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Land Use Regulation and Access to Amenities: Exploring Spatial Equity Using GIS

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LAND USE REGULATION AND ACCESS TO AMENITIES:

EXPLORING SPATIAL EQUITY USING GIS

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CHAPTER 1—INTRODUCTION

I. Background of Study

Land use regulation in the United States is common practice. For the last century, following the precedent of the City of New York Zoning Ordinance of 1916 and the US Supreme Court ruling in *Village of Euclid, Ohio v. Ambler Realty* which legitimized zoning as an appropriate and effective tool for land use regulation, most municipalities have adopted zoning as a tool for regulating land use (Levy, 2012). Municipalities use zoning to preserve the character of communities, protect residences against undesirable land uses, and guard against land use incompatibility; thus, zoning is largely seen as leaving a positive impact on the community as a whole (Sussna, 1961; Shlay and Rossi, 1981; Levy, 2012). However, critics note that there are often unintended consequences of land use management and separating residential areas from commercial and industrial areas: excessive land use separation, dependence on automobiles, separation of peoples, and an uneven distribution of resources, services, and amenities may result (Fischel, 1978; Shlay and Rossi, 1981; Pogodzinski and Sass, 1990; Clingermayer, 1993; Fernandez and Rogerson, 1997; Conley and Dix, 2004).

II. Problem Statement and Objectives

The gains of land use regulation far outweigh its costs—for example, through zoning, communities can protect their residents from undesirable land uses, preserve their character, and guard against land use incompatibility, among other things (Sussna, 1961; Shlay and Rossi, 1981). However, the unintended consequences of zoning are not concealable. Empirical evidence has shown that the separation of land uses—which is at the very core of zoning practices—has the tendency to impact distribution of services and amenities in cities (Harvard Law Review, 1971; Shlay and Rossi, 1981; Pogodzinski and Sass, 1990; Clingermayer, 1993; Conley and Dix, 2004).

The purpose of this study is to use geographic information systems (GIS) to examine the impacts of zoning on accessibility of amenities in cities across the United States. Specifically, the study will: 1. Establish a correlation between location of amenities and land use regulation. 2. Examine the unintended effects of land use regulation practices among socially differentiated communities.

III. Significance of Study

This study has several implications. Firstly, this research contributes to ongoing debates on social and spatial exclusion in American cities. Cases of *de facto* and *de jure* segregation of minorities and other socially differentiated peoples using land use regulation tools such as zoning are well documented (*Buchanan v. Warley*, 1917; McGurty, 1997; Silver, 1997). However, zoning is still widely used and a popular land use regulatory device in American cities. This research examines place-based effects of zoning through the lens of socially differentiated communities and their access to basic urban amenities. Secondly, insights are offered into the previously unexamined impacts of zoning on accessibility to amenities in American cities. Studies of accessibility tend to focus on the location of publicly funded services such as parks and recreation or health facilities. Although these studies are important to provide a check and balance on the power of governmental decision makers, private businesses provide the market with essential services and are limited to locating within zones determined by planning departments. Thirdly, this study may yield interesting regional patterns of inequity that are currently unquestioned. Patterns of inequity are unexamined at a large scale, and this research compiles measures of accessibility for selected American cities located in various regions in the United States.

IV. Definition of Terminologies

Accessibility – distance dependent indication of ease of travel between two places; in this study, accessibility is defined as the nearness to amenities (distance driven model) and availability of goods at these amenities (modified gravity model)

GIS (Geographic Information System) – integrated system of computer hardware, specialized software, geographic methods, and human-computer interaction designed to visualize and analyze spatial patterns in data

Socially differentiated communities – historically marginalized peoples such as minorities, immigrants, females, LGBTQ, and the elderly; in this study, the three largest minority groups (black, Asian, and Hispanic) are included due to data limitations

Spatial equity – equal or justified variation in the geographic distribution of a service or amenity

Zoning – land use regulatory tool that designates specific land use and other restrictions to land parcels in a municipality.

CHAPTER 2—LITERATURE REVIEW

I. Zoning: the Good, the Bad, and the Ugly

Municipalities in the United States use various mechanisms to regulate land use. These include but are not limited to zoning, comprehensive plans, masterplans, and other various safety valves introduced to guard against the rigidity of zoning. As a land use regulatory tool, zoning has long been used for the preservation of communities, notably in the landmark case of *Village of Euclid, Ohio v. Ambler Realty* (Sussna, 1961; Shlay and Rossi, 1981). The municipality of Euclid, Ohio established zones that managed the growth and limited land-usage to designated zones— resulting in the prevention of commercial development in an area zoned for residential use (*Village of Euclid, Ohio v. Ambler Realty*, 1926). The first comprehensive zoning ordinance, City of New York Zoning Ordinance of 1916, helped preserve community identity and health by alleviating hazardous proximity of heavy industry to residences, increasing natural light by limiting building height and bulk, and ensuring public open space. The resolution reads in Article II Section 3:

> In a residence district no other building shall be erected other than a building with its usual accessories, arranged, intended or designed exclusively for one or more of the following specified uses: (1) Dwellings… (2) Clubs… (3) Churches. (4) Schools, libraries, or public museums. (5) Philanthropic or eleemosynary uses or institutions, other than correctional institutions. (6) Hospitals and sanitariums. (7) Railroad passenger stations. (8) Farming… (City Planning Commission, 1916, 6-7)

In the case of *Dolan v. Tigard* (1994), the city of Tigard conditionally approved a private land owner's plan to expand her store and pave a new parking lot upon the condition of constructing a public greenway and pedestrian and bike pathway on said property. This is an example of zoning being used to counteract a constitutional right to just compensation from the exercise of eminent domain. The city of Tigard placed undue and unrelated requirements of compliance to the proposed development. As stated in *Algins v. Tiburon* (1980), a land use regulation does not qualify as a taking if it "substantially advance[s] legitimate state interests" and does not "den[y] an owner economically viable use of his land." Chief Justice William Rehnquist rejects city of Tigard's argument, writing in the majority opinion:

> under the well settled doctrine of 'unconstitutional conditions,' the government may not require a person to give up a constitutional right—here the right to receive just compensation when property is taken for a public use—in exchange for a discretionary benefit conferred by the government where the property sought has little or no relationship to the benefit. (*Dolan v. City of Tigard*, 1994)

The Court found that the city of Tigard could establish a legitimate claim to require compliance when the proposed development impedes upon the public good by increasing impervious surface- therefore more runoff into the city's drainage system- and also that the pedestrian and bike pathway would alleviate increased traffic due to the expanded development. However, the city could not justify why the greenway required by the city must be a public use. The city overstepped its regulatory power, Dolan was sustained, and a check on the power of land use regulation was ensured by the Supreme Court of the United States.

There are also many cases of zoning used as a tool for environmental racism and social and spatial exclusion. An unfortunate and often cited example of environmental racism facilitated by zoning includes the case of Warren County, North Carolina. The placement of a hazardous waste facility was proposed to be located near a predominantly poor, African-American community despite major concerns over groundwater contamination from leachate (McGurty, 1997). The City of Louisville, in the early 20th century, enacted a zoning ordinance under the auspices of

> prevent[ing] conflict and ill-feeling between the white and colored races in the city of Louisville, and to preserve the public peace and promote the general welfare, by making reasonable provisions requiring, as far as practicable, the use of separate blocks, for

> residence, places of abode, and places of assembly by white and colored people respectively (*Buchanan v. Warley*, 1917).

By legalizing the separation of whites and socially differentiated communities in the city of Louisville, zoning authorities were granted the power and mandate to socially and spatially exclude African Americans and other racial minorities. The US Supreme Court unanimously ruled against the ordinance in 1917. More recently, the Atlanta Zoning Plan of 1952 established zones with such designation as “R1- White district” and “R2- colored district” that were struck down as unconstitutional (Silver, 1997). Yet the city still enacted race-based planning that redistributed the African American community to the west and southwest; the effects of these practices are still evident today—west and southwest Atlanta are predominately populated by African Americans (Silver, 1997).

Unintended negative consequences of zoning are substantially documented. Fernandez and Rogerson (1997) examine the effects of zoning in the disparity of spending per student in public education systems. “Zoning affects outcomes through…the allocation of individuals across communities, thereby affecting each community’s distribution of income… [,] the tax base available to that community… [, and] the property tax chosen, via majority vote, within a community” (Fernandez and Rogerson, 1997, 32). Fischel (1978) finds that zoning reallocates private property rights into collective community zoning laws which “causes land subject to zoning to be perceived as having a lower opportunity cost than under fully assigned rights. This in turn causes too little development in zoned communities, higher prices for new housing in the metropolitan area, and lower average values of suburban areas” (79). Pogodzinski and Sass (1990) explicate the effects of zoning in six categories: supply-side effects, demand-side effects, Tiebout effects, externality effects, endogenous zoning, and rent-seeking behavior.

II. Zoning and Spatial Equity

The concept of “equity” may be defined in various ways. Lucy (1981) offers five differing definitions of equity: equality, need-based, demand-based, preference-based, and willingness to pay. Equality implies that everyone receives the same service. Within the context of this study, an equal distribution of accessibility measurements to grocery stores and liquor stores is the null hypothesis—all peoples should have similar access. Need-based equity assumes that those who need more of a service should get more, rather than less; conversely, those who need less of a service should get less (Lucy, 1981; Johnston et al., 2000). Demand, preference-based, and willingness to pay equity concepts are similar to need-based in the pretext that services should be distributed as demanded or preferred by the populous or those who have more money to pay for a service, such as a grocery store. These concepts are not applicable to this study as demand, preference, and willingness to pay for items in grocery or liquor stores in general (not differentiated by quality of produce or perceived brand name prestige) are presumably equal. Subjective selection of criteria defining an equitable distribution of services being studied is inherent as Lucy (1981) cautions that “neither equity nor inequity can be analyzed objectively” (452). Johnston et al. (2000) discuss equity in a similar fashion—“Equity may be manifest in equality, but the two are not necessarily synonymous” (229). Conversely, since this study examines distribution of services that have equal need, that should not justify unequal treatment (or allocation of services). Johnston et al. (2000) alludes to the potential shortcomings of relying on the private sector to equitably supply public provisions: “Although the boundary between public and private sector provision has varied historically, in general services are provided collectively because reliance solely on the market or the non-profit sector would be inefficient or impossible” (657).

Talen and Anselin (1998), Nicholls (2001), Witten et al. (2003), Pearce, Witten, and Bartie (2006), Comer and Skrasstad-Jurney (2008), and Comber, Brunsdon, and Radburn (2011) use a GIS environment to examine differential access to urban amenities. Witten et al. (2003), Pearce, Witten, and Bartie (2006), and Comber, Brunsdon, and Radburn (2011) measure the distance from census units to health and recreational related facilities and find variations in access to general health practitioners, food establishments, and daycare centers. Witten et al. (2003) and Pearce, Witten, and Bartie (2006) find regional disparities of access but neglect to investigate potential variations among socio-economic groups. Talen and Anselin (1998), Nicholls (2001), Comer and Skrasstad-Jurney (2008) investigate the spatial equity of access to public parks. Talen and Anselin (1998) and Comer and Skrasstad-Jurney (2008) subscribe to the need-based definition of equity described by Lucy (1981) by identifying segments of society that they identify as ‘high-need’ groups including minorities and low income persons. Analyzing the results of their respective studies with the *a priori* declination introduces some subjectivity to the research which is accepted by the respective authors.

