Title
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Publication Date
2015-04-01

ITS UCDAVIS
INSTITUTE OF TRANSPORTATION STUDIES

Research Report – UCD-ITS-RR-15-10

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April 2015

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April 3, 2015

Contents

List of Figures

1. Introduction

Bike share systems are a unique opportunity to encourage active transportation within a public transportation framework. Bike share has the potential to deliver an array of benefits to communities, including reduced emissions, vehicle miles traveled, and parking needs, as well as increasing residents' participation in healthful exercise.

However, the benefits of bike share are often not equitably distributed among the diverse populations of the cities in which they have been implemented: statistics indicate that a large majority of current North American bike share users in the United States are overwhelmingly white and middle- to upper-class. A study of four North American bike share systems (Minneapolis, Montreal, Denver, and Washington D.C.) presented aggregate statistics that indicate bike share users in these systems are white (79%), highly educated (85% holding a Bachelor's Degree or higher) and middle-to-upper middle class (72% earn an annual income of $50,000 or above) (Shaheen 2012). These statistics are not representative of the demographics of these cities, suggesting the possibility of a lack of equitable system access for low-income and/or minority (LIM) populations in North America.

Bike sharing is a scheme whereby users can temporarily rent simple, sturdy bicycles for commute or recreational use within an urban environment. The system makes use of electronic kiosks at the bike share docking stations, which enable users to check out a bike with their debit or credit card. This system allows for a much greater level of accountability for the bicycles than previous coin-operated "second generation" bike share schemes, and allows for the system to charge the user different rates on the basis of the type of membership subscription chosen (annual, monthly, or daily) and the length of time the bicycle is in use.

The necessity of securing a debit or credit card before an individual can use "third generation" bike share was the first aspect of these bike share systems to create a divide in equitable access from previous iterations. Today many system operators attempt to rectify this rift by working with local financial institutions to help potential users obtain debit or credit cards. However, less attention has been directed towards many other issues inherent in the system, which when combined create a product that fails to attract many LIM users.

One of the most fundamental problems is that docking stations are placed in attractive, multi-use neighborhoods and commercial corridors with vibrant economies and public spaces, areas where decades of social and financial pressure have minimized the presence of LIM residents. Contemporary ridership forecasting models for bike share are based on current patterns of bicycle use, and generally assume a negative correlation between ridership and prevalence of non-white population, though these rates may be due to other factors such as poor infrastructure or blight rather than the LIM residents themselves.

In addition to the hurdle of obtaining a credit card, LIM users face other financial constraints such as additional fees that increase exponentially after the first 30 minutes, and the lack of a fare structure competitive with transit. Concerns regarding security while bicycling can also act as a barrier for bike share use by the LIM community, as these communities can have much poorer bicycle infrastructure and higher incidences of crime. Educational barriers such as language differences and lack of cycling knowledge or skills combine to make it difficult for LIM community members to understand the system, enroll in the system, or use the system easily. Studies have identified several other aspects that negatively affect LIM user's ability to benefit from the system, such as hours of operation not supportive of non-traditional shift hours or hardware that prevents users from bringing along children or cargo.

Barriers to equitable access to bike share must be met with thoughtful analysis and policy adjustments to ensure that, as this new opportunity for public active transportation spreads in the United States, all citizens have the opportunity to benefit. As the Sacramento Area Council of Governments (SACOG) plans a bike share system for the region, slated for opening in 2016, planners have many opportunities to ensure equitable access to bike share for LIM communities of the region. This report responds to a study presented by Fehr & Peers in 2014 (F & P, 2013) that was the first iteration of planning for the new system. The Fehr & Peers study presented a potential scheme of 88 stations primarily in central Sacramento, with satellite stations in West Sacramento and Davis, composed of 1,320 docking points and 616 bicycles. The study draws on quantitative data and qualitative surveys from multiple existing U.S. bike share systems, notably Capital Bikeshare D.C., Denver B-Cycle, and Nice Ride MN. Taking the Fehr & Peers study as a starting point, this

report aims to explore how system equity barriers could be removed so that all residents of Sacramento, regardless of ethnicity or income status, could enjoy the benefits of bike share.

2. Bike Share Station Site Selection

The physical location and relative density of bike share stations is of utmost importance to the success of a bike share system. In order for a shared bicycle to be returned at the user's destination, station locations must be placed in areas very close to the greatest number of possible destinations. This means stations must be located in areas that have a high volume of both origins, such as residences, as well as work or leisure destinations. Successful existing bike share systems generally place stations very close together to maximize both ease of use and program visibility, one more extreme example being Velíb of Paris, France, which places stations 100 meters apart (Buck 2013).

The Fehr & Peers bike share study lays out various tenets regarding station location selection. Its 88 stations proposed for Sacramento, West Sacramento, and Davis meet the criteria of serving mixed-use areas of high population and employment density, near popular destinations or potential tourist attractions. The study also adheres to avoiding placing stations in outlying areas to ease bicycle redistribution efforts, and minimizing costs generally by only serving areas likely to generate reasonable ridership. These guidelines have served other bike share systems well in the past by increasing efficiency, ridership, revenue, and keeping costs low.

However, for potential users whose origins and destinations are well outside the selected network of station sites, bike share quickly ceases to be a reasonable transportation option. In the case of LIM communities, which historically have been found in the less desirable quarters of cities, this issue is particularly relevant.

2.1 Station Siting

Literature Review

LIM communities often exist in less expensive quarters of the city, which in a 2009 study of federal transportation funding were found to receive much fewer and smaller allocations for infrastructure and public space (Cradock 2009). These areas also traditionally receive less private development attention for commercial and residential growth. Because of these disparities, they often score low on bicycle share's suitability screening examinations and are passed over when considering station siting options. In Minneapolis, three kiosks

were placed in the Near North LIM community only after residents and elected officials complained (Kretman 2011). Low levels of use by LIM communities members may thus reflect the dearth of bike share stations in these areas, rather than a lack of demand for bike sharing.

European research shows that the discrepancies between white and non-white cycling are much smaller than in the U.S., or even non-existent, which supports the possibility that U.S. system planners are underestimating potential success of bike share in LIM communities. A pair of studies (Ogilvie et al. 2012; Goodman et al. 2014) conducted using data from the Barclay's Cycle Hire in London, looked at user demographics and their relationship to bike share stations siting. The studies found that the ethnic makeup of bike share users was composed of more "Non-White British" than the population makeup of the neighborhoods in the bike share system area, with 36.1%, versus 34.3% (Ogilvie et al. 2012).

The results are even more striking for ridership levels among the low-income: there was no variation in the mean number of trips generated by users living in low-income versus middle or high-income areas. Furthermore, when these figures were adjusted via a linear regression for density of and distance to the nearest docking station, researchers found that residents of low-income areas made *more* trips on average than those in middle- or high-income areas. This model adjusted for the fact that low-income neighborhoods were generally farther from docking stations. Ogilvie et al. note that this correlation suggests latent demand for bike share among low-income Londoners, which could be explored further if the bike share system was expanded into more low-income neighborhoods.

In 2012 the London bike share system was indeed extended to include 3,000 more bikes and 260 additional docking stations spread over 20 square kilometers that included affluent Canary Wharf but also some of the most low-income neighborhoods of London's East End. After this expansion, the percentage of users from low-income areas doubled from 6% to 12% of total bike share system users. This change was a result of a fivefold increase in registered users in the low-income neighborhoods covered in the extension, as well as a modest increase in the initial bike share zone of low-income users, from 2.9% to 4.3% (Goodman et al, 2014). After these increases, the income status makeup of bike share

users almost exactly represents the income status makeup of the entire bike share system zone. These U.K. findings suggest greater potential for bike sharing in LIM communities in the U.S. than planners have generally assumed, although there may be additional uniquely American barriers regarding equity in bike share that must be addressed. To compound matters, planners in the U.S. see little value in addressing other barriers for LIM communities if bike sharing stations are not located in these areas: in a 2013 study of the 20 bike share systems operating nationally at that time, one bike share system administrator noted that "without funding identified to locate in low-income neighborhoods, few efforts are planned to lower access barriers to bike sharing, using the rationale that if there are no stations located near low-income populations, then any other measures would be largely wasted" (Buck 2013). However, this view discounts the potential for residents of LIM communities to use bike sharing systems elsewhere in the region, e.g. as a way of getting from a transit stop to a job site.

