Land Use Impacts on Transport

How Land Use Patterns Affect Travel Behavior

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TDM Encyclopedia

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This chapter describes how land use factors affect travel behavior. These factors include density, mix, roadway connectivity, parking facility management, and site design. This information is useful for evaluating how land use management strategies such as Smart Growth, New Urbanism and Access Management can help achieve transport planning objectives. For more information see the report "Land Use Impacts On Travel Behavior" at www.vtpi.org/landtravel.pdf.

Introduction

Land Use (also called *Land Development*, *Spatial Development*, *Community Design*, *Urban Design*, *Cityscape* or *The Built Environment*) refers to various land use factors, such as density, mix, connectivity and the quality of the pedestrian environment, as summarized in Table 1.

Table 1 **Land Use Factors** (CARB 2010-2011; Litman 2007; Sadek et al. 2011)

Factor	Definition
Density	People or jobs per hectare.
Regional Accessibility	A site's location relative to the regional urban center, and the number of jobs and public services available within a given travel time
Centeredness	Degree to which commercial and other public activities are located in downtowns and other activity centers.
Land Use Mix	Degree to which residential, commercial and institutional land uses are located close together.
Connectivity	Degree to which roads and paths are connected and allow direct travel between destinations.
Roadway Design	Scale and design of streets, and how various uses are managed. *Traffic calming* refers to street design features intended to reduce traffic speeds and volumes.
Walking & Cycling Conditions	Quality of walking and cycling transport conditions. (*Active transport* is a general term for walking, cycling, and their variants).
Transit Accessibility	Degree to which destinations are accessible by quality public transit.
Parking Management	Number of parking spaces per building unit or hectare. Parking management includes pricing and regulations
Site Design	
Transportation Demand Management	Various strategies and programs that encourage more efficient travel patterns, often implemented as an alternative to road and parking facility expansion, and in conjunction with land use policy reforms.

This table describes various land use factors that can affect travel behavior and population health.

These factors affect travel behavior by affecting the distances that need to be traveled between destinations, and the relative efficiency of different modes. Some TDM strategies change land use patterns directly (Smart Growth, Access Management, Transit-Oriented Development, Location-Efficient Development, Road Space Reallocation, Parking Management, Downtowns, Roadway Connectivity), and most TDM strategies affect land use indirectly through impacts on travel behavior. This chapter examines how land use factors affect travel behavior and therefore the effectiveness of land use planning strategies to achieve TDM objectives.

Land Use Factors That Affect Travel

This section describes how different land use factors affect travel patterns.

Density and Clustering

Density refers to the number of people or jobs in a given area (Campoli and MacLean, 2002). *Clustering* refers to related activities located close together, often in Commercial Centers. Density and clustering can be measured at various scales: regional, county level, municipal jurisdiction, neighborhood, census tract, city block or individual campuses and buildings. Density and clustering affect travel patterns through the following mechanisms:

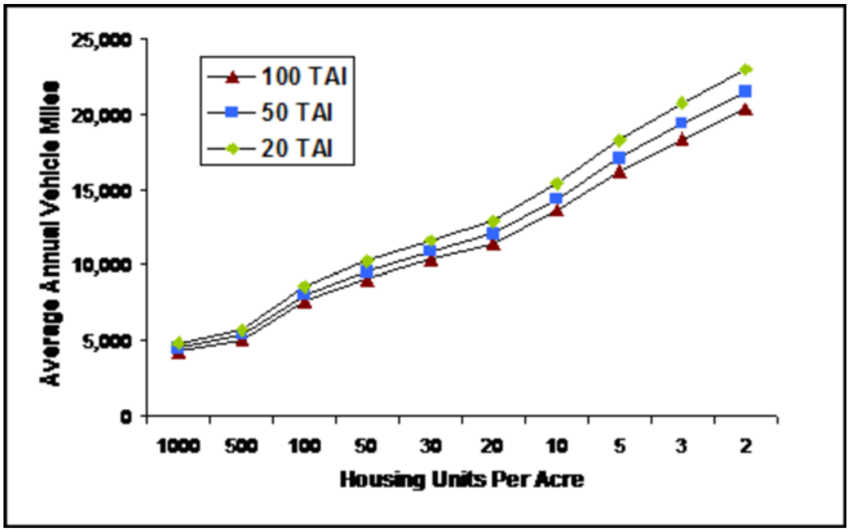
- *Land Use Accessibility.* The number of potential destinations located within a geographic area tends to increase with population and employment density, reducing travel distances and the need for automobile travel. For example, in low-density areas a school may serve hundreds of square miles, requiring most students to travel by motor vehicle. In higher density areas, schools may serve just a few square miles, reducing average travel distances and allowing more students to walk or cycle. Similarly, average travel distances for errands, commuting and business-to-business transactions can decline with density.

