Chapter 1: Introduction

In 2002, scientists sounded the alarm about the loss of ice on the Arctic Ocean. Global warming was having a more rapid influence on the arctic climate than anyone had previously thought possible. They predicted that if nothing was done to curb the level of greenhouse gas (GHG) pouring into the atmosphere there might be no summer ice covering the North Pole by 2050. Early in 2009 they updated their projection. Given the rate of ice loss, the new date by which the Arctic Circle will be ice free could be as soon as 2012. The loss of ice triggers other effects, none of them good. The white ice that once reflected warming sun rays no longer does so. The deep blue ocean water that takes its place absorbs those rays, warming the water and further accelerating the warming of the planet. Bad things happen in threes. The added heat also releases Methane gas that was previously trapped under polar ice. Methane gas, like CO2, traps heat in the atmosphere; but molecule per molecule it is many times more damaging. The cascading effects of climate change, previously predicted for the distant future, are already here.

[Figure 1.1 in margin]

Experts at the U.N. sponsored Intergovernmental Panel on Climate Change (IPCC) all agree that the 2 degree Celsius rise in global temperature, the so called “safe” level of warming that we will still get even if we cut greenhouse gas emissions (GHG) by 80%, is a rise that is unavoidable. The IPCC predicts that even at this “safe” temperature increase up to 50% of the planet’s species will become extinct. But we are on a path where GHG produced from the burning of fossil fuels is not dropping, but increasing rapidly. With a

five-degree rise much more would be lost. Vice President Gore, when seated before a senate hearing on climate change held in January 2009, was asked if a five degree rise in global temperature would “end life as we know it”. “No senator,” he replied “people will survive in some form, but likely all of our institutions would collapse and billions would die.”

What have all of these gloomy scenarios to do with a book on city design? Everything. If we change the way cities are built and retrofitted we can prevent the blackest of the nightmare scenarios from becoming real, and create the conditions for a livable life for our children and grandchildren. It is not apocalyptic to say we can save their lives.

Normally GHG production is described by sector. We often read that buildings account for about half of all GHG production, transportation for about 25%, and industry accounts for the rest.[1] But this division obscures a fundamental point: Cities are responsible for 80% of all GHG—caused by the way we build and arrange our buildings, by all the stuff we put in them, and by how we move from one building to the next. Since the problem is caused by cities the solution should be there too.[2]

Citizens and their elected officials have been slow to acknowledge the connection between GHG and urban form. This book may help change that. It is written for designers, policy makers, developers, regulators, and ordinary citizens, in the hopes that

it will arm them with an understanding of the ways our cities are failing, and very specific actions they might take to cure them.

How Did Cities Get This Sick?

In any journey, it is helpful to start with a look back from where you came. Various historical starting points could be studied, but the end of WWII marks the time after which cities changed the most. There were many compelling reasons for the crucial choices we made at that time, the most compelling was the need for a place to live.

[Figure 1.2 in margin]

After World War II, a variety of policy inducements provoked a massive redistribution of population across metropolitan landscapes. In the US, the mortgage interest income tax deduction, low interest G.I. loans, "red lining" of older residential areas, and the 1956 National Defense Highways act funding the construction of the interstate highway system were most significant.[3] Provoked by these inducements, middle class and working families who had traditionally previously occupied higher density walk-able and transit served neighborhoods, fled to much lower density and car dependent suburbs.[4] Average densities began to fall in every North American metropolitan area, while transit ridership as a percentage of all trips began to fall with it. Older pre war parts of the metropolitan landscape still maintained healthy transit ridership, but transit use in newer areas was near zero.[5]

As North Americans moved from transit to cars, their per capita GHG amounts began to rise too. Of course no one worried. GHG production was of no importance at that time, as the implications of this increase were not widely known and even less widely accepted. Buying fuel for the family car was also an insignificant consideration, as prices were low.[6] The brand new high speed freeways provided previously unimaginable freedom of motion, allowing workers to hold jobs 25 or more miles from home.[7] This was a massive change that fundamentally altered the reach of cities. In 1950 the Boston metropolitan urbanized area was only 345 square miles. In 2000 it sprawled over 1,736 square miles, a quintupling in only five decades (US Census Bureau, 2000).

During this period of dramatic metropolitan expansion, land was generally less expensive on the peripheries. This made it profitable to build residential developments ever further away from the metropolitan center, with single family homes generally dropping in price as you moved further out. This concentric reduction in house prices gave rise to the saying “drive till you qualify,” a widely used and humorous phrase meaning that home buyers were induced to push a home search further and further out from the center of the region until their income matches the qualification requirements for the mortgage.

With so much unprecedented freedom of movement in this new urban landscape, house price became a much more important factor than location. A distant job was easy to reach, and shopping centers catering to millions of auto nomads were not far behind. Eventually vast stretches of the metropolitan landscape become completely car dependent

forcing individuals and families to spend more and more time behind the wheel, and to rack up ever increasing vehicle miles traveled (VMT).