> Since all…block groups have three accessibility scores as well as abundant socio-economic data…, we can determine whether block groups with low incomes, high densities, and high percentages of minorities have correspondingly high access scores, which would provide some evidence of equity. If instead the correlations show high access for high income or heavily white areas then we will have uncovered patterns of inequity. (Comer and Skrasstad-Jurney, 2008, 135)

Talen and Anselin (1998), Sheppard, Leitner, McMaster, and Tian (1999), Comer and Skrasstad-Jurney (2008) and Shannon (2016) discuss methodological issues concerning the use of GIS to measure spatial equity of access. Sheppard, Leitner, McMaster, and Tian (1999) state

> Findings range from strong associations…to those observing no associations… [;] very different results are at least in part a consequence of differences in data used and measures of potential exposure, applied to different kinds of places, at different geographic scales, with data of different levels of spatial resolution. (19)

Talen and Anselin (1998) and Comer and Skrasstad-Jurney (2008) additionally demonstrate the propensity of different distance-based measurements (container approach, minimum distance, travel cost, and gravity potential) to yield a wide range of results. Noted by the analyses conducted by Talen and Anselin (1998) and according to Comer and Skrasstad-Jurney, "the minimum distance and the gravity potential measures revealed distinct clusters of high-access block groups, while the travel cost metric indicated a 'bull's-eye' of higher access centered on the downtown" (143). Shannon (2016) points out that "in treating food access as a distributional problem, much food desert work ignores racial and economic landscapes that shape everyday mobility" (199).

III. GIS and Accessibility

Accessibility is defined in varying terms; however, differing definitions largely attribute distance as a significant factor in determining access to one location from another location (Knox, 1978; Talen and Anselin, 1998; Comer and Skrasstad-Jurney (2008); Comber, Brunsdon, and Radburn, 2011). However, Pasaoguillairi and Doratli (2004) and Comer (2008) go beyond mere distance based measures and incorporate social-based variables to define accessibility. Following Tobler's first law of geography, "everything is related to everything else, but near things are more related than distant things": the smaller the distance between two points, the more accessible are two points to each other; conversely, the greater the distance between two points, the less accessible are the two points to each other (Tobler, 1970, 236).

McLafferty (1978) summarizes and Talen and Anselin (1998); Witten et al. (2003); Pasaoguillairi and Doratli (2004); and Comer and Skrasstad-Jurney (2008) find that access to public services is generally not underserved to minority groups and in some cases, these socially differentiated groups experience greater access to amenities than other communities. Contrarily, Weiss et al. (2011) bolster environmental justice claims that greater disamenities are located in low income areas with lesser access to positive amenities.

Comer and Skrasstad-Jurney (2008) build upon Talen and Anselin (1998) measuring access in three differing distance based functions: minimum distance, travel cost, and gravity potential. Both conclude that each approach to measuring accessibility can produce varying results which impugns the selection of appropriate access measurements in similar studies. Comer and Skrasstad-Jurney (2008) establish a strong methodology for measuring access using spatial analysis by utilizing publicly available demographic data from the US Census Bureau, clearly defining socioeconomic subgroups, and leveraging the Hot Spot Analysis module and other tools within an ESRI ArcGIS environment for analysis and visualization.

IV. Correlation Studies in GIS

i. Correlation

A key component of this research is to investigate possible correlations between access to amenities and the extent of land use regulation. This is accomplished with a simple correlation test—producing a coefficient that measures the linear association between two variables with values between -1 and +1. Contemporary literature suggests that a correlation coefficient of +1 indicates that two variables always occur together, a correlation coefficient of -1 indicates that two variables never occur together, and a correlation coefficient of 0 indicates that two variables are independent of each other (Encyclopedia Britannica).

ii. Global Moran’s I

Ample literature exists bolstering results of simple correlation measures with the Global Moran’s I test for spatial autocorrelation (Talen and Anselin, 1998; Kitron et al., 1996; Comer and Skrasstad-Jurney, 2008). Tests for global spatial autocorrelation using the Global Moran's I statistic indicate whether the assumption of spatial independence is violated in the data. If statistically significant and positive, the data are spatially correlated; if negative, the data are evenly dispersed. This provides additional insight into spatial patterning that may exist. Talen and Anselin (1998) and Comer and Skrasstad-Jurney (2008) incorporate a Global Moran's I test to test for spatial patterning of access in their respective studies. Essentially, the formula for calculating a Moran's I statistic equals the number of regions multiplied by a measure of spatial proximity between two regions and the deviation for the mean for all pairs of adjacent regions divided by the variance of the observed value for a region and the mean value. The open source statistical software, R, and a spatial autocorrelation tool within ArcGIS software are both capable of calculating a Moran's I statistic.

Moran's I formula:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2},$$

iii. Local Indicators of Spatial Autocorrelation (LISA)

Accessibility scores and mean distances to each amenity (gravity model and distance-driven measurements, respectively) can be formally analyzed for local spatial autocorrelation within a GIS environment utilizing a cluster analysis tool which executes a Local Indicator of Spatial Autocorrelation (LISA) statistical test. Results of this test include z-scores which indicate the standardized spatial autocorrelation measure of a block group's accessibility score or mean distance measurement in relation to its neighbors' scores: a z-score greater than 1.96 reveals significant positive correlation (a "high-high" cluster of high accessibility scores) whereas a z-score less than -1.96 reveals significant negative correlation (a "low-low" of low accessibility scores) at a 95% confidence level. The results of this analysis reveal statistically significant clusters of high and low access areas as measured through the accessibility models. Local spatial autocorrelation reveal patterns of clusters and outliers in the data. As noted by Talen and Anselin (1998), a LISA achieves two objectives: 1. Detects significant patterns of hot spots and outliers 2. Indicates whether the global Moran's I statistic is reflected uniformly throughout the dataset.

Local Moran's I formula: $I = \frac{z_i}{m_2} \sum_j w_{ij} z_j$, with $m2 = \sum_i zi2$

Although an abundance of literature exists concerning GIS and spatial equity and access to services, studies often examine access to a limited type of amenity—mainly public parks or health facilities. This underserves the need to examine access to other necessary services provided by the private sector but regulated by public land use regulatory tools such as zoning. Previous studies of spatial equity correlate distance-based measurements of access to amenities and socioeconomic variables without regard to the systematic and structural separation of land uses and peoples sanctioned and implemented by governmental agencies with a documented history of *de jure* and *de facto* segregation. This study approaches the research with this *a priori* knowledge- anticipating patterns of inequity in American cities. This is a fundamental gap in research concerning the impact of land use regulation on spatial equity in American cities.

CHAPTER 3—RESEARCH QUESTIONS AND METHODS

Two main research questions form the core of this research:

1. Is there a correlation between land use regulation and distance to amenities in US cities?
2. Is there a spatial relationship between localized patterns of access and socially differentiated communities in US cities?

To answer these questions, geospatial data is obtained from various sources, prepared, assembled, and analyzed using Global Moran's I, Local Moran's I, and correlation tests within a GIS and statistical software.

I. Data Preparation

The research questions proposed by this study are answered within a geographic information system (GIS) and with statistical analysis software. ESRI ArcGIS and R statistical software are utilized. Data for block group geographic boundaries, grocery store and liquor store locations, and socioeconomic variables are extracted from ESRI's Business Analyst 2015 dataset. Block group level data is appropriate for this study as it is the least aggregate geographic unit available that is supplemented with socioeconomic variables used in analysis: population counts of African American, Hispanic, Asian American, and whites, respectively; and population density.

The scale of this study spans the 47 metropolitan areas with ten or more observations from the Wharton Residential Land Use Regulation Index (WRLURI) with reported index values (Gyourko, Saiz, and Summers, 2007). The scores reported from this index comprise of eleven subindexes: Local Political Pressure, State Political Involvement, State Court Involvement, Local Zoning Approval, Local Project Approval, Local Assembly, Supply Restrictions, Density

Restrictions, Open Space, Exactions, and Approval Delay indexes. Gyourko et al. (2007) find positive correlations among 75% of the subindixes and use a factor analysis to create the overall Wharton Residential Land Use Regulation Index. The index is designed to “rank localities in terms of the degree or strictness of the land use regulatory environment” (Gyourko et al., 2007, 23) and finds that “highly regulated places tend to be so almost across the board” in terms of the subindex scores (26).

(See figure on next page for map of 47 metropolitan areas with Wharton Residential Land Use Regulation Index scores.)

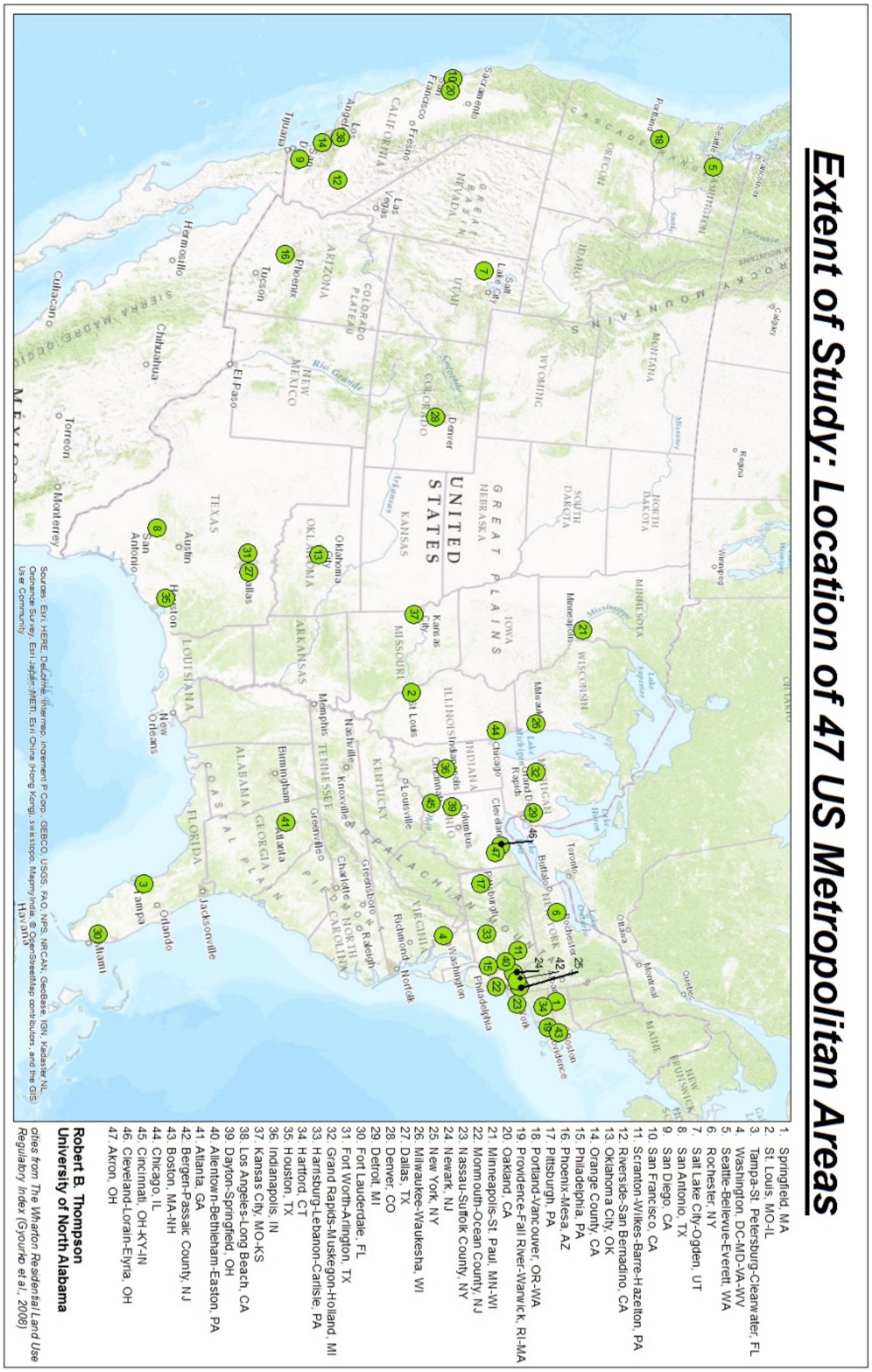


Figure 1: Map indicating the 47 metropolitan areas used in this study

Using a GIS and robust spatial data enables the direct measurement of distance from block group geographic units to point locations of the defined destinations (grocery stores and liquor stores). This is accomplished within an ESRI ArcGIS environment by isolating the desired destination points using the appropriate NAICS codes as a selection method. Population-weighted block group centroids are utilized to establish origin points for distance measurements.

