Prioritization of urban vacant land for conversion to public greenspace: A case study in Kansas City, Missouri

Elizabeth J. Wesley

Urbanization

According to the World Health Organization over 50% of the world's population now lives in urban areas, an increase from 20% in the early 1900s. According to projections, urban populations will increase to 70% of the world's total population by 2050 and already cover an estimated 3 percent of the world's land surface (World Health Organization 2014). In the United States, 80.7 % of the population lives within urban areas, an increase of 12.1% from 2000 (U.S. Census Bureau 2013). The amount of developed land in the U.S. is expanding even more rapidly; during the period from 1982 to 2002 the amount of developed land increased at nearly twice the rate as the rate of increase in population (Environmental Protection Agency 2011). As urban areas expand in size, there are associated land use changes, especially at the urban periphery as a result of urban sprawl. Vegetated land is converted to developed land, which causes the loss of natural and native ecosystems, decreases habitat connectivity, and reduces wetlands (U.S. Geological Survey 1999). Developed land is primarily covered with impervious surfaces, which alter resource flows and disturbance regimes within the urban ecosystem. With the conversion of vegetated land to impervious surface there is a decrease in net primary productivity, an increase in temperature (known as the Urban Heat Island effect), and a decrease in air and water quality (Tratalos, Fuller et al. 2007).

Another consequence of urban growth is often the increase in the amount of vacant land, especially within the central city. The causes of this increase are political, social, and economic, with the some of the most important interrelated factors being disinvestment in the city center, population migration to the suburbs, and deindustrialization (Bowman 2004). Many formerly economically robust U.S. cities have lost considerable portions of their population and have come to be known as shrinking cities, "a special subset of older industrial cities with significant and sustained population loss (25% or greater over the past 40 years) and increasing levels of vacant and abandoned properties, including blighted residential, commercial, and industrial buildings (Schilling and Logan 2008)." Such cities are the product of "five decades of globalization and technological change, and the dramatic shift of the country's population away from the urban core (Vey 2007)." The most noteworthy of these cities is Detroit, MI, which lost more than 50% of its population in the past 50 years. Consequently, more than 25% of properties in Detroit are vacant, and the aggregated area of the more than 100,000 vacant properties is approximately 20 square miles (Nassauer and Raskin 2014). Also associated with shrinking cities is the decrease in infrastructure and services supplied to extensively vacated areas (Frazier and Bagchi-Sen 2015).

Urban Vacant Land

What is considered to be urban vacant land can be difficult to define; often the use of the term is operational, and there are always various scales and numerous stakeholders. For a very basic definition, the EPA considers a vacant lot to be a “neglected parcel of property that has no buildings on it (Environmental Protection Agency 2014).” Although conveniently simple, this definition overlooks other urban sites that can include agricultural land on the urban periphery, brownfields, greenfields, and land with abandoned structures and buildings. Small, irregularly shaped parcels that are leftover from early development are often vacant, as are parcels unsuitable for development such as those in flood plains (Pagano 2000). The varying nature of vacant lands not only makes it difficult to assign an official definition, but also makes it difficult to quantify the amount of vacant land in cities. Consequently there are few comprehensive surveys. A 1998 survey estimated that on average 15% of urban land was classified as vacant (Pagano 2000).

There can be many problems associated with urban vacant lots including illegal dumping, hazardous materials in the landscape, rodents, the lowering of property values, and negative social effects (Environmental Protection Agency 2014). Urban vacant land is frequently described in negative terms: “abandoned, empty, dangerous – and has often come to symbolize disinvestment, blight and decay (Bowman 2004).” Vacant land lowers the market value of surrounding properties thus lowering tax revenue and decreasing the ability of the city to provide services. Vacant properties also may attract crime, vandalism, and fire thus decreasing neighborhood vitality (Accordino and Johnson 2000). An alternative view, however, is that urban vacant land holds tremendous potential. Vacant lands can be transformed, even temporarily, into spaces that benefit the community and the environment like community gardens, recreational facilities, and public greenspace.

