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Ecological Measure of Community Linkages: Connecticut as a Case Study

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ABSTRACT

This study suggests that attempts to categorize communities as suburban, exurban, etc., be redirected toward recognition of the multidimensional, continuous nature of community linkages. All communities in a given system are viewed as interrelated to various degrees. A methodology is proposed which describes the system in terms of the ecological relation of all the towns, the strength of interconnectedness with all other towns, and the relative size of each town in the system. Consideration is then given to the direction of major linkages each town has with the entire system.

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Much effort has been directed toward the development of typologies of suburban communities in an attempt to deal with the complex relationships between different areas. Some typologies are based on demographic or ecological criteria (Bogue and Harris; Chinitz; Farley; Schnore, a, b, c; and Logan) while others are based on social criteria (Dobriner; Gans, a, b; Whyte; and Wood). A body of literature that is critical of the basic concept of suburb also exists and suggests that clarification of the term is required before meaningful typologies can be constructed (Shryock; Schmitt; Kurtz and Eicher; Stauber; Pryor; and Hadden).

It is the argument of this paper that attempts to place communities into discrete categories be redirected toward recognition of the multidimensional, continuous nature of community linkages. A method is proposed which describes a system of interdependencies in a continuous way based on three underlying dimensions. With this method, all communities in a given system are viewed as interrelated to various degrees and it is unnecessary to place communities into nominal categories of suburban or not suburban.

The work of Walter T. Martin (1956) recognized the basic elements in the concept of suburb. He argued that there are definitive characteristics of communities thought of as suburbs and derivative features which may characterize suburbs but are not essential to suburban status. The three definitive characteristics which he used to differentiate between suburban and nonsurburban communities are: a) the unique ecological position in relation to a larger city, b) a high rate of commuting to that city, and c) the population size and density. These three definitive characteristics always influenced the derivative characteristics of demographic structure, socioeconomic characteristics, sociopsychological characteristics, and homogeneity of neighborhood groupings. The factor of commuting rates into the larger city is an attempt to measure the social and economic dependence of the suburban community on the larger city. It distinguished suburbs from satellite cities which, while located adjacent to urban centers, provide jobs for their own residents and other in-commuters.

Based on the work of Martin, the three definitive characteristics of a suburb will be generalized to describe the entire system of linkages between all elements in the network. A network is defined as any group of elements which can vary in terms of their location relative to all other elements, the strength of interconnectedness with all other elements, and the relative size of each element in the entire system. Elements are defined here as all towns within a state's boundaries.

Multidimensional Framework

The underlying assumptions of the following discussion are that the network system being analyzed has clearly defined boundaries and that the elements are comparable in terms of a characteristic relevant to the theoretical background of the study. The first assumption is necessary because the methodology requires all elements be included in the calculations. The second assumption is necessary to give meaning to the results of the analysis. For example, when the subject is suburban status, all the elements should be towns and not a mixture of towns, counties, planning regions or other such areas. In addition, the methodology is sensitive to the number of elements within the system and, other factors equal, will show greater variation for a system with more elements.

In dealing with the problem of describing the complex linkages between towns, the first dimension is the ecological position of each town in a state relative to all other towns. Here, geographic location is recognized as a basic feature of the system and the relative location to all other towns is emphasized, not just the nearest large city. An adequate measure of this dimension must provide an array of towns ranging from relative ecological isolation to relative ecological centrality within the defined system.

A second basic dimension is the degree of interconnectedness of each community with all other communities within a state. Again, the emphasis is on the relationship to the entire system of towns, not simply to the nearest large city. The measure of this dimension must reflect the complex system of inter-community ties and identify different degrees to which specific communities are bound to the total network system.

A third dimension recognizes the importance of element size in the system and views population density of each town as an independent dimension influencing the potential to participate in the system. In summary, the proposed multidimensional model should provide a continuum along which all towns can be located. It should also be able to identify towns traditionally thought of as suburbs as well as other communities with high interconnectedness not usually recognized as such by simple categorizations. Importantly, the methodology should avoid arbitrary cut-off points for integration, arbitrarily defined distances for ecological position, and the arbitrary selection of the nearest largest city as the only reference point.

Methodology

A measure of ecological or geographic position of a community within a defined system of other communities is known in the literature as the population potential (Stewart and Warntz). The value of the population potential for a given area is determined by the distances of all other persons in all other areas from the area of focus. It is defined as:

$$L_i = \sum_{j=1}^{j} \frac{P_j}{D_{ij}}$$

where P_j are the populations of the j communities within the system and the D_{ij} are the distances from community i to j, excluding area i. Communities located near large population concentrations will have high population potential scores while communities ecologically isolated from large population concentrations will have lower population potential scores. The important point is that all communities within the total system are included in the calculations.

Since population potential scores may have a very wide range of values depending on the geographic distribution of population and since it is desired to combine this measure of ecological position with measures of two other dimensions, a transformation analogous to that used in social area analysis (Shevky and Bell) is done to provide this measure with a lower limit of zero and an upper limit of 100. The transformed population potential score TL_i as a measure of ecological position is:

$$TL_i = X\,(L_i - L_o), \text{ where}$$

L_i is the population potential for community i,

L_o is the lower limit of the population potentials for all communities

X = 100 ÷ the range of population potentials for all communities

The state of Connecticut provides a convenient empirical illustration of the methodology. Its relatively small population of 3,032,217 (1970) is divided into 169 towns. These towns are the basis for the 11 standard metropolitan statistical areas (SMSA's) recognized by the Census Bureau as of 1970 (excluding the Springfield-Chicopee-Holyoke area). In view of this organization, the methodology should not only reaffirm known SMSA's but also identify other areas in the total network which are highly interrelated.

Population potentials, L_i, were calculated for each town in Connecticut based on the 1970 census count and a straight line mileage matrix was measured from the coordinates of the geographic center of each town. This value for each town was then standardized or transformed into the TL_i score as described above. A convenient way to examine this array of values is provided by the Symvu mapping program developed at Harvard University (Laboratory for Computer Graphics and Spatial Analysis, Harvard University). Symvu mapping is a three dimensional display which shows the major patterns of the data based on their geographic location. It treats the data as a continuous variable and the high or low values are fixed in their correct geographic location, an advantage tabular presentation cannot achieve.

Figure 1 presents the transformed population potential values for each town in Connecticut. In this view the observer is located in the southeast corner of the State looking toward the northwest at an altitude of 40 degrees above the surface of the earth. The high points in this graph represent towns clustered in the Hartford area in the north central section of Connecticut. Moving southward toward New Haven is a ridge of high potentials representing towns between the Hartford-New Haven areas. Moving westward along the Connecticut coast is another ridge of high values representing towns near the Bridgeport, Norwalk, and Stamford areas. Greenwich, located in the southwest corner of the State, had a low score because out of state areas, such as New York City, were not included in population potential values. Also noteworthy in Figure 1 are the declining values for communities east of the Connecticut River. In fact, towns in the northeastern section of the State had the lowest measures of ecological position.

The second dimension of the community network system to be measured is the degree of interconnectedness each area has with all other areas. The indicator of this dimension is derived from the 1970 census data on patterns of commuting to work, determined by comparing town of residence with town of employment. Consistent with the conceptual framework, the entire matrix of towns in Connecticut was used in the calculation of commuting rates, rather than establishing an arbitrary level of commuting above which towns would be considered interrelated. For each community, the total proportion of workers who commute to work in a different town was C_i, where:

