Bay Area Public Transit and Social Equity

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EXECUTIVE SUMMARY

Increasing mobility in the California Bay Area is a major objective of the region’s Transportation 2035 Plan. Extensive investments are being allocated for rail development (e.g. high speed and heavy rail). In order to pay for these high-priority projects, fares are expected to increase, to the dismay of residents of disadvantaged communities (called Communities of Concern). Statistics show that ridership on luxury heavy rail systems in the Bay Area are made up of a disproportionately high amount of high-income earners, compared to the unreliable, deteriorating bus network. Social equity issues are brought to light: will future transit investments bridge the employment accessibility gap between low and high income communities, or will they further increase racial and income disparities in the Bay Area? The purpose of this study is to build upon previous work done to identify transit need and incorporate a component of transit affordability into geographic information systems (GIS) to identify transit network service areas for Communities of Concern based on the cost of fares. This study looks specifically at the Bay Area Rapid Transit (BART) network for several reasons: (1) non-fixed fare rates, (2) route service area covers both east and west sides of the Bay Area, and (3) two route extensions are currently in advanced stages of development. The daily one-way fare allowance for commuting by transit is calculated based on households’ annual transportation budget, percentage of work trips, and number of income earners. Service areas using a cost impedance are generated for (1) current BART network using base fare rates, (2) future BART network using base fare rates, (3) current BART network using discounted Regional Transit Connection (RTC) fare rates, and (4) future BART network using discounted RTC fare rates. The service areas are compared to determine how much accessibility to medium-wage job opportunities increases after the implementation of fare discounts or rail extensions. Discounted RTC fare rates are shown to significantly increase the affordable service area for Communities of Concern. Rail extension projects will not improve the mobility of Communities of Concern if their affordable service area does not extend to the end of the current BART network (where the extension projects begin). This approach helps to visually identify where the transit network works for disadvantaged communities and where it is lacking. This study would benefit from future work to incorporate other modes of transport, creating a more realistic picture of commute options.
INTRODUCTION

The Bay Area has a population of over 7.1 million people and encompasses nine counties across 7,000 square miles (Association of Bay Area Governments, 2015). Transportation planning typically occurs at a regional level, since the social, economic, and technological worlds of the counties are highly interconnected. Income inequality has been increasing at a rapid rate in the region, exceeding nation-wide levels in 2013. The gap between high and low income households in the Bay Area rose to $263,000, compared to $178,000 in the U.S. (Silicon Valley Institute for Regional Studies, 2015). Local tech giants have caused housing costs to skyrocket, forcing many lower-income residents to move to the outskirts of city centers and face long commutes to work. The Metropolitan Transportation Commission (MTC, the transportation planning, coordinating and financing agency for the Bay Area) defines “Communities of Concern” (COCs) to be census tracts which exceeds the concentration threshold for four or more factors listed in Table 1, or census tracts that exceed the threshold value for both low-income and minority populations (Metropolitan Transportation Commission, 2009c).

<table>
<thead>
<tr>
<th>Disadvantage Factor</th>
<th>% of Regional Population</th>
<th>Concentration Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minority Population</td>
<td>54%</td>
<td>70%</td>
</tr>
<tr>
<td>Low-Income Population (&lt;200% of Poverty)</td>
<td>23%</td>
<td>30%</td>
</tr>
<tr>
<td>Limited English Proficiency Population</td>
<td>9%</td>
<td>20%</td>
</tr>
<tr>
<td>Zero-Vehicle Households</td>
<td>9%</td>
<td>10%</td>
</tr>
<tr>
<td>Seniors 75 and Over</td>
<td>6%</td>
<td>10%</td>
</tr>
<tr>
<td>Population with a Disability</td>
<td>18%</td>
<td>25%</td>
</tr>
<tr>
<td>Single-Parent Families</td>
<td>14%</td>
<td>20%</td>
</tr>
<tr>
<td>Cost-Burdened Renters</td>
<td>10%</td>
<td>15%</td>
</tr>
</tbody>
</table>

