Spatial approach to identifying trends in racial composition changes for large American cities 1990-2000-2010

A.Dmowska[1] and T.F. Stepinski *[2]

[1]Institute of Geoecology and Geoinformation, Faculty of Geographical and Geological Science, Adam Mickiewicz University, Poznan, Poland

[2]Space Informatics Lab, Department of Geography, University of Cincinnati, Cincinnati, USA, OH 45221-0131, USA

*Email: stepintz@uc.edu

Abstract

Frequent change trajectories (trends) of social landscape in large American cities are identified using spatial technique of landscape metrics applied to high resolution categorical grids of racial diversity. For 41 cities, nine communities (categories of diversity grids), and three observation times (censuses) we calculated class-level landscape metrics, percentage of landscape (PLAND) and aggregation index (AI). For these two metrics we calculated values of relative change over two change periods, 1990–2000 and 2000–2010. These changes were classified into eight characteristic types leading to the set of change trajectories for each community in each city. Frequent change trajectories indicate characteristic trends of changing social landscape. Eight such trends were identified and described. Change trajectories show no strong geographical dependence indicating that cities across the U.S. experienced similar changes of their social landscape during the two decades under consideration.

Keywords: Social landscape, race/diversity, landscape metrics, urban change

1 Introduction

United States is a multiracial but mostly segregated society. Most of minority populations are found in large cities living in spatial segregation from the majority white populations and from each other. However, over the last two decades, growing immigration from non-European countries and shifting societal attitudes had started to change this arrangement. Documenting, and eventually understanding this dynamics is of great interest to demographers and policymakers so they can make predictions about future racial character of American cities. Given the level of interest in this topic there are numerous studies documenting racial changes in American cities. Many of them lack explicit spatial element and rely only on overall population counts, but some newer study (Holloway et al., 2012; Wright et al., 2014) are spatial. When they are, they use US Census Bureau population counts aggregated to spatial units like census tracts. There are numerous technical problems with using tracts for studying changes in racial diversity Sperling (2012), the method introduces inaccuracies and it limits the type of analysis that can be performed.

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Since 2013 we undertook the project (Dmowska and Stepinski, 2014, 2016, 2017) aimed at producing a multiyear compatible, high resolution, U.S.-wide population grids of population. Those grids are a result of dasymetric modeling performed based on 1990, 2000, 2010 U.S block census data using multiyear compatible land cover datasets as an ancillary data. This project is now completed. Population grids and their derivatives (diversity grids) are available for direct download from http://sil.uc.edu. They can also be explored and downloaded from an online application SocScape (http://sil.uc.edu/webapps/socscape_usa/).

Here we propose to use diversity grids to identify the most pronounced trends in racial composition changes in large American cities over the two decades 1990-2010 (three censuses). The biggest difference between this approach and previous approaches is the use of diversity maps instead of sub-population counts. Thus, we use spatial rather than demographic technique. The diversity map is a categorical map with each category representing a community characterized by different level of racial diversity and dominant race. Such maps could be though of as a "social landscapes" and we compare them using the methodology of landscape metrics (McGarigal, 2014). By using two landscape metrics for nine different communities in 41 cities (Major Statistical Areas or MSAs) we identified and described dominant trends of spatio-temporal change in racial composition/diversity over the last three censuses.

2 Data and methods

2.1 Racial diversity grid

We downloaded 1990, 2000, and 2010 diversity grids from http://sil.uc.edu. These grids have nominal resolution of 30 m/cell. The grids feature 39 community classes but we reclassified them to only 13 classes by eliminating dependence on population density. Examples of diversity maps constructed from reclassified grids are shown in Fig.1. Only nine major classes were analyzed for trends. The "communities" are the result of classification of grid cells on the basis of level of diversity and dominant race. For details of this classification see Dmowska and Stepinski (2014). Nine communities we analyzed are: white low diversity(WL), white medium diversity (WM), black low diversity(BL), black medium diversity (BM), Hispanics low diversity(HL), Hispanics medium diversity (HM), Asians low diversity(AL), Asians medium diversity (AM), and high diversity (Hdiv). For example, the BM is an area containing cells where majority but not dominant majority of residents are black, and WL is an area where dominant majority of residents are white.

