Measuring pedestrian accessible bus transit supply in St. Petersburg Florida

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Abstract

Related to ideas of walkable city and urban design, pedestrian access is an important topic in transportation planning studies. The GIS buffer based method as presented by Currie (2010) measures accessibility spatially by identifying the relative ease of transit network access for pedestrians travelling from an origin to available access points for a specified mode of transportation. While this method has been applied internationally, this study contributes to the existing literature by measuring bus transit supply accessible by pedestrians for the City of St. Petersburg Florida. The index used to calculate this measure of walkable bus transit supply was adapted from an established formulation and applied to current transit data and census datasets. The results reveal patterns in the distribution of walkable bus transit supply for the city at the census block level.

1. Introduction

Previous transit access studies assess the quality of public transit services relative to a variety of social needs measurements (Currie 2010, Murray 1998). However, how these studies measure quality of public transit services varies by location, complexity, and method used (Mamun 2014, Ryan et al. 2012). One of the most important factors in transit planning is the level of accessibility to bus transit services for pedestrian users (Alshalalfah and Shalaby 2007, Currie 2010, Monteiro et al. 2012, Olszewski and Wibowo 2005). Pedestrian transit accessibility studies analyze the measured distance between households and public transport stops or the length of a journey from a user’s house to work via public transportation (Cheng and Chen 2015). Given these factors, it is commonly accepted that people are willing to walk 0.25 miles to access a bus transit network (Zhao et al 2013).

Commonly, transit accessibility is measured by the proportion of the population who reside within that 0.25 mi distance from transit facilities (Monteiro et al. 2012); transit facilities include bus stops, bus rapid transit, and train stations (Levinson 2002). Since a comprehensive list of indicators is not established in the literature regarding how pedestrian accessibility, mobility, and connectivity is measured or assessed, typical analyses measuring accessibility are based on a geographic information system (GIS) buffer-based method (Currie 2010, Delmelle et al. 2012, Foda et al. 2010). The GIS buffer method measures accessibility spatially by identifying the relative ease of transit network access for pedestrians travelling from an origin to available access points for a specified mode of transportation (Delmelle and Casas 2012).

The buffer method is known to have a few advantages and disadvantages. One advantage is the method is easy to implement in GIS. Buffer tools available in GIS make the associated distance calculations simple and easy to visualize in a mapping context (Delmelle et
al. 2012). Additionally, a buffer method considers not just distance to facility access but also establishes spatial relationships enabling examination of the service frequency access points provide to pedestrians, providing for a measure of transit supply (Currie 2010). While these points make it a useful measurement, they are not without limitations. One disadvantage to this method is that it operates under the assumption that populations are evenly distributed across the geographic units studied, for example, census blocks (Zielstra et al. 2011). Another assumption the buffer method implies is that a person accessing a transit facility will walk to an access point using straight line distances where the actual walking distance may be slightly longer if considered in the context of network distances (Zhao et al. 2014).

While this method acknowledges some limitations, the advantages make it widely used in transit planning scenarios because it provides a simple, easy to interpret measurement of accessibility (Currie 2010). This study aims to quantify a relative measure of supply for pedestrian accessible bus transit service in St Petersburg Florida. The measurement will be implemented using a buffer-based method which also considers transit service frequency in its formulation.

2. Methods

The methodology employed for this study calculates an index capturing pedestrian-accessible bus transit service supply levels in St. Petersburg, FL. The index was calculated for the City’s 6068 census blocks using an adaptation of the pedestrian transit supply metric found in Currie, 2010.

2.1 Study Area and Data

The City of St. Petersburg (27°N, 82°W) is on the Pinellas county peninsula located on the central west coast of Florida. Its population is estimated at 249,688 as of 2015. Bus service in the city is provided by the Pinellas Suncoast Transit Authority (PSTA). Datasets and tools collected for this analysis included:

- A database reflecting PSTA bus stop locations, routes, and counts of bus trips, arrivals and departures. This data represents service activity for the winter of 2014-2015 and was made available by PSTA in the GTFS transit feed format.
- Census TIGER LINE geographies for Pinellas County, FL, census block level. These files were loaded with population information held in census Summary File 1 and were made available by the Florida Geographic Data Library (2010).
- The BetterBusBuffers toolbox, by Melinda Morang at ESRI (2015). This toolbox contains routines for extracting service frequencies from transit data stored in the GTFS format and was used during the analysis. The functionality present in this toolbox leverages sqlite databases and stored query procedures designed to summarize incoming GTFS datasets.
2.2 Mapping Pedestrian Bus Accessibility

