COMPARISON OF THE PERCEPTION OF FACILITY MANAGERS ON GREEN ROOFS ATTRIBUTES AND BARRIERS TO THEIR IMPLEMENTATION

A Thesis

by

EDUARDO RAFAEL FERRER GARCIA

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Jose Fernandez Solis
Co-Chair of Committee,	Bruce Dvorak
Committee Member,	Sarel Lavy
Head of Department,	Joe Horlen

August 2014

Major Subject: Construction Management

ABSTRACT

This study compares perceptions of facility managers on green roof attributes and barriers for their implementation. The population under study were the four IFMA chapters of the State of Texas (Austin, Dallas-Fort-Worth, Houston and San Antonio). A questionnaire containing 21 statements related to green roof attributes and 14 statements related to green roof barriers for their implementation was used and responses were measured on a five-point Likert scale. Two types of questionnaires were used to collect responses. An online questionnaire that was distributed through the chapter's members list, and face to face responses were obtained on IFMA chapters meetings. The response rate for the questionnaire was 7.7%. The nonparametric statistic method of Kruskal-Wallis was used to check for differences among the four chapters with respect to perceptions on a given statement. The responses suggest that facility managers generally agreed with the majority of the statements regarding benefits that green roofs can provide. Similarly, the majority of facility managers tended to agree with the statements regarding barriers for green roofs implementation. The results of the investigation for α=0.05 and a p-value=7.815 showed that no significant differences were found for any of the 35 statements with respect to the facility managers perceptions.

DEDICATION

I dedicate this study to God, for giving me the spiritual support every man needs in his life. To my parents for giving me the most precious gift as it is life. To Natalia, for giving me her love and support during this long journey. To Anabella, Isabella, Lise and Vigi for their affection and support. To my friends, for making every single moment of this masters special. To all my professors from kinder garden, through mid-school, high school and university, for taking time of their life to educate me. Finally, to all the people I have known in this life for making me what I am today.

ACKNOWLEDGEMENTS

I would like to thank my committee chair, Dr. Jose Fernandez Solis, my co-chair Professor Bruce Dvorak, and my committee member, Dr. Sarel Lavy for their guidance and support throughout the course of this research.

I also want to extend my gratitude to the IFMA chapters of Texas, especially to Ms. Melody Williamson, Mr. Erik Lind, Mr. Rich Johnson, Mr. Michael Friend, Ms. Lauren Pryor, Mr. Robert Mosher, Mr. David Duvall, Ms. Cyndi Felts and to all the facility managers professionals from the IFMA chapters who were willing to participate in the study.

Thanks also to Dr. Ben Bigelow, for giving me ideas to make this thesis approachable. Thanks to all my colleagues and the department faculty and staff for making my time at Texas A&M University a great experience.

Finally, thanks to my mother and father for their encouragement and to Natalia for her patience and love.

NOMENCLATURE

IFMA	International Facility Management Association
DFW	Dallas Fort Worth
FMP	Facility Management Professional
SFP	Sustainability Facility Professional
CFM	Certify Facility Manager
GRP	Green Roof Professional Accreditation
GRAG	Green Roof Advisory Group
LEED	Leadership in Energy & Environmental Design
LEED GA	LEED Green Associate
LEED AP	LEED Advance Practices
LEED BD+C	LEED Building Design + Construction
LEED O+M	LEED Operations + Maintenance
LEED ID+C	LEED Interior Design + Construction
LEED ND	LEED Neighborhood Development
UHI	Urban Heat Island
GRHC	Green Roofs for Healthy Cities

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

1. INTRODUCTION

According to the USGBC (2009), “the built environment has a vast impact on the natural environment, on human health, and on the economy. By adopting green building strategies, builders can maximize both economic and environmental performance”. As LEED certifications are becoming more common in properties in the United States, it is worth noting that a green roof can help a property obtain LEED credits.

The 2012 annual green roof industry survey conducted by GRHC, the North American green roof industry grew by 24% in 2012 over 2011, keeping up with the strong growth rates the industry has experienced over the past decade. Although the report does not show cities of Texas among the top 20 North American Metro regions with more square feet of green roofs installed, it does recognize the efforts of Austin to implement policies that promote green roofs (Erlichman, P., Peck, S. 2013).

Peck (2010) states that to assure the success of a green roof a combination of knowledge and expertise on different areas like horticulture, building waterproofing, structural engineering, project management, water management, growing media, state laws, building codes and maintenance is required. “Facility managers are the professionals that encompass multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology” (IFMA2013). Thus, facility managers should have some expertise on these areas in order to provide the adequate maintenance to a green roof during its lifecycle (Peck 2010).

1.1 Problem Statement

A thesis on the perceptions of North Texas stakeholders on green roofs revealed perceptions of cost and lack of incentives as major barriers to the adoption of green roofs (House 2009). Facility managers have the capacity to influence how receptive an owner can be towards the issues of sustainability and green buildings. "If a facility manager can build an economic case for them, the odds of success for green projects increases dramatically" (Hodges 2005). Consequently, the opinion of facility managers can become important regarding the implementation of sustainable technologies. House (2009) suggests the necessity of research related to perceptions of maintenance personnel on green roof systems in the state of Texas.

The purpose of this study is to compare the perception of facility managers on green roofs attributes and barriers for their implementation among the IFMA chapters of the state of Texas.

1.2 Study Objectives

- Compare the perception of facility managers on green roofs attributes among the IFMA chapters of the State of Texas.
- Compare the perception of facility managers on green roofs barriers for their implementation among the IFMA chapters of the State of Texas.

1.3 Significance

The green roofs industry has been growing in the last years, cities like Austin Texas have adopted policies to promote green roof technologies. This research will provide an initial look at the perception that facility managers have on green roofs environmental, economic and aesthetic attributes; as well as technical, cost, knowledge, awareness, lack of government support, and physical barriers. After an extensive literature review, no other study was found that covered this area of knowledge. Therefore, providing a perspective of the green roof development in Texas through such important professionals as facility managers makes this study significant.

2. LITERATURE REVIEW

2.1 Facility Management and Sustainability

The concept of sustainability has spread among our society in almost every professional field. According to Hodges (2005) "the benefits of sustainability and green building practices in facility management are well established. Reduction in energy consumption, productivity increases, waste reduction, and many other beneficial effects of sustainability can be quantified and presented to an organization's leadership in order to defend sustainable practices and their positive effect on the bottom line".

Hodges (2005) describes on his paper "A facility manager's approach to sustainability", the impact facility managers can have on owners and organizations to promote green practices. Hodges (2005) also discusses the knowledge required by facility managers on finances to promote sustainability. Facility managers have the capacity to dictate how receptive an owner can be towards the issues of sustainability and green buildings. If a facility manager can demonstrate the economic viability for green technologies, the chances of these technologies succeeding grow considerably. (Hodges 2005).

On his paper, Hodges (2005) concludes that sustainable practices are not seen as long lasting technologies, therefore the drive towards a long-term view can come from the credibility and knowledge of facility managers. According to Hodges (2005)

"building the business case for sustainability starts with the group that has the most knowledge of the long-term costs and methodologies of managing physical assets".

Sustainable technologies like green roofs that have significantly longer life expectancy than conventional roofs, require optimal maintenance to keep them functioning at their best (Peck 2010). According to Peck (2010) successful green roofs require a combination ok knowledge and expertise on critical non-living elements such as waterproofing, structural engineering and project management. Also, on living architectural components such as water management, growing media, plants and maintenance.

2.2 Facility Management and Green Roofs

According to Peck (2010) "Facility managers play a key role in assuring the optimal performance level of green roofs. One of the main causes of plant failure on green roofs is the lack of proper maintenance over the first five years". Peck (2010) recommends establishing detailed maintenance plans during designing phases of the green roofs in order to assure short and long term success. Irrigation systems and waterproofing assembly require periodic maintenance, also hiring a landscape contractor to maintain healthy plants are many of the tasks a facility manager should consider. With so many disciplines involved with the construction and maintenance of green roofs systems, specialized training becomes valuable to any professional involved with this technology.

According to the GRHC annual green roof industry survey for 2012, the North America green roof industry grew by a remarkable 24% in 2012 over 2011. The total estimated amount of square feet installed in 2012 was 19,984,000. The top metropolitan regions with more square feet of green roofs in 2012 are Washington DC, Chicago, New York City, Toronto and Philadelphia. The jurisdictions with most green roofs installations are also those who have embraced policies to support their implementation (Erlichman and Peck 2013). Although green roofs systems are not vastly popular in southern states of the United States (House 2009), cities like Austin have managed to create policies that encourage their creation (2010 GRAG Report).

2.3 Perception Studies on Green Roofs

2.3.1 Study of Stakeholders Perceptions on Extensive Green Roofs

The increasing popularity of green roof systems, has motivated several researchers to evaluate the perception of professionals, stakeholders and residents regarding the technology. House (2009) conducted a study of the North Texas Stakeholders perceptions of extensive green roofs. The study examined developers, city officials, architects, and landscape architects in the North Texas region. House (2009) considered those professionals uniquely important to the decision making process in the areas of finance, public policy, design, and building practices.

House (2009) used a qualitative method approach, he conducted interviews with key stakeholders and decision makers in the Dallas-Fort Worth area. The transcripts of the interviews were later analyzed according to the theory regarding the diffusion of innovations. The interviews were conducted using a semi-structured approach with six open-ended questions. The research sample was selected from a working set of individuals that had certain characteristics such as being employed, conduct a business in North Texas and having more than 5 years of experience within the geographical area studied.

The findings of House (2009) study, suggest that green roofs had multiple positive perceptions. Three frequently negative perceptions were documented regarding cost installation, maintenance and liability of green roofs. The most commonly cited positive perceptions were aesthetics, management of storm water run-off, insulation, and the reduction of reflective and radiant heat. The perceptions related to compatibility of green roof technology with the North Texas region had a negative tendency. Structural limitations, climate and weather related issues, and meeting expectations were cited.

House (2009) arrived to the conclusion that stakeholders perceived extensive green roofs as being appropriate for use in North Texas. Concerns were raised regarding plant selection, weight requirements, initial cost, city codes and aesthetics. City officials and developers indicated their concern for the performance of green roofs in the North Texas extreme climate. Landscape architects, and architects spoke of the multitude of benefits and appropriateness for the region. The overall perception of extensive green roofs was favorable, nonetheless the lack of education and knowledge over cost issues

was cited as a major barrier for green roof implementation. House (2009) suggests further research to be done on the perceptions of management companies and maintenance personal regarding green roofs.

2.3.2 Study of Building Professionals Perception on Green Roofs

Wong et, al (2005) conducted a study on perception of building professionals on the issues of green roofs. The objective of the study was to determine the current perception of building professionals on the issues of green roof development and any conflicting opinions among them. Wong et, al (2005) used two components for the field study, a self-administered postal survey questionnaire and interviews.

The survey was conducted among three target populations, architectural firms landscape architectural firms, and developing firms. All of the firms consulted were recognized and registered in renamed national associations. The questionnaire had four sections and a five point Likert scale was used to measure the different levels of agreement on statements that were provided.

The first section was designed to identify benefits of green roofs. Section two aimed to determine perceived barriers to the development of green roofs. The third section consisted of two questions that intended to determine other barriers for green roof development. The fourth section identified the respondents and the organization particulars. A total of 332 firms were surveyed with a final response rate was 31.3%. The interview questionnaire was used to obtain a more detailed description on the issues

of green roof development. Professionals that participated in the Garden City Awards in 2001 and respondents of the postal survey that agreed on participating were selected for interviews. On the study data analysis, a T-test was used to check any significant differences on perceptions among the professional groups evaluated.

The conclusions of the investigation suggested that building professionals generally agreed with most of the benefits of green roof development. Landscape architects tended to disagree disagreed on the technical barrier statements. The research study provides an insight on green roofs concerns among building professionals and also reveals the positive perception this technology has. Wong et, al (2005) did not study facility manager's professionals in his study. The importance of facility managers on the issues of development of sustainable technologies is a relevant topic that should be addressed.

2.3.3 Study of Perceptions of Vertical Greenery Systems

Wong et, al (2010) also developed a study titled "Perception Studies of Vertical Greenery Systems in Singapore". The research objective was to discover the current perception of vertical greenery systems and barriers to their widespread adoption in Singapore. Wong et, al (2010) conducted a survey questionnaire among the five target populations used on Wong et, al (2005) study. The fourth target group were government agencies. The survey questionnaire was divided into three sections and a five-point Likert was used. The first section identified respondent's awareness on vertical greenery

systems and their preferences. The second section was designed to identify which benefits of vertical greenery systems were perceived to be true. The third section sought to determine the perceived concerns of installing vertical greenery systems. A total of 908 survey questionnaires were mailed out, with and overall response rate of 21.85%. Mean ratings where used to create radar charts in order to make inferential statements about the population studied.

The conclusions of the investigation suggested that several professionals have unclear conceptions of vertical greenery systems. According to the author, these misconceptions should be addressed by the government in order to rectify and promote vertical greenery systems. Education on vertical greenery systems are suggested as methods to correct the misunderstanding. The survey also revealed that more than half of the respondents would like to see vertical greenery systems implement in the buildings they work in, which indicates the demand for this green technology.

2.3.4 Study of Perceptions of Green Roofs in Sydney, Australia

In 2012 the city of Sydney in Australia started a development plan for green roofs and green walls. The city conducted a perception study to identify attitudinal factors influencing the local green roofs industry. The research objectives of the investigation were focused in understanding the levels of awareness on green roofs systems among the participants. Also, understanding the factors that motivated and promoted the installation of green roofs and determine the barriers that limited the

creation of more green roofs. The research had a qualitative approach, using a focus group conformed by 22 industry stakeholders for in depth interviews. And a community survey were 416 responses were gathered. A technical advisory panel was created that included experts in the field of green roofs to assist with the analysis section at key points in the research process (City of Sydney 2012).

The findings of the focus group interviews showed that reliability of the waterproofing and irrigation systems rise significant concerns regarding risks associated with leaks. Secondly, the selection of the correct plant species was considered critical for the viability of green roof systems when taking into account the local climate conditions. Maintenance and accessibility of the infrastructure were also perceived as cost barriers to installation. Furthermore, the industry experts were heavily concerned with the costs of green roofs, since cost are generally considered to be high in relation to the environmental return (City of Sydney 2012).

Further research was suggested by the city officials, to disseminate guidelines on appropriate plant species selection for different climatic conditions, and accurate data on costs associated with installation, maintenance and design. The focus group identified environmental and social amenity benefits as the strongest drivers for creating green roofs. The disposition of the city of Sydney to encourage green roof research, potential partnership approaches, and policy implementation are very important factors in the study (City of Sydney 2012).

The community perception survey revealed a high level of awareness on green roofs matters. The study attributes the awareness to the attention that green roofs were

receiving from local media, and new high profile developments occurring in the city. Improving air quality was one of the areas that people from the community considered most important. The community also agreed with the idea of the city promoting and encouraging constructions of green roofs (City of Sydney 2012).

The study concludes with 12 specific policy recommendations for the city of Sydney in order to guide further development and implementation of green roofs. In general the recommendations suggest the city, to play an active role in the leadership, education and awareness of green roof systems in the industry, community and stakeholders. Also, to enact a staged approach to a policy implementation that can contain financial and non-financial incentives to support the growth and development of green roofs (City of Sydney 2012).

2.3.5 Study of Perceptions of Building Residents on Green Roofs in Spain

Various investigations on green roofs perceptions of building residents have been conducted in different parts of the world. Fernandez-Cañero, Emilsson, Fernandez-Barba and Herrera (2013) conducted a study of public attitudes and preferences in southern Spain regarding green roof systems. The investigation was performed as a visual preference study using digital images created to represent eight different alternatives of green roofs.

Fernandez-Cañero, Emilsson, Fernandez-Barba and Herrera (2013) used a Likert-type scale survey, and evaluated 450 respondents that indicated their preferences

for each digital image. The results showed that green roofs with a more careful design, greater variety of vegetation structure, and more variety of colors were preferred over alternatives. Results also indicated that respondent's childhood environmental background and socio-demographics influenced their preferences toward different green roof types.

2.3.6 Study of Perceptions of Residents on Green Roofs in United Kingdom

White and Gatersleben (2011) conducted another perception study on green roofs. The increase of green roofs in the United Kingdom due to policies that promote them as aesthetically pleasing motivated the investigation. The study examined whether houses with vegetation would be more preferred than those without. Also, it examined if houses with vegetation were perceived as more beautiful and restorative, and have a more positive affective quality than those without. Two data collection methods were used, an online survey with 188 participants that rated photographs of houses with and without vegetation. And an interview to eight experts that examined preferences and installation concerns on green roofs.

Results of the investigation from White and Gatersleben (2011) showed that houses with some type of building-integrated vegetation were more preferred significantly. Also, they were considered more beautiful, restorative, and had more positive affective quality than those without. The two most rated facades in the survey, happened to be the ones that industry and landscape researchers claim to be the most

preferred. The study suggests that building-integrated vegetation will be a valuable addition to the urban environment.

2.3.7 Study of Perceptions of Office Workers on Green Roofs in Toronto and Chicago

Loder (2011) conducted a study that explores office workers perception of green roofs and how this influences their health/well-being in Toronto and Chicago. Using a phenomenological analysis of semi-structured interviews, Loder (2011) examines the awareness, attitudes, and feelings towards green roofs of 55 office workers with access to them physically or visually from their workplace in Toronto and Chicago. Another survey was used to explore office workers awareness and attitudes towards green roofs and the possible influence on their well-being. The 903 participants showed a high literacy on the environmental benefits of green roofs. A Chi-square analysis conducted showed significant association between visual access to a green roof and improved concentration at work. Loder (2011) also used a logistic regression on the first survey conducted to assess whether relationships of improved concentration with visual access were still significant when other variables were added to the model. Results found that concentration was no longer significant, but a trend towards improved concentration was visible.

2.3.8 Study of Perceptions of Building Residents on Green Roofs in Singapore

Another study conducted by Yuen and Wong (2005) examined resident perceptions and expectations of rooftop gardens in Singapore. Mixed method qualitative/quantitative sequential design was used for the research. A stratified random sample of 333 residents comprising households living near and away from Singapore's roof gardens was selected. The survey evaluated the level of usage and awareness, motive and purpose of use, and the relevance of green roofs for the community.

The results from Yuen and Wong (2005) investigation show that the majority of the residents had not visited a rooftop garden even when they had one located in their neighborhood. Also, the respondents considered the main purpose for using green roofs was to isolate themselves from the city. Finally, residents considered roof gardens as relevant but not more than any other open spaces like parks. Yuen and Wong (2005) suggest that with the increasing urban growth, growing population and competing demand on urban land, roof gardens are positioned to take importance in the urban landscape of cities.

3. METHODOLOGY

3.1 Study Design

This study has a quantitative approach, the population under study are facility managers of the state of Texas. The selected sample are the International Facility Management Association (IFMA) chapters of the state of Texas. The fact that IFMA is the world's largest and most widely recognized international association for facility management professionals (IFMA), makes the association a reliable place to obtain data for this study.

A survey questionnaire was the instrument used to compare the inherent benefits and barriers facility managers have on of green roof. The instrument was designed and tested on previous studies conducted by Wong et, al (2005) and Wong et, al (2010). On both studies, the instrument was based on the five-point Likert scale which is used in this study as well. The questionnaire is composed by 35 statements used by Wong et, al (2005) on "Perception Study of Building Professionals on the Issues of Green Roof Development in Singapore", and Wong et, al (2010) "Perception Studies of Vertical Greenery Systems in Singapore".

The areas covered by the questionnaire include: demographics of the participants, environmental attributes of green roofs, aesthetic attributes, economic attributes, cost barriers, technical barriers, lack of knowledge and awareness barriers, lack of government support and physical barriers. Wong et, al (2005) and Wong et, al (2010)

methodology, confer the necessary validity to the instrument in order to be used as a tool to answer the research question in this study. Since human subjects were used for this study, IRB approval was required for this investigation, the number assigned was IRB2014-0132.

3.2 Delimitations

This study is limited to professionals of the facility management area, and not to associates, vendors or sponsors of the IFMA chapters of Texas. The findings of this study are not generalizable to the populations of the samples due to statistical reasons explained in further sections.

3.3 Limitations

Several limitations were found in terms of colleting the data for this study. Each IFMA chapter had their own conditions for the distribution of the survey to their members, and any decision depended on the approval of the chapter's Board. This limitation will be further commented on the data collection section.

3.4 Data Collection

Two options for data collection were used, an online questionnaire generated with the online survey software Surveymonkey, and a hardcopy questionnaire. The online questionnaire was distributed by each chapter through their emails lists of members, and the hardcopy questionnaire was distributed during meetings of the chapters. The following part describes what data collection method was used for each chapter.

3.4.1 Austin IFMA Chapter

The Austin IFMA chapter agreed to send the online survey to their members through their emails list, and also agreed to allow the investigator to attend a luncheon and apply the survey face to face. The online survey was sent on April 7 of 2014, and the collector was open for 3 weeks.

3.4.2 Dallas Fort-Worth IFMA Chapter

The Dallas Fort-Worth IFMA chapter allowed investigator to attend a luncheon and apply the survey face to face. The online survey option was not allowed due to particular reasons of the chapter.

3.4.3 Houston IFMA Chapter

The Houston IFMA chapter agreed to send the online survey to their members through their emails list. The chapter's board approved the survey link to be attached to the weekly newsletter of the chapter and not an independent email sent to their members as expected. Due to time constraints these conditions were accepted. The newsletter with the link was sent out once every week during the month of April.

3.4.4 San Antonio IFMA Chapter

The San Antonio IFMA chapter agreed to send the online survey to their members through their emails list. The online survey was sent on April 3 of 2014, and the collector was open for 3 weeks.

3.5 Response Rate

The response rate for the survey after discarding invalid questionnaires can be found on Table 1. The criteria used to discard responses consisted on the evaluation of the respondent's profession and the sections completed of the questionnaire. If a respondent did not identify itself as a facility manager on question #5 of the questionnaire, it was automatically discard. Also, respondents that fail to answer every questions of Part II of the questionnaire, were also discarded. Respondents that were

facility managers and failed to answer some sections of Part II of the questionnaire, were considered valid for the sections that they answered.

Table 1: Response rate among chapters

Chapter	Facility Managers	Responses	% Response
Austin	105	27	25.7
DFW	278	13	4.7
San Antonio	120	14	11.7
Houston	354	12	3.4
Total	857	66	**7.7**

3.6 Data Analysis

The analysis of the data for this study will have a different approach from the one used by Wong et, al (2005) on the study "Perception Study of Building Professionals on the Issues of Green Roof Development in Singapore". Wong et, al (2005) used a *t* test to determine the variance among the means of different groups of professionals studied. Giving the fact that the data obtained from a Likert scale is considered ordinal, mathematical equations can't be used legitimately to analyze the data (Alreck, P. L., Settle, R. B. 2004).

According to Alreck, P. L., Settle, R. B. (2004) "Ordinal scale data can only be manipulated in what are called systems of inequalities, systems whose terms consist of "greater than" and "less than". Statistical analysis of ordinal data requires what are termed nonparametric statistics, rather than more common and powerful statistical tools".

Furthermore, in order to correctly use parametric statistics for a Likert scale analysis, conditions of normality and equal variances have to be met by the sample. A Likert scale question with only 5 possible answers cannot possibly possess a normal probability distribution. This is because the range of answers is discrete, not continuous. The researcher should make sure the distribution is mound shaped and check frequency of the results if using t-tests (SPSS Techniques series: Statistics on Likert Scale Surveys 2014).

Although Wong et, al (2005) approach for data analysis of Likert scales is commonly used for this type of data, it is highly discussed among statistics professionals if it is appropriate. To assure the highest level of stringency on the data analysis of this study, nonparametric statistics were used. The Kruskal-Wallis test for comparing more than two nonnormal populations fitted the research needs for statistical analysis.

3.6.1 Kruskal-Wallis Test

The Kruskal-Wallis test, is a nonparametric statistic used for testing the difference among more than two nonnormal populations. The assumptions for the test are that we have independent random samples of sizes *n1*, *n2*,...*nk* from population *k*. The population distributions of the samples are identical with the exception that one distribution may be shifted to the right of the other distribution, as shown in Figure 1.

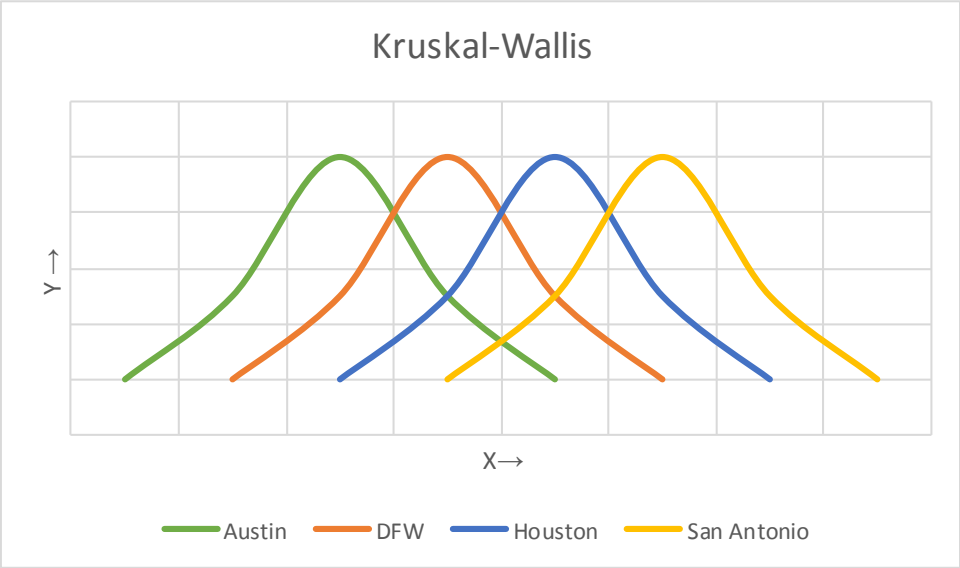


Figure 1: Kruskal-Wallis

The Kruskal-Walllis test does not require the population distributions to have a normal distribution, for this reason it can be used for small sample sizes of $n<10$. For this study the following hypothesis test will be used to test the differences among perceptions of facility managers of each statement:

- *H*o: There is no difference among the 4 chapters with respect to perceptions on a given statement.
- *H*a: At least one of the 4 chapters differs from the others with respect to perceptions on a given statement.

The test statistic is calculated with the following equation:

$$H = \frac{12}{nt(nt+1)} \sum_{i} \frac{(Ti^2)}{ni} - 3(nt+1)$$

Where *ni* is the number of observations from sample *i(i=1,2,…,k), nt* is the combined (total) sample size; that is, *nt* = ∑*iNi* and *Ti* denotes the sum of the ranks for the measurements in sample *i* after the combined sample measurements have been ranked.

For a specific value of α, reject *H*o if *H* exceeds the critical value of χ^2 for α and df=k-1. For this research an α=0.05 was used which is equivalent to a χ^2=7.815 for df=3. In cases when there are a large number of ties in the ranks of the sample measurements, the following equation for H' is used:

$$H' = \frac{H}{1 - [\sum j(tj^3 - tj)/(nt^3 - nt)}$$

- Where tj is the number of observations in the jth group of tied ranks.

For this research, *H'* was used for all the statements, since there was a large number of ties in the ranks of the sample measurements. The statistical software JMP 11 was used to perform the Kruskal-Wallis Test for all data.

3.6.2 Wilcoxon Rank Sum Test

In case there is significant evidence (H'> χ^2) from the Kruskal-Wallis Test to reject the null hypothesis, the Wilcoxon Rank Sum Test will be used to compare each chapters distributions in pairs to find between which chapters there is a significant difference. The Wilcoxon Rank Sum Test is the same Kruskal-Wallis Test for testing just two samples.

3.6.3 Descriptive Statistics and Charts

Descriptive statistics were calculated and presented to provide reference of the nature of the data. A distribution of the chapter's responses with smoothed lines was included for each statement to have a visual representation of the shape and location of the distributions. This distribution plot is just a merely visual representation of the modality of the responses, and do not represents the actual distributions after the sum ranks are computed for the Kruskal-Wallis test. Box plots for each distributions are also provided and their respective histogram.

3.7 Data Validation

The instrument for this study as stated before was tested on Wong et, al (2005) and Wong et, al (2010). Nonetheless, the instrument was revised and approved for

distribution by each board of the IFMA chapters of Texas. Furthermore, a revision was made by an expert on green roofs to assure the quality of the questionnaire.

4. DATA ANALYSIS AND FINDINGS*

4.1 Demographics

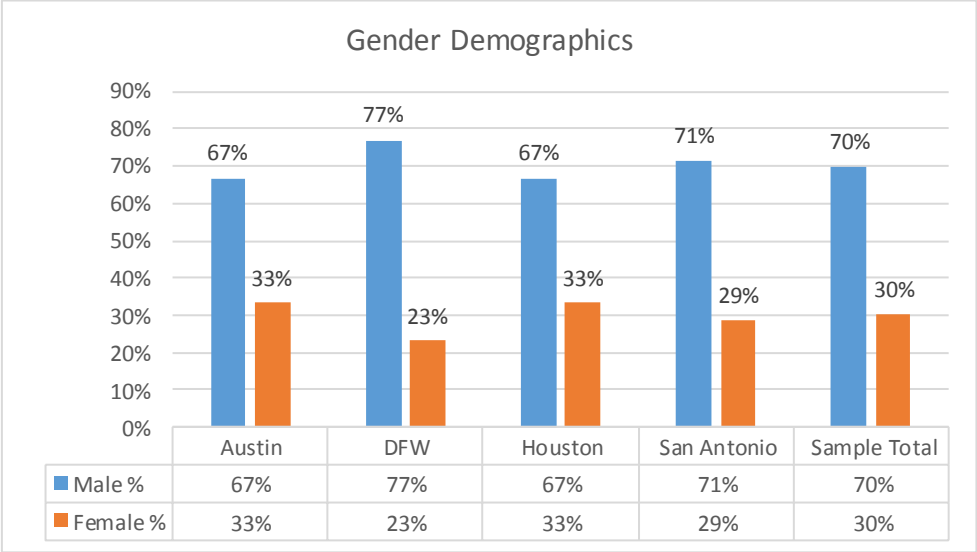
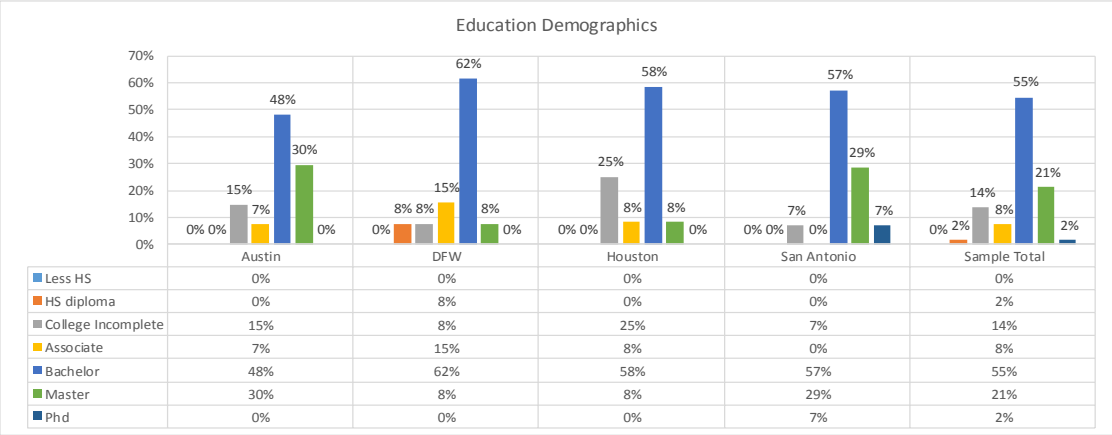


Figure 2: Gender demographics

The gender demographics of each chapter are similar, from Figure 2 we can observe a predominance of male (70%) over female (30%) professionals from the total sample.

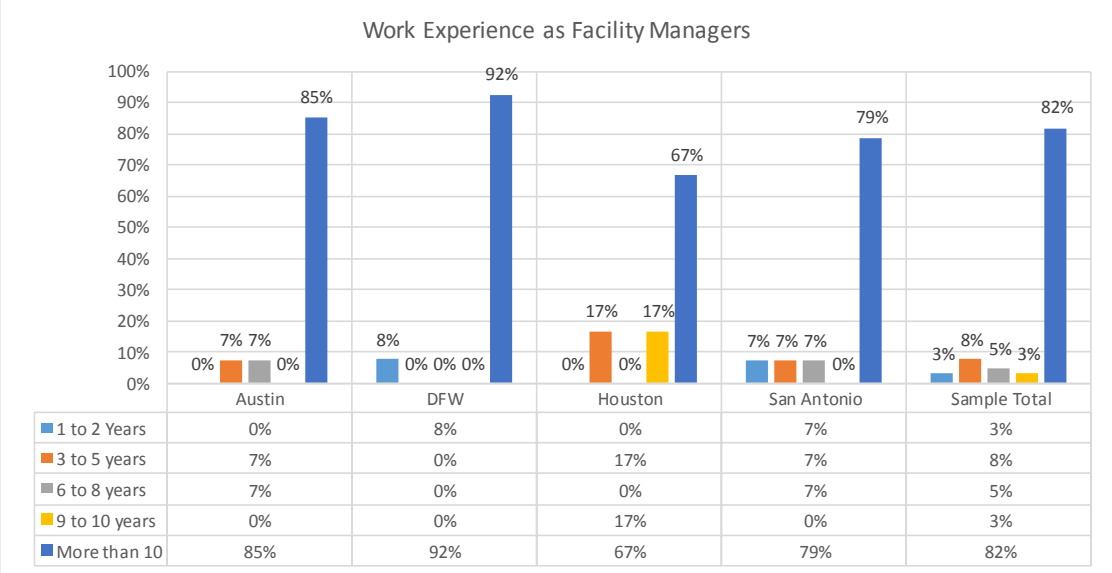
* Statement questions used on the survey of this study are reprinted with permission from Wong, N., Wong, S., Lim, T., Ong, C., Sia, A. (2005). "Perception study of building professionals on the issues of green roof development in Singapore", Journal of Architectural Science Review, 48 (3), 205-214.



	Austin	DFW	Houston	San Antonio	Sample Total
Less HS	0%	0%	0%	0%	0%
HS diploma	0%	8%	0%	0%	2%
College Incomplete	15%	8%	25%	7%	14%
Associate	7%	15%	8%	0%	8%
Bachelor	48%	62%	58%	57%	55%
Master	30%	8%	8%	29%	21%
Phd	0%	0%	0%	7%	2%

Figure 3: Education demographics

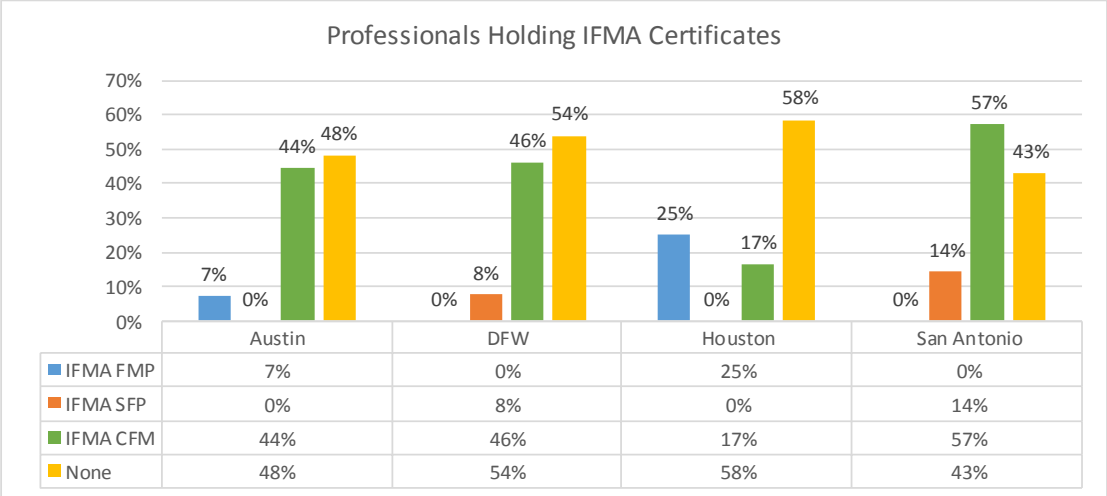
The education demographics from each chapter look similar as shown on Figure 3. The majority of the professionals have completed a 4 year college education or higher (78%). Only 2% of the total sample holds a PhD.



