Exploring Driving Forces of Avian Diversity in a Subtropical Asian City

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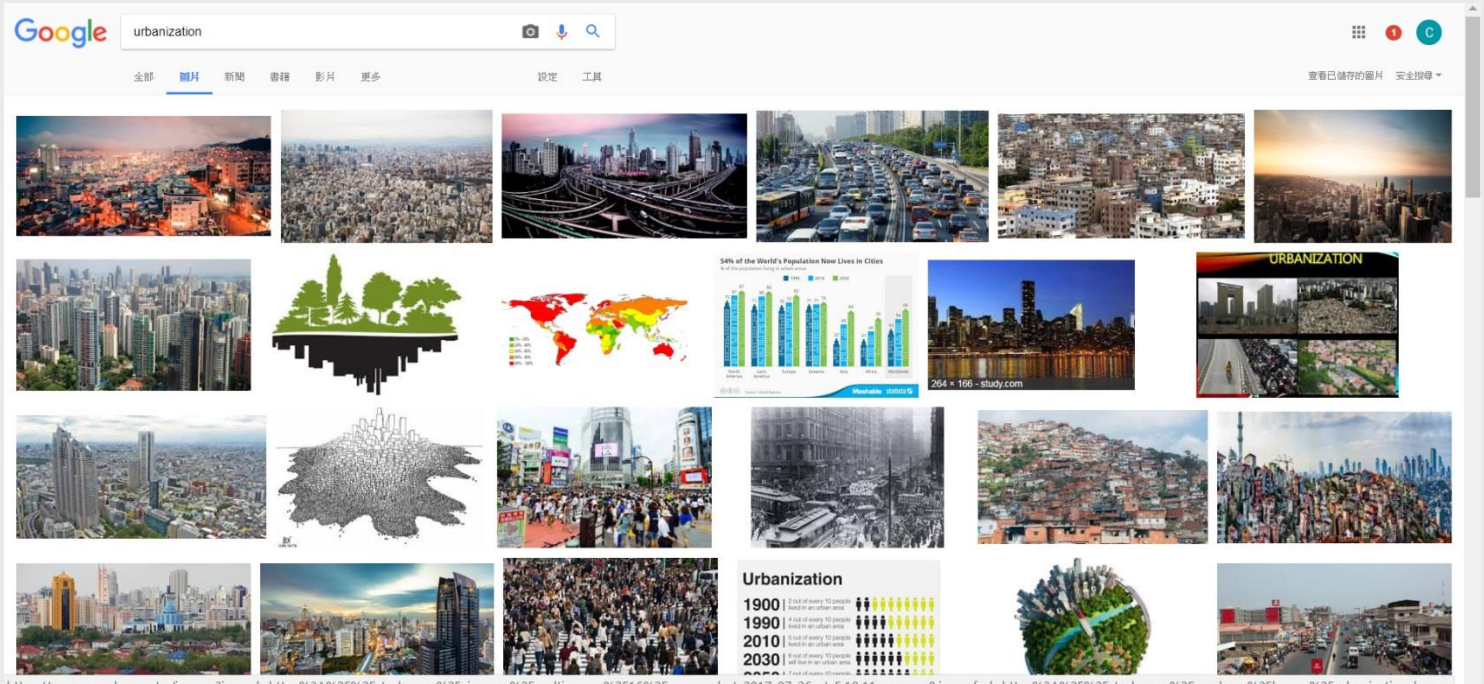
Outlines

