The Transportation Land-Use Link

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Transportation decisions clearly affect land-use patterns, and land-use decisions clearly affect transportation systems. Urban theorists have addressed the cyclical land-use-transportation relationship for many decades and economists have modeled it extensively. Field studies demonstrate what the economists have predicted and what many theorists have feared: that, in many ways, highways shape urban areas. Yet little of that knowledge has found its way into planning practice, and land-use planning and transportation planning remain separate decision-making processes. Now that Congress has mandated that transportation planners consider both land-use plans and the land-use impacts of their decisions, the literature of planning practice should draw on the theoretical and research literature and provide guidance to planners on how to manage the transportation-land-use cycle.

The relationship between transportation and land use is a complex one. Urban form, whether it is compact, multinodal, or sprawling, has an enormous impact on the type and cost of transportation systems needed to serve residents of a metropolitan area. On the other hand, the type and location of major transportation facilities greatly influences urban form. Stover and Koepke (1988) referred to the relationship as a cycle. It is intuitively easy for a planner or interested citizen to understand that suburbs that grew up around railroad stations, like those of Chicago's North Shore or Philadelphia's Main Line, are the kind of nodal-focused communities that are easiest to serve with fixed-rail transit; it is equally easy to understand the difficulty of retrofitting a fixed rail system to Los Angeles, which grew up around freeways (see, e.g., the comparison of Boston and Phoenix in Kain and Fauth 1977; see also Walbridge 1977).

Although the literature reflects a broad understanding of this complex relationship, and some of that literature dates back many decades, surprisingly little of the learning from the literature has been put into effect. Transportation planning and local "comprehensive" planning (which often really means only "future land-use" planning) continue to take place quite separately, resulting in combinations of public policies that rarely reinforce each other and that often work at cross-purposes. One of the problems with the literature on the subject is that it does not include much that is directed at mainstream planning practitioners. The literature described below includes some relatively recent urban design pieces and a handful of books directed to transportation planners. However, most of the rest of the literature is scholarly or theoretical. A few recent pieces, notably work by Anthony Downs (1992), are aimed at a broad public-policy audience but do not necessarily reach the planners who are developing local plans.

The 1991 passage of the federal Intermodal Surface Transportation Efficiency Act (ISTEA), some forty-five years into the construction of the National Interstate and Defense Highway System, suggests that it is time to change all of that—time for local planners and highway engineers to work together. As state transportation and highway departments begin to implement the new

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law, and as urban designers revisit some "traditional" transportation and land-use relationships, it is worth reviewing the literature to see what planners and engineers can learn from past plans and field experience.

This article examines literature on this issue spanning six decades, ranging from theoretical works to case studies and practical recommendations for implementing improved planning systems. It begins with a review of philosophical examinations of the relationship, followed by a discussion of the economic principles involved in land-use and location theory. It then discusses some of the practical implications of public land-use and transportation decisions in the context of these principles and then reviews the literature most often used by those who make such decisions.

PHILOSOPHICAL EXAMINATIONS OF THE RELATIONSHIP

It seems important to start with an examination of basic philosophies about transportation and the city. A number of these essays pose basic questions about the nature of the relationship. Some argue that transportation should be made to fit the city. Their starting point is largely with cities like New York, Philadelphia, Chicago, and great world cities like London and Paris—all cities that grew up with rail commuting. The urban form of those cities is highly compact and typically oriented toward nodes of activity around railroad stations. Attempting to preserve such cities and to make others more like them is a strong argument for fixed-rail transit, for such transit is an integral part of those cities. At the other extreme is the argument that the modern city should be redesigned at lower densities around an auto-oriented transportation system. The one area of agreement in the essays is the need for better planning—planning for transportation as a system rather than as a collection of discrete elements, and coordinating transportation and land-use planning.

In a late 1950s essay, Lewis Mumford (1963) warned:

> Now that motorcars are becoming universal, many people take for granted that pedestrian movement will disappear and that the railroad system will in time be abandoned; in fact, many of the proponents of highway building talk as if that day were already here, or if not, they have every intention of making it dawn quickly. The result is that we have actually crippled the motorcar, by placing on this single means of transportation the burden for every kind of travel. Neither our cars nor our highways can take such a load. This over-concentration, moreover, is rapidly destroying our cities, without leaving anything half as good in their place. (p. 235)

In an article on "Urban Sprawl," William H. Whyte, Jr. (1958) expressed concerns similar to those of Mumford:

> Under the provisions of the Federal Highway Act of 1956, some 41,000 miles of new highway are going to be laid down, and the effect, as the planners of the act have frankly declared, "will be to disperse our factories, our stores, our people; in short, to create a revolution in living habits."
>
> The communities affected, however, have little to say about the revolution; the act puts the program entirely in the hands of state highway engineers.
>
> But perhaps the most important feature of the new highway program will be the location of the interchanges, for these will be to the community of the future what river junctions and railroad division points were in the past. The interchanges become the nodes of new developments, and whatever ideas planners may have had for the area, the pressure of land prices can be an irresistible force for hit-or-miss development. (p. 126)

Whyte was more optimistic than Mumford; he saw the possibility of good planning and coordination of transportation systems, land development, and open space protection. Like Mumford, however, he realized that the National Interstate and Defense Highway System would forever change the urban form of the United States.

Mumford did not oppose the highway system. He saw it as a valuable resource for intercity transportation but as a threat if used for commuting and other circulation within the city. Mumford advocated a "townless highway" and its corollary, the "highwayless town," which he credited to Benton MacKaye (1930). Mumford saw the highway system as a useful link between metropolitan areas, but one that should feed a city through linear arterials rather than through "capillaries and veins." Actually, MacKaye's (1928, 1930) approach was a little different from Mumford's; he did use the term *townless highway* but did not refer to a *highwayless town*. As that semantic analysis may suggest, the issue that he addressed was the impact of development on highways, not the obverse. He was an early advocate of limited-access expressways and was not at all concerned by the implications of long-range commuting, focusing only on what he saw as the benefits of such expressways:

> The lawyer's son (or daughter) who aspires to a legal career need not go and live in a large city nor in the suburbs of a large city; he (or she) is enabled, physically, to live in the real country—by private motor or community bus to be in the office promptly in the morning and back again in the village in plenty of time for supper. (MacKaye 1928, 163)

MacKaye's great fear was a strip of endless development along the highway, something that he called "roadtown" (MacKaye 1930) and that planners today call "strip commercial." To avoid the creation of roadtowns, he advocated a combination of limited-access expressways and communities designed like Radburn, New Jersey, with hierarchical street systems and residences facing only on the nonarterial streets. It is ironic to note that MacKaye's worst fears have been realized,

despite the implementation of an extensive system of limited-access expressways and despite the fact that the hierarchical street system has replaced the grid as the preferred design of traffic engineers (Stover and Koepke 1988).

Lewis Mumford's view of the city and its relationship to the automobile is in many ways similar to that of urban designer Victor Gruen (1964), who called for "the taming of the motorcar." Gruen's ideal city included concentric beltways but no radial routes into the center of the city. His vision also incorporated pedestrian malls on Main Street, a largely failed concept that he included in many local plans developed by his consulting firm. It is an ironic historical note that Gruen is viewed by many as the creator of a frequent destination of today's drivers—the indoor shopping mall.

In his "The Highway and the City," Mumford (1963) went on to raise a fundamental question about transportation planning:

> What's transportation for? This is a question that highway engineers apparently never ask themselves, probably because they take for granted the belief that transportation exists for the purpose of providing suitable outlets for the motorcar industry. To increase the number of cars, to enable motorists to go longer distances, to more places, at higher speeds, has become an end in itself.... The purpose of transportation is to bring people or goods to places where they are needed and to concentrate the greatest variety of goods and people within a limited area, in order to widen the possibility of choice without making it necessary to travel. A good transportation system minimizes unnecessary transportation. (p. 235)

Wilfred Owen eloquently made the argument for proponents of highways as the most modern and convenient form of transportation. In a much cited examination of *The Metropolitan Transportation Problem* (Owen [1956] 1966), he posed the broad question: "Should the city adapt to the automobile or should transport technology instead be adapted to existing patterns of urbanization?" (p. 26). Although he acknowledged negative impacts of automobiles on cities, including the fact that suburbanization had simply tended to move the city's mistakes outward, he also noted that there were many reasons other than convenience why people might rationally move outward from the city center. Factors that he cited as considerations in that decision ranged from diseconomies of scale in the hearts of large cities to the need to disperse the population in order to limit the impact of nuclear attacks; he cited Frank Lloyd Wright on the latter point.