The new single-family homes were not only auto dependent, but due to their shape and exposure to the elements, were inherently hard to heat. We now know that the GHG production of this style home is up to four times greater per capita than that of home types common to older center cities. [8]

[Figure 1.3 in margin]

It was not only price, but school quality that was a crucial factor in deciding on location, and here newer communities had a distinct advantage over older ones. Newly developing areas naturally had new schools while older areas had older schools populated by children from families without the economic resources to follow the migration, and in cities hampered by declining property to fund them adequately. Of course these new schools were sprawling one story buildings that were impossible to reach on foot, requiring expensive fleets of carbon producing buses to ferry children back and forth.[9]

Unquestionably, this new low density and car dependent development pattern successfully supplied millions of new housing units at prices that North Americans could afford. This success has led many to claim that sprawling urban areas are more affordable than those with metropolitan growth controls. Well financed lobbying groups have attacked Oregon's growth controls,[10] in force since 1974 on this ground for decades, even though Portland's housing costs are lower than other similar sized western US

communities like San Diego, Seattle, San Francisco and Sacramento, metropolitan areas with no such laws. Thus the claim that low density is more affordable than higher density cannot be credible.[11] This is especially true if transportation costs are considered. The more sprawling the metropolitan area the higher the percentage of family budget devoted to auto use. If these additional costs are factored in the "affordable" house in a third ring suburb is not nearly so affordable, a fact made sadly obvious when in 2008 the combination of sky high gas prices and the mortgage meltdown led to virtual abandonment of many US third ring subdivisions.

Low density sprawl also costs much more per dwelling unit to service than higher density development. A subdivision of single family and duplex units on 2,800-3,300 square foot lots can be serviced for 75% less per dwelling unit than single family homes on larger lots of 8,000-9,000 square feet. The cost of providing streets and utilities to a new home can be substantial. Each home requires a certain amount of paved street, storm drains, and utilities before it can be occupied. At lower densities the cost of providing required streets and services can be over $100,000 per dwelling unit.[12] Homebuyers are seldom aware of this cost as it is always buried in the cost of the home purchase, and thus don't know that streets and pipes can account for over 20% of the purchase price. This cost can make the difference between a home that is affordable and one that is not. When houses are built at higher densities they are closer together. Thus the length of roadway and utilities required to get from one house to the next is reduced as lot sizes shrink. If there are two dwelling units on the lot then the cost for servicing each dwelling unit is cut by half again. The land component of the house cost will also be proportionately less as

density increases, since the cost of an acre of land can be recouped on the sale of more houses.[13]

Separation by Class and Income

The "drive till you qualify" concentric rings of increasing affordability discussed above does not capture the whole story. After the war a second finer grain distinction emerged, particularly noticeable in metropolitan landscapes made up of dozens of quite small former rural communities like Boston's. Whether by accident or intent, formerly rural towns now, part of Boston's suburban ring adopted zoning policies which had the effect of narrowing the income range of new residents.[14] Towns that allowed subdivisions of one eighth, one quarter, or one half acre lots attracted middle class and lower middle class home buyers. Towns that allowed only large lots of two, four, or five acres per dwelling unit attracted only upper income earners. Land in towns with the large lots was quickly used up (it only takes 122 houses at one per five acres to consume a square mile of land). Exclusive zoning increased the average number of vehicle miles travelled (VMT), as home buyers, unable to afford homes in the low density communities near where they worked, could only to buy homes in distant communities and make long daily commutes. In many cases these low density communities went so far as to exclude any new commercial development to serve new residents, leaving it to neighboring communities to supply supermarkets and other shops, further increasing the need to drive.

[Figure 1.4 and Figure 1.5 in margin]

The Problem Emerges

The cracks in the system began to emerge after the 1974 “oil shock”, a supply constraint caused when the OPEC nations cut off the flow of oil to the West. Spending long hours in line for gas exposed the weakness of the economy to interruptions in the flow of imported oil, by now a clearly vital resource. At first the response was significant, provoking a shift away from larger cars and a lowering of speed limits to save fuel. But over the longer term the lesson went unlearned. Dependence on imported oil has increased dramatically in the intervening decades, and average fuel consumption per capita has risen sharply and steadily, only reaching a plateau in 2007. Also unfortunate: scientists who began loudly sounding the alarm about global warming at this time were largely ignored, and with the election in the US of Ronald Reagan, a man who had no interest in energy conservation, the moment was lost. During the 80s and 90s, suburban low density development moved the US from being a country where most of its residents lived in former streetcar served districts where alternatives to the car were possible to one where the majority of residents lived in districts that were completely auto dependent.[15] Rather than put in place national, state and regional policies to reverse or at least mitigate an ever rising per capita use of fuel for the single passenger automobile, the reverse occurred. US transportation bills from the 70s through the 90s favored the expansion of the interstates and feeder highways over transit, and no policy proposals to require walking distance access to transit and commercial services in new districts was ever seriously considered. Canada fared somewhat better. The Canadian federal government

was happy to collect a substantial gas tax, thank you very much, but unlike the US government was under no obligation to return it to the provinces in the form of highway funds. Thus Canadian cities have far fewer freeway miles per capita than do US cities.[16]

