5.7 Roadway Land Value

This chapter investigates the amount of land devoted to roads, the value of this land, and how this cost can be allocated to road users. Although roadway land is often treated as a sunk cost, it is a valuable resource with alternative uses. Failing to charge road users the equivalent of rent and taxes on roadway land underprices roads compared with other land uses, and underprices space-intensive travel modes. This tends to increase the amount of land devoted to roads and encourage lower-density urban development.

5.7.1 Chapter Index

5.7.2 Definition

Roadway land value reflects the cost of land used for road rights-of-way and other public facilities dedicated for automobile use. It can be defined as the rent that road users would pay for roadway land, or at a minimum, the equivalent of property taxes.

5.7.3 Discussion

Most roads are publicly owned. Highways and major arterials are usually funded and owned by state (in Canada, provincial) governments, while minor roads and streets are usually owned by local governments (roads in new developments are often funded originally by private developers but turned over to local governments). A small (but not insignificant) amount of land is devoted to private roads and driveways.

Roadway Land Area

Most roads have two to four lanes, each 10-14 feet wide, plus shoulders, sidewalks, drainage ditches and landscaping area. Road rights-of-way (the land that is legally devoted to the road) usually range from 24 to 100 feet wide. Most roads in developed countries are paved. In high density urban areas road pavement often fills the entire right-of-way, but in other areas there is often an unpaved shoulder area. The amount of land devoted to roads is affected by:

- Projected vehicle traffic demand (which determine the number of traffic lanes).
- Road design standards (which determine lane and shoulder widths). Such standards are usually adopted by transportation agencies based on recommendations by professional organizations such as the Institute of Transportation Engineers (ITE) or the American Association of State Transportation and Highway Officials (AASHTO).
- On street parking practices (which determine the number of parking lanes).
- Additional design features, such as shoulders, sidewalks, ditches and landscaping.
- Definition, such as whether unpaved land in road rights-of-way are included in the analysis.

The table below shows one estimate of total U.S. land devoted to roads. It indicates than more than 13,000 square miles is paved (about 0.4% of continental U.S.) and more than 20,000 square miles is devoted to road rights of way (about 0.7% of continental U.S.).

Table 5.7.3-1 **Land Area Devoted to Roads in the U.S.**[1]

	Avg. Lanes	Lane width	Shoulder & dividers	Total width road	Paved roads	Private paved rd. factor	Paved road area	Extent of unpaved roads	Private unpaved rd.	Total road area
Units		*Feet*	*Feet*	*Feet*	*Miles*		*Miles²*	*Miles*		*Miles²*
Urban										
Interstate	5.4	12.0	40	105	11,603	1.00	231	0	1.00	231
Other freeway	4.5	12.0	30	84	7,714	1.00	123	0	1.00	123
Major Arterial	3.4	11.5	15	54	52,349	1.00	532	0	1.00	532
Minor Arterial	2.5	11.3	10	39	74,516	1.00	546	463	1.00	550
Collector	2.1	11.1	8	32	76,251	1.01	463	846	1.02	468
Local road	1.8	10.9	8	28	491,926	1.03	2,650	34,196	1.04	2,837
Subtotal urban					*714,359*		*4,545*	*35,505*		*4,739*
Rural										
Interstate freeway	4.1	12.0	35	84	33,677	1.00	533	0	1.00	533
Other Highway	2.5	11.7	30	60	85,729	1.00	971	0	1.00	971
Major Arterial	2.1	11.5	15	39	142,866	1.00	1,058	0	1.00	1,058
Major collector	2.0	10.9	10	32	388,611	1.00	2,355	48126	1.00	2,647
Minor collector	2.0	10.1	5	25	196,006	1.01	941	97,494	1.05	1,428
Local road	1.7	10.0	4	21	720,229	1.05	3,008	1,426,697	1.10	9,250
Subtotal rural					*1,567,118*		*8,867*	*1,572,317*		*15,888*
Total					*2,281,477*		*13,412*	*1,607,822*		*20,627*

[1] Mark Delucchi with James Murphy (1998), "Motor Vehicle Goods and Services Bundled in the Private Sector," *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991*, Vol. 6, ITS (www.uctc.net).

Table 5.7.3-2 shows the estimated portion of land devoted to roads in various countries. Although this is a small portion of total land, roads tend to concentrate in areas with high populations and industrial activities and so compete with other productive uses. In regions with high vehicle ownership rates, 10-20% urban land is typically devoted to roads and parking, with higher values (more than 50%) in commercial centers.[2]

Table 5.7.3-2 **Land Area Devoted to Road and Parking Facilities**[3]

	Road & Parking	Portion of Total Land Area	Area Per Capita	Area Per Motor Vehicle
	Hectares		Meters^2	Meters^2
United States	15,920,615	1.7%	573	746
Canada	2,276,656	0.2%	734	1319
Mexico	863,832	0.4%	87	1100
Japan	1,316,591	3.5%	104	184
France	1,020,586	1.9%	173	308
Germany	749,725	2.1%	91	164
United Kingdom	425,149	1.8%	72	137
Sweden	241,146	0.6%	268	566

Overall, pavement covers about about 35% of the surface area of most residential areas and 50–70% in most non-residential areas according to research by Akbari, Rose and Taha (2003). Table 5.7.3-3 and Figure 5.7.3-1 summarize these results.

