Park Suitability Index: Developing a Landscape Metric for Analyzing Settlement Patterns in the Context of a Rapidly Urbanizing Area in Central Florida, USA

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Abstract: Central Florida has experienced sustained and substantial urban land expansion over the last half-century. In Florida, urban expansion intersects natural and human systems. Investigating the relationship between landscape conditions and urbanization processes in Central Florida, therefore, requires a critical assessment of local natural and human conditions through time. In this paper, we examine the relationship between urbanization and landscape patterns through the lens of urban public parks. As a vital component of landscapes, parks reveal patterns and processes that influence landscape ecology in urban settlements (TURNER 1989). To better understand the multiple influences of natural and human factors on park design and planning, this paper introduces the idea of a park suitability index (PSI), which is targeted at quantifying the form, function and distribution of parks as they compare to settlement patterns. Critically, the PSI combines multiple measures into a single comparative metric for informing land use planning and landscape design for urban parks. Using a sample of 12 Orlando parks and a subset of variables, we develop the framework for a methodology that defines key parameters of the PSI for use in urban design and planning. Specifically, we evaluate the influence of urbanization patterns on park resource availability and diversity. In addition, we examine community-level functions of parks by considering the form and distribution of parks as compared to settlement patterns. These analyses provide the baseline for developing a more generalizable PSI for use in landscape planning both in Florida and elsewhere.

Keywords: Geodesign, urbanization, settlement patterns, Orlando Florida, urban parks

1 Introduction

Parks are critical elements of human life in the Anthropocene, bridging the benefits of public health and environmental conservation in increasingly urbanized settlements. The quality of parks is highly dependent on the condition of their natural and built landscape characteristics, including water access, recreational infrastructure, and surrounding land use contexts. In a broader context, parks can also be critical sources of ecosystem and community services. They provide essential opportunities for recreation, and as a natural heritage resource, often give a spiritual sense of belonging and other cultural services for surrounding communities (FAO 2007). Additionally, parks have been shown to be a possible environmental factor for encouraging public health (STURM & COHEN 2014). It has also been demonstrated that positive mental health status is associated with the green space found not only in nature-focused parks, but also in recreational and sporting parks (WOOD et al. 2017). Given all the important functions and social roles of parks, identifying a clear, culturally informed methodology for measuring park quality and needs can offer important information for designers.

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In this paper, we discuss the definition and development of a Park Suitability Index (PSI), a park-level urban landscape metric, that can be used to assess landscape conditions, park function and form, as well as other relevant attributes for understanding the quality of particular parks within a given urban context. Although the particular types of activities or amenities may vary across parks in different contexts, the overarching functions and values associated with urban parks may show similar patterns. Our pilot study focuses on the Orlando Metropolitan Region, an area known globally for its theme parks and other tourism features (e. g. Universal Studios, Walt Disneyworld, SeaWorld, etc.). As such, this region is particularly interesting for also studying the importance and functions of local urban parks, because so much of the recreational infrastructure is designed for tourism and not open to communities.

We compared the unique and overlapping attributes from 12 Orlando parks to develop a preliminary PSI, which was then used to explore the possible interrelationship between park characteristics and urbanization patterns. By analyzing historical land use change and urbanizing processes, we also speculate how park distribution and size have been influenced by settlement patterns in Orlando at both the individual and multi-park levels. In addition, each park was described according to its primary features, such as recreational amenities, walkability, proximity to settlements and other variables. The final scoring PSI demonstrated the spatial distribution and physical features of parks that have been primarily influenced by the rapid process of urbanization in this region.

