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Noise Pollution, Environmental Justice, and Urban Green Space Accessibility: A Case Study in San José, California

Lauryn Duoto
San Jose State University

NOISE POLLUTION, ENVIRONMENTAL JUSTICE, AND URBAN GREEN SPACE ACCESSIBILTY: A CASE STUDY IN SAN JOSÉ, CALIFORNIA

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by

Lauryn Duoto

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Carolina Prado, Ph.D.	Department of Environmental Studies
Will Russell, Ph.D.	Department of Environmental Studies
William Harmon, M.A.	Department of Geography

ABSTRACT

NOISE POLLUTION, ENVIRONMENTAL JUSTICE, AND URBAN GREEN SPACE ACCESSIBILTY: A CASE STUDY IN SAN JOSÉ, CALIFORNIA

by Lauryn Duoto

Noise pollution is an environmental stressor associated with a number of poor health outcomes. Promisingly, recent studies have identified urban green spaces such as public parks and community gardens as-built environments that can minimize noise pollution in the urban context. The objective of this project was to identify low-income communities of color that lack urban green space accessibility within the city of San José, California, to determine if sound level could be an indicator of urban green space usage and to evaluate whether urban green space can mitigate noise. Neighborhood demographics based on census tract data, including ethnicity and socioeconomic status, were analyzed with Leq (average sound) data to compare sound levels in urban green spaces. Overall, urban green space ratings compared to average inside and outside Leq ratings were dependent upon the park attendee counts within the urban green space areas. It appeared that Leq measurements near the center of the urban green space were lower in decibel levels as compared to Leq outside measurements; however, there were no statistically significant relationships derived from statistical tests. The overall study also found no statistically significant results, although there were clear displays of low and low/middle-income urban green spaces experiencing lower decibel readings compared to middle/high and high-income urban green space areas.

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Introduction: Motivation and Scope

In 2016, San José was the largest growing city in Northern California, with an estimated population growth rate of 7.7% every six to seven years (U.S. Census Bureau, 2016). Accordingly, with an increased vehicle and air traffic, public transit expansion and usage, urbanization, and increased population density, city resident exposure to sound was estimated to escalate and urban green spaces were expected to become less accessible (Goines & Hagler, 2007; Guido & Farne, 2016; Hammer, Swinburn, & Neitzel, 2013). This presents a concerning public health dilemma, as chronic noise pollution could lead to stress, lack of sleep, cardiovascular disease, hearing loss, and overall decreases in quality of life. Urban green space has been found to mitigate those health effects (Hammer et al., 2013; Seidman & Standring, 2010). Urban green space has been linked to promoting health benefits and thus it has been found that accessibility to urban green space is crucial for psychological and physiological health (Barton & Pretty, 2010; Maas et al., 2009; McCormack, Rock, Toohey, & Hignell, 2010; Nowak, Crane, & Stevens, 2006; Ulrich et al., 1991).

Past studies have shown that the effects of noise pollution have a pattern of being distributed subjectively among populations based on ethnicity, class, and socioeconomic statuses (Houston, Krudysz, & Winer, 2008; Kingham, Pearce, & Zawar-Reza, 2007; Mohai, Pellow, & Roberts, 2009). Based on these data sets, it can be surmised that residents who live in low-income communities of color have been exposed to more noise pollution than those who live in high-income White communities; however, there is no clear evidence or research to support these issues relating to regionally-based accessibility. This lack of inquiry and understanding has generated an opportunity to examine a potential environmental justice and human rights issues in San José. The fair treatment and meaningful involvement of all people regardless of ethnicity, national origin, or income, in regard to the establishment and enforcement of environmental laws, regulations, and policies, is defined as environmental justice (Environmental Protection Agency [EPA], 2017).

It was the primary objective of this project to investigate the conditions of environmental justice and how local policies affect different communities disproportionately. A policy objective to promote San José's low-income and communities of color must be included in decision-making to obtain justice for those living in polluted environments with minimal access to urban green space (Arney, 2017).

Background

Accessibility to urban green space (parks, sports complexes, conservation sites, etc.) is considered an important component of the health and quality of an urban community (Kabisch & van den Bosch, 2017). Urban green space possesses the capabilities and qualities necessary to minimize air pollution, moderate stress, and reduce the risks of chronic disease, including diseases associated with noise pollution such as hypertension, insomnia, and tinnitus (Barton & Pretty, 2010; McCormack et al., 2010; Woodcock et al., 2009). Perceived accessibility to green space could be impeded by numerous factors, including the perception of safety in an urban green space resulting from the presence of trash, graffiti, un-housed communities, and drug paraphernalia (Beckett & Herbert, 2008; Dahmann, Wolch, Joassart-Marcelli, Reynolds, & Jerrett, 2010; Watts, Miah, & Pheasant, 2013; Wolch, Byrne, & Newell, 2014).

There is an association between urban green space usage and accessibility (of local neighborhood majority populations) based on the perception of urban green space safety and the availability of adequate amenities. (Giles-Corti et al., 2005; Kaczynski, Potwarka, & Saelens, 2008). This study focused on low-income communities of color that may be at risk for environmental injustice. Low-income communities are defined as Santa Clara County households making less than $54,500 annually, based on 2017 data (California Department of Housing and Community Development, 2017).

Communities of color are defined as communities with 51% or more African American, Latinx, Asian, Pacific Islander, Native American, other ethnicities, or two or more ethnicities other than Caucasian (U.S. Census Bureau, 2010). White-dominated communities are defined as those that have 51% or more of the overall population as white/Caucasian. One potential impediment to green space accessibility is noise pollution. Noise pollution is defined as an unwanted sound of at least 60-decibels that causes significant irritation. For the purpose of this study, noise pollution was also defined at the 60-decibel level due to San Jose City's ordinance of noise permitted in open space areas (Thill & Rodkin, 2010). Accessibility has not been measured in relation to sound level, and it has not yet been analyzed as an indicator of urban green space usage. The purpose of this study is first, to determine whether urban green spaces were distributed unequally based on urban green space perception and overall park rating. Second, this study aims to pinpoint any relationships between decibel levels measured inside of urban green spaces, Last, this study will analyze whether urban green space areas have the ability to mitigate noise from their perimeters to shelter their centers.

Literature Review

Globally, there are low-income communities of color that are exposed to environmental injustice based on socioeconomic and social disparities (Kenworthy & Laube, 1996; Stansfeld & Matheson, 2003). Noise pollution and lack of perceived accessibility to urban green space can be harmful, as urban green space can mitigate the negative side effects of noise on health. In regard to environmental justice, the lack of accessibility for low-income individuals of color to local urban green spaces can be detrimental to health. This dynamic can largely be attributed to the historical injustices by which low-income communities of color have been limited in opportunities to participate in social and political processes to advocate the need for urban green spaces in their communities (Abercrombie et al., 2008; Carrier, Apparicio, & Séguin, 2016; Casey et al., 2017; Dale et al., 2015; Sister, Wolch, & Wilson, 2010).

Environmental Justice

To address the relationship between low-income communities of color and urban green space accessibility, it is crucial to understand the term *environmental justice*. "Environmental justice is defined as the fair treatment and meaningful involvement of all people regardless of ethnicity, color, national origin, or socioeconomic status, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA, 2017, para. 1). Conversely, environmental injustice concerns have been institutionally neglected by the decision-making processes regarding an environmental change in their community, in contrast to high-income communities, where funding and policy more accurately reflect the wants and needs of the community

(Kruize, Driessen, Glasbergen, & van Egmond, 2007; Schlosberg, 2013). Environmental ills are the result of locally unwanted land uses, designated as point sources of pollution, that have negative impacts on nearby residents (Greenberg, 1993). Environmental goods are features in a community that have health and social benefits such as parks, well-paved roads, bike lanes, and more.

Environmental racism analyzes that communities are unequally exposed to environmental ills based on race, ethnicity, and class. Moreover, environmental racism points to the exclusion of communities of color from taking part in the environmental movement decisions as well as environmental policy making, law enforcement, and the regulation and distribution of pollutant guidelines (Chavis, 1994) Environmental justice can be expanded to encompass not only ethnicity, but also class, socioeconomic status, gender, and other individual identities.

An abridged analysis reveals three common issues that create environmental injustices: economic conditions that are detrimental to the quality of living, disregard for communities in favor of leniency, and the introduction of physiological stressors. First, there is a significant financial advantage, or a lack of financial loss, based on the geographical location of development in close proximity to vulnerable communities. This can occur because of widespread situational instances where it is more cost-effective and advantageous to develop or pollute a community (particularly a low-income community of color) than it is to develop in a more affluent community (Bullard, 1996). Policymakers and planners find that it is easiest to take the path of least resistance. This is ubiquitous in low-income communities of color where there has been a historic track record of a lack of participatory justice (speaking for oneself when it comes to environmental injustice) in socially excluded or marginalized populations (Mathieson et al., 2008). This can stem from a lack of social recognition, or justice as recognition, when low-income communities of color lack representation and are not acknowledged in the development process (Cutter, 1995; Haldemann, 2008; Schlosberg, 2013). The lack of social inclusion can be powerful in its ability to marginalize communities, which in turn can contribute to a community lacking recognition and clout. Through this type of institutional racism, foreign physiological stressors to communities are introduced where they did not originate, systemically polluting communities of color with contaminants and noise (Taylor, 1999). As the progression of these symptoms continues, compounding factors and interests can contribute to injustices in both governmental law and policymaking.

These three primary issues, which contribute to environmental injustices, are defined as distributive justice, procedural justice, and corrective justice. These three parameters directly correspond to environmental racism through policy, practice, or directive, which differentially affect or disadvantage (whether intended or unintended) individuals, groups, or communities based on ethnicity or color (Bullard, 1993; Kuehn, 2000). Environmental racism focuses on participation and recognition, although the larger emphasis of environmental racism expresses the basic needs of individuals or communities, which is a human and civil right (Bullard, 1993; Schlosberg, 2013). Environmental injustice is not always straightforward and within these specified guidelines. Environmental justice literature is multifaceted and the concept, which is still evolving, can be interpreted in many different ways, as the movement began relatively recently in the 1980s (Beretta, 2012). The environmental justice movement additionally focuses on the rights of all people to have a healthy place in which to live, work, and recreate. Although the Environmental Protection Agency (EPA, 2017) defines environmental justice as a clear way to take legal action, there is much work that is being done to understand the theoretical concept of environmental justice.

Social exclusion theory provides a lens for understanding how environmental injustice relates to inequitable access to resources such as urban green space. Correspondingly, social exclusion theory highlights the exclusion of low-income communities of color in decision-making processes (Burchardt, Le Grand, & Piachaud, 1999; Mathieson et al., 2008). Social exclusion theory denotes the exclusion of these communities as a state of extreme disadvantage experienced by particular groups in society (Mathieson et al., 2008). Social exclusion parameters revolve around culture, economic, political, and social interactions, more specifically: geography, ethnicity, religion, gender, age, and socioeconomic status (Appasamy, Guhan, Hema, Majumdar, & Vaidjanathan, 1996).

Peter Townsend, a United Kingdom theorist, drew many concepts from social exclusion theory, including the idea that there is an inequity in resources, services, living standards, and social participation in communities (Burchardt et al., 1999; Mathieson et al., 2008). Social exclusion and pollution are compounded social injustices that operate through the exclusion of communities in participatory justice. Populations who are deprived of social recognition are then exposed to health problems due to pollution in their communities (Marmot, Allen, Bell, Bloomer, & Goldblatt, 2012; Simpson, 2003; World Health Organization [WHO], 2011). Subsequent to these processes, exclusion, and pollution contribute to overall lower quality of life for disparate populations than those who are socially recognized as an element of environmental justice theory named *recognition justice* (Cutter, 1995). Schlosberg defines recognition justice as the fair representation for all individuals while being offered complete and equal political rights without the presence of physical threats (Schlosberg, 2003). Recognition in environmental justice should be considered globally but in localized contexts, to ensure that specified communities and situations are individually addressed without a sweeping solution to ensure fair representation and recognition (Schlosberg, 2003).

