GENDERED WALKABILITY: BUILDING A DAYTIME WALKABILITY INDEX FOR WOMEN IN SAN FRANCISCO

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by

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CERTIFICATION OF APPROVAL

I certify that I have read Gendered Walkability: Building a Daytime Walkability Index for Women in San Francisco by Yael Golan, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Arts in Geography: Resource Management and Environmental Planning at San Francisco State University.

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Urban walkability is determined both by built environment features and pedestrian characteristics. Research has shown that factors influencing women's walking differ than those affecting men's. Using a mixed-method approach, this study aims to create a new women-specific walkability index and answer three questions: 1) *Which variables most influence women's propensity to walk?* 2) *Where in San Francisco are the most and least walkable places for women?* And 3) *Does the leading walkability index at present, Walk Score, account for women's walkability?* Focus group participants (n=17) ranked crime, homelessness and street and sidewalk cleanliness as the three most influencing factors on women's walkability, accounting for 56%-67% of the Women's Walkability Index's total score. The lowest walkability areas in San Francisco according to this index are the Downtown and South of Market (SoMa) areas, which are some of the most walkable neighborhoods in the city according to Walk Score, despite high crime and homelessness density. Walk Score is negatively correlated with the new Women's Walkability Index (Spearman's rho = -0.585) and is therefore concluded to inaccurately represent women's walkability. If the new index accurately represents the reality of women's walking then some of the most deep-rooted assumptions and widely accepted conventions about what kind of areas promote walking are false when it comes to women.

I certify that the Abstract is a correct representation of the content of this thesis.

Chair, Thesis Committee Date

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Introduction

This study aims to devise a new, women-specific walkability index, and answer these three research questions: *1) Which variables most influence women's propensity to walk? 2) Where in San Francisco are the most and least walkable places for women?* And *3) Does the leading walkability index at present, Walk Score, account for women's walkability?*

Urban walkability has been linked to many benefits for those residing in walkable neighborhoods, including increased physical activity and related health benefits; increased social cohesion; and improved economic performance, with higher real estate values for both residences and businesses. Walkability also provides many environmental benefits. Because of walkability's ability to promote walking, biking and use of public transit (Cervero & Duncan, 2003), and its association with reduction in vehicle miles traveled (VMT) (Diao & Ferreira, 2014; Frank et al., 2006; Talen & Koschinsky, 2014), walkable neighborhoods are associated with higher air quality (Frank et al., 2006), and walkability is considered a key component in curtailing greenhouse gas (GHG) emissions from vehicles in urban areas.

The level of walkability in an area is largely influenced by built environment features like pedestrian amenities, land-use mix and proximity to destinations, and is also affected by individual characteristics like the level of familiarity with the area, and by demographic factors such as gender. With the aid of Geographic Information Systems (GIS) and other advanced technologies, researchers can now measure, model and understand the physical and built-environment features that influence walkability better than ever before (Leslie et al., 2007), though the question of how specific personal characteristics influence walking remains largely unanswered.

One prominent online tool that makes use of modern technology to analyze walkability is Walk Score, which uses a distance decay function (which represents the rate at which a particular activity or process diminishes with increasing distance) to rank the walkability of an address based on its proximity to nearby destinations such as restaurants and retail businesses (Walk Score, n.d.). Walk Score is generally considered by academics a reliable measure for neighborhood walkability, but has also been criticized in some peer-reviewed studies for being over simplistic and neglecting to incorporate many elements considered to be associated with walkability (Carr, Dunsiger, & Marcus, 2010; Duncan, Aldstadt, Whalen, & Melly, 2012; Talen & Koschinsky, 2013).

Despite both the richness of available data and the large volume of current research on walkability, the study of specific needs and concerns of women when walking continues to be limited (Owen, Humpel, Leslie, Bauman, & Sallis, 2004). Studies that have focused on gender in the context of walking have generally pointed to substantial differences between men and women in regards to their sensitivity to traffic (Clifton & Livi, 2005), pedestrian infrastructure (Clifton & Dill, 2005) and other built environments and streetscape features (Park & Calvert, 2008). Fear of violent crime when walking has been the most dominant theme of research in the context of women's walkability (Koskela & Pain, 2000; Loukaitou-Sideris, 2006; Pain, 2001; Valentine, 1989) and little attention has been given to the gendered patterns of walking outside this dominant perspective of women's fear of crime.

The limited academic attention to women's pedestrian experiences points to a gap in the research on walkability, and in our understanding of walkability. Consequently, existing patterns of gendered spatial exclusions (Law, 1999) may be exacerbated, leading to the further exclusion of women, establishment of 'no-go' areas and reduced walking at night (Hodgson, 2012).

This thesis aims to address some of the gaps in women's walkability research by creating a women-specific walkability index focusing on daytime walking, when fear of crime is assumed to be less pronounced. By employing a mixed-method approach comprised of focus groups, GIS analysis and statistical analysis, three research questions are specifically explored: 1) *Which variables most influence women's propensity to walk?* 2) *Where in San Francisco are the most and least walkable places for women?* And 3)

Does the leading walkability index at present, Walk Score®, account for women's walkability?

The focus on San Francisco in this study stems both from its status as a highly walkable city – consistently ranked the second most walkable large city in the U.S. (Walk Score, 2016) – and the city's culture of walking, with almost a quarter of daily trips made by foot (SFMTA, 2014), a much larger share than the national average of about 10% (U.S. Department of Transportation, 2011). However, the methodology utilized to create the Women's Walkability Index for San Francisco can be replicated for any city given availability of relevant data.

Understanding the mechanisms and built-environment features that influence women's propensity to walk in a large city like San Francisco can have important implications for the ability of urban planners and policy makers – locally, regionally and nationally - to improve female residents' pedestrian experience, increase overall walkability, and create better, more pedestrian-friendly environments that encourage walking over driving, for both genders. Furthermore, improving walkability for women today may prove to have positive implications for future generations' walking patterns.

Literature Review

What is Walkability?

The issue of walkability, the degree to which an area or a neighborhood is considered "walkable" or hospitable to pedestrians, has gained prominence in the last decade. Scholars from various disciplines including public health, urban planning, geography and others, have taken an interest in the determinants of walkability and in its potential benefits. This newfound interest has resulted in an abundance of current research on walkability.

Over the past century, pedestrian access in many cities has declined due to advances in auto-centric transportation that degraded the pedestrian environment. This degradation eventually resulted in auto-oriented and pedestrian-hostile cities and neighborhoods, initially in the U.S., and later throughout the world (Forsyth & Southworth, 2008). But auto-oriented development is not the only thing hindering walkability. Other elements, like safety concerns, lack of appealing destinations and, perhaps, a preference for the auto-centric lifestyle, are also at play. As Cervero & Duncan (2003) put it, "Many factors conspire against walking and bicycling in contemporary urban America, and car-dependent landscapes is just one of those factors" (p. 1482).

In recent years, with increased understanding of the connections between automobility and environmental degradation, and between physical activity (such as walking) and physical and mental health, improved walkability and the creation of walkable human environments have become widely accepted goals by researchers, urban planners, environmentalists and health professionals.

Walkability is a broad concept that can be defined and interpreted in many ways, depending on the specific context in which it is being discussed. In fact, different scholarly fields define walkability and what constitutes a walkable environment quite differently. Forsyth and Southworth (2008) claim that the recent focus on walkability in the context of health – in which a walkable environment is one that promotes physical activity - has overshadowed other connotations of walkability. They offer several examples for competing definitions. By one definition, prevalent in the realm of transportation planning, walkable is interpreted as “close”, and a walkable environment is therefore one that involves short distances to various destinations, thus reducing or eliminating automobile dependency. A walkable environment can also be interpreted as barrier-free or easily traversable; equipped with pedestrian infrastructure such as sidewalks, street furniture and trees; objectively safe or perceived as such in terms of crime or traffic; or upscale and cosmopolitan, with pleasant, clean, lively and interesting streets (Forsyth & Southworth, 2008).

Geographers Talen & Koschinsky (2013) define the walkable neighborhood as a “safe, well-serviced neighborhood, imbued with qualities that make walking a positive experience” (p. 43), meaning that pedestrian routes are both comfortable and visually interesting. The walkable neighborhood is characterized by social, economic and land use diversity; mixed uses and functions; an urban layout that encourages pedestrian activity; quality public spaces that promote social interaction; and equitable access to goods, services, and facilities (Talen & Koschinsky, 2013). Elsewhere, these same researchers describe a walkable neighborhood as having “plenty of nearby destinations” and employing “certain forms known to enhance walkability, such as interconnected street networks and short blocks” (Talen & Koschinsky, 2014, p.727). That is to say, no one definition of walkability, even within a specific field of study, can presume to represent the entirety of the concept and include its many physical and social attributes.

Health Benefits

The focus of walkability research in the last decade or so has been on the potential health benefits of walkable environments. Walking is the most prevalent physical activity in adults (Moudon et al., 2006; Owen et al., 2004), and much research in the last decade has examined the relationship between walkability and such health-related parameters as physical activity, body mass, weight and chronic illness. Neighborhoods considered walkable have been shown by researchers to have a positive impact on rates of physical activity, particularly walking, thus improving health (Durand, Andalib, Dunton, Wolch, & MA, 2011; Mitra & Buliung, 2014; Talen & Koschinsky, 2013, 2014).

Some studies, however, have found that walkability does not necessarily enhance physical activity. For example, the positive association between walkability and physical activity consistently found in adults does not hold true for children. Janssen & King (2015) found that children who lived in low-walkability neighborhoods were more likely to be physically active outside of school hours and to achieve recommended levels of moderate-to-vigorous physical activity than were children who lived in high-walkability neighborhoods.

Other research has shown that the physical benefits of walkability may vary greatly across gender, race, age and socioeconomic status. For example, affluent residents have been shown to be less likely to walk, even in the most walkable of neighborhoods, when compared to low-income populations with limited car access in the most hostile pedestrian environments (Hess & Farrow, 2010; Manaugh & El-Geneidy, 2011).

Economic benefits

A second assertion regarding the benefits of walkability is that walkable locations enjoy certain economic benefits. Generally speaking, increased walkability leads to higher economic performance, including premiums on office, retail and residential rents; premiums in residential housing values; and an increase in retail sales (Leinberger & Alfonzo, 2012).

One of the best-studied economic benefits is the real estate premium associated with walkability. Cortright (2009), for example, examined 15 U.S. housing markets and found that in 13 of them, an additional one-point increase in Walk Score was associated with a home value increase of $700 to $3,000. In San Francisco, every one-point increase in Walk Score was associated with an increase of $2,985 in house value. In addition, in 13 of 15 housing markets examined, houses with above-average walkability levels enjoyed a premium of $4,000 to $34,000 in sale price compared to houses with only average levels of walkability. In San Francisco this walkability premium was as high as $32,837 per house (Cortright, 2009). Leinberger & Lynch (2014) analyzed the 30 largest metropolitan areas in the U.S. and found that walkable urban office space was priced at 74% above office space in drivable suburban areas, in terms of rent-per-square-foot, and that these price differences seem to be growing. Gilderbloom, Riggs, & Meares (2015) found that walkability is able to predict an increase in neighborhood housing values, and that it has a significant negative correlation with housing foreclosures (meaning that there are less foreclosures in more walkable neighborhoods).

Walkability's economic benefits do not only manifest in real estate premiums, but also in residents' affluence. In a study of Washington D.C. metropolitan area, Leinberger & Alfonzo (2012) found that residents of walkable neighborhoods are generally more affluent and have higher educational attainment and higher employment rates than do residents of less walkable neighborhoods. Additionally, residents of more walkable areas enjoy lower transportation costs and higher transit access (but have higher housing costs) compared to residents of low walkability neighborhoods. The researchers also found that clustered walkable neighborhoods rate better in terms of most economic indicators than do stand-alone walkable neighborhoods, meaning that walkable neighborhoods benefit from proximity to other walkable neighborhoods.

Social Benefits

Another strain of walkability research has examined the social implications of living in a walkable neighborhood or a walkable community. Such research often finds enhanced sense of community and enhanced sociability in walkable neighborhoods. For example, a study of the new walkable community Mueller in Austin, Texas, revealed that residents who moved to Mueller from less walkable neighborhoods not only increased their walking, but also their social interactions, and as a result improved their perception of social cohesion (Zhu, Lu, & Yu, 2013).

Leyden (2003) found that residents of walkable neighborhoods have higher levels of social capital than residents of car-oriented suburbs, and are more likely to know their neighbors, participate politically, trust others, and be socially engaged than suburbanites. Yet differences emerge when examining actual versus perceived walkability. While perceived walkability seems to be positively and significantly correlated with social interaction, actual physical walkability is not, and neighborhood social interaction only increases when *perceived* walkability is high but not when *actual* walkability is high. Furthermore, sense of community is found to be negatively correlated with actual walkability, possibly because high walkability also means higher density and higher levels of crime, which hamper residents' sense of community (Jun & Hur, 2015).

Women's Mobility

Beginning in the late 1970's, as feminist geographers and urban planners began criticizing gender-blindness in transportation research, some researchers started incorporating gender-related issues into their studies. Still, as Law (1999) claims, the gendered analysis of mobility remained mostly limited to travel behavior and policy and women's shorter work-trips, completely ignoring non-work trips, trips made by older or unemployed women, and potential trips that were not made. Despite some progress, the potential of a feminist geography of gender and mobility remains largely unexploited (Law, 1999).

Studies from the past few decades have documented significant differences in the mobility patterns of men and women, which manifest both in trip distance and in travel mode choice. Historically, men took control over the car while women turned to other modes like walking and public transit, and women today still drive far less than men do and use a more varied mix of transportation modes (Frändberg & Vilhelmson, 2011).

Studies have consistently shown that western women (particularly in the United States, where most studies have taken place, but also in Europe) tend to travel shorter distances and by different travel modes than men, who typically enjoy greater car access than women (Domosh & Seager, 2001; Frändberg & Vilhelmson, 2011; Hess & Farrow, 2010), yet women's travel patterns tend to be more complex. Despite the fact that they travel fewer miles than men, they make more daily trips than men, although the gap is decreasing (Frändberg & Vilhelmson, 2011; Gossen & Purvis, 2004; Rosenbloom, 2004). For example, a 2004 UC Davis study found that women drive an average of 141 miles in a typical week compared to 184 miles for men (Handy, 2006), and a study by Frändberg and Vilhelmson (2011) found that men's average daily travel distance was 48 kilometers (≈30 miles) in 2006, while women travelled an average of 35 kilometers (≈22 miles) per day. The same study found that women in 2006 were more likely than men to travel by foot (27% of women vs. 19.2% of men) or by public transit (8.4% of women vs. 6.2% of men), and were more likely than men to travel by car as passengers (17.5% compared to 7.2% of men), but were less likely than men to travel by car as drivers (36.7% of women vs. 56% of men).

Women's work commutes in particular tend to be shorter than those of men (Gossen & Purvis, 2004; Hudson, 2015; Law, 1999). Gossen and Purvis (2004) compared Bay Area Travel Surveys, for the years 1990 and 2000, and found that in both years, men had longer commute times than women, though the difference was decreasing: in 1990 men's average work commute was 10 minutes longer than women's, and in 2000, while both genders have increased their average work commute, the difference between men's and women's commute had decreased to three minutes. Nevertheless, a more recent study in two Swedish cities conducted by Hudson (2015) found that more women than men commute distances of 10 kilometers or less (57% of women compared with 46.5% of men), while more men (53.5%) than women (43%) have commutes of 11 kilometers or more.

Though gaps between the genders in terms of general mobility and commute-to-work distances seem to be converging (Frändberg & Vilhelmson, 2011; Gossen & Purvis, 2004), feminist geographers point to these distance and mobility constraints as limitations on women's access to opportunities (Law, 1999; Tivers, McDowell, & Bowlby, 1984) and view gender differences in patterns of travel as mirroring gender differences in resource access, social positions and activity patterns (Frändberg & Vilhelmson, 2011).

Women's Walking

In light of the differences described above in the general daily mobility patterns of women and men, it is to be expected that gender differences will be evident in walking patterns as well. As women commute shorter distances than men, and many times have diminished car access compared to men, it seems only natural that many women will turn to walking as a major transportation mode. Indeed, when Hess and Farrow (2010, pg. 4) studied the walkability of Toronto's high-rise neighborhoods they noted the significance of walking to women: "For women in particular, walking is extremely important to the quality of their daily lives as many reported not having access to a vehicle and also as being responsible for most household maintenance activities". It is therefore imperative to understand female pedestrians' preferences and needs, as well as barriers to walking.

While a considerable amount of research has focused on gender differences in travel patterns, little of this work has focused on pedestrian travel (Clifton & Livi, 2005), and much of the academic research on walkability has been gender-blind. In a systematic review of studies on the relationship between built environment attributes and walking, very few of the studies included a gendered analysis, though the few studies that incorporated such an analysis reported significant differences between men and women (Owen et al., 2004). A few researchers, like Clifton and Livi (2005) for example, have acknowledged that built environment attributes may have different effects on women and men, and have therefore began studying the gender differences in pedestrian behavior, attitudes about walking, and perceptions of the built environment. Clifton's and Livi's results show that, generally speaking, "women tend to be more sensitive to safety issues, frequent different destinations and have different amounts of pedestrian activity compared to men" (Clifton & Livi, 2005, pg. 83).

The question of who walks more - men or women - remains unanswered. While some claim that women tend to make fewer walking trips than men (Cervero & Duncan, 2003; Handy, 2006) and that walking for transportation is more prevalent among men than women (Berrigan, Pickle, & Dill, 2010), others find that women are more likely to engage in some level of walking and less likely to be completely sedentary compared to men, but men are more likely to walk longer distances of more than one mile per day (Clifton & Livi, 2005). In a study of 2,800 Czech adults over 50, significantly more women than men reached the recommended walking-time of 30 minutes five times a week (67.3% and 60.7%, respectively). These differences were significant when walking for transport (51.8% of women compared to 40% of men), but not when walking for leisure (22.3% of women vs. 21.2% of men) (Pelclová, Frömel, & Cuberek, 2013).

Regardless of who walks more, it seems that women value walkability more: in a 2015 survey of adults living in the 50 largest metropolitan areas in the U.S., 61% of women stated it was very important to have sidewalks and places to take walks when deciding where to live, compared to only 49% of men; and 46% of women said it was very important to them to be within easy walking distance of places in the community, compared to only 37% of men (Dill & Morris, 2015).

Women are also more sensitive as pedestrians to built environment features. Guo and Loo (2013), for example, had pedestrians in New York and Hong Kong rate several route attributes and found that in both cities, women were generally more sensitive to the pedestrian environment than were men. When asked if improvements to the built environment would change their walking behavior, women are less likely than men to respond in the negative (Clifton & Livi, 2005). Indeed, a systematic review of 47 different studies on the determinants of intensity and type of physical activity among adults found that the only type of physical activity for which environmental determinants may differ between men and women is walking behavior (Wendel-Vos, Droomers, Kremers, Brug, & Van Lenthe, 2007). Walking is also seen as a particularly important form of exercise for women (Handy, 2006). Sugiyama et al. (2007) looked at the relationship between walkability and TV viewing time among adults in Australia and found that while men's TV viewing time was not associated with walkability, women's viewing time was: women in low walkability neighborhoods spent approximately 30 more minutes a day watching TV than women in high walkability neighborhoods. This suggests that for women, not only does walkability promote walking, but it also has the potential to reduce the time spent in sedentary behaviors.

Built environment attributes seem to affect women differently when walking for transport than when walking for leisure (Handy, 2006). Differences between women's walking for transport and their walking for leisure were found in a study by Kylie Ball et al. (2007), in which walking track length, and perceived neighborhood aesthetics and safety were both positively correlated with women's walking for leisure, but not with walking for transport. On the other hand, street connectivity was associated only with walking for transport, and not with walking for leisure. Pelclová et al. (2013) found that in women walking for transport, two built environment attributes were significantly related to meeting walking recommendations: land-use mix and neighborhood aesthetics. Women living in highly mixed neighborhoods and women living in more aesthetically pleasing neighborhoods were more likely to meet walking recommendations when walking for transport.

These studies suggest that women's leisure-time walking is more sensitive to built environment attributes, while walking for transportation may be based primarily on need and distance and allows for less choice. While the distinction between leisure-time walking and walking for transportation is an important one, this study will not differentiate between these two types of walking. Since the goal of this study is to identify the variables that affect women's overall pedestrian experience - negatively or positively - and create an index of women's walkability, partitioning by walking purpose may reduce generalizability and thus undermine the analysis. Therefore, with the exception of walking for exercise, all types of women's daytime walking will be considered in this analysis.

Additional built environment attributes that have been shown to interact with women's walking behavior, other than those related to fear of crime (which will be reviewed later in a dedicated section), include pedestrian amenities such as the presence (Clifton & Dill, 2005) and width (Handy, 2006) of sidewalks and walkways, which tend to affect women more than they do men; noise and construction (Guo & Loo, 2013); and pedestrian safety attributes (safety from traffic), which can be measured by such variables as street lights, traffic volume (Handy, 2006) and the number of street crossings (Guo & Loo, 2013).

Pedestrian safety is usually of greater importance to women than it is to men. In a pedestrian survey conducted near transit stops in California and Oregon in 2008, women were much more likely than men to rate traffic safety factors as important in the context of walking, with 69% of women rating the presence of traffic as very important compared to only 43% of men (Weinstein Agrawal, Schlossberg, & Irvin, 2008). In a survey conducted among residents of a walkable neighborhood in Portland, Oregon, women were more likely than men to list safety issues in an open-ended question about their walking habits (28.8% versus 15.6%, respectively), and 10% of the women mentioned the amount of traffic in the context of walking, whereas none of the men did (Clifton & Dill, 2005).

The Role of Children

Children are an important component in women's walking for several reasons. First, because many parents escort children to and from school and other activities, parents' travel behavior both affects, and is affected by, their children. While differences in men's and women's mobility seem to be converging (Frändberg & Vilhelmson, 2011; Gossen & Purvis, 2004; U.S. Department of Transportation, 2011), women's mobility patterns are still different than those of men, and women are still primarily responsible for the majority of household- and family-related trips. According to the 2009 U.S. National Household Travel Survey (U.S. Department of Transportation, 2011), men only made about 80% of the number of trips women made for shopping, family and personal errands, while almost half of all trips by women were for family and personal errands, including escorting children to school or other activities. Yarlagadda & Srinivasan (2008) point to the importance of women's employment status and its interaction with their travel mode choice as mothers: these researchers found that mothers who work full-time are less likely to walk their children to school, and more likely to drive them, compared to part-time and non-working mothers. Thus, women's mode choice is directly influenced by their maternal duties and employment status. In a Montreal, Canada, study Manaugh & El-Geneidy (2011) found that in most households with children, being a woman is positively and significantly associated with walking (the exception was rich households with children), suggesting that for women, having children is conductive to walking. However, a Northern California survey found the contrary: that in walkable neighborhoods, women with children walk less frequently than women without children (though they still walk more frequently than suburban women, with or without children) (Handy, 2006). These findings attest to the important effects that children have on women's mobility and mode choice.

Additionally, as Valentine (1989) notes, "girls are socialized into a restricted use of public space through observing both their parents' differential fears for them and the control of the spatial range of their activities in relation to boys". Thus, the walking patterns that young girls adopt during childhood years may persist into womanhood. Whatever gender differences in walking exist during childhood years are therefore important to identify. Although some researchers have not found any differences in walking between boys and girls (Mitra & Buliung, 2014), others have recorded differences in mode choice and in built environment effects on walking in youth. In an analysis of the 2000 San Francisco Bay Area Travel Survey (BATS), boys were found more likely to bike or drive alone to school and less likely to be walked by their mothers (instances of fathers walking the child to school were very few), suggesting that they enjoy greater independence in their school travel than girls (Yarlagadda & Srinivasan, 2008). Kerr et al. (2007) looked at pedestrian travel of youth aged 5-18 in Atlanta and found that while residential density, intersection density, and mixed land use were all significantly related to walking for both genders, the relationships between walking and intersection density, land use mix, and commercial land use were stronger for girls, while access to recreation space and high residential density showed a stronger association with walking among boys than among girls.

Finally, research indicates that having children makes women somewhat more concerned about their environments (Koskela & Pain, 2000). Poor built environment design can, for example, make it more difficult for mothers with strollers or young children to move around the city (Pain, 2001). Indeed, curb ramps are significantly and positively associated with women's walking, but do not have the same association for men (Clifton & Livi, 2005).