1.1 Site Selection and Study Context

At the broader regional scale, the Orlando Metropolitan Region covers 862,720 acres and includes both Orange and Seminole Counties. Within this region, there are a total of 621 community and neighborhood parks which make up 27,721 acres of public land. Not including state or private parks, the ratio of community and neighborhood level public parkland to other land use types in the region is 3.2 %. According to our previous historical land use change study in Orlando (MURTHA et. al. 2019), over the course of a half century of urbanizing processes, most parks in the Orlando metropolitan region are located in urban core areas. Zooming into the city scale, currently 196 parks are situated within 5 miles from the Orlando urban center and constitute 32 % of public parks in the region as a whole. However, these parks only occupy 8.6 % of the total parkland area, based on calculations from dataset at Florida Geography Data Library (FGDL 2019). In addition, within 5 miles of the urban center, 11.6 % of the total land cover is defined as residential and includes three main household (HHD) categories: low-density unit (LDU), medium-density units (MDU), and high-density unit (HDU) (FGDL 2019). Given the high number of parks within 5 miles of the urban center and our interest in comparing park distribution and settlement patterns, we chose to select our initial study sample of parks from those located within this 5-mile radius. These parks are notably all influenced by long-term urbanizing processes and high-density settlement patterns. All pilot study sites were located to the north of the urban center and were intentionally selected along a gradient of different acreage, functions, typologies, amenities, and social and ecological conditions (Figure 1).

We assessed publicly available data from the FGDL and other official online park resources in order to compile park-level attributes along out PSI themes for the 12 sampled sites. After ranking the most frequent amenities from the sample parks, the most common amenity identified was access to lakeshore, followed by the presence of walking trails, bike trails, and finally picnic facilities. About the low frequency amenities, some of these features actually highlight the unique aspects of particular types of parks. Such unique features include a wide range of amenities, for example: interpretive signs or infrastructure, municipal administration (e. g. museums, theaters, etc.), bird watching spots, golf courses, and bike trails.

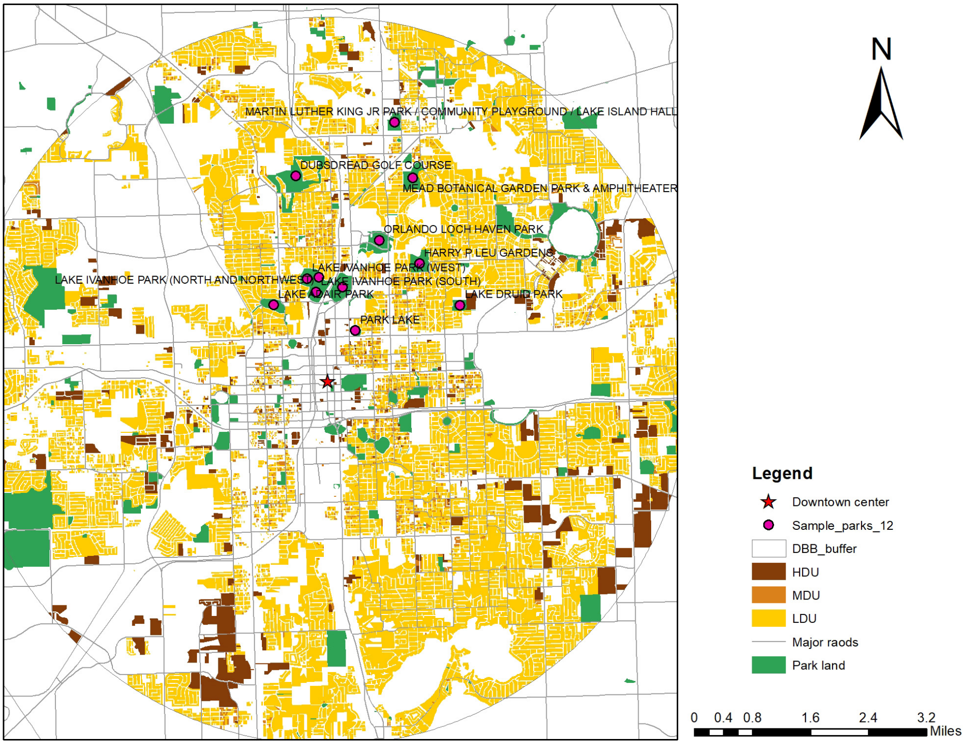

Fig. 1: Locations of sample parks

2 Materials and Methods

In order to explore landscape metrics and evaluate individual grades across parks, we calculated the PSI score for the sample parks based on the following variables: DC, MAP, MCP, UH, AH, GN, PA, TC, TRL, PLG, PCF, NAP, NEP, and WA (see Table 1). Park locations, attribute data, and land use/land cover (LULC) were obtained from Florida Geography Data Library (FGDL 2019), along with additional information from Orange and Seminole Counties. Sample areas were drawn around the Orlando Metropolitan Area. Since this work is part of a broader Geodesign project focused on Orlando and greater Central Florida, the map formats are based on the standards established by the International Geodesign Collaboration. In addition, a site visit was made by the lead author to Orlando in January 2020 to investigate several parks firsthand.

