METHODOLOGICAL ISSUES

IN CREATING A REGIONAL NEIGHBORHOOD TYPOLOGY

Z. Asligul Gocmen

Urban and Regional Planning Program, University of Michigan
Ann Arbor, MI 48109
Tel: +1 734-904-2762 (c)
Fax: +1 734-763-2322
Email: zgocmen@umich.edu

Abstract

Since the late 1990s, the exploration of neighborhood typology (classification of neighborhoods based on physical features) has been profoundly effected by the use of Geographic Information Systems (GIS). By enabling researchers to easy access and greater power to analyze and visualize spatial data, GIS has led both to a greater interest in investigating neighborhood typology as well as enhancements of prior classifications. This study addresses several of the potential methodological issues involved when creating such neighborhood typologies. Specifically, the role of geographic extent, neighborhood size, parameters in the analysis, and data characteristics in the creation of a typology are explored. In addition, issues dealing with the verification of results and the applicability of such analysis in creating neighborhood typologies are discussed. A two-county region in Southeast Michigan is chosen as the geographic extent in this study.

1. Introduction

Neighborhood typology, which investigates physical characteristics of places, can be used not only for characterizing metropolitan regions, but also for examining policy outcomes or for incorporating objective measures in conjunction with survey research. Applications of such a typology are numerous with survey research; neighborhood typology can be used in examining residential choice and preferences, neighborhood satisfaction, and travel/walking behavior, to name a few.[i] In addition, it can be used in selecting survey sample based on the characteristics of the sample population's residential locations.

Since the late 1990s, the exploration of neighborhood typology has been profoundly effected by the use of Geographic Information Systems (GIS). By enabling researchers to easy access and greater power to analyze and visualize spatial data, GIS has led both to a greater interest in investigating neighborhood typology as well as enhancements of prior classifications (i.e. the dichotomous classification as traditional urban and suburban sprawl). The main purpose of this study is to address several of the potential methodological issues involved when creating such neighborhood typologies with the use of GIS and to discuss methods to evaluate the outcomes.

2. A Brief Background on Previous Neighborhood Typologies in the Literature

Neighborhood typology, in some works defined as urban form, has been explored by several planning researchers. Since 1990s, studies that explore neighborhood typology have incorporated GIS in the analysis to delineate different neighborhood classes. These studies mainly aim to characterize regions and to examine impacts of neighborhood typology on various planning related issues. Examples include the impact of the urban form on residential choice and preference in the Boston and Atlanta regions (Levine et al., 2005), accessibility in the Puget Sound region (Krizek, 2001), traffic accidents in Wayne County, Michigan (Torng, 2001), and characterization of new housing development in the Portland area (Song and Knaap).

All of these mentioned studies have incorporated three main groups of spatial data: land use (e.g. land use mix, retail space), accessibility (e.g. street design, intersection density, presence of sidewalks), and density (e.g. housing, residential, employment). Apart from Song and Knaap's study, which has examined new developments only and is based on parcels, the other studies have attempted to create regional typologies based on neighborhood statistics around grid cells. All of these studies have used GIS software to prepare the data layers (i.e. perform neighborhood statistics); however, the analyses were carried out in statistical packages such as Minitab and SPSS.

3. Methodology in Creating the Neighborhood Typology

In this study, I conducted a similar regional analysis with the use of GIS software, ArcView and ArcInfo. This section provides an overview of the geographic extent, spatial data, and the different parameters used in the spatial analysis.

3.1 Geographic Extent

Washtenaw and Livingston County in the Southeast Michigan region are chosen as the geographic extent of this study (see Appendix A). These two counties do not make up a metropolitan region alone, they are part of the metropolitan Detroit area. The choice of these two counties was primarily based on this area being the geographic extent of my dissertation research which explores the causes of a disconnect between pro-environmental attitudes and environmentally damaging residential choices and preferences.[ii]

While Washtenaw County is a more urban county, accommodating a mid-sized city (Ann Arbor), two significant universities (University of Michigan and Eastern Michigan University), and many small towns, Livingston County is still considered a rural county, with a significant proportion of the natural areas in the study region. However, while it is more rural, the pace of growth in Livingston is staggering. It is the fastest growing county in the State of Michigan, accommodating many newcomers in a wide-range of neighborhoods.

3.2 Spatial Data

Similar to the previous studies as discussed above, I used three data layers for the Washtenaw and Livingston County typology: land use, street network, and density. The choice of specific variables was significantly restricted by the availability of the data. For instance, in identifying urban places and creating a regional typology, retail floor space or the presence of sidewalks would have been very useful; however, land use, street network, and density were the only readily and uniformly available spatial variables.

3.2.1 Land Use

The land use layer is obtained from the Southeast Michigan Council of Governments (SEMCOG) and captures land use in the year 2000. One important issue to note is that the original land use layer was created based on the satellite imagery taken in 1978, and updates to this layer take place every five years by SEMCOG just for the areas that have become "urbanized." In other words, several of the changes (e.g. wooded areas converted to agricultural uses) are not captured with the updates.

This layer is used to create three main measures: land use variety (trying to depict the amount of land use mix in the "neighborhood"), percentage of single family residential areas, and percentage of urban type uses. High presence of urban type uses possibly indicates the area is urban or is surrounded by large number of residents. Thus, the greater the percentage of urban uses, the greater urbanity in the location could be expected. This data layer in the analysis was based on two different reclassifications: central business district (CBD)-like (i.e. retail sore and offices) and other urban uses (e.g. other commercial, institutional, and industrial uses such as industrial parks, shopping centers/malls, office parks, and education centers). This way, the reclassification enabled assigning different weights to each of these two broad types, and thus captured downtown areas more accurately. Incorporating the degree of land use mix in the neighborhood enables the researcher to distinguish between residential areas that are more representative of high-mix, traditional urban versus low-mix, suburban subdivisions. Incorporating the percentage of single family residential uses serve the same purpose; the higher percentages may be indicators of single-use suburban residential areas, whereas a low or medium percentage may indicate downtowns, traditional urban neighborhoods, rural areas, and natural areas.

3.2.2 Accessibility

Accessibility is based on the 2000 TIGER street layer. Highways were excluded from the analysis because they have limited access and they are not walkable road segments. For accessibility, street length and number of street intersections were used as measures. The assumption is that the shorter the average street length, the more urban or suburban the neighborhood is, and the higher the number of intersections of "T" or higher, the more urban the neighborhood is (suburban neighborhoods could be characterized with cul-de-sacs which have fewer intersections).[iii] A single measure to depict accessibility was obtained from these two variables.

3.2.3. Density

Density refers to housing density, and is the housing units per acre, based on the 2000 U.S. Census Block Geography.[iv] Higher densities indicate the location to be more urban than lower densities, which might suggest the presence of a rural or exurban neighborhood.

3.3 Methods Used

In this study, typology for neighborhoods was created using a multivariate cluster analysis in ArcInfo. The cluster analysis is based on neighborhood statistics of the different rasterized data layers (with a cell size of 30 x 30 meter). Neighborhood statistics for different layers were conducted based on neighborhoods with different radii. Originally, a neighborhood size of 0.25 mile radius was chosen to represent the traditional "neighborhood" definition in the planning field, stemming from the easy walking distance to schools and other amenities (as defined in the 1920s and the 1930s). Later on, different neighborhood sizes were used (with radius 0.125 mile and 0.5 mile) to compare results. Neighborhood statistics were composed of variety for land use, sum for single-family residential uses, sum of urban type of uses (with a map algebra performed later to reduce the two layers into one), sum of intersections of "T" and higher, mean street length, and mean housing density.[v]

Cluster analysis, which is an unsupervised classification, aims to identify naturally occurring clusters (groupings of areas with similar characteristics) in the data. Cluster analysis in ArcInfo uses K-Means clustering approach, where K is the number of clusters identified by the analyst[vi]. The results of the cluster analysis performed in the grid functionality in ArcInfo are saved in "signature" files which report the means and covariances of these different data layers within each cluster. Interpretation of the different classes is the analyst's task.