Station Siting in Sacramento

The station site selections presented in the Sacramento Fehr & Peers study were shown to be adequate with regards to suitability, connectivity, and other criteria, but this research will show that they do not provide equitable walkable access to the system for LIM Sacramento residents. The Sacramento Fehr & Peers bike share study models a Regional Suitability Screening Score for Sacramento, West Sacramento, and Davis using the following variables:

- **Housing Density:** Units per unprotected acre (2010 Census)
- **Population Density:** People per unprotected acre (2010 Census)
- **Job Density:** Jobs per unprotected acre (2008 Census LED)
- **Land Use Diversity:** Entropy index of commercial/industrial/retail/recreational/residential within a block group (2009 ESRI Business Demographics)
- **Urban Design:** Intersections per square mile (2009 Census)

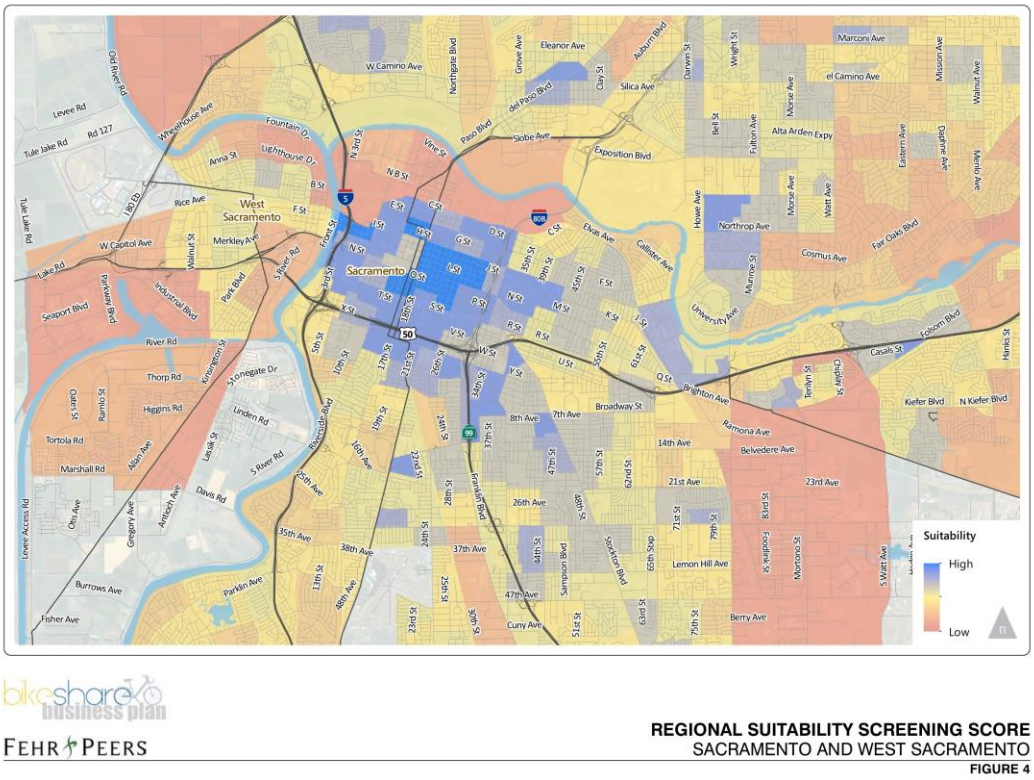

Figure 1: Sacramento Suitability Screening Score Heat map

These variables were scaled and layered to create a single suitability map [see **Figure 1**]. The study states that technical stakeholders then used this information to select station locations within a high scoring area, guided by the following additional considerations:

- **Contiguous Network:** Clear physical station connections, avoiding isolated stations
- **Station Proximity:** Stations within ¼ - ½ mile of each other
- **bike Facilities:** Stations near designated bike facilities
- **Institutions:** Stations near government, medical and educational institutions
- **Density:** Stations near dense, mixed-use areas
- **Attractions:** Stations near tourist destinations
- **Transit:** Stations near existing transit hubs
- **Equity:** Stations in a variety of neighborhoods to support geographic and social equity

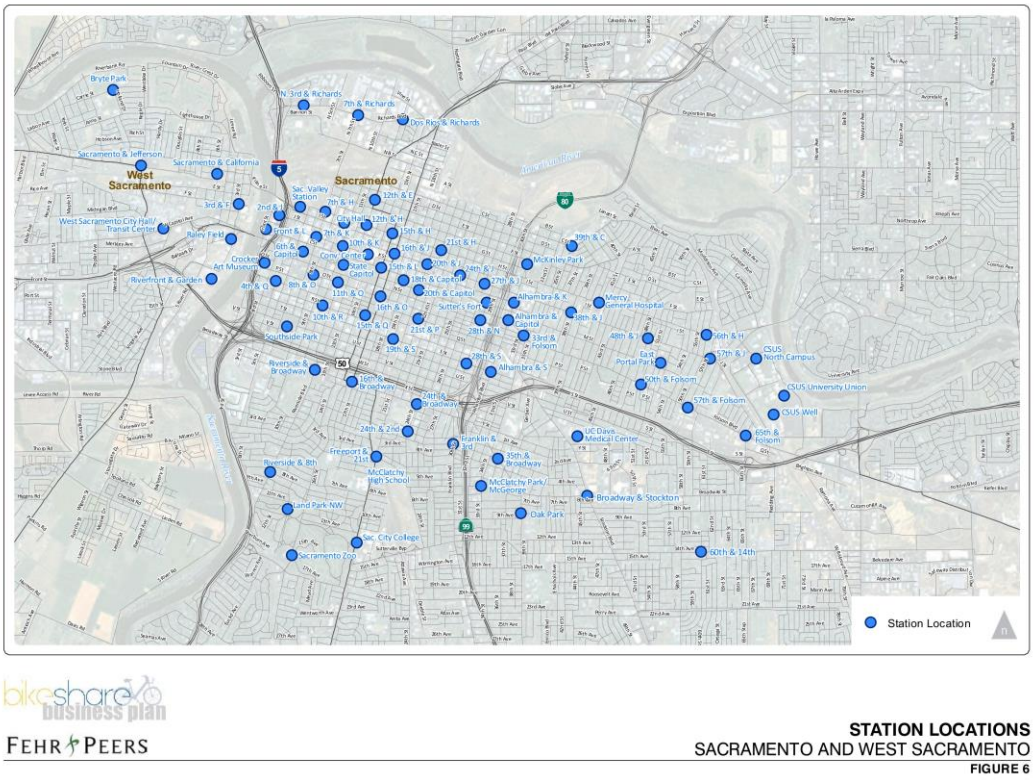

Figure 2: Proposed Sacramento Station Locations

The final stations selected by the stakeholders clearly conform to a majority of these additional considerations [see **Figure 2**]. The scheme has few outlying stations, many stations serve large institutions or tourist attractions, transit hubs are well served. It is the equity consideration, as stated in the study, which does not appear to be sufficiently accounted for in the final station selection. One way to assess equity is to compare the ethnic makeup of residents within a ¼ mile of the selected stations sites, a benchmark walkable distance in transportation planning, to the majority-minority ethnic makeup of Sacramento (45.0% of residents are white (U.S. Census, 2010)). This comparison can help us understand the scope to which Sacramento's LIM residents are allowed equitable walkable access to the system.

