Preface

Transportation is arguably the lifeblood of urban existence. Without transportation, activities in cities grind to a halt, but it is also the source of many seemingly intractable urban problems such as congestion, pollution, inequality, and reliance on fossil fuels. This fourth edition of *The Geography of Urban Transportation* sustains the fundamental line of argument that informed the book's previous incarnations: how citizens and policymakers conceptualize a problem informs how they go about studying and analyzing it; analysis, in turn, informs policy formulation, decision making, and ultimately the shape of the urban transportation system itself.

The book encourages students to see the links among problem formulation, research design, analytical approach, and planning decisions. We hope that students can appreciate how the current geography of urban transportation can be understood in large part as the outcome of policy choices, themselves a result of how planners, citizens, business and labor interests, and elected officials have conceptualized problems, envisioned solutions, and taken action. And we hope that understanding will enable students to imagine—and actively work for—new transportation geographies. The book is appropriate for advanced undergraduates and beginning graduate students. It also serves as a comprehensive overview of contemporary urban transportation for the professional community.

WHY THE NEED FOR A FOURTH EDITION?

For many years the urban transportation problem was equated with congestion, and the analytical structure devised to address the problem (the four-stage urban transportation model system) aimed to guide the building of capacity-increasing new infrastructures, most often highways. Growing concerns about air pollution and other environmental damage, mobility problems of those without access to a private vehicle, and the long-term consequences of an urban transport system almost entirely dependent on the private vehicle brought pressure for policy change. The passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991 was the culmination of these forces and symbolized a fundamental change in perspective. The urban transportation problem was no longer conceived of simply as congestion; questions of environmental management, historic preservation, and citizen participation, among others, were placed firmly on the mainstream transportation agenda.

Since the sea change in thinking embodied in ISTEA a quarter century ago, many new technologies, trends, and concerns have emerged and continue to alter the urban transportation landscape. Among these are the growing importance of planning for freight movement, the increased interest in nonmotorized travel modes, the shifts in transportation funding sources, the changes underway related to mobile technologies, and the need to understand the transportation-related ramifications of global climate change. In this fourth edition we retain the overall approach and philosophy of the previous editions while thoroughly updating content in light of these ongoing developments.

ORGANIZATION OF THE BOOK

The fourth edition retains the basic three-part structure of the previous editions: Part I asks how stakeholders have *conceptualized* urban transportation; Part II asks how scholars and planners have gone about *analyzing* urban transportation; and Part III asks how data and analysis might help *expand understanding and resolution* of major policy issues in urban transportation.

The four chapters in Part I set the scene by explaining core concepts, providing overviews of current trends in passenger and freight movements, describing the historical and contemporary role of transportation in urban development, and assessing the impacts of information technologies on travel patterns and urban form. The three chapters in Part II introduce students to the urban transportation planning process and contemporary trends in this process, emphasizing the political context of the planning process and the differences between aggregate and disaggregate approaches in transport analysis and planning. Each of the seven chapters in Part III takes up a pressing policy issue: public transit, land use, finance, environment, energy, equity, and the future. Across all three parts we emphasize the importance of attention to geographic scale and the links among conceptualization, analytical approach, and policymaking.

By design, each of the three parts builds on what's come before. We therefore recommend that instructors adhere to the sequential order of the three parts. Within each part, however, the order of the chapters is flexible, although Chapter 1 is intended as the introductory chapter and Chapter 14 is intended as the concluding chapter.

New to the Fourth Edition

In addition to updated content in every chapter, nine of the 14 chapters have new authors and therefore have completely new content. In Part I, Chapter 2 for the first time focuses on urban freight, and Chapter 4 is an entirely new treatment of telecommunications and travel. Part II departs from previous editions by having an overview chapter of the urban transportation planning process, followed by a chapter on regional transportation planning focused on the urban region. The final chapter in Part II focuses on neighborhood-level analysis. In Part III, new authors present new perspectives on public transportation, environmental impacts, and social and environmental justice. In every chapter authors recognize new technologies, trends, and concerns that were not relevant when the third edition was written.

Pedagogical Features

Edited volumes face the challenge of presenting a single voice. This book provides consistency through its organization in three linked parts. Each chapter is organized to provide an opening overview (including concepts and theories), present evidence and analysis, and close with a discussion of future issues. The first chapter introduces the core concepts to be discussed throughout the book, and the last chapter summarizes the main points of the book while taking a look to the future.

ACKNOWLEDGMENTS

Thanks are due to many. First and foremost, we thank the contributors, whose research, ideas, and insights are the heart of this book. We appreciate the patience and cooperation of the chapter authors as we worked through often many drafts of each chapter in an effort to bring coherence and consistency to a volume with multiple authors. Second, we thank our colleagues and users of the previous edition for providing valuable advice on how the book could be improved. Third, we thank graduate classes at the University of Southern California for providing input on draft versions of the chapters. Finally, we thank the editors at The Guilford Press for persuading us to produce a fourth edition and for their excellent support and assistance in generating the final product.

CHAPTER 1

Introducing Urban Transportation

SUSAN HANSON

Many trace the dawn of the modern civil rights movement in the United States to events on a city bus in Montgomery, Alabama, on December 1, 1955, when Rosa Parks refused an order from a municipal bus driver to give up her seat to a white man. Her arrest and the subsequent Montgomery bus boycott (1955–1959), in which blacks refused to patronize the segregated city bus system, proved the power of collective action and brought Martin Luther King, Jr., to prominence. That the civil rights movement should have been born on a city bus is just one measure of how urban transportation is woven into the fabric of U.S. life.

Can you imagine what life would be like without the ease of movement that we now take for granted? The blizzards that periodically envelop major cities give individuals a fleeting taste of what it is like to be held captive (quite literally) in one's own home (or some other place) for several days. With roads buried under 6 feet of packed snow, you cannot obtain food, earn a living, get medical care for a sick child, or visit friends. As floods and earthquakes occasionally remind us, the collapse of a single bridge or destruction of a small segment of roadway can disrupt the daily lives of tens of thousands of people and hundreds of businesses.

Transportation is vital to urban life around the world; without transport, the food and other goods that come from distant places and sustain life in cities would not appear in city markets. Because cities consist of spatially separated, highly specialized land uses—food stores, law firms, banks, hospitals, libraries, schools, and so on—obtaining necessary goods and services involves travel. Moreover, home and work are in the same location for only a small percentage of the workforce (less than 4% of the U.S. workforce in 2009), so that to earn an income as well as to spend it one must travel.

Although people do sometimes engage in travel entirely for its own sake (as in taking a family bike ride), most urban travel occurs as a by-product of some other, nontravel activity such as work, shopping, or seeing the dentist. In this sense, the demand for urban transportation is referred to as a *derived demand* because it is derived from the need or desire to do something else. A trade-off always exists between doing an activity at home (such as eating a meal or watching a movie) or paying the costs of movement to accomplish that activity somewhere else, such as at a restaurant or a movie theater.

All movement incurs a cost of some sort, which is usually measured in time or money. Some kinds of travel, such as that made by automobile, bus, or train, incur both time and monetary costs; other trips, such as those made on foot, involve an outlay almost exclusively of time. In deciding which mode(s) to use on a given trip (e.g., car or bus), travelers often trade off time against money costs, as the more costly travel modes are usually the faster ones. A trade-off is also involved in the decision to make a trip: the traveler weighs the expected benefits to be gained at the destination against the expected costs of getting there. Each trip represents a triumph of such anticipated benefits over costs, although for the many trips that are made out of habit this intricate weighing of costs and benefits does not occur before each and every trip.

Although transportation studies have emphasized the costs of travel, recent research suggests that for many people daily mobility can also be a source of pleasure and is not simply a hardship to be endured in order to accomplish a necessary activity, like going to work. Some people, for example, actually enjoy the time they spend alone in the car on the commute, saying it's the only time during the day they have to themselves. Contrary to most transportation theory, these people don't seek to minimize the time or distance traveled on the journey to work or other trips (Mokhtarian, Solomon, & Redmond, 2001). In this case, the demand for travel is not entirely "derived" from the demand to accomplish other activities, but something undertaken at least to some extent for its own sake.

This chapter introduces some key concepts in urban transportation and sets the stage for the chapters that follow. In particular, I describe (1) the concepts of accessibility, mobility, equity, and externalities; (2) certain aspects of the urban context within which travel takes place; (3) recent trends in U.S. travel patterns; and (4) the policy context within which transportation analysis and planning in the United States are set. The overall goal of this book is to help you understand the central role of transportation and transportation planning in shaping urban places and urban life. While many concepts have broad applicability and international comparisons enrich many of the book's chapters, our primary focus is on the United States.

CORE CONCEPTS

Accessibility and Mobility

Two concepts that are central to understanding transportation are accessibility and mobility. *Accessibility* refers to the ease of reaching potential destinations, also called "opportunities" or "activity sites"; it depends on the number of opportunities available within a certain distance or travel time, and on *mobility,* which refers to the ability to move between different activity sites (e.g., from home to grocery store). As the distances between activity sites have become longer (because of lower density settlement patterns), accessibility has come to depend increasingly on mobility, particularly in privately owned vehicles.

Accessibility and Land Use Patterns

Let me give an example from my neighborhood in inner-city Worcester, Massachusetts. About 50 years ago, many kinds of activities were located within three blocks of my house: schools, churches, parks, and many kinds of retail stores and services. In addition, several large manufacturing employers (a steel plant, a carpet-making firm, a textile machine manufacturer) were located close to the residential neighborhood. Anyone who could walk had excellent accessibility to goods and services as well as to employment. Access depended on pedestrian mobility rather than vehicular mobility. Since then, many of these places have closed, including the manufacturing companies and the supermarket; food stores across the metropolitan United States have become significantly larger and simultaneously fewer and farther apart. Access to most goods and services now requires mobility by bus, car, or taxi. The successful creation of ever larger retail establishments *depends* on ever-escalating levels of mobility, made possible because we can now travel much farther by car in about the same amount of time it took us to get somewhere on foot.

This example illustrates how the need for mobility can be seen as the *consequence* of the spatial separation between different types of land uses in the city, but enhanced mobility can also be seen as *contributing* to increased separation of land uses. Because improved transportation facilities enable people to travel farther in a given amount of time than they could previously, transportation improvements contribute to the growing spatial separation between activity sites (especially between home and work) in urban areas. As you will learn in the following chapters, the major goal of transportation planning has been to increase people's mobility as *the* way to increase accessibility. Planners and policymakers now recognize, however, that increased accessibility can also be achieved through attention to land use planning, that is, by creating high-density urban neighborhoods much like many urban neighborhoods of yore (see Chapter 7).