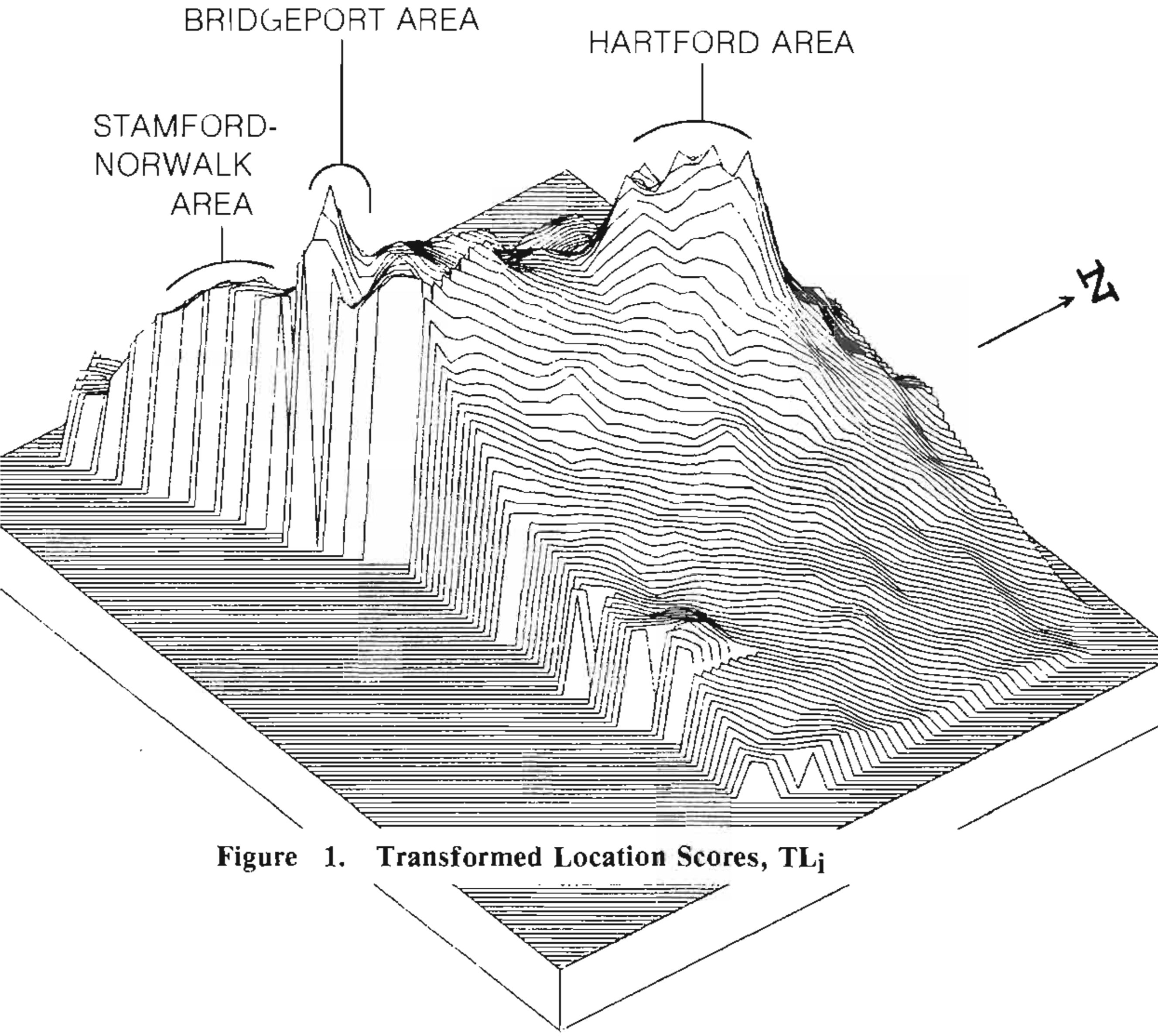

Figure 1. Transformed Location Scores, TL_i

$$= \frac{OC_i}{TE_i}$$

OC_i is the total number of persons in town i employed outside their town of residence (out-commuters) and $TE_i$is the total employed population of town i regardless of place of work (including the out-commuters). This measure was then transformed to be consistent with the measure of ecological position, so that the transformed integration score TI_i for each town is:

$$TI_i = X\,(C_i - C_o), \text{ where}$$

C_i is the proportion of workers who commute to work from town i,

C_o is the lower limit of the proportion of commuters for all towns, and

X $= 100 \div$ the range of the proportion of commuters for all towns in the system.

Figure 2 shows the configuration of transformed integration scores for each town in Connecticut and the complex nature of the system of community interconnectedness is clear from the many peaks and valleys. Figure 2 emphasizes the degree of oversimplification when towns are classified as suburban or not suburban. The basic data on commuting to work shows a very complex pattern for the majority of towns in Connecticut. For example, the town of Mansfield, southeast of Tolland, contains the main campus of The University of Connecticut and is not located within SMSA boundaries but of the total labor force in 1970 of 6,859 workers, 40.4 commute to work in 62 other towns in the State. The town of Coventry had a total work force of 3,240 in 1970 of which 86.8 percent were out-commuters. In Lebanon, 79.5 percent of the 1,452 work force were out-commuters and in Columbia, 87.6 percent of the 1,306 work force were out-commuters. All of these towns are not part of an SMSA but have substantial linkages, in terms of commuting, with many other towns throughout Connecticut. While the largest number of the out-commuters work in Windham, Hartford, and East Hartford, there is a significant pattern of interconnectedness with many other towns.

Plotting the standardized integration score of each town on a map of the State (with data not shown here) reveals the general pattern that towns located within SMSA boundaries have higher integration scores than towns outside of SMSA boundaries. There are, however, some significant exceptions. Towns in the northwest section located in the Torrington area, such as North Canaan and Goshen, have high integration scores, as do a cluster of towns located between the New Haven-New London areas. Interestingly, the town of Thompson has a relatively high integration score although it is located in the extreme northeast corner of the State. Many of the valleys or low integration scores in Figure 2 are the central cities of SMSA's which send relatively low proportions of their labor force to work in other towns.

Comparison of the pattern of ecological position in Figure 1 with the integration scores of Figure 2 shows that there is no systematic decline in integration scores as one moves east of the Connecticut River. Although the towns become relatively more ecologically isolated east of the river, they do not become less integrated with the other towns in the State in terms of commuting to work.

The third dimension of the community network system to be measured is population density or the number of people per square mile of land in

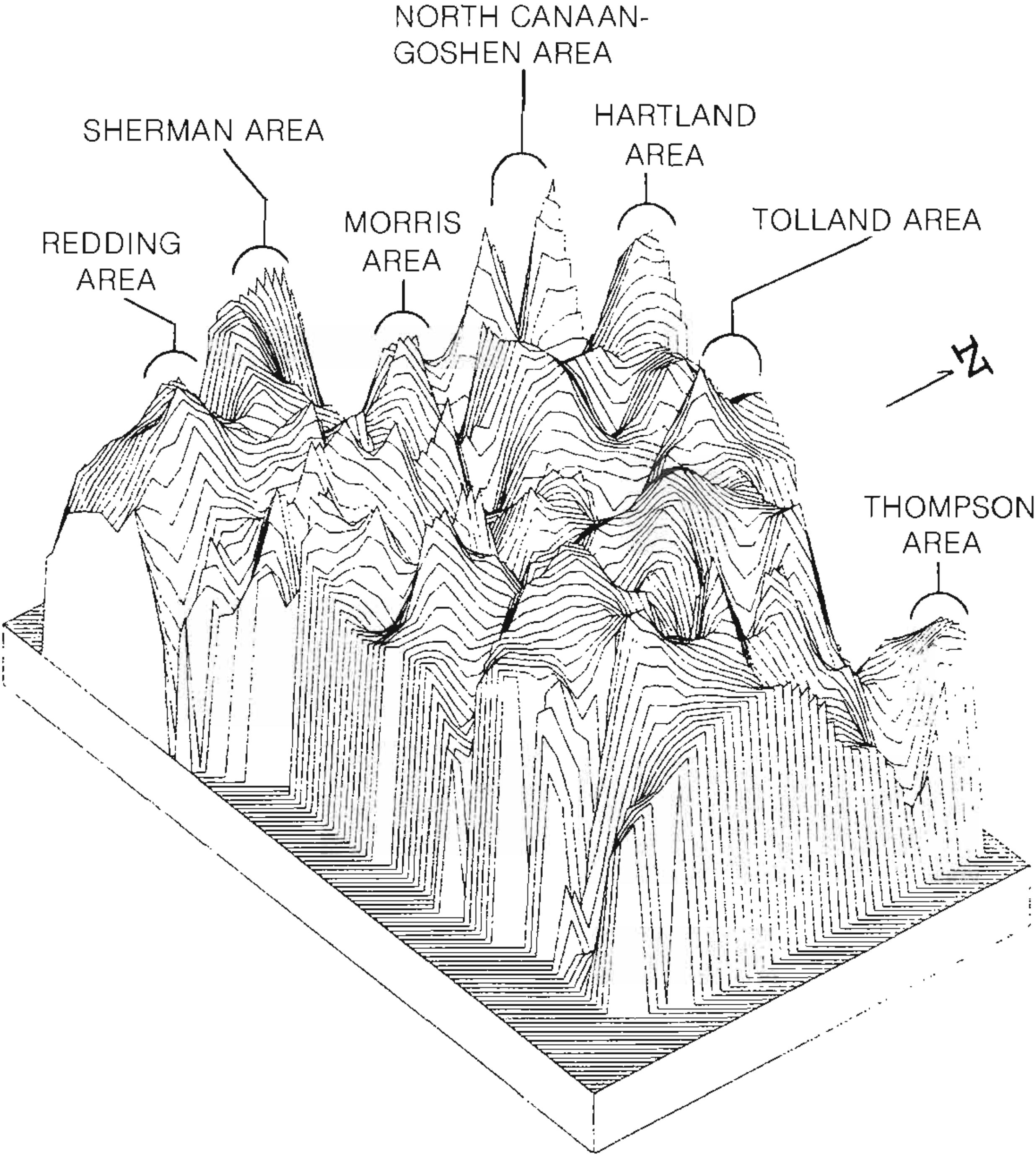

Figure 2. Transformed Integration Scores, TI_i

each town. The population density, D_i, for each town was calculated from the 1970 Census data and then transformed into a standardized density measure, TD_i:

$$TD_i = X\,(D_i - D_o), \text{ where}$$

D_i is the population per square mile of land, excluding water area, for town i,

D_o is the lower limit of population densities for all towns, and

X $= 100 \div$ the range of population densities for all towns in the system.