Figure 3 shows the results of analysis conducted for this report using ArcGIS and block level data from the 2010 Census to identify the level to which the currently proposed Sacramento bike share stations provide equitable access to communities of color. The pie

chart at each proposed station shows the ethnic makeup of residents of the blocks with centroids that are within ¼ mile of that station. Approximately 19 (24.4%) of the 78 Sacramento and West Sacramento stations provide access to bike share that reflects the minority-majority population of Sacramento: where the white population makes up 50% or less of the residents with walkable access. This data analysis, as well is Figure 5 in section 4.1, show communities of color concentrated in the north, northwest, and southeast areas of Sacramento, with comparatively less diversity in the main downtown area and the predominantly white, more affluent neighborhoods directly south and east of downtown, which were the focus areas of the system proposed in the Fehr & Peers study.

Figure 4 shows the degree to which the currently proposed Sacramento bike share stations provide equitable access to low-income communities based on data from the 2012 American Communities Survey Data at the block group level. The pie chart at each proposed station shows the household income makeup of residents of the block groups with centroids that are within ¼ mile of that station. This analysis reveals that in contrast to the ethnicity analysis, more of the stations proposed in the study, particularly in the northwest quadrant of the system, provide access to a broader range of income groups. In 2010 Census the median household income for Sacramento was $55,836 (U.S. Census, 2010), which is the approximate median income for many of the proposed stations. Thirty-four (43.6%) of the 78 stations serve a population with a median that is equivalent to or lower than $55,836. This analysis highlights the potential to easily increase low-income access, especially within the defined low-income Environmental Justice areas (SACOG 2008) near Highways 5 and 99, south of Highway 80, which abut the current bike share system along its southern edge.