This symbiotic relationship between transportation and land use is one reason geographers are interested in urban transportation. One could never hope to understand the spatial structure of the metropolis or to grasp how it is changing without knowledge of the movement patterns of people and goods. The accessibility of places has a major impact upon their land values, and hence on how the land is used. The location of a place within the transportation network determines its accessibility. Thus, in the long run, the transportation system (and the travel on it) shapes the land use pattern, In Chapter 2, Laetitia Dablanc and Jean-Paul Rodrigue introduce the role of freight transport in shaping urban landscapes, and, in Chapter 3, Peter O. Muller provides numerous historical examples of the interaction between transportation innovation and urban land development. In the short run, however, the existing land use configuration helps to shape travel patterns. The intimate relationship between transportation and land use is explicitly acknowledged by the fact that at the heart of every city's transportation plan is a land use forecast. In Chapter 4, Giovanni Circella and Patricia L. Mokhtarian explore the fascinating question of how information and communication technologies such as the Internet and mobile devices are changing the relationship between distance and accessibility, and therefore the relationship between accessibility and land use.

Measuring Accessibility

We can talk about the accessibility of *places* (i.e., how easily certain places can be reached) or of *people* (i.e., how easily a person or a group of people can reach activity sites). As we saw in the example above, an individual's level of accessibility will depend largely on where activity sites are located vis-à-vis the person's home and the transportation network, but it will also be affected by when such sites are open and even by how much time someone can spare for making trips. Urban planners and scholars have long argued that the ease with which people can get where they want to go—in other words, accessibility—should be considered in any assessment of the health of a city or any measure of the quality of life (see, e.g., Chapin, 1974; Scott, 2000; Wachs & Kumagi, 1973). Measuring accessibility in a meaningful way can be difficult, however.

Personal accessibility is usually measured by counting the number of activity sites (also called "opportunities") available at a given distance from the person's home and "discounting" that number by the intervening distance. Often accessibility measures are calculated for specific types of opportunities, such as shops, employment places, or medical facilities. One measure of accessibility is presented in the following equation:

$$A_i = \sum_j O_j d_{ij}^{-b}$$

where A_i is the accessibility of person i, O_j is the number of opportunities at distance j from person i's home, d_{ij} is some measure of the separation between i and j (this could be travel time, travel costs, or simple distance), and b is a measure of how quickly accessibility declines with increasing distance. Such an accessibility index is a measure of the number of potential destinations available to a person and how easily they can be reached. Accessibility is usually assessed in relation to the person's home because that is the base from which most trips originate; personal accessibility indices could (and perhaps should) also be computed around other important bases, such as the workplace.

The accessibility of a place to other places in the city can be measured by the same equation, with A_i now the accessibility of zone i, and O_j the number of opportunities in zone j.

Although we can use the same equation, the difference between measuring the accessibility of individuals and that of places (or zones) within a city is important. When we measure accessibility at the level of places, the access measure treats all those living in zone i as if they have the same level of accessibility to activity sites in the city; it does not distinguish among different types of people within a zone, such as those with or without a car.

Both these measures of accessibility are highly simplified representations; neither really addresses mobility nor includes dimensions such as the ability to visit places at different times of day. A third measure—that of space–time autonomy—takes both accessibility and mobility into consideration; it is a more satisfying measure conceptually than measure (1) but far more difficult operationally. The concept of space–time autonomy has been developed in the context of time geography and focuses on the constraints that impinge on a person's freedom of movement (Hägerstrand, 1970). These constraints include:

Capability constraints—the limited ability to perform certain tasks within a given transportation technology and the fact that we can be in only one place at a time; for example, if the only means of transport available to you are walking and biking, the number of activity sites you can visit in, say, half an hour is lower than it would be if you had access to a car.

Coupling constraints—the need to undertake certain activities at certain places with other people; for instance, that lunch meeting with your boss can only be scheduled when you both can be in the same place at the same time.

Authority constraints—the social, political, and legal restrictions on access—for example, you can only see your dentist or go to the movies during the hours they are open, and certain locations are off-limits to people without access permits.

Your access to places and activities is restricted by these constraints.

A measure of an individual's space–time autonomy is the *space–time prism,* a visual representation of the possibilities in space and time that are open to a person, given certain constraints (see Figure 1.1). The larger the prism, shown in each frame of Figure 1.1 as a parallelogram, the greater the individual's space–time autonomy in a specific situation.

Figure 1.1a, for example, shows the space–time autonomy for a person who is currently (at 5:00 P.M.) at work and who must arrive at the childcare center no later than 6:00 P.M. to pick up his daughter; the distance between these two locations is shown on the "space" axis. Somewhere in between he must stop at a food store to buy salad greens and tofu. In addition to these location and time constraints, the father in this example must conduct all travel either on foot or by bicycle. The slope of the lines in Figure 1.1 shows the maximum speed (in 1.1a, presumably by bicycle) that he can travel. The prism outlines the envelope within which lies the set of all places that are accessible to him given these constraints. If no food store selling what he needs exists between x and y (shown on the "space" axis), then he lacks accessibility in this instance.

The concept of a space–time prism also illustrates how changes in constraints can affect accessibility. If, in this example, the childcare center were to extend its hours to 6:30 P.M., the prism defining the set of possibilities would be enlarged (see shaded area in Figure 1.1b), and this man's space–time autonomy would be increased. Or suppose he traveled by car: he could then travel farther in the same amount of time, and the prism would therefore be larger. Notice that this greater speed is shown by the slope of the lines in Figure 1.1c, which is not as steep as in 1.1a and 1.1b, where he

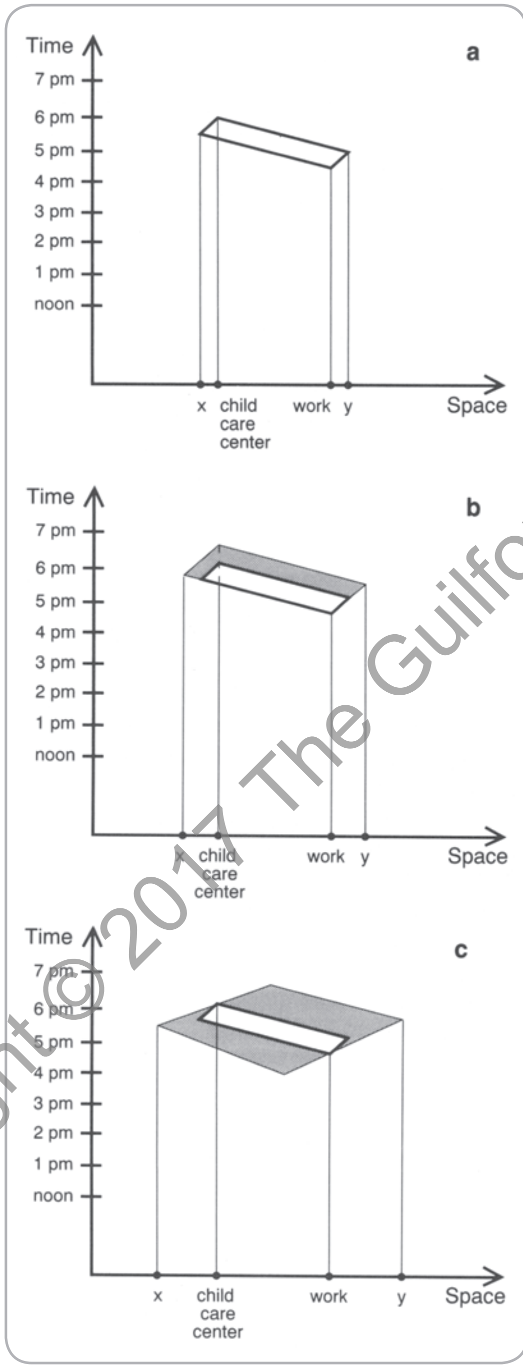

FIGURE 1.1. One measure of space–time autonomy is the space–time prism. (a) The prism defines the set of possibilities that are open to this father who must travel on foot or by bike from his place of work, where he is at 5:00 P.M., to the child care center, which closes at 6:00 P.M. (b) Effects of extended hours; the shading shows the increases in space–time autonomy if the child care center were to extend its hours from 6:00 P.M. to 6:30 P.M. (c) Effects of car availability; the shading shows the increase in space–time autonomy if a car is available, thereby permitting higher speed travel.

is assumed to be traveling by bike. The shading in Figure 1.1c indicates the increase in space–time autonomy that would result from the availability of a car. Notice that the outer spatial limits of possibilities, shown in each case by x and y on the space axis, shift outward as constraints are eased. In general, the prisms show the relationship between time and space, and you can see that as the time constraints facing this father are reduced, the greater the space within which he can move.

Many factors can, then, affect space–time autonomy. For example, flexible work schedules, longer store hours, and purchasing an additional family car all enhance space–time autonomy by adding margins to the space–time prism. Lower speed limits, rigid school hours, and traffic congestion all constrain choice. Large families impose coupling constraints, which often affect women more than men. Babysitters, day care centers, and children's growing up all reintroduce issues of space–time autonomy for parents. You can see that measuring space–time autonomy by including all of these relevant factors would be complicated; nevertheless, the concept has been influential in thinking about transportation planning (see Chapter 5).

Increasing people's space–time autonomy seems desirable in that it implies a greater accessibility to places and more discretion for spending one's time. We might question, however, the need for ever-increasing space–time autonomy and ever-increasing personal mobility. Transportation geographers among others have begun to ponder whether or not there is such a thing as too much mobility.

Equity

As we can see from the concept of space–time autonomy, someone's ability to reach places depends only in part on the relative location of those places; it also depends on *mobility,* the ability to move to activity sites, which in many places requires an automobile. We have seen how the spatial organization of contemporary society demands—indeed assumes—mobility; yet not all urban residents enjoy the high level of mobility that the contemporary city requires for the conduct of daily life. Assessing the equity of a transportation system or a transportation policy requires that we consider who gains accessibility and who loses it as a result of how that system or policy is designed; it requires that we consider to what degree people's travel patterns are the outcomes of choice or constraints. How are the costs and benefits of transportation systems distributed across different groups of people?

At the time of the bus boycott in Montgomery, Alabama, in the late 1950s, a disproportionate share of people with fewer economic resources relied on buses for transportation (as they do today). At the start of the boycott in 1955, blacks comprised 45% of Montgomery's population but 75% of the city's bus ridership, and the majority of bus riders were women (Garrow, 1988; Powledge, 1992). People without access to cars are especially likely to lack the mobility necessary to reach job locations or other activity sites. In fact, lower-income people travel significantly less (they "consume" less transportation) than do higher-income people. In 2009, among all households in the U.S. National Household Travel Survey with valid data on vehicle miles traveled (VMT), households with incomes under $25,000 were 14% of the total, but accounted for only 7% of all vehicle miles traveled.[1] Equity issues are so important in transportation that we devote a chapter to this topic (see Chapter 13).

