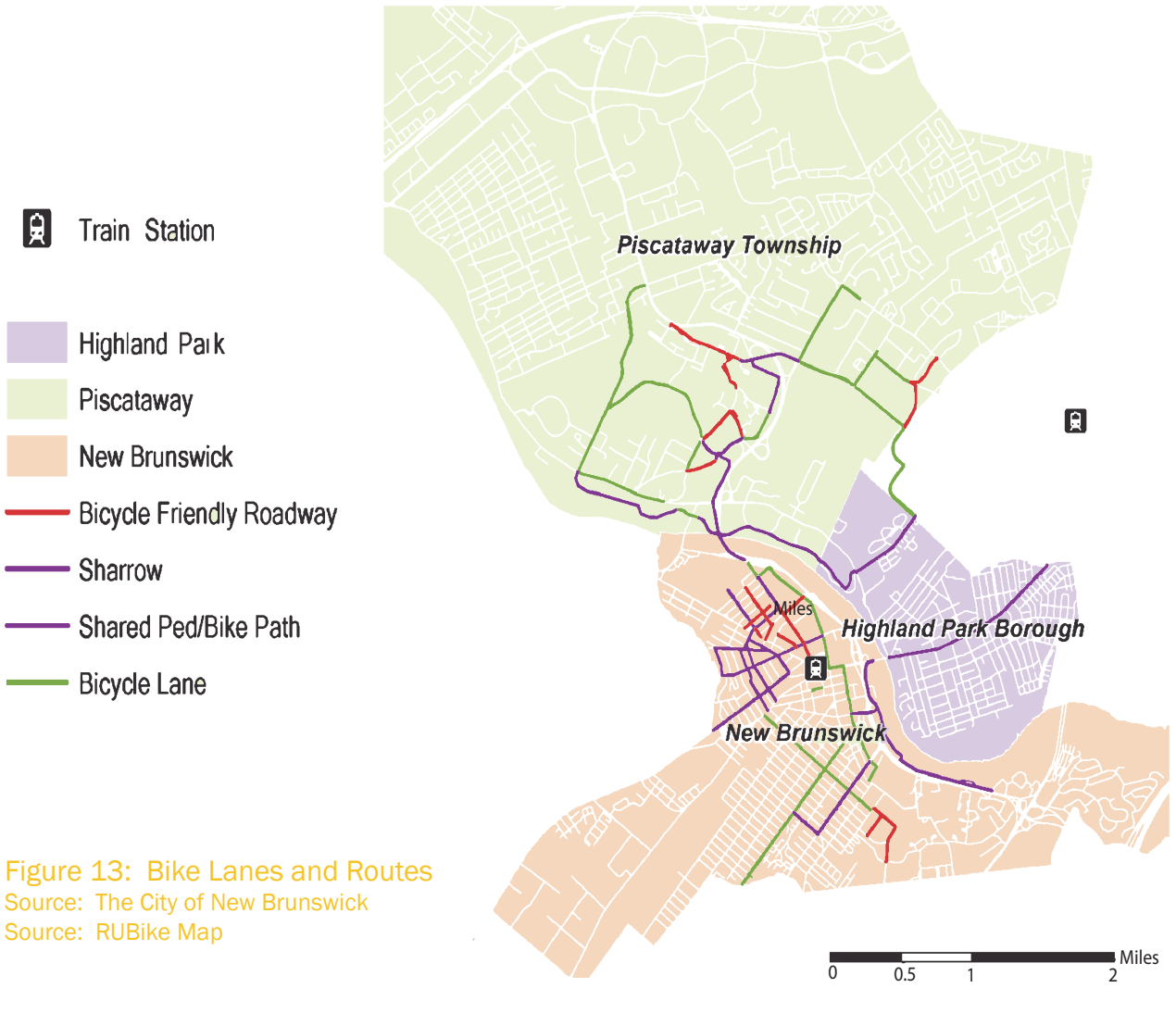


Figure 13: Bike Lanes and Routes
Source: The City of New Brunswick
Source: RUBike Map

- 10.8 miles of dedicated bike lanes, or lanes that are demarcated on the roadway

- 6.2 miles of sharrows, or lanes that are shared with both cars and bikes. These shared streets are painted with a large bike symbol to raise motorist awareness of potential cyclists and to also position cyclists in the roadway to avoid parked cars and to be more visibile in traffic. They are often used when the roadway is not wide enought for dedicated bike lanes.

- 6.6 miles of shared pedestrian and bike paths

- 4.0 miles of bicycle-friendly roadways, or roadways that have sufficient wide shoulders for cyclists to ride comfortably

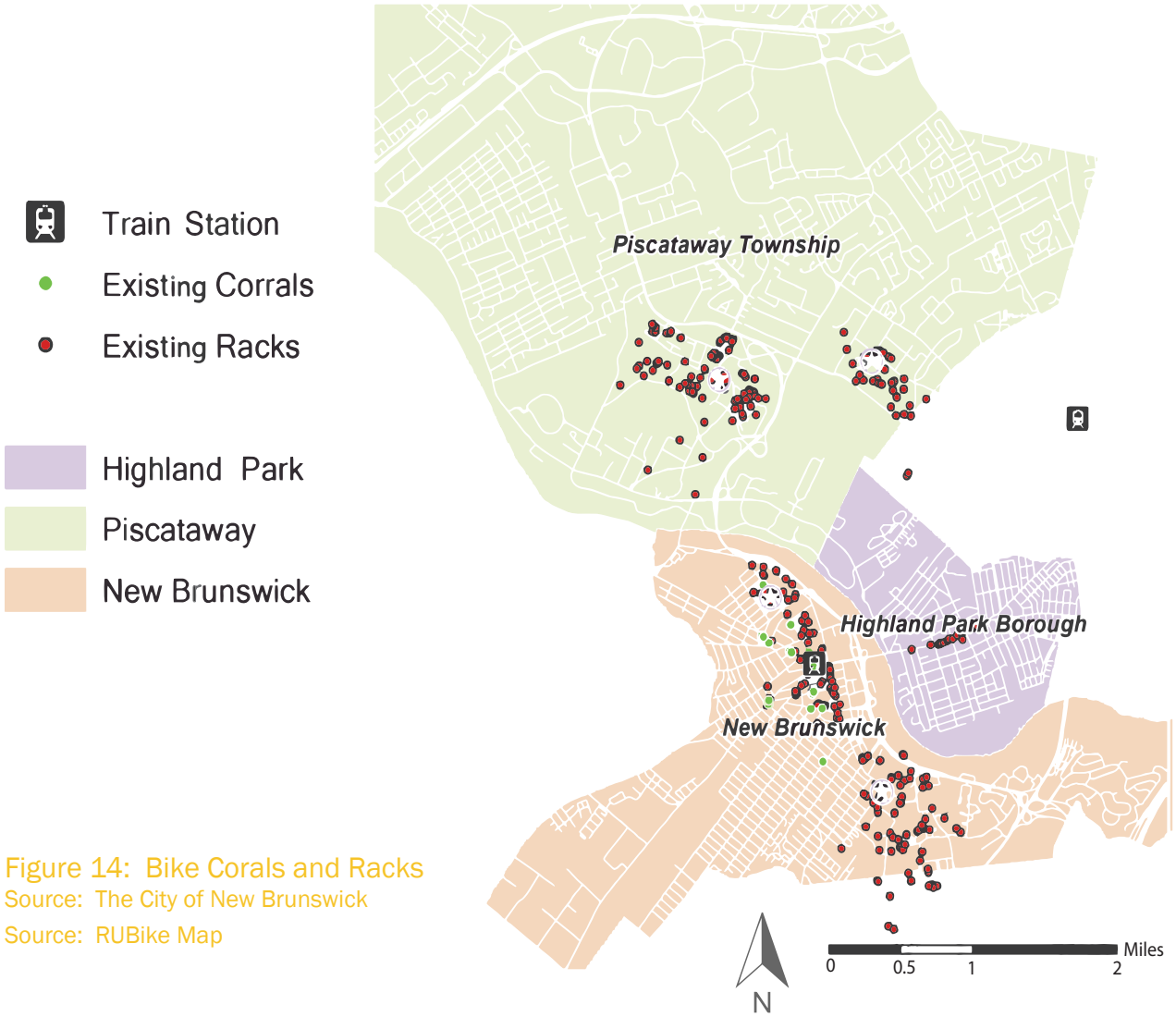


Figure 14: Bike Corals and Racks
Source: The City of New Brunswick
Source: RUBike Map

There are 376 known bike racks in the three municipalities The racks are spread across all five Rutgers campuses; they are also available along main streets in both New Brunswick and Highland Park.[140] [141] There are also 16 bike corrals that have been installed in New Brunswick. Bike corrals are installed in the street along curbs. They are popular because they can accommodate many more bicycles than a typical sidewalk bike rack. Further, they prevent vehicles from parking too close to intersections. Bike corrals are especially useful in areas with narrow sidewalks or high pedestrian density where sidewalk bike racks could be obstructive.[142] [143] Figure 15 shows a recently installed corral in New Brunswick, New Jersey.

Finally, 14 bike lockers exist at the New Brunswick train station, 10 exist at the Edison train station, and there are 20 bike lockers each on Rutgers Cook and Livingston campuses.[144] [145] Bike lockers provide a place for students and commuters to safely store their bikes out of the elements.[146]

Figure 15: Bike Corrals on the Corner of Easton Avenue and Mine Street in New Brunswick, New Jersey [147]

Bike Repair Stations

Bicycle repair stations are all-in-one bicycle repair and maintenance device. The Rutgers University Department of Transportation has installed one repair station the University's Busch, Livingston, College Avenue, and Cook/Douglass campuses. Each repair station is free to use and provides many professional tools for basic maintenance. These stations can be used to change or refill a flat tire, adjust the seat height, or fine tune the brakes. They are also equipped with a hanger arm, allowing cyclists to suspend their bicycle while repairing; this allows the pedals and wheels to spin freely while also supporting the bicycle's weight so it does not fall over.[148]

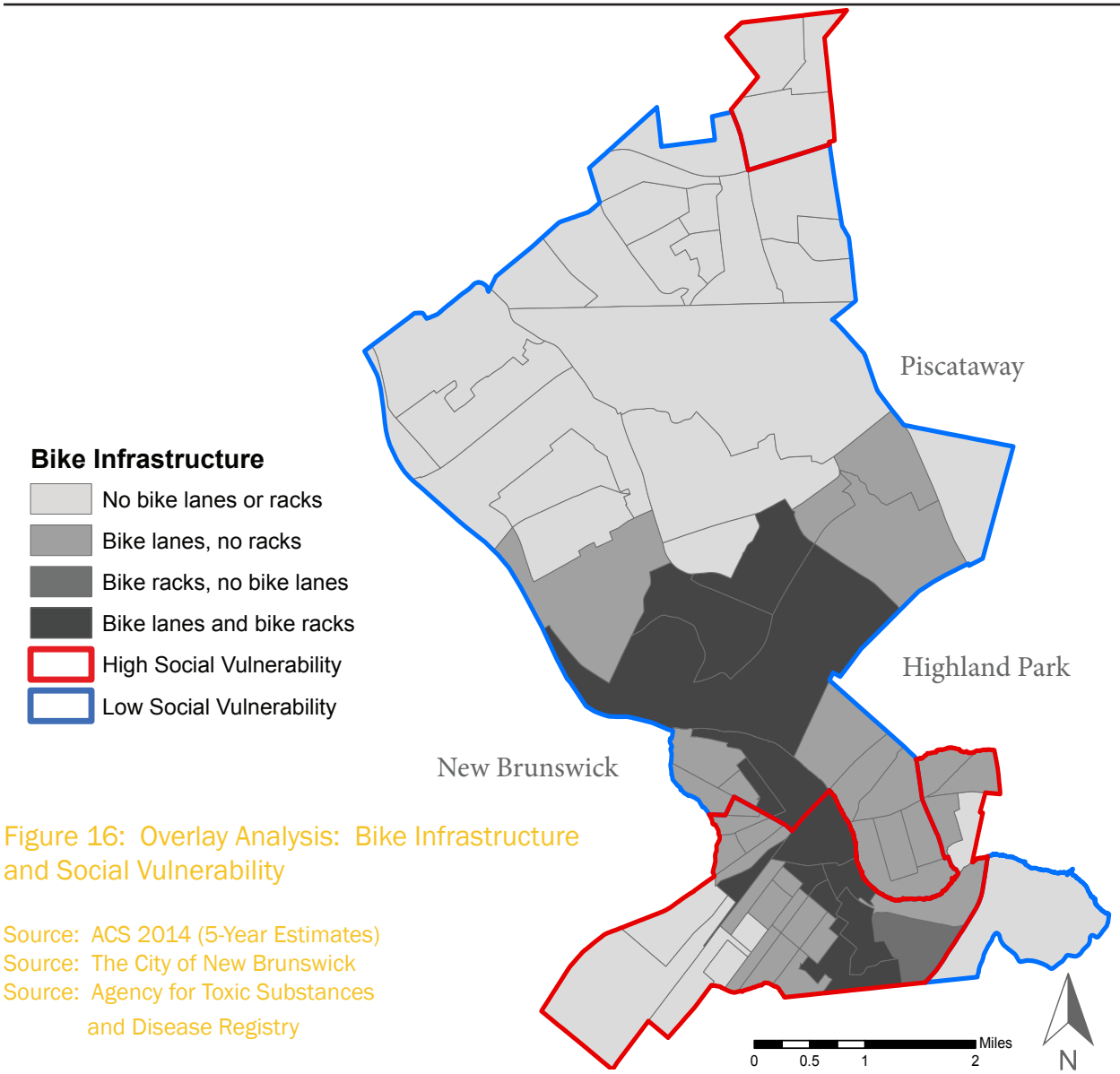


Figure 16: Overlay Analysis: Bike Infrastructure and Social Vulnerability

Source: ACS 2014 (5-Year Estimates)
Source: The City of New Brunswick
Source: Agency for Toxic Substances and Disease Registry