Fear of Crime and Women's Use of City Streets

Women's access to public space and city streets has been, and in many ways still is, riddled with a history of policing and restriction. As Domosh and Seager (2001, p.69) put it, "some of our most powerful assumptions about cities and gender are rooted in a distant past. One of the most powerful of these is the assumption that the city is somehow more masculine. That it is men who are allowed to enjoy its pleasures". These assumptions were evident in 19^{th}-century cities like New York, where women's use of city streets was only allowed if they were accompanied by men or other women, and only during certain times of day (Domosh & Seager, 2001). In many developing countries that is still the case today, and even in western countries women's use of city streets is still spatially and temporally restricted, mostly by their fear of violent crime. This is why, notes geographer Gill Valentine (1989, pg.385), "an understanding of women's use of space necessitates an awareness of their geography of fear". Women, claims Valentine, are socialized from childhood to adopt strategies to mediate and mitigate their fear of crime, predominantly the avoidance of 'dangerous places' at 'dangerous times'.

As aforementioned, fear of crime is the dominant prism through which women's interaction with city streets and women's pedestrian experience have been investigated. Researchers often detect a strong relationship between certain urban built-environment features, women's fear of violence or crime, and women's walking. As Valentine (1989, pg. 386) puts it, "most women, especially at night, have a heightened consciousness of the micro design features of their environment, and adjust their pace and path accordingly". Feminists have argued against 'man-made' built environments that reproduce women's fear and traditional views about women's place in society (Koskela & Pain, 2000; Pain, 2001), claiming that "urban spaces are designed so that they become a 'trap' for women, unpleasant and thus unused...planners created or designed those spaces without paying enough attention to gendered sensitivities" (Fenster, 2006, pg. 224).

While nightfall is considered a barrier to walking for both genders (Cervero & Duncan, 2003), "nighttime entails special fears for women" (Loukaitou-Sideris, 2006, p. 106). Around half of women report being afraid to walk alone at night in their own neighborhood (Albany, 2003), and women report in surveys being fearful walking alone to their car in a parking garage, using public transportation, visiting laundromats or walking by parks, bars and empty lots after dark (Loukaitou-Sideris, 2006). A 2003 Canadian study found that 61% of female respondents in a national survey reported they were somewhat or very worried walking in their neighborhood at night, and almost two thirds (64.4%) of women respondents stated that they walked alone in their neighborhood after dark less than once a week (Scott, 2003).

One cannot discuss fear of crime on city streets without referring to Jane Jacobs' concept of "eyes on the street". Jacobs places streets and sidewalk on the front line of the battle of "civilization versus barbarism in cities" (Jacobs, 1961, pg. 30). She claims that the urban street's most significant role is handling the multitude of strangers that pass through a vibrant city daily, in a way that would promote safety and reduce crime and disorder. In order to do so there must be "eyes on the street" at all times, eyes belonging to residents, shopkeepers and pedestrians. “The sidewalk must have users on it fairly continuously, both to add to the number of effective eyes on the street and to induce the people in buildings along the street to watch the sidewalks in sufficient numbers” (Jacobs, 1961, pg. 35). Thus, claims Jacobs, “a well-used city street is apt to be a safe street” (pg. 34). According to Valentine (1989), women’s fear of crime in public space is basically a fear of unpredictable and uncontrollable behavior by strangers (it is worth noting here that according to Valentine’s research, women perceive only men as strangers). Indeed, a 2008 pedestrian survey held in California and Oregon showed that “eyes on the street”, or the presence of other people on the street when walking, is three times more important to women than it is to men (Weinstein Agrawal et al., 2008). Women are also significantly less likely to walk alone than are men, and report walking with family and friends much more often than men (49% versus 36%, respectively) (Clifton & Livi, 2005), a difference which may be attributed to women’s fear of crime, but may also, at least in part, attest to the differences in household and family-related responsibilities between the two genders.

Koskela and Pain (2000) examined the relationship between the built environment and women’s fear of crime in two European cities, Edinburgh and Helsinki, and found that nearly two-thirds of women in each city reported that they were worried about being attacked by a stranger outside, or found certain parts of the city unsafe or frightening. In Helsinki, 44% of the women surveyed said that certain places in their daily environment were frightening or unpleasant to walk in. Poor street lighting, badly designed buildings and badly placed bushes and shrubbery were among the built environment attributes that deterred women from walking, as were parks, tunnels, underpasses, bridges and cellars.

Roman & Chalfin (2008) analyzed the effects of crime and disorder on walking outdoors in 55 neighborhoods in Washington D.C., and discovered that age, gender and race were highly associated with fear of crime. Older individuals, women and African Americans were more fearful of crime. Women were 52% more likely to report fear than were men, and were more likely to avoid walking in low-crime areas due to fear. In high-crime areas though, both men and women were fearful. In contrast to most studies examining fear, this study did not find an association between the examined built environment features (green space and vacant houses) and fear of crime, for either gender. Hess and Farrow (2010) studied walkability in Toronto's high-rise low-income neighborhoods, and found that many of the residents avoided walking in certain areas or at night. Men generally felt more secure when walking than did women, and women (and the elderly) were more likely to avoid walking at night, or to walk only in well-lit areas if they did.

A survey of transit riders at the ten highest-crime bus stops in Los Angeles revealed that women felt more vulnerable to crime than men, with 59% of the women surveyed feeling unsafe waiting for their bus compared with 41% of men. Additionally, it was found that certain types of crime are more visible to women than to men. Drunkenness, obscene language, verbal threats and groping were particularly concerning to women, as were individuals standing behind them, homeless people, and the proximity of bus stops to vacant buildings or fenced lots, empty of people (Loukaitou-Sideris, 2006).

Other areas or attributes that women try to avoid due to fear of crime, or that are negatively associated with women's walking are large, frequently deserted open spaces, closed spaces with limited exits, subways, alleys and multistory parking lots (Valentine, 1989); streets with hidden spaces, streets with dumpsters and streets with narrow passageways (Park & Calvert, 2008) and parking lots (Clifton & Livi, 2005). Graffiti, vandalism and disrepair were also used by researchers as proxies for the potential for crime (Craig, Brownson, Cragg, & Dunn, 2002), though the relationships between these variables and walking were not studied specifically among women.

Parks, though usually considered by planners and architects to be pedestrian traffic generators, may in fact contribute to women's sense of fear and vulnerability in the public space (Koskela & Pain, 2000). Research has shown that significantly smaller numbers of women than men use parks and open space (Loukaitou-Sideris, 2006) and that in women's eyes, parks are associated with 'dirty old men' (Valentine, 1989). Loukaitou-Siders (2006) surveyed 80 park users in four large parks in Los Angeles and found that while 93% of men felt safe in the park in the daytime, only 75% of women felt the same. While a quarter of male respondents indicated that they came to the park alone, very few women (less than 7%) indicated the same, and more than 75% of the women surveyed said that they would never visit the park after dark, unless going to a large public event.

Finally, specific land uses may also affect women's walking. Certain types of land uses, like liquor stores or bars, for example, are believed to decrease perceived safety for women (Handy, 2006) and are therefore seen as possible deterrents to women's walking. Other types of establishments, like churches, stores and shopping malls, have been shown to be frequented more on foot by women (Clifton & Livi, 2005).

While fear of crime is certainly one of the most influential, if not *the* most influential, factors in women's walking, the complexity of women's mode choice and walking behavior cannot be reduced to one single element and warrants a broader view. Furthermore, women's fear of crime is not evenly distributed throughout the day: it is much more pronounced at night than it is during the day (Valentine, 1989), though for most women it is always present. Since fear of crime at night has such a significant effect on women's travel behavior in general, and walking in particular, to a point that many women refrain from walking at night altogether (Clifton & Livi, 2005; Valentine, 1989), this study's analysis of women's walkability will focus exclusively on daytime walking, which is still closely tied to fear of crime, but is more likely to be the product of interactions between many different factors, fear of crime being one of them. Thus, this study will examine the relationship between women's daytime walkability and some of the factors reviewed here and shown to affect women's walking, in an attempt to understand which of these factors are most important to women pedestrians.

Measuring Walkability: Walk Score

Distance-based measures are some of the most prevalent methods of measuring walkability, by simply calculating the walking distances between residential areas and certain destinations. Distance may also be weighted with built-environment characteristics, such as housing or population density, block length, number of street intersections and others, to create a more precise measure (Goodwin, 2005). Another version of this method is to create a buffer around a certain location and count the number of facilities and amenities, or “opportunities”, within the buffer that can be reached on foot. These “opportunities” can also be weighted according to proximity and importance.

A general measurement of what can be reached on foot is based on the fact that pedestrians walk approximately 3 miles per hour; it takes the average pedestrian 5 minutes to walk 0.25 miles, and 10 minutes to walk 0.5 mile. A 30-minute walk (1.5 miles) is considered an “upper bound” for the maximum distance that people are willing to walk for utilitarian purposes (as opposed to recreational walking). Services, facilities and amenities within 0.25 to 0.5 miles of residences make for a walkable neighborhood (Talen & Koschinsky, 2013).

Using this rule-of-thumb, Walk Score, the popular online walkability index, measures the walkability of an address by analyzing hundreds of walking routes to nearby amenities and assigning points based on the distance to amenities in each category. Amenities within a 5-minute walk (0.25 miles) are given the maximum number of points. The further the amenities are, the fewer points they receive, with no points given to amenities located farther than 1.5 miles (30-minute walk) away (Walk Score, n.d.).

Walk Score was founded in 2007 as a start-up company with the mission to promote walkable neighborhoods for economic and environmental reasons. The company, which was purchased in 2014 by real-estate company Redfin, says its vision is to “make it easy for people to evaluate walkability and transportation when choosing where to live” (Walk score, n.d.). Though its advisory board includes urban planners, smart growth advocates and fellows from The Sightline Institute and The Brookings Institution, Walk Score is a private company in the real estate business and probably has its own agenda, which may or may not affect the way it measures walkability. Nevertheless, the fact that Walk Score is an open-access online tool, readily available to anyone, makes it valuable as it is able to expose the general public to the concept of walkability and its benefits, thus promoting walkability in ways that academia and public policy are not always able to.

Distance-based measures for walkability like Walk Score have been criticized for ignoring the urban design element and creating simplified measures based only on distance and destinations (Talen & Koschinsky, 2013). However, following such criticism, Walk Score has made some changes to its methodology and has reportedly added pedestrian friendliness measures such as population density, block length and intersection density to its algorithm (Walk Score, n.d.), which may have increased its reliability (Duncan et al., 2012).

Even before these changes were made, academic studies of Walk Score’s methodology have generally validated this index as a useful and reliable tool to measure neighborhood walkability (Duncan et al., 2012; Manaugh & El-Geneidy, 2011; Talen & Koschinsky, 2013). In one study that examined the reliability of Walk Score as a measure of walkability, Manaugh & El-Geneidy (2011) compared four existing walkability indices at multiple geographic scales with actual observed travel behavior for over 44,200 home-based trips in Montreal. They found that all four walkability indices performed well in describing pedestrian behavior, though Walk Score proved to be slightly superior to the other indices at predicting whether a home-based shopping trip would be made on foot.

Duncan et al. (2012) tried to validate Walk Score as a measure of neighborhood walkability and found that while it is valid as a neighborhood walkability index for certain aspects like retail and open space density, intersection density and residential density, it does not account for other aspects of walkability, like sidewalk completeness and average speed travelled. They also found Walk Score to most accurately capture a larger spatial scale of 1600 meters (1 mile). Carr, Dunsiger, and Marcus (2010) also explored Walk Score's validity as a walkability index and found strong and significant correlations between Walk Score and all objective measures of the physical environment assessed in their study, but also found positive correlations between Walk Score and reported crime. They concluded that while it is a valid and reliable measure for access to amenities, it is not able to serve as an absolute measure of walkability.

Academic criticism of Walk Score as a walkability measure focuses on the fact that it does not account for the size of nearby destinations or how frequently destinations are used, nor does it consider such factors as neighborhood aesthetics, traffic, topography and barriers like highways that can reduce walkability (Duncan et al., 2012). The algorithm is also criticized not only for ignoring crime, but in fact being positively correlated with it (Carr et al., 2010).

More importantly, Walk Score does not account for time of day and almost exclusively focuses on flexible activities and leisure-time walking, neglecting walking related to fixed activities like work, childcare etc. Thus, it only reflects walkability when the individual is free to choose when and where to walk, ignoring walking that requires the individual to be present in a specific place at a specific time (Vale, Saraiva, & Pereira, 2015). Finally, as Duncan et al. (2011, pg, 4174) argue, "it remains an empirical question whether people equally weight all destinations and if the destinations specified in the Walk Score algorithm are salient to people, with varied socio-demographic characteristics such as gender and race/ethnicity."

Building upon the criticism of Walk Score, the current study aims to create a women-centered walkability index with variables weighted specifically for female walkers, and compare its walkability scores with those of Walk Score, hoping to decipher how suitable Walk Score is for women walkers. One previous study has noted that gender might have an influence on the ability of Walk Score to accurately account for neighborhood walkability (Carr et al., 2010), but did not explore this question further.

This literature review has examined the academic research on women's walking and gendered patterns of walkability, and has identified a gap in the research of walkability despite the proliferation of academic studies on this topic. Specifically, research looking at women's walking and its interaction with built environment attributes is limited, and the majority of such studies focus on women's fear of crime.

Women and men do not walk in the same places, at the same times, or for the same reasons, and these differences should be investigated and understood. An index of women's walkability can therefore present an important contribution to knowledge on women's walking and the gendered patterns of walking behavior. Such an index should not be based solely on the effects of women's fear of crime, as important and meaningful as these are. An index focusing on women's *daytime* walkability should take into account a variety of other relevant variables, ones which may be more pronounced in daytime walking, while still incorporating the effects of fear of crime. While Walk Score has been validated as a measure for neighborhood walkability, none of the studies examining and validating it have investigated its validity as a measure for women's walkability. As the leading index for walkability in use today by both academics and the general public, its ability to account for walkability of particular population groups, and especially women, should be investigated.

Methods

Study Area

San Francisco is a city of approximately 830,000 residents, 49.2% of whom are women (U.S. Census Bureau, 2013). It is densely populated and highly walkable, and is consistently ranked the second most walkable large city in the nation, after New York City (Walk Score, 2016). The majority of San Francisco was built on a grid street pattern, resulting in steep ascents of many of the city's characteristic steep hills. The largest concentration of jobs in the city is in the northeastern Downtown and Financial District areas (City and County of San Francisco Department of Public Health, n.d.), characterized by densely built skyscrapers. Population density is highest in and around the Downtown area, the northeastern Nob Hill, Russian Hill and Chinatown neighborhoods, and in the southeastern Mission neighborhood (City and County of San Francisco Department of Public Health, n.d.). The western part of the city is characterized by lower population, fewer jobs, and lower housing density compared to the central and eastern parts of the city (City and County of San Francisco Department of Public Health, n.d.) - though it is still very densely populated compared to the rest of the country - and is comprised mostly of single-family homes, parks and beaches with a few clusters of shops and regional shopping centers.

Walking accounts for an estimated 23% of all daily trips in San Francisco (SFMTA, 2014), compared with only 10.4% of trips nationally (U.S. Department of Transportation, 2011), and it is the city's stated goal to improve walking conditions (San Francisco Planning Department, 2011).

Focus Groups

Two focus groups were held during the fall of 2016. Each focus group meeting took about 90 minutes. A total of seventeen women participated. Recruitment of focus group participants was done using snowball sampling procedures. A recruitment email was sent to the researcher's friends and acquaintances and a recruitment message was posted on the Nextdoor neighborhood social network in 31 San Francisco neighborhoods. Participants were female residents of San Francisco over the age of eighteen. The only exclusion criteria for focus group participants were 1) being a resident of San Francisco for less than three months; or 2) residing in on-campus housing in a school, hospital, or army base. Focus group meetings were held on weekdays in the afternoon and early evening hours. Participants were not paid for their participation nor were they reimbursed for parking or transit costs, but snacks and drinks were provided in the focus group meetings. The focus group conversations were audio-recorded to allow for transcription and qualitative content analysis of participants' comments.

At the focus group meetings, the researcher facilitated a discussion about daytime walking in the city of San Francisco, encouraging participants to ignore nighttime walking, which, as aforementioned, is heavily influenced by fear of crime. An emphasis was placed on participants' day-to-day patterns of walking for transit, leisure and daily errands, as opposed to walking as a form of exercise. Participants were asked to describe and discuss positive and negative walking experiences, favorite and least favorite walking routes, and things that affect them the most, or are most important to them, when walking or making walking-related decisions, like route choice. Participants were also asked to discuss the importance of ten variables selected by the researcher based on an extensive literature review to identify factors important in the context of women's walking (a list of focus group discussion questions is available in appendix A).

One of the main goals of conducting focus groups as part of this research was to create a ranking system for the index variables based on women's actual preferences, that could be later translated into variable weights. While many existing walkability indices assign equal weights to all variables (Krambeck, 2006), assigning different weights ensures that less important variables do not skew index ratings and that each variable's contribution to the overall index rankings reflects its actual relative importance to women's walking. Therefore, at the end of each focus group meeting, participants were asked to fill out an anonymous ranking sheet with a prioritizing grid for the ten variables discussed in the meeting (Figure 1).

Figure 1: Paired Comparison Prioritizing Grid for the Ten Variables

	A: Sidewalk quality	B: Street & sidewalk cleanliness	C: Fear of crime	D: Presence of parks	E: Curb ramps	F: Homeless people/encampments	G: Volume of vehicular traffic	H: Parking garages	I: Grafitti	J: Types of Businesses on the street
A: Sidewalk Quality (width, completeness)										
B: Street & sidewalk cleanliness										
C: Fear of crime										
D: Presence of parks										
E: Curb ramps										
F: Presence of homeless people/encampments										
G: Volume of vehicular traffic										
H: Parking garages										
I: Grafitti										
J: Types of Businesses on the street										

The prioritizing grid was based on the Paired Comparison Analysis method, which is used to measure individuals' preference ranking of items presented to them as distinct binary choices. Paired Comparisons are a simple way to elicit participants' judgment by asking them to compare two given choices at a time (Brown & Peterson, 2009). In order to determine each participant's individual rankings, the number of times each discrete choice (each variable) was chosen as the more important one was summarized. This process was repeated for all prioritizing grids (all participants). Finally, the number of times each variable was chosen as the more important one was summed across all participants, and the variables were ranked accordingly, resulting in an aggregate ranking of the importance of each of the ten walkability-related variables, based on focus group participants' preferences.

Transforming Variable Rankings into Index Weights

The Analytical Hierarchy Process (AHP) (Saaty, 2008) was used to transform focus group participants' rankings into index weights. AHP transforms a pairwise comparison-based ranking to weights that account for the relative importance of each variable compared to the other variables. The process starts by creating a *pairwise comparison matrix* **A**, where m is the number of evaluation criteria considered (in this case, the ten variables). Each entry a_{jk} in the matrix represents the jth variable relative to the kth variable. If $a_{jk} > 1$, then j is more important than k. If $a_{jk} < 1$, then j is less important than k, and when $a_{jk} = 1$ both variables are of equal importance. The relative importance between the two variables is measured on a scale from $1/9$ to 9, based on the number of participants who chose one variable over the other, where: 1 means that j and k are equally important (half the participants, or 8-9 women, chose j over k); 9 means that j is absolutely more important than k (all 17 participants chose j over k); and $1/9$ means that j is absolutely less important than k (none of the participants chose j over k). Once the matrix **A** is built, it is possible to derive from **A** the *normalized pairwise comparison matrix* **A***norm* by making the sum of the entries on each column equal to 1. Each entry $\bar{a}_{jk}$ of the matrix **A***norm* is basically the corresponding entry a_{jk} in matrix **A**, divided by the sum of the column in matrix **A**, computed as:

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}}$$

Once the matrix **A***norm* is constructed, the variable weights can be computed by summing the entries of each row of **A***norm*:

$$W_j = \frac{\sum_{l=1}^{m} \bar{a}_{jl}}{m}$$

where W_j is the weight of variable j, $\bar{a}_{jl}$ is entry $\bar{a}_{jl}$ of the matric **A**norm, and m is the number of variables considered. The AHP analysis results in each of the ten variables being assigned a weight in the form of percentages, with the sum of all weights totaling 100%. These weights were later incorporated when calculating the index.

GIS Analysis

Data Used

The Women's Walkability Index (WWI) was created using ArcGIS software version 10.4.1 (ESRI, Redlands, CA). Built environment variables were chosen *a priori* based on an extensive literature review pointing to fear of crime, safety from traffic, and safe sidewalk conditions as key components of women's walkability. The majority of variables included in the index represent these three main concerns. Because certain types of businesses are also important predictors of walking among women, the type of businesses on the street was an additional component. The ten selected variables included: sidewalk quality, sidewalk cleanliness, crime, presence of parks, presence of homeless people or encampments, vehicular traffic, graffiti incidents, off-street parking lots and garages, American with Disabilities Act (ADA) curb ramps, and types of businesses (deterring or promoting women's walking). Each variable was assigned a weight based on the AHP transformation of its focus group ranking.

Slope was added as an eleventh variable to account for San Francisco's unique hilly terrain. Slope was discussed in both focus group meetings, and participants in both groups noted that it was an influential factor in their walking behavior. However, since it was not part of the original prioritizing grid, slope was not given a rank by participants and a corresponding AHP weight. To solve this, slope was added to the AHP analysis as an eleventh variable and was given a median rank, as if half of the women found it more important than other variables, and half of the women did not. This was only done after all variable rankings and weights had been calculated without slope being included, to allow for an analysis both with and without slope. This provides an opportunity to see what the rankings for San Francisco would look like if the city were flat, and allows for a replication of the index in other geographies that are not influenced by slope without having to change variable rankings and weights.

All data sets were obtained from SF OpenData (https://data.sfgov.org), the online portal for data published by the City & County of San Francisco. For parking garages, parks, and speed limits, shapefiles were available on the SF Open Data platform. The other data sets were downloaded as comma-separate values files with location information (either latitude/longitude or street addresses). Latitude and longitude measurements were converted to spatial data and address data were geocoded using an ESRI 2013 U.S. street address locator. Slope was derived from the 10-meter digital elevation model (DEM) of San Francisco obtained from the United States Geological Survey (USGS) website. All datasets were reprojected and analyzed in the North American Datum (NAD) 1983 State Plane coordinate system.

Table 1 describes the variables (Appendices B and C), measures, data sources and direction of influence of each measure on women’s walking: negative (-) or positive (+).

Pavement Condition Index (PCI) scores, the measure for sidewalk quality, were not available for 1,416 city blocks (9.6% of blocks), so blocks with missing values were assigned the mean PCI score of 69.9. In order to avoid WWI scores from being skewed by the missing PCI scores, AHP weights were calculated both with without the sidewalk quality variable, to allow for analysis with and without it, much like with slope. Finally, since 266 city blocks did not have speed limit data, these blocks were excluded from the analysis so that 14,507 of 14,773 city blocks were eventually scored by the index (98.2%).

For the crime variable, only crimes relevant to pedestrians and street life were included: assault, burglary, disorderly conduct, drug/narcotic, drunkenness, gang activity, liquor laws, loitering, prostitution, robbery, sex offenses, vandalism and vehicle theft. Other types of crimes, like fraud, arson, bribery etc. were excluded from analysis because it is assumed that they do not affect pedestrians. Additionally, nighttime crimes occurring between 8pm and 6am were excluded, due to this index’s focus on daytime walkability.

Table 1: Variables, Measures, Direction of Influence and Data Sources

Variable	Measure	Direction of Influence	Data Source (city department) and Data Year
Crime	Number of daytime "pedestrian affecting" crimes per block	(-)	SF Police Department 2016 data
Presence of homeless people or encampments	Number of requests for cleanup of encampments, carts, needles or human waste per block	(-)	SF 311 (customer service) 2016 data
Street and sidewalk cleanliness	Number of requests for cleanup of street, garbage cans, bulky items and other waste per block	(-)	SF 311 (customer service) 2016 data
Vehicular traffic	Maximum speed limit per block (MPH)	(-)	SF Municipal Transportation Agency, 2016 data
Parks & open space	Presence of parks and open spaces on or adjacent to a block	(+)	SF Recreation & Parks Department, 2016 data
Type of businesses on the street	Number of walkability-promoting businesses per block	(+)	SF Treasurer – Tax Collector 2015 data
	Number of walkability-inhibiting businesses per block	(-)	
	Number of walkability-neutral businesses per block	(+)	
Sidewalk quality	Block score on city PCI (Pavement Conditions Index) evaluations	(+)	SF Department of Public Works Updated 2016, small number of evaluations predates year 2000
Off-street parking lots and parking garages	Number of parking spaces in off-street parking garages and parking lots per block	(-)	SF Municipal Transportation Agency, 2016 data
Graffiti incidents	Number of reported graffiti incidences per block in last 30 days	(-)	SF 311 (customer service) 2016 data
Curb ramps (ADA)	Number of curb ramps per block	(+)	SF Department of Public Works 2016 data

For the 'types of businesses' variable, registered business locations were divided into three categories and analyzed separately: 1) 'Positive' businesses included walkability-promoting businesses such as retail, restaurants, coffee shops, grocery stores, physical fitness facilities, beauty salons, schools and child day care centers 2) 'Negative' businesses included walkability-inhibiting businesses such as liquor stores, auto repair shops, gas stations, drinking places, warehouses and industrial activities 3) 'Neutral' businesses were neither negative nor positive, and included such businesses as accountants, banks, law offices and such.

