Exploring Suitable Indicators for Residential Development and Resilient Landscape: A Case Study in Orlando Metropolitan Region

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Abstract: This study examines the form and distribution of public parks in the Orlando Metropolitan Region in Central Florida, USA, to understand the impact of residential land use on the local landscape. Research examining the landscape impacts of rapid urbanization is critical for a holistic understanding of planning and design. However, we have not yet thoroughly examined the urban landscape to assess the full impact of urbanization regionally. Here, a novel methodology is proposed to evaluate the relationship between residential development and public parks based on the cumulative metropolitan structures (e. g., urban sprawl) in the study region. Three metropolitan zones in Orlando Region, namely the core, intermediate and periphery, are defined, examining the structure, form, and distribution of parks in those zones. Two key indicators: park service areas and their proximity to residential development are explored and measured. The spatial distribution of residential development in each of the three zones is also analyzed to examine the influence of metropolitan patterns on park accessibility and proximity. These emerging spatial measures offer a broader angle to address landscape inequality and resilience in future design and planning.

Keywords: Public parks, urban sprawl, residential development, resilient landscape

1   Introduction

The concept of resilience has been studied in interdisciplinary science and has progressively shifted into coupled terms such as disaster resilience and socio-ecological resilience (HOLLING 1973, WANG et al. 2020). Landscape resilience is a connected term that integrates landscape ecology, resilience, and sustainability to reflect the coupled human-nature relations (CUMMING 2011, PLIENINGER & BIELING 2012). Applying the principles of landscape resilience to urban dynamics studies is crucial in mitigating the effects of environmental degradation, climate change, and disaster impact (MOREITZ et al. 2011). Rapid urbanization puts natural landscape into urban land use, countering landscape resilience. Addressing the impact of urban sprawl is particularly important in this regard. While many efforts have been made to enhance the landscape and minimize environmental degradation, some are limited to on-site design and facilities planning, not fully addressing the role of regional urban growth. A comprehensive approach is needed to promote a resilient landscape that reconciles the relationship between landscape efficiency and regional sprawling patterns. This study aims to capture the intrinsic values of the local and residential landscape by examining the impact of regional urbanization on public parks. Exploring spatial indicators, the study investigates the influence, structure, form, and distribution of public parks in the urban environment.

Selecting suitable indicators for measuring public parks and residential development remains a challenge for landscape resilience research and landscape design. Some existing park indexes (e. g., Park Score Index) have been put into multiple metrics (e. g., acreage, access, investment, amenities, equity) to assess the quality of the city park systems (PARK SCORE

INDEX 2022). ParkServe, for example, uses ParkScore to compare demographic features in U.S. cities (PARK SERVE 2022). However, finding what parks or park systems need in an area by applying only common indicators at the city level is inappropriate. The regional level extent lacks interpretation. How can suitable indicators that are better applied and reflect the urbanized environment in the region be used? Resilient landscape design and planning rely on a science-based decision-making process (DE GROOT et al. 2010), making the development of metrics that better capture park access and residential trends critical. This study addresses two key research questions: 1) how can complex models of residential development and park accessibility/proximity be linked to reflect metropolitan patterns? 2) What broader geographic understanding is needed prior to the application of specific landscape plans and design details? To address these gaps, the study proposes a regional park access metric that includes indicators of park service area and their proximity to residential development.

The objective of this study, which is conducted in the Orlando Metropolitan Region, Central Florida, USA, is to: 1) analyze the process of urbanization and its impact on parks in metropolitan zones; 2) examine any existing patterns of park distribution in relation to residential typologies by utilizing two key indicators: park service area and proximity to residential areas; 3) compare the differentiated regional patterns with residential typologies.

Our study is based on the following hypothesis: Park indicators are influenced by metropolitan patterns. This hypothesis is being tested against the null hypothesis, which states that park indicators are not influenced by regional urbanization patterns. The goal is to determine if parks display variability in discrete metropolitan zones, spatially. In return, the captured park patterns can provide a deeper understanding to inform regional landscape design and planning for a more resilient landscape.