2.2 Calculating changes to race/diversity landscape

For a single city a spatio-temporal change of diversity landscape between two observations (censuses) could be calculated and visualized in the way analogous to change detection in land cover datasets. Examples of such change assessment for Chicago, Houston, and San Francisco can be found in Dmowska and Stepinski (2016). However, here we want to assess spatio-temporal change over three observations for 41 cities. For this purpose we describe each community in each city by a pair of class-level landscape metrics, percentage of landscape (PLAND) and aggregation index (AI). PLAND refers to a percentage (0% to 100%) of a city occupied by a given community. Aggregation index (0 to 100) describes a level of aggregation (low to high) of an area occupied by a given community. Change in PLAND indicates growing or shrinking of a given community, whereas

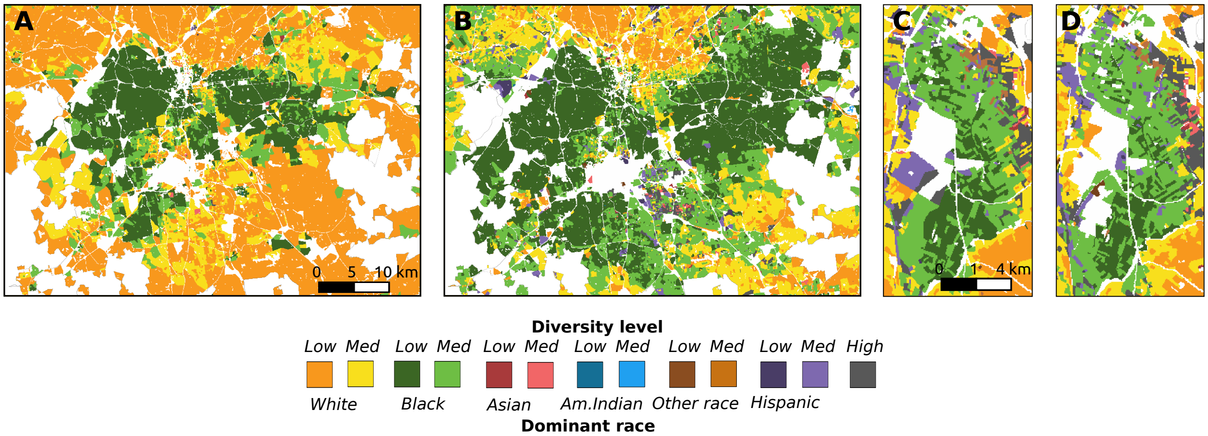

Figure 1: Maps of racial diversity: A. Atlanta in 1990, B. Atlanta in 2010, C. Part of Boston urban area in 2000, D. Part of Boston urban area in 2010.

change in AI indicates agglomeration or fragmenting of an area occupied by a given community. Calculation of PLAND and AI were performed using R software. Diversity maps for the 41 cities and three observation times (123 grids altogether) were imported to SpatialGridsDataFrame object in R. PLAND and AI were calculated using SDMTools - Species Distribution Modeling Tools.

Fig.1 shows two examples of social landscape change. Panels A and B show diversity maps for Atlanta in 1990 and 2010, respectively; the BL community grew from 6% in 1990 to 10% in 2010 but its aggregation index remain the same at about AI=96. Panels C and D show a fragment of the Boston urban area in 1990 and 2010, respectively; percent of area occupied by the BL community droped from 0.16% to 0.13% and the AI changed from 86 to 81 indicating shrinking accompanied by fragmentation – a strong indicator of an overall decay.

