CHAPTER 4

Locate Commercial Services, Frequent Transit, and Schools within a Five-minute Walk

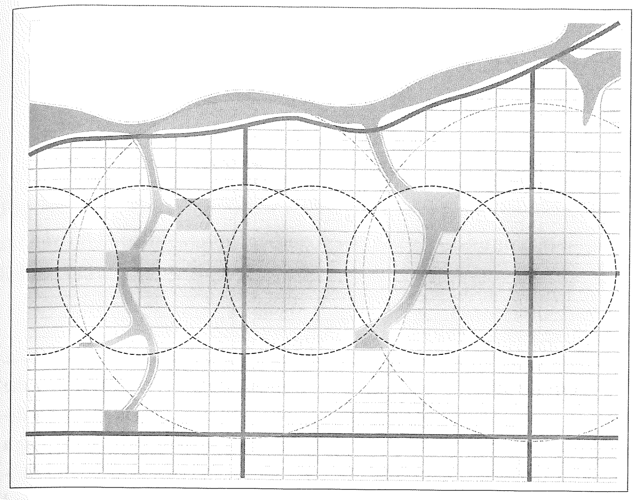

Figure 4.1. Proximity of destinations to where people live is important in creating walkable communities. This diagram shows five- and ten-minute walking distances along a major corridor.

Many believe that electric cars and windmills will solve the climate change crisis, with no need for fundamental change in city form. This belief excludes an acknowledgment of the gargantuan energy and material demands consequent to such an ever more sprawling metropolitan pattern. Professor William Rees of the University of British Columbia, co-inventor of the ecological footprint concept, maintains that we are, as a species, already in "ecological overshoot" mode. Ecological overshoot is the point at which human activities are draining down more resources from the planet than the planet can resupply. In Rees's estimation, we are "draining down" the planet's "capital" now. Even more depressing, he also maintains that if every person on the planet enjoyed the same consumption levels as North Americans, it would take six planets to supply them. And these calculations do not even include the consequences of greenhouse gas (GHG) buildup in the atmosphere, and the extent to which climate change would further drain the planet's "capital" resources and the ecological services that the planet can supply. Accepting these calculations then, a much more radical restructuring is required, as technology and manufacturing cannot save us. In fact, they are what created the problem in the first place.

The conclusion is inescapable. The per capita consumption of materials and energy must be dramatically cut if we are to find a balance with the planet's ability to supply them. Since 80 percent of North Americans now live in cities, it follows that the form and function of the city, along with the resource content of the food and material goods that flow into it for our use, must be substantially changed. Given that transportation is responsible for up to 40 percent of the problem, and that walking is a zero carbon substitute, a careful look at walking seems like a good place to start.

In our current situation, in which the car is always at hand, North Americans will walk only if it is easier than driving. The break point for walking trips seems to be five minutes, which is enough time to walk approximately one quarter mile, or four hundred meters.[1] Most people think that walking five minutes is easier then firing up the car, pulling it out of a parking space, negotiating streets, finding a place to park, and exiting from the auto driver's crouch. Humans are incredibly sensitive to the minor benefits and costs of choosing one mode over the other, no matter how short the trip. Naturally, some people will choose to make longer walks, while others will opt for the car even if the walk is ridiculously short, but the average threshold for walking is five minutes.

But the five-minute walk rule is meaningless if there is no place to walk to. Many new suburban developments are equipped with walking trails, but while these trails may be used every day by people who are in the habit of walking and jogging for exercise, the average person will use them much less regularly if at all. For the average person, the most compelling destination for regular walking is the corner store. If a convenience store is located less than a five-minute walk from home, the average person will walk there many times a week to pick up bread, eggs, milk, newspapers, and many other impulse items. In suburban-sprawl locations, there is a different kind of five-minute rule in play. There you will usually find "gas and go" stores distributed evenly throughout the suburban matrix, but at a five-minute *driving* distance; these stores are usually inaccessible on foot, further exacerbating auto dependence in these landscapes.

If the basic corner store is joined by a video rental, a hair stylist, a tavern, and a café, then it is that much more likely that walking will be a daily part of life for nearby residents. If conditions are perfect, these stores will be joined by coffee shops, hardware stores, used book stores, fruit and vegetable stands, pizza shops, accountants, dentists, and the local grocery store. When most of residents' daily commercial needs can be met within walking distance, not only do they walk more but they use the car significantly less. Residents of Vancouver, for example, where most residents can satisfy their daily commercial needs on nearby streetcar arterials, use their cars over 30 percent less than do residents of South Surrey/Langley, British Columbia, a car-oriented community. Residents of Vancouver also own fewer cars, 1.25 per family compared to1.7 per family in Surrey, British Columbia.[2] Access to commercial services and frequent transit seems to explain these differences, as average family income in the two communities is nearly the same.