	Austin	DFW	Houston	San Antonio	Sample Total
1 to 2 Years	0%	8%	0%	7%	3%
3 to 5 years	7%	0%	17%	7%	8%
6 to 8 years	7%	0%	0%	7%	5%
9 to 10 years	0%	0%	17%	0%	3%
More than 10	85%	92%	67%	79%	82%

Figure 4: Work experience as facility managers

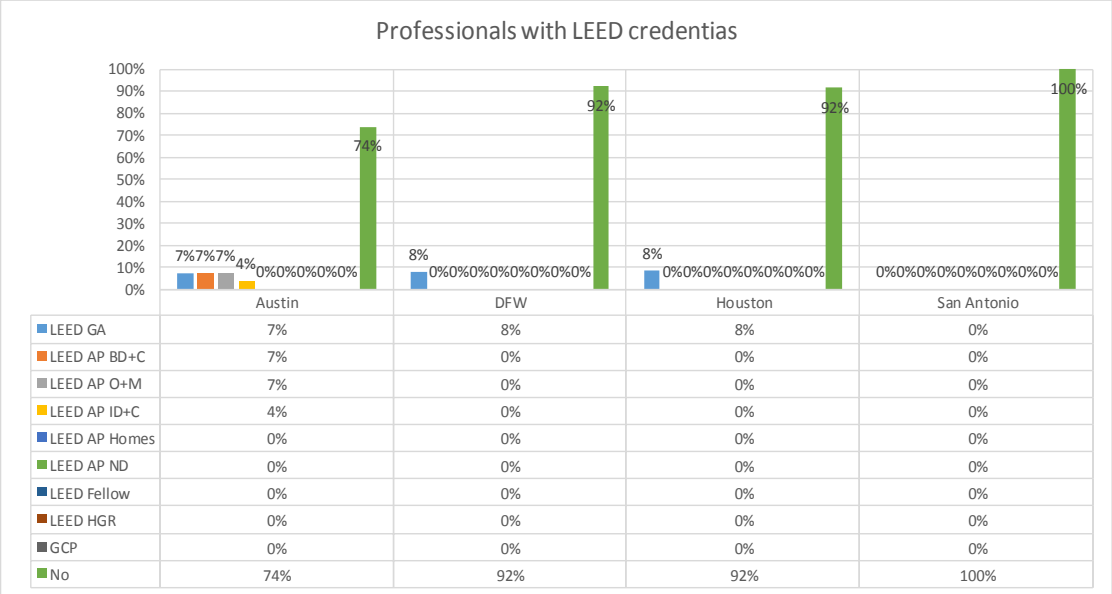
The work experience demographics for each chapter looks similar as shown on Figure 4. From the sample total, the majority of professionals (82%) have more than 10 years of experience working as facility managers.



	Austin	DFW	Houston	San Antonio
IFMA FMP	7%	0%	25%	0%
IFMA SFP	0%	8%	0%	14%
IFMA CFM	44%	46%	17%	57%
None	48%	54%	58%	43%

Figure 5: Professionals holding IFMA certificates

The majority of the professionals by chapter hold an IFMA certificate as seen on Figure 5, except for Houston were 58% of the sample does not holds one. The Certified Facility Management certificate is the most common. Only 14% of the San Antonio chapter and 8% of Austin chapter holds an IFMA sustainable facility professional certificate.



	Austin	DFW	Houston	San Antonio
LEED GA	7%	8%	8%	0%
LEED AP BD+C	7%	0%	0%	0%
LEED AP O+M	7%	0%	0%	0%
LEED AP ID+C	4%	0%	0%	0%
LEED AP Homes	0%	0%	0%	0%
LEED AP ND	0%	0%	0%	0%
LEED Fellow	0%	0%	0%	0%
LEED HGR	0%	0%	0%	0%
GCP	0%	0%	0%	0%
No	74%	92%	92%	100%

Figure 6: Professionals with LEED credentials

The majority of the professionals from the sample don't hold any LEED credentials as shown on Figure 6. San Antonio stands out with no professionals holding any LEED credential. Austin is the chapter with the most LEED accredited professionals (25%).

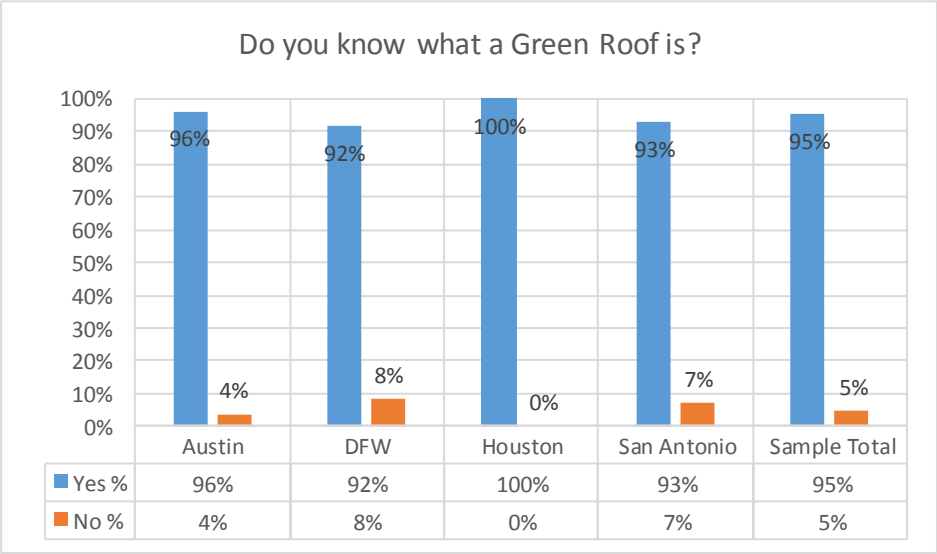


Figure 7: Category item #1

The majority of professionals (95%) know what a green roof is as shown on Figure 7.

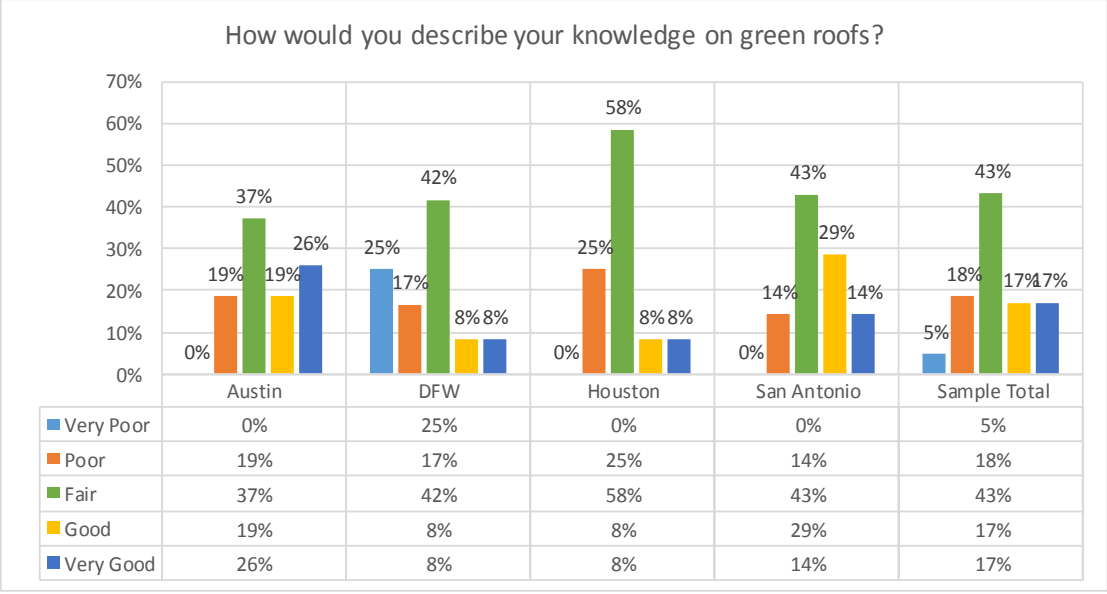
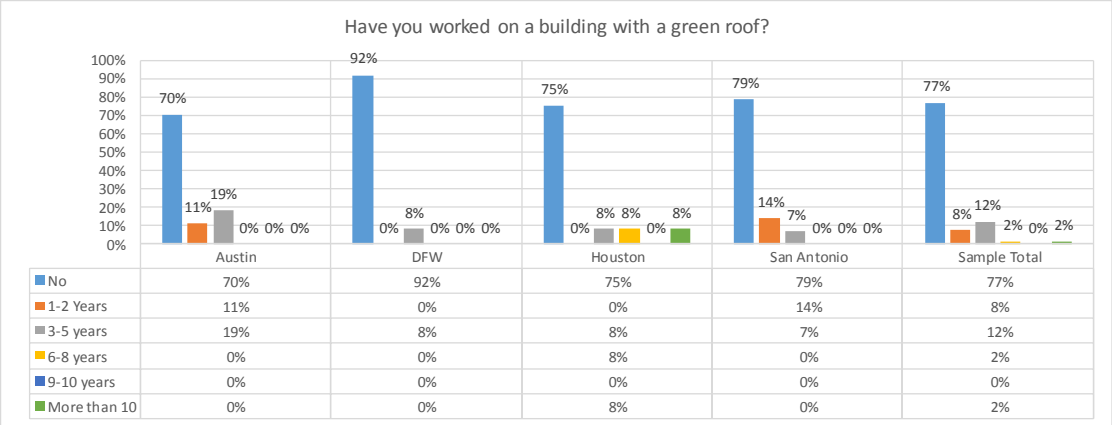


Figure 8: Category item #2

The majority of the professionals (43%) will describe their knowledge of green roofs as fair as shown on Figure 8. The Austin chapter seems to have the most professionals educated about green roofs, with 19% considering their knowledge good and 26% fair. Houston and DFW chapters seem to be the least familiarized.



	Austin	DFW	Houston	San Antonio	Sample Total
No	70%	92%	75%	79%	77%
1-2 Years	11%	0%	0%	14%	8%
3-5 years	19%	8%	8%	7%	12%
6-8 years	0%	0%	8%	0%	2%
9-10 years	0%	0%	0%	0%	0%
More than 10	0%	0%	8%	0%	2%

Figure 9: Category item #3

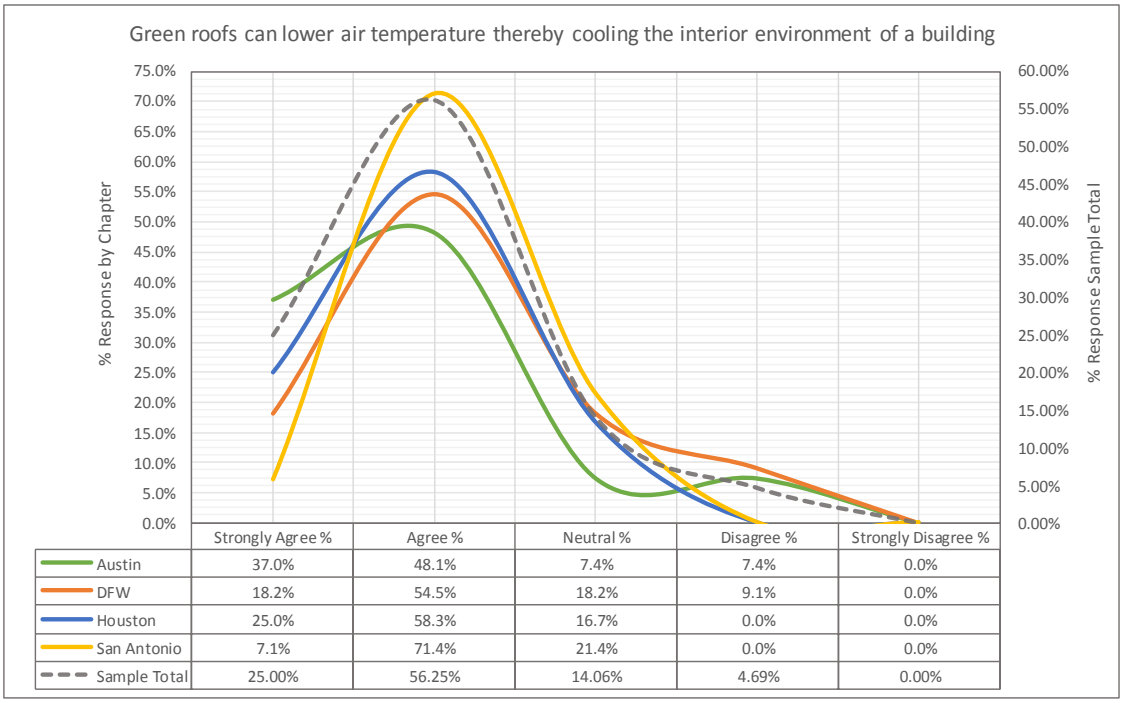
The majority of professionals from the total sample have not worked on a building with a green roof (77%) as shown on Figure 9. The Austin chapter is the one with the highest percentage of professionals that have worked on a green roof (30%), Houston follows (24%). The high percentage of the Austin chapter, may be associated with the efforts from the city to promote green roofs.

4.2 Green Roofs Attributes Perception Comparison

The following section presents the results and findings of comparing the perception of facility managers on green roofs attributes about environmental performance, economics, aesthetics and social aspects.

4.2.1 Statements Related to Environmental Performance

4.2.1.1 Statement #1: Green roofs can lower air temperature thereby cooling the interior environment of a building



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	37.0%	48.1%	7.4%	7.4%	0.0%
DFW	18.2%	54.5%	18.2%	9.1%	0.0%
Houston	25.0%	58.3%	16.7%	0.0%	0.0%
San Antonio	7.1%	71.4%	21.4%	0.0%	0.0%
Sample Total	25.00%	56.25%	14.06%	4.69%	0.00%

Figure 10: Statement #1, responses distributions by chapter and sample total

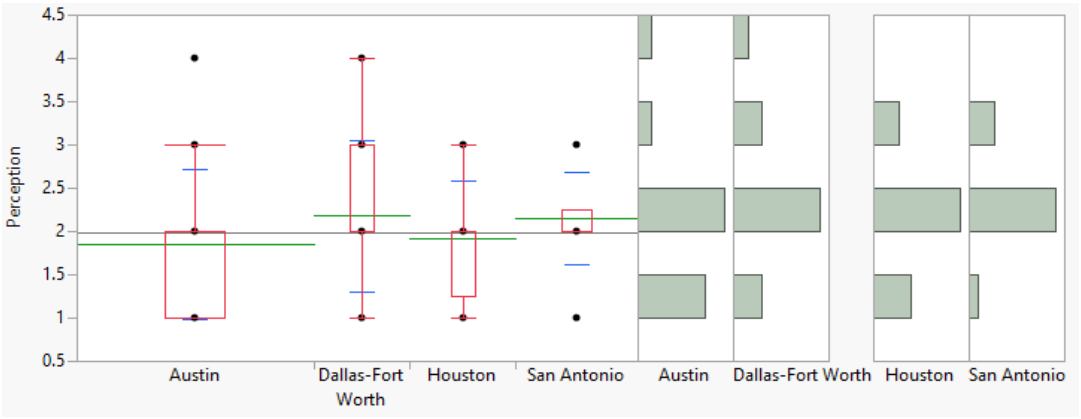


Figure 11: Statement #1, boxplot and distributions

Table 2: Statement #1, descriptive statistics and Kruskal-Wallis test JMP

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	2	3.2	4
Dallas-Fort Worth	1	1	2	2	3	3.8	4
Houston	1	1	1.25	2	2	3	3
San Antonio	1	1.5	2	2	2.25	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	27	1.85185	0.863967	0.16627	1.5101	2.1936
Dallas-Fort Worth	11	2.18182	0.873863	0.26348	1.5947	2.7689
Houston	12	1.91667	0.668558	0.19300	1.4919	2.3414
San Antonio	14	2.14286	0.534522	0.14286	1.8342	2.4515

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	27	773.500	877.500	28.6481	-1.569
Dallas-Fort Worth	11	401.000	357.500	36.4545	0.854
Houston	12	381.000	390.000	31.7500	-0.163
San Antonio	14	524.500	455.000	37.4643	1.250

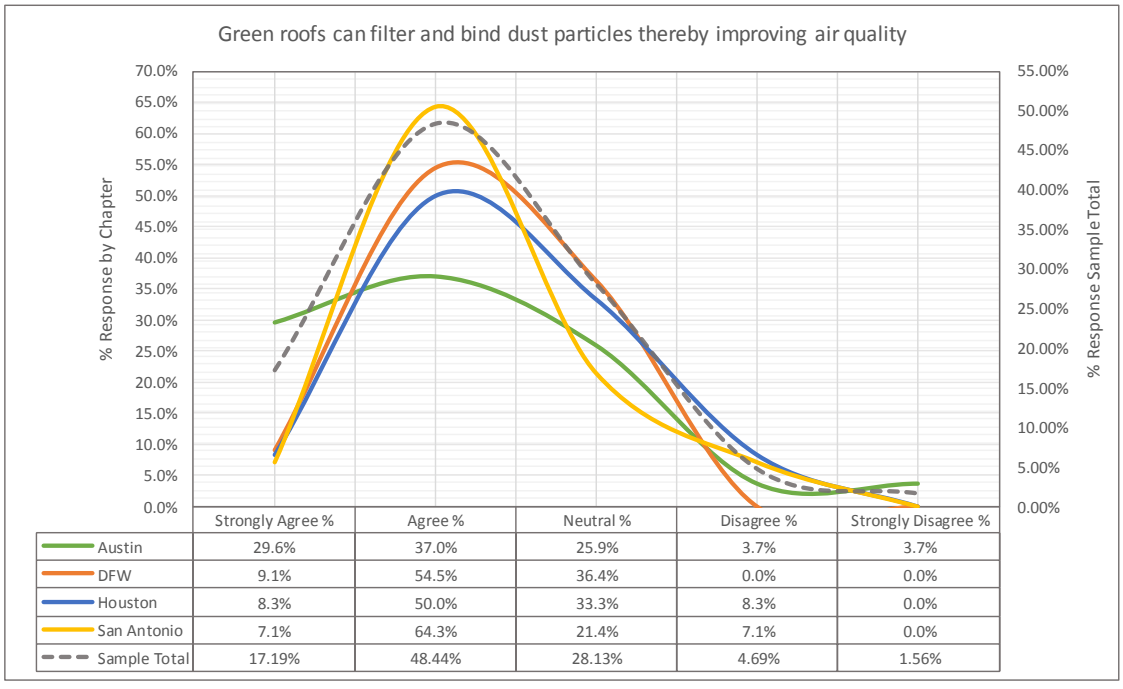
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
3.3177	3	0.3452

The descriptive statistics for statement #1 (Figure 10), show all the chapters have the same median (2). The distributions look similar in shape on each chapter, with an apparent positive perception of the statement (Figure 11). The Kruskal-Wallis Test

results (Table 2) for $\alpha=0.05$ and $df=3$, show $\chi^2=3.3177 < 7.815$ and a p-value of $0.3452 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #1. The z-scores for each chapter do not present major differences between them. Austin with a -1.560 z-score, leans slightly towards a more positive perception and San Antonio with a 1.250 z-score slightly towards a neutral perception.

4.2.1.2 Statement #2: Green roofs can filter and bind dust particles thereby improving air quality



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	29.6%	37.0%	25.9%	3.7%	3.7%
DFW	9.1%	54.5%	36.4%	0.0%	0.0%
Houston	8.3%	50.0%	33.3%	8.3%	0.0%
San Antonio	7.1%	64.3%	21.4%	7.1%	0.0%
Sample Total	17.19%	48.44%	28.13%	4.69%	1.56%

Figure 12: Statement #2, responses distributions by chapter and sample total

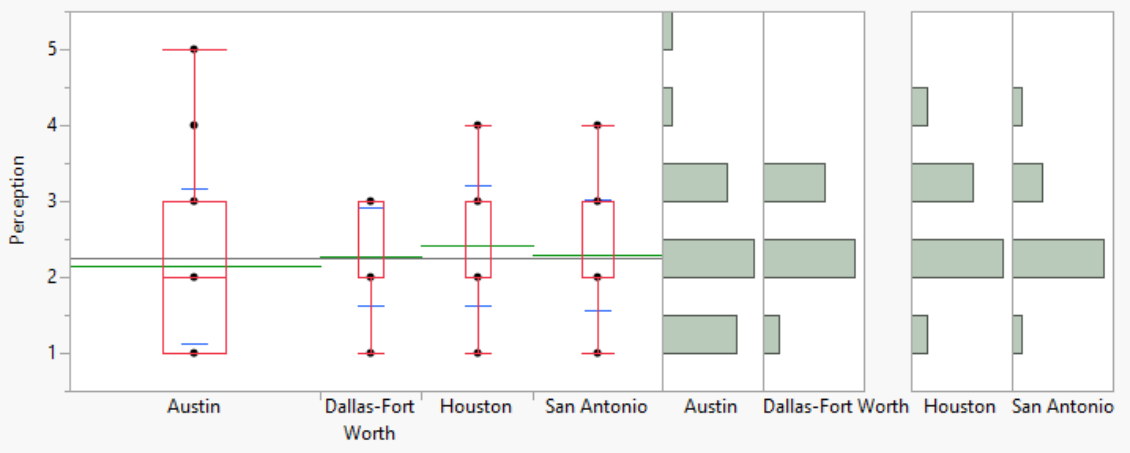


Figure 13: Statement #2, boxplot and distributions

Table 3: Statement #2, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	3.2	5
Dallas-Fort Worth	1	1.2	2	2	3	3	3
Houston	1	1.3	2	2	3	3.7	4
San Antonio	1	1.5	2	2	3	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	27	2.14815	1.02671	0.19759	1.7420	2.5543
Dallas-Fort Worth	11	2.27273	0.64667	0.19498	1.8383	2.7072
Houston	12	2.41667	0.79296	0.22891	1.9128	2.9205
San Antonio	14	2.28571	0.72627	0.19410	1.8664	2.7051

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

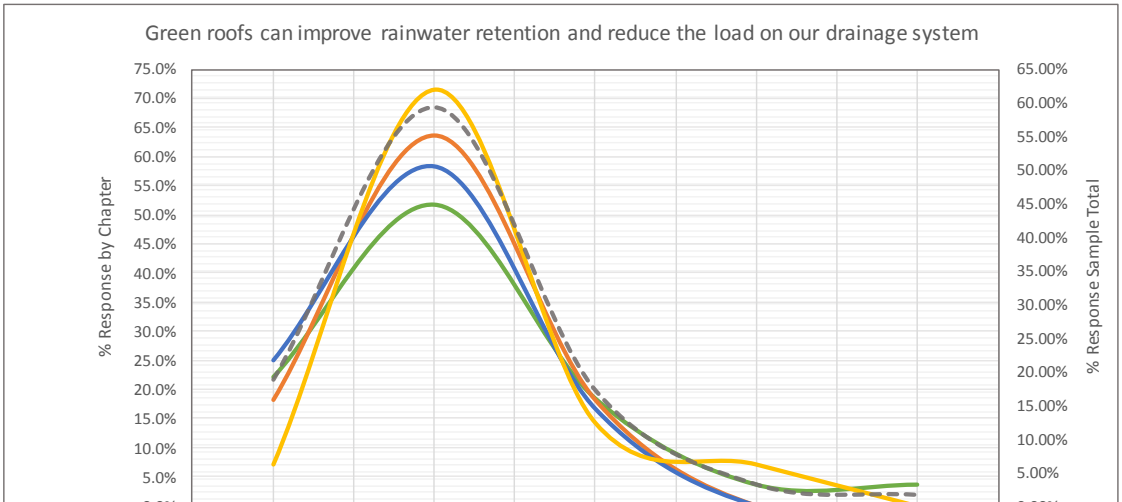
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	27	804.500	877.500	29.7963	-1.063
Dallas-Fort Worth	11	374.000	357.500	34.0000	0.307
Houston	12	436.000	390.000	36.3333	0.844
San Antonio	14	465.500	455.000	33.2500	0.175

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.3643	3	0.7139

The descriptive statistics (Figure 12) for statement #2, show all the chapters have the same median (2). The distributions look similar in shape on each chapter, with an apparent positive perception of the statement (Figure 13). The Kruskal-Wallis Test results (Table 3) for $\alpha=0.05$ and $df=3$, show $\chi^2=1.3643 < 7.815$ and a p-value of $0.7139 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #2. The z-scores for each chapter do not present major differences between them, with Austin being the chapter that differs the most (-1.063) towards a more positive perception of the statement.

4.2.1.3 Statement #3: Green roofs can improve rainwater retention and reduce the load on our drainage system



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	22.2%	51.9%	18.5%	3.7%	3.7%
DFW	18.2%	63.6%	18.2%	0.0%	0.0%
Houston	25.0%	58.3%	16.7%	0.0%	0.0%
San Antonio	7.1%	71.4%	14.3%	7.1%	0.0%
Sample Total	18.75%	59.38%	17.19%	3.13%	1.56%

Figure 14: Statement #3, responses distributions by chapter and sample total

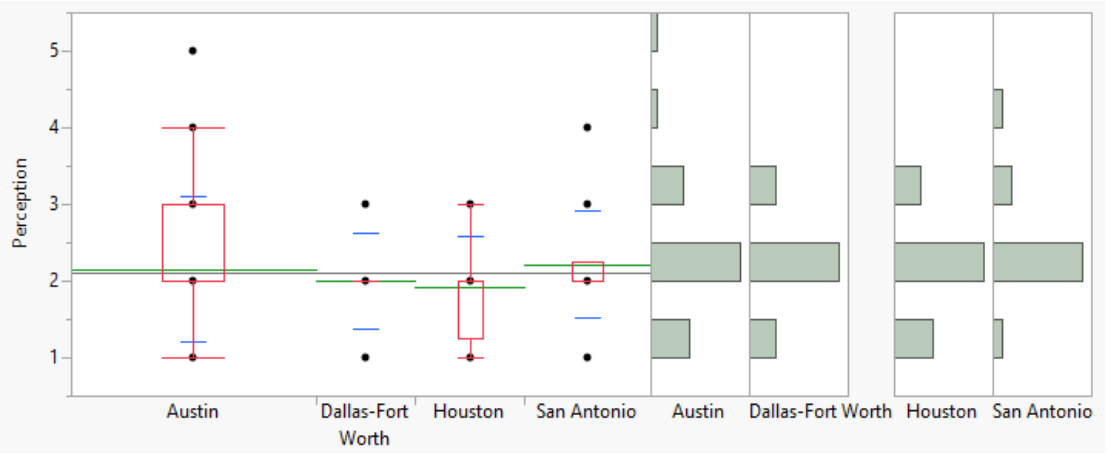


Figure 15: Statement #3, boxplot and distributions

Table 4: Statement #3, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	2	3	3.2	5
Dallas-Fort Worth	1	1	2	2	2	3	3
Houston	1	1	1.25	2	2	3	3
San Antonio	1	1.5	2	2	2.25	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	27	2.14815	0.948833	0.18260	1.7728	2.5235
Dallas-Fort Worth	11	2.00000	0.632456	0.19069	1.5751	2.4249
Houston	12	1.91667	0.668558	0.19300	1.4919	2.3414
San Antonio	14	2.21429	0.699293	0.18689	1.8105	2.6180

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

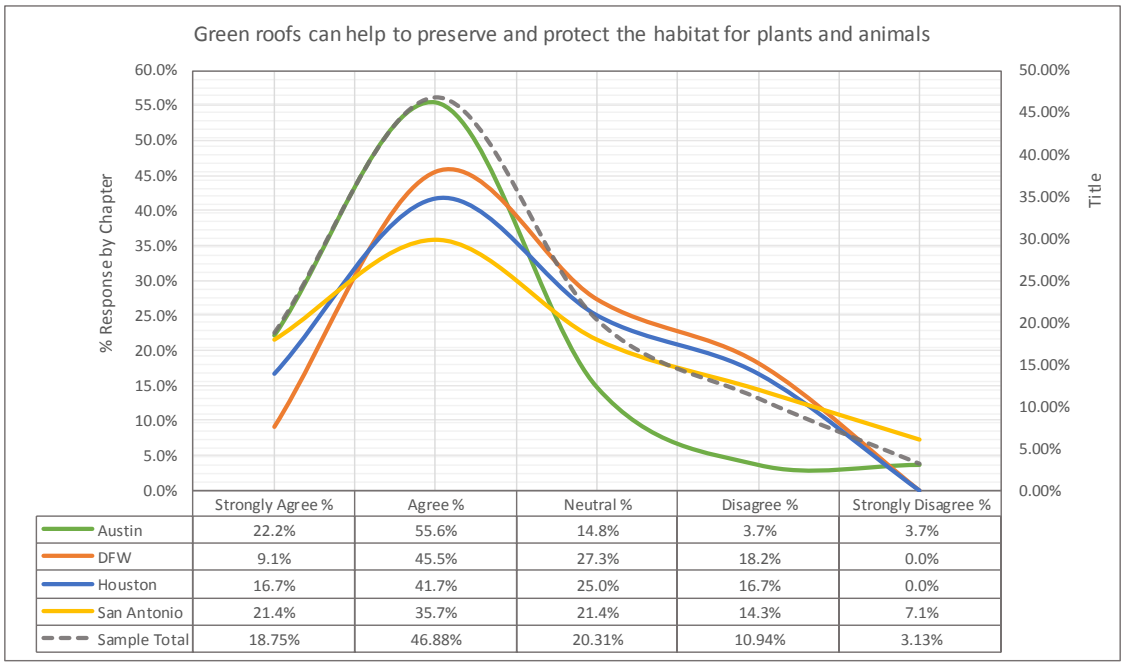
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	27	886.500	877.500	32.8333	0.131
Dallas-Fort Worth	11	345.500	357.500	31.4091	-0.232
Houston	12	352.000	390.000	29.3333	-0.731
San Antonio	14	496.000	455.000	35.4286	0.745

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.9496	3	0.8134

The descriptive statistics for statement #3 (Figure 14), show all the chapters have the same median (2). The distributions look similar in shape on every chapter, with an apparent positive perception of the statement (Figure 15). The option agree with 59.38% for the sample total, was the highest on every chapter. The Kruskal-Wallis Test results (Table 4) for $\alpha=0.05$ and df=3, show $\chi^2=0.9496 < 7.815$ and a p-value of $0.8134 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #3. The z-scores for each chapter do not present major differences between them, all chapters apparently favoring the agreement of the statement.

4.2.1.4 Statement #4: Green roofs can help to preserve and protect the habitat for plants and animals



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	22.2%	55.6%	14.8%	3.7%	3.7%
DFW	9.1%	45.5%	27.3%	18.2%	0.0%
Houston	16.7%	41.7%	25.0%	16.7%	0.0%
San Antonio	21.4%	35.7%	21.4%	14.3%	7.1%
Sample Total	18.75%	46.88%	20.31%	10.94%	3.13%

Figure 16: Statement #4, responses distributions by chapter and sample total

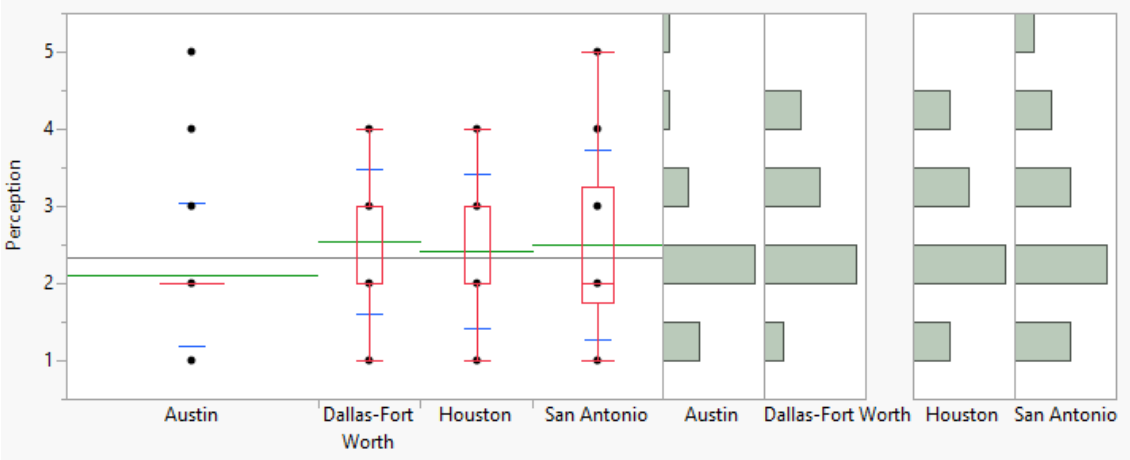


Figure 17: Statement #4, boxplot and distributions

Table 5: Statement #4, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	2	2	3.2	5
Dallas-Fort Worth	1	1.2	2	2	3	4	4
Houston	1	1	2	2	3	4	4
San Antonio	1	1	1.75	2	3.25	4.5	5

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	27	2.11111	0.93370	0.17969	1.7418	2.4805
Dallas-Fort Worth	11	2.54545	0.93420	0.28167	1.9179	3.1731
Houston	12	2.41667	0.99620	0.28758	1.7837	3.0496
San Antonio	14	2.50000	1.22474	0.32733	1.7929	3.2071

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	27	770.000	877.500	28.5185	-1.550
Dallas-Fort Worth	11	409.000	357.500	37.1818	0.967
Houston	12	415.500	390.000	34.6250	0.458
San Antonio	14	485.500	455.000	34.6786	0.519

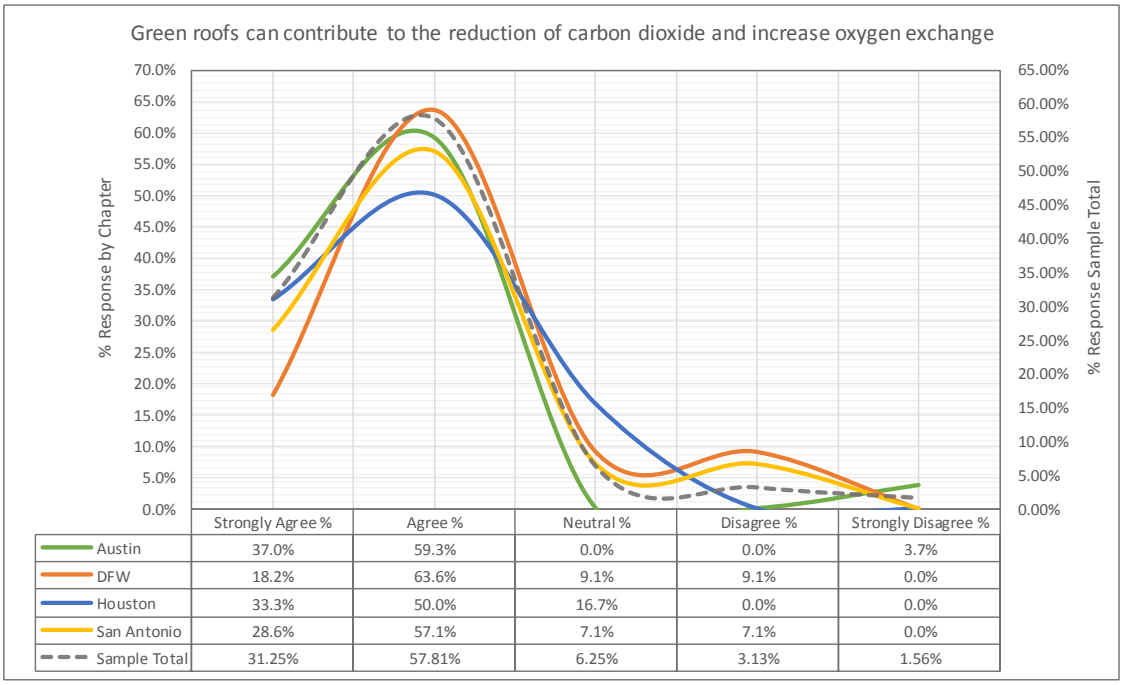
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.5861	3	0.4599

The descriptive statistics for statement #4 (Figure 16), show all the chapters have the same median (2). The distributions look similar in shape for each chapter, with an apparent positive perception of the statement (Figure 17). The option agree with 46.88% for the sample total, was the highest on every chapter. The Kruskal-Wallis Test results (Table 5) for $\alpha=0.05$ and $df=3$, show $\chi^2=2.5861 < 7.815$ and a p-value of $0.4599 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #4. The z-scores for each

chapter do not present major differences between them, except for Austin being that differs the most (-1.550) towards a more positive perception of the statement in respect to the other chapters.

