Socioeconomic and Land Use Determinants of Tree Canopy in Portland, Oregon

Jeff Ramsey
Department of Geography, Portland State University

Portland State UNIVERSITY

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Introduction

This study has two goals: 1) to create a tree canopy extent metric which represents the amount of human access to the benefits of nearby canopy and 2) to use regression techniques to determine the socioeconomic and land use drivers of tree canopy access in Portland, OR. Connecting this new metric of urban tree canopy to the factors that determine canopy extent will inform urban forestry managers in which areas to prioritize for tree planting efforts in the future.

Background

Many studies have found positive links between urban forests and a variety of human and environmental factors, including air quality (Escobedo and Nowak 2009), reduced stormwater volume (Xiao et al. 1998), urban heat island mitigation (Akbari, Pomerantz, and Taha 2001), energy savings (Akbari et al. 1997), increased property values (Tyrvbinen 1997; Mansfield et al. 2005; Donovan and Butry 2008), and human health outcomes (Donovan et al. 2011; Lovasi et al. 2008). In acknowledgement of these benefits, cities around the world have engaged in large-scale urban reforestation efforts aimed at achieving canopy extent goals, and much research has focused on calculating canopy extent in urban areas as a way to set baselines for goal setting.

Methods

In order to calculate canopy access values for census block groups (CBGs), this study uses a moving window approach, placing a grid of 100m² cells over the study area and calculating the canopy coverage within a ¼ mile buffer of each cell's centroid. While the various benefits of tree canopy operate at multiple scales, the ¼ mile buffer choice is based on the impact of canopy on housing prices in Portland, OR (Netusil, Chattopadhyay, and Kovacs 2010), and represents the extent of canopy benefits enjoyed by citizens in this study area.

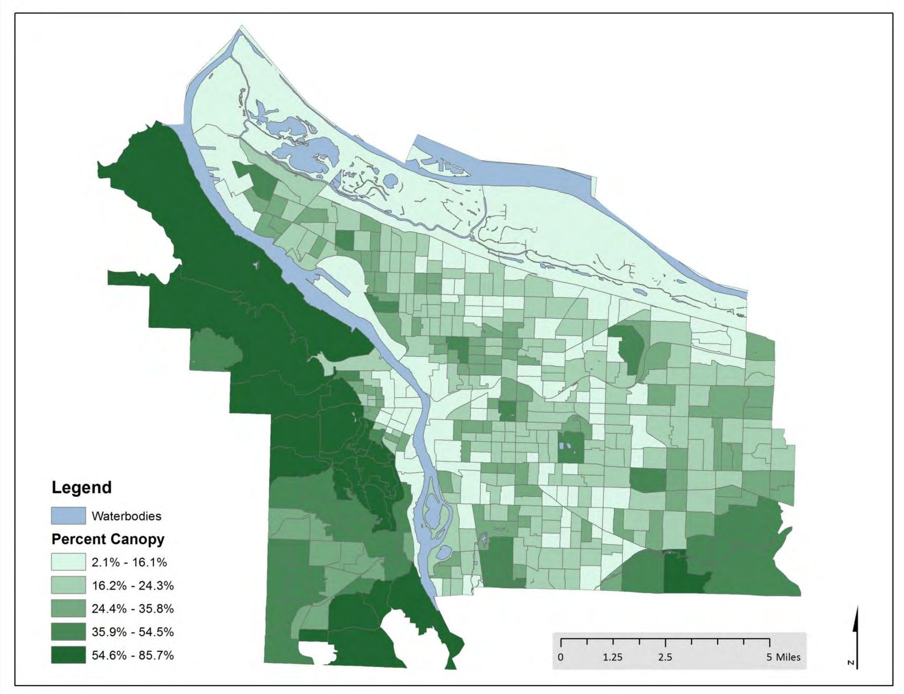
Using this new metric for canopy access, this study employs regression to determine which socioeconomic and land use factors determine access to the benefits of tree canopy in Portland, OR.