- *Transportation Diversity.* Increased density tends to increase the number of transportation options available in an area due to economies of scale. Higher density areas tend to have better sidewalks, bicycle facilities and transit service because increased demand makes them more cost effective.

- *Reduced Automobile Accessibility.* Increased density tends to reduce traffic speeds, increase traffic congestion and reduce parking supply, making driving relatively less attractive than alternative modes.

As a result of these factors, increased density and clustering tend to reduce per capita automobile ownership and use, and increase use of alternative modes (Ewing, Pendall and Chen, 2002; Kuzmyak and Pratt, 2003; TRL, 2004; Turcotte, 2008; TRB 2009). Bento, et al (2004) conclude that residents reduce their automobile travel by about 25% if they shift from a dispersed, automobile-dependent city such as Atlanta to a more centralized city, multi-modal city such as Boston, holding other economic and demographic factors constant. Lui (2003) finds that higher density infill development can reduce per capita vehicle travel by up to 27% compared with conventional residential development.

Figure 1 **Annual VMT Per Household** (Holtzclaw 1994)



This figure illustrates how density and transit accessibility affect household vehicle mileage. The Transit Accessibility Index (TAI) indicates daily transit service nearby.

Holtzclaw (1994) and Holtzclaw, et al (2002) find that average vehicle ownership, vehicle travel, and vehicle expenditure per household decline with increasing residential densities and proximity to public transit, holding constant other demographic factors such as household size and income. The *This View of Density Calculator* (www.sflcv.org/density) uses this model to predict the effects of different land use patterns on travel behavior. For example, a reduction from 20 to 5 dwelling units per acre (i.e., urban to suburban densities) increases average vehicle travel and automobile expenditures by about 40%.

Density at both origins and destinations affect travel behavior. One study found that increasing urban residential population density to 40 people per acre increased transit use from about 2% to 7%, while increasing densities in Commercial Centers to 100 employees per acre resulted in an additional 4% increase in transit use, to an 11% total mode share (Frank and Pivo, 1995). Both work trips and shopping trips are affected by population and employment densities.

Some of the differences in travel behavior between higher and lower density land use patterns may result from demographic *sorting* (also called *self-selection*). People who cannot drive are more likely to choose homes in older, higher-density urban neighborhoods, and some of these neighborhoods have low average household incomes, which also tends to reduce per capita vehicle travel. However, studies that account for demographic factors find that virtually all groups that live in higher density areas reduce their average annual vehicle mileage (Cambridge Systematics, 1994; Holtzclaw, 1994; Cao, Mokhtarian and Handy 2008; Cervero 2007).

Regional Accessibility

Regional accessibility refers to an individual site's location relative to the regional urban center (either a central city or a central business district [CBD]), or other major employment centers, and the portion of residents, employment and activities located close to that center (Kuzmyak and Pratt, 2003; Ewing, 1995).

Although regional accessibility tends to have little effect on total trip generation (the total number of trips people make), it tends to have a major effect on trip length and therefore per capita vehicle travel. People who live and work several miles from a city tend to drive significantly more annual miles than if located in the same type of development closer to the urban center. Kockelman (1997) found that accessibility (measured as the number of jobs within a 30-minute travel distance) was one of the strongest predictors of household vehicle travel, stronger than land use density.

Travel time maps use *isochrones* (lines of constant time) to indicate the time needed to travel from a particular origin to other areas (Lightfoot and Steinberg, 2006). For example, areas within one hour may be colored a dark red, within two hours a lighter red, within three hours a dark orange, and within four hours a light orange. Maps can indicate and compare travel times by different modes. For example, one set of maps could show travel times for automobile travel and another for public transit travel. Travel time maps are an indication of accessibility.