Urban Ecosystem Services

Urbanization produces four primary ecological effects: the urban heat island effect whereby temperatures are greater at the urban core, altered hydrology whereby more precipitation is shed as runoff rather than being absorbed by surface materials, an increase in carbon dioxide and decrease in carbon sequestration, and a decrease in biodiversity (Whitford, Ennos et al. 2001). These effects are largely the product of a decrease in vegetated surfaces through their conversion to impervious surfaces. Much of the loss of this ecosystem functionality in urban areas is due to the extreme fragmentation caused by urbanization, the result of which is a complex and highly heterogeneous urban matrix interspersed with semi-natural habitats that are altered in function and value by the surrounding land uses.

Ecosystem services are defined as "the benefits human populations derive, directly or indirectly, from ecosystem functions" (Robert, Ralph et al. 1997) and include water filtration, carbon sequestration, air pollution filtration, climate moderation, flood control, erosion control and biodiversity support (Alberti 2010). Loss of diversity in ecosystems results in a loss of ecosystem stability and declines in species richness can lead to declines in overall functioning of the ecosystem. This is especially true for ecosystems that already function with lower levels of diversity like the managed ecosystems of urban areas. Losses in functionality can reduce an ecosystem's resilience to environmental stress like drought. Similarly, ecosystem processes that regulate soil nitrogen levels, plant productivity, water use, and pest and disease cycles may fluctuate more dramatically, reducing the overall health of the ecosystem (Naeem, Chapin III et al. 1999). Organisms help direct the flow of energy and materials through an ecosystem and healthy ecosystems create an efficient energy flow. They also provide direct benefit to humans in the form of ecosystem services (Naeem, Chapin III et al. 1999). A highly functional ecosystem provides many ecosystem services, including: purification of water, purification of air and pollution mitigation, carbon sequestration, regulation of the surrounding microclimate, erosion control, and soil quality control (Khera, Mehta et al. 2009) (Naeem, Chapin III et al. 1999). Urban greenspaces can strengthen the functionality of urban ecosystems (Urbanova 2009). Urban greenspaces support urban biodiversity and broaden the range of ecosystem services available in urban areas, including cultural services like recreational opportunities and improved public health (Dallimer, Rouquette et al. 2012). Studies show that exposure to nature is a major determinate in sensitivity to environmental issues (Savard, Clergeau et al. 2000).

Urban Greenspace

Although highly fragmented, urban greenspaces can form interconnected networks within the urban matrix (Shwartz, Muratet et al. 2012). Habitat fragmentation is the process by which landscapes are continuously subdivided into smaller patches of habitat. The high degree of fragmentation in urban landscapes increases the pressure on naturally occurring ecosystems within the urban area (Urbanova 2009). Larger greenspaces have greater ecosystem service provision potential because they increase the proportion of greenspace to impervious cover and there is an increase in habitat heterogeneity. Homogenous patterns of land use, including those often found in cities, suppress natural ecosystem processes and decrease biodiversity (Alberti 2010). The distribution and abundance of greenspace within an urban area, as well as the size of the individual greenspaces, affects the overall provision of ecosystem services within an urban area (Savard, Clergeau et al. 2000).

Urban greenspace also has social and economic implications. Proximity to urban greenspace can increase psychological and physical wellbeing, and decrease fear, aggression, and violent behavior (Chiesura 2004). Easy access to parks provides opportunity for leisure, exercise, spiritual, and community activities. Parks in residential areas promote positive feelings about a community and encourage positive interactions (Tzoulas, Korpela et al. 2007). Additionally, cultural ecosystem services are directly experienced and perceived. Studies show that participation in pro-environmental activities and feelings of environmental stewardship are directly affected by the interactions that people have with nature, and that aesthetic enjoyment of nature is a strong factor in a person's desire to protect it (Andersson, Tengö et al.). Urban nature parks hold the strong potential for public education on the environment and environmental issues. Nearness to greenness can also increase property values (Chiesura 2004) and encourage investment.

The transformation of urban vacant lots into public greenspace is a potential solution to an issue of urban blight and neighborhood disinvestment. The greening of vacant lots in urban areas can increase ecosystem services and contribute to the physical and mental health of individuals and communities and has the facility to combine social and ecological needs in a manner that enhances both community and environmental resiliency (Kremer, Hamstead et al. 2013).