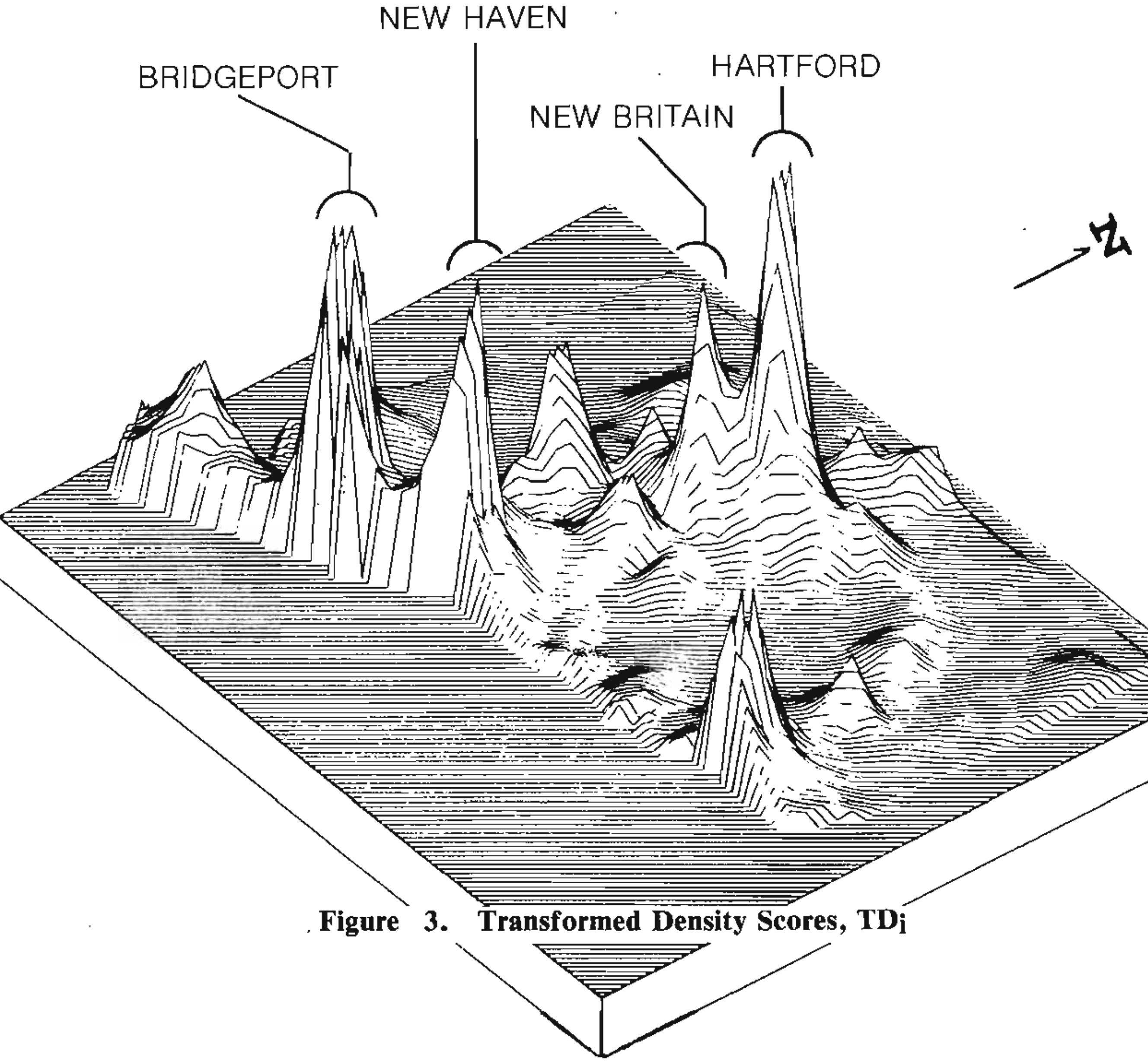

Figure 3. Transformed Density Scores, TD_i

Figure 3 shows the geographic distribution of the transformed density scores for each town in Connecticut. The pattern is as expected with the towns of Hartford, Bridgeport, New Haven, New Britain, and New London showing the highest population density. It is also the case that all of the towns with relatively higher density scores fall within the 1970 boundaries of SMSA's and all of the towns with lower density scores were outside of SMSA's.

Comparison between the pattern of density and ecological location in Figure 1 and integration in Figure 2 suggests very little systematic relationship. The intercorrelations between the scores for the three dimensions for all towns were: $r = .08$ for location and integration; $r = .43$ for location and density; and $r = -.41$ for integration and density. The relatively low intercorrelations suggest that the three dimensions of the system under consideration are not simple redundancies but are different aspects of the entire structure.

