Adopting Soundscape Technology to Assess Urban Landscape Performance

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Abstract: This paper documents, analyses, and discusses the sound levels in Klyde Warren Park in Dallas, Texas by conducting soundscape research as part of urban landscape performance. Relevant literature is reviewed and the recent developments in digital/mobile technologies in collecting, analysing, and communicating data in relation to physical environment is summarized. Researchers applied the grid method to collect and measure the sound data (MORRILAS et al. 2011). The analysis and findings reveals that varying programmed spaces of the Klyde Warren Park (KWP) produces different levels of sound pressures in different times of the day, and the week. Research also finds statistically significant difference in recorded sound pressures within the different times of the day. In conclusion, the research illustrates that the advancement of digital/mobile technologies allow landscape architects to study other dimensions of human senses/experience, specifically sounds, as part of comprehensive landscape performance studies.

Keywords: Soundscape, sound, grid method, urban landscape, Klyde Warren Park, preference, landscape performance, sound pressure levels

1 Introduction

Landscape architects are constantly seeking ways to create better environments for human experience and delight. To do this, the profession over the years attempts to respond all human senses (hearing, sight, smell, taste, touch) in some capacity through their design. Yet, some of the most essential qualities of human experiences, such as the sounds, are still not scrutinized to their fullest in landscape research to better understand urban landscapes.

Landscape performance research, which concern with the systematic evaluation of completed projects to assess their value, have gained a greater momentum with the recent years in United States (LAF 2015) especially with the advancement of digital and mobile technologies in collecting and analysing data, and the dissemination of knowledge. Although all human senses are identified as integral part of landscape practice and therefore its performance (MARCUS & FRANCIS 1998), sounds have not been systematically studied to better understand the human dimension of landscape architectural projects. Specifically the impact of sounds in relation to physical environment, one of the major subjects of landscape architects, architects, and urban planners (COM 2002), only start seeing stronger coverage in literature within the recent years (LAM 2015, ESCOBAR et al. 2012, MORILLAS et al. 2011).

Measuring and investigating sound levels, meanings, and preferences that are based on natural and/or artificial events are grounded by *World Soundscape Project* initiated by Murray Schafer. Sound pressure (generally a weighted sound pressure level) is a common concept that provides measurement and investigation of environmental based sound appropriately (KANG 2006). It is believed that gathering such sound samples by using state-of-the-art instruments plays a major role for measuring and simulating the soundscapes of the environment (ESCOBAR et al. 2012). By doing so, it contributes characterization and categorization

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of the existing auditory scenes. The measurement of sound levels is a cornerstone for examining the environment (ZANNIN et al. 2002). Integration of available technologies further allows researchers to incorporate many other factors in to consideration such as spatial distribution, climate impact, activity time intervals, demographic features and so on (ESCOBAR et al. 2012). Techniques to measure sound are also evolved over time but only small numbers of them is adopted in design and planning literature to study human preferences and needs in urban landscapes. In a similar way, there are limited number of studies that focused on sounds in urban landscape using grid method in the United States (COLLINS et al. 2013).

This paper evaluates the sound levels in Dallas's renowned Klyde Warren Park (KWP) to investigate the distribution and the impacts of sounds in urban landscape. The goal of this research is to study, review and examine the soundscape measurement tools and techniques available to landscape performance researchers to inform future practices. The paper is also an inquiry on improved methods and technologies in measuring sounds in order to better understand its implications. In the following section, paper briefly articulates the importance of research in relation to relevant research. Later, it covers the methodology adopted to achieve the goals and objectives of the study in urban landscape. Paper continues with results and discussing the relevance of study.

