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**The Development of a Walkability Index:
Application To the Neighborhood Quality of Life Study**

Lawrence D. Frank, Ph.D.¹, James F. Sallis, Ph.D.², Brian E. Saelens, Ph.D.³,
Lauren Leary, M.S.⁴, Kelli Cain, M.A.², Terry L. Conway, Ph.D.², Paul M. Hess, Ph.D.⁵

¹University of British Columbia

²San Diego State University

³University of Cincinnati and Cincinnati Children's Hospital Medical Center

⁴Lawrence Frank and Company

⁵University of Toronto

Corresponding author: Lawrence D. Frank, PhD, AICP, ASLA, Bombardier Chair In Sustainable Transportation, School of Community and Regional Planning, University of British Columbia, 231-1933 West Mall, Vancouver, BC Canada V6T 1Z2,
ldfrank@interchange.ubc.ca

Abstract

Emerging evidence supports a link between neighborhood built environment and physical activity. Systematic methodologies for characterizing neighborhood built environment are needed that take advantage of available population information such as Census-level demographics. Based on transportation and urban planning literatures, an integrated index for operationalizing walkability using parcel-level information is proposed. Validity of the walkability index is examined through travel surveys among areas examined in the Neighborhood Quality of Life Study, a study investigating built environment correlates of adults' physical activity.

Introduction

Urban planners and transportation professionals have been studying how urban form is related to walking and cycling for transport, transit use, traffic congestion, air quality, and open space conservation.¹⁻⁵ Active transportation is consistently positively associated with urban form variables of greater mixed land-use, street connectivity, residential density, and combinations of these variables.⁶⁻⁸ Urban form is related to total amount of physical activity for both recreational and transportation purposes.⁹⁻¹³ People living in more “walkable” and “bikeable” neighborhoods with homes in proximity to non-residential destinations are less likely to be overweight or obese than people living in more suburban neighborhoods that require that require motorized transportation.^{11 13-15} Improving the built environment to make it easier for people to be physically active, in part through more active transportation, is an essential component of increasing physical activity.¹⁶⁻¹⁹

However, some investigators have either not found such an association or have found weak relations between built environment factors and active transportation.²⁰ These investigators posit that it is not clear which urban form factors are the most influential on active versus non-active transport. This necessitates further research and better specification of the urban form variables most influential on active transport.

Ways of measuring urban form in physical activity studies

This paper focuses on the systematic measurement of urban form to enhance the study of active transportation and physical activity. To date, measurement of walkability variables has included expert opinion about community typology⁵, census data, systematic observations^{12 21}, land-use databases using Geographic Information Systems

(GIS)²², and a regional “sprawl index”. (1) The urban form variables evaluated have been numerous, including land use mix, street connectivity, sidewalk availability, building setbacks, and dozens of others.

Given the large number of potential built environment factors that may influence transportation mode choice, there has been interest in deriving composite factors that combine multiple aspects of community design. Cervero and Kockelman developed such measures through factor analysis in an attempt to operationalize the larger constructs of *density*, *diversity*, and *design* (3Ds) from a variety of built environment variables within 50 San Francisco Bay-area neighborhoods (single or clustered census tracts).²³ Using a different geographic unit of 150-meter grid cells, Krizek operationalized neighborhood accessibility through factor analysis of housing density, retail employee density, and street design.²⁴ Levine and colleagues further developed a composite measure of walkability through the use of cluster analysis in their work on neighborhood preference.²⁵ Variable reduction tools and use of resulting factors help address collinearity problems. However, using data reduction techniques like factor analysis for survey design purposes and resulting neighborhood selection based on walkability can rule out important vectors of the built environment that explain travel choice and physical activity. For example, Cervero and Kockelman (1997)²³ found that certain built environment variables that did not load on their intensity and walking quality factors (e.g., land use mix) were related to mode choice. In addition, factor analysis is designed to examine unique effects of one derived environmental factor or variable, not the collective effects of multiple land use variables. Some would argue that synergy for environmental factors already naturally exists (e.g., land use mix is usually found in high

residential dense areas), but Krizek (2003)²⁴ highlights many instances to the contrary. In the present study, we propose a new composite index of built environment factors.

In addition to the need to examine the influence of a combination of built environment factors on active transport and physical activity, health research necessitates sampling at a geographic level at which other critical data sources are available. For instance, to examine influences of neighborhood-level socio-demographic factors on health behaviors such as physical activity, geographic units with known socio-demographics must be selected. For example, Krizek's 150-meter grid cell provides excellent pedestrian scale resolution, but existing socio-demographic information is not available at this scale (e.g., Census data). The Transportation Research Board—Institute of Medicine⁸ report identified the limitation that built environment-health associations in specific population subgroups are essentially unstudied.

Therefore, the primary aim of the present paper was to develop, test, and apply an integrated method of identifying and sampling diverse built environments and populations to optimize the power and relevance of studies of the built environment and health. The current study builds on the work done to date by establishing a systematic and “orthogonal” approach for neighborhood level sampling that can help to isolate urban form or “walkability” from socio-demographic characteristics that also impact travel and activity patterns. The methods presented can be applied to test a variety of policy-related outcomes that encompass issues of equity, health, and environmental sustainability. It was hypothesized the GIS-based walkability index would be related to household travel patterns such as levels of walking and driving.

The composite index was used to select neighborhoods for investigation in the Neighborhood Quality of Life Study (NQLS). Most studies in the health field examine only demographic, psychological, and social variables, and these variables explain a limited amount of variance in physical activity.²⁶ Unlike prior studies, NQLS is based on an ecological model that emphasizes multiple levels of influence on behaviors, including the physical environment^{27 28} and integrates concepts and methods from urban planning, public health, and behavioral science disciplines. The primary aim of NQLS is to explore the association of physical environment characteristics with physical activity. It is hypothesized that physical environment variables are independently associated with adults' physical activity above and beyond the variance explained by psychosocial and sociodemographic variables. Further, it is hypothesized that individuals who live in higher "walkable" neighborhoods (defined in this study as an adjacent cluster of census block groups) will engage in more physical activity than those living in lower "walkable" neighborhoods. The generalizability of findings will be assessed by examining associations in high- and low-income participants.

Methods

Possible land use variables to include in the walkability index were chosen *a priori* based on extensive conceptual^{2 21} and empirical literature⁵ that point to residential density, mixed used, and connectivity as key components of walkability. Because building setbacks are also important predictors of walking and pedestrian-oriented design^{23 28 29}, retail floor area ratio was added as a novel component. Rather than requiring all these variables to co-vary, as in factor analysis, the individual variables are summed, based on the rationale that the combination of these theory- and empirically-

based variables represents walkability and will explain travel behavior and other outcomes. Although many other variables have been hypothesized, and in some cases shown to be related to active transport^{4 7 23} such as sidewalks, traffic calming, and intersection characteristics, those variables are not widely available in existing datasets, so the present four-component index represents a practical starting point, and improved versions can be developed as conceptualization and data availability improve.