- Introduction
- Methods & materials
- Results
- Discussion

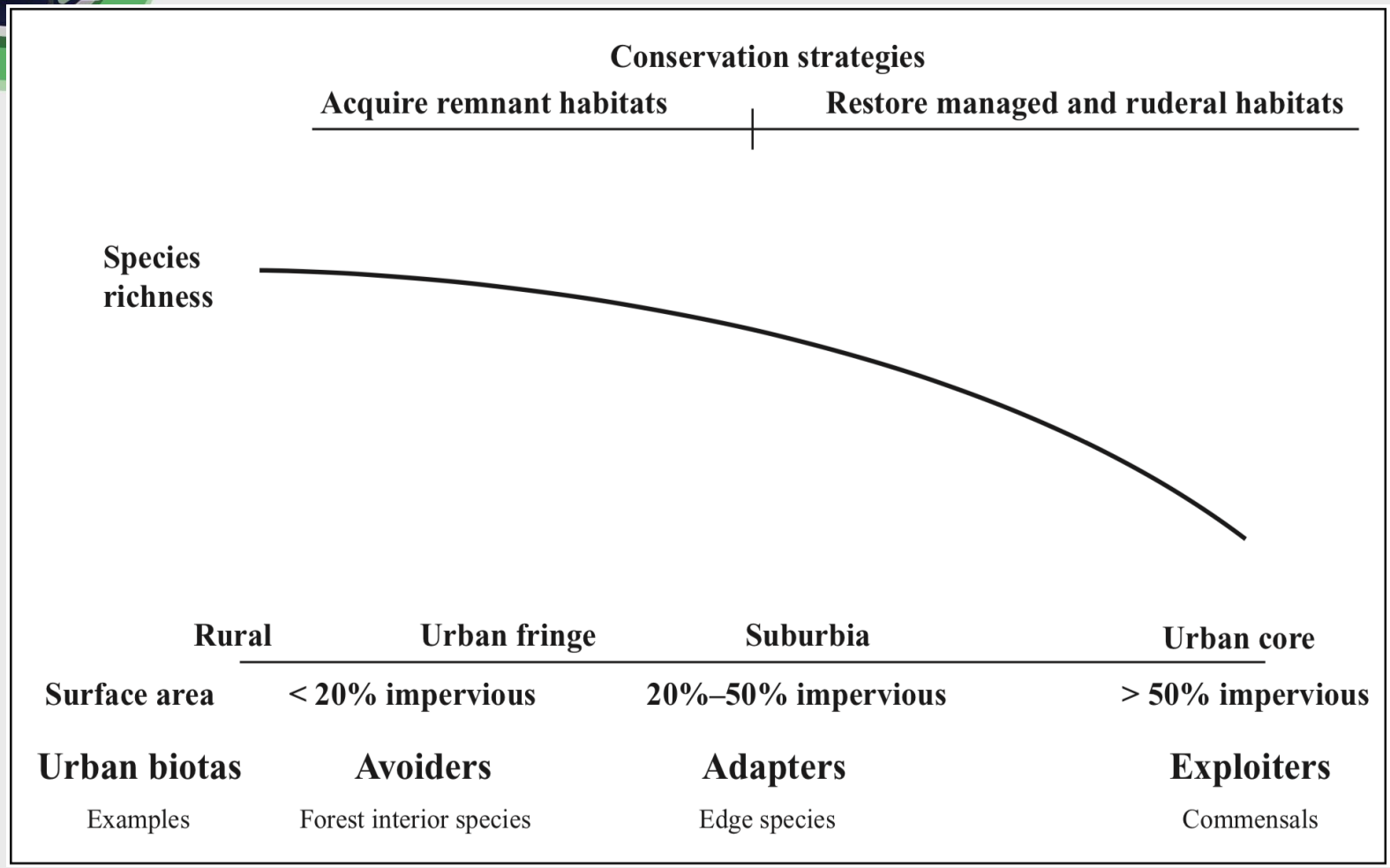
Introduction

An Era of Global Urban Expansion

- By 2030 the global urban population is estimated to be 70 % or 6.3 billion, nearly doubling the urban dwellers worldwide in 2010 (Seto et al., 2013).
- Urban areas are expanding on average twice as fast than their populations (Angel et al., 2011; Seto et al., 2011).



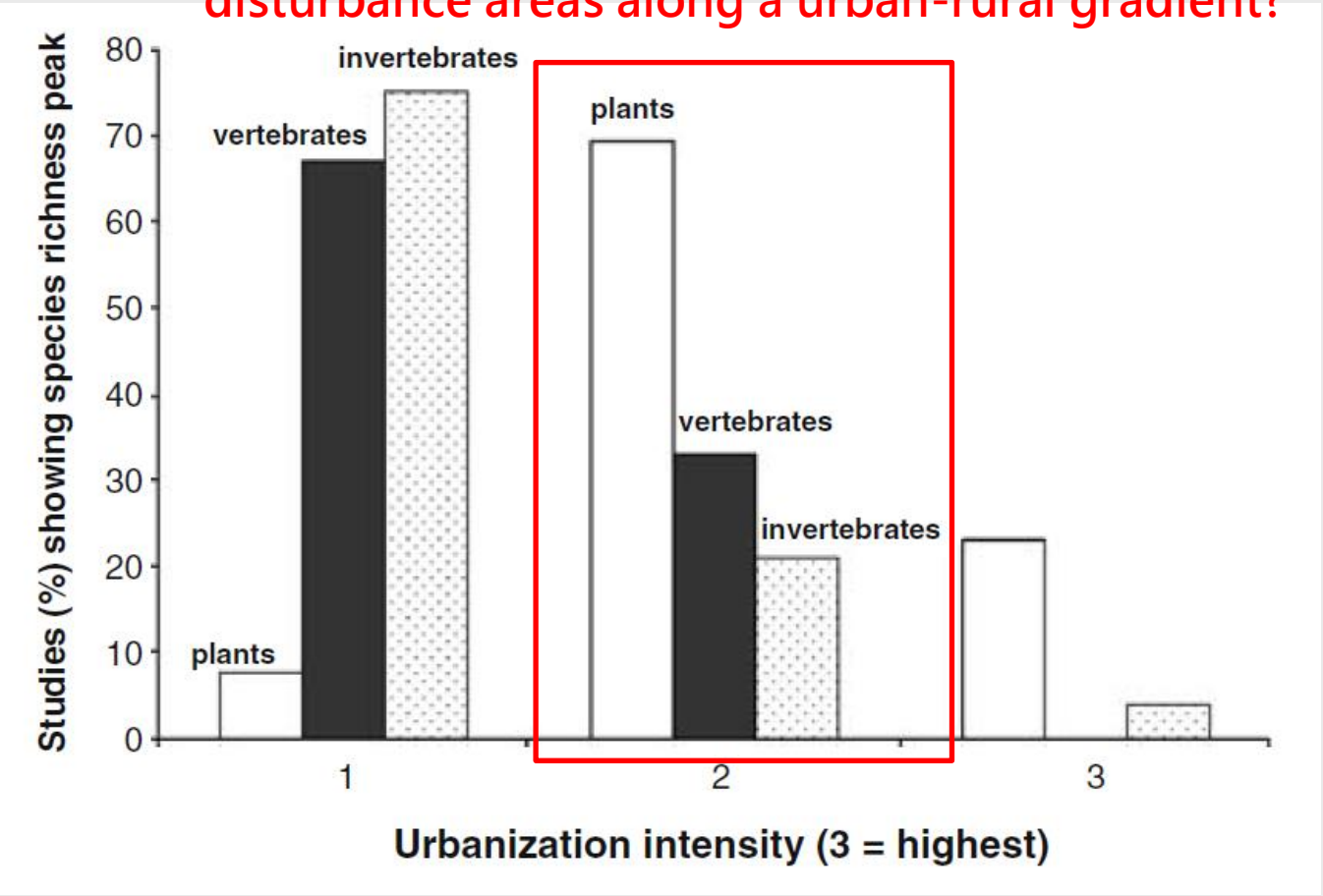
Urban-Rural Gradient



(McKinney, 2002)

Urban-Rural Gradient

Why high biodiversity exists in some intermediate disturbance areas along a urban-rural gradient?