[Figure 1.6 in margin]

Absent any national, state and provincial policies average densities in metropolitan regions continued to drop till at least the year 2000. Exceptions were few, Vancouver BC and Portland, Oregon notable among them. More numerous were the extreme examples of centrifugal forces pushing population to peripheries, impelled by vast new highway expenditures, even where regional population was stable. Detroit and St. Louis are two instructive examples. Unabated freeway construction even absent significant population increase has left the older center cities of St. Louis and Detroit virtually abandoned, losing two thirds of their population to the suburbs during that period.[17]

Current aerial photos of once attractive Detroit single family home neighborhood, show urban blocks with all but one or two houses razed. The same population that once lived there has been spread out over a landscape four times its original size. Now a population that prior to WWII lived almost entirely in walkable transit served communities mostly lives in auto dependent low density districts.

[Figure 1.7 in margin]

Infinitely Increasing Car Dependence

All of these forces combined to create an entirely new Canadian and American urban landscape Many thoughtful voices argue that this is a good landscape where families can find a house they can afford with a yard for the kids in a community of their own choosing. This is a strong argument, but an argument that can only be sustained if we are willing to forever increase the percentage of national treasures we commit to highway construction, the amount of personal wealth we pour into the gas pump, and the amount of carbon we pour into the atmosphere.

The trends are not hopeful. Per capita driving has increased alarmingly for decades, and until 2008 when fuel costs leapt briefly to over four dollars per gallon, was increasingly inelastic (meaning not responsive to market signals like increased fuel price).[18] For most people driving is no longer a discretionary expense. They cannot just shift to walking or taking mass transit in auto-dependent landscapes; there are no sidewalks to walk on, there are no walkable destinations to walk to, and for all intents and purposes there are no busses to catch. Absent a practical way to shift to alternative modes, residents in auto-dependent landscapes can only economize by cutting discretionary car trips, forcing families to give up the leisure or social activities they once enjoyed to preserve precious fuel for trips to work. Much of the 2008 drop in VMT seems a consequence of such sad choices.

Auto-dominated landscapes have forced families to devote ever larger shares of their income to transportation, a share that now for the first time in history approaches the

share consigned to paying for a home. While in 1965 most families owned one car, now two cars is the norm.[19] The growth in two income households is one crucial contributor to this trend. The two incomes needed to pay off the mortgage on the home can only be maintained if both workers have a car to get to work. Dropping children at daycare and driving older children to otherwise inaccessible schools makes a car even more indispensable.

[Figure 1.8 in margin]

But its not just "bread winners" who need a car. Everyone of driving age needs one. To be without a car in these landscapes imprisons one in the home, and the craving for escape with a car as the means. But in this case escape does not mean freedom.[20]

Health Effects

A landscape where walking is impossible is a landscape where our legs are only used to get from the couch to the refrigerator and from the front door to the driveway. Residents of auto oriented suburbs walk less and weigh more than people in walkable areas. While direct causation is difficult to definitively ascribe, the evidence is highly suggestive. The body is designed primarily for walking. If walking is systematically denied by ones environment this cannot be a good thing. Many studies suggest that the epidemic increase in teenage obesity and alarming rise in juvenile onset diabetes can at least partly be ascribed to the physically paralyzing influence of auto oriented landscapes.[21]

Spending and Spending to Stay in One Place

For all of these reasons a system that had the capacity to accommodate the family car trips of thirty years ago when these trips were half their current level now utterly fails. The limited access highway system and its corollary, auto-dependent sprawl development generates ever greater demand for travel. Families are not driving twice as much because they like to but because they have to. All this "induced demand" (the cause/effect relationship between adding highway capacity and changes in driver behavior and land uses that quickly eat up that capacity) leads inevitably to paralyzing congestion. We should have seen this failure coming. To get the system back, even temporarily, to the efficiencies of thirty years ago would require a doubling of highway lanes per square mile in most metropolitan areas;[22] a proposition that most metropolitan regions have understandably shied away from.

But even if we could double the amount of national treasure committed to such an enterprise the dream cannot become real.[23] The space demands of the car are such that in many sprawling metropolitan areas there are ten parking spaces scattered around the region for every car.

[Figure 1.9 in margin]

That's an acre of land for every fifteen cars not counting the roads, garages, driveways and freeways they also demand. In the city of Sacramento, California over 35% of all city

lands are paved for car use.[24] As auto dependence increases, the percentage of land required to keep the system smoothly flowing increases steadily even beyond 35% to absurd heights. Many metropolitan areas are in danger of being consumed by roadways and parking lots while worthy destinations to drive to and from become increasingly rare.

