



A multi-scale study of the relationship among land composition, land fragmentation, and bird biodiversity in the Phoenix area

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1. INTRODUCTION

This study explores the effects of land composition and land fragmentation on bird biodiversity in the Phoenix metropolitan area, a rapidly growing urban region in the central Arizona.

2. METHOD

Land cover is grouped into five classes based on the 2001 National Land Cover Dataset: 1Open space, 2Low-Intensity, 3Mid-Intensity, 4High-Intensity, 5Desert and 6Water. "Developed area" is the sum of class 1-4. A suite of fragmentation indices are calculated, including Contrast Weighed Edge Density (CWED), which focuses on the edges between "Developed area" and "Desert". Biodiversity indices include abundance, richness, and evenness.

We identify monitoring sites as Urban, Desert and Agriculture, and group birds into urban exploiters, urban adaptors, and urban avoiders (Blair, 1996).

We test the relationships among land composition, fragmentation, and bird biodiversity at five scales of buffering area (90m to 2470m) side-length square areas (Hostetler and Knowles-Yanez, 2003.)

4. ANALYSIS AND RESULTS

Land composition and land fragmentation

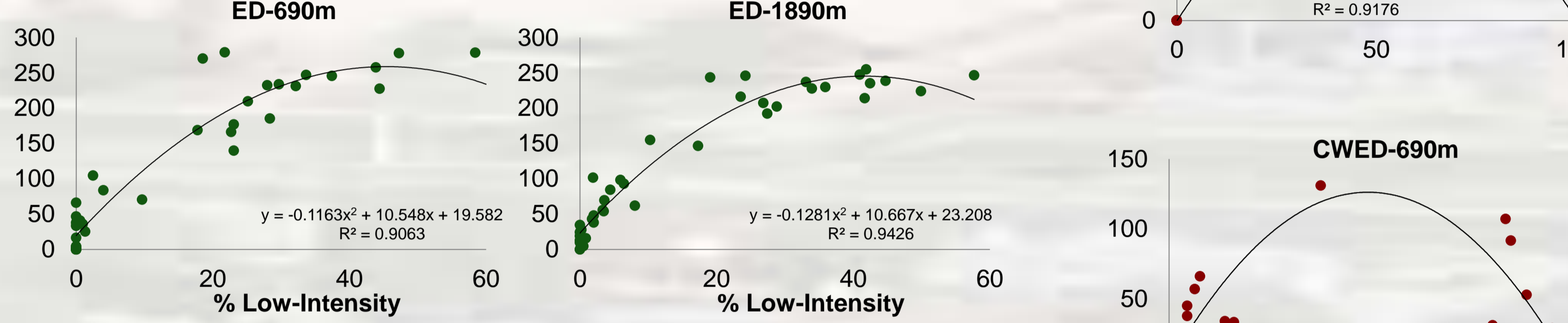


Figure 3 % Low-Intensity and edge density (ED) at five scales

Bird distribution in three types of sites



Figure 5 Number of bird species in each type of sites

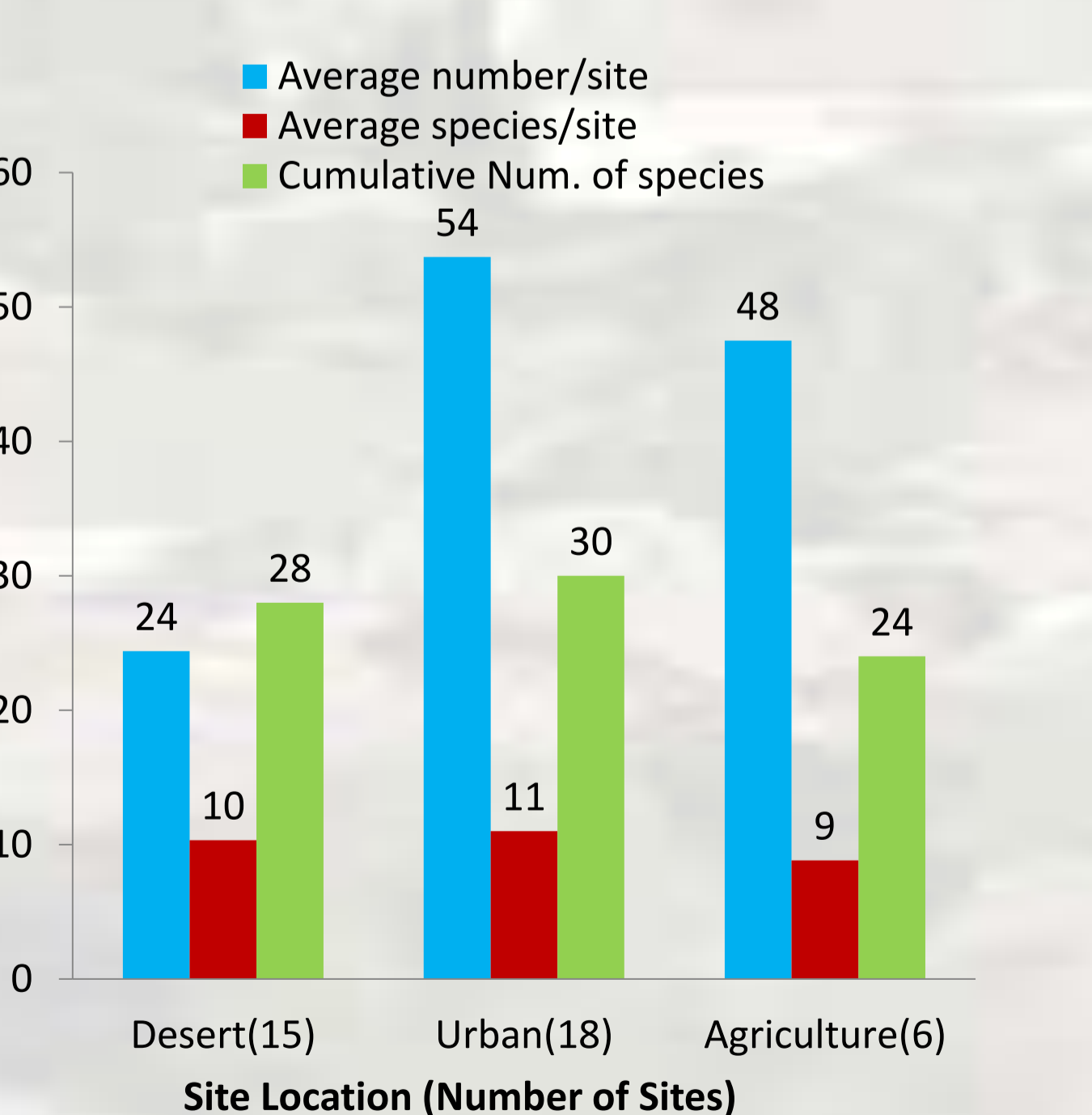
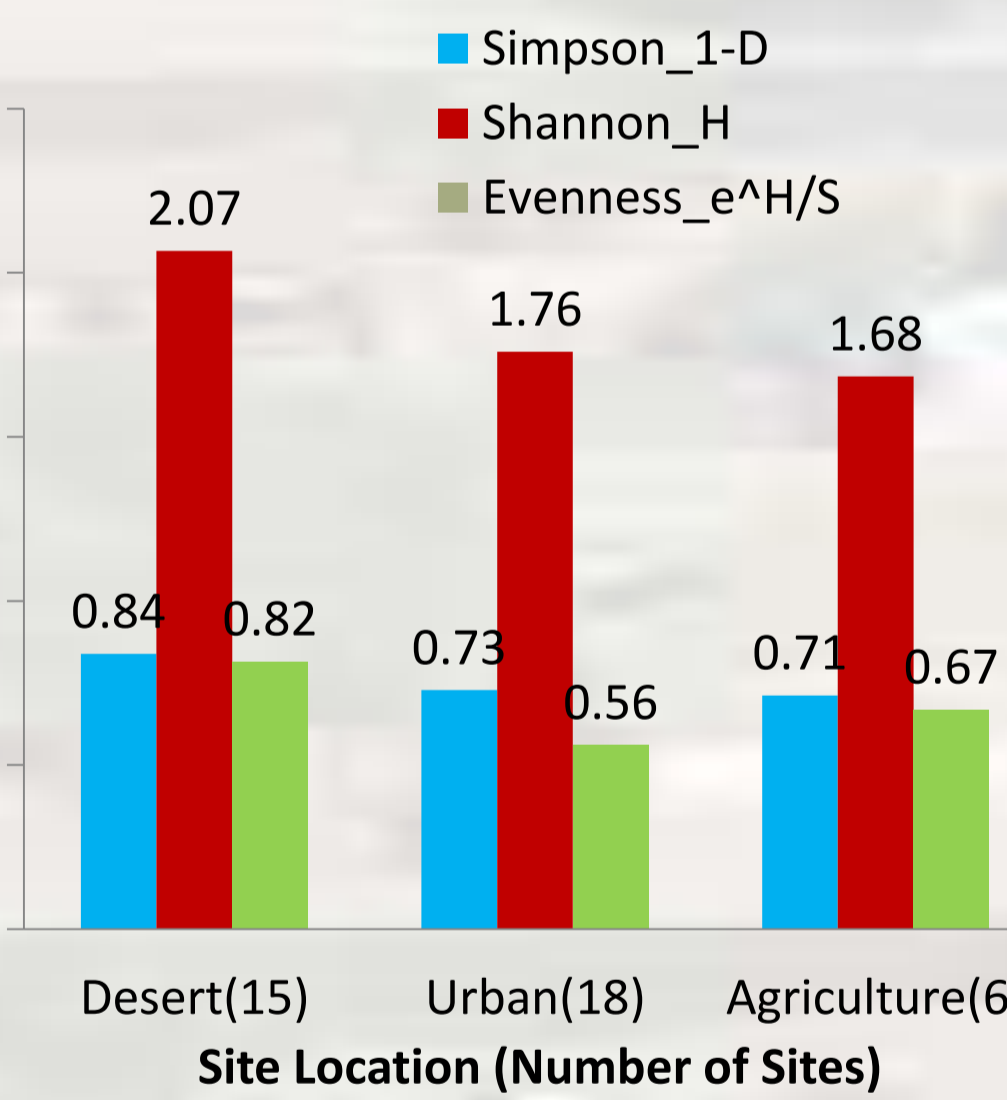