Centeredness

Centeredness refers to the portion of employment, commercial, entertainment, and other major activities concentrated in multi-modal Centers, such as central business districts (CBDs), downtowns and large industrial parks. Such centers reduce the amount of travel required between destinations and are more amenable to alternative modes, particularly public transit. People who work in major multi-modal activity centers tend to commute by transit significantly more than those who work in more dispersed locations, and they tend to drive less for errands. Centeredness affects overall regional travel, not just the trips made to the center. For example, Los Angeles is one of the densest cities in North America, but it lacks strong centers, and so is relatively automobile dependent, with higher rates of vehicle ownership and use than cities such as Chicago, which have similar density but stronger centers (Ewing, Pendall and Chen, 2002).

Land Use Mix

Land Use Mix refers to locating different types of land uses (residential, commercial, institutional, recreational, etc.) close together. This can occur at various scales, including mixing within a building (such as ground-floor retail, with offices and residential above), along a street, and within a neighborhood. It can also include mixing housing types, so an area contains a variety of demographic and income classes. Such mixing is normal in cities and is a key feature of New Urbanism.

Increased land use mix tends to reduce the distances that residents must travel for errands and allows more use of walking and cycling for such trips. It can reduce commute distances (some residents may obtain jobs in nearby businesses), and employees who work in a mixed-use commercial area are more likely to commute by alternative modes (Modarres, 1993; Kuzmyak and Pratt, 2003). Certain combinations of land use are particularly effective at reducing travel, such as incorporating schools, stores, parks and other commonly-used services within residential neighborhoods and employment centers. This creates *urban villages*, which are walkable centers and small neighborhoods that contain the services and activities people most often need. The table below summarizes the results of one study concerning how various land use features affected drive-alone commute rates. Important amenities include bank machines, cafes, on-site childcare, fitness facilities, and postal services.

Table 2 **Drive Alone Share At Worksites Based on Land Use Characteristics** (Cambridge Systematics, 1994, Table 3.12)

Land Use Characteristics	Without	With	Difference
Mix of Land Uses	71.7	70.8	*-0.9*
Accessibility to Services	72.1	70.5	*-1.6*
Preponderance of Convenient Services	72.4	69.6	*-2.8*
Perception of Safety	73.2	70.6	*-2.6*
Aesthetic Urban Setting	72.3	66.6	*-5.7*

Jobs/Housing Balance refers to the ratio of residents and jobs in an area. Research indicates that a jobs/housing balance of about 1.0 tends to reduce average commute distance and per capita vehicle travel (Weitz, 2003; Kuzmyak and Pratt, 2003). In some situations, suburban dispersion of employment can reduce average commute distance, although it tends to increase total per-capita vehicle travel. Crane and Chatman (2003) find that a five percent increase in the amount of employment in a metropolitan area's outlying counties will lead to a 1.5 percent reduction in the average commute distance, with significant differences by industry. The suburbanization of construction, wholesale, and service employment is associated with shorter commutes, while manufacturing and finance deconcentration (weakly) explain longer commutes. However, this may be offset by increased non-work vehicle mileage.

Connectivity

Connectivity refers to the degree to which a road or path system is connected, and therefore the directness of travel between destinations ("Connectivity," VTPI, 2005). A hierarchical road network with many dead-end streets that connect to a few major arterials provides less accessibility than a well-connected network. Increased connectivity reduces vehicle travel by reducing travel distances between destinations and by improving walking and cycling access, particularly where paths provide shortcuts, so walking and cycling are relatively direct.

Connectivity can be evaluated using various indices (Handy, Paterson and Butler, 2004; Dill, 2005). This can be measured separately for pedestrian, bicycle and motor vehicle travel, taking into account shortcuts for nonmotorized modes. The Smart Growth Index (USEPA, 2002) describes a methodology for calculating the effects of increased roadway connectivity on vehicle trips and mileage.

Roadway Design

Roadway design can affect travel behavior in several ways. A Connected road network provides better Accessibility than a conventional hierarchical road network with a large portion of dead-end streets (Handy, Paterson and Butler, 2004). Increased connectivity can reduce vehicle travel by reducing travel distances between destinations and by improving Walking and Cycling conditions, particularly where paths provide shortcuts, so walking and cycling are relatively direct (Dill, 2005).

