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# Pavement Busters Guide

*Why and How to Reduce the Amount of Land Paved for Roads and Parking Facilities*

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**Abstract**

This guide identifies ways to reduce the amount of land required for roads and parking facilities. It examines ways to determine optimal road and parking supply and the full economic, social and environmental costs of increased impervious surface. It identifies current policies and planning practices that unintentionally contribute to economically excessive road and parking requirements, and specific strategies for reducing the amount of land paved for roads and parking facilities. This analysis indicates that road and parking pavement area can often be reduced significantly in ways that are cost effective and maintain adequate levels of accessibility.

Summarized in
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*More efficient management can often reduce the amount of land paved for roads and parking facilities.*

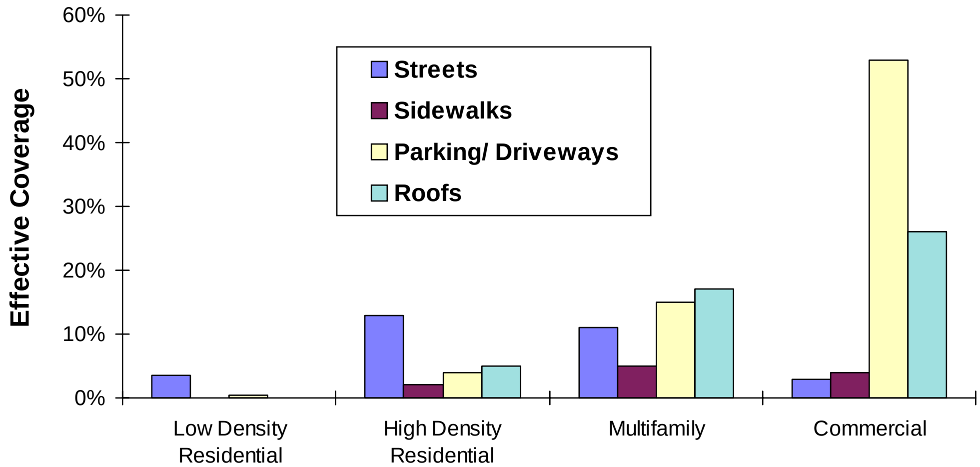
*"Form no longer follows function, fashion, or even finance; instead, form follows parking requirements."* Donald Shoup

## Introduction

The *landscape* (the earth's surface) is a unique and valuable resource. It is used in various ways, ranging from wildlands and farmlands to buildings and transportation facilities. Public policies and planning practices affect these land use patterns, which can have significant economic, social and environmental impacts.

A significant portion of the *built environment* (land developed for human activities) consists of *impervious surface* (land covered by materials impenetrable to water, such as asphalt, concrete, brick, and stone), a major portion of which consists of roads and parking faculties. Roads and parking facilities typically cover 10-25% of urban land, and more than 50% in major commercial centers such as downtowns and shopping malls, as illustrated in Figure 1. Although such facilities are useful and necessary, they also impose significant economic, social and environmental costs.

***Figure 1*** **Impervious Surface Coverage** (Arnold and Gibbons 1996)




*Roads, parking facilities and sidewalks represent a major portion of urban land area.*

Current policies and planning practices favor generous road and parking supply. They are often inefficient and unfair, resulting in an economically excessive amount of land devoted to transport facilities. Alternative, cost-effective practices can significantly reduce road and parking pavement area, providing many benefits.

This guide identifies ways to reduce the amount of land paved for transportation facilities. It investigates the full costs of paving land, describes ways to determine optimal road and parking supply, identifies current practices that unintentionally expand transport facility area beyond what is optimal, and identifies various strategies for reducing the amount of land paved for roads and parking facilities.

## Measuring Pavement Area

A typical residential street is 36 feet (12 meters) wide. If homes have 100 foot average frontage, each house requires 1,800 square feet (sf) (or 180 square meters [sm]) of residential street area, and somewhat more to account for intersections. Residential streets represent half of all urban street area,[1] which suggests that there are about 3,600 sf (350 sm) of road pavement per household, or about 1,500 sf (150 sm) per capita.

A typical parking space is 8-10 feet (2.4-3.0 meters) wide and 18-20 feet (5.5-6.0 meter) deep, totaling 144-200 square feet (13-19 sm). Off-street parking requires driveways (connecting the parking lot to a road) and access lanes (for circulation within a parking lot), and so typically requires 300-400 sf (28-37 sm) per space, allowing 100-150 spaces per acre (250-370 per hectare), as illustrated in Figure 2. Assuming there are two to three off-street parking spaces per capita, parking pavement totals about 1,000 sf per capita.

This suggests that on average about 2,000 sf of urban land is paved for roads and parking facilities per capita, which is about three times the land devoted to homes. Per capita pavement area varies depending on many factors. For example, increased population density reduces per capita road pavement (since there are more people per length of roadway), reduced per capita vehicle ownership or off-street parking spaces per capita reduces total parking area, and reduced peak-period vehicle travel reduces the need to expand roadways.

***Table 1*** **Impervious Surface Of Various Housing Types** (Square Feet)

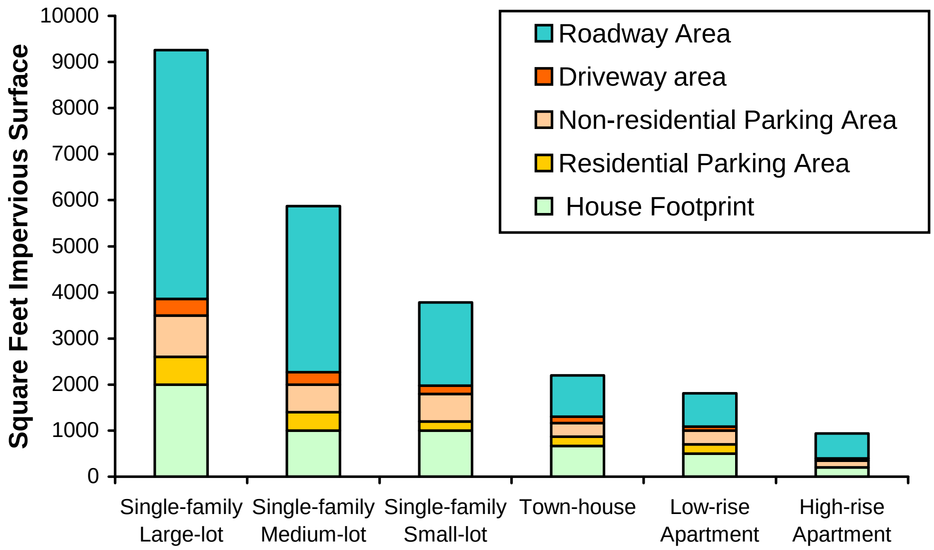
| Housing Type | Units | Single-family Large-lot | Single-family Medium-lot | Single-family Small-lot | Town-house | Low-rise Apt. | High-rise Apt. |
|---|---|---|---|---|---|---|---|
| Stories | | 1 | 2 | 2 | 3 | 4 | 10 |
| House footprint | Sq. Ft. | 2,000 | 1,000 | 1,000 | 667 | 500 | 200 |
| Residential parking | Spaces | 3 | 2 | 1 | 1 | 1 | Underground |
| Res. parking land | Sq. Ft. | 600 | 400 | 200 | 200 | 200 | 0 |
| Vehicles | | 3 | 2 | 2 | 1 | 1 | 0.5 |
| N.R.* parking | Spaces | 4.5 | 3 | 3 | 1.5 | 1.5 | 0.75 |
| N.R.* parking land | Sq. Ft. | 900 | 600 | 600 | 300 | 300 | 150 |
| Driveway length | Feet | 40 | 30 | 20 | 15 | 10 | 5 |
| Driveway land | Sq. Ft. | 360 | 270 | 180 | 135 | 90 | 45 |
| Street frontage | Feet | 150 | 100 | 50 | 25 | 20 | 15 |
| Roadway land | Sq. Ft. | 5,400 | 3,600 | 1,800 | 900 | 720 | 540 |
| Total land | Sq. Ft. | 8,000 | 5,000 | 3,000 | 1,767 | 1,420 | 740 |
| Residents | Per home | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Per capita | Sq. Ft. | 3,200 | 2,000 | 1,200 | 707 | 568 | 296 |

*This table indicates typical impervious surface area for various housing types with 2,000 square feet of interior space. (* N.R. = Non-residential)*

[1] According to Table HM-20 in FHWA's *Highway Statistics 2005* (www.fhwa.dot.gov/ohim/ohimstat.htm), there are 1,022,725 total urban road miles of which 723,952 are local. Assuming that local roads average half the width of other types of roads, they represent about half the total road area.

Table 1 indicates impervious surface area for various housing types, all with the same 2,000 sf of interior floor area. Figure 2 illustrates the results. This analysis suggests that roads are the largest category of impervious surface area, followed by parking and housing, and that impervious surface area per household can vary significantly depending on factors including development density, vehicle ownership rates, parking spaces per vehicle and building type.

***Figure 2*** **Impervious Surface Area Of Various Housing Types** (Square Feet)




*Land requirements per parking space vary depending on type and size. Off-street spaces require driveways and access lanes. Landscaping typically adds 10-15% to parking lot area.*

Although land paved for roads and parking facilities represents a relatively small portion of total land area, roads and parking facilities tend to concentrate in areas with high populations and industrial activities, and so compete with other productive uses.[2] More efficient management that reduces road and parking land requirements can free up valuable land for other productive uses and provide other benefits.

Davis, et al. (2010) used detailed aerial photographs to estimate the number of parking spaces in surface lots in Illinois, Indiana, Michigan, and Wisconsin. Parking lots were identified as paved surfaces with stripes painted on the surface or where more than three cars were parked in an organized fashion, which excluded on-street and structured parking spaces (other than the top floor if the structure has an open roof), and residential parking spaces not in parking lots. They identified more than 43 million parking spaces in these four states, which averages approximately 2.5 to 3.0 off-street, non-residential parking spaces per vehicle. They estimate that these four states allocate 1260 $km^2$ of land

[2] For more discussion of road and parking land area see the "Roadway Land Value" and "Parking Costs" chapters of *Transportation Cost and Benefit Analysis*, Victoria Transport Policy Institute (www.vtpi.org).

to parking lots, with a lower bound estimate of 976 $km^2$ and an upper bound of 1,745 $km^2$. This accounts for approximately 4.97% of urban land, with a higher proportion of land devoted to parking in areas where urban sprawl is more prevalent.