2 Materials and Method

We conduct our study within the boundaries of the Orlando Metropolitan Region, which encompasses the two counties of Orange and Seminole in Central Florida, USA. To carry out our research, we utilize two primary datasets. The first dataset is the 2019 parcel dataset obtained from Florida Parcel Data Statewide (fgdl.org), which we clean and reclassify into three categories: multiple-family, single-family, and other residential. The second dataset is the park and the recreational dataset obtained from the Florida geographic data library (FGDL), which provides information on public parks in 2019. Our study area encompasses 631 parks, including various types such as city parks, county parks, facilities, sports, nature, trial, camping, boating, beach, and local parks.

The metropolitan zones of Orlando have been extensively documented, featuring a sprawl structure that is typical of the region (WANG & MURTHA 2019, WANG & MURTHA 2023). The three zones are defined based on the distance from the city center: core (2-8 miles), intermediate (8-12 miles), and periphery (12-18 miles). To analyze the relationship between park indicators and metropolitan patterns, we calculate Euclidean distances using the parcel level data for two typical indicators: park service area and their proximate residential. We apply network analysis in ArcGIS Pro to measure service areas of parks with respect to different residential typologies. Based on previous research (NICHOLLS 2001, WOLCH et al. 2005), we set walking distances of 1 km and 2 km for residents, as these are considered suitable thresholds. The proximity of residential lands to parks is measured using a program written in Py-

thon language that calculates the average distance of residential to parks (DIST) and the average weighted distance from residential to parks (WDIST). The latter is calculated by weighing the distance to parks based on the park area.

3   Results

3.1   Metropolitan Zones and Parks

The Orlando Metropolitan Region has undergone significant urban development, particularly in areas located between 8 and 14 miles from the city center (WANG & MURTHA 2023). This growth has resulted in a historical association between the number of parks and metropolitan influences shaped by the urban context. Examining four decades of change from 1970 to 2010 (Chart 1), both the urbanized parks' context and urban land development show increasing trends within 2 to 8 miles, and declining trends at 12 to 18 miles. However, in the 8 to 12 miles sprawling structure, the trend is reversed, with increased urban growth correlating with a decline in the number of urbanized parks. In other words, despite high rates of urban expansion, fewer parks are distributed within the sprawling structure between 8 and 12 miles in the Orlando Region. To reflect this theme of sprawl-parks, three typical metropolitan zones have been defined in the region: the urban core area (2 to 8 miles), intermediate (8 to 12 miles), and periphery (12 to 18 miles).

Chart 1: Percentage change in numbers of urbanized parks vs. urban land development on sprawl structures between 1970 and 2010
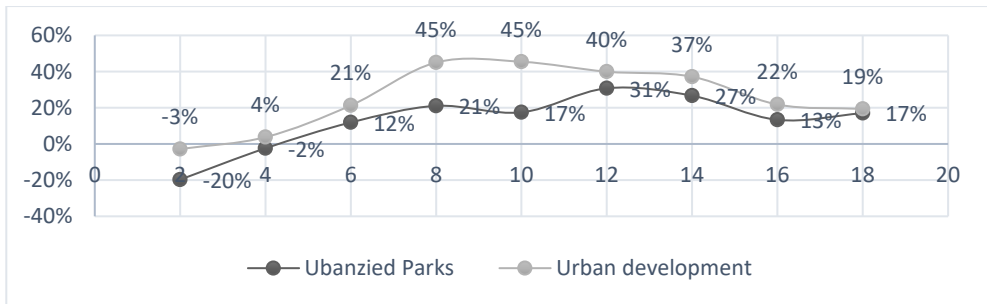

Note: Horizontal axis represents distances (in miles) to the city center of Orlando. The vertical axis represents percentage changes.