2 Literature Review

A review of literature illustrates that the influences of sound onto the human quality of life is unquestionable (MORILLAS et al. 2011) and understanding sounds as part of built environment has been a topic of research. ESCOBAR (2012) studied sounds in Caceres, Spain using grid method and found that there is more than 2 decibel (dB) difference in 400 meter grid sizes. Piccolo's research built on Sanchis early work and focused on six similar areas in Messina, Italy, and classifying the measured sound levels in the city (PICCOLO et al. 2004). In addition, sound/noise level, sound preference (YILDIRIM 2015), physiological and psychological impacts of sound (KANG 2007) are examined throughout the world using varying methods (MORILLAS et al. 2011, ESCOBAR et al. 2012, SANCHIS et al. 2000). Literature review reveals that there are hardly any studies focus on the relationship of sounds to a varying programmable spaces of a given urban landscape. Piccolo et al analysed 35 pre-selected measurement sites to represent different acoustic zones for an experimental measurement purposes (PICCOLO 2004). A comparison was applied between performed sound levels and limits by Italian noise standards (ROMEU et al. 2005).

Literature review also revealed that there are many techniques to measure sounds and noises for the points based assessment (BROWN 1987). The grid method contains an applying virtual grid on a map the he selected points of the grid are used for the measuring purposes. The size, distance, and shape of the grids can be changed for the associated purposes (ESCOBAR et al. 2012, ISO 1996-2). Even though there are some shortcomings of the grid method, it provides a useful sound assessment (BARRIGON et al. 2005) and there are precedents in literature who suggest the value of using grid method (ZANNIN et al. 2002 and MARTIN et al. 2006).

Literature review reveals that there is a need for more accurate and reliable methods, tools and techniques needed in order to accurately measure, assess, and communicate sounds especially in design and planning fields.

3 Methods

This research follows quantitative methods and systematically records sound pressure levels on evenly distributed nodes on a hypothetical grid overlaid Klyde Warren Park (KWP) to investigate the distribution of sounds in urban landscape. Researchers utilized the grid method to measure and to collect sound data (MORILLAS et al. 2011). SPL (Sound Pressure Level) in dB(A) unit is applied by L_{Aeq} 5 minute method (KANG 2006).

3.1 Study Location

Klyde Warren Park in Dallas, Texas is chosen for this study due to its immediate proven success as people place since the day it open in late 2012 (KWP FOUNDATION 2016). Furthermore the unique conditions of the park such as being in complex downtown setting surrounded by various types of venues, such as AT&T Performing Arts Center, Dallas Museum of Art, Nasher Sculpture Center, Morton Meyerson Symphony Hall, Perot Museum of Nature and Science over a highway, and heavy use by people made it an attractive location for such research (see Figure 1).

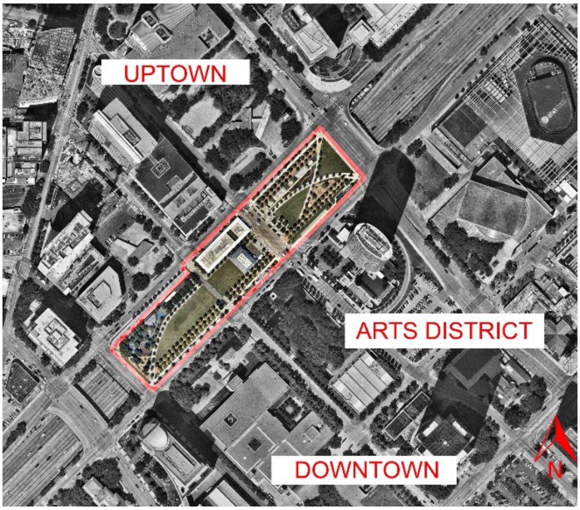

Fig. 1: Aerial View from Klyde Warren Park (NearMap 2015)

3.2 Data Collection Methods

The data collection for this research involved collecting primary and secondary data through systematic on-site sound recordings, site observations, and the review of available secondary data. The research followed quantitative methods and systematically record sound pressures on evenly distributed nodes on hypothetical grid overlaid on KWP. The grid size was selected 75 feet square shape providing 51 sound pressure level measurement points.