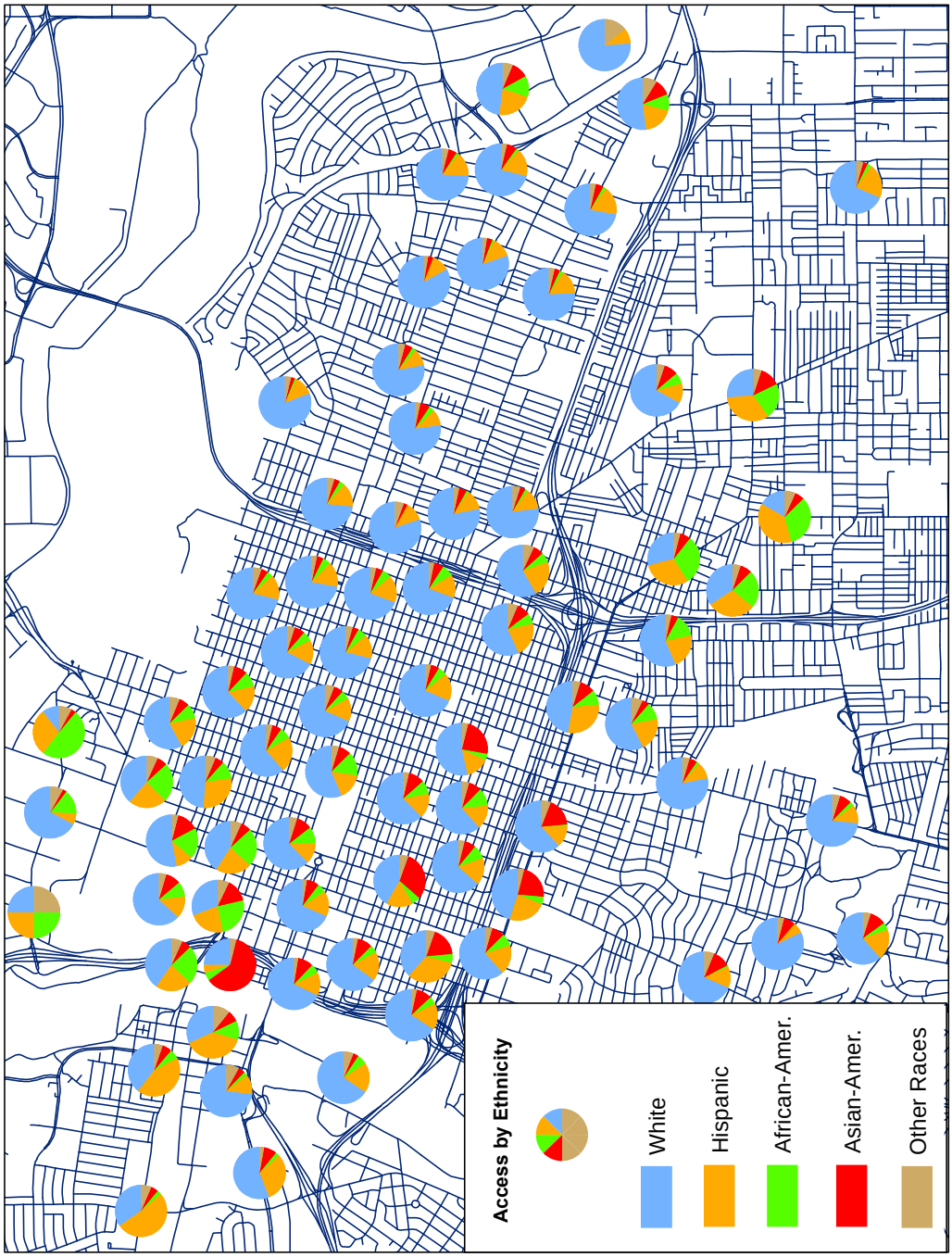

Figure 3: Equitable Station Access, Ethnicity Breakdown

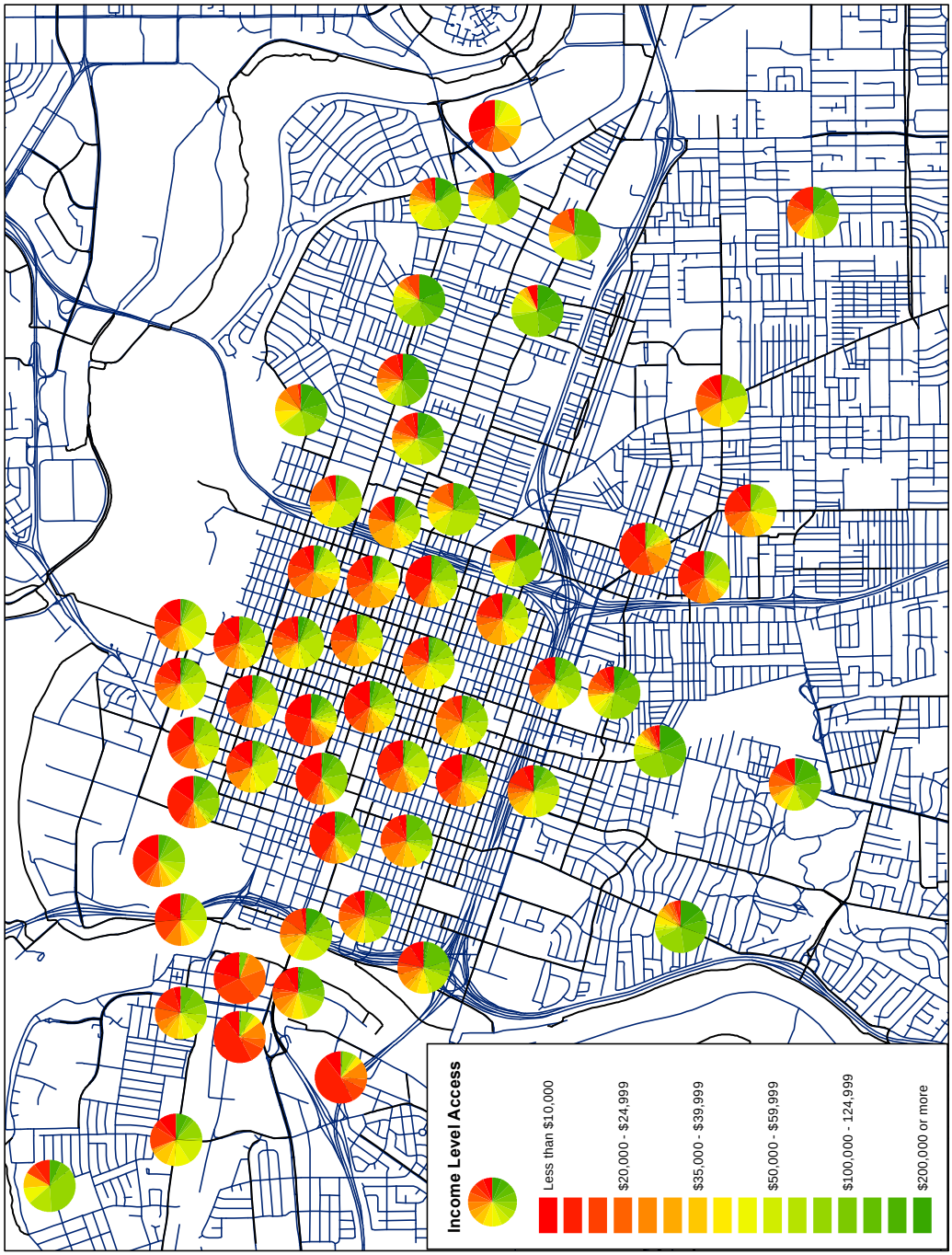

Figure 4: Equitable Station Access, Income Breakdown

2.2 Equity-Specific Stations

Literature Review

Many bike share systems in the U.S. specifically place stations to provide equitable access: 13 of 20 operating bike share systems in 2013 sited or planned to site stations specifically to increase low-income access (Buck 2013). Nice Ride Minnesota in Minneapolis has 30 stations, approximately 20% of its total, in areas identified as necessary for equity (Buck 2013). Nice Ride defines these areas as locations without optimal residential density, employment centers, or retail destinations associated with high bike share use. These locations are instead based on community input and focus on providing expanded mobility options for underserved, low-income, health-disparity, and transit dependent populations. Combined these stations operate at a loss of about $50,000 annually, or approximately 5% of Nice Ride's total annual operating budget (Community Design Group, 2013).

Equity-Specific Stations in Sacramento:

The Fehr & Peers study describes the need for stations to be placed specifically to promote equitable access, but does not define where these stations will be located in the first phase of the system, or provide a framework to define and place them in the future. The study mentions siting stations for equity considerations, often quite explicitly:

> The bike share system will take the following actions to support equitable access to bike share: ...Site stations not only according to anticipated ridership levels, but also to serve communities disproportionately underrepresented in bicycling, including low-income communities and communities of color. These stations will be well-connected to the overall network of stations to provide access to an attractive variety of bike share trip origins and destinations." (WP 0)
>
> "The Suitability Screening Score is focused solely on maximizing the number of check-outs at bike share stations based on empirical relationships in other cities between bike share ridership and the Score's input variables; however, goals other than maximizing ridership are relevant to the selection of a service area and the placement of stations. Stations placed in lower-income areas or areas with a higher non-white population are also desirable to better serve these communities and address economic and racial equity concerns. Placing a station in a lower-ridership suitability area in order to serve a particular attraction or to fill in a gap in the station network might also be desirable." (WP 2)
>
> "Locating bike share stations in communities disproportionately underrepresented in bicycling can improve their mobility by providing affordable access to bicycles; however, low potential ridership levels among these communities might deter systems looking to maximize ridership from locating stations there. In an equity survey of twenty bike share system operators, thirteen reported siting or planning to site stations primarily to serve low-income communities, and the remainder intend to site stations for this purpose in the future. Many systems reported placing stations that serve equity interests, but often incidental to other factors." (WP2) (F & P, 2013)

Further research is needed to identify and place additional stations specifically for the purpose of ensuring equitable access, ideally before the bike share program is launched. These Equity Stations could also be added as the system develops and its financial capability to support potentially lower performing docking stations becomes known. Locations could be identified that score high enough using other siting criteria, but are also locations with an opportunity to promote equitable access. This new Equity Station analysis could draw from data on concentrations of:

- Low-income households
- Non-white households
- "Zero Car" households
- Section 8 housing assistance recipients
- Food stamps recipients
- Locations that hold potential to aid the reach of bike share in LIM communities such as: after school clubs, churches, community centers, and parks

Once an appropriate number of new Equity Station sites have been selected based on this analysis, a framework would be developed for incorporating equity-based site selection into future system expansion. A survey of potential LIM bike share users could aid in this development, with respondents indicating potential origin/destination pairs and other information that could be used to map alternate high-suitability zones to promote equity, outside of the Fehr & Peers study's scheme.

2.3 Ridership Forecasting Models

Literature Review

Station siting decisions are heavily influenced by forecasts of the ridership potential stations will generate, as ridership is critical to the financial success of the system. Current methods of forecasting bike share ridership often assume a negative correlation between station ridership levels and proximity to non-white population, drawing on data from existing bike share systems. One forecasting model using data from Washington D.C., Minneapolis, and Denver bike share systems gave non-white population a larger negative

coefficient than precipitation (Rixey, 2013) when predicting bike share use: non-white population had a coefficient of -0.442, versus
-0.309 for precipitation days.

A regression analysis of bike share use in Washington D.C. also found a strong negative correlation with non-white population prevalence, the second strongest after distance from the bike share system's centroid. But the author included the following caveat:

> Although the District continues to reach out to underprivileged communities through marketing and expanded membership access, these results point to larger structural forces and spatial constraints to increasing Capital Bikeshare usage among marginalized groups. Most significant among these forces is extreme gentrification over the last 20 years that price low income, primarily African American communities, out of the central city… Planners should use performance measures and indicators to carefully weigh goals of equity and coverage against ridership. This study in no way discounts the importance of providing active, multi-modal transportation options to low-income and minority communities. That being said, it is important to carefully assess the tradeoffs in achieving various objectives; especially in light of the opportunity costs of providing other mobility options.
> (Daddio 2012)

These models reflect the current reality of these bike share systems, including the reality that relatively few stations have been places in areas with high percentages of non-white population. If they are used to forecast ridership for system expansions or for new systems in other regions, they may under-predict the potential ridership in these areas. If station siting decisions are then based on these forecasts, the forecasts will be self-fulfilling: ridership will remain low in LIM communities. When used in this way, this forecasting codifies racial bias and runs the risk of compounding such bias if used to evaluate existing station use or modify station site selection in the future.

Ridership Forecasting Models for Sacramento:

As with other models, the forecasting model used in the Fehr & Peers study included a negative coefficient for percentage non-white population near stations. The regression model was based on data from three currently operating U.S. bike share systems: Capital Bikeshare, Denver B-Cycle, and Nice Ride MN. Although R. Rixey whose work is cited above also works for Fehr & Peers, the Sacramento study's model has a much a larger negative coefficient of -2.100 for Non-White population than the Rixey model based on the same three U.S. systems.

The Fehr & Peers study used this model to produce 6-month, 18-month, and 3-year ridership forecasts to help gauge revenue generation and approximate cost recovery rates from fees and additional funding needed by the system.

If the bike share plan for Sacramento uses this or a similar model to predict usage and calibrate its station locations, inequity of station locations may be compounded over time. Moving forward, Sacramento could clarify how ridership forecasting will be conducted in the future, specifically as it pertains to the removal of low performing stations or the selection of new station sites. The negative coefficient for concentration of non-white households would best be avoided for any future analysis of the system if equity concerns are to be accurately addressed.