305 out of 1,405 total tracts in the nine Bay Area counties were identified as COCs. Map 1 shows the location of each COC tract and the distribution of COCs in each county. Alameda County is shown to have a disproportionally high number of COCs, with 107 total. Santa Clara County and San Francisco County follow behind with 59 and 56 COCs, respectively. Napa County is the only county without any COCs.
Map 1. Bay Area Communities of Concern
Many residents of Communities of Concern are considered “transit dependent” for reasons such as being too young or too old to drive, they cannot afford to drive, or they are physically incapable of driving. In 2010, the demographics of public transit ridership showed that the riders of AC Transit, a large bus operator in the Bay Area, is made up of nearly 80% minorities and 70% of riders earn less than $30,000 annually. On the other hand, riders on the Bay Area’s heavy rail systems are made up of approximately 43% Caucasians on Bay Area Rapid Transit (BART) and 60% Caucasians on Caltrain (Mayer and Marcantonio, 2010). In an effort to increase ridership for all public transit systems, the MTC arranged tens of billions of dollars in government subsidies and countless incentives. Low-income communities claim that they do not see any benefits from the subsidies and incentives, stating that the MTC gives rail riders a 2-5 times larger subsidy compared to bus riders. As a result, ridership of non-transit dependents has increased on the heavy rail systems while bus service deteriorates and per capita usage of mass transit in the San Francisco Bay Area continues to drop (Mayer and Marcantonio, 2010). With several costly rail projects in development, one must wonder if these projects will increase racial and income disparities in the Bay Area rather than provide services to increase social equity in the region.

The MTC issued the final Transportation 2035 Plan for the San Francisco Bay Area in April 2009, titled “Change in Motion”. This document specifies how $218 billion in anticipated federal, state, and local transportation funds will be allocated in the Bay Area over the next 25 years (Metropolitan Transportation Commission, 2009b). Approximately $142 billion of the funds will be spent on operations, maintenance, and expansion of our existing public transit network. Major transit projects outlined in the plan include: a BART extension from Fremont to San Jose/Santa Clara; electrification of the Caltrain system; implementation of the Sonoma-Marin Area Rail Transit (SMART) system; expanded ferry service around the region; enhanced service along the Amtrak Capitol Corridor; a rail extension from the Pittsburg/Bay Point BART station to eastern Contra Costa County; and improvement to local and express bus services (including Bus Rapid Transit services on Oakland’s Grand-MacArthur Corridor, San Francisco’s Van Ness Avenue, and San Jose’s Santa Clara Street/Alum Rock Corridor).

Two months earlier (February 2009), the MTC released an Equity Analysis Report to analyze whether minority and low-income communities in the region would obtain the similar benefits from the Plan without bearing a disproportionate share of the burdens. The Equity Analysis Report analyzed five equity measures: financial analysis of Plan investments, access to low-income jobs by auto and transit, access to non-work activities by auto and transit, vehicle emissions, and housing and transportation affordability (Metropolitan Transportation Commission, 2009a). The results of this equity analysis showed that the conditions in Communities of Concern are not better off overall compared to the remainder of the region for affordability, and in terms of low-income jobs accessible by transit, Communities of Concern do not receive similar or greater benefit compared to the remainder of the region (relative to no project being implemented). Despite these unfavorable results, the MTC is moving forward with its Transportation 2035 Plan, choosing to focus instead on a Smart Growth strategy to accommodate the projected population growth in the next few decades.

Historically, transit expansion projects have been prioritized based on unmet demand. In order to identify areas that lack adequate public transit service, Jiao and Dillivan (2013) established a method for quantifying gaps between demand and supply using Geographic
Information Systems (GIS), termed “transit deserts”. By limiting transit demand to the population which are transit dependent, this method can be used to promote equity. Geographic areas identified to be transit deserts can be used as guidelines to improve access to employment opportunities and other societal benefits. In 2015, Jiao and Nichols extended the transit desert concept by adding two criteria to the measurement of transit supply. In addition to the vicinity of transit, they included the number of miles of low speed limit roads and intersection density in each block group to capture the ability to access transit. Beduhn (2014) uses GIS to identify factors (i.e., higher population and employment densities, lower incomes, lower auto ownership, mixed land-use) which increase ridership along a fixed bus route in Austin, Texas. This approach can provide urban planners with information on how to foster transit-friendly development in the future.

The United States Environmental Protection Agency (U.S. EPA) further studies transit demand by analyzing the accessibility of neighborhoods (via transit) characterized by the density of low, medium, and high wage jobs. Using 45-minute transit and walking commute as the standard threshold, they are able to provide statistics such as percentage of all low-wage workers in the region with access by transit and percentage of workers with access by transit. Kaplan (2014), used this rich dataset to evaluate access to jobs via transit from disparate neighborhoods in Austin, Texas. He designed a replicable geospatial analytical method for evaluating transit connectivity specifically from areas with affordable housing to medium-wage jobs ($15,000-$40,000 annual pay). This approach allows Kaplan to identify areas which can improve the accessibility score of corridors studied (e.g., ineffective bus routes which do not travel to areas of low-wage jobs). I would like to build upon the work previously conducted to study accessibility of medium-wage jobs from disadvantaged communities and incorporate a component of transit affordability into the analysis. My focus area will encompass the nine-county Bay Area region in California. Instead of assembling data of affordable housing locations, I will be using the Communities of Concern (identified by the MTC) as the home location of medium-wage workers. While Kaplan excludes rail from his analysis, my study will focus exclusively on the BART rail network in order to determine whether it is a viable commute option for COCs.