Externalities

By its very nature, transportation creates externalities: unpriced costs and benefits. Externalities are "unpriced" in the sense that those who produce unwanted effects or who enjoy certain benefits from elements of the transportation system did not pay for them. Examples of the many *negative externalities* (external costs) stemming from transportation include the costs associated with (1) air pollution from auto and truck emissions, (2) the neighborhood disruption and safety hazards of major urban arterials, and (3) increased travel times from congestion. In each of these cases those who contribute to creating the problem have not paid the full costs of the resulting health problems, injuries and deaths, or lost incomes associated with these examples, respectively. Examples of the many *positive externalities* (also called "merit goods") linked to transportation include the benefits associated with (1) increased access and mobility from autos and urban arterials, (2) improved health and safety from a pedestrian or bicycle path, and (3) decreased travel times for autos using corridors also served by high-speed bus or rail, which divert traffic from roadways. In each of these cases, those who benefit are not paying the full costs of these advantages. If, for example, the accessibility benefits of living near a transit stop are fully reflected in higher housing prices, or if the full health care costs of air pollution were included in the price of gasoline, then these benefits and costs would no longer be externalities.

As these examples illustrate, the impact of an externality, whether negative or positive, is almost always place-specific; moreover, the same facility or service can produce positive *and* negative externalities. Households living close to a major arterial will enjoy better access to places they want to go but also will experience worse air quality than will those living farther from the arterial. The geographic specificity of externalities often motivates place-based groups either to oppose or to support infrastructure projects, depending on whether such groups see mainly the negative or the positive externalities of a project. The impacts of externalities depend in large part on *geographic context*, meaning the nature of the places in which they occur. The next section of this chapter describes the overall urban context of travel and a few of the many, diverse urban contexts in which U.S. travel takes place.

THE CHANGING URBAN CONTEXT

How have U.S. cities been changing in recent decades? In particular, how have residential and employment patterns been changing? In addition to looking at patterns for U.S. cities as a whole, we focus on two medium-sized metro areas, one from the Rust Belt—Worcester, Massachusetts—and one from the Sun Belt—Modesto, California—to examine intraurban patterns and trends.

Residential Patterns

Table 1.1 presents data on some important demographic trends from 1970 to 2010 for U.S. metropolitan areas as a whole, and Table 1.2 contains data for the Worcester and Modesto metropolitan areas for the same years. Although both metro areas had

TABLE 1.1. Demographic Trends, Metropolitan Areas in the United States, 1970–2010

	1970[b]	2010
Population of MSAs[a]	139,418,811	262,348,562
Number of households in MSAs	43,862,993	96,674,419
Percentage of households in MSAs that are single person	18.1	33.7
Percentage of MSA population living in		
City	45.8	38.6
Suburbs	54.2	61.4
Percentage of households with no vehicle		
MSA	18.6	9.7
City	28.4	15.7
Suburbs	9.2	5.8
Percentage of households with more than one vehicle		
MSA	35.6	56.0
City	26.2	45.3
Suburbs	44.7	63.0
Percentage of population over 65 years of age		
MSA	9.3	12.5
City	10.8	11.5
Suburbs	8.0	13.2
Percentage of families below the poverty level		
MSA	8.5	11.2
City	11.0	15.5
Suburbs	6.3	8.9
Percentage of families headed by women		
MSA	11.5	20.2
City	15.5	26.7
Suburbs	8.3	16.7

[a]MSAs: Metropolitan Statistical Areas, which includes a central city/cities and the surrounding suburbs.

[b]For 1970, figures refer to SMSAs (Standard Metropolitan Statistical Areas) as defined at that time.

Source: Adapted from the Censuses of Population and Housing (U.S. Bureau of the Census, 1970, 2010, and the American Community Survey).

TABLE 1.2. Demographic Trends, Worcester, Massachusetts, and Modesto, California, 1970–2010

	Worcester		Modesto	
	1970	2010	1970	2010
Population of MSA[a]	344,320	548,050	194,506	515,358
Number of households in MSA	104,694	219,625	62,100	201,520
Percentage of households in MSA that are single person	17.6	26.6	18.6	23.8
Percentage of MSA population living in central city	51.3	33.0	31.7	39.1
Percentage of households with no vehicle				
MSA	17.7	8.6	10.7	7.0
City	26.2	16.2	11.2	8.1
Suburbs	7.6	5.0	10.5	6.2
Percentage of households with more than one vehicle				
MSA	28.6	57.2	41.1	61.7
City	19.4	40.6	43.9	57.9
Suburbs	39.3	65.0	39.7	64.4
Percentage of population over 65 years of age				
MSA	12.0	12.8	10.3	10.6
City	14.7	11.7	9.9	11.6
Suburbs	9.2	13.4	10.5	10.0
Percentage of families below the poverty level				
MSA	5.4	7.2	11.8	17.2
City	7.1	15.4	8.8	17.1
Suburbs	3.7	4.0	9.1	17.3
Percentage of families headed by women				
MSA	11.3	12.3	10.6	20.4
City	15.2	17.0	11.9	24.3
Suburbs	7.2	10.0	10.1	17.8

[a]MSA: Metropolitan Statistical Area, which includes the principal city and the surrounding suburbs. Source: Adapted from the Censuses of Population and Housing (U.S. Bureau of the Census, 1970, 2010).

similar 2010 populations of more than half a million, their different histories reflect their locations in the industrial northeast and the agricultural Central Valley of California, respectively. Located about 50 miles west of Boston, Worcester's once strong manufacturing employment base has been replaced by health care and higher education as major employers. Worcester's low-cost housing relative to Boston's, along with increased job opportunities to the west of Boston, have contributed to the Worcester area's growth in recent years.

With the San Francisco Bay Area about 90 miles to the west, the state capital Sacramento 60 miles to the north, and Fresno 60 miles to the south, Modesto has served as a central place for a large swath of California's Central Valley. It also has served as a food-processing center for the agricultural products grown in the surrounding area, although many food processors once located in the center of Modesto have closed. High housing prices in the Bay Area, together with freeway access, have made Modesto attractive as a bedroom community. Clearly, neither Worcester not Modesto exist in isolation from other places; both are linked into—and therefore are in part shaped by—the national and international systems of cities, perhaps most notably via commute flows to the nearby large metro areas of Boston and San Francisco, respectively, but also via freight flows. Nevertheless, the effects of their distinctive regional contexts are also evident.

The census figures in Tables 1.1 and 1.2 disclose a number of trends that hold important implications for travel patterns and for access, mobility, and urban transportation planning. Worcester and Modesto illustrate interesting similarities to and differences from these national trends.

First, while the *populations* of U.S. metro areas as a whole (Table 1.1) and of the two metro areas in Table 1.2 have certainly increased in the 40 years between 1970 and 2010, the number of households and the number of single-person households have grown faster than has the population. The proportion of single-person households increased from 18.1% of all Metropolitan Statistical Area (MSA) households in 1970 to 33.7% of all households in 2010 (Table 1.1). The greater increase in households relative to population has implications for trip making because the number of trips made per person per day generally declines as household size increases. The trend to more households and more single-person households contributes significantly, then, to an overall growth in travel.

A second national trend is that the proportion of the U.S. metropolitan population residing in central cities continues to decline. A larger proportion (61.4% in 2010 vs. only 54.2% in 1970) now lives in the suburbs, which, with their lower density, are more difficult to serve efficiently with public transportation. This trend is clear in Worcester, where the central-city proportion of MSA population fell from 51.3% to 33%, but in the Modesto case the central-city proportion actually increased, from 31.7% to 39.1% (Table 1.2). Why? Whereas in eastern urban areas city boundaries remain fixed as population shifts occur, in the U.S. west, cities often annex land as it becomes developed, thereby extending the boundary of the metro area's central city to encompass the growing population. Modesto illustrates this process. In the early 1980s when Modesto became a bedroom community for the San Francisco Bay Area, the newly developed areas were incorporated into the city. Third, although the proportion of households having no vehicle has dropped in cities and suburbs across the

United States since 1970, the percentage of households without a car has remained higher in cities than in suburbs. This latter point is to be expected, given the higher incidence of low-income households in the central city and the greater availability of public transportation there. Nevertheless, despite fewer U.S. metro households lacking a car now than was the case in 1970 ("only" about 10% in 2010 vs. 18.6% in 1970), many people must still rely for mobility upon the bus, taxis, a bicycle, their own feet, or rides from other people. The much smaller proportion of central-city carless households in Modesto (8.1%) than in Worcester (16.2%) in 2010 reflects in part Worcester's higher density and better public transportation. Fourth, while the proportion of carless households has declined, the proportion of households with more than one vehicle has grown dramatically in both city and suburbs (Table 1.1); note especially the higher proportion of multivehicle households in low-density central-city Modesto (57.9%) than in higher-density central-city Worcester (40.6%) (Table 1.2).

A fifth national trend that is reflected also in the data for Worcester and Modesto is the growth in the numbers and the proportions of two types of households that are likely to have special transportation needs: low-income households and households headed by women. Lack of access to a vehicle is likely to pose mobility problems for low-income households, many of whom must rely on public transportation, a problem that can be especially acute in suburbs where public transportation is limited or entirely absent. The travel problems of single-parent households, headed mostly by women, stem from the difficulty of running a household single-handedly; earning an income, shopping, obtaining medical care and childcare all must be done by the one adult in the household, sometimes without the aid of an automobile.

Employment Patterns

Since the 1960s, jobs have been decentralizing from the central city to the suburbs. Traditionally, especially from the standpoint of transportation planning, the suburbs were viewed as bedrooms for the central-city workforce. Radial transportation systems, focused on the urban core, were organized in large part around moving workers from the suburbs to the central city in the morning and back to the suburbs again in the evening. But this simple pattern now describes only a small portion of current reality. In Worcester in 1960, for example, 42% of suburban workers had jobs in the central city; by 2010 only 20% of employed people living in the suburbs worked in the central city, the same proportion as for all metro areas in 2010. Similarly, the proportion of the metropolitan labor force that works in the City of Worcester as opposed to surrounding suburbs has declined from more than two-thirds in 1960 to less than one-third in 2010.[2]

In an iconic case study, Hughes (1991) documented the extent to which employment moved from central-city Newark, New Jersey, and into the surrounding region in the 30 years after 1960. Although the Newark region as a whole experienced considerable job growth during this period, the spatial distribution of employment shifted dramatically within the region, from the central city to the suburbs. Central-city job loss coupled with suburban job growth makes access to employment extremely difficult for people who live in the central city but do not have a car. Relatively few suburban jobs in the Newark region could be reached by carless people living in central

Newark; if they took a commuter train, how could they reach the employment site from a suburban train station?