3. Financial Barriers

Third generation bike share systems derive much of their success in combating vandalism and theft from linking each bicycle check-out to a user's credit card. However, this system is inherently inequitable, as income high enough to qualify and maintain a line of credit is required for use. Recognizing this, many bike share operators in the United States have implemented alternate payment and accountability methods. But as administrators of the Denver bike share system have articulated, "Achieving a broad, diverse customer base is complicated, it's not just about the credit card" (F & P, 2013). There are many aspects of the monetary framework of bike share that merit additional attention, such as the half hourly pricing schedule and price competitiveness with other transit options.

Bike share holds the potential to overcome two important financial barriers to bicycling among the LIM community: by removing the cost burden of personal bicycle purchase and maintenance. But if credit-based access limits keep low-income individuals from being able to use the system such potential is could fail to be utilized.

3.1 Increasing Accessibility of Monthly and Annual Memberships

Literature Review

The financial structure for using bike share systems has evolved over time, though the current U.S. trend in bike share pricing is towards remarkably similar structures across systems. Those who wish to use bike share regularly, often as part of their daily commute, commit to an annual membership. This is a larger initial investment than shorter-term memberships but if used regularly becomes the most economic option. Monthly or weekly memberships are often utilized by tourists or other semi-temporary users, or those who wish to try out the system before they commit to an annual membership. Daily membership subscriptions, while often the most common type selected by bike share users, are the most expensive selection with regards to cost per use and quickly become impractical if a bike share user has financial limitations.

Several bike share systems in the United States (Arlington, Washington D.C., Montgomery, Miami, and Minneapolis) allow for low-income individuals to pay for annual memberships in installments to overcome the financial barrier such a large one-time

payment could present (Buck 2013). To expand opportunities for bike share system use to those for whom even such allowances would still prove too costly, Capital Bikeshare of Washington, D.C. offered reduced annual memberships to homeless and/or unemployed individuals regularly attending job-training sessions (F & P, 2013).

Increasing Membership Accessibility in Sacramento

Finding a source of funding for reduced cost annual membership programs is a challenge. The Fehr & Peers study forecasts that significant additional funding, approximately $684,000 annually, will be required to operate the Sacramento system beyond the expected $794,00 annual farebox recovery. Given that the payment structure it not expected to come close to covering costs, it is worth exploring what small adjustments might be made to the payment structure to ensure that low income community members are not priced out of equitable access to the system.

In the Fehr & Peers study, the cost of an annual pass was proposed at $65, a 30-day pass $30, a 7-day pass $20, and a 24-hour pass $7. For pricing structures for trips lasting longer than 30 minutes refer to Section 3.2. The study explored financial barriers to equitable access and proposed a structure that removed some barriers seen in other systems. The study proposed that agency in charge work with community financial organizations to offer no-fee, no-minimum debit or credit cards to interested parties who currently do not have such accounts, commonly referred to as "unbanked individuals."

In addition, the Fehr & Peers study proposed that bike share users in Sacramento not be subject to a credit card hold for the duration of their trip, as is common in other bike share systems. While this type of hold is logical for system administrators from an asset security standpoint, if a bike share user has only one debit or credit card, this renders them unable to make additional purchases until the bike is returned. This could have the potential to block many low-income users from using bike share for most shopping or purchase-based leisure trips, such as dining. For residents of low-income housing, who may lack the finances necessary to acquire a debit or credit card even through the planned community financial partnerships, the Fehr & Peers study proposed a partnership with the Sacramento Housing and Redevelopment Agency (SHRA) to provide subsidized memberships not tied to any debit or credit card.

Additional policies could improve access for others who cannot qualify for any lines of credit and are not SHRA residents. Possible target populations include, but are not limited to: SNAP recipients, Sacramento residents receiving unemployment benefits, and youths enrolled in free school lunch or similar low-income benefit programs. Sacramento could explore options to seek grant funding for such subsidies, as was received by Montgomery's bike share system through the Federal Transit Administration's Job Access and Reverse Commute Program (Buck, 2013).

Beyond providing free or subsidized long-term memberships, encouraging the use of more economic annual and monthly subscriptions in general has the potential for increased use of Sacramento's system by low-income riders. The price difference in fees at the monthly subscription level of $30 versus that of a similar Sacramento transit pass, which costs $100 for the general population or $50 for students and seniors, could be significant enough to attract low-income, transit dependent individuals. Further analysis could focus on creating opportunities for low-income individuals to pay for the $65 annual memberships in installments, and utilizing directed marketing to low-income groups focusing on the economic benefits of annual or monthly passes.

3.2 Modification of the 30-minute "Free" Use Window

Literature Review

Most systems have a stepped pricing scheme that allows free use for trips less than 30 minutes but then charges for every 30-minute period beyond the initial 30 minutes at an increasing rate. In the study of perceptions of bike share in Near North, Minnesota, LIM participants spoke of the 30-minute free period as a "30-minute time limit," perhaps because the idea of paying into the service a second time for an additional 30 minutes was simply out of the question (Kretman, 2011). In Boston, this 30-minute free period is extended to a full hour for users who secure low-income memberships (Buck, 2013).

The effect of this type of stepped pricing scheme on bike share use by users of all income levels can be quite acute: a 2013 study comparing the Boston and Washington, D.C. bike share systems noted that trip lengths under the 30-minute free period were evenly distributed (with a frequency peak at 6 minutes). But trip durations just beyond the 30-minute mark dropped strongly, though even longer trips were more common: once bike

share users had exceeded the free period, most chose to keep using the bikes until the next pricing tier was almost reached (Jurdak, 2013). This pattern, with similar distributions of trip lengths, was observed in both systems, even though Boston has a much denser arrangement of stations and a user would be able to return a bicycle much more quickly than in Washington, D.C. if they desired to. Jurdak also points out that, while the average bicycle trip lasts 42 minutes, the average bike share trip lasts just 14 minutes.

Jurdak's findings on trip lengths could stem from users intentionally restricting their use to avoid additional fees but could also reflect demand for longer bike share trips that is not being adequately met through the current pricing structure. Although the pricing structure could be dampening longer trips for users of all income groups, the financial disincentive for longer trips is much stronger for low-income users, and could be strong enough to prevent them from using the system at all out of concern for accruing additional charges.

Pricing schemes can also be used to address other operational challenges. Velíb of Paris gives users an extra 15 minutes free for users who check out bicycles in docking stations at the bottom of large hills, to allow the user time to complete the trip to the top (Jurdak 2013). This study also suggests that incentive pricing could be used to encourage bike share users to pick up or drop off bikes at specific stations to aid in increasing use of a particular station or make rebalancing of the number of bicycles in a given station easier.

Modification of the 30-minute "Free" Use Window in Sacramento

The 30-minute window to use the bicycles at no additional charge may not be long enough for many trips to be affordable for LIM community members, especially to and from communities without high accessibility to destinations as discussed in Section 2.1. The pricing structure proposed in the Fehr & Peers study would charge a daily subscription user $7 for a 30-minute use, $9 for a 60-minute use, and $13 for a 90-minute use, with an additional $8 charge per half-hour over 90 minutes. It should also be noted that the Fehr & Peers study would have only $1 in additional fees for a 60-minute ride for annual members, compared to the additional $2 charged to daily subscription users. As described above, Jurdak's findings suggest that even slight changes in trip duration pricing schemes could have a large effect on demand.

Therefore further research into effects of modifying the 30-minute "free" window could explore opportunities to encourage use of bike share by low-income users and Sacramento residents in general. Understanding of user preferences, possibly through the implementation of a survey of potential LIM users, is necessary to ascertain the probable response to various pricing schemes in Sacramento. Adjustments to pricing schemes after the opening of the system could also prove effective. For example, if a docking station in a LIM community is experiencing low ridership, longer "free" periods for bicycles checked out from that station could provide a powerful incentive to try out the system.