Creating a “Walkability Surface”

Census blockgroup-level data were chosen as the most appropriate geographical scale, to take advantage of available socio-economic data at this geographic level such as median household income, race and ethnic distribution, the number of households, median age, and education. For each blockgroup, the “walkability” index was derived as a function of net residential density, retail floor area ratio (FAR), land use mix, and intersection density. The measures were computed from parcel-based land use data, street centerline files (supplied by King County, Maryland Property View, and Baltimore City), and census data in the two study areas (King County, WA and Maryland). Retail floor area ratio was introduced to increase the sensitivity to retail use believed to stimulate pedestrian activity. Since the measures relied on values such as structure square footage and parcel land area, the accuracy of the parcel-based land use data was critical. Multiple steps were taken to evaluate and improve accuracy and completeness of the data. In some cases, regression was used to populate missing building square footage values, based on assessed improvement (structure) value, parcel land area, and year-built data fields.

The four components of the walkability index include:

- Net residential density; the ratio of residential units to the land area devoted to residential use per block group.
- Retail floor area ratio; the retail building square footage divided by retail land square footage. The rationale was that a low ratio indicated a retail development likely to have substantial parking, while a high ratio indicated smaller setbacks, and less surface parking; two factors thought to facilitate pedestrian access.
- Intersection density measured the connectivity of the street network, represented by the ratio between the number of true intersections (3 or more legs) to the land area of the block group in acres. A higher density of intersections corresponds with a more direct path between destinations.
- Land use mix, or entropy score, indicated the degree to which a diversity of land use types were present in a block group. For this project, the mix measure considered five land use types: residential, retail (excluding region-serving or “big box” uses of 300,000 square feet or larger), entertainment (including restaurants), office, and institutional (including schools and community institutions). Values were normalized between 0 and 1, with 0 being single use and 1 indicating a completely even distribution of floor area across the 5 uses.

The four calculated values were normalized using a Z-score. For example, a normalized net residential density score of “1” would indicate that the raw value was one standard deviation above the mean value for the category. Z-scores were computed in the two regions separately, so block groups were normalized for the distribution in each region. The walkability index was the sum of the z-scores of the four urban form measures, as stated in the following expression:

$$\text{Walkability} = [(2 \times z\text{-intersection density}) + (z\text{-net residential density}) + (z\text{-retail floor area ratio}) + (z\text{-land use mix})]$$

The street connectivity z-score was weighted by a factor of two within the walkability index. This was based on prior evidence regarding reported utilitarian walking distances⁷ and the resulting strong influence of street connectivity on non-motorized travel choice.⁵ Further input confirming this weighting scheme was obtained through iterations between alternative weighting schemes and resulting neighborhood types that emerged. Census block groups and corresponding neighborhoods selected with different weighting schemes were evaluated based on expert opinion and against primary data collection on pedestrian travel in King County.³⁰ The resulting geographic distribution of walkability at the block group level for King County and the Baltimore-Washington region is shown in Figures 1 and 2, respectively. Darker colors indicate census block groups that were the most walkable.

<FIGURES 1 AND 2 ABOUT HERE>

The walkability index values ranged from -1.29 to 8.28 in the Seattle region, and from -1.57 to 8.17 in the Baltimore-Washington region. The fact that the two regions with completely different sources of data produced similar walkability values supports the face validity of the index. It further suggests comparability of the land use and street network data that were used in the neighborhood selection process.

Testing the walkability index

Our tests of the construct validity employ travel data from both Census Journey to Work for both King County-Seattle and Baltimore -Washington, DC regions and

Household Travel Survey Data available in the King County-Seattle region. Census journey to work data examines whether the walkability index is associated with work-related travel in two regions, but it was a limited test. Household travel survey data provide better measures of overall travel patterns, because approximately 83 percent of trips taken in the U.S. are for non-work purposes.^{7 31}

Data from the 1999 Puget Sound Transportation Survey collected by the Puget Sound Regional Council include 2581 King County households who reported travel patterns over a two-day period. Households in the Puget Sound Transportation Survey were geo-coded to the census block groups in which they resided. Each of the census block groups within King County were arrayed and grouped into deciles according to their walkability index scores as shown in Figures 1 and 2. The distribution of households from the lowest to highest decile of walkability was: 181, 210, 259, 266, 265, 304, 243, 278, 268, 307, and 307 respectively. Walk trips were examined according to walkability decile. While number of walk trips is an important predictor of physical activity, the number of miles traveled per day in private vehicles or vehicle miles of travel (VMT) is widely used in transportation research as overall measure of vehicle travel demand. Distances for each of the vehicle trips taken were derived through a shortest time-path modeling assignment for the reported trips in the 1999 Puget Sound Transportation Survey. Trips were assigned to routes in the transportation network to minimize travel time between destinations when taking into account levels of congestion for the time of day and direction of travel for each trip. Miles of travel were subsequently divided by the number of passengers in the vehicle to avoid over-counting for trips reported by multiple household members. We were unable to find an available similar household travel survey

across the Baltimore-Washington DC area that had adequate sample sizes within census block groups and contained non-work travel information.

Applying the walkability index

The walkability index and census-based demographic data were applied to select neighborhoods to study within NQLS. The intent was to maximize variation in walkability and income of selected neighborhoods so the separate and combined associations of these variables with physical activity and other outcomes could be evaluated as accurately as possible. In the first step, block groups in King County, WA and five counties in the Baltimore—Washington, DC region were ranked and divided into deciles based on the normalized walkability index within each region. The top four and bottom four deciles, and corresponding ranges in walkability (represented as “high walkability” and “low walkability” areas), are shown for both regions in Table 1. The fifth and sixth deciles were omitted from the analysis to create a separation between low and higher walk environments. Deciles are presented from lowest to highest.

<TABLE 1 ABOUT HERE>

Similarly, the median household income data for each block group were deciled and categorized into “high income” and “low income”. Household income values less than \$15,000 and greater than \$150,000 were not included in this process in order to avoid income outliers. The second, third, and fourth deciles constituted the “low income” category, and the seventh, eighth, and ninth deciles made up the “high income” category. Again, the 5th and 6th deciles were omitted to create a separation between low and high income neighborhoods. Table 2 shows the corresponding range in income associated with

each decile for King County and Baltimore-Washington. Deciles are presented from lowest to highest.