An extensive public transportation network currently exists in the Bay Area with five main modes: commuter rail, heavy rail, light rail, bus, and ferry. This study looks specifically at the BART network for several reasons: (1) non-fixed fare rates, (2) route service area covers both east and west sides of the Bay Area, and (3) two route extensions are currently in advanced stages of development. Social equity is a critical issue in the Bay Area and with BART fares scheduled to increase at the beginning of 2016, it is important to understand how the cost of public transit can be inhibitive to Communities of Concern. The MTC estimates that low-income households earning less than $40,000 per year spend on average, 26.7% of their household income on transportation costs (Metropolitan Transportation Commission, 2009a). So even if COC residents live near a heavy rail station, they may not be able to afford the daily commute cost. Current adult one-way tickets for BART range from $1.85 to $11.65 (Bay Area Rapid Transit or BART, 2014). Riders who have the Regional Transit Connection (RTC) Clipper card (created for riders under 65 years of age with qualifying disabilities) receive transit discounts of approximately 65% off the base fare rate.
The U.S. EPA defines three pay levels of employment opportunities nationwide: (1) low-wage job pay $15,000/year or less, (2) medium-wage jobs pay between $15,000 and $40,000 per year, and (3) high-wage jobs pay more than $40,000 per year. Since jobs in the lowest level will not be able to sustain households in the Bay Area, they will not be considered in this study. Also, since there is no upper limit to the pay in the highest level, this category will also not be considered. Medium-wage jobs will be used as the desired job location destinations for workers in COCs. **Map 2** is a reference map which highlights neighborhoods with medium (1,000-5,000 jobs), to high (more than 5,000 jobs) concentrations of medium-wage job opportunities.

**Map 2.** Bay Area Medium-Wage Job Densities
Map 3 is a reference map of the existing BART routes and stations, which will be used in the analysis for this report. BART extensions which are currently in development are displayed in dashed lines and will be evaluated to see if they address transit needs of Communities of Concern.

Map 3. Bay Area Rapid Transit Map
PROBLEM STATEMENT

The Equity Analysis Report released by the Metropolitan Transportation Commission in 2009, evaluates public transit equity for Communities of Concern in the Transportation 2035 strategic mobility plan. The report reveals that Communities of Concern do not receive greater, or even similar benefit compared to the remainder of the region in terms of affordability and low-income jobs accessible by transit. The MTC aims to address this issue by identifying several actionable areas to continue to advance transportation equity in the region and providing funding for locally-based transportation needs assessments for Community of Concern. This research study is an effort to aid this transportation needs assessment, by examining commute costs for adults using the BART system in the Bay Area. I hypothesize that COCs will not be able to affordably reach the majority of high-density medium-wage job opportunities that are currently accessible by BART. I also predict that the San Jose/Santa Clara and east Contra Costa County BART extensions will not address the equity issues faced by COCs.

RESEARCH QUESTIONS

This research study intends to provide insight to the following questions:

1. Where are the highest clusters of Communities of Concern in the Bay Area?
2. Can Communities of Concern affordably reach high job density neighborhoods using the existing BART network?
3. Can Communities of Concern affordably reach more high job density neighborhoods using the future extended BART network?
4. How much of a difference does the Regional Transit Connection discount make on the accessibility of job opportunities?
5. Where are the critical areas where Communities of Concern can benefit from additional rail service? Is there a rail route which can be built to increase accessibility to job opportunities for Communities of Concern?