Climate Change

Thirty percent of the world's CO2 production comes from the United States and Canada, where only about 6% of the world's people live. Of this about a quarter comes directly from transportation, and the bulk of that from single passenger automobiles. This number does not include the CO2 consequences of the immense infrastructure of car manufacturing and support, and the CO2 production from building the roads and highways all those cars need (concrete production is the largest single industrial producer of climate change gas, with most concrete in North America used for highway and bridge construction).[25] Factoring those in brings the CO2 share for transportation closer to 40% (Gagnon, 2006).

The community of nations is finally agreeing that planetary meltdown can only be avoided if we cut climate change gases by 80% by 2050. The US and Canada, who have heretofore been the most reluctant of the G8 nations to acknowledged the crisis, have now agreed. During a period where just the US alone will add 130 million more people, it is madness to assume an 85-90% per capita reduction can be achieved unless we reverse the trend toward ever greater auto dependence. Misplaced faith in technological quick fixes such as hydrogen cars, electric cars, or switching to ethanol won't help us.

Changing to alternative energy sources will do nothing to change the fundamental entropy of our transportation choices, many other sources require huge energy inputs in their creation, lead to food scarcity in third world countries, and in the case of corn based ethanol require more petroleum to make the fertilizer, drive the farm equipment, and to truck the raw materials here and there than they give back in fuel.[26]

Reasons for Hope

At this point the reader is no doubt tempted to reach for a strong drink and ignore the problem. It seems too big to solve. But all is not lost. Robert Yaro, president of the Regional Plan Association of New York often says: "The bad news is that we have massively overbuilt the freeway system. The good news is that we have massively overbuilt the freeway system." By the first part of this sardonic aphorism he means: America has over invested in a system that has, in the absence of any other land use planning controls, made a sprawling and highly inefficient urban landscape inevitable, as the excessive transportation demands that this infrastructure unleashes became impossible to satisfy. By the second part he means: The exact same system that unleashed these forces is of such a size and extent that it could accommodate through infill the massive increases in population expected. If a way could be found to increase the land use intensity of all of the districts within the freeway service area to double or triple their present level (and surely given the low coverage by buildings such a thing should be easily possible), then per capita demand for long distance travel should gradually drop as well. When land use intensity increases, alternatives to the car become possible, allowing a gradual mode shift to transit walking and biking. What this suggests is that the retrofit and intensification of the North American suburb is both eminently possible and a means

to address the three linked sustainability problems of the city; our downward cycle of ever increasing car use, our increasingly unaffordable infrastructure maintenance costs, and the larger global crisis of climate change and our own responsibility for it (Nelson, 2004).

Happily, in many areas this infill is already underway. According to the US Census Bureau, the year 2000 marked the first time in fifty years that the average density of metropolitan areas has gone up. This is not just because young professionals are flocking to high density warehouse districts; it's much more systemic than that. The five room ranch house of the 1950s, a 1,200 square foot home on a 20,000 square foot lot is now a thing of the past. Now the 3,500 square foot home on the 5,000 square foot lot is much more the norm.[27] While these puffed up houses on smaller lots are decried by many, they represent a huge shift in the market to a density that is at least conceivably compatible with walkable and transit served communities. This trend is most advanced in the greater Vancouver region, where in the years between 1986 and 2001 the percentage of residents living in compact, transit friendly neighborhoods increased from 46% to 62%.[28] Also, the city of Vancouver is now North America's most successful example of center city densification. In the ten years between 1990 and 2000 the population of the downtown peninsula increased from 40,000 to 80,000. During that same time the total number of car trips into and out of the downtown actually decreased, while average commute times in the region dropped by six minutes (Vancouver was the only Canadian city where commute times went down during this period, a period where no additional freeway miles were added but during which population increased by over 20%).[29]

And there is more. Center city urban infill projects have been very successful in this decade, notably in Portland's "Pearl District".

[Figure 1.10 in margin]

Three decades spent maintaining Portland's compact metropolitan region, often against the weight of tremendous political and industry opposition, have helped the city avoid the crippling shift of property value from center city to sprawling suburbs, a shift that has killed cities including Detroit and St. Louis. Portland, by controlling the amount of suburban land available for development and by limiting freeway construction, has successfully protected inner city property values, making reinvestment in that city's former warehouse district possible. What is now sadly inconceivable in Detroit or St Louis is an accepted fact in Portland: There is a strong market for center city high density housing even in a relatively small cities. Young professionals are willing to invest up to $500 per square foot for an urban lifestyle, if past decisions have been such that there is any urban life remaining. Significantly, these values have stayed relatively strong despite the 2008 global market meltdown, when compared with the more precipitous declines experienced in newer second and third ring suburbs in more sprawling metropolitan areas.[30]

The success of Vancouver, echoed later by Portland, and increasingly in other cities like San Francisco, Washington DC, and Toronto, give reason for hope. Efforts to infill, complete, and re urbanize the metropolitan landscape are possible, and indeed seem to be compatible with current market demand.