3.2   Indicators

3.2.1 Park Service Area

Our results reveal the specific residential typologies that can be accessed by parks based on the number of residential lots and area of residential served by parks. Figure 1 illustrates the total area of parks served (within a walking distance of 0-1km and 1-2km) in the Orlando Metropolitan Region across three metropolitan zones. The clustering patterns are diverse in each zone, with the most pronounced clusters located in the core zone, near the city center. Although some scattered clusters are found at specific locations (e. g., near transportation routes), the intermediate and periphery zones exhibit uneven trends in their serviced patterns.
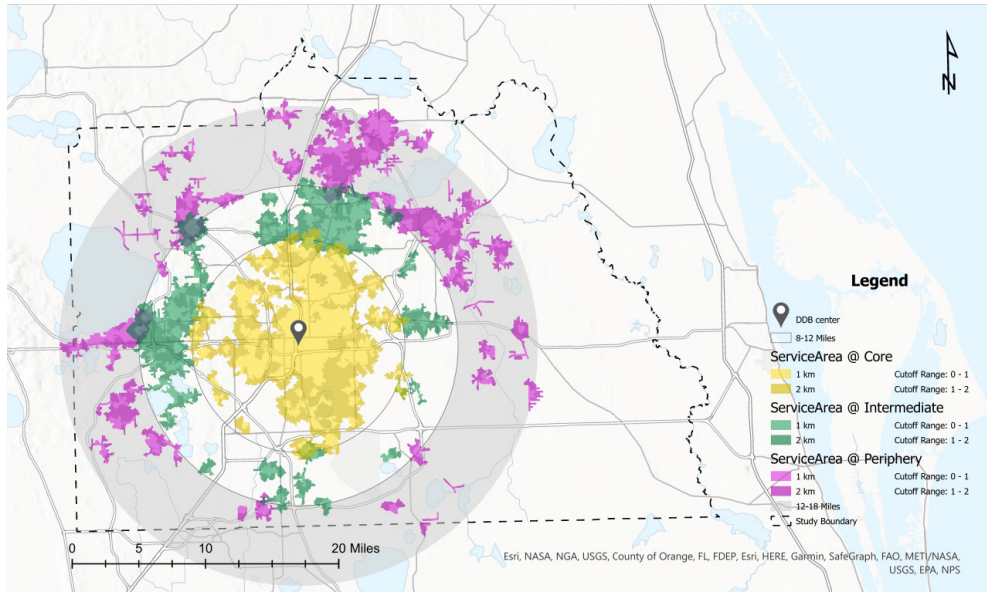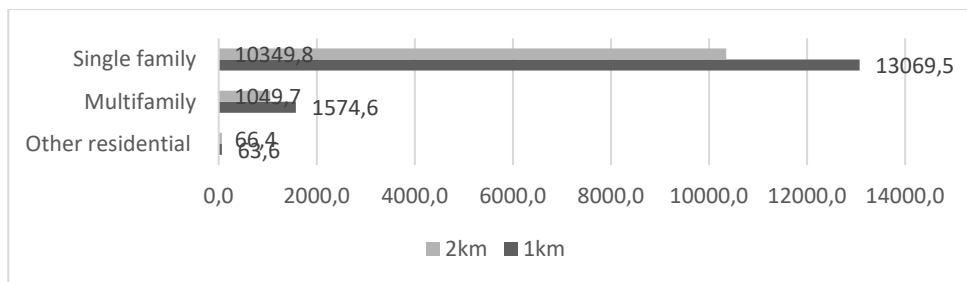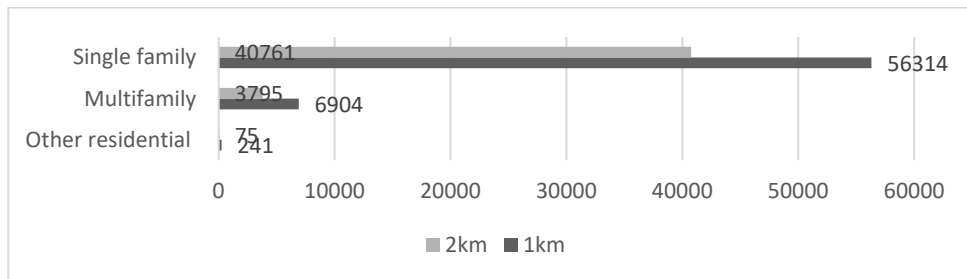
Note:1km means 0-1 km walking distance; 2km means 1-2 km walking distance.

