Spaciousness & preference: a study in the perception of density in the suburban residential built environment

A THESIS

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL

OF THE UNIVERSITY OF MINNESOTA

BY

Erin Elizabeth Lilli

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE

Julia Robinson, PhD (advisor)

June 2013

Acknowledgements

A special thank you is extended to Alton Harvey for his kind assistance in connecting me with city officials in Beaverton, Oregon.

I would like to recognize Pat Zimmerman from the University of Minnesota's Stats Clinic for his great help in conducting the data analysis.

Thanks to my wonderful adviser, Julia Robinson, PhD for her nurturing support and academic zest.

Thank you to my great friends Jennifer Garman and Rosie Dolata. Our 'ERJ' meetings and camaraderie were vital in reaching this goal. I love you guys!

Dedication

Thank you to my parents, Bob & Kee, to whom I owe my successes in life.

Your unwavering love and support has helped me so much more than you know.

Abstract

As the country's population increases, it is worth determining what types of residential settings people currently residing in the low density suburbs environments would prefer- simply because those environments would need to increase their density to mitigate sprawl. To inform the creation of high density residential living, this study seeks to identify specific characteristics of a dense settlement most acceptable to people wanting suburban living. Residential suburban communities, as in the United States, often have low dwelling unit densities, as antidote to the congestion and crowding of the urban core environment. Primarily consisting of single family homes on individual plots of land with private yards and wide streets; these developments are becoming more ubiquitous despite the role of both the automobile and land conversion as major contributors to the high concentrations of carbon dioxide in the atmosphere. The question this study asks is, 'what residential physical and spatial configurations are a preferred environmental quality and/or are perceived as low density by people currently living in low density suburban environments?' In other words, can we design a desirable environment that is perceived as low density, while actually utilizing less land area, thus being denser than existing low density counterparts? To investigate this question four residential elements (housing typologies street width, set back depth, and tree coverage) were systematically configured in images of a street scene. These images were the subject of a survey sent to 400 randomly selected inhabitants of Beaverton, Oregon who were asked to choose the images they felt were the most spacious and most preferred from a sets of scenes using discrete choice modeling. Results indicated that the strongest predictors of preference and spaciousness lie in the relationship between tree coverage and setback depth- thus the areas where housing design may be used to increase density.

Table of Contents

List of Tables

List of Figures

I. INTRODUCTION

A. Premise for the Thesis

The predominant, and often preferred, suburban housing typology is the detached single family home on a private lot which, at present, generally does not support an environmentally sustainable community. Therefore this study asks, ‘is it possible to design environments to be perceived as spacious (low density), when they actually have a high objective density?’ The state of rapid urbanization and increased awareness of global warming demands an interest in environmental perception as it pertains to people’s residential environments. This study uses environmental perception to inform the design of residential environments with sufficiently high density to minimize land conversion and subsequently foster a pedestrian–oriented economy. In the United States, there is a large portion of the population that desire, for various reasons, to work and/or live in the urbanized area known as suburbia. If, given these trends, we are to achieve housing densities necessary for sustainable communities; it is crucial to design residential environments with spatial configurations that are both preferred by the dwellers and meet the densities required for sustainable community living. Naturally, environmental perception is a concept key to an investigation aimed at understanding a relationship between people and their built spatial environment. This study aims to both understand the role of density in environmental preference and identify physical and spatial qualities that are preferred and contribute to a perception of low density (spaciousness) within a limited range of objective densities[1].

B. Statement of the Problem

Some existing suburban environments, such as Beaverton, Oregon will face a

[1] Objective densities are hard number figures such as people/acre or dwelling units/acre. This study uses du/a.

sizeable influx of new residents within the next decade[2]. According to the Brookings Institute's review of the 2010 Census; the distinction between cities and suburbs are blurring and many suburban environments are no longer the bedroom communities they once were, but rather are destinations for employment. Suburbanized areas could continue the practice of expanding development onto undeveloped agricultural lands or natural habitats, but this is both highly unsustainable and not cost effective (Burchell, Down, McCann & Mukherji, 2009). The challenge for these suburban environments will be one of increasing the density (ie. people or dwelling units per acre) with a minimum of land conversion in the process. Beaverton makes for an interesting case study because of its expected population increase and restricted outward expansion due to an urban growth boundary (UGB)[3]. The benefits of a UGB have been debated[4], although its ultimate goal is to deter sprawl[5], concentrate vitality at the urban core, and conserve pre-settlement land (vital to carbon sequestration). While the UGB does undergo modifications and its borders pushed outward, it is done parsimoniously and with thorough consideration[6]. Furthermore, according to Marshall, author of *How Cities Work: Suburbs, Sprawl, and the Roads Not Taken*, many of the suburbs surrounding Portland do not want to move their growth boundaries even if it causes an unwelcome increase in density (2000). This may be due to the highly judicious and parsimonious manner in which allowances for

2 Contributing to the increase in density is Beaverton's major shopping center that will attract more people as the Portland Metro area is expected to receive 500,000 more inhabitants and will need 250,000 more homes by 2017 with a portion of these newcomers diverted to the Portland downtown core while others will reside in the suburbs (Marshall, 2000).

3 Accoding to the Spring 2011 draft of Beaverton's Housing and Neighborhood Strategy, an estimated 13,555 more dwelling units will need to be created in Beaverton between 2008 and 2035.

4 As cited in Jun (2004, p. 1335) some argue that Portland's UGB has contributed to controlling urban sprawl and urbanized density increases (Patterson, 1999; Nelson and Moore, 1993; Kline and Alig, 1999),while others insist that Portland's trend of suburbanization and land use patterns is no better than those of other metropolitan areas (Richardson and Gordon, 2001; Cox, 2001).

5 A counter argument to the negative effects of sprawl on density and land use can be found in Peiser, 1989. The author of this paper questions Peiser's position on the scale of discontinuous sprawl, as to whether infill would always be likely to occur, and how increased automobile transportation could ever be a positive thing as Pieser claims.

6 See Metro website (http://www.oregonmetro.gov/index.cfm/go/by.web/id=24198) for information about the political process involved in adding small areas of land to the UGB.

expansion are granted. The UGB has been moved only 36 times from form the late 1970s to 2012 (according to the Metro).

According to Beaverton's zoning map and adopted land use practices; the predominant residential zoning is R7 (6.2du/a) with a minimum setback of 17 feet and conditions that prohibit detached housing in those areas. Therefore, a study in environmental perception including variables that contribute the most to reduced land consumption (street width, setback depth, and housing typology in addition to tree coverage) is prudent for Beaverton in order to determine both residents' preferences towards varying physical and spatial configurations and the role that said variables play on perceived density. Lastly, density's role in environmental preference is perhaps most key to the success of increasing density within restricted land area. Qualitative residential feedback of this nature can have tremendous implications on future zoning policy and practice.

The following subsections will briefly introduce three concepts central to this thesis; they are: environmental perception, suburbia, and density. Both environmental perception and density will be more thoroughly discussed in the Literature Review section.

C. Environmental Perception

Perception is defined by the Academic Press Dictionary of Science and Technology as, "the process of organizing and interpreting information about one's environment that has been acquired through the senses". A wide variety of studies fall under the purview of environmental perception, such as: infill housing compatibility (Nasar & Stamps III, 2009); place attachment (Lewicka, 2010; Kim & Kaplan, 2004); walkability (Moudon et al., 2006; Brown, Werner, Amburgey & Szalay, 2007); perceived density (Moch, Bordas & Hermand, 1996); environmental preference (Herzog, 1992; Crump, 2003); residential satisfaction (Kearney, 2006); neighborhood satisfaction (Hur, Nasar & Chun, 2010); and spaciousness (Stamps, 2009, 2010, 2011) to name a few. This study mainly relied on literature from quantitative and qualitative studies that focused on: spaciousness, environmental preference, and neighborhood and residential satisfaction.

In addition to specific qualitative and quantitative studies, cited in this paper, the written works of Martin Heidegger, Christian Norberg-Schulz, Yi-Fu Tuan, John Brinckerhoff Jackson, and Amos Rapoport were seminal texts that influenced the development of a foundation for this particular study in environmental perception. It is with respect to the philosophical contentions put forth by these thinkers that special attention must be given to the use of language. Use of the terms perception, phenomenology and place, existential space, and space will be discussed in the literature review section and carefully interpreted in the context of building a foundation for this current study and its methodology. Additionally, the levels of existential space, as defined by Norberg-Schulz (1971), is a supporting theory that will also be elaborated upon in connection with the images used in this study's survey.

As put forth by Christian Norberg-Schulz (1971),"architectural space may be understood as the concretization of environmental schemata or images, which form a necessary part of man's general orientation or 'being in the world'" (pg. 7), and "perception aims at valid assumptions about the nature of the environment, and these assumptions vary according to the situations with which we are taking part" (pg. 10). These statements echo the importance of environmental perception studies to a body of knowledge developed for constructing our built environments. Suffice it to say, however, Rapoport most succinctly stated, in his 1970 essay, *The Study of Spatial Quality*, that "if the objective is a broadly based theory allowing for adequate generalizations rather than ad hoc research dealing with specific problems, notions of spatial quality cannot be studied adequately at one moment in time or in one culture" (pg. 90). This statement is important because it not only advocates the need for developing useful theories to apply to space creating, but it makes clear that the pursuit of knowledge must consider a variety of cultures over time to reveal underlying patterns and identify common values associated with particular space types. This preliminary study is an exercise in identifying a plausible methodology, focusing on the culture of the North American suburb, which could be applied to the study of a broader scope of participants and space types.

D. Suburbia

Suburbia is a complex entity that spans many topical areas not limited to: socioeconomics, housing, transportation, place identity, racial segregation, sense of community, and demographics. This study is most concerned with suburbia in the following three ways: 1) its ubiquitous low density housing, 2) the expected increase in populations desiring to move to suburban locations, and 3) its spatial patterns- each to be discussed in this section.

Defining suburbia is complicated and the definitions are as myriad as the studies it inspires. The Merriam Webster Dictionary defines suburb as: 1) an outlying part of a city or town, and 2) a smaller community adjacent to or within commuting distance of a city. As simple as these definitions are, they get to the core of many of the issues and concerns with suburbia, namely that is it 'outlying'. The fact that it is away from the congested (and at times unhealthy) city is why, in some respects, people flocked to them so heavily in the first half of the 20th century. They continue to do so in large part, one could argue, because:

> "Suburbia symbolizes the fullest, most unadulterated embodiment of contemporary culture; it is the manifestation of such fundamental characteristics of American society as conspicuous consumption, a reliance upon the private automobile, upward mobility, the separation of family into

nuclear units, the widening division between work and leisure, and a tendency toward racial and economic excluseveness" (Jackson, 1985, pg. 4).

The often cited James Howard Kunstler (1994) provides another evocative observation in that, "Eighty percent of everything ever built in America has been built in the last 50 years, and most of it is depressing, brutal, ugly, unhealthy, and spiritually degrading…" (pg. 10). Despite the negative tone these two authors' description of the suburban conditions; the notion of "separation of family into nuclear units" and " built in the last 50 years" can be attributed to the single family home- perhaps one of the main desires and perceived positive attribute that draws people to the suburbs and is commonly associated with the 'American Dream'.

Low density housing, embodied by the single family home on a private lot, is practically synonymous with suburbia. In the aptly titled *anti* anti-sprawl book, *Sprawl: a compact history*, Robert Bruegmann defines sprawl (or the expanding suburbs) as a, "…low density, scattered, urban development without systematic large-scale or regional public land-use planning" (2006, pg. 18). In a similar manner Burchell et al. (2009) have narrowed down the concept of suburbia to three traits: 1) unlimited outward expansion into undeveloped areas, 2) low density, and 3) leap frog [or discontinuous] development. Harris and Larkham (1999) discuss five common dimensions to the suburban entity: 1) periphery to dominant urban core, 2) partly or wholly residential in character, 3) low density- decentralized patterns of development, 4) a distinctive culture or way of life, and 5) separate community identities. All of these authors have 'low density' in their definition. As this paper will point out, even in the case study of Beaverton, Oregon, with its infill policies, there is still a high desire to build single family homes in the future.

The second concern of this paper, with regard to suburbia is that people keep moving from the central city and densities need to accommodate increased populations. Beaverton and many other metropolitan areas in the Unites States are facing such issues. Demographers find that as people get older, like the X generation (generally born in the 1960s through 1980); they begin having families and choosing to settle down and plant roots in the suburbs (Kotkin, 2011). Using 2010 Census data and US postal information economist Jed Kolko discovered that in the major metropolitan areas of the country; suburban-like neighborhoods are outpacing urban-like neighborhoods in growth. The qualifying distinction between the two neighborhood types was residential density. A recent article by Joel Kotkin and demographer Wendell Cox (2011), posted to the site Newgeography[7], analyze the recent 2010 Census claiming that despite a perception that city cores were growing and suburbs were declining- the opposite is indeed true. Urban centers are not growing at an appreciable rate, yet even today, more people, especially those ages 35-44 (Kotkin, 2011) are settling down in the suburbs referring to it as the "ideal place to live" (Winograd & Hais, 2010b). Lastly, an analysis of 11,000 suburbs, by Coldwell Banker (2012), found the following trends to be evident in suburbs across the United States: 1) a high ranking in safety with 40% less likelihood of crime than the national average, 2) an automobile commute to work that is under 25 minutes, and 3) 75% of suburbanites own single family homes. It may not be the bucolic setting and return to nature that historically brought people to the early suburbs like Riverside and Llewelyn Park, but it is apparent that people still desire the suburban lifestyle which has commonly been associated with better schools, safer communities, more space, peace and quiet, and auto independence. Riverside's planners Olmsted and Vaux created zoning controls to plan against future adulterations; the results of which Kunstler (1993) remarks; "The vast housing tracts that were laid down for them had all the monotony of the industrial city they were trying to flee and have none of the city's benefits nor any of the of the country side's real charms" (p.52).

---

[7] Several articles were posted to this site relaying similar and overlapping information. Also see citation for Winograd & Hais, 2010a.

While this opinion may be valid, one can't ignore that Riverside utilizes mass transit (along a railroad) which is more than can be said about most suburban residential developments such as those the factory classes were moving to around the turn on the 19th century.

Thirdly and most crucial to this study is suburbia's spatial configurations and patterns which some authors describe as 'objects in the landscape'(Lukez, 2007; Kunstler, 1993) as opposed to the spaces between buildings lauded by great urban design thinkers such as Jan Gehl and Jane Jacobs. Others have expressed it as a, "sprawling and placeless, banal environment (Jacobs & Appleyard, 1987) riddled with low density single family homes and strip malls where the automobile reigns supreme, walkability is limited (Hess, Moudon, Snyder & Stanilov, 1999), and people value their independence and physical space at the expense of quality public space and street life (Girling & Helphand, 1996). In their book *Yard- Street- Park*, Girling and Helphand state that, "Open space defines the suburbs, but the suburbs also have redefined open space" (pg. 3). These descriptions speak to residential land use types and beyond, but it is the residential area that is the focus of this paper. The space defined by dwelling units and trees which are a boundary to the street and setback are an explicit focus of this study. Increasing density in a low density environment and exploring the inherent spatial implication of this will bring a rich set of ideas to bear on these spatial challenges faced by suburbia today. How space is created or defined and the quality of its character are crucial to creating sustainable and meaningful places.

Lastly, on the topic of space, theorist Christian Norberg-Schulz, in his essay, *The Phenomenology of Place*, states that, "Concrete human actions in fact do not take place in a homogenous isotropic space, but in a space distinguished by qualitative differences such as "up" and "down." (1976, pg. 418). Homogeneous isotropic space, that is space that is more or less the same and uniform in all directions, is a qualitative description that befits the suburban environment in many ways; a classic example of this would be the Levittown developments with their uniform, evenly spaced dwelling units that stretched for miles. Norberg-Schulz's essay continues with scholars' attitudes towards defining space in concrete and qualitative terms, yet what seems to be clear is how antithetical these definitions are to those describing the banality of the suburban morphology. For instance, Sigfried Giedion, Keving Lynch, Paolo Portoghesi, and Martin Heidegger define space in concrete and qualitative terms of: outide/inside distinctions; node, path, edge, district; a system of places; and location respectively. The outside-inside relationship implies extension and enclosure understood as landscape and settlement which create a figure-ground relationship. This figure-ground relationship is a quality and experience notably lacking in the suburban environment, yet it can be consciously designed into a new 'densified' suburbia. This research begins the conversation of creating liveable, quality environments by studying how people perceive space and density.

Despite its long existence[8], suburbia has fallen under much scrutiny by those who deride it as an environmentally degrading middle ground lacking in identity; to those who argue for its necessity as an ever evolving, fundamental component of growth and urbanization (Bruegmann, 2005). The appropriateness or importance of suburbia is debatable; therefore this study questions its practice of space consumption in reference to density- which is often used to define suburbia by its opponents and supporters. Suburban development contributes to global warming through its widespread land conversion process (Litynski, 2006), automobile dependency, and fundamental neglect for energy efficient practices in terms of extending infrastructure for single family homes- which themselves, require more energy and materials than

[8] The concept of the suburb has been on the civilized conscience since built developments began forming outside of the post- Roman defensive walls circumscribing a medieval pre-urban nucleus of habitation and commerce. The origin of the term itself *sub urbe* means below/beneath, hence outside, the *urbs* (Harris & Larkham, 1999, pg. 3).

multifamily typologies (Frank, Kavage & Appleyard, 2007; Girling & Helphand, 1996). Utilizing less land area will ultimately require reduced energy, infrastructure, and vehicle miles travelled. The case study of Beaverton, Oregon is especially interesting because it is restricted by an urban growth boundary; thus accommodating an influx of people has implications for housing typologies and street character.

E. Density and its Complexity with Respect to Physical Character

In the current state of rapid globalization, the topic of density is more crucial than ever as planners and architects design the built environment to house a steadily increasing population on a finite land area. Density matters because it is a measure of how efficiently we are using land and is an indicator as to the type of activities or amenities that can exist in a region. 'People per acre' is a measure of density informing us of how many people may be housed in a given area. For example, if two distinct 10 acre areas house an extreme difference in total population of people; the area of higher density is more likely to allow for amenities (or easier access to them) such as theaters, sports arenas, or mass transit than its low density counterpart.

Since the latter half of the 19th century density has historically been used to describe evolving cities and is conceptually vital in prescribing what formal qualities a city might take. Initially this was done through the assessment of street width and building height. Most importantly, density is the common language with which urban planners communicate about the built environment, such as the case with residential zoning requirements. However, despite its many uses, the term itself evades any clear definition and can never fully describe the complexity of the built environment (see Pont & Haupt, 2010). Critics have argued that density is more of a statistical tool and cannot reflect the spatial and formal relations of the built environment. To understand what is meant by this, simply ask a question associated with dwelling typologies; "what does 7 dwelling units per acre (du/a) look like?" What would change if it became 4du/a? These types of questions cannot be easily answered with objective densities, but if future planners and architects aspire toward more sustainable cities[9] that people would prefer to inhabit; density will need to be drastically redefined to include more qualitative aspects. Physical and spatial constructs, as discussed here, refer to the elements of the built environment such as: single family detached homes (sfdh), row houses, stacked row houses (srh), streets, yards, trees, and their positioning with respect to each other in space.

The complex nature of density may be made most apparent when considering the relation between objective-density inspired physical and spatial constructs (such as sfdh versus srh and their relationship to each other and the streetscape) with respect to both preference and perceived residential density. Also, this complexity may be made apparent when considering the role perceived density plays in environmental preference. Suburbs, in the United States, generally tend to physically manifest in finite physical/ spatial constructs, provided a particular dwelling unit per acre is established, and these constructs will possess a particular built character and atmosphere. This study chose objective densities, feasible in many suburban environment, within a range from 8.5du/a to 18du/a expressed in

[9] A "sustainable city" has no one definition or single aspect that makes it sustainable. Rather, there are a multitude of goals, factors and means of application that will vary from city to city which is why there are not examples of "sustainable" cities listed in this paper. For examples of the type of work devoted to making our cities more sustainable, refer to Sustainable City International and City University New York's Institute for Sustainable Cities.

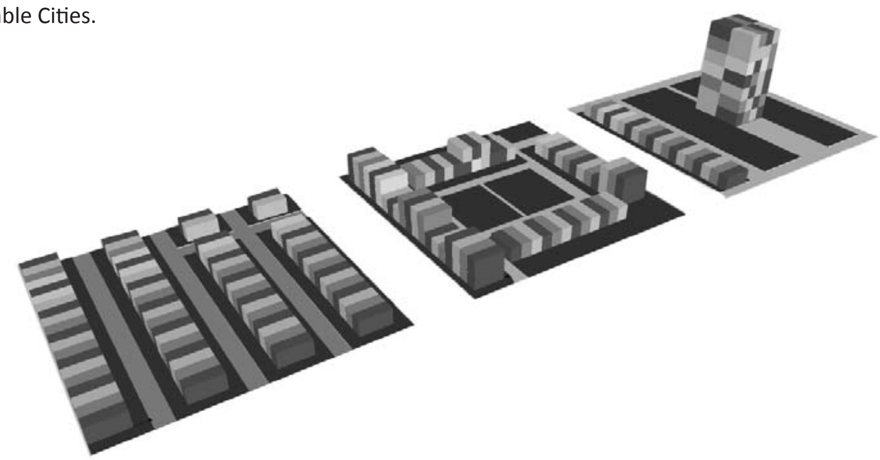


Figure 1: Different arrangements of 75dua/ (after Pont & Haupt, 2010)

terms of four independent variables (street width, setback depth, housing typology, and tree coverage) in order to measure: 1) residential preferences for the manifest built character of these different densities, and 2) perceived density of the manifest physical and spatial constructs, in terms of spaciousness.

Density measurements may be difficult to interpret and compare because, "the standard measure relies too much on where the urbanized area's formal boundary is drawn, and second, the measure is determined by total land area, even if some of the land is sparsely populated" (Eidlin, 2010). These are a couple of the reasons why mere objective densities cannot adequately describe the physical and spatial qualities of the built environment they measure (Chuang, 2001, pg. 55); thus three areas with identical densities can physically manifest very differently, as indicated in Figure 1 (pg. 11) (Campoli & MacLean, 2007; Pont & Haupt, 2010). Furthermore, determining the boundary of the area to measure is very complicated (Richardson et al, 1998), as can be the case in deciding which elements constitute a 'residential area' or a 'neighborhood'. Hence, the ecological fallacy of "The Modifiable Area Unit Problem" (MAUP) (Pont & Haupt, 2010), which is a statistical bias that can radically effect statistical results or hypotheses. This happens when a point based measurements, such as population density, are aggregated into districts- these spatial districts are often arbitrary and modifiable (refer to Openshaw, 1984 for more details concerning MAUP). Essentially, different spatial configurations will yield different statistical results.

In their book, *Spacematrix*, Pont and Haupt hypothesize that urban density does contain valuable information about urban form and performance, and support this argument with a multivariate definition of density that includes three fundamental indicators of: land use intensity (Floor Space Index), coverage/compactness (Ground Space Index), and network density (N). Pont and Haupt's work aims at a "general correlation between objective density and built form" (2010, pg. 17). In contrast to the thesis in Pont and Haupt, this research focuses on perceived density, operationalized as perceived spaciousness, and its role in environmental preference- all expressed though the four independent variables: 1) housing typology, 2) street width, 3) setback depth, and 4) tree coverage.

In this study the physical elements, their spatial relationships, and perception are the focus rather than an exhaustive critique of the complexities of measuring and comparing densities- a topic of which there is much literature (see Churchman, 1999 for a comprehensive review of literature on density).

F. Research Question

This research asks two question: 1) 'what are the designed residential physical and spatial configurations that have a preferred environmental quality and/ or perception of low density by people currently living in low density suburban environments?', and 2) 'what role does perceived density play in environmental preference for people currently living in low density suburban environments?'
A range of objective densities were used as a lens to focus the investigation of perception with regard to preference and perceived density (operationalized as spaciousness). To ask the related question, 'is it possible to design environments to be perceived as spacious (low density), when they actually have a high objective density?' These questions begin to articulate the role that design can play in people's preference for environments because, after all; creating lasting places that people want to live in is arguably the most sustainable thing a designer can do.

1. *Methodology*

A challenge with social science methodologies, as a means to inform design motives, is the manner in which the built environment variables are represented and measured.

In order to design livable and efficient urbanized areas, we must derive quantifiable social attitudes concerning environmental perceptions in the residential built environment. For this study, the complexity of the built environment's character- with its layers of history and rich agglomeration of buildings, spaces, materials, symbols, and people- has been simplified into graphic representations to reveal a relationship between a general physical and spatial quality and a person's environmental perception of it with regard to preference and spaciousness (see survey instrument in Appendix A). The advantage to using line drawings (as opposed to photographs) is the ability to eliminate unwanted variables such as: cars, lamp posts, people, fences, etc. ; and include those pertinent to the study and be able to mnaipulate them. These line drawings of residential street scenes with their systematically varied independent variables offer an ego-centric perspective which represent a three dimensional condition. Rapoport (1969, pg. 24) contends that while objective densities are important, there is a strong need to consider the relationship among physical elements in three dimensional terms. The independent variables, which create the overall residential character, involve housing, landscape, and street character by specifically focusing on: street width, setback depth, housing typology, and tree coverage. Fundamentally, these everyday things relate to spatial characteristics of horizontality, verticality, and permeability- as will be discussed in more depth later.

2. *Need for Research Based Approach*

Design of sustainable communities must embrace a research based approach, as advocated by Rapoport (2010), in order to effectively create high density places which people want to live. Designing for people, as architects and urban planners are tasked with doing, must explicitly involve knowledge of people and their relationship with the built world. Despite the wave of environmental behavior studies, which began in the 1970s (Rapoport, 2010, p. 6)- research informed design has not become mainstream in today's architectural and urban design fields (Rapoport, 2010).

As early as 1977, Schiffenbauer et al. stated that, "It should be the role of social scientists to provide designers with data which answer this question about the effects of density in a way which will lead to the construction of the best possible environments"[10] (p. 4). Unfortunately, there remains a communication gap between the work of social scientists and practicing designers. Despite the illustrative commentary and social research contributing to the body of knowledge about people and their environments, there is no definitive answer to the question of how people perceive residential built environments with regard to preference and spaciousness. This thesis argues that *things*[11] in ones' built environment may be perceived as physical and spatial constructs whereby their roles may be further understood in the context of two dependent variables; human perception of spaciousness and environmental preference.