Owen examined fixed-rail systems, buses, and automobiles as modes of urban transportation. He saw the most untapped potential in buses, although he also supported the early proposals for the addition of fixed-rail systems to the Washington and San Francisco metropolitan areas. After examining all of the options, however, he came out in favor of highways:

> Only a total network of controlled-access expressways and parking facilities can provide a skeleton that will support the giant metropolis of the future. If only parts of the highway network are of satisfactory design, the skeleton is bound to collapse under the weight of the peak-hour movement attracted by expressway standards. (Owen [1956] 1966, 215)

In another publication, based at least in part on *The Metropolitan Transportation Problem*, Owen's (1968) vision of the impact of highways on the city sounded more like that of Mumford, although with a different philosophical cast:

> The big hope for moving around in urban areas is to move the urban areas themselves around. We will have to attack the congestion of moving by overcoming the congestion of living. Metropolitan mobility depends on regional planning that creates a more orderly arrangement of urban living and working.... The highway program, combined with urban renewal, is offering us the chance. (p. 242)

Owen's piece expressed great concern about sprawl and again suggested some form of population limits and the movement of employment centers out of the central city. He was convinced that "the highway program itself can help to achieve the environment that is essential to its success. Highways are, in fact, one of the most potent tools of the planner. The highway system forms the skeleton of the giant metropolis" (p. 243).

Although a true believer in the highway system, Owen ([1956] 1966) was thinking far ahead of most highway advocates of the 1950s and well ahead of many transportation planners in the 1990s. Among the concepts that he advocated were the following:

- condemnation of excess right-of-way to be used for controlled commercial development along the expressways (p. 215);
- use of pricing policies, including tolls on urban expressways, to control transportation demand, particularly at peak hours (pp. 216, 218);
- pooling of financing for all metropolitan area transportation, so that highway users might "help support improved peak-hour transit service . . . rather than to subsidize little used rural roads" (p. 217);
- combined governance of metropolitan transportation systems, a logical corollary of the concept of pooling funding (p. 218);
- staggered hours "for working, shopping and school" (p. 222); and, last but not least
- "both population limits and geographical limits . . . on urban development. There is increasing evidence of the need for directing more urban growth into new towns and existing smaller towns. This would seem preferable to the overcrowding that modern transportation now makes unnecessary, or to the endless sprawl that modern transport has made possible" (p. 222).

In short, Owen saw many of the problems that concerned Mumford and Whyte. He simply saw more opportunities to solve them with a highway-dominated metropolitan transportation system. Interestingly, many of those were heavily dependent on good planning and regional cooperation. One of Owen's concepts may have been farther ahead of its time than others, or perhaps just wrong. He suggested that "the helicopter, convertiplane, or other direct-lift aircraft will some day furnish the transportation service necessary to spread the urban traffic load over a wider area" (Owen [1956] 1966, p. 214). The implications of helicopter suburbs are perhaps best left to a later piece.

Urban designers Arthur Gallion and Simon Eisner (1950) had made a similar argument in a classic text a decade before Owen:

> It is sometimes claimed that the motor vehicle created the congestion of cities. The opposite is true. The extent of the city was only 2 or 2½ miles in radius in the days of the horse-car. The electric street car expanded the radius to 5 miles with a travel time of about one-half hour each way. The automobile stretched this radius to 15 miles in the same travel time. The only relief from congestion has been possible because of the motor vehicle. It is an unplanned and obsolete street and transportation system and excessive population density that have caused congestion. (p. 193)

Gallion and Eisner argued that the solution to urban congestion was to solve the parking problem entirely with surface-level, off-street parking, an approach that "would lead to a gradual balance between building floor space and open ground space. It would also lead to a gradual removal of blighted structures" (p. 201).

A decade later, a group of RAND researchers (Meyer et al. 1965) took a position much nearer that of Owen than that of Whyte and Mumford. They concluded that the dispersal of both industry and housing would have occurred with or without the convenience of the freeway system and regardless of the availability of transit. They cited both technological and economic factors in support of their conclusions. The economics were not complex. They found that workers with larger families traded increased transportation cost and time for larger homes on larger lots in the less-expensive suburbs. Also leading to dispersal were urban problems and industry's need for sprawling, one-story assembly line plants to replace the multistory factories of the first half-century or so of the Industrial Revolution. One of their conclusions, however, seems somewhat at variance with their notion that the highways were incidental to the changes. By modeling the elasticity of demand, an economic concept used to measure how sensitive consumers are to price changes, they concluded that consumers were wedded to their autos—price increases did not easily influence them to switch modes of travel. Freeway convenience was clearly a major factor in people's growing attachment to the automobile and, indeed, the RAND team found that all urban transportation systems worked surprisingly well when viewed in context; they noted in particular that it was unrealistic for commuters to expect the highways to function as smoothly at peak hours as they would during the rest of the day.

In their conclusion, the RAND team, like Owen earlier, emphasized the need to manage the transportation resource, particularly highways. Like Owen, they suggested the use of tolls with higher peak-hour charges as a method of demand management. Like Owen, they hoped for technological improvements to increase the efficiency of highways. Some of their recommendations, such as metered access at peak hours and priority access or priority lanes for buses, have now been implemented in many cities. Like Owen, they saw increased use of helicopters and other aircraft for commuting. Unlike Owen, however, they strongly opposed subsidies from highway users or others to urban transit systems.

THEORETICAL ANALYSES OF THE RELATIONSHIP

Before turning to field studies of the relationship between transportation systems and land use, it is important to consider what those studies might show—to form a sort of minihypothesis as a context for reviewing the field studies.

In what may be the longest view of transportation and urban form, Schaeffer and Sclar (1975) offered their history of urban form, beginning with "the walking city," then evolving to the "tracked city," and, finally, "the rubber city." They argued that a lack of transportation created the earliest cities because people needed to be near each other, and that the relative scarcity of transportation before "the rubber city" kept cities reasonably compact and contiguous.

Basic theory about the relationship between land use and transportation is rooted in economic concepts, which are, in turn, based on notions of consumer behavior. "The Journey to Work" in 1951, an early theoretical look at the issue by the American Society of Planning Officials (ASPO), recognized that the major issue that concerned most consumers was not the distance of their residence from where they worked but the length of time that it took them to travel that distance. The ASPO report introduced the use of "iso-time" lines, the irregular modifications of circles that transportation planners continue to use to geographically represent the travel-time relationship between different parts of the community and the center city. That report focused on the importance of accessibility in determining land uses,

with particular emphasis on new industries (employers) and new housing developments. The "journey to work" as measured by the time-based iso-time zones was presented as an important factor in determining appropriate locations for industrial and residential development. In one sense, this was an early argument for adequate public facility standards (discussed below), although the report did not go so far as to suggest that local governments go beyond zoning to control the location of new development.