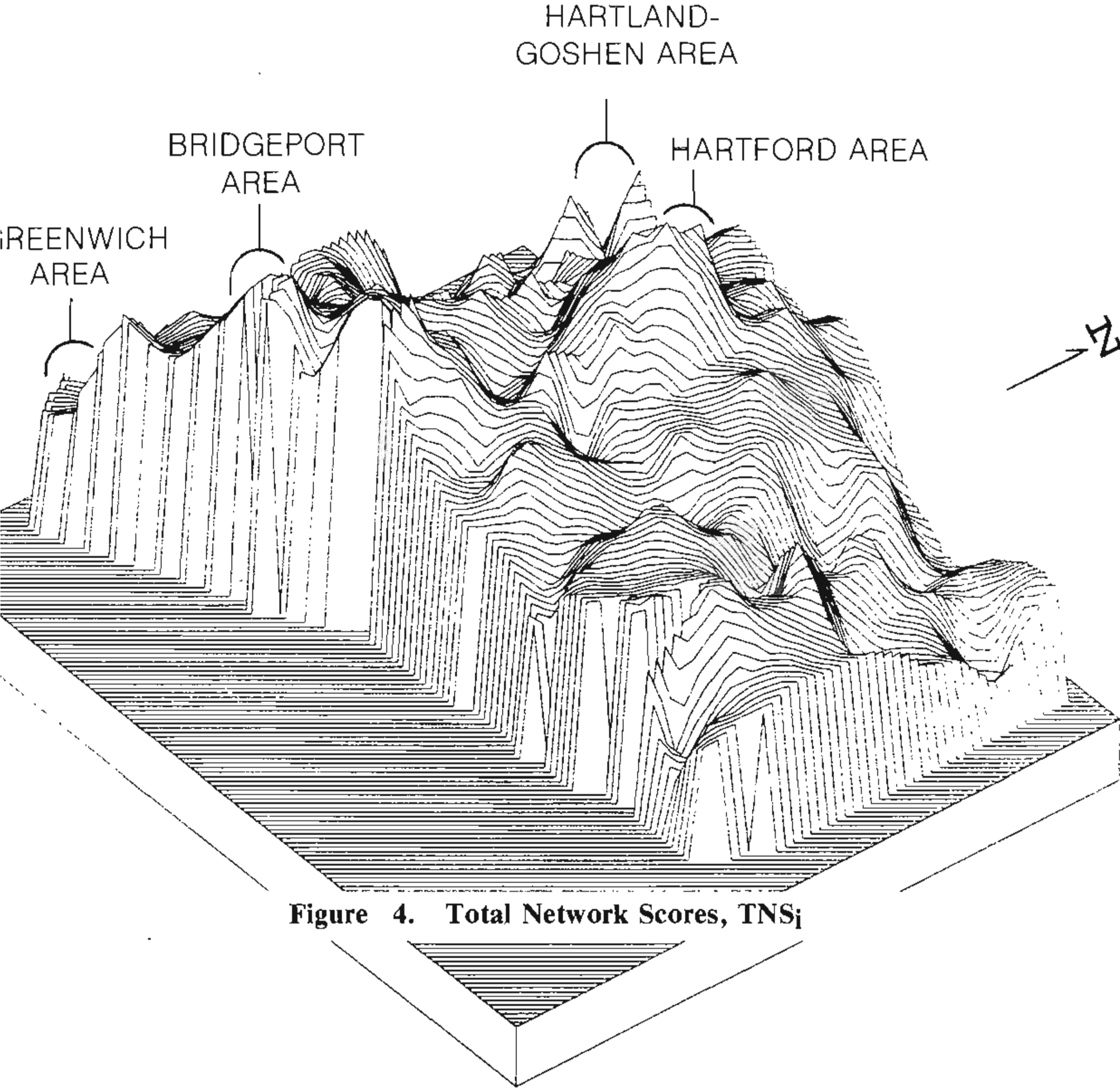

Figure 4. Total Network Scores, TNS_i

In an attempt to derive a single measure of the extent to which each town is a part of the entire system of interconnected areas, a total network score for each town, TNS_i is defined as:

$$TNS_i = \frac{(TL_i + TI_i + TD_i)}{3}$$

and is the arithmetic average of the scores of the three previous dimensions. Figure 4 presents this data for each of the towns in the State. The actual total network scores for the 169 towns in Connecticut ranged from a low of 6.23 for Putnam in the northeast corner, to a high of 67.4 for West Haven in the south central coastal area. The mean score in this distribution was

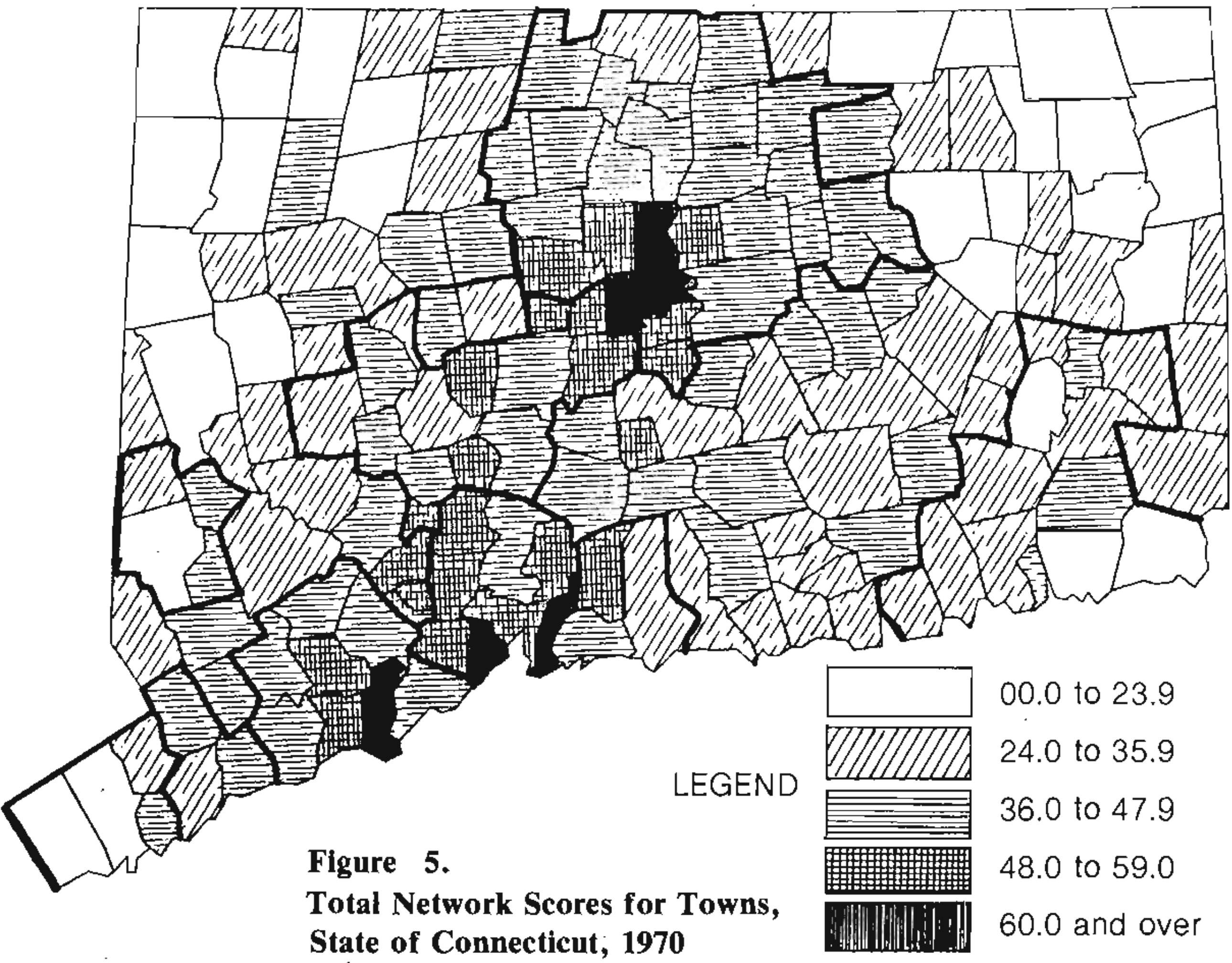

Figure 5.
Total Network Scores for Towns, State of Connecticut, 1970

36.5 with a standard deviation of 12.5. It is clear from the contours that the system of interrelatedness for towns in Connecticut is very complex and attempts to describe this system in terms of nominal categories of suburban or non-suburban conceal the true nature of the network.

While the display of data as a continuous variable in the Symvu program is helpful in giving an overview of the entire pattern, it does not allow specific areas to be identified in relation to other areas. For this reason the same data values for the total network scores were plotted on a representation of the State showing town boundaries. Figure 5 portrays the State with the 1970 boundaries of the SMSA's indicated in black outline. The total network scores were classified into five categories, and plotted on the map according to the symbols shown in the key.

Several observations are possible from this distribution. First, towns within the boundaries of SMSA's have higher network scores than many other towns. However, there are some towns within SMSA boundaries that have low total network scores possibly due to commuting to work to towns outside of Connecticut. Thus, certain towns near Greenwich in the southwest corner, near New London-Groton in the southeast corner, and near Danbury in the western section of Connecticut, are not strongly tied to the Connecticut network of towns even though they are part of SMSA's in the State.

Secondly, towns located adjacent to the boundaries of SMSA's generally have higher total network scores than non-adjacent towns. This pattern is consistent with the known tendency for persons to commute to work in areas inside SMSA's and could possibly indicate where current SMSA boundaries might be expanded. There is, however, considerable variation in the network scores for adjacent towns as some of these towns have relatively low scores.

Thirdly, the pattern of total network scores allows identification of highly interdependent areas within the total system which may not have been previously recognized. One such area in Connecticut centers around the Torrington region, involving Hartland-Goshen areas, in the northwestern section. This area of high interconnectedness shows clearly in Figure 4 as the two high peaks lying behind the Hartford area. A second such area, but to a lesser extent, centers around the Mansfield-Windham area north of the New London-Groton-Norwich SMSA.

While the intercorrelations between the scores on the three dimensions being measured were relatively low, the total network score had a correlation coefficient of .85 with the transformed location score TL_j, which means that 72.2 percent of the variance in the total network score is accounted for by changes in TL_j. The other correlations were much lower, with $r = .48$ between the total network score and integration, TI_j, and $r = .43$ between the total network score and density, TD_j. These correlations may vary with different data sets however.

Discussion

Viewing a total system of points or towns in terms of the three dimensions of the location in the system, the degree of interconnectedness of each element, and the density of each element allows each to be scored or described along a continuum of all elements in the defined system. The methodology presented here, illustrated by data for the 169 minor civil divisions in Connecticut, has reaffirmed the general interdependencies of towns within SMSA boundaries and has provided a means of locating other areas of interdependencies within the total system which are located away from the recognized areas. Most importantly, this methodology has altered the view of the system from one of discrete categories to one of a multidimensional continuous description in which the relationship of every point to the entire system is considered.

