DEPARTMENT OF ECONOMICS AND FINANCE WORKING PAPER SERIES • *March 2013*

Veblen in the Metropolis: Land Use Proximity in United States Urban Landscapes*

E. Anthon Eff **
Middle Tennessee State University, Murfreesboro, TN

Abstract

Some land uses are considered incompatible. When a parcel is bordered by parcels with incompatible land uses, external costs will impact the property owner. Collective action by property owners then results in land use regulations designed to restrict neighboring parcels from incompatible uses. The pattern of observed land use contiguities thus testifies to cultural notions regarding incompatible land uses. Using urban planning data, a GIS, and methods from social network analysis, this paper attempts to uncover the tacit rules of spatial proximity among land uses in a United States city. The most salient patterns are a separation between places of residence and places of work, a separation of single family homes from other residential land uses, a separation of rural land uses from everything else, and a separation of condominiums from everything else. The paper then attempts to tie these observed spatial patterns to ideas from Thorstein Veblen, Georg Simmel, and Mancur Olson. It is suggested that the United States urban landscape has been shaped by the ethos of the middle class under capitalism, especially the cult of the family and the need to display status.

Key words: Built Environment; Symbolism; Land use Patterns

JEL category: R14, Z13

*Earlier versions of this paper presented at the 2005 meeting of the *Society for Economic Anthropology*, and the 2007 meeting of the *North American Regional Science Association*.

**Professor, Department of Economics and Finance, Middle Tennessee State University, Murfreesboro, TN 37132, phone: 615-898-2387, fax: 615-898-5045, email: Anthon.Eff@mtsu.edu

1. Introduction

United States cities have relatively shallow histories. They lack the proliferation of structures and sites with historical associations found in the cities of Europe and Asia. Historically significant sites function as symbols of national and local identity, and can serve as the focus of rituals, as documented by Hilda Kuper (1972) for the Swazi. The significance of such sites to identity makes them inviolate, sharply constraining the potential for changing the surrounding built environment. Even in the United States, some cities—such as Philadelphia, Boston, and Charleston—are considered of such historical importance that entire districts are protected from change. But for most cities west of the Appalachians, only isolated sites are protected, and the great bulk of the city can be considered *tabula rasa* for purposes of future development.

As Georg Simmel (1978) noted, pecuniary valuation tends to displace all other ways of valuing subjects. A random tract of land in the United States may once have been valued by its indigenous inhabitants in complex ways: everywhere there were stories attached to the landscape, stories of mythical beings and remembered persons. The land was invested with sacred significance. Eventually, these inhabitants were displaced by European speculators, who viewed land as a commodity, and who held land as a means of obtaining money (Linklater 2002). The land passes from speculators to settlers, who raise families and bury their dead in the soil, investing the landscape with new layers of significance. But the land nevertheless remains a commodity, readily sold for the right price, to anybody, for any purpose. Pecuniary valuation trumps any other way of valuing the land, and the incentives of owners tend to turn land toward the use that offers the highest return.

One might argue that the pattern of land use in a United States city represents an optimal use of space, in the sense that all parcels have been converted to the use with the highest opportunity cost, since owners have an incentive to turn over land to buyers who value it most. But the allocation of land across uses is sharply constrained, by at least five forces. First, dedicating a site to a particular land use often constrains future options—for example, a sanitary landfill cannot be converted to a housing tract—so that *path dependence* operates as a kind of constraint. Second, a land use may create *external costs or benefits* for adjacent parcels; a sanitary landfill, for example, would reduce the suitability of adjacent parcels as sites for housing. Third, *transactions costs* may make it infeasible to convert to a particular land use, such as when multiple parcels must be assembled into a single large site. Fourth, *endowment effects* are likely to make land owners value the land they hold more than a potential buyer would value it. And fifth, *land use regulations*, with all the force of law, often very narrowly define what uses are permitted on particular tracts of land.

Of these constraints, land use regulations are undoubtedly the most salient, but one can argue that land use regulations are primarily attempts to mitigate the effect of the second constraint—the uses of adjacent parcels. In a representative democracy, land use regulations are formed through collective action, and in the United States political system, characterized by federalism, land use regulations are usually established by the most local levels of governance: counties, municipalities, and homeowner associations. Hence, the collective action of local agents, who primarily value land as a commodity, shapes land use regulations in a United States city. Since adjacent parcels may create external costs or benefits, land owners have an interest in the uses to which adjacent parcels are put, and therefore have an incentive to restrict the options of their neighbors.

Thus, the patterns of land use proximity can be said to be a result of land use regulation, created through the collective action of landowners seeking to constrain neighboring parcels from using land in a way that would diminish the value of their own parcels. Implicit here is the idea that certain land uses are incompatible, that there exist rules declaring some land uses must not be

associated with others. As in the example of the sanitary landfill being a poor neighbor for a housing tract, some of the rules express instrumental knowledge about health and well-being. But not all rules. For example, why are there no cemeteries adjacent to nursing homes?

The capacity to make and use tacit rules is certainly a human universal of the kind that Donald Brown (1991) discusses. Even certain features of the logic of rule-making may be universal, such as Mary Douglas's (1966) idea that humans dislike anomaly, and that rules of taboo are rules banning items that fail to fit cleanly within a culture's categorization scheme. But the specific content of the rules must be culturally specific. Urban economics, with its "black box" utility maximization approach, does not examine the tacit rules of spatial association—urban economists simply take the rules as given, just as all preferences are taken as given. Thus, anthropology can shed additional light on the structure of cities, particularly "symbolic approaches" which "interpret the built environment as an expression of culturally shared mental structures and processes" (Lawrence and Low 1990: 466).

One theme among anthropological studies of space—particularly those influenced by Lévi-Strauss—is that the classification of space is often homologous with other cultural systems of classification (Lawrence and Low 1990: 468). This insight suggests that the way in which space is classified might be isomorphic to the way in which social classes, the parts of the body, the sexes, etc. are classified. A tacit rule governing which land uses are unacceptable neighbors might therefore be isomorphic to a rule in another social domain, and in fact might make more sense in that other social domain. As suggested here, the classification of domestic space is isomorphic to the way in which the larger landscape is classified.

The tacit rules defining culturally sanctioned land use associations are not known *a priori*. The rules must be uncovered empirically. Rules are often flouted, and the tacit rules of land use associations are no exception. Perhaps agents choose to flout the rules in order to gain some advantage. Perhaps two rules conflict, and agents choose the lesser of two evils. Perhaps an urban palimpsest is so riddled with confusing land use signals that agents can no longer discern the rules. And there will always be boundaries where incompatible land uses meet. Whatever the reason, any empirically derived rules of land use association must be probabilistic, rather than absolute.

This paper begins with an empirical derivation of some of the rules determining land use association in a United States city: Nashville, Tennessee. The first section describes the empirical procedure, which employs GIS and techniques from social network analysis. The next section presents the results. There follows an interpretation of the results, and then the summary and conclusion.

2. Data and Methods

The data begin with a GIS map layer containing polygons for the nearly 225,000 parcels in Davidson County, Tennessee.[1] The first step is to extract the four million points representing vertices for the polygon boundaries. Next, all proximate points are identified, and those proximate points belonging to different parcels are retained, resulting in a data file in which each record represents a pair of proximate parcels. By the criterion adopted here, two parcels are proximate when the boundaries of each parcel lie within 70 feet of each other, so that proximity pairs may lie across a road from each other, and may even be separated by a small parcel. Each parcel is then categorized into one of 77 land use categories, given in Table 1. The final step is to create a matrix **M** from this the list of proximate parcels, in which each cell m_{ij} gives the number of times that a parcel of land use *i* is proximate with a parcel of land use *j*.

[1] The Nashville Metropolitan Planning Commission generously gave access to this GIS map layer.

Matrix **M** can be used to create the transition matrix[2] **P**, where each cell p_{ij} gives the probability that a parcel of land use *i* is proximate with a parcel of land use *j*.

$$p_{ij} = \frac{m_{ij}}{\sum_i m_{ij}} \tag{1}$$

In addition, a matrix **X** can be created where each cell x_{ij} gives the expected number of times that a parcel of land use *i* would be proximate with a parcel of land use *j*.

$$x_{ij} = \frac{\sum_i m_{ij}}{\sum_i \sum_j m_{ij}} \tag{2}$$

Each cell x_{ij} in matrix **X** gives the expected probability that a parcel of land use *i* is proximate with a parcel of land use *j*.[3] The expected proximity matrix **X** can then be compared with the actual proximity matrix **P** to give matrix **D**:

$$\mathbf{D} = \mathbf{P} - \mathbf{X} \tag{3}$$

where each cell d_{ij} gives the net probability that a parcel of land use *i* is proximate with a parcel of land use *j*. A value $d_{ij} < 0$ implies that proximity between *i* and *j* occurs d_{ij} less than pure chance would suggest, while a value $d_{ij} > 0$ implies that proximity occurs d_{ij} more than pure chance would suggest. Matrix **D** provides the best view of the strength of association between a specific *i* and a specific *j*. Each cell d_{ij} in matrix **D** provides a probabilistic view of the tacit rule governing the association between *i* and *j*.

A useful measure can be derived from matrix **D**, similar to the measure "actor-degree centrality" (Wasserman and Faust 1994: 178) used in social network analysis. This measure, which I call *openness*, is the column means of matrix **D**:

$$openness_j = \sum_i d_{ij} \Big/ n \tag{4}$$

Openness is the unweighted mean, across all land uses, of the net probability of proximity with land use *j*. A positive value shows that the land use is in frequent association with other land uses; a negative value shows that the land use is isolated from others. Table 1 reports openness for each land use: the most open land use is VCL (vacant commercial land); the most closed land use is SFDPP (single family dwelling per parcel).

Table 1 also reports the column land uses with the highest and lowest values in each row of matrix **D**. The land uses that occur most frequently as the lowest values (least often in proximity) are SFDPP (single family dwelling per parcel) and RESCU (residential condominium unit). The land use occurring most often among the highest values (most often in proximity) is VCL (vacant commercial land).

Sociologists employ the concept of "structural equivalence" to describe the similarity between two network nodes in the quality of their connections. Two nodes are structurally equivalent not if they are connected to *each other*, but if they are connected to the *same others*, in about the same degree (Burt 1976; White, Boorman, and Breiger 1976; Wasserman and Faust 1994). In the

[2] **P** is a transition matrix in the sense that each cell gives the probability that a person who walks from a parcel of land use type *i* will enter into a parcel of land use type *j*.

[3] An interesting property of transition matrix **X** is that it is identical to the limiting probability of the transition matrix **P** (Ross 1980: 123).

sociological context, structural equivalence is used to classify observed persons into social roles; in the present context, structural equivalence can be used to classify observed land use associations into classes with similar associations.

Ecologists take a similar approach in comparing communities (Faith, Minchin, and Belbin 1987). Each community contains a variety of species. Communities are considered to be more similar to each other when they contain the same species, in the same proportions. Both community similarity and structural equivalence are calculated by using distance measures, such as Euclidean distance. A widely used distance measure is Bray-Curtis distance, also known as Steinhaus, Czekanowski, or Sørensen. Bray-Curtis distance has won support because of its performance in simulation tests (Faith, Minchin, and Belbin 1987) and has the attractive property that its value lies between zero and one. It can only be used with non-negative inputs, however, so it cannot be calculated using matrix **D** above, which contains negative elements. In ecological work, the Bray-Curtis measure is calculated using species count data, analogous to our matrix **M**. Bray-Curtis distance is semimetric, but a transformation of it is metric;[4] this transformation is known as Jaccard or Ružička distance, and is generally preferred (Oksanen, *et al* 2007: 124).