A decade later, Lowdon Wingo (1961) outlined his economic model of the relationship in *Transportation and Urban Land*. Although the ASPO report discussed the costs of the journey to work, the emphasis there was on the length of that journey as measured by the clock. In contrast, Wingo placed the emphasis on money. He argued that a rational consumer would spend a fixed amount on the combination of transportation (commuting) and housing and that the amount "spent" on commuting would include some recognition of the value of the time spent on the journey. Four years later, a book based on substantial field research (Meyer et al. 1965) supported Wingo's theory without citing it, noting that

> workers employed at high-density workplaces have an option between higher transportation expenditures and higher housing costs and many choose to make longer and costlier work-trips from the suburbs in order to obtain more cheaply the housing and yard space they want. (p. 119)

William Alonso (1964) developed a logical corollary of this theory in his frequently cited *Location and Land Use*. It has been called by another theorist "the most complete and general model of urban location theory" (Mills 1972a, 67). Alonso described a model of urban land values. The important variables in the model were location of the land in relation to the center city and transportation. Alonso hypothesized that the difference in land values of various parcels would vary inversely with the transportation cost from each parcel to the center city. His model, like Wingo's, suggests that the highest values will attach to property with the best access to the center city. It is interesting to note that Wingo's and Alonso's works were contemporaneous but independent (see discussion in Alonso 1964, p. 15, note 26). Wingo cited the unpublished 1960 dissertation version of Alonso's work, and Alonso's book then cited Wingo.

Some time earlier, Hoover (1948) had developed a much more complex model of the local land market. It recognized that access is more important to some industries than others and that inherent qualities of land (such as soil type), may affect the value of that land to some producers (such as agriculture) and not others. Nonetheless, Hoover's model recognized the physical "transfer costs" of goods as a key factor in valuing particular sites for particular uses. He cited a Chicago report, noting that accessibility for industries had first been defined by river frontage, then by rail access, and, more recently and only in part, by truck access. Mills (1972b) also developed a more complex model of the urban land market. Like Hoover (whom he did not cite), Mills recognized that transportation was an important variable, but not the only variable, in determining land rents and thus land values. Hoover had focused on the inherent characteristics of land (based on traditional agricultural economics), but Mills emphasized production inputs and the ability to make substitutions of capital for labor, labor for capital, or capital for land (perhaps building a taller building) as key variables in determining land rents. In a separate work, Mills (1972a) discussed both Alonso's and Wingo's models in the context of his urban economic theory. He criticized both, basically on the grounds that they were too simple. The essence of his critiques is that the models are imperfect predictors of particular land values under particular circumstances. Nothing in those critiques contradicts the fundamental notion that accessibility is a key element in land value and use.

All of these models accepted accessibility essentially as an uncontrolled variable. None of them discussed (although presumably each of the authors would acknowledge) the implications for their work if accessibility were considered to be a controllable variable. Building a new radial highway from the center city to a suburb expands the boundary of the iso-time zones farther out from the city along that route, thus making sites all along that route relatively more attractive for the location of residential or industrial development (ASPO 1951). Because of the increased accessibility, residences along that route will have increased value to consumers, who now must spend less commuting time (and possibly money) to reach those residences or sites of potential residences (Wingo 1961). For exactly that reason, and confirming Alonso's model, land along that route will increase in value—a fact that also recognizes the increased attractiveness of such land for development, such attractiveness being the private sector's corollary of the public sector's recognition of the increased appropriateness of development along that route.

Schaeffer and Sclar (1975) approached this economic relationship differently. They argued that "most of the benefits of urban transportation accrue not to the traveler, but to third parties such as real estate developers, retailers and employers whose land or services have become accessible through the existence of transportation" (p. 121). Therefore, their argument continued, it is not rational to require that transportation systems be user funded, if the traveler is considered to be the user.

They urged a combination of peak-hour surcharges for using highways and gasoline-tax subsidies for mass transit as a method of limiting the subsidies to drivers and balancing the economic impacts of highways on cities.

In a more recent effort, de la Barra (1989) has outlined a method of integrated land use and transport modeling. In his book, he cited the work of Alonso, Wingo, and others; he also cited other models that examine behavior without attempting to determine why it occurs, as Hoover, Wingo, and other economists have done. De la Barra's model recognized the interactive nature of land use and transportation systems, with feedback loops demonstrating how a change in land use affects related transportation systems and how a change in transportation systems affects accessibility and probable future land-use decisions. His book gave examples of applications of the model to both land-use and transportation planning decisions in Brazil.

Viewing the relationship from the other perspective, Pushkarev and Zupan (1977) examined what kind of development works well with fixed-rail public transit. Their findings were the following:

- At densities between one and seven dwellings per acre, transit use is minimal.
- A density of seven dwellings per acre appears to be a threshold above which transit use increases sharply.
- At densities above sixty dwellings per acre, more than half the trips tend to be made by public transportation. (p. 173)

This, of course, brings back full force the chicken-and-egg nature of the problem. If one views public transit as desirable, it can exist only with relatively high-density development. Yet the models suggest (and studies cited below illustrate) that contemporary, highway-oriented cities are unlikely to evolve at the kinds of high densities necessary to support transit use.

There are a number of other theoretical models of the relationship between transportation and land use, all built on basic concepts of how individuals and business organizations make site-location decisions, all of which comes back to basic principles of economic behavior. For the scholar particularly interested in those models, both Deakin (1991) and de la Barra (1989) included good bibliographies, and de la Barra summarized and compared many of the models before outlining his own. Handy's (1992) bibliography, discussed in the following section, also contains several theoretical models.

APPLIED ANALYSIS OF THE RELATIONSHIP

A 1975 study examined the impacts of public investments in infrastructure on development patterns in the metropolitan areas of Boston, Denver, the Twin Cities, and Washington, D.C. (Environmental Impact Center 1975):

> A basic conclusion of this study, supported by both the literature review and the statistical analyses, is that public infrastructure investment can have an important impact on the location, type and magnitude of development, particularly for single-family homes. The strong relationship with single-family homes should be interpreted as meaning that the secondary effects are particularly strong at the urban fringe since this is where most single-family home construction has taken place over the last two decades. (P. 1)

The report noted that earlier studies (those cited were unpublished local government studies) had found that "highways have little influence on single-family, low-density residential land use" (Environmental Impact Center 1975, 7). However, the studies cited were dated before major construction on the interstate highway system began, a factor that clearly caused a paradigm shift in many transportation models. By 1975, the authors concluded:

> The available evidence suggests that households and businesses prefer good access by highway, all other factors held constant. In terms of actual location, single-family housing construction has a tenuous connection to new highways, multi-family residential and commercial development appear to be influenced by highways; and the relationship of industrial development to highways is unclear. (Environmental Impact Center 1975, 8)

They also found that the greatest impact of infrastructure investment occurred where there were large quantities of undeveloped land at a reasonable price—in other words, where developers had a choice of multiple locations in which to build. Not surprisingly, they found that the impact of such investments was significantly greater where the existing levels of access to developable areas were not good. The authors found local land-use controls to be so ineffective as not to be significant factors in most of their examples.

A year later, the Council on Environmental Quality published a slim report entitled *The Growth Shapers* (Urban Systems Research & Engineering 1976). This well-illustrated seventy-two-page report noted,

> The link between infrastructure investments and land use changes has long been recognized in a general way, but little has been done to control the design and location of new infrastructure. Instead, the tactic has been to attempt to reduce the negative impacts of unplanned growth with tools such as zoning, subdivision controls, and local planning. These techniques often fail, particularly when land use is changing rapidly, as it often does following construction of new infrastructure. Changing the design of the infrastructure itself can be an effective additional control method, reinforcing the effectiveness of the other land use controls. (p. 5)

The Growth Shapers was not a scholarly report, and it attempted to prove nothing. It simply used case studies and theoretical examples to illustrate its fundamental point, which is that infrastructure investments—particularly those in highways, mass transit, and sewer lines—shape the growth that occurs in metropolitan areas.

The use of the word *shape* is important. No one has asserted that infrastructure investment causes growth. Careful examination suggests that a lack of transportation facilities may discourage economic development in a particular area and that excellent transportation facilities may, in theory, give one region an advantage over another. However, with the well-developed highway system throughout the continental United States, it is unlikely that construction of a new road in an area that is not otherwise attractive to growth will stimulate economic development there (Kraft et al. 1971; Forkenbrock et al. 1990). While Forkenbrock and his colleagues found that rural highways alone were unlikely to trigger economic development, Moon (1987) used case studies in Kentucky to illustrate how interstate highway interchanges reshape rural communities. A 1971 bibliography contained an examination of the planning and regulatory issues related to highway interchanges (Mason 1971), and a 1974 bibliography contained a large section of material on the same topic (Chipman et al. 1974).