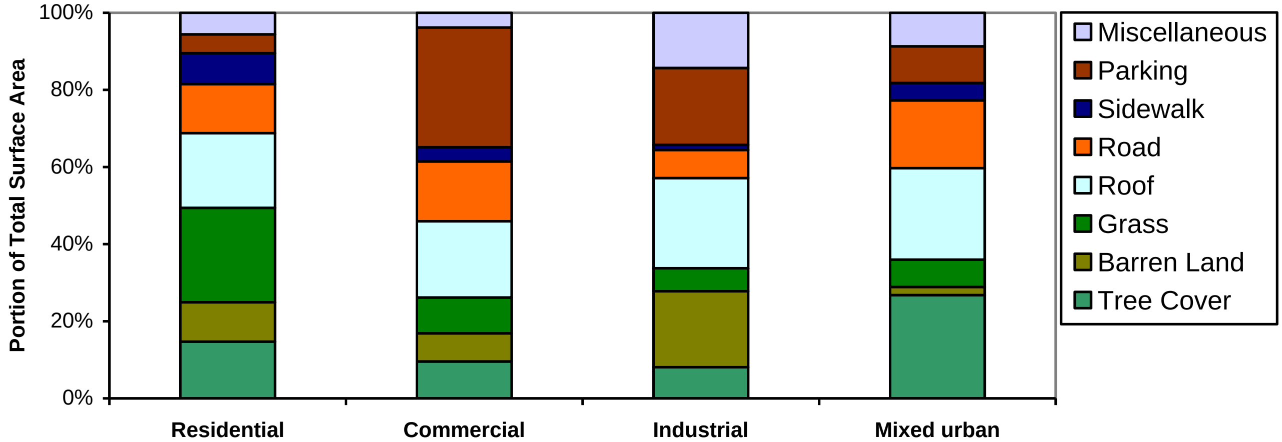
Table 5.7.3-3 **Calculated Surface-Area Percentages**[4]

	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.

[2] H. Levinson (1982), *Transportation and Traffic Engineering Handbook*, Prentice Hall (www.prenticehall.com), p. 256; K. Button (1994), *Transport Economics*, Edward Elgar (www.e-elgar.co.uk), p. 117.
[3] Rea Janise Kauffman (2001), *Paving The Planet*, Worldwatch Institute (www.worldwatch.org).
[4] 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.

Figure 5.7.3-1 **Calculated Surface-Area Percentages**[5]



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

Accounting for Roadway Land Value

Roadway land is often considered a sunk cost, with no rent or property taxes charged to users except whn land acquisition costs are incorporated into roadway user fees. However, such assets should be valued as they would be in a competitive market, that is, at their replacement cost.[6] Economic neutrality requires that land be priced and taxed at the same rate for competing uses,[7] particularly in urban areas where land costs are high and multiple modes compete.[8] Failure to charge for roadway land underprices space-intensive modes (such as single-occupant automobile travel compared with transit, ridesharing, cycling and walking), roads relative to rail (which pays rent and taxes on right-of-way), underprices roads compared with other land uses, and underprices transport relative to other goods.[9] As Lee states, "*Land in highway right-of-way has alternative uses, and this value is included in published figures only when the purchase of new land is a part of current expenditures. Normally, any long-lived business investment is expected to earn a rate of return at least equal to the interest rate on borrowed funds.*"[10] This underpricing reduces economic efficiency and results in overinvestment in roads.[11]

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[5] Akbari, Rose and Taha (2003)

[6] Ronald Hirshhorn (2003), *Concepts And Practical Values Of Land Costs And Capital Charges For A "Full-Cost Accounting" Of Transport Infrastructure In Canada*, Transport Canada Policy Group (www.tc.gc.ca); at www.tc.gc.ca/pol/en/aca/fci/transmodal/menu.htm

[7] Alex Anas, Richard Arnott and Kenneth Small (1997), *Urban Spatial Structure*, University of California Transportation Center (www.uctc.net), No. 357.

[8] William Vickrey (1997), *Public Economics; Selected Papers by William Vickrey*, Cambridge University Press (http://uk.cambridge.org), p. 211 and 309.

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

[10] Douglass Lee (1992), *An Efficient Transportation and Land Use System*, Volpe National Transportation Research Center (www.volpe.dot.gov).

[11] Gabriel Roth (1996), *Roads in a Market Economy*, Avebury (1995), "Use of Land for Roadways in a Growing Mills-de Ferranti Urban Area," *Journal of Urban Economics*, Vo. 37, pp. 131-160.

Exempting roadway land from property taxes also imposes a financial burden on municipal governments. The American Planning Association's Policy on Transportation Planning (October 1990) states, "*Equal tax treatment requires that transportation facilities and services not be exempted from general property and sales taxes that contribute revenues to the general-purpose operation of government*." Poole points out that land used for transport facilities is undertaxed and tends to be inefficiently managed because it is not expected to earn rent.[12] In addition to financial costs, incremental increases in the amount of land devoted to roads creates a more dispersed, automobile dependent land use pattern. Such sprawl tends to increase a number of costs to society, including public service costs, transportation costs and environmental impacts.[13]

Since roads often increase adjacent property values, some people argue that roadway land provides a positive rather than negative social value. It is true that *access* can increase property values, but not just automobile access. Failing to charge users for roadway land favors space-intensive modes over space-efficient modes.

The amount of land required for transport tends to increase with vehicle size and speed. For example, an automobile traveling at 30 miles-per-hour (mph) requires about 12.5 feet of lane width and 80 feet of lane length, or about 1,000 square feet in total, but at 60 mph this increases to 15 feet of lane width and 150 feet of length, or about 2,250 square feet in total. The table below compares the time-area requirements of various modes for a 20-minute commute with 8 hours of vehicle parking (no parking is required for walking or public transport). This indicates that driving consumes several times as much space as other modes.