METHODOLOGY

Data Acquisition

The main data sources needed to conduct this study were Bay Area Communities of Concern, BART routes and stations, the cost of transit fares from each origin, and locations of medium-wage jobs. It was difficult to obtain data sets from all sources for one consistent year, so I used the most current data that I could find. From the Metropolitan Transportation Commission Open Data website, I was able to obtain COC shapefiles from 2014. I obtained BART routes and stations from California Department of Transportation (CADOT) from 2013. I georeferenced images of the BART extension routes into a new shapefile. Current transit fares were collected from the BART Fares and Schedules brochure (fares effective as of January 1, 2014), as well as their online Fare Calculator. Fares for BART extensions were estimated using information found on the Warm Springs Extension Project page (Bay Area Rapid Transit or BART, 2015c), and the cost of comparable-distance trips on the existing network. I used the Smart Location Database to obtain the location of medium-wage jobs as of 2013.
Additional feature data including county boundaries, ocean, primary roads, and zip code areas were obtained from the Metropolitan Transportation Commission’s Maps & Data website, Data.gov, and the U.S. Census. All shapefiles are projected to the California (Teale) Albers (Meters) 2011 coordinate system (Datum: NAD 1983).

Note: For the following detailed methodology, **tools** are bolded and *layer names* are italicized.

### Georeference Rail Extension Routes

These steps will need to be repeated for each non-contiguous route extension. After these steps, the two BART extensions will be georeferenced into shapefiles for use.

- **Insert Picture** of the route image to the data frame.
- Right-click the *CA_roads_projected* layer and select **Zoom to Layer**. Using the **Zoom In** tool, drag a rectangle to **zoom** to approximately the extent, using the roads as reference points.
- On the Georeferencing toolbar, click the **Georeferencing** button and then select **Fit to Display**.
- **Add Control Points** to the image and the corresponding data layer. Please note that the residual values for the control points generally should stay under 10 in order to ensure accuracy, but due to the scale of the study area, this will not be possible to adhere to. This will result in a slightly skewed rail route which is still sufficient for the level of analysis in this study.
- In ArcCatalog, create a new shapefile called *BART_SanJose_Extension*. Add the shapefile to the data frame. Click **Start Editing** in the Editor toolbar and select that layer to edit. Use the **Line Construction Tool** in the Create Features box and trace each possible trip in the extension. **Save Edits** and **Stop Editing**.

### Average Nearest Neighbor Analysis

In order to determine whether spatial clustering occurs in Communities of Concern, the Average Nearest Neighbor tool was used. I created centroids to represent each COC tract and used the centroids as the input feature class.

- Use **Feature to Point** (Data Management) tool to create centroids for each Community of Concern census tract.
- Assign *COC_centroids* as the Input Feature Class of the **Average Nearest Neighbor** (Spatial Statistics) tool.
- Assign Euclidean Distance as the Distance Method of the **Average Nearest Neighbor** tool.
- Click OK to run the analysis. Go to the Results window to view the analysis.
Hot Spot Analysis

To answer the first question regarding the location of the highest clusters of Communities of Concern, I conducted a Hot Spot Analysis of the COC centroids and Bay Area zip code areas.

- **Clip** 5-Digit Zip Code Tabulation Area data (tl_2010_06.zcta510.shp) to the *Bay_Area_counties* layer.
- **Join** the *Bay_Area_zip_codes* layer with data from another layer based on spatial location. Choose *COC_centroids* as the layer to join to this layer. The new shapefile *Bay_Area_zip_COC_join* contains a *Count_* column that stores the number of COCs in each zip code.
- Apply a **Select by Attributes** query on *Bay_Area_zip_COC_join* that includes only zip codes with at least one COC: “Count_” >= 1. Export selected data into a new shapefile *COC_zip_codes*.
- Run the **Hot Spot Analysis (Getis-Ord Gi*)** (*Spatial Statistics*) tool with the following settings:
  - **Input Feature Class** -> *COC_zip_codes*
  - **Input Field** -> Count_
  - **Output Feature Class** -> *COC_HotSpot_zip_codes*
  - **Conceptualization of Spatial Relationships** -> CONTIGUITY_EDGES_CORNERS
  - **Distance Method** -> EUCLIDEAN_DISTANCE

Walkability Analysis

In order to determine whether the COC hot spots can access BART stations and which ones, I intersected the walkable area from the COC with the BART stations.

- **Create a half mile Buffer** for the hot spot zip codes in the *COC_HotSpot_zip_codes* layer to represent the walkable area from the home location.
- **Intersect** the buffered shapefile with *BART_Existing_Terminals* to find current walkable BART stations and with *BART_CCC_Extension_Terminals* or *BART_SanJose_Extension_Terminals* to find future walkable BART stations. Save output shapefiles as *Walkable_BART_Stations*.