Among sustainable community advocates, the five-minute walk rule has become axiomatic. However, it is usually imagined and applied as a walking distance radius or a circle surrounding some fixed commercial point. This is indeed the way it works if there is only a small commercial node with one or two stores, but in Vancouver and other vibrant streetcar cities, commercial activities spread many miles along the streetcar arterial. Where this occurs, the five-minute walk is no longer a circle but, rather, a continuous band that extends a quarter mile perpendicular in both directions to the streetcar arterial. The basic pattern for streetcar cities is a grid of streetcar arterials spaced at half-mile intervals (see chapter 3).[3] This means that everyone will be within a five-minute or quarter-mile walk of some streetcar arterial, and often able to choose between two. These long linear commercial corridors comprise the bulk of public realm spaces in streetcar cities. This linear public realm, so characteristic of most Canadian and U.S. cities, has implications for our understanding of their qualitative aspects—their "sense of place."

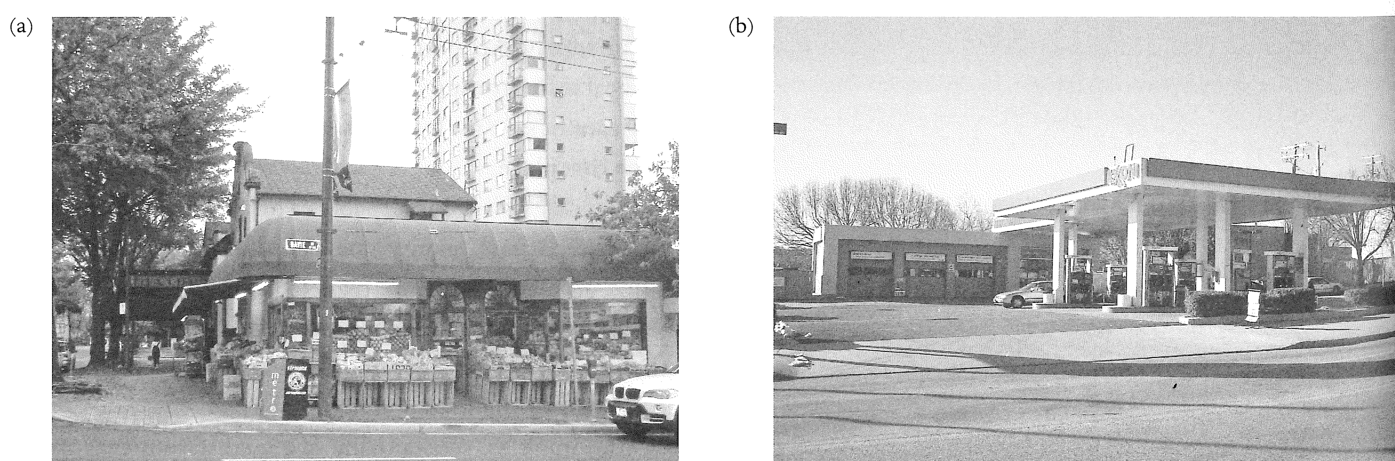

Figure 4.2. The corner store (a) is located within a five-minute *walk* of residences in a more densely populated neighborhood. The gas station (b), on the other hand, is located within a five-minute *drive* in a low-density, auto-oriented district. Photos: Kari Dow.

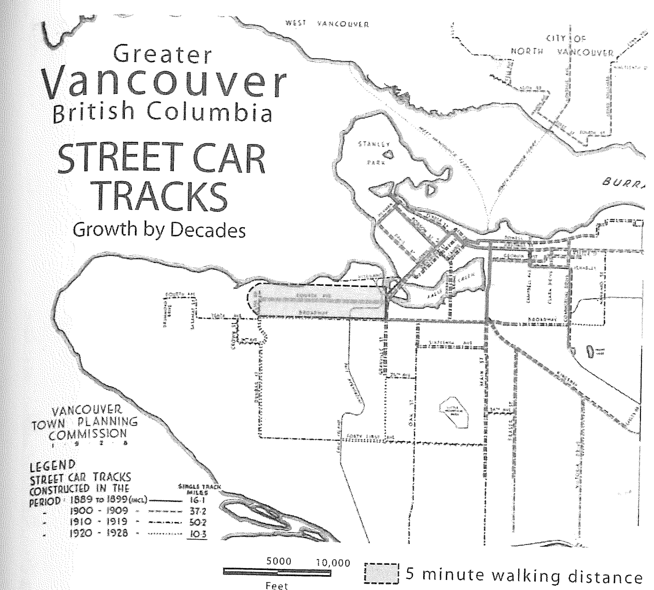

Figure 4.3. The five-minute walking distance from the old streetcar line on Fourth Avenue in Vancouver, British Columbia, is highlighted here.

[1]A pedestrian shed, or pedestrian catchment area, is determined by the distance most people will typically be willing to walk and is generally defined as a five-minute walk to the center of each neighborhood, creating a unit with approximately a quarter-mile radius (Watson, Plattus, and Shibley, 2003). Studies at the Port of New York Authority bus terminal found that a five- to seven-minute walk is typically the maximum amount people will walk, although this varies somewhat depending on the trip purpose, walking environment, and available time (Watson, Plattus, and Shibley, 2003).

