

Historical Analysis of Land Use Change and Geodesign of Rapid Urbanization: Orlando, Florida, USA

Timothy Murtha¹, Luwei Wang², Leilei Duan³

¹University of Florida, Florida/USA · tmurtha@ufl.edu

²University of Florida, Florida/USA

³University of Southern California, California/USA

Abstract: A geodesign frameworks offers useful potential for identifying, understanding, and planning for land use change in regions of rapid urbanization. The framework has proven useful for thinking about future land use change, but isn't commonly coupled to historical trajectories of land use change. We have initiated a project to study how historic spatial and temporal dynamics of urban land use change can potentially inform the scale and approach for how geodesign frameworks are applied. This is especially true when examining these dynamics in regions where geodesign frameworks have been previously applied. Our new project is investigating these ideas and this paper reports our initial results. Focused on the Orlando city region in the state of Florida in the United States, we first compare the spatial and temporal patterns of urbanization and urban sprawl between 1974 and 2011. Importantly, a similar study of urbanization was conducted in 2005 in order to develop scenarios for future development of the LUCIS model (Land Use Conflict Identification System). We describe changes in the pattern of urbanization of Orlando through a detailed analysis of Land Use Land Cover (LULC) decadal data. We then overlay a subset of earlier LUCIS model results to introduce a brief discussion about what we've learned so far and what work needs to be done. From these early results, we are certain that studying the historic spatial and temporal dynamics of urban land use change can potentially inform the scale and approach for how geodesign frameworks are applied.

Keywords: Geodesign, land use/ land cover (LULC), change detection, urban sprawl, Orlando and Tampa Metropolitan Regions

1 Introduction

The continued development and application of geodesign as a framework for design and planning cities and settlements offers promise for creatively exploring alternatives to future land allocation challenges. Florida and specifically, Central Florida in the United States of America has been the geographic setting for a number of geodesign efforts investigating the potential future land allocation demands associated with projections of population growth and pressure relying on the Land Use Conflict Identification System (LUCIS) developed by Zwick and colleagues (CARR & ZWICK 2007, ZWICK, PATTEN, & ARAFAT 2015). These innovative models have been used to guide, inform, and influence regional planning throughout Florida. In a broader effort to understand the influence of historic land use change and advance the application and utility of geodesign as an analytical framework, we conducted a historical study of urbanization and accompanying land use change of the Orlando City region in the state of Florida. Population growth, especially associated with rapid urbanization, initiates substantial spatial landscape and regional challenges (EHRlich & HOLDREN 1971). In the United States and specifically in Florida, the rapid development of urban land has been primarily accompanied by urban sprawl. In turn, this urban sprawl has initiated additional landscape scale problems, including threats to groundwater and a decrease of multi-functional open space (EWING 2008). Interestingly, many of these changes in Florida occurred

very recently. Understanding the spatial and temporal dynamics of these recent historical changes using a geodesign framework offers critical insight into alternative future models of growth and development, especially as we consider more complex challenges. While we aim in our broader research to study more completely the relationship between historical patterns of urbanization and its influence on trajectories of change in geodesign frameworks, we limit the scope in this paper.

This paper describes the spatial and temporal dynamics of population growth, urban development, urban sprawl and landscape outcomes between 1974 and 2011. We first compare the changes in land use and land cover (LULC) at the city scale and the regional scale. We compare land use changes in the city of Orlando to the Orange and Seminole County region. This simple analysis clearly demonstrates the importance of a regional (or geodesign) scale of analysis for urban design and planning. Second, we study land conversion during three key periods of change. Changes in urban development between 1974 and 2011 are quantified to document changing land conversion pressures. Third, we document the changing pattern of sprawl for Orlando. Throughout the state of Florida, even though land conversion pressures vary regionally, historical analysis suggests similar spatial patterns of urban sprawl throughout Florida. It is clearly the case in Orlando. Finally, our historical analyses are overlaid to a small subset of the outcomes of a series of Central Florida geodesign land allocation models conducted by CARR & ZWICK (2007) to introduce a discussion about integrating historical analysis in geodesign and the next steps of our research.