Figure 6 Site location and bird biodiversity

Land composition, fragmentation and bird diversity

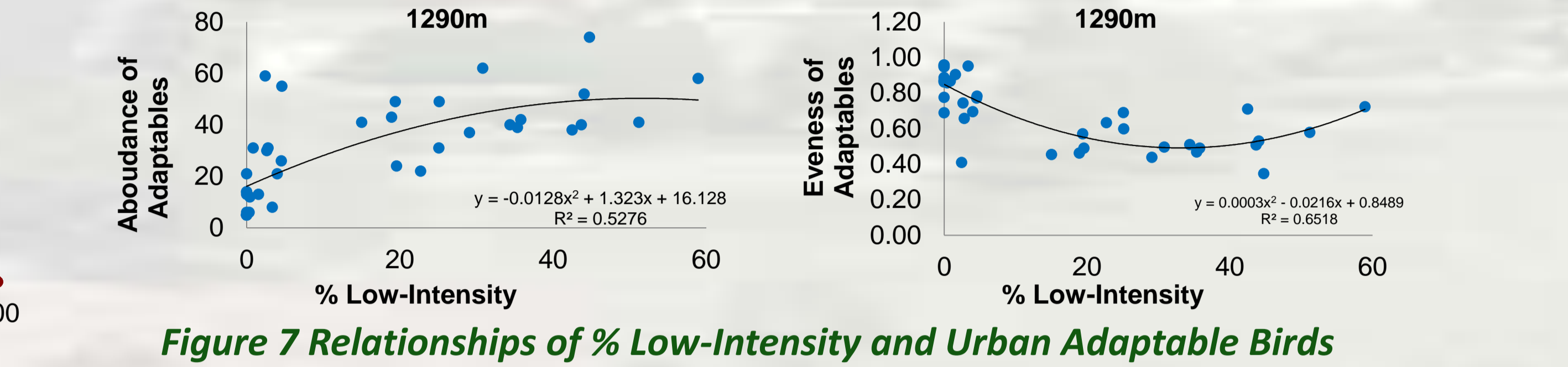


Figure 7 Relationships of % Low-Intensity and Urban Adaptable Birds

1890m scale		%OPEN	%LOWDENSI	%MIDDENSI	%HIGDENSI	%DESERT	%CULTIVAT	%WETLAND
ExploiterNUM	Pearson Correlation	0.300	0.579	0.638	0.317	-0.646	-0.073	-0.076
	Sig. (2-tailed)	0.064	0.000	0.000	0.049	0.000	0.659	0.644
ExploiterSPE	Pearson Correlation	0.337	0.646	0.744	0.516	-0.771	-0.068	-0.030
	Sig. (2-tailed)	0.036	0.000	0.000	0.001	0.000	0.679	0.858
AvoiderNUM	Pearson Correlation	-0.235	-0.503	-0.482	-0.275	0.592	-0.035	-0.215
	Sig. (2-tailed)	0.150	0.001	0.002	0.090	0.000	0.833	0.188
AvoiderSPE	Pearson Correlation	-0.242	-0.535	-0.533	-0.321	0.829	-0.315	-0.230
	Sig. (2-tailed)	0.138	0.000	0.000	0.047	0.000	0.051	0.159
AdaptNUM	Pearson Correlation	0.280	0.715	0.515	0.143	-0.788	0.187	0.108
	Sig. (2-tailed)	0.084	0.000	0.001	0.384	0.000	0.256	0.511
AdaptSPE	Pearson Correlation	0.223	0.469	0.238	-0.001	-0.402	0.040	-0.015
	Sig. (2-tailed)	0.173	0.003	0.145	0.995	0.011	0.809	0.929

Table 2 Correlation between land composition and bird abundance and species richness

