Internally Connected, No Commercial, With a Touch of Open Space:

The Neighborhoods of New Homes in the Portland Metropolitan Area

Yan Song[a] and Gerrit-Jan Knaap[b]

[a] ys@email.unc.edu
Department of City and Regional Planning, CB#3140
University of North Carolina
Chapel Hill, NC 27599-3140
Phone: 919-962-4761
Fax: 919-962-5206

[b] gknaap@ursp.umd.edu
Suite 1112, Preinkert Field House, Bldg. 054,
National Center for Smart Growth Research and Education
University of Maryland
College Park, MD 20742
Phone: 301-405-6083
Fax: 301-314-5639

Yan Song is an assistant professor at the Department of City and Regional Planning at the University of North Carolina at Chapel Hill. She received her Ph.D. in Urban and Regional Planning from the University of Illinois at Urbana-Champaign. Her research interests include land use planning, urban built environment, and economics of land use regulations.

Gerrit-Jan Knaap is director of the National Center for Smart Growth Research and Education at the University of Maryland. His research interests include the economics and politics of land use planning, the efficacy of economic development instruments, and the impacts of environmental policy.

Internally Connected, No Commercial, With a Touch of Open Space: The Neighborhoods of New Homes in the Portland Metropolitan Area

Abstract

For many years, neighborhoods have been classified as either "suburban" or "traditional." But new homes today are built in many different types of neighborhoods with many different design features. In this paper, we develop a quantitative method for classifying the neighborhoods of new homes in the Portland metropolitan area. We proceed in three steps. First we measure urban form attributes of neighborhoods around newly developed homes. We then use factor analysis to identify a small set of factors that capture essential differences in urban form. Finally we use cluster analysis on these factor scores to identify distinctly different neighborhood types. Applying these methods to neighborhoods around new single family homes in the metropolitan Portland, Oregon, we are able to identify eight factors of urban form and six neighborhood types. We then show that most new single family homes in metropolitan Portland are built in new suburban neighborhoods but a substantial portion is occurring in traditional urban neighborhoods.

Introduction

The character, causes, and consequences of urban form remains hotly debated subjects. In much of the debate, however, neighborhoods are often classified as "traditional urban" or "suburban sprawl." While useful as a general characterization, this simple distinction fails to capture the tremendous variation in the physical form of metropolitan landscapes. Thus this simple classification limits our ability to address meaningful distinctions and evaluate change in the quality of neighborhoods.

Better characterizations of neighborhood types is also needed for studies on residential location choice and consumer preferences. Most previous studies presume that there are only two kinds of neighborhoods: traditional/neo-traditional and suburban and then analyze differences in preferences between the two. Aurbach (2001), however, argues that residential environments cannot be adequately characterized as simply traditional or suburban and several recent studies have sought to develop richer characterizations of urban form. Song and Knaap (2003), in their analysis of the impacts of urban form on property values, argued that in fact there are many different types of neighborhoods with many different design features.

Better methods of classifying neighborhood types are also needed for transportation planning. Hall (2001), for example, detailed the shortcomings of conventional transportation planning practice which only recognizes two zones: urban and rural. He argued that this coarse classification system leads to poorly designed and malfunctioning street systems. A new comprehensive classification system is essential for designing a transportation system that serves a broad range of residents and activities. In addition, a more accurate classification of neighborhood types is needed to improve models involving travel behavior (Bagley *et al.* 2002).

In this paper we develop a quantitative method of classifying neighborhoods that goes beyond the dimensions of traditionalness and suburbanness. We begin by identifying relevant attributes of physical form and computing indicators of street pattern, density, mixed land uses, accessibility, alternative transportation modes, and natural environment based on parcel-level GIS data. We then use factor analysis to derive generalized dimensions of neighborhood character. We then use cluster analysis to understand the variation in neighborhood form found among the individual residential parcels based on their similarity and dissimilarity within the predetermined set of dimensions. Finally, we examine the proportion of new homes in the Portland metropolitan area that are built in each neighborhood type. Our results reveal that most new single family homes in metropolitan Portland are built in new suburban neighborhoods but a substantial portion is occurring in traditional urban neighborhoods.

Previous Studies on Classification of Neighborhood Types

In the past few years, urban designers have worked towards the development of more nuanced characterizations of urban form. The Urban Transect, developed by Duany Plater-Zyberk & Company (DPZ), is a recent example of a more nuanced classification system. The central notion of the Transect is a geographical cross-section of a region including a gradient of area types, ranging from rural to urban. Components of the built environment: building, lot, land use, and streets, can then be organized into each area type (Duany and Talen 2002 and Berke *et al.* forthcoming). As shown in Figure 1, the rural-to-urban continuum can be further segmented into six discrete area types: rural preserve, rural reserve, sub-urban, general urban, urban center, urban core.[1] As one moves along the gradient of these area types, differences in design, ecology and social structure are apparent. According to Duany and Talen (2002), the transect can be used as the basis for a regulatory land use code to systematize differences in design, ecology and social structure and to plan for the character of places. Urban elements such as housing types, street design, and housing setback can be specified, using the transect, by each area type.

Despite recent efforts to identify the gradient of area types along the Transect, clear standards remain elusive. Berke *et al.* (forthcoming) argue that the assignment of boundaries of the Transect districts introduces a subjective aspect to the classification process. Thus it is necessary to formalize the classification of area/neighborhood types ranging from rural to urban to facilitate the plan-making process of the land classification plan across the Transect.

--insert Figure 1 about here--

Quantitative attempts to classify neighborhoods are rare. Bagley *et al.* (2002) provide a recent review. They found that most efforts of characterizing neighborhood types have appeared in the residential choice and transportation literatures and take one of two general approaches. The first approach uses location as the principal criterion. Neighborhoods that are located in or close to the central business district (CBD) area or city centers are defined as urban and neighborhoods that are further away from CBD are defined as suburban. The second approach relies on a particular set of intrinsic traits of the neighborhoods themselves, rather than on their location. Using this approach, “traditional”, “neo-traditional”, or “urban” neighborhoods are characterized by traits such as higher densities, mixed land uses, and a grid street network pattern. On the opposite extreme, “suburban” neighborhoods are characterized by segregated land uses and curvilinear streets with cul-de-sacs. Bagley *et al*. (2002) argue that a central theme of these approaches is to classify neighborhoods as either traditional/neo-traditional or suburban (pp. 690):

> "There are several problems with this dichotomous approach to classifying neighborhoods. First, traditionalness-suburbanness is not an either-or condition; rather, it is a continuum along which it is possible to fall. Further, it is not a monolithic construct; rather, neighborhood type designation is a composite of a number of traits and it is possible for a neighborhood to look more traditional on some traits and more suburban on others. Thus, neighborhood type may involve multiple dimensions rather than a single continuum.…restricting the designation of an entire neighborhood to one of two discrete types either results in discarding considerable data (for 'hybrid' neighborhoods) or distorting the subsequent analysis (through misclassification)."

A number of studies use a variety of dimensions of to classify neighborhood type. In an early study, Handy (1996) acknowledged that there are at least three types of neighborhoods: the traditional, the early-modern, and the late-modern neighborhoods. She found variations in the design of street layouts, housing and garage setbacks, level of integrating multifamily housing, and commercial establishments in different neighborhoods. For example, the traditional neighborhoods have rectilinear grids, the late-modern neighborhoods have curvilinear layouts, and the early-modern neighborhoods have a combination of both. More recently, Bagley *et al.* (2002) employed demographic, socioeconomic, attitudinal, lifestyle, and travel-related data collected through surveys, and land use, the roadway network and public transit data collected through site surveys of five San Francisco Area neighborhoods and identified two distinct dimensions through a factor analysis: a traditional factor which is associated with higher population density, more convenient public transit, smaller home size, less presence of backyard and less parking, and a suburban factor which is associated with higher speed limit, longer distance to nearest grocery store and park, higher ease of cycling, and less presence of a grid street network. Rather than being either "traditional" or "suburban", neighborhoods can score high or low on both dimensions. They therefore concluded that the concept of traditionalness and suburbanness might be better viewed as two dimensions instead of two extreme ends of one dimension.