The notion that highway investments shape growth within a region is entirely consistent with Alonso's model of land rents, with Hoover's model of economic location decisions, and with Wingo's commuting/housing cost model. Under any of these models, a new road makes land with access to it relatively more accessible and thus more attractive to particular types of development (Hoover), or more valuable (Alonso), or simply more valuable for residential purposes (Wingo). All of this is entirely consistent with findings that new highways will not bring economic development to a stagnant area; if demand is inelastic—as it will be in a stagnant area—a small change in one factor will not greatly change demand. Viewed more simply, if no one is buying, simply making land more attractive will not make it sell (see, generally, Deakin 1991).

Although *The Growth Shapers* (Urban Systems Research & Engineering 1976) was the first study of its kind directed to an audience of public officials, a number of studies of particular communities have yielded results supporting the hypothesis of the growth shapers. In the mid-1950s, Clarkstown, New York, adopted what may have been the first local-growth management program in the country when construction of the Tappan Zee Bridge brought it within convenient commuting distance of New York City. Ramapo, its more famous neighbor to the west, adopted a similar program a decade later when the completion of a New York State Thruway link further extended the convenient iso-time zones of New York City to include it (see Kelly 1993a, 78).

Most of the discussion in the literature concerns the relationship of automobiles, and automobile commuting, to the urban area and urban form in particular. The automobile, however, is not the only vehicle that has changed urban land patterns. Schaeffer and Sclar (1975) argued that the truck caused earlier changes to the city than the automobile.

> Before the truck, industry had to locate in the urban core or at railroad sidings. Since these sites were limited, good industrial land was scarce. With truck transport any area with serviceable roads and not too far from the core could become an acceptable site. (p. 84)

Using data from Boston, they noted that several major indexes of industrial activity showed that there was a rapid shift of such activity from the core to "inner-ring" communities (within two to six miles of the core) beginning in 1914. Industrial land uses, once concentrated along railroad lines, now generally adjoin major highways. In this way, too, the highway shapes the city.

Although most of the cited studies of the impact of highways on cities rely on the evidence of experience, Nelson (1950) foresaw both that radial highways would "compound congestion" in the urban core and that they would facilitate and expedite urban flight. He argued for the "planning and rebuilding of compact and pleasant cities" (p. 122).

The notion that transportation influences growth patterns is hardly new. Philadelphia's toniest suburbs have long been referred to as "the Main Line," recognizing their location along the commuter stations of the old Pennsylvania Railroad Main Line—the transportation link that led to their development in the last part of the nineteenth century. Warner (1962) made a rigorous study of the pattern of growth from 1870 to 1900 in the *Streetcar Suburbs* of Boston. Like such later studies as *The Growth Shapers*, Warner noted that the suburban expansion was a function of the expansion of several types of infrastructure, of which transportation was probably the dominant one.

In a 1980 study, two consulting firms under contract to the U.S. Department of Transportation and the Department of Housing and Urban Development examined the land use and urban development impacts of beltways (Payne-Maxie Consultants and Blayney-Dyett 1980). The consultants examined the impacts of beltways around Atlanta, Baltimore, Columbus, Louisville, the twin cities of Minneapolis-St. Paul, Omaha, Raleigh, and San Antonio. Their findings were the following:

- "Interstate 285 has affected the distribution and location of new development in the Atlanta SMSA. . . . It

contributed to dispersal of economic activity but was not the major factor in this process" (p. 7).

- In the Baltimore area, "The counties' permissive planning posture and their competition with the city were more critical factors to stimulating suburban development than was the existence of the beltway, although its presence probably added momentum to the dispersal process" (p. 9).
- "Columbus' beltway provided regional benefits without adversely affecting the CBD because of the city's strong political leadership, which combined an aggressive annexation policy with an active commitment to downtown, as illustrated by several major tax increment and tax abatement financed renewal efforts. Coordination of transportation and land use planning, and the powerful influence of the timing and location of Interstate projects also underlie the positive impact of the beltway in the region" (p. 10).
- "From a regional perspective, the [Louisville] case demonstrates growth dynamics only vaguely perceived in the comprehensive plans prepared by local officials and planning consultants" (p. 11).
- In the Twin Cities, "the belt has had no discernible fiscal impact upon the central city, for other forces far outweighed the outward pull of the belt, and these have been partially mitigated by active community concern for the viability of the downtowns. . . . Committed leaders of the business community working closely with city planning departments have created a successful innovative and far-reaching revitalization program for the downtowns, particularly in Minneapolis" (p. 13).
- In Omaha, the study found that highways were important, but not the beltway. "Interstate 80, running out of town to the southwest, has been a much more important focus for the growth allowed to slip out of central Omaha by very permissive land use policies. The Omaha Industrial Strip, 90 percent of which is comprised of firms previously located near downtown, has grown up over the last 30 years between I-80 and the main line of the Union Pacific Railroad. Residential suburbanization has occurred to the southwest where utilities were easily available and access to the downtown via I-80 maintained Omaha's reputation as the 'twenty-minute city' " (p. 14).
- "Like Columbus, Raleigh's strong annexation policy and control over water and sewer service resulted in the retention of beltway-related activity within the city, minimizing adverse fiscal effects of outlying development" (p. 15).
- "From a planning perspective, the San Antonio case study shows how highways can influence development patterns in the absence of explicit land use policies and maps, restrictive zoning regulations, and comprehensive infrastructure improvement programming" (p. 17).

In sum, the study found that highways were an enormous influence on urban form. Interestingly, the success of the Raleigh and Columbus cases was not that they maintained a more compact urban form but that they were able to expand their city limits through annexation to keep the sprawling beltway development within the legal (and fiscal) jurisdiction of the respective city governments. Omaha illustrated the power of the combination of the growth shapers, where the availability of sewer and water reinforced the availability of transportation (there measured in time, the "twenty-minute city") to attract development to the southwest. A defect in the analysis is the authors' rather naive assumption that land-use controls might overcome the economic forces unleashed by the growth shapers. The communities that succeeded in managing growth did so not through land-use controls, but through the control of sewer and water and through annexation policies; this should have alerted the authors to the possibility that land-use controls are inadequate to stop these economic forces. A study published several years earlier (Clawson 1971) found that zoning was not an effective tool to direct suburban growth. That is not a particularly surprising finding, because zoning was developed as a tool to maintain established neighborhoods, not as a tool to manage the development of the suburbs (see, generally, Kelly 1988).

The beltways illustrate the changing nature of the relationship between highways, urban form, and commuting patterns. The early urban highways, like the earlier transit systems, were generally continuous routes that went through (or near) the urban core, serving lands in two directions; or they were radial routes, primarily linking the urban core with outlying areas. Beltways, which go around the urban areas generally near the fringe, are something quite different. Although they were conceived in part to divert the "interstate" part of traffic on urban freeways around the urban core, beltways serve another purpose as well: commuting to destinations other than the urban core.

Planners have hoped to reduce congestion by achieving a jobs-housing balance in various subsectors of the metropolitan region; the idea is to provide people with job opportunities near their homes and thus reduce the need for commuting (Giuliano 1991; Cervero 1989a; see, e.g., Montgomery County Planning Board 1990). Giuliano (1991) noted that the "jobs-housing balance is a new label for a planning concept that has a long history; the balanced or self-contained community . . . [is] one in which residents can both live and work" (p. 305). The mere transfer of employment centers out of the urban core does not solve the problem, however. Despite a large increase in suburban employment opportunities, commuting in major metropolitan areas has increased (Cervero 1989b). That is not particularly surprising, for, as Giuliano (1991) noted, "it is not clear that living close to work is a high priority for most people" (p. 308). Giuliano found that the relationship is far more complex than it seems and thus difficult to manage. For example, different types of housing attract different kinds of people. Thus it is necessary to balance the types of housing with the types of jobs, as well as to balance the raw numbers. Further, it is not clear that a particular municipality, or even a county within a met-

ropolitan region, is necessarily the appropriate geographical unit within which to measure such a balance.