G. Structure of the Thesis

This paper is based upon preliminary research, completed as part of this Master of Science in Architecture thesis, that develops a methodology to explore the social and environmental implications of human perception of the residential built environment with regard to preference and spaciousness. It is divided into three main parts:

1) An Introduction which has provided a foundation and set of expectations for the reader to become familiar with the premise and supportive topics.

2) A Literature Review which will expound on some of these topics in more detail

10 Density in those studies referred to the effects of crowding people in a room.

11 Heidegger's term (1954)

with theories, supporting concepts, and the Beaverton, Oregon case study.

3) The Research Study focused on the research itself inclusive of a detailed explanation of the research methodologies employed including analysis, results, discussion, and recommendations.

II. LITERATURE REVIEW

A. Environmental Perception

This study investigates the physical and spatial character of the 'neighborhood place' that many Americans identify as suburban and where many desire to live. By studying people's preferences for these neighborhood environments and their attitudes towards residential density; this research is a study of environmental perception.

Amos Rapoport states the following in the introduction to *The Study of Spatial Quality,*

> "The features of the environment which are seen as important, the way they all combine into the perceived environment, and the way the quality of this perceived environment is evaluated are not only complex but variable--although this variability is lawful and shows regularities. The man-environment interaction is thus crucially linked by perception and cognition and this, in turn, is affected by culture".

In respect to this complexity, pertinent supporting literature and explanations are used to explain this research's chosen focus and methods. The following subsection refers to terminology that is referenced in literature on environmental perception. These terms will be defined and couched within the current study; however, this author wants to make clear that many of these terms have philosophical or theoretical significance beyond the scope of this study. For instance, the subject of phenomenology is filtered here with regard to "things" and "location", but this study does not claim that the images shown to the participants convey anything more than a culturally identifiable place made of things seemingly located within a larger context-the schemata of a neighborhood. Whether or not the images, "depict[s] phenomena applying directly to the consciousness" (Pallasmaa, pg. 450), or, depict things gathering as a fourfold (Heidegger, 1951; Norberg- Schulz, 1983) is not relevant since it cannot be measured in this study. Therefore, phenomenology is a philosophy, guiding this research, "in contrast to the desire for objectivity of the positivist standpoint" (Pallasmaa, pg. 450).

One last caveat that should be briefly addressed is the notion of place. The term 'place' is used in this paper phenomenologically to mean a space with character where the viewers identify themselves in terms of the values they see generated by the image or way they would feel inhabiting that location. Tuan defines place as "centers of felt values where biological needs, such as those of food, water, rest and procreation, are satisfied" (1977, pg. 4). There has been a propagation of literature studying 'sense of place', 'place identity', or 'place attachment' whereupon two camps exists in this effort- a positivistic one engaging quantitative research and the phenomenological one that focuses on "the particularistic nature of place (specific to the individual, the group, the setting)" (Stedman, 2002, pg. 562). Additionally, sentiments regarding suburbia are commonly relegated to the conception of a sprawling and <u>placeless</u>, banal environment (Jacobs & Appleyard, 1987). This study does not measure any of these aspects of place, but presumes that the phenomenal aspect of place allows participants to identify the survey images as a "neighborhood place".

1. *Terminology*

<u>Perception</u> is defined as, "the process of organizing and interpreting information about one's environment that has been acquired through the senses", but Norberg-Schulz offered an equally useful description stating that, "perception aims at valid assumptions about the nature of the environment, and these assumptions vary

according to the situations in which we are taking part" (1971, pg. 10). However, 'perception' summons a whole philosophical contention, in regard to phenomenology and science (objective knowledge), which has been addressed, at length in literature, most notably by Gaston Bachelard, Edmund Husserl, Maurice Merleau-Ponty, Martin Heidegger, and Tony Hiss. It is far beyond the scope and focus of this thesis to fully engage in the topic of perception- which can be understood as an act independent of the conscious obtaining of objective knowledge, ergo a world existing as something which is to be perceived. However, this quotation from Merleau-Ponty provides a sense of the core philosophy behind perception. He stated that, "All knowledge takes place within the horizons opened up by perception" (1958, p. 241)- meaning that all knowledge is come to be known only from being filtered through our human senses.

Phenomenology is a "'return to things', as opposed to abstractions and mental constructions" (Norberg-Schulz, 1976, pg. 415). In recent decades phenomenology has become part of architectural discourse, despite the fact that its prominent pioneer, Martin Heidegger, never explicitly connected his ideas to architecture. In his seminal piece, *Building, Dwelling, Thinking*, Heidegger relies on etymology and poetry to become conversant about people's use of building as a means to dwell as mortals on the earth. Norberg-Schulz argues for Heidegger's claims that a building may be a piece of art that does not merely 'represent', but rather 'presents'- that is "it brings something into presence" (Norberg-Schulz, 1983, pg. 431). Stated in a related way; Heidegger speaks of space, in *Building, Dwelling, Thinking*, as something which "receives their being from location and not from 'space'" (1951, pg. 154). Interpreted for this current study; the images (stimuli) used in the survey (measuring instrument) are not purely concerned with abstract notions of space; not just with mathematical measurements of distances, heights, and densities- although these abstract notions helped develop the survey drawings and are one lens with which the results could be filtered. More importantly though, the survey images were designed to convey everyday “things”, and their physical and spatial relationships to each other that create a place.

The notions of wide, narrow open, closed, continuous, and permeable, are examples of the qualitative descriptions intended to be associated with the images as opposed to a focus on calculated distances, area, or volumes of space. This is a similar method to that utilized by Stamps (2009, 2010,2011), to be discussed later, in his qualitative work on perceived spaciousness.

Specifically, these ‘things’, as Heidegger refers to them, are in this case those phenomena which are culturally identified with the suburban residential built environment. Participants perceive the phenomena of streets, yards, trees, and dwellings with doors and windows, as part of an “’environmental character’, which is the essence of place” (Norberg-Schulz, 1976, pg. 414). Christian Norberg-Schulz expounds on Hiedegger’s essay in his own, *The Phenomenon of Place*, and states that, “the structure of place ought to be described in terms of ‘landscape’ and ‘settelment’, and analyzed by means of the categories of ‘space’ and ‘character’” (Norberg-Schulz, 1976, pg. 414). Arguably, this study has some limitations in the case of the “character” aspect due the need to control for other variables through a hand drawn method. This method purposefully simplifies the images by eliminating extraneous objects and things (other potential variables). This was purposefully done in order to focus on the environmental quality (preference and spaciousness) as influenced by the specific independent variables (street width, setback depth, tree coverage and dwelling type). While the images convey a distinct character, they do so through a reduced number of elements, that a photograph would more fully depict, to stay within the scope of this preliminary study. “’Space’ as a three dimensional organization of the elements that make a place” (Norberg-Schulz, 1976, pg. 418) is the primary focus over character as “atmosphere”.

Existential space, is defined by Norberg-Schulz in his book *Existence, Space & Architecture*, as, “a relatively stable system of perceptual schemata, or ‘image’ of the environment” (pg. 17). This ‘image’, conveyed through the graphic representation of the survey drawing, has some inherent limitations in this study of environmental perception. The survey images depict only one particular view of what would generally be understood to be part of a larger place. Additionally, it is not experienced as a person in lived space, but rather by looking at the image printed on paper. Given this removed vantage point of a portion of a place, the following section on existential space (pg. 20) shows how this seeming limitation is resolved by the argument that there are levels of existential space spanning different scales. Each singular view can thus be justified as one of these levels of existential space- scaled in from the larger place.

Space. Perhaps the term with the most meanings, again Norberg-Schulz and Rapoport will be referred to for an explanatory definition. Rapoport (1970) contends that space is more than a mere physical entity to be manipulated, but rather it must be recognized as a particular kind of space, such as: human/ non-human, designed/ non-designed, religious, symbolic, cognitive, behavioral, or subjective to name a few. In this study, the survey images were designed/human/cognitive spaces- cognitive (or cultural) space being space defined by different groups as affected by: training, previous experience, adaptation, memory, and cognitive categories of the group (Rapoport, 1970, pg. 85).

Norberg-Schulz (1971) discusses five types of space and the two most significant, for this study’s purposes, are perceptual and existential. Perceptual space is concerned with orientation and is based on the ego-centric self perceiving varying spaces that link together to form a total, meaningful whole experience which is then categorized into particular schemata. Existential space is understood as the realization of this schemata and the feeling of belonging to the socio-cultural totality of the space. As will be detailed in the following section; the images used in this study are perceived, but not in the manner that perceptual space would be because it is one given ego-centric view and not a totality of several varying spatial experiences that one would gain by navigating and orientating them self. In short, the images are intended to trigger the notion of larger scale neighborhood schemata.

2. *Existential Space*

The intent of this section is to discuss the survey images, used as the stimuli for the measuring instrument, within the context of the different levels, or scales, of existential space. Because this thesis' focus is on environmental perception and the images are the means of measuring this perception; an argument must be made to justify their use despite their being a single ego-centric framed view.

In his text, *Existence, Space and Architecture*, Norberg- Schulz discusses the levels of existential space beginning with the more cognitive and abstract 'geography', then transitioning to 'landscape', which is considered the ground for configuration which affords place creation. The next move in levels, which is most pertinent for these purposes, is the "urban level", that of the structured environment for human activity. He refers to Kevin Lynch's nodes, paths, and districts as subcomponents of the urban structure onto which human interaction and socializing take place. The neighborhood district, as viewed along a path, is the imagery which the participants of this study perceive with their visual sense. The argument can be made that despite this single framed view that supplies the imagery; it is cognitively conceived as part of a larger schema supplied by the individual's past experiences and culture.

3. *Spatial Qualities and Phenomenal Space*

This section aims to briefly address the notion, put forth by Heidegger, that "existence is spatial" (Merleau-Ponty, 1958, pg. 342), a position that is taken for granted in this research that investigates environmental perception with regard to, what is called here, 'physio-spatial' configurations. That is to say, the images created in this research to convey different residential schemata, also have inherent spatial qualities perceived as wide/narrow (horizontal), high/low (vertical), permeable/not permeable (boundary), and open/closed. These spatial qualities vary in predetermined ways according to the particular residential schemata.

People come to know themselves as beings existing on the earth under the sky (horizontal-vertical) by virtue of the perceived relation between their corporeal self and the *things* around them (Hediegger, 1951). These things constitute the totality of concrete phenomena, in the lived-world, and *how* these things *are* is considered to be their *character*. "Similar spatial organization may possess very different characters according to the concrete treatment of the space defining elements (the boundary)" (Norberg-Schulz, 1976, pg. 418). Accordingly, it is the phenomenal concept of 'being' as 'spatial orientating' that necessitates the perceived physio-spatial qualities of horizontality, verticality, boundary, path, and point (Kevin Lynch's concepts). The thinking corporeal self that is *behind*, *on top of*, *underneath*, *next to…* these *things* in the environment and these *things* can provide paths for navigating and destinations to orientate one on the earth under the sky.

Orientation, in this respect echoes the type of cognitive development that takes place in a growing child, who is becoming independently mobile. Change of position studies by Piaget showed that children ages 4-10 began to use landmarks, which they would eventually link in a more complete reference system, to describe their walking path form home to school (Piaget, Inhelder, Szeminska, 1981, pgs. 4-5).

According to Piagetian models, as infants grow they transition through four stages each adding new cognitive structures gained from their surroundings. Building on previously developed structures they begin to understand defined space and path. Niraula (2006) claims that these ideas are "linked to the assumption that development in a child are first egocentric, taking into account only their own point of view, [and] the ability to take others point of view 'perspective taking' develops with age [with] projective Euclidean spatial concepts develop[ing] later on" (pg. 2). Euclidean metrics, like vertical and horizontal spatial conceptions, develop as children mature and are fundamental to the perception of space studies in this research.

4. *Perceived Density*

The concept of density requires further defining given that suburbia is ubiquitously referred to as a "low density" environment; a perceptual term and fact upon which this thesis is grounded. Rapoport suggested that objective density is different from perceived density and only perceived density, with respect to a given social norm, can determine a collective impression of low, medium, or high density for a given culture (1975, pg. 137). Urban planners use objective densities when discussing the built environment, therefore, it was important to make that connection and consider a range of objective densities to investigate environmental perceptions for preference and perceived density. This range of densities would physically manifest in ways familiar to the suburban residential culture of the United States. Before discussing the concept of perceived density, a brief explanation of objective density will be made.

In very basic terms objective density refers to the number of units of something per a given area such as the number of people or dwelling units per acre (Forsyth, 2003). These quantitative measures are useful to urban planners and architects (or at times completely ambiguous, see Churchman, 1999, pg. 391) in order to understand several things such as: the amount and type of residential housing needed in an area, the amount of open space left in a built up area, the relation between population and dwelling size, the intensity of street networks related to population, or where to locate specific infrastructure, to identify a few. Referring to only the number of people in an area is too vague as a means to describe the physical qualities of a place because a given objective density can manifest in a multitude of ways (partly by virtue of the spatial distribution of those people); therefore, provided only that metric, it is difficult to grasp what character the built environment might take (Campoli & MacLean 2007; Ellis, 2004, Chuang, 2001). Similarly, dwelling unit rates do not take into account the size of the units nor how many people occupy them. According to Rapoport (1975, 1969), objective density is the hard number as defined above- eg. a dwelling unit per area; whereas perceived density is spatial[12] and more qualitative.

This study interpreted Rapoport's use of the term "spatial" as referring to the physical entities (such as buildings, trees, blocks, streets, wall, posts, etc.) and how they are arranged or configured in relation to each other regardless of the number of people within the given area. These conditions would consider the height, width, and form of physical masses as well as the porosity, rhythm, edges, and voids they create due to their organizational structure. Further complexities such as building materiality and texture can influence the perceived density of a place in addition to visual cues that allude to the presence of people such as: the number of cars parked or the number of doors and windows on buildings (Rapoport, 1982). Both spatial and perceived densities need to be considered in planning high quality urban environments that attract inhabitants.

Rapoport (1975, p. 138-140) proposes that there are perceptual, symbolic, temporal, physical, and sociocultural cues in the environment triggering people's

[12] Rapoport (1975, p. 136) argues that perceptual density has a social interaction component in addition to the spatial; however, this study focused on the built environment's physio-spatial characteristics.

perception of environments as being high or low density. Some of the low density cues are: open space, low height to space ratio, greenery, presence of gardens, and low buildings. Some of the high density cues are: tight spaces, large building height to space ratio, mostly human made, tall buildings, and an absence of residential gardens. Furthermore, there are cultural preferences imbued in degrees of density. Rapoport (1982, pg. 167-168) exemplifies this in a list of environmental characteristics developed by James et al. (1974), in a study on wellbeing in Atlanta neighborhoods. The study concluded that dense or congested conditions were generally perceived as negative when compared to open spaces, at least in this American example. Some of those positive characteristics were: much open space, open space with natural vistas, many trees, and narrow streets. Some of the negative characteristics were: congested, high pedestrian densities, many visitors, and few trees.

Provided these characteristics, this research focused on a limited set of independent variables, within a range of higher density environments (8.5, 12, and 18 du/a), to determine how these particular physio-spatial configurations contribute to preference and perceived density or spaciousness. Assuming that planners and designers cannot continue to design housing that is predicated on vast amounts of open space; open space alternatives were excluded from this study.

a. Definitions

Perceived density involves a person's sense of or feelings about a place. Rapoport defines perceived density in spatial terms as the relationships among elements, such as in their "height, spacing or juxtaposition" (1975, pg. 136). This line of reasoning suggests that more enclosed and intricate spaces would be perceived as higher density than more open spaces. These relationships can manifest differently given identical objective densities. Furthermore, people will have a different sense of how dense they feel that space or place is regardless of the actual number of people in the given area. Churchman offers another definition of perceptual density as, "an individual's perception and estimate of the number of people [cues] present in a given area, the space available, and the organization of that space" (1999, p. 390). Both Rapoport's and Churchman's definition for perceived density are applied to this thesis.

From Rapoport comes the idea that built environment relationships, or relating elements of the built environment, foster a sense of low or high perceived density; a perception that is based on particular cultural norms. Rappoport's position is exemplified, in this study, through the use of street width, setback depth, housing typology, and degree of tree coverage as independent variables. From Churchman the research employs the notion that the number of environmental cues can alter the perception. Churchman's definition led to the use of single family and multi-family homes as independent variables in the survey images. A multi-family building with more levels, doors and windows would, according to Churchman, add to a sense that more people lived in that area- a perception of higher density. Potential interesting outcomes of this study are how the spatial relationships (eg. dwellings close or far apart, attached or not), intrinsic to those housing typologies, effects how those cues are perceived. For instance, would a multi-family dwelling typology always be perceived as high density; or would ample street widths and wide setbacks mitigate those effects? What other factors may effect the perception? These are some questions worth asking and can inform design thinking.

Churchman (1999), also referring to Rapoport (1975), hypothesizes that there are physical variables such as: tight/open spaces, intricate/simple spaces, signs, lights, cars, people etc., that contribute to a perception of low density (less stimulus) or high (more stimulus). In this preliminary and exploratory study the built environment has been limited to four independent variables (street width, setback depth, housing typology, and tree coverage), which have strong implications for the design of residential neighborhoods. Additional related stimuli, such as: cars, signs, lights, people etc., would add another layer of complexity worthy of study, but beyond the scope of this current work and would have required a different method of study- perhaps with the use of photographs.

b. Studies

There is little written and researched on the topic of perceived density (Chuang, 2001, pg. 57) and what has been is “scattered through the disciplines of environmental psychology, social psychology, city planning, urban design, and architecture” (Bergdoll & Williams, 1990, pg. 17). Some of those studies on perceived density will be discussed in this section; each with varying methodologies.

Aside from the numerical ratio conditions (objective density), perceptions of density differ as a result of other factors. A study performed by Bergdoll & William (1990) closely aligns with this current study, but their work focused on three higher density residential streets (35-47du/a as opposed to 8.5-18du/a), in San Francisco, using elements contributing to overall scene complexity as the means to measure perceived density. Similar to this study, they were highly interested in what physical factors of the built residential environment contribute to a sense of low or high density. Their study found (contrary to Rapoport’s position on environmental stimuli and perceived density) three factors contributing to a perception of low density: 1) greater building articulation- as in recesses between the buildings and variations in the facade plane , 2) less façade area/ smaller buildings, and 3) increased number of house-like dwellings (ie. detached dwellings with gable roofs). A key difference between this study and Bergdoll’s & Williams’ is that their study was more strongly focused on the character details of the physical elements over the spatial configurations. By using hand drawn stimuli that omit these features; this study controls for complex elements (cars, lights, street furniture) where Bergdoll and Williams' study used photographs of streets with similar objective densities that included them. Three other studies, performed at UC Berkley, cited in their study are:

1. Beck, Gladman & Sisson, 1987; Aiden Boland & Evron, 1988: Street trees had no effect on perceived density, but were positively associated with higher density environments.

2. Beck, Gladman & Sisson, 1987: Street width had a mild effect of perceived density.

3. Beck, Bressi & Early, 1987: Focused on suburban communities to test physical characteristic's effect on perceived density and found it to be partly dependent on the: space between houses, size of front yards, street trees, variety of housing styles, and views from the neighborhood.

A study of perceived density, performed by Flachsbart (1979) surveyed residents in 17 Los Angeles neighborhoods to determine whether they perceived their neighborhood as high or low in density. Interestingly, the variable of street width was not a factor in perceived density although wider streets were preferred; however, shorter blocks with more intersection were correlated to a perception of low density. As will be discussed in this study's results section (pg. 72), a wide street width was a factor in perceived low density (spaciousness), yet it played little role in preference.

While this research created the residential environments as graphical stimuli in the measuring instrument; some researchers focus on existing neighborhood environments and draw conclusions by surveying its inhabitants. For example, Kearney (2006) conducted a study on neighborhood satisfaction asking participants to, among other variables; rate their satisfaction with the density of their community, which was operationalized as the dwelling unit square footage per area for their specific community. Kearney's study speculated that actual density may not effect neighborhood satisfaction as much as people think and that views to nature may mitigate some of the negativity associated with increased density. While, in these studies, the variables are linked to existing, real life, environments (the participants' own community), a fundamental limitation exists by relying only on objective densities and not considering their physical manifestation.

B. Preference

Measuring people's preference for a particular environment is an important variable to consider in this type of research since ultimately we need to create places that people will actually want to live in. Using preference as a dependent variable, in conjunction with spaciousness (as will be discussed in the results section of this paper) permits exploration of the role of perceived density in environmental preference- a key relationship for the creation of a successful sustainable community.

In the last 20 years, there have been a plethora of studies performed to gauge people's preferences towards a particular type of residential environment. In an effort to determine future demands for denser, more walkable suburban residential environments; Myers and Gearin (2001) cited several surveys[13] that all consistently supported five key preferences: 1) suburban location, 2) single family detached home, 3) low density neighborhood, 4) ease of automobile use, and 5) low costs. Interestingly there is an inherent contradiction in many of the responses. Survey participants often displayed a preference for typical suburban environments (meaning low density, single family homes and auto-oriented), but also have a strong desire for more urban attributes, such as mixed use, walkability and transportation[14]. This

[13] Included are the: 1999 National Association of Homebuilder's Smart Growth Survey (83% preferred single family detached home (sfdh) in a suburb yet 33% desired easy access to transportation); 1998 Vermont's Attitudes on Sprawl Survey (74% preferred a suburban sfdh with a large lot over a similarly priced urban home near shops and transport, yet 48% also desired mixed use communities); 1997 Fannie Mae National Housing Survey (71% preferred sfdh); and the 1995 American Living New Urbanism Study: Revitalizing Suburban Communities (73% preferred suburb with large lots and wide streets over narrow streets with sidewalks and shared recreations space).

[14] 1998 Vermonters Attitudes on Sprawl Survey: 74% of respondents preferred a suburban home vice a similarly priced one near transportation, work and shopping; yet, 48% also claimed to prefer communities with housing, stores and services within walking distance. 1999 NAHB Survey: 83% of respondents preferred a single

research posits the existence of physical and spatial configurations that can address the desire for the suburban morphology, while affording[15] these more urban characteristics.

In November of 2004, the Public Policy Institute of California published the *Special Survey of Californians and their Housing* (Baldassare, 2004), citing that most Californians were not willing to give up the lifestyle of the single family home with automotive commute. The survey stated that 70% of the 2,502 surveyed preferred a single family detached home, even if it meant they had to rely on a car to travel locally; 75% of 35-54 year olds responded this way. Californians, however, were near evenly split, when confronted with the choice of living in either a mixed use, walkable area or a purely residential area. Given these data it would behoove the urban design field to perform more environmental preference studies (or utilize those already conducted) to determine how people would really like to live. The car oriented environment is so ubiquitous, that many people may feel that they have no real choice.

Preference for suburban locations was noted in the Kotkin and Cox (2011), article on Newgeography[16], showing that the suburbs are still acquiring more people. People, ages 35-44 (Kotkin, 2011) are settling down in the suburbs because it's the "ideal place to live" (Winograd & Hais, 2010b). This research seeks to identify those physical and spatial characteristics that contribute to environmental preferences towards this "ideal place". "Ideal place" is interpreted by this author to be the consensus of a culturally specific group, in this case the residents of Beaverton. These residents were asked to identify a particular residential schemata which is

family detached home in the suburbs over a townhome in the city even if it required a longer commute; yet 33% supported access to public transportation.

15 Lang (1994, pg. 81-83) defines affordances as "those of its [anythings'] properties that enable it to be used in a particular way by a particular species or an individual member of that species".

16 Several articles were posted to this site relaying similar and overlapping information. Also see citation for Winograd & Hais, 2010a.

highly preferred and potentially ideal. This is based on Rapoport's (1970) definition of cognitive/cultural space as previously mentioned.

Low density residential areas, such as those with single family detached housing, are linked to the notion of open space, or spaciousness, as noted by many authors on the subject. Girling & Helphand (1996) emphatically state, in the beginning of their book, that suburbia is all about open space (wide streets, detached housing, large yards and park space) and it is this open space that sets it apart from its urban counterpart. Similarly, Bruegmann (2006) further reinforces this idea in his critically pro suburbia book *Sprawl,* that large private lots and openness are preferred characteristics of the suburban environment. Crump (2003) refers to the desire for nearby open space that draws many to the suburbs and exurbs; and Hur (2010) found the amount of openness to be strong predictor for neighborhood preference. Again, this research seeks a relationship not just between preference and spaciousness, but also with the specific physical and spatial elements that create these concepts.

People move to the suburbs for a variety of reasons- cheaper mortgages, low density, and single family housing typology are a few variables that may draw people to suburban locations. These have direct physical influence over land consumption, materials, and energy use, and require consideration. According to a study of six suburban communities in Fox Valley, Wisconsin; the five main 'pull factors' for these residents were: 1) rural atmosphere at 48%, 2) lower taxes at 12%), 3) a cleaner environment at 9%, 4) closer to family and friends at 6%, and 5) closer to work at 7% (Koles & Muench, 2002). In the Fox Valley study, " less government and better schools did not rank as primary pull factors, suggesting local urban schools and governments of the Fox Valley are fairing well in the eyes of the public" (pg. 4). However, these are surely pull factors in other suburban communities in the United States.

Given these varying reasons for seeking a suburban lifestyle and the often contradictory preferences highlighted in the surveys from the Myers & Gearin (2001) study; an investigation of residential preferences with respect to the physical and spatial character and perceived density is very timely.

C. Spaciousness

Spaciousness, as articulated by Yi-Fu Tuan in his book *Space and Place*, is condition specific. It is both an abstract, cognitive construct and an experienced physical manifestation. Culture, circumstance, relative conditions and personal history all determine what is spacious and how something is spacious. Most succinctly stated, Tuan professes that, "ample space is not always experienced as spaciousness, and high density does not necessarily mean crowding" (pg. 51). That statement expresses the spirit of this research; that is to say feelings towards a place are caused by components of the built environment which are very nuanced and dependent upon various factors and the individual perceiver.

Spaciousness has been used in quantitative studies on space perception (Stamps 2009, 2010, 2011; Fisher-Gewirtzman, Burt & Tzamir, 2003; Herzog, 1992) and as an independent variable in relation to categorical qualities of built and natural environmental scenes (Skjaeveland & Garling, 1997). A more in-depth discussion of Stamps' work, in reference to the independent variables of this study can be found on pages 53-56.

In his research on preference for urban spaces Herzog defines spaciousness as, "the feeling of spaciousness or room to wander", to empirically assess predictions of openness (1992, pg. 238). He then concluded that spaciousness was an ineffective predictor of the preference variable for the four categories of space he identified (open-undefined, well structured, enclosed setting and blocked view) which were based on Kaplan's study in *Assessing Amenity Resource Variables* (1979). Since Kaplan's work dealt with natural environment settings, it was Herzog's goal to translate those spatial configurations into an urban setting. Despite the ineffectiveness of the spaciousness variable, Herzog contended that further research, in the urban environment, needs to be pursued. This author is following Herzog's advice by studying spaciousness in the urbanizing suburban city environment.