2 Materials and Methods

Standardized land use land cover (LULC) data for county and city boundaries were obtained from the Florida Geography Data Library (FGDL, see: <https://www.fgdl.org>) for Orlando and for Orange and Seminole counties. Data were processed and analysed for each of the following years: 1974, 1990, 2000 and 2011. Initially two spatial contexts, the city and the region, were used for analysis. Simply, we performed basic quantitative LULC descriptive analysis for the City of Orlando and compared those results to the full regional boundaries of Orange and Seminole Counties. Major land use categories, also referred to as L1 or Level 1, were quantified for each scale and decadal data set. Specifically focused on urban land conversion, we isolated the most significant land cover changes between each temporal sample and across the entire time period. We then quantified LULC change as a function of distance from the city center using multiple ring buffers. Our core purpose was to more fully document using basic quantitative metrics the spatial and temporal dynamics in the Orlando metropolitan region. We finally overlaid our urban land conversion data set from 2011 with some of the analytical coverages developed by ZWICK & CARR's 2005 study with partners of Central Florida's 2050 alternative futures (CARR & ZWICK 2007).

3 Results

The preliminary results of our analysis can be summarized under three key headings: 1) City vs. Region; Land Conversion; and, 3) Sprawl.

3.1 City vs. Region

Many planning projects studying changes to urban land use limit studies to urban boundaries in order to emphasize the importance of urban land conversion. In the context of rapid urbanization, a regional boundary (e. g., that typically studied using a geodesign framework) offers important insight into the spatial dynamics of urbanization. Sprawl, despite efforts to contain and limit, is persistent and an overwhelming pattern of rapidly urbanized regions of Florida (see section 3.3). Restricted to the urban metropolitan area, the clear patterns of sprawl cannot be quantitatively compared to land use change. In this context, sprawl is overwhelming.

Table 1: Land use/cover statistics of the Orange and Seminole County; in 1974, in 1990, in 2000, in 2011

Land Class	1974		1990		2000		2011	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Agriculture	93759	26.83	75048	21.47	43108	12.33	39892	11.42
Rangeland	57348	16.41	22845	6.54	26673	7.63	13138	3.76
Transportation, Communication & Utilities	3619	1.04	8493	2.43	12304	3.52	17643	5.05
Upland Forests	48111	13.77	42996	12.30	38447	11.00	29850	8.54
Urban & Built-Up	50202	14.37	87432	25.02	100759	28.83	120708	34.54
Water	32295	9.24	33680	9.64	37694	10.79	39284	11.24
Wetlands	64106	18.35	69707	19.95	84188	24.09	87708	25.10
Barren Land	0	0.00	566	0.16	6302	1.80	1220	0.35
Special Classifications	0	0.00	8725	2.50	17	0.00	0	0.00
Total	349441	100	349492	100	349492	100	349444	100

Our analysis of LULC changes in Orlando reveals that from 1974 to 1990, 1990 to 2000, and 2000 to 2011, agricultural lands were converted or lost in the City unevenly between 1974 and 2011, i. e., 45 %, 10 %, and 24 % respectively in three decades. Rangeland decreased 28 %, 46 % to 47 % in each period. The decreases in agricultural land and rangeland, were accompanied by increases in communication and utilities, which nearly tripled across the three decades. Urban and built-up increased 47.4 % between 1974 and 2011. Across these three decades and at the city scale there was an early investment in infrastructure and transportation. Regionally, a similar decrease occurred in agriculture, rangeland, with descending rates of 57.5 % and 77.1 %, between 1974 and 2011 respectively. Transportation, communication, and utilities increased at a slightly higher rate than that observed for the city boundaries. However, urban and built-up areas, exhibited a radically different pattern of growth between 1974 and 2000, increasing by 140 %. The trends for the city and region are similar, but the quantities offer a striking comparison. While 4,000 hectares of urban area were converted in the boundaries of the City of Orlando between 1974 and 2011, the region increased to nearly 121,000 hectares of urbanized area in 2011, more than double the original area of

urban area in 1974 (see table 1). The simple comparison of Orlando's urban region to city boundaries clearly demonstrates a requirement for urban design and planning to study the region beyond city boundaries.

