Cities and People Project:
A White Paper on
Human Interaction with the Built Environment

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I. Executive Summary

This research conducts a broad examination of the human interactions with the built environment in relation to the goal of creating low-carbon cities. Cities are composed of the interactions of buildings, spaces and people. While individual buildings or groups of buildings may use the latest in green technology, how people incorporate the urban built environment into their lives does more to promote low-carbon cities than technology alone can.

This research project focuses on the social, cultural, and psychological dimensions of human behavior in the urban context. We attempt to highlight the ways that these dimensions work to promote or hinder the movement toward carbon neutrality, with a focus at the municipal level within the U.S. context. The U.S. context is important for the substantive reason that, per capita, Americans contribute more greenhouse gases than anyone else.

Specific elements of urban design—such as transit, biking, walking, mixed-use development, density, and multi-functioning open spaces—are increasingly being used to promote carbon-neutral cities. This research examines how basic processes of social psychology, as filtered through cultural background, socioeconomic status, and other demographic factors, affect how different groups engage with each of these elements of the built environment. We review over 130 citations drawn from the fields of environmental psychology, environment and behavior studies, city planning, sociology and anthropology to aid in this endeavor. The report also consolidates the insights of key experts in planning and design in both professional and academic fields, as well as including expertise from within the Institute.

One way to summarize the Findings is that one must not over-generalize the actions of "people," because their cultures, motivations and capacities are so varied. Talking about "people" in general is no more productive in the urban planning realm than talking about "buildings" or "infrastructure" in general.

We identified the following key conclusions and recommendations for thinking about planning for carbon neutrality. All of these are described in more detail in the Overall Findings section of paper. Our key conclusions include:

1. **The stage in your life strongly influences where you want to live.** There is more variation in interaction with the built environment across a given individual's lifetime than there is between different socio-demographic groups.

2. **Gender significantly structures interactions with the built environment.** More precisely, studies have shown that women have particular needs and expectations of city amenities and public transit, specifically as they pertain to their sense of personal safety in the urban context and whether or not they have children.

3. **Peer/social norms influence how people use space.** The importance of peer groups and social norms as influences on how people use space and environmentally sustainable transportation options acts as an important foil to analyses that emphasize the role of information in behavior change.

4. **The historical regulation, planning, and management of spaces influence their present day use.** Cityscapes evolve over time, yet the residues of earlier planning and management inevitably shape the way people think about and interact with buildings and spaces.

5. **The "feel" or embodied experience of space and transit is important for determining how people will use them.** Aesthetics and related design elements can act as powerful incentives to use urban public spaces and particular modes of transit.

6. **Upward social mobility will influence housing and transportation choices for new immigrants.** As immigrant income increases, the continued use of these more sustainable patterns decreases in favor of private automobiles. The implications of this for low-carbon development are significant.

Our recommendations for applying this research and moving forward include:

1. **Specific social scientists and behaviorists need to be basic parts of expert teams that plan and implement urban developments.** Given that how "different groups of people" use a given environment is more relevant than how "people" in general use the same environment, the perspective of social scientists will help planners and developers gain insight into the needs of different groups throughout the development of a project.

2. **Be critical when using design precedents: One size "doesn't fit all."** The context of a place is important. Buildings and open spaces that "succeed" in one place and at one time may not translate to other places and times. The context matters: not only the political, socio-demographic, and cultural context, but also the historical context.

3. **Buildings and spaces intended for one set of functions can be appropriated for new uses.** The provision of infrastructure and amenities may be perceived as a "fixed" and single-use asset, but they may actually function with variation and be of little value regarding their original purpose. The built environment does not just structure human behavior; humans also "act back" on buildings and spaces.

4. **Flexible design is key.** Despite the ability of humans to "act back" on the built environment and re-appropriate it for new uses, the design limitations of the physical infrastructure remain in place. One approach is that even within a large project, there might be opportunities to design an open plan that consists of more smaller components rather than fewer large components.

5. **New concepts of the roles of public and market-based incentives are required to make low-carbon cities feasible.** The public goods of GHG reduction and livability will likely require more of a public role in providing incentives for builders, as well as new concepts for private return on investment, which will include all elements of the "triple bottom line": financial, environmental and social. Fortunately, new investment models are emerging, new roles for government are evident in the work of the C40 Cities, and a new generation's expectations for low-carbon lifestyles are being practiced as well as theorized.

At the conclusion, we offer elaborations on these key findings and recommendations, and avenues for further research as well as leadership opportunities to move us forward.

II. Introduction

A. The 21st Century Challenge: Climate Change

Climate change is now an undeniable problem that must be dealt with at multiple scales: global, national, regional, and local. Urban design and planning have the potential to mitigate and offer adaptive solutions most effectively at the local level. According to the International Panel on Climate Change (IPCC 2007a), extreme weather events are expected to become more intense and/or more frequent with the onset of climate change. In an increasingly urbanizing world, the economic and social costs of these events will be greatly magnified for cities. As average temperatures increase worldwide, severe storms, tropical cyclones, extreme rainfalls, riverine floods, heat/cold waves, and droughts will all become more numerous. Rural-urban migration is expected to be a significant problem in the Global South, especially if extreme weather events cause population displacement (IPCC 2007a). According to many studies (Drogue et al. 2004; Ewing et al. 2008; IPCC 2007b), the recent temperature rise has been exacerbated by human activity, namely through the emission of greenhouse gases (GHG).

Specifically, carbon (CO_2) emissions measured in cities are largely responsible for the climate change problem via two sectors pertinent to city planning: transportation and buildings. Transportation is a significant contributor and accounts for 33.5 percent of the United States' energy-related CO_2 emissions (Ewing et al. 2008). Energy use by people in buildings contributes even more significantly to emissions, accounting for 46.9 percent of U.S. CO_2 emissions (U.S. Energy Administration 2009). In 2008, the building sector accounted for 40 percent of U.S. total energy consumption, and the transportation sector accounted for 28 percent (US Department of Energy 2008). Within an urban development context, Norman et al. (2006) suggest that targeted measures to reduce GHG emissions should be aimed at transportation-related emissions, while targeted measures to reduce energy usage should focus on building operations.

The proposed solutions to the climate change problem so far have been physical, infrastructural, and technical fixes, such as the promotion of more fuel-efficient vehicles, smart growth and "LEED-ND[1]" planning and "green" buildings. However, the root of the problem remains an anthropogenic one. A gap remains in the study of human activity and behavior in relation to low-carbon development and sustainable consumption that is just starting to be examined. The American Psychological Association (APA 2010) has emphasized that psychologists can provide behavioral analysis of how people consume by focusing on individual predictors of consumption, such as ability (income, skills) and motivation (needs versus wants), and contextual predictors of consumption, such as the opportunities and constraints afforded by physical infrastructure. The Garrison Institute (www.garrisoninstitute.org) has begun to generate networks of institutions and city-level leaders to put existing research into policy. These lines of research and policy are emerging, but the pursuit of carbon neutrality needs to be further refined as a qualitative sociological, anthropological and psychological pursuit in terms of how individuals behave and what infrastructure exists.

[1] LEED-ND is an acronym for Leadership in Energy and Environmental Design-Neighborhood Development. It is a rating system that integrates the principles of smart growth, urbanism and green building into the first national system for neighborhood design. LEED-ND is a collaboration among the United States Green Building Council, Congress for the New Urbanism, and the Natural Resources Defense Council.

It is not merely enough that cities are conceptualized as "sectors" that happen to contain people; further analysis *at the level of the individual* is required. Reorganizing the discussion in this way changes the way we frame our questions: instead of using terminology such as "transportation sector," academics and practitioners need to instead investigate "how people transport themselves." The current state of the field uses terminology like "building sector" and "transportation sector" because they allow the organization of measurement. This can lead to technological solutions, such as improving efficiency in machinery. However, this bypasses the effects that humans have on the system. In fact, it is the human activity in these sectors that generates GHG. The shift in focus from sectors to human activity challenges us to look beyond technological solutions that may be applied on a widespread scale and instead to examine more closely the unique characteristics of how different people live within a given place. Emphasis on sectors, as they are defined, also reinforces solutions based on trends, an approach that may be inadequate given that we are faced with the disruptive reality of climate change.

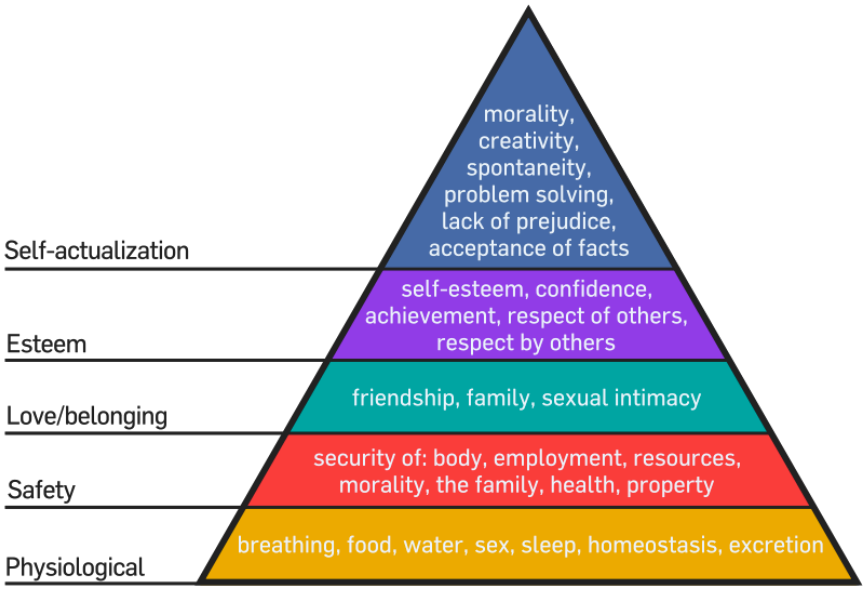
We can also make our language more appropriate to the work ahead; for example, what is conventionally referred to as "alternative transportation" (walking, bicycling and public transit) needs to be redefined as "sustainable transportation"— the baseline norm that needs to be reached, rather than the alternative to the "primary" form of personal vehicle use. Re-structuring the dialogue around the human needs and wants that drive these larger scale problems of climate change and fossil fuel use will help us generate different solutions than those that are already being tested.

B. About The Cities and People Project

Arup Global Research sponsored the research for the Cities and People Project with the Institute for Environmental Entrepreneurship in order to synthesize knowledge on how humans interact with the built environment, with a specific focus on the social, cultural, and psychological dimensions that shape these interactions in ways that facilitate and/or hinder efforts to create a carbon-neutral city. The Project drew on the strengths of Arup's practice-based research in engineering, technology, and design. Much of the climate change research in Arup's Research Roadmap for 2010, as well as their work with the C40 Cities initiative, involves a component of human behavioral research. In this and other documents, Arup draws on the psychology of sustainable behavior (Manning 2009; Arup, "A Framework for Community Engagement" 2010; Arup, "Low-carbon lifestyles"), which emphasizes the role of information in driving behavior change. This (implicit) theorization of human behavior neglects other drivers of practices; much of human interaction with the built environment is a matter of habit or norms, which are culturally and socially generated and perhaps less susceptible to change through information alone. Sociologists recognize that there are greater behavioral differences among cultures than within cultures. Understanding individuals as embedded in cultures, social groups and networks, and socioeconomic structures, IEE built out from the "user focus" of our research to consider how cultural, social, and structural overlays inform human interaction with the built environment, particularly in relation to the task of reducing carbon emissions.

The emphasis on these overlays also highlights the existence and significance of meaningful differences between groups of people, which inform and are reflected in their patterns of practices. In the research that follows, we are especially attentive to how the answers to our research questions differ for different socioeconomic and racial/ethnic groups, for people of different ages and genders, and for people at different stages in life and in different roles. Being precise about *which* populations we know about allows us to avoid problematic generalizations regarding how "people" in general act and what motivates them. Cities are diverse places, and designs for carbon neutrality will intersect with many different needs, wants, and lifestyles.

Maslow's (1954) hierarchy of human needs provides a useful framework for assessing the success of urban buildings and spaces [see Figure 1]. While the precise ranking of needs has been criticized on empirical and theoretical grounds, the hierarchy provides a useful framing for the research questions undertaken in the Project. IEE has sought out insights in published scholarship and in interviews with experts regarding how culturally and socially inflected needs are generated. How do people expect to—and actually—fulfill their needs and wants in the urban context? How do we differentiate between a truly human "need" versus luxuries we "want"?



C. About the Report: Organization and Methods

This report was developed in close collaboration with representatives from Arup's San Francisco, California office and London, England headquarters. A comprehensive academic and professional literature review with over 130 articles was conducted in the three areas of 1) mobility and culture, 2) density and culture and 3) open space and consumption. Journals reviewed ranged widely from transportation planning, housing policy, urban design, sociology, environmental and public health studies, landscape and urban planning, and leisure studies. When appropriate and topical, practitioner-based documents and materials were also reviewed.

In addition, interviews were conducted with a variety of experts from the fields of urban planning, urban design, landscape architecture, transportation and geography. Academics were interviewed, a strong majority of whom are currently engaged in teaching and research at the University of California, Berkeley. Practicing professionals in design firms and think tanks, such as Van Meter Williams Pollack LLP (VWMP) and the Center for Resource Efficient Communities (CREC), were also interviewed in the Bay Area.

III. Mobility and Culture: Factors that motivate people to use lower-carbon forms of mobility [2]

A. Travel by Private Vehicle: The time-cost trade-off impacts mode choice for all classes

Of the experts interviewed, most agreed that the topic of mobility and culture was well-covered in the literature. However, one of the main caveats is that sociodemographics are usually controlled for in "travel-and-the-built environment" studies, which examine how urban form impacts travel choice (Ewing and Cervero 2010), and stated preference or revealed preference studies (Dill and Voros 2007). Intersectional patterning, whereby one examines how various biological, social and cultural categories such as gender, race, class, ability, and other axes of identity[3] interact on multiple and often simultaneous levels, is not generally carried out. As such, this study seeks to illuminate that controlling these sociodemographic variables is not always beneficial, especially when considering the needs of specific populations, such as ethnic and racial groups. Closer study of income, race, ethnicity and gender needs to be done regarding these social costs and trade-offs for trip-making and will allow us better to understand how different groups rationalize choices related to low-carbon cities.

A significant contributor to CO_2 production in and near U.S. cities is the use of motor vehicles for making daily trips. One contributor to private car use is post-WWII land use planning and regulation, which prioritized the suburban lifestyle, and a mid-century government focus on freeway planning in major U.S. cities. This trajectory of planning has produced present-day suburban sprawl that disconnects cities and neighborhoods today in North America (Southworth and Ben-Joseph 1995). The persistent draw of the suburbs on these grounds has led to the worsening of suburban commuting sheds in the San Francisco Bay Area of California over the years, despite the fact that, with transportation costs accounted for, the cost of living in the suburbs is often higher than in the cities (Center for Neighborhood Technology 2012). Robert Cervero (1989), Professor of City and Regional Planning at UC Berkeley, notes that the third wave of suburbanization"—the displacement of white collar office jobs to the suburbs, and high Bay Area housing costs and shortages— encouraged a jobs-housing imbalance, where most Bay Area suburban workers resided outside of their immediate employment area. Actively providing workers the opportunity to reside close to their job sites if they so chose could have ameliorated this problem. In 1996, Cervero revisited this study and found that jobs-housing imbalances had generally worsened in the Silicon Valley area (in other areas it had decreased due to the creation of "dormitory" housing near office parks). Cervero discovered that restricted housing production in fast-growing cities had in many cases increased housing prices, displacing workers and increasing average commute distances (Cervero 1996). Additionally, North Americans show particularly strong cultural attachments to personal vehicle ownership and use (Wachs and Crawford 1992; Wollen and Kerr 2002; Cervero 2011).