This research explicitly uses spaciousness to measure a feeling of openness (ie. low density) defined, similarly to Herzog, as "the feeling of openness or room to wander" (Skjaeveland & Garling, 1997, pg. 182). Spaciousness is often related to preferences for openness (Herzog, 1992; Hur, Nasar & Chun, 2010; Thiel, Harrison & Alden, 1986, Kaplan, Kaplan, and Brown, 1989). In their use of the Spatial Openness Index (SOI)[17] Fisher-Gewirtzman et al. (2003) successfully conducted an indicator test to confirm the assumed correlation between: the SOI (openness), compression (low spatial openness), and perceived density. In other words, they positively correlated high spatial openness with feelings of less compression to yield a perception of low density (Fisher-Gewirtzman et al, 2003; Fisher-Gewirtzman & Wagner, 2003). The Fisher Gewirtzman et al. (2003) research used different configurations of the same 'building' masses to calculate an SOI and correlate that to the participants' perception of density.

Based on others' previous work, this research assumes a correlation between degrees of spaciousness (most/least) and perceived density (low/hi). According to Rapoport (1977, p. 202), low density environments (having less information) are perceived as less complex and less stressful and therefore preferred, thus explaining why a majority of Americans may seem to prefer lower density environments.

---

17 Defined in their study as: "the volume of the part of a surrounding sphere, which is visible from a given point of view", (p. 579). Their study focused on urban high rise settings by manipulating floor area ratio, height, and configuration.

The reasons that the specific terms “spaciousness” and “openness” are both used in the survey (Apendix A) are:

1) Several studies used ‘spaciousness’ when dealing with perception, so it was logical to use that verbiage in this study.

2) Literature supported the idea of people desiring more physical “space”[18] in the suburbs, thus it was again logical to include the descriptor spaciousness.

3) Studies have used spaciousness as a predictor of ‘openness’ indicating their related nature.

4) Perceived openness is also used to describe physical vistas with open views or a lack of spatial enclosure (Hur et al., 2010). Spatial enclosure has also been a factor in studies measuring spaciousness (Stamps, 2009) thus indicating the related qualities and potentially interchangeability of the terms.

Furthermore, this author believes that the general public would use the terms interchangeably and having both terms increases the likliehod that a participant will identify witht he language of at least one of them. From the review of literature, ‘spaciousness’ and ‘openness’ refer to perceptual qualities whereas ‘space’ an ‘open’ are physical descriptors. In the future a pilot study could be performed to better understand if people do use these terms interchangeably. Moving forward, this paper will simply use the term “spaciousness”.

Identifying how the same objective densities can physically manifest in a multitude of ways, as this study does, allow for the exploration of what it means for a majority of Americans prefer an apparently spacious suburban environment.

---

[18] The authors of *Yard-Street-Park* emphatically state that “open space” is what makes a suburb a suburb. They also contend that open space must be thought of as more than parks and natural areas (open green spaces), and should begin to consider the streets and yards of homes as open space opportunities. In terms of this research it is their idea of space, over the literal openness that is of interest. The scope of this study does not include adjacencies to actual open areas and is more intrigued with the spaces created by the street, yard, tree coverage, and dwellings.

D. Case Study: Within an Urban Growth Boundary

1. Criteria for Analysis Based on Definitions

Given the definitions of suburbia discussed in the Introduction plus what has been written about the topic in a broader sense; a set of criteria can be established to analyze and interpret the Beaverton, Oregon case study.

Rowe (1991) and Archer (1983) discuss the idea of the suburbs as a middle ground or combination between the urban core and rural small town (country). In reference to this theoretical city-country spectrum criteria can be established through macro or micro scales. The fact that this study focuses on residential suburban environments does not exclude the need to discuss its greater context. The purported disjunctive nature and lack of spatial relationships brings suburbia under criticism in many cases (Gehl, 2011, p. 58; Dover 2001, Walsh, 2005).

Starting at the macro level is the relationship between the city center and its suburban periphery- in total often referred to as the Metropolitan area. From this scale overall *patterns* of developed and undeveloped (open space) can be deciphered. Diagramming these patterns can identify discontinuous developments (activity) or neighborhoods that may be choked off from certain amenities. From this vantage point the length of travel between the city center and its suburban expanse can be quantified. In direct relation to this mileage distance is the next criteria- *transportation*. The location and relation of major highways, thoroughfares and secondary roads can be determined and studied. The influence of transportation corridors can be assessed by the *grain* (Lynch, 1981, pg. 265) of the development that is produced. The grain can be fine or coarse and is partly a result of accessibility (transportation), natural features, and *infrastructure* such as street configurations and dwellings. Fine grain means a consistent mix of different uses (ie. residential, commercial, and recreational) tightly packed within smaller areas which encourages walkability; where a coarse grain involves larger swaths of single use zones in larger areas, ie. large residential and large isolated commercial areas. The type of developed area- whether it is commercial, residential, industrial, recreational, or mixed- is contingent upon not only zoning and development strategies, but affordances such as acreage available, accessibility of transportation and utilities, desirable natural features, and socioeconomic needs. Zooming in from this macro level to a micro scale; the detailed relationships of the buildings to each other can then be analyzed. Lastly, given its pertinence in this study, *residential* areas are analyzed for the relationship between their housing typologies and densities.

While this paper distinguishes five different criteria; the reciprocal and overlapping relationships among them is clear. The criteria for analysis (pattern, transportation, grain, infrastructure, residential) will now be taken forward, for a deeper level of scrutiny, in analysis of the U.S. case study of Beaverton, Oregon. It is this case study, with its selection of housing typologies, residential spatial organizations, and objective densities that informed the design of the measuring instrument used in the survey research of this preliminary study.

Figure 2: Beaverton, OR_ Auto Oreinted (Source: Author)

An example of non-pedestrian scaled streets designed to accommodate auto travel.

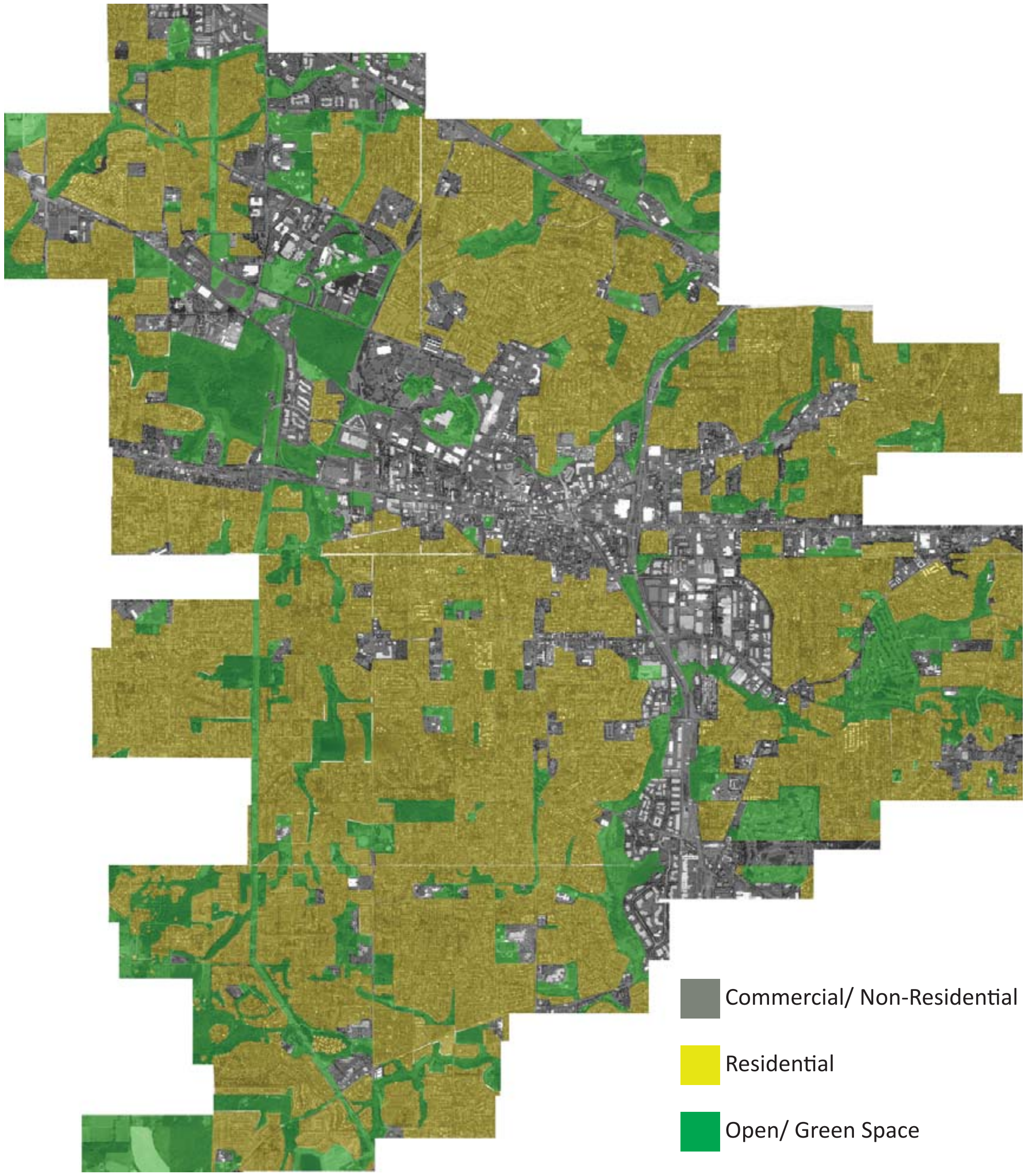


Figure 3: Beaverton, OR_Coarse Grain (Source: Author)

2. Beaverton, Oregon in the Context of Sustainability

The selection of Beaverton, a suburb seven miles southwest of Portland, as a case study for investigating perceptions of residential preference and perceived density was due to its unique position within an urban growth boundary (UGB) and its forecasted population increase[19]. Portland has a regionally elected metropolitan

19 See http://www.ti.org/2040.html

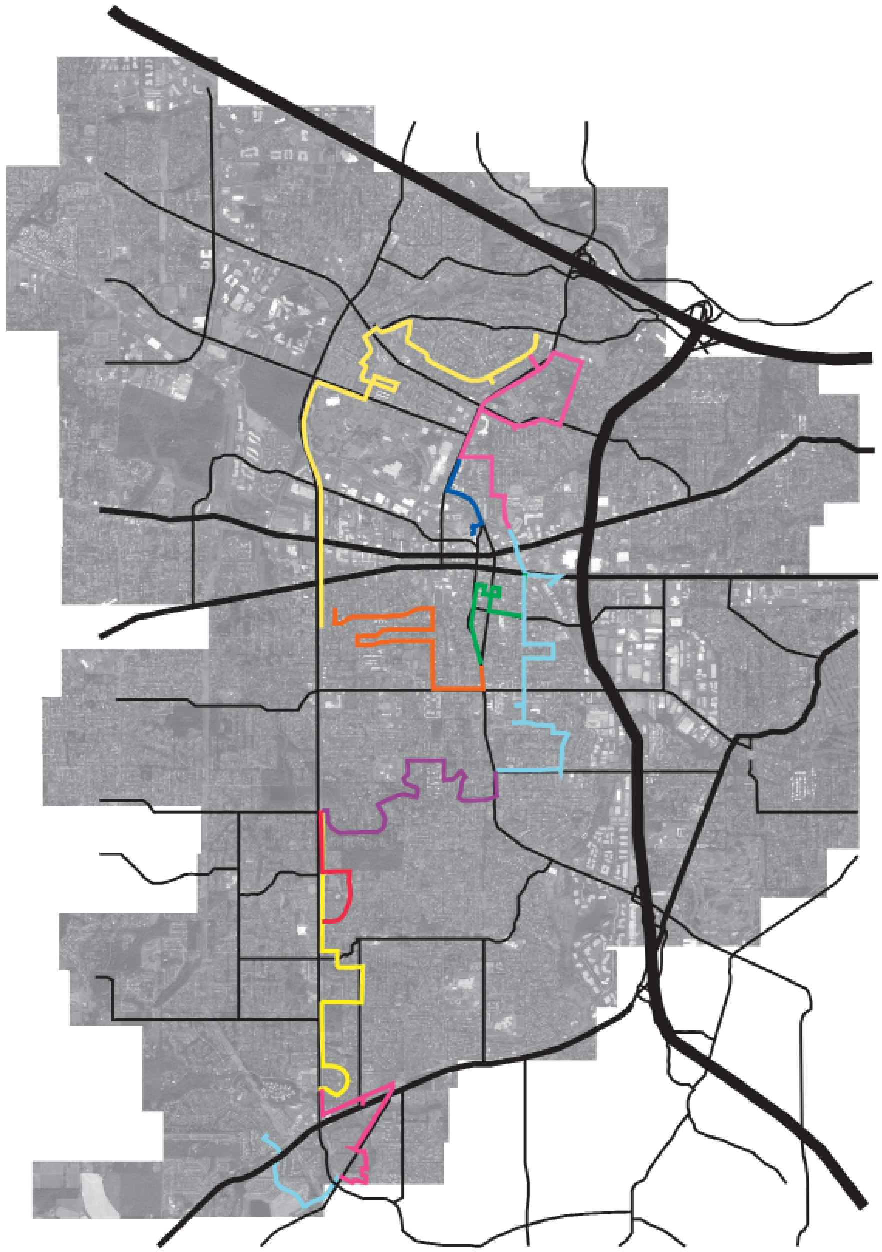


Figure 4: Beaverton, OR_ Site Analysis Path (Source: Author)
Each color represents one of the 11 identified areas.

council (they call the Metro) that governs land use via the UGB for Portland and its 24 'edge' city members that reside within the UGB (established in 1979). The Metro council formed "Region 2040", in the early 1990s, to begin managing a land use strategy to accommodate the projected 1.9 million residents by 2040. Forecasts, based on the 2000 census, placed the metropolitan area population at just over 2 million by 2030, mainly in the suburbs (Stanlilov & Scheer, 2004).

Of the Portland metropolitan areas, Beaverton has the second highest population at 89,803 residents, the second highest person/acre density[20], and a predominant dwelling unit per acre of approximately 6.2 as based on the R7 zoning coverage which designates 7,000sf allotted per dwelling (visit http://www.beavertonoregon.gov/DocumentCenter/Home/View/878 for the zoning map). Contributing to the likelihood of increasing densities is Beaverton's major shopping center which will attract more people as Portland's metropolitan area is expected to receive 500,000 more inhabitants. This will cause a need for 250,000 more homes by 2017 with a portion of these newcomers diverted to the Portland downtown core while others will reside in the suburbs (Marshall, 2000). These suburban cities have made it clear that they do not want to move their growth boundaries[21], despite newcomers' disdain for dense living conditions (Marshall, 2000).

This combination of restricted expansion, increasing population, and desire for low density living makes Beaverton an interesting case study. Despite the Metro council's unique and progressive approach to urban planning, by including an increased proportion of attached single family homes and multifamily housing, Beaverton maintains a spatial typology that is, in many ways, typical of postwar suburban developments. However, Beaverton's future demands are forecast to be smaller condos and townhomes in addition to single family homes as cited in the *Beaverton Civic Plan: Housing and Neighborhood Strategy* (spring 2011 draft). Much of the information presented in this section is the result of a site visit that analyzed Beaverton's suburban spatial typology. The following descriptions serve both to place Beaverton in the context of post war suburban planning as well as

[20] Beaverton is second in population only to the Portland city core, with over 89,000 inhabitants (2010 Census) and is second in people per acre with a density of 7.5. (2010 US Census)

[21] "The danger is that the citizens of Portland, Beaverton, Sherwood, and other political districts will say they will accept the additional housing, but resist the case by case rezoning to accomplish it, and so end up not accepting the additional residents'". (Marshall, 2000, p. 174)

introduce the methodology for choosing the independent variables.

Since 1998, Beaverton has been accessible, from Portland and many other cities in its metropolitan area, by the Trimets's MAX light rail line. There are a few buses providing transportation along certain major corridors within Beaverton, however private automobile traffic outpaces public transit and the majority of the shopping centers are designed for car travel (see Figure 2, pg. 36). Even though the light rail provides transit between Portland's metropolitan cities, those living and

3-4 du/a: Single family home, wide street, shallow setback, and large trees

4 du/a: Single family home and wide street, deep setback, and large trees

4 du/a: Single family home, wide street, shallow setback, adjacent open space

4-5 du/a: Single family home, narrow street, deep setback, few trees

4-6 du/a: Single family home, wide street, deep setback, few trees

4-6 du/a: Multi-family housing, wide street, deep setback, few trees

Figure 5: Beaverton, Oregon_ Densities (Source: Author)
Examples of housing with similar densities based on city census data.

working in Beaverton still have to use their vehicles for more frequent and shorter trips. As depicted in Figure 3 on pg. 37, large swaths of purely residential and purely commercial areas exist next to one another. As previously discussed, this is considered a coarse grain, meaning that one has to travel farther to get to amenities. A coarse grain often inhibits walkability since one must travel over a quarter mile to reach another type of infrastructure; which is often the case in some master planned communities. This scenario leads to more roads that have to be designed to handle busy car traffic and these roads are often wider, permit buildings to be set farther back from the road, and are difficult to traverse by foot.

In February of 2011 an on-site analysis of Beaverton was conducted over the course of four days. Approximately 27 miles (see Figure 4, pg. 38) of on-foot analysis was conducted to: 1) gather measurements of street widths and setback depths, 2) note the types of housing and their locations, and 3) photograph housing and streets to document the types of landscape and tree coverage, scale, character, and atmosphere of the place. This was accomplished for 11 residential areas identified based on morphology observable in aerial images. Through studying and diagramming maps and aerial photos prior to the on site visit, these 'predetermined areas' or zones were identified based on observable differences in texture, grain and scale. The visual interpretation of the grain was assumed to represent zones of different housing typologies and densities- as opposed to commercial areas. Using the maps and aerial photos, some of the infrastructure was easily identified as commercial, residential, or natural with some of the residential areas further distinguished between single family home and apartments upon visiting. The following information has been collected from city publications, primary sources such as maps and aerial photographs, and the on site analysis. Five key environmental attributes were collected during the site visit in Beaverton; they are: 1) character and scale, 2) housing typologies, 3) objective densities, 4) physical elements, and 5) measured spatial relationships.

Prior to studying perceptions of density, it was crucial to gain an understanding of the scale and character of the existing residential built environment in Beaverton to ensure the appropriate scope and focus of the investigation. The many possible housing typologies and configurations create such a multitude of environments ranging from five-acre lot fringe conditions to urban high rises that it was necessary to select those appropriate to Beaverton. Observing the scale and character of Beaverton's residential built environment served the purpose of providing a language and materials palette to inform the images in the final survey instrument. The photo documentation, through on-foot observation of 11 residential areas in Beaverton, found a high proportion of single family detached homes in comparison to other housing typologies. There were no observed four-plexes and only a few duplexes interspersed with single family homes. While the many apartment complexes were most often situated near highly trafficked streets, no row houses or stacked row houses were readily observed. The majority of the homes observed were single story, detached dwellings with hip and gable roofs, wood or brick siding, and often pediments over entry ways. These on-site observations resulted in the use of single family homes, albeit at slightly higher density of 8.5du/a, as one of the housing typology variables in this study. Additionally, the row house and stacked row house were also used as variables for three reasons: 1) multi-family and townhome units now make up the majority of residential building permits in Beaverton (Beaverton Civic Plan, spring 2011 draft), 2) they afford an increased housing density still appropriate to the predominant dwelling scale in Beaverton, and 3) these typologies will assist in accomodating the influx of new residents as described by Marshall (2000).

Census information from 2010 found single family detached homes to be nearly half (44%) of all the dwelling types in Beaverton, clearly indicating the lack of multifamily dwellings. As discussed in the density section of this paper, the objective densities from the Census do little to describe the physical environment, thus, photographs of housing typologies and their spatial relationships were correlated with the densities provided by the city. As the images in Figure 5 (pg. 40) depict, there are a variety of differences in the spatial organization of these residential areas of similar objective densities. These differences lie in street width, setback depth, housing height and degree of tree coverage. Objective densities were determined by maps from the city of Beaverton and correlated to census data locations where photos were taken. Another layer to the observation are the physical elements and spatial relationships between them. In relation to housing typologies of certain scale and character, are the other physical elements such as: trees, blocks, streets, sidewalks, driveways, and the relative height and width of the residences themselves. These elements all lie in a spatial relationship with each other and with the housing typologies manifesting in: street widths, setback depth, degrees of block infill, and adjacencies to open green spaces.

Upon completion of the field analysis, more precise measurements were taken using Google maps for: street widths, setback depths, gap width (between detached homes), and building widths from a sampling of streets from the 11 zones (See Appendix B). It was the surveying and documenting of these relationships that informed the specifics of the independent variables which will be discussed in more detail later in the paper.

Arguably, Beaverton is an atypical suburb. That is to say it is not uncontrollably sprawling with predominantly 1 to 2 du/a densities and zero public transportation, which is the case in many post war suburban developments. However, the field work brought its walkability in to question while validating its heavy reliance on the automobile, despite the presence of public transportation. That condition, in addition to the restricted land growth, population increases, residents' desire for low density (as manifest in their housing choices), and predominance of detached single family homes has made Beaverton an ideal U.S. case study and useful tool in creating the stimuli of the survey instrument.

E. Environmental Implications and Global Warming

Land consumption, the crux of the suburban dilemma, is due to its inherent morphology- that of the single family home[22] on large lot. According to Burchell, et al. (2009), land conversion for low density housing is taking place at three times the rate as household construction and requires much more money for infrastructure than its compact counterpart. This fast rate is in part fueled by the fact that agricultural land can be purchased cheaply. An irony lies in the fact that early suburbs[23] had their start on agricultural lands, yet it was the birth of non-agricultural employment that caused their growth- which then repurposed land away from agricultural uses, but in turn created more mouths to feed. A more recent irony involves people's desires to live near the country which led to over development of the rural landscape, which in turn placed these rural-seekers next to other suburban developments in a blanket of urbanization. Girling & Helphand (1996) describe this as "tragedy of the commons". According to Burchell et al. (2009, pg. 16), the land consumed by sprawl increased by half from 1950-80, then by half again from 1980-2000.

One of the most devastating results of land conversion is deforestation. Deforestation accounts for 25% of global carbon dioxide emissions (World Resource

[22] The average size of the American home has been increasing over the last 40 years, and by 27% since the 1990s. (http://www.eia.gov/consumption/residential/reports/2009-square-footage.cfm)

[23] Early suburbs here refers to results of the feudal system and low productivity of medieval agriculture which forced small towns to rely on trade and manufacturing to survive (Davis, 1965), thus creating what would, over centuries, develop into an urbanized society. Eventually, these urbanized societies would cease in economic growth (not necessarily population) due both to the inability of the farmers to feed the large urban population and to the upstart in rural non-farming populations (Davis, 1965). These rural non-farming societies began to grow as the previous cities had, but at lower densities- similar in theory to the contemporary suburb.

Institute). Furthermore, stripping the earth of its terrestrial biosphere not only destroys habitats and alters natural hydrology, but it contributes to the removal of a means for sequestering 1/6 of the annual global CO_2 emissions (Litynski et al., 2006). Natural sequestration of carbon is crucial in keeping the carbon levels in a healthy balance. A side effect of habitat destruction is the disruption of migratory and feeding patterns of the species within the ecosystem. They find themselves boxed within the urbanized boundaries. In his article, *A more protective urban landscape*, Professor Charles Reith argues that wildlife corridors, weaving developed areas with undeveloped natural habitats, is crucial to maintaining a healthy ecosystem (2006). One could argue that some of the early prewar suburbs, with their park like settings, behaved as wildlife corridors. The main purposes of Portland's, and Beaverton's, urban growth boundary is to control outward, sprawling development and to protect and conserve natural habitats.

When suburban residential areas, like Beaverton, do incorporate green space, it is often in the form of manicured turf grass which, according to a University of Florida study (Hostetler & Escobedo, 2010), actually contributes to CO_2 concentrations and releases nitrous oxide (N_2O) after fertilization. N_2O has a heat-absorbing potential 300 times that of CO_2 which makes its global warming potential far more threatening than that of carbon's (Hostetler & Escobedo, 2010). This is devastating news when one considers that the most prominent housing type, the detached single family, is typically set on a lot of turf grass- which requires copious amounts of water. Fortunately, in Beaverton, a majority of new housing will be typologies such as condos and apartments that have little to no yard space and would therefore not require watering. Furthermore, their current planning strategies are encouraging low impact design which includes: permeable paving, native grasses along streets and in parks, and bioswales.

Undoubtedly, the automobile has not only made suburbia feasible and dictated its morphology, but became a necessary component to its survival. Americans took 411 billion car trips in 2007, covered 2.9 trillion miles and produced 1,959 million metric tons of CO_2- the nation's greatest contributor to greenhouse gas (GHG) emissions (U.S. Dept. of Transportation). Energy use is of crucial concern to the prosperity of a modern society that is predicated on personal automobile

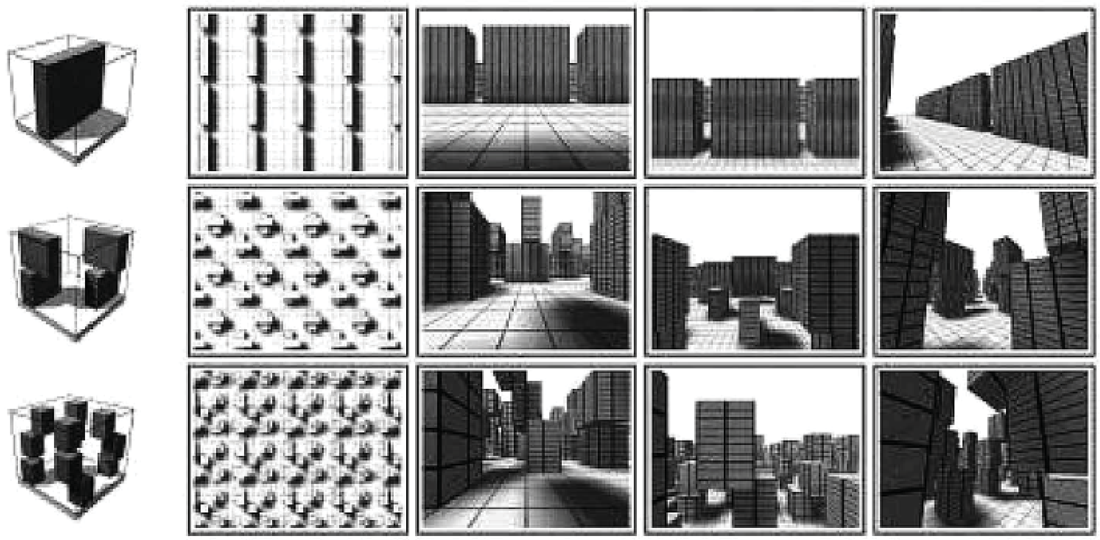


Figure 6: Computerized Virtual Environment
Three spatial configurations used for comparative participant response in the Fisher- Gewirtzman & Wagner, 2003 study of perceived density.

transportation and large, energy inefficient homes. In their article on green cities, written for the Harvard Kennedy School, Glaeser and Kahn (2008) assert that nearly 40% of the U.S.'s CO_2 emissions come from cars and residences; the four main sources being: private in-city transport, public transport, and residential heating and electrical consumption. According to the Environmental Protection Agency (EPA) and the Intergovernmental Panel on Climate Change (IPCC), the earth is in a state of harmful global warming, in part due to increases in carbon dioxide (CO_2). Beaverton's Civic Plan draft (spring 2011) strongly emphasizes the need to increase walkability and create more transit oriented developments to decrease the dependency on car travel and take advantage of their public transit infrastructure.

