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MORPHOLOGICAL CHARACTERISTICS OF THE AMERICAN CITY

A case study benchmarking measures of street connectivity

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ABSTRACT

Many studies have looked at the measures of existing street networks, analysing dense, traditional urban areas and sparse, suburban areas. In most cases, these studies contrast the two extremes to describe both quantitative and qualitative differences. Cervero and Gorham (1995) analysed the scale of road segments to distinguish automobile versus transit-oriented neighbourhoods. Siksna (1997) examined block size and its effects on urban development. Hillier (1999) analysed the intelligibility and connectivity of several city centres to describe the local principles of city growth and their impacts on sustaining strength and vitality. Jacobs (1993), Major (2015), and Peponis, Allen, Haynie, et al. (2007) illustrated significant differences in the scales and densities of various neighbourhoods of historical influence. Few have looked at the American city comprehensively and tried to adequately depict its more common morphological characteristics. In response, this work establishes a description of the measures of street connectivity for existing street networks, as they occur across the American city, and creates a comparative database to describe the multitude of urban morphologies encountered.

A comparative database of 4,321 local areas, each measuring 2-miles in diameter, is created from the 24 largest Metropolitan Statistical Areas. These local areas are sampled randomly to capture, with equitable probability, an even distribution across each metropolitan region. Four measures describing street connectivity – length, block area, metric reach and directional distance, are averaged for the road segments and blocks within each local area and analysed to define a range of measures. Distributions, frequencies, and interquartile ranges are examined to determine the most often encountered measures of street connectivity within these selected MSAs. Lastly, measures are benchmarked against noteworthy street networks (Peponis et al., 2007), particularly those with distinguishing characteristics like Riverside (Chicago), Levittown (Philadelphia), Radburn (New Jersey), and Reston (Virginia).

Acknowledged distinctions between the measures of these MSAs are captured by their associated means, and yet, few differences are demonstrated through their modes, or frequency intervals capturing the measures most often encountered. As a general characterization, the scale, density, and circuitousness of existing street networks far exceeds the anticipated range of measures. Most local areas of the random sample are significantly longer in their average length of road segments, larger in their average area of blocks sparser in their average metric reach, and more circuitous in their directional distance than even the most sprawling suburban areas originally considered. If the goal of a street network is to fundamentally 'connect spatially separated places,' as suggested by Handy, Paterson, and Butler (2003), then clearly this study demonstrates that there is much work to be done within the American metropolitan region.

KEYWORDS

American cities, urban morphology, street networks, street connectivity

1. INTRODUCTION

Many studies have looked at the measures of existing street networks, analysing dense, traditional urban areas and sparse, suburban areas. In many cases, these studies contrast two extremes to describe both quantitative and qualitative differences related to modes of transportation, land use, density, and connectivity. Cervero and Gorham (1995) analysed the scale of road segments to distinguish automobile versus transit-oriented neighbourhoods. Siksna (1997) examined block size and its effects on urban development. Major (2015) compared urban grids in American cities to those in Europe, illustrating the immense differences in the scale of block area and line length.

Others have sought to examine a range beyond the established contrasts in spatial processes and urban forms. Hillier (1999) analysed the intelligibility and connectivity of several city centres to describe the local principles of city growth and their impacts on sustaining strength and vitality. Jacobs (1993), Southworth and Owens (1993) and Peponis et al. (2007) illustrated significant differences in the scales and densities of distinctive types of neighbourhoods to establish an expected range of measures. Marshall (2005) critically reviewed the nature of various street networks and proposed a matrix of four types.

Of these case studies, familiar street networks were selected for their historical, morphological and/or planning significance. Few have looked at the American metropolitan area comprehensively and tried to adequately depict its more common morphological characteristics. In response, this work samples street networks randomly, as they occur across the American metropolitan area, and assesses four measures of street connectivity to create a comparative database of measures.

2. DATASETS AND METHODS

To more broadly understand the morphological characteristics of the American city, local areas were sampled randomly from 24 of the most populated American metropolitan areas. In premise, these metropolitan areas represent an array of geographical conditions and historical planning influences, adequately capturing its many morphological characteristics. Samples are selected randomly from Atlanta, Baltimore, Boston, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Houston, Los Angeles, Miami, Minneapolis, New York City, Philadelphia, Phoenix, Pittsburgh, Portland, San Diego, San Francisco, Seattle, St. Louis, Tampa, and Washington D.C.[1]

Sampling was structured to capture ten percent of the total area of each Metropolitan Statistical Area (MSA), using an established framework to ensure an even distribution and equitable probability for the random sample. The framework was defined by a politically significant point of centre[2], radiating rings that established distance from that point of centre, and a coordinate system to delineate North, South, East and West. From each section of this established framework, x and y coordinates were randomly selected, and a provision was included to eliminate the potential of overlapping areas.

1 For consistency in defining each American city, the boundary of the Metropolitan Statistical Area (MSA) was used, as defined by the U.S. Census Bureau in 2000. In several instances, established urban areas of development cross MSA boundaries. In these cases, the data files for each MSA are joined. These instances include the union of Cleveland with Akron, Denver with Boulder, Los Angeles with Riverside and Ventura, Philadelphia with Trenton, and San Francisco with San Jose.

2 Similar to French and Scoppa (2007), the rings radiated outward from the point of centre at five-, fifteen-, thirty-, and sixty-mile intervals.

Using these coordinate pairs, circular buffers, measuring 2 miles in diameter, were constructed, and road segments, blocks, and their associated measures were extracted. For consistency, those road segments and blocks that were completely contained within and those that intersected each buffer were extracted from the larger context of the metropolitan area. Pairs that fell outside the political boundary of the MSA were discarded (Figure 1).

Many of the circular buffers captured significantly more block area or road segment length than was initially intended. Rural areas, containing extremely large blocks and long road segments, were captured because of the U.S. Census Bureau's method in defining a MSA politically, in lieu of economically or morphologically. Similarly, small extremes, or residuals resulting from the way in which the Esri maps were drawn, were also captured. The inclusion of such extremes, at either scale, greatly affected the statistical summaries, distributions, and confidence in the inferences. As a result, road segments and blocks of extreme scale, both large and small, were identified and excluded to ensure more discerning conclusions.[3]

The resulting, random sample consists of 4,321 local areas, measuring two-miles in diameter, across all 24 American metropolitan areas. It provides a means for examining the morphological characteristics of the existing street networks in the American city – their measures of connectivity and central tendency. It also provides an extensive sample to benchmark measures of street connectivity against those of the more familiar, historically significant local areas known for their distinctive morphological characteristics.

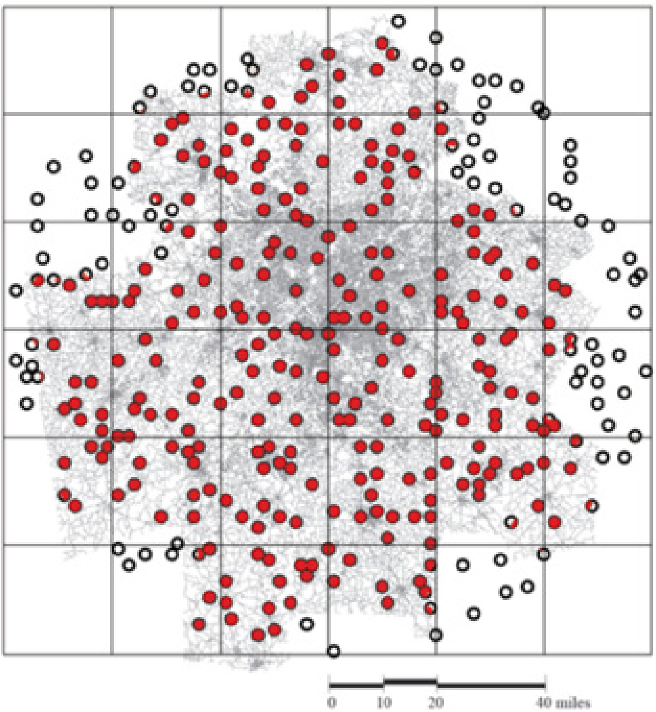

Figure 1 - Illustration of the Sampled Local Areas from the metropolitan area of Atlanta. Measures for the circular buffers shown shaded are extracted and examined further. Circular buffers shown without shading are discarded, given that they fell outside the established political boundary of the MSA.