Using GIS datasets, Hulme-Moir (2010) calculated that in Porirua, New Zealand, 24% of the central city district land area is parking facilities, compared to 7% green space and 4% recreation.

Chester, Horvath and Madanat (2010) estimate there are between 105 million and 2.0 billion on- and off-street parking spaces in the U.S., based on the five scenarios below, indicating between 0.5 to 8 parking spaces per vehicle.

***Table 2*** **Estimated U.S. Parking Spaces** (Chester, Horvath and Madanat 2010)

| Type | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 |
|---|---|---|---|---|---|
| On-street | 35 | 92 | 180 | 150 | 1,100 |
| Surface | 36 | 520 | 520 | 610 | 790 |
| Structure | 34 | 110 | 110 | 84 | 120 |
| *Total* | *105* | *730* | *820* | *840* | *2,000* |

*This table summarizes various estimates of U.S. parking spaces.*

Akbari, Rose and Taha (2003) used high-resolution orthophtos of to estimate the surface area for various categories of land-use types in Sacramento, California:

1. Downtown and city center. Vegetation covers 30% of the area, whereas roofs cover 23% and paved surfaces (roads, parking areas, and sidewalks) 41%
2. Industrial. Vegetation covers 8–14% of the area, whereas roofs cover 19–23%, and paved surfaces 29–44%.
3. Offices. 21% trees, 16% roofs, and 49% paved areas.
4. Commercial Vegetation covers 5–20%, roofs 19–20%, paved surfaces 44–68%.
5. Residential. Residential areas exhibit a wide range of percentages among their various surface-types. On average, vegetation covers about 36% of the area, roofs about 20%, and paved surfaces about 28%. Trees mostly shade streets, parking lots, grass, and sidewalks.

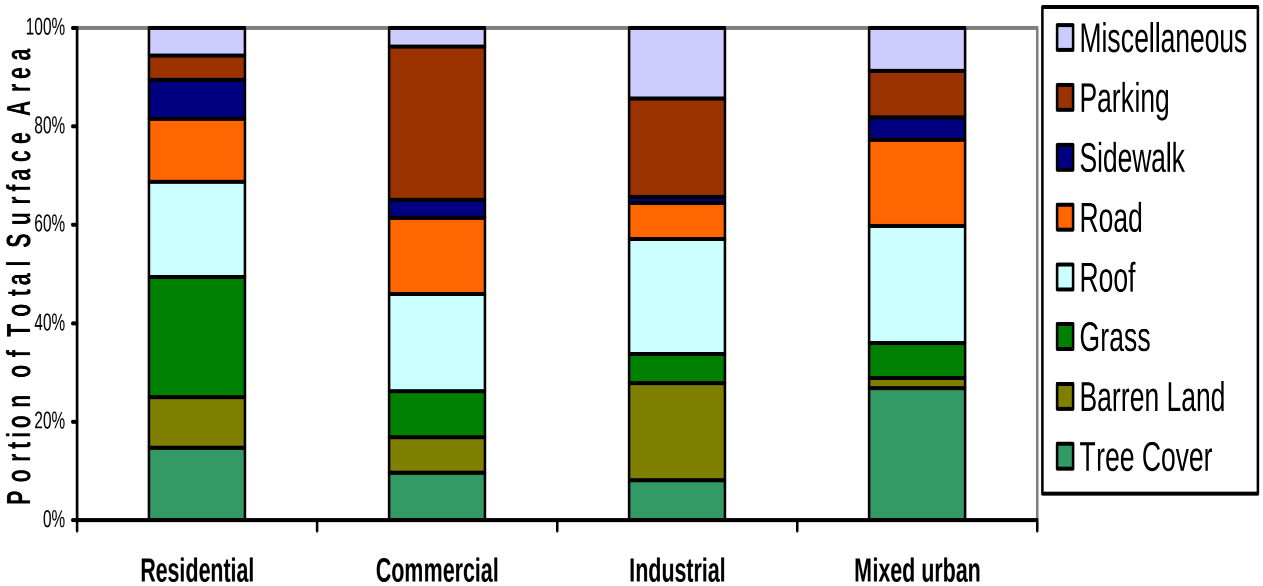
***Table 3*** **Calculated Surface-Area Percentages** (Akbari, Rose and Taha 2003)

| | Tree Cover | Barren Land | Grass | Roof | Road | Sidewalk | Parking | Miscellaneous |
|---|---|---|---|---|---|---|---|---|
| Residential | 14.7 | 10.2 | 24.5 | 19.4 | 12.7 | 8.0 | 4.9 | 5.6 |
| Commercial/service | 9.6 | 7.3 | 9.3 | 19.8 | 15.5 | 3.7 | 31.1 | 3.8 |
| Industrial | 8.1 | 19.7 | 6.0 | 23.4 | 7.3 | 1.3 | 20.0 | 14.3 |
| Transport/communications | 0.0 | 4.0 | 0.0 | 5.0 | 80.0 | 1.0 | 10.0 | 0.0 |
| Industrial and commercial | 2.8 | 15.6 | 5.6 | 19.2 | 10.3 | 1.3 | 32.1 | 13.1 |
| Mixed urban | 26.8 | 2.1 | 7.1 | 23.7 | 17.6 | 4.5 | 9.5 | 8.7 |

*This table summarizes the surface area of various types of land uses in Sacramento, California.*

They found that pavement covers about 35% of the surface area of most residential areas and 50–70% in non-residential areas. Table 3 and Figure 3 summarize these results.

***Figure 3*** **Calculated Surface-Area Percentages** (Akbari, Rose and Taha 2003)




*This figure illustrates the surface area of various types of land uses in Sacramento, California.*

## Impervious Surface Costs

Paving land for roads and parking facilities imposes various direct and indirect costs, as described below (USEPA 1999; Litman 2006a and 2007a). Current planning practices tend to overlook some of these costs, which skews decisions toward economically excessive pavement area. Described more positively, strategies that reduce road and parking pavement area can provide more benefits than usually recognized.

- *Land costs.* Land devoted to roads and parking facilities has opportunity costs, that is, it could be used in other productive ways, including housing, farming and openspace (van Essan, et al. 2004). The value of land devoted to roads and parking is estimated to total $1,000 to $2,000 annually per motor vehicle (Litman 2003). Conventional planning generally ignores these costs except when additional land must be purchased for new facilities; the opportunity costs of existing roads and parking facilities, and land costs to businesses for parking facilities, are not generally considered in the planning process.

- *Facility costs*. Roads and parking facility construction and operating costs are also estimated to total about $1,000 to $2,000 annually per motor vehicle (Litman 2007a).

- *Hydrologic impacts*. Impervious surfaces repel water, and prevent precipitation from infiltrating soils (NEMO Project). This increases stormwater management costs and reduces groundwater recharge, which has ecological impacts (for example, reduced wetlands) and reduces groundwater available for human uses. Water quality degrades significantly if impvervious surface covers just 5% of a watershed (Horner, et al. 1996).

- *Water Pollution*. Paved surfaces collect and concentrate water pollutants such as phosphorous, nitrogen and suspended solid (Jacob and Lopez 2009).

- *Heat island effects*. Pavement, particularly dark-colored asphalt, absorbs and stores solar radiation, which increases ambient temperatures. As a result, urban areas are 2-8° F hotter in summer, which increases energy demand, smog and discomfort (USEPA 1992).

- *Increased vehicle travel and associated costs*. Increased parking and roadway capacity tends to increase per capita vehicle ownership and use, and degrade other travel options (Shoup, 2005). This increases various costs, including traffic congestion, consumer costs, accidents, energy consumption and pollution emissions (Litman 2007a).

- *Sprawl costs*. Expanding road and parking area encourages more dispersed, automobile-dependent development patterns, which increases the costs of providing public services (water, sewage, garbage, emergency response, school), increases total transportation costs, and imposes environmental costs (Burchell, et al. 2005; Litman 2006a).

- *Reduced housing affordability*. Local roads and residential parking costs are borne through development costs and property taxes, so increasing these costs tends to reduce housing affordability (Jia and Wachs 1998).

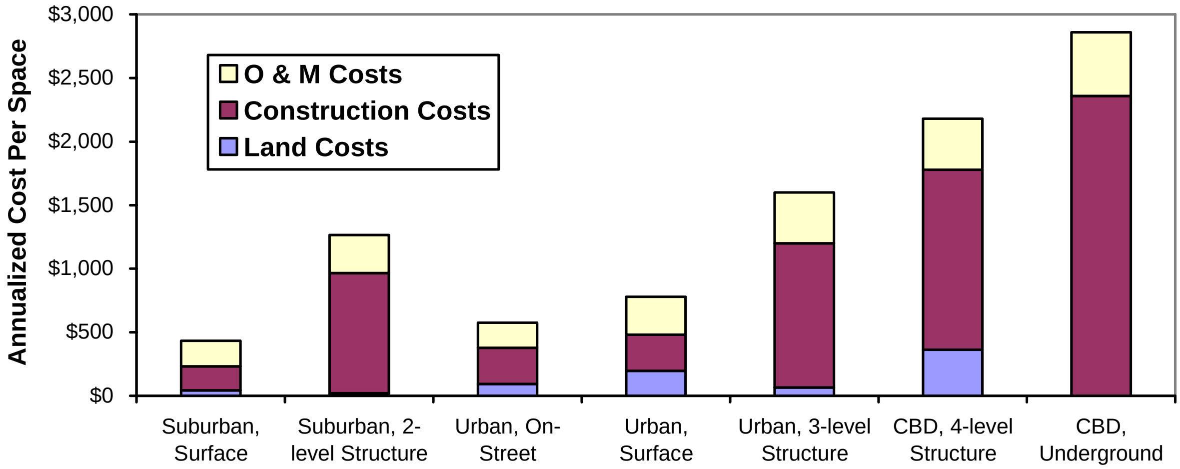
- *Lost openspace and habitat.* Undeveloped land, farmland and greenspace provide various environmental and aesthetic benefits, including wildlife habitat, groundwater recharge, air and noise pollution reduction, and reduced ambient temperatures (White 2007).