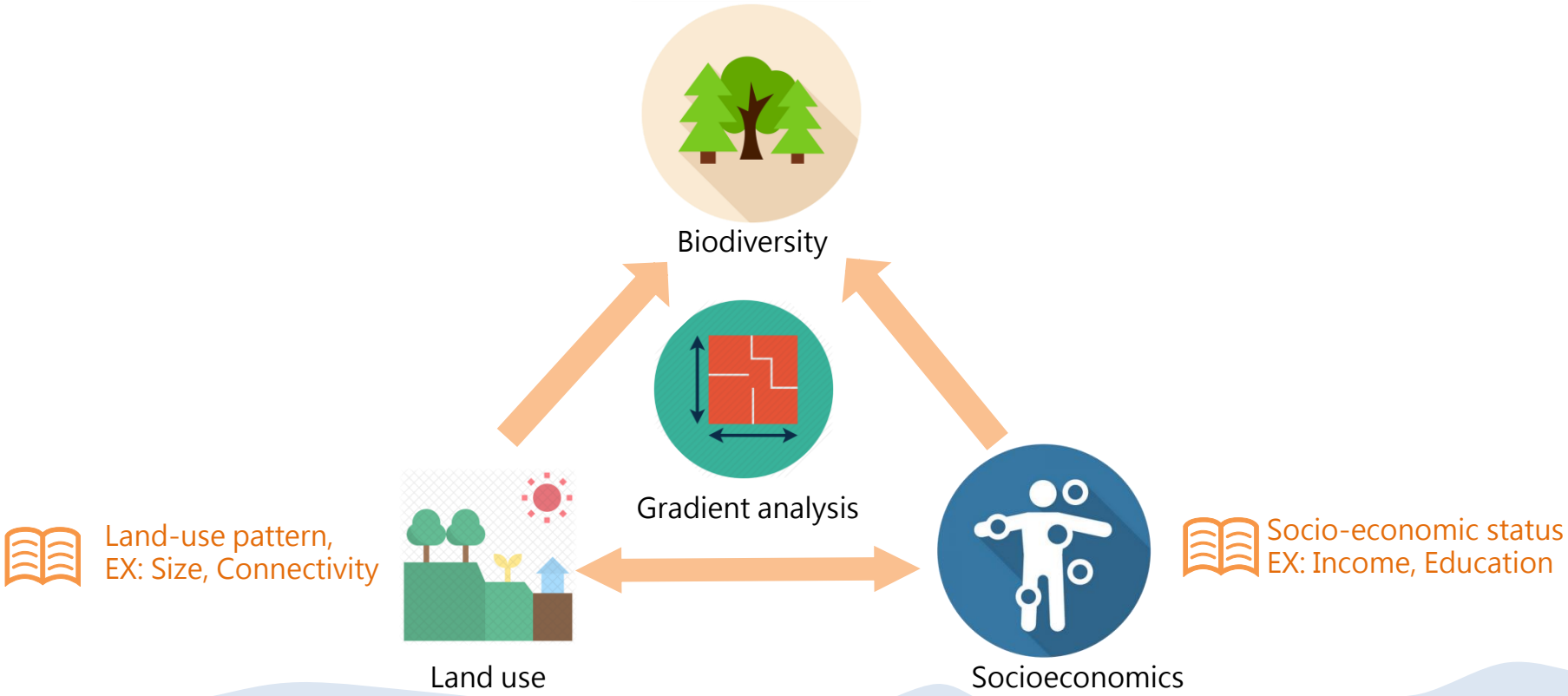


Synthesis from 105 studies (McKinney, 2008)

Luxury Effects along a Socio-economic Gradient

- Increasing urbanization may not only represent challenge in habitat conservation but also opportunities for environmental improvement (Elmqvist et al., 2013; Chamberlain et al., 2019).
- In desert city, well-watered lawn areas are added to increase open habitats in an urban matrix. As such, the phenomenon that biodiversity increases with the socio-economic status, termed "luxury effect" (Hope et al., 2013).
- However, few studies of the luxury effect have been done in the tropics (Leong et al., 2018).

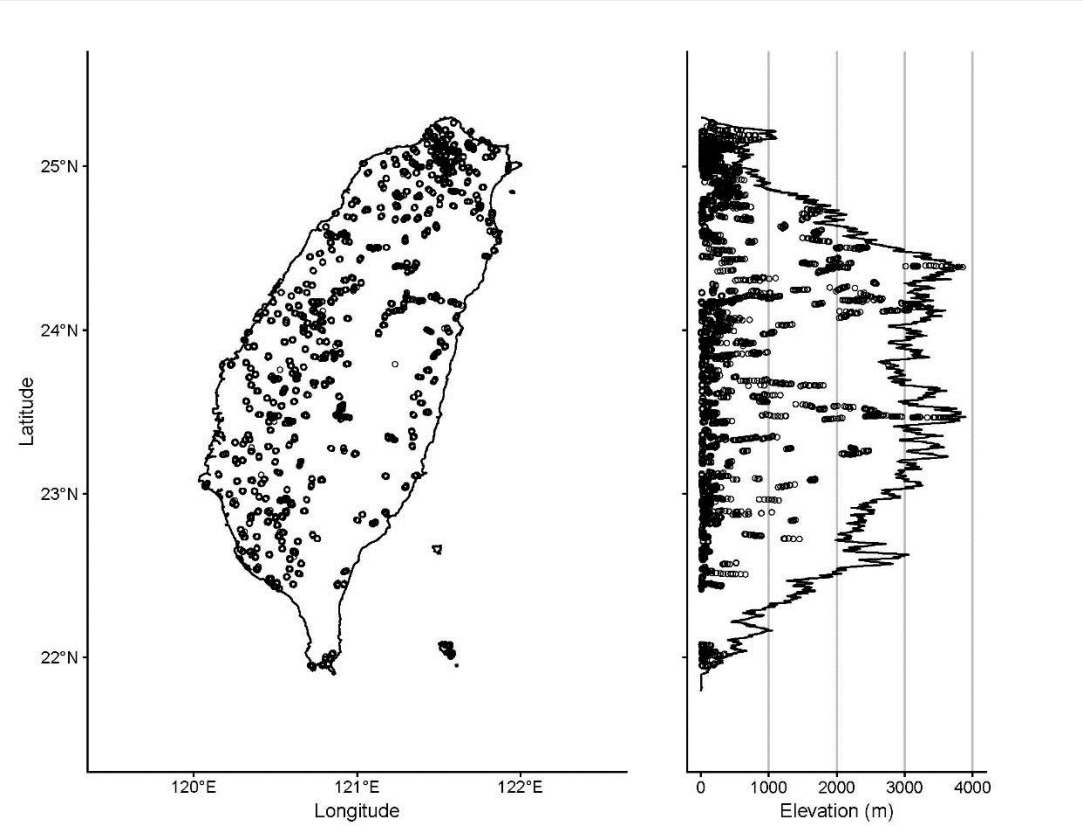
Driving Forces along a Urban-Rural Gradient



