Monitoring Landscape Fragmentation Under Conditions of Rapid Urbanization in the Central Arizona -- Phoenix Region

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INTRODUCTION

Urban sprawl and "leapfrog" development patterns increasingly fragment natural areas in the United States. Previous studies have shown that landscape fragmentation has important consequences on ecosystems and social implications. To gain a better understanding of the process of fragmentation, and the effect on the change of urban spatial pattern under different land use regulations and policies, we investigated the spatial and temporal pattern of fragmentation in the Phoenix metropolitan area.

METHODS AND DATA

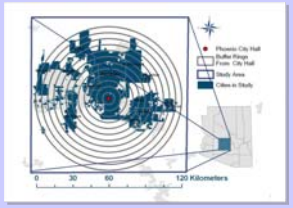


Figure 1. Study Area

We tested a suite of fragmentation metrics across twelve valley city jurisdictions. The selection of the cities depends in part on their distance from Phoenix City Hall in order to represent urban, suburban, exurban and rural areas. We used a 270m by 270m square moving window to examine the fragmentation spatial distribution, and analyzed the fragmentation gradient through 12 buffer rings within 60 kms from Phoenix City Hall (Fig. 1)

Data used in this study are from National Land Cover Dataset (NLCD) for the years 1992 and 2002 compiled from Landsat satellite TM. The statistical accuracy of the 1992 data known for the region is around 70% to 75%.

We reclassified the original land use/cover classes into 3 categories: Undeveloped, Developed, and Cultivated. In Fragstats, software that computes a number of landscape metrics (http://www.umass.edu/landeco/research/fragstats/fragstats.html), we quantified the fragmentation pattern through landscape metrics, including density, edges, shape, contrast, contagion, and diversity metrics. We calculated these metrics for individual cities, then examined the fragmentation level of each pixel within the whole research area using a moving window. Finally, we developed a temporal spatial fragmentation pattern for Metropolitan Phoenix.

Metrics	Range	Description
Interspersion & Juxtaposition Index (IJI)	0 ≤ IJI ≤ 100	A higher IJI value means the corresponding patch type is equally adjacent to all other patch types
Contagion (CONTAG)	0 ≤ CONTAG ≤ 100	Contagion is inversely related to edge density, and describe the level of land connectivity
Largest Patch Index (LPI)	0 < LPI ≤ 100	LPI is the percent of the landscape that the largest patch comprises
Landscape Shape Index (LSI)	LSI ≥ 1	LSI increases with increasing landscape shape irregularity or increasing amounts of edge
Edge Density (ED)	ED ≥ 0	ED reflects the amount of edge in the landscape area
Number of Patches (NP)	NP ≥ 1	NP is a measure to describe landscape heterogeneity
Shannon's Diversity Index (SHDI)	SHDI ≥ 0	The increase of SHDI value indicates the increase of number of different patch types
Contrast-Weighted Edge Density (CWED)	CWED ≥ 0	CWED is a measure of density of edge in a landscape with a user-specified contrast weight

RESULTS

1. Fragmentation change in twelve cities

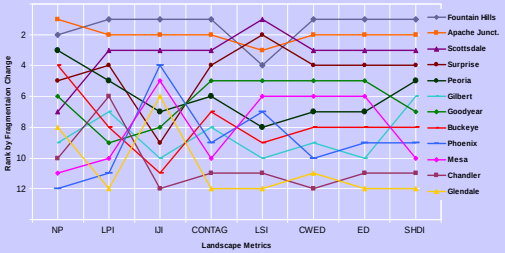


Figure 2. Relative Rank Position of the Cities by Fragmentation Change Level, 1992-2001

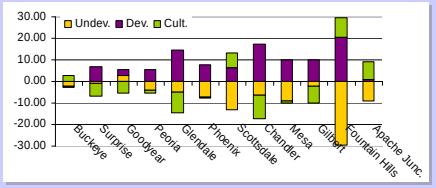


Figure 3. Change of Percentage of Landscape (PLAND), 1992-2001

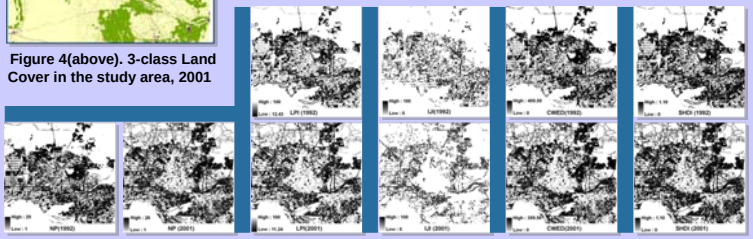
Main Findings: From 1992 to 2001, Fountain Hills, Apache Junction and Scottsdale experienced the most fragmentation change (Fig. 2); Fountain Hills, Chandler, and Glendale experienced the highest conversion of non-developed land (Fig 3).

2. Spatial Pattern of Fragmentation change

Figure 4(above). 3-class Land Cover in the study area, 2001

Figure 5(left). Land Cover Overlay with Fragmentation Metrics (using CONTAG as an example), 2001

Figure 6(below). Fragmentation Spatial Pattern, 1992 and 2001



Main Findings: 1) Fig. 4-5 verified that the most fragmented area is occurring along the fringe of "Developed" and "Cultivated" land; 2) Land cover near the urban core became more aggregated while in suburban areas it became more fragmented between 1992 and (Fig. 6).

3. Fragmentation at differing distances from Urban Center

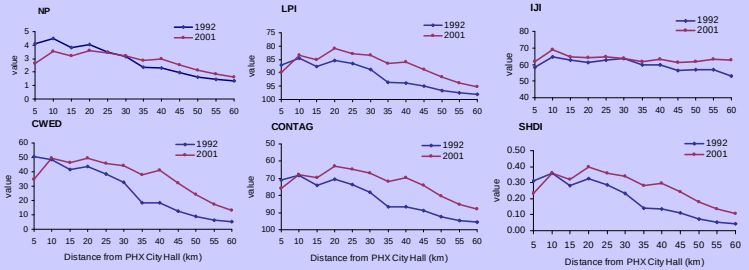


Figure 7. Fragmentation at differing distance from Urban Center (PHX City Hall), 1992 and 2001

Main Findings: 1) Areas with the highest fragmented rates are found 10km from the urban center in 1992 and 20km from the urban center in 2001; 2) Fragmentation grew fastest at 40km from urban center from 1992-2001 (Fig. 7).

CONCLUSIONS

Rapid urbanization has resulted in increased fragmentation in peri-urban areas, as expected. Fragmentation near the urban core decreased over the period of study. Different fragmentation results among the 12 jurisdictions may be linked to variations in land use regulations and consequent development patterns.

The moving window and gradient analyses offer a robust method for analyzing the spatial distribution of fragmentation over time. The main finding from this study is that the highest-level of fragmentation has spread out 10kmfrom the urban center during the past 9 years, and that suburban areas at 40km from the urban center are experiencing the fastest rates of fragmentation. The next step for the study will be to link this land use phenomenon to policies and social factors to explore the potential causes of landscape fragmentation.