[2]According to Metro Vancouver's Livable Region Strategic Plan 2000 report, 22 percent of households in Vancouver do not own a car and only 26 percent have two or more cars, while in Surrey and Delta only 5 percent of households do not have a car and 52 percent have two or more cars. South Surrey/Langley residents took about the same number of trips as residents in Vancouver, but 88 percent were by automobile (Canadian Facts, 2000a) as opposed to 58 percent in Vancouver (Canadian Facts, 2000b). Between 2005 and 2007, 30.1 percent of commuters in the New York metropolitan statistical area (MSA) used public transportation, 6.1 percent walked, 7.5 percent carpooled, and 50.5 percent drove alone (U.S. Census Bureau, 2005–2007). During the same time period, only 3.5 percent of commuters in the Atlanta MSA used public transit, 1.3 percent walked, 10.8 percent carpooled, and 77.9 percent drove alone (U.S. Census Bureau, 2005–2007).

[3]Figure 4.3 shows the historic grid of streetcar arterials in Vancouver distributed in regular intervals. A five-minute walking distance is indicated along Fourth Avenue in Kitsilano. As you can see, the majority of Vancouver is within a five-minute walk of a historic streetcar arterial.

SENSE OF PLACE IN CORRIDORS

As touched on in chapter 2, planners and urban theorists have focused on urban *nodes*, even though streetcar city *corridors* are the unique and defining characteristic of the North American city. It seems likely that their training and good intentions have made it difficult to cherish the seemingly undifferentiated linear corridors that are such a humble and ubiquitous datum for our experiences in most U.S. and Canadian cities. It may be that this inattention to the meaning and value of the corridor came from the careful study of older European and East Coast cities, whose web of streets usually focused on key "five-corner" intersections or squares, as in Kevin Lynch's Boston.[4]

What may appear to outsiders to be miles of undifferentiated shops in the commercial corridor of the streetcar city appears quite different to those who use these corridors every day. Local users do not experience every mile of the corridor, but just the transition from their residential block to the more active arterial. Along the way, they might pass the community school, a number of gardens, some townhouses on the block closer to the corridor, and then the streetcar arterial itself. Once at the arterial, they turn either ninety degrees right or ninety degrees left to take advantage of services on the two or three blocks in either direction. Thus, their sense of the place is determined by their walk to the arterial and their eventual familiarity with the blocks immediately in either direction. People who live two or three blocks away in one or the other direction will have a similar and overlapping, but not identical, experience. Some of the shops they use and the people they encounter will be the same, but others will be different.

In this way, corridors are unique and different from urban nodes. They allow for shared and similar experiences, but ones that gradually change depending on where you reside along the corridor. Vibrant streetcar streets are experientially very rich, with buses or streetcars arriving and departing every few minutes, familiar shopkeepers sweeping sidewalks, denizens of ethnic social clubs arguing on sidewalks, school kids walking to the local library branch, and teens showing off. They offer a unique dialectic between the freedom of action allowed by the apparently infinite length of the corridor and the proxemic familiarity that characterizes the best of village environments.

More can and should be said about the undervalued expe-

[4]Kevin Lynch, *The Image of the City* (Cambridge, MA: MIT Press, 1960).