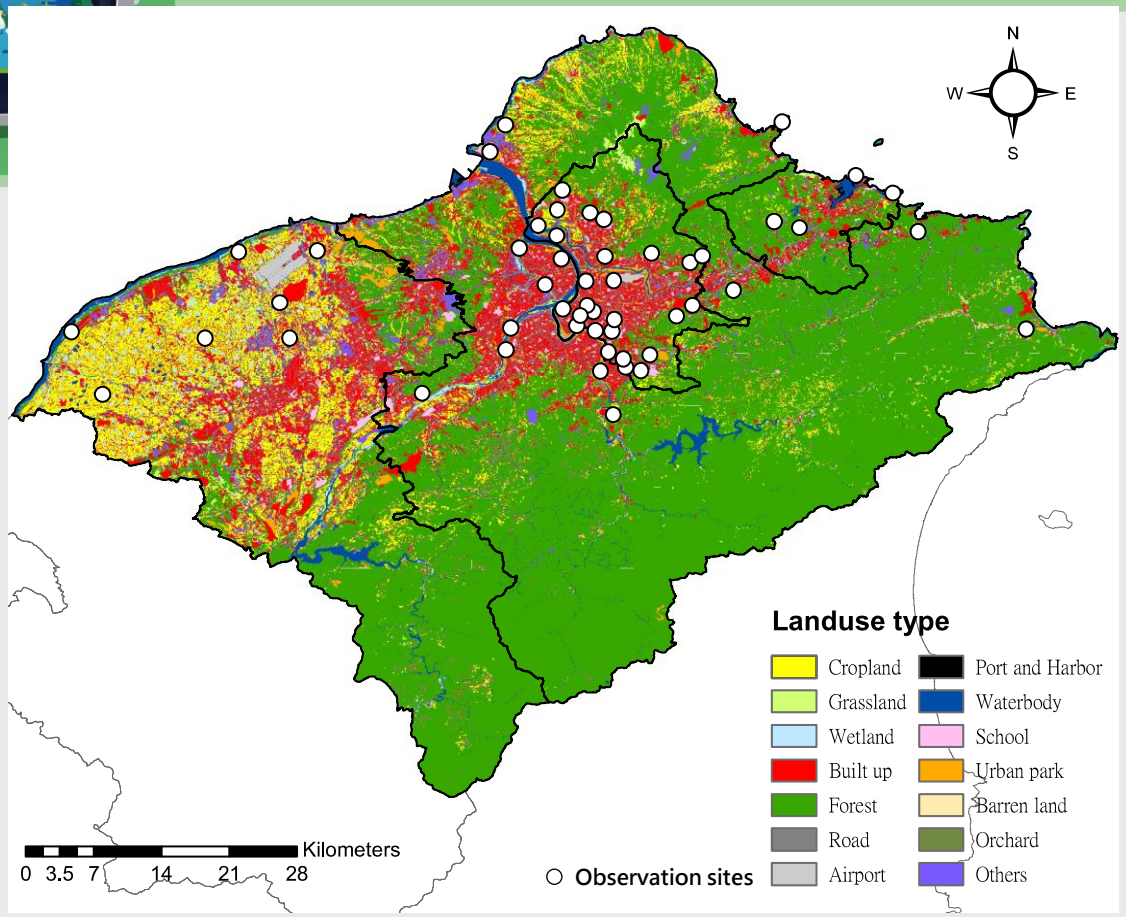
Methods and Materials

Taiwan Breeding Bird Survey

- Ranges of data
  - 2009-2016
  - c. 0.4 million records
  - 480 sites
- Methods
  - Point Count
  - 6min. duration, 100m radius circle
- Data available at GBIF
  - https://www.gbif.org/zh-tw/dataset/f170f056-3f8a-4ef3-ac9f-4503cc854ce0



The Greater Taipei Metropolitan Area



To reduce the influences from altitude, we select 52 observation sites under 100 a.s.l. for avian species

	Taipei	New Taipei	Keelung	Taoyuan	Total
Population	2,645,041	4,018,696	368,893	2,249,037	9,281,667
Area size	272	2,053	133	1,221	3,679
Population density	9,732	1,958	2,779	1,842	2,523

Backward Stepwise Regression

- AIC-based stepwise deletion of predictors and interactions of the full model.
  - Number of samples = 52 bird sites below 100m
  - Number of variables = 34
- Methods
  - Start with all variables in the model (full model).
  - Iteratively remove the variable with the largest p-value (the least statistically significant).
  - Stop when the model with all predictors are statistically significant.

Explanatory Variables

	Variables		Abbreviations
Environmental factors	Elevation		Elevation
	Temperature Mean		Temperature Mean
	Coefficient of Variation of Temperature		Temperature CV
	Precipitation Mean		Precipitation Mean
	Coefficient of Variation of Precipitation		Precipitation CV
Socio-economic factors	Population density		Population density
	Education ratio		Education ratio
	Median income		Median income
Landscape-ecological factors	Class area	Grassland	$CA_{Grassland}$
		Wetland	$CA_{Wetland}$
		Built up	$CA_{Built\ up}$
		Forest	CA_{Forest}
		Road	CA_{Road}
		Waterbody	$CA_{Waterbody}$
		School	CA_{School}
		Urban park	$CA_{Urban\ park}$