Hughes links this decentralization of employment over the past few decades to the increase in poverty in inner-city Newark. Clearly, as we saw in the case of Worcester, large numbers of residences as well as jobs have been moving to the suburbs in the past four decades. But because of the unequal access of different groups of people to suburban housing, not all social groups have been able to decentralize to the same degree. In particular, low incomes, racial discrimination in the housing market, and people's preferences for living with others who are like themselves have hindered many people, especially those from minority groups, from moving to the suburbs. Hughes's analysis, as well as work by other scholars (e.g., Wilson, 1987), underlines how the reality of residential segregation in U.S. cities, together with changes in job location, has important implications for people's access—or lack of access—to employment opportunities. The term *spatial mismatch* refers to this "mismatch" between inner-city residential location and suburban job location, without the automobility needed to "connect the dots" (for reviews of the spatial mismatch literature, see Holzer, 1991; Mouw, 2000).

In a detailed study of the Boston metropolitan area, Shen (2001) extends and deepens understanding of the spatial access of low-skilled job seekers to employment. In particular, Shen argues that analysts should focus on the location of job *openings* rather than on the location of *employment* as Hughes (1991) did, and he shows that preexisting employment, concentrated in the central city, is the main source of job openings. Shen's analysis also demonstrates that residential location (e.g., city vs. suburb) is not as important as transportation mode is in accounting for differences in job seekers' access to jobs. That is, job seekers who travel by car will have higher than average accessibility to job openings from just about any residential location, whereas job seekers who depend on public transit will have substantially lower than average accessibility from most residential locations (Shen, 2001, p. 65). Evelyn Blumenberg (Chapter 13, this volume) takes up these issues of equity in access in greater detail.

THE ISSUE OF SCALE

Our discussions of residential and employment location patterns provide a useful snapshot of some important urban processes that have transportation implications: the decentralization of population and employment and the concentrations of low-income, carless, and female-headed households in the central city. But the spatial resolution of the information discussed thus far is generalized to large areas, in that we've emphasized distinctions no finer than that between central city and suburbs. For understanding some problems, such general data are sufficient, but if transportation policies and facilities are to be tailored to the specific needs of different kinds of people such as those who lack access to autos, then it is important to know as precisely as possible where, *within* the suburbs and *within* the central city, members of a target group live.

Maps at the level of the census tract (an area comprising 4,000–5,000 people on average) or the census block group (an area within a census tract, encompassing about 1,000 people) reveal the degree to which people and households with certain characteristics are clustered in certain areas within the city or within the suburbs. Of particular interest are maps showing the residential locations of people who are likely to have special transportation needs. Census tract maps for the City of Worcester, Massachusetts, provide examples. Compare Figures 1.2, 1.3, and 1.4, which show the distributions of households in poverty, households without a car, and female-headed households in 2010, respectively. First, look carefully at the mapped categories for each of these variables; these show, for example, that in at least one census tract in Figure 1.2 (poverty) more than 64% of the households had annual incomes in 2010 that fell below the federal poverty threshold of $22,050 for a family of four, while in many tracts less than 4% of households had incomes this low.

Second, the high level of spatial clustering of households with low incomes (Figure 1.2), without a car (Figure 1.3), and headed by women (Figure 1.4) within certain tracts is clear. The same level of clustering is not evident in the suburban tracts (Figure 1.5, suburban carless households, and Figure 1.6, suburban female-headed households), where the majority of tracts have relatively low incidences of these types

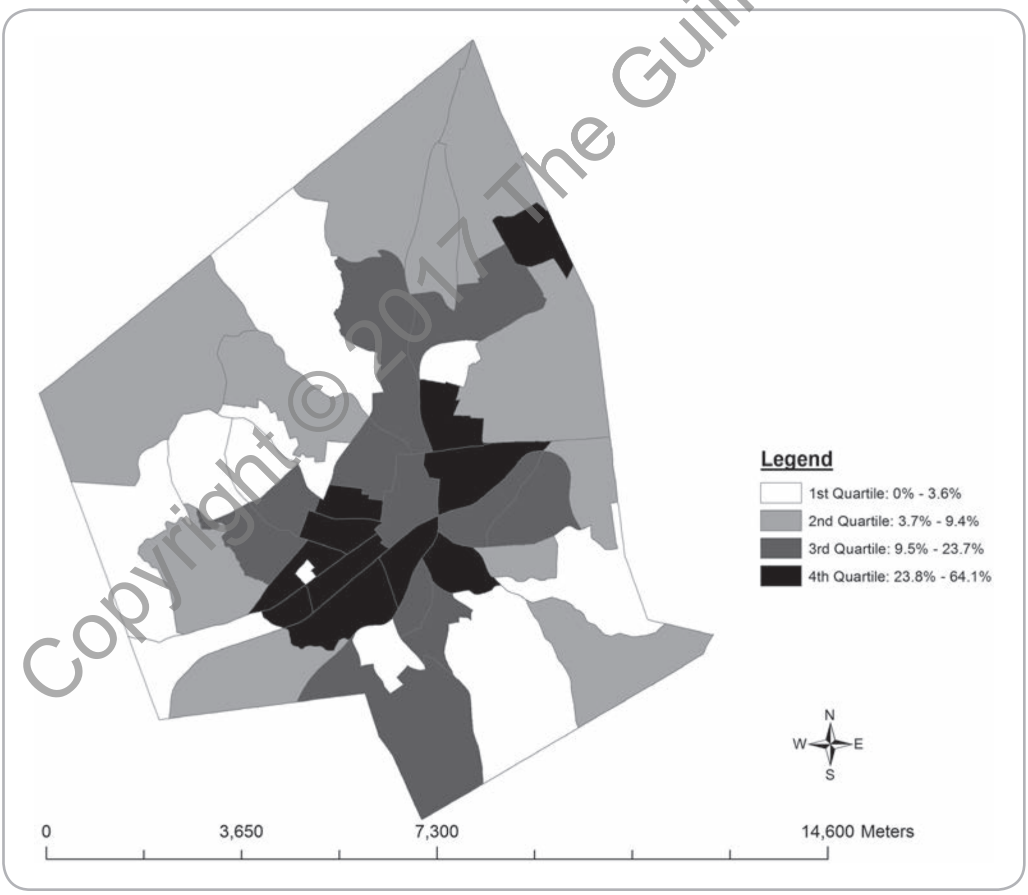

FIGURE 1.2. Percentage of households in poverty by census tract, 2010, Worcester, Massachusetts. Source: U.S. Bureau of the Census, American Community Survey 5-year estimates (2007–2011).

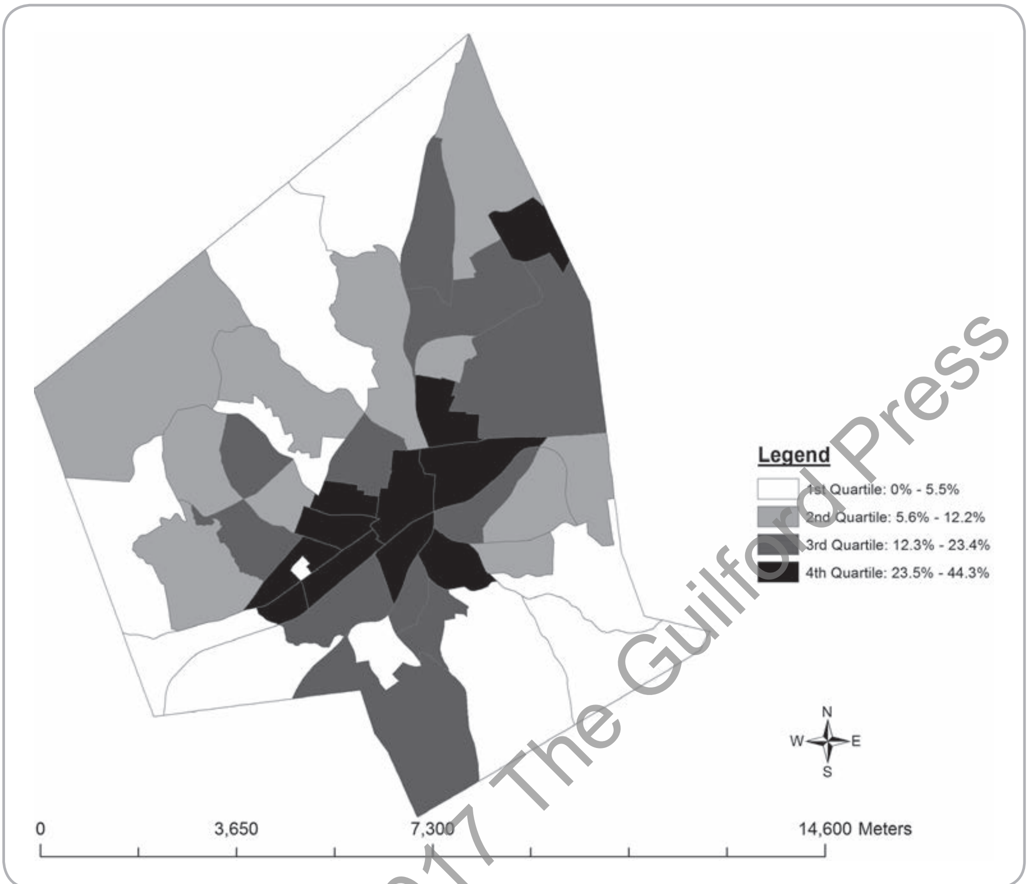

FIGURE 1.3. Percentage of households without a vehicle by census tract, 2010, Worcester, Massachusetts. Source: U.S. Bureau of the Census, American Community Survey 5-year estimates (2007–2011).

of households and the tracts with the highest proportions of carless or female-headed households are dispersed.

Third, note the spatial coincidence of female-headed households, the carless, and the poor within the City of Worcester; that is, the same areas tend to have high proportions of female-headed households, households in poverty, and households without an automobile. These spatial correlations are not as strong for suburban tracts, which show little overlap in the locations of carless (Figure 1.5) and female-headed (Figure 1.6) households. Finally, note the high levels of variation among suburban tracts in the percentages of households without a vehicle (Figure 1.5) and households headed by women (Figure 1.6), demonstrating the folly of generalizing about "the suburbs" as if they were a homogeneous region, even within one MSA.