Calculating the dissimilarity between land uses *i* and *j* in the pattern of their connections begins by taking the Bray-Curtis distance between row *i* and row *j* of matrix **M**, giving matrix **B**:

$$b_{ij} = \frac{\sum_{k=1}^{n} \left| m_{ik} - m_{jk} \right|}{\sum_{k=1}^{n} \left(m_{ik} + m_{jk} \right)} \tag{5}$$

where each cell b_{ij} gives the Bray-Curtis distance between land use *i* and land use *j*. The matrix of Jaccard distances **E** is a transformation of the Bray-Curtis: $e_{ij}=2b_{ij}/(1+b_{ij})$. The values e_{ij} lie between zero and one. A high value of e_{ij} indicates that land use *i* and land use *j* are dissimilar in their associations. A low value of of e_{ij} indicates that land use *i* and land use *j* are similar, and they are deemed to be structurally equivalent. A pair of land uses that are structurally equivalent are following much the same rules for spatial association.

3. Results

Declaring two land uses to be structurally equivalent is in some ways subjective, since one must make some judgment about how low the value of e_{ij} must be for the two land uses to be considered to follow the same tacit rules. When the value of e_{ij} is zero, the two are of course equivalent, but in only the rarest of cases will this be true. Burt (1976) suggests a hierarchical clustering procedure, progressively increasing the threshold for e_{ij} until one arrives at an intuitively reasonable set of associations. White, Boorman, and Breiger (1976), on the other hand, suggest "block modeling," a method based on iterated correlations. The block modeling approach has proved particularly popular (Scott 2000: 125). Figure 1 presents a graph depicting the associations among the 77 land uses, based on block modeling of matrix **P**. Each node in the graph is labeled using the abbreviations found in Table 1. In general, the upper part contains the branches with commercial land uses, while the lower part of the diagram contains one branch with residential and cultural land uses, and another with rural and industrial land uses. SFDPP

[4] A distance measure $d(x, y)$ between x and y is metric when it satisfies three conditions:
Non-negativity: $d(x, y) \geq 0$, and $d(x, y) = 0$ if and only if $x = y$
Symmetry: $d(x, y) = d(y, x)$
Triangle inequality: $d(x, z) \leq d(x, y) + d(y, z)$
A semimetric distance satisfies only the first two conditions (Rektorys 1969: 998).

(single family dwellings per parcel) has D (duplexes) as its closest neighbor. Land uses without a built structure are circled; these are scattered throughout the graph.

Methods such as block modeling are useful for *ordination*—for supplying a visual means of judging proximity among the 77 land uses. Ordination is needed because the 5,929 cells in each of the matrices **D** and **E** provide too much information for cognitively limited humans to absorb.[5] Non-metric multidimensional scaling (Kruskal and Wish 1978)—for over twenty years the preferred ordination method in community ecology (Minchin 1987; Oksanen 2007: 64)—translates a distance matrix into a two dimensional map. Figure 2 presents the plot from a Jaccard distance matrix derived from matrix **P**. Again, the land uses are labeled using the abbreviations in Table 1. The closer together two land uses are in Figure 2, the more similar they are in their pattern of interactions with other land uses. Land uses on the periphery of multidimensional scaling plot are distant from all other land uses—that is, they have unique rules of association with other land uses. Land uses crowded in toward the center, on the other hand, have very similar rules of association with each other

Figure 3 presents the same multidimensional scaling plot, but adds "bagplots" for residential and commercial land uses. A bagplot is a two-dimensional box and whisker plot, where the median is indicated by a point, the inner loop encloses the second and third quartile, and the outer loop extends out to include values 1.5 times the range within the inner loop, unless the minimum or maximum are less than that amount, in which case they extend out to the minimum or maximum. The points beyond the outer loop are considered outliers. The residential and commercial clusters are separated except at one point, where DTOS (drive-in theatres and stadiums)—actually a cultural land-use—touches the border of the residential cluster. SFDPP lies at the point of the residential cluster furthest from the commercial cluster. The residential cluster has two outliers: MH (mobile homes), which are located next to rural land uses; and RESCU (residential condominium units), which are isolated from everything else. The commercial cluster has two outliers: DS (department stores) and COOC (commercial condominiums). Both of these are isolated from all other uses.

As confirmation of the multidimensional scaling results, Figure 4 presents another ordination method: a plot of the two first principal components. Again, bagplots are drawn, and again they show clear separation between residential and commercial clusters. Mobile homes and residential condominium units are residential outliers, as before. Commercial condominiums repeat their outlier position, and a few cultural land uses fall out of the commercial cluster: NCOL (night clubs or lounges) and DTOS (drive-in theatres and stadiums). SFDPP again lies at the point of the residential cluster furthest from the commercial cluster.

Figure 5 is a hierarchical cluster plot. The algorithm is based on a Euclidean distance matrix, calculated from matrix **P**. Each land use starts out in its own cluster. At each step in the algorithm, the two closest clusters are aggregated, and the distance matrix recalculated. Through successive iterations, the root is reached (Lucas 2007). Like the previous ordination methods, the results show that residential and commercial condominiums are isolated from other land uses. SFDPP are closely joined to duplexes, and these are distant from other residential land uses. Rural uses are clustered together, but distant from other uses.

Figure 6 repeats Figure 5, but uses the taxon (Table 1) as label for all land uses except those which can be considered residential. The figure reinforces the notion that residential and commercial uses are separated. The only commercial land uses in the residential cluster are "day care center" and "greenhouse or nursery." These figures do show a few unexpected results, such

[5] The Excel workbook http://www.mtsu.edu/~eaeff/downloads/ViM.xls contains Table 1, as well as matrices M, P, D, and E.

as the location of "nursing home, convalescent home, or sanitarium" in a cluster together with warehouses, open storage, and lumberyards. On second thought, this result might not be so unexpected: there is arguably a popular association of nursing homes as storage places (rather than as residences), and this semantic association may both reflect and contribute to the spatial association.

Figure 7 shows how compliance with tacit rules of spatial proximity varies across the entire county. Each parcel *k* has a set of *s=(1,…,n)* neighbors whose borders lie within 70 feet of its own borders. The relationship of *k* with each of these parcels *s* has a distance, found in matrix **E**, which is the distance between the land use of *k* and the land use of *s*. The mean distance across all *n* parcel neighbors gives a sense of whether parcel *k* is in proximity to similar land uses (a low mean distance) or dissimilar land uses (a high mean distance). The formula for mean distance is:

$$\bar{e}_k = \sum_{s=1}^{n} e_{i(k),j(s)} \Big/ n \qquad (6)$$

In Figure 7, the map displays the local G* z-scores (Getis and Ord 1992) for mean distance. The G* calculates a kind of local moving average (here over just itself and the five closest neighbors) and tests whether that is significantly different from the county-wide average. The map has three colors: the darkest color shows those parcels with mean distance significantly above the average, and the lightest color shows those parcels with mean distance significantly below the average. A transect is drawn through the center of the county, on a north-south axis, intersecting the parcel with the state capital (shown as a star). The plot at the right shows the mean distance as it varies along the transect; each point is a parcel. The smoothed line is calculated using the LOWESS smoother (Cleveland 1979), and shows that mean distance is highest in the downtown area, and declines towards the periphery.

Figure 8 examines mean distance for SFDPP (single family dwelling per parcel). The pie charts illustrate that SFDPP is the single largest land use, and that it has a very high propensity to be in proximity to itself. The scatterplots at the bottom of Figure 8 plot mean distance on the ordinate, and four variables related to SES on the abscissa. Each point represents a census tract, and mean distance is actually the mean of mean distance for all SFDPP parcels within the tract. The results show conclusively that race has no association with mean distance. The same cannot be said for the appraised value of the SFDPP parcels: the most expensive homes are in tracts with low mean distance. Likewise, tracts with the highest median household income all have low mean distance.

Figure 9 compares the spatial structure of an inner-city neighborhood with a suburban neighborhood. Again, the colors represent the local G* z-scores for mean distance: the dark color indicates significantly high, the light color is significantly low, and the intermediate color is insignificant. In the inner-city neighborhood, there is a rectangular grid of streets, each parcel fronting to a street and backed by a narrow alley, and businesses lined up along the major streets. Only in the centers of some blocks is mean distance exceptionally low, and these are places where no vacant lots, duplexes or commercial properties lie within the set of neighbors. In the suburban neighborhood, there is a tree-like structure of streets, where parcels are layered around both the branches and trunk of the tree. Here and there within the subdivision, common area and vacant residential land increase the mean distance of adjacent parcels, but the overall structure is such as to insulate the core of the subdivision from any other land uses, so that the mean distance of most parcels is exceptionally low.

3.1 Results summarized

Table 1, as well as the various ordination methods, show that SFDPP and RESCU are the most segregated land uses, with the lowest measure of openness, and isolated even from other residential land uses. Residential land uses are generally segregated from other land uses, though

the ordination methods tend to locate schools, day care centers, religious institutions, parks, clubs, museums, cemeteries, and charitable services, in proximity to multi-unit residential land uses. Two types of residential land uses are located away from other residential uses, in a group with rural land uses: mobile homes, and single family dwellings (not on a standard city parcel).

Rural land uses form a relatively compact cluster in all of the ordination methods. Rural land is the raw material from which urban land is created; it is the most easily converted into any other land use, and is the least encumbered by restrictions. For this reason, rural land can be a dangerous neighbor, since a property owner never knows what land use might appear in the future. Proximity to rural land would therefore be shunned, leading to its relative isolation in the figures.

Condominiums are located adjacent to other condominiums, and are often multistory, so that each layer of condominiums shares the same parcel boundary. In some tall buildings, a single condominium can be proximate with over 30 other condominiums, so that self-proximity is very high. Of all forms of land use, condominium offices (COOC) and residences (RESCU) are designed with the greatest effect of isolating each parcel from other land uses.

In all Figures, residences form a gradient, from single family homes through duplexes, triplexes, quadplexes, dormitories and boarding houses, then apartments, and then institutionalized residences such as nursing homes, orphanages, and hospitals. Associated with residences are institutions for cultural transmission such as schools, museums, clubs, and religious institutions, as well as green space ranging from parks and golf courses to nurseries. The open space associated with residences is more tamed, and certainly much less likely to convert to another land use, than the green space of rural land uses.

The ordination methods and Table 1 give us a sense of the tacit rules governing land use associations in Nashville. Overall, the tacit rules of residential land uses are more similar to each other than to those of non-residential land uses. But, as residential land uses move from single-household structures to increasingly greater numbers of households per structure, the tacit rules become more similar to those of commercial land uses. The tacit rules governing rural land uses are sharply different from all other tacit rules, as are the tacit rules governing condominiums. Most commercial land uses have similar tacit rules, and those rules allow commercial land uses to freely associate with each other, though restricting association with residential, rural, and condominium land uses. Within the mass of promiscuously associated commercial land uses, one can find similar land uses with similar tacit rules: gas stations (GS) are similar to car washes (CW), fast food restaurants (FFR) are similar to restaurants and cafeterias (ROC), etc. The fact that these clusters have similar rules seems intuitively reasonable, but the most striking result is that these clusters are only slightly distinguished from the mass of commercial land uses. The most salient distinctions are, again: rural from everything else, condominium from everything else, residential from non-residential, and within residential, single family from multi-family.

The following section takes a brief look at the evolution of the built environment in Europe and the United States, in order to develop some ideas which might explain the salient patterns that we found.

4. Capitalism and the evolution of the built environment

Herbert Spencer's dictum that evolution is a process of increasing differentiation certainly holds true in the evolution of the built environment. Beginning with the eighteenth century, both domestic space and the urban fabric have shown increasing internal differentiation and separation of activities (Braudel 1981: 280, 308). A set of tacit rules guide this increasing differentiation, rules stating which activities belong in proximity to which other activities. We proceed from the assumption that the same set of rules governs both domestic interiors and the larger metropolitan

space. This assumption is consistent with the position taken by many anthropologists studying space: that the classification of space is often homologous with other cultural systems of classification (Lawrence and Low 1990: 468). The assumption allows us to gain insight into the tacit rules by studying two kinds of differentiation.