Figure 16 shows the results of an overlay analysis where the social vulnerability index was combined with the bike infrastructure data. The purpose is to find areas that are both vulnerable and underserved by current bicycle friendly infrastructure. Census block groups outlined in blue are areas with relatively low social vulnerability (a score lower than 8), and block groups outlined in red show areas with higher vulnerability (scores of 8 or greater). The shade of gray shows which bike infrastructure elements are present in that block group. Generally, as the shade darkens, the amount and variety of infrastructure increases. There is no systemic trend of underserving vulnerable areas. However, there are pockets of vulnerable areas with a complete absence of bike infrastructure, such as in southwestern New Brunswick, eastern Highland Park, and the extreme northern end of Piscataway. Much of Piscataway's affluent northern half is also currently unserved by bike infrastructure of any kind.

Low Stress Bicyling and Network Connectivity

Low stress bicycle networks are important to attract a wide range of cyclists. The manner in which roads are connected plays a role in rider comfort and access. The varying levels of stress influence the type of trip that is made and their duration. Each Level of Traffic Stress (LTS) can be tolerated by different types of riders:

- LTS 1 is meant to be a level that children over the age of 12 can tolerate
- LTS 2 is tolerated by the mainstream adult population
- LTS 3 is accessible to cyclists who are "enthused and confident" but prefer having a dedicated lane
- LTS 4 is accessible only to cyclists who are "strong and fearless"

Speed limit and street width play an important factor in the level of stress cyclists endure on the roadways. Table 14 provides general guidelines on how LTS is determined based on these factors. These guidelines were applied to roads in the study area to determine local LTS levels. This information may be used to target areas where LTS should be reduced to increase bike network connectivity. For example, while LTS 4 roads are few in number, River Road and Albany Street cut through the heart of the study area. This combination of two LTS 4 surface streets divides the study area into four distinct quarters that are inaccessible to one another by mainstream cyclists. It is useful for recommending the least stressful bike routes for unfamiliar cyclists.[149]

In particular, the survey yielded informative details regarding traffic stress in the open-ended section. Current riders have an issue with traveling from College Avenue to Livingston or Busch campuses. Many comments were also directed toward areas of improvement like the bike path along Route 18. Improved connectivity along Route 18 will help to encourage more bicycling between campuses.

	Street Width		
Speed Limit	**2-3 lanes**	**4-5 lanes**	**6+ lanes**
Up to 25 mph	LTS 1[a] or 2[a]	LTS 3	LTS 4
30 mph	LTS 2[a] or 3[a]	LTS 4	LTS 4
35+ mph	LTS 4	LTS 4	LTS 4

Note: Use lower value for streets without marked centerlines or classified as residential and with fewer than 3 lanes; use higher value otherwise

Table 14: Criteria for Level of Traffic Stress [150]

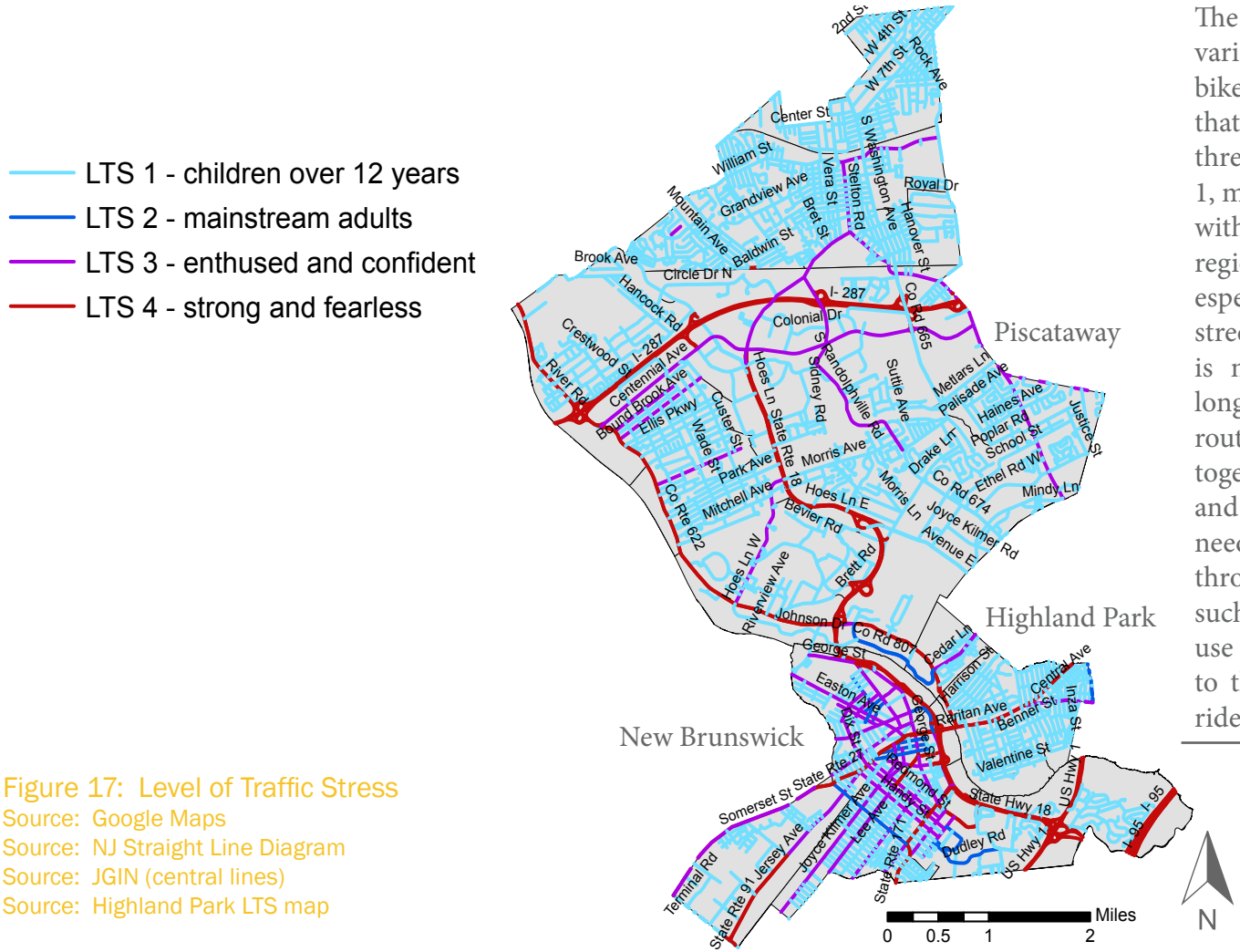


Figure 17: Level of Traffic Stress
Source: Google Maps
Source: NJ Straight Line Diagram
Source: JGIN (central lines)
Source: Highland Park LTS map

The results of the LTS study show a wide variety of street types in the proposed bike share service area. Figure 17 show that many of the residential streets in all three municipalities are rated at LTS level 1, meaning that they are already bikeable without any improvements. However, regional connectivity is a real challenge, especially in Piscataway. While most streets in the township are LTS 1, there is no consistent street grid, meaning longer trips are difficult. By and large, the routes that connect the municipalities together are rated at LTS level 4 (strong and fearless riders). This highlights the need for dedicated bike infrastructure throughout the service area. Without such investments, widespread bike share use for regional travel will be restricted to the most experienced and confident riders only.

EXISTING PLANNING INITIATIVES

The Rutgers Bike Share will need to fit in with the existing planning context of Rutgers University, the three proposed service area municipalities, and Middlesex County. This study looked at relevant planning documents for anything pertinent relating to cycling and bike share. A short summary is below.

Complete Streets

Middlesex County is the largest county in New Jersey that has adopted a Complete Streets Policy. According to New Jersey Department of Transportation, Complete Streets are defined as "means to provide safe access for all users by designing and operating a comprehensive, integrated, connected multi-modal network of transportation options."[151] Since 2012, New Brunswick and Highland Park have adopted Complete Streets policies. Piscataway does not have a policy.[152]

New Brunswick Master Plans

According to the 2004 New Brunswick Master Plan, the percentage of bicycle commuters is higher than the county average, and residents were noted for using bicycles to transport to school, shopping and other recreation.[153] In November 2016, the City of New Brunswick was designated a Bronze level Bicycle Friendly Community the League of American Bicyclists for its streets design, bicycle amenities, community education, planning, and encouraging residents to ride. Rutgers University was mentioned for assisting with installing bicycle repair stations in New Brunswick, however Rutgers is not designated a Bicycle Friendly University.[154]

A 2008 Downtown New Brunswick cycling study concluded that improvements to the "trench" bike path from Route 27 to Route 18 were needed. Such improvements would include better ingress and egress, better lighting, widening, and other safety improvements.[155] As of 2016, the path is largely unchanged.

Highland Park Master Plans

In Highland Park's 2003 Master Plan a proposed Bicycle Route System was included to increase safety for riders and better connect Highland Park to New Brunswick. This system encourages riders to use local streets on the north and south sides of the borough. The plan identified the Raritan Avenue-River Road intersection as an accident-prone area warranting special consideration. To avoid the narrow lanes and high traffic, cyclists usually ride on the sidewalk across the Albany Street Bridge.[156] Also relating to safety, the 2015 Highland Park Capital Improvement Plan recommends equitable and regular road repair, as potholes and cracks can be dangerous to cyclists.[157] It is important to note that most bike infrastructure in the borough is owned by Middlesex County.

The 2007 Highland Park Green Community Plan notes that 5% of residents walk or cycle to work, which is similar to New Brunswick and Piscataway. The Borough has plans to prioritize cycling and pedestrian paths, and to require active transportation be included in all transportation planning and development. Specific plans include updating sidewalks, crosswalks, signs and lightening on Raritan and Woodbridge Avenues. Other plans include improving residential streets with speed bumps, updating road and street signage, and hosting bicycle rodeos with Police Department.[158] [159]

Rutgers Physical Master Plan

The Rutgers University Physical Master Plan, Rutgers 2030, is consistent with the future benefits and infrastructure needs of a bike share system. There are plans to construct a pedestrian and bike bridge over Route 18, connecting the College Avenue, Busch and Livingston campuses. Mobility is also a key area for planned improvements in the master plan, and using active transportation to reduce congestion around campus. Rutgers plans to achieve this by supporting Complete Streets initiatives and improving bike and pedestrian networks. The Rutgers 2030 Master Plan predicts that bicycle use may increase by improving storage, parking and pathways. Of note, Rutgers mentions that commuter students should have a variety of transportation options once they arrive on campus, such as cycling or transit, instead of using their car between campuses.[160] A bike share could provide the necessary choices to commuters and local students alike.