All studies that focus on neighborhoods must confront the difficult problem of defining neighborhoods. In previous studies on the neighborhood classification, neighborhood boundaries were generally defined as census tracts, traffic analysis zones (TAZs), zip codes or other pre-defined neighborhood boundaries. Thus use of such boundaries introduces the modifiable areal unit problem (MAUP), where the units of analysis are too large to reflect more localized patterns of development. To avoid this problem we define neighborhoods as the 1/4-mile buffer around a particular parcel. This definition avoids the MAUP problem and enables use to focus on the neighborhoods around newly developed single family parcels.

The Study Area and Data

Empirical Context

Metropolitan Portland, Oregon, our study area (see figure 2) is well known as a pioneer in the effort to manage urban sprawl. The effort involves many policy instruments including its infamous urban growth boundary, its light rail transit system, and Metro's[2] 2040 plan. Many of these policies are explicitly intended to alter urban design.

Portland's UGB was adopted in 1979 and has expanded very little since then. Under Oregon State Law, all land outside the UGB is designated for farm or forest use and all land inside the UGB is designated for urban use. The intent of the UGB is to protect natural resource land, foster high density urban development, and minimize public service costs.

Portland's light rail system was established on the east side of the metropolitan area in 1986, and was extended to the west-side in 1998. To increase transit ridership and accommodate growth within the UGB, a number of policies were adopted to facilitate transit-oriented development. Such policies include transit area overlay zones with minimum density requirements and several public-private partnerships established to encourage high-density housing and employment growth around station areas. In addition, there are transit supportive plans in every jurisdiction along the transit corridor. Further, the Oregon Transportation Planning Rule requires local jurisdictions to establish subdivision and development ordinances which promote transit and walking, and requires a 10 percent reduction in both parking and driving per capita over twenty years.

-- insert Figure 2 here --

Metro's 2040 Growth Concept Plan, adopted in 1996, was developed to guide the process of urban development within the UGB. The plan explicitly encourages redevelopment within the urban growth boundary, especially in designated urban centers and transit corridors. The plan also features a hierarchy of central places each with unique urban design elements. To implement the plan, Metro has set binding targets and performance measures, such as designating small lot subdivisions and establishing minimum housing densities, for its subordinate cities and counties (Metro 1992, 1996 and 2002*)*. As a result, many jurisdictions within the metro area have adopted their own urban design policies and guidelines. Multnomah County, for example, adopted a "design zone" which overlays the entire downtown and specified that all new projects must meet more than 200 design guidelines. These guidelines focus mainly on the street level to encourage pedestrian activity (Multnomah County 1991). In Washington County, subdivision regulations provide detailed urban design standards for street design, sidewalk width, and shape of blocks (Washington County 1997).

In what follows, we compute measures of urban form, factor them into a limited set of design factors, and develop statistically defined neighborhood classifications. We also report the types of neighborhoods in which each of 6788 new single family homes was constructed in the year 2000. Though our analysis identifies the types of neighborhoods in which new developments are taking place, our intent is not to analyze the efficacy of Portland's efforts to manage urban growth or alter urban design per se. Such an analysis would require information on how neighborhoods have changed over time or how neighborhoods in Portland compare with those in other metropolitan areas. We caution, however, that the classifications developed using data from Portland could well differ significantly from those developed with data from other, less progressive metropolitan areas.

Data

Neighborhood types can be characterized by analyzing GIS data, hard-copy maps, aerial photographs and data collected through site visits (Handy 1996). Here we use GIS data from Metro's Regional Land Information System (RLIS). These data include: (1) Parcel based property (taxlot) data. For each of the properties there are attributes such as: yearbuilt of the structure, land use type, lot size, and floor space. (2) Street network centerlines, (3) Major transit stations and lines, (4) Parks, open space and other recreational land uses, (5) Tree canopy, (6) Sidewalks and bikepaths, (7) Political and planning boundaries, such as county and city boundaries and urban growth boundaries, and (8) Aerial photographs.

Measures of Physical Form of Built Environment

To classify residential neighborhood types, we first identify a set of measures that can be used to examine residential development patterns. Variables associated with the physical form of the built neighborhoods have been established in the literature. Street design, mixed land uses, accessibility, density and alternative transportation modes are common variables used to identify neighborhoods types (Cervero and Radisch 1996, Filion and Hammond 2003, Friedman *et al.* 1994, Handy 1996, Moudon *et al.* 1997, Song and Knaap 2004, Southworth 1997, and Srinivasan 2002). One additional dimension – natural environment – is added in this study.

Before elaborating on the set of measures, it is noteworthy that adoption of appropriate unit of analysis is essential to reflect correctly development patterns (Moudon *et al.* 1997 and Srinivasan 2002). Past studies used TAZ or Census Tracts as neighborhood boundaries to compute measures of neighborhood types. These measures might be misleading since the units of analysis were too large (Moudon *et al.* 1997) and thereby neglecting the fact that characteristics of development patterns vary across different parts of the predetermined neighborhood. To avoid this problem of ecological fallacy, in this study, all measures are computed based on individual parcels. Specifically, the measures are either based on the immediate locale to quantify the characteristics of the parcel itself, or the ¼-mile buffer area around the parcel to quantify the characteristics of the immediate neighborhood (Figure 3). Our methodology of computing characteristics of physical form of neighborhoods based on the parcel allows us to compute the following unique measures for each of the 6788 single-family houses.

Street Design Measures include:

- #Intersection – number of intersections in the buffer area of the parcel;
- #Cul-de-sac – number of cul-de-sacs in the buffer area;
- StreetLength – length of street miles in the buffer area;
- BlockSize – perimeter of the block where the parcel is located in;
- Nbr_BlockSize – median area of the blocks in the buffer area;
- Setback – Distance from the centroid of the lot to the nearest street.

Density Measures include:

- LotSize – lot size of the parcel;
- Nbr_LotSize – median lot size of single-family parcels in the buffer area;
- #Lots – number of single-family lots in the buffer area;
- FloorSpace – floor space of the single-family house on the lot;

- Nbr_FloorSpace – median floor space of all single-family houses in the buffer area;

Mixed land uses Measures include:

- Commercial – acres of commercial land use in the buffer area;
- #Store – number of neighborhood stores in the buffer area;
- Industrial – acres of industrial land use in the buffer area;
- Public – acres of public land use in the buffer area;
- Mfr – acres of multi-family residential land use in the buffer area;

Accessibility Measures include:

- Com_Dist – distance from the lot to the nearest commercial land;
- Bus_Dist – distance from the lot to the nearest bus stop;

Alternative Transportation Modes include:

- #BusStops – number of bus stops per buffer;
- Sidewalk – length of sidewalks in the buffer area;
- Bikelane – length of bikelane the buffer area; [3]

Natural Environment Measures include:

- OpenArea – acres of open space per buffer;
- TreeCanopy – acres of the area with tree canopy in the buffer area.[4]

Summary statistics for all these measures are provided in Table 1.

-- insert Figure 3 and Table 1 here --

Method of Classification of Neighborhood Types

Factor analysis

Some of the above measures of physical neighborhood form are highly correlated. The distribution of cul-de-sacs, for example, is highly correlated with the distribution of large blocks. Therefore it is useful to condense these variables into a smaller set of variables that removes the correlation in the data. We use factor analysis, a technique for data reduction, to help us understand the dimensional structure of our group of variables.

From the above defined twenty-three correlated variables measuring various aspects of physical neighborhood form, we use factor analysis to extract eight dimensions (factors). The results are presented in Table 2. The variables are listed in the order of the size of their factor loadings sequentially for each factor. The extracted factors reproduce about 82% of the total variation among the cases on these twenty-one[5] characteristics by knowing the cases' scores on the eight factors. Principle component analysis for extraction and Varimax with Kaiser Normalization as rotation method[6] in the factor analysis are used since this combination explained the most variation in the data.