Fig. 2: KWP Defined Programmable Areas (LAF 2013)

Sound pressure level measurements were made using convenient sampling in the summer of 2015. Measurements were completed in one month period between the months July and August. The sound levels were measured weekdays and weekends at 10 am – 1 pm – and 4 pm. Each grid point was measured 8 times, thus there were a total of 408 sound measurements recording for the research. Convenient sampling accommodated researchers' schedules and scheduling preferences on the field. Recordings are done on different times/days of the week allowing uniform distribution along similar temporal period in one month period in late summer. Weather conditions were not severe during the measurements. So, there was not rain, strong wind, and extreme humid during the research. In addition, measurements were conducted 20 feet inside from the roads in order to concentrate on pedestrian landscapes rather than roadways surrounding the park.

4 Analysis and Findings

As it is introduced in the beginning of the paper the primary focus of the research is to investigate the sound levels of KWP using grid methods. Later data is reviewed using more detailed rigorous statistical methods to further understand soundscape of KWP.

The research findings reveal several insights and associations about the sounds of KWP. Overall the sound level measurements of the park yielded recordings between 62.1 and 96.5 dB (see Figure 3). The arithmetic average value of 408 measurements for the park is 70.5 dB and the median is 68.4 dB for the period under investigation. The descriptive statistics revealed that 90% of the sounds produced in the data collection points are within the acceptable (comfortable range suggested in literature is 60-80 dB for park visitors). As it is suggested earlier there were no severe weather conditions and average temperature was 94.5 degrees (between 86 and 102 degree) and average humidity was % 48 (between % 38 and % 59).

As anticipated the sound levels in weekends were slightly higher than the weekdays likely to due to weekend use and activity. While the average sound levels for weekdays was 70.2 dB, the average for weekends were 71.2 dB. Humidity and temperature slightly varied between the weekends and weekdays but not significant. Average humidity was % 50.5 and average temperature was 92.8 degrees in weekdays whereas average humidity was % 44 and average temperature was 99.5 degree for weekends.

Review of sounds measurements in different time intervals such as morning (10 am), noon (1 pm), and afternoon (4 pm) reveal higher sounds pressures at noon measurement which researchers attributes this to lunch hours visit in busy downtown. Whilst noon measurements had the highest sound pressure levels (average 74.6 dB), morning measurements had the lowest sound values (average 66.0 dB) and afternoon measurements were at the moderate level (average 69.4 dB).

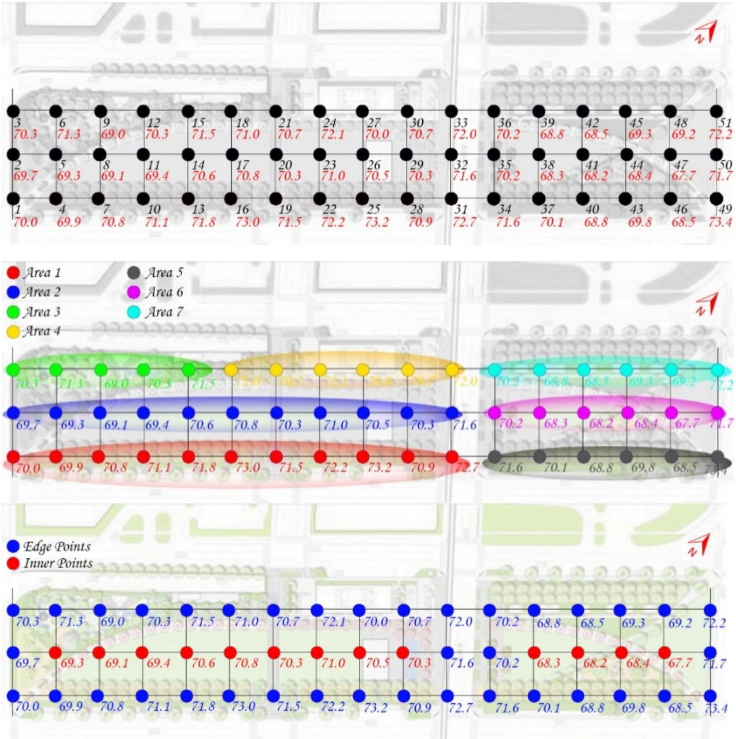

Fig. 3: Average sound pressure levels (dB) in the 51 grid points with programmable areas and inner/edge of the park (LAF 2013)