Given three observations (1990, 2000, and 2010) we have two periods of change, 1990–2000 and 2000-2010. For a particular community in a given city we are interested in relative change for each change period, $\delta^X_{i+10,i} = (X_{i+10} - X_i)/X_i$, where δ^X is the relative change, X refers to either PLAND or AI and $i = 1990$ or 2000. To simplify the change data we classify the pairs $(\delta^{PLAND}, \delta^{AI})$ for a given change period into eight categories as shown in a legend to Fig.2. A change trajectory is a pair of this categories where the first element is the change category in the period 1990–2000 and the second element is the change category in the period 2010–2000. Each of the nine communities in each of the 41 cities is assigned one of the 64 possible change trajectory. For example, the BL community in Miami is assigned a trajectory (4,1) meaning that in the decade of 1990–2000 it grew but also fragmented although the rate of fragmenting was lower than the rate of growing, but in the decade of 2000–2010 it reversed its growth, started shrinking while still fragmenting. Change trends are defined as frequent change trajectories.

3 Results

We identify change trends in each of the nine communities separately. For each community we construct a histogram of change trajectories. Such histogram allocates 41 trajectories to 64 possible bins. We identify trends as prominent peaks in those histograms. Prominent peak means that a

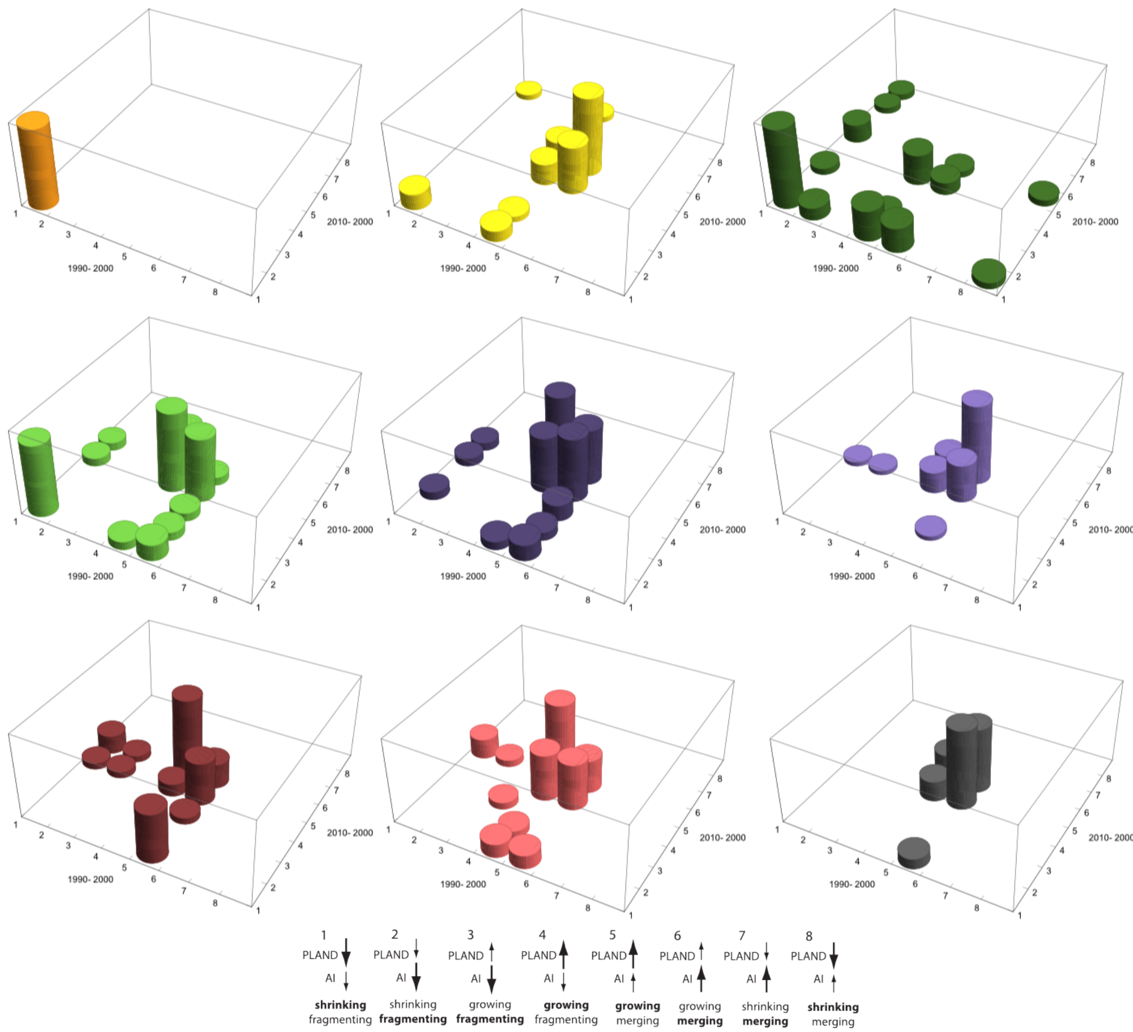

Figure 2: Histograms of change trajectories for each of the nine communities. Communities are indicated by a color of histogram bins, see Fig.1 for the legend. Bins indicate the number of cities which followed a given change trajectory during 1990–2000-2010. In the legend bold font indicates stronger relative change.