Noise Pollution

Environmental justice provides a path to public justice through the equity and rights that all people and communities are entitled to such as protection from noise pollution and perceived accessibility to urban green spaces. Noise is an unwanted sound that can cause annoyances and physiological disturbances through auditory and non-auditory side effects (Basner et al., 2014). Sound level is measured in decibels, or amplitude of pressure changes (dB), and in hertz, or frequency (Hz) (Basner et al., 2014). The longer the exposure to higher decibel-emitting sources, the more damaging the effects become to human health (Basner et al., 2014). For example, at 33 decibels, the noise has been associated with low quality of sleep, mental health issues, and cardiovascular disease (Babisch, Beule, Schust, Kersten, & Ising, 2005; Muzet, 2007; WHO, 2011). Higher frequencies directly related to the exposure time: the higher the frequency and decibel, the shorter the time of exposure to the noise point source should be to decrease the risk of side effects (Basner et al., 2014).

It is because of the prevalence of modern noise sources that there is a public health risk for exposure. Noise is often associated with stress, cardiovascular disease, sleep disturbance, and tinnitus (Davis & El Refaie, 2000), thus presenting a concerning public health issue. Noise interferes with daily activities, leading to exhaustion and stress in response to external stimuli. Noise is also associated with cardiovascular dysfunction such as hypertension, ischemic heart disease, and stroke (Babisch et al., 2005).

There are differentiated levels of exposure to sound levels. Some communities' exposure is more common, based on proximity to the road and air traffic (Dale et al., 2015; Gonzalez et al., 2011; Nega, Chihara, Smith, & Jayaraman, 2013). It has been noted that people of color and economically disadvantaged communities experience higher exposure to hazards that negatively affect their health (Kruize et al., 2007; Williams, Mohammed, Leavell, & Collins, 2010). Some researchers have found an association between noise pollution and low-income communities of color, such that these populations are exposed to high levels of noise over long periods of time (Chakraborty & Green, 2014; Dale et al., 2015; WHO, 2011).

Researchers outside of the United States and Canada have found that socioeconomic status and communities of color experience greater decibels of noise. In contrast a study in Paris, France, researchers found that sound is associated with higher housing values and higher income (Havard, Reich, Bean, & Chaix, 2011). Researchers in another study in Birmingham, England found no relationship between a primarily African American neighborhood and higher daytime sound levels (Brainard, Jones, Bateman, & Lovett, 2004). On the other hand, researchers throughout the United States and Canada have found that noise pollution can be more impactful in residential areas with residents of color and lower socioeconomic status (Carrier et al., 2016; Casey et al., 2017; Dale et al., 2015; Nega et al., 2013). In a 2016 U.S. study, Carrier et al. found that their model-based estimates of sound exposure throughout the contiguous U.S. displayed a nonlinear pattern of increased levels of sound exposure within Asian, African American, and Hispanic communities in urban and suburban neighborhoods and lower levels in primarily White neighborhoods. Inequalities have been found between populations of different socioeconomic status and ethnic backgrounds across various neighborhoods throughout the United States. It has been suggested that this could relate to health care access and access to healthier amenities (WHO, 2011). Due to a lack of environmental justice and noise studies in the United States, it is important to understand the correlation between sound level exposure and socioeconomic status and ethnicity in San José. The highest and lowest levels of sound were found by this study to occur in urban green spaces and were correlated with urban green space perceived accessibility inequalities based on ethnicity and class.

Mobile sources of pollution have become the secondary contributor to air and noise pollution surpassed only by the products of industrial pollution (Guido & Farne, 2016; Kay, 1999). For every gallon of gasoline that is manufactured and burned, 25 pounds of carbon dioxide are produced. Sound increases from the stop-and-go characteristics of traffic are caused by the revving of the engine (Zhang & Batterman, 2013). These traffic events can affect the vehicle owners and those who live on the peripheries of these roads, including freeways, major roadways, and arterial roads (Zhang & Batterman, 2013). Many of the immediate problems of commuting with traffic are increases in-car use, poor infrastructure systems, lack of functional open space areas, and lack of accessibility to urban green space (Serdaroğlu Sağ & Karaman, 2011).

Individuals and organizations work to further environmental justice in efforts to end discrimination and to advocate for equality throughout all demographics, communities, and environments (Mohai et al., 2009; Schlosberg, 2013; Williams et al., 2010). In 1994, President Clinton issued Executive Order 12898, titled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (Executive Order No. 12898, 1994). This Executive Order focused on ensuring that communities of color are protected throughout policy decision making and implementation to ensure there is equity for previously exposed communities of color to health, economic, and social injustices (Forkenbrock & Schweitzer, 1999).

With Executive Order 12898, the previously affected communities are able to provide input on transportation and what mitigation measures should be put into effect. A year later in May 1995, the U.S. Department of Transportation held an Environmental Justice and Transportation Conference based on creating strategies to build partnerships and work to avoid environmental injustices. The U.S. Department of Transportation has since created procedures to include environmental justice in planning (Forkenbrock & Schweitzer, 1999).

Urban Green Space

Urban green space provides many ecosystem services and alleviates environmental stressors that have the ability to lead to health effects in growing cities with rapidly increasing populations. The foundational basis of ecosystem services is that nature and its biophysical processes can benefit human health, quality of life, and help encourage societal functions (Daily, 1997; Ernston, 2013). Ecosystem services from urban green space can be categorized in four ways. First, these services offer provision, as the ecosystem can provide food and energy. Urban green space can be a provision in the form of food, with urban gardens that provide a healthy source of fruits and vegetables (Andersson, Barthel, & Ahrné, 2007). Second, ecosystem systems are regulating, as they offer air and water filtration (Escobedo, Kroeger, & Wagner, 2011). Urban green space can be used as a water-filtration system by being a barrier to rain or floodwater through the vegetation, creating a permeable layer that water runs through, and separating pollutants before they enter the groundwater (Bolund & Hunhammar, 1999; Pataki et al., 2011). Urban green space can reduce air pollution through the absorption and fixation of ozone, particulate matter, nitrogen dioxide, sulfur dioxide, carbon dioxide, and carbon monoxide (Nowak et al., 2006). Reducing these air pollutants can also increase the health of the public (Woodcock et al., 2009).

Third, ecosystem services include a cultural element where they provide cognitive and spiritual experiences (Andersson et al., 2007; Barthel, 2010). Urban green space has also been shown to promote mental health benefits by reducing stress (Maas et al., 2009; Ulrich et al., 1991). Last, ecosystem services support habitat-ecological functions through soil formation and nutrient cycling (Maas, Verheji, Groenewegen, de Vries, & Spreeuwenberg, 2006; Millennium Ecosystem Assessment, 2005).

Urban green space areas are beneficial for improving quality of life, ecosystem services, recreation, pollution reduction, and sound minimization (Escobedo et al., 2011; Fuks et al., 2011; Nowak et al., 1998). Urban green space has been linked to the enhancement of health and the reduction of chronic disease risk, by providing a place for physical exercise (Barton & Pretty, 2010; McCormack et al., 2010). Lack of access can be attributed not only to systemic inequities in socioeconomic disadvantaged areas, but also limits to the distribution of wealth, capital, and resources to support the quality of life (Jones-Webb & Wall, 2008).

Urban green space is distributed throughout urban areas based on urban space design, the evolution of leisure and activity, history of land use and class, infrastructure, and by neighborhoods based on per capita populations (Byrne & Wolch, 2009). Urban green space accessibility can be based on the availability of location and distance (Heynen, Perkins, & Roy, 2006). Additionally, urban green space accessibility can be based on how urban green spaces are utilized and if they seem plausible to use with respect to the safety of space, cleanliness, and physical stressors (i.e., noise, safety, and dominance of groups, including gang activity or specific demographics based on sex or age) (Wolch et al., 2011; Wolch et al, 2014).

There is some discord in the analysis of factors that influence urban green space use. Some researchers have found that there is a minimal association between urban green space use and size, distance, and accessibility, but there is a correlation with perception

(Giles-Corti et al., 2016; Kaczynski et al., 2008). Moreover, others have found that urban green space accessibility has positive associations with urban green space usage and perception of area (McCormack et al., 2004; Owen, Humpel, Leslie, Bauman, & Sallis, 2004). In related studies, researchers have found that the convenience of urban green space destination, availability of sidewalks, and traffic conditions influence urban green space usage (Wolch et al., 2014). Another group found that the neighborhood, in general, played a key component in urban green space usage, including the neighborhood walkability score, residential density, and land use mix (Saelens, Sallis, Black, & Chen, 2003). These researchers ultimately concluded that safety and the perceived aesthetics of urban green space impacted the urban green space usage (McCormack et al., 2004; Owen et al., 2004; Saelens et al., 2003).

The atmosphere of urban green space, including trash, graffiti, and drug paraphernalia, may also affect urban green space usage and accessibility (Beckett & Herbert, 2008; Dahmann et al., 2010; Watts et al., 2013; Wolch et al., 2014). Researchers have found that communities of color and low-income communities have less urban green space perceived accessibility compared to White higher-income communities. Access to urban green space programs is also found with more frequency in higher income and White neighborhoods (Heynen et al., 2006). With a lack of perceived accessibility, including quality of the urban green spaces, low-income communities of color may not receive the benefits of urban green spaces that are more common in affluent neighborhoods (Abercrombie et al., 2008; Sister et al., 2010). This differential access is an example of distributive environmental injustice (Schlosberg, 2003).

Problem Statement

Noise pollution is detrimental to human health and behavior (Babisch et al., 2005; Field, 1993). The health concerns associated with high sound levels include annoyance, stress, cardiovascular disease, tinnitus, and sleep deprivation (Davis & El Refaie, 2000). The effects of noise pollution can be distributed unequally throughout regions, disproportionately impacting low-income communities of color, such that they bear a disproportionate burden of these health effects (Mathieson et al., 2008). Environmental injustice occurs when a community is ignored, when there is an economic gain or less loss involved, when a community is considered non-resistant, or when the community is considered to lack participatory justice (Schlosberg, 2013).

Low-income communities of color are at risk for higher exposure to environmental injustices such as air and noise pollution, which urban green space can help reduce, although accessibility to these urban green spaces can be hindered by overall perceived access (Hammer et al., 2013; Seidman & Standring, 2010; Wolch et al., 2014). This project determined if sound levels in urban green spaces are distributed unequally through census block data and in locations where park attendees are subjected to the highest and lowest levels of noise. In addition, this study served to identify whether or not urban green space is accessible and capable of mitigating noise pollution (Hammer et al., 2013; Seidman & Standring, 2010; Wolch et al., 2014).

Research Questions

1. How do the inside sound level measurements compared to outside sound level measurements inform urban green space noise mitigation?
2. What is the relationship between the sound level in urban green spaces and the socioeconomic and ethnic makeup of a community?
3. What is the relationship between urban green space sound levels and perceived accessibility to urban green space?

Hypotheses

1. Urban green space sound level measurements are lower in the center of the urban green space areas, and average inside Leq (average weighted sound levels over the measurement period) measurements are lower than outside Leq measurements due to the mitigating effects of urban green space.
2. Urban green space is distributed unequally with regard to ethnicity, and socioeconomic status resulting in more disparities in communities of color and low-income communities (Houston et al., 2008; Kingham et al., 2007; Mohai et al., 2009).
3. Urban green spaces with higher park ratings (better accessibility) experience higher park attendee counts, resulting in overall higher inside and outside Leq.