3.3 Assessing Competitiveness with Transit

Literature Review

The price of bike share use relative to the price of transit is an important factor in encouraging bike share demand. When the bike share system of London, U.K. was expanded to include kiosks in more "deprived" (i.e. low-income) neighborhoods, ridership among low-income Londoners increased. However, it was shown that this increase was quickly tempered by a drop in "casual users" (one-day subscribers) when the cost of a one-day subscription doubled from £1 to £2. A similar drop in longer-term subscriptions was not found, even though rates doubled for those users as well. Goodman et al stated, "Poorer casual users may have disproportionately reduced their usage of the scheme," and posited that these numbers likely resulted because one-day subscriptions were now more expensive than a £1.40 adult bus fare (Goodman et al. 2014).

Evidence from the U.S. also points to the importance of relative pricing. In a study composed of focus groups from the LIM community of Near North in Minneapolis, MN, one of the concerns regarding bike share usage voiced by study participants was that the cost of a daily subscription, at $5, was not financially competitive with the bus which cost $1.75 - $2.25 for a 2.5 hour transfer (Kretman, 2011).

Assessing Competitiveness with Transit in Sacramento

In the Sacramento area more than twice as many residents of Environmental Justice (EJ) Areas (defined LIM communities) use transit as residents of non-EJ areas (SACOG, 2008). While monthly and annual bike share passes are competitive with long-term transit passes,

a Sacramento Transit Day Pass costs $6 while the bike share study costs $7 plus additional fees beyond the first 30 minutes, so low-income residents who rely on day passes may find little impetus to switch from transit to bike share.

Running a cost-benefit analysis of reducing the daily subscription rate from $7 to $6, to make bike share financially competitive with the $6 one-day Sacramento Transit Pass, could clarify if increasing the financial attractiveness of a bike share daily pass is feasible. Alternately, if a combined media fare card with transit is discovered to be feasible (see Section 6.2) a combination rate for using transit and bike share in a given day or month could have great potential for increasing bike share use among low-income transit dependent residents.

The proposed monthly bike share subscription, as mentioned in Section 3.1, costs $30 compared to $100 for a monthly transit pass. This cost discrepancy could potentially be used to the advantage of Sacramento bike share through directed marketing to attract the longer-term membership of LIM community members who currently purchase transit passes on a monthly basis.

4. Safety Barriers

Physical safety while bicycling is a concern that has the potential to keep many travelers in their cars. Even dedicated bike lanes, when not physically separated from car traffic, can be perceived as unsafe, particularly by non-expert bicyclists such as occasional users of a bike share system. A safe, comfortable place to ride is not an amenity that can easily be provided by a bike share program, but is rather the responsibility of state or local government to install and maintain.

Other safety barriers, perceived and otherwise, to bicycling include personal security against crime while riding and a secure location to park a bike. The inherent structure of the bike share system has the potential to overcome the need for bike parking, but additional effort is needed to address other safety concerns.

Recent data regarding bike share does counter these concerns: out of the 23 million bike share rides throughout the United States since the first system opened in 2007, there have been no fatalities (Goldberg, 2014). In comparison, 726 other cyclists died nationally in 2012, a rate of almost two per day (NHTSA, 2014). This impressive statistic could be due to a variety of factors, from the sturdier design of the bicycles to motorists allowing bike share users more space than other cyclists. But this does show that bike share has the potential to be a way to encourage cycling.

4.1 Active Transportation Infrastructure in LIM Communities

Literature Review

According to data from the League of American Bicyclists, bicycling is generally less safe for people of color. Indeed, the fatality rate for Hispanic cyclists is 23% higher than for white cyclists, and the rate for African American cyclists is 30% higher than for whites (League of American Bicyclists, 2013). The League states that this discrepancy is due in part to the so called "transit deserts," areas with a dearth of safe facilities for alternative transport such as bike lanes and sidewalks that tend to be found in LIM neighborhoods.

A study of federal transportation funding found that counties characterized by low educational attainment and persistent poverty were significantly less likely to implement bicycle or pedestrian projects (Cradock, 2009). In counties where such projects were

implemented, per-capita spending on these facilities was much lower. This pattern is discouraging because LIM community members generally have a lower rate of car ownership, and that rate coupled with low investment in alternative transportation leaves LIM residents with few transportation options.

In Europe, the world-class cycling city of Odense, Denmark has invested considerable effort, financial and otherwise, towards promoting bicycling. Despite all the time and money spent on festivals, giveaways, contests, and other promotions, cyclists in the city consistently ranked improved facilities and safety measures as most useful in the promotion of cycling in polls (Pucher, 2009). In Odense, these infrastructure improvements were beyond the scope of most American bicycling facilities and included elements such as "Green Wave" priority signal timing and widening of key bicycling thoroughfares to accommodate up to 2,300 cyclists per hour. But even at a reduced scope, decent bicycling facilities, including a gap-free bike lane or cycle-track system, are important to the success of bike share.

Active Transportation Infrastructure in LIM Communities in Sacramento:

In U.S. cities, low investment in active transportation infrastructure in LIM communities, so-called "transit deserts," hampers the ability of members of these communities to safely use bike share. Current SACOG bike infrastructure improvement plans could be further analyzed to determine if the active transportation needs of LIM communities are being adequately planned and financed. The 2035 MTP/SCS states that current allocations for new bicycle and pedestrian infrastructure projects are not concentrated in Environmental Justice Areas. However, rates of cycling are 50% higher in Environmental Justice areas, with 12% of mode share for all trips vs. 8% in non-EJ areas (SACOG 2012), which could imply that more focus on infrastructure improvements in these areas is warranted.

Figure 5 shows concentrations of non-White populations within the Sacramento area, as well as current bicycle infrastructure. Note that the northern neighborhoods above the American River and Discovery Park have a high concentration of Class 1 cycle paths within communities with high prevalence of