significant percentage of cities followed the same change trajectory for a community in question. Fig.2 shows the histograms of change trajectories for the nine communities under consideration. For every community its corresponding histogram shows a variety of change trajectories, the BL community displayed the most trajectories (13) while the WL community displayed the least (1). We arbitrarily decided that a histogram peak containing $\geq 30\%$ (12 or more out of 41) cities constitutes a trend. Given this criterion we have identified eight change trend; these trends are summarized in Table 1.

The most striking result is a decay of the WL community coupled with the growth of WM community – together these two trends indicate erosion of white-only neighborhoods. The other consistently decaying community is BL. In addition to WM two other communities, HL and Hdiv experienced consistent growth and merging. In addition, in 16 cities the Hdiv community experienced growth/merging followed by growth/segmentation. The interpretation is that in 1990–2000 Hdiv expanded around existing neighborhoods, but in 2000–2010 it developed additional neighbor-

Table 1: Trends of racial composition change in 1990–2000-2010

Rank	Community	Trajectory	# of cities (%)	Description
1	WL	(1,1)	41 (100)	**Shrinking**/fragmenting both decades
2	HL	(5,5)	19 (46)	**Growing**/merging both decades
3	Hdiv	(5,4)	16 (39)	**Growing**/merging + **Growing**/fragmenting
4	WM	(5,5)	15 (37)	**Growing**/merging both decades
5	AL	(4,5)	13 (32)	**Growing**/fragmenting + **Growing**/merging
6	BL	(1,1)	13 (32)	**Shrinking**/fragmenting both decades
7	Hdiv	(5,5)	13 (32)	**Growing**/merging both decades
8	AM	(4,5)	12 (30)	**Growing**/fragmenting + **Growing**/merging