Materials and Methods

The study's central problem was the environmental justice issue of unequal distribution of urban green space, which can result in health disparities, throughout low-income communities of color (Houston et al., 2008; Kingham et al., 2007; Mohai et al., 2009). The objectives of this project were to analyze 1) the ability of urban green spaces to mitigate sound, 2) distribution of urban green space in the City of San José, and 3) whether sound can be an indicator of urban green space accessibility and usage. The purpose of this research was to analyze sound levels, urban green space usage, and perceived accessibility, as well as to examine the relationship between ethnocultural communities of color, socioeconomic status, sound levels, and accessibility to urban green space in San José.

This exploration of population geography based on spatial perspectives (Neely & Samura, 2011) and social exclusion built a framework for understanding the social issues of demographically defined regions in San José. Currently, the City of San José identifies neighborhoods comprised of 51% or more of a specified ethnicity, race, or socioeconomic status for residential planning guidelines in San José (Colby & Ortman, 2015; San José Planning [SJPlanning], 2011). Therefore, I identified which areas in the city were communities of color. For socioeconomic status, I used the U.S. Census Bureau's American Community Survey 2010–2015 for income, which helped me identify which areas of the city are low income, middle income, and high income (U.S. Census Bureau, 2010). I used the software program JMP to identify community percentages that were mapped in ArcGIS to identify communities based on color and socioeconomic status (U.S. Census Bureau, 2010). To date, there has not been a comprehensive study in San José regarding the relationship of communities of color and socioeconomic standing and sound levels as an indicator of urban green space usage, while encompassing urban green space distribution among low-income communities of color. My analysis of sound in relation to ethnicity census blocks and socioeconomic status and urban green space accessibility was modeled after the study, "Racial/ethnic and socioeconomic disparities in urban green space accessibility: Where to intervene?" (Dai, 2011) and put into the context of the City of San José Environmental Noise Assessment (Thill & Rodkin, 2010).

Population Studied

The City of San José is located in Santa Clara County, California (Santa Clara Local Agency Formation Commission of Santa Clara County, 2015). In 2016, San José was the third-largest city in California and the tenth-largest city in the United States (U.S. Census Bureau, 2016). It became incorporated in 1850 with a square mileage of 180.2 (U.S. Census Bureau, 2016). The population in 2016 was estimated to be 1.03 million. The populations that were studied to address the relationship of sound levels and low-income communities of color are socioeconomic status (high, medium, low, and poverty) and ethnicity (African American, Latinx, Asian, Pacific Islander, and White).

The 2015 estimates from the 2010 U.S. census showed that 35% of the population was of Asian descent, 32% identified as Latinx, 26% as White, 3% as multiethnic, 3% as African American, .03% as Pacific Islander, and .02% as Native American (County of Santa Clara, 2019; Datausa, 2015). The median household income was approximately

$84,647; per capita income was $35,811; and the population in poverty was 11.3% (San José City [SJCity], 2013; U.S. Census Bureau, 2016).

Using the 2010 census tracts, San José residents were categorized by neighborhood, ethnicity, and socioeconomic status throughout the fifteen planning areas: Alviso, North, Berryessa, West Valley, Central, Alum Rock, Willow Glen, South, Evergreen, Cambrian/Pioneer, Edenvale, Almaden, Coyote, San Felipe, and Calero (Thill & Rodkin, 2010). These fifteen planning areas were permanent boundaries from which planners could collect and analyze data over long time periods, monitoring, and tracking development (Thill & Rodkin, 2010).

Eleven of the fifteen planning areas were used because they were within urban and suburban parameters. The selection of these eleven areas took into consideration the city's income and diversity indices, which provided context for urban green space surrounding communities. The four areas that were excluded were Alviso, Calero, Coyote, and San Felipe because they are rural, non-urban planning areas. Thirty-three out of 358 urban green spaces were used as the study locations and were chosen at random, with three locations in each planning zone. The urban green spaces include parks, community gardens, and sports areas such as multi-purpose fields. Urban green space areas were selected as they address urban green space accessibility and which urban green spaces experience the highest and lowest levels of sound.

Study Design

Urban green spaces in the City of San José that experienced sound-related disturbances were selected for the study; the design consisted of measuring three urban green spaces in each of the eleven planning areas, adding up to a total of thirty-three urban green spaces. These urban green spaces were selected based on the urban green space Geographic Information Systems (GIS) shapefile (County of Santa Clara, 2017) from the San José Parks Department. The GIS shapefile data were converted to an Excel sheet, then separated into eleven lists based on the planning area and randomized to pull the top three urban green spaces in each of the eleven lists, from which thirty-three locations were selected. After this process, a shapefile was created with the acreage, location, and parameters to visualize the data. Sound level measurements were taken at each of these thirty-three urban green space locations. The hypothesis that urban green space is distributed unequally throughout ethnicity and socioeconomic status was analyzed by comparing the relationship of low-income communities and communities of color, using U.S. census tract data from 2010 (U.S. Census Bureau, 2010). The socioeconomic status and ethnicity data were used in comparison with urban green space GIS data to identify the correlation between levels of sound and neighborhood demographics.

Urban green space public data from online sources through the City of San José were accessed and analyzed to understand demographics and their relationship to neighborhood urban green spaces (City of San José, 2018; Thill & Rodkin, 2010; U.S. Census Bureau, 2010). Microsoft Excel was utilized to organize census tract shapefiles with ethnicity and income data incorporated that display social vulnerability from the Centers for Disease Control and Prevention (Centers for Disease Control and Prevention [CDC], 2014). The social vulnerability index refers to a community's resilience to stressors on human health, whether nature-based or human-based. The CDC database was used for comparisons with urban green space and sound layers in GIS (CDC, 2014; County of Santa Clara, 2017; U.S. Census Bureau, 2010).

For the purpose of this project, urban green space included parks, community gardens, and field/golf courses. The data sound points that were collected were located in each urban green space on the edge of the urban green space counting as one measurement, in tandem with the second sound level measurement at fifty meters from the edge of the urban green space/road (Ow & Ghosh, 2017), and inside of the urban green space at 1.5 meters from the ground in four locations north, south, east, and west (see Figure 1) (Bashir, Taherzadeh, Shin, & Attenborough, 2015; Ow & Ghosh, 2017). The methods followed sound level measurement protocols by measuring on Saturday and Sunday between 7:00 a.m. and 7:00 p.m. during “popular time frames” according to Google, gathered by cell phone locations. These time frames (between 7:00 a.m. and 7:00 p.m.) were chosen for consistency and to avoid using the community sound equivalent level, which requires adding five decibels to the sound measurements between 7:00 p.m. and 10:00 p.m. and adding 10 decibels to measurements recorded between 10:00 p.m. and 7:00 a.m. (Thill & Rodkin, 2010). The data were modeled statistically by normalizing inside and outside Leq to the noise pollution level of sixty decibels to provide a form of regression to illustrate noise pollution as a measurement in relation to perceived accessibility of urban green space.

Ambient sound was recorded to include composite sound from point sources such as planes, traffic, and people-induced sound while also measuring intrusive sound from point sources. Point sources are defined as:

> the sound which intrudes over and above the existing ambient sound at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient sound level. (Thill & Rodkin, 2010, p. 4)

For a study based on representing urban green space and neighborhood sound characteristics, it was important to factor in all ambient sounds to establish a Leq, which is defined as the average weighted sound levels over the measurement period (Thill & Rodkin, 2010). Based on Bashir et al.'s 2015 model, five separate locations were chosen to record decibel readings within each urban green space: north, south, east, west, and center.

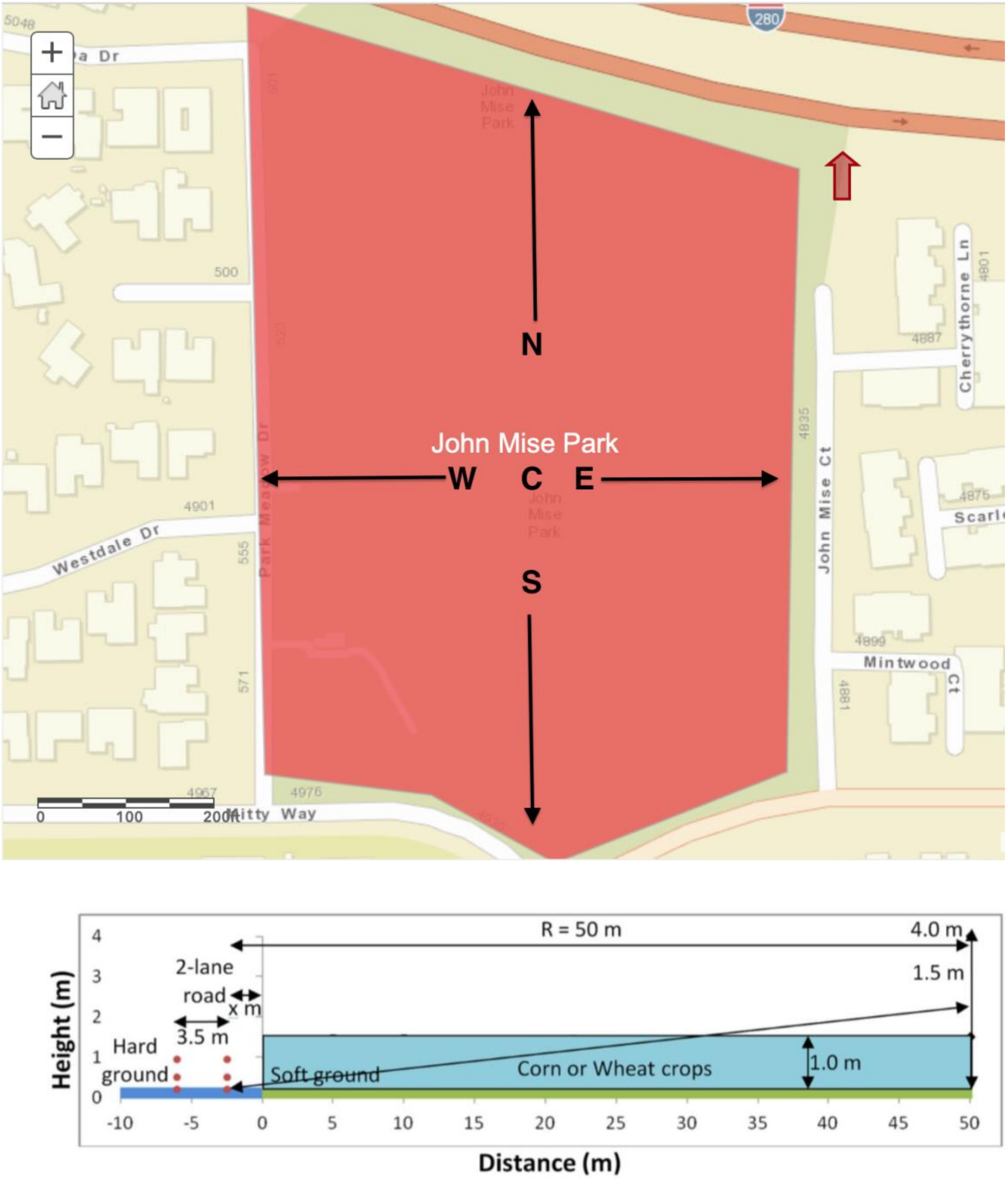

Figure 1. Methods of sound level meter placement in urban green spaces. Measurements were taken on the north, south, east, west, and center of the urban green spaces at 50 meters from the road's edge.