Study Area

Kansas City, Missouri had an estimated population of 467,007 in 2013 and a land area of 314.95 square miles (U.S. Census Bureau 2015). Downtown KCMO is located near the confluence of the Kansas and Missouri Rivers, and the city spreads south over Jackson, Clay, Platte, and Cass counties. KCMO is part of the larger Kansas City Metropolitan Area, which spans the Kansas and Missouri border and encompasses 14 counties (**Fig. 1**) (Mid-America Regional Council 2015). About 10% of cadastral parcels in KCMO were vacant as of 2009, with these 20442 parcels making up about 25 square miles, or approximately 8% of the city's area. The purpose of this GIS analysis is to determine which of these vacant parcels may be most appropriate for conversion to public greenspace.

Data

GIS analysis was completed using ESRI's ArcMap 10.2.2 for Desktop and GoogleEarth. The parcels data was obtained from the City Of Kansas City, Missouri as part of their cadastral database. Economic and population data for the Kansas City census block groups was obtained from the U.S. Bureau of the Census via their American Fact Finder website in the form of TIGER/Line Shapefile products. The land use land cover data came from the Mid-America Regional Council (MARC) in the form of their Natural Resource Inventory raster product, a high-resolution raster dataset of land cover classifications for the Kansas City Region. Data for the regional parks also came from MARC. Map base data was collected from both the City of Kansas City, Missouri (city limits) and MARC (highways and water bodies).

Methodology

The first step in processing the data was to identify and subset the vacant parcels (**Fig. 2**). The vacant parcels were identified by their land use code: 9500 – vacant residential and 9600 – vacant non-residential. The parcels were then dissolved so that adjacent parcels that shared boundaries would be considered a single parcel, and singlepart features were generated from multipart features so that each feature in the vacant parcels layer would contain a single, continuous tract of land. The area in acres was also calculated for the vacant parcels. In order to focus on parcels large enough to provide both neighborhood cultural services and possibly significant ecosystem services, all parcels less than 2 acres were deemed unsuitable.

In order to determine the percent of each parcel that is vegetated, the Tabulate Area tool was used with the dissolved singlepart vacant parcels as zones, and with the MARC LULC raster as the input data (**Fig. 3)**. Areas were calculated for the Level 1 LULC classifications of barren, impervious, not classified, vegetation, and water. The percent of total area that is vegetated or water was calculated for each vacant parcel. The resulting table was then joined to the vacant dissolved singlepart parcels and the data was exported in order to save the percent vegetated as a permanent attribute of the feature class. The parcels less than 75% vegetated were deemed unsuitable due to the amount of impervious surface that would have to be removed before the area could be vegetated.

Next, the population and income data from the U.S. Census Bureau were joined to the census block groups for Kansas City. Total sample population and median family income per year were the statistics used. Both of these statistics were then normalized to a scale of 0 to 1 with the equation $\frac{x_i - min_{(x)}}{max_{(x)} - min_{(x)}}$. An inverse scale for median income was created by multiplying the scaled value by -1 and then adding 1 in order to give the lowest median income the highest need value. The two statistical scales were added together and then rescaled to 0 to 1 to create one scale measuring need, with low density/high income areas close to 0; high density/low income areas close to 1; and high density/high income, low density/low income, and medium density/medium income all in the mid ranges (**Fig. 4**). This scaled need was added as an attribute to the census block groups

The vacant dissolved singlepart parcels were then spatially joined to the census block groups and the scaled need extracted to the vacant parcels layer. These potential park sites now contained attributes measuring the area in acres, the percent of the total area that is vegetated or water, and the scaled need value from 0 (low density/high income) to 1 (high density/low income). Using the Natural Breaks classification method, the potential parks parcels were grouped into three classes based on the need scale: low (0 – 0.44), medium (0.44 – 0.56), and high (0.56 – 1). The parcels classified as high need were deemed suitable.

In order to estimate the suitability of the potential park parcels to provide connectivity to the larger urban greenspace network in Kansas City, a Euclidean distance surface was created for the regional parks within the KCMO city limits (**Fig. 5**). Based on a visual inspection of the resulting map, a mid-range of distance values from 295m to 985m was determined to be the range within which a new park might provide connectivity to the green network and also increase greenspace within an underserved area. The Zonal Statistics to Table tool was used to extract the Euclidean distance between regional parks for the zones represented by the potential park parcels. The mean distance per zone was then joined to the potential parks parcels. The parcels within the specified range were deemed suitable.