I ranked the means of different layers of these clusters created, based on my knowledge that represents the continuum of what I call "most urban to least urban". For instance, "most urban" clusters could be characterized as high urban uses, high land use variety, high accessibility, high residential densities, but low or medium percentage of single-family residential uses. "Least urban", on the other hand, would be low on each variable in the study, low urban uses, segregated land use (low land use variety), low accessibility, low residential densities, and low percentage of single-family uses, representing rural, exurban, and natural areas.

4. Findings

Cluster analyses in this dissertation were performed based on:
1). different data values (raw versus standardized)
2). different radius for neighborhoods
3). the variables used (some analyses did not include land use variety)
4). different number of clusters
5). geographic extent

Cluster analysis results can be seen in Maps 1a through Map 5. The means obtained for each data layer and cluster are shown in Table 1 through Table 5.

4.1. Influence of data standardization

In general, the means obtained from the signature files were not straightforward enough to be classified in the different neighborhood types easily.[vii] For instance, the cluster identified as "7" in table b, is very different in accessibility than other clusters close to it. However, the other variables in the same cluster follow characteristics of sprawling communities (i.e. low-density, absence of urban type uses), thus this cluster is rated as the 7th most urban among 9 classes. In addition, having very close values for certain variables, such as for "urban uses" as seen in Table 1b makes it very hard for the data analyst to assign these clusters to a type. Overall, examining the two maps, I am more satisfied with the results obtained using the "raw" data. Surprisingly, they are more representative of the area, especially the urban core around Ann Arbor.

4.2. Influence of Neighborhood Sizes

As could be expected, with shorter radius for the neighborhood, there is more differentiation of neighborhood types in the study area (Maps 2a, 2b, 2c). For instance, in the urbanized areas, at least five different types can be detected and are pretty balanced with one-eighth of a mile radius neighborhood. On the other hand, with quarter mile radius, the urban area is classified overwhelmingly by the top two most urban categories. Moving to the coarsest map, which is derived with the use of a half-mile radius as the neighborhood statistics window, we find the most interesting results. According to Map 2c, urban neighborhoods are pretty homogenous, while the outlying areas are not and are characterized even more urban. This controversial finding could be an artifact of how I decided to rank the clusters (see Table 2c); except for the "most urban" category, there doesn't seem to be any clear ranking. Ranking the clusters differently, unfortunately, has not led to a meaningful classification. Changing the labeling might solve the issue of urban edge being more urban than urban areas, but it cannot solve the problem of urban edge being more heterogeneous than the urban area.

4.4. Influence of Inclusion of Land Use Variety

While there are not many changes in the urban areas, influences can be observed in the urban fringe and in some non-urban areas well (Map 3a and Map 3b). In the analysis with the quarter-mile radius neighborhood, the third most urban classification has shrunk considerably. Examining the values in Table 3b, it can be seen that land use variety has not changed much among different types of neighborhoods. This could be due to the different compositions of land use mixes in urban, suburban, and non-urban locations in general. For instance, while in the urban areas, we could expect to find commercial, institutional, and industrial uses in addition to residential (thus four land uses in total), we could expect to find agricultural, natural, and office-parks in the outlying neighborhoods (again four land uses in total including residential uses). On the other hand, it could be due to high correlations between this layer and another; the percentage of urban uses already indicates the presence of non-residential uses in the neighborhood. Thus, interpretation of land use variety could pose potential problems.[viii] When the typology map with land use variety for the 0.125 mile radius neighborhood is examined, the region appears to be dominated by development. This is, unfortunately, not a good representation of the region.

4.3. Influence of Number of Clusters

Performing cluster analysis on the four variables (accessibility, urban use, single-family use, and housing density) at the 0.125 mile radius level, Map 4 and Map 2a show impacts of identifying different number of clusters. Classifying neighborhoods into five classes in the study area has resulted in the urban areas being dominated by two classes only similar to the two-class domination over the rural-urban fringe. The decrease in the number of clusters have also led to the collapse of the two least urban categories, possible eliminating the differences between uninhabited and exurban landscapes.

4.5 Influence of Geographic Extent

The typology within Washtenaw and Livingston County changed greatly when the analysis was expanded to a seven-county region (Map 6). The most significant changes were in the shrinking of the middle classes, mostly apparent within the urbanized area boundaries. These middle classes represent suburban areas; with their reduction in size, it seems like there is not much suburbanization in the area. In fact, the two-county area hosts many suburban style developments and subdivisions. The changes accrued with the increase of the geographic extent could be due to the inclusion of the City of Detroit. Even though there is high vacancy rates within the City of Detroit, it is still the most urban location in the region, with high urban uses, high accessibility, and high residential density, thus possibly skewing analysis outcomes.

5. Evaluation

In order to evaluate the outcomes of the analyses, three different evaluations were used: field checks, aerial photography checks, and check against the boundaries of the urbanized area as defined by the Census Bureau.

Five different areas in the study region, comprising a variety of development patterns (e.g. downtown, traditional urban, suburban, exurban, rural), were selected for quality control via field checks. During these field checks, it was found that the classes as identified in Map 2a could be distinguished in most areas. The trouble points were between consecutive clusters, where the differences were not necessarily large, or where values could be overlapping (since the interpretation of the tables was based on the means). For such areas, aerial photos were examined. It was determined that Map 2a had a nice fit.

After observing how closely the typology follows the boundaries of the urbanized area, my satisfaction increased with the results of the two cluster analysis as shown in Map 1a and Map 2a in general. They are the only outcomes in which the top three most urban classes fall almost completely within the urbanized area boundary. Since Map 2a used the standardized data values, I believe it is the visualization of the most appropriate analysis.

6. Discussion

Cluster analysis results change significantly changed with modifications to neighborhood search radius, standardization of data values, number of clusters identified, the geographic extent of the analysis, and also the inclusion of different variables in the analyses.

Inclusion of different neighborhood statistics (such as land use dissimilarity), different treatment of data (e.g. inclusion of dominant land uses, rather than the percentages of urban and single-family uses), or a better measure for housing density (e.g. dasymetric mapping of density based on different land uses) may also produce different and more accurate results for cluster analysis.

The analysis has presented many interesting issues. Availability of data and unit of analysis of data restrict spatial cluster analysis quite significantly. Technical troubles during the study also had some restrictions. Even though I realize that data values for different layers need to be standardized in cluster analysis, data standardization has produced means that are very close to each other in many clusters, and thus, hard to interpret among different classes.

The analysis performed in this study has produced an ordinal classification of neighborhoods suggesting a ranking ranging from most urban to least urban (similar to the classification of Levine et al, 2005). This emerges primarily as a result of the variables that are included in the cluster analysis. Changing variables or examining smaller geographic areas may produce a non-ordinal classification if desired.

Nevertheless, based on the results of the various quality check measures used, the neighborhood typology as suggested here, particularly in Map 2a (typology with the use of a smaller neighborhood size and the exclusion of the land use mix variable) could be used in multiple urban studies. It is important to emphasize that classification of neighborhoods in a region is likely to be based considerably on trial and error, and thus knowledge of the region is an important benefit in creating such typologies. However, with the inclusion of other variables that explain differences in the rural to urban landscapes, and more precise measures (e.g. housing density that is not solely based on agglomerated census units) can make the analyst's task easier and the analysis more generalizable.

Acknowledgments

I would like to thank Prof. Emeritus John Nystuen, Associate Prof. Dan Brown, Prof. Rachel Kaplan, and Prof. Robert Marans at the University of Michigan for their useful suggestions in various stages of the study. Spatial analysis undertaken in my dissertation is partly funded by the USDA Forest Service North Central Station, and the typology for the seven-county region is funded by the Office of the Vice President for Research at the University of Michigan. Any errors and omissions are my own.

References:

ArcInfo Help Menu (accessed between January and December 2004).