A USEPA study (2004) found that regardless of population density, transportation system design features such as greater street connectivity, a more pedestrian-friendly environment, shorter route options, and more extensive transit service have a positive impact on urban transportation system performance, (per-capita vehicle travel, congestion delays, traffic accidents and pollution emissions), while roadway supply (lane-miles per capita) had no measurable effect. The Smart Growth Index (USEPA, 2002) describes a methodology for calculating the effects of increased roadway connectivity on vehicle trips and vehicle travel.

Traffic Calming, Streetscaping and Walking and Cycling Improvements can also affect travel behavior. Cervero and Kockelman (1997) find that residents of neighborhoods with connected street networks and limited commercial parking rely more on alternative modes for non-work trips and drive significantly less than residents of conventional suburban neighborhoods. Residents in a pedestrian friendly community walked, bicycled, or rode transit for 49% of work trips and 15% of their non-work trips, 18- and 11-percentage points more than residents of a comparable automobile oriented community (Cervero and Radisch 1995). Another study found that walking is three times more common in a community with pedestrian friendly streets than in otherwise comparable communities that are less conducive to foot travel (Moudon, *et al*, 1996).

Parking Management

Parking Management refers to the supply, price and regulation of parking facilities. How parking is managed can significantly affect travel behavior. As parking becomes more abundant and cheaper, automobile ownership and use increase and destinations become more dispersed, reducing land use Accessibility. Parking supply and pricing have a significant impact on commute mode split (Morrall and Bolger, 1996; Shoup, 1997).

Transit-Oriented Development

Transit Oriented Development (TOD) refers to communities designed to provide convenient access to high-quality transit services. Several studies indicate that TOD can significantly reduce per capita automobile travel (Cervero, et al, 2004; Gard, 2007). This occurs because some trips shift to transit, and because transit stations often serve as a catalyst for more accessible land use, creating higher density, mixed-use, walkable Centers. People who live or work in such areas tend to own fewer cars, drive less and use transit more than in other locations (Cambridge Systematics, 1994). As a result of these various factors, Transit Oriented Development tends to “leverage” much greater reductions in vehicle travel than what is directly shifted from automobile to transit (Litman, 2005). Cervero, et al. (2004) develop a model for predicting the effects of increased residential and commercial density, and improved walkability around a station on transit ridership. For example, increasing residential density near transit stations from 10 to 20 units per gross acre increases transit commute mode split from 20.4% to 24.1%, and up to 27.6% if implemented with pedestrian improvements.

The table below shows trip reduction predictions for travel impacts of development location and design factors used in Portland, Oregon. For example, if development has a FAR (Floor Area Ratio) of 1.0, and is located in a commercial area near an LRT station, vehicle trips are expected to be 5% less than the same development in a typical suburban area.

Table 3 **Trip Reduction of Development Location, Design and Density** (Portland, 1995)

Minimum Floor Area Ratio	Mixed-Use	Commercial Near Bus	Commercial Near LRT Station	Mixed-Use Near Bus	Mixed-Use Near LRT
No minimum	-	1%	2.0%	-	-
0.5	1.9%	1.9%	2.9%	2.7%	3.9%
0.75	2.4%	2.4%	3.7%	3.4%	4.9%
1.0	3.0%	3.0%	5.0%	4.3%	6.7%
1.25	3.6%	3.6%	6.7%	5.1%	8.9%
1.5	4.2%	4.2%	8.9%	6.0%	11.9%
1.75	5.0%	5.0%	11.6%	7.1%	15.5%
2.0	7.0%	7.0%	15.0%	10.0%	20%

Mixed-Use means commercial, restaurants and light industry with 30% or more floor area devoted to residential. Near bus or LRT (Light Rail Transit) means location within ¼-mile of a bus corridor or LRT station. Floor Area Ratio (FAR) = ratio of floor space to land area.

Walking and Cycling Conditions

Walking and Cycling (also called *nonmotorized* or *active* transportation) conditions are affected by the quantity and quality of sidewalks, crosswalks and paths, path system connectivity, the security and attractiveness of pedestrian facilities, and support features such as bike racks and changing facilities. Improved walking and cycling conditions tend to increase nonmotorized travel, increase transit travel, and reduce automobile travel (Mackett and Brown 2011; "Nonmotorized Transport Planning," VTPI, 2005).