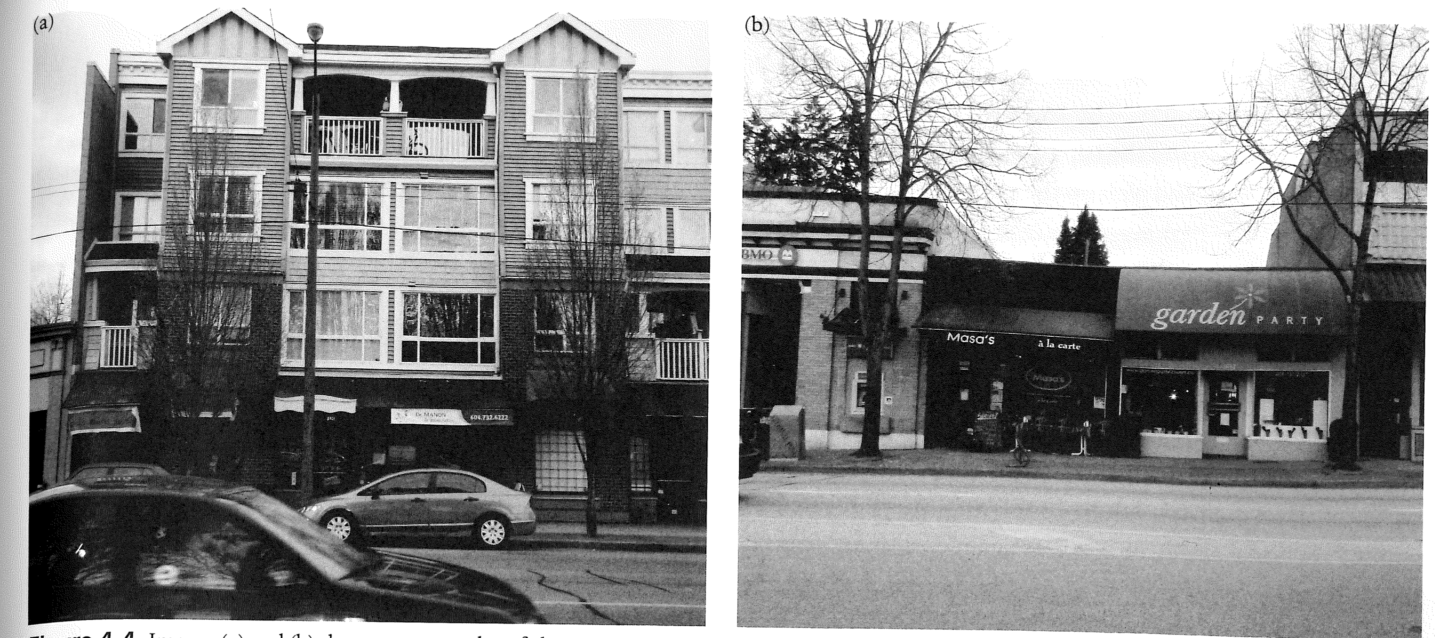

Figure 4.4. Images (a) and (b) show two examples of the experiential diversity along Fourth Avenue, a streetcar arterial, in Vancouver, British Columbia (Photos: Kari Dow)

riential qualities of these overlooked spaces, but for our purposes it is only necessary to add a qualitative argument to the practical, as the streetcar city principle must work in both practical and experiential terms to be of value. This discussion of the experiential value of the corridor is not intended to supplant the articulate explorations of the sense of place attributable to urban *nodes*, just to give *corridors* equal standing. Most of the eloquent arguments of Christian Norberg-Ŝchulz (1980) and Christopher Alexander (1977) can be equally applied to corridors, if one leavens these insights by also appreciating how corridors create both a personal and a communal sense of place. The sense is personal depending on what side street you live on, providing an individualized experience based on your own habitual trips to and from the corridor; and it is communal, providing a shared sense of place for thousands of residents who use some or all of a corridor that is many miles long.

TRANSIT, DENSITY, AND THE FIVE-MINUTE WALK

Transit has a synergistic relationship with pedestrian-dependent commercial services. If the solitary corner store has a bus stop outside, both the store and the transit service are enhanced. The store is enhanced when bus riders pop in to buy a newspaper before jumping on the bus. The transit service is enhanced because riders can now use the trip to the bus to do more than one thing—ride to work and pick up the paper, ride back from work and pick up milk—making the bus that much more attractive. The more commercial functions at the stop the better, as this makes it even more possible to "trip chain," meaning to perform more than one errand on the same trip.

On streetcar arterials, trip chaining is even easier. Riders can hop off the bus or streetcar to stop at the pharmacy, the toy store, the electronics store, or the wine shop, and then hop back on to continue their trip home. In this way, stores located along highly functional streetcar corridors gain customers from both the pedestrians who walk from nearby homes and the transit users passing by on the corridor. Some of these synergies also accrue to developments that are commonly known as transit-oriented developments (TODs), although as pointed out previously, anyone who lives outside a five-minute or at most a ten-minute walk from the center of the TOD will not gain these advantages. Only through chaining TODs in a pattern can these advantages be equally available. The streetcar city corridor is the simplest way to chain TODs in a pattern that is universally accessible.

DESIGNING FOR THE BUS OR STREETCAR

At headways (or frequencies, the length of time between one bus leaving and the next arriving) of seven minutes or less, users no longer need to consult schedules. They know that their wait will be four minutes on average—sometimes less, sometimes more—but never more than seven minutes. These waits are insignificant in the minds of most riders, making it that much more likely they will use transit. For this reason, many transit authorities make achieving seven-minute headways their Holy Grail.

In suburban areas of Vancouver, the transit authority has provided bus service within four hundred meters of almost all homes (thanks to the legacy of the agricultural grid and its quarter-section roads on the half-mile interval), although this is often

Figure 4.5. Lonely bus stop in a car-oriented suburban development.

as the crow flies. But the dendritic street system of "loops and lollipops" inside the half-mile super blocks often forces walks of ten minutes or more. Given the low riderships characteristically generated by these suburban landscapes, regional transit authorities cannot justify buses at seven-minute headways. More typically, they are at thirty-minute intervals and in some cases an hour. In low-density landscapes dominated by the dendritic pattern, destinations usually require one or two transfers, thus taking many times longer than car trips. Furthermore, stops at the most common suburban destinations, such as shopping malls, are notoriously unfriendly for transit customers. With so many disincentives for transit built into the suburban dendritic street system, it is no surprise that transit captures only a few percentage points of all trips in such landscapes. Short of a major and gradual urban retrofit, nothing short of $10-per-gallon gasoline is likely to change this.