Cervero (1989b), still seeking the jobs-housing balance while acknowledging the traffic problems associated with current suburban employment centers, argued for a much more sophisticated system of managing transportation and land-use systems.

It is worth considering briefly the question of why transportation investments have an impact on land-use patterns, although the answer will be intuitively obvious to many readers. Using the twenty-minute city example suggested above, construction of a new radial highway leading out from the central city increases the supply of land that falls within a twenty-minute commuting distance; it also, of course, increases the supply of land within five minutes, ten minutes, and fifteen minutes. That makes residences on the land more attractive to consumers and thus makes the land more attractive to developers and, presumably, more valuable. Stover and Koepke (1988) gave a dramatic example: from 1957 to 1970, vehicle registrations in San Diego nearly doubled; thanks to the construction of 166 miles of freeway in the same period, however, the land area within twenty peak-hour minutes of the central business district *tripled* (p. 3).

Because accessibility is important to housing consumers, it is important to developers. A Twin Cities study found that the availability of highway access was a checklist item that might eliminate a site from consideration by a developer early in the review process (Baerwald 1981). A late 1920s study found a positive correlation between transit access and land values in New York City (Spengler 1930). A study seventy years later found that access to mass transit in the San Francisco Bay Area of California had tangible value to consumers, and that the consumers living in the transit-oriented projects were much more likely than others to use the system (Bernick and Carroll 1991). Interestingly, although developers were satisfying consumer demand for such projects, they apparently did not place a premium price on the land or on the units that they built on it (Bernick and Carroll 1991).

Using land in the Baltimore area, Czamanski (1966) sought to determine the effect of public investments on urban land values. He hypothesized that accessibility would be a key predictor of land values, but he used a more sophisticated concept of predictability than Alonso's model had suggested. Czamanski recognized that within a metropolitan area there are important functions at multiple locations, ranging from shopping to employment to health care and education. He constructed an accessibility index to urban functions and computed that index for each of the test parcels. From his empirical analysis, he found that "the value of all types of urban land depends to a very high extent (often to the point of exclusion) upon the Accessibility Index as defined in this study" (Czamanski 1966, 211).

The relationship between transportation and land use is not one way. As Stover and Koepke (1988) have suggested, it is a cycle. Transportation facilities influence land-use patterns, which in turn influence transportation demand. Handy (1992) synthesized the research from a number of reports on how land use patterns affect travel patterns. Among her conclusions are the following:

> Density: Higher densities decrease the number of trips taken [per dwelling unit], the percent auto, and total energy, but decrease speed and may increase trip length.
>
> Activity mix: the influence of the mix of activities on travel has been less extensively and less consistently explored. Studies show a weak link between land use mix within specific areas and travel patterns for these areas.
>
> Jobs decentralization: the net impact on travel and energy use is uncertain. (p. 3)

Handy's annotated bibliography included a number of works cited here. Her general conclusions are entirely consistent with those of others mentioned (e.g., Pushkarev and Zupan 1977; Cervero 1989a), although not all agree with her conclusion that higher densities reduce the number of trips. It is important to remember that trips per acre of land will *increase* with higher densities, because there will be more dwelling units per acre and thus more people per acre. It is trips *per dwelling unit* that will presumably be reduced. However, this is not always true. One of the factors affecting such an assertion is that the occupancy of higher density dwelling units is likely to be significantly different from the occupancy of single-family detached units (see discussion in *The Costs of Sprawl* [Real Estate Research Corporation 1974] below, particularly the critiques by Altshuler [1977] and Windsor [1979]). To put it simply, the older people and younger people who typically occupy apartments are likely to generate fewer trips per household than are the families who typically occupy houses.

Newman and Kenworthy (1989a) expanded their earlier Australian study of the relationship between transportation systems and urban densities to include thirty-two cities from around the globe (see Newman and Kenworthy [1989b] for an overlapping discussion of the data that appeared in journal form). In their study, they found a high correlation between high density and transit dependence, a finding that is hardly surprising and that reinforces the more theoretical work of Schaeffer and Sclar (1975). As a solution to the problem of automobile dependence, they suggested the reurbanization of smaller cities at densities sufficient to discourage the use of automobiles. In his review of their book, Gomez-

Ibanez (1991) pointed out that correlation did not necessarily amount to causation; other factors also influence modal choices, such as incomes, gasoline prices, and public policies to subsidize various means of transportation. In an earlier critique, Gordon and Richardson (1989) raised similar objections but also criticized Newman and Kenworthy's focus on the single goal of reducing gasoline consumption; Gordon and Richardson also raised the issue of the strong personal preference for the convenience of the automobile in the United States, and they noted that the increase in suburb-to-suburb commuting and nonwork trips makes it more difficult to realize Newman and Kenworthy's goal of replacing much automobile travel with trips by light-rail. They ignored a key point raised by Gomez-Ibanez, which is the choice of subsidy patterns by various government agencies, and they failed to discuss how reduced highway subsidies might affect the strong personal preference for automobiles.

There have been a number of other studies of the impacts of particular facilities and a few more general studies not mentioned here. Handy (1992), Chipman et al. (1974), and Mason (1971) all offer good bibliographies. There is, of course, fertile ground here for additional research. A 1991 symposium on "Transportation, Urban Form, and the Environment" posed more questions than answers and suggested extensive additional areas for research (Transportation Research Board 1991). The thrust of the suggestions, however, was not to question the strong link between transportation and urban form but rather to suggest a greater need to understand its details as the basis for future public policy analyses. One can, of course, wait for perfect answers before beginning to act. On the other hand, one can begin to act in logical ways while continuing to analyze the issue, the typical and necessary behavior of public planners in many contexts. Some have even argued that it is impossible in so complex a society to obtain a complete set of information about any problem and that it is thus always necessary to act with imperfect knowledge (Braybrooke and Lindblom 1963). While continued research in this field is clearly desirable, this article now turns to the substantial theoretical, empirical, and anecdotal data linking transportation and land-use decisions.

IS THIS KNOWLEDGE IMPORTANT?

The discussion so far has focused generally on the fact that transportation facilities and land use influence each other. Studies discussed above show that, both in theory and in the field, different patterns of urban development are best served by different types of transportation systems. Similarly, the location and type of transportation improvements play a critical role in determining urban form. As these studies, and others cited above, indicate, the type of development facilitated by and best served by highways is suburban sprawl (see, generally, Kelly 1993a). Whereas fixed-rail systems, reinforced by appropriate land-use controls, can encourage nodal subcommunity development around railroad and transit stations, highways allow, if not encourage, dispersal of population and activity over a wide area. Of course, sprawl cannot be blamed entirely on highways. They have merely facilitated choices that consumers seem inclined to make. As Milwaukee County Executive David Schulz (1991) noted at a conference on research on transportation and urban form:

> I believe that those of us concerned with transportation in urban America can no longer wait for people to start to behave as we would like them to: living in compact, high density, residential development patterns; traveling short distances to work along well-defined corridors to destinations in orderly, compact business districts; using public transit in large numbers . . . ; planning their non work travel in orderly and efficient ways; and being very socially conscious in their selection and very limited personal use of an automobile. (p. 12)

What highways do is to change one of the variables in the economic formula that Wingo hypothesized and that others have confirmed: they make longer commutes less time-consuming and thus less costly than they would be otherwise. Thus, when the consumer is making the choice between a more costly house and a more costly commute, the time factor in the cost of commuting is artificially reduced by the highway. Many argue that it is subsidized. As Anthony Downs (1992) has recently argued:

> The failure to confront commuters with the true social costs of their driving alone during congested periods has two other ill effects. It understates the cost of living in low-density patterns and leads to an overinvestment in highways. Both outcomes contribute to an excessive spreading out of American metropolitan areas. That raises energy costs, increases infrastructure costs, increases vehicle-miles traveled, and worsens air pollution. (p. 142)

Hanson (1992) developed a detailed model of highway subsidies using figures available through reports on transportation financing in Wisconsin. Note that the amount of the subsidy is considerably greater if computed on a marginal cost basis, recognizing that peak-hour users are the most expensive users of any system and that the subsidies are thus greatest to commuters (Schaeffer and Sclar 1975, 131).