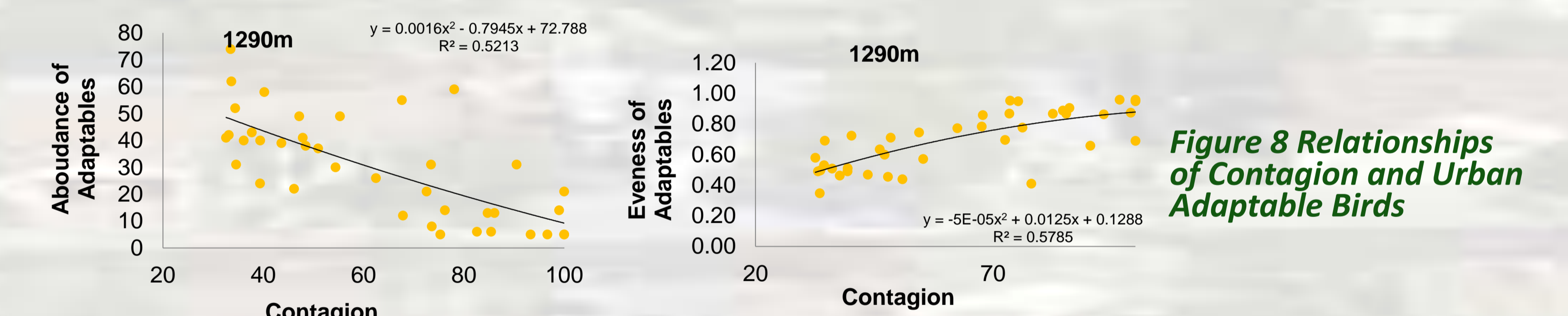


Figure 8 Relationships of Contagion and Urban Adaptable Birds

1890m scale		Patch Density	Largest Patch	Edge Density	Land Shape	CWED	CONTAG	COHESION
ExploiterNUM	Pearson Correlation	0.686	-0.512	0.674	0.674	-0.045	-0.647	-0.404
	Sig. (2-tailed)	0.000	0.001	0.000	0.000	0.785	0.000	0.011
ExploiterSPE	Pearson Correlation	0.781	-0.629	0.787	0.787	-0.072	-0.743	-0.560
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.663	0.000	0.000
AvoiderNUM	Pearson Correlation	-0.501	0.504	-0.520	-0.520	0.100	0.513	0.401
	Sig. (2-tailed)	0.001	0.001	0.001	0.001	0.545	0.001	0.011
AvoiderSPE	Pearson Correlation	-0.616	0.614	-0.637	-0.637	-0.008	0.649	0.509
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.962	0.000	0.001
AdaptNUM	Pearson Correlation	0.727	-0.685	0.735	0.735	0.191	-0.743	-0.595
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.245	0.000	0.000
AdaptSPE	Pearson Correlation	0.476	-0.492	0.482	0.482	0.347	-0.541	-0.415
	Sig. (2-tailed)	0.002	0.001	0.002	0.002	0.031	0.000	0.009