In this study, we first evaluate the PSI on sample parks. These PSI measurements are subject to the methodologies under which each variable was calculated. To assess the efficacy and interpretation of each variable within the PSI, we started with a small subset of variables upon which we anticipate expanding in future studies. We filtered the data and used the network analyst tool in ArcMap in order to measure the proximity of households and parks along several dimensions. In addition, each map in this paper visualizes the range of serviced households at particular thresholds away from each park, thereby conveying additional information about the relationship between park and residence locations. Second, we evaluated the form and distribution of parks through the lens of PSI, especially in measuring the proximity and walkability for individual parks and compare these results to other variables about park functions and amenities. Finally, we discuss the relationship between sprawl or settlement patterns and PSI scores across the geography of Orlando.

2.1 Outline of Multi-Park Analysis and PSI Development

There are a significant number of potential variables that could meaningfully inform the development of a park suitability index. In our study site, we chose variables that most closely reflected the diversity and uniqueness of functions and forms for local parks. Given current social and environmental justice issues such as unequal access to green spaces, gentrification, and social inequality, we selected particular variables to begin to address some of these concerns. The particular metrics and overarching themes informing the PSI are outlined in Table 1. Moreover, we also assessed several proximity metrics to better understand the distribution and accessibility of parks as a whole within the city of Orlando. Major selected variables include 1) proximity, 2) walkability, 3) connectivity, 4) amenities, and 5) typology, each of which is explained in detail below.

Proximity is adapted from the measurements of Apparicio and colleagues and is metric assessed at the multi-park scale within a city and for individual parks (APPARICIO et al. 2008). In assessments of the relationship between green space proximity and health, a maximum walking distance of 400-1600m from one's residence to the nearest greenspace providers is seen as an appropriate distance (NICHOLLS 2001, WOLCH et al. 2005). We followed this guideline and added an additional threshold of up to 2000 m. We further divided proximity measures into several additional metrics. First is the park-level index of the distance to the closest residence for each park. Other proximity measures were calculated as a city-wide attribute of all parks. Using the near tool in ArcMap, we calculated the distance to the closest residence from each park. The mean of the 12 parks' collective closest distances became the MAP metric. In addition, we calculated the mean distance of residences within particular thresholds away from each park. These thresholds include residences between 0-400 m, 400-800 m, and 800-2000 m away from each park. These metrics were then averaged across all 12 parks in our study sample. Collectively, these proximity metrics offer insights into evaluating the role of parks in provisioning services for local needs.

Walkability emphasized how many residences are potentially able to easily walk to a given park in specific distances. For instance, more than 100,000 Orlando residents must walk a further than 1000 meters to the nearest park (GILLESPIE 2018). Although previous studies suggested that 800 m is the maximum suitable walking distance from residences to the nearest greenspace, we used the threshold of 2,000m, which more closely reflects the reality faced by many Orlando residents (BROWNING & Lee 2017, MIYAKE et al. 2010). For each park, the number of households within a 2000 m walking distance was calculated (UH variable). These individual park calculations can be averaged to understand walkability across the sampled

Orlando parks. In addition, we calculated the total acreage of residential areas within the 2000 m walking distance from each park (AH variable).

Connectivity is calculated following the Fragstat method, which highlights landscape structure and connectivity (MCGARIGAL 1995). Several perceived landscape patterns such as the greenness areas and tree coverage are taken into account. This metric is not included in this pilot assessment but is an area for future development.

Amenities describes the available features and infrastructure within each park. These data were collected from publicly available databases and are subject to potential limitations based on data availability. An assessment of amenities in Orlando parks involved creating binary variables for each type of amenity including walking trails, biking trails, playgrounds, and picnic facilities.

Typology is an assessment of specific categories of parks based on a combination of park self-assessment and researcher expertise. Within the Florida Geography Data Library, parks are categorized into nature parks, water access parks, and neighborhood parks. These categories follow typical park patterns in the United States and will vary across different social and national contexts.

