Parcel-Level Land Architecture and Land Surface Temperature in the Phoenix Metropolitan Area

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Central Arizona-Phoenix Long-Term Ecological Research
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Abstract

The relationship between land surface temperature (LST) and characteristics of the urban land system has received increasing attention in urban heat island research, especially for desert cities. In this study, we explore the effects of land system architecture—composition and configuration of different land-cover classes—on LST in the central Arizona-Phoenix metropolitan area at a fine-scale resolution, focused on the composition and configuration of single family residential parcels.

A 1 m resolution land-cover map is used to calculate landscape metrics at the parcel level, and 6.8 m resolution data from the MODIS/ASTER are employed to retrieve LST. In addition, socio-economic factors are employed as explanatory variables to help control for potential neighborhood effects. Ordinary Linear Squares regression models examine the effects of landscape configuration on LST at the parcel scale, controlling for the effects of landscape composition and neighborhood characteristics. Results show that the configuration of parcels affects LST, revealing significant variable relationships between that architecture and LST at nighttime and daytime, and the role of the neighborhood effects on the outcomes.

Study Area

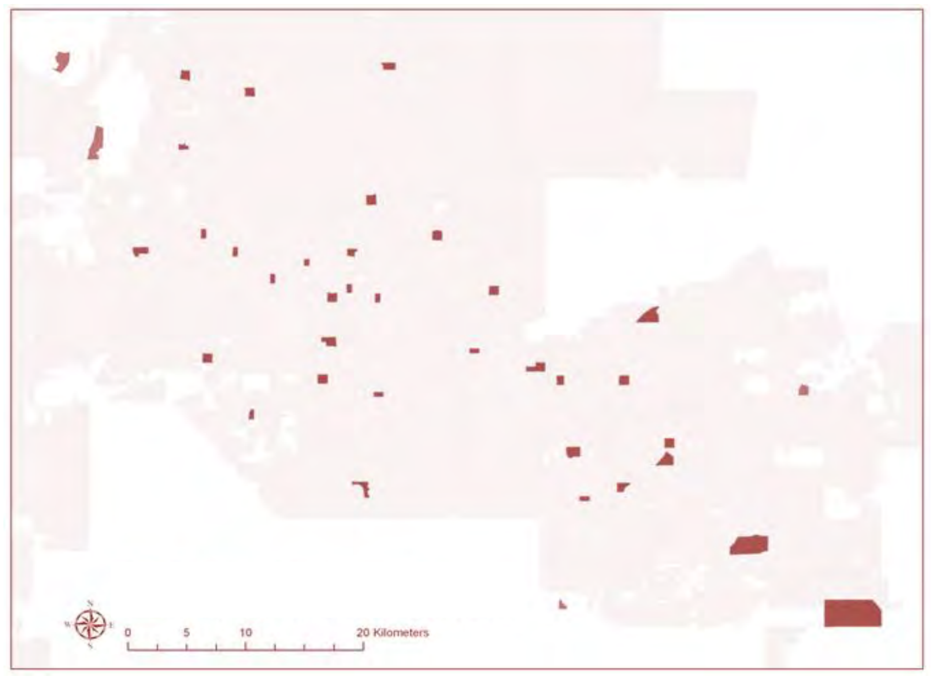

Fig 1: The study area covers the CAP site. The 38 dark blue patches are the area of interest.