By comparison, Europe fares much better in terms of the number of trips people make by taking sustainable transportation: walking, bicycling and transit use. Cities such as Copenhagen have

[2] Please note that many of the issues discussed in this paper relate to both the disabled and general populations. However, there are significant obstacles faced by disabled people regarding many aspects of urban life, and for those, separate research is vitally needed.

[3] These often interact together to contribute to social inequality.

made large strides in reducing citywide carbon footprints by making bicycle use and infrastructure a priority (Arup 2011). According to Cervero (2011), Europe is moving towards low-carbon at a faster rate, because they possess higher fuel taxes, car registration and licensing fees. This type of regulation promotes the increased use of public transport, bicycling and walking. This is but one of many examples throughout our research illustrating the importance of regulation in modifying behavior toward lowering carbon emissions.

One of the primary challenges in reducing emissions from transportation is finding ways for people who are already currently using private cars as their primary transportation to change to more environmentally sustainable forms of transportation, such as walking, biking or public transit. With respect to socioeconomic status, Cervero (2011) stated that one of the largest trade-offs for people, especially those who are more affluent, is door-to-door travel time. If people can make a more rapid trip in their cars, they are more likely to take their vehicles. However, if people can make the trip within the equivalent time using a commuter train, while reading or working via mobile devices, then this is perceived as a better choice as they are 1) productive and 2) the trip itself may be less stressful. At the 2011 Pacific Cities Green Transportation Conference, Jeffrey Tumlin (2011) mentioned that the addition of free wireless Internet aids in increasing a transit rider's productivity. Karen Chapple (2011), also a Professor of City and Regional Planning at UC Berkeley, seconded this statement, by relating that productivity drives commute choice among high-income populations. Chapple (2011) also mentioned that such regional commuter trains are more common and have better networks in the eastern United States. In the west, and in particular the Bay Area of California, she notes, real commute choices do not exist, unless you live within a reasonable distance of the Bay Area Rapid Transit corridor. Ultimately, Chapple believes that more regional commute options and close housing proximity need to be made available in the Bay Area, in order to persuade high-income populations to take transit.

Cervero (2011) and Chapple (2011) both mentioned that while productivity drives choices for more affluent populations, price is the primary mode-choice driver among low-income people. Ultimately, the cheapest alternative will always appeal the most to low-income populations, which is usually public transit, namely buses. To most, the cost of using public transport is a very visible cost. The out-of-pocket daily fare for transit may seem like one is constantly "shelling out" more, in comparison to using one's own vehicle (Cervero 2011). However, there are many "sunk costs" in vehicle usage, including maintenance, insurance, and parking, which are not perceptibly incorporated into this mental trade off. In addition, if deeply discounted passes (Nuwoorsoo 2004) are used in place of daily tickets, people are more likely to believe they are getting more value for the money out of their transit pass. When immigrants first arrive in the U.S., they tend to have lower incomes, without as much access to private cars, and to use sustainable forms of transportation (Chatman & Klein 2009, 2011). Given past trends of upward social mobility by immigrants and that private car ownership and use is a part of this, further research needs to be done on how to maintain and promote the use of sustainable transportation choices among these emerging groups of private car users.

There is some evidence that points to carshare and casual carpooling programs as increasingly popular alternatives to ownership for some vehicle users. These rapidly expanding programs, which develop through the active collaboration of private entrepreneurs and public institutions,

provide a glimpse into how transportation needs might be met differently in low-carbon cities. In their longitudinal study, Cervero et al (2007: 70-71) found that four years after the initiation of San Francisco's City CarShare program, users were split evenly between female and male, with an average age of 39.6 years. The racial/ethnic distribution was 77.1 percent white, 6.5 percent Asian, 4.5 percent African American, 4.2 percent Latino, and 7.7 percent "other." Participating households surveyed had a median household income of $50,000. Around one-third of surveyed users lived alone, and more than 75 percent lived in carless households.

Casual carpooling is also another phenomenon that appeals to commuting professionals. According to Kelley (2007), casual carpooling refers to the "sharing of a ride with a driver and one or more passengers, where the ridesharing between the individuals is not established in advance but coordinated on the spot." Chwierut et al. (2011) and Deakin et al. (2011) found that casual carpoolers in the San Francisco Bay Area are highly educated and possess higher than average Bay Area incomes. Cost savings and time savings (through toll discounts and use of High Occupancy Vehicle lanes) historically have been the two main reasons why casual carpoolers initially choose this option and continue to do so. As such, productivity and time-cost tradeoffs are certainly relevant for professionals when they decide on a commute option.

Looking beyond the everyday commute to long-distance and vacation travel, it is evident that one's willingness to jet somewhere for a vacation versus our careful trip-chaining is a trade-off that negatively affects the development of low-carbon cities. In an attitudinal study carried out in South West England, Barr and Prilwitz (2012) illustrated that despite strong statements of environmental concern and the belief that climate change is an imminent threat, individuals showed less commitment to avoiding highly polluting forms of transport when they went on holiday. This mobility style issue needs to be considered in the application of social marketing approaches for behavior change. In essence, there is a symbolic value embodied in the idea of a "holiday," and thus it is treated differently than everyday commuting.

B. Travel by Transit: Accessibility and Comfort

1. The "gender-blind" nature of transit has detrimental impacts on accessibility

The study and planning of public transit has generally been "gender-blind" (Law 1999) with regard to planning for women's needs, especially women of color, in part because of the domination of transportation and civil engineering by men (Chinn 1999). Within engineering, there is an assumption of a certain level of physical capacity and proportion, the universal standard figure being a white male, for whom there are no real challenges of accessibility (Preiser and Ostroff 2001:16.1). To increase transit use, gender, age, and disability truly need to be considered more often when planning for transit systems in order to meet the accessibility needs of all populations. Planning for a more diverse user population should also be sensitive to the daily needs of different individuals. For instance, professionals who use transit to commute may prize comfort, Internet access, and workspaces. Individuals who use transit to accomplish tasks connected to caregiving—shopping, transporting children and the elderly, etc.—may prioritize spaciousness, ease of entry and exit, and designated areas for strollers and wheelchairs.

Studying the needs of women transit users generally has implications for all transit users. When gender has been addressed in relation to transit, it has focused more narrowly on women's typically shorter work trips (Gordon, Kumar, and Richardson 1989; Hanson and Johnston 1985), and other "significant gender differences in trip purpose, trip distance, transport mode and other aspects of travel behavior " (Law 1999:518). At no point has transportation planning engaged wholeheartedly with women's needs, although the writings of Law (1999) have begun to lead this sector in becoming more attuned to the multi-dimensional world of gender. For example, women are often the majority users of public transit in North America (Sandercock 2005:53), and as such the effects of the cost of transportation on their budget and livelihood are compounded if prices rise. Furthermore, women often have to take their children or elders on public transit and benefit immensely from walkable distances and safe routes to schools, childcare, eldercare, parks, and community/recreation centers. Accordingly, both directness and ease of access for them is particularly important when planning trips. Interestingly, transportation policy has not often taken into account or considered the difference between men's and women's body sizes, stature, and shape, while planning transit amenities, although this has been cursorily explored by Little (1994). Yet such studies are still not comprehensive enough.

More recently, women's fear of using transit and unfamiliarity with transit systems has come into the spotlight as a particularly gendered element with respect to populations and commute mode choice. Although women are more likely to use transit that men (Sandercock 2005), it does not mean that they choose to do so willingly. In her dissertation research (completed in 2000), Karen Chapple (2011) found that low-income African-American women on welfare in the Bayview/Hunter's Point area of San Francisco had an aversion to the city's Bay Area Rapid Transit (BART) system and possessed deep suspicions about it. They actually preferred taking the bus, as they were more familiar with it. Familiarity and a sense of security was clearly an important concept for these low-income women. To them, BART was not familiar, especially the long underwater tunnel between the Embarcadero stop in San Francisco and the West Oakland stop across the bay. Taking Muni (the city's light rail system) or the bus was preferable; BART was perceived as a "scary" experience for them. Geographic familiarity with the Bay Area, in this instance, represented an ability to expand their job search range. As such, if these women had possessed more geographic familiarity, they may have had greater residential mobility and access to a larger labor market radius.

Overall, commuting has a greater detrimental psychological impact on women than on men (Roberts, Hodgson, and Dolan 2011). Roberts et al (2011) argue that this is due to the fact that women's greater sensitivity to commuting time seems to be a result of their larger responsibility for daily household tasks, including childcare and housework. Similarly, Rapino and Cooke (2011) in their study have found that women's gender roles tend to negatively affect their commuting range, thus devaluing their labor market status.

While such studies assess and reveal accessibility levels and residential mobility for women at the level of the regional economy, others have attempted to address defined problems within the transit systems themselves. The United States has not fared well in terms of instituting schemes and policy for gender equality within transportation and addressing perceptions of fear. Loukaitou-Sideris (2009) completed an assessment of U.S. transport policy with regard to gender equality. She found that any special attention to the specific anxieties and needs of women

passengers is all but missing from the practices of U.S. governmental and transit agencies. Ultimately, there is no funded mandate for this, there are limited financial resources, and few risk management calculations are undertaken. Loukaitou-Sideris (2009) found that women have distinct safety/security needs and are often fearful in transit settings with specific social and physical characteristics. Fear leads women to adjust their behavior and travel patterns, for example, by avoiding certain modes or routes altogether or at night. She discovered that age, income, type of occupation, sexual preference, and place of residence also impact one's sense of vulnerability. Specifically, minority and low-income women who live in high-crime neighborhoods are particularly vulnerable. In general, older women feel less safe than younger women feel. Two other groups of women who feel less safe are women with disabilities and lesbians. The environmental factors associated with greater fear include darkness, desolation, lack of opportunities for informal surveillance, lack of maintenance, and poor environmental quality. Loukaitou-Sideris (2009) found that women look for "cues" that an environment is safe, e.g. lighting. Such environmental design responses suggested by women include: design features like lighting; maintenance; presence of staff/policing; and education and outreach.

With regard to the international scope, the UK has addressed gender equality in public transport systems more comprehensively from a public policy standpoint than North America. In London, the Gender Equality Act was passed in 2006. This act mandated that all public authorities would document how they hope to improve gender equality and harassment (with a focus on women). In terms of public transport in London, a woman prefers the bus to any other mode of transport. This is similar to findings from Chapple's research, in which women preferred the bus because they were more familiar with it, and it served lower income groups better. The Transport for London (2007) report states, though, that the reason is not due to familiarity, but instead to cost, the proximity of the bus stop to a journey's beginning and end, the directness of routes, speed and convenience. Although a woman will use the bus more often than a man, she will use the Underground less often, as they are worried about safety and security issues. According to the report, both rail and the Underground are mainly used by women who don't have children. The presence of CCTV (closed circuit and monitoring television), attendants, and informational architecture is suggested as a solution to ameliorate this. She is also more likely to walk, but less likely to cycle. On average, women also make more overall daily trips than men, due to their roles as caretakers and the "trip-chaining" effects of shopping and accessing childcare and educational facilities. These trips are shorter than men's commute trips and typically within their own borough, done on foot and by bus. However, women prefer the car for carrying groceries and other items that are difficult on public transit. A woman with a child under the age of five is 87 percent less likely to drive than a man. Only 57 percent of London women have a driver's license, compared to 75 percent of men; this difference narrows for 17-24 year olds (40 vs. 46 percent) (Transport for London 2007:19). The "women as carers" angle on this highlights the influence of life events in determining habits; women may not be significantly more likely to drive, but *mothers* are.

Mobilizing urban design principles for conditions of public safety in transit scenarios that accommodate women's needs is an area of planning that is relatively new, but there is widespread recognition that this area needs attention (Kallus and Churchman 2004). One strong effort that stands out in the field to ensure public safety in the urban environment for women is Crime Prevention Through Environmental Design (CPTED) (ICA 2007), which provides

physical design guidelines that attempt to deter criminal behavior through the design of safe spaces, given dangerous urban conditions. Design elements and strategies include reduced glare lighting, a focus on transparency, windows at street level, non-sight limiting fences and encouraging pedestrian and bicycle treatments. As Day (1999:325) concludes, "fear in public space is shaped by one's identity—including race, class, and gender. It is misleading to speak of women's fear as if it were uniform, because race, class, and gender are not always equally salient in the experience." Although a relatively new field of study since the late 1980s and 1990s, CPTED can be used as a guideline to promote safer spaces for women within the urban context (Cozens 2008), given similar problems in different communities. By surveying, interviewing, and soliciting responses about safety in certain communities, specific or latent cultural issues may arise that had not crossed the minds of planners or designers. For example, in some cultures and communities, women are not permitted to walk in the company of men who are not related to them. The way some women experience the built environment is profoundly related not only to the characteristics of the environment but also to the status of women in the society and their cultural backgrounds (Kallus and Churchman 2004: 199). Cultural factors can thus influence time of day activities and demonstrate how the "geography of fear" (Valentine 1989) can be especially constraining for women in various different communities. One community-based tactic planners can utilize is a "safety audit" (Sweet and Ortiz Escalante 2010:2133). A safety audit consists of a community member or planner gathering a group of women to walk through a particular environment, usually in the evening, evaluating feelings of safety and noting ways to make that space safer.

2. The "bodily experience" on transit needs to be a dignified journey for all

Taking transit is not just an economic trade-off. There are also social costs and aspects that are embedded in one's decision to take transit. One such social aspect is the "bodily experience" of taking transit. Authors have written extensively from a phenomenological and cultural perspective of "dwelling" and experience in the built environment (Christian-Norberg Schulz 1988) and thermal comfort within buildings (Heschong 1979), but less has been written about comfort and quality in public transit systems.

Jeffrey Tumlin (2011) noted that to increase public transit use, the experience must be a "dignified journey"—a journey that is safe, on time, reliable and comfortable. In our discussions with John King (2011), he noted that systems should not feel "run-down." A system needs to be trustworthy and frequent. For example, King discussed the fact that many American bus systems have more trouble, due to anti-social behavior, in comparison to rapid transit systems like BART in the San Francisco Bay Area, which are more reliable and known for their comfortable seats. While buses function for those with the lowest income (Cervero 2011, Chapple 2011), it was mentioned that they do not provide the same level of comfort, frequency and reliability in order to draw in the more affluent people. Cervero (2011) mentioned that buses are lumbering vehicles that have to stop frequently, whereas rail possesses a grade-separated system with better flow, so it is perceived to be more comfortable for riders. In all of our interviews, it was expressed that BART provides the most alluring option for more affluent people.