But is that a problem? If people in the United States want to live in sprawling suburbs, should public policymakers dispute that choice? Although few public officials are likely to want to try to stop sprawl as a few communities have done, there is substantial reason for

public officials not to subsidize or facilitate it. The basis of that reason is economic. In a period when the nation is suffering from disinvestment in infrastructure (National Council on Public Works Improvement 1988), the additional cost of serving sprawling development is a matter of great public concern.

Does it really cost more to serve sprawling development? Definitely. The first major study to suggest such a conclusion was *The Costs of Sprawl* (Real Estate Research Corporation 1974), a study that was criticized at the time for weaknesses in its methodology. One of the principal defects in its comparison of the costs of providing public services to various development types was that the dwelling units in the different development types were quite different, suggesting different occupancies. Thus the high-density development with ten thousand units was cheaper to serve than the sprawling development with the same number of units, in part because it would have a smaller population (see, generally, Altshuler 1977; Windsor 1979). However, even one of the critics of the study found significant fiscal savings for roads and other public facilities in the more compact development types (Windsor 1979).

In his 1989 literature review, James Frank calculated the difference in capital costs for different types of development and development in different locations. Increasing single-family densities from one unit per acre to five units per acre reduced capital costs for streets from $12,308 per unit to $7,526 and reduced utility capital costs from $19,789 to $8,843. Capital costs for town houses were calculated at $6,785 for roads and $6,019 for utilities. Reductions were even more dramatic for multifamily units, with multifamily units at thirty units per acre involving less than 30 percent of the capital costs for roads and about 20 percent of the capital costs for utilities of single-family units on one-acre lots (Frank 1989, 40). It is important to note that, even where local government passes the increased capital costs on to developers (and probably to consumers), the local government will continue to bear the maintenance costs; and, of course, maintenance costs are higher for longer streets and utility lines serving more dispersed development.

The figures in the previous paragraph are primarily of interest to local officials, who either bear or assess to developers most of those costs. A different set of figures from Frank's synthesis should be of great interest to highway planners. He found incremental community capital costs, ranging from roughly $6,000 per unit up to $14,000 per unit to serve residential development in leapfrog locations five and ten miles from major urban service centers (Frank 1989, 40). That is exactly the sort of exurban development that radial highways and beltways facilitate.

The state of Florida hired a team of consultants to compare the actual capital and operating costs of existing development patterns in Florida (James Duncan and Associates et al. 1989a, 1989b). Not surprisingly, the team found significantly lower capital costs for compact and contiguous development patterns than for scattered, or exurban, development. For roadways in particular, the study team found that the state recovered a much smaller portion of its capital and operating costs from gasoline taxes and other sources for satellite and scattered residential communities than for other development types (James Duncan and Associates et al. 1989a, 20).

A commission in Maryland used the Florida team's figures and methodology and computed some dramatic statewide figures. It computed a potential saving of 15 percent in capital costs, some $1.2 billion over fifteen years, by encouraging compact and contiguous development rather than allowing the current trend of sprawl to continue (Governor's Commission on Growth in the Chesapeake Bay Region 1991). Savings for roads alone were projected at $700 million over fifteen years, or some 25 percent.

Some of the savings computed in any of these studies result from more efficient use of existing infrastructure rather than from absolute savings. If a new development takes place along a major arterial road with adequate capacity to absorb the traffic from it, the marginal capital road or highway cost for that project is arguably zero. On the other hand, if that same development is built in an area served only by a gravel road that must be upgraded or in an area with overloaded highways that will have to be widened to accommodate traffic from the project, there is a measurable marginal cost to serve that development. The Maryland study commission acknowledged that much of its projected savings resulted from such efficiencies. If such savings are possible from better use of existing facilities in a state containing portions of two congested metropolitan areas (Baltimore and Washington), then clearly there is similar potential for savings elsewhere.

CAN WE USE THIS KNOWLEDGE?

Scholars and others have been writing about the land-use transportation relationship for the better part of a century. Yet, at least in the United States, there appears to be almost a negative learning curve. As the discussion above suggests, traffic has continued to increase, even as jobs have followed people to the suburbs. Is this an uncontrollable cycle, so rooted in personal preferences that there is little opportunity to make a difference? Clearly not.

Certainly many of the opportunities are at the federal level, in reconsidering the federal subsidy to automo-

bile travel (see, generally, Hanson 1992; Downs 1992). The issues involved in rethinking federal transportation policy are somewhat beyond the scope of this article, but it is important to note that ISTEA is a good step in the right direction.

There are many things that can be done at the local or metropolitan level, however. One technique that more communities are using to encourage development near existing infrastructure is an "adequate public facilities" ordinance or regulation. Called the "concurrency" requirement in Florida, such a rule requires that adequate public facilities be available to serve a new development concurrently with the construction of the project (Kelly 1993a, 1993b).

Cervero (1991) has argued that the nation needs a combination of land-use initiatives that include much denser development ("densification"), mixed-use projects, a good jobs-housing balance, and pedestrian-friendly site planning in individual projects as a planning basis for reducing total automobile travel. Although acknowledging the institutional and political obstacles to accomplishing it, he, like others, urged strongly that land-use planning should guide transportation planning. Newman and Kenworthy (1989a) argued simply for reurbanization of cities at much higher densities to discourage automobile use and, presumably, to encourage more ridership on light-rail systems.

Much of the work discussed here has dealt with macroscale urban-design issues—those issues that determine the general shape of urban areas and the location of economic activity within them. Microscale urban design is also important to this discussion, however. Certainly one of the reasons that U.S. cities have become automobile dependent is that, through zoning, cities and suburbs alike have created residential areas that are not only relatively low-density but that are generally zoned free of even basic retail and service businesses (for a general discussion, see Kelly [1988]). Because obtaining a loaf of bread or a clean shirt is not possible in the neighborhood, and the neighborhood has not been built at a scale that makes sense for mass transit service, residents almost have to use automobiles to handle basic errands. It is hardly surprising, then, that the places where they conduct their business are oriented toward the automobile, often in mammoth strip centers along major arterials. Local governments have reinforced those patterns with zoning that not only discourages such developments in neighborhoods but that often mandates that they take place in strips along arterials, with setbacks and off-street parking almost guaranteed to make the shopping areas hostile to pedestrians or bicyclists.

Some contemporary urban designers have argued that it is time to rethink the patterns of neighborhood development. Calthorpe (1993) has urged the creation of "transit-oriented developments." Although his developments are certainly transit oriented, they are far more than that: they are pedestrian oriented, bicycle oriented, and very human oriented. Calthorpe proposed (and he has designed) projects that recapture some of the character of prezoning communities, with commercial buildings fronting on sidewalks, residences above the stores, and parks and village greens integrated into neighborhood planning. He also proposed integrating transit stops into the project design and adding pedestrian overpasses to provide access across major arterials. These ideas are not new, but recognizing their value and their relationship to the transportation patterns of the city is new.

Duany and Plater-Zyberk (1991) have marketed their concept of neo-traditional town planning extensively and effectively. They focus on many of the same issues as Calthorpe, with a major difference. One of the recurring themes of their work is the importance of a nonhierarchical grid system of roads, in contrast to the arterial-collector-local hierarchy used in many communities today. Their view of the grid is that it avoids the creation of the kinds of arterial streets that become barriers to pedestrianism and thus keep all streets pedestrian-friendly. Although that may be true where the grid can be relatively isolated from through traffic (as it appears to be at Seaside, their landmark project in Florida), congestion on major streets leading to the heart of Chicago, Denver, Miami, Los Angeles, and other cities with old grids demonstrates clearly that even in a grid, some streets may carry disproportionate shares of traffic. One of the arguments for a hierarchical street system is that it dictates which streets will carry heavy traffic, rather than simply letting the traffic patterns evolve. Like Calthorpe's, Duany and Plater-Zyberk's work has emphasized communities that are pedestrian-friendly and that resemble towns built when people walked many places more than they resemble today's automobile suburbs.