4.1. Domestic space

Fernand Braudel (1981: 308) maintains that the internal differentiation of domestic space is "an eighteenth century innovation." Living quarters for the well-to-do, previously characterized by large multi-purpose rooms, were subdivided into many smaller rooms with specific functions: "the pantry was distinct from the kitchen, the dining-room from the drawing room." The larger theme of the differentiation, however, was to separate the zone for private, family living from the public zone visited by outsiders.

To be sure, the division of a dwelling into a private space for the family, and a public space accessible to some outsiders, is a feature found among many peoples, and is not unique to eighteenth century Europe. For example, Fredrik Barth (1961: 12) describes how the Basseri—a pastoral people of Persia—pile up their belongings to form a wall within a tent, "closing off a narrow private section in the very back…" Nevertheless, for Europe, the eighteenth century constituted a break from the past.

Studies of English working class housing note that families of agricultural laborers typically lived in one room structures prior to 1800. By 1850, though, the structure had differentiated into two rooms: one for sleeping, the other for eating, cooking, sitting, and storing tools. In essence, one room for night, the other for day, with work items located in the day room. In towns, a typical artisan around 1800 would live in a three story structure, with a ground floor containing a sleeping room, and a room for living in (eating, cooking, sitting, etc.). On the next floor up there would be a shop for working, and above that an attic used as a pantry and sometimes as a roost for poultry. Note that the ground floor is differentiated into a day room and night room in the same manner as the two room agricultural laborer's home, with a workshop in the less accessible area upstairs, so that the floors differentiated living areas from work areas. By the middle of the nineteenth century, the working class "terrace house" typically contains two floors. The ground floor contains a parlor at the front, and a kitchen/scullery at the rear. The upper floor contains bedrooms. Thus the work area had vanished from the home. The floors now demarcate day areas from night areas, and there is a clearly defined gradient marking private from public, so that guests were often admitted only to the parlor, and only family members would venture upstairs to the bedrooms (Lawrence 1983: 107-109).

In the mid-nineteenth century, the physical structure of the western European middle class house differentiated to separate servants from family. Servants were housed on an upper floor, accessible by a "back staircase," while a "semi-sacred space, equipped with portraits, albums, and mementos" was "reserved for the family members." At the same time, another space was reserved for the family father and his male friends (Guttormsson 2002: 264-265). The tendency is to isolate the family from outsiders.

As domestic space becomes differentiated, tacit rules determine which activities can be carried on within the same space. Roderick Lawrence's examination of the use of domestic space in Australia and England shows that tacit rules in these countries isolate laundry from socializing, in that there is a preference for laundering and eating in separate rooms. In England, laundering is done in the kitchen, but the English prefer to eat in a dining room or living room separate from the kitchen. In Australia, a laundry exists distinct from the kitchen, and Australians prefer eating in the kitchen (Lawrence 1983: 122, 125). Nevertheless, not all of the English in Lawrence's sample eat outside the kitchen. They are constrained by other rules: rules which say that "activities which occur in the living room should not be spatially related to eating food"

(Lawrence 1983: 120). Were the resources available, a resolution to the conflicting rules could be found by adding a third room, separate from both the living room and the kitchen, for dining. Alternatively, a laundry room could be created, leaving the kitchen suitable for eating. Differentiation can thus be seen as a response to conflicting rules. This example illustrates the culturally specific nature of these tacit rules, as well as illustrating the fact that the rules are not universally followed. In addition, it suggests that rule conflict may serve as a driving force behind the process of differentiation.

4.2. Urban fabric

Like domestic space, the urban fabric began a process of increasing differentiation in the eighteenth century. One way in which the urban fabric has progressively differentiated is by social class. Residential quarters in ancient cities tended to have members of all social classes living in close proximity (Cowgill 2004: 538). But virtually all modern cities associate social class with residential districts. David Gilmore's (1977) study of a small Spanish town finds that the salient emic spatial divisions are projections of class divisions. Three social classes are acknowledged by the town's residents, and three districts are acknowledged in the town's physical space, with each social class associated with a specific district. In recent years, cities in much of the world have seen the rise of "fortified enclaves," in which ethnic minorities or wealthy elites occupy spaces to which access is restricted, so that cities are transformed "from spaces of openness and free circulation to more fractured and fragmented archipelago-like localities" (Rodgers 2004: 1), characterized by social class segregation. Recent literature has documented an increasing tendency toward spatial segregation by income in US cities (Forsyth 2000), resulting in increasingly homogenous neighborhoods.

But post-eighteenth century differentiation of the urban fabric not only served to separate persons by class, it also served to separate work from family life. Braudel (1981: 280) finds that the eighteenth century is a critical period in which, for the relatively wealthy, the place of work splits off from the place of residence, occupying a separate structure in a separate quarter of the city. This phenomenon occurred in large cities, in Europe and in China, at about the same time. One can see that the separation of work and residence in the urban fabric occurs contemporaneously with the separation of private and public in domestic space. And it also occurs contemporaneously with the emergence of capitalism as the dominant mode of production in Europe.[6]

One feature of capitalism is that ascribed status yields to achieved status. While the nobles of medieval Europe were the elite by descent, and known to all through the long-established status of their families, the capitalists of early modern Europe were the elite by success in business, newly arrived and unknown. Business success tends to last but one generation (Marshall 1920: 250), so that there is a constant "circulation of the elite," in Pareto's memorable phrase, as newly successful capitalists displace the old. Concern with the display of status is a characteristic of the capitalist elite: since their status is insecure and perhaps only very recently acquired, signals of status must be constantly reiterated in order to be accepted by others. As Eric Wolf (1955: 465-466) describes for "open communities" in Latin America, conspicuous consumption is characteristic of capitalist *arrivistes*, who are seeking to redefine social status to mark their upward economic trajectory.

[6] If it seems controversial to say that capitalism in the eighteenth century became the "dominant mode of production in Europe," one should consider that the eighteenth century marked the diminished influence of two intellectual traditions hostile to capitalism (Christianity, and the tradition of Civic Republicanism), and the emergence of Enlightenment and Liberal thought (e.g., Voltaire, Hume, Smith) friendly to capitalism (Muller 2002: Chapter 1). One could argue that by the eighteenth century the presence of capitalism had become so predominant that there arose intellectual justifications.

As Georg Simmel (1957) points out, *arrivistes* seek to display membership in the upper class by emulating the cultural features—dress, speech, etc.—of the established upper classes. The upper classes, in turn, resist emulation by adopting new cultural traits, so that they remain distinct from those beneath them. It is this reaction by the upper classes that, according to Simmel, creates the phenomenon of fashion. Braudel (1981: 316-317) maintains that fashion's first weak origins in Europe occur about 1100; prior to that time, dress was as it had been in Roman times. Around 1350, the first "really big change came," and fashion first becomes "all-powerful… about 1700." Braudel (1981: 312-313) notes that fashion is a phenomenon of a society that is at the same time rich and relatively unstable, and echoes Simmel in asserting that fashion results "from the desire of the privileged to distinguish themselves… from the masses" (Braudel 1981: 324). Thus, the eighteenth century saw rapid changes in the cultural sphere of dress, instigated by the efforts of the newly prosperous to display their newfound status. And just as nobles resisted assimilation of the bourgeoisie by producing new fashions, so they also passed sumptuary laws outlawing bourgeois emulation of noble costume (Braudel 1981: 311).

There is some evidence that the home is particularly important as a locus of status display for persons of insecure status. In a study of twentieth century Hyderabad, James S Duncan (1982) compares the Hyderabadi traditional elite, who have ascribed status based on descent from Muslim noble families, with the new elite of managers, professionals, and officials, most of whom migrated to Hyderabad from other areas of India. For the traditional elite, there is no need to display status since their status is known by the members of their social circle. On the other hand, the Hyderabad new elite are near-strangers, and since their status is unknown to their new acquaintances, it must be displayed, through individualistic consumption. For the new elite, the house is the site of display of individual consumption goods, signaling status.

One might speculate that the eighteenth century changes in the urban fabric relate to the emergence of a capitalist elite. For this new elite, the home is a primary site of status display. They seek to emulate the noble upper classes, and to differentiate themselves from the artisan class beneath them. One feature of the noble elite is that they are under no constraint to do useful work, and their homes therefore have no space used for work; artisans, on the other hand, have a workshop in the home. Emulation of the nobles, and differentiation from artisans, would lead the new capitalist elite to remove spaces for work from their residences. Abstention from labor is after all the most potent signal of status (Veblen 1953: 41), so a home that successfully signals status would be untainted by suggestions of productive work. By the middle of the nineteenth century, the displacement of craft production by factory production would similarly remove production from the living spaces of the working class.

Capitalism did more than simply generate a constant stream of newly rich. It also eroded traditions. As recognized by the eighteenth century German social theorist Justus Möser, the efficiency of capitalist production ruined the livelihood of crafts producers, thus destroying the traditional guild system and shrinking the pool of citizens participating in political life, since guild members had been the vast majority of persons prosperous enough to meet the property qualifications for citizenship in the small German states. By producing new and cheaper products, and peddling these in the countryside, capitalism also created new wants among the peasantry, who were no longer satisfied with the life of their ancestors. And by replacing the traditional paternalistic relationships of serf to landowner with the instrumental relationship of renter to landowner, capitalism eroded the sense of obligation felt by the rich to the poor (Muller 2002: Chapter 4).

Many thinkers have noted that capitalism is a system of means, for which the ends are indeterminate. Some, such as Voltaire, admired this characteristic, pointing out that people of different religions (i.e., with very different ends) interact harmoniously in the pursuit of economic self-interest (Muller 2002: Chapter 2). Others were not so sure. If capitalism destroys traditions,

then it destroys the ends of human striving, leading to a purposeless floundering after more and more money. Simmel (1978: 232) was to argue that the accumulation of money "is the most extreme example of a means becoming an end," so that pecuniary valuations eventually displace other ways of valuing. Relationships become increasingly contractual, and therefore contingent on the whims of the contracting parties, as well as limited in scope to the explicit terms of the contract. Hegel acknowledged the corrosive nature of capitalism and—like Möser—"was concerned that individuals feel themselves to be part of some larger whole" (Muller 2002: 151). Thus, "countermarket institutions"—the family, the state, the ethny, cultural institutions (such as the church, universities, and journalism), and professional institutions—have been advocated by even the friends of capitalism, such as Smith, Burke, and Hegel (Muller 2002: 393-395).

Of particular importance is the family. By centering their affections on the family, the middle classes could find the purposefulness so evidently missing from a world where values had become increasingly instrumental and contingent. Why the family? Perhaps simply because the most persistent values are those that rest on biological imperatives. The principle of kin selection (Hamilton 1964; van den Berghe 1987) suggests that providing for ones own offspring is an end not easily eroded by capitalism. During the middle of the nineteenth century, a new "domestic ideology" representing a "quasi-religious attitude toward family life" emerges among the middle classes of Western Europe (Guttormsson 2002: 263). Features of this new ideology include a redefining of the sexual division of labor, such that adult males work outside the home, in exchange for money income, while adult females stay at home, avoiding work that might bring in money income.[7] This division of work into an outside male world and a domestic female world contrasts with traditional peasant households, where males, females, and children work at home, as well as households of the nineteenth century proletariat, where males, females, and children work outside the home.

Avner Offer (2006: 282) notes that housing is "the prime example" of a status display good in the contemporary U.S. and U.K. The real cost of housing has increased at a greater rate than wages, as basic needs have been met and wage-earners bid up the prices of a limited supply of status display goods. Housing is now the largest component of middle-class consumer expenditures (prior to 1950 food held that honor). But, for families with children, housing in the right location can be considered not just a display good, but a necessity, since it provides access to safe neighborhoods and good schools (Offer 2006: 283). Thus, homes in the contemporary U.S. not only display status, but they serve as the key input in a family's efforts to live a life consistent with the "domestic ideology."

To sum up then, we see with the emergence of capitalism in the eighteenth century an erosion of traditions, which clears the way for a "domestic ideology" giving the home a quasi-sacred role in the lives of middle class people. Domestic space differentiates into a private area, reserved for the family, and a public area, which serves as the primary locus of status display to persons outside the family. Work leaves domestic space, apparently to provide a more ceremonially adequate display of status.