Adapting the pedestrian bus transit supply measurement found in Currie, 2010, the data sources were processed using functionality present in ArcGIS 10.2 (ESRI 2015) and the ‘BetterBusBuffers’ toolbox to express the following calculation:

\[ SI_{\text{block}} = \sum N \left( \frac{\text{Area}_{B_n}}{\text{Area}_{\text{block}}} \times SF_{B_n} \right) \]

Where \((SI_{\text{block}})\) is the calculated pedestrian bus transit accessibility index (service index) for a census block, \(N\) is the number of bus stops falling within 0.25 miles of the boundary of the census block, \(B_n\) is the 0.25 mile radius buffer \(n\) for each bus stop serving the census block, \(\text{Area}_{\text{block}}\) is the area of the census block in square meters, and \(SF_{B_n}\) is the service frequency (number of bus arrivals in a week) for the bus stop. Adaptations to the index as it appears in this paper include omission of an associated social disadvantage index used in Currie 2010, which further specified the spatial distribution of walkable transit access in the context social need. The index is referred to as a “buffer based” method in this paper as a reference to the walkable distance buffer \(B_n\) each bus stop is subjected to during calculation of the service index \(SI_{\text{block}}\) for the census block under consideration.

First, the GTFS information provided by PSTA was processed using the BetterBusBuffers toolbox (ESRI), creating an sql database storing a service frequency value for each PSTA bus stop location in St. Petersburg. Next, the service frequency information was joined to PSTA bus stop point locations, and these locations were each buffered to a 0.25 mile radius, representing a walkable access distance. A one-to-many spatial join task between bus stop buffers and St. Petersburg census blocks produced a feature class storing an association between census block GEOID’s, the STOPID’s of all bus stops serving the census block, and the service frequency provided by each stop. A python script was developed and used to calculate the service index formula shown above using the result of the join task as input for the script.

3. Results

The result pattern presents an index of pedestrian accessibility to bus transit service supply. It considers both spatial arrangement and service frequency in its formulation. The results were mapped based on 5 percentile classes, with zero-index representing no pedestrian access areas highlighted (Figure 1). The classes chosen represent 20\(^{th}\) percentile intervals categorizing calculated service index scores for all census blocks.

Given the method parameters described above, Table 1 represents the distribution of population within each service index category. Just under 11% of the population residing in the City of St. Petersburg Florida have no walkable access to bus stop locations from their residences based on the 400m buffer distance. This accounts for 26156 residents in the city who reside mostly in the areas of Northeast St Petersburg including parts of Snell Island, Shore Acres, and neighborhoods in south-central St Petersburg. Demographic profiles derived from 5-
year (2009-2013) American Community Survey estimates at the block group level for these and other associated low-access subdivision areas are illustrated in Table 2. The areas with minimal or low service levels include parts on the periphery of the central business district and on the eastern bay shoreline of the city. These areas accounted for almost 54% of the residential population. The areas with highest levels of walkable access to transit include the downtown central business district, 5th Street and Central Avenue. These areas service just over 5% of the population. The areas with average service appear sporadic throughout areas of the city with no immediately apparent trend and provide service to 33% of the population.

There are a total of 2023 bus stops and 6068 census blocks in the city of St Petersburg. This is on average 0.3 bus stops per census block, each stop averaging 69.3 bus arrivals per week, however census blocks vary greatly in size; the smallest census block has an area of 312 m$^2$ and the largest census block has an area of 2870950 m$^2$, both likely a commercial district or managed lands since they each have a population of zero.