The final suitability criteria for potential parks are as follows: parcels are vacant according to the most recent cadastral information available from the City of Kansas City, Missouri; the agglomerated vacant parcels are over 2 acres in size; the parcels are at least 75% vegetated and/or water; the parcels are located in areas that are greater than 295 meters but less than 985 meters of Euclidean distance between existing regional parks; and the scaled need of the census block group in which the parcel resides is greater than 0.56.

Results

17 sites fit these criteria. As a final step, each site was visually inspected with both ESRI World Imagery base data and Google Earth. 6 sites were eliminated for containing a high percent cover of impervious surface (LULC misclassification) or for being directly adjacent to highways. A total of 10 sites fit all criteria for selection as potentially suitable sites for conversion from vacant land to public urban greenspace (**Fig. 6**). The sites range from approximately 2 to 19 acres, and cover a moderate range of need, from .57 to .68.

Conclusions

By considering need in addition to site and situation, it is possible to examine urban vacant land in terms of potential urban greenspace development. Prioritization of parcels for conversion to urban greenspace is the first step in developing vacant land to maximize cultural and ecosystem service benefits. Fieldwork will provide further assessment and prioritization. Mechanisms to access funds and land may take place across several scales of government and non-government organizations. The Land Bank of Kansas City, Missouri and the Heartland Conservation Alliance both advocate for and work towards sustainable reuse of vacant land in the Kansas City area. Any future planning to develop the prioritized parcels must take into consideration the needs of multiple stakeholders, most importantly those who live in the affected community. Community, organizational, and governmental cooperation can only further enhance all services provided by urban public greenspace.

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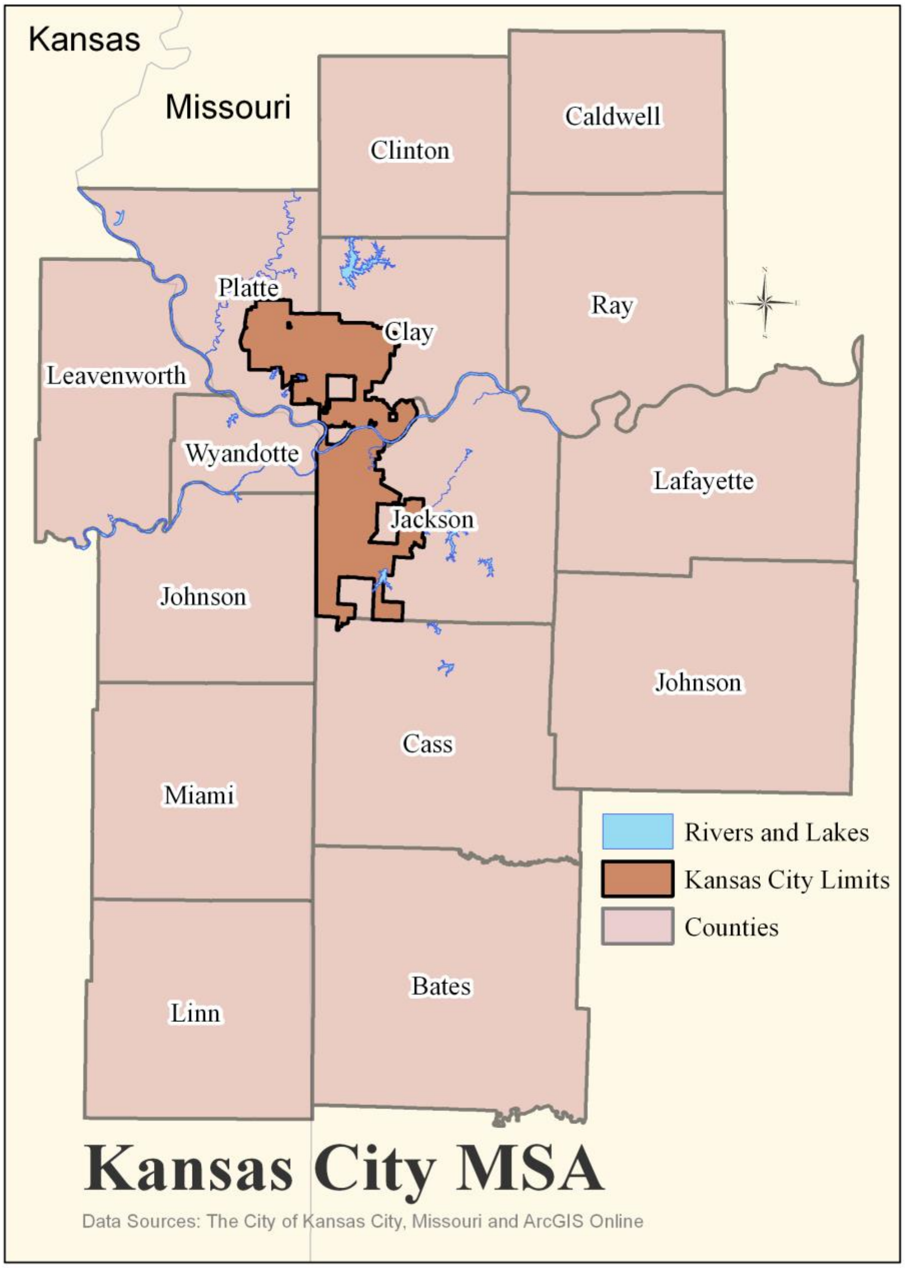