Inspection of Table 2 shows that there are eight dimensions (factors) of physical neighborhood form that emerge from the analysis. The last row of Table 2 presents the percent of the total variation accounted for by each factor. The first factor reflects the dimension *Street Network Design*. Factor loadings indicate that more intersections, more street miles, less cul-de-sacs and smaller blocks contribute to a smaller value of factor 1. The second factor includes *Density* variables: smaller lots (both the lot itself and other lots in the immediate buffer area), more lots in the buffer area and shorter setback contribute to a larger value of factor 2. The third factor reflects the level of *Commercial Uses*: more commercial land uses, more neighborhood stores and shorter distance to commercial units contribute to a smaller value of factor 3. The fourth factor relates to *Transit* variables and shows that shorter distance to nearest bus stop and more bus stops in the buffer area contribute to a larger value of factor 4. The fifth factor relates to *House Size* and shows that larger houses (both the structure itself and other houses in the buffer area) contribute to a larger value of factor 5. The sixth factor relates to other *Mixed Land Uses*: more industrial and more public land uses lead to a smaller value of factor 6. The seventh factor detects variables related to *Natural Environment*: more area of tree canopy and more open space contribute to a smaller value of factor 7. The last factor relates to *Multi-family Use* and indicates that more multi-family land use in the buffer area leads to smaller value in factor 8.

Cluster analysis

Understanding and distinguishing the variation in physical neighborhood characteristics found among the 6788 sites is the key goal of this research. To do that, it is necessary to identify regions of data points that share similar characteristics in the value of the above dimensions (factors) no matter where they are located spatially.

An empirical cluster analysis, a method of combining observations into groups based on their similarity within a set of predetermined characteristics, is performed to facilitate the identification of neighborhood types. K-means cluster analysis[7] is used to classify all 6788 homes into different neighborhood types on the basis of similarities and dissimilarities in the values of the eight factors derived from previous step[8] in such a way that each neighborhood type is internally as similar as possible but externally dissimilar to other neighborhood types.

The best clustering solution, based on the interpretability of the results and associated cluster statistics, is found to be a six-cluster solution. The values of the cluster centroids for each of the six neighborhood types are presented in Table 3 and again graphically in Figure 4. The centroids values of the individual clusters uncover the characteristics of the each neighborhood type. Performance of each neighborhood type on each of the eight dimensions of physical neighborhood form can be derived from the centroids values. The last row of Table 3 reveals the distribution of homes by each neighborhood type. For example, there are 2852 homes built in year 2000 belonging to neighborhood type 3. Table 4 provides additional information on the distribution of homes within each neighborhood type by age of their immediate neighborhoods – determined by the median "year built" attribute of all single-family units contained in the ¼-mile buffers of the homes.

Analysis of Neighborhood Types

Combined with information provided in Figure 4 and Tables 4 and 5, the following discussion describes characteristics of each neighborhood type.

- Neighborhood Type 1 – Sporadic rural developments. Only 37 structures, which account for 0.5% of all structures built in year 2000, were built in neighborhood type 1. Most of these structures are built in unincorporated areas outside the urban growth boundary (Figure 5). Neighborhood type 1 has typically rural features: large lots and houses, sparse transportation networks, dominant rural land uses with abundant open spaces. Type 1 neighborhoods are dispersed across the rural landscape.

- Neighborhood Type 2 – Bundled rural developments. Three hundred twenty five structures, 5% of all structures built in year 2000, were built in neighborhood type 2. Type 2 neighborhoods resemble type 1 in their rural ambience, however, type 2 neighborhoods have a cluster of structures. These neighborhoods are dense although not quite connective, and are proximate to public land uses such as schools. More than 76% of the type 2 structures are built into neighborhoods (buffers) that are developed after the 1990s. Most of type 2 structures are located in small towns around Portland. For example, there are 139 type 2 homes grouped into three subdivisions in the city of Sandy which is about seven miles southeast to Gresham. These homes have small lots and the subdivisions are developed with densities higher than the minimum densities specified by the city's comprehensive plan and zoning code. The fact that these subdivisions have developed at densities well above the minimum density might be an indication of the power of market forces in keeping lots small due to high cost of land.

- Neighborhood Type 3 – Outer Ring Suburban Infill. The largest neighborhood type is the outer ring suburban infill, which makes up 42% of the houses built in year 2000. Type 3 structures are located in Portland's suburbs which host the very image of the standard postwar cityscapes: relatively large lots are of a uniform size and shape, curvilinear street arrangements and cul-de-sacs dominate the landscape, street widths are exceedingly wide, and predominant detached single-family homes with moderate open space close repeat themselves over and over. Generally there are no nonresidential land uses in type 3 neighborhoods. An additional observation reveals that the outer ring suburbs do not have metro-wide public facilities and concentrated employment centers which is equivalent to Houston's Galleria (Abbott 1997). That is to say, "edge city" did not happen here in the outer ring suburbs.

- Neighborhood Type 4 – Downtown, Inner and Middle Ring Suburban Redevelopments/Infill. Strikingly, neighborhood type 4, which presents homes that are located in downtown areas or at the inner and middle ring of the cities, makes up to the third largest neighborhood type holding 17% of the houses built in year 2000. Information provided in Table 4 reveals that most of these structures are built in areas developed before the 1980s – with 82% in areas developed before 1960. The homes in downtown area are on sites for most pre-World War II urbanization and have characteristics such as: grid street networks, small lots and high density, accessible bus services, and abundant mixed land use such as commercial and multi-family residential uses. However, there are virtually no open space nearby which presents a major shortcoming of many older traditional neighborhoods. Another distinct character of the homes in downtown area is their location on 200-foot blocks. These small blocks were developed by the pre-war land developers to maximize the rent received from higher priced corner lots – the smaller the blocks, the more corners to rent per land claim. From the late 1930s when the car was added to the settlement pattern of earlier years, the inner and middle suburban rings kept much of the pre-war characteristics: grid systems of streets remain typical in these older parts of the region. Although, there began to show a modified rectilinear grid with blocks of varying sizes. The fact that 17% of new homes have been refilled into this area reflects the efforts of the city to revitalize downtown.

- Neighborhood Type 5 – Composite Greenfields. To a large extent neighborhood type 5, which contains almost 10% of the houses built in year 2000, resembles neighborhood type 4: modified grid and connective street networks, high density, moderate accessibility to bus stops, and ample multi-family residential uses in the immediate neighborhoods. However, it differs from type 4 in that most (82%) of these structures are built into new neighborhoods developed after 1990, as indicated by Table 4. In the above mentioned dimensions they are “neo-traditional.” Homes built in Orenco Station Neighborhood, one touted new urbanist neighborhood, fit into this neighborhood type. However, this neighborhood type is only partially “neo-traditional” due to the general absence of commercial uses and the neighborhoods’ disengagement from the rest of the region. Thus the rubric “composite greenfields” – a composite of neo-traditional and conventional styles. Most of these structures are located in recent greenfields located at the fringe of Washington County, the fastest growing county in Oregon and are close to Intel Corporation. Probably this is the area that Joel Garreau has described as an “emerging edge,” but unequivocally, it presents a less sprawling picture at least in its site design.

- Neighborhood Type 6 – Partially Cluster Greenfields. Neighborhood type 6 contains 25% of the new homes built in year 2000. Type 6 homes are similar to type 5 homes in their greenfields location, but very much resemble type 3 (the outer ring suburban) homes, in most of the physical neighborhood form dimensions: some cul-de-sacs, curvilinear streets, and absence of mixed land uses and transit services. Type 6 is distinct in its inviting environment which presents lavish open spaces. Type 6 bears a close resemblance to "conservation development" or "cluster development," which calls for site design technique that concentrates dwelling units in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site. It is necessary to note that the benefits of open space design can be amplified when it is combined with other site design techniques such as narrow streets and alternative turnarounds. However, these traits appear to be missing in type 6 neighborhoods, thus the name "Partially cluster greenfields."

Caveats and Limitation

Note that our approach of classifying neighborhood types only focuses on physical neighborhood form. We do not consider any social or economic characteristics.

It is also essential to note that the results of identifying neighborhood types and examining distribution of the new homes built in 2000 apply only to Portland metropolitan area which is not necessarily representative. Future study can be carried out by selecting a fairly uniform set of relevant variables for different geographic areas. Generalizations can then be made through a comparative study of the housing development patterns and neighborhood types across several metropolitan areas. This is our next task.

Finally, it is noteworthy to point out one additional finding. In our study, neighborhoods are defined in terms of various characteristics rather than as a geographic location *per se*. In other words, spatial contiguity is not included as a criterion in our methodology of classifying neighborhood types. However, not surprisingly, our neighborhood types coincide with location. This implies an intrinsic relationship between location and neighborhood characteristics. Inference on spatial location can be made by observing internal characteristics of neighborhoods, and vice versa. We leave this for future exploration.