Hultgren, Torrin and Jeremy Mennis. *Automated Dasymetric Mapping Routine,* accessed in December 2004 at: http://astro.temple.edu/~jmennis/research/dasymetric

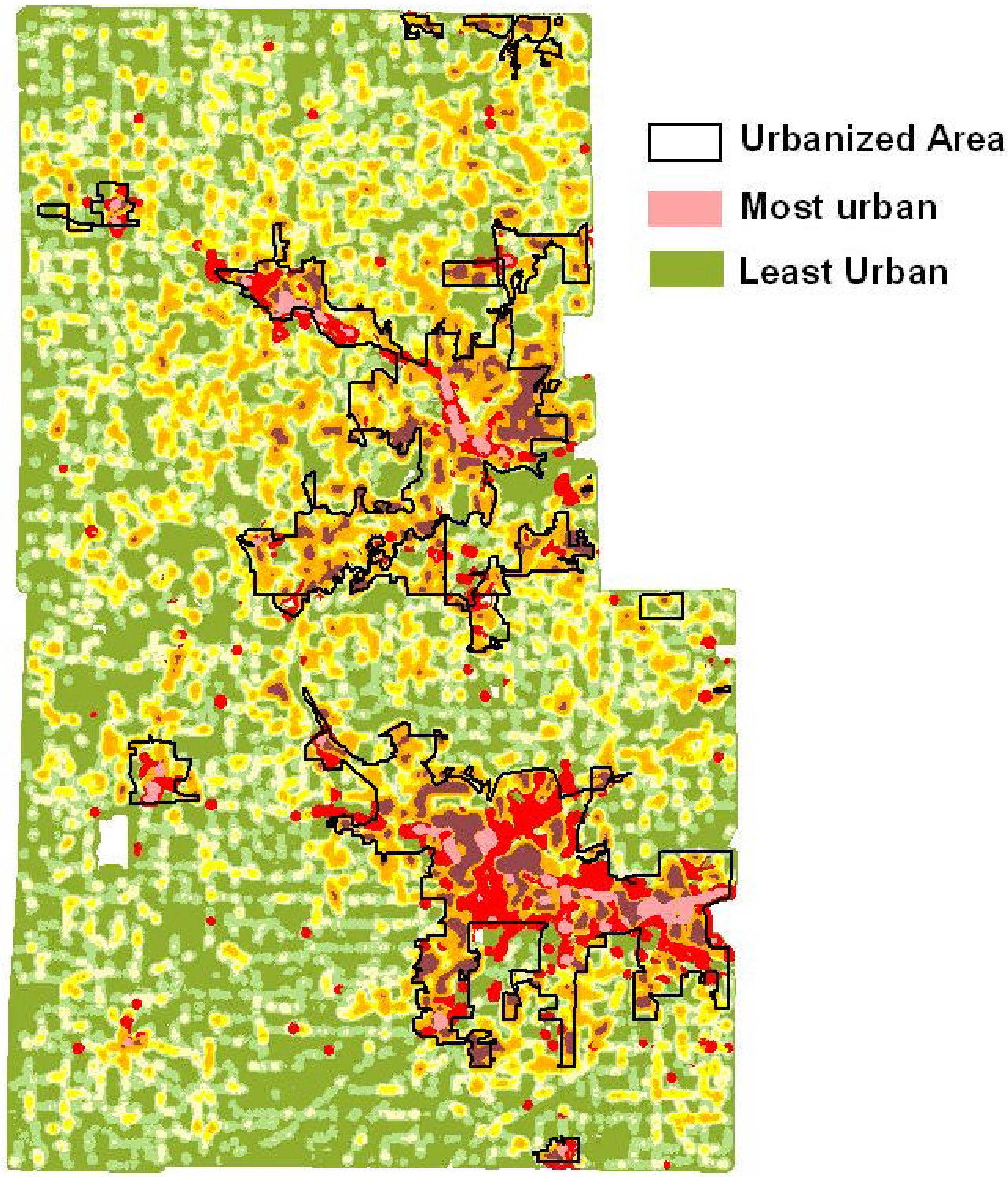
Krizek, Kevin (2001). *Relationships between Neighborhood-scale Urban Form, Travel Behavior, and Residential Location: Implications for Land Use and Transportation Planning and Policy*, unpublished dissertation, University of Washington

Levine, Jonathan, Aseem Inam and Gwo-Wei Torng (2005). "A Choice-Based Rationale for Land Use and Transportation Alternatives: Evidence from Boston and Atlanta" in the *Journal of Planning Education and Research*, 24, 317-330.

Song, Yan and Gerrit-Jan Knaap. "Internally Connected, No Commercial, with a Touch of Open Space: The Neighborhoods of New Homes in the Portland Metropolitan Area". Working paper.

Torng, Gwo-Wei (2001). *Urban Form and Drivers' Behavior: Transportation Safety Implications of Residence in Urban, Suburban and Rural Environments,* unpublished dissertation, University of Michigan, Ann Arbor, MI.

Map 1a: Influence of Data Value Standardization – Clusters with Raw Data
(for a key for the colors, please see Appendix B)



Map 1b: Influence of Data Value Standardization – Clusters with Standardized Data