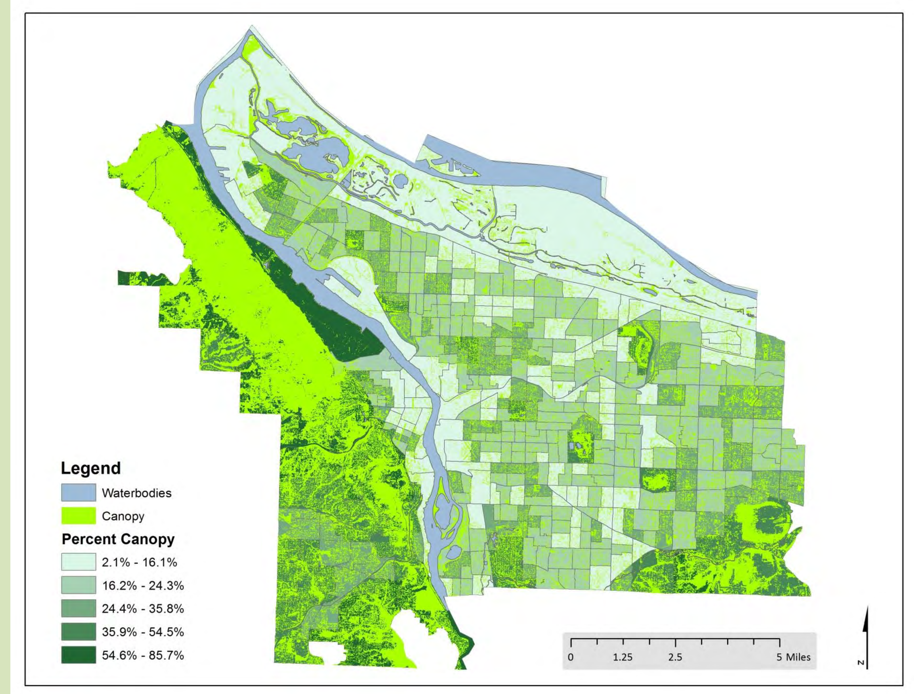
Data

Data	Year	Source
Canopy	2007	Metro
Race/ethnicity	2006-2010 average	US Census, ACS
Income	2006-2010 average	US Census, ACS
Home ownership	2006-2010 average	US Census, ACS
Impervious surfaces	2014	City of Portland, Metro
Zoning	2014	City of Portland

Calculating Tree Canopy: A Systematic Approach

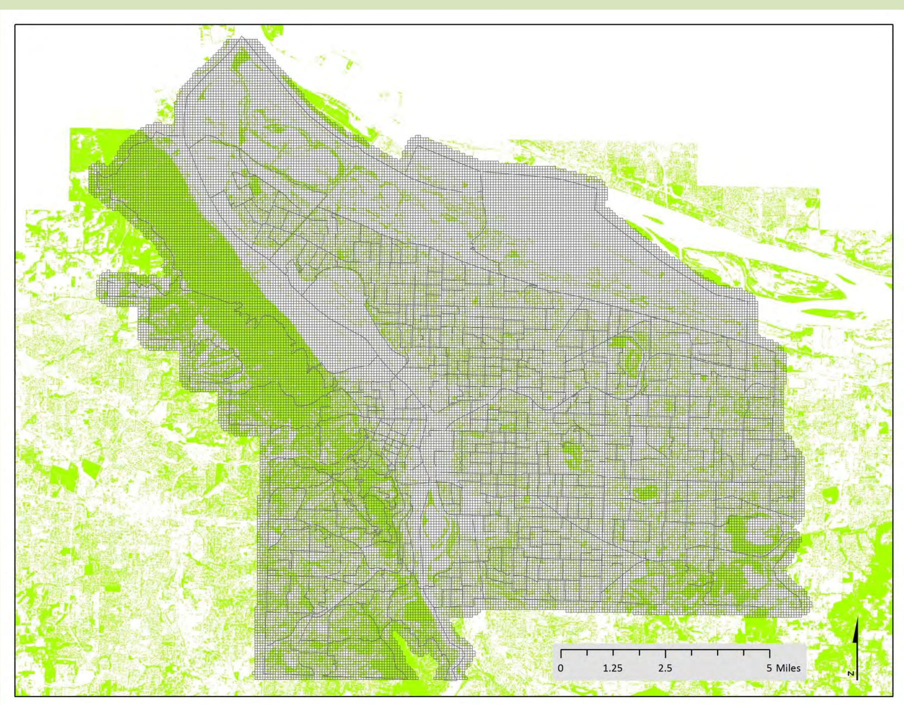
When calculating canopy extent in cities, most researchers choose to report data in smaller spatial units such as neighborhood (AMEC 2011), council district (Xiao et al. 2013), or watershed (AMEC 2010). In doing this, the well-known *modifiable areal unit problem*, or MAUP (Openshaw and Taylor 1979), becomes an issue, as the resulting canopy value for any location will be influenced by the arbitrary boundaries of its given zone. This study creates a new metric with which to measure tree canopy in urban areas, *canopy access*, which includes all canopy within a given distance of a spatial unit, thereby negating the impact of MAUP and creating a more realistic picture of how tree canopy is distributed and enjoyed within a city.

