Evaluating Landscape Metrics for Urban Policy Design

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Abstract

Land use policies—such as zoning laws, protected area designations, and environmental regulations—are key components to sustainable development and ecosystem management. The composition and configurations of land use affect the function of ecosystems including biologically active nitrogen, habitat loss, greenhouse gasses, and the carbon or hydrologic cycles (Lambin et al. 2001). Access to meaningful measurements of current and historic patterns of land use enables decision makers to make scientifically sound and sustainable land management policies for the future. Landscape metrics, however, can be easily misused or misinterpreted; their application in urban configuration research has led to varied, sometimes contradictory results, depending on methods or study area (Li and Wu 2004; Li et al. 2016; Zhou, Huang, and Cadenasso 2011; Zhou, Wang, and Cadenasso 2017). Using satellite imagery, I plan to calculate and evaluate seventeen commonly applied metrics for composition, diversity, size, shape, distribution, and connectivity. Specifically, I will evaluate their performance over time and the strength of their relationship to ecological outcomes. This study focuses on an approximately one mile buffer around the Rio Salado riverfront in Tempe, Arizona, USA. This area has seen considerable development since 1985, and there is future change on the horizon with Senator John McCain's proposed legacy project, Rio Salado 2.0. Evaluating historical change will improve understanding of the ecosystem impacts of past policies, thereby aiding in the design of future policies related to the Rio Salado 2.0.

Research Questions

1: Are the current typologies of composition sufficient for urban landscapes?

2: Are some composition and configuration metrics superior to others for different environmental outcomes and in what context?

3: Are there additional configuration metrics needed for measuring urban landscapes?

Landscape Metrics

Table 1. Landscape metrics, and their significance, by calculation method and landscape architecture (LSA) component. The components of LSA are: composition, diversity, size, shape, distribution and connectivity.

Component	Metric	Method	Description
Comp	Largest Patch Index	FRAGSTATS	Percentage of the landscape covered by the largest landscape element
Diversity	Shannon Diversity Index	FRAGSTATS	A measure of the diversity of land covers
	Landscape Coincidence Probability	Graph Theory	Probability that two random points on the landscape belong to the same class type
Size	Patch Area	FRAGSTATS	Area of a specific landscape element
	Patch Density	FRAGSTATS	Number of landscape elements per hectare
Shape	Normalized Moment of Inertia	Spatial Statistics	A measure the degree to which all elements on a natural planar shape are concentrated
	Landscape Shape Index	FRAGSTATS	Total length of edge divided by the shortest edge length for a landscape element
	Shape Index	FRAGSTATS	Average or median shape index of patches in the landscape. Can be weighted by patch area.
	Fractal Dimension	FRAGSTATS	A measure of departure from Euclidean geometry
	Edge Density	FRAGSTATS	Sum of all edge segments divided by total landscape area
Distribution	Local Moran's I	Spatial Statistics	A measure of the extent to which observations of similar and dissimilar values are clustered
	Getis statistic	Spatial Statistics	A measure of the extent to which observations are higher or lower than the surrounding area
	Interspersion and Juxtaposition Index	FRAGSTATS	A measure of the observed interspersion divided by the maximum possible for the number of landscape elements
Connectivity	Contagion	FRAGSTATS	A measure of the adjacency of landscape elements
	Euclidean Nearest-Neighbor Distance	FRAGSTATS	Distance to closest landscape element using Euclidian geometry
	Integral Index of Connectivity	Graph Theory	A measure of connectedness using land cover patch attributes and the distance between the patches
	Harary Index	Graph Theory	A measure of connectedness based on the number of links that make up the shortest path between every pair of patches