Table 5.7.3-4 **Space Required By Travel Mode**[14]

Mode	Average Speed	Standing Area	Moving Area	Travel Area	Parking Area	Total Area
	Km/Hr	Sq. Meters	Sq. Meters	Sq. Meter-Minutes/km	Sq. Meter-Minutes/km	Sq. Meter-Minutes/km
Walking	5	1	3	24	-	24
Bicycling	15	2	9	24	64	88
Bus Transit	25	2	2	3	-	3
Solo Driving – Urban Arterial	30	10	30	40	160	200
Solo Driving - Suburban Highway	100	20	300	120	96	216

This table compares road and parking space requirements for a 20-minute commute by various modes, measured in square-meter-minutes (square meters times number of minutes).

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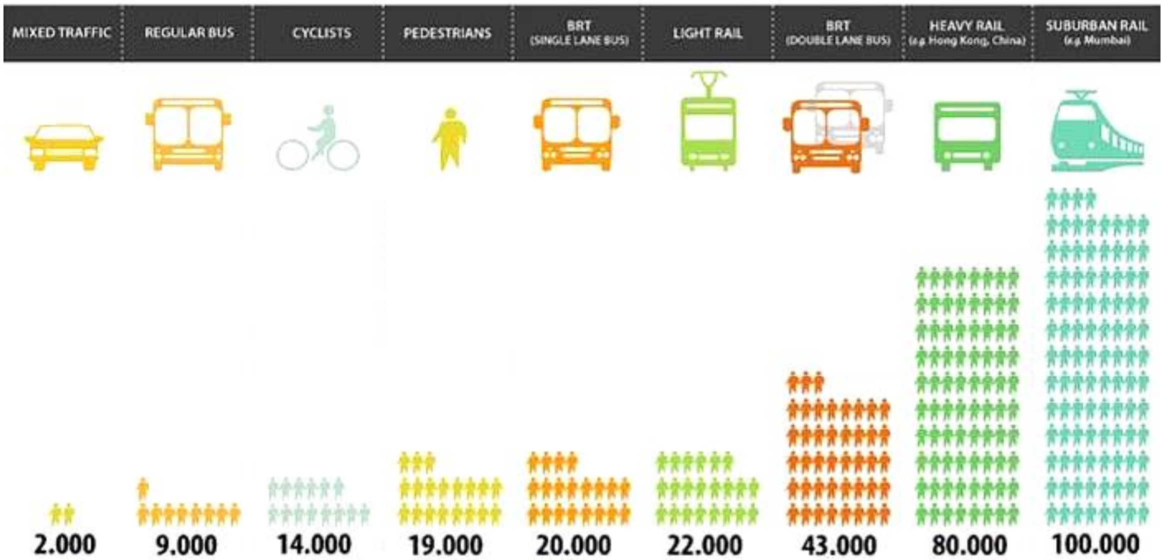
[12] Robert Poole (1997), "Privatization: A New Transportation Paradigm," *Annals*, AAPSS (www.aapss.org), 553, Sep. 1997, 94-105.
[13] Todd Litman (2001), *Transportation Land Valuation: Evaluating Policies and Practices that Affect the Amount of Land Devoted to Transportation Facilities*, VTPI (www.vtpi.org).
[14] *Transport Land Requirements Spreadsheet* (www.vtpi.org/Transport_Land.xls), based on Eric Bruun and Vukan Vuchic (1995), "The Time-Area Concept: Development, Meaning and Applications," *Transportation Research Record 1499*, TRB (www.trb.org), pp. 95-104.

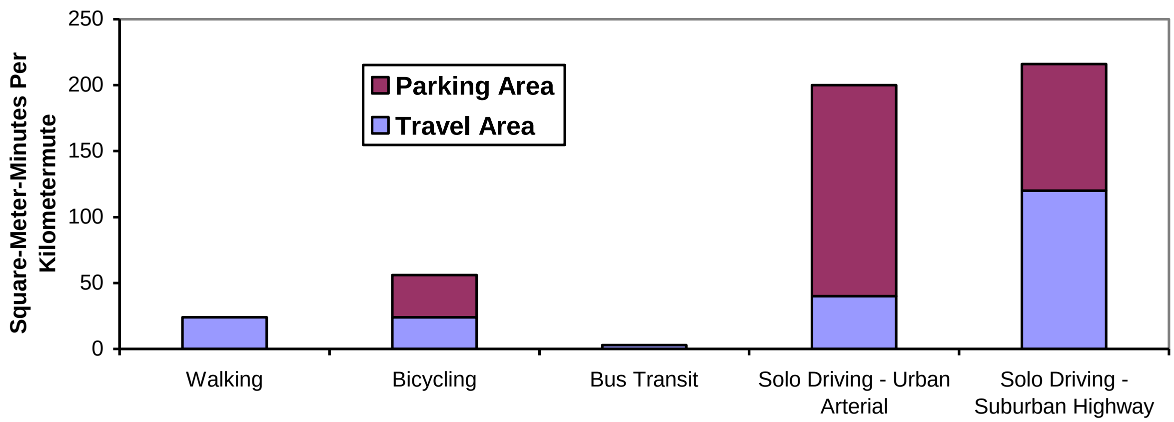
Figures 5.7.3-2 and 5.7.3-3 illustrate these differences. Automobile travel requires much more space than walking, bicycling and public transit travel, particularly considering both road and parking space requirements. Actual space requirements can vary depending on road design, traffic conditions (speed) and vehicle load factors (passengers per vehicle).