3 To prevent potential distortion from extremes within the database, the work of Thomas Jefferson and his influence on the Land Ordinance of 1785 (Rashid, 1996) was assessed in conjunction with the work of Doxiadis (1965) and Krier (1976) to set parameters for pragmatically defining and removing extremes. Blocks more than 640 acres in area or less than 0.12 acres were excluded. Similarly, road segments more than 1 mile in length or less than 72 feet were excluded.

2.1 LIMITATIONS OF THE DATA

The automated process in collecting data created a substantially larger and statistically significant sample for analysis, but it is not without limitation. The aggregate size of the random sample made it impossible to examine the data to correct and edit errors. As a result, the data is only as good as the original data sourced from Esri. Second, street centre-line data was used to construct the blocks within this data set, without consideration of street width, affecting measures of block area. Lastly, unlike those neighbourhoods previously studied in the literature by Peponis et al. (2007), many of the local areas sampled here are not complete, congruent sets of road segments and blocks. Consequently, aggregate measures of connectivity, like density, and their associated statistical correlations, should be analysed carefully.

2.2 MEASURES OF STREET CONNECTIVITY

Many measures have been used to describe street connectivity (Dill, 2004; B. Hillier, 1996; Peponis, Bafna, & Zhang, 2008; Turner, 2007). For this case study, four measures– road segment length, block area, metric reach and directional distance, are analysed for the road segments and blocks within each local area and analysed to establish a range. Road segment length and block area are used to capture morphological characteristics of scale. Metric reach is used to capture the density of a street network, and directional distance is used to describe the configuration, or the directness, of the streets within each local area. Parameters for metric reach are set at 1 mile (1.6 km), to capture the average walking distance for pedestrians in an American city, and those for directional distance are set at 1 mile (1.6km) and 10 degrees.

For convention, statistical measures for the random sample of local areas (RSLAs) will be referenced as the following: length (LA) describes the average length of road segments within a particular local area;[4] the mean of length (RSLA) describes the average length for all 4,321 randomly sampled local areas; and the MSA mean of length (RSLA) describes the average length for the randomly sampled local areas within a particular American metropolitan area.[5] Other measures, as reported here, are referenced and calculated similarly, i.e. the mean of block area (RSLA), the mean of metric reach (RSLA), and the mean of directional distance (RSLA).

3. RESULTS

When measures for these RSLAs are analysed, the mean of length (RSLA) measures 1382.66 feet, the mean of block area (RSLA) measures 134.24 acres, the mean of metric reach (RSLA) measures 9.28 miles, and the mean of directional distance (RSLA) measures 4.85 changes in direction for the captured reach (Table 1). When compared to historically and morphologically significant areas, as defined by Peponis et al. (2007), the mean of length (RSLA) is substantially higher than those sprawling suburban areas of Reston (Virginia) and Crabapple (Atlanta). The mean of block area (RSLA) is also higher, though only slightly. The mean of metric reach (RSLA) is lower than most of the notable areas, and yet, the mean of directional distance (RSLA) is within the range.

Given this extension to the previously established range of expected measures, particularly for the measures of length and area, the interquartile range, or the difference between the first and third quartiles, is also described to give a sense of the asymmetry in the distributions. As reported in Table 2, the interquartile range of length (RSLA) measures 1105.36 feet, suggesting significant skewness within the distributions. Similarly, the interquartile range for the mean of block area (RSLA) measures 177.14 acres, which also suggests significant skewness. In contrast, the interquartile ranges, for both the mean of metric reach (RSLA) and the mean of directional

4 When calculating length (LA), (n) will vary given the number of road segments captured in each local area.

5 When calculating the MSA Mean of Length (RSLA), (n) will vary given the number of local areas captured within each MSA. The number of local areas captured within each MSA is reported in Table 3.

distance (RSLA), suggest a more normal distribution. The interquartile range for the mean of metric reach (RSLA) measures 7.01 miles, and the interquartile range for the mean of directional distance (RSLA) measures 3.44 changes in direction.

	Mean of Length (feet)	Mean of Block Area (acre)	Mean of Metric Reach (1 mile) (miles)	Mean of Directional Distance (1 mi./10 deg.) (changes in direction)
RSLAs	1382.66	134.24	9.28	4.85
Morphologically Significant * Kensington (Philadelphia)	286.42	2.23	77.80	2.52
Brookline (Boston)	375.23	7.50	43.96	4.90
Riverside (Chicago)	497.31	12.18	29.29	3.3
Levittown (Philadelphia)	556.33	13.05	28.70	5.67
Radburn (New Jersey)	438.06	10.80	31.02	3.85
Reston (Virginia)	530.41	37.88	15.13	8.99
Crabapple (Atlanta)	630.28	106.77	8.99	8.62

* Data for these historically and morphologically significant local areas was sourced from Peponis et al. (2007), with the units of meters and kilometres manually converted for comparison.

Table 1 - Statistical Measures of the Random Sample of Local Areas (RSLAs) compared to several Morphologically Significant Areas already defined within the existing literature angular choice weighted by segment length in the case study areas.

Given the significant differences illustrated by the interquartile range, particularly for length and area, distributions are examined in further detail. For the 4,321 RSLAs, the distribution of length (LA) illustrates positive skewness across a wide range of measures (Figure 2a). With the bins in the histogram distribution set at 100 feet, the mode for length (LA) measures 500–600 feet and captures 10 percent of this sample set. Notably, 58 percent of the RSLAs measure, on average, less than 1200 feet in average length. Similarly, the distribution of metric reach (LA) illustrates positive skewness across a wide range of measures, but most the local areas are clustered around a much narrower range (Figure 2b). With the bins of the histogram distribution set at 5 miles, the mode of metric reach (LA) measures less than 5 miles and captures 43 percent of this sample set. Notably, 93 percent of the local areas measure, on average, less than 25 miles of reach. Distinctly different from length and metric reach, the distribution of directional distance (LA) illustrates a more normal distribution (Figure 2c). With the bins of the histogram distribution set at 2 direction changes, the mode of directional distance (LA) measures more than 2 but less than 4 direction changes and captures 31 percent of this sample set. Notably, 58 percent of the local areas measure less than 5 changes in direction, on average, to navigate the distance captured by metric reach.

	Maximum	75.0%	Median	25.0%	Minimum	Interquartile Range
Length (RSLA)	5275.16	1801.760	1193.43	696.39	117.969	1105.3670
Block area (RSLA)	638.869	202.495	75.610	25.357	0.1256	177.1379
Metric Reach (RSLA)	78.3917	11.0025	5.5704	3.9945	0.0223	7.0080
Directional Distance (RSLA)	27.4721	6.3547	4.4678	2.9113	0.0000	3.4434

Table 2 - Quartile Measures of Length (RSLA), Block Area (RSLA), Metric Reach (RSLA), and Directional Distance (RSLA)

For block area (LA), the distribution also illustrates positive skewness across a wide range of measures (Figure 3a). With the bins in the histogram set at 20 acres, the mode of block area (LA) measures less than 20 acres and captures 20 percent of this sample set. Among local areas that are less than 20 acres, on average, the distribution illustrates a bimodal distribution with a primary spike at 4–6 acres and a secondary spike at 10–12 acres (Fig 3b).