Methods

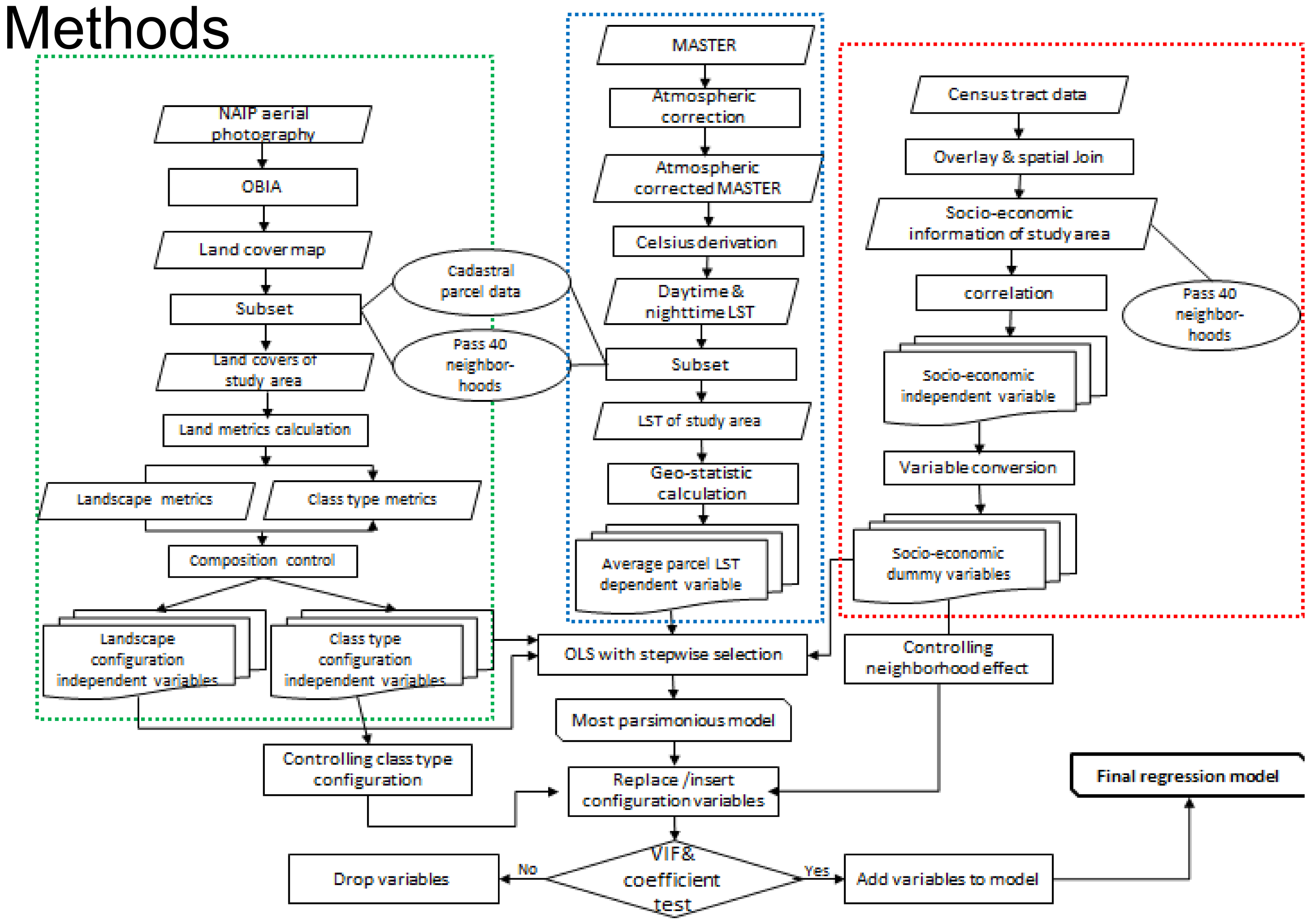

Fig 2: . Flow chart of this research.

Results

	Variable	Coefficient	Std Error	t statistic	p-value	std coefficient	VIF
Parcel variable	logPLAND_Building	0.037869	0.002602	14.55	<.0001	0.127271	1.705402
	logPLAND_Soil	0.118276	0.004524	26.14	<.0001	0.248919	2.022317
	logPLAND_Tree	-0.01554	0.002062	-7.54	<.0001	-0.09197	3.322152
	logPLAND_Grass	0.001219	0.001649	0.74	0.4599	0.007097	2.056935
	logLSI	-0.07985	0.00875	-9.13	<.0001	-0.09851	2.598647
	logPD	0.021688	0.004091	5.3	<.0001	0.054657	2.370751
	logFRAC	0.217428	0.032333	6.72	<.0001	0.048449	1.157778
	logCONTAG	-0.03041	0.010637	-2.86	0.0043	-0.0355	3.439215
	With pool (vs Without pool; dummy)	-0.01399	0.000646	-21.65	<.0001	-0.16883	1.356122
Neighborhood variable to control neighborhood effect (dummy variables)	High income (vs Middle income)	-0.02358	0.000974	-24.2	<.0001	-0.27539	2.888504
	Low income (vs Middle income)	0.034098	0.001128	30.24	<.0001	0.334434	2.727641
	City core (vs Suburban)	-0.01008	0.001206	-8.36	<.0001	-0.08695	2.415002
	Fringe (vs Suburban)	-0.00964	0.000955	-10.09	<.0001	-0.11183	2.738851
	Retirement community (medium age over 55)	0.02969	0.000898	33.08	<.0001	0.284511	1.649992
PLAND: Percent of landscape PD: Patch density FRAC: Fractal dimension	LSI: Landscape shape index ED: Edge density CONTAG: Contagion						
R Square	0.4315						
R Square Adjusted	0.4308						

Table 1: The result of regression model 1. Model 1 shows the effects of **aggraded** class configuration on **daytime** surface temperature by controlling for aggraded class composition (PLAND) and neighborhood characteristics.