- *Energy and pollution.* Road and parking facility construction and operation cause significant energy consumption and pollution (Chester, Horvath and Madanat 2010).

- *Aesthetic degradation.* Larger roads and parking facilities tend to reduce adjacent property values because they are unattractive and noisy (Nelessen 1994).

Most consumers never purchase parking spaces or roadways as a separate item (these facilities are usually bundled with building space or provided by governments and businesses) and so they have little idea of their costs. Figure 3 illustrates typical annualized costs per parking space, excluding indirect and environmental costs.

***Figure 3*** **Typical Annualized Costs per Parking Space** ("Parking Costs" Litman, 2007a)




*This figure illustrates typical annualized costs per parking space.*

## Optimal Road and Parking Supply

According to market theory, optimal road and parking supply is the amount consumers would purchase if they had various options available and directly paid all costs ("Market Principles," VTPI 2007; Litman 2007b). For example, optimal road supply is the amount that could be financed if travelers had reasonable transport options available (walking, cycling, ridesharing, driving, transit, telework, etc) and paid all direct and indirect roadway costs through user fees. Similarly, optimal parking supply is the amount consumers would purchase if they had a reasonable variety of transport and parking options available and paid fees that covered all direct and indirect costs.

From a planning perspective, optimal road and parking supply is the most cost effective way to provide an adequate level of service, taking into account all impacts and options ("Least Cost Planning," VTPI, 2007). For example, optimal road supply is the amount that allows people to reach the destinations they want with minimum costs to users (delay, risk and user fees) and governments (roadway construction and operating expenses). From a narrow perspective, this assumes that roads should be sized to accommodate unlimited vehicle traffic, but planners increasingly recognized that in some situations this is infeasible, so alternative options may be acceptable. For example, optimal urban road supply may be less than needed to accommodate unlimited automobile travel if improvements to alternative modes and demand management strategies (such as road pricing), can maintain an adequate level of service.

## How Current Practices Oversupply Road Space and Parking

Decisions concerning road and parking to supply (such as the number and width of traffic lanes, and the number and size of parking spaces) should reflect consideration of all impacts (benefits and costs) and options (including management solutions instead of expanding supply), including strategic planning objectives such as a community's desire to support smart growth land use development and alternative travel modes. Current planning practices tend to assume it is desirable to maximize road and parking supply and minimize user charges. They consider management strategies measures of last resort, to be applied only when road and parking expansion is infeasible.

For example, conventional planning uses recommended standards published by professional organizations to determine road and parking supply in a particular situation. These standards tend to be economically excessive and can usually be reduced significantly by applying various adjustment factors and cost effective management strategies. To appreciate why it is helpful to know a little about how these standards are developed. They are based on demand surveys, which measure the number of trips generated and parking spaces occupied at various sites (Knepper, 2007). However, the standards are often based on fewer then a dozen surveys, the results of which are often highly variable, and the analysis usually fails to account for geographic, demographic and economic factors that can affect parking demand, such as whether a site is urban or suburban, and whether parking is free or priced (Shoup 1999a; Diasa and Parker 2010).

These standards favor oversupply in many ways. Most demand studies were performed in automobile-dependent locations, where parking is not managed or priced for efficiency. They are generally based on $85^{th}$ percentile demand curves (which means that 85 out of 100 sites will have unoccupied parking spaces even during peak periods), an $85^{th}$ occupancy rate (a parking facility is considered full if 85% of spaces are occupied) and a $10^{th}$ design hour (parking facilities are sized to fill only ten hours per year). These standards results in more supply than actually needed at most destinations, particularly where land use is mixed, there are good travel options, or where transport and parking management programs are implemented. Table 4 summarizes various factors that result in economically excessive parking standards, supply and demand. More accurate and efficient planning practices can significantly reduce road and parking requirements.

Although individual distortions may seem modest and reasonable, their impacts are cumulative and synergistic (total impacts are greater than the sum of individual impacts), resulting in economically excessive road and parking supply. Many parking facilities are frequently underutilized (Shoup 2005; Kuzmyak, et al, 2003). A parking demand study at suburban office sites in southern California found that conventional standards are nearly twice what is needed, and this oversupply will increase if commute trip reduction efforts are successful (Willson 1995). Parking surveys in 26 Seattle neighborhoods found that most had only 40-70% peak-period occupancy (Seattle 2000). Comparing two automobile-oriented suburban areas in Nashville, Tennessee, Allen and Benfield (2003) found that a combination of improved roadway connectivity, better transit access, and modest density increases can reduce per capita VMT 25%, and impervious surface 35%.

***Table 4*** **Planning and Market Distortions and Corrections** (Litman 2007b)

| Distortions | Corrections |
|---|---|
| Most demand studies are performed at single-use, suburban sites where parking is unpriced, resulting in standards that are excessive in other conditions. | Perform more research to determine how geographic, demographic and management factors affect transport and parking demand. |
| Standards are seldom adjusted to reflect geographic, demographic and economic factors that affect demand. | Apply more accurate standards that reflect specific conditions. |
| Standards are often based on an 85% percentile demand curve, the 10th or 20th annual design hour, and 85-90% occupancy, resulting in excessive supply at most sites and times. | Apply more accurate standards that reflect specific conditions. |
| Standards are often designed to accommodate the greatest demand a site may ever encounter over the facility's lifespan, although this is usually excessive. | Apply more accurate standards, with contingency-based solutions available to address future changes in demand. |
| Generous minimum standards result in abundant parking supply, which discourages owners from charging for parking, creating a self-fulfilling prophesy. | Apply more accurate parking standards and parking management solutions before expanding parking supply. |
| Governments often provide subsidized parking, which discourages businesses from charging for parking at their sites. | Price public parking efficiently. |
| Road and parking facility funding often cannot be used for management programs, even if such programs are more cost effective and provide greater total benefits. | Apply "least cost planning," so management strategies receive equal support as capacity expansion. |
| Evaluation often overlooks some costs of paving land for transport facilities, such as opportunity costs (if the land is owned), stormwater management and environmental impacts. | Use comprehensive evaluation which takes into account all economic, social and environmental impacts. |
| Generous standards were created when land costs were lower and there was less concern about traffic impacts and sprawl. | Adjust planning practices to reflect changes in land values and planning objectives. |
| Current planning practices tend to be automobile-oriented. | Apply more multi-modal planning. |

*This table summarizes various planning and market distortions that result in economically-excessive road and parking requirements, and how they can be corrected.*

Similarly, current planning practices result in economically-excessive roadway supply, because roadway expansion is favored over cost-effective management strategies (Lee 1999; "Least Cost Planning," VTPI 2007). Alternative standards can significantly reduce roadway requirements (Homberger 1996). For example, Eugene, Oregon planners found that local road rights-of-way could be reduced 16-20% over standard practices without reducing performance (West and Lowe 1997). Noble prizewinning economist William Vickrey estimated that the current road system is a quarter to a third overbuilt compared with what is optimal, due to inefficient pricing (Hau 2000, footnote #1).

Most studies indicating economically excessive land devoted to transportation facilities only consider one or two distortions, such as unpricing, biased investment practices or excessive zoning requirements. More comprehensive analysis is likely to identify even greater oversupply.

## Explanations For Excessive Road and Parking Supply

It is important to consider the reasons that decision-makers often favor generous road and parking supply.

- Many decision-makers are unaware of full road and parking facility costs. For example, one survey found that employers estimated their parking costs at just $13 per month although actual costs were much higher (COMSIS 1994).
- Transportation agencies are primarily concerned with traffic movement, parking spillover problems, regulatory simplicity, and fiscal impacts (Willson 1999). They are less concerned with other impacts and objectives, particularly indirect costs, and planning objectives outside their responsibility.
- A certain amount of road and parking supply can be justified for basic access ("Basic Access," VTPI 2007). Even non-drivers may value having paved roads and parking at their property, to facilitate access and increase property values. Only supply beyond what is needed for basic access (for example, a second traffic lane) may need to be tested based on individual users' willingness to pay ("Roadway Land Value," Litman 2007a).
- Generous road and parking supply help prevent congestion, insure emergency access, and prevent problems such as spillover impacts and enforcement requirements.
- Convenient vehicle access is considered important to businesses, and therefore for local economic development. Parking regulations, metered parking, and parking enforcement are frustrating to users and unpopular.
- From an administrative perspective it seems easiest and fairest to apply rigid standards rather than more flexible policies that may be challenged. Professional organizations provide recommended minimal standards but fewer resources for flexible requirements.
- Generous minimum parking requirements impose no direct cost on government budgets. Increasing parking requirements is cheaper than providing public parking facilities. Incorporating parking into building costs appears equitable, since businesses simply pass such costs onto their customers.
- Automobile ownership and use have grown steadily over the last century, and roads and parking facilities are durable and can be difficult to expand. It may therefore seem sensible oversupply parking to accommodate possible increases in future demand.
- Transportation agencies generally lack incentives to reduce land requirements by sharing rights of way with other utilities (Feitelson and Papay 1999).

These factors help explain why decision-makers often favor excessive road and parking capacity. However, most of these issues can be addressed with cost-effective strategies described in this guide. For example, mobility management strategies can reduce traffic congestion problems without increasing roadway supply (for example, by encouraging cycling, ridesharing, public transit, flextime and telework), and improved parking enforcement can help avoid parking spillover problems. New pricing methods significantly reduce transaction costs, increasing the feasibility of efficient road and parking pricing. Increasing concerns about economic, social and environmental impacts justifies more emphasis on management solutions.

An important issue in this analysis is the ease of adjusting road and parking supply if needed in the future. Excessive standards are often justified on grounds that additional supply may be needed sometime and is cheaper to provide during initial construction than later. Once land is paved there is often little consideration of converting it to other uses.

