

CARTOGRAPHIC MODELING OF BRAZILIAN MEDIUM-SIZED CITIES URBAN SPRAWL: A METHODOLOGY BASED ON FRACTAL DIMENSION ANALYSIS

TRENTIN G., FERREIRA M.C.

State University of Campinas; UNICAMP, CAMPINAS, BRAZIL

INTRODUCTION

The fractal approach in the study of the urban areas had contributed to the interpretation of physical and morphological aspects related to space-time analysis, especially with the requirement of new methodologies considering the urban spatial dynamic complexity. Most of the methods traditionally employed in the analysis of urban areas not consider the morphology, the spatial distribution of urban voids and the edge effects of the perimeter. On the other hand, the fractal measures of urban form allow analyzing the growth and space-filling of urban area.

From the fractal dimension of urban areas is possible to verify the complexity degree of its border, besides of urban occupation pattern and its distribution along the time. Fractal dimension values that vary along a time series are indicative of disordered occupation, while high values of fractal dimension represent more homogeneous filling of the city.

Considering the above mentioned, the aim of this work was to analyze the urban sprawl evolution of Brazilian medium-sized cities (between 100,000 and 500,000 urban inhabitants) with differences in population gradients, urban morphology, geographical position, which are located into different regional units of relief, through the fractal dimension estimative (D).

To estimate D, the occupation density method in relation to distance from urban center (CBD) was utilized. In this study three medium-sized cities of São Paulo state, southeastern Brazil, were selected as test: Botucatu (113,719 inhabitants), center of the state, in the Basaltic Cuestas; the urban agglomerate Taubaté-Tremembé (282,527 inhabitants), southeast of the state, in Atlantic Plateau; São José do Rio Preto (376,828 inhabitants), north of the state, in Occidental Plateau.

MATERIALS AND METHODS

The perimeters of the selected cities in the years of 1938, 1985, 1995 and 2005, were delimited with maps and Landsat TM 5 satellite images, at the 1:50,000 scale. The values of the built-up areas in each city for all dates were obtained overlapping concentric circles with 500 meters of radius. Then we obtained the D values for each circle accordingly to the occupation density method (Marques and Ferreira, 2003; Batty and Longley, 1994; Batty and Xie, 1996). The D values indicate that when D=2, the circle is completely filled with built-up areas; values of $1 < D < 2$ suggest the existence of fragmentation of the built-up area in each circle.

RESULTS AND DISCUSSION

The three cities showed an increasing population and urban sprawl in the period considered. Botucatu and Taubaté-Tremembé presented urban form elongated while the urban form of São José do Rio Preto tended to circularity. This fact can be related with the spatial impediments that determine the resistance to urban growth.

The fractal signatures were distinct, as expected (Figure 1). D values around 2 were found close to the central areas, where the urban occupation is more homogeneous and concentrated. Towards to the urban edges, the forms of the built-up areas tend to be more fragmented along the time, especially when urbanization was influenced for road axes. This result was also verified by Marques and Ferreira (2006) in the urban agglomeration of São Paulo in Brazil. There was also a tendency to raise D when the urban population density increases, consequently, a greater space-filling occur in these urban areas.