Vector Analysis

A vector-based approach was used to analyze most variables, in order to capture their density at the city block level and provide a per-block index score. The rationale for this approach was twofold: first, the City of San Francisco reports much of its data at the block level rather than providing exact addresses; second, for many of the examined measures, like street cleaning requests, the intensity (i.e. density) of incidents for any given city block is more meaningful to women pedestrians than the exact location of each incident.

First, a 10-meter buffer was added to the streets layer to capture only those incidents that occurred 10 meters from the center of the road in either side. The 10 meter buffer distance was chosen because San Francisco regulations require a minimum street and sidewalk width of 44-50 feet (13.4-15.2 meters), depending on the type of street, and recommend a 56-60 feet (17-18.3 meter) wide street in most cases (San Francisco Fire Department, n.d.; San Francisco Planning Department, 2010). Next, the number of incidents per block was calculated using a spatial join for walkability-promoting businesses, walkability-inhibiting businesses, walkability-neutral businesses, parking spaces in off-street lots and garages, requests for street cleaning, reports of graffiti and intersections with curb ramps. Parks were given a score of 1 if the block was immediately adjacent to a park, and a score of 0 otherwise. This was done since the benefits of parks appeared to only occur immediately adjacent to them, according to the focus group discussion. The datasets for maximum speed limits and sidewalk quality scores were already in a block format so no further manipulation was needed.

For businesses, a new dataset, “total businesses” was calculated based on the three categories for businesses: positive, negative and neutral. The density per block of each of these three categories was multiplied by a weight selected to reflect each category’s relative importance, under the assumptions that negative and positive businesses have the same magnitude of influence on walkability, and that neutral businesses have half as much the influence as positive or negative businesses because even if they are not themselves attractants, neutral businesses still contribute to a livelier street, which in turn contributes to walkability. The weights selected were therefore 40% for positive and negative businesses, and 20% for neutral businesses. The formula for the aggregation of business categories is as follows, where *D* is the density per block of the corresponding business type:

$$Total\ Businesses = (0.4 * D_{Negative}) + (0.4 * D_{Poisitve}) + (0.2 * D_{Neutral})$$

Once the density per block was calculated for each of the datasets, attributes from all the different layers were joined into one master table, and the density per block measure for each variable was normalized by block length to neutralize the influence of exceptionally long blocks. To allow for comparison of metrics with different units and scales, data were normalized by block length and rescaled to a continuous 1-10 scale, with 10 representing the best-case scenario for the variable and 1 representing the worst-case scenario. Most variables were rescaled using the Natural Breaks method (Jenks, 1967), based on ten natural breaks (Appendices D and E). However, for the nonlinear variables speed limit and parking garages, rescaling was done manually (Table 2). Sidewalk scores were already at 1-100 scale and therefore only needed to be divided by ten to be rescaled. Finally, each variable's normalized and rescaled density per block was multiplied by the weight it was assigned by the AHP.

Raster Analysis

With the two remaining variables, crime and presence of homeless people or encampments, a raster approach was taken in order to account for the spillover effects of these types of variables. Spillover means that the effects that crime and homelessness in one block have on women's walking tend to 'spill' outwards and affect adjacent blocks as well, an effect that cannot be captured with vector analysis counts of incidents on a block-by-block basis. For the raster analysis, the Kernel Density tool was used to calculate the density of crime reports and of requests for cleanup of encampments, carts, needles or human waste per 3-meter cell, at a 100-meter kernel search radius. The Zonal Statistics As Table tool could not be used to transform the cell-based raster layers into block-based vector layers because of its inaccuracy in computing overlapping polygons. Therefore, the values in each raster cell centroid were extracted and clipped to the buffered streets layer, and then aggregated by block using a Spatial Join and Summary Statistics combination. These measures did not need to be normalized by block length, so they were rescaled into ten natural breaks, weighed by their respective index weight and joined back to the master dataset.

As mentioned, the slope analysis was done separately since the slope was not part of the focus group prioritizing grid and was therefore not assigned a weight. The slope for each city block was calculated using the LineSlope Tool (Davis, 2014), which calculates the difference in elevation between the two edges of the block. This was done because some streets in San Francisco are cut into the side of hills, so while their slope based strictly on a digital elevation model may seem steep, they can be relatively flat. Slopes were then reclassified manually into five categories and assigned scores of 0, 3, 5, 8 or 10 to allow for easy comparison with other datasets, with flat blocks receiving the highest score (Table 2). Slope categories and scores were informed by the city of San Francisco's Walk First methodology for determining pedestrian activity (San Francisco Planning Department, 2011). Slope was then added to the master table with all other layers to further inform the index. Once the vector and raster sections of the analysis were combined, the complete index was calculated, resulting in a women's walkability score between 1 and 10 for each city block.

Table 2: Manually Classified Categories for Non-Linear Variables

Class	Speed Limit (MPH)	Parking Spaces Per Block	Slope
1	> 45	> 350	> 0.11
3	36-45	36-350	0.09-0.11
5	25-35	11-35	0.06-0.08
8	16-25	1-10	0.03-0.05
10	=<15	0	=< 0.02

Walk Score Comparison

Once the Women's Walkability Index was completed and scores were available for every block in the city, the scores were compared to those generated by Walk Score. Since Walk Score provides point-specific scores (by exact address or latitude-longitude coordinates) and WWI provides a block-level score, block-midpoint latitude and longitude coordinates served as the basis for comparison. A basic JavaScript tool (https://github.com/zivzs/walkscore-client-js) was built to use these midpoint coordinates to retrieve the corresponding walkability scores from Walk Score's API. Spearman's Correlation test was used to examine the correlation between WWI scores and Walk Scores.

Results

<u>Focus Groups Discussions</u>

Two focus groups meetings were held in San Francisco in the fall of 2016. Each meeting lasted about 90 minutes. A total of seventeen (17) women participated in the focus groups. Most participants were in their early thirties to late forties, though five participants were in their early to mid twenties, and three participants were in their fifties and sixties. The mean participant age was 37 and the median age was 36. All participants had been living in San Francisco for at least several months, and most were long-time residents of the city. Among the participants were residents of the following neighborhoods (Map 1): Noe Valley, Bernal Heights, Cole Valley, Glen Park, Inner Sunset, Outer Sunset, Ingleside, The Bayview, Excelsior, Inner Richmond, Outer Richmond, Crocker-Amazon and Lower Pacific Heights. Noe Valley (four participants) and The Sunset (four participants) were the most heavily represented neighborhoods. Each focus group meeting lasted about 90 minutes and in that time, participants discussed aspects of their daytime walking in an informal, conversation-like manner. An emphasis was placed on the ten variables that were identified in the literature review as influencing women's walkability, and participants were asked to discuss how these variables related to their daytime walking, and were later asked to choose among paired variables which was the more important.

Crime and personal safety: Crime and personal safety proved the most influential variable on women's walking, even during the daytime. Most participants stated that they would prefer walking on streets where other people are present, rather than on small side streets and alleys. Several participants noted that quiet streets are "eerie" or "unsettling". Some participants did say they prefer quieter streets with fewer people, but would only walk in such streets if they were familiar with them and had walked them before. Most participants were highly aware of their surroundings while walking, and had adopted personal walking strategies to keep themselves safe. Examples

Map 1: Focus Groups Participants' Residential Neighborhoods

include avoiding walking under bridges or in alleys and small side streets, walking on the traffic side of the sidewalk so that they cannot be grabbed from within buildings or crevices between buildings, crossing the street when seeing a group of men, and others. One participant, a young woman named Laurie (all names have been altered), summarized the experience of a female pedestrian in these words:

> *"Generally when walking as a woman: always look up and know where you're going; don't look at your phone; look confident; be alert".*

Homelessness: most participants only felt comfortable walking by homeless people when there were not many of them, or if they were "neighborhood regulars" and were familiar. When this was the case, participants tended to view the homeless person or people as neighbors and were not intimidated by their presence. However, there was a consensus among participants that groups of homeless people, as well as homeless encampments, are very intimidating and should be avoided. Almost all participants said that they would avoid walking in streets with tents, encampments, or a large concentration of homeless people, partly because of personal safety issues and worrying about erratic, unpredictable behavior by the homeless people (and their dogs), and partly because some participants felt that they were intruding into the homeless individuals' personal space and were disturbing their privacy. Isabel, one of the participants, explained:

> *"My 'homeless comfort zone' (is) 2, 4, 6 people max. More than that – (I) would not walk there. If it's homeless people that are always there, you treat them like neighbors: say hello in the morning and offer some fruit every now and then. The problem with encampments is that they don't belong to anyone. Nobody controls anything there, there's no boss on the street."*

Some participants were angered by the tents encroaching on public sidewalks and forcing pedestrians to go down to the street, where they are at risk of getting hit by vehicular traffic. Most participants noted that homeless encampments were also affecting their walking due to cleanliness issues and smell associated with the encampments. Some of the women noted that they also sought to avoid streets with homeless people because they were saddened by their situation and were being forced to confront things they would otherwise prefer not to think about.

Street and Sidewalk Cleanliness: sidewalk cleanliness seemed to highly affect participants' walking. They differentiated between "normal city dirtiness" – some trash, animal feces, etc. - and "nasty" streets where the location and amount of garbage and trash suggest that the street is neglected and there are no "eyes on the street", indicating a possible threat to personal safety. Several participants also mentioned bad smells (mostly of human feces or urine) as major deterrents to walking. One participant, Jenny, a long-time resident of the city noted:

> *" The city is getting dirty. Perhaps it's because of lack of rain? And the sidewalks are kind of disgusting, and it makes the walking experience a lot less pleasant."*

Another participant, Julie, added:

> *"You have to be a 'defensive walker' in the city: always aware of poop, dirt and broken sidewalks"*

Parks and Open Space: most participants agreed that parks are an attractant in terms of walking and that they increase walkability. One participant, Sharon, said she would prefer to walk where there are trees and scenery, rather than "this industrial wasteland". There was a consensus among participants about not walking in or near parks at night or early in the morning. Even during the daytime, most participants said they would not walk alone in larger parks with lots of hidden spots and remote trails. While smaller parks felt safe during the daytime, most participants said they would not go off-trail by themselves in Golden Gate Park during the daytime (with the exception of women who grew up in neighborhoods adjacent to the park and were very familiar with it), and all participants agreed that they would never walk in McLaren Park alone during the daytime.

Businesses: most participants stated that they liked walking on "visually interesting" streets with businesses, particularly retail with interesting shop fronts, and food and beverage businesses. Participants also stated that they would prefer to avoid blocks with certain types of businesses such as liquor stores and auto shops. One participant mentioned she doesn't like walking by coffee shops with sidewalk seating because it bothers her that they encroach on the sidewalk and force her to traverse around them, but all other participants liked seeing people sitting outside and also enjoyed walking by one of San Francisco's few dozen parklets (small sidewalk extensions that are usually installed on parking lanes, sometimes adjacent to coffee shops or restaurants, and provide additional open space and amenities for pedestrians). Two participants mentioned that when they are walking with their dogs, as opposed to walking by themselves, they tend to avoid streets with multiple retail businesses due to the density of people, which makes walking their dogs more challenging. One participant noted that she tends to avoid commercial streets when walking with her toddler, though she does prefer commercial streets when walking alone.

Vehicular Traffic: most participants were quite troubled by vehicular traffic as pedestrians, and would avoid major streets with many traffic lanes and high traffic volumes or high speed limits. One participant said she tends to avoid streets with many buses or delivery trucks. Participants' strategies for avoiding or minimizing the risks of vehicular traffic while walking included changing routes and walking in smaller streets (one participant said she specifically walks two blocks out of her way to avoid a dangerous intersection by her house), walking opposite to oncoming vehicular traffic so you can see what's coming, and opting for streets with street lights rather than stop signs. Some participants also noted that traffic noise and exhaust bother them when walking on major streets. A few participants, particularly older ones, were also troubled by cyclists and preferred to refrain from walking on streets they knew to have a large volume of bicycle traffic, even when there were designated bike lanes present.

The four remaining variables – graffiti, off-street parking, curb ramps and sidewalk quality - were only discussed briefly as there was a consensus among focus group participants that these were relatively inconsequential in terms of their impact on women's daytime walking. **Slope** was also discussed briefly, when a few participants mentioned that hilly streets, while challenging to climb, might be safer or more pleasant to walk on since there are fewer crimes and fewer homeless people, but on the other hand they are less appealing since fewer people walk on them, which makes them feel deserted and unsettling.

Some additional noteworthy themes emerged in focus groups discussions. First, a significant age gap became evident while participants were discussing public space sexual harassment, particularly in the first focus group. While participants in their thirties and forties seemed to be repelled by most, if not all, forms of male attention on the street – regardless of whether they felt threatened by the situation - and were going out of their way to avoid such attention, younger participants - in their early to mid twenties - were not as affected by catcalling, whistling and leering. It seemed that these young women experienced being a female pedestrian quite differently. Younger participants said they would change their mode of transportation (using Uber or Lyft rather than walking or taking public transit) when they want to "look cute" (i.e. dress provocatively), in order to stay safe (this was discussed mostly in the context of nighttime walking, which was not part of this research's focus). However, the younger participants were generally not worried about male attention - daytime or night - as long as there was no physical interaction, and would not change their walking route to avoid catcalling or other such behaviors. Daniela (participant in her early twenties):

"I want to go out and look cute, I know that I'm going to get harassed and catcalled that night, and I don't care, but I can't take the bus back home at night with those clothes cause I know I'm going to get harassed or get followed"

Nora, also in her early twenties, agrees:

"I'll change my mode of transportation rather than my clothes"

Many of the older participants, however, had adopted tactics to avoid catcalling and other unwarranted male attention altogether, would actively avoid walking by groups of men (even a group of men in suits whom they did not perceive as a threat) and were generally repulsed by the culture of sexual harassment in public spaces (not necessarily equating that with fear for their own personal safety). It seems that the older participants experience the urban street as a venue of feminist struggle, and are constantly trying to navigate city streets (and other public spaces) without being harassed or objectified. These women are willing to make substantial changes to how they dress and where they walk in order to avoid these types of experiences. These differences between the older and younger participants may be the result of a generational gap, or that of life experience. As one participant, Haley, in her late thirties noted:

"*Perhaps the older you get the more sexual harassment you've experienced, the more you've been exposed to this type of behavior, the more sensitive you are to it and the more you try to avoid it. And even now that I'm older, and they don't do it to me anymore, I see them doing it to younger girls and it still disgusts me"*.

A second interesting theme that emerged from the discussion was the relationship between walking and clothing. Many of the participants mentioned that the clothes and shoes they were wearing, as well as what they were carrying, might very well affect whether or not they walk, how much they walk, or where they walk. For example, one participant could not walk to her bus stop, which was on a steep street, while wearing high heels and would therefore take a cab on days on which she had work meetings.

Another participant mentioned changing her route to avoid cracked sidewalks while wearing high heels, and a third participant said she keeps all of her high heeled shoes at the office and changes from sneakers when she arrives at work every morning. Other participants who were self-proclaimed “avid walkers” noted that their entire wardrobe had evolved over the years to fit a walker’s lifestyle, and that they currently only own shoes and clothes that are “pedestrian friendly”. These themes, while outside the scope of this current research, reveal new and interesting aspects of women’s walking, ones that are receiving very little research attention.

Focus Groups Rankings and Weights

Index weights were calculated based on the Prioritizing Grid ranking sheet that was handed out to all participants at the end of each focus group meeting, in which were asked to compare pairs of variables and determine which of the two was the more important one to them. Variable rankings were aggregated across all participants (Table 3) and then transformed into index weights using the Analytical Hierarchy Process (AHP), as detailed in the methods section of this paper.

Table 3 - Focus Groups Rankings

Variable	Rank
Fear of crime	1
Presence of homeless people or encampments	2
Street and sidewalk cleanliness	3
Vehicular traffic volume	4
Parks & open space	5
Type of businesses on the street	6
Sidewalk quality	7
Off-street parking garages and parking lots	8
Graffiti incidents	9
Curb ramps	10
Slope*	-

* Slope was not part of the prioritizing grid and was no ranked by focus group participants

It is interesting to note that participant rankings were quite consistent, with the majority of participants ranking crime and homelessness at the first and second places, respectively, followed by vehicular traffic and cleanliness (not necessarily in that order). Graffiti and curb ramps were consistently ranked as the least important variables. Variation across participants' rankings was largest with regards to businesses and sidewalk quality, but these variables, too, were generally consistently ranked as medium-importance variables.

The AHP process was repeated four times, to create four different models:

1) Model 1 – All 10 variables, excluding slope
2) Model 2 – All 10 variables + slope
3) Model 3 – 9 variables (excluding sidewalk quality), excluding slope
4) Model 4 – 9 variables (excluding sidewalk quality) + slope

This was done for two reasons. First, since the sidewalk scores dataset, which served as the measure for sidewalk quality, had a relatively high share of missing values (9.6% of city blocks did not have sidewalk scores associated with them) it was important to compute the index both with and without using the sidewalk quality variable. In the two models that did take sidewalk quality into account, missing values were assigned the mean sidewalk score value (69.9). Second, since slope was not included in the Prioritizing Grid ranking sheet and focus group participants did not get to rank it as they did the other variables, it was important - here too - to see how the addition or subtraction of slope data affected the final index. As seen in Table 4, variable weights do not vary significantly between models. Under all four models, crime and homelessness exert the strongest effects on women's walkability (about 31%-37% and 17%-20% of index score, respectively).

Table 4 - Variable Weights Under Each of the Four Models

	Model 1	Model 2	Model 3	Model 4
	10 Variables, No Slope	10 Variables + Slope	9 Variables (excluding sidewalk quality), No Slope	9 Variables (excluding sidewalk quality) + Slope
A: Sidewalk Quality	4.3%	4.5%	0.0%	0.0%
B: Street & Sidewalk Cleanliness	10.4%	9.7%	10.2%	9.7%
C: Fear of Crime	34.9%	29.5%	37.0%	31.1%
D: Presence of Parks	8.7%	8.3%	8.9%	8.5%
E: Presence of Curb Ramps	1.3%	1.8%	1.4%	2.1%
F: Homelessness	19.3%	17.3%	20.3%	17.5%
G: Vehicular Traffic Volume	9.2%	8.7%	9.1%	8.8%
H: Off-Street Parking Lots & Garages	2.5%	2.9%	2.9%	3.4%
I: Graffiti Incidents	2.0%	2.5%	2.4%	2.9%
J: Types of Businesses	7.5%	7.2%	7.8%	7.6%
K: Slope	0.0%	7.6%	0.0%	8.4%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Street and sidewalk cleanliness are also of great importance to women (around 10%), and these three factors combined (crime, homelessness and street cleanliness) account for about 56%-67% of the final index score. Also important, but to a lesser extent, are the presence of parks (around 8.5%), the volume of vehicular traffic (about 9%) and the type of businesses found on the street (≈7.5%). The four remaining variables - graffiti, off-street parking, curb ramps and sidewalk quality together account for about 10% of the final index score, or about 7%-8% when excluding sidewalk quality (Models 3 and 4).

Statistical Analysis

The correlations between the variables used in the models were examined. While many of the variables indeed showed statistically significant correlations, these relationships varied in strength, with most correlations being of weak to moderate strength. The strongest correlations, between crime and homelessness, and cleaning requests and homelessness, had Spearman's rho coefficient values of 0.629 and 0.628, respectively (Table 5).

Index results

All four models had similar outcomes with few substantial differences between them (Table 6). Map 2 shows the reclassification of each variable into a 1-10 score (individual maps of each variable's scores are available in appendix F). Map 3 shows the aggregated WWI score for each city block based on Model 2 (the most extensive model which included both sidewalk quality and slope). Map 4 shows a hot and cold spot analysis (Getis & Ord, 1992) of Model 2 WWI scores, where cold spots (marked blued) are clusters of very low walkability scores and hot spots (marked red) are clusters of very high walkability scores.

Table 5 - Non-Parametric Correlations – Spearman's rho

		Presence of Parks	Off-Street Parking Spots Per Block	Graffiti Incidents Per Block	Number of Curb Ramps Per Block	Cleaning Requests Per Block	Number of Businesses Per Block	Crime Density Per Block	Homeless Density Per Block	Block Slope (Normalized by Length)	Block Speed Limit (MPH)
Presence of Parks	Correlation Coefficient	1.000	-.048**	-.036**	-.014	-.066**	-.116**	-.047**	-.087**	.030**	-.015
	Sig. (2-tailed)	.	.000	.000	.079	.000	.000	.000	.000	.000	.069
Off-Street Parking Spots Per Block	Correlation Coefficient	-.048**	1.000	.195**	.022**	.195**	.215**	.316**	.249**	-.199**	.066**
	Sig. (2-tailed)	.000	.	.000	.009	.000	.000	.000	.000	.000	.000
Graffiti Incidents Per Block	Correlation Coefficient	-.036**	.195**	1.000	.134**	.429**	.295**	.413**	.420**	-.138**	.084**
	Sig. (2-tailed)	.000	.000	.	.000	.000	.000	.000	.000	.000	.000
Number of Curb Ramps Per Block	Correlation Coefficient	-.014	.022**	.134**	1.000	.328**	.263**	.168**	.117**	-.024**	.088**
	Sig. (2-tailed)	.079	.009	.000	.	.000	.000	.000	.000	.003	.000

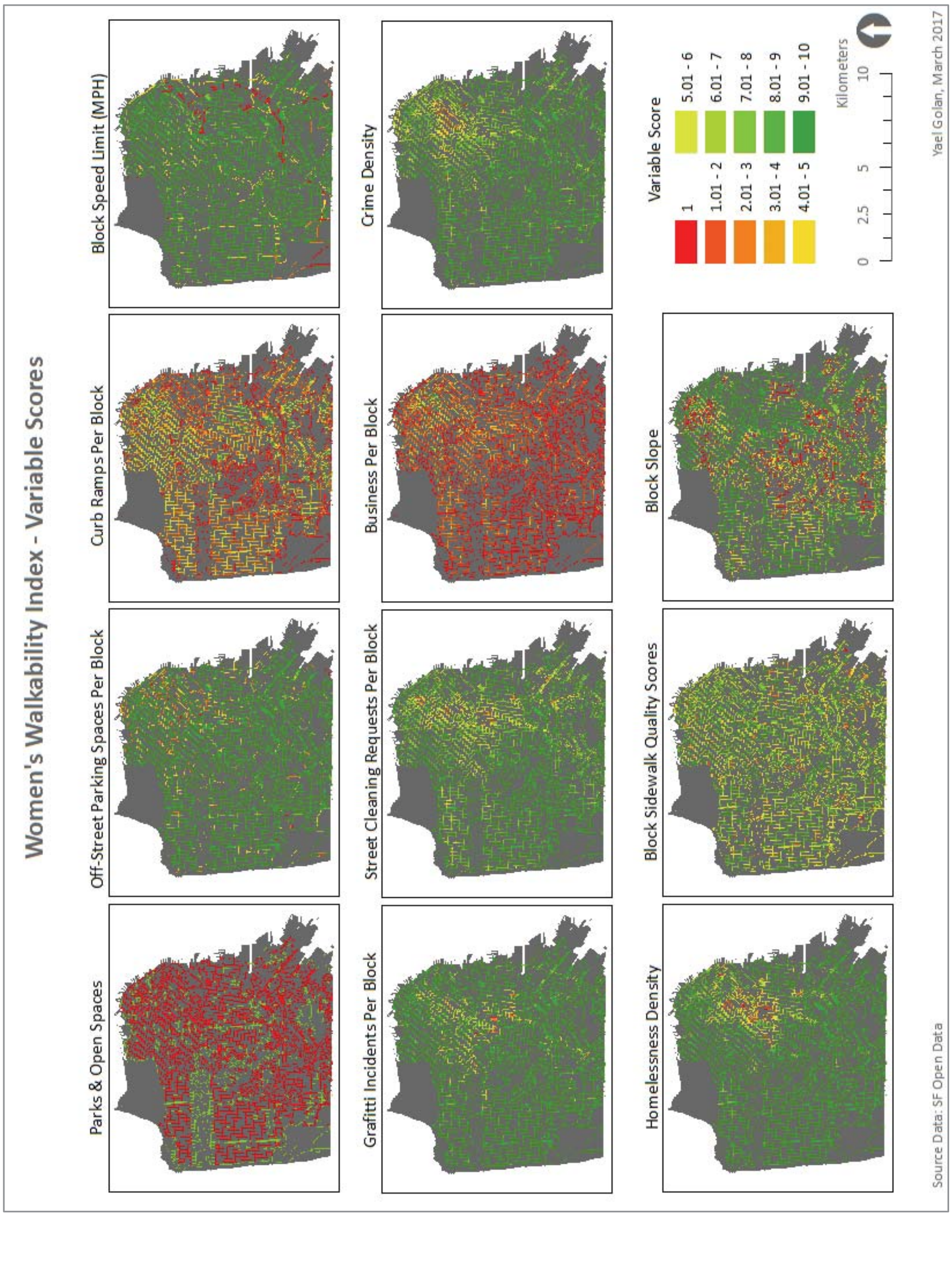
Cleaning Requests Per Block	Correlation Coefficient	-.066**	.195**	.429**	.328**	1.000	.448**	.522**	.628**	-.183**	.141**
	Sig. (2-tailed)	.000	.000	.000	.000	.	.000	.000	.000	.000	.000
Number of Businesses Per Block	Correlation Coefficient	-.116**	.215**	.295**	.263**	.448**	1.000	.425**	.371**	-.129**	.019*
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.	.000	.000	.000	.023
Crime Per Block	Correlation Coefficient	-.047**	.316**	.413**	.168**	.522**	.425**	1.000	.629**	-.199**	.075**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.	.000	.000	.000
Homeless Density Per Block	Correlation Coefficient	-.087**	.249**	.420**	.117**	.628**	.371**	.629**	1.000	-.245**	.112**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.	.000	.000
Block Slope (Normalized by Length)	Correlation Coefficient	.030**	-.199**	-.138**	-.024**	-.183**	-.129**	-.199**	-.245**	1.000	-.112**
	Sig. (2-tailed)	.000	.000	.000	.003	.000	.000	.000	.000	.	.000
Block Speed Limit	Correlation Coefficient	-.015	.066**	.084**	.088**	.141**	.019*	.075**	.112**	-.112**	1.000
	Sig. (2-tailed)	.069	.000	.000	.000	.000	.023	.000	.000	.000	.