Figure 5.7.3-2 **Maximum Passengers Per Hour on Lane By Urban Mode**[15]



The maximum number of passengers that a 3.5-meter urban road lane can carry varies by mode, travel speed and load factor (number of passengers per vehicle). Automobiles are generally least space-efficient. This underestimates total automobile road space requirements where city streets also have parking lanes.

Figure 5.7.3-3 **Space Required By Travel Mode**



Automobile travel requires far more space for travel and parking than other modes.

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15 ADB (2012), *Solutions for Urban Transport*, Asian Development Bank (www.adb.org); at http://farm8.staticflickr.com/7228/7399658942_267b1ba9fc_b.jpg.

This does not mean that automobile transport always increases roadway land requirements 15-100 times. Vehicles often follow closer than safety experts recommend, reducing road space requirements 20-50% than this analysis indicates, while other conditions (such as inclement weather) increase road space requirements. Even cities built before the automobile often had wide roads to accommodate wagon traffic, and to provide sunlight and air flow.[16] But transport land requirements tend to increase with vehicle ownership.[17] Walking cities typically devote less than 10% of land to transport, while automobile-oriented cities devote two or three times that.[18] Automobile dependent cities average about 7 meters of road length per capita, compared with 2.5 meters in cities that have more balanced transport systems.[19] Figure 5.7.3-1 illustrates how per capita road supply tends to increase with automobile travel. This indicates that automobile-dependency increases transport land requirements 3 to 5 times. Put another way, 66% to 80% of the land devoted to roads and parking facilities in modern cities results from the greater space requirements of automobile transport.

In addition, motor vehicle traffic tends to reduce development density indirectly by increasing the need for sidewalk and building setbacks to avoid traffic noise and dust, so larger boulevards, highways shoulders and front lawns can be considered, in part, a land use cost of motor vehicle transport.

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[16] Kenneth Button (1994), *Transport Economics*, 2nd Ed., Edward Elgar (www.e-elgar.co.uk), p. 117.

[17] Michael Manville and Donald Shoup (2005), "People, Parking, and Cities," *Journal Of Urban Planning And Development*, American Society of Civil Engineers (www.asce.org), December, pp. 233-245; at http://shoup.bol.ucla.edu/People,Parking,CitiesJUPD.pdf.

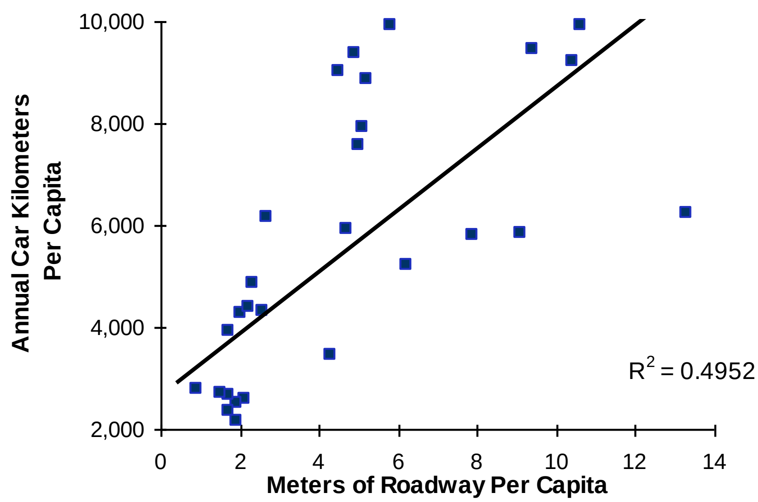
[18] Harry Dimitriou (1993), *Urban Transport Planning*, Routledge, (www.routledge.com).

[19] Peter Newman and Jeff Kenworthy (1999), *Sustainability and Cities; Overcoming Automobile Dependence*, Island Press (www.islandpress.org), Table 3.9.

Roadway Land Valuation

There is some uncertainty concerning urban road rights-of-way valuation. At a minimum, it is the value of urban periphery land, on the assumption that land used for roads can be replaced by urban expansion. For example, if automobile transport doubles roadway land requirements from 10% to 20%, then a city that would otherwise be 1,000 acres could increase to 1,100. However, this tends to be inappropriate for two reasons. First, many jurisdictions cannot expand due to physical or political barriers. In such as case, each acre used for roads represents one less acre available for other purposes.

Figure 5.7.3-4 **Relationship Between Vehicle Travel and Road Provision**[20]



As per-capita vehicle travel increases, so too must the amount of land devoted to roads.

The second reason is that cities provide agglomeration economies.[21] Land value tends to increase with development density because it provides more accessibility to desirable activities, so urban land is generally worth more than rural land. Expanding cities outward to replace land used for roads reduces this value. The opportunity cost of land used for roadway rights-of-way is therefore somewhere between that of adjacent parcels and urban periphery land. It is sometimes argued that not all roadway costs should be charged to motorists. Even residents who never drive use roads for walking, bicycling, public transit, deliveries and utility lines. This can be addressed by defining *Basic Access* road supply that is unrelated to driving. This is the roadway capacity required to meet the needs of people who never travel by automobile. The costs of providing this basic road network can be charged to all residents, while incremental capacity beyond this can be charged to vehicle users who require additional road space ("users" includes consumers of products delivered by vehicles, with roadway costs included in delivery charges).

[20] Peter Newman and Jeffrey Kenworthy (1989), *Cities and Automobile Dependence*, Gower (www.ashgate.com).
[21] Jean Jaskold Gabszewicz, et al (1986), *Location Theory*, Harwood (www.taylorandfrancisgroup.com).