[Figures 1.11 a and b here or in margin]

So while the symptoms of the disease are most certainly debilitating, and the disease itself life threatening, there are signs that the patient is capable of responding. As in so many other things there has to be a desire for change, and this desire is now apparent. The first step in recovery is always an admission that there is a problem and then taking responsibility for change. But proven therapies for restoring the health of the region are required. Citizens are justifiably insecure about how and what to change. Changing the way we build regions is like changing any habitual behavior. Habitual behaviors, like drinking, smoking or drugs, anesthetize us in the near term, but lead to larger problems in the long term. Building sustainable regions is the same. NYMBYism in the face of higher-density development proposals is tremendously satisfying for citizens who understandably feel they have protected their community through their opposition. But the long term effects of these actions, multiplied by many thousands of other equally habitual actions, is to worsen the disease. A set of principles, call them rules for healing cities if you will, are a necessary tool for recovery.

Over the years many have recognized this same thing. The list of simple rules, or “steps to recovery” that form the core of this book are not original. What is unique to this book is the attempt to simplify and order them clearly as a set of integrated urban design therapies for healing the urban landscape. The hope is to provide citizens and leaders in the public and private sector with a simple but credible framework for action. What

follows then is listing of the rules, followed by a short explanation, which introduces and anticipates the seven following chapters where they are explicated in much greater detail.

Seven Rules for Sustainable, Low-Carbon, Communities

1. Restore the Streetcar City

The North American city was and is a streetcar city. Streetcar cities are characterized by easy access to transit, a wide variety of house types, and services and job sites very close at hand, the exact elements of a sustainable city. We have largely ignored this fact. It needs rediscovery.

2. Design an Interconnected Street System

Fine grain interconnected street grids insure that all trips are as short as possible, disperse congestion and are compatible with walking, biking, and transit.

3. Locate Commercial Services, Frequent Transit, and Schools within a Five-Minute Walk

People will walk if there is something to walk to. The most important walking destination is the corner store and a transit stop. A minimum density of ten dwelling units per acre gross density is required for this to work.

4. Locate Good Jobs Close to Affordable Homes

The trend to ever larger commute distances for workers must be reversed. “Good jobs close to home” is a fundamental requirement. The vast majority of new jobs in the U.S. and Canada are compatible with complete community districts.

5. Provide a Diversity of Housing Types

Zoning laws have been an instrument to segregate communities by income. Communities designed for only one income cannot be complete and when repeated throughout the region add to transportation problems.

6. Create a Linked System of Natural Areas and Parks

To keep our waters clean and our streams and rivers healthy requires a rethinking of urban drainage systems and stream protection policies. Maintaining the integrity of these systems must be a first design move when planning new communities. Far from protecting these systems through restriction, these systems must form the public space armature of new and restored communities.

7. Invest in Lighter, Greener, Cheaper, Smarter, Infrastructure

Suburban homes have at least four times more infrastructure per dwelling unit than do walkable streetcar neighborhoods. Exaggerated municipal standards for roads and utilities cost too much to build and maintain, and destroy watershed function. Smarter, cheaper, and greener strategies are required.

Love One Principle, Love Them All

These principles represent the elements of a whole. Achieving one without the others, and particularly if it is at the expense of the others, will be of limited value and could be counterproductive.

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[1] EPA. 2009. *U.S. Greenhouse Gas Inventory Report (1990-2007)*. United States Environmental Protection Agency. Available online: http://epa.gov/climatechange/emissions/usinventoryreport.html. Accessed 09.07.20.

[2] Gurney, Kevin, R., Daniel L. Mendoza, YuYu Zhou, Marc L. Fischer, Chris C. Miller, Sarath Geethakumar, and Stephane De La Rue Du Can. 2009. High Resolution Fossil Fuel Combustion CO2 Emission Fluxes for the United States. Environ. Sci. Technol. Accepted May 23, 2009.

[3] As U.S. and Canadian populations moved outwards from the central cities, urbanized population density dropped dramatically. In the United States population density in urbanized areas fell from 3,175 persons/square mile in 1960 to 2,900 persons/square mile in 2006 (Demographia, 2006). A similar pattern can be seen in Canada where the urbanized population density dropped from 6,803 persons/square mile in 1960 to 4,000 persons/square mile in 2006 (Demographia, 2006).

[4] Historically, the rate of decentralization in Canada was most pronounced between 1941 and 1961 and again between 1966 and 1971, coinciding with major expansions of highway construction in metropolitan Canada (Edmonston et al. 1985). There are clearly a number of factors influencing growth and development patterns in cities (see Burchfield et al. 2006; Ellis 2001) however there is little doubt of the significant role highway construction has on expanding boundaries and decreasing density in metropolitan areas

(Handy 1993). Interstate highways transformed urban America by opening up the peripheries of cities for development and facilitating the blending of communities along their corridors (Milner 2007).