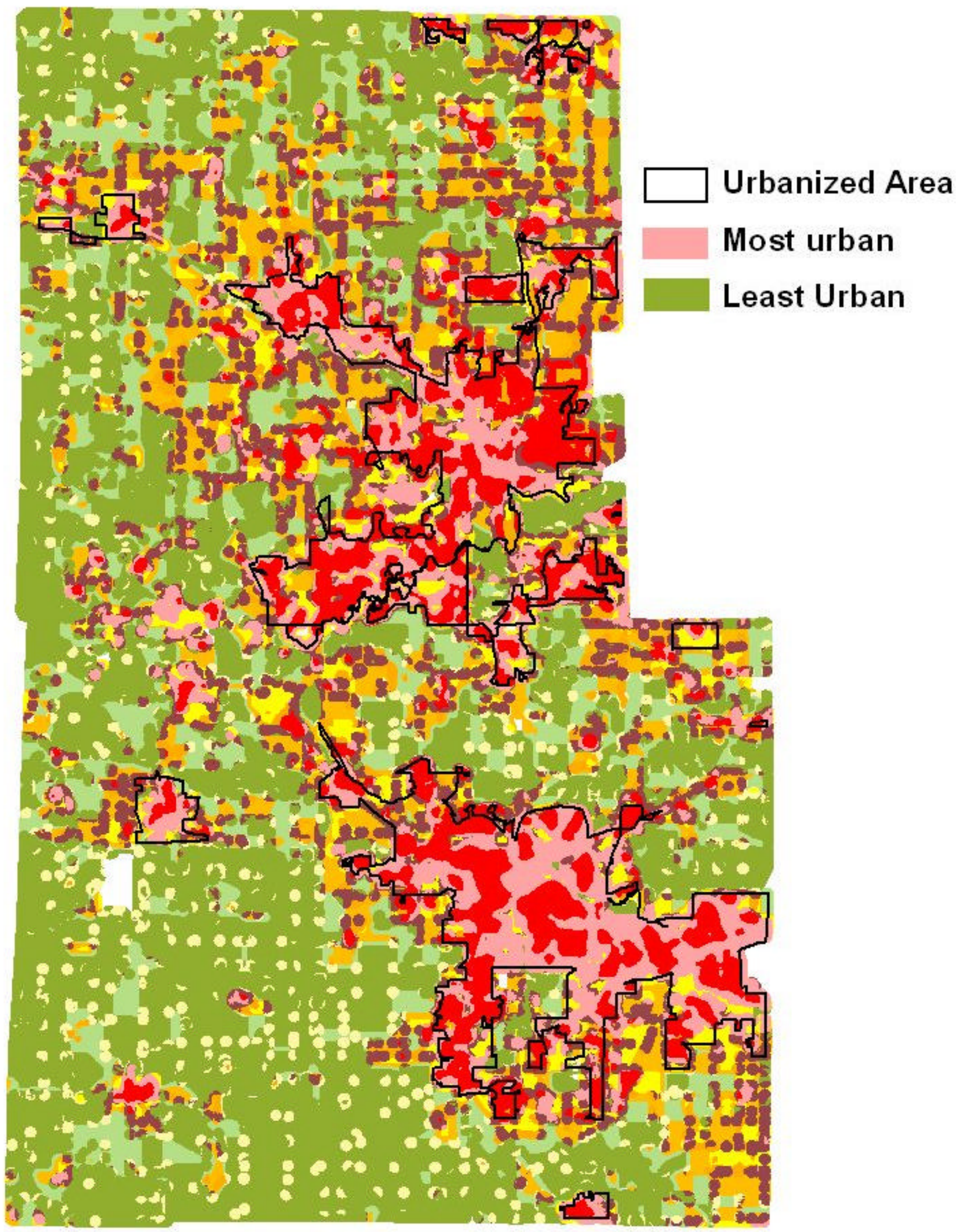


Table 1: Comparison of raw versus standardized data values in cluster analysis

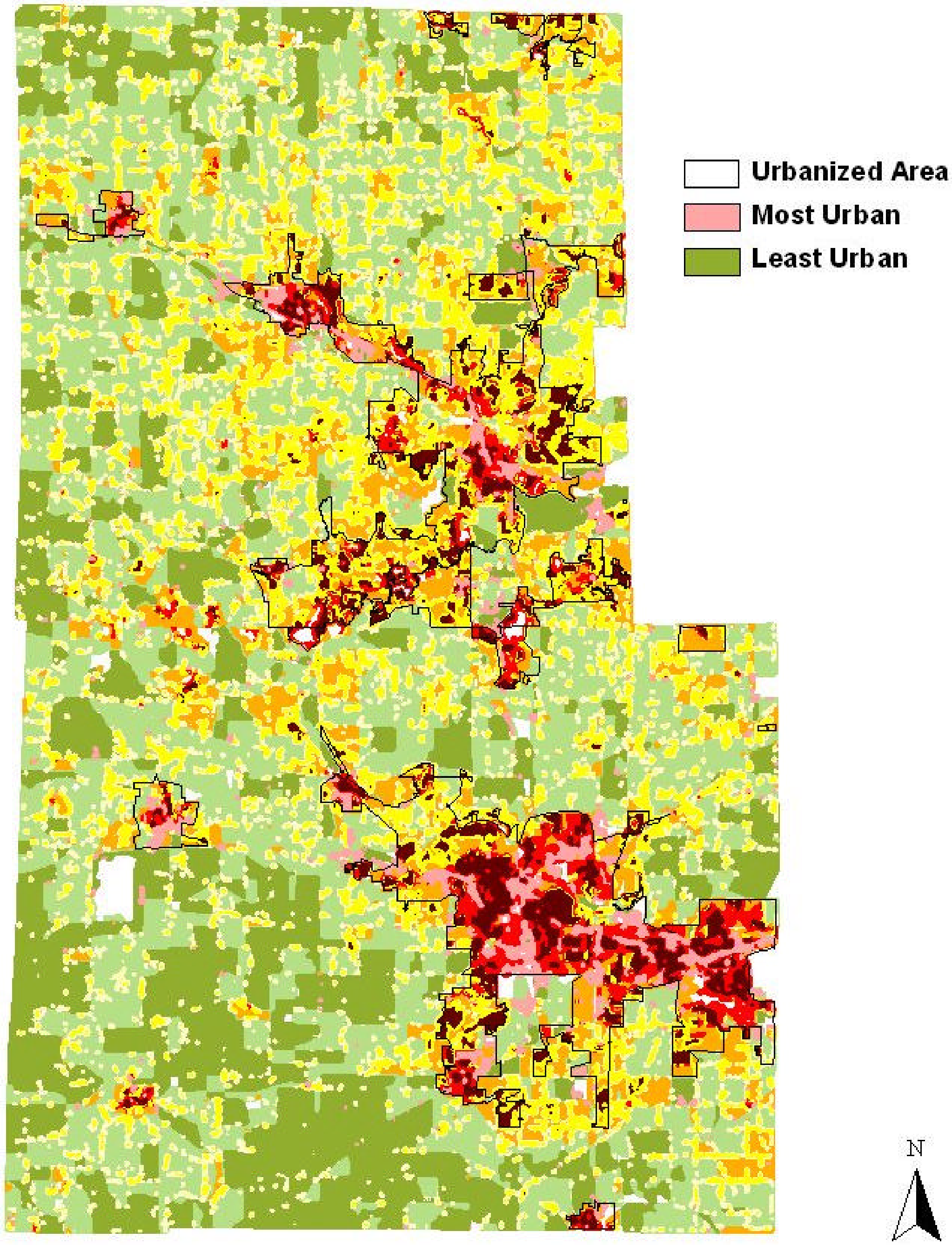
a. 0.25 mile radius with raw data values (9 clusters)

Means	Most Urban	2	3	4	5	6	7	8	Least Urban
Accessibility (reversed)	2.3	4.81	3	4.95	7.65	10.86	13.9	17.21	20.08
Urban Uses	460.59	158.63	12.15	12.95	4.89	3.23	2.04	2.01	2.74
Single-family Residential	142.25	72.22	422.05	293.44	199.7	131.2	79.41	39.18	6.67
Housing Density	5.33	4.06	4.94	3.99	3.09	2.56	2.21	1.92	1.69

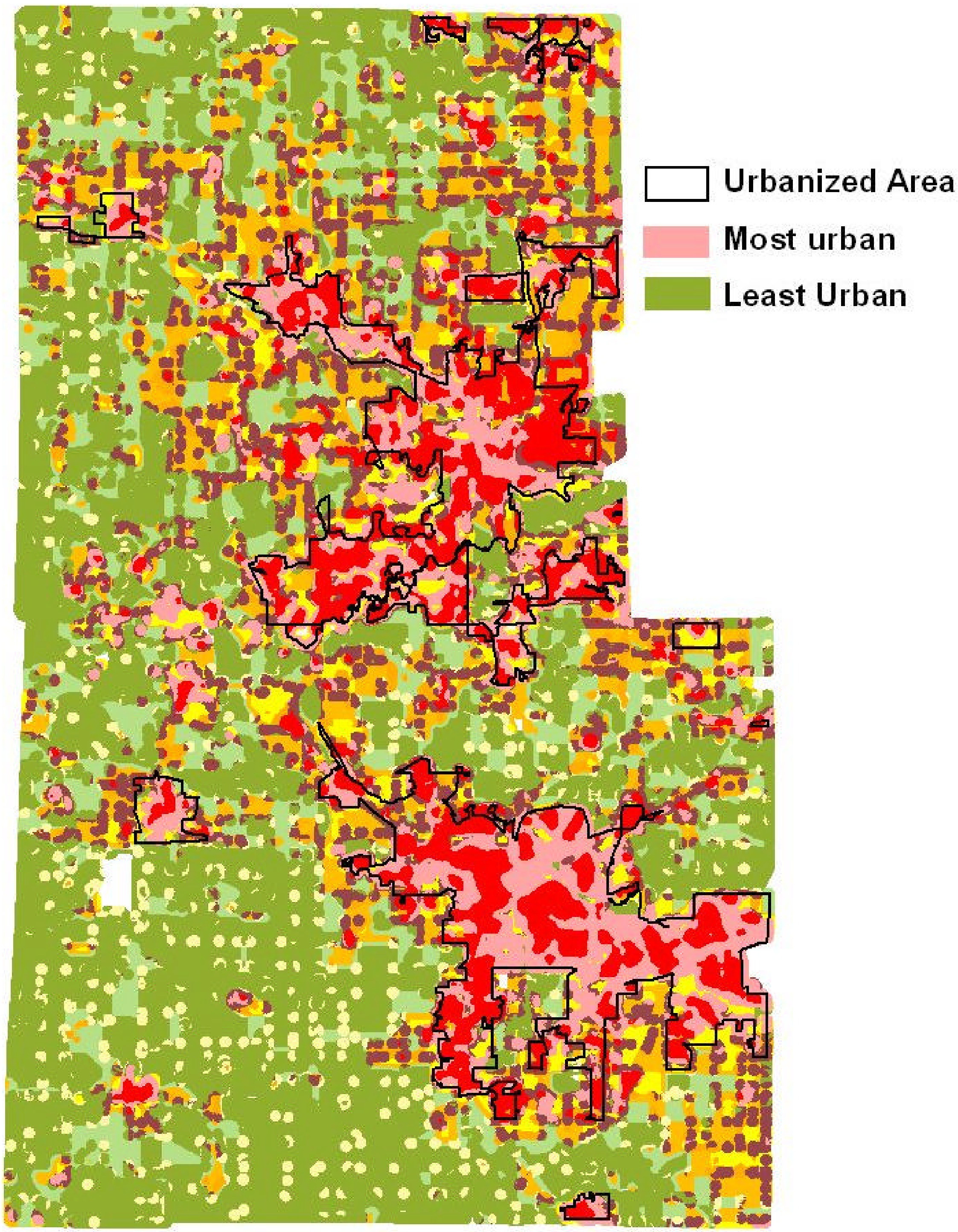
b. 0.25 mile radius with standardized data values (9 clusters)