Service Area Analysis

Once the walkable BART stations have been identified, create separate Service Area data frames for (1) current network paying base fare, (2) future network paying base fare, (3) current network paying discounted RTC fare, and (4) future network paying discounted RTC fare. This set of steps needs to be repeated for each data frame, for each hot spot that contains at least one walkable BART station. The existing (no expansions included) service area for the hot spot in Alameda County is used as an example below.

- **Obtain base and RTC fares for adult one-way tickets on BART assuming each hot spot is the origin and any high density job neighborhood is the destination.**
- **Add a Field** to the `BART_Existing_Routes` Attribute Tables for fare cost and assign costs to the corresponding route trips.
- Apply a **Select by Attributes** query on `Walkable_BART_Stations` that includes only the zip code currently being analyzed (e.g. “ZCTA4CE10” = “94621” for the hot spot in Alameda County). Export selected data into a new shapefile `AC_Walkable_Stations`.
- In ArcCatalog, right click on a geodatabase and create a **New Feature Dataset**. Create one for the existing rail network and a separate one for the future rail network (includes the existing routes). **Import** the appropriate Feature Class(es).
    - Import Feature Class (single): `BART_Existing_Routes`
    - Output Geodatabase: `AC_NetworkFares`
- Create a **New Network Dataset** under the same Feature Dataset.
  - `AC_NetworkFares` -> New Network Dataset -> `AC_NetworkFares_ND`
    - Elevation: None
    - Add New Attribute
      - Name: `ac_fare`
      - Usage Type: Cost
      - Units: Unknown
      - Data Type: Double
      - Evaluators: `BART_Existing_Routes` field -> `ac_fare`
      - Establish Driving Directions: No
    - Add `AC_NetworkFares_ND` to the data frame
- Create a **New Service Area** using Network Analyst. Load `AC_Walkable_Stations` as the Facilities.
  - Use the following Analysis Settings:
    - Impedance: `ac_fare`
    - Default Breaks: 1.30 2.61
    - Direction: Away From Facility
    - U-Turns at Junctions: Not Allowed
  - Use the following Polygon Generation settings
    - Polygon Type: Generalized
    - Trim Polygons: Uncheck
    - Multiple Facilities Options: Overlapping
    - Overlap Type: Rings
  - Click **Solve**
  - Right click on Polygons and Export Data
    - Export: All features
    - Output feature class: `AC_ServiceArea`
  - `AC_ServiceArea`
    - Properties -> Symbology
    - Show: Quantities
    - Classification -> Manual -> 2 Classes (1.30 and 2.61)
- Add a half mile **Buffer** to `AC_ServiceArea` named `AC_ServiceArea_HalfMileBuffer` to represent maximum walkable distance to work from the transit terminal.
  - Dissolve: All
FINDINGS

The following figures, maps, and tables present the major findings in this study.

Figure 1. Average Nearest Neighbor Analysis of Communities of Concern Centroids

Given the $z$-score of -20.813102, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.
Map 4. Community of Concern Zip Code Hot Spot Analysis
Transportation Budget Analysis

The information in the table below was assembled from a variety of sources. The zip codes were identified during the Hot Spot analysis. Median Household Income values were obtained for each zip code from the 2009-2013 American Community Survey 5-Year Estimates (United States Census Bureau, 2014). Annual Transportation Budget is calculated to be 26.7% of the Median Household Income, as stated by the MTC (2009a) for low-income households in the Bay Area. The 2009 National Household Travel Survey (Santos et al., 2011) indicated that women spend approximately 13.78% of their total travel on work-related trips, while men spend more than that (17.62%), on average. I used the average of these percentages and allocated 15.7% of the Annual Transportation Budget into the Annual Commute Budget. Accounting for 250 business days in a calendar year, I came up with this equation below which determines the maximum one-way transit fare allowance per income earner in the household. These values are used in the Service Area analysis to determine where residents of COCs can affordably commute to for work.

One-Way Fare Allowance = [ (Income * Transportation Cost Percentage) * Percentage of Trips Spent To and From Work ] / # of Income Earners / # of Annual Business Days / 2