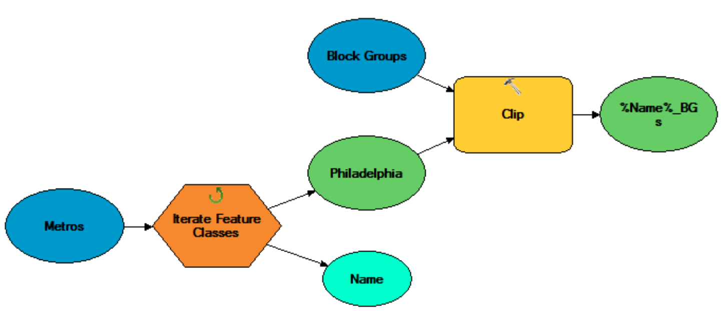
Extracting an accessibility score is accomplished by leveraging the tools within a GIS environment to measure the distance from a block group's centroid to the point location of an amenity. Distance as a proxy measure of access is not without some methodological flaws; some studies demonstrate that perceived access and distance-driven access measurements are not congruent (Comber, Brundston, and Radburn, 2011). However, other studies have proven distance-based accessibility measures to be an effective examination of access in an objective research environment such as this study (Talen and Anselin, 1998; Witten, Exeter, and Field, 2003; Comer and Skrasstad-Jurney, 2008; Comber, Brunsdon, and Radburn, 2011). There are several approaches for measuring distance-based access—container, minimum distance, travel cost, and gravity model. The container approach determines that one place has access to another place if they are within a specified radius of each other or within the same geographic boundary. Minimum distance only measures the distance to the nearest node location from an origin point, whereas all other locations are unmeasured. Travel cost measures "the total or average distance between each origin…and all destinations" (Talen and Anselin, 1998, 600). The gravity model divides the total number of destinations by a distance decay variable (the distance from the origin point to a destination raised to the power of a friction parameter), iterated for each destination point, and summed. Distances to all locations are theoretically accessible in the gravity model, although the distance decay variable ensures that destinations nearer to the origin point have a higher accessibility score than those less near. For this study, the gravity model is most appropriate. A gravity model identifies all locations as potentially accessible, with the nearest locations having more weight than those locations that are more distant. The results may also be interpreted as an indicator of spatial autocorrelation. If the accessibility score is extremely high or low, a given origin point must be very near to or far away from destination points, respectively.

Gravity model: $Z_i^G = \sum_j \frac{S_j}{d^{\alpha}_{ij}}$

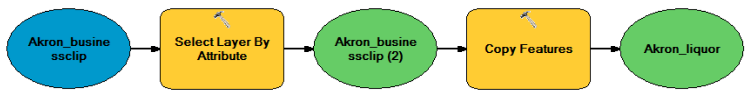
where, S_j represents number of facilities available for location j and d^{α}_{ij} representing the distance decay variable (d_{ij} is the distance between location i and location j, and α is the friction parameter, often arbitrarily set as 2).

II. Access score

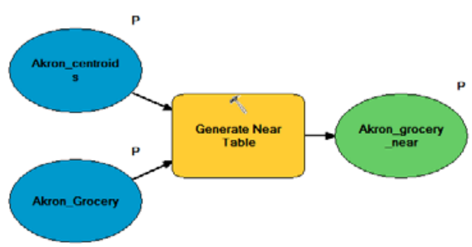
Two different models of accessibility are implemented: distance-driven and modified gravity model. The modified gravity model of accessibility uses distance as one variable and complemented by number of available amenities multiplied by the sales volume of the store in question. Deriving the distances to amenities and generating values representing the amount of access to grocery stores and liquor stores from census block groups is calculated in ESRI's ArcMap software and entered into the two accessibility models. First, metropolitan boundaries are extracted from ESRI's Business Analyst dataset to clip block groups to new feature classes. The following model was created in ArcGIS ModelBuilder to automate the clipping function:

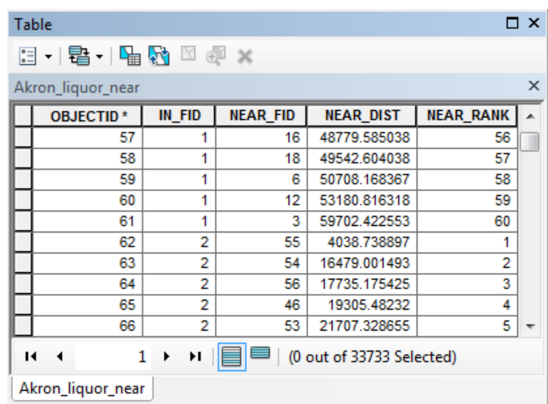


Using a similar model as the one above to clip business points to respective metropolitan extents, grocery stores (NAICS code 445110) and liquor stores (NAICS code 445310) were then selected and copied to new respective feature classes in the following model:



The "Generate Near Table" tool in ArcGIS software prints distance measurements from input features (population-weighted block group centroid points from the US Census Bureau) to near features (grocery store and liquor store points, respectively) to a standalone table. (See both model and table with sample distance data below.)





Table

Akron_liquor_near

OBJECTID *	IN_FID	NEAR_FID	NEAR_DIST	NEAR_RANK
57	1	16	48779.585038	56
58	1	18	49542.604038	57
59	1	6	50708.168367	58
60	1	12	53180.816318	59
61	1	3	59702.422553	60
62	2	55	4038.738897	1
63	2	54	16479.001493	2
64	2	56	17735.175425	3
65	2	46	19305.48232	4
66	2	53	21707.328655	5

1 (0 out of 33733 Selected)

Akron_liquor_near

The distances for each metropolitan area generated by the previous model provide the basis for examining distance-driven accessibility as well as a key variable in a modified gravity accessibility model:

$$Z_i^G = \sum_j \frac{V_i S_j}{d^{\alpha}_{ij}}$$

where, S_j represents number of facilities available for location j, V_i is the sales volume of the facility location, and d^{α}_{ij} representing the distance decay variable (d_{ij} is the distance between location i and location j, and α is the friction parameter, sometimes arbitrarily set as 2, in this model it is 1).

Access scores identified by the modified gravity approach examines a wider scope of variables affecting accessibility than a distance-based approach. Distance to amenities is still a strong influencer, but sales volume and number of stores available are additional factors affecting accessibility.

III. Correlation

Determining a possible correlation between access in US cities and land use regulation is possible by utilizing the access scores generated in the ArcGIS environment and with the open source statistical software. R. As each block group is attributed an access score, an overall score for metropolitan areas is needed to analyze correlation of access scores to values from the Wharton Residential Land Use Regulation Index. This is to be done by finding the mean value of each block group's access score.

IV. Spatial Patterns

Global Moran's I is an indicator of spatial autocorrelation. Using the Global Moran's I test, distance measurements and access scores of each city will be tested for spatial autocorrelation. The results will reveal whether clustering, dispersion, or randomness of distance to amenities or of access scores exist in the selected US cities.

The Cluster and Outlier Analysis (Anselin Local Moran's I) tool in ArcGIS indicates localized patterns in a dataset otherwise not revealed by the Global Moran's I test. The results of this tool identify statistically significant hot and cold spots as well as outliers. Examining the socioeconomic characteristics of the high and low access clusters and conducting a difference of means test will reveal possible spatial relationships between localized patterns of access and socially differentiated communities.

Spatial equity of access in US cities is important to consider. Therefore, clusters of high and low access are summarized based on population density, white population counts, black population counts, Asian population counts, and Hispanic population counts. Two-tailed difference of means t-tests highlight any statistically significant differential access of socially differentiated communities.

CHAPTER 4—ANALYSIS AND RESULTS

This research investigates the correlation between land use regulation and distance to amenities in US cities and the spatial relationship between localized patterns of access and socially differentiated communities in US cities.

The result of the correlation test between distances to grocery stores and Wharton Residential Land Use Regulation Index scores indicates a correlation measure of -0.26 with a p-value of 0.072. The correlation between distances to liquor stores and Wharton Residential Land Use Regulation Index scores is -0.04 with a p-value of 0.780. Neither analysis of the distance-driven accessibility model reveal statistically significant results at a 95% confidence level, although the correlation between distances to grocery stores is significantly correlated at a 90% confidence level to Wharton Residential Land Use Regulation Index scores.

The correlation between access scores to grocery stores (generated from the modified gravity accessibility model) and Wharton Residential Land Use Regulation Index scores is valued at 0.26 with a p-value of 0.075. The result of the correlation test between access scores to liquor stores and Wharton Residential Land Use Regulation Index scores indicates a correlation measure of 0.29 with a p-value of 0.049. Both access scores to grocery and liquor stores are correlated to the Wharton Index scores at a confidence level of 90%, and the correlation of access to liquor stores to the Wharton Index scores is significant at a 95% confidence level.

One premise of this research is to investigate the correlation between access to amenities and land use regulation in United States. Both the distance-driven and modified gravity models of accessibility yield weak correlation measures between access and extent of land use regulation. Using distance as the only measure of access, the correlation is negative—distance to amenities decreases as land use regulation scores increase. Incorporating sales volume and number of amenity locations available into the accessibility measure reverses the trend positively—access scores (derived from the modified gravity model) increase as land use regulation scores increase. These measures are two sides of the same coin however; both suggest that a higher land use regulation score is related to higher access. There is a stronger, positive correlation between population density and land use regulation index scores. Although these statistical tests indicate that a relationship exists between land use regulation (values from the Wharton Residential Land Use Regulation Index) and access (both from distance-driven and modified gravity models), land use regulation cannot be considered causation of access in US cities.