In terms of personal comfort, Edward T. Hall (1966) completed a variety of qualitative studies on "proxemics": how different cultures perceive and act in space differently, including

possessing different personal boundaries. Hall (1966) believed that all cultures have some variation on how they negotiate 1) intimate distance (0-1.5 feet), 2) personal distance (1.5-4 feet), 3) social distance (4-12 feet) and 4) public distance (12 + feet). For example, in Japan, the concept of space, or the *ma*, is entirely different from spatial concepts "Western" culture (Hall 1966 19-144). How people negotiate their own personal spatial boundaries, given their cultural background, will thus affect how they experience a trip and perceived levels of crowding. Academics refer to proxemics today and Hall's work stands as a classic piece in environment and behavior studies, but no recent studies have expanded upon the topic.

C. Travel by Bicycle

1. The typical cyclist

One important question today is who is the typical commuter cyclist in North America? If researchers have a better idea of the trends regarding who is taking sustainable transportation and their reasons for doing so, then they will be better able to understand how to encourage cycling commutes at a larger scale.

In their appraisal of cycling trends in North America aggregated from 2009 ACS and 2010 Statistics Canada data, Pucher et al. (2011) found that cycling is concentrated in the central cities, especially near universities and gentrified neighborhoods. In another study, Buehler and Pucher (2011) also discovered that cities with lower rates of auto ownership, more students, safer cycling, less sprawl, and higher gasoline prices possessed more commuter cyclists. The authors state that almost all the growth in commuter cycling in the USA has been among men aged 25-64. With regard to women, cycling rates have remained stable, but for children they have fallen. In both Canada and the U.S., cycling rates are higher in the Western parts of the countries, but the geographical disparity is much greater in the U.S. (Pucher et al. 2011:452). They note that the bike share of work commuters is especially low in the southeastern part of the U.S. They also state that social and recreational trips continue to have a higher bike mode share than work trips (2.5 percent as compared to 0.7 percent) (Pucher et al. 2011:454).

2. Social and peer norms significantly influence commuter cycling rates

Social and peer norms have been found to positively affect bicycling commute rates. Dill and Voros (2007), in their survey of cyclists in Portland, Oregon, found that those who had coworkers who cycled to work, those who lived in households with other adults who cycled regularly, or who saw adults cycling on their street frequently, were more likely to be regular cyclists themselves. Handy and Xing (2011) argue that the attitude of one's supervisor towards bicycle commuting is significant. The implementation of "soft strategies," such as bike-to-work days, and guidance on community bicycle routes, are shown to have a measurable impact on bicycling (Pucher, Dill, and S. Handy 2010). According to Eliot Rose (2011), basic education, awareness and social exposure towards commuter cycling is integral for people to feel comfortable enough to change modes. If people see others biking and walking, they are likely to do it more themselves.

Outside of the U.S., in their study of bicycle use in Germany, Goetzke and Rave (2010) discovered that one's social network and peer group will increase one's probability of cycling for shopping and recreational activities. However, one's social network will not increase their probability of cycling for commuting to work, school or errands. As such, cultural norms are just as influential as social norms, in determining cycling patterns around the globe. These are similar to cultural and social factors contributing to the attractiveness of the private car, perhaps providing hope for mode shifts away from cars to bikes.

3. Fun and fitness through bicycling fulfills human needs

Bicycling is not just about making the trip to work. It is also about having fun and keeping fit. Handy and Xing (2011) state that comfort level and enjoyment are the biggest factors in a person's decision to cycle to work, alongside the peer impetus mentioned above. McCarthy (2010) found in 41 qualitative interviews of commuter cyclists in Charleston, South Carolina, that exercise and fitness is the number one ranked individual reason for cycling, followed by "doing something good for the environment and nature," followed by enjoyment.

For some, bicycling offers a fun, unique lifestyle. Fincham (2007) has studied the culture of bicycle couriers in the U.K., from an ethnographic perspective. Fincham (2007) notes that bicycle couriering has become a new subculture, a vocation that allows flexible work hours in the face of the 9-5 standard. Overall, the overwhelming response Fincham received as the rationale to the adoption of a bicycle courier lifestyle was the sense of enjoyment and fulfillment it provided. The opportunity to "cycle for a living" and the unconventional, trendy lifestyle if offered were perceived to be the largest benefits. This illustrates that young people are venturing toward employment and modes of transport that allow them to experience both physical and social enjoyment.

4. Motorists and non-cyclists perceive cyclists as eccentric and dangerous

How people perceive bicyclists on a daily basis impacts how bicycling is perceived as a future, viable commute choice for larger populations. Gatersleben and Haddad (2010) attempted to answer how bicyclists are perceived in the U.K., by interviewing 244 bicyclists and non-bicyclists. They found that four different stereotypes of bicyclists emerged: the "lifestyle cyclist", the "responsible cyclist," the "commuter cyclist" and the "hippie go-lucky" cyclist. "Responsible cyclists" were perceived to be courteous users of the road who abide by rules, stop at traffic lights and are kind people. In contrast, the "lifestyle cyclist" is someone who uses the bicycle for a variety of trips and may spend a significant part of his/her income and time on cycling, similar to a hobby. They are more likely to bike on scenic, mountainous terrain and be part of a biking club. Importantly, the more people perceived the typical bicyclist as someone who uses their bicycle for normal day-to-day activities, the more likely they were to indicate they would take up bicycling in the future. The "commuter" cyclist is perceived as a young professional male, assertive and well-educated, who commutes in all-weather conditions. Finally the "hippie go-lucky" cyclist is more likely to be thought of as cycling for everyday activities such as shopping, not owning special equipment, and more likely to be kind and female.

One of the major barriers to converting more people to bicycle commuting is the negative stereotypes that are perpetuated about cyclists. Gatersleben and Haddad (2010) note that if bicycling is stereotyped as an activity exclusive to a few energetic people, and not as an activity that can be incorporated into daily life or perceived as normal, this can be a major barrier to the increase of numbers of bicyclists and bicycle trips. The authors frame the discussion by emphasizing that marketing and information campaigns should target and endorse bicycling as an everyday activity, conducted by normal people.

With regard to attitudes toward bicycling, in their U.K. study, Gatersleben and Appleton (2007) found that people who had never contemplated cycling had very different attitudes about cycling than did infrequent or frequent cyclists. They found that non-contemplators possessed the most negative attitudes towards bicycling and were most likely to think that they would feel uncomfortable on a bicycle. They were also more prone to thinking others would find it strange if they used a bicycle. The authors suggested that public information campaigns designed to enhance the image of the cyclist might be effective, relative to those focusing on health and safety.

In general, many motorists have a negative perception of cyclists. Handy et al (2010) discovered that there is a public perception in the U.S. that "most bicyclists look like they are too poor to own a car" (2010: 978). In addition to being perceived as impoverished, cyclists are also perceived as hazardous to others on the road. In a study conducted by Sharpe et al. (2011) in South Carolina, researchers found that most motorists understood that cyclists have a legal right to ride on the road. However, approximately one half believed that cyclists created a traffic hazard, even when they follow traffic rules. From the other perspective, the cyclists expressed safety concerns and felt threatened by motorists. Sharpe calls for education of both user groups, regarding sharing the road, in order to increase tolerance.

McCarthy (2010) conducted 41 qualitative interviews with commuter cyclists in Charleston, South Carolina. Thirty-nine out of 41 of her respondents revealed that the risky behavior of motorists is part of an anti-bicycle culture. She argues that motorist, anti-bicycle culture is based on a system of exclusion in which drivers are insiders who belong on the road and treat cyclists as outsiders who do not belong. Commuter cyclists are seen as "norm violators." Ultimately, drivers—who see themselves as the insiders on the road— do not feel any moral obligation to take precautionary action when in the presence of cyclists. This dynamic makes cycling even more dangerous for bike riders.

In addition to negative perceptions and attitudes, cyclists also experience direct verbal harassment from motorists. Heesch et al. (2011) conducted a study of 1830 survey respondents in Queensland, Australia. Interestingly, 72 percent of women and 76 percent of men reported harassment while cycling in the previous 12 months. The most common forms of harassment included 1) driving too close (66 percent), 2) shouting abuse (63 percent) and 3) making obscene gestures/sexual harassment (45 percent). Those who lived in higher-income communities and those who cycled for recreation and competition were more likely to experience forms of harassment. Old age, obesity, less cycling experience (less than two years), and less frequent cycling (less than three days/week) were associated with decreased harassment levels. These findings are significant as they suggest that from a gendered perspective, women who cycle do

not perceive more harassment than men, although females may initially limit their cycling due to fear of harassment and safety concerns (Garrard et al. 2006). Heesch et al. (2011) argue that in order to deter hostility, campaigns that raise awareness of acceptable road behavior and that reinforce the rights of the cyclists are particularly warranted.

Walker (2007), in his examination of motorists overtaking cyclists, has found that cyclists are more vulnerable to be overtaken while passing closely when the rider wears a helmet, rides away from the edge of the road, is male or the vehicle in question is a bus or truck with heavy goods. These actions are based on quick assumptions that the motorists make about the cyclists, based on a quick visual examination of their experience levels. When the motorist perceives a cyclist to be more advanced, he/she will leave little room for passing and overtake the cyclist quickly.

5. Safety "counts" for women cyclists

There are distinct differences between women and men with regard to bicycling commute patterns. In their study of six small U.S. cities, Handy and Xing (2011) found that women are substantially less likely to bicycle than males. One of the reasons behind this difference is the issue of safety. In a recent study undertaken in Melbourne, Australia, Garrard et al. (2008) demonstrated from their observations of 6589 cyclists that female commuter cyclists preferred to use routes with maximum separation from motorized traffic. Overall, they preferred off-road paths instead of on-road lanes or roads with no bicycle facilities. This is consistent with findings from the United States, whereby Krizek et al. (2004) found that females tended to be more concerned about safety factors than males.

6. Climate is not a significant factor in the decision to commute by bicycle

Climate appears to be an insignificant factor in the choice to commute by bicycle to work. Buheler and Pucher (2011) found that with regard to climate and public transport, annual precipitation and the number of cold and hot days were not statistically significant predictors of bike commuting in large cities in the U.S. In their study of 42 U.S. cities, Dill and Carr (2003) found that rain is not an impediment to bicycling: three of the top ten cycling cities have more than 100 days of rain per year (Minneapolis, MN, Portland, OR, and Tampa. FL).

Pucher and Buehler (2006), in their comparison of Canadian and American commuter cyclists, found that Canadians are three times more likely to cycle than are Americans, despite the colder climate. Pucher and Buehler (2006) attribute this difference between Canadian and U.S. cities to a variety of factors produced from a multiple regression analysis: shorter trip distances; higher urban densities and mixed-use development; lower incomes; the higher costs of owning, driving and parking a car, safer cycling conditions; more cycling infrastructure; and more extensive training education. They state that just because a cool climate does not prevent cycling, a warm climate does not necessarily insure that it will occur. The authors cite the example of the Yukon Territory, at the same latitude as Alaska, which has a bike share of work trips twice as high as California, and three times as high as Florida (Pucher and Buehler 2006:265).

7. Providing bicycle infrastructure encourages people to commute by bicycle

Dill and Voros (2007), in their U.S. study, illustrate that there is a positive correlation between favorable perceptions of a bicycle-oriented neighborhood and frequent commuter cycling. Respondents who perceived that their neighborhood contained accessible, connected bike lanes were more likely to be regular or commuter cyclists. Thus, in order for people to transition to bicycle commuting, not only is it important for people to have the knowledge of how one's commute is more sustainable, but the infrastructure needs to be already in place for commuting to become a reality.

With regard to factors in the physical environment that influence bicycle commuting, Buehler and Pucher (2011), in their newly collected data on cycling amenities in 90 large US cities, found that both on-street and off-street lanes have a similar positive correlation with bicycle commute rates in the U.S. In short, they both contribute positively to one's decision to cycle to work. Macdonald et al. (2008) note that clearly marked on-street bicycle lanes tend to be preferred by the majority of bicyclists and may even encourage more people to cycle. Dill and Carr (2003) similarly note that higher levels of bicycle infrastructure are positively and significantly correlated with higher rates of bicycle commuting. They state that the presence or absence of a striped lane or separated path can increase or decrease a cyclist's perception of safety. Taylor and Mahmassani (1996) found that bike lanes are superior to wide curb lanes for casual and inexperienced cyclists, but that bike lanes and wide curb lanes are equally influential as incentives for the more experienced cyclist. As such, bike lanes are an incentive to draw out the inexperienced cyclist, who is defined as having a moderate-to-low comfort level in light vehicular traffic. Hunt and Abraham (2006), in a stated preference survey conducted in Edmonton, Canada, discovered that time spent cycling in mixed traffic is more onerous than time spent cycling on separated bike lanes or bike paths. Xing et al (2008) note that the perception of cycling safety to selected destinations is a significant factor in people's decision to ride a bike, pointing to the possibility of an indirect effect of bicycle infrastructure on perceptions of bicycling safety. Interestingly, Tilahun et al. (2007) in their stated preference survey found that respondents stated that they would travel up to 20 minutes more to switch from an unmarked on-road facility with side parking to an off-road bicycle trail. Thus, both on-street and off-street bicycle paths are perceived to be beneficial amenities to commuters.

Within the European context, Goetzke and Rave (2010) note that cycling infrastructure is important primarily for shopping and errand trips in Germany. However, the authors illustrate through their regression models that more bicycle lanes increase cycling only for shopping and errand trips in Germany, not for daily commuting. Vandenbulcke et al. (2009) have shown that regional land use configuration plays an important part in the rate of cyclist fatalities. They conducted a study in Belgium, which ranks as the fourth highest cycling country in Europe, after the Netherlands, Denmark and Germany. Interestingly, they found cycling takes place in regional towns (25,000-120,000) more than in large cities (over 250,000), most likely as a result of people choosing to take good public transport in central cities. In comparing Flanders and Wallonia, they discovered that land use matters. In Flanders, Belgium, the presence of densely built, compact urban environments encourages the use of non-motorized transport, in particular cycling, and less fatalities occur. In contrast, in Wallonia, Belgium, driving is more common, given topographic change and longer commute distances. As such, the low proportion of commuters cycling to work in Wallonia is often associated with a high risk of accident.

In researching building scale bicycle-oriented infrastructure, Handy and Xing (2011) in their study of six small U.S. cities note that bicycle parking and showers at the workplace have a marginal effect on a person's choice to commute by bicycle. However, they do state that the provision of parking spaces may have a significant effect on one's bicycle commute choice. Accordingly, they suggest that implementing a policy of parking fees at the workplace may discourage driving. Hunt and Abraham (2006) in their stated preference experiment acknowledge that secure bicycle parking is more important than showers at the destination. In a study examining the stated preferences of cyclists for "bike-and-ride" trips in Texas, Taylor and Mahmassani (1996) found that indoor bicycles lockers (over lockable/outside, lockable/sheltered) are the preferred bicycle-parking amenity among users and would increase bike and ride mode choice.