The SPLnFFT sound level phone application was used to record ambient sound level data; the ambient sound is defined as “the composite of sound from all sources near and far” (Thill & Rodkin, 2010, p. 4). While the SPLnFFT App was used for the study, the app is not equivalent to a sound level meter. Researchers find a 1–2-decibel difference from the sound level meter acceptable if calibrated correctly while using an external microphone (Murphy & King, 2016). The decibel data were collected to address levels of sound in urban green spaces using SPLnFFT on two separate iPhones. Additionally, SPLnFFT is an application that is accessible to community members for less than five dollars, which is more affordable across socioeconomic status levels as opposed to a professional sound level meter, which in 2016 could cost on average $1,500. This study could be used to demonstrate the uses of these types of affordable sound level measurement tools for potential community-based projects.

For the purpose of this study and determining averages above or below sixty decibels, this application worked sufficiently to understand if the sound was an indicator of urban green space accessibility. Both iPhones were calibrated with each other before every urban green space measurement through the app calibration setting while using external lavalier microphones for accurate readings. Calibration through the application was done by turning the volume on the phone to maximum, clicking on the microphone, and using the reset button, waiting for the tone to finish, and then pressing the reset button again based on SPLnFFT directions. Outdoor methods were used from the Noise Measurement Manual from Queensland, Australia, as the developer of the SPLnFFT App recommended this source (Queensland Department of Environment and Heritage

Protection [QDEHP], 2013). The phones were placed on two separate tripods 1.5 meters above ground level (QDEHP, 2013). The measurements were 3.5 meters away from vegetation, buildings, or reflective surfaces (Bashir et al., 2015; QDEHP, 2013).

To test the hypothesis of whether urban green space sound measurements are lower in the middle compared to the outside measurements, an assistant and I recorded decibel readings for ten minutes in each location in accordance with Illingworth and Rodkin's methods in 2010 used for the City of San José's Noise Assessment (Thill & Rodkin, 2010). Each urban green space location had fifty minutes or more of recording decibel averages. At the central location, a sound sample was recorded to represent the soundscape at each urban green space. The date, time, time started, time finished, description of the sound, and any notes regarding pitch, source, and weather variables were also recorded. To test the hypothesis that urban green spaces with higher park ratings experience higher park attendee counts, urban green space attendance counts were conducted throughout the entirety of the sound level measurements in each urban green space. This was done by tallying marks on paper to record attendees who walked into the urban green space from north, south, east, and west.

To assess urban green space accessibility based on park ratings, population counts, and urban green space condition assessments were drawn from the San José Parks, Recreation, and Neighborhood Services (PRNS) Department. These assessments showed the conditions of urban green spaces, evaluating urban green space features such as urban green space appearance, restrooms, walkways, picnic areas, and turf appearance (PRNS, 2017). Urban green space attendance counts were also taken at each urban green space.

To analyze urban green space ratings in relation to park attendee counts, urban green space condition assessments from the PRNS Department were analyzed using Prism (version 6), which utilized numbers from the rating system based on a five-point scale. The five-point scale outlines urban green spaces based on the following criteria, which provided additional urban green space accessibility measures to analyze with measured decibel levels (PRNS, 2017):

1. Unacceptable—cannot be repaired; must be replaced
2. Needs Improvement—needs major renovation
3. Acceptable—needs work, but generally functional
4. Good—generally good condition; minor repairs
5. Excellent—new or like new

PRNS park managers evaluated trails during a three-week period in November 2017; a mean score based on the individual feature ratings was then calculated using a weighted average scoring system (PRNS, 2017):

- Pavement – 30%
- Weed and Plant Encroachment – 20%
- Striping and Signage – 10%
- Cleanliness – 15%
- Furniture – 5%
- Drinking Fountain – 10%
- Landscape Health – 10%

Photos were taken at each location where the phones were set up for measurement, excluding photos of any humans in the urban green space. These photos were stored in a secured, encrypted Dropbox account for future inquiries and methodology requests. Park attendance was measured through population counting, by tallying park attendees during the first sound measurement. The purpose of measuring inside the urban green space area was to analyze the sound levels in accordance with urban green space edge/road and to measure what urban green space attendees experience with regards to sound levels. It was used to represent activity and cumulative population attending the urban green space to additionally compare with census block data. The SPLnFFT app created an average or Leq (equivalent continuous sound pressure level – average constant sound level over a given time period) (Lee, Kim, Kim, & Kim, 2012), minimum, and maximum sound. This information was also recorded in graphs to show sound levels over time or over the ten-minute span of each measurement, which was exported as averages as a linear measurement over the ten minutes and as one average measurement over the ten minutes.

Data Analysis

To address the hypothesis that urban green space inside sound level measurements are lower than outside measurements, a paired Student's *t*-test analysis of the categorical variables of Leq outside by urban green space type compared to Leq inside readings was conducted. Data were analyzed using the JMP statistical software package (version 14). A Kruskal-Wallis H test was used to determine if there was a statistically significant difference between Leq inside and Leq outside of urban open space. The Kruskal-Wallis H (K-W Subcommand) test was used to determine whether the two measurement variables (sound levels and location), that did not meet the normality assumptions of a one-way ANOVA, contained statistically significant differences in relation to the ordinal variable (demographics). A bootstrap derivative was run to find the confidence intervals for the independent and dependent data.

To address the hypothesis that urban green space is distributed unequally throughout ethnicity and socioeconomic status, the dependent categorical variables of perceived accessibility, income and census (ethnicity and socioeconomic status) and the independent variable of the sound level were analyzed by comparing population means using one-way analyses of variance (ANOVAs) through the JMP statistical software package (version 14). These statistical tests generated comparisons between decibel levels (independent variable) and ethnicity and socioeconomic status(dependent variables). Additionally, decibel levels, ethnicity, and socioeconomic status mean, were compared using ANOVA.

A standard multiple regression model was utilized to test the dependence of ethnicity and socioeconomic status. Standard multiple regression modeling consisted of a comparative analysis between the independent variable of sound and the dependent variables of ethnicity and socioeconomic status (Yale University, 2011). The urban green space layer was defined by parameters that contain both the primary and secondary qualities of urban green space (Stanescu, 2013). The standard multiple regression analysis modeled the statistical relationship and interaction effects between the dependent variables of communities and urban green space.

To identify if urban green space is distributed unequally by ethnicity and socioeconomic status, three qualitative ArcGIS layers used (a) U.S. census tract data based on ethnicity and socioeconomic status (U.S. Census Bureau, 2010); (b) sound levels data measured in the urban green spaces; and (c) urban green space data from Santa Clara County Parks (County of Santa Clara, 2017; Thill & Rodkin, 2010). These separate layers provided a spatial representation of where certain populations reside, sound levels, and where urban green spaces were located to address the question of which urban green spaces were subjected to the lowest and highest levels of sound. The layers were compared to each other to visualize spatial relations. This information represents the relationship of sound levels as an indicator of urban green space usage with demographics (Verbyla, 2003). The information from GIS map layers was analyzed by displaying the relationship of demographic factors to sound.

The hypothesis that urban green spaces with higher park ratings, which experience higher park attendee counts, resulting in overall higher inside and outside Leq was evaluated using a one-way ANOVA to assess the mean comparison between urban green space ratings and the inside and outside Leqs. Another one-way ANOVA was used to determine statistical evidence of significant differences between urban green space attendance and inside and outside Leqs. The demographics layer provided groupings of communities to geo-locate each population and the urban green space that lies within (see Figure 2 and Figure 3). The combination of these layers showed the community's socioeconomic status and diversity indices. Diversity indices were determined on a 0–100 scale, from 0 = no diversity to 100 = complete diversity (U.S. Census Bureau, 2010).

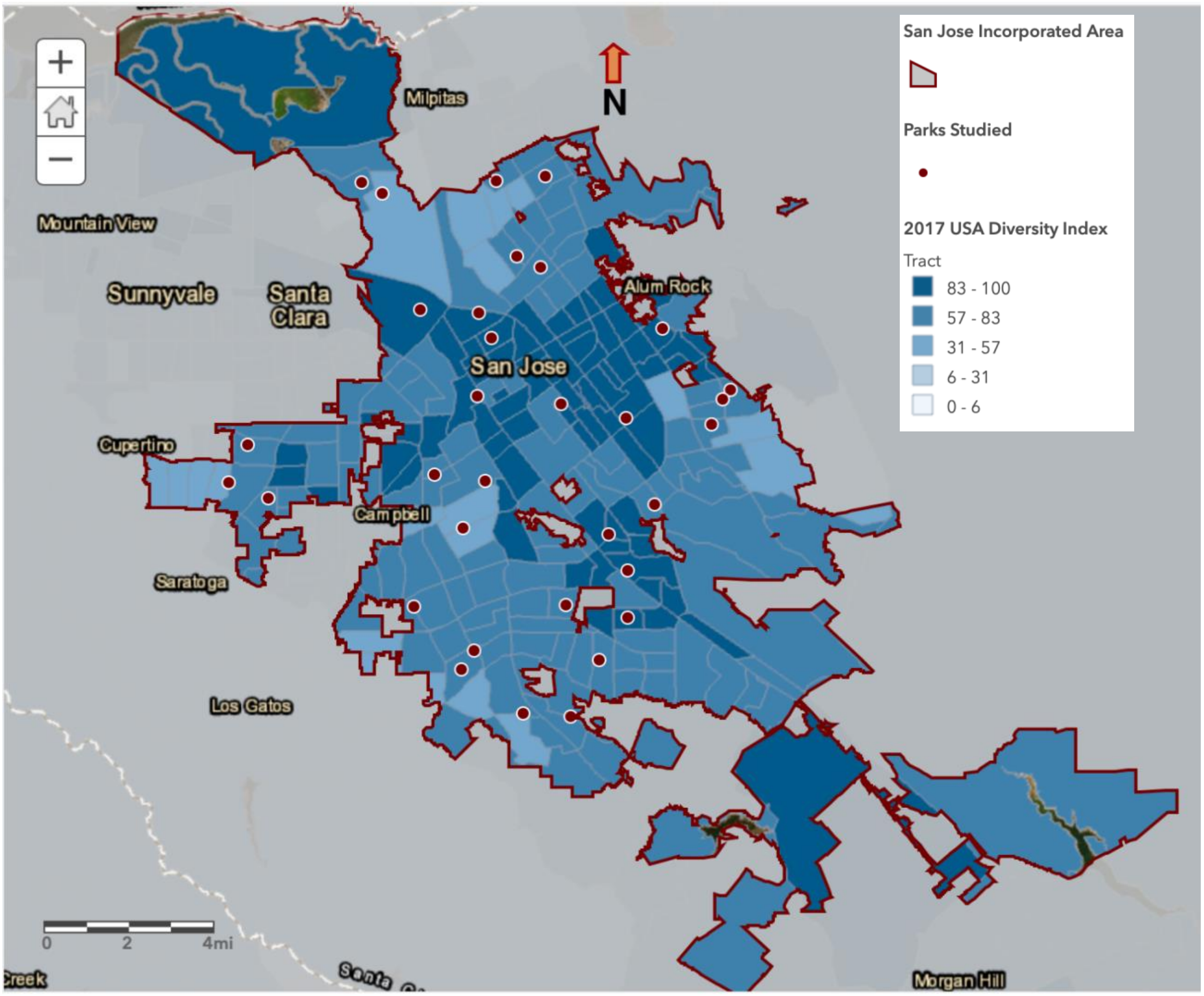

Figure 2. Diversity index of the City of San José with mapped urban green spaces (ArcGIS_Hub, 2017).