When comparing the mean of length (RSLA), block area (RSLA), metric reach (RSLA), and directional distance (RSLA) to those more familiar areas with distinct morphological characteristics, the established range is substantially expanded. Only 17.6 percent of the local areas in the sample measured less than 600 feet, on average, in length (LA), and only 17.1 percent of the local areas exhibited a measure of metric reach (LA) more than 15 miles, demonstrating that a significant proportion of the randomly sampled local areas are even larger and more poorly connected than originally anticipated. These results raise the question: how does distance from the metropolitan centre, and in particular, the sampling method for these local areas, affect the results reported here?

To ensure equitable distribution in the sampling of local areas randomly, the established framework extracted more local areas from the periphery of each metropolitan area. As established within the literature (French & Scoppa, 2007), areas at the periphery and those often described as sprawling suburban neighbourhoods exhibit increases in their measures of length (LA) and block area (LA) with associated decreases in their measures of metric reach (LA), particularly when compared to those at the metropolitan centre. Presumably then, there are more local areas greater in scale and lower in density for this set of RSLAs, and because of their proportions, they could have greater influence on the statistical measures like mean and interval mode. As a result, the distributions and frequencies of length (LA), block area (LA), metric reach (LA), and directional distance (LA) are studied for only those 521 local areas within a fifteen-mile radius of the metropolitan centre to assess the effects of distance on the measures reported here.

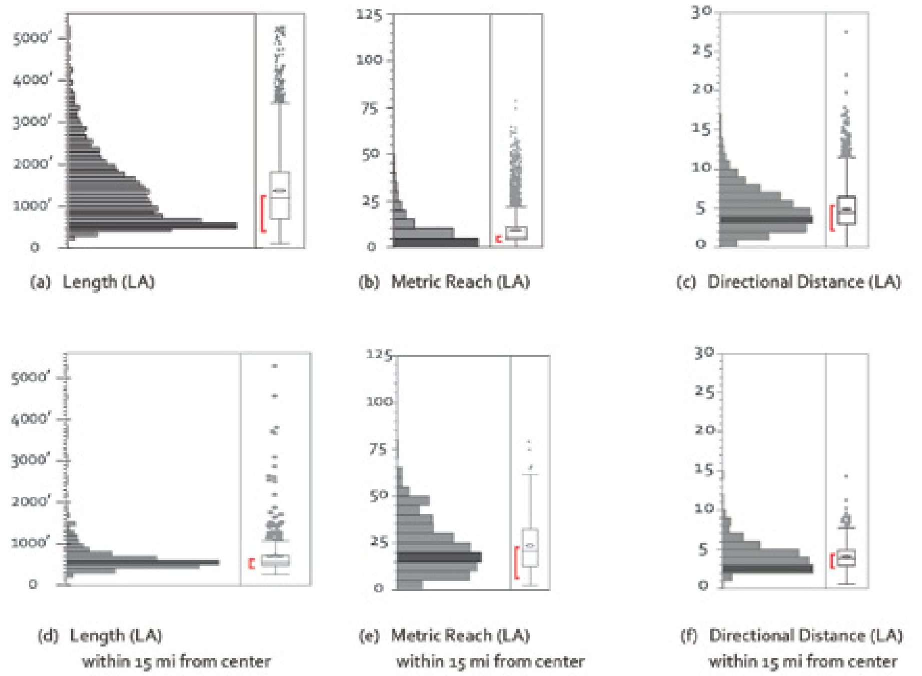

Figure 2 - Illustration of the Distributions for Measures of Length (LA), Metric Reach (LA), and Directional Distance (LA). Measures for all 4,321 RSLAs are included in figures (a), (b), and (c). As a test to examine the effects of distance on the distribution, only measures for those 521 RSLAs within 15 miles of the city centre are included in figures (d), (e), and (f).

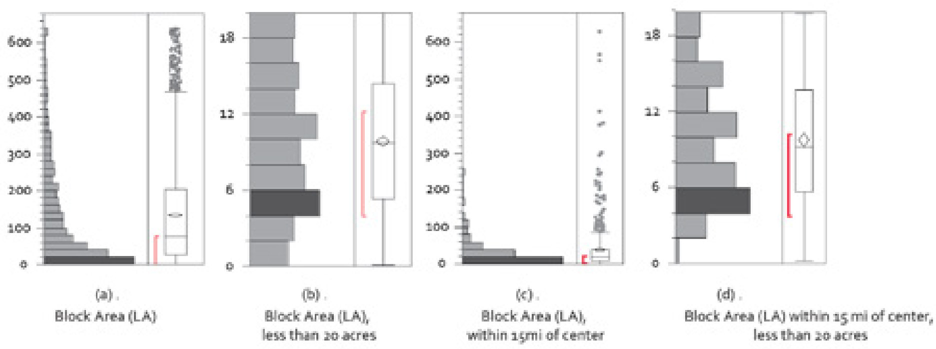

Figure 3 - Illustration of the Distributions for Measures of Block Area (LA). Measures for all 4,321 RSLAs are included in figures (a). Measures of those 4,321 RSLAs with an average Block Areas (LA) less than 20 acres are included in figure (b). Again, as a test to examine the effects of distance on the distribution, only measures for those 521 RSLAs within 15 miles of the city centre are included in figure (c), with those measuring less than 20 acres, on average, in figure (d).

When examined, the measures of length (LA), block area (LA), and directional distance (LA), as they occur at the periphery, are not significantly affecting the distributions. For this subset of local areas within a fifteen-mile-radius of the metropolitan centre, the distributions demonstrate modes of scale and directness like those for the entire set of local areas. For this subset, the mode of length (RSLA<15) measures 500–600 feet and captures 26 percent of this subset (Figure 2d). The mode of block area (RSLA<15) measures less than 20 acres and captures 90 percent of this subset (Figure 3c). Of those, the mode measures four to six acres and captures nineteen percent of this subset (Figure 3d). Likewise, the mode of directional distance (RSLA<15) measures 2-3 changes in direction (Figure 2f).

Distinctly different, distance, as measured from the metropolitan centre, is likely affecting the reported mean of metric reach (RSLA). As illustrated for the local areas within 15-miles of the metropolitan centre, the distribution of metric reach (LA) illustrates less skewness (Figure 2e), and the mode is substantially higher. With bins of the histogram distribution set at five miles, the mode of metric reach (RSLA<15) measures 15–20 miles, and it captures 16 percent of this subset.

3.1 COMPARING MEASURES FOR EACH AMERICAN CITY

When measures for these local areas are aggregated for each American city, and the MSA means are examined, distinctions begin to emerge, and a range of measures is established for these American cities. For instance, the MSA mean of length (RSLA) varies from 894.88 feet in New York City to 1790.68 feet in Denver–Boulder (Table 3). Similarly, the MSA mean of block area (RSLA) varies from 66.44 acres in Miami to an extra ordinary 231.67 acres in Minneapolis–St. Paul. In terms of the average scale for these local areas, as measured by length and area, New York exhibits the lowest MSA mean of length (RSLA) and one of the lowest MSA means of block area (RSLA) suggesting, on average, local areas with shorter road segments and smaller blocks. Boston, Los Angeles–Riverside–Ventura, and Miami are similar. In contrast, Minneapolis–St. Paul exhibits the highest MSA mean of block area (RSLA) and one of the highest MSA means of length (RSLA) suggesting, on average, local areas with longer road segments and larger blocks. Cleveland – Akron and St. Louis are similar.