With so few customers to serve per square mile in such landscapes, transit officials are hard-pressed to provide frequent transit. At these headways, users must organize their whole day around the schedule of the bus, not just on their departure trip but also on their return. Long headways combined with long multiseat trips and pedestrian-unfriendly destinations make it unlikely that residents with a car will choose transit, and they don't. The large majority of transit users in most suburban areas are the infirm, the young, and those too poor to own a car.[5]

Conversely, in streetcar cities, this kind of entropy toward failure is reversed. Features of the landscape conspire to reinforce pedestrian and transit use, making it more and more likely that residents will choose transit for its convenience and economy, resulting in a more efficient transit system, more revenue for the transit agency, and a compelling justification to reduce headways on the corridor even more. But the key factor in this success is density.

It is now accepted that the higher the density in a service area the more likely it is that residents will use transit. Evidence for this comes from analysis of real places. Almost everyone in high-density Manhattan uses transit; almost no one in low-density, sprawling Phoenix does.[6] A density of ten dwelling units per gross acre, or twenty-five residents per gross acre, is the usual minimum standard for frequent bus service.[7] This guideline is borne out by transit ridership figures from the Vancouver

[5]Income is the primary determinant of auto ownership, which in turn is the main determinant of modal choice. In the United States, transit use drops from 19.1 percent of trips in households with no car to 2.7 percent of trips by households with one car (Pucher and Renne, 2003).

[6]Based on data from the 2000 census, the commuter public transit rate for New York City, for workers over age sixteen was 59.6 percent, while in Phoenix this number was only 3.3 percent (U.S. Census Bureau, 2000b).

[7]Dittmar and Ohland (2003) state that transit agencies in the United States generally use a planning criteria of seven dwelling units per acre to support basic bus service. Densities of thirty dwelling units per gross acre can easily support light and heavy rail transit.

region, where the average density is between ten and fifteen dwelling units per acre. Here, less than 50 percent of all commuters use the single-passenger automobile to get to work. Conversely, in third-ring suburban locations, such as Coquitlam, British Columbia, where gross density is less than five dwelling units per gross acre, and despite the availability of express buses, more than 90 percent of all commuters get to work in the single-passenger automobile.

While density is the most important factor influencing transit use, other more subtle factors also have an influence. An interconnected street network, which helps users get to buses; the even distribution of commercial services along streetcar arterials, which makes trip chaining possible; and lots of jobs located on the corridor all play a crucial role but have proven more difficult for researchers to definitively link to ridership.

If the average density of a very large area—say, greater than ten thousand acres or fifteen square miles—is ten dwelling units per acre or more, and if this area is balanced with one job per household, and if there are convenient transit connections to the larger metropolitan region, and if a full range of commercial services is available in the district, then transit may be able to provide an alternative to the car. That's a lot of ifs. Fortunately, many streetcar city areas already meet these criteria, and many suburban areas, as they mature, are approaching those thresholds as well. Most U.S. and Canadian suburbs start out with average densities of between one and four dwelling units per gross acre. Newer suburban areas in many parts of the nation—Las Vegas for example—are higher, at about six dwelling units per gross acre.[8] Other metropolitan areas are finding ways to add density to previously built low-density areas. Vancouver and Portland, for example, are adding density and jobs to formerly car-dependent areas in numbers that make it possible to provide additional transit service and anticipate viable commercial services within walking distance from most homes, in locations that could not previously support them.[9]

Ten dwelling units per acre is the accepted figure at which buses can be economically supplied at short headways. For streetcars or trams, the accepted figure is closer to twice that.[10] Densities of seventeen to twenty-five dwelling units per gross acre are not uncommon in streetcar cities and not unachievable in new communities. Also, as discussed in chapter 2, there are

[8]In 2000, the density of Las Vegas's suburbs rose to between five and six dwelling units per gross acre (U.S. Census Bureau, 2000a). Today, even higher density communities are being planned and built under new comprehensive community plans (Smith, 2006).

[9]According to Nelson and Lang (2007), up to 35 million of the 40 million new housing units needed to meet the demand of the next 100 million people living in the United States will likely be built for childless occupants. This group is already helping to fuel the resurgence of in-town living, high demand in many transportation-oriented developments, unprecedented demand for central city and close-in suburban infill and redevelopment, and greater stability of housing prices outside of more distant suburbs.

[10]Pushkarev and Zupan (1997) found that seven to fifteen dwelling units per acre can support moderate levels of convenient transit of all type, including streetcar and light rail, which is reasonably sustained at nine to twelve dwelling units per acre.