D. Travel by Walking

1. Native-born people of color walk less, while new immigrants walk more

Research has shown that race/ethnicity and nativity correlate with travel behavior, including walking. In a study conducted by Giuliano (2003) using 1995 NPTS (National Personal Transportation Survey) data, the author found that age, gender and income do not have the same effect on travel across race/ethnic groups in the United States. She notes that the effects of low income on travel are particularly strong for African Americans and Hispanics. Employment status has a more pronounced effect on travel for all three minority groups (Blacks, Hispanics and Asians) than for Whites.

Immigrants account for a majority of recent urban population growth in the United States, and this is expected to continue for the next several decades (Chatman 2009). With regard to recent immigrants and travel choice in general, Tal and Handy (2005) have discovered that recent immigrants have different patterns of travel than people born in the U.S. and than immigrants who have lived in the U.S. for longer periods of time. Importantly, their multivariate analysis illustrated that immigrant status, race/ethnicity, and place of birth are associated with aspects of travel behavior, even after accounting for socio-demographic factors such as differences in income level, household lifecycle stage, and age. Their findings reveal that white U.S.-born respondents walk more than others, while Asian and Black respondents walk less, and respondents born in the U.S. walk less than foreign-born respondents. The authors do not attempt to account for why race/ethnicity or immigrant status itself would influence travel behavior, but instead suggest that factors such as needs, limitations, preferences, attitudes, culture, and prior experiences are important drivers in this respect.

Chatman and Klein (2009, 2011) have done a significant number of studies that suggest that the foreign-born are much more likely to walk, bicycle, use transit, and carpool, particularly in their first few years of living in the United States. The authors have found that there is little support for cultural explanations for transit persistence, home country habitual travel patterns, or culturally based spatial assimilation within the U.S. Chatman and Klein (2011) instead postulate six specific reasons based on their focus group findings in New Jersey: 1) driving conditions are more difficult in places where immigrants tend to initially settle in the United States; 2) remittances sent home delay auto ownership; 3) immigrants are dominated by single-person,

work-focused households for whom sustainable transportation is more convenient; 4) job recruits may use transit more; 5) a critical mass of non-English speaking riders is growing; and 6) new shared transit modes are becoming more important among immigrants, such as the private transit services that often serve immigrant communities. Despite these different theories, the clear differences between immigrant transportation and non-immigrant are significant for future low-carbon development, especially if new immigrants transition to using vehicles. Studies have shown that those immigrants who have been in the country longer than twenty years use personal automobiles only slightly less than the U.S.-born populations (Myers 1997; Rosenbloom 1998; Blumenberg and Shiki 2007; Blumenberg 2009; Smart 2010; Tal and Handy 2010).

2. Livable streets make vibrant pedestrian and cyclist environments

The more vibrant and pedestrian-friendly a street is, the more likely people are to walk and bicycle in the neighborhood. In 1972, in partnership with Mark Lintell, Appleyard published "The Environmental Quality of City Streets: The Residents' Viewpoint." In this study, which combined a variety of methods including cognitive mapping, interviews and observations, the authors analyzed how traffic conditions affected livability on three San Francisco streets with differing levels of traffic. The authors found that livability—as defined by the absence of noise, stress and pollution, levels of social interaction, territorial extent, environmental awareness and safety—was negatively associated with traffic intensity. In addition, traffic intensity was also correlated with the departure of families from the neighborhood. Appleyard went on to further define a "protected neighborhood" (Appleyard, Gerson, and Lintell 1982; Appleyard 1980), suggesting the Dutch *woonerf* (a shared/play street) as an example and several criteria based upon acceptable speeds, volumes, noise levels, reduction of accidents, and pedestrian right-of-ways. The shared street's adaptability worldwide and its popularity have since been discussed in the literature (Ben-Joseph 1995).

Bosselmann, Macdonald and Kronemeyer (1999) revisited the concept of livable, walkable streets more than 30 years later, conducting a study on the livability of boulevards. Using identical methods as in the original study, the authors found that boulevards with local access lanes separated by landscaped malls were more livable than neighboring conventionally designed streets. The urban fabric had previously cut off pedestrian access through its overuse of limited access streets and had segregated neighborhoods and communities from one another (Bosselmann 2011). Allan Jacobs, a former Director of the San Francisco Planning Department, is known for continuing Appleyard's legacy with the publication *Great Streets* (1993). In this book, Jacobs chronicles the magical quality of 15 great streets, noting special pedestrian-friendly conditions and dimensions, such as building heights, tree spacing, relative widths of streets, and sidewalks. Jacob's rich drawings define and add to the placemaking characteristics of the precedents provided. With the same attention to detail, Jacobs, in collaboration with Macdonald and Rofé, published *The Boulevard Book: History Evolution, and Design of Multiway Boulevards* (2002). The publication celebrates these thoroughfares and their tradition of creating multi-modal spaces, which have gone out of favor in the second half of the twentieth century due to safety concerns and the devotion to vehicles-only roads. They suggest that multi-way boulevards can re-vitalize street complexity and encourage pedestrians and cyclists to mix on vehicular streets.

Most importantly, a walkable place is a livable place—a place that is designed with the person in mind. With regard to street design and urban design factors in the built environment, Ewing and Cervero (2010) have found that walking is most strongly related to measures of land use diversity (land use mix), intersection density (number of intersections per square mile), and the number of destinations within walking distance. In terms of property values, Song and Knaap (2003) have found that home prices increase with increases in street connectivity and reductions in block size. Matthews and Turnbull (2007) state that a gridded street pattern increases sales prices in neighborhoods with other pedestrian features, but decreases prices in more automobile-oriented neighborhoods. Donovan and Butry (2010) assert that street trees fronting and within 100 feet of a residential property can add substantially to the price of a home. The literature also states that houses located on loud, busy high-trafficked streets sell at lower prices than houses on quieter, calmer, streets (Hughes and Simans 1992; Kawamura and Mahajan 2005; Nelson 1982). Thus, the argument can be made that good, well-connected and traffic-calmed streets designed for the pedestrian are an inextricable part of creating not only a place that is livable place, but also one that is more desirable on the market.

In short, livability theory has addressed effectively the changes that need to be made for the public sphere, but on a very general level. No populations or groups are looked at specifically within such studies.

E. Non-social and cultural aspects: land use, pricing policy, and regulation

According to Cervero (2011), low-carbon development requires a multi-pronged strategy: technological change needs to be accompanied by land use regulation and pricing mechanisms. For example, fuel efficient vehicles alone will not reduce our carbon footprint; land uses must promote more high density development in appropriate centers; and pricing can also play a part in reducing congestion.

In the report *Entering the Ecological Age* by Peter Head (2011), it was mentioned that a "rebound effect" typically occurs whereby improvements in technology unintentionally allow people to consume more. One excellent example of this effect that occurs in transportation is the theory of induced demand (Noland 2001). This theory asserts that increases in highway capacity will induce additional growth in traffic. This can occur through a variety of behavioral mechanisms including the generation of new trips, route shifts, redistribution of trips, mode shifts, and long run land use changes that create longer and newer trips. Noland (2001) has found that approximately 25 percent of vehicle miles traveled (VMT) is estimated as a result of lane mile additions. These findings strongly support the theory of induced demand, that added lane mileage can induce additional travel: technology induces consumption. As such, quick technological fixes, such as more fuel efficient vehicles, will not easily solve complex travel consumption problems such as these.

IV. Density, Mixed Use, and Culture

A. Defining Density: building density vs. population density

One of the places where the range of types and ages of people inhabiting cities collides forcefully with the desire to create livable, sustainable urban spaces is in the concept of "density." It is a term freely used in a neutral fashion by planners and architects, yet is subject to a variety of interpretations and affect by the public and their elected officials.

An antidote to increased VMT necessitated by suburban sprawl is to encourage location in more compact urban areas. Measures of how compact—how dense—the various areas are, is central to the discussion. Density, within the planning language, is mainly perceived as the number of housing dwelling units within a prescribed land area. In the United States, it is defined as the number of units per acre (upa) or dwelling units per acre (dua). In the United Kingdom and other commonwealth countries, building density is referred to as the number of units per hectare (uph).

Although the planning and development refers to density in the context of buildings, density can also be defined according to population: the population by land area or housing unit. Population density is critical in demonstrating the reality of density and is linked to affective density and overcrowding (Southern California Association of NonProfit Housing 2012).

Virtually all urban planning terms carry both quantitative and qualitative meanings. The term "density" is perhaps at the forefront of this reality. This concept is also integral to discussions of how the built environment can reduce the GHG emissions by enabling the creation of compact urban areas. The subsequent literature review provides great detail on the psychological, cultural and aesthetic aspects of "density." Our conclusions: formulas or recipes for thinking about density should be subsumed to design of buildings, inside and out, that flexibly accommodates different types of people during the useful life of the building.

B. Density is both a number and a feeling

Rappoport (1975) has differentiated between population density or "evaluation of density" (number of people per unit area) and the preferential result of this evaluation, which he terms "affective density." Affective density (otherwise known as evaluative/perceived or subjective density) is much more than a simple measurement of people per unit area. It is not only physical, but it is also a social and mental construct. Affective density encompasses both the social and physical dimensions, as it is the perception of density itself. For example, a feeling of crowding may be elicited when there is an inadequate relationship between perceived density and desired density. As such, the feeling of crowding may arise—a subjective experience of psychological stress. Edward Hall (1996:30) notes that such feelings of crowding and stress have biochemical and biological origins. This subjective element is important, and may influence individuals differently when matched against varying norms and desires. For one to say "the room is crowded" is much different than saying "I feel crowded" since the latter is based upon personal preferences, whereas the former is based on a quantitative count.

C. Different cultures and ethnic groups perceive density differently

In the literature, perceived density and feelings of crowding are linked with particular physical and social and cultural contexts. Bordas-Astudillo et al. (2003) conducted a study of 162 tenants living in a thirteen-story building and two in high-rise towers in order to ascertain the predictors of feelings and overcrowding in France. The authors quantified internal density (rooms per person and square meters per person) and found that 13 percent of the sample interviewed lived in overcrowded apartments, according to the definition of INSEE (National Institute of Statistics and Economics), whereby they had less than 17 square meters per person and/or less than one room per person. In addition to calculating evaluative density, the authors examined the predictors of affective density.

In the Bordas-Astudillo (2003) study, respondents were asked to complete questions on a five-point scale relating to these six dimensions: 1) the quality of life in the neighborhood; 2) the quality of the building; 3) subjective density in the building; 4) comfort at home (number of rooms, area of rooms, layout, acoustic isolation, luminosity and view); 5) social relationships between inhabitants; and 6) well-being. The authors found that affective density was significantly tied to these six dimensions. With regard to subjective density, the authors found that there is a strong correlation between the feeling of crowding and the feeling of "crampedness." These two feelings illustrate the state of psychological stress, which relates to lack of space. They also found that affective density is strongly related to the social context of the building. With regard to social relationships between inhabitants, they noticed that poor relations with neighbors who live across the landing are correlated with feelings of crowding and crampedness. The last dimension they found to be significantly associated with affective density was housing comfort. For example, the more the inhabitants feel cramped in the building, the more they are unhappy with the area of their apartment, and with the number of rooms in their apartment. Acoustic isolation was a significant predictor feeling of crowding crampedness, specifically with regard to internal density, the area allotted per person. The authors acknowledge that the findings reveal that the quality of relationships is determinant in feelings of crowding and crampedness. They also note that satisfaction with respect to spatial comfort is also important in determining feelings of crowding and comfort. As such, due to the recent increases in housing size in France, and to the fact that residences of the suburbs are growing larger, in order to limit urban sprawl, it is necessary to propose housing types and unit types that meet the needs for space in the city centers and suburbs. They suggest that urban concentration and multi-family housing will be more accepted in city centers in France if individual space needs are met.

Gillis et al. (1986) acknowledge that there are human thresholds for population density in residential areas, and there exists a tipping point for social pathologies, i.e. there are densities at which incidents of conflict and crime increase. They note that density is cultural, however. For example, Asian cities with the highest levels of population density, such as Tokyo and Hong Kong, have relatively low levels of social pathology, in comparison to other high density cities such as New York. The authors conducted a study in Metro Toronto, where they examined the power of room density (persons per room) and dwelling type to predict psychological stress for three different ethnic categories: British, Asian and Southern European, controlling for gender and socio-economic status. For the British population, room density and dwelling type were significant predictors of psychological strain. For Asian populations, room density and dwelling

type were not significant predictors of psychological stress. Southern Europeans were found to be unaffected by room density, but affected by dwelling type. As a result, the authors conclude that Asians are the most tolerant of high-density room and building types, with the British least tolerant, and the Southern Europeans somewhere in between.

Unfortunately, there is a lack of recent studies in the United States done on density and socio-demographic preference. More and more attention is being paid in the literature to the rapidly urbanizing cities in the Global South where overcrowding and quality of life are more imminent problems, or in Asian cities where densities have become extreme (Jenks and Burgess 2000). A few studies were conducted in the late 1970s, the most prominent of which was work by Baldassare (1979), who delineated solid research methods for quantifying and qualitatively analyzing density.

With regard to this small pool of studies conducted in the United States, Marans and Rodgers (1973) were among the earliest to innovate within the field of planning. The authors conducted a study of 1300 individuals nation-wide. They found that people living at the lowest densities (dwellings per acre) in the U.S. were the most satisfied with their neighborhoods, while those at the highest densities were the least satisfied. Baldassare (1979) points out that most Americans reside at rather low densities by historical and cross-cultural standards. However, in a more recent study, Myers and Gearin (2001) illustrate that the tide for density preferences might be turning. The authors analyzed future demand for denser, walkable environments as a whole in the United States. They found that heads of households older than 45 years old showed a distinct interest in densely configured, central neighborhoods—a result of the baby boom generation desiring compact urban form. They note that homeowners 45 years and older would account for 31 percent of growth during the 2000-2010 period. No updates on this study for the 2010-2020 projections have been done to date. Bramley and Power (2009) have found similar results to Marans and Rodgers in the UK. Their findings indicate that a more compact and dense urban form is associated with residential dissatisfaction, and even with the incidence of neighborhood problems. However, Bramley and Power (2009) do note that in the UK, compact urban form improves access to amenities and services. Thus, there is a trade-off in this respect between social pathology, affective density and access to services.

In a more recent work examining the megalopolises of the world, Banerjee (2009: 95) notes that within the 10 municipalities of greater Los Angeles, immigrants tend to populate cities of higher densities, which he suggests is related to the low-income status of many immigrant groups. The author states that the trend of growing number of immigrants in US cities from the developing world—many of whom are used to living in higher-density environments and use public transit—could potentially boost inner-city, high density living, along with baby boomer empty nesters who are on the verge of retiring. However, Banerjee postulates that given past historical immigrants trends have pointed toward upward social mobility, most immigrants who can afford to will choose to live in suburban communities comprised of single-family homes. One interesting dimension that would further support this point is that income and exclusivity both increase in Los Angeles municipalities, as density decreases.