There are two issues in all of this that are more difficult to recognize. One issue hidden in all of the published analyses of general infrastructure costs is that coordination of the location of development and all major public facilities is crucial. If the city has a new fire station north of town, a major interceptor sewer line with excess capacity south of town, and good access to a major interstate highway leading west out of town, there is no cost-effective location for growth. If all of the new investment in public facilities were concentrated in one direction, all of the entities involved in building and maintaining infrastructure and other public facilities would gain. A policy encouraging coordination of the location of infrastructure may suggest that it encourages preemptive strikes and that all other infrastructure investments should follow the locational lead of the first

major one. Clearly, a coordinated and comprehensive plan is a better approach (see the next section).

The other issue is more subtle, and yet it is obvious to anyone who has worked with local planning. It simply makes sense to encourage development in some directions rather than others. A community may want to preserve wetlands, farmland, fragile slopes, or mountain vistas in a particular direction. Building infrastructure in that direction will be counterproductive to the preservation effort, but building new infrastructure in other areas can reinforce the land preservation policy. When the issue is one like fragile slopes or wetlands, highway engineers and public planners are likely to agree on the reasons to avoid such areas. In other cases, however, they may not. Agricultural land is often available at reasonable cost, and it is highly buildable. Thus it may provide an attractive routing for a major roadway. Railroads and highways have frequently followed rivers because the rivers provide a relatively continuous area of land that is often open or used only for marginal purposes. But by using this often inexpensive and available right-of-way, highway engineers attract development to the floodplain—an action that contravenes both federal and local policies, as well as common sense. The desire to provide good access to a new airport may also lead to providing good access to land around the airport that the airport operator would like not to see developed.

In short, major transportation facilities influence both the type of growth that takes place and the location of that growth. Even if critics like Altshuler (1979) are correct and urban form will remain decentralized no matter what is done with transportation planning, coordinated transportation and land-use planning can still help to focus that decentralized development in the most appropriate locations within a metropolitan area. Focusing capital investments and development in the same areas can result in substantial fiscal benefits and land savings, as the Maryland study showed. That policy approach can also locate public and private development on land most suitable for such development, keeping it away from lands that the community wishes to preserve.

Even Owen, clearly an advocate of the highway system, recognized that highways should not be the exclusive means of urban transit. He expressly urged the adoption of pooled funding systems and of tolls on congested urban roadways as a method of increasing the availability of funding for urban transportation and also as a method for encouraging drivers to think about carpooling and other means of commuting (Owen [1956] 1966, 216). A 1991 study at Northwestern University examined the market effects of various approaches to the reduction of congestion (Koppelman et al. 1991). A 1989 Brookings Institution study (Small et al. 1989) strongly recommended a new system of highway financing, based on road wear and congestion charges. The Brookings Institution study suggested the use of tolls on congested roadways and the possibility of building future auto-only roadways in urban areas, possibly financed from the tolls. The authors argued that congestion pricing could reduce peak-hour congestion by as much as 25 percent in many cities. They also argued that a rationally priced system would encourage private enterprise to help meet highway needs. A recent Urban Land Institute report (Eager 1993) cited two successful examples of congestion reduction: the Houston Mobility Project, a massive construction project including both roadway and transit system improvements; and an experiment in Curitiba, Brazil, in which high-density development was focused along radial axes, which were also provided with express bus lanes.

Communities use a variety of regulations and fees in efforts to mitigate traffic impacts, particularly in the immediate area of the development. Adequate public-facilities ordinances may actually preclude development in a particular location if system capacities are inadequate to handle the traffic from it (Kelly 1993a, 1993b; Freilich and White 1991). Other programs simply assess impact fees, traffic mitigation costs, or site-specific fees on a development and then use the funds to improve the traffic facilities serving the site (Freilich and White 1991; Wachs 1990). None of these programs address the fundamental problem unless they are region-wide and tied to incentives to develop in appropriate locations. For example, Montgomery County, Maryland, permits traffic congestion in the areas near transit stations for two reasons: first, it recognizes that such hubs of activity are naturally congested; and second, congestion on streets in the area may encourage more people to ride the transit system (see Kelly 1993a, chap. 9). On the other hand, as one of the referees of this article noted, such congestion may cause commuters to avoid the area—and the transit station—entirely.

Echoing Blucher's (1950) warning that the work of the traffic engineer is "inevitably doomed to fail" (p. 849), the 1989 Brookings Institution study started in part from the premise that congestion-management programs cannot succeed:

> The problem is that none of these policies accounts for the latent demand for peak-period highway travel. This latent demand consists of all potential peak-period users whose trips are now diverted or deterred by congestion itself. Any policy that makes some alternative to peak highway travel more attractive will founder on its own success, because any perceptible improvement in congestion will itself attract new peak-period highway users. (Small et al. 1989, 85)

Downs (1992) called this phenomenon the "triple-convergence principle." He argued that persons "who formerly (1) used alternate routes, (2) traveled at other times, or (3) used public transit" would fill any new gaps in capacity resulting from road widening or congestion management (p. 145). Three decades earlier, Blucher (1950) stated it more simply: "When the traffic engineer does succeed in improving the flow of traffic . . . invariably other people see that traffic is moving faster and more freely and decide there is room for more" (p. 849).

In arguing that better coordination of transportation and land-use planning is essential, it is important to recognize that there are significant institutional barriers to accomplishing this kind of coordination. State departments of highways and (now more commonly) departments of transportation, build region-shaping interstate highways, using a great deal of money and following federal guidelines. In metropolitan areas with fixed-rail transit systems—the one type of mass transportation that clearly plays a major role in shaping the region—those transit systems are usually operated by an independent authority of some sort. In New York and Philadelphia, the authority that operates the toll bridges also operates part, but not all, of the fixed-rail transit systems. Weiner (1986) described the structure of urban transportation planning in the United States in some detail. He also described the variety of federal policies that affect such planning when federal funding is involved, as it often is.

Further, the philosophical debate continues over whether transportation or land-use planning comes first. Transportation planners expect to rely on projections of future land use (Creighton 1970, esp. chap. 8), projections that may be changed significantly by the construction of a particular project. On the other hand, land-use planners need to know what the transportation network will be like to make land-use plans.

Things do not get better at the local level. Local streets and separate local bus lines are managed by a plethora of local governments, special districts, and authorities. The 1987 Census of Governments found more than thirty-two thousand entities of local government in the nation's 115 metropolitan areas (Bureau of the Census 1988); this fact led Porter (1991) to argue at a symposium on coordinating transportation and land use that the only hope for doing so is with effective regional governance. Clawson (1971) made a similar argument two decades earlier, as have many others. Even within a particular local government, there are at least two separate planning functions. Planning for future land use is generally a function of the planning commission and planning staff (So and Getzels 1988), while planning for public improvements such as streets and bridges is typically carried out by a combination of elected officials and staff from the finance and public works departments (Brevard 1985; So 1986; Bowyer 1993).

The simple coordination of the two systems of planning within local governments (Kelly 1993b) may be the most likely of any of these suggestions to be followed, because it is the easiest to accomplish. In a freestanding city, like Albuquerque or Lincoln, simple coordination can accomplish a lot. For the majority of U.S. metropolitan areas, however, it will accomplish little without coordination among the dozens to hundreds of cities, counties, and special districts that dot their geographic regions. Owen's call for a geographically comprehensive system is critical.

Stover and Koepke (1988) proposed that land-use and transportation planning should be integrated in a four-stage planning process: very long-range planning for both land-use and transportation scenarios, a twenty-year plan for major changes in infrastructure and land use, a five- to ten-year plan for capital improvements, and site design for specific improvements and developments. Their model is philosophically consistent with that of simple coordination (Kelly 1993b), but it appears to assume that there is a single decision-maker dealing with long-range plans for highways, other infrastructure, and land use. Clearly, that is not the case anywhere in the United States. Although most commentators at least nominally favor coordinated planning, at least one does not. Small (1985) acknowledged that "technological improvements in transportation have greatly influenced historical development of the present urban structure," but he maintained that future influences will be smaller and thus transportation planning should focus primarily on "the need to serve transport" (p. 222).