[5] Transit ridership is lowest in the suburbs where low population densities make reliable service difficult. This is illustrated by the difference in auto-oriented areas of the Vancouver metropolitan region, such as Surrey and Langley, BC where the transit ridership is 4.4 percent and 1.2 percent of all trips respectively and streetcar neighborhoods such as Vancouver, BC where the transit ridership is 20.1 percent (GVTA, 2005).

[6] In the United States families spent an average of 3.1% of their household expenditures on transportation in 1918; by 1950 this number had risen to 13.8% (Johnson and Tan 2001). In 2001 households spent 21% of all household expenditures on transportation (US Department of Transportation, 2003). Personal expenditures (meaning all pre tax dollars made) on transportation climbed as high as 12.7 percent in 2000 but have since dropped to 11.3 percent in 2008 (RITA, 2009). Between 1995 and 2006 average household transportation expenditures rose from $6,361 to $8,508 (in 2006 dollars) (US Department of Transportation, 2008). Bernstein et al. (2005) found that lower income households generally spend proportionally more than the national average on transportation, however, regions that have invested in public transportation are not being hit has hard, even as gasoline prices are rising. Lipman (2006) found that when many working families move far from work to find affordable housing they end up spending

their savings on transportation and by moving 12 to 15 miles the increase in transportation costs outweighs the savings on housing.

[7] In both US and Canadian cities commuting distance is increasing. Between 1969 and 2001 commuting distance in the United States increased from 15.12 km (9.4 miles) to 19.48 km (12.11 miles) (Hu, 2004) while in Canada the commuting distance increased by 0.2 km between 1996 and 2001 (Statistics Canada, 2003). In the United States this increase in commuting distance was greatest between 1983 and 1990 with a jump from 13.75km (8.54 miles) to 17.15km (10.65 miles) (Hu, 2004). In the US the average commuting time increased to 24.3 minutes in 2003 (US Census Bureau, 2005). In Canada travel time has increased from 27 minutes in 1992 to 31.5 minutes in 2005 (Statistics Canada 2005).

[8] Norman, Jonathan, Heather L. McLean, and Christopher A Kennedy. 2006. Comparing high and low residential density: Life-cycle analysis of energy use and greenhouse gas emissions. *Journal of Urban Planning and Development* (March):10–21.

[9] In 2005-06, more than 25 million children enrolled in public K-12 were bused to school at public expense (US Department of Education, 2009). During the same period the United States spent $18.86 billion on school bus transportation at an average cost of $746 per student transported (NCES, 2008). This is up from $198 per student transported in 1980-81 (US Department of Education, 2009).

[10] In 1973, the Oregon Legislature enacted landmark state planning legislation called Senate Bill 100 under which cities and counties implement zoning at the local level

subject to state oversight. The central policy of Oregon's land use planning program is curbing urban sprawl (OCZMA, 2008). A copy of the bill can be accessed online at: http://www.oregon.gov/LCD/docs/bills/sb100.pdf

[11] Condon, P. and J.M. Teed. 1998. *Alternative Development Standards for Sustainable Communities: Design Workbook.* James Taylor Chair in Landscape and Livable Environments. Available online: http://www.jtc.sala.ubc.ca/projects/ADS.html

[12] Homes built at one dwelling unit per five acres would require over 300 feet of roadway to serve each one. Assuming standard suburban infrastructure of underground services for all utilities, curb and gutter road designs, and storm systems designed to deliver the 100 year storm, the cost per lot could easily exceed this amount.

[13] Housing prices are determined by a host of interacting factors, such as the price of land, the supply and types of housing, the demand for housing, and the amount of residential choice and mobility in the area (Nelson et al., 2002). Urban Growth Boundaries can affect land values but their effects on housing affordability remain in dispute. Research done in Portland shows that growth in housing prices is more attributable to increased housing demand, increased employment, and rising incomes than urban growth boundaries (Phillips, 2000). Traditional zoning and land use regulations often place greater limits on the supply and accessibility of affordable housing (ie. low-density-only, minimum housing size, bans against attached or cluster homes) (Nelson et al. 2002).

[14] Davidoff (2005) found that the Boston MSA is heavily income sorted by jurisdiction and that housing quality and extra-governmental amenities play a large part in this process. Boston's suburbs show a large range in both median home price and household income. Newton has the highest median home price at $438,400 (in 1999 dollars) compared with Lawrence at $114,100 (US Bureau of the Census, 2000). The highest median household income of $141,818 is found in Dover while the lowest, at $27,983, is found once again in Lawrence (US Bureau of the Census, 2000).

[15] According to the U.S. Census Bureau (2000) 21% of the total U.S. population lived in central cities in 1910 while only 7% lived in suburbs. From 1910 to 1930 population increased rapidly in both central cities and suburbs however after 1940 suburbs accounted for more population growth than central cities and by 1960 the proportion of total U.S. population living in the suburbs (31%) was almost equal to the proportion living in central cities (32%). From 1940 to 2000 the proportion of the total US population (urban, suburban, and rural) living in central cities remained relatively stable (ranging from 30 to 32.8%) while the proportion living in suburbs continued to grow steadily, finally reaching the 50% mark in 2000.