Fig. 1:   Park Service Area in the Orlando Metropolitan Region

In detail, charts from 2 to 7 illustrate the number of residential lots and areas served by parks within 1 km and 2 km walking distance in the three metropolitan zones. The results show that the core zone of the Orlando Metropolitan Region serves a greater number of households and residential areas than the intermediate and periphery zones. The core zone's early investments in landscape infrastructure are reflected in the higher number of households and residential areas served by parks within a 1 km walk as compared to a 2 km walk. Conversely, in the intermediate and periphery zones, parks serve a greater number of residential lots and areas within a 2 km walk than a 1 km walk, highlighting the trend of sacrificing park spaces for housing in these areas. This shift away from public open spaces like parks in recent developments, especially in the form of single-family housing with backyards, leads to decreased access to parks for health purposes and undermines park space's social and environmental benefits.

Charts 2 & 3: Core zone: # Residential lots vs. Residential area (acre) serviced by parks
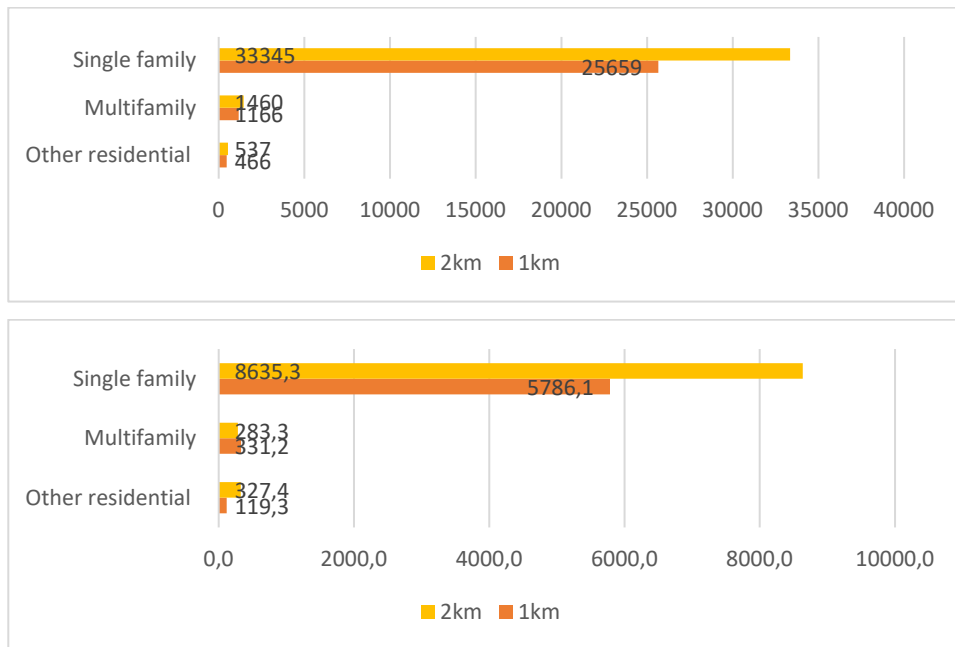

Note:1km means 0-1 km walking distance; 2km means 1-2 km walking distance.