5. Collective action and the built environment

A common theme in literature on the meaning and use of the built environment is that income groups contest public space. For example, the upper classes contest the use of public squares in San Jose Costa Rica with the lower classes, employing architecture and law enforcement as instruments of control (Low 1996). David Gilmore (1977) explains how the class structure of a

[7] The success of the domestic ideology can be seen in the way in which it conquered the ritual calendar. Where once the most important rituals had been celebrated outside the home, they now were celebrated in the home. By the middle of the nineteenth century, Christmas—celebrated at home—had "become the pivot of the annual cycle" (Guttormsson 2002: 264).

Spanish town is projected unto the town's physical space, so that certain districts are associated with specific classes. Mitchell Duneier (1999) describes the life of homeless sidewalk vendors in Greenwich Village, who are in constant conflict with the urban professional homeowners and tenants for control of the sidewalk.

Georg Simmel's (1957) theory of fashion creation provides some insight here. Boundary maintenance between the upper classes and lower classes is sought by the upper classes, for whom the boundary is a public good, benefiting every member of the upper classes. The lower classes seek to transgress the boundary, but each act of transgression only benefits the individual transgressor (who attains the benefit of appearing more like a member of the upper classes), not the lower class as a whole. Therefore, only the upper classes would have an incentive to engage in collective action, while the lower classes would engage exclusively in individual action.

Since the first emergence of stratified societies, upper classes have attempted to differentiate themselves from the lower, and certain features of upper class culture have proved difficult for the lower class to emulate, so that these features have become persistent and are now readily identified with upper class culture. The most important of these features is certainly Thorstein Veblen's (1953) principle of *conspicuous waste.* Since the upper classes control more resources, they can display status by conspicuously wasting resources, a display that the lower classes can scarcely emulate. And as Veblen again noted, only the upper classes can abstain from work, so that *conspicuous leisure* has become a distinctive trait of status.

For upper class cultural features not involving conspicuous waste or conspicuous leisure, emulation by the lower classes is much easier, and the upper classes may need to engage in collective action to maintain the boundary between the classes. Current thinking on collective action maintains that self-interested persons have an incentive to participate in collective action only when public goods are created and free-riding is difficult (Olson 1965). In collective action to maintain class boundaries, free-riding is likely to be a problem, since an individual from the upper classes may benefit from the boundary maintenance of her class fellows, but find her individual self-interest in selectively violating the boundaries. For example, a district in which only wealthy persons live will be desired by the less wealthy. In a scenario common in late 19th century U.S. cities, "speculators" would target a "good neighborhood" as a place to "erect apartment houses on vacant lots or convert large homes into several cheap rental units" (Scott 1969: 75), renting these to less wealthy persons who would be willing to pay a high rent because of the coveted address. The district's value as a signal of membership in the upper classes is now diminished, because one member of the upper class did not participate in boundary maintenance. Not only is the symbolic value of a home in the district diminished, but the pecuniary value is diminished, since the sale price of the home incorporates—among other factors—its value as a class membership marker.

Free riding of this type can be curtailed through the power of the state. The collective action of the upper class can take the form of lobbying to introduce legislation governing land uses. The list of potential land uses in a district can be restricted to only those types that send a clear signal of upper class membership. Alternatively, each new property owner in a district can be required to sign an agreement (a set of "restrictive covenants") spelling out permissible uses of the property.

This perspective provides an explanation of why land use restrictions appear designed to isolate the residences of the upper classes from classes below them. One never sees land use regulations designed to ensure the access of the lower class to homes in proximity to upper class homes. Boundary maintenance provides a public good to the upper classes, giving them an incentive to engage in collective action. Boundary transgression provides only individual benefits to the lower classes, so that they do not have any incentive to engage in collective action. Hence, land use

restrictions take the form of rules that serve to maintain boundaries—boundaries that are of course spatial (since they deal with land) but more importantly are class boundaries, insulating the upper classes from the lower. In essence, land use regulations are upper class boundary maintenance regulations little different from sumptuary laws.[8]

While this discussion focuses on the separation of low-income homes from higher-income homes, the arguments apply with equal force to the separation of work from residences. The reputable home does not contain spaces for work. The tacit rule that banishes work from the home manifests in urban space as a tacit rule that a reputable home will not exist in an area that contains work activities. Hence, home owners engage in collective action to prevent their neighbors from introducing work activities in proximity to their homes. Thus one finds that the most salient divisions among land uses are those between the single-family home and places of work.

6. Summary and Conclusions

The single most salient result from our empirical investigation is that single family homes have a strong tendency to avoid proximity with other land uses, and especially commercial land uses. The tendency toward isolation is evident throughout the city, but especially in suburban neighborhoods and in higher income areas. Commercial land uses, on the other hand, freely associate with each other, with the exception of commercial condominiums.

The isolation of single family homes is explained as the result of the evolution of urban structure under capitalism, a process that begins by the 18th century in Western Europe. Members of the emerging capitalist middle class, unknown and insecure, engaged in conspicuous consumption and conspicuous leisure to signal their newly won status. As part of this signaling, work activities were separated from middle-class residences, and relocated to entirely different quarters of the city. At the same time, capitalism eroded traditional values, impelling people to seek now sources of meaning. Foremost among these new sources of meaning for the emerging middle class was a quasi-religious cult of the family. The single family home became the shrine of this new ideology, and the space within the home differentiated into a public area, where status was conspicuously displayed, and a private space, where the family was shielded from the outer world.

In the U.S., collective action by property owners seeks to impose restrictions on the use that neighboring property owners can make of their property. These restrictions take on many and familiar forms, all expressing tacit rules regarding appropriate land use proximities: no liquor stores near schools, no adult bookstores near churches, no cemeteries near nursing homes, and so on. But the most salient of all land use restrictions express the tacit rules governing the appropriate proximities for single family homes: no workplaces proximate to homes, and no lower-class housing (apartments, boarding houses, mobile homes) proximate to homes.

The secular tendency is toward a city increasingly differentiated both by income class and by function. From a policy perspective, one can lament the decline of neighborhoods characterized by mixed uses or mixed social classes. Jane Jacobs has eloquently made the case for mixed use neighborhoods: they are interesting to live in, they are safe, they provide many conveniences (Jacobs 1961). Mixed use neighborhoods are also creative places, likely to produce the social networks that spawn innovative ideas and new firms (Jacobs 1969). Socially mixed neighborhoods facilitate upward mobility, by providing role models for the poor, by ensuring that the poor are not isolated from places of employment, and by speeding the assimilation of ethnic minorities. Socially mixed neighborhoods are more interesting places to live and are likely to be more stable since they provide housing for persons in all stages of the life cycle (Evans 1976;

[8] They differ from sumptuary laws only in the sense that members of an upper class impose land use regulations upon themselves, while sumptuary laws are passed on the members of lower classes.

Sarkissian 1976). One can conclude that the tacit rules of land use association are taking us toward more unlivable cities.

References

Barth, Fredrik. 1961. *Nomads of South Persia: The Basseri Tribe of the Khamseh Confederacy.* Oslo: Universitatsforlaget.

Braudel, Fernand. 1981. *The Structures of Everyday Life: Civilization and Capitalism 15th-18th Century, Volume 1*. New York: Harper and Row.

Brown, Donald E. 1991. *Human Universals.* New York: McGraw-Hill.

Burt, Ronald S. 1976. "Positions in Networks." *Social Forces.* 55(1): 93-122.

Cleveland, W. S. (1979) "Robust locally weighted regression and smoothing scatterplots." *Journal of the American Statistical Association*. 74, 829–836.

Cowgill, George L. 2004. "Origins and Development of Urbanism: Archaeological Perspectives." *Annual Review of Anthropology.* 33: 525-549.

Douglas, Mary. 1966. *Purity and Danger: An Analysis of Concepts of Pollution and Taboo.* New York: Frederick A. Praeger.

Douglas, Mary. 1970. *Natural Symbols: Explorations in Cosmology.* New York: Pantheon Books.

Duneier, Mitchell. 1999. *Sidewalk.* New York: Farrar, Straus, and Giroux.

Evans, Alan. 1976. "Economic Influences on Social Mix." *Urban Studies.* 13: 247-260.

Forsyth, Ann. 2000. "Analyzing Public Space at a Metropolitan Scale: Notes on the Potential for Using GIS." *Urban Geography.* 21(2): 121-147.

Faith, D. P, Minchin, P. R. and Belbin, L. (1987). "Compositional dissimilarity as a robust measure of ecological distance." *Vegetatio.* 69: 57–68.

Frykman, Jonas and Orvar Löfgren. 1987. *Culture Builders: A Historical Anthropology of Middle-Class Life.* New Brunswick: Rutgers University Press.

Getis, A., and J.K. Ord. 1992. The analysis of spatial association by use of distance statistics. *Geographical Analysis*. 24:189-206.

Gilmore, David. 1977. "The Social Organization of Space: Class, Cognition, and Residence in a Spanish Town." *American Ethnologist.* 4(3): 437-451.

Gordon, Peter and Harry W. Richardson. 1997. "Are compact cities a desirable planning goal?" *Journal of the American Planning Association*. 63(Winter): 95-106.

Guttormsson, Loftur. 2002. "Parent-Child Relations," pages 251-281 in David I. Kertzer and Marzio Barbagli, editors, *The History of the European Family, Volume Two: Family Life in the Long Nineteenth Century 1789-1913.* New Haven: Yale University Press.

Hamilton, William D. 1964. "The Genetical Evolution of Social Behavior. I." *Journal of Theoretical Biology* 7: 1–16.

Jacobs, Jane. 1961. *The Death and Life of Great American Cities.* New York: Random House.

Jacobs, Jane. 1969. *The Economy of Cities.* New York: Random House.

Kruskal, Joseph B., and Myron Wish. 1978. *Multidimensional Scaling.* Beverly Hills, California: Sage Publications, Inc.

Kuper, Hilda. 1972. "The Language of Sites in the Politics of Space." *American Anthropologist.* 74: 411-425.

Lawrence, Denise L., and Setha M. Low. 1990. "The Built Environment and Spatial Form." *Annual Review of Anthropology.* 19(4): 453-505.

Lawrence, Roderick J. 1982. "Domestic Space and Society: A Cross-Cultural Study." *Comparative Studies in Society and History.* 24(1): 104-130.

Linklater, Andro. 2002. *Measuring America: How the United States Was Shaped by the Greatest Land Sale in History.* New York: Plume.

Low, Setha M. 1996. "Spatializing Culture: The Social Production and Social Construction of Public Space in Costa Rica." *American Ethnologist.* 23(4): 861-879.

Lucas, Antoine. 2007. "amap: Another Multidimensional Analysis Package." *R package version 0.7-3.* http://mulcyber.toulouse.inra.fr/projects/amap/

Marshall, Alfred. 1920. *Principles of Economics* (eighth edition). Philadelphia: Porcupine Press.

Minchin, P.R. 1987. "An evaluation of relative robustness of techniques for ecological ordinations." *Vegetatio.* 71: 145-156.

Muller, Jerry Z. 2002. *The Mind and the Market: Capitalism in Modern European Thought*. New York: Alfred A. Knopf.

Offer, Avner. 2006. *The Challenge of Affluence: Self-control and Well-being in the United States and Britain since 1950*. Oxford University Press.

Ohnuki-Tierney, Emiko. 1972. "Spatial Concepts of the Ainu of the Northwest Coast of Southern Sakhalin." *American Anthropologist.* 74(3): 426-457.

Oksanen, Jari, Roeland Kindt, Pierre Legendre, Bob O'Hara, M. Henry H. Stevens. (2007). vegan: Community Ecology Package. Version 1.8-7. http://cran.r-project.org/doc/packages/vegan.pdf

Olson, Mancur. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge: Harvard University Press.

Pader, Ellen J. 1993. "Spatiality and Social Change: Domestic Space Use in Mexico and the United States." *American Ethnologist.* 20(1): 114-137.