Policies aimed at providing mobility for low-income carless people might effectively be focused on the census tracts that have the largest percentages of households with these characteristics. You can see that such policies would be far easier to implement in the city, where target tracts are clustered together, than in the suburbs, where

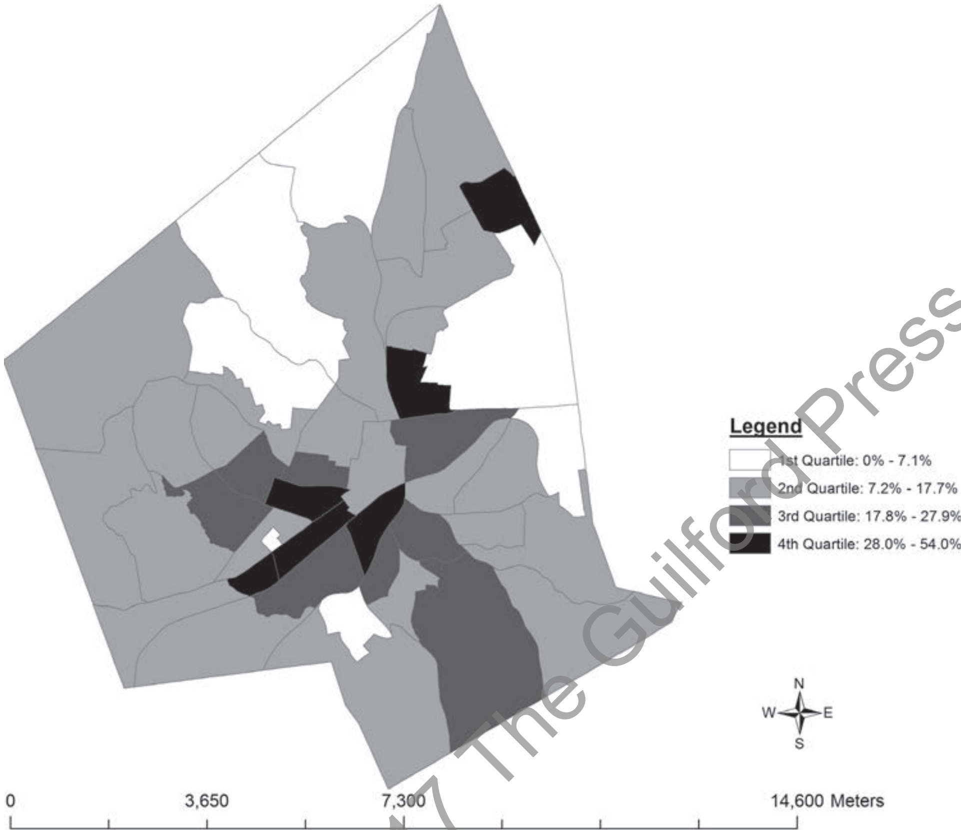

FIGURE 1.4. Percentage of households headed by women in each census tract, 2010, in Worcester, Massachusetts. Source: U.S. Bureau of the Census, American Community Survey 5-year estimates (2007–2011).

they are widely dispersed. Even when an area-targeted policy can be implemented, it provides services to many households who live in the targeted tracts but *do* have a car or are not in poverty, and it would miss the many carless households that do *not* live in the target census tracts. Also, numerous *individuals* (rather than households) are carless for much of the day—people, for example, who remain at home while someone else takes the household's one car to work. The census tract maps are little help in locating these people.

What these maps show is the familiar pattern of people with similar characteristics clustering together in space. What they do not show is the extent to which different types of people live within each census tract or the extent to which certain variables that covary at the area (tract) level also covary at the individual level. For instance, what percentage of female-headed households within a tract are below the poverty line or do not have access to a car?

Consider the three hypothetical census tracts in Figure 1.7. All have an average household income of $30,000, and in this fictitious example we have information not only for the tract but also for households within the tract. In the tract in Figure 1.7a, every household's income is identical, exactly $30,000, so the zonal average income is an accurate measure of the individual household incomes within the zone. In Figure 1.7b, however, the zonal average masks two distinct subareas within the zone. In one part, every household's income is $35,000, and in the other, every household's income is $22,000. In Figure 1.7c the $35,000 households are interspersed with the $22,000 households.

The complete zonal homogeneity depicted in Figure 1.7a simply does not occur in the real world; data for areas (or zones) smooth out whatever internal heterogeneity exists. People in $35,000 households are likely to have quite different travel patterns from members of $22,000 households, but the zonal data will portray only an "average" behavior for the people of the zone.

The more homogeneous an area is, the closer the zonal data will come to approximating the characteristics of the individuals living within that zone. Census tract boundaries or the boundaries of traffic zones (areal units often used in transportation studies) sometimes split relatively homogeneous areas, adding heterogeneity to the resulting zones. In general, the larger a tract or zone, the less likely it is that all the households living there will share similar characteristics.

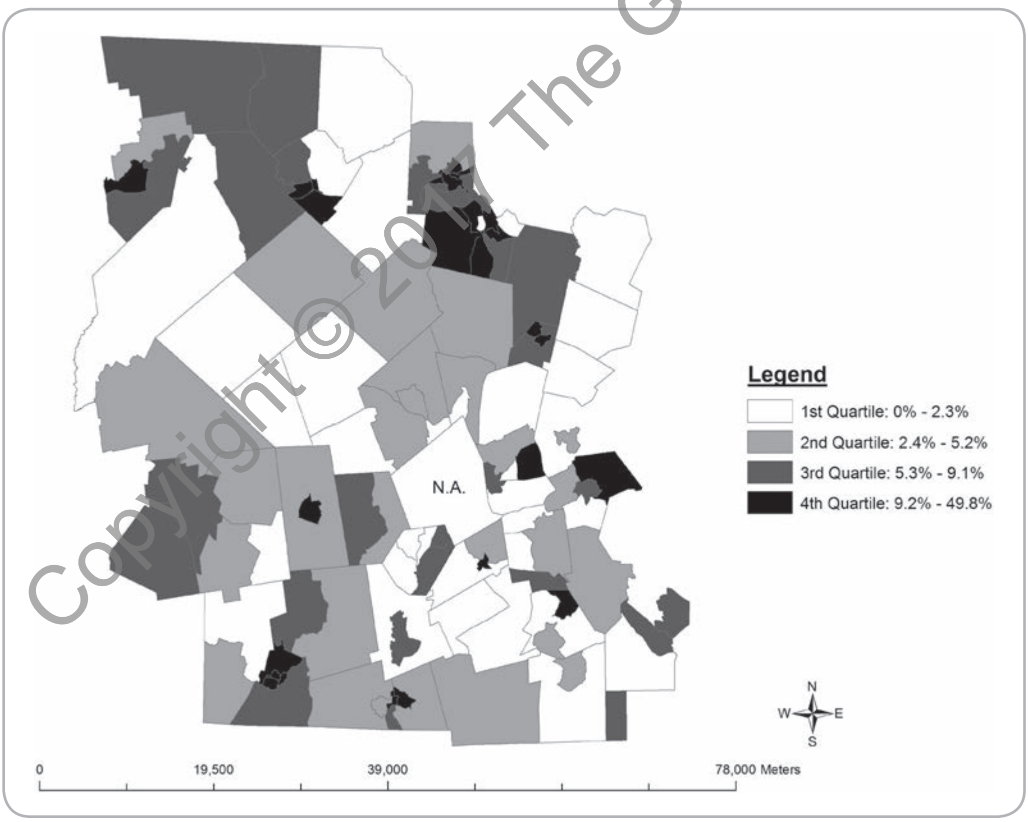

FIGURE 1.5. Percentage of households without a vehicle in each census tract, 2010, Worcester, Massachusetts, suburbs. Source: U.S. Bureau of the Census, American Community Survey 5-year estimates (2007–2011).

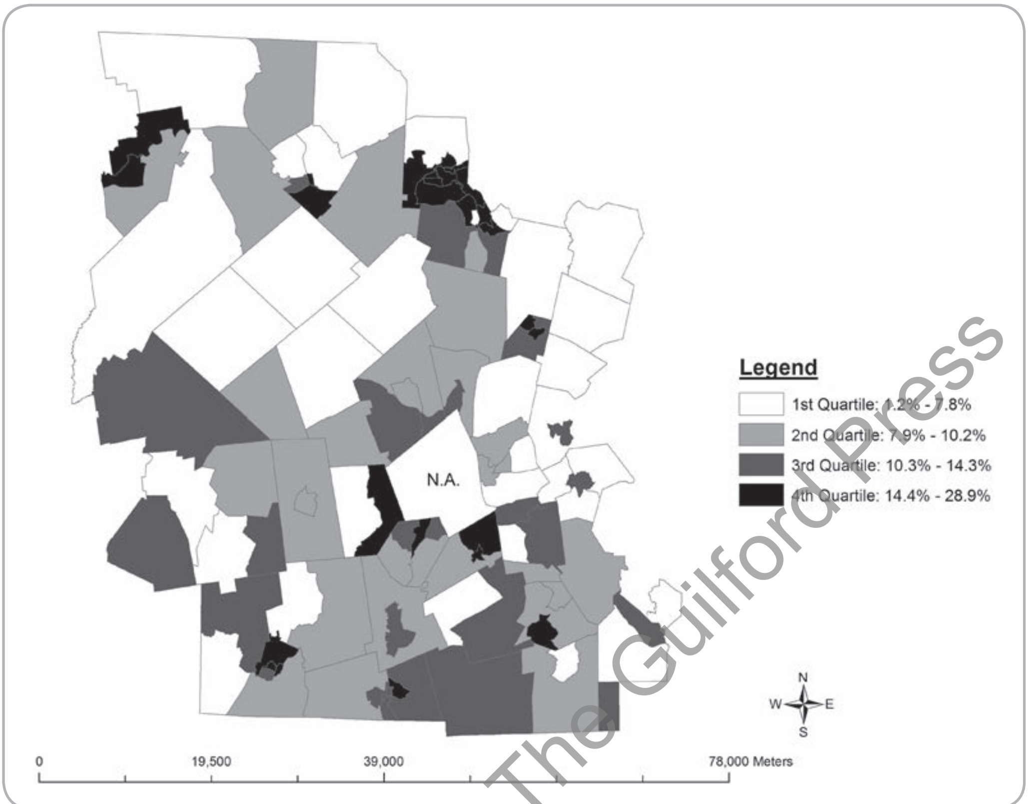

FIGURE 1.6. Percentage of households headed by women in each census tract, 2010, in Worcester, Massachusetts, suburbs. Source: U.S. Bureau of the Census, American Community Survey 5-year estimates (2007–2011).