< TABLE 2 ABOUT HERE >

The “walkability” and income characteristics of each blockgroup were crossed with each other to produce a list of blockgroups that fit into one of four quadrants (High walkability & high income, high walkability & low income, low walkability & high income, low walkability & low income). Numerous blockgroups were included in each of the four categories which meant that additional factors needed to be considered in choosing the 16 neighborhoods, four in each quadrant, in each region. For example, out of 2,366 blockgroups in the Baltimore-Washington dataset, there were 127 in the Low Walk / Low Income quadrant, 401 in the Low Walk / High Income quadrant, 339 in the High Walk / Low Income quadrant, and 113 in the High Walk / High Income quadrant. Thus, to select possible candidates for inclusion in the study, the highest of the high walkability block groups and the lowest of the low walkability block groups were screened. These areas were mapped to determine if there were clusters of adjacent blockgroups that could reasonably be defined as a neighborhood with a sufficient population size for recruitment. Additionally, a geographic distribution of neighborhoods was desired to enhance diversity of racial and ethnic composition, access to transit, school systems, housing stock, and regional accessibility to employment. When several clusters were identified that met the above characteristics, these blockgroups were flagged as the first choice targets for site visits.

Field Verification

Site visits were made to both regions to field verify the data due to the novelty of the methodology and the critical nature of the neighborhood selection to the design of the study. Site visits were made by informal windshield observations by the NQLS investigative team. Characteristics of urban form such as the presence of sidewalks, types of retail (strip or main street), housing stock, construction, and mix of single family and multi-family housing, to name a few, were inspected for each area. Personal inspections were critical because an area could have a connected road network and be classified as High Walk, but generate little foot traffic due to a lack of sidewalks, heavy congestion, truck traffic, poor lighting, vacant parcels, incivilities such as trash and graffiti, or other factors. Site visits were generally conducted to find the optimal representatives within the high walkable and low walkable communities, rather than to distinguish between high and low walkable communities.

An example of the importance of site visits was seen in Baltimore-Washington, DC Region concerning the size and type of retail parcels. Since the original parcel data used in this region for community selection was largely comprised of centroids, or points to mark the middle of the parcel, it was difficult to determine whether the centroid represented a few larger stores or several smaller stores co-located on a single parcel (such as a strip commercial center). This distinction could affect calculations of the distances to destinations and the relative utility of active versus sedentary forms of transport.³¹

Enhancing Demographic Diversity

Census block group information such as race and ethnicity, median age, and education was a very important consideration in the neighborhood selection process. Race and

ethnicity data were used to ensure that diversity was achieved among neighborhoods in the same quadrant. For example, the four King County neighborhoods in the High Walk / Low Income group included Auburn which was comprised of 84.5% White, 1.9% Black, and 3.0% Asian residents. Beacon Hill, on the other hand, had 27.9% White, 8.5% Black, and 48.2% Asian residents. Census median age and education were used to select neighborhoods within the high and low walkability quadrants that were comparable on these demographic variables known to be related to physical activity.

Final Neighborhood Selection

During the field verification process some block groups were added to or deleted from neighborhoods to improve their adherence to actual boundaries of a community – and based on their adherence with the quadrant definition (e.g. walkability and income level). After the site visits, spreadsheets were created with the most relevant urban form and demographic data for each candidate neighborhood.

Defining “neighborhoods” based on census block group boundaries which often follow major roadways or “main streets” and tend to divide rather than capture entire neighborhoods presented a challenge. Therefore, blockgroup combinations were selected that approximated real neighborhoods; otherwise variations in urban form within neighborhoods can affect travel behavior and activity choices. Neighborhood definition was especially problematic in Low Walk / High Income areas that were typified by large residential parcels and unconnected roads, and often did not have a commercial core. Parcel data used for the study also presented some challenges that impacted neighborhood selection. For example, if the parcel data did not include different codes for large and neighborhood retail, it was impossible to determine, without visual inspection,

whether a parcel represented one large store or a collection of smaller stores under the same ownership. These two types of retail arrangements often have different parking and access features that may affect a person's ability to walk instead of drive.

Results

Census Journey to Work

The percentage of residents from the higher income neighborhoods who walked to work was 4% higher in the high walkability neighborhoods in King County and 6% higher in the high walkability neighborhoods in Baltimore when compared with low walkability-high income neighborhoods in each region. The corresponding analyses from lower income communities were similar. The percentage of residents from the lower income communities who walked to work was 7 % higher in the high walkability neighborhoods in King County and 4% higher in the high walkability neighborhoods in Baltimore compared with low walkability -- low income neighborhoods.

Seattle / King County Household Travel Survey Validation

The number of walk trips and vehicle miles traveled reported per household per day were associated with the mean value of walkability that corresponded with the walkability index decile in which their census block group was located. A one-way analysis of covariance (ANCOVA) controlling for household size, total number of vehicles, and income found statistically significant differences for walk trips [F=18.02; $p<.01$] and vehicle miles traveled [F=6.67; $p<.01$]. Figure 3 demonstrates the incremental increases in self-reported walk trips per day for all trip purposes with associated increases in walkability. Trip distances for each of the trips taken by each household member were

summed to the household level and the results by walkability decile are shown in Figure 4.

< FIGURE 4 ABOUT HERE >

Sixteen neighborhoods were selected in the King County, WA and 16 in the Baltimore-Washington, DC regions for NQLS and their associated block groups and relative locations are shown in Figures 5 and 6.

<FIGURES 5 AND 6 ABOUT HERE>

Individual component values for the variables that constituted the walkability index of the selected neighborhoods are provided for the King County and Baltimore-Washington regions in Tables 3 and 4.

< TABLE 3 ABOUT HERE >

Table 3 highlights some variation in the walkability scores within each quadrant. For example, Kent East Hill was a low walk, low income neighborhood; however it had a relatively high walkability score (walkability = 0.33) compared with Kenmore (walkability = -1.74). Kent had a strong commercial core in close proximity to multi family housing, which increased its walkability score. However, the area has a super-block road network (i.e., relatively low intersection density) and vast areas of surface parking, which was evidenced by the low FAR retail value ($z = -0.03$). The Kent East Hill community, shown in Figure 7 has several state routes passing through its core designed to accommodate the through movement of vehicles and has large building setbacks. Thus, Kent was judged to be a good example of a low walkable neighborhood.

<FIGURE 7 ABOUT HERE>

Capitol Hill / Broadway, a high walk, low income neighborhood, had the highest walkability score (walkability score = 9.2), due to strong values for all of the 4 walkability factors, and a particularly high intersection density value ($z = 2.24$) which was weighted more heavily, and residential density ($z = 1.6$). On average, there are nearly 160 dwelling units per residential acre in this community. The most walkable high income neighborhood in the King County region was the Admiral District (walkability score = 4.27) with fairly high values for each of the 4 walkability variables and in particular a good score for both mixed use ($z = 1.44$) and the FAR for retail ($z = 1.30$).