Chan et al (2002) have researched the impact of increasing density in Asian cities. In particular, they have studied the density question in the city of Hong Kong, where there is no minimum

amount of living space per capita, and the "saleable" unit for living space is lower than most other countries. The authors have found that lower-density private development is associated with the large and commodious units of affluent households, whereas higher-density housing development is associated with smaller dwelling units that are less lavish. In a study comparing Hong Kong, Singapore and the UK, the authors found that high-density buildings in Hong Kong are least likely to have more than 20 percent of their floor area dedicated to public common space. This is a result of the developers trying to maximize the salable floor area and reduce communal spaces such as elevator lobbies, corridors, and utilities areas, due to Gross Floor Area Controls (GFAs). Cruciform building plans that have dark and narrow hallways have emerged as the most popular building type, bereft of balconies and socially active spaces, as these add to the GFA calculation. The authors argue that as a result, the building types in Hong Kong have become less and less socially responsive.

Yuen (2002) has conducted a study of the influence of high-density apartments on residential living in Singapore, where public housing is general 25 stories or higher. According to Yuen's survey, increasingly more and more Singaporean households are both willing to and moving to live on higher floors. They are largely motivated by their living experience and the attractions of the view, breeze and privacy afforded by high floor living. While most people were comfortable living between the 16th-40th floors, very few people wanted to live above 50 floors. Certain aspects of high-rise living still remain as concerns for some residents, including living on low floor levels (due to mosquito problems, rubbish smells, blocked views and lack of privacy), the elevators (journey time) and safety (height/falling issues). Due to the fact that the Redevelopment Authority has focused on quality and variety in terms of buildings, there is little concern around this. These high-rise buildings are planned within the framework of new towns, which allows residents access to a wide range of amenities and transportation options.

D. Density can be attractive if internal and external visual quality is considered

Stamps (2007, 2009, 2011) has done considerable work on the perceived spaciousness of buildings—both in indoor and outdoor environments. In one visual preference experiment of perceived spaciousness, Stamps (2007) found that the factors of increased lighting, floor area, and occlusion (removal of partitions) could modify impressions of spaciousness of indoor settings without recourse to making larger spaces. These determinants were tested against an experiment conducted with virtual reality models, and were found to be similarly correlated with the perception of spaciousness. In another study assessing indoor spaciousness, Stamps (2011) also found that horizontal area had the strongest affect on perceived spaciousness of an indoor room, followed by height. The effect of color on indoor spaces, when controlled for light, was a much less significant factor. In another study looking at shape and spaciousness, Stamps (2009) studied the association between street setbacks, length and depth. In a virtual reality experiment, he found that (a) streets appeared to be more spacious if the areas of the setback were larger, and (b) streets appeared to be more spacious if the setbacks were shallower but longer. Streets with aspect ratios of setbacks that were shallower but longer were judged as being more spacious than streets with aspect ratios that were deeper but shorter.

Jantien Smit (2011) has conducted a study of the influence of visual quality on residential location decisions made by creative entrepreneurs in the Randstad, within the Netherlands.

Jantien Smit conducted 63 interviews in the Eastern Docklands in Amsterdam, the Lloyd Quarter in Rotterdam, and the Hortus Quarter in Groningen, all medium-to-high density locations. Smit's findings reveal that there is a significant relationship between the location behavior of creative entrepreneurs, and the visual quality of the district in the Netherlands. Significantly, there is not one visual model for cultural production districts, but this may be varied and take different urban forms. Visual elements that were perceived to add to the "quality" of the location included: 1) public spaces with creatively designed parks, squares, street furniture, and trees; 2) landmark buildings, of appropriate urban scale and "fit"; 3) waterfronts, especially the views they foster; and 4) a mix of "old" and "new" buildings that is not too tidy, thematic and too programmed or "commodified."

Specifically with regard to visual preference and transit-oriented development (TOD), Machell et al (2010), using evidence from their focus group workshops conducted at four potential TOD sites in the San Francisco Bay Area, note that good design can facilitate TOD acceptance by the community. They state that when marketing TOD projects, images need to be tailored to the appropriate context, and the images need to be local. Multiple angles of the buildings need to be shown, in order illustrate its overall bulk and massing. The interior amenities should be stressed, in addition to design features such as balconies, terraces, awnings, trees, and cafes, which illustrate how the building connects to life on the street. Images should include people, as abandoned buildings seem both lonely and intimidating. In addition, floor plans should be included where possible, in order to help convey the size of the rooms and the layout of the development. In response to decreased parking, residents perceived that the space should be instead used for public amenity, such as a park, rather than going toward extra developable units. Overall, they argue that developers should emphasize that they are creating place for the whole community—turning the station area into a place with sense of identity and a desirable destination. More precisely, developers should specify what a new project will add to the wider community in tangible, visible amenities (open space, revenues, retail customers, and pedestrian streets) and intangible benefits (diversity, safety by changing the quality of the station, revitalization of historic main street area) (Machell et al. 2010:7).

E. The human life-cycle trumps all in housing choice and building type choice

In interviews, both Chapple (2011) and Cervero (2011) stated that, for people with the financial means to exercise choice, the stage in a person's life-cycle ultimately trumps all other factors in housing choice, location and housing type. When people have the financial means to make a move, they will often do so once they have children. According to Cervero (2011), there is the perception that once middle-class individuals have children, especially in large urban areas, they are more likely to look for good private schools or school districts in more suburban contexts, as many inner-city and urban schools are perceived to be riddled with "problems." Of course, for low-income families with children, migration to the suburbs may not be possible, even if the desire to move is there.

Despite this desire for low-density living, the tide for the "suburban dream" may finally be turning. Interestingly, the current supply of conventional-lot single-family detached homes in California exceeds the projected demand for these homes in 2035, as households without children are on the rise (Nelson 2011). Ultimately, increased rental demand will be on the rise in

California's metropolitan areas, and thus higher-density apartments, condominiums, unit conversions, accessory dwelling types and non-traditional housing types will become more in demand. Transit-accessible land uses will become an increasingly important element, given consumer preference for locations served by public transit (Nelson 2011). As suggested by Nelson (2011), people are largely inconsistent in reporting their preferences. Everyone wants their "own castle" but they also want access to transit, safe access to schools, and many also report wanting to live in a mix of housing types. Even among families with children, one-third or more are willing to trade lot size and "ideal" homes for walkable diverse communities. The next few decades to come may witness a desire for more high-density living in California. Such long-term market trends represent a directional alignment between the real estate preferences expressed by consumers and the greenhouse gas reduction objectives expressed by the state of California in the form of Senate Bills AB 32 and SB 375. While AB 32 required state government to set goals for the reduction of California's greenhouse gas emissions to 1990 levels by 2020, SB 375 provides key support to achieve the goals of AB 32 through the implementation of metropolitan "Sustainable Community Strategy" (SCS) that integrates transportation, land-use and housing policies for achievement of regional emissions targets.

F. What does a dense, sustainable, non-sexist city look like?

Within the sphere of housing, the double burden of women's employment and domestic work becomes a most pressing issue, not only for women, but also for society in general. As Sandercock (2005:53) notes, the increasingly privatized nature of housing can disproportionately affect women relative to men, as women are more likely than men to receive public assistance. She argues that the deterioration of social services as a result of accelerating privatization can take away independence from women by restricting their options, disposable income, and leisure time. Ownership by a housing cooperative or residence in a public housing development, as opposed to a private or corporate landlord, offers greater price control and services for women. Other policy mechanisms such as rent control should consider single-mother and/or single-parent households that strive to make ends meet. In attempting to illustrate the inadequacy of the market housing situation for women, Dolores Hayden (1980), in "What would a Non-Sexist City Look Like," outlines housing types that would suit employed women who may also have to look after children or elders. Her proposed ideal proposed collective housing development would include:

> *"...(1) a day-care center with landscaped outdoor space, providing day care for forty children and after-school activities for sixty-four children; (2) a laundromat providing laundry service; (3) a kitchen providing lunches for the day-care center, take-out evening meals, and "meals-on-wheels" for elderly people in the neighborhood; (4) a grocery depot, connected to a local food cooperative; (5) a garage with two vans providing dial-a-ride service and meals-on-wheels; (6) a garden (or allotments) where some food can be grown; (7) a home help office providing helpers for the elderly, the sick, and employed parents whose children are sick." (*Hayden 1980:182).

It is through Hayden's higher density, collectivist theoretical housing arrangement that the double burden of employment and domestic work is lessened for women. Hayden's model is not only positive model for women, but can also serve as a wonderful model for moving toward low-

carbon development in the city in general. In addition to permanent strategies, planning strategies and policies should also consider the public provision of temporary housing for women, such as women-only hostels and shelters for women experiencing domestic violence and homelessness (Bachrach 1987). In particular, the pattern of violence that is mapped on to women of color and particularly African-American women may be culturally complex and require specific resources (Sullivan and Rumptz 1994). Overall, it is prudent to consider the impact of housing design and policy for women, on a variety of scales.

G. Density and Language: tossing around "loose quips" makes density an ill-defined word

Cervero (2011) notes that the term "density" is a "loose quip" that get tossed around all the time, largely for its positive associations. However, the term also encompasses negative aspects of urban form. For example, Cervero mentioned that the Los Angeles metropolitan area is very dense, but possesses extremely dysfunctional density, as the typology predominant in Los Angeles is mainly three-story garden apartments stretched out over a large area, which has led to sprawl. According to the 2000 census (American Factfinder 2000), the "Los Angeles-Long Beach-Santa Ana" urbanized area (UA) has a population density of 7,068 inhabitants per square mile, making it the most densely populated UA in the United States. By comparison, the "New York–Newark" Urbanized Area as a whole had a population density of 5,309 per square mile. In this instance, density does not function appropriately for walkability or alternative transportation, because it is not concentrated along transit corridors. Instead it is dispersed over the decentralized region.

In Douglas Farr's *Sustainable Urbanism* (2008), the term "density" is explained and graphically illustrated through planning and urban design language: as a measure of building type (single-family detached, tuck-under townhouses, etc.), the number of stories, and where these buildings types fall on the construction cost index. In addition, transit-supportive "densities" are also calculated, with special remarks reserved for the specific urban context (rapid transit requires 12 dwelling units per acre, but also can only occur in downtowns larger than 50 million square feet of nonresidential floor space). This reflects Cervero's (2011) comment that density needs to be concentrated around transit to be a viable option.

H. Density and transit: clustering density around transit

Clustering density around transit ultimately contributes to more sustainable urban city form. Bosselmann (2008: 7-8) notes that the densest cities in the world use the least per capita energy consumption for private vehicles. The inverse is true for the lowest density cities in the world; they use the highest amount of fuel for private vehicles. Many of these dense cities provide well-connected transit systems for residents to use, such as Barcelona, Amsterdam and Tokyo. However, with the top three worst offenders—Atlanta, Houston and Denver—the total energy consumption for private vehicles could be considerably lessened if higher densities were clustered around transit.

In examining transit and density in the San Francisco Bay Area, the number one reason that people choose to move in to a higher-density transit-oriented development in California is the quality of housing, with cost of housing second, and quality of neighborhood third. Evidence

points toward the main user of transit-oriented developments as higher income, white and older populations—most likely empty nesters. However, developers today require more incentives to build higher-density complexes of high construction quality.

In areas of the U.S. with significant suburban populations, whose VMT we would like to reduce, transit-oriented development (TOD) has been touted as the silver bullet that will aid in making our cities more sustainable, since density promotes the use of alternative transportation. Why move to a higher-density, transit-oriented development? A stated preference survey conducted by Lund (2006) in Los Angeles, San Diego and the San Francisco Bay Area, found that the top reason for living in TOD was type or quality of housing. Cost of housing came second, with quality of neighborhood as the overall third choice. Access came next, with access to shops and services ranked fourth, access to transit ranked fifth, access to highway ranked sixth, and recreational opportunities and quality of schools at the bottom of the list. Within the three locations, rankings varied, with cost of housing ranked first instead of second in the Bay Area. In Los Angeles, quality of neighborhood ranked first, with cost of housing second and quality of housing third. In San Diego, the cost of housing was ranked third.

Who currently lives in transit-oriented developments? In his 2007 household survey comparison of the New Urbanist Orenco Station located in the Tri-Met area of Portland, Oregon, Podobnik (2011:116) notes from his 108 households surveyed that the average age of respondents were 42, their median monthly income was $6,750, and that 95 percent identified as white. The Orenco Station TOD showed less diversity, had the highest monthly incomes and the oldest age compared to four other neighborhood typologies identified as suburban, urban hills and urban grid. However, compared to Podobnik's 2002 survey, his 2007 survey illustrated that the majority of residents appeared to be open to increasing the economic diversity and ethnic diversity at Orenco Station neighborhood. In summary, the 2007 survey suggests that more inclusionary attitudes with regard to ethnic and class diversity seem to be emerging in Orenco Station as the community grows.

Lund (2006), in her stated preference evaluation of Los Angeles, San Diego and San Francisco Bay Area TODs found that those who had moved to TODs within the previous five years were not unlike the general population of the area, though they had higher household incomes and were less likely to be Hispanic. She also notes that they were just as likely to own cars as the general population of the areas, which appears to contradict one of the TOD paradigms of limiting parking availability. The general trend of those living in TODs seems to be empty nesters, predominantly white with higher incomes.

I. Mixed-use: another ill-defined term

In terms of mixed-use, the term remains ill-defined in the planning literature, as it can relate to a vertical mix of uses within a single building, a mixing of land use types, or functional mixing within a building. Within a development itself, efforts can be made to incorporate equity and diversity through a "checkerboard" approach by placing buildings of mixed income groups throughout a development, versus mixing people with different incomes in the same building.

The idea of incorporating "mixed use" building types became popular during the late 1980s and 1990s, when New Urbanists incorporated the concept into their platform (Talen 2002:181). The current literature that focuses specifically on mixed-use building types and social implications in the United States is relatively thin. There is a richer body of city-scale literature that addresses overall diversity within cities and socially mixed neighborhoods (Fainstein 2005; Talen 2006). Mixed use has also been incorporated into the metrics of LEED-ND, and Douglas Farr's (2008) *Sustainable Urbanism*. In *Sustainable Urbanism* (Farr 2008), the concept of "neighborhood completeness," which incorporates mixed-use, defined as the product of the number of pedestrian destinations and the proportional area balance of all pedestrian destinations in the quarter-mile pedestrian walking shed. In addition to neighborhood completeness, the optimum residential mix of buildings is outlined for a) new traditional neighborhoods (suburban context) and for b) downtown and in-town neighborhoods (urban context). With respect to the concept of neighborhood retail, metrics are given for the amount of dwellings necessary to support retail. For example, 2000 dwellings are needed to support convenience centers, which are 10,000-30,000 square feet. The authors mention that these numbers can be significantly reduced if the store is located along a major road with 15 cars per day, or near a gas station.