Churchman's (1999) comprehensive literature review on density found that many authors agree on advantages to increased density. Some of these advantages are: reduced energy needs from less infrastructure and multifamily buildings, reduced depletion of natural resources, improved air quality due to mass transit, and preservation of green space.

This paper contends that mass suburbanization is inherently consumptive, inefficient and wasteful; however there are counter arguments (Bruegmann, 2006; Peiser, 1989; Teaford, 2008, Martinson, 2000) that choose to view sprawl as: self limiting, a natural force of the market economy, more community oriented than urbanists claim them to be, or unfairly ridiculed in some cases (Craig, 1989). While arguing for or against these positions, is not within the scope of this preliminary research, this author believes it is important to acknowledge the two sided nature to an issue that is very complex and multifaceted.

Beaverton, is a suburb that is carefully and consciously managing its need for new single family homes which are exceeding the capacity allotted with in its current growth boundary. While the city may need to adjust these boundaries, it does not do it carelessly and has very strong infill initiatives to combat sprawl.

III. Research Study

Within the field of environmental perception and the built environment; there appear to be very few studies specifically focusing on observable elements of the suburban residential built environment. Furthermore, there were none found that examined the specific variables of: street width, setback depths, degree of tree coverage, and housing typology forms (which will be referred to as "physio-spatial' elements in the rest of the paper), with regard to preference and perceived density. The supporting concepts and theories, presented in the Literature Review, will now be

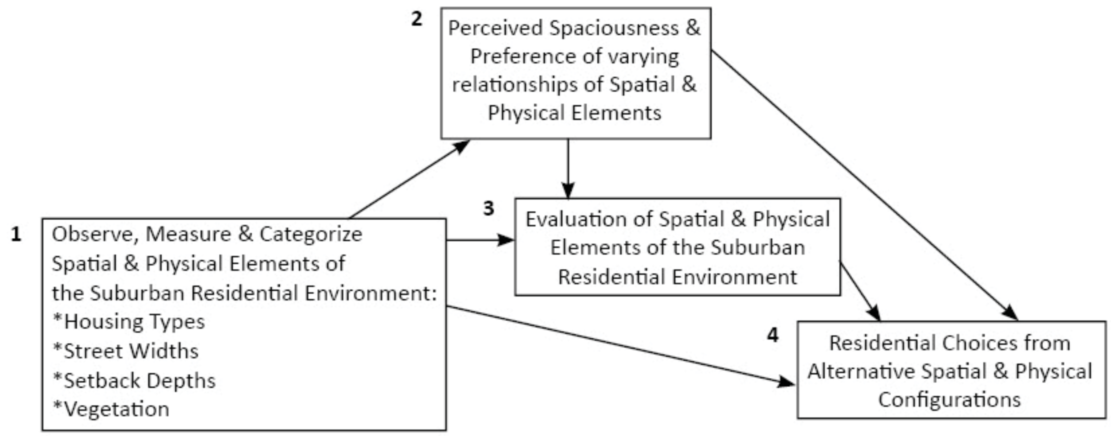


Figure 7: Research Concept Diagram (Based on Hur, et al., 2010, pg. 53)

practically applied in the research study. An exploratory study of this nature serves to investigate the reality of what, we as designers, might otherwise take for granted, or assume, about people's preferences and perceptions of density in the residential environment. There are two main differences in this study from those previously discussed that address environmental preference or satisfaction and perceived density or spaciousness:

> 1) this study has a stronger focus on the physio-spatial relationships of specific things as opposed to: character elements such as façade articulation and materials (Berdoll & Williams, 1990); façade heights and proximity (Zacharias & Stamps, 2004); general proximity to open space (Kearney, 2006); and spatial categories as predictor variables (Herzog, 1992).
>
> 2) this study's use of three dimensional line drawings to represent everyday things, set in a characteristic neighborhood, for the stimuli as opposed to abstract, computerized conceptions of space (Fisher-Gewirtzman, Burt & Tzamir, 2003; Fisher- Gewirtzman & Wagner, 2003; Stamps, 2010, 2011 Experiment II). See to Figure 6, on page 46 for an example of a simplified, computerized built environment.

When observing the residential built environment one finds such ubiquitous features as: parks, streets, blocks, buildings, sidewalks, trees, plantings, lawns, and housing typologies. This research selected four of those elements deemed to have the most implication for combating land area consumption; they are: street width, setback depth, and housing typology- plus the added variable of tree coverage chosen because of its positive environmental impacts for clean air, habitat creation, and its potential affects on perceptions of density (Beck, Bressi, and Early, 1987). These variables were isolated to study environmental preferences and perceptions of density; asking the specific question, *how is environmental preference and the perception of density (operationalized as spaciousness) affected by street width, setback depth, housing typology, and tree coverage?*

While this is an exploratory investigation, due to its scale, and can't be expected to provide a definitive answer; this preliminary research is valuable as a guide to future studies to assist designers, planners, and architects in three areas:

1) To understand which elements of a place's physio-spatial organization appeals to or resonates with a particular culture of people.

2) To understand how physio-spatial organizations contribute to a perceived spaciousness.

3) To understand the role of spaciousness (density) in preference.

Architectural graphics developer and educator Francis Ching is well known for his teachings on the basic spatial elements of horizontality, verticality and permeability which will be elaborated on in following sections. Translating these basic spatial elements into the measurable physio-spatial elements allows a corollary to be drawn between the concrete elements of our residential spatial typology (street width, setback depth, tree coverage, and housing typology), preference, and a perception of density. Ideally this knowledge will provide designers with the tools to create a more environmentally sustainable residential places that will have the same appeal as the current residential spatial paradigm[24].

---

[24] Although this research will not take for granted variations in the fabric of suburban areas, for the sake of explanation here, the paradigm refers to a built environment marked by wide lanes, minimal to no sidewalks, big box stores, sprawling parking lots, single family homes with turf lawns, and a general homogenous banality. Refer to Kevin Miller's Icons of Sprawl as an example of this common vision. (Lang & Miller ed., 1997)

The nature of this thesis is built upon the belief that the built environment influences human behavior through perception[25]. Figure 7 (pg. 48) shows the conceptual framework guiding this study; it is based on Hur et al's. (2010) study on neighborhood satisfaction. Physical and spatial elements of the residential environment, chosen as independent variables, were observed and measured to be utilized in the survey images as sets of varying physio-spatial configurations (box 1). Participants view the stimuli and based on past experience perceive it as a neighborhood scheme whereupon they choose an image that is most preferred and one they feel is the most spacious (box 2). Evaluation of the participant choices is done through analysis (box 3). The physio-spatial configurations that attribute to perceived preference and spaciousness are identified (box 4).

The burgeoning evidence based design movement has begun changing attitudes toward research- informed design decisions to a degree; however of these evidence-based cases most reside in healthcare design (Sailer et al., 2008) and do not deal with density. Rapoport (1971) discusses the disconnect between man-environment studies and the proposed intentions of designers. Using social science research to study the relationship between people and their built environment is rare in architectural design and planning practices, (Rapoport, 2010). According to Lang, it is a commonly held conception that environmental designers and architects believe the "central role of the built environment is in determining human social behavior patterns and values" (1994, pg. 101). Christopher Alexander's *A Pattern Book*, would certainly support this statement, yet he even includes scientific studies to make some of his arguments. This cause and effect relationship, between the environment and behavior, is broadly known as environmental or architectural determinism and

---

25 Literature on this topic is numerous and much of it has been used in this paper. Conferences such as the Environmental Design Research Association (EDRA) and the International Association of People Environment Studies (IAPS) are dedicated to disseminating this type of work. An earlier version of this thesis was presented at the IAPS 2012 conference in Glasgow, Scotland.

commonly focused on the relation of physical elements to behavior, although more recent studies began to focus on social factors in predicting behavior (Lang, 1994, pg. 102). A classic example of architecture influencing behavior, not intended by the architect, was the infamous Pruitt Igoe building in St. Louis which afforded opportunities to strengthen social decay. Much has been learned from this failure, such as the notion of defensible space, which has informed and developed work in community designing, or designing places that afford social interaction and create a sense of shared community. While many designers and architects take the normative position and value their world view and intuition as sufficient to design- believing that their built work effects behavior in particular ways; this position is changing and more designers are beginning to respect the role of research in informing their designs during the creative processes. Such is evident in current literature, the evidence-based design movement, and the structure of firms that use research in their practice. Lastly, Lang states that there is the ability to scientifically approach normative theories of design and develop a body of knowledge about normative positions that designers take (1994, pg. 217). Assumptions are often made about the affordances a particular building or environment might offer, but how do we know this is really the case? Are people reacting to or perceiving a space in the way that the architect intended? Did the architect even have an intention? One could argue that it is a moral or ethical situation for an architect or designer to be able to substantiate their claims on their buildings and environments.

In the following sections, the broad approach taken in this research will be addressed, beginning with an overview of the Beaverton case study and its influence in determining the independent variables (street width, setback depth, tree coverage, and housing typology). This will be followed by a discussion of the basic spatial qualities of the independent variables (horizontal, vertical, and boundary permeability) based on Francis Ching's architectural spatial elements

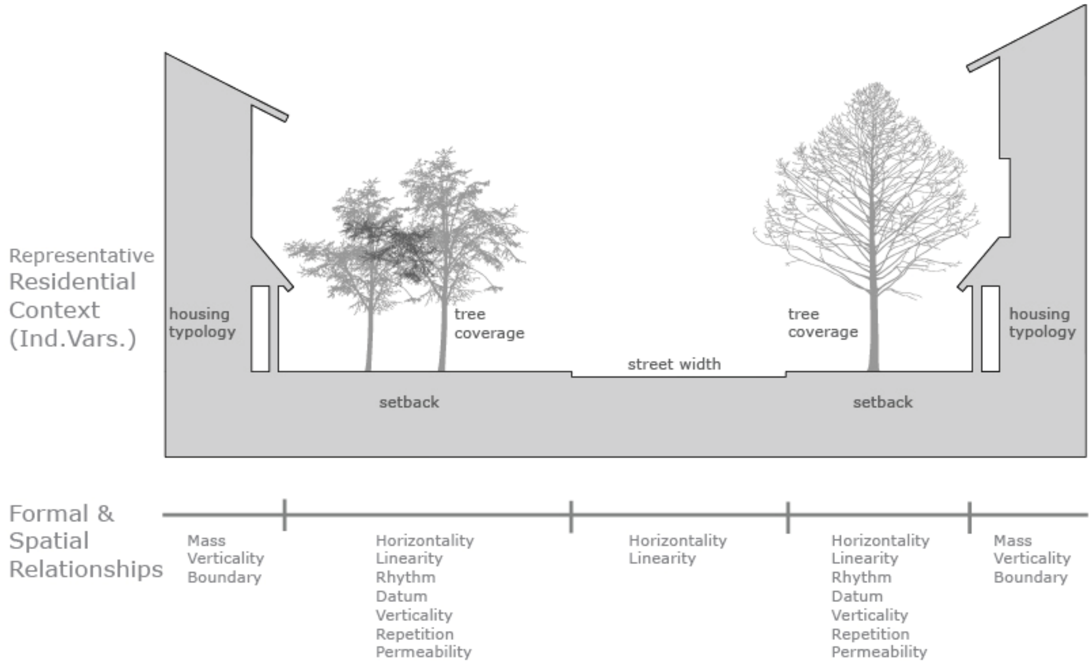


Figure 8: Residential Spatial Quality Diagram (Source: Author)

(Ching, 1996) and Stamps's work on perceived spaciousness (2009, 2010, 2011). With this foundation, the independent variables will then be discussed more specifically culminating in a series of hypotheses. This portion of the paper will also include sections on: research methodology, analysis, results, discussion, and recommendations.

A. Determining the Independent Variables: Beaverton Case Study

In order to understand the specific variables in Beaverton, a case study was performed to provide a guide in designing the methodology of the measuring tool. As discussed in the literature review section, the Portland, Oregon Metro area is a significant case for investigating acceptable levels of residential density due to its unique urban growth boundary (UGB).

Beaverton, arguably, is an atypical suburb. The housing is predominantly 6 du/a, as opposed to a more sprawling 1 to 2 du/a, and there is some public transportation with bus lines and a light rail stop. However, its walkability is in question with heavy reliance on the automobile, and the housing is predominantly single family homes on a range of lot sizes. Despite Beaverton's atypical suburban qualities, the data collected from this study are meant to be fundamental and applicable to a wide range of suburban environments.

To ensure that the appropriate independent variables were used in the survey, it was crucial to gain an understanding of the scale and character of the existing residential built environment in Beaverton. There are many different housing typologies and configurations that create a multitude of environments ranging from five acre lot fringe conditions to urban high rises. Beaverton's variation in housing density from 4.3 du/a (single family homes) to 43 du/a (multi-family housing) offered an opportunity to measure the dimensions of the environment that relate to the four variables being studied. This study is concerned with experiences of the suburban residential environments that are found surrounding most US cities where single family homes are ubiquitous and travel by car is prevalent.

By studying and diagramming maps and aerial photos, 11 'distinct areas' or zones were identified (see Figure 4, pg. 38), each color denotes the path connecting the distinct zones selected based on observable differences in texture, grain and scale. Some of these areas were easily identified as commercial, residential, or natural with some of the residential areas further distinguished between single family home and apartments. However, field work was necessary to determine the scale, sense of character and actual typologies present. Field analysis of the 11 distinct areas was conducted by photographing neighborhoods along the predetermined routes and correlating them to a map. Rough measurements of street widths and setbacks were first taken with a 2 foot walking pace. The results of this work provided a clearer understanding of possible independent variables, such as: building type, street

Figure 9: Stamps' Spaciousness Study, this particular scene uses a "small setback area with deep setback" (Stamps, 2009, pg. 534)

widths, setback, presence of sidewalks or driveways, buildings heights, block size, degree of block infill, adjacency to open green spaces, and use of vegetation. Upon completion of the field analysis, more precise measurements were taken, from the aerial photographs, of: street widths, setback depth, building width, and the spacing between buildings from a sampling of streets in eight of the areas.

These measurements were applied to the construction of the line drawings (graphical stimuli), for the measuring instrument, which included the four independent variables: street width, setback depth, housing typology, and tree coverage. This was accomplished by mocking up perspectives in a computer modeling program (SketchUp v.8) utilizing the dimensions and façade character from the field analysis (see Appendix C).

B. Operationalizing the Independent Variables

Girling and Helphand's book, aptly titled *Yard-Street-Park*, places suburban space typologies into three categories; that of the yard, street, and park. Two of the

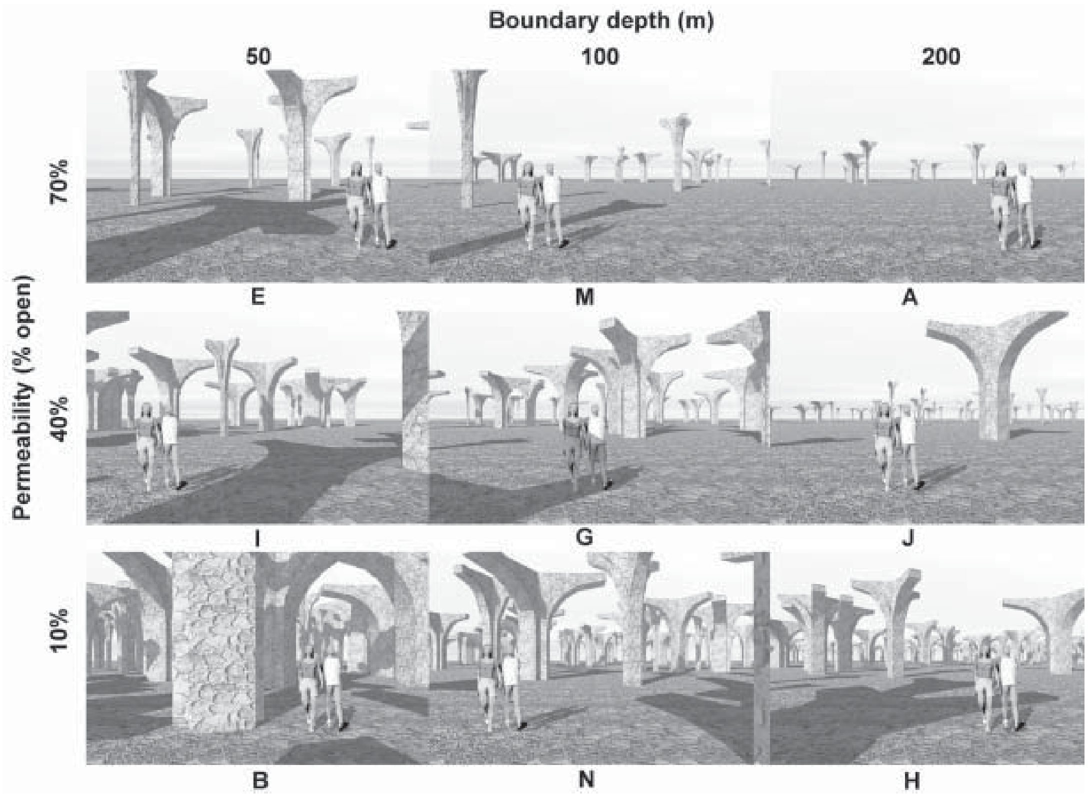


Figure 10: Danish Megaliths, study on perceived spaciousness (Stamps, 2009, pg. 877)

categories, street and yard (yard space has been operationalized as setback in this study) make for two of the four independent variables with housing typology and tree coverage. These four independent variables will now be understood in terms of their inherent spatial qualities of horizontality, verticality, and boundary permeability (see Figure 8, pg. 52). Refer to page 20 for the discussion on 'Spatial Qualities and Phenomenal Space'.

In his book *Architecture: Form, Space, and Order*, Francis Ching describes horizontal planes as defining fields of space in which vertical boundaries would be implied. In this study the two vertical boundaries, literal as opposed to implied, are: 1) the row of street trees in their varying degree of coverage, and 2) the housing typologies in varying heights attached or detached (See Figure 8). Ching (1996) further states that vertical forms "have a greater presence in our visual field than horizontal planes and are therefore more instrumental in defining a discrete volume of space" (pg. 120). In this study, the width of the street and depth of the setback are therefore understood as possessing a horizontal spatial quality within the vertical bounds of the trees and houses. As discussed it the results section, the role of the vertical and horizontal elements were identified and compared in relation to preference and perceived spaciousness.

In reference to Stamps 'qualitative research on the perceived spaciousness of street scenes with setbacks (discussed in detail in the following subsection) the spatial quality of *horizontal* was identified as a strong indicator of spaciousness. Stamps' work on the perceived enclosure and spaciousness, through boundary permeability (2010), was accomplished through a study using scenes depicting a boundary composed of a series of vertical members at varying distances from each other. As previously stated, the housing typologies and rows of street trees are vertical elements, acting as a boundary with varying spacing from one another.

Accepting the preference for Beaverton, this study is based on the assumption that study participants will prefer certain physio-spatial configurations; this will be enumerated in the discussion section on page 76.

The following subsections intends to briefly elucidate several studies in support of the relevancy of spatial perception and its place in social science research of the built environment. The studies included here focus on discussion of the four independent variables of street width, setback depth, tree coverage, and housing typology; and are germane to the basic spatial qualities of horizontality, verticality, and boundary permeability. It should be noted that there is literature discussing the perceived and associational aspects of objects in the environment as symbols (Rapoport, 1970 & 1977, pg. 201), but this thesis aims to understand how people perceive physio-spatial elements of the built environment with regard to preference

Figure 11: Beaverton, OR_Dense Infill Housing (Beaverton Civic Plan: Housing and Neighborhood Strategy, spring 2011 draft, pg. 2)

and spaciousness. This does not preclude the idea that the physical elements used in this study may have associational influences beyond what can be addressed here. An example of this would be the association some people may make between taller buildings, such as stacked row houses, and a high density of people.

1. Street Width and Setback Depth

Street and setback depth are discussed together since they are primarily horizontal spatial elements. The justification of street and setback as having horizontal spatial qualities can be found in Stamps' 2009 study, *On Shape and Spaciousness*, where participants were asked to rate the spaciousness of street scenes with setbacks. Stamps designed 12 setback conditions each having different square meter areas with varying aspect ratios, and modeled sets of three dimensional images (see Figure 9, pg. 54) for participants to rate for spaciousness. The amount of horizontal area was found to be the strongest predictor of spaciousness as measured by setback ratios in streets. The heights of the buildings, in that case, seemed to have little bearing on the perception of spaciousness.

Horizontal area was again found to have the largest effect of perceived spaciousness as determined by three experiments in Stamps' article, *Effects of Area, Height, Elongation, and Color on Perceived Spaciousness*. That research undertook three experiments based on four properties of enclosure (horizontal area, boundary height, elongation, and color) in order to measure the perceived spaciousness of an exterior street, an interior room and an interior room with colored walls.

Data like these make for an interesting translation into the setbacks of houses along streets as will be discussed. While there are several other studies that explore characteristics of the built environment and their influence on the perception of space (see literature in Stamps, 2011); some of these studies use abstract environments (devoid of character) to measure both perceived enclosure and spaciousness through boundary permeability (Stamps 2010), and perceived spaciousness based on elongation, height, and area of interior spaces (Stamps 2011). A point of distinction between this research and Stamps' is the use of line drawings of landscape elements including: streets, trees, and houses.

2. Tree Coverage

Another study by Stamps (2010) used the visual permeability of a boundary, amount of light and horizontal area as elements used to judge enclosure or spaciousness. Scenes were composed of elements creating a boundary that could be made more or less distinct. Two of the scenes were of rooms enclosed by screens or removable panels and the other two scenes were composed of sticks or Danish megaliths, see Figure 10, pg. 55 .

Across several of the experiments, Stamps' research concluded that boundaries with high permeability had the largest influence on perceived spaciousness; in other words, a less distinct boundary contributed to a sense of spaciousness among participants. A correlation can be made to this thesis with the independent variable of tree coverage. Trees, along a street, form a boundary in the same nature as in Stamp's stick experiment. The denser the row of tree coverage, the less permeable the boundary becomes making an enclosure of the residential street scene. On the other end of the spectrum would be a series of sparsely placed, less dense trees creating a permeable boundary.

3. Housing Typology

Provided the necessity for increasing *actual* residential density in reference to a perception of low density; the housing typology was included as the fourth independent variable. Specifically, the *single family home*, *row house* and *stacked row house* were used as independent variables for the study on perceptions of density. Criteria for their choosing were based on four factors: the Beaverton field analysis, cultural preference, objective density, inherent massing qualities, and the potential to increase density.

The housing typologies used in this study's survey were influenced by the Beaverton site visit and literature identifying the relationship between house type and the typical objective density associated with them. This latter information came from examples put forth in literature from the City of Minneapolis in conjunction with the American Institute of Architect's Urban Design Committee (City of. Mpls., 2006), as well as from a compilation of data from the University of Minnesota's Metropolitan Design Center (Forsyth, 2003). According to the spring 2011 draft of the Beaverton Housing and Neighborhood Strategy document, most of the new housing will be denser infill typologies such as those depicted in Figure 11 (pg. 57)- note the gable roof line and projected entry which is similar to the formal language used in the survey images.

This study used a traditional form for the housing typologies consisting of hip or gabled roofs and pediment entries that are often seen in Beaverton and are culturally recognizable in the North American residential landscape. Using basic typologies that satisfied the range of densities considered in this study- three levels of the housing typology variables came to exist. The levels with their representative objective densities are the: single family detached home (SFDH) (8.5du/a), row house (12du/a), and stacked row house (18du/a). Both the information from literature and analysis of Beaverton, informed the creation of the graphical images used in the survey; specifically the floor area, size and proximity of the different housing typologies.

Typologies chosen for the study have varying degrees of density (in dwelling units per acre) that are higher than the average for Beaverton, but formally "fit into" the existing scale and character of the place; as determined by a thorough visual analysis several of Beaverton's residential areas. Numerous sources indicate that the single family home is the most prevalent and desired type of housing in the United States; thus, presuming that the average person will maintain their preference; this typology was included in the study. Row houses and stacked row houses were included by virtue of their similarity to single family homes (direct access from the street, alleys, and identifiable individual units) and their moderately larger dwelling unit per acre density[26]. The last criteria, inherent massing qualities, refer to basic physical characteristics of the buildings themselves such as height, width, and spacing. These formal massing qualities were hypothesized to bear influence on people's environmental perceptions with reference to preference and spaciousness.

Rapoport (1969, pg. 17) has suggested that an important part of perception lies in the *relationship* among the elements in an urban setting rather that the elements

---

26 The following publications aided in decision making regarding the use of specific typologies: *What does density look like?* (brochure from the city of Minneapolis), *Explaining Residential Density* (Ellis, 2004), Housing Density from http://www.corridordevelopment.org, and 2005 Brisbane Perception Management: I*ncreasing Density (*Mccorkle, 2005)

themselves. Rapoport's contention translates to this study's survey images with respect to the housing typology characteristics. In order to focus more on the physio-spatial *relationships* of the housing elements; a simple visual vernacular language was used in the line drawings. This was done for the sake of cultural familiarity[27],as previously stated, and because this study was concerned with the physio-spatial configuration of the overall setting rather than the influence from façade detailing (Mavridou, 2006, studied façade detailing on perceived sense of scale).