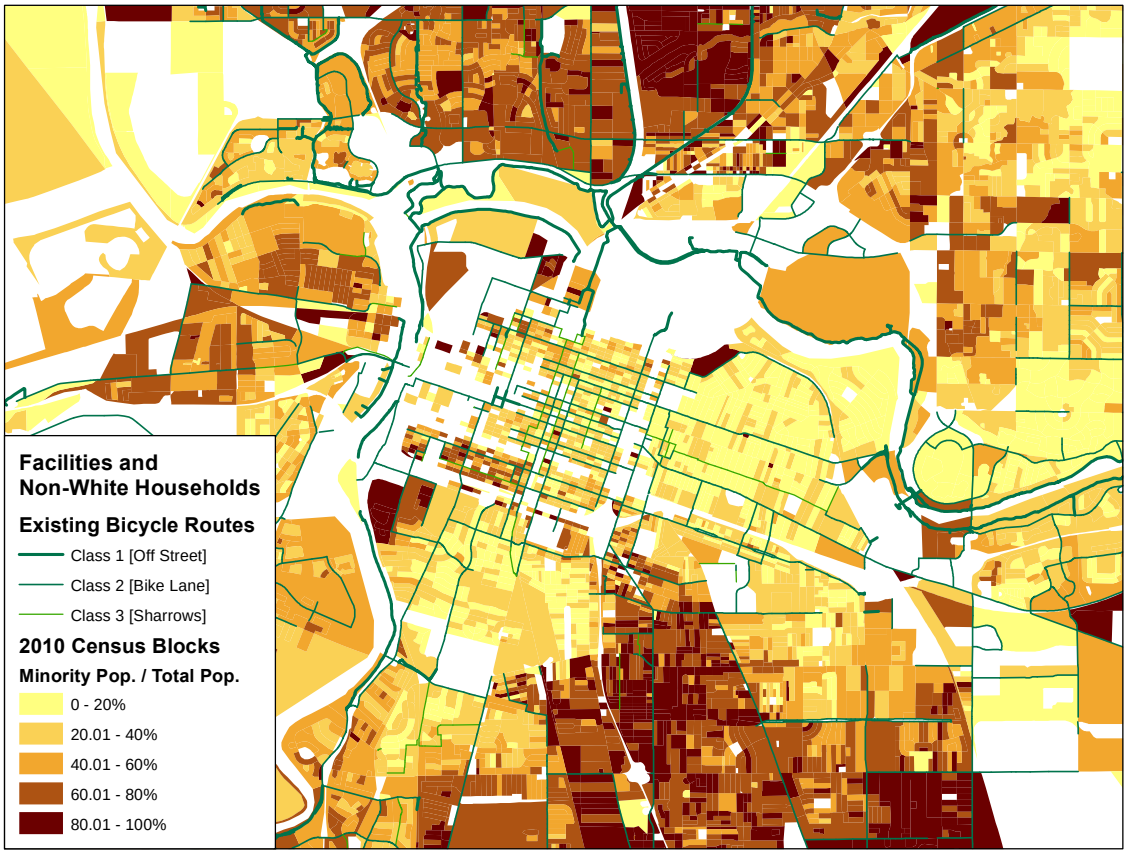

Figure 5: Sacramento bicycling facilities, and non-white household concentration

residents of color. This area in particular could be the focus of further work regarding safe access to bicycling facilities, closing gaps in the system, and similar efforts.

4.2 Personal Security while Bicycling

Literature Review

A secondary aspect of bicycling safety that is particularly prevalent in LIM neighborhoods is the issue of personal security while bicycling. In areas with higher levels of crimes such as assault or robbery occurring in the street, potential bike share users may be unwilling to risk the exposure of their person that is inherent in bicycling but not private auto or to some extent, transit. In the study of the LIM community of Near North in Minneapolis, MN, one of the main concerns regarding bike share use voiced by LIM participants was a perception of unsafe cycling conditions, especially personal security (Kretman, 2011). These findings are consistent with studies of outdoor physical activity among low-income

children. For example, a 2009 public health study in four counties in Florida indicated that perceived neighborhood safety among those polled is a more consistent indicator of whether or not the respondent's children engage in adequate outdoor physical activity than all other factors measured, such as neighborhood density, number of dead ends, small vs. busy roads, or land use mix (Greene, 2009). Together, these studies emphasize the importance of broader community concerns such as personal security and crime in LIM communities. Even the *perception* of bicycling as unsafe, whether or not the perception is accurate, works against the success of bike share in LIM communities.

Personal Security Concerns in Sacramento

Improving personal security for cyclists in Sacramento generally falls under the larger umbrella of protection against crime in the city that is one of the ongoing responsibilities of the Sacramento Police Department. However, in the last several years, reports of assaults, stabbings, and other attempted crimes along local Class 1 bike paths such as the American River Bike Trail have multiplied (American River Bike Trail, 2015). Bike share systems and municipalities in which they operate who collaborate to optimize infrastructure and safety have the potential to make cycling better for both bike share users and local cyclists.

Sacramento's bike share system could partner with Sacramento Police to develop crime reduction plans for the American River Bike Trail and similar bicycle infrastructure. Safety measures that warrant further exploration include but are not limited to: increased lighting along Class 1 bicycle paths, installation of Blue Light Call Boxes in areas where incidents are reported, removal of brush to mitigate potential for ambushes. As is currently standard for "fourth generation" bike share bicycles (see description below), cycles could be equipped with GPS trackers to mitigate personal security issues with regard to attempted theft of the bicycles themselves.

5. Education Barriers

Because bike share is relatively new in the United States, a lack of understanding among the general population about how the system works is quite common. Most bike share programs in the United States are of the "third generation" type, meaning that they are a midpoint in bike share evolution from the simple coin deposit "second generation" systems to the station-less "fourth generation" systems, which locate and unlock bicycles remotely via smartphone. Third generation systems are accessible both via smartphone or computer, and also through kiosks at their docking stations, though this is typically for daily memberships only. This can create some difficulty in signing up for the longer-term system membership options if a user does not have easy access to the Internet.

Other educational issues regarding bike share include the needs of any non-expert occasional cyclist, such as: understanding how to bicycle, understanding traffic laws regarding bicycling, and understanding where the best bicycling facilities exist and how to access them. These are all concerns any first-time bike share user could face but can be more prevalent in LIM communities due to lack of financial resources to purchase a personal bicycle for learning opportunities.

5.1 Understanding and Accessing the System

Literature Review

Due to its relative novelty, the bike share concept receives a fair amount of free press each time a system is opened. This news coverage as well as traditional advertising campaigns and the presence of docking stations on the street go a long way towards increasing awareness of the system but does little to help potential users understand it enough to successfully check out and ride a bicycle. If a LIM community member does not hear of the system through more traditional media channels, or if the LIM community member does not have adequate English proficiency, they may be denied access to the system merely by lack of proper communication.

Many bike share programs attempt to mitigate this issue by directing targeted marketing toward particular cultural or language groups, such as Capital Bikeshare's Latino marketing campaign (Buck, 2013). Bike share operators can also solicit for the program by

partnering with LIM community organizations such as affordable housing authorities, churches, and others.

Lack of computer access is one of the most commonly cited barriers to understanding and signing up for the system for potential LIM users (Kretman 2011, Buck 2013). In particular because many bike share systems only offer daily subscriptions in the kiosks at the docking stations. For longer monthly or annual memberships, the user must sign up online, and a card or key fob will be mailed to them. This severely limits access to the bike share system for those who do not have easy access to a smartphone or computer. The daily subscription purchased at the kiosk is easiest for users without Internet access but costs more over the long run. An annual membership is much more cost effective for those interested in taking full advantage to the system, but selling these memberships exclusively online could be detrimental to LIM community member participation in the program.

Understanding and Accessing the System in Sacramento

Lack of awareness of the bike share system and its benefits and lack of understanding of how the system works could be rectified by targeted marketing campaigns in the most commonly spoken non-English languages in the Sacramento area. According to statistics from the Centers for Disease Control, 36.5% of Sacramento residents do not speak English at home. The top languages spoken, in order of frequency, are Spanish, Hmong, Chinese, Vietnamese, Tagalog, and Russian (CDC, 2007). In addition to this focus on non-native English speakers, marketing campaigns could also target low-income housing residents and recipients of food stamps.

To better serve potential users who may lack Internet access, kiosk software could be modified to enable users to receive full access to all bike share System options at docking stations. Bike share users could sign up for an annual or monthly membership subscription at the kiosk with a small down payment (perhaps the cost of a one day membership) with the remaining cost to be billed to the member via mail at a later date. Five U.S. bike share systems allow payment in installments; for example, Capital Bikeshare in Washington D.C. allows annual memberships to be paid in 12 monthly installments of $7

(Buck 2013). If this transaction could be handled at the kiosk instead of online, system access could be expanded to those without Internet access.

5.2 Cycling Skills and Knowledge

Literature Review

Even if these barriers to the bike share system can be overcome by targeted outreach or digital access, the larger question of bicycling ability or understanding of bicycling infrastructure and regulation comes into play for users who do not own their own bicycle or have little bicycling experience. In Europe, where in some countries cycling is a point of national pride, the journey toward universal bicycling proficiency starts early. In Amsterdam, children participate in bicycle training classes in public schools on bikes provided for the children to use free of charge (Pucher, 2009). In Berlin, children must pass a cycling test conducted by a policeman on a closed course between the 3rd and 4th grades. This type of uniform, publicly-funded training increases access to bicycling for all residents at an early age, even among the low-income who cannot afford their own bicycles or for the children of immigrants whose home countries may not have a robust bicycle culture.

Some attempts at this type of cycling education for LIM community members have been attempted in the U.S. A safety training intervention conducted in Austin, TX was tailored for members of the African-American community to practice cycling skills along a new segment of bicycling infrastructure (McCray 2013). This intervention covered basic cycling skills such as hand signals, shifting, and moving with auto traffic, as well as a thorough introduction to the different kind of bicycling facilities available in the city and their connections. Surveys of participants demonstrated significant improvements in perceptions of cycling after the intervention, particularly with regards to safety and riding confidence.