Aside from its use in New Urbanism and LEED-ND, the term "mixed-use" over the years has unfortunately earned itself a polyvalence with respect to how it is defined in the planning and housing literature. Rowley (1996) discusses the problem that the definition is ambiguous, multi-faceted and used in a cursory, prescriptive fashion. He states that generally, "places containing a mix of uses tend to have varied buildings and varied architecture and the legibility of districts and of smaller scale environments is promoted"(Rowley 1996:88). However, he warns that many mixed-use developments in the USA have failed to deliver visual quality, either in isolation or in relation to the surrounding urban fabric. In particular, he argues that many mixed-use developments in North America have been on a monolithic and monumental scale and are certainly a far cry from the models found in traditional European cities—where Jan Gehl's (1987) notion of "life between buildings" truly materializes. John King (2011) echoes this sentiment, whereby he advocates that building quality and design are issues in California for higher-density apartments. He argues that developers in the U.S. are not ambitious enough in this regard to building high-density complexes of good quality, design and construction.

Rowley (1996) also argues that prospective occupiers are more likely to accept mixed-use housing conditions and higher densities if the developments are located on inner city brownfield sites rather than on suburban greenfield locations. Until mixed-use development is made more attractive and visually pleasing than their suburban single-family counterparts, however, little will change in the market economy of preference for suburban lifestyles.

Angnotti and Hanhardt (2001) similarly note the variability in the term "mixed-use." They question whether it refers to vertical mixing in building types or to the mixing of land uses and stress the discrepancy in the definition. The authors enter the debate from an environmental justice and social equity perspective, stating that in order for mixed-use communities to truly exist in New York City, the public health aspect of industrial zoning and hazardous waste siting must be better distributed across the landscape. Land-use planning must incorporate the effects of environmental hazards into zoning. They also argue for more parks and open spaces, which also improve healthy, complete communities.

With regard to real estate and development, mixed-use places, and in particular the presence of retail, have been shown to increase nearby residential property values (Grether and Mieszkowski 1980; Li and Brown 1980; Song and Knaap 2004; Matthews and Turnball 2007). John King (2011) and Rick Williams (2011) both stated that a mix of uses should occur at the scale of the development or neighborhood. Williams (2011) noted that mixed-income buildings are not possible, based on current development regulation. Thus, "checkerboard approaches" to mixed-income within the development can be done to increase the overall diversity of a place. King (2011) mentions that people of different income and background have different needs, which can be better met through specific building types.

J. Livable neighborhoods address human needs through urban design

Livability theory within the discipline of urban design has attempted to tackle sociological and cultural dilemmas. Theorists working in this area have focused their research on how daily human needs and desires could be met and addressed widespread social concerns. The discipline of urban design transpired out of a normative desire to change the practice of city-building for the public good.

Jane Jacob's *The Death and Life of American Cities* (1961) shocked North American urban planners into questioning current modes of planning practice. By condemning and mobilizing against planning czar Robert Moses' design for an expressway to be constructed in New York's Greenwich Village, Jacobs can be accredited with the first neighborhood efforts to intervene against totalistic megaprojects. Today, Jacob's efforts serve as a cautionary counterpoint to what urban cities could become if car use goes unregulated. Writing at a time when modernist housing project schemes and expressway building was in full force, Jacobs illustrated how many of these practices undermined qualities that created livable neighborhoods and streets. Specifically, Jacobs emphasized the importance of pedestrian use of the street. Critical to successful environments were a mix of land uses, short block lengths, and consistent building setbacks, and 24-hour activity. Her "eyes on the street" surveillance theory is important to understanding dimensions of neighborhood ownership and territory. A positive street atmosphere—where people spent time on their front porches and yards—can contribute to the sense of community in a neighborhood. Her work continues today to serve as inspiration for the New Urbanist movement, in addition to the Crime Prevention through Environmental Design movement (CPTED).

Around the same time as Jacobs was advancing the notion of cities for people, Kevin Lynch first published the influential work *The Image of the City* (1960). In it Lynch describes how people perceive cities as comprising of five underlying conceptual elements: paths, edges, nodes, districts and landmarks. He argued that if urban designers can understand psychologically how people perceive cities, then they have the essential knowledge to design cities that are more legible or "imageable" for people. *The Image of the City* became one of the important tomes for environmental psychology and environmental design research, including studies in cognitive mapping and wayfinding (Golledge 2003; Kitchin and Freundschuh 2000; Pearce and Fagence 1996; Raubal et al. n.d.). Importantly, Lynch followed up on this effort 20 years later with a normative account of how cities should be. In *Good City Form* (1981), Lynch focused on

differentiating his domain of "normative theory" from "decision theory" (planning theory) and "functional theory" (why cities take the form they do and how it functions). In his prescriptive approach, Lynch delineates five performance dimensions for the spatial form of cities: *vitality, sense, fit, access and control*. Appended to these are two meta-criteria, *efficiency* and *justice*. Lynch argues that the meta-criteria are meaningless if the first five performance dimensions are not addressed, and in essence they are truly sub-dimensions of the first five. Ford (1999) states that although these dimensions may not always be simple to measure and may be in conflict with one another, they do provide a general context for and framework for evaluating the quality of cities and places.

With regard to housing-specific livability studies, Marcus and Sarkissian (1988) were the first to survey tenants and develop guidelines in order to improve people-environment relations in medium-density residential buildings. Macdonald's (2005) work studying the effects of high-density residential development on social interaction and street life is an important recent contribution that extends its scope beyond the limited realm of street design to include the semi-private spaces between building facade and street.

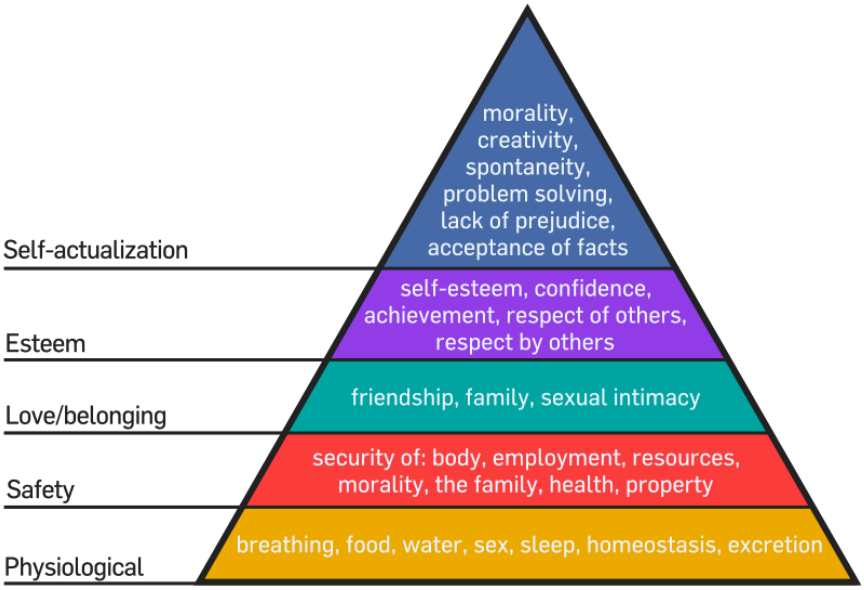
What consists of livable building type today? Many of our interviewees pointed to the City of Vancouver as a model for sustainable built form with high-density housing. Elizabeth Macdonald (2011) and Peter Bosselman (2011), both professors in urban design in the department of City and Regional Planning at UC Berkeley, stated that traditional development that involves double-loaded corridor buildings (an apartment wing hallway with units on either side) inhibits social interaction, and does not provide enough cross-ventilation for users. One of the problems is that building codes in North America do not allow for single-loaded corridor development. Another important element, according to Macdonald (2011, 2005), is that multi-family housing units should allow for privacy. She notes this can be done through half level grade separations that require residents to walk up to the apartment, so that people passing by cannot easily see in (and allow for space-conserving underground parking). While the more lively side faces the street, a more quiet side opens up to a courtyard behind. This livable model can be seen in the City of Vancouver (Macdonald 2005).

V. Open Space

The notion of "open space" encompasses a diversity of possible spaces and is itself used interchangeably with "public space" and "green space." This definitional ambiguity is reflected in the academic literature: all of the aforementioned terms are capacious, encompassing everything from small and unregulated green spaces in urban neighborhoods, to formally managed parks. "Public spaces" may include parks (ranging from the wild to the very manicured) and plazas, may take up acres or less than a square block ("pocket-parks" and "parklets"), may incorporate recreational programming, and may stand alone or be part of larger residential or commercial developments. Francis (2010), drawing on Carr et al. (1992) and Lynch 1990), defines "public space" as an "open, publicly accessible place where people go for group or individual activities"; they may be "formed naturally over time or deliberately by design and policy" (432). In their book *People Places: Design Guidelines for Urban Open Spaces* (1990), Cooper Marcus and Francis develop a typology of different urban open spaces, noting how different kinds of spaces have the potential to serve different sets of needs. Spaces also have specific histories that color their contemporary use. Low, Taplin, and Scheld (2005) note that if people are not represented in parks and urban spaces, or if their histories have been erased from them, they will not use them. Therefore, the conclusions regarding how public space is used and by whom necessarily depend on the features and contexts of a given place. For instance, we cannot expect to observe the same patterns of use in public squares, mini-parks, city parks, and plazas. People will seek out—or avoid—manicured parks for different reasons than they might seek out a "wilder" space. The literature and interviews thus present two key and interrelated takeaways: 1) the need for greater parsing of the category "open space," which should 2) sensitize designers and planners to the importance of designing spaces that correspond to the capacities of a place, with its specific history and context.

A. Open spaces fulfill potentially universal human needs

Despite the conceptual ambiguity, there is some consensus that open green space fulfills certain universal human needs. Jay Appleton (1975) was the first to hypothesize that humans have certain sociobiological and evolutionary desires that play out in landscapes. In his view, humans have an evolutionarily derived preference for spaces that provide "prospects," an unimpeded opportunity to see, and "refuges," the opportunity to hide. Appleton's (1975) prospect-refuge theory postulates that the ability to see without being seen is critical for meeting the innate human desire for survival. A landscape that is both protective, yet inculcates a sense of one's omniscience, will be experienced as the most comfortable and beneficial at universal level. Even if we do not wish to trace back an evolutionary heritage for our relationship to open spaces, Appleton's theoretical contributions underscore the deep-seated and often unconscious needs we feel are fulfilled—or go unfulfilled—when we are in open spaces. Maslow's (1954) hierarchy of human needs provides a useful framework for assessing the success of urban buildings and spaces in terms of which needs they fulfill: do they fulfill more basic needs (the bottom of the pyramid), or secondary needs, or some combination? [See figure below].



In addition, the social and psychological benefits of open space (e.g. mitigation of sedentary lifestyles, improved mental health, access to quality food through community gardens, increase in property values, mitigation of incivility) are well-documented in the literature (Crewe 2001; Gobster 2001; Ho et al. 2005; Kaplan et al. 2004; Maller et al. 2005; Orsega-Smith et al. 2004). Faber Taylor, et al. (2002) found that children living in buildings with merely a *view* of trees and green space exhibited superior attention capacities and impulse control than did similar children without those views. In his influential book, *The Great Good Place* (1999), Ray Oldenburg cites plazas and other open spaces as potential "third spaces": spaces where people can gather easily, inexpensively, regularly, and pleasurably. Depending upon the available features, urban open spaces can serve human needs for comfort, relaxation, discovery, active recreation (e.g. walking, playing sports, riding bicycles, etc.) and passive recreation (e.g. sunbathing, picnicking, reading, people-watching, etc.) (Carr et al. 2007[1992]). Differing levels of access to open space means these benefits are unevenly distributed.

How do we then create spaces that fulfill human needs? Research on creating vibrant public spaces for the general public can be traced back to William Whyte's (1980) original publication "The Social Life of Small Urban Spaces" and Jan Gehl's (2010) work. Gehl and Whyte were among the first to document and observe how people actively use public open spaces, and they were carefully attuned to the correspondence between use and human needs. In "Cities for People," Gehl (2010) discusses how quality open space provides an informal, relaxed means of maintaining social ties and a sense of community in an urban environment. Gehl and Gemzøe (2004) provide instructive examples of how to measure the number of stationary and mobile activities in a given public space. Stationary activities measured may include sitting on benches in public and semi-private spaces, café seating, and secondary seating. Mobile activities will be divided into a) daily comings and goings (walking to and from) b) daily transportation activity (walking or biking through the area), c) short-term staying activity (chatting while standing), d) recreational or play activity and planned activity (spectator and participant). Through this careful observation, Whyte (1980) was able to conclude that, in public parks in New York, the volume

of seating space, and the flexibility and comfort of these spaces, proved to be the most valuable assets for open spaces. However, neither authors consider race or class or socio-demographic breakdowns within their studies (although Whyte considers gender).

B. The "failure" of open space is often a failure of access

Designers of public spaces endeavor to create areas that local populations will "choose" to use. When public spaces "fail," the question that often gets asked is: why aren't people choosing to use this space? This framing of the issue may be too narrow to provide real leverage for understanding the success and failure of public spaces. Much of the scholarship, and many of the experts we interviewed, underscored that use of public spaces is largely determined by access, which varies with race/ethnicity, socioeconomic status, age, gender, and nativity. Instead of examining how public spaces lack imageability (Lynch 1960) or fail to provide vibrant, watchful street life (Jacobs 1961) *for all,* we need to consider how these spaces fail specifically for *particular* socio-demographic groups.

Many studies have concluded that the marginalization of minority racial/ethnic and low-income urban residents is reinscribed in their relatively limited access to and use of public spaces. Low-income areas, with their largely substandard housing, are less likely to have bike paths, sidewalks, and recreational areas (Frumkin 2005). In their study of Los Angeles, Wolch et al (2002) found that poorer neighborhoods, as well as areas of predominately Latino, African American, and Asian-Pacific Islander residents, have significantly lower levels of access to park resources than do areas of predominately white residents. They calculated that Latinos have approximately 1.6 acres of parks per 1,000 people; African Americans have 0.8 acres of parks per 1,000 people; Asians 1.2 acres per 1,000; and Whites 17.4 acres per 1,000. The loss of public space (due to privatization or its redevelopment) also disproportionately affects low-income residents (Gobster 1993). Experts in design and planning noted that open spaces should be designed to connect to streets and other features of the city that residents use (Williams 2011; Mozingo 2011). In already dense cities, where it may not be possible to increase open space by constructing on greenfield or brownfield sites, access to open space can be promoted through creative design and re-use, such as the development of derelict sites, pedestrianization through road closure, demolition of obsolete buildings, re-planning of transit hubs, and creation of rooftop gardens (Gensler and ULI 2011).

For a number of reasons, minority populations are also less likely to use outdoor public spaces (recreation areas, local parks, nature centers) when they *are* available (California State Parks 2005; Elmendorf, Willits, & Sasidharan 2005; Rodriquez & Roberts 2002). In reviews of the literature spanning the use of national and state parks (Floyd 1999) and urban parks (Strife and Downey 2009), a consistent finding is that non-Hispanic whites are overrepresented in most types of outdoor recreation, both active (e.g. walking, playing sports, riding bicycles, etc.) and passive (e.g. sunbathing, picnicking, reading, people-watching, etc.) and African Americans are the most underrepresented of all racial and ethnic groups. Some of this underrepresentation has been attributed to attitudes. In a study of 1200 African American and White, male and female, middle- and high-school students, Floyd et al. (2005) found that levels of fear of nature and desire for urban environments were higher for African American students than for White students. The threat of crime keeps many inside, even in low-income areas that do have available

outdoor park space (Hood 2005). In the 2002 Public Opinions and Attitudes Survey conducted by the California Department of Parks and Recreation, Hispanic residents were far more likely to report that they did not feel safe in public parks (California Department of Parks and Recreation 2003). In an interview, Rick Williams (VMWP) also underscored the importance of safety considerations in the planning of open space, citing in particular the desires of residents to have "eyes on the street" (Jacobs 1961).