Figure 1: Kansas City, Missouri is located at the confluence of the Kansas and Missouri Rivers and is part of the 14 county Kansas City Metropolitan Statistical Area.

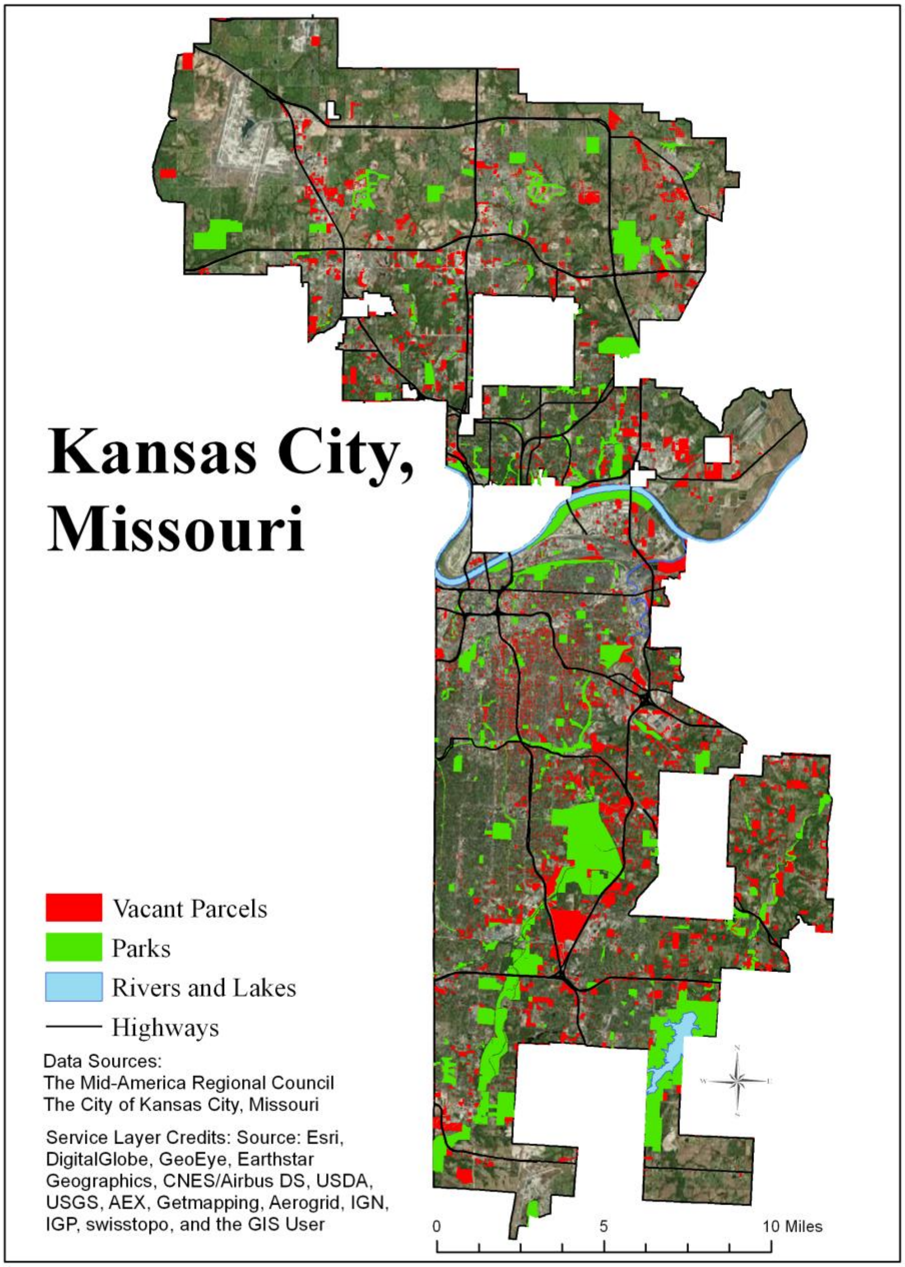

Figure 2: There are 20,442 vacant parcels in Kansas City, an area of almost 25 square miles.