In terms of average density, as measured by metric reach, Atlanta and Cincinnati exhibit lower measures, which suggest that their local areas, or neighbourhoods, are lower than average in their density (Table 3), with Denver – Boulder and St. Louis similar. In contrast, Miami and New York City exhibit a higher MSA mean of metric reach (RSLA), suggesting greater densities with Chicago and Los Angeles – Riverside – Ventura similar.

In terms of the configuration, or the directness of road segments within these existing street networks measured by directional distance, Cleveland – Akron demonstrates the lowest MSA mean of directional distance (RSLA), which suggests that road segments within these local areas are more direct in their configuration (Table 3). Chicago, Dallas, Detroit, and unexpectedly, Minneapolis – St. Paul are similar. In contrast, Portland and San Diego demonstrate higher MSA means of directional distance (RSLA), suggesting road segments higher in their circuitousness. Pittsburgh is similar.

	(n) RSLAs	MSA Mean of Length (RSLA) (feet)	MSA Mean of Block Area (RSLA) (acre)	MSA Mean of Metric Reach (RSLA) (miles)	MSA Mean of Directional Distance (RSLA) (changes in direction)
all MSAs	4,321	1382.6562	134.2432	9.2827	4.8549
Atlanta	291	1279.3100	152.5512	6.7647	5.8918
Baltimore	90	1145.9438	142.3519	10.1801	3.7571
Boston	125	921.0272	81.7104	11.8741	5.4695
Chicago	213	1328.2620	133.1570	11.9539	3.5503
Cincinnati	155	1516.6831	204.4641	6.4354	4.8119
Cleveland - Akron	101	1528.7196	164.3451	10.2234	2.6507
Dallas	258	1450.6091	151.0491	8.7846	3.5818
Denver - Boulder	190	1790.6753	137.9317	6.4861	4.8325
Detroit	134	1323.7026	177.0784	11.6944	3.3131
Houston	280	1423.4125	126.3528	8.2462	3.6928
Los Angeles	212	1195.4960	73.3082	14.0722	5.2082
Miami	68	926.6310	66.4412	14.6685	3.8043
Minneapolis - St. Paul	225	1671.2101	231.6870	7.7011	3.1527
New York City	209	894.8752	75.4649	15.2736	5.1628
Philadelphia - Trenton	188	1171.5391	119.7133	11.3799	4.5559
Phoenix	209	1751.4890	125.3527	8.4101	4.4213
Pittsburgh	189	1259.9701	175.7874	8.6590	6.9142
Portland	211	1532.9129	137.9359	5.9333	7.0853
San Diego	114	1365.8487	86.2608	8.3709	7.2356
San Francisco - San Jose	181	1526.1984	111.9393	9.2437	6.2463
Seattle	150	1569.4133	104.3815	8.1577	6.2033
St. Louis	266	1568.2355	168.6837	6.7238	4.3662
Tampa - St. Petersburg	96	1186.9352	84.0708	11.4623	3.6418
Washington D.C.	166	1176.1295	92.4470	8.1887	6.1529

Table 3 - Statistical Measures for the MSA Mean of Length (RSLA), the MSA Mean of Block Area (RSLA), the MSA Mean of Metric Reach (RSLA), and the MSA Mean of Directional Distance (RSLA)

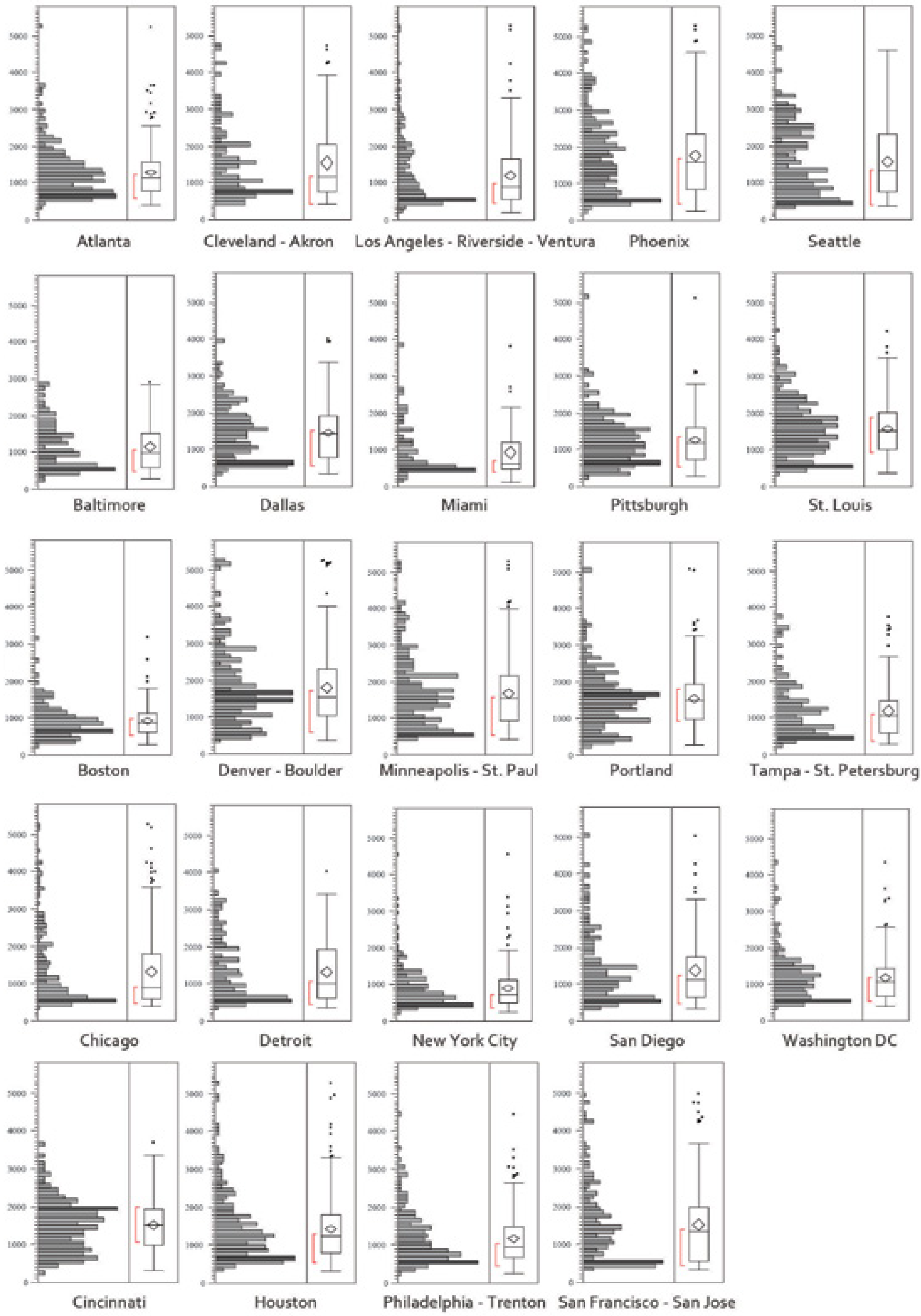

Figure 4 - Illustration of the Distributions of Length (LA) for each American City. Although these distributions are multi-modal, the modal interval consistently measures less than 800 feet, with Cincinnati, Denver-Boulder, Portland as the exceptions.