Middlesex County Bicycle Pedestrian Plan Recommendations

The 2002 Middlesex County Bicycle and Pedestrian Plan identifies Downtown New Brunswick, College Ave, and the Cook/Douglass Campus as areas with significant bike travel. Additionally, the plan notes that the New Brunswick train station has many well-utilised bike racks, suggesting that it's a major cyclist destination. The plan also suggests infrastructure improvement priorities. Improvements to the Albany Street (Route 27), John Lynch (Route 18), and Landing Lane Bridges would foster a more complete network. Adding a bicycle route on How Lane between Route 27 and Livingston Avenue would extend a bike-friendly route from neighboring Somerset. Lastly, the plan suggests adding a bike route from George and Albany Streets to Route 1.[161] [162]

PHASE I
RECOMMENDATIONS

The Fall 2016 Bloustein Bike Share HIA Studio suggests the following recommendations based on our findings. In the tables below, we list each recommendation along with monetary costs associated, stakeholders and other responsible parties, quality of evidence on its impact to health, and proposed metrics. We suggest implementing recommendations in two phases as we found certain recommendations require more immediate attention and action.

INFRASTRUCTURE

The following infrastructure recommendations reflect necessary partnerships across municipalities and local transportation agencies. Bicycle facilities should be expanded to connect existing lanes to form a more complete network. And bicycle parking should be added in currently sparse areas to make the experience as convenient as possible for bike share users. In addition, infrastructure should also increase safety on the road, in the form of signage, painted lanes, and safety warnings on bicycles. We view these infrastructure recommendations to be critical in increasing bicycling in the study area and the potential use of the bike share program, that will ultimately impact health, hence they were chosen for Phase 1. Future success in infrastructure improvements will be measured by comparing the number of bicycle lanes, racks and paths currently to how many are in place after bike share implementatio; as well as user trip data for origins and destinations to gauge success of added bicycle parking.

RECOMMENDATION: Expand bike parking facilities at points of interest such as throughout the CBD, supermarkets, grocery stores, open spaces & parks, public transit hubs, and major employers.

Cost

Quality of Evidence

Stakeholders

Monitoring

Number of trips taken to and from given destinations in proportion to overall trips taken within system's boundaries.

RECOMMENDATION: Connect future bicycle lanes with existing paths. Provide lanes separated from vehicular traffic (protected bike lanes), where possible.

Cost

Quality of Evidence

Stakeholders

Monitoring

Number of new bike lanes created.

RECOMMENDATION: Expand bike lanes within the Cook/Douglass Campus to connect with downtown New Brunswick and other portions of Rutgers Campus.

Cost

Quality of Evidence

Stakeholders

Monitoring

Number of bike lanes and paths that existed in area prior to and after bike share; number of people riding bikes on-campus before and after.

RECOMMENDATION: Add bike parking facilities in residential areas that lack them, e.g. Southern New Brunswick and Highland Park.

Cost

Quality of Evidence

Stakeholders

Monitoring

Number of bike racks/corrals before and after bike share; number of trips taken in area before and after bike share; number of racks in-use at new locations during peak hours.

RECOMMENDATION: Increase bike signage and number of painted lanes.

Cost

Quality of Evidence

Stakeholders

Monitoring

Percentage or number of lanes within the service area that have bike infrastructure.

SAFETY

The safety recommendations consider the bike share user and the infrastructure priorities needed. The minimum age to join the bike share program should be 17 years of age, so that the program will not have to require helmets according to New Jersey law.[162] The recommendations were chosen for Phase 1 because they provide current and future safety considerations that could impact health while using the potential bike share program. Crash data should be assessed to prioritize infrastructure needs.

RECOMMENDATION: Helmets should not be required for bike share use.

Cost

Quality of Evidence

Stakeholders

Monitoring
N/A

RECOMMENDATION: A rider age minimum of 17 should be required.

Cost

Quality of Evidence

Stakeholders

Monitoring
Overall number of people signed up for bike share.

RECOMMENDATION: Use crash data when siting bike stations and prioritizing infrastructure projects.

Cost

Quality of Evidence

Stakeholders

Monitoring
Monitor crash data on an annual basis.

RECOMMENDATION: Work with local bike advocate groups, cultural groups, and partners to provide on-bike educational programs on road safety for inexperienced riders as well as elementary, middle, and high school school students (future bike share participants). Compensate sparticipants with trial memberships.

Cost

Quality of Evidence

Stakeholders
Local bike advocate groups, local cultural groups

Monitoring
Overall number of people signed up for bike share.

RECOMMENDATION: Place safety warnings on bicycles.

Cost

Quality of Evidence

Stakeholders

Monitoring

Collect data on crashes and misuse of bike share bikes.

RECOMMENDATION: Kiosk stations should be solar-powered.

Cost

Quality of Evidence

Stakeholders

Monitoring

Estimate CO2 Emissions negated by kiosks.

ENVIRONMENTAL

In an effort to reduce greenhouse gas emissions and other pollutants, environmental sustainability should be a goal for the proposed bike share program. By finding opportunities to use clean energy where possible, including simple measures such as utilizing solar-powered kiosk stations, the program can contribute to cutting the state's carbon footprint. This recommendation was prioritized for Phase 1 in order to avoid having to perform kiosk upgrades early on, as well as to ensure that the bike share assures local environmental vitality. The success will be measured by avoided CO2 emissions.

ECONOMIC

The following economic-related recommendations seek to uplift all of the communities in the proposed bike share network. This can be done by creating job opportunities and workforce development targeted for vulnerable populations. Stimulating the economy and creating new jobs will impact the health of residents in the service area, which is why we found the following necessary to be included in Phase 1 of the recommendations. The success of this goal can be measured by assessing bike share employment, specifically on hire numbers from vulnerable groups.

RECOMMENDATION: Partner with local social service agencies and workforce development programs to hire from vulnerable social groups.

Cost

Quality of Evidence

Stakeholders

local community & social service providers,

State of New Jersey
Department of Labor and Workforce Development

Monitoring

Collect data on number of individuals hired from vulnerable groups, such as veterans, formerly incarcerated, youth, mature workers, and lower-income residents in proportion to total bike share workforce.

RECOMMENDATION: Collect data on how much bike share users spend at local businesses and, if local businesses start advertising, work with them to offer discounts or to promote said businesses to bike share users.

Cost

Quality of Evidence

Stakeholders

local businesses, local business improvement districts

Monitoring

Money spent at local businesses; Amount spent by businesses to promote to bike share users; number of businesses along bike routes.

RECOMMENDATION: Promote bike share by identifying and collaborating with local public health agencies throughout the three municipalities. Should include a task force with representatives from New Brunswick, Highland Park, Piscataway, Rutgers University, and local health and cultural groups to oversee data collection, review policies, monitor bike share implementation, and troubleshoot any issues.

Cost

Quality of Evidence

Stakeholders

Monitoring

Collect data on enrollment (percentage of individuals who credited local agency for enrollment); Number of public health advocacy groups in area; number of those partnered in proportion to the total in area.

EQUITY

Equity recommendations highlight partnering with other organizations and community groups to make the proposed bike share program accessible and affordable to lower-income residents through subsidized membership costs. Regional and national organizations like Better Bike Share, People for Bikes, and National Association of City Transportation Officials (NACTO) should be consulted for best practice in how to address equity in the program. Equitable considerations are important in planning a bike share program, we believe the following recommendations are most important to the success of the potential bike share and should be implemented as early as possible in the program. Success will be measured by number of subsidized memberships and percentage of memberships purchased on a pay-as-you-go basis at local stores.

RECOMMENDATION: Marketing materials must be inclusive; should include diverse participation of users on-bike, displaying all shapes and sizes, ages, gender, and racial/ethnic backgrounds.

Cost

Quality of Evidence

Stakeholders
local community and social service providers

Monitoring
Number of members across different demographics; Percentage of members that are not Rutgers University students

RECOMMENDATION: Provide subsidized memberships to lower-income residents via partnerships with Robert Wood Johnson and other health focused groups (prescribe-a-bike).

Cost

Quality of Evidence

Stakeholders
community groups

Monitoring
Number of subsidized memberships provided; Subsidized memberships in proportion to total lower-income residents in each municipality; how many subsidized members renew after the first year.

RECOMMENDATION: Subsidized memberships for lower-income individuals should have cash option, which may be purchased at select convenience stores, and is promoted on kiosks and at participating stores or agencies. Subsidized membership also includes reduced overage charges.

Cost

Quality of Evidence

Stakeholders
local businesses, local BIDs,

Monitoring
Percentage of memberships that are purchased via local stores versus through the bike share's app.

POLICY

The following policy recommendations aim to shape the proposed bike share program with measures in place to promote healthy living and equity for disadvantaged populations. These policy recommendations were included in the Phase 1 recommendations because we believe they will aid in forming a healthy and equitable program that is also accessible to the communities in the study area. The success of policy recommendations will be assessed through quantitative measures and survey results.

RECOMMENDATION: Collaborate with nonprofit groups to initiate community ambassador programs that hire members from vulnerable populations.

Cost

Quality of Evidence

Stakeholders
local communities and social service providers,

Monitoring
Distribution of workforce that comes from specific wards and neighborhoods.

RECOMMENDATION: Collect and analyze anonymized demographic and health information on users upon initial sign-up. Data on membership and daily use of program by vulnerable populations should also be of particular concern.

Cost

Quality of Evidence

Stakeholders

Monitoring
Number of members across different demographics and other statistics generated based on voluntary information provided.

RECOMMENDATION: Develop and implement a program that can be used to educate target groups on how to use a bike share, and compensate individuals for attending via memberships.

Cost

Quality of Evidence

Stakeholders
local communities and social service providers,

Monitoring
Number of people that attend programs; number of people from vulnerable populations that attend programs.

RECOMMENDATION: Provide volunteer work opportunities in exchange for free memberships.

Cost

Quality of Evidence

Stakeholders

Monitoring

Estimated cost-savings from work exchange; average number of volunteers within given intervals.

PHASE II
RECOMMENDATIONS

While we have found phase one recommendations to be pertinent to the overall success of the bike share program, second phase recommendations provide supportive functions to the original recommendations. They are not pivotal to the program's initial success, though strengthen health outcomes and promote a growing cyclist community.

RECOMMENDATION: Link bike share cards to public transit system cards

Cost

Quality of Evidence

Stakeholders

Monitoring

Number of members who have linked their bike share with their public transit card. Number of new members that began bike share with a membership linked to public transit.

RECOMMENDATION: Program should perform a health survey at intake and annually.

Cost

Quality of Evidence

Stakeholders

Monitoring

Number of members who opt to take survey and survey results.

RECOMMENDATION: Have a carbon emissions reduction calculator on membership site.

Cost

Quality of Evidence

Stakeholders

Monitoring

C02 emissions prevented as a result of bike share and bike trips.

RECOMMENDATION: Partner with local schools to promote a walk/bike culture, especially in lower-income communities where they are generally higer levels of pollutants.

Cost

Quality of Evidence

Stakeholders

Monitoring
Number of schools in the area that choose to participate in the partnership.

RECOMMENDATION: Identify truck routes and prevent them from being within bikeable routes.

Cost

Quality of Evidence

Stakeholders
Number of trucks routes that are proximate to bike lanes,

Monitoring
Number of complaints received from blockages.

RECOMMENDATION: Connect to information and innovation sharing networks.

Cost

Quality of Evidence

Stakeholders

Monitoring
Number of new partnerships.

RECOMMENDATION: Improvements such as lighting for bridges that cross the Raritan River.

Cost

Quality of Evidence

Stakeholders

Monitoring
N/A

RECOMMENDATION: Work with NJ Transit to prevent buses from being parked in bike lanes during off-hours.

Cost

Quality of Evidence

Stakeholders

Monitoring

Number of complaints received from blockages.

HUB LOCATIONS

To compile a set of bike share hub location suggestions, four types of potential users were considered: students, workers, residents, and visitors. Each user group has distinct travel purposes and corresponding origin-destination pairs. These pairs helped inform the location suggestions.

Equity and access were also important components of the analysis: social vulnerability and the location of existing bike facilities were taken into account. The resulting list of hub suggestions can be divided into four groups based on estimated utilization frequency and function: high-capacity hubs, low-capacity hubs, park hubs, and event hubs (see Figure 19). High-capacity hubs are located at places where high demand and high visit frequency are expected.