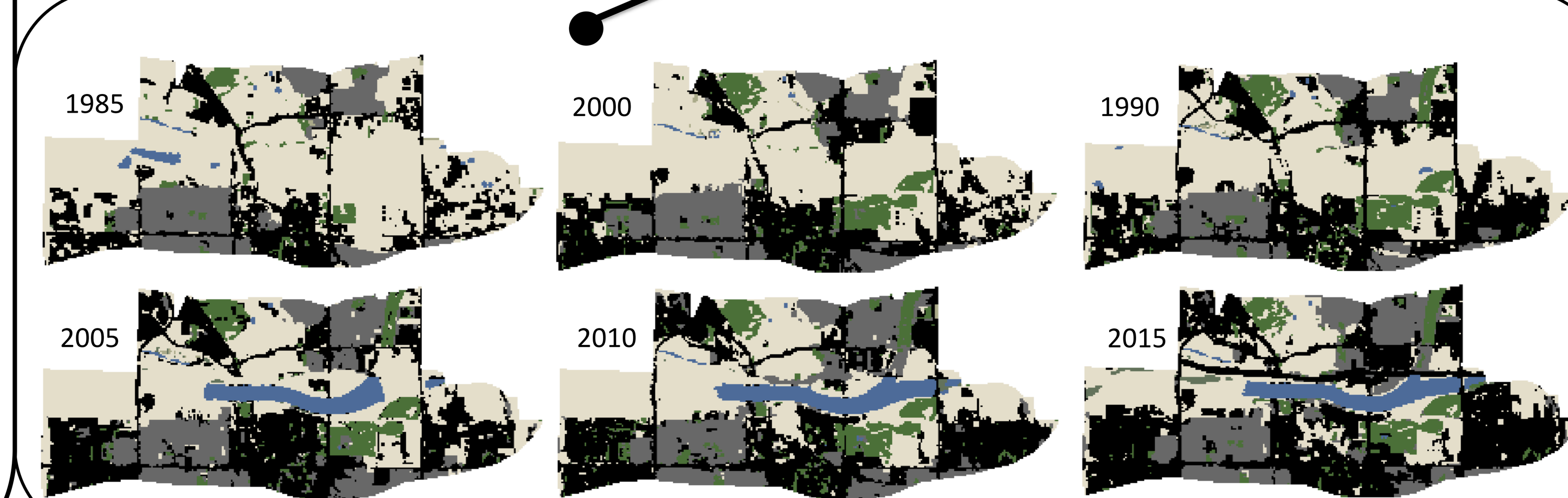
Study Area

Figure 1. The study area is one mile on either side of the Rio Salado within the bounds of the City of Tempe.

Central Arizona Project Long Term Ecological Research (CAP LTER) Data

- Tempe Town Lake Water Quality
- Rio Salado Tributary Water Quality
- Arthropod Trap Data
- Bird Census Data
- Land Cover Classifications

Land cover classifications will but used to calculate landscape metrics



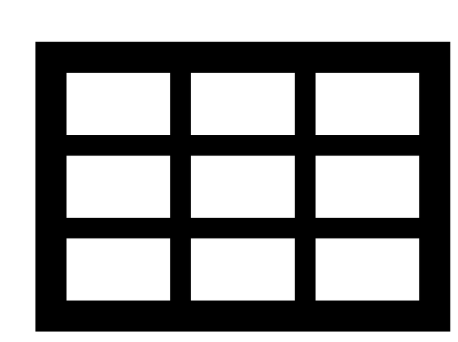
Statistical Analysis

Variables

Landscape Metrics on:

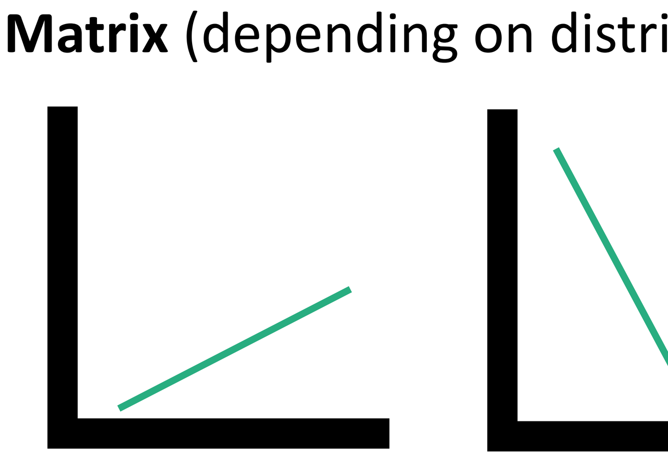
- Composition
- Diversity
- Size
- Shape
- Distribution
- Connectivity

Initially will evaluate the correlation coefficient between variable pairs using a correlation matrix.



Pearson or Spearman Rank Correlation Matrix (depending on distributions)

Regressions will be used to evaluate the power each landscape metric has to explain environmental variables



Multiple Linear Regressions

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