Conclusions

Despite the need for a more accurate taxonomy of neighborhood types which captures multi-dimensional neighborhood forms to facilitate land use classification plan, residential location choice modeling, consumer housing preference identification, travel behavior modeling, and transportation planning practice, classifying neighborhood types has received limited formal analysis. In this paper we developed a method of identifying regions of similar characteristics. We began by identifying and computing relevant attributes of physical form: street pattern, density, mixed land uses, accessibility, alternative transportation modes, and natural environment based on parcel-level data using Geographic Information Systems (GIS). We then employed factor analysis to derive the generalized dimensions of neighborhood character. Finally, we adopted cluster analysis to understand the variation in neighborhood form found among the individual residential parcels based on their similarity and dissimilarity within the predetermined set of dimensions.

We then applied the methodology to identify neighborhood types for the 6788 single-family homes built in year 2000 in Portland, Oregon, metropolitan area. Our findings suggest that the neighborhoods where the new homes in 2000 are built into can be categorized into six types: the largest group is the outer ring suburbs which houses 42% of the new homes, the second largest is the partially cluster greenfields which holds 26% of the structures, the third largest neighborhood type is identified as the downtown, inner and middle ring suburbs which makes up to 17% of the home constructions, composite greenfields contain 10% of the new homes, and bundled and sporadic rural developments hold 5% and 0.5% of the homes respectively.

Though our intent was not to evaluate the efficacy of Portland's approach to growth management, our results do have policy implications. The finding that the dominant share of new homes are still being built in suburban-style neighborhoods suggests that Portland is not immune to the problems that plague new, poorly planned suburbs elsewhere in the country, such as isolated residential areas, automobile dependence, and lack of metro-wide public facilities and concentrated employment centers. People who live in those greenfields locations at the edges of Portland, like those who live in most new suburbs elsewhere, must get in their cars to go to other activities. However, despite the main picture presenting plentiful standard suburban housing, the findings depict several positive views:

- Old neighborhoods with tightly packed houses have also become hot spots for new home redevelopments. The fact, that 17% of new homes/redevelopments are widely dispersed in downtown areas and inner and middle rings of suburbs, makes for a healthy metro area in its center. The reasons for the vital metropolitan center are multifold. The main argument is the Metro and Portland's efforts to maintain strong downtowns and to recycle older pre-war neighborhoods built from the 1880s through the 1930s. Portland has seen essentially no abandoned neighborhoods or "dead zone" of derelict industrial districts, with many of its downtown areas attracting gradual reinvestment. Another explanation is offered by Abbott (1997). He argues that a tight housing market has led to price increases in previously undervalued neighborhoods and therefore families and speculators were hunting for new home constructions or redevelopment opportunities in those neighborhoods.

- The existing underutilized outer ring suburbs have become the largest area accommodating new house developments, despite the general resistance from many developers who argue that it's more expensive to do "infill" – developing small pockets of land within existing developed areas – than to develop new land at the urban fringe. The typical opposition experienced elsewhere, such as NIMBY and/or no-growth, seems to be less a concern here in Portland either due to the moral merits that Portlanders have to promote public realm (Abbott 1997) or as a result from "tough policy choices – choices that have won and maintained strong majority support on the basis of economic self-interest" (Richmond 1997, p 54).

- House developments that are neo-traditional (Orenco Station developments) or partially neo-traditional accounts for 10% of the new homes in 2000. While the question of whether neo-traditional developments are more or less expensive to build remains to be answered, developers and researchers find that the properties in Orenco Station neighborhood often garner premiums that are 15.5% higher than conventional subdivisions (Song and Knaap 2003). Portland has also witnessed some partial conservation developments. This type of cluster developments, used to preserve open spaces, were found to appreciate 12% faster than conventional subdivisions over a twenty year period in Massachusetts (Lacey and Arendt 1990). Clearly, neo-traditional and conservation developments are valuable from an economic standpoint – what makes for better lives will be more marketable. Despite the marketability, there are a number of real and perceived barriers to the wider acceptance of neo-traditional and conservation designs by developers, local governments and the general public. The review process is generally more lengthy, costly, and potentially controversial than that required for conventional subdivisions. Local governments sometimes lack the efficiency to revise zoning ordinances and to relax the minimum lot sizes, setbacks and frontage distances for the residential zone in order to facilitate neo-traditional developments. Finally, the general public is often suspicious of neo-traditional or conservation development proposals, fearing more intense development and amount of traffic. It is the planners' tasks to address these misconceptions through a clear ordinance and by providing training and incentives to the development and engineering community.

Clearly, development patterns of housing and neighborhood form are influenced by a variety of factors. The market is of course important in shaping our current development patterns. Socioeconomic changes, for example increased wealth and increased economic and social polarization, have affected neighborhood morphology (Filion and Hammond 2003). It is equally clear that factors that exist to accomplish specific public policy goals, such as housing, transportation, environmental protection, have also played a substantial role in shaping development patterns, intentionally or accidentally (Mondale and Fulton 2003; Nelson et al. 2002).

In sum, as the problems sprawl creates are complex and it is hard to switch to a different pattern of growth after several decades of precedent, the picture that Portland's new housing developments draw is an indeed encouraging one – the maturation of the suburbs and the revitalization of older urban neighborhoods. This picture corresponds to two components that Calthorpe and Fulton (2001) draw for a regional city. In a regional city, neighborhood design is seen as one "building block" of regional design and new investment would be provided in transit systems, transit-oriented development, multifamily housing, urban revitalization, and open space. The findings here provide some evidence of the reassertion of urban design and physical planning strategies as tools to build an alternative to sprawl in Portland. However, the very necessary one component – the emergence of networked, connected and polycentric regional communities – is still missing from the portrait. These findings are consistent with results from previous study conducted by Song and Knaap (2004). Their study suggests that Portland's widely publicized growth management tools may have altered subdivision designs, but those tools appear to have had no effect on land use mix or accessibility. Different aspects of smart growth are incorporated in the planning models in Portland, but only partially so because some aspects are filtered out by inefficiencies in implementation or incapableness in comprehending the complexities of the issues. As the thrust of current planning initiatives are in developing physical planning and urban design strategies for the metropolitan region and in elaborating new urbanist rhetoric, the complexities of the political, social and economic obstacles hindering the alternative to sprawl need to be understood and incorporated in implementing planning reforms.

References

Abbott, C. 1997. The Portland region: Where city and suburbs talk to each other – and often agree. *Housing Policy Debate*, Vol 8 (1): 11 – 51.

Abbott, C. 2002. Planning a sustainable city: The promise and performance of Portland's Urban Growth Boundary. In Squires, G. D. (Ed.), *Urban sprawl: Causes, consequences and policy responses* (pp. 207 – 235). Washington, DC: The Urban Institute Press.

Aurbach, L.J. 2001. "The First Transect Seminar," *New Urban News*, vol. 6, no. 5, pp. 18-19.

Bagley, M.N., P.L. Mokhtarian and R. Kitamura. 2002. A methodology for the disaggregate, multidimensional measurement of residential neighborhood type. *Urban Studies*, Vol. 39, (4): 689 – 704.

Berke, P., D. Godschalk, E. Kaiser and D. Rodriguez, forthcoming. *Urban Land Use Planning*. Chicago: University of Illinois Press.

Calthorpe, P. and W. Fulton. 2001. *The Regional City: Planning for the End of Sprawl*. Washington. D.C.: Island Press.

Cervero, R. and C. Radisch. 1996. Travel choices in pedestrian versus automobile oriented neighborhoods. *Transport Policy*, 3: 127 – 141.

Duany, A. and E. Plater-Zyberk. 1992. The second coming of the American small town. *Plan Canada* (May): 6 – 13.

Filion, P. and K. Hammond. 2003. Neighborhood land use and performance: The evolution of neighborhood morphology over the 20th century. *Environment and Planning B: Planning and Design*, Vol 30: 271-296.

Friedman, B., S. Gordon. and J. Peers. 1994. Effects of neo-traditional neighborhood design on travel characteristics. *Transportation Research Record*, 1466: 63-70.