Table 3 Correlation between land fragmentation and bird abundance and species richness

3. DATA FILTERING

Survey sites: Due to the extraordinary effect of riparian on birds (Table 1), 12 riparian sites are excluded from the study. Total there are 39 sites, inc. 18 Urban, 15 Desert, and 6 Agricultural sites. Site identification is based on CAP LTER land use code, NLCD2001 data, and visually view from Google Earth (Fig. 1).

Bird data: We use the maximum bird count among three surveys in the Spring 2001 (excluding the birds that flew through, observed > 40m, or monitored only in one site). Totally 39 species are grouped in three categories (Fig. 2).

Site Type (num of sites)	Average num/site	Average species/site	Cumulative num of species
Desert Non-ripar(15)	25	11	34
Urban Non-ripar(18)	54	11	37
Agri Non-ripar(6)	58	10	29
Desert Ripar(6)	53	20	58
Urban Ripar (5)	62	15	36
Agri Ripar(1)	126	15	15

Table 1 Comparison between Riparian and Non-riparian sites

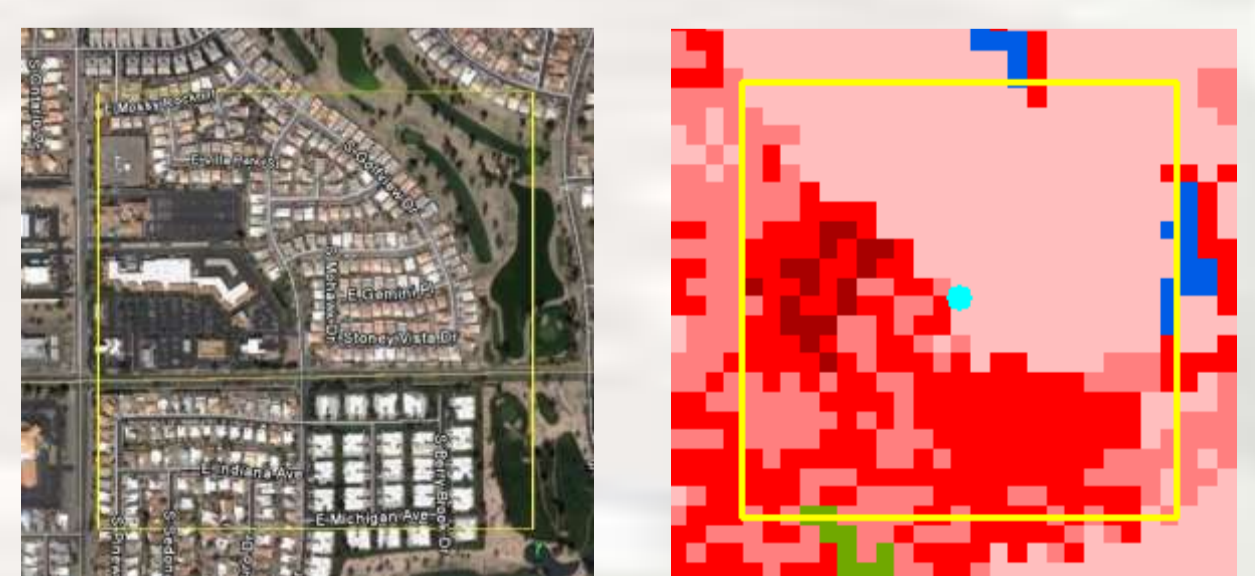


Figure 1 Urban site Z-23. Example of site identification of bird survey sites to three types