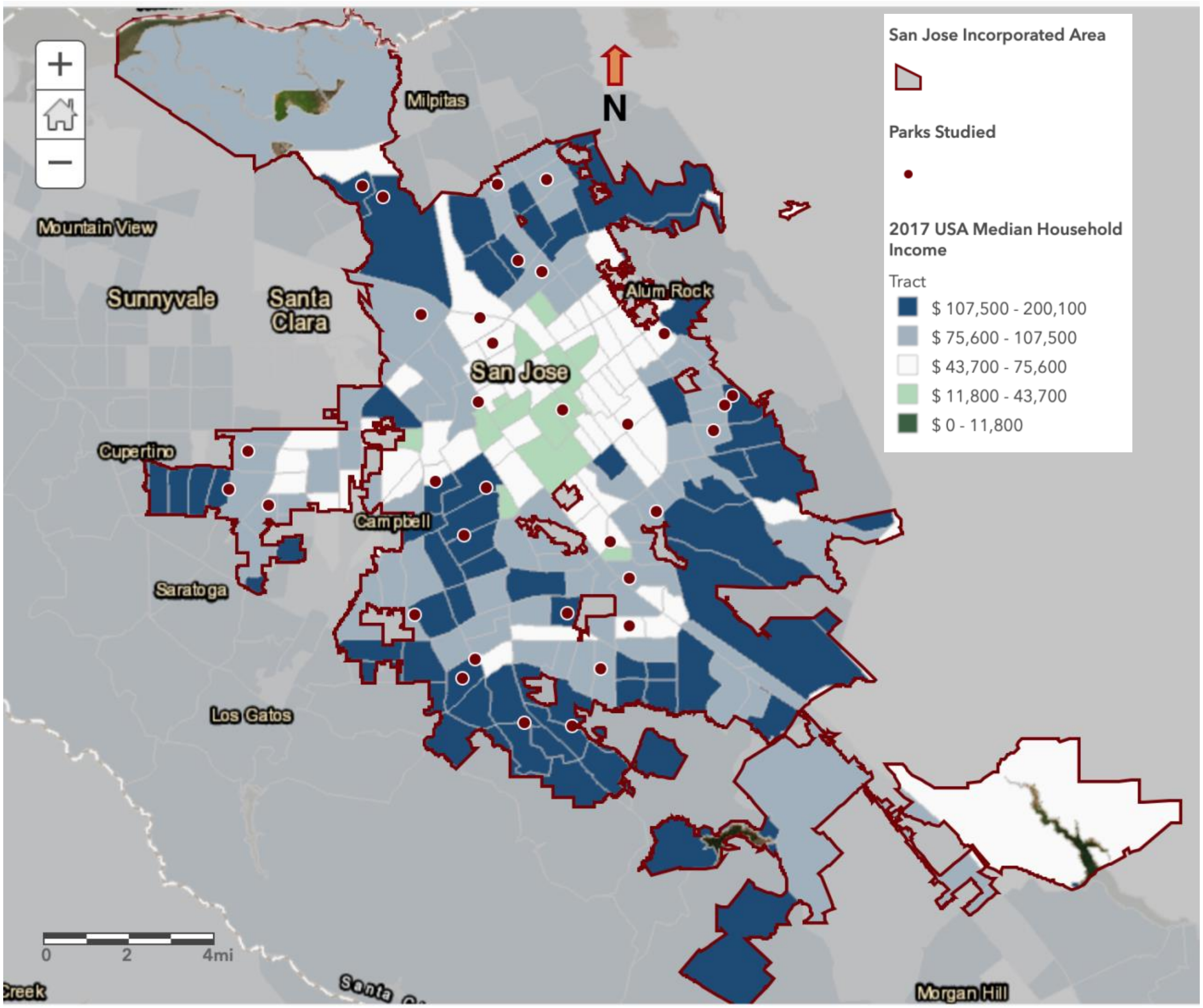

Figure 3. Median household income of the City of San José with mapped urban green spaces (Environmental Systems Research Institute, 2016).

Results

Relationship Between Urban Green Space Decibel Distribution

A Kruskal-Wallis H test indicated no significant difference between Leq inside and Leq outside measurements (*p* value at 0.4667). Although there was an apparent indication that Leq inside had lower decibel readings than Leq outside, there was not a statistically significant difference (see Figure 4). The comparison represented that the Leq outside breached the noise pollution line more frequently than the Leq inside, although the Leq inside average decibel ratings were higher than the Leq outside. The Leq inside and outside was lower than the noise pollution threshold, with Leq outside slightly higher than Leq inside.

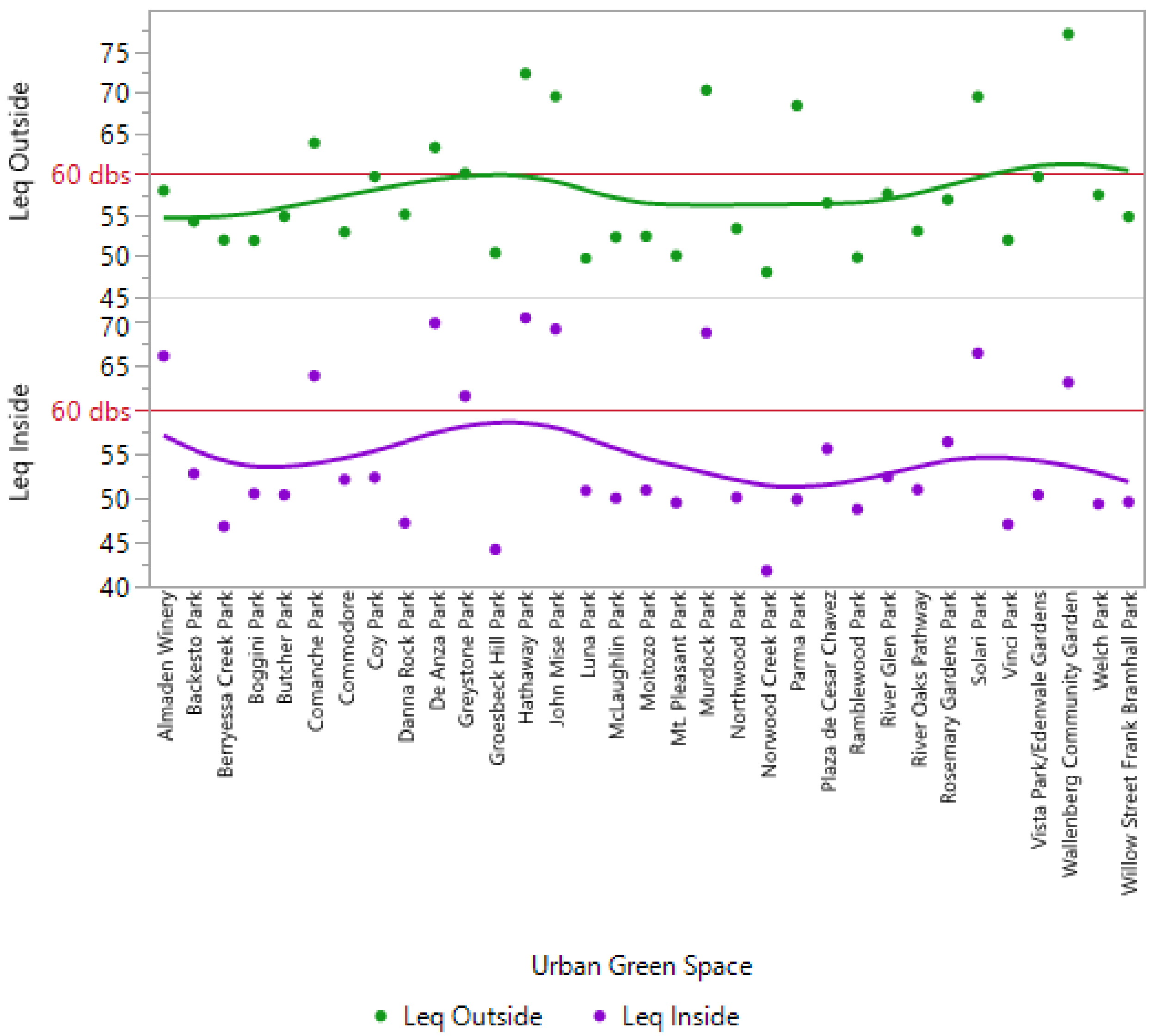

Figure 4. Leq inside and Leq outside in comparison to urban green space. This figure represents the comparison of Leq inside and Leq outside in relation to noise pollution (represented by the red line). The curved purple and red lines represent a comparison in sound level data measured with inside and outside Leqs in comparison to urban green spaces.

A one-way ANOVA analysis of Leq outside and Leq inside by urban green space was conducted with a mean of 56.32 decibels, compared to a Leq inside readings mean of 54.99 decibels (see Table 1 and Figure 5). Although there was no statistically significant difference between Leq outside and Leq inside, there was a trend towards the urban green space sound level measurements being lower in the center of the urban green space areas, and average inside Leq measurements were typically lower than outside Leq measurements due to the mitigating effects of urban green space.

Table 1

Leq Outside and Leq Inside Throughout Urban Green Space Areas: Analysis of Variance

Leq Outside	Source	*DF*	Sum of Squares	Mean Square
	Urban Green Space	32	1802.1733	56.3179
	Error	0	2.2737e-13	
	C. Total	32	1802.1733	
Leq Inside	Source	*DF*	Sum of Squares	Mean Square
	Urban Green Space	32	2111.9314	54.9867
	Error	0	0.0000	
	C. Total	32	2111.9314	

Relationship between urban green space dbs. ethnicity and socioeconomic status. One-way ANOVA indicated that there was a higher decibel level in middle/high and low-income urban green spaces than in the low/middle and high-income urban green spaces, but this did not suggest a trend in decibel levels ($p = 0.4667$) from high to low income (see Table 2).

There were no statistically significant results found, although there was a comparison in low and low/middle-income urban green spaces having lower decibel readings than the middle/high to high-income urban green space areas, which addresses the first hypothesis regarding unequal distribution of urban green space (see Figure 6 and Table 2). It was hypothesized that low-income urban green spaces would have higher decibel readings, but that hypothesis was not supported. Higher-income urban green spaces appeared to have higher decibel readings, but the difference between socioeconomic status areas was found not to be statistically significant. Although not statistically significant, an inclination toward higher Leq outside the middle/high and high-income groups as compared to the other groups was observed.