Hall, Richard, "TND Transportation Issues" in *New Urbanism: Comprehensive Report & Best Practices Guide*, New Urban Publications (2001) available at http://www.newurbannews.com/compreport.html

Handy, S.L. 1996. Urban form and pedestrian choices: Study of Austin neighborhoods. *Transportation Research Record* 1552: 135 – 144.

Knaap, G. (2000, June). *The Urban growth boundary in metropolitan Portland, Oregon: Research, rhetoric, and reality.* Paper presented at the workshop on urban growth management policies in the United States, Japan, and Korea, Seoul.

Lacey, J. and R. Arendt. 1990. *An examination of market appreciation for clustered housing with permanently protected open space.* Amherst, MA: Center for Rural Massachusetts.

Metropolitan Service District. 1992. *The Metro 2040 Growth Concept.* Portland, Ore.: Metropolitan Service District.

Metropolitan Service District. 1996. *2040 Regional Framework Plan and Functional Plan.* Portland, Ore.: Metropolitan Service District.

Metropolitan Service District. 2002. *Metro at a glance.* Portland, Ore.: Metropolitan Service District.

Mondale, T. and W. Fulton 2003. 'Managing Metropolitan Growth: Reflection on the Twin Cities Experience. A discussion paper prepared for the Brookings Institution Center on Urban and Metropolitan Policy. Available online: http://www.brook.edu/es/urban/publications/200309_fulton.htm

Moudon, A.V. 1992. A catholic approach to organizing what urban designers should know. *Journal of Planning Literature* 6: 331 – 349.

Multnomah County. 1991. *Special Design Guidelines for the Design Zones*. Available online: http://www.planning.ci.portland.or.us/pdf/dg_central_eastside.pdf

Nelson, A.C. 1994. Oregon's Urban Growth Boundary Policy as a Landmark Planning Tool, in Abbott, C., D. Howe and S. Adler (Ed), *Planning the Oregon way: A twenty-year evaluation*, Corvallis, OR: OSU press.

Nelson, A.C., R. Pendall, C.J. Dawkins and G.J. Knaap. 2000. The link between growth management and housing affordability: The academic evidence. A discussion paper prepared for the Brookings Institution Center on Urban and Metropolitan Policy.

Richmond, H.R. 1997. Comment on Carl Abbott's 'The Portland region: Where city and suburbs talk to each other – and often agree.' *Housing Policy Debate*, Vol 8 (1): 54 – 64.

Song, Y. and G.J. Knaap. 2003. New urbanism and housing values: a disaggregate assessment. *Journal of Urban Economics* 54: 218 – 238.

Song, Y. and G.J. Knaap. 2004. Measuring Urban Form: Is Portland Winning the War on Sprawl? *Journal of American Planning and Association*, Vol. 70, No. 2 (2004) 210 - 225.

Southworth, M. 1997. Walkable suburbs? An evaluation of neotraditional communities at the urban edge. *Journal of American Planning Association* 63: 28 – 44.

Srinivasan, S. 2002. Quantifying spatial characteristics of cities. *Urban Studies*, Vol. 39, No. 11, 2005 – 2028.

Washington County. 1997. *Community Development Code.* Available online: http://www.co.washington.or.us/deptmts/lut/plan01/comdev.htm

Table 1. Summary Statistics for All Variables

Variable	Unit of Measure	Mean	Std. dev.	Minimum	Maximum
#Intersection	# of counts	26.49	14.25	0.00	113.00
StreetLength	Feet	18038.45	6651.26	1879.45	52381.46
#Cul-De-Sac	# of counts	10.50	6.15	0.00	36.00
BlockSize	Acre	38.12	106.85	0.00	2744.579
Nbr_BlockSize	Acre	31.45	72.54	0.78	2542.09
Lot Size	Feet	8257.83	26451.72	797.49	1114563.74
Nbr_LotSize	Feet	8606.51	14163.86	1506.91	540419.55
#Lot	# of counts	256.74	129.60	2.00	732.00
Setback	Feet	81.20	61.33	0.08	1852.25
Commcial	Acre	2.91	7.07	0.00	125.93
#Store	# of counts	4.22	13.14	0.00	346.00
Com_Dist	Feet	2099.11	1417.55	52.88	15486.21
Bus_Dist	Feet	2831.26	5043.71	25.43	58237.29
#BusStops	# of counts	5.83	4.25	0.00	18.00
Sidewalk	Feet	14845.28	5853.93	0.00	64983.27
Bikelane	Feet	4236.65	5358.64	0.00	16849.85
Nbr_FloorSpace	Feet	1920.26	587.13	944.50	9290.00
FloorSpace	Feet	2177.26	1120.02	0.00	42513.00
Industrial	Acre	1.64	6.53	0.00	95.69
Public	Acre	7.17	11.17	0.00	66.18
TreeCanopy	Acre	4.38	3.62	0.00	11.98
OpenArea	Acre	3.69	2.97	0.00	9.83
Mfr	Acre	4.40	8.39	0.00	75.20

Table 2. Factor Analysis of Each Physical Neighborhood Form Dimension

Variable	Factor1 Street Design	Factor 2 Density	Factor3 Commercial Use	Factor4 Transit	Factor5 House Size	Factor6 Pub & Ind	Factor7 Nature Environment	Factor8 Mfr
#Intersection	**-0.927**	0.080	-0.107	-0.107	-0.066	-0.091	-0.048	0.162
StreetLength	**-0.907**	0.075	-0.166	-0.073	-0.055	0.010	0.029	0.228
#Cul-De-Sac	**0.903**	0.116	-0.016	-0.073	-0.025	-0.155	0.078	0.131
BlockSize	**0.895**	-0.079	-0.011	0.050	-0.025	-0.022	-0.100	0.097
Nbr_BlockSize	**0.694**	-0.381	0.099	-0.139	-0.019	0.113	-0.094	0.221
Lot Size	0.039	**-0.825**	0.003	0.218	-0.001	-0.029	-0.032	-0.056
Nbr_LotSize	0.079	**-0.818**	0.030	0.154	0.008	-0.032	-0.029	-0.153
#Lot	0.086	**0.759**	0.005	-0.213	0.154	0.203	0.203	0.246
Setback	0.121	**-0.726**	0.020	-0.002	-0.044	0.101	0.074	-0.134
Commercial	0.102	0.015	**-0.891**	-0.089	0.045	0.038	-0.032	0.035
#Store	-0.221	-0.02	**-0.813**	-0.013	-0.100	0.023	0.030	0.015
Com_Dist	0.241	-0.143	**0.657**	0.332	0.123	0.082	0.028	-0.316
Bus_Dist	0.198	-0.157	0.145	**-0.798**	0.185	0.142	0.209	-0.245
#BusStops	0.119	-0.003	-0.167	**0.764**	-0.025	0.086	0.092	0.039
Nbr_FloorSpace	0.250	-0.100	0.219	0.077	**0.731**	0.124	0.022	-0.067
FloorSpace	0.119	-0.276	0.039	-0.025	**0.661**	0.105	0.086	-0.003

Industrial	0.141	-0.006	-0.040	-0.204	-0.253	**-0.727**	-0.154	0.129
Public	0.163	0.049	0.062	-0.175	0.036	**-0.654**	-0.248	0.152
TreeCanopy	-0.059	-0.003	-0.107	-0.062	-0.049	0.004	**-0.747**	0.049
OpenArea	0.183	-0.002	0.104	-0.220	-0.178	0.104	**-0.655**	0.174
Mfr	-0.054	0.028	-0.004	-0.082	0.001	0.042	0.003	**-0.825**
% Var	0.20	0.16	0.11	0.09	0.08	0.07	0.06	0.05

Table 3. Cluster Centroid Values for Each of the Neighborhood Type

Dimensions	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6
Street Design	1.3264	1.1031	0.2791	-2.7458	-1.4626	0.6376
Density	-15.1439	0.0297	0.0214	0.6576	0.2489	-0.1945
Commercial Use	0.4125	0.7064	0.1580	-1.171	0.1186	-0.0966
Transit & Walk	-2.4084	-0.6375	0.4385	3.2652	1.0284	-0.4045
House Size	8.6918	0.3229	0.3306	-0.4385	-0.1582	-0.3817
Pub & Ind	-0.4284	1.2652	0.2538	0.4513	-0.0582	-1.0223
Nature Environment	-1.4045	0.3085	-0.8430	0.4084	-0.4638	-1.4507
Mfr	0.4084	0.4040	0.3430	-1.4507	-2.1202	0.0342
Counts	37	325	2852	1129	692	1753
Percentage of All	0.5%	5%	42%	17%	10%	26%