Researchers have also put forward language and legacies of discrimination as discouraging factors for use of urban public spaces. Hong and Anderson (2006) found that language barriers between Latinos and non-Spanish speaking staff also discouraged use, fostering the perception that certain places were "not for them." Bryne and Wolch (2009) emphasize that parks are not physically homogeneous and are historically configured such that legacies of racism and discrimination reflected in the design and planning of parks can discourage access and use by minority groups. For example, many parks have historically imposed behavioral rules and dress codes meant to maintain the space as belonging to White, middle-class users (Bryne and Wolch 2009:747). A park's history can inform perceptions regarding accessibility, safety, conviviality, and a sense of welcome in ways that attract some park users and discourage others. In an interview, UC Berkeley Landscape Architecture Professor Louise Mozingo (2011) also underscored that "successful" open spaces will emerge from, and adapt to, the capacities of a place; we cannot expect that open spaces designs that work in one place can be grafted onto others. The use of space has a historical trajectory that must be considered in planning.

C. "People" don't use open space in the same ways

Just as the category of "open space" needs greater conceptual precision, the category of "people" who use space must also be parsed. The literature shows that patterns of use will vary along the same social axes as access: race/ethnicity, socioeconomic status, age, gender, and nativity.

Some research, much of it in leisure studies, has shown that different socio-demographic groups have different preferences for leisure settings, have different reasons for visiting parks, and favor different activities. In their survey of Cleveland residents, Payne, Mowen and Ortega-Smith (2002) found that older adults and African Americans were more likely to prefer recreation to conservation as the purpose of their parks, but they were also more likely to be non-visitors to the parks. African Americans are also less likely than Whites to prefer nature-based recreation opportunities, in favor of more organized recreation in well-groomed settings with peer groups (e.g. playing fields, picnic areas) (Phillipp 1993; Dwyer 1994; Loukaitou-Sideris 1995). In his study of Illinois residents, Dwyer (1994) found independent effects of race/ethnicity on participation, controlling for age, residence, income, gender, and household size; he found that African Americans were less likely than whites to participate in rural, wildland, and water-based activities. Hispanic Americans were less likely to participate in bicycling, even controlling for socio-economic factors. Asian Americans, compared to whites, differed primarily in favored sports (softball and baseball) and pool swimming. Less is known about the use preferences of Asian Americans, in part because they are often lumped into an "other" category in national and regional surveys (Floyd 1999), but some studies have shown that they tend to value "scenic beauty" over recreational functionality (Gobster 2002; Payne et al. 2002; Ho et al. 2005). In her study of four urban parks in Los Angeles, Loukaitou-Sideris (1995) found that Hispanics used

the parks as social spaces. The results of the 2002 Public Opinions and Attitudes Survey confirm the continued relevance of this finding: Hispanic California residents voiced support for the social assets of public space. Their preferences included: 1) recreation in larger groups and forested sites with amenities to support on-site cooking; 2) outdoor experiences with a strong social recreation component, such as facilities and programs that involve families; 3) outdoor experiences as stress relief and quality family time; 4) picnicking, day hiking, camping, and large family gatherings in outdoor settings; and 5) interpersonal communication from multilingual and culturally diverse staff (California Department of Parks and Recreation 2003). The Survey also found that White park users tend to seek solitude and opportunities to exercise, also a conclusion of the earlier Loukaitou-Sideris study.

The available literature on use by nativity consistently indicates that first generation immigrants are more likely to recreate with immediate and extended family groups, while second and subsequent generations are more likely to recreate in friendship rather than kinship groups. For immigrants, recreation appears to preserve cultural heritage and traditions (Floyd 1999). Racial and ethnic variation in outdoor recreation is less pronounced at the local level, in highly developed outdoor recreation settings, and for high-volume outdoor recreation pursuits like picnicking, sightseeing, and walking (Floyd 1999).

Relatively few studies describe intersectional patterning (e.g. how do white women, white men, black men, etc. use space compared to black women) (Bryne and Wolch 2009). The combination of gender, class, and race can diminish access to environmental goods and services in ways and at levels different from any one of these factors in isolation. For example, in his study of Fairmont Park in Philadelphia, Brownlow (2006) found that women of color became especially vulnerable to attack in parks. One intersectional study by Shinew et al. (1995) found that race and social class interactively affect leisure preferences irrespective of gender. African American men and White men of the same class ranked the same activities similarly. The greatest dissimilarity in preferences was between poor-working-class African American women and the middle-to-upper-middle class White men. In one survey of women of color, Roberts and Drogin (1996) found that most women preferred to recreate outdoors with friends and with individuals of similar ethnic backgrounds. Respondents identified cultural acceptance and norms, limited exposure to outdoor activities, lack of awareness of opportunities, stereotype of the outdoors as a "white thing," and outdoor activities as inappropriate for women of color as constraints. More frequent participation in outdoor activities was constrained by lack of equipment, lack of knowledge and/or expertise, health and safety issues, fear, and distance to outdoor recreation areas.

Experts also provided examples of ways in which types of use will vary not only across different groups of people, but across stages and roles in life (e.g. parents using parks differently than people without children; residents using green space differently than workers) (Carr et al. 1992; Mozingo 2011; Williams 2011).

Louise Mozingo also noted that histories of park management, in terms of funding and governance, will influence how spaces are programmed and hence how they are used. Furthermore, groups often can and do appropriate spaces to serve their own needs; spaces that were designed with one use in mind will be used for multiple or different uses by the people who

have access to them (e.g. shopping malls used as plazas, where "loitering" becomes a problem) (Carr et al. 2007[1992]). Future research could attempt to develop tools that would minimize the unanticipated uses of parks and other spaces, perhaps by including more robust community participation.

D. The connections between open space and increased sustainability may exist, but are hard to prove conclusively

Open space can conceivably encourage sustainable lifestyles in two ways: by encouraging sustainable behaviors on the part of residents, and/or by improving the urban areas such that residents are living in literally and figuratively greener environments. In the former sense, research has shown that early childhood experiences in nature significantly influence the development of environmental attitudes and values. Connecting open space to sustainable behaviors is methodologically difficult, but some studies have examined the relationship between the two. Vaske (2001) found that environmentally responsible behavior was directly associated with place dependence (a sense that a place is indispensable), mediated by place identity (an emotional attachment to the place). Chawla (1998) reviewed the literature about the development of "environmental sensitivity" and found that it is connected to life experiences in many studies (see also Chawla 1999). For instance, many environmental activists cited exposure to natural areas, particularly childhood experiences in the outdoors, when they were asked to give autobiographical accounts of their practical concern for the environment. In a survey of Amsterdam residents, Chiesura (2004) found that urban parks, meaning spaces in the city where people felt they were experiencing nature, filled "important immaterial and non-consumptive human needs" (p. 136), though she could draw no conclusions regarding the relationship between time spent in parks and consumption behavior. She noted that the overwhelming majority of people (73 percent) studied chose to come to the park "to relax," which is most likely due to the fact that hectic pace of city life. Interestingly, 32.2 percent come to the park "to escape the city." This indicates that for many, the park acts an urban oasis, a refuge removed from noise, traffic and poor air quality of the city. From a visual perspective, respondents mentioned that they desired to see things other than concrete, buildings and cars. As such, this means that residents turned to urban nature, as it provided relief from the physical hardscape of the city, in addition to routine everyday life. While Chiesura's research took place in a European context, we can imagine the same needs and satisfactions in a North American context.

In the latter sense, the availability of green open space provides economic, ecological, and social benefits that effectively make cities more sustainable. Anderson and West (2006) found that home prices increase by 0.0035 percent for every percentage decrease in distance to neighborhood parks; the effect increases with proximity to the central business district and for areas of higher densities. Thus, living closer to a park in an urban area will increase one's home value. In their study of Los Angeles, Pincetl and Gearin (2005) found that "greening" areas that currently had no public parks or open green spaces would contribute to the environmental sustainability of both the neighborhoods and the lives lived within them. In addition, open green spaces are typically not "spaces of consumption"; they provide alternatives to resource-intense activities associated with shopping malls and other commercial developments (Mansvelt 2008). Louise Mozingo (2011) is more skeptical that spending time in open space is viewed as an alternative to shopping.

While the precise connection between open space and consumption behavior is understudied, some researchers have attempted to gain leverage on the formation of attitudes as they relate to consumption behavior. Shove (2009, 2007, 2003) has written extensively on the culture of consumption, with specific attention paid to how consumption is embedded not only in social practices and behavioral norms, but also in the availability of amenities and technologies; consumption practices evolves *along with* material circumstances. For instance, we shower daily because we now all have bathrooms with showers—which was not always the case—not because we need to be so clean. This suggests that "editing" the built environment can revise human practices, even deeply habitual ones. In some planning contexts, the discussion has moved in to how to make sustainable options the "social default" and how to actively change unsustainable habit formation (Manning 2009). It is not yet certain what role the design and planning of open spaces in particular can play.

VI. Overall Findings

A. Conclusions

With this report, IEE has endeavored to synthesize the state of the art in thinking about human interaction with the built environment in order to identify potential inducements and obstacles to achieving the goal of carbon neutral cities. From the literature review and interviews, we have identified the following six key conclusions, as well as five key recommendations for thinking about planning for carbon neutrality:

1. **The stage in your life strongly influences where you want to live.** Literature and experts suggest that there is more variation in interaction with the built environment across a given individual's lifetime than there is between different socio-demographic groups. We can understand this in part as derivative of changing needs and desires over the span of a lifetime, which will dictate shifting interactions with buildings, transport systems, and open space. A household with children will have different preferences than those without. Currently, within the state of California, households without children are on the rise, and an increased demand for rental units and accessory dwelling units will also be on the rise, instead of suburban single-family homes.

2. **Gender significantly structures interactions with the built environment.** More precisely, studies have shown that women have particular needs and expectations of city amenities and public transit, specifically as they pertain to their sense of personal safety in the urban context and whether or not they have children.

3. **Peer/social norms influence how people use space.** Many studies and experts underscore the importance of peer groups and social norms as influences on how people use space and environmentally sustainable transportation options. This insight acts as an important foil to analyses that emphasize the role of information in behavior change. Providing the public with more information about the impacts of current behavior and the benefits of different behaviors may not be sufficient to motivate change. Interventions that target norms, especially in the workplace, may be powerful levers. Exemplifying behavior is more important than marketing it with words and images.

4. **The historical regulation, planning, and management of spaces influence their present day use.** Buildings, transit systems, and open spaces are historical artifacts: they were fashioned in a particular historical moment, as the result of particular constellations of political will, resources, and technological capacities. Cityscapes evolve over time, yet the residues of earlier planning and management inevitably shape the way people think about and interact with buildings and spaces.

5. **The "feel" or embodied experience of space and transit is important for determining how people will use them.** Aesthetics and related design elements can act as powerful incentives to use spaces and particular modes of transit. Experts noted that people need to feel that they are having a "dignified" experience when riding transit, and that spaces should be well maintained so that people don't feel they are in an "abandoned" space. Though "feel" in general is likely

universally important for understanding human interaction with the built environment, what precisely that "feel" is will vary culturally and socially.

6. **The upward social mobility will drive housing and transportation choices for new immigrants.** With increasing city in-migration in the United States, evidence illustrates that new immigrants tend to initially live in higher-density environments and use more sustainable forms of transportation (walking, bicycling and transit). As immigrant income increases, the continued use of these more sustainable patterns decreases in favor of private automobiles. The implications of this for low-carbon development are significant.

B. Recommendations: These recommendations come out of the literature review and interviews. We have brought our perspective to bear on identifying important tools for moving forward.

ACHIEVING LOW-CARBON DEVELOPMENT				
Recommendation 1:	**Recommendation 2:**	**Recommendation 3:**	**Recommendation 4:**	**Recommendation 5:**
ENHANCING EXPERTISE	**ONE SIZE DOESN'T FIT ALL**	**ADAPTIVE REUSE**	**FLEXIBLE DESIGN IS KEY**	**PUBLIC-PRIVATE PARTNERSHIPS**
Enlist social scientists and behaviorists as basic parts of the expert teams that plan and implement urban developments	Successful places serve changing demographics, beyond the current market	Design for adaptive re-use to minimize the disjunctures between intended/actual use and past/ present/ future use	Use an Open Plan design with small components, enabling future repurposing, a lower-carbon resilience	Pursue the public-private mindsets and partnerships that will be required to make low-carbon cities feasible

1. **Specific social scientists and behaviorists need to be basic parts of expert teams that plan and implement urban developments.** Galen Cranz (2010) has introduced sociological levels of analysis into architecture to clarify the cultural, societal, institutional, complex organizational, interactional, technological, individual, and environmental dimensions of the built environment. Her framework provides a structured way for considering the intersections of human behavior with architecture from different angles and points of view. Additionally, we have noted the importance of the work of anthropologists, historians, social psychologists and others to bring their expertise to specific groups of people in specific contexts. Given that how "different groups of people" use a given environment is more relevant than how "people" in general use the same environment, the perspective of social scientists will help planners and developers gain insight into the needs of different groups throughout the development of a project. Use of the variety of social scientists is comparable to the differing types of engineers, architects, etc. involved in changing the built environment.

2. **Be critical when using design precedents: one size "doesn't fit all."** The context of a place is important. Buildings and open spaces that "succeed" in one place and at one time may not translate to other places and times. The context matters: not only the political, socio-demographic, and cultural context, but also the historical context. Spaces that have histories of

marginalization and discrimination may not be used by historically excluded groups, even when those circumstances change. In his synthesis of the literature, Francis (2003) underscores that "successful" spaces are responsive to the needs of their users, are democratic in their accessibility, and are meaningful for the larger community and society. How we fulfill these criteria will necessarily vary from place to place.

3. **Buildings and spaces intended for one set of functions can be appropriated for unintended uses, and re-appropriated for new uses.** The provision of infrastructure and amenities may be perceived as a "fixed" and single-use asset, but they may actually function with variation and be of little use value regarding their original purpose. Several experts noted that the built environment does not just structure human behavior; humans also "act back" on buildings and spaces. Flexible designs may minimize the disjuncture between intended and actual use of buildings and spaces, allowing not only for the fulfillment of a wide range of needs, but also accommodating shifts in needs and preferences over time. The adaptive re-use of existing structures for new uses can accommodate a community's changing needs, while at the same time reducing the embodied carbon required. This kind of repurposing of buildings is common today in older European and Asian cities; they may be a useful model not only for this type of development, but also for thinking about how we might design *new* buildings with the expectation that they will be reused. San Francisco and New York City have pursued innovative repurposing of paved areas of the cities, turning them into "parklets" and plazas through collaboration with local communities. Demographics change, regulatory regimes change, political calculations change, but we currently design buildings to stay the same. Buildings as spaces should be treated as "services" rather than as inanimate, static objects, which means designing them with flexible uses in mind.