Expanding roads and parking facilities tends to be costly, particularly in established urban areas. However, alternatives are often cost effective, such as management strategies that encourage peak-period travelers to use more efficient modes (ridesharing, public transit, telework, etc.). These often provide significant additional benefits, including facility cost savings, consumer cost savings, improved mobility for non-drivers, increased safety, energy conservation and pollution emission reductions. The availability of these management strategies reduces the need to oversupply urban roadways.

Land used for roads and parking facilities is often treated as a sunk cost, with no opportunity value recognized. However, virtually all land has alternative potential uses, either to be rented or sold for monetary gain, or converted to greenspace (landscaping, farms or forests) for environmental benefits. It therefore makes sense to reduce the amount of land paved for roads and parking facilities whenever alternative uses could provide greater benefits (Lee 1999).

This suggests that optimal road and parking supply is significantly less than what results from current planning practices (Litman, 2007b):

- More accurate planning, which adjusts minimum parking requirements to reflect specific geographic and demographic factors, and allows cost effective management strategies such as sharing and use of off-site parking for to accommodate occasional peaks, can typically reduce parking supply by 10-30% compared with current practices.
- Efficient pricing, including cost-based road and parking fees (users directly pay all road and parking facility costs), parking cash out (non-drivers receive the cash equivalent of parking subsidies), and unbundling (parking facilities are sold or rented separately from building space) typically reduces peak-period traffic and parking demand about 20%.
- Least-cost planning, which applies the most cost-effective transportation improvement options, typically reduces peak-period traffic and parking demand by 10-30%.
- More flexible, contingency-based planning allows reduced road and parking supply, since cost-effective management strategies can be deployed if needed in the future.

Of course, the degree of road and parking oversupply varies depending on specific circumstances. In rural areas, most roads and parking facility pavement may be justified for the sake of basic access, and because paving land for roads and parking facilities imposes modest costs. In urban areas there are more transport options and expanding roads and parking facilities tend to impose greater costs, so greater reductions may be justified.

## Strategies to Reduce Road and Parking Requirements

*The following strategies can reduce the amount of land paved for roads and parking. For more information see NEMO; SPUR (1998); Litman (2006b); VTPI (2007); UTTIPEC (2010).*

### *Educate Decision Makers*

Educate decision-makers concerning the full costs of generous road and parking capacity, biases in current planning practices that favor oversupply, and alternative strategies that can help reduce paved area.

### *More Accurate and Flexible Standards*

As described earlier, current road and parking supply standards tend to be economically excessive and can often be reduced due to geographic, demographic and management factors, such as listed in Table 5.

***Table 5*** **Adjustment Factors** (Litman 2006b; Cuddy 2007)

| Factor | Description | Typical Adjustments |
|---|---|---|
| Geographic Location | Vehicle ownership and use rates in an area. | Requirements should reflect variations identified in census and travel survey data. |
| Density | Number of residents, employees or housing units per acre/hectare. | Increased density tends to reduce per capita vehicle ownership and use. |
| Land Use Mix | Range of land uses located within convenient walking distance. | Increased mix tends to reduce per capita vehicle ownership and use. |
| Transit Accessibility | Nearby transit service frequency and quality. | Improved transit accessibility tends to reduce per capita vehicle ownership and use. |
| Carsharing | Whether a carsharing service is located nearby. | Carshare service availability tends to reduce per capita vehicle ownership and use. |
| Walkability | Walking environment quality. | Improved walkability reduces vehicle traffic and allows more sharing of parking facilities. |
| Demographics | Age and physical ability of residents or commuters. | Demand tends to decline for young (under 30) elderly (over 65) and disabled people. |
| Income | Resident or commuter incomes. | Lower incomes reduce demand (SPUR, 1998). |
| Pricing | Road and parking pricing, unbundling and cashing out. | Efficient pricing tends to reduce vehicle ownership and use. |
| Parking & Mobility Management | Parking and mobility management programs are implemented at a site. | Efficient pricing tends to reduce vehicle ownership and use. |
| Design Hour | Annual hours a facility may fill. | Higher values allow reduced supply. |
| Facility design | The type of facility design applied. | Improved design sometimes allows roadway dimensions to be reduced (Cohen, 1997). |
| Contingency-Based Planning | Development of a plan of actions to address future problems. | Having a plan allows reduced supply. |

*This table summarizes various factors that affect parking demand and optimal parking supply.*

### *Mobility Management*

*Mobility management* (also called *Transportation Demand Management* or *TDM*) includes various policies and programs that encourage more efficient travel, as listed in Table 6. If broadly implemented such strategies can significantly reduce vehicle traffic.

***Table 6*** **Mobility Management Strategies** (VTPI 2007)

| Improved Transport Options | Incentives to Shift Mode | Land Use Management | Policies and Programs |
|---|---|---|---|
| Alternative Work Schedules | Bicycle and Pedestrian Encouragement | Car-Free Districts | Access Management |
| Bicycle Improvements | Congestion Pricing | Compact Land Use | Campus Transport Management |
| Bike/Transit Integration | Distance-Based Pricing | Location Efficient Development | Data Collection and Surveys |
| Carsharing | Commuter Financial Incentives | New Urbanism | Commute Trip Reduction |
| Guaranteed Ride Home | Fuel Tax Increases | Smart Growth | Freight Transport Management |
| Park & Ride | High Occupant Vehicle (HOV) Priority | Transit Oriented Development (TOD) | Marketing Programs |
| Pedestrian Improvements | Pay-As-You-Drive Insurance | Street Reclaiming | School Trip Management |
| Ridesharing | Parking Pricing | | Special Event Management |
| Shuttle Services | Road Pricing | | Tourist Transport Management |
| Improved Taxi Service | Vehicle Use Restrictions | | Transport Market Reforms |
| Telework | | | |
| Traffic Calming | | | |
| Transit Improvements | | | |

*Mobility management includes numerous strategies that affect vehicle travel behavior.*

### *Parking Management*

*Parking management* includes various strategies to encourage more efficient use of parking facilities, as listed in Table 7 (some of which are also mobility management strategies).

Mobility management and parking management should be implemented instead of road and parking facility expansion whenever it is overall cost effective, taking into account all impacts ("Least Cost Planning," VTPI 2007). For example, governments should implement mobility management when cheaper than expanding roads, and businesses should implement parking management when cheaper than adding parking supply. This requires supportive policies, including comprehensive analysis (which considers all benefits of management solutions), flexible funding (so money can be used for mobility management programs rather than facility expansion), and flexible road and parking requirements (which are reduced in exchange for management programs).

***Table 7*** **Parking Management Strategies** (Litman 2006b)

| Strategy | Description | Typical Reduction |
|---|---|---|
| Shared Parking | Parking spaces serve multiple users and destinations. | 10-30% |
| Parking Regulations | Regulations favor higher-value uses such as service vehicles, deliveries, customers, quick errands, and people with special needs. | 10-30% |
| More Accurate and Flexible Standards | Adjust parking standards to more accurately reflect demand in a particular situation. | 10-30% |
| Parking Maximums | Establish maximum parking standards. | 10-30% |
| Remote Parking | Provide off-site or urban fringe parking facilities. | 10-30% |
| Smart Growth | Encourage more compact, mixed, multi-modal development to allow more parking sharing and use of alternative modes. | 10-30% |
| Walking and Cycling Improvements | Improve walking and cycling conditions to expand the range of destinations serviced by a parking facility. | 5-15% |
| Increase Capacity of Existing Facilities | Increase parking supply by using otherwise wasted space, smaller stalls, car stackers and valet parking. | 5-15% |
| Mobility Management | Encourage more efficient travel patterns, including changes in mode, timing, destination and vehicle trip frequency. | 10-30% |
| Parking Pricing | Charge motorists directly and efficiently for using parking facilities. | 10-30% |
| Improve Pricing Methods | Use better charging techniques to make pricing more convenient and cost effective. | Varies |
| Financial Incentives | Provide financial incentives to shift mode such as parking cash out. | 10-30% |
| Unbundle Parking | Rent or sell parking facilities separately from building space. | 10-30% |
| Parking Tax Reform | Change tax policies to support parking management objectives. | 5-15% |
| Bicycle Facilities | Provide bicycle storage and changing facilities. | 5-15% |
| Improve User Information and Marketing | Provide convenient and accurate information on parking availability and price, using maps, signs, brochures and electronic communication. | 5-15% |
| Improve Enforcement | Insure that parking regulation enforcement is efficient, considerate and fair. | Varies |
| Transportation Management Associations | Establish member-controlled organizations that provide transport and parking management services in a particular area. | Varies |
| Overflow Parking Plans | Establish plans to manage occasional peak parking demands. | Varies |
| Address Spillover Problems | Use management, enforcement and pricing to address spillover problems. | Varies |
| Parking Facility Design and Operation | Improve parking facility design and operations to help solve problems and support parking management. | Varies |

*This table summarizes the parking management strategies. It indicates the typical reduction in the amount of parking required at a destination.*

Some parking management strategies are particularly effective at reducing pavement area. Sharing parking facilities is particularly effective at reducing parking requirements ("Shared Parking," VTPI 2007). This can be done in several ways:

- *Shared Rather Than Reserved Spaces*. Motorists share parking spaces, rather than being assigned a reserved space. For example, 100 employees can usually share 60-80 parking spaces, since at any particular time some are away or using alternative commute modes.
- *Share Parking Among Destinations.* Parking can be shared among multiple destinations. For example, office buildings can share parking with restaurants and theaters since office demand peaks during weekdays while restaurant and theater demand peaks evenings.
- *Public Parking Facilities.* Public parking, including on-street, municipal off-street, and commercial (for profit) facilities generally serve multiple destinations. Converting from free, single-use to paid, public parking allows more efficient, shared use.
- *In Lieu Fees.* "In lieu fees" mean that developers help fund public parking facilities instead of providing private facilities serving a single destination (Shoup, 1999b). This tends to be more cost effective and efficient. It can be mandated or optional.