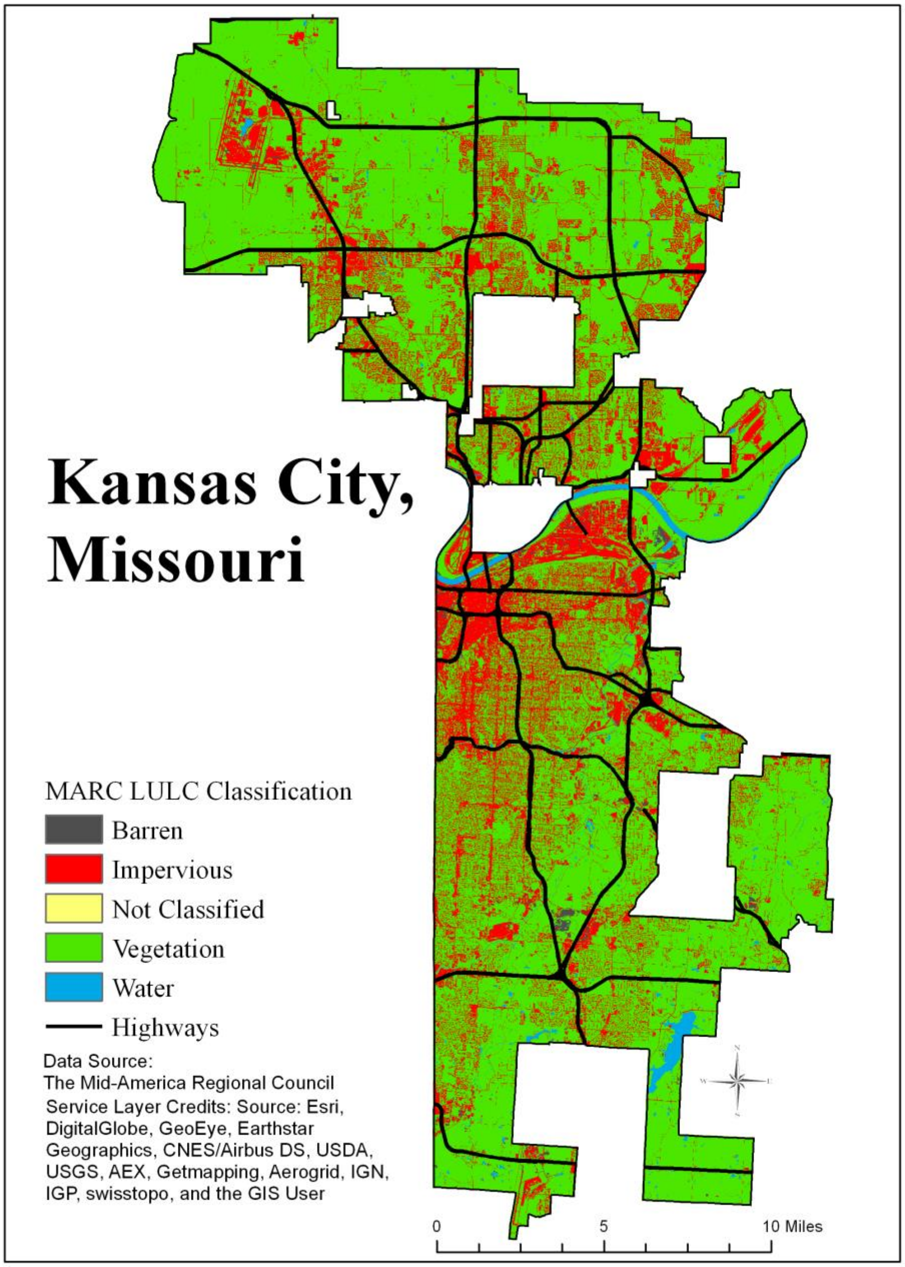

Figure 3: A land cover and land use classification for Kansas City, from the Natural Resource Inventory created by the