The following figures illustrate the correlation of accessibility measures from both distance-driven and modified gravity models to Wharton Residential Land Use Regulation Index scores:

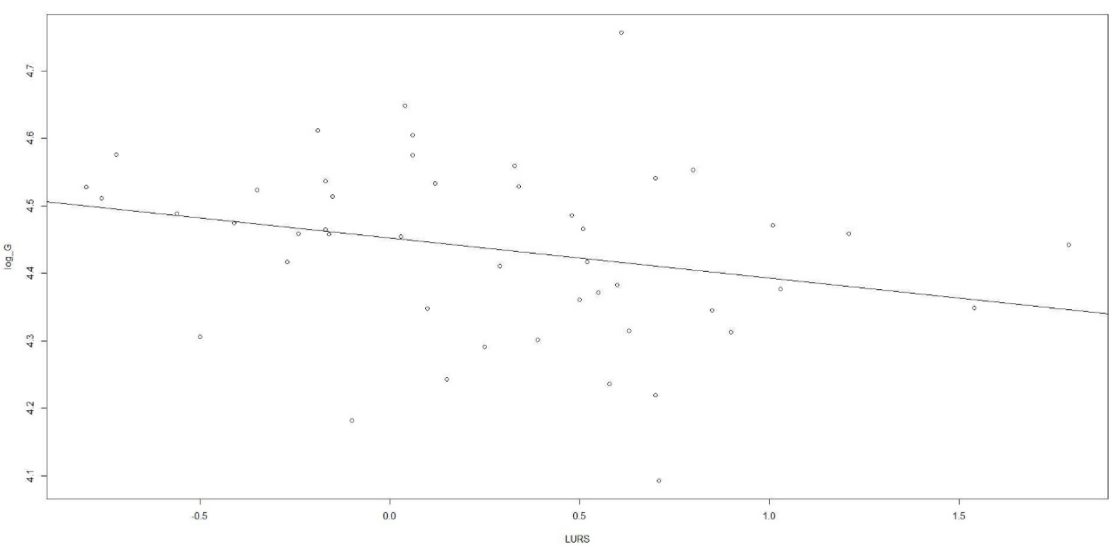


Figure 2: Log10 distance to grocery stores as a function of Wharton Residential Land Use Regulation Index value (correlation measure: -0.26; p-value: 0.072*)

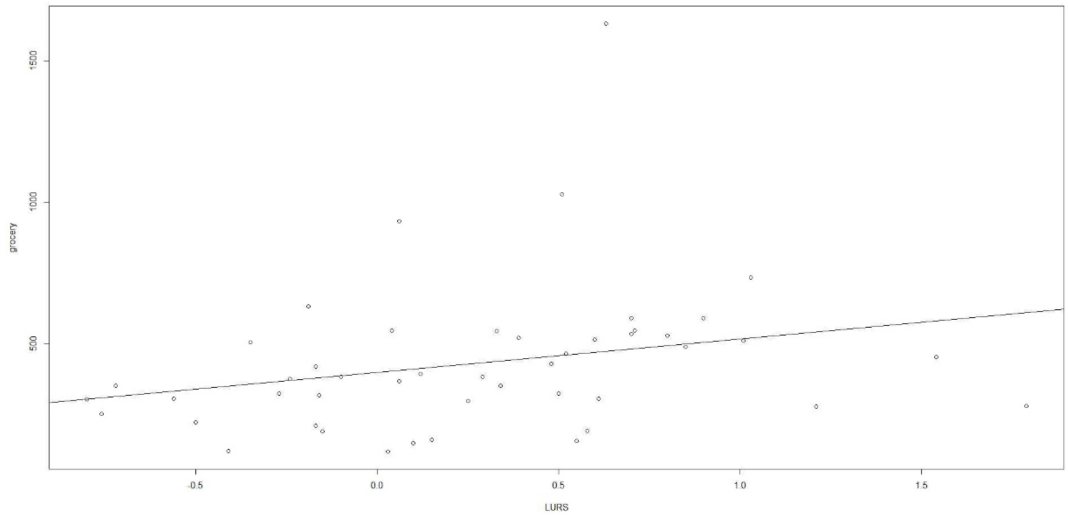


Figure 3: Grocery store access scores from modified gravity model as a function of Wharton Residential Land Use Regulation Index value (correlation measure: 0.26; p-value: 0.075*)

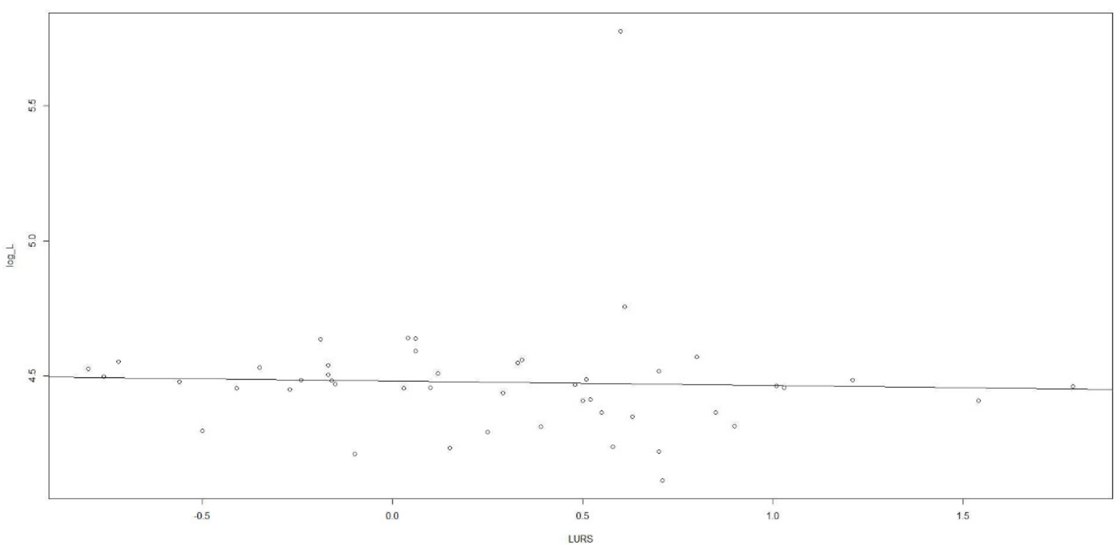


Figure 4: Log10 distance to liquor stores as a function of Wharton Residential Land Use Regulation Index value (correlation measure: -0.04; p-value: 0.780)

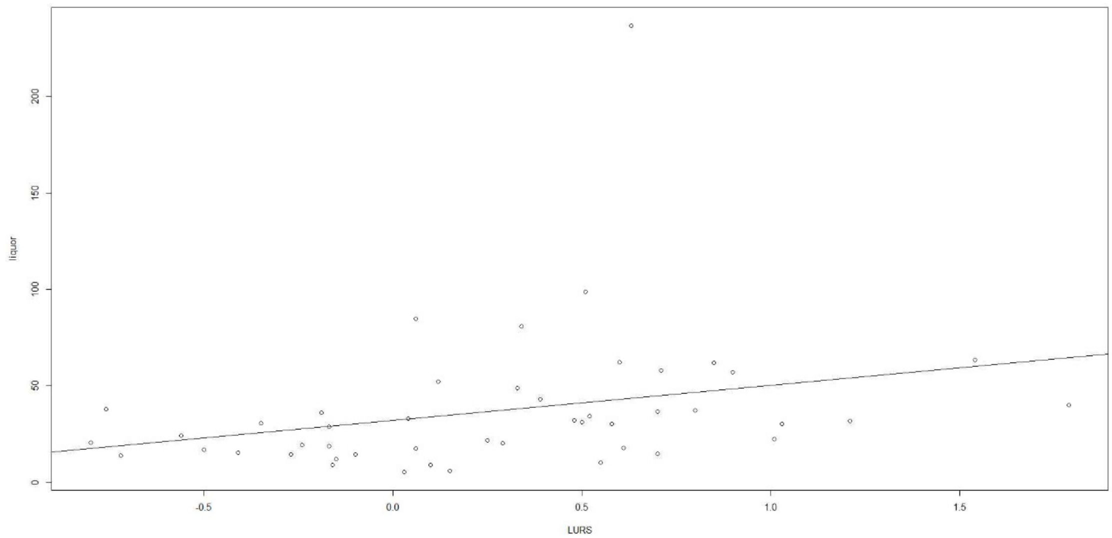


Figure 5: Liquor store access scores from modified gravity model as a function of Wharton Residential Land Use Regulation Index value (correlation measure: 0.29; p-value: 0.049**)

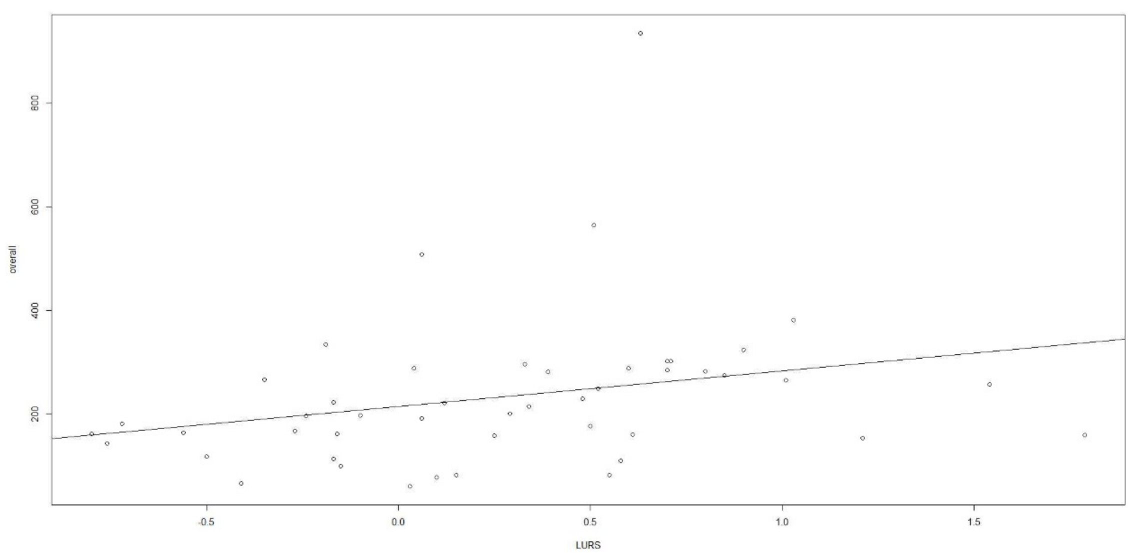


Figure 6: Overall access score from modified gravity model as a function of Wharton Residential Land Use Regulation Index value (correlation measure: 0.27; p-value: 0.067*)

Table 1

Mean distance to grocery and liquor stores, derived access scores, and Wharton Residential Land Use Regulation Index study scores (Gyourko et al., 2007)

		Mean Dist. to Amenities	***Access Score***	***WLURS***
1.	Akron	17308.73	82.35	0.15
2.	Allentown	25404.24	77.65	0.10
3.	Atlanta	44025.30	288.44	0.04
4.	Bergen	12660.45	301.70	0.71
5.	Boston	23993.34	257.74	1.54
6.	Chicago	41843.77	508.19	0.06
7.	Cincinnati	30399.56	163.78	-0.56
8.	Cleveland	29516.56	162.09	-0.16
9.	Dallas	33666.92	267.01	-0.35
10.	Dayton	20020.79	118.34	-0.50
11.	Denver	22665.77	274.59	0.85
12.	Detroit	33199.29	221.66	0.12
13.	Fort Lauderdale	16575.30	284.53	0.70
14.	Fort Worth	27117.27	167.94	-0.27
15.	Grand Rapids	31073.85	99.97	-0.15
16.	Harrisburg	23318.94	82.58	0.55
17.	Hartford	24270.30	176.52	0.50
18.	Houston	42031.27	333.73	-0.19
19.	Indianapolis	31925.62	143.99	-0.76
20.	Kansas City	33680.43	161.50	-0.80
21.	Los Angeles	29972.52	563.45	0.51
22.	Milwaukee	19563.19	158.41	0.25
23.	Minneapolis	35049.49	215.13	0.34

	Mean Dist. to Amenities	*Access Score*	*WLURS*
24. Monmouth	29667.36	153.43	1.21
25. Nassau	36462.55	282.02	0.80
26. Newark	311780.42	287.90	0.60
27. New York	21501.12	934.35	0.63
28. Oakland	26004.43	249.13	0.52
29. Oklahoma City	29108.98	66.67	-0.41
30. Orange	20271.29	281.46	0.39
31. Philadelphia	26175.73	381.38	1.03
32. Phoenix	33865.46	301.64	0.70
33. Pittsburgh	38314.03	191.62	0.06
34. Portland	26532.77	200.72	0.29
35. Providence	28289.44	159.18	1.79
36. Riverside	57048.52	160.54	0.61
37. Rochester	30598.43	113.53	-0.17
38. Salt Lake City	15704.35	197.68	-0.10
39. San Antonio	29695.47	196.12	-0.24
40. San Diego	29971.25	229.87	0.48
41. San Francisco	20559.14	323.43	0.90
42. Scranton	28431.73	60.66	0.03
43. Seattle	29296.05	265.69	1.01
44. Springfield	17245.47	109.98	0.58
45. St Louis	36654.85	181.74	-0.72
46. Tampa	34538.07	223.23	-0.17
47. Washington DC	35822.48	296.11	0.33

Correlation between population density and Wharton Residential Land Use Regulation Index scores is 0.53 with a p-value of 0.000.