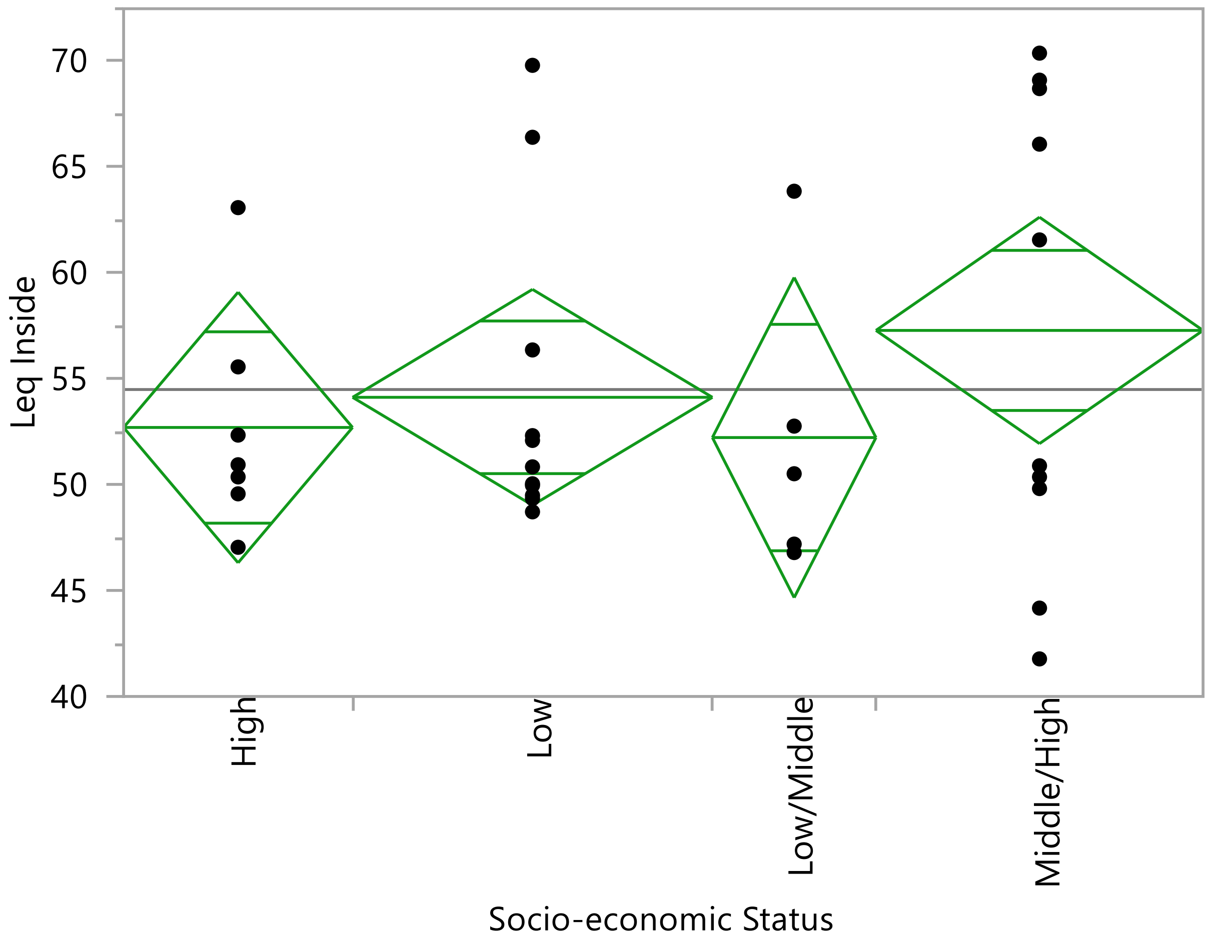

Figure 5. One-way analysis of Leq inside by socioeconomic status. One-way ANOVA (Kruskal-Wallis H Test) with a bootstrap derivative of Leq inside versus socioeconomic status. This diamond plot indicates measures two or more populations at a 95% confidence interval for each mean. The means for Oneway Anova, contain summary statistics and confidence intervals for each mean (based on the pooled estimate of the standard error). Although not statistically significant, an inclination toward higher Leq inside the middle/high group as compared to the other groups can be observed. Figure 5 illustrates the socioeconomic portion of the answer to this question by running a one-way ANOVA. Figure 5 represents high, low, low/middle, and middle/high socioeconomic statuses in relation to Leq inside ratings.

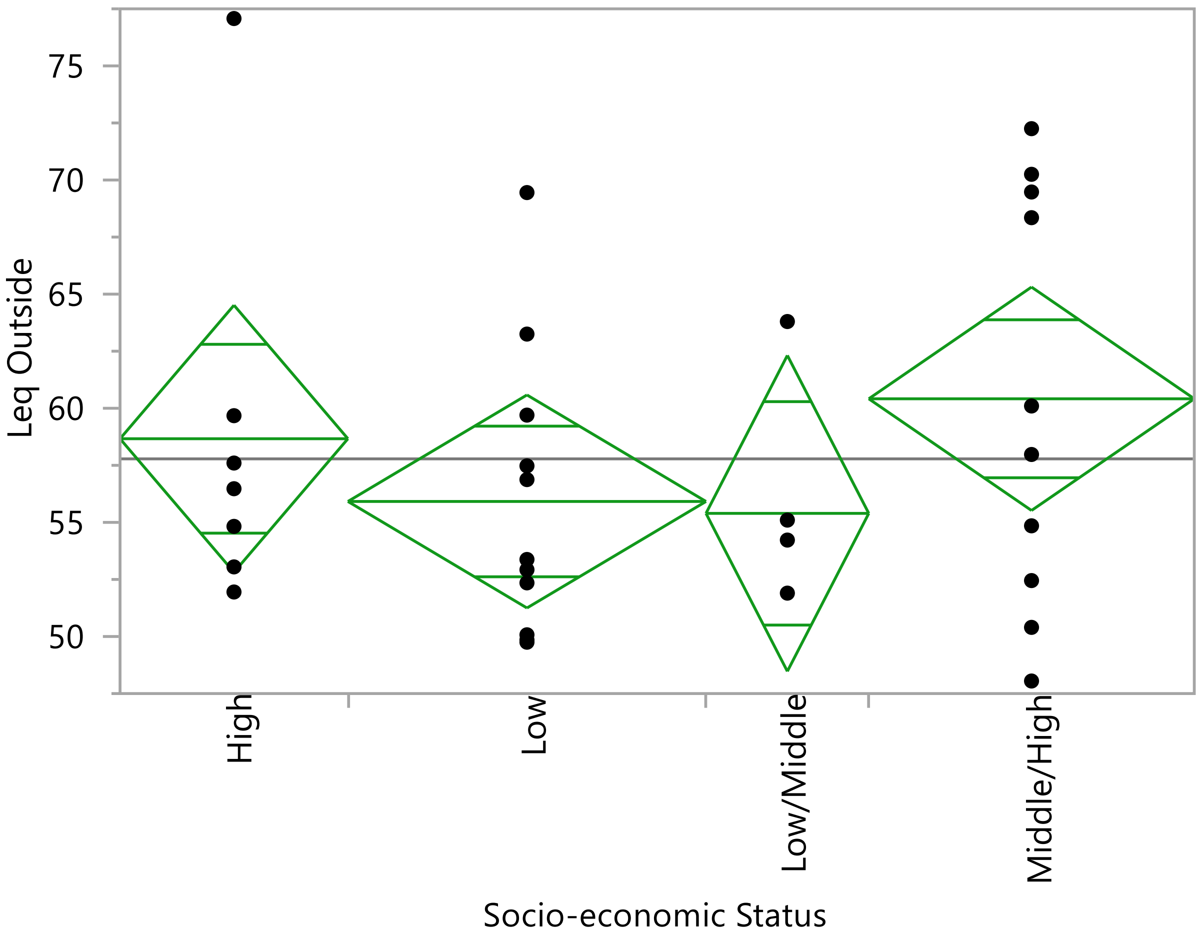

Figure 6. One-way analysis of Leq outside by socioeconomic status. One-way ANOVA (Kruskall-Wallis H Test) with bootstrap derivative of Leq outside versus socioeconomic status. This diamond plot indicates measures two or more populations at a 95% confidence interval for each mean. The means for Oneway Anova, contain summary statistics and confidence intervals for each mean (based on the pooled estimate of the standard error). Figure 6 illustrates the socioeconomic portion of the answer to this question by running a one-way ANOVA. Comparatively, Figure 6 illustrates the Leq outside decibel levels compared to low, low/middle, middle/high, and high socioeconomic statuses.

Table 2

Summary Analysis of Leq Inside and Leq Outside by Socioeconomic Status

	Sum of Squares	**Mean Square**	**Chi-Square**	**P-value**	**Significant?**
Leq Outside	2111.93	65.997	32	0.4667	Not Significant
Leq Inside	1802.17	56.317	32	0.4667	Not Significant

One-way ANOVA indicated that there were no statistically significant differences in inside Leq vs. outside Leq. between demographic groups. However, there were visual indications that urban green spaces in African American, Latinx, and Mixed neighboring demographics experience lower Leq inside and Leq outside decibel readings than White and Asian neighboring demographics in relation to urban green space decibel readings (see Figure 7).

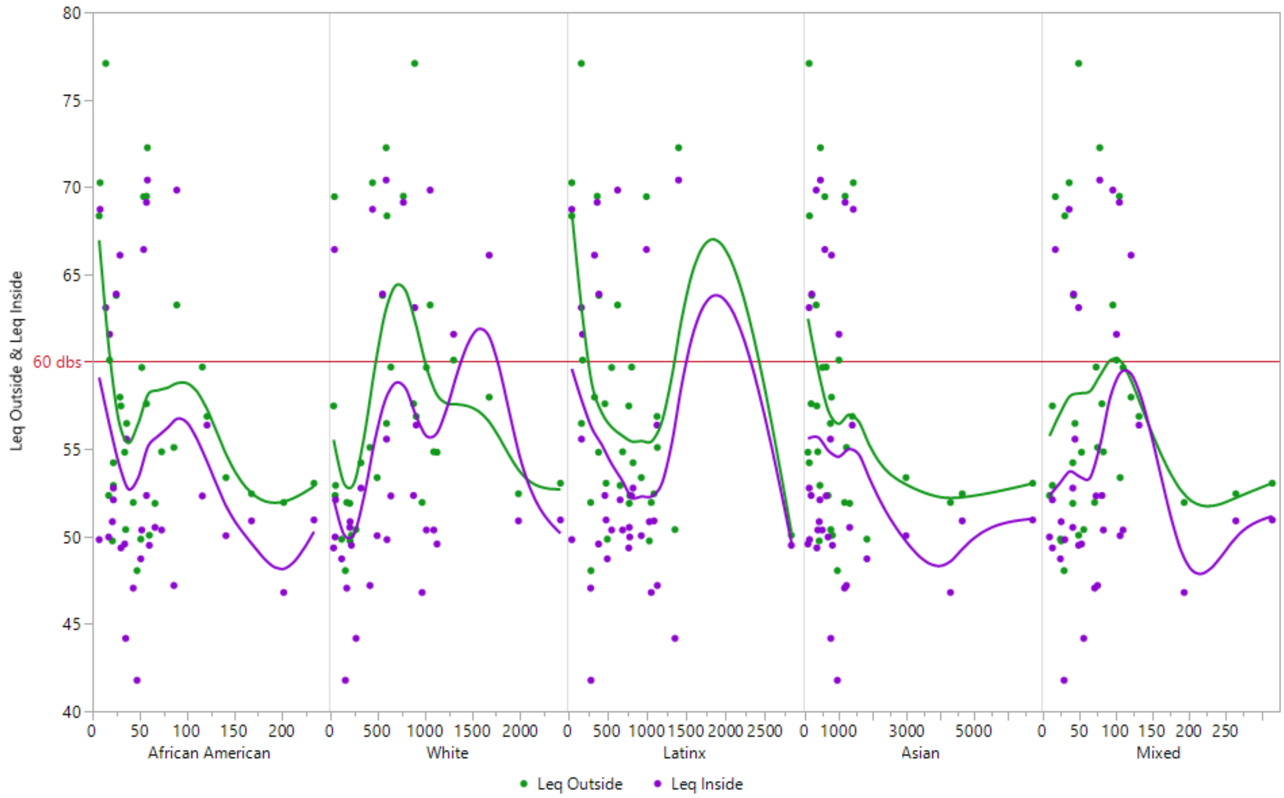

Figure 7. Leq outside and Leq inside in comparison with ethnicity. A one-way ANOVA was conducted and serves to illustrate the relationship between decibel readings and ethnic demographics of the neighboring communities. The curves are trend lines to indicate inside and outside Leq recorded in neighborhoods with these demographics.

Relationship between urban green space dbs. and urban green space accessibility. One-way ANOVA indicated no statistically significant differences between urban green space rating and decibel levels (see Figure 8 and Figure 9). However, there was a comparison between higher decibel readings in both inside and outside Leqs and higher park ratings, contrary to the hypothesis that communities of color with lower park ratings would experience higher decibel readings (see Table 3).