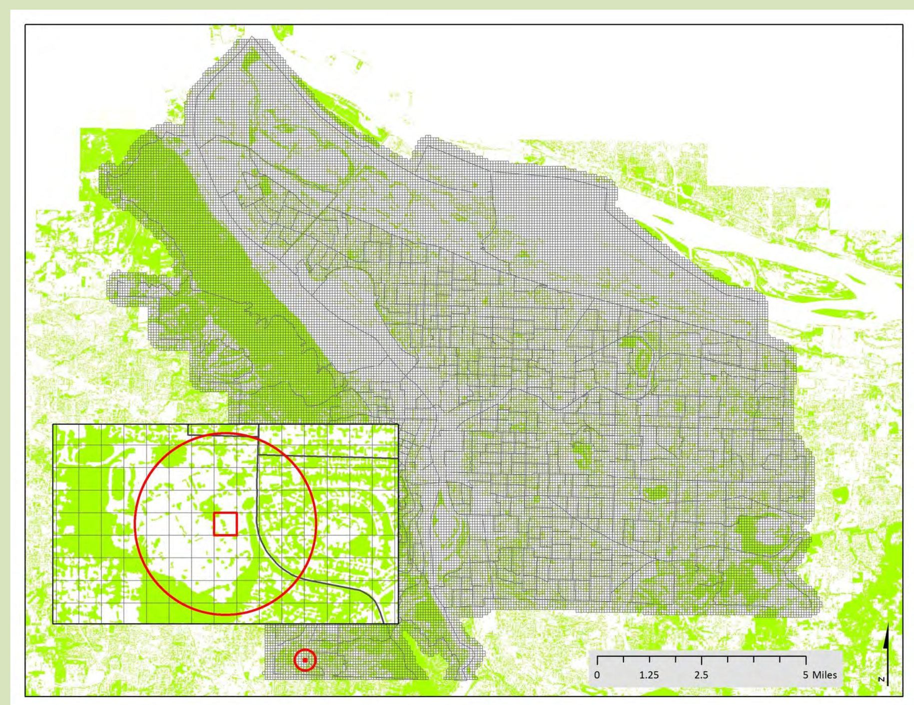




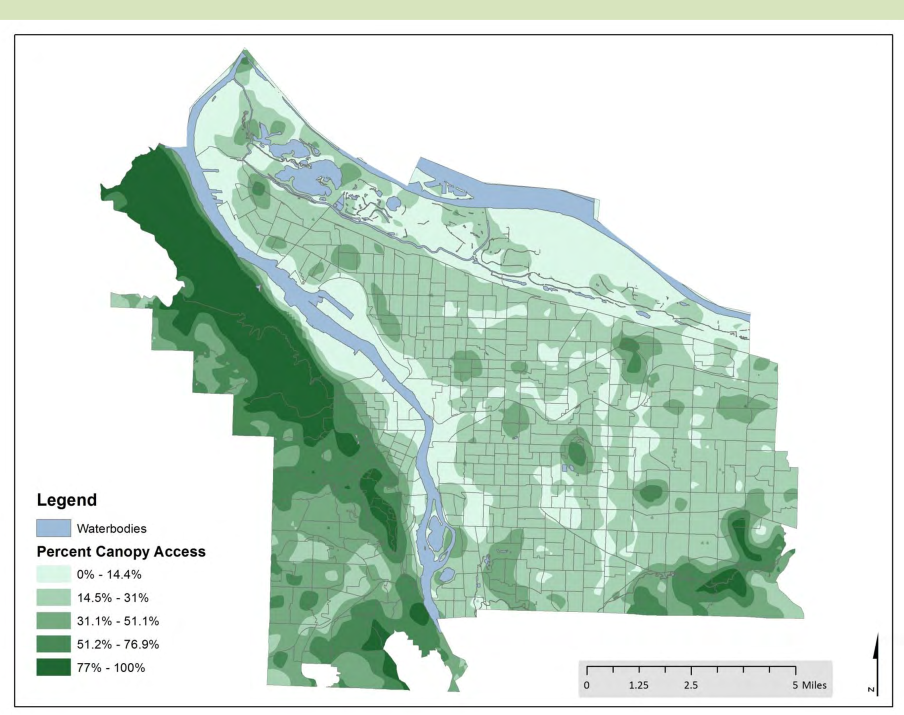
The traditional method of calculating tree canopy cover (TCC) is a simple sum of canopy cover within given zones. The maps to the left show 2007 TCC in Portland, OR, by census block group. Two problems are inherent in this method:

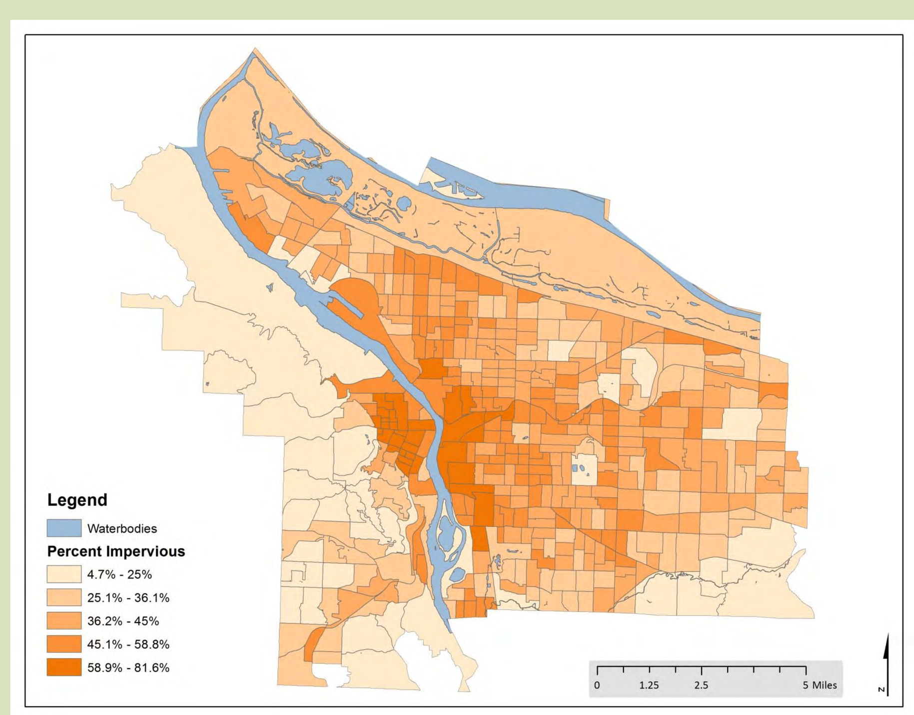
1) Information is always lost when aggregating canopy data to a larger spatial unit—the map on the right demonstrates that TCC distribution within block groups is not uniform.
2) The problem of MAUP especially effects areas on the edge of a zone. A resident of a "low-canopy" zone may actually live across the street from a dense forest assigned to another neighborhood. This method fails to capture the scale at which canopy benefits are enjoyed by urban populations.