Means	Most Urban	2	3	4	5	6	7	8	Least Urban
Accessibility (reversed)	11.36	9.74	35.34	99.76	96	97.89	21.56	99.64	99.48
Urban Uses	4	2.59	1.29	1.34	1.07	1.08	1.35	1.05	1.04
Single-family Residential	20.21	61.2	23.24	8.39	36.85	11.61	11.84	7.04	4.59
Housing Density	84.1	89.26	62.84	75.62	69.45	55.67	30.34	37.56	10

Map 2a: Influence of Neighborhood Sizes – With 0.125 mile radius (standardized data values)



Map 2b: Influence of Neighborhood Sizes – With 0.25 mile radius (standardized data values)



Map 2c: Influence of Neighborhood Sizes – With 0.5 mile radius (standardized data values)

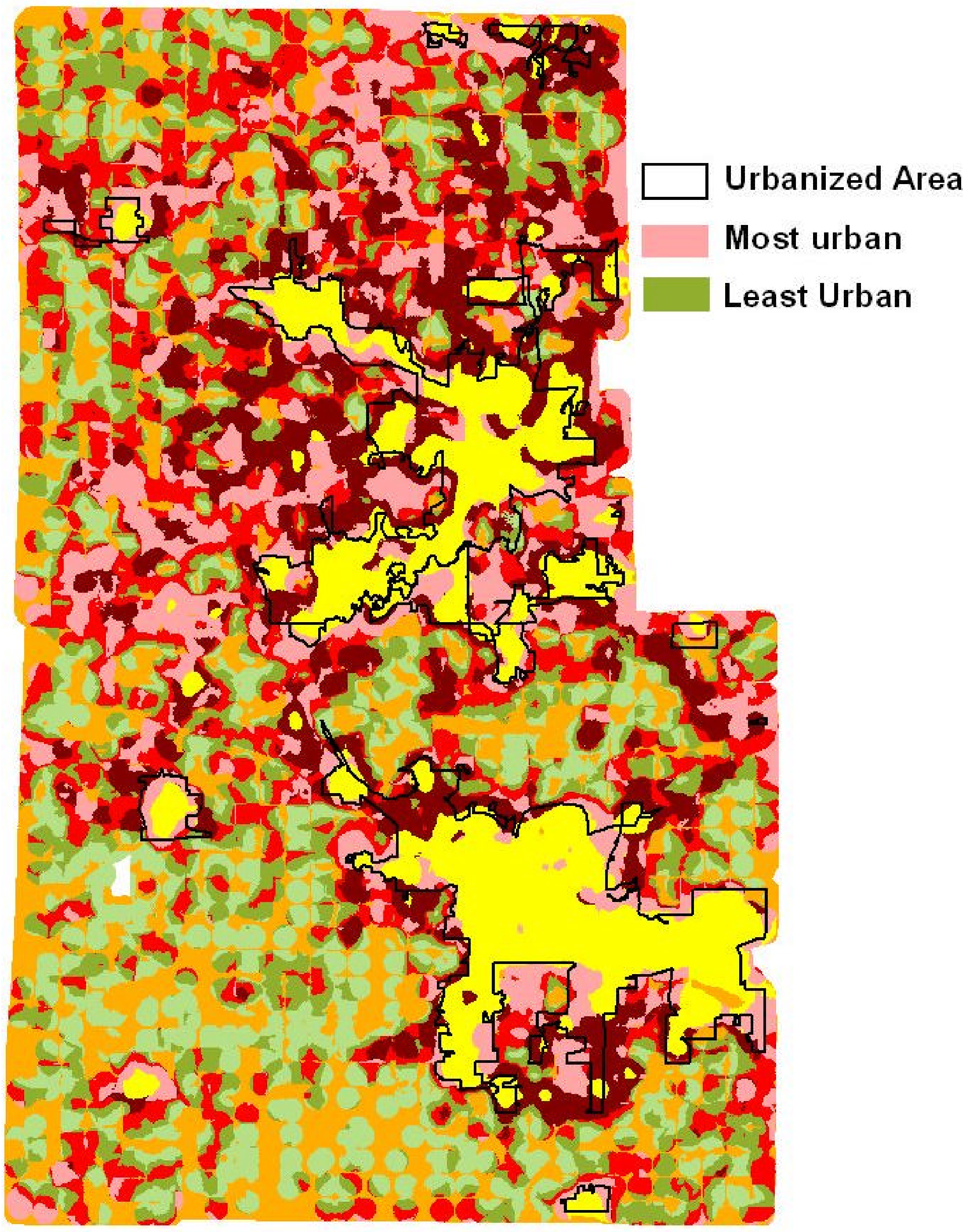


Table 2: Comparison of standardized values for different neighborhood sizes

a. 0.125 mile radius with standardized data values (9 clusters)

Means	Most Urban	2	3	4	5	6	7	8	Least Urban
Accessibility	11.07	11.69	18.75	2.37	5.42	3.82	2.38	1.52	1.37
Urban Uses	40.37	5.4	2.77	1.9	1.36	1.36	1.28	1.34	1.42
Single-family Residential	8.48	23.53	87.42	4.55	69.08	40.45	19.61	2.29	1.69
Housing Density	45.7	61.1	56.44	33.78	30.81	26.13	21.05	20	10.57