Similarly, low-capacity hubs are located at places with less demand and less visits, but still in need of service. Park hubs are designed to accommodate recreational needs and provide access to parks in the service area. Lastly, event hubs are temporary hubs set up for special events, such as a football game at High Point Solutions Stadium or a Sunday church event. Specific hub locations can be found in Appendix C. The suggestions do not include many residential areas. However, the City of New Brunswick has daylighted curb space at many intersections throughout residential districts. These street spaces could easily be converted to bike share hubs, should the need arise.

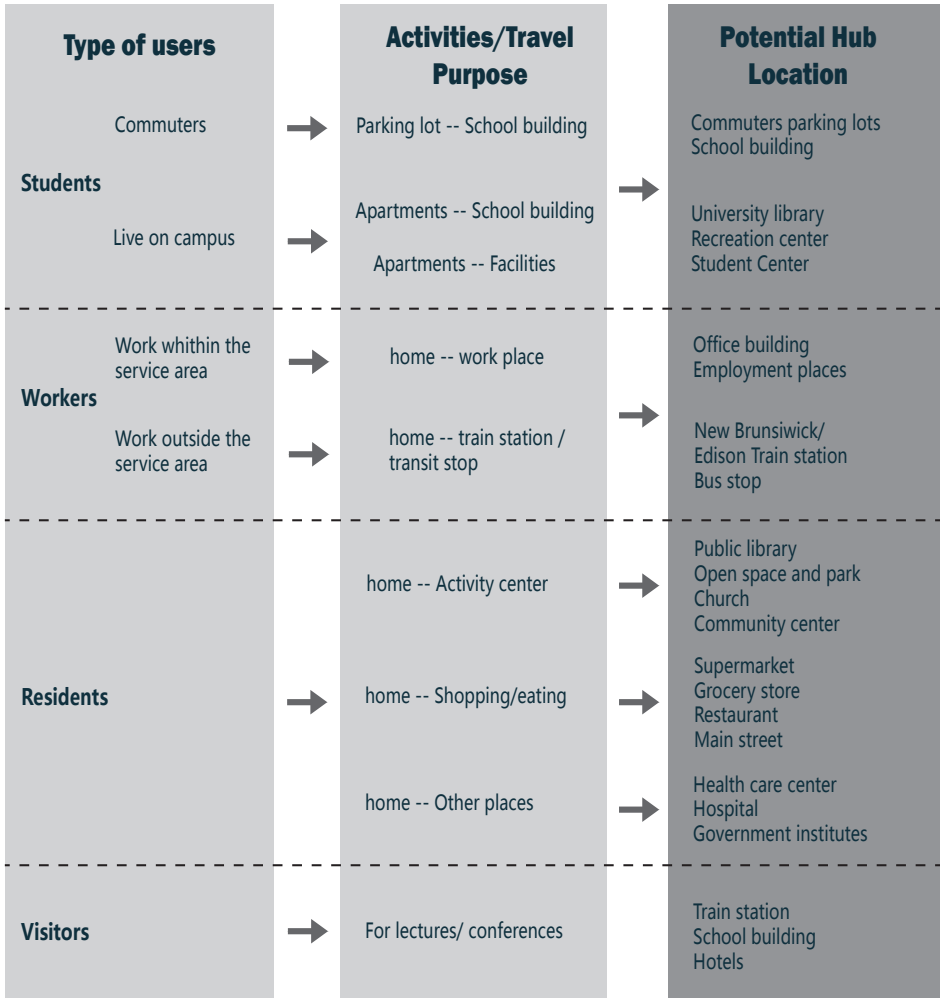


Figure 18: Potential Users, Travel Purposes, and Hub Locations

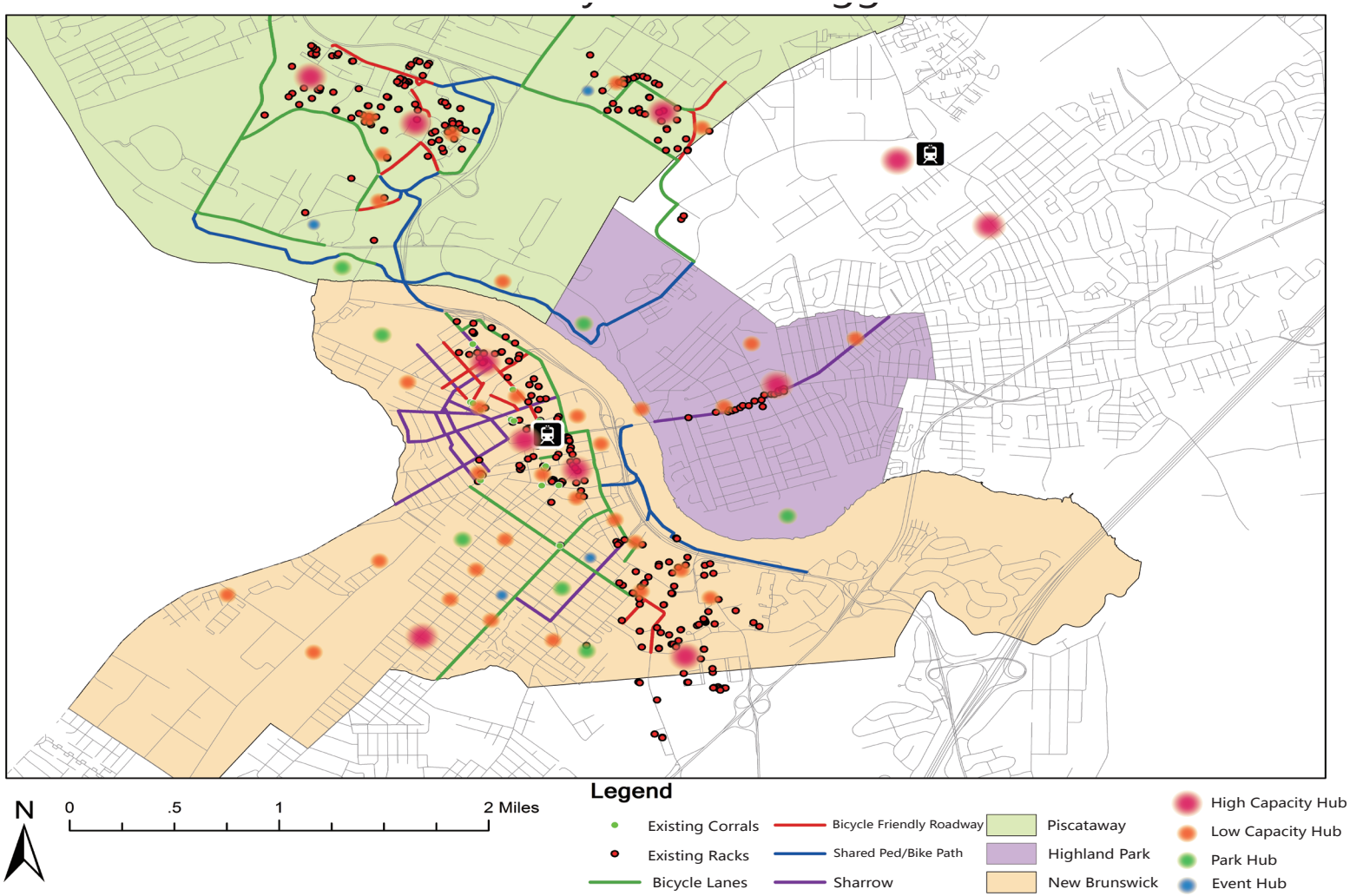


Figure 19: Potential Bicycle Hub Suggestions

FINAL THOUGHTS

This study has identified specific health needs in the greater Rutgers – New Brunswick community, as well as special health considerations for certain large populations of interest (students and socioeconomic vulnerable residents). Cycling can improve physical, mental, and economic health through many pathways, and using bike share for transportation or recreation can provide these benefits. The potential user survey conducted as part of this study shows that there is active interest and willingness to participate in such a program in the Rutgers University population. Although there many bike share models, each unique in its implementation, structure, pricing, and outreach, there is encouraging precedent in other university communities similar to Rutgers. Additionally, by identifying and targeting vulnerable populations, it is possible to make maximum community health impacts.

There are several areas of additional research needed to better understand health impacts of a Rutgers bike share system. First, this study did not engage community members in New Brunswick, Highland Park, and Piscataway with no university affiliation. While interest amongst student, faculty, and staff is high, there is a need for information on the broader community, where some of the largest health impacts may be made. This was intentional, as issues of program funding and scope are still unresolved. Once these issues are resolved, a comprehensive community survey should be conducted.

Another challenge is the lack of robust community health data. While some general areas of need can be identified, a richer picture would be helpful. Better health data would enable the program to be tailored for specific needs, and give an indication of the size of potential health benefits.

REFERENCES

1. Richter, Felix. "Bike-Sharing Is Taking Off Around the World." Statista-The Statistic Portal, March 19, 2015, 1-2. Accessed December 02, 2016.
2. Shaheen, Susan and Stacey Guzman. “Worldwide Bikesharing.” Access Magazine, Number 39, Fall 2011, 22-27. Accessed December 02, 2016
3. DeMaio, Paul. “Bike-sharing: History, Impacts, Models of Provision, and Future.” Journal of Public Transportation, Volume 12, Number 4, 2009, 41-56. doi:10.5038/2375-0901.12.4.3.
4. United States Department of Transportation. “Department of Transportation.” Lost modified 2016. Accessed December 09, 2016. <https://www.transportation.gov/>.
5. Richter, Felix. "Bike-Sharing Is Taking Off Around the World."
6. Meddin, Russell. "The Bike-sharing World - End of 2013." The Bike-sharing blog, December 31, 2013, 1-3. Accessed December 02, 2016.
7. Richter, Felix. "Bike-Sharing Is Taking Off Around the World."
8. United States Department of Transportation. “Department of Transportation.”
9. Zagster Staff. “Bike sharing basics: Guide to bike share program types.” Zagster, October 14, 2015, 1-6. Accessed September 17, 2016.
10. Zagster Staff. “Bike sharing basics: Guide to bike share program types.”
11. BikeRU Initative. “Bike RU | Rutgers, The State University of New Jersey.” Last modified 2010. Accessed September 17, 2016. <http://bikes.rutgers.edu/>.
12. Zagster Staff. “Bike sharing basics: Guide to bike share program types.”
13. Citi Bike 2016. "Citi Bike: Unlock a Bike, Unlock New York | Citi Bike NYC." Last modified 2016. Accessed December 02, 2016. <https://www.citibikenyc.com/>.
14. Citi Bike 2016. "Citi Bike: Unlock a Bike, Unlock New York | Citi Bike NYC."
15. Citi Bike 2016. "Citi Bike: Unlock a Bike, Unlock New York | Citi Bike NYC."
16. Citi Bike 2016. "Citi Bike: Unlock a Bike, Unlock New York | Citi Bike NYC."
17. Zagster Staff. “Bike sharing basics: Guide to bike share program types.”
18. Zagster Staff. “Bike sharing basics: Guide to bike share program types.”
19. Hudson Bike Share. “Public bike rentalHudson Bike Share.” Last modified 2016. Accessed December 02, 2016. <https://hudsonbikeshare.com/>.
20. Hudson Bike Share. “Public bike rentalHudson Bike Share.”

21. Hudson Bike Share. "Public bike rentalHudson Bike Share."
22. Hudson Bike Share. "Public bike rentalHudson Bike Share."
23. Zagster Staff. "Bike sharing basics: Guide to bike share program types."
24. Marcus, John. "One City Finally Solved Bike Sharing's Big Safety Problem." Time Magazine, November 14, 2013, 1-2. Accessed September 17, 2016.
25. Corbin, April. "Seattle Bike Share's Surprisingly Simple Solution To A Mandatory Helmet Law." People For Bikes, February 23, 2015, 1-2. Accessed September 17, 2016.
26. CTV Vancouver. "Viewer inbox: Mobi helmet cleaning, holiday pay, Samsung washers." CTV News Vancouver, September 30, 2016. <http://bc.ctvnews.ca/>.
27. Mobi. "Vancouver Bike Share | Mobi." Last modified 2016. Accessed December 12, 2016. <https://www.mobibikes.ca/en>.
28. Capital Bikeshare. "Capital Bikeshare." Last modified 2016. Accessed September 28, 2016. <https://www.capitalbikeshare.com/>.
29. Citi Bike 2016. "Citi Bike: Unlock a Bike, Unlock New York | Citi Bike NYC."
30. Denver B-cycle. "Home." Last modified 2015. Accessed December 02, 2016. <https://denver.bcycle.com/>.
31. Hubway. "Hubway: Metro-Boston's Bike share Program | The Hubway." Last modified 2016. Accessed December 02, 2016. <https://www.thehubway.com/>.
32. Hudson Bike Share. "Public bike rentalHudson Bike Share."
33. Indego. "Indego – Philly's Bike Share." Last modified 2016. Accessed December 02, 2016. <https://www.rideindego.com/>.
34. Metro Bike Share. "Metro Bike Share – LA's Bike Share." Last modified 2016. Accessed December 09, 2016. <https://bikeshare.metro.net/>.
35. Boise Green Bike. "Boise Green Bike." Last modified 2016. Accessed December 02, 2016. <http://boise.greenbike.com/>.
36. Reddy Bikeshare. "Reddy Bikeshare." Last modified 2016. Accessed December 02, 2016. <https://reddybikeshare.socialbicycles.com/.>
37. UBike. "UBike." Last modified 2016. Accessed December 02, 2016. <http://ubike.virginia.edu/>.
38. FactFinder. "American FactFinder." Last modified 2016. Accessed December 02, 2016. <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>.
39. Boise Green Bike. "Boise Green Bike."
40. FactFinder. "American FactFinder."
41. Reddy Bikeshare. "Reddy Bikeshare."