The park was divided into seven programmable areas (see Figure 2 & 3) in order to interpret the relationships between sound levels and designated programmable areas of the park. As it can be seen in Figure 3 and Table 1, Jane's Lawn area (1) has the highest sound level (Mean 71.56 dB). On the other hand, East Lawn and North East Jane's Lane area have the lowest sound levels. So, east part of the park is the quietest locations in overall. This is, particularly area 7 attributed to pedestrian/walking, created through the amenities provided in the park.

Once the preliminary review of the data is completed with descriptive averages further detailed statistical analysis conducted to understand any emerging patterns in data for the research period under investigation. Three questions looked at closely: (1) Were there statistically significant difference between the seven programmable areas of the park and the sound levels produced as a result? (2) Were there statistically significant difference between inner areas of the park and the outer data collections points? (3) Were the different times of the day, or weekends vs. weekdays produced statistically different sound levels? To do this, Analysis of Variance (ANOVA) test was performed to evaluate the relationship between the sounds and seven programmed area depicted for this research and T-test was used to interpret two variables such as weekends vs weekdays measurements and inner/edge measurements. The mean values of all 51 grid points were applied to analyze those tests.

ANOVA test is not revealed any statistically significant difference among the programmed areas of KWP for the period under investigation even though have been some differences in sound level averages among different parts of the park (see Table 1). For example the walking area near food trucks (71.5 dB) and children playgrounds (70.4 dB) have higher sound levels. In addition, east part of the park, particularly lawn areas (69.0 dB), is the quietest location in the park.

Table 1: Descriptive Information and ANOVA Results of sound levels of the 7 Programmable Areas

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	258.235	6	43.039	1.090	.368
Within Groups	15517.883	393	39.486		
Total	15776.117	399			

Sound Measurements and Programmed Areas

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 (Jane's L)	88	71.561	7.1362	.7607	70.049	73.073	65.1	96.5
2 (Great L)	88	70.233	6.6142	.7051	68.832	71.634	62.1	92.6
3 (Playgrnd)	40	70.478	5.8983	.9326	68.591	72.364	63.9	89.7
4 (Restrnt)	40	71.295	7.9609	1.2587	68.749	73.841	64.5	95.4
5(E.Jane's)	48	70.346	5.0772	.7328	68.872	71.820	63.1	83.5
6(EastLawn)	48	69.088	4.6395	.6697	67.740	70.435	64.7	83.7
7(N.E. Jane)	48	69.696	5.1150	.7383	68.211	71.181	63.5	84.0
Total	400	70.468	6.2880	.3144	69.849	71.086	62.1	96.5

T-test was applied for investigating the difference between the inner and the outer grid points of the park (see Figure 3). No statistically significant difference was found between inner and outer grid points. The reason might be caused by the location of the park since it is surrounded by freeways, high buildings, and not big difference in terms of vegetation and other design components. So, it may create a similar sound pattern in varying grid points.

However, the sound pattern of the edge of the park is higher (70.8 dB) than the sound levels of the inner of the park (69.5 dB).

T-test was also used for analyzing the sound pressure levels in weekdays and weekends. There is not any significant difference between weekdays and weekends sound levels. Even though there is not any significance for the measurements, sound levels of weekends are higher (71.2 dB) than the weekdays (70.2 dB).

At last different time intervals of the grid points were analyzed by using ANOVA test for the time intervals, ANOVA test was performed and there is significantly difference between different time intervals (see Table 2). Since Significance level (0.000) is smaller than p value ($p < 0.05$), there is significantly difference. After running Tukey test for the time intervals, while 1 pm has the highest (74.5 dB) sound pressure levels in grid points, 4 pm sound pressure levels have the lowest sound levels (65.9 dB). 10 am measurements have the medium sound levels (69.3).