3.2 Land Conversion

While the spatial dimensions of land use change are one theme of historical analysis we are studying, we are also interested in how land converts through time and how land use is historically allocated. To better measure these changes, we investigated the significant conversions occurring in the Orlando region during our study period.

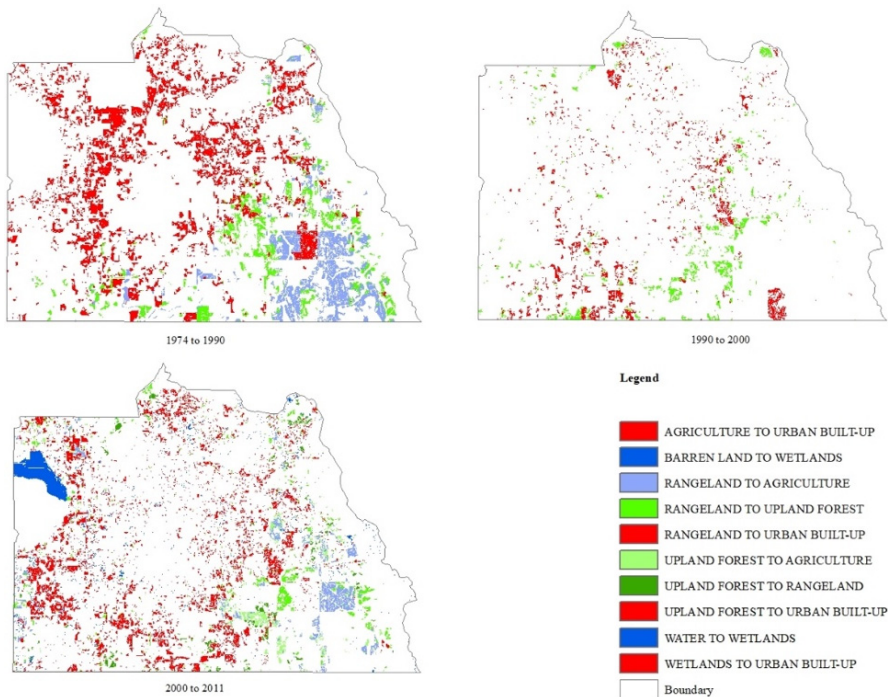


Fig. 1: Orange and Seminole County Land use/ cover change conversion from 1974 to 2011

We simply quantified patterns of accretion and reduction. The most substantial reduction was in agricultural land, of which 26 % was converted to urban area between 1974 to 1990. Rangeland, which includes fallow, grazing, and natural land also reduced significantly prior to 1990. Rangeland was also the most converted land use type before 1990, with 87,000 hectares changing from rangeland to another land use during this period. Changes between 1990 and 2000, slowed down, but exhibited similar patterns to the changes occurring prior to 1990. From 2000 to 2011, urban land was converted from agriculture and upland forest. In total, between 1974 and 2011, 38,000 hectares of agricultural land were converted to urban and built up, while more than 26,000 acres of upland forest are converted from forest to urban (see figure 1 and table 2). So, while agriculture and rangeland dominated land use conversion in Orlando's regional history, upland forest was increasingly converted more recently.

Table 2: Land use/cover statistics of the Orange and Seminole County; in 1974, in 1990, in 2000, in 2011

LULC change	1974-1990 (area in ha)	1990-2000 (area in ha)	2000-2011 (area in ha)
Agriculture to Built-up	22395	8309	8524
Upland forest to Built-up	11566	6939	9247
Rangeland to Built-up	6155	4229	5942
Wetland to Built-up	5407	3163	2485

3.3 Sprawl

While our initial comparison of each city to its regional context indicated a pattern of sprawl, it didn't offer any information to understand the structure of the sprawl. For example, did periphery communities convert to suburbs or did exurbs of the 1990s convert into suburbs of the 2000s?