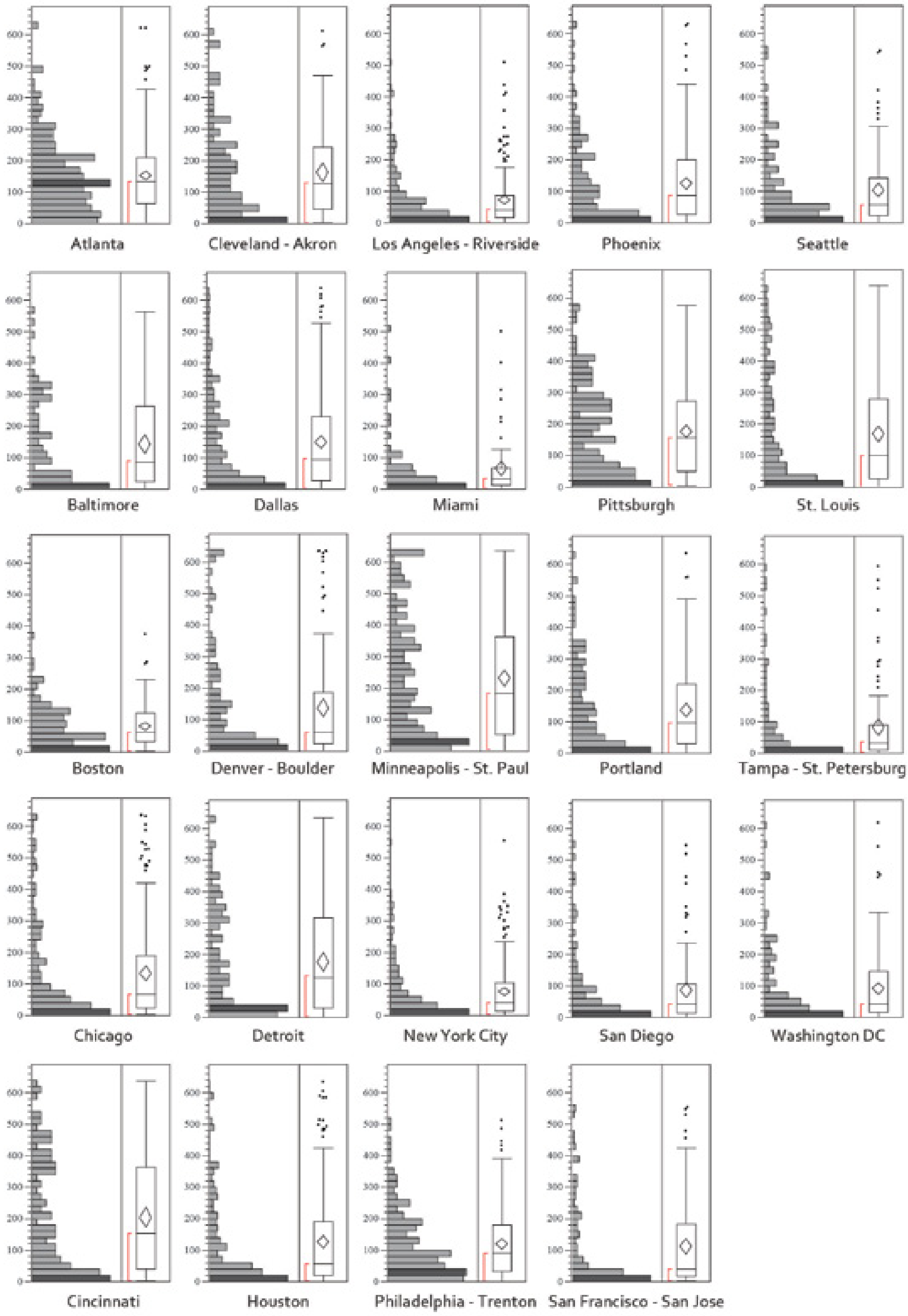

Figure 5 - Illustration of the Distributions of Block Area (LA) for each American City. Despite differences in geography and planning histories, the modal interval remains consistent, with Atlanta as the exception.

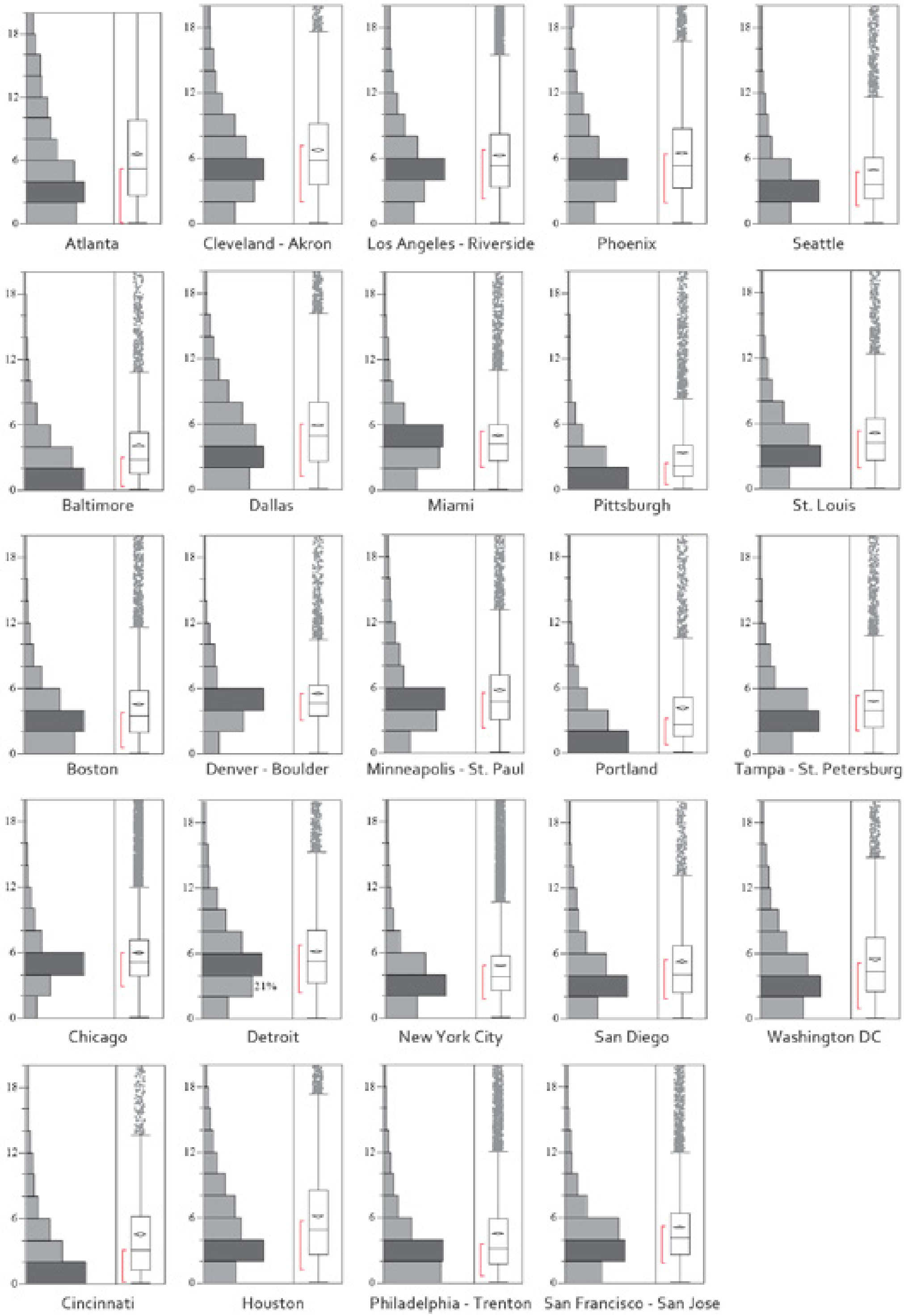

Figure 6 - Illustration of the Distributions for a subset of local areas with measures of Block Area (LA) Less Than 20 Acres for each American City