Clearly, land-use and transportation planning are interdependent. It seems only logical to urge that they should be interconnected. Stover and Koepke's (1988) single-decisionmaker model is too simple, but it at least points in the right direction. Other works cited above also provide suggestions for improving communities based on our knowledge of the transportation-land-use link.

IS THIS KNOWLEDGE ACCESSIBLE TO THOSE WHO NEED IT?

Decisions about the shapes of cities and of neighborhoods are made by tens of thousands of people in thousands of agencies around the country. Planning commissions, presumably with the advice of their professional staffs, make decisions about new developments that become new neighborhoods. They recommend new zoning ordinances to governing bodies. Public works departments make decisions about the construction of new arterial and other roads, often without the advice of either their respective planning com-

missions or planning staffs. State transportation departments make city-shaping decisions about new urban highways and beltways, with some acknowledgment of the ISTEA mandates, it is hoped, to recognize the land-use impacts of their decisions and to coordinate them with land-use plans. This section provides a brief look at some of the literature used as reference and training material by those who make such decisions.

The classic International City Management Association (ICMA) "planners' greenbook" (So and Getzels 1988) contains a chapter on transportation planning written by Sandra Rosenbloom, well-known among planners interested in transportation. In it, she described the difficulties of predicting the land-use impacts of transportation decisions and then traced the history of metropolitan transportation planning. She noted the institutional isolation between land-use planners and transportation planners (Rosenbloom 1988, 147) and the separation of the regional transportation planning process from local planning efforts. Nothing in the chapter gives planners any guidance on how to coordinate land-use and transportation decisions, and much of it is discouraging because of her analysis of difficulties in predicting mutual impacts. Another greenbook chapter on "General Development Plans" (Hollander et al. 1988) acknowledged the existence of transportation plans as a separate element of such broad community plans, but it did not include any real discussion of the complex relationships and their implications for planning.

Two widely used teaching texts for planners also give short shrift to the subject. Branch's (1985) *Comprehensive City Planning* acknowledges that "the location of transportation routes and municipal utilities shapes the use of land in cities" (p. 46), but transportation issues are discussed on a total of 4 pages of some 230 in the book. Levy's (1994) *Contemporary Urban Planning*, now in its third edition, has a chapter devoted to transportation planning. In it, he defined the relationship between transportation and land use as "very much a chicken and egg situation" (p. 197) and noted that, "in the ideal case, transportation planning and land-use planning would go hand in hand" (p. 197). However, Levy then described a demand-responsive transportation planning system in which policy analysis is limited to the weighing of costs and benefits and the consideration of citizen concerns. Nothing in the book provides any guidance to a planner who might want to develop transportation planning and land-use planning processes that in fact go "hand in hand."

What is missing from the literature is practical advice to the planner in the trenches, telling him or her how to make transportation decisions and land-use decisions work together as mutually supportive links in a system of real comprehensive planning. Although Stover and Koepke (1988) outlined a theoretical model with a great deal of appeal, their underlying assumption of a single decisionmaker renders the model useless in practice; it remains a useful construct for researchers and theoreticians in the field. Although a recent Planners Advisory Service report has made a modest contribution to this literature (Kelly 1993b), much more is needed. The next edition of the ICMA greenbook should acknowledge this relationship throughout the chapters on both land-use and transportation planning. Teaching texts should suggest to students that they can intervene in this cycle. Teaching and reference materials for transportation planners should remind them that they are shaping cities as well as roadways. As long as transportation planning and land-use planning remain separate processes rather than coordinated ones, or perhaps more often individual parts of a comprehensive whole, we will all remain "stuck in traffic" (see Downs 1992) far more often and for far longer periods than we should be. Better planning alone cannot fix the problem, but it can certainly make it better.

CONCLUSION: PLANNING IS THE CONSTRAINT AND THE OPPORTUNITY

It is not difficult to recognize the problem as one of planning. A recent report from an organization representing large developers complained, "We continue to suffer disjointed land use and transportation planning efforts" (Eager 1993, 32). The report went on to call for "synchronization of land use and transportation policy decisions" (p. 37). As William H. Whyte (1958) urged more than thirty-five years ago, "There can be coordination between the engineers, and if there is, the highway program will be a positive force for good land use" (p. 127).

Wilfred Owen ([1956] 1966) set forth these criteria for implementing a more successful system:

> An effective solution to the urban transportation problem, then, should meet three tests. First, it should be functionally comprehensive. . . . Second, it should be comprehensive geographically. . . . Third, it should be comprehensive from a planning standpoint by assuring that the transportation is used to promote community goals, and that community plans make satisfactory transportation possible.
>
> This latter test is the most important. (p. 224)

That is much easier said than done. Transportation planning itself is rarely comprehensive.

To cite a good example of integrated land use and transportation planning, a 1975 study turned to Edmonton, Alberta, Canada (Schaeffer and Sclar 1975). That city combined policies of land banking, replatting, hierarchical streets, and the immediate extension of transit service to new areas to create a compact and "land-managed" city.

Finally, in 1991, Congress began to heed some of these concerns. Under the Intermodal Surface Transportation Efficiency Act, Congress has mandated that there be more planning. The act, which replaced the traditional "highway bills," represented a paradigm shift in transportation planning (Morris 1992). It requires that transportation plans now include "the likely effect of transportation policy decisions on land use and development and the consistency of transportation plans and programs with the provisions of all applicable short- and long-term land use and development plans" (sec. 134f). Partly in response to that act, Iowa's Department of Transportation has been reorganized without the traditional highway division, so that everyone in the department is presumably working on all types of transportation. There are undoubtedly similar reorganization efforts taking place around the country.

Whether the new law and the new organizational structures are largely symbolic or whether they really begin to change the way in which transportation in the United States is planned remains to be seen. However, if the present efforts fulfill the apparent congressional intent, some of the learning reflected in decades of theoretical and empirical work may begin to affect metropolitan transportation systems and the nation may begin to achieve some of the potential that Owen saw so optimistically. It is interesting to note in passing that similar discussions and analyses are taking place in the United Kingdom, where Hart (1992) found a distinct shift in the mid-1980s—a shift away from unbridled expansion of automobile capacity toward a more diverse and "sustainable" transportation system, possibly including the "compact city."

> What the future of the city will be or what the city of tomorrow ought to be like are questions closely related to the provision of transportation. Transport innovation will to a large degree dictate what is possible, and the extent to which transport policy is directed to achieving urban goals will help determine what is feasible. (Owen [1956] 1966, 21)

Or, as Charles Nelson argued in 1950, the answer to the question of whether highways will "promote or retard a wholesome growth . . . will, I am sure, depend on the extent to which expressway planning is an integral part of comprehensive planning for better organized and more livable cities" (p. 123). Blucher (1950) urged, "We must have proper planning of cities so as to get a suitable relationship between home, work, school, recreation and shopping" (p. 856).

The real challenge is for planners to put this knowledge to work in the field. The topic has been discussed in the literature for decades. We understand the philosophy, the economic theories, the principles, and the relationships. Certainly, as some of the critics point out, the land-use-transportation relationship is a complex and cyclical one. Thus simplistic changes may make the problem worse rather than better. On the other hand, we can make a difference. Few would argue with Downs's (1992) assertion that too many of us spend too much time stuck in traffic. Clearly, building more highways will not solve that problem in a growing metropolitan area. Part of the solution must include a reduction of the automobile dependence of cities. That can only happen with truly comprehensive planning that creates neighborhoods as well as metropolitan areas suited to the use of multimodal transportation systems, and that simultaneously creates attractive and efficient multimodal transportation systems to serve the people living there. Congress has now essentially mandated that. It is up to planners and public officials to make it work. The change must start in the textbooks, the handbooks, and the classroom. The greatest need for expanded literature in this field is in the literature for the practicing planner and public official.

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