Using community gathered data to detect differences in bird community composition across the urban gradient in the Seattle area

UNIVERSITY of WASHINGTON

Karen Dyson
Urban Design and Planning, University of Washington
Urban Ecology Research Laboratory

1. Introduction

Urban ecologists frequently employ landscape gradients to describe patterns of species distribution. Early analyses focused on traditional "urban-to-rural" gradients that emphasized the distance from the city center of a given plot (e.g. Blair, 1999). More recent analyses have added socio-economic variables to the traditional gradient analysis (e.g. Kinzig et al., 2005, Loss et al., 2009; Melles, 2005). These authors have successfully argued that residents' interaction with their environment, and in particular yard care, is tied to economic and cultural differences (Kinzig et al., 2005)

The majority of gradient analysis studies have examined land zoned for residential use. However, residential areas represent a fraction of cities. Non-residential land has the potential to conserve biodiversity and may also represent significant opportunities for interaction with nature (e.g. at the workplace).

This research used community collected data from eBird to look at patterns of species distribution in the Seattle, WA area across zoning types. To our knowledge, community collected data has not been used for urban gradient analysis, and may represent a viable alternative to researcher collected data.

2. Methods

Data: Bird survey data came from eBird, operated by the Cornell Lab of Ornithology and the National Audubon Society, zoning data from the City of Seattle, and demographic / socio-economic data from the US Census American Community Survey. The dataset was assembled in ArcGIS and analyzed in R.

The most common 32 species were used for analysis, as they were deemed the most likely to be correctly identified by hobbyist birders. As a result, the analysis focused on the richness and distribution of common species across Seattle.

Linear modeling: Previous researchers used linear modeling to explore urban gradients. Forward and backwards stepwise selection based on AIC and a priori models based on the literature were tested. The linear models used species richness (total species observed at a site) following Kinzig et al. (2005).

PERMANOVA: Three different standardizations of eBird data were used for PERMANOVA (Anderson, 2001). Raw count data were used to explore absolute changes in community structure. The Wisconsin standardization was used to examine shifts in species composition (McCune and Grace, 2002). Data converted to presence/absence measures were used to examine shifts in species presence. In addition, non-native, native, and water birds were separated and analyzed separately. Bray-Curtis distances were used for all analyses.

Hypotheses

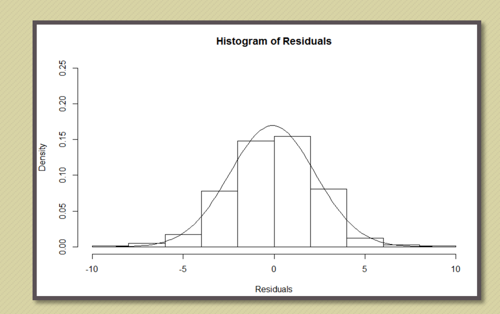
- Zoning is an important predictor of bird distribution after accounting for other gradient measures.
- Using eBird provides similar results to researcher collected data.

3. Results

Zoning was significant in both linear models (stepwise and a priori) and in all PERMANOVA tests. Districts zoned residential were sampled by citizen contributors to eBird much more frequently than other zoning types. The L3 (multifamily low rise), SF 5000 (single family 5000sf minimum lot), and SF 9600 had the largest estimated species richness while IG1 (general industrial), DH1 (downtown harborfront), and DMC (downtown mixed commercial) had the lowest estimated species richness.

Forward and backwards stepwise selection based on AIC resulted in the selection of the same model. The residuals from the stepwise selection model are normally distributed, reflecting positively on the model fit.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Zoning	8	2266.26	283.28	48.863	< 2.2e-16	***
Effort	1	651.63	651.63	112.3988	< 2.2e-16	***
Per Capita Income	1	212.05	212.05	36.5755	2.97E-09	***
Season	3	188.59	62.86	10.8431	6.66E-07	***
Median Year Built	1	87.5	87.5	15.0928	0.000117	***
Year	1	54.84	54.84	9.4584	0.002222	**
Latitude	1	19.27	19.27	3.3234	0.068925	.
Shoreline	1	26.66	26.66	4.5987	0.032499	*
Residuals	478	2771.2	5.8			
TOTAL	495	6278				