While this approach comes closer to reflecting the empirical complexities of the actual relationships between towns, several refinements could be made to the methodology. For example, the dimension of interconnectedness could be defined in terms of occupation/industry-specific commuter rates for each town. For Connecticut, it has been recognized since 1949 that different towns are the major suppliers of commuters for different industries in other towns (McKain and Whetten). The pattern of the total network may vary significantly by specific industry or occupational commuting rates. Likewise, the dimensions of ecological position and density could be based on occupation/industry–specific employment data, rather than total population. This refinement can be extended to include any economic or socio-demographic characteristic of the system under analysis.

The proportion of the total work force commuting to work for each town was used as an indicator of interconnectedness. An important limitation of this measure is that the destination of commuting is ignored. While towns adjacent to SMSA boundaries had higher total network scores, we do not know if they worked inside or outside of the SMSA. An attempt was made to include the destination of commuting by calculating a location-specific integration score for each town:

$$TI_{ik} = X_k (C_{ik} - C_{ok}) \text{ where}$$

C_{ik} is the proportion of out-commuters from town i who work in towns located in k categories

C_{ok} is the lower limit of proportion of out-commuters for all towns who work in towns located in k categories, and

X_k is 100 ÷ the range of out-commuting proportions for all towns to each of the k categories

In the above formulation, the proportion is the number of out-commuters to towns in k categories divided by the total employed of that town regardless of place of work. The k location categories were defined as:

k	*In SMSA*	*k*	*Out of SMSA*
1	Central City	4	Adjacent to SMSA
2	Adjacent to Central City	5	Nonadjacent to SMSA
3	Nonadjacent to Central City	6	Out of State

Transformed integration scores for each of the six location categories were calculated, displayed on a map of the State and are presented in Figures 6 through 11. Based on the distinct differences in the contours of these data, it is clear that the direction of the measure of system interconnectedness has a significant impact on how each town is linked to the entire system. Figure 6 shows TI_1 scores, commuting to central cities of an SMSA, for every town and reveals considerable differences between SMSA's in terms of how the central city attracts commuters.

For example, within the Hartford SMSA the towns of West Hartford, Wethersfield and Newington ranked high in the proportion of their out-

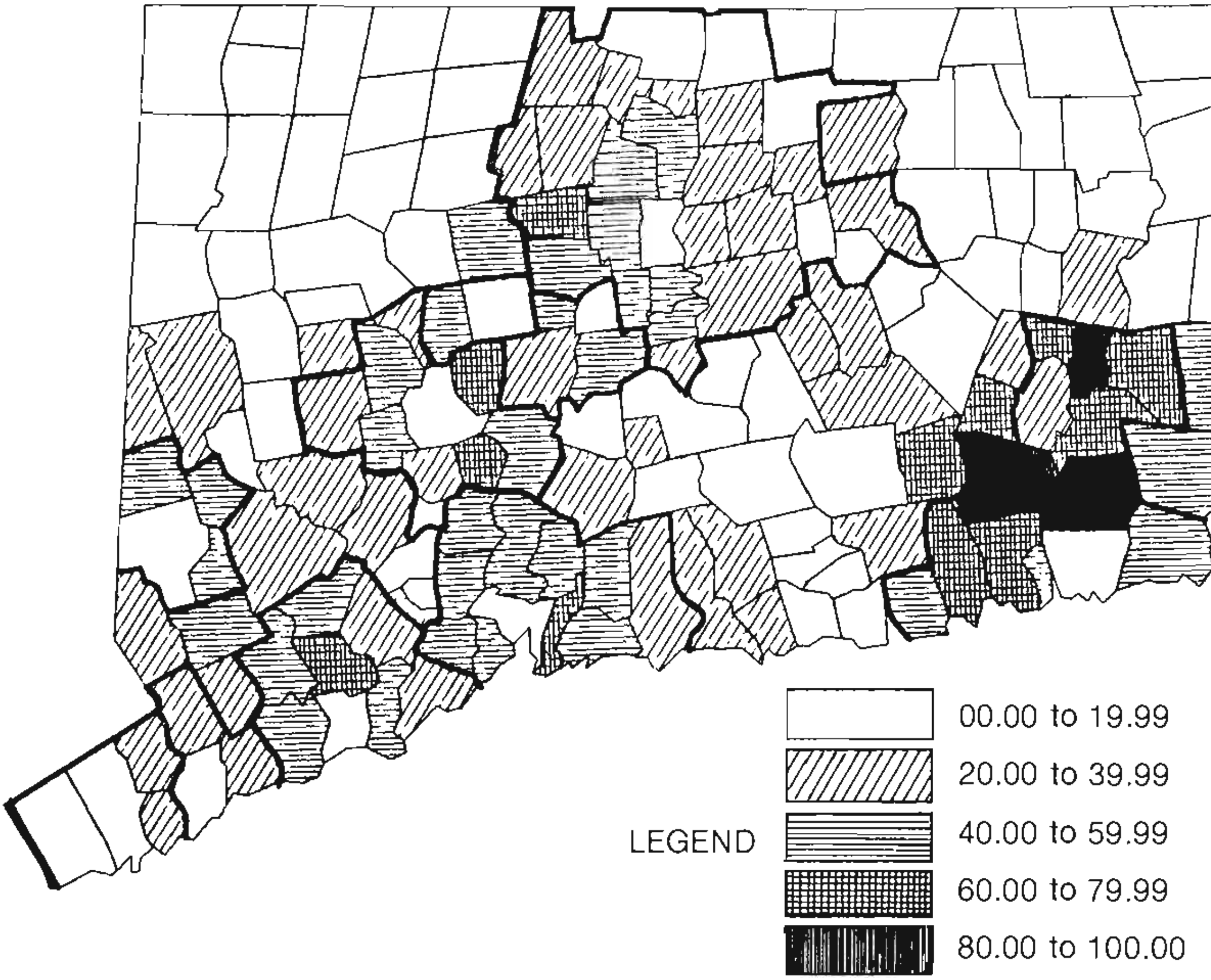

Figure 6. Integration Score of Towns With Central Cities of SMSA, 1970

commuters to central cities while the towns of Enfield, South Windsor, and Windsor Locks ranked relatively low in their proportion of out-commuters to central cities. In the calculation of location-specific integration scores, all towns are ranked relative to each other in terms of the percentage commuting to central cities. In this instance, Ledyard ranked highest in the State with 84.9 percent of its work force commuting to a central city of an SMSA to work and Union ranked last with no commuters working in a central city within the State. Although the volume of commuting to the central cities may be large for towns within the SMSA boundaries, the relative proportion who do so varies considerably across different SMSA's. The Hartford, Stamford and Norwalk SMSA's have clearly different patterns than the New London-Groton-Norwich SMSA. On this basis, the central cities are not always major places of employment for all other towns within the SMSA boundaries but rather for a selected number of towns.