Cervero and Radisch (1995) found that residents in a pedestrian friendly community walked, bicycled, or rode transit for 49% of work trips and 15% of their non-work trips, 18- and 11-percentage points more than residents of a comparable automobile oriented community. Another study found that walking is three times more common in a community with pedestrian friendly streets than in otherwise comparable communities that are less conducive to foot travel (Moudon, *et al*, 1996). Handy and Mokhtarian (2005) also found that people tend to walk more in more walkable communities, and that a portion of this walking substitutes for driving.

Research by Buehler, et al. (2011) using comparable travel surveys in Germany and the U.S. in 2001 and 2008 indicates that transport and land use policies can significantly affect walking and cycling activity. Between 2001 and 2008, the proportion of "any walking" was stable in the U.S. (18.5%) but increased in Germany from 36.5% to 42.3%. The proportion of "any cycling" in the U.S. remained at 1.8% but increased in Germany from 12.1% to 14.1%. In 2008, the proportion of "30 minutes of walking and cycling" in Germany was 21.2% and 7.8%, respectively, compared to 7.7% and 1.0% in the U.S. Virtually all demographic groups in Germany walk and cycle much more than their counterparts in the U.S.

Site Design and Building Orientation

Some research indicates that people walk more and drive less in areas with traditional pedestrian-oriented commercial districts where building entrances connect directly to the sidewalk than in areas with automobile-oriented commercial strips where buildings are set back and separated by large parking lots (PBQD, 1994).

Transportation Demand Management

Transportation Demand Management (also called *Mobility Management*) policies and programs, which encourage more efficient travel behavior, can be implemented as an alternative to road and parking facility capacity expansion. TDM affects land use indirectly, by reducing the need to increase road and parking facility capacity, providing incentives to businesses and consumers to favor more accessible, clustered, development with improved transport choices. Mobility management programs, such as Commute Trips Reduction programs, can often reduce affected automobile trips by 10-30% compared with what would otherwise occur. Smart Growth can be considered the land use component of TDM, and TDM can be considered the transportation component of Smart Growth.

Cumulative Impacts

The effects of individual land use factors tend to be cumulative. Areas that contain a combination of land use density, mix, connectivity and walkability tend to have significantly lower overall per capita vehicle ownership and use, and higher use of alternative modes than average (Ewing, Pendall and Chen 2002). Allen and Benfield (2003) found that a suburban New Urbanist neighborhood in Tennessee, with modestly higher density, mix and connectivity, has 25% less per capita VMT than otherwise comparable nearby neighborhoods. Similarly, Khattak and Rodriguez (2005) found that residents of a New Urbanist neighborhood in North Carolina generate 22.1% fewer automobile trips and take three times as many walking trips than residents of an otherwise similar neighborhood, even when controlling for demographic factors and preferences. Daisa and Parker (2010) also find that automobile trip generation rates and mode shares are much lower (typically 25-75%) in urban areas than ITE publication recommendations for both residential and commercial buildings.

Ewing and Cervero (2002) calculate the elasticity of per capita vehicle trips and vehicle travel with respect to various land use factors, as summarized in Table 4. For example, this indicates that doubling neighborhood density reduces per capita automobile travel by 5%. Similarly, doubling land use mix or improving land use design to support alternative modes also reduces per capita automobile travel by 5%.

Table 4 **Typical Elasticities of Travel With Respect to the Built Environment** (Ewing and Cervero 2002)

Factor	Description	Trips	VMT
Local Density	Residents and employees divided by land area.	-0.05	-0.05
Local Diversity (Mix)	Jobs/residential population	-0.03	-0.05
Local Design	Sidewalk completeness/route directness and street network density.	-0.05	-0.03
Regional Accessibility	Distance to other activity centers in the region.	--	-0.20

This table shows the elasticity values of Vehicle Trips and Vehicle Miles Traveled (VMT) with respect to various land use factors.

Vernez Moudon and Stewart (2013) reviewed research on how various land use factors affect travel activity, and the tools available for modeling these imapcts and related outcomes such as vehicle emissions and health co-benefits. Table 5 summarizes their findings.