4.2.1.5 Statement #5: Green roofs can contribute to the reduction of carbon dioxide and increase oxygen exchange



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	37.0%	59.3%	0.0%	0.0%	3.7%
DFW	18.2%	63.6%	9.1%	9.1%	0.0%
Houston	33.3%	50.0%	16.7%	0.0%	0.0%
San Antonio	28.6%	57.1%	7.1%	7.1%	0.0%
Sample Total	31.25%	57.81%	6.25%	3.13%	1.56%

Figure 18: Statement #5, responses distributions by chapter and sample total

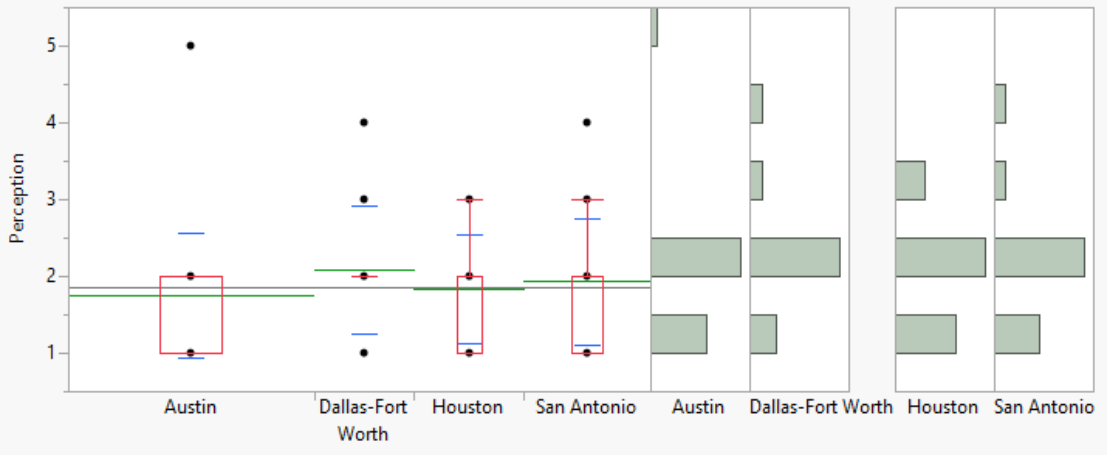


Figure 19: Statement #5, boxplot and distributions

Table 6: Statement #5, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	2	2	5
Dallas-Fort Worth	1	1	2	2	2	3.8	4
Houston	1	1	1	2	2	3	3
San Antonio	1	1	1	2	2	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	27	1.74074	0.813000	0.15646	1.4191	2.0624
Dallas-Fort Worth	11	2.09091	0.831209	0.25062	1.5325	2.6493
Houston	12	1.83333	0.717741	0.20719	1.3773	2.2894
San Antonio	14	1.92857	0.828742	0.22149	1.4501	2.4071

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

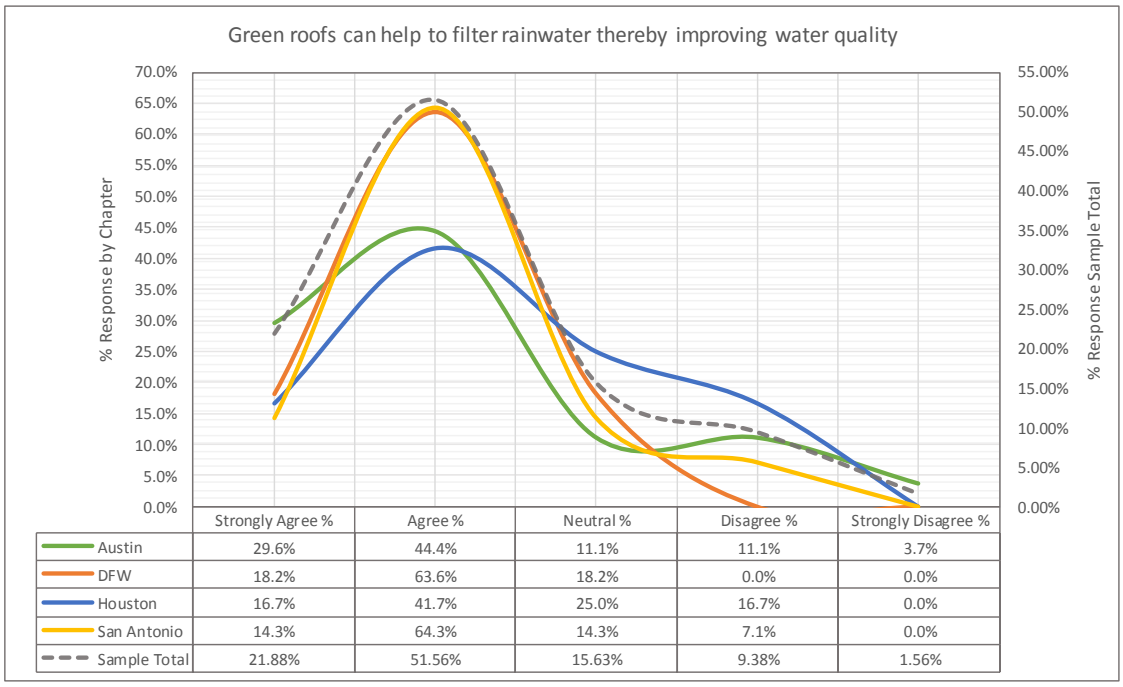
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	27	793.000	877.500	29.3704	-1.296
Dallas-Fort Worth	11	416.000	357.500	37.8182	1.172
Houston	12	395.000	390.000	32.9167	0.088
San Antonio	14	476.000	455.000	34.0000	0.378

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.2639	3	0.5195

The descriptive statistics for statement #5 (Figure 18), show all the chapters have the same median (2). The distributions look similar in shape for each chapter, with an apparent positive perception of the statement and a small percentage of disagreement from the DFW and San Antonio chapters (Figure 19). The option agree with 57.81% for the sample total, was the highest on every chapter. The Kruskal-Wallis Test results (Table 6) for $\alpha=0.05$ and $df=3$, show $\chi^2=2.2639 < 7.815$ and a p-value of $0.5195 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #5. The z-scores for each chapter do not present major differences between them. Austin chapter leans slightly towards a more positive perception (-1.296) of the statement, and DFW leaning slightly (1.172) towards disagreement.

4.2.1.6 Statement #6: Green roofs can help to filter rainwater thereby improving water quality



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	29.6%	44.4%	11.1%	11.1%	3.7%
DFW	18.2%	63.6%	18.2%	0.0%	0.0%
Houston	16.7%	41.7%	25.0%	16.7%	0.0%
San Antonio	14.3%	64.3%	14.3%	7.1%	0.0%
Sample Total	21.88%	51.56%	15.63%	9.38%	1.56%

Figure 20: Statement #6, responses distributions by chapter and sample total

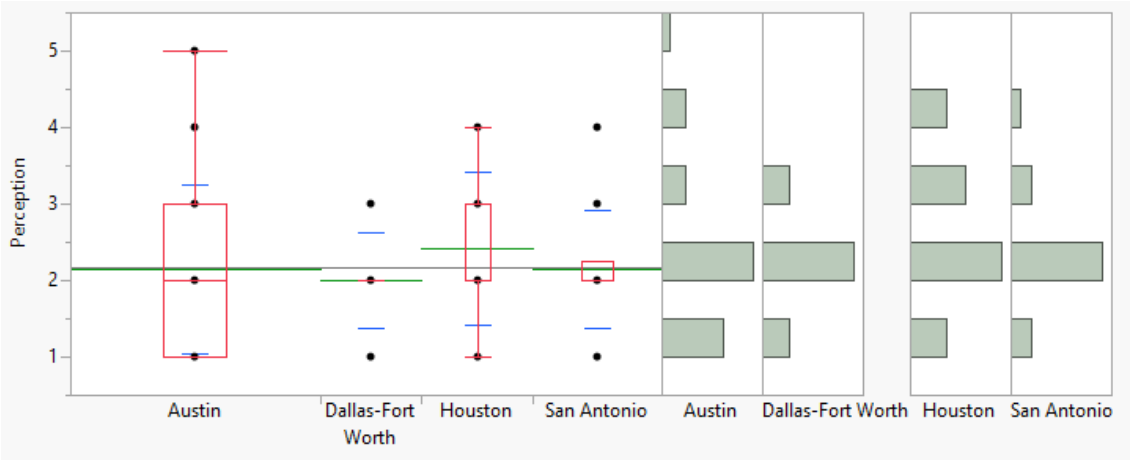


Figure 21: Statement #6, boxplot and distributions

Table 7: Statement #6, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	4	5
Dallas-Fort Worth	1	1	2	2	2	3	3
Houston	1	1	2	2	3	4	4
San Antonio	1	1	2	2	2.25	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	27	2.14815	1.09908	0.21152	1.7134	2.5829
Dallas-Fort Worth	11	2.00000	0.63246	0.19069	1.5751	2.4249
Houston	12	2.41667	0.99620	0.28758	1.7837	3.0496
San Antonio	14	2.14286	0.77033	0.20588	1.6981	2.5876

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	27	835.000	877.500	30.9259	-0.620
Dallas-Fort Worth	11	337.000	357.500	30.6364	-0.386
Houston	12	448.500	390.000	37.3750	1.083
San Antonio	14	459.500	455.000	32.8214	0.071

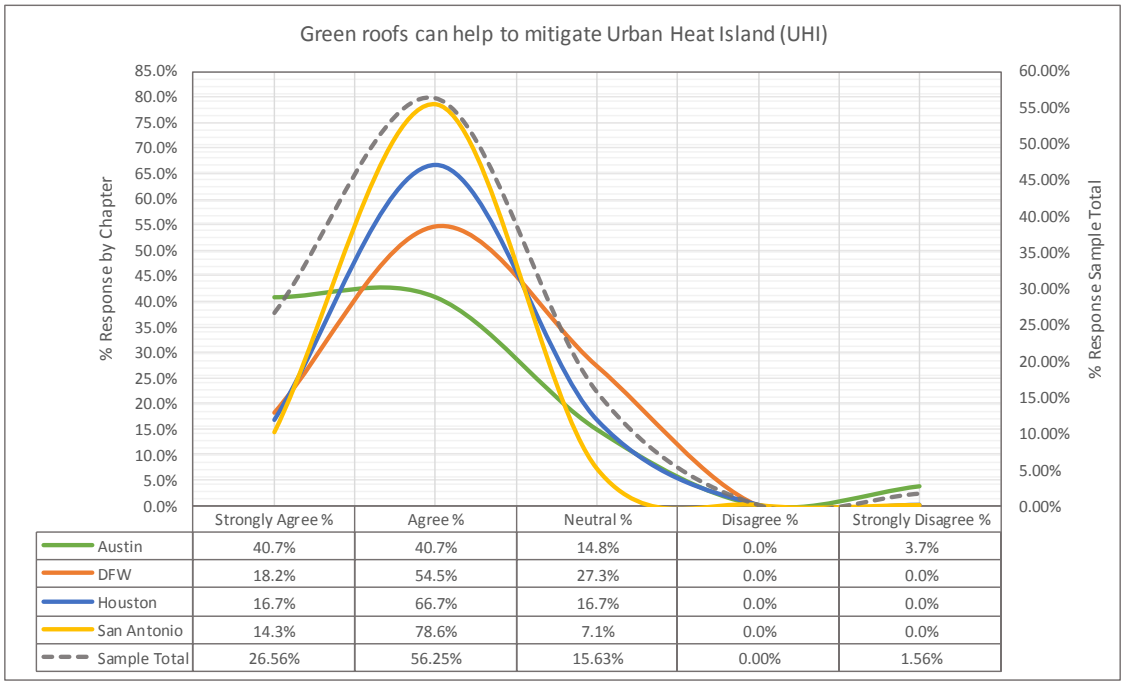
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.3325	3	0.7214

The descriptive statistics for statement #6, show all the chapters have the same median (2) (Figure 20). San Antonio and DFW distributions look similar to each other, while Austin and Houston have values that are more spread. There is an apparent positive perception of the statement in general among all the chapters (Figure 21). The option agree with 51.56% for the sample total, was the highest on every chapter. The Kruskal-Wallis Test results (Table 7) for $\alpha=0.05$ and $df=3$, show $\chi^2=1.3325 < 7.815$ and a p-value of $0.7214 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #6.

The z-scores for each chapter do not present major differences between them, with Houston leaning slightly towards neutrality or disagreement of the statement.

4.2.1.7 Statement #7: Green roofs can help to mitigate Urban Heat Island



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	40.7%	40.7%	14.8%	0.0%	3.7%
DFW	18.2%	54.5%	27.3%	0.0%	0.0%
Houston	16.7%	66.7%	16.7%	0.0%	0.0%
San Antonio	14.3%	78.6%	7.1%	0.0%	0.0%
Sample Total	26.56%	56.25%	15.63%	0.00%	1.56%

Figure 22: Statement #7, responses distributions by chapter and sample total

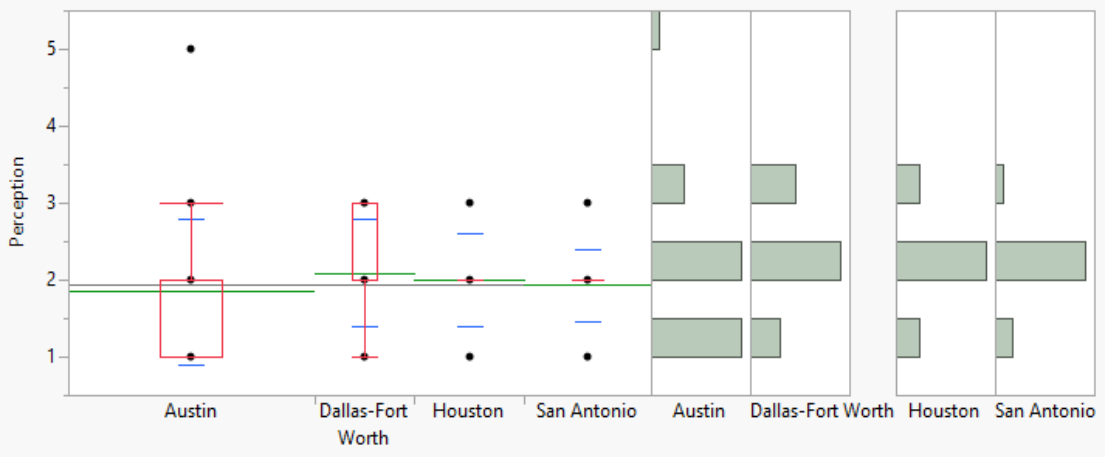


Figure 23: Statement #7, boxplot and distributions

Table 8: Statement #7, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	2	3	5
Dallas-Fort Worth	1	1	2	2	3	3	3
Houston	1	1	2	2	2	3	3
San Antonio	1	1	2	2	2	2.5	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	27	1.85185	0.948833	0.18260	1.4765	2.2272
Dallas-Fort Worth	11	2.09091	0.700649	0.21125	1.6202	2.5616
Houston	12	2.00000	0.603023	0.17408	1.6169	2.3831
San Antonio	14	1.92857	0.474631	0.12685	1.6545	2.2026

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	27	787.500	877.500	29.1667	-1.361
Dallas-Fort Worth	11	406.500	357.500	36.9545	0.965
Houston	12	419.000	390.000	34.9167	0.548
San Antonio	14	467.000	455.000	33.3571	0.209

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.1595	3	0.5400

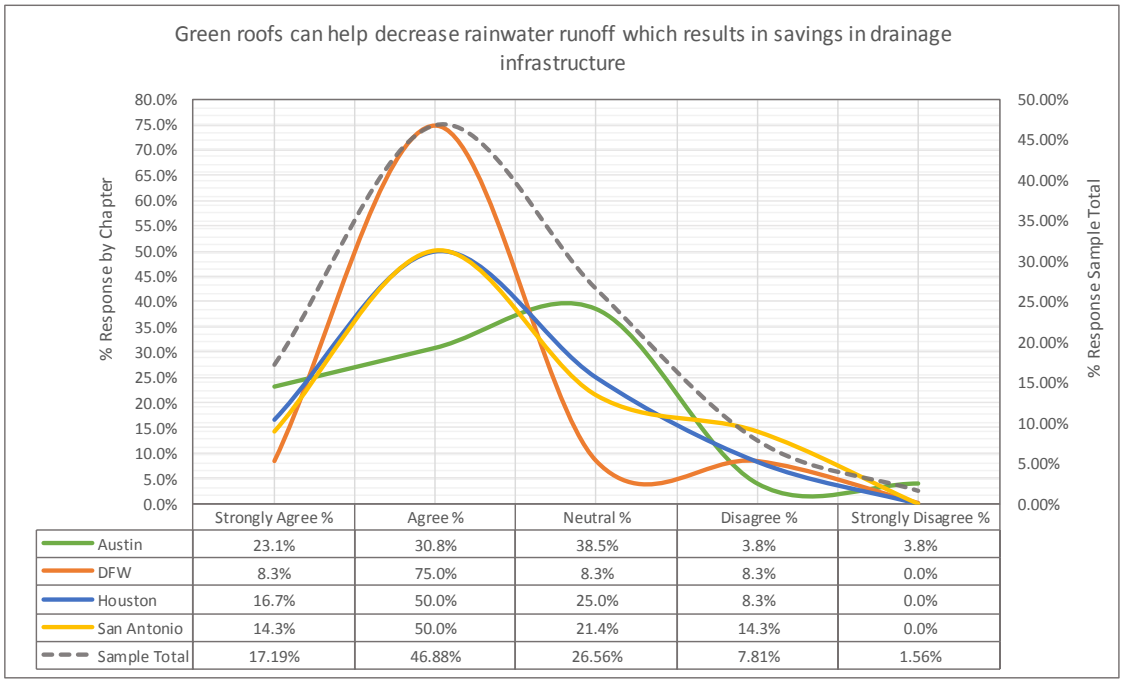
The descriptive statistics for statement #7, show all the chapters have the same median (2) (Figure 22). The distributions look similar for all the chapters except for Austin, which is more spread. There is an apparent positive perception of the statement in general among all the chapters. The option agree with 56.25% for the sample total, was the highest on every chapter (Figure 23). The Kruskal-Wallis Test results (Table 8) for α=0.05 and df=3, show χ^2=2.1595 < 7.815 and a p-value of 0.5400 > 0.05, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #7. The z-scores for each chapter do not present major differences between them, with Austin (-1.361) leaning slightly towards a more positive perception of the statement.

4.2.1.8 Environmental attributes general findings

The environmental performance analysis section of the survey showed in general, a tendency towards the agreement of the statements. Statement #1 had the largest difference among chapters in regards to the perception of facility managers on the capacity of green roofs to lower air temperature and help cooling the interior environment of a building. Statement #3 regarding the capacity of green roofs to improve rainwater retention and reduce the load on drainage systems showed the least differences among the opinions of the chapters.

4.2.2 Statements Related to Economic Attributes

4.2.2.1 Statement #8: Green roofs can help decrease rainwater runoff which results in savings in drainage infrastructure



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	23.1%	30.8%	38.5%	3.8%	3.8%
DFW	8.3%	75.0%	8.3%	8.3%	0.0%
Houston	16.7%	50.0%	25.0%	8.3%	0.0%
San Antonio	14.3%	50.0%	21.4%	14.3%	0.0%
Sample Total	17.19%	46.88%	26.56%	7.81%	1.56%

Figure 24: Statement #8, responses distributions by chapter and sample total

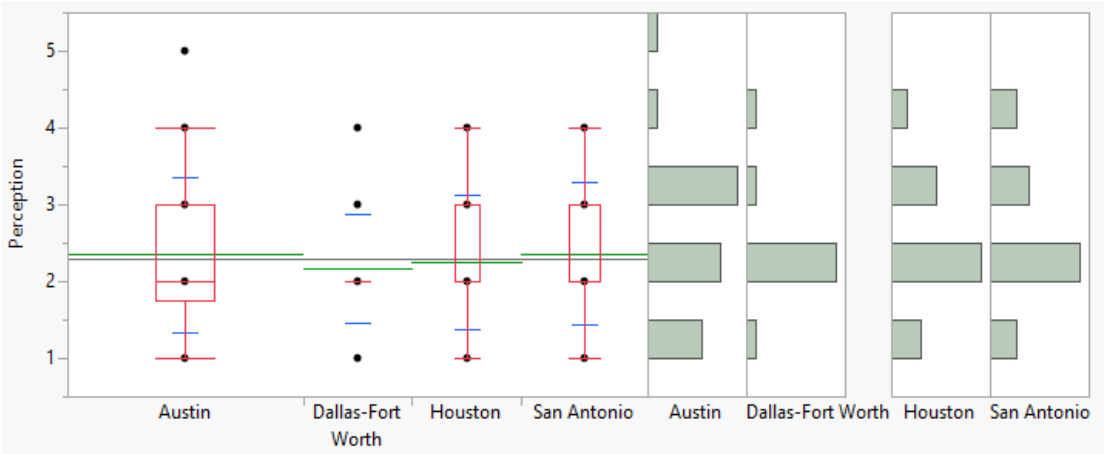


Figure 25: Statement #8, boxplot and distributions

Table 9: Statement #8, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1.75	2	3	3.3	5
Dallas-Fort Worth	1	1.3	2	2	2	3.7	4
Houston	1	1	2	2	3	3.7	4
San Antonio	1	1	2	2	3	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.34615	1.01754	0.19956	1.9352	2.7571
Dallas-Fort Worth	12	2.16667	0.71774	0.20719	1.7106	2.6227
Houston	12	2.25000	0.86603	0.25000	1.6998	2.8002
San Antonio	14	2.35714	0.92878	0.24823	1.8209	2.8934

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

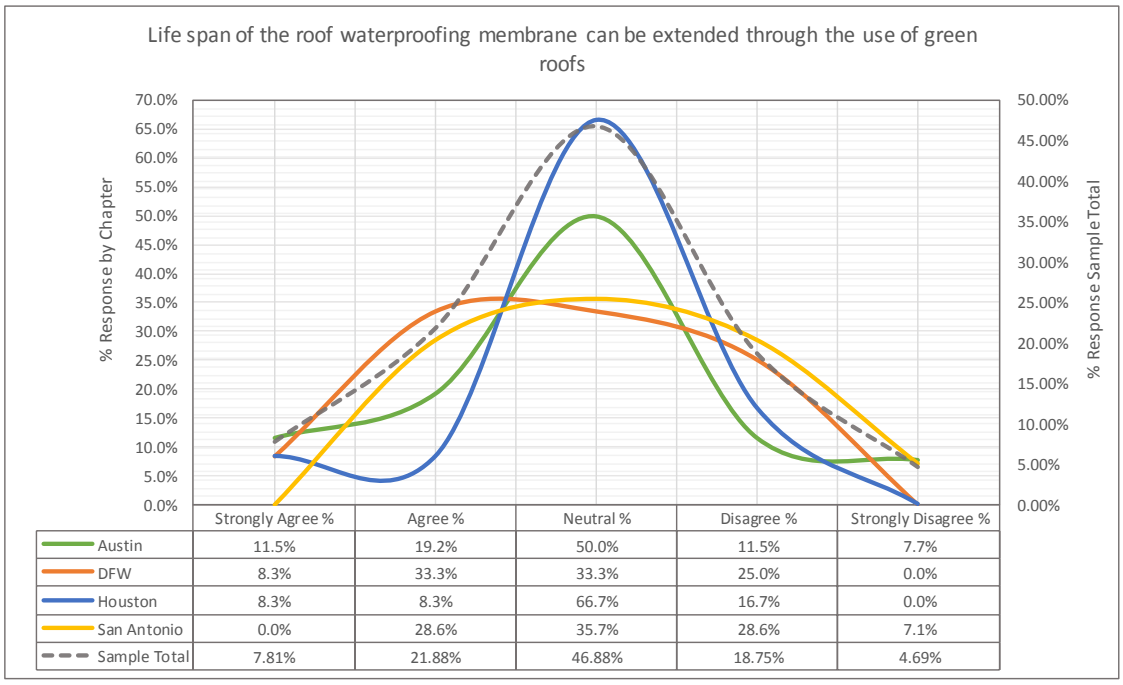
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	873.000	845.000	33.5769	0.402
Dallas-Fort Worth	12	355.500	390.000	29.6250	-0.626
Houston	12	382.000	390.000	31.8333	-0.138
San Antonio	14	469.500	455.000	33.5357	0.243

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.4947	3	0.9201

The descriptive statistics for statement #8, show all the chapters have the same median (2) (Figure 24). San Antonio and Houston's distributions look similar, while Austin shows a tendency towards neutrality. There is an apparent positive perception of the statement in general among all the chapters. The option agree with 46.88% for the sample total, was the highest on every chapter except for Austin in which the neutral position was higher (38.5%) (Figure 25). The Kruskal-Wallis Test results (Table 9) for α=0.05 and df=3, show χ^2=0.4947 < 7.815 and a p-value of 0.9201 > 0.05, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #8. The z-scores for each chapter do not present major differences between them.

4.2.2.2 Statement #9: The life span of the roof waterproofing membrane can be extended through the use of green roofs



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	11.5%	19.2%	50.0%	11.5%	7.7%
DFW	8.3%	33.3%	33.3%	25.0%	0.0%
Houston	8.3%	8.3%	66.7%	16.7%	0.0%
San Antonio	0.0%	28.6%	35.7%	28.6%	7.1%
Sample Total	7.81%	21.88%	46.88%	18.75%	4.69%

Figure 26: Statement #9, responses distributions by chapter and sample total

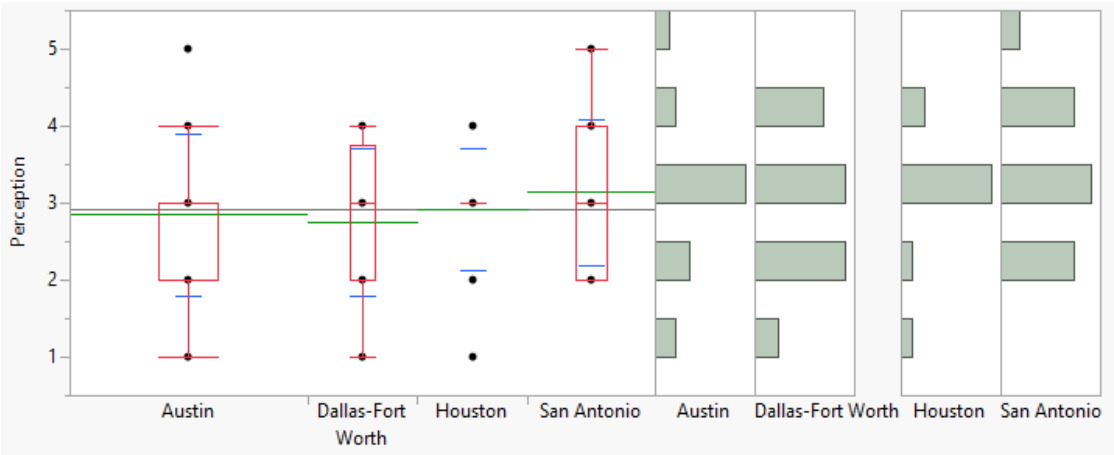


Figure 27: Statement #9, boxplot and distributions

Table 10: Statement #9, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	3	3	4.3	5
Dallas-Fort Worth	1	1.3	2	3	3.75	4	4
Houston	1	1.3	3	3	3	4	4
San Antonio	2	2	2	3	4	4.5	5

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.84615	1.04661	0.20526	2.4234	3.2689
Dallas-Fort Worth	12	2.75000	0.96531	0.27866	2.1367	3.3633
Houston	12	2.91667	0.79296	0.22891	2.4128	3.4205
San Antonio	14	3.14286	0.94926	0.25370	2.5948	3.6909

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	812.500	845.000	31.2500	-0.466
Dallas-Fort Worth	12	357.500	390.000	29.7917	-0.587
Houston	12	402.500	390.000	33.5417	0.220
San Antonio	14	507.500	455.000	36.2500	0.900

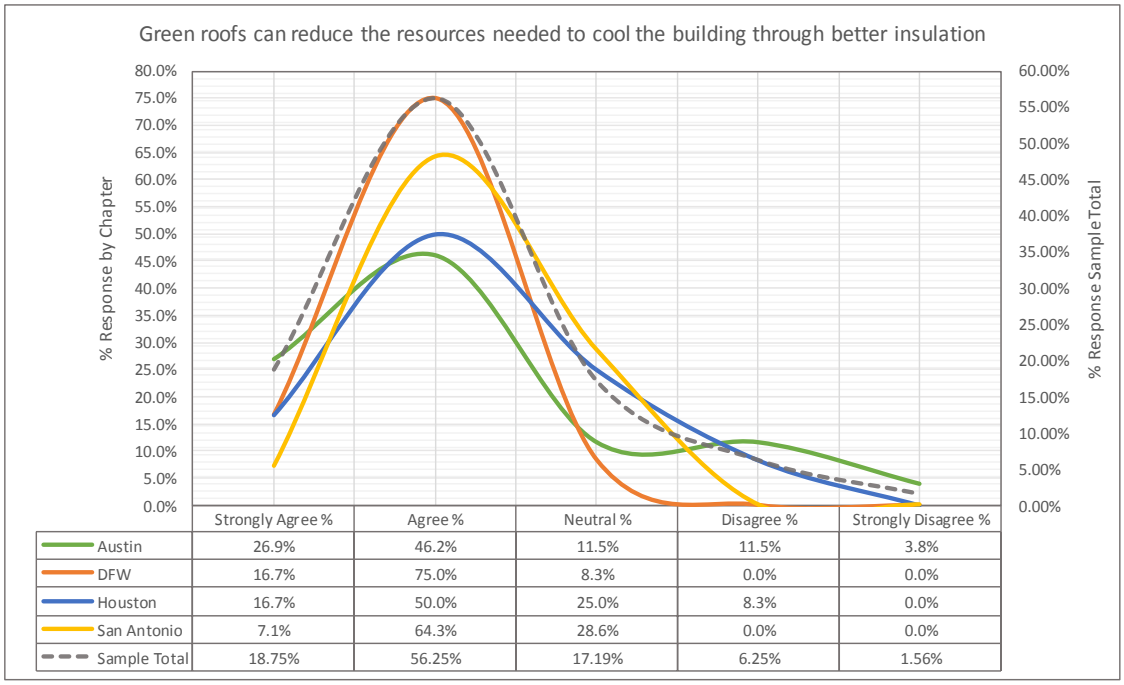
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.1103	3	0.7746

The descriptive statistics for statement #9, show all the chapters have the same median (3) (Figure 27). San Antonio's and DFW's responses distributions are more spread, while Austin's and Houston's show a tendency towards neutrality. There is an apparent neutral perception of the statement in general among all the chapters, with the option neutral selected by 46.88% of the sample total (Figure 26). The Kruskal-Wallis Test (Table 10) results for $\alpha=0.05$ and $df=3$, show $\chi^2=1.1103 < 7.815$ and a p-value of $0.7746>0.05$, therefore fail to reject the null hypothesis and conclude that there is no

significant difference among the chapters on the perception of statement #9. The z-scores for each chapter do not present major differences between them.

4.2.2.3 Statement #10: Green roofs can reduce the resources needed to cool the building through better insulation



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	26.9%	46.2%	11.5%	11.5%	3.8%
DFW	16.7%	75.0%	8.3%	0.0%	0.0%
Houston	16.7%	50.0%	25.0%	8.3%	0.0%
San Antonio	7.1%	64.3%	28.6%	0.0%	0.0%
Sample Total	18.75%	56.25%	17.19%	6.25%	1.56%

Figure 28: Statement #10, responses distributions by chapter and sample total

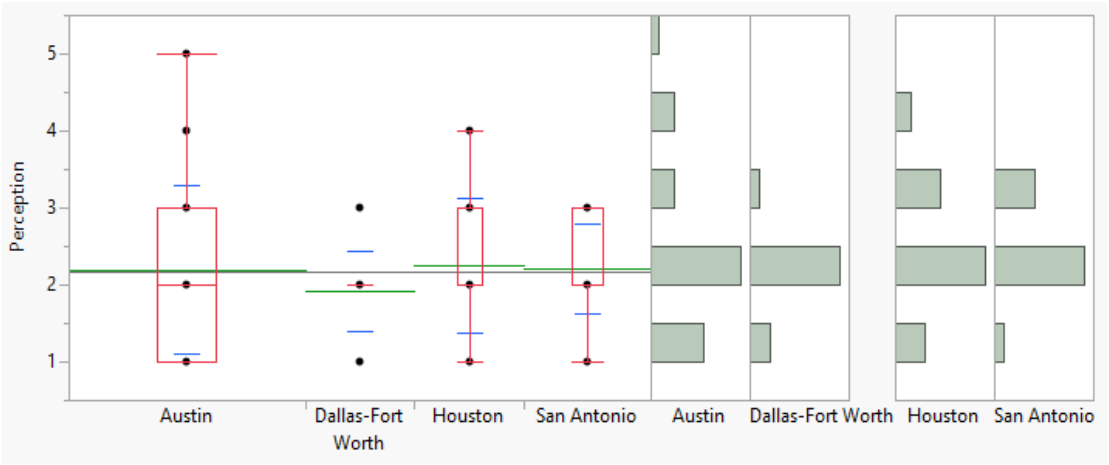


Figure 29: Statement #10, boxplot and distributions

Table 11: Statement #10, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	4	5
Dallas-Fort Worth	1	1	2	2	2	2.7	3
Houston	1	1	2	2	3	3.7	4
San Antonio	1	1.5	2	2	3	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.19231	1.09615	0.21497	1.7496	2.6351
Dallas-Fort Worth	12	1.91667	0.51493	0.14865	1.5895	2.2438
Houston	12	2.25000	0.86603	0.25000	1.6998	2.8002
San Antonio	14	2.21429	0.57893	0.15473	1.8800	2.5486

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

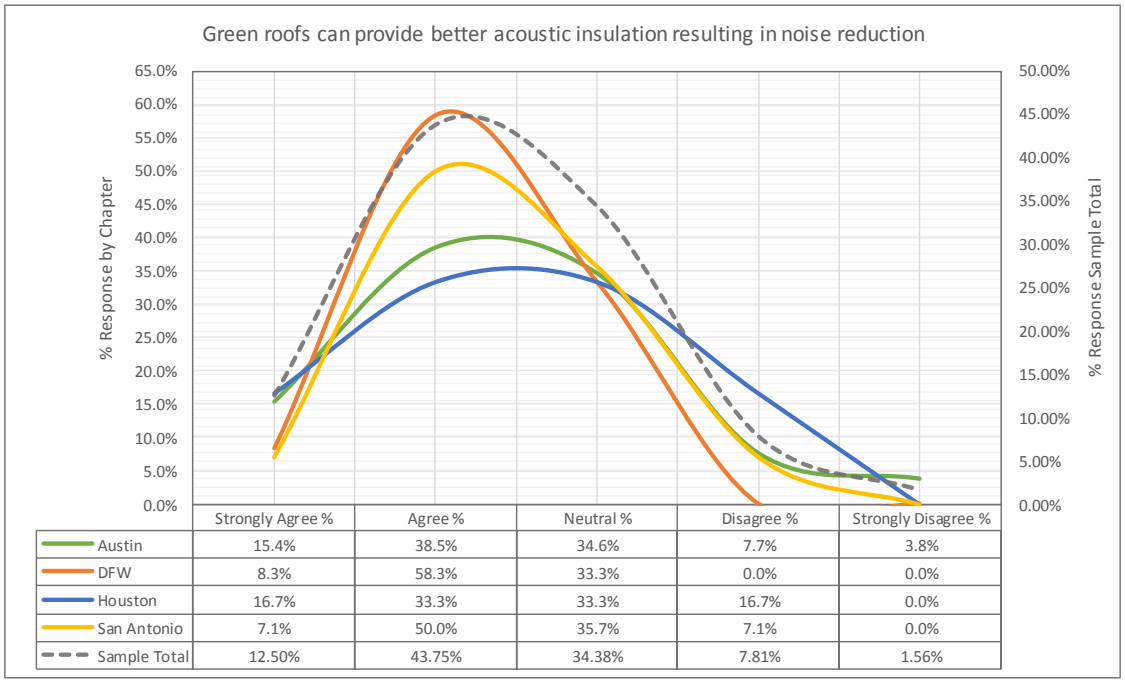
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	822.000	845.000	31.6154	-0.342
Dallas-Fort Worth	12	341.500	390.000	28.4583	-0.917
Houston	12	419.500	390.000	34.9583	0.554
San Antonio	14	497.000	455.000	35.5000	0.749

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.4770	3	0.6876

The descriptive statistics for statement #10, show all the chapters have the same median (2) (Figure 28). The distributions among the chapters look similar, with an apparent positive perception of the statement in general. The option agree with 56.25% for the sample total, was the highest on every chapter (Figure 29). The Kruskal-Wallis Test results (Table 11) for α=0.05 and df=3, show χ^2=1.4770 < 7.815 and a p-value of 0.6876>0.05, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #10. The z-scores for each chapter do not present major variations between them.