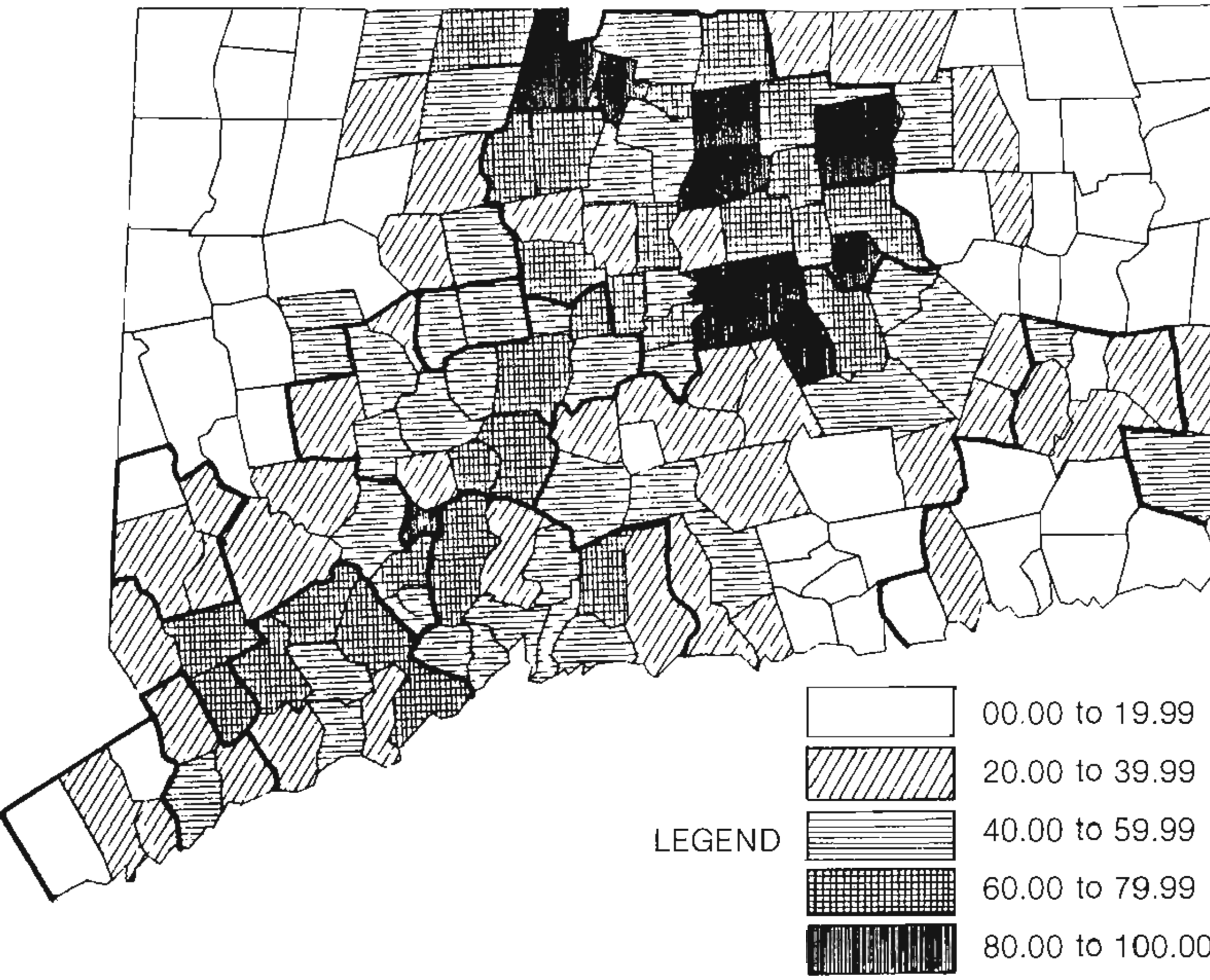

Figure 7. Integration Score of Towns With Towns Adjacent to Central Cities of SMSA, 1970

Figure 7 shows TI_2 scores, commuting to towns adjacent to the central cities, and indicates that for most of the SMSA's, commuting to adjacent towns by other towns within the SMSA boundaries is a major form of integration in this network. The major exception is the New London-Groton-Norwich SMSA in which the central cities are the center of integration. There are also several towns around the Hartford, Bridgeport, and New Haven SMSA boundaries which are strongly integrated with towns adjacent to the central cities.

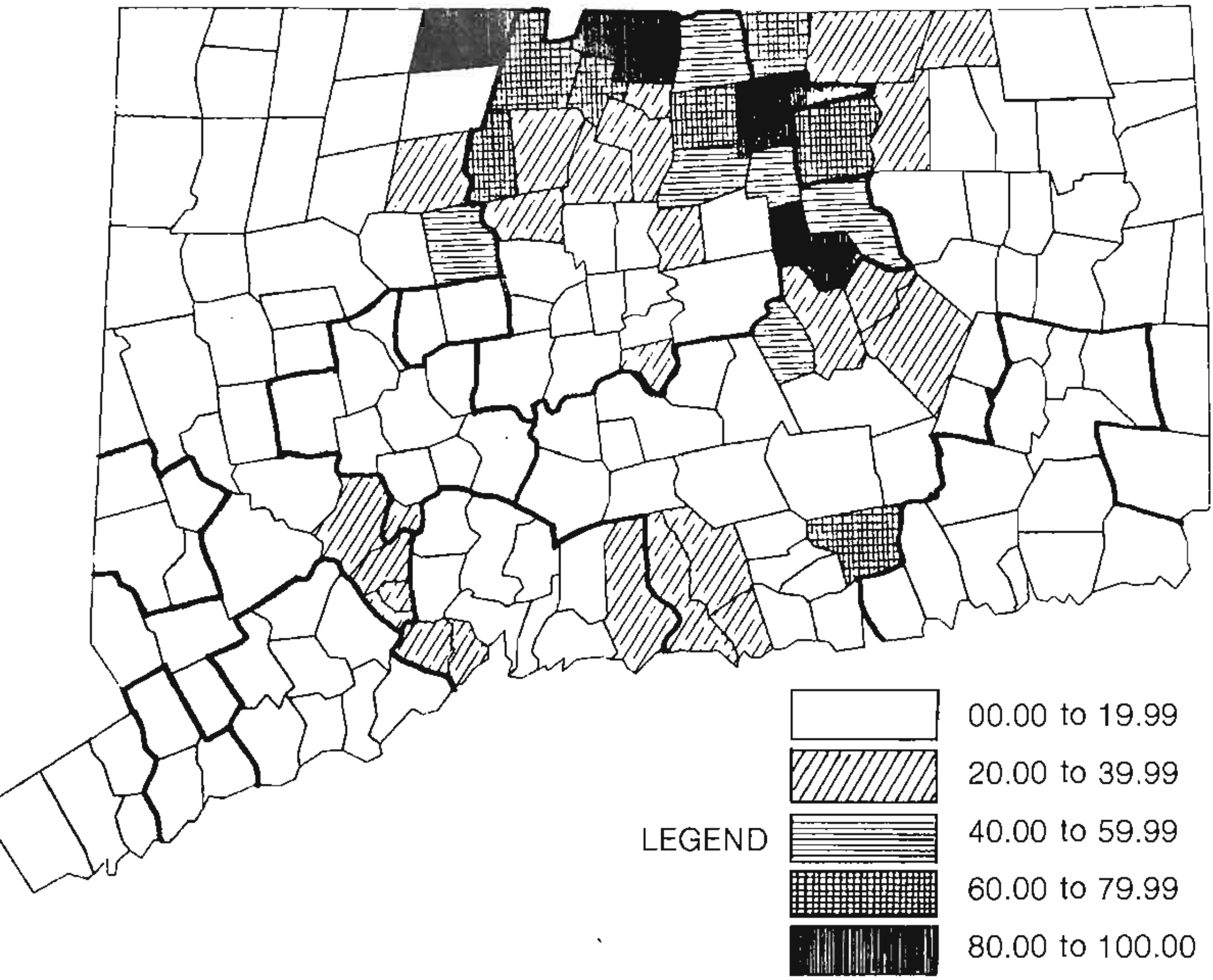

Figure 8. Integration Score of Towns With Towns Not Adjacent to Central Cities of SMSA, 1970

Figure 8 presents TI3 scores based on commuting to areas not adjacent to central cities but within the boundaries of SMSA's. With the exception of areas located in the northern and eastern sections of the Hartford SMSA, the general pattern is one of low levels of integration between nonadjacent towns within SMSA boundaries and with other areas outside SMSA boundaries. This pattern suggests that, unlike towns adjacent to the central city, towns not adjacent to the central city do not have a strong system of interconnectedness with each other but with other locations in the total system, such as towns adjacent to the central city.