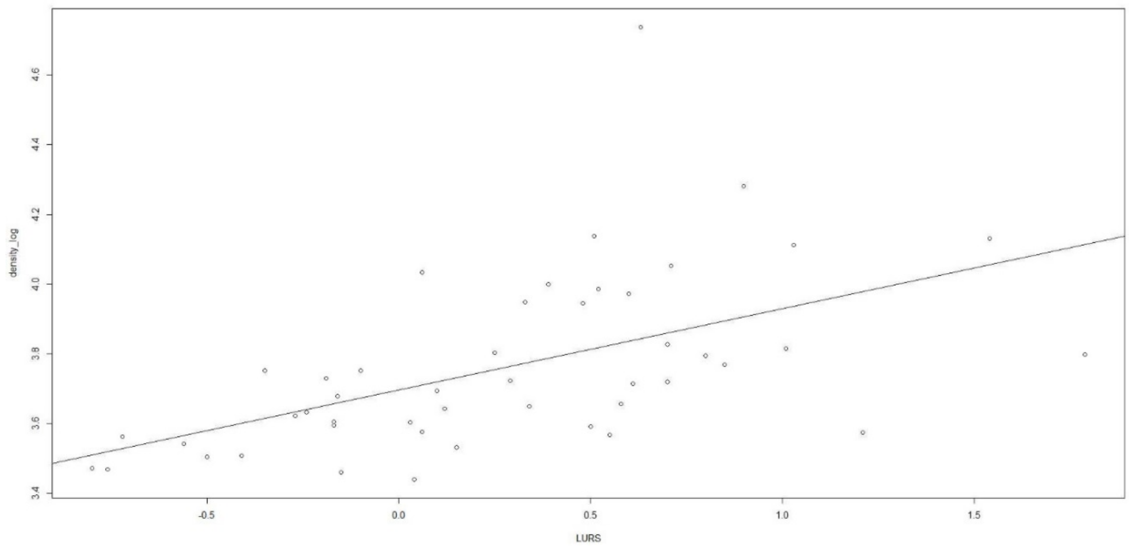


Figure 7: Log10 population density as a function of Wharton Residential Land Use Regulation Index value (correlation measure: 0.53; p-value of 0.000**)

In the modified gravity accessibility model, there is a significant difference of means between the global average of population density in the high-high (90% confidence level) and low-low clusters (95% confidence level) of access scores to both grocery and liquor stores, respectively. There is a significant difference of means of white population counts from the global average in the high-high and low-low clusters of access scores to both grocery and liquor stores (significant at a 95% confidence level). There is also a significant difference of means of black population counts from the global average in the low-low clusters of access scores to grocery stores (significant at a 95% confidence level) and in the low-low and high-high clusters of access scores to liquor stores (significant at a 95% confidence level).

Another foundation of this study is to investigate the spatial relationship between localized patterns of access and socially differentiated communities. Strong positive spatial autocorrelation of access variables is significant at a 99.99% confidence level in both models of accessibility suggesting a global clustering of high and low access places. On a localized scale, clusters of high and low access to grocery and liquor stores are associated with significantly differing white population counts than the average with both accessibility models. High and low access to liquor stores as well as low access to grocery stores are associated with significantly differing black population counts in both distance-driven and modified gravity accessibility models. As noted by Talen and Anselin (1998), different measures of accessibility yield varied results.

In the distance-driven accessibility model, there is a significant difference of means between the global average of population density and the population density of the high-high clusters of distances to both grocery and liquor stores (at a 95% confidence level). There is a significant difference of means of white population counts from the global average in the high-high, low-low, and non-significant clusters of distance measures to both grocery and liquor stores (significant at a 95% confidence level in the high-high and low-low clusters, significant at a 90% confidence level in the non-significant clusters). There is a significant difference of means of black population counts from the global average in the high-high and low-low clusters of distances to both grocery and liquor stores (significant at a 95% confidence level). Asian population counts also differ significantly from the global mean in the high-high clusters of distances to both grocery and liquor stores (significant at a 95% confidence level).

Comparing the distance-driven accessibility model with the modified gravity model reveals interesting results. One important note is that in the distance-driven accessibility model, the high-high and low-low clusters correspond with distance measured to an amenity. Therefore, the low-low clusters in the distance-driven model are the block groups with greater access to amenities as they are the block groups nearer to amenities than high-high clusters. In the modified gravity model, high-high clusters identify block groups with greater access to amenities than low access (low-low clusters) block groups. There is a weak, negative correlation—significant at 90% confidence level— of mean distances to amenities and Wharton Residential Land Use Regulation Index values (correlation measure of -0.26; p-value: 0.072). There is a weak, positive correlation—significant at 90% confidence level—of access scores generated from the modified gravity model and Wharton Residential Land Use Regulation Index values (correlation measure of 0.27; p-value: 0.067). There is a stronger positive correlation of population density and Wharton Residential Land Use Regulation Index (correlation measure of 0.53; p-value of 0.000).

Table 2

47 cities from Wharton Residential Land Use Regulation Index study (Gyourko et al., 2007) and Global Moran's I value of spatial autocorrelation of grocery and liquor store access

	Moran's I (distance-driven) grocery/liquor	**Moran's I (modified gravity) grocery/liquor**
1. Akron	0.95**/0.96**	0.72**/0.69**
2. Allentown	0.98**/0.97**	0.60**/0.64**
3. Atlanta	0.98**/0.98**	0.92**/0.90**
4. Bergen	0.98**/0.98**	0.74**/0.82**
5. Boston	1.00**/0.99**	0.89**/0.88**
6. Chicago	0.99**/0.99**	0.93**/0.88**
7. Cincinnati	0.97**/0.97**	0.84**/0.76**
8. Cleveland	0.98**/0.98**	0.83**/0.71**
9. Dallas	0.98**/0.98**	0.87**/0.83**
10. Dayton	0.98**/0.97**	0.75**/0.71**
11. Denver	0.80**/0.80**	0.37**/0.36**
12. Detroit	0.99**/0.99**	0.82**/0.93**
13. Fort Lauderdale	0.76**/0.74**	0.71**/0.97**
14. Fort Worth	0.95**/0.94**	0.70**/0.73**
15. Grand Rapids	0.99**/0.99**	0.83**/0.72**
16. Harrisburg	0.98**/0.98**	0.47**/0.59**
17. Hartford	0.98**/0.98**	0.81**/0.88**
18. Houston	0.96**/0.96**	0.77**/0.65**
19. Indianapolis	0.98**/0.98**	0.87**/0.72**
20. Kansas City	0.97**/0.97**	0.81**/0.82**
21. Los Angeles	0.89**/0.89**	0.45**/0.40**
22. Milwaukee	0.98**/0.98**	0.82**/0.73**
23. Minneapolis	0.98**/0.98**	0.88**/0.84**

	Moran's I (distance-driven) grocery/liquor	*Moran's I (modified gravity) grocery/liquor*
24. Monmouth	0.99**/0.99**	0.68**/0.74**
25. Nassau	0.99**/0.99**	0.79**/0.89**
26. Newark	1.00**/0.99**	0.82**/0.77**
27. New York	0.99**/0.99**	0.94**/0.89**
28. Oakland	0.98**/0.98**	0.61**/0.87**
29. Oklahoma City	0.95**/0.95**	0.66**/0.69**
30. Orange	0.99**/0.99**	0.82**/0.76**
31. Philadelphia	0.99**/0.98**	0.86**/0.82**
32. Phoenix	0.89**/0.89**	0.43**/0.38**
33. Pittsburgh	0.98**/0.98**	0.89**/0.83**
34. Portland	0.89**/0.87**	0.56**/0.45**
35. Providence	0.99**/0.99**	0.81**/0.81**
36. Riverside	0.98**/0.98**	0.56**/0.56**
37. Rochester	1.00**/0.99**	0.74**/0.81**
38. Salt Lake City	0.69**/0.68**	0.28**/0.23**
39. San Antonio	0.93**/0.92**	0.67**/0.58**
40. San Diego	0.94**/0.95**	0.59**/0.65**
41. San Francisco	0.96**/0.96**	0.57**/0.69**
42. Scranton	0.96**/0.96**	0.64**/0.58**
43. Seattle	0.95**/0.95**	0.69**/0.64**
44. Springfield	0.91**/0.90**	0.59**/0.69**
45. St Louis	0.98**/0.98**	0.90**/0.86**
46. Tampa	0.98**/0.98**	0.85**/0.87**
47. Washington DC	0.99**/0.99**	0.90**/0.92**

Notes: ** p-value < 0.00

Table 3

Two-tailed t-test difference of means between global mean of demographic variables and demographic characteristics of cluster type in the distance-driven accessibility model

	Global Mean	HH cluster mean	p-value	LL cluster mean	p-value	NS cluster mean	p-value
Density (grocery)	7240.08	2419.73	0.000**	10108.10	0.149	6771.58	0.779
Density (liquor)	"	2390.07	0.000**	9888.98	0.202	6914.45	0.842
White (grocery)	1048.08	1332.11	0.000**	789.35	0.000**	1129.98	0.064*
White (liquor)	"	1328.92	0.000**	784.31	0.000**	1121.62	0.091*
Black (grocery)	184.09	81.01	0.000**	260.61	0.018**	169.48	0.622
Black (liquor)	"	84.61	0.000**	260.49	0.021**	172.04	0.682
Hispanic (grocery)	282.98	233.62	0.331	330.83	0.392	274.73	0.871
Hispanic (liquor)	"	232.90	0.327	330.02	0.396	276.09	0.892
Asian (grocery)	97.04	56.40	0.026**	93.40	0.852	112.41	0.430
Asian (liquor)	"	57.78	0.030**	89.86	0.711	113.19	0.412

Notes: HH: high-high cluster, LL: low-low cluster, NS: non-significant cluster,

*$p < 0.10$, ** $p < 0.05$

Table 4

Two-tailed t-test difference of means between global mean of demographic variables and demographic characteristics of cluster type in the modified gravity accessibility model

	Global Mean	HH cluster mean	p-value	LL cluster mean	p-value	NS cluster mean	p-value
Density (grocery)	7240.08	11239.46	0.064*	2786.27	0.001**	6383.51	0.608
Density (liquor)	“	11474.59	0.053*	3016.82	0.001**	6748.18	0.789
White (grocery)	1048.08	797.49	0.000**	1342.26	0.000**	1128.90	0.122
White (liquor)	“	763.08	0.000**	1341.46	0.000**	1096.70	0.281
Black (grocery)	184.09	230.79	0.101	113.68	0.014**	183.69	0.990
Black (liquor)	“	251.91	0.025**	110.80	0.015**	180.72	0.915
Hispanic (grocery)	282.98	325.55	0.421	235.47	0.350	270.00	0.801
Hispanic (liquor)	“	326.36	0.413	222.94	0.221	282.76	0.997
Asian (grocery)	97.04	93.93	0.865	71.18	0.160	121.93	0.256
Asian (liquor)	“	85.64	0.514	79.58	0.354	121.59	0.277

Notes: HH: high-high cluster, LL: low-low cluster, NS: non-significant cluster,

*$p < 0.10$, ** $p < 0.05$

The following maps depict the distribution of grocery and liquor stores as well as variation in access to these amenities as defined by the distance-driven and modified gravity accessibility models in Tampa-St. Petersburg, Florida. Note the prominent variation of access clusters among the two models.