Table 1: Park suitability index components (compiled after APPARICIO 2008, NICHOLLS 2001; WOLCH et al. 2005, BROWNING & LEE 2017, MIYAKEL et al. 2010, MCGARIGAL 1995). Shaded boxes indicate multi-park variables, while unshaded boxes represent individual park-level variables.

Themes	Acronym	Park Suitability Index
1. Proximity	DC	Distance to the closest household
Multi-park proximity variables	MAP	The mean distance to all parks.
	MAP1	The mean distance in 0-400 m for all parks.
	MAP2	The mean distance in 400-800 m for all parks.
	MAP3	The mean distance in 800-2000 m for all parks.
	MCP	The mean distances in ranges of 0-400 m, 400-800 m, and 800-2000 m proximate to parks.
2. Walkability	UH	The numbers of household units within 2000 m walkable distance.
	AH	The acreage of households within 2000 m walkable distance.
3. Connectivity	GN	The ratio of greenness.
	PA	The acreage of individual park
	TC	Tree coverage
4. Amenities	TRL	Walking trails (Y/N)
	BT	Biking trail (Y/N)
	PLG	Playgrounds (Y/N)
	PCF	Picnic facilities (Y/N)
5. Typology	NAP	Nature parks (Y/N)
	NEP	Neighbourhood parks (Y/N)
	WA	Water access (Y/N)

3 Results and Discussion

We used the PSI to assess the typology, functions, and structures of sampled parks, which are evaluated across different land use categories. Here, we describe the results related to 1) the description of sample parks; 2) the distribution of PSI; and 3) what PSI tells us about urban sprawl patterns observed in prior studies (MURTHA et al. 2019).

3.1 Description of Sample Parks

To evaluate how parks are influenced by urbanization, the proximity of sample parks to various housing density areas (LDU, MDU, HDU) are listed in Table 2. Several proximity metrics are calculated, as described in the PSI overview section above. According to the multi-park level proximity analysis, the MDU type residential areas are on average closer to parks (443 m) compared to either LDU (649 m) or HDU (514 m) residential areas. Using the traditional buffering methods, we also examined the residential patterns for households within 2000 m walking distance to the sample parks (Table 3). For each park and residential density type, the distance to the nearest household was calculated. These park-level distances were then averaged across all 12 sample parks to yield the average distance from the parks to the closest residential units. Without considering the road networks, residents who live in the LDU were the least distance (183 m) on average to parks, MDU were in the middle (359 m), while the HDU had the furthest distance away from parks (493 m).

Table 2: Multi-park proximity measurements

HHD Categories	MAP	MCP1	MCP2	MCP3	MCP4
LDU	649	372	486	604	882
MDU	443	347	491	600	836
HDU	514	310	484	647	859

3.2 The Distribution of PSI for Individual Parks

PSI also reveals the performance of individual parks. From the PSI assessments conveyed in Table 3, it can be seen that although Park Lake has the smallest acreage of 11.751 acres, it actually was the shortest distance to the nearest household of all the parks (117 m) and served the greatest number of residential units (within the 2000 m threshold). On the contrary, Lake Ivanhoe Park (West) was larger, at 22.423 acres, but has the furthest near distance of all the parks and serviced the least number of household units. Despite these differences in accessibility and size, from a typology and feature perspective, these two parks share the common features of being nature parks and providing lake access.

Our preliminary assessment of the PSI involved directly ranking parks relative to one another based on their respective scores for each variable measured. Future efforts will improve limitations arising from this calculation method, but for this pilot, we relied on direct ranking. Based on each park's value for each variable, we ranked them from 1-12. The highest score of 12 was assigned to the largest number of park acreage, the nearest distances, most serviced households' acreage, and most serviced units. Because HDU serve more people than LDU, we assigned a full score of 12 to HDU and a half score of 6 to LDU. Individually, PSI scores enable the assessment of performance across the sample parks in a manner that can be easily listed and offer pathways to identifying the major differences across parks. However, as variables differ by multiple hidden dimensions, the scoring process requires a follow-up study for discussing the methods of proportioning in variables.