Perin, Constance. 1977. *Everything in Its Place: Social Order and Land use in America*. Princeton: Princeton University Press.

Rektorys, Karel. 1969. *Survey of applicable mathematics*. Cambridge: MIT Press.

Rodgers, Dennis. 2004. "Disembedding the City: Crime, Insecurity, and Spatial Organization in Managua, Nicaragua." *London School of Economics and Political Science, Development Studies Institute, Working Papers Series*. No. 04-50. July 2004.

Ross, Sheldon M. 1980. *Introduction to Probability Models* (second edition). New York: Academic Press.

Sarkissian, Wendy. 1976. "The Idea of Social Mix in Town Planning: An Historical Review." *Urban Studies.* 13: 231-246.

Scott, John. 2000. *Social Network Analysis: A Handbook* (second edition). London: Sage Publications, Ltd.

Scott, Mel. 1969. *American City Planning Since 1890*. Berkeley: University of California Press.

Simmel, Georg. 1957[1904]. "Fashion." *The American Journal of Sociology*. 62(6): 541-558.

Simmel, Georg. 1978[1900]. *The Philosophy of Money*. London, Henley, and Boston: Routledge & Kegan Paul.

Spiegel, Henry William. 1991. *The Growth of Economic Thought*. Durham & London: Duke University Press.

van den Berghe, Pierre L. 1987. *The Ethnic Phenomenon*. New York: Praeger.

Veblen, Thorstein. 1953 [1899]. *The Theory of the Leisure Class*. New York: Mentor Books.

Ward, J.H. 1963. "Hierarchical Grouping to Optimize an Objective Function." *Journal of the American Statistical Association.* 58: 236-244.

Wasserman, Stanley and Katherine Faust. 1994. Social Network Analysis: Methods and Applications. Cambridge: Cambridge University Press.

White, Harrison C., Scott A. Boorman, and Ronald L. Breiger. 1976. "Social Structure from Multiple Networks. I. Blockmodels of Roles and Positions." *The American Journal of Sociology*. 81(4): 730-780.

Wolf, Eric R. 1955. "Types of Latin American Peasantry: A Preliminary Discussion." *American Anthropologist.* 57: 452-471.

Table 1: Parcel Categories and Parcel Frequencies

landuse	description	taxon	freq. in pairs	no. of parcels	as pct. of all parcels	net prob. self-proximity	openness	lowest net prob.	second lowest	highest net prob.	second highest
ADS	Auto Dealer - Sales	C	3,369	447	0.206	0.0900	0.00730	SFDPP	RESCU	VCL	ADS
AH	Apartment High-rise	R	978	50	0.023	0.0016	0.00048	SFDPP	RESCU	VRESL	RI
AL	Apartment Low-rise	R	15,270	569	0.262	0.1654	0.00694	SFDPP	RESCU	AL	VCL
AO	Apartment walkup	R	1,264	119	0.055	0.1909	0.00292	RESCU	XXX	AO	D
ARBS	Auto Repair and Body Shop	C	4,456	558	0.257	0.0612	0.01039	SFDPP	RESCU	VCL	ARBS
BC	Business Center	C	1,558	107	0.049	0.0815	0.00429	SFDPP	RESCU	VCL	BC
BFI	Branch Financial Institution	C	2,374	144	0.066	0.0227	0.00840	SFDPP	RESCU	OSGRS	SS
CA	Common Area	O	55,564	6,155	2.838	0.6404	-0.00866	SFDPP	RESCU	CA	D
CG	Camp Ground	S	125	6	0.003	0.1040	0.00138	SFDPP	RESCU	XXX	CG
CLOUH	Club, Lodge or Union Hall	I	1,576	79	0.036	0.0057	0.00065	SFDPP	RESCU	VRL	XXX
CM	Convenience Market without gas	C	1,043	141	0.065	0.0072	0.00305	SFDPP	RESCU	OBNML	OSGRS
COOC	Condominium Office or other Commercial Condominium	C	8,323	512	0.236	0.5941	0.00717	SFDPP	VRESL	COOC	XXX
CW	Car Wash	C	795	66	0.030	0.0097	0.00247	SFDPP	RESCU	FFR	TOHDW
D	Duplex	R	70,939	9,426	4.346	0.2176	-0.00722	RESCU	XXX	D	SFDPP
DCC	Day Care Center	C	1,064	118	0.054	0.0108	0.00460	SFDPP	XXX	GS	AL
DOBH	Dormitory or Boarding House	R	1,246	133	0.061	0.1283	0.00196	RESCU	XXX	DOBH	D
DOM	Dock or Marina	S	52	3	0.001	0.0000	0.00003	SFDPP	RESCU	XXX	LW
DS	Department Store	C	909	17	0.008	0.0194	0.00368	SFDPP	RESCU	PL	OBML
DTOS	Drive-in Theater or Stadium	C	1,085	91	0.042	0.0143	0.00131	SFDPP	RESCU	MCOC	VRL
F	Federal	I	599	46	0.021	0.0791	0.00155	SFDPP	RESCU	VCL	SOC
FBO	Farm Buildings Only	F	2,453	98	0.045	0.0006	-0.00013	SFDPP	RESCU	SFD	XXX
FFR	Fast Food Restaurant	C	3,251	343	0.158	0.0613	0.01061	SFDPP	RESCU	VCL	OSGRS
GCODR	Golf Course or Driving Range	S	2,112	24	0.011	0.0597	0.00147	SFDPP	RESCU	VCL	XXX
GON	Greenhouse or Nursery	C	330	25	0.012	-0.0001	0.00047	RESCU	XXX	D	SFDPP
GS	Gasoline Station	C	2,447	298	0.137	0.0190	0.00503	SFDPP	RESCU	PL	ROC
HM	Heavy Manufacturing	M	2,233	97	0.045	0.0174	0.00168	SFDPP	RESCU	VIL	VCL
HOC	Hospital or Clinic	H	985	55	0.025	0.1742	0.00699	SFDPP	RESCU	HOC	VCL
HOM	Hotel or Motel	C	2,109	204	0.094	0.0930	0.00510	SFDPP	RESCU	VCL	PL
LM	Light Manufacturing	M	5,462	366	0.169	0.0470	0.00697	SFDPP	RESCU	VIL	TOHDW
LW	Light Warehouse	C	7,723	836	0.385	0.1150	0.01469	SFDPP	RESCU	LW	VCL
LY	Lumber Yard	C	477	34	0.016	0.2451	0.00339	SFDPP	RESCU	LY	LM
MCOC	Mortuary, Cemetery, or Crematorium	H	3,205	216	0.100	0.0372	0.00835	RESCU	XXX	SFD	DTOS
MH	Mobile Home	R	8,315	664	0.306	0.1771	0.00360	SFDPP	RESCU	SFD	MH
MOCO	Museum or other Cultural Organizations	I	236	21	0.010	0.1313	0.00184	RESCU	SFDPP	MOCO	PORA
MOMRA	Metro or Metro Related Agencies	I	9,609	324	0.149	0.0883	0.00330	SFDPP	RESCU	VRESL	VIL
MP	Mineral Processing	M	3,947	56	0.026	0.0490	0.00157	SFDPP	RESCU	VRL	LW

landuse	description	taxon	freq. in pairs	no. of parcels	as pct. of all parcels	net prob. self-proximity	openness	lowest net prob.	second lowest	highest net prob.	second highest
MW	Mini-Warehouse	C	969	81	0.037	0.0450	0.00199	SFDPP	RESCU	VCL	SSO
NCOL	Night Club or Lounge	C	1,307	158	0.073	0.0408	0.00248	SFDPP	RESCU	VRL	VCL
NHCH	Nursing Home, Convalescent Home, or Sanitarium	H	793	51	0.024	0.0816	0.00127	SFDPP	RESCU	MCOC	VIL
NS	Neighborhood Supermarket	C	1,182	70	0.032	-0.0005	0.00274	SFDPP	RESCU	SSO	DS
OBMH	Office Building (Medical High-rise)	H	183	14	0.007	0.0054	0.00100	SFDPP	RESCU	DCC	HOC
OBML	Office Building (Medical Low-rise)	H	2,513	298	0.137	0.0646	0.00729	SFDPP	RESCU	VCL	OBNML
OBNMH	Office Building (Non-Medical High-rise)	C	3,624	218	0.101	0.2386	0.00739	SFDPP	VRESL	OBNMH	OBNML
OBNML	Office Building (Non-Medical Low-rise)	C	15,636	1,766	0.814	0.1586	0.02601	SFDPP	RESCU	OBNML	VCL
OO	Orphanage or other such nonprofit Charitable Services	I	694	60	0.028	0.0559	0.00119	SFDPP	XXX	OBNML	OO
OS	Open Storage	C	1,978	116	0.054	0.0452	0.00303	SFDPP	RESCU	TOHDW	ADS
OSGRS	One Story General Retail Store	C	10,193	878	0.405	0.2123	0.02061	SFDPP	RESCU	OSGRS	VCL
P	Parsonage	R	712	85	0.039	-0.0003	0.00009	RESCU	XXX	VRESL	SFDPP
PG	Parking Garage	C	801	40	0.018	0.1120	0.00369	SFDPP	VRESL	RESCU	PG
PL	Parking Lot	O	11,847	1,441	0.664	0.2078	0.02814	SFDPP	RESCU	PL	VCL
PORA	Park or Recreation Areas	S	4,230	128	0.059	0.0447	0.00214	SFDPP	RESCU	XXX	VRL
PPFP	Packing Plant and other Food Processing	M	989	59	0.027	0.0208	0.00352	SFDPP	RESCU	OS	BC
Q	Quadplex	R	2,481	319	0.147	0.0784	0.00155	RESCU	XXX	Q	D
R	Recreational	S	2,476	58	0.027	0.0038	0.00152	SFDPP	RESCU	RTVORS	XXX
RCA	Rural Combination	F	2,163	159	0.073	0.0074	-0.00009	SFDPP	RESCU	SFD	VRL
RESCOM	Residential, Combination or Miscellaneous	R	5,921	479	0.221	0.0112	0.00064	RESCU	XXX	VRESL	VRL
RESCU	Residential Condominium Unit	R	295,806	19,272	8.885	0.6426	-0.09271	SFDPP	SFD	RESCU	XXX
RI	Religious Institutions	I	9,320	872	0.402	0.0358	0.00379	RESCU	XXX	SFDPP	RI
ROC	Restaurant or Cafeteria	C	3,557	312	0.144	0.0443	0.01084	SFDPP	RESCU	SS	SSO
RTVORS	Recording, TV or Radio Studio and transmitting facilities	C	1,424	117	0.054	0.1665	0.00714	SFDPP	RESCU	VCL	RTVORS
S	State	I	955	32	0.015	0.0363	0.00206	SFDPP	RESCU	ARBS	VRESL
SC	Satellite City	I	203	19	0.009	0.0098	0.00047	SFDPP	RESCU	MCOC	PL
SFD	Single Family Dwelling	F	118,039	6,580	3.034	0.4551	-0.01068	SFDPP	RESCU	SFD	VRL
SFDPP	Single Family Dwelling Per Parcel	R	1,017,839	132,670	61.167	0.3741	-0.25249	RESCU	XXX	SFDPP	D
SOC	School or College	I	5,556	279	0.129	0.0679	0.00792	RESCU	SFDPP	AL	SOC
SS	Strip Shopping (at least one major tenant)	C	3,304	66	0.030	0.0201	0.00658	SFDPP	RESCU	SSO	ROC
SSO	Strip Shopping (no major tenants)	C	6,134	560	0.258	0.0926	0.01903	SFDPP	RESCU	OSGRS	SSO
SSSI	Small Service Shop on an Individual Parcel	C	3,153	473	0.218	0.0351	0.00552	SFDPP	RESCU	VCL	OBNML

landuse	description	taxon	freq. in pairs	no. of parcels	as pct. of all parcels	net prob. self-proximity	openness	lowest net prob.	second lowest	highest net prob.	second highest
T	Triplex	R	4,217	532	0.245	0.0601	0.00101	RESCU	XXX	SFDPP	D
TOA	Theater or Auditorium	C	296	12	0.006	0.0066	0.00066	SFDPP	VRESL	SSO	XXX
TOHDW	Terminal or Heavy Duty Warehouse	C	10,819	690	0.318	0.1343	0.01608	SFDPP	RESCU	TOHDW	VIL
VCL	Vacant Commercial Land	O	36,751	3,219	1.484	0.2441	0.05106	SFDPP	RESCU	VCL	OSGRS
VIL	Vacant Industrial Land	O	14,447	689	0.318	0.2526	0.02212	SFDPP	RESCU	VIL	LM
VRESL	Vacant Residential Land	O	212,654	14,220	6.556	0.2891	-0.02360	SFDPP	RESCU	VRESL	AL
VRL	Vacant Rural Land	F	101,637	3,665	1.690	0.3578	-0.00010	SFDPP	RESCU	VRL	SFD
WOOPH	Wholesale Outlet or Produce House	C	571	73	0.034	0.0330	0.00209	SFDPP	RESCU	VCL	LW
XXX	Unknown (always open land)	O	252,510	3,620	1.669	0.3527	-0.02056	SFDPP	SFD	XXX	RESCU