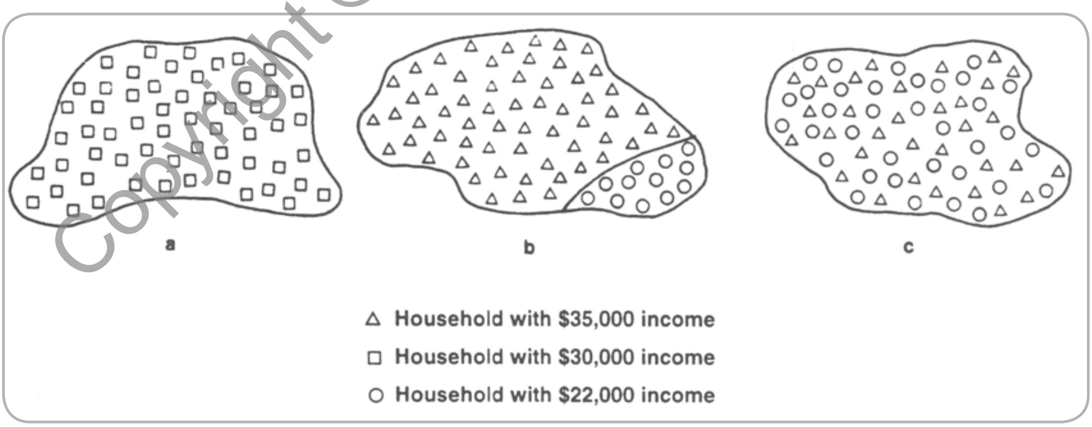

FIGURE 1.7. Hypothetical distributions of households with different income levels.

Maps of data for areas are useful for providing an overview of population distributions and employment locations within an MSA, for showing where certain population characteristics coincide in space, and for suggesting where certain transportation policies might best be deployed. They are not particularly useful for indicating what characteristics occur together at the *household* or *individual* level or for investigating how and why people make travel decisions or how they might respond to a particular transportation policy such as increased headways on a bus route (i.e., longer times between buses) or the installation of a bicycle lane on a certain route. Such questions require data for individuals rather than for areas.

UNDERSTANDING URBAN TRAVEL: AGGREGATE AND DISAGGREGATE APPROACHES

Transportation analysts use both area (*aggregate*) and individual-level (*disaggregate*) data in studying movement patterns in cities. Studies taking an aggregate approach use data for areal units called "traffic zones" and group separate trips together according to their zone of origin and their zone of destination (see Figure 1.8). Data are usually collected at the individual or household level (e.g., by asking people about their daily trip making), but, in the aggregate approach, for analytical purposes such data are aggregated into zones, as shown in Figure 1.8 as well as in the census tract maps of Worcester. In aggregate transportation studies, the focus is on the flows between zones: how many trips does a particular zone "produce" (in other words, how many trips leave zone *i*) or "attract" (how many of those trips end in zone *j*)? Disaggregate travel analyses use information on individuals and households—not zones—and usually use more finely grained spatial codes as well such as street addresses instead of zones. The conceptual base of the disaggregate approach is the person's daily travel activity pattern, rather than flows between zones. Figure 1.9 shows a schematic,

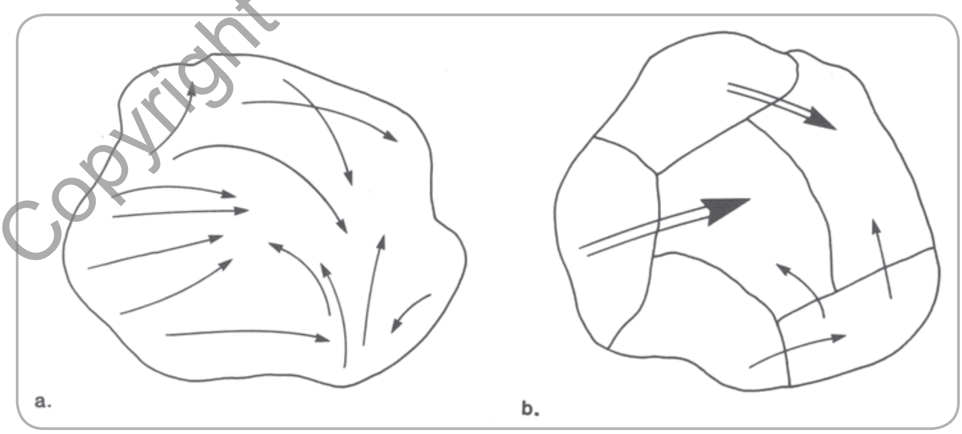

FIGURE 1.8. (a) Individual trips, showing points of origin and destination. (b) Individual trips aggregated by origin and destination zones. Thickness of arrow indicates volume of flow between zones.

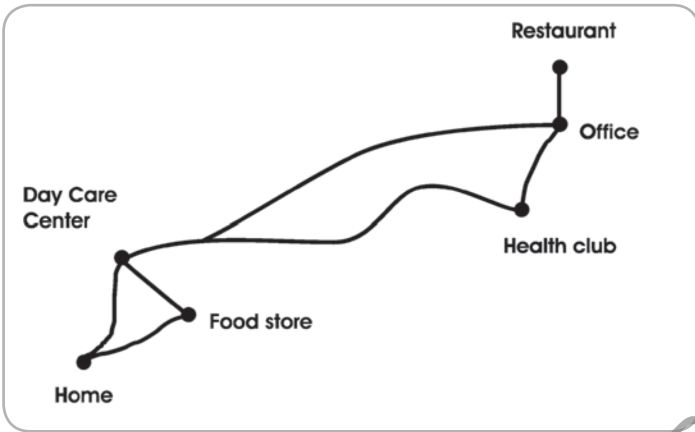

FIGURE 1.9. One person's hypothetical daily travel pattern.

bird's-eye-view of a hypothetical daily travel pattern; you could try mapping your own travel behavior like this over the course of several days. You can also represent your daily travel as a three-dimensional space-time path (see Figure 5.2 in Chapter 5).

Studies of person travel usually focus on the number of trips made and the times or distances traveled for various purposes (e.g., work, shopping, recreation), time of day of travel, locations of destinations, and modes of travel by trip purpose. Transportation analysts view person travel as a function of the characteristics of the traveler (e.g., household size, income, and auto ownership; employment status; gender) and the nature of the travel environment (e.g., available travel modes; density and diversity of, and distances to, potential destinations). For example, people tend to make more trips if they have higher incomes, an automobile for their own use, or are part of a smaller household. Men generally travel longer distances than do women. People tend to make a higher proportion of their trips by transit if they live near a transit stop and a higher proportion of their trips on foot if they live in a dense urban environment instead of a low-density suburb. However, people who want to walk and use transit may selectively choose to live in transit- and walk-friendly places, so it is difficult to determine exactly how much influence the local urban environment has on travel behavior (see Chapter 7).

To understand patterns of aggregate flows, analysts look at the characteristics of trip origin zones i and destination zones j that might account for the volume of flows leaving from i and arriving at j. Such characteristics might be median household size, income, and car ownership in origin zones—all measures of the propensity of people living in that zone to make trips—and the nature of shopping and employment in destination zones—measures of the attractiveness of different zones as trip destinations. Also important in understanding the size of the flow from i to j is the distance between the zones: more trips are made between proximate than between distant zones. Aggregate modeling approaches using data for zones are routinely used at the metropolitan-wide scale to answer transportation planning questions such as: Where within the metro region are new transportation investments (such as a new transit line or a new bridge) most needed? Where should new infrastructure be built in order to accommodate the mobility needs of the metro population 20 years hence? In Chapter 5, Harvey J. Miller describes the aggregate models used to help answer questions like these, and, in Chapter 6, Gian-Claudia Sciara and Susan Handy discuss transportation planning at the metropolitan-wide scale.

In disaggregate studies, data are not smoothed out into zonal averages, and different kinds of questions as well as questions about subareas within the metro area can be posed: What factors affect why a person selects one destination or mode rather than another? What proportion of those who live in the suburbs and work in the central city will shift from commuting by drive-alone auto to a car pool or van pool if a high-speed, high-occupancy vehicle (HOV) lane is installed on their journey-to-work route? The authors of Chapter 5 (Harvey J. Miller) and 7 (Marlon G. Boarnet) discuss the nature of the disaggregate data and the models used to answer such questions.

The scale distinction—between aggregate and disaggregate approaches—threads throughout many of the chapters in this book, particularly those in Part II, which focuses on the ways planners analyze movement patterns in order to design and implement changes to the urban transportation system. It is important to understand at the outset the close interdependencies among the scale at which you collect data, the types of models you can build (i.e., how you can simplify and make more comprehensible some of the overwhelming complexities that characterize flow patterns), and the kinds of policy analysis you can carry out. Always ask, "At what scale is this transportation issue or problem being conceptualized?"

TRENDS IN U.S. TRAVEL PATTERNS

Americans have more mobility, particularly the kind that is provided by motorized vehicles, than people anywhere else on earth. Figure 1.10, which compares the United States with several other countries in terms of automobile travel, vividly illustrates this point. In 2011, Americans logged 4.3 trillion passenger miles of travel by all motorized modes (excluding air travel), and 98% of those miles were by private vehicle (a passenger mile is one person traveling 1 mile) (U.S. Department of Transportation, Bureau of Transportation Statistics, 2012). After decades of steadily increasing to a high of 5 trillion miles in 2007, this measure of American person mobility began to decline slightly, reflecting in part the economic downturn that began in 2008 as well as other recent trends discussed in subsequent chapters of this book.