Cycling Skills and Knowledge in Sacramento:

The need for additional knowledge of bicycling in general, including how to bicycle, traffic rules regarding cyclists, and how to access and benefit from bicycle infrastructure, could be rectified through the sponsorship of outings and classes to increase prevalence of bicycling

skills in LIM communities. The work by McCray et al. (2013) outlines a step-by-step method of introducing LIM community members to basic bicycling skills, infrastructure, and laws. These workshops should be made available to the community at large, with possible workshops targeting youth enrolled in Boys and Girls Club or similar after-school programs. If funding and project scope permit, analysis of feasibility of bicycling lessons for Sacramento schoolchildren modeled after those which are mandatory in European countries where cycling is a major part of transportation culture could ensure equitable access to opportunities to learn about bicycling for all Sacramento schoolchildren.

6. Other System Structure Issues

Most of the barriers to equitable access to bike share fall into either the station siting or financial categories. However, certain other aspects of the system structure are also worth mentioning as considerations for scheme adjustment or further research.

Bike share, due to its nature as a shared active transportation mode, cannot be perfectly aligned to the specific needs of all users. Some cyclists may prefer a mountain type or road type bicycle for the trip they intend to take; some users may desire more space for shopping bags, more gears for steep climbs, or longer operation hours to return a bike at the end of a night out. The current bike share model attempts to provide a happy medium of sturdy, simple bikes that are effective within a range of transit needs while still being financially viable for the company, government agency, or non-profit running the system.

This happy medium, however, is most beneficial to individuals who can simply choose to drive their car or ride their own bike if the bike share system does not fit the needs of their trip. In order to facilitate equitable bike share use for all potential riders, the systems must address needs of users beyond the young, middle- to upper-middle class and typically white users that take trips for recreation, short commutes, or leisure activities (Shaheen, 2012). LIM community transportation needs that could be addressed include: very early or very late commute trips, ability to easily connect to transit for very long commutes, and the ability to haul children or cargo for shopping trips.

6.1 Hours of Operation

Literature Review

Hours of operation decisions may affect the ability of LIM users who work non-traditional hours to use the bikes to commute. Many low wage jobs are scheduled outside of the traditional 9am to 5pm, Monday through Friday framework of the traditional commute. These include janitorial, food service, security, warehouse, retail, or manufacturing jobs that compel the worker to start much earlier than “normal” start hours, end a shift much later, or in many cases work an all night shift when most of a city’s population is asleep. Since research has shown that low-income households are much less likely to own a car

than other income groups (Downing 2013), they must rely heavily on public transportation that may not adequately serve their commute hours. These findings leave open the possibility that, if priced and operated on a schedule that is practical for access to low-income jobs, bike share has the potential to become a viable active transportation option for LIM users.

Hours of Operation for Sacramento

The Fehr & Peers study does not propose hours of operation for the Sacramento system. Rather, it lays out operation timetables of bike share systems currently in operation. Four of the systems operate on a seasonal March/ April through November/ December schedule due to snowy or icy winter conditions (Denver, Madison, Minneapolis, Boston). Of those that operate year round, a majority (7 out of 11) also operate 24 hours a day. Though liability resulting from alcohol-related accidents was cited as a concern in this schedule choice, the increased operations costs associated with a 24-hour customer service were also cited as a concern for Sacramento in the Fehr & Peers study.

Constant access to bike share could prove extremely helpful to LIM workers who have non-traditional shift hours by giving them additional transit options beyond bus and light rail, which do not run 24 hours in Sacramento. Analysis of increased cost due to extended customer service hours could be warranted, but from an equity standpoint this relatively small additional cost has the potential for broad benefits.

6.2 Connectivity with Transit

Literature Review

The 2012 study of 4 North American bike share systems found over 97 percent of respondents viewed bike share as an enhancement to the public transportation system (Shaheen 2012). This understanding of how users view bike share is important to remember when planning for connectivity with transit. Bicycles, like walking, can complement transit to serve a trip previously undertaken by car. Though there are some European examples of this type of collaboration, in the United States rigorous integration of bike share and public transit has been the exception rather than the rule. Only two of the 17 current North American bike share systems offer even a discount on

bike share membership to transit pass users (Shaheen, 2012), and no such discount was proposed in the Fehr & Peers study. When bike share is priced higher than an equivalent public transportation fare or day pass, bike share will often cease to be seen as a viable transportation option (Kretman 2011). A combined bike share/ transit card that allows users to access both modes as a seamless transportation option has great potential to overcome this barrier to bike share use.

While Europe has many examples, most notably the fully transit integrated Yélo bike share system of La Rochelle, France (Shaheen 2010) and systems in Stockholm as well as Guangzhou, China, the U.S. has no examples yet of successful integration with existing transit fare systems.

Connectivity with Transit in Sacramento

Integrated connection to transit would give LIM users an easy and financially viable method of using bike share to solve the first mile/last mile problem of public transportation. The bike share system, as proposed in the Fehr & Peers study, is intended to be used for trips between 0.5 and 3 miles. For a shorter trip, walking is the most feasible mode choice, and for longer trips several options are available: driving, public transportation, or by bike share combined with public transportation. However, integrated fare cards to make this connection were not proposed in the study.

The Sacramento Area Council of Governments (SACOG) offers a transit partnership card that connects eight local transit agencies and has the potential to be used for bike share. The Fehr & Peers study cites a variety of reasons it would be difficult to include bike share on this transit card: card software integration issues, issues regarding correct management of fare/user fee separation, and concerns over setting a precedent regarding allowing non-profit or for profit bike share entities to partner with government transit authorities.

Other international bike share systems have managed to integrate fare cards, so these issues regarding linking software and the proper allocation of funds to the different agencies should not be viewed as insurmountable barriers. Further research into international methods of creating a successful shared fare card could be beneficial for Sacramento.

6.3 Exploring Accessory Options

Literature Review

A final aspect of system structure deserving of consideration is that of shortfalls in the design of the bicycles themselves. The standard bike share design, as mentioned above, caters to the simpler demands of a single adult seeking to use the system for commuting or recreation. Some of the current features aiming to facilitate this type of use are: lights powered by pedaling for nighttime outings, front baskets (some with coffee cup holders) to carry purses or other small cargo, and fenders and chain guards to prevent grease, mud or water from soiling the rider's clothing. These amenities do not, however, aid users who might seek to use bike share to replace a trip involving moving cargo such as groceries or small children that would typically necessitate the use of a personal car or public bus. In Near North, Minnesota, participants of color in the outreach study cited the need for these types of features to make bike share workable for their common trips (Kretman 2011).

Exploring Accessory Options in Sacramento

Modification to the physical design of the bicycles or providing optional accessories could enable the use of bike sharing with small children or other cargo; thereby expanding transportation options for LIM users' varied trip types. As no such accessory options currently exist for bike share bicycles in the United States, the potential of such latent demand could be explored through a preliminary pilot study. Sacramento bike share has the potential to help the industry evolve through exploration of the feasibility of additional accessories such as a cargo trailer suitable for children or baggage that could be checked out with a bicycle for a small additional fee.

7. Conclusion

Sacramento is well suited to serve as a location for research on bike sharing and pilot testing of new system elements, to the benefit of its residents but also the larger bike share industry in the U.S. Sacramento has few natural limitations to bike share, with its mild climate, lack of acute elevation gains that would discourage bicycling, and excellent Class 1 bicycling facilities. Sacramento also boasts a robust minority-majority population, with many opportunities to engage residents in the benefits of bicycling. If SACOG is interested in the equitable success of Sacramento's bike share system, and in promoting active transportation for low-income and minority residents in general, the policies and practices discussed here are worth consideration.

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