As discussed in Chapter 5.6, basic access usually requires just one or two lanes, which is what consumers typically choose when paying for a driveway, and typically provided in pedestrian areas such as campuses. Roadway capacity beyond this can be allocated to vehicle users. Even special pedestrian and bicycle facilities can be considered costs of driving if motor vehicle traffic is incompatible with these modes, creating the need for separate facilities; pedestrians and cyclists often use street space rather than sidewalks or paths in areas with minimal motor vehicle traffic. This implies that two-thirds to three-quarters of urban roadway land requirements can be charged to motor vehicle users.

Transport Land Costs Tend To Increase With Wealth and Urbanization
With increased wealth and urbanization, land value becomes an increasingly important component of total transport costs. Traffic and parking congestion problems tend to increase with wealth because consumers purchase more vehicles, which greatly increases the amount of space needed for travel (a car trip typically requires an order of magnitude more space than the same trip made by walking, cycling or transit). Although increased wealth allows greater facility construction expenditures, the supply of land does not increase. Road and parking facilities must compete for land that is increasingly expensive due to demand by other uses, so land costs become an increasing portion of project costs and a limiting factor in roadway and parking capacity expansion. Although sprawl may seem to overcome this problem by shifting travel to the urban fringe where land costs are lower, dispersed development increases per-capita vehicle mileage, requiring more lane-miles and parking spaces per capita, so land costs continue to be a major constraint. As a result, traffic and parking congestion problems tend to increase, and alternative modes and demand management tend to become more important with increased wealth and urbanization.

5.7.4 Estimates

All values are in U.S. dollars unless otherwise indicated.

Land Value Studies Summary Table

Table 5.7.4-1 **Land Value Studies Summary Table – Selected Studies**

Publication	Costs	Cost Value	2007 USD
Delucchi (1998)	Total US roadways	$218 billion (1991)	$331
	Annual value	$17 billion	$26
	Per vehicle mile	$0.008	$0.012
KPMG (1993)	Per vehicle Km.	$0.047 Canadian/km*	$0.052
	Per vehicle mile		$0.084
Lee (1995)	Total US per year	$75 billion*	$102
	Per vehicle mile	$0.034	$0.046
TeleCommUnity (2002)	Total US roadways	$4,676 billion - $10.9 trillion	$5,377 billion to $13 trillion
	Annual value	$305 to $366 billion	$351 to $421 billion
Woudsma, Litman, and Weisbrod (2006)	Urban land value - Canada	$100 to $200 per square meter (2000 Can $)	$81 to 162 per square meter
	Rural land value - Canada	$0.40 to $0.60 per square meter	$0.32 to $0.48 per square meter

More detailed descriptions of these studies are found below, along with summaries of other studies. 2007 Values have been adjusted for inflation by Consumer Price Index[22]*. * Indicates that the currency year is assumed to be the same as the publication year.*

Monetary Estimates

- Levinson estimates that roadway land value (the rents required to pay roadway land opportunity costs) average $1.45 per vehicle-trip or $529.25 per vehicle-year.[23]

- Delucchi estimates that roadway land value (roadbed and shoulder area) totaled $218 billion in 1991 ($331 in 2007 dollars), as indicated in Table 5.7.4-2. This represents an annualized value of $17.5 billion (using an 8% discount rate), or 0.8¢ per vehicle-mile (1.2¢ per vehicle-mile in 2007 dollars). In a subsequent study, Delucchi and Murphy calculate that the property tax forgone on the additional amount of roadway land needed to accommodate automobile travel has an annualized value of $6-24 billion in the U.S.[24]

[22] Note that CPI is not the only way to adjust for inflation and results can vary significantly with different methods, see: Samuel H. Williamson (2008), "Six Ways to Compute the Relative Value of a U.S. Dollar Amount, 1790 to Present," MeasuringWorth (www.measuringworth.com).

[23] David Levinson (2018), *Road Rent – On The Opportunity Cost Of Land Used For Roads*, Transportist (https://transportist.org); at https://transportist.org/2018/06/21/road-rent-on-the-opportunity-cost-of-land-used-for-roads.

[24] Mark A. Delucchi and James J. Murphy (2008), "How Large Are Tax Subsidies To Motor-Vehicle Users in the US?" *Transport Policy*, Vol. 15/3, pp. 196 – 208; at http://pubs.its.ucdavis.edu/publication_detail.php?id=1170.

Table 5.7.4-2 **Estimated U.S. Roadway Land Value in 1991**[25]

	Road Area (mi²)		Extra ROW Factor		Price of Land ($/acre)		Value of Land (1991$10⁹)		Totals
Urban	**P**	**UP**	**P**	**UP**	**P**	**UP**	**P**	**UP**	**P & UP**
Interstate Freeway	231	0	1.2	1.2	$50,000	$35,000	$7.4	$0.0	$7.4
Other Freeway	124	0	1.2	1.2	$50,000	$35,000	$3.9	$0.0	$3.9
Principal Arterial	532	0	1.2	1.2	$50,000	$35,000	$17.0	$0.0	$17.0
Minor Arterial	546	3	1.2	1.2	$55,000	$38,500	$19.2	$0.1	$19.3
Collector	458	5	1.2	1.2	$65,000	$45,500	$19.1	$0.1	$19.2
Local Road	2,573	179	1.2	1.2	$70,000	$49,000	$115.3	$5.6	$120.9
Subtotal Urban	*4,463*	*187*	*Na*	*na*	*na*	*na*	*$181.9*	*$5.8*	*$187.7*
Rural	**P**	**UP**	**P**	**UP**	**P**	**UP**	**P**	**UP**	
Interstate Freeway	533	0	1.25	1.25	$5,000	$600	$1.7	$0.0	$1.7
Other Freeway	971	0	1.25	1.25	$5,000	$600	$3.1	$0.0	$3.1
Principal Arterial	1,058	0	1.25	1.25	$5,000	$600	$3.4	$0.0	$3.4
Minor Arterial	2,355	292	1.25	1.25	$5,000	$600	$7.5	$0.1	$7.6
Collector	932	464	1.25	1.25	$5,000	$600	$3.0	$0.2	$3.2
Local Road	2,865	5,674	1.25	1.25	$5,000	$600	$9.2	$2.2	$11.4
Subtotal Rural	*8,715*	*6,430*	Na	na	na	na	*$27.9*	*$2.5*	*$30.4*
Urban + Rural	***13,178***	***6,617***	***na***	***na***	***na***	***Na***	***$209.8***	***$8.3***	***$218.1***