Both socio-economic and zoning variables were significant when comparing the a priori models. (1. Data collection: *Lat., Long., Yr., Season, Time, Effort*; 2. Traditional Grad.: *Park Dist., Yr. Built, Home Dens., Shoreline*; 3. Socio-economic: *PCI*; 4. Zoning)

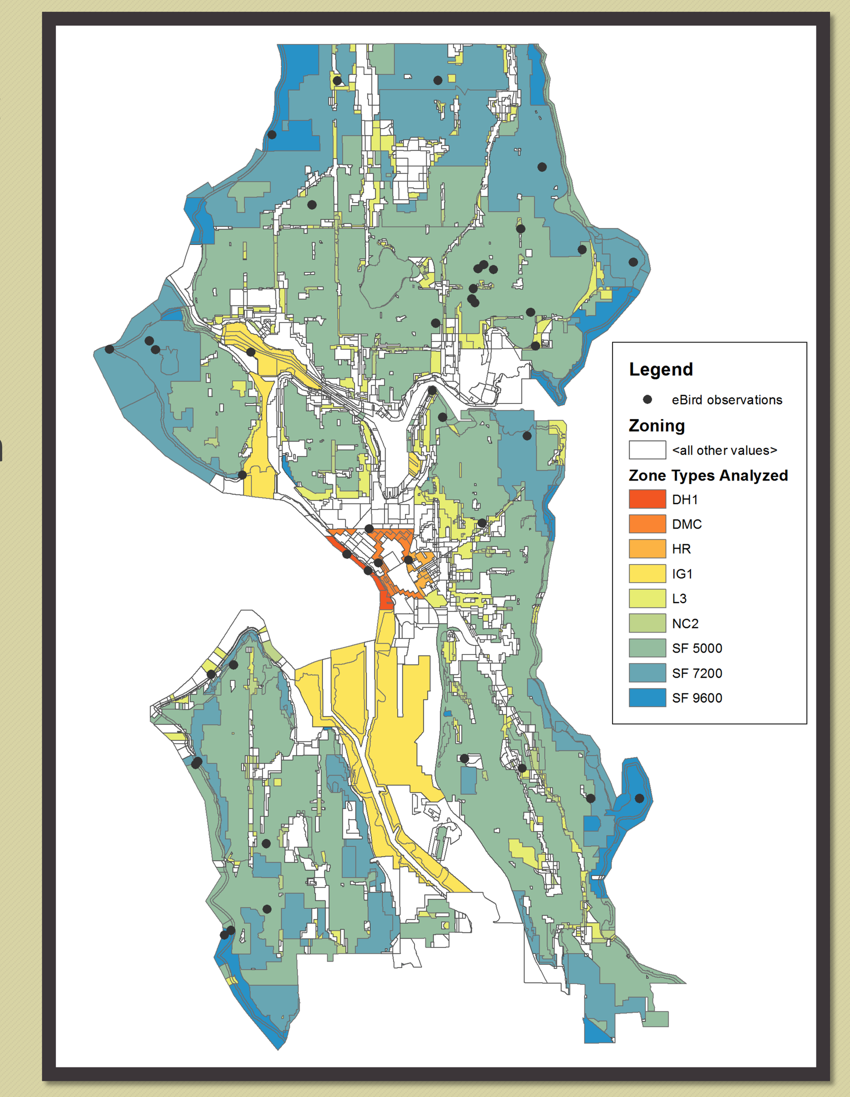
	AICc	Residual MS	F test w/ prev. model
Data Collection	2606.42	10.96	---
Traditional Gradient	2395.17	7.1	3.29E-45
Socio-Economic	2388.22	6.98	0.002997
Zoning	2305.47	5.8	2.20E-16

Zoning was also significant in all PERMANOVA runs. Similar patterns emerged between the different standardizations. Shoreline and time of day were consistently not significant. However, differences between linear modeling and PERMANOVA were apparent.