Mid-America Regional Council.

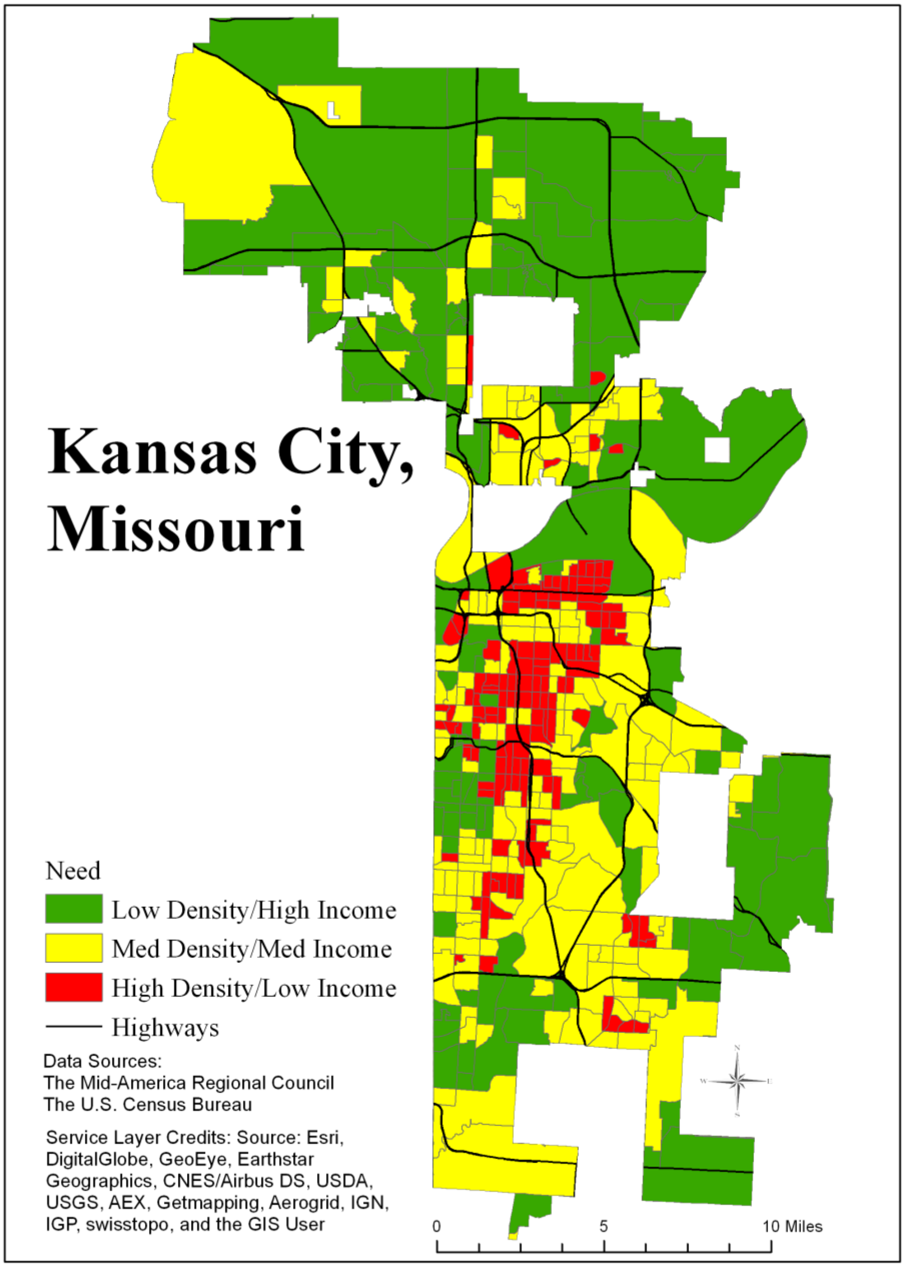

Figure 4: Need as defined by income and population density by U.S. Census block group.