Table 5 **Typical Elasticities of Travel With Respect to the Built Environment** (Vernez Moudon and Stewart 2013)

Category	Variable	VMT	Walking	Transit
Density	Household/population density	–0.04	0.07	0.07
	Job density	0.00	0.04	0.01
	Commercial Floor Area Ratio (FAR)	n/a	0.07	n/a
Diversity	Land use mix	-0.09	0.15	0.12
	Jobs/housing balance	-0.02	0.19	n/a
	Distance to a store	n/a	0.25	n/a
Design	Intersection/street density	-0.12	0.39	0.23
	Percent 4-way intersections	-0.12	-0.06	0.29
Destination accessibility	Job accessibility by auto	-0.20	n/a	n/a
	Job accessibility by transit	-0.05	n/a	n/a
	Jobs within one mile	n/a	0.15	n/a
	Distance to downtown	– 0.22	n/a	n/a
Distance to Transit	Distance to nearest transit stop	-0.05	0.15	0.29

An extensive body of literature examines how various land use factors affect travel activity.

This suggests that neighborhood design factors (density, diversity and design) can reduce per capita vehicle travel on the order of 10-20%, while regional accessibility factors (i.e., where a neighborhood is located with respect to the urban center) can reduce automobile travel by 20-40%. These values are incorporated into the US Environmental Protection Agency's Smart Growth Index (SGI) Model, that can be used to predict how various types of land use management strategies can help achieve transportation management objectives (www.epa.gov/dced/topics/sgipilot.htm). Even greater reductions are possible if land use changes are reinforced by other TDM strategies.

Tomalty and Haider (2009) evaluated how community design factors (land use density and mix, street connectivity, sidewalk supply, street widths, block lengths, etc.) and a subjective walkability index rating (based on residents' evaluation of various factors) affect walking and biking activity, and health outcomes (hypertension and diabetes) in 16 diverse British Columbia neighborhoods. The analysis reveals a statistically significant association between improved walkability and more walking and cycling activity, lower body mass index (BMI), and lower hypertension. Regression analysis indicates that people living in more walkable neighbourhoods are more likely to walk for at least 10 daily minutes and are less likely to be obese than those living in less walkable areas, regardless of age, income or gender. The study also includes case studies which identified policy changes likely to improve health in specific communities.

Nelson/Nygaard (2005) use the results of various studies to develop a model which predicts the impacts of various Smart Growth and TDM on per capita vehicle trip generation and related emissions, including land use density, mix, transit service, walking and cycling conditions, affordable housing, parking management and pricing, transit service discounts, and other TDM programs. They indicate that significant reductions can be achieved relative to ITE trip generation estimates.

Table 6 summarizes these land use impacts on travel.

Table 6 **Land Use Impacts on Travel** (Litman 2006)

Factor	Definition	Travel Impacts
Density	People or jobs per unit of land area (acre or hectare).	Increased density tends to reduce per capita vehicle travel. Each 10% increase in urban densities typically reduces per capita VMT by 2-3%.
Mix	Degree that related land uses (housing, commercial, institutional) are mixed	Increased land use mix tends to reduce per capita vehicle travel, and increases use of alternative modes, particularly walking for errands. Neighborhoods with good land use mix typically have 5-15% lower vehicle-miles.
Regional Accessibility	Location of development relative to regional urban center.	Improved accessibility reduces per capita vehicle mileage. Residents of more central neighborhoods typically drive 10-30% fewer vehicle-miles than residents of more dispersed, urban fringe locations.
Centeredness	Portion of commercial, employment, and other activities in major activity centers.	Increased centeredness increases use of alternative commute modes. Typically 20-50% of commuters to major commercial centers drive alone, compared with 80-90% of commuters to dispersed locations.
Connectivity	Degree that walkways and roads are connected and allow direct travel between destinations.	Improved roadway connectivity can reduce vehicle mileage, and improved walkway connectivity tends to increase walking and cycling.
Roadway design and management	Scale, design and management of streets.	More multi-modal street design and management increases use of alternative modes. Traffic calming tends to reduce vehicle travel and increase walking and cycling.
Walking and Cycling conditions	Quantity and quality of sidewalks, crosswalks, paths and bike lanes, and the level of pedestrian security.	Improved walking and cycling conditions increases nonmotorized travel and can reduce automobile travel, particularly if implemented with land use mix, transit improvements, and incentives to reduce driving.
Transit quality and accessibility	Quality of transit service and degree to which destinations are transit accessible.	Improved transit service quality increases transit ridership and can reduce automobile trips, particularly for urban commuting.
Parking supply and management	Number of parking spaces per building unit or acre, and how parking is managed.	Reduced parking supply, increased parking pricing and increased application of other parking management strategies can significantly reduce per capita vehicle travel. Cost-recovery parking pricing (charging motorists directly for the cost of providing parking) typically reduces automobile trips by 10-30%.