P = Paved, UP = Unpaved, Na = not applicable

- The accounting firm KPMG calculated the value of road land dedicated to motor vehicle use in the Vancouver area to be worth $578 million a year when amortized at 10%, averaging 4.7¢ Canadian per vehicle km.[26]

- Lee applies FHWA prototypical land acquisition costs per mile to estimate total U.S. road system land value and calculate annual interest forgone to be $75 billion ($102 billion in 2007 dollars), or 3.4¢ per VMT (4.6¢ per VMT in 2007 dollars).[27]

- The New Zealand Ministry of Transport estimates the annualized value of "recoverable" road system capital assets (i.e., the value of land and related property) at NZ$750 million (with a range of $300 million to $980 million), which is about the same as total annual roadway maintenance expenditures, and the value of "non-recoverable" assets (i.e., sunk costs associated with building roads is estimated at $1,860 million).[28]

[25] Mark Delucchi (1998), "Motor Vehicle Infrastructure and Services Provided by the Public Sector," *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991*, Vol. 7, Institute of Transportation Studies (http://engineering.ucdavis.edu), UCD-ITS-RR-96-3 (7).
[26] KPMG (1993), *Cost of Transporting People in the British Columbia Lower Mainland*, Greater Vancouver Regional District (www.metrovancouver.org), p. 27.
[27] Douglas Lee (1995), *Full Cost Pricing of Highways*, Volpe National Transportation Systems Center (www.volpe.dot.gov), p. 11.
[28] Booz Allen Hamilton (2005), *Surface Transport Costs and Charges Study*, Ministry of Transportation New Zealand (www.transport.govt.nz), March 2005.

- Researcher Kerry Wood calculated that standard return on capital required for New Zealand's roadway investments (value of land and facilities) would be US$1,155 million, 1.4 times current annual roadway expenditures.[29]

- TeleCommUnity (2002) estimated that U.S. roadway rights-of-way total 22,437 square miles, with a value of $3,565 billion, or up to $10.9 trillion using a *comparable transaction valuation* methodology.[30] They estimate that the entire roadway system has a present value of $4,676 billion, of which $3,565 billion (76%) is land value and $1,110 billion (24%) is for improvements. Using a different valuation methodology they estimate that entire value of the nation's rights of way for a single year produces annual rental value ranging between $305 and $366 billion. They comment, "…the cost of acquiring a right-of-way corridor necessarily is more expensive than simply the ATF (Across the Fence) value of the abutting land. Applying the lowest corridor enhancement factor now employed by appraisers suggests the value is $7.1 Trillion. These results are consistent and conservative when measured against comparable transactions reported by federal government agencies."

- Woudsma, Litman, and Weisbrod developed practical methods for quantifying the values of land used for transport facilities, including roads, railroads, ports and airports.[31] They use property value data to calculate the average value of land in various geographic zones, with separate techniques for urban and rural conditions to reflect differences in land use markets and data availability. The results indicate that urban land values typically range from $100 to $200 per square meter, and rural land values typically range from $0.40 to $0.60 per square meter (2000 Canadian dollars).

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[29] Kerry Wood (1997),"New Zealand's Land Transport Pricing Study," *Streets for People*, No. 4, March, p. 8.
[30] TeleCommUnity (2002), *Valuation Of The Public Rights-Of-Way Asset*, TeleCommUnity (www.telecommunityalliance.org); at www.telecommunityalliance.org/images/valuation2002.pdf
[31] Clarence Woudsma, Todd Litman, and Glen Weisbrod (2006), *A Report On The Estimation Of Unit Values Of Land Occupied By Transportation Infrastructures In Canada*, Transport Canada (www.tc.gc.ca); at www.vtpi.org\TC_landvalue.pdf.

Area Estimates

- The U.S. Department of Agriculture's maintains a database of land uses in the U.S. Table 5.7.4-3 indicates trends in transportation land use.

Table 5.7.4-3 **Transportation Land Use in the United States** (Million Acres)[32]

	1959	1964	1969	1974	1978	1982	1987	1992	1997	2002
Roadways	20.2	21.2	21.0	21.2	21.5	21.5	21.2	21.0	21.0	21.8
Railroads	3.4	3.3	3.2	3.1	3.0	3.0	2.3	2.0	1.9	3.1
Airports	1.4	1.5	1.8	2.0	2.2	2.3	2.2	2.2	2.5	2.4

- Meyer and Gomez-Ibanez estimated the portion of land devoted to public streets in various U.S. cities during the 1970s. Their analysis indicates that denser cities devote a larger *portion* of land to streets, but less *per capita*, as summarized in Table 5.7.4-4.