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

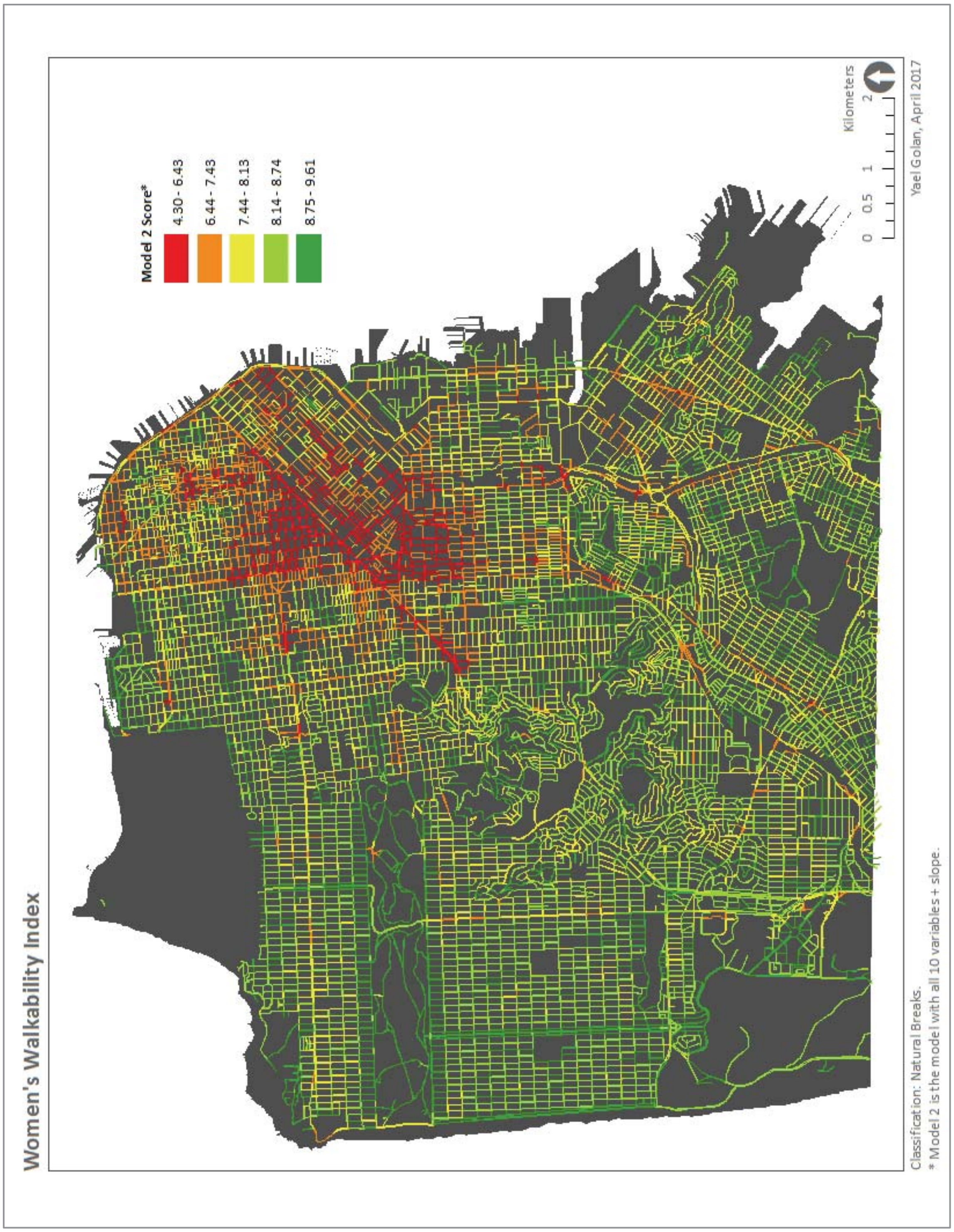
Table 6 - Descriptive Statistics of the Four Models

	Model 1	**Model 2**	**Model 3**	**Model 4**
N	14,507	14,507	14,507	14,507
Min	3.71	4.27	3.44	4.07
Max	9.66	9.61	9.63	9.58
Mean	8.11	7.99	8.15	8.01
Standard Deviation	0.92	0.80	0.96	0.83

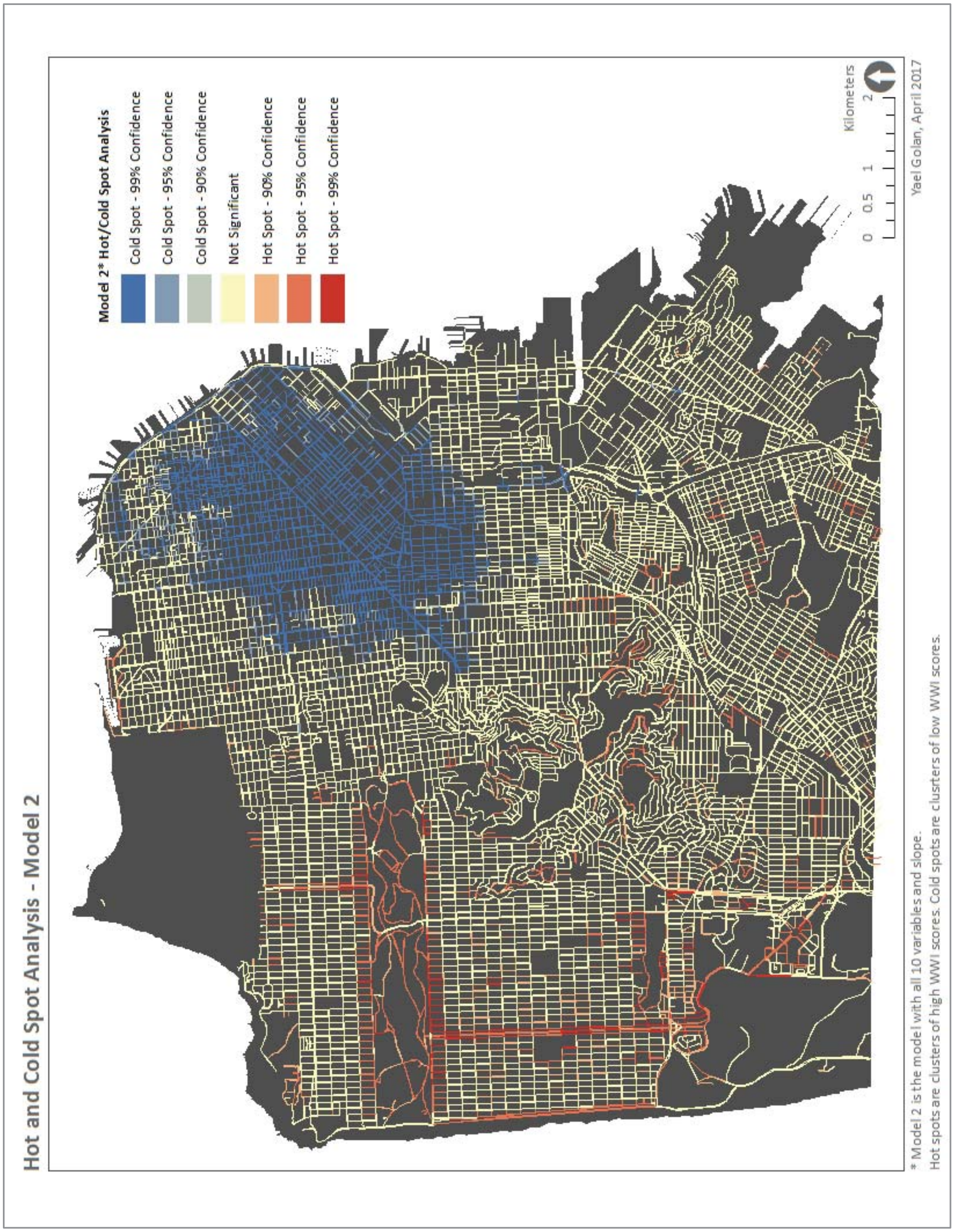
Map 2 - Women's Walkability Index – Variable Scores



Map 3 - Women's Walkability Index Block Scores – Model 2



Map 4 - Hot and Cold Spot Analysis – Model 2



Walk Score Comparison

Women's Walkability Index scores were examined against Walk Score for each of the 14,507 city blocks analyzed and for all four models, by comparing the mid-block Walk Score to the corresponding block's WWI score. All four models show a moderate negative correlation with Walk Score, with Spearman's rho coefficients ranging from -0.524 to -0.585. These correlations are all statistically significant at a 0.01 level (Table 7).

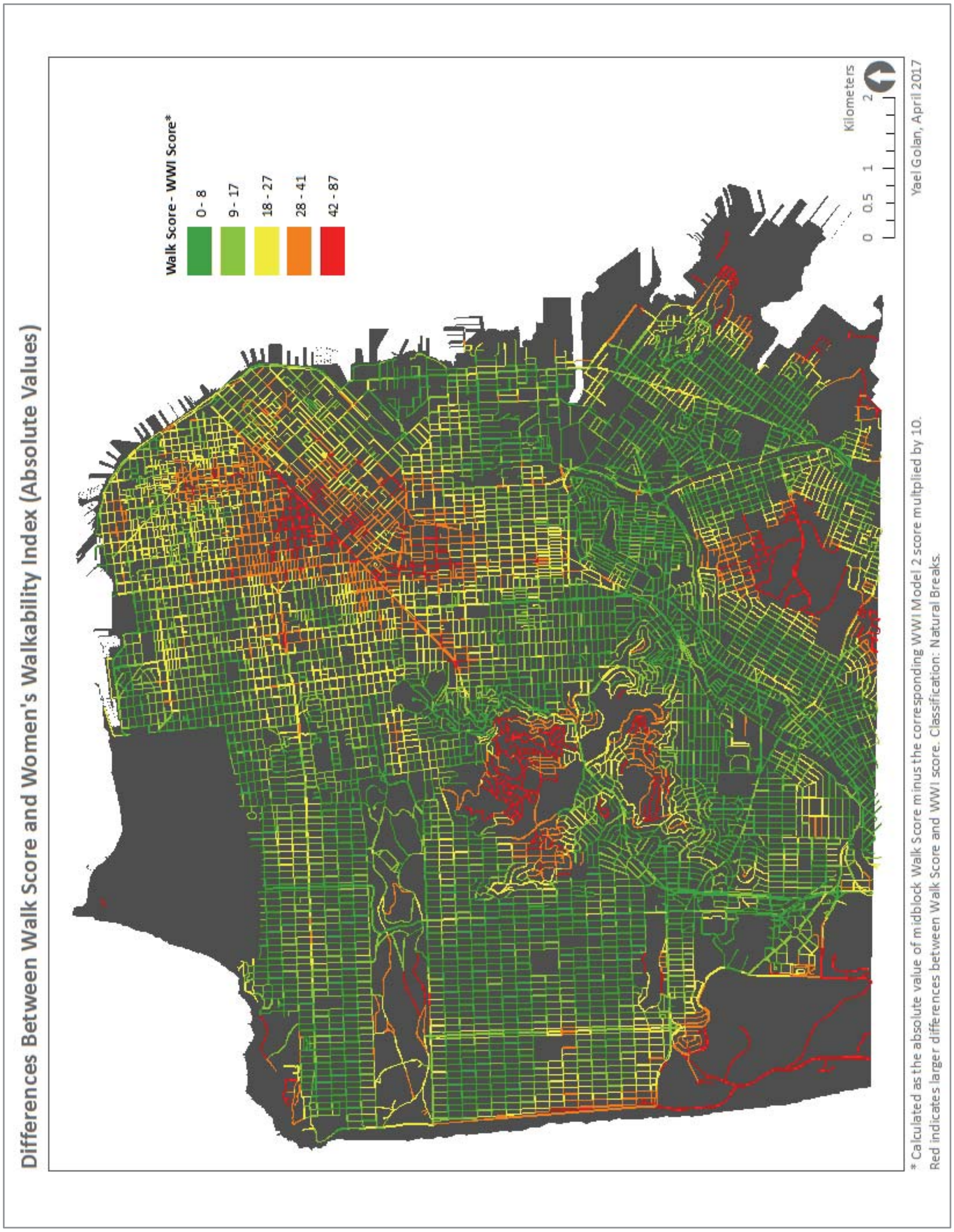
Table 7 – Walk Score-Women's Walkability Index Correlations

		Model 1	Model 2	Model 3	Model 4
Walk Score	Correlation Coefficient	-.579**	-.524**	-.585**	-.525**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	14507	14507	14507	14507

**. Correlation is significant at the 0.01 level (2-tailed)

WWI scores were transformed from their original 1-10 scale to a 1-100 scale to allow for easier comparison with Walk Score. Map 5 shows the absolute value differences between Walk Score and WWI scores, computed by subtracting the rescaled WWI score from the corresponding Walk Score for each block. Green areas on this map are ones where both indices agree (have similar scores). Red areas are ones with large differences (in absolute values) between the two scores.

Map 5 - Differences Between WWI Score and Walk Score



Discussion

This study aimed to answer three research questions: 1) *Which variables most influence women's propensity to walk?* 2) *Where in San Francisco are the most and least walkable places for women?* And 3) *Does the leading walkability index at present, Walk Score®, account for women's walkability?*

In regards with the first research question, the results of this study reaffirm the importance of fear of crime as an influencing factor, if not *the* influencing factor, in women's walkability, even during the daytime. By focusing specifically on daytime walkability, this study attempted to capture some of the additional factors and considerations influencing women's walking behavior *other than* fear of crime. However, as focus group discussions and variable rankings by focus group participants have shown, fear of crime remains the number one factor affecting women when they decide where, when and how to walk, regardless of time of day. The idea that fear of crime is less pronounced in women's daytime walking seems to be false.

Studies exploring the relationship between crime and walkability are typically subject to various measurement-related limitations. Most prominently, there is a common disassociation between respondents' sense of neighborhood safety and crime incidents - fear of crime is many times only weakly associated with actual crime (Foster & Giles-Corti, 2008). By using both subjective (focus group input) and objective (reported crime incidents) data, this study is able to significantly minimize this common limitation. Focus group participants discussed their personal sense of safety (perceived safety) in a more general way, and were not asked to rank parts of the city by how safe they perceive them to be. Instead, participants were asked to choose the elements in the built environment that most influence them when walking anywhere during the daytime, and their choices were used to create a ranking and weighting system which later served as the basis for analysis of objective crime data. Thus, the potential for a crime-perception-related bias was minimized.

It is interesting to note that some of the participants said they feel safer and much less vulnerable when running, or when cycling, than they do walking. Participant Sharon:

> *"I feel safer on my bike than I do walking, day or night, and I don't mind biking through some areas that I would never normally walk in"*

This perceived sense of safety when running or biking makes walking the most vulnerable mode of transportation in the eyes of women, a perception that undoubtedly has some important ramifications. Future studies should further investigate and compare women's perceptions of safety in different non-motorized modes of transit. Additionally, while the issue of transit network companies (TNCs), such as Lyft or Uber, and their influence on women's walking was not discussed in depth by focus group participants, anecdotal evidence from the focus groups reveal a potential impact of TNCs on women's walking, particularly at night. It may be the case that TNCs help minimize women's no-go areas and change existing patterns of gendered spatial exclusions. Future studies should investigate the relationship between TNCs and women's walking.

While women may differ in the types of situations they find threatening, there was a consensus among participants in this study that a sense of personal safety is a prerequisite for women's walking. It is not surprising, then, that three of the four top-ranking variables were related to sense of safety: crime, homelessness and vehicular traffic (ranked numbers 1, 2, and 4, respectively).

The presence of homeless people on a street block does not automatically deter women from walking there. Rather, as focus group participants pointed out, it is a matter of familiarity and magnitude. When there are only one or two homeless people on the block, or when the women recognize them as "neighborhood regulars", their presence does not deter walking. However, groups of homeless people and the presence of homeless encampments do significantly affect women's walking, with most participants saying they would avoid such areas at almost any cost. While the "familiarity" effect of homeless people could not be accounted for in this index, the issue of magnitude was addressed in the GIS analysis, by using a density measure for homelessness (looking at the density of homelessness-related reports per square kilometer, and then translating that number into a block-based scale). Use of the Kernel Density tool allowed the spillover effects of homelessness, i.e. – the effect of the presence of homeless people in one block on women's walking in an adjacent block – to be accounted for as well (the same strategy was used to analyze crime incidents, for the same reasons).

It is worth noting that many of the participants explained their inclination to avoid walking near homeless people as an attempt to avoid unpredictable situations. This echoes Valentine's (1989) claim that women's fear in public spaces is basically a fear of unpredictable and uncontrollable behaviors by strangers. More importantly, Valentine's assertion that women perceive only men as strangers is also echoed in this study, as the women in one of the focus groups agreed - after a long discussion of fear of crime and homelessness, objectification of women in the public sphere, and catcalling by construction workers - what they are really trying to avoid are groups of men:

Participant A: "*I would avoid construction sites because of catcalling… I'm not afraid of them, just disgusted by male objectification of women*"

Participant B: "*Yeah, just leave me alone, just let me walk down the street*"

Participant C: "*Depends on the size of construction. Small contractors who live in the city and raise daughters here are more respectful*"

Participant D: "*I get catcalled by homeless people and would prefer construction workers over homeless (people)*"

Participant E: "*So I think the point is that it's not necessarily construction workers, just groups of men. Even a group of men in suits would bother me*"

Participant A: "*I agree, I'd avoid groups of men*"

(Most other participants nod or mumble in agreement)

Street and sidewalk cleanliness (ranked third) and the presence of parks or open spaces (ranked fifth) both point to the importance of aesthetics to women when walking, in line with previous studies that found women's walking to be strongly associated with neighborhood aesthetics (Pelclová et al., 2013), more so than men's (Dyck et al., 2011). As one focus group participant noted, trees and scenery are important features because they alleviate some of the surrounding "industrial wasteland" (referring to the SoMa neighborhood of the city). However, the relationship between parks, greenery and open spaces and women's walking is convoluted. Previous studies have shown that parks and badly placed bushes and greenery (Koskela & Pain, 2000) and deserted open spaces (Valentine, 1989) can deter women's walking, but the results of this study point to small urban parks as a major attractant to women's walking, at least during the daytime. Most women in this study would not avoid parks and greenery, and in fact would actively seek green areas to walk in or near during the daytime, with the exception of very large parks with remote trails, and large wilderness-like open spaces. Participants agreed that San Francisco's McLaren Park - the city's second largest park - is somewhere they would never dare walk alone, day or night, because of its large size, secluded trails, and remote wilderness-like areas. The importance of park size with regards to women's walkability is an interesting finding that could perhaps be expanded upon in future studies.

As for vehicular traffic, previous research has shown that women are more likely than men to view the presence of traffic as an important factor when walking (Weinstein Agrawal et al., 2008) and are more likely than men to list reasons related to the amount of traffic as deterrents to walking (Clifton & Dill, 2005). Indeed, focus group participants ranked vehicular traffic as the fourth most influential factor on their walking, and extensively discussed their fear of vehicular traffic and their apprehension of major thoroughfares, noise from traffic and exhaust fumes. Interestingly, some participants were almost as concerned about bicycle traffic as they were about vehicular traffic. Future research into the relationship between walkability and bicycling may shed some light on this issue.

While mixed-use streets with retail businesses are generally shown to promote walkability (Pelclová et al., 2013; Talen & Koschinsky, 2013), the presence of businesses on the street seems to have a mixed effect on focus group participants. The concept of “eyes on the street” (Jacobs, 1961) and the presence of other people on the street were mentioned by many of the participants as an important issue when walking, but there was no consensus around this topic. Most participants did state that having “eyes on the street” and seeing other people on the street when walking were important to them, in accordance with previous research by Weinstein Agrawal et al. (2008). However, at least during the daytime, this seems to be an issue of personal preference, with a small minority of focus group participants saying that they preferred walking in quieter streets and avoiding the hustle and the bustle of busy commercial streets. The choice of busy vs. quiet streets also depends, according to focus group discussions, on who is walking (walking with dogs or small children seems to favor quieter streets, while walking alone favors busy commercial streets), the time of day (rush hour vs. mid-day) and on mood, as one participant noted:

> *“If I’m in a hurry I’ll go down a street with not many people, like Guerrero; if there’s time to linger, or I want to be around people, I’ll go down Valencia; and if Valencia is too much “San Francisco”, I’ll walk on Mission and see the “other” people.”*

In terms of the types of businesses that promote or deter walking, participants mentioned liquor stores, mini-marts that sell liquor and snacks, and auto shops as deterrents to walking, and restaurants, coffee shops and small boutique shops as attractants. Other types of establishment believed to promote walkability for women, like churches and shopping malls (Clifton & Livi, 2005), were not discussed in the focus groups.

The other variables examined in this study, which were found in previous studies to influence women’s walking, like parking lots (Valentine, 1989; Clifton & Livi, 2005), graffiti (Craig et al., 2002), sidewalk conditions (Clifton & Dill, 2005; Handy, 2007) and curb ramps (Clifton & Livi, 2005) turned out to be only marginally important to focus group participants and had a very minimal affect on index score (these four variables combined accounted for only 10.1% - 11.7% of a block's final score, or 6.7% - 8.3% when excluding sidewalk quality).

As for the second research question, *where in San Francisco are the most and least walkable places for women*, the Women's Walkability Index Map (Map 2) reveals that the least walkable areas for women are the Downtown, Tenderloin, Western Addition and SoMa neighborhoods, the northern half of the Mission neighborhood, Chinatown and the touristic Fisherman's Wharf area, with some additional pockets of low women's walkability along Market street in the Castro, along the southern parts of Mission street, in Haight-Ashbury, along Third street in the Bayview, and around highway intersections and underpasses.

These areas received low walkability rankings because they are high-crime, high-homelessness and relatively dirty areas (i.e., have large numbers of street and sidewalk cleaning requests), three variables that together account for 56.5% (Model 2) to 67.5% (Model 3) of the entire walkability score. Interestingly, the lowest-walkability areas according to the WWI are also some of the most densely populated, mixed-use, business-rich areas of San Francisco, most popular with tourists and locals. SoMa neighborhood, for example, has some of the lowest WWI block scores in the city, however its Walk Score is 96 (out of 100), and apartments in the neighborhood are currently being advertised on Walk Score's website for prices ranging from $2,700 to $3,600 per month, for a studio apartment. If WWI scores accurately represent the reality of women's walking then some of the most deep-rooted assumptions and widely accepted conventions about what kind of areas promote walking are false when it comes to women.

The most consistently walkable areas for women are concentrated on the western side of the city, mostly as a result of relatively low crime and low homeless densities in these areas. These include the Outer Sunset and Parkside neighborhoods and the southern parts of the Richmond neighborhoods (Central and Outer). Sunset Blvd, Park Presidio Blvd and the streets adjacent to Golden Gate Park rank particularly high as a result of the positive impact parks and open spaces have on their score, as do most low-crime residential streets which are adjacent to parks throughout the city. Some high-end neighborhoods in the northern part of the city are also high-walkability areas, including Seacliff, Presidio Heights, Pacific Heights and the Marina.