[16] Transportation plans from the 1920s and 1930s were simpler designs with less capacity and lower speeds than those eventually built; they were meant to facilitate a multimodal system, were often connected to adjacent land uses, and were tied closely to existing roads (Taylor, 2000). Ambitious planning goals in the 1920s and 30s including rejuvenating communities, reducing congestion, preserving central business districts and improving public transit suffered dramatically when the depression brought a severe drop

in property tax revenue and with it, urban road and highway finance (Taylor, 2000). State departments and federal transportation boards took control from cities and implemented their own agendas focused around moving people long distances quickly rather than supporting local communities (Taylor, 2000; Brown 2005)

[17] Birch (2005) found that between 1970 and 2000 the cities with the largest decreases in central city populations were St. Louis (-52%), Columbus, OH (-52%), Columbus, GA (-46%) and Detroit (-46%). Many experts attribute growth away from central cities in part to the building of the highway system in the United States (Berry and Dahmann, 1977; Chi, 2006; Goldberg and Mercer,1980). In Canada, Saskatoon and Regina exemplify this "doughnut hole effect," but in a less extreme way. According to the 2001 census Saskatoon's core population grew by 1.6% while its surrounding area grew by 14.6%; Regina's core declined by 1.2% while its surrounding area increased by 10% (Statistics Canada 2001b).

[18] Turcotte (2008) shows that the proportion of people aged 18 and over who went everywhere by car rose from 68% in 1992 to 74% in 2005 while the proportion of Canadians who made at least one trip by bicycle or on foot has declined from 26% in 1992 to 19% in 2005. In low density neighborhoods over 80% of residents made at least one trip by car per day while less than half of the people living in very high density neighborhoods did so (Turcotte 2008). Dependence on automobiles differs considerably between CMAs, but one of the most important reasons is housing density (Turcotte 2008). In Canada, the Montreal Metropolitan Region has the lowest percentage of people making all their trips by car (65%) and only 4 percent of dwellings in Montreal's central

neighborhoods were single-family detached homes (Turcotte 2008). In the United States the number of miles driven every year per capita by Americans rose by 151% between 1977 and 2001 (Polzin 2006).

[19] In both Canada and the United States the number of vehicles per capita has been steadily increasing from the 1950s (Schimek 1996). By 2007 there were 247 million motor vehicles in the United States, 42 million more than the number of drivers (Federal Highway Administration, 2007).

[20] For many people the suburban home is little more than a place to sleep, eat a meal or two and store personal belongings; most of their waking hours are spent elsewhere, either at work, school or in recreation (Gurstein 2001). This leaves people who work from home, especially those with young children, particularly isolated. Because the majority of people in their age group work outside of the community, the streets and other public spaces where passive social interaction would normally occur are empty and therefore ineffectual places for socializing (Gurstein 2001). Similarly, suburban teenagers suffer from the lack of active and passive participation in street life. Neighbourhoods separated from their main streets and from each other in highly disconnected street networks deter walking (Barnett 1995) and create a street environment often devoid of life. In an article by Teri Karush Rogers a growing number of suburbanites are shown to suffer from the isolation and lack of social contact in suburban communities (*New York Times*, January 8, 2006).

[21] Ewing et al. (2003) found that residents of sprawling counties were likely to walk less during leisure time, weigh more and have a greater prevalence of hypertension than residents of compact communities. Frank et al. (2004) found that land-use mix had the strongest association with obesity and that each quartile increase was associated with a 12.2% reduction in the likelihood of obesity. Their study also found that each additional hour spent in a car per day was associated with a 6 percent increase in the likelihood of obesity while each additional kilometer walked per day was associated with a 4.8 percent reduction in the likelihood of obesity. Papas et al. (2007) reviewed the literature on built environment and obesity between 1966 and 2007 and found that 84% reported a statistically significant positive association between some aspect of the built environment and obesity.

[22] Between 1989 and 2003 Houston has invested billions of dollars annually in highway improvements resulting in significant progress in relieving traffic congestion, far above that of most other metro areas in the United States (Cervero 2003, p159).

[23] The national funds dedicated to transportation are already significant. In 2007, the total transportation-related final demand in the United States reached $1,469.4 billion and accounted for 10.6 percent of the national GDP (RITA 2009). The average cost of owning and operating an automobile (assuming 15,000 vehicle-miles per year) was 14.4 cents in 1975 and rose to 54.1 cents in 2008 (AAA, 2008).