45. Citi Bike 2016. "Citi Bike: Unlock a Bike, Unlock New York | Citi Bike NYC."
46. Denver B-cycle. “Home.”
47. FactFinder. “American FactFinder.”
48. Hubway. “Hubway: Metro-Boston’s Bike share Program | The Hubway.”
49. Hudson Bike Share. “Public bike rentalHudson Bike Share.”
50. Chicago Divvy 2016. "Divvy: Chicago's Bike Share Program | Divvy Bikes."
51. Chicago Divvy 2016. "Divvy: Chicago's Bike Share Program | Divvy Bikes."
52. Citi Bike 2016. "Citi Bike: Unlock a Bike, Unlock New York | Citi Bike NYC."
53. Indego. “Indego – Philly’s Bike Share.”
54. Streetsblog Chicago. “Streetsblog Chicago.” Last modified December 02, 2016. Accessed December 02, 2016. <chi.streetsblog.org>.
55. Capital Bikeshare. “Capital Bikeshare.”
56. Citi Bike 2016. "Citi Bike: Unlock a Bike, Unlock New York | Citi Bike NYC."
57. Indego. “Indego – Philly’s Bike Share.”
58. Metro Bike Share. “Metro Bike Share – LA’s Bike Share.”
59. Streetsblog Chicago. “Streetsblog Chicago.”
60. Boise Green Bike. “Boise Green Bike.”
61. UBike. “UBike.”
62. Boise Green Bike. “Boise Green Bike.”
63. UBike. “UBike.”
64. Streetsblog Chicago. “Streetsblog Chicago.”
65. Reddy Bikeshare. “Reddy Bikeshare.”
66. BikeRU Initative. “Bike RU | Rutgers, The State University of New Jersey.”
67. New Brunswick Ciclovia. “About | New Brunswick Ciclovia.” Last modified 2016. Accessed December 09, 2016. <http://newbrunswickciclovia.com/about/>.
68. Fuller, Daniel, Lise Gauvin, Yan Kestens, Patrick Morency, and Louis Drouin. “The potential modal shift and health benefits of implementing a public bicycle share program in Montreal, Canada.” International Journal of Behavior Nutrition and Physical Activity, Volume 10, May 24, 2013, 1-6.

69. UBike. “UBike.”
70. Capital Bikeshare. “Capital Bikeshare.”
71. Chicago Divvy 2016. "Divvy: Chicago's Bike Share Program | Divvy Bikes." Last modified 2016. Accessed December 02, 2016. <https://www.divvybikes.com/>.
72. Physical Activity Guidelines Advisory Committee. “Physical activity guidelines advisory committee report, 2008.” US Department of Health and Human Services, 2008, A1-H14.
73. Mueller, Natalie, David Rojas-Rueda, Tom Cole-Hunter, Audrey de Nazelle, Evi Dons, Regine Gerike, Thomas Götschi, Luc Int Panis, Sonja Kahlmeier, and Mark Nieuwenhuijsen. "Health impact assessment of active transportation: A systematic review." Preventative Medicine, Volume 76, July 2015, 103-114.
74. Physical Activity Guidelines Advisory Committee. “Physical activity guidelines advisory committee report, 2008.”
75. Berrigan, David, Richard P. Troiano, Timothy McNeel, Charles DiSogra, and Rachel Ballard-Barbash. "Active transportation increases adherence to activity recommendations." American Journal of Preventive Medicine Volume 31, Issue 3, September 2006, 210-216.
76. Shephard, Roy J. "Is active commuting the answer to population health?." Sports Medicine, Volume 38, Issue 9, 2008, 751-758.
77. Berrigan, David, et al. "Active transportation increases adherence to activity recommendations."
78. Rojas-Rueda, David, Audrey de Nazelle, Oriol Teixido, and Mark J. Nieuwenhuijsen. "Replacing car trips by increasing bike and public transport in the greater Barcelona metropolitan area: a health impact assessment study." Environment International, Volume 49, 2012, 100-109.
79. Shephard, Roy J. "Is active commuting the answer to population health?"
80. Gordon-Larsen, Penny, Melissa C. Nelson, and Kristen Beam. "Associations among active transportation, physical activity, and weight status in young adults." Obesity Research, Volume 13, Issue 5, May 2005, 868-875. doi:10.1038/oby.2005.100
81. Alberts, Brian, Jamie Palumbo, and Eric Pierce. “Vehicle 4 Change: Health Implications of the Capital Bikeshare Program.” The George Washington University, December 06, 2012, 1-37.
82. Misra, Ranjita, and Michelle McKean. "College students' academic stress and its relation to their anxiety, time management, and leisure satisfaction." American Journal of Health Studies, Volume 16, Issue 1, 2000, 41-51.
83. Evans, Gary W., and Kimberly English. “The environment of poverty: Multiple stressor exposure, psychophysiological stress, and socioemotional adjustment.” Child Development, Volume 73, Issue 4, 2002, 1238-1248.
84. Yeager, Selene. “How Cycling Makes You Smarter and Happier.” Bicycling.com, March 31, 2014, 1-7. Accessed November 4, 2016.

85. Pucher, John, and Lewis Dijkstra. "Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany." American Journal of Public Health, Volume 93, Issue 9, 2003, 1509-1516.
86. Woodcock, James, Marko Tainio, James Cheshire, Oliver O'Brien, and Anna Goodman. "Health effects of the London bicycle sharing system: health impact modelling study." The BMJ, Volume 348, February 12, 2014, 1-14.
87. Johan de Hartog, Jeroen, Hanna Boogaard, Hans Nijland, and Gerard Hoek. "Do the Health Benefits of Cycling Outweigh the Risks?" Environmental Health Perspectives, Volume 118, Issue 8, August 2010, 1109-1116.
88. Johan de Hartog, Jeroen, et al. "Do the Health Benefits of Cycling Outweigh the Risks?" 88. Rojas-Rueda, David, et al. "Replacing car trips by increasing bike and public transport in the greater Barcelona metropolitan area: a health impact assessment study."
89. Martinez-Ruiz, Virginia, Pablo Lardelli-Claret, Eladio Jiménez-Mejías, Carmen Amezcua-Prieto, José Juan Jiménez-Moleón, and Juan de Dios Luna del Castillo. "Risk factors for causing road crashes involving cyclists: An application of a quasi-induced exposure method." Accident Analysis and Prevention, Volume 51, 2013, 228-237.
90. Pucher, John, and Lewis Dijkstra. "Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany."
91. Teschke, Kay, Anne Harris, Conor C. O. Reynolds, Meghan Winters, Shelina Babul, Mary Chipman, Michael D. Cusimano, Jeff R. Brubacher, Garth Hunte, Steven M. Friedman, Melody Monro, Hui Shen, Lee Vernich, and Peter A. Cripton. "Route Infrastructure and the Risk of Injuries to Bicyclists: A Case-Crossover Study." American Journal of Public Health, Volume 102, Number 12, December 2012, 2336-2343.
92. Clifton, Kelly J., Sara Morrissey, and Chloe Ritter. "Business Cycles: Catering to the Bicycling Market." Transportation Research News, May-June 2012, 26-32. Accessed November 22, 2016.
93. Flusche, Darren. "Bicycling Means Business: The Economic Benefits of Bicycle Infrastructure." League of American Bicyclists, July 2012, 1-28. Accessed November 22, 2016.
94. Buehler, Ralph and Andrea Hamre. "Economic Benefits of Capital Bikeshare: A Focus on Users and Businesses." Mid-Atlantic Universities Transportation Center, 2014, 1-40. Accessed November 22, 2016.
95. Timothy, Dallen J., and Stephen Boyd. Tourism and Trails. Cultural, Ecological, and Management Issues. Bristol: Channel View Publications, 2014. 88. Rojas-Rueda, David, et al. "Replacing car trips by increasing bike and public transport in the greater Barcelona metropolitan area: a health impact assessment study."

96. Flusche, Darren. “Bicycling Means Business: The Economic Benefits of Bicycle Infrastructure.”
97. Smart Growth America. “Complete Streets Stimulate the Local Economy.” National Complete Streets Coalition, nd., 1-4. Accessed November 22, 2016.
98. Meisel, Drew. “Bike Corrals: Local Business Impacts, Benefits, and Attitudes.” Portland State University School of Urban Studies and Planning, 2010, 1-23. Accessed November 22, 2016.
99. Virginia Tech Planning Studio. “Economic Impact & Operational Efficiency for Bikeshare Systems: Local, Domestic & International Lessons.” Virginia Polytechnic Institute and State University, Urban Affairs and Planning, 2014, 1-116. Accessed November 22, 2016.
100. LoSapio, Renee. “Is Capital Bikeshare Good for Businesses: Initial Evidence from the Dupont Circle Area in Washington, D.C.” Virginia Polytechnic Institute and State University, Urban Affairs and Planning, 2013. Accessed November 22. 2016.
101. Virginia Tech Planning Studio. “Economic Impact & Operational Efficiency for Bikeshare Systems: Local, Domestic & International Lessons.”
102. DeMaio, Paul. “Bike-sharing Creates Jobs.” The Bike-sharing blog, August 24, 2012, 1-2. Accessed November 22, 2016.
103. FactFinder. “American FactFinder.”
104. DeMaio, Paul. “Bike-sharing Creates Jobs.”
105. Hamilton, Timothy, and Casey J. Wichman. “Bicycle Infrastructure and Traffic Congestion: Evidence from DC’s Capital Bikeshare.” SSRN Electronic Journal, August 2015, 1-51. Accessed November 22, 2016. doi:10.2139/ssrn.2649978
106. NACTO Staff. “Equitable Bike Share Means Building Better Places for People to Ride.” National Association of City Transportation Officials, July 2016, 1-12. Accessed November 11, 2016.
107. NACTO Staff. “Equitable Bike Share Means Building Better Places for People to Ride.”
108. Clabots, Barbara. “Even in the Most Bike-Friendly States, Women Are Left Behind.” Yes Magazine, September 30, 2016, 1-6. Accessed November 15, 2016.
109. Better Bike Share Partnership. “Home – Better Bike Share.” Last modified 2016. Accessed December 09, 2016. <http://betterbikeshare.org/>.
110. Hoe, Nina. "Bike Sharing in Low Income Communities: Results from a Spring 2015 Baseline Survey." Temple University Institute of Survey Research, July 1, 2015, 1-45. Accessed September 27, 2016.
111. NACTO Staff. “Can Monthly Passes Improve Bike Share Equity?” National Association of City Transportation Officials, September 2015, 1-8. Accessed December 02, 2016.