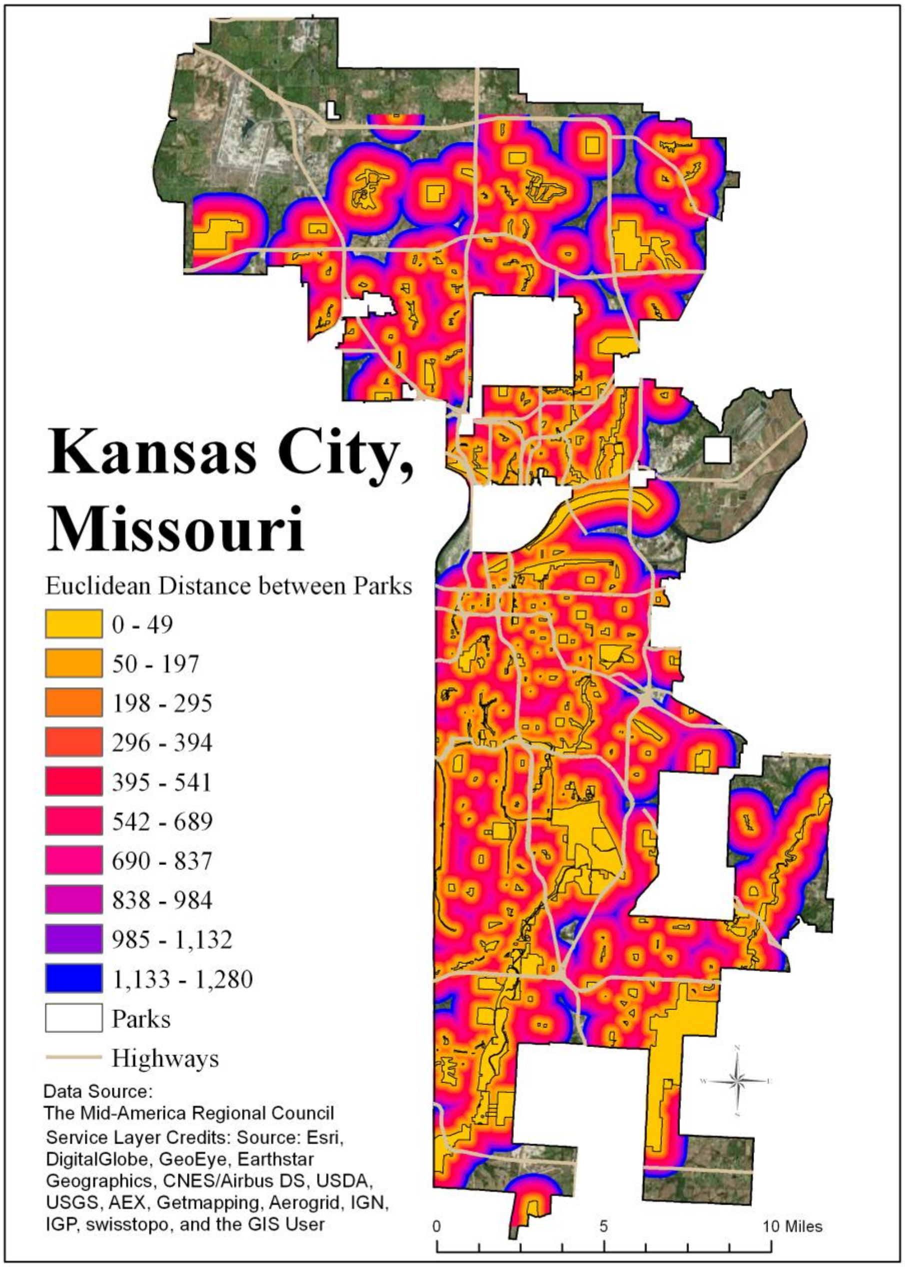

Figure 5: The distance between existing parks shows where there are gaps in service and connectivity.

Figure 6: Based on the criteria, there are 10 vacant parcels suitable for conversion to public greenspace.