< TABLE 4 ABOUT HERE >

Descriptive statistics are presented for the Baltimore neighborhoods in Table 4. The walkability scores within the Baltimore – Washington region convey less variability within and between quadrants than was found in the Seattle region. The most walkable community was Federal Hill, located just north of the City Center with a walkability score of 3.41. Waverly, a high walk / low income community, is shown in Figure 8 with ground level retail, residential above, and on-street parking.

< FIGURE 8 ABOUT HERE >

There are some similarities in the spatial distribution of communities by quadrant for the two study regions. The high walk / high income communities were older urban core areas, often to the north or west, and upwind of the nearest central business district. The high walk / low income communities were somewhat less central, more randomly scattered, and also found in older urban core areas, and often adjacent to highways or rail yards and industrial land uses. Low walk / high income communities were towards the

periphery of both regions. Low walk / low income areas were the most randomly scattered in each region and were found near industrial, manufacturing, and warehousing districts.

Discussion

Patterns of land use have been linked with a wide variety of health and environmental consequences. In particular, low density development with separate uses has been associated with traffic congestion, air pollution, physical inactivity, and risk of hypertension and overweight.^{3 17} Improvements in the measurement of land use could contribute to advances in research in health, transportation, and behavioral and social science disciplines. Because there are socioeconomic and racial/ethnic disparities in most health outcomes related to land use³¹⁻³³, it is important to understand the health effects of environmental variables in diverse populations. The purpose of the present article was to develop, test, and apply a method of neighborhood selection for environment and health studies combining walkability and socio-demographic factors.

The walkability index presented here was designed to be related with travel choice. Using census data from two regions of the U.S., people in high walkability high income and high walkability low income neighborhoods walked to work more often than those in low walkability neighborhoods. In a second test using 2-day travel diaries from King County, WA, the number of reported walk trips was found to be 6.45 times greater and household vehicle miles traveled was 52% lower in the highest compared to lowest decile of walkability. Thus, the construct validity of the four-component walkability index was strongly supported. The pattern of more walking in high-walkability neighborhoods provides initial support for the validity of the walkability index. The

replication of very similar patterns across two regions of the country increases confidence in applicability of the walkability index to other regions.

The walkability index was used in the selection of neighborhoods for a study of built environment and physical activity, and the diversity of the selected neighborhoods was documented in two regions of the U.S. Building a walkability surface at the census block group scale across a given region or study area can then be used for multiple applications. The index can be used to investigate associations between urban form and a wide range of outcomes, it can be used to identify priority areas for transportation enhancements and redevelopment, and it can be applied to monitor changes in urban form over time. Although the utility and validity of the walkability index was supported, and it appears to be applicable to a broad range of research and policy applications, further development and evaluation is warranted.

This paper provides an overview of the Neighborhood Quality of Life Study. NQLS was jointly designed by planners and health researchers to examine associations between the built environment and physical activity. Increased collaboration between planners and public health professionals is needed to devise methods to increase population levels of physical activity.^{4 12} Low levels of physical activity increase the risk of a variety of adverse health conditions and are responsible for at least 200,000 deaths per year in the United States³⁴ so this is an important public health priority. It is widely believed that major societal trends, in particular the dominance of automobile-oriented land development patterns over the past several decades and the associated decline in walking for transportation, contribute to the low levels of physical activity.^{3 17 18} Though there is substantial evidence to support a conclusion that people walk and cycle less for

transportation in low-density, single-use suburban neighborhoods^{8 13 17}, few studies to date have examined total physical activity, investigated socio-demographically diverse samples, or measured variables with the quality and detail needed to provide guidance to urban planners, urban designers, landscape architects, and developers about how to build more activity-friendly communities. NQLS fills these and other important gaps in the literature and it investigates the relation of urban form to a variety of other health-related outcomes that have been proposed but seldom investigated.^{16 19 28}

There are many opportunities to build on the current NQLS study. One priority is the assessment of older adults in the same NQLS neighborhoods. Because international trends in land development, physical activity, and obesity prevalence apparently are becoming more similar to the U.S.³⁵ it is important to conduct parallel studies in other countries. In collaboration with the NQLS team, researchers from the University of Queensland in Australia are employing the methods presented in this paper with funding from the National Health Medical Research Council. Thirty-two neighborhoods in Adelaide, South Australia were selected using these methods as part of the Physical Activity in Localities and Community Environments (PLACE) and comparative analyses with the current study (NQLS) are underway. The Australian study provides the first basis for cross-cultural validating of the approach to community selection presented in this paper.

The Neighborhood Quality of Life Study (NQLS) demonstrates the importance of transdisciplinary teams who by working together have a unique capability to conceptualize innovative research questions, methods, and interpretation of outcomes.^{4 12 36} The study required input from urban planning, behavioral science, and

public health professionals. This project could not have been conceived or implemented within any single field, yet may contribute to advancements in science and practice in several fields. By working across disciplines, it is possible for transportation, health, and environmental sectors to leverage each other's fiscal and political resources. This synergy across disciplines can lead to a greater understanding of the health, environmental, and quality of life impacts of transportation investments and land use decisions.^a

^a Surveys and related documentation on the NQLS study are available for download from www.nqls.org.

Acknowledgements

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Table 1: King County and Baltimore-Washington Walkability Deciles Based on z-Scores

	King County			Baltimore-Washington	
	Decile	Low End	High End	Low End--High End	
Low Walkability	1	-1.3	-0.98	-1.57	-1
	2	-0.97	-0.75	-0.99	-0.75
	3	-0.74	-0.55	-0.74	-0.56
	4	-0.54	-0.4	-0.55	-0.35
	5	-0.39	-0.21	-0.34	-0.16
	6	-0.2	-0.01	-0.15	0.02
High Walkability	7	0	0.24	0.03	0.26
	8	0.25	0.58	0.27	0.59
	9	0.59	1.16	0.6	1.13
	10	1.17	6.96	1.14	8.18

Note: shaded cells were not used for selecting neighborhoods.

Table 2: King County and Baltimore-Washington Income Deciles

		King County		Baltimore-Washington	
	Decile	Low End --- High End		Low End --- High End	
	1	\$ -	\$ 33,106	\$ -	\$ 26,336
Low Income	2	\$ 33,107	\$ 40,761	\$ 26,337	\$ 33,500
	3	\$ 40,762	\$ 46,078	\$ 33,501	\$ 33,392
	4	\$ 46,079	\$ 51,618	\$ 39,393	\$ 44,931
	5	\$ 51,619	\$ 56,696	\$ 44,932	\$ 50,907
	6	\$ 56,697	\$ 62,431	\$ 50,908	\$ 58,500
High Income	7	\$ 62,432	\$ 69,063	\$ 58,501	\$ 67,250
	8	\$ 69,064	\$ 77,242	\$ 67,251	\$ 77,781
	9	\$ 77,243	\$ 88,705	\$ 77,785	\$ 94,796
	10	\$ 88,706	\$ 150,000	\$ 94,797	\$ 150,000

Note: shaded cells were not used for selecting neighborhoods.