4.2.2.4 Statement #11: Green roofs can provide better acoustic insulation resulting in noise reduction



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	15.4%	38.5%	34.6%	7.7%	3.8%
DFW	8.3%	58.3%	33.3%	0.0%	0.0%
Houston	16.7%	33.3%	33.3%	16.7%	0.0%
San Antonio	7.1%	50.0%	35.7%	7.1%	0.0%
Sample Total	12.50%	43.75%	34.38%	7.81%	1.56%

Figure 30: Statement #11, responses distributions by chapter and sample total

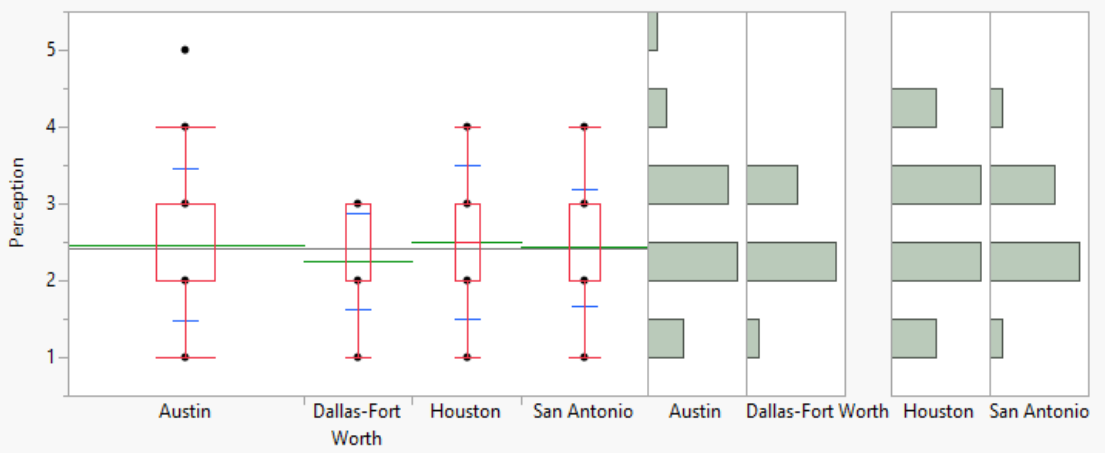


Figure 31: Statement #11, boxplot and distributions

Table 12: Statement #11, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	2	3	4	5
Dallas-Fort Worth	1	1.3	2	2	3	3	3
Houston	1	1	2	2.5	3	4	4
San Antonio	1	1.5	2	2	3	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.46154	0.98917	0.19399	2.0620	2.8611
Dallas-Fort Worth	12	2.25000	0.62158	0.17944	1.8551	2.6449
Houston	12	2.50000	1.00000	0.28868	1.8646	3.1354
San Antonio	14	2.42857	0.75593	0.20203	1.9921	2.8650

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

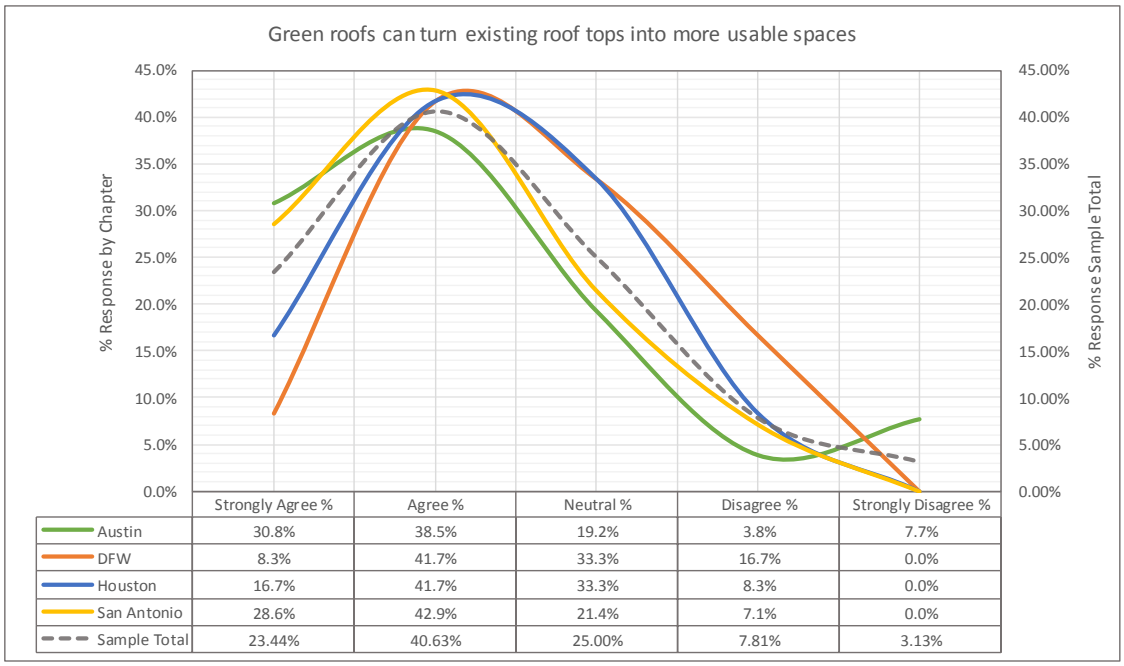
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	856.500	845.000	32.9423	0.161
Dallas-Fort Worth	12	352.000	390.000	29.3333	-0.690
Houston	12	411.000	390.000	34.2500	0.377
San Antonio	14	460.500	455.000	32.8929	0.087

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.5427	3	0.9094

The descriptive statistics for statement #11, show the median for Austin, DFW and San Antonio is 2, Houston's chapter median is 2.5 (Figure 30). The distributions among the chapters look similar, with an apparent positive perception of the statement in general. The option agree with 43.75% for the sample total, was the highest on every chapter (Figure 31). The Kruskal-Wallis Test results (Table 12) for $\alpha=0.05$ and $df=3$, show $\chi^2=0.5427 < 7.815$ and a p-value of $0.9094 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #11. The z-scores for each chapter do not present major variations between them.

4.2.2.5 Statement #12: Green roofs can turn existing rooftops into more usable spaces



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	30.8%	38.5%	19.2%	3.8%	7.7%
DFW	8.3%	41.7%	33.3%	16.7%	0.0%
Houston	16.7%	41.7%	33.3%	8.3%	0.0%
San Antonio	28.6%	42.9%	21.4%	7.1%	0.0%
Sample Total	23.44%	40.63%	25.00%	7.81%	3.13%

Figure 32: Statement #12, responses distributions by chapter and sample total

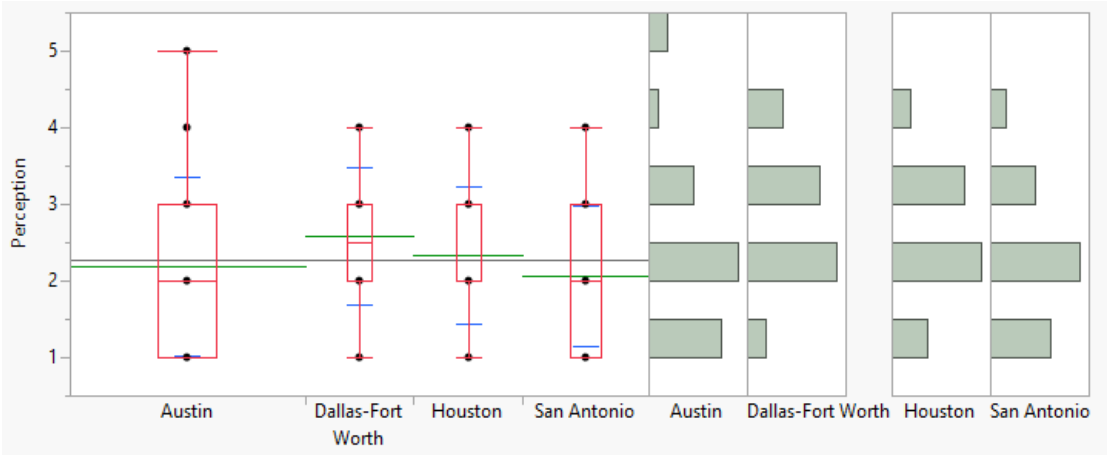


Figure 33: Statement #12, boxplot and distributions

Table 13: Statement #12, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	4.3	5
Dallas-Fort Worth	1	1.3	2	2.5	3	4	4
Houston	1	1	2	2	3	3.7	4
San Antonio	1	1	1	2	3	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.19231	1.16685	0.22884	1.7210	2.6636
Dallas-Fort Worth	12	2.58333	0.90034	0.25990	2.0113	3.1554
Houston	12	2.33333	0.88763	0.25624	1.7694	2.8973
San Antonio	14	2.07143	0.91687	0.24505	1.5420	2.6008

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	783.500	845.000	30.1346	-0.877
Dallas-Fort Worth	12	468.500	390.000	39.0417	1.411
Houston	12	416.500	390.000	34.7083	0.470
San Antonio	14	411.500	455.000	29.3929	-0.734

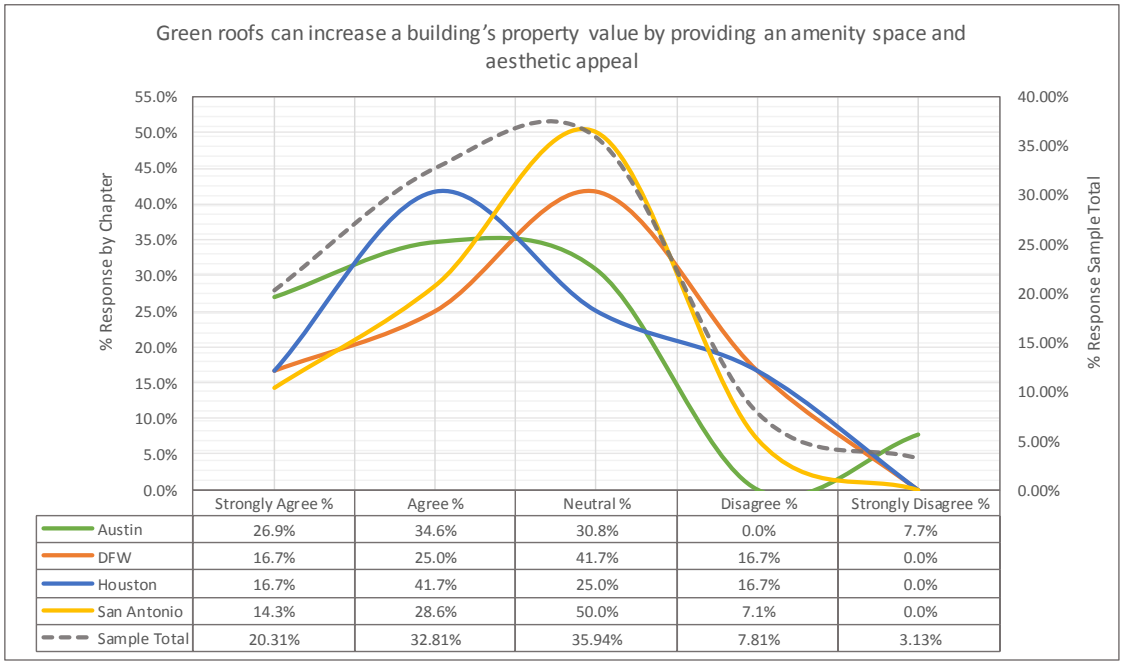
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.7203	3	0.4368

The descriptive statistics for statement #12, show the median for Austin, Houston and San Antonio is 2, DFW's chapter median is 2.5 (Figure 32). The distributions among the chapters look similar, with an apparent positive perception of the statement in general. The option agree with 40.63% for the sample total, was the highest on every chapter (Figure 33). The Kruskal-Wallis Test results (Table 13) for α=0.05 and df=3, show χ^2=2.7203 < 7.815 and a p-value of 0.4368 > 0.05, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #12. The z-scores for each chapter do not present major

variations between them, except for DFW with a z-score of 1.411 the perception for this statement leans towards neutrality.

4.2.2.6 Statement #13: Green roofs can increase a building's property value by providing an amenity space and aesthetic appeal



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	26.9%	34.6%	30.8%	0.0%	7.7%
DFW	16.7%	25.0%	41.7%	16.7%	0.0%
Houston	16.7%	41.7%	25.0%	16.7%	0.0%
San Antonio	14.3%	28.6%	50.0%	7.1%	0.0%
Sample Total	20.31%	32.81%	35.94%	7.81%	3.13%

Figure 34: Statement #13, responses distributions by chapter and sample total

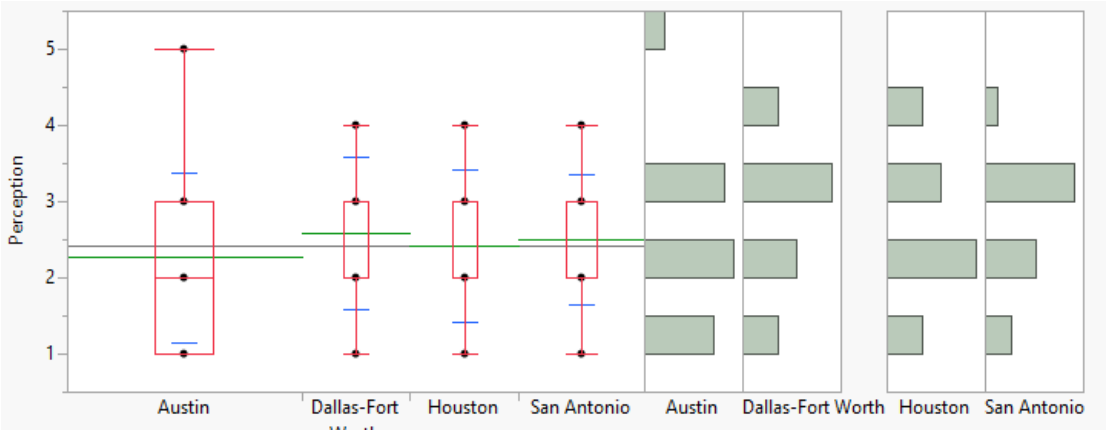


Figure 35: Statement #13, boxplot and distributions

Table 14: Statement #13, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	3.6	5
Dallas-Fort Worth	1	1	2	3	3	4	4
Houston	1	1	2	2	3	4	4
San Antonio	1	1	2	3	3	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.26923	1.11562	0.21879	1.8186	2.7198
Dallas-Fort Worth	12	2.58333	0.99620	0.28758	1.9504	3.2163
Houston	12	2.41667	0.99620	0.28758	1.7837	3.0496
San Antonio	14	2.50000	0.85485	0.22847	2.0064	2.9936

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

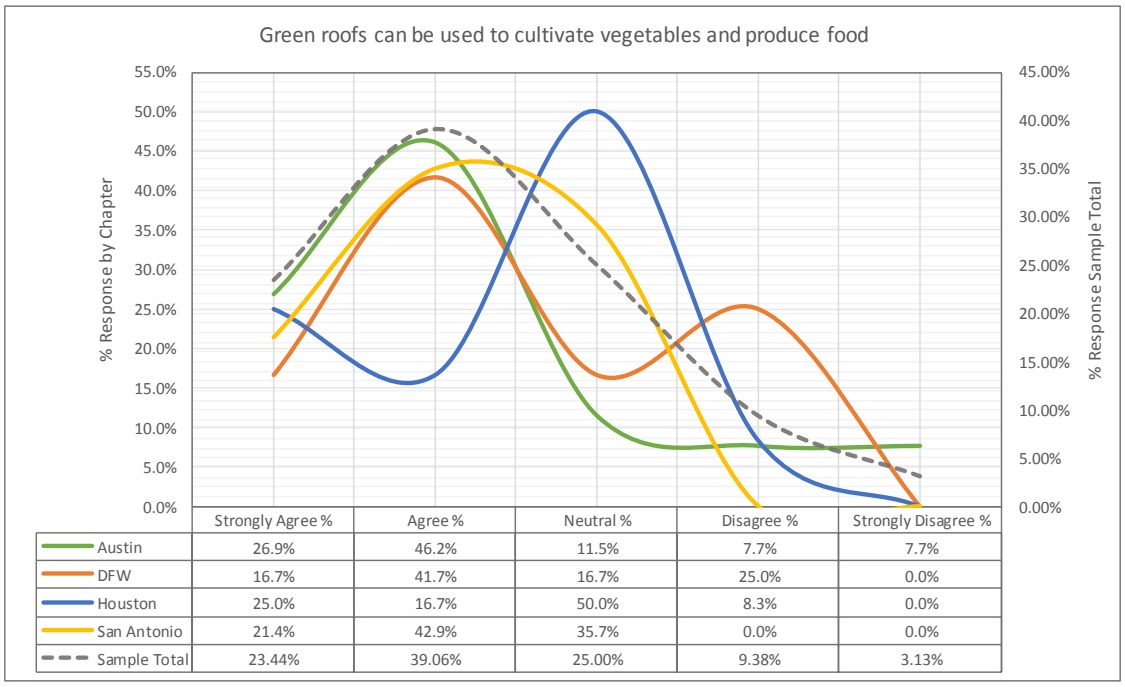
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	760.000	845.000	29.2308	-1.211
Dallas-Fort Worth	12	436.000	390.000	36.3333	0.821
Houston	12	392.000	390.000	32.6667	0.027
San Antonio	14	492.000	455.000	35.1429	0.622

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.7516	3	0.6255

The descriptive statistics for statement #13, show the median for Austin and Houston to be the same (2), and San Antonio and DFW (3) respectively (Figure 34). The distributions among the chapters look different, with San Antonio and DFW moving around a neutral perception of the statement, while Houston and Austin around a more positive perception. The option neutral (35.94%) was the most common for the sample total, and DFW and San Antonio chapters (Figure 35). The Kruskal-Wallis Test results (Table 14) for $\alpha=0.05$ and df=3, show $\chi^2=1.7516 < 7.815$ and a p-value of $0.6255 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #13. The z-scores for each chapter do not present major variations from each other's median, except for Austin with a z-score of -1.21 the perception for this statement leans slightly towards agreement.

4.2.2.7 Statement #14: Green roofs can be used to cultivate vegetables and produce food



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	26.9%	46.2%	11.5%	7.7%	7.7%
DFW	16.7%	41.7%	16.7%	25.0%	0.0%
Houston	25.0%	16.7%	50.0%	8.3%	0.0%
San Antonio	21.4%	42.9%	35.7%	0.0%	0.0%
Sample Total	23.44%	39.06%	25.00%	9.38%	3.13%

Figure 36: Statement #14, responses distributions by chapter and sample total

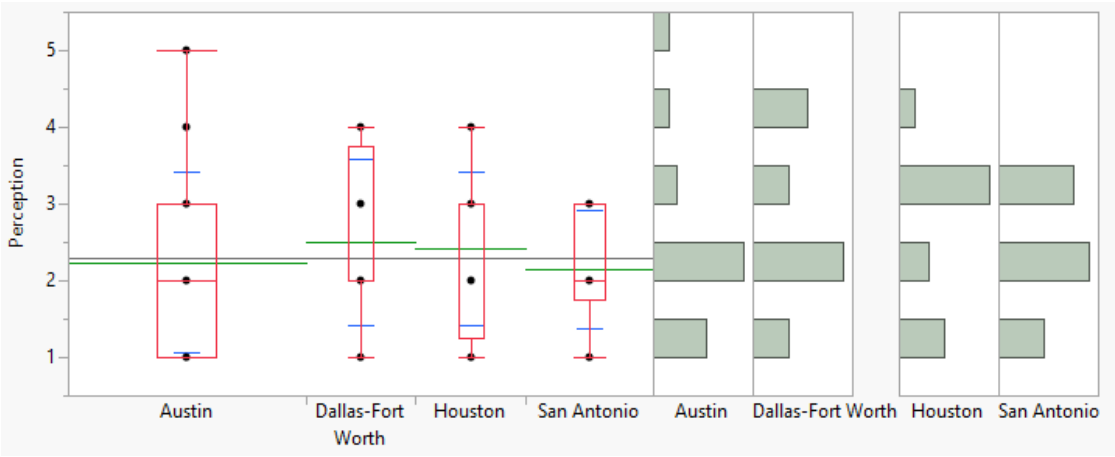


Figure 37: Statement #14, boxplot and distributions

Table 15: Statement #14, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	4.3	5
Dallas-Fort Worth	1	1	2	2	3.75	4	4
Houston	1	1	1.25	3	3	3.7	4
San Antonio	1	1	1.75	2	3	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.23077	1.17670	0.23077	1.7555	2.7060
Dallas-Fort Worth	12	2.50000	1.08711	0.31382	1.8093	3.1907
Houston	12	2.41667	0.99620	0.28758	1.7837	3.0496
San Antonio	14	2.14286	0.77033	0.20588	1.6981	2.5876

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	783.500	845.000	30.1346	-0.874
Dallas-Fort Worth	12	431.500	390.000	35.9583	0.739
Houston	12	430.500	390.000	35.8750	0.721
San Antonio	14	434.500	455.000	31.0357	-0.340

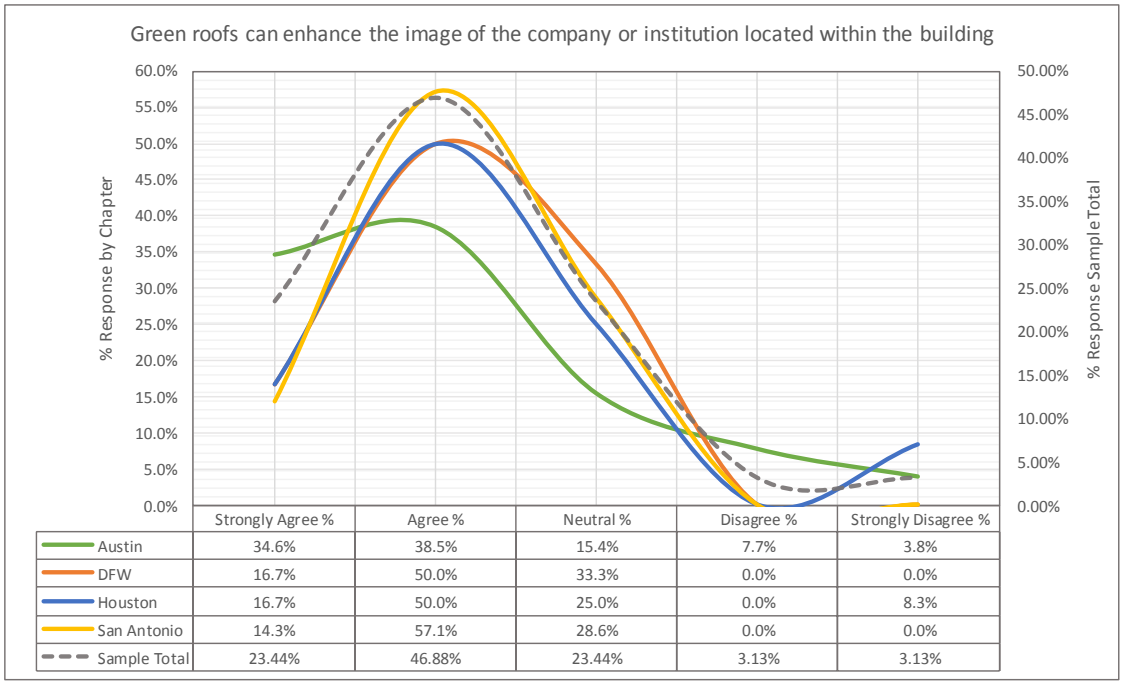
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.4425	3	0.6956

The descriptive statistics for statement #14, show the median for Austin, Houston and San Antonio to be the same (2), and DFW (3) (Figure 36). The distributions among the chapters look different, with DFW showing some type of bimodality between options agree and disagree. Austin, Dallas and San Antonio distributions lean towards a positive perception of this statement. The option agree (39.06%) was the most common for the sample total and all the chapters except for Houston (Figure 37). The Kruskal-Wallis Test results (Table 15) for $\alpha=0.05$ and $df=3$, show $\chi^2=1.4425 < 7.815$ and a p-value of $0.6956 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no

significant difference among the chapters on the perception of statement #14. The z-scores for each chapter do not present major variations between them.

4.2.2.8 Statement #15: Green roofs can enhance the image of the company or institution located within the building



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	34.6%	38.5%	15.4%	7.7%	3.8%
DFW	16.7%	50.0%	33.3%	0.0%	0.0%
Houston	16.7%	50.0%	25.0%	0.0%	8.3%
San Antonio	14.3%	57.1%	28.6%	0.0%	0.0%
Sample Total	23.44%	46.88%	23.44%	3.13%	3.13%

Figure 38: Statement #15, responses distributions by chapter and sample total

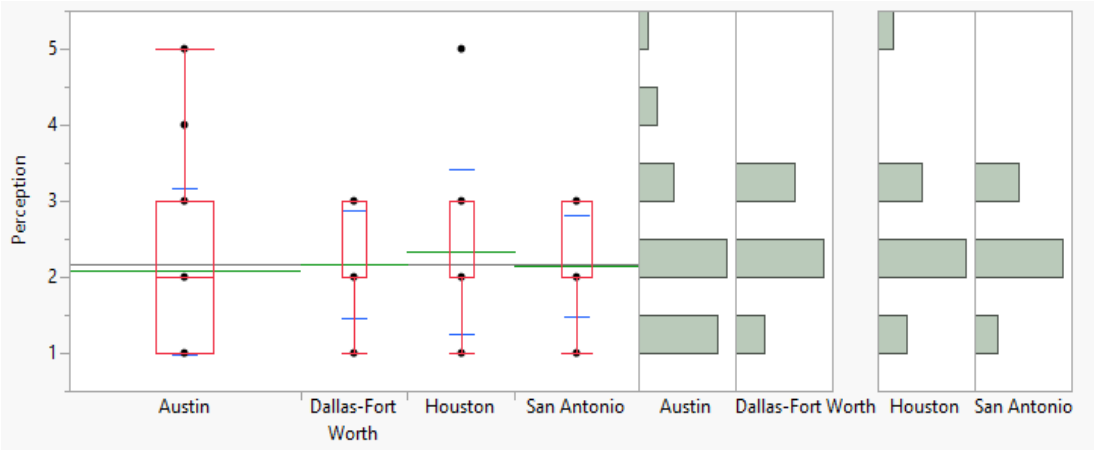


Figure 39: Statement #15, boxplot and distributions

Table 16: Statement #15, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	4	5
Dallas-Fort Worth	1	1	2	2	3	3	3
Houston	1	1	2	2	3	4.4	5
San Antonio	1	1	2	2	3	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.07692	1.09263	0.21428	1.6356	2.5182
Dallas-Fort Worth	12	2.16667	0.71774	0.20719	1.7106	2.6227
Houston	12	2.33333	1.07309	0.30977	1.6515	3.0151
San Antonio	14	2.14286	0.66299	0.17719	1.7601	2.5257

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	775.500	845.000	29.8269	-1.010
Dallas-Fort Worth	12	411.000	390.000	34.2500	0.378
Houston	12	421.500	390.000	35.1250	0.571
San Antonio	14	472.000	455.000	33.7143	0.287

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.0787	3	0.7822

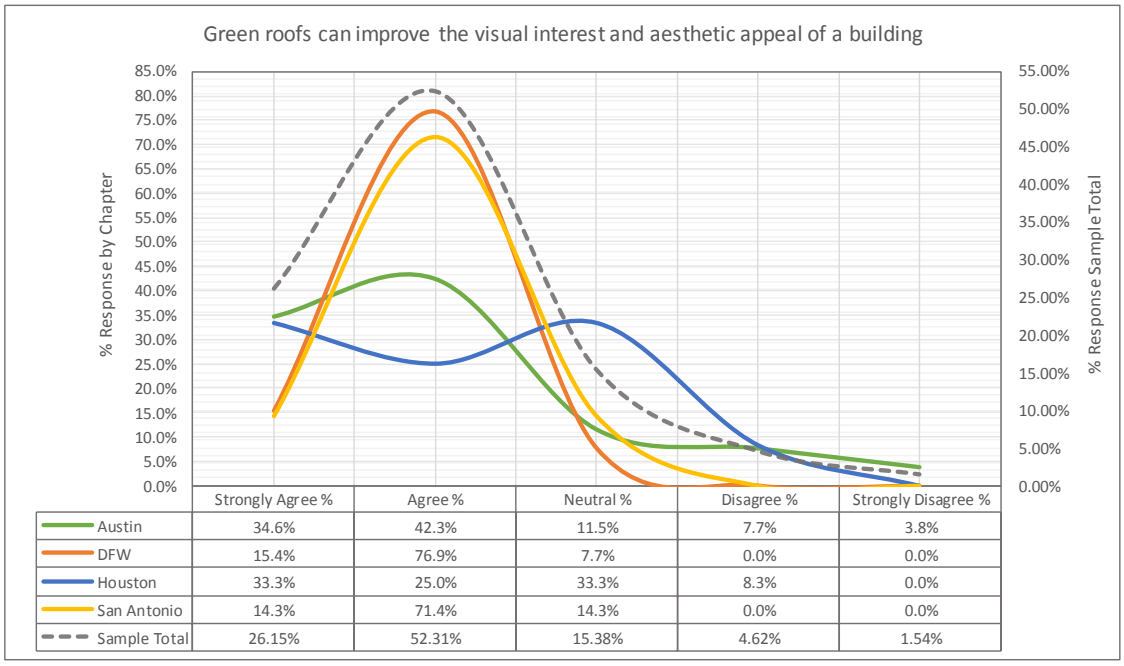
The descriptive statistics for statement #15, show all the chapters have the same median (2) (Figure 38). The distributions among the chapters look similar, with Austin leaning towards a more positive perception. The option agree with 48.88% was the most common for the sample total and all the chapters (Figure 39). The Kruskal-Wallis Test results (Table 16) for $\alpha=0.05$ and df=3, show $\chi^2=1.0787 < 7.815$ and a p-value of $0.7822 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #15. The z-scores for each chapter do not present major variations between them, except for Austin that with a z-score of -1.010 leans slightly towards a more positive perception.

4.2.2.9 Economic attributes general findings

The economic attributes section of the survey showed in general, a tendency towards the agreement of the statements. Statement #8 had the largest difference among chapters in regards to the perception of facility managers on the capacity of green roofs to decrease rainwater runoff which can result in savings in drainage infrastructure. Statement #12 regarding the capacity of green roofs to turn existing roof tops into more usable spaces showed the least differences among the opinions of the chapters.

4.2.3 Statements Related to Aesthetic Attributes

4.2.3.1 Statement #16: Green roofs can improve the visual interest and aesthetic appeal of a building



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	34.6%	42.3%	11.5%	7.7%	3.8%
DFW	15.4%	76.9%	7.7%	0.0%	0.0%
Houston	33.3%	25.0%	33.3%	8.3%	0.0%
San Antonio	14.3%	71.4%	14.3%	0.0%	0.0%
Sample Total	26.15%	52.31%	15.38%	4.62%	1.54%

Figure 40: Statement #16, responses distributions by chapter and sample total

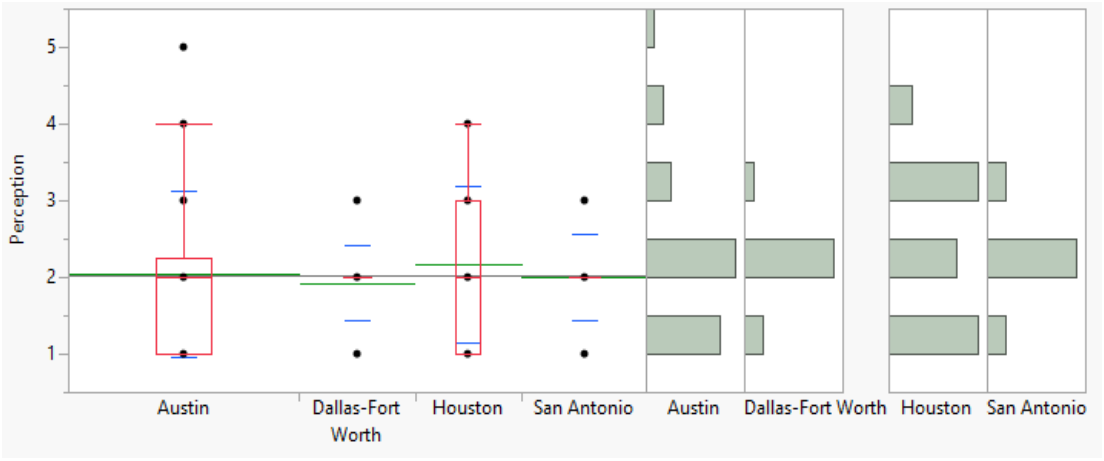


Figure 41: Statement #16, boxplot and distributions

Table 17: Statement #16, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	2.25	4	5
Dallas-Fort Worth	1	1	2	2	2	2.6	3
Houston	1	1	1	2	3	3.7	4
San Antonio	1	1	2	2	2	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.03846	1.07632	0.21108	1.6037	2.4732
Dallas-Fort Worth	13	1.92308	0.49355	0.13689	1.6248	2.2213
Houston	12	2.16667	1.02986	0.29729	1.5123	2.8210
San Antonio	14	2.00000	0.55470	0.14825	1.6797	2.3203

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

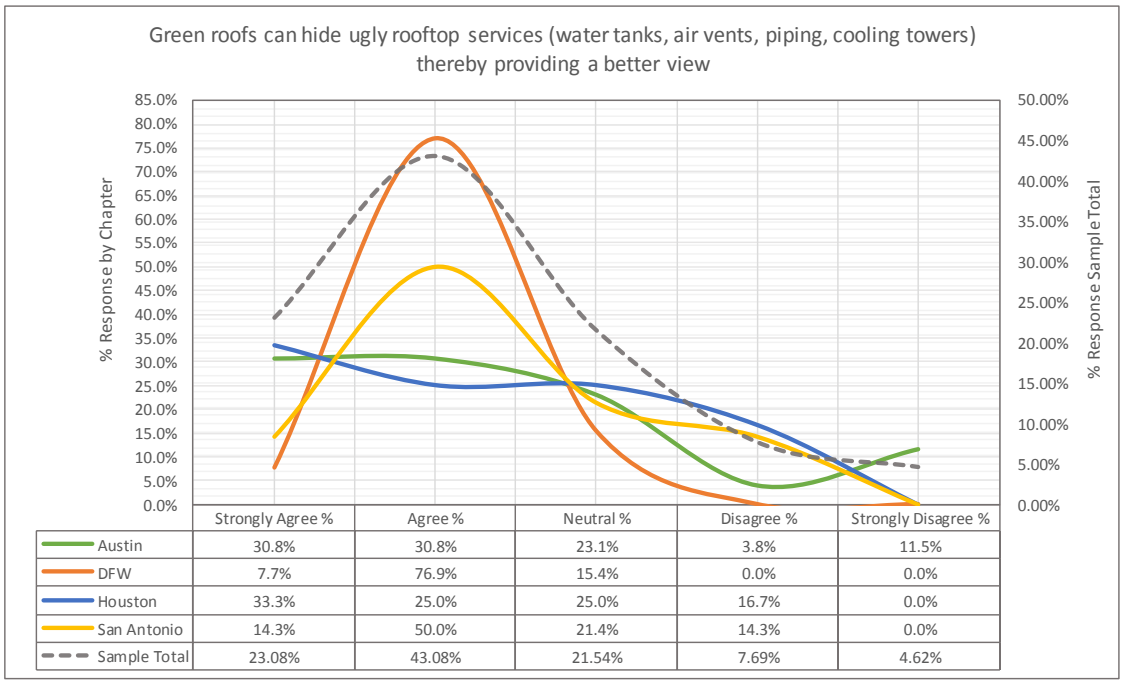
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	821.000	858.000	31.5769	-0.535
Dallas-Fort Worth	13	419.500	429.000	32.2692	-0.161
Houston	12	428.500	396.000	35.7083	0.592
San Antonio	14	476.000	462.000	34.0000	0.236

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.5411	3	0.9098

The descriptive statistics for statement #16, show all the chapters have the same median (2) (Figure 40). The distributions for DFW and San Antonio look similar, while Austin leans more towards a positive perception of the statement. Houston's data shows some bimodality between strongly agree and neutral. The option agree with 52.31% was the most common for the sample total and all the chapters except Houston, which had 33.33% for the option strongly agree and the same value for neutral (Figure 41). The Kruskal-Wallis Test results (Table 17) for $\alpha=0.05$ and $df=3$, show $\chi^2=0.5411 < 7.815$ and a p-value of $0.9098 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #16. The z-scores for each chapter do not present major variations between them.

4.2.3.2 Statement #17: Green roofs can hide ugly rooftop services (water tanks, air vents, piping, cooling towers) thereby providing a better view



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	30.8%	30.8%	23.1%	3.8%	11.5%
DFW	7.7%	76.9%	15.4%	0.0%	0.0%
Houston	33.3%	25.0%	25.0%	16.7%	0.0%
San Antonio	14.3%	50.0%	21.4%	14.3%	0.0%
Sample Total	23.08%	43.08%	21.54%	7.69%	4.62%

Figure 42: Statement #17, responses distributions by chapter and sample total

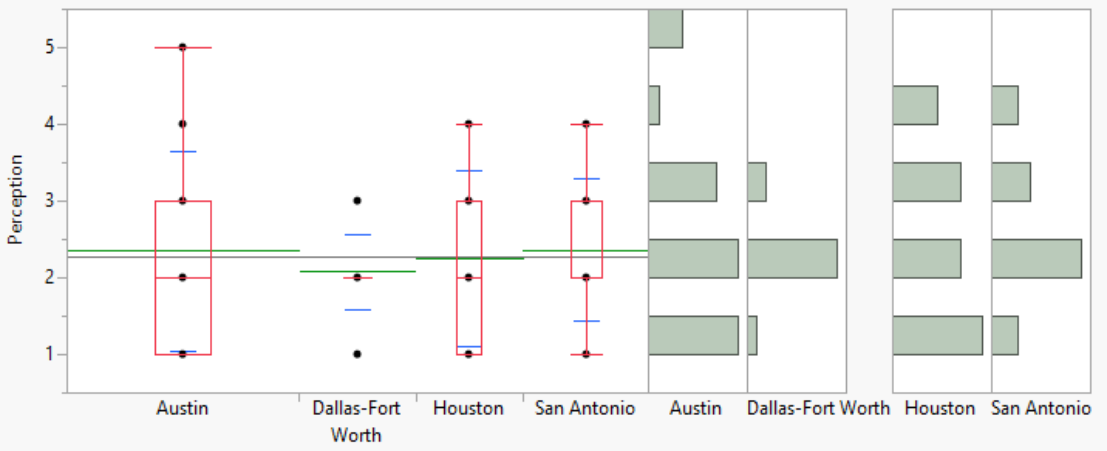


Figure 43: Statement #17, boxplot and distributions

Table 18: Statement #17, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	5	5
Dallas-Fort Worth	1	1.4	2	2	2	3	3
Houston	1	1	1	2	3	4	4
San Antonio	1	1	2	2	3	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.34615	1.29437	0.25385	1.8233	2.8690
Dallas-Fort Worth	13	2.07692	0.49355	0.13689	1.7787	2.3752
Houston	12	2.25000	1.13818	0.32856	1.5268	2.9732
San Antonio	14	2.35714	0.92878	0.24823	1.8209	2.8934

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	855.000	858.000	32.8846	-0.035
Dallas-Fort Worth	13	404.000	429.000	31.0769	-0.424
Houston	12	392.000	396.000	32.6667	-0.062
San Antonio	14	494.000	462.000	35.2857	0.531

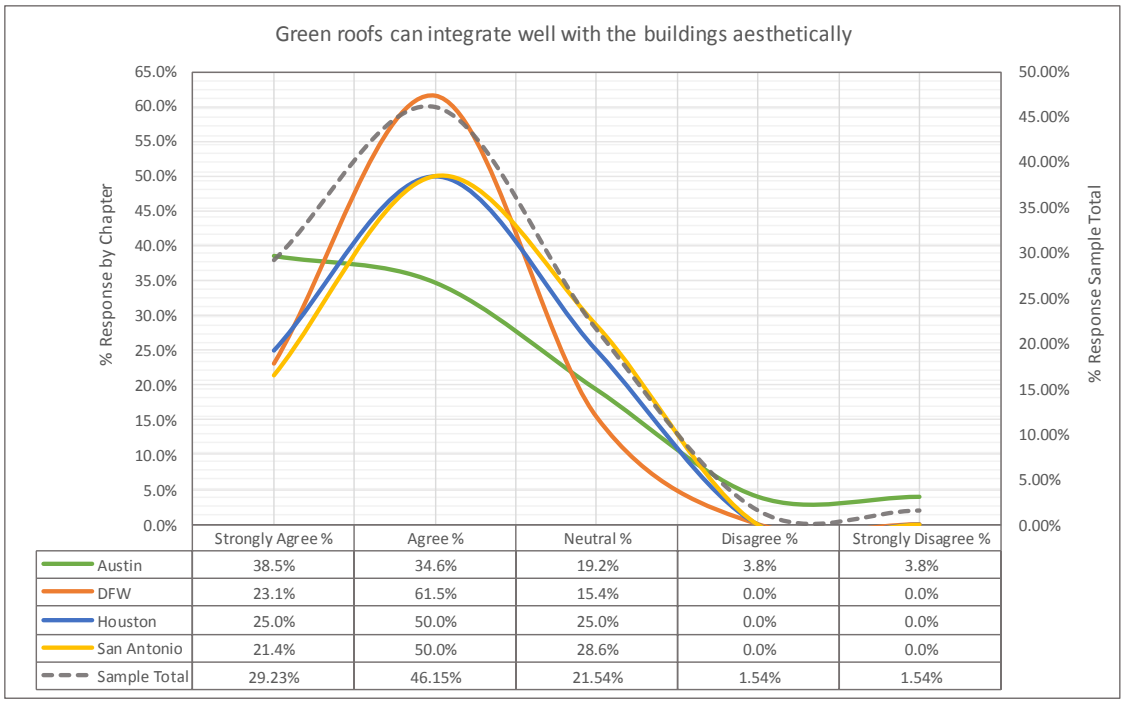
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.3831	3	0.9437

The descriptive statistics for statement #17, show all the chapters have the same median (2) (Figure 42). The distributions for DFW and San Antonio look similar, while Austin leans more towards a positive perception of the statement. Houston's data is distributed similarly with the option strongly agree having the most responses (33.33%). The option agree with 43.08% was the most common for the sample total and all the chapters except Houston (Figure 43). The Kruskal-Wallis Test results (Table 18) for $\alpha=0.05$ and $df=3$, show $\chi^2=0.3831 < 7.815$ and a p-value of $0.9437 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among

the chapters on the perception of statement #17. The z-scores for each chapter do not present major variations between them.