<table>
<thead>
<tr>
<th>County</th>
<th>Zip Code</th>
<th>Median Household Income</th>
<th>Annual Transportation Budget</th>
<th>Annual Commute Budget</th>
<th>Daily Commute Budget</th>
<th>One-Way Fare Allowance</th>
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</thead>
<tbody>
<tr>
<td>Alameda County</td>
<td>94621</td>
<td>$31,082</td>
<td>$8,298.89</td>
<td>$1,302.93</td>
<td>1*: $5.21 2: $2.61</td>
<td>1*: $2.61 2: $1.30</td>
</tr>
<tr>
<td>San Francisco County</td>
<td>94124</td>
<td>$50,146</td>
<td>$13,389.00</td>
<td>$2,102.07</td>
<td>1: $8.41 2: $4.20</td>
<td>1: $4.20 2: $2.10</td>
</tr>
<tr>
<td>San Francisco County</td>
<td>94110</td>
<td>$82,111</td>
<td>$21,923.60</td>
<td>$3,442.01</td>
<td>1: $13.77 2: $6.88</td>
<td>1: $6.88 2: $3.44</td>
</tr>
<tr>
<td>Santa Clara County</td>
<td>95116</td>
<td>$48,805</td>
<td>$13,030.90</td>
<td>$2,045.86</td>
<td>1: $8.18 2: $4.09</td>
<td>1: $4.09 2: $2.05</td>
</tr>
</tbody>
</table>

* Number of income earners in the household
Map 5. Alameda County Hot Spot Current and Future Base Fare Service Areas

Base Fare Service Area for Alameda County Hot Spot

Medium Wage Job Density
- Less than 1,000
- 1,000 to 5,000
- More than 5,000
- Zip Code 94621
- 1/2 Mile Buffer from Home
- Existing BART Routes
  - BART Stations
  - Walkable BART Stations

Existing Service Area
- 2 Earners: Less than $1.30
- 1 Earner: Less than $2.61

Future Base Fare Service Area for Alameda County Hot Spot

BART Extensions

Future Service Area
- 2 Earners: Less than $1.30
- 1 Earner: Less than $2.61

This map was created by Alice Chu on December 10, 2015. The datum used was NAD 1983. The map was projected to the California (State) Albers (Meters) coordinate system. Data in the map was obtained from Data.gov, California Department of Transportation, Metropolitan Transportation Commission, U.S. Census, BART, and the United States Environmental Protection Agency.
Map 6. Alameda County Hot Spot Current and Future Discount Fare Service Areas
Map 7. San Francisco County 94124 Hot Spot Walkability Analysis
**Map 8.** San Francisco County Hot Spot Current and Future Base Fare Service Areas

**Base Fare Service Area for San Francisco County Hot Spot**

- **Medium Wage Job Density**
  - Less than 1,000
  - 1,000 to 5,000
  - More than 5,000
  - Zip Code 94110
- **1/2 Mile Buffer from Home**
- **Existing BART Routes**
  - BART Stations
  - Walkable BART Stations

**Existing Service Area**
- 2 Earners: Less than $3.44
- 1 Earner: Less than $6.88

**Future Base Fare Service Area for San Francisco County Hot Spot**

- **Future Service Area**
  - 2 Earners: Less than $3.44
  - 1 Earner: Less than $6.88

This map was created by Alice Chu on December 10, 2015. The datum used was NAD 1983. The map was projected to the California (Teale) Albers (Meters) coordinate system. Data in the map was obtained from Data.gov, California Department of Transportation, Metropolitan Transportation Commission, U.S. Census, BART, and the United States Environmental Protection Agency.
Map 9. San Francisco County Hot Spot Current and Future Discount Fare Service Areas

Discount Fare Service Area for San Francisco County Hot Spot

Existing Service Area
- 2 Earners: Less than $3.44
- 1 Earner: Less than $6.88

Future Discount Fare Service Area for San Francisco Hot Spot

Future Service Area
- 2 Earners: Less than $3.44
- 1 Earner: Less than $6.88

This map was created by Alice Chu on December 10, 2015. The datum used was NAD 1983. The map was projected to the California (Transverse) Albers (Meters) coordinate system. Data in the map was obtained from Data.gov, California Department of Transportation, Metropolitan Transportation Commission, U.S. Census, BART, and the United States Environmental Protection Agency.
Map 10. Santa Clara County Hot Spot Walkability Analysis

Current Walkable BART Station Analysis for Santa Clara County Hot Spot

Future Walkable BART Station Analysis for Santa Clara County Hot Spot

This map was created by Alice Chu on December 10, 2015. The datum used was NAD 1983. The map was projected to the California (Teale) Albers (Meters) coordinate system. Data in the map was obtained from Data.gov, California Department of Transportation, Metropolitan Transportation Commission, U.S. Census, BART, and the United States Environmental Protection Agency.
Map 11. Santa Clara County Hot Spot Future Service Areas