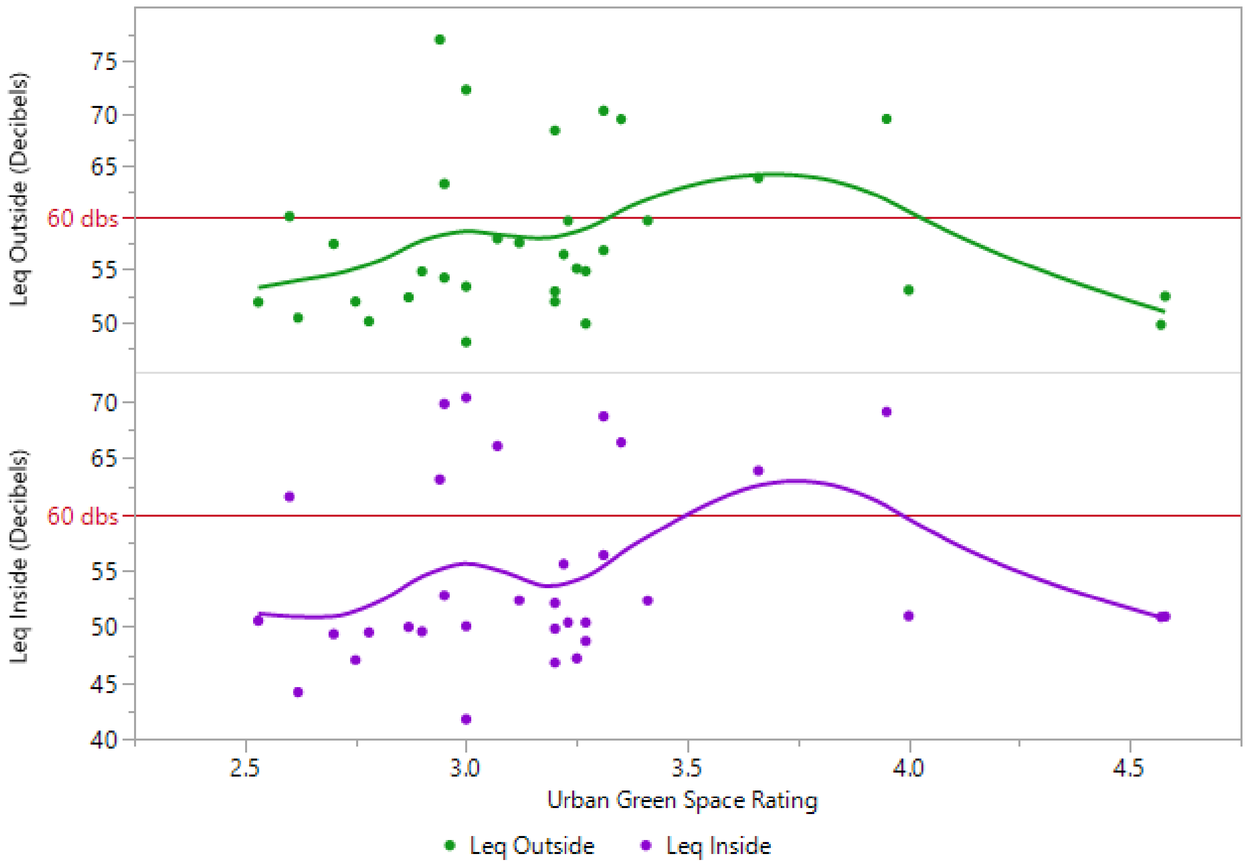

Figure 8. Leq inside and Leq outside measurement comparisons of urban green spaces. The decibel levels both inside and outside of urban green spaces incline with increasing urban green space rating until a threshold score is reached and it declines.

Table 3

Bivariate Fit of Leq Inside and Leq Outside in Comparison to Urban Green Space Rating

Leq Outside		**Value**	**Lower 95%**	**Upper 95%**	**Signif. Prob**
	Correlation	0.016285	-0.32886	0.357595	0.9283
	Covariance	0.059591			
	Count	33			
	Variable	**Mean**	**Std Dev**		
	Urban Green Space Rating	3.20484	0.487597		
	Leq Outside	57.7833	7.504526		
Leq Inside		**Value**	**Lower 95%**	**Upper 95%**	**Signif. Prob**
	Correlation	0.103369	-0.24877	0.43137	0.5670
	Covariance	0.409465			
	Count	33			
	Variable	**Mean**	**Std Dev**		
	Urban Green Space Rating	3.20484	0.487597		
	Leq Outside	54.5037	8.123906		

One-way ANOVA was conducted, and the analysis found no statistically significant correlation between urban green space attendance and decibel levels. Additionally, the one-way ANOVA indicated that there were higher decibel ratings in Leq outside 57.78 dbs. readings compared to Leq inside readings 54.50 dbs. (see Table 4). There was a comparison between illustrating an increase in decibels from attendance levels fifty to 125 and decreased after 125 to 300 urban green space attendees, addressing the third hypothesis that inside and outside Leq readings were dependent upon population counts inside the urban green space areas. Urban green spaces with higher park ratings experience higher park attendee counts, resulting in overall higher inside and outside Leq.

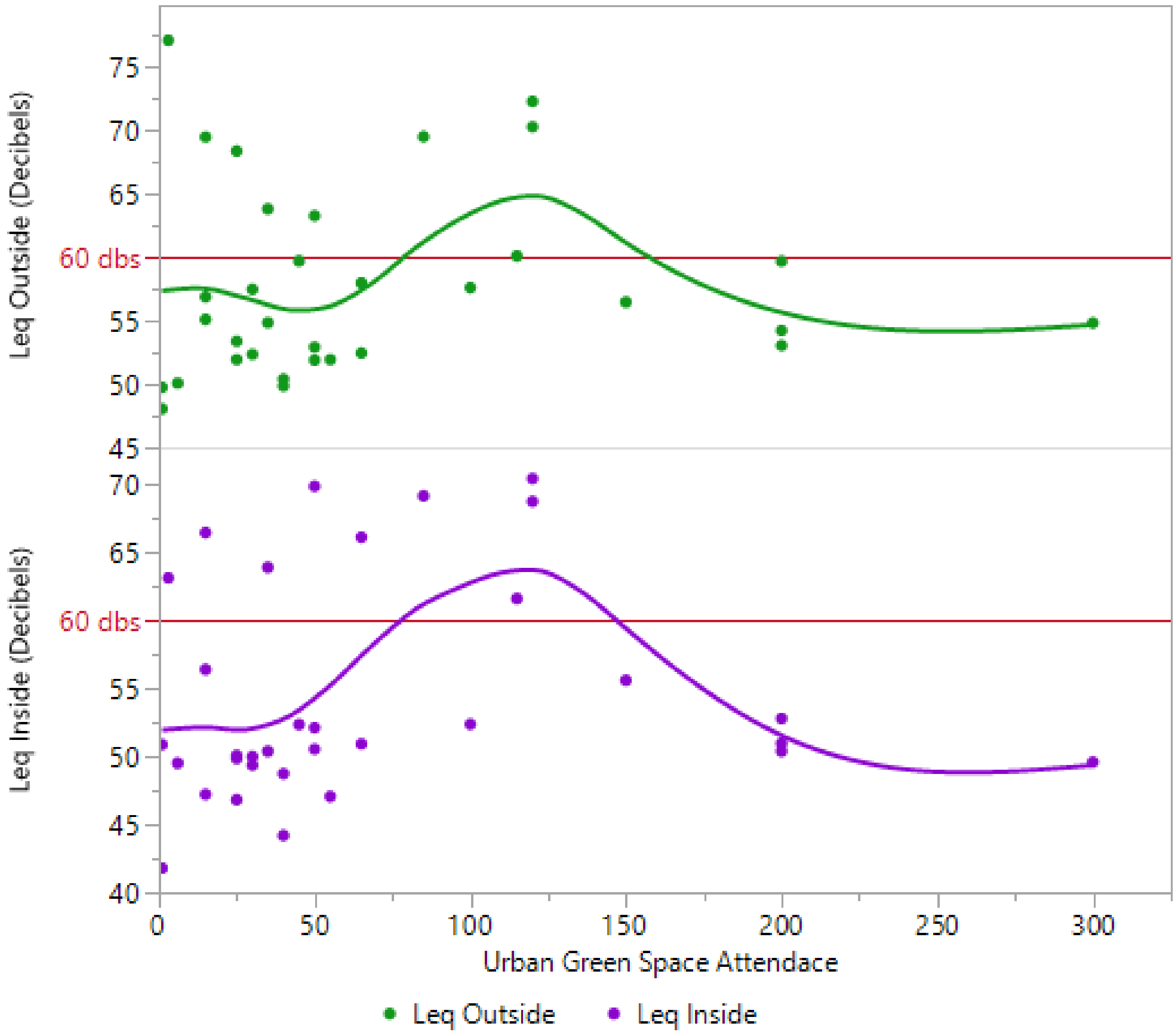

Figure 9. The decibel levels both inside and outside of urban green spaces incline with increasing urban green space attendance until attendance reaches a tipping point and declines.

Table 4

Bivariate Fit of Leq Inside and Leq Outside in Comparison to Urban Green Space Attendance

Leq Outside		**Value**	**Lower 95%**	**Upper 95%**	**Signif. Prob**
	Correlation	0.042491	-0.30527	0.380253	0.8144
	Covariance	22.61536			
	Count	33			
	Variable	**Mean**	**Std Dev**		
	Urban Green Space Rating	70.0303	70.92183		
	Leq Outside	57.7833	7.504526		
Leq Inside		**Value**	**Lower 95%**	**Upper 95%**	**Signif. Prob**
	Correlation	0.087726	-0.26352	0.418433	0.6274
	Covariance	50.54441			
	Count	33			
	Variable	**Mean**	**Std Dev**		
	Urban Green Space Rating	70.0303	70.92183		
	Leq Outside	54.5037	8.123906		

Additionally, the relationship between urban green space rating and urban green space attendance was analyzed using a bivariate fit test (see Figure 10 and Table 5). Although there were no statistically significant results between urban green space rating and urban green space attendance, there was a comparison in overall urban green space rating and urban green space attendance. The comparison helped illustrate that the lower the urban green space rating, the lower the attendance counts, addressing the third hypothesis that "Urban green spaces with higher park ratings experience higher park attendee counts resulting in overall higher inside and outside Leq."