Table 4. Cross-Tabulation of Neighborhood Types Versus Age of Buffer

Cluster	1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000	All
1	0	0	0	0	4	4	6	11	4	5	4	37
% of Cluster 1	0.00	0.00	0.00	0.00	0.11	0.11	0.16	0.30	0.11	0.14	0.11	1.00
2	0	0	0	1	3	5	10	47	13	164	82	325
% of Cluster 2	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.14	0.04	0.50	0.25	1.00
3	0	0	0	0	9	47	163	478	364	1588	203	2852
% of Cluster 3	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.17	0.13	0.56	0.07	1.00
4	34	66	207	30	189	438	104	47	1	12	0	1129
% of Cluster 4	0.03	0.06	0.18	0.03	0.17	0.39	0.09	0.04	0.00	0.01	0.00	1.00
5	0	0	0	0	7	2	25	44	45	504	65	692
% of Cluster 5	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.06	0.07	0.73	0.09	1.00
6	0	0	0	0	0	12	51	148	182	1057	303	1753
% of Cluster 6	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.08	0.10	0.60	0.17	1.00
All	34	66	207	31	212	508	359	775	609	3330	657	6788
% of All	0.01	0.01	0.03	0.00	0.03	0.07	0.05	0.11	0.09	0.49	0.10	1.00

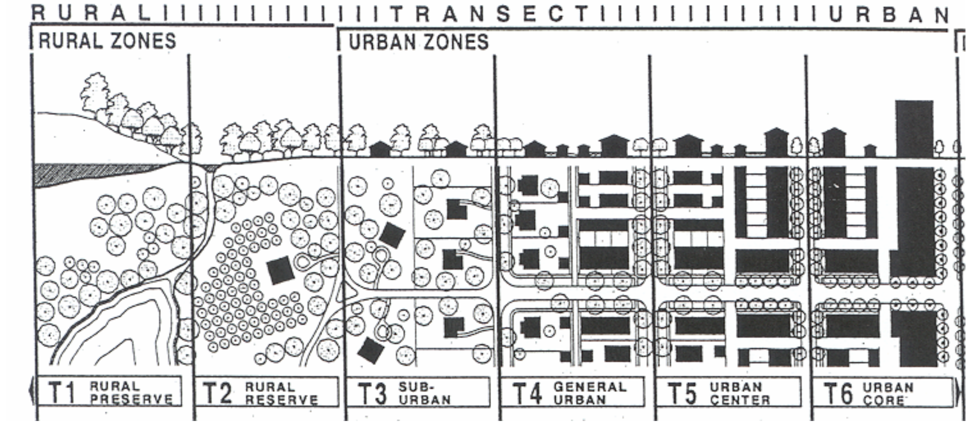

Figure 1. Urban Transect (Source: Duany and Talen 2002: p. 248)