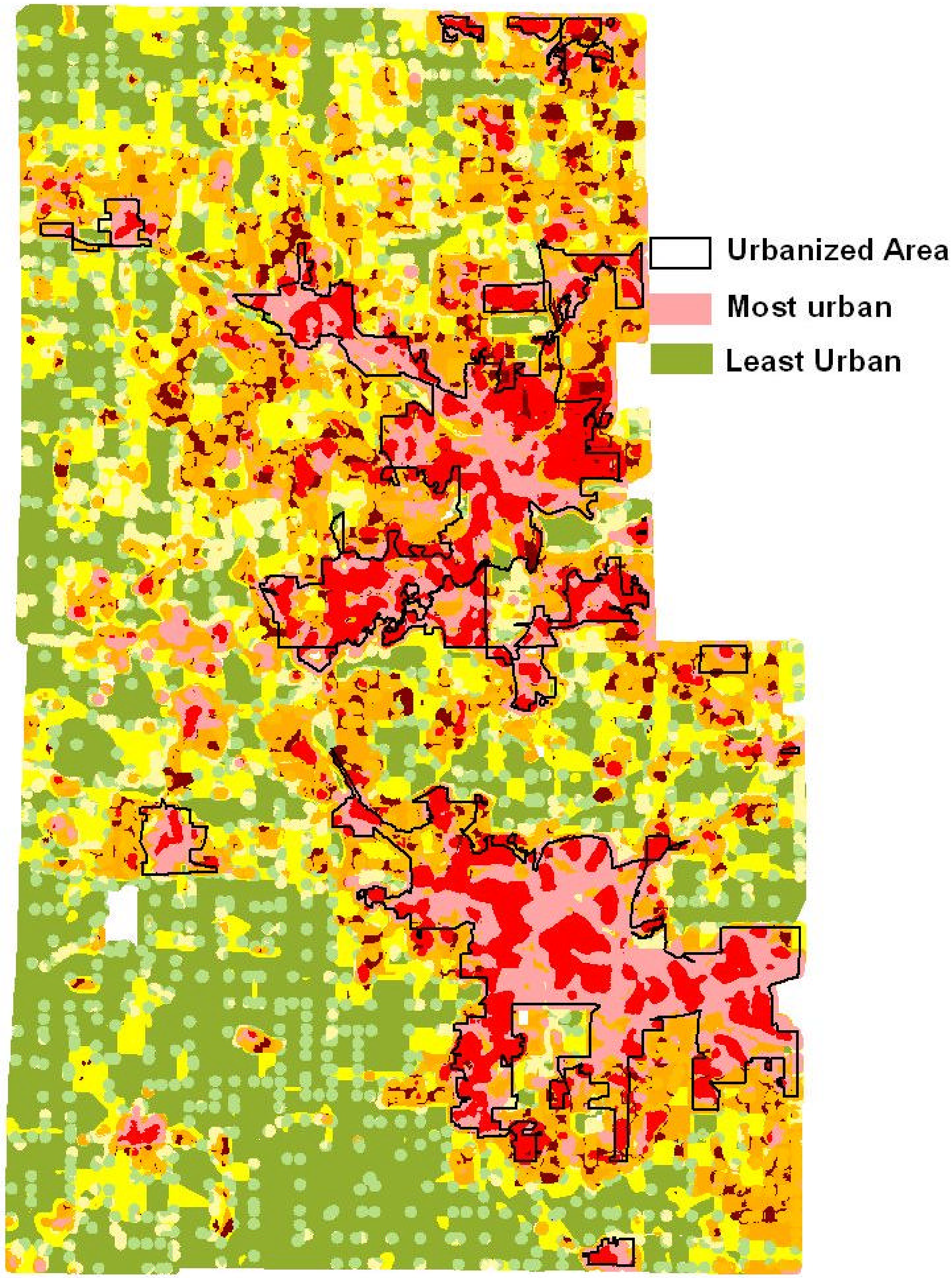
b. 0.25 mile radius with standardized data values (9 clusters)

Means	Most Urban	2	3	4	5	6	7	8	Least Urban
Accessibility (reversed)	11.36	9.74	35.34	99.76	96	97.89	21.56	99.64	99.48
Urban Uses	4	2.59	1.29	1.34	1.07	1.08	1.35	1.05	1.04
Single-family Residential	20.21	61.2	23.24	8.39	36.85	11.61	11.84	7.04	4.59
Housing Density	84.1	89.26	62.84	75.62	69.45	55.67	30.34	37.56	10

c. 0.5 mile radius with standardized data values (7 clusters)

Means	Most Urban	2	3	4	5	6	Least Urban
Accessibility (reversed)	1.02	3.53	2.35	1	3.64	8.53	5.92
Urban Uses	4.29	1.82	1.55	1.09	1.01	1.29	1.44
Single-family Residential	1.37	9.48	3.04	3.89	4.38	6.79	1
Housing Density	1.69	1.05	1.87	6.19	4.14	7.82	9.73

Map 3a: Influence of Inclusion of Land Use Variety (with 0.25 mile radius neighborhood)



Map 3b: Influence of Inclusion of Land Use Variety (with 0.125 mile radius neighborhood)

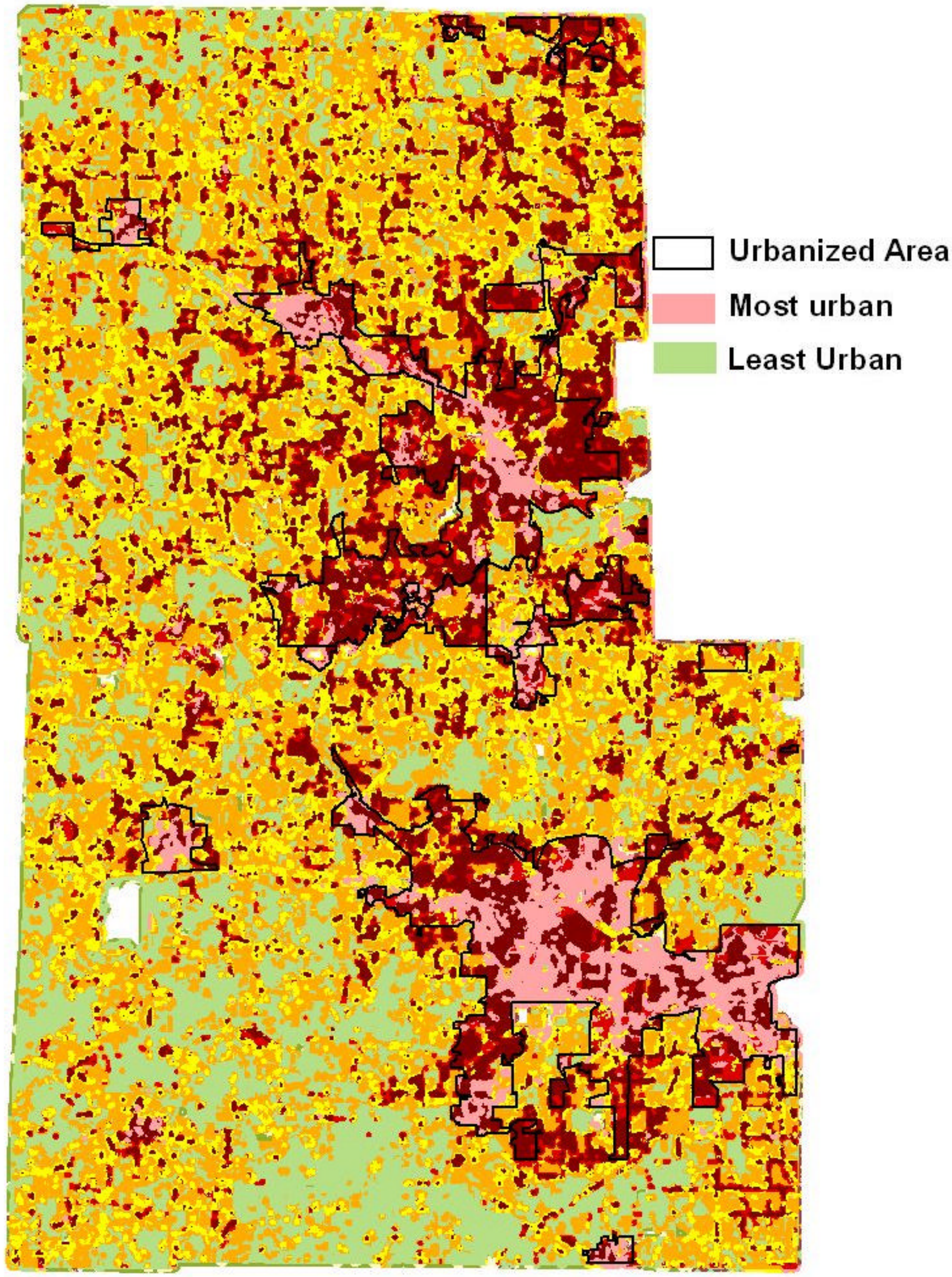


Table 3: Comparison of clusters with and without land use variety (with standardized data values)

a. 0.25 mile radius without land use variety (9 clusters)

Means	Most Urban	2	3	4	5	6	7	8	Least Urban
Accessibility (reversed)	11.36	9.74	35.34	99.76	96	97.89	21.56	99.64	99.48
Urban Uses	4	2.59	1.29	1.34	1.07	1.08	1.35	1.05	1.04
Single-family Residential	20.21	61.2	23.24	8.39	36.85	11.61	11.84	7.04	4.59
Housing Density	84.1	89.26	62.84	75.62	69.45	55.67	30.34	37.56	10

b. 0.25 mile radius with land use variety (9 clusters)