4.2.3.3 Statement #18: Green roofs can integrate well with the buildings aesthetically



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	38.5%	34.6%	19.2%	3.8%	3.8%
DFW	23.1%	61.5%	15.4%	0.0%	0.0%
Houston	25.0%	50.0%	25.0%	0.0%	0.0%
San Antonio	21.4%	50.0%	28.6%	0.0%	0.0%
Sample Total	29.23%	46.15%	21.54%	1.54%	1.54%

Figure 44: Statement #18, responses distributions by chapter and sample total

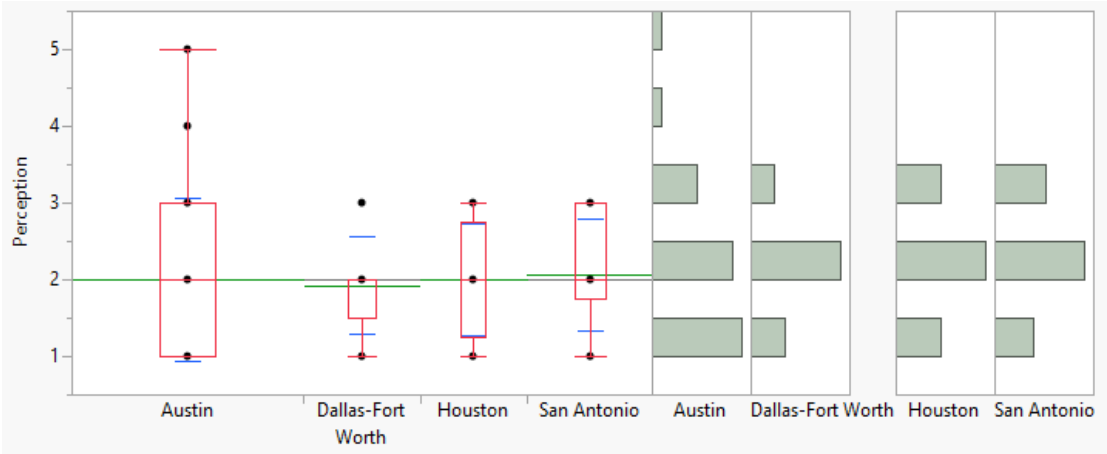


Figure 45: Statement #18, boxplot and distributions

Table 19: Statement #18, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	3.3	5
Dallas-Fort Worth	1	1	1.5	2	2	3	3
Houston	1	1	1.25	2	2.75	3	3
San Antonio	1	1	1.75	2	3	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.00000	1.05830	0.20755	1.5725	2.4275
Dallas-Fort Worth	13	1.92308	0.64051	0.17765	1.5360	2.3101
Houston	12	2.00000	0.73855	0.21320	1.5307	2.4693
San Antonio	14	2.07143	0.73005	0.19511	1.6499	2.4929

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	822.000	858.000	31.6154	-0.511
Dallas-Fort Worth	13	419.000	429.000	32.2308	-0.167
Houston	12	406.500	396.000	33.8750	0.182
San Antonio	14	497.500	462.000	35.5357	0.600

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.5058	3	0.9176

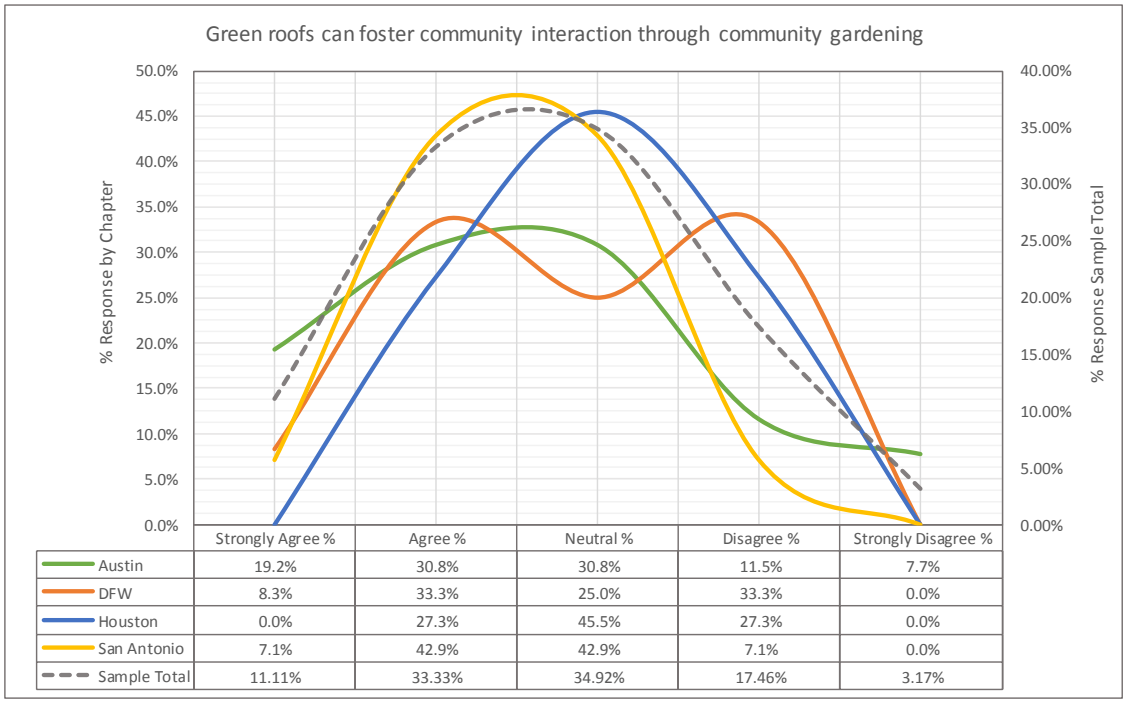
The descriptive statistics for statement #18, show all the chapters have the same median (2) (Figure 44). The distributions for DFW, San Antonio and Houston look similar, while Austin leans more towards a strongly positive perception of the statement. The option agree with 46.15% was the most common for the sample total and all the chapters except Austin, which highest was 38.5% for the option strongly agree (Figure 45). The Kruskal-Wallis Test results (Table 19) for $\alpha=0.05$ and df=3, show $\chi^2=0.5058 < 7.815$ and a p-value of $0.9176 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #18. The z-scores for each chapter do not present major variations between them.

4.2.3.4 Aesthetic attributes general findings

The aesthetic attributes section of the survey showed in general, a tendency towards the agreement of the statements. Statement #17 had the largest difference among chapters in regards to the perception of facility managers on the capacity of green roofs to hide ugly rooftops thereby providing a better view. Statement #16 regarding the capacity of green roofs to improve the visual interest and aesthetic appeal of a building showed the least differences among the opinions of the chapters.

4.2.4 Statements Related to Social Attributes

4.2.4.1 Statement #19: Green roofs can foster community interaction through community gardening



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	19.2%	30.8%	30.8%	11.5%	7.7%
DFW	8.3%	33.3%	25.0%	33.3%	0.0%
Houston	0.0%	27.3%	45.5%	27.3%	0.0%
San Antonio	7.1%	42.9%	42.9%	7.1%	0.0%
Sample Total	11.11%	33.33%	34.92%	17.46%	3.17%

Figure 46: Statement #19, responses distributions by chapter and sample total

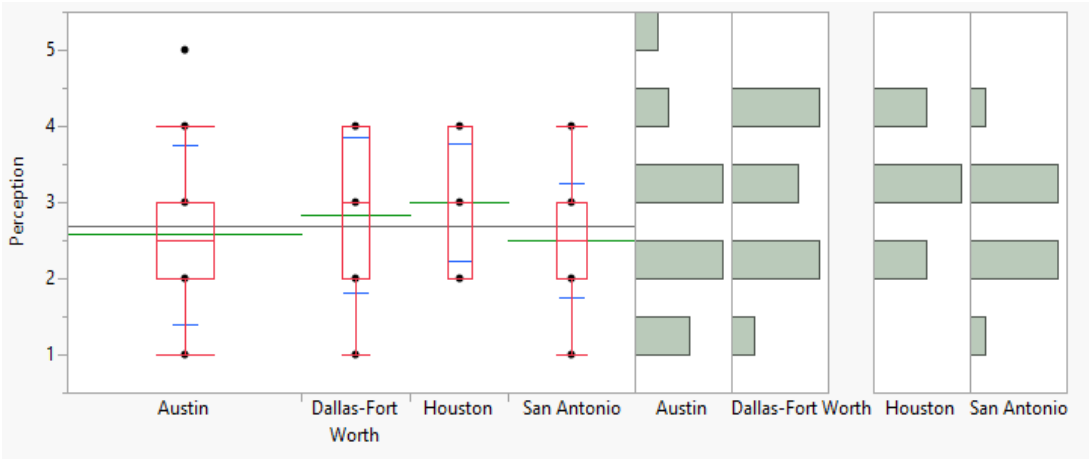


Figure 47: Statement #19, boxplot and distributions

Table 20: Statement #19, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	2.5	3	4.3	5
Dallas-Fort Worth	1	1.3	2	3	4	4	4
Houston	2	2	2	3	4	4	4
San Antonio	1	1.5	2	2.5	3	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.57692	1.17211	0.22987	2.1035	3.0503
Dallas-Fort Worth	12	2.83333	1.02986	0.29729	2.1790	3.4877
Houston	11	3.00000	0.77460	0.23355	2.4796	3.5204
San Antonio	14	2.50000	0.75955	0.20300	2.0614	2.9386

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

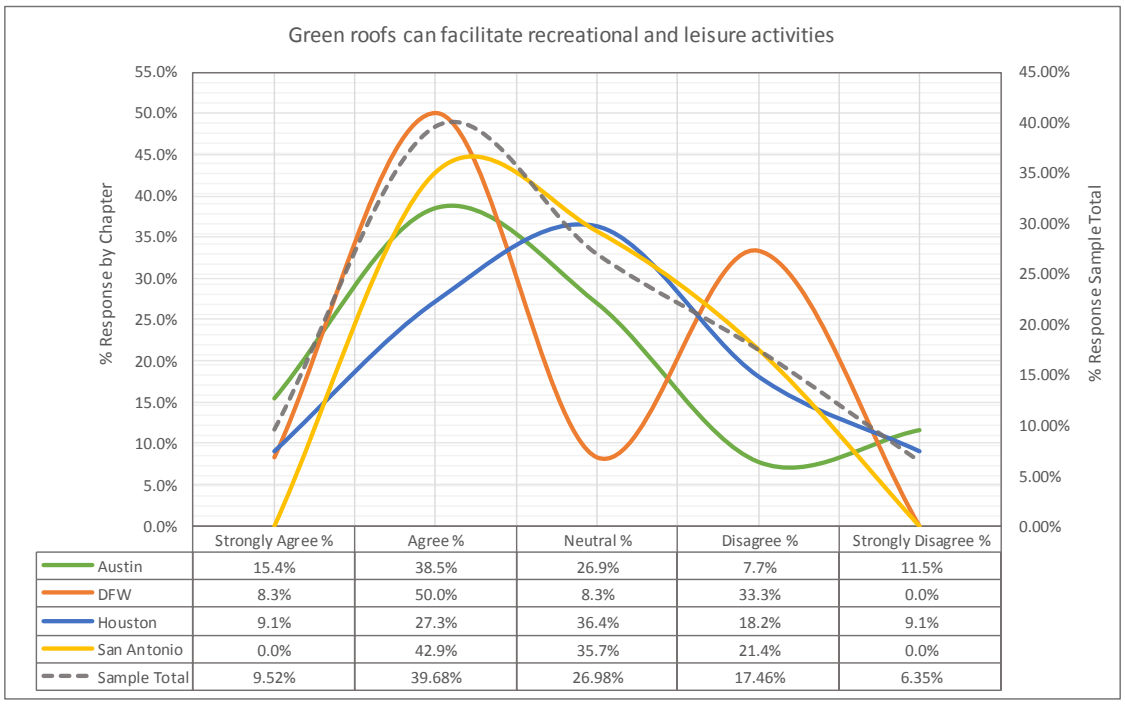
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	773.000	832.000	29.7308	-0.854
Dallas-Fort Worth	12	418.500	384.000	34.8750	0.623
Houston	11	419.500	352.000	38.1364	1.269
San Antonio	14	405.000	448.000	28.9286	-0.735

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.5381	3	0.4685

The descriptive statistics for statement #19, show Austin and San Antonio both with a 2.5 median, and Houston and DFW with a median of (3) (Figure 46). The distributions for DFW shows bimodality between the options agree and disagree, while San Antonio and Austin are between the options agree and neutral. Houston leans towards the option neutral (Figure 47). The Kruskal-Wallis Test results (Table 20) for $\alpha=0.05$ and df=3, show $\chi^2=2.5381 < 7.815$ and a p-value of $0.4685 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #19. The z-scores for each chapter do not present major variations between them except for Houston with a z-score of 1.269 leans slightly towards a negative perception.

4.2.4.2 Statement #20: Green roofs can facilitate recreational and leisure activities



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	15.4%	38.5%	26.9%	7.7%	11.5%
DFW	8.3%	50.0%	8.3%	33.3%	0.0%
Houston	9.1%	27.3%	36.4%	18.2%	9.1%
San Antonio	0.0%	42.9%	35.7%	21.4%	0.0%
Sample Total	9.52%	39.68%	26.98%	17.46%	6.35%

Figure 48: Statement #20, responses distributions by chapter and sample total

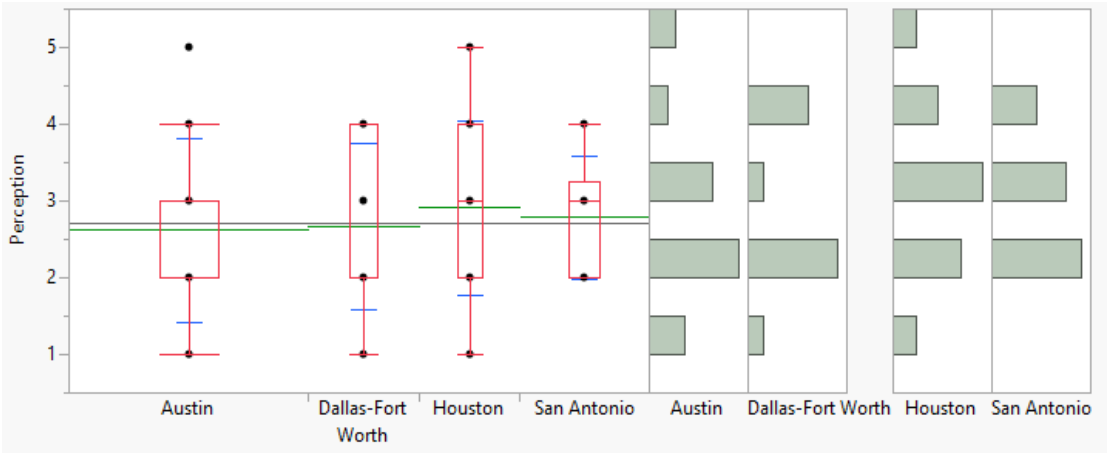


Figure 49: Statement #20, boxplot and distributions

Table 21: Statement #20, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	2	3	5	5
Dallas-Fort Worth	1	1.3	2	2	4	4	4
Houston	1	1.2	2	3	4	4.8	5
San Antonio	2	2	2	3	3.25	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.61538	1.20256	0.23584	2.1297	3.1011
Dallas-Fort Worth	12	2.66667	1.07309	0.30977	1.9849	3.3485
Houston	11	2.90909	1.13618	0.34257	2.1458	3.6724
San Antonio	14	2.78571	0.80178	0.21429	2.3228	3.2487

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	776.500	832.000	29.8654	-0.804
Dallas-Fort Worth	12	373.500	384.000	31.1250	-0.183
Houston	11	390.000	352.000	35.4545	0.711
San Antonio	14	476.000	448.000	34.0000	0.476

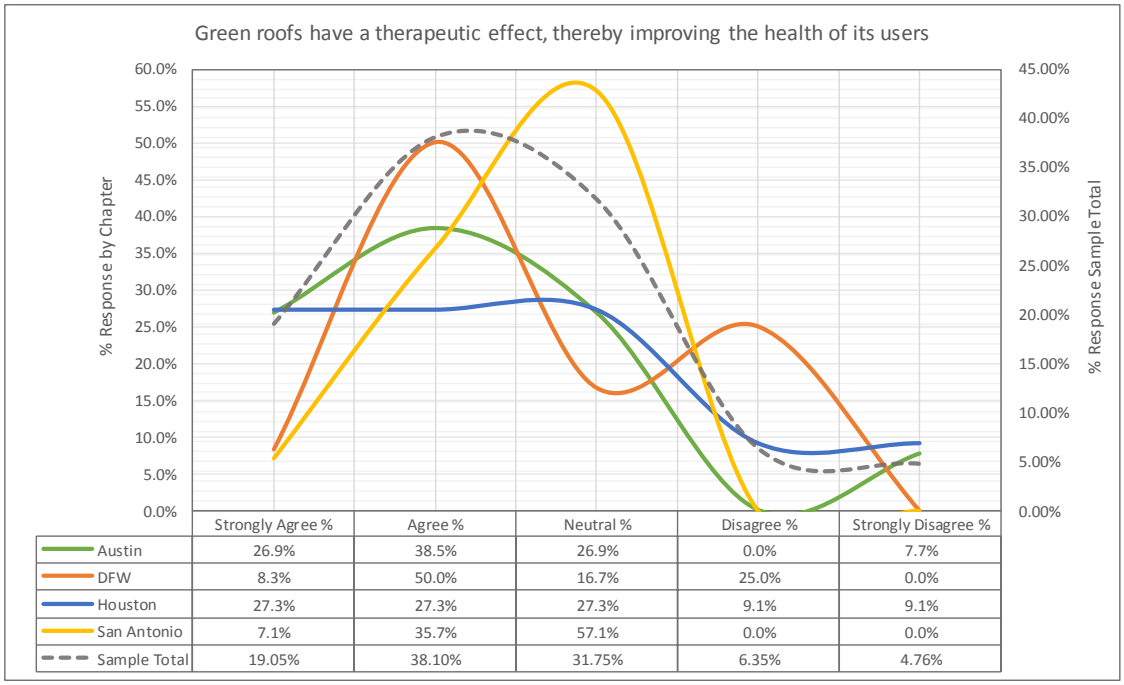
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.0281	3	0.7944

The descriptive statistics for statement #20, show Austin and DFW both with a median of 2, while Houston and San Antonio a median of 3 (Figure 48). The distributions for DFW shows bimodality between the options agree and disagree, while San Antonio and Austin are between the options agree and neutral. Houston leans towards the option neutral (Figure 49). The Kruskal-Wallis Test results (Table 21) for $\alpha=0.05$ and df=3, show $\chi^2=1.0281 < 7.815$ and a p-value of $0.7944 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among

the chapters on the perception of statement #20. The z-scores for each chapter do not present major variations between them.

4.2.4.3 Statement #21: Green roofs have a therapeutic effect, thereby improving the health of its users



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	26.9%	38.5%	26.9%	0.0%	7.7%
DFW	8.3%	50.0%	16.7%	25.0%	0.0%
Houston	27.3%	27.3%	27.3%	9.1%	9.1%
San Antonio	7.1%	35.7%	57.1%	0.0%	0.0%
Sample Total	19.05%	38.10%	31.75%	6.35%	4.76%

Figure 50: Statement #21, responses distributions by chapter and sample total

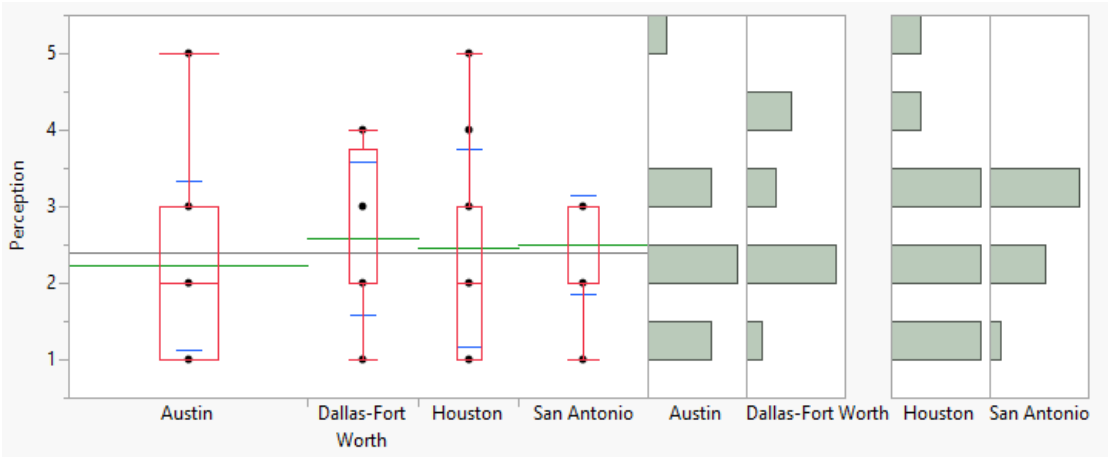


Figure 51: Statement #21, boxplot and distributions

Table 22: Statement #21, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	3.6	5
Dallas-Fort Worth	1	1.3	2	2	3.75	4	4
Houston	1	1	1	2	3	4.8	5
San Antonio	1	1.5	2	3	3	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.23077	1.10662	0.21703	1.7838	2.6777
Dallas-Fort Worth	12	2.58333	0.99620	0.28758	1.9504	3.2163
Houston	11	2.45455	1.29334	0.38996	1.5857	3.3234
San Antonio	14	2.50000	0.65044	0.17384	2.1244	2.8756

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	740.000	832.000	28.4615	-1.342
Dallas-Fort Worth	12	422.000	384.000	35.1667	0.690
Houston	11	353.000	352.000	32.0909	0.010
San Antonio	14	501.000	448.000	35.7857	0.912

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.1248	3	0.5469

The descriptive statistics for statement #21, show a median of (2) for all the chapters except San Antonio with (3) (Figure 50). The distributions for DFW shows bimodality between the options agree and disagree favoring the agree option. San Antonio leans towards a neutral position. Austin shows an inclination towards a positive perception (Figure 51). The Kruskal-Wallis Test results (Table 22) for $\alpha=0.05$ and $df=3$, show $\chi^2=2.1248 < 7.815$ and a p-value of $0.5469 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #21. The z-scores for each chapter do not present major variations between them, except for Austin with a z-score of -1.342 leaning towards a positive perception.

4.2.4.4 Social attributes general findings

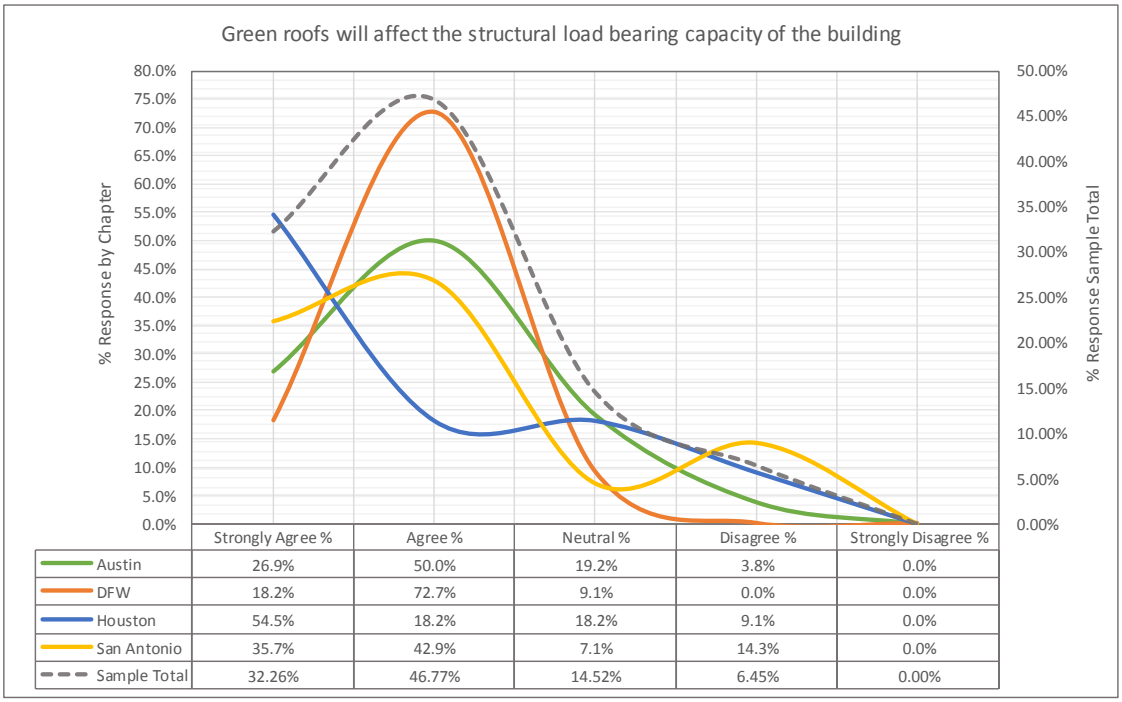
The social attributes section of the survey showed in general, a tendency towards the agreement of the statements. Statement #20 had the largest difference among chapters in regards to the perception of facility managers on the capacity of green roofs to facilitate recreational and leisure activities. Statement #19 regarding the capacity of green roofs to foster community interaction trough community gardening showed the least differences among the opinions of the chapters.

4.3 Green Roofs Barriers for their Implementation Comparison

The following section presents the results and findings of comparing the perception of facility managers on green roofs barriers for their implementation.

4.3.1 Statements Related to Technical Barriers

4.3.1.1 Statement #22: Green roofs will affect the structural load bearing capacity of the building



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	26.9%	50.0%	19.2%	3.8%	0.0%
DFW	18.2%	72.7%	9.1%	0.0%	0.0%
Houston	54.5%	18.2%	18.2%	9.1%	0.0%
San Antonio	35.7%	42.9%	7.1%	14.3%	0.0%
Sample Total	32.26%	46.77%	14.52%	6.45%	0.00%

Figure 52: Statement #22, responses distributions by chapter and sample total

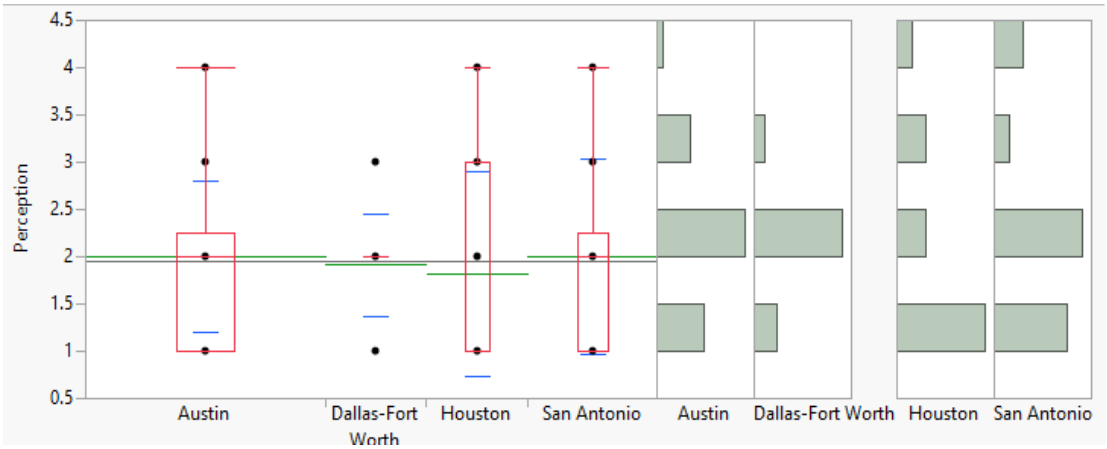


Figure 53: Statement #22, boxplot and distributions

The descriptive statistics for statement #22, show a median of (2) for all the chapters except Houston with (1) (Figure 52). The distributions for Austin, DFW and San Antonio seem similar showing agreement on the statement, while Houston is highly skewed towards a strongly agreement of the statement (Figure 53). The Kruskal-Wallis Test results (Table 23) for α=0.05 and df=3, show χ^2=0.9030 < 7.815 and a p-value of 0.8247 > 0.05, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #22. The z-scores for each chapter do not present major variations between them.

Table 23: Statement #22, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	2.25	3	4
Dallas-Fort Worth	1	1	2	2	2	2.8	3
Houston	1	1	1	1	3	3.8	4
San Antonio	1	1	1	2	2.25	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.00000	0.80000	0.15689	1.6769	2.3231
Dallas-Fort Worth	11	1.90909	0.53936	0.16262	1.5467	2.2714
Houston	11	1.81818	1.07872	0.32525	1.0935	2.5429
San Antonio	14	2.00000	1.03775	0.27735	1.4008	2.5992

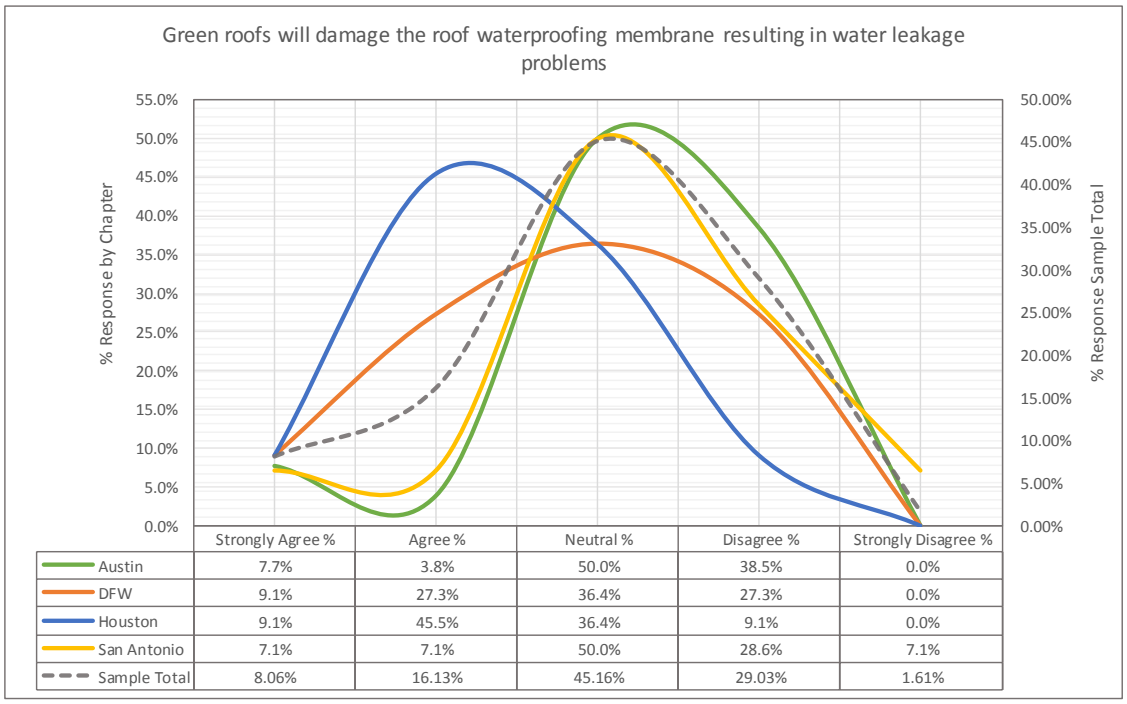
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	859.000	819.000	33.0385	0.607
Dallas-Fort Worth	11	355.000	346.500	32.2727	0.159
Houston	11	301.500	346.500	27.4091	-0.884
San Antonio	14	437.500	441.000	31.2500	-0.054

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.9030	3	0.8247

4.3.1.2 Statement #23: Green roofs will damage the roof waterproofing membrane resulting in water leakage problems



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	7.7%	3.8%	50.0%	38.5%	0.0%
DFW	9.1%	27.3%	36.4%	27.3%	0.0%
Houston	9.1%	45.5%	36.4%	9.1%	0.0%
San Antonio	7.1%	7.1%	50.0%	28.6%	7.1%
Sample Total	8.06%	16.13%	45.16%	29.03%	1.61%

Figure 54: Statement #23, responses distributions by chapter and sample total

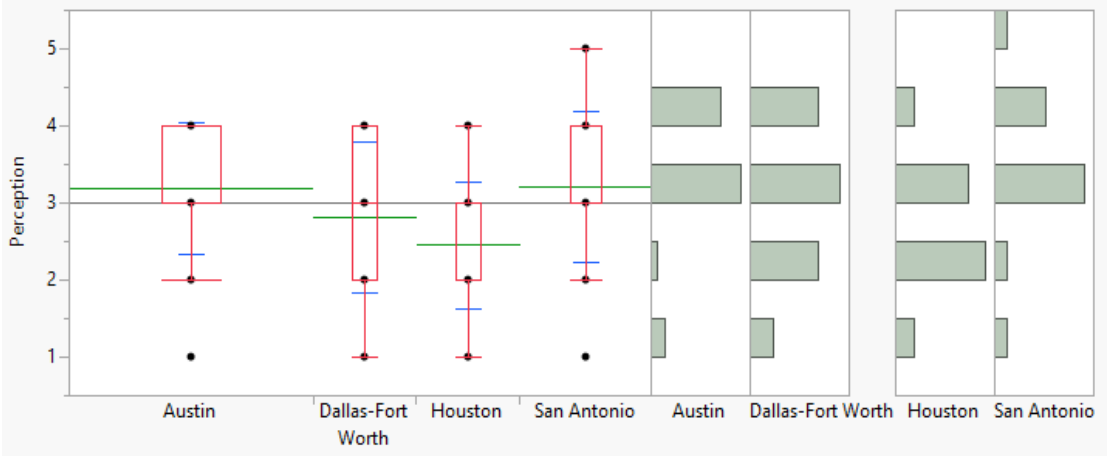


Figure 55: Statement #23, boxplot and distributions

Table 24: Statement #23, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1.7	3	3	4	4	4
Dallas-Fort Worth	1	1.2	2	3	4	4	4
Houston	1	1.2	2	2	3	3.8	4
San Antonio	1	1.5	3	3	4	4.5	5

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	3.19231	0.849434	0.16659	2.8492	3.5354
Dallas-Fort Worth	11	2.81818	0.981650	0.29598	2.1587	3.4777
Houston	11	2.45455	0.820200	0.24730	1.9035	3.0056
San Antonio	14	3.21429	0.974961	0.26057	2.6514	3.7772

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	925.000	819.000	35.5769	1.605
Dallas-Fort Worth	11	310.000	346.500	28.1818	-0.708
Houston	11	226.000	346.500	20.5455	-2.359
San Antonio	14	492.000	441.000	35.1429	0.907

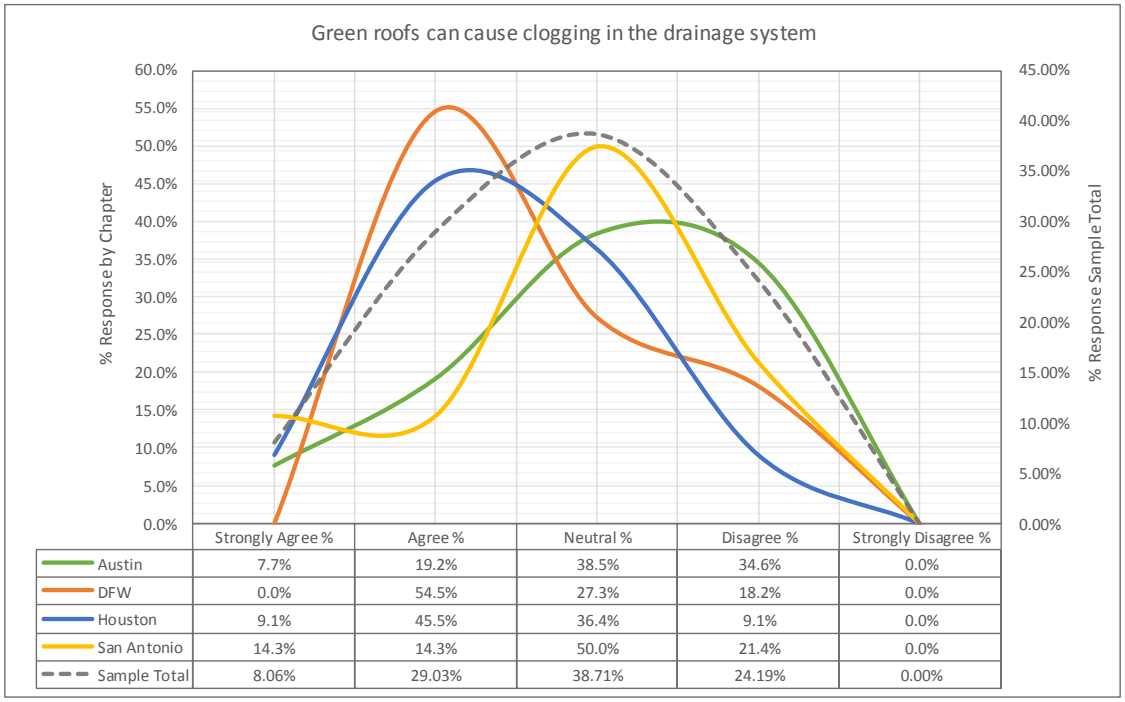
1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
7.1973	3	0.0659

The descriptive statistics for statement #23, show a median of (3) for all the chapters except Houston with (2) (Figure 54). The distributions for Austin, DFW and San Antonio seem similar showing a tendency for neutrality and disagreement for the statement, while Houston is shifted towards an agreement of the statement (Figure 55). The Kruskal-Wallis test (Table 24) results for $\alpha=0.05$ and $df=3$, show $\chi^2=7.1973 < 7.815$ and a p-value of $0.0659 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement

#23. Clearly Houston's chapter distribution with a z-score of -2.359 is shifted to the left towards a more positive perception of the statement in comparison to the other chapters. Austin leans towards disagreement with a z-score of 1.605.