It seems that the answer to the third and final research question, *Does the leading walkability index at present, Walk Score®, account for women's walkability?* is no. Based on focus group discussions and variable rankings, the most influential factor on women's walking is fear of crime, accounting for 29.5% - 37% of the total WWI score. Since Walk Score's algorithm does not take crime into account, and given the importance of crime to women, it is hard to claim that Walk Score accurately reflects women's walkability. In fact, though Walk Score has been validated by academic studies as a reliable walkability measure (Duncan, et al., 2012; Manaugh & El-Geneidy, 2011), it has also been criticized for ignoring crime, and one study found it to be positively correlated with crime (Carr et al., 2010). The correlation between Walk Score and crime reports in San Francisco was examined here, too, and the result was a statistically significant positive correlation of moderate strength (Spearman's rho value of 0.678). Walk Score also ignores some of the other built environment aspects that were part of WWI, like traffic, topography and neighborhood aesthetics (Duncan et al., 2012). Additionally, Walk Score was found to best capture walkability at a large spatial scale of 1,600 meters (1 mile) (Duncan et al., 2012), which is much larger than the average city block length in San Francisco (about 120 meters, or just under 400 feet), the spatial scale analyzed by WWI. Walk Score, being a large scale, nationally applied, 'one size fits all' walkability index, may not be nuanced enough to detect relative walkability within a generally walkable place like San Francisco, as WWI does.

Given these differences between Walk Score and WWI, and especially given the importance of crime in WWI and its absence from Walk Score, it is no surprise that the two indices show a statistically significant negative correlation of moderate strength (Spearman's rho values of -0.524 to -0.585, depending on model).

Study Limitations

Several limitations of this study should be noted. One important limitation is the potential focus group bias. Focus group participants were recruited via Nextdoor, a social network that, given its history with racial profiling by users (Seung Lee, 2016), may under-represent certain demographics, like minorities. Additionally, the recruitment post on Nextdoor was only published in 31 neighborhoods, all in the southern part of the city, which may have excluded women who live in other parts of the city from participating. None of the participants were from the neighborhoods with lowest walkability scores according to WWI (though some of the participants work in these lower walkability neighborhoods), which may have affected participants' perceptions of things like crime and homelessness. The participant recruitment method may also have introduced a self-selection bias, with women who are particularly interested in walking, or are avid walkers, more likely to volunteer. Seasonality was not accounted for in this study, but may have affected focus group participants' responses. The fact that focus group meetings were held in the fall may have influenced participants' perceptions of walkability.

Second, some of the datasets used in the analysis, particularly homelessness and street and sidewalk cleanliness, are based on data reported to the city by residents (i.e. SF 311 reports). Such reports may be more likely in certain neighborhoods, or by certain residents, than others, and it is impossible to know whether absence of reporting indicates absence of occurrences, or whether occurrences are simply being under-reported in certain places.

Certain data availability and GIS limitations may also have had an effect on the results. Sidewalk quality scores were not available for all city blocks, and missing scores were substituted by the mean sidewalk quality score. Additionally, some of the sidewalk scores in the dataset are from the 1990s or early 2000s and may not accurately represent current sidewalk conditions. The dataset used for businesses was from 2015 and therefore did not account for new businesses that opened during 2016 or ones that closed that year. Certain areas in the city – the Presidio, Golden Gate Park and Hunter's Point Shipyard - were excluded from analysis because of lack of available data. These areas are large open spaces that are not part of the city's street grid and therefore were not as important to analyze from a walkability standpoint. Computational limitations causing inaccurate calculations for homelessness and crime densities may have also had an impact on model results. Finally, the exclusion of nighttime crimes from analysis may have created a bias, since it may very well be that areas known to have many nighttime crimes become less walkable during the daytime, even if crimes are not committed during the day.

The models used in this study are based on many assumptions, and some of these assumptions may prove to be inaccurate. For example, the division of businesses into "positive", "negative" and "neutral" businesses and the weights associated with each category may be inaccurate or false, or may differ from woman to woman, as may the "spill over" distance of crime and homelessness (assumed to be 100 meters), or the radius of influence of parks and open spaces on nearby streets. Choice of data classification methods – Manual Classification for parking, slope and speed limit, and Natural Breaks (Jenks) for the other variables – may also alter results, as may the threshold values selected for the manually classified variables. The fact that focus group participants did not rank slope and that AHP weights were calculated for slope based on the assumption that it was more important than half of the other variables and less important than the other half, may have slightly skewed variable weights, although based on the comparison between the four models there is no evidence for any kind of bias in variable weights.

The Women’s Walkability Index models walkability in an additive way, which assumes a decision making process that considers all walkability-influencing factors simultaneously. However, anecdotal evidence from focus group discussions suggest that women’s decision-making process may be comprised of several binary decisions, where some minimum factors – like an acceptably low level of crime or homelessness – must be met, before other factors of lower importance can be weighed additively.

Finally, and perhaps most importantly, the analysis does not take into account the temporal aspects of walking-related decision-making. When does a woman pedestrian make the decision to walk or not to walk somewhere? Does a woman (or any pedestrian, for that matter) decide to avoid a block only when she approaches it, when the block is visible to her, or is that decision made long before, perhaps even before leaving her origin? It is not hard to imagine that each woman has a mental map of the streets in her city of residence to guide her when walking, a map that is continuously updated based on life experience. This idea was unfortunately not discussed in the focus groups, and future women’s walkability research should perhaps explore the spatio-temporal aspects of women’s walking-related decision making.

Conclusion

The Women's Walkability Index, in each of its four versions, is heavily affected by crime, homelessness and sidewalk cleanliness. These three variables combined account for 56.5%-67.5% of the index's final score, depending on the model utilized.

It seems that the Index under-values the presence of businesses on the street, which is traditionally believed to increase walkability, leading to low walkability scores in areas otherwise considered highly walkable and highly appealing for pedestrians. Still, there is no reason to suspect that the index over-represents the importance of fear of crime, homelessness and cleanliness, and anecdotal evidence suggests that this is, indeed, a fair representation of the most important things for women pedestrians.

As most of the variables comprising the Women's Walkability Index have a negative association with walking, WWI could be interpreted as an index that captures deterrents to walking, rather than attractants. Walk Score, on the other hand, is heavily, if not entirely, influenced by the proximity of walking destinations, i.e. attractants. Perhaps, since the two models seem to be antipodal, but are also complementary in many ways, WWI should be used to inform Walk Score, or vice versa. A walkability model integrating both Walk Score and WWI could possibly become the most accurate representation of women's walkability to date.

This is a first attempt at creating a women-specific walkability index, and future iterations of this index may prove more accurate and provide more insight into women's walking. This study's main contributions to the walkability discussion are its focus on women's walkability, and its mixed-method approach, combining the added value of hearing from women first-hand what matters to them, with the analytical capabilities of GIS software, which provides the opportunity for a large-scale, replicable analysis. Another major contribution of this study is the understanding that women's daytime walkability is not much different than nighttime walkability and that it, too, is heavily influenced by fear of crime. This understanding should guide policy makers, urban planners, landscape architects and walkability advocates in designing existing and future urban environments that are safe and welcoming for women.

Gill Valentine (1989) claimed that it is impossible to understand women's use of space without being aware of their geography of fear, as women are socialized throughout their lives to avoid 'dangerous places' at 'dangerous times'. This study into women's use of space has tried to eliminate the effects of 'dangerous times'. Thus, it became evident that, almost 30 years after Valentine's comment was made, women still seek to avoid dangerous places, even at 'non-dangerous' times.

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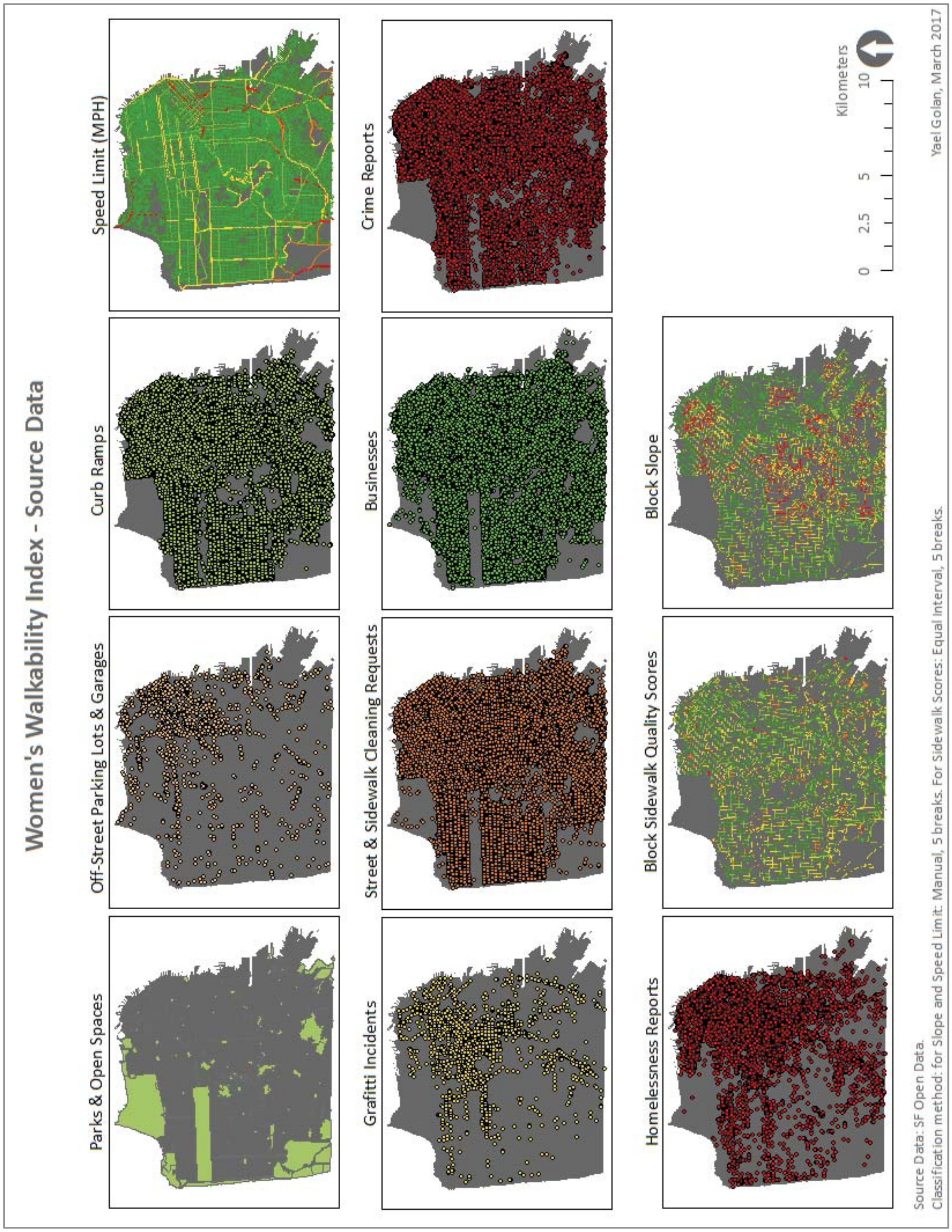
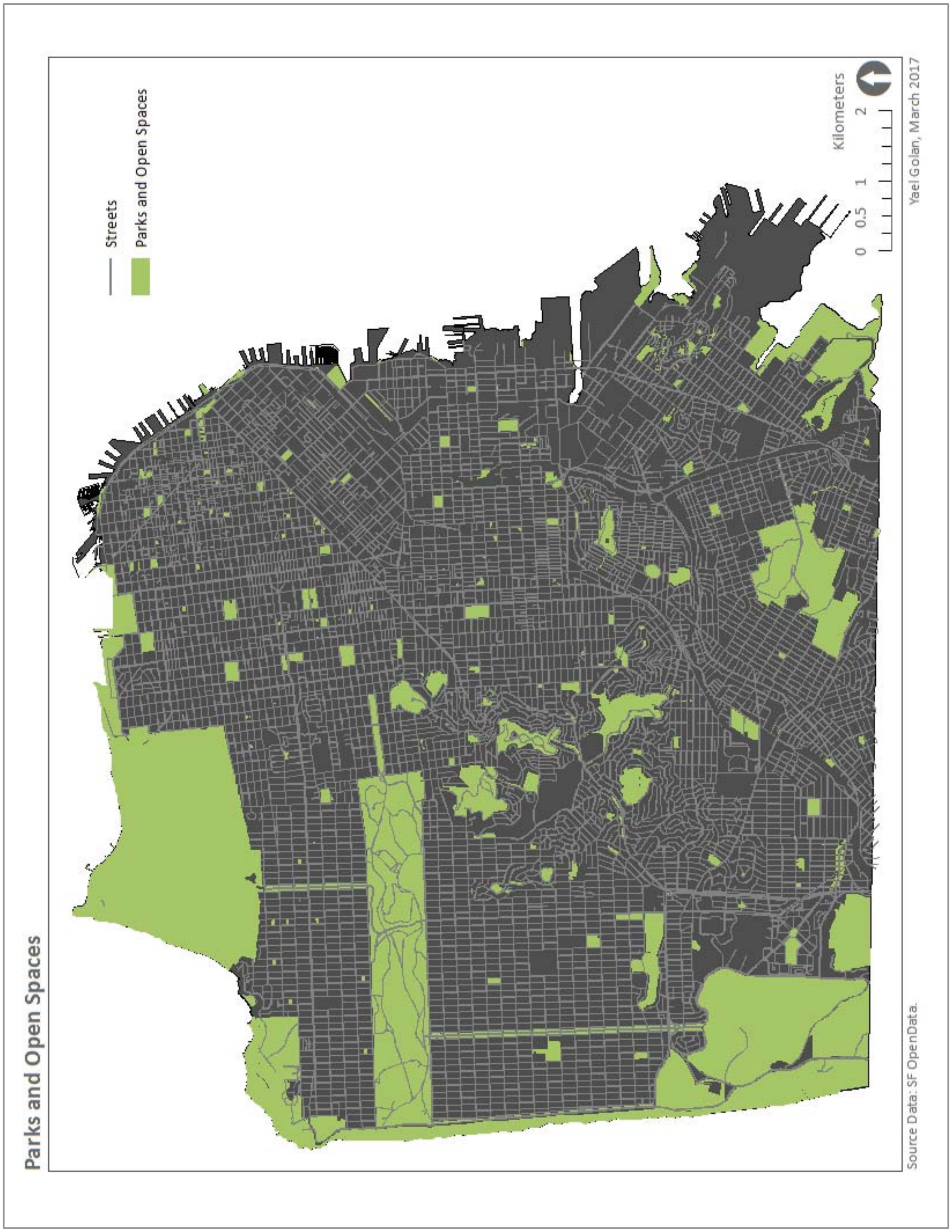
Appendix A – List of Focus Groups Discussion Questions

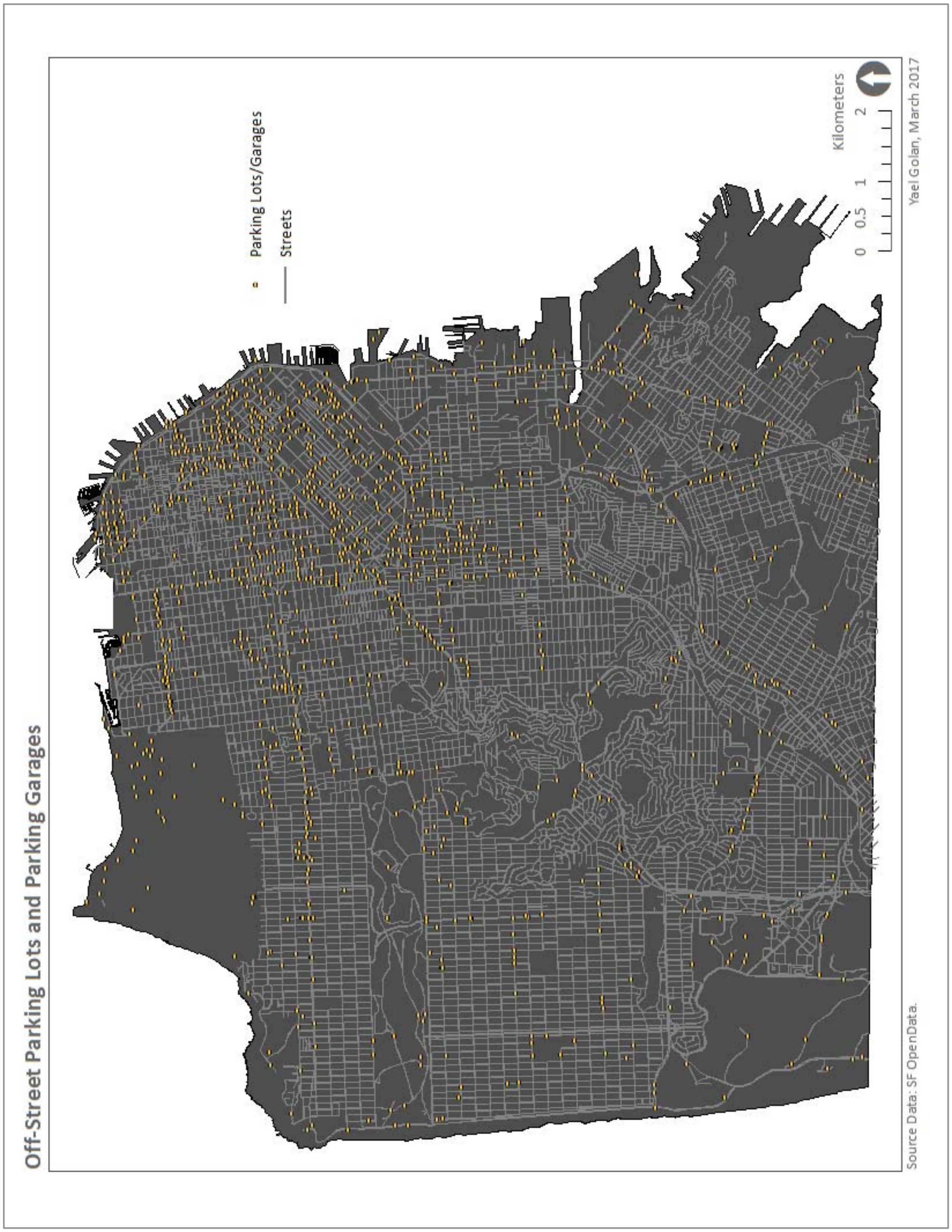
1. Where in San Francisco do you most like or enjoy walking?
    - Why? What makes it pleasant to walk there?
2. Where in San Francisco do you most dislike or hate walking?
    - Why? What makes it unpleasant to walk there?
3. We are now going to discuss a series of street characteristics to see which of them most influence your desire or willingness to walk somewhere (the influence could be either positive or negative):
    - The quality of sidewalks (width, completeness, cracks etc.)
    - Crime (is crime a major influence on *daytime* walking?)
    - Nearby parks (does the size of the park matter?)
    - Curb ramps (ADA ramps for easy access with stroller or wheelchair)
    - Street and sidewalk cleanliness (trash, bulky items, odors)
    - Presence of homeless people or encampments
    - Vehicular traffic
    - Off-street parking lots and parking garages
    - Graffiti
    - Specific businesses or services (which ones? how do they influence you?)
    - Slope
4. I will now hand out a form for you to fill out with comparisons of these characteristics we just discussed. For each two variables compared in the table, please choose the one that influences your walking (either negatively or positively) more, and write the letter associated with that variable in the designated spot.
5. Is there anything else, other than what we have already discussed today, that you think influences you when walking, or generally influences women’s walking?
6. Do you have anything else to add?

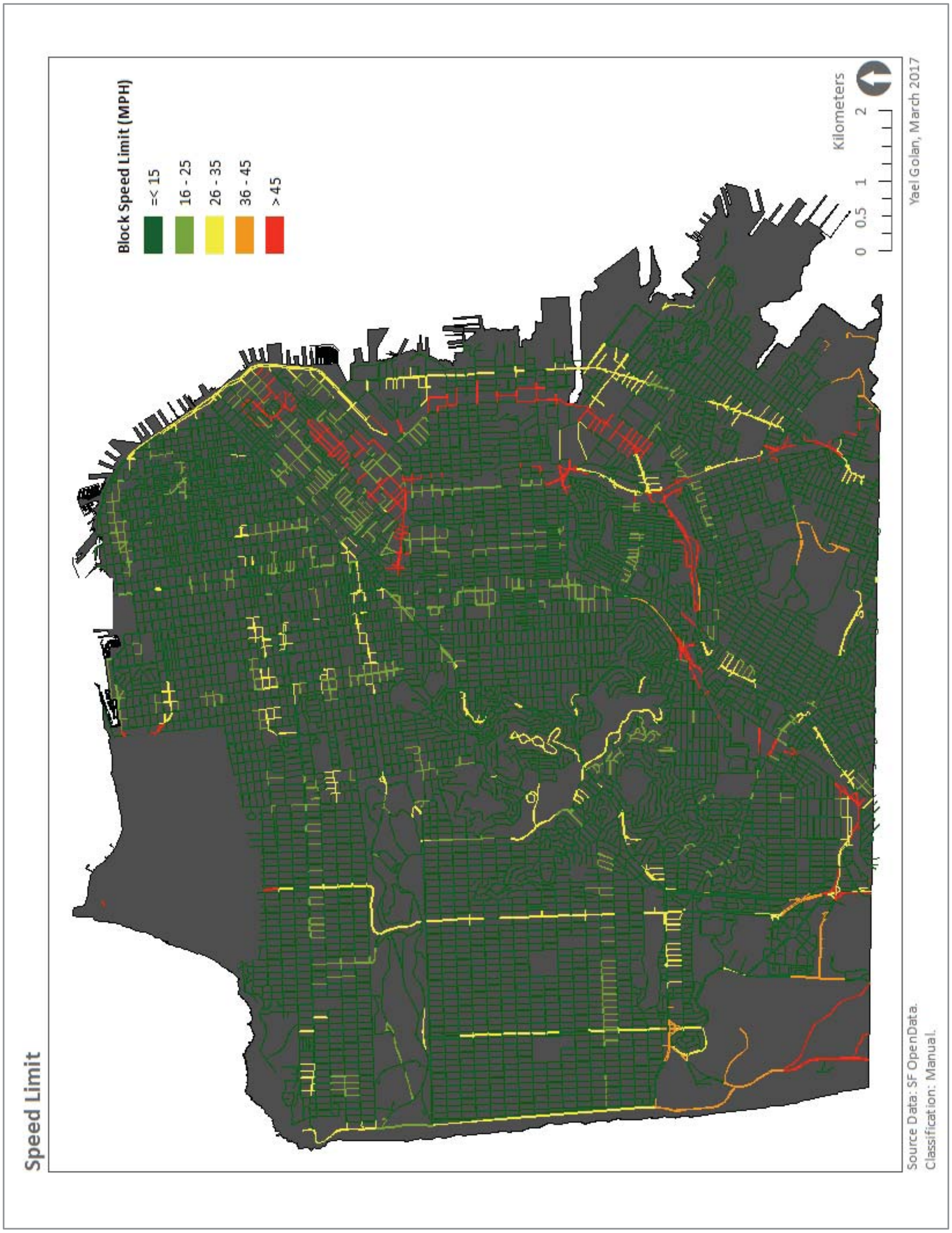
Appendix B – Spatial Distribution of Source Data (Map of All Non-Normalized Variables)