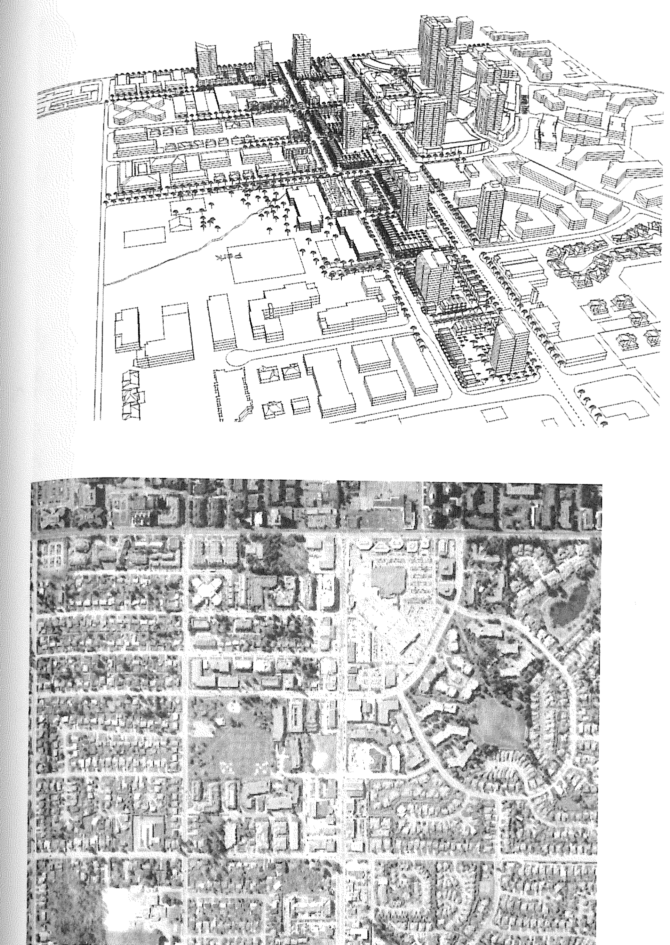

Figure 4.6. Semiahmoo Town Centre, British Columbia, as planned and as it existed in 2009.

many reasons other than ridership for investing in the streetcar, which may make the streetcar an intelligent economic development strategy at average densities between ten and twenty dwelling units per gross acre. Trams or modern streetcars cost less to install and run than buses if you look at the thirty-year amortization costs. And trams, no matter what the power source, produce only a fraction of the GHG per passenger mile that diesel buses do (Condon and Dow, 2009).

The greatest opportunity for making suburbs more sustainable is along strip commercial corridors. While whole-scale alterations of existing single-family fabric are not conceivable in most suburban communities, the gradual intensification of low-density commercial strips is. These vast areas that typically have a residential density of close to zero could easily accept redevelopment where the residential component could be forty dwelling units per gross acre or more. Conversions of this type are already widespread in the Vancouver area and in many communities across the United States.[11] As these developments proliferate along suburban strips, they increasingly exhibit the defining characteristics of streetcar arterials—higher densities within walking distance, continuous commercial, an even distribution of jobs and services along the corridor—and thus provide transit authorities with sufficient justification for reducing headways. Strip commercial zones often occupy between 8 and 15 percent of developed land in the suburbs. Were 10 percent of this land developed at forty dwelling units per gross acre, it could move what might be average gross residential densities from six dwelling units to ten and would likely be more effective at increasing walking and transit use than that figure implies, since all the new residents would be within one or two minutes of commercial services and a bus stop.

THE WALK TO SCHOOL

In many suburban locations, the neighborhood school is indistinguishable from the shopping center; it is a sprawling one-story box set behind a parking lot and a drop-off loop, attached to the arterial via the umbilicus of the cul-de-sac stem. With more and more school kids getting to school by bus, the need to scale schools in relation to the population within a walking

[11]In Surrey, BC Bosa Properties is converting a suburban strip mall into a high rise urban village called the Semiahmoo Town Centre. This development features mixed use, pedestrian-friendly streets and high residential densities. An example in the United States is Belmar in Lakewood, Colorado, where a mixed-use renovation and redevelopment of a failed mall site has become one of the most successful grayfield transformations in the nation (Dunham-Jones and Williamson, 2008).

distance circle, formerly assumed to be ten minutes or less, has been eliminated. For decades now, single-minded school parcel size standards, issued by the Council of Educational Facility Planners (CEFPI) in "The Guide for Planning Educational Facilities," have set minimum "recommended" land area requirements for schools—forty acres for a middle school, for example, or sixty acres for a high school. Although the figures are offered as "recommendations," many states and provinces have turned them into requirements. Such minimum school site size standards have made small schools within walking distance impossible to build or preserve, ensuring that virtually all students will need a motorized trip twice a day just to go to school. If these same standards for school sizes had been in use when streetcar cities were laid out, over 25 percent of all development land would be occupied by elementary school grounds, rather than the less than 5 percent they used.