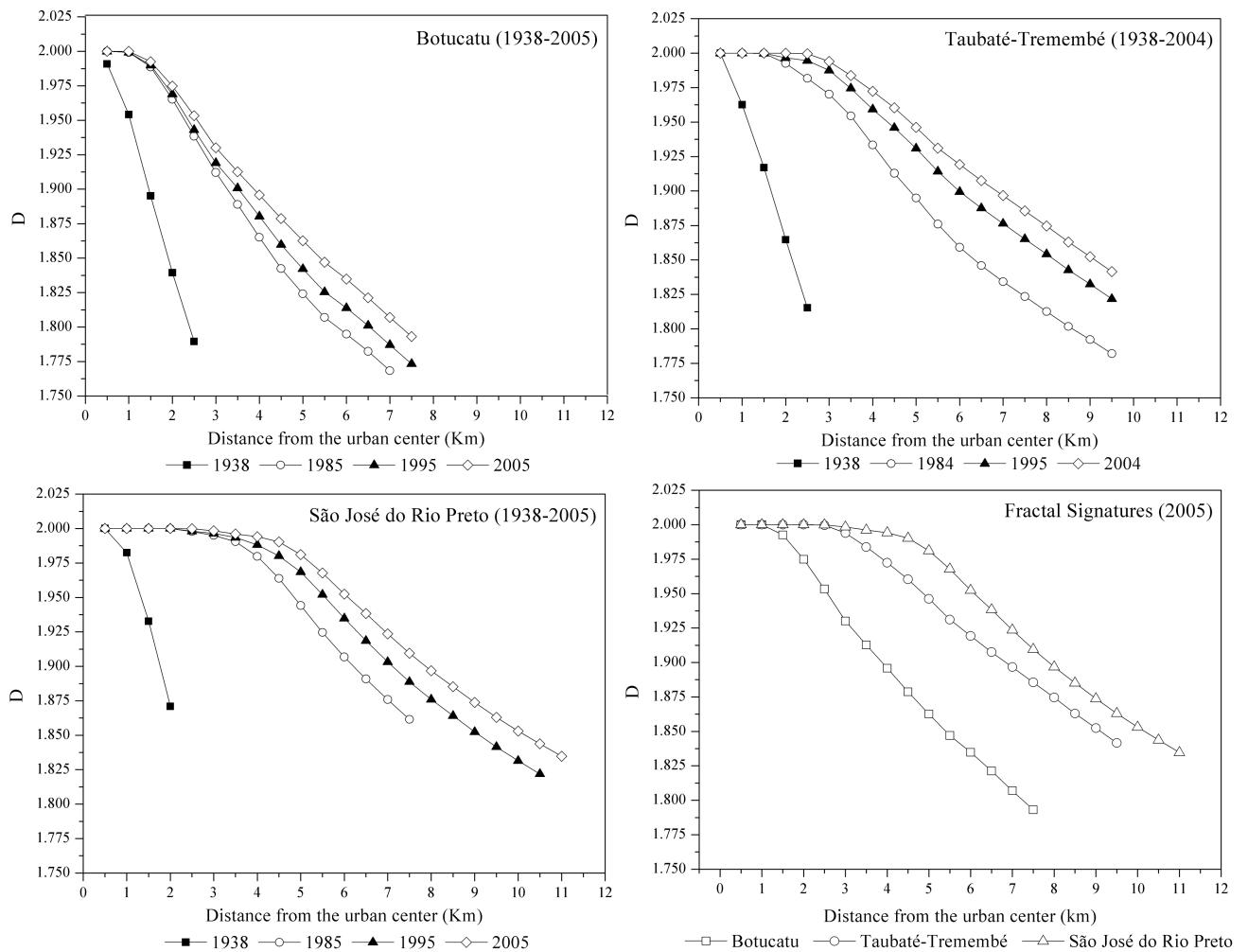


Figure 1. Fractal dimension signatures along the time and a comparison of signatures in 2005 for the three cities.

Botucatu, the city with the smaller population in this study, showed the most urban fragmentation (averages between $D=1.894$ in 1938 and $D=1.900$ in 2005). Taubaté-Tremembé showed the same behavior that Botucatu (increasing averages of $D=1.912$ in 1938 and $D=1.938$ in 2005), while in São José do Rio Preto was observed higher D values (1.946 in 1938 and 1.941 in 2005). This fact can be explained by the lesser topographical impediments which favor the urban sprawl. Differences of D values among the urban areas were associated to the influence of traffic routes, existence of topographical impediments – such as hills and slopes – as well as socioeconomic factors.

The D values obtained to three cities are in accordance with values reported in earlier studies testing the same method. The behavior of D was compatible with the D values for London (Batty and Longley, 1994) and urban agglomeration of São Paulo (Marques and Ferreira, 2006). In these cases the values showed less variability along the time, indicating coordination between compaction and urban growth. Frankhauser (1994) also used this method in Berlin, but the D values were more variables in function of the time.

Therefore, from the fractal dimension calculated by occupation density method is possible to discriminate the spatial distribution of urban structure, the mobility conditions, allowing the accompaniment of occupation dynamic of voids spaces. This research is part of a wide study concerning the performance of methods for fractal dimension estimative in the urban sprawl analysis for Brazilian medium-sized cities.

REFERENCES

- Batty M, Longley P (1994) *Fractal cities: a geometry of form and function*. London, Academic Press.
- Batty M, Xie Y (1996) Preliminary evidence for a theory of the fractal city. *Environment and Planning A*, 28:1745-1762.
- Frankhauser P (1994) *La fractalité des structures urbaines*. Paris, Anthropos.

Marques ML, Ferreira MC (2006) Análise da densidade de ocupação do aglomerado urbano da região metropolitana de São Paulo pela estimativa de dimensão fractal. *Geografia*, 31:293-316.