With more efficient management and improved travel options, some parking facilities can be converted to other uses. For example, one study found that surface parking lots around rail transit stations could be profitably developed into mixed-use, pedestrian friendly, transit-oriented developments, which would help to meet the demand for affordable housing near transit, and provide a variety of benefits including increased tax revenues and reduced per capita vehicle travel (CNT 2006).

Some communities limit parking supply, typically in commercial centers with high quality transit. Queens, New York, is limiting the amount of residential front lawns that may be paved for parking. Imposing a parking limit encourages better utilization of existing facilities, forces businesses to encourage their employees and customers to use alternative travel modes, and allows more parking to be priced.

### *Efficient Road and Parking Pricing*

Charging users directly for using roads and parking facilities, with higher fees under peak conditions, encourages more efficient use, reducing supply. Efficient road pricing typically reduce peak traffic by 10-30%, and even more if part of a comprehensive mobility management program (ICF 1997). Cost-recovery parking pricing (fees set to pay for parking facilities) typically reduces parking demand 10-30% ("Parking Evaluation," VTPI 2007), with similar impacts from parking *cash-out* (travelers can choose to receive the cash equivalent of parking subsidies when they use alternative modes) and *unbundling* (parking is rented separately from building space, so occupants only pay for the amount of parking they actually need). This allows pavement area to be reduced.

Older road and parking pricing methods had high transaction costs, including inconvenience to motorists who were required to use specific change, and high labor costs for collecting money. Newer, electronic pricing methods are more convenient, accurate, flexible, and cost effective. They can accommodate various payment methods (coins, bills, credit and debit cards, mobile telephone and the Internet), eliminate the need for toll booths, incorporate multiple rates and discounts, automatically vary rates by day and time, charge only for the amount of time parked, and are convenient to use. Newer systems also produce printed receipts and record data for auditing, which prevents fraud.

### Smart Growth

*Smart growth* (also called *location-efficient development*) is a general term for policies and planning practices that result in more efficient land use development by creating more compact, mixed-use, multi-modal communities. Smart Growth is an alternative to urban sprawl. Major differences between these two land use patterns are compared in Table 8. *New Urbanism* (also called *Neotraditional Development*) refers to smart growth applied at the neighborhood or local scale. *Access management* is a term used by transportation engineers for improved integration between land use and roadway planning, which tend to support smart growth.

***Table 8*** **Comparing Smart Growth and Sprawl** ("Smart Growth," VTPI 2007)

| | Smart Growth | Sprawl |
|---|---|---|
| Density | Compact development. | Lower-density, dispersed activities. |
| Growth pattern | Infill (brownfield) development. | Urban periphery (greenfield) development. |
| Land use mix | Mixed land use. | Homogeneous (single-use, segregated) land uses. |
| Scale | Human scale. Smaller buildings, blocks and roads. More detail since people experience the landscape up close, as pedestrians. | Large scale. Larger buildings, blocks, wide roads. Less detail, since people experience the landscape at a distance, as motorists. |
| Public services (shops, schools, parks) | Local, distributed, smaller. Accommodates walking access. | Regional, consolidated, larger. Requires automobile access. |
| Transport | Multi-modal transportation and land use patterns that support walking, cycling and public transit. | Automobile-oriented transportation and land use patterns, poorly suited for walking, cycling and transit. |
| Connectivity | More connected roads, sidewalks and paths, allowing relatively direct travel by nonmotorized as well as motorized modes. | Hierarchical road network with numerous loops and dead-end streets, and unconnected sidewalks and paths, with many barriers to nonmotorized travel. |
| Street design | Streets designed to accommodate a variety of activities. Traffic calming. | Streets designed to maximize motor vehicle traffic volume and speed. |
| Planning process | Planned and coordinated between jurisdictions and stakeholders. | Unplanned, with little coordination between jurisdictions and stakeholders. |
| Public space | Emphasis on the public realm (streetscapes, pedestrian environment, public parks, public facilities). | Emphasis on the private realm (yards, shopping malls, gated communities, private clubs). |

*This table compares smart growth with sprawl development patterns.*

Smart growth and new urbanism can reduce per capita pavement area in several ways (although they may increase pavement per acre due to increased density). They emphasize more compact development patterns and building designs, including narrower streets, multi-story structures and structured parking. They support and are supported by transport and parking management. They increase transport options (particularly walking, cycling and public transit access). Residents and employees in such areas tend to own 10-20% fewer cars and make 20-40% fewer vehicle trips than in more automobile-dependent areas, allowing road and parking supply to be reduced (Litman 2005).

Smart growth policy reforms encourage more compact, mixed, multi-modal land use development (Litman 2006c). They can provide many benefits including infrastructure cost savings, improved housing affordability, reduce transportation problems, increased livability, and economic development. These include (SGN 2002 and 2004):

- More comprehensive planning – develop local and regional planning programs, and tools for evaluating land use impacts and options.
- Location-based fees – restructure development fees, taxes and utility charges to reflect the lower cost of providing public services in more accessible locations.
- Smart public facility location and design – locate and design public facilities (government offices, schools, recreation centers, etc.) so they are accessible by multiple-modes and reflect other smart growth objectives.
- Reform zoning codes – reduce minimum parking and setback requirements, and increased density and mix.
- Encourage urban redevelopment – develop policies and programs that favor infill redevelopment over new, greenfield development.
- Growth controls and openspace preservation – develop policies and programs that limit growth outside of existing urban areas and preserve openspace.
- More neutral transport funding – reduce dedicated funds for roads and parking facilities, and apply least-cost planning for solving transportation problems.
- Educate decision-makers – sponsor workshops and training programs for planners, development professionals, public officials and the general public concerning the benefits of smart growth and tools for achieving land use planning objectives.

### Overflow Plans

Excessive parking requirements are often justified to meet occasional peak demands. Parking supply can often be reduced if facility managers and transportation agencies establish overflow parking plans and special event transport management plans, which indicate how occasional peak demands will be managed. This may include use of off-site parking, special shuttle services, user information, and incentives for employees to use alternative modes during peak periods.

### Structured And Underground Parking

Structured and underground parking reduces land required per space compared with surface parking. A 4-story parking structure uses only about a quarter as much land per space as a surface parking lot, and underground parking requires almost no additional land. Although more costly to build (typically $10,000 to $30,000 more per space), this saves land costs, allows increased development density and greater design flexibility. Structured parking is generally cost effective when land prices exceed about $2 million per acre, considering just construction costs, and less if other planning objectives, such as accessibility and aesthetics, are also considered.

### *Use Parking Facilities More Efficiently*

The number of vehicles that can be parked in a facility can be increased in various ways:

- Use currently wasted areas (corners, edges, undeveloped land, etc.). This can be particularly appropriate for small car spaces, motorcycle and bicycle parking.
- Where there is adequate street width, change from parallel to angled on-street parking.
- Allow existing parking facilities with low utilization rates to be reduced in size.
- Maximize the number of on-street parking spaces, for example, by using a curb lane for parking rather than traffic during off-peak periods.
- Reduce parking space size. Commuter and residential parking spaces can be somewhat smaller than shorter-term uses which have more entering and exiting activity. A portion of spaces can be sized for compact vehicles, motorcycles and bicycles. Motorcycles can be allowed to share parking spaces.
- Allow *tandem parking* (one vehicle parked in front of another, so the first must be moved for the second to exit) to count toward minimum residential parking requirements.
- Use car stackers and mechanical garages, as illustrated in Figure 4.
- Use valet parking, particularly during busy periods. This can increase parking capacity by 20-40% compared with users parking their vehicles. Commercial lots often have attendants park vehicles during busy periods, but not off-peak.
- Remove or consolidate non-operating vehicles, equipment, material and junk stored in parking facilities, particularly in prime locations.

***Figure 4*** **Carstackers**

*Carstackers allow more vehicles to be stored in a given area.*

### *Parking Tax Reform*

*Parking tax reform* includes various tax policies that support parking management (PCW 2002; Litman 2006c):

- *Per-space levies.* This is a special tax imposed on parking facilities, such as a $30 annual tax on each non-residential parking space. If applied specifically to employee parking it is called a *workplace parking levy.*
- *Free parking levy*. This is a special tax imposed on unpriced parking, for example, a $50 annual tax per space provided free to employees. This is a variation on per-space levies designed to discourage unpriced parking.
- *Stormwater management fees.* This is a utility fee based on impervious surface area to fund stormwater management services, such as a $15 annual fee per 1,000 square feet of pavement, or a $5 annual fee per parking space (Minneapolis 2005).
- *Car-free tax discounts.* This is a property tax discount provided to households that do not own an automobile, reflecting their lower roadway and traffic service costs they impose. For example, if municipal roadway expenditures average $200 annually per vehicle, a tax discount up to this amount could be provided to households that do not own a car.

### *Infill and Brownfield Redevelopment*
Many communities have older neighborhoods and brownfields (contaminated industrial lands) suitable for redevelopment. Redeveloping these areas instead of greenfields (currently undeveloped lands) avoids increasing impervious surface (www.epa.gov/brownfields). A variety of public policies and programs can help encourage this, including targeted cleanup, to favorable tax policies and public support of redevelopment projects in blighted areas.

### *Streetscaping*
*Streetscaping* refers to roadway design intended to create safer, more multi-modal and attractive roadways. It can include changes to the road cross section, traffic management, sidewalk conditions, landscaping, street furniture (utility poles, benches, garbage cans, etc.), building fronts and materials specifications, which may include use of more permeable surfaces. It often involves *traffic calming* and *road diets* which reduce lane widths and the number of traffic lanes (Burden and Lagerway 1999).

### *Encourage Shared ROW*
There may be opportunities for more sharing rights-of-way between roads and other utilities that are overlooked because agencies have insufficient resources and incentives for coordinated planning and sharing (Feitelson and Papay, 1999). It may be helpful to develop more coordinated utility planning which specify how roadway rights-of-way can be used by other agencies.

### *Improve Facility Design*
Various design features can reduce road and parking facility environmental impacts (Smith 1988; Childs 1998; Mukhija and Shoup 2006; Toronto 2007):

- Use on-site stormwater storage and percolation, with natural wetlands for filtering.
- Maximize greenspace, particularly shade trees along roadways and in parking lots.