Table 3: Descriptive Statistics of King County Neighborhoods Selected for NQLS

Neighborhood	Walk / Income Status	Intersection Density		Net Residential Density		Entropy (Land Use Mix)		Retail FAR		Walkability Z-Score	Median Household Income (2000 Census)
		Raw Score	Z- Score	Raw Score	Z- Score	Raw Score	Z- Score	Raw Score	Z- Score		
Kenmore	Low / Low	14.41	-1.00	2.77	-.24	.25	.17	.27	0.33	-1.74	\$61,154
Kent East Hill	Low / Low	22.07	-.76	18.70	-.05	.68	1.93	.16	-0.03	0.33	\$31,959
Martin Luther King	Low / Low	72.17	.60	8.18	-.17	.07	-.57	.36	0.64	1.1	\$42,342
Skyway	Low / Low	36.45	-.39	3.63	-.23	.39	.73	.38	0.72	0.44	\$57,705
Federal Way	Low / High	48.72	-.05	8.52	-.17	.05	-.69	.16	-0.03	-0.99	\$65,983
Newport/Newcastle	Low / High	30.47	-.55	4.36	-.22	.01	-.82	.00	-0.56	-2.7	\$80,708
Redmond	Low / High	33.57	-.47	8.81	-.16	.10	-.48	.00	-0.56	-2.14	\$64,427
Sammamish	Low / High	24.92	-.71	2.57	-.24	.04	-.69	.32	0.51	-1.84	\$97,690
Auburn	High / Low	54.22	.11	9.77	-.15	.70	1.99	.58	1.37	3.43	\$31,817
Beacon Hill	High / Low	120.03	1.93	25.84	.03	.30	.36	.44	0.91	5.16	\$36,077
White Center	High / Low	69.46	.53	9.99	-.15	.60	1.61	.50	1.12	3.64	\$36,464
Broadway	High / Low	131.87	2.24	159.79	1.6	.67	1.95	.51	1.17	9.2	\$37,105
Kirkland	High / High	50.44	.00	18.56	-.05	.88	2.73	.40	0.78	3.46	\$62,627
Capitol Hill	High / High	60.88	.29	13.12	-.11	.17	-.20	.44	0.90	1.17	\$85,695
Upper Queen Anne	High / High	77.01	.74	13.72	-.11	.30	.37	.56	1.30	3.04	\$82,029
Admiral	High / High	74.29	.66	20.53	-.02	.56	1.44	.56	1.30	4.04	\$46,876

Table 4: Descriptive Statistics of Baltimore – Washington Region Neighborhoods Selected for NQLS

	Walk / Income Status	Intersection Density		Net Residential Density		Entropy (Land Use Mix)		Retail FAR		Walkability Z-Score	2000 Median House-hold Income
		Raw Score	Z-Score	Raw Score	Z-Score	Raw Score	Z-Score	Raw Score	Z-Score		
Millford Mill	Low / Low	46.05	-0.31	6.63	-0.10	0.18	-0.78	0.00	-0.49	-0.66	\$ 42,278
Langley Park	Low / Low	44.56	-0.33	14.51	0.69	0.24	-0.48	0.02	-0.40	-0.28	\$ 43,036
Carney	Low / Low	57.10	-0.15	6.64	-0.10	0.07	-1.30	0.05	-0.31	-0.67	\$ 44,508
Belvedere	Low / Low	23.03	-0.63	5.56	-0.20	0.43	0.39	0.08	-0.19	-0.42	\$ 40,720
Oakland Mills	Low / High	54.35	-0.19	3.77	-0.39	0.18	-0.78	0.00	-0.49	-0.68	\$ 81,777
Damascus	Low / High	2.91	-0.91	0.45	-0.72	0.45	0.44	0.08	-0.21	-0.77	\$ 86,772
New Carrollton	Low / High	35.35	-0.45	4.70	-0.29	0.32	-0.13	0.04	-0.36	-0.56	\$ 68,224
Landing Road	Low / High	12.05	-0.78	2.15	-0.55	0.26	-0.39	0.05	-0.29	-0.93	\$ 83,617
Silver Spring	High / Low	94.78	0.37	33.17	2.57	0.59	1.11	0.26	0.47	2.83	\$ 37,571
Mount Rainier	High / Low	54.61	-0.19	9.46	0.19	0.54	0.87	0.38	0.95	0.55	\$ 41,433
Waverly	High / Low	182.20	1.59	7.39	-0.02	0.43	0.38	0.00	-0.49	1.02	\$ 34,668
Belaire Edison	High / Low	116.33	0.67	11.97	0.44	0.26	-0.42	0.78	2.44	1.27	\$ 35,358
Bethesda	High / High	66.59	-0.02	35.45	2.80	0.57	1.01	0.64	1.91	1.90	\$ 65,789
Roland Park	High / High	83.63	-0.22	10.59	-0.30	0.41	0.31	0.47	1.26	0.77	\$ 86,300
Federal Hill	High / High	273.62	2.86	8.11	0.05	0.55	0.96	1.06	3.48	3.41	\$ 66,739
Rockville	High / High	44.68	-0.33	8.59	0.10	0.56	0.98	0.11	-0.08	0.12	\$ 69,224

Figure 1: Distribution of Seattle-King County Walkability Measures

Figure 2: Distribution of Baltimore-Washington Walkability Measures

Figure 3: Household # of walk trips by walkability deciles

Figure 4: Household Vehicle Miles Traveled by walkability deciles

Figure 5: Map of the 16 King County Neighborhoods

Figure 6: Map of the 16 Baltimore – Washington Metropolitan Region Selected Neighborhoods and Walk and Income Deciles