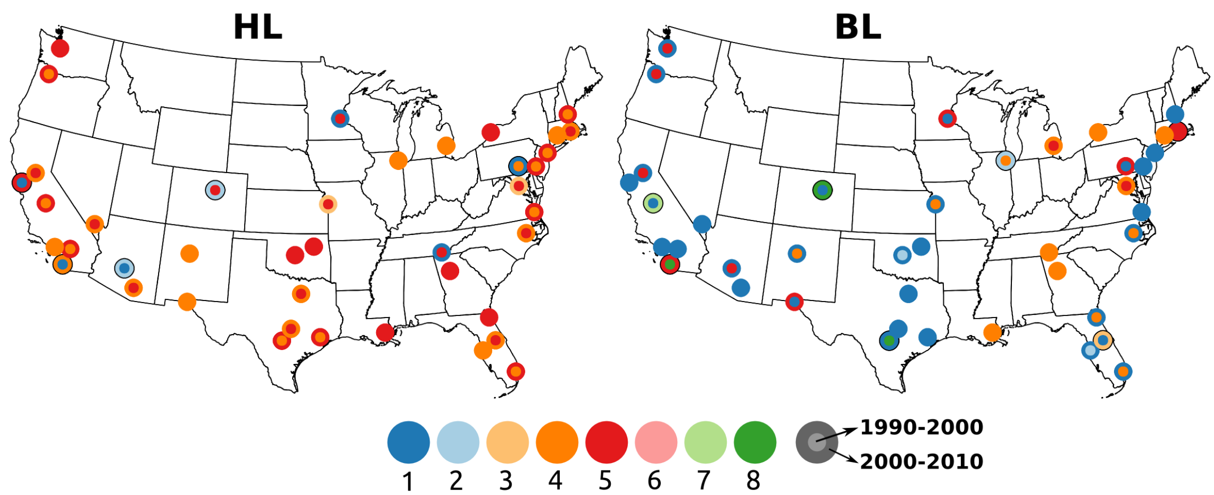

Figure 3: Sample of 41 large American cities mapped using symbols depicting their change trajectories for HL community (left) and BL community (right).

hoods. Finally, both AL and AM experienced growth/fragmenting followed by growth merging. The interpretation is that in the 1990–2000 these communities established itself in numerous separate neighborhoods and in 2000–2010 they started to consolidate.

We also mapped the 41 cities by symbols depicting their change trajectories. This allows for assessment of geographical distribution of different types of social landscape change. Fig.3 shows such maps for HL and BL communities (space restrictions prevents us from showing the other 7 maps). On these maps a city is marked by a symbol that encodes the change category in 1990-2000 period and the change category in the 2020-2000 period. Warm colors (3,4,5,6) correspond to growth and cold colors (1,2,7,8) correspond to shrinkage. No clear geographical differences between character of change are observed for neither community, the BL is shrinking everywhere with few exceptions and HL is growing everywhere with few exceptions. For HL an interesting exception is the city Phoenix, AZ which shows decay despite strong overall growth of Hispanic population; these population is however distributed among more diverse communities of HM and WM. For BL an interesting exception is Boston, MA which shows growth albeit a small one.

4 Conclusions

We demonstrated that a demographic problem of assessing changes to racial makeup and diversity of American cities can be effectively addresses using purely spatial approach. The key to this approach is an introduction of categorical diversity grid – a product derived from grids of race sub-populations. Categorical character of the diversity grid makes it technically analogous to the map of land cover, so a temporal change of its character can be analyzed using landscape metrics. By following this approach we were able to perform the analysis of racial/diversity change that is more in-depth than those based on analysis of race/diversity sub-population aggregated to census tracts. Instead of just reporting year-to-year changes in the number of people of different races living in a city we calculate change in the sizes and characters of areas inhabited by different communities. We also identified change trajectories that contain information about changes from two change periods instead of just one. Overall, our approach give more information to demographers and policymakers to better understand processes that drive these changes.

5 Acknowledgements

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6 References

Dmowska, A. and T. F. Stepinski
2014. High resolution dasymetric model of u.s. demographics with application to spatial distribution of racial diversity. *Applied Geography*, 53:417–426.

Dmowska, A. and T. F. Stepinski
2016. Mapping changes in spatial patterns of racial diversity across the entire united states with application to a 1990–2000 period. *Applied Geography*, 68:1–8.

Dmowska, A. and T. F. Stepinski
2017. A high resolution population grid for the conterminous united states: The 2010 edition. *Computers, Environment and Urban Systems*, 61:151–161.

Holloway, S. R., R. Wright, and M. Ellis
2012. The Racially Fragmented City ? Neighborhood Racial Segregation and Diversity Jointly Considered. *The Professional Geographer*, 64:63–82.

McGarigal, K.
2014. *FRAGSTATS Help. Documentation for FRAGSTATS 4.0.* University of Massachusetts, Amherst.

Sperling, J.
2012. The tyranny of census geography: Small-area data and neighborhood statistics. *Cityscape*, 14(2):219–223.

Wright, R., M. Ellis, S. R. Holloway, and S. Wong
2014. Patterns of racial diversity and segregation in the United States: 1990-2010. *The Professional Geographer*, 66(2):173–182.