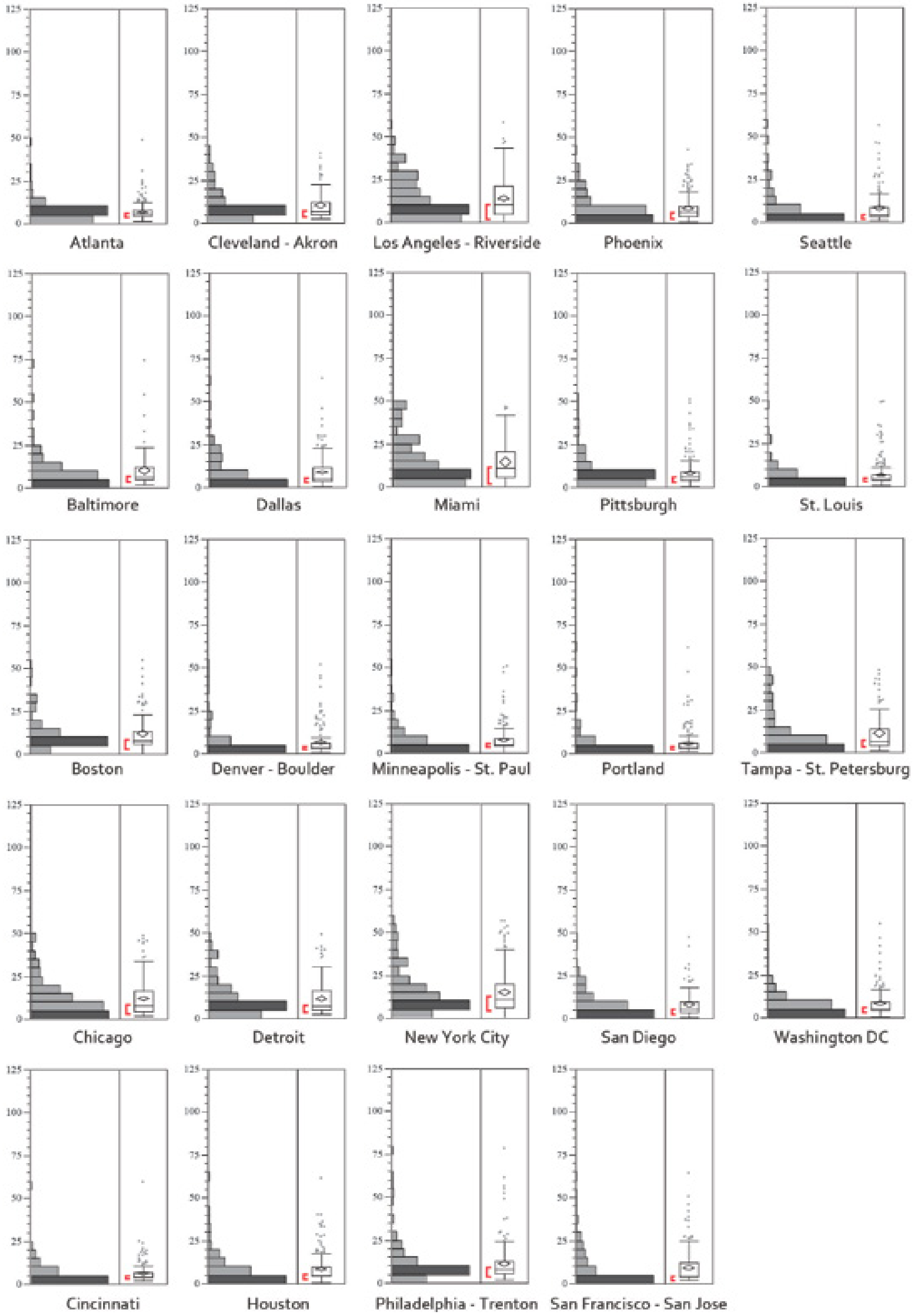

Figure 7 - Illustration of the Distributions of Metric Reach (LA) for each American City. As with Block Area (LA), the modal interval for Metric Reach (LA) remains consistent across all 24 cities.

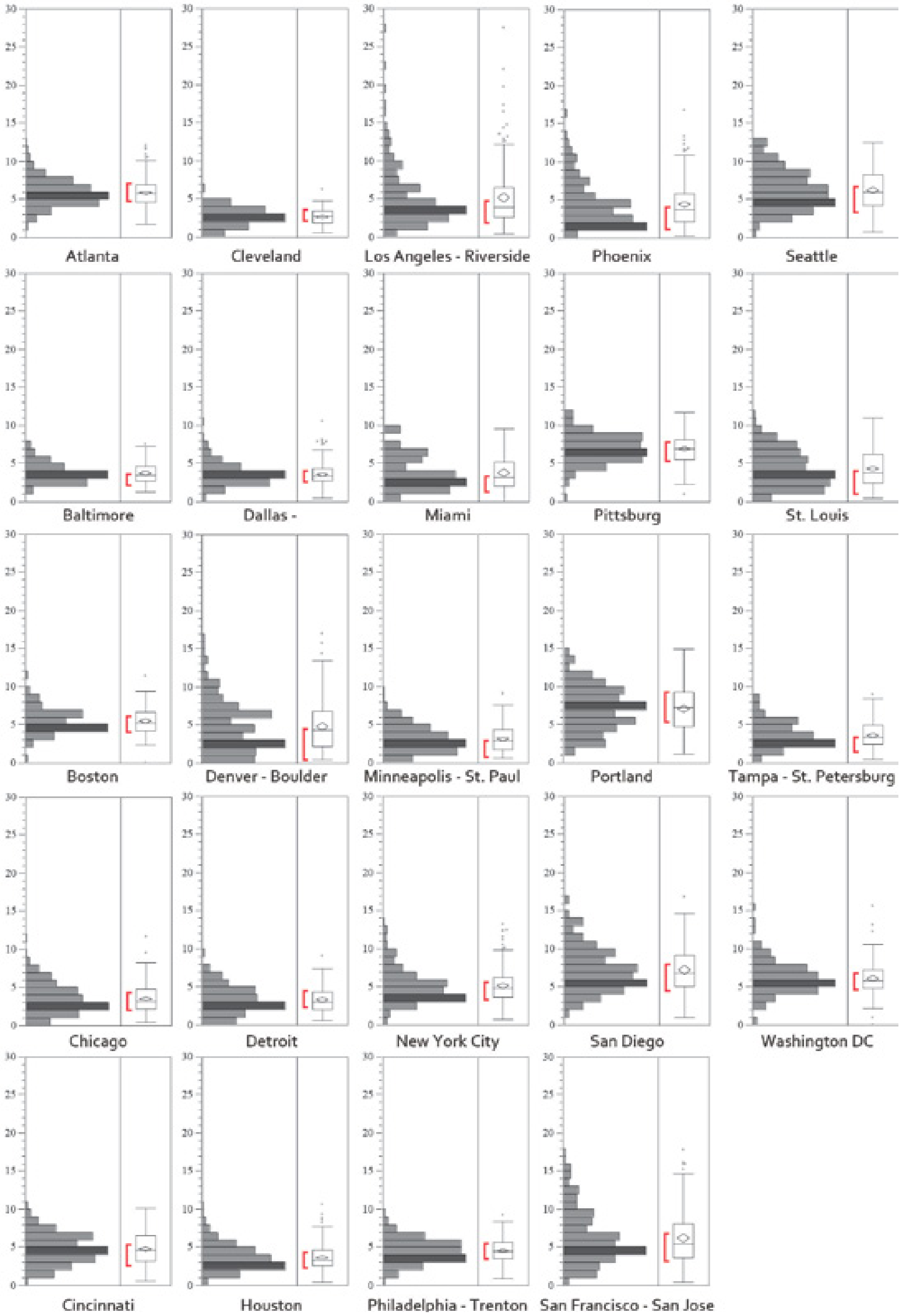

Figure 8 - Illustration of the Distributions of Directional Distance (LA) for each American City. Like Length (LA), the modal interval consistently measures less than 6 changes in direction for the captured metric reach, with Pittsburgh and Portland as the exceptions.