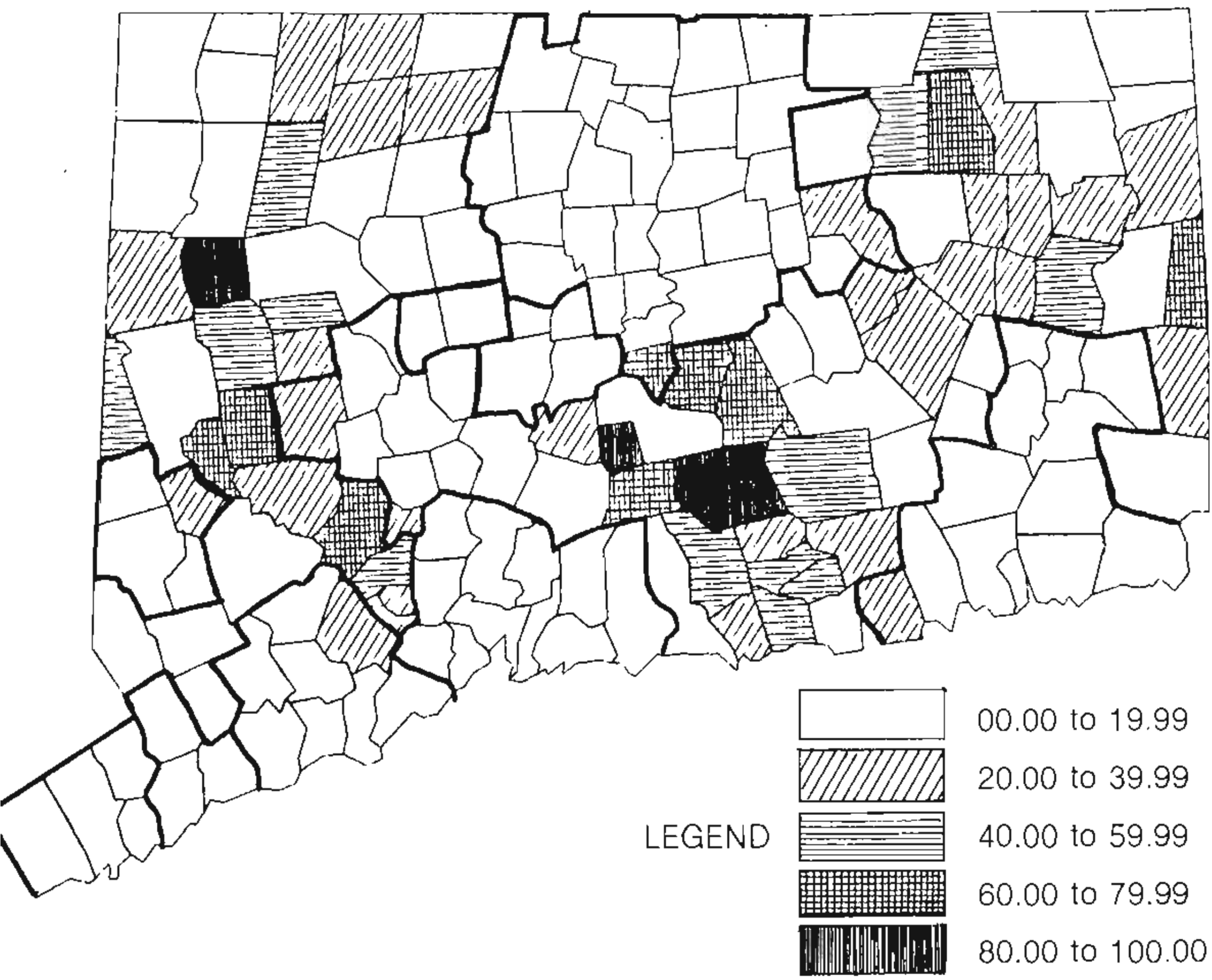

Figure 9. Integration Score of Towns With towns Adjacent to SMSA Boundaries, 1970

Figure 9 shows the location of areas in terms of TI4 scores, commuting to areas adjacent to the boundaries of SMSA's. There are two general patterns apparent from these contours. First, there are no towns within SMSA boundaries that have strong integration scores with towns adjacent to SMSA boundaries. Secondly, there are six areas scattered over the State whose major ties in the total system are with areas adjacent to SMSA boundaries.The area of the highest relative interconnectedness in this regard lies south of the Hartford SMSA and northeast of the New Haven SMSA.

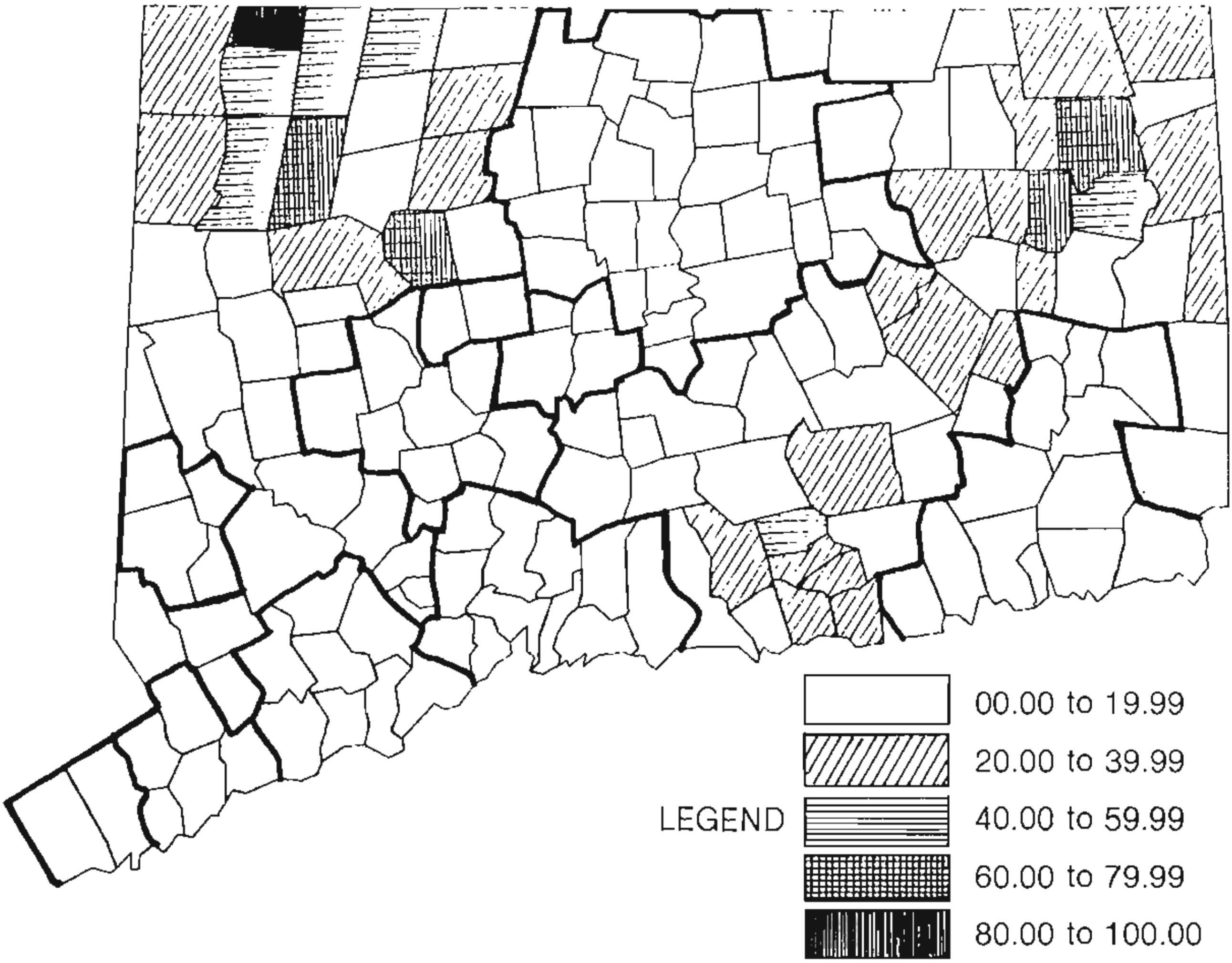

Figure 10. Integration Score of Towns With Towns Not Adjacent to SMSA Boundaries, 1970

Integration scores based on commuting to areas which are not adjacent to SMSA boundaries are shown in Figure 10. Again it is clear that there are no towns within the SMSA's that are highly integrated with towns located away from SMSA boundaries. However, there are three areas in the State in which the relatively strong linkages are with the nonadjacent areas. This is particularly the case in the northwest section of the State and to a lesser extent in the northeastern and south central sections of Connecticut.