Some researchers rely on two dimensionality, as was the case in Zacharias' and Stamps' (2004) study measuring the accuracy of density perception based on elevation drawings and the influence of building details on perceived density. Their work was beneficial in exploring the influence of representational drawings on clients' perceptions of density; but this study argues that the built environment is rarely observed as straight on facades[28], and rather as a set of three dimensional relationships. Indeed, this research aims to correlate perceptions of density to *actual* densities and building spacing[29],thus Zacharias' and Stamps' (2004) work proves provocative in terms of housing typology. They conclude that: buildings with larger spaces between them were perceived as lower density despite an increase in height. Therefore, perception was more influenced by horizontal than vertical elements in their study. Please refer to the discussion section on page 76, to understand the findings in regard to the influence of street width and setback depth on perceived density.

This previous section enumerated several studies in support of the independent

---

27 Refer to Krampen's (1979, pg. 123) study indicating gabled roofs, picture windows, and gardens as properties associated with the single family home.

28 It should be noted that Thiel, Harrison, and Alden (1986, pg. 229), refer to a study by Spreiregen concerning façade ratios and sense of enclosure in reference to plaza spaces.

29 This comment is made in recognition of Zacharias and Stamps' (2004) appropriate remark, "…although it is unclear how public perception of density is simultaneously related to actual density and spacing." (p. 777)

variables used in this study. The following section uses these studies to develop a set of hypotheses.

C. Hypotheses

Based on the review of literature and case studies, the following general hypotheses were made.

1. Environments with three story or taller buildings will be perceived as less spacious that those with fewer stories; regardless of tree cover or setback.

2. Environments with more tree coverage will be preferred (Hur et al, 2010, Kearney 2006) AND perceived as less spacious than environments with less tree coverage; regardless of setback or housing typology. (Stamps, 2010, trees as less permeable boundary)

3. Setback depth will be the strongest predictor of perceived spaciousness. (Stamps, 2009, 2011, street setbacks)

4. Street width will not factor into perceived spaciousness when the setback is 30' deep. (Stamps, 2009, 2011, street setbacks)

5. All factors equal, environments with detached housing will be perceived as more spacious than attached. (Stamps & Zacharias, 2004, building spacing; Stamps, 2010, boundary permeability)

D. Methodology

This section is broken into five subsections to provide a detailed explanation of the methodology. Using a discrete choice modeling method, participants responded to a survey (Appendix A) by choosing both which image (scene) they would prefer to live in and which felt the most spacious (ie. the lease dense).

1. Discrete Choice Modeling[30]

The discrete choice model (DCM) is a popular econometric method often employed in market research to identify factors that contribute to why a person

[30] Author's Note: I would like to acknowledge Pat Zimmerman, with the University of Minnesota statistics clinic; he was a crucial and indispensable contributor to the statistical analysis portion of this research study.

(potential customer) chooses one product or scenario over another. DCM allows for a small number of scenarios with a large number of variables to be included while still being able to make statistically sound correlations between all the variables. A simple demonstration is illustrated by the "Candy Example", in Kuhfeld (2002, pg. 83), whereupon participants were asked to choose their preferred candy by selecting each of three variables (chocolate type, consistency, nuts) each with two alternative attributes (milk/dark, chewy/soft, nuts/no nuts).

The decision to use the discrete choice model method in this research was three-fold. Firstly, it was necessary to find a method that would allow for analysis of the inherently complex nature of the built environment- using multiple variables in a setting that most realistically represents the situation's factors. DCM allows up to 15 variables and 15 alternatives for each variable (Berdie, 1998) which would enable the study of the actual built environment with its many components (essentially a 15x15 matrix). For instance, a study to determine preference for apartment building configuration on a block could consider such variables as: building height, materials, window size, green space, entry typology, distance between buildings, etc. These elements would be variables within the carefully taken photographic depictions, and coded as such, allowing up to 15 alternatives for each variable; eg. Materials: brick, wood siding, concrete, stucco etc. Secondly, DCM has an advantage over direct methods, such as Likert scales (scoring alternatives on a scale) or ranking, in that it accurately ascertains the drivers of behavior (Berdie, 1998), ie. what specific factors contribute to the choosing of a scenario. It allows identification of the important variables with fewer questions. Thirdly, DCM does not require every scenario combination possible to be included so that it allows for a relatively brief survey to be completed by participants in a reasonable time. This study aimed for 15 minutes or less. Furthermore, using this method permits participants to make choices, among alternatives, that closely resemble the way they would weight options and make tradeoffs when making choices in the real world. As Michel Bierlaire (1997, pg. 2) states in his paper on DCM,

"A model as a simplified description of reality provides a better understanding of complex systems. Moreover it allows for obtaining prediction of future states of the considered system, controlling its behavior and optimizing its performance".

This research chose to reduce the residential built environment to four independent variables that have been controlled via hand drawn depictions in a choice set of three alternatives.

One specific mathematical technique, employed for DCM, is a multinomial logit model[31] (see Candy Example provided by Kuhfeld, 2002, pg. 83) which was used in this study due to its ability to consider more than two alternative scenarios (a choice set of three alternatives). According to Kuhfeld, "The multinomial logit model assumes that the probability that an individual will choose one of *m* alternatives, c_i, from choice set *C* is (2003, pg. 83):

$$p(c_i|C) = \frac{\exp(U(c_i))}{\sum_{j=1}^{m} \exp(U(c_j))} = \frac{\exp(\mathbf{x}_i \boldsymbol{\beta})}{\sum_{j=1}^{m} \exp(\mathbf{x}_j \boldsymbol{\beta})}$$

Additionally, "the probability that an individual will choose one of the *m* alternatives, c_i, from choice set *C* is the exponential of the utility of the alternative divided by the sum of all of the exponentiated utilities" (pg. 83). This is expressed in the formula: $\frac{\exp(U(c_i))}{\sum_{j=1}^{m} \exp(U(c_j))}$, where *U* is the utility, and is equal to : $\frac{\exp(\mathbf{x}_i \boldsymbol{\beta})}{\sum_{j=1}^{m} \exp(\mathbf{x}_j \boldsymbol{\beta})}$, where β is the vector of unknown parameters.

Before looking at an example of this, the model's assumptions should be stated. According to Bierlaire (1992, pg. 3) the modeling assumptions for discrete choice anaylsis are:

[31] "A special form of regression used to analyze the relationship between predictor variables and a categorical outcome variable. The multinomial logit is used when the categorical outcome variable has more than two values, e.g., marital status could be never married, married, or divorced." http://www.researchconnections.org/childcare/research-glossary#M

1. The decision-maker: these assumptions define who is the decision-maker, and what are his/her characteristics;

For this study, the decision makers are resident participants in Beaverton, Oregon.

2. The alternatives: these assumptions determine what are the possible options of the decision-maker;

For this study, the options are the set of line drawings depicting residential built environments.

3. The attributes: these assumptions identify the attributes of each potential alternative that the decision-maker is taking into account to make his/her decision;

For this study, the attributes are: the type of housing, the width of the street, the depth of the setback, and the degree of tree coverage.

4. The decision rules: they describe the process used by the decision-maker to reach his/her choice.

For this study, the decision-makers (participants) were asked to choose the scene that they most preferred and felt to be the most spacious from a choice set of 3 images.

Consider the following example, adapted from Kuhfeld's *Candy Example,* using this thesis's research results. The results will give the probability, as a percent, that a participant would choose an alternative m consisting of the vector of attributes x_1.

There are m=24 attribute vectors, one for each alternative, and in this study that is 8 alternatives for the 3 housing typologies, see Table 1 (pg. 66). In Table 1 x is: (single family home/rowhouse/stacked rowhouse; narrow street/wide street; shallow setback/deep setback; few trees/many trees). Table 2 (pg. 66), shows how these variables were coded for the multinomial regression analysis; these codes appear in Table 1.

	Single Family Home = 0			Rowhouse = 1			Stacked Rowhouse = 2			
x_1	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Trees Controlled as 'Few'
	0	1	0	0	1	0	0	1	0	
x_2	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	
	0	0	0	0	0	0	0	0	0	
x_3	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	
	0	2	0	0	0	0	0	0	0	
x_4	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	
	0	2	0	0	0	0	0	0	0	
x_5	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Trees Controlled as 'Few'
	1	1	0	1	1	0	1	1	0	
x_6	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	
	1	0	0	1	0	0	1	0	0	
x_7	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	
	1	2	0	1	0	0	1	0	0	
x_8	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	Street Width	Setback Depth	Tree Coverage	
	1	2	1	1	0	1	1	0	1	

Table 1: Vector attributes in a set of 24 choices.

Housing Typology	0	1	2
	Single Family	Rowhouse	Stacked Rowhouse

Street Width	0	1
	Narrow (20')	Wide (30')

Setback Depth	0	1	2
	Shallow (12'6")	Deep (30')	Ave. SFH (22')

Tree Coverage	0	1
	few	many

Table 2: Coded variables

The results from one of the analyses (Preference analysis, trees not controlled) will be used in the example here.

	B	Sig. (P value)	Exp (B)
Typology (0)	0	0.005	1
Typology (1)	-1.165	0.001	0.312
Typology (2)	0.031	0.756	1.032
Trees (1)	-0.474	0	0.623
Street (1)	-0.122	0.134	0.886
Setback (1)	-1.167	0.001	0.311

More information concerning the number of analyses run will be explained in the analysis on page 71. Results from the Cox regression, run in the SPSS software program, are as follows:

First, the statistical significance of each variable was determined. This was indicated by a P-value less than .100. Noted in red, Typology (2), the stacked rowhouse, and Street (1), 30' wide, had P-values greater than .100 as were not statistically significant; therefore, these variables were not included in the rest of this analysis.

Second, the significant variables are arranged in a list that is the aggregate of the possible choices made by all the participants, or decision-makers (Street width is included here, but has a multiplier of 1 and will therefore not have any bearing on the final probabilities). They are:

C_1	Typo (0), Trees (0), Street (0), Setback (0)
C_2	Typo (0), Trees (1), Street (0), Setback (0)
C_3	Typo (0), Trees (1), Street (0), Setback (1)
C_4	Typo (0), Trees (0), Street (0), Setback (1)
C_5	Typo (1), Trees (0), Street (0), Setback (0)
C_6	Typo (1), Trees (1), Street (0), Setback (0)
C_7	Typo (1), Trees (1), Street (0), Setback (1)
C_8	Typo (1), Trees (0), Street (0), Setback (1)

Note that choices for the two significant housing typologies (0) and (1), have only one variable change from each preceding choice. This allows for the isolation of the tree coverage variable and setback variable so they may be compared for their predicting values.

From this point, the exponentiated vector of the unknown parameters, Exp (β), can be applied to the formula, $\frac{\exp(\mathbf{x}_i\boldsymbol{\beta})}{\sum_{j=1}^{m}\exp(\mathbf{x}_j\boldsymbol{\beta})}$. By using this formula the probability of a decision-maker choosing a variable, for Preference or Spaciousness, can be determined and compared to the probability of other the variables. For instance, choices c_1 and c_2 have all factors equal except the amount of tree coverage. The probability that a decision-maker will choose fewer trees (c_1) over more trees (c_2) would be: $c_1 / c_{1+}c_{2,}$ such that:

C_1 (0,0,0,0) and

C_2 (0,1,0,0)

are multiplied by their corresponding Exp (β), taken from the SPSS results, as shown here:

	B	Sig. (P value)	Exp (B)
Typology (0)	0	0.005	1
Typology (1)	-1.165	0.001	0.312
Typology (2)	0.031	0.756	1.032
Trees (1)	-0.474	0	0.623
Street (1)	-0.122	0.134	0.886
Setback (1)	-1.167	0.001	0.311

$C_1\,(0,0,0,0) \rightarrow (\mathbf{1} \times 1 \times 1 \times 1) = \mathbf{1}$

$C_2\,(0,1,0,0) \rightarrow (\mathbf{1} \times \mathbf{.623} \times 1 \times 1) = \mathbf{.623}$

$c_1 / c_{1+}c_2 = 1/\ 1.623 = .6161$ or **62%**

In other words, a decision-maker is 62% more likely, all factors equal, to *prefer* the environment with more trees in the case of a single family home with a shallow setback. (Note that the multiplier of 1 was used when the Exp β, for that particular variable was not listed in the results. Conversely, the probability of fewer trees being preferred would simply be 100%-62%, or 38%- roughly 4 out of every 10 people).

Comparing scenarios that have only one independent variable changed (all others equal) allows the researcher to determine how that isolated variable would effect the percent of likelihood that a participant would choose (or prefer) that scenario. This was one example, but several of these comparisons were made for all four analyses, see Appendix D: Statistical Data.

A limitation to some practical applications of DCM include the Independence from Irrelevance Alternatives (IIA) problem, which indicates that the ratio of the probabilities of any two alternatives is independent of the choice set (Bierlaire, 1997). Bierlaire's Path Example (see Figure 12, pg. 69) is a good description, whereby there is no real difference between travel option 2a and 2b, thus there is a 50% probability that Path 1 or Path 2 will be chosen despite there being three choices in the set (1, 2a, and 2b). IIA is not a concern in this thesis study. For example, if in a given choice set two of the alternatives had few trees and a shallow setback (one with a wide street the other a narrow street); the introduction of a third alternative (few trees with a wide street and deep setback) would have an effect on the probability of choice between the other two since it is a truly different alternative.

> *We consider a commuter traveling from an origin O to a destination D. He/she is confronted with the path choice problem described below, where the choice set is $\{1, 2a, 2b\}$ and the only attribute considered for the choice is travel time. We assume furthermore that the travel time for any alternative is the same, that is $V_1 = V_{2a} = V_{2b} = T$. Finally, the travel time δ on the small sections a and b is supposed to be significantly smaller than the total travel time T. As a result, we expect the probability of choosing path 1 or path 2 to be almost 50%, irrespectively of the choice between a and b.*

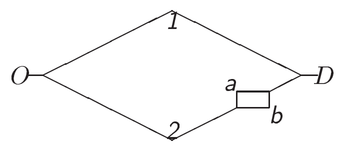


Figure 12: DCM Path Example (Bierlaire, 1997, pg. 20)

Another limitation, disclosed by Berdie (1998), is the extreme difficulty in calculating individual utility scores for each respondent because all the participant's responses are aggregated together to determine the utility of choice. Furthermore, the DCM model does not allow for interactions between variables, therefore it is not possible to determine the degree of influence that one variable has over another. Only the probability of the participant choosing (ie. preferring or finding it spacious) a particular condition is possible. However, as the earlier example showed, it is possible to isolate one particular variable (ie. keep in unchanged) while comparing two different attributes of another variable.

The possibilities for DCM as a method for studying the built environment are virtually untapped, but ripe with potential. Its ability to include a high number of variables lends itself to considering urban and residential spaces with their inherent complexity. Unlike Likert scales, such as were used in Herzog's (1992) study on preference for urban spaces via nine predictor variables for spaciousness- using DCM permits the considerations of finer details in the scene as opposed to the overall compositions. These data can provide a better understanding of what elements of the built environment are factors in choices for preference. Scenes (stimuli) that were originally categorized by a particular environmental character (in the case of Herzog, 1992, these would be open-undefined, well structured, enclosed setting, and blocked view) could, with DCM, include such detailed physical and spatial characteristics such as: materiality, window size/placement, number of stories etc. This permits discovery of the correlation between the spatial composition as well as other architectural features.

Being a preliminary study, the next step could entail the use of photographic images that have been coded for specific variables and analyzed with the DCM method, as a means to examine specific built environments while maintaining their complexity to the fullest degree possible. However, a deeper investigation into DCM and partnering with a colleague who has statistical expertise would be necessary in future non- preliminary studies.

2. Participants

Of the 400 surveys that were mailed to the residents of Beaverton, 53 surveys were returned; one participant only completed the demographic questions while four others had some incomplete responses bringing the total to 48 complete surveys plus four partially complete equaling 52 participants. Since most of the demographic data had similar responses across all participants, it was excluded from the discrete choice analysis. Table 3 on page 71 shows the percentage of participant responses.

The survey was sent to 400 randomly selected residents of Beaverton, Oregon. When several attempts to obtain an electronic list of current residents failed with various city departments; participants were selected from a Dex phonebook. The methodology for the selection involved using a random number generator (found at http://www.random.org/) to determine which pages of the phonebook to use. Since each page had four columns (assigned numbers 1-4 from left to right, by the author), a column number was then randomly chosen. Once the page number and column had been identified, all of the complete, non-repeated Beaverton addresses were entered into a spreadsheet. This task was continued until 400 addresses were reached. One limitation to this method seemed to be that there were no apartment units included in the study. None of the addresses that were randomly selected from the DEX had an apartment number designation and many of the surveys that came back 'return to sender' had the same address and were assumed to have been apartments.

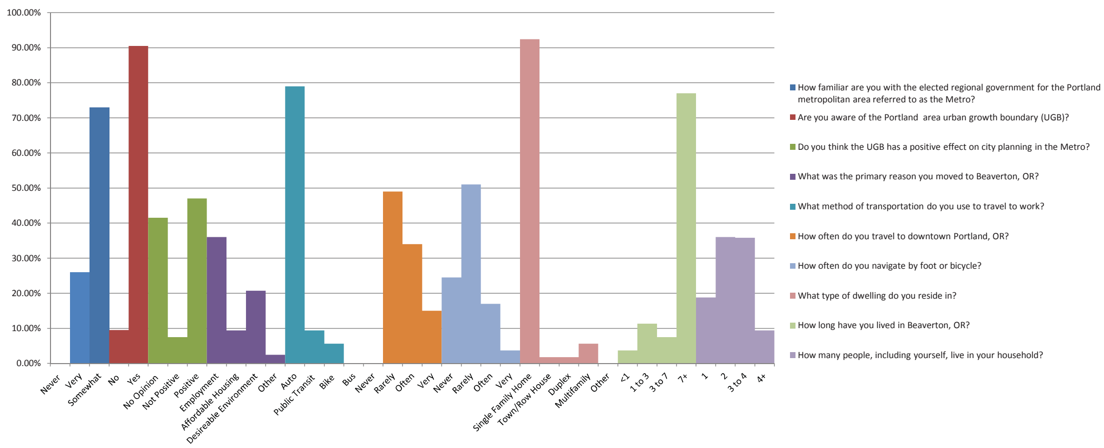


Table 3: Survey Demographic Data

3. Survey

The nature of the research query required some form of graphical depiction asking participants to respond to them. The use of a graphical methods was strongly encouraged by Amos Rapoport from the early days of this type of work during EDRA's 1969 Conference (Rapoport, Oct. 1970). To easily reach a large enough population and ensure a statistically significant sample, a survey method was employed in the form of a 34 item questionnaire (see Appendix A). Ten multiple choice questions (mostly ordinal) were in reference to lifestyle habits, demographics, and awareness of the UGB; and 24 questions were the graphical depictions of residential built environments in the form of a set of three line drawn images or scenes. Of the graphically based questions, the three housing typologies were each a controlled variable in eight questions (Note: 3 typologies x 8 questions each = 24 questions, see Table 1, pg. 66). In other words, each choice set of three images had the same housing typology in all three images. This was done to eliminate limitations from participants only choosing the scene with their preferred housing typology. The other three independent variables were systematically altered to create eight different drawings per housing typology. These eight images were grouped in varying sets of three for the eight questions per housing typology. Additionally, of the eight questions for each housing typology; four controlled for both housing typology AND tree coverage as a means to focus on setback variations.

Given the complexity of the built environment, the images were hand drawn depictions of residential built environments explicitly inclusive of the specific independent variables to ensure that the measurements would address the research question. However, it is a hope of this author, that future studies could be done using DCM to study complex built environment settings with the use of coded photographs.

4. Creating the Drawing Stimuli

With the information obtained from the field research a matrix was created to aid in composing the hand drawn graphical depictions. The matrix includes variations of the independent variables applied to the three different housing typologies (single family home, row house, and stacked row house) yielding 24 graphically represented built environments.

Hypothetical four acre residential blocks measuring, 300' by 600', were drawn using AutoCAD 2010 so the foot prints for the housing typologies (single family home at 8.5du/a, row house at 12.25du/a, and stacked row house 18du/a) could be overlaid (see Appendix C for samples). The spacing of the footprints on the blocks were adjusted to allow for the correct number of dwelling units per acre to match each typology. These blocks were spaced apart from each other at either 20' or 30' street widths. The block diagrams were further developed into three dimensional perspectives in a free version of Google Sketch Up v 8. The vernacular formal character of the typologies were massed in SketchUp and arranged on the blocks at their appropriate setback depth. Cameras were placed at fixed locations to provide an egocentric street view of each environment. These views were then printed in color on 8 ½" x 11" landscape sheets of paper and traced over with pen onto vellum with material details and shading added. The vellum ink drawings were then scanned, rendered, and had trees added in PhotoShop CS4 (See Appendix A).

Four crucial factors strongly influenced the final design of the hand drawn portion of the survey, they were: 1) legibility and clarity of graphical depiction, 2) distinguish -ability amongst environmental depictions, 3) level of task complexity, and 4) overall time to complete the survey. In order to assure that these factors were addressed, several rendering techniques were evaluated for the hand drawings while a consistent language among the typology "designs" was utilized. The limited number of independent variables would keep the survey instrument short and simple, for the participants involved, and thus help guarantee clarity in the statistical results.

In closing this subsection on creating the stimuli, a definition of cognitive/ cultural space, from Rapoport (Oct. 1970), is timely as it relates to the appropriateness of content and context of the images themselves as viewed by the participants. He states that, "…cognitive or cultural space… [is] defined by different groups affected by training, previous experience, adaptation, memory, and cognitive categories of the group" (p. 85). In short, the neighborhood schemata are presumed to be understood by the participants by virtue of them living in an American culture.

5. Procedure

Participants were asked to evaluate each set of images for preference and perceived spaciousness/ openness. Each of these questions utilized the discrete choice modeling methodology asking participants to *choose* the residential scene, from the series of three, first that they most preferred and second that they felt was the most spaciousness. This was done by circling an ‘A’, ‘B’, or ‘C’ that corresponded to the image being chosen. This was done twice for each set of images, once for preference and once for spaciousness.

E. Analysis

In order to account for the controlled tree variable (in the 12 questions that focused on setback) each of the dependent variables ran two Cox regression analyses using IBM SPSS Statistics 20. One analysis studied the questions where trees were controlled (fixed as many), and the other analysis studied questions where the trees were not controlled. This was done for both the ‘preference’ and ‘spaciousness’ responses creating four separate Cox regression analyses, each discussed in the following sections. The independent variables were numerically coded (see Table 2, pg. 66) and entered into SPSS. In the conditions where the tree coverage was not controlled, the setbacks were defaulted to typical design standards (refer to housing typology section, pg.56). This means that the row house and stacked row houses were always at a shallow (12.5’) setback (coded as 0) and the single family home was at a deeper (22’) setback (coded as 2).

When the tree variable was controlled (fixed as “few”) the setbacks were either shallow (12.5’) or deep (30’) for each housing type. This was done to isolate the tree and setback variables to study their role in preference and spaciousness. For instance, when the trees were not controlled the setbacks were fixed at 22’ for SFH and 12.5’ for the other typologies so the tree variable could be isolated and studied in reference to street width. Therefore, in the “trees not controlled” analyses, the setback results are inconclusive, all other variables being equal. In other words, in those cases the setbacks were the same in each drawing set and would have had no bearing on the participant's choice for that set.

Data consisted of the chosen response, with its alternatives, from each question, for every participant. See Appendix D for the raw data.

F. Results

Key points from the results suggest a preference for conditions that were counter to what had been hypothesized. As hypothesized, spaciousness was closely associated with the increased horizontality found in wider streets and deeper setbacks; however, when tree coverage was a factor, the setback was not found to affect spaciousness. Counter to this hypothesis, wider streets and deeper setbacks were not strongly associated with preference. It was also found that conditions with fewer trees were found to be spacious, thus supporting the hypothesis of increased permeability (visibility) with spaciousness. Fewer trees were the only factor that predicted a high probability in preference and spaciousness. The results indicated that spaciousness was associated with fewer trees (setback not a factor), and preference with fewer trees and shallow setbacks; thus placing a strong emphasis on the factor of trees, specifically the level of fewer trees and their mitigating effect.

The following sections discuss the results from each of the four Cox regression analyses. For the statistical data from SPSS see Appendix D and refer to pages 63-66 for an example of the calculations.

1. Preference: trees not controlled

In this analysis, the factor of housing typology had a statistically significant p-value of .005. Isolating this variable; the results indicate (all other factors aside) that there was a 42% predictability in preference for the single family home, a 13% predictability in preference for the row house, and a 44% predictability in stacked row house. Additionally, street width was not a factor in this particular analysis, thus having no conclusive predictability with regard to preference. The variables with statistical significance were coded and aggregated into a list of choice scenarios and systematically compared so only one variable would change between the two scenarios compared (see Appendix D).

In conditions with the row house (12.5' setback) there was 60% likelihood that fewer trees would be preferred over many trees. In other words, all factors equal except for tree coverage; participants would prefer the environment with fewer trees 6 out of 10 times. Conversely, with the single family home typology (22' setback), there was a 60% likelihood that many trees would be preferred over few. At this point, fewer trees are predicted to be slightly more preferred in conjunction with a shallow setback, whereas more trees are slightly more preferred in conjunction with a deeper setback. Three out of four times, participants were more likely to prefer a single family home versus a row house. A predictable preference for deeper setbacks cannot substantiated due to the fact that, in this analysis, the deeper setback was always with the single family home and the shallower setback was always with the row house. The research couldn't claim whether it was the housing type or setback depth which was causing the preference. In order to focus on the affects of setback, another analysis was performed that controlled the variable of tree coverage.

2. Preference: trees controlled

In this analysis, the factor of housing typology was not statistically significant meaning that it had no conclusive predictability with regard to preference. The degree of tree coverage, in these cases, was controlled to be few, thus trees were not a factor either. The variables with statistical significance were coded in scenarios and systematically compared so only one variable would change between the two scenarios compared (see Appendix D).

The analysis found that there was not a strong predictable preference for a particular street width, regardless of other factors. A narrow street had only 54% likelihood of being preferred over a wider street regardless of the setback. Although these are near 50%, it is interesting to note the slightly higher percent of predictability (54%) inherent in environment with less horizontal expanse. Future studies with a larger sample would need to be conducted to get a more accurate results.