Figure 7 – Kent East Hill

Figure 8 – Greenmount Avenue in Waverly

Figure 1: Distribution of Seattle-King County Walkability Measures

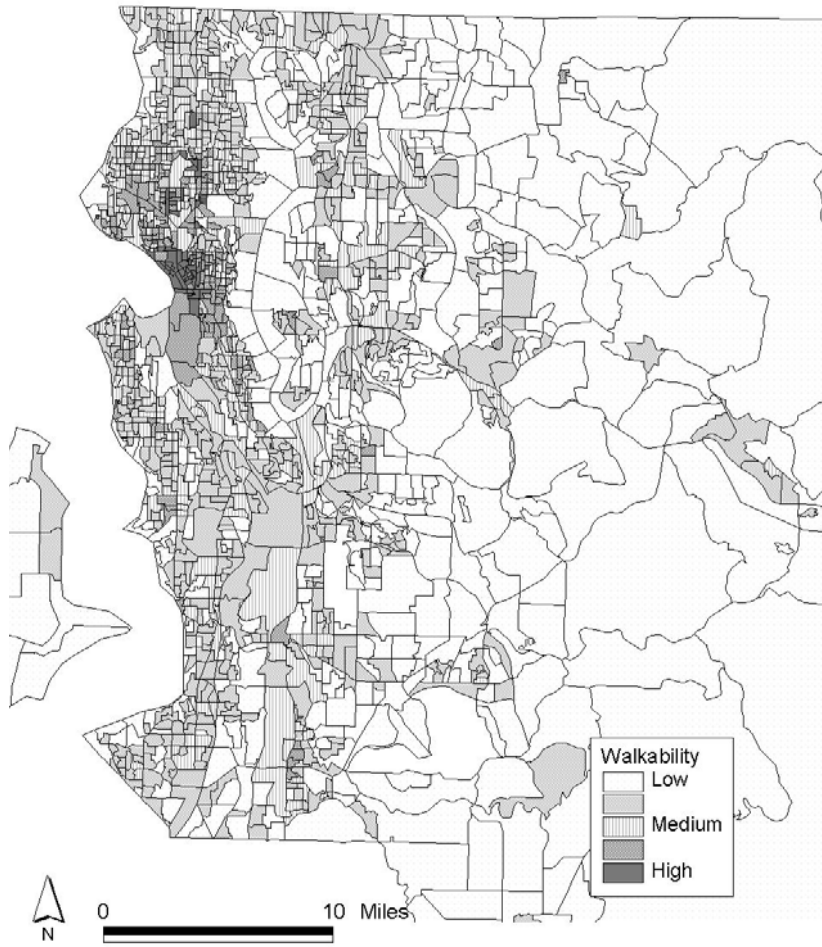


Figure 2: Distribution of Baltimore-Washington Walkability Measures

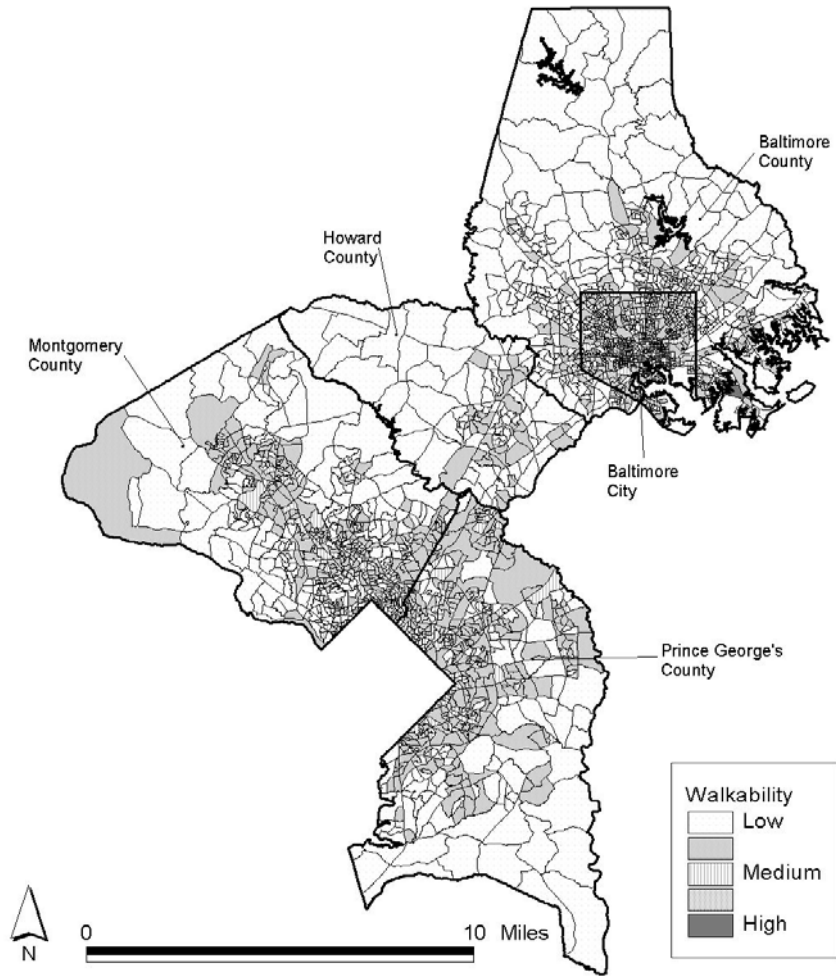