A similar trend is evident in vehicle miles traveled (VMT; 1 VMT is 1 mile traveled by a vehicle; if a vehicle has four passengers, then 1 VMT would equal 4 PMTs [passenger miles traveled]). Annual VMT per person in the United States rose steadily from about 3,000 miles in 1950 to a peak of more than 10,000 miles in 2004; since then it has declined—to 9,360 miles in 2012 (U.S. Department of Transportation, Federal Highway Administration, 2012). The long, steady increase in VMT reflects long-term growth in household income and auto ownership, increased labor force participation by women, shifts from walking and transit to autos as well as lower levels of vehicle occupancy (Pisarski, 2005); average vehicle occupancy for all trips fell from 1.9 persons per vehicle in 1977 to 1.6 in 1990 (Pisarski, 1992, p. 12) and

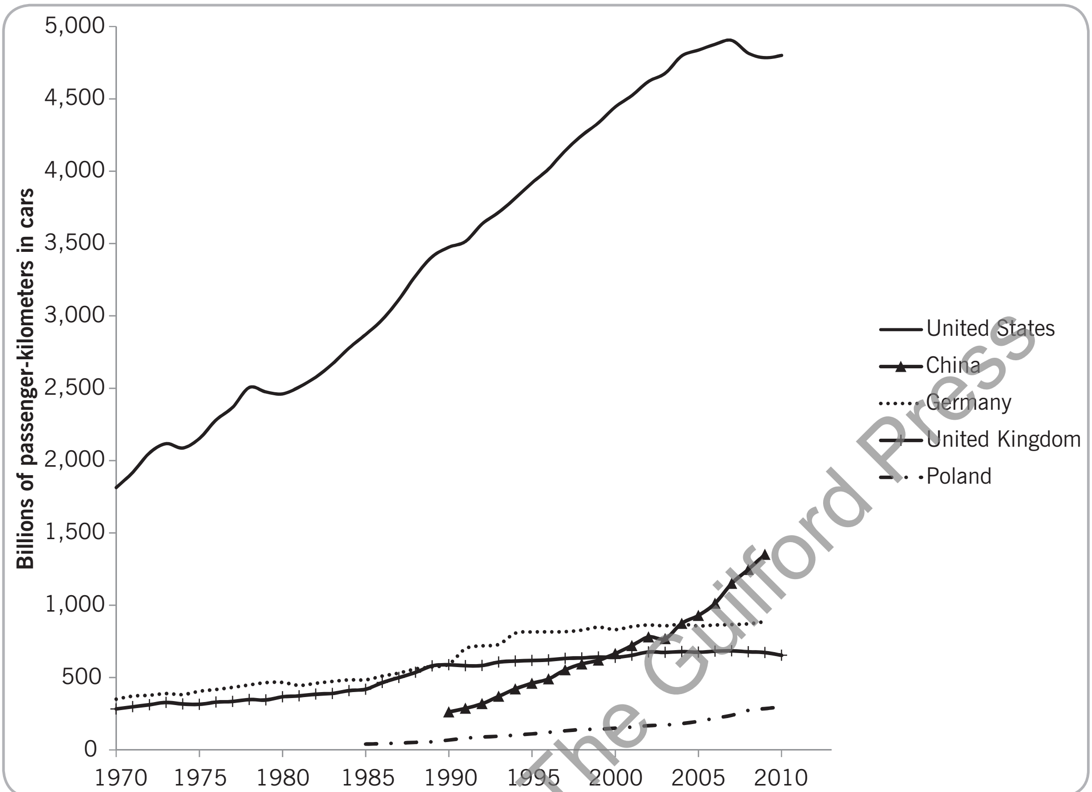

FIGURE 1.10. Trends since 1970 in passenger kilometers traveled in cars, selected countries (Organisation for Economic Co-operation and Development, 2013).

has stayed at that level since (U.S. Department of Transportation, Federal Highway Administration, 2011). Compared to several decades ago, fewer people are now passengers and more are drivers, so that, increasingly, more cars are needed to serve the same number of riders, driving the upward trend in per person VMT. The decline in VMT since 2004 is less well understood: Does it signal the beginning of a long-term trend? Is it due to durable changes in people's preferences for living in denser urban environments and using other travel modes, such as walking, biking, and transit? Marlon G. Boarnet in Chapter 7 explores these questions and examines the potential impacts of neighborhood-scale land use patterns on people's travel patterns.

Urban transportation planning has for decades focused largely on the work trip. This overarching concern with the journey to work reflects several factors. First, of all the purposes for which people travel (including work, socializing, recreation, shopping, and personal business), work used to account for the largest proportion of trips. Second, work trips are associated with the morning and evening "peaking problem"; because most people have to be at work between 7:00 A.M. and 9:00 A.M. and leave 8 hours later, work trips have been concentrated in time. The peak load associated with the work trip has placed the greatest demands on the transportation system. As you will see in the chapters describing the urban transportation planning process (Chapters 5, 6, and 7), urban transportation planners have traditionally aimed to provide a transportation system with enough capacity to handle the work trip, under the assumption that such a system can then easily accommodate travel for other purposes. (Obviously, this assumption will be erroneous if nonwork trips have a markedly different spatial configuration from work trips.) A final reason for transportation planners to focus on the work trip is that people tend to travel longer distances for work than for other purposes. The average work trip length in 2009 (13.7 miles) was more than double the average distance traveled for shopping (6 miles), for example (calculated from the 2009 National Household Travel Survey [NHTS]).

In recent years, however the proportion of travel for nonwork purposes (e.g., socializing, recreation, personal business) has increased significantly. Whereas in 1969, work and work-related travel accounted for more than 41% of all local trips, by 2009, it accounted for only about 15% (NHTS, 2009; U.S. Department of Transportation, 2003). Although travel for all purposes has grown substantially, nonwork travel has increased at a faster rate than work travel has. This increase in nonwork travel can be traced to increases in the number of affluent households and two-earner households, which spur more trips to childcare centers, restaurants, shops, fitness centers, and the like. Another reason is the decline in household size (and therefore a greater number of households for a given population) because "it is the care and upkeep of households, almost independent of the number of persons in the household that frequently governs trip making (U.S. Department of Transportation, Bureau of Transportation Statistics, 1994, p. 54). Commuting costs are now a smaller proportion of the average household's total transportation cost than in the past.

In part because of this increase in nonwork travel and because most nonwork trips begin between late morning and midafternoon (U.S. Department of Transportation, Federal Highway Administration, 2011, Figure 12), congestion that used to be confined to the morning and evening peaks has spread to encompass larger portions of the day (from 4.5 hours in 1982 to 7 hours in 2001) and a greater portion of all travel (from 33% of trips in 1982 to 67% in 2001) (U.S. Department of Transportation, Federal Highway Administration, 2013; data are for the 75 largest U.S. metro areas). The blame for traffic congestion can no longer be placed solely on the work trip.

Not only do people travel longer distances to work than they do for other purposes, work travel *distances* have been increasing, whereas *travel time* to work has been holding fairly steady. In 1975, average travel distance to work was about 9 miles and the average travel time was approximately 20 minutes (U.S. Bureau of the Census, 1979). In 2009, the average work trip covered 13.7 miles and took 23 minutes (NHTS, 2009). As described in greater detail in the chapters that follow, these national averages mask a great deal of variability, of course, among different places (region of the country, metro area size, and central city vs. suburb all affect commute distances and times) and among different groups of people, defined, for example, by age, gender, and travel mode.

Other important characteristics of work travel are the changing spatial pattern of commute trips and the modes of transportation used. The traditional suburb-to-central-city commute has not been the dominant work trip type since at least as long ago as 1970 (Plane, 1981). If we exclude work trips made within and between nonmetropolitan areas and look only at trips made within metropolitan areas, the national pattern of commuting flows looks quite intricate (see Table 1.3). By 2009 the within-suburb commute (which includes suburb-to-suburb) clearly dominated, accounting for 36.8% of all metropolitan work trips. The "traditional" commute (suburb to central city) accounted for only 20% of all journeys to work, and the reverse commute (central city to suburb) was 7.6% of commuting flows.

Given the complexity of the flow patterns depicted in Table 1.3, it is perhaps not surprising that the proportion of work trips made by auto has consistently increased while the proportion made on public transit (bus, commuter rail, subway) has remained fairly stable. In 2009, only 4.5% of work trips in the United States were made on transit, a figure that masks a great deal of place-to-place variability (U.S. Bureau of the Census, 2009). (For a thorough discussion of public transit, see Chapter 8.) By 2009, the proportion of people driving alone to work had increased to nearly 80% (up from 64.4% in 1980; U.S. Bureau of the Census, 1980), while the proportion carpooling had decreased from roughly 20% in 1980 to 9%. Those commuting by private vehicle in 2009 accounted for close to 88% of all work trips (U.S. Bureau of the Census, 2009).

Taken together, these trends—more vehicles on the road, increasing VMT, longer trips in terms of distance—add up not only to more mobility, which people clearly value, but also to many of the problems associated with transportation and primarily with the car. Among these problems, whose impacts are widely felt within and well beyond the United States, are the following: traffic congestion; air, water, and noise pollution; energy consumption; greenhouse gas emissions; urban sprawl; traffic accidents; and health problems. As mentioned earlier, in the section on externalities, a substantial portion of the cost of automobile travel is borne not by the user, but by government and by society, including future generations. Many people perceive transit as being more heavily subsidized than the auto, in that a large portion of the costs of transit are not paid directly by the user but via government support of transit agencies. Transportation analysts have argued that the automobile is also heavily subsidized, but that these subsidies tend to be less visible, more complex, and more difficult to quantify and thus not as much a part of public discourse as are

TABLE 1.3. Commuting Flows in U.S. Metropolitan Areas, 2010

Suburbs to central city	20.0%
Within suburbs	36.8%
From suburbs to outside home MSA	4.8%
Central city to suburbs	7.6%
Within central city	29.1%
From central city to outside home MSA	1.8%

Source: Data from National Household Travel Survey (2009).

transit subsidies (Delucchi & McCubbin, 2011; Miller & Moffet, 1993). Delucchi and McCubbin (2011) provide quantitative estimates of the external costs (costs not borne directly by those incurring them) of transport in the United States (see Table 1.4). The ranges provided for each type of cost vary substantially depending on a number of factors such as type of vehicle, road type (urban vs. rural), and density of urban area. The total external costs (in 2006 U.S. cents) per passenger mile, which range from 2.6 to 37.8 cents, can be put in the context of the direct costs of driving (costs borne by the driver), which range from 37.6 to 72.9 cents per passenger mile depending on vehicle size (American Automobile Association, 2006). Clearly the proportion of the total cost of driving (direct plus external) that is not borne by the driver—and therefore might be considered a subsidy—varies a great deal depending on circumstances, but is not trivial.

Although increases in automobile ownership and in VMT by car are evident in most countries, the patterns described in this section for the United States are not replicated everywhere; in fact, high levels of economic efficiency and of personal mobility are possible without the extreme automobile dependency that characterizes the U.S. transportation system. Despite European trends that mimic those in the United States (increases in car usage, reductions in walk, bike, and transit trips), public transport is still far more widely used in Western Europe than in the United States, accounting for about 10% of total urban travel in Europe, but only 2% in the United States (Transportation Research Board, 2001); similarly, Europeans are more likely to get places via walking or biking (they make between 25% and 35% of their trips by these modes) than are Americans, who make only 12% of their trips via walking or bicycle (Buehler & Pucher, 2012). As many of the chapters in this book make clear, public policy plays a vital role in shaping international differences in land use and transportation patterns. Within the United States, policy shifts over the past 25 years demonstrate a more comprehensive approach to conceptualizing transportation issues.

TABLE 1.4. External Costs of Transport in the United States

Costs in 2006 cents per passenger mile	Range
Congestion	0.88–7.5
Accidents	1.4–14.4
Air pollution	0.09–6.7
Climate change	0.06–4.8
Noise	0.00–3.5
Water pollution	0.01–0.05
Energy security	0.2–0.84
Total	**2.56–37.79**

Source: Delucchi and McCubbin (2011).