4.3.1.3 Statement #24: Green roofs can cause clogging in the drainage system



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	7.7%	19.2%	38.5%	34.6%	0.0%
DFW	0.0%	54.5%	27.3%	18.2%	0.0%
Houston	9.1%	45.5%	36.4%	9.1%	0.0%
San Antonio	14.3%	14.3%	50.0%	21.4%	0.0%
Sample Total	8.06%	29.03%	38.71%	24.19%	0.00%

Figure 56: Statement #24, responses distributions by chapter and sample total

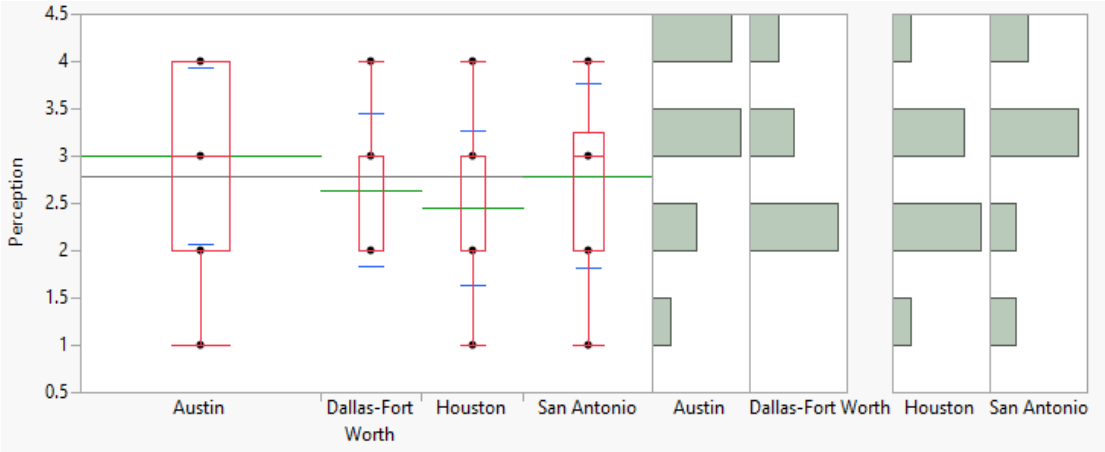


Figure 57: Statement #24, boxplot and distributions

Table 25: Statement #24, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1.7	2	3	4	4	4
Dallas-Fort Worth	2	2	2	2	3	4	4
Houston	1	1.2	2	2	3	3.8	4
San Antonio	1	1	2	3	3.25	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	3.00000	0.938083	0.18397	2.6211	3.3789
Dallas-Fort Worth	11	2.63636	0.809040	0.24393	2.0928	3.1799
Houston	11	2.45455	0.820200	0.24730	1.9035	3.0056
San Antonio	14	2.78571	0.974961	0.26057	2.2228	3.3486

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	928.500	819.000	35.7115	1.636
Dallas-Fort Worth	11	303.500	346.500	27.5909	-0.824
Houston	11	272.500	346.500	24.7727	-1.425
San Antonio	14	448.500	441.000	32.0357	0.124

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
3.8479	3	0.2784

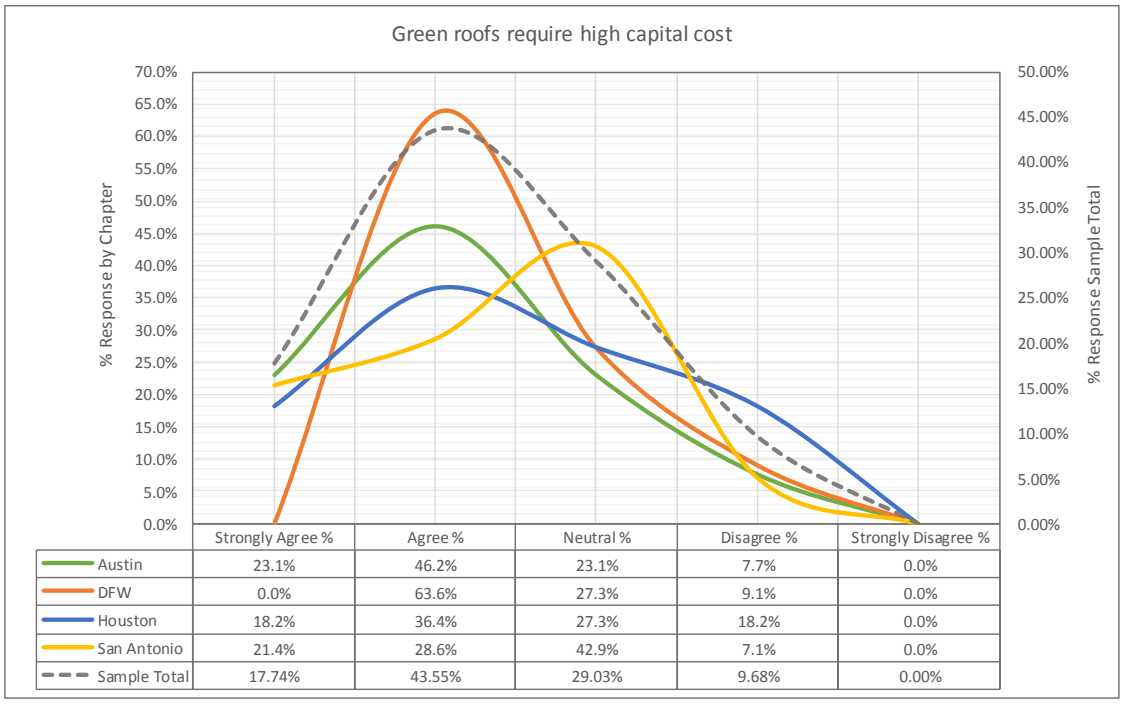
The descriptive statistics for statement #24, show a median of (3) for Austin and San Antonio. Houston and DFW share a median of (2) (Figure 56). The distributions seem shifted one to another with Austin and San Antonio leaning towards a neutrality and disagreement of the statement, while Houston and DFW seem similar showing a tendency for agreement of the statement (Figure 57). The Kruskal-Wallis Test results (Table 25) for $\alpha=0.05$ and df=3, show $\chi^2=3.8479 < 7.815$ and a p-value of $0.2784 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #24. The z-scores of Austin (1.636) means the distribution is leaning towards the disagreement of the statement, while Houston's z-score of -1.425 means the distribution leans towards a positive perception of the statement.

4.3.1.4 Technical barriers general findings

The technical barriers section of the survey showed in general, a tendency towards the agreement of the statements. Statement #22 had the largest difference among chapters in regards to the perception of facility managers on the capacity of green roofs to affect the structural load bearing capacity of a building. Statement #23 regarding the capacity of green roofs to damage the roof waterproofing membrane resulting in water leakage problems showed the least differences among the opinions of the chapters.

4.3.2 Statements Related to Cost Barriers

4.3.2.1 Statement #25: Green roofs require high capital cost



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	23.1%	46.2%	23.1%	7.7%	0.0%
DFW	0.0%	63.6%	27.3%	9.1%	0.0%
Houston	18.2%	36.4%	27.3%	18.2%	0.0%
San Antonio	21.4%	28.6%	42.9%	7.1%	0.0%
Sample Total	17.74%	43.55%	29.03%	9.68%	0.00%

Figure 58: Statement #25, responses distributions by chapter and sample total

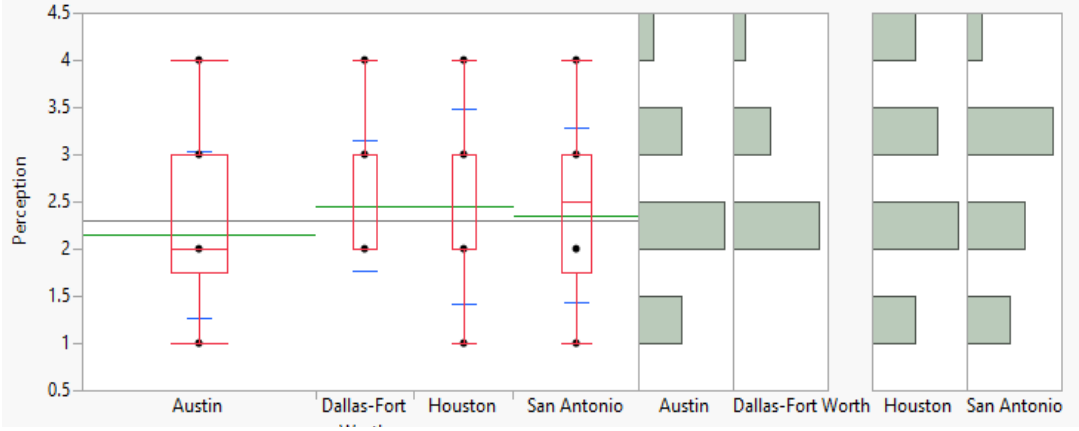


Figure 59: Statement #25, boxplot and distributions

Table 26: Statement #25, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1.75	2	3	3.3	4
Dallas-Fort Worth	2	2	2	2	3	3.8	4
Houston	1	1	2	2	3	4	4
San Antonio	1	1	1.75	2.5	3	3.5	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.15385	0.88056	0.17269	1.7982	2.5095
Dallas-Fort Worth	11	2.45455	0.68755	0.20730	1.9926	2.9164
Houston	11	2.45455	1.03573	0.31228	1.7587	3.1504
San Antonio	14	2.35714	0.92878	0.24823	1.8209	2.8934

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

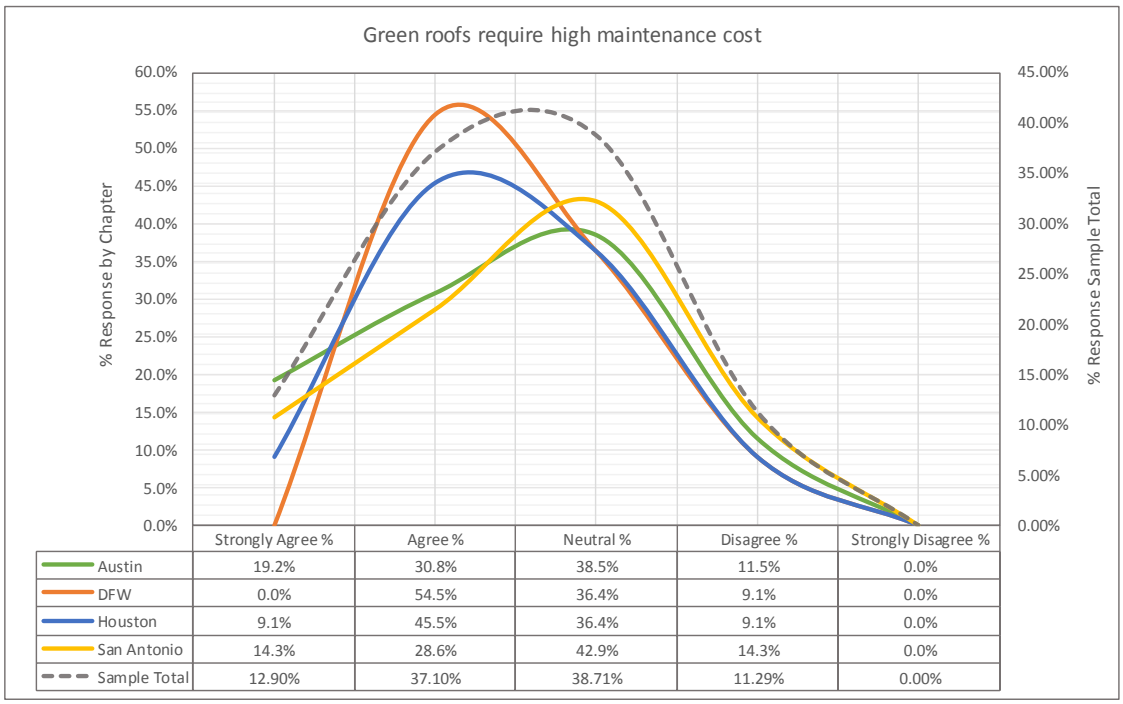
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	740.000	819.000	28.4615	-1.189
Dallas-Fort Worth	11	377.000	346.500	34.2727	0.587
Houston	11	373.500	346.500	33.9545	0.519
San Antonio	14	462.500	441.000	33.0357	0.375

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.4687	3	0.6895

The descriptive statistics for statement #25, show a median of (2) for all the chapters except for San Antonio with (2) (Figure 58). The distributions from Austin, DFW and Houston look focused in the agree option, while San Antonio is shifted towards a neutrality of the statement (Figure 59). The Kruskal-Wallis Test results (Table 26) for $\alpha=0.05$ and df=3, show $\chi^2=1.4687 < 7.815$ and a p-value of $0.6895 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #25. The z-scores of Austin (-1.189) means the distribution is leaning towards the agreement of the statement.

4.3.2.2 Statement #26: Green roofs require high maintenance cost



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	19.2%	30.8%	38.5%	11.5%	0.0%
DFW	0.0%	54.5%	36.4%	9.1%	0.0%
Houston	9.1%	45.5%	36.4%	9.1%	0.0%
San Antonio	14.3%	28.6%	42.9%	14.3%	0.0%
Sample Total	12.90%	37.10%	38.71%	11.29%	0.00%

Figure 60: Statement #26, responses distributions by chapter and sample total

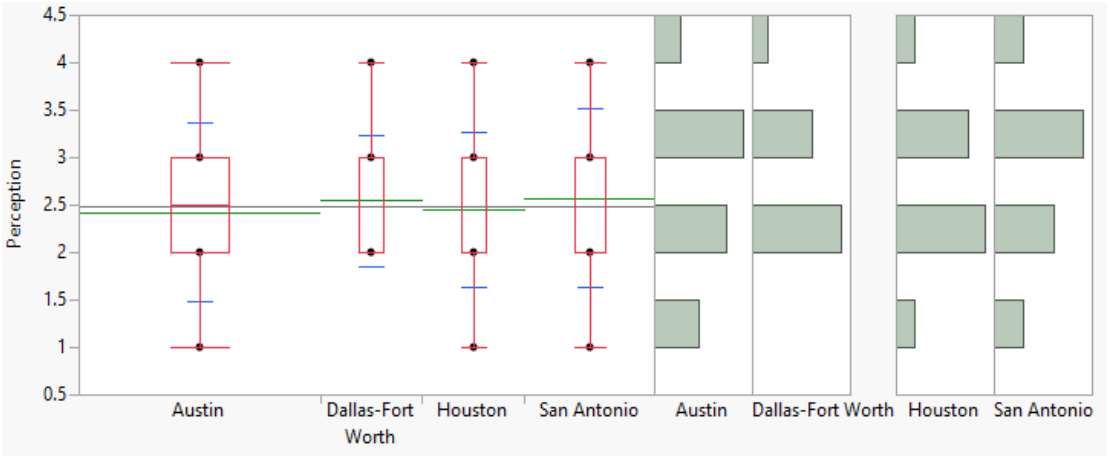


Figure 61: Statement #26, boxplot and distributions

Table 27: Statement #26, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	2.5	3	4	4
Dallas-Fort Worth	2	2	2	2	3	3.8	4
Houston	1	1.2	2	2	3	3.8	4
San Antonio	1	1	2	3	3	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.42308	0.945434	0.18541	2.0412	2.8049
Dallas-Fort Worth	11	2.54545	0.687552	0.20730	2.0836	3.0074
Houston	11	2.45455	0.820200	0.24730	1.9035	3.0056
San Antonio	14	2.57143	0.937614	0.25059	2.0301	3.1128

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	794.500	819.000	30.5577	-0.363
Dallas-Fort Worth	11	353.000	346.500	32.0909	0.117
Houston	11	337.500	346.500	30.6818	-0.166
San Antonio	14	468.000	441.000	33.4286	0.474

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.2989	3	0.9602

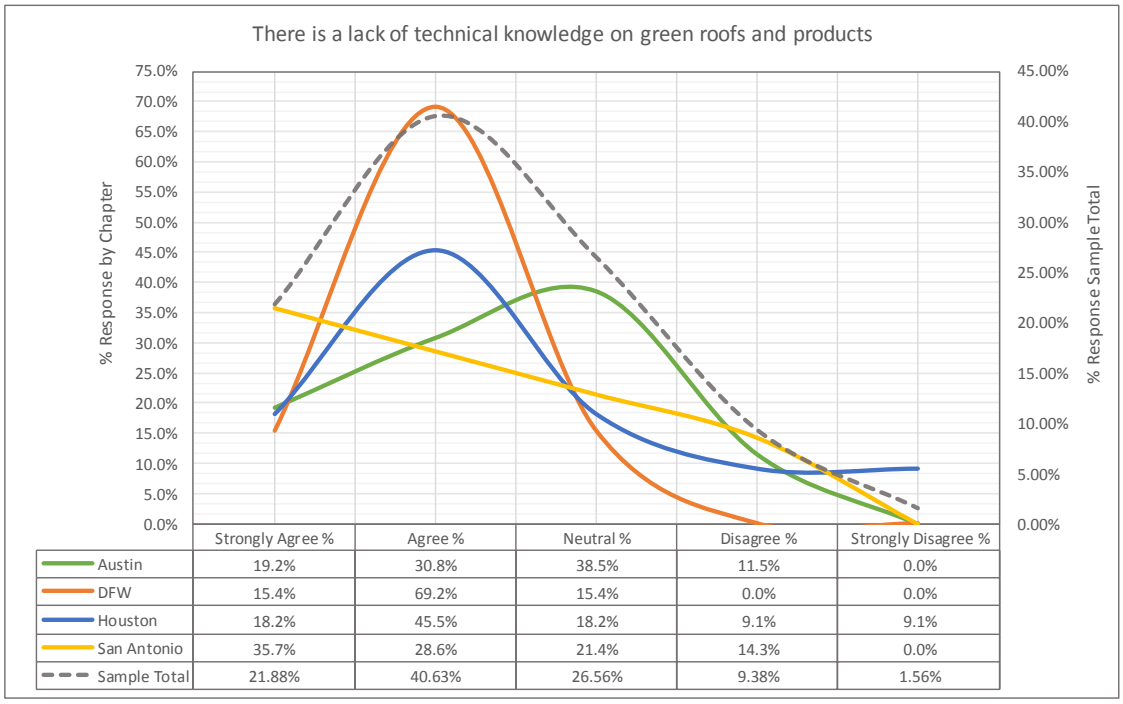
The descriptive statistics for statement #26, show a median of (2) for DFW and Houston and (2.5) and (3) for Austin and San Antonio respectively (Figure 60). The distributions from Austin and San Antonio look focused around the agreement and neutrality of the statement. While DFW and Houston are shifted towards an agreement of the statement (Figure 61). The Kruskal-Wallis Test results (Table 27) for $\alpha=0.05$ and df=3, show $\chi^2=0.2989 < 7.815$ and a p-value of $0.9602 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #26.

4.3.2.3 Cost barrier statements general findings

The cost barriers section of the survey showed in general, a tendency towards the agreement of the statements. Statement #26 had the largest difference among chapters in regards to the perception of facility managers on the high maintenance cost required by green roofs. Statement #25 regarding the high capital cost of green showed the least differences among the opinions of the chapters.

4.3.3 Statements Related to Lack of Knowledge and Awareness Barriers

4.3.3.1 Statement #27: There is a lack of technical knowledge on green roofs and products



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	19.2%	30.8%	38.5%	11.5%	0.0%
DFW	15.4%	69.2%	15.4%	0.0%	0.0%
Houston	18.2%	45.5%	18.2%	9.1%	9.1%
San Antonio	35.7%	28.6%	21.4%	14.3%	0.0%
Sample Total	21.88%	40.63%	26.56%	9.38%	1.56%

Figure 62: Statement #27, responses distributions by chapter and sample total

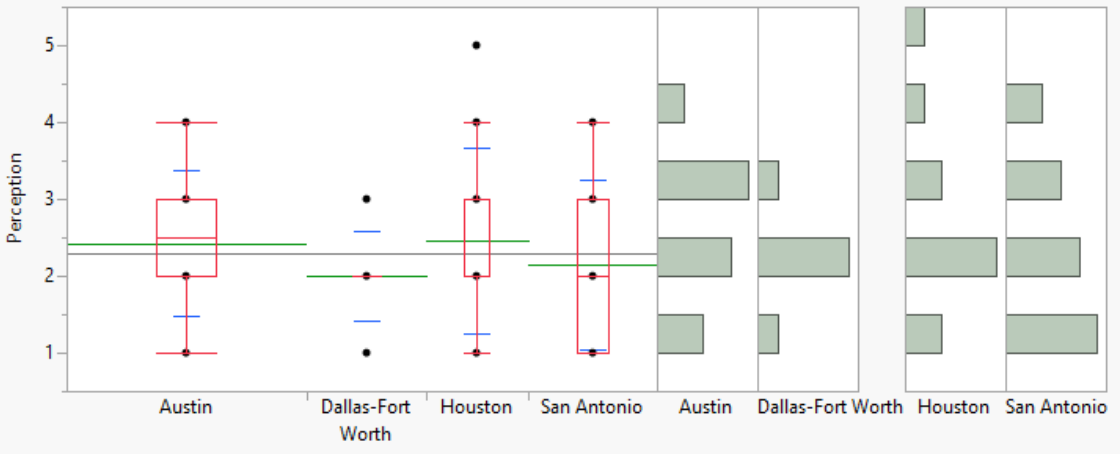


Figure 63: Statement #27, boxplot and distributions

Table 28: Statement #27, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	2.5	3	4	4
Dallas-Fort Worth	1	1	2	2	2	3	3
Houston	1	1	2	2	3	4.8	5
San Antonio	1	1	1	2	3	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.42308	0.94543	0.18541	2.0412	2.8049
Dallas-Fort Worth	13	2.00000	0.57735	0.16013	1.6511	2.3489
Houston	11	2.45455	1.21356	0.36590	1.6393	3.2698
San Antonio	14	2.14286	1.09945	0.29384	1.5081	2.7777

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

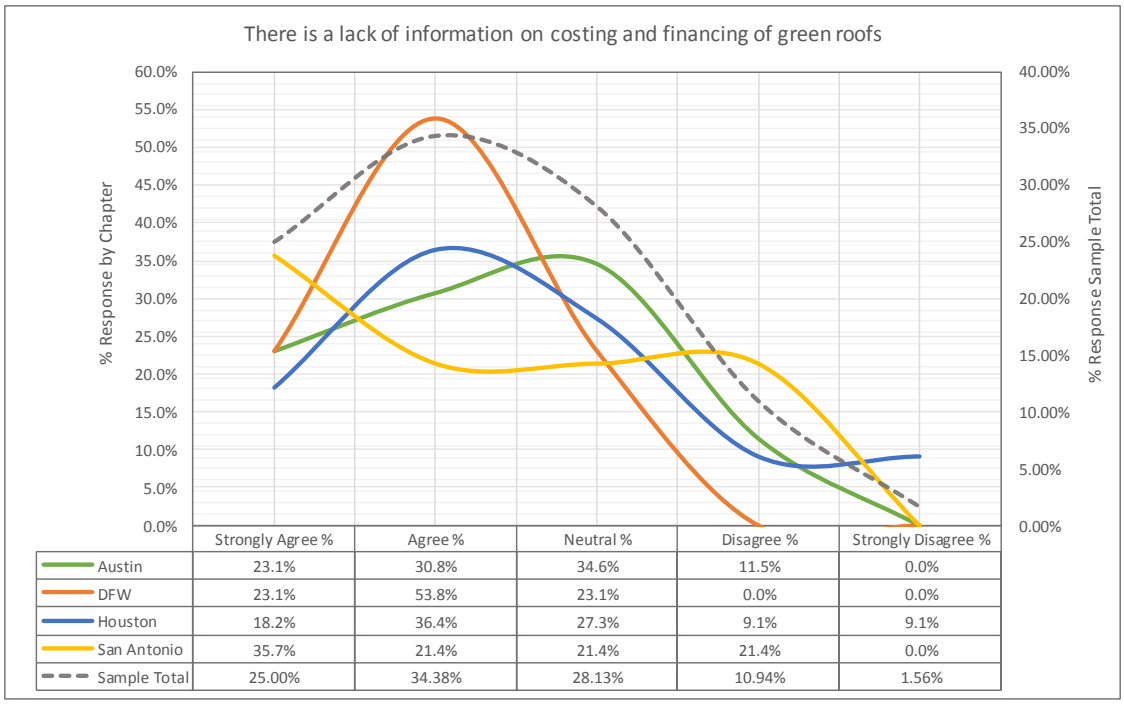
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	929.000	845.000	35.7308	1.201
Dallas-Fort Worth	13	360.500	422.500	27.7308	-1.080
Houston	11	375.000	357.500	34.0909	0.318
San Antonio	14	415.500	455.000	29.6786	-0.666

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.2561	3	0.5210

The descriptive statistics for statement #27, show a median of (2) for all the chapters except DFW with (2) (Figure 62). The distributions of Houston and DFW look focused around the agreement of the statement. Austin's distribution looks between the agreement and neutrality of the statement, while San Antonio is heavily skewed towards the strongly agreement of the statement (Figure63). The Kruskal-Wallis Test results (Table 28) for $\alpha=0.05$ and $df=3$, show $\chi^2=2.2561 < 7.815$ and a p-value of $0.5210 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #27.

4.3.3.2 Statement #28: There is a lack of information on costing and financing of green roofs



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	23.1%	30.8%	34.6%	11.5%	0.0%
DFW	23.1%	53.8%	23.1%	0.0%	0.0%
Houston	18.2%	36.4%	27.3%	9.1%	9.1%
San Antonio	35.7%	21.4%	21.4%	21.4%	0.0%
Sample Total	25.00%	34.38%	28.13%	10.94%	1.56%

Figure 64: Statement #28, responses distributions by chapter and sample total

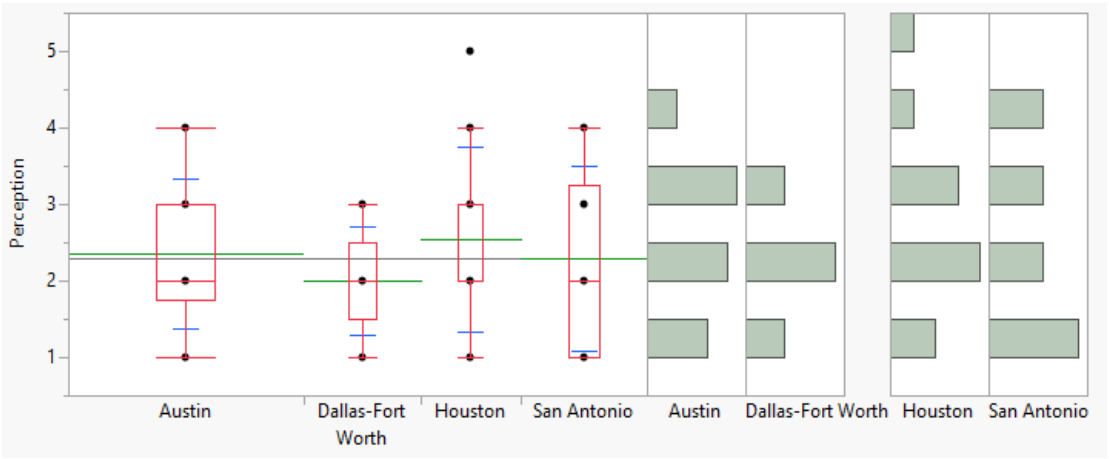


Figure 65: Statement #28, boxplot and distributions

Table 29: Statement #28, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1.75	2	3	4	4
Dallas-Fort Worth	1	1	1.5	2	2.5	3	3
Houston	1	1	2	2	3	4.8	5
San Antonio	1	1	1	2	3.25	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.34615	0.97744	0.19169	1.9514	2.7409
Dallas-Fort Worth	13	2.00000	0.70711	0.19612	1.5727	2.4273
Houston	11	2.54545	1.21356	0.36590	1.7302	3.3607
San Antonio	14	2.28571	1.20439	0.32189	1.5903	2.9811

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

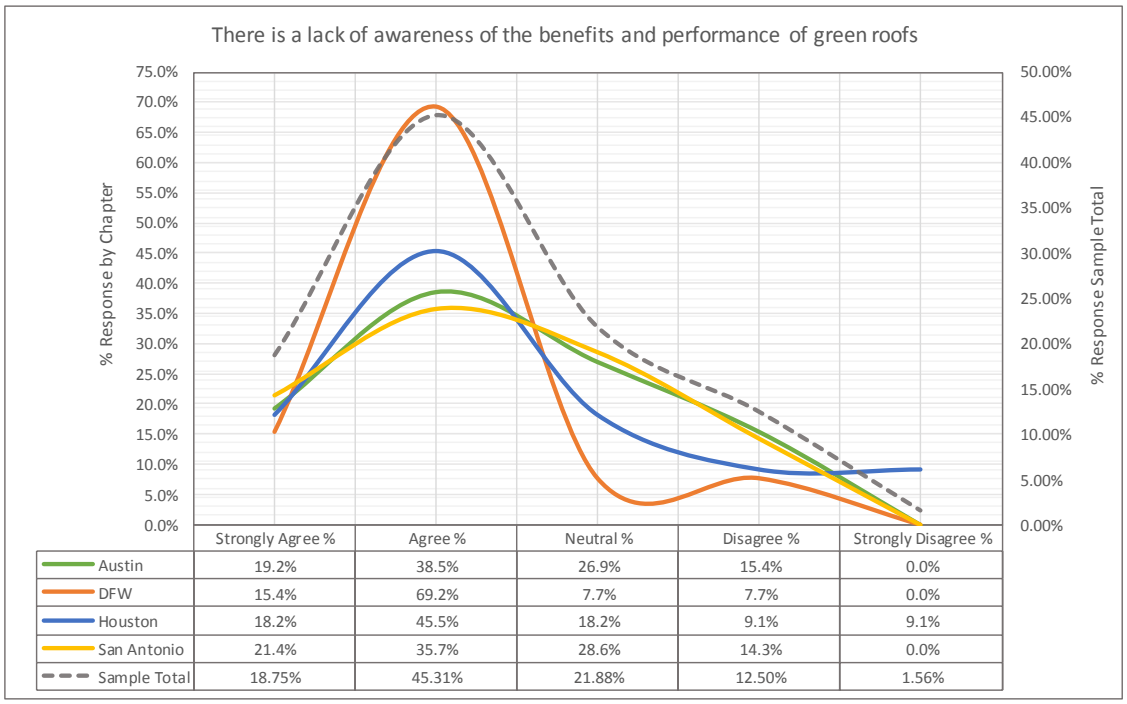
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	878.500	845.000	33.7885	0.470
Dallas-Fort Worth	13	360.500	422.500	27.7308	-1.070
Houston	11	393.500	357.500	35.7727	0.658
San Antonio	14	447.500	455.000	31.9643	-0.118

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.4438	3	0.6953

The descriptive statistics for statement #28, show a median of (2) for all the chapters (Figure 64). The distributions from DFW and Houston are focused on the agreement of the statement, while Austin is spread between the strongly agreement of the statement and neutrality, while San Antonio is heavily skewed towards the strongly agreement of the statement (Figure 65). The Kruskal-Wallis Test results (Table 29) for α=0.05 and df=3, show χ^2=1.4438 < 7.815 and a p-value of 0.6953 > 0.05, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #28.

4.3.3.3 Statement #29: There is a lack of awareness of the benefits and performance of green roofs



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	19.2%	38.5%	26.9%	15.4%	0.0%
DFW	15.4%	69.2%	7.7%	7.7%	0.0%
Houston	18.2%	45.5%	18.2%	9.1%	9.1%
San Antonio	21.4%	35.7%	28.6%	14.3%	0.0%
Sample Total	18.75%	45.31%	21.88%	12.50%	1.56%

Figure 66: Statement #29, responses distributions by chapter and sample total

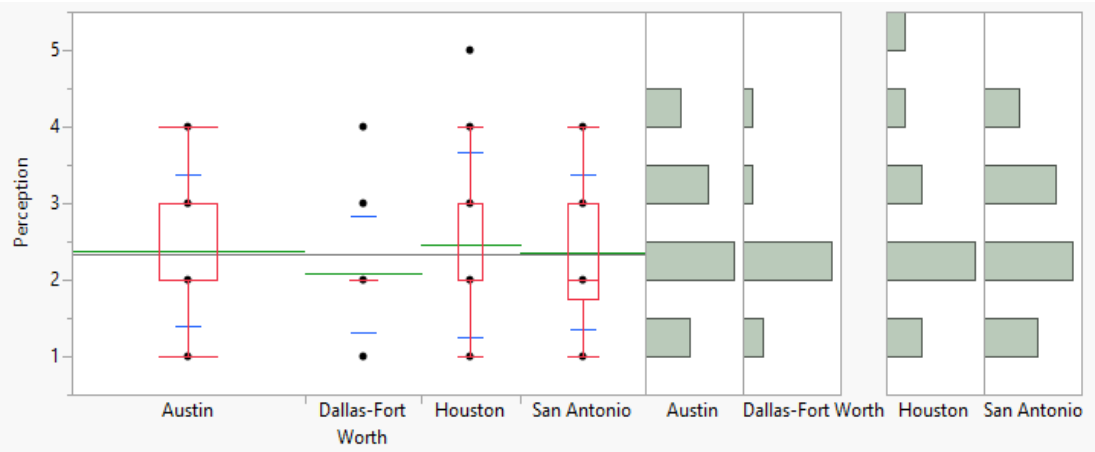


Figure 67: Statement #29, boxplot and distributions

Table 30: Statement #29, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	2	3	4	4
Dallas-Fort Worth	1	1	2	2	2	3.6	4
Houston	1	1	2	2	3	4.8	5
San Antonio	1	1	1.75	2	3	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.38462	0.98293	0.19277	1.9876	2.7816
Dallas-Fort Worth	13	2.07692	0.75955	0.21066	1.6179	2.5359
Houston	11	2.45455	1.21356	0.36590	1.6393	3.2698
San Antonio	14	2.35714	1.00821	0.26945	1.7750	2.9393

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

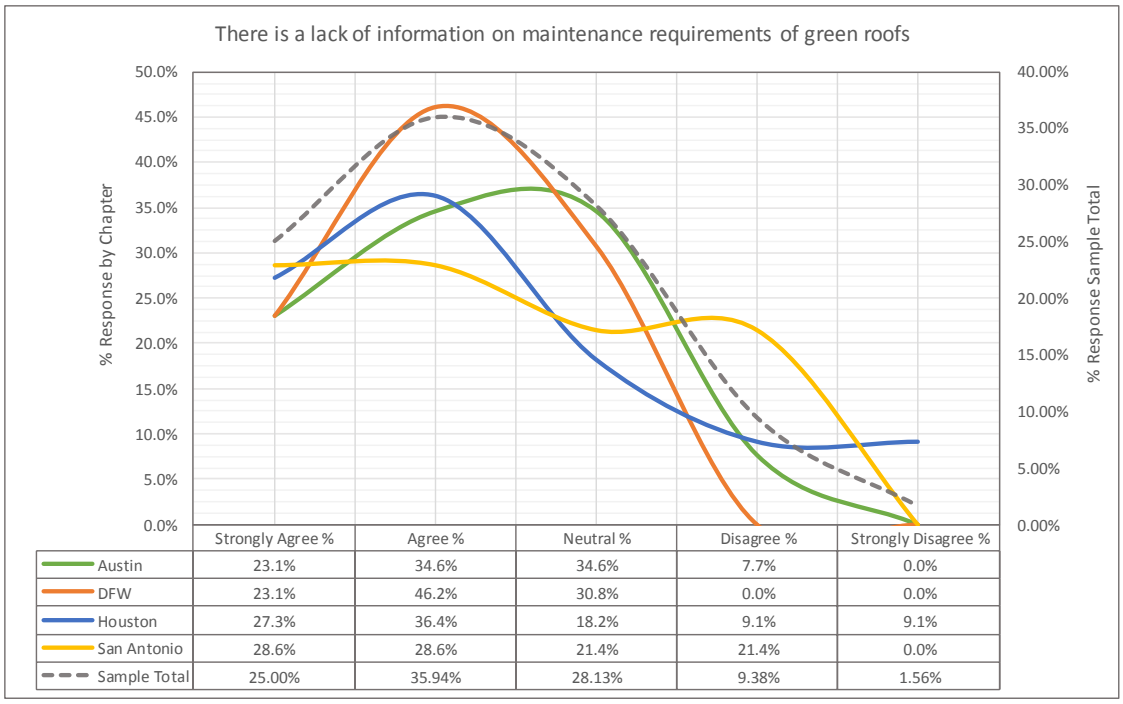
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	880.000	845.000	33.8462	0.500
Dallas-Fort Worth	13	364.000	422.500	28.0000	-1.027
Houston	11	368.500	357.500	33.5000	0.198
San Antonio	14	467.500	455.000	33.3929	0.207

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
1.0800	3	0.7819

The descriptive statistics for statement #29, show a median of (2) for all the chapters (Figure 66). The distributions from all the chapters are focused on the agreement of the statement option, with Austin and San Antonio leaning somehow towards the disagreement of the statement (Figure 67). The Kruskal-Wallis Test results (Table 30) for $\alpha=0.05$ and $df=3$, show $\chi^2=1.0800 < 7.815$ and a p-value of $0.7819 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #29.