Figure 3: Household # of walk trips by walkability deciles

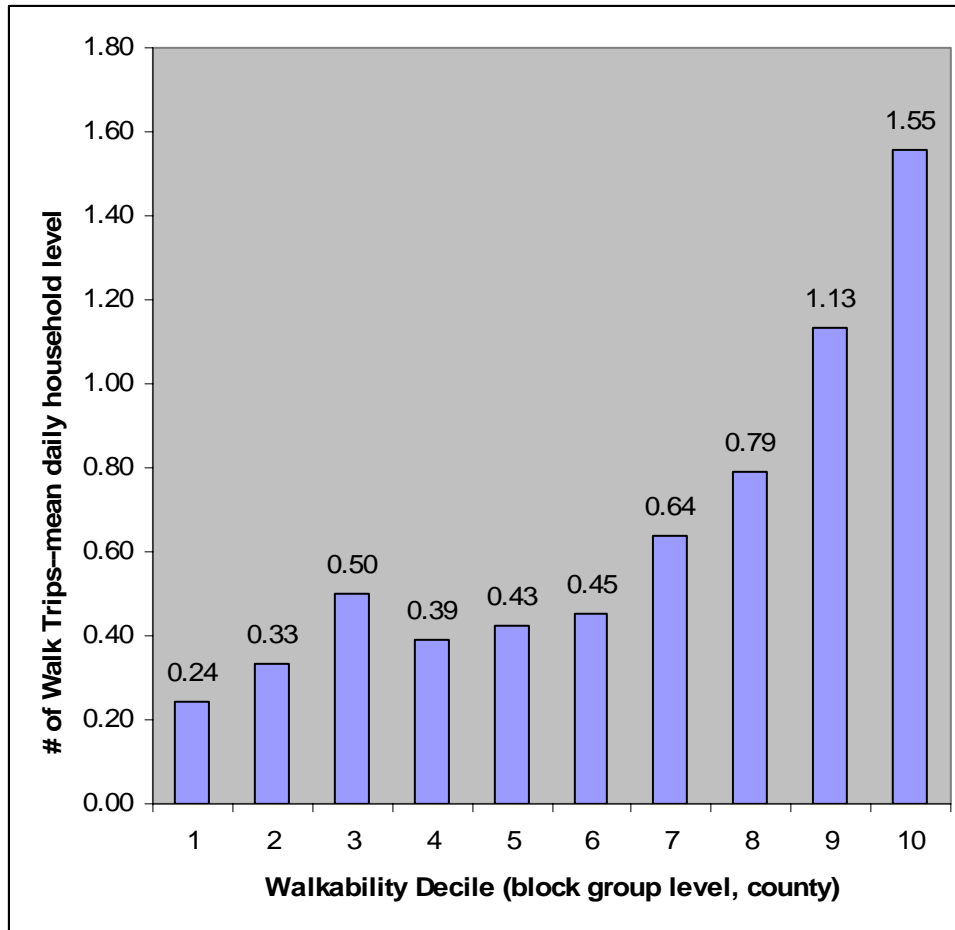


Figure 4: Household Vehicle Miles Traveled by walkability deciles

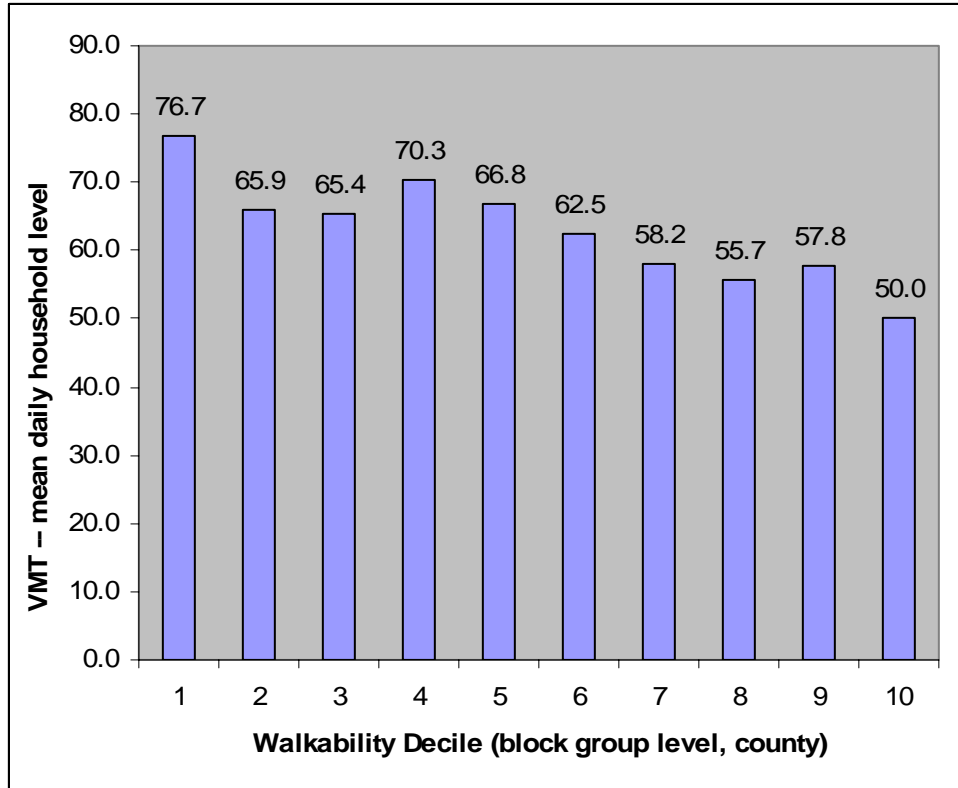
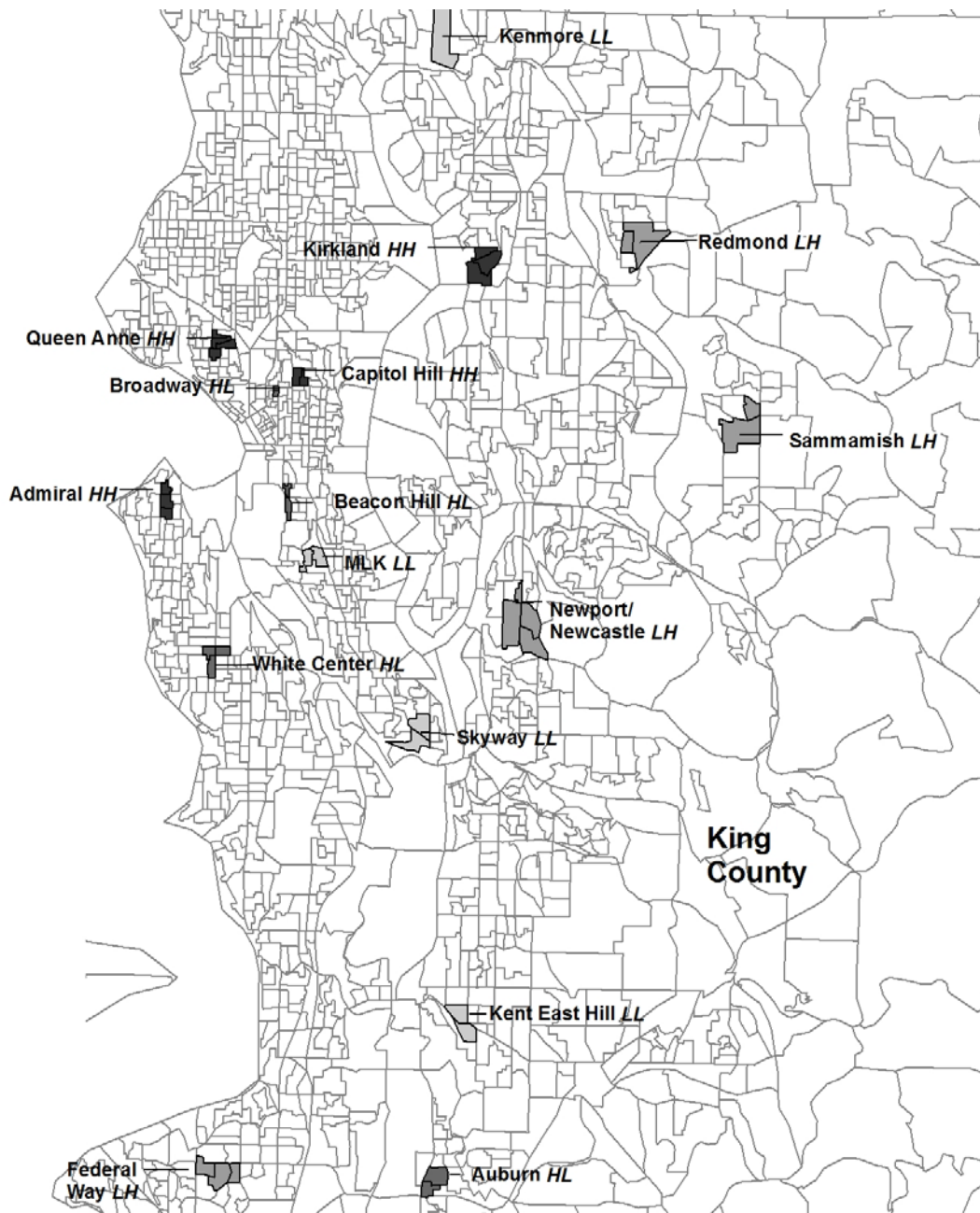