In addition to the statistical means, the distributions and frequencies are considered independently for each American city. As an exception for length (LA), Denver–Boulder exhibits a bimodal distribution, with a primary spike at 1,400–1,500 feet and a secondary spike of equal probability at 1,600–1,700 feet (Figure 4) with Cincinnati and Portland similar. For block area (LA), Baltimore, Cincinnati, Cleveland–Akron, Dallas, Denver–Boulder, Detroit, Minneapolis–St. Paul, Philadelphia–Trenton, Phoenix, and Pittsburgh exhibit multimodal distributions (Figure 5), but the modes remain similar, measuring less than 20 acres with the exceptions of Atlanta, Detroit, Minneapolis – St. Paul, and Philadelphia – Trenton. Subsequently, for those local areas measuring, on average, less than 20 acres in block area (LA), the distributions are again multimodal (Figure 6). For instance, Atlanta, Dallas, San Diego and St. Louis exhibit two modes with each capturing equal percentages of the local areas in the random sample. For measures of scale, the distributions are often multimodal, yet the mode remains relatively consistent.

For measures of density and directness, the distributions are consistent between these metropolitan regions, and the modes of metric reach (LA) and directional distance (LA) vary only slightly. Atlanta, Boston, Cleveland–Akron, Detroit, Los Angeles–Riverside–Ventura, Miami, New York City, Philadelphia–Trenton, and Pittsburgh have a mode of metric reach (LA) slightly higher at 5–10 miles than the rest at 0-5 miles (Figure 7). Likewise, the mode of directional distance (LA) remains relatively consistent, with Pittsburgh and Portland as exceptions (Figure 8).

Acknowledged distinctions between these American cities, and their associated measures of scale, density, and directness are captured by the MSA means of length (RSLA), block area (RSLA), metric reach (RSLA), and directional distance (RSLA). And yet despite these distinctions, when measures of the RSLAs are analysed as distributions for each metropolitan area, few differences are demonstrated between their modes, or the interval capturing the measures of those local areas most often encountered. As illustrated, most local areas in these American cities exhibit, on average, higher measures of scale and directness with lower measures of density, regardless of the different planning histories, geographies, and transportation policies influencing them. How then do these local areas of the random sample compare to the historically significant local areas previously studied in the literature?

3.2 BENCHMARKING MEASURES

As already discussed, most RSLAs have an extremely high average of length, block area, and directional distance with a significantly lower average of metric reach. When their measures are benchmarked against previously defined periods of development (Peponis et al., 2007), the scale, density, and directness of existing street networks far exceeds the anticipated range of measures. The mean of length (RSLA) is almost three times as long; the mean of block area (RSLA) is almost four times greater; and the mean of metric reach (RSLA) is less than half than the edge cities previously studied (Table 4).

Explicitly, of the 4,321 RSLAs, 87.7% were even larger in their average length of road segments than the average length reported for previously sampled Edge Cities. For block area (LA), 81.6% were larger in their average area of blocks. For metric reach (LA), 92.5% were less dense in their average metric reach than the Edge Cities, and for directional distance (RSLA), 53.9% were more circuitous.

	(n)	Mean of Length (feet)	Mean of Block area (acre)	Mean of Metric Reach (parameter of 1 mi) (miles)	Mean of Directional Distance (parameter of 1 mi/10 degrees) (changes in direction)
RSLAs	4,321	1382.66	134.24	9.28	4.85
Period of Development *					
Pre – 1950	39	406.79	6.68	45.26	3.19
Post – 1950	26	569.23	34.86	20.43	5.21
Planning Influences *					
Pre – 1925	16	344.57	3.82	54.28	2.83
Olmsted	3	479.12	12.78	32.79	4.03
City Beautiful/Garden City	3	477.83	9.55	35.10	3.64
Levittown	2	498.04	10.56	32.03	5.13
Edge Cities	10	541.29	17.85	25.11	4.20

** Data for these historically and morphologically significant local areas was sourced from Peponis et al. (2007), with unit of meters and kilometres manually converted for comparison*

Table 4 - Mean of Length (RSLA), Block Area (RSLA), Metric Reach (RSLA), and Directional Distance (RSLA) in Comparison to the Local Areas Sampled for their Period of Development and Planning Influence

When measures are benchmarked against noteworthy street networks with distinguishing morphological characteristics (Peponis et al., 2007), like Riverside (Chicago), Levittown (Philadelphia), Radburn (New Jersey), and Reston (Virginia), 82% of these RSLAs measured, on average, more than 600 feet in length, and 62% of the local areas measured, on average, more than 45 acres in block area (Figure 9). With parameters established at 1 mile and 10 degrees, 83% of local areas measured, on average, less than 15 miles in metric reach, and 42% of the local areas measured, on average, more than 5 changes in direction to navigate that captured reach (Figure 10).

As a general characterization of areas within these American cities, most of the RSLAs are longer in their average length, larger in their average block area, sparser in their average metric reach, and more circuitous in their directional distance than even the largest cul-de-sac areas morphologically sampled originally.