Notes: "taxon": commercial (C), open (O), institutional (I), manufacturing (M), residential (R), recreational (S), health (H), farm (F); "*freq. in pairs*": the number of occurrences of parcels in this land use as a member of a parcel pair (row sum of matrix **M**); "*no. of parcels*": the number of parcels in that land use; "*as pct. of all parcels*": the parcels in that land use as a percent of all parcels; "*net prob. self-proximity*": the net probability that a parcel is proximate to another parcel of the same land use (the diagonal of matrix **D**); "*openness*": the mean net probability of all land uses having proximity with parcels in this land use (column means of matrix **D**); "*lowest net prob.*": the minimum net probability for each row in matrix **D** (the column land use to which the row land use is least attracted); "*second lowest net prob.*": after the minimum, the next lowest net probability for each row in matrix **D** (the column land use to which the row land use is next least attracted); "*highest net prob.*": the maximum net probability for each row in matrix **D** (the column land use to which the row land use is most attracted); "*second highest net prob.*": after the maximum, the next highest net probability for each row in matrix **D** (the column land use to which the row land use is next most attracted).

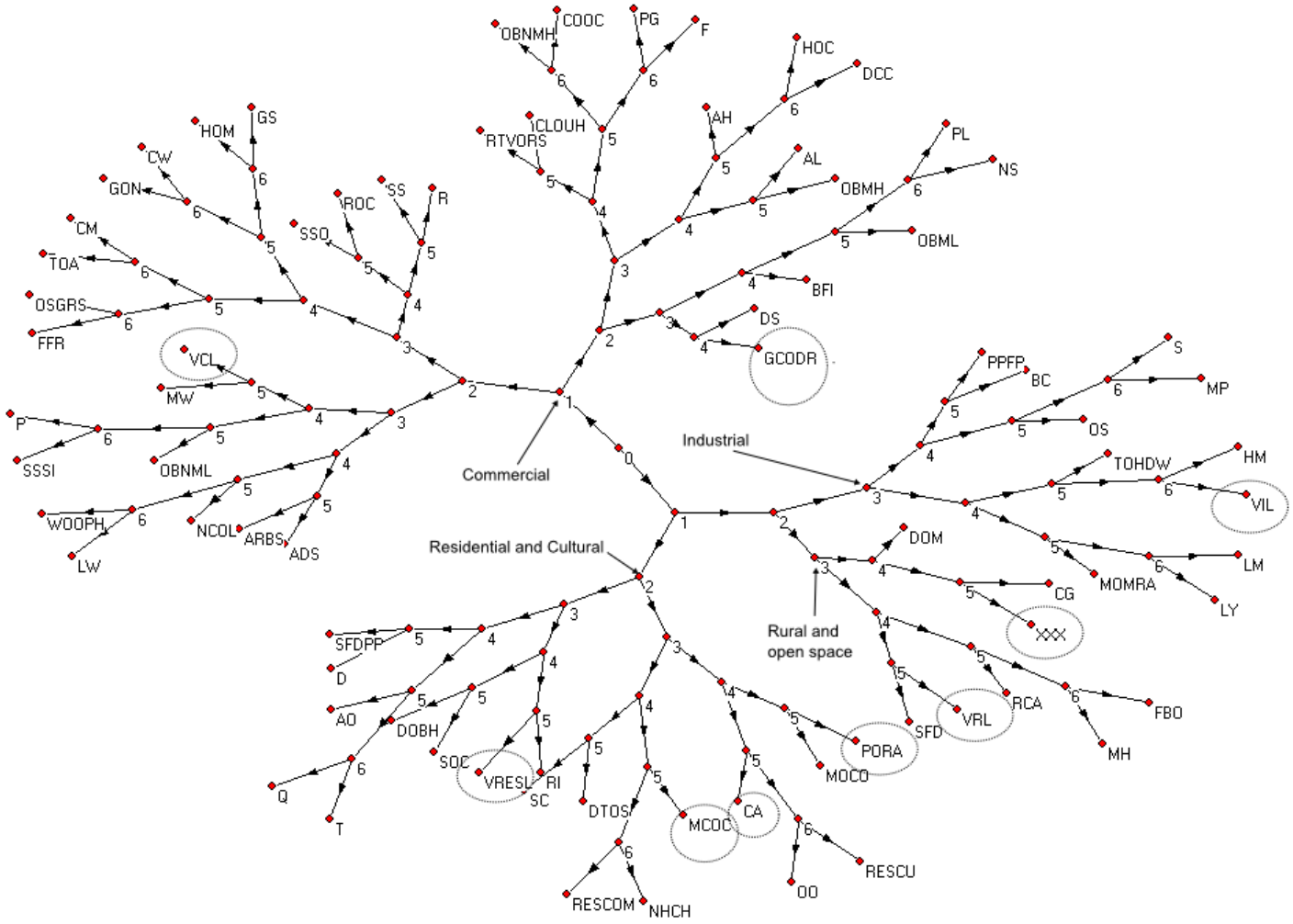

Figure 1: Graph of block-modeled matrix P. The abbreviations are defined in Table 1. Nodes representing open land are circled—these are distributed throughout the graph.

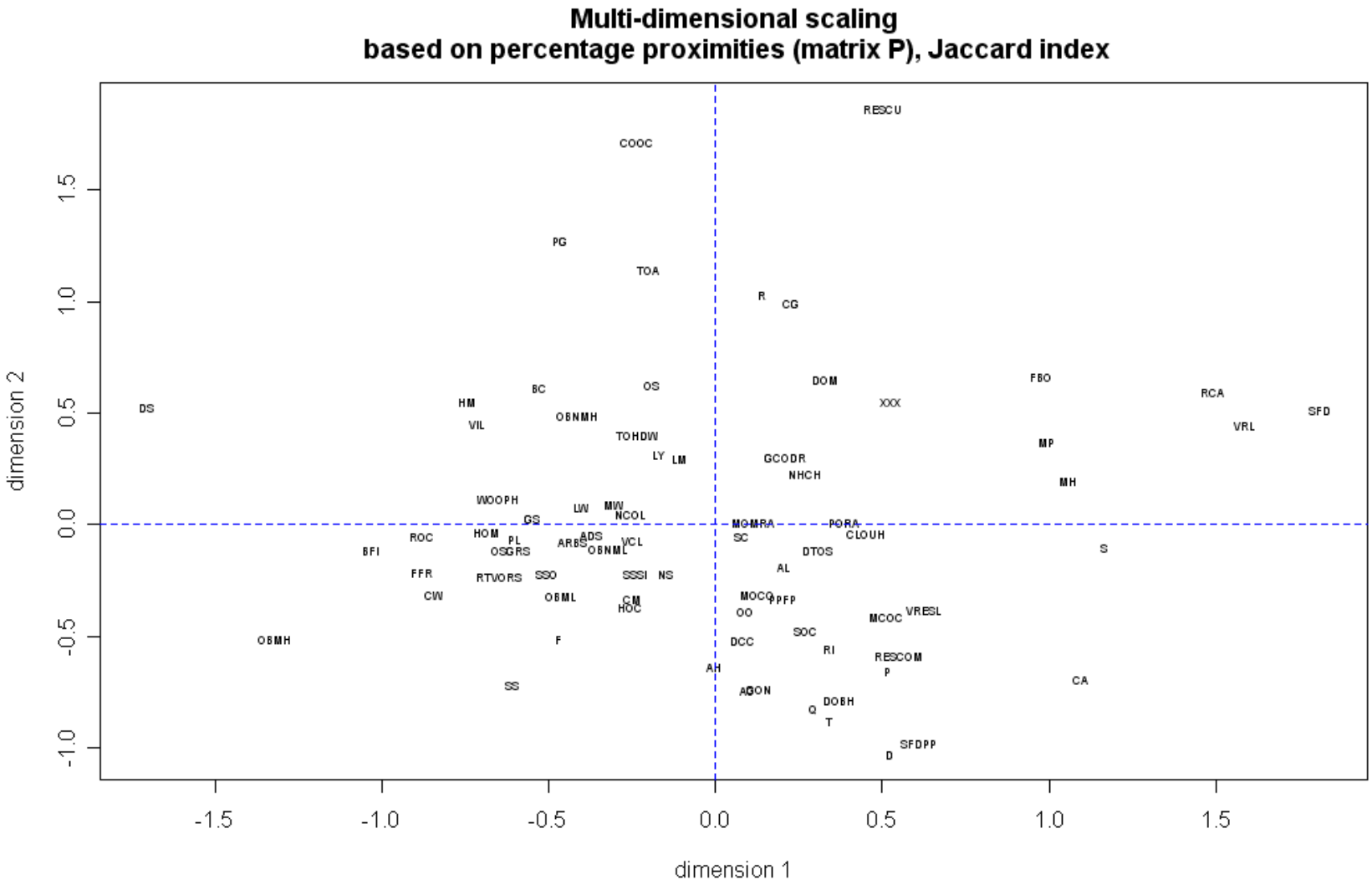

Figure 2: Multidimensional scaling, based on matrix P, using Jaccard index. The abbreviations are defined in Table 1.