- Cover parking lots with awnings. Some parking lots charge extra for covered areas. Parking lot awnings are perfect locations for solar panels.
- Use lighter materials, such as concrete rather than asphalt, to reduce solar gain.
- Design and maintain parking facilities to be attractive and safe.
- Use transport facility land efficiently. Sell air rights above roads and parking lots. Incorporate ground-floor retail into parking structures, to create more attractive and lively streetscapes.
- Use paving permeable pavement (Figure 5) and *pervious cement* (cement, rock and fiber without fine particles). Such materials reduce surface runoff (Booth and Leavitt 1999).
- Use "Hollywood" driveways, which are two strips of pavement instead of a full lane (Figure 6). This reduces paved area by about half.

***Figure 5*** **Permeable Pavement Blocks**

*Permeable pavement blocks allow grass to grow and water to drain into the ground.*

***Figure 6*** **Hollywood Driveway**

*"Hollywood" driveways only pave two strips.*

The city of Toronto (2007) developed parking facility design guidelines that incluce:

- Generous landscaped areas with trees and good quality soil.
- Enhance pedestrian and cycling infrastructure.
- Manage stormwater on-site.
- Reduce the urban heat island effect.
- Use sustainable materials and technologies.

**Country Lanes (www.cityfarmer.org/lanes.html)**

VANCOUVER - The City of Vancouver will officially open its first Country Lane, an environmentally sustainable design that makes lanes "greener" and more attractive. Mayor Philip Owen will be on hand to unveil the demonstration pilot project. The Country Lane is designed to provide a rural aesthetic while reducing environmental impacts and discharges to the City's storm sewer system.

The lane features two narrow strips of concrete that provide a smooth driving surface. The area between and beside these bands is made up of a structural component that can support vehicles, but is top-soiled and planted with grass. The road base is a mixture of aggregate, which provides structural stability, and a sand/soil mixture that allows for drainage and provides the necessary organic material for grass growth. This engineered soil was developed by the City of Vancouver's staff.

This design will allow rain water to percolate over vegetation and through the ground. The natural absorption allowed by this combined lane surface reduces discharges into the storm sewer system and provides natural drainage. The increased vegetation will filter storm water and improve air quality.

The lane at East 27th is the first of three Country Lanes planned as demonstration pilot projects. The proposed locations were chosen because of strong community support, and a commitment by area residents to help maintain, and promote this innovative alternative to asphalt lane paving. If successful, Country Lane designs will be available for local improvements throughout the city.

### *Summary*

Table 9 summarizes potential pavement reduction strategies identified in this guide.

***Table 9*** **Pavement Reduction Strategies**

| Management Strategy | Description |
|---|---|
| Educate decision-makers | Educate decision-makers concerning the costs of excessive road and parking supply, distortions in current planning practices, and alternative options that result in more efficient use of available road and parking capacity. |
| More accurate and flexible standards | Adjust road and parking standards to more accurately reflect demand in a particular situation taking into account various geographic, demographic and management factors. |
| Mobility management | Implement mobility management programs that reduce vehicle ownership and use. |
| Parking management | Implement parking management policies and programs that encourage more efficient use of parking facilities by sharing, pricing and use of off-site parking facilities. |
| Efficient pricing | Charge users directly for using roads and parking facilities. Cash out and unbundle currently free parking. |
| Smart growth | Encourage more compact, mixed, multi-modal development, which encourages sharing of parking facilities and use of alternative modes. |
| Overflow plans | Develop plans which indicate how parking and traffic will be managed during occasional peaks and special events. |
| Structured and Underground Parking | Use structured and underground parking facilities rather than surface lots in order to reduce impervious surface area and increase development density. |
| Use existing facilities more efficiently | Increase parking supply by using otherwise wasted space, smaller stalls, car stackers and valet parking. |
| Parking tax reform | Various tax policy changes that support parking management objectives. |
| Infill and brownfield redevelopment | Encourage redevelopment of existing urban areas rather than expansion into greenfields. |
| Streetscaping | Improve roadway design, including traffic calming and road diets. |
| Shared rights of way | Encourage government agencies and utilities to share rights of way among various utilities and other land uses. |
| Parking facility design and operations | Improved parking facility design and operations to help solve problems and achieve parking management objectives. |

*This table summarizes the parking management strategies described in this report.*

## Building Institutional Support

Many of the pavement reduction strategies described in this guide involve changing current practices and organizational structures. It is important to build institutional support for such reforms ("Institutional Reforms," VTPI, 2007). This often involves changing the way problems are defined and solutions evaluated. Reform proponents should highlight the benefits of change, for example, pointing out that many pavement reduction strategies also help reduce traffic congestion, accidents and pollution emissions.

Most transportation agencies where created to build roads and are not well structured to support alternatives. Many transportation planning and funding practices are biased toward road and parking capacity expansion, away from demand management alternatives. It is important to educate practitioners and decision-makers concerning new planning and management techniques that can support more efficient use of road and parking facilities and allow pavement area to be reduced.

*Least-cost planning* is an approach to resource planning that gives demand management solutions equal consideration and chooses the most cost effective option, taking into account all impacts (costs and benefits). Least cost planning tends to support transport and parking management, because they tend to be more cost effective than facility expansion.

*Transportation Management Associations* (TMAs) coordinate transport activities in a particular area, such as a commercial or employment center, which is more effective than smaller, individual programs managed by individual employers (VTPI 2007). They can provide *parking brokerage services*, allowing parking facilities to be used more efficiently through sharing and renting. This provides a framework for implementing mobility management and parking management policies and programs.

*Contingency-based planning* is a strategy that deals with uncertainly by identifying specific responses to possible future conditions. Contingency-based planning can help support many of the pavement reduction strategies described in this guide. A contingency-based plan typically consists of various *if-then* statements that define the solutions to be deployed if certain problems occur: *if* parking supply proves to be inadequate *then* we will implement certain strategies, and *if* those prove to be insufficient *then* we will implement an additional set of strategies. For example, a contingency-based parking plan might initially allow developers to build fewer parking spaces than required by conventional standards, with a list of solutions that will be implemented if that proves inadequate and motorists experience significant problems finding parking or neighbors experience parking spillover problems. These might include various parking management strategies (such as programs to encourage employees to use alternative modes, arrangements to share parking facilities with nearby buildings, and increased regulation and pricing of onsite parking), improved enforcement if needed to address any spillover problems, and additional capacity (some land might be reserved for future parking lots, or a potential budget identified to build a parking structure), if needed.

**Vancouver EcoDensity Program (www.vancouver-ecodensity.ca)**

The city of Vancouver's EcoDensity will create greater density throughout the city in order to reduce environmental impacts, ensure necessary physical and social amenities, and supports new and different housing types as a way to promote more affordability.

EcoDensity supports increasing density in a variety of contexts (i.e. in lower density areas; along transit routes and nodes, neighbourhood centres,). The key will be to support density that is high quality, attractive, more energy efficient, and respects neighbourhood character, while lowering our footprint. This requires reforming some existing policies, bylaws, incentives and zoning to reduce barriers and promote ideas that will create communities that are sustainable, livable and affordable.

EcoDensity involves an extensive research, planning and public consultation process. Some of the related issues are summarized below:

- Do people want the city to allow more flexibility in our bylaws to promote sustainable building practices such as: use alternative energy sources (e.g., solar and geo-thermal energy systems); green roofs; use recycled rain water; recycled building materials?
- Should the city make it easier for residents in single-family zoned areas to build a secondary suite above their garage, or convert their garage to a coach house?
- How does the city encourage the creation of more secondary suites? Should we require that any new single family home rough in a secondary suite?
- Do people want the city take more advantage of streets and nodes well served by transit or areas located around transit stations by increasing density significantly in those areas?
- What aspects of our bylaws need to be changed in order to better accommodate or promote sustainable building practices such as energy-saving systems, recycling of grey water and rain water, green roofs, etc.
- Should the city reduce its parking requirements on new developments, and if so, which type of developments? Should we require spaces for car sharing, or electric plugs in new underground garages to promote the use of electric vehicles? Should the city establish car free neighbourhoods?
- How can the city help ensure that the necessary community amenities are included in areas where only smaller, incremental developments are built.
- How could the city promote a greater range of types, sizes, locations and tenures of housing?

## Conclusions

There are economic, social and environmental reasons to reduce the amount of land paved for roads and parking; it can reduce facility costs, free up land for other productive uses, reduce stormwater management costs and heat island effects, create more livable communities, increase land use accessibility, and encourage more efficient travel behavior.

Current planning practices often result in economically excessive road and parking supply. Many zoning codes and development practices are based on outdated assumptions and inadequate information. Evaluation practices ignore many of costs of increased pavement and benefits of management solutions. Funding is often dedicated to roads and parking facilities, and cannot be used for alternative solutions even if they are more cost effective and beneficial overall. Transportation policies favor automobile travel over other modes. Many decision-makers are unaware of these problems and so continue to apply wasteful policies that contradict other planning objectives.

There are many cost-effective ways to use road and parking facilities more efficiently, reducing pavement requirements. These include:

- More accurate and flexible standards
- Mobility management programs
- Parking management programs
- Efficient pricing
- Smart growth policies
- Use existing facilities more efficiently
- Infill and Brownfield Redevelopment
- Streetscaping

These strategies tend to be most effective when implemented as an integrated program. Parking supply reductions of 10-30% are often justified by simply applying more accurate and flexible standards, for example, by reducing parking requirements in more accessible locations with multi-modal transportation systems, where on-street parking is available, or by using a $50^{th}$ percentile demand curve. Additional 10-30% reductions are often justified if cost-effective management strategies are implemented, such as sharing parking facilities and relying on off-site facilities to meet occasional peak parking demands. Further 10-30% reductions are usually justified by efficient pricing, including cost recovery road tolls and parking fees, parking cash out, and parking unbundling. Mobility and parking management can be used to reduce minimum road and parking requirements, avoid the need to expand road and parking facilities, or even to reduce existing supply to help achieve other objectives, such as freeing up land for other uses, and reducing environmental impacts.