A shallow setback was a strong predictor of preference. There was over a 70% likelihood that a participant would prefer a shallow setback regardless of other factors. This correlated to a nearly 75% likelihood that participants would prefer a condition with narrow streets and shallow setbacks versus one with wide streets and deep setbacks.

A comparison between a wide street with shallow setback to a narrow street with a deep setback was performed to investigate if similar overall horizontalities were perceived in the same way. The results indicated that there was a 68% likelihood that a participant would find the condition with a wide street and shallow setback preferred. Again, this speaks to the shallow setback's strong predictability for preference.

3. Spaciousness: trees not controlled

In this analysis, the factor of housing typology was not statistically significant meaning that it had no conclusive predictability with regard to preference. Additionally the setback was not a factor in this analysis. The variables with statistical significance were coded in scenarios and systematically compared so only one variable would change between the two scenarios compared (see Appendix D).

Wide streets were found to be a strong predictor of perceived spaciousness, which is counter to the study by Beck, Gladman, and Sisson (1987). Participants were 66%-67% likely to choose an environment with wide streets as spacious, all other factors equal.

A comparison between a tree coverage and street width was performed and found that there was just over 66% likelihood that a participant would find the condition with fewer trees to be spacious, all other factors equal.

Provided that this analysis resulted in the setback not being a factor, the following analysis controlled for one variable (trees) in order to focus on the setback relationships-as was done in the Preference analysis.

4. Spaciousness: trees controlled

In this analysis, the factor of housing typology was not statistically significant meaning that it had no conclusive predictability with regard to preference. The degree of tree coverage, in these cases, was controlled to be few, thus trees was not a factor either. The variables with statistical significance were coded in scenarios and systematically compared so only one variable would change between the two scenarios compared (see Appendix D).

Wide streets were found to be a strong predictor of spaciousness. Participants were over 70% likely to associate a wide street with spaciousness, regardless of other factors. Similarly, results indicated that participants were also 70% likely to find an environment to be spacious when the setback was deep, regardless of other factors. Participants were overwhelmingly likely (85% predictability) to find a setting with a wide street and deep setback to be spacious over a narrow street and shallow setback.

Demographic data was excluded from all the analyses due to the fact that the sample size was small and the majority of the responses were very similar- thus is was determined that no conclusive results could be found. In the future, the age of the respondent would be asked as well.

G. Discussion

This section will first recap the main findings of this preliminary research study and briefly discuss them in the context of density with existing examples. Following these findings, the four independent variables (housing typology, street width, setback depth, and tree coverage) will each be discussed in subsections placing them in the context of existing suburban examples from the literature. Author interpretations as well as limitations and possible future studies will also be discussed in this section.

1. Overview

The most striking results of this preliminary study were: 1) the housing typologies were not statistically significant in three of the four analyses, and 2) the surprising result that participants were more likely to prefer the shallow setback while the street width, despite its strong association with spaciousness, was not strongly preferred at either level. Thus, the zone of space inclusive of the trees and setbacks, typically experienced as the front yard, had a stronger influence on perception of spaciousness and preference than did the actual dwelling types themselves. Street width bore more influence in spaciousness than in preference.

This may suggest that, in the U.S. context, the setback and tree coverage may be able to mitigate the affects of high density housing typologies on perceived density. For instance, row houses and three-story, attached multi-family dwellings, would not evoke a sense of high subjective density if they are properly integrated into the environment with a shallow setback and moderate tree coverage. Critics of master planned communities (MPCs), such as Richard Untermann and Doug Kelbaugh have stated the need for the streets in these communities to be made narrower (Moudon, 1990, pg. 57-58). This preliminary study concludes that since the street condition was often not a factor in preference; people may be accepting of narrower streets. Shallower setbacks and narrow streets both require less acreage, thus increasing the du/a density which is crucial in developing transit oriented developments.

One of the questions posed in this research study was, “what role does density have in preference, hence design?” Before continuing with the rest of the discussion, it is interesting to note that in exactly half of the 2,471 responses from the 52 participants, choices for preference and spaciousness were one and the same. This means that half of the participants chose the same image, from the choice set, as their preferred and their most spacious. This research was predicated on literature-supported assumption that a large number of North Americans prefer a spacious feeling built environment, thus the fact that there were not more correlations between preference and spaciousness is intriguing. This recalls some ideas about preference which Myers and Gearin (2001) culled from a series of studies indicating that while many people desired the suburban environment, they were also conflicted in that they desired urban attributes as well. Results for preference seemed to indicate that spaciousness may be perceived in ways other than through horizontal spatial elements (as was indicated in Stamp’s studies previously discussed); yet it is worth noting that 50% of this study’s respondents did not equate preference with spaciousness.

2. Housing Typology

The predictability of choice among different housing types (ignoring other factors) found that the 18du/a stacked row house had a slightly higher predictability (44%) of being chosen over the 8.5du/a single family home (42%). As counter-intuitive as this seems, based on the literature discussed, it is surmised that the row house and single family home were difficult to distinguish form one another in the survey. Possibly a portion of the row houses could have been interpreted as single family homes and preferred as such. However, this limitation may not have made the single family home an overwhelming preference over the stacked row house. One possibility may be a shift in the desire for urban amenities (walkability and public transit), as suggested by Myers and Gearin's (2001) research; or the fact that over 88% of the participants were aware of Portland's urban growth boundary and may appreciate the advantage of denser housing typologies. Attached housing and the use of zero lot lines is becoming a popular planning strategy to increase density, and is used in many MPCs; thus they may be more acceptable to residents. When the row house and single family home were statistically significant as preferred (excluding the stacked row house), the single family home was preferred with a 75% likelihood. This does coincide with the literature, and implies that higher density single family home environments may be preferable if their relation to the street is mitigated by some tree coverage.

Krampen's work (1979, Ch. 4) used psychosemiology to understand what properties of the built environment people associate with a certain concept of it. In one study he argued for a threshold amount of formal and façade detailing necessary for an observer to perceptually categorize a building type (such as single family home or multifamily). In the case of this preliminary study, the tree coverage or rendered perspective view may have diminished those observable details from communicating a type as a multifamily dwelling (a limitation of the study). Contextually appropriate formal detailing of the dwellings (such as was done in the MPC Villages of Woodbridge) may not be necessary for reducing the visual impact of high density dwellings if they are spatially arranged as to minimize the perception of high density. However, this study cannot determine that, since the dwellings all use the same traditional language. See Figure 13 on page 82 for an example of formally integrated multi-family housing in a single family home setting.

Figure 13: Beaverton, OR_ Contextual Design (Source: Author)

It would be interesting to conduct a study focusing on the housing typology while keeping the other spatial relationships constant in order to determine in what context particular housing typologies are preferred or not. Another limitation to this study may be in the way the images were rendered making distinctions between the housing typologies difficult when the trees coverage was high or the street and setback for very wide. Lastly, given that the images in each choice set had the same housing typology depicted in them, it is unclear how the one analysis showed a statistical significance. This may be a characteristic of discrete choice modeling that would benefit from having a statistician as part of the research team. Although, results for the housing typology are best deemed inconclusive, the data here make for meaningful discussion.

3. *Tree Coverage*

John Brinckerhoff Jackson, in his book, *A Sense of Time, A Sense of Place*, reflects on the tree- the one variable in this study that is planted, rather than built.

> "Looking back over more than half a century, I am struck by our growing desire for trees in our domestic environment, by our desire

to plant trees, regardless of their economic value, in order to express a variety of basic emotions…" (pg. 102)

Tree coverage was found to be a factor in preference suggesting that either few or many trees were preferred in relation to a particular setback and housing typology. While the likelihood in each case was only 60%, it is curious that with a row house (shallower setback) fewer trees were preferred and with a single family home (deeper setback) more trees were preferred. When keeping all of the factors, equal there was over a 60% predictability in preference for fewer trees. While literature has shown that the typical U.S. residential pattern involves tree lined streets; no cases could be found where the level of tree coverage was an explicit topic. Girling and Helphand wrote of the continuous front yards acting as public open space in the Levittown example (1996); perhaps people prefer an environment where the space is not occluded or made more private by dense tree coverage.

An interpretation of the tree data, in reference to the housing typologies and setback, indicate that increased permeability (fewer trees) could be desired when overall horizontality is decreased (shallower setback). Conversely, a decreased permeability (more trees) is desired when horizontality is increased (deeper setback). This suggests that there may be a midpoint between too much horizontal spaciousness, and too little, that is balanced by the relationship between tree coverage and setback depth. A strong horizontal emphasis characterized by a deep setback, can be visually broken up with many tall and fuller trees, thus creating a vertical element bounding the street space. Or, a more compressed environment, with a shallow setback, could communicate a layering of space as suggested by a permeable "screen" of smaller trees (see Figure 14, pg. 84). This aligns with the notion that there was more predictable preference for fewer trees with the shallower setback. The idea of another spatial quality attributing to spaciousness, other than horizontality as hypothesized through Stamps' (2009) work, was interpreted as a layering of space. Another argument can be made that trees represent nature and nature is associated with spaciousness (Hur, 2010, pg. 57) which is why more trees were preferred in the more spacious single family home condition (deeper setback).

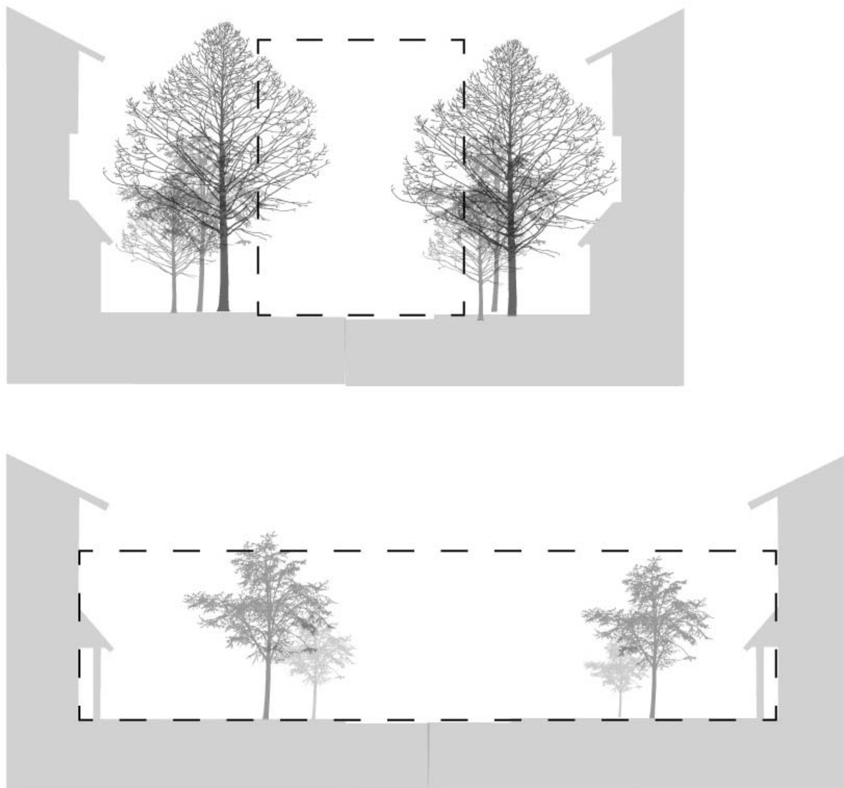


Figure 14: Vertical and Horizontal Spatial Qualities (Source: Author)

This allusion to nature was expressed, through radical theories of the time, in Llewellyn Park. One could argue that the lots in Llewellyn Park were not easily perceived and that it felt, at times, more like a forested landscape that happened to have houses nestled among the lush environment (Wilson, 1979, pg. 83). This communicates a very different pattern than the ubiquitous suburban streetscape of rhythmically repeated houses and tree lined streets. Deeper setbacks and more tree coverage, to a degree, could begin to blur the repetitious pattern of homes, and dissolve views of the human-made elements which are cues for perceived higher density (Rapoport, 1982).

Fewer trees would exist in a shallow setbacks (simply because there is less plantable surface), and overall land use would be minimized, thus opening up the "extra" land use for possibilities like wildlife corridors, as suggested by Reith (2006). This action could create a finer grained urban pattern, in some respects, allowing more access to green space such as in the greenbelt communities of the 1930s, or pocket neighborhoods, ie. cluster housing. One classic example of cluster housing is Radburn, New Jersey. The homes were essentially turned backwards on their plots with the living room space facing the central spine of a superblock where the automobiles could park in cul-de-sac fashioned spaces. The "other" front of the house, where the kitchen was, faced a continuous green corridor lined with a pedestrian walkway. These superblocks were arranged together to create linkages of natural habitat- an intended green space as opposed to a left over residue of open space that is a by-product of disjunctive , sprawling development patterns. Modern pocket neighborhoods have a common off-site parking area from which a pedestrian path takes you to your home. The closeness of these houses is conducive to shallow setbacks and smaller yards.

There was a 66% predictability in spaciousness being associated with the fewer trees, other factors being equal. These data align with the analysis of preference where there was a 60% predictability in preference of few trees. This resultant increase in visibility was hypothesized to feel spacious and aligns with this author's interpretation of layered space feeling spacious, as well as adds to William Dorbiner's argument of the " visibility principle" (see pg. 86). More than half of the time, people are predicted to associate fewer trees with spaciousness and preference. Since we know that not all participants associate preference with spaciousness, these near-equal percentages (60) is understandable, yet 60% is surprisingly high since preference for fewer trees was not hypothesized.

Counter to what was discovered in the preference for shallow setbacks, narrow streets and fewer trees; there was an overwhelming likelihood (85%) that a wide street and deep setback were indicators of spaciousness over the narrow street and shallow setback. This makes sense both intuitively and based on Stamps' (2009) work on horizontal spaciousness; however it is interesting that this was not the case when participants had a choice among few or many trees. When participants were presented with choices of 'few' and 'more' tree coverage it effected how they perceived spaciousness in conjunction with street width (preferring the narrow street) and there was no noted affect from the setback in those cases. It wasn't until the tree variable was isolated and fixed as few that the wide street was seen to be a very strong predictor of spaciousness and the setback became a factor. This indicates that tree coverage, as a factor, may have a stronger influence than the setback factor. Thus, trees can be used as a mitigating factor on the affect of setbacks. Additionally, there were similar results of the deep setback being a strong predictor (70% likelihood) for spaciousness with fewer trees. These data again indicate that trees have a mitigating effect on street width and setback depth and can be strategically used to influence perceptions of density in the residential built environment.

4. Street Width

Street widths (wide and narrow) were found to be in nearly equal probability of being preferred. Another study would need to be performed that controlled the tree coverage as 'many' (instead of few as done here) to determine if the decreased permeability had any effect on preferences for street width. Narrow streets had only a slightly higher percent (54) likelihood of being preferred over wide streets. This, in conjunction with wide streets not being statistically significant, suggests that narrower streets could be accepted in residential areas, thus decreasing the amount of land area needed, as in the case of New Urbanist communities like Seaside, Florida, or the

Dutch community of Leidsche Rijn.

In alignment with Stamps' work on the horizontal spatial aspect of spaciousness (2009), the analysis did find an association between spaciousness and street width. There was a 70% likelihood that participants would find an environment with wide streets, all else equal, to be more spacious over a narrow street. These wider streets (like those in many typical suburban developments) then could be redesigned in a way to incorporate pedestrian pathways and bicycle routes, thus narrowing the car portion of the street and activating the street life not far from people's front doors. Consider the concept of the Woonerf, or "Living Street", developed by Dutch urban transportation planner Hans Monderman (http://www.pps.org/reference/hans-monderman/) which advocates the removal of all traffic signs and signals and the shared space of pedestrians, bicyclists, and drivers who would communicate through gesturing. An extreme case, but it may offer some interesting ideas on a smaller scale.

5. Setback Depth

Analysis of setbacks uncovered a surprising result that opposed the literature concerning preferences for spaciousness. This study hypothesized that setbacks would be a contributing factor to spaciousness and that people prefer spacious and open-feeling environments, however; there was a 70% likelihood that participants would prefer a shallower setback! This seems to validate the results from the previous analysis. Gehl suggests that setbacks of 20 to 25 feet is too deep to afford social contact and that semi-public smaller yards provide a means for spontaneous recreating and causal socializing (2001, pg. 190-191). Another possibility, from these results, suggests that preferred spaciousness is not merely a function of horizontality, as was posited in the previous analysis. Do shallower setbacks, ie., smaller front yards, mean more of a cultural shift to the importance of backyards?

What implications could this have for the front yard space? If it is no longer intended to show off the frontispiece of the home (ie. the façade), or be a respite for the dweller (Wilson-Doegnes, 2001), can it be repurposed as public space?

Figure 15: Beaverton, OR_ Shallow Setbacks (Source: Author)

In an effort to determine if similar overall horizontal relations would render the same affect, a combination of wide street/shallow setback and the inverse narrow street/ deep setback were considered. This yielded a 68% likelihood that participants would prefer the condition with wider streets and the shallow setback. Again, this reinforces the discovery that the space between the street and housing mass has a strong effect on perception and that shallow setbacks are preferred. Counter to the notion of the large single family lot with a spacious lawn- this preliminary study suggests that more compact developments may be desirable and that the housing typology (if fitting in the character and scale of the environment) is not a deterring factor. Even more surprising was the 75% predictability in preference for the combination of a narrow street with a shallow setback versus a wide street with a deep setback! See Figure 15 for an example of this in Beaverton. Once again, this seems to contradict the literature and the notion of spaciousness which, as expressed in Girling and Helphand's, *Yard- Street- Park,* seems to be the essence of the suburban environment- an environment preferred by many for that very reason. The early American suburbs, such as Riverside described earlier, were predicated on the idea of wide streets and large setback acting as the generator for modern suburban morphology. It would be interesting to study how the form of the street network (grid or curvilinear) effects the preference for street width and setback depth. Perhaps a straight street, such as that in the survey images, is evocative of city neighborhoods, yet a wider street and deeper setback would have been preferred along a curved, more typically suburban street. This question is fodder for future work.

Taking this new information concerning the preference for shallower setbacks, it is interesting to consider Girling and Helphand's reference to William Dobriner's "visibility principle". He is quoted as stating, in reference to the suburban environment's visual openness, that residents "observe each other's behavior and general lifestyle far more easily that the city dweller" (1999, pg. 26). The ability to keep an eye on your neighbor therefore may be an important factor in suburban environments thus discouraging housing that is set too far away from the curb. Additionally, Girling and Helphand (1996, pg. 25) historically refer to the concept of the front yard as an ornamental piece that dresses the house- otherwise referred to as curb appeal. If a dwelling, and its immediate plant adornments, were located too far from the street or occluded by dense trees (although no claim can be made for tree preference in this particular analysis- trees were controlled as few), there is a chance that the landscaping would be less likely to be noticed and admired by others. This is a cultural attribute of home ownership in the United States and was exemplified by the owner-initiated landscaping that has evolved in Levittown since the 1950s (Kelley, 1993).

H. Design Strategies for Increasing Density in Suburban Areas

As the literature and preliminary study results have made clear; in the United

States the: home, front yard with trees, lot, and street area are fundamental aspects of the residential built environment and are influential in preference and perceived spaciousness. Based on the discussion from the previous section, the following will list some general recommendations that can be taken into the design studio. These recommendations may guide planners and architects, such as those currently developing Beaverton's Civic Plan, as they design residential environments that both meet people's diverse desires and foster higher density living.

1. Use of Narrow Streets:

Given the even preference for either narrow or wide streets; designers and planners can explore the implications of using a narrow street width in residential designs. Narrow streets would limit on street parking, promote reduced car traffic, and would be ideal as pedestrian and bike transportation paths.

2. Use of Shallow Setbacks:

Smaller front yards may be more acceptable given that there was a strong preference for shallow setbacks.

3. Placing High Density Housing Along Wide Streets with Deeper Setback:

Wide streets and deep setbacks, with their inherent horizontal quality, were a strong predictor of perceived spaciousness and may have mitigating affects on environments with high density housing typologies that may otherwise be perceived as dense, crowded, and undesireable.

4. Use of Trees to Mitigate the Effects of Perceived Density:

Planting fewer trees may increase the sense of perceived spaciousness, even with shallow setbacks.

5. Preference and Perceived Spaciousness are Often Mutually Exclusive

Not all people prefer a the spacious environment and people may have different ways of interpretting spacious.

I. Future Studies

Since this preliminary study did not, for the most part, yield any statistical significance from the housing typologies it would be valuable to conduct another study focusing directly on the housing typologies themselves, and their inherent geometries in their relation to the street. Keeping other factors equal and depicting housing typologies with a vertical emphasis (tall and thin), versus others with a horizontal emphasis (low and long) a hypothesis concerning the vertical quality of the housing typology could be made for its effect on perceived spaciousness. This would be especially useful considering that trees may not always be feasible (especially many larger ones) in conditions with shallower setbacks. Also, if vertical qualities of spaciousness, achieved through taller building masses set closer to the street, can be desirable on par with horizontal spaciousness- this would create opportunities to increase density in ways not previously thought to be desirable in suburban environments. Natural settings would be attainable due to the decreased land conversion (habitat conservation) as a result of the increased objective density by the incorporation of multi-family housing typologies. Furthermore, studies, such as Kearney's (2006) indicate that shared views to natural settings may alleviate the effects of higher densities.

It would be worth repeating the analysis to see if heavier tree coverage had any effect on the spaciousness of wide streets. The final analysis of spaciousness purported an increased likelihood (70%) of the wide street predicting feelings of spaciousness, but this was due to the fact that one other variable (tree coverage) was controlled as 'few' and therefore not a factor.

One limitation in this study, with regard to preference, is that the preference questions should have been asked within a context. For example, the participants would have been asked to choose the most preferred image and state if they preferred it as an 'suburban scene' or a 'place you'd like to live', or both. Future studies would use this method.

Studies like this would be very useful in informing the development of design principles, such as those put forth by Portland's Infill Design Toolkit (Beaverton has goals to develop a similar toolkit). The Toolkit section 'Prototypes' is summarized as, "illustrating 'approvable' housing types and configurations that are suitable for common infill situations, meet City regulations and design objectives, and are market feasible". To that this author would add, ", and meet the desires of those who will live there". A statement especially true for Beaverton where there is still a projected desire and need for traditional neighborhoods with detached single family homes, but not the land capacity to support it. What are other physio-spatial alternatives that will satisfy those desires?

IV. REFERENCES

Aiden, Boland, & Evron. 1 988. UC Berkeley, College of Environmental Design.

Alexander, C. (1977). *A Pattern Language.* New York, NY: Oxford University Press.

Arhcer, J. (May, 1983) Country and city in the American romantic suburb. J*ournal of the Society of Architectural Historians*, 42(2), 139-156. Retrieved on Oct. 21, 2011 from JSTOR database.

Baldassare, Mark et al. (Nov., 2004). *PPIC Statewide Survey*: *Special survey on Californians and their housing.* San Francisco, CA: Public Policy Institute of California.

Beaverton Civic Plan. (Spring 2011). *Housing and Neighborhoods Strategy, working public draft*. Retrieved on Feb. 8, 2013 from http://civicplan.wpengine.com/wp-content/uploads/2011/03/Housing_Strategy_032111_web1.pdf

Berdie, D. 1998. Discrete Choice Modeling (DCM)L An exciting marketing research survey method for educational researchers. Presented at the Annual Mtg of the American Educational Research Assoc. San Diego, CA April 13-17.

Beck, Bressi, & Early. 1 987. UC Berkeley, College of Environmental Design.

Beck, Gladman, & Sisson. 1 987. UC Berkeley, College of Environmental Design.

Bergdoll, James Richard, and William, R. (1990). Density perception on Residential Streets. *Berkley*

Planning Journal, 5, 15-38. Retrieved on Sept. 30, 2012 from eSholarship Web site: http://escholarship.org/uc/item/7wb3g30c

Berghauser Pont, M. and Haupt, P. (2010). *Spacematrix -Space, Density and Urban Form*. NAi Publishers: Rotterdam.

Bierlaire, M. (1998). Discrete choice models. In Labb´e, M., Laporte, G., Tanczos, K., and Toint, P., (Eds) *Operations Research and Decision Aid Methodologies in Traffic and Transportation Management*, 166 of NATO ASI Series, Series F: Computer and Systems Sciences, 203–227. Retrieved on March 11, 2012 from Springer Verlag.

Brookings Institute found at http://www.brookings.edu/research/speeches/2011/07/14-census-suburbs-berube.

Brown, Barbara B., Werner, Carol M., Amburgey, Jonatha W., and Szalay, Caitlin. (2007). Walkable route perceptions and physical features: converging evidence for en-route walking experiences. *Environment & Behavior*, 39 (1), 34-61.

Bruegmann, Robert. (2006). *Sprawl: a compact history.* Chicago, IL: University of Chicago Press.

Burchell, R., A. Down, B. McCann, and S. Mukherji. (2009). *Sprawl Costs: Economic Impacts of Unchecked Development.* : Washington DC: Island Press.

Campoli, J. & MacLean, A. (2007) *Visualizing Density*. Cambridge, MA: Lincoln Institute of Land Policy.

Ching, Francis, D.K. (1996) *Form, Space and Order*. New York, NY: John Wiley & Sons, Inc.

Chuang, Tami Chia-Ling. (2001). *Understanding residential density: The relationship between policy, measurement, and perception.* [Masters thesis, Massachusetts Institute of Technology, 2001]

Churchman, A. (May, 1999). Disentangling the concept of density. J*ournal of Planning and Literature,* 13 (4), 389-411. Retrieved on June 20, 2011 from Sage publications.

City of Minneapolis and AIA Minneapolis. (2006). *What does density look like?: Examples from Minneapolis.* [Brochure].

City of Portland Bureau of Planning. (Dec. 2008). The infill design toolkit: Medium-density residential development, A guide to integrating infill development into Portland's neighborhoods. Found at http://www.portlandoregon.gov/bps/article/223700

Coldwell Banker Analyzes 11,000 Suburbs for New Ranking. Retrieved Feb. 8, 2013 Coldwell Banker Real EState Web site: from http://www.coldwellbanker.com/real_estate/learn/coldwell_banker_analyzes_11000_suburbs_for_new_ranking

Cox, W. (2001) American dream boundaries: urban containment and its consequences (www.gppf.org/pubs/analyses/2001).

Craig, Lois. (1986) Suburbs. *Design Quarterly*, 132, 1+3-32. Retrieved April 22, 2012 from JSTOR database.

Crump, J. (2003). Finding A Place In The Country. *Environment and Behavior,* 35, 187-202. Retreived on Jan. 5, 2010 from Sage publications.