Figure 5: Map of the 16 King County Neighborhoods



Legend:






-  Low Walk - Low Income Communities
-  Low Walk - High Income Communities
-  High Walk - Low Income Communities
-  High Walk - High Income Communities
-  Census Blockgroups

Figure 6: Map of the 16 Baltimore – Washington Metropolitan Region Selected Neighborhoods and Walk and Income Deciles

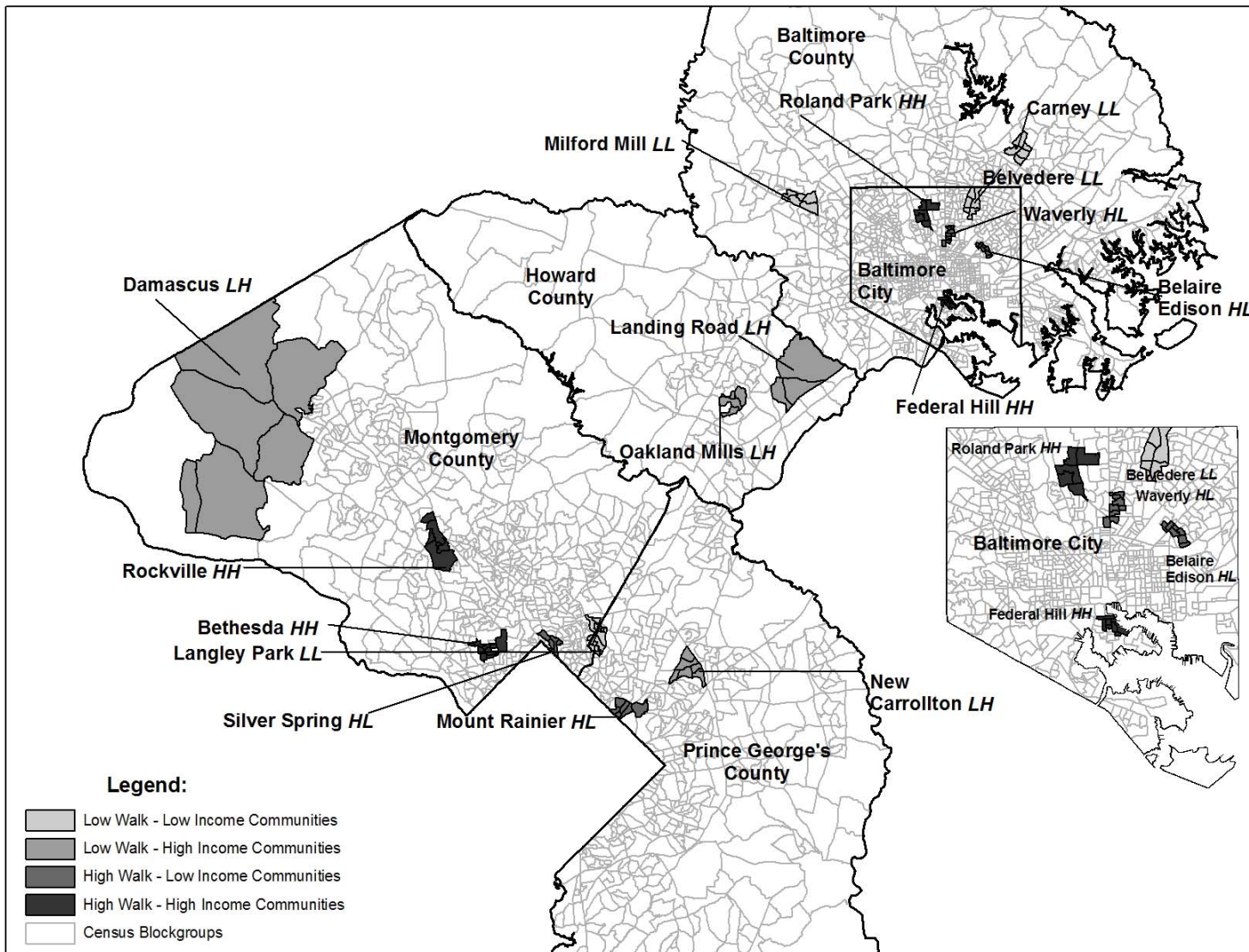


Figure 7 – Kent East Hill

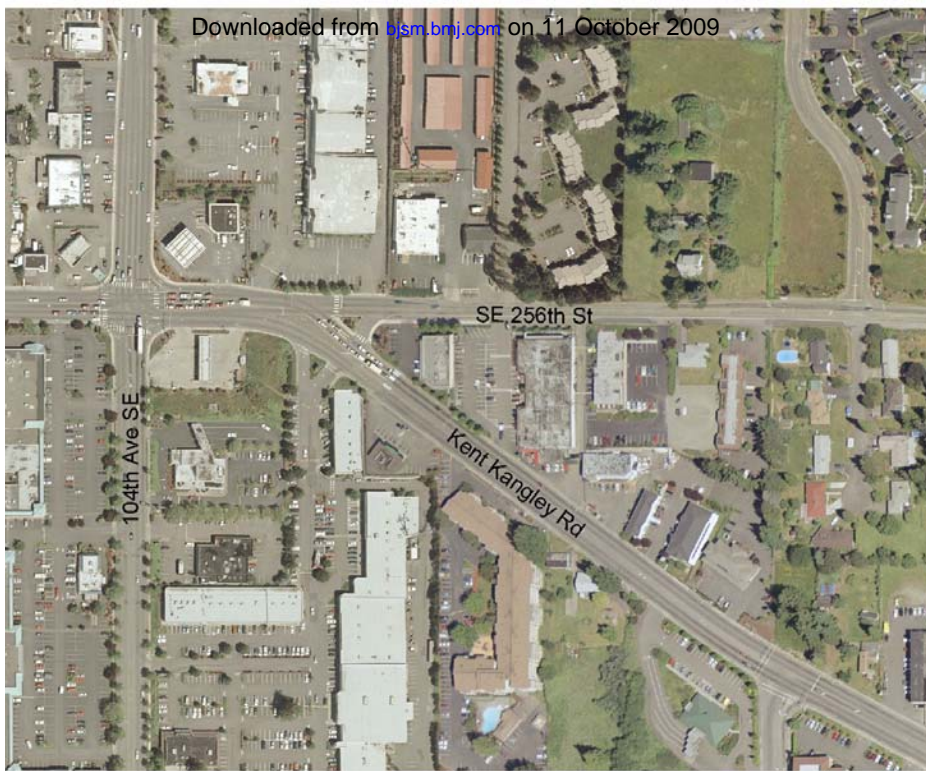


Figure 8 – Greenmount Avenue in Waverly