<table>
<thead>
<tr>
<th>Service Index Category</th>
<th>Population in Category</th>
<th>Percent of Total Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Walkable Service</td>
<td>26156</td>
<td>10.73</td>
</tr>
<tr>
<td>Minimal Service</td>
<td>53578</td>
<td>21.98</td>
</tr>
<tr>
<td>Low Service</td>
<td>77770</td>
<td>31.91</td>
</tr>
<tr>
<td>Average Service</td>
<td>73914</td>
<td>30.33</td>
</tr>
<tr>
<td>Above Average Service</td>
<td>11838</td>
<td>4.86</td>
</tr>
<tr>
<td>Excellent Service</td>
<td>460</td>
<td>0.19</td>
</tr>
<tr>
<td>Total</td>
<td>243716</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1: The distribution of population within each service index category
Figure 1. Pedestrian bus transit accessibility index, St. Petersburg, Florida
<table>
<thead>
<tr>
<th>Subdivision</th>
<th>Total Population</th>
<th>Median HH Income</th>
<th>Households</th>
<th>HH Below Poverty</th>
<th>HH Above Poverty</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAKEWOOD</td>
<td>1483</td>
<td>55376</td>
<td>513</td>
<td>50</td>
<td>463</td>
</tr>
<tr>
<td>PLACIDO GARDENS</td>
<td>1995</td>
<td>72563</td>
<td>818</td>
<td>21</td>
<td>797</td>
</tr>
<tr>
<td>SNELL ISLE</td>
<td>1446</td>
<td>99485</td>
<td>509</td>
<td>33</td>
<td>476</td>
</tr>
<tr>
<td>TROPICAL SHORES</td>
<td>774</td>
<td>65909</td>
<td>360</td>
<td>68</td>
<td>292</td>
</tr>
<tr>
<td>VENETIAN ISLES</td>
<td>1525</td>
<td>88911</td>
<td>602</td>
<td>38</td>
<td>565</td>
</tr>
<tr>
<td>YACHT CLUB ESTATES</td>
<td>1821</td>
<td>103266</td>
<td>773</td>
<td>42</td>
<td>731</td>
</tr>
<tr>
<td>LAKEWOOD</td>
<td>1483</td>
<td>55376</td>
<td>513</td>
<td>50</td>
<td>463</td>
</tr>
</tbody>
</table>

Table 2: ACS 2013 summary information for block groups falling within low-service subdivision areas

4. Discussion

Pedestrian access is an important topic in transportation planning studies, which further ties into ideas of new urban design and walkable cities. This study utilizes a buffer-based approach to measure bus transit access for pedestrian users in St Petersburg Florida. It should be noted the index calculated for this study does not consider any measure of transit demand in its formulation. The index is concerned with measuring the supply level of walkable transit at a given location. While amounts of covered population is suggested in the results, these are provided under the assumption that travelers may often seek walkable access to bus transit with their residence as their trip origin. The index calculated is not a measure of ridership, transit demand, or trip origin. Therefore, this approach does not by itself provide enough information to inform policy decisions or to make recommendations for future service changes. Instead, it is a measure of existing conditions from a pedestrian access viewpoint that may provide direction for further analysis. Additionally, it is a demonstration that a buffer-based method developed elsewhere in the world can be applied locally in St Petersburg, Florida.

While a buffer-based method is commonly used elsewhere, it is not without limitations. As shown in the results, one limitation is that this particular supply measurement uses
Euclidean distance instead of network distance. This is a simple measurement of access which only looks at if a person gets on the bus, not other factors such as trip destinations or purpose of the ridership for each particular trip, meaning this method also does not address where travel is being supplied to. For example, if a person has a nearby stop with a high supply of buses, this approach does not consider the bus route accessible from that stop. This may offer another element to studying the ridership in future analyses in this area.

Another limitation to this method is that all census blocks are allotted a measure of supply across the entire area without considering the spatial distribution of the population in that census block; this approach assumes even spatial distribution across the entire census block. For example, an area with zero population such as a commercial district may have high supply but an area with a high population may have minimal access as seen in a few census blocks in this particular city. Further, the 0.25 miles pedestrian access distance is counted from the edge of census block features and does not consider distances within census blocks traveled by pedestrians.

While some limitations to this method have been addressed, a full analysis identifying spatial gaps in pedestrian access to transit as required for this city is considerable and would be particularly cumbersome given the relative scale of St Petersburg Florida. This approach is instead suitable for a preliminary analysis of pedestrian accessibility. Given the trade-off to these limitations, the approach is simple, easy to measure, and easy to interpret. While this method is used internationally, this paper contributes to the existing literature by demonstrating a GIS buffer-based approach to pedestrian accessibility in Florida. Future research could apply a similar method at a variety of walkable distance thresholds to provide a more comprehensive representation of walkable access to bus transit in the area.

References


Morang, Melinda. Better Bus Buffer tool accessed http://www.arcgis.com/home/item.html?id=42e57c5ff9a0497f831f4fced087b9b0