Explanatory Variables

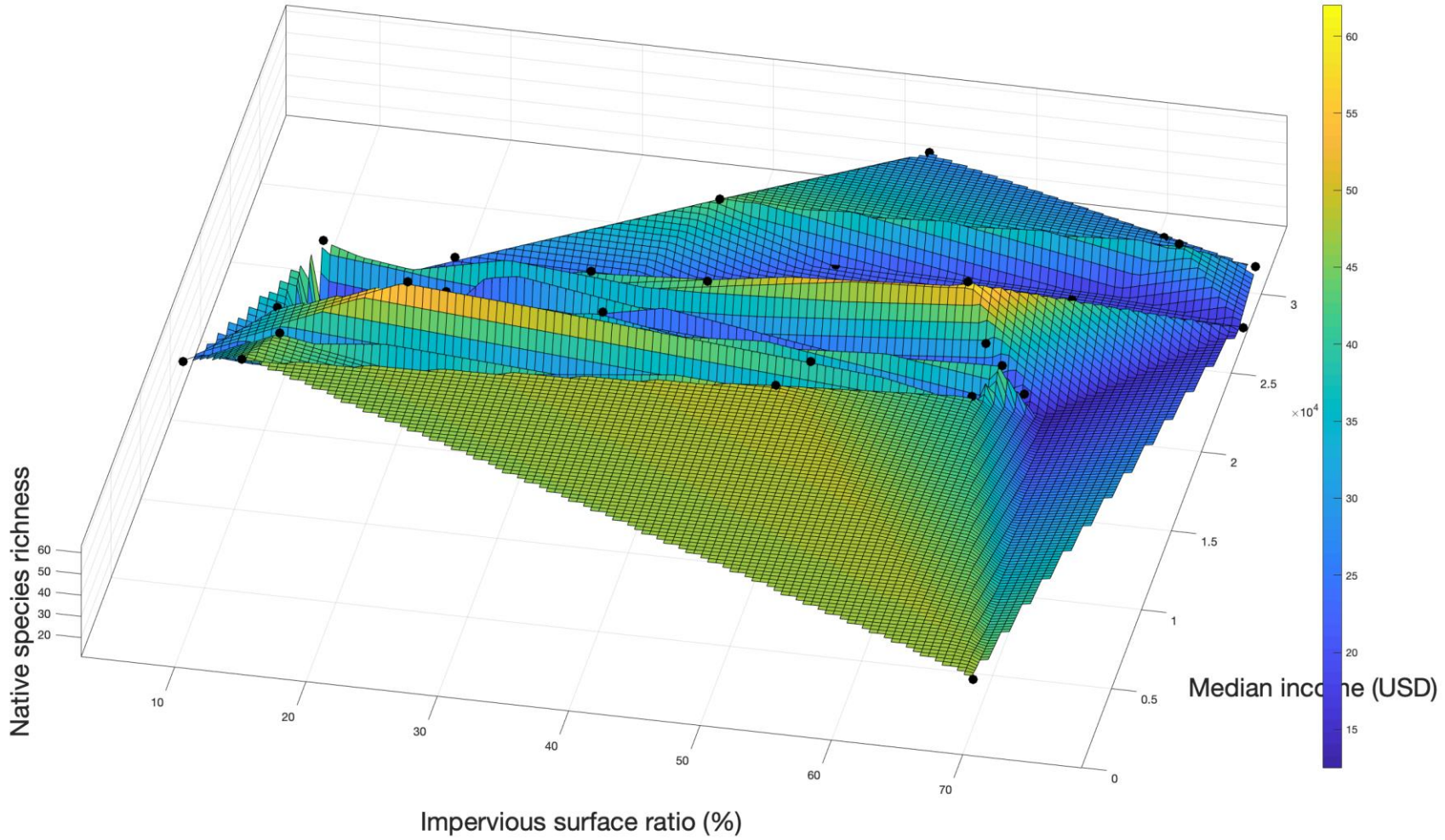
	Variables		Abbreviations
Landscape-ecological factors	Cohesion index	Grassland	$Coh_{Grassland}$
		Wetland	$Coh_{Wetland}$
		Built up	$Coh_{Built\ up}$
		Forest	Coh_{Forest}
		Urban park	$Coh_{Urban\ park}$
	Edge density	Grassland	$ED_{Grassland}$
		Wetland	$ED_{Wetland}$
		Built up	$ED_{Built\ up}$
		Forest	ED_{Forest}
		Urban park	$ED_{Urban\ park}$
	Sum of edge length	Built up - Wetland	$ES_{Built\ up,\ Wetland}$
		Built up - Forest	$ES_{Built\ up,\ Forest}$
		Built up - Waterbody	$ES_{Built\ up,\ Waterbody}$
		Built up - Urban park	$ES_{Built\ up,\ Urban\ park}$
		Forest - Waterbody	$ES_{Forest,\ Waterbody}$
	Large Patch Index		LPI
	Impervious surface ratio		Impervious surface ratio

Regression Results

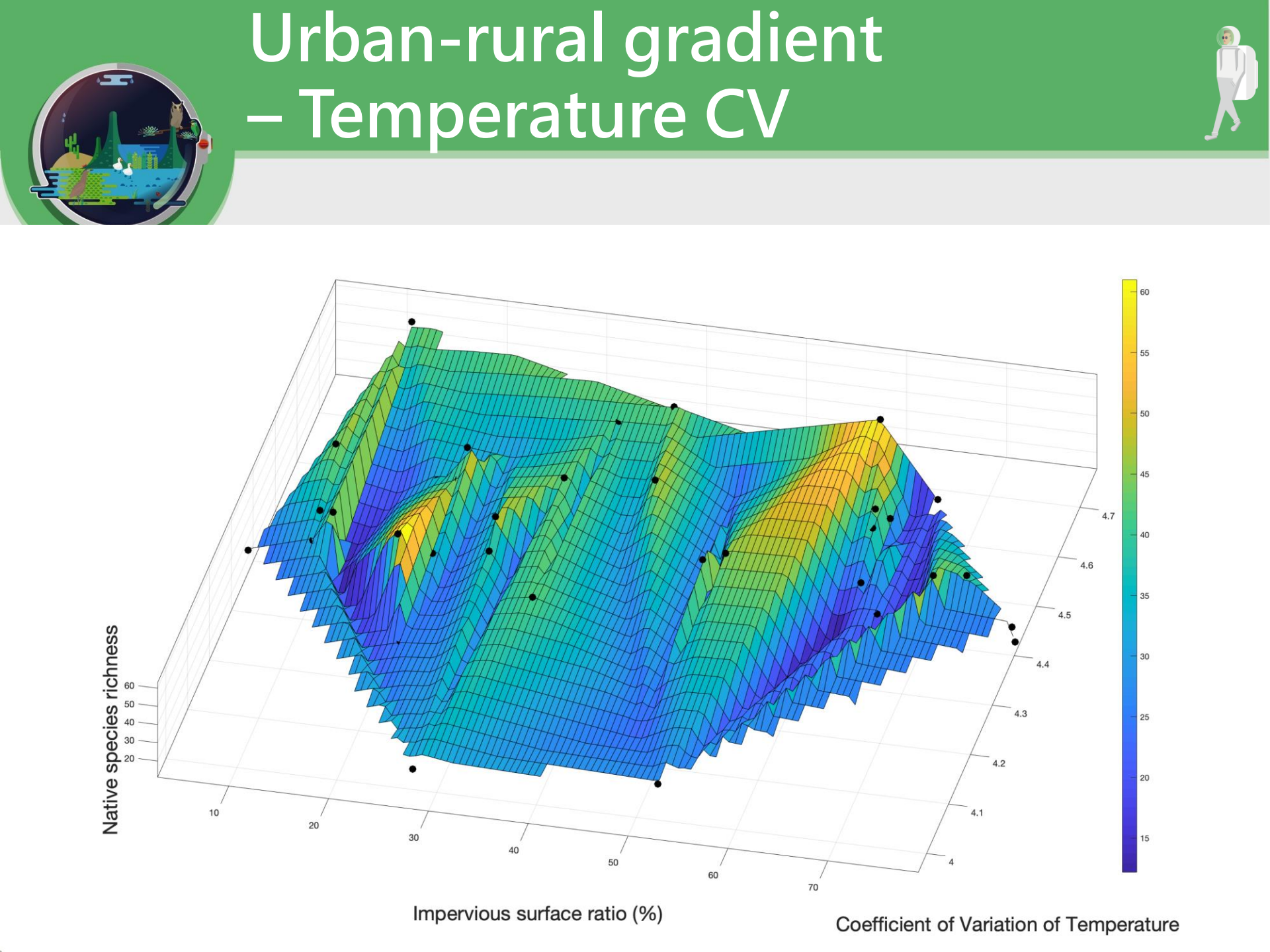
	Coefficients	Std. Error	t value	Pr (>|t|)	
(Intercept)	-0.5476	0.4587	-1.194	0.240221	
Median income	-0.7998	0.2401	-3.331	0.001971	**
Elevation	0.2747	0.1581	1.737	0.090683	.
Elevation CV	0.4335	0.2043	2.121	0.040643	*
Temperature Mean	0.5294	0.2093	2.530	0.015792	*
Temperature CV	0.8894	0.2258	3.938	0.000350	***
CA Forest	-1.3513	0.3050	-4.431	8.05E-05	***
CA Waterbody	-0.4665	0.2527	-1.846	0.072879	.
Coh Built up	0.4195	0.2459	1.706	0.096472	.
Coh Forest	0.4695	0.1630	2.881	0.006559	**
ES Built up, Urban park	0.3277	0.2514	1.304	0.200436	
ES Built up, Wetland	-0.4864	0.2447	-1.987	0.054314	.
ES Built up, Waterbody	0.4941	0.1707	2.894	0.006336	**
ES Forest, Waterbody	0.9237	0.2493	3.705	0.000687	***
Impervious surface ratio	-0.6024	0.3436	-1.753	8.79E-02	.