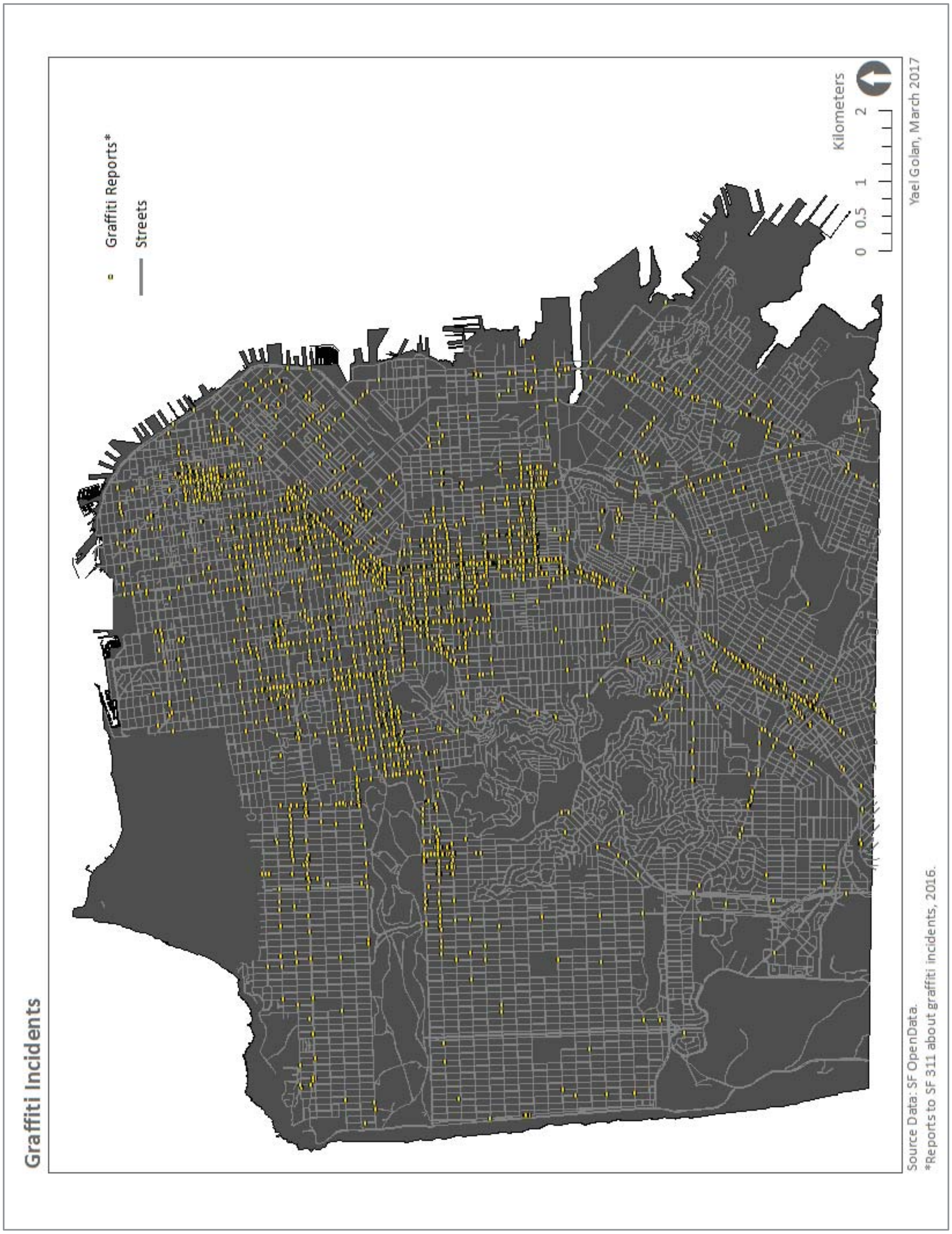


Appendix C – Individual Maps of Source Data (Non-Normalized)

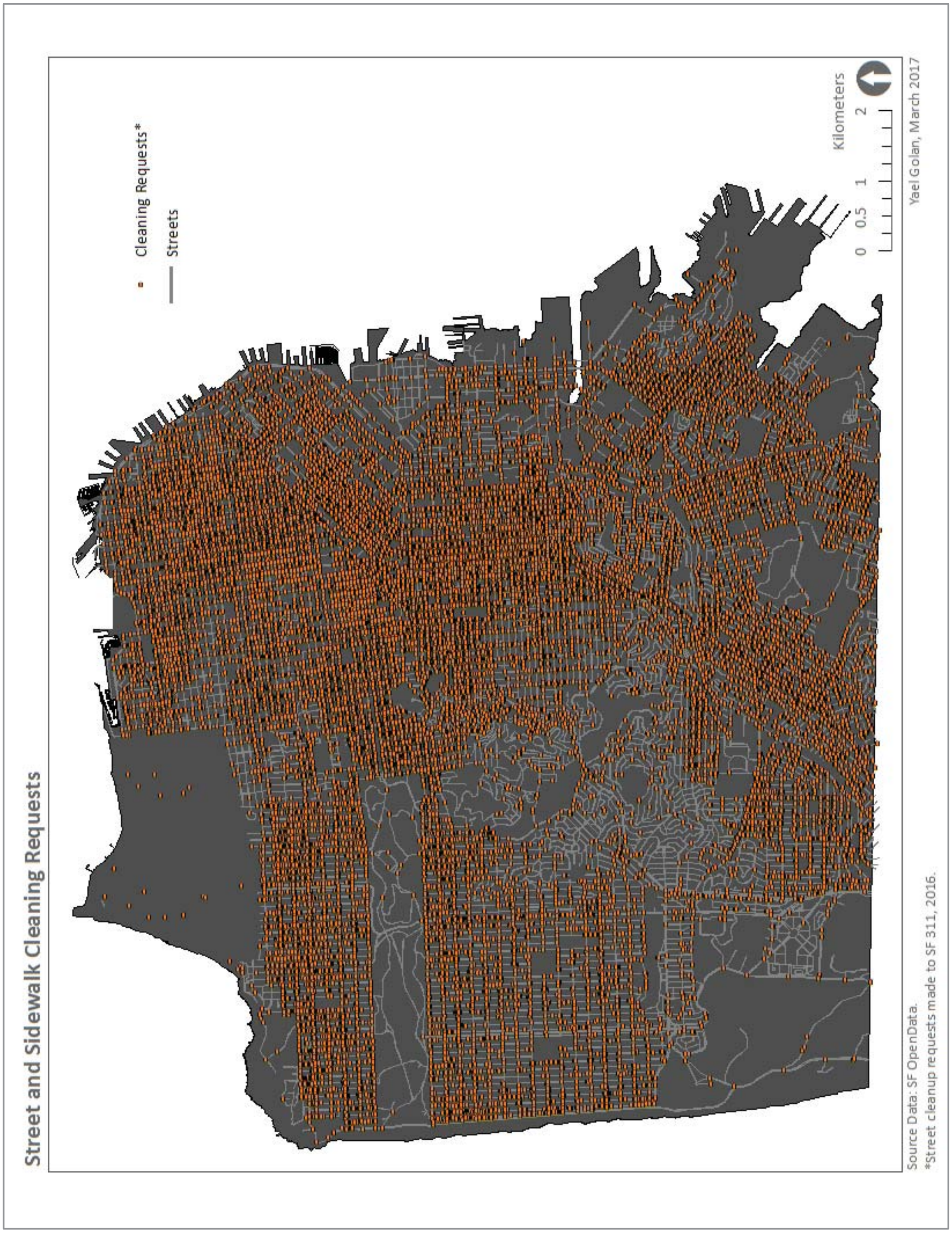


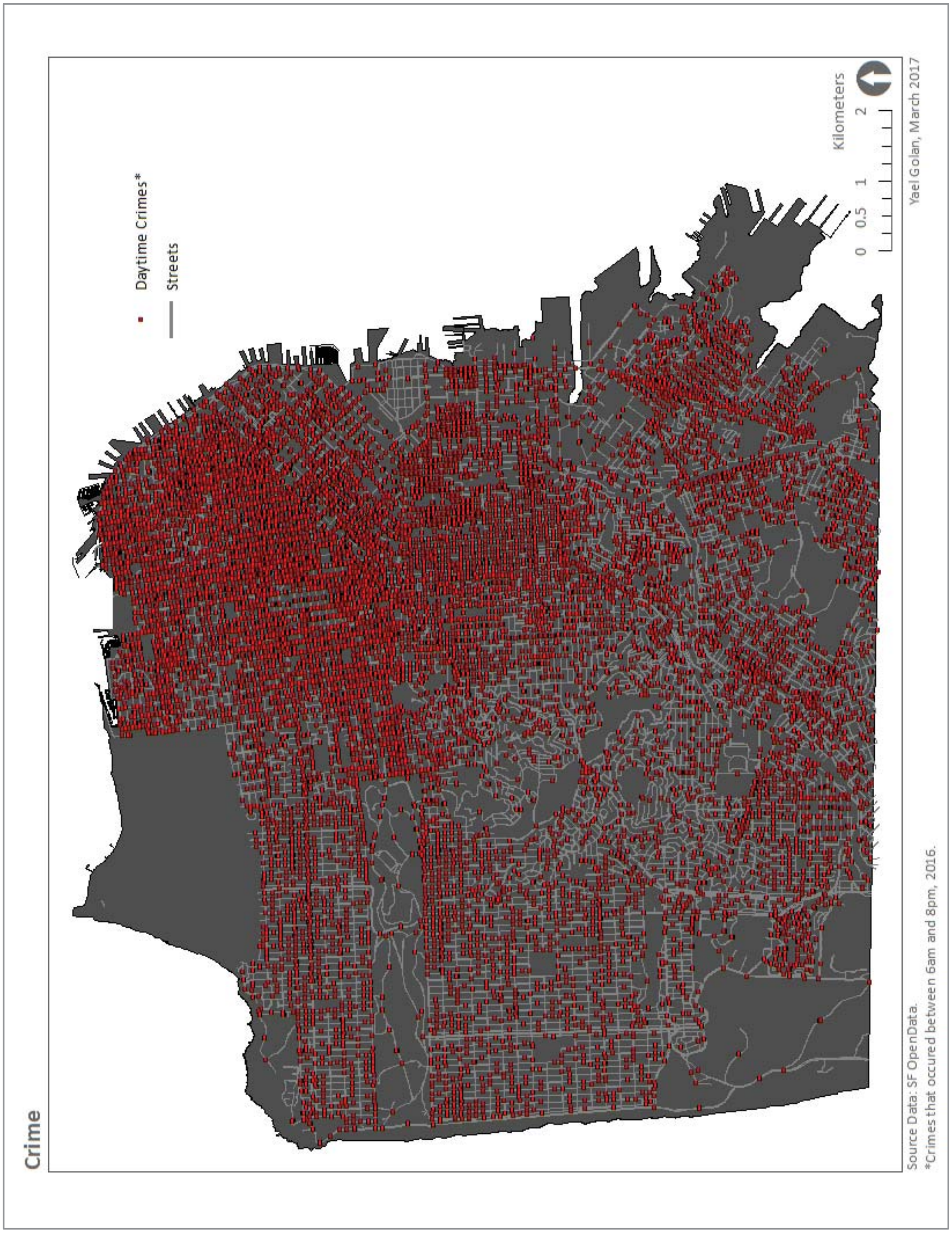

Off-Street Parking Lots and Parking Garages
Parking Lots/Garages
Streets
0 0.5 1 2
Kilometers
Source Data: SF OpenData.
Yael Golan, March 2017

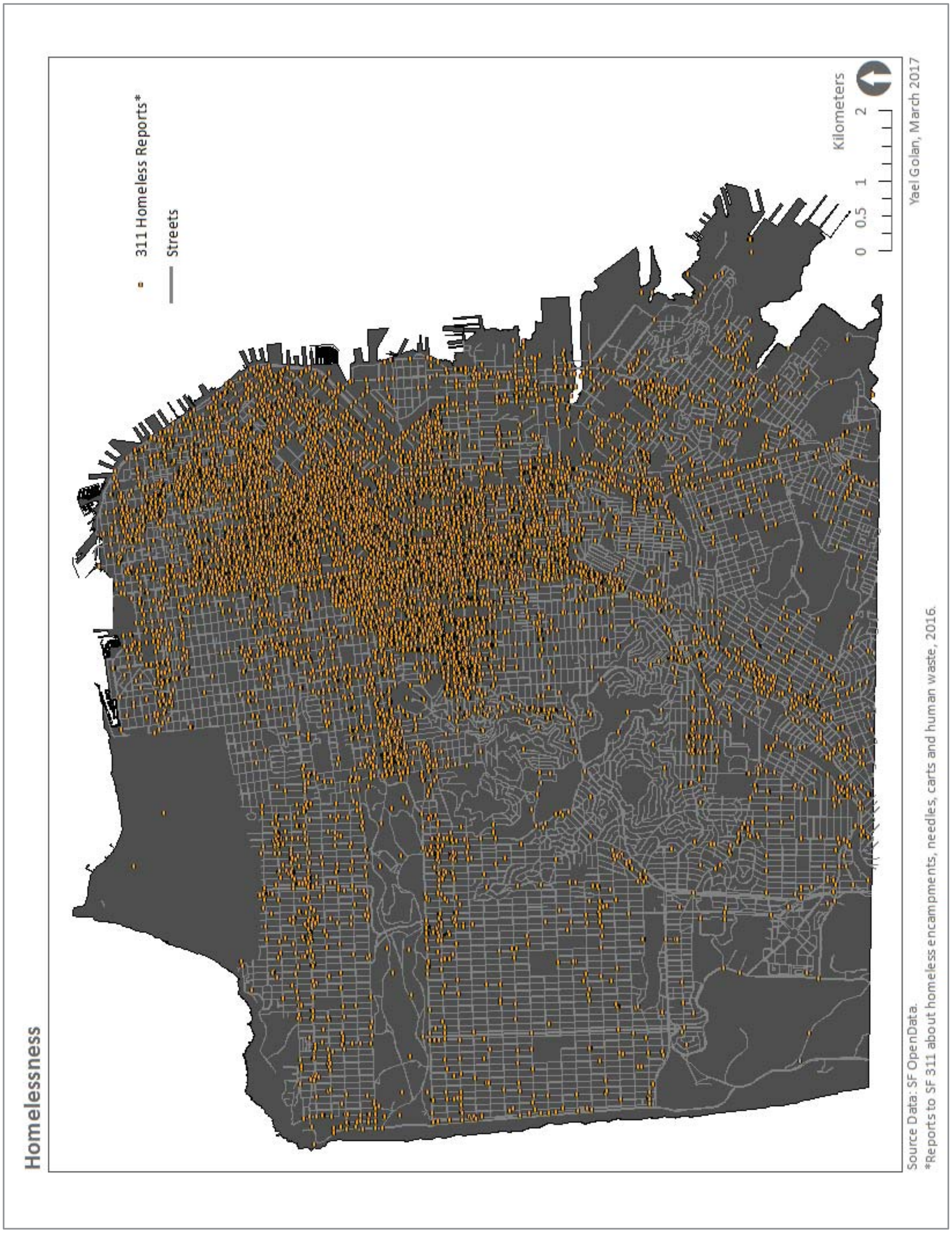

Speed Limit
Block Speed Limit (MPH)
=< 15
16 - 25
26 - 35
36 - 45
> 45
Kilometers
0 0.5 1 2
Yael Golan, March 2017
Source Data: SF OpenData.
Classification: Manual.


Graffiti Incidents
Graffiti Reports*
Streets
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.
*Reports to SF 311 about graffiti incidents, 2016.

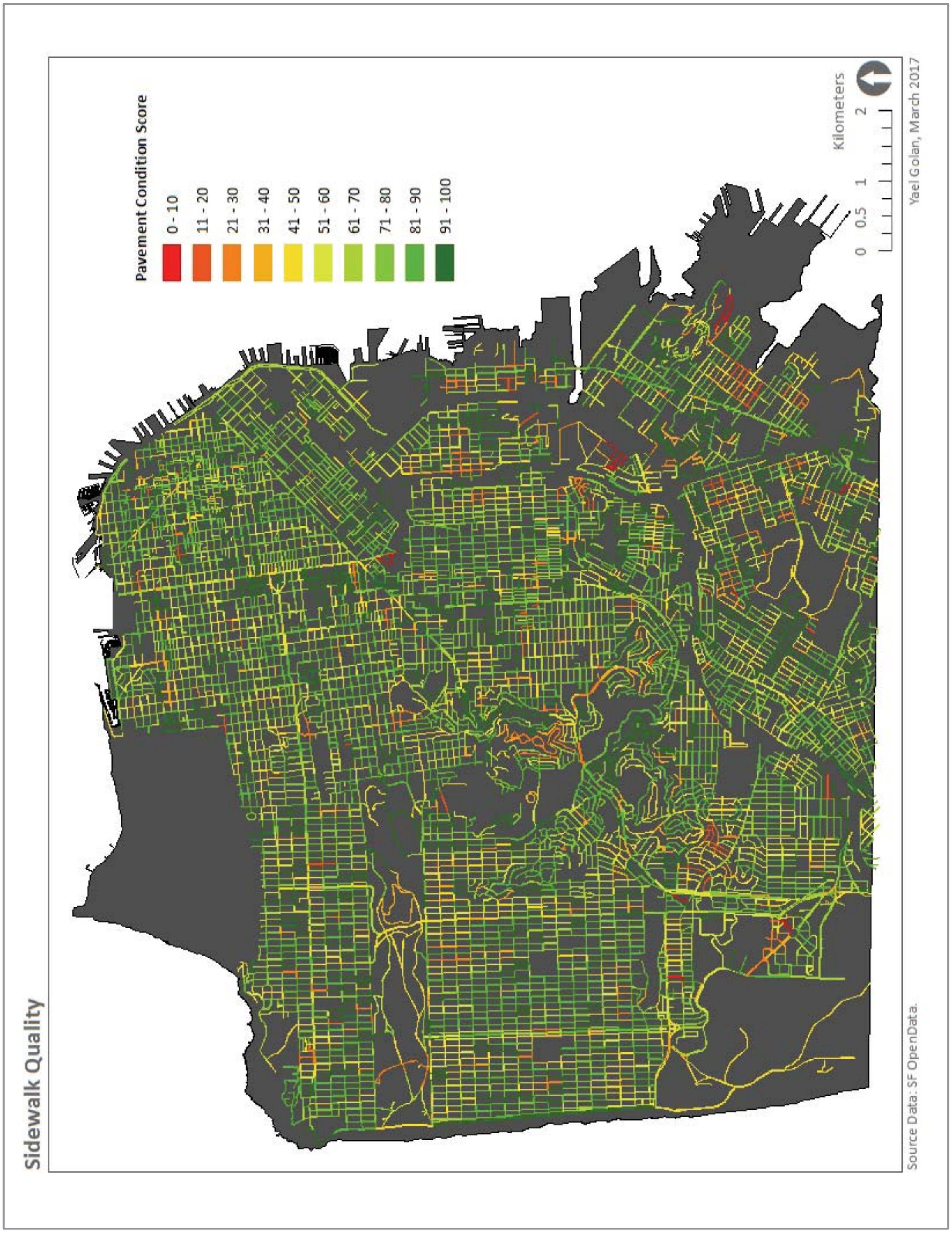

Curb Ramps
Intersections with Curb Ramps*
Streets
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.
* ADA ramps

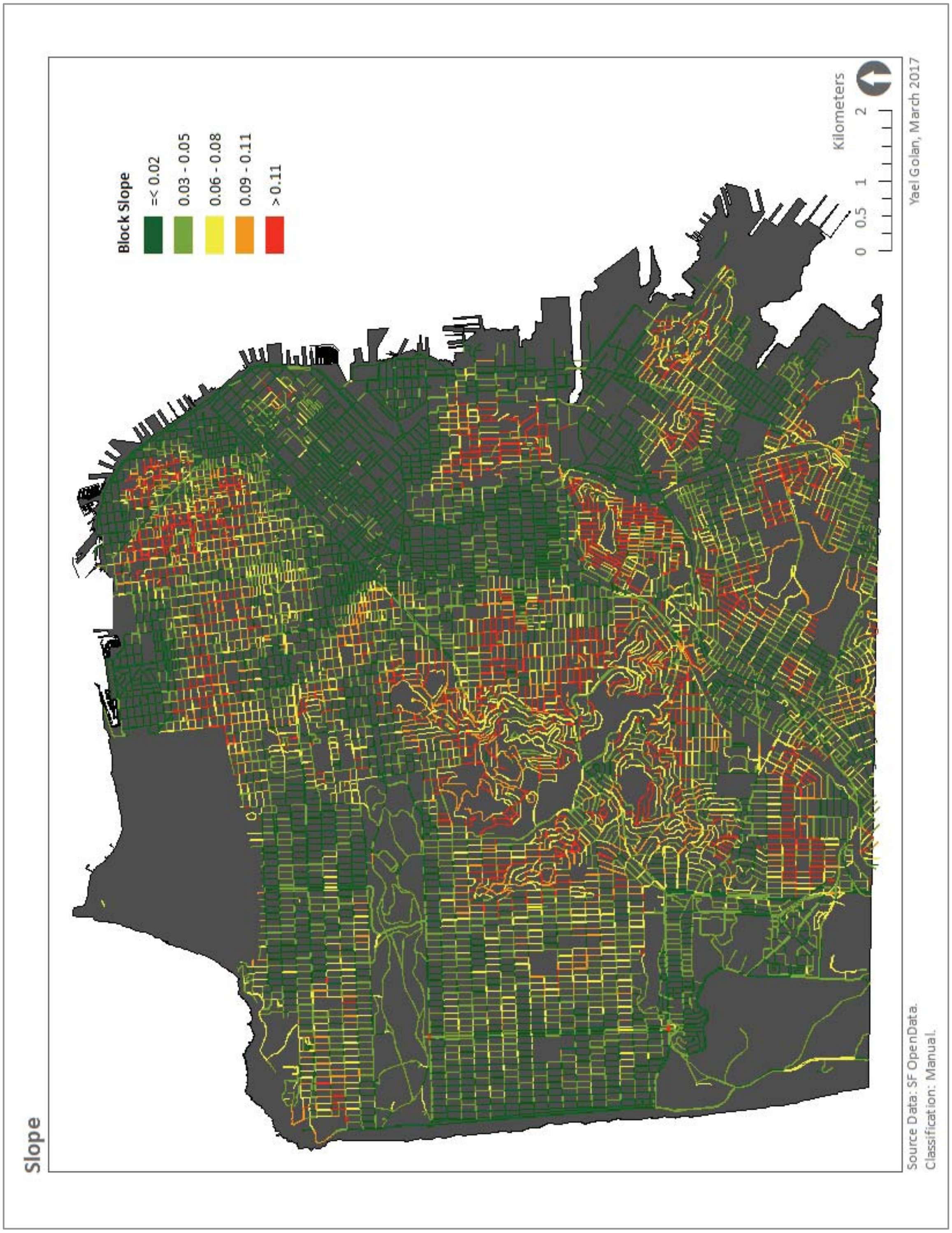

Street and Sidewalk Cleaning Requests
Cleaning Requests*
Streets
Kilometers
0 0.5 1 2
Yael Golan, March 2017
Source Data: SF OpenData.
*Street cleanup requests made to SF 311, 2016.

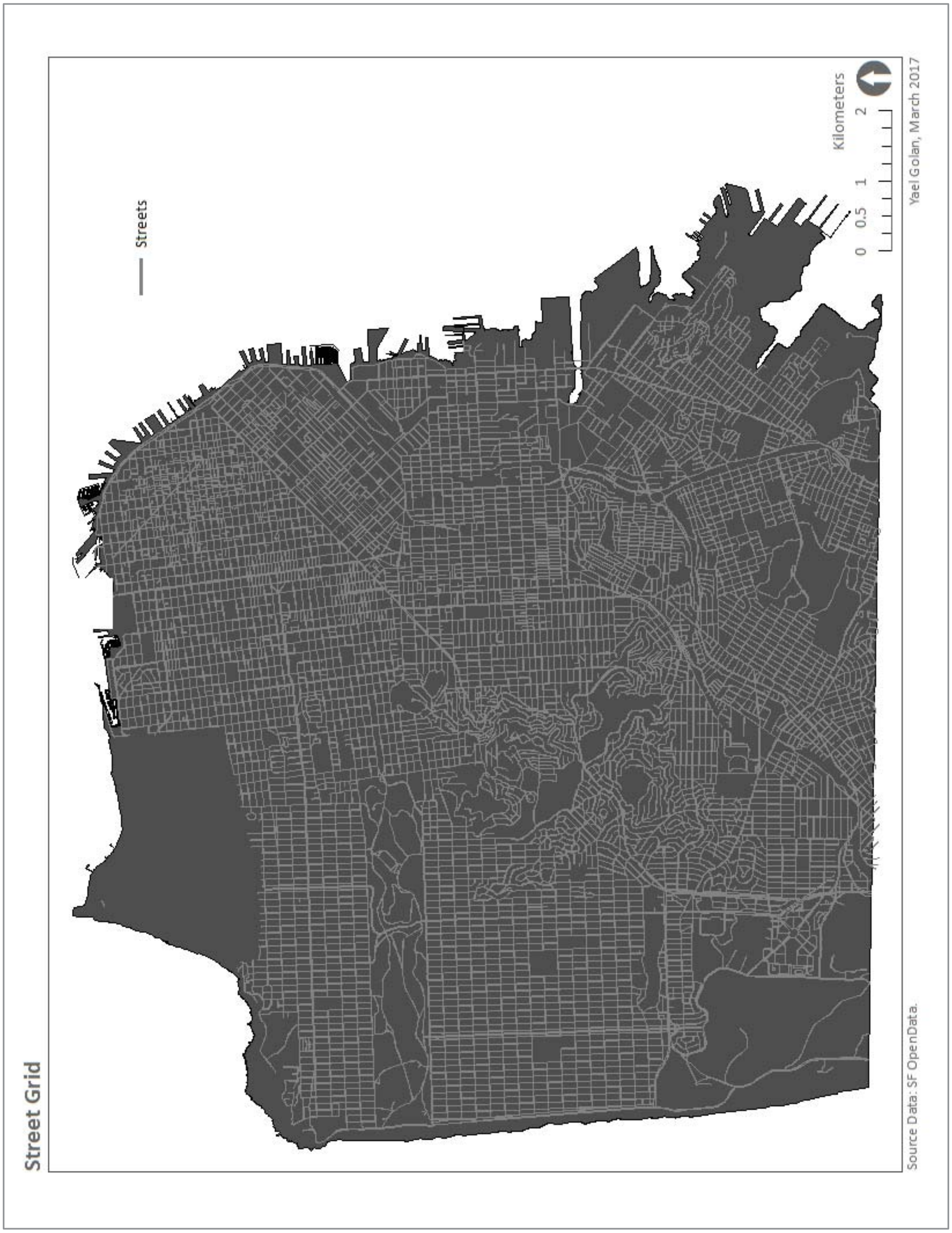

Crime
Daytime Crimes*
Streets
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.
*Crimes that occured between 6am and 8pm, 2016.