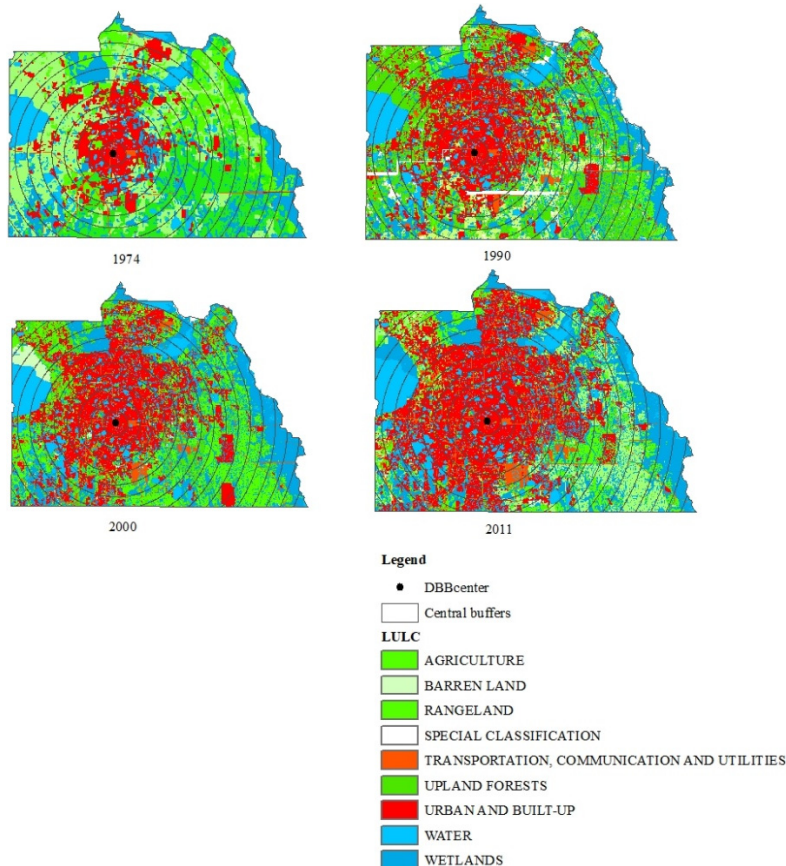


Fig. 2: Orange and Seminole County central measurements for Urban development land 1974 to 2011

In the Orlando regional area, our analysis demonstrates that urban development increased from 1974 to 2011. Regionally, the clearest changes occurred more than 4 miles from the city center (see figure 2 and table 3). Between a 4- and 12-miles radius of the city center, urban and built-up land increased most, smaller but steady increases are observed more than 12 miles. Even though sprawl has been well documented in the US and specifically in Florida, it was surprising how uniform the process of sprawl occurred in the Orlando region. Each decade witnessed an increased ratio of urban area to all area in the rings around the city. Today, the ratio of urban land to all land is 0.8 within 8 miles of the city center. That ratio steadily declines to 0.36 in the ring that is 18 miles outside the city center (see table 3).

4 LUCIS and Urbanization

Recently, we initiated a process for overlapping the results of a 2005 study of Central Florida's Four Futures, conducted by Zwick and colleagues. The purpose of the 2005 study was to investigate alternative futures for the expanding metropolitan region of Orlando. Data up until 2005 was combined with projections of population growth until 2050. First the team developed a current trend model, which was combined with preferred land use surveys to develop a "Conflict Model", using LUCIS (Figure 3a). In this model, urban preferred areas were coded as white, while conservation areas were coded in green and conflict areas were coded in red. Shown in figure 3, we are starting to compare existing urban areas as of 2011 and how they compare to areas identified as urban or as potential conflicts in the LUCIS model. Our aim in the broader project is to quantify the different outcomes in the Orlando Region and to see how recent urbanization influences new potential conflicts and new trajectories of change. Clear patterns can be observed. For example, in figure 3, we have illustrated an urban preferred area that has not been developed adjacent to an area of development that was identified as conflicted in the 2005 study.