Charts 4 & 5: Intermediate zone: # Residential lots vs. Residential area (acre) serviced by parks
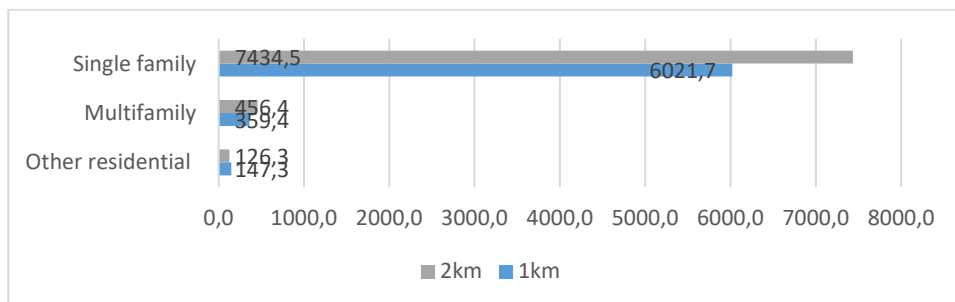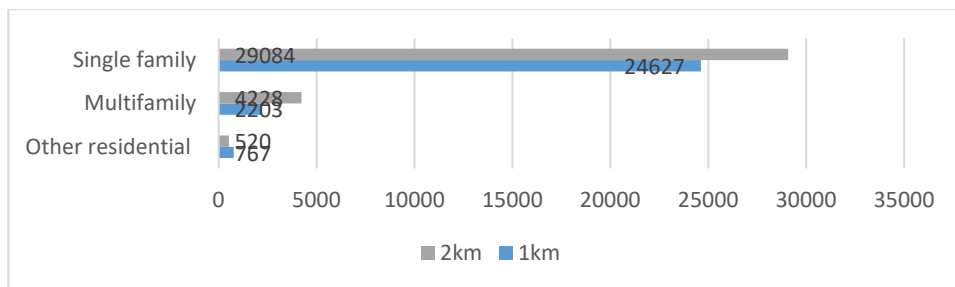
Note:1km means 0-1 km walking distance; 2km means 1-2 km walking distance.

Charts 6 & 7: Periphery: # Residential lots vs. Residential area (acre) serviced by parks

Note:1km means 0-1 km walking distance; 2km means 1-2 km walking distance.

The trend of increasing housing construction in the Orlando Metropolitan Region has brought to light the park availability issue for different residential areas. As shown in Chart 4, parks in the intermediate zone serve the least number of single-family households. The imbalance of park provision to residential areas in the 8-12 mile range from the urban center suggests different demographic communities may be experiencing less access to park infrastructure. In the region, single-family housing continues to be the dominant trend in urban development, while multi-family housing and other residential types are less influenced by park service area measures. However, it is worth noting that parks in the intermediate zone serve more multi-family housing compared to other zones.

At the regional level, our results illustrate a spatial disconnect between typical residential patterns and the supply of parks. Simply, while Orlando's metropolitan landscape has many parks servicing communities, there is an uneven distribution. First, greater park accessibility has benefited people near the downtown core, which can be attributed to early historic urban growth. On the other hand, there is a lack of park access in the intermediate zone. This has been addressed in the newer developments in the periphery far from the urban center, but remains a factor in the intermediate zone. As a result, Orlando's intermediate zone is a uniquely sprawling area that needs further examination.

When interpreting the above results to a regional extent, our findings demonstrate an inequality of park service areas in Orlando's metropolitan area. People residing near the downtown core have benefited from better park accessibility and recent urban design and planning efforts. However, those who chose to live away from the urban center, specifically in the intermediate zone, have limited park access but with single-family housing, including back-

yards. How are parks being valued by residents? For example, what unique combination of features in the intermediate zone has made parks in a sprawling area that deserves further study.