Davis, Kingsley. The Urbanization of the Human Population. In the Richard T. Legates, and Frederic Stout (Eds.) *City Reader*. New York, NY: Routledge.

Desor, J.A. 1972. Toward a Psychology Theory of Crowding. *Journal of Personality and Social Psy chology*, 21(1), 79-83.

Dover, Victor. (2001). *Retrofitting Suburbia*. Retrieved October 23, 2010 from http://www.doverkhol.com/writings_images/umaryland.html.

EDRA sources: http://www.edra.org/content/publications

Eidlin, E. 2010. What density doesn't tell us about sprawl. *Access*, 37, 2-9. Retrieved Feb. 20, 2011 from http://www.uctc.net/access/37/access37_sprawl.shtml

Ellis, John G. (2004). Explaining Residential Density [Research & Debate]. *Places*, 16(2), 34-43. Re trieved on July, 22, 2011 from: http://escholarship.org/uc/item/2np5t9ct

EPA: www.epa.gov

Fisher-Gewirztman, D., Burt, M., and Tzamir, Y. (2003). A 3-D visual method for comparative evalu ation of dense built-up environments. *Environment and Planning B: Planning and Design*, 30, 575-587. DOI:10.1068/b2941.

Fisher-Gerirtzman, D. & Wagner, I. (2003). Spatial openness as a practical metric for evaluating built-up environments. *Environment and Plannning B: Planning and Design*, 30, 37-49. DOI:10.1068/b12861.

Flachsbart, Peter G. (Nov. 1979). Resiential Site Planning and Perceived Densities. *Journal of the Urban Planning and Development Division*, 105(2), 103-117). Retri=eved Oct. 2, 2012 from MNU Main Library.

Forsyth, A. (2003) Measuring Density: Working Definitions for Residential Density and Building De nity. *Design Brief*, 8, Retrieved March 7, 2011 from http://www.corridordevelopment.org/pdfs/from_MDC_Website/db9.pdf

Frank, L., Kavage, S. & Appleyard, B. Aug/Sept. 2007. How transportation and land development affect greenhouses gas emissions. *Planning*. pp. 18-27.

Gehl, Jan. (2011). *Life Between Buildings: Using Public Space*. Washington, DC : Island Press.

Girling, C. & Helphand, K. (1996) Yard, street, park: the design of suburban open space. John Wiley & Sons, Inc.: New York.

Glaeser, E. & Kahn, M. (2008). The greenness of cities: carbon dioxide emissions and urban devel- opment. (Working paper 14238). Retrieved on July 16, 2011 from University of California eScholarship Web iste: http://escholarship.org/uc/item/2pk7j5cp#page-1

Ghorbanian, M. (2011). Recognizing neighborhood satisfaction: Significant dimensions and assess- ment factors. *International Journal of Academic Research*, 3(1), 273-282.

Harris, R., and Larkham PJ. (1999). Suburban foundation, form and function. In R. Harris, and P.J. Larkham (Eds) *Changing Suburbs: Foundation, Form and Function.* London: E & FN Spon.

Heidegger, M. (1951). Building, dwelling, thinking. In Hofstadter, A. (Ed.), *Poetry, language, thought* (pp. 145-161). New York: Harper & Row, Publishers.

Herzog, T. 1992. A Cognitive Analysis of Preference for Urban Spaces. *Journal of Environmental Psychology,* 12, 237-248. Retrieved on June 9, 2011 from Elsevier, Ltd.

Hess PM, Vernez Moudon A, Snyder MC, Stanilov K. (1999). Site design and pedestrian travel. T*rans-*

portation Research Record, 1674, 9–19. Retrieved Dec. 12, 2010 from http://faculty.washington.edu/moudon/writing%20docs/sitedesign.pdf

Housing Density. Retrieved June 20, 2011 from Corridor Development Initiative Web site: http://www.corridordevelopment.org/15/index.php?option=com_content&view=article&id=75&Itemid=88

Hostetler, M. & Escobedo, F. (2010). What Types of Urban Greenspace are Better for Carbon Dioxide Sequestration? *Univ. of Florida IFAS Extension*. Retrieved on July 16, 2011 from http://edis.ifas.ufl.edu.

Hur, M., Nasar, J. & Chun, B. (2010). Neighborhood satisfaction, physical and perceived naturalness and openness. *Journal of Environmental Psychology,* 30, 52-59. Retreived June 10, 2011 from Elsevier, Ltd.

IAPS Digital Library at http://iaps.scix.net/

IPCC at http://www.ipcc.ch/

Jacobs, Jane. (1993). *Life and Death of Great American Cities*. The Modern Library: New York. Original edition, 1961.

Jackson, John B. (1994). *A sense of place, a sense of time.* New Haven, CT: Yale University Press.

Jackson, Kenneth, T. (1985). *Crabgrass Frontier.* Oxford University Press: New York.

Jacobson A. & Appleyard, D. 1987. 'Toward and Urban Design Manifesto'. J*ournal of the American Planning Association*, 53(1). Retrieved June 21, 2011 on from Optimised: University of Minnesota Libraries, Twin Cities.

James, L. D., et al., Community Well-Being as a Factor in Urban Land Use Planning. Environmental Resources Center Report No. ERC-0174, Atlanta: Georgia Institute of Technology, 1974.

Jun, Myung-Jin. (2004). The effects of Portland'surban growth boundary on urban development patterns and commuting. Urban Studies, 34, p. 1333-1346. DOI: 10.1080/0042098042000214824.

Kaplan, S. (1979). USDA Forest General Technical Report: Assessing Amenity Resource Variable. (RM-68)

Kim, J, and Kaplan, R. (2004). Physical and Psychological Factors in Sense of Community : New Urbanist Kentlands Village. *Environment and Behavior*, 36, 313-340. Retrieved on Oct. 26, 2010 from Sage publications.

Kaplan, R., S. Kaplan, and T. Brown. (1989). Environmental preference: a comparison of four domains of predictors. *Environment and Behavior*, 21(5), 509-530. Retrieved on April 27, 2012 from Sage publications.

Kaplan, S., R. Kaplan, and J.S. Wendt (1972). Rated preference and complexity for natural and urban visual material. *Perception and Psychophysics*, 12, 354- 356. Retrieved on April 27, 2012 from http://www.ideal.forestry.ubc.ca/frst524/03_KaplanKaplanWendt.pdf

Kearney, A. (2006). Residential development patterns and neighborhood satisfaction: impacts of density and nearby nature. *Environment and Behavior*, 28, 112- 139. Retrieved on Feb. 20, 2011 from Sage publications.

Keating, Ann D., (2005). *Chicago Land: Cities and Suburbs in the Railroad Age.* University of Chicago Press: Chicago.

Kelley, B. (winter, 1993). Little boxes, big ideas. *Design Quarterly*, 158, 26-31. Retrieved on April 14, 2012 from JSTOR database.

Kline, J. and Alig, R. (1999). Does land use planning slow the conversion of forest and farm lands. Growth and Change, 30, 3–22.

Koles, M. and Muench, D. (Dec. 2002). Why people are moving to suburbia (and beyond): Examining the pull factor in the Fox Valley. *Journal of Extension*, 40(6). Retreieved Feb. 7, 2013 form http://www.joe.org/joe/2002december/a6.php.

Kolko, J. (2012, Oct. 11). Even after the housing bust, American still love the suburbs. *Newsgeography.* Retrieved on Feb. 8, 2013 from http://www.newgeography.com/content/003139-even-after-housing-bust-americans-still-love-suburbs

Kotkin, J. (2011, July 20). Why America's young and restless will abandon cities for suburbs. *Newsgeography.* Retrieved on Oct. 1, 2011 from http://www.newgeography.com/content/002349-why-america's-young-and-restless-will-abandon-cities-for-suburbs

Kotkin, J. and Cox, W. (2011, April 7). Cities and the census: cities neither booming nor withering. *NewGeography*. Retrieved on Oct. 1, 2011 from http://www.newgeography.com/content/002173-cities-and-census-cities-neither-booming-nor-withering

Krampen, R. (1979). *Meaning in the Built Environment. London:* Pion Limited.

Kuhfeld, W. F. (Aug. 2002). Multinomial logit, discrete choice modeling an introduction to designing choice experiments, and collecting, processing, and analyzing choice data with SAS. Retrieved on March 4, 2012 from http://www.stat.auckland.ac.nz/~balemi/Choice.pdf

Kunstler, J.H. (1994) *Geography of Nowhere*. New York, NY: Simon & Schuster.

Lang, J. (1994), *Creating Architectural Theory: The Role of the Behavioral Sciences in Environmental Design*, New York: Van Nostrand Reinhold.

Lewicka, M. (2010). What makes neighborhood different from home and city? Effects of place scale on place attachment. *Journal of Environmental Psychology*, 30, 35–51. Retrieved on Oct. 23, 2010 from Elsevier, Ltd.

Lukez, Paul. (2007). *Suburban Transformations.* New York, NY: Princeton Architectural Press.

Lynch, Kevin. (1981). *Good City Form.* Cambridge , MA: MIT Press.

Lytinski, John T.,Klara, Scott M., Mcilvried, Howard G. 2006. An overview of terrestrial sequestra tion of carbon dioxide: the United States department of energy's fossil energy r&d program. Climate Change: 74: 81–95. DOI: 10.1007/s10584-005-6960-6

Marshall, Alex. (2000). *How cities work: suburban sprawl, and the roads not taken*. Austin, TX: University of Texas Press.

Martinson, Tom. (2000). *American Dreamscape: The Pursuit of Happiness in Post War Suburbia.* New York, NY: Carroll & Graf.

Mavridou, M. (2006). Perception of architectural and urban scale in an immersive virtual environment. In Christoph Hölscher, Ruth Conroy Dalton, Alasdair Turner (Eds.), *Space Syntax and Spatial Cognition Proceedings of the Workshop held in Bremen, 24th September 2006* (pp.113-130)

Merleau-Ponty, M. (1958). *Phenomenology of Perception.* (Colin Smith Trans.). New York: Taylor and Francis e-Library, 2005. (Original work published 1945).

Metro website , see http://www.oregonmetro.gov/index.cfm/go/by.web/id=277)

Miller, K. (1997). Icons of Sprawl. In Lang, P., and T. Miller (Eds.), *Suburban Discipline*. Princeton, NY: Princeton University Press.

Moch, A., Bordas, F., Hermand, D. (1996). Perceived density : how apartment dwellers view their surroundings. *European Journal of Geography.* Retrieved from Cybergeo Web site: http://cybergeo.revues.org/294. DOI : 10.4000/cybergeo.294

Moudon, Anne Vernez, Bill Wiseman, Kwang-joong Kim, and University of Washington. Urban Design Program. Master-planned Communities: Shaping Exurbs In the 1990s. Seattle, Wash.: Urban Design Program, College of Architecture and Urban Planning, University of Washington, 1990.

Moudon, A.V, C. Lee, A. Cheadle, C. Garvin, D. Johnson, T. Schmid, R. Weathers, and L. Lin. (2006) Operational definitions of walkable neighborhood: theoretical and empirical insights. J*ournal of Physical Activity and Health*, 3, Suppl. 1, 99-117. Retrieved Oct. 26, 2010 from http://activelivingresearch.com/files/JPAH_7_Moudon.pdf

Myers, D. & Gearin, E. (2001). Current practice and future demands for denser residential environments. *Housing Policy Debate*, 12(4), 633-659. (Fannie Mae Foundation 2001).

Nasar, J.L., and Stamps III, A.E. (2009). Infill McMansions: Style and the psychophysics of size. *Journal of Environmental Psychology*, 29, 110–123. Retrieved on Oct. 23, 2010 from Elsevier, Ltd.

Nelson, A. C. and Moore, T. (1993) Assessing urban growth management: the case of portland, Oregon, the USA's largest urban growth boundary, Land Use Policy, 10, pp. 293–302.

Niraula, S. (2006). Spatial orientation of Newar children in Nepal. *Journal of Dynamic Society Nepal,* 1(2), 1-17. Retrieved FEb. 8, 2013 from http://www.sosref.org.np/my_file/24.pdf

Norberg-Schulz, C. (1971). *Existence, Space &Architecture*. New York, NY: Praeger Publishers.

Norberg-Schulz, C. (1976). The Phenomenon of Place. In Nesbitt, K. (Ed.), *Theorizing a new agenda for architecture: An anthology of architectural theory 1965-1995* (pp. 415-428). New York: Princeton Architectural Press.

Norberg-Schulz, C. (1983). Heidegger's thinking on architecture. In Nesbitt, K. (Ed.), *Theorizing a new agenda for architecture: An anthology of architectural theory 1965-1995* (pp. 430-439). New York: Princeton Architectural Press.

Openshaw, S. (1984). *The Modifiable Areal Unit Problem*. Norwich: Geo Books.

Pallasmaa, J. (1986). The geometry of feeling: A look at the phenomenology of architecture. In Nesbitt, K. (Ed.), *Theorizing a new agenda for architecture: An anthology of architectural theory 1965-1995* (pp. 448-453). New York: Princeton Architectural Press.

Patterson, J. (1999) Urban growth boundary impacts on sprawl and redevelopment in Portland, Oregon. Working Paper, University of Wisconsin–Whitewater.

Peiser, R. (1989). Density and urban sprawl. *Land Economics,* 65(3), 193-204. Retrieved June 21, 2011 from JSTOR database.

Perception Management: Increasing Density. Retrieved Feb. 20, 2011 from http://www.emergingurbanfutures.com/land/land_10.pdf. [Natalie McCorckle: Author]

Piaget, J., B. l Inhelder, and A. Szemonska. (1981). *The Child's Conception of Geometry.* New, York: W.W. Norton & Co.

Portland's Infill Design Toolkit found at http://www.portlandoregon.gov/bps/article/223700

Rapoport, A. (1969). The Notion of Urban Relations. *Area,* 1(3), 17-26. Retrieved on May, 23, 2011 from JSTOR database.

Rapoport, A. (Oct. 1970). Special Issue: The Study of Spatial Quality. *Journal of Aesthetic Education*,4(4), 81-95. Retrieved May, 23, 2011 from JSTOR database.

Rapoport, A. (1970). Symbolism and Environmental Design. Milwaukee, WI: University of Wisconsin Press.

Rapoport, A. (1975). Toward a Definition of Density. *Environment and Behavior,* 7, 133-158. Retrieved May 20, 2011 from Sage publications/

Rapoport, A. (1977). *Human Aspects of Urban Form: Towards a Man-Environment Approach to Urban Form and Design*. Pergamon: Oxford.

Rapoport, A. (1982). *Meaning of the Built Environment*. London: Sage Publications.

Rapoport, A. (2010). Designing for People- Some Implications. *Trialog*, 106, 4-45.

Reith, C. (Oct. 2006). A more protective urban landscape. *Urban Land*, , 134- 136. Retrieved July 16, 2011 from http://www.planetizen.com/files/21906.pdf.

Richardson, A.J., Brunton, P.J. and Roddis, S.M. (1998). The Calculation of Perceived Residential Density, *Road & Transport Research*, 7(2), 3-15. Retrieved Feb. 21, 2011 from http://www.tuti.com.au/1998wigantrails.pdf

Richardson, H. W. and Gordon P. (2001) Portland and Los Angeles: beauty and the beast. Paper pre sented at the 17th Pacific Regional Science Conference, Portland, OR.

Rowe, Peter, G. (1991). *Making a Middle Landscpe.* Cambirdge , MA: MIT Press.

Sailer, K., Budgen, A., Lonsdale, N. Turner, A., and Penn, A. (2008). Evidence-based design: Theoretical and practical reflections of an emerging approach in office architecture. Retrieved from Sheffield Hallam University Research Archive (SHURA) website: http://shura.shu.ac.uk/492/

Schiffenbauer, A., Brown, J., Perry, P., Shulack, L., & Zanzola, A. (1977). The relationship between density and crowding: some architectural modifiers. *Environment and Behavior*, 9, 3-14. Retrieved on March, 5, 2011 from Sage publications.

Skjaeveland, O. & Garling, T. (1997). Effects of interactional space on neighboring. J*ournal of Environmental Psychology*, 17, 181-198. Retrieved Feb. 21, 2011 from ScienceDirect.

Stanilov, K., and Barbara Scheer. (2004). *Suburban Form An International Perspective*. New York, NY: Routledge.

Stamps, A.E. (2009). On space and spaciousness. *Environment and Behavior*. Advance online publication. doi: 10.1177/0013916508317931

Stamps, A.E. (2010). Effects of Permeability on Perceived Enclosure and Spaciousness. *Environment* *and Behavior*, 42, 864-886. Retrieved Feb 20, 2011 from Sage publications.

Stamps, A.E. (2011). Effects of Area, Height, Elongation, and Color on Perceived Spaciousness. *Environment and Behavior*, 42, 252- 273. Retrieved Feb 20, 2011 from Sage publications.

Stamps, A. & Zacharias, J. (2004). Perceived Building Density as a Function of Layout. *Perceptual and Motor Skills*, 98, 777-784. Retrieved on Feb. 22, 2011 from EbscoHost.

Stedman, R.C. (2002). Toward a Social Psychology of Place : Predicting Behavior from Place-Based Cognitions, Attitude, and Identity. *Environment & Behavior,* 34, 561-581. Retrieved on Feb. 11, 2013 from Sage publications.

Sustainable Cities at http://www.cunysustainablecities.org/

Teaford, Jon C. (2008). *The American Suburb: The Basics*. New York, NY: Routledge.

Thiel, P., Harrison, E., & Alden, R. (1986). The Perception of Spatial Enclosure As a Function of the Position of Architectural Surfaces. *Environment and Behavior*, 18, 227-245. Retrieved on March 5, 2011 from Sage publications.

Tuan, Yi-Fu. (1977). *Space and Place: The Perspective of Experience*. Minneapolis, MN: University of Minnesota Press.

US Census (2000 & 2010): www.census.gov

US Dept. of Transportation: www.dot.gov

Walsh, K. (2005) Paper presented at Walk21-VI "Everyday Walking Culture", The 6th International Conference on Walking in the 21st Century, September 22-23 2005, Zurich, Switzerland.

Wilson, R. G. (Oct.,1979). Idealism and the origin of the first American suburbs: Llewellyn park, New Jersey". *American Art Journal,* 11(4), 79-90. Retrieved on April 22, 2012 from JSTOR database.

Wilson-Doegness, G. (2001). Push pull forces away from front porch use. *Environment & Behavior*, 33, 264- 278. Retrieved on Oct. 29, 2011 from Sage publications.

Winograd, M. and Hais, M. (2010a, April 20) Twenty-first century electorate's heart is in the suburbs. *NewGeography*. Retrieved on Oct. 1, 2011 from http://www.newgeography.com/content/001591-twenty-first-century-electorate's-heart-suburbs

Winograd, M. and Hais, M. (2010b, April 19) The millennial metropolis. *NewGeography*. Retreived April 26, 2012 from http://www.newgeography.com/content/001511-the-millennial-metropolis.

World Resource Institute at www.wri.org

V. APPENDICES A-F

A. Survey Instrument

University of Minnesota Student Researcher: Erin Lilli, 979.204.1368, lill0157@umn.edu

SURVEY

After reading the consent form, your voluntary completion and return of this questionnaire grants consent for your responses to be used as data in this research.

This should take approximately 15 minutes to complete.
A Million Thanks for your participation!
Your generous time is making my graduation possible.

EASY INSTRUCTIONS

Beginning on the following page, please choose the response that most accurately reflects your opinion, attitude or knowledge. With questions that ask you to respond to an image, consider the scenes as if you were to be viewing them as walking down the neighborhood street.

QUESTION 1: How familiar are you with the elected regional government for the Portland metropolitan area referred to as the Metro? (*Please mark the box next to your answer)*

- ❑ I have never heard of the Metro
- ❑ I am somewhat familiar with the Metro
- ❑ I am very familiar with the Metro

QUESTION 2: Are you aware of the Portland area urban growth boundary (UGB)?
(*Please mark the box next to your answer)*

- ❑ I am NOT aware of the UGB
- ❑ I am aware of the UGB

QUESTION 3: Do you think the UGB has a positive effect on city planning in the Metro?
(*Please mark the box next to your answer)*

- ❑ I have no opinion on the UGB in regard to city planning in the Metro
- ❑ I think the UGB is NOT having a positive effect on city planning in the Metro
- ❑ I think the UGB is having a positive effect on city planning in the Metro

QUESTION 4: What was the primary reason you moved to Beaverton, OR?
(*Please mark the box next to your answer)*

- ❑ Employment
- ❑ Affordable Housing
- ❑ Desirable Environment
- ❑ Other:___________________________

QUESTIONS 5-8 *on the proceeding pages*

Part 1: For the 3 residential environment scenes depicted in each question, please CHOOSE the scene that you PREFER the MOST and circle that corresponding letter.

Part 2: For the 3 residential environments scenes depicted in each question, please CHOOSE the scene that you find to be the MOST SPACIOUS or OPEN FEELING and circle the corresponding letter.

QUESTION 5

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

A

B

C

QUESTION 6

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

A

B

C

A. Survey Instrument (cont)

QUESTION 7

Part 1:
I MOST PREFER scene: A   B or C *(please circle one letter)*

Part 2:
I find scene A   B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

A

B

C

QUESTION 8

Part 1:
I MOST PREFER scene: A   B or C *(please circle one letter)*

Part 2:
I find scene A   B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

A

B

C

A. Survey Instrument (cont)

QUESTION 9: What method of transportation do you use to travel to work?
(*Please mark the box next to your answer)*

- ❑ Automobile
- ❑ Public Transit- MAX or bus
- ❑ Bike
- ❑ Walk

QUESTION 10: How often do you travel to downtown Portland, OR?
(*Please mark the box next to your answer)*

- ❑ I never travel to downtown Portland, OR
- ❑ I rarely travel downtown Portland, OR
- ❑ I often travel to downtown Portland, OR
- ❑ I very frequently travel to downtown Portland, OR

QUESTION 11: How often do you navigate by foot or bicycle? (*Please mark the box next to your answer)*

- ❑ I never travel by foot or bicycle when I can use a car or public transportation instead
- ❑ I rarely travel by foot or bicycle and prefer to use a car or public transportation instead
- ❑ I often travel by foot or bicycle instead of using a car or public transportation
- ❑ I very frequently travel by foot or bicycle and prefer it to the use a car or public transportation

QUESTIONS 12-15 *on the proceeding pages*

Part 1: For the 3 residential environment scenes depicted in each question, please CHOOSE the scene that you PREFER the MOST and circle that corresponding letter.

Part 2: For the 3 residential environments scenes depicted in each question, please CHOOSE the scene that you find to be the MOST SPACIOUS or OPEN FEELING and circle the corresponding letter.

A. Survey Instrument (cont)

QUESTION 12

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*


A


B


C

QUESTION 13

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*


A


B


C

A. Survey Instrument (cont)

QUESTION 14

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

QUESTION 15

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

A. Survey Instrument (cont)

QUESTION 16: What type of dwelling do you reside in?
(*Please mark the box next to your answer)*

- ❑ Single Family Home
- ❑ Townhouse or Row House
- ❑ Duplex
- ❑ Multiple Family Home, ie. apartment or condo
- ❑ Other:___________________________________

QUESTION 17: How long have you lived in Beaverton, OR?
(*Please mark the box next to your answer)*

- ❑ Less than 1 year
- ❑ 1-3 years
- ❑ 3-7 years
- ❑ Over 7 years

QUESTION 18: How many people, including yourself, live in your household?
(*Please mark the box next to your answer)*

- ❑ 1
- ❑ 2
- ❑ 3-4
- ❑ More than 4

QUESTIONS 19-34 *on the proceeding pages*

Part 1: For the 3 residential environment scenes depicted in each question, please CHOOSE the scene that you PREFER the MOST and circle that corresponding letter.

Part 2: For the 3 residential environments scenes depicted in each question, please CHOOSE the scene that you find to be the MOST SPACIOUS or OPEN FEELING and circle the corresponding letter.

A. Survey Instrument (cont)

QUESTION 19

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*


A


B

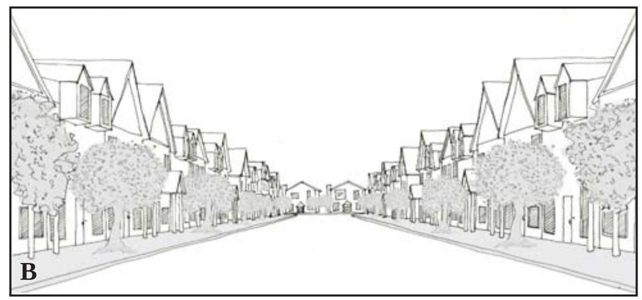

C

QUESTION 20

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*


A


B


C

A. Survey Instrument (cont)

QUESTION 21

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

QUESTION 22

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

A. Survey Instrument (cont)

QUESTION 23

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

QUESTION 24

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

QUESTION 25

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*


A


B


C

QUESTION 26

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*


A


B


C

A. Survey Instrument (cont)

QUESTION 27

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*


A


B


C

QUESTION 28

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*


A


B


C

A. Survey Instrument (cont)

QUESTION 29

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

A

B

C

QUESTION 30

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

A

B

C

A. Survey Instrument (cont)

QUESTION 31

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

QUESTION 32

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

QUESTION 33

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

QUESTION 34

Part 1:
I MOST PREFER scene: A B or C *(please circle one letter)*

Part 2:
I find scene A B or C to be the MOST SPACIOUS and OPEN FEELING. *(please circle one letter)*

END OF SURVEY!

THANK YOU for participating in this research study! Your information will help inform designers and planners on how to create built environments that have a positive impact on people and the planet.

IMPORTANT

Please place this completed survey in the pre-addressed and pre-posted envelope, that is provided, and send it by US mail back to the researcher.

Thank you!