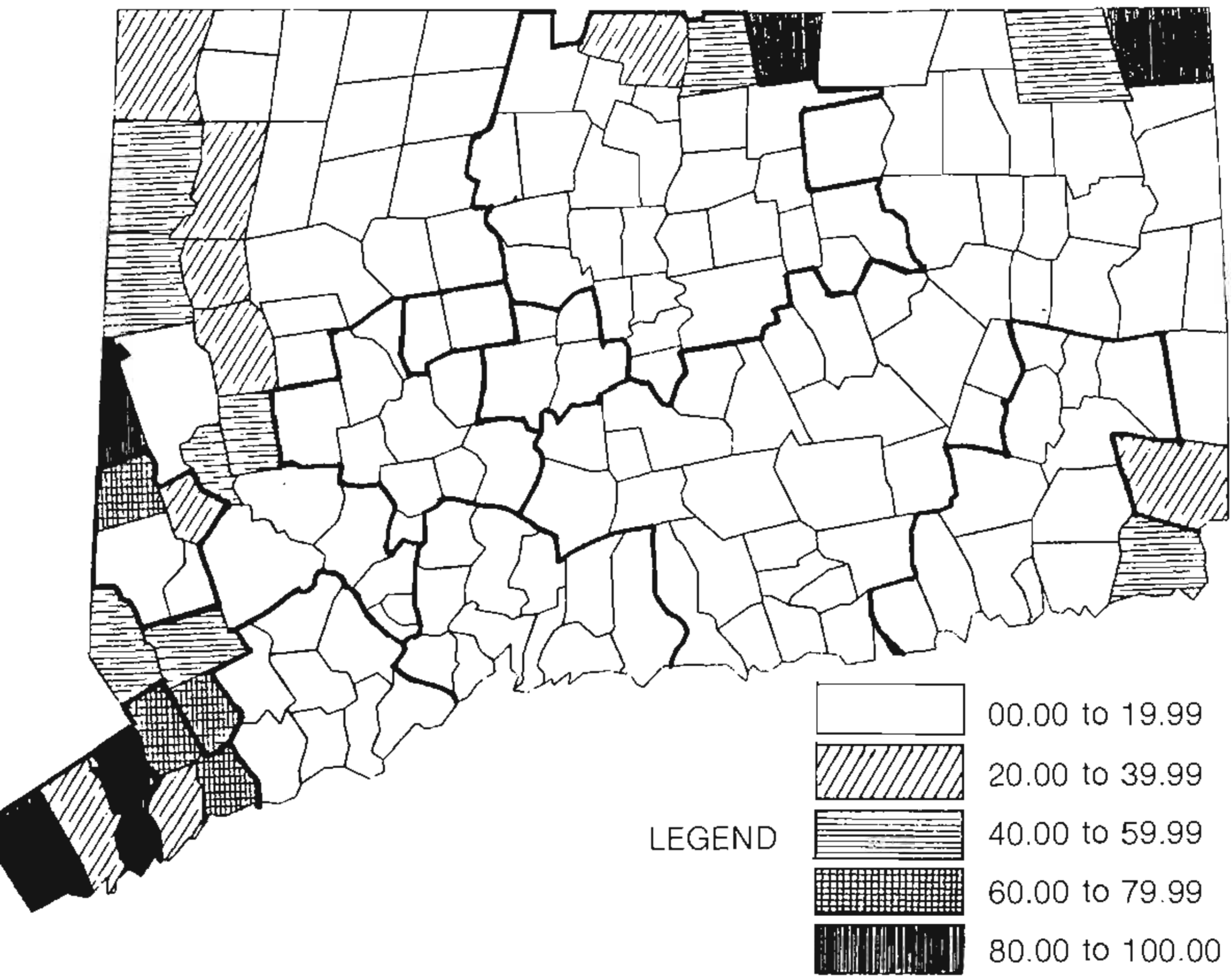

Figure 11. Integration Score of Towns With Towns Outside of Connecticut, 1970

Figure 11 presents the transformed integration scores on commuting to all areas outside of the State. As might be expected, the strongest relative linkages occur for areas located at or near the State line. The Stamford-Norwalk area shows high scores in this regard as does the Danbury area. Interestingly, an area just north of the Hartford SMSA and the area in the northeast corner of the State also have the strongest relative linkages with areas in New York and Massachusetts. There is also an area in the southeast corner in which the linkage is strongest with Rhode Island.

While these location-specific integration scores show significant differences in the way in which towns are linked to the entire system, the calculation of these scores gives relative values only and not an absolute

Table 1: Distribution of Transformed Integration Scores With Different Locations, Connecticut, 1970

Transformed Integration Scores	In the SMSA			Out of SMSA		
	TI_1	TI_2	TI_3	TI_4	TI_5	TI_6
0- 9.9	34	25	84	89	122	127
10-19.9	39	25	42	26	14	14
20-29.9	28	21	16	17	10	5
30-39.9	18	21	9	12	12	4
40-49.9	17	17	3	7	5	7
50-59.9	18	22	3	6	1	2
60-69.9	8	15	6	3	3	2
70-79.9	4	14	1	6	1	2
80-89.9	1	6	2	1	0	3
90-100.0	2	3	3	2	1	3
Total	169	169	169	169	169	169
Mean*	28.8	39.1	16.5	18.4	9.9	12.6
Standard Dev.*	21.1	24.8	20.6	21.6	16.8	21.3
Max Percent**	84.9	38.4	37.5	51.0	76.7	37.2

* Refers to the distribution of transformed scores.

** The maximum percentage of out-commuters to each location.

score which is comparable across the various locations. Table 1 on the distribution of transformed integration with different locations emphasizes this point. For example, the transformed integration scores for TI_1 were based on the percentage of out-commuters working in central cities of an SMSA and had an upper limit of 84.9 percent, which would give a transformed score of 100.0 for that particular town. The transformed integration scores for TI_3 were based on the percentage of out-commuters to nonadjacent towns within SMSA boundaries and had an upper limit of 37.5 percent, which also gives a transformed integration score of 100.0 for that particular town. Thus, the resulting contours based on each integration score must be interpreted as a relative ranking of each town along the single dimension.

The total integration score TI_1 does not indicate the direction of the linkage but does offer a summary measure of relative strength of interconnectedness of each area with the entire system. A visual inspection of the various integration scores suggests a low order of intercorrelation and this impression is generally confirmed by the zero-order correlation matrix:

Correlation Matrix of Integration Scores

	Total	In SMSA			Out of SMSA		
	TI_i	TI_1	TI_2	TI_3	TI_4	TI_5	TI_6
TI_i	1.0	.51	.35	.39	.16	.02	-.03
TI_1		1.0	.22	−.07	−.34	−.43	−.16
TI_2			1.0	.51	−.27	−.48	−.25
TI_3				1.0	−.08	−.17	−.16
TI_4					1.0	.16	−.11
TI_5						1.0	−.06
TI_6							1.0

The aggregate integration score, TI_i, had the highest correlation with the integration scores based on commuting to the central city of an SMSA, TI_1, with $r = .51$. Its correlation with the other location-specific integration scores was low. Interestingly, the integration scores based on commuting to towns adjacent to the central city, TI_2, were clearly correlated to integration scores based on commuting to towns nonadjacent to the central city but within the SMSA boundaries, TI_3, with $r = .51$. This suggests a stronger pattern of relative linkages between non-central city towns within SMSA's than with the central city of the SMSA.

A further refinement of the methodology to reflect the direction of the commuting ties might include the specification of the area in which the commuters work. Under the above procedure, for example, commuters were classified as working in a central city of an SMSA but no attempt was made to determine which central city it was. Presumably, most commuters living within a given SMSA who work in a central city remain within their SMSA boundaries but the methodology as described ignores this point. Such a refinement would, however, give a large matrix of location-specific integration scores and may present problems of description and interpretation.

Conclusions

The multidimensional description of a network of interrelated towns suggested here attempts to avoid the arbitrary criteria used in classification schemes. The difficulties involved in selecting criteria for a standard metropolitan statistical area in terms of population size, metropolitan character, and integration are well understood (Berry, a). Several alternative classification schemes exist, such as state economic areas (Bogue and Beale), the daily urban system areas (Berry, b) and commuting fields of central cities (Berry, a) but none deal with the problem of describing all elements in the system along several dimensions. The total network score also reflects the multicentric structure of town linkages which is consistent with a recent analysis of daily person movements in 1970 in the central Connecticut region (Meyer).

Given a continuous measure of a town's linkage in a system, a next step would be to examine variation in the derivative characteristics of demographic structure, socioeconomic characteristics, and socio-psychological characteristics. While the previous work along these lines provides an essential basis for specific variable selection, it is argued here that variation in derivative characteristics is also a continuous phenomenon for all towns in the system and not restricted to those communities classified as suburban, exurban, satellite, etc., In fact, plans are underway to examine the extent to which there is a systematic relationship between the total network scores and selected derivative characteristics.

The particular way in which the three basic dimensions of the network were operationalized for this presentation is not intended to be restrictive. Other measures of integration could have been used, such as in-commuters, net commuters, gross commuting, or different indicators of community interaction. The dimension of element size, measured as person per square mile, might have been defined as occupied housing units per square mile. For some research purposes, changing the empirical measures of the three dimensions may be theoretically required. The three dimensional view, however, is proposed as essential to a correct description of the system.

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