In the streetcar city, a school was provided for each 160-acre half-mile square, with each square surrounded by streetcar arterials. The school was almost always located in the middle of the square, meaning no child was more than a six-minute walk from the school, and very few children had to cross the arterial to get there. With a residential density of at least ten dwelling units per acre (and larger family sizes than now), those 1,600 units usually produced enough kids to fill two classrooms for each grade 1–7. This meant that schools had about four hundred kids in them, a school size now considered "small" but one that the Small Schools Foundation considers ideal.[12] The principal of the Bayview School in Vancouver's Kitsilano district, my son's school, knows the names of all four hundred students, and the kids know the names of almost everyone who goes there too.

When you get much over this four-hundred-student size, however, it becomes more and more difficult to establish a "first name" school community. A school for four hundred students ideally should fit into one four-acre block. This likely means a school that is tall rather than spread out. Traditional schools were three stories served by stairs. This is still an efficient form. Elevators for physically challenged students can be installed at less cost than the building and land costs of sprawling one-story schools. A three-story school for four hundred will have a footprint of under an acre, leaving three acres for recreation, enough for a large playground and a soccer field. Whatever

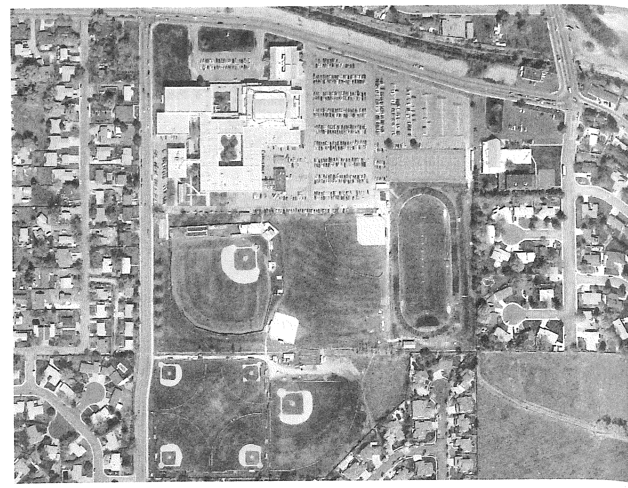

Figure 4.7. This aerial photo of a new school site built in a sprawling suburb near Boise, Idaho, shows a school site that takes up over forty acres.

[12]See http://www.smallschoolsfoundation.org/.

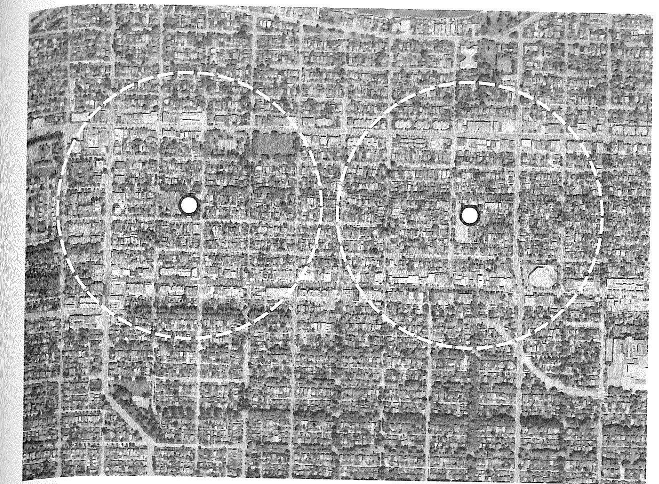

Figure 4.8. This diagram shows an example of smaller school catchment areas in Vancouver, British Columbia. The circles indicate a 2,300-foot (700 m) walking radius. These school sites take up less than three acres each.

parking is necessary should be accommodated on surrounding streets. The full perimeter of the block is usually more than ample for this purpose.

A four-acre site would be a very hard sell with most school districts. The habit of large sites is so strong that it won't be easily overturned. The compromise is the two-block site of eight acres. The negative consequence of a two-block site is that it marginally impedes interconnectivity and, assuming schools stay below the four-hundred-student threshold, removes an additional 2 to 4 percent of land otherwise available for housing or services within the five-minute walk circle, increasing the difficulty of achieving sustainable densities with the detached housing forms so heavily favored in many metropolitan areas.

Fixing this problem usually requires action at the state or provincial level, where funding for school construction and the standards governing construction most often originate. This is the case in Minnesota, where until 2009 CEFPI standards had the force of law, in effect mandating the construction of a few oversized schools far from students and the closing of older neighborhood schools when it came time for major rehabilitation. It took a new law, the Minnesota Education Omnibus Law (HF 2), signed by Governor Tim Pawlenty in June 2009, to fix what should not have even been a problem.[13] The law includes provisions to eliminate minimum acreage requirements for schools and to remove the bias against renovating, rather than rebuilding, old schools. School requirements, such as "recommended minimum" parcel sizes for new and retrofitted schools, are just one strand of the Gordian knot that must be untied before low-carbon communities can be built and rebuilt.