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
AREA#1							
Cedar Hill from Huntington to Berkshire (DSC 683-696, 701-703)	sfh	41	45	1	50	hip or gabled	65
4 units per acre		67	36		50		65
		76	20		60		65
		67	14		58		65
		68	31		55		65
		81	45		58		65
		79	42		50		65
		74	28		51		65
		77	29		46		65
		67	28		58		65
		74	23		45		65
		73	38		66		65
		71	27		56		65
		76	27		63		65
		62	45		61		65
		70	33		58		65
		74	20		66		65
		79	21		40		65
		65	17		65		65
		52	15		76		65
		58	15		66		65
		61	16		66		65
		60	24		70		65
		63			75		65
		55			53		65
							65
AVERAGE		**68**	**28**		**58**		
MEDIAN		**68**	**27**		**58**		
MODE		**67**	**45**		**58**		
AREA#1							
SW 119th Ave. off Walker (DSC 749-753)	sfh	39	26	1	47	hip or gabled	25
4 -5 units per acre		48	23		52		25
		45	14		60		25
		57	26		52		25
		63	10		47		25
		48	31		45		25
		53	10		50		25
		52	31		48		25
		50	10		61		25
		38	36		60		25
SW 121st Ave. off Walker (DSC 755-757)	sfh	36	40	1	26	hip or gabled	21
4 -5 units per acre		48	22		43		21
		45	22		50		21
		50	24		55		21
		45	41		54		21

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		24	28		37		21
		51			61		21
		31			42		21
AVERAGE		**46**	**25**		**49**		
MEDIAN		**48**	**25**		**50**		
MODE		**48**	**10**		**47**		
AREA#2							
Parkway, portion across from church and park (DSC 223-233)	sfh	35	15	1	44	hip or gabled	38
4 units per acre		30	16		56		38
		30	10		63		38
		30	21		63		38
		35	12		58		38
		37	22		54		38
		33	13		68		38
		31	23		66		38
		33	10		39		38
		35	17		43		38
		36	15		59		38
		35	18		69		38
		42	18		65		38
		18			61		38
AVERAGE		**33**	**16**		**58**		
MEDIAN		**34**	**16**		**60**		
MODE		**35**	**15**		**63**		
AREA#2							
SW Edgewood from Filmont to Westfield (DSC 236-243)	sfh	37	29	1 and 2	25	hip and gabled	24
4 -5 units per acre		37	16		54		24
		38	38		62		24
		37	15		73		24
		35	15		55		24
		36	15		51		24
		50	15		48		24
		43	15		56		24
		50	31		34		24
		45	12		30		24
		34	18		64		24
		37	13		51		24
		37	12		50		24
		37	36		59		24
		35	30		57		24
		39	35		42		24
		42			59		24
		36			49		24
AVERAGE		**39**	**22**		**51**		
MEDIAN		**37**	**16**		**53**		
MODE		**37**	**15**		**51**		

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
AREA#2							
Burlwood	sfh	34	34	all 1?	34	hip and gabled	28
4 units per acre		37	13		64		28
		44	27		49		28
		44	12		55		28
		42	12		67		28
		43	12		64		28
		35	10		66		28
		43	7		69		28
		38	11		66		28
		40	13		58		28
		33	16		64		28
		40	15		61		28
		40	13		52		28
		42	10		66		28
		37	8		64		28
		38	33		67		28
		39	10		51		28
		45	16		48		28
		44			54		28
		55			51		28
AVERAGE		**41**	**15**		**59**		
MEDIAN		**40**	**13**		**63**		
MODE		**44**	**13**		**64**		
AREA#5							
6th St. from Murray to Fairmont (DSC 154-160)	mostly sfh, some small scale multifamily	31	14	mostly 1 story	34	hip or gabled	35
4-6 units per acre		31	22		28		35
		28	19		28		35
		31	18		75		35
		35	43		65		35
		36	95		32		35
		36	69		63		35
		25	19		35		35
		36	5		40		35
		33			40		35
		29			54		35
		34			67		35
AVERAGE		**32**	**34**		**47**		
MEDIAN		**32**	**19**		**40**		
MODE		**31**	**19**		**28**		
AREA#5							
Berthold from 141st to Menlo (DSC 125-143)	sfh	37	13	1 & 2	55	hip or gabled	34
4-6 units per acre		34	17		60		34
		32	9		62		34
		44	8		63		34

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		46	10		62		34
		47	15		63		34
		48	12		61		34
		37	21		63		34
		38	24		65		34
		38	17		64		34
		46	17		54		34
		36	14		63		34
		43	17		64		34
		37	14		51		34
		36	73		72		34
		59	25		49		34
		39	11		56		34
		41	17		64		34
		42	15		65		34
		43	118		64		34
		27	15		67		34
		42	7		63		34
		33			55		34
		34			61		34
		37			53		34
		32			74		34
AVERAGE		**40**	**22**		**61**		
MEDIAN		**38**	**15**		**63**		
MODE		**37**	**17**		**63**		
AREA#5							
Allen from Erickson to Main (DSC 100-102)	mixed	20	37	mixed	45	mixed	50
4-6 units per acre		73	68		32		50
		91	56		41		50
		17	28		52		50
		17	19		52		50
		19	48		40		50
		19	16		40		50
		19	24		40		50
		19	31		40		50
		28	121		75		50
		45	155		30		50
		44	60		30		50
		23	20		42		50
		25	42		57		50
		27	48		41		50
		27	25		42		50
		40			97		50
		33			80		50
		19			45		50
		24			66		50
		15			118		50
		15			100		50
AVERAGE		**30**	**50**		**55**		

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
MEDIAN		**24**	**40**		**44**		
MODE		**19**	**48**		**40**		
AREA#6							
9th St. from Lombard to Algers	sfh	28	42	1	31	hip or gabled	28
2 units per acre		38	15		31		28
		40	22		55		28
		33	14		43		28
		27	14		50		28
		39	16		51		28
		33	10		48		28
		33	13		60		28
		33	27		56		28
		52	47		31		28
		147	32		51		28
		30	27		33		28
		54	16		49		28
		46	60		33		28
		22	30		36		28
		23	7		42		28
		25	25		35		28
		28	60		45		28
		28	20		51		28
		29	13		42		28
		24	12		27		28
		32	21		52		28
		24	11		51		28
		26	9		31		28
		30	12		51		28
		22	30		52		28
		18			28		28
		19			27		28
		20					28
AVERAGE		**35**	**23**		**43**		
MEDIAN		**29**	**18**		**44**		
MODE		**33**	**14**		**51**		
AREA#6							
Lombard from 5th-7th (DSC for 7th t- 11th 283-287)	sfh	28	30	mixed	64	mixed	42
3-4 units per acre		28	34		57		42
		93	19		65		42
		40	26		49		42
		40	34		30		42
		46	18		26		42
		23	17		42		42
		25	12		56		42
		45	16		37		42
		23	23		31		42
		40			33		42

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		38			54		42
AVERAGE		**39**	**23**		**45**		
MEDIAN		**39**	**21**		**46**		
MODE		**40**	**34**		**#N/A**		
AREA#6							
Queen and Holland (DSC 333-337)	sfh	27	6	2	42	hip or gabled	20
8 units per acre		21	5		37		
		22	8		34		
		22	6		41		
		21	5		36		
		22	8		31		
		23	7		38		
		17	5		38		
		23	6		38		
		24	6		38		
		25	4		41		
		23	7		40		
		27	8		38		
		26	7		36		
		26	6		28		
		26	4		28		
		26			28		
					35		
					29		
AVERAGE		**24**	**6**		**36**		
MEDIAN		**23**	**6**		**37**		
MODE		**26**	**6**		**38**		
AREA#6							
Cheshire from Lombard to Alice (DSC 300-315)	sfh	36	39	1 and 2	35	hip or gabled	28
3-4 units per acre		36	19		59		28
		37	15		63		28
		33	26		55		28
		34	37		51		28
		32	22		51		28
		30	23		71		28
		29	40		64		28
		32	19		41		28
		45	13		77		28
		36	32		39		28
		37	24		35		28
		32	30		63		28
		30	13		38		28
		34	15		47		28
		35	17		42		28
		35	19		62		28
		35	26		50		28
		33	36		55		28

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		43			70		28
		50			42		28
		36			40		28
		40			39		28
AVERAGE		**36**	**24**		**52**		
MEDIAN		**35**	**23**		**51**		
MODE		**36**	**19**		**35**		
AREA#6							
Denney from Lombard to Queen (No pics)	mixed	48	28	mixed	54	mixed	34
2-3 units per acre		53	21		72		34
		50	29		70		34
		59	40		54		34
		54	56		70		34
		56	91		96		34
		54	18		76		34
		43	13		73		34
		36	39		61		34
		41	7		39		34
		58	7		40		34
		58	5		29		34
		58	5		29		34
		71	5		29		34
		82	12		38		34
		96	40		37		34
		41	17		40		34
		39	41		29		34
		71	5		29		34
		139	35		92		34
		75	15		27		34
		106			22		34
		82			55		34
		31			92		34
		43			53		34
		91			34		34
		37			57		34
					33		34
AVERAGE		**62**	**25**		**51**		
MEDIAN		**56**	**18**		**47**		
MODE		**58**	**5**		**29**		
AREA#7							
Stallion (DSC 478-491)	sfh	36	27	1 and half	65	hip or gabled	34
4 units per acre		36	10		55		34
		33	16		60		34
		36	18		59		34
		33	73		50		34
		35	43		62		34
		32	43		69		34
		40	40		57		34

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		32	14		20		34
		37	17		69		34
		50	10		67		34
		32	16		65		34
		37	24		57		34
		38	14		60		34
		35	24		56		34
		49	18		47		34
		40	70		64		34
		38	47		62		34
		37	48		71		34
		32	57		51		34
		57	17		66		34
		38	10		62		34
		50	18		63		34
		50			71		34
		50			23		34
		40			70		34
					67		34
AVERAGE		**39**	**29**		**59**		
MEDIAN		**37**	**18**		**62**		
MODE		**32**	**10**		**62**		
AREA#7							
Davies (DSC 492-508)	mixed over all, mostly sfh	40	55	1 and 2	49	hip or gabled	34
4 units per acre		28	88		53		34
		55	19		71		34
		46	28		77		34
		38	50		79		34
		44	27		58		34
		34	40		52		34
		44	27		70		34
		44	41		76		34
		35	7		79		34
		49	14		68		34
		42	42		63		34
		42	33		80		34
		20	54		74		34
		61	45		56		34
		73	18		52		34
		41	26		60		34
		50	81		71		34
		62			62		34
		58			35		34
		39			63		34
		50			66		34
		48					34
		39					34
		47					34

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		46					34
		39					34
AVERAGE		**45**	**39**		**64**		
MEDIAN		**44**	**37**		**65**		
MODE		**44**	**27**		**71**		
AREA#8							
Wilson (DSC 414-425)	sfh	27	13	1 and 2	65	hip or gabled	32
4 units per acre		40	32		57		
		44	62		45		
		60	30		55		
		35	18		64		
		30	44		58		
		49	59		60		
		34	63		60		
		30	13		53		
		42	21		46		
		29	34		51		
		51	19		40		
		30	54		74		
		35	48		55		
		38	20		62		
		36	48		53		
		41	19		58		
		35	20		55		
		29	15		57		
		22	18		46		
		56	27		49		
		31	52		63		
		63	44		75		
		41	25		69		
		46	65		72		
		44			53		
		39			54		
		36			62		
		33			76		
		45			56		
		46			55		
		37					
		42					
		40					
AVERAGE		**39**	**35**		**58**		
MEDIAN		**39**	**30**		**57**		
MODE		**35**	**13**		**55**		
AREA#8							
Barlow (DSC 379-403)	sfh	29	17	1 and 2	41	hip or gabled	43
4 -5 units per acre		37	27		58		
		39	30		51		
		33	34		61		

B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		35	17		61		
		46	14		65		
		35	19		58		
		39	10		51		
		34	10		63		
		34	13		66		
		34	10		60		
		34	13		60		
		34	32		60		
		37	12		49		
		40	26		55		
		43	18		69		
		39	38		57		
		40	83		54		
		28	54		57		
		31	31		71		
		26	17		61		
		29	8		54		
		35			41		
		35			64		
		37			66		
		36			62		
AVERAGE		**35**	**24**		**58**		
MEDIAN		**35**	**18**		**60**		
MODE		**34**	**17**		**61**		
AREA#8							
Juniper Terrace (DSC 350-362)	sfh	40	43	1 and 2	65	hip or gabled	45
4 -5 units per acre		35	26		70		
		36	37		63		
		53	20		54		
		36	22		58		
		34	23		48		
		37	63		53		
		37	62		55		
		38	56		59		
		41			65		
AVERAGE		**39**	**39**		**59**		
MEDIAN		**37**	**37**		**59**		
MODE		**36**	**#N/A**		**65**		
AREA#9							
Maverick Terrace from Tennessee to Murray (DSC 443-465)	sfh and apt across on hill	33	22	1 and 2	54	hip or gabled	34
4 units per acre		36	19		67		
		41	17		69		
		32	18		55		
		33	33		68		
		44	24		47		
		33	13		59		

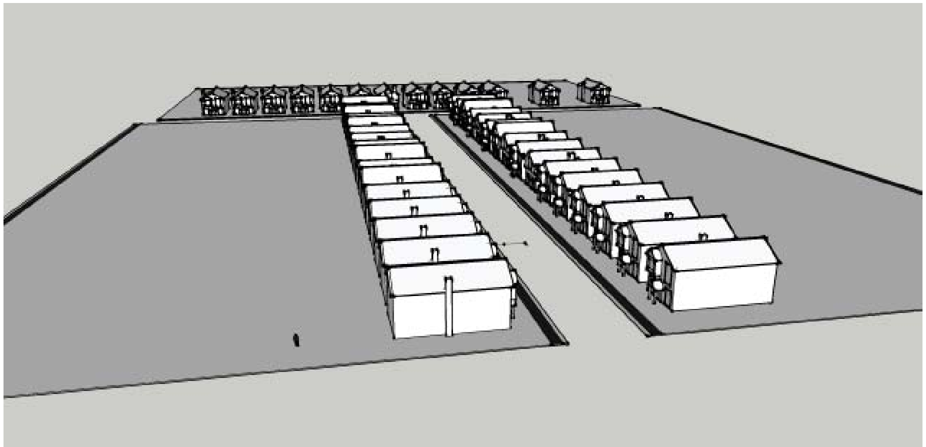
B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		36	27		63		
		33	11		46		
		38	19		64		
		36	34		44		
		37			65		
		36			47		
		31			49		
AVERAGE		**36**	**22**		**57**		
MEDIAN		**36**	**19**		**57**		
MODE		**33**	**19**		**47**		
AREA#10							
Wilson (NO DSC)	sfh	18	7	1nd 2 ?	31	hip or gabled	25
12 -15 units per acre		18	8		30		
		18	8		37		
		19	14		28		
		21	11		33		
		22	9		31		
		17	7		33		
		18	12		33		
		16	6		33		
		24	9		32		
		24	9		42		
		16	13		26		
		21	18		33		
		23	7		30		
		23	13		28		
		22	9		33		
		20	16		39		
		22	5		33		
		19	17		36		
		20	7		38		
		23			33		
		19					
AVERAGE		**20**	**10**		**33**		
MEDIAN		**20**	**9**		**33**		
MODE		**18**	**7**		**33**		
AREA#10							
Walnut Creek (DSC 593-599)	sfh	26	5	2	23	hip or gabled	17
12 -15 units per acre		23	5		25		
		26	5		27		
		13	5		23		
		22	5		25		
		24	5		27		
		24	5		23		
		24	5		25		
		25	5		27		
		23	5		23		
		17	5		25		

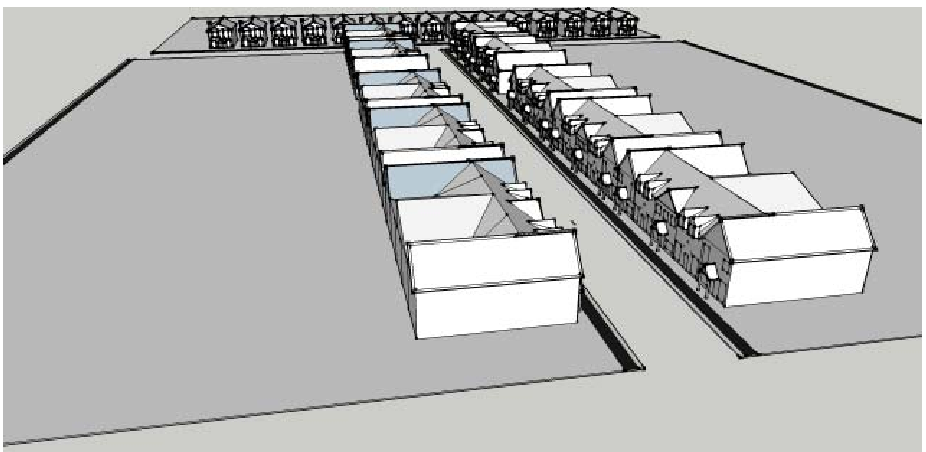
B. Measurements of Beaverton's Residential Areas (cont)

	Typology	Setback	Gap	Stories	Bldg Width	Roof Type	Street Width
		17	5		27		
		17	5		23		
		17	5		25		
		17	5		27		
		14	5		23		
		14			25		
		14			27		
		22			23		
		22			25		
		17			27		
		17			23		
		17			25		
		17			27		
AVERAGE		**20**	**5**		**25**		
MEDIAN		**17**	**5**		**25**		
MODE		**17**	**5**		**25**		

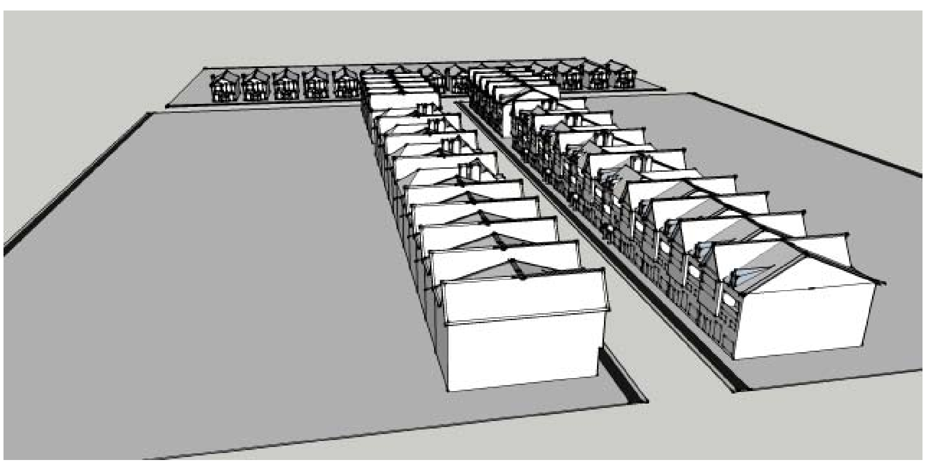
C. Block Configuarions for Survey Stimuli



Single Family Homes: 8.5 du/a, 4 acre blocks



Row Houses: 12 du/a, 4 acre blocks



Stacked Row Houses: 18 du/a, 4 acre blocks

D. Statistical Data

PREFERENCE> trees controlled to focus on setbacks

	B	Sig. (P value)	Exp (β)
Typology (0)	0	0.631	1
Typology (1)	-0.084	0.398	0.919
Typology (2)	-0.003	0.979	0.997
Trees (0)	0		1
Street (1)	-0.161	0.048	0.851
Setback (1)	-0.916	0	0.4

***add the (0) level, maybe?) is reference level

*Trees were controlled and have no stat. sig.

*The housing typologies had no statistical significance

*Setback had the most significance, then street

C_1:	Typo (0), Trees (0), Street (0), Setback (0)
C_2:	Typo (0), Trees (0), Street (1), Setback (0)
C_3:	Typo (0), Trees (0), Street (1), Setback (1)
C_4:	Typo (0), Trees (0), Street (0), Setback (1)

	$\exp(x_1\beta)$
C_1:	1
C_2:	0.851
C_3:	0.3404
C_4:	0.4

	$\exp(x_1\beta)/(\exp(x_1\beta))(\exp(x_2\beta))$	**as %**
Choices 1/2:	0.540248514	54.02%
Choices 1/3:	0.746045956	74.60%
Choices 1/4:	0.714285714	71.43%
Choices 2/3:	0.714285714	71.43%
Choices 2/4:	0.680255795	68.03%
Chocies 3/4:	0.459751486	45.98%

D. Statistical Data (cont)

PREFERENCE> trees NOT controlled

	B	Sig. (P value)	Exp (β)
Typology (0)	0	0.005	1
Typology (1)	-1.165	0.001	0.312
Typology (2)	0.031	0.756	1.032
Trees (1)	-0.474	0	0.623
Street (1)	-0.122	0.134	0.886
Setback (1)	-1.167	0.001	0.311

C_1:	Typo (0), Trees (0), Street (0), Setback (0)
C_2:	Typo (0), Trees (1), Street (0), Setback (0)
C_3:	Typo (0), Trees (1), Street (0), Setback (1)
C_4:	Typo (0), Trees (0), Street (0), Setback (1)
C_5:	Typo (1), Trees (0), Street (0), Setback (0)
C_6:	Typo (1), Trees (1), Street (0), Setback (0)
C_7:	Typo (1), Trees (1), Street (0), Setback (1)
C_8:	Typo (1), Trees (0), Street (0), Setback (1)

*The stacked row housing typologyhad no statistical significance

*The street factor had no statistical significance

Housing typology choices

0.42662116	SFH (0)
0.133105802	Row (1)
0.440273038	STR (2)

Order: Row, SFH, STR

	$\exp(x_1\beta)$
C_1:	1
C_2:	0.623
C_3:	0.193753
C_4:	0.311
C_5:	0.312
C_6:	0.194376
C_7:	0.060450936
C_8:	0.097032

all same- only housing type changed and setback

SFH housing typology- setback change

ROW housing typology- setback change

	$\exp(x_1\beta)/(\exp(x_1\beta))(\exp(x_2\beta))$	as %
Choices 1/2:	0.616142945	61.61%
Choices 1/3:	0.83769423	83.77%
Choices 1/4:	0.762776506	76.28%
Choices 1/5:	0.762195122	76.22%
Choices 1/6:	0.837257279	83.73%
Chocies 1/7:	0.942995066	94.30%
Chocies 1/8:	0.911550438	91.16%
Chocies 2/3:	0.762776506	76.28%
Chocies 2/4:	0.667023555	66.70%
Chocies 2/5:	0.66631016	66.63%
Chocies 2/6:	0.762195122	76.22%
Chocies 2/7:	0.911550438	91.16%
Chocies 2/8:	0.865239323	86.52%
Chocies 3/4:	0.383857055	38.39%
Chocies 3/5:	0.383098074	38.31%
Chocies 3/6:	0.499197432	49.92%
Chocies 3/7:	0.762195122	76.22%
Chocies 3/8:	0.66631016	66.63%
Chocies 4/5:	0.499197432	49.92%
Chocies 4/6:	0.615383398	61.54%
Chocies 4/7:	0.837257279	83.73%
Chocies 4/8:	0.762195122	76.22%
Chocies 5/6:	0.616142945	61.61%
Chocies 5/7:	0.83769423	83.77%
Chocies 5/8:	0.762776506	76.28%
Chocies 6/7:	0.762776506	76.28%
Chocies 6/8:	0.667023555	66.70%
Chocies 7/8:	0.383857055	38.39%

Limitations

Row and SFH looked too much alike in the survey

D. Statistical Data (cont)

SPACIOUSNESS> trees controlled to focus on setbacks

	B	Sig. (P value)	Exp (β)
Typology (0)	0	0.528	1
Typology (1)	-0.099	0.315	0.906
Typology (2)	-0.005	0.961	0.995
Trees (0)	0	-	1
Street (0)	-0.873	0	0.417
Setback (0)	-0.894	0	0.409

*The housing typologies had no statistical significance

C_1:	Typo (0), Trees (0), Street (0), Setback (0)
C_2:	Typo (0), Trees (0), Street (1), Setback (0)
C_3:	Typo (0), Trees (0), Street (1), Setback (1)
C_4:	Typo (0), Trees (0), Street (0), Setback (1)

	$\exp(x_1\beta)$
C_1:	0.170553
C_2:	0.409
C_3:	1
C_4:	0.417

	$\exp(x_1\beta)/(\exp(x_1\beta))(\exp(x_2\beta))$	as %
Choices 1/2:	0.294283698	29.43%
Choices 1/3:	0.145702928	14.57%
Choices 1/4:	0.290276792	29.03%
Choices 2/3:	0.290276792	29.03%
Choices 2/4:	0.495157385	49.52%
Chocies 3/4:	0.705716302	70.57%

D. Statistical Data (cont)

SPACIOUSNESS> trees NOT controlled

	B	Sig. (P value)	Exp (β)
Typology (0)	0	0.998	1
Typology (1)	-0.006	0.954	0.994
Typology (2)	-0.005	0.961	0.995
Trees (0)	0.691	0	1.995
Street (0)	-0.679	0	0.507
Setback (0)	0	-	1

*The housing typologies had no statistical significance

C_1:	Typo (0), Trees (0), Street (0), Setback (0)
C_2:	Typo (0), Trees (0), Street (1), Setback (0)
C_3:	Typo (0), Trees (0), Street (1), Setback (1)
C_4:	Typo (0), Trees (0), Street (0), Setback (1)
C_5:	Typo (0), Trees (1), Street (0), Setback (0)
C_6:	Typo (0), Trees (1), Street (1), Setback (0)
C_7:	Typo (0), Trees (1), Street (1), Setback (1)
C_8:	Typo (0), Trees (1), Street (0), Setback (1)

	$\exp(x_1\beta)$
C_1:	1.011465
C_2:	1.995
C_3:	1.995
C_4:	1.011465
C_5:	0.507
C_6:	1
C_7:	1
C_8:	0.507

	$\exp(x_1\beta)/(\exp(x_1\beta))(\exp(x_2\beta))$	as %
Choices 1/2:	0.336429993	33.64%
Choices 1/3:	0.336429993	33.64%
Choices 1/4:	0.5	50.00%
Choices 1/5:	0.666110184	66.61%
Choices 1/6:	0.502849913	50.28%
Chocies 1/7:	0.502849913	50.28%
Chocies 1/8:	0.666110184	66.61%
Chocies 2/3:	0.5	50.00%
Chocies 2/4:	0.663570007	66.36%
Chocies 2/5:	0.79736211	79.74%
Chocies 2/6:	0.666110184	66.61%
Chocies 2/7:	0.666110184	66.61%
Chocies 2/8:	0.79736211	79.74%
Chocies 3/4:	0.663570007	66.36%
Chocies 3/5:	0.79736211	79.74%
Chocies 3/6:	0.666110184	66.61%
Chocies 3/7:	0.666110184	66.61%
Chocies 3/8:	0.79736211	79.74%
Chocies 4/5:	0.666110184	66.61%
Chocies 4/6:	0.502849913	50.28%
Chocies 4/7:	0.502849913	50.28%
Chocies 4/8:	0.666110184	66.61%
Chocies 5/6:	0.336429993	33.64%
Chocies 5/7:	0.336429993	33.64%
Chocies 5/8:	0.5	50.00%
Chocies 6/7:	0.5	50.00%
Chocies 6/8:	0.663570007	66.36%
Chocies 7/8:	0.663570007	66.36%

E. Research Process Diagram