4.3.3.4 Statement #30: There is a lack of information on maintenance requirements of green roofs



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	23.1%	34.6%	34.6%	7.7%	0.0%
DFW	23.1%	46.2%	30.8%	0.0%	0.0%
Houston	27.3%	36.4%	18.2%	9.1%	9.1%
San Antonio	28.6%	28.6%	21.4%	21.4%	0.0%
Sample Total	25.00%	35.94%	28.13%	9.38%	1.56%

Figure 68: Statement #30, responses distributions by chapter and sample total

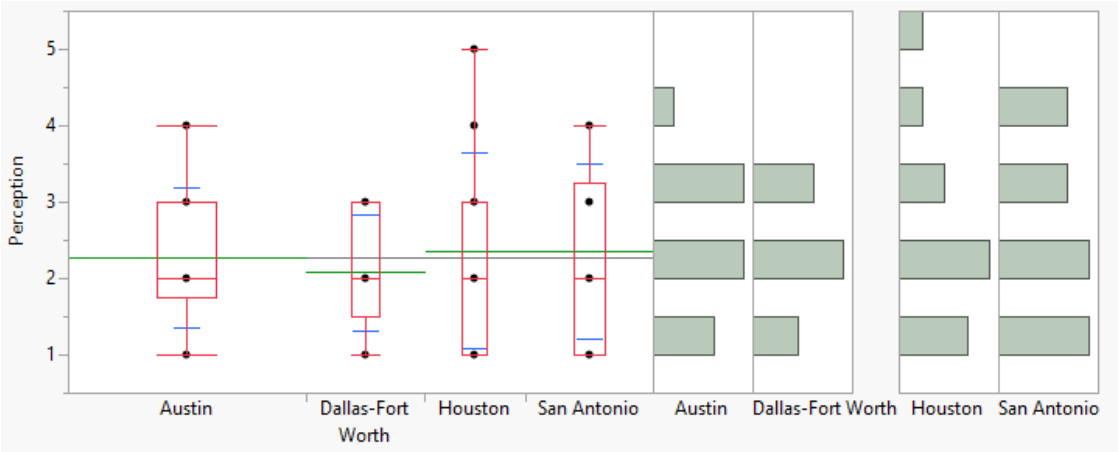


Figure 69: Statement #30, boxplot and distributions

Table 31: Statement #30, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1.75	2	3	3.3	4
Dallas-Fort Worth	1	1	1.5	2	3	3	3
Houston	1	1	1	2	3	4.8	5
San Antonio	1	1	1	2	3.25	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.26923	0.91903	0.18024	1.8980	2.6404
Dallas-Fort Worth	13	2.07692	0.75955	0.21066	1.6179	2.5359
Houston	11	2.36364	1.28629	0.38783	1.4995	3.2278
San Antonio	14	2.35714	1.15073	0.30755	1.6927	3.0216

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

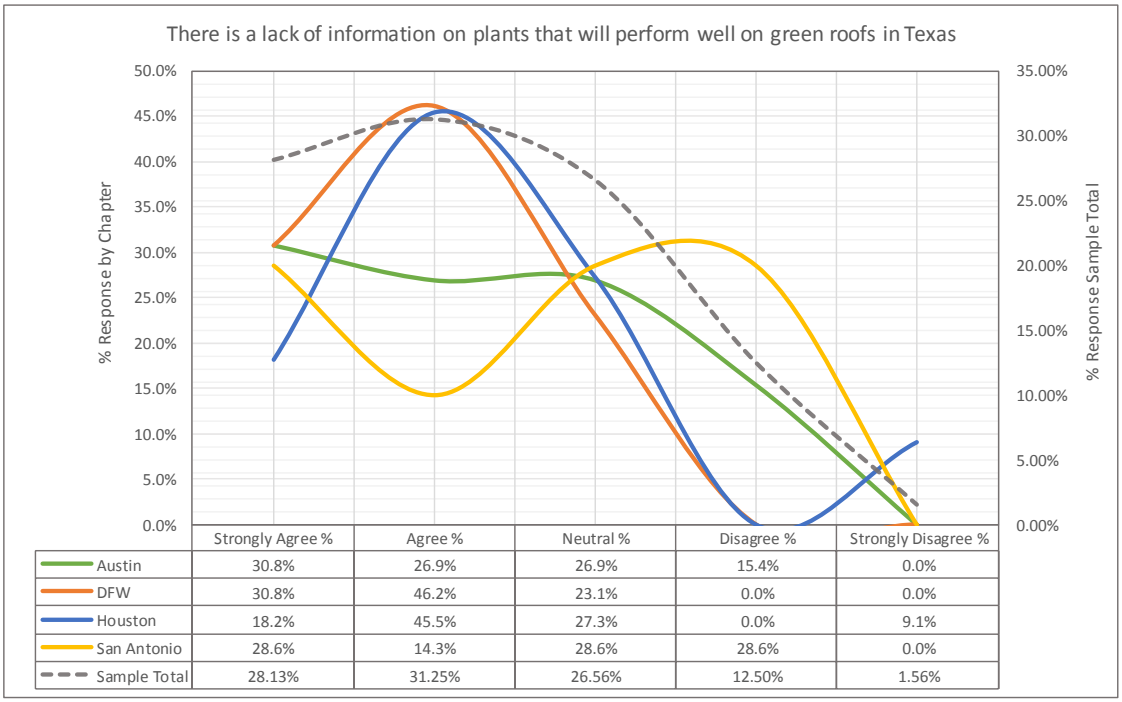
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	860.500	845.000	33.0962	0.214
Dallas-Fort Worth	13	387.500	422.500	29.8077	-0.602
Houston	11	359.000	357.500	32.6364	0.019
San Antonio	14	473.000	455.000	33.7857	0.297

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
0.3998	3	0.9403

The descriptive statistics for statement #30, show a median of (2) for all the chapters (Figure 68). The distributions from DFW and Houston are focused on the agreement of the statement option, while Austin is between agreement and neutrality. San Antonio looks skewed towards the agreement of the statement (Figure 69). The Kruskal-Wallis Test (Table 31) results for $\alpha=0.05$ and $df=3$, show $\chi^2=0.3998 < 7.815$ and a p-value of $0.9403 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #30.

4.3.3.5 Statement #31: There is a lack of information on plants that will perform well on green roofs in Texas



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	30.8%	26.9%	26.9%	15.4%	0.0%
DFW	30.8%	46.2%	23.1%	0.0%	0.0%
Houston	18.2%	45.5%	27.3%	0.0%	9.1%
San Antonio	28.6%	14.3%	28.6%	28.6%	0.0%
Sample Total	28.13%	31.25%	26.56%	12.50%	1.56%

Figure 70: Statement #31, responses distributions by chapter and sample total

The descriptive statistics for statement #31, show a median of (2) for all the chapters except San Antonio with (3) (Figure 70). The distributions from DFW and Houston are focused on the agreement of the statement option, while Austin is between agreement and neutrality. San Antonio looks bimodal between the strongly agree option and neutral and disagree together (Figure 71). The Kruskal-Wallis Test results (Table 32) for $\alpha=0.05$ and $df=3$, show $\chi^2=2.2506 < 7.815$ and a p-value of $0.5220 > 0.05$,

therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #31.

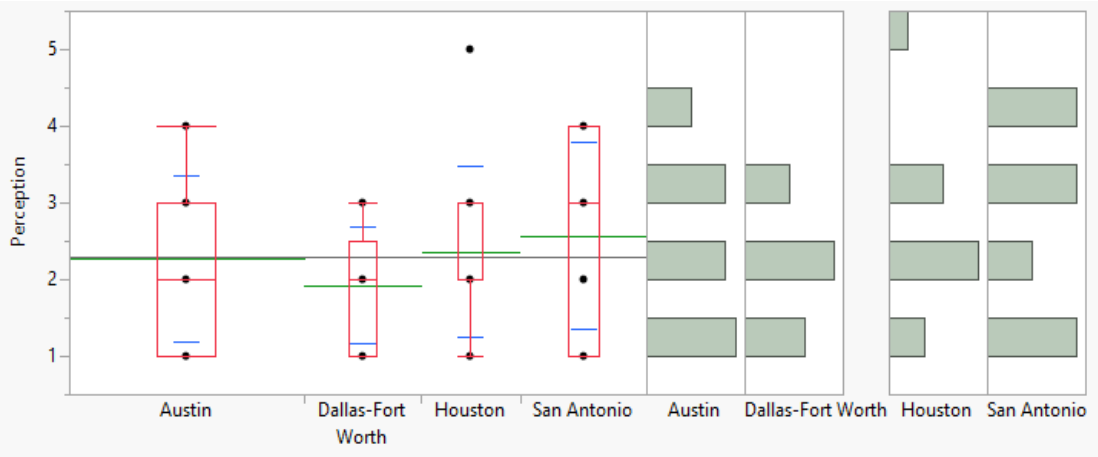


Figure 71: Statement #31, boxplot and distributions

Table 32: Statement #31, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	1	2	3	4	4
Dallas-Fort Worth	1	1	1	2	2.5	3	3
Houston	1	1	2	2	3	4.6	5
San Antonio	1	1	1	3	4	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.26923	1.07917	0.21164	1.8333	2.7051
Dallas-Fort Worth	13	1.92308	0.75955	0.21066	1.4641	2.3821
Houston	11	2.36364	1.12006	0.33771	1.6112	3.1161
San Antonio	14	2.57143	1.22250	0.32673	1.8656	3.2773

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	842.500	845.000	32.4038	-0.028
Dallas-Fort Worth	13	350.000	422.500	26.9231	-1.248
Houston	11	366.500	357.500	33.3182	0.157
San Antonio	14	521.000	455.000	37.2143	1.105

1-way Test, ChiSquare Approximation

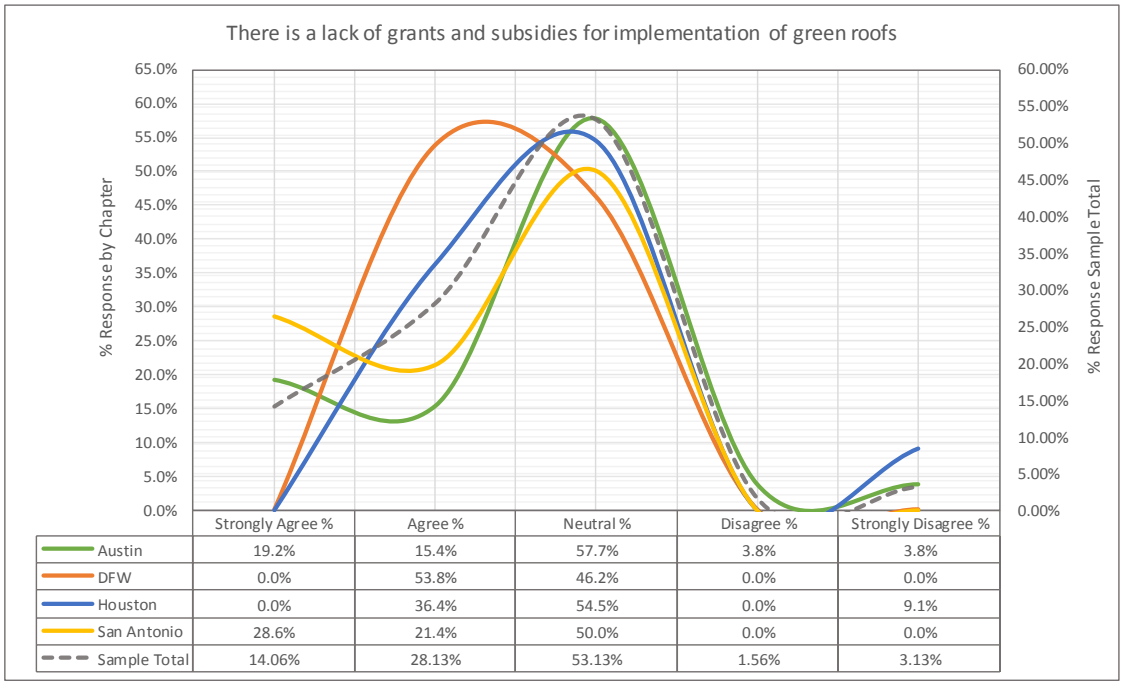
ChiSquare	DF	Prob>ChiSq
2.2506	3	0.5220

4.3.3.6 Lack of knowledge and awareness barriers general findings

The lack of knowledge and awareness barriers section of the survey showed in general, a tendency towards the agreement of the statements. Statement #30 had the largest difference among chapters in regards to the perception of facility managers on the lack of information on maintenance requirements of green roofs. Statement #27 regarding the lack of knowledge on green roofs and products showed the least differences among the opinions of the chapters.

4.3.4 Statements Related to Lack of Government Support Barriers

4.3.4.1 Statement #32: There is a lack of grants and subsidies for implementation of green roofs



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	19.2%	15.4%	57.7%	3.8%	3.8%
DFW	0.0%	53.8%	46.2%	0.0%	0.0%
Houston	0.0%	36.4%	54.5%	0.0%	9.1%
San Antonio	28.6%	21.4%	50.0%	0.0%	0.0%
Sample Total	14.06%	28.13%	53.13%	1.56%	3.13%

Figure 72: Statement #32, responses distributions by chapter and sample total

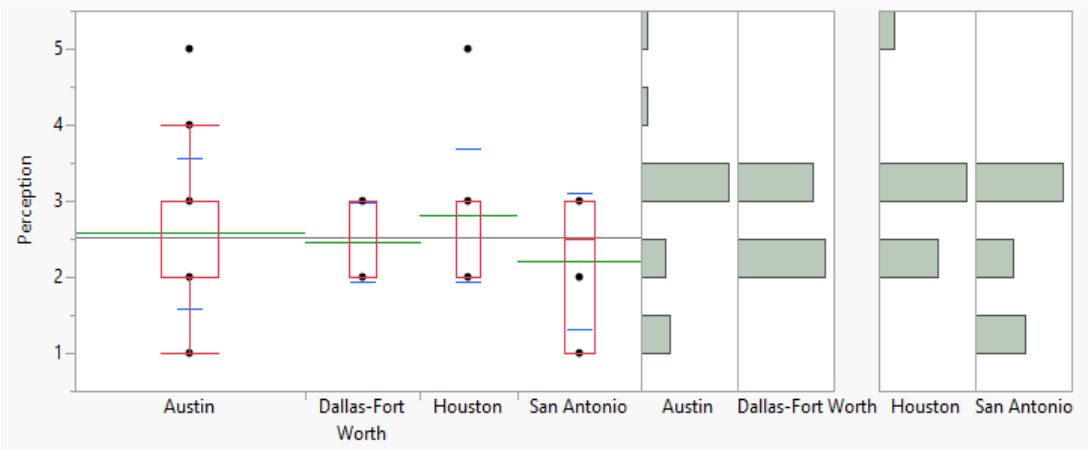


Figure 73: Statement #32, boxplot and distributions

Table 33: Statement #32, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	3	3	3.3	5
Dallas-Fort Worth	2	2	2	2	3	3	3
Houston	2	2	2	3	3	4.6	5
San Antonio	1	1	1	2.5	3	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.57692	0.986836	0.19353	2.1783	2.9755
Dallas-Fort Worth	13	2.46154	0.518875	0.14391	2.1480	2.7751
Houston	11	2.81818	0.873863	0.26348	2.2311	3.4053
San Antonio	14	2.21429	0.892582	0.23855	1.6989	2.7296

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

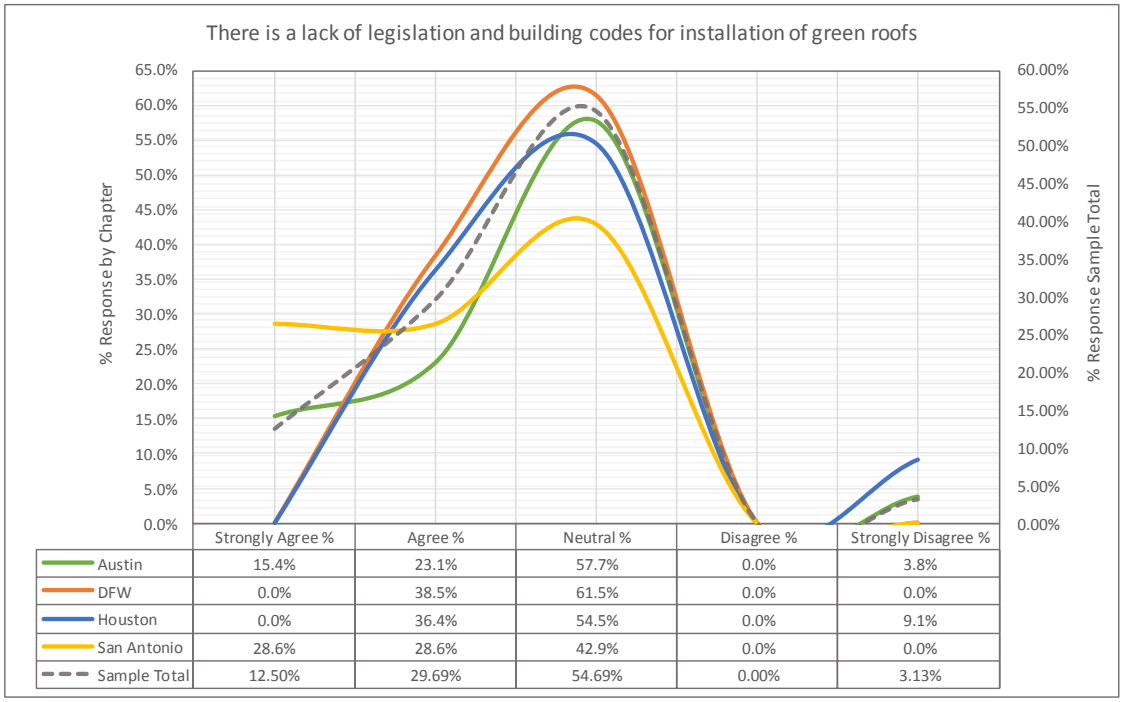
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	892.000	845.000	34.3077	0.700
Dallas-Fort Worth	13	396.500	422.500	30.5000	-0.468
Houston	11	404.500	357.500	36.7727	0.911
San Antonio	14	387.000	455.000	27.6429	-1.207

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
2.3353	3	0.5058

The descriptive statistics for statement #32, show a median of (3) for Austin and Houston, and (2) for DFW (Figure 72). The distributions from Austin, Houston and San Antonio look similar focusing on the neutrality option, while DFW is shifted towards the agreement of the statement (Figure 73). The Kruskal-Wallis Test results (Table 33) for α=0.05 and df=3, show χ^2=2.3353 < 7.815 and a p-value of 0.5058 > 0.05, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #32.

4.3.4.2 Statement #33: There is a lack of legislation and building codes for installation of green roofs



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	15.4%	23.1%	57.7%	0.0%	3.8%
DFW	0.0%	38.5%	61.5%	0.0%	0.0%
Houston	0.0%	36.4%	54.5%	0.0%	9.1%
San Antonio	28.6%	28.6%	42.9%	0.0%	0.0%
Sample Total	12.50%	29.69%	54.69%	0.00%	3.13%

Figure 74: Statement #33, responses distributions by chapter and sample total

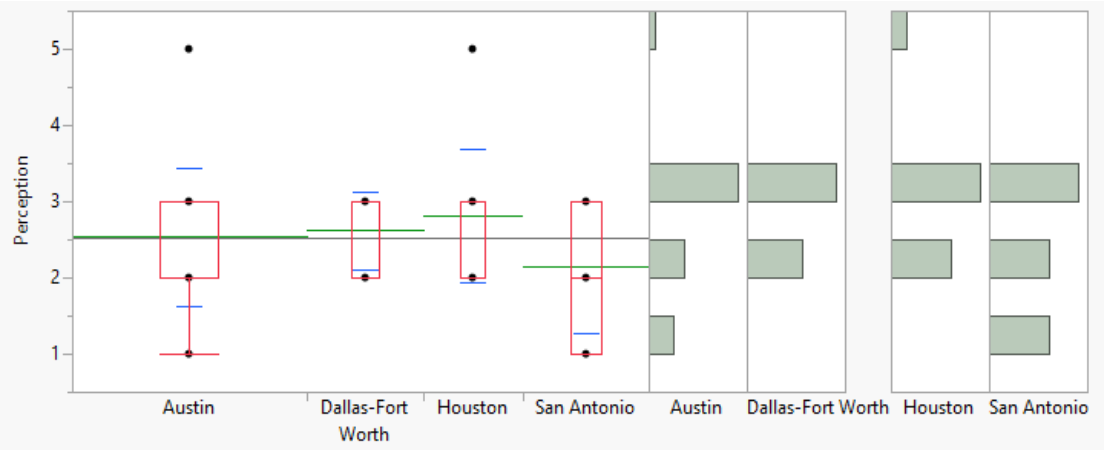


Figure 75: Statement #33, boxplot and distributions

Table 34: Statement #33, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1	2	3	3	3	5
Dallas-Fort Worth	2	2	2	3	3	3	3
Houston	2	2	2	3	3	4.6	5
San Antonio	1	1	1	2	3	3	3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.53846	0.904689	0.17742	2.1730	2.9039
Dallas-Fort Worth	13	2.61538	0.506370	0.14044	2.3094	2.9214
Houston	11	2.81818	0.873863	0.26348	2.2311	3.4053
San Antonio	14	2.14286	0.864438	0.23103	1.6437	2.6420

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	864.500	845.000	33.2500	0.289
Dallas-Fort Worth	13	450.000	422.500	34.6154	0.501
Houston	11	405.500	357.500	36.8636	0.940
San Antonio	14	360.000	455.000	25.7143	-1.707

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
3.3071	3	0.3467

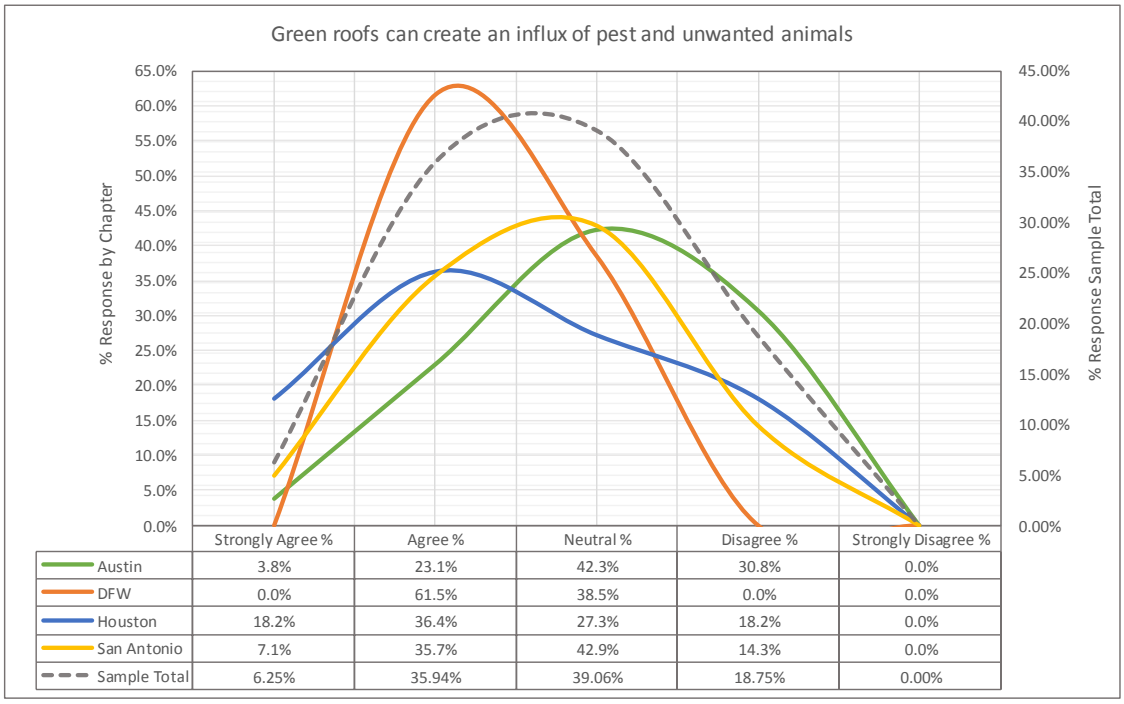
The descriptive statistics for statement #33, show a median of (3) for all the chapters except San Antonio with (2) (Figure 74). The distributions are all focusing on the neutrality option with a tendency towards the agreement of the statement (Figure 75). The Kruskal-Wallis Test results (Table 34) for $\alpha=0.05$ and df=3, show $\chi^2=3.3071 < 7.815$ and a p-value of $0.3467 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #33.

4.3.4.3 Lack of government support barriers general findings

The lack of government support barriers section of the survey showed in general, a tendency towards the agreement of the statements. Statement #33 had the largest difference among chapters in regards to the perception of facility managers on the lack of legislation and building codes for installation of green roofs. Statement #32 regarding the lack of grants and subsidiaries for the implementation of green roofs showed the least differences among the opinions of the chapters.

4.3.5 Statements Related to Physical Barriers

4.3.5.1 Statement #34: Green roofs can create an influx of pest and unwanted animals



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	3.8%	23.1%	42.3%	30.8%	0.0%
DFW	0.0%	61.5%	38.5%	0.0%	0.0%
Houston	18.2%	36.4%	27.3%	18.2%	0.0%
San Antonio	7.1%	35.7%	42.9%	14.3%	0.0%
Sample Total	6.25%	35.94%	39.06%	18.75%	0.00%

Figure 76: Statement #34, responses distributions by chapter and sample total

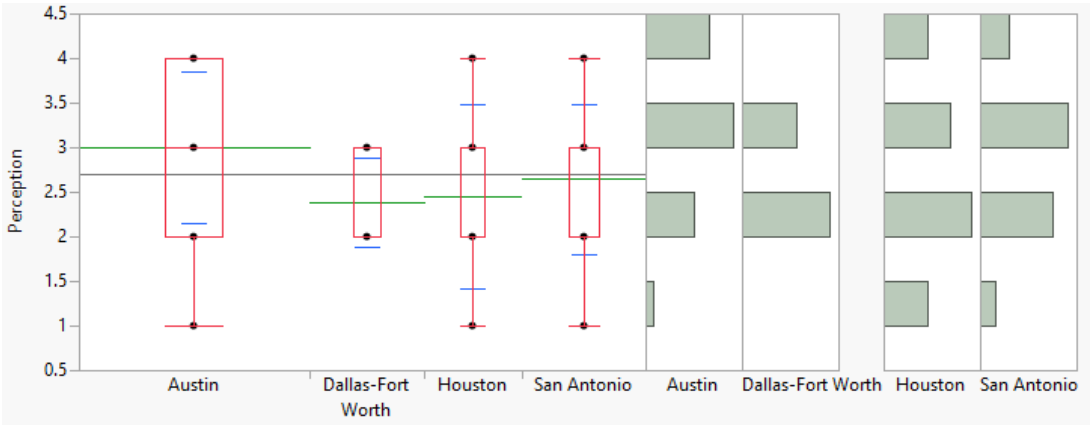


Figure 77: Statement #34, boxplot and distributions

Table 35: Statement #34, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	2	2	3	4	4	4
Dallas-Fort Worth	2	2	2	2	3	3	3
Houston	1	1	2	2	3	4	4
San Antonio	1	1.5	2	3	3	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	3.00000	0.84853	0.16641	2.6573	3.3427
Dallas-Fort Worth	13	2.38462	0.50637	0.14044	2.0786	2.6906
Houston	11	2.45455	1.03573	0.31228	1.7587	3.1504
San Antonio	14	2.64286	0.84190	0.22501	2.1568	3.1290

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

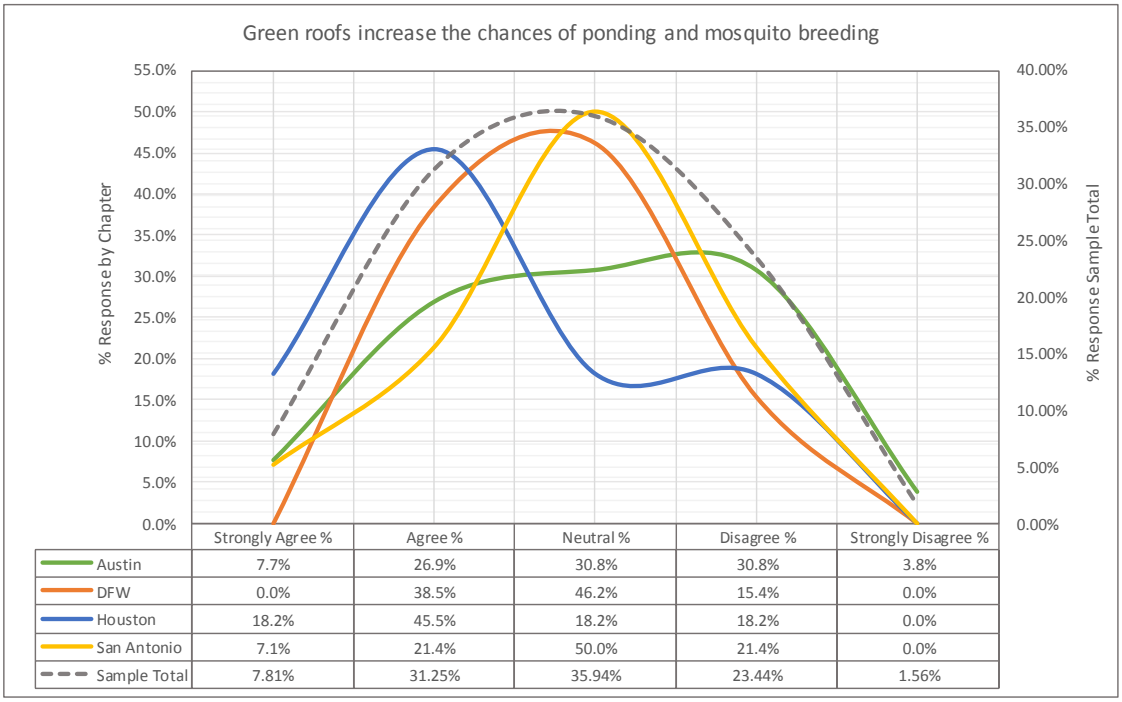
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	1006.50	845.000	38.7115	2.336
Dallas-Fort Worth	13	328.000	422.500	25.2308	-1.665
Houston	11	306.000	357.500	27.8182	-0.963
San Antonio	14	439.500	455.000	31.3929	-0.259

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
6.3337	3	0.0965

The descriptive statistics for statement #34 (Figure 76), show a median of (3) for Austin and San Antonio and (2) for DFW and Houston (Figure 77). The Kruskal-Wallis Test (Table 35) results for $\alpha=0.05$ and df=3, show $\chi^2=6.3337 < 7.815$ and a p-value of $0.0965 > 0.05$, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #34. Austin's chapter distribution with a z-score of 2.336 is shifted to the right towards neutrality and disagreement of the statement in comparison to the other chapters.

4.3.5.2 Statement #35: Green roofs increase the chances of pounding and mosquito breeding



	Strongly Agree %	Agree %	Neutral %	Disagree %	Strongly Disagree %
Austin	7.7%	26.9%	30.8%	30.8%	3.8%
DFW	0.0%	38.5%	46.2%	15.4%	0.0%
Houston	18.2%	45.5%	18.2%	18.2%	0.0%
San Antonio	7.1%	21.4%	50.0%	21.4%	0.0%
Sample Total	7.81%	31.25%	35.94%	23.44%	1.56%

Figure 78: Statement #35, responses distributions by chapter and sample total

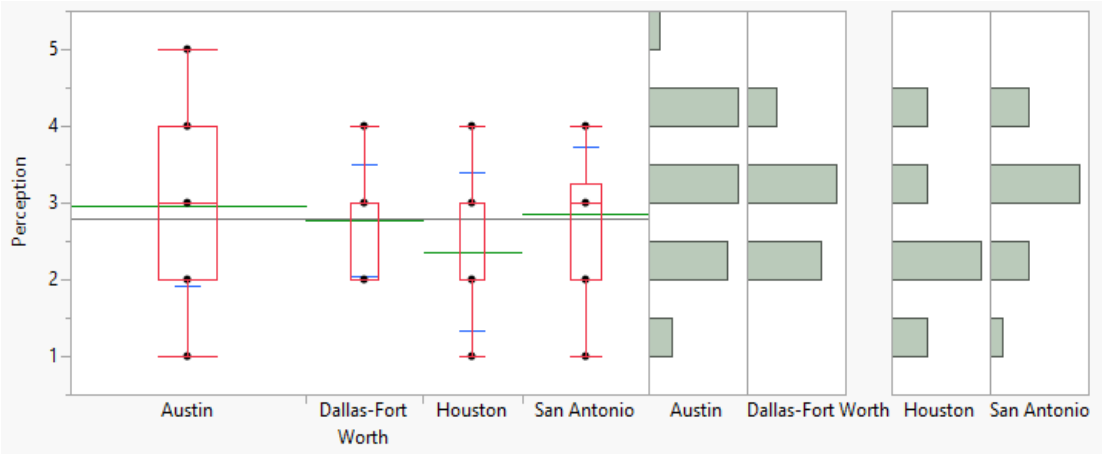


Figure 79: Statement #35, boxplot and distributions

Table 36: Statement #35, descriptive statistics and Kruskal-Wallis test JMP

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Austin	1	1.7	2	3	4	4	5
Dallas-Fort Worth	2	2	2	3	3	4	4
Houston	1	1	2	2	3	4	4
San Antonio	1	1.5	2	3	3.25	4	4

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Austin	26	2.96154	1.03849	0.20366	2.5421	3.3810
Dallas-Fort Worth	13	2.76923	0.72501	0.20108	2.3311	3.2074
Houston	11	2.36364	1.02691	0.30963	1.6737	3.0535
San Antonio	14	2.85714	0.86444	0.23103	2.3580	3.3563

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Austin	26	922.500	845.000	35.4808	1.103
Dallas-Fort Worth	13	411.500	422.500	31.6538	-0.184
Houston	11	269.500	357.500	24.5000	-1.632
San Antonio	14	476.500	455.000	34.0357	0.358

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
3.0983	3	0.3767

The descriptive statistics for statement #35 (Figure 78), show a median of (3) for all the chapters except Houston, with a median of (2) (Figure 79). The Kruskal-Wallis Test results (Table 36) for α=0.05 and df=3, show χ^2=3.0983 < 7.815 and a p-value of 0.3767 > 0.05, therefore fail to reject the null hypothesis and conclude that there is no significant difference among the chapters on the perception of statement #35. Houston's chapter distribution with a z-score of -1.632 is shifted to the left towards agreement of the statement in comparison to the other chapters.

4.3.5.3 Physical barriers general findings

The physical barriers section of the survey showed in general, a tendency towards the agreement of the statements. Statement #34 had the largest difference among chapters in regards to the perception of facility managers on the possibility of green roofs creating an influx of pest and unwanted animals. Statement #35 regarding the increasing chances of ponding and mosquito breeding on green roofs showed the least differences among the opinions of the chapters.