112. Better Bike Share Partnership. “Home – Better Bike Share.”
113. Hoe, Nina. "Bike Sharing in Low Income Communities: Results from a Spring 2015 Baseline Survey."
114. Hoe, Nina. “Bike Sharing in Low Income Communities: Results from a Spring 2015 Baseline Survey.”
115. Stead, Thom. “SHARING IS CARING: An Analysis of Citi Bike’s Discounted Program for NYCHA Residents.” Pratt Institute, February 2015, 1-99.
116. Malamut, Melissa. “’Prescribe-a-Bike’ Coming To a Hospital Near You.” Boston Magazine, March 26, 2014, 1-2. Accessed December 15, 2016.
117. Cox, Stefanie. “Planning for equity: How LA bike share is building diversity from the start.” Better Bike Share Partnership, November 11, 2016, 1-6. Accessed December 15, 2016.
118. Corbin, April. “4 Bike Share Equity Lessons From Nice Ride.” Better Bike Share Partnership, June 16, 2016, 1-8. Accessed December 15, 2016.
119. Golub, Aaron, Melody L. Hoffman, Adonia E. Lugo, and Gerardo F. Sandoval. Bicycle Justice and Urban Transformation: Bike for all? London: Routledge Taylor & Francis Group, 2016.
120. Keatts, Andrew. “Most Cyclists are Working-Class Immigrants, Not Hipsters.” The Kinder Institute for Urban Research, October 26, 2015, 1-6. Accessed December 15, 2016.
121. FactFinder. “American FactFinder.”
122. FactFinder. “American FactFinder.”
123. PolicyOptions.org. "PolicyOptions.org | New Brunswick, NJ: About." Accessed September 28, 2016. < http://www.policyoptions.org/new-brunswick/about>.
124. FactFinder. “American FactFinder.”
125. PolicyOptions.org. "PolicyOptions.org | New Brunswick, NJ: About."
126. Redlawsk, David P. “New Brunswick Tomorrow Final Report.” Rutgers Eagleton Center for Public Interest Polling, October 2012.
127. Pellerano, Maria B., and Eric Jahn. “Measurement to Promote a Healthier New Brunswick: Survey of New Brunswick, N.J. Data.” Robert Wood Johnson Medical School, December 2014, 1-38
128. Lloyd, Kristen, Punam Ohri-Vachaspati, Susan Brownlee, Michael Yedidia, Dorothy Gaboda, and Jolene Chou. “New Jersey Childhood Obesity Survey.” Rutgers Center for State Health Policy, Summer 2010, 1-67.
129. Redlawsk, David P. “New Brunswick Tomorrow Final Report.” Rutgers Eagleton Center for Public Interest Polling, October 2012.

129. Pellerano, Maria B., and Eric Jahn. "Measurement to Promote a Healthier New Brunswick: Survey of New Brunswick, N.J. Data."
130. Premier's Community Non-Profit Task Force. "Blueprint for Action." City of New Brunswick, September 13, 2007. Accessed December 12, 2016.
131. Pellerano, Maria B., and Eric Jahn. "Measurement to Promote a Healthier New Brunswick: Survey of New Brunswick, N.J. Data."
132. Pellerano, Maria B., and Eric Jahn. "Measurement to Promote a Healthier New Brunswick: Survey of New Brunswick, N.J. Data."
133. Pellerano, Maria B., and Eric Jahn. "Measurement to Promote a Healthier New Brunswick: Survey of New Brunswick, N.J. Data."
134. City of New Brunswick Annual Plan. New Brunswick Department of Planning, Community and Economic Development, July 2015, 1-53.
135. Pellerano, Maria B., and Eric Jahn. "Measurement to Promote a Healthier New Brunswick: Survey of New Brunswick, N.J. Data."
136. County Health Rankings & Roadmaps. "Middlesex County, New Jersey | County Health Rankings & Roadmaps." Last modified 2016. Accessed December 04, 2016. <http://www.countyhealthrankings.org/app/new-jersey/2016/rankings/middlesex/county/outcomes/overall/snapshot>.
137. City of New Brunswick. "Bike Lanes | Planning and Development." New Brunswick Department of Planning and Development. Last modified 2016. Accessed December 10, 2016. <http://thecityofnewbrunswick.org/planninganddevelopment/bike-lanes/>.
138. City of New Brunswick. "Bike Lanes | Planning and Development."
139. Black, Cameron. Survey of bike racks. Highland Park, NJ; New Brunswick, NJ; and Piscataway, NJ, September-October 2016.
140. City of New Brunswick. "Public Bike Racks | Planning and Development." New Brunswick Department of Planning and Development. Last modified 2016. Accessed December 10, 2016. <http://thecityofnewbrunswick.org/planninganddevelopment/public-bike-racks/>.
141. City of New Brunswick. "Public Bike Racks | Planning and Development."
142. Sinclair, James. "New Brunswick Begins Introducing On-street Parking Corrals." NJ Bicycle & Pedestrian Resource Center, September 03, 2014, 1-3.
143. City of New Brunswick. "Public Bike Racks | Planning and Development."
144. BikeRU Initative. "Bike RU | Rutgers, The State University of New Jersey."
145. Sinclair, James. "New Brunswick Begins Introducing On-street Parking Corrals."
146. Sinclair, James. "New Brunswick Begins Introducing On-street Parking Corrals."
147. BikeRU Initative. "Bike RU | Rutgers, The State University of New Jersey."
148. Mekuria, Maaza C., Peter G. Furth, and Hilary Nixon. "Low-stress bicycling and network connectivity." Mineta Transportation Institute, May 2012, 1-68. Accessed December 08, 2016.

149. Mekuria, Maaza C., Peter G. Furth, and Hilary Nixon. "Low-stress bicycling and network connectivity."
150. New Jersey Department of Transportation. "NJDOT - New Jersey Department of Transportation." Last modified 2012. Accessed December 10, 2016. <http://www.state.nj.us/transportation/>.
151. NJ Bicycle and Pedestrian Resource Center. "Complete Streets in NJ | NJ Bicycle and Pedestrian Resource Center." Last modified November 7, 2016. Accessed December 10, 2016. <http://njbikeped.org/complete-streets-2/>.
152. City of New Brunswick Master Plan. New Brunswick Department of Planning and Development. Last modified November 10, 2004. Accessed December 10, 2016. <http://thecityofnewbrunswick.org/planninganddevelopment/master-plan/>.
153. Bradshaw, Jennifer. "Bicycle and Pedestrian Improvements Continue in the City of New Brunswick." The City of New Brunswick, November 23, 2016, 1-6. Accessed November 23, 2016.
154. DMJM Harris | AECOM. "New Jersey's Long-Range Transportation Plan." New Jersey Department of Transportation and NJ Transit, September 2008, 1-48.
155. Borough of Highland Park. "2003 Master Plan." Highland Park Borough, May 2003, 1-92.
156. Rutgers University Planning Studio. "Capital Improvement Plan: Highland Park, NJ." Rutgers University-New Brunswick, September 10, 2015, 1-78.
157. "Highland Park 2020; A Sustainable Community." Highland Park Borough, March 29, 2003, 1-9.
158. New Jersey Sustainable State Institute. "Highland Park Green Community Plan." Highland Park Borough, 2007, 1-105.
159. Rutgers University. "Rutgers 2030: Physical Master Plan Volume I." Rutgers University-New Brunswick, June 18, 2015, 1-330.
160. City of New Brunswick Master Plan.
161. Middlesex County Planning Department – Transportation Division. "Middlesex County Bicycle Pedestrian Plan." Middlesex County, March 2002, 1-72.
162. Motor Vehicles and Traffic Regulation, NJ Title 39 § 4

APPENDIX

APPENDIX A: INTERVIEWS

Lauren Severe, Business Affairs Assistant, Denver BCycle

Denver BCycle began a pilot program for Denver Housing Authority residents in 2011. They began by distributing free one year demo-cards to residents. After the initial year, the program was extended based on federal low-income requirements, expanding it from just public housing residents to include Medicare and Medicaid recipients. With the expansion of the program Denver BCycle initiated a $10 annual fee to those qualified. Based on use statistics more low-income individuals utilized the program when they were engaged as consumers, rather than being gifted the membership. Currently they have roughly 125 low-income participants and 30 docking stations in areas with high concentrated poverty.

Jonathan Monceaux, Program Director, uBike

uBike began as a student project in the early 2010s which then, after a competitive and arduous grant process, was fully implemented in 2015. A few interesting tidpits from the inteview focused on the rebalancing of the system. UVA focuses on desinations versus origins, that is they have bikes at classrooms and dining facilities rather than dorm rooms and commuter parking lots. The systems is created this way to limit the staff required in cycling the bikes. That said, the chief complaint comes from the opeartion style - a lack of bikes near dorms.

UVA contracts out with a local repair shop with a contract at $975 a bike which was found to be comparable to other systems. Majority of maintenace issues are either adjusting brakes or replacing batteries when have tended to have a short life span.

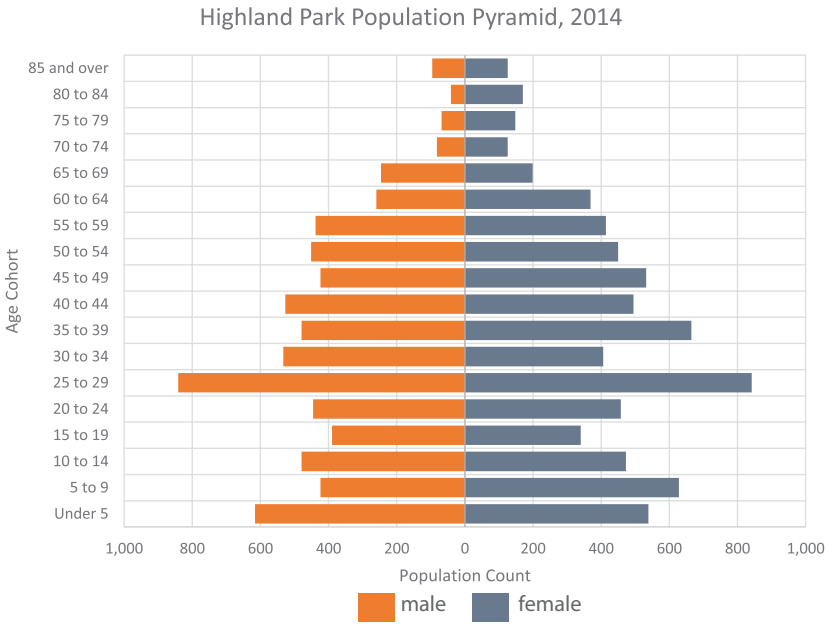
Zipcar plans on introducing their own line of bike shares, so any future collaberation would not likely occur.

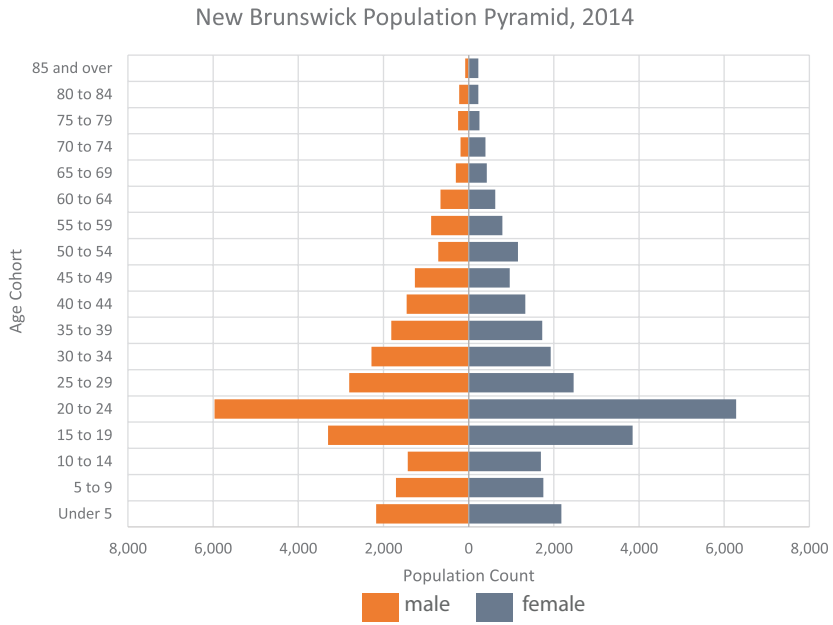
Dave Fotsch, Director, Bosie GreenBike

Dave discussed interesting strategies on marketing and how they add hub locations, into new neighborhoods, especially past the first phase when funding dried up. GreenBike works with companies offering advertising on the hub for two years for free, then offers right of first refusal in the future. This technique has allowed the bikeshare to expand hub locations - a major request from the users.