3.2.2 Park Proximity to Residential

We are also looking at how the proximity of parks to residential areas varies by metropolitan zone and type of residential, specifically on average distance and average weighted distance. In Charts 8 & 9, parks at the periphery have a greater distance from residential between three residential types. In contrast, the core zone of the study region shows shorter average distances to parks. Those distinct trends highlight the impact of sprawl patterns over the proximity of park infrastructures. As we move from the city center to peripheral areas, both the average and average weighted distances between parks and single-family and multiple-family housing increase for all three metropolitan zones. For other residential lands, there is no significant difference in proximity to parks between core and intermediate zones. However, compared to multi-family and single-family, other residential lands are further away from the core, indicating a less favorable location for this type of development.

Chart 8 & 9:   Average distance (meter) vs. Average weighted distance (meter) from residential to parks in three metropolitan zones
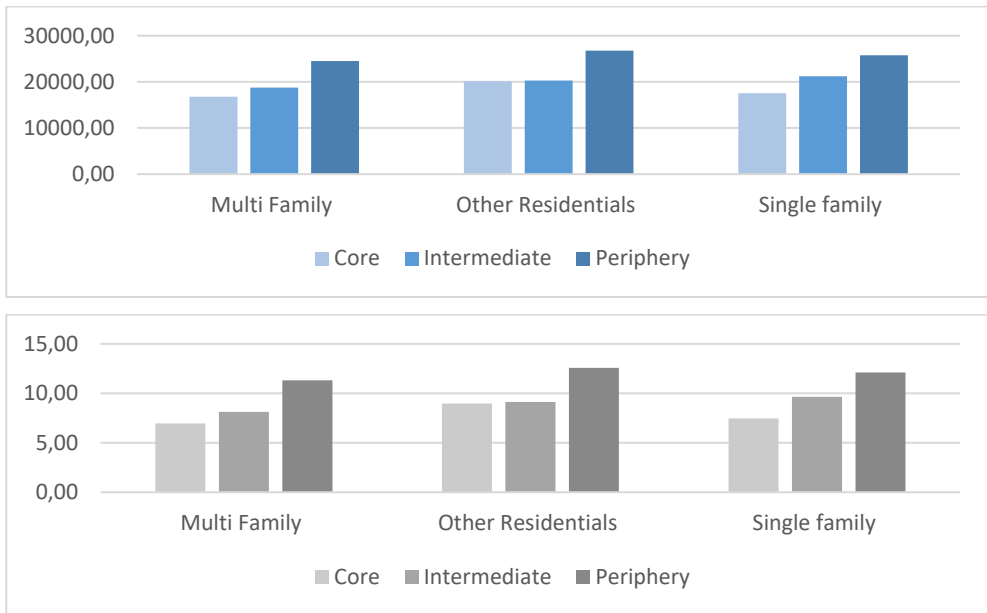
4   Conclusion and Outlook

This study adopts two important spatial indicators, park service area and park proximity to residential, to reveal the urbanization influences in Orlando Metropolitan Region. The areas, numbers, and distances of residential land use to parks are examined based on the spatial

measurements within typical metropolitan structures in Orlando Region. The study reveals several significant findings: 1) The core zone of the study area has the closest proximity between residential and parks, with a large area of residential land use. However, in the metropolitan area beyond the core zone, there are declining trends in both park service areas and park proximity. 2) Early planning actions have significantly contributed to the core zone, where has the dominant access to park infrastructures, but these benefits decreased as one moves away from the urban center. 3) The study highlights that single-family housing is the typical form of urban development and has a major impact on residents' access to a nearby park. In particular, the periphery has the least number of single-family and multi-family that are serviced by parks. 4) The intermediate zone has a lack of parks, which calls for further study to examine the multiple factors behind this phenomenon.

As a pilot study, our study proposes that two spatial measures of a regional landscape examination are an integrated approach to enhancing resilient landscape design and planning. By examining the regional spatial patterns of parks and their coupled human-nature relations, our study offers a new perspective on evaluating parks' master plan priorities. In the future, we aim to integrate demographic factors into this research by exploring the correlations between race, age, income, and residents' preferences. In this regard, we aim to address inequality further in a resilient landscape.

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