Significant differences : . P<0.1, *P<0.05, **P<0.01, and ***P<0.001 .

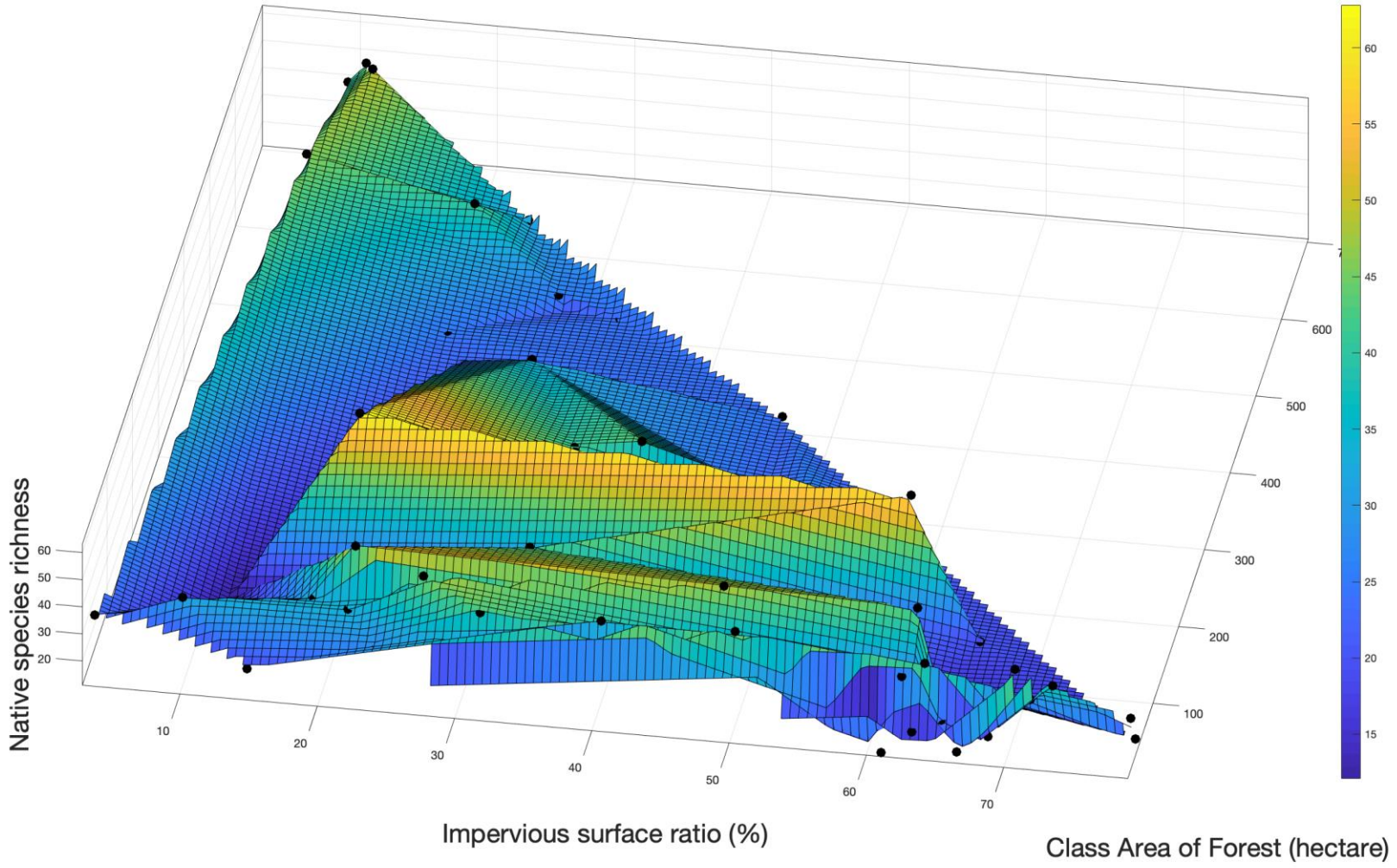
Urban-rural gradient – Median income