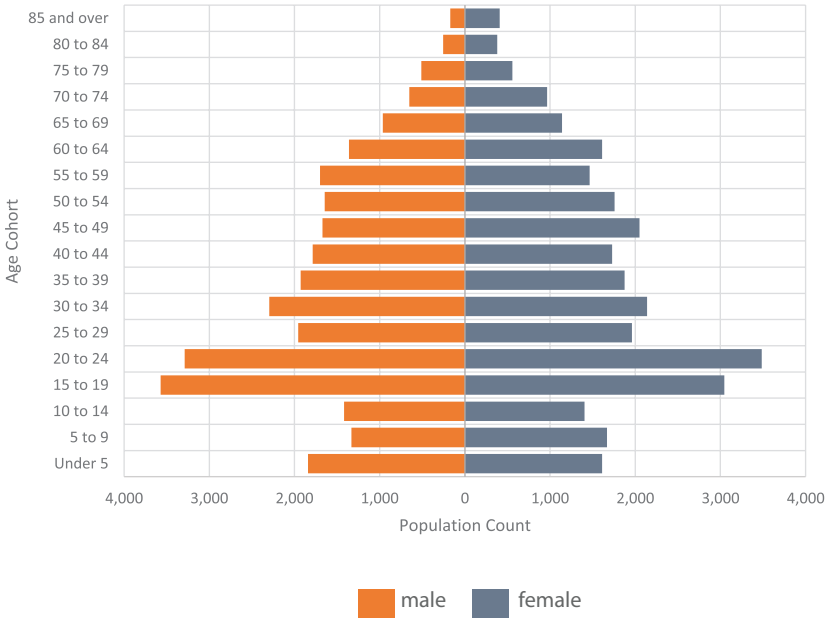
Also, something to consider when bidding, Dave mentioned the price of leasing the software, and how that was not something they immediately considered in the planning process. GreenBike uses Social Bikes with a monthly licensing fee on each bike, hub, and an overall system charge.

APPENDIX B: DEMOGRAPICS

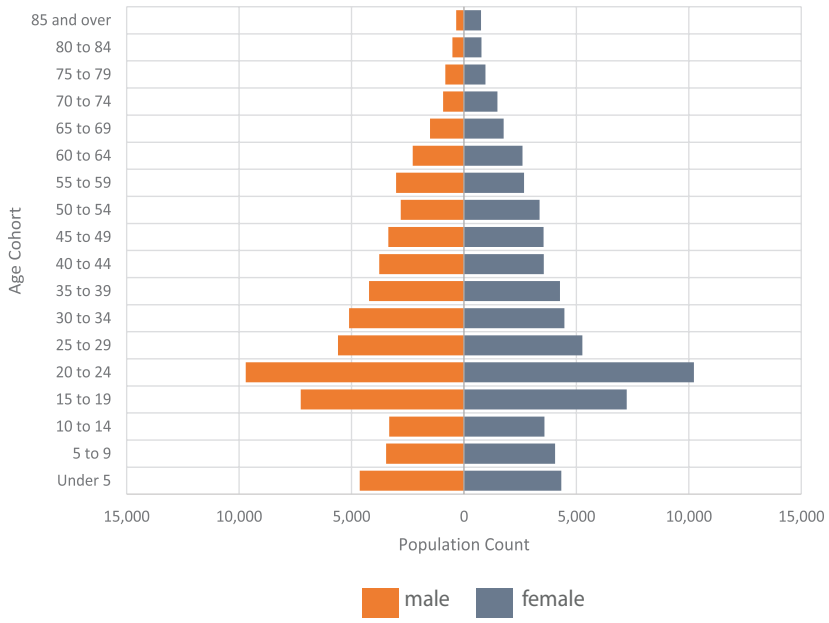




Piscataway Population Pyramid, 2014

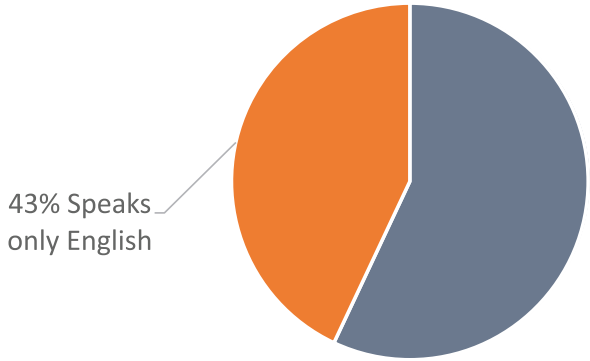


Full Service Area Population Pyramid, 2014

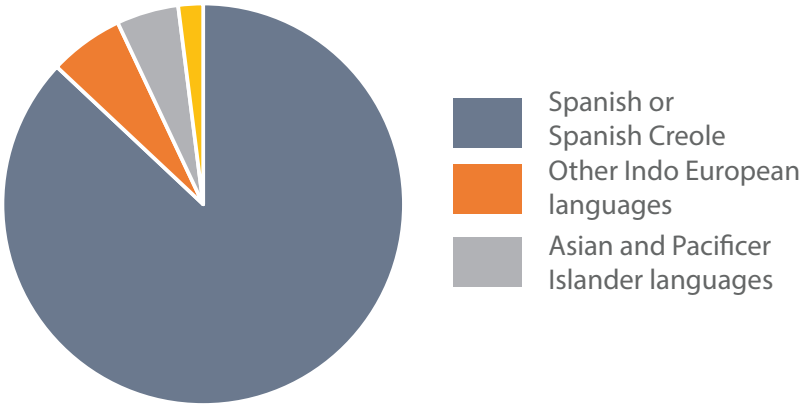


New Brunswick, New Jersey

Language Spoken at Home

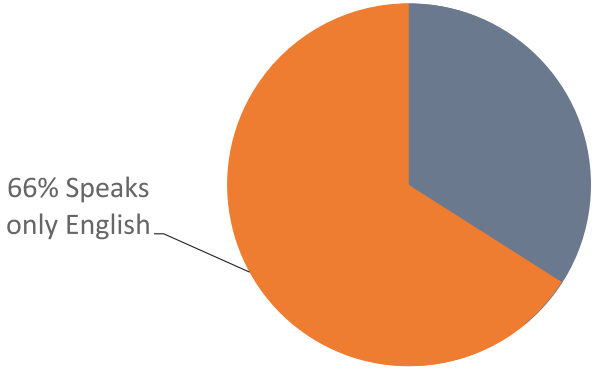


Languages Spoken other than English

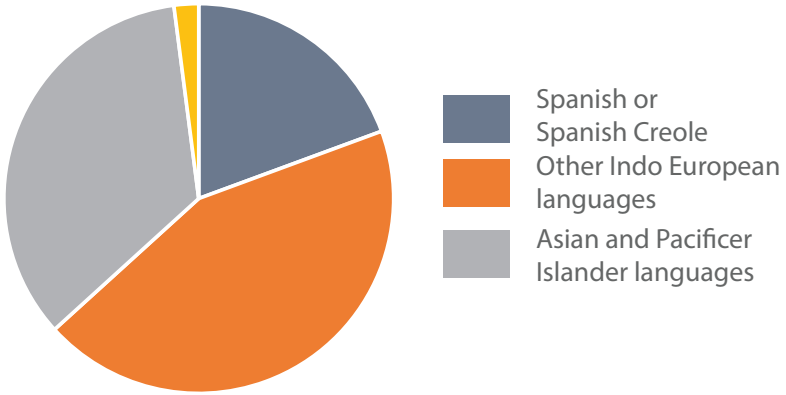


Piscataway, New Jersey

Language Spoken at Home

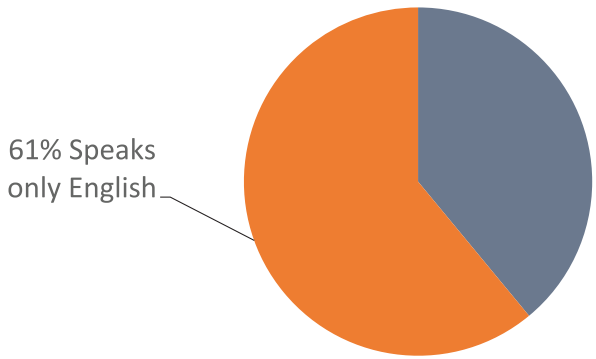


Languages Spoken other than English

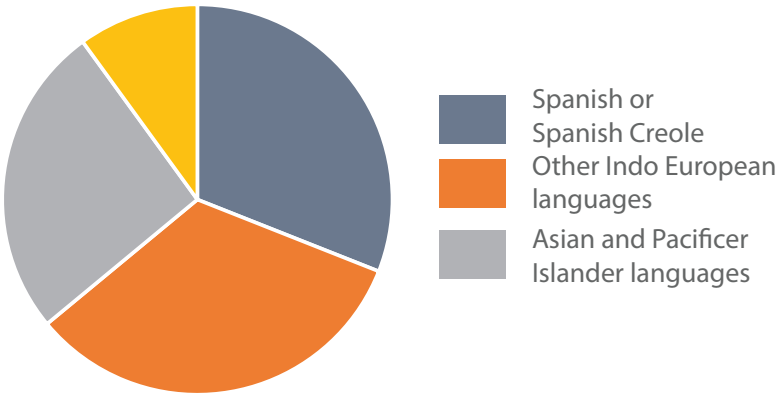


Highland Park, New Jeresey

Language Spoken at Home



Languages Spoken other than English



APPENDIX C: PROPOSED HUB LOCATIONS

High Capacity Hub

Highland Park
1 H-mart 2 Edison Train Station 3 Main street: NJ-27 route, and library, church.
Pisctaway
1 Livingston Student Center and dining hall 2 Buch Campus Student Center and dining hall 3 Library of Science and Medicine
New Brunswick
1 College Avenue Student Center, College Avenue Gym and Alexander Library 2 New Brunswick Train Station and Key food 3 Main Street: George Street 4 Cook Student Center and Cook/Douglass Recreation Center 5 Foodtown supermarket

Park Hubs

Highland Park
1 Donaldson Park 2 Johnson Park
Piscataway
1 Johnson Park
New Brunswick
1 Buccleuch Park 2 Feaster Park 3 Joyce Kilmer Park 4 Recreation Park