	Lat.	Long.	Year	Seasn	Time	Effort	Park Dist.	Yr Built	Home Dens.	Shore-line	PCI	Zoning
Wisconsin												
All Species	X	X	X	X		X	X	X	X	X	X	X
Native	X	X	X	X		X	X	X	X		X	X
Non-Native	X	X	X	X		X	X	X	X		X	X
Water Birds		X	X	X			X	X	X		X	X
Pres./ Abs.												
All Species	X	X	X	X		X	X	X	X	X	X	X
Native	X	X	X	X		X	X	X	X	X	X	X
Non-Native	X	X	X	X		X	X		X		X	X
Water Birds		X	X	X			X	X	X		X	X
Abundance												
All Species	X	X	X	X	X	X	X	X	X	X	X	X
Native	X	X	X	X		X	X	X	X	X	X	X
Non-Native	X	X	X	X	X	X	X	X			X	X
Water Birds		X	X	X			X	X	X		X	X

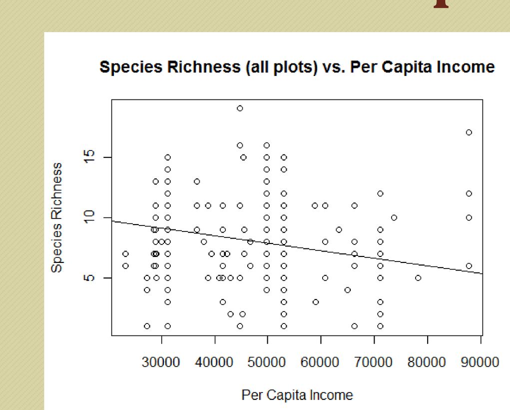
4. Discussion

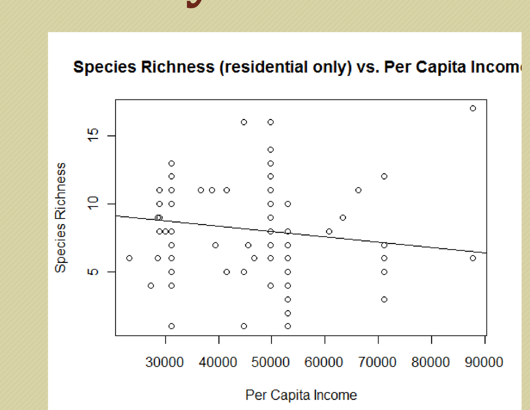
Biodiversity in cities enhances human wellbeing and shapes residents' perceptions of the natural environment and the importance of conservation (Fuller et al., 2007; Goddard et al., 2009). Zoning's significance in both linear and PERMANOVA models suggests that urban planners and urban ecologists need to examine the disparity of species richness between zones and try to learn from zones with higher species richness. The zones with lower richness tend to be work environments where residents spend significant amounts of time, and are thus important for human health. Future research should look for differences between zoning types, as well as for ties to public / zoning policy.

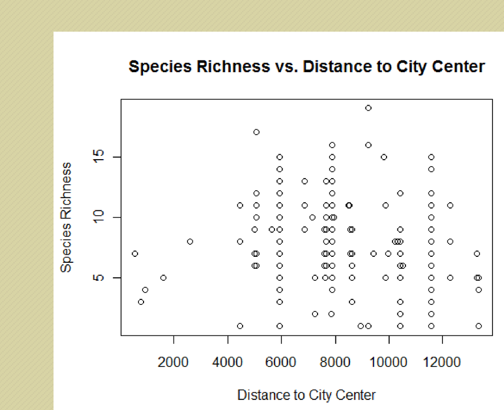


The results of both linear modeling and PERMANOVA suggest that eBird data behaves similarly to data collected by urban ecologists. However, eBird data requires careful consideration before use, and the present implementation is not perfect. The largest concern is uneven sampling between different sites, specifically the repeated sampling of the same point in residential areas and few replicate data points in non-residential zoning types. Points of repeated sampling impact the statistical validity and results of both linear modeling and PERMANOVA analyses. Future research should try to address this issue in order to increase the statistical validity of using eBird data.

5. Some further preliminary results...







Species richness is negatively correlated with per capita income, opposite of most current literature. Evidence of intermediate disturbance hypoth. is seen.

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