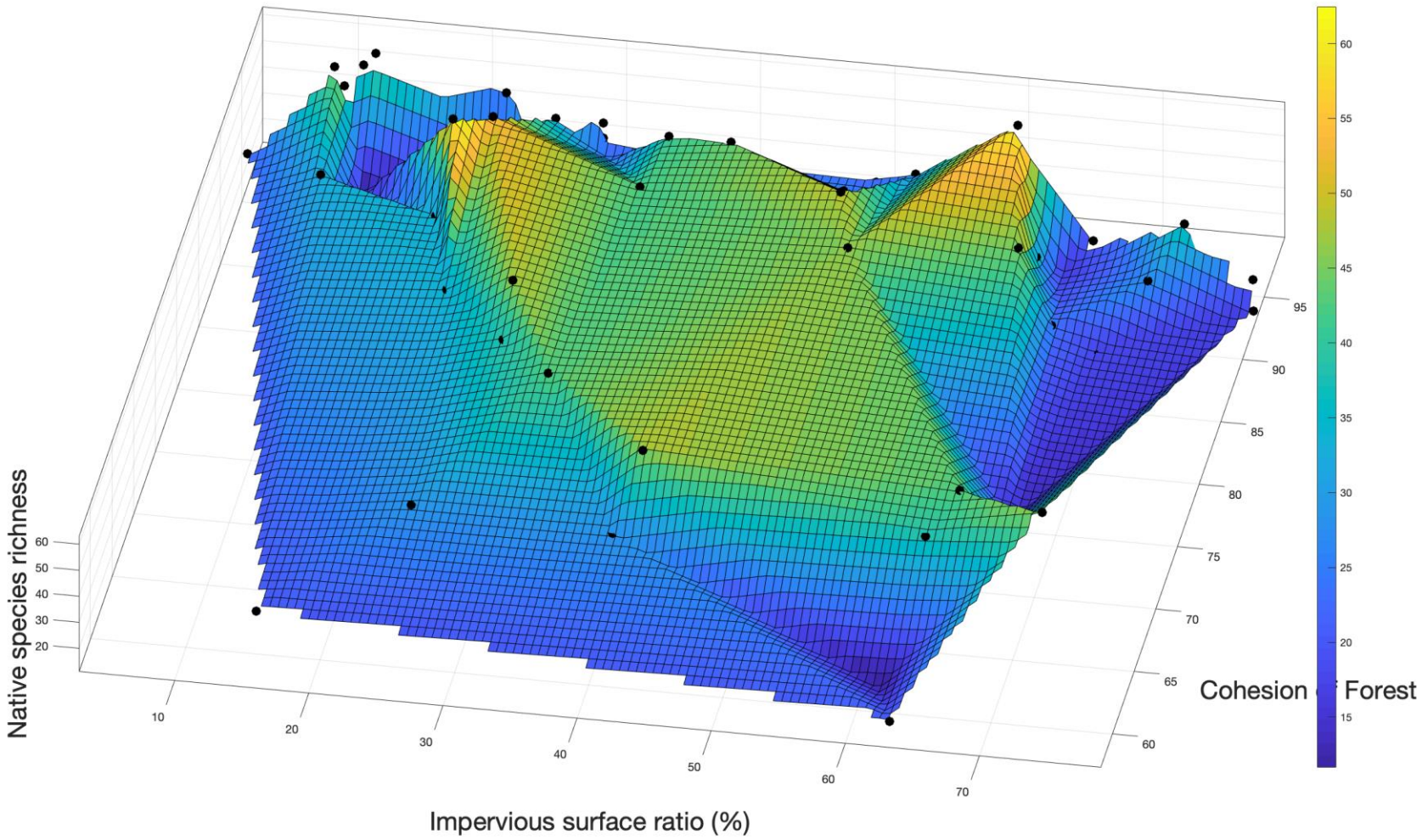
Urban-rural gradient – Temperature CV



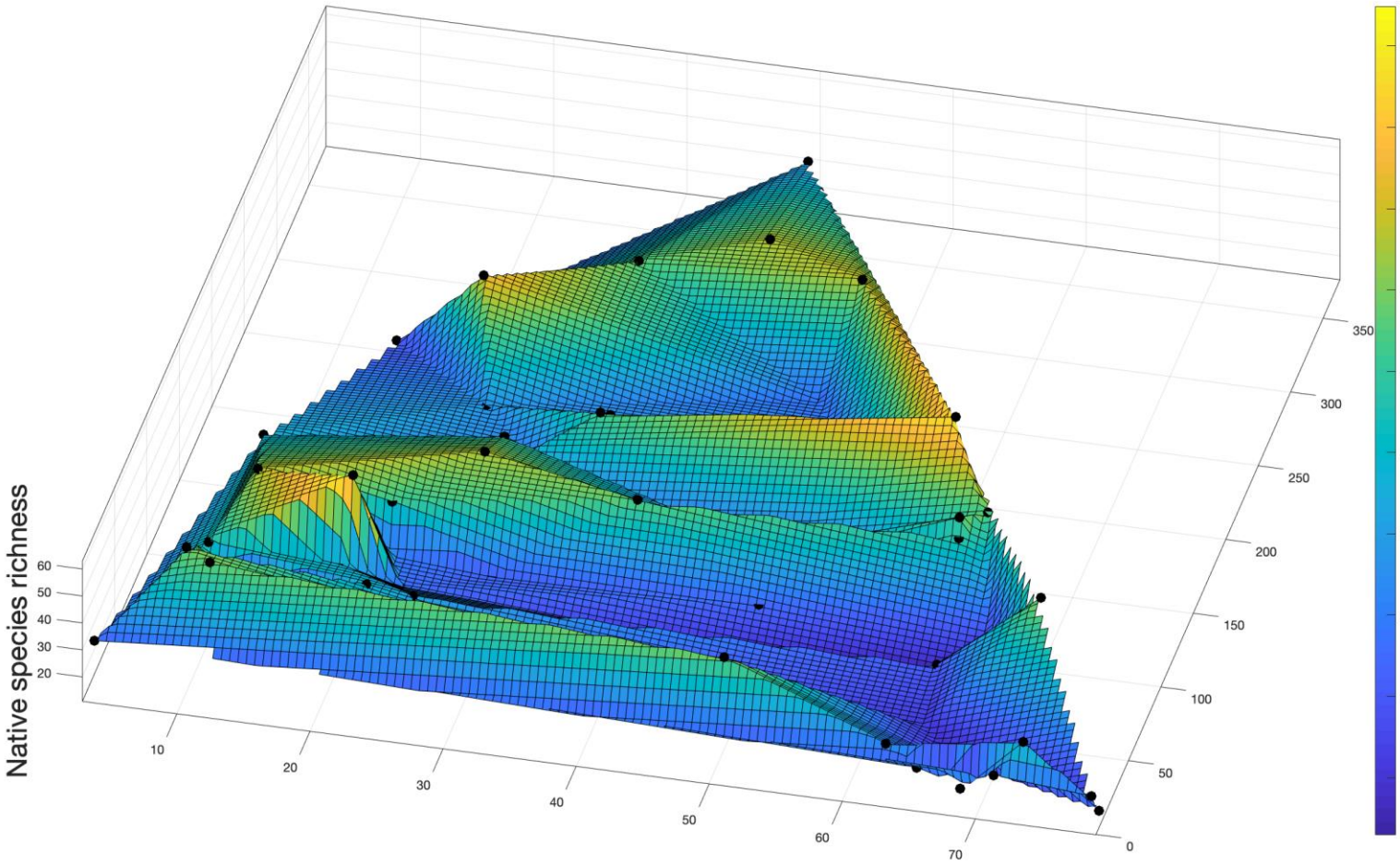
Urban-rural gradient – Class Area of Forest