These strategies face various obstacles. Institutional reforms, least-cost planning, and supporting organizations such as transportation management associations can help facilitate implementation of the strategies described in this guide.

## References and Resources

Hashem Akbari, L. Shea Rose and Haider Taha (2003), "Analyzing The Land Cover Of An Urban Environment Using High-Resolution Orthophotos," *Landscape and Urban Planning* (www.sciencedirect.com/science/journal/01692046), Vol. 63, Issue 1, pp. 1–14.

Eliot Allen and F. Kaid Benfield (2003), *Environmental Characteristics of Smart-Growth Neighborhoods*, National Resources Defense Council (www.nrdc.org/cities/smartGrowth/char/charnash.pdf).

*American Forests* (www.americanforests.org) promotes protection and enhancement of trees and forests, and provides analysis tools for evaluating forest values and impacts, including *CITYgreen* software that calculates the monetized value of forests under specific circumstances.

APA (1983), *Flexible Parking Requirements*, PAS, American Planning Association (www.planning.org).

Chester Arnold and James Gibbons (1996), "Impervious Surface Coverage: The Emergence of a Key Environmental Indicator," *American Planning Association Journal*, Vol. 62, No. 2, Spring, pp. 243-258.

Barton-Aschman Associates (1982), *Shared Parking*, Urban Land Institute (www.uli.org).

Matthew R. Cuddy (2007), *A Practical Method For Developing Context-Sensitive Residential Parking Standards*, Dissertation, Rutgers University (www.rutgers.edu); at http://transportation.northwestern.edu/news/2007/Cuddy_dissertation_final_cv.pdf.

Derek Booth and Jennifer Leavitt (1999), "Field Evaluation of Permeable Pavement Systems for Improved Stormwater Management," *Journal of the American Planning Association*, Vol. 65, No. 3, Summer, pp. 314-325.

Dan Burden (1998), *Street Design Guidelines for Healthy Neighborhoods*, Center for Livable Communities (www.lgc.org/clc).

Dan Burden and Peter Lagerway (1999), *Road Diets Free Millions for New Investment*, Walkable Communities (www.walkable.org).

Stephen Burrington & Veronika Thiebach, *Take Back Your Streets; How to Protect Communities from Asphalt and Traffic*, Conservation Law Foundation (Boston; www.clf.org), 1995.

Robert Burchell, Anthony Downs, Barbara McCann and Sahan Mukherji (2005), *Sprawl Costs: Economic Impacts of Unchecked Development*, Island Press (www.islandpress.org).

Center for Livable Communities (www.lgc.org/clc), helps local governments and community leaders improve land use and transportation planning.

Center for Watershed Protection (www.cwp.org) provides analysis and resources for minimizing hydrologic impacts and pollution.

Mikhail Chester, Arpad Horvath and Samer Madanat (2010), "Parking Infrastructure: Energy, Emissions, And Automobile Life-Cycle Environmental Accounting," *Environmental Research Letters*, Vol. 5, No. 3; at http://dx.doi.org/10.1088/1748-9326/5/3/034001; project of the UC Berkeley Center for Future Urban Transport (www.sustainable-transportation.com).

Mark Childs (1998), *Parking Spaces; A Design, Implementation, and Use Manual for Architects, Planners, and Engineers*, McGraw Hill (www.booksite.com).

CNT (2006), *Paved Over: Surface Parking Lots or Opportunities for Tax-Generating, Sustainable Development?*, Center for Neighborhood Technology (www.cnt.org); at www.drcog.org/documents/PavedOver-Final.pdf.

CNU (2008), *Parking Requirements and Affordable Housing*, Congress for the New Urbanism (www.cnu.org); at www.cnu.org/node/2241.

Alan B. Cohen (1997), *Narrow Streets Database*, Congress for the New Urbanism (www.cnu.org); at http://lists.cacities.org/pipermail/hced/attachments/20031030/91bd1be8/NARROWSTREETSDATABASE-0003.doc.

COMSIS (1994), *A Survey and Analysis of Employee Responses to Employer-Sponsored Trip Reduction Incentive Programs*, California Air Resources Board (Sacramento).

W. Bowman Cutter, Sofia F. Franco and Autumn DeWoody (2010), *Do Parking Requirements Significantly Increase The Area Dedicated To Parking? A Test Of The Effect Of Parking Requirements Values In Los Angeles County*, Paper No. 20403, Munich Personal RePEc Archive (http://mpra.ub.uni-muenchen.de); at http://mpra.ub.uni-muenchen.de/20403/1/MPRA_paper_20403.pdf.

James M. Daisa and Terry Parker (2010), "Trip Generation Rates for Urban Infill Uses In California," *ITE Journal* (www.ite.org), Vol. 79, No. 6, June 2010, pp. 30-39.

Amélie Y. Davis, Bryan C. Pijanowski, Kimberly D. Robinson and Paul B. Kidwell (2010), "Estimating Parking Lot Footprints In The Upper Great Lakes Region Of The USA" *Landscape and Urban Planning*, Vol. 96, Issue 2, May, Pages 68-77; at www.citeulike.org/article/6869205.

Reid Ewing (1996), *Best Development Practices; Doing the Right Thing and Making Money at the Same Time*, Planners Press (www.planning.org).

Eran Feitelson and Nir Papay (1999), "Sharing Rights of Way Along Inter-Urban Corridors: A Spatial, Temporal and Institutional Analysis," *Transportation Research D*, Vol. 4, No. 4, July, pp. 217-240.

*The Green Values Calculator* (http://greenvalues.cnt.org) automatically evaluates the economic and hydrological impact of green versus conventional stormwater management.

Timothy D. Hau, "Congestion Pricing and Road Investment," Chapter 3 of *Road Pricing, Traffic Congestion and The Environment*, Kenneth Button and Erik Verhoef (eds), Edward Elgar (Cheltenham, UK), 2000, pp. 39-78; at www.econ.hku.hk/~timhau.

Wolfgang Homburger (1989), *Residential Street Design and Traffic Control*, Institute of Transportation Engineers (www.ite.org).

Homburger, Kell and Perkins (1992), *Fundamentals of Traffic Engineering*, Institute of Transportation Studies, UCB (Berkeley)

Richard Horner, Derek Booth, Amanda Azous, and Christopher May (1996), "Watershed Determinates of Ecosystem Functioning," *Effects of Watershed Development and Management on Aquatic Ecosystems*, L.A. Roesner Ed., American Society of Civil Engineers (New York).

HUD (2008), "Parking Regulations and Housing Affordability," *Regulatory Barriers Clearinghouse*, Volume 7, Issue 2, US Department of Housing and Urban Development, (www.huduser.org); at www.huduser.org/rbc/newsletter/vol7iss2more.html.

Angus Hulme-Moir (2010), *Making Way for the Car: Minimum Parking Requirements and Porirua City Centre*, Thesis, School of Geography, Environment and Earth Sciences, Victoria University of Wellington (http://researcharchive.vuw.ac.nz/handle/10063/1458).

ICF (1997), *Opportunities to Improve Air Quality Through Transportation Pricing*, Office of Mobile Sources, US Environmental Protection Agency (www.epa.gov).

ITE (2005), *Parking Generation*, Institute of Transportation Engineers (www.ite.org).

ITE (2010), *Promoting Sustainable Transportation Through Site Design: An ITE Recommended Practice*, Institute of Transportation Engineers (www.ite.org); at www.ite.org/emodules/scriptcontent/Orders/ProductDetail.cfm?pc=RP-035A.

John S. Jacob and Ricardo Lopez (2009), "Is Denser Greener? An Evaluation Of Higher Density Development As An Urban Stormwater-Quality Best Management Practice," *Journal of the American Water Resources Association* (JAWRA), Vol. 45, No. 3, pp. 687-701.

Wenya Jia and Martin Wachs (1998), *Parking Requirements and Housing Affordability; A Case Study of San Francisco*, Paper 380, University of Calif. Transportation Center (www.uctc.net).

Luke H. Klipp (2004), *The Real Costs Of San Francisco's Off-Street Residential Parking Requirements: Analysis Of Parking's Impact On Housing Finance Ability And Affordability*, Transport for a Livable City www.livablecity.org/resources/Parking_Housing_Affordability_Final.pdf.

Valerie Knepper (2007), *Existing Bay Area Parking Policies – Technical Paper*, Wilber Smith Associates, for the Metropolitan Transportation Council (www.mtc.ca.gov); at www.mtc.ca.gov/planning/smart_growth/parking_seminar/Technical_Paper_Existing_Parking_Policy.pdf

Michael Kodama, et al., *Using Demand-Based Parking Strategies to Meet Community Goals*, South Coast Air Quality Management District (Los Angeles), 1996.

J. Richard Kuzmyak, Rachel Weinberger, Richard H. Pratt and Herbert S. Levinson (2003), *Parking Management and Supply*, Chapter 18, Report 95, TCRP, TRB (www.trb.org).

Douglass B. Lee (1999), *The Efficient City: Impacts of Transportation on Urban Form*, Volpe Transportation Center (www.volpe.dot.gov), presented at ACSP Annual Conference.

LGC (2007), *Emergency Response and Traditional Neighborhood Street Design*, Local Government Commission (www.lgc.org); at www.lgc.org/freepub/land_use/factsheets/er_streetdesign.html.

Todd Litman (2003), *Transportation Land Valuation: Evaluating Policies and Practices that Affect the Amount of Land Devoted to Transportation Facilities*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/land.pdf.

Todd Litman (2004), *Parking Requirement Impacts on Housing Affordability*, VTPI (www.vtpi.org); at www.vtpi.org/park-hou.pdf.

Todd Litman (2005), *Land Use Impacts on Transport*, VTPI (www.vtpi.org); at http://www.vtpi.org/landtravel.pdf.

Todd Litman (2006a), *Evaluating Transportation Land Use Impacts*, VTPI (www.vtpi.org); at www.vtpi.org/landuse.pdf.

Todd Litman (2006b), *Parking Management: Strategies, Evaluation and Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/park_man.pdf.

Todd Litman (2006c), *Smart Growth Policy Reforms*, VTPI (www.vtpi.org); available at www.vtpi.org/smart_growth_reforms.pdf.