All of our attempts to substantially reduce GHG will fail unless we can make walking and taking transit easier than driving. And this will be possible only if the things we need and want every day are within a five-minute walk. If this five-minute walk brings us to zones where buses and streetcars abound, then it becomes equally convenient to hop on and hop off regularly, until at some point life without a car seems like not such a bad idea. None of this works without a balance among density, street network, frequent bus and streetcar headways, and even sensible locations for schools. Miss one of these components, and you compromise the others. Streetcar city models provide

[13]See http://blog.smartgrowthamerica.org/2009/06/09/.

many lessons for reapplying to other newer contexts, and they impel us to protect these features in landscapes where they are threatened.

Creating new communities and retrofitting old ones for walkability and alternatives to the car will be the challenge of our time. The various monumental pathologies identified in chapter 1 have their source in what seems like a humble decision. Should I drive to get that loaf of bread, or can I walk? That decision amplified and repeated by many millions results in impossibly overloaded freeways and ridiculously expensive and unsustainable patterns of movement. Reconstructing our urban landscapes around the five-minute walk is a key part of restoring their health.

CHAPTER 5 *Locate Good Jobs Close to Affordable Homes*

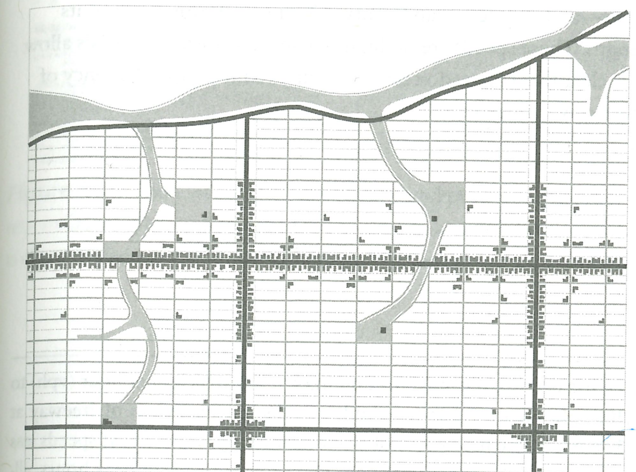

Figure 5.1. This diagram shows the distribution of jobs. The highest concentration of jobs is along the corridor, within easy walking distance of transit.

Private car use is responsible for an increasing share of total U.S. and Canadian greenhouse gas (GHG) production. Short of an immediate increase in fleet efficiency (not possible) or a dramatic breakthrough in battery technology (not likely), this share is likely to continue its climb for years to come.

On the other hand, the relative contribution of other sectors to GHG production, notably industry, is declining because industry has made major efficiency gains in how it produces and uses energy per unit output.[1] The per square foot use of energy for buildings is also declining, particularly in the residential sector.[2] But these gains are more than offset by the increase in per capita vehicle-miles traveled (VMT) per person per day, a rate of increase that has held amazingly consistent since the 1940s, with tiny interruptions for the oil shock of the 1970s and the spike in gas prices to over $4 per gallon in 2008 (Federal Highway Administration, 2009; Valdez, 2009).

As mentioned in chapter 1, the construction of the interstate highway system, and the girdling of metropolitan regions with one, two, or even three interstate highway ring roads, induced the dramatic rise in average commute distances, making the relationship between home location and job location irrelevant. Any point in the entire region could be accessed from any other point in the region by car if the commuter was willing to drive up to an hour—at least, that is, until the inevitable increase in VMT per capita overwhelmed the capacity of even this bloated system. Los Angeles, appropriately, became the first victim of this phenomenon. Now, speeds on its most congested freeways average only twelve miles per hour during peak hours—ludicrous for a road engineered for eighty miles per hour.[3] Many Los Angeles drivers have taken to the surface arterials for commuting, out of frustration with their long slow

[1]Emissions from industry accounted for about 20 percent of U.S. GHG emissions in 2007. Unlike electricity generation and transportation, emissions from industry have in general declined over the past decade due to structural changes in the U.S. economy (that is, a shift from manufacturing based to service based), fuel switching, and efficiency improvements (U.S. Environmental Protection Agency, 2009a). Globally, primary energy consumption and CO_2 emissions in the industrial sector are projected to continue increasing until 2010, when developed countries will peak and start declining. Emissions from developing countries and economies in transition are forecast to continue their growth after 2010, although at a much slower pace (de la Rue du Can and Price, 2008).

[2]The energy use per square foot for single-family, detached housing dropped from 59,000 btu (British thermal units) in 1980 to 42,000 btu in 2001 and 39,000 btu in 2005 (Energy Information Administration, 2004; U.S. Department of Energy, 2009).

[3]By plotting speed and flow on lane 1 (the fast lane) in one section of I10-W in Los Angeles, Chen and Varaiya (2001) found that by 7:00 a.m. in the peak morning period, speed is a stop-and-go fifteen miles per hour and