THE POLICY CONTEXT

In the early 1990s the policy context for transportation planning in the United States changed dramatically with the passage of two key pieces of federal legislation: the Clean Air Act Amendments (CAAA; passed in 1990) and the Intermodal Surface Transportation Efficiency Act (ISTEA; passed in 1991). The Clean Air Act of 1970 identified the automobile as a major contributor to the nation's air pollution problems and explicitly enlisted transportation planners in the effort to meet air quality goals. The 1990 CAAA required that the transportation planning process be broadened to integrate clean air planning and transportation planning at the regional level. Specifically, the CAAA set out goals for cleaner vehicles, for cleaner fuels, and for transportation programs to meet air quality standards.

ISTEA allocated funding support and set out institutional processes to meet these goals. As Howe put it, ISTEA embodied "a whole new attitude toward transportation planning" (1994, p. 11). ISTEA stated, "It is the policy of the United States to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy-efficient manner." As you can see from this policy statement, ISTEA construed the transportation problem far more broadly than had previous policies—to include energy consumption, air pollution, and economic competitiveness as goals in addition to increasing mobility. In 1998 Congress passed the Transportation Equity Act for the 21st Century (TEA-21), legislation that continued the transportation planning and funding philosophy embodied in ISTEA. TEA-21 was followed in 2005 by SAFETEA-LU (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users) and in 2012 by MAP-21 (Moving Ahead for Progress in the 21st Century). The latest multiyear transportation funding bill, known as the FAST (Fixing America's Surface Transportation) Act, became law in December 2015.

These federal surface transportation authorization bills (ISTEA and its successors) have increased the flexibility of the regional agencies responsible for transportation planning, known as Metropolitan Planning Organizations (MPOs), in their approaches to solving transportation problems. Funds that earlier had been reserved for highway projects can now be used for all surface modes of transportation, including walking, bicycling, and public transit, which federal transportation funding bills had neglected in the past. Significantly, ISTEA encouraged the building of bicycle and pedestrian facilities and gave priority to managing the existing transportation system more efficiently rather than increasing supply (i.e., building more roads). Beginning with ISTEA, regional planning agencies have enhanced power in the transportation planning arena, and public participation (the involvement of the users of the transportations system) is a mandated, integral part of the planning process. Other goals of the federal transportation spending bills passed since 1991 include protecting environmental quality, preserving the integrity of communities, and providing increased mobility for the elderly, the disabled, and the economically disadvantaged.

All this is a far cry from the days, not so long ago, when transportation planning meant highway building. Throughout the remaining chapters in this book you will see how, together, the CAAA and the ISTEA and its successors—all federal transportation funding bills—have had a significant impact on the way planners conceptualize and try to solve urban transportation planning problems. Keep in mind, however, the close association between transportation and land use (see Chapter 9, in particular); whereas MPOs address transportation issues at the regional scale, local jurisdictions retain control over land use, thereby creating a scale mismatch between planning for transportation and land use.

What are the issues, the problems, the questions that transportation analysts seek to understand and to remedy? Some are evident from the above discussions of recent trends in travel and the contemporary urban context within which travel and transportation planning take place. The increasing separation between home and work and between activity sites in general—together with the growth in population, in households, in the civilian labor force, and in consumption—mean not only that more travel is undertaken for each individual to carry out his or her round of daily activities but also that more and more people are traveling more and more miles. Congestion has long been viewed as the main urban transportation problem to be "solved," mainly by constructing more and more highways with ever greater capacity. Since the 1950s, however, we have learned the ironic lesson that increased highway capacity generally cannot keep pace with the increased travel demand that is attracted by faster movement and lower-cost travel; as a result, even with more highway capacity roads remain congested.

Legislation passed over the past 25 years has articulated a range of transportation-related policy concerns—other than traffic congestion—and a number of these are addressed in Part III of this book. Not every major transportation-related problem is accorded a separate chapter in Part III. One example is health. The growing distance between activity sites along with the overwhelming automobile orientation of U.S. society makes travel on foot or by bicycle difficult and often dangerous. In 2009 pedestrian and bicycle travel accounted for only 0.48% and less than 0.02%, respectively, of all person miles traveled but fully 14% of all traffic fatalities (U.S. Department of Transportation, 2009). One might argue, therefore, that part of the urban transportation problem is the threat to health and safety posed by the monopoly that motorized vehicles seem to have in urban travel. Air pollution, water pollution, and traffic accidents (some 34,000 traffic deaths per year in the United States) are all health problems that can be related to the current configuration of urban transportation. There is also the question as to whether the current U.S. transportation system discourages physical activity and encourages a sedentary lifestyle; how would you go about investigating that question?

The policy concerns that *are* addressed in Part III reflect the range of questions that transportation geographers and planners are grappling with: transit, land use change, transportation finance, environmental impacts, energy, and equity issues. Politics surrounds decision making in all of these policy arenas: careful analysis by transportation planners may conclude that a particular plan or policy would best serve the transportation needs of a community, but whether that plan or policy gets implemented is the result of a political process. Because every transportation-related decision will benefit some people more than others—and because who the "winners" and "losers" will be is often defined by *where they live*—the politics of urban transportation often has a distinct geographic dimension, which is evident in the chapters in Part III.

A topic of much public debate is the appropriate role for public transport in U.S. cities. In the 1960s and the early 1970s planners (and the public) looked to transit to reduce air pollution, energy consumption, and congestion, as well as to revitalize downtown areas and to promote mobility for the carless. It is now clear that, although public transportation is not a panacea for all these urban problems, it does fill an important niche in many, if not all, U.S. cities. What are the reasons behind the precarious finances of transit companies in U.S. cities? What is an appropriate role for public transportation in a country as devoted to the private automobile as is the United States? In Chapter 8, Lisa Schweitzer covers the complex policy issues surrounding public transportation.

The intimate relationship between transportation and land use was highlighted at the outset of this chapter, but what are the policy implications of this close relationship? To what extent are transportation projects responsible for increasing urban land values and for generating urban development? Can urban sprawl be attributed to large-scale transportation improvements? Are certain transportation investments, such as light-rail rapid transit lines, an effective means of changing urban land use patterns (e.g., intensifying urban land use or revitalizing certain parts of the city)? Genevieve Giuliano and Ajay Agarwal take up these and other questions about the land use/transportation relationship in Chapter 9.

Transportation investments involve huge amounts of money. What is the economic rationale for investing public funds in transportation systems? How should public monies for transportation be raised and how should they be allocated? What determines how and where that public money gets spent? How can we assess whether or not transportation funds are being allocated equitably across geographic areas and various social groups? In Chapter 10, Brian D. Taylor delves into these and other complexities of transportation finance.

Because most travel in the United States is conducted in motor vehicles, another dimension of the urban transportation problem is the set of environmental impacts stemming from facility construction and from the use of motor vehicles. Although the amount of air pollution generated per automobile has declined significantly in the past 20 years, increases in VMT mean that transportation sources remain a primary contributor to air quality problems. For example, transportation accounts for 86.5% of carbon dioxide; 45.5% of volatile organic compounds, which contribute to ground-level ozone formation; and 61.9% of nitrogen dioxide released into the air (U.S. Environmental Protection Agency, 2010). Transportation planners are now federally mandated to play a key role in maintaining air quality standards. How can transportation investments be made so as to minimize these and other adverse environmental impacts such as noise and water pollution and wildlife habitat fragmentation? In Chapter 11, Scott DeVine and Martin Lee-Gosselin focus on the environmental impacts of transportation.

Transportation is a major consumer of energy, especially energy from petroleum, accounting for 28% of the energy used in the United States but fully 70% of the petroleum consumed (Bureau of Transportation Statistics, 2014; Knittel, 2012). Although the United States has less than 5% of the world's population, it consumes 30% of the transportation energy used worldwide (Davis, Diegel, & Bundy, 2013). In the 1970s the price of energy rose substantially, and the reality of petroleum shortages—and of

U.S. reliance on petroleum imports—forced its way into the American consciousness. What impact have these earlier changes in energy price and availability had upon American energy consumption? What are the policy options for reducing the consumption of fossil fuels in transportation? In Chapter 12, David L. Greene analyzes the many key issues related to transportation and energy.

Because social status in the U.S. city is closely related to location, as is illustrated in this chapter in the maps of Worcester, Massachusetts, the placement of transportation projects will affect various social groups differently. One dimension of the urban transportation problem is, then, who pays for and who benefits from any given transportation investment. Are public transportation costs and benefits distributed evenly among transit users? How can transportation services be provided in an equitable manner? Similarly, are various social groups equally or differentially exposed to the environmental costs associated with urban mobility (e.g., noise, air pollution, traffic accidents)? In Chapter 13, Evelyn Blumenberg explores these and other questions associated with equity in transportation.

Because transportation is so completely intertwined with all aspects of urban life, questions of policy are closely linked to questions of sustainability, and sustainable transportation has to be at the core of any effort to promote sustainable development. While difficult to define, *sustainable development* involves meeting current needs in ways that improve economic, environmental, and social conditions while not jeopardizing the ability of future generations to meet their own needs (Brundtland Commission, 1987). Strategies for sustainable transportation are primarily aimed at reducing fossil fuel consumption, via changing vehicle technologies or altering people's travel patterns (e.g., reducing vehicle trip frequencies and trip distances; promoting walking, bicycling, and use of public transportation). Concerns about social justice and environmental quality are also integral to sustainable transportation strategies. With the U.S. transportation sector the single major source of greenhouse gas emissions in the world (see Chapter 13), current transportation practices in the United States are far from sustainable. Will transportation become more sustainable through reduced vehicle use, through further technology improvement, or through some of each? We invite you to think carefully about how citizens and transportation professionals might improve the sustainability of urban transportation.

Each of the policy chapters examines the evidence that bears upon an issue related to sustainability. An interesting theme that emerges from these chapters is that careful empirical analysis often yields results that challenge long-held ideas. Some of these established, accepted notions emerged from microeconomic theory; others came from earlier, less carefully controlled empirical work. But the message that comes through again and again in Part III is that we cannot assume that an assertion is true simply because it has been accepted and unquestioned for a long time. So, we invite you to read critically and to think about how *you* would go about improving transportation in cities.

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NOTES

1. Calculated from the 2009 National Household Travel Survey; for the U.S. population as a whole, 22% have incomes under $25,000 annually.

2. In 1960, 67.2% of Worcester's MSA labor force worked in the City of Worcester, and in 2000 the percentage was 32.2. The MSA boundaries changed over this period as well; in 1960, the MSA included 20 towns, but by 2000 it included 35 towns. Although the number of workers in the city increased slightly in these four decades (from about 81,500 to 82,800), suburban employment grew at a far greater rate.

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