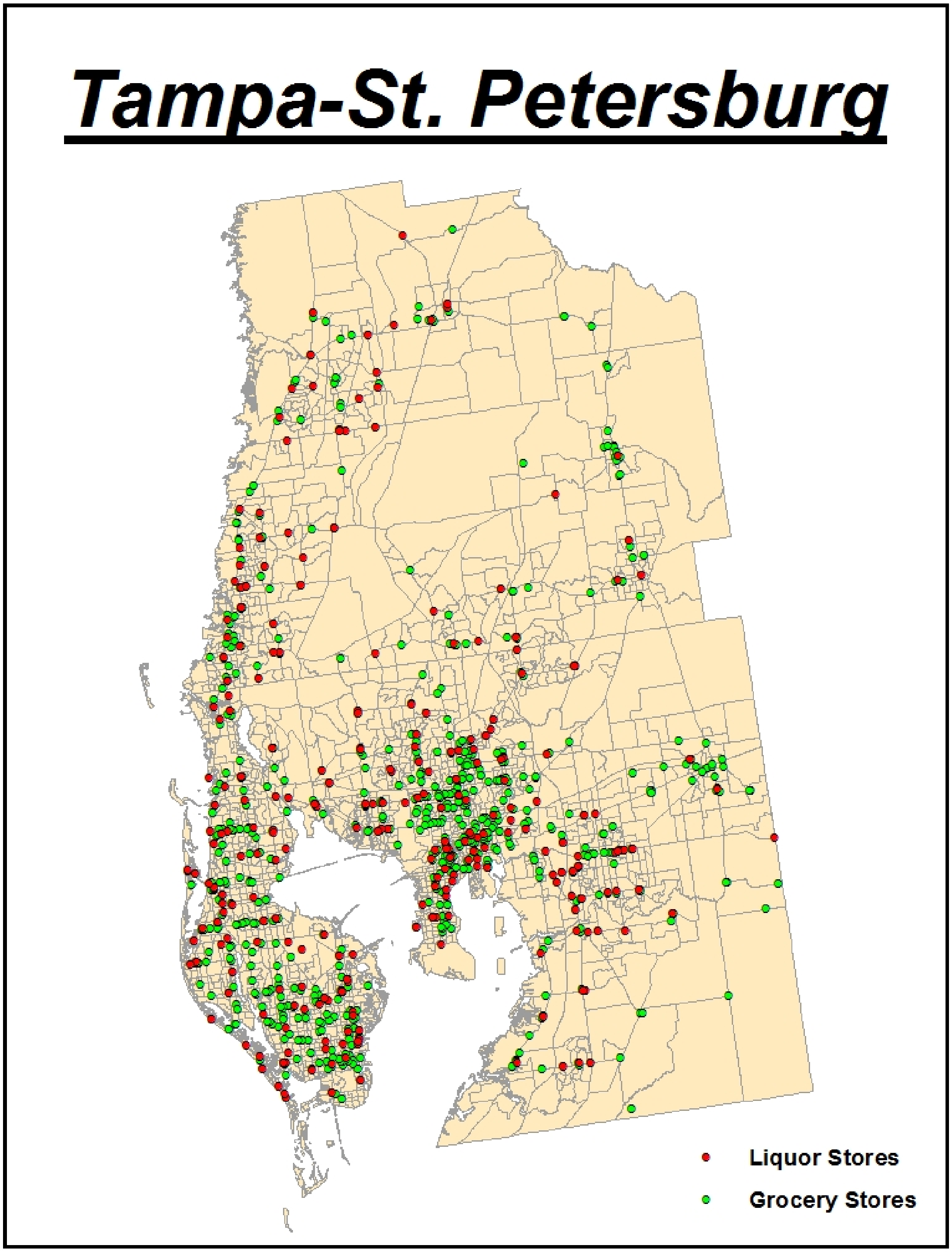


Figure 8: Grocery and liquor store point locations in Tampa-St. Petersburg

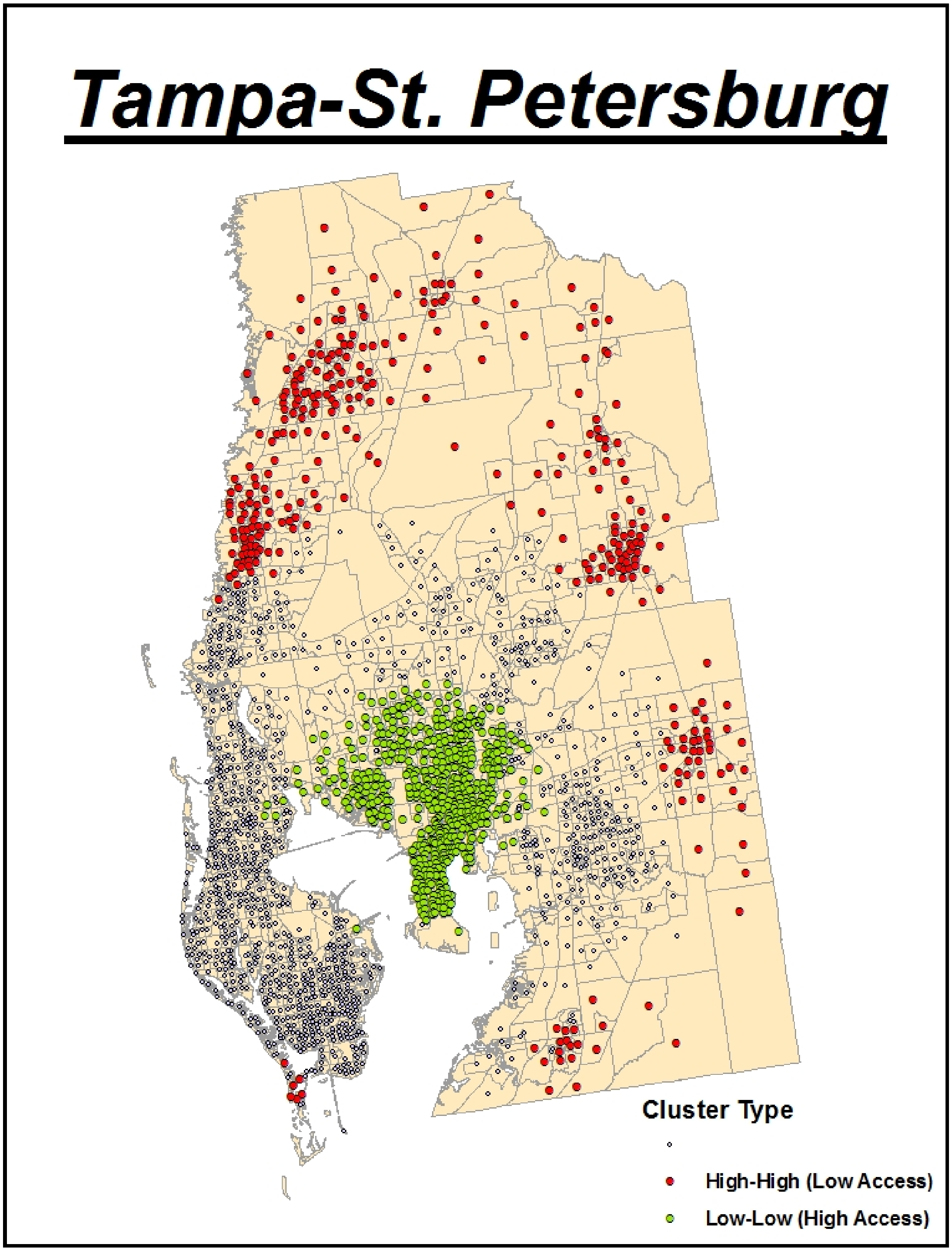


Figure 9: Distance-driven model of access to grocery stores in Tampa-St. Petersburg