3.3 PSI vs. Urban Sprawl

Comparing PSI scores to urban sprawl patterns (Figure 2 & Table 6), we can start to explore how PSI reflects or is influenced by historic patterns of sprawl (MURTHA et al. 2019). For

Table 3: Direct measures of variables within Park Suitability Index

Parks	PA(acre)	DC(m)	Proximate to HHD	AH(m)	UH
Harry P Leu gardens	42.305	198	LDU	304	1480
Gaston Edwards Park	43.508	320	LDU	303	1384
Lake Druid Park	19.704	229	LDU	208	1019
Orlando Loch Haven Park	41.184	268	LDU	283	1452
Park Lake	11.751	117	LDU	377	1857
Lake Adair Park	28.244	154	LDU	247	983
Lake Ivanhoe Park (S)	40.625	265	MDU	134	531
Lake Ivanhoe Park (W)	22.423	413	LDU	94	256
Martin Luther King Jr Park	25.172	148	LDU	274	1332
Mead Botanical Garden Park	45.398	213	LDU	220	1038
Dubsdread Golf Course	124.206	340	LDU	251	1102
Lake Ivanhoe Park (N& NW)	22.382	183	LDU	134	581

example, three parks that are 1.5 miles away from the urban center (Lake Ivanhoe Park (West), Lake Ivanhoe (North and North West), and Lake Ivanhoe (South)) all had relatively lower PSI scores, with Lake Ivanhoe Park (West) having the lowest PSI score overall. By contrast, Harry P Leu Gardens, which has the highest PSI score, is located even further from the urban core, 2.5 miles distant. Within the 1.5 miles radius of the urban center, the remaining PSI ranks vary considerably. Moving further from the urban center, at the 2.5-mile radius scale, there are also no clear patterns in park rank based on current PSI indicators. This does not necessarily indicate that there is no relationship between sprawl and park-level attributes, however, it does suggest a potential limitation in our current evaluative metrics. In order to more clearly disentangle the relationship between park amenities and urban sprawl, future work on refining PSI indicator variables will be an important next step.

In addition to assessing overall park suitability as it relates to distance from urban cores, it is also critical to consider the relationship between park location and park function. Comparing the two parks that are closest and furthest from the urban center highlights the diversity of park functions within Orlando. The farthest park, Park Lake is the smallest park with water access, while the closest park, Martin Luther King Jr. Park, is similarly a smaller park although it can be classified as a mixed recreation park with multiple amenities catering to community needs. Although these two parks are similar in size, the park furthest from the urban core has only one notable park feature while the closest park has multiple functions.

This suggests a possible relationship between park location and diversity of park functions. In our future work we plan to both expand our sample size and work to clearly define distinct categories of park functions.

In our previous work, we assessed historical land use change, urbanization patterns, and park distribution in Orlando over 40 years in order to evaluate variables for inclusion in the PSI metric (MURTHA et al. 2019), here we expand upon this analysis. Investigating the spatial distribution of PSI variables – namely, park functions – reveals a complex pattern. For instance, Florida's largest rose garden – Harry P Leu gardens – not only services the nearby settlements within the urban core, but also has several important and unique functions including maintaining a historical home and delivering educational programs. In addition, Harry P Leu gardens services a high number of households despite being further from the urban core, while two other sampled parks – Lake Druid Park and Orlando Loch Haven Park – conversely were closer to the urban core but serviced the least number of households out of all sampled parks. In addition, our preliminary analysis did not fully reflect the total service area for some of the parks, such as the Lake Ivanhoe cluster of parks. Upon observations of the street networks during a site visit in January 2020, it seems that these parks may in fact serve a wider community than was previously understood. A follow-up analysis on the Lake Ivanhoe parks cluster will be needed to more accurately assess park service areas.