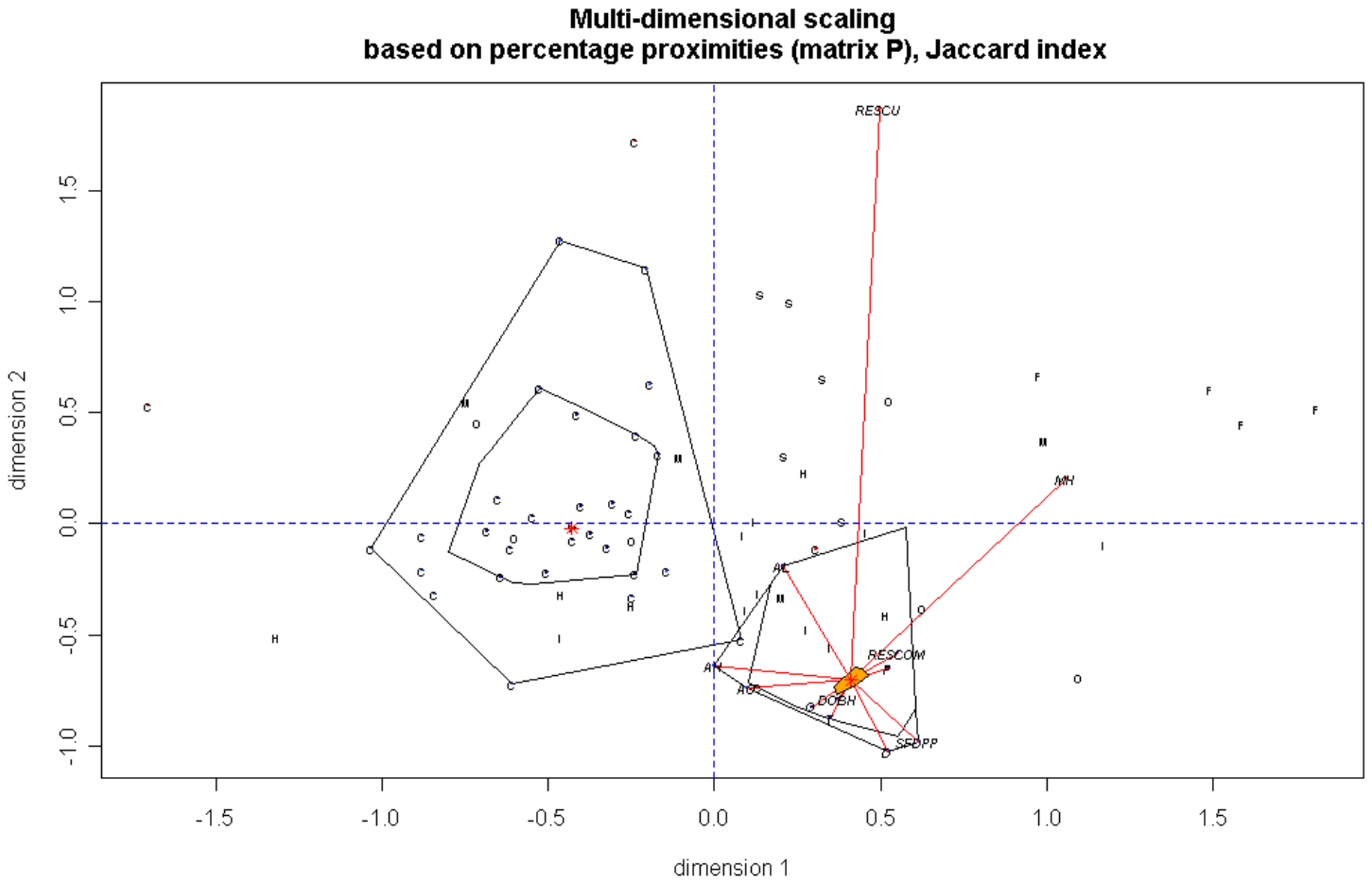

Figure 3: Like Figure 2, but with bagplots drawn for residential and commercial land uses; note the clear separation between these two groups. The one letter abbreviations give the "taxon" (from Table 1): commercial (C), open (O), institutional (I), manufacturing (M), residential (R), recreational (S), health (H), and farm (F); residential land uses are given the full abbreviation (see Table 1). Mobile homes (MH) and residential condominium units (RESCU) are the outliers for residential land uses, and single family dwellings per parcel (SFDPP) is the most distant point in the residential cluster from the commercial cluster.

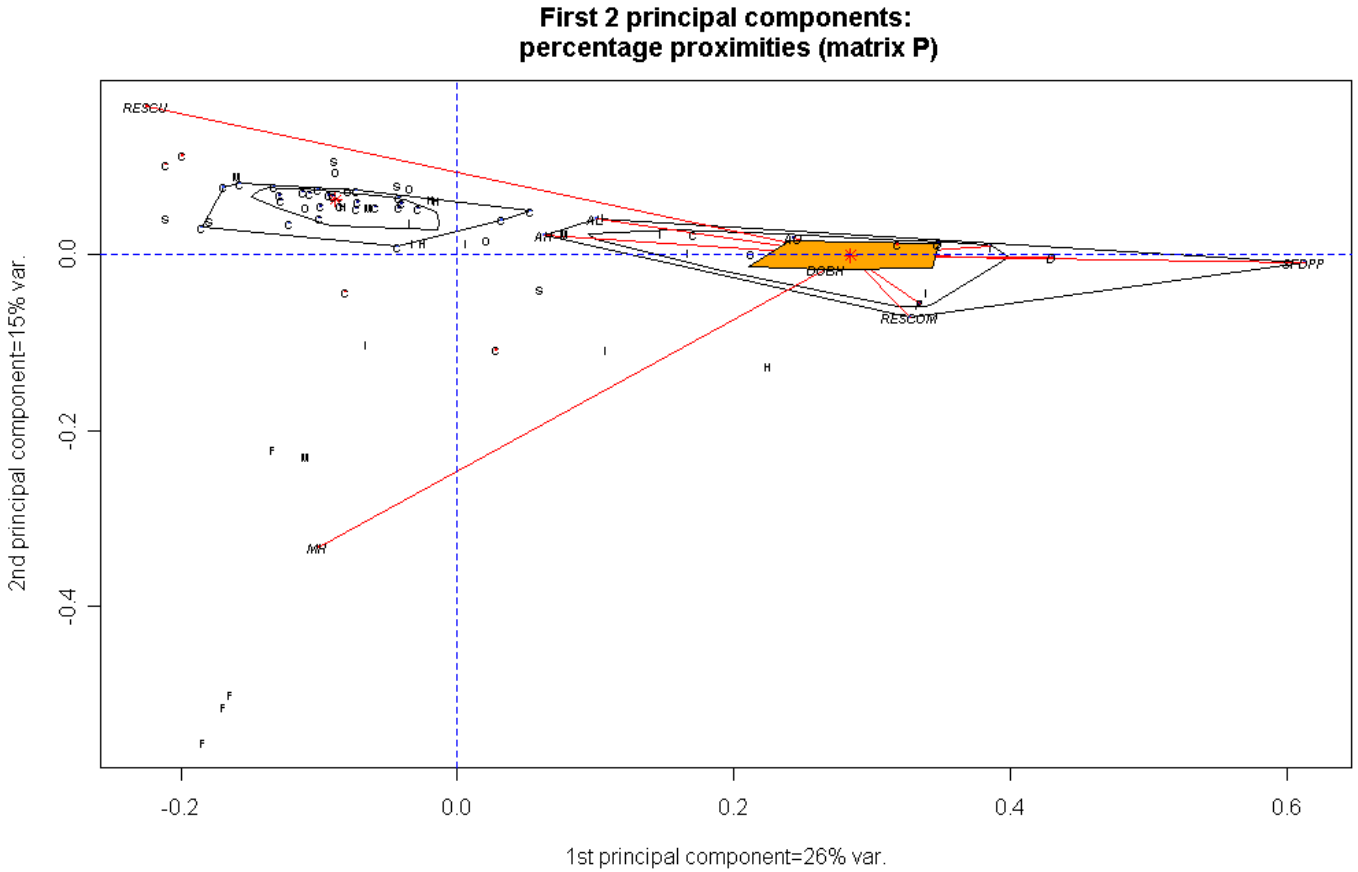

Figure 4: A plot of the first two principal components from matrix P. Bagplots are drawn for residential and commercial land uses; as in Figure 3, there is clear separation between these two taxa. Mobile homes (MH) and residential condominium units (RESCU) are again residential outliers, and single family dwellings per parcel (SFDPP) are situated on the side of the residential cluster furthest from the commercial cluster. The one letter abbreviations are for taxa: commercial (C), open (O), institutional (I), manufacturing (M), residential (R), recreational (S), health (H), and farm (F).

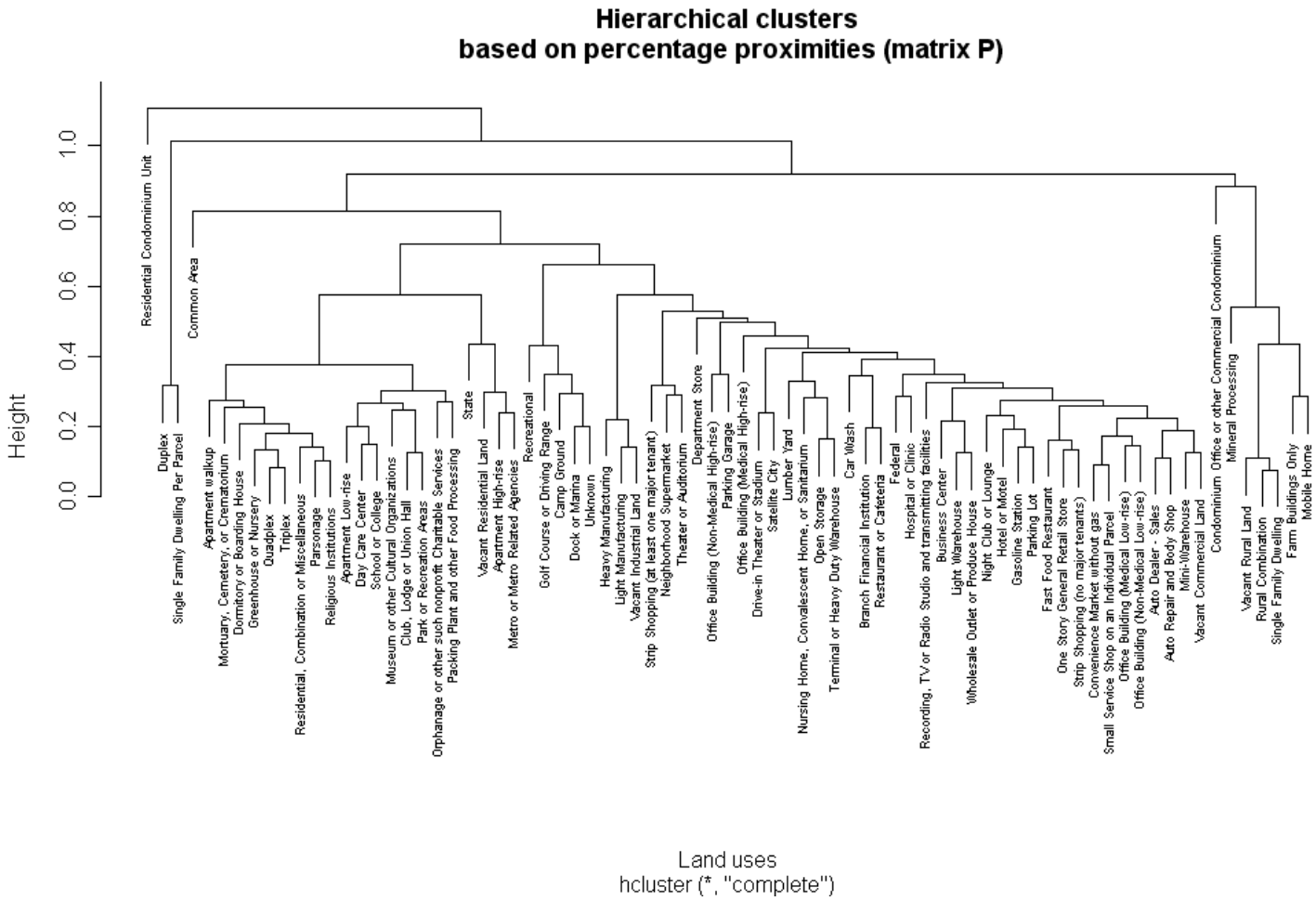

Figure 5: Hierarchical cluster plot. The algorithm is based on a Euclidean distance matrix, calculated from matrix P. Each land use starts out in its own cluster. At each step in the algorithm, the two closest clusters are aggregated, and the distance matrix recalculated. Through successive iterations, the root is reached (Lucas 2007).