Table 5.7.4-4 **Portion of Land Devoted to Streets In 1960s**[33]

	Persons/Sq. Mi.	Portion of Land Devoted to Streets	Square Feet Of Street Per Capita
New York	24,697	30%	345
Newark, N.J.	17,170	16%	257
San Francisco	16,559	26%	441
Chicago	15,836	24%	424
Philadelphia	15,743	19%	365
St. Louis	12,196	25%	609
Pittsburgh	11,171	18%	455
Cleveland	10,789	17%	416
Miami	8,529	24%	778
Milwaukee	8,137	20%	724
Cincinnati	6,501	13%	573
Los Angeles	5,451	14%	741
Atlanta	3,802	15%	1,120
Houston	2,860	13%	1,585
Dallas	2,428	13%	1,575

Increased urban density increases the portion of land devoted to streets, but reduces per capita street area. Manville and Shoup (2005) find the same relationship exists in 2000.

[32] Ruben N. Lubowski, et al. (2006), *Major Uses of Land in the United States, 2002*, Economic Information Bulletin No. EIB-14, U.S. Department of Agriculture (www.ers.usda.gov), May 2006; at www.ers.usda.gov/publications/eib14

[33] John Meyer and J. Gomez-Ibanez (1983), *Autos, Transit and Cities*, Harvard University Press (www.hup.harvard.edu), cited in Manville and Shoup (2005).

- Émile Quinet provides a European estimate of the relative land use area of different modes shown in Table 5.7.4-5.[34] This indicates that automobiles require approximately 4 times the road space as a bicycle or motorcycle, and 10 to 40 times that of buses.[35]

Table 5.7.4-5 **Land Use Requirements by Mode** (m2 per hour)

Mode	Use	Parking	Traffic	Total
Bicycles and Motorcycles	Work (9 hours)	13.5	7.5	21
"	Leisure (3 hours)	4.5	7.5	12
"	Shopping (1.5 hours)	2.5	7.5	10
Automobiles (1.33 passengers)	Work (9 hours)	68	17	85
"	Leisure (3 hours)	23	17	40
"	Shopping (1.5 hours)	11	17	28
Bus (daily average: 20 pass.)	Normal Roads	0	7.5	7.5
"	Bus Lane	0	30	30
Bus (peak period: 80 pass.)	Normal Roads	0	2	2
"	Bus Lane	0	7.5	7.5

- The European Environmental Agency estimates that transport infrastructure covers 1.2 % of the total available land area in the EU.[36] The road network (motorways, state, provincial and municipal roads) occupies 93% of the total area of land used for transport, rail uses about 4%, airports (including military airports) and canals each occupy about 1%. Land-take efficiency (the ratio between land used and the infrastructure's traffic carrying capacity) varies from one infrastructure type to another. For example, land take per passenger-km by rail is about 3.5 times lower than for passenger cars.

Table 5.7.4-6 **Land Use Requirements by Mode** (Hectares Per Km of Route)

Infrastructure Type	Direct Land Consumption	Indirect Land Consumption
Motorway	2.5	7.5
State Road	2.0	6.0
Provincial Road	1.5	4.5
Municipal Road	0.7	2.0
Rail	1.0	3.0
Canal	5	10
Airport		Airports

34 Émile Quinet (1994), "The Social Costs of Transport: Evaluation and Links With Internalization Policies," in *Internalising the Social Costs of Transport*, OECD (www.oecd.org), p. 55.
35 This appears to underestimate U.S. conditions where motorcycles normally take a full lane, and overstates bicycle road space needs.
36 TERM (2000), "Land Take," *Are We Moving In The Right Direction? Indicators On Transport And Environmental Integration In The EU*, TERM 2000, European Environmental Agency (www.eea.europa.eu); at http://reports.eea.eu.int/ENVISSUENo12/en/page011.html

- van Essen, et al, describe various method that can be used to calculate the value of land devoted to transport infrastructure.[37] The table below summarizes estimates of the amount of land devoted to transport infrastructure in the Netherlands.

Table 5.7.4-7 **Transport Infrastructure Land Use in The Netherlands** (Square Kms)

		Components	Urban	Rural	Allocation
Roads	Direct	Roadways	360	748	Full/partial
		Parking space	119.1	n.a.	Full
		Service areas	n.a.	15.8	Full
		Cycle lanes	25.3	40.3	Partial
	Indirect	Risk contour	2.1	18.9	None
		Noise contour	65	335	Partial
Railroads	Direct	Track & other Infrastructure	18.6	55.9	Full
	Indirect	Risk contour	4.1	n.a.	None
		Noise contour	50	100	Partial
Inland shipping		Harbours & anchorages	21.8	n.a.	Partial
	Indirect	Sight zones	15.7	154.6	Partial

5.7.5 Variability

Road land costs are based on vehicle use (which creates demand for roads) and varies depending on location, with higher land market values in urban areas, and higher non-market values in areas with high environmental worth.

5.7.6 Equity and Efficiency Issues

Since roadway land is usually considered a sunk cost and users pay no rent or taxes on it, roadway land value can be considered an external cost. Put differently, public land devoted to road rights-of-way is a public resource that benefits people in proportion to their motor vehicle travel. To the degree that this benefits some people at the expense of others (for example, people who prefer less land for roads and more for schools, houses or parks), it can be considered unfair. To the degree it makes vehicle use more affordable, it can be considered progressive (vertically equitable), although since vehicle use tends to increase with income, this benefit is regressively distributed overall. To the degree that this increases the amount of land devoted to driving, or increases total vehicle travel beyond what is economically optimal, it is economically inefficient.