The moving window approach used in this study creates a grid of 100m² cells over the study area and calculates all canopy within a ¼ mile (402m) buffer measured from the center of each cell. The map on the right shows how the value for each cell is calculated, without regard to the arbitrary boundaries of the block group (shown) or city. In the case of the cell outlined in red above, while only having a 20% TCC within its boundaries, its canopy access value exceeds 43%.





The results of moving window analysis yield a realistic map of canopy access in the city. The map on the right reflects the impervious surface area of Portland CBGs, one of the variables most strongly correlated with lower canopy access values. Note that there are areas of the city with relatively high canopy access and impervious surface values—these areas may provide a guide for planners in maintaining canopy as Portland continues grow in population.

Regression Analysis

Explanatory variables for this study were chosen based on findings from researchers in cities across the United States, and include both socioeconomic as well as land use and land cover characteristics.

Spatial autocorrelation can present problems when analyzing correlations among spatial datasets (Talen and Anselin 1998), therefore this study compares the results of an ordinary least squares (OLS) regression with those of spatial error regression (SAR_{err}), which accounts for spatial dependence through the use of a spatial error term in calculations.

In order to test whether canopy access dynamics in residential areas are different than elsewhere in the city, an additional step of regression analysis was confined to CBGs >50% residentially zoned.

Results and Discussion

Spatial error regression results in a more robust canopy model with stronger R² and AIC values. Citywide, zoning, especially industrial zoning, has a strong impact on CBG canopy access. In residential CBGs as well as citywide, results are strongly significant for both impervious surface area and median family income.

These results point to familiar themes in environmental equity literature, with wealthier communities receiving significantly more benefits from environmental amenities such as tree canopy.

This study can inform urban forest planning and management in Portland, as the negative correlations with impervious surface area and industrial zoning point to opportunities to extend reforestation efforts to areas of the city where these characteristics are most prevalent.

While the population of the Portland area is expected to grow in coming decades, this study finds that development need not negatively impact urban tree canopy, as population density is not found to negatively impact canopy access. Continued efforts to support low-impact development and consideration of urban forest impacts of new development are recommended for the future.

	Citywide block groups						*Residential block groups*					
	OLS			SAR_{err}			OLS			SAR_{err}		
% Commercial	.001	1.13	.261	-.001	-1.45	.147	.002	3.05	**.002****	.001	.496	.620
% Industrial	-.001	-1.20	.229	-.001	-2.79	**.005****	.001	.983	.326	-.001	-.835	.404
% Open Space	.002	3.14	**.002****	.001	3.96	**.001****	.001	1.47	.143	-.001	-.673	.501
% Impervious	-.005	-7.25	**.000****	-.001	-1.70	**.089***	-.001	-10.15	**.000****	-.004	-6.38	**.000****
% African American (non-Hispanic)	-.050	-.913	.362	.030	.735	.462	-.030	-.561	.575	.010	.264	.792
% Hispanic	.014	.260	.795	.030	.865	.387	-.077	-1.39	.164	.004	.113	.910
% Owner Occupied	-.134	-4.54	**.001****	.020	1.03	.304	-.185	-6.30	**.000****	-.037	-1.96	**.048****
Median Family Income (2010 adjusted dollars)	1.86	10.23	**.000****	.001	2.21	**.027****	.001	10.61	**.000****	.001	2.99	**.003****
Population Density 2010 (persons/acre)	.002	3.26	**.001****	.001	.037	.970	.003	3.99	**.001****	-.001	-.722	.470
(Adjusted) R^2 Akaike information criterion	(.435) -794.98			.812 -1160.22			(.474) -778.58			.834 -1106.31		

*$p < 0.10$, **$p < 0.05$

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