Homelessness
311 Homeless Reports*
Streets
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.
*Reports to SF 311 about homeless encampments, needles, carts and human waste, 2016.


Businesses
Businesses
Streets
Kilometers
0 0.5 1 2
Source Data: SF OpenData.
Yael Golan, March 2017


Sidewalk Quality
Pavement Condition Score
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
0 0.5 1 2
Kilometers
Source Data: SF OpenData.
Yael Golan, March 2017


Slope
Block Slope
=< 0.02
0.03 - 0.05
0.06 - 0.08
0.09 - 0.11
> 0.11
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.
Classification: Manual.

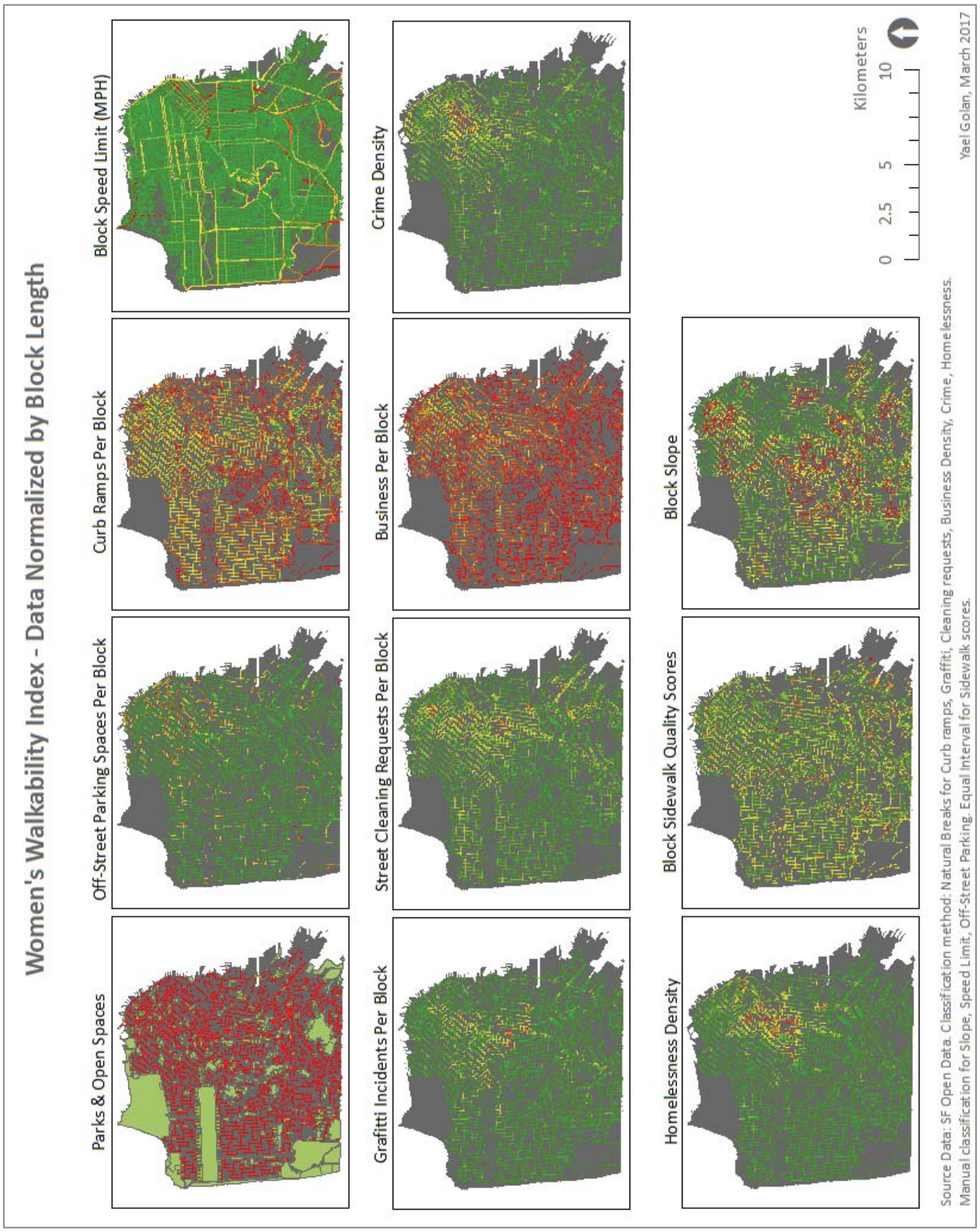

Street Grid
Streets
Kilometers
0 0.5 1 2
Yael Golan, March 2017
Source Data: SF OpenData.

Appendix D – Reclassification of Normalized Variables into Ten Classes

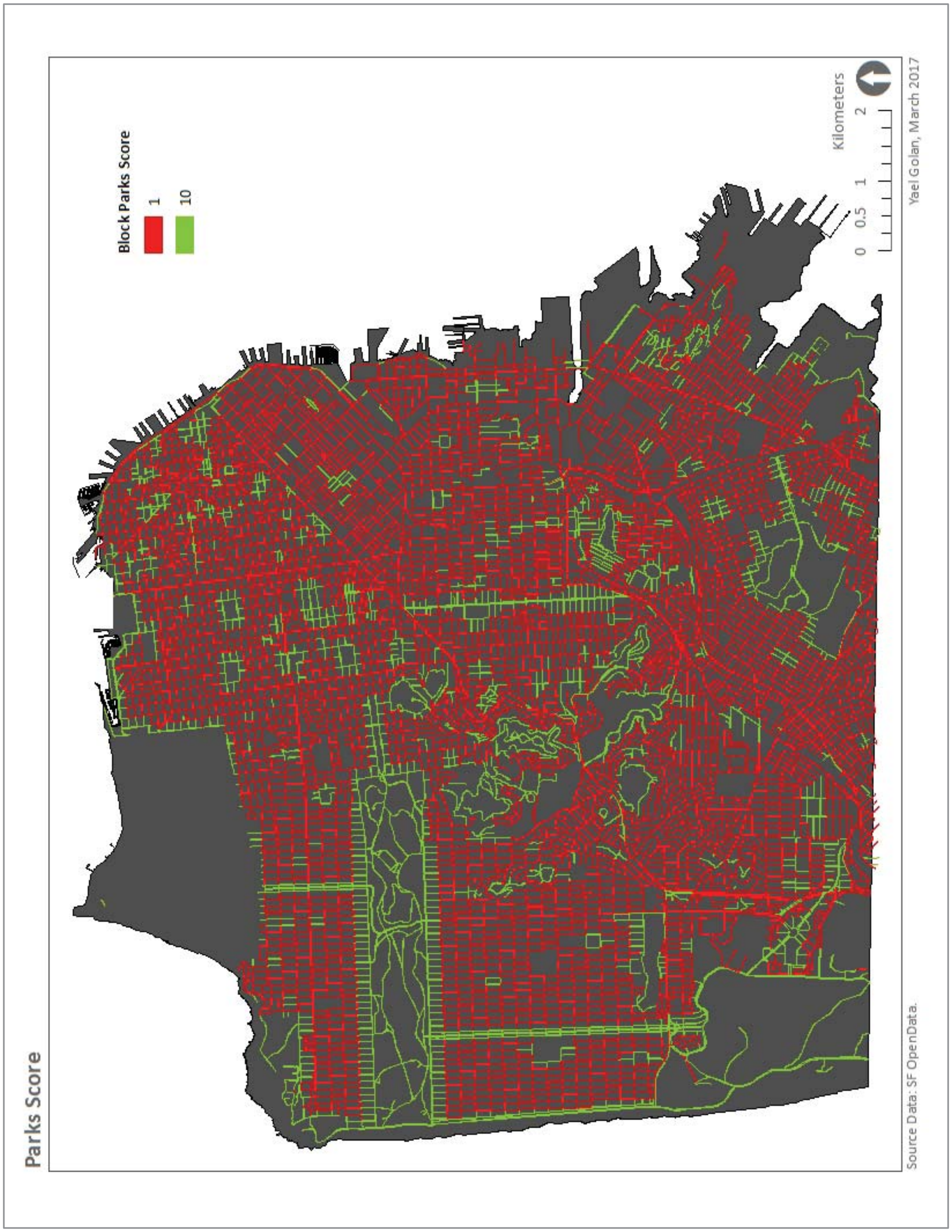
Class	Parks*	Off-Street Parking Spaces Per Block**	Curb Ramps Per Block*	Graffiti Incidents Per Block**	Cleaning Requests Per Block**	Homelessness Density Per Block**	Crime Density Per Block**	Positive Businesses Per Block **	Negative Businesses Per Block**	Neutral Businesses Per Block**	Block Sidewalk Score***	Block Speed Limit (MPH)*	Block Slope*
1	0	2.333-60.0	0-0.002	0.136-0.287	1.726-3.282	16,581-24,233	22,468-61,928	0-0.002	0.045-0.109	0-0.007	0-10	> 45	> 0.11
2			0.003-0.006	0.08-0.135	1.116-1.725	12,176-16,580	13,485-22,467	0.003-0.007	0.023-0.044	0.008-0.021	11-20		
3		0.233-2.333	0.007-0.010	0.054-0.079	0.736-1.115	8,916-12,175	8,919-13,484	0.008-0.015	0.015-0.022	0.022-0.04	21-30	36-45	0.09 - 0.11
4			0.011-0.014	0.039-0.053	0.494-0.735	6,358-8,915	5,928-8,918	0.016-0.027	0.011-0.014	0.041-0.07	31-40		
5		0.067-0.233	0.015-0.017	0.027-0.038	0.332-0.493	4,271-6,357	3,950-5,927	0.028-0.045	0.008-0.01	0.071-0.119	41-50	26-35	0.06 - 0.08
6			0.018-0.022	0.018-0.026	0.213-0.331	2,717-4,270	2,599-3,949	0.046-0.071	0.006-0.007	0.12-0.189	51-60		
7			0.023-0.028	0.011-0.017	0.131-0.212	1,645-2,716	1,582-2,598	0.072-0.109	0.004-0.005	0.19-0.289	61-70		
8		0.007-0.067	0.029-0.039	0.006-0.010	0.072-0.13	833-1,644	833-1,581	0.11-0.185	0.003	0.29-0.447	71-80	16-25	0.03 - 0.05
9			0.04-0.056	0.003-0.005	0.028-0.071	269-832	322-832	0.186-0.314	0.002	0.448-0.669	81-90		
10	1	0-0.007	0.057-0.093	0-0.002	0-0.027	0-268	0-321	0.315-0.54	0-0.001	0.67-1.031	91-100	0-15	0 - 0.02

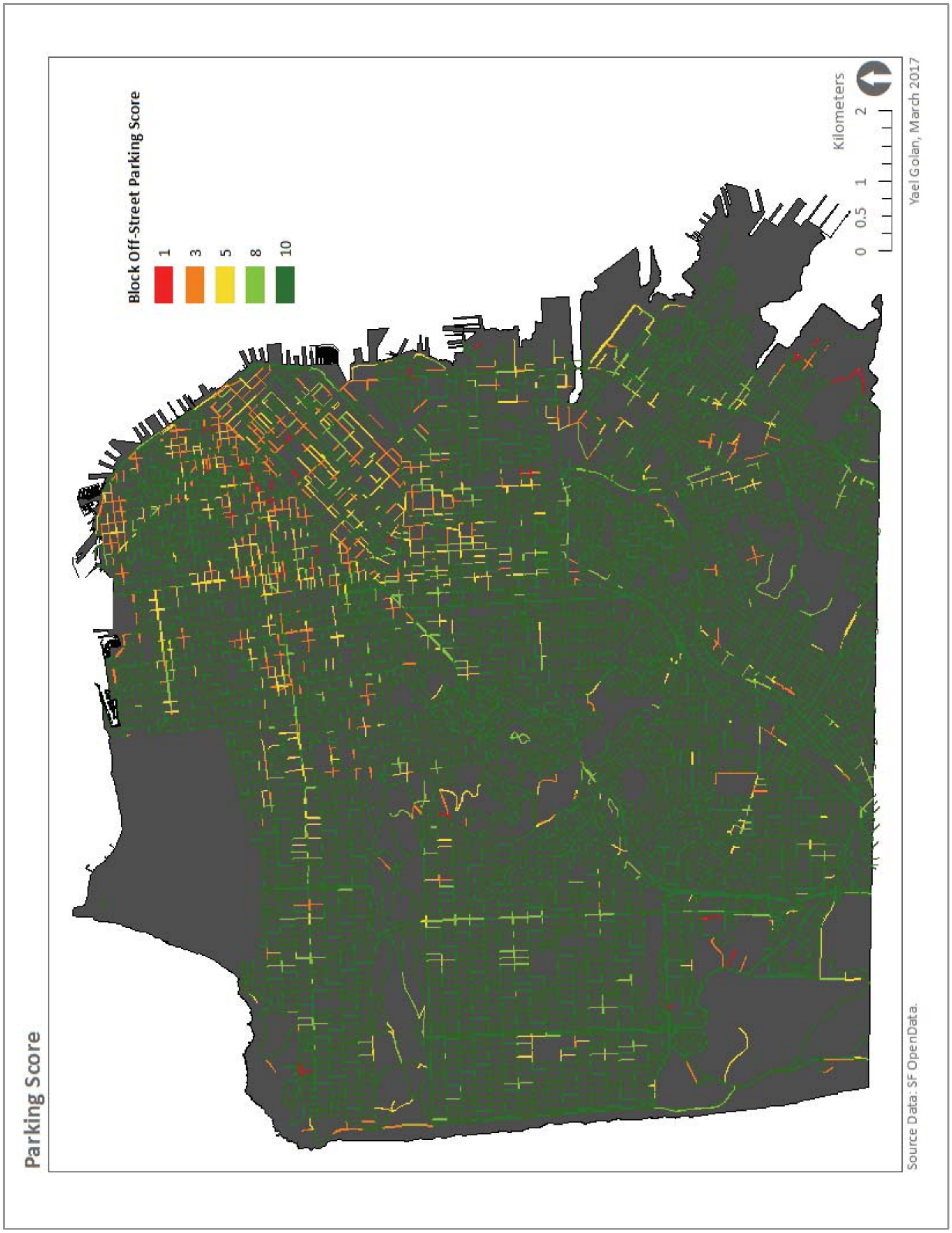
* Manual Classification
** Natural Breaks (Jenks) Classification
*** Equal Interval Classification

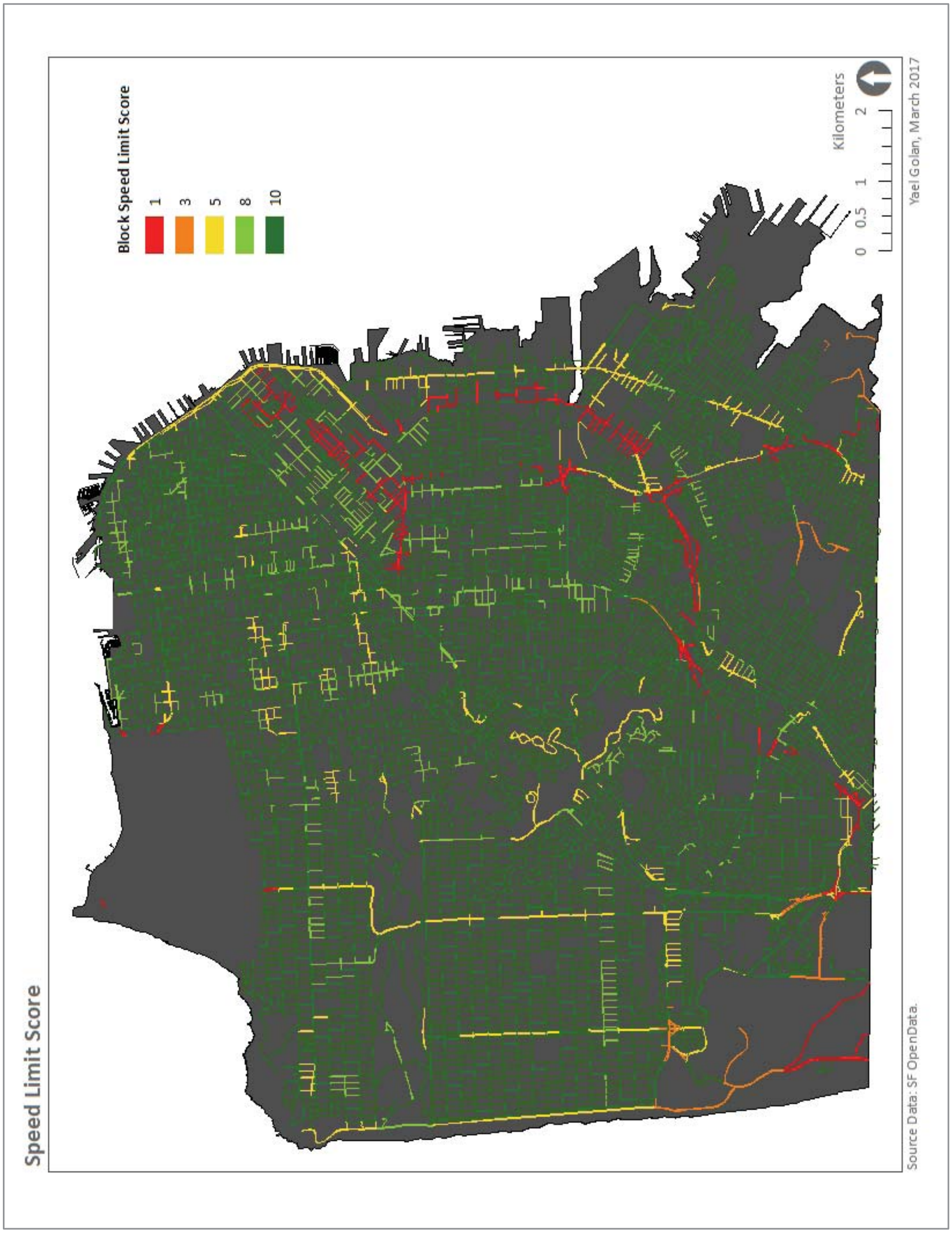
Appendix E – Spatial Distribution of Normalized Data (Map of All Normalized Variables)

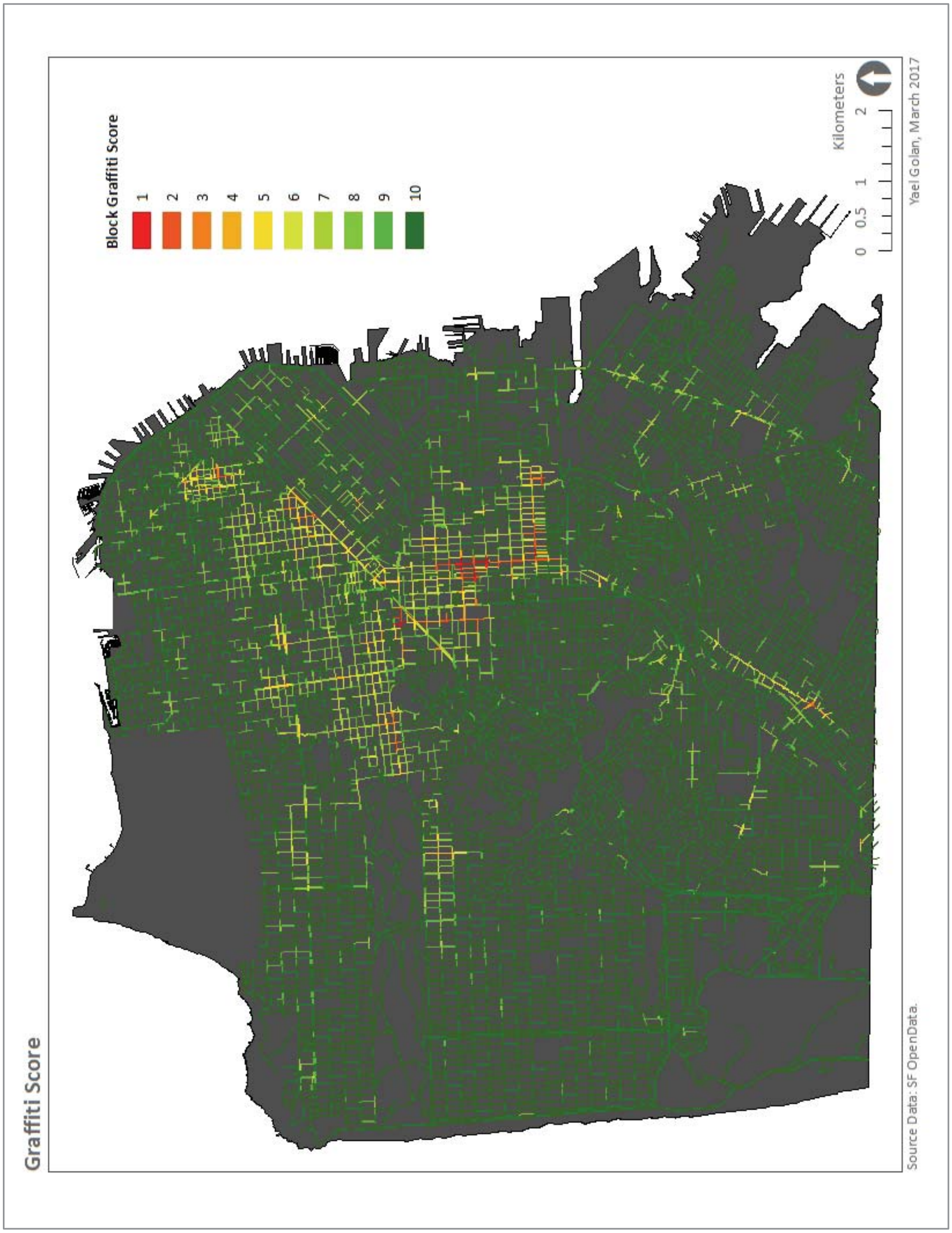


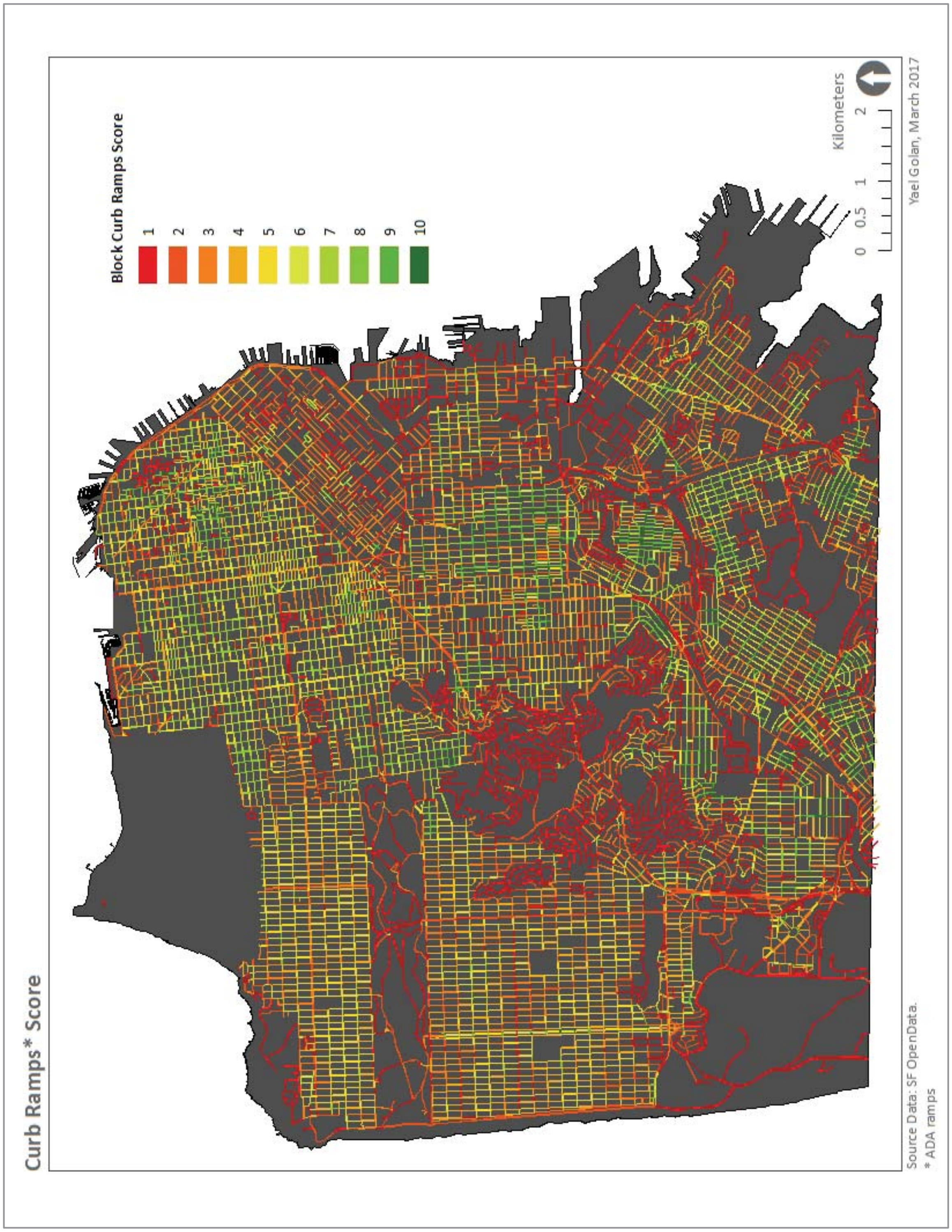
Appendix F – Individual Maps of Variable Scores