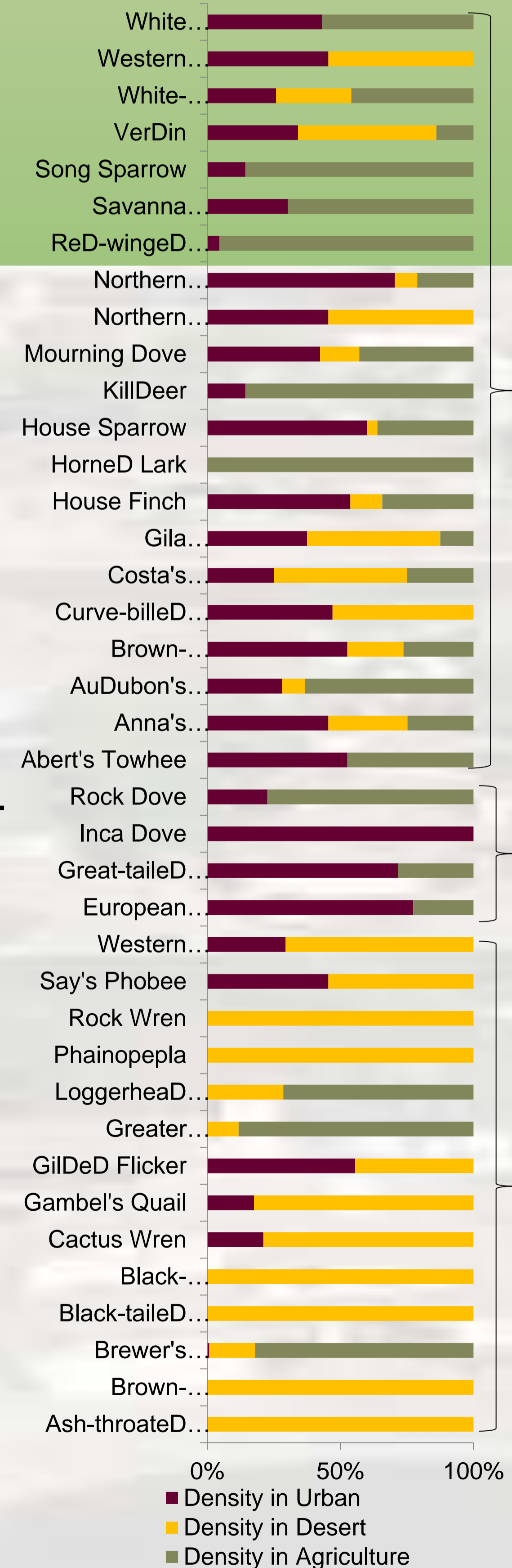


Figure 2 Three group of birds identified based on distribution of relative bird density

5. MAIN FINDINGS

- Low-Intensity has an essential role in land fragmentation (Fig. 3).
- Fragmentation and urbanization present non-linear relationship. With the increase of % developed area, fragmentation firstly rises and then falls (Fig.4).
- Overall bird diversity (e.g. Simpson, Shannon index, and evenness indices) is the highest in desert, but the number of species and abundance are highest in urban. Agriculture has the lowest species and diversity (Fig. 6).
- "Urban Adaptable" birds are the largest group of birds (Fig. 2). While their abundance is positively correlated with %low-Intensity area and land fragmentation level (e.g. Contagion index), the diversity (e.g. Evenness index) is negatively correlated with %low-Intensity area and land fragmentation (Fig. 7 & 8).
- The abundance and species richness of "Urban Avoiders" are negatively correlated with all four types of developed area and land fragmentation level (Table 2 & 3).
- Scale has effect when linking land composition, fragmentation and birds.

Reference
Blair, R. B. (1996). Land use and avian species diversity along an urban gradient. *Ecological Applications*, 6(2), pp. 506-519.
Hostetler, M., & Knowles-Yanez, K. (2003). Land use, scale, and bird distributions in the phoenix metropolitan area. *Landscape and Urban Planning*, 62(2), 55-68.