5. CONCLUSIONS

The research findings suggest, that facility managers tend to agree with the attributes that green roof systems provide. After comparing the distributions of the facility manager's responses provided by each chapter for the statements regarding attributes of green roofs, we failed to reject the null hypotheses on all 21 statements. Consequently the Kruskal-Wallis test suggests that there is no difference among the four IFMA chapters evaluated regarding the perception of facility managers on green roofs benefits. The fact that for all 21 statements there is no evidence of difference on the distributions is an indicative of the consistency of answers of all four chapters. Furthermore, even when sample sizes for DFW, Houston and San Antonio IFMA chapters were small, there was no significant difference with Austin's distributions that had a much larger sample size, demonstrating de uniformity on the responses. The responses suggest that facility managers generally agreed with the majority of the statements regarding benefits that green roofs can provide. It is important to recognize that although the findings provided by this study should not be generalized, the statistics used provide a solid foundation for further statistical tools that can build over to generalize the findings.

The comparison of distributions for the statements regarding barriers for green roof implementation lead to similar results. This section of the study had a strong dispersion on the distributions, with two considerably low p-values that almost rejected the null hypothesis (Statements #23 and #24). Still, for all 15 statements we failed to

reject the null hypothesis. Consequently the Kruskal-Wallis test suggests that there is no significant difference among the four IFMA chapters evaluated regarding the perception of facility managers on green roofs barriers for their implementation. Again, the rejection of the research hypothesis on all the statements is an indicative of the consistency of answers of all 4 chapters. Further studies on the data collected is suggested, as the sample size is large enough to be able to generalize the findings.

REFERENCES

Alreck, P. L., Settle, R. B. (2004). "The survey research handbook", McGraw-Hill, New York, NY.

City of Sydney. (2012). "Green roofs and walls strategy 2012". City of Sydney. Sydney, Australia.

Erlichman, P., Peck, S. (2013). "Annual green roof industry survey for 2012". Green Roofs for Healthy Cities. Toronto, On., Canada.

Fernandez-Cañero, R., Emilsson, T., Fernandez-Barba, C., Herrera, M. A. M. (2013). "Green roof systems: a study of public attitudes and preferences in southern Spain." Journal of Environmental Management, 128 (2013), 106-115.

Green Roof Advisory Group Report. (2010). "GRAG 2010 report to Austin city council".<http://www.austintexas.gov/sites/default/files/files/Sustainability/Green_Roof/2010_GRAG_Report_to_Council.pdf>. (Apr 25, 2013)

Hodges, C. (2005). "A facility manager's approach to sustainability." Journal of Facilities Management, 3(4), 312-324.

House, M.-H (2009). "North Texas stakeholders: perceptions of extensive green roofs," MLA Thesis, University of Texas at Arlington, Arlington, TX.

IFMA. "About IFMA". <http://www.ifma.org/about/about-ifma> (Oct. 15 2013).

Loder, A. (2011). "Greening the city: exploring health, well-being, green roofs, and the perception of nature in the workplace." MLA Thesis, University of Toronto, ON, Canada.

Peck, S. (2010). "Green roof trends: facility managers and green roofs." Today's Facility Manager, <http://www.todaysfacilitymanager.com/2010/08/green-roof-trends-facility-managers-and-green-roofs> (Apr 15, 2013).

University of Northern Iowa. (2014). "SPSS techniques series: statistics on Likert scale surveys". Information Technology Services, http://www.uni.edu/its/support/article/604 (04/14/2014).

United States Green Building Council (USGBC) (2009). "LEED credentials". <http;//www.usgbc.org/DisplayPage.aspx?CMSPageID=222> (Nov. 15, 2013)

White, E. V., Gatersleben, B. (2011). “Greenery on residential buildings: does it affect preferences and perceptions of beauty?” Journal of Environmental Psychology, 31 (2011), 89-98.

Wong, N., Tan, P., Sia, A., and Wong, N. (2010). “Perception studies of vertical greenery systems in Singapore.” Journal of Urban Planning and Development. 136 (4), 330-338.

Wong, N., Wong, S., Lim, T., Ong, C., Sia, A. (2005). “Perception study of building professionals on the issues of green roof development in Singapore.” Journal of Architectural Science Review, 48 (3), 205-214.

Yuen, B., Wong, N. H. (2005). “Resident perceptions and expectations of rooftop gardens in Singapore.” Journal of Landscape and Urban Planning, 73 (2005), 263-276.

Supplemental Material

Acuff, Z., Harris, A., Larsen, L., Magnus, B., Pumpbrey, A. (2005). “Building green for the future.” Case Studies of Sustainable Development in Michigan. Urban Catalyst Associates. University of Michigan, Ann Arbor, MN.

Carter, T., Fowler, L. (2008). “Establishing green roof infrastructure through environmental policy instruments.” Environmental Management, 42 (2008), 151-164.

Clark, E., Hinxman, L. (1999). “Developing a framework of competencies for facilities management.” Facilities, 17 (7/8), 246-252.

Climate Protection Partnership Division. “U.S. Environmental Protection Agency’s Office of Atmospheric Programs”. <http://www.epa.gov/hiri/resources/pdf/GreenRoofsCompendium.pdf> (Nov. 3, 2013)

Dagenais, D., Gagnon, C. and Pelletier, J.L. (2010). “Development of design criteria to improve aesthetic appreciation of extensive green roofs.” Acta Hort. (ISHS) 881:703-708 http://www.actahort.org/books/881/881_115.htm

United States Department of Energy Efficiency and Renewable Energy (EERE) (2004). “Green Roofs.” Federal Technology Alert. Washington DC. < https://www1.eere.energy.gov/femp/pdfs/fta_green_roofs.pdf> (Sep. 22, 2013)

Floyd, J. F. (2009). “Survey research methods”, SAGE Publications, Thousand Oaks, CA.

General Services Administration (GSA) (2011). “The benefits and challenges of green roofs on public and commercial buildings.” A report of the United States General Services Administration. Washington, DC.

Green Roof Advisory Group Report. (2011). “GRAG 2011 report to Austin city council”<http://www.austintexas.gov/sites/default/files/files/Sustainability/Green_Roof/2011_GRAG_report_to_council.pdf>. (Apr. 25, 2013)

Henry, A., Frascaria-Lacoste, N. (2012). “The green roof dilemma – discussion of Francis and Lorimer (2011).” Journal of environmental management, 104 (2012), 91-92.

Hollon, M., McKinney, E. (2012). “Building a green roof program in hot, drought-prone climates.” 10th Annual green roof & wall conference. Chicago, IL.

Jungels, J., Rakow, D. A., Allred, S. B., Skelly, S. M. (2013). “Attitudes and aesthetic reactions toward green roofs in the northeastern United States.” Landscape and Urban Planning, 117 (2013), 13-21.

Keith, A. (2003). “A strategy for facilities management.” Facilities, 21 (11/12), 269-274.

Leedy, P. and Ormrod, J. (2010). Practical Research Planning Design, Upper Saddle River, NJ.

Longnecker, M., Ott, R. L. (2010). “An introduction to statistical methods and data analysis”. Brooks/Cole. Belmont. CA.
Punch, K. F. (1998). Introduction to Social Research. Sage Publications, Thousand Oaks, CA.

Miller, C., Weeks, K., Bass, B., Berghage, S. B. (2010). “Stormwater policy ad a green roof (Dis)incentive for retail developers.” 8th Annual green roof & wall conference. Vancouver, Canada.

Peck, S. W., Callaghan, C., Kuhn, M. E., Bass, B. (1999). “Greenbacks from green roofs: forging a new industry in Canada.” Status report on benefits and opportunities for green roof and vertical garden technology diffusion. Toronto, Canada.

Rahman, S. R. A., Ahmad, H., Rosley, M. S. F. (2013). “Green Roof: its awareness among professionals and potential in malaysian market.” Procedia – Social and Behavioral Sciences, 85 (2013), 443-453.

Rahman, S. R. A., Ahmad, H. (2012). “Green roofs as urban antidote: a review on aesthetic, environmental, economic and social benefits.” In: 6th South East Asian Technical University Consortium Symposium, 6 - 7 March 2012., King Mongkut's University of Technology Thonburi, Thailand.

Roper, K. O., Beard, J. L. (2006). "Justifying sustainable buildings-championing green operations." Journal of Corporate Real Estate, 8 (2), 91-103.

Siegler, D. (2006). "Green roofs for Austin: toward a more progressive model of technology transfer," thesis, presented to University of Texas at Austin, TX, in partial fulfillment of the Requirements for the Degree of Master of Science in Sustainable Design.

Sullivan, K., Georgolulis, S. W., Lines, B. (2010). "Empirical study of the current United States facilities management profession." Journal of Facilities Management, 8 (2), 91-103.

Taheri, M. R., Rahman, N. A., Salleh, E. (2007) "The perception of cooling roofs among professionals in Iran." ALAM CIPTA, International Journal on Sustainable Tropical Design Research & Practice, 2 (1), 27-32.

Taylor, D. A. (2007). "Growing green roofs, city by city". Environmental Health Perspectives, 115 (6), 306-311.

United States Green Building Council (USGBC) (2014). "LEED rating systems: what is LEED?" <http;//www.usgbc.org/DisplayPage.aspx?CMSPageID=222> (Sep. 15, 2013).

Weisberg, H. F., Krosnick, J. A., Bowen, B. D., (1996). "An introduction to survey research, polling, and data analysis". SAGE Publications, Thousand Oaks, CA.

Wilkinson, S. J., Reed, R. (2009). "Green roof retrofit potential in the central business district." Property management. 27 (5), 284-301.

Wong, N., Wong, S., Lim, T., Ong, C., Sia, A. (2005). "Perception study of building professionals on the issues of green roof development in Singapore." Architectural Science Review, 48 (3), 205-214, < http://www.tandfonline.com/doi/abs/10.3763/asre.2005.4827?journalCode=tasr20#.U7TAlfldX7Q> (Aug. 18, 2013).

Yin, R. (2009). Case Study Research Design and Methods, Thousand Oaks, California.
Yuen, B., Wong N. (2004). "Resident perceptions and expectations of rooftop gardens in Singapore". Science Direct Landscape and Urban Planning, 73(2005) 263-276.

Yudelson Associates (2007). "Green building incentives that work: a look at how local governments are incentivizing green development." Green Building Incentives That Work. Tucson, AZ.

APPENDIX A IRB APPROVAL FORM

DIVISION OF RESEARCH

Research Compliance and Biosafety

TEXAS A&M UNIVERSITY

DATE: March 27, 2014

MEMORANDUM

TO: Jose L Fernandez-Solis
TAMU - College Of Architecture - Construction Science

FROM: Human Subjects Protection Program
Institutional Review Board

SUBJECT: Approval – Initial Review

Study Number: IRB2014-0132

Title: Current Perception of Facility Managers on the Issues of Green Roof Development in Texas.

Approval Date: 03/27/2014

Continuing Review Due: 02/15/2016

Expiration Date: 03/15/2015

Documents Reviewed and Approved:

Title	Version Number	Version Date	Outcome
Thesis Questionnaire IRB Eduardo Ferrer	Version 1.0	03/20/2014	Approved
Online Questionnaire IRB Eduardo Ferrer	Version 1.0	03/20/2014	Approved
IFMA Support Letter IRB	Version 1.0	03/20/2014	Approved
Recruitment Script Eduardo Ferrer	Version 1.0	03/20/2014	Approved
research proposal eduardo ferrer	Version 1.0	02/20/2014	Approved
consent form eduardo ferrer	Version 1.0	02/20/2014	Approved
thesis questionnaire irb eduardo ferrer	Version 1.0	02/20/2014	Approved
Consent Information Sheet Form Eduardo Ferrer	Version 1.2	02/19/2014	Approved

Document of Consent: Waiver approved under 45 CFR 46.117 (c) 1 or 2/ 21 CFR 56.109 (c)1

This research project has been approved. As principal investigator, you assume the following responsibilities:

1. **Continuing Review:** The protocol must be renewed by the expiration date in order to continue with the research project. A Continuing Review application along with required documents must be submitted by the continuing review deadline. Failure to do so may result in processing delays, study termination, and/or loss of funding.
2. **Completion Report:** Upon completion of the research project (including data analysis and final written papers), a Completion Report must be submitted to the IRB.
3. **Unanticipated Problems and Adverse Events:** Unanticipated problems and adverse events must be reported to the IRB immediately.

750 Agronomy Road, Suite 2701
1186 TAMU
College Station, TX 77843-1186
Tel. 979.458.1467 Fax. 979.862.3176
http://rcb.tamu.edu

A- 1

4. **Reports of Potential Non-compliance:** Potential non-compliance, including deviations from protocol and violations, must be reported to the IRB office immediately.
5. **Amendments:** Changes to the protocol must be requested by submitting an Amendment to the IRB for review. The Amendment must be approved by the IRB before being implemented.
6. **Consent Forms:** When using a consent form or information sheet, you must use the IRB stamped approved version. Please log into iRIS to download your stamped approved version of the consenting instruments. If you are unable to locate the stamped version in iRIS, please contact the office.
7. **Audit:** Your protocol may be subject to audit by the Human Subjects Post Approval Monitor. During the life of the study please review and document study progress using the PI self-assessment found on the RCB website as a method of preparation for the potential audit. Investigators are responsible for maintaining complete and accurate study records and making them available for inspection. Investigators are encouraged to request a pre-initiation site visit with the Post Approval Monitor. These visits are designed to help ensure that all necessary documents are approved and in order prior to initiating the study and to help investigators maintain compliance.
8. **Recruitment**: All approved recruitment materials will be stamped electronically by the HSPP staff and available for download from iRIS. These IRB-stamped approved documents from iRIS must be used for recruitment. For materials that are distributed to potential participants electronically and for which you can only feasibly use the approved text rather than the stamped document, the study's IRB Protocol number, approval date, and expiration dates must be included in the following format: TAMU IRB#20XX-XXXX Approved: XX/XX/XXXX Expiration Date: XX/XX/XXXX.

1. **FERPA and PPRA:** Investigators conducting research with students must have appropriate approvals from the FERPA administrator at the institution where the research will be conducted in accordance with the Family Education Rights and Privacy Act (FERPA). The Protection of Pupil Rights Amendment (PPRA) protects the rights of parents in students ensuring that written parental consent is required for participation in surveys, analysis, or evaluation that ask questions falling into categories of protected information.
2. **Food:** Any use of food in the conduct of human subjects research must follow Texas A&M University Standard Administrative Procedure 24.01.01.M4.02.
3. **Payments:** Any use of payments to human subjects must follow Texas A&M University Standard Administrative Procedure 21.01.99.M0.03.

This electronic document provides notification of the review results by the Institutional Review Board.

A- 2

APPENDIX B SURVEY

Part I: Please circle the option that best fits you.

1. From which of the following IFMA Chapters are you member?

- ◯ Houston
- ◯ Dallas-Fort Worth
- ◯ Austin
- ◯ San Antonio
- ◯ None

2. What is your Gender?

- ◯ Male
- ◯ Female

3. Which of the following certificates do you hold? You can choose more than one option

- ☐ IFMA FMP (Facility management Professional)
- ☐ IFMA SFP (Sustainability Facility Professional)
- ☐ IFMA CFM (Certify Facility Manager)
- ☐ None

4. What is the highest level of education you have completed?

- ◯ Less than High School.
- ◯ High School diploma or equivalent.
- ◯ Some college, no degree.
- ◯ Associate's degree.
- ◯ Bachelor's degree.
- ◯ Master's degree.
- ◯ Phd.

5. How many years of experience do you have working as a Facility Manager?

- ◯ None
- ◯ 1 to 2 years.
- ◯ 3 to 5 years.
- ◯ 6 to 8 years.
- ◯ 9 to 10 years.
- ◯ More than 10 years.

6. Do you know what a Green Roof is?
Definition: Green roofs or vegetated roofs, are an extension of roof covered to some degree with vegetation.

- ◯ Yes
- ◯ No

7. How would you describe your knowledge on green roofs?

- ◯ Very Poor
- ◯ Poor
- ◯ Fair
- ◯ Good
- ◯ Very Good

8. Are you aware of any building in Texas with a green roof?

- ◯ Yes
- ◯ No

9. Have you worked on a building that has a green roof? If you have, please select how many years.

- ◯ No
- ◯ 1 to 2 years.
- ◯ 3 to 5 years.
- ◯ 6 to 8 years.
- ◯ 9 to 10 years.
- ◯ More than 10 years.

10. Do you know about educational opportunities for facility managers on the area of green roofs?

- ◯ Yes
- ◯ No

11. Have you pursued any education on green roofs?

- ◯ Yes
- ◯ No

If yes, please specify which

12. Do you hold a GRP (Green Roof Professional) Accreditation?

- ◯ Yes
- ◯ No

13. Do you hold any LEED credential or certificate? You can choose more than one option.

- ☐ LEED GA (Green Associate)
- ☐ LEED AP BD+C (Building Design +Construction)
- ☐ LEED AP O+M (Operations + Maintenance)
- ☐ LEED AP ID+C (Interior Design + Construction)
- ☐ LEED AP Homes
- ☐ LEED AP ND (Neighborhood Development)
- ☐ LEED Fellow
- ☐ LEED for Homes Green Rater
- ☐ Green Classroom Professional
- ☐ No

14. Would you like to see green roofs systems implemented in the building (s) that you work or live in?

- ◯ Yes
- ◯ No

Part II: Please select how much you agree or disagree with each statement.

15. Statements related to Aesthetic benefits

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Green roofs can improve the visual interest and aesthetic appeal of a building.	◯	◯	◯	◯	◯
Green roofs can hide ugly rooftop services (water tanks, air vents, piping, cooling towers) thereby providing a better view.	◯	◯	◯	◯	◯
Green roofs can integrate well with the buildings aesthetically.	◯	◯	◯	◯	◯

B- 3

16. Statements related to environmental performance.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Green roofs can lower air temperature thereby cooling the interior environment of a building.	○	○	○	○	○
Green roofs can filter and bind dust particles thereby improving air quality.	○	○	○	○	○
Green roofs can improve rainwater retention and reduce the load on our drainage system.	○	○	○	○	○
Green roofs can help to preserve and protect the habitat for plants and animals.	○	○	○	○	○
Green roofs can contribute to the reduction of carbon dioxide and increase oxygen exchange.	○	○	○	○	○
Green roofs can help to filter rainwater thereby improving water quality.	○	○	○	○	○
Green roofs can help to mitigate Urban Heat Island (UHI).	○	○	○	○	○

17. Statements related to Technical Barriers.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Green roofs will affect the structural load bearing capacity of the building.	○	○	○	○	○
Green roofs will damage the roof waterproofing membrane resulting in water leakage problems.	○	○	○	○	○
Green roofs can cause clogging in the drainage system.	○	○	○	○	○

18. Statements related to Cost Barriers

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Green roofs require high capital cost.	○	○	○	○	○
Green roofs require high maintenance cost.	○	○	○	○	○

B- 4

19. Statements related to economic benefits

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Green roofs can help decrease rainwater runoff which results in savings in drainage infrastructure.	○	○	○	○	○
Life span of the roof waterproofing membrane can be extended through the use of green roofs.	○	○	○	○	○
Green roofs can reduce the resources needed to cool the building through better insulation.	○	○	○	○	○
Green roofs can provide better acoustic insulation resulting in noise reduction.	○	○	○	○	○
Green roofs can turn existing roof tops into more usable spaces.	○	○	○	○	○
Green roofs can increase a building's property value by providing an amenity space and aesthetic appeal.	○	○	○	○	○
Green roofs can be used to cultivate vegetables and produce food.	○	○	○	○	○
Green roofs can enhance the image of the company or institution located within the building.	○	○	○	○	○

20. Statements related to Social Benefits

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Green roofs can foster community interaction through community gardening.	○	○	○	○	○
Green roofs can facilitate recreational and leisure activities.	○	○	○	○	○
Green roofs have a therapeutic effect, thereby improving the health of its users.	○	○	○	○	○

CONTINUES ON THE NEXT PAGE...

B- 5

21. Statements related to lack of knowledge and awareness barriers.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
There is a lack of technical knowledge on green roofs and products.	○	○	○	○	○
There is a lack of information on costing and financing of green roofs.	○	○	○	○	○
There is a lack of awareness of the benefits and performance of green roofs.	○	○	○	○	○
There is a lack of information on maintenance requirements of green roofs.	○	○	○	○	○
There is a lack of information on plants that will perform well on green roofs in Texas.	○	○	○	○	○

22. Statements related to lack of government support barriers.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
There is a lack of grants and subsidies for implementation of green roofs.	○	○	○	○	○
There is a lack of legislation and building codes for installation of green roofs.	○	○	○	○	○

23. Statements related to physical barriers

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Green roofs can create an influx of pest and unwanted animals.	○	○	○	○	○
Green roofs increase the chances of ponding and mosquito breeding.	○	○	○	○	○

24. Statements related to facility managers

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Facility managers have influence over owners in the implementation of sustainable technologies on new or existing buildings.	○	○	○	○	○

B- 6

APPENDIX C RAW DATA TABLES

C- 1: What is your Gender?

	Male	Female	Total
Austin	18	9	27
DFW	10	3	13
Houston	8	4	12
San Antonio	10	4	14
Total	46	20	66

C- 2: Which of the following certificates you hold?

	Austin	DFW	Houston	San Antonio	Total
IFMA FMP	2	0	3	0	5
IFMA SFP	0	1	0	2	3
IFMA CFM	12	6	2	8	28
None	13	7	7	6	33
Total	27	13	12	14	66

C- 3: What is the highest level of education you have completed?

	Less than High School	High School diploma or equivalent.	Some college, no degree.	Associate's degree.	Bachelor's degree.	Master's degree.	Phd.	Total
Austin	0	0	4	2	13	8	0	27
DFW	0	1	1	2	8	1	0	13
Houston	0	0	3	1	7	1	0	12
San Antonio	0	0	1	0	8	4	1	14
								66

C- 4: How many years of experience do you have working as a facility manager?

	1 to 2 Years	3 to 5 years.	6 to 8 years.	9 to 10 years.	More than 10 years.	Total
Austin	0	2	2	0	23	27
DFW	1	0	0	0	12	13
Houston	0	2	0	2	8	12
San Antonio	1	1	1	0	11	14
						66

C- 5: Do you know what a green roof is?

	Yes	No	Total
Austin	26	1	27
DFW	11	1	12
Houston	12	0	12
San Antonio	13	1	14
			65

C- 6: How would you describe your knowledge on green roofs?

	Very Poor	Poor	Fair	Good	Very Good	Total
Austin	0	5	10	5	7	27
DFW	3	2	5	1	1	12
Houston	0	3	7	1	1	12
San Antonio	0	2	6	4	2	14
						65

C- 7: Have you worked on a building with green roofs?

	No	1 to 2 Years	3 to 5 years.	6 to 8 years.	9 to 10 years.	More than 10 years.	Total
Austin	19	3	5	0	0	0	27
DFW	11	0	1	0	0	0	12
Houston	9	0	1	1	0	1	12
San Antonio	11	2	1	0	0	0	14
							65

C- 8: Are you aware of any building in Texas with a green roof?

	Yes	No	Total
Austin	18	9	27
DFW	6	6	12
Houston	7	5	12
San Antonio	10	4	14
			65

C- 9: Do you know about educational opportunities for facility managers on the area of green roofs?

	Yes	No	Total
Austin	8	19	27
DFW	2	10	12
Houston	2	10	12
San Antonio	7	7	14
			65

C- 10: Have you pursued any education on green roofs?

	Yes	No	Total
Austin	4	23	27
DFW	1	11	12
Houston	1	11	12
San Antonio	3	11	14
			65

C- 11: Do you hold a GRP?

	Yes	No	Total
Austin	0	27	27
DFW	0	13	13
Houston	0	12	12
San Antonio	0	14	14
			66

C- 12: Do you hold any LEED credential or certificate?

	Austin	DFW	Houston	San Antonio
LEED GA (Green Associate)	2	1	1	0
LEED AP BD+C (Building Design +Construction)	2	0	0	0
LEED AP O+M (Operations + Maintenance)	2	0	0	0
LEED AP ID+C (Interior Design + Construction)	1	0	0	0
LEED AP Homes	0	0	0	0
LEED AP ND (Neighborhood Development)	0	0	0	0
LEED Fellow	0	0	0	0
LEED for Homes Green Rater	0	0	0	0
Green Classroom Professional	0	0	0	0
No	20	12	11	14

C- 13: Would you like to see green roofs implemented in the buildings that you live or work?

	Yes	No	Total
Austin	12	15	27
DFW	3	9	12
Houston	5	7	12
San Antonio	8	6	14
			65

C- 14: Statement #1

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	10	13	2	2	0	27
DFW	2	6	2	1	0	11
Houston	3	7	2	0	0	12
San Antonio	1	10	3	0	0	14
	16	36	9	3	0	64

C- 15: Statement #2

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	8	10	7	1	1	27
DFW	1	6	4	0	0	11
Houston	1	6	4	1	0	12
San Antonio	1	9	3	1	0	14
	11	31	18	3	1	64

C- 16: Statement #3

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	6	14	5	1	1	27
DFW	2	7	2	0	0	11
Houston	3	7	2	0	0	12
San Antonio	1	10	2	1	0	14
	12	38	11	2	1	64

C- 17: Statement #4

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	6	15	4	1	1	27
DFW	1	5	3	2	0	11
Houston	2	5	3	2	0	12
San Antonio	3	5	3	2	1	14
	12	30	13	7	2	64

C- 18: Statement #5

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	10	16	0	0	1	27
DFW	2	7	1	1	0	11
Houston	4	6	2	0	0	12
San Antonio	4	8	1	1	0	14
	20	37	4	2	1	64

C- 19: Statement #6

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	8	12	3	3	1	27
DFW	2	7	2	0	0	11
Houston	2	5	3	2	0	12
San Antonio	2	9	2	1	0	14
	14	33	10	6	1	64

C- 20: Statement #7

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	11	11	4	0	1	27
DFW	2	6	3	0	0	11
Houston	2	8	2	0	0	12
San Antonio	2	11	1	0	0	14
	17	36	10	0	1	64

C- 21: Statement #8

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	6	8	10	1	1	26
DFW	1	9	1	1	0	12
Houston	2	6	3	1	0	12
San Antonio	2	7	3	2	0	14
	11	30	17	5	1	64

C- 22: Statement #9

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	3	5	13	3	2	26
DFW	1	4	4	3	0	12
Houston	1	1	8	2	0	12
San Antonio	0	4	5	4	1	14
	5	14	30	12	3	64

C- 23: Statement #10

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	7	12	3	3	1	26
DFW	2	9	1	0	0	12
Houston	2	6	3	1	0	12
San Antonio	1	9	4	0	0	14
	12	36	11	4	1	64

C- 24: Statement #11

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	4	10	9	2	1	26
DFW	1	7	4	0	0	12
Houston	2	4	4	2	0	12
San Antonio	1	7	5	1	0	14
	8	28	22	5	1	64

C- 25: Statement #12

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	8	10	5	1	2	26
DFW	1	5	4	2	0	12
Houston	2	5	4	1	0	12
San Antonio	4	6	3	1	0	14
	15	26	16	5	2	64

C- 26: Statement #13

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	7	9	8	0	2	26
DFW	2	3	5	2	0	12
Houston	2	5	3	2	0	12
San Antonio	2	4	7	1	0	14
	13	21	23	5	2	64

C- 27: Statement #14

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	7	12	3	2	2	26
DFW	2	5	2	3	0	12
Houston	3	2	6	1	0	12
San Antonio	3	6	5	0	0	14
	15	25	16	6	2	64

C- 28: Statement #15

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	9	10	4	2	1	26
DFW	2	6	4	0	0	12
Houston	2	6	3	0	1	12
San Antonio	2	8	4	0	0	14
	15	30	15	2	2	64

C- 29: Statement #16

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	9	11	3	2	1	26
DFW	2	10	1	0	0	13
Houston	4	3	4	1	0	12
San Antonio	2	10	2	0	0	14
	17	34	10	3	1	65

C- 30: Statement #17

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	8	8	6	1	3	26
DFW	1	10	2	0	0	13
Houston	4	3	3	2	0	12
San Antonio	2	7	3	2	0	14
	15	28	14	5	3	65

C- 31: Statement #18

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	10	9	5	1	1	26
DFW	3	8	2	0	0	13
Houston	3	6	3	0	0	12
San Antonio	3	7	4	0	0	14
	19	30	14	1	1	65

C- 32: Statement #19

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	5	8	8	3	2	26
DFW	1	4	3	4	0	12
Houston	0	3	5	3	0	11
San Antonio	1	6	6	1	0	14
	7	21	22	11	2	63

C- 33: Statement #20

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	4	10	7	2	3	26
DFW	1	6	1	4	0	12
Houston	1	3	4	2	1	11
San Antonio	0	6	5	3	0	14
	6	25	17	11	4	63

C- 34: Statement #21

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	7	10	7	0	2	26
DFW	1	6	2	3	0	12
Houston	3	3	3	1	1	11
San Antonio	1	5	8	0	0	14
	12	24	20	4	3	63

C- 35: Statement #22

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	7	13	5	1	0	26
DFW	2	8	1	0	0	11
Houston	6	2	2	1	0	11
San Antonio	5	6	1	2	0	14
	20	29	9	4	0	62

C- 36: Statement #23

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	2	1	13	10	0	26
DFW	1	3	4	3	0	11
Houston	1	5	4	1	0	11
San Antonio	1	1	7	4	1	14
	5	10	28	18	1	62

C- 37: Statement #24

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	2	5	10	9	0	26
DFW	0	6	3	2	0	11
Houston	1	5	4	1	0	11
San Antonio	2	2	7	3	0	14
	5	18	24	15	0	62

C- 38: Statement #25

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	6	12	6	2	0	26
DFW	0	7	3	1	0	11
Houston	2	4	3	2	0	11
San Antonio	3	4	6	1	0	14
	11	27	18	6	0	62

C- 39: Statement #26

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	5	8	10	3	0	26
DFW	0	6	4	1	0	11
Houston	1	5	4	1	0	11
San Antonio	2	4	6	2	0	14
	8	23	24	7	0	62

C- 40: Statement #27

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	5	8	10	3	0	26
DFW	2	9	2	0	0	13
Houston	2	5	2	1	1	11
San Antonio	5	4	3	2	0	14
	14	26	17	6	1	64

C- 41: Statement #28

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	6	8	9	3	0	26
DFW	3	7	3	0	0	13
Houston	2	4	3	1	1	11
San Antonio	5	3	3	3	0	14
	16	22	18	7	1	64

C- 42: Statement #29

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	5	10	7	4	0	26
DFW	2	9	1	1	0	13
Houston	2	5	2	1	1	11
San Antonio	3	5	4	2	0	14
	12	29	14	8	1	64

C- 43: Statement #30

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	6	9	9	2	0	26
DFW	3	6	4	0	0	13
Houston	3	4	2	1	1	11
San Antonio	4	4	3	3	0	14
	16	23	18	6	1	64

C- 44: Statement #31

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	8	7	7	4	0	26
DFW	4	6	3	0	0	13
Houston	2	5	3	0	1	11
San Antonio	4	2	4	4	0	14
	18	20	17	8	1	64

C- 45: Statement #32

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	5	4	15	1	1	26
DFW	0	7	6	0	0	13
Houston	0	4	6	0	1	11
San Antonio	4	3	7	0	0	14
	9	18	34	1	2	64

C- 46: Statement #33

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	4	6	15	0	1	26
DFW	0	5	8	0	0	13
Houston	0	4	6	0	1	11
San Antonio	4	4	6	0	0	14
	8	19	35	0	2	64

C- 47: Statement #34

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	1	6	11	8	0	26
DFW	0	8	5	0	0	13
Houston	2	4	3	2	0	11
San Antonio	1	5	6	2	0	14
	4	23	25	12	0	64

C- 48: Statement #35

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	2	7	8	8	1	26
DFW	0	5	6	2	0	13
Houston	2	5	2	2	0	11
San Antonio	1	3	7	3	0	14
	5	20	23	15	1	64

C- 49: Statement #36

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Austin	5	17	3	1	0	26
DFW	2	10	1	0	0	13
Houston	1	5	2	1	2	11
San Antonio	3	9	0	2	0	14
	11	41	6	4	2	64

APPENDIX D PERMISSION TO USE COPYRIGHTED MATERIAL

Asunto: DE/TASR/P1291

De: East, Deborah (Deborah.East@tandf.co.uk)

Para: edu1987@tamu.edu;

Fecha: Viernes, 30 de mayo, 2014 8:12 A.M.

Our Ref: DE/TASR/P1291

30th May 2014

Dear Eduardo Ferrer,

Thank you for your correspondence requesting permission to reference the following material from our Journal in your printed thesis at **Texas A&M University** entitled **Comparrison of the Perception of Facitlity Manager on Green Roofs Atributes and barriers to their implementation** and to be posted in your university's repository.

Material Requested to reference - **Perception Study of Building Professionals on the Issues of Green Roof Development in Singapore – Architectural Science Review Volume 48 Issue 3 PP 205-214 – Authors – Nyuk Hien Wong, Sui Jin Wong, Guan Tiong Lim, Chui Len Ong & Angelia Sia.**

We will be pleased to grant entirely free permission on the condition that you acknowledge the original source of publication and insert a reference to the Journal's web site: www.tandfonline.com

Please note that this licence does not allow you to post our content on any third party websites or repositories.

Taylor and Francis do not provide access to our published articels free of charge, if your institution holds a subscription to the content you are requesting to read you will be able to view the article free of charge, if your institution does not hold a subscription to the content then you will need to purchase this for your own personal use.

Should you require further information /instructions on how to purchase the article, please let me know and I can forward you the instructions.

D- 1

Thank you for your interest in our Journal.

Yours sincerely

Debbie East– Permissions & Licence Administrator - Journals.

Routledge, Taylor & Francis Group.

3 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN, UK.

Tel :+44(0)20 7017 6960

Fax:+44 (0)20 7017 6336

Web: www.tandfonline.com

E-mail: deborah.east@tandf.co.uk

From: EDUARDO FERRER [mailto:edu1987@tamu.edu]
Sent: 29 May 2014 20:57
To: Academic UK Non Rightslink
Subject: tasr20:Perception Study of Building Professionals on the Issues of Green Roof Development in Singapore

Permissions Request
Contact name: EDUARDO FERRER
Street address: 1101 Luther Street West
Town: College Station
Postcode/ZIP code: 77840
Country: United States
Contact telephone number: 9795759322
Contact email address: edu1987@tamu.edu
Article title: Perception Study of Building Professionals on the Issues of Green Roof Development in Singapore
Article DOI: 10.3763/asre.2005.4827
Author name: Nyuk Hien Wong, Sui Jin Wong, Guan Tiong Lim, Chui Leng Ong, Angelia Sia
Journal title: Architectural Science Review
Volume number: 48
Issue number: 3
Year of publication: 2005
Page number(s): 207,208,209,210,211
Are you the sole author/editor of the new publication?: Yes
Are you requesting the full article?: No
If no, please supply extract and include number of word: Words: 454 Statements related to environmental benefits: a) Green roofs can lower air temperature thereby cooling the environment. b) Green roofs can filter and bind dust particles thereby improving air quality. c) Green roofs can improve rainwater retention and reduce the load on our drainage system. d) Green roofs can help to preserve and protect the habitat for plants and animals. e) Green roofs can contribute to the reduction of carbon dioxide and increase oxygen exchange. f) Green roofs can help to filter rainwater thereby improving water quality. Statements related to economic benefits: a) Green roofs can help decrease rainwater runoff which results in savings in drainage infrastructure. b) Life span of the roof waterproofing membrane can be extended through the use of green roofs. c) Green roofs can reduce the resources needed to cool the building through better insulation. d) Green roofs can provide better acoustic insulation resulting in noise reduction. e) Green roofs can turn existing roof tops into more usable spaces. f) Green roofs can increase a building's property value by providing an amenity space and aesthetic appeal. g) Green roofs can be used to cultivate vegetables and produce food. h) Green roofs can enhance the image of the company or institution located within the building. Statements related to Aesthetic benefits. a) Green roofs can improve the visual interest and aesthetic appeal of a building. b) Green roofs can hide ugly rooftop services (water tanks, air vents, piping, cooling towers) thereby providing a better view. c) Green roofs can integrate well with the buildings aesthetically. Statements related to Social Benefits a) Green roofs can foster community interaction through community gardening. b) Green roofs can facilitate recreational and leisure activities. c) Green roofs have a therapeutic effect, thereby improving the health of its users. Statements related to Technical Barriers. a) Green roofs will affect the structural load bearing capacity of the building. b) Green roofs will damage the roof waterproofing membrane resulting in water leakage problems. c) Green roofs will cause

clogging in the drainage system. Statements related to Cost Barriers a) Green roofs require high capital cost. b) Green roofs require high maintenance cost. Statements related to lack of knowledge and awareness. a) Lack of technical knowledge on green roofs and products. b) Lack of information on costing and financing of green roofs. c) Lack of awareness of the benefits and performance of green roofs. Statements related to lack of government support. a) Lack of grants and subsidies for implementation of green roofs. b) Lack of legislation and building codes for installation of green roofs. Statements related to physical barriers a) Green roofs will create an influx of pest and unwanted animals. b) Green roofs increase the chances of ponding and mosquito breeding.

If no, please supply details of figure/table:

Name of publisher of new publication: Texas A&M University

Title of new publication: COMPARISON OF THE PERCEPTION OF FACILITY MANAGERS ON GREEN ROOFS ATTRIBUTES AND BARRIERS TO THEIR IMPLEMENTATION

Course pack: No

Number of Students:

Is print: No

Electronic: Yes

E-reserve: No

Period of use:

Short loan library?: No

Thesis: Yes

To be reprinted in a new publication?: No

In print format: No

In ebook format?: No

ISBN:

Languages:

Distribution quantity:

Retail price:

Additional comments: I am going to use the questions used in the survey of this study, in my study.