Future Base Fare Service Area for Santa Clara County Hot Spot

Medium Wage Job Density
- Less than 1,000
- 1,000 to 5,000
- More than 5,000
- Zip Code 95116
- 1/2 Mile Buffer from Home
- Existing BART Routes
- BART Extensions
- BART Stations
- Walkable BART Stations

Existing Service Area
- 2 Earners: Less than $2.05
- 1 Earner: Less than $4.09

Future Discount Fare Service Area for Santa Clara County Hot Spot

Future Service Area
- 2 Earners: Less than $2.05
- 1 Earner: Less than $4.09

This map was created by Alice Chu on December 10, 2015. The datum used was NAD 1983. The map was projected to the California (Teale) Albers (Meters) coordinate system. Data in the map was obtained from Data.gov, California Department of Transportation, Metropolitan Transportation Commission, U.S. Census, BART, and the United States Environmental Protection Agency.
ANALYSIS

My study focused on five research questions. Here I will discuss my findings and how they were able to answer the research questions.

1. Where are the highest clusters of Communities of Concern in the Bay Area?

**Figure 1** shows the results of the Average Nearest Neighbor analysis. With a z-score of -20.81 and a p-value of 0.00, the COC centroids exhibit significant clustering. Note that typically a p-value that is less than 0.01 indicates significance to a 99% level of confidence and the critical z-score value for high levels of significant clustering is -2.58. This is visually apparent in Map 1, which displays all Communities of Concern and a breakdown of the distribution by county.

The Hot Spot analysis in **Map 4** identified four Community of Concern hot spots. These four hot spots correspond with the counties which contain the highest number of COCs (i.e., Alameda County, San Francisco County, and Santa Clara County). These four zip codes will be the focal point of the Service Area analysis.

2. Can Communities of Concern affordably reach high job density neighborhoods using the existing BART network?

High job density neighborhoods (more than 5,000 medium-wage jobs) are indicated by a dark green color in Map 2, followed by medium density neighborhoods (between 1,000 to 5,000 medium-wage jobs) in a lighter green color. Neighborhoods with less than 1,000 medium-wage jobs are not considered significant enough to include in this study. The existing BART network can be seen in Map 3, in a solid magenta color. The existing routes do travel along corridors with large clusters of COCs, but do not reach them all. Using the One-Way Fare Allowances outlined by income earner by county in Table 2, I conducted Service Area analyses on each hot spot zip code, as can be seen in the top map in Maps 5 and 8. Alameda County’s hot spot (zip code 94621), as shown in Map 5, is within walking distance to one BART station and can reach 12 other BART stations if the household has only one income earner (daily one-way fare allowance is $2.61). If the household has two income earners, they cannot afford the base BART fares at all (minimum fare is currently $1.85). None of the reachable terminals are within walking distance of high job density neighborhoods. One of San Francisco County’s hot spots (zip code 94110), as seen in Map 8, is within walking distance to three BART stations. This zip code’s median household income is more than $50,000 higher compared to the Alameda County hot spot. This increases their one-way fare allowance to $3.44 and $6.88 for two and one income earners, respectively. While households with one income earner can affordably traverse the entire existing BART network, households with two income earners can only make it across the bridge to West Oakland, or south to South San Francisco. This puts them just out of reach of the high job density neighborhood in San Mateo County. However, it can also be seen that the half mile walkable area from the BART network is not reachable to large clusters of high job density neighborhoods in Alameda County. This indicates that even if transit affordability was not an issue, the BART network does not service critical areas of employment. Map 7 and Map 10 show that two of the four hot spots (zip codes 94124 and 95116) have zero BART stations within a half mile walking distance from their home location.
3. Can Communities of Concern affordably reach more high job density neighborhoods using the future extended BART network?

The bottom map in Map 5 shows the service area for the Alameda County Hot Spot on the extended rail network. For this hot spot, the rail network is less of a hindrance compared to the affordability of base fare rates, so the service area remains the same as it was on the existing BART network. The bottom map in Map 8 shows the impact of the extended BART network on mobility from zip code 94110. While there is no change in service area for households with two income earners, households with only one can travel farther east in Contra Costa County and farther south into Santa Clara County. The BART route in the south provides access to one high density neighborhood, confirming that the future extended BART network does allow COCs to affordably reach more high job density neighborhoods. While zip code 95116 in Santa Clara County previously had no access to the BART network, the San Jose/Santa Clara BART extension directly connects this COC hot spot to the BART system, adding two walkable BART stations, as shown in the bottom map in Map 10. The affordable service area shown in the top map in Map 11 illustrates a large increase in mobility to several high and medium job density neighborhoods for households with either one or two income earners. This analysis indicates an increase in transit equity for two of the four COC hot spots.