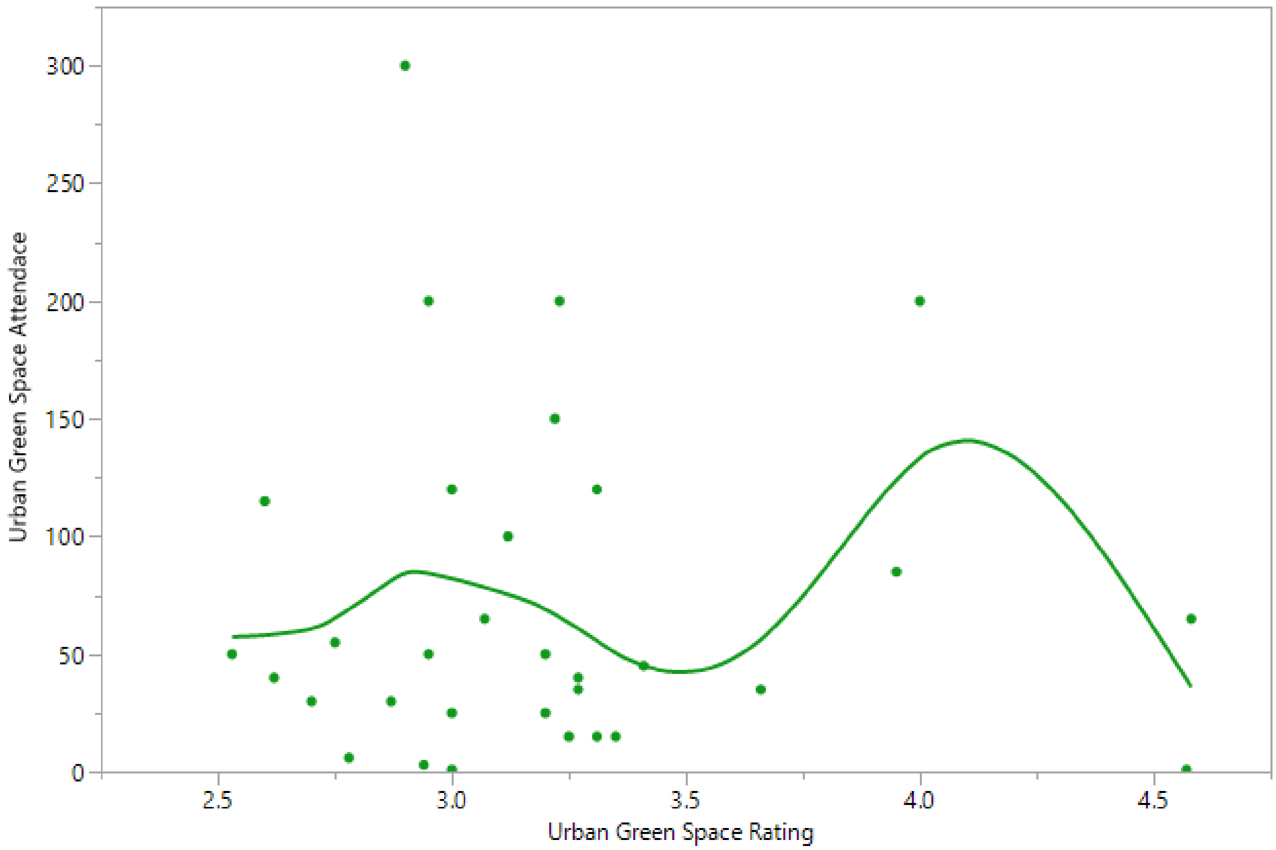

Figure 10. Urban green space attendance in comparison with urban green space rating.

Table 5

Urban Green Space Attendance in Comparison to Urban Green Space Rating Analysis

Variable	Mean	Std Dev
Urban Green Space Rating	3.204848	0.487597
Urban Green Space Attendance	70.0303	70.92183

	Value	Lower 95%	Upper 95%	Signif. Prob
Correlation	-0.01404	-0.35563	0.330865	0.9382
Covariance	-0.48546			
Count	33			

Limitations

Ambient sound measurements, which contained multiple sound level sources from traffic, nature, and humans affected sound measurements. This included decibel readings such as peaks from loud vehicles, cheering crowds, and air traffic, which added to the decibel readings inside of urban green space areas. An important aspect of this study was an analysis of sound level differences from high-income to low-income communities of color neighborhoods based on urban green space, which recordings of ambient sound provided.

An alternative way to measure sound would be to isolate the sound source to identify vehicles, airplanes, and industrial sound and isolate them from ambient sound. This would provide more data to measure the relationships of urban green spaces and low-income communities of color neighborhoods and help to determine which neighborhoods experience specific point sources of sound. A mobile app was utilized to analyze sound, as opposed to a professional sound level meter. Beneficially, this provided access to a handheld platform costing less than five U.S. dollars; an affordable system that is a useful measuring process for low-income communities of color that otherwise may not have access to a professional sound level meter.

Another limitation was that the census data measurements were taken in 2010. They were approximately seven to eight years old, although this was the most accurate data to date in San José. These data sets were considered accurate, as they were the most detailed and comprehensive data including age, sex, ethnicity, households, families, and relationships to the householder within a community (Occupational Safety and Health Administration, 2017; U.S. Census Bureau, 2010).

Discussion

The results did not indicate that low and low/middle-income neighborhood urban green spaces experience as much sound as middle to middle/high-income urban green spaces (Houston et al., 2008; Kingham et al., 2007; Mohai et al., 2009). A mean comparison of high-income White/Asian and Latinx/African American low-income urban green space areas although not statistically significant displayed frequent acute high decibel events in the White/Asian communities. There were some decibel level anomalies in low-income Latinx/African American/two or more ethnicity and urban green space areas, such as De Anza and Solari urban green space that experience high amounts of sound, which indicates frequent urban green space attendance. There were also urban green spaces in Latinx/African American/two or more ethnicity and middle-income areas that experienced low amounts of sound, such as Groesbeck Hill, Moitozo, and Norwood Creek, which had little pedestrian traffic and low urban green space attendance. Although not statistically significant, the data that White/Asian ethnicity and middle/high-income urban green spaces had higher sound readings and higher parks ratings relate to environmental justice by assuming that the more affluent neighborhoods have access to better quality urban green spaces. This is in contrast to the Latinx/African American/two or more ethnicity and low/middle-income group, whose urban green spaces had lower attendance, less sound, and less overall urban green space amenities. This presented an example of environmental injustice, where not all urban green spaces are being maintained equally throughout San José. While these results are not statistically significant, the comparisons align with the study in Paris, France, which associated higher sound readings in higher-income areas (Havard et al. 2011). Additionally, these results correspond to the Brainard study that found no association with higher daytime sound in communities of color (Brainard et al. 2004). An additional direction for further study would be to explore if this unequal maintenance of urban green spaces relates to participatory justice. To explore this may help clarify access to political power and political recognition.

From the park attendee counts taken at each urban green space, there were significantly more people in the White/Asian ethnicity and middle/high to high-income urban green spaces compared to the Latinx/African American/two or more ethnicity and low to lower-middle-income urban green spaces. The White/Asian ethnicity and middle to high-income urban green spaces also had noticeably higher quality amenities such as maintained bocce ball courts, clean public restrooms, a lack of graffiti, and higher urban green space ratings. Urban green spaces in low-income African American, Latinx, and Mixed neighboring demographics, while non-statistically significant, displayed lower sound readings than White and Asian neighboring demographics. This initially contradicted the hypothesis that there would be higher decibel readings in low-income communities of color.

The average urban green space ratings drawn from the City of San José analyzed with average inside and outside Leq readings of urban green spaces, found that the urban green spaces with higher park ratings had higher Leqs and higher park attendee counts (Figure 8 and Figure 9). While non-statistically significant, a comparison was identified that supports the hypothesis that overall urban green space ratings compared to average inside and outside Leq ratings are dependent upon the park attendee counts within the urban green space area.

Groesbeck Hill, Moitozo, and Norwood Creek were less used and therefore quieter inside because a smaller number of attendees visited them; there is an incline in the data, which represents that the urban green space areas with higher attendance (from approximately fifty attendees) experienced higher levels of sound than those with park attendance fewer than fifty (see Figure 9). Although there was no statistically significant data to support that Leq inside was lower than Leq outside, the averages represent that the centers of urban green space areas have lower decibel readings than the decibel readings recorded on the edges of the urban green spaces. This supports the hypothesis that urban green space sound level measurements are lower in the center of the urban green space areas and average inside Leq measurements are lower than outside Leq measurements due to the mitigating effects of urban green space.

The sound level can be considered an indicator of urban green space usage by articulating that higher populated urban green spaces experienced higher urban green space attendance, with increasing overall urban green space sound averages (Leq) and sound on the edges of urban green spaces measured at north, south, east, and west from people entering urban green spaces (Bashir et al., 2015). While non-statistically significant, it was assumed the more populated the urban green space, the higher the sound level measurements. The least populated urban green spaces were the low-income and low/middle-income areas that had lower urban green space ratings (see Figure 8).

When assessing relationships between urban green space ratings and the inside and outside Leq of urban green spaces, a significant amount of variation was found between urban green spaces. Latinx/African American/two or more ethnicity and low to low/middle-income urban green spaces comparative to White/Asian ethnicity and medium/high and high-income urban green space areas had lower population counts and lower urban green space ratings. There is an inclination in the data (see Figure 7) that the hypothesis that urban green space is distributed unequally throughout ethnicity, class, and socioeconomic status (Houston et al., 2008; Kingham et al., 2007; Mohai et al., 2009).

The purpose of the sound level measurements was to elucidate whether or not noise pollution can be found in certain urban green spaces and whether or not there was bias with respect to sound level and urban green space rating, urban green space attendance, socioeconomic status, or ethnicity-based neighborhoods and overall differences of decibels recording in the inside or outside of the urban green space. Although decibel levels were higher in White/Asian ethnicity and middle/high-income neighborhoods, while non-statistically significant it was identified that urban green spaces are able to reduce decibel levels in all neighborhoods. Therefore, urban green spaces need to be accessible to all communities and need to have working facilities, clean areas, and usable amenities. Urban green space must be accessible for communities to have equal opportunity of receiving the benefits that come from them, including noise pollution reduction.

Implications for Practice

City planners have the necessary capabilities to mitigate noise pollution and advocate for communities at risk of urban green space perceived inaccessibility. The policy has been created in order to keep planning, residents, and government entities in check. The EPA (2017) and the enforcement of the California Environmental Quality Act (California Environmental Quality Act [CEQA], 2014) require that any potentially significant environmental and human health effects must be reported and either avoided or mitigated before the construction process can begin. Maintenance of urban green space (through vegetation upkeep, graffiti removal, trash removal, and maintenance on park amenities) in all communities in the City of San José would require additional government funds for monitoring urban green spaces in all communities, including low-income communities of color. CEQA must approve, approve with mitigation, or deny the proposed project's plan. There were two parties that must follow these guidelines when planning; there were many instances where approval with mitigation was not sufficient under health standards and certain neighborhoods may suffer side effects (CEQA, 2014). This needs to be addressed for future monitoring of urban green spaces and addressing funding for the upkeep and preservation of urban green spaces to elucidate urban green space accessibility for all communities.

In order to assess future urban green space perceived accessibility, there has been the implementation of policies regulated by the EPA and the CEQA, which focus on fair treatment and meaningful involvement of all people regardless of ethnicity, color, national origin, or socioeconomic status, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (CEQA, 2014; EPA, 2017). These regulations could help reduce environmental injustice by creating perceived and physically accessible urban green spaces through urban planning (Thill & Rodkin, 2010); added benefits with maintaining accessible urban green space include a reduction in air and noise pollution through vegetation (Escobedo et al., 2011; Heinz, 2011; Nowak et al., 1998). These solutions could be adopted by San José to help address the environmental injustices of noise pollution and the concerns associated with urban green space accessibility.

Conclusions

Urban green space accessibility based on amenities, graffiti, trash, and broken structures reveals an inclination with urban green space usage. The cleaner and safer an urban green space appear the more likely it is to experience higher levels of sound due to the large number of people visiting and driving by the urban green spaces. Most, but not all lower-income neighborhood urban green spaces had lower urban green space ratings based on amenities that were broken and vandalized.

The hypothesis that urban green space is distributed unequally throughout ethnicity and socioeconomic status was addressed by measuring poverty, low-middle, and middle-income neighborhood urban green spaces in comparison to the middle to middle/high-income urban green spaces. This showed that there is an unequal distribution of sound throughout ethnicity, class, and socioeconomic status. The measurements of sound level readings did provide evidence that the outside Leq decibel readings were higher than the inside decibel readings, providing support and lending credence to the hypothesis that urban green space can mitigate the effects of sound.

Additionally, overall urban green space ratings compared to average inside and outside Leq ratings are dependent upon the park attendee counts within the urban green space area, as the more populated an urban green space area is, the more likely it is that there will be higher decibel levels.

Lastly, the amenities of higher-income neighborhoods were well kept and were found to be devoid of graffiti and un-housed populations, providing evidence for my hypothesis that sound levels can be an accessibility measure of urban green spaces.

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