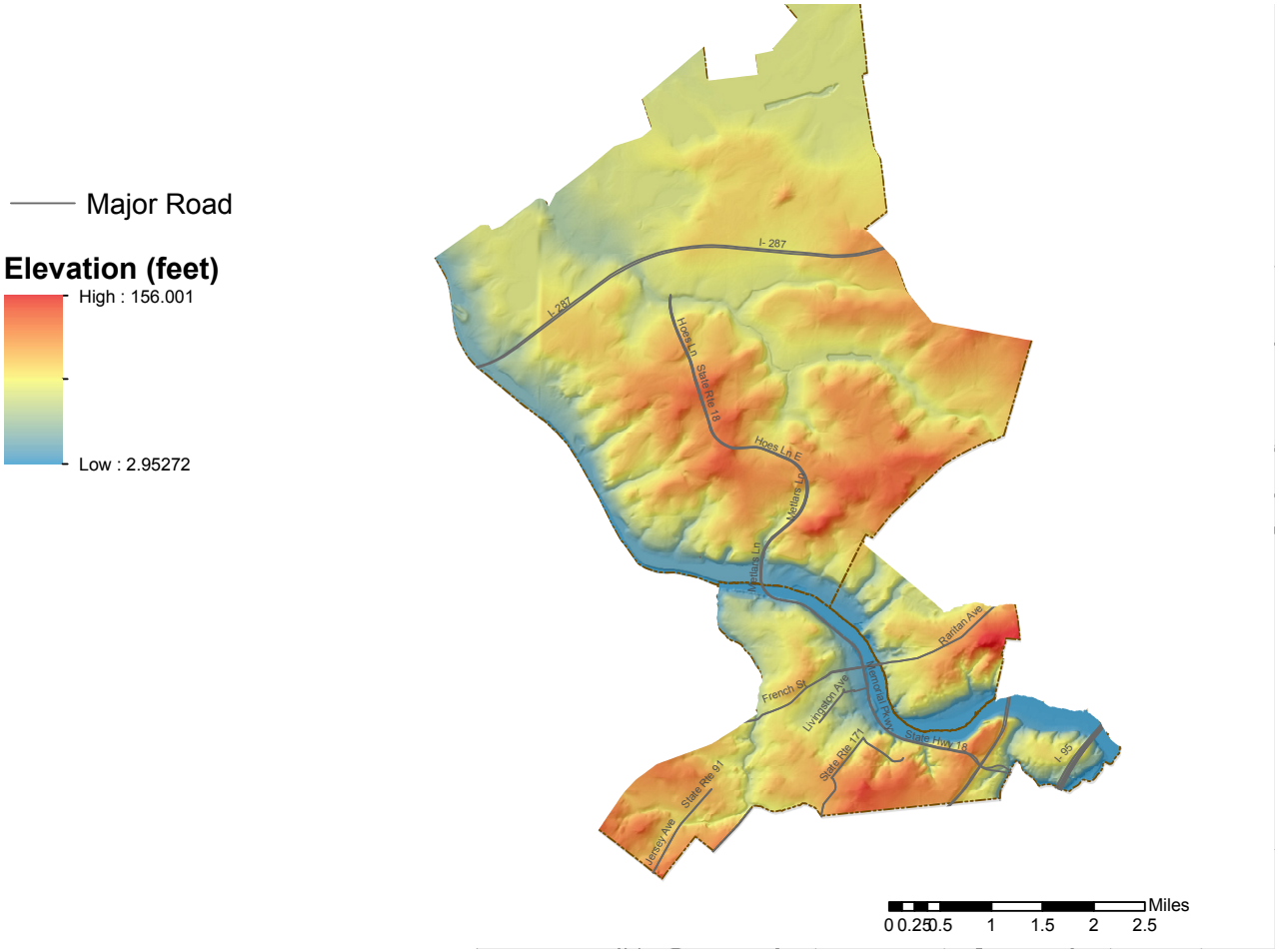
Low Capacity Hub

Highland Park
1 Main Street (NJ-27 and 2nd Ave) 2 Highland Park High School 3 Environmental education center and Pipeline Medical 4 NJ transit bus stop (Raritan Ave at Barnard St)
Piscataway
1 Johnson Park Zoo 2 Livingston Recreation Center 3 Apartment, restaurant and Rutgers Cinema 4 Sonny Werblin Recreation Center and University Park and Recreation Complex 5 School Buildings: Mathematical Sciences and Physics Library, Science and Engineering Resource Center 6 Apartment area: Buell Apartments, Silvers Apartments 7 Visitor Center
New Brunswick
1 Johnson & Johnson Plaza 2 School Buildings (College Ave and Hamilton st) 3 Main Street: Easton Ave and mine st 4 Easton Ave and Saint Peter's University Hospital 5 Commercial area and Bus stop (French st and Suydam St) 6 Bloustein School and New Brunswick Municipal Buildings 7 Rockoff Hall and Bravo Supermarket 8 New Brunswick Apartments and Bus Stop 9 Riverside Towers Apartments and Bus Stop 10 Gambino's Inn and St Mary's Apartments 11 Bust Stop (Livingston Ave at Ward St) 12 New Brunswick Community Farmers Market 13 Grocery Store: AlDI New Brunswick 14 Jersey Avenue station and US Social Security Administration 15 Bus Stop and Saint Peter's Cemetery 16 Douglass school building 17 Cabaret Theatre, Douglass Campus Center Computer lab 18 Rutgers University Inn and Conference Center 19 Hyatt Regency New Brunswick 20 Livingston Ave and Stanford St 21 Bus Stop: Livingston Ave and Stanford St

Event Hub

Piscataway
1 HighPoint Solutions Stadium 2 Rutgers Athletic Center
New Brunswick
1 Sacred Heart Church 2 St Mary of Mount Virgin Church

APPENDIX D: ELEVATION MAP



APPENDIX E: RU BIKE SHARE SURVEY

RUTGERS Bike-Share Survey You are invited to participate in a research study that is being conducted at the Bloustein School of Planning and Public Policy at Rutgers University as part of a Master's planning studio class. The purpose of the survey is to obtain information about student bicycle use and preferences to help to understand the impacts of a possible new BikeShare program and recommend ways to maximize student health impacts. There are no foreseeable risks to participation in this study. In addition, you may receive no direct benefit from taking part in this study. The benefits of completing the survey are that you will contribute to further knowledge and insight about impacts to student fitness and health from bicycle use and help to inform the prioritization of actions to improve access, use, health and safety. The survey should take about 5 minutes to complete. We hope to obtain between 100-200 valid responses to the survey. Participation in this study is voluntary. You may choose not to participate, and you may stop the survey at any time without any penalty to you. In addition, you may choose not to answer any questions with which you are not comfortable. This survey is anonymous. Anonymous means that we will record no information about you that could identify you. There will be no way to link your responses back to you. The research team and the Institutional Review Board at Rutgers University are the only parties that will be allowed to see the raw data, except as may be required by law. If a report of this study is published, or the results are presented at a professional conference, only summarized results will be stated. All study data will be kept for three years. If you have any questions about the study or study procedures or wish to see a copy of results, you may contact Karen Lowrie at: Bloustein School, 33 Livingston Ave., New Brunswick, NJ, 08901, 848-932-2708, klowrie@rutgers.edu. If you have any questions about your rights as a research subject, you may contact the IRB Administrator at Rutgers University at:Arts and Sciences IRBRutgers, The State University of New JerseyOffice of Research Regulatory Affairs335 George Street Liberty Plaza /Suite 3200New Brunswick, NJ 08901Phone: 732-235-9806Email: humansubjects@orsp.rutgers.edu If you are 18 years of age or older, understand the statements above, and will agree to participate in the study, check "Yes" If not, please check "No".

Yes (1)
No (2)

Please select the group to which you belong:
Student (1)
Faculty (3)
Staff (4)
Other (please specify) (5) _____

What is your year of study? (students only)
Freshman (1)
Sophomore (2)
Junior (3)
Senior (4)
Graduate (Masters or PhD) (5)

Which campus(es) do you frequent most? (Please select up to two)
College Avenue (1)
Cook (2)
Douglass (5)
Livingston (3)
Busch (4)
Not Listed (please specify): (6) _____

How do you typically travel between campuses? (e.g. from Busch to College Ave)
Mostly Rutgers Bus System (1)
Usually non-driving methods (bicycle or walk) (2)
Usually drive (3)
Mostly non-driving methods (bicycle or walk) (6)
Mostly drive (4)
Other (please specify): (8) _____
I do not travel between campuses (7)

Do you have access to a working bicycle while living, attending or working at Rutgers?
Yes (1)
No (2)
No, and I do not know how to ride a bicycle (3)

If yes, how often do you use your bicycle on and around Rutgers-New Brunswick?
Every day (1)
Almost every day (2)
Several times a week (3)
Several times a month (4)
Occasionally (5)
Never (6)

If yes, what purpose do you use your bicycle for on and around New Brunswick and Piscataway?

Traveling across campus (1)
Often (1)
Sometimes (2)
Rarely (3)
Never (4)

Traveling between two or more campuses (2)
Often (1)
Sometimes (2)
Rarely (3)
Never (4)

Often (1)
Sometimes (2)
Rarely (3)
Never (4) Riding for fun (recreation) (3)

Shopping and running errands (4)
Often (1)
Sometimes (2)
Rarely (3)
Never (4)

Visiting friends/parties (socializing) (5)
Often (1)
Sometimes (2)
Rarely (3)
Never (4)

Fitness (6)
Often (1)
Sometimes (2)
Rarely (3)
Never (4)

Traveling to off-campus destinations (7)
Often (1)
Sometimes (2)
Rarely (3)
Never (4)

What is the greatest distance you would consider bicycling on or around the Rutgers-New Brunswick campuses?
Less than a mile (1)
1-2 miles (6-12 minutes) (2)
2 - 5 miles (13-30 minutes) (3)
5 - 10 miles (31-60 minutes) (4)
Greater than 10 miles (5)

On a bicycle, I wear a helmet:
Every time I ride (1)
Most of the time I ride (2)
Occasionally (3)
Almost Never (4)
Never (5)
I do not ride a bike (6)

Please rate potential impediments to bicycling for you in and around Rutgers-New Brunswick:

Lack of access to a bicycle (1)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Too many motor vehicles (traffic) (2)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Speed of traffic on roads (3)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Aggressive/careless/distracted vehicle drivers (4)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Unsafe intersections and street crossings (5)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Drivers opening car doors (6)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Not enough bike paths or bike lanes (7)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Not enough showers/changing facilities (8)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Unclear rules for cyclists (9)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Fear of crime or theft (10)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Personal safety concerns (11)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Other (please specify) (12)
Definitely a problem (1)
Somewhat a problem (2)
Not much of a problem (3)

Is it clear where bike lanes & facilities (such as bicycles specifics signals, bicycle racks, etc.) are in and around New Brunswick?
Yes (1)
No (2)
Somewhat (3)

Is it clear to you where bicycles can be safely parked?
Yes (1)
No (2)
Somewhat (3)

If the Rutgers-New Brunswick campuses were more bicycle-friendly and you had access to a bicycle, how likely is it that you would ride a bicycle more often?
Very likely (1)
Likely (2)
Undecided (3)
Not likely (4)
I would never ride a bicycle at Rutgers (5)

How familiar are you with bike-share systems?
I have used bike-share in other locations (1)
I have heard of bike-share but never used it (2)
I have never heard of bike-share (3)

Bike share systems allow people to pick up a bicycle at a station or hub location and ride it for a short period of time, and then return the bike to a station location or anywhere within a certain zone. It usually requires a fee for using the bicycle. The next 6 questions are about a potential bike share that will serve the Rutgers-New Brunswick campus and surrounding towns.

How likely is it that you would participate in a bike-share program?
Very likely (1)
Likely (2)
Undecided (3)
Not likely (4)
I would not use a bike-share system. (5)

What is the farthest you would walk to get a bicycle?
Outside my building in the same block (1-2 minutes) (1)
A few blocks (3-5 minutes) (2)
¼ - ½ mile (6-10 minutes) (3)

Traveling across campus (1)
Most often (1)
Sometimes (2)
Almost never (3)
Never (4)

Traveling between two or more campuses (2)
Most often (1)
Sometimes (2)
Almost never (3)
Never (4)

Riding for fun (recreation) (3)
Most often (1)
Sometimes (2)
Almost never (3)
Never (4)

Shopping and running errands (4)
Most often (1)
Sometimes (2)
Almost never (3)
Never (4)

Visiting friends/parties (socializing) (5)
Most often (1)
Sometimes (2)
Almost never (3)
Never (4)

Fitness (6)
Most often (1)
Sometimes (2)
Almost never (3)
Never (4)

Traveling to off-campus destinations (7)
Most often (1)
Sometimes (2)
Almost never (3)
Never (4)

Q20 For an ANNUAL fee (in dollars), what is the maximum amount would you be willing to pay to access bicycles through a bike-share system?
_____ Annual Fee (1)

Q21 For an HOURLY use fee (in dollars), what is the maximum amount would you be willing to pay to access a bicycle?
_____ Hourly Use Fee (1)

Q25 How important is each of the following in your decision about whether to use a bike-share system at Rutgers-New Brunswick

Convenience of bicycle pickup location (4)
Very important (1)
Somewhat important (2)
Not very important (3)
Not important at all (4)

Convenience of bicycle dropoff location (5)
Very important (1)
Somewhat important (2)
Not very important (3)
Not important at all (4)

Cost of use (6)
Very important (1)
Somewhat important (2)
Not very important (3)
Not important at all (4)

Type of bicycle equipment (7)
Very important (1)
Somewhat important (2)
Not very important (3)
Not important at all (4)

Improved bike-friendliness of local area (lanes, racks, etc.) (3)
Very important (1)
Somewhat important (2)
Not very important (3)
Not important at all (4)

Ability to take a free bicycle lessons or safety course (2)
Very important (1)
Somewhat important (2)
Not very important (3)
Not important at all (4)

Positive environmental impact (1)
Very important (1)
Somewhat important (2)
Not very important (3)
Not important at all (4)

Ability to get more physical activity (8)
Very important (1)
Somewhat important (2)
Not very important (3)
Not important at all (4)

Q3 Which gender do you most identify?
Male (1)
Female (2)
Transgender Male (3)
Transgender Female (4)
Not Listed (5) _____

Q4 Which of the following categories best describes your race/ethnicity? (Select all that apply.)
White/Caucasian (1)
Hispanic/Latino (2)
Black/African-American (3)
Asian/Pacific Islander (4)
Native American (5)
Other (please specify): (6) _____
Prefer not to answer (7)

Q24 Please tell us if there are any other important factors about bicycling in and around Rutgers University campuses and the surrounding towns, or opinions or suggestions about BikeShare that we should know about.

RUTGERS

Edward J. Bloustein School
of Planning and Public Policy