Table 2: ANOVA Results for Times of the Day

ANOVA

dbgtime

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4707.300	2	2353.650	84.417	.000
Within Groups	11068.817	397	27.881		
Total	15776.117	399			

Descriptives

dbgtime

					95 % Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
0 (10 am)	100	65.958	1.2596	.1260	65.708	66.208	62.1	69.4
1 (1 pm)	150	74.550	8.2495	.6736	73.219	75.881	64.7	96.5
2 (4 pm)	150	69.391	2.2757	.1858	69.024	69.758	64.7	76.3
Total	400	70.468	6.2880	.3144	69.849	71.086	62.1	96.5

5 Discussion

This paper assessed the sound levels in Klyde Warren Park in Dallas, Texas by adopting technologies, tools and methods for soundscape research as part of urban landscape performance. As it is introduced in the beginning of the paper the aim of the research was three folded. First and foremost the research was an inquiry on relevant literature, improved methods and technologies in measuring sounds in order to better understand their availability, implication, and value for landscape research. Then, it was to measure and evaluate sounds levels in Klyde Warren Park in relation to different programmed components of the park as well as in relation to different times of the day and the week not only to test suggested tools and methods but also to provide insights to KWPs' design qualities. Last, it was to discuss the importance of sounds in urban landscape performance research.

The research illustrated that the advancement of digital/mobile technologies allow landscape architects to study other dimensions of human senses/experience, specifically sounds, as part of comprehensive landscape performance studies. The availability, affordability, and practically of the mobile tools and technologies within recent years provide researchers and professionals alike with new opportunities to study and assess complex landscape performance issues on the field.

Although literature was fairly limited in soundscape research in design and planning fields this research supports the importance of using empirical methods for greater research validity and reliability. This research adopts quantitative techniques and applies grid method to measure, analysis, and interpret the sound levels in Klyde Warren Park in an effective and economical way. The researcher finds that the technologies and methods adopted here can be replicable across multiple case studies.

The findings reveals that varying programmed spaces of the KWP produces different levels of sound pressures in different times of the day, and the week during the period under investigation. Paper highlighted three research questions (among many others reviewed): (1) Were there statistically significant difference between the seven programmable areas of the park and the sound levels produced as a result? (2) Were there statistically significant difference between inner areas of the park and the outer data collections points? (3) Were the different times of the day, or weekends vs. weekdays produced statistically different sound levels? The descriptive statistics revealed that over 90 % of the sounds produced in the data collection points are within the comfortable range suggested in literature (60-80 dB for park visitors) and there were only slight variation in sound levels in KWP even though 5.2 acre park is on a deck over an eight-lane highway in downtown Dallas. Even under such circumstances research captured statistically significant different among the times of the day measurements. Question one and two did not produced statistically significant results. This may be attributed to the level of use/activity present throughout the park during the time of the investigation over the hot summer months or to the limited design features segregating the different programmable areas of the park. In all cases soundscape research was informative in testing the tools and methods as well providing reliable methods.

The research also signifies the importance of understanding sounds in relation to landscape architecture research given that the profession is responsible for providing experiences for all five senses and sounds happen to be one of the important ones impacting people's experience and perception of urban landscapes. Even though some of the statistical tests were not as revealing, the research illustrate that many white sounds are generated through natural and man-made amenities that not only enhance user's perception of the KWP but also attract them to various parts of the park in different times of the day.

Research illustrated that the KWP has the highest sound levels near the food trucks, roads and children playgrounds. East part of the park is relatively quiet which seems intentional based on the programmed amenities provided on this side such walking paths, small lawns, pocket gardens, and dog parks while west part of the park offers many other services. Such information can be critical in evaluating the performance of an existing park to renovate it for future use or designing new parks or urban landscapes.

Landscape architects should consider the implications of sounds in their design. Even after designing and implementing the project, there are still opportunities to discover and solve the problems, or enhance spatial qualities of existing and future soundscapes. After all landscape architecture is constantly seeking ways to create better environments for human experience and delight and what better way to associate soundscape as part of built environment experience.

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