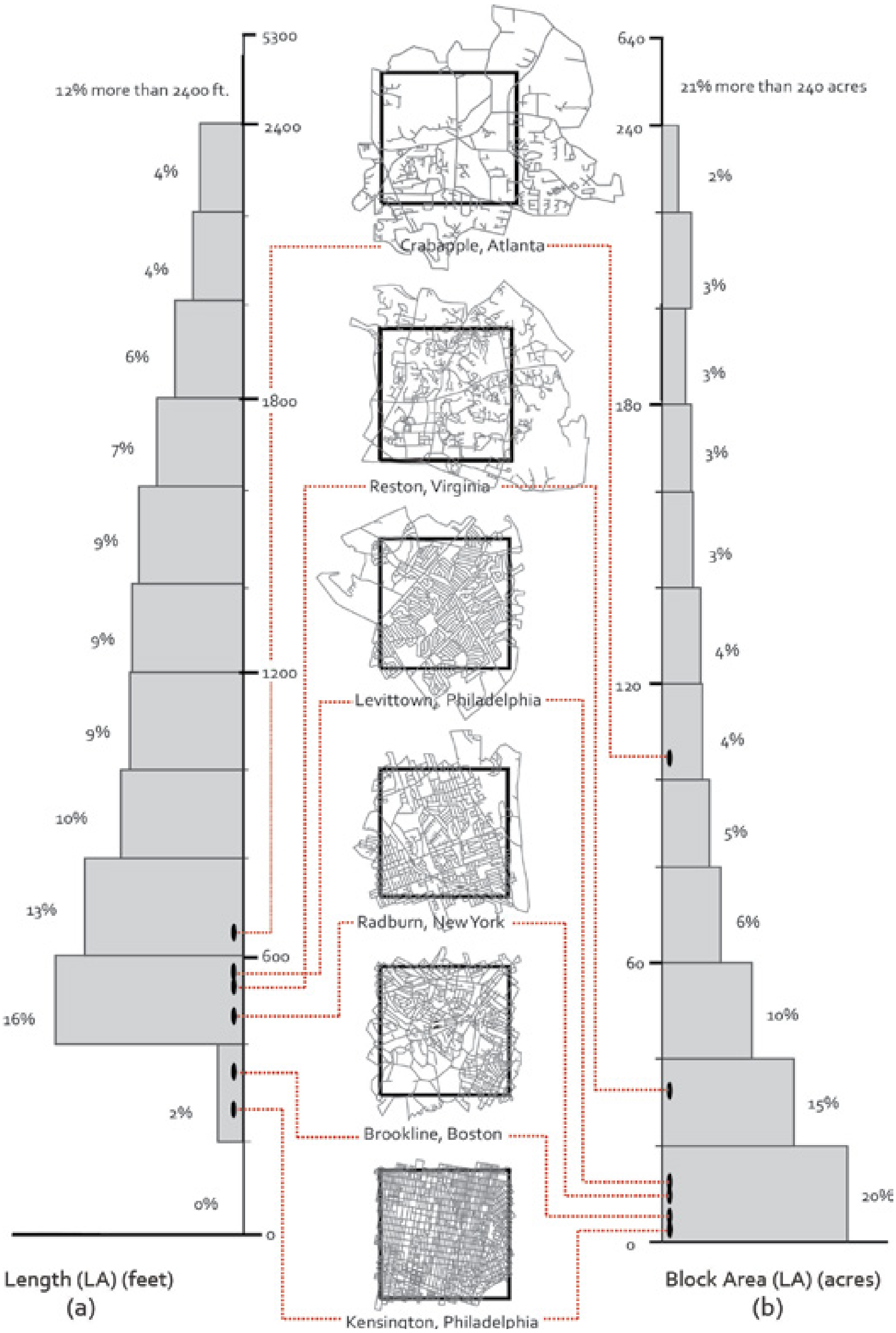

Figure 9 - Illustration of the Distributions for Length (LA) and Block Area (LA) in comparison to Influential and Historically Significant Local Areas previously studied within the literature

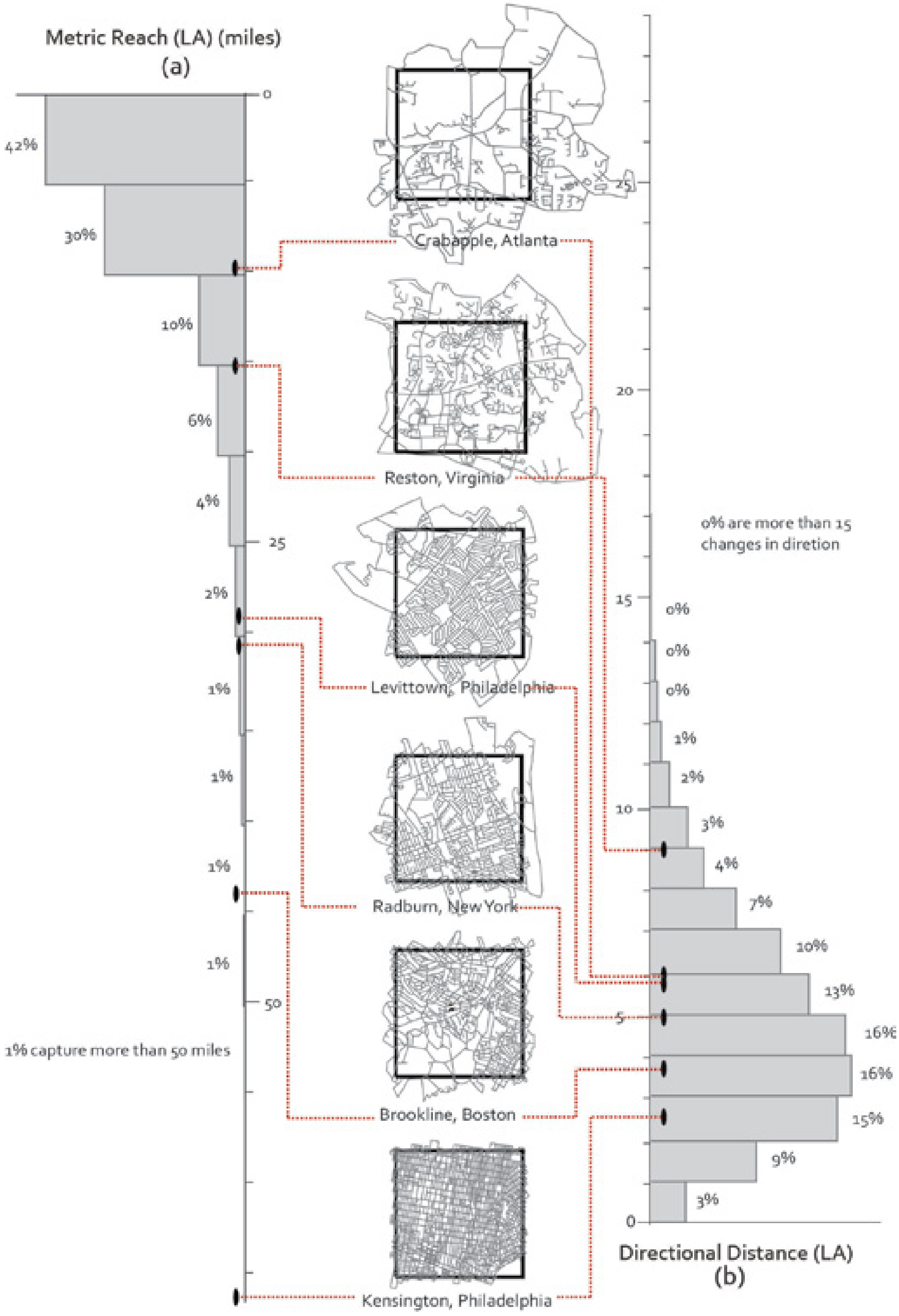

Figure 10 - Illustration of the Distributions for Metric Reach (LA) and Directional Distance (LA) in comparison to Influential and Historically Significant Local Areas previously studied within the literature

4. CONCLUSIONS

The aim of this research was to more adequately depict the morphological characteristics of the American city, examining measures of its scale, density, and directness. Distributions and frequencies were illustrated to both define a more accurate range of measures and determine those encountered most often. Distinctions between the measures of these selected American metropolitan areas were recognized, and lastly, measures of the RSLAs were compared to those noteworthy street networks with distinguishing morphological characteristics for benchmarking purposes.

Acknowledged distinctions between the measures of these American cities are captured by their associated means. Distinctive differences were confirmed by the MSA mean of length (RSLA), block area (RSLA), metric reach (RSLA), and directional distance (RSLA). And yet, when measures were analysed as a distribution, few distinctions were demonstrated between their frequencies. The modes of length (LA), block area (LA), metric reach (LA), and directional distance (LA) were relatively consistent, suggesting then that these American cities share many of the same morphological characteristics of street connectivity, despite their varied planning, economic, geographical, and historical influences. Arguably, this consistency could be capturing the effects of federally mandated policies regulating land subdivision and development across the American landscape, despite different jurisdictions (Ben-Joseph, 2005; Major, 2015).

As a general characterization, the scale, density, and circuitousness of existing street networks in American metropolitan areas far exceeds the anticipated range of measures. Most local areas of the random sample are significantly longer in their average length of road segments, larger in their average area of blocks, sparser in their average metric reach, and more circuitous in their directional distance than even the most sprawling suburban areas originally considered. If the goal of a street network is to fundamentally 'connect spatially separated places,' as suggested by Handy et al. (2003), then clearly this study demonstrates that there is much work to be done.

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