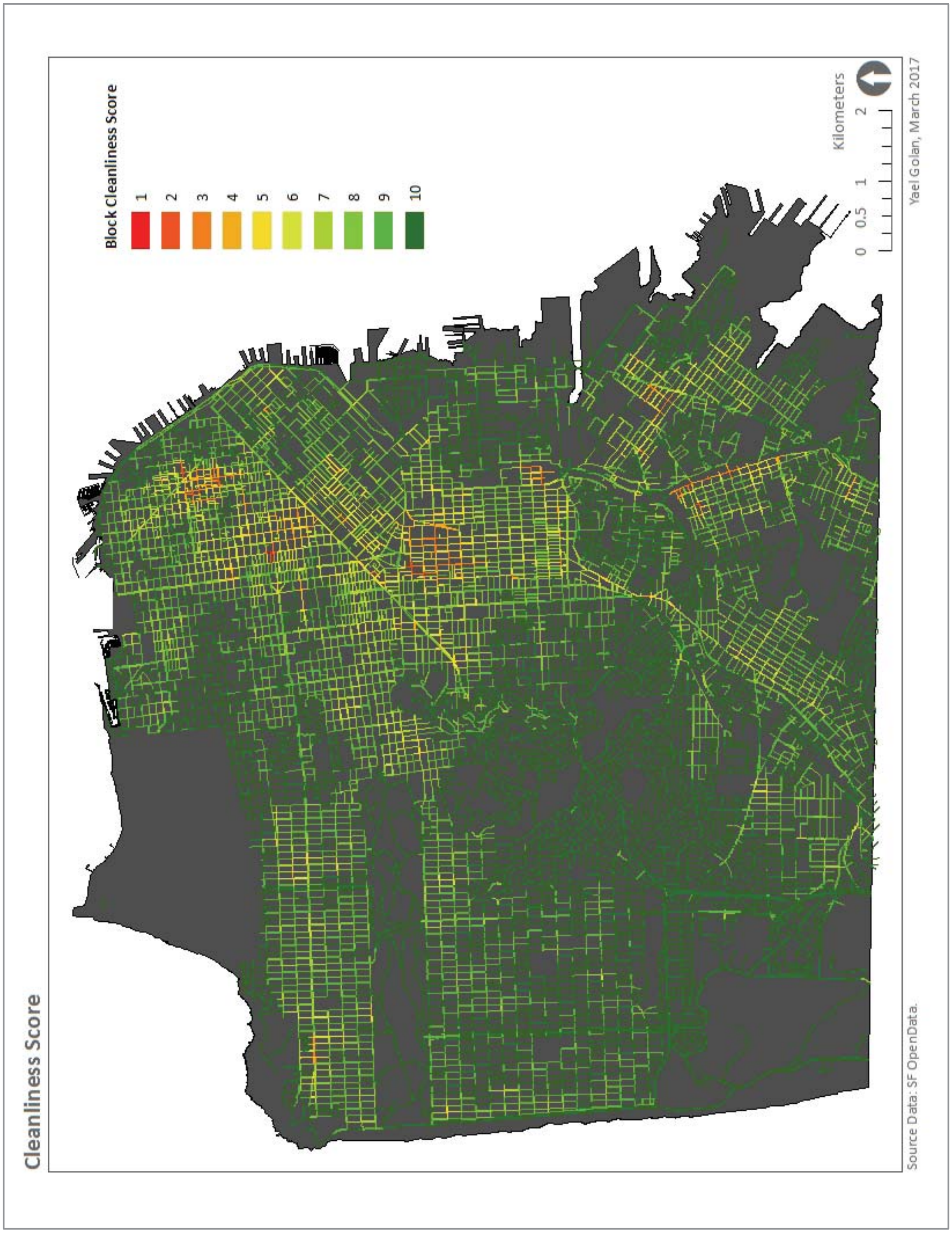


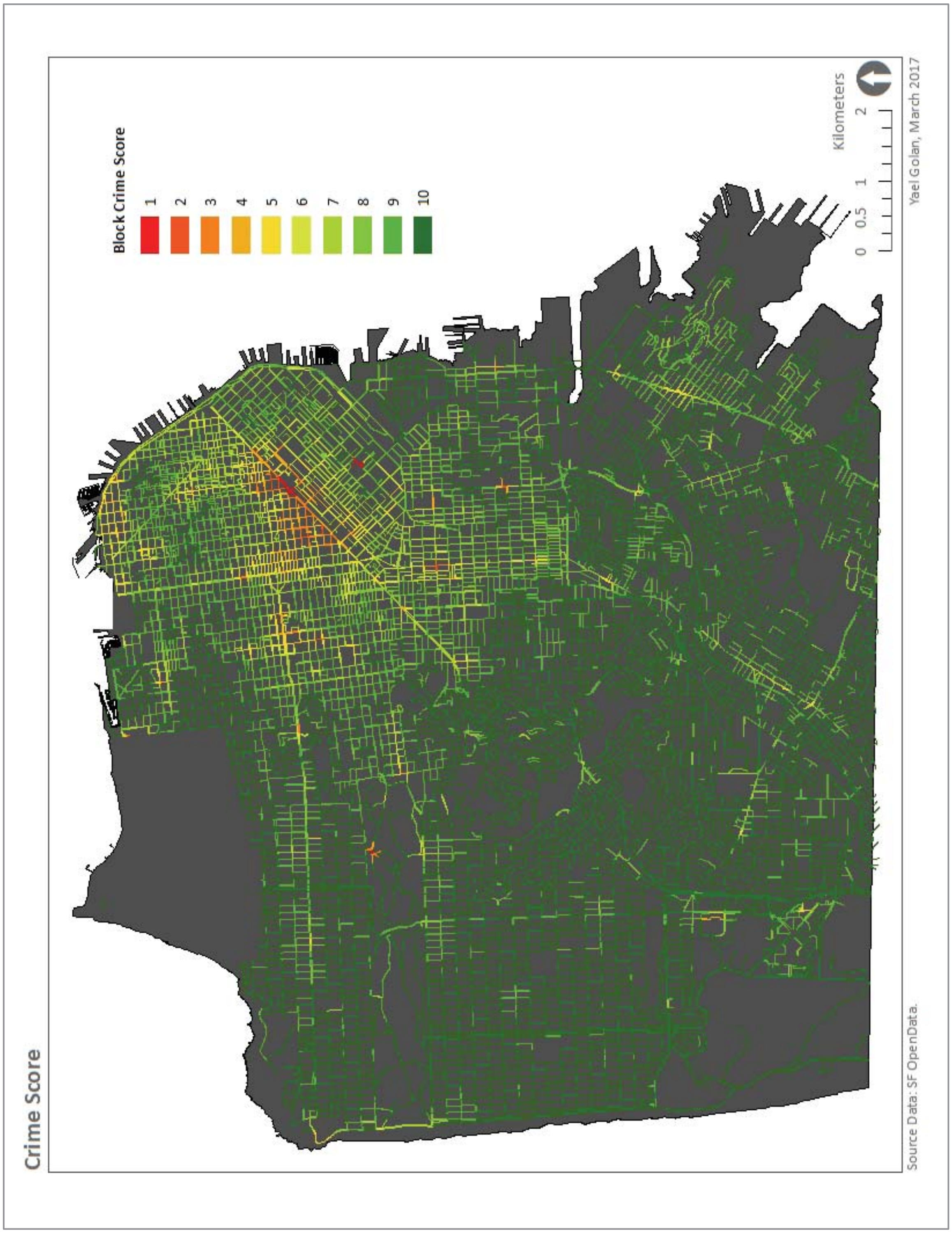

Parking Score
Block Off-Street Parking Score
1
3
5
8
10
0 0.5 1 2
Kilometers
Source Data: SF OpenData.
Yael Golan, March 2017

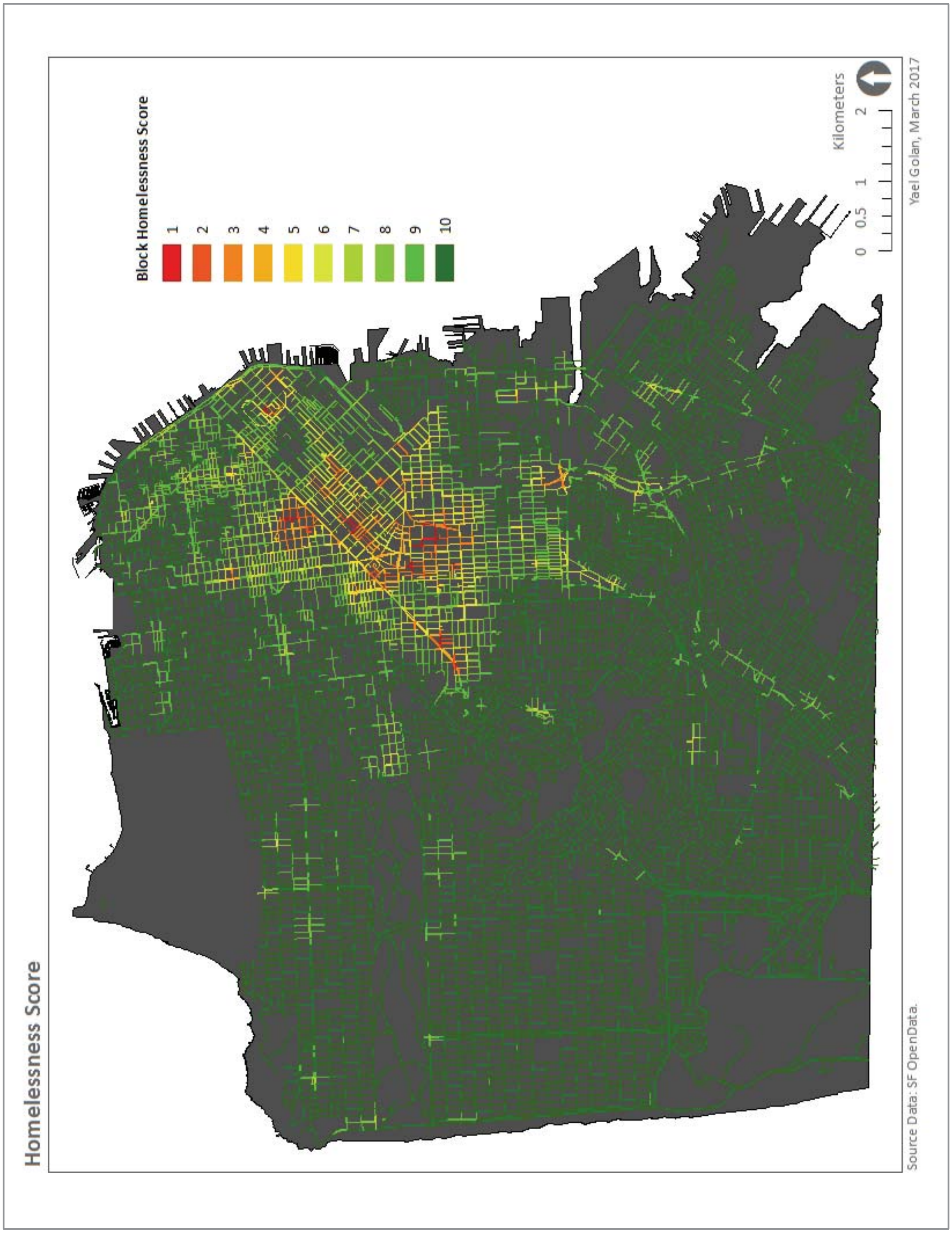

Speed Limit Score
Block Speed Limit Score
1
3
5
8
10
Kilometers
0 0.5 1 2
Source Data: SF OpenData.
Yael Golan, March 2017

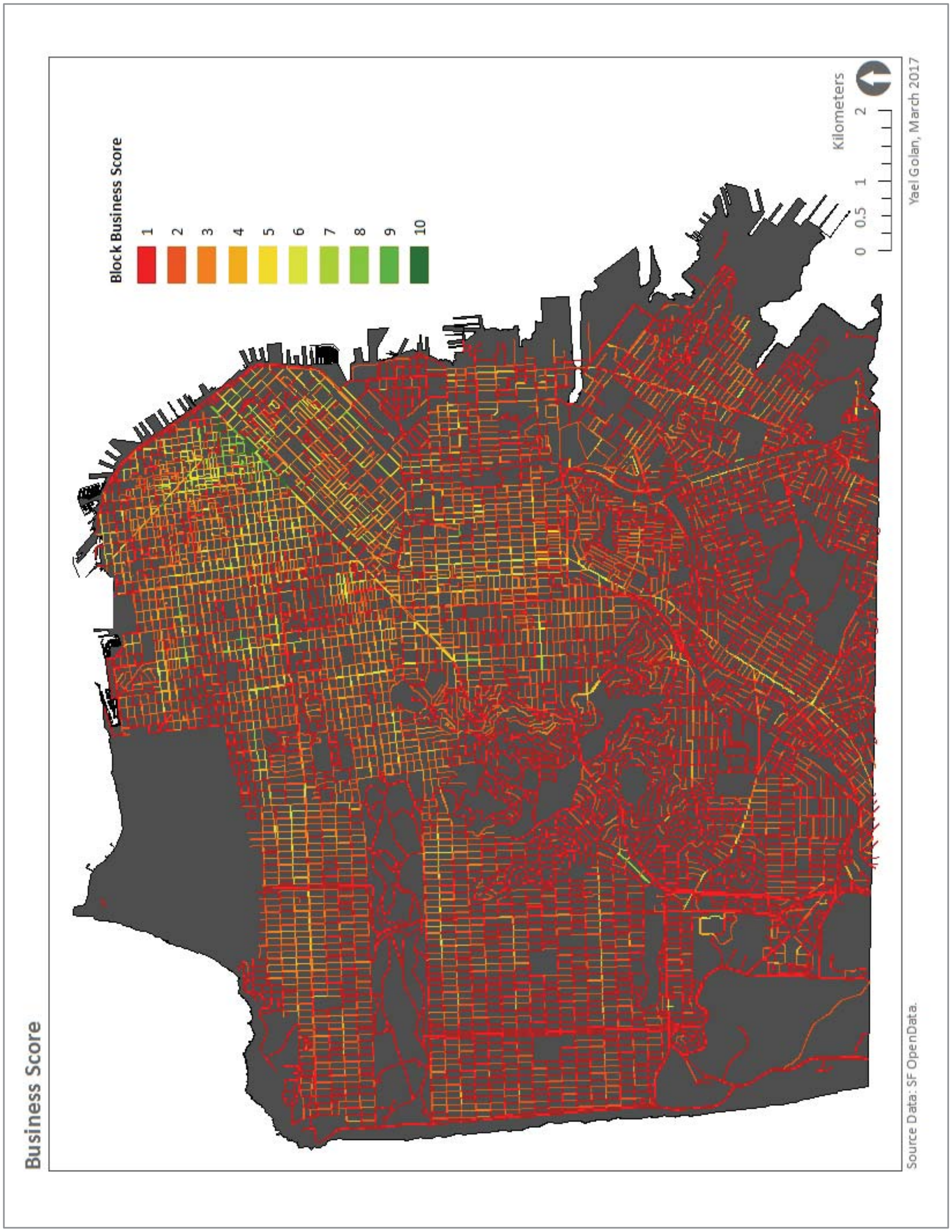

Graffiti Score
Block Graffiti Score
1
2
3
4
5
6
7
8
9
10
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.

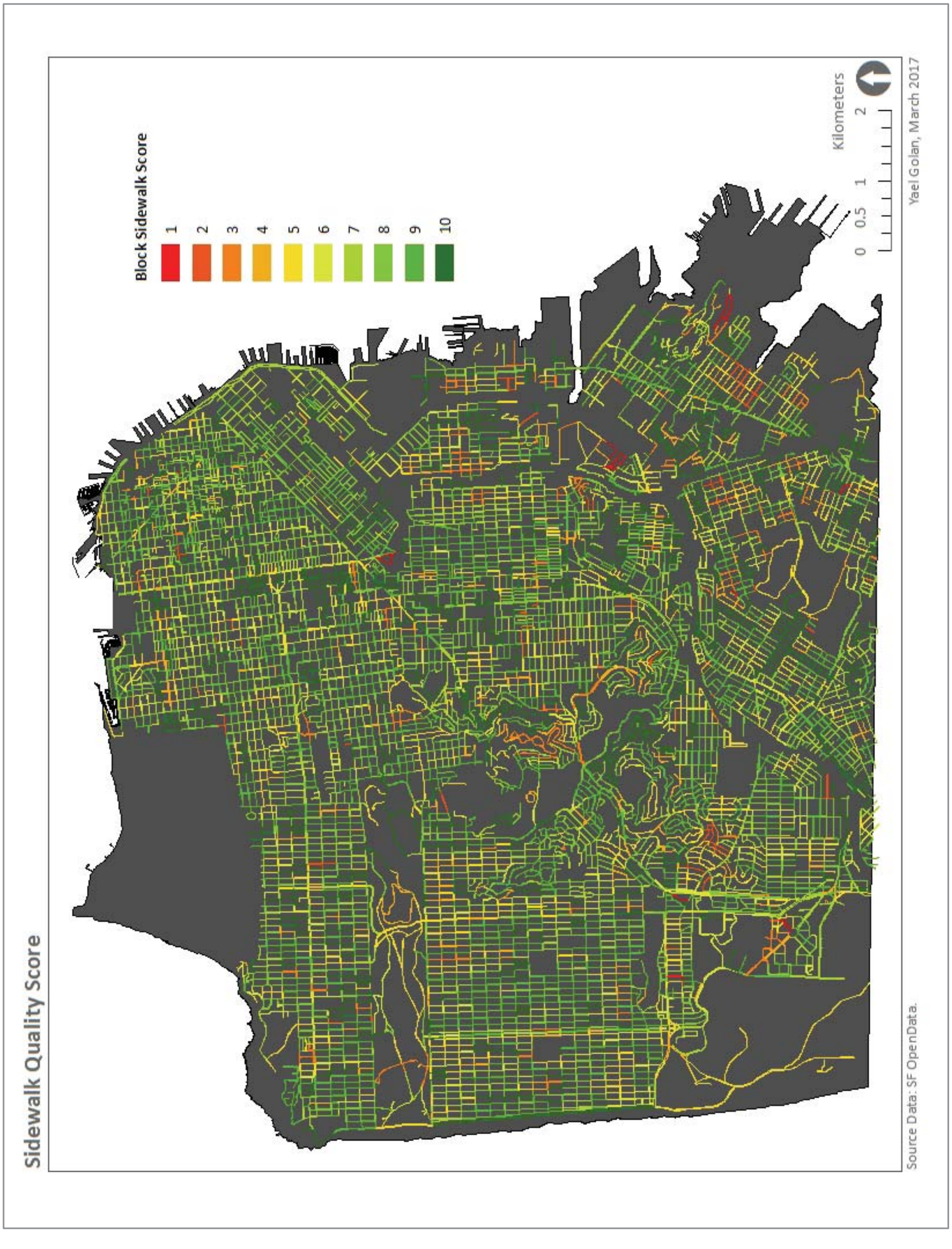

Curb Ramps* Score
Block Curb Ramps Score
1
2
3
4
5
6
7
8
9
10
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.
* ADA ramps


Cleanliness Score
Block Cleanliness Score
1
2
3
4
5
6
7
8
9
10
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.

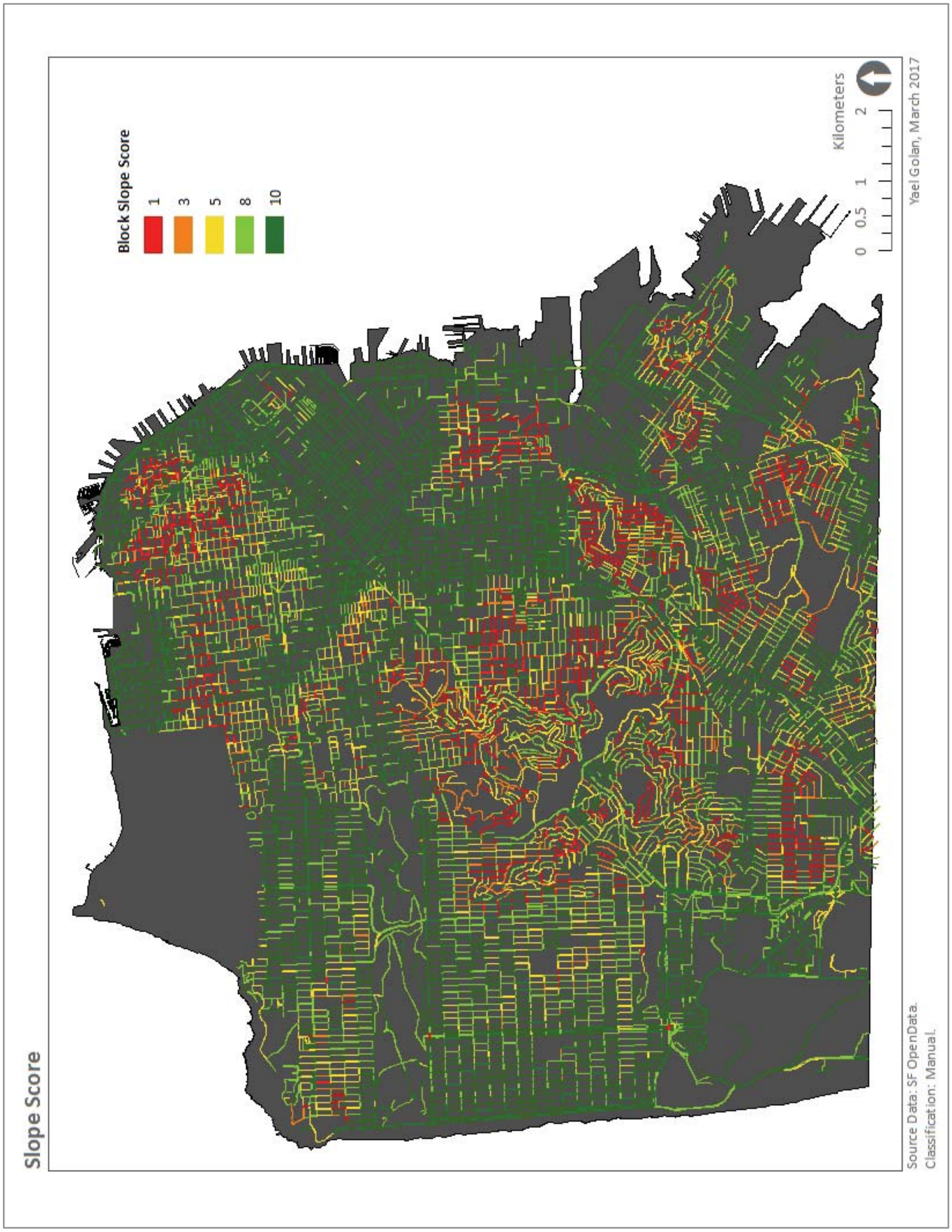

Crime Score
Block Crime Score
1
2
3
4
5
6
7
8
9
10
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.


Homelessness Score
Block Homelessness Score
1
2
3
4
5
6
7
8
9
10
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.


Business Score
Block Business Score
1
2
3
4
5
6
7
8
9
10
0 0.5 1 2
Kilometers
Source Data: SF OpenData.
Yael Golan, March 2017



Sidewalk Quality Score
Block Sidewalk Score
1
2
3
4
5
6
7
8
9
10
Kilometers
0 0.5 1 2
Yael Golan, March 2017
Source Data: SF OpenData.


Slope Score
Block Slope Score
1
3
5
8
10
0 0.5 1 2
Kilometers
Yael Golan, March 2017
Source Data: SF OpenData.
Classification: Manual.