Table 4: PSI and settlement patterns

Park	Type	Sprawl dist. miles	PSI
Harry P Leu gardens	Nature park/Gardens	2.5	1
Gaston Edwards Park	Nature park/Boat ramp	1.5	3
Lake Druid Park	Neighbourhood park/Open space	2.5	10
Orlando Loch Haven Park	Neighbourhood park/Cultural park	2.5	4
Park Lake	Nature park/Water access	1	2
Lake Adair Park	Nature park/Water access	1.5	7
Lake Ivanhoe Park (S)	Nature park/Water access	1.5	8
Lake Ivanhoe Park (W)	Nature park/Water access	1.5	11
Martin Luther King Jr Park	Neighbourhood park/Mixed-use	4	4
Mead Botanical Garden Park	Nature park	3.5	5
Dubsdread Golf Course	Neighbourhood park/Golf course	3	6
Lake Ivanhoe Park (N&NW)	Nature park/Water access	1.5	9

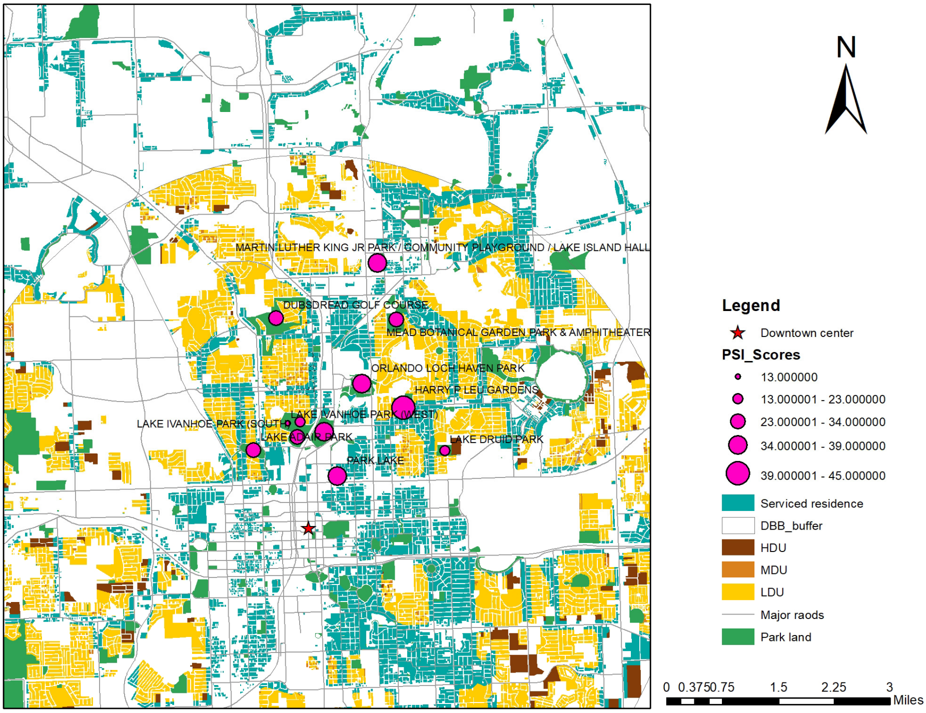

Fig. 2: Distances to the closest parks by PSI via measuring 2000 m distances around parks

4 Discussion and Outlook

Based on this preliminary PSI analysis of parks and settlement in central Florida, we are certain that PSI can offer critical information for design and planning, but there is much work to be done. Here, we discussed and quantified the unique feature of distances within the variables of proximity and walkability and explored their potential relationship with other dimensions such as typology and amenities. On average MDU residential areas were closest to parks while LDU residential areas were furthest from parks. Moreover, these data suggest that the relationship between park walkability and other features such as proximity and number of households served may be complicated by additional factors such as park amenities or typologies. For example, one of the parks, Park Lake, is unique in that both small and serves the highest number of residences within walking distance and is characterized by lake access. Our current sample is too small to draw generalizable conclusions, but this remains an area of interest for future investigations. In addition, during the lead author's site visit observations, it was found that although some parks appear on the map to be adjacent to residential areas, access to some parks, such as Lake Druid Park was actually blocked by a fence which only obstructed access from surrounding neighbourhoods making local use difficult. This suggests that a follow up study would benefit from considering the methodological limitations of measuring distance and walkability through major road networks, which may miss local neighbourhood road networks as well as particular nuances of access specific to individual sites (e. g. fences or canals impeding access). To refine the PSI, we will consider additional datasets such as open street data, tree cover ratio, and greenness. Ultimately, the PSI methodology may offer insights that can be generalized to inform park planning and assessments across a variety of urban contexts.

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