Means	Most Urban	2	3	4	5	6	7	8	Least Urban
Land use variety	37.92	29.09	29.01	30.72	31.14	26.89	30.76	26.16	22.69
Accessibility (reversed)	10.97	9.9	95.75	98.25	24	99.53	21.47	58.32	99.49
Urban Uses	4.29	2.41	1.05	1.22	1.27	1.05	1.38	1.12	1.04
Single-family Residential	20.14	61.15	38.26	9.91	23.17	7.54	11.96	10.49	4.57
Housing Density	84.98	88.98	70.19	66.55	63.47	39.3	30.54	20.19	9.99

Map 4: Influence of different number of clusters (0.125 mile radius neighborhood with 5 clusters)

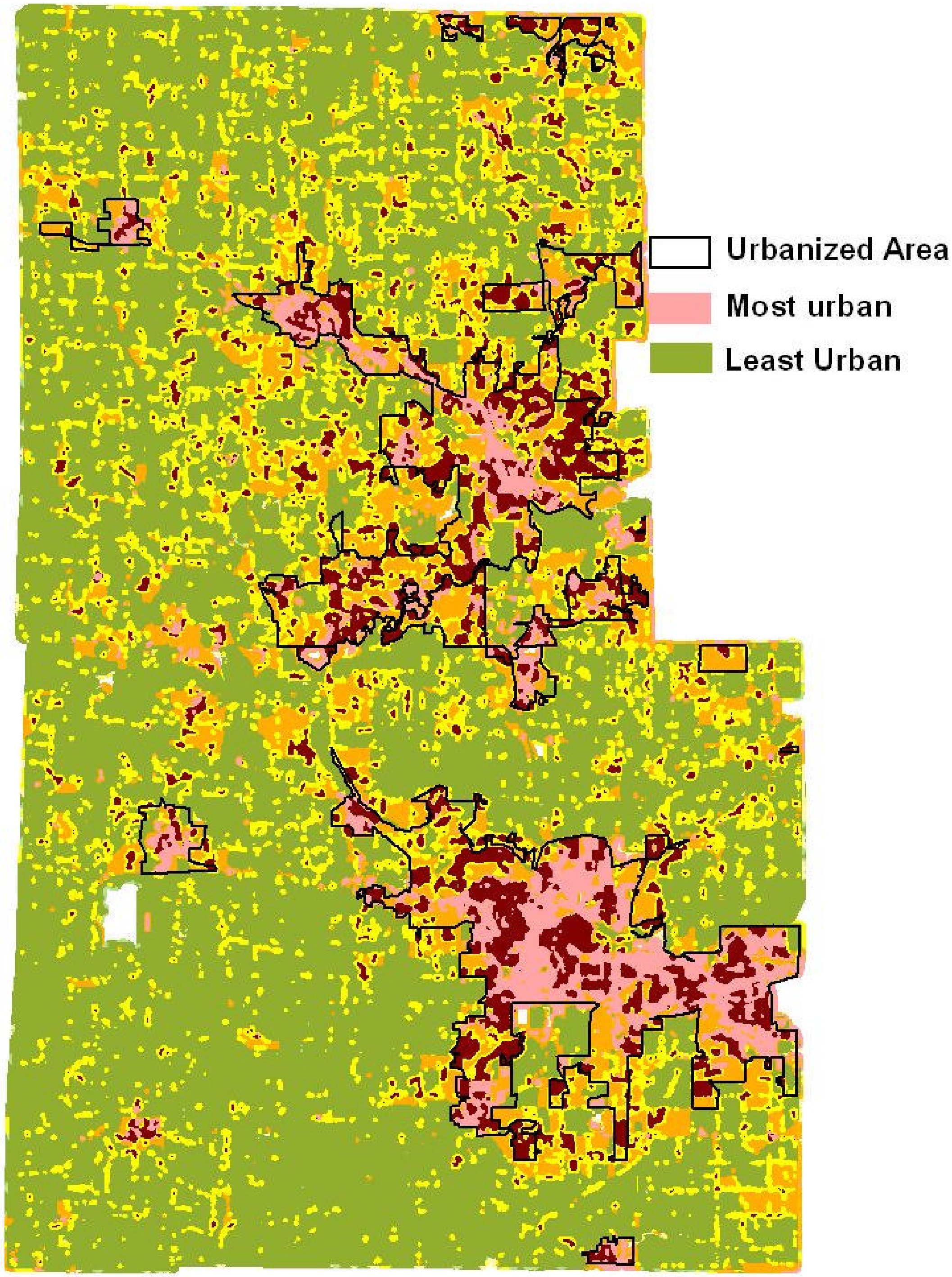


Table 4: Comparison of different number clusters

a. 0.125 mile radius with standardized data (5 clusters)

Means	Most Urban	2	3	4	Least Urban
Accessibility	12.62	12.25	2.67	3.58	1.49
Urban Uses	16.18	2.02	2.55	1.34	1.42
Single-family Residential	17.99	79.98	7.4	38.54	3.5
Housing Density	60.16	44.7	32.33	25.01	16.37

b. 0.125 mile radius with standardized data values (9 clusters)

Means	Most Urban	2	3	4	5	6	7	8	Least Urban
Accessibility	11.15	16.53	7.95	17.09	4.76	3.68	2.38	1.51	1.36
Urban Uses	41.13	5.9	5.96	1.82	1.23	1.31	1.28	1.31	1.39
Single-family Residential	7.9	52.42	10.38	91.89	68.99	39.83	19.52	2.28	1.69
Housing Density	41.5	57.13	60.13	53.63	28.47	25.86	21.02	19.98	10.58