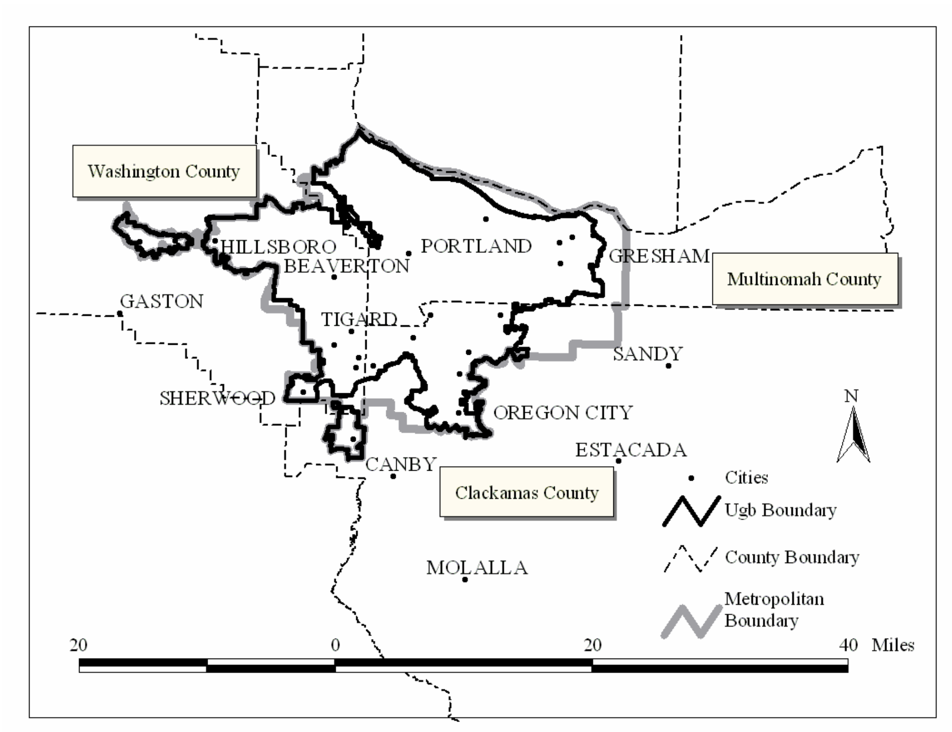

Figure 2. A Map of Study Area

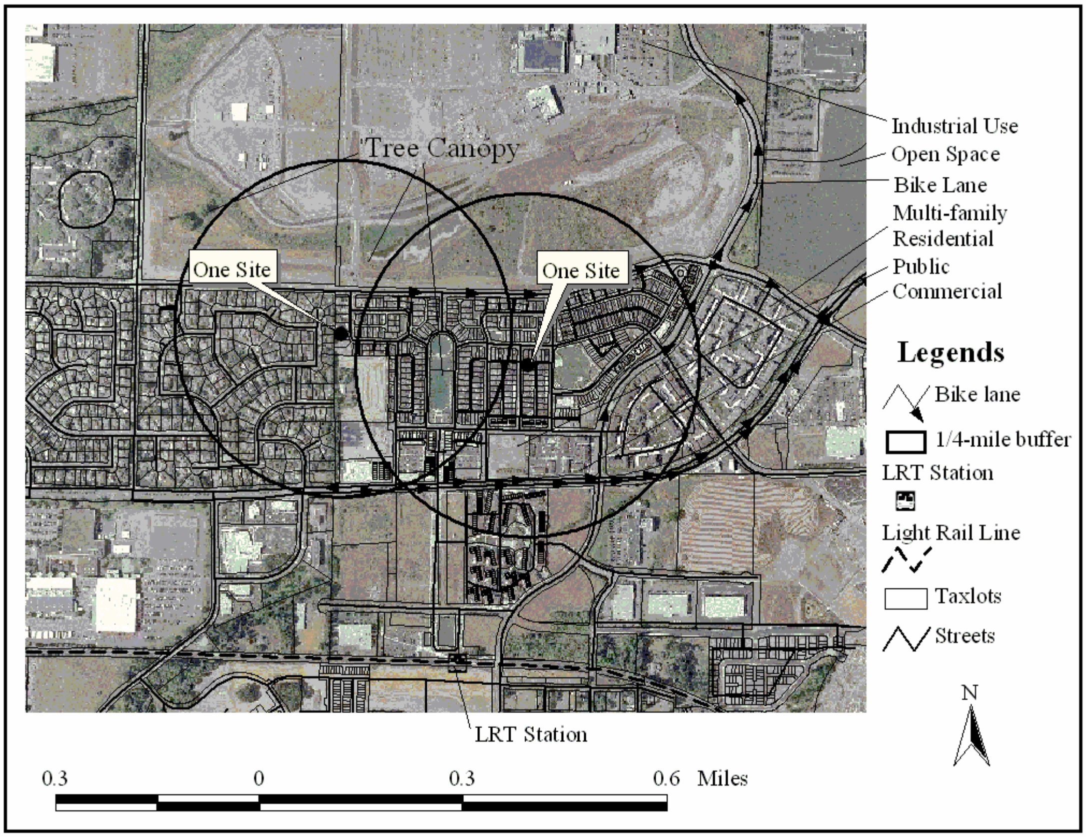

Figure 3. Visualization of Measuring Scales and Variables

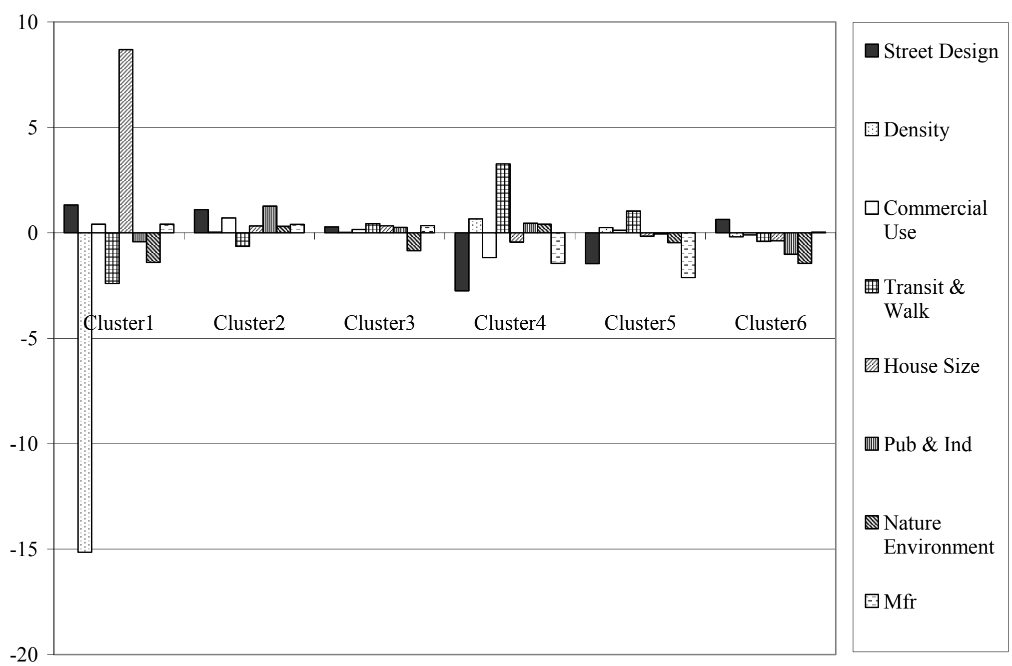

Figure 4. Cluster Centroid Values for Each of the Neighborhood Type Shown Graphically