Table 3: Orange and Seminole County central measurements for the ratio of urban development land from 1974 to 2011

Central radius (mile)	1990		2011	
	Ratio	Ratio	Ratio	Ratio
2	0.80	0.80	0.83	0.85
4	0.67	0.75	0.81	0.84
6	0.49	0.66	0.78	0.84
8	0.35	0.57	0.71	0.82
10	0.24	0.46	0.63	0.77
12	0.16	0.34	0.51	0.68
14	0.10	0.23	0.39	0.55
16	0.07	0.18	0.30	0.44
18	0.08	0.18	0.27	0.36

5 Discussion

Relying on a comparative analysis of rapidly urban areas in Florida, our aim in this paper is to explore the spatial and temporal dynamics of land use change and settlement patterns. Focusing on historical quantitative analysis, we attempt to expand the analytical application of the geodesign framework. Orlando, Florida has long been the focus of geodesign inquiries, emphasizing future land allocation in the context of population growth and pressure. Our research here quantifies the outcomes of four decades of settlement expansion, comparing the spatial and temporal patterns of change between regions experiencing similar growth. While regional contexts exhibit clear patterns of urban sprawl the spatial patterns and temporal dynamics vary. Land conversion in the two regions is particularly distinct, especially recent land conversion between 2000 and 2011. While we have only briefly explored the previous geodesign data, we can start to identify areas of analysis for future studies.

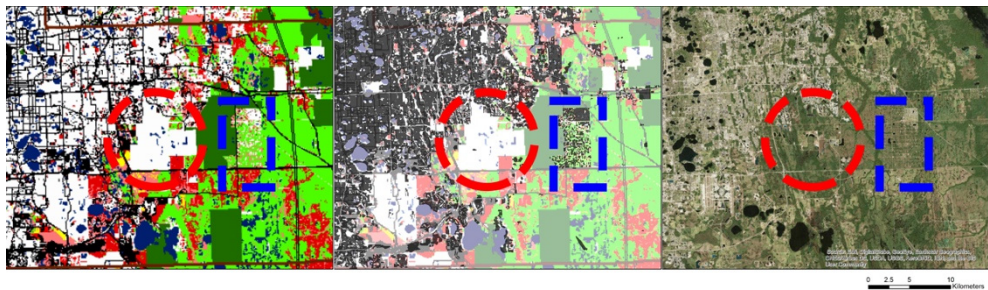


Fig. 3: Left to right, figures 3a-c illustrate: a) the LUCIS model conflict surface, b) the 2011 urbanized area overlaid (black) and c) aerial photo from 2011. Annotated, an urban preferred area has not been developed adjacent to an area of development that was previously identified as conservation and conflicted in the 2005 study.

References

- CARR, M. H. & ZWICK, P. D. (2007), Smart land-use analysis: the LUCIS model land-use conflict identification strategy. ESRI, Inc.
- ESBAH, H. & DENIZ, B. (2007), Effects of land use development on urban open spaces. *Journal of Applied Sciences*, 7 (8), 1138-1144.
- EWING, R. H. (2008), Characteristics, causes, and effects of sprawl: A literature review. In *Urban Ecology*. Springer, Boston, MA., 519-535.
- LÓPEZ, E., BOCCO, G., MENDOZA, M. & DUHAU, E. (2001), Predicting land-cover and land-use change in the urban fringe: a case in Morelia city, Mexico. *Landscape and urban planning*, 55 (4), 271-285.
- LÓPEZ, E., BOCCO, G., MENDOZA, M., VELÁZQUEZ, A. & AGUIRRE-RIVERA, J. R. (2006), Peasant emigration and land-use change at the watershed level: A GIS-based approach in Central Mexico. *Agricultural systems*, 90 (1-3), 62-78.
- MOELLER, M. S. & BLASCHKE, T. (2005), Monitoring LULC dynamics in the urban-rural fringe population, 663510, 3072149.

- SHALABY, A. & TATEISHI, R. (2007), Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. *Applied Geography*, 27 (1), 28-41.
- ZWICK, P. D., PATTEN, I. E. & ARAFAT, A. (2015), *Advanced Land-use Analysis for Regional Geodesign: Using LUCISplus*. Esri Press.