[24] Litman (2008) found that given two to three off-street parking spaces per capita there would be approximately 1,000 square feet of parking pavement per capita and 2,000

square feet of urban land devoted to paved roads and parking per capita. In Canada this is about three times the land devoted to homes (Litman 2008). A study, led by Bryan Pijanowski from Purdue University, surveyed the total area devoted to parking in a midsize Midwestern county and found that parking spaces outnumbered resident drivers 3-to-1 and outnumbered resident families 11-to-1 (Main 2007). In 2005, freeway lane-miles per square mile in London was 0.58, Paris and New York are similar with 1.52 and 1.50 respectively and Los Angeles had 2.57 (Demographia 2005).

[25] In 2006 the US transportation sector's Greenhouse Gas (GHG) emissions from fossil fuel combustion totaled 1,856 $TgCO_2$ Eq., accounting for 26.3 percent of the total GHG emissions in the United States (EPA 2008). This estimate did not include vehicle, fuel or infrastructure lifecycle emissions such as the extraction and processing of raw materials, production of fuel or infrastructure construction and maintenance. The total lifecycle emissions for the transportation sector (not including emissions from the construction and maintenance of transportation infrastructure) are estimated to be 27 to 34 percent higher than direct fuel combustion emissions (EPA 2003). Emissions associated with the construction and maintenance of transportation infrastructure have yet to be studied in depth but CO_2 emissions from the chemical process of cement production is the second largest source of industrial CO_2 emissions in the United States at 45.7 $TgCO_2$ Eq. (EPA 2008). According to the World Business Council for Sustainable Development (2002) only 50 percent of the CO_2 emissions produced from the production of cement come from this chemical process; 40 percent are from the combustion of fossil fuel for energy and are not included in the GHG inventory for the cement industry. Taking the chemical,

combustion and energy emissions into account Worrel et al. (2001) estimate that the cement industry is responsible for 5 percent of global anthropomorphic CO_2 emissions.

[26] Ethanol has higher total energy use than gasoline due primarily to the large amount of process energy consumed in ethanol plants and the significant energy loses accrued during the conversion of corn or cellulosic biomass to ethanol (Wang et al. 2007). Searchinger et al. (2008) found that "corn-based ethanol, instead of producing a 20 percent savings [in greenhouse gas emissions], nearly doubles greenhouse gas emissions over 30 years and increases greenhouse gases for 167 years." In addition, as global energy prices jumped in 2007, the value of corn as an energy source sky-rocketed (Blythe, 2007). This in turn had impacts on the price of corn for the food industry and for feeding livestock like pigs and chickens. Any diversion of land from food or feed production to production of energy biomass will influence food prices from the start, as both compete for the same inputs (Doornbosch and Steenblik, 2007).

[27] Looking at neighborhoods of varying age in five study areas (Maricopa County, Arizona; Orange County, Florida; Minneapolis-St. Paul, Minnesota; Montgomery County, Maryland; and Portland, Oregon), Knapp et al. 2004 found that lot sizes rose between 1940 and 1970 and then fell continuously, reaching an all time low in 2000. Hubble (2003) found similar trends in Las Vegas where the average lot size for a new home fell 500 square feet in the last two years. In 2001 only 13% of new residential lots in Las Vegas were smaller than 4,000 square feet,however, in 2003 this number had doubled to 26% (Smith, 2003). In 1976, the median lot size of new one-family houses was 10,125 square feet but fell to 8,854 in 2008 (US Census Bureau 2008). The US

Census shows an decrease in the density of urbanized areas in the United States from 3,052 people per square mile in 1990 to 2,300 in 2009 (Demographia 2009).

[28] Northwest Environment Watch. 2002. Sprawl and Smart Growth in Greater Vancouver: A comparison of Vancouver, British Columbia, with Seattle, Washington. Northwest Environmental Watch/Smart Growth BC. Available online at: http://www.sightline.org/research/sprawl/res_pubs/sprawl_smart_van

[29] Nationally, the average time spent commuting to and from work in Canada increased between 1992 and 2005 from 54 minutes to 63 minutes. In contrast, residents in Vancouver spent no more time on average getting to work in 2005 than they did in 1992 (Turcotte, 2008).

[30] Cities are reviving at the end of the twenty first century and surviving a recession that has been much harsher for other parts of the landscape (Dougherty, 2009). In many parts of the country suburban developments are in fast decay. In Charlotte, N.C. the ten highest foreclosure areas are suburban areas filled with starter-home subdivisions (Chandler and Mellnik, 2007). House prices in the urban sprawl of Ashburn, VA fell 50% between August 2005 and April 2008 while inside the city of Washington, the median home prices rose 3.5% between 2007 and 2008 (Schalch, 2008). According to David Goldberg of Smart Growth America, “Philadelphia was losing downtown housing and in-town housing until very recently. And now that’s the hottest part of their market” (Schalch 2008). In general, neighborhoods with the shortest commutes are faring better than places with long drives into the city (Schalch, 2008). The evidence suggests that cities are big

enough and diverse enough that they are able to survive these ups and downs in the economy much better than their suburban counterparts (Dougherty, 2009).