Map 5: Typology for the Seven-county Region

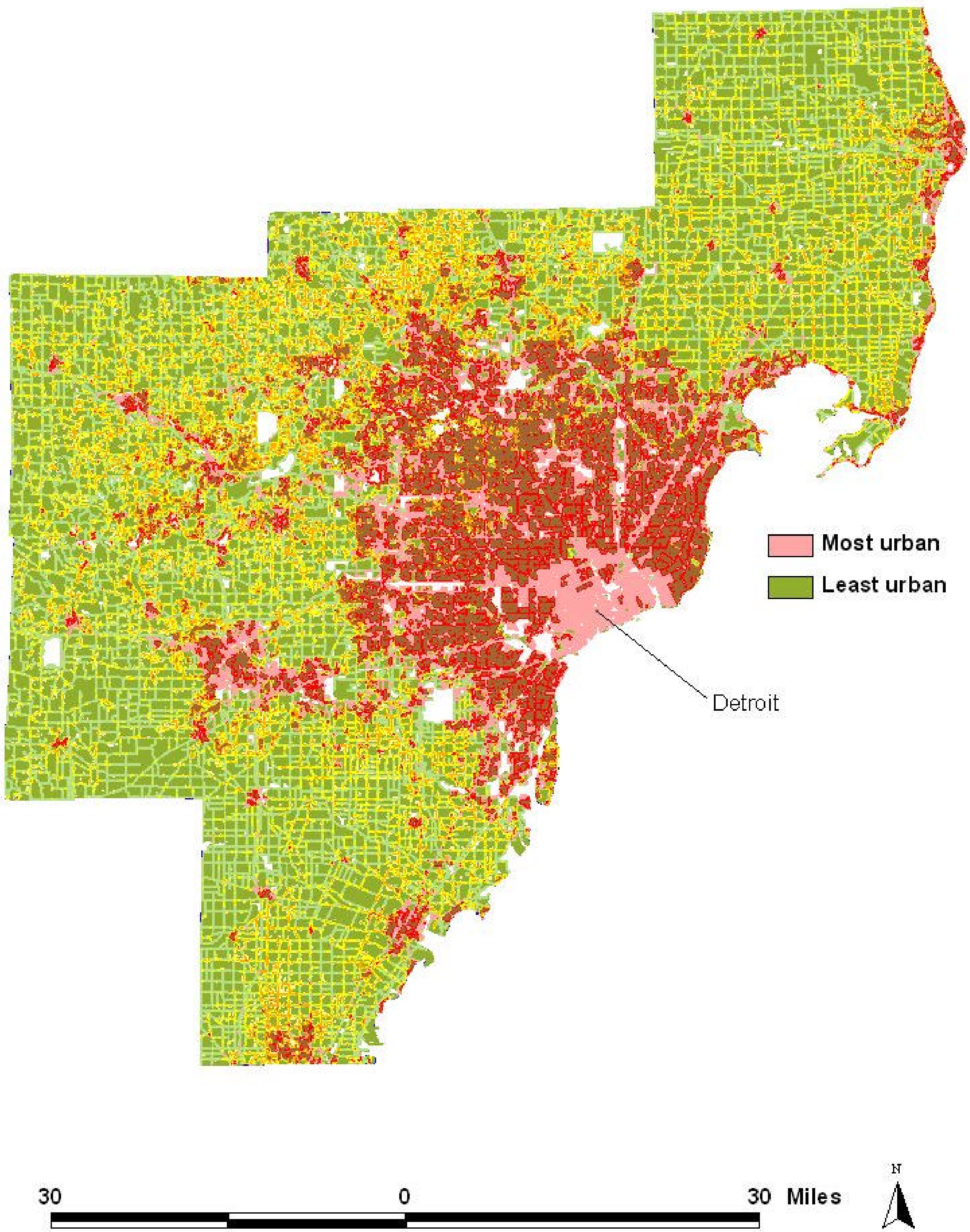


Table 5: Comparison of values based on geographic extent

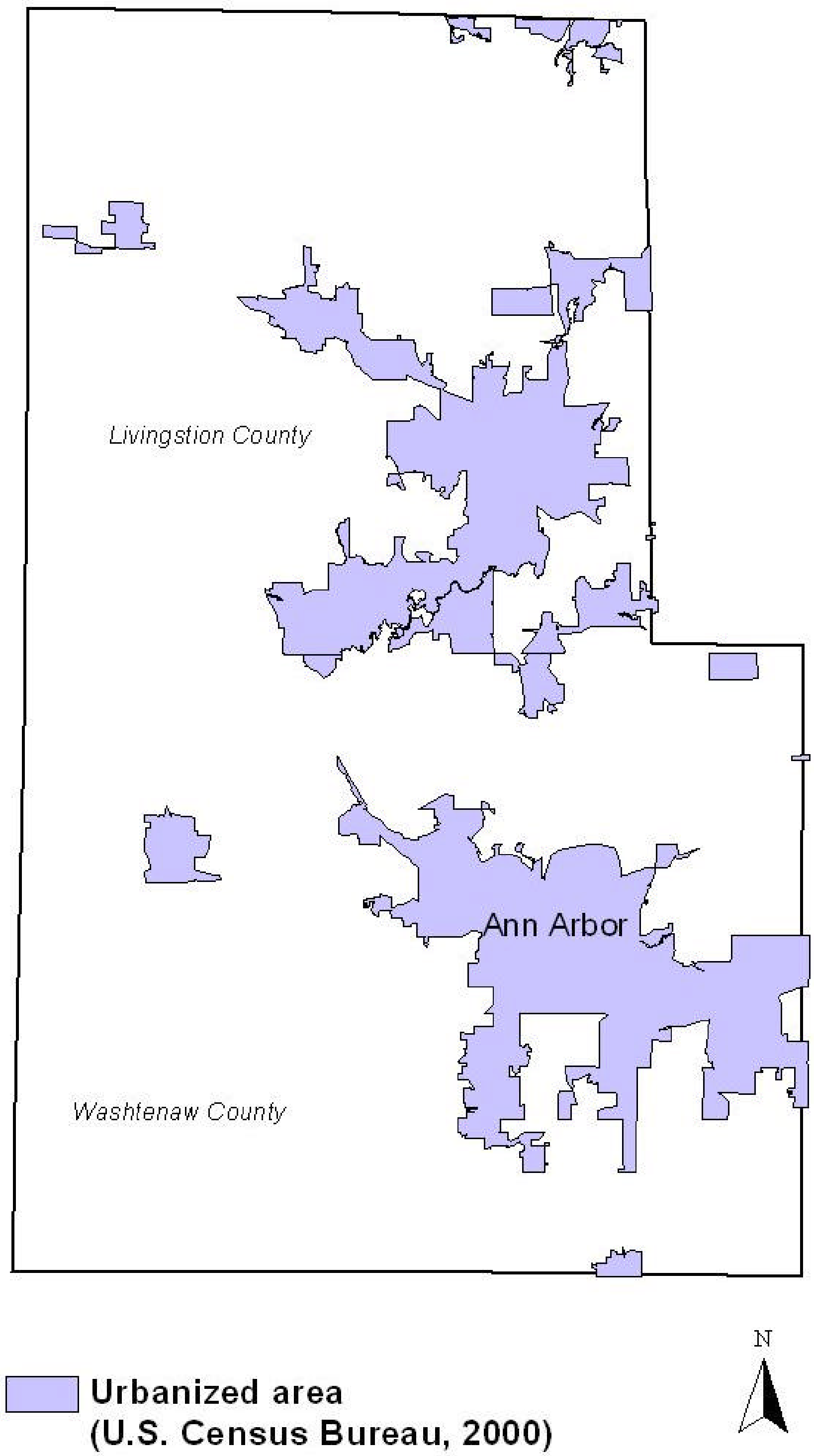
a. 0.125 mile radius for Washtenaw and Livingston (9 clusters)

Means	Most Urban	2	3	4	5	6	7	8	Least Urban
Accessibility	11.07	11.69	18.75	2.37	5.42	3.82	2.38	1.52	1.37
Urban Uses	40.37	5.4	2.77	1.9	1.36	1.36	1.28	1.34	1.42
Single-family Residential	8.48	23.53	87.42	4.55	69.08	40.45	19.61	2.29	1.69
Housing Density	45.7	61.1	56.44	33.78	30.81	26.13	21.05	20	10.57

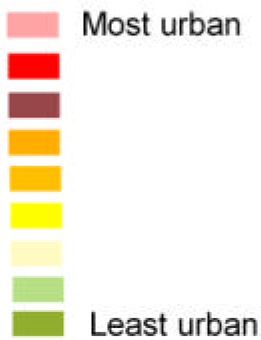
b. 0.125 mile radius for eight-county region (8 clusters)

Means	Most Urban	2	3	4	5	6	7	Least Urban
Accessibility (reversed)	12.16	10.78	11.48	21.94	24.86	99.64	28.16	99.97
Urban Uses	21.88	10.69	2.41	1.46	1.69	1.15	2.37	1.55
Single-family Residential	8.3	52.03	91.99	67.56	32.4	40.39	6.57	2.73
Housing Density	37.39	39.06	40.75	14.97	10.95	10.58	7.31	6.87

Appendix A: The two-county study region



Appendix: B



---

[i] Research questions could include: “Are residents of a certain type of neighborhood more likely to walk to destinations than residents of another type?” or “Are the residential preferences of a metropolitan region, which is composed of balanced and different kinds of neighborhoods met more often than a metropolitan region which is quite homo genous?”

[ii] In my dissertation research, a neighborhood typology is needed for: sampling; examining whether a lack of different types of neighborhoods could be a factor in choices for low-density, auto-mobile oriented, land use segregated neighborhoods; and for reporting and displaying trends in the study area.

[iii] Cul-de-sacs were also incorporated as measures in some of the analyses I have undertaken, however, those analyses are not included in this paper or in the final typology, mainly due to obtaining results that could not be verified in field checks.

[iv] Due to technical difficulties observed in creating a dasymetric map to better allocate the location of housing unites via the use of the land use layer, housing unit density obtained from the Census Bureau was used as the sole indicator of density.

[v] The two layers; intersections and street length, were reduced to one layer with the use of cluster analysis to depict accessibility.

[vi] Means are derived from attribute values for different layers. Cluster analysis is sensitive to data values, thus, a common data value range is important to have among different data layers

[vii] Several of the following maps and tables display this issue more clearly than Maps 1a & 1b and Table 1 a & b (such as Table 2c and Map 2c).

[viii] Tables 3a and 3b suggest that with the addition of land use variety, means of the other variables in different clusters have not changed significantly. If land use variety layer had large differentiation among different clusters, other variables may have had as well compared to Table 3a