Todd Litman (2007a), *Transportation Cost and Benefit Analysis*, Victoria Transport Policy Institute (www.vtpi.org/tca).

Todd Litman (2007b), *Socially Optimal Transport Prices and Markets*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/sotpm.pdf.

Todd Litman (2008), *Recommendations for Improving LEED Transportation and Parking Credits*, VTPI (www.vtpi.org); at www.vtpi.org/leed_rec.pdf.

Todd Litman (2011), "Why and How to Reduce the Amount of Land Paved for Roads and Parking Facilities," *Environmental Practice*, Vol. 13, No. 1, March, pp. 38-46; http://journals.cambridge.org/action/displayJournal?jid=ENP.

*Local Government Parking Policy and Commute Trip Reduction; 1999 Review*, Commute Trip Reduction Office, WSDOT (www.wsdot.wa.gov/pubtran/ctr), 1999.

Michael Manville and Donald Shoup (2005), "People, Parking, and Cities," *Journal of Urban Planning and Development*, December, pp. 233-245; at http://shoup.bol.ucla.edu/People,Parking,CitiesJUPD.pdf; summarized in *Access 25*, (www.uctc.net), Fall 2004, pp. 2-8.

Mary Marr (1999), *Downtown Parking Made Easy*, Downtown Research and Development Center (www.alexcommgrp.com/drdc).

Wesley E. Marshall and Norman W. Garrick (2006), "Parking at Mixed-Use Centers in Small Cities," *Transportation Research Record 1977*, Transportation Research Board (www.trb.org);

www.darien.org/communitymatters/blog/archives/ParkingstudyfromUCONN.doc; also see, *'Place First' Parking Plans* (www.planetizen.com/node/34152).

Minneapolis (2005), *Minneapolis Stormwater Utility Fee*, City of (www.ci.minneapolis.mn.us); at www.ci.minneapolis.mn.us/stormwater/fee.

Anne Vernez Moudon, et al. (2003), *Strategies and Tools to Implement Transportation-Efficient Development: A Reference Manual*, Washington State Department of Transportation, WA-RD 574.1 (http://depts.washington.edu/trac/bulkdisk/pdf/574.1.pdf).

MRSC, *Downtown Parking Solutions*, Municipal Research and Service Center of Washington (www.mrsc.org/Subjects/Transpo/Tpark/transsolut.aspx).

Vinit Mukhija and Donald Shoup (2006), "Quantity Versus Quality in Off-Street Parking Requirements," *Journal of the American Planning Association*, Vol. 72, No. 3, pp. 296-308; at http://shoup.bol.ucla.edu/QuantityVersusQualityInOff-StreetParkingRequirements.pdf.

Anton C. Nelessen (1994), *Visions for a New American Dream*, Planners Press (www.planning.org)

*NEMO Project* (www.nemo.uconn.edu) addresses impervious surface impacts.

PAS (2009), *Parking Solutions: Essential Info Packet*, Planning Advisory Service, American Planning Association (www.planning.org): at www.planning.org/pas/infopackets. These packets consist of compilation of related documents that provide practical information on various parking management strategies, suitable for use by planners and developers. These include:

- *Parking Solutions* (130 pages). Six documents that describe modern approaches to parking management.
- *Shared Parking* (133 pages). More than thirty documents concerning shared parking, parking in-lieu fees, parking requirement reductions and exemptions, and downtown parking requirements.
- *Green Parking Lot Design* (66 pages). Three documents that describe ways to improve parking lot environmental performance through landscaping, stormwater management and alternative surfaces.
- *Permeable Pavement and Bicycle Parking* (38 pages). Five documents concerning the use of permeable parking lot pavement materials, and five documents concerning bicycle parking.

*Pavement to Parks* (http://sfpavementtoparks.sfplanning.org) describes a program to convert on-street parking and other small areas of streetspace into "parklets."

PCW (2002), *Some Existing Water District Funding Sources*, Legislative and Regulatory Issues Technical Advisory Committee, Project Clean Water (www.projectcleanwater.org).

Bryan Pijanowski (2007), *Parking Spaces Outnumber Drivers 3-to-1, Drive Pollution and Warming*, Purdue University (www.purdue.edu/uns/x/2007b/070911PijanowskiParking.html).

Gary Roth (2004), *An Investigation Into Rational Pricing For Curbside Parking: What Will Be The Effects Of Higher Curbside Parking Prices In Manhattan?* Masters Thesis, Columbia University; at http://anti-bob.com/parking/Rational_Pricing_for_Curbside_Parking-GRoth.pdf).

The *San Francisco Planning and Urban Research Association* (www.spur.org).

Seattle (2000), *Comprehensive Neighborhood Parking Study*, City of Seattle (www.cityofseattle.net/transportation/pdf/CNPS.pdf).

SGN (2002), *Getting To Smart Growth: 100 Policies for Implementation*, and (2004), *Getting to Smart Growth II: 100 More Policies for Implementation*, Smart Growth Network (www.smartgrowth.org) and International City/County Management Association (www.icma.org); at www.epa.gov/smartgrowth/getting_to_sg2.htm.

John Shaw, *Planning for Parking*, Public Policy Center, University of Iowa, Iowa City (www.uiowa.edu), 1997.

Donald Shoup (1999a), "The Trouble With Minimum Parking Requirements," *Transportation Research A*, Vol. 33, No. 7/8, Sept./Nov. 1999, pp. 549-574; at www.vtpi.org/shoup.pdf.

Donald C. Shoup (1999b), "In Lieu of Required Parking," *Journal of Planning Education and Research*, Vol. 18, pp. 307-320.

Donald Shoup (2005), *The High Cost of Free Parking*, Planners Press (www.planning.org). Also see "The High Cost of Free Parking," *Access* No. 10 (www.uctc.net), Spring 1997.

The Smart Growth Network (www.smartgrowth.org) includes planners, govt. officials, lenders, community developers, architects, environmentalists and activists.

Sprawl Watch Clearinghouse (www.sprawlwatch.org) provides information on land use issues.

SPUR (1998), *Reducing Housing Costs by Rethinking Parking Requirements*, The San Francisco Planning and Urban Research Association (www.spur.org)

Frederick Stutz (1995), "Environmental Impacts," *Geography of Urban Transportation*, Susan Hanson, Ed., Guilford (New York).

Toronto (2007), *Design Guidelines for 'Greening' Surface Parking Lots*, Toronto City Planning; at www.toronto.ca/planning/urbdesign/greening_parking_lots.htm.

TRB (1997), Toward *a Sustainable Future*, Special Report 251, TRB (www.trb.org).

USEPA (1992), *Cooling Our Communities*, USEPA (Washington DC), GPO#055-000-00371-8.

USEPA (1999), *Indicators of the Environmental Impacts of Transportation*, Office of Policy and Planning, USEPA (www.itre.ncsu.edu/cte).

USEPA (2006), *Growing Toward More Efficient Water Use: Linking Development, Infrastructure, and Drinking Water Policies*, Development, Community, and Environment Division (DCED); U.S. Environmental Protection Agency (www.epa.gov).

USEPA (2006), *Parking Spaces / Community Places: Finding the Balance Through Smart Growth Solutions*, Development, Community, and Environment Division (DCED), U.S. Environmental Protection Agency, (www.epa.gov); at www.epa.gov/smartgrowth/parking.htm.

USEPA (2009), *Essential Smart Growth Fixes for Urban and Suburban Zoning Codes*, U.S. Environmental Protection Agency (www.epa.gov); at www.epa.gov/smartgrowth/pdf/2009_essential_fixes.pdf.

USEPA (2009), *WaterQuality Scorecard: Incorporating Green Infrastructure Practices at the Municipal, Neighborhood, and Site Scales*, U.S. Environmental Protection Agency (www.epa.gov); at www.epa.gov/dced/pdf/2009_1208_wq_scorecard.pdf.

UTTIPEC (2010), *Parking Policy as a Travel Demand Management Strategy*, Delhi Development Authority (www.uttipec.nic.in); at www.uttipec.nic.in/writereaddata/linkimages/7460355562.pdf.

van Essen, et al (2004), Marginal Costs of Infrastructure Use Towards a Simplified Approach, CE Delft (www.ce.nl); at www.ce.nl/publicatie/marginal_costs_of_infrastructure_use_%96_towards_a_simplified_approach/456.

*Vancouver EcoDensity* (www.vancouver-ecodensity.ca) is an integrated programs to increase urban livability, affordability and environmental performance throught policy and planning reforms that encourage more compact, mixed, infill development.

VTPI (2007), *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org).

Rachel Weinberger, John Kaehny and Matthew Rufo (2009), *U.S. Parking Policies: An Overview of Management Strategies*, Institute for Transportation and Development Policy (www.itdp.org).

Jim West and Allen Lowe (1997), “Integration of Transportation and Land Use Planning Through Residential Street Design,” *ITE Journal*, August 1997, pp. 48-51.

Patricia White (2007), *Getting Up To Speed: A Conservationist’s Guide to Wildlife and Highways*, Defenders of Wildlife (www.GettingUpToSpeed.org).

Wilbur Smith Associates, Michael R. Kodama Planning, Richard Willson, KT Analytics and Rick Williams Consulting (2006), *Developing Parking Policies to Support Smart Growth in Local Jurisdictions: Best Practices*, Metropolitan Transportation Commission (www.mtc.ca.gov); at www.mtc.ca.gov/planning/smart_growth/parking_study/Nov06/MTC_Parking_BestPracticesDraft.pdf.

Richard Willson (1995), “Suburban Parking Requirements; A Tacit Policy for Automobile Use and Sprawl,” *Journal of the American Planning Association*, Vol. 61, No. 1, Winter, pp. 29-42.

Richard Willson (1999), *Reading Between the Regulations; Planners Perspectives on Minimum Parking Requirements*, Transportation Research Board Annual Meeting (www.trb.org).

Robin Zimbler (2005), *Driving Urban Environments: Smart Growth Parking Best Practices*, Maryland Governor’s Office of Smart Growth (www.smartgrowth.state.md.us).