Site design	The layout and design of buildings and parking facilities.	More multi-modal site design can reduce automobile trips, particularly if implemented with improved transit services.
Mobility Management	Various programs and strategies that encourage more efficient travel patterns.	Mobility management policies and programs can significantly reduce vehicle travel by affected trips. Vehicle travel reductions of 10-30% are common.

This table describes various land use factors that can affect travel behavior and population health.

Modeling Land Use Impacts on Travel Behavior

Several studies have examined the ability of transportation and land use models to predict the effects of land use management strategies on travel behavior (Cambridge Systematics, 1994; Frank and Pivo, 1995; Rosenbaum and Koenig, 1997; USEPA, 2001; Hunt and Brownlee, 2001; OTREC 2009). These studies indicate that land use factors can have significant impacts on travel patterns, but that current transportation models are not accurate at predicting their effects. For example, most travel surveys undercount nonmotorized trips (since they often ignore short trips, travel by children, and walking links of motorized trips), most models use analysis zones that are too large to capture small-scale design features (see discussion in Evaluating Nonmotorized Transport). As a result, the models are unable to predict the full travel impacts of land use management strategies such as Pedestrian and Cycling Improvements.

Current transportation models tend to incorporate relatively little information on many of the land use features that affect travel behavior, such as fine scale analysis of land use mix and pedestrian conditions. The following improvements are needed to allow existing models to evaluate land use management strategies (Rosenbaum and Koenig, 1997):

- Analyze land use at finer spatial resolutions, such as census tracts or block level.
- Determine effects of special land use features, such as pedestrian-friendly environments, mixed-use development, and neighborhood attractiveness.
- Determine relationships between mixed-use development and travel mode selection.
- Improved methods for analyzing trip chaining.
- Improve the way temporal choice (i.e., when people take trips) is incorporated into travel models.

General Conclusions

The following are general conclusions that can be made about the effects of land use patterns on travel behavior.

- Per capita automobile travel tends to decline with increasing population and employment density, particularly if clustered into compact centers.
- Per capita automobile travel tends to decline with increased land use mix, such as when commercial and public services are located within or adjacent to residential areas.
- Per capita automobile travel tends to decline in areas with connected street networks.
- Per capita automobile travel tends to decline in areas with attractive and safe streets that accommodate pedestrian and bicycle travel, and where buildings are connected to sidewalks rather than set back behind parking lots.
- Per capita automobile travel tends to decline in areas with traffic calming and other measures that reduce automobile traffic speeds.
- Larger and higher-density Commercial Centers tend to have lower rates of automobile commuting because they tend to support better travel choices (more transit, ridesharing, better pedestrian facilities, etc.) and amenities such as cafes and shops, although they may increase average commute distances.
- Per capita automobile travel tends to decline with the presence of a strong, competitive transit system, particularly when integrated with supportive land use (high-density development with good pedestrian access within ½-kilometer of transit stations).
- Most land use strategies are mutually supportive, and are more effective if implemented together and in conjunction with

other TDM strategies. Some land use management strategies that improve access could increase rather than reduce total vehicle travel unless implemented with appropriate TDM strategies.

- Land use management can provide additional benefits and costs to society in addition to transportation objectives.

Wit and Humor
A son was sitting at his elderly father's death bed.
"Where do you want to be buried," asked the son, "Forest Lawn or Pleasant Acres?"
The old man looked at his son and replied, "Surprise me!"

Related Chapters and Resources

Smart Growth, New Urbanism, Access Management, Location Efficient Development, Clustering and Transit Oriented Development, Density, Road Space Reallocation, Parking Management, Downtowns, Roadway Connectivity, are specific land use management strategies. Land Use Evaluation describes how transportation decisions affect land use, and the economic, social and environmental impacts that can result. More detailed discussions of this subject is available in the comprehensive report *Land Use Impacts On Travel Behavior* available at www.vtpi.org/landtravel.pdf.

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