4. **Flexible design is key.** Building and development projects tend to be built to meet a specific purpose at a specific point in time. Despite the ability of humans to "act back" on the built environment and re-appropriate it for new uses, the design limitations of the physical infrastructure remain in place. Mega-projects, in particular, are hard to repurpose, despite how "green" the project itself may be. One approach to consider is that even within a mega-project, there might be opportunities to create a built environment that consists of a number of smaller components rather than fewer large components. The benefit of this is that it will reduce the barriers to future repurposing of buildings, ensuring that the resources already utilized in the initial development of the built environment are preserved while allowing the building to be put to new uses. The challenge to "retrofit suburbia," for example, will undoubtedly be a difficult one.

5. **New concepts of the roles of public and market-based incentives are required to make low-carbon cities feasible.** Historically, cities have grown unchecked around the idea of facilitating the movement of people and commodities through them using fossil-based fuels. When we think about designing for carbon neutrality, we confront the question of balancing traditional functions while creating human-serving spaces that conserve energy, with smart design and ongoing maintenance and operations that will be required to keep city infrastructure resilient and adaptive over time. If a major goal of cities goes beyond the market-based movement of people and commodities – to draw people in with livability and encourage reduction in the use of high-carbon fuels – the role of the financial incentives will change. The

public goods of GHG reduction and livability will likely require more of a public role in providing incentives for builders, as well as new concepts for private return on investment, which will include all elements of the "triple bottom line:" financial, environmental and social. Fortunately, new investment models are emerging, new roles for government are evident in the work of the C40 Cities, and a new generation's expectations for low-carbon lifestyles are being practiced as well as theorized.

VII. Opportunities for Leadership and Future Research

Collectively, we do not have a model or a handbook for building cities with reducing carbon emissions as the goal, and yet progress on this goal is urgently needed. Building on the existing knowledge base, as well as emerging information, IEE has identified opportunities for leadership and future research.

A. Leadership

Viewed through the lens of lowering carbon emissions, the materials scientists, engineers, designers, planners and others that design the urban built environment are way ahead of the developers, investors, government regulators and implementers, and general public who will interact with the physical forms.

We think that puts those professionals who build our urban environments in an historically unprecedented position. In the face of market forces, political short-sightedness, or consumer preference, the most efficient and long-lasting design might take a back seat. But when the focus is on low-carbon choices, engineers, designers and planners are back in the front seat. Maybe not the driver's seat, since good design must take into account the human needs detailed in this paper – but on a much more equal footing.

More specifically, we can look at the case of the Bullitt Center going up in Seattle (Nelson, 2011). Its cutting edge design, integrating the latest in technology, building materials, siting, etc. will allow unprecedented energy and waste reduction, and longevity – the building is designed to last 250 years. The City of Seattle sees it as a definite feather in the City's sustainability cap and it will contribute greatly to the livability of the neighborhood. It is important to note that construction financing could have been achieved only with a hefty contribution by the Bullitt Foundation. It is equally important that the Foundation intends to make back its investment by prorating the cost of office space and energy savings, over a longer time frame than is customary to many investors. Significantly, the role of engineering systems of all kinds has been at the forefront of making the Foundation's desire come to pass.

As the reality of climate change more powerfully motivates the public and policy makers, this will be translated into the desire for more buildings, streets and public spaces to be built, or re-built, sustainably. But, how will it be financed? No doubt, public financing will be a factor, but private sector financing, through what is generally called "impact investing," will play an

increasing role, as a new breed of socially conscious investor steps up.[4] David Wood (2011), Director of the Initiative for Responsible Investment, at the Hauser Center, Harvard University, has written on "Making Sustainable Cities Investable," suggesting a mechanism for uniting new investment pools with emerging municipal policies for sustainability. Antony Bugg-Levine and Jed Emerson (2011), in *Impact Investing: Transforming How We Make Money While Making a Difference*, offer information on the many new investors and investment instruments in the field.

We believe that the increase in financial instruments that use market-based solutions to increase social and environmental impacts and the application of those instruments to sustainable cities will create an opportunity for engineering, design and planning companies. By combining their technical expertise with a broad understanding of how people will interact with their buildings, they will be well-positioned to demonstrate to potential investors, developers, and policy makers that it is indeed possible to transition to low-carbon cities that can meet the needs of different groups of people now and in the future.

B. Future research: Unanswered questions

This paper has been about how human beings interact with the built environment by living in it. But, people also determine what will be built, and where, and under what conditions. We could call these two ways people interact with the built environment the "demand side" of living in what is built and the "supply side" of determining what is built. Professionals who translate possibilities into physical form are in the middle of these two sets of forces.

Future research on the "demand" side of how people live in what is already built:

- *The question of human expectations:* The research IEE has undertaken focused on human behavior in the urban context. Related to this, but understudied, is the question of human expectations of city life. We do not know what people expect cities to be and to do, and how malleable these expectations are. Residents' and workers' expectations regarding the convenience and accessibility of urban amenities will undoubtedly inform how they go about their day-to-day lives, in ways that have direct implications for the resource intensity of their various activities. British sociologist Elizabeth Shove has assessed how expectations of convenience and cleanliness are culturally embedded and fluid over time; her work may provide a useful framework going forward, particularly instructive for the possibility of designing *for* changing expectations, or even designing *to* change expectations.
- *Flexible design:* The topic of flexible design requires more research, since if we can utilize our existing infrastructure for alternative purposes, the embodied carbon required

[4] See, for example, the Global Impact Investing Ratings System, www.giirs.org, which is not a method for making investments, but for measuring their environmental and social impacts. This is both a mechanism that could be applied to assessing sustainable investing in cities, and indicative of a large, strong trend. The Social Capital Markets conferences have been occurring for five years, in San Francisco and internationally. SoCap (http://socialcapitalmarkets.net/) declares that it is "a new form of capitalism is arising that recognizes our ability to direct the power and efficiency of market systems toward social impact. Social Capital Markets is dedicated to supporting the growth of this market."

is lessened. Flexible design also allows communities to use spaces for their specific needs and preferences, which are certain to change over what should be an extended useful life of buildings and other infrastructure. Human beings have historically used natural surroundings of woods and plains for a variety of purposes; how does this apply to continuous re-purposing of the built environment?

- *The interaction of behavioral choices, urban design that encourages choices in favorable directions, and cultural shifts that use less carbon.* Current information does not let us know how important changing the behavior people choose actually is for lowering emissions (estimates of reductions are modest, in the neighborhood of 5%). The refinement of urban design toward encouraging low-carbon behavior might be more productive. Most productive of all might be achieving cultural shifts within that refined environment, in which lower-carbon lifestyles are favored and the ability to act upon them is enhanced. How can that be accomplished?
- *We need to operationalize concepts like "density."* The opportunities for increasing the positive externalities of compact urban life are greatest in the U.S. where there are not already large cities. The amenities that make urban life attractive depend on having a customer base that is easily accessible by walking or transit. This translates to numbers of people per block, or neighborhood, which is one measure of urban density. But we do not know how to calculate the numbers of people necessary to support the variety of amenities that contribute to livability. We need to investigate measurable relationships among such variables as retail offerings, customer base, building height and occupancy, in order to craft a concept like "density that supports livability."

Future research on the "supply" side of determining what is built:

- *Assessment of the new financial models for sustainable urban investment*: For these to be viable, we need to examine their expected and realized rates of return, time frame for investments, integration with environmental and social expectations, and their integration with public funding, as public-private partnerships will be both needed and desirable.
- *Incorporating C40 Cities learnings on technology and urban form with "demand side" human interaction*: We need to get beyond general concepts of human behavior, to culturally- and gender-specific behavior in specific urban contexts, which will increase the productivity of social science in helping to craft lower-carbon development; pilot projects with rigorous evaluation components in C40 cities are now possible, to test all the variables for reducing carbon footprints.
- *Shifts in public behavior*: Alternative lifestyle movements to shift to low-carbon lifestyles have mostly been rural; the adaptation of such behavior into the urban context should be studied, and if necessary enabled on a pilot basis, integrated with new urban regulations and infrastructure.
- *Demonstration projects integrating supply side and demand side forces*: Learning at the level of new building technologies is initiated and refined in part by testing what is built; emerging interest in impact investing, city-based carbon reduction and low-carbon lifestyles should be tested as they interact in real time, as C40 demonstration projects.

Our current, "high-carbon" cities are composed of integrated systems of finance, policy, building and human behavior which are unsustainable. While there are individual real-world examples of

finance, policy, building and behavior that are suggestive of being the elements of low-carbon cities, they must be integrated into new systems of sustainability and resilience. Market forces alone will not get us there, nor will government fiat or individual action. This paper has documented some of the human behavior elements that interact with cities, helping to inform what must be our collective next steps in action and research to clarify the meaning of that action.

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IX. Addendum of Further Relevant Readings

Jankovic, Ljubomir. 2012. *Designing Zero Carbon Buildings Using Dynamic Simulation Methods*. London: Routledge.

Jankovic combines dynamic simulation with economic analysis to develop a structured method for zero carbon design. He demonstrates that it is possible to design new or retrofit zero carbon buildings today, using existing technologies.

Ng, Edward, ed. 2009. *Designing High-Density Cities: For Social and Environmental Sustainability*. London: Earthscan Publications Ltd.

Pearce, Annie, Yong Han Ahn, and HanmiGlobal Co Ltd. 2012. *Sustainable Buildings and Infrastructure: Paths to the Future*. London: Routledge.

This textbook is aimed at students taking courses in Construction Management and the Built Environment. It covers the concept of embedding sustainability across all construction activities, with the premise that the construction industry has the largest potential of any industry to contribute to reducing greenhouse gas emissions.

Sinh, Sumita. 2012. *Architecture for Rapid Change and Scarce Resources (Paperback)* London: Routledge.

This book explores what it means for development activists to practice architecture on a global scale, and provides a blueprint for developing architectural practices based on reciprocal working methods with local communities. The book covers Sinh's extended field research and contacts with architecture schools and architects, as well as participating NGOs. It demonstrates that the ability to produce appropriate and sustainable design is increasingly relevant, whether in the field of disaster relief, longer-term development or wider urban contexts, both in rich countries and poor countries.

SustainAbility, GreenBiz, and Ford Motor Co. 2012. "Citystates: How cities are vital to the future of sustainability." Retrieved 15 Mar 2012 (http://www.greenbiz.com/sites/default/files/SustainAbility_Citystates_March2012_0.pdf).

This report lauds cities as sites of dynamic energy, making them promising launch pads for shifts towards sustainability, especially relative to a broader world increasingly characterized by uncertainty and economic fragility. The report posits that "sustainability needs cities as much as cities need sustainability." The authors identify seven characteristics of cities that are key to advancing sustainability both within and beyond the city, with attention to what businesses can learn and contribute to further their potential success.

X. About the Institute for Environmental Entrepreneurship

The Institute for Environmental Entrepreneurship was founded in 1999. IEE advances environmental and social sustainability for our planet, all people and our collective prosperity, now and into the future.

Early in its existence, IEE created the Green MBA program, the first in the nation to teach business practices devoted to achieving environmental and social sustainability while maintaining a solid financial bottom line. The Green MBA program is offered at Dominican University in San Rafael, California. IEE has broadened its focus, which is now centered on Research and Development for the triple bottom line. Towards this end, IEE is developing a meta-sustainability platform that will serve as a knowledge base for sustainability. More information about IEE can be found at www.enviroinstitute.org.

About the Team

Edward Church, Ph.D., Executive Director

Over the past 30 years, Edward Church has had wide-ranging experience in government, nonprofits and private business. Ed has served as the Executive Director of the Institute for Environmental Entrepreneurship since 2007, during which time he also had a part-time appointment with the Green MBA program of Dominican University in San Rafael. He won an award for innovation from the San Francisco Business Times as well as awards from the State of California, the County of Alameda and the City of Oakland. Ed was the founding Executive Director of the Berkeley Community Fund and for 20 years was a consultant and program executive for the Trio Foundation.

Ed also directed the Livable Communities Initiative at the East Bay Community Foundation, was Program Director at Urban Strategies Council, an anti-poverty think-tank based in Oakland, California, and was the Founding Executive Director of Brighter Beginnings, a maternal and child health organization, going strong since 1984.

Carolina Miranda, MBA, Associate Director

Carolina Miranda has more than ten years combined teaching and management experience. She has developed and restructured departments in both for-profit and non-profit businesses. Her experience includes developing and implementing Sustainability Management Systems, preparing Corporate Sustainability Reports, and working on Green Business and B Corporation Certifications.

Carolina is the founder of Cultivating Capital, a certified B Corporation specializing in helping small business owners to go green and market their businesses online. She is also a Green Business Consultant with the Alameda County Green Business Program and a Board Member of the Sustainable Business Alliance.

She has a B.A. in history and English from the College of Wooster, and an MBA in Sustainable Enterprise from Dominican University of California

Rebecca Elliott, Ph.D. Candidate, UC Berkeley, Research Associate

Rebecca is a PhD student in the Department of Sociology at UC Berkeley. Her research concerns the social organization and politics of sustainable consumption in the United States. She is a member of the Sustainable Consumption Research and Action Initiative and of the Environment & Technology section of the American Sociological Association. Rebecca received a BA in Political & Social Thought from the University of Virginia in 2008 and an MA in Sociology from UC Berkeley in 2011.

Nicola Szibbo, Ph.D. Candidate, UC Berkeley, Research Associate

Nicola Szibbo is a PhD student in the Department of City and Regional Planning at UC Berkeley. At UC Berkeley, Nicola has worked for the Center for Resource Efficient Communities (CREC) and Global Metropolitan Studies (GMS) researching sustainable community strategies. She has also worked for the City of Surrey, in British Columbia and the Port of San Francisco on their greenways, parks and open space designs and best practice guidelines. Nicola obtained her BA in Anthropology from the University of British Columbia, and her Masters in City and Regional Planning from UC Berkeley. Her dissertation research is centered on sustainable urban design and community energy systems.

Galen Cranz, Ph.D., Professor of Architecture at UC Berkeley

Professor Galen Cranz is Professor of Architecture, a Ph.D. sociologist, designer, author, lecturer, and certified teacher of the Alexander Technique, a system of body-mind postural education. Her research specialties are urban parks, chairs and body conscious design, and qualitative research methods. She teaches courses in social and cultural processes in architecture and urban design, including research methods. Current research activity includes body conscious design, the sociology of taste, ethnography for design, and post-occupancy evaluation.

Professor Cranz is author of *The Chair: Rethinking Culture, Body and Design*, which received the Achievement Award from the Environmental Design Research Association (EDRA) in 2004. She is a founding member of the international Association for Body Conscious Design and lectures worldwide on this topic. *The Politics of Park Design: A History of Urban Parks in America* has become a classic that exemplifies how physical design expresses and reinforces social forces over time. Professor Cranz's research on parks has led her to a long-standing interest in landscape architecture and public art.