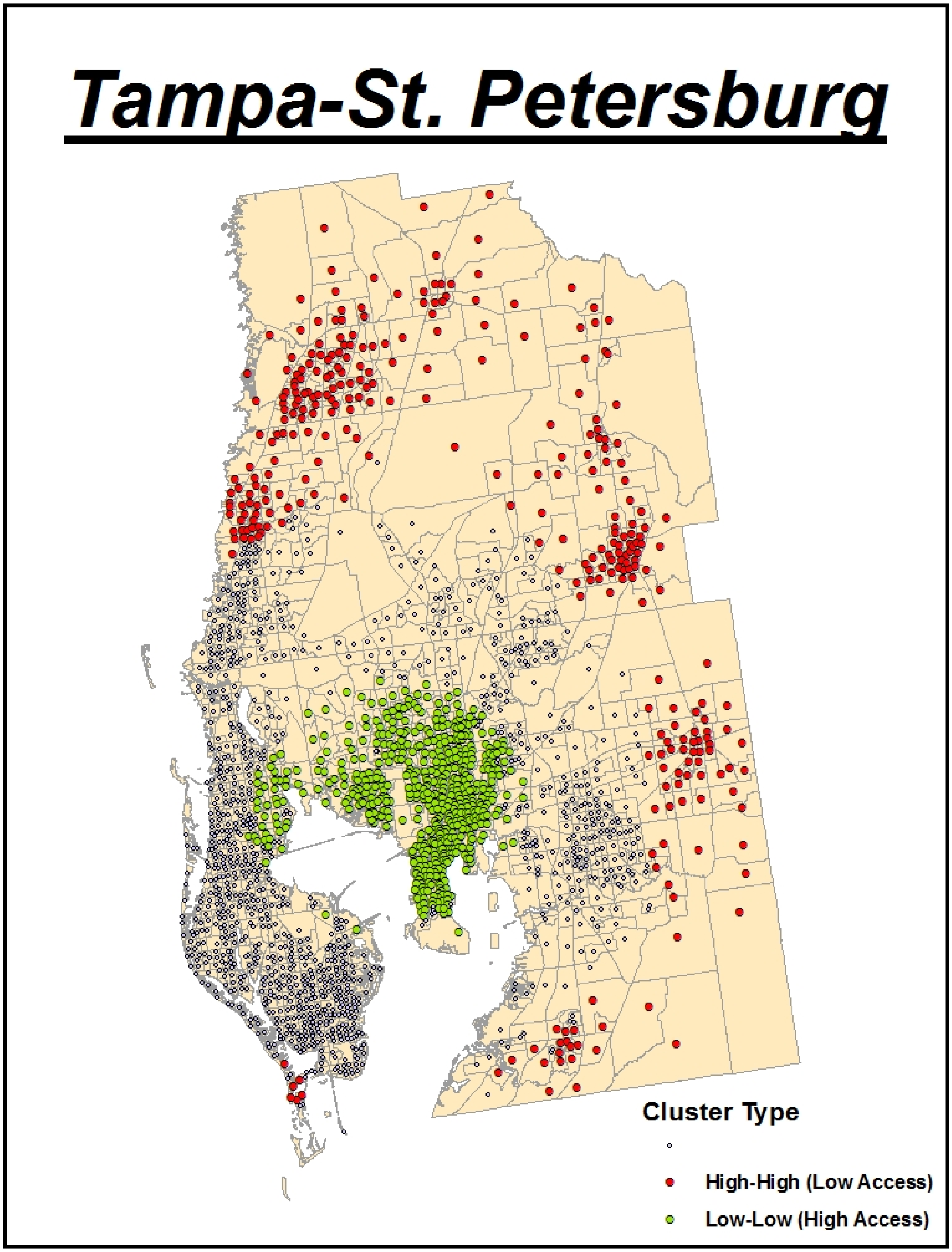


Figure 10: Distance-driven model of access to liquor stores in Tampa-St. Petersburg

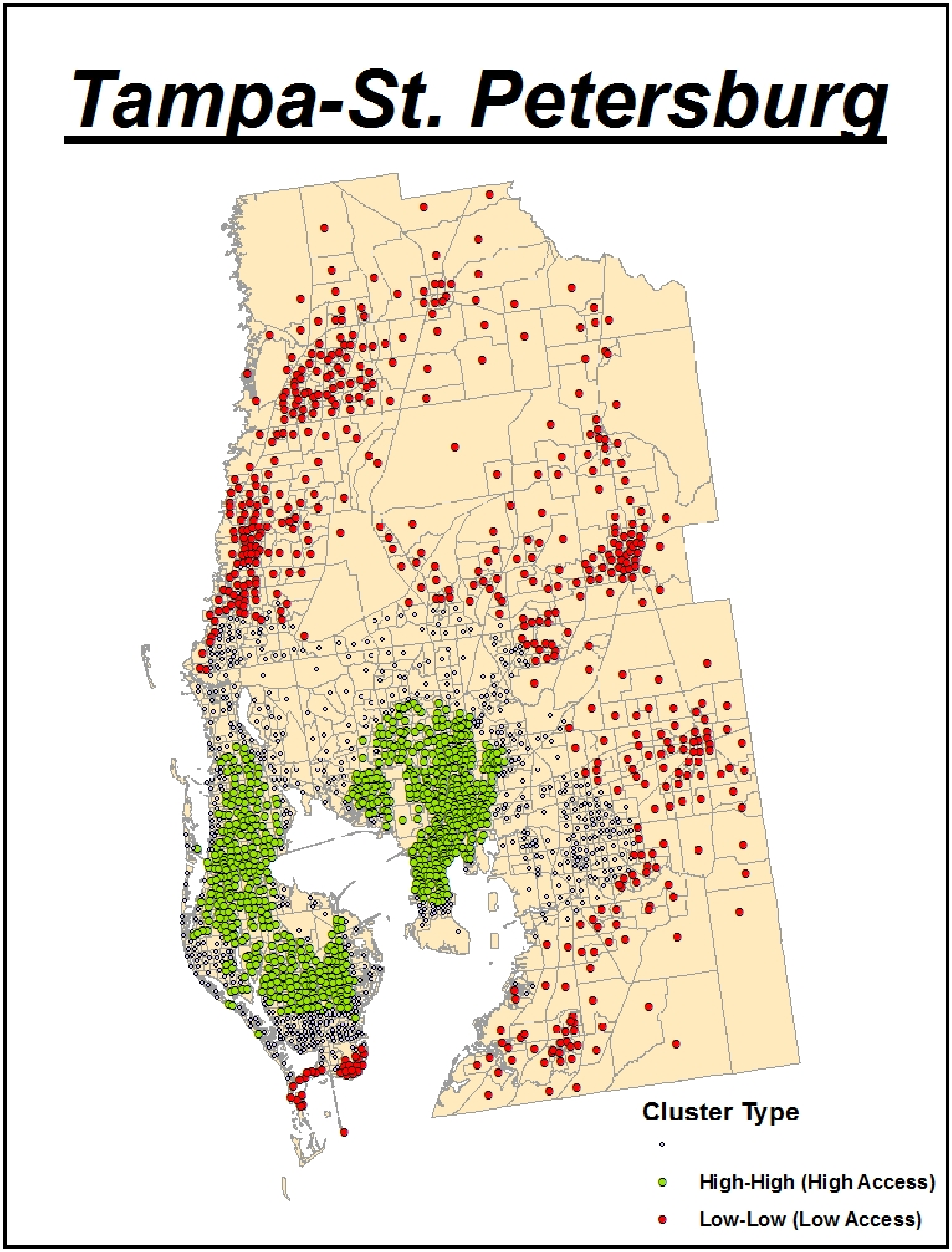


Figure 11: Modified gravity model of access to grocery stores in Tampa-St. Petersburg

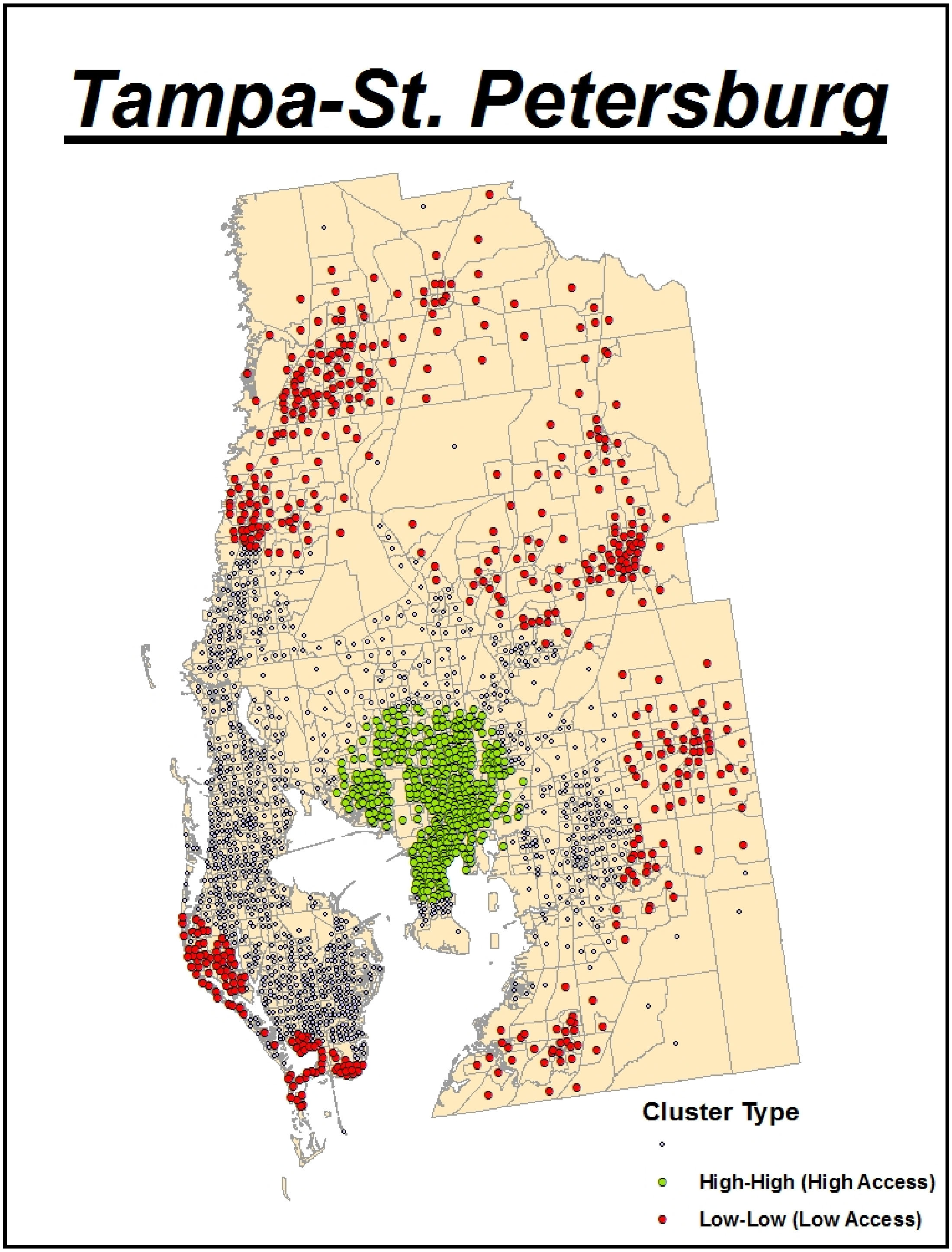


Figure 12: Modified gravity model of access to liquor stores in Tampa-St. Petersburg

The two accessibility models yield similarities in the local patterning: both indicate a statistically significant difference (90% confidence level) between the global mean population density and the population density of low access clusters for both grocery and liquor stores. Likewise, both models highlight strong deviation from the global mean of the white population count in the high and low access clusters for both grocery and liquor stores (significant at a 99.9% confidence level). Black population counts varied significantly from the global average in both accessibility models in low access to grocery stores as well as high and low clusters of access to liquor stores. However, the modified gravity model does not account for the difference of means of Asian population counts to the global average in the high-high (distance to grocery and liquor stores) clusters that is found in the distance-driven model. Nor does the modified gravity model account for the difference of means of black population counts to the global mean in the high access clusters described by the distance-driven model. Furthermore, the distance-driven model does not find a significant difference of population density in the low-low (distance to grocery and liquor stores) clusters that is accounted for in high-high (access) clusters in the modified gravity model.

CHAPTER 5—CONCLUSION

I. Discussion

Land use regulation is commonplace in the United States. Regulatory tools, particularly zoning, are intended to preserve the character of communities, protect residences against undesirable land uses, and guard against land use incompatibility. Despite unintended consequences of land use management and separating residential areas from commercial and industrial areas, zoning is largely seen as a positive practice. Existing literature concerning spatial equity and access to services measured in a GIS neglect the *a priori* knowledge of *de jure* and *de facto* segregation in US cities and predominantly examine access to publically provided amenities. This research addresses the current gap in literature concerning the impact of land use regulation on spatial equity in American cities. This large scale examination suggests a weak, but positive, relationship between land use regulation and access to amenities and strongly suggests systematic spatial inequity given the significant variation of white and black population counts in high and low access places in US cities.