	Variable	Coefficient	Std Error	t statistic	p-value	std coefficient	VIF
Parcel variable	logPLAND_Building	0.041947	0.002524	16.62	<.0001	0.140976	1.616947
	logPLAND_Soil	0.093101	0.005645	16.49	<.0001	0.195938	3.171297
	logPLAND_Tree	-0.02156	0.002267	-9.51	<.0001	-0.12759	4.045567
	logPLAND_Grass	-0.00197	0.001615	-1.22	0.2218	-0.01149	1.986378
	logLSI_Soil	-0.08918	0.009832	-9.07	<.0001	-0.12457	4.237622
	logLSI_Tree	0.028936	0.006153	4.7	<.0001	0.063185	4.056033
	logPD_Building	0.009742	0.002501	3.9	<.0001	0.035103	1.824171
	logPD_Grass	0.013641	0.002587	5.27	<.0001	0.045548	1.676105
	logED_Soil	0.017964	0.007526	2.39	0.017	0.030757	3.730051
	LogFRAC_Tree	0.083128	0.017865	4.65	<.0001	0.032728	1.11144
	LogFRAC_Grass	0.080172	0.014642	5.48	<.0001	0.038164	1.091492
	With pool (vs Without pool; dummy)	-0.01442	0.000633	-22.78	<.0001	-0.17403	1.311796
Neighborhood variable to control neighborhood effect (dummy variables)	High income (vs Middle income)	-0.02371	0.000975	-24.33	<.0001	-0.27696	2.91055
	Low income (vs Middle income)	0.034552	0.001137	30.39	<.0001	0.338885	2.793833
	City core (vs Suburban)	-0.011	0.001223	-9	<.0001	-0.09488	2.498153
	Fringe (vs Suburban)	-0.00819	0.000959	-8.54	<.0001	-0.09495	2.777376
	Elder age group (medium age over 55)	0.027925	0.000922	30.27	<.0001	0.267596	1.755605
PLAND: Percent of landscape PD: Patch density FRAC: Fractal dimension	LSI: Landscape shape index ED: Edge density						
R Square	0.4357						
R Square Adjusted	0.4350						

Table 2: The result of OLS regression model 2. Model 2 shows the effects of **class specific** configuration on **daytime** surface temperature by controlling for class specific composition (PLAND) and neighborhood characteristics.

Fig 3: Optimal configuration for cooler daytime temperature

Fig 4: Optimal configuration for warmer daytime temperature

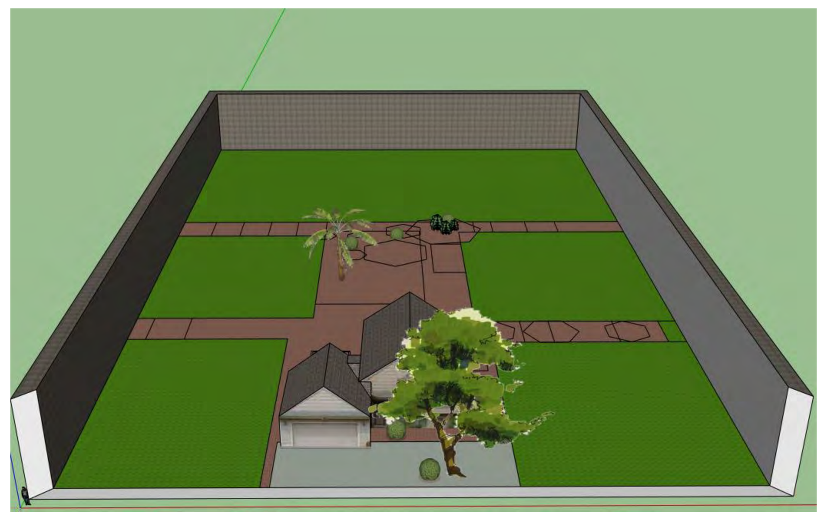

Fig 5: Optimal configuration for cooler nighttime temperature

Fig 6: Optimal configuration for warmer nighttime temperature

Conclusions

Our research corroborates emerging research finding that land system architecture affects LST. Our work elaborates those findings, however, by demonstrating that (1) controlling for neighborhood effects, land composition and configuration are important and significant factors affecting LST at the SFR or parcel level, and (2) controlling for land composition, land configuration at the landscape level (parcel mosaic) proves to be an important and significant factor affecting LST. By doing so, we find that the interplay among explanatory variables result in their different directional influences on LST at different times of day, as well as different landscape metric levels. Taken together, the results point to the need for more research on the land architecture of the city-scape, its impacts of the UHI, possible use to reshape the configuration of the city-scape to achieve a more temperature friendly outcome for desert cities, and tradeoffs and synergies with other environmental services.

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