[37] van Essen, et al (2004), *Marginal Costs of Infrastructure Use – Towards a Simplified Approach*, CE Delft; results published in Vermeulen, et al (2004), *The Price of Transport*, CE Delft (www.ce.nl).

5.7.7 Conclusions

Land used for roads is a valuable resource with an opportunity cost. To allocate this cost to vehicles it is appropriate to first subtract the portion of the road system that provides basic access, which typically represents about 25% of paved road area and a smaller portion of road rights-of-way. The remaining 75%+ is charged based on vehicle travel. Although large vehicles require more road space under congested conditions, this is not considered significant for the total amount of land allocated to road right-of-way.

Inflation adjusted land value estimates from Table 5.7.4-1 range from $0.012 per vehicle mile (Delucchi 1998) to $0.084 (KPMG 1993). Douglass Lee's (1995) value of $0.046 is very close to the mid-range of these values, and is used as the starting point. Subtracting 25% of this cost for basic access leaves $0.036 per mile, which is applied to all motor vehicles. Although urban land values are higher, urban roads receive greater use per lane mile, so average costs per vehicle mile are considered to be comparable for both urban and rural travel. Bicycling and walking are estimated to require 5% of an average automobile's road space (walking is not considered to increase road requirements in rural areas), while rideshare passengers and telework require none.

Table 4.7.7-1 **Roadway Land Value Costs (2007 U.S. Dollars per Vehicle Mile)**

Vehicle Class	Urban Peak	Urban Off-Peak	Rural	Average
Average Car	0.034	0.034	0.034	0.034
Compact Car	0.034	0.034	0.034	0.034
Electric Car	0.034	0.034	0.034	0.034
Van/Light Truck	0.034	0.034	0.034	0.034
Rideshare Passenger	0.000	0.000	0.000	0.000
Diesel Bus	0.034	0.034	0.034	0.034
Electric Bus/Trolley	0.034	0.034	0.034	0.034
Motorcycle	0.034	0.034	0.034	0.034
Bicycle	0.002	0.002	0.002	0.002
Walk	0.002	0.002	0.002	0.002
Telework	0.000	0.000	0.000	0.000

Automobile Cost Range

The range is based on inflation adjusted values discussed in detail in section 5.7.4 above, in particular $0.012 per mile (Delucci 1998) and $0.084 (KPMG 1993).

Minimum	Maximum
$0.01	$0.08

5.7.8 Information Resources

Resources listed below provide information on transportation land evaluation.

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.

Booz Allen Hamilton (2005), *Surface Transport Costs and Charges Study*, Ministry of Transportation New Zealand (www.transport.govt.nz); at https://bit.ly/2FtelkI.

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.

EEA (2006), *Land Accounts for Europe 1990-2000*, European Environment Agency (www.eea.europa.eu); at http://reports.eea.europa.eu/eea_report_2006_11.

Ronald Hirshhorn (2003), *Concepts and Practical Values of Land Costs and Capital Charges for a "Full-Cost Accounting" of Transport Infrastructure in Canada*, Transport Canada Policy Group (www.tc.gc.ca); at www.tc.gc.ca/pol/en/aca/fci/transmodal/menu.htm.

Ben Janke, John S. Gulliver and Bruce N. Wilson (2011), *Development of Techniques to Quantify Effective Impervious Cover*, Center for Transportation Studies, University of Minnesota (www.cts.umn.edu); at www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=2058.

Artem Korzhenevych, et al. (2014), *Update of the Handbook on External Costs of Transport*, CE Delft, for the European Commission DG TREN; at https://bit.ly/2zC02Xk. Provides estimates of various external costs.

David Levinson (2018), *Road Rent – On The Opportunity Cost Of Land Used For Roads*, Transportist (https://transportist.org); at https://bit.ly/2HzQ2Ua.

Todd Litman (2006), *Evaluating Transportation Land Use Impacts*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/landuse.pdf.

Todd Litman (2005), *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 (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); at www.vtpi.org/EP_Pav.pdf.

Todd Litman (2018), *Pavement Busters Guide*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/pavbust.pdf.

Ruben N. Lubowski, et al. (2006), *Major Uses of Land in the United States, 2002*, Economic Information Bulletin EIB-14, USDA (www.ers.usda.gov); at www.ers.usda.gov/publications/eib14.

Michael Manville and Donald Shoup (2005), "People, Parking, and Cities," *Journal Of Urban Planning And Development*, American Society of Civil Engineers (www.asce.org), 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.

Christopher McCahill and Norman Garrick (2012), "Automobile Use And Land Consumption: Empirical Evidence From 12 Cities," *Urban Design International*, Vol. 17, Autumn, pp. 221-227 (doi:10.1057/udi.2012.12); summarized in "Cars and Robust Cities Are Fundamentally Incompatible," *The Atlantic Cities*, www.theatlanticcities.com/commute/2013/02/cars-and-robust-cities-are-fundamentally-incompatible/4651.

TERM (2000), "Land Take," *Are We Moving In The Right Direction? Indicators On Transport And Environmental Integration In The EU*, TERM 2000, European Environmental Agency (www.eea.europa.eu); at http://reports.eea.eu.int/ENVISSUENo12/en/page011.html.

Clarence Woudsma, Todd Litman, and Glen Weisbrod (2006), *A Report On The Estimation Of Unit Values Of Land Occupied By Transportation Infrastructures In Canada*, Transport Canada (www.tc.gc.ca); at www.vtpi.org\TC_landvalue.pdf.