II. Study Limitations and Future Research

Measuring accessibility in a GIS environment provides merely a glance at the overall distribution and availability of amenities in cities. Yet, it is an incomplete examination as actual consumer behavior has been noted to rely on variables other than nearest available location such as perceived prestige, previous positive or negative interactions with store employees, and other subjective factors. Amenities are concentrated in city centers and densely populated areas disproportionately populated by socially differentiated peoples. Therefore, measurements of access to these amenities is higher in the densely populated block groups. The accessibility models leveraged by this study do not address the quality of amenities located in densely populated city centers nor consumer preferences which tend to favor amenities located in places other than where one resides. This raises a question for future research whether measured access, even when stratified by sales volume and number of available amenities, is a true indicator of consumer behavior or perceived access. Supplementary qualitative research is needed to verify or debunk objective measures of access generated within a GIS.

It is important to question the sublime realities that shape communities (such as zoning laws) to refine and reshape the existing systems for a higher quality of life for all people. The impetus is on academia to supply rigorous research concerning issues for stakeholders (including socially differentiated communities) in municipalities as well as urban planners and municipal authorities to mitigate variations in access to amenities through policy change in order to realize that goal.

APPENDIX

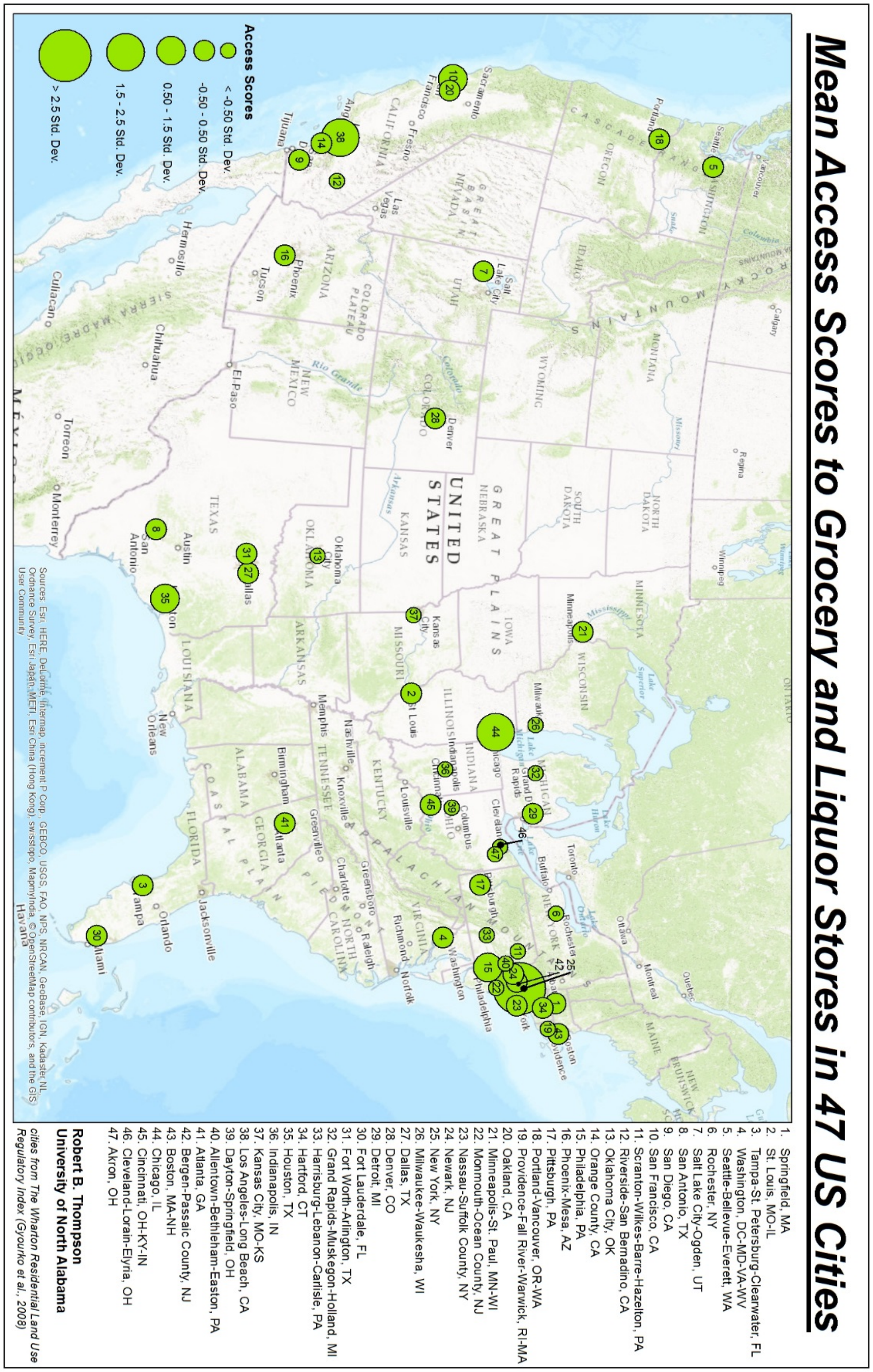


Figure 13: Graduated symbols of access scores from modified gravity accessibility model

BIBLIOGRAPHY

Algins v. Tiburon, 447 U.S. 255. 1980. Retrieved from http://caselaw.findlaw.com/us-supreme-court/447/255.html#260

Buchanan v. Warley, 245 U.S. 60. 1917. http://caselaw.findlaw.com/us-supreme-court/245/60.html

City Planning Commission. 1960. Zoning Resolution: The City of New York. Retrieved from http://www1.nyc.gov/assets/planning/download/pdf/about/city-planning-history/1960_zoning_resolution.pdf

Clingermayer, J. 1993. Distributive Politics, Ward Representation, and the Spread of Zoning. *Public Choice* 77(4): 725-738.

Comber, A.J., C. Brunsdon, and R. Radburn. 2011. A spatial analysis of variations in health access: linking geography, socio-economic status and access perceptions. *International Journal of Health Geographics*, 10(44): 1-11.

Comer, J. C. and P. D. Skrasstad-Jurney. 2008. Assessing the locational equity of community parks through the application of Geographic Information Systems. *Journal of Park and Recreation Administration*, 26(1): 122-146.

Conley, J. and M. Dix. 2004. Beneficial Inequality in the Provision of Municipal Services: Why Rich Neighborhoods Should Get Plowed First. *Southern Economic Journal* 70(4): 731-745.

Correlation. 2016. *Encyclopedia Britannica.* Retrieved from http://www.britannica.com/science/correlation

Dolan v. City of Tigard, 512 U.S. 687. 1994. Retrieved from http://caselaw.findlaw.com/us-supreme-court/512/374.html

Fernandez, R. and R. Rogerson. 1997. Keeping People Out: Income Distribution, Zoning, and the Quality of Public Education. *International Economic Review* 38(1): 23-42.

Fischel, W. 1978. A Property Rights Approach to Municipal Zoning. *Land Economics* 54(1): 64-81.

Gyourko, J., A. Saiz, and A. A. Summers. 2007. A New Measure of the Local Regulatory Environment for Housing Markets: The Wharton Residential Land Use Regulatory Index. University of Pennsylvania.

Harvard Law Review. 1971. Exclusionary Zoning and Equal Protection. *Harvard Law Review* 84(7): 1645-1669.

Johnston, R.J., D. Gregory, G. Pratt, and M. Watts. 2000. *The Dictionary of Human Geography*. Blackwell Publishing: Oxford, UK. pp. 229-230, 657-658.

Kitron, U., L.H. Otieno, L.L. Hungerford, A. Odulaja, W.U. Brigham, O.O. Okello, M. Joselyn, M.M. Mohamed-Ahmed, and E. Cook. 1996. Spatial Analysis of the Distribution of Tsetse Flies in the Lambwe Valley, Kenya, using Landsat TM Satellite Imagery and GIS. *Journal of Animal Ecology* 65(3): 371-380.

Knox, P.L. 1978. The Intraurban Ecology of Primary Medical Care: Patterns of Accessibility and their Policy Implications. *Environment and Planning* 10: 415-435.

Knox, P.L. 1980. Measures of Accessibility as Social Indicators: A Note. *Social Indicators Research* 7(1/4): 367-377.

Levy, J. 2013. *Contemporary Urban Planning* (10th edition). New York: Routledge.

Lucy, W. 1981. Equity and Planning for Local Services. *Journal of the American Planning Association*, 47(4): 447-457.

McGurty, E. 1997. From NIMBY to Civil Rights: The Origins of the Environmental Justice Movement. *Environmental History* 2(3): 301-323.

McLafferty, S. 1982. Urban Structure and Geographical Access to Public Services. *Annals of the Association of American Geographers*, 72(3): 347-354.

Nicholls, S. 2001. Measuring the Accessibility and Equity of Public Parks: a Case Study Using GIS. *Managing Leisure* 6: 201-219.

Nicholls, S. and C.S. Shafer. 2001. Measuring Accessibility and Equity in a Local Park System: The Utility of Geospatial Technologies to Park and Recreation Professionals. *Journal of Park and Recreation Administration* 19(4): 102-124.

Pasaoguillari, N. and N. Doratli. 2004. Measuring accessibility and utilization of public spaces in Famagusta. *Cities*, 21(3): 225-232.

Pearce, J., K. Witten, and P. Bartie (2006). Neighbourhoods and health: a GIS approach to measuring community resource accessibility. *Journal of Epidemiology and Community Health* 60(5): 389-395.

Pogodzinski, J.M. and T.R. Sass. (1991). Measuring the effects of municipal zoning regulations: a survey. *Urban Studies*, 28(4): 597-621.

Shannon, J. 2016. Beyond the Supermarket Solution: Linking Food Deserts, Neighborhood Context, and Everyday Mobility. *Annals of the Association of American Geographers* 106(1): 186-202.

Sheppard, E., H. Leitner, R.B. McMaster, and H. Tian. 1999. GIS-Based Measures of Environmental Equity: Exploring their Sensitivity and Significance. *Journal of Exposure Analysis and Environmental Epidemiology* 9(1): 18-28.

Shlay, A.B. and P.H. Rossi. 1981. Keeping up the Neighborhood: Estimating Net Effects of Zoning. *American Sociological Review* 46(6): 703-719.

Silver, C. 1997. Thomas, J. and M. Ritzdorf eds. The Racial Origins of Zoning in American Cities. *Urban Planning and the African American Community: In the Shadows*. Thousand Oaks, CA: Sage Publications.

Skraastad-Jurney, P.D. 2006. *The Spatial Equity of Parks in the Oklahoma City Metropolitan Area* (Doctoral dissertation, Oklahoma State University Press).

Sussna, S. 1961. Zoning Boards: In Theory and in Practice. *Land Economics* 37(1): 82-87.

Talen, E. and L. Anselin. 1998. Assessing Spatial Equity: An Evaluation of Measures of Accessibility to Public Playgrounds. *Environment and Planning A*, 30: 595-613.

Tobler, W.R. 1970. A Computer Movie Stimulating Urban Growth in the Detroit Region. *Economic Geography* 46: 234-240.

Weiss, C.C., M. Purciel, M. Bader, J.W. Quinn, G. Lovasi, K. Neckerman, and A.G. Rundle. 2011. Reconsidering Access: Park Facilities and Neighborhood Disamenities in New York City. *Journal of Urban Health*, 88(2): 297-310.

Witten, K., D. Exeter, and A. Field. 2003. The Quality of Urban Environments: Mapping Variation in Access to Community Resources. *Urban Studies* 40(1): 161-177.