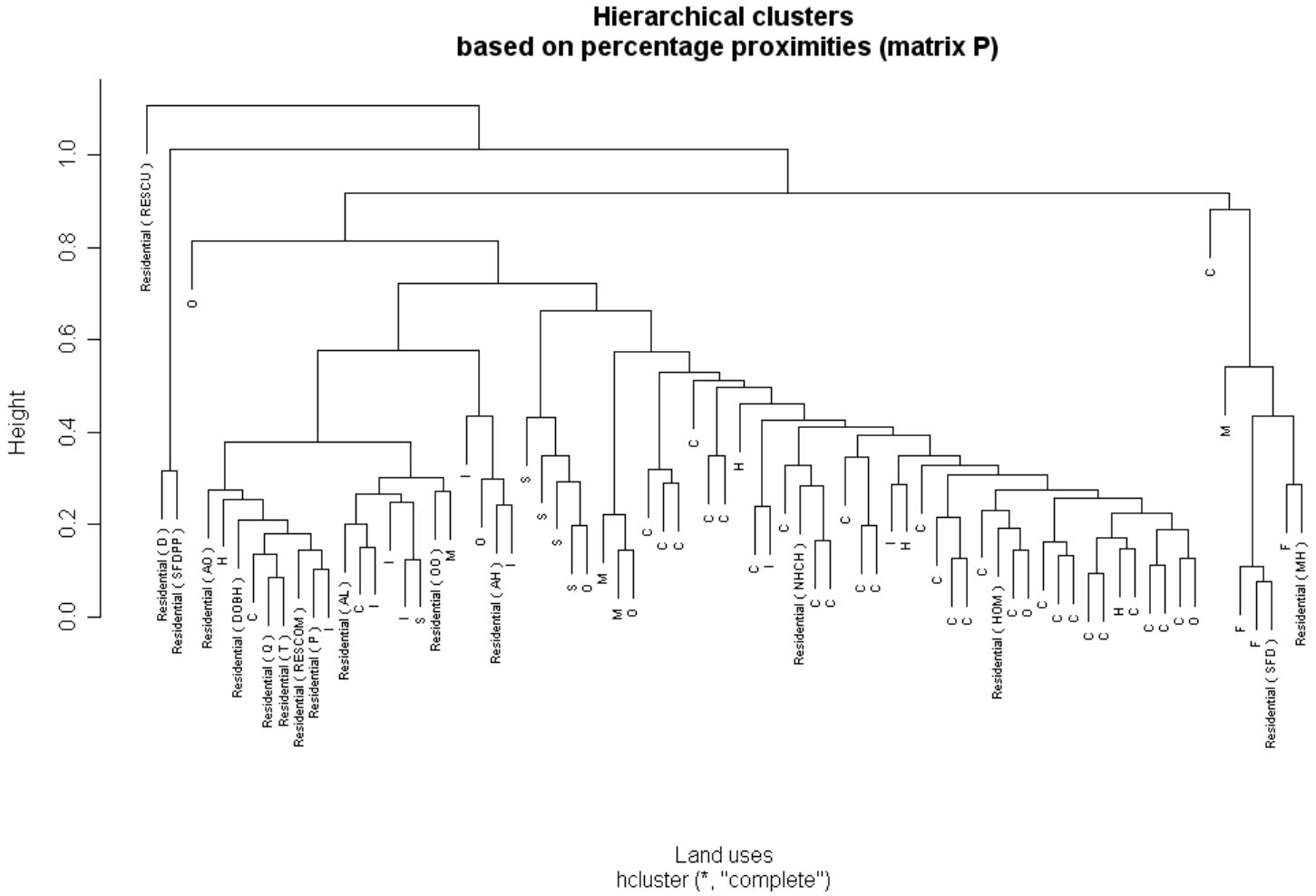

Figure 6: Hierarchical cluster plot. This differs from Figure 5 in that the labels have been replaced with "taxon", except for land uses that can be considered residential. The separation of commercial from residential has only a few exceptions: nursing homes and hotels are in the commercial cluster, and day care centers and (plant) nurseries are in the residential cluster.

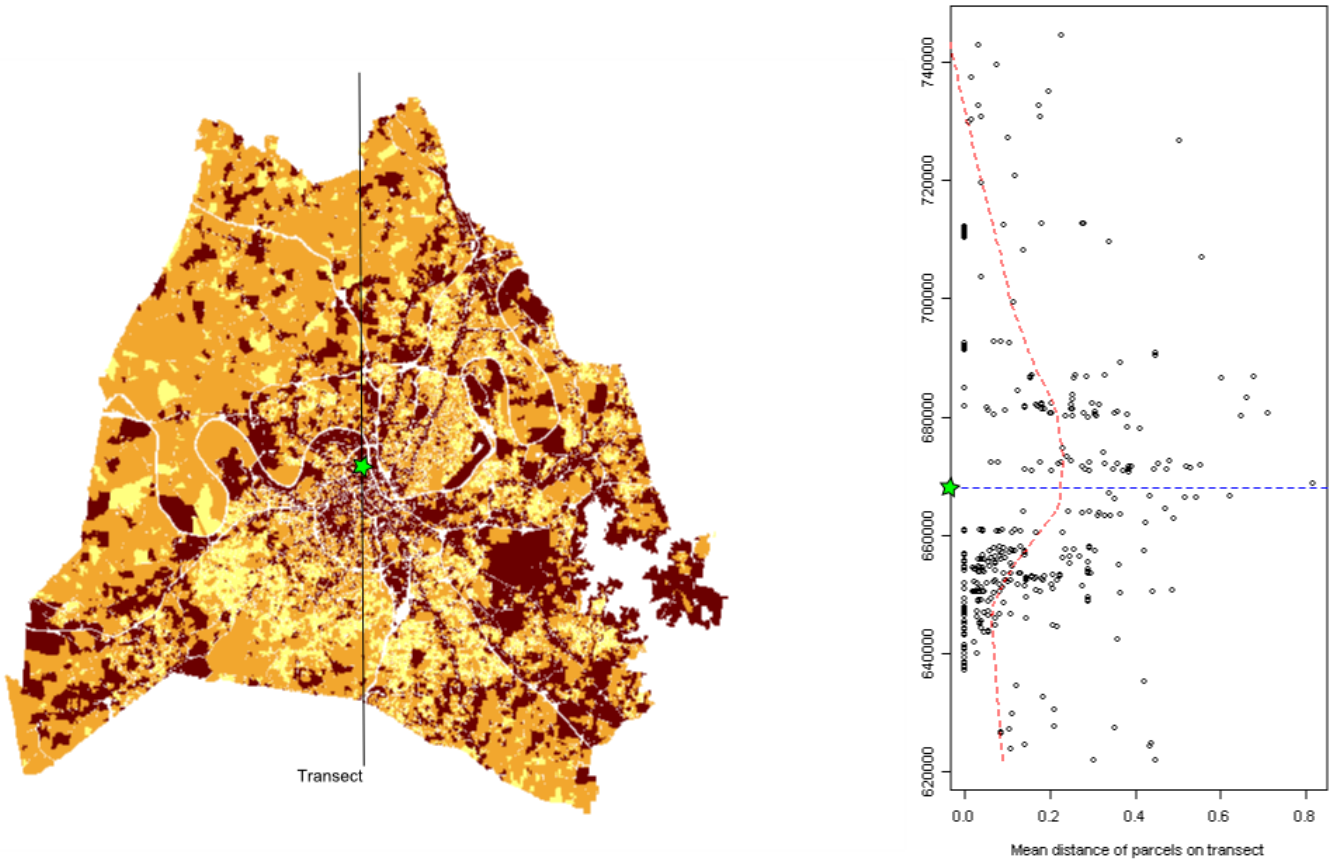

Figure 7: Mean distance between a parcel and its neighbors. For each parcel, its neighbors are enumerated, and a distance assigned to each neighbor-relationship from matrix E. The mean distance to its neighbors is then calculated. The map shows the local G* z-score (Getis and Ord 1992) for mean distance. The darkest areas have significantly higher mean distance; the lightest areas have significantly lower mean distance. The mean distance for the parcels along the transect are plotted at right. The star represents the position of the state capital on both the map and the plot. The line is the LOWESS smoother based on locally-weighted polynomial regression (Cleveland 1979). Mean distance is clearly higher toward the urban core, where land uses are more diverse.

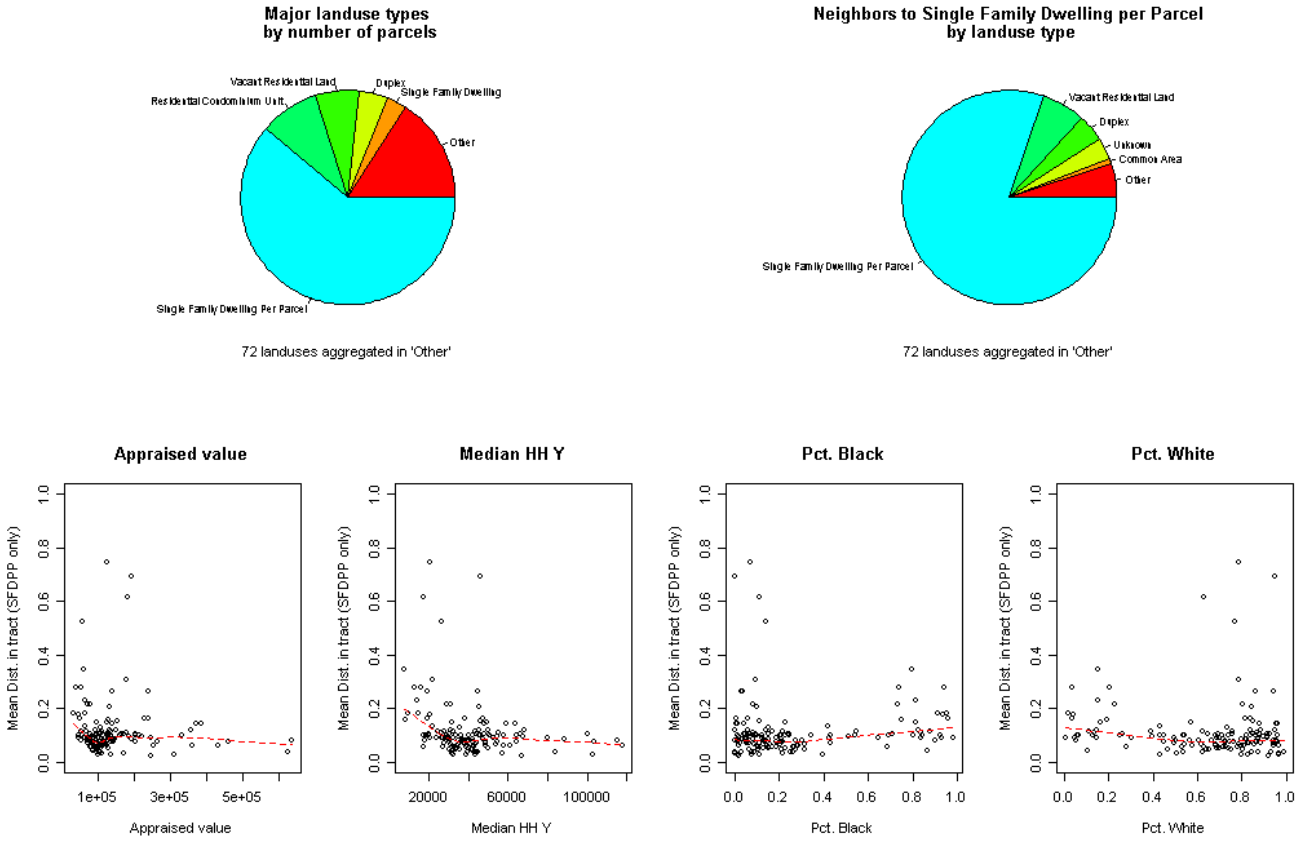

Figure 8: Single family dwellings per parcel (SFDPP) constitute about 61 percent of all parcels (pie chart at top left), but about 80 percent of all of SFDPP proximity relationships are with itself (pie chart at top right). For this reason, SFDPP parcels have, on average, the lowest mean distance of all land uses. The scatter plots at the bottom show the average mean distance across SFDPP parcels for each census tract (n=142) plotted against demographic features of the census tract. Mean distance apparently is no higher in predominantly African-American tracts, but it is clear that those tracts with the highest median household income and the highest appraised home values have very low mean distance. The line is the LOWESS smoother based on locally-weighted polynomial regression (Cleveland 1979).

Figure 9: A comparison of the structure of a suburban neighborhood and an inner-city neighborhood. The map shows the local G* z-score (Getis and Ord 1992) for mean distance. The darkest areas have significantly higher mean distance; the lightest areas have significantly lower mean distance. Mean distance is much lower in the suburban neighborhood, due to the homogeneity of the cluster of homes.