4. How much of a difference does the Regional Transit Connection discount make on the accessibility of job opportunities?

The RTC discounted fares (65% discount off base fares) make a significant difference in the accessibility to job opportunities for these hot spots. Map 6 shows a significantly larger service area for zip code 94621, compared to the base fare service area. Households with two income earners can access several medium job density neighborhoods, whereas single income earning households can directly access one high job density neighborhood and more than twice the number of medium job density neighborhoods compared to their base fare service area. The BART extensions provide no additional benefits to households with two income earners, but does allow single income earning households to access an additional two high density job neighborhoods. The base fare service area for two income earner households in zip code 94110 in San Francisco County encompassed 11 BART terminals. With the RTC discount rate, these disadvantaged households can now travel the entire existing and future expanded BART network (as seen in Map 9), thus greatly improving their accessibility to job opportunities. The bottom of Map 11 shows a fully accessible BART network for households with one income earner in zip code 95116 (in Santa Clara County), whereas the base fare service area would only take them as far as the Union City Station. Households with two income earners can now reach Lake Merritt Station, which gives them more access to medium job density neighborhoods. These results give residents of COCs a major incentive to apply for RTC Clipper cards.

5. Where are the critical areas where Communities of Concern can benefit from additional rail service? Is there a rail route which can be built to increase accessibility to job opportunities for Communities of Concern?

There is a large cluster of high and medium job density neighborhoods bordering the waterfront in Union City, Newark, Milpitas, Mountain View and Palo Alto. While there are
major highways (I-880, 84, 237, 101) that run through these neighborhoods, there is no BART access. It may be beneficial to explore an additional BART extension from the South Hayward Station across the bay into San Mateo County. Otherwise, a most cost effective solution could be to ensure that high frequency bus routes go directly from those BART stations to the neighborhoods with high job opportunities for COCs. This strategy can be utilized for any BART stations that are close but not within walking distance to high job opportunity neighborhoods. Another interesting observation is the significantly higher fare rates to get to the San Francisco International Airport (SFO) Station. The base fares to this station from zip code 94621 (Alameda County) and 94110 (San Francisco County) are $9.40 and $8.25, respectively. The RTC discounted fare rates are $3.50 and $3.05 for the same zip codes. These fares are not viable for daily commutes by residents of COCs. The airport employs many low-income workers and they should be able to qualify for additional subsidies if they have proof of employment, or SFO should provide a monthly transit stipend for their employees.

CONCLUSION

This study explores an innovative way to analyze transit equity for disadvantaged communities. Previous studies have focused on location of transit stations and transit frequency to identify transit gaps, while others measure walking and transit commute times from areas of affordable housing to low-wage job locations. My goal was to build upon these studies and identify the affordable service area from several Community of Concern (characterized by high populations of low-income and minority families) hot spots in the California Bay Area. As a case study for feasibility, I started by looking only at the BART system, since it posed several interesting elements to consider (i.e., distanced-based fare rates, rail extension projects). The results show that this approach can help to visually identify where the transit network (and fares) works for disadvantaged communities and where it is lacking. Rail expansion projects are extremely costly and it may not always be an option to build where transit gaps have been identified. These service area maps clearly show where additional (affordable) service is needed to increase mobility and it opens doors for discussing alternate solutions.

There are several limitations to this approach. By considering only BART in the analysis, this creates a very incomplete picture of the public transportation system in the Bay Area. With over twenty separate operators and five different modes of transit, there are many more options to commute to work than I have shown here. Future work can incorporate additional modes (e.g., bus, ferry, fixed-fare light rail) to expand the public transit network, with the appropriate transfer stations and fares identified. Ferries can take workers across the Bay into Marin and Solano Counties. Connection to the SMART rail line in Marin and Sonoma Counties can connect workers to job opportunities in the North Bay. The complexity here increases, as it is necessary to make sure all modes are properly connected and the accurate fare is stored (with transfers across operators taken into consideration). The General Transit Feed Specification (GTFS) data is a potential source for exact fares charged for each possible transit trip. However, GTFS files no longer all contain the shapes.txt file needed for route creation. Matching fares to rail segments provided by MTC would not be an automatable task. If the necessary data can be acquired, my proposed transit affordability approach can provide a clear picture of how cost-prohibitive commuting by transit can be for transit-dependent populations.
REFERENCES