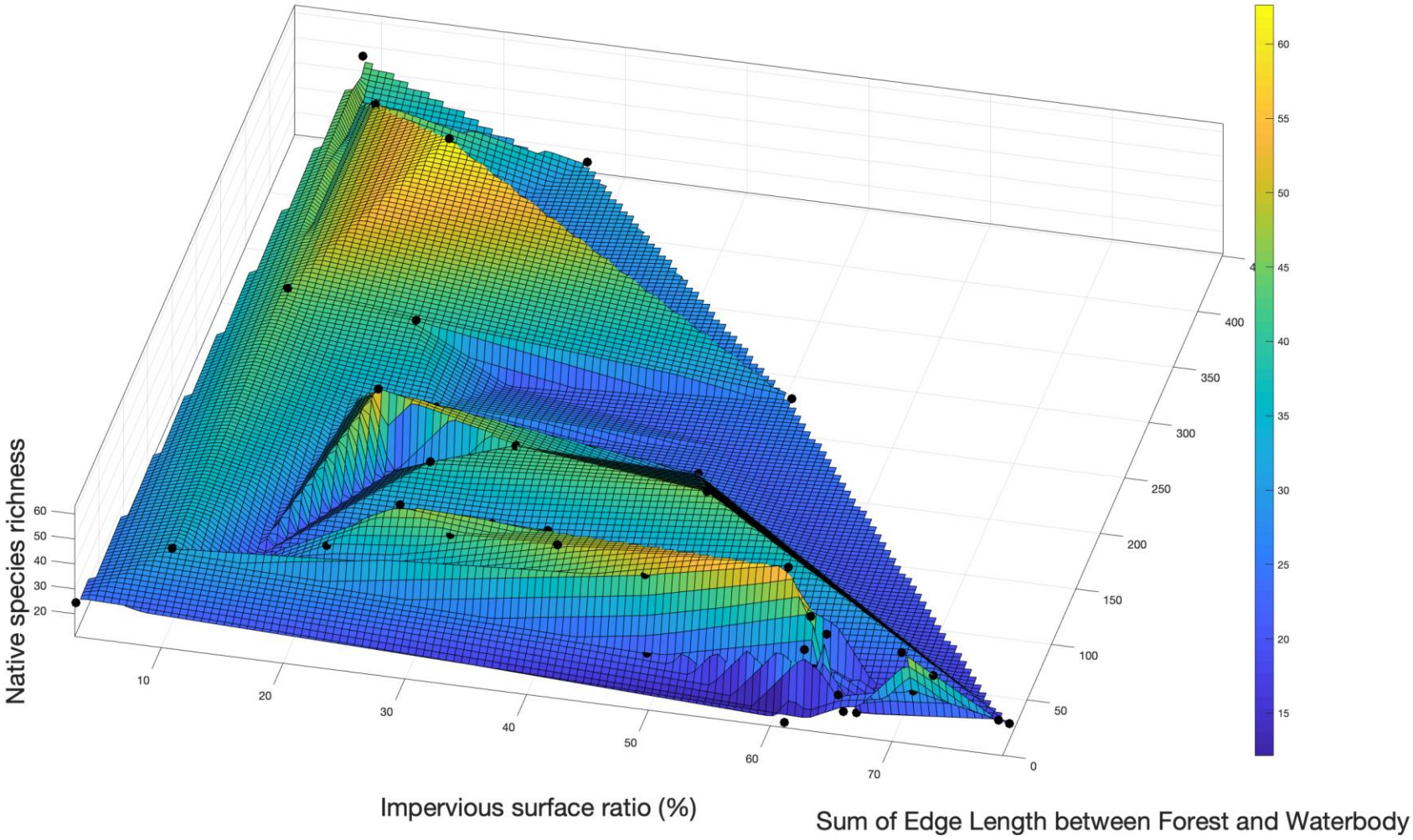
Urban-rural gradient – Cohesion of Forest



Urban-rural gradient – Sum of Edge Length between Built up and Waterbody



Urban-rural gradient – Sum of Edge Length between Forest and Waterbody



Discussion
Socio-economic factors

- Human activities driven by socio-economic status shape urban microclimate, such as urban water cycle. As such, many studies have pointed out the "luxury effect" on urban plant diversity (Hope et al., 2003; Bigirimana et al., 2012; Avolio et al., 2015; Leong et al., 2018)
- Birds depend directly on plant species for food and nesting. As such, their diversity may be correlated with socioeconomics (Leong et al., 2018)
- However, our study indicates negative relationship between income and bird diversity in a subtropical city.

Discussion
Landscape-ecological factors

- Landscape patterns affect the avian diversity in Taipei, Taiwan.
- High avian diversity exists in landscapes with long edge between forest and water body, aggregated forest and built-up.
- Conserving landscapes with birds preferred features may be needed to maintain the avian diversity in the study area.

References

1. Angel, S., Parent, J., Civco, D. L., Blei, A., & Potere, D. (2011). The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050. Progress in Planning, 75(2), 53-107.
2. Avolio, M., Pataki, D. E., Gillespie, T., Jenerette, G. D., McCarthy, H. R., Pincetl, S., & Weller-Clarke, L. (2015). Tree diversity in southern California's urban forest: the interacting roles of social and environmental variables. Frontiers in Ecology and Evolution, 3, 73.
3. Bigirimana, J., Bogaert, J., De Cannière, C., Bigendako, M. J., & Parmentier, I. (2012). Domestic garden plant diversity in Bujumbura, Burundi: role of the socio-economical status of the neighborhood and alien species invasion risk. Landscape and Urban Planning, 107(2), 118-126.
4. Elmqvist, T., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P. J., McDonald, R. I., ... & Wilkinson, C. (2013). *Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment* (p. 755). Springer Nature.
5. Hope, D., Gries, C., Zhu, W., Fagan, W. F., Redman, C. L., Grimm, N. B., ... & Kinzig, A. (2003). Socioeconomics drive urban plant diversity. Proceedings of the national academy of sciences, 100(15), 8788-8792.
6. Leong, M., Dunn, R. R., & Trautwein, M. D. (2018). Biodiversity and socioeconomics in the city: a review of the luxury effect. Biology letters, 14(5), 20180082.
7. McKinney, M. L. (2002). Urbanization, Biodiversity, and ConservationThe impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. Bioscience, 52(10), 883-890.
8. McKinney, M. L. (2008). Effects of urbanization on species richness: a review of plants and animals. Urban ecosystems, 11(2), 161-176.
9. Seto, K. C., Parnell, S., & Elmqvist, T. (2013). A global outlook on urbanization. In Urbanization, biodiversity and ecosystem services: Challenges and opportunities (pp. 1-12). Springer, Dordrecht.