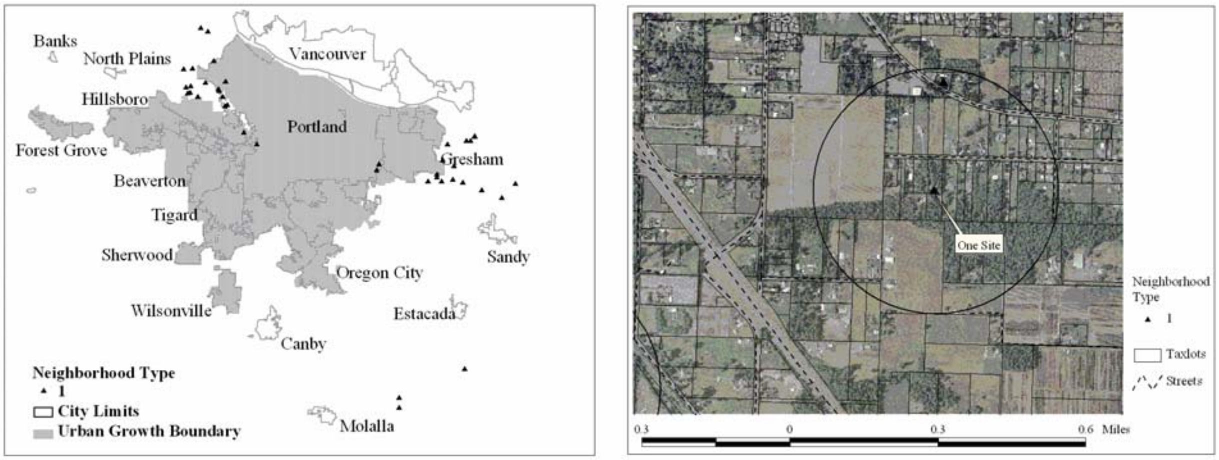

Figure 5. Neighborhood Type 1 – Sporadic Rural Developments

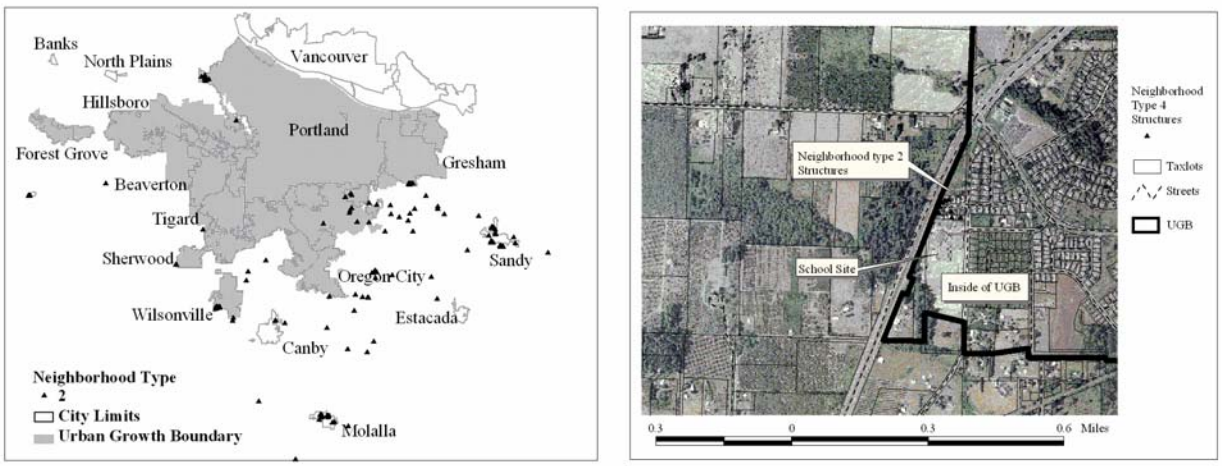

Figure 6. Neighborhood Type 2 – Bundled Rural Developments

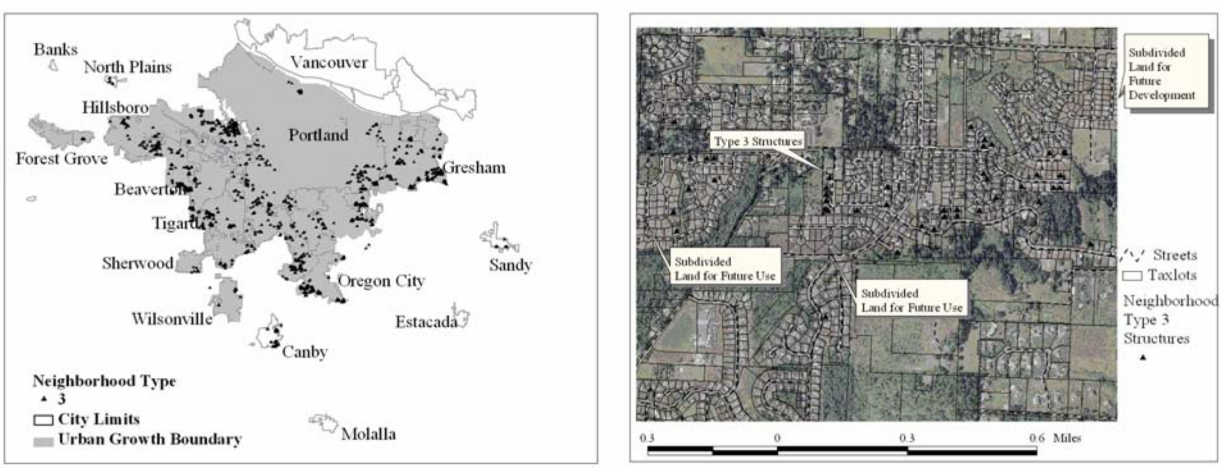

Figure 7. Neighborhood Type 3 – Outer Ring Suburban Infill

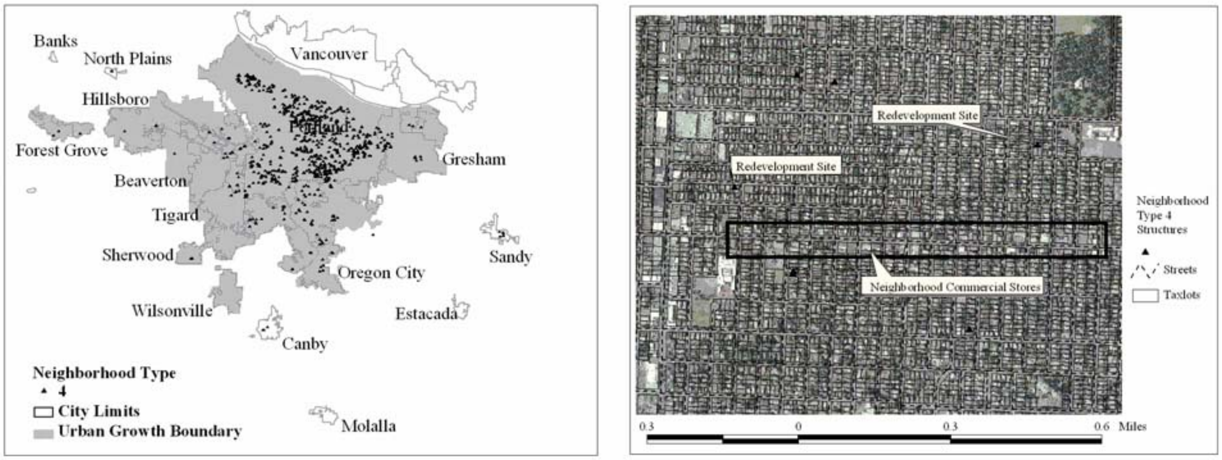

Figure 8. Neighborhood Type 4 – Downtown, and Inner and Middle Ring Suburbs

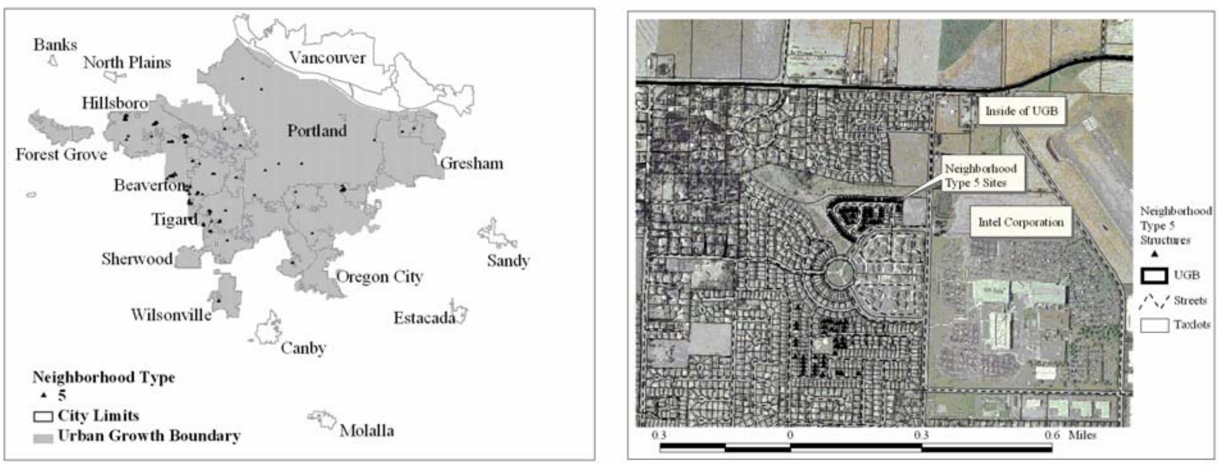

Figure 9. Neighborhood Type 5 – Composite Greenfields

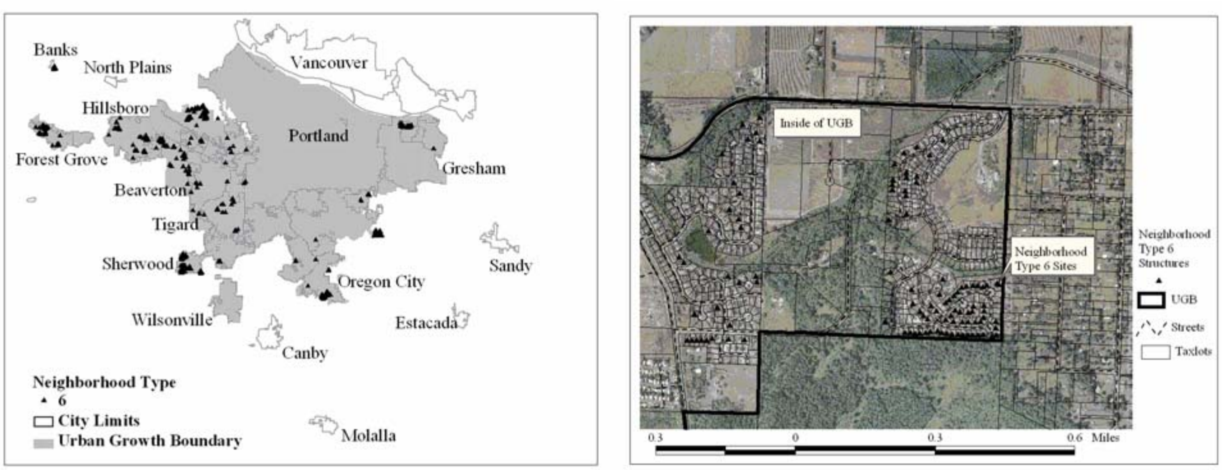

Figure 10. Neighborhood Type 6 – Partially Cluster Greenfields

[1] Definitions of each category follow: *Rural preserve* includes open space that is legally protected from development in perpetuity. *Rural reserve* includes open space that is not yet protected from development but which should be. S*ub-urban* includes most naturalistic and least dense residential community habitat with single-family detached houses and open space in rural character. *General urban* includes primarily single-family residential uses, limited office, lodging, and retail, and open space in the form of greens and squares. *Urban center* includes the denser and fully mixed-use community habitat with higher density of multifamily residential units, offices above shops, office, retail, lodging, and open space in the form of squares and plazas. *Urban core* includes the densest residential, business, cultural, and entertainment concentration of a region.

[2] The nation's only directly elected regional government.

[3] A closer examination on data quality of Bikelane and Sidewalk reveals that these data are not consistently developed throughout the metropolitan area. These two variables are therefore not included in the analysis since the inclusion generates misleading results.

[4] To proceed with the calculations of variables such as Nbr_BlockSize, Nbr_LotSize, Commercial, Industrial, Public, OpenArea and Mfr, the first step is to identify those blocks, lots and commercial, industrial, public, open and multifamily land parcels with their centroids within the ¼-mile buffer area of the structures. Then the *original* values of acre (or square feet) of the blocks, lots and other land parcels identified as having the median values are retrieved. Therefore it is possible that the area values of these variables are larger than the area value of a ¼-mile buffer.

[5] Bikelane and Sidewalk are not included.

[6] Varimax is used to maximize the variance of the squared loadings. Varimax is an orthogonal rotation method which simply rotates the axes of the first factor to a variable or group of variables and then rotates the subsequent factors to be at right angles (uncorrelated) with the first. By this way it removes the effects of variables which could be highly loaded on the first factor. Compared to unrotated factor solution, an orthogonal rotation minimizes the number of samples needed to account for the variation of distinct groups of variables.

[7] K-means clustering begins with a grouping of observations into a predefined number of clusters. It evaluates each observation and moves it into its nearest cluster. The nearest cluster is the one which has smallest Euclidean distance between the observation and the centroid of the cluster. When a cluster changes by losing or gaining an observation, the cluster centroid is recalculates. At the end, all observations are in their nearest cluster.

[8] Cluster analysis procedures are affected by the magnitude of the variables included, that is to say, variables with large numbers have a greater impact on the outcome of the analysis than variables with small magnitudes. To control for this imbalance, scaling is necessary to convert the original variable values to standard scores. Since the eight factor scores derived from the factor analysis are used here in the cluster analysis, the magnitude of the variables is not a concern here.